Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3201.3 (2017-11)

Components of the Reactor Coolant Pressure Boundary
of Light Water Reactors
Part 3: Manufacture

(Komponenten des Primärkreises von Leichtwasserreaktoren;
Teil 3: Herstellung)

Previous versions of this Safety Standard were issued
1979-10, 1987-12, 1998-06 and 2007-11

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

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

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KTA SAFETY STANDARD

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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 (SiAnf) 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. In no. 3.1 furthermore the use of qualified materials and manufacturing as well as the assurance and maintenance of the quality features during manufacturing. Safety requirement no. 3.4 (1) requires, among other things, that the reactor coolant pressure boundary shall be designed, located and operated such that the occurrence of rapidly extending cracks and of brittle fracture need not be postulated. Safety standard KTA 3201.3 is intended to specify detailed measures which shall be taken 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 components of the reactor coolant pressure boundary the requirements of the aforementioned safety requirements are further substantiated with the following safety standards

KTA 3201.1 Materials and Product Forms,

KTA 3201.2 Design and Analysis,

KTA 3201.4 In-service Inspections and Operational Monitoring

KTA 3203 Surveillance of the Irradiation Behaviour of Reactor Pressure Vessel Materials of LWR Facilities.

as well as with

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

(3) The requirements specified under KTA 3201.3 address, in particular,

a) the organisations that are involved in manufacture,

b) the weld design, welding, heat treatment, and forming of the components in consideration of the materials and the type of welded joints,

c) the certification and supervision procedures for attaining and meeting the required quality of the components such as welding procedure qualifications, 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 test results obtained during manufacture.

(4) This safety standard does not specify any requirements that do not serve the primary purpose of a safe enclosure of the reactor coolant.

1 Scope

(1) This safety standard applies to the manufacture of pressure-retaining components of the reactor coolant pressure boundary of light water reactors.

(2) This safety standard does not apply to pipes and valves with nominal diameters equal to or smaller than DN 50.

(3) In the case of pressurised water reactors, the reactor coolant pressure boundary comprises the following components without internals:

a) the reactor pressure vessel,

b) the primary side of the steam generators
(the secondary shell of the steam generators including the feedwater inlet and main steam exit nozzles up to the pipe connecting welds, but not the minor nozzles and nipples, shall also be treated in accordance with this safety standard),

c) the pressurizer,

d) reactor cooling pump casing,

e) the connecting pipes between the above components and the valve bodies of any type contained in the pipe system,

f) the pipes branching off from the above components and their connecting pipes including the valve bodies installed in the piping system up to and including the first shut-off valve,

g) the pressure retaining walls of the control rod drives and the in-core instrumentation,

h) the integral parts of the component support structures in accordance with Fig. 8.5-1 of KTA 3201.2 and the welded attachments.

(4) In the case of boiling water reactors, the reactor coolant pressure boundary comprises the following components without internals:

a) the reactor pressure vessel,

b) the pipework belonging to the same pressure space as the reactor pressure vessel including the installed valve bodies up to and including the first shut-off valve, pipework penetrating the containment shell and belonging to the same pressure space as the reactor pressure vessel up to and including the last shut-off valve located outside the containment shell,

c) the pressure retaining walls of the control rod drive, of the in-core instrumentation and of the recirculation pump (seal casing),

d) the integral parts of the component support structures in accordance with Fig. 8.5-1 of KTA 3201.2 and the welded attachments.

(5) Internals of shut-off valves required to isolate the pressure space shall be considered part of the pressure boundary. Requirements for the fabrication of such parts shall be laid down in each individual case in due consideration of their functions.

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 made between base metals and surfacing materials (see DIN EN ISO 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 buffer layers (buffering) 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) Final inspection

Final inspection is the inspection of finished components, sub-units, components or systems at the manufacturer's works or on the site for compliance with the design-approved documents.

(4) Part

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

(5) In-process inspection

In-process inspection is the design approval performed by the competent authority or the authorized inspector as well as the check of a component or system for compliance with the design-approved documents within the course of in-process inspection and final inspection.

(6) Echo height evaluation

Echo height evaluation is the evaluation of indications by comparison of the echo height (signal amplitude of the ultrasonic signal generated at the reflector) with the recording level and evaluation limit and as shown in Figure 2-1 of KTA 3201.4. Echo height evaluation does not include the sizing of reflectors.

(7) Product form (synonymous for semi-finished product)

A product form is the form in its raw condition into which materials are processed, e.g. plate, forging and casting.

(8) Fabrication step

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

(9) Total heat treatment time for stress-relieving

The total heat treatment time for stress-relieving is the total time of stress-relief heat treatment performed on a component during fabrication at a temperature above 500 °C.

(10) Coarse-grain zone

The coarse-grain zone is that part of the heat-affected zone (HAZ) which has been overheated at least once and has not been grain refined under further heat influence ($T < A_{C1}$) or has been overheated again under the influence of heat subsequently applied (T > approx. 1100 °C).

(11) Semi-finished product

See product form (7).

(12) 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.

(13) 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.

(14) Combined welding procedure qualification / production control test (VP/AP)

The combined welding procedure qualification / production control test relates to a test piece welded at the beginning of component production for the purpose of welding procedure qualification and simultaneously used for the production control test for subsequent component production.

(15) Component

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

(16) 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).

(17) 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 tested or from which the specimens are to be taken.

(18) Room temperature

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

(19) Noise

Noise means randomly distributed signals in the screen image which are due to test conditions, reflections from the structure of the material, its surface condition or the electronics.

(20) Noise level

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

(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 pursuant to 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 a weld, including the welding process(es), reference to materials, welding consumables, preparation, preheating (if necessary), method and control of welding and postweld heat treatment (if relevant), and necessary equipment to be used.

(24) 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.

(25) Repeat parts

Repeat parts are identical parts of which more than one is built into a component.

3 Requirements to be met by the manufacturer

3.1 General requirements

The component manufacturer shall ensure the proper performance 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 (see also Section 3.3) at his disposal to be capable of proper-

ly carrying out the processing, testing and inspection as well as transport of product forms, parts, sub-units, and components. Equipment and personnel from other organisations meeting these requirements may also be employed. The testing and inspection facilities shall permit the implementation of the tests and inspections in accordance with the applicable rules and standards.

(2) The measuring and testing equipment to be used shall be monitored. The type and intervals of monitoring shall be fixed by the equipment manufacturer with a view to the accuracy of the equipment. The testing of such measuring and testing equipment shall be certified.

(3) The manufacturer shall ensure that the required quality of the parts to be manufactured is obtained. The persons or organisations conducting quality assurance activities shall be independent of the persons or organizations responsible for fabrication.

(4) The manufacturer shall employ responsible and competent supervisory personnel for all manufacturing steps to be taken under his control. The task and responsibilities of the welding supervisors shall be laid down in writing.

(5) The organisational and personnel requirements for the maintenance and transfer of identification markings of the product forms shall be available.

(6) Prior to the beginning of first manufacture it shall be proved to the inspector, within the manufacturer's evaluation (audit), that the aforementioned requirements have been satisfied. This shall be laid down by a written statement of the authorized inspector. In the case of essential changes with respect to the conditions found during the manufacturer's audit, the latter shall apply for a supplementary evaluation.

(7) Within the course of manufacture the authorized inspector is entitled at any time to satisfy himself that these requirements have been fulfilled.

(8) The manufacturer's works audit shall be valid for 24 months upon receipt of the authorized inspector's statement. If fabrication and testing has been done within this period of validity, the latter may be extended by 24 months upon application of the manufacturer. The extended period shall begin at the end of the first validity period.

(9) Where the fulfilment of the fabrication requirements as per sub-clause (6) is checked by the authorized inspector, available documentation on reviews made by other agencies may be taken into account [see also clause 2 (21)].

3.3 Organisational and personnel requirements for the performance of welding work and non-destructive examination

3.3.1 Welding supervision

3.3.1.1 Independence

The welding supervision department shall be independent of the department which is to carry out the welding work, and shall be notified to the authorized inspector by the manufacturer.

3.3.1.2 Tasks

The welding supervision department of the manufacturer's works has the task to fix, under its responsibility, the respective quality assuring measures and to control that these measures are complied with. The welding supervision department has to satisfy itself of the effectiveness of welding supervisors.

3.3.1.3 Personnel requirements

(1) Only such persons shall be employed as responsible welding supervisors who due to their training, experience and skills are capable of evaluating and supervising all welding work from the planning to the performance in accordance with the codes, standards, guidelines, and procurement guidelines to be observed.

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

a) Responsible welding supervisors of the manufacturer's works:

   Engineers who have undergone a special welding training at recognized training facilities, or have been trained in manufacturers` works audited in accordance with Section 3.2.

   The responsible welding supervision personnel shall be employed by the manufacturer's works.

b) Further personnel for welding supervision (e.g. by delegation of individual parts or as representative):

   ba) Persons with special welding training and experience on the field of activities with which they are tasked. Where persons according to clause 3.3.2.3 are employed, they shall be under the direction of the responsible welding supervisor with regard to their field of activity.

   bb) Further personnel shall also be employed by the manufacturer's works. In justified cases, personnel not being employed by the manufacturer shall be employed subject to approval by the authorized inspector.

3.3.2 Welding supervision

3.3.2.1 General requirements

(1) The welding supervisor shall be employed by the manufacturer's works and be notified to the authorized inspector by the manufacturer. Within the course of the manufacturer's audit and fabrication, the authorized inspector shall satisfy himself of the effectiveness of welding supervision.

(2) The welding supervisor shall intervene when fabrication documents are established for welding.

(3) The welding supervisor shall be authorized within the limits of design-approved fabrication documents, to see on its own that the required measures are taken for obtaining the intended quality of welding.

(4) Where several persons are nominated to act as welding supervisors in one workshop, their individual areas of responsibility shall be clearly defined. Where required by the extent of welding work - e.g. in the case of several work shifts - the welding supervisors shall be represented or supported by additional welding experts.

3.3.2.2 Tasks

(1) The welding supervisors shall supervise, under their responsibility, the welding work according to Section 5 including heat input prior to, during and after welding, and shall be responsible for establishing welding records. The supervisors shall ensure that the rules belonging to their field of activity are adhered to, and are also responsible for the use of qualified welders/operators as well as the proper operating conditions of welding and auxiliary equipment during fabrication.

(2) The times where the supervisors are present shall be adapted to the extent of welding work and the degree of difficulty of the work to be supervised.

3.3.2.3 Personnel requirements

(1) Only such persons shall be employed as welding supervisors who, after having been trained accordingly, are considered to be suited for this job on the basis of their training, experience and qualification. Above all they shall have practical experience in such areas of welding technology, welding processes and their combinations in particular, as are applied in the course of fabrication of primary circuit components.

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

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

b) Additional personnel for welding supervision (e.g. by delegation for individual tasks or as representative):

   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 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.

3.3.3 Welders and operating personnel of fully mechanized welding equipment (except for welders and operating personnel of fully mechanized welding equipment for hard surfacing)

Note:

See Section 3.3.4 for hard surfacing welders and operating personnel of fully mechanized welding equipment.

3.3.3.1 Training and qualification

(1) Welders employed for manual and partly mechanized welding shall be trained at training facilities which systematically deal with the training of welders.

(2) The training facilities shall fulfil all requirements for the instruction of welders necessary to meet the qualification requirements. Training facilities may also be facilities belonging to manufacturers audited in accordance with Section 3.2.

(3) 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 to include the examination of the welder's technical knowledge, and shall comply with the essential variables requirement of Section 5 of DIN EN ISO 9606-1 in conjunction with AD 2000 Merkblatt HP 3. For the scope of application of base metals Table 2 of DIN EN 287-1:2011-11 shall be satisfied. For weldments on nickel alloys DIN EN ISO 9606-4 shall apply to include the examination of the technical knowledge.

(4) 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 and 22 NiMoCr 3 7 it is required to perform the qualification test on each of these materials or on another high-temperature steel of this material group.

(5) Where welders have been qualified on one of the aforementioned steels, the qualification shall also apply to the other steels of material group 4.2 to DIN CEN ISO/TR 15608, except for high-tensile fine-grained steels with a guaranteed minimum yield strength exceeding 520 MPa. 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.

(6) In deviation from the requirements of DIN EN ISO 9606-1, Section 6.4, Table 13

a) in the case of qualification tests for welding procedures 131, 135 or 138 radiographic testing 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 welding position) shall be made and be examined.

3.3.3.2 Performance of first welder's qualification test

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

a) the authorized inspector,

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

(2) Prerequisite to the performance of initial qualification tests is, upon agreement with the authorized inspector, that the welder has been trained in accordance with clause 3.3.3.1. Expert personnel and suitable facilities shall be available for training and qualification. The results of the qualification tests shall be recorded and be kept at the authorized inspector's disposal at the manufacturer's works.

3.3.3.3 Operators of fully mechanized welding equipment

(1) It shall be demonstrated by a test to DIN EN ISO 14732 to the authorized inspector that the operators of fully mechanized welding equipment have sufficient knowledge to operate the equipment. The qualification test shall be performed

a) by the personnel during welding procedure qualification or pre-manufacturing production control tests to DIN EN ISO 14732, clause 4.1 a),

or

b) as test prior to the beginning of fabrication to DIN EN ISO 14732, clause 4.1 b).

For test 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 9606-4, Section 7.4 and evaluation criteria of DIN EN ISO 9606-4, 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.

3.3.3.4 Performance of the welder's qualification renewal test

(1) Deviating from the requirements of DIN EN ISO 9606-1 and DIN EN ISO 14372, renewal tests shall be repeated at two-year intervals or after the welding operator has not been employed as welder or welding operator for fully mechanized welding equipment for more than 6 months.

(2) 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 welder's qualification in the welding processes 131, 135 or 138, results from fracture tests shall be submitted additionally. The welding operator's qualification shall be renewed in accordance with DIN EN ISO 14372, clause 5.3 a) or clause 5.3 b).

(3) Welding procedure qualifications and welder's qualification tests are recognized as renewal tests for welders and operators of fully mechanized welding equipment.

(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.

3.3.3.5 Test certificates

Certificates shall be established on the qualification tests performed according to clause 3.3.3.2, 3.3.3.3 and 3.3.3.4 by the qualifying agency. The certificates shall be kept available at the location of employment of welders or operators of fully mechanized welding equipment. Qualification tests not performed by the authorized inspector shall show the following remark:

> "Qualification test performed by agreement with the authorized inspector from ..... (name of authorized inspection agency) ..... the test was conducted on .....".

3.3.4 Hard surfacing welders and operators of fully mechanized welding equipment

3.3.4.1 Training and qualification

(1) Welders for manual or partly mechanized welding shall be trained at training facilities which deal systematically with the training of welders.

(2) The training facilities shall meet all requirements for the instruction of welders necessary to meet the qualification requirements. The training facilities may also be facilities belonging to manufacturers approved in accordance with Section 3.2.

3.3.4.2 Performance of first welder's qualification test

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

a) the authorized inspector

b) competent independent agencies to AD 2000-Merkblatt HP 3.

(2) The welders shall demonstrate that they have the manual skills and technical knowledge required to conduct their work properly. In general, this practical demonstration shall be made by welding of a single-layer hard surface with a hard alloy on a ferritic base metal belonging to material group 4.2 to DIN CEN ISO/TR 15608. These welder's qualification tests 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. on Co or Ni alloys) and of a Rockwell hardness greater than 35 HRC constitute hard alloys.

(3) If welders are to be qualified who only apply austenitic or nickel alloy buttered hard-surface layers to austenitic base metals, a base metal belonging to material group 8 to DIN CEN ISO/TR 15608 may also be selected.

(4) The dimensions of the test piece and the hard surfacing layer are specified in **Figure 3-1**. Hard surfacing shall be effected by means of the stringer-bead technique.

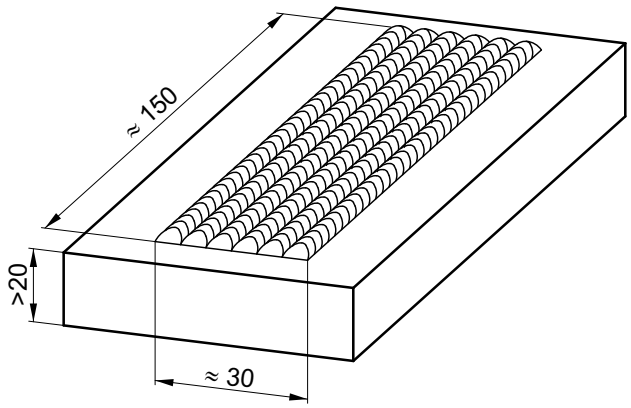


Figure 3-1: Test specimen for the welding of hardsurfaces

(5) The following tests and inspections shall be performed on the test piece:

a) visual inspection of uniformity of bead formation,

b) macrosection transverse to the weld progression for assessment of penetration depth and overlapping,

c) microsection to cover weld metal and toe of weld,

d) ultrasonic testing for coalescence with the base metal by means of straight-beam scanning from the back of the test piece. With respect to the requirements the stipulations of clause 12.8.5 shall apply,

e) liquid penetrant testing of the undressed hard surface layer. Indications arising from surface irregularities shall be removed by grinding and be examined again. Systematically occurring cracks and porosity are not permitted.

(6) The practical demonstration of manual skill may also be effected by welding work within welding procedure qualification or pre-manufacturing production control tests.

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

3.3.4.3 Operators of fully mechanized welding equipment

(1) It shall be demonstrated to the authorized inspector that operators of fully mechanized welding equipment have sufficient knowledge to operate such equipment. This demonstration may be effected by the personnel during welding procedure qualifications or production control tests.

(2) Where none of the foregoing conditions is satisfied, a test coupon shall be welded and be tested in conformance with clause 3.3.4.2 (5).

3.3.4.4 Performance of renewal tests

For the renewal tests the requirements of clause 3.3.3.4 apply.

3.3.4.5 Test certificates

Certificates shall be established on the qualification tests performed according to the requirements of clause 3.3.4.2, 3.3.4.3 and 3.3.4.4 by the qualifying agency. The certificates shall be kept available at the location of welder's or fully mechanized welding equipment operator's employment. Qualification tests not performed by the authorized inspector shall show the following remark:

> "Qualification test performed by agreement with the authorized inspector from ..... (name of authorized inspection agency) ..... the test was conducted on .....".

3.3.5 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 discontinuities.

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 examination 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 clause 10.3.7 and in Section 12. They shall have been qualified and certified to DIN EN ISO 9712 for the applicable examination procedure in the relevant product or industrial sectors. For radiographic and ultrasonic testing as well as for leak testing with helium at least level 2 qualification and certification is required.

4 Design approval and documentation

4.1 Design approval

Note:
The design approval of product forms is covered by KTA 3201.1.

4.1.1 Design approval documents

4.1.1.1 Preparation

(1) The design approval documents shall be established in due time prior to the planned beginning of manufacture of a part, sub-unit or component.

(2) 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.

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

a) structural design,

b) selection of materials,

c) dimensioning,

d) manufacturing processes,

e) capability of being tested,

f) feasibility of periodic tests and inspections,

g) accessibility for maintenance and repair,

h) measuring equipment required on the component to be design-approved,

i) installation and assembly,

k) function.

(4) The design approval documents as per clauses 4.1.1.3.1 to 4.1.1.3.17 shall be submitted to the authorized inspector for design approval.

(5) 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 (4) 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 respective standards, in German. Foreign languages may 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 4-1** 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. These requirements are contained in the sample forms in **Annex A**; the layout of the forms is to be regarded as recommendation. By agreement with the authorized inspector, it is also permissible to use an adapted data processing program for the information contents and documentation requirements specified in the sample forms.

(4) All tests and inspections to be conducted in accordance with this safety standard shall be laid down in the design approval documents.

4.1.1.3 Type of design approval documents

4.1.1.3.1 Cover sheet

(1) A cover sheet (**Forms A-1a** to **A-1c**) shall list the individual design approval documents with abbreviations and page numbers in addition to the exact designations of the product forms, parts, sub-units or components to be subjected to design approval.

(2) It shall also contain a table on the state of the latest revisions and a list of all KTA safety standards and specifications applicable to manufacture as well as any testing, inspection and work instructions.

4.1.1.3.2 Design data sheet, pipe loading specifications

The required specifications are compiled in **Table 4-2**.

(1) Tests and inspections

AP : production control test
APM : production control test on accompanying heat treated test coupons
APS : production control test on simulated heat treated test coupon
CHP : welding material test
DOP : review of documents
DRP : pressure testing
EK : receiving inspection
LT : leak test
MK : dimensional check
MT : magnetic particle testing
MTP : mechanical-technological testing
PAU : product audit
PT : penetrant testing
RP : cleanliness check
RT-D : radiographic testing (digital radiography)
RT-F : radiographic testing (film radiography)
SUE : welding supervision
UT : ultrasonic testing
VP : welding procedure qualification
VWP : materials identification check
WBK : heat treatment check
WP : materials testing
WPM : materials testing on accompanying heat treated production control test coupons
WPS : material test on simulation heat treated test coupons
WPV : materials testing in the quenched and tempered condition
ET : eddy-current examination
VT : visual inspection
ZfP : non-destructive testing

(2) Times of inspection

ND : inspection upon pressure testing
NE : inspection upon final annealing
NS : inspection upon welding
NV : inspection upon quenching and tempering
NZ : inspection upon intermediate annealing

(3) Participation in testing

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

(4) Documents

AB : non-conformance report
ADB : design data sheet
AW : work instructions
CHPP : plan for material tests
DBL : cover sheet
DRPP : pressure test plan
DSP : radiographic testing plan
IVZ : contents
ISO : isometric fabrication drawings
ISO-SL : isometric parts list
KSP : component flow chart
MSL : list of measuring points
PA : test instruction
PFP : test and inspection sequence plan
PWP : plan for periodic inspections
QB : quality certificate
RBA : pipe loading specifications
RPL : cleaning plan
SP : welding procedure sheet (welding procedure specification)
SPK : welding record
SPS : welding records overall certificate
SSP : weld location plan
STL : weld location list
STPL : list of stampings
SZL : list of welding filler metals
UB : marking transfer certificate
WBP : heat treatment plan
WBPK : heat treatment record
WPQR : welding procedure qualification record
WL : list of materials
WPP : materials testing and specimen-taking plan
ZG : drawing

(5) Miscellaneous

AN : establishment of a certificate
ASG : deposition welding
BG : sub-unit
BT : part
E : final file
EG : part group
ES : final file for overall certificate
KKS : power plant identification system, alternatively also plant identification system (AKZ)
KN : fillet weld
LN : longitudinal weld
MN : meridional weld
PB : maximum allowable working pressure
QS : quality assurance
QST : quality department
RN : circumferential weld
SF : welding sequence
SN : weld
SPL : weld cladding
SST : weld location
ST : stamping
STN : nozzle weld
Z : interim file
ZS : interim file for overall certificate
..-R.. : marking of documents in case of repairs
..-RM : marking of documents in case of reserve material
..-L : marking of documents regarding specimen-taking for the determination of service life

(6) Participants in tests and inspections

B : purchaser / plant owner
H : manufacturer
S : authorized inspector

Table 4-1: Abbreviations to be used

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 K1) and Seismic Class	X	X	X
4	Drawing number	X [3]	X	X
5	Special ambient conditions (temperature, dose rate)	X	X	X
6	Production and permissible operating data (pressures, temperatures, power data, weights, leak tightness requirements); specifications concerning the drives of valves and pumps	X	X	X
7	Operating medium	X	X	X
8	Materials and material group of the main parts (including pipe connections)	X [3]	X	X
9	Essential planning measurements (main dimensions, overall planning sketch, anchoring)	–	X	–
10	Arrangement and dimensions of main nozzles	X	X	–
11	Arrangement of inspection ports (sight glasses, manholes, headholes and handholes)	–	X	–
12	Forces and moments acting on nozzles	–	X	X
	Forces acting on integral supports	–	X	–
13	Loads resulting from external and internal events (EVA/EVI) (requirements for integrity, support stability, functional capability)	X	X	X
14	Transient loads (loading conditions, loads, frequency, service limit levels)	X	X	X
15	Superposition of loads	X	X	X
16	Structural loads (pumps, pressure vessels)	–	X	–

[1] With respect to items no. 6 and 12 to 16, references to detailed documents are also permitted.

[2] If Identification System for Power Plants allocation (KKS) is available, this is to be specified.

[3] Not applicable if specified by type number.

Table 4-2: Required design data in the Design Data Sheet (ADB) and Pipe Loading Specifications (RBA)

4.1.1.3.3 Drawings

(1) The components and parts to be subjected to a design approval shall be represented in an assembly drawing. Detail and sub-unit drawings shall be clearly assigned.

(2) The drawings shall contain the information required for design approval, i.e. on

a) materials used,
b) design pressure, MPa (bar),
c) design temperature, °C,
d) working pressure, MPa (bar),
e) operating temperature, °C,
f) dimensions including tolerances and tolerances for deviations from specified shape and location, which are required for the dimensioning, analysis of mechanical behaviour (including proof of functional capability) as well as for planning and inspection,
g) volume, m^3 (for vessels),
h) indication of fluid,
i) type and location of measuring points for temperature, pressure and other measurements,
k) type of installation or hanger systems,
l) location of all welds,
m) intended lining (e.g. weld cladding),
n) welded attachments,
o) type and location of component identification marking,
p) component weight,
q) location of centre of gravity of valves,
r) indication of inlet and outlet nominal sizes of valves,
s) tightening characteristics of fasteners,
t) surface condition of welds (dressed or undressed) as well as of sealing and functional surfaces.

(3) The data as per paragraph 2 sub-clauses a, d, e, g, h, and p may be omitted in the drawing if reference is made to pertinent documents (e.g. dimensioning documents, list of materials).

(4) All individual parts including repeat parts - irrespective whether they are subject or not to design approval - as well as the weld locations shall be positioned on part or sub-unit drawings and be assigned to the respective assembly drawing if this information is not contained on the assembly drawing itself.

(5) 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 List of materials

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

a) the position number of the part in the assembly drawing,

b) the material number or abbreviation in accordance with DIN,

c) requirements to be met by the product form in accordance with KTA 3201.1 or the specification used (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 documents for dimensioning (part of VPU 1) and for calculation (part of VPU 2) shall be drawn up in accordance with the specifications laid down in KTA 3201.2.

4.1.1.3.6 Weld location lists

(1) The weld location lists (**Form A-3**) shall contain all weldments (parts and field welds as well as temporary welds) with weld location numbers in accordance with the parts, sub-unit or assembly drawing as per clause 4.1.1.3.2.

(2) For each weld reference shall be made in the weld location list to the production control, welding material and welding procedure qualification tests required for the parts' weld.

(3) It shall be ensured that for production control tests not relating to parts, the plans on which design approval is based with respect to the scheduled and component-specific assignment of these production control tests are adhered to (e.g. production control test plan).

(4) In addition, the respective test numbers of the related test and inspection sequence plan shall be indicated for all welded joints

4.1.1.3.7 Test and inspection sequence plans

(1) The test and inspection sequence plans (**Form A-4**) shall contain, in chronological order, information on the fabrication process from the beginning of fabrication to the finished component, i.e. on

a) all non-destructive examinations on parts, sub-units or components with references to production-control tests that are to be performed,

b) the intended final and partial inspections,

c) the 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,

d) the required releases for production control and base metals testing,

e) the standards, specifications, working and test instructions required for points a) to d),

f) the parties involved in inspection and/or testing with description of activities (e.g. performance, participation),

g) the type of documentation (final file, stamping, interim file).

(2) Where several test and inspection sequence plans are required for one component (e.g. due to sub-contracting), their relationship must be clearly identified.

4.1.1.3.8 Measuring instructions

(1) Measuring instructions shall be established for significant dimensions with respect to dimensioning and functioning, which shall be e.g. laid down in writing as marking-ups in drawings, dimension plans and prepared dimensional survey records.

(2) The measuring instructions shall contain the following information:

a) reference or co-ordinate system for the measurement to be made,

b) given measuring tolerances and tolerances for deviations from specified shape and location,

c) if required, special measuring procedures to be used (e.g. mechanical or electronically controlled measuring procedures (optical measuring techniques),

d) extent of dimensional checks,

e) time stage of and parties involved in inspection and testing with reference to the test and inspection sequence plan.

(3) Where the check of significant dimensions (e.g. wall thicknesses, cladding thicknesses) is made by subtraction (indirect dimensional check) of checked dimensions at various test/inspection stages (e.g. wall thickness measurement in the uncladded or cladded condition of the part by means of ultrasonics or templates), a measuring instruction for both inspection hold-points or a cross-reference in the test and inspection sequence plan shall ensure that the results obtained at the two hold-points are evaluated together.

4.1.1.3.9 Welding procedure sheets (welding procedure specifications)

(1) For all weldments on the part the following items shall be contained in the welding procedure sheet (**Form A-5**) irrespective of the type of weld:

a) weld preparation with form of weld and shaping of fusion faces,

b) material designation,

c) weld build-up, if required sequence of individual welding steps,

d) welding process/combination of welding processes,

e) welding parameters,

f) welding position,

g) weld filler metals and consumables,

h) storage and handling of filler metals and consumables,

i) heating prior to, during and after welding,

k) welding procedure qualification.

(2) For the design approval, each welding procedure sheet shall be accompanied by the manufacturer's WPQR and the authorized inspector's certificate in accordance with Section 9.1.5.

4.1.1.3.10 Heat treatment plans

(1) The heat treatment plans (**Form A-6**) for all types of heat treatment on parts, sub-units, test pieces and on the component (e.g. upon forming or welding) as well as for base metal test coupons to be subjected to simulated heat treatment as well as test pieces of production control tests shall contain at least the following:

a) type of heat treatment,

b) heat treatment facility,

c) type, number, position of temperature measuring points

d) time-temperature chart (e.g. heat-up rate, holding time, cooling rate),

e) type of cooling, cooling fluid,

f) production control test specimens during heat treatment of parts, sub-units and components.

(2) Where local heat treatment is performed, the heat treatment plan shall additionally indicate the heat input area, the temperature measuring points and the heat insulation.

4.1.1.3.11 Materials testing and specimen-taking plans

(1) The materials testing and specimen-taking plans (**Form A-7**) shall contain the destructive and non-destructive tests for welding materials tests, welding procedure qualifications and production control tests.

(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-8**).

(3) All specimens shall be clearly identified.

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

a) the rules, specifications, working and testing instructions applying to the individual inspection hold points,
b) the 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) the parties involved in inspection and/or testing with description of activities (e.g. performance, participation),
d) the type of documentation (final file, stamping, interim file).

4.1.1.3.12 Pressure test plans

They shall contain at least

a) the test pressure, MPa (bar),
b) the test temperature, °C,
c) the test fluid,
d) the chronological sequence of pressure build-up, holding times and pressure decrease as well as times of measurements,
e) if required, the stress-strain measuring program.

4.1.1.3.13 Repair plans

(1) Each individual repair plan for repairs on parts, sub-units or components and, if required, on product forms subject to processing and the relevant documents shall be marked with the letter ”R” in addition to the plan description and number.

(2) Standard repair plans may also be used.

4.1.1.3.14 Isometric item list

The isometric item list (**Form A-9**) 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-10**) shall contain at least 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 sheet number, revision,
k) test and inspection sequence plan number, revision,
l) accompanying isometric item list,
m) classification (class K1),
n) design pressure, MPa (bar), and design temperature, °C.

(2) Upon assembly, all isometric drawings shall be revised to contain the as-built true-to-size representation of all parts.

4.1.1.3.16 Stress isometry

The stress isometry shall contain at least the following information:

a) classification (class K1),
b) maximum allowable working pressure, allowable operating temperature, fluid,
c) all dimensions of pipes, fittings as well as the position and function of hangers and supports required for calculation,
d) materials,
e) marking of parts (e.g. Ident. no.) and components (KKS or AKZ identification system for nuclear power plants),
f) reference to the centre line,
g) specifications on the pipe hanger (limited degrees of freedom, designation).

4.1.1.3.17 Test instructions for non-destructive testing

See the requirements of clause 12.2.1.

4.1.2 Performance of design approval

(1) On the basis of the submitted design approval documents the authorized inspector shall assess whether the requirements of clause 4.1.1.1 (3) are met with regard to safety, as far as required for the component or system.

(2) It shall be stated for the tests and inspections laid down in the design approval documents how to document the test and inspection documents and results. This shall be done by abbreviations (E = final file at the licensee’s plant, Z = interim file at the manufacturer’s works, ST = Stamping).

(3) Where an overall certificate is considered proof of tests and inspection, this shall be stated in the design approval documents in the form of ZS (interim file for overall certificate) or ES (final file for overall certificate).

(4) Where a stage-by-stage design approval has been fixed as per clause 4.1.1.1 (5), the documents submitted for each individual approval stage must permit the assessment of the effects of the fabrication step on the finished component. Partial inspections shall be adapted to the approval and fabrication stages.

(5) 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 be marked by the authorized inspector.

(6) If several product forms, parts, sub-units, and components of identical design are to be manufactured for a plant, and in the case of identical manufacture, the previously design-approved documents shall remain valid.

4.1.3 Mark of approval

If the design approval performed by the authorized inspector leads to 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 marking which shows the organisation having performed the design approval, the authorized inspector, and the date of approval.

4.1.4 Validity

(1) Manufacture shall only be effected in accordance with valid design-approved documents.

(2) In principle, the design-approved documents shall remain valid until completion of the component. However, review of the documents is required if:

a) manufacture has not started within 24 months after the date of approval marking,

b) manufacture has been interrupted for more than 24 months.

(3) Where the specification and standards on which design approval was based have been changed essentially the necessity of renewal of design approval shall be discussed with the inspector.

(4) If an extension of the validity period of the design-approved documents is required for the manufacture of individual parts (e.g. spare parts), separate agreements shall be made.

4.1.5 Changes in design-approved documents

(1) If the design-approved documents are to be changed after completion of 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 changed 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 General requirements

(1) All design-approval documents (see clause 4.1.1) according to which a part, sub-unit or component is manufactured, shall be documented along with the related certificates on the conformance with required values within the course of manufacture. Thus, the documentation contains all design-approved documents regarding the requirements to be met as well as the proofs of quality describing the actual condition.

(2) A table of contents (**Form A-11**) shall precede the documentation.

(3) To ensure a systematic documentation accompanying manufacture, test and inspection sequence plans (PFP) or materials testing and specimen-taking plans (WPP) (see **Figure 4-1**) shall be used. According to **Figure 4-2** these plans are subdivided into the respective design approval and documentation column. Depending on the requirements of this safety standard, the results of test and inspections (see **Table 10-1**) shall be confirmed either by signature and stamping (ST) directly in the plans or by individual certificates which by means of their reference number can be clearly assigned to the plans. According to the requirements in **Table 10-1** distinction shall be made between the documentation at the manufacturer's works (interim file Z) according to clause 4.2.3 and the documentation at the licensee's plant (final file E) according to clause 4.2.4.

4.2.2 Document filing at the manufacturer’s work

(1) The manufacturer of a part, sub-unit or component shall ensure that all documents relevant to documentation are established and compiled in the course of manufacture either at his or his subcontractors' works. The manufacturer shall task a central agency (e.g. documentation department) within his works for the purpose of such documentation. This agency shall be notified to the authorized inspector.

(2) The manufacturer shall ensure that:

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

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

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

d) all documents required for the interim file (Z) are available for final inspection upon completion of manufacture.

(3) All design-approval documents (cover sheet according to clause 4.1.1.3.1) and certificates shall be listed. Listing and filing shall be effected in accordance with the number of the pertinent materials testing and specimen-taking plan or the test and inspection sequence plan.

(4) Changed and approved documents shall be documented such that traceability to the original plans is ensured.

(5) Where certificates are changed as to technical contents or supplemented, this shall be done in the original document by the same agency that has drawn up the original document. If this is not possible, corrections or additional entries shall be made on a supplementary sheet to the original document. The correction or additional entries shall show the signature and date.

(6) Documents on repairs made (see clause 4.1.1.3.13) shall be documented in the same manner as the manufacturing documents.

4.2.3 Manufacturer's documentation (interim file Z)

The documents (Z) identified in the design approval documents for filing by the manufacturer (see **Table 10-1**) shall be filed in orderly and expertly manner to enable cross-referencing. The documents comprise attestations of examinations not necessary for product quality description for the condition prior to commissioning, such as

a) records on expedition of schedules,

b) tests and inspections to be repeated in the component’s final condition,

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

Note:
Details on the type period of filing are laid down in KTA 1404.

4.2.4 Documentation at the licensee’s plant (Final file E)

(1) A uniform filing system of the documents for the final file shall be agreed with the applicant or licensee. The filing system shall be adapted to the manufacturing process so that a review from the design to the fabrication and installation of components or systems including deviations or tolerances is possible.

(2) According to this filing system the manufacturer of a component shall compile all documents intended for final file (E) at the applicant's or licensee’s plant.

(3) Component-related documents for final file are:

a) the design-approval documents where the dimensioning documents are only part of this component documentation if no other design documents according to KTA 3201.2 are established. Otherwise, these documents along with the other design documents shall be established as independent part of the documentation. The procedure shall be fixed within the course of design approval.

b) the certificates and results of materials tests identified with the letter E in the design-approval documents

c) the certificates and results of final and partial inspections identified with the letter E in the design-approval documents

d) all documents that are required e.g.:

da) for verifying the proper performance according to the approval,

db) for in-service/periodic inspections,

dc) for examining damage on the component,

dd) for fixing repair measures,

de) for procuring replacement and wear parts.

(4) All documents regarding manufacture and assembly work that are intended for final file shall be submitted in the as-approved condition and be compiled with reference to the system prior to the system pressure test.

(5) For components which are assembled on the site the documentation shall be compiled in accordance with clause 4.2.6 and be examined.

(6) The documents for final file shall be properly filed at the applicant's or licensee's plant.

Note:
Details on the type and period of filing are laid down in KTA 1404.

4.2.5 Stamping in the design-approval documents (Stamping ST)

(1) According to the stipulations in **Table 10-1** the performance of specific tests/inspections shall be documented in the design-approval documents by signature, date and stamping. These tests/inspections are:

a) inspections with yes/no statement,

b) inspections the performance and evaluation level of which is laid down in this safety standard or in test instructions such that recording of actual values is not required for evaluation.

(2) Where deviations from required values are ascertained, the required documents (e.g. non-conformance report) referring to the respective deviation and its treatment shall be added to the final file (E).

4.2.6 Documentation review and release of assembly work

(1) Upon completion of a component the manufacturer shall submit the original version of the documentation, checked by him for completeness and correctness, to the authorized inspector for final review.

(2) The assembly of components on the construction site shall only be effected upon release by the authorized inspector. This release shall only be granted if the review of the documentation of manufacture has been completed and confirmed by the authorized inspector, i.e.:

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

b) all test results are available and meet the specified requirements; any decision-making on deviations and tolerances shall have been concluded

(3) Where components are delivered as sub-units to the construction site, all tests/inspections required for shop fabrication shall have been conducted and led to positive results. In such cases, the confirmation of the inspector on the check of shop fabrication documentation shall suffice for the release. The documentation shall be continued on the site with respect to the stages of manufacture. The final review of the documentation by the authorized inspector shall be made after the system pressure test, or if required after the non-destructive tests to be performed according to Section 12.12.

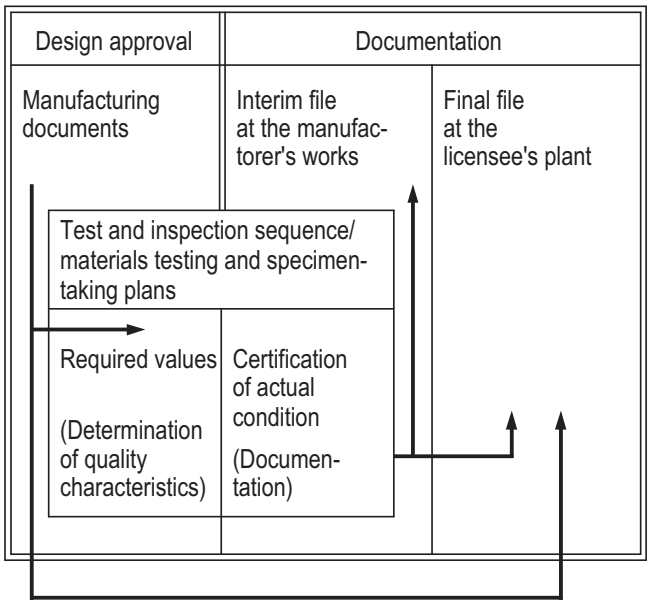
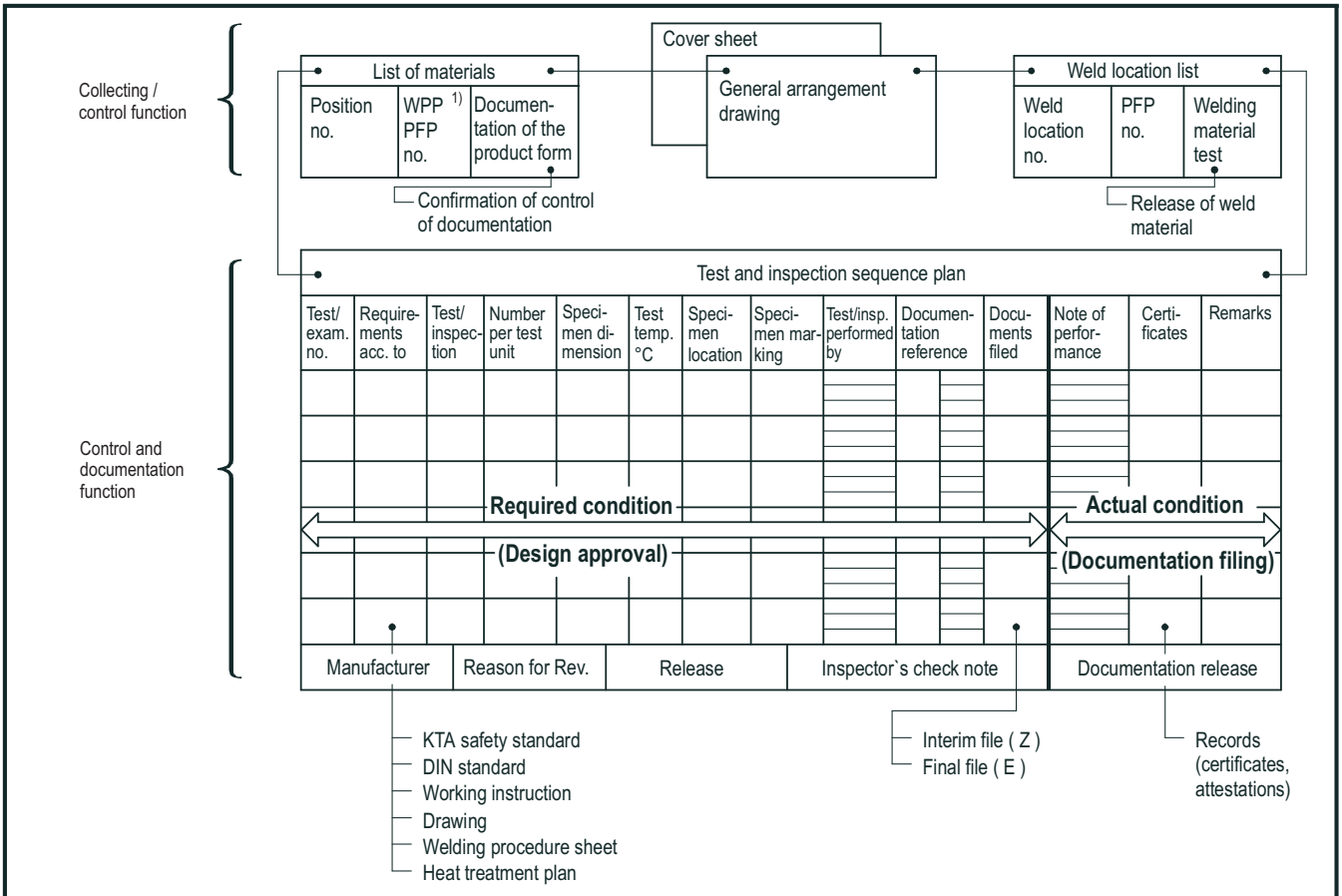
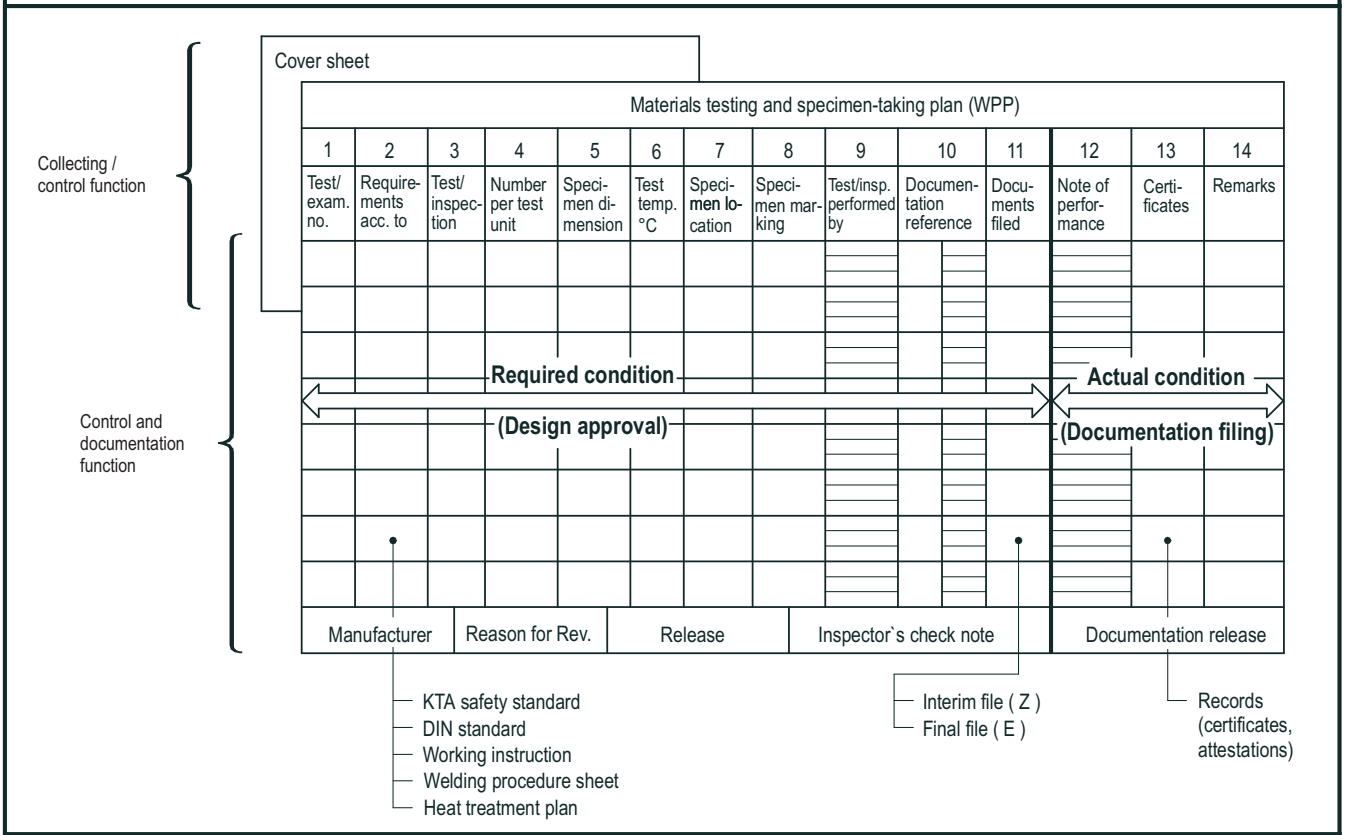


Figure 4-1: Interrelationship of design approval and documentation



Interrelationship of design approval documents for parts, sub-units, components and systems



Interrelationship of design approval documents for welding material test, welding procedure and production control tests

Figure 4-2: Interrelationship of design approval documents

5 Weld design and operating principles

5.1 Weld design and requirements for the surfaces

(1) All welds on pressure-retaining walls shall be welded such that they meet fabrication and inspection and testing requirements. It has to be ensured that they can be fully non-destructively examined in accordance with Section 12 and KTA 3201.4 to obtain clear test results. This means that the welds have to be designed as multi-layer and full-penetration welds. In the case of double-vee, double-U and double-bevel groove welds to DIN EN ISO 9692-1 and DIN EN ISO 9692-2 as well as all welds accessible from the opposite side, the root shall be back-welded or be fully machined flush. Back-welding without dressing is permitted if its suitability has been proved by a procedure qualification test.

(2) In the case of pipe circumferential 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 Sections 5.4.1 and 12 of this safety standard and the requirements of Table 8.4-1 of KTA 3201.2 are met.

(3) Single-side welding of butt welds in pressure vessel shells is only permitted if any other possible design solution with back-welding is unfavourable with respect to safety and the single-side weld can be properly and fully examined both during fabrication and periodic inspections.

(4) Cylindrical ends for pipe bends or elbows are required if this is necessary to perform non-destructive testing according to Section 12 (if required in due consideration of the requirements for periodic inspections).

(5) The weld design shall avoid the following joint types:

a) cruciform joints,

b) corner joints,

c) fillet welds,

d) accumulations of welds.

Exemptions, i.e. fillet-type welds, are only permitted by agreement with the authorized inspector.

(6) All accessible surfaces of butt welds to be examined shall be ground flush to base metal contour. The outside surfaces of nozzle and attachment welds shall be machined to smooth contour. For pipe circumferential and nozzle welds that can be welded from one side only, the requirements of (2) shall be met as regards gouging of the root. The weld surfaces shall meet the requirements of clause 12.2.3. Fillet-type welds shall be welded as concave fillets (e.g. fillet welds, double-bevel grooves, nozzle welds).

(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 requirements have been met:

a) the equipment, documents and personnel shall meet the requirements of Sections 3 and 4,

b) the required procedure qualification tests to Section 9 shall have been completed,

c) the required welding material tests to Section 4 of KTA 1408.3 shall have been completed,

d) all non-destructive tests to Section 12 required prior to welding to check the quality of the respective weldments, including the non-destructive tests of the edge zones to KTA 3201.1, shall have been completed successfully,

e) all documents required for welding (welding procedure specifications, drawings) shall be design-approved and be available at the location of welding,

f) the manufacturer's working instructions required for welding shall be available at the location of welding.

5.3 Preparation of fusion faces

(1) Fusion faces shall be dressed by machining.

(2) Where fusion faces are dressed by thermal processes (e.g. thermal cutting, gouging), the product forms or parts shall be heated to the preheat temperature required for the material within the area of the fusion faces to be prepared.

(3) On thermally cut fusion faces at least 3 mm of material shall be dressed mechanically.

(4) Upon thermal gouging the fusion faces shall be so ground to obtain a surface amenable to examination.

(5) Prior to the beginning of welding work the fusion faces and the parts` surfaces to be cladded shall be free from rust, scale, fat, paint, moisture or other contaminants. Notches shall be so ground that they do not impair welding.

5.4 Requirements for weldments

5.4.1 Welded joints

5.4.1.1 External findings

(1) Cracks, lack of fusion, root non-fusion, undercutting, incompletely filled grooves, root concavity, overlap, poor restarts, arc strikes, and weld spatter (outside the weld groove) are not permitted.

(2) Section 12 applies with respect to the acceptability of pores and solid inclusions.

(3) Section 5.1 applies with respect to the surface condition of the welds. Where, in individual cases, the weld surface is not ground flush with the base metal contour, a maximum value of $0.1 \cdot s$ applies to the cover layer excess weld metal and excess penetration in the final weld condition.

(4) For linear misalignment (mismatch of welds) the clauses 5.4.1.2 and 5.4.1.3 apply.

5.4.1.2 Misalignment of welds on pressure vessels

(1) The misalignment e (see **Figure 5-1**) only applies in the case of equal wall thicknesses (nominal wall thickness s) of the parts to be joined provided the weld edges have been prepared in accordance with DIN EN ISO 9692-2. The misalignment shall also consider the workpiece wall thickness tolerance in which case the smallest value applies.

Note:

See 5.4.1.4 as to procedure to follow in the case of differing wall thicknesses.

(2) For wall thicknesses equal to or greater 70 mm the following applies for the misalignment e in forged and turned-out diameter parts as well as for longitudinal welds:

a) for double-welded joints:

e equal to or smaller than 3 mm,

b) for single-welded joints:

e equal to or smaller than 2 mm,

For non-turned-out diameter parts with circumferential weld the following applies additionally:

a) a maximum of 5 mm for outside course diameters equal to or greater than 3500 mm,

b) a maximum of 3 mm for outside course diameters equal to or greater than 1000 mm up to smaller than 3500 mm.

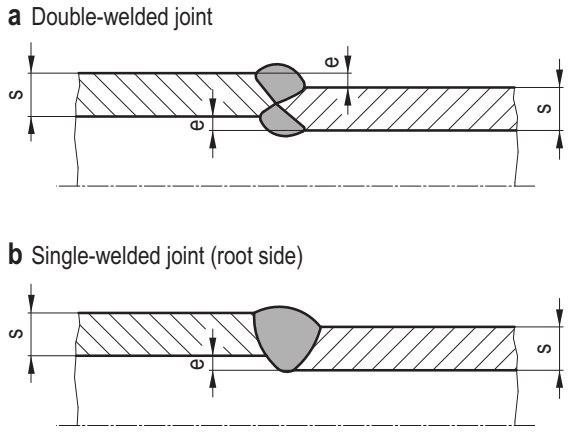


Figure 5-1: Misalignment of welds for vessels and piping

(3) For wall thicknesses smaller than 70 mm the following applies to double and single-welded joints:

$e \leq 0.10 \cdot s$, but not to exceed 2 mm.

(4) Deviations from the required shape shall be ground flush such that performance of ultrasonic testing - also with mechanized equipment - is ensured. Angular deviations, if any, from the required shape shall be equal to or smaller than 5 degrees. Additional requirements for the surface condition shall be met in accordance with clause 12.1.3.

5.4.1.3 Misalignment on pipings

(1) In the case of double-sided welds on pipings, the misalignment (see **Figure 5-1**) upon welding shall not exceed the value of $0.1 \cdot s$, however, not more than 2 mm. In the case of greater wall thickness and diameters greater misalignments or greater local misalignments may be permitted for back welds subject to approval by the authorized inspector, if the misalignment is ground at an angle equal to or smaller than 5 degrees.

(2) In the case of single-sided welds misalignment after welding shall not exceed the following values:

a) for diameters equal to or smaller than DN 120:

$e \leq 0.1 \cdot s$ (however, not to exceed 1 mm),

b) for diameters greater than DN 120:

$e \leq 0.1 \cdot s$ (however, not to exceed 1.6 mm).

These misalignments shall be ensured by suitable measures, such as

c) adjustment with qualified line-up clamp,

d) adjustment with partial root welding,

e) weld preparation according to DIN 2559-2 where the inside diameter of the parts to be welded at the root area shall not be misaligned by more than 0.5 mm, and in the case of diameters equal to or smaller than DN 120 shall be at maximum 0.3 mm.

By exact adjustment in the root area and the use of suitable welding procedures a uniform root configuration with a smooth contour shall be obtained so that ultrasonic testing is not affected by reflections originating from the contour and a proper evaluation of the root area by radiography is possible.

5.4.1.4 Adjustment of differing wall thicknesses

(1) Where joints are welded between product forms, parts and sub-units with different wall thicknesses, the thicker wall shall be reduced to the dimension of the thinner wall.

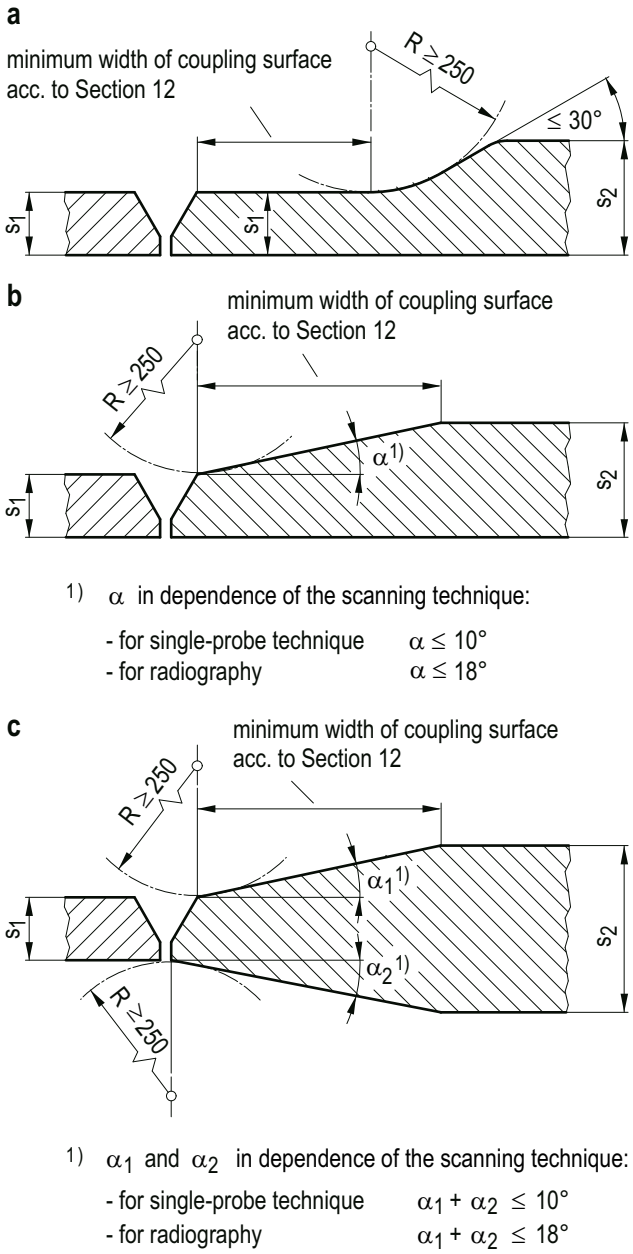
(2) This adjustment of wall thicknesses shall be effected such that the weld can still be examined to the extent required according to Section 12 (if necessary, by taking the requirements for periodic inspections into account). **Figure 5-2** shows examples for the adjustment of differing wall thicknesses in dependence of the scanning technique used.

Note:

Section 12.1 contains requirements as to the design for ensuring sufficient amenability to examination.

5.4.1.5 Internal condition

The acceptance criteria laid down in Section 12 shall apply to internal irregularities.



1) α in dependence of the scanning technique:

- for single-probe technique $\alpha \leq 10°$
- for radiography $\alpha \leq 18°$

1) α_1 and α_2 in dependence of the scanning technique:

- for single-probe technique $\alpha_1 + \alpha_2 \leq 10°$
- for radiography $\alpha_1 + \alpha_2 \leq 18°$

Figure 5-2: Examples for adjustment of differing wall thicknesses

5.4.2 Deposition welding (cladding)

(1) The cladding shall be properly fused to the base metal.

(2) The surface contour of claddings shall be such that all tests/examinations required can be performed in accordance with Section 12 to comply with the requirements of Section 12.

(3) Where in the case of austenitic claddings, the cladding thickness specified for the part is less than required due to mechanical dressing, this is permitted if the cladding thickness proved to be resistant to intergranular corrosion by means of procedure qualification, production control and welding material tests is exceeded by at least 1 mm. Otherwise, further processing is to be laid down by agreement with the authorized inspector.

(4) For the assessment of internal irregularities the acceptance criteria of Section 12 apply.

5.5 Performance of welding work

5.5.1 General requirements

(1) All welding work (e.g. joint, tack, temporary, deposition and repair welding) shall only be done by welders qualified in accordance with the requirements of Sections 3.3.3 or 3.3.4.

(2) The filler metals to be used shall meet the requirements of KTA 1408.1 to KTA 1408.3.

(3) For hard surfacing the penetration depth shall be determined by selecting the respective welding variables so that lack of fusion is avoided on the one hand, and there is no excessive dilution with the base metal on the other hand.

(4) Welding rods shall be kept at the work place in suitable heated quivers.

(5) For the welding on the parts the same type of equipments as for the procedure qualification tests shall be used, i.e. the equipment shall have

a) the same type of current,

b) the same power source supply characteristics,

c) the same polarity,

d) in the case of semi- or fully automatic welding processes, additionally the same arc voltage control (so-called internal, internal with external, or external voltage control).

(6) The power sources shall have the intensity of current for the welding duty cycle usual in fabrication in conformance with the welding procedure qualification requirements.

(7) The welding conditions laid down within the scope of the procedure qualification shall be satisfied during welding of parts. In the case of deviations (e.g. change of weld build-up, deviations from the allowable heat input, change of welding heat input prior to and during welding or post-weld heat treatment, range of welding parameters), the authorized inspector shall decide on the necessity and performance of a supplementary test. To this end, the manufacturer shall prepare a proposal and submit it to the authorized inspector. Production control tests may be used as supplementary tests.

(8) Within the welding area the temperatures (preheat temperature, interpass temperature) shall not be less than or exceed the specified temperature range until completion of welding work.

(9) The preheat temperature shall be measured in accordance with DIN EN ISO 13916 on the base metal at the weld area, the interpass temperature on the surface to be welded over (base metal or weld bead).

(10) Where soaking is required upon welding in accordance with KTA 3201.1, Annex A, this shall be effected with the welding heat still prevailing. Soaking may be omitted if stress-relief heat treatment is performed with the welding heat prevailing.

(11) Austenitic welds shall be welded with the minimum possible amount of heat input. This shall normally be effected preferably by means of the stringer bead technique. Discolourations that may occur during welding shall be avoided by taking suitable measures. Discolourations including annealing colour 2 (Figure F.1 to DIN 25410) are permited. Decision on the acceptability of annealing colour 3 (Figure F.1 to DIN 25410) shall be made in each individual case.

(12) To set and monitor the welding variables, the welding equipment for semi- and fully automatic welding processes shall be equipped with measuring instruments for welding current amperage and voltage. In addition, these parameters have to be continuously monitored (e.g. by recording) in the case of fully mechanized welding processes. If required the welding travel speed shall be determined by suitable measures.

(13) The measuring, control and recording instruments shall be adjusted prior to welding and be calibrated at fixed intervals.

(14) During welding work welding records in accordance with Section 5.7 shall be established.

5.5.2 Arc striking

Arc striking shall be avoided on the surfaces of parts. If, however, arc strikes occur they shall be ground and subjected to a surface crack detection examination. Cracks detected by such examination are not permitted.

5.5.3 Tack welds

(1) Tack welds to remain on the part shall be welded at least as double-layer weld on a length of at least 50 mm unless they have been qualified by procedure qualification tests.

(2) For tack welds on ferritic materials the workpiece shall be preheated on an area of 2 times the wall thickness (at least 100 mm) around the location of tack.

(3) In the case of single-sided welds, welding over of tack welds is only permitted if it has been proved by procedure qualification or production control tests that the quality of the entire weld is not affected hereby.

5.5.4 Welded attachments on the pressure-retaining wall of components

(1) Design approved welding procedure sheets must be available for welds of welded attachments.

(2) For welded attachments filler metals and welding consumables to KTA 1408.1 to KTA 1408.3 that have been subjected to welding material tests and are required for the part shall be used.

(3) 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.

(4) Welded attachments shall be welded under the same conditions as part welds. The welds shall be executed as two-pass welds at least.

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

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

(7) 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) a surface examination in accordance with Section 12.10

and

b) in addition, in the case of ferritic components, a hardness test in the attachment weld area to include the heat-affected zone.

(8) The locations of all permanent and temporary welded attachments on the part shall be documented in a drawing with exact dimensions (e.g. temporary weld location plan).

(9) In the case of attachment welds on austenitic components the requirements for discolouration as per 5.5.1 (11) apply to the fluid-wetted surface. When welding attachments, forming gas shall be used if necessary, in dependence of the wall thickness.

5.5.5 Hard surfacings

Hard surfacing shall be effected such that the specified characteristics of the surfacing are maintained after final processing of the part.

5.5.6 Use of current contact tubes

(1) If weld heads with current copper contact tubes are used, the contact tubes shall be numbered. Only undamaged contact tubes shall be used. The contact tubes shall be released for use by the welding supervisory personnel who shall inspect each contact tube. The welding record shall indicate which contact tubes have been used for which weldments. The welding supervisory personnel shall make intermediate checks on the condition of the contact tubes. After each use, the contact tubes shall be inspected anew for melting spots by the supervisory personnel. The authorized inspector shall satisfy himself that these measures have been properly taken.

(2) If a contact tube starts to melt during welding, welding shall be interrupted immediately and the inspector shall be informed. If melting of the contact tube is ascertained immediately, clause 6.6.1 shall apply. If melting is detected at a later date, a non-conformance report shall be established, and further measures, shall be laid down by agreement with the authorized inspector.

5.5.7 Gouging of welds

The gouging of welds for the purpose of depositing the backing run or repairing detective areas shall normally be made by mechanical means. Gouging of welds with carbon electrodes is permitted only if electrodes without copper cover or with copper-metallized carbon layer are used and a subsequent mechanical dressing is performed.

5.6 Corrective changes and repairs

5.6.1 Corrective changes

(1) Corrective changes may be performed without repair plan and without evidence of documentation if during welding corrective changes, without interrupting heat input, on a weldment are required due to defects detected, with the corrective changes being covered by valid procedure qualification tests, or if corrective changes on a weldment become necessary, which can be performed without welding work. This applies to defects, such as

a) arc strikes,

b) poor restarts,

c) undercutting,

d) stress-induced cracking within the area of tack welds,

e) temper bead defects,

f) copper inclusions detected immediately during welding.

(2) The removal of visible porosity and slags during the welding process is permitted and is not considered a corrective change.

5.6.2 Repairs

5.6.2.1 General requirements

(1) Prior to each repair of a defect it shall be assessed whether a repair, compared to leaving the defect as it is, is advantageous or disadvantageous for the integrity and function of the part. Deviations shall be documented. Where the defect is left as it is, its admissibility shall be well founded.

(2) Repairs shall only be made in accordance with reviewed standard or individual repair plans. A repair in the root area of fluid-wetted single-side pipe welds shall be avoided. In such cases, re-welding of the joint shall be preferred and it shall be ensured that on both sides at least 3 mm of the original heat-affected zones are removed.

(3) In addition to the prescriptions in (2), weld repairs in the root area and local repairs in filler runs and cover layers are neither permitted on austenitic reactor-water containing BWR plant components with operating temperatures equal to and exceeding 200 °C nor generally on welded joints between ferritic and austenitic steels. Circumferential weld repairs are permitted if the weld is re-welded or circumferential repair welding is performed in filler runs and cover layers with a minimum distance of 5 mm to the fluid-wetted surface.

(4) Regardless of the fact whether the manufacturer leaves a defect as it is or carries out a weld repair, a non-conformance report shall be established to contain, if required in the form of added test records, the following information:

a) location of defect (e.g. weld metal, heat-affected zone, base metal),

b) extension and orientation of the defect related to the part or in relation to the direction of welding progress,

c) techniques by which the defect was detected (e.g. visual inspection, non-destructive examination),

d) type and assumed cause of defect.

5.6.2.2 Standard repair

(1) Individual local defects detected by non-destructive examination upon completion of welding work, may be eliminated by repairs in accordance with standard repair plans if the performance of the repair was proved by a procedure qualification test. Within the course of design-approval of manufacturing documents, standard repair plans shall be reviewed by the authorized inspector. The defects which may be eliminated in accordance with standard repair plans are the following weld defects, such as:

a) pores, linear porosity, clustered porosity, wormholes,

b) slag inclusions, linear inclusions,

c) lack of fusion, lack of bonding,

d) isolated cracks, hot cracks, crater cracks.

(2) Repairs to be made in accordance with standard repair plans are permitted prior to the final heat treatment required and prior to pressure testing. Performance of repairs in other cases is permitted only by agreement with the authorized inspector.

(3) A standard repair shall be released for performance by the authorized inspector who is to countersign the non-conformance report established by the manufacturer, with the non-conformance report containing a reference to the standard repair plan to be used.

(4) The performance of a repair shall be certified like the first fabrication and be documented.

5.6.2.3 Single-repair

(1) For the removal of deviations from the specified quality requirements by welding on product forms, parts or components, which cannot be repaired in accordance with clause 5.6.2.2, single repair plans shall be established and be design-approved by the authorized inspector prior to the beginning of repair work.

(2) Single repair plans are e.g. required for:

a) confusion of materials (filler metals),
b) copper inclusions in the weld metal (submerged-arc welding) which are detected on completion of welding work,
c) cracks after heat treatment or forming,
d) repairs not qualified by a procedure qualification test.

(3) The performance of single repairs shall be certified like the first fabrication and be documented.

5.6.2.4 Multiple repairs

Repeated repairs at the same location of a component shall be avoided.

5.7 Welding record

5.7.1 Purpose and contents of welding records

(1) By means of the welding record (SPK) it shall be demonstrated that the requirements of the design-approved welding procedure sheet are complied with during fabrication, and which welders have done the respective welding work.

(2) The welding record shall state in which cases and for which reasons deviations from the welding procedure sheet were required. Unplanned interruptions of welding work as well as other irregularities shall be indicated.

5.7.2 Data to be entered

(1) The welding supervisory personnel is responsible for the establishment of the welding procedure sheet (WPS). For each welding sequence to be entered in the WPS (SF... to **Figure 5-3**) at least one item shall be entered in the welding record indicating its dimensions (marking-up). In the case of weldments of longer duration within one single welding sequence at least two items per workshift each shall be entered.

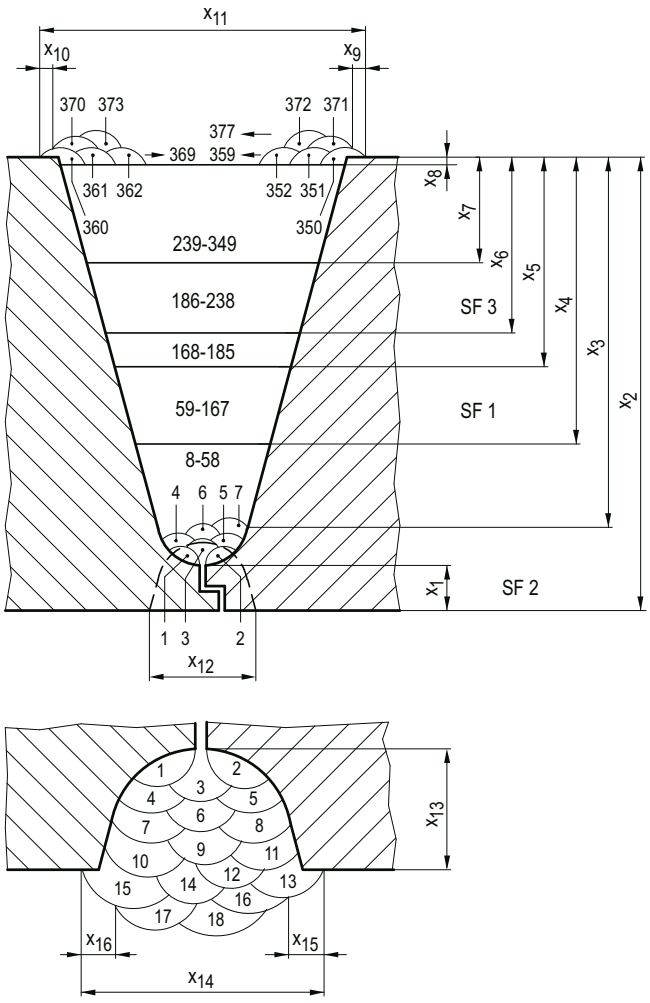
(2) If within an intended welding sequence changes are made, this shall be stated in a new line in the welding record to include the marking-up of dimensions (e.g. residual depth of the weld groove). Such changes may be:

a) change of welder,
b) change of filler metal dimensions,
c) change of batches (fabrication lots) of filler metals and consumables,
d) change of copper contact tips during submerged arc welding,
e) deviation from the welding procedure sheet,
f) changes in temporary welds.

(3) Where for fabrication reasons, changes in temporary weldments become necessary, they shall be indicated in the welding record at a later date.

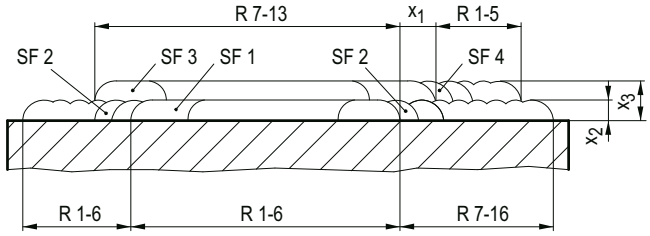
(4) Any interruption of welding due to changes in accordance with (2) shall be entered in the respective line indicating the reason and be marked up in the sketch.

(5) Reviews by the welding supervisory personnel of the manufacturer or by the authorized inspector shall be indicated by a new line in the welding record also to include the approval mark of the controlling agency.



Note:
The build-up of individual layers is always effected from the fusion faces to the middle of the weld.

$x_1 - x_n$: required dimensions
R: Bead



Date Signature of welding supervision

Confirmed: QA Department
Final inspection
(Authorized inspector)

Figure 5-3: Examples for sketches in welding records

5.7.3 Form for welding records

(1) For welding records forms shall be used as are shown as example by **Forms A-12** and **A-13** in which case the contents are considered to be compulsory requirements, and the form type to be a recommendation only.

(2) Any information shall be entered that is required for the respective weld. To this also belong the type of weld, e.g. longitudinal weld, nozzle weld, weld cladding, test coupon of production control test.

(3) The items entered in the columns apply to the following:

a) Column: ”Layer no., bead no.”

The number of layers and beads shall be indicated and marked up if required by the welding procedure sheet.

b) Column: ”Welding filler metals and consumables”

To identify the filler metals the following shall be indicated in this column:

ba) for rod electrodes the fabrication lot and the number of receiving inspection, if any,

bb) for wire and strip-type electrodes, welding wires and rods, the number of melt (heat) and number of receiving inspection.

bc) For weld flux the serial number and the number of the packing unit (bag or barrel number) shall be indicated.

c) Column ”Welding data”

The indication of the welding travel speed is only required for semi- or fully mechanized welding processes and only if pertinent requirements have been laid down in the welding procedure sheet.

The rate of filler metal feed need not be indicated in this column if the feed rate is controlled by suitable instruments of the welding equipment (so-called internal ΔI or external ΔU control).

The electrode run-out length and the oscillation width shall only be indicated if pertinent requirements have been laid down in the welding procedure sheet.

In special cases further information shall be given, e.g. in the case of:

ca) tandem submerged-arc welding (several wire electrodes),

cb) welding with internal gas shielding,

cc) keeping to a certain specified flux height,

cd) oscillation width and weaving frequency in the case of weld claddings made with wires,

ce) keeping to a certain specified weld bead overlay.

(4) The configuration of the joint to be welded shall be shown on a sketch (**Figure 5-3**). The welding sequences shall be marked up (e.g. residual depth of groove).

(5) Where the welding procedure sheet specifies, for certain locations of a weld, a weld bead sequence, it shall be proved that this requirement has been complied with. This may be done by entering the actual sequence of beads in basic layout sketches or drawings at the respective location of weldment (**Figure 5-3**). In all other cases, the representation of the individual beads in a drawing is not required.

(6) In the case of weld claddings each clad layer shall be marked up (**Figure 5-3**).

5.8 Certification of welding work done

5.8.1 Welding of parts

(1) Upon completion of welding work the welding records shall be reviewed by means of the specified data of the welding procedure sheet. If welding records are replaced by comparable documentation, **Form A-14** may be used accordingly.

(2) Supplementary information to the welding procedure sheet or deviations the acceptability of which has been proved by valid procedure qualification and production control tests, shall be indicated in the review sheet or in **Form A-14**, and the respective data shall be added as annex to the certificate.

(3) In the case of deviations the acceptability of which has not been proved by procedure qualification or production control test, further measures to be taken (e.g. repair, toleration) shall be laid down by agreement with the authorized inspector and be documented.

(4) The certificate to be countersigned by the authorized inspector shall be added to the final documentation.

5.8.2 Temporary welds

(1) The review of the welding records is principally confirmed by stamping in the test and inspection sequence plan.

(2) In the case of deviations important to the quality of the part or component in its final condition, further measures to be taken (e.g. repair, toleration) shall be laid down by agreement with the authorized inspector and be documented.

6 Forming of parts

6.1 General

(1) This Section covers hot and cold forming used in the processing of product forms and parts, e.g. by bending, die-forming and pressing.

(2) The hot and cold forming processes used in the manufacture of product forms are covered by KTA 3201.1.

6.2 Hot forming

(1) During hot forming of parts made of ferritic steels the temperature shall not be less than the allowable temperature for stress relief heat treatment.

(2) During hot forming of parts made of austenitic steels the temperature shall not be less 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 3201.1.

(4) The processing conditions for hot forming shall correspond to the specifications laid down in KTA 3201.1 or to the results of the forming process review in order to ensure the required properties also 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 requirements to be met by the part. Otherwise, the hot formed weld metal shall be removed and the part be re-welded.

6.3 Cold forming

(1) The cold forming of parts made of ferritic steels shall be effected within the temperature range of room temperature and allowable temperature for stress relief heat treatment. During cold forming of ferritic parts it shall be ensured that the allowable temperature is not exceeded in the course of forming operation.

(2) The cold forming of parts made of austenitic steels shall be effected at temperatures less than 400 °C. If this temperature limit is exceeded, it shall be demonstrated once that the material properties remain unchanged.

(3) Product forms which are to be cold-formed shall be heat treated and tested prior to forming in accordance with KTA 3201.1.

(4) Cold formed parts shall be heat treated in dependence of the degree of cold forming as specified in KTA 3201.1. Otherwise, it shall be demonstrated by means of a review of the cold forming process that the material properties specified in KTA 3201.1 are maintained with a view to the intended use of the part - if required, by taking welds also into account.

(5) In the case of cold-formed pipes made of austenitic steels with degrees of cold forming exceeding 5 %, which are not heat treated, the influence of cold forming on the corrosion resistance shall also be considered. 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:

$$\frac{d_a - s}{2 \cdot R_m} \cdot 100\% \qquad (7\text{-}1)$$

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 Testing and inspection of formed parts

6.4.1 Cold-formed parts without subsequent heat treatment, except for pipes

Cold-formed parts which have not been quenched and tempered or solution-annealed after forming shall only be subject to a surface examination in accordance with the requirements of KTA 3201.1.

6.4.2 Cold and hot-formed parts with subsequent heat treatment, except for pipes

(1) Cold-formed parts which have been quenched and tempered or solution-annealed after forming, and hot-formed parts shall be subject to the non-destructive examinations and mechanical tests in accordance with the requirements of KTA 3201.1.

(2) Where mechanical tests cannot be performed on the parts themselves, sufficiently large simulated test coupons shall be formed, be added to the heat treatment lot and be tested.

6.4.3 Formed pipes

6.4.3.1 Qualification of the forming process

(1) Before fabrication is started, it shall be demonstrated on a formed pipe section or on an adequately formed production control test piece that the forming process is suited.

(2) For proof of qualification, the following documents (if required) according to Section 4 shall be established by the manufacturer and be reviewed by the authorized inspector:

a) test and inspection sequence plan,

b) heat treatment plan,

c) materials testing and specimen-taking plan,

d) test instructions for non-destructive examinations.

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

a) material,

b) heat treatment condition prior to bending,

c) wall thickness,

d) forming process,

e) degree of forming or ratio R_m/d_a with

R_m : average bending radius

d_a : outside diameter,

f) heat input during forming,

g) subsequent heat treatment,

(4) The tests to be conducted for proof of qualification shall be laid down by agreement with the authorized inspector, taking available test results into account. A higher degree of forming includes lower degrees of forming in consideration of wall thickness and heat input. The qualification principally applies to the material tested. For austenitic steels the qualification for the cold forming process with respect to the mechanical properties is also deemed to have been proved if qualification was proved for another austenitic material. 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.

(5) The scope of qualification shall be fixed in the authorized inspector's report.

6.4.3.2 Cold bending without subsequent heat treatment

(1) Where pipes are cold formed without subsequent heat treatment in accordance with the specifications of KTA 3201.1 and are within the scope of the forming process qualification, the following tests and inspections shall be performed on the formed pipes:

a) visual inspection,

b) dimensional check (wall thickness, out-of-roundness, mounting dimensions),

Note:

See also clause 6.4.3.5.

c) non-destructive tests of the bent area in accordance with Section 12.13.

(2) To renew the qualification, it shall be demonstrated once a year and once per scope of forming process qualification on a formed section or on an adequately formed production control test piece that the manufacturer is capable of reproducing the respective forming process.

(3) Bending within the course of fabrication shall be performed in accordance with the process variables laid down in the forming process qualification test. The forming parameters shall be recorded.

6.4.3.3 Hot bending without subsequent heat treatment

(1) Where pipes are hot formed and are within the scope of the forming process qualification, the following tests and inspections shall be performed on the bent pipes:

a) visual inspection,

b) dimensional check (wall thickness, out-of-roundness, mounting dimensions),

Note:

See also clause 6.4.3.5.

c) non-destructive tests of the bent area in accordance with Section 12.13,

d) mechanical testing in accordance with the requirements of Sections 16 and 23 of KTA 3201.1 on an additionally bent section or bent excess length pipe:

da) of ferritic bent pipes for reactor coolant piping:

within the scope of the forming process review, specifications shall be agreed with the authorized inspector.

db) of other ferritic or austenitic parts:

per melt, area with specified dimensions and comparable heat treatment, however, on a maximum of 10 bends per test lot.

(2) According to the state of qualification of the forming process, testing per melt may be waived if the authorized inspector agrees.

(3) The specimens shall generally be taken from the bent area under tension of the bent pipe or bend unless deviating specifications on the location of specimen-taking and orientation of specimens have been laid down in the authorized inspector's analysis and report.

(4) Bends or bent pipes with the smallest R_m/d_a ratio shall be tested.

(5) Bends to be made during fabrication shall be bent according to the process parameters fixed by the forming process qualification. The forming process parameters shall be recorded.

(6) Where, upon acceptance of straight pipes, austenitic pipes are subjected to a stabilising heat treatment on the entire pipe length prior to induction bending, the condition of the material of the straight legs shall be additionally examined in which case it shall be demonstrated that the requirements regarding the mechanical properties and the resistance to intergranular corrosion have been met in accordance with Section 23 of KTA 3201.1. Regarding the extent of testing the test lot size shall be the same as that for the bent areas.

6.4.3.4 Hot and cold bending with subsequent heat treatment

(1) Where pipes are hot or cold bent and are within the scope of the forming process qualification, and after bending are solution-annealed, quenched and tempered or normalised, the requirements of clause 6.4.3.3, subclauses 3 to 5 shall apply additionally:

a) visual inspection,

b) dimensional check (wall thickness, out-of-roundness, mounting dimensions),

Note:

See also clause 6.4.3.5.

c) non-destructive tests of the bent area in accordance with Section 12.13,

d) mechanical testing in accordance with the requirements of Sections 16 and 23 of KTA 3201.1 on an additionally bent section or bent excess length pipe:

da) of ferritic bent pipes for reactor coolant piping:

within the scope of the forming process review, specifications shall be agreed with the authorized inspector.

db) of other ferritic or austenitic bends:

per melt, area with specified dimensions and comparable heat treatment, however, on a maximum of 10 bends per test lot.

(2) According to the state of qualification of the forming process, the lot size may be extended if the authorized inspector agrees.

(3) The comparability of heat treatments shall be ensured by the authorized inspector by reviewing the heat treatment diagrams of the lots comprised to form one heat treatment test lot.

(4) Per comparable heat treatment, tests shall be performed on the end of a bent pipe (specimen-taking like for straight pipe) unless tests have already been performed on bends or bent pipes as described above.

6.4.3.5 Tolerances for pipe bends

(1) The ovality in accordance with Equation 6-2 shall not exceed 5 %. The ovality at the welding edges shall not exceed 2 %.

$$U = 200 \cdot \frac{d_{a,max} - d_{a,min}}{d_{a,max} + d_{a,min}}, \% \qquad (6\text{-}2)$$

(2) The specifications laid down in the design approval documents 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 3201.2 Section A 4.3.3 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 6-1** for standard bends in dependence of the R_m/d_a ratio. The tolerance range shown in **Figure 6-1** 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 3201.2 shall be evaluated in each individual case by means of a calculation.

c) The minimum design wall thickness to KTA 3201.2, cl. A 4.3.4 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 6-1** 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 3201.2 Section A 4.3.4 is met. Greater fabrication wall thicknesses at the intrados are permitted if they are substantiated by way of calculation.

6.5 Record on forming work done

(1) A record shall be established by the manufacturer on the forming work done, stating

a) the heat treatment and forming equipment used,

b) the maximum degree of forming,

c) the temperature control during forming.

(2) For parts subjected to normalising, quenching and tempering, or solution-annealing upon forming the degree of forming can be omitted.

6.6 Inspection certificates

All tests/inspections required according to Section 6.4 shall be verified by means of the acceptance test certificates to DIN EN 10204 as specified in KTA 3201.1. Inspection certificates 3.2 shall be confirmed or be established by the authorized inspector to § 20 of the Atomic Energy Act or by the technical inspecting agency tasked by him.

6.7 Heat exchanger tube-to-tubesheet expanding

Note:

Depending on each individual case, joints between tube and tubesheet shall be fabricated by a mechanical rolling or hydraulic expansion process, with the tubes being welded into the tubesheet afterwards.

(1) The manufacturer shall establish a written instruction for the processes which shall lay down the process parameters and fabrication steps.

(2) The manufacturer shall prove by means of procedure qualification and production control tests that he is capable of fabricating such joints in due consideration of the intended processes and combination of processes.

Note:

As regards tube-to-tubesheet welding see Sections 9.9 and 11.6.

(3) The conditions for the procedure qualification and production control tests shall be laid down by agreement with the authorized inspector.

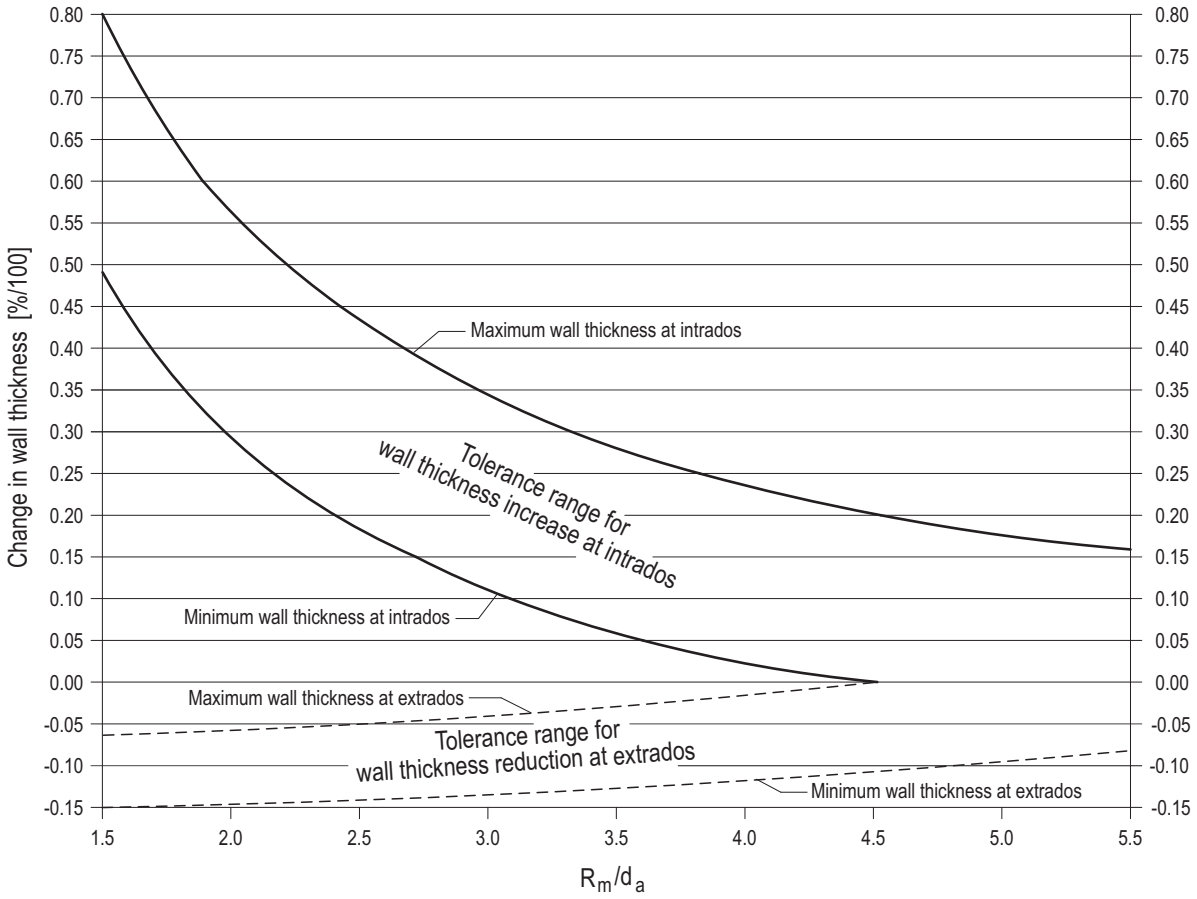


Figure 6-1: Expected values for wall thickness increase at intrados and wall thickness reduction at extrados of standard induction bends in dependence of the R_m/d_a ratio

7 Heat treatment

7.1 General requirements

(1) For all heat treatments conducted on parts or test pieces, heat treatment plans shall be established the form and contents of which shall satisfy the requirements of clause 4.1.1.3.10. Pre-heating and soaking (see Annex A of KTA 3201.1) are not considered heat treatments for the purpose of this safety standard.

(2) In addition, the heat treatment plans shall take into account, with respect to KTA 3201.1, all characteristics specific to the heat treatment process which influence the material properties. When specifying the heat-up and cooling rates, the thermal transient loads of the part shall be taken into consideration.

(3) Deviations from the design-approved heat treatment plan shall be justified by the manufacturer. Further steps to be taken then shall be laid down by agreement with the authorized inspector.

(4) Parts shall be heat treated as a whole. In the case of stress relieving local heat treatment may be conducted in special cases, e.g. on circumferential welds in which case restraint to thermal expansion, if possible, and its effect on the part shall be taken into account. For example, the installation of expansion bends or expansion joints in pipings or the support on rollers may become necessary for larger parts.

(5) For the heat treatment of larger parts (e.g. shell courses, flange rings, heads, covers, large nozzles and sub-units made of such parts) or annealing lots of larger parts, thermocouples shall be provided on each part. For smaller parts or annealing lots of smaller parts adequate instrumentation of furnaces, e.g. with tracking thermocouples will suffice.

(6) The manufacturer shall check the heat treatment equipment at regular intervals and to record such checks. The records shall be kept at the manufacturer's works.

(7) Stationary heat treatment equipment shall be inspected at intervals of not more than 6 months. During such inspections it shall be ensured that the values of temperature distribution in the furnace are comparable to the values determined in the first inspection.

(8) The indicating accuracy of the measuring devices of stationary heat treatment equipment (furnace thermocouples, instrument lines, measuring and recording devices) shall be checked at intervals of not more than 3 months.

(9) Where the parts are e.g. provided with thermocouples, the latter (trailing elements and their instrument lines) as well as the indicating accuracy of the measuring devices shall be checked prior to each heat treatment. This shall apply accordingly to sensors when used for temperature control.

(10) Portable heat treatment equipment shall be subjected to functional testing (prior to use) at intervals of not more than 6 months, however, at least after each change of location, and the measuring instrument shall be calibrated.

(11) If test pieces are to be heat treated for the purpose of materials testing, the time-temperature sequences of the part's annealing shall be fulfilled on the test pieces in which case a sufficient number of test pieces shall be equipped with thermocouples. In the case of production control test pieces of different cross-sections, the test pieces may be attached to the part by means of certain fixing devices in which case the corresponding cross-sections shall be allocated to each other. Program-controlled furnaces may be used for simulated heat treatment of test pieces. The time-temperature sequence of simulated heat treatments shall be selected in accordance with the requirements of KTA 3201.1. When conducting heat treatments each time-temperature sequence shall be recorded.

(12) When annealing parts, the total time of annealing applied during procedure qualification, referred to the sum of interim and final stress relief heat treatments above 450 °C, may be exceeded by up to 20 %, except for heat treatments on austenitic weld-clad parts where the total time of annealing applied during procedure qualification shall not be exceeded.

(13) The surface of the base metals to be heat treated shall be examined in accordance with Section 12.11.

7.2 Ferritic materials upon welding

7.2.1 Welded joints

(1) Parts made of quenched and tempered or normalised product forms shall be subjected, upon completion of welded joints, to a heat treatment in accordance with KTA 3201.1. Deviation from this requirement is permitted if it is substantiated by appropriate examinations.

(2) Final stress relief heat treatment shall be performed prior to hydrostatic testing.

7.2.2 Deposition welds

(1) The products forms and parts with deposition welds shall be stress-relieved in accordance with KTA 3201.1 if this is required in the event of the base metal being influenced by the deposition weld.

(2) In the case of hard surfacings heat treatment of the part may become necessary due to the filler metals used (e.g. in the case of precipitation-hardening filler metals).

7.2.3 Local stress-relief treatment

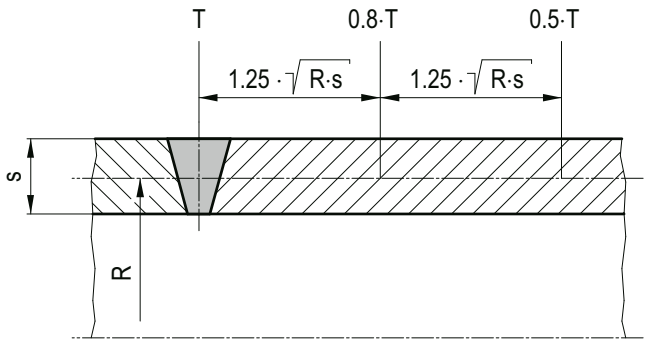
(1) In the case of local stress-relief heat treatment the width of the annealing area shall normally be two times the wall thickness (at least 100 mm, except for pipe dimensions equal to or smaller than DN 100) in which case the weld shall normally be located in the centre of this annealing area.

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 shall be avoided. This requirement is generally met in the case of walls without geometric discontinuities, where the temperature on both sides of the weld is controlled in the areas as shown in **Figure 7-1**.

(3) For areas with geometric discontinuities and in the case of small pipe dimensions specific measures shall be laid down by agreement with the authorized inspector.



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

7.3 Austenitic steels upon welding

(1) For welded joints on austenitic steels stress-relief heat treatment is not required.

(2) If special requirements are to be met by hot or cold-formed parts or by welded joints, e.g. with regard to machining, dimensional accuracy, risk of stress-corrosion cracking, resistance to intergranular corrosion, heat treatment may become necessary which shall be laid down by agreement with the authorized inspector.

7.4 Certificates

(1) The manufacturer shall establish a certificate of heat treatment to contain at least the following:

a) a confirmation of compliance with all specifications of the heat treatment plan,

b) the heat treatment equipment used.

(2) This certificate shall be signed by the authorized inspector upon review of the manufacturer's documentation on

a) the location of parts in the heat treatment equipment (in the case of local heat treatment this shall include data on

the width of the annealed zones as well as the thermal gradient in the heat-input area),

b) the location of test pieces subjected to the same heat treatment,

c) the number and location of temperature measuring points as well as statements on the temperature measuring techniques,

d) the type of heat supply,

e) a specification of the furnace atmosphere (neutral, oxidising, reducing).

(3) The original time-temperature chart countersigned by the authorized inspector shall be analyzed and represented in short form.

(4) The certificates on heat treatments shall be added to the final file.

8 Requirements for filler metals and consumables

(1) The welding filler metals and consumables shall meet the requirements laid down in KTA 1408.1, KTA 1408.2 and KTA 1408.3.

(2) Basic coated 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/mm^2:

a) rod electrode weld metal:
equal to or smaller than 5 ml/100 g of deposited weld metal (H 5 to DIN EN ISO 2560),

b) submerged arc weld metal:
equal to or smaller than 5 ml/100 g of deposited weldmetal (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) at operating temperatures equal to or higher than 300 °C,

b) if heat treatments become necessary after welding,

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 reactor coolant pressure boundary welding filler metals made of nickel alloys are used, filler metal with increased Cr content (e.g. NiCr20Mn3Nb, material no. 2.4806) shall be used for the root run.

(7) For austenitic materials to KTA 3201.1, Annex A 3 (Table A 3-1, footnote 4) to be used for hot (operating temperature equal to or greater than 200 °C) reactor water containing piping and components in boiling water reactor plants welding filler metals and consumables with appropriate analysis limits (low-carbon content) shall be used.

9 Welding procedure qualification tests

9.1 General requirements

9.1.1 Principles

(1) Prior to the beginning of fabrication the manufacturer shall demonstrate to the authorized inspector by means of a welding procedure qualification (WPQ) test that he is capable of performing the specified welding procedure in accordance with the requirements laid down hereinafter: WPQ tests (welding work, examination and testing) shall be performed in the presence of the authorized inspector.

(2) Welding procedure qualifications shall be adapted to the intended fabrication process, and the following shall be taken into account:

a) the welding process/combination of welding processes used,

b) the range of welding variables,

c) the welding position,

d) the filler metals and consumables,

e) the materials to be welded, their wall thickness and particularities,

f) the shape of the welded joint,

g) the heat treatment condition indented for the part,

h) abnormal conditions, e.g. narrow spaces, influences of the weather, clean-room conditions.

(3) In principle, WPQ tests may be performed in the course of a pre-manufacturing production control test (combined WPQ/production control test) in due consideration of **Table 11-1**. In such a case the general requirements of Section 11.1 shall be additionally taken into account.

(4) Repair welding on welded joints made with a welding process other than that used for the initial weld shall be simulated and tested in the WPQ. In such a case, the requirements laid down in the subclauses hereinafter for the respective welded joints shall be satisfied.

(5) Having successfully performed the welding procedure qualification for joint welding the manufacturer is entitled to carry out repairs on the base metal within the scope of the WPQ.

(6) Prior to performing the WPQ including simulated repair welding, the manufacturer shall establish and submit for review by the authorized inspector the following documents:

a) the materials testing and specimen-taking plan,

b) the welding procedure sheet,

c) the heat treatment plan.

(7) These documents shall meet the requirements of Section 4 with regard to form and contents. They shall not be included in the component documentation.

(8) Welders shall be employed for the welding procedure qualification who are to perform welding work within the scope of the WPQ. The welders shall be made known to the authorized inspector.

(9) In the case of welding procedure qualifications for electron beam and laser beam welding processes, the requirements of DIN EN ISO 15614-1 shall be met in addition to the requirements of Section 9.

9.1.2 Requirements for test coupons of base metal

(1) The base metal of the test coupons shall have been tested in accordance with and meet the requirements of KTA 3201.1. Prior to welding, the material shall be in the heat-treated condition (e.g. quenched and tempered, normalised,

solution-annealed) provided for the base metal of the pertinent part.

(2) The test coupon wall thickness shall be fixed such that the destructive and non-destructive tests required for the wall thickness of the component can be performed. Where excess lengths of already accepted parts are used for test coupons, a renewal of the qualification test is not required.

(3) Where test coupons are not taken from excess lengths of already accepted parts, but are cast, forged or rolled separately, these test coupons shall be subject to acceptance testing per melt in accordance with subclause (4).

(4) Per test coupon each, the following examinations/tests shall be performed, at a weight exceeding 3.5 t or a length exceeding 3 m at two locations of specimen-taking (head and base), at a weight equal to or less than 3.5 t and a length equal to or less than 3 m at one specimen-taking location (head or base), with the depth of specimen-taking being in accordance with KTA 3201.1:

a) Verification of chemical composition

The elements specified in the respective Annex to KTA 3201.1 shall be verified by a product analysis.

b) Metallographic examinations

The grain size (for ferritic materials, secondary grain size) shall be determined by means of a 100 times magnification. The micrographs of the structure shall be made with a magnification allowing a clear evaluation (generally 200:1 enlargement).

c) Tensile test

The tensile test shall be performed in accordance with DIN EN ISO 6892-1 or DIN EN ISO 6892-2. When using procedure A, the strain rates recommended by the standard shall normally be used. Tensile test specimens to DIN 50125 may also be used. The following shall be tested:

ca) for plates, pipes and forgings:

- one transverse tensile specimen at room temperature and at 350 °C each; R_m, $R_{p0.2}$, A and Z shall be determined, for austenitic steels $R_{p1.0}$ additionally,
- one tensile specimen normal to the product surface in accordance with DIN EN 10164 at room temperature (only for ferritic materials); Z shall be determined.

cb) for cast steel parts:

- one specimen at room temperature and 350 °C each; R_m, $R_{p0.2}$, A and Z shall be determined, for austenitic steels $R_{p1.0}$ additionally.

d) Notched bar impact test

The test shall be performed in accordance with DIN EN ISO 148-1 on non-aged specimens with V-notch using a striker with 2 mm radius (KV_2) to determine:

da) the impact energy absorbed (KV_2),

db) the ductile fracture portion (for ferritic steels only),

dc) the lateral expansion (for ferritic steels only).

One set of transverse specimens shall be tested from each location of specimen-taking. The test temperatures shall be: 0 °C, 33 °C and 80 °C (the test at 80 °C may be omitted if 100 J are obtained at 33 °C). For austenitic steels: 1 set of transverse specimens at room temperature.

For cast-steel parts the orientation of specimens is not fixed.

e) Nil-ductility transition temperature (for ferritic steels only)

The Pellini drop-weight test shall be performed in accordance with SEP 1325. On two transverse specimens per specimen-taking location (specimen shape P2) it shall be demonstrated that the NDT temperature requirements are met.

For cast-steel parts the orientation of specimens is not fixed.

f) Corrosion resistance (for austenitic steels only)

The resistance to intergranular corrosion shall be demonstrated in accordance with DIN EN ISO 3651-2, procedure A, in which case sensitisation shall be performed at 650 °C for a period of 30 minutes.

(5) The tests listed in clause 4 a) to f) may be performed without subjecting the steels 20 MnMoNi 5 5 and 22 NiMoCr 3 7 as well as the austenitic steels to simulated stress relieving prior to the test.

(6) The test performed to clause 4 a) to f) shall be certified by inspection certificates as follows:

Tests in acc. with clause 9.1.2 (4)	Inspection certificate to DIN EN 10204	
	Components acc. to clause 1 (3)	
	a) to e)	f) to h)
	Components acc. to clause 1 (4)	
	a) and b)	c) and d)
a)	3.1	3.1
b)	3.1	3.1
c)	3.2	3.1
d)	3.2	3.1
e)	3.2	3.1
f)	3.1	3.1

The inspection certificate 3.2 shall be confirmed or be established by the authorized inspector to § 20 of the Atomic Energy Act or by the technical inspecting agency tasked by him.

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

(8) The fusion faces or surfaces to be clad-welded shall be tested in accordance with the requirements of Section 12.

(9) The operating principles to Section 5 shall be satisfied in the welding procedure qualification. The test piece shall be so dimensioned that the specimens provided in the materials testing and specimen-taking plan can be taken and the required non-destructive examinations can be performed. Where no other stipulations have been laid down in the clauses to follow, sufficient material for substitute test specimens shall be provided.

(10) Corrective changes according to clause 5.6.1 during welding of a test piece for procedure qualification are permitted by agreement with the inspector if the test piece is still representative for the welding procedure to be qualified.

(11) All corrective changes shall be recorded with statement of cause, type and extent and be indicated by the manufacturer in the report as per clause 9.1.5.

(12) Repairs according to clause 5.6.2 are not permitted on a test piece used for welding procedure qualification where they do not fall under the scope of the welding procedure qualification as simulated repair weld.

(13) Where a specimen or a set of specimens does not obtain the values required, two additional specimens or sets of specimens may be tested. All substitute specimens shall meet the requirements. The cause of failure shall be ascertained.

(14) Where insufficient test results are due to test influences or a limited defect location in a specimen, the respective specimen may not be considered in the decision-making on whether the requirements have been fulfilled. The respective test shall be repeated on a substitute test specimen.

(15) Systematically occurring defects or defects due to the procedure used (e.g. linear porosity) may lead to a rejection of the procedure qualification test even if the other requirements have been met.

9.1.3 Scope

9.1.3.1 General

(1) The scope of the welding procedure qualification test shall be laid down in the authorized inspector's written report.

(2) The scope of welding procedure tests may be extended by production control tests by agreement with the inspector.

(3) The procedure qualification being valid for one manufacturer's works also applies to welding work done outside the works, e.g. on construction sites if the welding personnel of the manufacturer's works is employed in accordance with Section 3.3.1 to 3.3.3.

9.1.3.2 Base metal

(1) The welding procedure qualification (WPQ) applies to the base metals used in that test.

(2) Where the welding procedure qualification is to apply also to base metals of other composition, this shall be laid down in the authorized inspector's report on the procedure qualification.

9.1.3.3 Welding filler metals and consumables

(1) The WPQ shall apply to the welding filler metals (rod electrodes including type of coating, strip or wire electrodes, filler rod and welding rod) and to the welding consumables (shielding gases, flux).

(2) Basically, welding filler metals shall be welded on the same diameters which are also intended for the welding of the parts. Other diameters may be used if the heat input during welding of the part does not exceed, by 25%

a) the value during welding of the test piece if requirements for absorbed impact energy are to be met,

b) the value during welding of the test piece if requirements for hardness are to be met,

in which case the heat input shall be calulated to DIN EN 1011-1.

(3) Where change-over is made to another brand of welding consumables of the same type, no renewal of procedure qualification is required if the consumables satisfy the requirements of DIN EN ISO 14341, DIN EN ISO 2560, DIN EN ISO 3580, DIN EN ISO 3581, DIN EN ISO 636, DIN EN ISO 6847, and DIN EN ISO 14343.

(4) In the case of shielding gases to DIN EN ISO 14175, a change of manufacturer is permitted if identical gas composition is ensured.

(5) The electrode-flux combination used in the WPQ shall be valid for submerged-arc welding; an exchange of standard wire or strip electrodes with comparable chemical composition is permitted irrespective of the manufacturer.

(6) It is not permitted to change the flux type used in the WPQ test.

(7) Where the re-use of fluxes (multiple recirculation) is provided it shall be ascertained within the WPQ whether this is acceptable.

(8) In the case of electron beam and laser beam welding, welding with and without filler metals shall be subject to separate WPQs.

9.1.3.4 Form of welded joint

(1) The form of welded joint used in the WPQ shall normally meet the requirements of the intended fabrication weld.

(2) Where the welding variables fixed in the WPQ remain unchanged, i.e.

a) dimensions of filler metals,

b) welding position,

c) amperage,

d) voltage (for semi- or full mechanized welding),

e) welding speed,

deviations from the dimensions of the form of welded joint as used in the WPQ (e.g. angle of fusion faces, groove face depth in the case of both-sides welds) are permitted for the welding of parts as per **Table 9-1**, **Figure 9-1** and clause 9.1.3.6.

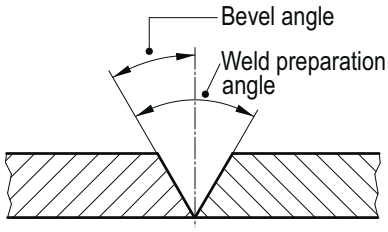


Figure 9-1: Definition of bevel angle and weld preparation angle (schematic)

9.1.3.5 Welding position

Depending on the welding position selected for the WPQ, other welding positions allocated in accordance with **Table 9-4** are permitted for the welding of parts or components.

9.1.3.6 Weld build-up

(1) Where several welding procedures are used during a WPQ, the portion of the filler metals of the various welding procedures used, referred to the weight of the deposited weld metal, may deviate from the portion of filler metals used in the welding of the parts or components.

(2) The sequence of the welding procedures used may be changed by agreement with the inspector.

9.1.3.7 Heat treatment

(1) The heat treatment to be applied in a WPQ test shall be laid down in accordance with KTA 3201.1 and in consideration of Section 7.1.

(2) In addition to the heat treatments as per Section 7 expected to be applied during fabrication at least an interim and final stress relief heat treatment shall be performed on the test piece.

9.1.3.8 Validity

(1) The period of validity shall be 24 months after successful completion of a WPQ test. The effective date for the beginning of the period of validity within 3 months after completion of welding work is the date at which the authorized inspector will issue his statement on the test results. If the results are obtained at a later date, the effective date for the beginning of

the period of validity shall be 3 months after completion of welding work.

(2) If fabrication has started and production control tests according to Section 11 are performed within these 24 months, the period of validity shall be extended for additional 24 months after successful completion of the production control test. The extension of the period of validity of a WPQ refers to the completion of welding work during the production control test. The extended period will become effective with the submission of the authorized inspector's statement on the test results obtained during simulation heat treatment of the part of the production control test piece.

(3) If fabrication has not started within 24 months after successful completion of the WPQ test or is interrupted for more than 24 months, the first production control test performed is considered a renewal of the WPQ test. The specifications of the first WPQ test shall apply to the extent of this production control test and to both the beginning and period of validity. The production control test shall principally be performed prior to the welding of the part. Where fabrication is interrupted for more than 12 months, the production control test as required by Section 11 shall have been conducted prior to the start of fabrication.

9.1.4 Retention of remainders

Table 11-2 applies with regard to the retention of remainders of specimens and test pieces, untested specimens and substitute material.

9.1.5 Report

(1) The manufacturer shall draw up a report on the welding procedure qualification test (WPQR) on the basis of which the the authorized inspector will establish a certificate.

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

a) certificates for base metals, welding filler metals and consumables,

b) geometry and dimensions of the test pieces,

c) information on welders, welding procedures, welding conditions and welding data,

d) welding procedure specification and welding record,

e) heat treatment plan and heat treatment record or heat treatment charts,

f) materials testing and specimen-taking plan,

g) results of the tests required as per f) with the pertinent certificates to DIN EN 10204. The results of the chemical analysis and the results of the checks for resistance to intergranular corrosion shall be certified by inspection certificate 3.1 to DIN EN 10204, and all other test results be certified with inspection certificate 3.2 to DIN EN 10204.

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

a) a summarized final result,

b) a final evaluation,

c) a limitation of the scope.

9.2 Ferritic butt welds

9.2.1 Non-destructive tests and inspections

(1) The test pieces shall be subjected to the non-destructive tests and inspections as per Section 12.3 except for the angled-pitch catch technique required by this Section.

(2) Instead of the angled-pitch catch technique, the weld shall be additionally examined from the sides by a normal probe. To this end, the sides parallel to the weld shall be normal to the test piece surface.

(3) The probe-to-test piece scanning surface beside the weld surface shall be at least so wide that examination

a) at wall thicknesses equal to or smaller than 100 mm at an angle of incidence of 45° by double traverse technique,

b) at wall thicknesses greater than 100 mm at an angle of incidence of 45° by single traverse technique (direct scanning) is possible.

(4) The results obtained shall meet the requirements of Section 12.3 and be recorded in test reports.

9.2.2 Mechanical and other tests

9.2.2.1 General requirements

(1) The mechanical tests and other tests as per **Table 9-2** shall be performed.

(2) The results obtained shall meet the requirements of **Table 9-3** and shall be recorded in test records.

(3) All specimens shall be shown to scale in the materials testing and specimen-taking plan.

(4) Where a procedure qualification test has already been performed for the welding positions PA (flat position) and PF (vertical-up position), a supplementary test in horizontal-vertical position with a reduced extent of testing according to **Table 9-2** will suffice. This does not apply to circumferential welds made by fixed position welding. The transverse microsections shall be examined according to clause 9.2.2.4. It shall be demonstrated by means of impact tests performed at 0 °C and 33 °C that the temperature range over the dropping branch of the temperature curve in the welding positions PA (flat position) and PF (vertical-up position) is not essentially displaced compared to the energy absorbed-temperature curves KV_2-T obtained in procedure qualification.

(5) Depending on the type of welded joint (e.g. single-vee or single-U butt joint to DIN EN ISO 9692-1 or DIN EN ISO 9692-2) and the wall thickness the test shall be performed one test layer or several test layers to **Figure 9-2**. In the case of combination processes the test layers shall be arranged such that each welding process is covered.

(6) The specimens from the layer O shall be taken as close as possible from the test piece surface. In the case of single-sided welds (e.g. pipings with s equal to or smaller than 30 mm) the specimens shall be taken such that the root layer is covered by the test.

(7) Where several welding processes (combination process) qualified in one test piece, the test layer shall be selected such that each welding process can be covered by the evaluation.

(8) In the case of wall thicknesses s equal to or smaller than 30 mm, the specimens (if required, integral specimens) shall be taken such that each welding process can be covered by the evaluation.

9.2.2.2 Tensile tests on the welded joint

Specimens to DIN EN ISO 4136 with a diameter equal to or greater than 8 mm or with a specimen thickness equal to or greater than 10 mm shall be tested. Specimens to DIN 50125 may be used.

9.2.2.3 Bend test

(1) Where test pieces with a wall thickness exceeding 30 mm are subjected to a bend test, the side with the lesser width of weld shall be located on the compression side.

(2) For specimens taken from the root layer the tensile side of the specimens shall be close to the root.

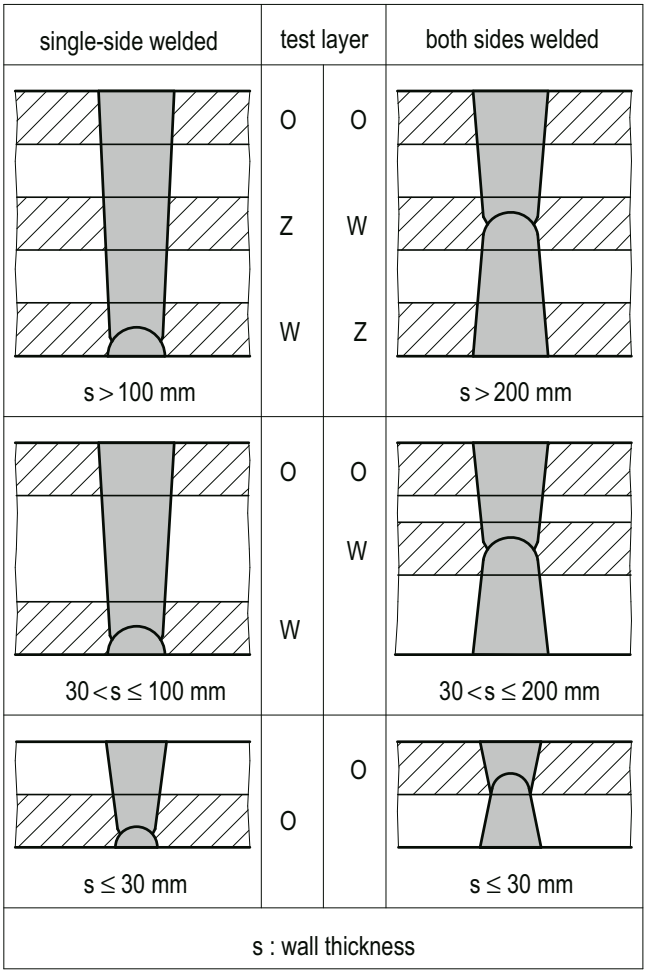
(3) In the case of wall thicknesses equal to or smaller than 30 mm, 4 bend specimens shall be tested, two as face-bend and two as root-bend specimens. Two specimens each shall be subjected to tension over the one and over the other side of the weld, respectively.

9.2.2.4 Metallographic examination

In addition to the tests as per **Table 9-2** extended metallographic examinations (transverse microsections or transverse microsections in connection with tangential microsections); as fas as provided in **Annex B**, shall be performed and evaluated

9.2.2.5 Hardness tests

The hardness traverse HV 5 over base metal - weld metal - base metal shall be taken from **Figure 9-3**. For the evaluation of the test results **Table 9-3** applies.



O : subsurface layer
W : layer covering the root layer
Z : additional layer within the filler bead range

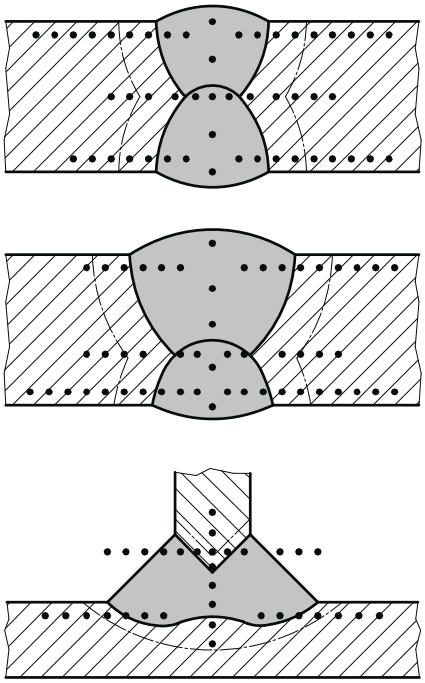
Figure 9-2: Test layers for several wall thicknesses and types of welds for butt welds of ferritic steels

9.2.3 Scope

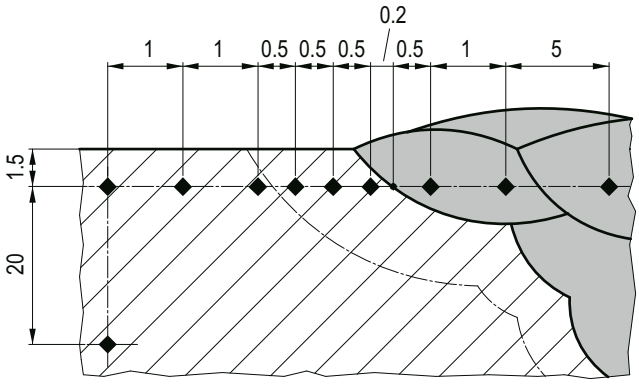
9.2.3.1 Wall thickness

The wall thickness of a test piece for procedure qualification limits the scope of this procedure qualification for the welding of parts of different wall thicknesses as follows:

a) A welding procedure qualification conducted on a test piece of a wall thickness s equal to or smaller than 100 mm applies
   aa) for multi-pass arc welds for the wall thickness range of 0.75 · s up to 1.5 · s,
   ab) for submerged-arc narrow-gap welding for the wall thickness range of 0.5 · s to 1.25 · s,
   ac) for special welding procedures for the wall thickness range of 0.75 · s to 1.25 · s.
b) A procedure qualification test performed on a test piece wall thickness s greater than 100 mm for semi- or fully automatic welding applies to the wall thickness range 0.5 · s up to 1.5 · s.
c) A procedure qualification test performed on a test piece wall thickness s greater than 100 mm for manual arc welding applies to the wall thickness range s to be laid down with the authorized inspector.
d) For test pieces with wall thicknesses greater than 300 mm and for test pieces for parts with wall thicknesses greater than 450 mm the scope shall be laid down by agreement with the authorized inspector.



Examples of locations of hardness indentations



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

Figure 9-3: Hardness test on transverse microsections of ferritic welded joints

9.2.3.2 Pipe diameter

The pipe diameter of a test piece for procedure qualification limits the scope of this procedure qualification for the welding of parts with different pipe diameters as follows:

A procedure qualification performed on a test piece with a pipe diameter d applies

a) in the case of manual welding with
   aa) d equal to or less than 168.3 mm for pipe diameters 0.5 · d up to 2.0 · d,
   ab) d greater than 168.3 mm for all pipe diameters equal to or greater than 0.5 · d,

b) in the case of semi- or fully mechanized welding with
   ba) d equal to or less than 168.3 mm for pipe diameters 1.0 · d up to 2.0 · d,
   bb) d greater than 168.3 mm for all pipe diameters equal to or greater than 0.5 · d.

9.2.4 Simulated repair welding

(1) Repair welds on welded connections, which are to be made with a welding process other than that used for the original weld shall be simulated within the WPQ.

(2) For the simulated repair weld 50% of the wall thickness shall be repaired such that the faces of the repaired location cover both the weld metal and base metal.

(3) In the case of single-side pipe circumferential welds with a wall thickness equal to or less than 30 mm simulated repair welding shall be effected such that the repaired location covers the entire wall thickness.

(4) **Table 9-2** applies with regard to the mechanical and other tests and Section 12.3 to non-destructive testing.

9.3 Butt welded joints on austenitic steels

9.3.1 Non-destructive tests and inspections

(1) The test pieces shall be subjected to non-destructive tests and inspections as per Section 12.5.

(2) The result obtained shall meet the requirements of Section 12.5 and shall be recorded in test reports.

9.3.2 Mechanical and other tests

9.3.2.1 General requirements

(1) Mechanical and other tests as per **Table 9-5** shall be performed.

(2) For wall thicknesses greater than 50 mm the extent, areas to be examined and the requirements of the examination shall be laid down by agreement with the authorized inspector.

(3) The results obtained shall meet the requirements of **Table 9-6** and be recorded in test records.

(4) All specimens shall be shown to scale in the materials testing and specimen-taking plan.

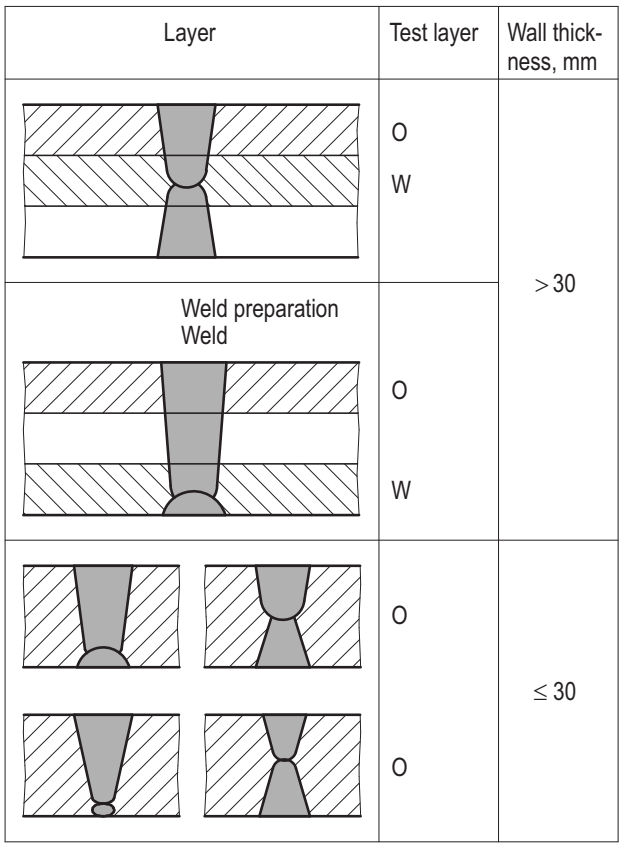
(5) Where a procedure test has already been performed for the welding positions PA (flat position) and PF (vertical-up position), a supplementary test in horizontal-vertical position with the following extent of testing will suffice:

a) one round tensile test specimen each in the required test layers (specimen location according to sketch I of **Figure 9-5**),

b) one set of impact test specimen each in the required test layers (specimen location in accordance with sketch II of **Figure 9-5**),

c) one microsection at the transition from weld metal to base metal.

(6) The test shall be performed on the test layers to **Figure 9-4**.



Testing acc. to Table 9-5
O : subsurface layer
W : test layer to cover the root layers

Figure 9-4: Test layers for several wall thicknesses and types of welds for butt welds of austenitic steels

(7) The specimen from test layer O shall be taken as close as possible from the test piece surface. In the case of single-sided welds (e.g. pipings with s equal to or smaller than 30 mm) the specimens shall be taken such that the root layer is covered by the test.

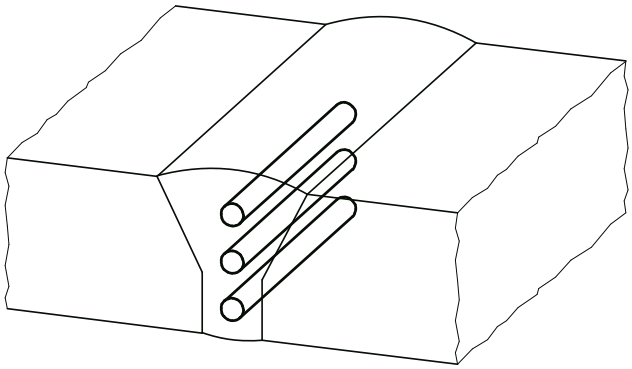
(8) Where several welding processes (combination process) are used to weld a joint, the test layer shall be selected such that each welding process can be covered by the evaluation.

(9) In the case of wall thicknesses equal to or smaller than 30 mm the specimens (if required, integral specimens) shall be taken such that each welding process can be covered by the evaluation.

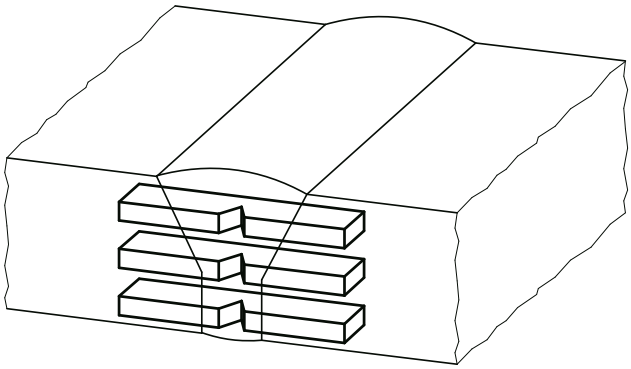
(10) The tests shall be performed at room temperature.

9.3.2.2 Tensile test on the welded joint

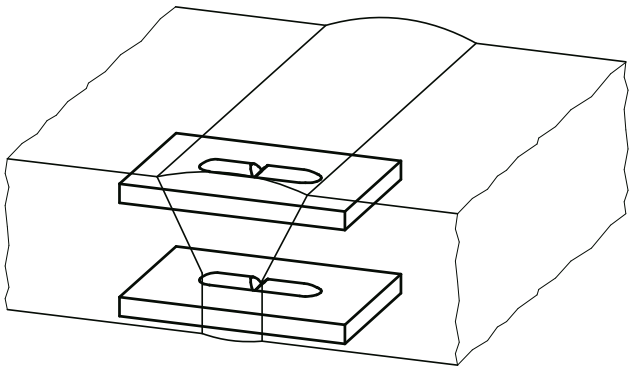
Specimens to DIN EN ISO 4136 with a diameter equal to or greater than 8 mm or with a specimen thickness equal to or greater than 10 mm shall be tested. Specimens to DIN 50125 may be used.



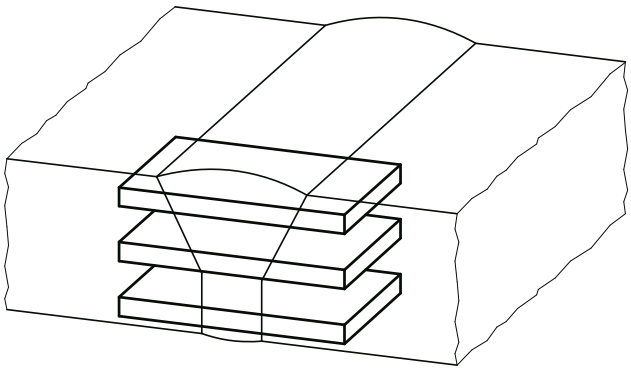
I. Round tensile test specimens in the weld metal



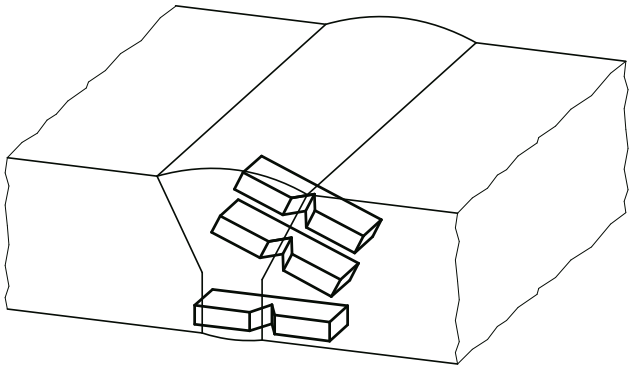
II. Impact test specimens in the weld metal



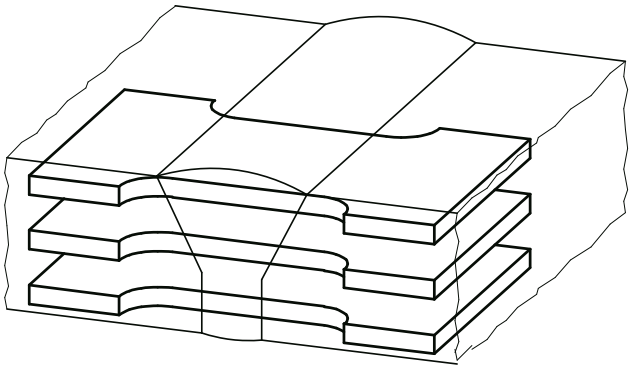
III. Drop-weight test specimens in the weld metal



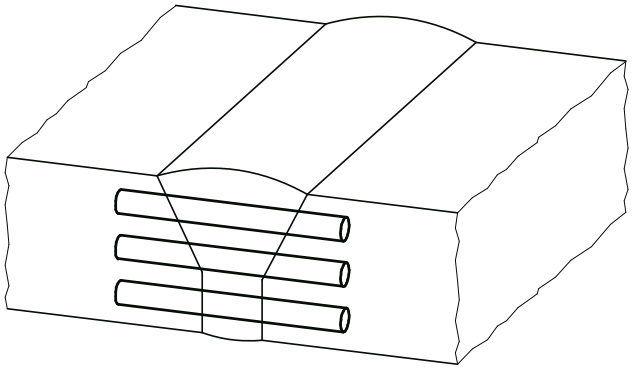
IV. Bend test specimens in the weld metal



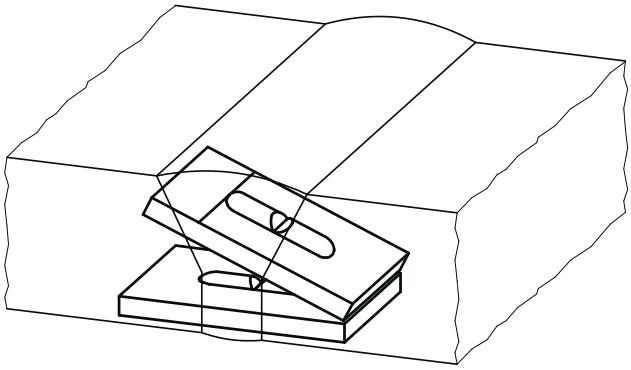
V. Impact test specimens of the welded joint
(0.5 ± 0.3 mm beside the fusion line in the base metal)



VI. Flat tensile test specimens of the welded joint



VII. Round tensile test specimens of the welded joint



VIII. Drop-weight test specimens of the welded joint

Figure 9-5: Location of specimens

9.3.2.3 Bend test

(1) Where test pieces with a wall thickness greater than 30 mm are subjected to a bend test, the side with the lesser width of weld shall be located on the compression side. For specimens taken from the root layer the tensile side of the specimen shall be close to the root.

(2) The surface finish of the test piece shall correspond to that of the part.

(3) In the case of wall thicknesses equal to or less than 30 mm, two bend specimens shall be tested. One specimen each shall be subjected to tension over the one and over the other side of the weld, respectively.

9.3.2.4 Check for resistance to corrosion

The check for corrosion resistance is only required if corrosion resistance has to be demonstrated due to the component loading by the fluid.

9.3.3 Scope

9.3.3.1 Wall thickness

The wall thickness of a test piece for procedure qualification limits the scope of this procedure qualification for the welding of parts of different wall thickness of follows:

a) A procedure qualification test performed on a test piece wall thickness s applies to a wall thickness range of a part's weld of $0.75 \cdot s$ up to $1.5 \cdot s$.
b) A procedure qualification test performed with a weld electrode on a test piece with the wall thickness s greater than 6 mm for multi-layer manual arc welded joints applies also to wall thickness up to a lower limit of $0.5 \cdot s$.

9.3.3.2 Pipe diameter

The pipe diameter of a test piece for procedure qualification limits the scope of this procedure qualification for the welding of parts with different pipe diameters as follows:

A procedure qualification performed on a test piece with a pipe diameter d applies

a) in the case of manual welding with
   aa) d equal to or less than 168.3 mm for pipe diameters $0.5 \cdot d$ up to $2.0 \cdot d$,
   ab) d greater than 168.3 mm for all pipe diameters equal to or greater than $0.5 \cdot d$,
b) in the case of semi- or fully mechanized welding with
   ba) d equal to or less than 168.3 mm for pipe diameters $1.0 \cdot d$ up to $2.0 \cdot d$,
   bb) d greater than 168.3 mm for all pipe diameters equal to or greater than $1.0 \cdot d$.

9.3.4 Simulated repair welding

(1) Repair welds on welded connections, which are to be made with a welding process other than that used for the original weld, shall be simulated within the WPQ.

(2) For the simulated repair weld 50 % of the wall thickness shall be repaired such that the faces of the repaired location cover both the weld metal and the base metal.

(3) In the case of single-side pipe circumferential welds with a wall thickness equal to or less than 30 mm, simulated repair welding shall be effected such that the repaired location covers the entire wall thickness.

(4) **Table 9-5** applies with regard to the mechanical and other tests, and the stipulations of Section 12.5 apply to the non-destructive tests and inspections.

(5) In addition, the following metallographic examinations are required:

a) one macrosection in the transition to the repaired weld metal,
b) one microsection in the repaired weld metal,
c) one microsection in the transition from the repaired weld metal to the base metal.

9.4 Weld claddings made of austenitic steels and nickel alloys

9.4.1 General requirements

(1) The surface condition of the test piece prior to weld cladding shall be comparable to that of the intended part to be welded.

(2) Prior to welding, the surface to be cladded shall be subjected to a surface examination in accordance with clause 12.8.1.

(3) During welding it shall be ensured that restraint of the test piece is provided. This is generally required for wall thicknesses equal to or less than 100 mm. For wall thicknesses greater than 100 mm this may also be required in dependence of the weld cladding process used. Such restraint shall be maintained in the case of subsequent heat treatment.

(4) Suitable welding parameters shall be selected to specify the penetration depth such 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. if the allowable delta-ferrite content is less than required in the case of austenitic weld cladding).

(5) The surface condition of the weld cladding shall satisfy the conditions of the part. It shall be possible to perform the non-destructive examinations according to clause 12.8.2 and 12.8.3.

(6) In the case of weld claddings where one welding process follows another process, each individual process as well as the transition zone between the two processes including the transition between differing strip widths (except for examinations according to clause 9.4.3.3 and 9.4.3.4) shall be qualified.

(7) For weld claddings subject to tensile loading in thickness direction special requirements shall be laid down by agreement with the authorized inspector.

(8) The examinations shall be performed upon simulated repair welding.

(9) By means of the tests and examinations as per clause 9.4.2, 9.4.3.2, 9.4.3.5.1 and 9.4.3.5.2 it shall be proved that the heat-affected zone is free from cracks (e.g. underclad cracking).

9.4.2 Non-destructive tests and inspections

(1) Non-destructive tests and inspections as per clauses 12.8.2 and 12.8.3 shall be performed on the test piece.

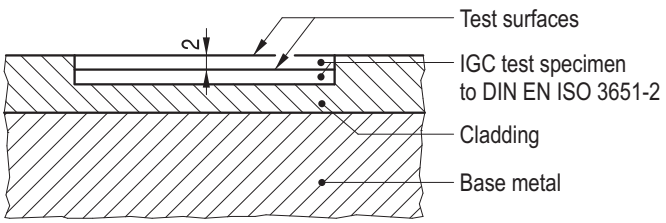
(2) The results obtained shall meet the requirements of clause 12.8.2 and 12.8.3 and shall be recorded in test reports.

9.4.3 Mechanical and other tests

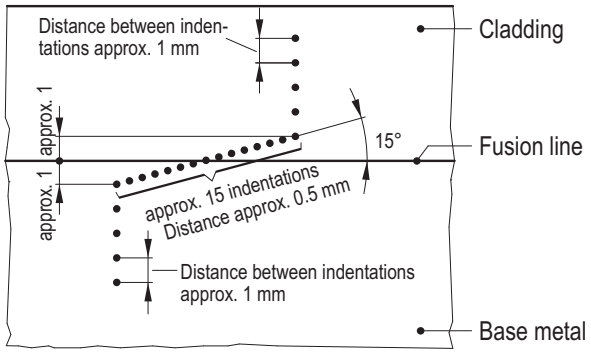
9.4.3.1 General requirements

(1) Mechanical and other tests as per **Table 9-7** shall be performed.

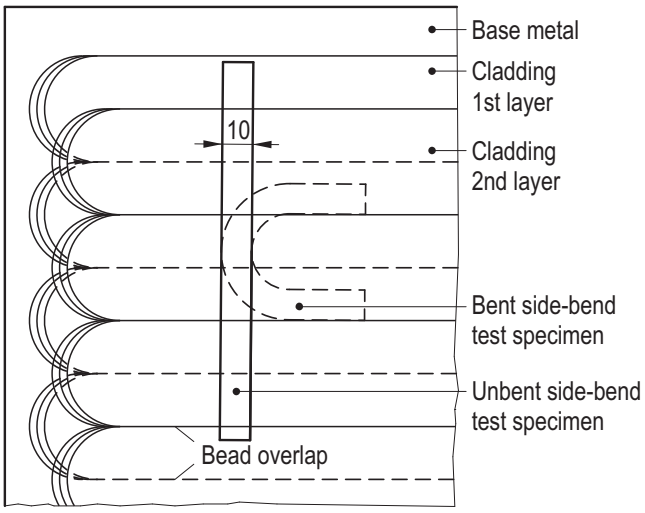
(2) The results obtained shall meet the requirements of **Table 9-6** and be recorded in test records.



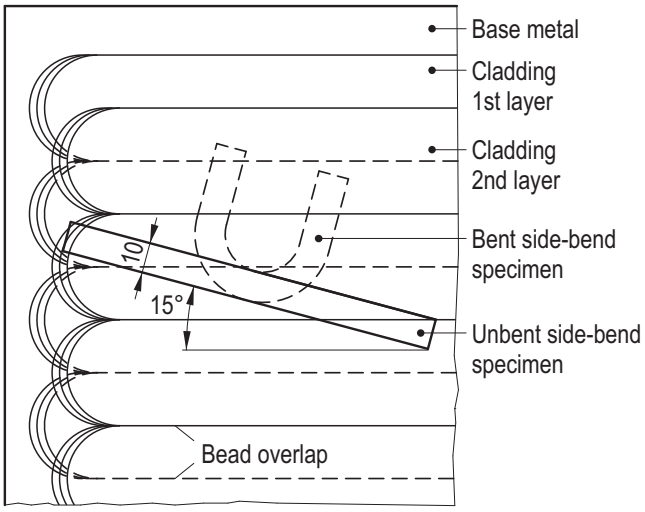
Sketch 1: Corrosion test



Sketch 2: Hardness test



a transverse to direction of weld progression



b 15° to direction of weld progression

Sketch 3: Side bend test (for welding with strip electrode)

Figure 9-6: Test on weld-cladded test pieces

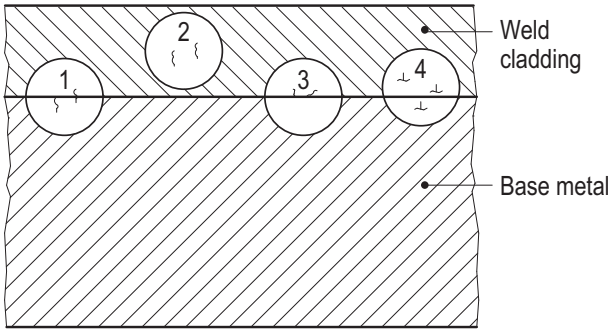
9.4.3.2 Bend tests

(1) For side-bend test specimens transverse or at angle of 15° to the direction of welding process (acc. to sketch 3 in **Figure 9-6**) the following dimensions apply:

a) specimen thickness 10 mm
b) specimen width approx. 30 mm
c) minimum length 200 mm
d) mandrel diameter 40 mm
e) bending angle 180 degrees.

(2) The specimens shall be taken such that an as large as possible portion of the transition zone between two beads of the first layer is located in the tensile zone.

(3) Discontinuities in the case of side-bend specimens after bending shall satisfy the requirements of **Figure 9-7**.



Defect type 1: Discontinuities affecting the base metal are only permitted if the bending strain has 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 9-7: Evaluation of discontinuities on side-bend specimens to clause 9.4.3.2 in the bent condition

9.4.3.3 Chemical analysis

(1) The chemical composition of the weld cladding shall be checked at distances of 1 mm beginning from the surface through the entire cladding thickness.

(2) At cladding thicknesses greater than 8 mm a distance of 2 mm is permitted in which case it shall be taken into account that the layer welded first is covered. Below a depth of 2 mm this examination is used for total evaluation.

(3) Each of these layers shall be checked for C, Si, Mn, Mo, Cr, Ni, Co, stabilizing elements (nickel alloys additionally for Fe, Nb and Ti); N_2, P, S shall only be analyzed up to a depth of 2 mm.

(4) The chemical composition of the upper 2 mm of the weld cladding shall meet the requirements set for the part's weld cladding.

9.4.3.4 Check for resistance to intergranular corrosion in the case of austenitic steels

(1) The check for intergranular corrosion resistance shall be performed in accordance with the requirements for the part

and the composition of materials of the weld cladding in conformance with a procedure suited for austenitic steels (e.g. DIN EN ISO 3651-2, procedure A, without sensitisation).

(2) The specimens to DIN EN ISO 3651-2 with a dimension of 100 mm · 30 mm shall be taken at a thickness of 2 mm from the final surface of the weld cladding.

(3) The test shall be performed two times each on the original surface and two times each on the area at 2 mm depth (**Figure 9-6**, sketch 1).

9.4.3.5 Metallographic examinations

9.4.3.5.1 Macrosection transverse to the direction of welding progress

(1) A macrosection shall be made over the entire specimen width transverse to the direction of welding progress and be photographed.

(2) The weld cladding structure shall be free from such cracks as are detectable by macroscopy at a magnification of 10:1 or by non-destructive examination.

(3) Where individual structural discontinuities are found they shall be examined metallographically to find out the cause and whether they can be avoided. Only if the number and configuration of the discontinuities lead to the conclusion that they are due to unsuited filler metals or incorrect welding conditions the procedure qualification shall be rejected.

(4) Local and isolated porosity and slag inclusions are permitted. For the heat-affected zone the acceptance level is based on the freedom from cracks.

9.4.3.5.2 Microsection transverse to the direction of welding progress

(1) Micrographs with a magnification of at least 100:1 shall be made of the microsections of transition and overlapping zones within the weld cladding and the heat-affected zone of the base metal.

(2) These micrographs shall be fixed by means of a master shot or sketch to **Figure 9-8**.

9.4.3.5.3 Parallel surface microsection

(1) The overlapping zones of clad-welds made by different welding processes for nickel claddings as well as the overlapping zones at the transition from the nickel to the austenitic cladding shall be examined by parallel surface microsections per clad layer each.

(2) Discontinuities detected by parallel surface microsections (magnification 10:1) are only permitted if they are clearly evaluated to be isolated defects with regard to number and location. Defects in the form of coherent imperfections are not permitted.

9.4.3.5.4 Delta-ferrite content in the case of austenitic steels

(1) The delta-ferrite content shall be determined metallographically on a transverse microsection. In the case of multilayer claddings each layer shall be examined.

(2) The delta-ferrite content in the weld metal of austenitic steels shall amount to approximately 4 % to 10 %. A coherent lattice is not permitted.

(3) In single-layer claddings or in the first layer of multiple-layer claddings areas with low delta-ferrite content are not cause for rejection if the requirements of clause 9.4.3.5.1 have been met.

9.4.3.6 Hardness tests

(1) The hardness test (HV 5) shall be performed on indentations through the thickness of the cladding and the transition to the base metal (**Figure 9-6**, sketch 2).

(2) The hardness in the ferritic base metal shall not exceed 350 HV 5. 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.

9.4.4 Scope

9.4.4.1 Number of layers

Single and multi-layer weld claddings shall be considered separate welding procedures. Regarding the limitation of the scope of the welding procedure qualification by number or layers the following applies:

Procedure qualification	Number of layers in production	
	Austenitic steels	Nickel alloys
1	1	1
2	2 to 4	2
n	2 to (n+4)	2 to n

9.4.4.2 Wall thickness

(1) At a test piece wall thickness smaller than 100 mm the procedure qualifies for the range of test piece thickness and 100 mm.

(2) The minimum test piece thickness in procedure qualifications for parts with a wall thickness equal to or greater than 100 mm shall be 100 mm.

9.4.4.3 Welding positions

(1) The welding position chosen in the procedure qualification qualifies for the welding of parts in the same welding position.

(2) Where procedure qualifications have been performed for the welding positions PA (flat position) and PC (horizontal position) or PE (overhead position) and PC (horizontal position), they include all pertinent intermediate positions on the part.

9.4.4.4 Extension of scope

(1) Where the conditions on the part (e.g. spherical surfaces with strong curvature, small inside diameter) essentially deviate from the conditions of the welding procedure qualification, a supplementary test shall be performed to extend the scope.

(2) The extent of the supplementary test shall be agreed with the authorized inspector.

9.4.5 Simulated repair welding

(1) Where simulated repair welding is to be made within the course of welding procedure qualification, it shall be performed to be comparable to a repair weld on a weld cladding of a part.

(2) Examinations within simulated repair welding shall be made within the following clauses:

a) surface inspection by means of liquid-penetrant testing, according to clause 12.8.2,

b) ultrasonic testing, according to clause 12.8.3,

c) macrosection transverse to the direction of welding progress, according to clause 9.4.3.5.1,

d) microsection transverse to the direction of welding progress, according to clause 9.4.3.5.2,

e) hardness traverse (HV 5) in the transition zone, according to clause 9.4.3.6,

f) two side-bend specimens transverse to the direction of welding progress, according to clause 9.4.3.2. The specimen shall be taken such that the repaired area lies in the middle of the specimens.

g) check for resistance to intergranular corrosion on claddings made of austenitic steels, according to clause 9.4.3.4 (3).

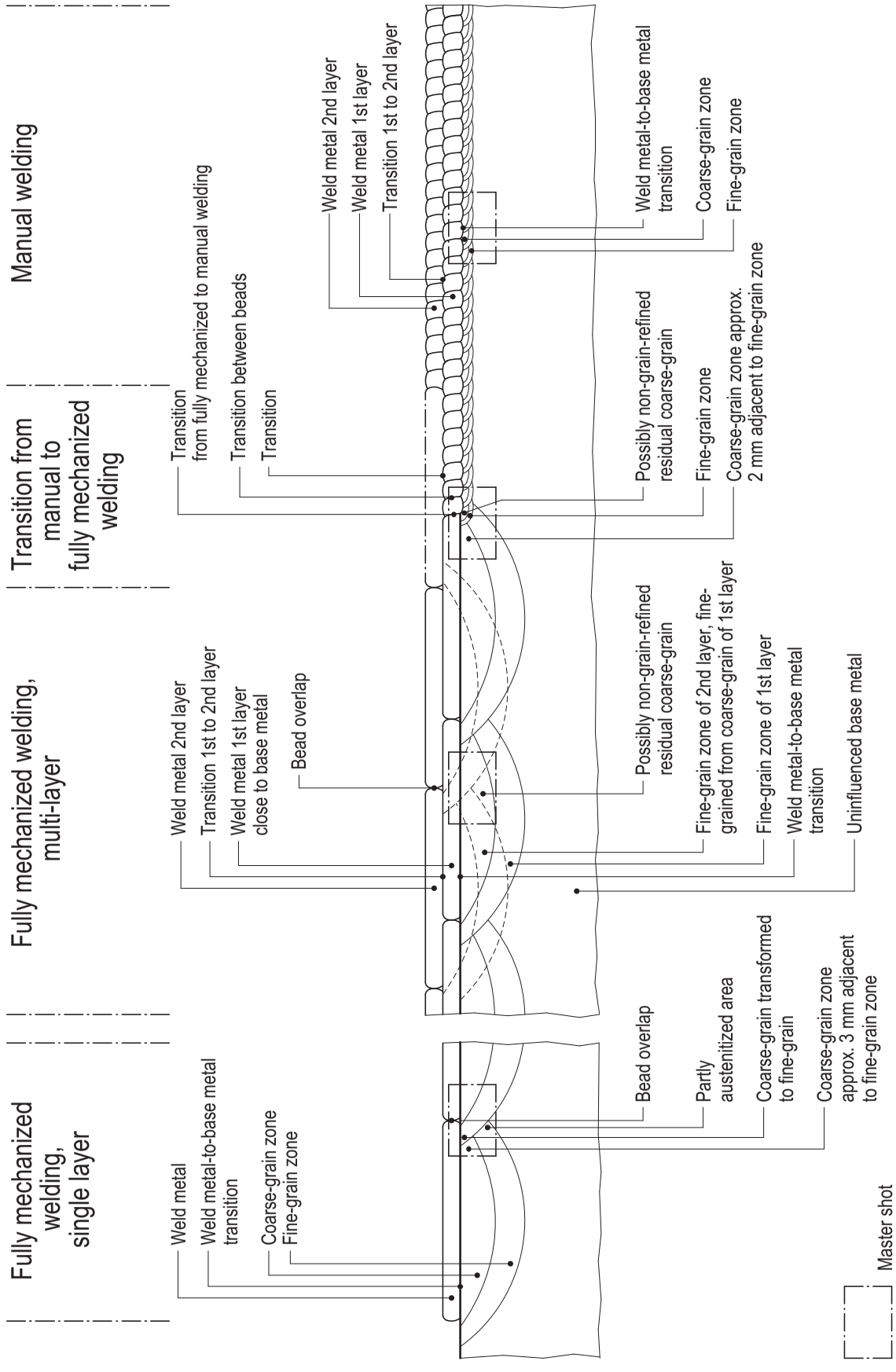


Figure 9-8: Location of master shots in case of metallographic examinations of weld claddings

9.5 Special ferritic welded joints

9.5.1 Double-bevel groove welds

9.5.1.1 General requirements

(1) For double-bevel groove welds - also on non-load-bearing welded attachments made of ferritic steels - a procedure qualification shall be made on a test piece with double-bevel groove weld.

(2) The test piece shall be made such that all specimens required according to Section 9.2 as well as the specimens additionally required according to clause 9.5.1.3 can be taken.

(3) Where a procedure qualification for ferritic butt welded joints to Section 9.2 has been performed with a scope fixed by the welding position according to **Table 9-4**, the performance of additional examinations as per clauses 9.5.1.2 and 9.5.1.3 will suffice.

(4) The stipulations of Section 9.2 are considered requirements for the examinations.

(5) For part wall thicknesses s_2 equal to or greater than 70 mm the test piece shall be in accordance with **Figure 9-9**, sketch 1.

(6) For wall thicknesses s_2 smaller than 70 mm the test piece shall be in accordance with **Figure 9-9**, sketch 2.

(7) Subsize specimens may be taken.

(8) When evaluating the rejection, if any, of specimens, the base metal values shall be taken into account.

9.5.1.2 Non-destructive tests and inspections

(1) The test pieces shall be subjected to non-destructive tests and inspections as per Section 12.3.

(2) The results obtained, shall meet the requirements of Section 12.3 and be recorded in test reports.

9.5.1.3 Mechanical and other tests

9.5.1.3.1 Flat tensile test

(1) A flat tensile specimen to DIN EN ISO 4136 shall be tested at room temperature.

(2) During this test, the root area shall lie in the middle of the specimen (see **Figure 9-9**, sketches 2 and 3). The tensile strength R_m shall be determined.

(3) The location of fracture shall be ascertained.

9.5.1.3.2 Notched-bar impact test

(1) One set of impact test specimens (specimens with V-notch) shall be tested at 0 °C and 33 °C to DIN EN ISO 148-1.

(2) The notch shall be located in the HAZ 0.5 mm $\pm$ 0.3 mm adjacent to the fusion line in the base metal, as shown in **Figure 9-9**, sketch 4.

9.5.1.3.3 Alternative examinations

(1) For wall thicknesses s_1 which do not permit the taking of specimens intended for mechanical testing, the tests covered by clause 9.5.1.3.1 and 9.5.1.3.2 shall be omitted.

(2) Alternatively, the hardness traverses (HV 5) over the base metal / weld metal / base metal in test layers O and W as well as over the entire throat thickness in the weld metal centre shall be taken. For the evaluation of the test results **Table 9-3** applies.

9.5.1.3.4 Metallographic examinations

(1) The requirements of **Table 9-3** shall be met.

(2) A macrosection shall be made from the entire weld cross-section.

(3) One microsection each shall be made of the root area and at two other locations which shall be determined upon evaluation of the macrosection.

(4) In addition, extended metallographic examinations (transverse microsections or transverse microsections combined with tangential microsections), as far as provided in **Annex B**, shall be performed and evaluated.

9.5.1.4 Scope

9.5.1.4.1 Wall thickness

(1) The procedure qualification applies to wall thicknesses on welded attachments of $0.5 \cdot s_1$ up to $2 \times \cdot s_1$ (see **Figure 9-9**, sketch 1).

(2) For wall thickness s_2 of a part an upper limit is not to be provided if $s_2 \geq s_1$.

9.5.1.4.2 Welding positions

For the scope of welding positions **Table 9-4** applies. In this case, the footnote in the Table applying to the position PC (horizontal position) shall be disregarded.

9.5.2 Welding of nozzles

9.5.2.1 General requirements

(1) Welding of nozzles on ferritic steels shall be subjected to procedure qualification on a test piece.

(2) The test piece shall be welded such that all specimens required according to Section 9.2 as well as additional specimens required by clauses 9.5.2.3.1 and 9.5.2.3.2 can be taken. These specimens shall include longitudinal and circumferential welds according to Section 9.2 in the respective wall thickness range.

(3) Where a procedure qualification in accordance with Section 9.2 has been performed for ferritic butt welded joints with the pertinent wall thickness range - referred to the average throat thickness of the nozzle weld - the performance of supplementary tests as per clause 9.5.2.2 and 9.5.2.3 will suffice.

(4) The stipulations of Section 9.2 shall apply with respect to the requirements for the tests / examinations.

(5) On the test piece a nozzle may be welded into an oblique plate instead of a saddle curve in which case the scope of the plate shall correspond to the saddle curve angle shown in **Figure 9-9**, sketch 6. The nozzle may also be simulated by a circular section with respective weld restraint.

(6) The test mentioned under clause 9.5.2.3 shall be performed in the 3 and 9 o'clock positions of the saddle curve (see **Figure 9-9** sketch 6).

9.5.2.2 Non-destructive tests and inspections

(1) The test piece shall be subjected to non-destructive tests and inspections as per Section 12.3.

(2) The results obtained shall meet the requirements of Section 12.3 and be recorded in test reports.

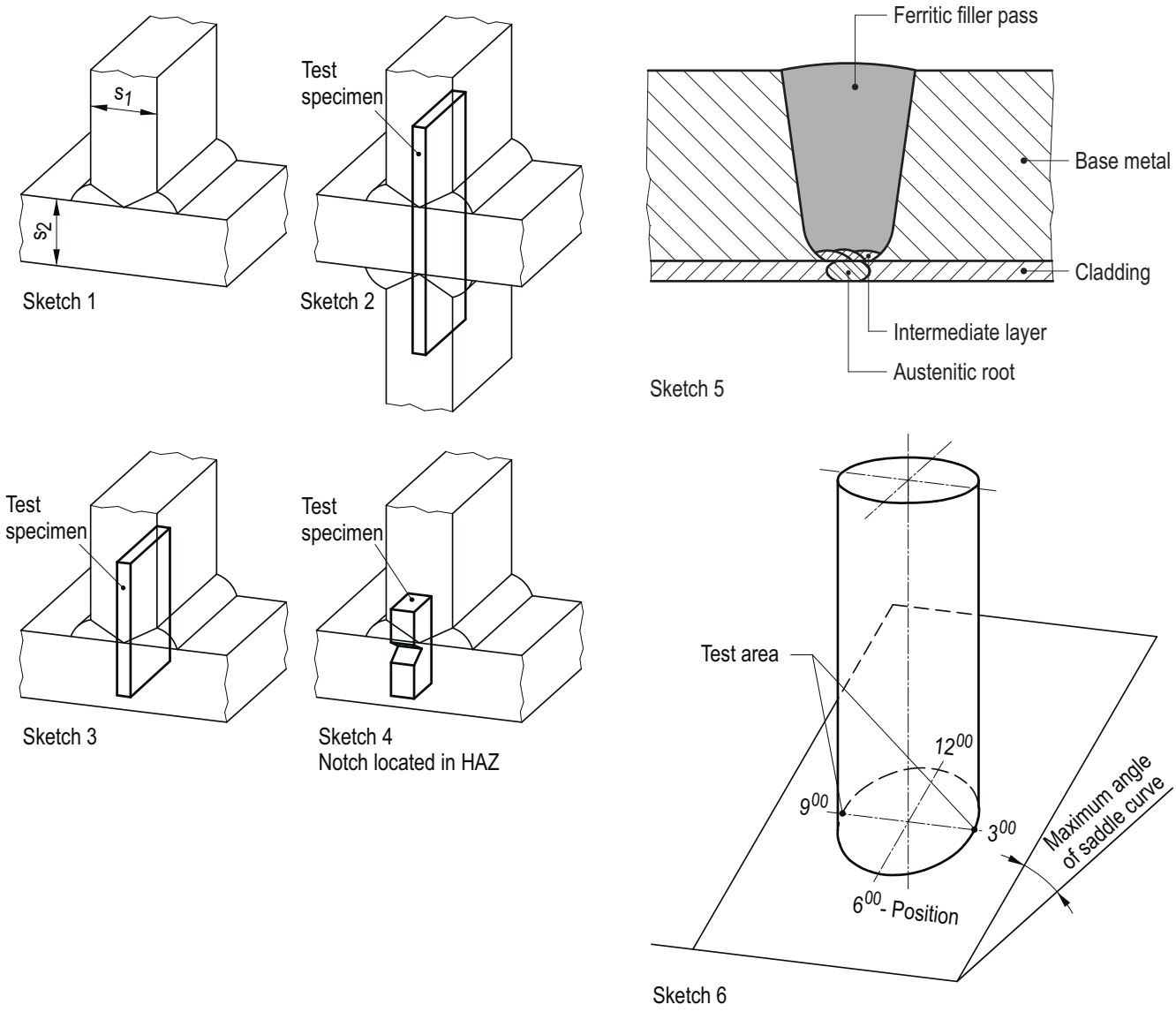


Figure 9-9: Examples of specimen configurations and specimen locations in the case of double-bevel groove and nozzle welds as well as butt welded joints with intermediate layers of low-carbon filler metal

9.5.2.3 Mechanical and other tests

9.5.2.3.1 Tensile test

(1) A tensile test to DIN EN ISO 6892-1 shall be performed transverse to the weld at room temperature. Specimens to DIN 50125 may be used.

(2) The tensile strength R_m shall be determined.

(3) If required due to geometric reasons the specimen may be extended or subsize specimens may be used.

9.5.2.3.2 Notched-bar impact test

(1) One set of impact test specimens (specimens with V-notch) shall be tested at 0 °C and 33 °C to DIN EN ISO 148-1.

(2) The notch shall be located on the nozzle side HAZ at 0.5 mm ± 0.3 mm adjacent to the fusion line into the base metal.

9.5.2.3.3 Alternative tests

(1) At diameters equal to or smaller than DN 50 the mechanical tests mentioned in clauses 9.5.2.3.1 and 9.5.2.3.2 shall be omitted.

(2) Alternatively, the hardness transverses (HV 5) over the base metal / weld metal / base metal in test layers O and W as well as over the entire throat thickness in the weld metal centre shall be taken. For the evaluation of the test results **Table 9-3** applies.

9.5.2.3.4 Metallographic examinations

(1) The requirements of **Table 9-3** shall be met.

(2) A macrosection shall be made over the entire weld cross-section.

(3) One microsection each shall be made of the root area and at two other locations which shall be determined upon evaluation of the macrosection.

(4) In addition, extended metallographic examinations (transverse microsections, or transverse microsections combined with tangential microsections), as far as provided in **Annex B**, shall be performed and evaluated.

9.5.2.4 Scope

9.5.2.4.1 Smallest intended diameter of weld

The scope of the procedure qualification shall be limited to a weld diameter equal to or greater than 0.5 times the smallest test piece weld diameter. There is no upper limit.

9.5.2.4.2 Type of nozzle weld

A procedure qualification performed for one of the nozzle designs here after shall also qualify for the design following the respective qualified design (see **Figure 9-10**):

a) set-through nozzle,

b) partly set-in nozzle,

c) set-on nozzle,

d) set-in nozzle, or

e) buttered nozzle.

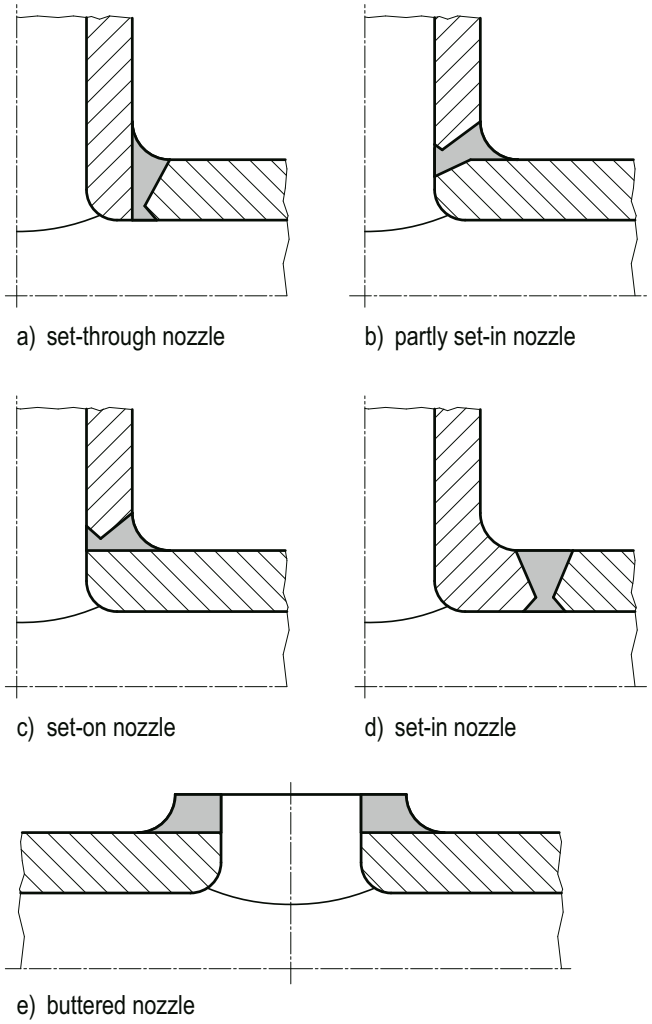


Figure 9-10: Examples of various nozzle designs to clause 9.5.2.4.2

9.5.2.4.3 Welding positions

For the scope of welding positions **Table 9-4** applies. In this case the footnote in the Table applying to the position PC (horizontal position) shall be disregarded.

9.5.3 Shape welding

9.5.3.1 General requirements

(1) This clause covers the shape welding on product forms and parts within the course of production.

(2) For shape weldings procedure qualification shall be performed in dependence of the loading as per (3). To this end, test pieces as per (5) shall be welded.

(3) The extent of the procedure qualification tests depends on the respective loadings shown in **Table 9-8**:

Case A: ferritic deposition weld on pressure-retaining wall welded permanently to the part and subjected to external loadings

Case B: ferritic deposition welds on pressure-retaining wall welded temporarily to the part and not subjected to additional external loading (e.g. wall thickness corrections, butterings),

Case C: ferritic deposition welds (butterings) on pressure-retaining wall for the welding of temporary attachments (lugs, fixing clamps).

(4) A procedure qualification for the type of loading as per (3), Case A, also qualifies for cases B and C. A procedure qualification for the loading as per (3), case B also qualifies for case C.

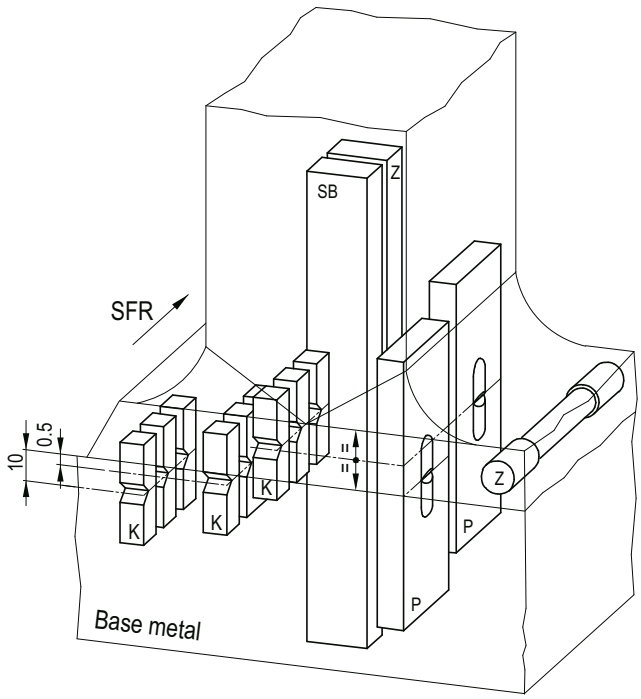
(5) Where no procedure qualification as per Section 9.2 has been performed, the tests as per **Table 9-8**, column “a“ shall be performed for the various load cases on a test piece as per **Figure 9-11**.

(6) Where a procedure qualification has been performed in accordance with Section 9.2, the tests on the all-weld metal are considered to have been verified by these procedure qualifications. The tests shall be performed in accordance with **Table 9-8**, column “b“ on a test piece as per **Figure 9-12**.

(7) The surface condition of the test piece prior to deposition welding shall be comparable to that of the intended part.

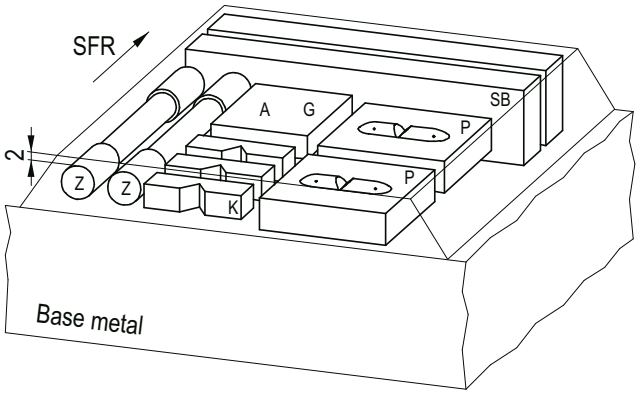
(8) Prior to the beginning of welding the surface to be deposition-welded shall be subjected to a surface crack detection test as per clause 12.7.1.

(9) During welding it shall be ensured that restraint to shrinkage is provided. Such a restraint to shrinkage is generally required for wall thicknesses equal to or smaller than 100 mm. In the case of a subsequent post-weld stress relief treatment this restraint shall be maintained.



SFR: Direction of weld progression
SB: Side-bend test specimens
K: Impact test specimens (Charpy-V)
Z: Tensile test specimens
P: Drop-weight test specimens

Figure 9-11: Location of specimens (schematic) for shape weldings as per clause 9.5.3.1 (5)



SFR: Direction of weld progression
SB: Side-bend test specimens
K: Impact test specimens (Charpy-V)
Z: Tensile test specimens
P: Drop-weight test specimens (omitted in the case of shape TIG welding)
A: Analysis
G: Structure

Figure 9-12: Location of specimens (schematic) for shape weldings as per clause 9.5.3.1 (6)

(10) The surfaces of the deposition weld shall be such that the non-destructive examinations as per clauses 12.7.2 and 12.7.3 can be performed.

(11) The thickness of the ferritic deposition weld shall be at least equal to that intended for the part and shall make testing of the weld metal possible.

9.5.3.2 Non-destructive tests and inspections

(1) Non-destructive tests and inspections shall be performed to meet the requirements of clauses 12.7.2 and 12.7.3 in which case the following shall be examined:

a) for surface inspection, the entire surface of the deposition weld including HAZ by means of magnetic particle testing,

b) within ultrasonic testing the deposition weld including HAZ.

(2) The results obtained shall meet the requirements of clauses 12.7.2 and 12.7.3.5 and shall be recorded in test reports.

9.5.3.3 Mechanical and other tests

(1) For the extent of testing **Table 9-8** applies.

(2) For the requirements **Table 9-3** applies.

(3) The requirements specified for transverse and tangential testing shall be met when examining the HAZ and the non-affected base metal.

9.6 Special welds on austenitic steels

9.6.1 Nozzle welds and double-bevel groove welds

9.6.1.1 General requirements

(1) For double-bevel groove welds and nozzle welds procedure qualifications shall be performed on test pieces.

(2) Where no procedure qualification test as per Section 9.3 has been performed, a test piece shall be welded to simulate the conditions on the part to be welded and to ensure that all specimens required as per clause 9.3.2 can be taken.

(3) Where a procedure qualification test has been performed in accordance with Section 9.3, it will suffice to perform an additional examination as per clause 9.6.1.3 (2) in which case the conditions on the part shall be simulated.

9.6.1.2 Non-destructive tests and inspections

(1) The test pieces shall be subjected to non-destructive tests and inspections as per Section 12.5.

(2) The results obtained shall meet the requirements of clauses 12.5.4 and 12.5.5.3 and be recorded in test reports.

9.6.1.3 Mechanical and other tests

(1) Where no procedure qualification test as per Section 9.3 has been performed the following applies:

a) for the extent of testing, the stipulations of **Table 9-5**,

b) for the requirements **Table 9-6**,

c) for double-bevel groove welds with wall thickness s_1 to **Figure 9-9**, which do not permit the taking of specimens for mechanical tests and for nozzles equal to or smaller than DN 50 mechanical tests may be omitted,

d) alternatively, to substitute the tests omitted as per c), the hardness traverses HV 5 over the base metal / weld metal / base metal in test layers O and W as well as over the entire throat of the weld shall be taken in the middle of the weld metal.

(2) Where a procedure qualification test to Section 9.3 has been performed, it will suffice to take a macrosection and a microsection transverse to the weld, for which the requirements of **Table 9-6** shall apply.

9.6.2 Strength fillet welds

9.6.2.1 General requirements

(1) For strength fillet welds (see also Section 5.1, e.g. welded-in heating tubes) a procedure qualification is required to qualify the manufacturer for the welding of butt welds or weld claddings. The procedures used shall correspond to the procedure used for the welding of strength fillet welds on the part.

(2) In addition to the procedure qualifications as per Section 9.3 or 9.4 examinations according to clause 9.6.2.2 and 9.6.2.3 shall be performed to simulate the conditions on the part to be welded.

9.6.2.2 Non-destructive tests and inspections

(1) The test pieces shall be subjected to a surface inspection as per clause 12.5.4.

(2) The results obtained shall meet the requirements of clause 12.5.4 and be recorded in test reports.

9.6.2.3 Metallographic examinations

(1) One microsection and one macrosection transverse to the weld shall be made.

(2) Regarding the requirements the stipulations of **Table 9-6** apply.

(3) A gap end run-out, if any, (see e.g. **Figure 9-13**) shall not exceed 20 % of the weld cross-section with a maximum of 0.2 mm in the case of single-layer welds, and shall be at maximum 0.4 mm in the case of multi-layer welds.

9.6.3 Seal welding against the weld cladding

9.6.3.1 General requirements

For seal weldings against the weld cladding (e.g. at control rod and instrument nozzles, sleeves in the reactor coolant pumps for bolt holes, plugs in the reactor containment, weld lip seals, and instrument lines) a procedure qualification test shall be performed by simulation of the effective conditions of the part.

9.6.3.2 Non-destructive tests and inspections

(1) The test piece shall be subjected to surface inspection by means of liquid penetrant testing in accordance with Section 12.4.

(2) The results obtained shall meet the requirements of Section 12.4 and be recorded in test reports.

9.6.3.3 Metallographic examinations

(1) A macrosection shall be made over the entire seal weld cross-section in accordance with the requirements of **Table 9-6**.

(2) A microsection the location of which is to be determined upon evaluation of the macrosection shall be made to meet the requirements of **Table 9-6**.

(3) A run-out, if any, at the gap end (see e.g. **Figure 9-13**) shall not exceed 20 % of the weld cross-section with a maximum of 0.2 mm in the case of single-layer welds, and shall be at maximum 0.4 mm in the case of multi-layer welds.

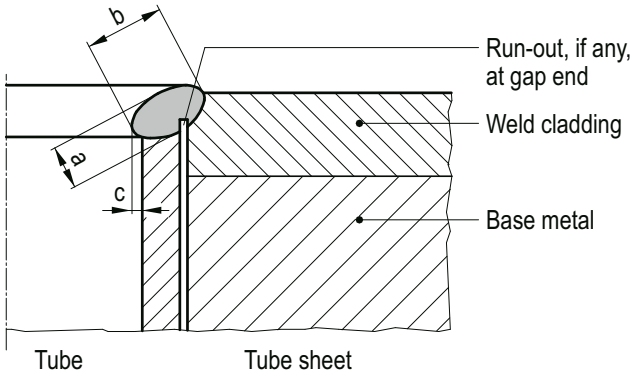


Figure 9-13: Tube-to-tubesheet weld

9.6.4 Shape weldings

(1) Shape weldings on austenitic base metals are only permitted if a procedure qualification test as per Section 9.3 has been performed.

(2) Shape weldings on austenitic or nickel alloyed claddings (e.g. ligament welds or steam generator tubesheets) are only permitted if a procedure qualification test as per Section 9.4 has been performed.

9.6.5 Temporarily welded attachments

For temporarily welded attachments a procedure qualification is not required.

9.7 Welded seams between ferritic and austenitic steels

9.7.1 Butt-welded joints between ferritic tubes and tubes made of austenitic steels according to Figure 9-14

9.7.1.1 General requirements

(1) For the welded joint, the procedure qualification test piece shall be so dimensioned that all examinations and test as per clause 9.7.1.2 and 9.7.1.3 can be performed. The tests shall be conducted at the seam welds in their final state in the areas to **Figure 9-15**.

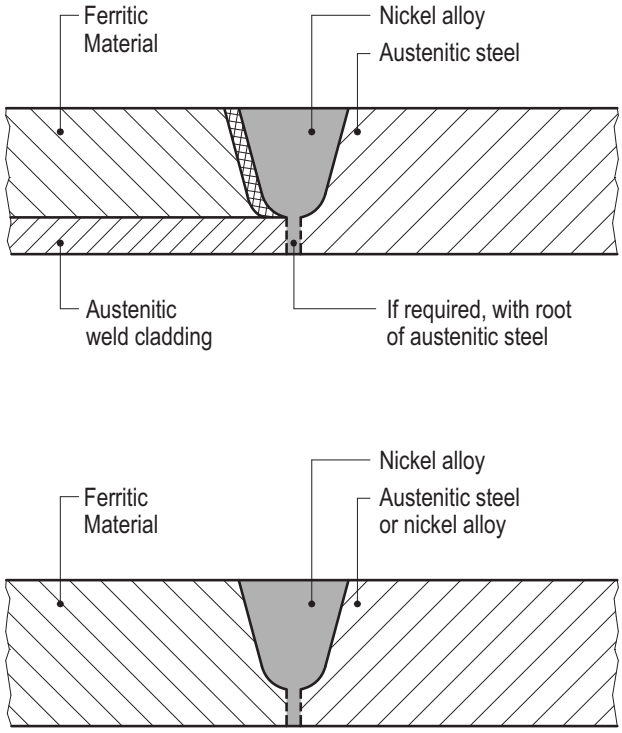


Figure 9-14: Examples of butt welds between ferritic or clad-ded ferritic tubes with tubes of austenitic steels

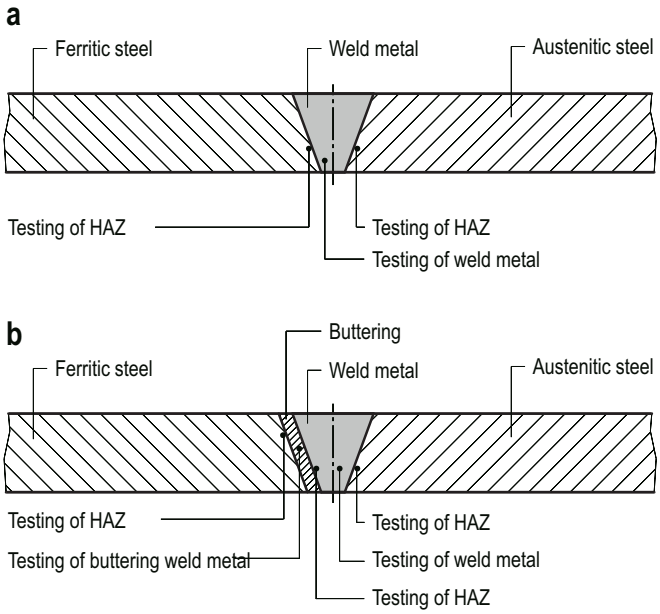


Figure 9-15: Testing areas for seam welds between ferritic and austenitic steels

(2) The test shall be performed in the test layers as per **Figure 9-4**.

(3) The specimens from test layer O shall be taken as close as possible from the test piece surface. In the case of single-side welds (e.g. pipings with s equal to or smaller than 30 mm) the specimens shall be taken such that the root layer is covered by the test.

(4) The requirements for ferritic materials apply to the 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 in accordance with clause 9.7.1.3.5 b)

and

b) a bend test (side-bend test specimen) in accordance with clause 9.7.1.3.3

shall be performed.

(6) Where several welding processes are used to weld a joint, the test layers shall be laid such that each welding process can be covered by the evaluation.

(7) In the case of wall thicknesses equal to or smaller than 30 mm, the specimens (if required, integral specimens) shall be taken such that each welding process is covered by the evaluation.

9.7.1.2 Non-destructive tests and inspections

(1) The test pieces shall be subjected to non-destructive tests and inspections in accordance with Section 12.6.

(2) The result obtained shall meet the requirements of Section 12.6 and be recorded in test reports.

9.7.1.3 Mechanical and other tests

9.7.1.3.1 Tensile test

(1) Tensile tests shall be performed transverse to the weld and in the weld metal in accordance with **Table 9-5**.

(2) The requirements for testing in accordance with the stipulations of KTA 3201.1 shall be met for austenitic steels.

9.7.1.3.2 Notched-bar impact test

(1) One set of impact test specimens to DIN EN ISO 148-1 shall be tested on specimens with V-notch in the HAZ at 0.5 mm ± 0.3 mm adjacent to the fusion line in the ferritic base metal. The required value is: 68 J at 33 °C.

(2) **Table 9-5** applies to the notched-bar impact test with V-notch loacated in the weld metal.

9.7.1.3.3 Side-bend test

(1) Two side-bend specimens to **Figure 9-17** shall be tested for each weld seam.

(2) The requirements of **Table 9-3** (except for the determination of the bending strain) shall be met.

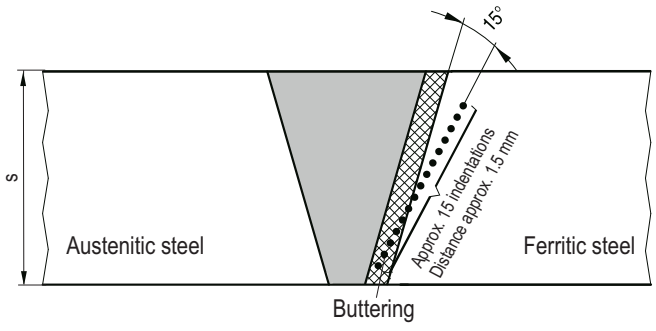
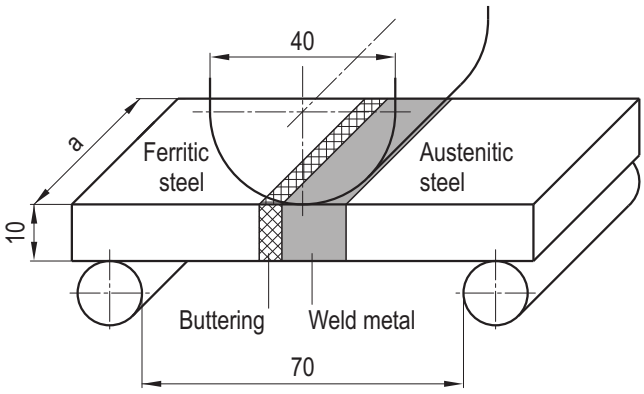


Figure 9-16: Hardness indentations HV 5 on buttered seam welds between ferritic and austenitic steels



Specimen thickness: 10 mm
Specimen width (a): Product form thickness in base metal area (welds may be ground flush)
Minimum length: 200 mm
Mandrel diameter: 40 mm
Bending angle: 180 degrees

Figure 9-17: Specimen and test geometry of side-bend test on welded seams between ferritic and austenitic steels

9.7.1.3.4 Metallographic examinations

Metallographic examinations to meet the requirements of **Table 9-3** shall be performed:

a) one macrosection shall be made over the entire cross-section of the welded line,

b) one microsection the location of which is to be determined upon evaluation of the macrosection shall be made.

9.7.1.3.5 Hardness tests

A hardness test HV 5 shall be made on the macrosection in which case

a) the transition from weld metal across the buttering (if provided) to the ferritic base metal as per **Table 9-2** and **Figure 9-3**,

b) the dilution area between the ferritic material and the austenitic weld metal or the nickel weld metal as per **Figure 9-16**

shall be examined.

9.7.1.3.6 Check for resistance to intergranular corrosion

Clause 9.4.3.4 shall apply to the check for resistance to intergranular corrosion of austenitic steels.

9.7.1.4 Scope

The stipulations of clause 9.2.3 shall apply.

9.7.2 Butt-welds with intermediate layer of low-carbon filler metal

9.7.2.1 General requirements

(1) For the welded joints the test piece for procedure qualification shall be made to **Figure 9-9**, sketch 5 such that all specimens as required by Section 9.2 and clause 9.7.2.3 can be taken.

(2) Where a procedure qualification test as per Section 9.2 has been performed for the scope of the ferritic weld, the performance of the tests and examinations to meet the requirements of clauses 9.7.2.2 and 9.7.2.3 will suffice.

9.7.2.2 Non-destructive tests and inspections

(1) The test piece shall be subjected to non-destructive tests and inspections in accordance with Section 12.3.

(2) The results obtained shall meet the requirements of Section 12.3 and be recorded in test reports.

9.7.2.3 Mechanical and other tests

9.7.2.3.1 Side-bend tests

(1) Two side-bend test specimens transverse to the direction of welding progress shall be taken such that the root and intermediate layer area is covered (**Figure 9-9**, sketch 5).

(2) The test shall be performed in accordance with clause 9.4.3.2.

(3) The evaluation shall be made in conformance with **Figure 9-7**.

9.7.2.3.2 Metallographic examinations

The metallographic examinations given hereinafter shall be effected to meet the requirements of **Table 9-3**:

a) one macrosection shall be made over the root area of the weld,

b) one microsection the location of which is to be determined upon evaluation of the macrosection shall be made.

9.7.2.4 Scope

The requirements of clause 9.2.3 shall apply.

9.8 Hard surfacings

9.8.1 General requirements

(1) The surface condition of the test piece prior to hard surfacing shall be comparable to that of the intended part. Test piece dimensions as per **Figures 9-18** and **9-19** are recommended.

(2) Prior to the beginning of welding, the surface shall be subjected to a surface examination as per clause 12.9.1.

(3) During the hard surface overlay welding of sheets or plates a restraint to shrinkage of the test piece shall be provided.

(4) Where the test piece is to be post-weld heat treated in accordance with Section 7.2, the intended restraint to shrinkage shall be maintained.

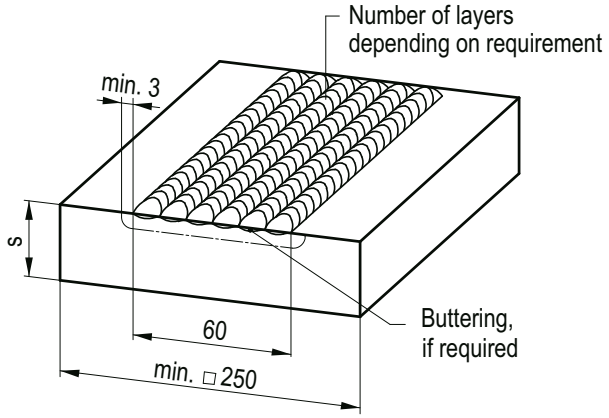
(5) Where buttering is intended to be welded, it shall be welded in a machined groove of the test piece and be dressed prior to applying the hard surface overlay welds on the surface of the test piece (see also **Figures 9-18** and **9-19**) and be subjected to a surface examination as per clause 12.9.2.

(6) Prior to performing the tests/examinations, the surface of the last layer shall be dressed flush by grinding. The surface shall meet the requirements of clause 12.2.3.

9.8.2 Non-destructive tests and inspections

(1) Non-destructive tests and inspections as per Section 12.9 shall be performed.

(2) The results obtained shall meet the requirements of Section 12.9 and be recorded in test reports.



Butterings if any, shall be made in a machined groove

Figure 9-18: Recommended test piece dimensions for test welds on sheets and plates

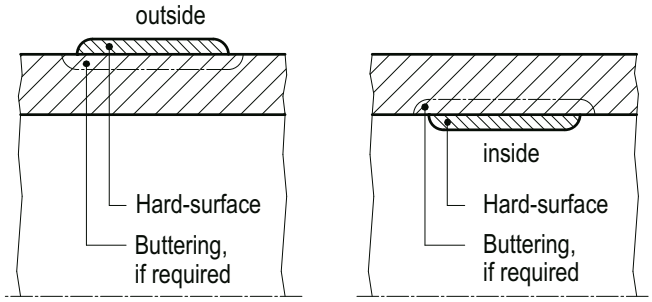


Figure 9-19: Hard surfacing on tubes

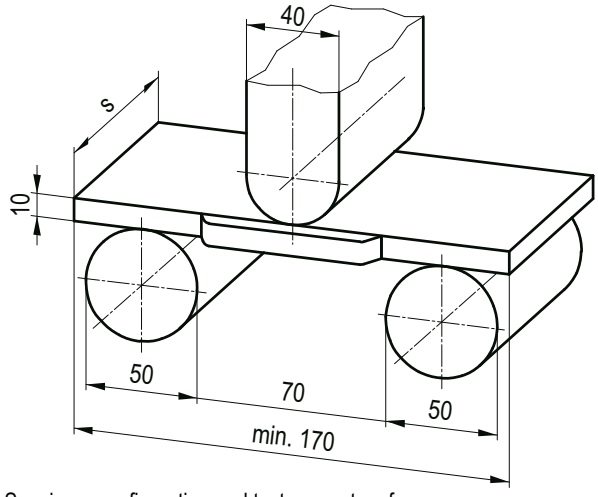
9.8.3 Mechanical and other tests

9.8.3.1 Bend test

(1) The following shall be tested:

a) two side-bend specimens with the configuration and test geometry as per **Figure 9-20**,

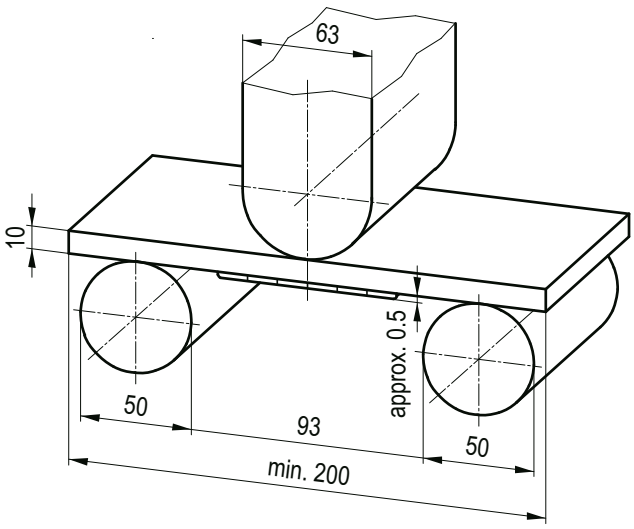
b) two bend specimens with the configuration and test geometry as per **Figure 9-21**. Where the hardness of hard surfacings is less than that of the base metal, they shall be dressed to a thickness of 0.5 to 0.3 mm.



Specimen configuration and test geometry of side-bend test according to DIN EN ISO 5173.

Rounding of edges as per DIN EN ISO 5173.

Figure 9-20: Specimen configuration and test geometry of side-bend test in conformance with DIN EN ISO 5173

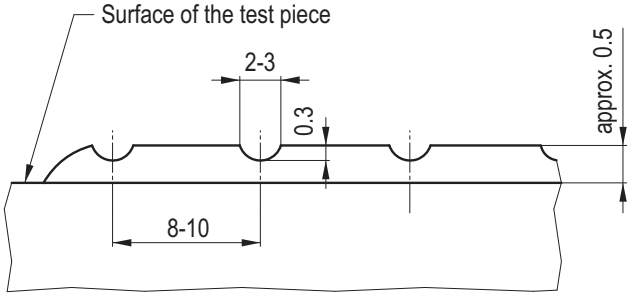


Specimen configuration and test geometry of side-bend test according to DIN EN ISO 5173.

Rounding of edges on the specimen tension area as per DIN EN ISO 5173

Figure 9-21: Specimen configuration and test geometry of bend test in conformance with DIN EN ISO 5173

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.

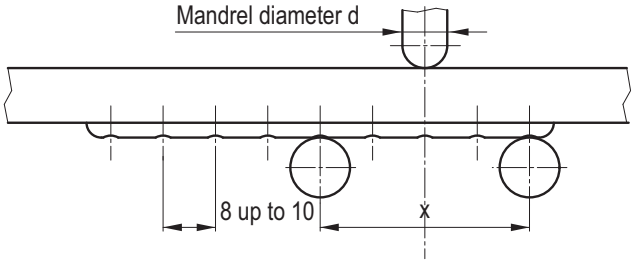


Figure 9-22: Preparation of bend-test specimens for hard surfacings

(2) It shall be demonstrated that

a) the fusion between hard surface overlay and buttering, if any, with the base metal,

b) the influence of the overlay on the base metal,

c) the behaviour of the hard surface overlay under bending

meet the requirements.

(3) Prior to conducting the bend test on hard surface overlays it is recommended to embed cracks in the overlay at defined distances. For this purpose, the specimen may be provided with ground-in grooves as per **Figure 9-22**. The cracks will be generated by slow step-by-step bending in a bending facility.

(4) Where the hardness of hard surface overlays is less than that of the base metal, the test surface shall be dressed to be notch-free.

(5) The specimen shall be bent by 180 degrees or until fracture in which case no large-area peeling of the hard surface overlay shall occur which are due to lack of fusion. Bending angles less than 90 degrees require further examinations, such as:

a) evaluation of the surface of the fracture,

b) bend test with dressed hard surface overlay/buttering,

c) bend test on uninfluenced base metal of the test piece (comparison test),

d) impact test (notched-bar impact test).

9.8.3.2 Metallographic examinations transverse to the direction of weld progression

(1) Metallographic examinations shall be performed to meet the following requirements:

a) one macrosection with master shot (macrograph). The thickness of the hard surface overlay shall be recorded.

Wormholes extending through the thickness to the base metal or the buttering and systematically occurring imperfections (e.g. porosity, lack of fusion) are not permitted. Isolated porosity and isolated lack of fusion is permitted unless the non-destructive examination shows an inadmissible extension.

Cracks in the buttering and base metal are not permitted. Cracks in the hard surface overlay are only permitted in hard surfacings if they are isolated or do not extend through the thickness to the base metal or buttering. This shall be demonstrated by additional sections.

b) one microsection with micrograph at suitable magnification (preferably 100 : 1) to cover

ba) the base metal,

bb) the interfaces between hard surface overlay / base metal and buttering / base metal.

Microcracks in the HAZ of the buttering or base metal are not permitted. Isolated microcracks in the hardsurface overlay are permitted. In case of doubt, further sections shall be examined to demonstrate that they are no systematically occurring imperfections.

9.8.3.3 Hardness tests

9.8.3.3.1 Hardness traverse

(1) On the macrosection the hardness traverse over the base metal, hard surface overlay and buttering, if any, shall be determined in accordance with **Figure 9-6** (HV 5).

(2) In the heat-affected zone of the base metal and the buttering the hardness shall not exceed 350 HV 5.

(3) The hardness peaks typical for hard surface overlays (exceeding 350 HV 5) within the area of the fusion line are only permitted if it is proved in the procedure qualification that they do not affect the hard surfacing.

9.8.3.3.2 Surface hardness

(1) The surface hardness shall be determined by means of several indentations on the ground-over surface of the hard surface overlay (HRC or HV).

(2) The surface hardness (HRC) of the hard surface overlay shall be that specified by the component manufacturer.

9.8.3.4 Tests in the case of special loadings

Where special requirements for the behaviour of the hard surface overlay against corrosion, erosion, wear, etc. are to be met, additional tests shall be laid down for each individual case.

9.8.3.5 Scope

9.8.3.5.1 Wall thicknesses

(1) The procedure qualification test qualifies for all thicknesses (see **Figure 9-18**) if welding is done on a test piece with s greater than 25 mm.

(2) In the case of wall thicknesses equal to or less than 25 mm the procedure qualification tests qualifies maximally for $1.5 \cdot s$.

(3) In the case of laser beam and electron beam overlay welding a value of 12 mm applies instead of the limit value 25 mm.

9.8.3.5.2 Special parts` welding

(1) In the case of procedure qualifications only to qualify special parts` welds thus admitting an objective evaluation in the case of welds similar to that of the part's weld, deviations from the specified extent of qualification are permitted. In such a case, suitable examinations shall be agreed with the authorized inspector. The examinations and tests shall be performed accordingly in conformance with this safety standard.

(2) Where the size of the part (e.g. valve body seat liner) does not permit the taking of certain specimens and the performance of certain tests, suitable tests/examinations shall be agreed with the authorized inspector.

9.9 Welding-in of tubes into tube plates (tubesheets)

9.9.1 General requirements

(1) For tube-to-tubesheet welding a procedure qualification shall be performed on a test piece for each welding procedure applied (referred to the tube-to-tubesheet welding procedure and tubesheet weld cladding procedure), for each welding position and each combination of individual welding procedures.

(2) Where the tubes are expanded to contact the tube hole wall prior to welding, this shall also be taken into account for the procedure qualification.

(3) Where in the course of repair welding, combinations of several welding procedures become necessary, a test within the course of a production control test as per Section 11.6 to supplement the procedure qualification will have to be performed.

(4) The thickness of the test piece tube plate shall be equal to that of the tube plate of the intended part. Where the thickness of the tube plate exceeds 100 mm, a thickness of 100 mm will suffice for the test piece plate.

(5) Deposition welding shall be performed under the conditions required for the part to be welded and be heat treated and non-destructively examined in the same way as the part.

(6) Where deposition welding on the test piece tube plate is not made in the course of a procedure qualification or production control test as per Section 9.4 or 11.4, respectively, the weld cladding of the test piece plate shall be tested prior to welding the tubes into the tubesheet, as follows:

a) non-destructive tests and inspections as per Section 12.8,
b) chemical analysis of the deposited weld metal in accordance with clause 9.4.3.3,
c) microscopic examination at a 100:1 magnification on a transverse microsection effected over weld cladding / interface / base metal.

(7) Machining of material in parallel direction and microscopic examination at a 100:1 magnification in the areas of approx. 0.5 mm to 1.0 mm and 1.5 mm below the surface intended for welding-in of tubes shall be effected, in which case a bead transition shall be covered in the case of weld claddings made by semi- or fully mechanized procedures.

(8) The tube plate of the test piece shall be provided with 31 holes, 9 of which are used as reserve for the welding-in of tubes.

(9) In these boreholes, tubes and plugs shall be welded in as follows:

a) for the first welding-in: 8 tubes (+4 as reserve),
b) for the first repair welding: 6 tubes (+2 as reserve),
c) for the second repair welding: 6 tubes (+2 as reserve),
d) for plug welding: 2 tubes (+1 as reserve).

9.9.2 Non-destructive tests and inspections

(1) All welded tubes shall be inspected visually, the inside tube diameter be checked with a plug gauge, and a surface inspection by means of liquid penetrant testing to **Annex E** shall be performed.

(2) The requirement to be met is freedom from cracks in the weld metal and the heat-affected zone (HAZ).

9.9.3 Metallographic examinations

(1) One transverse microsection each is to be made of
a) 4 first welds,
b) 3 first repair welds,
c) 3 second repair welds,
d) 1 plug weld

on 2 locations set apart by 180 degrees. Here, the locations of microsections shall be selected for the majority of test welds such that the area of double heat input is covered. For the remaining test welds a transverse section normal to the aforementioned location of microsection shall be made. In the case of several start positions one transverse section each shall be made per start position.

(2) Surface-parallel microsections shall be made of
a) 4 first welds,
b) 3 first repair welds,
c) 3 second repair welds,
d) 1 plug weld,

as follows:

on each of the first welds for welding-in of tubes, surface parallel microsections shall be made at three levels (in-depth location) above the gap end run-out, which beside the metallographic examination serve to fix the level at which all other tube-to-tube plate welds need be examined, however, by means of a surface-parallel microsection only.

(3) For the evaluation of the tube-to-tube plate welds by means of the micrographs the following applies:

a) The microsections shall be evaluated at a maximum magnification of 20:1. The structure-phase examination and the assessment of imperfections shall be made at a magnification of 50:1 or 100:1.
b) The structure shall be free from cracks that can be detected by macroscopy or surface examination.
c) The structure of the weld metal, interface and the base metal shall show a proper build-up of layers and complete penetration of the weld (see **Figure 9-13**).

d) The smallest effective weld cross-section (see dimension a in **Figure 9-13**) shall be equal to the actual tube wall thickness or the dimension fixed in the design approval.

e) The excess weld material (dimension c) is limited by plug gauging. A concave surface ($c \leq 0$) is not permitted.

f) A run-out, if any, at the gap end (see e.g. **Figure 9-13**) shall not reduce the weld cross-section (dimensions) by more than 20 % and shall not exceed 0.2 mm.

g) The microsections shall show a proper structure. Microcracks are only permitted if they can be considered isolated defects with respect to number and location.

Weld preparation angle after procedure qualification performed	Angle tolerance for welding of parts in case of individual procedure qualification	Angle tolerance if several procedure qualifications have been performed [1]		
		0 ° and 45 °	45 ° and 90 °	0 ° and 90 °
0 °	+ 10 °	0 ° to 60 °	—	—
45 °	± 15 °	—	30 ° to 110 °	—
90 °	+ 20 ° / - 45 °	—	—	0 ° to 110 °

[1] Where procedure qualifications have been performed with weld-preparation angles between the given values, the angle tolerance shall be interpolated accordingly.

Table 9-1: Angle tolerances for weld preparation angles for part's welding (see **Figure 9-1**)

Mechanical tests [1]						Number of specimens				
Type of specimens	Test temp.	Test in acc. with	Values to be determined	Specimen location to **Fig. 9-5**	Test layer to **Fig. 9-2**	Butt weld	Simulated repair weld	Reduced extent of testing as per clause 9.2.2.1 (4)	Pipings and valves $s \leq 30$ mm [2]	Simulated repair weld on pipings and valves $s \leq 30$ mm [2]
(1) Weld metal										
Tensile test specimen	Room temp.	DIN EN ISO 5178 [3] DIN EN ISO 6892-1 [3]	R_m, $R_{p0.2}$ or R_{eH}, A, Z	I	O	1	—	—	—	—
					W	1	—	—		
					Z	1	—	—		
	350 °C	DIN EN ISO 5178 [3] DIN EN ISO 6892-2 [3]	R_m, $R_{p0.2}$ or R_{eH}, A, Z	I	O	1	—	1	—	—
					W	1	—	1		
					Z	1	—	1		
Impact test specimen	[4] [5]	DIN EN ISO 148-1 DIN EN ISO 9016	KV_2-T-curve, lateral expansion, portion of ductile fracture	II	O	3 [4]	—	—	3 [5]	—
					W	3 [4]	—	—		
					Z	—	—	—		
	33 °C [6]	DIN EN ISO 148-1 DIN EN ISO 9016	KV_2, lateral expansion, portion of ductile fracture	II	O	—	3	3 [7]	—	3
					W	—	3	3 [7]		
					Z	—	—	3		
Drop-weight test specimen	5 °C [8]	SEP 1325 (specimen shape P 2)	broken/not broken	III	O	2	—	—	—	—
					W	2	—	—		
					Z	—	—	—		

Table 9-2: Procedure qualification tests for ferritic butt welds: Extent of testing (continued on next page)

Mechanical tests [1]						Number of specimens				
Type of specimens	Test temp.	Test in acc. with	Values to be determined	Specimen location to **Fig. 9-5**	Test layer to **Fig. 9-2**	Butt weld	Simulated repair weld	Reduced extent of testing as per clause 9.2.2.1 (4)	Pipings and valves $s \leq 30$ mm [2]	Simulated repair weld on pipings and valves $s \leq 30$ mm [2]
(2) Welded joint										
Tensile test specimen	Room temp.	DIN EN ISO 4136 [3]	R_m, location of fracture	VI or VII	O	1	1	—	1	1
					W	1	1	—		
					Z	1	—	—		
	350 °C	DIN EN ISO 4136 [3]	R_m, location of fracture	VII	O	1	1	—	1 [9]	1 [9]
					W	1	1	—		
					Z	1	—	—		
Impact test specimen	[4] [5]	DIN EN ISO 148-1 DIN EN ISO 9016	KV_2-T-curve, lateral expansion, portion of ductile fracture	V [10]	O	3 [5]	—	—	3 [5],[11]	—
					W	3 [5]	—	—		
					Z	—	—	—		
	33 °C [6]	DIN EN ISO 148-1 DIN EN ISO 9016	KV_2, lateral expansion, portion of ductile fracture	V [10]	O	—	3 [12]	—	—	3
					W	—	3 [12]	—		
					Z	3	—	—		
Bend-test specimen	Room temp.	DIN EN ISO 5173	bending angle to first crack	IV	O	2	—	—	2 x 2	—
					W	2	—	—		
					Z	—	—	—		
Side-bend test specimen	Room temp.	DIN EN ISO 5173	bending angle to first crack	transverse to weld	—	—	2	—	—	2
Drop-weight test specimen	5 °C [8]	SEP 1325 (specimen shape P 2)	broken/not broken	VIII	O	2	—	—	— [13]	—
					W	2		—	—	
					Z	—		—	—	
(3) Base metal [14]										
Tensile test specimen	Room temp.	DIN EN ISO 6892-1 [3]	R_m, $R_{p0.2}$ or R_{eH}, A, Z	—	O	1	—	—	—	—
					W or Z	1 or 1	—	—		
Impact test specimen	33 °C	DIN EN ISO 148-1	KV_2, lateral expansion, portion of ductile fracture	—	O	3	—	—	—	—
					W or Z	3 or 3	—	—		

(4) Additional tests/examinations

a) Macrograph of an etched macrosection over the entire weld cross-section including a repair weld, if any.
Certification by inspection certificate 3.2 to DIN EN 10204.

b) Analysis of alloying elements in the weld metal in the test layers as per **Figure 9-2** for:
C, Mn, Si, P, S, Cr, Mo, Ni, Al, V, N_2, Cu.
This examination ist required for SAW processes, for all other welding processes using filler metals only if no chemical analysis of the weld filler metal is available.
Certification by inspection certificate 3.1 to DIN EN 10204.

c) Hardness traverse HV 5 (DIN EN ISO 6507-1) over base metal-weld metal-base metal in the test layers as per **Figure 9-2** as well as over the entire throat of the weld in the centre of the weld metal (see **Figure 9-3**).
Certification by inspection certificate 3.2 to DIN EN 10204.

d) Metallographic micrographs on traverse sections, generally at a magnification of 200 : 1, in the test layers as per **Figure 9-2**, for each layer.
Certification by inspection certificate 3.2 to DIN EN 10204.
Here, the following shall be covered:
da) Weld metal (in the case of pipings with wall thicknesses ≥ 30 mm on the root and cover pass side)
db) Weld metal-base metal interface (for pipings with wall thicknesses ≥ 30 mm on the root and cover pass side),
dc) Uninfluenced base metal.

e) Extended metallographic examinations shall be performed, if required by **Annex B**, and be evaluated.
Certification by inspection certificate 3.2 to DIN EN 10204.

Table 9-2: Procedure qualification tests for ferritic butt welds: Extent of testing (continued on next page)

Footnotes

1) All tests as per (1), (2) and (3) shall be certified by inspection certificate 3.2 to DIN EN 10204.
2) Where for geometric reasons the specified specimen locations cannot be adhered to, further processing shall be laid down by agreement with the authorized inspector.
3) Test specimens to DIN 50125 may be used.
4) Test temperature: -12°C, 0°C, 20°C. The remaining three test temperatures shall be determined such that the upper and lower shelf of the transition curve are covered.
5) At 0 °C, 33 °C, 70 °C (Testing at 80 °C can be omitted if upper shelf is obtained at lower temperatures).
6) 20 °C in the core belt line area.
7) Test temperature 0°C and 33°C.
8) -7 °C in the core belt line area
9) Where the design temperature exceeds 250 °C.
10) Notch location 0.5 mm ± 0.3 mm adjacent to fusion line in base metal.
11) Notched-bar impact tests within the heat-affected zones on three specimens, notch location at wall thicknesses > 10 mm parallel to the surface. In the case of wall thicknesses between 5 mm and 10 mm the test shall be performed on the largest possible specimens.
12) In the juncture between repaired weld metal to base metal.
13) Where a procedure qualification is specified for parts with s > 30 mm, 2 drop-weight test specimens shall be tested.
14) Testing of base metal is only required if the respective base metal values in test layers O, W, Z obtained from the materials tests as per KTA 3201.1 are not available.

Table 9-2: Procedure qualification tests for ferritic butt welds: Extent of testing (final page)

Test	Requirements 1)
(1) Weld metal	
Tensile test at room temperature and at 350 °C	As for the base metal (see KTA 3201.1, Annex A) or as specified by the filler metal qualification.
Notched-bar impact test KV_2-T-curve	KV_2 (0 °C) ≥ 41 J KV_2 (33 °C) 2) ≥ 68 J, lateral expansion (33 °C) 2) ≥ 0.9 mm
Drop-weight test	Verification of NDT temperature ≤ 0 °C 3)
Analysis	As specified by the filler metal qualification.
(2) Welded joint	
Tensile test at room temperature and at 350 °C	As for the base metal (see KTA 3201.1, Annex A) or as specified by the filler metal qualification.
Notched-bar impact test	KV_2 (0 °C) ≥ 41 J, KV_2 (33 °C) 2) ≥ 68 J, lateral expansion (33 °C) 2) ≥ 0.9 mm
Bend test	Bending angle 180° at mandrel diameter 3 · specimen thickness a Determination of bending strain Incipient cracks caused by porosity or lack of fusion are permitted. Cracks without clearly discernible cause shall not exceed a length of 1.6 mm.
Drop-weight test	Verification of NDT temperature ≤ 0 °C 3)
Metallographic examination over the weld cross-section	The structure of the weld metal and base metal HAZ shall show a proper build-up of layers and complete penetration of the weld (macrosection) as well as a proper microstructural composition (microsection). Discontinuities (microsection) are only permitted if they can be clearly defined to be isolated imperfections with regard to number and location. An accumulation of such imperfections in the form of coherent fields is not permitted.
Hardness traverse on macrosection	In the heat-affected zones the hardness shall not exceed 350 HV 5. Hardness peaks exceeding this value in small HAZ's shall be examined additionally in which case 350 HV 10 shall not be exceeded. Individual hardness peaks exceeding this value can be disregarded if they are proved to be locally limited.
(3) Base metal	
Tensile test at room temperature	As for the base metal (see KTA 3201.1, Annex A)
Notched-bar impact test	KV_2 (33 °C) ≥ 68 J, as far as specified in the product form-related sections of KTA 3201.1 for the respective test layers.

1) Where specimens with a width < 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.
2) 20 °C in the core belt line area.
3) ≤ - 12 °C in the core belt line area.

Table 9-3: Procedure qualification tests for ferritic butt welds. Requirements for testing

Welding positions [1], qualified during procedure qualification (plates, forgings, and pipes $D_i \geq 1000$ mm) [3]	Allowable welding positions [1] for welds on parts (plates, forgings, and pipes $D_i \geq 1000$ mm)
PA	PA [2]
PF	PF
PC [4]	PC and fillet welds
PE	PE
PA + PF	PA, PF and PC if the supplementary tests as per clauses 9.2.2.1 (4) and 9.3.2.1 (5) have been performed
PF + PE	PF, PE, PA
PF + PC	PF, PC, PA and fillet welds
Welding positions qualified on test pieces for pipes $D_i < 1000$ mm	**The welding positions qualified on pipes $D_i < 1000$ mm also qualify for plates, forgings, and pipe $D_i \geq 1000$ mm**
Pipe axis horizontal PH	PA, PF and PE
Pipe axis vertical PC	PC
Pipe axis horizontal PH and pipe axis vertical PC	PA, PF, PC and PE
Pipe axis horizontal (rotating pipe) PA	PA
Further welding positions	The welding position qualified in the procedure qualification test

1) Designations in accordance with DIN EN ISO 6947.

2) In the case of semi- or fully automatic welding processes this welding position also applies to pipes $D_i < 1000$ mm.

3) A welding position is considered to have been qualified in a procedure qualification test if the specified extent of testing (see also **Tables 9-2** and **9-5**) has been fully performed in the respective welding position.

4) See clause 9.2.2.1 (4).

PA : flat position
PF : vertical-up position
PC : horizontal position
PE : overhead position
PH : pipe position for vertical-up welding

Table 9-4: Allowable welding positions for welded joints on parts in dependence of the working positions qualified during welding procedure qualification tests

Mechanical tests [1]							Number of specimens			
Type of specimens	Test temperature	Test in acc. With	Values to be determined	Specimen location to **Fig. 9-5**	Test layer to **Figure 9-4** s > 30 mm	Test layer to **Figure 9-4** s ≤ 30 mm	Austenitic butt welded joint > 30 mm	Simulated repair welding	Pipings and valves s ≤ 30 mm	Simulated repair welding
(1) Weld metal										
Tensile test specimen	Room temp.	DIN EN ISO 6892-1 [2]	R_m, $R_{p0.2}$, $R_{p1.0}$, A, Z	I	O	O	1	—	—	—
					W	—	1	1	—	—
	350 °C [3]	DIN EN ISO 6892-2 [2]			O	O	1	—	—	—
					W	—	1	1	—	—
Impact test specimen	Room temp.	DIN EN ISO 148-1 DIN EN ISO 9016	KV_2	II	O	O	3	—	3	3
					W	—	3	3	—	—
(2) Welded joint										
Tensile test specimen	Room temp.	DIN EN ISO 4136 [2]	R_m, location of fracture	VI or VII	O	O	1	—	1	1
					W	—	1	1	—	—
	350 °C [3]	DIN EN ISO 4136 [2]		VII	O	O	1	—	1	1
					W	—	1	1	—	—
Bend-test specimen [4]	Room temp.	DIN EN ISO 5173	Bending angle at 1st incipient crack	IV	—	O	—	—	2	—
Side-bend test specimen [4]	Room temp.			transverse to weld	—	—	1	1	1	1

(3) Additional tests/examinations

a) Macrograph of an etched macrosection over the entire weld cross-section including a repair weld, if any.

Certification by inspection certificate 3.2 to DIN EN 10204.

b) Analysis of alloying elements in the weld metal in the test layers as per **Figure 9-4**:

Austenitic filler metals: C, Mn, Si, P, S, Cr, Mo, Ni, N_2, Co, stabilizing elements.

Nickel alloyed filler metals: C, Mn, Si, P, S, Cr, Mo, Ni, N_2, Fe, Ti, Nb, Co.

Certification by inspection certificate 3.1 to DIN EN 10204.

c) Check for resistance to intergranular corrosion for austenitic steels in test layer O to DIN EN ISO 3651-2 without sensitisation.

Certification by inspection certificate 3.1 to DIN EN 10204.

d) Metallographic micrographs on transverse sections, generally at a magnification of 200:1, in the test layers to **Figure 9-4**, for each layer.

Here, the following shall be covered:

da) Weld metal (in the case of pipings with wall thicknesses □ 30 mm on the root and cover pass side),

db) Weld metal-base metal interface (for pipings with wall thicknesses □ 30 mm on the root and cover pass side),

dc) Base metal (uninfluenced)

dd) Delta-ferrite content in the weld metal of austenitic steel in the test layers as per **Figure 9-4**.

Certification by inspection certificate 3.2 to DIN EN 10204.

[1] All tests under (1) and (2) shall be certified by means of acceptance test certificate 3.2 to DIN EN 10204.

[2] Test specimens to DIN 50125 may be used.

[3] Hot tensile tests shall only be performed on production control test specimens in accordance with clause 11.3.1.4.

[4] Side-bend test for s ≥ 10 mm
Bend test for s < 10 mm.

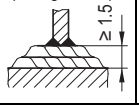
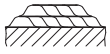
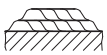
Table 9-5: Procedure qualification tests for welded joints of austenitic steel up to a wall thickness of 50 mm: Extent of testing

Test	Requirements
(1) Testing of weld metal	
Tensile test at room temperature and at 350 °C	As for the base metal (see KTA 3201.1, Annex A) or as specified by the filler metal qualification.
Notched-bar impact test on austenitic steels	Non-annealed: ≥ 70 J / ≥ 60 J Stress-relieved: ≥ 55 J / ≥ 40 J (average value / smallest individual value)
Notched-bar impact test on nickel alloys	≥ 80 J / ≥ 56 J (average value / smallest individual value)
(2) Testing of welded joint	
Tensile test at room temperature and at 350 °C	As for the base metal (see KTA 3201.1, Annex A) or as specified by the filler metal qualification.
Side-bend test for s ≥ 10 mm	Bending angle 180° at mandrel diameter 2 · specimen thickness a
Bend test for s < 10 mm	Bending angle 180° at mandrel diameter 2 · specimen thickness a
Macrosection transverse to weld	The weld metal shall show a proper build-up of layers and adequate side-wall fusion.
Microsection transverse to weld	The structure of the weld metal and the HAZ of the base metal shall show a proper microstructural composition. Discontinuities detected by microsections are only permitted if they can be clearly defined to be isolated imperfections. An accumulation of such imperfections in the form of coherent fields is not permitted.
Determination of delta-ferrite content for austenitic steels	A coherent lattice is not permitted. The delta-ferrite content shall not be less than 2 %.
Check for resistance to intergranular corrosion	to DIN EN ISO 3651-2, procedure A, without sensitisation

Table 9-6: Procedure qualification tests for welded joints of austenitic steels up to a wall thickness of 50 mm: Requirements for testing

Tests					Number of specimens		
Type of specimens	Test temp.	Test in acc. with	Values to be determined	Specimen location	Weld cladding	Simulated repair welding	Inspection certificate to DIN EN 10204
Side-bend test specimen, transverse to the direction of weld progression	Room temp.	DIN EN ISO 5173, mandrel diameter 40 mm	Bending angle 180°	Acc. to clauses 9.4.3.2 and 9.4.5 (f)	2	2	3.2
Side-bend test specimen, 15° to the direction of weld progression	Room temp.	DIN EN ISO 5173, mandrel diameter 40 mm	Bending angle 180°	Acc. to clause 9.4.3.2	2	—	3.2
Further tests and examinations:							
a) Analysis of alloying elements in the weld cladding (acc. to clause 9.4.3.3).							3.1
b) Check for resistance to intergranular corrosion for austenitic steels to DIN EN ISO 3651-2, procedure A (acc. to clause 9.4.3.3).							3.1
c) Metallographic examination (acc. to clause 9.4.3.5).							3.2
d) Hardness test HV 5 (acc. to clause 9.4.3.6).							3.2
The tests and examinations shall be evaluated in accordance with clause 9.4.3.							

Table 9-7: Procedure qualification tests for weld claddings made of austenitic steels and nickel alloys: Extent of testing

Mechanical tests					Case A load bearing (strength weld) 		Case B permanent weld 		Case C temporary weld 		Inspection certificate to DIN EN 10204
Type of specimens	Test temp.	Test in accordance with	Values to be determined	Specimen location as per **Figure 9-11** or **Figure 9-12**	Number of specimens [1]						
					a	b	a	b	a	b	
Tensile test specimen	Room temp.	DIN EN ISO 6892-1 [2]	R_m, $R_{p0.2}$ or R_{eH}, A, Z	In the weld metal	1	—	1	—	—	—	3.2
	350 °C	DIN EN ISO 6892-2 [2]	R_m, $R_{p0.2}$ or R_{eH}, A, Z	In the weld metal	1	—	1	—	—	—	3.2
	Room temp.	DIN EN ISO 4136	R_m, location of fracture	Across the welded joint	1	—	—	—	—	—	3.2
Impact test specimens	33 °C [3]	DIN EN ISO 148-1 DIN EN ISO 9016	KV_2, lateral expansion, portion of ductile fracture	Weld metal	3	—	3	—	—	—	3.2
				Junction (HAZ)	3	3	—	—	—	—	3.2
				Base metal	3	3	—	—	—	—	3.2
Drop-weight test specimen	0 °C [4]	SEP 1325 P 2	broken/not broken	Weld metal	2	—	2	—	—	—	3.2
				Junction (HAZ)	2	2	—	—	—	—	3.2
Side-bend test specimen	Room temp.	DIN EN ISO 5173	Bending angle up to 1st incipient crack	Vertical (acc. to sketch)	2	2	—	—	—	—	3.2
				Transverse (acc. to sketch at the juncture)	—	—	2	2	—	—	3.2
Further examinations											
Metallographic examination		Macrograph of an etched macrosection over the entire weld cross-section, micrographs (200:1) from the weld metal and HAZ			+	+	+	+	+	+	3.2
Hardness test HV5 at an angle of 15° in conformance with **Figure 9-6**, sketch 2					+	+	+	+	+	+	3.2
Chemical analysis of the alloying elements in the weld metal as per **Table 9-2**					+	—	+	—	+	—	3.1

[1] a: No procedure qualification as per Section 9.2.
b: Procedure qualification performed, as per Section 9.2.

[2] Test specimens to DIN 50125 may be used.

[3] 20 °C in the core belt line area.

[4] ≤ - 12 °C in the core belt line area.

Table 9-8: Procedure qualification tests for shape weldings: Extent of testing

10 In-process inspection, final inspections and identification marking

10.1 General

(1) The basis for in-process inspection and final inspections is the in-process inspection sheet to **Table 10-1**. The manufacturer shall establish a component-specific test and inspection sequence plan to cover all required final or partial inspections. He shall ensure that the inspections and checks laid down in the test and inspection sequence plan are performed, that the as-built condition corresponds to the design-approved documents and their requirements have been satisfied. It shall be ascertained in accordance with the Inspection sheet requirements by stamping and, where required, by means of a record that the tests and inspections have been performed.

(2) Deviations from the design-approved documents are only permitted upon agreement with the authorized inspector.

(3) Prior to the beginning of fabrication or fabrication step the manufacturer shall establish a time schedule indicating the test and checks specified in the design-approved documents.

(4) Regarding fabrication the times for the tests specified in the test and inspection sequence plan shall be fixed such that the authorized inspector can be informed in time.

10.2 Identification marking on product forms and parts

10.2.1 General requirements

(1) The material identification marking of the product form as laid down in KTA 3201.1 shall be maintained during further processing or be transferred in due consideration of clauses 10.2.2 and 10.2.3.

(2) For product forms with clear direction of forming, the identification markings shall be placed on the parts as well as on the test coupons such that it is vertical seen from the base of the product form in direction of the top side thus showing the direction of main forming as well as the location of top and base. Where this is not possible, at least the test coupon number shall be placed in the aforementioned way. This may also be explained by suitable information, e.g. sketches.

(3) The reference origin of coordinates of the part and its coordinates shall be fixed and recorded by the manufacturer during the first dimensional check or non-destructive testing.

(4) The welds shall be indelibly marked at that time where it is known that the marking will no more be changed during assembly of the parts, at the latest, however, prior to the first pressure test.

(5) The reference points and counting directions on each part and each weld as well as the welds` identification markings shall be recorded with regard to their locations on the assembled component and be entered in a general location plan.

(6) Marking shall be effected by means of low-stress steel stamps. Other types of marking in the case of thin-walled or small component parts are permitted upon agreement between manufacturer and authorized inspector.

(7) The transfer of product form identification markings as per clauses 10.2.3.1, 10.2.3.6 and 10.2.3.7 shall be recorded by means of a marking-transfer certificate to be established.

(8) The parts´ identification marking shall be clear enough such that all test results can be easily retraced, and shall be indelibly marked on the part and be documented.

10.2.2 Responsibility

(1) In the case of tests/examinations to be certified with inspection certificate 3.2 to DIN EN 10204, the product identification marking, transfer of markings and recording shall be done by the authorized inspector. The inspection certificate 3.2 shall be confirmed or be established by the authorized inspector to § 20 of the Atomic Energy Act or by the technical inspecting agency tasked by him.

(2) In the case of materials to be certified with inspection certificate 3.1 to DIN EN 10204, the transfer of identification marks by stamp may be effected by the fabricator upon written agreement with the authorized inspector. Such agreement shall indicate the person employed by the fabricator works who is responsible for the transfer of identification marking, and the type of works` stamp used.

10.2.3 Performance

10.2.3.1 Transfer of identification marks on product forms

(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 inspection 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 laid down 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.

10.2.3.2 Identification marking of the product form upon completion of heat treatment

Upon completion of hot forming and heat treatment, the product form shall be marked with the test coupon number prior to taking the test coupon.

10.2.3.3 Marking of test sections (test piece) and remaining parts prior to taking of coupons

(1) Prior to taking the test pieces and the remaining parts, they shall be marked with the test piece number and the stamp of the authorized inspector.

(2) It shall be ensured that the location of the test piece and the remaining part in the product form can be clearly assigned in due consideration of the specimen location plan.

10.2.3.4 Identification marking of test coupons

Prior to taking the test coupon, it shall be marked by the authorized inspector with the test coupon number and the stamp in accordance with the specimen location plan such that they it can be clearly assigned with regard to its location in the product form.

10.2.3.5 Transfer of test coupon identification marks on specimens when taking specimens

During specimen-taking the test coupon identification mark shall be transferred by the authorized inspector onto the specimens such that the original location of the specimens in the test coupon is clearly recognizable with regard to the specimen location plan.

10.2.3.6 Transfer of identification marks of a product form during fabrication

(1) Where the identification mark of a product form has to be removed during fabrication it shall be transferred to another location prior to its removal.

(2) The authorized inspector shall compare the original marking with the transferred marking and to stamp the transferred identification marking field with the respective stamp.

10.2.3.7 Transfer of identification markings on nozzle cut-outs, punched-out metal slugs or trepanned plugs

(1) On nozzle cut-outs, punched-out metal slugs or trepanned plugs taken within the course of mechanical processing and being suited for testing, the respective markings shall be transferred prior to taking.

(2) The authorized inspector shall confirm the correctness of the identification marking transfer by his stamp.

(3) A supplementary marking of the nozzle cut-outs, slugs or plugs shall make a clear assignment to the location of taking in the part possible.

10.2.3.8 Identification marking of a part or component upon completion

10.2.3.8.1 Welds

(1) The marking of piping and component welds shall be specified in a sketch or drawing prior to the beginning of non-destructive tests and inspections.

(2) The origin and the counting direction of the reference system shall be marked permanently.

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

10.2.3.8.2 Parts and components

(1) Upon completion of a part or component and the final inspection by the authorized inspector, the part or component shall be provided at a suitable location (e.g. main reference line), with an identification marking laid down by agreement between the manufacturer and the authorized inspector.

(2) To this identification marking the inspector's final inspection stamping shall be added.

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

10.3 In-process inspection and final inspections by the manufacturer and the authorized inspector

10.3.1 General requirements

(1) During manufacture an in-process inspection shall be performed by the manufacturer's quality department and the authorized inspector as specified by the test and inspection sequence plan.

(2) The requirements of **Table 10-1** shall apply. For checks and inspections not laid down in the aforementioned table, stipulations shall be laid down within design approval. The manufacturer shall ensure that all checks and inspections on the part are performed by the agencies/bodies specified in the test and inspection sequence plan.

(3) Records on results (e.g. test certificates, welding records, heat-treatment charts, dimensional survey records) shall be established and be signed by the person responsible for testing.

(4) Within the course of manufacture the authorized inspector shall satisfy himself that all quality-assuring measures specified for fabrication are adhered to.

(5) Where deviations from quality-assuring measures are ascertained they shall be entered in a report to be drawn-up by the authorized inspector who shall send this report to the manufacturer.

(6) Upon completion of manufacture of a part or sub-unit, the authorized inspector shall confirm the performance of the specified tests/inspections by means of a partial inspection certificate.

10.3.2 Receiving inspection

(1) The product forms shall be subject to a receiving inspection to comprise:

a) check of stampings and identification marking of the product form with certificates and, if required, comparison of drawings,
b) visual inspection (e.g. for completeness, transport damage).

(2) Where parts, sub-units or components are transported to another manufacturer or to the site, receiving inspections shall also be performed prior to the beginning of further processing or assembly of such parts, sub-units or components.

(3) The receiving inspection of the weld filler metals shall be in accordance with KTA 1408.3.

10.3.3 Dimensional checks

(1) The manufacturer shall perform all dimensional checks with suitable procedures (e.g. mechanical procedures, ultrasonic wall thickness measurements) and establish a record on the checks made.

(2) Where specified dimensions are to be confirmed by a Yes/No statement, stamping in the test and inspection sequence plan or in the materials testing and specimen-taking plan will suffice.

(3) In the case of indirect dimensional checks [see clause 4.1.1.3.8 (3)], the record shall contain a statement for the second hold-point on the final result obtained from the two dimensional checks.

(4) The dimensional checks and their recording shall refer to a suitable reference system of the part, component or system in compliance with clause 10.2.1 (e.g. system of coordinates) with regard to performance, reproducibility and renewal of tests.

(5) Records on actual dimensions shall basically be established. In justified cases, e.g. grid-pattern examinations, non-conforming or global records may be laid down.

(6) The authorized inspector shall satisfy himself of the completeness of the dimensional checks, spot-check their correctness and confirm the results obtained in his checks and examinations by his signature on the manufacturer's record. Where in individual cases (e.g. important dimensions, ultrasonic grid-pattern examinations) the dimensional checks are performed by the authorized inspector, he shall confirm this by a record established by him.

(7) Where the authorized inspector does not perform own dimensional checks, the manufacturer shall submit to him all documents and results obtained from such checks.

10.3.4 Visual inspections within welding supervision

(1) The visual inspections prior to, during and upon welding shall be performed in accordance with DIN EN ISO 17637.

(2) The requirements of Sections 5.3 and 5.4 apply.

10.3.5 Non-destructive testing (NDT)

10.3.5.1 Point in time of NDT

(1) Testing prior to welding

a) The 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 test shall be performed whenever it has not been performed on the product forms before in accordance with KTA 3201.1.
b) The surface inspection of the fusion faces shall be performed in the final machined condition.

(2) Testing upon welding

a) The tests shall be performed in the final condition and, if heat treatments are provided, basically upon the final heat treatment (including stress relieving).
b) Where testing of the surfaces upon final heat treatment can only be performed to a limited extent, testing of those areas which can only be examined to a limited extent shall be performed at an earlier point in time.
c) Radiography may also be performed prior to the heat treatment if an ultrasonic test is performed upon the heat treatment.
d) Where claddings are no more accessible upon final heat treatment, the tests shall be performed prior to the final heat treatment, but at least upon stress relieving.

(3) Tests prior to and upon first hydrostatic testing

Higher stress locations shall be subjected to the same test procedures prior to and after the first hydrostatic test in accordance with Section 12.12.

(4) Additional requirements

The additional requirements of Section 12 shall be met.

10.3.5.2 Extent of non-destructive testing

(1) The manufacturer shall perform the tests on each weld in which case the test area mentioned in Section 12, which

consists of the weld metal and the adjacent base metal, shall be completely covered.

(2) The respective test method to be applied shall be taken from **Tables 10-2** to **10-4**. Other test procedures (e.g. eddy current testing, digital radiography) may be applied if their suitability to meet the required tasks has been proved.

(3) The performance of the examinations shall meet the requirements of Section 12.

10.3.5.3 Attendance at non-destructive tests

The authorized inspector shall attend the non-destructive tests with due consideration of **Table 10-1**:

a) ultrasonic testing
   aa) the manual ultrasonic test 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, the authorized inspector shall attend the sensitivity calibration of the test equipment, spot-check the performance of sensitivity calibration and evaluate the results obtained by the test,

b) radiography
   the results obtained by radiographic testing (images) to be performed by the manufacturer shall be evaluated by the authorized inspector. The performance of radiographic testing shall be spot-checked by the authorized inspector,

c) surface inspection (magnetic particle and penetrant testing)
   the authorized inspector shall attend the examination to be performed by the manufacturer and evaluate the results obtained.

10.3.6 Hardness tests on ferritic welds

(1) The hardness tests required shall be laid down by agreement with the authorized inspector within the design approval procedure.

(2) Each of the hardness tests HV 10 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).

10.3.7 Leak test

(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, test procedures, test pressure, medium and duration 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) If a component is no longer cleaned after a leak test, the test media shall meet the cleanliness requirements to be met by the component.

(5) Leak tests for vessels, pipes and pumps generally refer to detachable connections, tube-to-tubesheet connections and cast casings. In accordance with the leak tightness requirements, the test procedure which is suitable in accordance with **Table 10-5** shall be applied.

(6) For valves the requirements of **Table 10-5** apply as to the application of the test procedure and performance of tests, unless more detailed requirements (e.g. in accordance with the design data sheet) have been laid down. Other test procedures are only permitted upon agreement by the authorized inspector. The design data sheet shall indicate the pertinent leak tightness requirement.

For the acceptance criteria the following applies:

Leak tightness of cast casing:	The leakage rate shown in the design data sheet shall be substantiated at minimum
Leak tightness of detachable connections:	The leakage rate shown in the design data sheet shall be substantiated at minimum
Back seat:	The leakage rate to DIN EN 12266-2 shown in the design data sheet shall be substantiated at minimum
Seat tightness:	The leakage rate to DIN EN 12266-1 shown in the design data sheet shall be substantiated at minimum

(7) Tube-to-tubesheet welds shall be subjected to a helium leak test applying the vacuum technique to DIN EN 1779, technique A1 (total test) and technique A3 (local test). The process requirements shall be laid down in a written specification. Unless the design data sheet sets more stringent requirements, the leak test requires a leakage rate (total and local) of less than or equal to 10^{-7} Pa · m^3 · s^{-1}.

10.3.8 First hydrostatic test

10.3.8.1 General requirements

(1) Upon successful completion of all tests and inspections specified in the course of manufacture, the first hydrostatic test shall be performed on the component in compliance with clause 10.3.8.2 in the presence of the authorized inspector.

(2) Prior to the beginning of hydrostatic test the following documents shall be submitted by the manufacturer:

a) all design-approved manufacturing documents,
b) certifications on all tests and checks performed in accordance with Section 10.3,
c) the design-approved pressure test plan,
d) the strain-measurement program (if provided).

(3) The component to be subjected to the first hydrostatic test shall be provided with the identification marking as specified in the design-approved drawing.

(4) Bolted joints to be used in component operation shall be provided during hydrostatic testing with the bolts and the same gasket type to be used in operation.

(5) Additional bolted and welded joints which are only used for sealing the component during hydrostatic testing shall meet the state-of-the-art.

(6) The component shall be provided in clean condition for hydrostatic testing so that the quality of the test fluid is ensured and the component can be tested.

(7) Preliminary pressure tests by the manufacturer are not permitted.

(8) The manufacturer shall establish a test record on the performance and result of the first hydrostatic test, which shall be countersigned by the authorized inspector.

10.3.8.2 Performance

(1) Upon completion of components a hydrostatic test shall be performed at a pressure level to be determined in accordance with KTA 3201.2.

(2) The hydrostatic test shall be performed with fully demineralized water with purity as specified in the pressure test plan. Deviations may be possible for valves, if cleaning is performed immediately after the testing of the valves.

(3) The water shall have a temperature such that the temperature required on the component external walls exceeds the determined reference NDT-temperature by at least 33 K. Details on the temperature on the walls, the temperature during filling-in and temperature maintenance during hydrostatic testing shall be laid down in the pressure test plan.

(4) It shall be ensured by suitable measures, e.g. use of a master pressure gauge (accuracy class 0.6 with certificate to DIN EN 837-1) that the pressure indicated by the test pressure gauge corresponds to the actual pressure. The specified maximum test pressure shall be obtained at the highest point of the component.

(5) During the hydrostatic test the component external walls shall be dry.

(6) The environment shall show such a temperature that no condensation water is formed.

(7) The hydrostatic test shall be performed at the sequence of times for pressurization and depressurization specified before to include:

a) the time which shall not be less than required for pressurization and depressurization,
b) the holding time of test pressure for all pressure levels,
c) the pressure levels used for strain measurements if required in accordance with clause 10.3.8.3,
d) the stipulations for temperature control if required by the pressure test plan.

10.3.8.3 Strain measurements

(1) During the first hydrostatic test of a component strain measurements shall be made if no sufficient reference stresses can be given when determining the stresses by way of calculation.

(2) Strain measurements may be waived if measuring results obtained on duplicate components are available.

(3) Strain measurements shall primarily be made in the areas where the highest loadings are to be expected and their adjacent areas.

(4) The results shall make possible a statement on the actual strain values, as well as a comparison with the calculated strain values and shall show permanent strain, if any, with related deformations. Where the component function requires, the deformation behaviour of the component or component parts (e.g. bolted joints) under test pressure shall be ascertained.

Note:
The strain measurements may also be necessary where geometric fabrication tolerances are exceeded.

(5) Details on the number, location, position, and type of measuring points shall be laid down in a detailed list of measuring points (plan) and be checked by the authorized inspector.

10.3.8.4 Measures to be taken in case of leakage

(1) In case of leakage on the pressure-retaining wall the pressure test shall be interrupted and be repeated after removal of cause.

(2) Individual leakage on sealing faces or bolted joints is only permitted in hydrostatic testing if the test pressure can be maintenained at the specified level for the intended time.

10.3.8.5 Non-destructive examination after the first hydrostatic test

(1) The requirements of Section 12.12 apply with regard to the extent of non-destructive examinations after the first hydrostatic test.

(2) With regard to the performance and attendance clause 10.3.5 shall apply.

10.3.9 Partial inspections

(1) Where partial inspections become necessary during stage-by-stage fabrication of parts or sub-units the authorized inspector, upon completion of the respective fabrication stage, shall examine the following by means of the design-approved manufacturing documents:

a) the proper identification marking of the component and its parts or sub-units including the identification marking of all processed product forms and the related material certificates,
b) the completeness and correctness of all documents to be established in accordance with Section 4.2,
c) the check of the dimensions specified in the design approval.

(2) The authorized inspector shall establish a certificate on the final inspection including the first hydrostatic test.

10.3.10 Final inspection

(1) Upon completion of a component, the authorized inspector shall examine the following by means of the design-approved manufacturing documents:

a) the relationship of certificates on partial inspections performed on parts or sub-units,
b) the proper identification marking of the component and its parts or sub-units including the identification marking of all processed product forms and the related material certificates,
c) the completeness and correctness of all documents to be established in accordance with Section 4.2,
d) the check of the dimensions specified in the design approval.

(2) The authorized inspector shall stamp the components with his test stamp to state that all tests and inspections including the first hydrostatic pressure test have been performed successfully.

(3) The authorized inspector shall establish a certificate on the final inspection including the first hydrostatic test.

Abbreviations used:

Ar : Valves
B : Heat exchangers and vessels
P : Pumps
R : Pipes

H : Manufacturer
S : Authorized inspector
DU : Performance of test
ÜW : Test supervision

TE : Participation in test
ST : Stamping
AN : Issue of a certificate
E : Final file
E/S : Final file / summary certificate
Z : Interim file

Test no.	B	Ar	P	R	Requirements to	Description of tests/examinations	Test by	Test activity, certification	Document file
1						**Review of the manufacturing preconditions prior to beginning of manufacture**			
1.1	X	X	X	X		Review of the general manufacturing preconditions	H	DU ST	–
					Section 3	– check of manufacturer's qualification or recognition	S	DU ST	–
					Section 3	– check of welder's qualification test certificates			
					Clause 3.3.5	– check of validity of NDE supervisor and examiner certifications for non-destructive examinations			
					Section 3	– check of the fabrication, measuring and testing equipment			
					Section 10.2	– check of the authorisation to transfer markings			
					Sections 3, 7	– check of calibration of welding equipment and heat treatment facilities			
					Section 6	– availability of valid process forming approvals			
					Sections 6.7, 9.9	– availability of valid approvals for heat exchanger tube-to-tubesheet expanding/welding processes			
					Section 3	– check of equipment for measuring the tightening parameters of bolted joints			
1.2	X	X	X	X		Review of the component-specific manufacturing preconditions	H S	DU ST DU ST	
					Section 4	– availability of valid design approval documents			–
					Sections 9, 11	– validity of welding procedure qualifications and pre-manufacturing production control tests			–
					Section 8	– availability of welding material tests			E
2						**Receiving inspection and transfer of markings**			
2.1	X	X	X	X	Clause 6.4.3.5, Sec. 10.2, 10.3, design approval documents	Check for transportation damage, identification marking (assignment to material certificate) and dimensions [9]	H S	DU ST DU ST	– –
2.2	X	X	X	X	Section 10, design approval documents, KTA 3201.1	Check of material certificates with confirmation in the list of materials [1]	H S	DU ST DU ST	 –
2.3	X	X	X	X	Section 10.2	Transfer of markings on product forms	S (H) [2]	DU AN	E
2.4	X	X	X	X	Section 10.2	Materials identity check	H	DU ST	–
3						**Tests and inspections prior to welding**			
3.1	X	X	X	X	KTA 3201.1 clause 22.4.2.3.2	Determination of ultrasonic testability of austenitic product forms, unless already performed by the product form manufacturer	H S	DU AN DU AN [4]	E E
3.2	X	X	X	X	Clauses 10.3.5.1, 12.3.1, 12.5.1, 12.6.1, 12.8.3.6	Ultrasonic testing of weld edges and welding areas for connecting welds with s ≥ 8 mm, unless already performed by the product form manufacturer	H S	DU AN DU AN [4]	E E
3.3	X	X	X	X	Clauses 12.3.2, 12.3.3, 12.5.2, 12.5.3, 12.6.1, 12.7.1, 12.8.1, 12.9.1	Surface examination on weld fusion faces, hard surfacing areas and surfaces to be cladded (MT for ferritic and martensitic materials, where possible, otherwise PT)	H S	DU ST [3] TE ST [3]	– –
3.4	X	X	X	X	KTA 3201.1 Sections 25.6, 26.6, 27.6 Section 12.8.2	Surface examination (MT, PT) on subsequently machined areas of castings and forgings, bar steel and sealing surfaces	H S	DU AN TE [4]	E –
3.5	X				Section 6.7, design approval documents, welding procedure qualification test	Visual examination of tube bores prior to tubing the tubesheet	H S (spot check)	DU ST DU ST	– –
3.6	X				Section 6.7, design approval documents, welding procedure qualification test	Check for damage of heat exchanger tubes on tube outside and visual examination of expanding areas of heat exchanger tubes	H S (spot check)	DU ST DU ST	– –
3.7	X	X	X	X	Section 10.3.3, design approval documents	Dimensional check of weld fusion faces	H	DU ST	–
3.8	X	X	X	X	Section 10.3.3, design approval documents	Dimensional check of areas to be cladded which are subjected to machining by a processor	H S	DU AN TE [6]	E –
3.9	X	X	X	X	Section 5.2	Check of availability of the reviewed valid welding procedure sheet on the welding site	H S (spot check)	DU ST DU ST	–

Table 10-1: Inspection sheet for components and piping systems (continued on next pages)

Test no.	B	Ar	P	R	Requirements to	Description of tests/examinations	Test by	Test activity, certification	Document file
3.10	X	X	X	X	Section 8, clause 10.3.2	Filler metals identity check and control of filler metals and welding consumables (storage, handling, drying)	H S (spot check)	DU ST DU ST	– –
4						**Tests and examinations during and upon welding Supervision of welding work (including repair welding) and heat treatment**			
4.1	X	X	X	X	Sections 5.3, 5.4, 5.5.3	Check of weld preparation and centering of welds in tacked condition (weld gap, misalignment, cleanliness)	H S	DU ST DU ST	– –
4.2	X	X	X	X	Section 5.7	Maintenance of welding records for welds > DN 50 as well as for hard surfacings (maintenance of shop-internal records for welds ≤ DN 50) – recording of welder's no. – confirmation of preheat and interpass temperatures – control of welding filler metals and consumables with registration of lot number – confirmation of welding data acc. to welding procedure sheet	H S	DU AN ÜW [6]	E –
4.3	X	X	X	X	Sections 5.4, 5.5, 10.2, 10.3.4	Visual examination of undressed weld, weld identification marking, check for discoloration	H S	DU ST DU ST	– –
4.4	X	X	X	X	Clauses 5.5.2, 5.5.4	Check for proper dressing of arc strikes or proper removal of temporary weld attachments	H	DU ST	–
4.5	X	X	X	X	Sections 5.4, 5.5, 10.2, clauses 10.3.4, 12.2.3	Visual examination of welds in final dressed condition with confirmation that the requirements for weld surfaces (surface condition, outside irregularities) have been met Visual internal examination, where possible Check of weld identification marking	H S	DU ST DU ST	– –
4.6	X	X	X	X	Clauses 9.1.4, 11.1.4, 12	Identification of remaining material of new welding procedure qualifications and production control tests as well as of reference blocks (test blocks)	H S	DU AN DU [6]	E –
4.7	X	X	X	X	Design approval documents	Layer thickness measurements of hard surfacings and claddings	H S (spot check)	DU ST TE ST	– –
4.8	X	X	X	X	Section 7	Monitoring of heat treatment (furnace records, furnace allocation plan, etc.)	H S	DU AN ÜW [6]	Z –
4.9	X	X	X	X	Section 7.4	Check of the heat treatment certificate	H S	DU AN DU [6]	E –
4.10	X	X	X	X	Clause 10.3.6	Hardness tests on ferritic welds	H S (spot check)	DU AN TE [6]	E –
4.11	X				Section 6.7, design approval documents, welding procedure qualification test	Supervision of expanding and welding of heat exchanger tubes into the tubesheet	H S	DU AN ÜW [6]	E –
4.12	X	X	X	X	Section 6, design approval documents	Tests and examinations during cold or hot forming of parts	H S	DU AN DU [6]	E –
5						**Non-destructive examinations of welds and deposition welds including butterings and hard surfacings as well as of base material surfaces** [8]			
5.1					Tables 10-2 to 10-4	Surface examination			
5.1.1	X	X	X	X	Clauses 12.3.4, 12.5.4, 12.6.3, 12.6.4.1	Surface examination on welds, inside and outside	H S	DU AN TE [4]	E
5.1.2	X	X	X	X	Clauses 12.7.2, 12.8.2	Surface examination on deposition welds and weld claddings *Note:* *Prior to tubing of tubesheet.*	H S	DU AN TE [4]	E
5.1.3		X	X	X	Clauses 12.9.2, 12.9.4	Surface examination on hard surfacings and butterings	H S	DU AN TE [4]	E
5.1.4	X				Section 12.4	Surface examination on seal welds	H S	DU AN TE [4]	E
5.1.5	X	X	X	X	Sections 5.5.2, 12.10	Surface examination on ground-flush arc strikes and on removed and ground-flush tack and auxiliary welds	H S	DU AN TE [4]	E
5.1.6	X	X	X	X	Section 12.11	Examination of base material surfaces upon last heat treatment	H S	DU AN TE [4]	E
5.2					Tables 10-2 to 10-4	Ultrasonic testing (UT)			
5.2.1	X	X	X	X	Section 12.3	UT of ferritic butt welds (longitudinal and circumferential) s ≥ 8 mm and DN ≥ 80	H S	DU AN DU AN [4]	E E
5.2.2	X	X	X	X	Section 12.3	UT of ferritic nozzle welds ≥ DN 125 mm and s or s_1 > 15 mm	H S	DU AN DU AN [4]	E E

Table 10-1: Inspection sheet for components and piping systems (continued)

Test no.	B	Ar	P	R	Requirements to	Description of tests/examinations	Test by	Test activity, certification	Docu-ment file
5.2.3	X	X	X	X	Section 12.3	UT of ferritic attachment welds – (single-bevel and double-bevel butt joint) s_1 > 15 mm – (single-bevel and double-bevel butt joint) $s_1 \leq$ 15 mm and length > 100 mm – fillet welds $s_1 \geq$ 10 mm or length > 100 mm	H S	DU AN DU AN 4)	E E
5.2.4	X	X	X	X	Clauses 12.6.2, 12.7.3, 12.8.3, 12.9.3, 12.9.5	UT of deposition welds, weld claddings, butterings and hard surfacings	H S	DU AN DU AN 4)	E E
5.2.5	X	X	X	X	Clause 12.6.4.2	UT of the interface buttering/ferritic base metal for welded joints between ferritic and austenitic steels	H S	DU AN DU AN 4)	E –
5.2.6	X	X	X	X	Clauses 12.5.4, 12.6.4.1	UT of inner surface of austenitic butt welds and welded joints between ferritic and austenitic steels (s ≥ 8 mm and DN ≥ 80)	H S	DU AN DU AN 4)	E –
5.2.7	X	X	X	X	Clause 12.5.4	UT of the inner surface of austenitic nozzle welds (s ≥ 8 mm and DN ≥ 80)	H S	DU AN DU AN 4)	E –
5.3					Tables 10-2 to 10-4	Radiographic testing (RT) 5)			
5.3.1	X	X	X	X	Sections 12.3, 12.5, clause 12.6.4.1	RT of butt welds (longitudinal and circumferential welds) with s ≤ 40 mm	H	DU AN	E
5.3.2	X	X	X	X	Sections 12.3, 12.5	RT of ferritic and austenitic nozzle welds	H	DU AN	E
5.3.3	X	X	X	X	Clause 12.6.4.2	RT of the interface buttering/ferritic base metal for welded joints between ferritic and austenitic steels	H	DU AN	E
5.3.4	X	X	X	X	Clause 12.5.4	RT of the inner surface of austenitic nozzle welds (s < 8 mm)	H	DU AN	E
5.3.5	X	X	X	X	Clause 10.3.5.3	Supervision of performance of radiographic testing	S (spot check)	DU ST	–
5.3.6	X	X	X	X	Sections 12.3, 12.5	Evaluation of the radiographs for test nos. 5.3.1 and 5.3.4	H S	DU AN DU 4)	
5.4	X	X	X	X	Section 12.12	Non-destructive examinations prior to first hydrostatic test as basis for the examinations after the first hydrostatic test	H S	DU AN DU 4)	E –
6						**Tests and examinations upon fabrication**			
6.1	X	X	X	X	Section 11	Check that the required production control tests have been performed and that these tests have been assigned to the pertinent seam welds	H S	DU ST DU ST	– –
6.2	X	X	X	X	Clauses 11.1.3, 11.1.5	Documentation of parts-related production control tests; Final test report	H S	DU AN DU AN	E E
6.3	X				Section 6.7, design approval documents, welding procedure qualification test	Control of expanding of heat exchanger tubes, final tube expansion and expanded length of tubes, check of diameter of welded-in tubes, check for free passage of tubes	H S (spot check)	DU ST TE ST	– –
6.4	X	X	X	X	Section 10	Early final inspection for parts of the pressure-retaining wall which are no longer accessible upon assembly	S	DU AN	E
6.5	X	X	X	X	Section 10	Check of identification marking, dimensional check and control of inner and outer surfaces prior to assembly	H S	DU AN DU 6)	E –
6.6	X			X	Section 10	Wall thickness measurements on ground-flush welds	H S	DU AN DU 6)	E
6.7						Early leak and hydrostatic tests without internals *Note:* *The tests shall be waived if they are performed in accordance with test nos. 7 ff.*			
6.7.1		X	X		Drawing, materials list	Check of stamping of the parts loaded in the hydrostatic test	H S	DU ST DU ST	– –
6.7.2		X	X		Section 10, drawing	Dimensional check prior to hydrostatic test	H S	DU AN DU 6)	E –
6.7.3		X	X		Clause 10.3.7	Leak test of castings	H S	DU ST TE ST	– –
6.7.4		X	X		Clause 10.3.8, design data sheet	Hydrostatic test	H S	DU AN TE 6)	E –
6.8				X	Section 10, Drawing, fabrication isometric drawing	Dimensional check of the parts tested in the manufacturer's works or pre-fabricated pipe parts (spools) including check of identification markings	H S	DU ST DU ST	– –
6.9	X	X	X	X	Drawing	Check of sealing surfaces (eveness, surface condition)	H	DU AN	E
7						**Final tests and inspections on components and piping systems or system sections**			
7.1						Dimensional check			
7.1.1	X	X	X		Section 10, drawing	Checking of actual dimensions of the component (tie-in and mounting dimensions)	H S	DU AN DU 6)	E

Table 10-1: Inspection sheet for components and piping systems (continued)

Test no.	B	Ar	P	R	Requirements to	Description of tests/examinations	Test by	Test activity, certification	Document file
7.1.2	X	X	X		Section 10, drawing	Dimensional check within the scope of in-process inspections on the basis of the design-approved documents (may be waived in the case of valves and pumps if performed under test no. 6.7.2)	H S	DU ST DU ST	– –
7.1.3				X	Stress isometry, list of hangers and supports, pre-set loads	Checking of the actual dimensions of the as-built system and the data relevant to the analysis of the mechanical behaviour including position and functionability of pipe hangers and supports in the system *Note:* *Pre-set loads; testing to KTA 3205.2 and KTA 3205.3.*	H S	DU ST DU ST	– –
7.2				X	Section 10 fabrication isometric drawing, isometric item list	Control of identification markings and confirmation in the isometric item list, Inspection of piping system installation with as-built confirmation of fabrication isometric drawing, e.g.: – installation of the correct parts – marking and location of welds – dimensions These checks shall be performed during manufacture, where possible.	H S	DU ST DU ST	– –
7.3	X	X	X	X	Section 4.2	Checking of documentation on tests and inspections as per test nos. 1 to 7.2	H S	DU ST DU ST	– –
7.4	X	X	X	X		Leak test			
7.4.1	X	X	X	X	Clause 10.3.7	Leak test on detachable connections for external leakage (for cast valves on the complete valve), unless performed under test no. 6.7.3	H	DU ST	–
7.4.2		X			Clause 10.3.7	Back-seat leak test	H	DU ST	–
7.4.3	X				Clause 10.3.7	Leak test of tube-to-tubesheet joint	H	DU AN	E
7.5	X	X	X	X	Clause 10.3.8, pressure test plan	Hydrostatic test of the complete component, in the case of pipes, test of the piping system or system sections (may be waived in the case of valves and pumps if test no. 6.7.4 has already been conducted)	H S	DU AN TE [6]	E –
7.6	X	X	X	X	Clause 10.3.8.3 measuring points plan	Stress-strain measurements	H S	DU AN TE [6]	E
7.7						Tests and examinations upon hydrostatic testing			
7.7.1		X			Clause 10.3.7	Seat tightness test	H S	DU ST TE ST	– –
7.7.2		X			Design approval documents	Check of the safety valves, including adjustment of the set pressure, measurement of the closing pressure and safeguarding against unintentional adjustment Check of set-pressure adjustment	H S	DU ST TE AN	– E
7.7.3		X			Design approval documents	Check for freedom of movement and ease of operation of all movable functional parts	H	DU ST	–
7.7.4			X		Design approval documents	Performance test	H S (spot check)	DU AN ÜW [6]	E –
7.7.5			X		Design approval documents	Check of moving and bearing parts after performance testing	H S	DU ST DU ST	– –
7.7.6	X	X	X		Section 10, materials list	Check of marking prior to assembly	H S	DU ST DU ST	– –
7.7.7	X	X	X	X	Section 12.10	Surface examination (MT/PT) on all subsequently machined surfaces (e.g. pressure test rings)	H S	DU AN TE [4]	– –
7.7.8	X				Design approval documents	Steel ball tests	H S	DU ST DU ST	– –
7.7.9					Section 12.12	NDT upon hydrostatic testing on highly loaded areas; determination of extent of testing and test method in the design approval documents			
7.7.9.1	X	X	X	X	Section 12.12	Surface examination (MT/PT)	H S	DU AN TE [4]	– –
7.7.9.2	X	X	X	X	Section 12.12	Ultrasonic testing	H S	DU AN DU AN [4]	E E
7.7.9.3	X	X	X	X	Section 12.12	Radiographic testing	H	DU AN	E
7.7.9.4	X	X	X	X	Section 12.12	Evaluation of radiographs	H S	DU AN DU [4]	E
7.7.9.5	X			X	Clause 12.14.5	Establishment of a general list to indicate the results of non-destructive examinations	H S	DU AN ÜW [6]	E –
7.8	X	X	X		Section 10 drawing	Recording of the actual tie-in and mounting dimensions if machining is still to be effected after test no. 7.1	H S	DU AN [7] DU [6]	E
7.9	X	X	X	X	Design approval documents	Checking of the specified tightening parameters of mechanical fasteners	H S	DU AN TE [6]	E –

Table 10-1: Inspection sheet for components and piping systems (continued)

Test no.	B	Ar	P	R	Requirements to	Description of tests/examinations	Test by	Test activity, certification	Document file
7.10		X	X		Design approval documents	Confirmation of fabrication supervision performed on auxiliary systems	H S	DU ST DU ST	– –
7.11	X	X	X	X	Design approval documents	Conductivity measurement of rinsing water	H	DU ST	–
7.12	X	X	X	X	Design approval documents	Cleanliness check	H	DU ST	–
7.13	X	X	X	X	Design approval documents	Inspection of packing	H	DU ST	–
8						**Review of documentation before delivery**			
8.1	X	X	X	X	Section 4.2, design approval documents	Documentation of the material tests	H S	DU ST DU ST	– –
8.2	X	X	X	X	Section 4.2, design approval documents	Documentation of in-process inspections for the entire component, in the case of piping systems for pre-fabricated parts (spools)	H S	DU ST DU ST	– –
8.3	X	X	X	X	Section 10	Establishment of the in-process inspection report	S	DU AN	E
9				X	Sections 4.2 and 10	**Review of the final documentation for the completely assembled piping system including establishment of the in-process inspection report**	H S	DU AN DU AN	E E

1) The correct assignment as required of product forms and pre-fabricated parts shall be checked.
- test requirements with regard to the allowable operating temperature (TB)
- comparison of the lowest loading temperature with the results of the notched-bar impact test
- performance of the required tests for loading in thickness direction
- comparison of simulated annealing with part annealing

2) Manufacturer in accordance with authority to transfer identification markings

3) The examination methods for the surface examination (MT or PT) shall be indicated in the test and inspection sequence plan.

4) See clauses 10.3.5.3 and 12.14 as to the attendance of the authorized inspector and recording of test results.

5) Joints between ferritic and austenitic steels are treated like austenitic welds.

6) To be countersigned on the manufacturer's certificate.

7) The actual dimensions shall be entered in the drawing or in the dimensional check sheet.

8) Non-destructive examinations shall basically be performed upon final heat treatment (see clause 10.3.5.1 for exceptions) Interim examinations or examinations prior to the final heat treatment shall be laid down in the test and inspection sequence plan and be performed by the manufacturer (with the authorized inspector attending if the examination can only performed to a limited extent upon final heat treatment).

9) When performing the dimensional check, care shall be taken that the requirements of the design approval documents are met.

Table 10-1: Inspection sheet for components and piping systems (final page)

Time of examination	Examination area / material	Volumetric examination	Examination of outer surface	Examination of inner surface
Prior to welding [1]	weld edge areas s ≥ 8 mm	UT [2]	—	—
	fusion face austenitic [3]	—	PT	—
	fusion face ferritic s < 20 mm	—	MT or PT	—
	fusion face ferritic s ≥ 20 mm	—	MT (PT [4])	—
Upon welding of seam weld	ferritic s < 8 mm	RT [5]	MT (PT [4])	MT [8] (PT [4] or RT [6])
	ferritic 8 mm ≤ s ≤ 40 mm	UT [7] and RT	MT (PT [4])	MT [8] (PT [4])
	ferritic s > 40 mm	UT [7]	MT (PT [4])	MT [8] (PT [4])
	austenitic [9] s < 8 mm	RT [5]	PT	PT [10] (RT [6])
	austenitic [9] s ≥ 8 mm	RT [11]	PT	PT [10] and UT [12] (RT [13])
	interface buttering/ferritic base metal in the case of dissimilar welds with s < 8 mm	RT [14]		
	interface buttering/ferritic base metal in the case of dissimilar welds with 8 mm ≤ s < 16 mm	UT [14] or RT [14]		
	interface buttering/ferritic base metal in the case of dissimilar welds with s ≥ 16 mm	UT [14] (RT [14]) [15]		

[1] The examination of butterings prior to welding of the seam weld is laid down in **Table 10-4**.

[2] Radiographic testing in the case of austenitic steel casting.

[3] Including butterings for welded joints between ferritic and austenitic steels (dissimilar welds).

[4] Instead of magnetic particle testing (MT) in the case of limited accessibility or insufficient magnetizability.

[5] May be replaced by the perpendicular radiographic technique according to clause 12.2.4.2 (3) d).

[6] Perpendicular radiographic technique according to clause 12.5.4 (4) instead of liquid penetrant testing (PT) if the inner surface is not accessible for PT.

[7] Ultrasonic testing (UT) also covers the examination of the surfaces and subsurface areas in which case the requirements of clause 12.3.5.3.2 shall be taken into account.

[8] Where the inner surface is accessible for magnetic particle testing (MT).

[9] Including dissimilar welds.

[10] Where the inner surface is accessible for liquid penetrant testing (PT).

[11] The procedural requirements shall specify the detection of lack of side fusion and be laid down in the test instruction as per clause 12.2.1.

[12] Examination of the inner surface in accordance with clause 12.5.6 or 12.6.4.

[13] Perpendicular radiographic technique according to clause 12.5.4 (4) if evaluation is limited when using the ultrasonic method.

[14] For fusion.

[15] A radiographic testing shall be performed additionally if ultrasonic testing is only possible to a limited extent.

Table 10-2: Non-destructive testing methods for butt welds

Time of examination	Examination area / material	Volumetric examination	Examination of outer surface	Examination of inner surface
Nozzle and attachment welds prior to welding	Weld edges and weld attachment areas with s ≥ 8 mm	UT	—	—
	Fusion face, surfaces prepared for welding; austenitic	—	PT	—
	Fusion face, surfaces prepared for welding; ferritic	—	MT (PT [1])	—
Nozzle welds upon welding	ferritic < DN 80 and s < 8 mm	RT	PT	PT [2]
	ferritic < DN 80 and s ≥ 8 mm	UT and RT	PT	PT [2] and UT [3]
	ferritic ≥ DN 80 and s < 8 mm	RT	MT (PT [1])	MT [4] (PT [1])
	ferritic ≥ DN 80 and 8 mm ≤ s ≤ 40 mm	UT and RT	MT (PT [1])	MT [4] (PT [1]) and UT [3]
	ferritic ≥ DN 80 and s > 40 mm	UT	MT (PT [1])	MT [4] (PT [1]) and UT [3]
	austenitic < DN 80	RT	PT	PT [2]
	austenitic ≥ DN 80 and s < 8 mm	RT	PT	PT
	austenitic ≥ DN 80 and s ≥ 8 mm	RT [5] (UT [6])	PT	PT and UT [7]
Attachment welds upon welding	ferritic	UT	MT (PT [8])	—
	austenitic	UT [9] or RT [9]	PT	—

1) Instead of magnetic particle testing (MT) in the case of limited accessibility or insufficient magnetizability.
2) Where accessible.
3) The requirements of clause 12.3.5.3.2 shall be taken into account.
4) If the inner surface is accessible for magnetic particle testing.
5) The procedural requirements shall specify the detection of lack of side fusion and be laid down in the test instruction as per clause 12.2.1.
6) The procedural requirements shall specify the detection of lack of side fusion and be laid down in the test instruction as per clause 12.2.1. Ultrasonic testing only required if the radiographic testing to detect lack of side fusion is possible to a limited extent.
7) Examination of the inner surface in accordance with clause 12.5.6.
8) In the case of limited accessibility or insufficient magnetizability.
9) The examination procedure and the procedural requirements shall specify the detection of lack of side fusion and be laid down in the test instruction as per clause 12.2.1.

Table 10-3: Non-destructive testing methods for nozzle and attachment welds

Test object	Time of examination	Examination area / material	Volumetric examination	Testing for coalescence	Surface examination
Deposition welds	Prior to welding	Surfaces prepared for deposition welding, austenitic	—	—	PT
		Surfaces prepared for deposition welding, ferritic	—	—	MT (PT [1])
	Upon welding	Shape welding, ferritic	UT	UT	MT (PT [1])
		Shape welding, austenitic	RT [2] or UT [2]	UT	PT
		Weld claddings, austenitic or of nickel alloys	UT [3]	UT	PT
		Butterings for hard surfacing	—	UT [4]	MT or PT
		Butterings for seam welds, austenitic or of nickel alloys	RT [5]	UT	PT
		Hard surfacings	—	UT	PT
Seal welds			—	—	PT
Area with removed tack welds		Ferritic product forms	UT [6]	—	MT
		Austenitic product forms	—	—	PT

1) In the case of limited accessibility or insufficient magnetizability.
2) The examination procedure and the procedural requirements shall be laid down in the test instruction as per clause 12.2.1.
3) Examination for underclad cracking, only knuckle of steam generator tubesheet (fillet at transition of tube plate to spherical section) and welding procedure qualification tests.
4) The examination may be performed along with the examination of the hard surfacing.
5) The examination shall be performed along with the examination of the seam weld.
6) Only required if the attachment area including HAZ has not been removed.

Table 10-4: Non-destructive testing methods for deposition welds, seal welds and areas with removed tack welds

Test method	Performance of test	Minimum detectable leak rate in $Pa \cdot m^3 \cdot s^{-1}$
Examination of leak tightness of cast casings and detachable connections (Examination no. P 11 to DIN EN 12266-1 with the following supplementing or deviating requirements)		
Bubble test [1] to DIN EN 1779	1. Technique C 2 (with foaming agents) a) Test pressure: max. 0.2 MPa, recommended 0.05 MPa b) Time: ≥ 2 minutes upon pressure application	10^{-4}
	2. Technique C 1 (immersion in water) a) Test pressure: 0.1 · PB, max. 0.2 MPa b) Test duration: ≥ 2 minutes	10^{-4}
Vacuum technique [2] to DIN EN 1779	1. Technique A 3 (local measurement) Test pressure and duration shall be laid down within the design approval.	10^{-7}
	2. Technique A 1 (total measurement) Test pressure and duration shall be laid down within the design approval.	10^{-10}
Pressure technique by accumulation [2] to DIN EN 1779	1. Technique B 4 (sniffing test) Test pressure and duration shall be laid down within the design approval.	10^{-7}
	2. Technique B 3 (integral measurement of leaking gas) Test pressure and duration shall be laid down within the design approval.	10^{-5}
Leak tightness test of valve back-seats (Examination no. P 21 to DIN EN 12266-2 with the following supplementing or deviating requirements)		
With water, without gland packing	Test pressure: 1 · PB Test duration: ≥ 2 minutes	10^{-3}
With gas, with gland packing box and gland ejection device	1. With foaming agents (at the ejection device opening) a) Test pressure: max. 0.2 MPa b) Dwell time: ≥ 2 minutes	10^{-5}
	2. Immersion of valve in water a) Test pressure: 0.1 · PB, min. 0.2 MPa b) Test duration: ≥ 2 minutes	10^{-5}
Seat tightness test [3] (Examination no. P 12 to DIN EN 12266-1 with the following supplementing or deviating requirements)		
With water pressure on the seat side	Test pressure: 1 · PB 1.1 · PB (for valves with pressure under valve disc) Test duration: ≥ 2 minutes	10^{-3}
With gas gauge pressure on one seat side	1. with foaming agents [4] a) Test pressure: max. 0.1 MPa b) Test duration: ≥ 2 minutes	10^{-5}
	2. Immersion of valve in water a) Test pressure: aa) for safety valves: 0.9 · set pressure ab) for valves (pressure under disc): 1.1 · PB b) Test duration: ≥ 2 minutes	10^{-5}

[1] The leak test shall be performed on the outside prior to the hydrostatic test.

[2] Upon a pneumatic test or prior to the hydrostatic test.

[3] To perform the test the valve shall be reset with the usual reseating force. For gate valves the seat tightness test shall be performed with the valve in its specified position. For valves where pressure can be applied from both sides, the tightness shall be checked from both sides.

[4] Alternatively, the bubble may be checked via a defined bore in the cover on the pressu

reless opposite side.

Table 10-5: Test methods and performance of leak tests

11 Production control tests

11.1 General requirements

11.1.1 Principles

(1) Production control test shall be performed in addition to the non-destructive examinations to prove the quality characteristics of welded joints on parts.

(2) The requirements for the examinations to be performed shall comply with those of the production control test.

(3) The same documents as for the procedure qualification tests are required for production control tests.

(4) Production control tests (welding work, examination and inspection) shall be conducted in the presence of the authorized inspector.

(5) Production control tests shall be performed on test pieces being equivalent to the pertinent welded joint on the part with a view to the product form and its degree of forming as well as the fabrication processes (e.g. rolling, forging, casting, quenching and tempering) and dimensioning (e.g. plate thickness, wall thickness and diameter of pipes) of the base metal.

(6) The welding performed in production control tests (welding procedure, filler metals, welding conditions, range of variables, welders performing the test, heat treatment) shall correspond to the conditions for the welded joint on the part unless other stipulations are made hereinafter.

(7) For production control tests for electron and laser beam welding the same requirements additionally apply as for welding procedure qualifications to clause 9.1.1 (9).

(8) By the agreement with the authorized inspector, the scope of procedure qualification tests may be extended by production control test.

(9) The extension of the period of validity of procedure qualifications by production control tests is covered by clause 9.1.3.8 (2).

11.1.2 Requirements for test pieces

11.1.2.1 Base metal

(1) The test pieces used in production control tests for longitudinal or meridional welds, for welds in core belt line areas (core weld) and for one circumferential weld per component or system each shall be equal to the pertinent weld on the part with regard to the base metal heat.

(2) For the test pieces of all further production control tests a base metal heat may be used upon agreement by the authorized inspector which is not equivalent to the base metal heat of the associated part. All base metal heats used shall be covered by the test with respect to their processing and corrosion resistance. Stipulations hereto shall be fixed in the course of design-approval.

(3) The test coupons for production control tests shall be tested according to clause 9.1.2 with regard to the base metal.

11.1.2.2 Dimensions

(1) The test pieces shall be so dimensioned that

a) all specimens required for the production control tests at the heat treatment conditions fixed and

b) sufficiently large reserve parts for substitute specimens can be provided. Details hereupon are laid down in **Tables 11-3** to **11-5**.

(2) The test pieces used for production control tests shall correspond to the pertinent welded joint on the part with regard to the wall thickness (and the diameter for pipes).

(3) For welded joints on parts for which the production control also applies, the wall thickness (and the diameter of pipes) shall be within the scope of the procedure qualification regarding the welded joint on the part allocated to the production control test.

11.1.2.3 Welded joints

(1) The filler metals shall be taken from the same lot as was used for the allocated welded joint on the part. Deviations herefrom are only permitted by agreement with the authorized inspector.

(2) The test piece shall be welded under conditions comparable to those for the welded joint on the part (e.g. narrow space, influences of the weather, clean-room conditions).

(3) The test piece shall be welded by welders performing welding work on the respective allocated part.

(4) The test pieces shall be welded directly prior to, during or immediately after the allocated joints on the part have been welded.

(5) The test pieces for combined procedure qualification and production control tests as per clause 9.1.1 (3) shall always be welded and tested prior to welding the welded joint on the allocated part.

(6) During test piece welding the weld design and operating principles as per Section 5 shall be adhered to.

(7) A welding record shall be established as per Section 5.7 on the test piece welding.

11.1.2.4 Heat treatment

11.1.2.4.1 Ferritic steels

(1) For connecting and deposition welds all heat treatment cycles shall be taken into account to which the welded joint of the part is subjected until completion of the component. Stress-relief heat treatment on the part performed prior to welding the joint on the part shall not be considered for the test piece heat treatment.

(2) Distinction is to be made between the following heat treatments:

a) Simulated heat treatment prior to production control test ($SV_{max.}$):

   The procedure qualification heat treatment shall be simulated on the test piece. The individual intermediate heat treatments may be added as to time and be performed as one heat treatment only at the same temperature. Final stress-relief heat treatments to be effected at higher temperatures, however, shall be simulated individually.

b) Actual final heat treatment during production control test (M):

   Upon completion of welding of the welded joint on the part, the test piece shall be added to the part for all subsequent heat treatments to which also heat treatments effected due to repairs belong.

c) Simulated final heat treatment, after production control test (SN):

   On the test piece all heat treatments to be effected on the part shall be simulated which have been performed upon completion of the associated welded joint on the part until completion of the part. These heat treatments shall be based on the course of heat treatment verified on the associated part's welded joint.

d) Simulated final heat treatment, prior to production control test ($SV_{min.}$):

On the test piece all heat treatments to be effected on the part shall be simulated which are to be performed upon completion of the associated welded joint on the part until completion of the part.

11.1.2.4.2 Austenitic steels

For austenitic steels the requirements of Section 7.3 apply.

11.1.2.5 Simulated repair welding

(1) Repairs on welded joints on parts shall be simulated in a production control test if the repair process has not been qualified by a procedure qualification. Simulated repair welding shall be performed, as far as possible, on that part of the test piece which shows the same condition as the part prior to repair.

(2) After the simulated repair welding a heat treatment ($SV_{min.}$) as per clause 11.1.2.4.1 (2) d) shall be performed.

11.1.2.6 Non-destructive examinations

Upon completion of the final heat treatment, the non-destructive examinations shall be performed on the test pieces in accordance with Section 12. The weld surface shall not be dressed before the outer surface condition has been evaluated with regard to further non-destructive examinations to be performed. In addition, the respective stipulations laid down in clauses 9.2.1, 9.5.3.2 and 9.6.5.2 shall be taken into account. The defects detected by such examinations shall not be repaired. The type of the defects shall be examined and be incorporated in the evaluation of the production control test.

11.1.2.7 Identification marking

(1) The test pieces shall be indelibly be marked such that the allocation to the part's welded joint is still clearly possible.

(2) The marking of the specimen material including of test piece remainders and reserve material shall ensure that it can be clearly allocated to the test piece by means of the materials testing and specimen-taking plan.

11.1.2.8 Test results

(1) Where a specimen or set of specimens does not obtain the specified values, two additional specimens or set of specimens shall be examined. The course of failure shall be ascertained.

(2) All substitute specimens shall meet the requirements.

(3) Where insufficient test results are due to influences caused by the examination itself or due to a small imperfection in a specimen, this specimen may be left out when deciding whether the requirements have been met. The respective examination shall be repeated on a substitute specimen.

11.1.3 Validity, allocation and number of production control tests

(1) For each welded joint on a part, a production control test shall be performed to comply with the scope of the procedure qualification. This shall be done by directly allocating a production control test to a part's welded joint or by including part's welded joints in the scope of comparable production control tests as per **Table 11-1**.

(2) Where a production control test is allocated to a part's welded joint, the weld shall be welded at the same production stage as the welded joint of the part.

(3) Where other welded joints on parts are to be covered by the scope of this production control test to comply with the requirements of Sections 11.2 to 11.5, this is only permitted for such welded joints on parts that are welded at the same production period, but at the latest 12 or 24 months (acc. to **Table 11-1**) after the performance of the production control test. The effective date for this period of validity is subject to the completion of welding work during the respective production control test.

(4) For part's welded joints to **Table 11-1**, lines 4 to 13, combined production control /procedure qualification tests are permitted.

(5) During the fabrication of several identical components by the manufacturer, a reduction of the number of production control tests is only permitted where the work on the reactor pressure vessel does not cover the weld with the highest expected radiation exposure.

11.1.4 Retention of remaining parts

The remaining parts of specimens - which are the stamped remainders of tested specimens, such as tensile, impact, drop-weight and bend test specimens, metallographic sections - and remainders, if any, of test pieces including untested specimens - which is stamped material intended for non-destructive examinations, which at the moment is not be used - as well as reserve material - which are excess lengths of test pieces - shall be retained in accordance with **Table 11-2**.

11.1.5 Report

(1) The manufacturer shall establish a report on the production control tests performed.

(2) The report shall contain:

a) cover sheet with certification of the authorized inspector on the performance, examination and release,

b) compilation of the documents

ba) design-approved documents:

materials testing and specimen-taking plan, welding procedure sheet indicating the respective welding materials tests, heat treatment plan, test instructions, if required,

bb) welding record,

bc) heat treatment record,

bd) certificates on tests/examinations performed,

be) comments regarding unusual events (e.g. failure of specimens, tolerated deviations from design-approved documents, special features of the crystalline structure in the base metal, HAZ or weld metal),

bf) certificates on base metal.

11.2 Welded joints on parts made of ferritic steels

11.2.1 Longitudinal and meridional welds

11.2.1.1 General requirements

(1) For each longitudinal and each meridional weld, a production control test shall principally be performed.

(2) The test piece for the production control test shall be welded in prolongation of the weld.

(3) Where several identical welds are welded in one process, only one production control test is required.

(4) Up to 4 welds in a course or spherical section may be covered by one production control test if the welds are welded to the same method and under identical conditions.

11.2.1.2 Dimensions of test pieces

(1) For the first production control test per component each or the first production control test within a 12 months' period where identical components are fabricated simultaneously by one manufacturer, the test piece shall meet the requirements of **Table 11-3** with respect to its dimensions.

(2) Regarding further production control tests for the same component or identical components at simultaneous fabrication by one manufacturer, the test piece shall meet the requirements of **Table 11-4** with respect to its dimensions.

(3) The dimensions of the test piece used for the production control test on longitudinal welds on pipings and pipe bends shall be selected such that the tests required by **Table 11-6** can be performed.

Note:
For pipe bends in reactor coolant piping the requirements can generally be met where a curved pipe with a 10°-radius of curvature is available.

11.2.1.3 Heat treatment of test pieces

(1) The test pieces as per clauses 11.2.1.2 (1) and (2) shall be discarded and heat treated in conformance with **Tables 11-3** and **11-4**.

(2) The test pieces for longitudinal welds of pipings and pipe bends shall be heat treated as follows:

a) half the number of the test pieces shall be heat treated to obtain the final heat treatment condition of the longitudinal weld,

b) for the other test pieces the final heat treatment condition of the longitudinal weld shall be obtained in which case the weld shall be additionally subjected to the heat treatment of the connecting circumferential weld and to a simulated repair heat treatment.

(3) If it is not ensured that the portion of the test piece heat treated during the production control test is subjected to the same heat treatment as the part, this test piece portion shall be subjected to a simulated heat treatment (SN) after the production control test.

11.2.1.4 Mechanical and other tests

(1) The mechanical and other tests shall be performed to meet the requirements of **Table 11-6**.

(2) For the requirements the stipulations of **Table 9-3** apply.

11.2.2 Circumferential welds

11.2.2.1 General requirements

(1) For the circumferential weld in the core belt line area of each reactor pressure vessel a production control test shall be performed which shall also apply to other welded joints on parts under the scope of the procedure qualification performed on the same component.

(2) For all other circumferential welds of primary circuit components under the scope of the respective procedure qualification, a production control test shall be performed for each component. These circumferential welds may also be qualified by a production control test for a longitudinal weld being under the scope of the procedure qualification as per Section 9.2.

(3) For circumferential welds on pipings a production control test shall be performed for the respective scope of the procedure qualification per piping system each both in the shop and on the construction site.

11.2.2.2 Dimension of test pieces

(1) For circumferential welds the test piece dimensions as per **Table 11-3** shall be adhered to in which case the developed length applies.

(2) When determining the test piece dimensions for the circumferential weld located in the core belt line area the requirements of KTA 3203 shall be considered additionally.

(3) For circumferential welds in pipings and valves the number of test pieces (pipe sections) shall be selected such that the tests as per **Table 11-6** can be performed.

11.2.2.3 Heat treatment of test pieces

(1) The heat treatment of the test pieces for production control tests on circumferential welds shall be effected in accordance with **Table 11-3**.

(2) Test pieces for production control tests on pipe circumferential welds shall be subjected to a simulated heat treatment ($SV_{max.}$) prior to production control test.

(3) If it is not ensured that the portion of the test piece heat treated during the production control test is subjected to the same heat treatment as the part, this test piece portion shall be subjected to a simulated heat treatment (SN) after the production control test.

11.2.2.4 Mechanical and other tests

(1) The mechanical and other tests shall be performed to meet the requirements of **Table 11-6**.

(2) For the requirements, the stipulations of **Table 9-3** apply.

(3) When determining the extent of testing and the requirements for the production control test of the circumferential weld in the core belt line area, the requirements of KTA 3203 shall be considered additionally.

11.2.3 Welded nozzles and double-bevel groove welds

11.2.3.1 General requirements

(1) For welded nozzles and double-bevel groove welds under the scope of procedure qualification one production control test each shall be performed on a component.

(2) Other welded joints on parts under the same scope of procedure qualification to Section 9.5 may be covered by these production control tests on the same component or identical components made by the same manufacturer.

(3) This also applies to non-load bearing welded attachments made of ferritic steels and permanently welded to the part.

11.2.3.2 Dimensions of test pieces

The dimensions and number of test pieces shall be selected such that all tests as per clause 11.2.3.4 can be performed.

11.2.3.3 Heat treatment of test pieces

The test pieces shall be subjected to a simulated heat treatment ($SV_{max.}$) prior to production control test.

11.2.3.4 Mechanical and other tests

(1) The mechanical and other tests of the test pieces shall be performed to the extent of the supplementary test to the procedure qualification (see clauses 9.5.1.3 and 9.5.2.3).

(2) For the requirements, the stipulations of **Table 9-3** apply.

(3) Where the production control test is only performed for non-load bearing attachments welded permanently to the part, one set of impact test specimens to DIN EN ISO 148-1 shall be tested on V-notch specimens. The specimens shall be taken with the notch located in the HAZ between pressure-retaining wall and weld metal. Further tests shall be performed as per **Table 11-6** (4), except for the chemical analysis.

11.3 Welded joints on austenitic steels

11.3.1 Longitudinal and circumferential welds

11.3.1.1 General requirements

(1) For longitudinal and circumferential welds under the scope of procedure qualification tests, one production control test each shall be performed on a component or piping system.

(2) Other welded joints on parts under the same scope of the procedure qualification to Section 9.3 may be covered by production control tests on the same component or identical components made by the same manufacturer.

(3) Production control tests on longitudinal or circumferential welds also apply to shape welds on similar base metals.

11.3.1.2 Dimensions of test pieces

The dimensions and number of test pieces shall be selected such that all tests as per clause 11.3.1.4 can be performed.

11.3.1.3 Heat treatment of test pieces

The test pieces shall be heat treated as required by Section 7.3.

11.3.1.4 Mechanical and other tests

(1) The mechanical and other tests shall be performed to the extent of the procedure qualification test (see clause 9.3.2).

(2) Regarding requirements, the stipulations of **Table 9-6** apply.

11.3.2 Welded nozzles and double-bevel groove welds

11.3.2.1 General requirements

(1) Where a production control test to clause 11.3.1 has been performed wherein the test piece was welded with comparable welding variables, the performance of a supplementary examination as per clause 9.6.1.3 (2) will suffice.

(2) Where no comparable production control test as per (1) has been performed, a production control test to the extent of the procedure qualification as per 9.6.1.3 (1) shall be performed.

(3) Other welded joints on parts under the same scope of the procedure qualification to Section 9.6 shall be covered by a production control test on the same component or on identical components made by the same manufacturer.

11.4 Weld claddings made of austenitic steels and nickel alloys

11.4.1 General requirements

(1) For semi- and fully automatically welded joints under the scope of procedure qualification one production control test per component each shall be performed.

(2) Where several identical components are fabricated by one manufacturer within a period of two years, one production control test per set of components each (e.g. steam generator, tubesheets, reactor coolant pump cladding) will suffice.

(3) For manually welded joints including the transition from semi-/fully automatically welded joints to manually arc welded joints one production control test per component each shall be performed.

(4) For components of the reactor coolant pipe (claddings on pipes, pipe bends and half pipe sections) one production control test of the pipe cladding and one production control test for pipe bend and half-pipe section claddings shall be performed for each piping system. The backing cladding in the weld area shall be examined by means of a production control test for a circumferential or longitudinal weld.

11.4.2 Dimensions of test pieces

(1) For weld claddings on pressure vessels the test piece dimensions given in **Table 11-5** shall be adhered to.

(2) For weld claddings on pipings the test piece dimensions shall be selected such that the tests can be performed as required by **Table 11-7**.

Note:
For pipe bends in reactor coolant piping this is generally achieved where a curved pipe with a 10°-radius of curvature is available.

11.4.3 Heat treatment of test pieces

The test pieces shall be subjected to a simulated heat treatment ($SV_{max.}$) prior to production control test.

11.4.4 Mechanical and other tests

(1) The mechanical and other tests as per **Table 11-7** shall be performed.

(2) Regarding the requirements, the stipulations of clause 9.4.3 apply.

11.5 Other welded joints on parts

11.5.1 General requirements

11.5.1.1 Shape welding on ferritic steels

(1) Where a production control test as per Section 11.2 has been performed wherein the test piece was welded with comparable welding variables it shall also cover shape weldings.

(2) Where no comparable production control test as per (1) has been performed, a production control test as per clause 9.5.3 shall be performed. For the extent of testing column a in **Table 9-8** applies.

(3) Other welded joints on parts under the same scope of the procedure qualifications to clause 9.5.3 shall be covered by these production control tests on the same component or identical components made by the same manufacturer.

Note:
Where whole parts are made by shape welding, the requirements of KTA 3201.1 shall apply.

11.5.1.2 Butt welds with intermediate layers of low-carbon filler metal

In the course of the production control tests as per clause 11.2.2.1 (3) the intermediate layers of low-carbon ferritic filler metal shall be covered by the test.

11.5.1.3 Strength fillet welds on austenitic steels

(1) For strength fillet welds under the scope of the procedure qualification a production control test as per clause 9.6.2 shall be performed on one component.

(2) Other welds on the part under the same scope of the procedure qualifications to 9.6.2 shall be covered by these production control tests on the same component or on identical components made by the same manufacturer.

11.5.1.4 Seal welds on the weld cladding

(1) For seal welds under the scope of the procedure qualification a production control test to clause 9.6.3 shall be performed on one component.

(2) Other welded joints on parts under the same scope of the procedure qualifications to clause 9.6.3 shall be covered by these production control tests on the same component or on identical components made by the same manufacturer.

11.5.1.5 Hard surfacings

(1) For hard surfacings under the scope of the procedure qualification a production control test to Section 9.8 shall be performed on test pieces similar to the parts.

(2) Other welded joints on the part under the same scope of the procedure qualification to Section 9.8 shall be covered by these production control tests on the same component or identical components made by the same manufacturer.

11.5.1.6 Butt welds between tubes made of ferritic steels and tubes made of austenitic steels

(1) Within the scope of the respective procedure qualification a production control test to clause 9.7.1 shall be performed on one component (see also **Table 11-8**).

(2) Other welded joints on a part under the same scope of the procedure qualifications to clause 9.7.1 shall be covered by these production control tests on the same component or identical components made by the same manufacturer.

11.5.2 Dimensions and number of test pieces

The dimensions and number of test pieces shall be selected such that the test can be performed like in the procedure qualifications to Section 9.

11.5.3 Heat treatment of test pieces

The test pieces as per clauses 11.5.1.1, 11.5.1.2, 11.5.1.5, and 11.5.1.6 shall be subjected to a simulated heat treatment ($SV_{max.}$) prior to production control test.

11.5.4 Mechanical and other tests

(1) The mechanical and other tests shall basically be performed to the extent of the procedure qualification.

(2) Regarding the requirements the stipulations of the procedure qualification apply.

(3) Deviating from (1) the following applies:

a) in the case of production control tests to clause 11.5.1.2, two side bend specimens shall be taken transverse to the direction of welding progress such that the root area and intermediate layers are covered.

b) in the case of production control tests to clause 11.5.1.5 the bend test to clause 9.8.3.1 shall be omitted. In the case of production control tests that are to cover only specific welded joints on parts thus permitting objective evaluation only in the case of welded joints similar to that of the part, deviation from the extent of testing fixed by this clause are permitted. In such a case, suitable examinations shall be agreed with the authorized inspector. Where the size of the part (valve seat bushing) does neither permit the taking of certain specimens nor the performance of specific tests, suitable examinations shall be laid down by agreement with the authorized inspector.

11.6 Tube-to-tube plate welding

11.6.1 General requirements

(1) Deviating from the stipulations in clause 11.1.3 test welds shall be made on each component in the course of fabrication to comply with the requirements of clause 9.6.5.1. To this end, a test plate shall be provided to be welded and tested in accordance with the requirements of clause 9.6.5. The test plate must be large enough to permit the performance of all test welds given hereinafter.

(2) The following test welds shall be welded for each component:

a) in the case of first welding, one test weld each
   aa) at the beginning of the shift,
   ab) per equipment,
   ac) per welder (only free-hand operation),
   ad) when adjusting the welding equipment anew (e.g. after malfunction),

b) in the case of semi- or fully automatically welded repair welds two test welds each
   ba) per equipment,
   bb) per shift,
   bc) upon adjusting the equipment anew,

c) in the case of manual repair welding up to three test welds per
   ca) welder,
   cb) shift (prior to beginning the repair),
   however not more repair welds than on the part,

d) in the case of plug welding per component and welding procedure up to two plug welds per welder, however, not more than on the component.

(3) From these welded joints one test weld per day shall be welded as test piece for a production control test in the presence of the authorized inspector. The documents on the other test welds shall be submitted to the authorized inspector.

11.6.2 Tests and inspections

(1) The test welds shall be examined as follows in which case the criteria and requirements for the procedure qualification to clause 9.6.5 apply:

a) on all test welds a visual inspection and check of the inside tube diameter by means of a screw plug gauge shall be performed,

b) on all test welds a surface examination by the liquid penetrant method to **Annex E** shall be made,

c) on 50% of the test welds transverse sections, and on 10% of the test weld surface-parallel sections shall be made. The remaining 40% shall be retained as reserve material.

(2) The evaluation of the test welds shall have been completed at the latest three days upon performance of the test weld.

No.	Type of weld	Acc. to Section/ clause	Type of test weld	Heat treat-ment	Number of production control tests	
					Semi or fully automatically welded joint	Manually welded joint
1	Longitudinal and meridional welds - ferritic	11.2.1	AP [1]	S and M [2]	on prolongation of the weld per longitudinal or meridional weld	per longitudinal or meridional weld
2	Circumferential welds - ferritic (except for valves)	11.2.2	AP [1]	S and M [3]	within the scope of procedure qualification 1 x per component or piping system [4]	1 x per component or piping system [4]
3	Weld claddings	11.4	AP [1]	S	1 x per component; if several identical components are fabricated in parallel: 1 x per set of components [5]	1 x per component
4	Nozzle welds - ferritic - austenitic	11.2.3 11.3.2	VP/AP or AP	S or U [6]	1 x every 12 months	1 x every 12 months
5	Longitudinal welds - austenitic	11.3.1	VP/AP or AP	S or U [6]	1 x every 12 months	1 x every 12 months
6	Circumferential welds - austenitic - ferrite/austenite	11.3.1 11.5.1.6	VP/AP or AP	S or U [6]	1 x every 12 months	1 x every 12 months
7	Strength fillet welds	11.5.1.3	VP/AP or AP	S or U [6]	1 x every 12 months	1 x every 12 months
8	Pressure-retaining deposition welds (compensating cover layer)	11.5.1.1	VP/AP or AP	S	1 x every 12 months	1 x every 12 months
9	Double-bevel groove welds - ferritic - austenitic	11.2.3 11.3.2	VP/AP or AP	S or U [6]	1 x in the validity period of VP (24 months)	1 x every 12 months
10	Non-pressure retaining ferritic deposition welds (shape weldings)	11.5.1.1	VP/AP or AP	S	1 x in the validity period of VP (24 months)	1 x every 12 months
11	Seal weldings on the cladding	11.5.1.4	VP/AP or AP	U [6]	1 x in the validity period of VP (24 months)	1 x every 12 months
12	Ferritic circumferential welds on valves	11.2.2	VP/AP or AP	S	1 x every 12 months	1 x every 12 months
13	Hard-surfacing	11.5.1.5	VP/AP or AP	S or U [6]	1 x in the validity period of VP (24 months)	1 x every 12 months
14	Tube-to-tube-sheet welds	11.6	AP [1]	U [6]	Acc. to clause 11.6.1 (2)	Acc. to clause 11.6.1 (2)

Note:

Decisive for the classification as semi- or fully automatically welded joint or manually welded joint is the portion of the weld volume.

[1] A pre-manufacturing production control test shall basically be performed.

[2] only for AP to clause 11.2.1.2 (1)

[3] for circumferential welds only S.

[4] A piping system is identified by a marking to the power plant identification system (KKS).

[5] e.g. steam generator tubesheet cladding, reactor coolant pump cladding

[6] for austenitic materials in accordance with welded joint on the part

S : Simulated final heat treatment condition

M : Actual final heat treatment condition, during production control test (or simulated after production control test)

U : Unannealed.

Table 11-1: Number of production control tests (AP) required in dependence of type of weld

Specimen originating from	Type of specimens (a: Period of retention; b: Location of retention)		
	Specimen remainders	Remainders of test pieces and untested specimens	Reserve material
Welding materials test (KTA 1408.3)	a) until establishment of certificate on the welding materials test	a) until establishment of certificate on the welding materials test	—
	b) at the processor's / fabricator's works	b) at the processor's / fabricator's works	
Procedure qualification test (clause 9.1.4)	a) 2 years or until successful completion of first production control test within the scope of the procedure qualification		a) if available: like for specimen remainders and remainders of test pieces
	b) at the processor's / fabricator's works		b) at the processor's / fabricator's works
Production control test (clause 11.1.4)	a) until completion of final inspection		For the total lifetime of the nuclear power plant: - for RPV in acc. with **Table 11-3**, Footnote 4 - for special cases
	b) at the processor's / fabricator's works [1), 2)]		

[1)] Where a production control test is used to extend the period of validity or the scope of a procedure qualification, the specimens shall be retained in accordance with the extended validity period for the procedure qualification to clause 9.1.4 if the latter extends beyond the completion of the final inspection.

[2)] For production control tests covering welds on several identical components the end of the retention period shall be the date of completion of final inspection on the last-fabricated component.

Table 11-2: Retention of specimen remainders, remaining and reserve material obtained by welding materials, production control and procedure qualification tests

Production step	Test piece dimensions [1), 2), 3)]				Remarks
	Width (mm)	Length (mm)			
Welding	For $s \leq 100$: width $b \geq 300$ For $s > 100$: width $b \geq 1.7 \cdot s$; at least 300	2000 [4)]			The length given is the one that can be evaluated
Discard [5)] test piece into 3 sections		1100	400	500	---------- means: discard sections
Simulated heat treatment ($SV_{max.}$) to clause 11.1.2.4.1 (2) a)		1100			
Test		900 200			900 mm test piece to be tested in acc. with **Table 11-6**; 200 mm reserve test piece for taking substitute specimens, if any
Heat treatment (M) during production control test, or simulated heat treatment (SN) in accordance with clause 11.1.2.4.1 (2) b) or 11.1.2.4.1 (2) c)			400		
Test			400		According to **Table 10-6**
Store reserve test piece				200 300 200 300	200 mm reserve test piece for substitute specimens, if any, 300 mm reserve test piece for simulated repair welding, if required
If required, simulated heat treatment (SN) to clause 11.1.2.4.1 (2) c)					
Test, if required				200 300	Simulated repair welding to **Table 11-6**

[1)] All dimensions are guide values. The dimensions of reserve test pieces shall be minimum values.

[2)] For circumferential welds the developed length shall apply.

[3)] In the case of deviations from the analysis as per clause B 2.2 (5), a 100 mm additional weld length for tangential sections, if required, to **Annex B** shall be reserved.

[4)] For the RPV circumferential weld in the belt-line area an additional test length to KTA 3203 shall be provided. For further RPV welds, if welded, an additional test piece length of 250 mm shall be provided for retention by the user over the nuclear power plant lifetime.

[5)] Where a heat treatment of the part and test piece is effected to start from the weld heat, discarding shall be effected upon such heat treatment.

Table 11-3: Dimensions of test pieces for butt welds on ferritic steels (except for pipings) in accordance with clauses 11.2.12 (1) and 11.2.2.2 (1).

Production step	Test piece dimensions [1), 2), 3)]				Remarks
	Width (mm)	Length (mm)			
Welding	For $s \leq 100$: width $b \geq 300$ For $s > 100$: width $b \geq 1.7 \cdot s$; at least 300	1600 [4)]			The length given is the one that can be evaluated
Discard [5)] test piece into 3 sections		1100		500	---------- means: discard sections
Simulated heat treatment ($SV_{min.}$) to clause 11.1.2.4.1 (2) d)		1100			
Test		900	200		900 mm test piece to be tested in acc. with **Table 11-6**; 200 mm reserve test piece for taking substitute specimens, if any
Store reserve test piece				200 300	200 mm reserve test piece for substitute specimen, if any; 300 mm reserve test piece for simulated repair welding, if required
Simulated heat treatment, if required (SN), to clause 11.1.2.4.1 (2) c)				200 300	
Test, if required				200 300	Simulated repair welding to **Table 11-6**

1) All dimensions are guide values. The dimensions of reserve test pieces shall be minimum values.

2) For circumferential welds the developed length shall apply.

3) In the case of deviations from the analysis as per clause B 2.2 (5) a 100 mm additional weld length for tangential sections, if required, to Annex B shall be reserved.

5) Where a heat treatment of the part and test piece is made to start from the weld heat, discarding shall be effected upon such heat treatment.

Table 11-4: Dimensions of test pieces for longitudinal and meridional welds on ferritic steels in accordance with clause 11.2.1.2 (1)

Production step	Test piece dimension [1)]			Remarks
	Width (mm)	Length (mm)		
Welding	$b \geq 300$	600		The length given is the one than can be evaluated
Discard test piece into 2 individual sections		300	300	---------- means: discard sections
Simulated heat treatment ($SV_{max.}$) to clause 11.1.2.4.1 (2) a)		300		
Test		300		300 mm test piece to be tested in accordance with **Table 11-7**.
			300	300 mm reserve test piece for substitute specimens, if any, or for simulated repair welding

1) All dimensions are guide values. The dimensions of reserve test pieces are minimum dimensions. Both shall be valid only for welding procedure qualification. For hollow parts the developed length shall apply

Table 11-5: Dimensions of test pieces for weld claddings made of austenitic steels and nickel-based alloys in accordance with Section 11.4

Mechanical tests [1]						Number of specimens						
Type of specimens	Test temp.	Test in acc. with	Values to be determined	Specimen location to **Fig. 9-5**	Test layer to **Fig. 9-2**	Butt weld, simulated heat treated	SSimulated repair weld [4], simulated heat treated	Heat treated during or after production	Reactor coolant piping [2] Longit. weld [3] simulated heat treated	Reactor coolant piping [2] Circumf. weld simulated heat treated	Welds on pipings and valves [3], [4] $s > 30$ mm	Welds on pipings and valves [3], [4] $s \leq 30$ mm [5]
(1) Weld metal												
Tensile test specimens	Room temperature	DIN EN ISO 5178 [6] DIN EN ISO 6892-1 [6]	R_m, $R_{p0.2}$ or R_{eH}, A, Z	I	O W Z	1 1 1	— — —	1 — —	— — —	1 1 —	1 1 —	— — —
	350 °C	DIN EN ISO 5178 [6] DIN EN ISO 6892-2 [6]	R_m, $R_{p0.2}$ or R_{eH}, A, Z	I	O W Z	1 1 1	— — —	— — —	— — —	1 1 —	1 1 —	— — —
Impact test specimens	33 °C [7]	DIN EN ISO 148-1 DIN EN ISO 9016	KV_2, lateral expansion, portion of ductile fracture	II	O W Z	3 3 3	3 3 —	3 3 —	3 3 —	3 3 —	3 3 —	3
Drop-weight test specimens	5 °C [8]	SEP 1325 (specimen shape P 2)	broken/not broken	III	O W Z	2 2 —	— — —	— — —	1 1 —	2 2 —	2 2 —	— — —
(2) Welded joint												
Tensile test specimens	Room temperature	DIN EN ISO 4136 [6]	R_m, location of fracture	VI or VII	O W Z	1 1 1	1 1 —	1 1 —	1 1 —	1 1 —	1 1 —	1
	350 °C	DIN EN ISO 4136 [6]	R_m, location of fracture	VII	O W Z	1 1 1	1 1 —	— — —	1 1 —	1 1 —	1 1 —	1 [9]
Impact test specimens	33 °C [7]	DIN EN ISO 148-1 DIN EN ISO 9016	KV_2, lateral expansion, portion of ductile fracture	V [10]	O W Z	3 3 3	3 3 —	3 3 —	3 3 —	3 3 —	3 3 —	3 [11]
Bend-test specimens	Room temperature	DIN EN ISO 5173	bending angle to first crack	IV	O W Z	2 2 2	— — —	— — —	— — —	— — —	— — —	2 x 2
Side-bend test specimens	Room temperature	DIN EN ISO 5173	bending angle to first crack	transverse to weld	—	—	2	—	2 [12]	2 [12]	2 [12]	—
Drop-weight test specimens [13]	5 °C [8]	SEP 1325 (specimen shape P 2)	broken/not broken	VIII	O W Z	2 2 —	— — —	— — —	— — 2	— — 2	— — 2	—
(3) Base metal [14]												
Tensile test specimens	Room temperature	DIN EN ISO 6892-1 [6]	R_m, $R_{p0.2}$, A, Z	—	O W or Z	1 1 or 1	— — —	— — —	1 1 —	1 1 —	1 1 —	—
Impact test specimens	33 °C	DIN EN ISO 148-1	KV_2, lateral expansion, portion of ductile fracture	—	O W or Z	3 3 or 3	— — —	— — —	3 3 —	3 3 —	3 3 —	—

Table 11-6: Production control tests for ferritic butt-welded joints: Extent of testing (continued on next page)

(4) Additional tests/examinations

a) Macrograph of an etched macrosection over the entire weld cross-section.

Certification by inspection certificate 3.2 to DIN EN 10204.

b) Analysis of alloying elements in the weld metal in the test layers O, W, Z for:
C, Mn, Si, P, S, Cr, Mo, Ni, Al, V, N_2, Cu.

Certification by inspection certificate 3.1 to DIN EN 10204.

c) Hardness traverse HV5 over base metal-weld metal-base metal in the test layers O, W as well as over the entire throat of the weld in the centre of the weld metal, (see **Figure 9-3**).

Certification by inspection certificate 3.2 to DIN EN 10204.

d) Metallographic micrographs on traverse sections, generally at a magnification of 200 : 1, in the test layers as per **Figure 9-2**, for each layer.

Certification by inspection certificate 3.2 to DIN EN 10204.

- Weld metal (in the case of pipings with wall thicknesses ≥ 30 mm on the root and cover pass side),
- Transition from weld metal to base metal (in the case of pipings with wall thicknesses ≥ 30 mm on the root and cover pass side,
- Base metal (uninfluenced).

e) Extended metallographic examinations, as far as required by **Annex B**, shall be performed.

Where a weld is examined in several heat treatment conditions (e.g. simulated heat treatment condition, prior to production control test, and actual final heat treatment condition, during production control test), the examinations as per d) shall only be performed in the simulated heat treatment condition.

1) All tests as per (1), (2) and (3) shall be certified by inspection certificate 3.2 to DIN EN 10204.

2) A check for resistance to intergranular corrosion to clause 9.4.3.4 is additionally required for butt welds to clause 11.5.1.2 on the austenitic root.

3) Heat treatment condition as per clause 11.2.1.3 (2).

4) Where a repair is required on the welded joint of the part, which is not covered by a procedure qualification as per clause 9.2.4, it shall be simulated by a production control test and be tested in accordance with **Table 9-2**.

5) Test layer O only.

6) Test specimens to DIN 50125 may be used.

7) 20 °C in core belt line area.

8) - 7 °C in core belt line area.

9) Where the design temperature exceeds 250 °C.

10) Notch location 0.5 mm ± 0.3 mm adjacent to fusion line in base metal.

11) Notched-bar impact tests within the heat-affected zones on three specimens, notch location at wall thickness > 10 mm parallel to the surface. In the case of wall thicknesses between 5 mm and 10 mm the test shall be performed on the largest possible specimens.

12) These tests are also required for butt welds to clause 11.5.1.2. On the austenitic weld cladding a chemical analysis as per **Table 10-7** shall be performed.

13) Impact and drop-weight test specimens shall be taken from the same HAZ for the production control test of the circumferential weld in the belt-line area.
The documents of the production control test shall make it possible to trace back the taking of the specimen to the melt number of the tested base metal.

14) Testing of base metal is only required if the respective base metal values in test layers O, W, Z obtained from the materials tests as per KTA 3201.1 are not available.

Table 11-6: Production control tests for ferritic butt-welded joints: Extent of testing (continued)

Type of specimens	Test temperature	Test in acc. with	Values to be determined	Specimen location acc. to	Heat treatment condition to clause 11.1.2.4		Inspection certificate to DIN EN 10204
					Number of specimens		
					First weld ($SV_{max.}$)	Simulated repair weld ($SV_{min.}$)	
(1) Mechanical testing of weld cladding (clad weld metal, interface base metal / cladding, HAZ) in conformance with DIN EN ISO 5173							
Side-bend test specimen transverse	Room temperature	Clause 9.4.3.2	Bending angle at first incipient crack, bending strain	Clause 9.4.3.2	2	2	3.2
(2) Check of clad weld metal for resistance to intergranular corrosion on austenitic steels							
IGC-specimen	Room temperature	DIN EN ISO 3651-2 procedure A [1]	Resistance to intergranular corrosion yes/no	Clause 9.4.3.4	2	2	3.2
(3) Additional tests / examinations [2]					a) to c)	a) and d)	
a) Metallographic examination transverse to the welding direction over the entire specimen width including simulated repair welds, if any, in accordance with clause 9.4.3.5.							3.2
b) Hardness test according to clause 9.4.3.6. and **Figure 9-6**, sketch 2.							3.2
c) Check of the chemical analysis of the clad weld metal according to clause 9.4.3.3.							3.1
d) Determination of the cladding surface condition in acc. with Section 12.							3.1

[1] Heat treatment conditions as per clause 11.4.3.

[2] In the case of deviations from the specified heat input, with regard to the verification of the freedom from cracks of the HAZ and the base metal, clause 12.8.3.1 (4) shall be taken in account.

Table 11-7: Production control tests on weld claddings of austenitic steels and nickel alloys: Extent of testing

Type of specimens	Specimen location acc. to	Number [1] of specimen	Test temperature	Test in acc. with	Values to be determined	Inspection certificate to DIN EN 10204
(1) Mechanical testing						
Tensile test specimen	**Fig. 9-5** VI or VII	1	Room temperature	DIN EN ISO 4136 [2]	R_m, location of fracture	3.2
Tensile test specimen	**Fig. 9-5** VI or VII	1	350 °C	DIN EN ISO 4136 [2]	R_m, location of fracture	3.2
Impact test specimen	Clause 9.7.1.3.2 (1)	3	Room temperature	DIN EN ISO 148-1 DIN EN ISO 9016	KV_2, lateral expansion	3.2
Side-bend test specimen	Clause 9.7.1.3.3	2	Room temperature	Clause 9.7.1.3.3	Bending angle at first incipient crack, bending strain	3.2
(2) Check for resistance to intergranular corrosion on austenitic steels						
IGC-specimen	Clause 9.7.1.3.6	2	Room temperature	DIN EN ISO 3651-2 procedure A without sensitisation	Resistance to intergranular corrosion yes/no	3.1
(3) Additional tests / examinations						
a) Macrosection transverse to the direction of welding						3.2
b) Microsection transverse to the direction of welding (to be determined upon evaluation of macrosection)						3.2
c) Hardness test on macrosection (**Figure 9-3**)						3.2

[1] Test layers as per **Figure 9-4**.

[2] Test specimens to DIN 50125 may be used.

Table 11-8: Production control tests for butt welds between ferritic tubes and tubes made of austenitic steels to Figure 9-14 in the heat treatment condition ($SV_{max.}$) prior to production control test: Extent of testing

12 Non-destructive examinations

12.1 Layout suitable for testing purposes

12.1.1 General

(1) The layout which is suitable for the testing of welded connections depends on the test procedure to be employed.

(2) If deviations from the prescribed shapes of weld interfaces are mandatory for cogent reasons, e.g. even if standard items are used, the testability shall be demonstrated within the scope of the design review.

12.1.2 Ultrasonic testing

12.1.2.1 Ferritic circumferential and longitudinal welds

Note:

***Figures 12-1** and **12-2** show examples of permissible wall thickness transitions.*

(1) For the ultrasonic examination, scan paths in accordance with **Table 12-1** 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 12-1** reduced scan paths are acceptable upon agreement by the authorized inspector; substitute test measures shall be fixed (e.g. additional angles of incidence, performance of radiography).

(3) Where the angled pitch-catch technique is to be applied, at least the scan paths as required by **Table 12-1** shall be adhered to on one side of the weld.

12.1.2.2 Ferritic nozzle welds

Note:

***Figure 12-3** illustrates examples of permissible wall thickness transitions.*

The required scan paths L and L' are specified in **Table 12-1**. 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 x 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.

12.1.2.3 Ferritic attachment welds

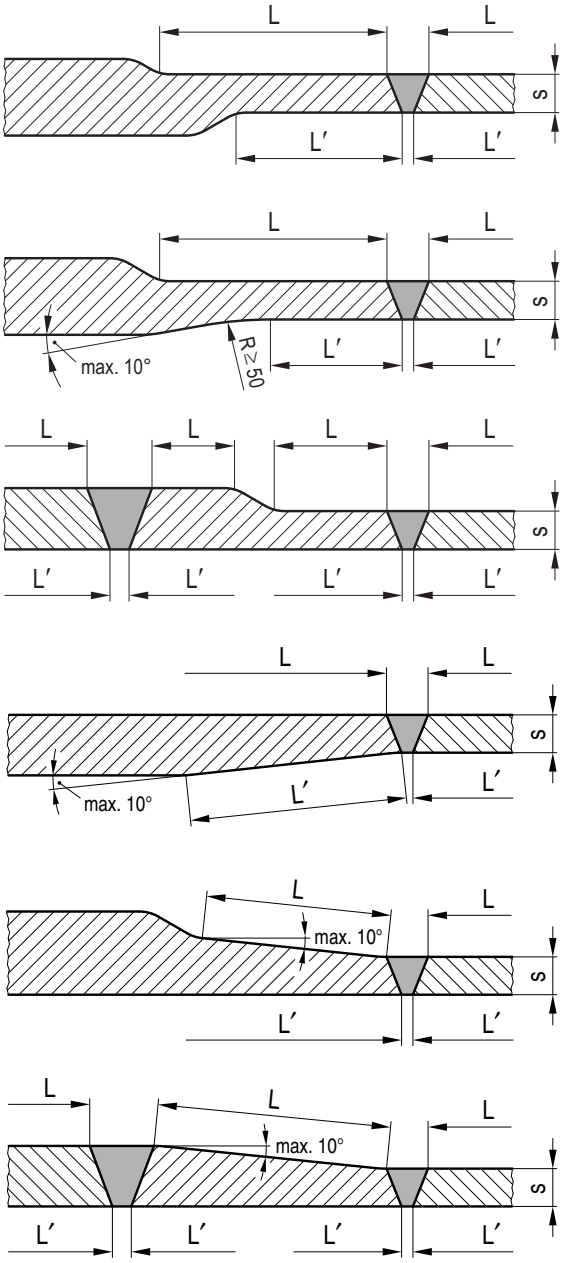
(1) In the case of single and double bevel groove welds, scan paths L and L' shall be adhered to in accordance with **Table 12-1** for web thicknesses s_1 (see **Figure 12-10**) equal to or greater than 15 mm. If both web surfaces are accessible for the test, scan paths L and L' may be reduced to 2 x s_1 + 30 mm in the case of web thicknesses s_1 equal to or smaller than 40 mm, or to 2 x s_1 + 50 mm in the case of web thicknesses which are greater than 40 mm. Scan paths L equal to or greater than 50 mm in accordance with **Figure 12-4** 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 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 equal to or greater than 50 mm shall be provided.

12.1.2.4 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 12-1** 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 12-1**.

(2) Where, in exceptional cases, it is not possible to adhere to the scan paths as per **Table 12-1** reduced scan paths are acceptable upon agreement by the authorized inspector; substitute test measures shall be fixed (e.g. additional angles of incidence, performance of radiographic testing).



L, L′: Scan paths
R : Radius (if machined)
s : Wall thickness

Figure 12-1: 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

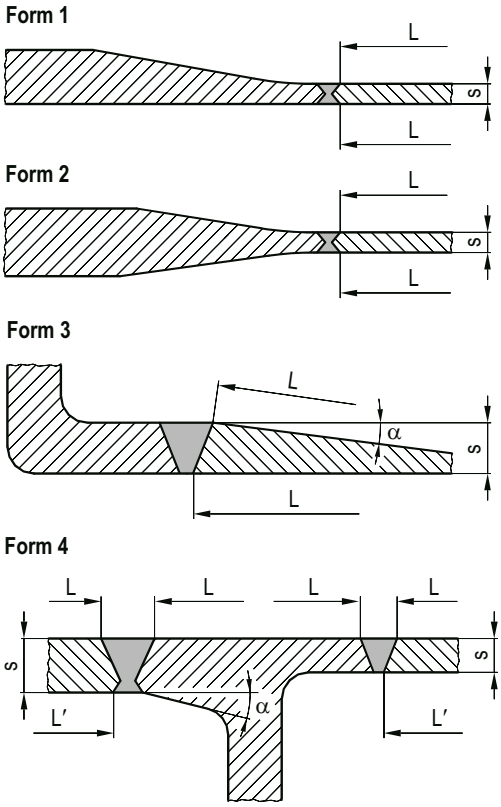


Figure 12-2: Examples of structural design of wall thickness transitions in consideration of the scan paths required for ultrasonic testing of flush butt welds ≥ DN 80 and s ≥ 8 mm (restricted scanning from opposite directions)

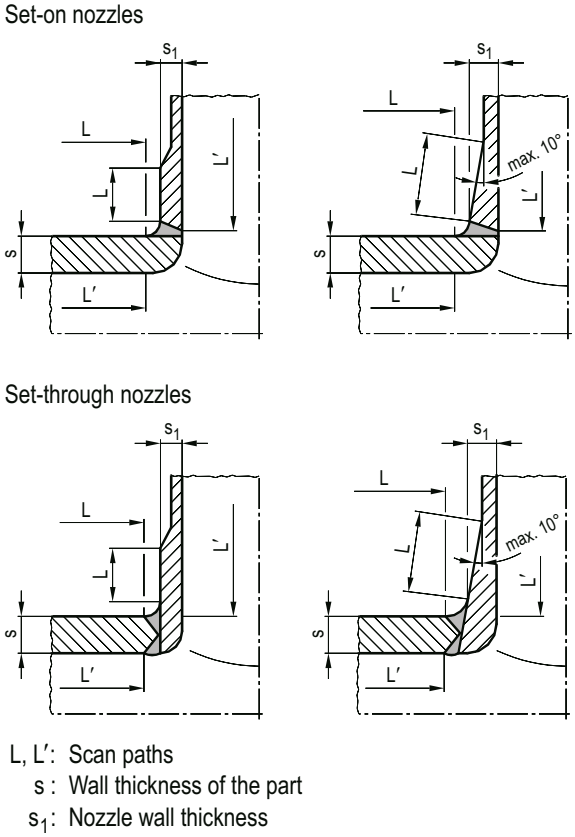


Figure 12-3: Examples of structural design of wall thickness transitions in consideration of the scan paths required for ultrasonic testing of nozzle welds if s or s_1 > 15 mm

12.1.3 Radiographic testing

(1) **Figure 12-4** illustrates examples of permissible shapes of nozzle welds.

(2) The paths L* as per **Table 12-2** shall be adhered to.

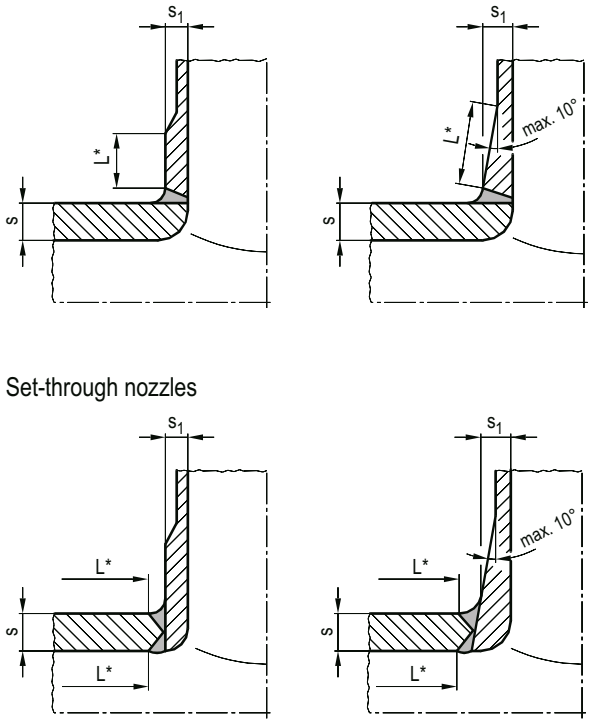


Figure 12-4: Examples of structural design of wall thickness transitions in consideration of the scan paths required for radiographic testing of nozzle welds if s or $s_1 \leq 15$ mm

12.2 General requirements

12.2.1 Test instructions

(1) Test instructions shall be established by the manufacturers for non-destructive examinations.

(2) These instructions may be established for identical test objects (e.g. welds of same shape and dimensions) in standardized form independently of the project.

(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.

(4) The test instructions shall contain detailed information on:

a) Assignment to the individual test objects,

b) time of testing as far as it influences the extent and performance of the test 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 for ultrasonic testing,

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) if required, supplementary information for recording and evaluating indications or irregularities (e.g. in the case of technical substitute measures).

12.2.2 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.

12.2.3 Requirements for surfaces

12.2.3.1 General requirements

(1) The surfaces shall be in a condition appropriate to the purpose of the test.

(2) In addition to the requirements for welded joints as per Section 5, the surfaces of the test objects shall meet the requirements given hereinafter.

12.2.3.2 Radiography

For radiographic testing, the weld surfaces shall be such that the evaluation is not adversely affected.

12.2.3.3 Surface examination by magnetic particle and liquid penetrant methods

(1) For surface examination by magnetic particle and liquid penetrant methods, the surfaces shall be free from scale, weld spatters 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 surfaces to be examined. Requirements for the surfaces of hard-surfacings outside functional surfaces shall be laid down in each individual case.

12.2.3.4 Ultrasonic testing

(1) The requirements of Section C3 apply.

(2) In addition to the stipulations of Section C3 the following applies:

a) Residual notches and deviations from the specified contour due to processing or fabrication are only permitted if the sensitivity of ultrasonic testing, including periodic (in-service) inspections, is not impaired.

b) Welded joints between ferritic steels and austenitic steels (dissimilar welds) with nominal wall thinesses equal to or greater than 8 mm, the inner surface including buttering and hard-surfacing (if any) shall be ground flush without any notches.

12.2.3.5 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) type of recording.

(3) These instructions shall be submitted to the authorized inspector for review.

12.2.4 Requirements for testing techniques

12.2.4.1 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.

12.2.4.2 Manual Examinations

(1) The general specifications laid down in **Annex C** to **E**,

a) Annex C: Performance of manual ultrasonic testing

b) Annex D: Performance of manual ultrasonic angled pitch-catch examinations,

c) Annex E: Performance of surface examinations by magnetic particle and liquid penetrant methods,

as well as the additional specifications resulting from the sections hereinafter shall apply to ultrasonic and surface examinations by magnetic particle and liquid penetrant methods.

(2) The magnetic particle method shall be used when examining the surfaces of sufficiently magnetizable materials, unless specified otherwise in Sections 12.3 and 12.7 to 12.9.

(3) For radiographic testing the following applies:

The examination 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 19232-2 shall be adhered to in which case the image quality indicators to DIN EN ISO 19232-1 shall be used.

c) The examination shall be performed on wall thicknesses ≥ 8 mm to detect incomplete side-wall fusion, unless the detection of such defects is covered by ultrasonic testing. To this end, the beam shall be directed onto the weld fusion face.

d) Where the perpendicular technique is required, the requirements of DIN 25435-7 shall be met.

12.2.4.3 Mechanized examinations

(1) Mechanized examinations are required

a) if an evaluation is not possible without extensive recordings and representation of measured data (e.g. in the presence of flaws due to external contour in the case of root notches, in the case of complex geometries of nozzle welds),

b) if extreme radiation exposure is to be expected in the areas to be tested.

c) for the examination of welded joints between austenitic steels and of welded joints between ferritic steels and austenitic steels (dissimilar welds).

(2) Where ultrasonic testing requirements are applied to automated and mechanised non-destructive examinations and where other examination 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.

12.2.4.4 Baseline inspections

(1) The non-destructive tests and examinations performed in the course of fabrication are considered baseline inspections for periodic (in-service) inspections if they are performed with the same test methods and techniques provided for future in-service tests and inspections. Where no non-destructive tests and inspections are required upon the initial pressure test as per Section 12.12 the last tests performed prior to the initial pressure test are accepted.

(2) In the case of welded joints between ferritic steels and austenitic steels with a weld metal consisting of a nickel alloy on the fluid-wetted surface, ultrasonic testing for transverse flaws in opposite scanning directions to meet the requirements of KTA 3201.4 shall be performed in addition to the requirements of Section 12.6. This test is also required if between the weld metal of nickel alloy and the fluid-wetted surface an austenitic root smaller than or equal to 3 mm is present.

(3) Baseline inspections are required again if examination procedures other than those performed in the tests and inspections during manufacture are used in in-service inspections.

(4) Overview lists for indications liable to recording

a) for vessels (component-wise)

b) for pipework (system-wise)

shall be established by the manufacturer allocated to the welds with indication of the respective record number and be added to the final documentation.

12.2.5 Evaluation of test results

(1) For the evaluation of the test results obtained by the various test methods the criteria as per Sections 12.3 to 12.13 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 evaluation criteria specified in Sections 12.3 to 12.13 are not adhered to, it may be demonstrated by further examinations (e.g. by using methods for a more exact determination of reflector extension) that the use of the component is permitted. Here a decision shall be made 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.

12.3 Welded joints on ferritic steels

12.3.1 Ultrasonic testing prior to welding

(1) The weld edges and weld areas shall be subject to ultrasonic testing in which case the post-weld test requirements shall be taken into account.

(2) The scan path width shall be at least 50 mm on both sides of the faying surfaces. Where the component nominal wall thickness exceeds 50 mm, the scan paths width at the faying surface shall be taken equal to the nominal wall thickness. It shall be ensured in both cases that the examined base metal area remaining upon dressing of the weld fusion faces has a width of at least 20 mm.

12.3.2 Surface examination prior to welding

(1) Prior to welding the fusion faces of the joint to be welded shall be examined for surface defects.

(2) The liquid penetrant method may be used instead of the magnetic particle method on product forms with a wall thickness less than 20 mm.

(3) Examinations performed by the liquid penetrant method shall be evaluated in accordance with **Table 12-3** and examinations performed by the magnetic particle method shall be evaluated in accordance with **Table 12-4**. In both cases the criteria given hereinafter shall be taken into account.

12.3.3 Additional evaluation criteria for fusion faces

Note:
In general, more stringent requirements are to be met regarding the quality of fusion faces for electro-slag welded joints than for fusion faces for submerged-arc welded joints. For the latter joints the requirements are more stringent than for fusion faces of manual welds.

(1) When evaluating the results obtained from surface examinations 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 the ultrasonic testing of the weld fusion faces performed in accordance with KTA 3201.1 or to clause 12.3.1 shall be covered by the evaluation.

12.3.4 Surface examination upon welding

(1) Welds shall be examined by means of the magnetic particle method on the outer and inner surface if these surfaces are accessible for this examination.

(2) In the case of limited accessibility or restrictions due to geometry the liquid penetrant method may be use instead of the magnetic particle method by agreement with the authorized inspector.

(3) The requirements of **Table 12-5** are considered acceptance standards for the magnetic particle and liquid penetrant methods.

12.3.5 Ultrasonic testing upon welding

12.3.5.1 General requirements

(1) The ultrasonic testing shall cover the entire weld metal.

(2) 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) The number of beam angles and the recording level shall be based on the nominal wall thickness of permanent welded attachment or set-on nozzle, and on the nominal wall thickness of the part in the case of set-through nozzles.

12.3.5.2 Extent and time of testing

(1) Welds with a wall thickness equal to or greater than 8 mm shall be ultrasonically tested for longitudinal and transverse defects over their full length. In the case of electroslag welds an ultrasonic testing for transverse defects shall be additionally performed from sound entry positions 9 to 16 (**Figure 12-9**).

(2) In the case of electroslag welds the ultrasonic testing shall be performed upon quenching and tempering. Upon final heat treatment an ultrasonic testing shall be additionally performed but only from one surface.

(3) Where the angled pitch-catch technique is to be applied in accordance with clause 12.3.5.4.1, this technique shall be applied at a date to be fixed in the test and inspection sequence plan, however, at least upon one stress relief heat treatment.

(4) Where the ultrasonic testing according to clause 12.3.5.4 or 12.3.5.5 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 testing. A supplementary measure can be a complete ultrasonic testing as per clause 12.3.5.4 or 12.3.5.5 at another stage of fabrication, e.g. upon at least one stress relief heat treatment, an examination with additional beam angles, the reduction of the recording level, the use of specific search units (probes) or an additional radiographic testing.

12.3.5.3 Procedural requirements

12.3.5.3.1 Test frequency and crystal dimensions

(1) Basically, search units with such crystal 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 search units care shall be taken to ensure that interference zones close to the search unit are minimised.

(2) In the case of a wall thickness s equal to or less than 40 mm, a nominal frequency of 4 MHz and in the case of a wall thickness exceeding 40 mm a nominal frequency of 2 MHz shall normally be used.

(3) Where an austenitic weld cladding is provided, the examination may be performed in accordance with clause 12.3.5.4 or 12.3.5.5 if the testing level required by clause 12.3.5.6 can be adhered to, e.g. by the use of 1 MHz shear wave search units (transverse wave probes).

12.3.5.3.2 Testing level adjustment

(1) The test systems shall be calibrated in accordance with Sections C 6 and D 4.

(2) The testing level may be adjusted in accordance with the DGS method as well as using the reference block method or the DAC method.

(3) In addition to the stipulations of **Annex C** the following applies:

a) The wall thickness of the reference block as per **Figure C-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 C-2**, the lesser reference echo height applies to the entire wall thickness. If the respective surface is subjected to a surface examination, the notch as reference reflector may be omitted.

(4) In the case of subsurface reflectors, the testing level obtained by the DGS method may be corrected by using the subsurface reference reflectors to **Figure C-2**.

12.3.5.3.3 Determination of the length of indication

(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 C 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 less than 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 magnitude of reflectors whose maximum echo amplitude is smaller than the original recording level, shall be determined in accordance with clause C 11.2.3 (half-amplitude method).

(3) If the echo amplitudes exceed the original recording level, the magnitude 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 magnitude of reflectors is required, the specifications of clause C 11.2.4 shall be satisfied.

(5) Reflectors with a length of indication less than 10 mm shall be considered point-type reflectors.

12.3.5.4 Examination of butt welds

12.3.5.4.1 Beam angles

(1) In the case of nominal wall thicknesses less than 15 mm the examination shall be made by angle beam scanning for longitudinal and transverse defects with a beam angle α to be selected such that the angles of incidence β_1 and β_2 (**Figure 12-5**) do not exceed 70° on the surfaces to be tested.

(2) In the case of nominal wall thicknesses equal to or greater than 15 mm up to less than 100 mm the examination shall be performed by angle beam scanning with two beam angles to detect longitudinal and transverse defects. Here, one beam angle shall be selected such that the angles of incidence on the surfaces are between 35° and 55°. At the second beam angle the angular deviation between the beam angle axis and the normal to the surface shall be as little as possible, however not exceed 20° for normal-to-surface defects (angle δ in **Figure 12-6**).

(3) In the case of welds with fusion face angles less than 5° and nominal wall thicknesses exceeding 40 mm, when being subjected to an examination for longitudinal defects, the angle beam scanning technique with the greater of the beam angles shall be replaced

a) in the case of a nominal wall thickness equal to or greater than 40 mm and less than or equal to 80 mm by the wave-conversion technique II (LLT technique) as per Section C 9 or the angled pitch-catch technique,

b) in the case of a nominal wall thickness exceeding 80 mm by the angled pitch-catch technique.

(4) In the case of nominal wall thicknesses equal to or greater than 100 mm the examination by angle beam scanning to detect longitudinal and transverse defects shall be performed with one beam angle and by means of an angled pitch-catch technique. Here, the beam angle for angle beam scanning shall be selected such that the angles of incidence for angle beam scanning on the surfaces are between 35° and 55°.

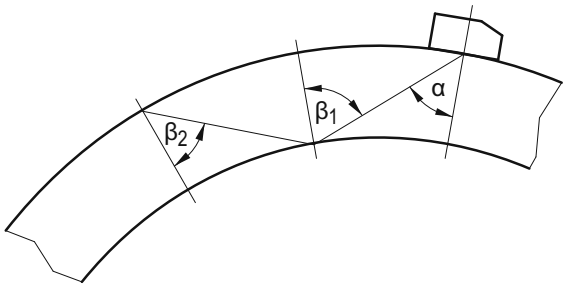


Figure 12-5: Beam angle α and angle of incidence β between axis of sound beam and line normal to surface

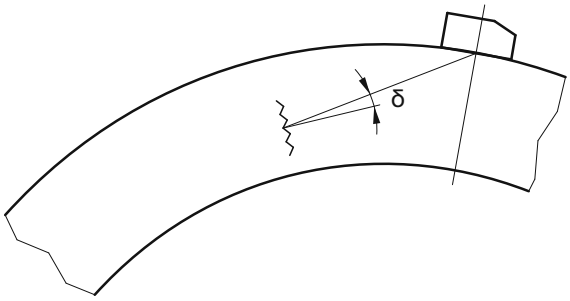


Figure 12-6: Angular deviation between the axis of sound beam and the normal to the surface for defects perpendicular to the surface

(5) Where in special cases for nominal wall thicknesses exceeding 100 mm an angle-pitch-catch technique to detect defects normal to the surface is not possible or reasonable for geometric reasons, a second beam angle shall be selected such that the angular deviation between the axis of the sound beam and the normal to the surface of the defect (angle δ in **Figure 12-6**) is as little as possible, however does not exceed 10°.

(6) When examining electroslag weld for transverse defects (sound entry positions 9 to 16 according to **Figure 12-9**), the same beam angles as used in the examination for longitudinal defects shall be used.

12.3.5.4.2 Scanning surfaces and scanning positions for angle beam and angled pitch-catch techniques

(1) For angle beam scanning the scanning positions shall be selected such that defects oriented in parallel and transversely to the direction of weld progression (longitudinal and transverse defects) are covered. Defect orientations deviating herefrom shall be covered, within the course of scanning for detecting defects longitudinal and transverse to the weld, such that besides oscillating the search unit in repeated to-and-from movements, also additional fanning movements are made.

(2) For nominal wall thicknesses less than 100 mm the following applies:

a) The examination for longitudinal defects (**Figure 12-7**) shall be performed either

aa) from one part surface from scanning positions 1 and 2 or 3 and 4 with full skip distance each, or

ab) from both part surfaces from scanning positions 1 to 4 with half skip distance each.

b) The examination for transverse defects (**Figure 12-7**) shall be performed either

ba) from one part surface from scanning positions 5 and 6 or 7 and 8 with full skip distance each, or

bb) from both part surfaces form scanning positions 5 to 8 with half skip distance each.

c) For angle beam scanning, scanning from two opposite directions with at least one beam angle each is basically required for each volume element. Where the examination is performed from only one surface of the part, at least a full node reflection (skip distance) counted from the end remote from the search unit of the non-evaluable interference zone shall be evaluated (see **Figure 12-8**) for each scanning position to ensure scanning from two opposite directions for all volume areas. Where angle beam scanning is performed from the two surfaces of the part, at least half a skip distance (direct scanning) counted from the end remote from the search unit of the non-evaluable interference zone shall be evaluated (see **Figure 12-8**).

d) Where angle beam scanning is made with two beam angles, the evaluation for the greater angle may only be made up to half the skip distance unless the thickness of the non-evaluable interference zone comprises more than one quarter of the wall thickness. Otherwise, the full node reflections (single bounce technique) shall be evaluated.

e) Where the required minimum evaluable zone cannot be observed or one of the required scanning positions cannot be used, the following substitute measures are permitted:

ea) the use of additional search units with short interference zones,

eb) extensions of the evaluable area for the applicable scanning positions,

ec) application of other ultrasonic techniques or additional radiographic testing,

ed) where the scanning from two opposite directions cannot be performed for certain volumetric areas and the aforementioned substitute measures cannot be taken, the testing level of the scanning direction that can be used shall be increased by 6 dB in the affected area of the sound path travel distance. Where two beam angles are used, this only applies to the smaller of the two angles.

(3) For nominal wall thicknesses equal to or greater than 100 mm the following applies:

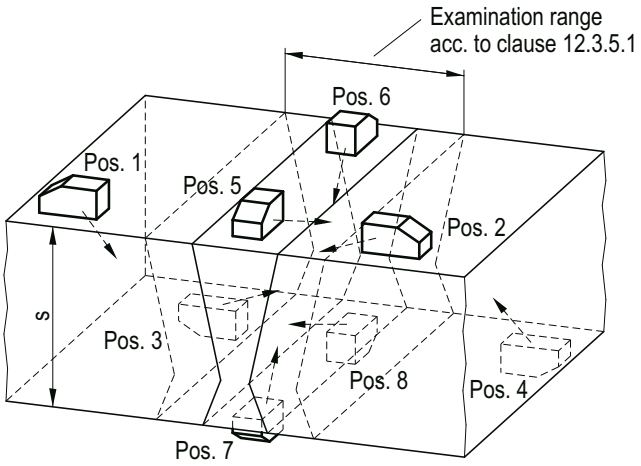
a) The examination for longitudinal defects (**Figure 12-7**) shall be made from both surfaces of the part from scanning positions 1 to 4.

b) The examination for transverse defects (**Figure 12-7**) shall be made from both surfaces of the part from scanning positions 5 to 8.

c) In addition, all stipulations of subclause (2) for angle beam scanning in the case of nominal wall thicknesses less than 100 mm apply if the examination is made from both surfaces.

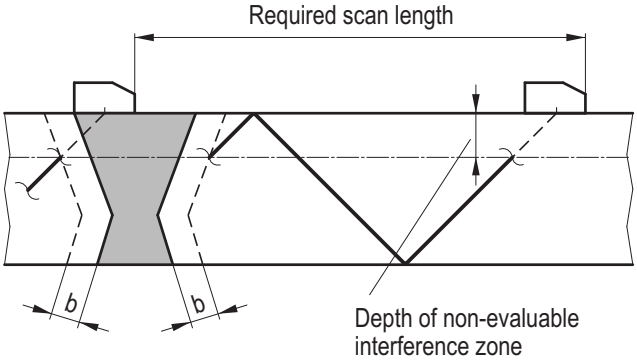
(4) The examination of electro-slag welds shall be made from scanning positions 9 to 16 (**Figure 12-9**).

(5) The angled pitch-catch technique may be performed from one side of the weld and one surface.

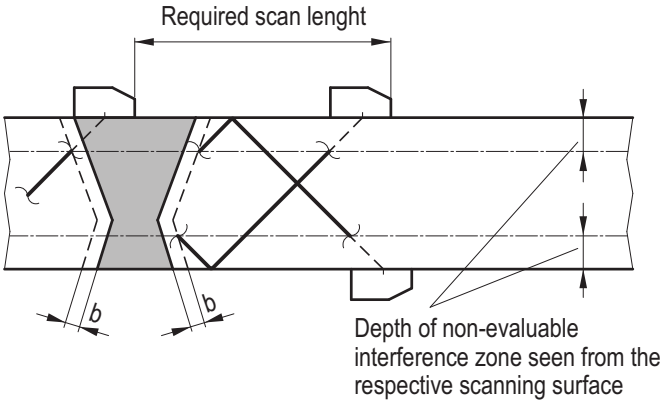


Nominal wall thickness s (mm)	Scanning positions for longitudinal defects	Scanning positions for transverse defects	Minimum area to be evaluated
< 100	1 and 2 or 3 and 4	5 and 6 or 7 and 8	Full skip distance + interference zone
	1 to 4	5 to 8	Half skip distance + interference zone
≥ 100	1 to 4	5 to 8	Half skip distance + interference zone

Figure 12-7: Scanning surfaces, scanning positions and minimum areas to be evaluated where angle beam scanning is performed in accordance with clause 12.3.5.4.2



Minimum evaluable (continuous line) for angle beam scanning from one surface on the part



Minimum evaluable area (continuous line) for angle beam scanning from both surfaces of the part

b: base metal area to clause 12.3.5.1

Figure 12-8: Examples of minimum evaluable area

12.3.5.5 Examination of nozzle and double-bevel groove welds

(1) The examination of nozzle and double-bevel groove welds shall be performed as specified in subclauses 2 to 4 such as to ensure that in the respective examination area longitudinal and transverse defects, lamellar tearing and underclad cracks are detected with regard to their specific locations.

(2) For double-bevel groove welds scanning positions, beam angles and areas to be evaluated as per **Figure 12-10** are required. In the case of wall thicknesses of welded attachments of more than 15 mm, two angles shall be used in positions 2 and 3 for angle beam scanning if straight-beam scanning does not lead to clearly evaluable indications.

(3) For the examination of nozzles scanning positions, beam angles and areas to be evaluated as per **Figures 12-11** to **12-14** are required.

(4) For the testing level adjustment of creeping wave search units, the requirements of **Figure C-10** apply. The creeping wave method is described in Section C 7.

12.3.5.6 Recording levels

(1) All indications reaching or exceeding the recording level shall be recorded.

(2) Indications due to geometric discontinuities that have been demonstrated as such in accordance with Section C 11.3 shall also be entered in the test reports with indication of location, position and size.

(3) In dependence of the method used for testing level adjustment the following recording levels apply:

a) For the testing level adjustment to the DGS method for disc shaped reflectors the echo height of disc shaped reflectors given in **Table 12-6** in dependence of the nominal wall thickness shall be used as recording level.

b) Where during straight beam scanning of double-bevel groove welds (scanning position 1a or 1b, **Figure 12-10**) scan paths 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) If the reference block method or DAC method according to clause 12.3.5.3.2 are used the testing level adjustment shall be based on the reference reflectors given in **Figure C-2**. 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 examined. This may be achieved, if required, by additional scanning positions, beam angles, test frequencies or methods (e.g. use of dual crystal search unit (twin probe testing).

(5) The testing level shall be selected such that during the examination for longitudinal defects reflector indications with echo amplitudes of 6 dB und during the examination for transverse defects reflector indications with echo amplitudes of 12 dB below the recording level as per (3) can be detected.

(6) When examining 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 C 11.2.3 as follows:

a) in the total examination area if their length exceeds twice the length of the allowable lengths of individual reflectors as fixed in **Table 12-7**,

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 12-7**.

(7) If several indications of reflectors (indication clusters) which are indistinguishable from each other appear during testing for transverse defects 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) Where the recording level-to-noise ratio is less than 6 dB, this shall be indicated in the test report and any action to be taken shall be laid down by agreement with the authorized inspector.

(9) Lowering the recording level by 6 dB may be required due to a limited testability at one scanning position (see clause 12.3.5.4.2 ed).

(10) When examining with creeping wave probes, the recording level corresponds to the echo height of a flat-bottom hole or the reference line of the flat-bottom holes as per **Figure C-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.

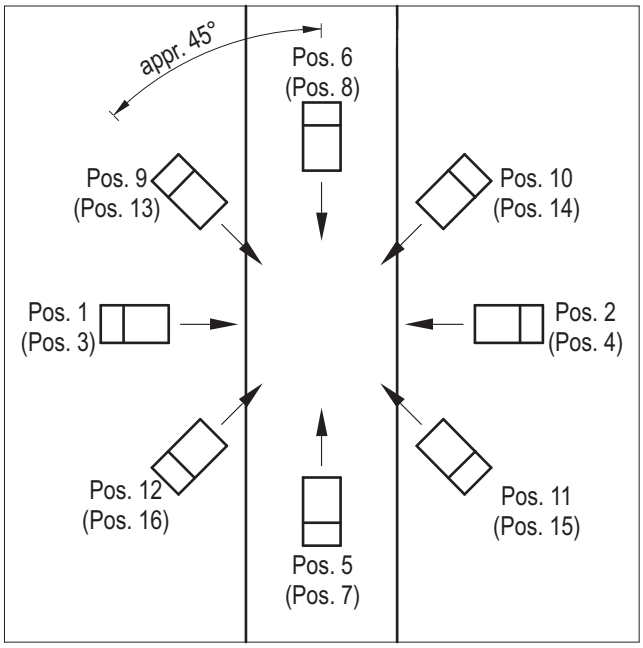
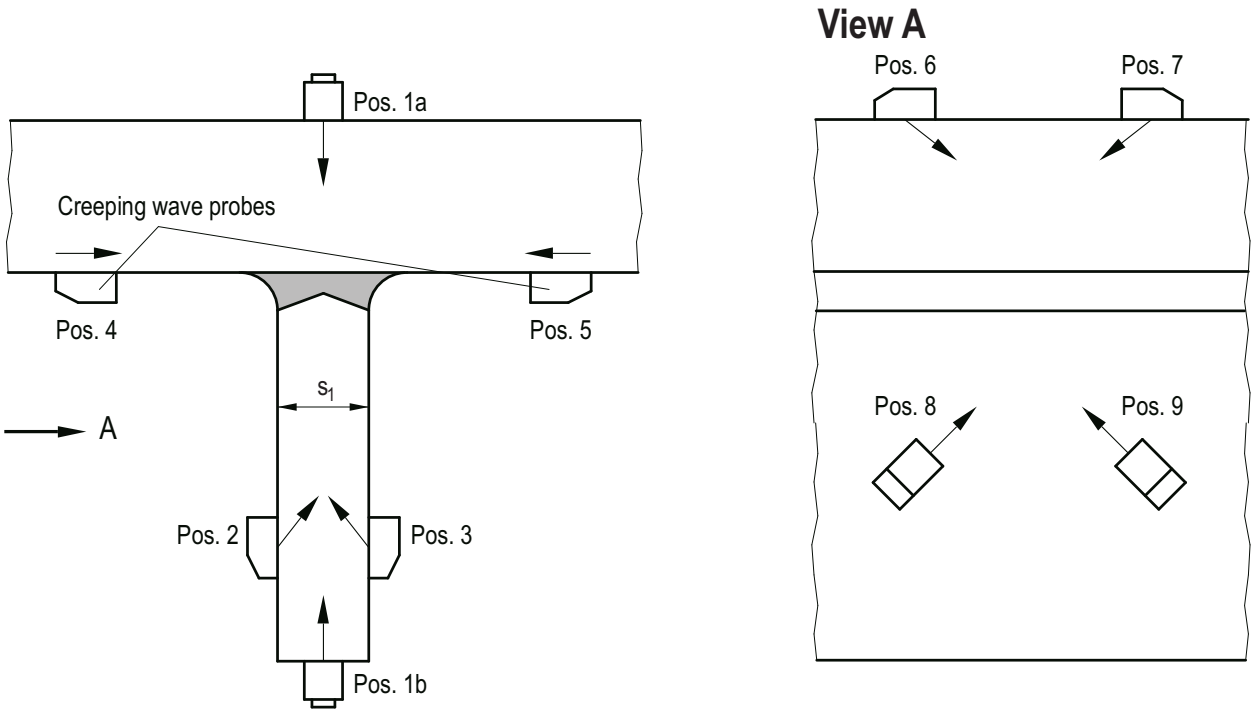
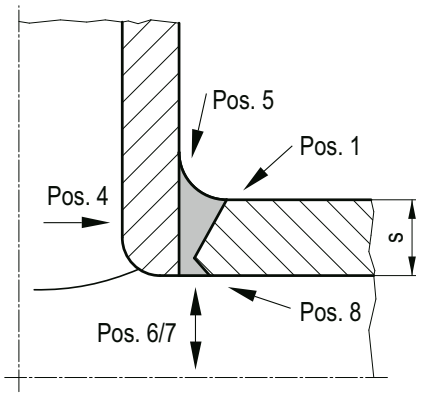


Figure 12-9: Scan directions of the various scanning positions for angle beam scanning for electro-slag welds



Wall thickness (mm)	Scanning positions		Area to be evaluated
	Examination for longitudinal defects	Examination for transverse defects	
$s_1 < 8$	1a, 4, 5	Irrespective of the wall thickness s_1, scanning positions 6 to 9 shall be used.	Pos. 2, 3: 1st angle: half skip distance plus interference zone 2nd angle: half skip distance Pos. 6 to 9: half skip distance
$8 \leq s_1 < 15$	1a or 1b, 4, 5 (2 and 3, if 1a or 1b are restricted)		
$s_1 \geq 15$	1a or 1b, 2, 3, 4, 5 (2 and 3 second angle, if 1b is restricted)		

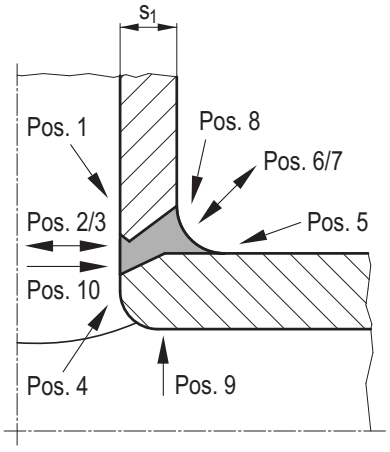
Figure 12-10: Scanning positions and number of beam angles for the examination of attachment welds (double bevel groove welds) as well as areas to be evaluated by angle beam scanning



Set-through nozzle

Wall thickness (mm)	Scanning positions	Area to be evaluated
s < 15	Longitudinal defects: Pos. 1, 8: One angle each Pos. 5: Creeping wave	Pos. 1: Half skip distance plus interference zone Pos. 8: Half skip distance
	Transverse defects: Pos. 6, 7: One angle each	Pos. 6, 7: Half skip distance
s ≥ 15	Longitudinal defects: Pos. 1, 8: Two angles each Pos. 4: Straight beam scanning Pos. 5: Creeping wave	Pos. 1: 1st angle: half skip distance plus interference zone; 2nd angle: half skip distance Pos. 8: Half skip distance
	Transverse defects: Pos. 6, 7: Two angles each	Pos. 6, 7: Half skip distance

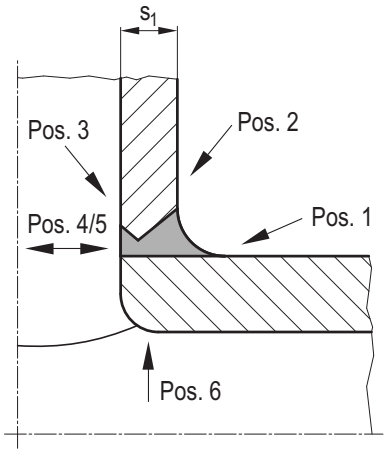
Figure 12-11: Scanning positions and number of beam angles for nozzle examinations (set-through nozzle) and areas to be evaluated by angle beam scanning



Partly set-in nozzle

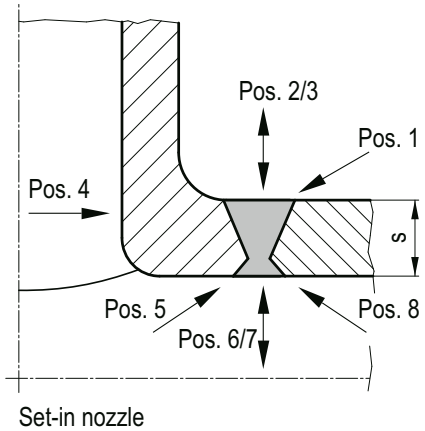
Wall thickness (mm)	Scanning positions	Area to be evaluated
$s_1 \geq 100$	Longitudinal defects: Pos. 1, 4, 8: Two angles each Pos. 5: Creeping wave Pos. 9, 10: Straight beam scanning	Pos. 1, 4, 5: Half skip distance Pos. 8: 1st angle: half skip distance plus interference zone 2nd angle: half skip distance
	Transverse defects: Pos. 2, 3, 6, 7: Two angles each	Pos. 2, 3, 6, 7: Half skip distance

Figure 12-12: Scanning positions and number of beam angles for nozzle examinations (partly set-in nozzle) and areas to be evaluated by angle beam scanning



Wall thickness (mm)	Scanning positions	Area to be evaluated
$s_1 < 15$	Longitudinal defects: Pos. 2, 3: One angle each Pos. 1: Creeping wave	Pos. 2: Half skip distance plus interference zone Pos. 3: Half skip distance
	Transverse defects: Pos. 4, 5: One angle each	Pos. 4, 5: Half skip distance
$s_1 \geq 15$	Longitudinal defects: Pos. 2, 3: Two angles each Pos. 1: Creeping wave Pos. 6: Straight beam scanning	Pos. 2: 1st angle: half skip distance plus interference zone 2nd angle: half skip distance Pos. 3: Half skip distance
	Transverse defects: Pos. 4, 5: Two angles each	Pos. 4, 5: Half skip distance

Figure 12-13: Scanning positions and number of beam angles for nozzle examinations (set-on nozzle) and areas to be evaluated by angle beam scanning



Wall thickness (mm)	Scanning positions	Area to be evaluated
$s \geq 15$	Longitudinal defects: Pos. 1, 5, 8: Two angles each Pos. 4: Straight beam scanning	Pos. 1, 5, 8: 1st angle: half skip distance plus interference zone 2nd angle: half skip distance
	Transverse defects: Pos. 2, 3, 6, 7: Two angles each	Pos. 2, 3, 6, 7: 1st angle: half skip distance plus interference zone 2nd angle: half skip distance

Figure 12-14: Scanning positions and number of beam angles for nozzle examinations (set-in nozzle) and areas to be evaluated by angle beam scanning

12.3.5.7 Acceptance standards

12.3.5.7.1 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 proved to be indications due to external contour as per Section C 11.3.

(3) Where radiographs cover the area with reflectors 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 cladded 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 by the angled pitch-catch technique, in the examination using LLT technique or in the examination with creeping wave probes, they shall be thoroughly examined in accordance with clause 12.3.5.7.4.

12.3.5.7.2 Indications detected in the examination for longitudinal defects

(1) The acceptance criteria for lengths of indication of individual reflectors and the allowable cumulated lengths of the reflectors referred to a reference length are indicated in **Table 12-7** in dependence of the wall thickness. The requirements of sub-clauses 3 to 8 shall be met additionally.

(2) The evaluation of the indications detected when using the single-probe technique depends on their echo height, length of indication, distance from each other and frequency in which case their frequency is represented by the cumulated length (sum of lengths of indications) per reference length. Where accumulations of indications occur over greater weld lengths (to exceed the reference length to **Table 12-7**) these accumulations are considered systematic weld defects and are not acceptable.

(3) Indications of point-type reflectors are permitted in the volume, i.e. outside the subsurface area to clause (4) a) up to an echo height not exceeding the recording level as per Section 12.3.5.6 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 radiography) shall be made.

(4) For sub-surface areas the following applies:

a) The subsurface area is determined as follows:

   aa) 5 mm at $s \leq 40$ mm

   ab) 10 mm at 40 mm $< s \leq 80$ mm

   ac) 20 mm at $s > 80$ mm

   below the finished surface, where s (s_1 for welds on set-on and partly set-in nozzles and weld attachments) is the nominal wall thickness.

b) In subsurface areas lying 5 mm below the finished surface only isolated indications of point-type reflectors are acceptable the echo height of which does not exceed the recording level by more than 6 dB (one reflector per reference length where in the case of a nominal wall thickness exceeding 80 mm the reference length is limited to 480 mm in this specific case).

c) The allowable lengths of indication of individual reflectors and the allowable cumulated length of reflectors in subsurface areas deeper than 5 mm below the finished surface referred to 6 times the nominal wall thickness are given in **Table 12-8** in dependence of the nominal wall thickness. The requirements of (1) to (3) and (5) to (8) of clause 12.3.5.7.2 shall principally be taken into account.

(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 summing-up is based on the length and distance between two admissible indications the echo heights of which exceed the rcording level. The length of one group shall not be used for further summing-up. For the evaluation, one group of indications shall be considered an individual unit if:

a) the distance d_x is less than double the length of the longest indication (see **Figure 12-15**);

b) the distance d_y is less than half the wall thickness, however does not exceed 10 mm;

c) the distance d_z is less than half the wall thickness, however does not exceed 10 mm

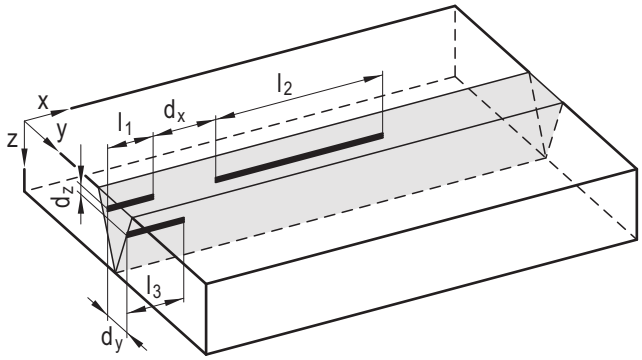


Figure 12-15: Geometric arrangement of accumulated indications during testing for longitudinal defects

(6) Indications recorded as per clause 12.3.5.6 (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 by more than 6 dB as per Section 12.3.5.6 Where indications are found the echo height of which exceeds the recording level by more than 6 dB as per Section 12.3.5.6,

a) their reflectivity shall be examined in dependence of all prescribed scanning directions,

b) a manual double probe technique for the purpose of optimised angled pitch-catch technique or an LLT technique 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 a length of indication of 10 mm.

12.3.5.7.3 Indications detected in the examinations for transverse and oblique defects

(1) The evaluation of indications detected during the examination for transverse and oblique defects which are clearly assignable to a reflector detected when examining for longitu-

dinal defect, shall satisfy the evaluation criteria for longitudinal defects. The evaluation standards hereafter only apply to indications for which it cannot be clearly proved that they originate from a reflector in the examination for longitudinal defects. The evaluation depends on the echo height and frequency of indications.

(2) Recordable indications of reflectors as per clause 12.3.5.6 (3) are only permitted without further check as per clause 12.3.5.7.4 if they are isolated (not more than 3 per metre of weld) and point-type indications, and they are not accompanied by frequent indications up to 12 dB below the recording level.

(3) If several indications indistinguishable from each other in the event of search unit movement appear on the screen (indication clusters) in the examination for transverse and oblique defects, all indications up to 12 dB below the recording level as per clause 12.3.5.6 (3) are permitted only if it can be demonstrated that they are no cracks. This may be demonstrated by means of random tests.

12.3.5.7.4 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 examinations in accordance with the aforementioned requirements may be determined more exactly by additional examinations, and additionally be used in the evaluation. Additional examinations may 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 sub-surface areas, the testing level set by means of the DGS method may be corrected by using sub-surface reference reflectors as per **Figure C-2**.

(3) Where, despite the additional analyses by means of non-destructive examinations, no decision on the acceptability of the indications is possible, a decision shall be made in accordance with clause 5.6.2.1 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.

12.3.6 Radiographic testing upon welding

12.3.6.1 Extent and time of examination

Butt welds and nozzle welds with a nominal wall thickness equal to or less than 40 mm shall be radiographed. For set-on as well as for partly set-in nozzles the nozzle wall thickness and for set-through as well as for set-in nozzles the wall thickness of the part shall govern the examination.

12.3.6.2 Performance of examination

(1) The specifications laid down in Section 12.2.4 apply.

(2) The adjacent base metal areas on both sides of the weld shall be radiographed on a width equal to or greater 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 examination 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.

12.3.6.3 Acceptance standards

(1) The requirements of acceptance limit 1 to DIN EN ISO 10675-1 apply and are supplemented by the following stipulations.

(2) Where the radiographs compared to the indications of ultrasonic testing do not show any or only unclear irregularities, the evaluation shall be made using the results of the ultrasonic testing (see clause 12.3.5.7).

(3) If the acceptability of an irregularity detected by radiography 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. optimised radiography or ultrasonic testing).

(4) 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 examinations.

(5) 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.

(6) For solid inclusions the following applies:

a) The allowable individual and cumulated lengths shall be taken from **Table 12-9**.
b) Where several solid inclusions, pores (porosity), gas pores or wormholes lying one after the other or adjacent to each other occur on greater weld lengths (exceeding six times the nominal wall thickness), they are considered systematic defects and are not permitted.

(7) For wormholes and elongated cavities, the following applies:

a) wormholes and elongated cavities 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.

12.4 Seal welds on claddings of austenitic steels and nickel alloys

(1) The seal welds shall be examined for surface defects by means of penetrant testing.

(2) For seal welds on steam generator tubes indications in the weld metal and HAZ are not permitted.

(3) For the other seal welds the stipulations of **Table 12-10** apply.

12.5 Welded joints on austenitic steels

12.5.1 Ultrasonic testing prior to welding

(1) The weld edges and weld areas shall be subject to ultrasonic testing in which case the post-weld test requirements shall be taken into account.

(2) The scan path width shall be at least 50 mm on both sides of the faying surfaces. Where the component nominal wall thickness exceeds 50 mm, the scan paths width at the faying surface shall be taken equal to the nominal wall thickness. it shall be ensured in both cases that the examined base metal area remaining upon dressing of the weld fusion faces has a width of at least 20 mm.

12.5.2 Surface examination prior to welding

(1) Prior to welding, the fusion faces of welded joints shall be examined for surface defects by means of penetrant testing.

(2) The examinations shall be evaluated in accordance with **Table 12-3**.

12.5.3 Additional evaluation criteria for fusion faces

(1) When evaluating the results obtained from surface examinations on fusion faces, the possible effects of defects, if any, on the weld quality shall be taken into account in dependence of the product form and the welding procedure.

(2) The results of the ultrasonic testing of the weld edges to be performed according to KTA 3201.1 or to clause 12.5.1 shall be included in the evaluation.

12.5.4 Surface examination after welding

(1) The welds shall be subjected to a liquid penetrant testing on their external and internal surfaces, where the surfaces are accessible for liquid penetrant testing.

(2) The stipulations of **Table 12-10** are the evaluation standards for liquid penetrant testing.

(3) Where the wall thickness s is equal to or exceeds 8 mm, the internal surface shall be subjected to ultrasonic testing in accordance with clause 12.5.6.

(4) Where the internal surface is not accessible for liquid penetrant testing in the case of a wall thickness less than 8 mm, a radiographic testing shall be performed with the beam angle perpendicular to the axis of the test object in the case of butt welds. For the evaluation of the radiographic testing the stipulations of clause 12.3.6.3 apply.

12.5.5 Radiography upon welding

12.5.5.1 Extent and time of testing

The stipulations of clause 10.3.5 apply.

12.5.5.2 Performance of testing

(1) The requirements of clause 12.2.4 apply.

(2) The adjacent base metal areas on both sides of the weld shall be radiographed on a width equal to or greater than 10 mm.

(3) Where the requirements for this examination and the requirements for the examination of the internal surface to clause 12.5.4 are satisfied with this test arrangement, one examination with this test arrangement will suffice.

12.5.5.3 Acceptance standards

The requirements of clause 12.3.6.3 apply.

12.5.6 Ultrasonic testing of the internal surface after welding

12.5.6.1 General requirements

(1) Welds with a nominal wall thickness equal to or exceeding 8 mm shall be subject to ultrasonic testing for longitudinal defects. The examination shall be performed as mechanized test from two opposite directions on both sides of single-side welds.

(2) By this examination the internal surface at the transition to the weld metal and the adjacent base metal including the root 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.

(3) Where only limited statements as to the results of the ultrasonic testing of butt welds can be made, a radiographic testing shall be performed with the beam angle perpendicular to the axis of the test object. As to the evaluation the requirements of clause 12.3.6.3 apply.

(4) For the examination of nozzle welds the procedural requirements shall be laid down in the test instructions.

12.5.6.2 Extent and time of examination

The stipulations of clause 10.3.5 apply.

12.5.6.3 Procedural requirements

12.5.6.3.1 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 12.5.6.3.2 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 12.5.6.3.2 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 C**, Sections C 7 and C 8,
e) angled pitch-catch technique as per **Annex D**.

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 seams and dissimilar welds) no sufficient proof of the suitability can be obtained with the above mentioned techniques, 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 transducers,

c) dual-element probe techniques with signal overlapping in half skip range,

d) horizontally polarized transverse waves.

12.5.6.3.2 Proof of suitability of the test technique and testing level adjustment

In addition to the requirements of **Annex C** 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 12-16**. The exact number, locations and dimensions of the notches to be provided on the reference block shall be fixed within the design approval procedure.

b) For the proof of suitability of the test technique, at least three notches with varying depths shall be scanned from both sides of the weld as well as from the edge of the reference block, and the related echo heights shall be determined. Here, one notch shall have a greater depth and one a lower depth than the notch used for testing level adjustment as per **Table 12-11**. The notches shall be provided in the base metal adjacent to the base metal/weld metal transition as per **Figure 12-16**. 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 an increase of the notch depth (**Table 12-12**, case 1)

   bb) the echo height of the notch to be selected as per **Table 12-12** exceeds the noise level with the sound beam angles as per **Figure 12-16** by 12 dB or more.

   bc) the edge echo or the echo height of the additional sufficently deep notch exceeds by at least 6 dB the echo height of the notch to be selected in accordance with **Table 12-11** with the beam angles as per **Figure 12-16**.

   If the edge echo exceeds the echo height of the notch to be selected as per **Table 12-11** by more than 6 dB, this notch shall be taken as reference reflector for testing level adjustment. Otherwise, the test technique shall be optimised. Where, upon optimization of the test technique, the edge echo still does not exceed the echo height of the reference notch by more than 6 dB, the procedure of e) shall be adhered to

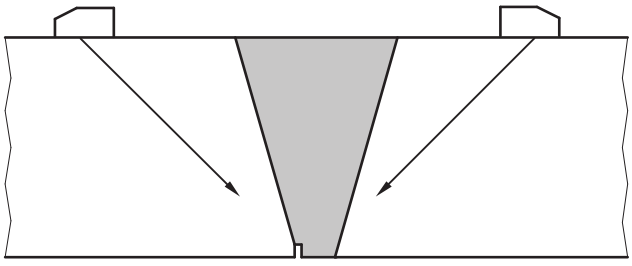


Figure 12-16: Location of notches and beam angles for the examination of welded joints on austenitic steels

c) The testing level adjustment shall be made to the reference block method in due consideration of the recording level to be adjusted. For the examination area „area adjacent to the weld“, the reference reflector shall be scanned directly. For the examination 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 3201.1, local variations of sound attenuations which were determinated within the testing suitability determination as per KTA 3201.1, clause 22.4.2.3.2 (9) on a circumferential notch shall be taken into account for the weld edge areas of such product forms.

d) Where a reduction of the signal-to-noise ratio of 6 dB and more compared to the reference block is ascertained during the examination, the suitability for through-transmission of the respective root area shall be checked by suitable measures (e.g. through-transmission of the root area on the reference block and the test object with reduced beam angle). If the signal-to-noise ratio is smaller than 6 dB even with an adapted test technique to 12.5.6.3.1 (4), the procedure of e) shall be adhered to.

e) Where the criteria of b) and d) cannot be satisfied in parts of the test area (e.g. in the case of dissimilar welds with buttering during the examination for longitudinal defects at the transition between buttering and weld metal, or during the examination for transverse defects) the following shall be done (see **Table 12-12**, 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 with the available notches cannot be determined, further depth-graduated notches or realistic reference flaws (cracks) shall be provided in the reference block. All notches with a depth greater than that of the reference notch shall show an echo height of at least 6 dB above the noise level including a transfer correction, if any.

   There must be a differentiation between the reference notch pattern and the noise signals as well as clear distinction between the reference notch pattern and the edge pattern. The evaluation criteria for comparing the display patterns shall be determined in the test instruction on the basis of the results obtained from reference block measurements (e.g. pattern dynamics, correlation of indication patterns at varying beam angles and wave modes, crack-tip signal detection).

   If the reference notch shows a depth greater than that of the notch to be selected according to **Table 12-11**, a safety evaluation shall be made regarding the conclusiveness of the test in which case the re-calculations shall be based on a conservative defect as regards its length and depth extension (reference value: double the depth of the reference notch with a length to correspond to the total area for which the reference notch with a depth greater than that of the notch to be selected according to **Table 12-11**) is used.

12.5.6.3.3 Determination of length of indication

Where the echo amplitudes reach or exceed the respective recording levels, the lengths of the pertinent reflectors shall be measured in accordance with clause C 11.2.3 (half-amplitude method).

12.5.6.4 Recording levels

(1) The echo height of the reference reflector in dependence of the nominal wall thickness as per **Table 12-11** plus a sensitivity allowance of 6 dB shall be used as recording level. When optimising the test technique, the recording level fixed in clause 12.5.6.3.2 b) shall be used.

(2) All echo indications shall be recorded where they reach or exceed the recording level.

(3) Where the test techniques to clause 12.5.6.3.2 e) are applied, all indications showing characteristic properties of the display patterns determined for reference reflectors shall be recorded and be evaluated.

(4) Echoes 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.

12.5.6.5 Acceptance standards

(1) On accessible locations surface imperfections causing indications shall be removed by machining.

(2) Indications from inaccessible root areas are only permitted if they are caused by excess penetration and if they can be verified to be indications due to external contour.

(3) Where radiographs cover the area with reflectors such that an evaluation is possible, they shall be included in the evaluation.

(4) Where the test techniques to clause 12.5.6.3.2 b) are applied, indications are permitted which, according to their number, echo height exceeding the recording level, and length, are within the limits shown in **Table 12-13**, and after verification, e.g. by means of the wave mode conversion method I, do not lead to planar separations.

(5) Where the test techniques to clause 12.5.6.3.2 e) are applied, the acceptance limit will be exceeded if the indications show characteristic properties of the display patterns determined for the reference reflectors.

(6) The distance between adjacent indications shall be at least 20 mm.

12.6 Welded joints between ferritic steels and austenitic steels

12.6.1 Examinations prior to welding

The requirements of clauses 12.3.1, 12.3.2, 12.5.1 and 12.5.2 apply.

12.6.2 Ultrasonic testing upon buttering for bonding

(1) Prior to dressing the fusion faces the butterings shall be completely examined for bonding by means of straight-beam scanning. Where heat treatment is performed, this examination shall be made upon such heat treatment.

(2) For 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. 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 extension of reflectors shall be determined in accordance with Section C 11.2.3 (half-amplitude method). Reflectors form the buttering to base metal transition reaching or exceeding 50 % (- 6 dB) of the reference echo amplitude shall be recorded indicating the reference echo. 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 by agreement with the authorized inspector.

(4) The evaluation of reflectors shall be based on the lengths of indication and frequency of indications unless their echo amplitudes exceed the recording level by more than 6 dB. **Table 12-7** contains acceptance criteria for the length of indication of individual reflectors and frequencies as accumulated length (sum of lengths of indications) per reference length. Reflectors which in depth orientation (in wall thickness direction, perpendicular to the beaming 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 progress. 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.

12.6.3 Surface examination upon buttering

Prior to welding the connecting weld, the butterings shall be examined for surface defects by means of liquid penetrant testing. The stipulations of **Table 12-10** apply to the acceptance standards for liquid penetrant testing.

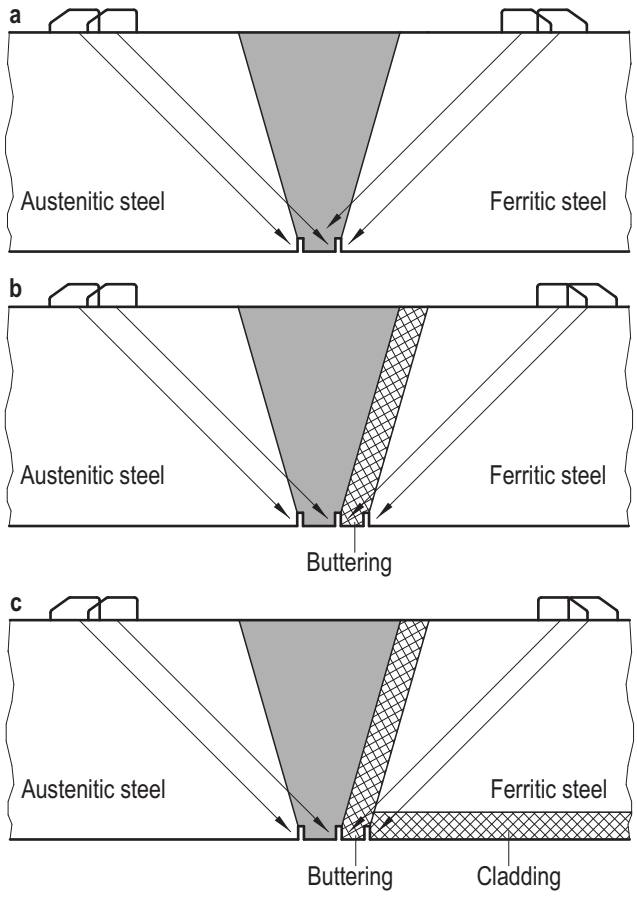


Figure 12-17: Location of notches and beam angles for the examination for longitudinal defects of welded joints between ferritic steels and austenitic steels

12.6.4 Examination upon welding

12.6.4.1 Examination of welds including buttering

(1) The requirements of clauses 12.5.4, 12.5.5 and 12.5.6 apply.

Note:
Additional requirements for baseline inspections are laid down in clause 12.2.4.4.

(2) Deviating from clause 12.5.6 the following applies: For the purpose of proving the suitability of the test technique and the testing level adjustment of the examination for longitudinal defects, the notches shall be milled into the reference block to clause 12.5.6.3.2 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 12-17**. As to the testing level adjustment the following applies:

a) For the examination area “adjacent to the weld” the reference reflectors shall be scanned directly.

b) For the examination area “weld root” in the case of unbuttered welds the reference reflectors shall be scanned through the weld metal.

c) For the examination 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.

12.6.4.2 Examination for bonding at the interface to the ferritic base metal

(1) Upon welding of the connecting weld, the interface shall be examined for bonding by means of the ultrasonic or radiographic method. The following shall be performed:

a) ultrasonic testing for wall thicknesses equal to or greater than 16 mm,

b) ultrasonic or radiographic testing in the wall thickness range equal to or greater than 8 mm and less than 16 mm,

c) radiographic testing for wall thicknesses smaller than 8 mm.

Where the use of ultrasonic testing is restricted for these areas, a radiographic testing shall be performed additionally.

(2) The ultrasonic testing shall normally be performed from the ferritic side of the weld. The test techniques and beam angles shall be selected such that flaws oriented in parallel to the interface of the ferritic base metal are covered. The extension of the reflectors shall be determined as per Section C 11.2.3 (half-amplitude technique).

a) For the examination 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 creep wave technique for the interface below the scanning surface,

ab) the transverse wave single probe technique for the interface ahead of the mating 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 12.5.6.3.2 as well as 12.6.4.1 (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 12-18a**. 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 fixed in dependence of the nominal wall thickness as per **Table 12-11**. In the case of clad ferritic base metal, a flat-bottom hole to **Figure 12-18b** located directly above the cladding may be used alternatively for adjustment of the testing level.

For the determination of the recording level clause 12.5.6.4 applies, the evaluation shall be made to clause 12.5.6.5.

b) For examination of non-subsurface areas including the lower flat bottom hole to **Figure 12-18b** the following techniques may be used:

ba) the angled pitch-catch technique,

bb) the wave mode conversion method II (LLT technique),

bc) 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 in due consideration of the requirements of Section D 4.6 on a reference block with 6 mm flat-bottom holes as shown in **Figure 12-18**. 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 examined. The reference reflectors (flat-bottom holes) 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 12-6 applies to the determination of the recording level, the evaluation shall be made to clause 12.6.2 (4).

Where beam angles are used to hit the interface vertically, the requirements of subclauses 2, 3 and 4 of clause 12.6.2 apply.

(3) In the 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 radiography shall be performed. Where single-wall radiography is not practicable, further procedural steps shall be laid down in the test instructions. In addition, the requirements of clause 12.3.6 apply.

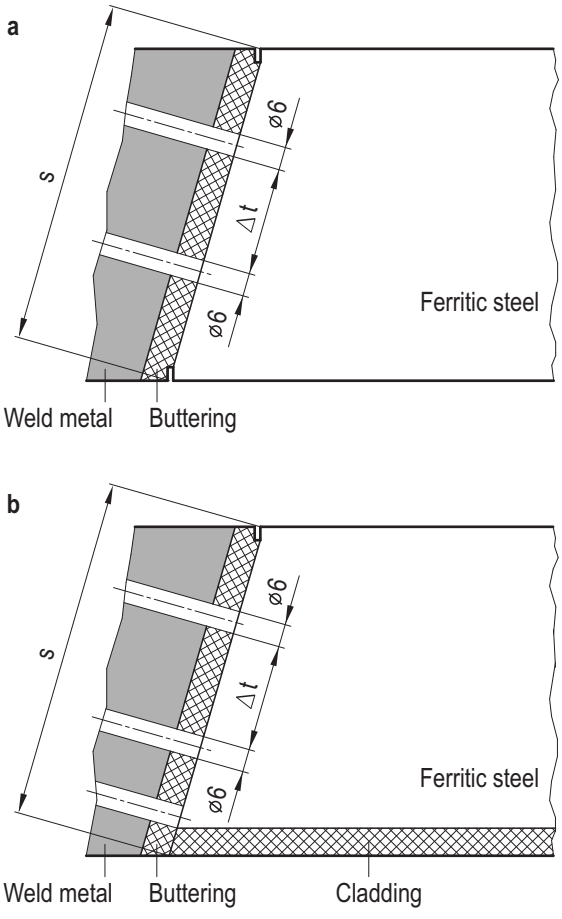


Figure 12-18: Location of flat bottom holes and notches for the examination for bonding at the interface to the ferritic base metal on welded joints between ferritic and austenitic steels

12.7 Ferritic shaping deposition welds (except for hard surface overlays and butterings for hard surface overlays)

12.7.1 Surface examination prior to welding

(1) Surfaces to be deposition welded shall be examined for surface defects unless this examination has already been performed to KTA 3201.1. In the case of limited accessibility or insufficient magnetizability the liquid penetrant method may be use instead of the magnetic particle method.

(2) For surfaces of product forms the respective requirements of KTA 3201.1 and for weld surfaces the requirements of clause 12.3.4 shall apply with regard to the evaluation of test results.

(3) For fusion faces to be buttered the requirements of clause 12.3.2 apply.

12.7.2 Surface examination upon welding

(1) Deposition welds shall be examined for surface defects in their final condition. Where heat treatments are performed, the examination shall be performed after the final heat treatment. Areas which can only be examined to a limited extent after the final heat treatment shall be examined at an earlier date where unrestricted examination is possible. Where a stress-relief treatment is made, the examination shall be performed after such heat treatment.

(2) In the case of limited accessibility or insufficient magnetizability the liquid penetrant method may be used instead of the magnetic particle method.

(3) The requirements of **Table 12-5** apply regarding the acceptance standards for magnetic particle or liquid penetrant testing.

12.7.3 Ultrasonic testing upon welding

12.7.3.1 Extent and time of examination

(1) Deposition welds shall be subjected to ultrasonic testing.

(2) Where heat treatments are made, the ultrasonic testing shall be performed upon final heat treatment.

(3) Areas which upon final heat treatment can only be examined to a limited extent shall be examined at an earlier date where unrestricted examination is possible.

12.7.3.2 Procedural requirements

(1) The requirements of clause 12.3.5.3 apply.

(2) When examining from the surface of the deposition weld (see **Figure 12-19**), the determination of the length of indication instead of the nominal wall thickness shall be based on the height of the deposition weld.

12.7.3.3 Performance of examination

(1) Deposition welds serving as butterings for welded joints (see examples in **Figure 12-19**) shall be examined along with the weld and are subject to the same acceptance standards for evaluation.

(2) The other deposition welds shall be examined from the surface of the deposition weld by means of angle-beam or straight-beam scanning. 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. It shall be ensured that the entire weld volume including an adjacent base metal area of at least 10 mm is covered and evaluated.

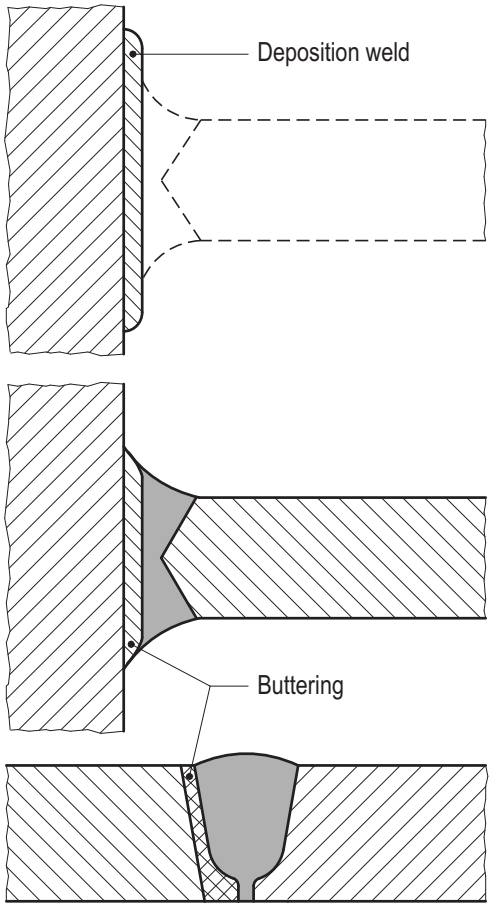


Figure 12-19: Examples of deposition weld and buttering for connecting welds

12.7.3.4 Recording levels

The specifications laid down in clause 12.3.5.6 apply with regard to the recording levels.

12.7.3.5 Acceptance standards

Deposition welds shall be evaluated in accordance with clause 12.3.5.7. **Table 12-7** shall be applied such that instead of the wall thickness the height of the deposition weld is used. Where the height of the deposition weld is smaller than its width, the width of the deposition weld shall govern. In such a case the deposition weld may be subdivided in strips of 60 mm width and each strip be evaluated individually with respect to the reflectors.

12.8 Weld claddings and shaping deposition welds of austenitic steels and nickel alloys

12.8.1 Surface examination prior to welding

(1) Surfaces to be clad welded or shaping deposition welded shall be examined for surface defects unless this examination has already been performed to KTA 3201.1.

(2) For surfaces of product forms the respective requirements of KTA 3201.1 and for weld surfaces the requirements of clause 12.3.4 shall apply with regard to the evaluation of test results.

12.8.2 Surface examination upon welding

(1) Weld claddings or shaping deposition welds shall be completely examined for surface defects by means of the liquid penetrant method. Where heat treatments are per-

formed, these examinations shall be performed upon final heat treatment. Areas which can only be examined to a limited extent after the final heat treatment shall be examined at an earlier date where unrestricted examination is possible.

(2) The requirements of **Table 12-14** apply regarding the acceptance standards for liquid penetrant testing.

12.8.3 Ultrasonic testing upon welding

12.8.3.1 Extent and time of testing

(1) Weld claddings or shaping deposition welds shall be completely examined by means of straight-beam scanning. Where heat treatments are performed, this examination shall be performed upon the final heat treatment.

(2) Where the weld claddings or shaping deposited welds is no more accessible upon final heat treatment, the examination shall be performed prior to the final heat treatment, but at least after a stress-relief treatment.

(3) Within the knuckle area of steam generator tubesheets (fillet at the tubesheet/spherical section transition) and in the case of welding procedure qualification tests to clause 9.4.2 the transition zone between weld cladding and base metal shall be examined for underclad cracking by means of angle-beam scanning.

12.8.3.2 Procedural requirements

12.8.3.2.1 Testing level adjustment

(1) For adjustment of the testing level the indication of a side-drilled hole of 3 mm diameter shall be used as reference echo, with the bore being parallel to the surface in the base metal at the interface to the deposition weld.

(2) The reference block shall correspond to the test object as regards the test-relevant characteristics (material, weld metal overlay, heat treatment, shape, wall thickness). In the case of differing scan paths in the reference block and in the part, formula C-10 to Section C 2.3 may be used for correcting the scanning sensitivity level of transceiver probes if the examination is performed from the base metal side.

12.8.3.2.2 Determination of the extension of reflectors

The extension of reflectors shall be determined in accordance with Section C 11.2.3 (half-amplitude method).

12.8.3.3 Performance of examination

(1) For straight-beam scanning the examination shall be performed either from the base metal side or the weld cladding or shaping deposition weld side.

(2) For angle-beam scanning the juncture between weld cladding or shaping deposition weld/ferritic base metal shall be examined with suitable angle beam search units, e.g. using the dual-element probe technique and longitudinal waves. The probes units shall have their maximum sensitivity level at the weld cladding or shaping deposition weld/base metal juncture.

12.8.3.4 Recording levels

(1) For indications from the transition weld cladding or shaping deposition weld/ferritic base metal the following recording level apply:

a) during straight-beam the echo amplitude of the reference reflector plus a sensitivity allowance of 6 dB,
b) during angle beam scanning the echo amplitude of the reference reflector plus a sensitivity allowance of 14 dB.

All indications reaching or exceeding the recording level shall be recorded.

(2) If the signal-to-noise ratio, referred to the recording 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.

12.8.3.5 Acceptance standards

(1) For straight-beam scanning the indications liable to recording are to be evaluated as follows:

a) Individual reflectors with a length of indication equal to or less than 10 mm shall be considered non-cohesive areas with a cross-sectional area of 100 mm^2 when determining the total cohesive area.
b) 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 cohesive area, linear reflectors shall be considered as non-cohesive areas with a width of 10 mm.
c) Plane reflectors are permitted up to a maximum cross-sectional area of 1000 mm^2.
d) Referred to the total area the portion of the cohesive area shall be 98 %, where it is permitted that locally, i.e. referred to a cross-sectional area of 1m · 1 m the portion of the cohesive area is only 95 %.

(2) For angle-beam scanning recordable indications suggesting crack-like defects shall be examined as to their cause (e.g. through telltale holes). Cracks are basically not permitted unless they are isolated and have been proven to be harmless.

12.8.3.6 Additional requirements for attachment weld areas on deposition welds (claddings) for welded attachments

(1) The area below the weld zone and the adjacent areas of a width each with 80 mm are considered to be the attachment area on the weld cladding for welded attachments.

(2) The attachment weld areas shall be examined by straight-beam scanning in accordance with clauses 12.8.3.1 to 12.8.3.4 prior to attachment welding from the base metal and the cladding and, after attachment welding, from the base metal side. Here, in addition to the requirements of clause 12.8.3.4, also indications from the full clad weld volume obtained by straight-beam scanning shall be recorded. Here, the recording level shall be the reference echo amplitude of a side-drilled hole of 3 mm diameter, plus a sensitivity allowance of 6 dB.

(3) In addition to the requirements of clause 12.8.3.5, the following acceptance standards apply:

a) Reflectors leading to indications which exceed the recording level by more than 6 dB are not permitted.
b) For the extension of reflectors, the following guide values apply:

   In the direction of deposition welds (cladding) progression reflectors with half-amplitude length exceeding 30 mm and smaller reflectors with half-amplitude lengths equal to or greater than 10 mm are not permitted if they have a distance from each other of less than 25 mm. Where accumulations of reflectors in the attachment area of a cladding are found, any further action to be taken shall be fixed jointly with the authorized inspector.

12.9 Hard surface overlays and butterings for hard surface overlays

12.9.1 Surface examination of the base metal prior to welding

(1) Surfaces to be covered with a hard surface overlay or buttering shall be examined for surface defects unless this examination has already been performed to KTA 3201.1. In the case of limited accessibility or insufficient magnetizability the liquid penetrant method may be used instead of the magnetic particle method.

(2) The requirements of KTA 3201.1 apply for acceptance standards for the respective product form.

(3) When evaluating the results, the effects of defects on the quality of the hard surface overlay and buttering shall be considered in dependence of the product form and the weld metal.

12.9.2 Surface examination of butterings for hard surface overlays

(1) The surfaces of butterings to be covered by a hard surface overlay shall be examined for detecting surface defects. Where heat treatments are performed, this examination shall be made upon final heat treatment.

(2) When evaluating the results, the effects of defects on the quality of the hard surface overlay in dependence of the overlay weld metal shall be considered.

(3) On surfaces to be covered by a hard surface overlay, isolated indications with extensions equal to or less than 1.5 mm detected by magnetic particle testing and isolated indications with extensions equal to or less than 3 mm detected by liquid penetrant testing are permitted.

12.9.3 Ultrasonic testing of butterings for hard surface overlays

The whole buttering shall be subjected to ultrasonic testing. The examination shall be made along with the examination of the hard surface overlay as per clause 12.9.5.

12.9.4 Surface examination of hard surface overlays

(1) The entire surface of the hard surface overlay and of the adjacent buttering shall be examined in the finished condition by the liquid penetrant method.

(2) The evaluation criteria (standards) hereinafter only apply to the functional area of hard surfacings (e.g. for the bearing surfaces of sliding and guiding elements, for the effective bearing face of seals subject to static or dynamic loadings). Outside the functional area (geometric transition to the base metal) the requirements for the base metal apply.

(3) Sealing surfaces shall be free from indications within their functional areas (e.g. tangent lines in the case of ball sealing surfaces). In the case of other surfaces, pores with a tail equal to or less than 6 mm at an effective extension equal to or less than 1.5 mm are permitted with a maximum number of 10 per dm^2 provided that the pore edges are spaced at least 3 mm from each other.

12.9.5 Ultrasonic testing of the hard surface overlay

12.9.5.1 Extent and time of testing

(1) The hard surface and, where provided, the adjacent buttering shall be examined with a beam angle perpendicular to the cohesive zone.

(2) Where heat treatments are made, the examination shall be performed after the final heat treatment.

12.9.5.2 Testing level adjustment

(1) For 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 surface in the base metal at the interface to the buttering or 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.

12.9.5.3 Determination of reflector extension

All recordable indications shall be measured as to length and width. The extension of the reflectors shall be given as the search unit movement path at the beginning and end of which the echo amplitudes have fallen by 6 dB below the recording level (see clause C 11.2.2). In this case, the sound beam diameter at the location of indication may be considered in accordance with clause C 11.2.4.3.

12.9.5.4 Performance of examination

The examination shall be performed from the side of the hard surface overlay by means of straight-beam scanning using the dual-element probe technique.

12.9.5.5 Recording levels

The recording level corresponds to the echo amplitude of the respective reference reflector as per clause 12.9.5.2 plus a sensitivity allowance of 6 dB. All indications reaching or exceeding the recording level shall be recorded.

12.9.5.6 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 cohesive area shall be 98 %. Individual lack of fusion is permitted up to an area of 250 mm^2.

12.10 Areas of removed welds on ferritic and austenitic parts

(1) Areas where welded attachments or depositions welds were temporarily attached the weld attachment area including the HAZ of which has not been removed shall, upon final heat treatment, be subjected to an examination for surface defects and additionally in the case of ferritic components an ultrasonic testing for subsurface defects.

(2) Areas that can be examined only to a limited extent upon final heat treatment shall be examined at an earlier date where unrestricted examination is possible.

(3) Where the weld attachment area including the HAZ is removed and this is proved by etching, a surface examination shall be performed.

(4) The requirements of KTA 3201.1 apply with regard to the procedural requirements for the surface examination and ultrasonic testing to be performed on the respective product form.

(5) During surface examination no crack-like defects are permitted. Where the indications reach or exceed the recording level as per **Table 12-6**, any further action to be taken shall be fixed jointly with the authorized inspector.

12.11 Base metal surfaces of the pressure boundary upon final heat treatment

(1) The surface of base metals in the accessible area of the pressure-retaining boundary shall be examined for surface defects upon the last heat treatment. In the case of local heat treatment the examination is limited to the area influenced by heat treatment.

(2) Regarding the extent, performance and evaluation of the examination the requirements of the product form-related section of KTA 3201.1 shall apply.

12.12 Tests and inspections in connection with the first pressure test

12.12.1 General requirements

(1) Prior to and after the first pressure test non-destructive tests and inspections shall be performed in areas where significant plastic deformations are expected due to the loading applied in the first pressure test. Taking the design, materials, and fabrication procedures into account, these areas shall be fixed jointly with the authorized inspector by means of the results of the design approval or strain measurements.

(2) Jointly with the authorized inspector a decision shall be made whether it is necessary to include tolerated deviations from specified fabrication (e.g. wall thickness less than required, misalignment, ultrasonic volumetric indications) in the extent of examination for the purpose of toleration.

(3) Prior to and after the first pressure test, the areas determined in accordance with (1) and (2) shall be examined with the same examination procedures and techniques.

(4) The non-destructive tests and examinations performed in the course of fabrication are considered tests and inspections prior to the first pressure test if they are performed with the same test methods and techniques provided for tests and inspections after the first pressure test.

12.12.2 Extent of examination

12.12.2.1 Clad-welded areas of parts

(1) Clad-welded ferritic areas of a part shall be subjected to ultrasonic testing to detect defects normal to the surface and normal to the direction of loading in the subsurface area of the base metal under the cladding. The subsurface areas are defined in clause 12.3.5.7.2 (4).

(2) In addition, the weld cladding shall be examined, if possible, for surface defects.

12.12.2.2 Areas of parts made of unclad ferritic and austenitic steels

(1) A surface examination shall basically be performed.

(2) Where surface examination is not feasible, an ultrasonic testing shall be performed to detect surface cracks normal to the surface and normal to the direction of loading.

12.12.3 Performance of examination and acceptance standards

12.12.3.1 Surface examination

12.12.3.1.1 Areas of a part made of ferritic steels

Clause 12.3.4 applies regarding the acceptance standards for welds. For ferritic base metals the examinations as per KTA 3201.1 shall be performed and be evaluated.

12.12.3.1.2 Areas of a part made of austenitic steels

For austenitic base metals the examination as per KTA 3201.1 shall be performed and be evaluated. For connecting welds the acceptance standard as per clause 12.5.4 applies.

12.12.3.1.3 Weld claddings of austenitic steels and nickel alloys

Clause 12.8.2 shall apply.

12.12.3.2 Ultrasonic testing

12.12.3.2.1 Clad weld areas of a part

(1) The zones beneath the claddings shall be examined by means of angle beam scanning with suitable angle-beam search units, e.g. using the dual-element probe technique and longitudinal waves from the side of the cladding. The search units shall have their maximum sensitivity level in the cladding/ferritic material transition.

(2) For the testing level adjustment a similar reference block shall be used with notches vertical to the surface which are to be made by milling or electric discharge machining. The width of the notches shall not exceed 1.5 mm and their length, not counting the runout, shall normally be 20 mm. The reference reflector shall be a notch penetrating the cladding with a depth extending 3 mm into the ferritic base metal. The reference block shall correspond to the test object as regards the test-relevant characteristics (material, heat treatment, shape, wall thickness, cladding).

(3) The recording level corresponds to the echo height of the reference reflector to **Table 12-11**, plus a sensitivity allowance of 6 dB. All indications reaching or exceeding the recording level shall be recorded. If the recording level-to-noise ratio distance is less than 6 dB, this shall be entered in the test report and any further action to be taken shall be fixed jointly with the authorized inspector.

(4) The extension of reflectors shall be determined in accordance with clause C 11.2.3 (half-amplitude method).

(5) Where recordable indications are obtained in the examination, which suggest the presence of crack-like defects, the type and cause of the indications shall be ascertained and any further action to be taken shall be fixed jointly with the authorized inspector.

(6) Where the examination cannot be performed from the weld cladding surface, the performance of the examination and the acceptance standards shall be fixed jointly with the authorized inspector.

12.12.3.2.2 Unclad areas of ferritic parts

(1) The examination shall be performed by angle-beam scanning from the accessible surface in which case transverse waves with an angle of incidence $ß_1$ of 35° to 55° on the opposite surface (see **Figure 12-5**) shall preferably be used.

(2) For setting the sensitivity level a 1 mm deep notch with a length exceeding the sound beam diameter at the opposite surface of a reference block shall be used.

(3) The wall thickness of this reference block shall have the wall thickness of the test object $\pm$ 10%.

(4) All echo indications from the opposite face which reach or exceed the reference echo amplitude shall be recorded.

(5) Where recordable indications are obtained in the examination, which suggest the presence of crack-like defects in the opposite face, the type and cause of the indications shall be ascertained and any further action to be taken shall be fixed jointly with the authorized inspector.

12.12.3.2.3 Welded joints on austenitic steels

The performance of the examination shall be fixed jointly with the authorized inspector, in which case the requirements of clause 12.5.6 shall be taken into account.

12.12.3.2.4 Welded joints between ferritic and austenitic steels

The performance of the examination shall be fixed jointly with the authorized inspector, in which case the requirements of clause 12.6.4 shall be taken into account.

12.13 Forming operations on pipes

(1) The unbent pipes shall have been tested in accordance with the requirements of KTA 3201.1. Bent pipes shall be examined for surface defects over the entire bent section on the inner and outer surface. Where heat treatment is performed after bending, the surface inspection shall be performed after such heat treatment. With respect to the examination method to be used, the procedural requirements and the acceptance standards, the stipulations for the examination of pipe bends as per Section 17 (ferritic materials) or Section 24 (austenitic materials) of KTA 3201.1 apply.

(2) The examination of the inner surface may be substituted by an ultrasonic testing for defects on the inner surface. Notches shall be used as reference reflectors in conformance with the requirements for the ultrasonic testing of pipe bends as per Section 17 (ferritic materials) or Section 24 (austenitic materials) of KTA 3201.1. The testing level required in the aforementioned sections of KTA 3201.1 shall be maintained over the entire scanning area with due consideration of the changes in wall thickness and curvature radii.

(3) The reference blocks shall be selected such that the notch depth and the calibration distances correspond to the wall thickness of the original pipe with a tolerance of 10%. In addition, the angles of incidence of the reference block and the part shall not differ by more than 5°.

12.14 Recording of test results

12.14.1 General

Where **Table 10-1** 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).

12.14.2 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) Examination results obtained from similar test objects for which identical test instructions have been established, may be comprised in overall records.

12.14.3 Mechanised ultrasonic testing

The manufacturer shall establish test reports. As regards the control of the performance of the examination and the test results obtained the other participants in the examination shall countersign the manufacturer's report.

12.14.4 Surface examination

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.

12.14.5 Radiography

The manufacturer shall establish test reports. As regards the random checking that the examination is performed and the test results obtained the other participants in the examination shall countersign the manufacturer's report. Deviating evaluation columns shall be entered and be marked by the authorized inspector.

12.14.6 Overview on the results obtained by non-destructive tests and inspections (NDT)

Recordable indications detected by ultrasonic testing and recorded imperfections detected by radiography 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 (zero atlas) indicating the sequence of welds examined with the pertinent test report number and be added to the final file. This also applies to tolerated deviations from NDT requirements.

12.14.7 Forms for test records

The use of **forms A-15** 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 the performed examinations.

Accessibility, scanning conditions		Testing at	Scan path L (scanning surface) [1], in mm		
			$s \leq 20$	$20 < s \leq 40$	$s > 40$
Welds on ferritic steels	Accessibility from both surfaces and scanning from one side of the weld or accessibility 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 face) 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 12-1: 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 12-2: Scan paths L* for radiographic testing (see Figure 12-4)

Indications ≤ 3 mm individual	Indications ≤ 3 mm clustered locally	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 locally	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 liquid penetrant indication is considered a linear indication if its dimension in the direction of maximum extension is at least three times its smallest dimension transverse to this direction.

[2] Differing from these stipulations and by agreement with the authorized inspector, indication lengths > 6 mm caused by linear carbo-nitride indications may be permitted for Ti-stabilized austenitic materials.

Table 12-3: Acceptance standards for liquid penetrant testing of fusion faces

Indications ≤ 1.5 mm individual	Indications ≤ 1.5 mm clustered locally	Indications > 1.5 mm up to ≤ 10 mm individual non-metallic inclusions parallel to part surface	Indications > 1.5 mm clustered locally	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 12-4: 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.			
(2) Liquid penetrant testing			
Indications outside the fusion line or HAZ			Indications in the fusion line or heat affected zone
Indications ≤ 3 mm	Indications > 3 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.			

Table 12-5: Acceptance standards for magnetic particle and liquid penetrant testing on ferritic seam and deposition welds

Nominal wall thickness [1] s in mm	Diameter of the respective disc shaped reflector in mm			
	Straight beam scanning	Angle beam scanning	Angled pitch-catch technique	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 [3]	—	6.0 [3]
40 < s ≤ 80	3.0	3.0 ; 6.0 [3]	6.0 [2]	6.0 [2] [3]
s > 80	3.0	3.0	6.0	—

[1] For butt welds with differing nominal wall thicknesses clause 12.3.5.1 (3) shall govern.

[2] Applies only to the examination of narrow gap welds in accordance with clause 12.3.5.4.1 (3).

[3] Applies to the examination for bonding at the interface to the ferritic base metal in accordance with Section 12.6.4.2.

Table 12-6: Recording levels for ultrasinic testing as a function of nominal wall thicknesses

Nominal wall thickness s [1] in mm	Indication length of individual reflectors for ultrasonic testing	Cumulated length (sum of indication lengths for ultrasonic testing) per reference length [2]
s < 8	≤ s	≤ s
8 ≤ s ≤ 20	≤ s	≤ 1.5 · s
20 < s ≤ 40	≤ 25 mm, but ≤ s	≤ 1.5 · s
40 < s ≤ 60	≤ 30 mm	≤ 1.5 · s
60 < s ≤ 120	≤ 40 mm	≤ 2 · s
s >120	≤ 50 mm	≤ 2 · s

[1] s_1 for welds on set-on nozzles and welded attachments (single bevel and double bevel groove welds)

[2] The reference length is 6 · s, for welds on set-on nozzles and welded attachments (single bevel and double bevel groove welds) 6 · s_1

Table 12-7: Acceptance criteria for indications detected by ultrasonic testing for longitudinal defects

Nominal wall thickness s [1], in mm	Indication length of individual reflectors during ultrasonic testing, in mm	Cumulated length (sum of indication lengths during ultrasonic testing) per reference length [2]
$40 < s \leq 80$	≤ 30	$\leq s$ [1]
$s > 80$	≤ 35	$\leq 1.5 \cdot s$ [1]

[1] s_1 for welds on set-on and partly set-in nozzles and welded attachments (single bevel and double bevel groove welds).

[2] The reference length is $6 \cdot s$, for welds on set-on and partly set-in nozzles as well as for welded attachments (single bevel and double bevel groove welds) $6 \cdot s_1$.

Table 12-8: Allowable indication lengths in subsurface areas lying more than 5 mm below the finished surface and cumulated lengths during ultrasonic testing for longitudinal defects

Nominal wall thickness s [1] of the seam weld in mm	Allowable width in mm	Allowable individual length l in mm	Allowable accumulated length $\sum l$ per reference length $L = 6 \cdot s$ [1] in mm
$s < 10$	$< 0.2 \cdot s$	$l \leq s$	$\sum l \leq s$
$10 \leq s \leq 25$	≤ 2	$l \leq s$	$\sum l \leq 1.5 \cdot s$
$25 < s \leq 40$		$l \leq 25$	
$40 < s$		$l \leq 30$	

[1] s_1 for welds on set-on nozzles and attachment welds (single bevel and double bevel groove welds)

Table 12-9: Acceptance criteria for the evaluation of metallic and non-metallic inclusions during 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 $s \leq 3$ mm and single-pass sealing welds	No indications permitted		
The second evaluation time in accordance with **Annex E** is decisive for the evaluation of the size of the indication.			

Table 12-10: Acceptance standards for liquid penetrant testing of welded connections on austenitic steels as well as between ferritic and austenitic steels and on sealing welds made of austenitic or nickel alloyed weld metal

Nominal wall thickness s in mm	$8 \leq s \leq 20$	$20 < s \leq 40$	$s > 40$
Notch depth in mm	1.5	2	3

Table 12-11: Depth of notches for testing level adjustment during ultrasonic testing of the internal 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 12.5.6.3.2 b)	Pattern recognition to clause 12.5.6.3.2 e)
Reference notch	Notch to be selected to Table 12-11	Notch to be selected to Table 12-11
Echo height difference between reference notch and noise level	≥ 12 dB	≥ 6 dB
Echo height difference between edge 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 12.5.6.5 (4)	As per 12.5.6.5 (5)

Table 12-12: 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, mm	Maximum echo amplitude above the recording level specified, dB
10	10	6

Table 12-13: Acceptance standards for the ultrasonic testing of the internal surface of welded joints on austenitic steels as well as of welded joints between ferritic and austenitic steels

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 permitted			
The second evaluation time in accordance with **Annex E** is decisive for the evaluation of the size of the indication. **Table 12-5** applies to ferritic claddings.				

Table 12-14: Acceptance standards for liquid penetrant testing of weld claddings made of austenitic or nickel alloyed weld metal

Annex A

Samples of Forms

Forms relating to Sections 4 and 5

A-1a - Cover Sheet

A-1b - Cover Sheet

A-1c - Cover Sheet

A-2 - List of materials

A-3 - Weld location list

A-4a - Test and inspection sequence plan

A-4b - Test and inspection sequence plan

A-5a - Welding procedure sheet (welding procedure specification)

A-5b - Welding procedure sheet (welding procedure specification)

A-6a - Heat treatment plan

A-6b - Heat treatment record

A-7 - Materials testing and specimen-taking plan

A-8 - Annex

A-9 - Isometric parts list

A-10 - Fabrication isometric drawing

A-11 - Contents final file

A-12 - Welding record

A-13 - Welding record (continued)

A-14a - Welding Record / Overall certificate (cover sheet)

A-14b - Welding Record / Overall certificate (review sheet)

Forms relating to Section 12

A-15a - Ultrasonic testing report

A-15b - Ultrasonic testing report

A-15c - Ultrasonic testing report

A-16 - Surface examination report

A-17a - Radiographic testing report (film radiography) - page 1

A-17b - Radiographic testing report (film radiography) - last page

A-18a - Radiographic testing report (digital radiography) - page 1

A-18b - Radiographic testing report (digital radiography) - last page

A-19 - Report on ultrasonic pitch-catch testing

A-20 - Annex to records as per form sheets A-14 to A 19

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:*	Einzelteilgruppe EG *parts group:*
	Typ, Antrieb, DN *type, drive, DN:*	
	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*	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-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:*

6

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.*	Stückzahl *quantity*	Stückgewicht *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.*	Kennzeichnung *identification marking*	Nachweis-Kennzeichnung *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:*
																	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*
00							Hersteller *manufacturer*
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
Schweißst.-Nr. *weld loc. no.* Schweißfolge *sequence of welding*	VP-Nr. *VP no.*	SP-Nr. *SP no.*	PFP-Nr. *PFP no.* Prüf-Nr. *test/inspection no.*	Arbeitsprüfungen *production control test (AP)* AP-Kennz. *AP ident.*	WPP-Nr. *WPP no.*	Erprobung bei *tested during* AP...S *AP...S*	AP...M *AP...M*	Chargenprüfung *welding materials testing (CHP)* CHR-Nr. *CHP no.*	Schmelzen-Nr. *heat no.*	Pulvercharge *flux no.*	Freigabe der Charge *release of batch* H	S		Bemerkungen *remarks*	Hersteller: *manufacturer:*
															Anlage/Projekt: *power plant / project:*
															Komponente: *component:*
															KKS/AKZ/Typ, Antrieb, DN: *NPP identification system/type, drive, DN:*
															Spezifikation: *specification:*
															Klasse: *classification:*
															WL-Nr.: *list of materials no:*
															Zeichnungs-Nr.: *technical drawing no.:*
															Auftrags-Nr.: *contract no.:*
															Bestell-Nr.: *order no.:*
															Werk-Nr./Index-Nr. 1): *plant no. / index 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 *manufactorer*	**Schweißstellenliste** *weld location list*
00								
01							Sachverständiger *authorized inspector*	STL-Nr.: *weld location list no:.*
02								
03							1) Nur für Rohrleitungen, Armaturen, Pumpen *only for pipes, valves and pumps*	Seite: *page:*
04								von: *of:*

Form A-3: Weld location list

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:*
												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						
01						
02						
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-4a: 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:*
																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-4b: 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: *classification:*
		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*
	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]	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(11)	(12)	(13)	(14)

Schweißnahtart *type of weld*	KKS/AKZ/Typ, Antrieb, DN: *code KKS or AKZ/ type, drive, DN:*
Schweißstellenliste *weld location list*	Zeichnungs-Nr.: *technical drawing no.:*
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-5a: Welding procedure sheet (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:* 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.:*

SAMPLE COPY

[17]	Hersteller: *manufacturer:*						**Schweißplan** *Welding procedure specification*
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*	SP-Nr.: *welding procedure specification no.:*
00							
01							
02							
03						1) nur für Rohrleitungen, Armaturen, Pumpen *1) only for pipes, valves, pumps*	Seite: *page:*
04							von: *of:*

Form A-5b: Welding procedure sheet (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:* 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-6a: Heat treatment plan

1 Hersteller: *manufacturer:*	**Protokoll über Wärmebehandlung** *heat treatment record*	Nachweis-Nr.: *certificationt no.:* **WBK-** Seite: *page:* von: *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: *specification:* Rev.: *revision:*	Werkstoff: *material:*	Prüfgegenstand einschließlich Angabe der mitlaufenden Prüfstücke: *test object incl. accompanying test pieces:*

2 Art der Wärmebehandlung:
type of heat tretament:

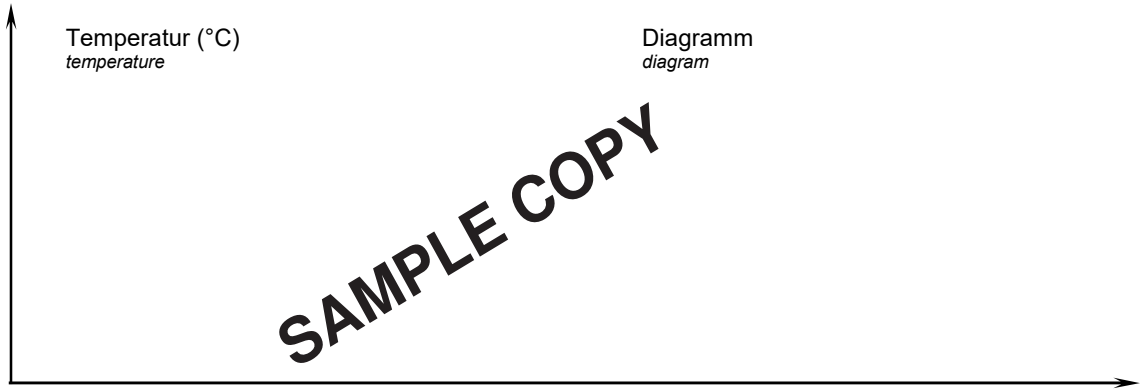
Datum der Wärmebehandlung:
date of heat treatment:

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



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-6b: 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*		Dokumentation *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:*
															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:*

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						

Dokumentationsfreigabe *release certification of documents*

Hersteller *manufacturer:*

Sachverständiger *authorized inspector*

[1] nur für Rohrleitungen, Armaturen und Pumpen *only for pipes, valves and pumps*

Werkstoffprüf- und Probenentnahmeplan

materials testing and specimen-taking plan

WPP-Nr.: *materials testing and specimen-taking plan no.*

Seite: / *page:*

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	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*
Vorprüfung *design review*						

12 Anlage/Projekt: *power plant / project:*	Spezifikation: *specification:*	Rev.: *revision*
Bestell-Nr.: *order no.:*	Hersteller: *manufactorer:*	
Auftrags-Nr.: *contract no:*	Klasse: *classification:*	

Bauprüfung *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-9: 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:
classification:

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-10: Isometric fabrication drawing

1 Anlage/Projekt: *power plant / project*	**Inhaltsverzeichnis Endablage** *Contents (IVZ) Final file*	Nachweis-Nr.: *certificationt no.:* **IVZ-** Seite: *page:* von: *of:*
Hersteller: *manufacturer:*		
KKS/Typ, Antrieb, DN: *NPP 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 (K): *signature (K):* Ort: *place:* Datum: *date:*	Unterschrift (S): *signature (S):* Ort: *place:* Datum: *date:*

[1] z.B. Vorprüfunterlagen, Nachweise (Art)
e.g. design approval documents, certificates (type)

Form A-11: Contents final file

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-12: Welding record

	Schweißprotokoll (Folgeseite) *welding record (SPK)*	Nachweis-Nr.: *certification no.* ***SPK-*** Seite: von: *pages: of:*	1	Hersteller: *manufacturer:* Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Schweißplan-Nr.: *weld procedure sheet no.:*
				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.:*

Schweißfolge *welding sequence*	Schweißverfahren *welding process*	Lagen-Nr. *layer no.*	Schweißzusätze und Hilfsstoffe / *welding filler metals and consumables*				Schweißdaten / *welding data*									
			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*	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*

Form A-13: 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-14b anzuwenden.
This form shall be used together with form A-14b only.

Form A-14a: 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-14b: 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}*									
			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 Δ 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	Zuschlag für Beobachtungsschwelle *evaluation level allowance* dB	Schallschwächung *sound attenuation* 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]*	Name Prüfaufsicht/UT Stufe 3 [2]: *name of supervisor/UT level 3 [2]*	Firma (B): *firm (plant owner)*
Zertifikat Nr.: *certificate no.*	Zertifikat Nr.: *certificate no.*	Name: *name*
Unterschrift: *signature*	Unterschrift: *signature*	Unterschrift: *signature*
Ort: *place*	Ort: *place*	Ort: *place*
Datum: *date*	Datum: *date*	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-15a: 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-15b: 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-15c: 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-16: 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-17a: 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-17b: 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-18a: 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*	Grauwert *grey value* Maximum *maximum*	Signal-Rausch-verhältnis SNR_N *signal-to-noise ratio SNR_N* Soll *required*	Signal-Rausch-verhältnis SNR_N *signal-to-noise ratio SNR_N* Ist *achieved*	Bildgütezahl nach DIN EN ISO 19232-1 *image quality index as per DIN EN ISO 19232-1* Gefordert *required*	Bildgütezahl nach DIN EN ISO 19232-1 *image quality index as per DIN EN ISO 19232-1* Erreicht *achieved*	Bildunschärfezahl nach DIN EN ISO 19232-5 *image unsharpness value as per DIN EN ISO 19232-5* Gefordert *required*	Bildunschärfezahl nach DIN EN ISO 19232-5 *image unsharpness value as per DIN EN ISO 19232-5* 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]*	Beschreibung von Unregelmäßigkeiten *characterization of imperfections* Ohne Unregelmäßigkeiten *without imperfections*	Die Anforderungen sind: *the requirements have* Erfüllt *been met*	Die Anforderungen sind: *the requirements have* 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-18b: Radiographic testing report (digital radiography) – last page

	Protokoll über Ultraschall-Tandemprüfung *report on ultrasonic pitch-catch testing*	Nachweis-Nr.: *record no.:* **UT-** 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 Oberflächenzustand *surface condition* — Prüffläche: *scanning surface:* — Gegenfläche: *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*

Registrierschwelle: *recording level:*

3

Einschallposition *scanning position*	Prüfköpfe *search units* Sender / *transmitter:* - Typ / *type* - Wandlerabmessungen *transducer dimensions* Empfänger / *receiver:* - Typ / *type* - Wandlerabmessungen *transducer dimensions*	Zonen-Nr. *zone no.*	Tiefelage der Zonenmitte *depth location of zone centre* mm	Abstand der Schallaustrittspunkte bei der Prüfung *distance of sound index points during scanning* mm	Justierung mittels V-Durchschallung am Prüfgegenstand *calibration by V-scanning on part*: Abstand der Schallaustrittspunkte bei der V-Durch-schallung *distance of sound index points in V-scanning* mm	ΔV_{KSR6} [3] dB	Schwankungsbreite der V-Durchschallungswerte *range of V-scan values* dB	Gesamte Verstärkungsdifferenz zur V-Durchschallung *total amplification difference to V-scanning* dB	Bemerkungen *remarks*

4 Firma (☐ H oder ☐ S): *firm manufacturer or authorized inspector*

Name Prüfer/UT Stufe 2 [2]: *name of examiner/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] Nicht zutreffendes streichen *delete where not applicable*

[2] Nur für Rohrleitungen, Armaturen und Pumpen *only for pipes, valves and pumps*

[3] Verstärkungsdifferenz für KSR = 6 mm zum V-Durchschallungsecho einschließlich des Empfindlichkeitsabfalls von Zonenmitte zu Zonenrand *amplification difference for circular disk reflector = 6 mm to V-scan path echo incl. drop in sensitivity level from zone centre to zone edge*

[4] Zertifizierungsstufe nach DIN EN ISO 9712 *level of certificate in acc. with DIN EN ISO9712*

Form A-19: Report on ultrasonic pitch-catch testing

	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 reports as per form sheets A-14 to A 19

Annex B

Extended examinations by transverse and multi-step tangential sections

B 1 General

(1) The requirements of this annex shall be met if all prerequisites under (2) to (4) are satisfied.

(2) Type of welded joint:

a) ferritic butt welded joints,

b) ferritic nozzle welds,

c) ferritic double-bevel groove welds,

d) ferritic production welds (unless quenched and tempered again)

on simulation heat treated parts of production control test pieces as well as on procedure qualification test pieces if within procedure qualification the same base metal heat as for the part is used.

(3) Components:

a) Reactor pressure vessel,

b) Steam generator (primary and secondary shell),

c) Reactor coolant pump,

d) Pressurizer,

e) Reactor coolant piping.

(4) Materials:

a) 20 MnMoNi 5 5,

b) 22 NiMoCr 3 7,

c) GS-18 NiMoCr 3 7.

B 2 Extent of examination

B 2.1 Extended transverse sections

Extended examinations by transverse sections shall be performed if this is specified by **Table B-1** due to general metallographic examinations already performed on the transverse section.

B 2.2 Tangential sections

(1) On all test pieces under the range of application a specimen section shall be provided for tangential section with dimension as per B 3.2.1.

(2) In the case of production control test pieces of longitudinal welds, at least one specimen section per base metal heat shall be provided.

(3) The tangential sections shall cover repair welds, if any.

(4) Findings made by non-destructive examination in the HAZ shall be taken into account when determining the location of test piece taking, such that by means of the tangential section the type and configuration of such findings can be obtained.

(5) The decision on the extent of the examinations to be performed by tangential sections shall be made by the manufacturer by agreement with the authorized inspector according to the following criteria:

a) For the materials 20 MnMoNi 5 5 and GS-18 NiMoCr 3 7 a tangential section shall be examined on a selected heat per component each if the extended analysis limits as per KTA 3201.1 are used.

Note:
The analysis limits which do not lead to stress relief cracking or embrittlement shall be extended by agreement with the authorized inspector within the course of progressing material analysis if positive experience is gained.

b) For the material 22 NiMoCr 3 7 a tangential section shall be examined on a selected heat per component each, if the analysis limits are exceeded for two or more of the following elements:

Cu $\leq$ 0.120 %
Sn $\leq$ 0.011 %
P $\leq$ 0.008 %
S $\leq$ 0.008 %
N $\leq$ 0.013 %
Mo $\leq$ 0.620 %

(6) Tangential sections on further heats shall be examined if during production or during welding simulation tests crack formation or embrittlement is detected.

B 3 Examination

B 3.1 Extended examination by transverse sections

B 3.1.1 Test piece dimensions

The test piece dimensions shall be (see **Figure B-1**):

a) Length (l): approx. 10 mm in direction of welding progress.

b) Width (b) for:

ba) butt welds:
width of cover layer or largest section of the weld, additionally approx. 15 mm uninfluenced base metal on both sides,

bb) T-joints:
Entire weld section on pressure-retaining wall, additionally approx. 15 mm uninfluenced base metal on both sides.

c) Thickness (s): Base metal thickness.

B 3.1.2 Performance of examination

(1) The examination shall be performed on the transverse section taken for the general metallographic examination.

(2) Depending on its dimensions and reference thickness, the transverse section may be discarded in several parts (see **Figure B-1**). The transverse section shall be evaluated upon suitable etching. The examinations shall be performed on both weld edges.

B 3.1.3 Evaluation

(1) The transverse sections shall be evaluated by the manufacturer and the authorized inspector.

(2) The coarse-grain zones adjacent to the cover, filler and root layers (see also **Figure B-2**) shall be determined.

(3) On the two weld edges the following shall be determined:

a) the areas with maximum secondary grain size to DIN EN ISO 643,

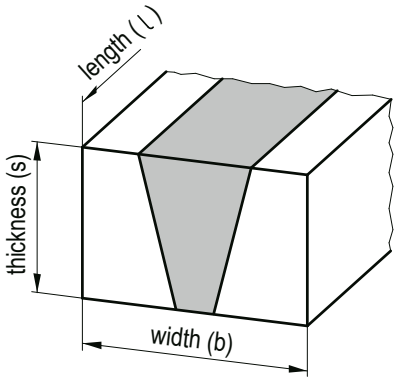
b) the maximum gusset length (along the fusion line) and maximum gusset width (extension into depth of coarse-grain zone). The maximum gusset lengths and widths shall be indicated according to **Figure B-2** in normal (N) and transverse (Q) direction with actual dimensions,

c) percentage coarse grain portion:
The percentage coarse grain share shall be calculated in accordance with **Figure B-2** (gusset length Z) over the summed-up individual lengths of the coarse-grain zones with the following formula:

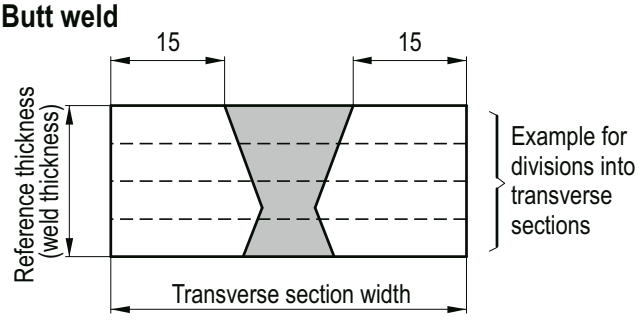
$$\text{Coarse grain portion} = \frac{\sum Z}{N} \cdot 100(\%)\,, \qquad \text{(B-1)}$$

where N is the reference thickness.

(4) The structure of the uninfluenced base metal, of the HAZ's and the weld metal shall be determined.



Butt weld



T-joint

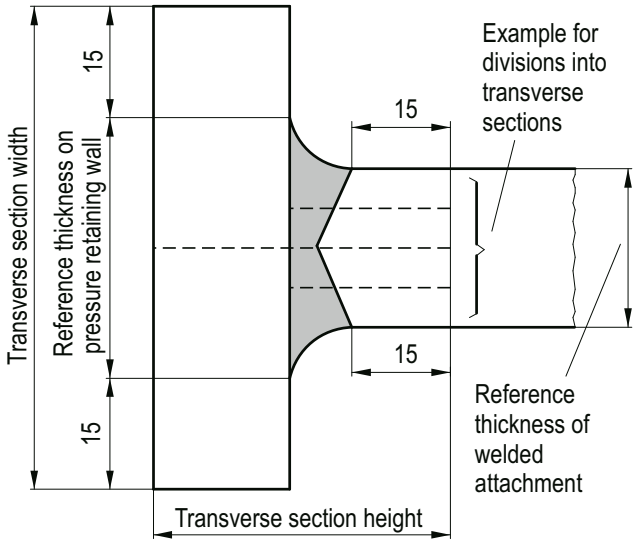
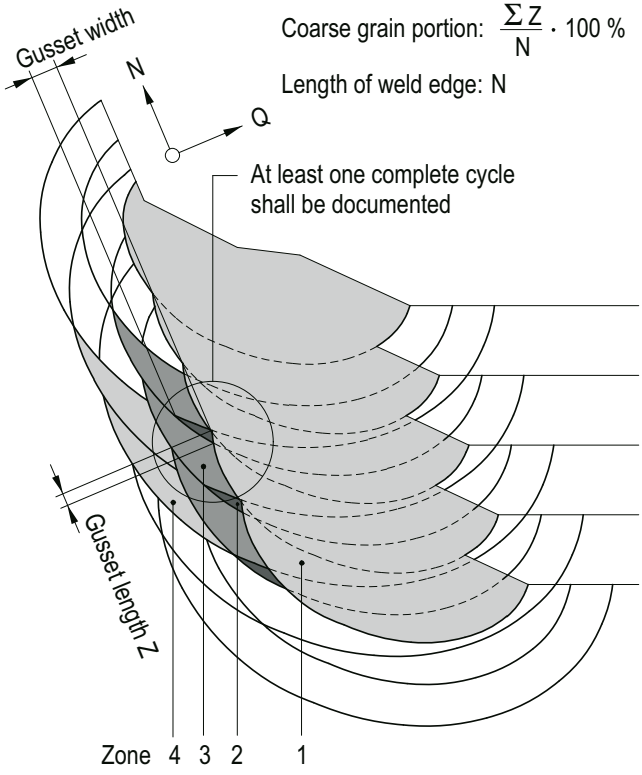


Figure B-1: Test coupons for extended examinations by transverse sections



Zone 1: Weld metal
Zone 2: Coarse-grain zone (overheated without grain refining)
Zone 3: Initially overheated zone which was grain refined during welding of subsequent beads
Zone 4: Fine-grain zone

Figure B-2: Evaluation of coarse-grain portion

B 3.1.4 Documentation

Results obtained from the examination shall be summarized in a report and in accordance with Section 4.2 be added to the final file. The report shall contain:

a) a master shot of the etched transverse section at a suitable magnification (generally 2:1),

b) a micrograph of the base metal from one surface and of the centre (up to 500:1),

c) a micrograph of the weld metal and the HAZ transverse to the fusion line (weld metal/HAZ/base metal) as well as a characteristic micrograph of the coarse-grain zone (500:1) with allocation of position in the macrosection,

d) a micrograph of a complete gusset in the coarse-grain zone at a suitable magnification (allocation of position in the macrosection),

e) the indication of gusset length and width,

f) the indication of the course-grain percentage share (referring to the reference thickness N) on both weld edges.

B 3.2 Examination by tangential section

B 3.2.1 Test piece dimension

The test piece dimension shall be as follows:

a) Length: The length shall be at least 100 mm of the weld length.

b) Width: The test piece width shall cover 10 mm of the weld metal on each side of the fusion line.

c) Thickness: The thickness shall correspond to the weld edge length N (see also **Figure B-2**).

B 3.2.2 Performance of examination

(1) The examination shall be performed on the weld edge considered more unfavourable due to the coarse-grain evaluation as per clause B 3.1.3.

(2) The examination by tangential sections shall be made at several steps in at least three section levels to cover the entire wall thickness. The tangential section may be subdivided into several parts in accordance with the geometric conditions.

(3) The tangential section levels shall be parallel to the fusion level through the HAZ. Here the first section level shall be at the respective outer edge (close to fusion line) of the HAZ. By stepwise grinding further parallel tangential section surfaces within the HAZ shall be examined. The number of. the tangential sections and the distance of the section surfaces to each other depends on the respective results obtained from the examination. The HAZ, however, shall be examined on at least three tangential section levels parallel to each other in which case the base metal side, weld metal side and centre area of the HAZ shall be covered.

B 3.2.3 Evaluation

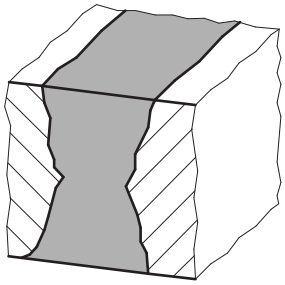
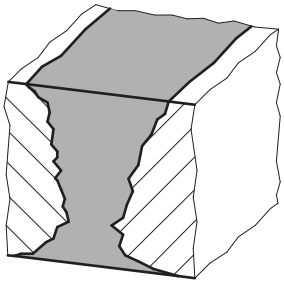
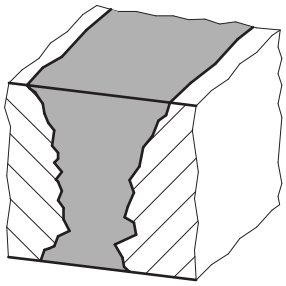
The section levels shall be evaluated for degree of purity, number and dimension of discontinuities (e.g. hot cracks, relaxation cracks), segregation zones with differences in hardness, microstructural composition.

B 3.2.4 Documentation

Results obtained from the examination shall be summarized in a report and in accordance with Section 4.2 be added to the final file. The report shall contain:

a) metallographic master shot of the etched tangential section with suitable magnification,

b) metallographic shots to a representative extent on microsections with suitable magnification and allocation of position to macrosection.

Macrograph of weld configuration	Results obtained on macrosection	20 MnMoNi 5 5 22 NiMoCr 3 7 GS-18 NiMoCr 3 7		20 MnMoNi 5 5 22 NiMoCr 3 7 GS-18 NiMoCr 3 7 [1]	
		Procedure qualification	Production control test	Procedure qualification	Production control test
	HAZ is continuous; minor fusions are permitted	—	—	An extended examination by transverse sections (EQ) shall only be performed if a tangential section examination was specified for a selected heat as per Section B 2.2.	
	Locally occurring major fusions of some beads in the base metal shall be verified to a greater extent	EQ	— [2]	EQ	— [2] [3]
	HAZ is discontinuous	EQ	EQ	EQ	EQ

[1] Extended analysis limits as per Section B 2.2 (5) are used.

[2] Where a production control test is to extend the validity of a procedure qualification, an extended examination by transverse sections (EQ) shall be performed.

[3] Where a tangential section examination as per Section A 2.2 was specified, an extended examination (EQ) shall be performed.

Table B-1: Performance of extended examinations on transverse sections in dependence of the weld configuration

Annex C

Performance of manual ultrasonic testing

C 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.

C 2 Definitions, symbols, formulae

C 2.1 Definitions

The definitions of DIN EN ISO 5577 apply.

C 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	—
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	—
V	Gain in the general DGS diagram	dB

Symbol	Variable or designation	Unit
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

C 2.3 Formulae

The variables to be calculated shall be determined by means of the following equations:

a) Required width of the reference block

$$C \geq D_{S\text{-}20dB} \qquad \text{(C-1)}$$

b) The beam width $D_{S\text{-}20dB}$ referred to a 20 dB echo amplitude decrease:

$$D_{S-20dB} = 2 \cdot \lambda \cdot \frac{S}{D_Q} \qquad \text{(C-2)}$$

c) Conversion of side-drilled hole echo amplitudes to disc shaped reflector echo amplitudes:

$$D_{KSR} = \sqrt{\frac{\sqrt{2}}{\pi} \cdot \lambda \cdot \sqrt{D_Z \cdot S}}\ , \qquad \text{(C-3)}$$

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:

$$D_{S\text{-}6dB} = 2 \cdot S \cdot \tan \gamma_6, \qquad \text{(C-4)}$$

e) Average value of instrument gain setting $\overline{G}_T$:

$$\overline{G}_T = \frac{\sum G_T}{n} = \frac{\text{sum of individual values}}{\text{number of individual values}}\ , \qquad \text{(C-5)}$$

f) Corrected recording length R_{LK}:

$$R_{LK} = R_L - D_{S-6dB} \cdot \left(1 - \frac{D_{S-6dB}}{R_L}\right) \qquad \text{(C-6)}$$

g) Sound path length without lateral wall influence:

$$S = \frac{s \cdot D_{eff}}{2 \cdot \lambda} \qquad \text{(C-7)}$$

h) Gain correction $\Delta V^{\sim}$:

$$\Delta V^{\sim} = 1.7 \cdot \sqrt{\frac{\sum G_T^2 - \frac{1}{n} \cdot \left(\sum G_T\right)^2}{n-1}} \qquad \text{(C-8)}$$

or

$$\Delta V^{\sim} = 1.7 \cdot \sqrt{\frac{\sum \left(G_T - \overline{G}_T\right)^2}{n-1}} \qquad \text{(C-9)}$$

i) Sensitivity correction ΔV_Z:

$$\Delta V_Z = 30 \cdot \lg \frac{S_2}{S_1} \qquad \text{(C-10)}$$

k) Resultant instrument sensitivity for adjustment of recording level:

$$G_R = G_K + \Delta V_T + \Delta V^{\sim} \qquad \text{(C-11)}$$

$$\text{with } \Delta V_T = \Delta V_{koppl} + \Delta V_\kappa \qquad \text{(C-12)}$$

l) Zero point displacement at longitudinal wave dual-element probes:

$$S = 1.5 \cdot s + a \qquad \text{(C-13)}$$

m) Sound path travel distance to scanning zone centre with LLT probes:

$$S_{Just} = S_{LW} + 2 \cdot S_{TW} \qquad \text{(C-14)}$$

$$\text{with } S_{LW} = \frac{2 \cdot s - Y_s}{\cos \alpha_{LW}} \qquad \text{(C-15)}$$

$$\text{and } S_{TW} = \frac{Y_s}{\cos \alpha_{TW}} \qquad \text{(C-16)}$$

or approximated for steel

$$S_{Just} = 2 \cdot \frac{s + Y_s}{\cos \alpha_{LW}} \qquad \text{(C-17)}$$

C 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.

C 4 Requirements to be met by the testing system

C 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 C-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.

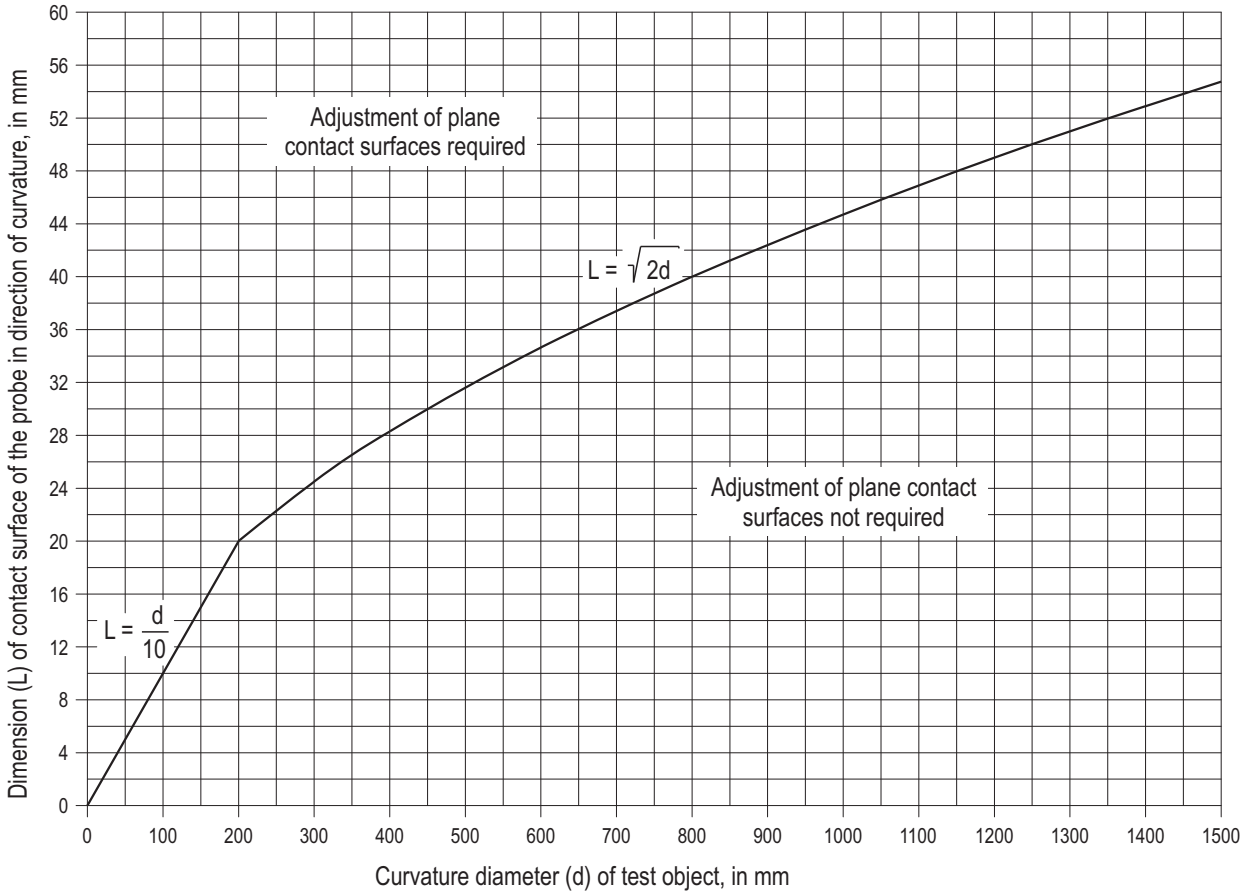


Figure C-1: Conditions for adjusting plane contact surfaces of angle-beam probes when scanning into convex scanning surfaces of the test object

C 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 ISO 2400 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 $\leq$ 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 C-3 shall be considered.

C 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).

C 6 Adjustment of test system

Note:

Sections C 7 to C 9 contain requirements for the test system adjustment as regards the use of wave conversion and creeping wave techniques.

C 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 C-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.

C 6.2 Adjustment of the testing level when applying the DGS method

C 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 C 2.3, equation C-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.

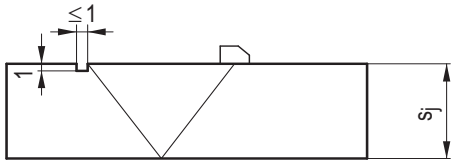
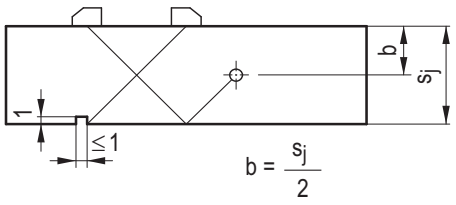
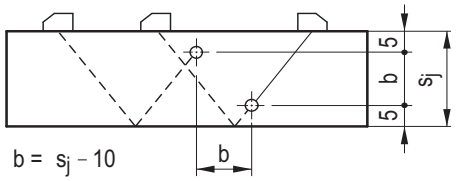
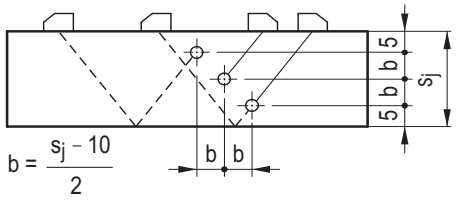
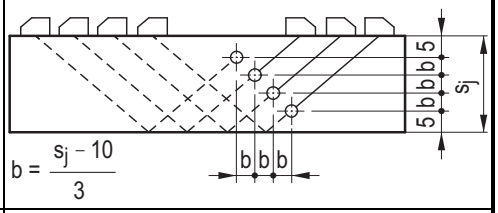
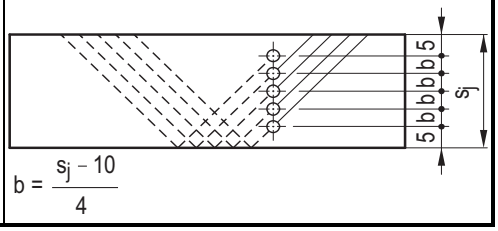
Wall thickness or nominal wall thickness of the test object in mm	Lateral view of the reference block
s ≤ 10	
10 < s ≤ 15	
15 < s ≤ 20	
20 < s ≤ 40	
40 < s ≤ 80	
s > 80	

Figure C-2: Reference blocks for adjusting the testing level for angle beam scanning

C 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 C 4.2 (2) ba),
   - ab) the back wall of the reference block provided the back wall meets the requirements according to clause C 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 C-3 shall be used.

C 6.3 Adjustment of the testing level for the reference block method and DAC method

C 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 C-2**) the smaller echo height shall be used as reference level.

C 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 C-2**) or by means of reference reflectors in the test object located at different distances. Clause C 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 C-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 C-4**.

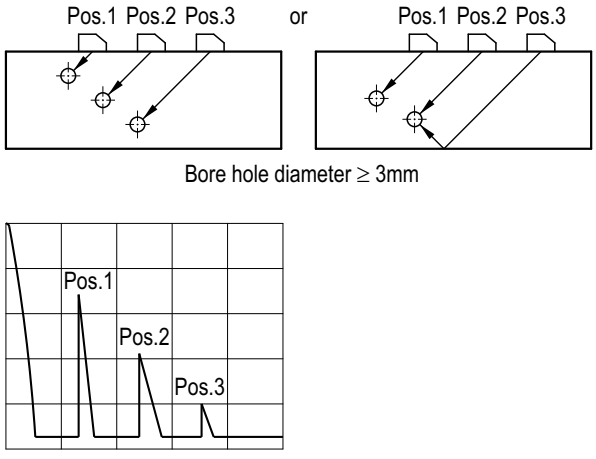


Figure C-3: Generation of reference echo heights from side-drilled holes located at different probe distances for angle beam scanning

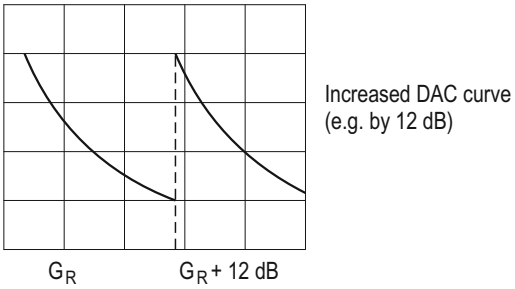


Figure C-4: Staged DAC curve

C 6.4 Corrections of testing level adjustment

C 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 C-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 C 6.2 of C 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.

C 6.4.2 Determination of the sound attenuation

(1) The sound attenuation for straight-beam scanning shall normally be determined as per **Figure C-6** and for angle-beam scanning as per **Figure C-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 C 6.4.1).

C 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 C 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.

C 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 C-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 C-8** when using the DGS method or as per **Figure C-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 C 6.4.3 is required, this shall be done by means of $\Delta\tilde{V}$. Otherwise, the correction value $\Delta\tilde{V}$ in equation C-11 shall be omitted.

C 6.5 Setting of the ultrasonic instrument

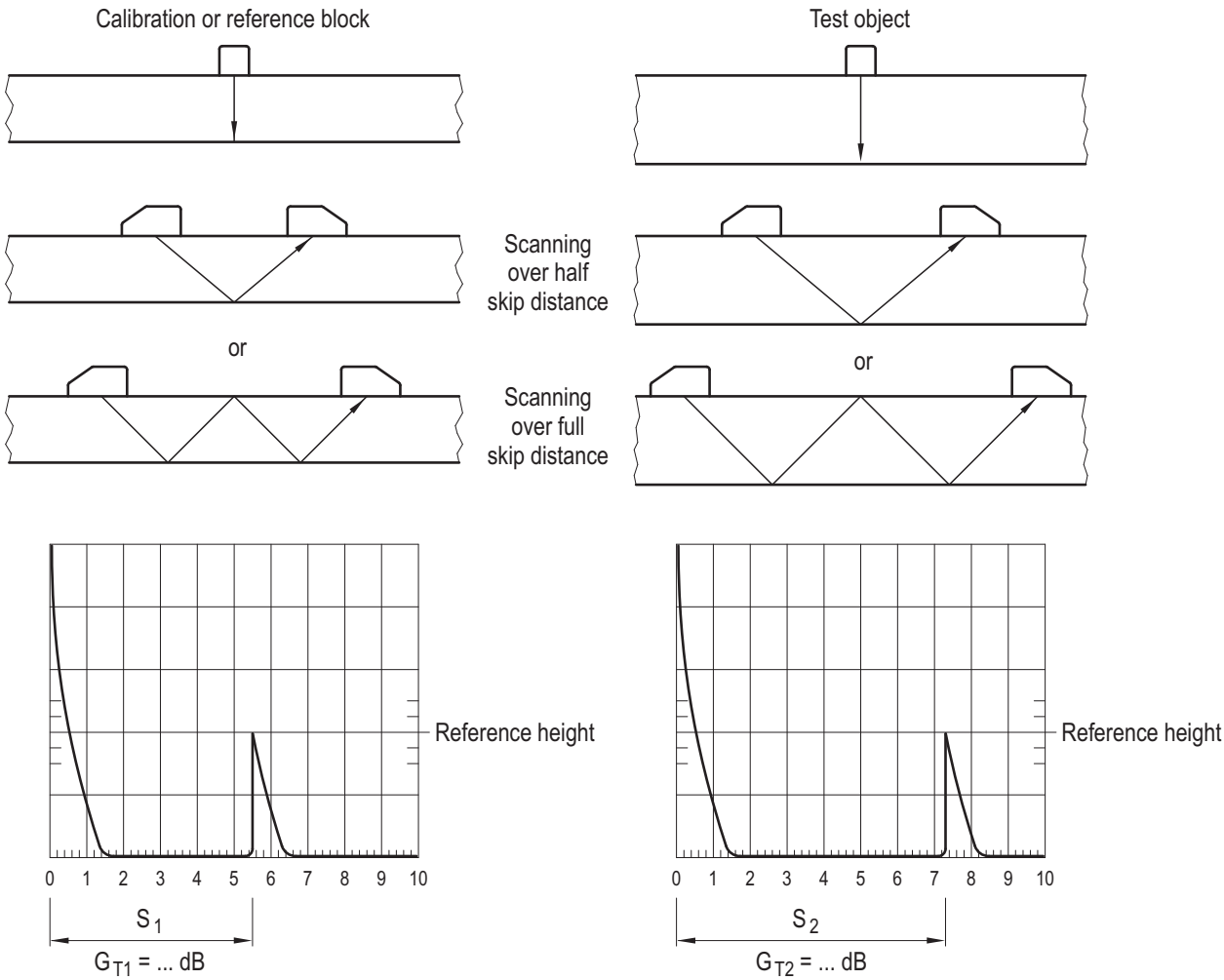
(1) Prior to adjusting the testing level it shall be ensured that

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 C 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

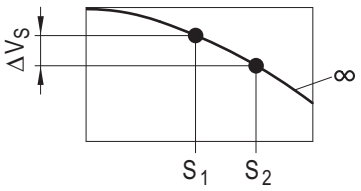
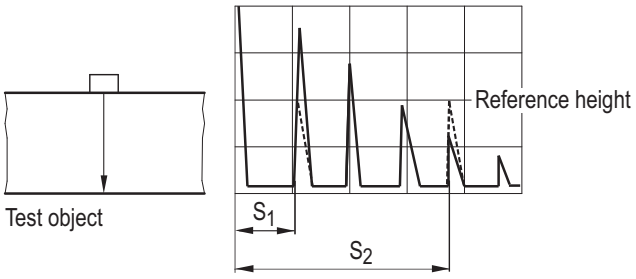


Figure C-5: Determination of transfer correction during straight and angle beam scanning performed as V or W-transmission

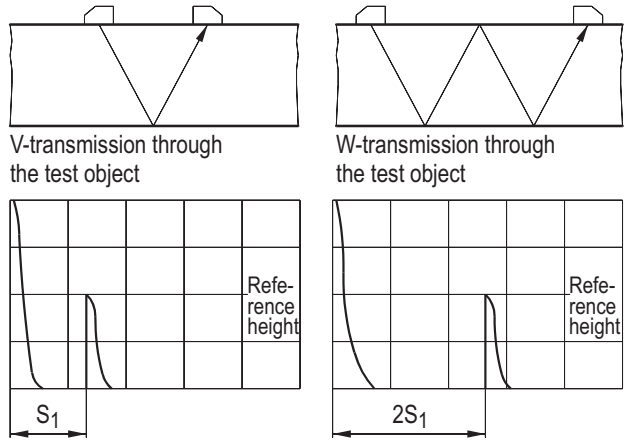


$$\kappa = \frac{G_{T2} - G_{T1} - \Delta V_S}{2 \cdot (S_2 - S_1)} \; [dB/mm]$$

$G_{T1} = \ldots dB$

$G_{T2} = \ldots dB$

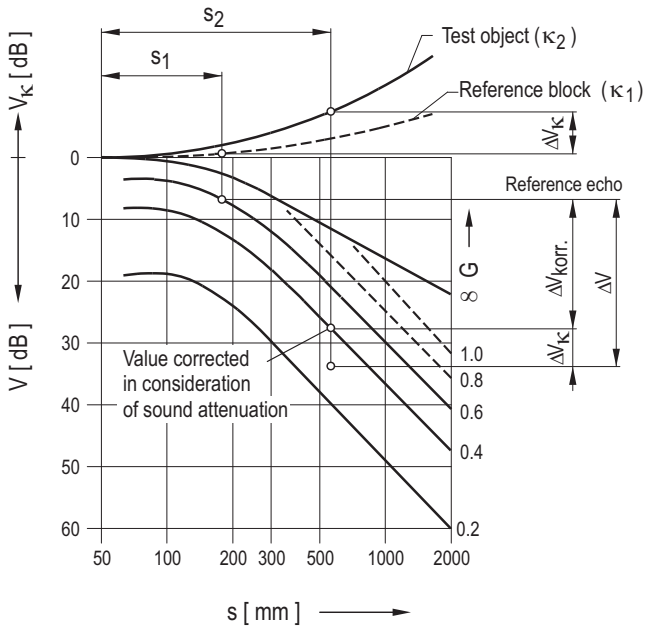
Figure C-6: Determination of sound attenuation for straight-beam scanning (example)



$G_{T1} = \ldots dB$ $G_{T2} = \ldots dB$

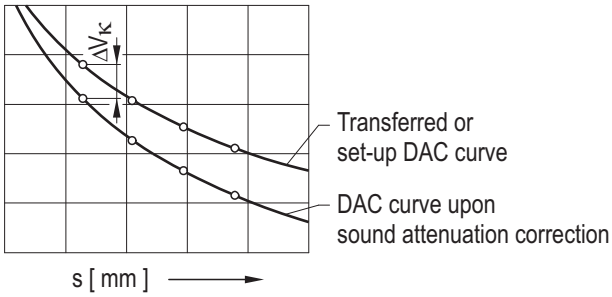
$$\kappa = \frac{G_{T2} - G_{T1} - \Delta V_S}{2 \cdot S_1} \quad [dB/mm]$$

Figure C-7: Determination of sound attenuation for angle-beam scanning



$$\Delta V_\kappa = 2 \cdot (S_2 \cdot \kappa_2 - S_1 \cdot \kappa_1) \; [dB]$$

Figure C-8: Consideration of sound attenuation in the DGS diagram for $\kappa_2 > \kappa_1$ (example)



$$\Delta V_\kappa = 2 \cdot S \cdot (\kappa_2 - \kappa_1) \; [dB]$$

Figure C-9: Consideration of sound attenuation for the DAC method for the case $\kappa_2 > \kappa_1$ (example)

C 7 Creeping wave method

C 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.

C 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 C-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 C-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.

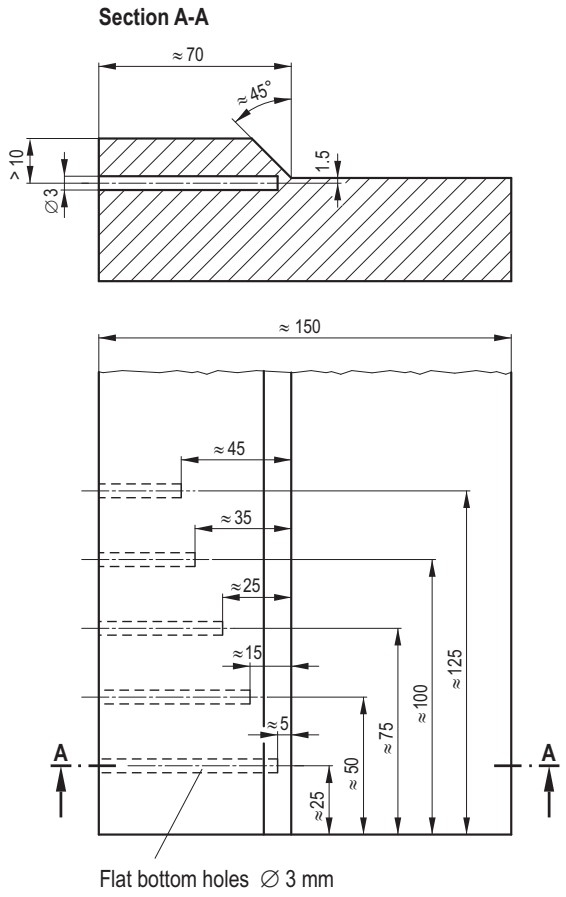


Figure C-10: Reference block for testing level adjustment when using the creeping wave technique (primary creeping wave)

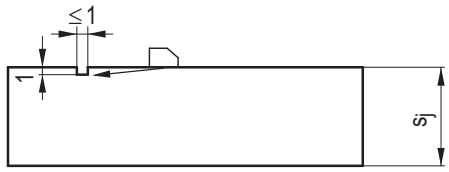


Figure C-11: Reference block for testing level adjustment when using the creeping wave technique (primary creeping wave) for testing near-surface areas

C 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 C 6.3 by means of scanning the respective flat bottom holes in the reference block according to clause C 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 C 7.2 (1) b).

C 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 C-12**.

(2) When testing on concave scanning surfaces of the test object, specific probes with properly contoured contact surfaces shall be used.

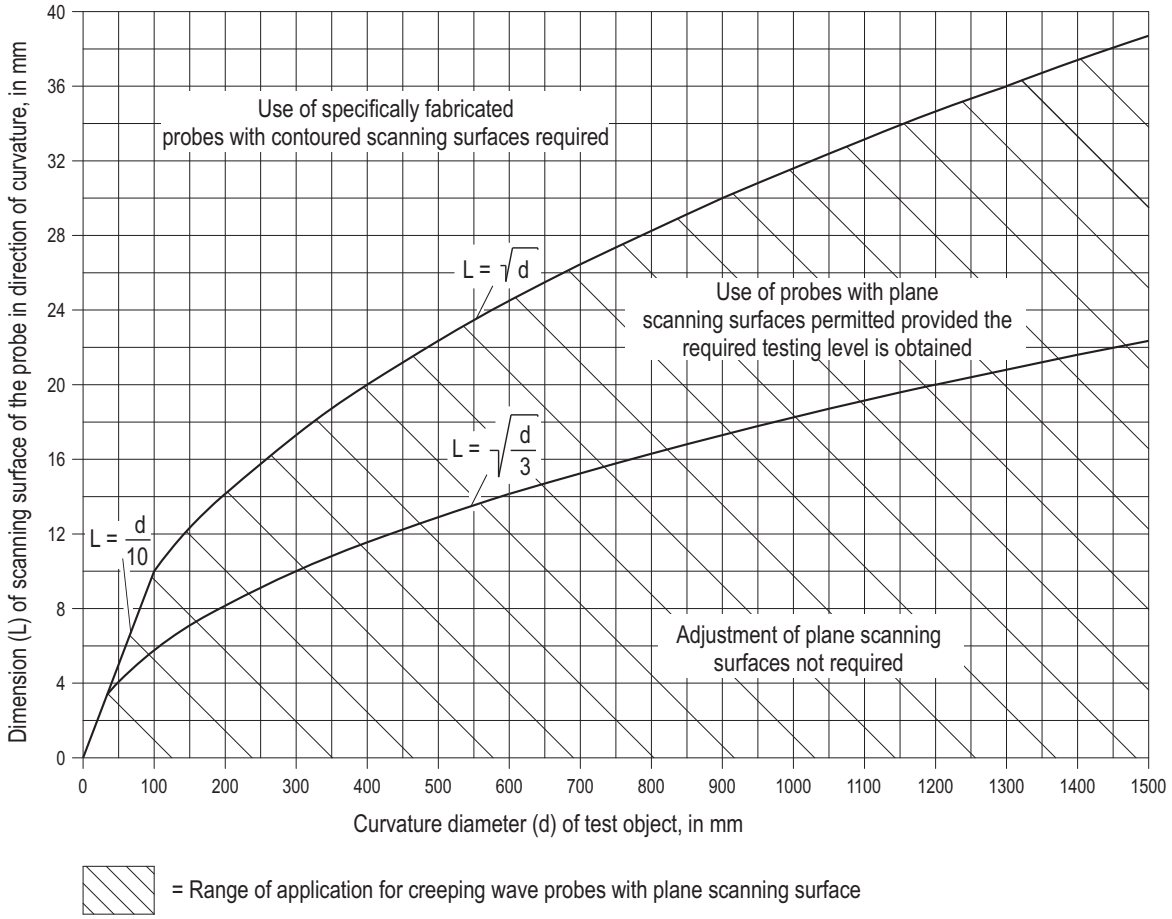


Figure C-12: Ranges of application of creeping wave probes with and without contouring of scanning surfaces for testing on convex test object scanning surfaces

C 8 Wave conversion method I (secondary creeping wave)

C 8.1 Description of method

(1) **Figure C-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 C-14**).

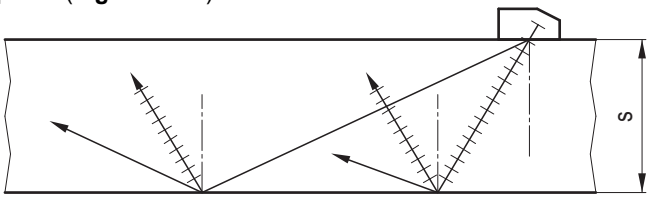


Figure C-13: Reflexion with wave conversion for longitudinal wave angle-beam probe

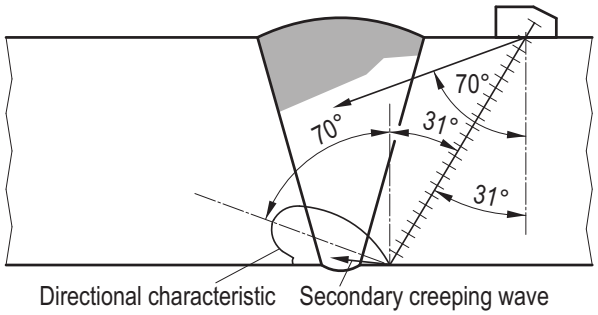


Figure C-14: Testing of internal near-surface area of welded joints by means of secondary creeping waves

(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 C-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 analysable 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 C-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 C-16**).*

C 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.

C 8.3 Range calibration

(1) The time base range shall be pre-adjusted in accordance with C 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 C-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.

C 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 C 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 C 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.

C 8.5 Corrections during testing level adjustment

C 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.

C 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.

C 8.6 Performance of testing

(1) Range calibration according to the requirements of Section C 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 C 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 C-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.

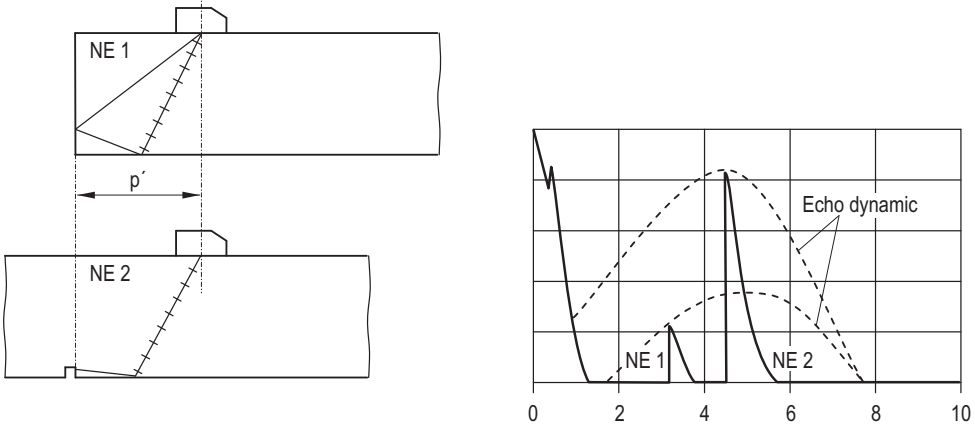


Figure C-15: Sound field geometry during transverse wave conversion

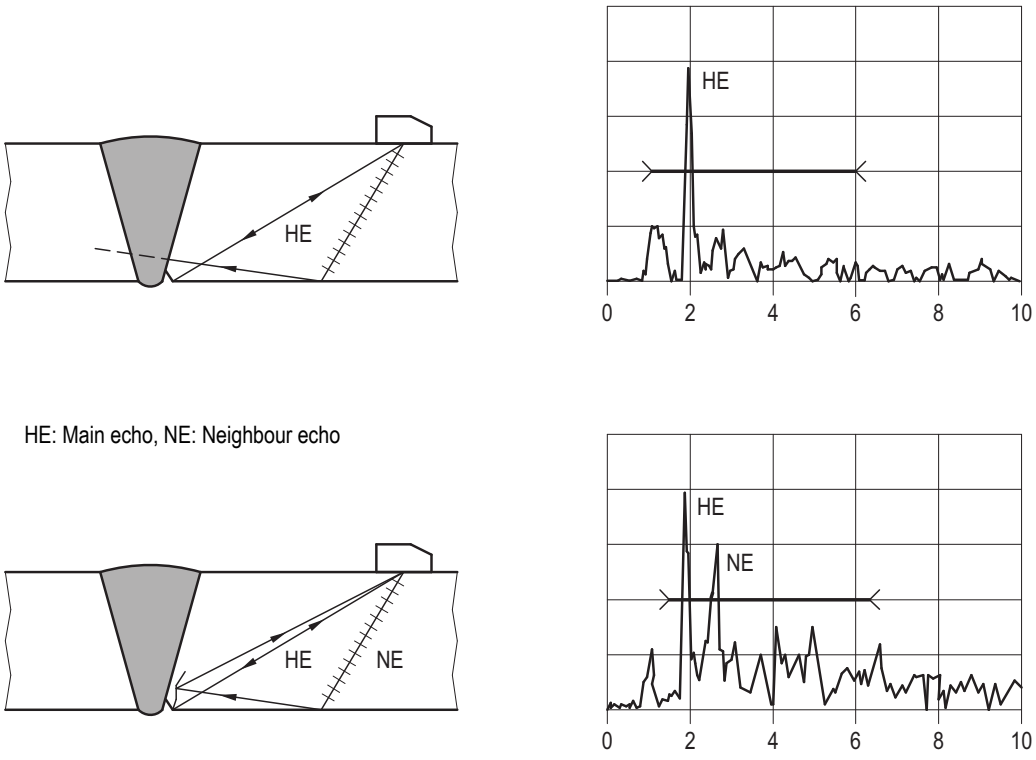


Figure C-16: Testing of components with nominal wall thicknesses 8 mm < s ≤ 20 mm by means of longitudinal waves (70 degree SEL probe)

C 9 Wave conversion method II (LLT technique)

C 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 C-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.

C 9.2 Probes, scanning zones, reference blocks, LLT sensitivity diagrams

C 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.

C 9.2.2 Probes and their scanning zones

C 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 C-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 C-17**). The height of the scanning zone depends on the wall thickness, the nominal frequency and the dimensions oft the transmitting and receiving transducer.

C 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.

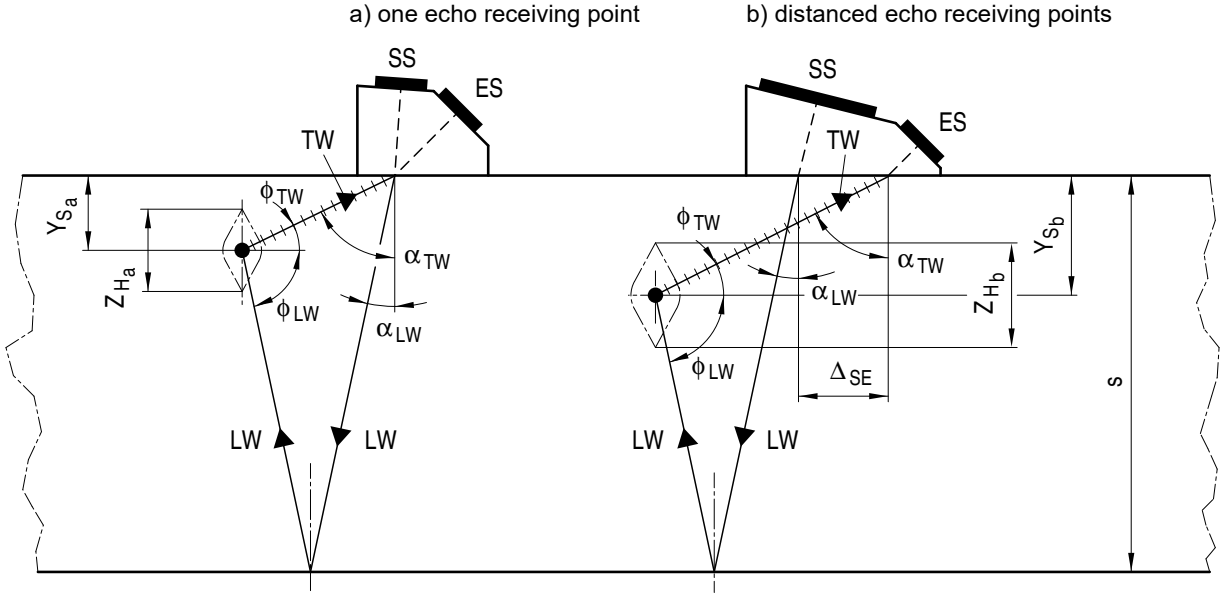
Note:
The volume to be examined normally comprises the non-subsurface area as of a depth of 10 mm distanced from the probe-remote surface and probe-adjacent surface.

(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.

C 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 C-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.



$$\alpha_{TW} = \arccos\left(\frac{c_{TW}}{c_{LW}} \cdot \cos \alpha_{LW}\right)$$

$$Y_{S_a}, Y_{S_b} = \frac{2\,s \cdot \tan \alpha_{LW} + \Delta_{SE}}{\tan \alpha_{TW} + \tan \alpha_{LW}}$$

Z_{H_a}, Z_{H_b} : depth zone

Figure C-17: Principle of LLT technique

C 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 C 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 C-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 C-19**). To this end, at least three flat bottom holes provided at the front-face side of the reference block are necessary.

C 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 C-14 to C-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 C 9.2.4 shall be used.

C 9.4 Testing level adjustment

C 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.

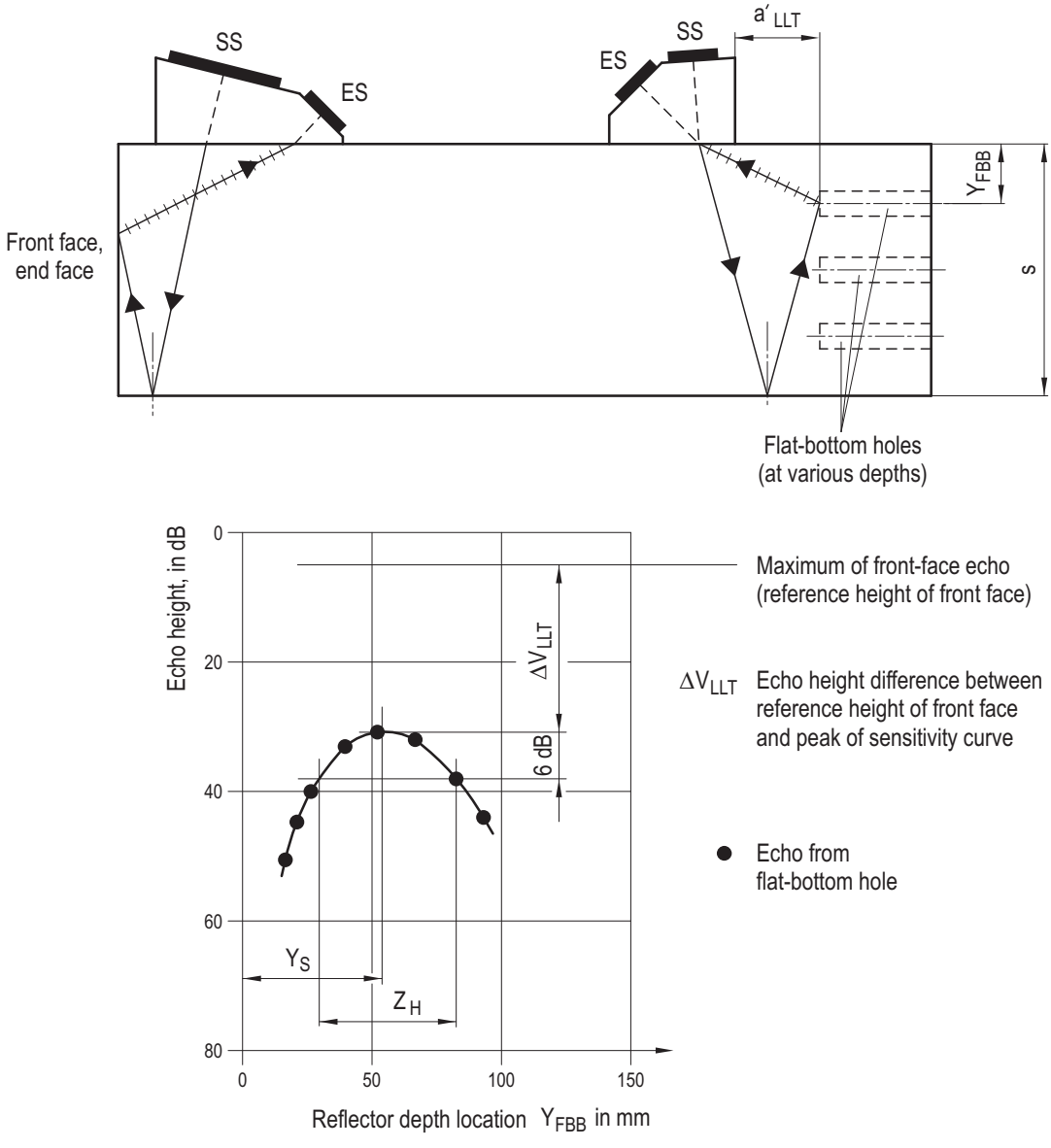


Figure C-18: Example for a LLT sensitivity diagram

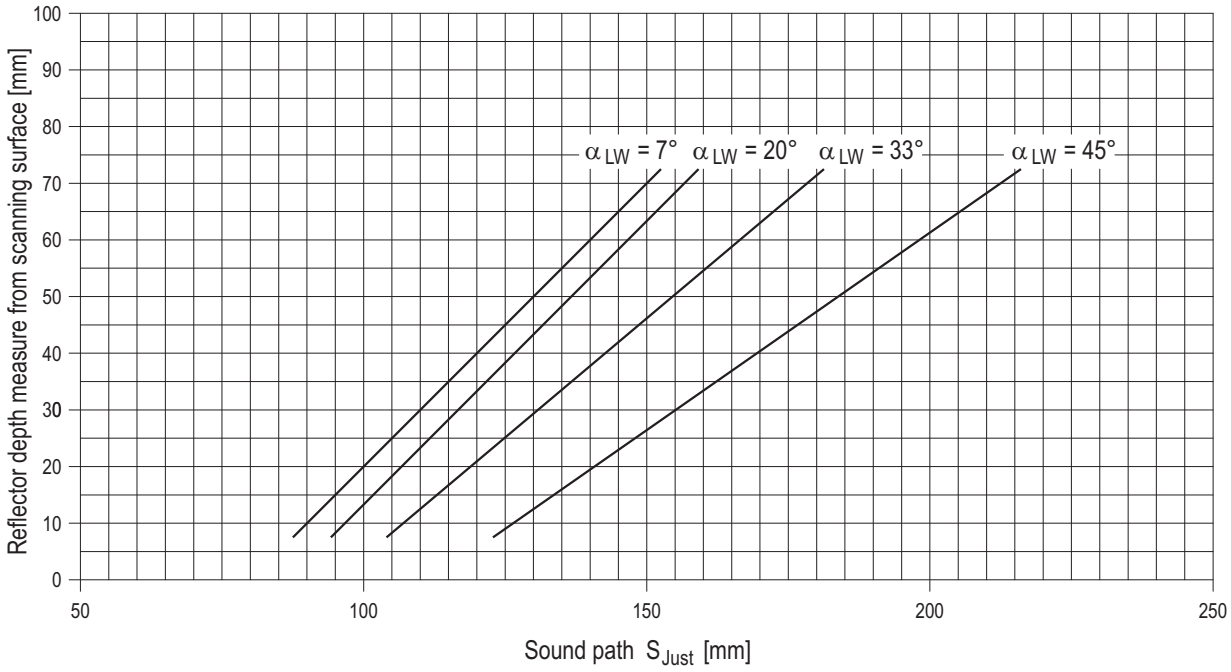


Figure C-19: Example for LLT reflector depth scales

C 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 C 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 C-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.

C 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.

C 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.

C 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 C-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.

C 10 Performance of testing

C 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.

C 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.

C 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.

C 11 Description of indications

C 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 reproducibility of the echo amplitude determination is generally ± 3 dB.

C 11.2 Extension of indications

C 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“.

C 11.2.2 Determination of the recording length at fixed recording level

The extension of reflector (see **Figure C-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.

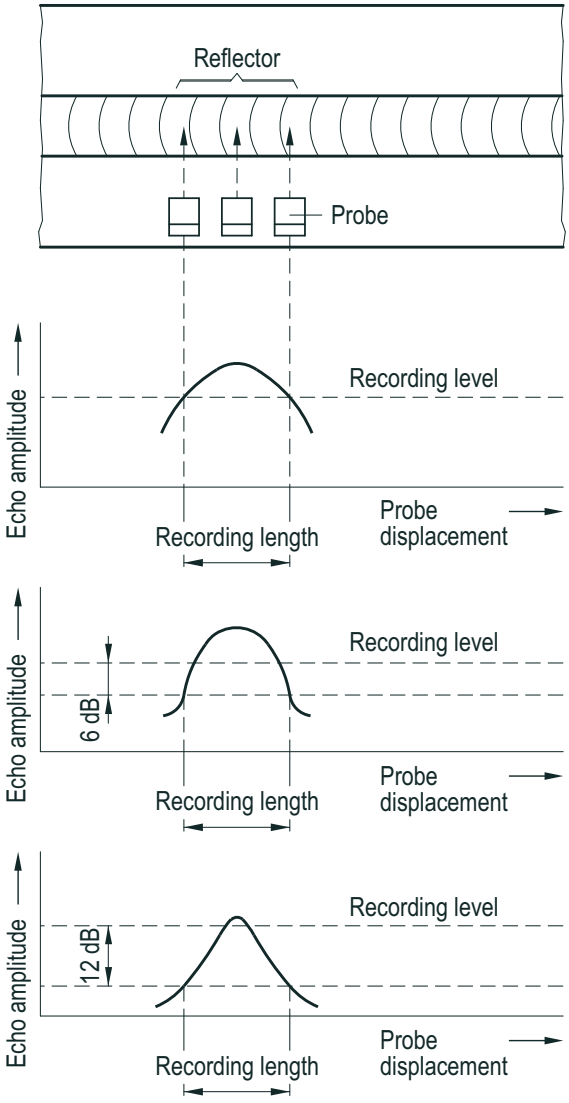


Figure C-20: Determination of recording length

C 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.

C 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 C 11.2.4.1 to C 11.2.4.4 or by examinations according to clause C 11.2.5.

C 11.2.4.1 Correction for curved surfaces

For curved surfaces the length shall be determined mathematically or graphically in the reflector depth determined.

C 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 $1.0 \cdot N$ however is greater than $0.7 \cdot N$. In such a case, a higher nominal frequency than during the test may be used.

C 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 C-6.

(2) The beam width shall be determined by calculation or experimental analysis.

(3) In the case of calculation equation C-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 C 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.

C 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 reproducibility in the case of focussing probes. The grid-line distances shall be smaller than the diameter of the focussing beam of the probe.

C 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

C 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 object (see **Figure C-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 C-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.

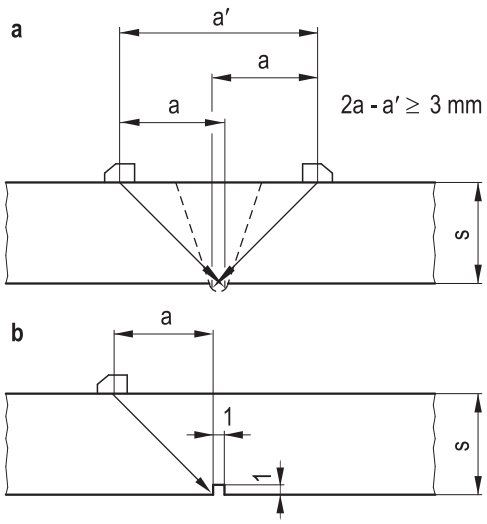


Figure C-21: Proof of indications caused by structural discontinuities from the root area of single-side welds

Annex D

Performance of manual ultrasonic angled pitch-catch examinations

D 1 General

(1) This Annex covers the performance of manual ultrasonic testing using the angled pitch-catch technique on test objects with plane-parallel or concentrically curved surfaces and reflectors oriented vertically to these surfaces.

(2) Testing by the angled pitch-catch technique on test objects with concentrically curved surfaces in scanning direction is limited to the following:

a) when coupling the probes on the inner surface and using 45° transverse wave angle-beam probes to test objects with a s/d_a ratio equal to or less than 0.04 and, when using 40° transverse wave angle-beam probes, to test objects with a s/d_a ratio equal to or less than 0.08,

b) when coupling the probes on the inner surface and using 45° transverse wave angle-beam probes to test objects with a s/d_a ratio equal to or less than 0.05 and, when using 50° transverse wave angle-beam probes, to test objects with a s/d_a ratio equal to or less than 0.08.

D 2 Definitions, symbols and 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
α	Beam angle	degree
b_0	Distance of scanning surface from upper zone edge	mm
b_m	Distance of scanning surface from centre of zone	mm
b_u	Distance of scanning surface from lower zone edge	mm
b	Given distance of scanning surface from the respective zone edges or zone centre	mm
d_a	Outside diameter of test object	mm
G_K	Instrument gain when setting the reference reflector echo for screen height level	dB
$\overline{G}_K$	Arithmetical average of G_K values	dB
G_R	Instrument gain for recording level	dB
G_T	Instrument gain when setting the transmission indication for screen height level	dB
$\overline{G}_T$	Arithmetical average of G_T values	dB
n	Number of individually measured values	—
PK1	Transmitter probe	—
PK2	Receiver probe	—
S_{ges}	Sound path travel distance between transmitter and receiver	mm
s	Wall thickness, nominal wall thickness	mm
ΔV_{KSR6}	Differences in gain for a 6 mm disc shaped reflector at zone edge to V-path echo	dB
ΔV_{rand}	Sensitivity decrease from centre of zone to zone edges added to V_{KSR6} value	dB
$\Delta V^{\sim}$	Corrected gain for considering variations of V path values	dB
Y_m	Distance of probe index points of the two probes during examination; in the case of curved surfaces the respective arc length	mm
Y_V	Distance of probe index points of the two probes during V path scanning	mm

D 2.3 Formulae

The variables to be calculated shall be determined by means of the following formulae:

a) Average value of instrument gain $\overline{G}_K$:

$$\overline{G}_K = \frac{\sum G_K}{n} = \frac{\text{sum of individual values of gain}}{\text{number of individual values}}, \qquad \text{(D-1)}$$

b) Corrected gain $\Delta V^{\sim}$:

$$\Delta V^{\sim} = 1{,}7 \cdot \frac{\sum G_K^2 - \frac{1}{n}\left(\sum G_K\right)^2}{n-1} \qquad \text{(D-2)}$$

or

$$\Delta V^{\sim} = 1.7 \cdot \frac{\sum G_K^2 - \frac{1}{n}\left(\sum G_K\right)^2}{n-1} \qquad \text{(D-3)}$$

c) Distances Y_m and Y_V of probe indices:

ca) Test objects with plan-parallel surfaces:

V path scanning: $Y_V = 2 \cdot s \cdot \tan \alpha$ (D-4)

Angled pitch-catch technique:

$Y_m = 2 \cdot (s - b_m) \cdot \tan \alpha$ (D-5)

cb) Test objects with concentric curved surfaces:

1. Examination from the inside:

V path scanning:

$$Y_V = \frac{d_a \cdot \pi}{180} \cdot \left(1 - \frac{2 \cdot s}{d_a}\right) \cdot \left[\alpha - \arcsin\left\{\left(1 - \frac{2 \cdot s}{d_a}\right) \cdot \sin \alpha\right\}\right] \qquad \text{(D-6)}$$

Angled pitch-catch technique:

$$Y_m = \frac{d_a \cdot \pi}{180} \cdot \left(1 - \frac{2 \cdot s}{d_a}\right) \left[\arcsin\left(\frac{1 - \frac{2 \cdot s}{d_a}}{1 - 2 \cdot \frac{s - b_m}{d_a}} \sin \alpha\right) - \arcsin\left\{\left(1 - \frac{2 \cdot s}{d_a}\right) \cdot \sin \alpha\right\}\right] \qquad \text{(D-7)}$$

2. Examination from the outside:

V path scanning:

$$Y_V = \frac{d_a \cdot \pi}{180} \cdot \left[\arcsin\left(\frac{1}{1-2\cdot\frac{s}{d_a}} \cdot \sin\alpha \right) - \alpha \right] \qquad \text{(D-8)}$$

Angled pitch-catch technique:

$$Y_m = \frac{d_a \cdot \pi}{180} \cdot \left[\arcsin\left(\frac{1}{1-2\cdot\frac{s}{d_a}} \cdot \sin\alpha \right) - \right.$$

$$\left. - \arcsin\left(\frac{1}{1-2\cdot\frac{b_m}{d_a}} \cdot \sin\alpha \right) \right] \qquad \text{(D-9)}$$

D 3 General stipulations and requirements

The requirements of clauses C 3, C 4 and C 10 apply. The following requirements shall apply additionally:

a) The scanning surface shall be so even that on an area of 50 mm · 50 mm no bulge or indentation equal to or greater than 1 mm is found (see **Figure D-1**).

b) The examination shall be performed with a probe holder ensuring a positive mechanical connection of the gimbal-mounted search units (probes) and continuously adjustable search unit distances. The probe holder shall be designed such that squint angles can be compensated.

c) Depending on the test object wall thickness and the test frequency transverse wave probes with the transducer dimensions given in **Figures D-3** to **D-16** shall be used.

D 4 Performance of the examination

The manual angled pitch-catch technique shall be performed separately for each zone (see **Figure D-2**).

D 4.1 Compensation of squint angles

Prior to calibrating the sensitivity level and the range, the squint angles of the two probes on the probe holder shall be compensated such that a maximum pulse transfer from the transmitter to the receiver is ensured.

D 4.2 Adjustment of test systems

D 4.2.1 Range calibration

(1) The range shall normally be calibrated by means of multiple echoes using the single-probe technique on calibration blocks No. 1 to DIN EN ISO 2400 or No. 2 to DIN EN ISO 7963. It shall be ensured that a sound path length difference of at least 80 mm (i.e. ± 40 mm distance from the echo) can be evaluated.

(2) The zero-point shall be displaced such that the V scan path echo on the test object is located on the centre of the screen. Indications of reflectors can be expected in the centre of the selected scanning zone from the sound path length of the V scan path echo.

D 4.2.2 Testing level adjustment

(1) When adjusting the testing level the echo amplitude of the V path on the test object shall always be taken as the basis. To consider sensitivity variations the V scan value G_T, in dB, shall be determined on at least 20 representative locations in the volume to be tested at constant probe distance which has to be determined once for the part.

Note:
When recording the V scan measuring values excellent coupling conditions are obtained by slightly displacing (at maximum 10 mm) the probe system. The transmitted indication is not optimized when observing the screen.

(2) Where no greater variation than 6 dB is obtained, the average value $\overline{G}_T$ obtained from V path scanning shall be used for testing level adjustment.

(3) Where greater variations than 6 dB are obtained and no objections are raised as to the further use or examination of the part due to the cause of variation, the average value of V scan values plus an allowance ($\Delta\tilde{V}$ = 1.70 x standard deviation) shall be used for testing level adjustment.

(4) The testing level G_R to be adjusted for zone edge level recording shall be

$$G_R = \overline{G}_T + \Delta V_{KSR6} + \Delta\tilde{V} \qquad \text{(D-10)}$$

D 4.2.3 Checking of the test system adjustment

Prior to the examination the test system shall be checked. To this end, suitable calibration or reference blocks shall be used.

D 4.3 Search unit (probe) distances

The V path scan measurements and the examination of the individual zones shall be performed with the probe index point distances to be determined by calculation as per sub-clause D 2.3 c).

D 4.4 Division into examination zones

(1) The required data for adjusting the probe distances and the sensitivity level shall be taken, for plan-parallel surfaces,

a) for test frequency 2 MHz, from **Figures D-3** to **D-10**,

b) for test frequency 1 MHz, from **Figures D-11** to **D-16**.

(2) In the case of curved scanning surfaces the sensitivity level adjustment shall be based, by approximation, on the allowance for the respective wall thickness ranges taken from **Figures D-3** to **D-16**.

D 4.5 Reference block

Where a reference block is to be used instead of the aforementioned method, its geometry shall be adapted to the test object geometry. The reference reflectors shall have the same size as the disc shaped reflectors to be recorded, and shall also be located on the test zone edges. Where the sensitivity level is adjusted on reference blocks, transfer losses shall be taken into account.

D 4.6 Coupling control

The coupling of the two probes shall be controlled by observing the structural noise.

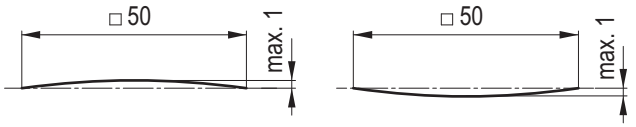


Figure D-1: Eveness of scanning surface for angled pitch-catch techniques

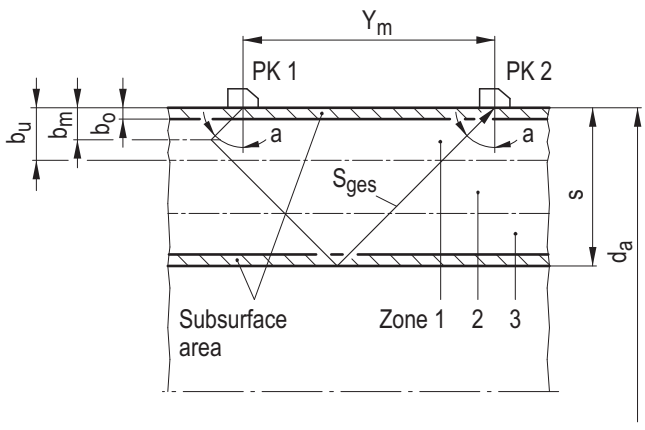
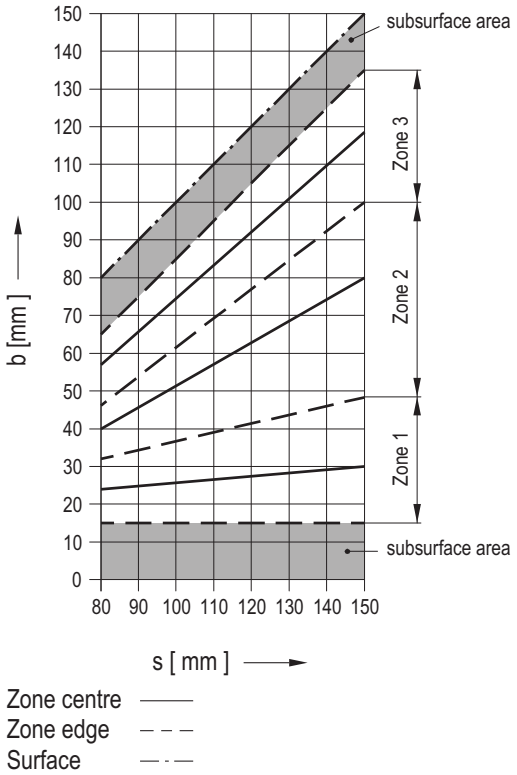


Figure D-2: Zones (1, 2, 3, ...) for angled pitch-catch technique

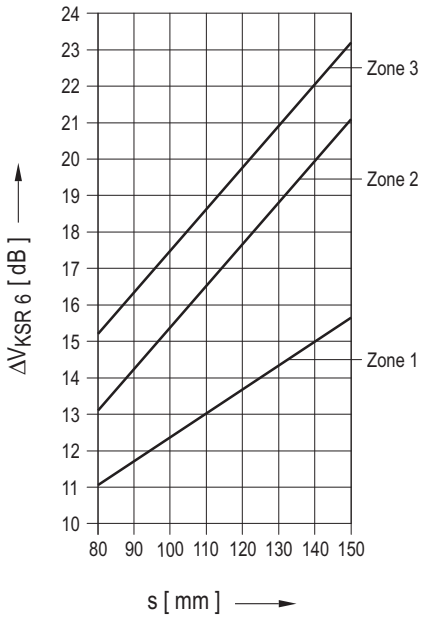


Wall thickness range (mm) 80 ≤ s ≤ 150

PK 1: 8 x 9 mm^2, 2 MHz, 45 degrees

PK 2: 8 x 9 mm^2, 2 MHz, 45 degrees

Figure D-3: Subdivision of zones for (mm) 80 ≤ s ≤ 150 for 2 MHz search units



Wall thickness range (mm) 80 ≤ s ≤ 150

PK 1: 8 x 9 mm^2, 2 MHz, 45 degrees

PK 2: 8 x 9 mm^2, 2 MHz, 45 degrees

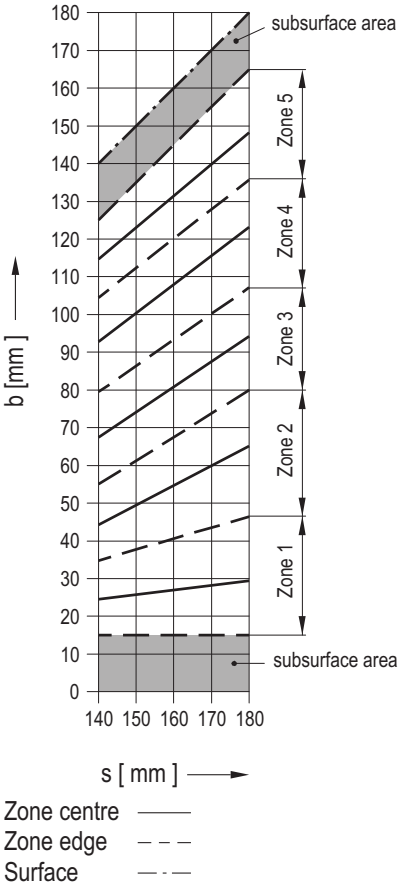
Edge zone allowance contained in ΔV_{KSR6}:

Zone 1: ΔV_{Rand} = 3 dB

Zone 2: ΔV_{Rand} = 4 dB

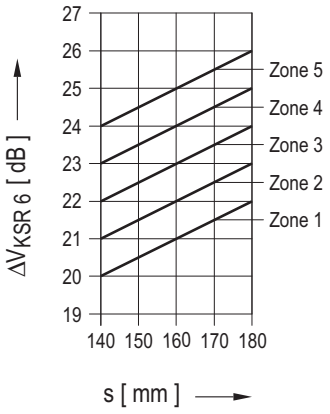
Zone 3: ΔV_{Rand} = 5 dB

Figure D-4: Gain difference ΔV_{KSR6} for recording level for disk shaped reflector = 6 mm to V path echo for the wall thickness range (mm) 80 ≤ s ≤ 150 for 2 MHz search units



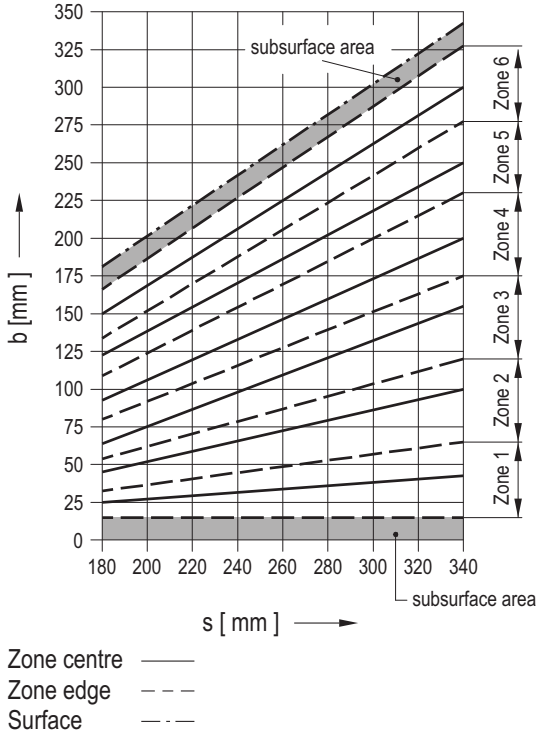
Wall thickness range (mm) 140 ≤ s ≤ 180
PK 1: 10 x 20 mm^2, 2 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 2 MHz, 45 degrees

Figure D-5: Subdivision of zones for wall thickness range (mm) 140 ≤ s < 180 for 2 MHz search units



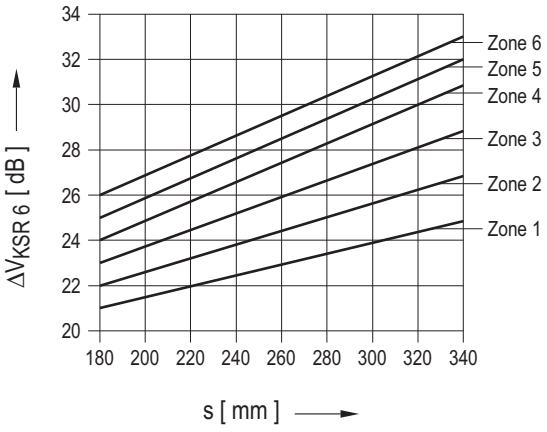
Wall thickness range (mm) 140 ≤ s ≤ 180
PK 1: 10 x 20 mm^2, 2 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 2 MHz, 45 degrees
Edge zone allowance contained in ΔV_{KSR6}:
ΔV_{Rand} = 5 dB

Figure D-6: Gain difference ΔV_{KSR6} for wall thickness range (mm) 140 ≤ s < 180 for 2 MHz search units



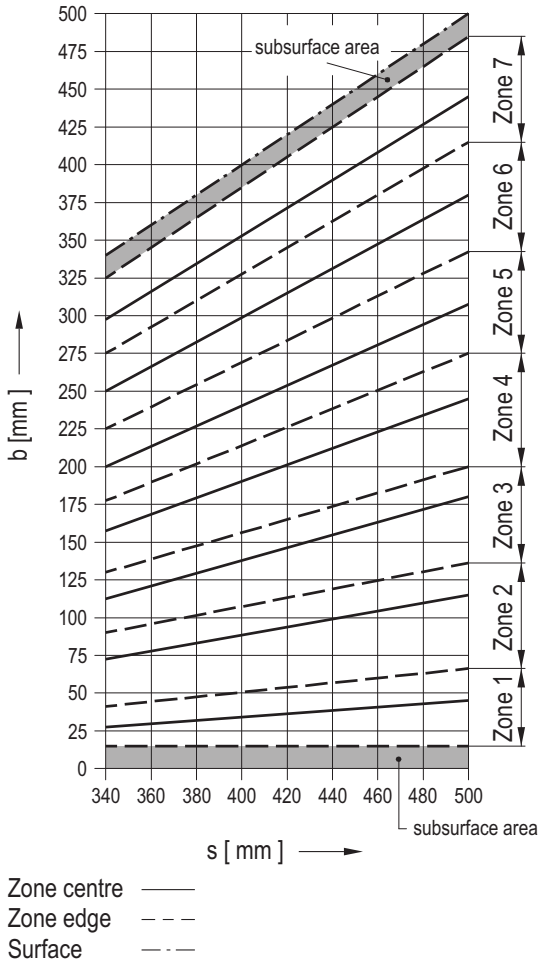
Wall thickness range (mm) 180 ≤ s ≤ 340
PK 1: 10 x 20 mm^2, 2 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 2 MHz, 45 degrees

Figure D-7: Subdivision of zones for wall thickness range (mm) 180 ≤ s < 340 for 2 MHz search units



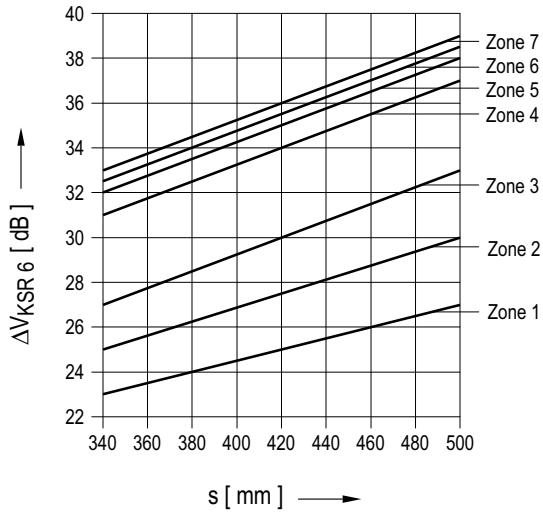
Wall thickness range (mm) 180 ≤ s ≤ 340
PK 1: 10 x 20 mm^2, 2 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 2 MHz, 45 degrees
Edge zone allowance contained in ΔV_{KSR6}:
ΔV_{Rand} = 5 dB

Figure D-8: Gain difference ΔV_{KSR6} for recording level for circular disk reflector = 6 mm to V path echo for wall thickness range (mm) 180 ≤ s < 340 for 2 MHz search units



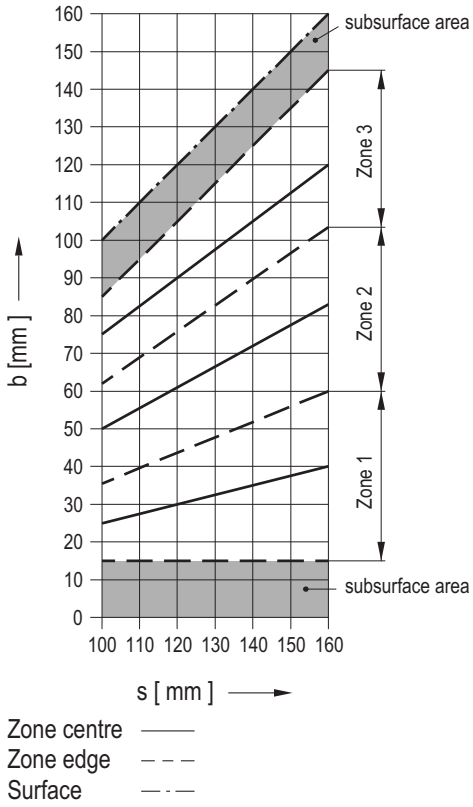
Wall thickness range (mm) 340 ≤ s ≤ 500
PK 1: 10 x 20 mm^2, 2 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 2 MHz, 45 degrees

Figure D-9: Subdivision of zones for wall thickness range (mm) 340 ≤ s ≤ 500 for 2 MHz search units



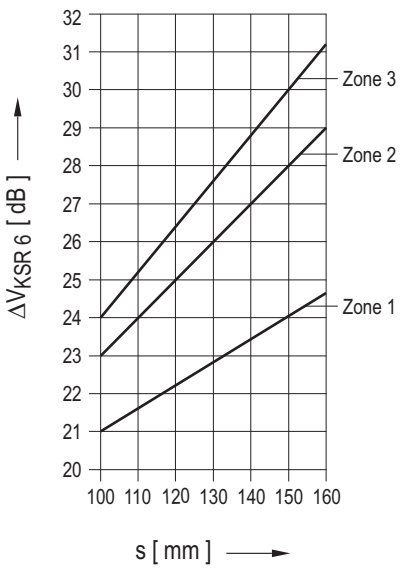
Wall thickness range (mm) 340 ≤ s ≤ 500
PK 1: 10 x 20 mm^2, 2 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 2 MHz, 45 degrees
Edge zone allowance contained in ΔV_{KSR6}:
Zones 1 to 3: ΔV_{Rand} = 3 dB
Zones 4 to 7: ΔV_{Rand} = 5 dB

Figure D-10: Gain difference ΔV_{KSR6} for circular disk reflector = 6 mm to V path echo for wall thickness range (mm) 340 ≤ s ≤ 500 for 2 MHz search units



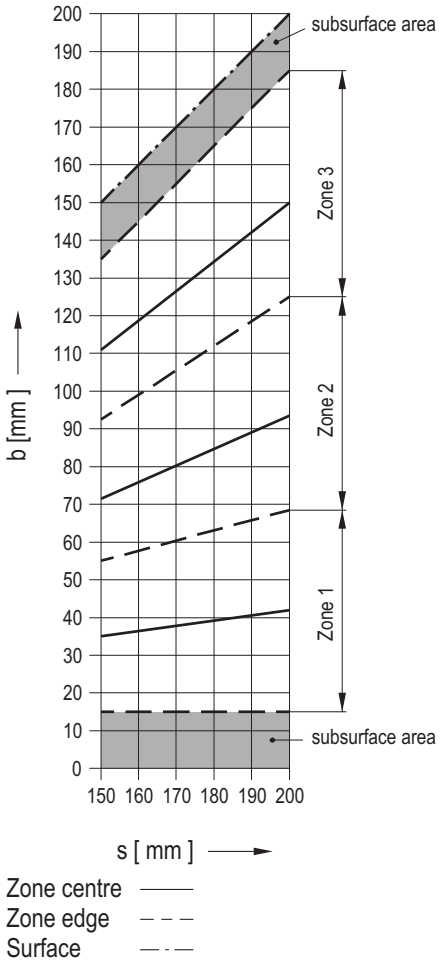
Wall thickness range (mm) 100 ≤ s ≤ 160
PK 1: 10 x 20 mm^2, 1 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 1 MHz, 45 degrees

Figure D-11: Subdivision of zones for wall thickness range (mm) 100 ≤ s ≤ 160 for 1 MHz search units



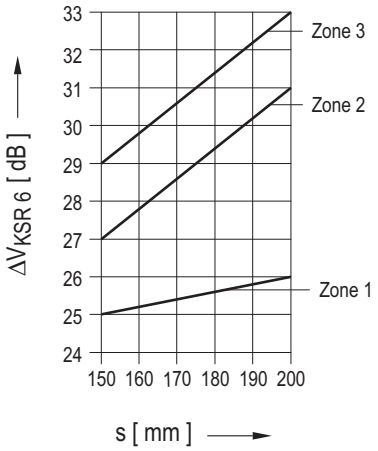
Wall thickness range (mm) 100 ≤ s ≤ 160
PK 1: 10 x 20 mm^2, 1 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 1 MHz, 45 degrees
Edge zone allowance contained in ΔV_{KSR6}: ΔV_{Rand} = 4 dB

Figure D-12: Gain difference ΔV_{KSR6} for recording level for circular disk reflector = 6 mm to V path echo for wall thickness range (mm) 100 ≤ s ≤ 160 for 1 MHz search units



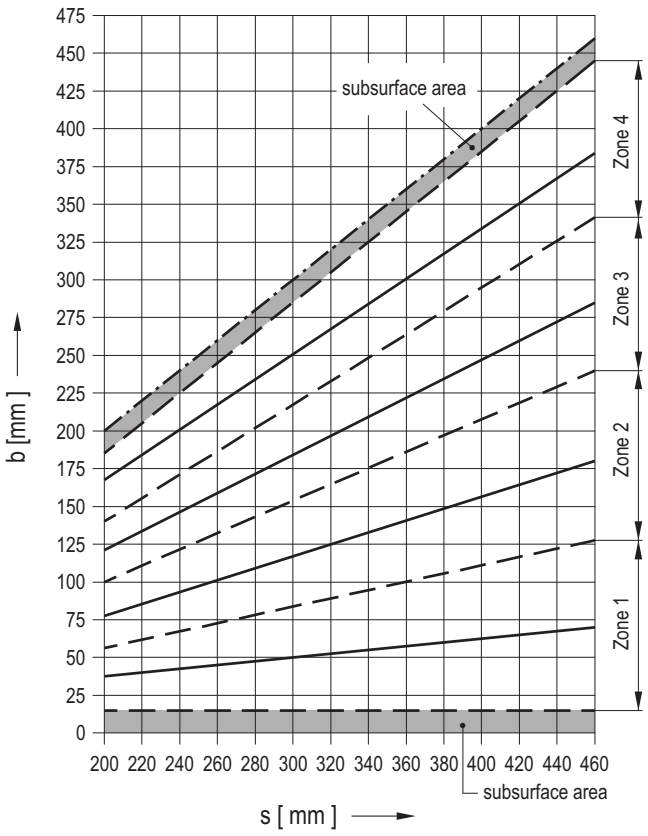
Wall thickness range (mm) 150 ≤ s ≤ 200
PK 1: 20 x 22 mm^2, 1 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 1 MHz, 45 degrees

Figure D-13: Subdivision of zones for wall thickness range (mm) 150 ≤ s < 200 for 1 MHz search units



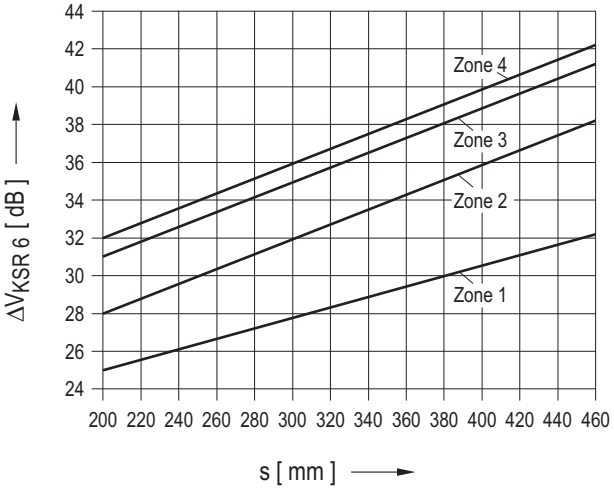
Wall thickness range (mm) 150 ≤ s ≤ 200
PK 1: 20 x 22 mm^2, 1 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 1 MHz, 45 degrees
Edge zone allowance contained in ΔV_{KSR6}: ΔV_{Rand} = 5 dB

Figure D-14: Gain difference ΔV_{KSR6} for recording level for circular disk reflector = 6 mm to V path echo for wall thickness range (mm) 150 ≤ s < 200 for 1 MHz search units



Wall thickness range (mm) 200 ≤ s ≤ 460
PK 1: 20 x 22 mm^2, 1 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 1 MHz, 45 degrees

Figure D-15: Subdivision of zones for wall thickness range (mm) 200 ≤ s ≤ 460 for 1 MHz search units



Wall thickness range (mm) 200 ≤ s ≤ 460
PK 1: 20 x 22 mm^2, 1 MHz, 45 degrees
PK 2: 20 x 22 mm^2, 1 MHz, 45 degrees
Edge zone allowance contained in ΔV_{KSR6}: ΔV_{Rand} = 4 dB

Figure D-16: Gain difference ΔV_{KSR6} for recording level for circular disk reflector = 6 mm to V path echo for wall thickness range (mm) 200 ≤ s ≤ 460 for 1 MHz search units

Annex E

Performance of surface examination by magnetic particle and liquid 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 UV-A may additionally be used to improve the contrast in liquid penetrant testing using fluorescent penetrants.

(4) During the examination 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 examination, 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 examination

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 current flow technique

(1) Where the examination 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 examined is avoided.

(2) Where overheating has occurred the overheated areas shall be marked, ground over after the examination 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 examined 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.

Notes:

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 the examination 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 occur. 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 Liquid penetrant testing

E 3.1 Examination system

(1) Liquid 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 examination system (penetrant, solvent remover and developer) shall be demonstrated by means of a sample examination as to DIN EN ISO 3452-2. Verification shall be submitted to the authorized inspector.

(6) Liquid 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 examination sensitivity obtained shall be recorded.

E 3.2 Performance

(1) Liquid 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 evaluation shall normally be made. A further evaluation shall normally not be made before half an hour after the first evaluation has passed.

(4) Further evaluation times are required if during the second evaluation indications are detected which were not visible during the first evaluation.

Note:

Further evaluation times may also be considered if during the second evaluation essential changings or additional indications are detected.

(5) The assessment shall be made in consideration of the results of all evaluations.

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)
Interpretationen	(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 Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 1: Qualification Testing
KTA 1408.2	(2017-11)	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 2: Manufacture
KTA 1408.3	(2017-11)	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 3: Processing
KTA 3201.1	(2017-11)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 1: Materials and Product Forms
KTA 3201.2	(2017-11)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 2: Design and Analysis
KTA 3201.4	(2016-11)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 4: In-service Inspections and Operational Monitoring
KTA 3203	(2017-11)	Surveillance of the Irradiation Behaviour of Reactor Pressure Vessel Materials of LWR Facilities
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 636:2004); German version EN ISO 636:2015
DIN EN ISO 643	(2013-05)	Steels - Micrographic determination of the apparent grain size (ISO 643:2012); German version EN ISO 643:2012
DIN EN 837-1	(1997-02)	Pressure gauges - Part 1: Bourdon tube pressure gauges; dimensions, metrology, requirements and testing; German version EN 837-1:1996
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 EN 1779	(1999-10)	Non-destructive testing - Leak testing - Criteria for the method and technique selection; German version EN 1779:1999
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 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 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 6947	(2011-08)	Welding and allied processes - Welding positions (ISO 6947:2011); German version EN ISO 6947:2011
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 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 9692-1	(2013-12)	Welding and allied processes - Types of joint preparation - Part 1: Manual metal-arc welding, gas-shielded metal-arc welding, gas welding, TIG welding and beam welding of steels (ISO 9692-1:2013); German version EN ISO 9692-1:2013
DIN EN ISO 9692-2	(1999-09)	Welding and allied processes - Joint preparation - Part 2: S ubmerged arc welding of steels (ISO 9692-2:1998, includes Corrigendum AC:1999); German version EN ISO 9692-2:1998 + AC: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 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 10164	(2005-03)	Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions; German version EN 10164:2004
DIN EN 10204	(2005-01)	Metallic products - Types of inspection documents; German version EN 10204:2004
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 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 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 15614-11	(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 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
SEP 1325	(1982-12)	Drop-weight test to W.S. Pellini
AD 2000-Merkblatt HP3	(2014-11)	Welding supervisors, welder

Annex G (informative)

Changes with respect to the edition 2007-11 and explanations

(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.

(3) Section 2 “Definitions” was supplemented to contain the definitions from KTA 3211.3 (2012-11) and KTA 3201.4 (2016-11) which are required for comprehension of the updated content of the standard. In addition, the term “Room temperature” was taken over. The terms “Welding process” and “Welding procedure” are based on DIN technical report ISO/TR 25901 and DIN EN ISO 15607, the terms “echo height evaluation”, “noise” and “noise level” were taken over from KTA 3201.4.

(4) In paras. 3.3.2, 3.3.3 and 3.3.4 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 DIN EN 287-1:2011-11, Table 2.

   To maintain the equivalence to the former requirements, sub-para. 3.3.3.1 (3) was supplemented to include, in addition to the requirements of DIN EN ISO 9606-1, that the scope for base metals as per DIN EN 287-1:2011-11, Table 2 has to be satisfied.

b) Sub-paras 3.3.3.2 (1) b), 3.3.4.2 (1) b) and 3.3.3.4 (2) were adapted to the current edition of AD-2000 Merkblatt HP 3 (2014-11).

c) At several locations in the text, preciser formulations were made on the basis of the stipulations of KTA 3211.3 (2012-11).

(5) In section 3.3.5, the formerly lacking requirements for personnel performing leak tests (LT) were added, since leak-testing is required in section 10.3.7.

(6) In sections 4, 5, 6, 7, 8, 9, and 11 the precise formulation, clarifications and adaptations to the current state of standardization made in the establishment of KTA safety standard 3211.3 (2012-11) – as far as applicable to KTA 3201.3 – were included. Here, the test requirements laid down in the Tables of sections 9 and 11 were also adapted to the current state of standards.

(7) The rules for applying inspection certificates to DIN EN 10204, edition 1995-08, contained up to now in sections 6.6, 9.1.2 and 10.2.2, were deleted since for new fabrications only DIN EN 10204, edition 2005-01, is applicable. Despite this fact, the following is recognized upon individual checking if stored material is used:

a) instead of inspection certificate 3.1 to DIN EN 10204 (2005-01) also inspection certificate 3.1 B to DIN EN 10204 (1995-08),

b) instead of inspection certificate 3.2 to DIN EN 10204 (2005-01) also inspection certificate 3.1 C to DIN EN 10204 (1995-08).

(8) By taking over the respective requirements from KTA 3211.3 (2012-11), the following changes were made in Section 9 “Welding procedure qualification tests“ and Section 11 “Production control tests“:

a) New requirements were included for laser and electron beam welding in consideration of the stipulations of AD 2000-Merkblatt HP 2/1.

b) In clause 9.1.2 it was made clear that the wall thickness of the test piece is to be fixed such that the destructive and non-destructive tests required for the part wall thickness can be performed.

c) The requirements for the performance of tensile and impact testing in clause 9.1.2 were adapted to the current state of standardization by maintaining the former requirements.

d) In clause 9.1.3.3 the requirements for weld filler metals were adapted to the requirements in AD 2000-Merkblatt HP 2/1 and the requirements in DIN EN ISO 15614-1.

(9) In addition, the following changes were made in Section 9:

a) For the examination of the resistance to intergranular corrosion procedure A to DIN EN ISO 3651-2 was generally prescribed.

b) The stipulations in clause 9.1.5 were changed to comply with KTA 3211.3.

c) The stipulations for tensile test specimens in clauses 9.2.2.2 and 9.3.2.2 were put more precisely with reference to the test standards to be used.

d) Figure 9-6 was supplemented to represent the side-bend test specimen transverse to the direction of weld progression.

e) In clause 9.5.3.1 (1) the reference to KTA 3201.1 was deleted since the current edition of KTA 3201.1 does no more contain a section for product forms and parts made by shape welding or shape melting.

f) Figure 9-16 was taken over from KTA 3211.3 to show the location of hardness indentations on buttered seam welds.

g) The stipulations in clauses 9.7.1.3.1 and 9.7.1.3.2 were put more precisely with reference to Table 9-5.

h) Based on current standards, Tables 9-2 to 9-8 were editorially revised as to content. Since the shape of the specimen is not to be specified for tensile testing at room temperature, pertinent stipulations were simplified in Tables 9-2, 9-5 and 9-8. In Table 9-2 the footnote was ommitted according to which tensile test values of the weld metal are to be determined within batch testing of weld filler metals to KTA 1408.3, as the characteristic values during batch testing are not determined selectively, but are required independently of the stipulations in Table 9-2. As regards the requirements for impact energy in Tables 9-3 and 9-6 (here adapted to austenitic steels), the provision contained in KTA 3211.1 regarding the use of sub-size specimens was included as footnote.

(10) Analogously to the stipulations in KTA 3211.3 (2012-11), an opening-up for test procedures was included in clause 10.3.5.2 that are not contained in Tables 10-2 to 10-4.

(11) In Tables 10-2 and 10-3 the footnotes 7 and 3 respectively were revised editorially.

(12) Analogously to the Tables in Section 9, Tables 11-6 to 11-8 were editorially revised as to the content on the basis of the current standards.

(13) In Section 12 “Non-destructive examinations“, the following changes were made:

a) In clause 12.2.3.4, it was made clear that for ultrasonic testing the requirements for the test object according to Section C 3 are to be met. The requirement for the inner surface of dissimilar welds was revised editorially.

b) In new clause 12.2.4.1, the requirement regarding the verification of the suitability of test procedures and techniques was taken over with the same wording as in clause 11.2.4.1 of KTA 3211.3 (2012-11).

c) In clause 12.2.4.2, new stipulations for the use of digital radiography were included. The entries in Tables 4-1 and 10-1 as well as the stipulations of clause 10.3.5.3 b) were adapted accordingly, and in Annex A a Form for digital radiography was added. The last sentence of sub-clause (3) d) was deleted since this stipulation is already contained in the current edition of DIN 25435-7.

d) Experience gained during testing of welds between austentic 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 12.5.6 and 12.6.4 are performed. Therefore, it was laid down in clause 12.2.4.3 as well as in clause 12.5.6.1 that these welds shall be tested by mechanized testing.

e) Clause 12.2.4.4 “Baseline inspections“ was supplemented to include requirements for the testing of dissimilar welds with the same wording as in KTA 3211.3 (2012-11). Consequently, the pertinent stipulations in former clause 12.6.4.1 (2) b) were deleted and replaced by a reference to clause 12.2.4.4.

f) The stipulations in clause 12.3.5.7.2 as regards the position of the reflectors during ultrasonic testing for longitudinal defects were updated and simplified by taking over the pertinent formulations from KTA 3211.3 (clause 11.3.4.6.2 of the edition 2012-11).

g) Based on KTA 3211.3 (2012-11), the acceptance criteria for the evaluation of solid inclusions during radiography were adapted to the current state of standardization (clause 12.3.6.3 and Table 12-9).

h) In clause 12.5.6.1 it was made clear that welded joints on austenitic steels have to be subjected to ultrasonic testing for longitudinal defects.

i) The criteria mentioned in 12.5.6.3 and 12.6.4.1 as regards the suitability of test techniques during testing of welds between austenitic steels as well as between ferritic and austenitic steels were revised and adapted to the stipulaions of KTA 3201.4 (2016-11). With the revised stipulations now a clear distinction is possible between cases where echo height evaulation is possible and cases where pattern recognition is to be applied. The revision was made based on experience gained with the apllication of the requirements laid down in KTA safety standard 3201.4 (2010-11). The criteria to be satisfied are shown in new Table 12-12. Cases 1 and 2 in this Table cover all relevant practical applications for the testing of butt welds and unclad base metal areas. Consequently, the requirements regarding the recording levels and the acceptance criteria were adapted accordingly.

j) In clause 12.12.3.2.1, the reference to DIN 25450 was deleted as this standard is no more applicable to modern ultrasonic testing equipment and the requirements for the test equipment are adequately regulated in Annex C 4.

(14) The sample forms in Annex A were updated to meet the current standards. New forms for digital radiography were amended.

(15) Annex C “Performance of manual ultrasonic testing“ was updated on the basis of“KTA 3211.1 (2015-11).

(16) In Annex E “Performance of surface examinations by magnetic particle and liquid penetrant methods“ some simplifications and clarifications were made which resulted from the current editions of the referrred standards.

(17) At several locations of the text in this safety standard clarifications and editorial improvements were made.