Safety Standards

of the

Nuclear Safety Standards Commission (KTA)

KTA 3103 (2015-11)

Shutdown Systems for Light Water Reactors

(Abschaltsysteme von Leichtwasserreaktoren)

The previous version of this safety standard was issued in 1984-03

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KTA SAFETY STANDARD

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Contents

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Comments by the Editor:

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

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, 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 the present safety standard.

Basic Principles

(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 of the Safety Requirements for Nuclear Power Plants.

(2) The present safety standard details the requirements for the shutdown systems that are contained in the Safety Requirements for Nuclear Power Plants (SiAnf), particularly, SiAnf, Sec. 3.2.

(3) By applying this safety standard, the reactor shutdown systems, in their entirety, will fulfill the general principles of safety precautions in accordance with SiAnf and the requirements detailed therein.

(4) In a demand case, the reactor shutdown systems have the safety-related task of transferring the reactor to the subcritical state and of maintaining its long-term subcriticality. The shutdown systems, in their entirety, must ensure an enduring reactor shutdown.

(5) The shutdown systems, interacting with the physical processes of nuclear power generation and core cooling and with other systems (e.g., the reactor protection system), contribute to achieving the general protective goals, i.e., the control of reactivity, the cooling of fuel assemblies and the containment of radioactive substances.

1 Scope

(1) This safety standard applies to the shutdown systems of nuclear power plants with light water reactors. It specifies the requirements to be fulfilled by these systems with their active control elements used to shut down a reactor. The requirements of the present safety standard are limited to Levels of Defense 1, 2 and 3 and to the ATWS (anticipated transients without scram) at the Level of Defense 4a, as well as to external events and the very rare human induced external hazards.

(2) Internal events are considered only regarding physical arrangement and plant construction (cf. Section 4.3.3)

(3) The present safety standard does not apply to:

a) the systems in a boiling water reactor for the feeding of auxiliary media such as water and nitrogen after an emergency shutdown,

b) the requirements regarding manufacture, design review, material testing, assembly testing, pressure and acceptance testing of the boron injection systems,

Note:

In so far as pressure-retaining and radioactivity-containing components are concerned, these requirements are specified in safety standard KTA 3211.3. Otherwise, the general technical standards, e.g., the European PED, are applied.

c) the instrumentation and control equipment ensuring the functional capability of the reactor shutdown systems,

Note:

The requirements for electric drive mechanisms for the control rod systems are specified in safety standard KTA 3504, Sec. 8. Requirements for hydraulic actuators are specified in safety standard KTA 3103, Sec. 4.2.2.4. Process-engineering requirements for the instrumentation and control equipment (e.g., maximum admissible reaction times) are not specified in the present safety standard since they are a result of the analyses of the event sequences to be considered.

d) the requirements (i.e., numeric specifications) for the reactivity effectiveness of the shutdown systems, and the reactivity rate during shutdown,

Note:

These requirements are specified in safety standard KTA 3101.2. The safety standard KTA 3101.2 deals with the reactivity-related requirements for the shutdown systems, specifically, regarding their interaction with the characteristics of the nuclear core design. The system-technology related requirements for the shutdown systems are specified in safety standard KTA 3103.

and

e) the residual heat removal systems that are provided for the control and mitigation of loss-of-coolant accidents and that ensure both the cooling of the reactor core as well as the reactor shutdown by means of boronization (PWR); however, the present safety standard does apply to the requirements regarding the boric acid supply and boric acid monitoring.

Note:

Requirement for the residual heat removal systems are specified in safety standard KTA 3301.

2 Definitions

(1) Shutdown facility

A shutdown facility comprises those shutdown systems which, in the individual demand case, will ensure that the reactor is transferred sufficiently fast to the subcritical state and that it is permanently kept in that state.

Notes:

Regarding their specific tasks, several shutdown systems are combined in a shutdown facility.

The shutdown facilities of the pressurized water reactor (PWR) are:

- the control rod system, possibly, in combination with a supporting, earthquake-secured borating system (e.g., extra borating system), and
- the entirety of the other borating systems (e.g., volume and chemical control system, accumulator injection and core flooding vessels including the associated injection pumps).

The shutdown facilities of the boiling water reactor (BWR) are:

- the control rod system with fast hydraulic insertion, and
- the control rod system with electromagnetic insertion and, additionally, the borating system.

In both reactor types, the control rod system serves as the emergency shutdown system, in case of the BWR with fast hydraulic insertion.

(2) Manufacturers

Manufacturers are companies that are commissioned to manufacture (i.e., fabricate and test) a component or a component part, or to perform a fabrication test or test step.

(3) Control assembly

In case of a PWR, the control assembly is understood to be the entirety of all mechanically connected absorber rods (fingers). Synonymously used is the term control rod.

Note:

In case of a BWR, the term control rod is more commonly used. Synonymously used is the term control assembly.

3 Functions of the Shutdown Systems

3.1 General Principles

(1) At the Levels of Defense 1, 2 and 3 and during ATWS (Level of Defense 4a), the shutdown systems, in their entirety, shall be able to fulfill the following safety-related functions:

a) transfer the reactor to the subcritical state,

b) at the Levels of Defense 1, 2 and 3, maintain long-term subcriticality of the reactor even in the case of the most unfavorable condition possible under the circumstances to be considered.

c) during ATWS at the Level of Defense 4a, transfer the reactor to the subcritical state at the most unfavorable point in time of the fuel cycle and starting from a full-power Xenon equilibrium, and maintain permanent subcriticality of the reactor

(2) Regarding external events, the requirements of the Level of Defense 3 shall be applied. The shutdown systems shall be designed such that their effectiveness is maintained even regarding very rare human induced external hazards.

(3) For the safety-related function specified under Section 3.1, para. (1), item a), two independent and diverse systems shall be provided:

a) An emergency shutdown system which, by itself, shall be able to transfer the reactor from conditions of the Levels of Defense 1, 2 or 3 sufficiently fast to the subcritical state, and to maintain its subcriticality for a sufficiently long time.

Note:

The required shutdown speed and the required duration of subcriticality result from the event sequence analyses (e.g., design bases accident analyses).

b) An additional shutdown system which, by itself, can transfer the reactor to the subcritical state and maintain its long-term subcriticality from all conditions of the Levels of Defense 1 and 2 and during all event sequences of Level of Defense 3 that do not require a rapid reactivity change.

Note:

This general requirement regarding the availability of two shutdown systems does not anticipate that the emergency shutdown system may not be available at the Level of Defense 3.

3.2 Emergency Shutdown System

(1) The emergency shutdown system is an integral part of the safety system.

(2) The reactivity-binding control elements are neutron absorbing control assemblies.

Note:

In the case of a boiling water reactor, the hydraulic drive system is part of the emergency shutdown system.

3.3 Additional Shutdown System

(1) In the case of a PWR, the additional shutdown system shall be one that uses coolant-soluble boron compounds as the reactivity-binding control agent; in the case of a BWR, the additional shutdown system shall be one that uses those control assemblies with electromechanical drives that are diverse from those of the emergency shutdown system.

(2) The additional shutdown system shall be able to transfer the reactor to a subcritical state from all those conditions of the Levels of Defense 1 and 2 that do not require a rapid reactivity change as well as during all events with a presumed failure of the emergency shutdown system (i.e., ATWS, Level of Defense 4a) and, in these cases, shall be able to maintain long-term subcriticality of the reactor.

Notes:

(1) In case of a PWR, several boron injection systems are used to carry out this function, either alternatively or in conjunction with each other.

(2) In case of a BWR, the available borating system supplements the additional shutdown system. The requirements regarding the shutdown reactivity of this system are detailed in safety standard KTA 3101.2, Sec. 6.3.2.

(3) After occurrence of Level of Defense 3 events, if the safety-related function specified in Section 3.1, para. (1), item b) cannot be fulfilled alone by the emergency shutdown system, those systems provided to carry out these safety-related functions shall be considered as part of the safety system. The timing of their deployment and the decision on whether their deployment can be initiated manually or must be initiated automatically shall be specified based on the event sequence analyses, taking the (reactivity) effectiveness of the emergency shutdown system into account.

4 Design

4.1 Superordinate Requirements

(1) Shutdown systems shall be designed such that they will safely fulfill their functions. They shall be constructed such that they are easily repaired, tested and serviced. They shall be designed such that operation, servicing and repairs as well as inservice inspections can be carried out with the least possible radiation exposure to the personnel.

(2) The emergency shutdown system shall be able to fulfill its safety-related function as specified in Section 3.1(1), para. (1), item a), even in case a single failure occurs, e.g., the failure of most reactivity effective control assembly.

(3) Those shutdown systems that are part of the safety system shall, in their entirety, be able to keep the reactor permanently in a subcritical state, even in case a single failure.

(4) The shutdown systems may be used, either entirely or partly, for operational control purposes. In this case, it shall be ensured that a sufficient reserve of (reactivity) effectiveness is available at all times for the safety-related requirements and that the safety-related demand cases have priority over operational demand cases. It shall be ensured that no function of the operational control nor a failure in the control system can detrimentally affect the safety-related function of the shutdown systems.

4.2 Control Assemblies and Control Assembly Drives

4.2.1 General requirements

(1) Based on the Levels of Defense 1, 2 and 3, the ATWS (Level of Defense 4a as well as external events, the requirements regarding

a) travel length,

b) travel velocity,

c) length of time until shutdown, and

d) number of insertion steps

are dependent on the individual reactor and shall be available prior to the mechanical design.

(2) The component parts shall be assigned to the following groups:

a) pressure retaining walls of the control assembly drives,

b) pressure retaining parts of the drive media systems,

c) pressure retaining parts inside the pressure boundary (boiling water reactor - BWR),

d) component parts of the drive mechanism,

e) structural parts of the control assemblies, and

f) absorber rods.

Note:

In case of the BWR, the absorber can be an integral part of the structural parts.

(3) The requirements for the design of the components of para. (2), items a) through d), are dealt with in Sections 4.2.2.1 through 4.2.2.4. In addition, the component parts of the emergency shutdown system shall be designed such that, when they interact with bordering parts of other components, the safety-related task of the control assemblies and control assembly drives as specified under Section 3 is fulfilled in the demand case.

(4) Regarding the component parts of the emergency shutdown system, based on their nominal geometries and respective tolerances as well as on the nominal geometries and respective tolerances of the other bordering component parts, the free path of the control assemblies shall be demonstrated for the operating temperatures at the Levels of Defense 1, 2 and 3 as well as for external events.

Note:

The design requirement under para. (4) assures that a sufficient clearance is available for the freedom-of-movement proof. In addition, the following para. (5) requires this freedom-of-movement proof under operating conditions.

(5) Regarding operating conditions, a sufficient freedom of movement of the control assemblies shall be demonstrated considering the condition of the bordering component parts. If the control assembly is blocked or difficult to move, or if delayed drop or injection times are detected, the circumstances shall immediately be evaluated from a safety perspective. If it cannot be ensured that the limit values specified for the reactor core are observed, the power plant shall be shut down to the subcritical cold state.

Note:

Typical limit values to be specified for the reactor core are, e.g., the required shutdown reactivity as well as the reactivity rates required for the control and mitigation of events of the Levels of Defense 2 or 3.

(6) The mechanical design of the component-part groups according to para. (2), items e) and f) shall meet the requirements specified in safety standard KTA 3101.3, Appendix B.

4.2.2 Component design

Note:

In accordance with the respective scopes of safety standards KTA 3201.1 through KTA 3201.4 as well as of safety standards KTA 3211.1 through KTA 3211.4, tubes with a nominal diameter less than DN 50 are excluded. In practice, the technical specifications for the respective areas are applied in these cases (e.g., “Konvoi” specifications K1 and K2).

4.2.2.1 Pressure retaining walls of the control assembly drives

(1) The components of the pressure retaining walls of the control assembly drives include the pressure housing, the sealant housing and the solenoid-operated switch housing (boiling water reactor –BWR), the pressure tube and the pressure tube closure (pressurized water reactor – PWR).

Note:

The components listed above are part of the pressure retaining boundary (cf. safety standard KTA 3201.1)

(2) The materials used, the design and analysis, the manufacture, testability and inservice inspections and the operational monitoring shall meet the requirements of safety standards KTA 3201.1 through KTA 3201.4.

4.2.2.2 Pressurized parts of the drive media systems of the boiling water reactor

The pressurized parts of the drive media systems of a boiling water reactor include the accumulators, valves and pipes. The materials used, the design and analysis, the manufacture, testability and inservice inspections and the operational monitoring shall meet the requirements of safety standards KTA 3211.1 through KTA 3211.4.

4.2.2.3 Pressurized parts inside the pressure retaining boundary (boiling water reactor)

(1) The analysis regarding the mechanical behavior of the pressure retaining parts of the control assembly drives of a boiling water reactor (hollow piston, throttle sleeve and cover bushing) shall meet the requirements of safety standard KTA 3204.

(2) The materials used shall be demonstrated to be suitable regarding the chemical, mechanical, thermal and radiation-related loads expected under operating conditions.

4.2.2.4 Component parts of the drive mechanism

(1) The adequate strength of the drive mechanism parts shall be demonstrated by means of analytical or experimental investigations. If the functional capability and wear are the design-determining factors of these parts, proof in the form of an experimental type test is admissible.

(2) If the analytic analysis of the mechanical behavior of the components of the drive mechanism parts is carried out, the analysis shall be based on the stress limits specified in the safety standard KTA 3204.

(3) The materials used shall be demonstrated to be suitable regarding the chemical, mechanical, thermal and radiation-related loads expected under operating conditions.

4.2.2.5 Absorber materials and materials of the structural parts

(1) Regarding their mechanical, chemical and neutron-physical characteristics, the absorber materials and the materials of the structural parts shall be suited to the operating conditions in the reactor.

(2) The (reactivity) effectiveness of the absorber material shall be demonstrated taking the burnup under reactor conditions into account. This may be demonstrated

a) by assuming an all-covering value for the absorber burnout, or

b) by an analytic consideration of the absorber burnup based on the actual deployment conditions.

(3) The materials used shall be demonstrated to be suitable regarding the chemical, mechanical, thermal and radiation-related loads expected under operating conditions.

4.2.3 Control assembly instrumentation

(1) A position indicator and a limit position indicator shall be provided for each control assembly.

(2) In the case of a boiling water reactor, there shall be duplicate sensors on the control assembly drive for detecting the separation of the control assembly from the drive.

(3) The power supply of the displays shall be monitored. Any failure shall be signaled. The required power shall be provided

by an uninterruptible emergency power supply. This power supply shall be monitored by displays and by hazard alarms in the case of failure.

(4) If the instrumentation is used for protective limitations and for the limitation of process variables, it shall comply with the requirements of safety standard KTA 3501.

4.3 Process-Technological Systems

4.3.1 General requirements

Process-technological systems of the shutdown system are:

a) the hydraulic drive of the emergency shutdown system in the case of a boiling water reactor,

b) boron injection systems as part of the safety system in the case of a pressurized water reactor.

Note:

The supplementary borating system of the BWR is not dealt with in this section, since it is not part of the safety system.

4.3.2 Single failure concept

The requirements detailed in SiAnf, Sec. 3.1, paras. (6) through (8), as well as the requirements detailed in SiAnf, Appendix 4, shall be applied.

4.3.3 Physical arrangement and plant construction

In as far as necessary, measures shall be provided against the accident-related loads to be considered, such as the reaction, jet and missile forces, the flooding and fire, the shock waves and pressure waves as well as the changing ambient conditions (e.g., humidity, pressure, temperature, radiation). Examples of such measures are:

a) spatially separated physical arrangement of the redundant devices,

b) design measures (e.g., pipe-whip restraints, coverings, reinforcements, shock suppressors),

c) structural measures (e.g., compartmentalization, walls, raised foundations), or

d) an appropriate design of the components.

4.3.4 Functional availability

(1) To ensure functional availability, only a few active switching actions shall normally be necessary when active control measures are required (e.g., valves shall normally be set in the standby state). The systems shall normally be designed such that functional tests can be performed on all components of the systems.

(2) It is admissible to use the systems for operating or other purposes than the safety-related purposes specified herein, provided, it is ensured that

a) operational control commands do not detrimentally affect the (reactivity) effectiveness of the safety-related function,

b) this does not significantly influence the availability and failure probability of the systems.

(3) The following shall be monitored:

a) in the case of the pressurized water reactor:

the fluid level in the boric acid tanks, the boric acid concentration and valve positions of the boron injection systems as well as the Boron-10 content if needed (e.g., when replenishing boron),

b) in the case of the boiling water reactor:

the fluid level and pressure in the shutdown tanks, the valve positions and, in case of shutdown tanks with an inner vessel, the humidity.

(4) A Class I hazard alarm as specified in safety standard KTA 3501 shall be derived from the measuring equipment for function monitoring. It shall be possible to test the measuring equipment needed for function monitoring.

(5) In the case of the pressurized water reactor, it shall be ensured that boron recrystallization is prevented. It shall be possible to determine the boron concentration as well as the Boron-10 content from a sampling in the controlled access area of the power plant.

4.3.5 Boric acid supply and injection rate of the boron injection system in a pressurized water reactor

The necessary (reactivity) effectiveness of the borating system determined from the operating and accident conditions determines the requirements regarding

a) the boric acid supply, and

b) the injection rate

of the boron injection systems. The boric acid concentration and the Boron-10 content shall be considered. The boric acid supply and the injection rate shall be determined individually for each power plant.

4.3.6 Power supply for drive media systems in a boiling water reactor

(1) The power supply shall be sufficient for the insertion of the control assemblies even under their most unfavorable initial conditions such that the reactor can be transferred from the Levels of Defense 1 and 2 as well as during all events of the Level of Defense 3 to a subcritical state and that this can be carried out within time substantiated by the safety analysis.

(2) The most unfavorable initial conditions to be assumed for the drive media systems are:

a) all control assemblies are fully withdrawn,

b) the minimum and the maximum limit value of the water volume and the minimum limit values of the gas pressure.

5 Functional Safety

5.1 General Requirements

(1) The functional safety of the shutdown systems that belong to the safety system shall be assessed

a) for the systems with no proof of successful service, e.g., in the case of new developments,

b) for any significant modifications of service-proven systems, and

c) for the estimation of the admissible repair times of the components of the safety systems.

(2) When assessing the functional safety of the shutdown systems,

a) the functional reliability of the shutdown systems in their entirety shall be compared with the functional reliability of already realized systems of the same or similar type of design and mode of operation,

b) the deviations in the details of the planned construction of service-proven systems shall be evaluated,

c) the consequences of an assumed failure of individual components shall be analyzed.

3) The functional safety of the shutdown systems shall be assessed based on

a) the construction and function,
b) the qualification test of the prototype, and
c) proof of successful-service.

5.2 Construction and Function

(1) For the assessment of the construction and function of the shutdown systems, documents shall be submitted that show the extent to which the systems provided correspond to or deviate from those for which prototype tests or operating experience are available.

(2) These documents shall contain information on the following:

a) travel velocity,
b) drop-down or fast-insertion time,
c) output capacity of the boron injection system,
d) number of demands (protective initiations, insertion steps, insertion sequence),
e) (reactivity) effectiveness of the absorber,
f) construction of the system (flow charts, circuit diagrams), and
g) design solutions (overview drawings).

In addition, they shall contain

h) a description of the mechanical components, and
i) a description of the electrical devices.

5.3 Qualification Test of a Prototype

In the case of newly conceived shutdown systems, qualification tests of a prototype are required. The following shall be examined to the extent applicable:

a) influence of pressure and temperature,
b) flow conditions in the reactor pressure vessel,
c) hydraulic design (e.g., the dynamic design of the boiling water reactor emergency shutdown system and of the pumps of the boron injection systems),
d) water quality (e.g., corrosive components, dirt),
e) influence of tolerances and misalignments,
f) aging test program in accordance with the design or with the insertion steps and insertion sequence to be assumed as specified in the controls concept,
g) influence of malfunctions (e.g., of cooling or flushing),
h) failure or malfunction of electrotechnical components,
i) effects of malfunctions in the instrumentation and control equipment, and
k) trial of assembly procedures including the tools used (e.g., coupling and decoupling of the control assemblies and of the control assembly drive as well as the assembly and disassembly of the control assembly drives).

Note:

A reliability analysis can supplement the qualification test of the prototype of a modified or newly conceived design or it can replace individual examinations. This is especially the case if the system is assembled from components for which the individual reliability and interaction can be assessed (e.g., in the case of circuits or circuit sections of the boron injection systems).

5.4 Satisfactory Service Life

To help assess the functional safety of a planned shutdown system prior to its final construction, the operating experience with same or similar types of shutdown systems shall be considered.

6 Tests

6.1 Accompanying Tests during Manufacture and Commissioning

The following requirements shall be applied to

a) control assemblies, and
b) control assembly drives with the exception of their pressure-retaining shells.

Note:

The requirements for accompanying tests during manufacture and commissioning

a) of the pressure-retaining shells of the control assembly drives, and of the drive media systems of a BWR are dealt with in safety standards KTA 3201.1 and KTA 3201.3,
b) of the borating system and of the emergency shutdown system of a BWR are dealt with in safety standards KTA 3211.1 and KTA 3211.3.

In the cited safety standards, pipes with a nominal diameter less than DN 50 are excluded. In practice, the technical specifications for the respective areas are applied in these cases (e.g., “Konvoi” specifications K1 and K2).

6.1.1 General requirements

Note:

The term "accompanying tests" is understood to imply all tasks performed when testing individual components of the shutdown systems as well as the entire systems.

(1) In the course of the accompanying test, it shall be determined whether the component or system in question meets the relevant requirements. The results of these tests shall be recorded in reports, attestations or certificates. The full scope of the test including their documentation shall be broken down into the following tasks:

a) design review,
b) materials, assembly and pressure tests,
c) acceptance and functional tests.

(2) All tests specified below shall be recorded in the form of an attestation of material testing or of test reports or individual test records. In these documents, the testing requirements, testing procedures, test results, testing scope and the person or institution performing the test shall be specified.

6.1.2 Design Review

(1) In the course of the design review, it shall be examined whether the construction and design of the component or system comply with the specified requirements.

(2) The design review shall include:

a) the analytical verification of all safety-related components (alternatively: experimental proof),
b) verification of whether in every case suitable materials have been specified,
c) verification of the suitability of the specified welding procedures and weld filler materials,
d) verification of whether the planned fabrication tests correspond to those specified and are adequate,
e) verification of whether the planned design permits performing the necessary tests,
f) verification of the measures provided to prevent the inadvertent loosening of connecting elements,
g) verification of the instrumentation and their electrical circuit diagrams, and

h) verification of whether the manufacturer has furnished proof of the necessary qualification for the tasks to be performed.

(3) The individual steps during fabrication and testing shall be recorded in detail and chronological order in the fabrication and test sequence schedules, also indicating who is responsible; each step shall be verified.

6.1.3 Material testing on product forms

(1) The materials shall be tested and accepted according to a material testing schedule that shall contain information regarding, e.g., the test specimen location, the testing method and the scope of the tests. Those responsible for these tests shall be named in the material testing schedule.

(2) Destructive tests and nondestructive examinations shall be carried out or supplemented after the last heat treatment. Ultrasonic tests shall normally be carried out on a simple geometric condition.

(3) The tests to be performed are listed in **Table 6-1**.

6.1.4 Assembly tests

(1) The assembly tests shall as establish whether the actual construction of the components and systems corresponds to the design reviewed documents.

(2) The following requirements shall be fulfilled prior to carrying out assembly tests:

a) The manufacturers shall have at their disposal the equipment and qualified personnel that enables them to properly process the materials and to perform the necessary tests.

b) The quality assurance systems of the manufactures shall meet the requirements of safety standard KTA 1401.

(3) Compliance with the requirements under para. (2) shall be demonstrated to the authorized expert. The latter is entitled to assure himself that the requirements are fulfilled in the course of fabrication.

(4) Further tests shall determine whether the materials listed in the material testing schedule specified under Section 6.1.3 are used, and whether the proofs are furnished as specified in that testing schedule.

6.1.5 Acceptance tests

An acceptance test shall be performed. This test shall be carried out prior to commissioning. The scope of the acceptance test shall cover the correct design as well as the proper installation and connections of the components.

6.1.6 Functional tests

6.1.6.1 General requirements

The functional tests shall include not only the standard examinations planned to be performed on the test bench but also commissioning tests performed in the plant. The type and scope of these tests shall be specified in test programs.

6.1.6.2 Functional tests performed on the test bench

(1) Functional tests on the test bench shall cover:

a) demonstrating the specified travel velocity of the drives and the travel characteristics,

b) demonstrating the specified drop-down or fast-insertion time,

c) demonstrating the specified opening and closing times of valves, and

d) demonstrating the safety-related functions.

(2) Those components or subunits subjected to a serial test shall be checked after the tests.

6.1.6.3 Functional tests performed in the plant during commissioning

(1) During commissioning, the function and interaction of the components of the shutdown systems shall be tested. In this context, it shall be demonstrated that the demand cases arising during specified normal operation will be dealt with. It shall further be demonstrated – in as far as this has not been demonstrated by other means – that demand cases arising in the case of events in Level of Defense 3 will also be dealt with.

(2) Type and extent of the functional tests shall be summarized in commissioning programs. The following tests are required:

a) proof of the specified drop-down or fast-insertion times and the travel times as well as verification of the travel characteristics,

b) proof of the specified opening and closing times of the valves as well as their dead times, and

c) checking the general condition, e.g., installation condition of the valves, anchorages, fixtures, insulations, measurement points, measurement cables, leak-tightness of the system, and oil leakage.

6.2 Inservice Inspections

(1) The following requirements shall be applied to

a) control assemblies,

b) control assembly drives with the exception of the pressure-retaining shells of the control assembly drives, and

c) borating systems with the exception of their pressure test.

Note:

The requirements for inservice inspections

a) of the pressure-retaining shells of the control assembly drives, and of the drive media systems of a BWR are dealt with in safety standards KTA 3201.4,

b) regarding the pressure tests of the borating system and regarding the emergency shutdown system of a PWR are dealt with in safety standards KTA 3211.4.

6.2.1 General requirements

A test schedule for inservice inspections shall be created for each power plant. This schedule shall specify the type and extent of the inspections and tests, the inspection and testing methods, the inspection and testing cycles and the form of the inspection and testing documentation.

6.2.2 Testing the function of the shutdown systems

6.2.2.1 Testing during power operation

(1) The control assemblies, individually or in groups, shall be inserted and extracted at regular intervals in accordance with the inservice inspection test schedule. The control assembly movements shall be demonstrated by means of position indicators or by other equipment.

Note:

Travel lengths of approximately 10 cm in the case of the PWR or approximately 3 cm in the case of the BWR are adequate.

(2) Both in a PWR and a BWR, the functional availability of the boron injection systems, in particular their boric acid

concentration and their fluid level, shall be tested at regular intervals in accordance with the inservice inspection test schedule. The Boron-10 concentration shall be checked when needed (e.g., when replenishing boron).

(3) In the case of a boiling water reactor, all safety-related times (e.g., the fast-insertion times of the control assemblies and the opening and closing times of the valves, as well as the dead times of the systems) shall be measured under operating conditions. This may also be carried out with the reactor in its zero-power state.

(4) In case of a pressurized water reactor, prior to each refueling and after the reactor pressure vessel is closed before commencing power operation but at least once a year, the drop-down times of all control assemblies shall be checked under operating conditions. This may also be carried out with the reactor in its zero-power state.

(5) If instrumentation is available to measure the times specified under paras. (3) and (4) or to measure the deviations from specified values even in the case of an unintentional emergency shutdown, the results of these measurements may be used in the inservice inspections.

6.2.2.2 Testing during power plant outage

(1) The safety-related times and the functional sequences shall be tested in accordance with the inservice inspection test schedule, unless these tests have already been carried out during operation.

Note:

This includes, e.g., valve opening times, opening conditions for valves that are pilot-controlled by their own media, time delays, output capacity and output pressure.

(2) Control assembly drives and control assemblies, and, for the boiling water reactor, the active components of the power supply, shall be inspected. The active components for supplying of power (e.g., scram valves and control assembly valves) shall be dismantled for their inspection.

(3) The number of units to be inspected shall be specified such that the inspection findings together with the operational records provide representative information on all existing units. The selection of the units to be inspected shall be in accordance with their operational loads, e.g., stress cycles. Component parts needed for safety-related functions shall be checked. An inspection may be waived, provided, a failure of the component parts has no safety-related consequences.

(4) The general condition shall be checked by visually examining the system.

Note:

This applies to the, e.g., installation condition of the valves, anchorages, fixtures, insulations, measurement points, measurement cables, leak-tightness of the system, and oil leakage.

(5) In the case of a boiling water reactor, after complete loading of a control rod cell with the fuel elements of the planned refueling or after complete refueling, the functioning of the control assemblies and control drives shall be checked by a complete insertion and extraction.

Note:

The shutdown safety tests possibly also performed during refueling are dealt with in safety standard KTA 3107.

Tests and Inspections	Component / Product Form						
	Pressure-bearing parts belonging to the pressure boundary	Control Assembly Drive				Control assembly	Vessels, pipes, valves, pumps
		Load-bearing parts in contact with the coolant			Non-load-bearing parts in contact with the coolant		
		Bolts, nuts, pins	Pipes, sheets, strips	Rods, forgings			
Ladle Analysis	requirements as specified in safety standard KTA 3201.1	x	x	x	x	requirements as specified in the relevant licensing procedures	requirements as specified for auxiliary and secondary systems, and as specified in safety standard KTA 3211.1
Hardness Test [1]		x	x	x	—		
Tensile Test at Room Temperature		x	x	x	—		
Tensile Test at Design Temperature		x	x	x	—		
Notched Bar Impact Test		x	x [2]	x [2]	—		
Metallography [3]		x	x	x	—		
Material Verification		x	x	x	—		
Heat Treatment Proof		x	x	x	x		
Resistance to Intergranular Corrosion [4]		x	x	x	x		
Destructive Examinations		—	x	x	—		
Pressure Test		—	—	—	—		
Visual Inspection of Surface and Dimension Check [5] [6]		x	x	x	—		
Ultrasonic Testing of Product Forms		—	x [7]	x [7]	—		
Magnetic Properties		—	—	x	—		

[1] not in the case of austenitic materials

[2] only in the case of pipe wall thicknesses greater than 12 mm, sheets thicker than 10 mm or diameters greater than 20 mm

[3] δ-ferrite content in the case of austenite; grain size, micrograph

[4] in the case of ferritic chrome steel: proof of rust resistance

[5] in the case of forged product forms: e.g., liquid penetrant examination

[6] on the finished product

[7] in the case of pipe wall thicknesses greater than 5.6 mm, sheets thicker than 10 mm, rod diameters greater than 30 mm or forged part reference cross sections larger than 30 mm

Table 6-1: Material testing of product forms

Appendix A

Regulations Referred to in the Present Safety Standard

(Regulations referred to in the present safety standard are valid only in the versions cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the latter regulations were established or issued.)

AtG		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act – AtG) of December 23, 1959, revised version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Article 307 of the Act of August 31, 2015 (BGBl. I 2015, No. 35, p. 1474)
StrlSchV		Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance – StrlSchV) of July 20, 2001 (BGBl. I, p. 1714; 2002 I, p. 1459), most recently changed by Article 5 of the Act of December 11, 2014 (BGBl. I, p. 2010)
European PED	(2014-05)	Pressure Equipment Directive 2014/68/EU of the European Parliament and the European Council of May 15, 2014, for the harmonization of legal provisions of the member states regarding the availability of pressure equipment in the European market
SiAnf	(2015-03)	Safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B2)
SiAnf-Interpretations	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B3)
KTA 1401	(2013-11)	General requirements regarding quality assurance
KTA 3101.2	(2012-11)	Design of reactor cores of pressurized water and boiling water reactors; Part 2: Neutron-physical requirements for design and operation of the reactor core and adjacent systems
KTA 3107	(2014-11)	Nuclear criticality safety requirements during refueling
KTA 3201.1	(1998-06)	Components of the reactor coolant pressure boundary of light water reactors; Part 1: Materials and product forms
KTA 3201.2	(2013-11)	Components of the reactor coolant pressure boundary of light water reactors; Part 2: Design and analysis
KTA 3201.3	(2007-11)	Components of the reactor coolant pressure boundary of light water reactors; Part 3: Manufacture
KTA 3201.4	(2010-11)	Components of the reactor coolant pressure boundary of light water reactors; Part 4: Inservice inspections and operational monitoring
KTA 3204	(2008-11)	Reactor pressure vessel internals
KTA 3211.1	(2015-11)	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	(2012-11)	Pressure and activity retaining components of systems outside the primary circuit; Part 3: Manufacture
KTA 3211.4	(2013-11)	Pressure and activity retaining components of systems outside the primary circuit; Part 4: Inservice inspections and operational monitoring
KTA 3301	(2015-11)	Residual heat removal systems of light water reactors
KTA 3501	(2015-11)	Reactor protection system and monitoring equipment of the safety system
KTA 3504	(2006-11)	Electrical drive mechanisms of the safety system in nuclear power plants