

Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3506 (11/84)

**Tests and Inspections of the Instrumentation and Control
Equipment of the Safety System of Nuclear Power Plants**

(Systemprüfung der leittechnischen Einrichtungen des Sicherheitssystems von Kernkraftwerken)

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

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KTA SAFETY STANDARD

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Tests and Inspections of the Instrumentation and Control Equipment of the Safety System of Nuclear Power Plants

KTA 3506

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

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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. |

Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety related requirements, which shall be met with regard to precautions to be taken in accordance with the state of science and technology against the damages arising from the construction and operation of the facility (Sec. 7 Atomic Energy Act), in order to attain the protective goals specified by the Atomic Energy Act and the Radiological Protection Ordinance.

(2) Relevant acts, ordinances and rules of the federal and state authorities as well as subordinate specifications by the authorities, e.g. the Safety Criteria for Nuclear Power Plants (approved by the States, Committee for Nuclear Energy) or the Guidelines of the Reactor Safety Commission, are considered in developing KTA safety standards.

(3) In this KTA safety standard it is assumed that rules and standards (e.g. accident prevention rules, DIN standards and VDE regulations) are adhered to unless other requirements are specified as a result of aspects specific to a nuclear power plant.

(4) On the basis of Criterion 2.1, "Quality Assurance", and Criterion 2.2, "Testability", of the Safety Criteria for Nuclear Power Plants, this safety standard deals with the requirements concerning scope, preparation and performance of the system testing in nuclear power plants with respect to the instrumentation and control equipment of the safety system in accordance with Section 7 of the RSK Guidelines for Pressurized Water Reactors (10/81).

(5) This safety standard is closely related to KTA 3501 "Reactor Protection System and Monitoring Equipment of the Safety System". In addition, the following safety standards are also of importance: KTA 3507 "Factory Testing of Instrumentation and Control Equipment of the Safety System", KTA 3503 "Type Testing of Electrical Modules of the Reactor Protection System", and KTA 3505 "Type Testing of Measuring Transmitters and Transducers of the Reactor Protection System". The proofs established on the basis of these tests are the prerequisites for the assembly of modules and equipment in the nuclear power plant (insofar as the equipment falls within the scope of the respective safety standard). The safety standard KTA 3506 deals with the testing of completely assembled systems in the nuclear power plant.

(6) The requirements for functional tests as specified in KTA 3403 "Cable Penetrations through the Reactor Containment Vessel", have been taken into account in this safety standard.

(7) With respect to switch gears and electric drives, Section 2.2 provides a delineation which is in agreement with KTA 3701 to 3705 and KTA 3504.

(8) The requirements of the safety standard KTA 3904 "Control Room and the Emergency and Local Control Equipment in Nuclear Power Plants" have been considered in KTA 3506.

(9) The safety standards KTA 1401 "General Requirements for Quality Assurance", KTA 1404 "Method of Documentation during Construction and Operation of Nuclear Power Plants", and KTA 1202 "Requirements for the Testing Manual" shall be considered as overriding standards for the entire nuclear power plant. KTA 3506 takes these overriding requirements into account and specifies the necessary requirements for the performance of tests relating to instrumentation and control.

1 Scope

(1) This safety standard applies to the instrumentation and control equipment of the safety system of nuclear power

plants. It applies to the reactor protection system, the limitations of process variables, safety-related control equipment and Classes S and I hazard alarms.

(2) The system testing of the instrumentation and control equipment of the safety system includes both commissioning tests and inservice inspections. It does not include accompanying tests during assembly.

2 Basic Test Requirements

2.1 General Requirements

(1) Through system testing it shall be demonstrated without any gaps that the instrumentation and control equipment of the safety system were fabricated and assembled in accordance with the documents reviewed by the authorized expert (under Sec. 20 Atomic Energy Act) and fulfill their intended functions.

(2) In the case of a step-by-step performance of the tests, the functioning of the instrumentation and control equipment shall be demonstrated by means of coordinated overlapping test sections. The functional tests should include actuation and operation of the drives (e.g. electrical motors, control drives, solenoid valves) to the extent that the feedback signals can be tested.

2.2 Systems to be Tested

The following systems of the instrumentation and control equipment of the safety system shall be tested:

- Reactor protection system,
- Limitations of process variables,
- Safety-related control equipment,
- Control level for safety-related drives,
- Class S hazard alarms,
- Class I hazard alarms.

3 Commissioning Tests of the Instrumentation and Control Equipment of the Safety System

3.1 Tests Without Operation of the Process Systems

3.1.1 General Requirements

The tests without operation of the process systems shall be performed in the two test sections visual tests and functional tests.

3.1.2 Visual Inspections

(1) At the beginning of the tests without operation of the process systems, visual inspections of the instrumentation and control equipment of the safety system shall be performed on the basis of the documents reviewed by the authorized expert (under Sec. 20 Atomic Energy Act).

(2) With these inspections it shall be demonstrated that a proper functioning can be expected on the basis of the layout of the instrumentation and control equipment even if the arrangement of the other power plant components (such as mechanical and electrical components and ventilation and air filtration systems) is taken into account, and that it will be possible to carry out maintenance.

The inspection criteria are:

- Completed fabrication and assembly of that part of the instrumentation and control equipment to be inspected,

- b) Undamaged condition of that part of the instrumentation and control equipment to be inspected,
- c) Construction suited to the function of the mechanical part of the instrument arrangements (e.g. sensors, sampling lines, transducers),
- d) Completed marking of all equipment, modules and cabinets as well as their allocation to the redundancy groups,
- e) Protection against mechanical impacts (e.g. as a result of maintenance work in the plant) of that part of the instrumentation and control equipment to be tested,
- f) Accessibility of equipment, modules and instrument arrangements for tests, servicing and repairs.

(3) The visual inspections shall only be carried out after completion of the accompanying tests of those parts of the instrumentation and control equipment of the safety system that shall be tested, and also after the assembly work in the compartments accommodating the instrumentation and control equipment to be tested has reached a stage where further assembly work can no longer detrimentally affect the systems tested with respect to the inspection criteria specified in Section 3.1.2(2).

3.1.3 Functional Tests

(1) The functional tests shall be carried out at the ultimate location of installation and shall demonstrate that the instrumentation and control equipment fulfills the functions required in the documents reviewed by the authorized expert (under Sec. 20 Atomic Energy Act) (e.g. overview diagrams, functional diagrams, circuit diagrams, measuring circuit data sheets, functional descriptions, specifications, explanatory reports).

(2) Those wiring and functional tests of system parts which have already been carried out as factory tests need not be repeated at the ultimate location of installation if

- a) the scope and documentation of the tests meet the requirements in accordance with Section 3.1 of this safety standard,
- b) no transportation or assembly damage was found to have detrimentally affected the function, and
- c) overlapping tests were carried out in accordance with Section 3.7 in the case of modifications.

Note:

Factory tests are provided for in KTA 3507.

(3) Functional tests of the mechanical and electrical components should be carried out by actuating the components to obtain the feedback signals of control drives, solenoid valves and circuit breakers. During these tests, the process systems need not be in operation. In the case of signals derived from media (e.g. pressure or flow rate), the physical variables may be preset using testing aids.

3.1.4 Testing Schedule

Before beginning the tests without operation of the process systems, a testing schedule has to be prepared and agreed upon with the authorized expert (under Sec. 20 Atomic Energy Act). This testing schedule shall specify the systems or sub-systems to be tested, the tests to be carried out, the associated testing instructions as well as the participation of authorized experts (under Sec. 20 Atomic Energy Act). This testing schedule may be combined into common commissioning programs with the testing schedules for the tests of the electro-technical and process systems.

3.1.5 Testing Instructions

(1) Before beginning the tests without operation of the process systems, testing instructions for the part of the instrumentation and control equipment of the safety system to be tested shall be prepared and agreed upon with the authorized expert (under Sec. 20 Atomic Energy Act).

(2) A test instruction consists of a process description and test record form sheet.

(3) The process description shall include:

- a) a designation, including state of revision, which ensures that the process description is correlated to the testing schedule,
- b) a description of the test procedure establishing both the test procedure and the work sequence for carrying out the test, and the testing instrument arrangement by means of a schematic wiring diagram (in the case of simple measuring arrangements, no descriptions concerning the testing arrangement are required),
- c) the inspection criteria for the visual inspections in accordance with Section 3.1.2,
- d) the types of documents on which the tests are based,
- e) the type of testing equipment to be used, including the necessary technical data.

(4) The test record form sheet shall include:

- a) the test object, including the location of installation or testing and the alphanumeric plant identification code,
- b) a reference to the associated process description,
- c) a list of the tests according to the individual test steps to be documented,
- d) the measurement parameters to be recorded, including specified values and permissible deviations.

(5) During the tests, the following information shall be recorded on the test record form sheets:

- a) the test equipment used, including equipment numbers,
- b) the test results of the individual test steps,
- c) the set values,
- d) the confirmation of successful testing, after all defects have been removed, with the tester's signature and the date of testing, as well as the signature of the authorized expert (under Sec. 20 Atomic Energy Act) if he participates in the test.

Note:

As a result of the information entered on the test record form sheet, it becomes a test record.

3.2 Tests of Interaction with the Process Systems

3.2.1 General Requirements

(1) The tests of interaction with the process systems shall be carried out during the process-related commissioning of the system. Depending on the operational states attained, the commissioning tests of the instrumentation and control equipment shall be carried out in interaction with the process systems. In doing so, it shall be verified whether, under the occurring operating conditions; the instrumentation and control equipment meet the requirements specified in the documents reviewed by the authorized expert (under Sec. 20 Atomic Energy Act).

(2) The actions to be initiated by the instrumentation and control equipment of the safety system shall be tested by process-related initiations or, if this would result in disproportionately severe loads on the plant, by a simulation of such initiations.

(3) If actions are actuated during the tests which would result in disproportionately severe loads on the plant, these loads shall be minimized with respect to the goal of the tests in an approach coordinated with process technology.

(4) The tests should be carried out under operating conditions during non-nuclear operation. Tests for which the nuclear operation of the plant is a prerequisite shall be completed by the end of the commissioning tests in the 100% power phase.

3.2.2 Prerequisites for the Performance of the Tests

(1) The tests without operation of the process systems of those parts of the instrumentation and control equipment of the safety system to be tested shall be completed, and the following documentation of the condition of the plant shall be available at least as handwritten revisions:

- a) Overview diagrams (e.g. limit signal processing plans, logic plan),
- b) Functional plans (e.g. interlocking plan),
- c) Circuit diagrams,
- d) Measuring characteristic diagrams,
- e) List of valid set points.

(2) The individual tests of the interaction with the process systems shall only be carried out when the process systems or subsystems required for this purpose are in a functioning condition.

(3) Before beginning the tests of the interaction with the process systems, a testing schedule and the testing instructions shall be prepared and agreed upon with the authorized expert (under Sec. 20 Atomic Energy Act).

3.2.3 Testing Schedule

The testing schedule in accordance with Section 3.2.2(3) shall specify the tests of interaction with the process systems. This testing schedule shall specify the systems or parts of the systems to be tested, the tests to be carried out, the associated testing instructions as well as the participation of authorized experts (under Sec. 20 Atomic Energy Act). This testing schedule should be combined into common commissioning programs with the testing schedules for the tests of the electrotechnical and process systems.

3.2.4 Testing Instructions

(1) A testing instruction consists of a description of procedure and test record form sheets.

(2) The description of procedure shall include:

- a) a designation, including state of revision, which ensures that the description of procedure can be correlated to the testing schedule,
- b) a description of the testing procedure and of the work sequence for carrying out the test,
- c) the testing conditions (e.g. plant and system conditions),
- d) the types of documents on which the tests are based,
- e) the type of the testing equipment to be used in addition to plant instrumentation, including the necessary technical data.

(3) The test record form sheet shall include:

- a) the test object, including the location of installation or testing, and the alphanumeric plant identification code,
- b) a reference to the associated description of procedure,
- c) a list of the tests according to the individual test steps to be documented,

d) the measurement parameters to be recorded, including plant identification code.

(4) During the tests, the following information shall be recorded on the test record form sheets:

- a) the test equipment used in addition to the plant instrumentation, including equipment numbers,
- b) the test results of the individual test steps,
- c) the evaluation of the test results in terms of process technology,
- d) the confirmation of successful testing, after all defects have been removed, with the tester's signature and the date of testing, as well as the signature of the authorized expert (under Sec. 20 Atomic Energy Act) if the latter participates in the test.

Note:

As a result of the information entered on the test record form sheet, it becomes a test record.

3.3 Testing Equipment Requirements

The commissioning tests shall be carried out with the testing equipment specified in the testing instructions. The testing equipment used in addition to the plant instrumentation shall be subject to a servicing and calibration service in accordance with Sec. 10 KTA 1401. The last check carried out and the time of the next check to be carried out shall be identifiable on the equipment or in a documentation that accompanies the equipment.

3.4 Testers

The commissioning tests shall be carried out by the expert personnel designated by the applicant. To the extent as provided for in the testing schedule, authorized experts (under Sec. 20 Atomic Energy Act) shall be consulted.

3.5 Documentation

The documentation of the commissioning tests shall include:

- a) testing schedule,
- b) description of procedure,
- c) test records.

These documents shall be stored by the licensee during the deployment period of the tested part of the instrumentation and control equipment of the safety system.

3.6 Testing Following Repairs

If repairs are carried out during or after completion of a commissioning test, the affected partial areas of the instrumentation and control equipment of the safety system shall be subjected to a renewed overlapping test in accordance with the testing instructions specified in Sections 3.1.5 and 3.2.4. The tests shall be documented in accordance with Section 3.5.

3.7 Testing Following System Modifications

If modifications in the instrumentation and control equipment or other modifications affecting the instrumentation and control equipment of the safety system are identified as necessary during or after completion of a commissioning test, the affected partial areas of the instrumentation and control equipment of the safety system shall be subjected to a renewed overlapping testing in accordance with the testing instructions specified in Sections 3.1.5 and 3.2.4 as soon as the relevant measures have been taken and the test documents have been

revised. The modifications and the scope of the tests shall be agreed upon with the authorized expert (under Sec. 20 Atomic Energy Act). The tests shall be documented in accordance with Section 3.5.

4 Inservice Inspections of the Instrumentation and Control Equipment of the Safety System

4.1 General Requirements

(1) During the entire life of the plant, the instrumentation and control equipment of the safety system shall be subjected to inservice inspections at specified intervals in order to demonstrate that they function as intended.

(2) Tests shall not detrimentally affect the actions to be initiated by the instrumentation and control equipment of the safety system lest an unallowable reduction of the efficiency of the safety system result.

(3) It should be possible to perform the tests in a simple manner with testing aids (e.g. test adapters, test sockets) and without having to interfere with the wiring.

(4) The first inservice inspection of the instrumentation and control equipment of the safety system shall be basically carried out before the first criticality of the plant. Systems needed for loading the reactor core shall be inspected prior to loading. If plant technology prevents inservice inspections prior to the first criticality, these tests may be carried out up to the commissioning tests in the 100% power phase, provided this is admissible from a safety point of view. If it is not admissible, substitute tests shall be agreed upon in each individual case with the authorized expert (under Sec. 20 Atomic Energy Act) and carried out in lieu of the original tests.

(5) A commissioning test in accordance with Section 3 may be accepted as the first inservice inspection if the following criteria are met:

- a) The testing instructions, including the testing aids and testing steps used, shall be identical with the testing instructions for the inservice inspection,
- b) The time interval that has elapsed since the performance of the commissioning test shall not be longer than the interval specified for inservice tests,
- c) The test instruction in accordance with Section 4.5 shall be available at the time the commissioning test is accepted as first inservice inspection.
- d) No assemblies or modifications shall have been carried out which might have detrimentally affected the instrumentation and control equipment of the safety system.

4.2 Prerequisites for the Performance of the Tests

(1) Before beginning the inservice inspections of the instrumentation and control equipment of the safety system, a testing schedule and testing instructions shall be prepared and agreed upon with the authorized expert (under Sec. 20 Atomic Energy Act).

(2) The plant shall be brought into a condition that permits a testing of the instrumentation and control equipment of the safety system in the manner specified in the testing instructions.

(3) In this context it shall be ensured that at least the minimum number of instrumentation and control equipment as well as process subsystems specified as to be available in the operating manual for the safe operation of the reactor are actually at all times available.

4.3 Testing Intervals

(1) With respect to inservice inspections of the instrumentation and control equipment of the safety system, the testing intervals shall be specified on the basis of operating experience or reliability analyses in agreement with the authorized expert (under Sec. 20 Atomic Energy Act). The periodic testing dates and the permissible deviations there from shall be specified on the basis of the testing intervals.

(2) Testing of systems which on the basis of the plant condition need not be in a functioning condition, may be suspended. New periodic testing dates may be fixed as a result. If a test was suspended, a test shall be carried out prior to or during the renewed starting of the system or of the plant.

4.4 Testing Schedule

(1) The testing schedule in accordance with Section 4.2(1) shall specify the inservice inspections of the instrumentation and control equipment of the safety system. The testing schedule shall specify the systems or subsystem to be tested, the tests to be carried out and the respective testing intervals, the plant condition, the associated testing instructions as well as the participation of authorized experts (under Sec. 20 Atomic Energy Act).

(2) On the basis of test results and operating experience, both the testing schedule and the testing instructions may be specified anew upon agreement with the authorized expert (under Sec. 20 Atomic Energy Act).

4.5 Testing instructions

(1) A testing instruction consists of a description of procedure and test record form sheets.

(2) The description of procedure shall include:

- a) a designation, including state of revision, which ensures that the description of procedure can be correlated to the relevant inspection schedule,
- b) a description of the test procedure establishing both the test procedure and the work sequence for carrying out the test and basically of the testing instrument arrangement on the basis of a schematic circuit diagram (in the case of simple measuring arrangements, no statements concerning the testing arrangement are required),
- c) the testing conditions (e.g. plant and system conditions),
- d) the type of the testing equipment to be used in addition to plant instrumentation, including the necessary technical data.

(3) The testing record form sheet shall include:

- a) the test object, including the location of installation or testing, and the alphanumeric plant identification code,
- b) a reference to the associated description of procedure,
- c) a list of the tests according to the individual test steps to be documented,
- d) specification of the simulation measures,
- e) the measurement parameters to be recorded, including alphanumeric plant identification codes, specified values and permissible deviations.

(4) During the tests, the following information shall be recorded on the test record form sheets:

- a) the test equipment used in addition to the plant instrumentation, including equipment identification numbers,
- b) the test results of the individual test steps,
- c) the determined and newly set values,
- d) defects found and the actions taken for their correction.

- e) the confirmation of the initiation and termination of the simulation condition,
- f) the reasons for deviations from the testing instruction,
- g) the evaluation of the test results,
- h) the signatures of the testers with the date of testing, and also the signature of the authorized expert (under Sec. 20 Atomic Energy Act) if the latter participates in the testing.

Note:

As a result of the information entered on the test record form sheet, it becomes a test record.

4.6 Testing Equipment Requirements

The testing shall be carried out with the testing equipment specified in the testing instruction. The testing equipment used in addition to the plant instrumentation shall be subject to a servicing and calibration service in accordance with Sec. 10 KTA 1401. The last check carried out and the time of the next check to be carried out shall be identifiable on the equipment or in a documentation that accompanies the equipment.

4.7 Testers

The inservice inspections shall be carried out by the expert personnel designated by the licensee. To the extent this is provided for in the testing schedule, authorized experts (under Sec. 20 Atomic Energy Act) shall be called in for participation in the tests.

4.8 Documentation

The documentation of the inservice inspections includes:

- a) testing schedule,
- b) description of procedure,
- c) test records.

These documents shall be stored by the licensee during the deployment period of the tested part of the instrumentation and control equipment of the safety system.

Note:

Testing schedule and description of procedure are documented in the testing manual.

4.9 Testing Following Repairs

If repairs are carried out during or after completion of an inservice inspection, the affected parts of the instrumentation, and control equipment of the safety system shall be subjected to a renewed overlapping test in accordance with the testing instructions of the commissioning tests specified in Section 3.1 and the testing instructions of the inservice inspections. The tests shall be documented in accordance with Section 4.8.

4.10 Testing Following Release Switchings and Simulations

If release switchings and simulations are carried out in parts of the instrumentation and control equipment of the safety system, and if the continued existence of these might detrimentally affect the function of the safety system, the respective partial area shall be tested in an overlapping manner as soon as all these measures have been made ineffective again. The tests shall be documented in accordance with Section 4.8.

4.11 Testing Following System Modifications

If modifications in the instrumentation and control equipment or other modifications affecting the instrumentation and control equipment of the safety system are identified as necessary, the affected parts of the instrumentation and control equipment of the safety system have to be subjected to a renewed overlapping testing in accordance with the testing instructions of the commissioning tests and inservice inspections as soon as the relevant measures have been taken and the test documents have been revised. These modifications and the scope of the tests have to be agreed upon with the authorized expert (under Sec. 20 Atomic Energy Act). The tests shall be documented in accordance with Sections 3.5 and 4.8.

Appendix A

Regulations Referred to in this Safety Standard

Regulations referred to in this safety standard are valid only in the version cited below.

Atomic Energy Act	Act on the Peaceful Use of Nuclear Energy and for the Protection against its Hazards (Atomic Energy Act) in the version made public on October 31, 1976 (BGBl. I Page 3053) modified by Act of August 20, 1980 (BGBl. I Page 1556)
KTA 1401	(02/80) General Requirements for Quality Assurance