Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3211.4 (2017-11)

Pressure and Activity Retaining Components of Systems Outside the Primary Circuit;

Part 4: Inservice Inspections and Operational Monitoring

(Druck- und aktivitätsführende Komponenten von Systemen außerhalb des Primärkreises;

Teil 4: Wiederkehrende Prüfungen und Betriebsüberwachung)

Previous versions of this Safety Standard
were issued 1996-06, 2012-11 and 2013-11

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

Editor:

KTA-Geschaeftsstelle c/o Bundesamt fuer kerntechnische Entsorgungssicherheit (BfE) • Willy-Brandt-Strasse 5 • 38226 Salzgitter • Germany
Telephone +49-30-18-333-1621 • Telefax +49-30-18-333-1625

KTA SAFETY STANDARD

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

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

KTA-Geschaeftsstelle c/o BfE, Willy-Brandt-Str.5, D-38226 Salzgitter, Germany or kta-gs@bfe.bund.de

Comments by the editor:

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

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

Fundamentals

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

(2) No. 3.1 of the Safety Requirements for Nuclear Power Plants, among other things, sets high requirements for the quality assurance and reliability of fabrication, the use of qualified materials, the safeguarding and maintenance of quality features during fabrication as well as the performance of in-service inspections to the extent of safety required. Requirement no. 3.4 requires, among other things, that a concept to maintain component integrity shall be put up to assure and evaluate the requisite quality of the pressure-retaining walls of components of the external systems with nominal diameters of more than DN 50 in operation. The safety requirements no. 3.2 “Requirements for the reactor core and the shutdown systems”, no. 3.3 “Requirements for the equipment for fuel cooling in the reactor core” and no. 3.10 “Requirements for the handling and storage of the fuel assemblies” specify further requirements regarding the design and quality of the safety systems. The Safety Standard KTA 3211.4 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. For the pressure and activity retaining components of systems outside the primary circuit the stipulations of the aforementioned safety requirements are further and comprehensively substantiated in conjunction with the following Safety Standards

KTA 3211.1 Materials and Product Forms,

KTA 3211.2 Design and Analysis,

KTA 3211.3 Manufacture.

(3) The task of this Safety Standard with respect to operational monitoring is to determine measures regarding the monitoring of causes and consequences of damage mechanisms. These measures consist of:

a) Monitoring of causes:
   aa) monitoring of the parameters and data relevant to component integrity,
   ab) monitoring of the quality of water and steam.
b) Monitoring of consequences by:
   ba) in-service inspections,
   bb) leakage monitoring,
c) Documentation and continuous recording of the monitoring results along with a foresighted evaluation in order to limit operational damage mechanisms.

(4) The task of this Safety Standard with respect to in-service inspections is to determine the relevant measures as listed in a) to d) hereinafter in order to ascertain and evaluate the actual component condition at the date of testing by:

a) non-destructive tests and examinations of the external and internal surfaces of pressure and activity retaining components,
b) evaluation of the general condition during regular plant inspection,
c) pressure tests as integral loading test,
d) functional tests addressing the safeguards against excessive pressure.

All above tests and examinations shall be documented in a so-called “test and inspection manual” which takes into consideration the requirements for the individual component and contains the entire extent of in-service inspections.

(5) During in-service inspections, test and examination procedures are used to detect defects due to operation in due time prior to reaching the acceptance level. When determining the extent of tests and examinations as well as the items to be examined, the design, material properties, fabrication processes and loading of the respective component as well as experience gained with already performed inspections shall be taken into consideration.

(6) The quality of the component with regard to materials, design and manufacture shall be documented and be evaluated by continuously recording the accumulated operational loadings including commissioning, and the results of the in-service inspections.

1 Scope

(1) This Safety Standard shall apply to in-service inspections of the pressure retaining walls of pressure and activity retaining systems and components of light water reactors which are not part of its reactor coolant pressure boundary but do have a certain significance with respect to reactor safety. This is given in the case where one of the following criteria applies:

a) The plant facility is required for the mitigation of design basis accidents with regard to shutdown, long-term maintenance of subcriticality and with regard to residual heat removal.
   Requirements regarding components of systems which only indirectly serve in residual heat removal – these are the non-radioactivity retaining closed cooling water systems and service water systems – shall be specified on a plant-specific basis taking the design redundancy (e.g. redundancy, diversity) into consideration.
b) Large energies are released in case of failure of the plant facilities and no mitigating measures such as structural measures, spatial separation or other safety measures are available to keep the effects of failure to an acceptable limit with respect to nuclear safety.
c) A failure of the plant facilities could either directly, or indirectly through a chain of assumed sequential events, lead to a design basis accident in accordance with Sec. 49 para. 1 of the Radiation Protection Ordinance (StrlSchV).
d) Systems and components to which none of the criteria a) through c) apply, the failure of which, however, would lead to major plant internal damages – these are the components of Group II from Appendix to Sec. 4.2 of the RSK Guidelines for PWR and the corresponding components for BWR. With regard to the intensity of testing and documentation graduated levels may apply.

(2) The scope of this Safety Standard extends to the following components:

a) pressure vessels,
b) piping and piping products including small-bore pipes,
c) pumps,
d) valves,
e) heat exchangers

including the integral parts of the component support structures.

Note:
The secondary shell of the steam generators including the feedwater inlet and main steam outlet nozzles, but not the minor nozzles and nipples are covered by the scope of KTA 3201.4. The pipe connecting welds themselves are within the scope of KTA 3211.4.

(3) This Safety Standard does not apply to

a) internals of components (that are not constituent part of the pressure retaining wall) and accessories,

b) systems and plant facilities performing auxiliary functions for the systems dealt with in this Safety Standard,

c) those system parts where the system pressure is determined solely by the geodetic pressure level in the suction regime,

d) component parts of the power transmission in pumps and valves nor to the tests with respect to proof of functional capability,

e) tests of functional capability within the framework of in-service inspections, except functional tests addressing the safeguards against excessive pressure,

Note:

Functional tests of shutdown systems are laid down in KTA 3103, functional tests of residual heat removal systems in KTA 3301 and functional tests of heat removal systems for fuel assembly storage pools in KTA 3303.

(4) This Safety Standard shall apply to systems and components which have been designed and manufactured in accordance with KTA 3211.1, KTA 3211.2 and KTA 3211.3.

(5) This Safety Standard may also be applied to those components or component parts where an evaluation performed in due consideration of the state of science and technology showed that the principles of basic safety are complied with and that no additional requirements for in-service inspections and operational monitoring are required.

(6) In the case of components that do not meet the requirements under paragraph (4) or (5), increased requirements regarding in-service inspections and operational monitoring may have to be specified on the basis of the special situations.

Note:

Besides the requirements possibly to be met regarding in-service inspection and operational monitoring further measures to be taken may be taken into account.

(7) In the case of components and systems outside the reactor coolant pressure boundary for which restricted design-basis leak and break assumptions are made, the component integrity shall be ensured during the total operational lifetime by means of a consistent concept in accordance with KTA 3201.4, Section 3 (integrity concept).The requirements of **Table 5-3** in section 5 "Extent of testing and test intervals" of Safety Standard KTA 3211.4 taking into consideration the footnote regarding the use of restricted leak and break postulates shall apply to the in-service tests and inspections required to monitor the consequences of possible operational damage mechanisms.

Note:

The procedures for break preclusion are laid down in KTA 3206.

2 Definitions

(1) Pipe attachment weld

The pipe attachment weld is a weld seam that connects the nozzle of a component with the corresponding pipe section.

(2) Indications and types of flaws

The correlation between indications and flaws are shown in **Figure 2-1**.

(3) Relevant indication

Relevant indication is an indication reaching or exceeding the evaluation limit.

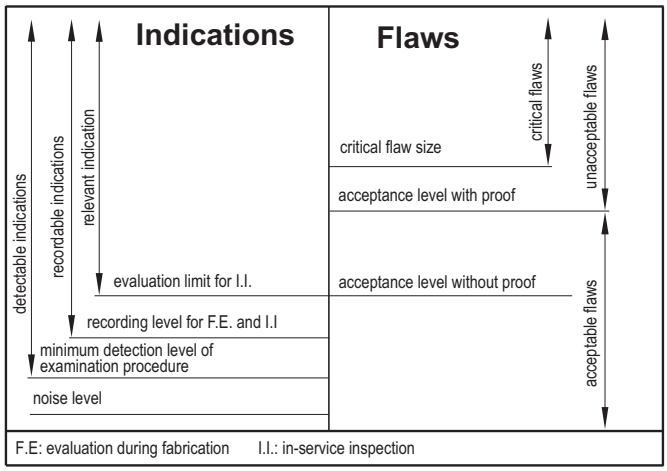


Figure 2-1: Indications and types of flaws

(4) Echo height evaluation

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

(5) Operational flaws

Operational flaws are flaws due to operational damage mechanisms.

(6) Higher stress locations

Higher stress locations are such locations of a component or component part that

a) compared to the general level of stress intensity are more highly stressed taking the frequency additionally into account

or

b) are more susceptible to corrosive action.

(7) Integrity

Integrity is the condition of a component or barrier, at which the required safety criteria with regard to strength, resistance to fracture and leak tightness are met.

(8) Reference standard

Reference standards to adjust and examine the test system or to examine the detection medium are

a) in the case of ultrasonic testing: unclad test blocks of a known material, with predetermined surface quality and geometry, e.g. calibration block no. 1 to DIN EN ISO 2400 or calibration block no. 2 to DIN EN ISO 7963,

b) in the case of penetrant testing: reference block 2 to DIN EN ISO 3452-3,

c) in the case of magnetic particle testing: flux indicator for controlling the detection medium (reference block 1 to DIN EN ISO 9934-2 Annex B),

d) in the case of visual testing: test pattern to DIN 25435-4,

e) in the case of radiographic testing: image quality indicator to DIN EN ISO 19232-1,

f) in the case of eddy current testing: reference block adapted to the task, made of a known material and with a specific surface quality and geometry.

(9) Measured values

Measured values are documented and stored values (e.g. pressure, temperature, amplitude, time of flight, position).

(10) Detection threshold

Detection threshold is the lowest limit of detection of indications.

(11) Types of tests, testing procedures and techniques

The terms, their acronyms and correlation of the types of tests, testing procedures and techniques are shown in **Table 2-1**.

(12) Surface inspection

Surface inspection is the non-destructive testing of surfaces using techniques which allow detecting indications on the surface and near-surface regions in which case the depth examined depends on the method used.

(13) Quality required

The required quality means the condition of a part, component or system with respect to their capability of meeting the specified requirements.

(14) Noise

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

(15) Noise level

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

(16) Recording level

Recording level means the specified threshold at which, when being reached or exceeded, indications from the test object are recorded.

(17) Representative locations, components or component parts

Such locations, components or component parts are considered to be representative where the in-service inspection will lead to sufficiently comparable safety related results for other locations, components or component parts, taking into consideration the material composition, design and manufacturing quality as well as the stress type, level and frequency.

(18) Authorized inspector

The authorized inspector for the tests and inspections to be conducted in accordance with this Safety Standard is the authorized inspector called in by the licensing or supervisory authority in accordance with Section 20 of the Atomic Energy Act.

(19) Damage mechanisms

Damage mechanisms are all physical, chemical and biological processes which may impair the integrity or function of a component.

(20) Standard instrumentation

The standard instrumentation serves to monitor the parameters and data relevant to the integrity of components within the scope of this Safety Standard and comprises measuring equipment to monitor global loadings and - if required - measuring equipment to monitor local loadings.

(21) Nozzle weld

A nozzle weld is a weld seam that connects the nozzle with the vessel wall or the pipe wall.

(22) Welded joint

A welded joint is a weld seam that joins component parts the cross-sections of which have been adapted in the connecting area.

(23) Reference block

A reference block is a block corresponding to the test object with respect to test-relevant characteristics (e.g. material, weld design, shape, wall thickness) and that contains reference flaws (e.g. notches, bores) adapted to the individual testing task.

(24) Acceptance level with proof

The acceptance level with proof relates to a defect size that can be accepted when being proved (e.g. by fracture mechanics verification) to be less than rejectable.

(25) Acceptance level without proof

The acceptance level without proof relates to a defect condition that is left unchanged and can be accepted without further proof.

Serial Number	Type of Test	Test Procedure	Testing Technique
1	Surface inspection	Magnetic particle testing (MT)	e.g. field magnetization by magnetomotive force
		Penetrant testing (PT)	e.g. colour contrast penetrant testing
		Ultrasonic testing (UT)	e.g. single transducer probetechnique, dual-element probetechnique, wave conversion technique, phased-array technique
		Eddy-current testing (ET)	Single frequency, multiple frequency
		Radiographic testing (RT)	X-ray, Radioisotope
		Visual testing (VT)	Selective or integral visual testing with or without optical means
2	Examination for wall thinning	Ultrasonic testing (UT)	E.g. wall thickness measurement with measuring techniques 1 to 3 acc. to DIN EN 14127
		Radiographic testing (RT)	Wall thickness measurement with projection technique, e.g. computerised radiography with imaging plates
3	Evaluation of the general condition	Regular plant inspection	
4	Pressure test	Hydrostatic test	
5	Functional test		

Table 2-1: Type of tests, testing procedures and techniques

3 Safeguarding of required component quality

(1) The principles laid down in this Section serve to safeguard the required component or system quality with respect to the functional capability of plant components acc. to sub-clause 1 (1) a) and with respect to the prevention of failure of plant facilities, systems or components involving serious consequences as indicated in sub-clauses 1 (1) b) to d) (see also **Figure 3-1)**.

(2) Temporary disturbance of individual component integrity shall neither lead to

a) a loss of functional capability of plant facilities as indicated in sub-clause 1 (1) a) nor

b) to plant facilities failure involving serious consequences as indicated in sub-clauses 1 (1) b) to d).

(3) The required quality as regards proper design and manufacture shall be the result of meeting the requirements of KTA 3211.1, KTA 3211.2 and KTA 3211.3 or the principles of basic safety.

Note:
See related sub-clauses 1 (4) and 1 (5).

(4) Where components deviate from the requirements of the Safety Standards KTA 3211.1, KTA 3211.2 and KTA 3211.3 or from the principles of basic safety such deviations shall be evaluated as to what extent increased requirements for in-service inspections and operational monitoring have to be laid down.

(5) For components for which a changed state of knowledge regarding possible damage mechanisms is available, additional requirements shall be laid down, where required, with regard to in-service inspections and operational monitoring with due respect of the specific conditions prevailing.

Note:
Besides possible requirements for standard instrumentation and in-service inspections further measures, e.g. preventive maintenance, may be taken into account.

(6) To safeguard the required quality during operation

a) operational monitoring measures,

b) monitoring of the consequences of operational damage mechanisms,

and

c) preventive maintenance measures

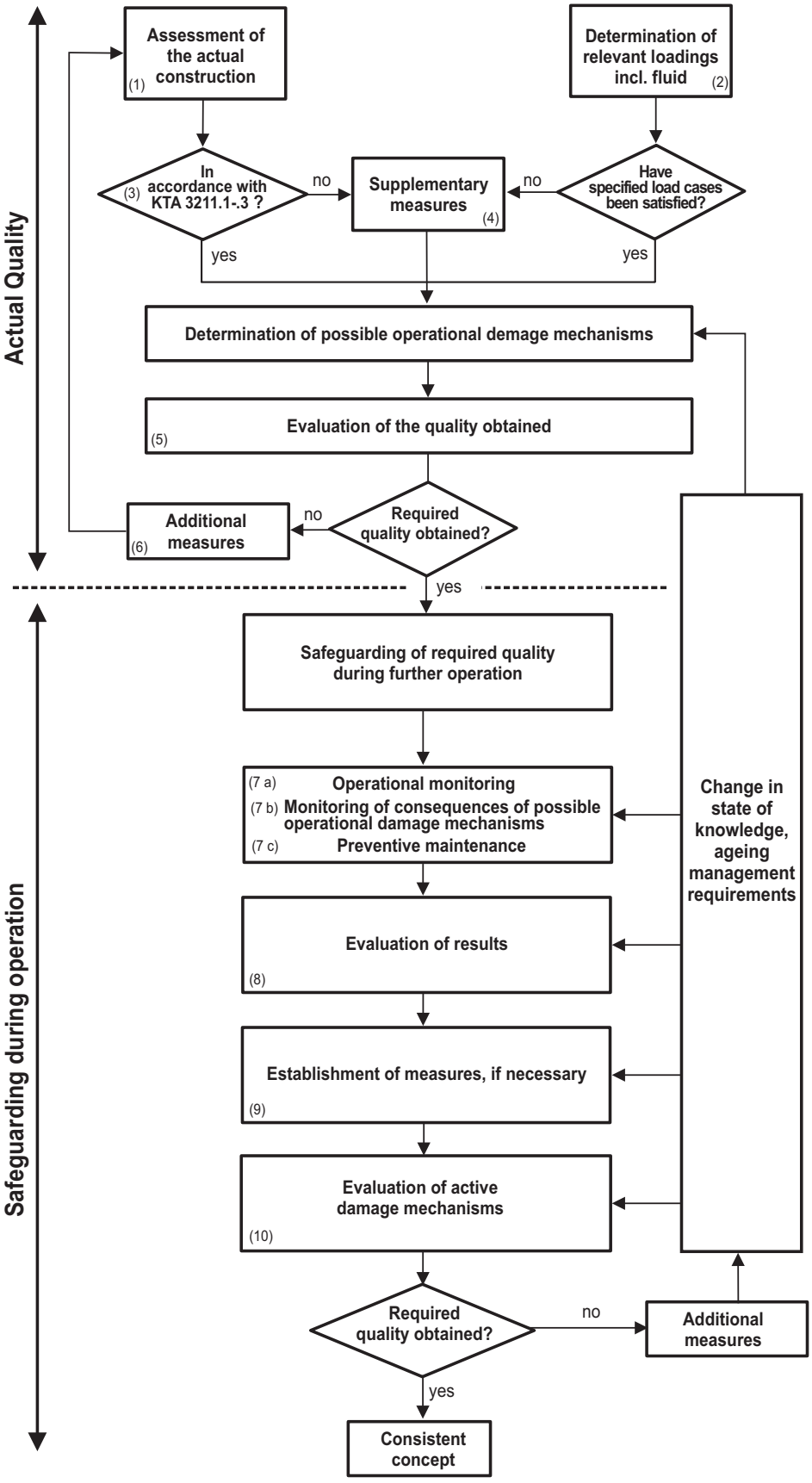
shall be taken and be evaluated in accordance with **Figure 3-1** (8).

(7) Where the required quality is no more available, respective measures shall be taken (**Figure 3-1** (9)).

(8) The effectiveness of the measures taken with respect to safeguarding against operational damage mechanisms shall be assessed (**Figure 3-1** (10)).

(9) Changes in the state of knowledge, e.g. due to new requirements for incident control, due to damage occurred, in the case of assessment of ageing phenomenons or in the case of other safety analyses, shall be considered within the re-evaluation of required component quality during further operation (see **Figure 3-1**).

(10) The procedural steps as per **Figure 3-1** form a consistent concept to ensure the required component and system quality.



(1) **Criteria**
- material
- welding
- design
- existing relevant indications from design and manufacturing documents

(2) **Data**
- specified operational and incidence loadings
- previous operational loadings

(3) This check is only possible for components > DN 50.
The criterion of this check is the quality obtained upon design and manufacture resulting if the requirements of KTA 3211.1, KTA 3211.2 and KTA 3211.3 or the principles of basic safety are satisfied.
This criterion is also satisfied if deviations do not require additional stipulations for in-service inspections or maintenance measures.
For components ≤ DN 50 the same requirements apply accordingly in which case the concrete requirements as regards the actual condition are to be laid down for each individual plant.

(4) **Additional measures (examples)**
- more detailed analysis
- materials testing
- special tests and examinations
- adaptation of the standard instrumentation
- adaptation of the in-service inspection concept

(5) **Evaluation criteria**
- stresses
- fatigue analysis usage factor
- safety margin to failure
- corrosion

(6) **Measures (examples)**
- modification of
  - process technology
  - hardware

(7a) **Operational monitoring**
- adherence to operational parameters specified (pressure, temperature, water chemistry)
- monitoring of switching operations

Measures
- verifikation by standard instrumentation

(7b) **Monitoring of consequences of operational damage mechanisms, e.g.:**
- cracking
- corrosion
- reduction of wall thickness

Measures (examples)
- non-destructive examination
- plant inspection by patrolling
- leakage monitoring

(7c) **Preventive maintenance**
- Time or condition-oriented maintenance
- functional tests
- leakage tests

(8) **Evaluation criteria**
- stresses
- fatigue analysis usage factors
- safety margin to failure
- corrosion resistance

(9) **Measures (examples)**
- modification of
  - process technology
  - hardware
- Adaptation of
  - the standard instrumentation
  - the preventive maintenance
  - the in-service inspection concept
- special tests and examinations

(10) **Criteria**
possible operational damage mechanisms safeguarded
  - cracking
  - corrosion
  - reduction of wall thickness

Figure 3-1: Safeguarding of the required component quality

4 Testing procedures and techniques

4.1 General requirements

4.1.1 Selection of testing procedures and techniques

(1) The testing procedures and techniques shall be chosen such that service-induced flaws with their possible orientations will be detected. Such orientations are:

a) planes perpendicular to the directions of principal stress,

b) planes parallel to the fusion faces of weld seams (longitudinal flaws),

c) planes perpendicular to the direction of welding progress (transverse flaws),

d) planes parallel to the surface (wall thinning).

(2) The test procedures as per **Table 2-1** as well as per Sections 4.2 and 4.3 shall basically be applied. Other test procedures are permitted provided their suitability for achieving the test objective has been demonstrated.

(3) The surfaces of components made of ferritic materials shall preferably be examined by magnetic particle testing. In the case of components made of austenitic materials the surfaces shall preferably be examined by penetrant testing.

(4) The testing procedures and techniques for testing areas of austenitic steel base metals for stress corrosion cracking shall be selected such that defects oriented in both axial and circumferential direction can be detected.

(5) In the case of ultrasonic testing, several techniques may be applied, where required, to fulfil the testing task.

Note:
See DIN 25435-1 Annex A for testing techniques.

(6) During ultrasonic testing scanning from both sides is basically required. Where, for design reasons, scanning from both sides is not possible, sufficient testing level shall be ensured for scanning from one side (e.g. by additional testing techniques).

(7) Mechanised ultrasonic testing is required if

a) an evaluation is not possible without extensive recordings and representation of measured data to DIN 25435-1 (e.g. in the case of spurious echoes on austenitic welds, of flaws due to external contour in the case of root notches, of complex geometries of nozzle welds),

or

b) by this means a reduction of radiation exposure of NDT personnel can be achieved.

(8) Other test procedures shall normally be performed by mechanised testing if the criteria to sub-clause (7) apply accordingly.

(9) If the test results from one procedure alone deliver insufficient information, then an additional procedure shall be applied that is based on physical interaction different from the first. Where the results obtained from the additional test procedure are not sufficient, further steps shall be laid down by agreement with the authorized inspector.

4.1.2 Suitability of test procedures

(1) The suitability of testing 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 testing technique is available and the applicability of which has been ascertained by the authorized inspector, no further proof of suitability is required.

(2) The test procedures and techniques are suited if their capability of detecting defects as required by Sections 4.2 and 4.3 in consideration of the type and location of the defects is satisfied.

(3) Where the required detection capability is not achieved in limited areas by the test procedures selected, special proofs shall be furnished regarding the effectiveness of the test or an analytical proof (e.g. fracture mechanic analysis) shall be performed. Where required, the inspection intervals e.g. shall be reduced.

4.1.3 Comparability of the results of consecutive tests

(1) The results of consecutive tests must be comparable to each other. If the test procedure or technique is changed, a proof of the comparability of results shall be furnished. This may e.g. made by evaluating possible deviations or supplementary use of the preceding test procedures or techniques.

(2) If in-service inspections are performed manually, the results of the first in-service inspection shall be compared with that production test which qualifies the final fabrication condition of the component.

(3) If in-service inspections are to be performed in a mechanized way, a reference test is initially required using the same testing equipment as intended to be used later for the in-service inspections.

4.1.4 Recording of test results

(1) In the case of mechanically performed tests, all measured values and the corresponding coordinates shall be documented by automatic recording equipment.

(2) In the case of manually performed tests all indications reaching or exceeding the recording level and the corresponding coordinates shall be recorded.

(3) The radiographs shall show the coordinates (e.g. item to be examined, zero point, direction of counting).

4.2 Surface inspection

4.2.1 Magnetic particle testing

When performing magnetic particle testing, the requirements of DIN 25435-2 shall be met.

4.2.2 Penetrant testing

When performing penetrant testing, the requirements of DIN 25435-2 shall be met.

4.2.3 Ultrasonic testing procedures

4.2.3.1 Surfaces close to the probe

(1) When testing surfaces and their near-surface regions close to the probe, a testing technique or several testing techniques with which the testing level to para. 4.2.3.3.4 can be obtained shall be employed to detect planar discontinuities.

(2) Ultrasonic testing techniques considered to be suitable are, e.g., techniques employing surface waves and creeping waves, the dual-element probe with longitudinal waves, or techniques exploiting the corner effect after reflection of the sound beam.

(3) When testing surface and sub-surface areas, an area with a depth of at least 10 mm shall be covered in dependence of

the testing technique employed. The imaging of the results obtained in mechanised ultrasonic testing shall ensure that the echo dynamics of recordable indications are fully reflected.

4.2.3.2 Surfaces away from the probe

(1) When testing the surface away from the probe with its near-surface regions for planar discontinuities, a testing technique or several testing techniques shall be employed which ensure that the testing level to para. 4.2.3.3.4 will be obtained. When selecting the testing technique, the acoustical properties (absorption, scattering, refraction, defraction) shall be considered. Where permitted by the geometry and acoustical properties, such testing techniques shall be preferred as to permit the echo height evaluation to subpara. 4.2.3.3.3 (3).

(2) Depending on examination task and test object the following testing techniques may e.g. be applied:

a) vertically polarized transverse waves with the incident angle of the sound beam in the range between 35 and 55 degrees (technique utilizing the corner effect),

b) vertically polarized transverse waves with the incident angle of the sound beam in the range between 60 and 70 degrees,

c) longitudinal waves,

d) wave conversion techniques to KTA 3211.3, Annex D, Section D 8 and D 9.

Note:

The testing techniques under a) and b) in general permit an echo height evaluation on homogenous materials.

(3) If, for reasons of test object geometry or of microstructure (e.g. in the case of austenitic weld seams and dissimilar material weld seams), the required demonstration of suitability of the above mentioned techniques cannot be achieved, an optimized testing technique or a combination of techniques shall be used, provided a prior verification of suitability was performed. Optimized testing techniques are, e.g.

a) testing frequencies ≤ 2 MHz,

b) probes with highly attenuated transducers,

c) dual-element probe techniques with signal overlapping in the half skip area,

d) horizontally polarized transverse waves.

(4) When testing surface and sub-surface areas, an area with a depth of at least 10 mm shall be covered in dependence of the testing technique employed. The imaging of the results obtained in mechanised ultrasonic testing shall ensure that the echo dynamics of recordable indications are fully reflected.

(5) Where the ultrasonic testing of a clad internal surface is made from the outer surface, the requirements of KTA 3201.4 shall be met.

Alternatively, the influence of the cladding on the ultrasonic signals may be determined on the test object itself or on the reference block and be considered in the evaluation of the test results if this is proved to be equivalent to the procedure of KTA 3201.4 as to the proof of suitability of this testing technique.

4.2.3.3 Procedural requirements

4.2.3.3.1 General requirements

(1) The testing level setting to clause 4.2.3.3.4 shall basically be performed on reference blocks with notches where the reflecting surface is oriented perpendicular to the surface.

Deviating from this, the testing level for welded joints between ferritic steels may also be set by applying the DGS method in accordance with the requirements of KTA 3211.3, clause 11.3, if it is demonstrated that the required testing level (i.e. sensitivity of the notch to be selected to **Table 4-2** with an additional sensitivity allowance of 6 dB and with consideration of a transfer correction) has been obtained. When applying the DGS method, a suitable reference standard shall be used for adjusting the testing level.

(2) Fluctuations of the ultrasonic signals due to coupling, absorption and scattering shall be considered in the testing level adjustment and in the evaluation.

(3) In the case of mechanized testing with liquid column coupling, an adjustment of the probe is required where the radius of curvature of the part surface would lead to a gap ≥ 0.5 mm under the probe. In the case of manual scanning of curved surface parts the probe shall be adjusted to meet the requirements of KTA 3211.3 Annex D.

4.2.3.3.2 Reference blocks

(1) The reflectors provided in the reference blocks shall be rectangular notches and be sufficient as regards their number and variation of dimensions and location so as to make possible statements on the testing technique's detection capability.

(2) The notches shall not be wider than 1.5 mm. Their acoustically effective length shall normally be 20 mm.

(3) The wall thickness of the reference block shall deviate not more than 10 % from that of the component to be tested.

(4) 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 examined.

Deviating here from plane reference blocks may be used in case of pulse-echo probes if the following requirements are satisfied:

a) The test object diameter does not require the use of contoured probes.

b) 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).

c) No wave conversion technique is used.

(5) If a weld does not cause geometric or material-related disturbances on the test object, an unwelded reference block may be used.

(6) Where reference blocks are provided with welds, the acoustic properties of the reference block shall be examined across the weld length, e.g. by means of V-transmission, and be considered accordingly when arranging the reflectors to be used.

4.2.3.3.3 Demonstration of suitability of the testing technique

(1) The suitability of the testing technique is deemed to be proved if

a) the echo height of the notch to be selected as per **Table 4-2** exceeds the noise level by 12 dB or more and the echo from the edge simulating a through-wall crack exceeds the echo height of the notch to be selected as per **Table 4-2** by at least 6 dB (see **Table 4-1**, case 1)

b) when setting the testing level to the DGS method, the requirements of sub-clause 4.2.3.3.1 (1) are met.

(2) In the case of materials difficult to examine and geometrically complex contours, the suitability of the testing technique shall be demonstrated for each sound beam direction and each testing area to be covered on a reference block having notches with varying depths. The notches shall be provided as shown in **Figures 4-1** to **4-3**.

At least three rectangular notches with varying depths as well as the edge of the reference block shall be scanned and the echo heights be entered in a diagram as a function of the notch depths. For testing in accordance with subparas (5) and (6), one notch shall have a greater depth and one notch have a lower depth than the notch as per **Table 4-2** required to adjust the testing level.

Where, for geometric reasons, the edge of the reference block is not available with regard to the testing area, another notch may be used as a substitute which is deeper than the deepest of the aforementioned three notches. In each individual case, the notch depth referred to the testing technique applied shall be fixed such that its reflection behaviour corresponds to that of an edge or a through-wall notch.

Where, for design reasons, the number of sound beam directions is limited, the location and number of the notches to be provided shall be laid down for each individual component.

The testing technique is considered to be suited if the criteria of sub-paras. (3) to (6) are satisfied.

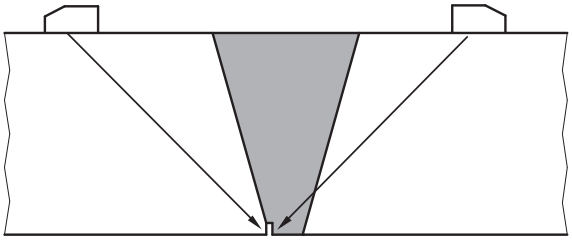


Figure 4-1: Location of notches and sound beam directions for the test of welded joints between ferritic steels and between austenitic steels

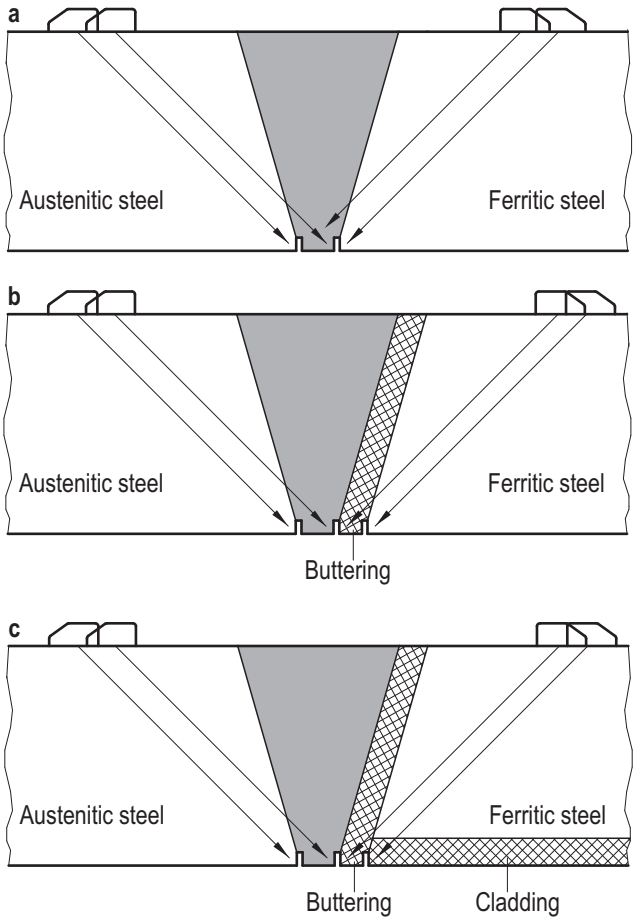
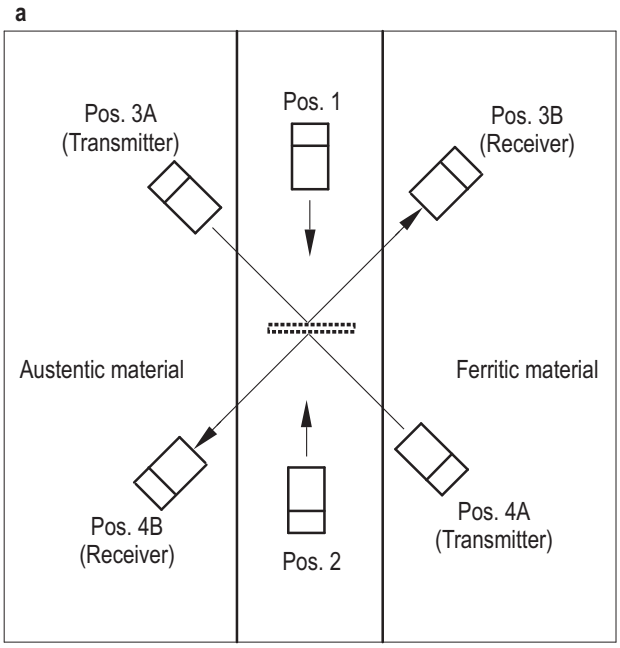


Figure 4-2: Location of notches and sound beam directions for the test for longitudinal defects of welded joints between ferritic and austenitic steels



Examination technique a: Scanning from positions 1 and 2 (single probe technique)
Examination technique b: Scanning from positions 3A and 4A (dual probe technique)

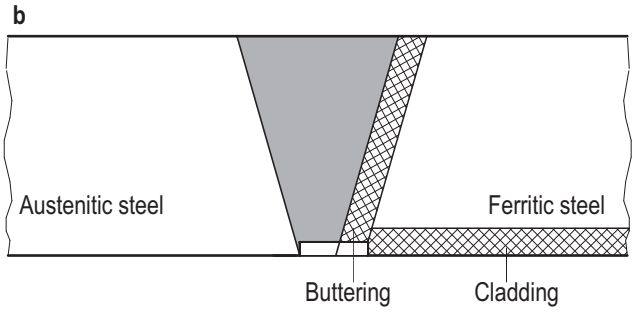


Figure 4-3: Location of notches and sound beam directions for the test for transverse defects of welded joints

(3) When examining butt welds the testing technique will be suited if (see **Table 4-1,** case 1)

a) the echo heights rise with an increase in notch depth when scanning across the base metal of the reference block,

b) the echo heights rise with an increase in notch depth when scanning across the weld metal or the buttering of the reference block,

c) the echo height of the notch to be selected as per **Table 4-2** (reference notch) exceeds the noise level by 12 dB or more in the case of sound beam directions as shown in **Figures 4-1** to **4-3**,

d) the edge simulating a through-wall crack or the echo height of the additional sufficiently deep notch exceeds the echo height of the reference notch by at least 6 dB in the case of sound beam directions as shown in **Figures 4-1** to **4-3**.

(4) Where the criteria of (3) in parts of the testing area (e.g. in the case of dissimilar welds with buttering where the test is made for longitudinal defects at the buttering to weld metal transition, or for transverse defects) cannot be satisfied, the following procedure applies (see **Table 4-1** case 2):

On the basis of the results obtained from reference block measurements the reference notch for testing level adjustment shall be a notch with an echo height of at least 6 dB in excess of the noise level by including a transfer correction. Where the capability of detecting defects cannot be proved with the available

notches, further notches with graded depths or realistic reference defects (cracks) shall be provided in the reference block. All notches having a greater depth than the reference notch shall show an echo height of at least 6 dB in excess of the noise level by including a possible transfer correction.

A differentiation shall be given between the signal pattern of the reference notch and the noise signals as well as a clear distinction between the reference notch pattern and the edge pattern simulating a through-wall crack. The evaluation criteria for comparing the signal patterns shall be fixed in the test instructions on the basis of reference block measurements (e.g. dynamic range of indication, correlation of indication patterns in the case of different beam angles and wave modes, crack-tip signal detection).

Where the reference notch shows a greater depth than the notch to be selected as per **Table 4-2**, a safety-related evaluation shall be made regarding the conclusiveness of the test in which case the re-calculations shall be based on a conservative defect with respect to its longitudinal and depth extension (reference value: double the depth of the reference notch with a length corresponding to the entire area for which the reference notch with a greater depth than that of the notch to be selected as per **Table 4-2** is used).

(5) The following applies to the location of notches and their related sound beam directions for the test of butt welds for longitudinal defects:

a) Testing of the inner surface of welds between ferritic steels

Notches shall be provided in the base metal of the reference block and be scanned from both sides. Where geometrical or material-related discontinuities are found (e.g. excess penetration, coarse grain structure), the notches shall be provided in the base metal adjacent to the base metal/weld metal transition as shown in **Figure 4-1** and be scanned from both sides of the weld.

b) Testing of the inner surface of welds between austenitic steels

Notches shall be provided at the austenitic base metal/weld metal transition as shown in **Figure 4-1** and be scanned from both sides of the weld.

c) Testing of the inner surface of welded joints without buttering between ferritic and austenitic steels with austenitic or nickel-alloyed weld metal.

Notches shall be provided at the transitions between austenitic base metal and weld metal as well as between ferritic base metal and weld metal as shown in **Figure 4-2 a** and be scanned from both sides of the weld.

d) Testing of the inner surface of welded joints with buttering between ferritic and austenitic steels with austenitic or nickel-alloyed weld metal.

Notches shall be provided at the transitions between austenitic base metal and weld metal, between weld metal and buttering as well as between buttering and ferritic base metal or between buttering and cladding as shown in **Figure 4-2 b**. The notches at the austenitic base metal/weld metal transition shall be scanned from the austenitic side; the notches at the transition between buttering/ferritic base metal shall be scanned from the ferritic side and the notches at the weld metal/buttering transition shall be scanned from both sides of the weld.

(6) The following applies to the location of notches and their related sound beam directions for the test of butt welds for transverse defects:

a) Testing of the inner surface of welds between ferritic steels

Notches shall be provided in the reference block and be scanned from two sides using either testing technique “a” or testing technique “b” as shown in **Figure 4-3 a**.

b) Testing of the inner surface of welded joints between ferritic and austenitic steels with nickel-alloyed weld metal

Notches transverse to the direction of welding progress shall be provided in the reference block as shown in **Figures 4-3 a** and **4-3 b**. The notches shall be positioned in the weld metal and the buttering. Where the width of the weld metal (including the buttering) is less than 20 mm, the notch length shall be limited to the width of the weld metal (including the buttering) on the inner surface. The notches shall be scanned from both sides with either testing technique “a” or testing technique “b” as shown in **Figure 4-3 a**.

	Case 1	Case 2
Evaluation method	Echo height evaluation to subpara. 4.2.3.3.3 (1) or 4.2.3.3.3 (3)	Pattern recognition to subpara. 4.2.3.3.3 (4)
Reference notch	Notchto be selected to Table 4-2	Notchto be selected to Table 4-2 or deeper notch[1)]
Difference in echo heights between reference notch and noise level	≥ 12 dB	≥ 6 dB [1)]
Difference in echo heights between edge simulating a through-wall crack and reference notch	≥ 6 dB	≥ 0 dB
Recording level	Reference notch plus a sensitivity allowance of 6 dB	Noise level
Recording	Any indication the echo height of which reaches or exceeds the recording level	Any pattern recognition equal to or exceeding the noise level
Evaluation	As per 8.2.2.3 (2)	As per 8.2.2.3 (3)

1) Where the difference in echo height is less than the required value, a notch with greater depth is to be selected as reference notch which meets the requirement. In such case, a safety evaluation is required.

Table 4-1: Criteria to be satisfied when proving the suitability of test techniques for ultrasonic testing of butt welds and base metal areas

4.2.3.3.4 Testing level adjustment

(1) General requirements

a) **Table 4-2** shows the depth of the notches as a function of the wall thickness.

When examining base metal areas of austenitic steels for damage due to transgranular stress corrosion cracking, the testing level shall be adjusted on a 1 mm deep notch.

Wall thickness s, mm	$8 < s \leq 20$	$20 < s \leq 40$	$s > 40$
Notch depth, mm	1.5	2	3

Table 4-2: Notch depth for adjusting the testing level

b) The testing level for contoured probes shall be adjusted on a curved reference block the radius of curvature of which shall not deviate from that of the component by more than 10 %.

c) The acoustic differences between the reference block and the test object shall be considered by transfer measurements (V transmission) in the base metal (weld-adjacent zone). In the case of circumferential welds, these measurements shall be made on representative measuring points distributed over the circumference, unless no documented measured values are available.

d) If, during testing, it is found out that the V transmission echo deviates by 6 dB or more from the reference block echo, sufficient testing level shall be ensured by suitable measures (e.g. through-transmission on the reference block and on the test object with an additional beam angle, by use of probes with other nominal frequencies, dual-element probe technique with longitudinal waves or wave conversion technique). Where the required testing level cannot be obtained even in the case of adapted testing techniques, the further procedure shall be fixed in consideration of subparas. 4.1.1 (9) and 4.1.2 (3).

e) For the testing level adjustment to the DGS method the requirements of KTA 3211.3 clause 11.3 shall apply.

(2) Testing on ferritic materials

For the purpose of setting the testing level, the reference reflector as per **Table 4-2** shall be subject to direct scanning over the entire testing area.

(3) Testing of the inner surface of austenitic welds and of welded joints without buttering between ferritic and austenitic steels with austenitic or nickel-alloyed weld metal for longitudinal defects

For the purpose of setting the testing level, the reference reflector as per **Table 4-2** and **Figure 4-1** or **Figure 4-2a** shall be subject to direct scanning over the testing area “weld- adjacent zone”. For the testing area “weld root” the reference reflector shall be scanned through the weld metal.

(4) Testing of the inner surface of welded joints with buttering between ferritic and austenitic steels with austenitic or nickel-alloyed weld metal for longitudinal defects.

For the purpose of setting the testing level, the reference reflector as per **Table 4-2** and **Figure 4-2b** or **Figure 4-2c** shall be subject to direct scanning over the testing area “weld-adjacent zone”. For the testing area “weld root including buttering“, the reference reflector in the weld/buttering transition zone shall be scanned from both the ferritic and austenitic base metal side.

(5) Testing of the inner surface of welded joints between ferritic and austenitic steels with nickel-alloyed weld metal for transverse defects.

For the purpose of setting the testing level, the reference reflector as per **Table 4-2** and **Figure 4-3** shall be subject to direct scanning.

(6) Where the testing techniques to subparas. 4.2.3.3.3 (4) or 4.2.3.3.3 (5) are used, the procedural requirements laid down in these subparas regarding testing level setting shall be followed. In this case, the differences in sound attenuation between component and reference block shall be determined by comparison of the noise levels in the testing area (e.g. comparison of C-scan images, statistical evaluation of noise level).

4.2.4 Eddy-current testing

4.2.4.1 Testing techniques

(1) When performing eddy-current testing for the surface inspection it is required that sensors and test frequencies adapted to the individual testing task are used.

(2) Suitable testing techniques are e.g.

a) Direct-field technique without or with DC pre-magnetization

Note:
Direct-field techniques may be used as single- or multiple-frequency technique in differential or absolute arrangement. To suppress noise caused by test object geometry or structure multiple-frequency techniques with superposition of the eddy-current signals from single-frequencies (mixture of frequencies) can be used.

aa) using surface probe coils with coiling perpendicular to the test object surface for the detection of flaws oriented parallel to the coil axis,

ab) using flat coils (so-called rotating pancake sensors) oriented in parallel to the surface for the detection of flaws in any direction

ac) using surface probe coils with two coils arranged mutually perpendicular to and above each other (so-called plus-point sensors) for the detection of flaws oriented longitudinally and transverse to the direction of sensor travel,

ad) using array sensors containing a great number of individual coils arranged in a specific matrix in which case any adjacent two coils are switched in the transmit-receive mode to detect flaws oriented longitudinally and transverse to the direction of array sensor travel,

b) far-field technique or pulsed eddy current testing technique with separate exciter and measuring probe for examining surfaces far from the sensor.

4.2.4.2 Procedural requirements

4.2.4.2.1 General

(1) The testing level shall be set on reference blocks with notches.

(2) It shall normally be ensured by the selection of suitable test parameters and application of signal processing algorithms that noise signals (e.g. caused by lift-off, local variations of electromagnetic material parameters) will not impair the test results. Where this is impossible, the effects on the useful signal shall be considered when adjusting the testing level.

4.2.4.2.2 Reference block

(1) The notches provided as reference objects in reference blocks shall be electro-eroded rectangular slots.

(2) The notches shall not be wider than 0.3 mm. The notch length shall be greater than the effective sensor width.

(3) For the purpose of testing base metal areas, the notches shall be provided in the reference block in longitudinal and transverse direction to the pipe or vessel axis, and for the testing of welds in longitudinal and transverse direction to the direction of weld progress, and the notch number and variation in

size and location shall suffice to make statements possible that the testing technique is adequately suited.

4.2.4.2.3 Suitability of test procedures

(1) The suitability of the testing technique shall be proved on the basis of reference block measurements by means of a characteristic curve. To this end, eddy-current signals of reference objects of varying depths and with the required orientations shall be used.

(2) The number and depths of the reference objects shall be determined such that the depth region required by the testing task is completely covered.

(3) The measured characteristic parameters (phase and amplitude) shall be entered in a diagram as a function of the depth of the reference objects. The evaluation area shall be determined in dependence of the characteristic parameters. The detection threshold shall be read from the diagram and be documented.

(4) The testing technique is suited if

a) the recording levels required as per subpara. 4.2.7 (5) exceed the noise level by 6 dB or more,

b) the characteristic curves clearly increase or decrease with the depth of the reference objects (depending on the testing technique),

c) a clear phase separation of defect and noise signals is ensured.

(5) Where individual criteria of (4) cannot be satisfied, the thus caused restrictions of the test statement shall be evaluated and additional testing techniques be used, where required.

4.2.4.3 Testing level adjustment

(1) In the case of wall thicknesses not less than 8 mm notches with a depth as per **Table 4-2** in dependence of the wall thickness, and in the case of wall thicknesses less than 8 mm one notch with a depth of 20 % of the wall thickness, but not deeper than 1.5 mm shall be used as reference objects during testing.

(2) During testing of base metal zones of austenitic steels for damage due to stress corrosion cracking the testing level shall be adjusted on a notch with a depth of 1 mm.

(3) Changes of the eddy-current signals caused by geometry influences and variations of material properties shall be considered when adjusting the testing level.

4.2.5 Radiographic testing

(1) When performing radiographic tests, the requirements of DIN 25435-7 shall be met.

(2) The application of radiographic testing shall normally be limited to a wall thickness s of less than or equal to 25 mm (in the case of double-wall radiography, the thickness of the radiographed wall $w \leq 50$ mm).

4.2.6 Visual testing

(1) When performing visual testing the requirements of DIN 25435-4 shall be met.

(2) Depending on the task, visual testing shall be either made as integral visual testing or as selective testing, in which case

a) integral visual testing is performed to evaluate the general condition of components

b) selective visual testing is performed as local visual testing for the unambiguous detection of specific characteristics

of the examined region.

(3) Visual testing shall be performed as a direct visual testing by the human eye and, if necessary, with the help of optical instruments (e.g. magnifying glasses, mirror, endoscope) or as an indirect visual testing by the human eye and with the help of a system of equipment receiving, transferring and displaying or recording the image.

(4) During visual testing the following shall especially be taken into consideration:

a) mechanical damage (points of friction, bends and tears),

b) material separations,

c) corrosion, erosion, wear,

d) indications of leakage,

e) defects on

ea) bolt connections (loosening, condition of the bolt locking devices),

eb) connections of measuring points and instrument lines,

ec) insulation,

f) displacement of components (free end displacement of pipes, damage to foundations and anchor points),

g) deposits, foreign matter.

(5) The object distance during direct visual testing and the recognizability of details during indirect visual testing shall be determined in dependence of the testing task.

4.2.7 Recording levels

(1) All indications reaching or exceeding the recording level shall be recorded.

(2) Magnetic particle and penetrant testing

The recording level corresponds to an indication with an extension of 3 mm. More than 2 indications on an area of 1000 mm^2 shall be considered an accumulation of indications and shall also be recorded even if the extension of the individual indication is less than 3 mm. Indications suggesting planar flaws shall be recorded independently of their length.

(3) Ultrasonic testing

During ultrasonic testing the following recording levels apply in dependence of the testing task:

a) Testing both in close vicinity of the probe down to a depth of less than or equal 10 mm and of the corresponding opposing surface

The recording level corresponds to the echo height of the reference reflector to para 4.2.3.3.4, plus a sensitivity allowance of 6 dB.

b) Use of testing techniques as per subpara. 4.2.3.3.3 (4)

All indications shall be recorded and be evaluated which show characteristic features of the indicated patterns determined on the reference reflectors in which case all indications above the noise level shall be evaluated.

c) Where the testing level is set to the DGS method, the recording levels laid down in KTA 3211.3 clause 11.3 shall apply.

The influence of the microstructure or of the shape of the weld seam on the ultrasonic signals shall be monitored on the test object itself or on the reference block and shall be taken into consideration when specifying the recording level.

(4) Radiographic testing

Indications visible on the radiographs shall be recorded and be classified to DIN EN ISO 6520-1.

(5) Eddy-current testing

The recording level for testing of welds and base metal zones shall correspond to

a) the signal height of the reference objects as per 4.2.4.3 (1) plus a sensitivity allowance of 6 dB in the case of ferritic steels,

b) the signal height of the reference objects as per 4.2.4.3 (1) and (2) in the case of austenitic steels.

(6) Visual testing

Deviations of the covered actual condition from the expected required condition shall be recorded as conspicuous indications.

4.3 Examination for wall thickness reduction

4.3.1 Techniques and procedural requirements

(1) Depending on the testing task, techniques shall be used which make possible the determination of wall thickness in the case of planar wear, e.g. flow-assisted corrosion, standstill corrosion or in the case of shallow pit formation, e.g. pitting corrosion.

(2) The technique considered suitable is ultrasonic wall thickness measurement with measurement techniques 1 to 3 to DIN EN 14127 with the procedural requirements laid down in this standard.

(3) Other test techniques, e.g. radiographic testing using projection technique to DIN EN 16407-1 and DIN EN 16407-2 may be used if their suitability to satisfy the testing tasks has been demonstrated. The procedural requirements shall be laid down in test instructions.

4.3.2 Recording levels

Any reduction in wall thickness referred to the basic condition shall be recorded in due consideration of the measuring technique inherent tolerances. The basic condition is

a) the wall thickness measured during the preceding in-service inspection,

b) the wall thickness measured during fabrication where no measured values are available from in-service inspections,

c) the wall thickness recorded in the fabrication documentation (in consideration of the tolerances indicated in the technical rules or material test sheets for semi-finished products) unless measured values from in-service inspections or fabrication are available.

4.4 Inspection of the general condition

(1) After shutdown and prior to restart of the unit, an inspection serving to assess the general condition of systems and components shall be performed. These inspections are usually performed within plant inspection without removing any insulation material.

(2) During the inspection of the general condition the following shall especially be taken into consideration:

a) mechanical damage (points of friction, bends and tears),

b) indications of leakage, especially in system parts containing flange connections,

c) defects on

ca) bolt connections (loosening, condition of the bolt locking devices),

cb) connections of measuring points and instrument lines,

cc) insulation,

d) displacement of components (free end displacement of pipes, damage to foundations and anchor points).

e) control of building structural connections e.g. dowel connections for conspicuous condition.

4.5 Pressure test

4.5.1 Test conditions

(1) The pressure test shall be performed at the pressure level of the pre-service hydrostatic test. However, if any connected non-isolatable systems may only be pressurized to a lower pressure level, this lower level shall be used as test pressure.

(2) The holding period at test pressure level shall be at least 30 minutes.

(3) Before starting the leakage check the pressure shall be reduced to the operating pressure.

(4) If a pressure test is not possible or expedient on account of the design or operating mode of the component or system then the pressure test to be performed during in-service inspections shall be substituted by suitable non-destructive tests and examinations.

4.5.2 Non-destructive tests and examinations following the pressure test

Subsequent to the periodic pressure tests non-destructive tests and examinations shall be performed in accordance with the test and inspection manual (cf. Section 6).

4.6 Functional tests on safeguards against excessive pressure

All safeguards against excessive pressure shall be subjected to functional testing at regular intervals. In these tests the following shall be checked:

a) the response pressure,

b) the opening and closing behaviour.

Parameters relevant to function (e.g. dead times, actuating force reserves) shall be evaluated with respect to the specific plant and design.

5 Extent of testing and test intervals

5.1 General requirements

(1) In-service inspections shall basically be performed to the extent and at the test intervals as specified in Sections 5.2 and 5.3.

(2) Where new findings are obtained from operational monitoring, from the monitoring of consequences of operational damage mechanisms as well as from the preventive maintenance measures as per **Figure 3-1**, the stipulations of Sections 5.2 and 5.3 shall be re-evaluated with respect to the specific plant. To this end, the testing procedures, areas and intervals for the component groups mentioned in Section 1 under (4), (5) and (6) shall be adapted accordingly.

(3) If the design, construction, fabrication or other aspects significantly limit the extent of testing, additional measures shall be taken (e.g. fracture mechanic analyses) that lead to the required information on safety. Any limitations with regard to the specifications of this Safety Standard shall be noted in the test instructions.

(4) If operational loading is one of the criteria in Section 5.2 for selecting the component areas to be tested, then representative higher stress locations shall be included within the intended extent of testing. Besides the usage factor operational experience shall also be taken into account.

(5) In relation to each specific plant, tests and examinations for damage by transgranular stress corrosion on austenitic pipes and components including instrumentation and control lines shall be laid down. The areas to be examined shall be laid down according to the following criteria:

a) stagnant fluid during operation, dead pockets,

b) partly filled horizontal pipe sections,

c) valves, flanged joints where ingress of foreign matter is possible.

5.2 Extent of testing

5.2.1 Non-destructive tests and examinations

5.2.1.1 General

(1) The extent of tests specified may be achieved by combining a number of representative weld seams or by a combination of representative weld seams and representative higher stress locations (e.g. pipe bends, fittings). In individual cases additional criteria shall be considered in specifying representative locations on which the tests are to be performed.

(2) When testing weld seams, the tests and examinations shall include the weld metal (including buttering in the case of weld connections between ferritic and austenitic steels) and the base metal zone on both sides of the weld seam.

The base metal zone to be included shall normally have a width of not less than 10 mm for a wall thickness $\leq$ 30 mm and a width of at least 20 mm on both sides for a wall thickness exceeding 30 mm.

When testing insertion and attachment weld seams of nozzles, the width of the adjacent base metal to be included in the tests and examinations is defined by the wall thickness of the connecting nozzle or attachment wall thickness respectively.

(3) Locations of former auxiliary welds shall be included in the extent of test and inspection if it cannot be ensured that the strain-hardened area of the heat affected zone has been completely removed by dressing.

(4) Component areas where the insulation has to be disassembled for the purpose of non-destructive tests and examinations, shall be subjected to an integral visual testing.

(5) The tests and examinations for corrosion damage shall be laid down individually for each plant. To this end, the damage potential for all types of corrosion shall be determined.

(6) The tests and examinations for flow-assisted corrosion damage shall be laid down individually for each plant in consideration of the following fluid parameters

a) flow rate,

b) pH value,

c) oxygen content,

d) steam content,

e) temperature.

The test and examination intervals shall be determined in due consideration of the materials and the prevailing geometric boundary conditions.

(7) Sea and river water-wetted components and systems shall be examined for corrosion damage. The test intervals shall be determined individually for each plant in due consideration of

a) possible concentrations of damaging substances (stagnating fluid during operation, dead spaces),

b) possible damage to internal linings (e.g. increased flow rate, turbulence, repair zones).

5.2.1.2 Vessels and ancillary equipment

The extent of test and examinations to be performed on vessels and ancillary equipment including the pressure retaining walls of their accessories is specified in **Table 5-1**.

5.2.1.3 Pumps and valves

(1) The extent of test and examinations to be performed on pumps and valves is specified in **Table 5-2**.

(2) Where possible, the examination shall cover the areas including the pipe connection along with the pipe weld. Internal components (trim) of isolation valves required to seal the pressure space (e.g.valve plugs, slide plates, valve discs) shall be subjected to a selective visual testing, if they are assigned to part group EG 1. In addition, penetrant testing shall be performed on austenitic steel valves where the risk of damage due to stress corrosion cracking exists (e.g. in no-flow zones where the risk of corrosive fluid concentration exists).

Note:
The criteria for classification into part groups are specified in Table 2-1 of KTA 3211.3.

5.2.1.4 Pipework

(1) The extent of testing to be performed on the pipework is specified in **Tables 5-3** and **5-4**. In addition, tests and examinations for the detection of stress-corrosion cracking shall be laid down to clause 5.1 (5).

(2) For buried pipelines the following applies:

a) When selecting representative locations for tests and examinations, those locations shall be considered which are subject to higher stresses in case of loadings of loading level D, e.g. building penetrations.

b) The selected visual testing of the outer surface may be replaced by an examination from the inner surface. The testing procedures/techniques to be applied shall be laid down for each individual plant.

(3) For piping with nominal sizes ≤ DN 50 the following applies:

a) Those pipes shall be determined which are required for the response of safety systems. The periodic non-destructive tests and examinations to be performed on internal and external surfaces of these pipes (methods, extent and intervals of tests and examinations) shall be laid down with respect to plant-specific requirements.

b) On pipes not required for the response of safety systems, the components shall be monitored for leakage, vibrations and displacement, see Section 9.4.

5.2.1.5 Welded joints between ferritic and austenitic steels

The extent of testing to be performed is specified in **Table 5-5**.

5.2.2 Evaluation of the general condition

The extent of evaluation of the general condition shall depend on the inspection objectives stated in Section 4.4 and shall be specified for each individual plant.

5.2.3 Pressure tests

(1) Basically all vessels and ancillary equipment including the pressure retaining walls of their accessories within the scope of this Safety Standard as well as non-isolatable parts of pipework shall be subjected to periodic pressure tests.

(2) If a pressure test is not possible or expedient on account of the design or operating mode of the component or system

then the pressure test shall be replaced by suitable non-destructive tests and examinations.

5.2.4 Functional testing of safeguards against excessive pressure

All safeguards against excessive pressure shall be subjected to functional tests. If the safety device consists of a pilot and a main valve, the test shall be performed such that in addition to the function of the pilot and main valve the functional capability of the control lines can also be assessed. The performance of the test shall be specified with respect to the specific plant design and construction.

5.3 Test intervals

(1) All test intervals start either at the time of first criticality of the reactor or at the time of component commissioning or at the time when a new test is included into the test and inspection manual (e.g. due to changed requirements in rules and standards). The time intervals within which the specified tests have to be performed are listed in the corresponding tables.

(2) The non-destructive tests and examinations in accordance with 5.2.1 shall be performed at test intervals specified in **Tables 5-1** to **5-5**, unless specified otherwise in clause 5.2.1. In case of pumps, valves and pipes (cf. **Tables 5-2** to **5-5**) a representative number of tests must have been performed by the end of half the testing interval.

(3) An evaluation of the general condition in accordance with 5.2.2 shall be performed after plant shutdown for refueling and in the course of plant restart.

(4) The pressure test in accordance with 5.2.3 shall be performed every 8 years (on feed water vessel, water separator or reheater and HP feedwater heater every 10 years).

(5) The test intervals and test dates for functional testing of the safeguards against excessive pressure in accordance with 5.2.4 shall be laid down individually for each plant.

(6) Since the time period between two refuelings can be up to 18 months, the individual tests shall be performed during that refueling that is closest to the due date of the tests. If this leads to longer time intervals than specified in the tables, the due dates for the next in-service inspections shall be advanced accordingly such that in the long run the time intervals averaged remain as specified. In the case of plant shutdowns of more than 6 months, special arrangements may be agreed.

Type of tests and examinations	Test procedure	Flaw orientation	Extent of testing	Test interval
Pressure test [1]	Hydrostatic test	—	Pressure retaining walls and accessories, flange connections, seals and sealing weld seams	8 years (10 years [2])
	MT or PT or UT [5] or RT or ET	l and t [6]	Representative locations (e.g. weld seams)	
Surface inspection [3]	VT (integral, selective) [4]	Any	- Outside and inside surfaces of pressure retaining walls - Internals, that are constituent part of the pressure retaining wall The test procedure to be used and the extent of testing shall be specified for each individual plant.	4 years (5 years [2]) [5]
	MT or PT or UT or RT or ET	l and t [6]	Representative locations (e.g. higher stress locations [7])	

Abbreviations for the test procedures are explained in **Table 2-1**. l : longitudinal flaw t : transverse flaw

1) See cl. 5.2.3 (2) as regards the replacement of pressure test by suitable non-destructive tests and examinations.

2) Applies to the tests of the feed water vessel, water separator or reheater and HP feedwater heater.

3) Where on-line monitoring of heat exchangers (e.g. water level, temperature, pressure conditions, radioactivity) ensures that damage is detected in time prior to loss of heat exchanger functional capability, surface inspections on heat exchanger tubes are not required.

4) If visual examination of the inner surface cannot be carried out to the extent required due to design or operational mode of the vessel or equipment, this examination shall be complemented or be replaced by a pressure test or other suitable tests and examinations.

5) If the due date of the surface inspection coincides with that of the pressure test it shall be performed after the pressure test.

6) For ultrasonic testing of welded joints between austenitic steels only the test for longitudinal defects is required.

7) In the case of vessels or heat exchangers similar in design, dimensions and loading, the number of vessels or heat exchangers to be tested may be reduced on a system specific basis taking the operating loads into consideration when selecting the units.

Table 5-1: Non-destructive in-service inspections on vessels and ancillary equipment including the pressure retaining walls of their accessories

Type of tests and examinations	Test procedure	Flaw orientation	Extent of testing [1]	Test interval
Surface inspection	VT selective [2]	Any	Inner surfaces of the pressure retaining walls of pumps and valves with a connecting nominal diameter ≥ DN 150 up to ≤ DN 400	8 years (10 years [3])
			Inner surfaces of the pressure retaining walls of pumps and valves with a connecting nominal diameter > DN 400	4 years (5 years [3])
			Inner valve body surface of valves [4] with a nominal diameter greater than DN 50 and less than DN 150	in conjunction with an inspection (opening of the valve body)

[1] In the case of pumps or valves similar in design, dimensions and loading, the number of pumps or valves to be tested may be reduced on a system specific basis taking the operating loads into consideration when selecting the units.

[2] Penetrant testing to 5.2.1.3 (2) shall additionally be performed on austenitic steel valves.

[3] Applies to the test of valves in the pipe sections as per Table 5-3 footnote 4.

[4] In the case of isolation valves the internal components (trim) required to seal the pressure space shall additionally be subject to a selective visual testing, if they are assigned to part group EG 1.

Table 5-2: Non-destructive in-service inspections on pumps and valves

Type of tests and examinations	Test procedure	Flaw orientation	Extent of testing[1]	Test interval [1]
Surface inspection [2]	MT or PT or UT or RT or ET	l and t	Weld seams of straight pipes, bends and elbows or higher stress locations ≥ DN 150 [3] [4] 15 % of all pipe welds, to be specified on basis of the following criteria: - connecting weld seams of vessel, valves, penetrations, (partial) anchor points - connecting weld seams of t-joints and elbows - operational loading - material pairing - manufacturing quality regarding weld seam surface A part of the weld seams shall normally be changed from test interval to test interval. In each case the outside and inner surface shall be examined.	8 years [5]
Surface inspection	VT selective [6]	Any	Outside surface of pipes > DN 50 The extent of testing shall be specified on a plant specific basis.	
Examination for wall thickness reduction	UT or RT [7]	p	Extent and interval of the tests shall be specified in a test instruction, see clauses 4.3, 5.2.1.1 (5) to (7).	
Surface inspection	Small-bore pipes (DN ≤ 50), see 5.2.1.4 (3)			

Abbreviations for the test procedures are explained in **Table 2-1**.
l : longitudinal flaw t : transverse flaw p : flaw parallel to the surface

[1] If restricted leak and break postulates are used, the in-service tests and examinations shall be carried out as follows:
The extent of tests and examinations shall be specified on a plant specific basis depending on the loadings and the measures specified within the framework of the concept for safeguarding of component integrity according to section 3 of KTA 3201.4. The extent of tests and examinations shall be at least equal to that required for pipes, for which no restricted leak and break postulates are used.

[2] In-service surface inspections (except VT selective) are not required if the following two criteria are met for normal operating conditions: operating pressure ≤ 2.0 MPa and operating temperature < 100 °C.

[3] As regards in-service periodic non-destructive tests and examinations on piping 50 < DN < 150 stipulations shall be laid down individually for each plant.

[4] For pipes of the main steam and feed water system the following applies:
PWR: the main steam system from the steam generator up to the turbine trip valve; the feed water system from the main feed pump up to the steam generator; and the steam generator blow down system > DN 50 from the steam generators up to the isolation valve outside the containment
BWR: the main steam system from the outer isolation valve of the containment vessel up to the turbine trip valve; the feed water system from the main feed pump up to the outer isolation valve of the containment vessel

[5] 10 years regarding the following extent of testing:
PWR: the feed water system from the outer isolation valve of the containment vessel up to the turbine trip valve; the feed water system from the main feed pump up to the outer isolation valve of the containment vessel
BWR: the feed water system from its point of exit from the reactor building up to the turbine trip valve; the feed water system from the main feed pump up to the point of entry into the reactor building

[6] Where required, other test methods, see sub-clause 5.2.1.4 (2).

[7] Where required, other test methods, see sub-clause 4.3.1 (3).

Table 5-3: Non-destructive in-service inspections on ferritic pipes. Type, extent and interval of tests and examinations

<table>
<tr><th>Type of tests and examinations</th><th>Test procedure</th><th>Flaw orientation</th><th colspan="3">Extent of testing</th><th>Test interval</th></tr>
<tr><td rowspan="7">Surface inspection [1)]</td><td rowspan="7">PT
or UT
or RT
or ET</td><td rowspan="7">l</td><td colspan="3">PWR | BWR</td><td rowspan="8">8 years</td></tr>
<tr><td colspan="3">Weld seams of straight pipes, bends and elbows or higher stress locations ≥ DN 150 to the following extent [2)]</td></tr>
<tr><td></td><td>hot (≥ 200 °C)</td><td>cold (< 200 °C)</td></tr>
<tr><td>10 %</td><td>20 %</td><td>10 %</td></tr>
<tr><td colspan="3">Weld seams of straight pipes, bends and elbows or higher stress locations 50 < DN < 150 to the following extent [2)]</td></tr>
<tr><td></td><td>hot (≥ 200 °C)</td><td>cold (< 200 °C)</td></tr>
<tr><td>5 %</td><td>10 %</td><td>5 %</td></tr>
<tr><td rowspan="2">Surface inspection</td><td>VT selective</td><td>Any</td><td colspan="3">Outside surface of pipes > DN 50
The extent of testing shall be specified on a plant specific basis.</td></tr>
<tr><td colspan="5">The weld seams to be examined shall be specified on the basis of the following criteria:
- operational loading
- connecting weld seams of t-joints, fixed points, reduction piece, valves, vessels
In each case the outside and inner surface shall be examined.
A part of the weld seams shall normally be changed from test interval to test interval.</td></tr>
<tr><td colspan="5">Small-bore pipes (DN ≤ 50), see 5.2.1.4 (3)</td></tr>
<tr><td colspan="7">Abbreviations for the test procedures are explained in Table 2-1. l : longitudinal flaw</td></tr>
</table>

[1)] In-service surface inspections (except VT selective) are not required for PWR plants if the following criteria are met for normal operating conditions:
a) operating pressure≤ 2.0 MPa and operating temperature < 100 °C or
b) duration of loading≤ 2 % of the duration of operation of the plant or
c) primary membrane stress < 50 N/mm^2.

[2)] PWR: - emergency and residual heat removal systems between the first and second isolation valve of the primary system and the adjacent pipes to the accumulator
- volume control system
- regular and standby emergency feedwater system from the steam generator to the outer isolation valve of the containment vessel

BWR: - residual heat removal system, high-pressure injection system, emergency cooling system, make-up feedwater system
- core flooding system
- reactor water cleanup system
- reactor trip system

Table 5-4: Non-destructive in-service inspections on austenitic pipes. Type, extent and interval of tests and examinations

Type of tests and examinations	Test procedure	Flaw orientation	Extent of testing	Test interval
Surface inspection	PT or UT or RT or ET	l and t [1)]	15 % of all dissimilar metal welds ≥ DN 150 [2) 3)] on systems as per Table 5-3 footnote 3 and Table 5-4 footnote 2. In each case the outside and inner surface of the entire seam length shall be examined.	8 years
Abbreviations for the test procedures are explained in **Table 2-1**. l : longitudinal flaw t : transverse flaw				

[1)] In the case of welded joints provided with Ni-alloy weld metal on the fluid-wetted surface, testing for transverse defects shall be performed additionally to the test for longitudinal defects. This test is also required if between the Ni-alloy weld metal and the fluid-wetted surface an austenitic root ≤ 3 mm is provided.

[2)] The requirements for periodic in-service non-destructive tests and examinations to be performed on welded joints with dimensions 50 < DN < 150 shall be laid down individually for each plant. For welded joints ≤ DN 50 the requirements of sub-clause 5.2.1.4 (3) apply.

[3)] Welds with repair weldings shall preferably be tested. A part of the weld seams shall normally be changed from test interval to test interval.

Table 5-5: Non-destructive in-service inspections on of welded joints between ferritic and austenitic steels

6 Test and inspection manual

6.1 Preparation

The extents, types and intervals of the tests shall be specified depending on the safety related significance of the systems or components. **Tables 5-1** to **5-5** specify certain requirements regarding the preparation of the test and inspection manual (cf. KTA 1202).

6.2 Review and updating

Prior to each, even partial, in-service inspection the type, extent and date of testing shall be reviewed for each individual component and shall be updated, if necessary. Here, the following shall be taken into consideration:

a) Previous in-service inspections
   The results of previous in-service inspections shall be taken into account. This may lead to an updating of the type, extent and date of testing for the previously specified in-service inspections as well as to a change in the specified test location within the range of items to be tested.

b) Repair or replacement
   After performance of repair or replacement it shall be decided upon whether or not in-service inspections should be introduced at these locations or whether or not the type, extent and date of already specified in-service inspections should be changed.

c) Operational monitoring
   The results of operational monitoring in accordance with Section 9 shall be considered in the reviewing and updating procedure.

d) Operational experience
   The operational experience from the own plant as well as from other plants shall be considered in the reviewing and updating procedure.

7 Preparation and performance of tests

7.1 General

The working conditions during the preparation, performance and evaluation of the tests (e.g. pressure of time, ambient temperature, noise, radiation) shall be such that negative influences on the quality of the test are avoided. For nuclear power plant overhauls, the time schedule and sequence of tests and inspections on systems outside the reactor coolant pressure boundary shall be planned accordingly.

7.2 Preparation

(1) The tests shall be adequately prepared with respect to general organization and required equipment. The preparation shall especially include the planning of the employment of test personnel taking the general organization of work, the Radiological Protection Ordinance and Guideline “Radiological Protection“ into consideration.

(2) The areas of the components that will be subjected to testing shall be put in a condition suitable to testing. Cleaning and further measures, if any, for preparing the testing areas shall be effected upon visual testing.

(3) Details of the tests shall be specified in test instructions (cf. KTA 1202). These include specifications of the locations to be tested, the test procedures to be applied and references to the corresponding standard test instructions or test specifications.

(4) The NDT personnel shall be instructed to become familiar with the specific testing task, the appearance of operational defects and the pertinent test boundary conditions (e.g. component geometry, impeded accessibility, work to be done under respiratory equipment, and exposure to dose rate).

7.3 Performance

(1) The test system adjustment and the checking of the adjustment as well as the checking of the test media to be used both in magnetic particle and penetrant testing shall be performed on reference standards.

(2) Magnetic particle testing shall be performed in accordance with DIN 25435-2 in conjunction with DIN EN ISO 9934-1.

(3) Penetrant testing shall be performed in accordance with DIN 25435-2.

(4) The performance of eddy current testing shall be specified in the test instructions.

(5) Radiographic testing shall be performed in accordance with DIN 25435-7.

(6) Automated ultrasonic testing shall be performed in accordance with DIN 25435-1.

(7) Manual ultrasonic testing shall be performed in accordance with Annex D of KTA 3211.3.

(8) Visual testing shall be performed in accordance with DIN 25435-4.

(9) The requirements specified in Section 4.5 shall be met when performing pressure tests. Details (e.g. media, temperature, pressure) shall be specified in the test instructions.

(10) Functional testing of the safeguards against excessive pressure shall be performed in accordance with the test and inspection manual.

7.4 Requirements regarding test personnel

(1) The test personnel performing tests and examinations to the procedures of **Table 2-1** ser. No. 1 or ser. No. 4, shall satisfy the minimum requirements for test personnel laid down in the standards DIN 25435-1 to DIN 25435-4, DIN 25435-6 and DIN 25435-7.

(2) The test personnel for manual ultrasonic testing shall satisfy all requirements of DIN 25435-1 Table 2.

(3) The test personnel employed for the examination of wall thickness reduction shall be qualified and certified to DIN EN ISO 9712 for the examination methods to be applied, as follows:

a) as NDT operator at least with level 1,

b) as test supervisor with level 2.

In addition, the NDT operator and the test supervisor shall prove that they have been instructed to perform wall thickness measurements accordingly. This proof of instruction shall contain data on the wall thickness measurement procedures performed and the damage mechanisms treated.

(4) The test personnel for evaluation of the general condition shall have the knowledge required to perform their tasks and shall have sufficient visual capacity.

(5) The test personnel for functional tests shall have the knowledge required to perform their tasks.

8 Evaluation of test results

8.1 General

(1) When evaluating the test results, the procedural steps shall be as specified in Sections 8.2 to 8.6.

(2) The test results as well as conspicuous findings and peculiarities which influence the test result shall be recorded in the test report and be evaluated.

(3) The plant owner and the authorized inspector shall convince themselves and confirm within the test certification that the tests have been performed completely to the requirements, have been evaluated correctly to ensure traceability and have been recorded.

8.2 Surface inspection

Note:
The steps specified in 8.2.1 and 8.2.2 refer to **Figure 8-1**.

8.2.1 Decision-making process

(1) At the end of an operational period (Step 1), the n-th in-service inspection II_n (Step 2) is performed.

(2) If indications are found, the further procedure shall follow the decision-making procedure (**Figure 8-1**) structured as flow chart.

(3) When evaluating the results (Step 3) it shall be decided whether or not the indications have exceeded the acceptance level. If this is not the case, the component may be operated further (Step 12).

(4) If indications reach or exceed the acceptance level, they shall be termed relevant indications. At first, a comparison with the results of the previous in-service inspection II_{n-1} shall be performed (Step 4). If findings have changed, the results of in-service inspections lying further back shall also be taken into account to possibly detect the time history of the change. On the basis of the comparison of the measured values it shall be decided whether it is a first occurrence of the indication or whether an existing indication has grown larger (Step 5). If this is not the case, the component may be operated further (Step 12).

(5) In the case of ultrasonic testing techniques, evaluation methods may be used that are based on an image presentation of the test results. The procedure shall be specified in the test instruction.

(6) In the case of first occurrence of an indication or growth of an existing indication, an analysis to Section 8.2.3 is required that leads to information on its type, location and size. Where required, further tests employing more refined testing techniques (Step 6) shall be performed.

(7) If it is found out that it is a first occurrence of an indication or an existing indication has grown (Step 7), then the cause shall be determined and subsequently a safety analysis shall be performed (Step 8). This shall be based, among other things, on the operational records.

(8) The safety analysis may, for instance, comprise:

- a stress analysis, verifications of strength,
- fracture mechanic evaluations,
- laboratory experiments,
- checks on similar components in the case of indication of systematic defects,
- an evaluation of experience gained with other plants.

(9) The results of the cause determination and the safety analysis are decisive regarding the specification of the acceptance level, i.e., the decision whether or not a flaw may be left as it is (Step 9). If it follows that the flaw may be left in the component as it is, then the causes, where possible, shall be removed e.g. by the following measures:

a) change of the operational mode of the plant,

b) installation of additional structures (e.g. pipe support structures).

(10) The success of the measures taken shall be checked, e.g. by:

a) instrumentation for a continuous monitoring of the flaw location,

b) inclusion of the area with findings as location to be tested into the test and inspection manual and determination of shorter intervals of in-service inspections.

(11) Taking the measures specified above into account, the component may be operated further (Step 12).

(12) If it is established that the flaw as it is cannot be left in the component, the causes shall, as far as possible, be removed and a repair or replacement of the component initiated (Step 11). The success of the measures shall be checked, e.g., by

a) instrumentation,

b) shorter intervals of in-service inspections.

Prior to the release for operation, a production test or, if required in accordance with Section 4.1.3, a reference test shall be performed on the repaired component.

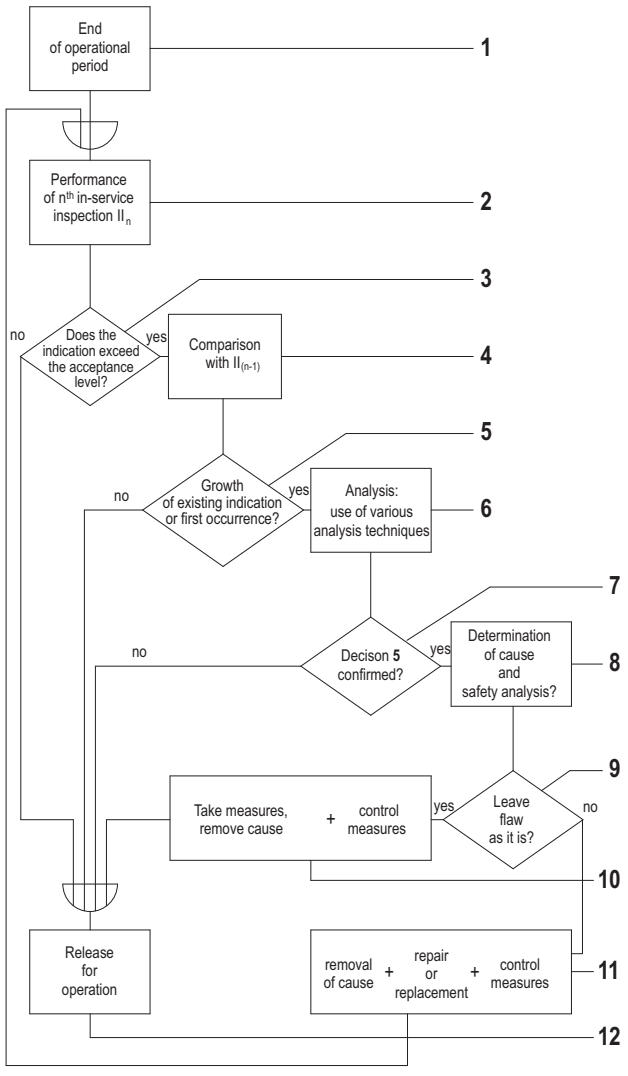


Figure 8-1: Schematic decision-making plan to evaluate the results of non-destructive tests and examinations

8.2.2 Acceptance levels

8.2.2.1 General

(1) To avoid that measured values which are scattered due to the testing technique used are to be evaluated as relevant indications, the following acceptance levels are specified for in-service inspections.

(2) All indications reaching or exceeding the recording level shall be documented in a test record and those above the acceptance level (Step 3) shall be treated as relevant indications. The individual acceptance levels are defined by the values specified in Sections 8.2.2.2 and 8.2.2.3.

(3) Indications caused by the geometric shape of the test object or are clearly proved not to be caused by defects, shall be evaluated to be indications of shape and be entered in the test report. In the case of periodically occurring indications of shape exemplary recording will suffice.

8.2.2.2 Magnetic particle and penetrant testing

(1) The acceptance level shall be considered to be exceeded if indications

a) are deemed to be attributable to planar flaws,

b) show a linear dimension of more than 10 mm or

c) in the case of components made of austenitic steels, show linear dimensions exceeding 3 mm and are deemed to be attributable to corrosion.

(2) The following applies additionally for fields of indication: the acceptance level will be exceeded if conclusion can be drawn that the indications are due to operational defects, e.g. corrosion.

8.2.2.3 Ultrasonic testing

(1) Indications not yet documented which have to be recorded in accordance with 4.2.7 (3) and cannot be explained by tolerances due to the test technique employed or when fixing anew the recording limit if an equivalent test method is applied, shall be liable to recording.

(2) When employing the test techniques with echo height evaluation to subparas. 4.2.3.3.3 (1) or (3) the acceptance level is considered to have been exceeded if

a) the echo amplitudes of the indications exceed the recording limit in accordance with Section 4.2.7 (3) by 6 dB or more

or

b) the echo amplitudes of the indications reach or exceed the recording limit and show a linear dimension exceeding

ba) 10 mm in the case of wall thicknesses less than 20 mm

bb) half the nominal wall thickness in the case of wall thicknesses ≥ 20 mm

in which case the linear dimension shall be determined by means of the half-amplitude technique.

(3) When employing the testing techniques to cl. 4.2.3.3.3 (4), the acceptance level is considered to have been exceeded if indications show characteristic features of the indication patterns obtained on the reference reflectors.

8.2.2.4 Radiographic testing

In radiographic testing, indications which suggest the presence of crack-like defects or incomplete fusions as well as wall thinning due to corrosion shall be treated as relevant indications.

8.2.2.5 Eddy-current testing

The acceptance level is deemed to be exceeded if

a) the amplitudes of the eddy-current signals exceed the recording level as per sub-para. 4.2.7 (5) by 6 dB or more and their phase is located in the phase analysis range,

b) the amplitudes of the eddy-current signals reach or exceed the recording level as per sub-para. 4.2.7 (5), their phase is located in the analysis range and

ba) the patterns suggest a planar flaw

or if the signal length exceeds

bb) 10 mm if the wall thickness is less than 20 mm

bc) half of the nominal wall thickness if the wall thickness is 20 mm or greater

in which case the linear dimension is to be determined to the half-amplitude technique.

8.2.2.6 Visual testing

Conspicuous indications as per sub-para. 4.2.7 (6) found by visual testing shall be treated as relevant indications which require

a) measures for restoring the proper condition (e.g. leakage, cracks) or

b) measures for a more detailed assessment as regards acceptability.

8.2.3 Analyses if relevant indications occur for the first time or are enlarged

(1) The following steps shall be taken in the analyses required by 8.2.1 (6):

a) Examination of the area of relevant indications with various testing methods or techniques, e.g. radiographic test, ultrasonic test with improved defect detection capability at the reflector location, visual testing, eddy-current test.

b) Where the examination of the area of relevant indication as per a) above does not provide further findings as to the type, size and location of the relevant indication, analyses shall be made to characterize the relevant indication regarding the following features:

ba) planar flaw or volumetric defect,

bb) in the case of planar flaws: whether they are open to the surface or not,

Where the analysis does not clearly clarify the features to bb), a planar flaw open to the surface shall be assumed.

(2) Where there is indication of a planar flaw or the presence of such flaw is assumed, analyses techniques shall be applied which, for the purpose of safety-relevant evaluation, deliver sufficiently exact information on the size and location of the defect (extension over depth and length).

Note:

The following analyses techniques may e.g. be applied:

a) Synthetic aperture focussing technique (SAFT),
b) Time-of-flight diffraction technique (TOFD),
c) Crack-tip signal detection technique,
d) Echo tomography,
e) Eddy current techniques,
f) Mechanised radiography.

(3) The suitability of the analysis techniques to be applied shall be proved by means of reference block measurements, in which case the methodology of VGB Guideline R516 (VGB-ENIQ-Guideline) shall be applied.

8.3 Examination for wall thickness reduction

Any recorded wall thickness reduction compared to the basic condition (see clause 4.3.2) shall be evaluated in due consideration of the measuring technique-related tolerances with respect to further wall thickness reductions to be expected at the next date of inspection.

Any wall thickness reduction compared to the basic condition shall be treated as relevant indications which require

a) measures for a more detailed assessment as regards acceptability

or

b) measures for restoring the proper condition.

8.4 Inspection of the general condition

If anything unusual is noticed in the course of inspection of the general condition, then decision shall be made in each individual case whether or not further tests and examinations and, if so, what kind of tests and examinations are required.

8.5 Pressure test

The pressure test is deemed to have been passed successfully if the components have withstood the required pressure level over the entire holding period (cf. Section 4.5.1) and if the non-destructive tests and examinations subsequently required do not show any new indications or any enlargement of former indications.

8.6 Functional tests of safeguards against excessive pressure

The functional tests shall be considered to have been passed successfully if the values specified in the test instructions have been achieved.

9 Operational monitoring

9.1 General requirements

(1) All operating parameters that are important regarding the integrity of pressure and radioactivity retaining components of systems outside of the reactor coolant pressure boundary shall be monitored.

(2) If operating conditions occur that are not covered by the specified load regime, their causes shall be determined and these operating conditions shall be evaluated with special regard to their safety-relevant effects.

(3) Where changes of boundary conditions with expected safety-relevant influence on the integrity of the pressure and radioactivity retaining components of systems outside of the reactor coolant pressure boundary are made, the unchanged validity of the proofs of integrity performed within the design calculations to KTA 3112.2 shall be confirmed, e.g. each load cycle cause by incidences of design loading level C shall be evaluated as to its contribution to component fatigue loading.

(4) Where the operating conditions as per (2) affect component fatigue, it is necessary to recalculate the predicted cumulative usage factor determined in accordance with the design as per equation (7.8-1) of KTA 3211.2.

(5) For components of test group A 1 the following applies: when the levels of attention as shown hereafter are reached

a) D = 0.9

if influence of the fluid on component fatigue can be excluded,

b) D = 0.4

if influence of the fluid on component fatigue is to be expected and in accordance with KTA 3211.2, clause 7.8.3 (2) the exclusive measure to consider the fluid influence was the incorporation of the relevant component areas in a monitoring program to KTA 3211.4,

Note:

See the explanations regarding section 7.8 in **Annex D** of the safety standard KTA 3211.2 for the attention threshold for austenitic steels in cases where the evaluation of the usage factor was not performed based on the design fatigue curves shown in **Figures 7.8-2** and **7.8-3** of KTA 3211.2.

it shall be ensured that the progress of fatigue is kept within safe permissible limits by appropriate measures taken with respect to operation, operational monitoring or in-service inspections, or by a combination of these measures.

To this end, proof shall be rendered that no crack formation has been detected by non-destructive testing, and analyses of postulated incipient cracks in due consideration of the fluid influence prove that there will only be a limited crack propagation in the time period until the next, maybe premature, in-service inspection.

(6) If the results of operational monitoring or new knowledge gained lead to new requirements regarding operational monitoring, it shall be modified accordingly, e.g. by installing measuring equipment to monitor local loadings. Measuring equipment installed additionally shall be regularly checked for functional capability and measuring accuracy.

9.2 Instrumentation

9.2.1 Standard instrumentation

The operating parameters which shall be monitored in accordance with Section 9.1 shall be specified by the manufacturer of the plant, listed in the operating manual and shall be measured and recorded by standard instrumentation. Essentially, these are measurement values regarding pressure, temperature, flow rating and filling level.

9.2.2 Additional instrumentation

In case of particular occurrences (e.g. damage to pipes on account of vibrations) as well as in the case of new knowledge gained, special instruments (e.g. measuring vibrations or elongations) and monitoring of the individual measurement parameters are required.

9.2.3 Monitoring for effects due to sudden impact loadings

(1) It shall be ensured that sudden impact loadings (e.g. condensation shocks, water hammer, hydrogen explosion) are detected by suitable measures.

(2) Suitable measures are:

a) Reports of shift personnel (e.g. on water hammers, pipe movements, deformed insulation of supports) during putting into operation, start-up and shutdown and during operation as specified,

b) Visual testing during overhauls (e.g. ascertainment of deformed insulation of support as well as of indication of abrasion).

9.3 Monitoring of water and steam chemistry

(1) The quality of the water and steam shall be monitored and be documented.

(2) Chemical analyses shall be performed to monitor that the water chemistry remains within the specified limit values. The sampling locations, the required chemical and physical values as well as the frequency of the measurements shall be specified by the reactor plant manufacturer and written down in the operating manual.

(3) Deviations from the chemical and physical values shall be evaluated in accordance with Section 3 [see **Figure 3-1** (7)].

9.4 Monitoring for leakage, vibrations, displacement of components and unrestrained movement of piping

(1) In regular intervals to be specified by the operator, the plant personnel shall perform plant walk-throughs to carry out the surveillance, in particular, for leakages, vibrations and displacements of components. This surveillance covers the in-service inspection of small-diameter pipes in the range smaller than or equal to DN 50 not required for the response of safety systems. In case of inaccessible regions, the surveillance for leakages may be performed by suitable technical systems, e.g. by leakage detection systems, by camera monitoring, installed in these regions.

(2) The monitoring of pipelines shall ensure that unrestrained displacement of the pipeline is possible.

9.5 Monitoring of accumulation of radiolysis gas

(1) Preventive measures shall be taken against the accumulation of radiolysis gas. To this end

a) the system areas where accumulation of radiolysis gas is possible shall be identified,

b) for each area the maximum effects of a radiolysis gas reaction shall be determined

c) in dependence of the maximum effects of a radiolysis gas reaction, active or passive preventive measures shall be taken for the areas identified

Notes:

(1) Passive measures are e.g. the provision of flushing bores on valves, by-pass lines and discharge of radiolysis gas through non-isolatable vents.

(2) Active measures are e.g. the recombination of radiolysis gas by means of catalysts, discharge of radiolysis gas at top locations through isolatable vents, intermittent flushing of pipes.

The preventive measures shall be listed in a document which shall be adapted if the design or mode of operation is changed.

(2) The effectiveness of the preventive measures shall be monitored. To maintain the effectiveness of the preventive measures, specifically

a) for valves, the open position of which is important for the accumulation of radiolysis gas, the control of the open position and the safeguarding of the valve shall be regulated in test instructions,

b) in-service inspections of the vent bores and by-pass lines shall be performed,

c) the function and effectiveness of thermostatic steam traps and of catalysts within maintenance prescriptions shall be checked.

(3) Where temperature measurements are required to monitor accumulations of radiolysis gas, they shall meet the following requirements:

a) The measuring system shall be suited to safely detect inadmissible accumulations of radiolysis gas.

b) The temperature measurements shall be made by means of devices installed at fixed locations and automatic limit-value signalling.

c) Failure of temperature measurements shall be recognizable. Where temperature measurements are not available, suitable substitute measures for the discharge of radiolysis gas shall be fixed, e.g. preventive regular flushing.

d) A limit value for the maximum temperature decrease below a base value (final value) shall be laid down at which the automatic limit-value signaling device responds.

Note:
As a rule, this limit value refers to a situation where no explosive mixture exists.

e) Within in-service inspections it shall be proved that the proper functioning of the measuring system is ensured.

(4) Continuous variations of temperature not caused by intermittent flushing measures, shall be treated like radiolysis gas reactions; the components subject to such variations shall be checked and preventive measures be taken to avoid repetition.

(5) The extent and type of in-service inspections shall be laid down in the test and inspection manual. The inspection instructions shall be extended on the basis of operational experience.

10 Participation in in-service inspections and operational monitoring

(1) The nuclear power plant user shall take the necessary steps to ensure that the tests and examinations listed in the test and inspection manual are performed at the dates fixed.

(2) The authorized inspector shall participate in in-service inspections and operational monitoring measures on the basis of a respective order by the competent authority. The participation of the authorized inspector in the in-service inspections shall ensure that he is able to perform the evaluation as per **Figure 8-1** steps 2 to 7. The participation of the authorized inspector in the operational monitoring measures shall be fixed individually for each plant.

(3) If the surveillance measures of the authorized inspector require that he himself performs manual ultrasonic tests, then the corresponding testing by the operator need not be performed. The test results shall be evaluated independently by the operator and the authorized inspector in accordance with Section 20, Atomic Energy Act.

11 Documentation

11.1 General

(1) The performance of in-service inspections, tests and operational monitoring as well as the results obtained shall be documented. The requirements specified in KTA 1404 apply.

(2) The qualification and certification of the NDT personnel and the calibration of the test equipment shall be documented.

11.2 Documents required for in-service inspections

(1) The documents required for documenting the automated ultrasonic tests are specified in **Figure 11-1**. Similar documents shall be established for other test methods.

(2) In accordance with KTA 1202, the test and inspection manual **1** shall contain the basic specifications regarding areas, procedure, extent and interval of the tests and inspections. The details regarding the performance of the tests or inspections shall be specified in test instructions **2** relating to the specific test object or general standard instructions/specifications **3** for each test or inspection method.

(3) In order to be able to smoothly perform the tests at the test/inspection locations, documents **4** specific to the test/inspection areas shall be established. In the case of automated ultrasonic tests, these shall contain, e.g., the manipulator drive

sequence, channel identification, testing level adjustment requirements.

(4) To be able to reproduce the test results, the essential data of the test equipment shall be documented in a technical manual **5**.

(5) The test shall be started on the basis of documents **1** to **5**. Should the conditions at the test location require that changes are to be made to the testing area documents or to the equipment data, these shall be documented in revision sheets **4a**.

(6) At first, all measured values (base data **6**) shall be recorded on data storage media. Upon evaluation of the test results **7** all indication liable to recording shall be entered in the list of indications **8**.

(7) All relevant indications shall be recorded in the relevant indication record **9**. The indication lists and the relevant indication records shall be contained in the test report (final test report **10**).

11.3 Period of document filing for in-service inspections

(1) The documents **1** to **5** and **10** shall be stored at the nuclear power plant for the operating life of the component.

(2) The base data storage medium **6** shall be filed at least until the completion of the next in-service inspection of the particular testing area of the component. Should the evaluation of indications show up changes with respect to the previous inspection (cf. Step 7 of **Figure 8-1**), the base data storage medium shall be filed for the operating life of the component.

(3) Since there are justified fears that over the period of storage and despite appropriate storage conditions documents or data storage media will show distorting data loss, the data shall be copied to new data storage media in time.

11.4 Documents required for the monitoring of mechanical and thermal loadings

For the purpose of documentation, the documents shall contain the following data on the:

a) measuring and evaluation system (systems and components to be monitored, their function and operational mode, requirements to be met by the measuring and evaluation system)

b) measuring system (temperature measuring range, response times, recording frequency, measuring accuracy)

c) location and site of measuring points, type of measuring points, recording frequency

d) measuring results and component-specific fatigue analysis.

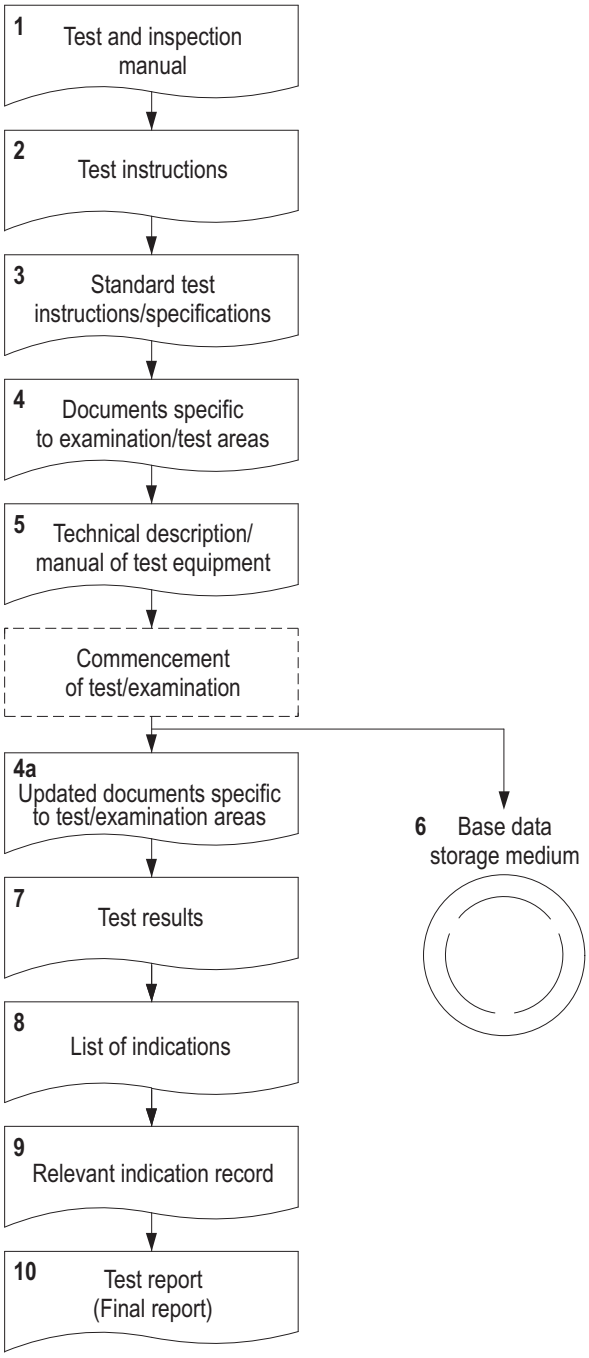


Figure 11-1: Documents for the documentation of automated ultrasonic in-service tests

Annex A

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 article10 by article 6 of the law dated 27th January 2017 (BGBl. I p. 114, 1222)
SiAnf	(2015-03)	Safety Requirements for Nuclear Power Plants (SiAnf) as Promulgated on March 3rd 2015 (BAnz AT 30.03.2015 B2)
Interpretations	(2015-03)	Interpretations of the Safety Requirements for Nuclear Power Plants of November 22nd 2012, as Amended on March 3rd 2015 (BAnz. AT 30.03.2015 B3)
Guideline "Radiological Protection"		Guideline for the Protection against Radiation of Personnel during the Execution of Maintenance Work, Modification, Disposal and the Dismantling in Nuclear Installations and Facilities Part II: The Radiation Protection Measures to be taken during the Operation or Decommissioning of an Installation or Facility (IWRS II) dated 17th January 2005 (Joint Ministerial Gazette (GMBl.) 2005, No. 13 p. 258)
General Specification of Basic Safety	(1981-10)	Reactor Safety Committee Guidelines for Pressurized Water Reactors, 3rd edition, 14 October 1981; Annex 2: General Specification of Basic Safety; Basic safety of pressure retaining components: vessels, ancillary equipment, pipework, pumps and valves
KTA 1202	(2017-11)	Requirements for the testing manual
KTA 1404	(2013-11)	Documentation during the construction and operation of nuclear power plants
KTA 3103	(2015-11)	Shutdown Systems for Light Water Reactors
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 3206	(2014-11)	Verification Analysis for Rupture Preclusion for Pressure Retaining Components in Nuclear Power Plants
KTA 3211.1	(2017-11)	Pressure and Activity Retaining Components of Systems outside the Primary Circuit; Part 1: Materials
KTA 3211.2	(2013-11)	Pressure and Activity Retaining Components of Systems outside the Primary Circuit; Part 2: Design and analysis
KTA 3211.3	(2017-11)	Pressure and Activity Retaining Components of Systems outside the Primary Circuit; Part 3: Manufacture
KTA 3301	(2015-11)	Residual Heat Removal Systems of Light Water Reactors
KTA 3303	(2015-11)	Heat Removal Systems for Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors
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 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 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 7963	(2010-12)	Non-destructive testing - Ultrasonic testing - Specification for calibration block No. 2 (ISO 7963:2006); German version EN ISO 7963:2010
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 9934-2	(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 14127	(2011-04)	Non-destructive testing - Ultrasonic thickness measurement; German version EN 14127:2011

DIN EN 16407-1	(2014-04)	Non-destructive testing - Radiographic inspection of corrosion and deposits in pipes by X- and gamma rays - Part 1: Tangential radiographic inspection; German version EN 16407-1:2014
DIN EN 16407-2	(2014-04)	Non-destructive testing - Radiographic inspection of corrosion and deposits in pipes by X- and gamma rays - Part2: Double Wall radiographic inspection; German version EN 16407-2:2014
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 25435-1	(2014-01)	In-service inspections for primary circuit components of light water reactors - Part 1: Automated ultrasonic inspection
DIN 25435-2	(2014-01)	In-service inspections for primary circuit components of light water reactors - Part 2: Magnetic particle and penetrant inspection
DIN 25435-3	(2006-12)	In-service inspections for primary circuit components of light water reactors - Part 3: Hydrotest
DIN 25435-4	(2014-01)	In-service inspections for primary circuit components of light water reactors - Part 4: Visual inspection
DIN 25435-6	(2014-01)	In-service inspections for primary coolant circuit components of light water reactors - Part 6: Eddy current testing of steam generator heating tubes
DIN 25435-7	(2014-01)	In-service inspections for primary coolant circuit components of light water reactors - Part 7: Radiographic testing
DIN 25475-3	(2015-04)	Nuclear facilities - Operational monitoring - Part 3: Determination of thermal loadings
VGB-R 516	(2010-12)	Guideline "Methodology for Qualification of Non-Destructive Tests" (VGB-ENIQ-Guideline), 2nd edition, published by VGB PowerTech e.V.

Annex B (informative)

Changes with respect to the edition 2013-11

(1) The section “Fundamentals” was adapted in paragraph 1 to the formulation obligatory for all KTA safety standards. Paragraph 2 was supplemented to include stipulations from the “Safety Requirements for Nuclear Power Plants” (SiAnf) and from the “Interpretations on the Safety Requirements for Nuclear Power Plants”. The former sub-clause (3) of the section “Fundamentals” was omitted.

(2) The complete standard was adapted to the current state of standardization and the normative references in Annex A were updated.

(3) The formulation in sub-clause 1 (1) a) of the scope was put more precisely. This corresponds to the requirements regarding in-service tests and inspections of systems for residual heat removal implemented on the plant level. Sub-clause (8) of the scope was deleted because small-bore pipes are already covered by sub-clause 1 (2) b).

(4) According to the requirements of KTA 3211.4, the monitoring of consequences of operational damage mechanisms is based on the fact that temporary disturbance of individual component integrity is permitted (see section 3). If the monitoring of consequences of operational damage mechanisms is performed according to the requirements of KTA 3201.4, the component integrity is ensured and a failure of the component precluded.

If restricted leak and break postulates are used for components of systems outside the primary circuit (KTA 3211.4), the arrangements for monitoring of these components shall be adapted to the break preclusion philosophy (integrity concept KTA 3201.4).This adaptation was already required in sub-clause 1 (7) of the edition KTA 3211.4 (2013-11), but not substantiated. The substantiation can be achieved by increasing the extent of in-service tests and examinations and/or by reduction of the test interval.

The following supplements were made to concretise the former stipulations in sub-clause 1 (7):Additional requirements for components, for which restricted leak and break postulates are used, were added in clause (2) of the scope as well as in Table 5-3. Thus, basic requirements are given for these components, which however still allow variations depending on the individual plant conditions.

Equivalent stipulations were not added in Tables 5-4 and 5-5, since no application case is known in German Nuclear Power Plants. If restricted leak and break postulates are intended to be used on austenitic pipes and on welded joints between ferritic and austenitic steels, the extent and interval of in-service tests and examinations shall be specified in each individual case based on the requirements given in footnote 1 of Table 5-3.

(5) In Section 2 the definition of the new term “echo height evaluation” was added.

(6) The text in subpara. 4.2.3.2 was revised

a) to show that the testing technique is to be selected by only considering the testing task and the acoustical properties of the test object,
b) to clarify that in this case testing techniques are to be preferred which permit an echo height evaluation,
c) to indicate the pertinent testing techniques in an unbiased manner,
d) to make a proper distinction between standard and optimized testing techniques.

(7) The criteria mentioned in clause 4.2.3.3.3 regarding the suitability of techniques for the testing of butt welds as well as the related Table 4-1 were revised and simplified. The revised stipulations now make a clear distinction between the cases where echo height evaluation is possible and the cases where pattern recognition is to be applied. The revision was made based on experience gathered with the application of the stipulations laid down in KTA safety standard 3201.4 (2010-11). The revision took into account that case 2 permitted to Table 4-1 of KTA 3201.4 in edition 2010-11 will rarely occur in practice. Cases 1 and 2 now shown in Table 4-1 cover all relevant practical applications for the testing of butt welds.

(8) In clauses 4.2.3.3.4, 4.2.7 and 8.2.2.3 the content was adapted and editorially revised on the basis of the changes made in clause 4.2.3.3.3.

(9) Sub-clause 4.3.1 (3) was supplemented to include DIN EN 16407-1 and DIN EN 16407-2, which are two standards based on which the examination for wall thickness reduction can be performed.

(10) The new footnote 4 in Table 5-1 was added to specify exceptions for cases when visual examination of the inner surface cannot be carried out. This provision corresponds to the requirements of the ordinance “Industrial Safety Regulation” and to the testing practice accepted by the competent authorities.

(11) The stipulations in clause 5.2.1.3 as well as in Tables 5-1 and 5-2 regarding internal components of isolation valves to be tested were put more precisely. In addition, in clause 5.2.1.3 a note was supplemented with a reference to Table 2-1 of KTA 3211.3 where criteria for classification into part groups are specified.

(12) The test range of the steam generator blow down system according to the scope of KTA 3211.4 was added in footnote 4 of Table 5-3, which had not been specified up to now.