Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 1505 (2022-11)

Suitability Verification of the Stationary Measurement Equipment for Radiation Monitoring

(Nachweis der Eignung von festinstallierten Messeinrichtungen zur Strahlungsüberwachung)

The previous versions of this safety standard were issued in 2003-11, 2011-11 and 2017-11

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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Contents

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 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 damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in the AtG, the Radiation Protection Act (StrlSchG) and the Radiation Protection Ordinance (StrlSchV) as well as further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the Interpretations of the SiAnf.

(2) The protection from ionizing radiation of persons inside and outside of the plant as well as the monitoring of the specified normal function of the equipment designated for

- retaining solid, liquid and gaseous radioactive substances within the designated enclosures,
- handling and the controlled conduction of radioactive substances within the plant, and
- monitoring the discharge of radioactive substances

is achieved among others by the stationary and the mobile radiation protection instrumentation. Safety standards series KTA 1500 specifies detailed safety-related requirements for this radiation protection instrumentation.

(3) Sec. 90 para. 1 and 5 StrlSchV, among others, requires that the radiation measurement equipment for measuring the personal dose, local dose, local dose rate, surface contamination and the activity concentration in air and water shall be suited to meet the requirements of the measurement objective.

(4) The present safety standard KTA 1505 specifies the procedures and requirements for stationary radiation measurement equipment with regard to

a) equipment-specific qualification, i.e., verification of the characteristics of the measurement equipment,

b) plant-specific suitability check, and

c) supplementary tests (cf. Section 6.3)

by which it is verified that the requirements in accordance with Sec. 90 para. 1 and 5, sentence 1a) StrlSchV are met.

(5) Requirements with regard to quality assurance are specified in safety standard KTA 1401.

1 Scope

(1) This standard applies to the suitability verification of the stationary radiation and radioactivity measurement equipment – and of the functional modules contained therein – that is permanently installed in nuclear power plants and research reactor facilities, especially with regard to fulfilling the requirements of Sec. 90 para. 1 and 5 StrlSchV. It applies to all stationary measurement equipment within the scopes of the safety standards KTA 1501, KTA 1502, KTA 1503.1, KTA 1503.2, KTA 1503.3, KTA 1504 and KTA 1507.

(2) This safety standard does not apply to the supply systems and serially connected instrumentation and control systems that are not assigned exclusively to the measurement equipment specified under para. 1.

2 Definitions

(1) Measurement equipment, stationary

Stationary measurement equipment within the scopes of the safety standards KTA 1501, KTA 1502, KTA 1503.1, KTA 1503.2, KTA 1503.3, KTA 1504, and KTA 1507 are such equipment

a) that is permanently installed,

b) that is connected to the control system and power supply, and

c) where the measurement signals are displayed and recorded in the control room.

(2) Functional monitoring during type testing

Functional monitoring during type testing is a test procedure by which the functional capability of the test objects is continuously monitored when performing the individual type testing steps.

(3) Intermediate functional test during type testing

Intermediate functional test during type testing is a test procedure by which the functional capability of the test objects is checked at particular hold points between certain type testing steps.

(4) Critical load test

The critical load test is a test by which the behavior of the measurement equipment with respect to its individual measurement task is determined for the worst possible combination of operating and ambient conditions.

(5) Measurement equipment

Measurement equipment encompasses all measurement and auxiliary devices necessary for determining a measurement parameter, for transmitting and adjusting the measurement signal and for displaying the measured value as a representation of the measurement parameter.

(6) Plant-independent tester (radiation and radioactivity surveillance)

Plant-independent tester is a person competent in the field of radiation and radioactivity surveillance who, in accordance with legal requirements, standards, guidelines, provisions or orders, is required to be consulted during a test. This person shall neither be involved in the manufacturing or marketing of the measurement equipment to be tested, nor shall this person represent other interests of the manufacturer.

3 Verification of Suitability

3.1 General Objective

(1) Within the framework of the nuclear licensing and supervisory procedures it shall be verified that the measurement equipment is suited for the respective measurement objective.

(2) The suitability of measurement equipment is considered verified if it is documented that the individual measurement equipment achieves the measurement objective at the location assigned to this equipment and for the particular operating and ambient conditions.

3.2 Procedure

3.2.1 Description of measurement task

(1) The measurement task shall be described. This shall present the measurement objectives, the measurement parameters to be determined, the requirements from the Radiation Protection Act (StrlSchG), the Radiological Protection Ordinance (StrlSchV) and from KTA safety standards as well as the safety-related and radiological significance of the measurement results.

(2) The ambient conditions at the designated measurement location as well as the possible influence parameters affecting the measurements shall be determined for the respective measurement equipment. Any resulting special requirements for the measurement equipment or for the functional units contained therein shall be specified.

3.2.2 Required documents

(1) Measurement equipment-specific and plant-specific documents shall be prepared for determining all characteristics that are required with regard to the functional capability of the measurement equipment at the designated location. These documents shall contain the following information:

a) description of the construction and function of the measurement equipment which shall include a data sheet (e.g., specification of the measurement parameter, measurement range, detection limit, energy dependence),

b) description of the ambient conditions (e.g., temperature, humidity, pressure, dose rate, acceleration),

c) description of the measurement medium (e.g., temperature, humidity, pressure, flow rate, chemical composition, activity concentration),

d) description of the power and auxiliary media supply (e.g., electrical power, control air, counter gas),

e) description of the interfaces to peripheral devices, supply systems and media-containing systems (e.g., sampling procedure, assembly, physical positioning),

f) description of reliability requirements taking into account any available redundancies or diverse equipment and any precautionary measures regarding permissible outage times (e.g., replacement measures, replacement part strategy).

g) description of the programming software (e.g., phase model, program architecture, stability, validation, standard software, requirements with respect to operation, security and programming changes).

(2) The safety-related significance of the measurement task and the characteristics of the measurement equipment shall be the determining factors for the length of individual documents and the depth of descriptions.

N o t e :

The different length and different depth may result

a) from the respective measurement equipment, in particular with regard to the safety-related significance of the measurement task for which the measurement equipment is intended to be qualified,

b) from the individual measurement task, in particular with regard to the quality characteristics (e.g., self-monitoring, plausibility checks, repair possibilities) of the measurement equipment designated to achieve this measurement task,

c) from the individual measurement task, in particular with regard to the available redundancies and diverse equipment.

3.2.3 Verification of characteristics

3.2.3.1 **L**ist of **C**haracteristics to be **V**erified (LCV)

(1) Based on the description of the measurement task and the documents specified under Section 3.2.2, a list (LCV) shall be compiled of all those characteristics of the measurement equipment that are necessary for achieving the measurement task and which are required to be verified in accordance with Section 4.

(2) For each characteristic, the list LCV shall list the individually applicable verification procedure specified under Section 3.2.3.2.

3.2.3.2 Permissible verification procedures

The individual characteristics listed in the list LCV shall be verified either by

a) type testing,

b) individual test certification,

c) satisfactory performance in service,

d) acknowledgement of suitability verifications from other legal nuclear procedures, or

e) trial operation.

3.2.4 Document review and documentation

(1) The documents specified under Sections 3.2.1, 3.2.2 and 3.2.3 shall be submitted to, and reviewed by the proper authority. The document review shall be closed in a test report.

(2) The documents submitted for document review and the test report shall be archived in the test documentation.

4 Requirements for Verification Procedures

4.1 Type Testing

(1) The type testing of measurement equipment shall be performed as a plant-independent suitability test on the basis of analytical and practical proofs. The procedure of type testing is described in **Appendix A**. Requirements regarding the tests of physical characteristics are presented in **Appendix B**.

(2) If individual components of the measurement equipment have already been subjected to type testing (e.g. detector, several electronic moduls), the validity of the results of these type tests shall be acknowledged.

4.2 Individual Test Certificates

If individual test certificates regarding specific characteristics of the measurement equipment are available that were performed in accordance with DIN IEC standards by qualified national or international testing laboratories, they shall be acknowledged, provided, the following requirements are met:

a) At the point in time of type testing the measurement equipment must be identifiable with regard to type and state of development (technical realization).

b) The individual tests must have been performed by a plant-independent tester or by a plant expert of the manufacturer.

c) The individual tests must have been documented such that they are verifiable with respect to the test sequence, test parameters, applied measurement media and methodology and the test results.

d) A description of the quality assurance system applied to items a), b) and c) must be available.

4.3 Satisfactory Performance in Service

(1) Satisfactory performance in service shall be verified by evaluating records from operation of the measurement equipment for the past service life; this evaluation shall be based on the characteristics and ambient conditions specified for the measurement equipment during its service life. The records to be evaluated shall cover at least one year.

(2) It shall be shown that the particular operating and ambient conditions for the term of past operation specified under para. 1 are comparable to the planned operating and ambient conditions.

(3) The records documenting the term of past operation of the measurement equipment shall be evaluated. This evaluation shall, particularly, take into consideration:

a) individual and overall duration of operation,

b) failure rates and rates of malfunctions,

c) servicing and test results, and

d) drift behavior.

(4) The documentation on servicing, repairs and inservice inspections shall be evaluated with regard to:

a) type and extent,

b) causes, and

c) assessment of failures or of impermissible deviations from the nominal condition.

(5) In case of series-produced components, deviations from the analyses and evaluations specified under paras. 2, 3 and 4 are permissible, provided, the specified and assured characteristics of these components already cover these points.

(6) The determination of satisfactory service in operation for the designated measurement equipment may also be based on the results from measurement equipment that is not identical in design and construction, provided, it is verified for any deviations that the design of this other measurement equipment is comparable and that comparable components and structural elements are used.

4.4 Acknowledgement of Suitability Verifications from other Nuclear Legal Procedures

If the suitability of the measurement equipment or individual components of the measurement equipment has already been certified in accordance with the present safety standard, albeit, in another nuclear legal procedure, this verification shall be acknowledged under consideration of the required operating conditions and current bases for testing.

4.5 Trial Operation

In case individual characteristics of the measurement equipment cannot be verified by a procedure specified under Section 3.2.3.2 items a) through d), they may be verified by trial operation. In this case, the individual characteristics shall be evaluated and documented on the basis of operating records covering a certain to be specified time period.

5 Documents for the Measurement Equipment

5.1 Equipment-Specific Documents

5.1.1 General requirements

(1) The equipment-specific documents shall identity the manufacturer, the type and state of revision of the equipment and shall include details of the respective programming software. These shall include a document index and the documents specified under Sections 5.1.2, 5.1.3 and 5.1.4.

(2) With regard to a proper identification of the programming software, the program code itself and the label on the respective data carrier shall contain the name or abbreviation of the software and the version number. Verification of the properly tested software version and of the required operating system shall be documented.

5.1.2 Functionality description

(1) The functionality description of the measurement equipment shall present information about the range of application, the objective and operating principle of the measurement equipment.

(2) With the help of conceptual flow diagrams, of wiring diagrams, construction drawings, listings of the modules as well as positioning plans of the components the mechanical and functional design of the measurement equipment shall be described in such a way that a fulfillment of the measurement task under the specified boundary conditions is verifiable.

(3) In the case of software-based measurement equipment, the available functions shall be described. This description shall cover all functions with regard to, e.g., measurement, calibration, controls, parametric configuration, testing and self-monitoring. With regard to evaluation functions, the signal processing and applied algorithms shall be described.

(4) All operating conditions and operating modes specified for the measurement equipment shall be described.

5.1.3 Data sheet

(1) The data sheet shall contain all data characterizing the measurement equipment including the bandwidth of permissible data deviations. The data sheet shall contain information regarding, e.g.:

a) input variables,

b) output variables,

c) data formats of the input data and output data,

d) auxiliary power,

e) permissible ambient conditions and environmental influences,

f) transfer behavior and calibration factors,

g) interference from radiation fields,

h) electrical characteristics, and

i) electromagnetic compatibility (EMC) behavior.

(2) Superordinate system data may be compiled in a separate system data sheet.

5.1.4 Measurement equipment manual and system manual

(1) The manual of the measurement equipment shall normally contain the following:

a) operating instructions including a user-oriented documentation of the software,

b) installation instructions,

c) commissioning instructions,

d) adjustment instructions,

e) testing instructions,

f) information on special accessories,

g) information regarding servicing and testing possibilities, and

h) packaging and storing instructions.

(2) Component-related data may be summarized in a system manual for the measurement equipment**.**

5.2 Additional Information

5.2.1 Reliability

Information shall be presented regarding the reliability data of decisively important components and regarding the estimation of the expected probability of failure of the measurement equipment under nominal conditions. In this context, it is permissible to employ data derived from operating experience. The drift and wear behavior as well as the concept for servicing and in-service inspections shall be taken into consideration.

N o t e :

Decisively important components regarding reliability are, e.g., photo multipliers, hard disks, detectors, moving parts, functionally important seals, batteries and the programming software.

5.2.2 Design

(1) The electrical, physical, radiological and thermal design of the measurement equipment shall be described with regard to the loading of critical components.

(2) A certified stress analysis shall be provided for the pressurized components.

5.2.3 Material certification

The materials shall be specified that are used for those components that come in contact with the measurement medium. Also any interactive reactions with the measurement media shall be specified.

5.2.4 Functional tests

Written documents shall be presented in which the procedure for testing the equipment function during the later operation is described under consideration of radiological protective measures and of possible repercussions on the condition of the plant.

6 Examinations

6.1 Documents

All documents specified under Sections 3.2.4, 4.1 through 4.5 and 5 shall be submitted for examination.

6.2 Objective of the Examination

Objective of the examination is to prove the suitability of the measurement equipment. In this context it is required

a) to evaluate the measurement equipment and the measurement principle with regard to proper execution of the measurement task,

b) to verify on the basis of a comparison of the documents that the characteristics specified in the list LCV have been achieved,

c) to confirm that the measurement equipment is suitable for the measurement task in the designated plant, and

d) to confirm, in the case of software-based measurement equipment**,** that the functions realized are correctly installed and parameterized.

6.3 Supplementary Examinations

If the examination shows that the documents specified under Sections 4.1 through 4.5 are not sufficient to be able to verify all characteristics listed in the list LCV, it is permissible to verify the respective characteristics by a complementary test or an additional qualification (e.g., expanded factory test, expanded commissioning test or trial operation).

6.4 Test Report

(1) The examinations shall be written up in a test report that shall describe the relevant facts and enable verifying the evaluation. The results of previous examinations shall be taken into consideration.

(2) The test report shall substantiate on the basis of the evaluation of the submitted test documents that the objective of the examination as specified under Section 6.2 has been achieved. The individual test documents concerned are:

a) document specifying the measurement task in accordance with Section 3.2.1 para. 1,

b) plant-specific documents in accordance with Section 3.2.1 para. 2,

c) **L**ist of the **C**haracteristics to be **V**erified (LCV) in accordance with Section 3.2.3.1 including indication of the verification procedure chosen for each of the listed characteristics,

d) verification for each of the characteristics listed in LCV. Depending on the individual verification procedure chosen, these are:

   da) records documenting the satisfactory performance in service in accordance with Section 4.3,

   db) available individual test certificates in accordance with Section 4.2 including the respective test documentation,

   dc) results of a type test performed in accordance with Section 4.1 including its test certification and test report,

   dd) acknowledgement of the suitability verification from other legal nuclear procedures in accordance with Section 4.4,

   de) results of a trial operation in accordance with Section 4.5,

e) specific documents for the measurement equipment in accordance with Section 5, and

f) documents of the results of the supplementary examinations in accordance with Section 6.3.

(3) The test report shall contain at least the following information:

a) manufacturer of the tested measurement equipment,

b) name and type of the measurement equipment including the state of revision,

c) identification of the tested software version and of the operating system used,

d) list of the test documents used,

e) **L**ist of **C**haracteristics to be **V**erified (LCV) including the respective verification procedures,

f) confirmation that the suitability has been verified,

g) place and date, and

h) organization, name and signature of the tester.

6.5 Test Certificate

The suitability verification shall be substantiated by a test certificate.

7 Documentation

7.1 Documentation of Test Documents Used

All documents cited for the examinations and in the test report in accordance with Section 6.4 shall be compiled in a special documentation.

7.2 Documentation of the Examinations

The test report specified under Section 6.4 and the test certificate specified under Section 6.5 shall be included in the documentation.

7.3 Place and Duration of Document Storage

The test documentation shall be stored and archived in accordance with requirements specified safety standard KTA 1404.

Appendix A

Type Testing of Measurement Equipment

A 1 General Requirements

A 1.1 Objective

(1) The objective of type testing is to verify independently of the designated plant that the specified characteristics are achieved by the respective type of equipment. This entails performing theoretical and practical tests with regard to the respective measurement task to be carried out. Type testing may also be applied analogy to individual components of the measurement equipment.

(2) The verification of the specified characteristics is considered as the theoretical verification that the measurement equipment is suited to fulfill the specific measurement tasks specified in the relevant KTA safety standards and that the measurement equipment meets the requirements with respect to the measurement objective in accordance with Sec. 90 para. 5, sentence 1a) StrlSchV.

(3) The verification of the specified characteristics of the measurement equipment is required to be confirmed by a plant-independent tester.

A 1.2 Procedure

(1) The procedure of type testing shall be subdivided into the following three phases:

Phase 1: Preparations for the theoretical and practical tests

Phase 2: Theoretical test

Phase 3: Practical test

(2) During Phase 1 of type testing, the documents required for the theoretical and practical tests shall be prepared by the manufacturer. These documents shall include, in particular,

a) description of the measurement task (documents as specified under Section 3.2.1),

b) description of the measurement equipment (documents as specified under Section 3.2.2 and Section 5),

c) **L**ist of the **C**haracteristics to be **V**erified (LCV, as specified under Section 3.2.3.1),

d) program and corresponding test instructions for performing the practical test.

(3) In Phase 2 of type testing, the plant-independent tester shall check the documents prepared in Phase 1 for completeness and accuracy of the presented data by comparing the characteristics to be tested with the requirements from the measurement task and by performing a plausibility check of the presented data.

(4) In Phase 3 of type testing, the characteristics specified in list LCV shall be verified by carrying out practical tests. The objective, here, is to prove the functional capability of the measurement equipment under specified conditions. If individual characteristics listed in LCV have already been confirmed in practical tests performed with participation of a plant-independent tester, or if documented results of their satisfactory performance in service are presented, then these test results shall be acknowledged.

A 2 Theoretical Tests

(1) The theoretical test in Phase 2 includes reviewing the equipment documents specified under Sections 5.1, reviewing the additional information specified under Section 5.2, as well as reviewing the test instructions for performing the practical tests. In this context, the documents shall be evaluated with regard to plausibility and detectable weak points taking the objectives of the examination specified under Section 6.2 into account.

(2) The safety-related significance of the measurement task and the characteristics of the measurement equipment documented as specified under Section 3.2 shall be taken into account.

A 3 Practical Test

A 3.1 General Requirements

(1) The objective of the practical test is to verify the functional capability of the measurement equipment in experiments under specified conditions. Basis for the test is the list LCV.

(2) The influence parameters specified in list LCV shall be individually varied within their nominal operating range. At the same time, the other influence parameters shall be adjusted to their reference values.

Note:
Reference values of influence parameters are specified, e.g., in Table 5-1 of safety standard KTA 1503.1.

A 3.2 Selecting Measurement Equipment for Testing (Test Objects)

(1) A minimum of one measurement equipment shall be selected for type testing. This shall be a factory tested unit. All testing steps of the practical test shall normally be performed on the same test object.

(2) The test objects shall be marked.

(3) The test objects may be selected from the pilot lot. In case of a small-series production, it is permissible to select an individually fabricated unit as test object.

(4) It is permissible to perform type testing in parallel with the development process.

(5) A summary report shall be prepared describing the individual history of the test objects. This summary report shall contain at least information regarding fabrication facility, date of fabrication, dates of factory tests, the storage times and other loading conditions of the test objects incurred prior to type testing.

A 3.3 Tester and Test Instructions

(1) The manufacturer is responsible for the preparation of the test documents and for the execution of the practical tests.

(2) The test instructions for the practical tests specified under Section A 3.5 shall be coordinated between manufacturer and plant-independent tester; the latter shall specify the extent of his participation for the individual test steps.

A 3.4 Testing Locations and Testing Facilities

The quality of the testing locations, testing facilities and associated measuring equipment shall be such that the test requirements specified in this safety standard are met.

A 3.5 Test Instructions for the Practical Tests

The test instructions shall describe the type of the tests, the testing facilities and the execution of the practical tests (sequence and extent of the test steps).

A 3.6 Identity Check

An identity check shall be performed to assure that the test objects including the associated programming software are in conformance with the documents specified under Section 5 for the measurement equipment.

A 3.7 Functional Tests

(1) Proper functioning of the measurement equipment shall be checked in accordance with the test instructions specified under Section A 3.5.

(2) In case the test objects contain multiple functional modules, each of these functional modules may be tested individually. The respective interfaces shall be tested by overlapping tests.

A 3.8 Intermediate Functional Tests

The adjustment conditions for the intermediate functional tests shall be selected such that changes of the measurement equipment characteristics caused by the directly preceding test steps can be detected.

A 3.9 Functional Monitoring

(1) The functioning of the test object shall be monitored during those tests in which the test object is normally required to be in operation.

(2) The relationship between the input and the output signals characteristic for the measurement task shall be monitored. In case a radiation detector is integral part of the test object, this detector shall be subjected to a suitable radiation field during functional monitoring.

(3) Functional monitoring shall be carried out such that even short-term changes of the output variables or functional failures of the measurement equipment can be detected, however, only if these events are relevant to the tested function.

A 3.10 Sequence of the Practical Tests

(1) The practical tests of measurement equipment not required to be resistant to ambient conditions from design basis accidents shall be subjected to practical tests normally in the following sequence:

a) identity check of the finished measurement equipment, as specified under Section A 3.6,

b) functional tests and tests of the electrical characteristics,

c) climate tests,

d) tests regarding resistance to radiation,

e) mechanical loadings,

f) repeating selected test steps of the functional tests, and

g) electromagnetic compatibility (EMC).

(2) The practical tests of measurement equipment that is required to be resistant to ambient conditions from design basis accidents shall be subjected to the associated practical test normally directly after the mechanical loading tests and before the climate tests and the repeating selected test steps of the functional tests.

A 3.11 Measures in Case of Failures during Practical Tests

In case of failure, the time of failure and the failure effect shall be determined. An investigation report shall be prepared which shall present information regarding the investigation performed and the determined cause of failure. If the investigation reveals a systematic failure, corresponding strengthening measures shall be carried out. If no systematic failure must be assumed, then the measurement equipment shall be repaired, the identity check and functional tests performed and, subsequently, test steps of the practical test shall be continued beginning with the test step where the interruption occurred. However, the extent of practical tests to be repeated shall be coordinated with the plant-independent tester.

A 3.12 Deployment of Tested Measurement Equipment

(1) The test objects may be deployed for use, provided, type testing was successfully completed and the test objects are verified as not having been previously damaged.

(2) This may be verified by repeating the functional test specified under Section A 3.7.

A 4 Test Certification and Test Documentation

A 4.1 Test Report

The type test together with gained insights shall be written up in a test report that shall describe the decisively important facts and, thus, shall enable verification of the evaluation. The results of any prior type tests shall be taken into account.

A 4.2 Test Certificate

The completed type test shall be verified by issuing a test certificate.

A 4.3 Test Documentation

All documents used for the type test, the test results, the test report and the test certificate shall be included in a test documentation.

Appendix B

Requirements for Tests of Technical Characteristics

B 1 General Requirements

(1) In the following sections, requirements for the tests of a number of technical characteristics of the stationary measurement equipment are specified.

(2) The requirements for the tests shall be met within the framework of the chosen verification procedure, provided, the corresponding characteristic is contained in the **L**ist of **C**haracteristics to be **V**erified (LCV).

B 2 Tests

B 2.1 Response Capability (Calibration)

(1) The response capability shall be determined for the specified radionuclides and energy ranges.

(2) A calibration certificate of the radioactivity source shall identify its radioactivity in terms of a national technical standard.

B 2.2 Calibration Transfer

In order to enable transferring the calibration, transfer values shall be determined with at least one solid calibration source in a defined geometry. These transfer values shall normally make it possible to check the response capability of design-identical measurement equipment.

B 2.3 Detection Limit

The detection limit of the measurement equipment shall be determined under the reference conditions specified in the corresponding KTA safety standard.

B 2.4 Minimum Background Level

The minimum background level of the equipment shall be determined. The values of those influence parameters that have an effect on the minimum background level shall be specified.

B 2.5 Characteristic

The (specified) relationship between input value and output value shall be checked over the entire measurement range.

B 2.6 Time Behavior

The time behavior of the output signal shall be tested with respect to a sudden increase and decrease of the measurement value or input value.

B 2.7 Resistance to Overshooting

It shall be ascertained by tests that a measured value exceeding the full-scale value of the measurement range is not displayed as a value smaller than the full-scale value of the measurement range.

B 2.8 Adjustable Parameters

The adjustment accuracy of adjustable parameters and the effects of the adjustment of these parameters shall be tested. This test shall involve, at least, setting the parameters to the beginning value and the end value of the permissible measurement range. Additional check points may result from the description of the measurement task.

B 2.9 Characteristics of the Output Signal

The specified characteristics of the output signal shall be tested (e.g., impedance, pulse shape, amplitude).

B 2.10 Critical Load Tests

Individual values of the test parameters, i.e.,

a) input signal,

b) output load,

c) ambient temperature, and

d) auxiliary power,

shall be combined at the limits of their respective nominal range of operation. Restrictions with respect to the combination of parameter values shall be substantiated.

B 2.11 Radiological Interference

The influence of ionizing background radiation on the measurement signal shall be determined. The designated shielding of the detector should be installed when performing this test. Ambient background radiation may be simulated by suitable radioactive test sources. Typical radioactive test sources are cobalt-60 and cesium-137.

B 2.12 Electrical Characteristics

B 2.12.1 General requirements

(1) The maximum current consumption of the measurement equipment shall be determined.

(2) The maximum occurring power dissipation of the measurement equipment shall be determined with regard to heat emission.

(3) The restart capability of the system after failure of the measurement equipment due to power loss shall be determined in practical tests. Within the framework of reviewing documents of the measurement equipment in accordance with Section 5, it shall be tested which combination of partial failures must be considered in these practical tests; it shall also be specified whether or not malfunctions must be expected to occur on account of a non-specified sequence of the return-to-function of partial systems.

(4) The short-circuit resistance of the signal output sockets and power supply sockets shall be tested with special regard to preventing fire and destruction of the measurement equipment.

(5) Tests shall be performed to prove the proper absence of feedback.

(6) The insulation resistance shall be tested.

(7) In case of a tendency for electrical oscillations, this tendency shall be tested under consideration of the specifications in the data sheet.

(8) The signal-to-noise ratio of the input signal shall be tested.

B 2.12.2 Behavior of the test object during plugging procedures

(1) If the electrical input and output current circuits are designed as plug-in connections, they shall be tested by a sufficiently high number of unplugging and plugging operations.

(2) If the plug-in connection is designed for, e.g., inservice inspections, then 100 of these plugging cycles shall normally be performed in this test.

(3) If the plug-in connection is designed to be used only on special occasions, e.g., during repair of a device, then 10 of these plugging cycles shall be performed in this test.

(4) The tests shall be performed under electrical load, unless this is prohibited by the manufacturer.

B 2.12.3 Power interruption

A test shall be performed to check whether or not a power interruption would cause a malfunction of the measurement equipment.

Note:
In case measurement equipment is operated with alternating current, it would be advantageous to design the equipment for power interruptions of up to 150 ms on account of bus bar switching.

B 2.12.4 Electromagnetic compatibility (EMC)

The electromagnetic compatibility of the measurement equipment shall be checked experimentally. This test shall be based on the requirements in accordance with legal regulations. Deviations from certain requirements of the industrial EMC standards (DIN EN 61000-6-2, DIN EN 61000-6-4) are permissible that are based on the scope of the measurement equipment's application.

B 2.13 Climate Tests

(1) Within the framework of climate tests it shall normally be verified that the functional capability of the measurement equipment is not impaired by any of the climatic loading permissible during transport, storage and operation.

(2) A visual examination and an intermediate functional test should be performed after each climate test.

(3) In case maximum permissible temperature gradients are specified for the measurement equipment**,** these gradients shall be taken into consideration when specifying the climate test conditions.

B 2.13.1 Constant low temperatures

It shall normally be verified that the measurement equipment is suited for transport or storage at low temperatures. In this test, the measurement equipment in a non-operating state and starting at room temperature shall be subjected to the minimum permissible storage temperature at constantly low temperatures for a test duration of 24 hours.

B 2.13.2 Constant dry heat

It shall normally be verified that the measurement equipment is suited for transport or storage in dry heat. In this test, the measurement equipment in a non-operating state and starting at room temperature shall be subjected to the maximum permissible storage temperature at constantly dry heat for a test duration of 24 hours.

B 2.13.3 Constant heat and humidity

It shall normally be verified that the measurement equipment is suited for storage and operation at constant heat and high humidity. In this test and unless otherwise specified, the measurement equipment shall be subjected to the following loading for a test duration of 24 hours:

a) temperature: (40 $\pm$ 2) °C

b) relative humidity: (93 $\pm$ 3) %

c) operating condition:

ca) test object in storage (not in operation)

cb) test object in operation with a cyclical change of the supply voltage between U_{max} and U_{min} every six hours of the test duration.

B 2.13.4 Long-term testing

(1) It shall normally be verified that the measurement equipment is suited for long-term operation with particular attention paid to the drift behavior of the equipment.

(2) Prior to the test, the temperature of the measurement equipment shall have adjusted to the initial temperature of the testing chamber, (25 $\pm$ 3) °C.

(3) Within the next hour, the temperature in the testing chamber shall be increased to the maximum permissible ambient temperature (T_{max}) for operation of the measurement equipment as specified in the data sheet.

(4) The measurement equipment shall then be cyclically loaded as follows:

a) The cycle period shall be 24 hours.

b) In each cycle, the duration of stress at the upper temperature (T_{max}) shall last at least 20 hours, and at the lower temperature, (25 $\pm$ 3) °C, at least two hours.

c) The measurement equipment shall be in operation with a cyclical change of the supply voltage between U_{max} and U_{min} every 24 hours of the test duration. Intermediate values of the supply voltage in accordance with the data sheet are permissible during change of the supply voltage.

d) The overall test duration shall be at least 1000 hours.

B 2.14 Verification of Radiation Resistance

In case the specified normal operation of the measurement equipment includes radiation exposure, the radiation resistance shall be verified. If, in addition, a maximum permissible integrally absorbed dose is specified for the measurement equipment**,** it shall be verified that the measurement equipment remains functional even after absorption of this dose. These verifications shall be performed experimentally or analytically. In case of an analytical verification, the sources of the data used shall be documented.

B 2.15 Mechanical Loading

(1) If the measurement task so requires, verification of the functional capability shall also include induced shocks from

a) vibrations at the location of installation,

b) earthquakes, or

c) aircraft crash.

(2) It shall be verified that the functional capability of the measurement equipment is not impaired by the specified mechanical loadings. The test steps for the verification of para. 1, item a) shall normally be performed in accordance with safety standard KTA 3504 and for the verification of para. 1, items b) and c), in accordance with safety standard KTA 3505.

B 2.16 Tests under the Ambient Conditions from Design Basis Accidents

(1) In case the measurement equipment is intended for operation under the ambient conditions from design basis accidents, their behavior under the respective pressure, temperature, humidity and radiation including their duration that are specified in list LCV shall be investigated.

(2) A visual examination and an intermediate functional test shall normally be performed before and after the respective type of loading.

(3) The load-over-time sequence of the test shall be specified in a diagram (test curve). This diagram shall normally include the values for pressure, temperature and humidity, the rising and falling gradients and the dwelling times, as well as the respective permissible deviations. The test object shall be subjected to these loadings.

(4) The measurement equipment shall be in operation and in the normal position of use. Input and output values shall be recorded.

(5) The testing facility shall be designed such that

a) the steam outlet nozzles are positioned in a way that the test objects will not be subjected to a direct steam jet or that, at least, a dispersion plate is installed, and

b) the temperature sensors for determining the temperature of the testing chamber are not positioned in the steam jet and not on the test object.

(6) Measurement equipment which is planned for operation under radiation exposure shall first be verified as being radiation resistant in accordance with the list LCV. This requires, either, that an irradiation test be physically performed or that the radiation resistance be verified analytically. In case of an analytical verification, the sources of the data used shall be documented.

(7) In order to verify the behavior under design basis accident conditions, an irradiation test shall be performed in addition to the requirements under para. 6. The testing parameters regarding absorbed dose and absorbed dose rate shall be specified as a function of the respective ambient radiation conditions.

(8) During the irradiation test, the measurement equipment shall be in operation. The input and output values shall be recorded.

(9) The following additional requirements shall be met when performing the irradiation test:

a) The measurement equipment may be irradiated with gamma rays and under atmospheric conditions (oxygen content of the air).

b) It shall be ensured that the measurement uncertainty of the dosimetric measurement procedure does not exceed ± 30 % of the measured value. The choice of the measurement procedure may be left up to the examiner performing the test.

c) The test object shall normally be subjected to an ambient climate with the temperature in the range between 18 °C and 28 °C (tolerance ± 2 K) and a humidity of up to 75 %. If the required constancy of the temperature cannot be achieved, then the ambient temperature shall be recorded during the irradiation.

Appendix C

Regulations Referred to in this Safety Standard

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

AtG		Act on the Peaceful Utilization of Atomic Energy and the Protection against its Haz-ards (Atomic Energy Act) Atomic Energy Act in the version promulgated on July 15, 1985 (BGBl. I, p. 1565), most recently changed by article 1 of the act dated December 4, 2022 (BGBl. I, p. 2153)
StrlSchG		Act on the Protection against the Harmful Effect of Ionising Radiation (Radiation Protection Act - StrlSchG) Radiation Protection Act of June 27, 2017 (BGBl. I, p. 1966), most recently changed by the promulgation of January 3, 2022 (BGBl. I, p. 15)
StrlSchV		Ordinance on the Protection against the Harmful Effects of Ionising Radiation (Radiation Protection Ordinance - StrlSchV) Radiation Protection Ordinance of November 29, 2018 (BGBl. I, p. 2034, 2036), most recently changed by article 1 of the ordinance dated October, 2021 (BGBl. I p. 4645)
SiAnf	(2015-03)	Safety Requirements for Nuclear Power Plants (SiAnf) of November 22, 2012, amended version of March 3, 2015 (BAnz AT 30.03.2015 B2), most recently changed as promulgated by BMUV on February 25, 2022 (BAnz AT 15.03.2022 B3)
Interpret of SiAnf	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, of November 29, 2013 (BAnz AT 10.12.2013 B4), changed on March 3, 2015 (Banz AT of March 30, 2015 B3)
KTA 1404 Draft	(2022-11)	Documentation during the construction and operation of nuclear power plants
KTA 1401	(2017-11)	General Requirements Regarding Quality Assurance
KTA 1501	(2022-11)	Stationary System for Monitoring the Local Dose Rate within Nuclear Power Plants
KTA 1502	(2022-11)	Monitoring Radioactivity in the Inner Atmosphere of Nuclear Power Plants
KTA 1503.1	(2022-11)	Surveilling the Release of Gaseous and Aerosol-bound Radioactive Substances; Part 1: Surveilling the Release of Radioactive Substances with the Stack Exhaust Air During Specified Normal Operation
KTA 1503.2	(2022-11)	Monitoring the Discharge of Gaseous and Aerosol-bound Radioactive Substances; Part 2: Monitoring the Stack Discharge of Radioactive Substances During Design Basis Accidents
KTA 1503.3	(2022-11)	Monitoring the Discharge of Gaseous and Aerosol-bound Radioactive Substances; Part 3: Monitoring the Non-stack Discharge of Radioactive Substances
KTA 1504	(2022-11)	Monitoring and Assessing of the Discharge of Radioactive Substances in Liquid Effluents
KTA 1507	(2022-11)	Monitoring the Discharge of Radioactive Substances from Research Reactors
KTA 3504	(2022-11)	Electrical Drive Mechanisms of the Safety System in Nuclear Power Plants
KTA 3505	(2015-11)	Type Testing of Measuring Sensors and Transducers of the Safety-Related Instrumentation and Control System
DIN EN IEC 61000-6-2	(2019-11)	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments (IEC 61000-6-2:2016); German version EN IEC 61000-6-2:2019
DIN EN IEC 61000-6-4	(2020-09)	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments (IEC 61000-6-4:20182019); German version EN 61000-6-4:2007