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# Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

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**KTA 3211.4 (06/96)**

**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)

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

Editor:
KTA-Geschaeftsstelle c/o Bundesamt fuer Strahlenschutz (BfS)
Willy-Brandt-Str. 5 • D-38226 Salzgitter • Germany
Telephone +49-5341/885-(0) 901 • Telefax +49-5341/885-905

# KTA SAFETY STANDARD

| June 1996 | Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 4: Inservice Inspections and Operational Monitoring | KTA 3211.4 |
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The following safety standard was prepared on behalf of the Kerntechnischer Ausschuß (KTA) under the responsibility of the Technische Vereinigung der Grosskraftwerksbetreiber e.V.(VGB)

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger No. 123a on September 28, 1996. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, D-50939 Koeln (Telefax 0221-94373603).

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

KTA-Geschaeftsstelle c/o BfS, Willy-Brandt-Str. 5, D-38226 Salzgitter, Germany

**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 task of specifying those safety related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against the damage arising from the construction and operation of the facility (Sec. 7 para. 2 subpara. 3 Atomic Energy Act), in order to attain the protection goals specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and which are further detailed in "Safety Criteria for Nuclear Power Plants" and in "Guidelines for the Assessment of the Design of PWR Nuclear Power Plants against Incidents pursuant to Sec. 28 para. 3 of the Radiological Protection Ordinance (StrlSchV) – Incident Guidelines".

(2) As part of the Safety Criteria for Nuclear Power Plants, criterion 1.1 "Basic Principles of Safety Precautions" requires among other things comprehensive quality assurance during fabrication, erection and operation; criterion 2.1 "Quality Assurance" requires among other things the creation and application of, and compliance with, instructions regarding design, materials, construction, testing and operation as well as documentation of quality surveillance.

The criteria 4.2 "Residual Heat Removal during Specified Normal Operation", 4.3 "Residual Heat Removal after Loss-of-Coolant", 5.3 "Equipment for Control and Shutdown of the Nuclear Reactor" and 8.5 "Heat Removal from the Containment" specify further requirements regarding the design and quality of the safety systems.

The safety standards KTA 3211.1 through KTA 3211.4 serve to specify the measures for fulfilling these requirements within their scope of application. In this context, a multitude of individual conventional engineering standards, especially DIN Standards, are also referenced.

(3) The scope specified in this safety standard includes those pressure and activity retaining systems and components outside of the reactor coolant pressure boundary (KTA 3201) which, in accordance with the RSK Guidelines for Pressurized Water Reactors (Section 4.2), are of special safety related significance.

(4) In particular, safety standard KTA 3211.4 contains the requirements pertaining to inservice inspections of pressure and activity retaining components that apply to:

a) non-destructive examinations for the detection of service-induced damages in particular of the surface and the near-surface regions. The examinations are performed on representative locations of the pressure retaining walls (e.g. locations highly stressed or fatigued) and, particularly, also their inner surfaces,

b) leakage tests for a qualitative proof for leaktightness of the systems, in particular the seals of nozzle connections, of valves and of bolt connections,

c) visual examinations with respect to the general condition of systems and components as well as the selective inspection of individual components,

d) pressure tests for the integral check of the pressure vessels and pressure retaining walls of component parts of the vessel as well as of the pipes tested together with the vessel.

(5) The object of an inservice inspection is to determine whether or not the components are in a proper condition at the time of the inspection and whether or not it can be expected that they will continue to meet the licensing requirements in the time period until the next in-serve inspection.

**1 Scope**

(1) This safety standard shall be applied to inservice 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 one of the following criteria applies:

a) The plant component is required for the mitigation of design basis accidents with regard to shut down, long-term maintenance of subcriticality and with regard to direct 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 component and no mitigating measures such as structural measures, spatial separation or other safety measures are available to keep the effects of the failure to an acceptable limit with respect to nuclear safety.

c) A failure of the plant component could either directly, or indirectly through a chain of assumed sequential events, lead to a design basis accident in accordance with Sec. 28 para. 3 StrlSchV.

d) Systems and components to which none of 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 the small-bore pipes,

c) pumps and

d) valves

including the integral parts of the component support structures.

(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 components 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 region,

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 inservice inspections,

f) the secondary shell of the steam generators of pressurized water reactors; the inservice inspections of this part are dealt with under the scope of KTA 3201.4.

(4) This safety standard may be applied to systems and components with a diameter larger than DN 50, provided, these have been designed and manufactured in accordance with KTA 3211.1 through KTA 3211.3.

(5) This safety standard may also be applied to those components which had been designed and manufactured before the safety standards cited in paragraph (4) were issued, provided a post-evaluation has shown that they meet the principles of 'basic safety'.

(6) In the case of components that do not meet the requirements under paragraph (4) and (5), increased requirements may have to be specified on the basis of the special situations. It is permissible to continue applying the specifications and guide lines so far applied to inservice inspections.

## 2 Definitions

(1) High-stress locations

High-stress locations with respect to this safety standard are such locations of a component or component part that, compared to the general level of the reference stress also accounting for the frequency, are more highly stressed or more apt to corrode.

(2) Calibration block

Standardized calibration block in accordance with DIN 54 120 (K1) and DIN EN 27 963 (K2) for the adjustment of the ultrasonic testing system and for checking the adjustments.

A calibration block of a known material with a specific surface quality and geometry for the adjustment of the ultrasonic testing system and for checking the adjustments.

(3) Representative locations, component parts or components

Such locations, component parts or components are considered as being representative where the inservice inspection will lead to sufficiently comparable safety related results also for other locations, component parts or components taking the quality of materials, design and fabrication as well as the type, level and frequency of stress into consideration.

(4) Calibration reference block

A calibration block adapted to the test object with respect to geometry and physical characteristics and that contains reference flaws adapted to the individual testing task.

## 3 Testing Procedures

### 3.1 General Requirements

(1) The testing procedures and techniques shall be chosen such that service-induced flaws will be detected. To meet this requirement the testing procedures specified below shall be applied. Other testing procedures are permissible, provided their suitability for achieving the testing objective has been proven. The non-destructive tests and examinations shall normally be evaluated with special preference to the inner and outer surfaces. However, indications from other volumetric regions shall also be registered.

**N o t e**:
A proof of suitability is generally required when a testing technology is applied for the first time.

(2) When testing weld seams, the weld material and the base material region adjacent to the weld seam on either side shall be included in the test; in case of a wall thickness up to 30 mm this region shall normally be at least 10 mm wide, and in case of a wall thickness beyond 30 mm, at least 20 mm wide.

### 3.2 Testing of Surfaces

#### 3.2.1 Examination procedures and methods

(1) The methods of the following examination procedures may be applied:

a) leakage flux procedure (Section 3.2.2),

b) liquid penetrant procedure (Section 3.2.3),

c) ultrasonic examination procedure (Section 3.2.4),

d) eddy-current examination procedure (Section 3.2.5),

e) radiographic examination procedure (Section 3.2.6)

f) selective visual examination (Section 3.2.7).

(2) The surfaces of components from ferritic materials shall preferably be examined with the leakage flux procedure, those of austenitic materials with the liquid penetrant procedure.

(3) If the test results from one procedure alone give insufficient information then an additional procedure shall be applied that is based on a physical interaction different from the first.

#### 3.2.2 Leakage flux procedure

When applying the leakage flux procedure, the magnetic particle examination shall, preferably, be employed.

#### 3.2.3 Liquid penetrant procedure

When applying the liquid penetrant procedure, testing media shall be applied the characteristics of which are tested and monitored in accordance with DIN 54 152 Part 2.

#### 3.2.4 Ultrasonic examination procedures

**3.2.4.1** Surface regions close to the search unit

(1) Suitable ultrasonic examination techniques shall be employed when examining surfaces and near-surface regions close to the search unit.

(2) The ultrasonic examination techniques considered to be suitable employ longitudinal waves and creeping waves, dual search units or the corner effect after reflection of the sonic beam.

**3.2.4.2** Surface away from the search unit

(1) When examining the surface away from the search unit with its near-surface regions for planar discontinuities a technique utilizing the corner effect shall, preferably, be employed. In this case vertically polarized transverse waves with the incident angle of the sonic beam in the range between 35 and 55 degrees shall be employed. Examination techniques with an incident angle of the sonic beam in the range between 65 and 70 degrees may also be employed.

(2) Furthermore, the following techniques may be applied:

a) the mode conversion technique, where the transverse waves striking the examined surface under an incidence angle of 33 degrees are converted to longitudinal waves that run almost parallel to the surface and encounter the expected flaw in a perpendicular direction,

b) the mode conversion technique where the longitudinal waves reflected from the flaw of the surface away from the search unit are converted to transverse waves and in this mode reach the search unit.

(3) If, for reasons of test object geometry or of microstructure (e.g. in the case of austenitic weld seams and multi-material seams), the above mentioned techniques do not achieve the necessary sensitivity then, provided a prior verification of suitability was performed, the examinations may be carried out employing horizontally or vertically polarized transverse or longitudinal waves with other than the specified beaming and incidence angles.

(4) In case an examination for wall thickness erosion is to be performed, the wall thickness shall, preferably, be measured using ultrasonic or radiographic examination techniques.

**3.2.4.3** Sensitivity calibration

(1) The sensitivity shall be calibrated using the grooves as specified in **Table 3-1**. In case a sonic beam is used with a diameter (see Sec. 5.3.3.4 DIN 25 450) larger than 20 mm at the location of the groove, then the groove must be created such that its acoustically effective length is restricted to 20 mm.

(2) **Table 3-1** specifies the depth of the grooves as a function of wall thickness. The reflecting surface shall be perpendicularl to the surface of the component. Rectangular grooves shall not be wider than 1.5 mm and, not counting the runout , shall normally be 20 mm long.

(3) In the case of materials or complex geometries that are acoustically difficult to examine, measurements shall be performed on calibration reference blocks and the resulting transfer corrections shall be considered in the sensitivity calibration.

| Wall thickness s in mm | $8 < s \leq 20$ | $20 < s \leq 40$ | $s > 40$ |
|---|---|---|---|
| Groove depth in mm | 1.5 | 2 | 3 |

**Table 3-1:** Groove depth for calibrating the testing sensitivity

(4) Calibration reference blocks shall be representative of the acoustic characteristics of the component to be tested. In case the opposing surface influences the examination method applied, then the wall thickness should deviate less than 10 % from that of the component to be tested.

(5) The reflecting surfaces machined into the calibration reference blocks shall be sufficient with respect to number and varying dimensions to enable making definite statements regarding the sensitivity of the examination technique.

(6) Reference blocks shall be designed such that a reproducible adjustment of the sensitivity is ensured.

(7) In case a dual search unit is used and a depth region further down than 10 mm must be examined, the sensitivity calibration shall be performed on transverse or flat-bottom bore holes extending down to the required depth.

(8) the search unit shall be adapted accordingly if the radius of curvature of the component surface would lead to a gap between search unit and component larger than or equal to 0.5 mm. The sensitivity calibration of adapted search units shall be performed with a curved reference block or calibration reference block where the radius of curvature shall not deviate from that of the component by more than 10 %.

Should deviations from this requirement be necessary, then proof is required that the specified sensitivity will be achieved.

**3.2.5** Eddy-current examination procedure

(1) When applying the eddy-current procedure for the examination of surfaces it is required that adapted coils and calibration reference blocks of materials with similar magnetic characteristics are employed

(2) The rectangular grooves for calibrating the sensitivity shall not be wider that 0.3 mm.

**3.2.6** Radiographic examination procedure

(1) When performing radiographic examinations it shall be ensured that S is no larger than 0.3, where S is the fog density of the film caused by the radioactivity of the component and by scattered radiation.

(2) The radiation source shall be aimed such that the direction of the flaws assumed as originating from the surface is parallel to the direction of radiation.

(3) The application of the radiographic examination procedures should be limited to a wall thickness in the range of less than or equal to 25 mm (in case of double-wall radiography, the thickness of the radiographed wall shall be less than or equal to 50 mm).

**3.2.7** Selective visual examination

(1) The selective visual examination is performed to assess certain examination regions with the goal of unambiguously detecting specific characteristics (e.g. erosion, corrosion, formation of cracks).

(2) It is performed as a direct visual examination by the human eye and, if necessary, with the help of optical instruments (e.g. magnifying glass, mirror, endoscope) or as an indirect visual examination by the human eye and with the

help of a system of equipment receiving, transporting and displaying or recording the image.

**3.2.8** Registration limits

(1) In the case of magnetic particle and liquid penetrant examinations any linear indication longer than 6 mm shall be registered. Linear or area accumulations of indications, the length or width of which amount to more than half the wall thickness, shall also be registered even if the individual indications are smaller than 6 mm.

(2) In the case of ultrasonic examinations both in close vicinity of the search unit down to a depth of less than or equal 10 mm and of the corresponding opposing surface, all indications shall be registered where the echo amplitude is equal to or exceeds the value of the echo amplitude of the grooves in accordance with **Table 3-1** minus 6 dB. Hereby, the sensitivity calibration shall basically be performed on grooves in the base material.

A signal-to-noise ratio of at least 6 dB with respect to the registration limit shall be observed.

The influence of the microstructure and on the ultrasonic signals, possibly, of the shape of the weld seam shall be monitored on the test object itself and shall be taken into consideration in evaluating the test results.

In the case of ultrasonic examinations in the close vicinity of the search unit down to a depth larger than 10 mm, all indications shall be registered where the echo amplitude corresponds to, or exceeds, that of a circular disc reflector with a diameter of 3 mm if the wall thickness is larger than 40 mm and of 2 mm if it is equal to or smaller than 40 mm.

(3) The registration limits for the eddy-current examination shall be specified on the basis of calibration reference block examinations. The groove depths shall be chosen on the basis of **Table 3-1**, taking Section 3.2.5 (2) into consideration with respect to their widths.

**3.3** Leakage Test

These tests shall be performed as visual examinations at operating pressure. The insulation material shall be removed in the test region for these tests. If the pressurization is created by gaseous media then the examination shall, preferably, be performed at a pressure of about 0.04 to 0.08 MPa and with the aid of foaming agents.

**3.4** Integral Visual Examination

(1) Integral visual examinations serve to assess the general condition of systems and components. These examinations are usually performed in the course of plant walk-throughs without removing any of the insulation materials.

(2) During integral visual examinations the following shall especially be taken into consideration:

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

b) Indications of leakages,

c) Faults with respect to

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

cb) connections of measurement locations and conductors or pipes,

cc) insulation,

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

(3) Extent and point in time of the integral visual examination are specified on a plant specific basis (e.g. in the testing instructions).

**3.5** Pressure Test

**3.5.1** Testing conditions

(1) The pressure test shall be performed at the pressure level of the preservice 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 in accordance with Section 6.2.2 the pressure shall be reduced to the operating pressure level.

(4) If a pressure test of the vessel is not possible or expedient on account of its design or operating mode then the pressure test to be performed during inservice inspections shall be replaced by suitable non-destructive examinations.

**3.5.2** Non-destructive examinations after the pressure test

Subsequent to the recurring pressure tests non-destructive examinations shall be performed in accordance with the test schedule (cf. Section 5).

## 4 Extent of Testing and Testing Intervals

**4.1** General Requirements

(1) The requirements with respect to type and extent of testing shall be oriented on the individual testing goal.

(2) If design, construction, fabrication or other aspects put limitations on the extent of testing, additional measures shall be taken (e.g. the use of fracture strength related analyses) in order to attain the desired safety related information. Any additional measures on account of limitations with respect to the requirements of this safety standard shall be noted in the testing schedule.

**4.2** Extent of Testing

(1) Inservice inspection shall basically be performed to the extent as specified in **Tables 4-1** through **4-4.**

**N o t e**:
See Section 8.4 regarding inservice inspections of pipes ≤ DN 50 and of valves ≤ DN 150.

(2) The extent of tests specified in the tables may be achieved by combining a number of representative weld seams or by a combination of representative weld seams and representative high-stress locations (e.g. pipe bends, fittings).

(3) The leakage tests of vessels and auxiliary equipment are performed in conjunction with the pressure tests during the subsequent check for leakages.

(4) The leakage tests of other systems are performed subsequent to maintenance tasks or in the course of regular plant walk-throughs (cf. Section 8.4).

(5) In individual cases additional criteria shall be considered in specifying representative locations on which the tests are to be performed.

**4.3** Testing Intervals

(1) All testing intervals start with the point in time of first criticality of the reactor. The time intervals within which the specified tests must have been performed are listed in the corresponding tables. Regarding the starting points of the test intervals for pressure vessels, the specifications in accordance with the Pressure Vessel Order (DruckbehV) shall be applied.

(2) Visual examinations shall be performed in the course of regular plant walk-throughs and during the preparation of other tests after removal of the insulation in the testing region. The testing intervals for visual examinations are specified in **Tables 4-1** through **4-4**.

(3) The pressure test in accordance with **Table 4-1** shall be performed every 8 years.

(4) Inservice inspections shall be performed in testing intervals as specified in **Tables 4-1** through **4-4**. In case of pumps, valves and pipes (cf. **Tables 4-2** through **4-4**) a representative number of tests must have been performed by the end of half of the testing interval.

(5) Since the time period between two refuelings may be as long as 18 months, the individual test shall be performed during that particular refueling that is closest to the due date of the test. If this results in longer time intervals than specified in the tables, the due dates for the next inservice inspections shall be advanced accordingly, such that the time intervals averaged over longer time periods remain as specified. In the case of plant shutdowns of more than 6 months special conditions may be arranged.

| Type of Tests | Extent of Testing | Testing Interval |
|---|---|---|
| Pressure test | In accordance with DruckbehV | 8 years (10 years[3)]) |
| Subsequent check for leakages | Nozzle connections, seals and sealing weld seams | |
| Surface examinations as per Section 3.2.1 a) through e) | Representative locations (e.g. weld seams) | |
| Visual examinations | Internal examination in accordance with DruckbehV | 4 years [2)] (5 years [3)]) |
| Surface examinations as per Section 3.2.1 a) through e) | Random tests of representative locations (e.g. high-stress locations) [1)] | |
| Visual examinations | External examination in accordance with DruckbehV | 2 years |

[1)] 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.

[2)] If the due date of the visual and the surface examinations coincide with that of the pressure test they shall be performed after to the pressure test.

[3)] Applies to the tests of the feed water vessel, water separator or reheater and HP feedwater heater

**Table 4-1:** Tests of vessels and ancillary equipment including the pressure retaining walls and their internals

| Type of Tests | Extent of Testing [1] | Testing Interval |
|---|---|---|
| Selective visual examination in accordance with Section 3.2.7 | Internal surfaces of the pressure retaining walls of pumps and valves with a connecting nominal diameter ≥ DN 150 through ≤ DN 400 | 8 years (10 years [2]) |
| | Internal surfaces of the pressure retaining walls of pumps and valves with a connecting nominal diameter > DN 400 | 4 years (5 years [2]) |

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

**Table 4-2:** Tests of pumps and valves

| Type of Tests | Extent of Testing | Testing Interval |
|---|---|---|
| Surface examination as per Section 3.2.1 a) through e) [1] | Weld seams of straight pipes, bends and elbows ≥ DN 150<br>Pipes of the main steam and feed water system [2]:<br>15 % of all pipes, to be specified on basis of the following criteria:<br>- connecting weld seams of vessel, valves, penetrations, (partial) anchor points<br>- connecting weld seams of t-joints and elbows<br>- operational loading taking fluid flow into consideration with regard to corrosion and erosion [3]<br>- material pairing<br>- manufacturing quality regarding weld seam surface<br>A part of the weld seams shall normally be changed from testing interval to testing interval.<br>Both the outer and internal surface shall be subjected to the examination. | 8 years (10 years [4]) |
| Visual examinations | Selective visual examination in accordance with Section 3.2.7 of pipes > DN 50<br>The extent of testing shall be specified on a plant specific basis. | |

[1] Recurring surface examinations are not required if the two criteria, operating pressure ≤£} 2.5 MPa and operating temperature < 120 °C, are met .

[2] 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
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

[3] Additionally: wall thickness measurement in the down-stream region next to the weld seam and in geometrically special locations (e.g. metering orifice, elbow)

[4] regarding the 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

**Table 4-3:** Inservice inspections of ferritic pipes

<table>
<tr><th>Type of Tests</th><th colspan="3">Extent of Testing</th><th>Testing Interval</th></tr>
<tr><td rowspan="8">Surface examination<br>as per Section 3.2.1 a) through e)</td><td>PWR [1]</td><td colspan="2">BWR</td><td rowspan="8">8 years</td></tr>
<tr><td colspan="3">Weld seams of straight pipes, bends and elbows or high-stress locations ≥ DN 150 to the following extent [2]</td></tr>
<tr><td></td><td>hot (≥ 120 °C)</td><td>cold (< 120 °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 high-stress locations 50 < DN < 150 to the following extent [2]</td></tr>
<tr><td></td><td>hot (≥ 120 °C)</td><td>cold (< 120 °C)</td></tr>
<tr><td>5 %</td><td>10 %</td><td>5 %</td></tr>
<tr><td colspan="3">The weld seams to be tested shall be specified on the basis of the following criteria<br>- operational loading<br>- connecting weld seams of t-joints, fixed points, reduction piece , valves, vessels<br>Both the internal and the outer surfaces shall be tested.</td></tr>
<tr><td>Visual examination</td><td colspan="3">Selective visual examination in accordance with Section 3.2.7 of pipes > DN 50<br>The extent of testing shall be specified on a plant specific basis.</td></tr>
</table>

[1] No recurring surface examinations are required, provided the following criteria are met

a) operating pressure ≤ 2,5 MPa and operating temperature < 120 °C or

b) duration of loading ≤ 2 % of the duration of operation of the plant or

c) primary membrane stress < 50 N/mm$^2$ and non-application of rupture exclusion .

[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
- volumetric 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 4-4:** Inservice inspections of austenitic pipes

## 5 Testing Schedule

**5.1** Preparation

The extents, types and intervals of the tests shall be specified depending on the safety related significance of the systems or components. **Tables 4-1** through **4-4** specify certain requirements regarding the preparation of the testing schedules (cf. KTA 1202).

**5.2** Updating

Prior to every, even partial, inservice inspection, the type, extent and point in time of the tests shall, if necessary be updated for the individual component. Hereby, the following shall be taken into consideration:

a) Previous inservice inspections

The results of previous inservice inspections shall be taken into consideration. This may lead to changes in type, extent and point in time of previously specified tests as well as to a change in the specified testing location within the region to be inspected.

b) Repairs and replacements

After performing repairs or replacements it shall be decided whether or not inservice inspections shall be introduced or whether or not type, extent or point in time of specified inservice inspections shall be changed.

c) Operational monitoring

The results of the operational monitoring in accordance with Section 8 shall be considered in the updating procedure.

d) Operational experience

The operational experience from the own plant as well as from other plants shall be considered in the updating procedure.

## 6 Preparation of Tests, Testing Instructions

**6.1** Preparation of Tests

(1) The tests shall be properly prepared with respect to general organization and required equipment. Foremost, this shall include planning the deployment of testing personnel taking the general work flow, the Radiological Protection Ordinance and Guideline Radiological Protection into consideration.

(2) The areas of the components that will be subjected to the testing shall be put in a condition suitable to testing (e.g. by removal of the insulation material, cleaning of the surfaces).

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

**6.2** Testing Instructions

**6.2.1** Examination for flaws in the surface and near-surface regions

(1) Magnetic particle examinations shall be performed in accordance with Secs. 5 and 6.3 DIN 25 435 Part 2.

(2) Liquid penetrant examinations shall be performed in accordance with DIN 54 152 Part 1. The penetration duration shall normally be at least 30 minutes.

(3) Ultrasonic examinations shall be performed in accordance with DIN 54 125 and DIN 54 127 Part 1.

(4) Radiographic examinations shall be performed in accordance with Testing Class B DIN 54 111 Part 1. The general aim shall be to meet Testing Class B in accordance with DIN 54 111 Part 1 without utilizing the replacement procedures cited therein.

(5) If no standards are applicable to special test procedures (e.g. eddy current examinations, examinations with special ultrasonic techniques) then the tests shall be performed only in agreement with the authorized expert.

**6.2.2** Leakage tests

The requirements specified in Section 3.3 shall be met when performing leakage tests. Details specified in the testing instructions (e.g. media, temperature, pressure) shall be taken into consideration.

**6.2.3** Visual examinations

(1) Visual examinations shall be performed using DIN 25 435 Part 4 as guideline.

(2) The objective of the visual examination shall be specified in the testing instruction. This shall be the basis for deciding which aids are required for performing the examination (e.g. illumination equipment, optical aids, recording equipment).

**6.2.4** Pressure test

The requirements specified in Section 3.5 shall be met when performing pressure tests. Details specified in the testing instructions (e.g. media, temperature, pressure) shall be taken into consideration.

## 7 Evaluation of the Test Results

**7.1** Examination for Flaws of the Surface and Near-Surface Regions

**7.1.1** Decision making procedure

(1) When evaluating the test results it shall be decided whether the indications have exceeded the evaluation limit. If this is not the case, the component may be returned to operation.

(2) If indications exceed the evaluation limit they shall be termed as relevant indications. First, a comparison with the results of the previous inservice inspection shall be performed. If findings have changed, the results of even earlier inservice inspections shall also be taken into consideration; this is in order to, possibly, detect a trend in the changes. 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 increased in size. If neither is the case, the component may be returned to operation.

(3) In the case of ultrasonic examination techniques evaluation methods may be used that are based on an image presentation of the test results. However, the registration limits in accordance with Section 3.2.8 shall remain discernible. The individual procedures may be performed only in agreement with the authorized expert.

(4) In case of a first occurrence of an indication or of an increase in size of an existing indication, an analysis is required that leads to information regarding type, size and location of the flaw. As necessary, further examinations with more refined testing techniques shall be employed and, possibly, shall be extended to further testing locations.

(5) If it is established that the flaw may be left in the component as is, the causes, as far as possible, shall be removed, e.g. by taking the following measures:

a) change in the operating procedure of the plant,

b) installation of additional structural components (e.g. pipe supports).

Provided these measures are taken, the component may be returned to operation.

(6) If it is established that the flaw may not be left in the component as is, the causes, as far as possible, shall be removed and a repair or exchange of the component initiated. The effectiveness of the measures performed shall be checked.

**7.1.2** Evaluation limits

(1) The following evaluation limits are specified for inservice inspections in order to avoid having to evaluate measurement dispersals inherent to the testing technique as relevant indications,.

(2) All indications above the registration limit shall be documented in a test report (with the exception of definitely shape-related indications) and shall be evaluated. In particular, the following requirements apply:

a) In the case of magnetic particle and liquid penetrant examinations, the evaluation limit is identical with the registration limit.

   Any accumulations of indications (indications fields) or numerous indications close together which, by themselves, are smaller than the registration limit shall be registered and treated as relevant indications if the length dimension of the indication field is larger than or equal to the wall thickness.

b) In the case of ultrasonic examinations, any indication shall be considered as a relevant indication if

   ba) its echo amplitude exceeds the registration limit in accordance with Section 3.2.8 by 6 dB or more or

   bb) its linear dimension, already been documented in earlier examinations, has grown or

   bc) the echo amplitude of a thus far non-documented indication reaches or exceeds the registration limit and this indication cannot be explained by examination technological tolerances.

c) The evaluation limit for the radiographic examination shall be specified on an individual-case basis.

d) The evaluation limit for the eddy-current examination shall be specified on an individual-case basis.

**7.2** Leakage Test

In the case of leakage tests, each individual leakage shall be evaluated.

**7.3** Visual Examination

If anything unusual is noticed in the course of a visual examination, then in each individual case it shall be decided whether or not and, if so, which further examination will be required.

**7.4** Pressure Test

The pressure test shall be considered as passed if the components have withstood the specified pressure level for the entire holding period (cf. Section 3.5.1) and if the visual and surface examinations subsequently required in accordance with **Table 4-1** show no new indications or no enlargements of older indications.

## 8 Operational Monitoring

**8.1** General Requirements

(1) All operating parameters that are important with respect to 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 collectives, these operating conditions shall be evaluated with special regard to their safety relevance.

In case additional operating conditions affect component fatigue it is required to recalculate the prognosticated cumulative usage factor determined in accordance with equation (7.8-1) of KTA 3211.2 during the design. Hereby and contrary to the specification for equation (7.8-1) of KTA 3211.2, a cumulative usage factor D larger than 1 may be applied, provided however, it is assured that the advance of fatigue is kept below permissible limits by appropriate measures with respect to operation, operational surveillance or inservice inspections, or by a combination of these measures.

In particular, plant operation may be continued in case of D larger than 1 as long as no crack formation has been detected and fracture strength related analyses of postulated incipient cracks prove that there will only be a limited crack propagation in the time period until the next, maybe advanced, inservice inspection. It shall, however, be ensured that no critical flaw size will develop even for the most unfavorable load case.

The point in time of the next inservice inspection shall be determined on the basis of the fracture strength related analysis and on the requirement that the newly prognosticated cumulative usage factor shall increase by no more than $\Delta D = 0.1$.

Any changes in this respect will have no effect on the intervals of inservice inspections as specified in this safety standard.

**8.2** Instrumentation

**8.2.1** Standard instrumentation

The operating parameters which shall be monitored in accordance with Section 8.1 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 and filling level.

**8.2.2** Additional instrumentation

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

**8.3** Monitoring of the Water or Steam Quality

Chemical analyses shall be performed to monitor that the water chemistry remains within the specified limit values. The specimen removal 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.

**8.4** Plant Walk-Throughs

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 inservice inspection of small-diameter pipes in the range smaller than or equal to DN 50 and valves in the range smaller than or equal to DN 150. In case of inaccessible regions, the surveillance for leakages may be performed by leakage detection systems installed in these regions.

## 9 Participation in Inservice Inspections

(1) The operator of the nuclear power plant shall take the necessary steps to ensure that the tests and examinations listed in the testing schedule are performed on time and by the participants as specified in **Table 9-1**.

(2) If the surveillance measures of the authorized expert require that he himself perform manual examinations, then the corresponding examination by the operator need not be performed. The test results shall be evaluated mutually by the operator and the authorized expert in accordance with para. 20 Atomic Energy Act.

## 10 Documentation

**10.1** General Requirements

The execution of the inservice inspections as well as the test results shall be documented in accordance with KTA 1404.

**10.2** Required Documents

The documents required for performing the inservice inspections are:

a) testing schedules,

b) testing instructions,

c) standard testing instructions,

d) test reports.

**N o t e:**
Regarding required documents, also see KTA 1202.

**10.3** Period of Storage

The documents in accordance with Section 10.2 shall be stored in the reactor plant for the entire service life of the component.

| **Type of Test, and Examination Technique** | **Performed and Recorded by ...** | **Certification of Technically Correct Performance, and Evaluation of Test Results** |
|---|---|---|
| Pressure test with subsequent leakage check | B + S | S |
| Visual examination | | |
| Examination of the surfaces and the near-surface regions | B (S) | |
| Ultrasonic examination | | |
| Radiographic examination | B | |

B - operator or his delegated contractor
S - authorized expert in accordance with para. 20 Atomic Energy Act
B (S) - operator performs the test, authorized expert carries our random checks
B + S - operator and authorized expert mutually perform the test

**Table 9-1:** Participation in inservice inspections

## Annex A

### Regulations Referred to in this Safety Standard

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

| | | |
|---|---|---|
| Atomic Energy Act | | Act on the Peaceful Utilization of Atomic Energy and the Protection against its Hazards (Atomic Energy Act) of December 23, 1959, as amended and promulgated on July 15, 1985, last amended by the Act of July 19, 1994 |
| StrlSchV | | Ordinance on the Protection against Damage and Injuries Caused by Ionizing Radiation (Radiological Protection Ordinance – StrlSchV), as promulgated on June 30, 1989 (BGBl. I, 1989, Page 1321) corrected on October 16, 1989 (BGBL.I, 1989), last amended by the Act of August 2, 1994 (BGBl. I, 1994, Page 1963) |
| DruckbehV | | Order on Pressure Vessels, Gas Pressure Vessels and Filling Plants (Pressure Vessel Order – DruckbehV), last amended on April 21, 1989 (BGBl. I, 1989, Page 843) |
| Guideline on Radiological Protection | | Guideline Relating for the Protection against Radiation of Personnel During the Execution of Maintenance Work in Nuclear Power Plants with Light Water Reactors;<br>Part 2: The Radiological Protection Measures During Commissioning and Operation of the Plant, made public on August 4, 1981 (GMBl. 1981, Page 363) |
| KTA 1201 | (06/84) | Requirements for the Testing Manual |
| KTA 1404 | (06/89) | Documentation During the Construction and Operation of Nuclear Power Plants |
| KTA 3201.4 | (06(90) | Components of the Reactor Coolant Pressure Boundary of Light Water Reactors;<br>Part 4: Inservice Inspection and Operational Monitoring |
| KTA 3211.1 | (06/91) | Pressure and Activity Retaining Components of Systems Outside the Reactor Coolant Pressure Boundary; Part 1: Materials |
| KTA 3211.2 | (06/92) | Pressure and Activity Retaining Components of Systems Outside the Reactor Coolant Pressure Boundary; Part 2: Design and Analysis |
| KTA 3211.3 | (06/90) | Pressure and Activity Retaining Components of Systems Outside the Reactor Coolant Pressure Boundary; Part 3: Manufacture |
| DIN 25 435 Part 2 | (11/87) | Inservice Inspections for Primary Circuit Components of Light Water Reactors; Magnetic Particle Method |
| DIN 25 435 Part 4 | (11/87) | Inservice Inspections for Primary Circuit Components of Light Water Reactors; Visual Examination |
| DIN 25 450 | (09/90) | Ultrasonic Equipment for Manual Testing |
| DIN EN 27 963 | (06/92) | Welds in Steel; Calibration Block No. 2 for Ultrasonic Examination of Welds<br>(ISO 7963:1985), German Version EN 27963:1992 |
| DIN 54 111 Part 1 | (05/88) | Nondestructive Testing; Radiographic Examination of Metallic Materials by X-ray or Gamma-rays;<br>Radiographing Fusion Welded Joints |
| DIN 54 120 | (07/73) | Nondestructive Testing; Calibration Block 1 and its Use for the Adjustment and Control of Ultrasonic Echo Equipment |
| DIN 54 125 | (01/89) | Nondestructive Testing; Manual Ultrasonic Testing of Welded Joints |
| DIN 54 127 Part 1 | (01/89) | Nondestructive Testing; Calibration of Ultrasonic Flaw Detection Equipment and Echo Height Evaluation |
| DIN 54 152 Part 1 | (07/89) | Nondestructive Testing; Penetrant Inspection; Procedure |
| DIN 54 152 Part 2 | (07/89) | Nondestructive Testing; Penetrant Inspection; Verification of Penetrant Inspection Materials |