

# Safety Standards

of the  
Nuclear Safety Standards Commission (KTA)

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**KTA 3401.3** (November, 1986)

**Steel Reactor Safety Containment**  
**Part 3: Manufacture**

(Reaktorsicherheitsbehälter aus Stahl;  
Teil 3: Herstellung)

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

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# KTA SAFETY STANDARD

Nov. 1986

## Steel Reactor Safety Containment Part 3: Manufacture

KTA 3401.3

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger No. 194a on October 14, 2000. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, 50939 Koeln (Telefax +49-221-94373-603).

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**Documents**

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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:

|                        |                                                                                                                                                                                                                                                                              |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>shall</b>           | indicates a mandatory requirement,                                                                                                                                                                                                                                           |
| <b>shall basically</b> | 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 <b>shall normally</b> - are specified in the text of the safety standard, |
| <b>shall normally</b>  | indicates a requirement to which exceptions are allowed. However, the exceptions used, shall be substantiated during the licensing procedure,                                                                                                                                |
| <b>should</b>          | indicates a recommendation or an example of good practice,                                                                                                                                                                                                                   |
| <b>may</b>             | indicates an acceptable or permissible method within the scope of this safety standard.                                                                                                                                                                                      |

## Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety-related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against the damages arising from the construction and operation of the facility (Sec. 7 para. 2 no. 3 Atomic Energy Act), in order to attain the protective goals specified in the Atomic Energy Act and the Radiological Protection Ordinance and further detailed in the "Safety Criteria for Nuclear Power Plants" and in the "Guidelines for the Assessment of the Design of Nuclear Power Plants with Pressurized Water Reactors against Incidents pursuant to Sec. 28 para. 3 Radiological Protection Ordinance".

(2) The reactor safety containment has the purpose of withstanding the loadings of the pressures and temperatures to be assumed for incidents where radioactive materials are released inside the containment, especially with regard to the leakage cross-sections to be assumed for the reactor coolant piping, such that an impermissible release of radioactive materials to the environment is prevented. The reactor safety containment including the penetrations and cooling systems as far as their functioning is required for the control of incidents shall, therefore, be designed and constructed such that they will resist the static, dynamic and thermal loads which can occur in conjunction with the above mentioned incidents and subsequent failures. The reactor safety containment, furthermore, has the purpose of guiding the air flow during normal operation.

(3) In the case of certain stationary light water reactors the reactor safety containment is conceived as a technically gas-tight steel sphere into which the required pipe and cable penetrations as well as tee personnel and materials locks are inserted.

(4) In order for this type of containment to fulfill its purpose certain technical and organizational measures are taken, for instance

- a) choice and application of materials with a high application toughness and a good workability,
- b) design and construction with regard to material strength,
- c) choice of fabrication and testing procedures and the documentation of testing steps and results,
- d) unambiguous instructions for activities with respect to the manufacture and further processing of the material.

(5) These measures are dealt with in our parts of the safety standard KTA 3401.

(6) The present Part 3 deals with the fabrication of the reactor safety containment and the tests required or the demonstration of its quality.

## 1 Scope

This safety standard applies to the manufacturing of the reactor safety containment of steel (referred to in the following text as containment) for stationary light water reactors and of the nozzles permanently connected with the containment and the pressure-retaining parts of the locks.

## 2 General Principles

### 2.1 Requirements Regarding the Manufacturer

(1) The manufacturer shall perform the tasks required regarding proper construction under consideration of this safety standard. The manufacturer may use only certified materials in

accordance with KTA 3401.1 for the containment and qualification tested weld additives in accordance with KTA 1408.1.

*Note:*

*In the following, the term "materials" shall stand for both the materials and their product forms.*

(2) The manufacturer shall demonstrate to the authorized expert prior to taking up manufacturing that the following prerequisites are fulfilled:

*Note:*

*In the case of tests in accordance with this safety standard, the experts are involved either on account of the nuclear or the building regulations:*

- *the experts under Sec. 20 Atomic Energy Act called in by the licensing or the supervisory authority are called in the following "authorized expert",*
  - *the licensing or supervisory authority responsible under the individual state's building code or the testing agencies or testing engineers for structural statics authorized by these authorities are called in the following "authorized civil engineer".*
- a) The manufacturer shall possess the "Grossen Eignungsnachweis" (extensive proof of qualification) in accordance with Sec. 6.2 DIN 18 880 Part 7.
  - b) The manufacturer shall have a quality division that is independent of fabrication.
  - c) The manufacturer shall have at his disposal equipment with which he is able to shape, weld, heat treat, transport and perform the required tests on the materials, all in accordance with the quality requirements of the containment. Equipment of other organizations may be used if these fulfill the prerequisites.
  - d) The manufacturer shall have qualified personnel for the manufacturing at his disposal.
  - e) The manufacturer may involve only welders whose qualification is demonstrated in accordance with Section 3.3. The requirements regarding welding supervision are presented in Section 3.2, the requirements regarding testing supervision in Section 6.1.2.
  - f) The manufacturer shall demonstrate to the authorized expert in a process qualification test corresponding to the manufacturing process that he is in sure command of the intended welding procedure.
  - g) The manufacturer may carry out the fabrication only in accordance with design reviewed, valid drawings and documents.

### 2.2 Authorized Structural Engineer

The authorized structural engineer shall assure himself during fabrication that the quality assurance measures pertaining to his area of responsibility are applied.

### 2.3 Preserving the Material Marking

#### 2.3.1 General Requirement

The marking of the materials shall be preserved (maintained) during the manufacturing process.

#### 2.3.2 Transfer of Markings

If during manufacture the original material markings are removed they shall be transferred prior to the separation of the parts. In the case of rolled components the markings shall be transferred such that the main direction of rolling is clearly identifiable.

### 2.3.3 Transfer of Markings in Case of Materials with Acceptance Test Certificate C or A in Accordance with DIN 50 049

(1) In the case of materials with acceptance test certificate C or A in accordance with DIN 50 049, the marking shall be transferred by the authorized expert. Thereby, the marking of the original part (material identification, melting bath number and specimen number) shall be transferred to the part to be newly stamped; the identification shall then be stamped by the authorized expert.

(2) In the case of small parts it is sufficient that the stamp of the authorized expert is affixed together with an identification mark which enables the correlation with the tested, initial material. With written consent of the authorized expert, the transfer of markings to small parts may be carried out by the component manufacturer.

(3) A certificate shall be issued which contains the complete markings of the originally delivered material and of the newly stamped parts. This certification may be carried out by including a corresponding note in the acceptance test certificate.

### 2.3.4 Transfer of Markings in Case of Materials with Acceptance Test Certificate B, Production Test Certificate or Statement of Compliance with the Order in Accordance with DIN 50 049

(1) With written consent of the authorized expert, the markings of materials with acceptance test certificate B, production weld test certificate or statement of compliance with the order in accordance with DIN 50 049 may be transferred by the component manufacturer. The written consent shall include a list of plant personnel responsible for the transfer of markings and shall show the stamp of the plant.

(2) In the case of small parts it is sufficient that the stamp of the plant expert is affixed together with an identification mark which enables the correlation with the tested initial material.

## 2.4 Corrosion Protection

All parts of the containment shall be effectively protected against corrosion. Section 6.3.3.3 shall be considered.

## 3 Basic Principles Regarding Welding Tasks

### 3.1 Documents

Prior to any welding tasks including weld seam preparation, the documents required for the individual manufacturing step shall be at hand with the mark indicating a completed design review in accordance with Section 7.

### 3.2 Welding Supervision

#### 3.2.1 General Requirements

(1) For every welding task on the containment a welding supervisor shall be designated in writing to the authorized expert. This welding supervisor shall belong to the personnel of the individual manufacturing plant.

(2) The welding supervisor shall, in particular, have practical experience in welding technology as well as in the particular welding process to be employed in fabrication. Within the framework of manufacturer appraisal and in the course of fabrication the authorized expert assures himself of the qualification and work of the welding supervisor.

(3) The welding supervisor shall with in the framework of the design reviewed welding schedule, be authorized to person-

ally initiate the measures for achieving the prescribed quality of the weld seam. He shall make sure that the technical standards pertaining to his field of activity are adhered to. He is responsible for the assignment of the welders as well as for the correct operating condition of the welding and auxiliary equipment during fabrication. The welding supervisor shall supervise the welding tasks and is responsible for their documentation, e.g. he welding record.

(4) If more than one person is named as weld supervisor, their individual areas of responsibility shall be delimited with respect to each other.

#### 3.2.2 Qualification

Only engineers with a special training in welding technology (Schweissfachingenieure) may become welding supervisor. After a corresponding period of vocational adjustment they must be qualified for the job on account of their training, experience and abilities. They may be supported by welding technicians, welding specialists and welding apprentices who may not however, perform the functions of welding supervision.

### 3.3 Welders

#### 3.3.1 Training and Education

The welders shall have been trained and educated in training centers which are regularly involved with the education and training of welders.

#### 3.3.2 Examination

(1) The examination of the welders shall be carried out in accordance with DIN 8560. The examination may be carried out

- a) by the authorized expert,
- b) with special approval of the authorized expert by the manufacturer or by the welding academies of the German Federation for Welding Technology (DVS or by training facilities of similar rank. Carrying out the examination with special approval by the authorized expert requires that a training facility qualified examiners and proper equipment are available. The results of the examinations shall be documented in writing and be available to the authorized expert. The certificate of examination shall contain the addendum "The examination was carried out with special approval of the authorized expert ... (name of the authorized expert) from .. (name of the institution)." The examination certificate shall be countersigned by the authorized expert. The authorized expert shall repeatedly assure himself of the proper execution of the examinations.

(2) The manufacturer shall present evidence to the authorized expert that the welding personnel for operating mechanical welding equipment has the required qualification and operating know-how. This proof may, among other possibilities, be presented within the framework of the procedure qualification tests or the production weld test prior to actual fabrication. The proof shall be in form of a manufacturer certificate which shall be countersigned by the authorized expert.

#### 3.3.3 Reexamination

(1) The welders shall be reexamined in biannual intervals or after the welding activity was interrupted for more than six months this also applies to the qualification test of the welders for operating mechanical welding equipment. The results of the procedure qualification tests and of the production weld tests are acceptable as reexaminations.

(2) The reexaminations in accordance with DIN 8560 shall be carried by the institutions named in Section 3.3.2.

(3) In substantiated cases the reexamination may be carried out in the form of a single application examination (Einzweckschweisserprüfung). The welding supervisor shall make sure that the welder is deployed only for tasks within the restrictions of this reexamination.

### 3.3.4 Examination Certificates

The examination certificates of examinations or proofs in accordance with Sections 3.3.2 and 3.3.3 shall be kept available at the place of deployment of the welder.

## 3.4 Treatment and Application of Weld Filler Materials

(1) The weld filler materials shall enable a weld connection that is tuned to the base material and the specified requirements.

(2) Only weld filler materials may be applied that were qualification tested in accordance with KTA 1408.1 and manufactured in accordance with KTA 1408.2.

(3) Weld filler materials may only be treated and applied in accordance with KTA 1408.3.

## 3.5 Welding Task Procedures

### 3.5.1 Work Related Requirements

(1) The weld connections shall be welded to correspond to the specifications of the design reviewed documents and to the conditions of the procedure qualification test.

(2) All weld connections shall be welded in at least two layers.

(3) All welds, including those for weld attachments, shall be created with basic coated electrodes or with weld additives that result in a weld connection of similar quality.

(4) Butt weld connections of pressure retaining components shall be created such that, with regard to their outer appearance excepting edge offset, they will meet the requirements of evaluation group AS in accordance with Table 1 DIN 8503 Part 3 and will enable the nondestructive testing in accordance with Section 9.3.

(5) The midplane offset shall be within the tolerance limits in accordance with Section 5.

(6) Butt weld connections welded from only one side are allowed only in exceptional cases. In the case of unavoidable one-sided butt welds (pipe connection welds) it shall be ensured that, regarding the weld connection an unambiguous test result is achievable. The outer appearance of the root shall meet the requirements of evaluation group BS in accordance with Table 1 DIN 8563 Part 3.

(7) Fillet welds are allowed only in the case of

- a) temporary weld attachments,
- b) covers which are attached to penetration nozzles inside the containment, and
- c) the cover of the leak-tight box (sealing sleeve of the penetration).

(8) The position of each weld connection shall be identifiable. The correlation of welders to each weld connection shall be recorded in drawings or welding records.

(9) Gouging with carbon electrodes shall be carried out only if the electrodes without copper cladding or vapor clad with copper were demonstrated to be qualified. The results of pro-

cedure qualification and production weld tests may be drawn upon for this demonstration.

(10) During gouging the preheating specified in the welding schedule shall be adhered to. The locations of carbonization and increased hardness due to gouging shall be removed by grinding or machining. The finished areas shall be subjected to a surface crack examination in accordance with Section 6.3.4. The examination results shall be assessed in accordance with Section 9.3.4.2.

(11) Testing the electric arc or igniting the electrodes on components outside of the weld edge is not allowed. If, however, arc strikes have occurred outside of the weld edge they shall be ground smooth and subjected to a surface crack examination in accordance with Section 6.3.4. These locations shall be free of any flaws.

(12) The welding area or the work location of the welder shall be protected against weather factors, e.g., rain and wind. For cutting and welding tasks at temperatures below +5 °C, measures to be taken shall be established in agreement with the authorized expert.

(13) Those weld seams of pressure retaining walls where no subsequent heat treatment is carried out shall be welded with the temper-bead technique if the material used so requires; here the distance between the bond lines of the border covering bead and the temper bead shall be between 1 and 5 mm. In case that distance deviates from this requirement a special consent shall be obtained from the authorized expert.

#### Note:

*Whether or not the temper-bead technique is required is specified for the containment in Appendix A KTA 3401.1. Accordingly, it is not required for the steel 15 MnNi 63.*

(14) In addition the requirements of SEW 088 and KTA 3401.1 shall be considered.

### 3.5.2 Edge Zone Examination

(1) All components for pressure retaining walls shall be subjected to edge zone examinations with ultrasonics in accordance with Sec. 5.3.3.4 KTA 3401.1 in the regions of the intended weld connections including the regions of weld connections of longitudinally welded nozzles.

(2) The examination zone width shall be at least 50 mm to both sides of the edge faces. In the case of components with a nominal wall thickness larger than 50 mm, the examination zone width to both sides of the edge faces shall be equal to the nominal wall thickness. In both cases it shall be ensured that, after undercutting the weld edge preparation surface, at least 20 mm of examined base material remain.

(3) The edge zone examination shall be carried out prior to undercutting the weld edge preparation surfaces. Any repairs of flaws in the base material require the consent of the authorized expert.

### 3.5.3 Fabrication Conditions for Weld Edge Preparation Surfaces and Wall Thickness Transitions

(1) Weld edge preparation surfaces may be fabricated by thermal cutting or by mechanical means. During welding, the weld edge preparation surfaces shall be free of rust, scale or other soiling.

(2) The thermal cutting shall be carried out in accordance with the requirements of Appendix A KTA 3401.1.

(3) Mechanical means, e.g. grinding procedures, are required if it cannot be ensured that the fusion zone is remolten during the welding procedure or if it is expected that the hard-

ness of the fusion zone would result in faults of the weld seam.

(4) The finished weld edge preparation surfaces and the weld areas of longitudinally welded nozzles shall be subjected to a surface crack examination in accordance with Section 6.3.4. The evaluation shall be carried out in accordance with Section 9.3.4.2.

(5) Areas of the metal surfaces which are beveled by thermal cutting, e.g., wall thickness transitions, shall be ground smooth and subjected to a surface crack examination in accordance with Section 6.3.4. The test results shall be evaluated in accordance with Section 6.3.3.4(2) KTA 3401.1. If this examination reveals indications that exceed the allowed level then, with special approval of the authorized expert, they shall be ground out and, as necessary, be repaired by special repair weldings.

### 3.5.4 Weld Attachments

#### 3.5.4.1 General Requirements

Weld attachments shall be welded under the same conditions as butt welds. Fillet welds are only allowed for weld attachments which must be removed prior to the pressure test (temporary weld attachments); in this case the last bead may not touch the base material of the pressure retaining wall. In the case that a stress relief annealing after welding is required in accordance with Section, the weld attachment should be welded connected prior to the stress relief annealing. Deviation from this requirement is allowed with special approval of the authorized expert if the characteristics of the material and welding conditions so allow.

#### 3.5.4.2 Permanent Weld Attachments

Weld seams on permanent weld attachments shall be subjected to nondestructive examinations in accordance with Section 9.3.

#### 3.5.4.3 Temporary Weld Attachments

(1) The weld attachments should be removed by machining or grinding. In case a removal by thermal means is required a minimum distance of 5 mm to the surface of the component shall be adhered to. The remaining material shall be ground down to the surface of the component. A reduction of the wall thickness below the nominal wall thickness is not allowed without an analytical proof in accordance with KTA 3401.2. Remains of weld seams shall be ground off.

(2) After removal of the temporary weld attachments the areas possibly affected by the welding and by the removal process shall be marked and subjected to a surface crack examination in accordance with Section 6.3.4 with the magnetic particle procedure. The results shall be evaluated in accordance with Section 9.3.4.4. Furthermore, the hardness of 5 % of the locations shall be determined in one hardness row of HV 10 in accordance with Section 8.4.3(8). The results shall be documented.

### 3.5.5 Repair Welding

(1) In the case of repair weldings the requirements in accordance with Sections 3.5.1 through 3.5.4, 6, 7, 9 and 11 shall be met.

(2) Repair welding is only allowed with the consent of the authorized expert.

(3) If repair weldings are carried out on weld connections that were already heat treated, the weld connections shall be subjected to a renewed heat treatment after the repair.

(4) In substantiated cases and with special approval of the authorized expert a renewed heat treatment may be dispensed with.

(5) In the case that weldings are required for the removal of undercuts or of locations where a reduction below the nominal wall thickness has occurred or for shape corrections, the consent of the authorized expert shall be obtained prior to starting the work.

(6) If there is no procedure qualification for a repair welding procedure then this procedure shall be simulated in a production weld test.

(7) Repair weldings and weldings for shape corrections shall be documented.

## 4 Principles for Heat Treatments after Weldings

### 4.1 Necessity for Heat Treatment (Stress Relief Annealing)

The necessity for the heat treatment after welding is dependent on the chemical composition of the materials, on the wall thickness of the component that is connected by a full penetration welding and on the mechanical characteristics. The requirement is specified in the certified material test report.

### 4.2 Requirements Regarding Heat Treatment Facilities

(1) Within the manufacturer qualification proof (see Section 2.1(2)) the qualification of the heat treatment facility shall be demonstrated to the authorized expert.

(2) Testing and calibration of the displaying and registering temperature measuring equipment shall not lie back further than one year and shall be repeated after every reconstruction and every transport and shall be certified by measuring records of the quality division that is independent of the fabrication.

## 5 Manufacturing Tolerances

### 5.1 Measuring Schedule

Prior to begin of manufacture a measuring schedule shall be set up to test the accuracy-to-gauge of the containment and the components. This schedule shall describe all measuring steps and their time sequence.

### 5.2 Containment

#### 5.2.1 Diameter

The outer diameter of the individual zones shall be determined by measuring the outer circumferences of the zones of welded plates. The outer diameter may not deviate more than 0.5 % from the specified required outer diameter. The measurements shall be taken on the lower edge of each zone.

#### 5.2.1 Out-of-Roundness

The deviation from circular shape (out-of-roundness) shall not exceed 0.5 %. The out-of-roundness shall be determined from the largest and the smallest radius in the cross-section plane using the following equation:

$$\text{out-of-roundness (\%)} = \frac{(R_{\max} - R_{\min})}{(R_{\max} + R_{\min})} \times 100 \quad (5-1)$$



The radius shall be measured in 16 locations distributed along the circumference of each zone at the lower edge of the zone.

### 5.2.3 Indentations

Indentations are only allowed if they have a flat course. Their depth, measured as the deviation from the required shape, shall not exceed 1 % of the width of the indentation. The deviation shall be measured with a 2-meter-template.

### 5.2.4 Seam Retractions

Seam retractions are only allowed if they have a flat course. Their depth, measured as the deviation from the required shape shall not exceed 5 mm (template length 500 mm).

### 5.2.5 Height Tolerance

The overall height of the containment shall not deviate more than 0.1 % from the specified required height.

### 5.2.6 Effect of Fabrication Tolerances on Attached and Inserted Parts

The tolerances specified in Sections 5.2.1 through 5.2.5 are only allowed if the functional capability of the attached and inserted parts (e.g., locks, pipe penetrations) is not affected. Corresponding requirements shall be specified during planning.

### 5.2.7 Unplanned Midplane Offset

#### 5.2.7.1 Equal Wall Thicknesses

Without a special proof regarding the calculated stresses, the unplanned midplane offset of butt welded product forms shall be less than 5 % of the wall thickness but shall not exceed 3 mm.

#### 5.2.7.2 Unequal Wall Thicknesses With and Without Bevelled Edges

Without a special proof regarding the calculated stresses the unplanned midplane offset shall not be less than 5 % of the smaller wall thickness but shall not exceed 3 mm.

## 5.3 Locks

### 5.3.1 Diameter

The average outer diameter of the body of the lock as determined from its circumference shall not deviate more than  $\pm 0.5$  % from the specified required outer diameter.

### 5.3.2 Out-of-Roundness

The deviation from circular shape (out-of-roundness) of the body of the lock shall not exceed 0.5 %. The out-of-roundness shall be determined from the largest and the smallest diameter in one cross-section plane using the following equation:

$$\text{out-of-roundness (\%)} = 2 \times \frac{(D_{\max} - D_{\min})}{(D_{\max} + D_{\min})} \times 100 \quad (5-2)$$

### 5.3.3 Indentations

Indentations are only allowed if they have a flat course. Their depth, measured as the deviation from the required shape, shall not exceed 1 % of the width of the indentation.

### 5.3.4 Seam Retractions

seam retractions are only allowed if they have a flat course. Their depth, measured as the deviation from the required shape shall not exceed 3 mm (template length 200 mm).

### 5.3.5 Straightness

Cylindrically shaped lock bodies shall not be out of line more than 0.5 % of the cylinder length.

### 5.3.6 Effect of Fabrication Tolerances on Function and Leak-Tightness

The tolerances specified in Sections 5.3.1 through 5.3.5 are only allowed if the functional capability and the leaktightness is not affected. Corresponding requirements shall be specified during planning.

### 5.3.7 Unplanned Midplane Offset

#### 5.3.7.1 Equal Wallthicknesses

Without special proof regarding the calculated stresses, the unplanned midplane offset of butt welded product forms shall be less than 10 % of the wall thickness but shall not exceed 2 mm.

#### 5.3.7.2 Unequal Wallthicknesses With and Without Bevelled Edges

Without special proof regarding the calculated stresses the unplanned midplane offset shall be less than 10 % of the smaller wall thickness but shall not exceed 2 mm.

## 5.4 Nozzles

The tolerances for the nozzles shall be specified in accordance with the components to be connected.

## 5.5 Testing Capability

The execution of nondestructive examinations shall not be essentially impaired by bevelling nor by mid plane offsets. If necessary, the capability for testing shall be demonstrated on test objects of similar dimensions and tolerances.

## 5.6 Exceeding of Tolerances

In case tolerances are exceeded, Section 9.7 applies.

## 6 Basic Requirements for Non-Destructive Examinations

### 6.1 Organization of Non-Destructive Testing at the Manufacturer

#### 6.1.1 Personnel Requirements

(1) The testing supervision shall be a part of the manufacturing plant.

(2) The testing personnel should belong to the manufacturing plant. Contract testing personnel may perform testing tasks only in the case of radiographic examinations. In the case of ultrasonic examinations and surface crack examinations, contract testing personnel may perform tests only in addition to the testing personnel of the manufacturing plant.

(3) In the case of changes in personnel or testing technology a renewed demonstration to the authorized expert is required that the requirements in accordance with Sections 6.1.2, 6.1.3

and 6.3 are met regarding the activities of the testing supervisor and the testing personnel.

### 6.1.2 Requirements Regarding Testing Supervisors

- (1) The testing supervisors shall be independent of the fabrication and shall be reported by name to the authorized expert.
- (2) The testing supervisors shall have the technical and basic knowledge required for their tasks and shall master the examinations to be performed by them in accordance with the specified requirements. The authorized expert shall assure himself of their qualification prior to the begin of manufacture.

### 6.1.3 Tasks of the Testing Supervisors

The testing supervisors shall ensure that the testing personnel has the necessary state of training and that the testing equipment is in perfect condition. They shall supervise the examinations to be performed by the manufacturer, shall evaluate their results and sign the test report.

### 6.1.4 Tasks of the Testing Personnel

The testing personnel shall have basic theoretical knowledge and shall master the examinations to be performed by them. The testing supervisor shall demonstrate this to the authorized expert on the basis of the testing personnel's practical testing experience, their plant-internal training or their certificates from external fasts.

## 6.2 Extent and Timing of Non-Destructive Examinations

- (1) All of the following shall be subjected to nondestructive examinations
  - a) connection welds of the pressure retaining walls,
  - b) weld seams connecting to the pressure retaining walls,
  - c) edge zones (of the welds)
  - d) weld edge preparation surfaces and gouged weld seam areas to an extent that the occurrence of systematic errors can be precluded,
  - e) repair weldings,
  - f) locations where weld attachments were removed,
  - g) bevelled edges.

The examinations c) and d) shall be carried out as intermediate test (examinations during fabrication).

- (2) The examination of the weld seams shall be scheduled such that systematic errors can be detected and remedied already during the welding procedure. The point in time of the examination shall, however, be chosen in consideration of possibly occurring delayed cracks. The time period specified in Appendix A 1 KTA 3401.1 shall be observed.
- (3) The nondestructive examination shall be carried out after the final heat treatment. An additional nondestructive examination shall be carried out after the pressure test in accordance with Section 10.8.

## 6.3 Procedural Requirements for Performing Non-Destructive Examinations

### 6.3.1 General Requirements

- (1) The weld connections shall be designed such that there is no unallowable impairment of the information from the test results.
- (2) Prior to the begin of testing, the testing supervision of the manufacturer shall, in particular specify in detail and describe

the type of examinations, the testing prerequisites and the testing techniques (testing instructions). The testing instructions shall be subjected to a design review.

### 6.3.2 System for Specifying the Location of Detected Flaws

Prior to performing nondestructive examinations, the manufacturer shall submit to the authorized expert his marking system which must ensure the reproducibility of detected flaws.

### 6.3.3 Ultrasonic Examination

#### 6.3.3.1 Locations of the Coupling Surfaces

- (1) In the case of nominal wall thicknesses up to 60 mm it is sufficient to scan from only one component surface.
- (2) In the case of nominal wall thicknesses larger than 60 mm the scanning should be carried out from both surfaces.
- (3) The position and dimensions of the coupling surfaces shall be chosen in accordance with Sections 6.3.3.2, 6.3.3.5 and 6.4.
- (4) Any deviations from the requirements of the paragraphs 1 through 3 (above) need the consent of the authorized expert.
- (5) It shall be ensured that the testing sensitivity is attained in each volume element (see Section 6.3.3.11).

#### 6.3.3.2 Examination Area and Width of Coupling Surfaces

- (1) The examination shall extend to the filler metal and the base metal on both sides of the weld connection. In the case of nominal wall thicknesses up to 50 mm the bordering base metal shall be tested to a width of at least 10 mm; in the case of larger nominal wall thicknesses the width shall be 20 mm.
- (2) The coupling surfaces for examining for longitudinal errors shall be wide enough such that the areas to be examined can be examined in all scanning directions and with all beam angles.

#### 6.3.3.3 Condition of Coupling Surfaces

- (1) All accessible weld surfaces shall be in such a condition that they can be tested. As necessary, they shall be prepared accordingly.
- (2) The coupling surfaces shall be in such a condition that the probes have a good contact and can be easily moved. All interfering unevenness and soiling (e.g., grooves, scale, weld spatter) shall be removed. Furthermore, the coupling surfaces shall be such that, even in consideration of a possible surface curvature, the distance between the probe base and the coupling surface shall nowhere exceed 0.5 mm. To meet this requirement in the case of curved surfaces, the probe base may have to be properly adapted.
- (3) The center line average roughness value  $R_a$  shall not exceed the value of 20  $\mu\text{m}$ .
- (4) If, prior to the examination, the coupling surfaces are coated with a corrosion protection it shall be demonstrated to the authorized expert that this coating has no effect on the test results.

### 6.3.3.4 Ultrasonic Beam Angle

#### 6.3.3.4.1 Butt Weld Connections

Butt weld connections shall be examined using the angle beam scanning technique. The following requirements shall be met:

- a) In the case of nominal wall thicknesses  $\leq 40$  mm the examination shall be carried out with one beam angle. This beam angle should be chosen such that the incident angles  $\beta_1$  and  $\beta_2$  (**Figure 6-1**) lie between  $45^\circ$  and  $55^\circ$ . In case of larger incident angles it shall be demonstrated that, compared to the indication from a 1 mm deep and 1 mm wide rectangular groove, the testing sensitivity in the near-surface regions is larger by at least 6 dB for nominal wall thicknesses  $\geq 7$  mm and by at least 12 dB for nominal wall thicknesses between 5 and  $< 7$  mm. Incident angles below  $45^\circ$  shall be avoided as far as possible.

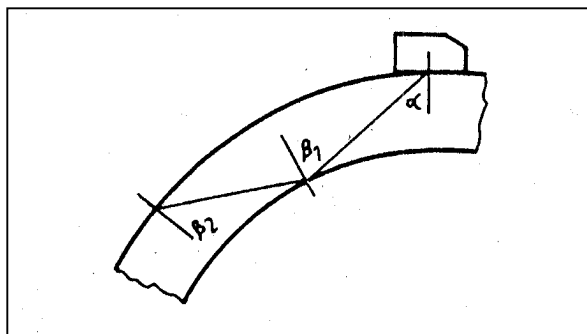


**Figure 6-1:** Incident angles for a product geometry curved in the direction of the sonic beam

- b) In the case of a nominal wall thickness  $> 40$  mm two angle probes shall be used in the examination. One beam angle shall be chosen such that, at the surface, the incident angles  $\beta_1$  and  $\beta_2$  lie between  $35^\circ$  and  $55^\circ$ . The second beam angle should be such that the angular deviation between the beam axis and the surface normal of faults running perpendicular to the surface (angle  $\delta$  in **Figure 6-2**) is not larger than  $30^\circ$ .
- c) In the case of a nominal wall thickness  $> 100$  mm the incident angles shall be specified in agreement with the authorized expert.

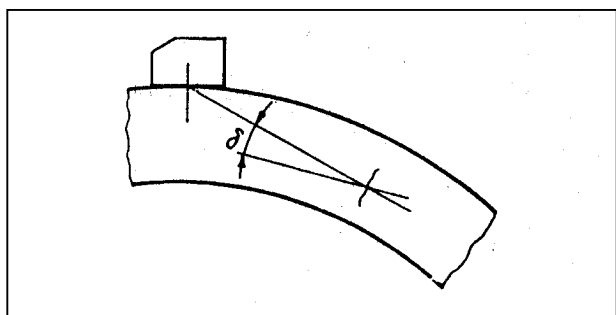


**Figure 6-2:** Additional incident beam angle

#### 6.3.3.4.2 Weld Connections of Nozzles and of Permanent Weld Attachments

Weld connections of nozzles and of permanent weld attachments shall be examined using the angle beam scanning technique. The following requirements shall be met:

- a) Weld seams of set-through nozzles shall be examined in accordance with **Figure 6-4** of Section 6.3.3.5(3) with one

sonic beam angle. In the case of a containment wall thickness  $> 40$  mm, additionally, the positions 8 and 9 shall be examined with a second beam angle that differs from the first by at least  $15^\circ$ .

- b) Weld seams of set-on nozzles shall be examined in accordance with **Figure 6-5** of Section 6.3.3.5(3) with one sonic beam angle. In the case of a nominal nozzle wall thickness  $> 40$  mm, the positions 6 through 11 shall be examined with a second beam angle that differs from the first by at least  $15^\circ$ .
- c) Weld seams of permanent weld attachments shall be tested in accordance with **Figure 6-6** with one sonic beam angle.
- d) If the angle beam scanning from the side of the weld attachment is hindered then, in the case of a favorable geometry of the component and of the weld seam, a straight beam scanning may be carried out from the side of the weld attachment.
- e) Regarding the incident angles for the angle beam scanning the requirements of Section 6.3.3.4 apply accordingly.

#### 6.3.3.4.3 Butt Weld Connections of Unequal Wall Thicknesses with the Thicker Wall Bevelled down to the Thinner Wall

Butt weld connections of unequal nominal wall thicknesses where the thicker wall is bevelled down to the thinner wall shall be examined with the angle beam scanning technique. The following requirements shall be met:

- a) The number of beam angles shall be determined on the basis of the thinner wall.
- b) The local coordinates of indications from reflectors located beyond the first reflection of the beam can only be determined with sufficient accuracy if the reflection occurs on plane parallel surfaces. If this is not the case the evaluation shall be carried out to only one half of the skip distance.

*Note:*

*In the case of bevel ratios between 1:3 and 1:4, beam angles of  $70^\circ$  have been proven to be effective in the examination of the full weld seam volume including the surrounding base material for longitudinal flaws with the angle beam scanning technique applied to the plan parallel surface of the thicker wall.*

- c) With respect to ultrasonic examinations bevelled edges may be considered as plan parallel surfaces if the one-sided bevel angle is under an angle  $\leq 6^\circ$ ; in the case of double-side bevelling the sum of the two angles should be  $\leq 6^\circ$ .
- d) The requirements specified for the incident angles shall be met also in the case of special geometric features (e.g., bevels, curvatures) in the regions to be evaluated.
- e) If, due to unfavorable geometric features of the component, these requirements cannot be met, the testing requirements shall be specified in collaboration with the authorized expert.

#### 6.3.3.4.4 Additional Sonic Beam Angles

If sonic beam angles and beaming locations other than the ones specified in the testing instruction seem better suited for an accurate determination of the location and dimension of the flaw then these shall be used in addition to the ones specified.

### 6.3.3.5 Direction of the Sonic Beam

#### 6.3.3.5.1 Basic Requirements

- (1) With relation to the tangential plane of the coupling surface all side angles shall be considered regarding the possible

flaw orientations; therefore all directions of the sonic beam shall be used. In examining for flaws that are oriented parallel and perpendicular to the weld seam this requirement is met by repeatedly moving the probe back and forth in a fanlike fashion.

- (2) If the examination can be carried out from only one side of the weld seam then the weld seam surfaces shall be machined or ground such that no shape indications will occur.

*Note:*

Generally, the region in close proximity of the probe cannot, or not to a full extent, be evaluated with regard to transmitter impulse or near field influence. This region can be examined either from the opposite surface using the same beam direction utilizing the surface reflections, or, if this is not possible, with special probes. In case of examinations with angle probes the close proximity region can also be covered by evaluating the entire skip distance.

- (3) When examining over the full or half of the skip distance as specified below, the signal interference zone where no evaluation can be carried out shall be considered.

*Note:*

In the case of the DGS-method the sonic path that can be evaluated for single oscillator probes begins at 0.7 times the near field distance. Evaluations below 0.7 times the near field distance are allowed if it is demonstrated that the required testing sensitivity was adhered to.

### 6.3.3.5.2 Probe Positions

The following requirements shall be met with respect to probe positions:

- a) Examinations of butt weld connections with nominal wall thicknesses  $\leq 60$  mm (**Figure 6-3**)
  - aa) Positions 1 and 2 or positions 3 and 4 over the whole skip distance or position 1 through 4 over half the skip distance to test for longitudinal flaws with the angle beam scanning technique.
  - ab) Positions 5 and 6 or positions 7 through 10 from one weld seam surface to test for lateral flaws with the angle beam scanning technique.
- b) Examinations of butt weld connections with nominal wall thicknesses  $> 60$  mm (**Figure 6-3**)
  - ba) Positions 1 through 4 over half the skip distance to test for longitudinal flaws with the angle beam scanning technique.
  - bb) Positions 5 and 6 or Positions 7 through 10 from both sides of the weld seam surfaces to test for lateral flaws with the angle beam scanning technique.
- c) Examinations of set-through nozzles (**Figure 6-4**)
  - ca) Position 1 or 2 over the whole skip distance or positions 1 and 2 over half the skip distance to test for longitudinal flaws with the angle beam scanning technique.
  - cb) Position 3 to test for longitudinal flaws and lamellar tearing with the straight beam scanning technique.
  - cc) Positions 4 and 5 over half the skip distance or positions 6 and 7 over the whole skip distance to test for under bead cracks with the angle beam scanning technique.
  - cd) Positions 8 and 9 over the whole skip distance or positions 10 and 11 over half the skip distance to test for lateral flaws with the angle beam scanning technique.

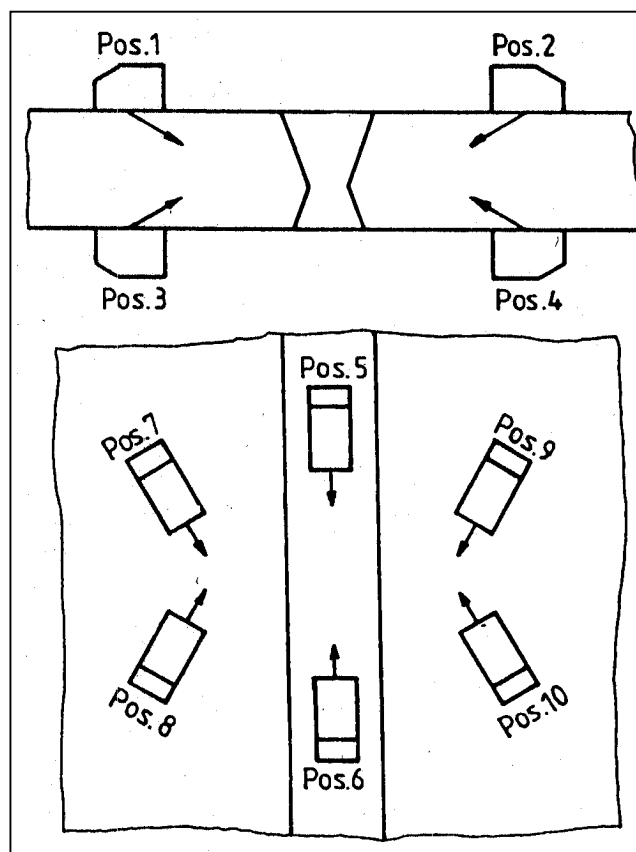


**Figure 6-3:** Probe positions for butt weld connections

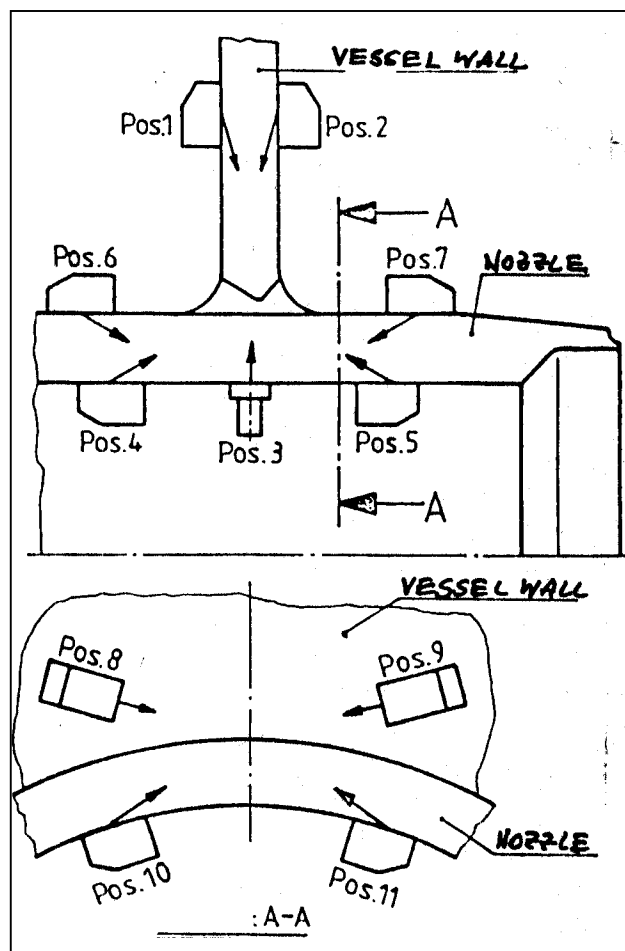


**Figure 6-4:** Probe positions for weld connections with set-through nozzles

d) Examinations of weld seams of set-on nozzles (**Figure 6-5**)

- da) Position 1 or 2 over the whole skip distance or positions 1 and 2 over half the skip distance to test for longitudinal flaws with the angle beam scanning technique.
- db) Position 3 to test for longitudinal flaws with the straight beam scanning technique.
- dc) Position 4 over half the skip distance or position 5 over the whole skip distance to test for under bead cracks with the angle beam scanning technique.
- dd) Positions 6 and 7 over the whole skip distance or positions 8 and 9 or positions 10 and 11 over half the skip distance to test for lateral flaws with the angle beam scanning technique.

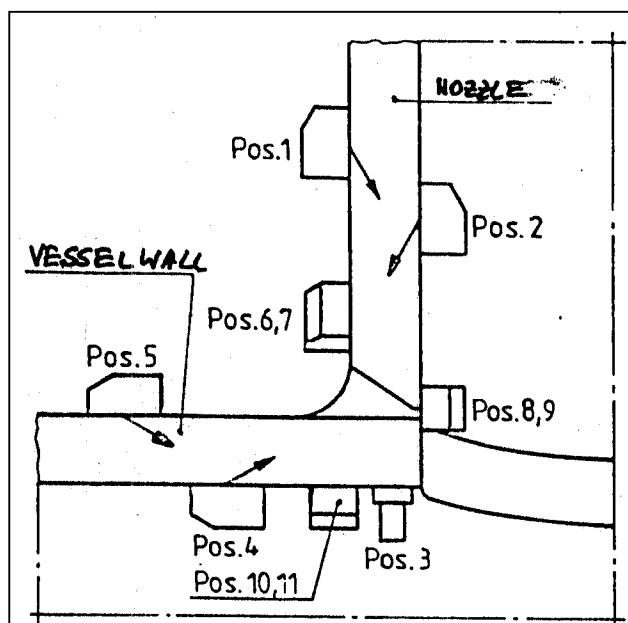


**Figure 6-5:** Probe positions for weld corrections

e) Examinations on weld seams of permanent weld attachments (**Figure 6-6**)

- ea) Position 1 or 2 over the whole skip distance or position 1 and 2 over half the skip distance to test for longitudinal flaws with the angle beam scanning technique.
- eb) Position 3 to test for longitudinal flaws with the straight beam scanning technique if the examination was not carried out from positions 1 and 2.
- ec) Positions 4 and 5 or positions 6 and 7 over the whole or half of the skip distance to test for under bead cracks with the angle beam scanning technique. Instead of at these positions, the examination may also be carried out with a creeping wave probe in positions 4 and 5.

f) Special Cases

In the case of other geometries of the weld connections, e.g., cover plates or flanges, the examination directions shall be chosen in analogy to the requirements above. In the case of bevels and curvatures it shall be ensured that the heat affected zone and the bordering regions of the base material are also covered in testing for lateral flaws. If one of the testing directions is not possible then appropriate measures shall be specified in the testing instructions.

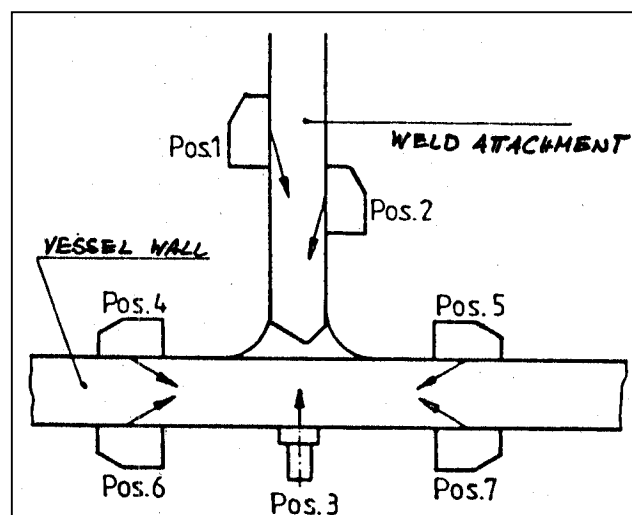


**Figure 6-6:** Probe positions for the weld seams of permanent weld attachments

### 6.3.3.6 Testing Frequency

- (1) Independently of the type of probe used, the testing frequency should lie between 2 and 5 MHz.
- (2) If in individual cases the exact determination of the position and extent of the flaw or the determination of the cause of the flaw requires other than the above mentioned frequencies, then these shall additionally be used.

### 6.3.3.7 Distance Calibration

The distance calibration shall be performed using calibration blocks in accordance with DIN 54 120 or DIN 54 122 or calibration reference blocks of similar geometry with special bore holes and grooves as calibration reflectors. The use of calibration reference blocks is necessary in particular if maximum requirements regarding the accuracy of the distance indication are to be met, e.g., to discern between geometry or flaw echoes in the case of one-sided welds with untreated roots.

### 6.3.3.8 Sensitivity Adjustment

- (1) The sensitivity adjustment may be performed employing calibration blocks K 1 in accordance with DIN 54 120 or K 2 in accordance with DIN 54 122 taking correction factors into account. It may also be performed on reference reflectors in calibration reference blocks or by utilizing the geometry of the component itself (back reflection). In the case of straight beam scanning preference shall be given to the component back reflection method.
- (2) The indications of the calibration reference blocks shall be recalculated as equivalent circular disc reflectors. In the case of grooves, the indications shall be presented either in percentages of the echo indication of a 1 mm deep and 1 mm wide groove, or in dB relative to the calibration reference block.
- (3) The type of sensitivity adjustment shall be specified in the testing instruction and the test reports.

### 6.3.3.9 Losses from Coupling and Sound Attenuation

The coupling and sound attenuation conditions in the component and the differences with respect to the calibration block shall be accounted for by transfer adjustment factors. The coupling and sound attenuation values for the test shall

be determined as the average values of a number of individual measurements. The sound path contributions in the weld material and the different surface conditions of the coupling surfaces shall be taken into account.

### 6.3.3.10 Adjustment of the Equipment Amplification

With consideration given to the coupling and sound attenuation losses, the CRT display shall be adjusted such that the

recording threshold reaches at least one fifth of the CRT display height for the individual testing range. If the distance between the recording threshold and the noise level is less than 6 dB this shall be indicated in the test report and the further procedure shall be decided upon in agreement with the authorized expert.

| Wallthickness <sup>2)</sup><br>s(mm)                                                                   | Type and Dimension of the Reference Reflector     |                                |
|--------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------------------------------|
|                                                                                                        | angle beam method                                 | straight beam method           |
| 5 < s < 7                                                                                              | 25 % of the echo indication from a                | 2.0 mm diameter disc reflector |
| 7 < s < 10                                                                                             | 50 % 1 mm deep and 1 mm wide groove <sup>1)</sup> | 2.0 mm diameter disc reflector |
| 10 < s < 15                                                                                            | 1.0 mm diameter disc reflector                    | 2.0 mm diameter disc reflector |
| 15 < s < 20                                                                                            | 1.5 mm diameter disc reflector                    | 2.0 mm diameter disc reflector |
| 20 < s < 40                                                                                            | 2.0 mm diameter disc reflector                    | 2.0 mm diameter disc reflector |
| 40 < s                                                                                                 | 3.0 mm diameter disc reflector                    | 3.0 mm diameter disc reflector |
| <sup>1)</sup> Miniature angle probes with a testing frequency of 4 MHz shall be employed               |                                                   |                                |
| <sup>2)</sup> In case of differing wall thicknesses the smaller wall thickness is the governing factor |                                                   |                                |

**Table 6-1:** Reference reflectors for different recording thresholds

### 6.3.3.11 Recording of Echo Indications

(1) All echoes which read or exceed the recording threshold shall be recorded as indications. Geometric reflectors identified as such shall be indicated as such in the test report. The recording thresholds are the indications from reference reflectors as specified in **Table 6-1** for different nominal wall thicknesses.

(2) It shall be ensured that the scanning sensitivity level prescribed by the recording threshold is achieved over the entire volume of material to be examined. This may require employing additional scanning directions beam angles, sonic frequencies or testing techniques.

(3) If the values in accordance with **Table 9-1** and Section 9.3.4.3.1 regarding the allowed frequency of occurrences or extents of reflector indications without further control examinations are exceeded, then in the affected area and in both directions for 500 mm of weld seam those indications from the longitudinal flaw examination shall be recorded that are up to 6 dB under the specified recording threshold. This is also required of indications down to 6 dB below the recording threshold whose lengths equal or exceed twice the maximum allowed length of an individual indication.

(4) The scanning sensitivity level for examining for transverse flaws shall be chosen such that even indications of 12 dB below the recording threshold can be detected. If multiple echo indications occur in this examination which cannot be separated from each other by probe movements (indication flock) or if one of a number of indications reaches the recording threshold, then under similar conditions the recording threshold shall be lowered by 12 dB over the entire (the welded?) weld seam segment.

(5) It shall be noted in the test report if the distance between the individual recording threshold and the noise level is less than 6 dB or if the required scanning sensitivity for examining for transverse flaws cannot be achieved because of the noise level; the further procedure shall be specified in agreement with the authorized expert.

(6) In case of a lacking scanning position it may become necessary to lower the recording threshold by 6 dB.

### 6.3.3.12 Echo Indications from Geometric Reflectors

(1) Before echo indications may be classified as geometric reflectors they have to be verified as such by control measurements. Echo indications are considered verified to be from geometric reflectors if no echoes result from the location of reflection when scanning from the opposite side of the seam. This proof has to be carried out over the entire expanse of the location of reflection.

(2) If, in the case of seams welded from one side and in the as-welded condition, it is intended to use the measurements of distances between linear projections to prove that the echoes originate from the root and not from weld flaws, then the exact distances between linear projections shall be determined by adjusting grooves in calibration blocks.

(3) In as far as radiographs cover the location of reflection in a way that can be evaluated, these radiographs shall be considered in the evaluation.

(4) All reflection locations that originate from surface irregularities shall, as far as they are accessible, be mechanically removed.

### 6.3.3.13 Determining the Recording Lengths

(1) When in the course of the examination the echo amplitudes reach or exceed the recording threshold as specified in Section 6.3.3.11, the lengths of the individual reflectors shall be measured and logged. Reflectors with lengths under 10 mm shall be logged as "smaller than 10".

(2) The expanse of a reflector is determined in terms of the distance of probe movement. This distance of probe movement is defined as lying between those positions where the amplitude of the indication

- in case of nominal wall thicknesses less than or equal to 10 mm falls below the recording threshold,
- in case of nominal wall thicknesses larger than 10 mm up to and including 40 mm falls below 6 dB under the recording threshold and



c) in case of nominal wall thicknesses larger than 40 mm falls below 12 dB under the recording threshold.

(3) In case of a lowered recording threshold, the expanse of those reflectors whose maximum echo amplitude is lower than the original recording threshold is determined from the probe positions where the echo amplitude is at 6 dB below the maximum echo amplitude. In case of surface curvatures, the expanse of reflectors shall be corrected for the position of depth.

(4) The accuracy in determining the expanse of reflectors shall be increased by additional examinations (e.g. focussing probes) if this examination alone is the determining factor in the evaluation of permissibility of the reflector.

#### 6.3.3.14 Special Geometric Features in Direct Vicinity of the Weld Connection

(1) In the case of beveled edges and curvatures and other special geometric features in direct vicinity of the weld connections, attention shall be paid to ensuring the testability with nondestructive examination procedures. This shall already be evaluated in the design review.

(2) Special attention shall be paid to the requirements concerning the scanning directions (Section 6.3.3.5), the beaming and incidence angle (Section 6.3.3.4) and the adjustment of the CRT display (Section 6.6.3.10) with regard to a possible 6 dB lowering of the recording threshold.

(3) In case the beveled edges or curvatures serve as coupling surfaces, they must meet the requirements in accordance with Sections 6.3.3.2 and 6.3.3.3. The transition to the weld seam shall in any case be such as not to hinder the examination for transverse flaws even in the adjoining base material. This region shall, therefore, be ground-polished over a large area.

### 6.3.4 Surface Crack Examination

#### 6.3.4.1 General

The surface crack examination using the magnetic particle method shall be used on ferro-magnetic materials. The current flow method may only be used with special approval of the authorized expert. The employment of different methods, e.g. the liquid penetrant method, is only allowed if this has been justified and an agreement has been reached with the authorized expert.

#### 6.3.4.2 Preparation of Surfaces for the Surface Crack Examination

The surfaces to be examined must be in a condition corresponding to the goal of the examination. They must be free of scale, weld spatter and other interfering soiling. Any notches or grooves that might adversely affect the result of the examination shall be removed. The mean roughness value shall not exceed  $R_a = 20\mu\text{m}$ .

#### 6.3.4.3 Magnetic Particle Method

##### 6.3.4.3.1 Magnetization

(1) The magnetization shall be carried out in accordance with DIN 54 130.

(2) If in partial areas the magnetization is carried out with the current flow method or by yoke magnetization, alternating current magnetization should be employed. The residual field strength may not exceed a value of  $10^3 \text{ A/m}$  (12.5 Oe).

(3) Every point on the surface shall be examined under two different directions of magnetization which, if possible, should be at an angle of about  $90^\circ$  to each other. The angle between the two directions of magnetization should not be less than  $50^\circ$  and not larger than  $150^\circ$ . It shall be ensured that all flaw orientations are indicated.

#### 6.3.4.3.2 Field Strength and Testing Agent

(1) The tangential field strength at the surface should be at least  $2 \times 10^3 \text{ A/m}$  (about 25 Oe) and shall not exceed  $6.5 \times 10^3 \text{ A/m}$  (about 80 Oe). The adherence to these values must be ensured either by surveillance measurements or by specifying the corresponding examination conditions.

(2) At random points before and during the examination, the testing agent shall be tested on the magnetized testing object by employing Berthold calibration locks.

(3) Special attention shall be directed to ensuring that the indication capability of the testing agent is not hindered by the carrier fluid.

*Note:*

*The tangential flux density is used as an intermediary flux indicator since it is difficult to experimentally determine the magnetic flux inside the testing object.*

#### 6.3.4.3.3 Contrast

To enhance the possibility for detecting errors provisions shall be made for achieving a sufficient contrast. Corresponding methods are, using fluorescent testing agents or applying a thin, barely covering paint to the surface. A sufficient contrast is achieved when metallically shining surfaces are examined with black magnetic powder.

#### 6.3.4.3.4 Contact Locations with the Current Flow Method

When employing the current flow method an overheating of the tested material at the contact locations shall be prevented. If this does occur, the overheated material shall be ground down. A subsequent reexamination of these locations is necessary and shall be carried out by the liquid penetrant examination or by the magnetic particle examination using yoke magnetization.

#### 6.3.4.4 Liquid Penetrant Examination

(1) The suitability of the examination procedure (penetrant, intermediate cleaner and developer) shall be demonstrated to the authorized expert in practical examination.

(2) The liquid penetrant examination shall be carried out in accordance with DIN 54 152 Part 1.

(3) The penetration period shall last for 30 minutes and the development period for 60 minutes.

(4) In this time the penetrant liquid may not dry up. Furthermore the developer shall be applied in a thin film only.

#### 6.3.5 Radiographic Examination

Radiographic examinations shall be carried out using X-ray machines as the radiation source. The conditions of testing class B in accordance with DIN 54 111 Part 1 shall be adhered to. The image quality characteristics of image quality class in accordance with DIN 54 109 Part 2 shall be achieved. In order to limit image distortions at the film borders the lengths of film to be evaluated shall be limited such that, during perpendicular irradiation, the material thickness in direction of the divergent rays nowhere exceeds the component thickness by more than 10 %.

### 6.3.6 Hardness Test

The hardness test shall be carried out in accordance with DIN 50 133. The hardness shall not exceed 350 HV 10.

### 6.4 Requirements Regarding Scanning Distances of the Weld Connections

The scanning distance for the sonic beam examination shall be determined using **Equation 6-1** for scanning from only one side over the full skip distance and using **Equation 6-2** for scanning from both sides over one half the skip distance:

$$l = 0.5 k + 2.3 s \tan \alpha \quad (6-1)$$

$$l = 0.5 k + 1.3 s \tan \alpha \quad (6-2)$$

with  $s$  being the corresponding wall thickness.

*Note:*

Examples are shown in **Figure 6-7** for butt weld connections and nozzle connections.

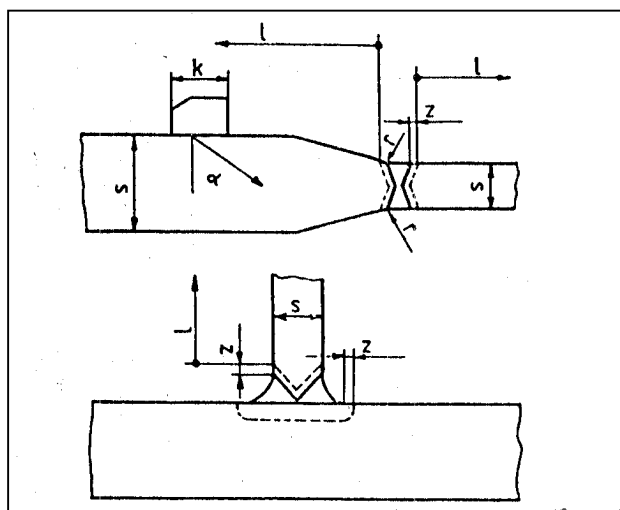


**Figure 6-7:** Examples for scanning distances

## 7 Design Review

### 7.1 Basic Principles

#### 7.1.1 General

(1) In the design review, the authorized expert and the authorized civil engineer shall in their respective areas of competence review the submitted documents with respect to whether or not the safety relevant requirements have been met.

(2) The documents for design review shall be submitted early enough such that a proper review and, possibly, a consideration of required changes prior to the individual manufacturing step can be carried out.

(3) All documents shall be written in German.

(4) Drawings should be kept scaled.

(5) Before preparation of the documents is begun, an agreement with the authorized expert and the authorized civil engineer should be reached regarding, e.g., system assumptions, analysis procedures, required accuracies.

(6) If the documents are pre paced by a number of manufacturers, one shall be named as being responsible for coordinating the documents and for checking them for completeness.

(7) Using the abbreviations in accordance with Section 11.3, all tests and inspections specified in the design review documents shall be characterized with regard to how the execution of the individual testing steps are to be documented. The characterizations E, ST or Z should be used:

E = final documentation by the operator

This group encompasses all proofs and certifications of tests and examinations which describe the quality of the product (product form component, component group, system) in the condition prior to commissioning, as well as the nonconformance reports.

*Note:*

The documents in the final documentation are required, e.g., for:

- demonstration of proper construction,
- inservice inspections,
- failure examinations,
- repair procedures and
- procurement of replacement and wear parts.

ST = certification stamping in design review documents

Stamping shall be allowed for tests and examinations with a yes or no result.

Z = short-term (intermediate) documentation by the manufacturer

These are certifications of tests and inspections which are not required for describing the quality of the product prior to commissioning (e.g., reports on tests and examination carried out to ensure a proper completion date of the product; reports on the quality assurance system).

(8) Proofs and certifications shall be documented in accordance with **Table 11-1**.

(9) If a collective (S) certification is intended for the proof of certain tests and inspections, these shall be identified as E/S or Z/S in the design review documents.

(10) In the case of series-produced product forms, parts components or component groups where similar manufacturing methods are used, the same design reviewed documents may be used (standardized plans).

### 7.1.2 Extent of the Design Review

The design review shall encompass the safety evaluation of

- the engineering design, also with respect to the capability of performing the first and repeated inservice inspections and maintenance tasks,
- the stress and stability analyses including the analyses of the conditions during erection and construction,
- the load distribution to the support structures and the foundation,
- the selected materials and
- the intended fabrication and testing procedures

on the basis of the submitted documents.

### 7.2 Design Review Documents

#### 7.2.1 Requirements Regarding Type and Shape of the Design Review Documents

(1) The documents shall be submitted to the authorized expert and, where necessary, to the authorized civil engineer.

(2) Prepared forms shall be used for the documents. Examples for these forms are collated in Appendix A. The subject matters listed shall be considered as requirements.