Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3503 (11/2005)

Type Testing of Electrical Modules for the Safety Related Instrumentation and Control System

(Typprüfung von elektrischen Baugruppen der Sicherheitsleittechnik)

Previous versions of this safety standard were issued in 06/82 and 11/86

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

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KTA SAFETY STANDARD

November 2005	**Type Testing of Electrical Modules for the Safety Related Instrumentation and Control System**	KTA 3503

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KTA 3503 11/86 (BAnz. No. 93a of May 20, 1987)

Contents

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 BAnz No. 101a of May 31, 2006. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, 50939 Koeln, Germany (Telefax +49-221-94373603).

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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 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) in order to attain the protective goals specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and further detailed in the "Safety Criteria for Nuclear Power Plants" and in the "Guidelines for the Assessment of the Design of Nuclear Power Plants with Pressurized Water Reactors Against Design Basis Accidents as Defined in Sec. 28, para. 3 StrlSchV – Design Basis Accident Guidelines" (the version released Oct. 18, 1983).

(2) Based on the Safety Criteria for Nuclear Power Plants issued by the Federal Interior Ministry, and here, specifically, on Criterion 5.1 "Monitoring and Alarm Equipment", Criterion 6.1 "Reactor Protection System" as well as the superordinate Criterion 2.1 "Quality Assurance", the safety standard KTA 3501 specifies, in particular, that if a successful service cannot be demonstrated for newly developed or modified electrical modules, type approval tests shall be performed before these electrical modules are employed in the reactor protection system.

(3) It is a basic assumption that the conventional provisions and standards (e.g., German Accident Prevention Provisions, DIN standards and VDE regulations) are met unless other nuclear power plant specific requirements are specified.

(4) The type approval tests in accordance with this safety standard are performed by authorized experts to evaluate whether or not the electrical modules are in accordance with the data sheet and have the specified characteristics.

(5) Requirements with respect to the type testing of measuring sensors and transducers for the safety-related instrumentation and control system are specified in safety standard KTA 3505.

(6) Requirements with respect to demonstrating the successful service are specified in safety standard KTA 3507.

(7) Requirements with respect to quality assurance and documentation are specified in safety standards KTA 1401, KTA 1404, KTA 3506, and KTA 3507.

1 Scope

This safety standard applies to the type approval test of those electrical modules for the safety-related instrumentation and control system in accordance with safety standard KTA 3501 that perform measurement and control functions in accordance with Class A of DIN IEC 61226.

2 Definitions

(1) Ageing

Aging is the change over time of the physical, chemical or electrical characteristics of a electrical module or component under operating conditions as specified in the design, in so far as these changes have a significantly adverse effect on the specified characteristics (technical data in accordance with the data sheet).

(2) Common-mode failure

A common-mode failure is the failure of several components on account of a similar cause.

Note:
A common-mode failure can be caused, e.g., by a faulty design or by faults in a production batch.

(3) Functional unit

A functional unit is an item that is delimited within a system either on account of its task or its function.

Note:
From the design point of view, a functional unit may be realized as an individual module, as a group of several modules or as part of an individual module.

(4) Type approval test

The type approval test is a test performed on representative samples of a production batch (type series) in order to ascertain the characteristics specified in the data sheet and in the functional description.

(5) Qualification of a module

Qualification of a module is the certification based on type testing, on analyses or on operating experience that this module, under the operating and ambient conditions to be assumed, will operate in compliance with the required accuracy and specified characteristics (technical data in accordance with the data sheet).

3 Test Procedures

(1) The type approval test of a module shall be subdivided into the theoretical examinations and the physical tests.

(2) Any available operating experience and the results of previously performed tests may be taken into consideration in the type approval test, provided, the safety-related requirements under this safety standard are fulfilled.

(3) In the case of software-based modules, the test of the software and its quality characteristics shall be performed within the framework of the theoretical examinations, and the functional test shall be performed within the framework of the physical tests.

(4) The employed interfaces of the test objects shall be subjected to the same conditions as the test object itself.

(5) Any modifications on type-tested modules shall be subjected to tests in accordance with the basic principles of this safety standard. These tests may be theoretical examinations or physical tests or a combination of two test procedures.

4 Theoretical Examinations

4.1 Extent of the Theoretical Examination

The theoretical examination shall comprise the examination of the module documents specified in Section 4.2, of the test certificates to be provided as specified in Sections 4.3 through 4.4 as well as of the test instructions specified in Section 4.5 [and the test program specified in Section 5.1 para. 1].

4.2 Module Documents

4.2.1 General requirements

(1) All module documents shall contain information on the manufacturer, the module type and state of revision of the device type as well as information on the associated software. The documents specified in Sections 4.2.2 through 4.2.9 are part of these module documents.

(2) The extent and degree of detail of the documents to be submitted shall be established in agreement with the authorized expert (under Sec. 20 Atomic Energy Act).

4.2.2 Index of engineering documents

The index of engineering documents for the module shall list all documents required to ascertain the identity of the module.

4.2.3 Functional description

The functional description of the module shall provide information on the field of application, the task and the mode of operation of the module.

4.2.4 Data Sheet

(1) The data sheet shall contain all data that characterize the module.

Note:
The data sheet shall contain, e.g., the following data together with the permissible deviations:

a) input parameters,
b) output parameters,
c) auxiliary power supply,
d) permissible ambient condition,
e) transmission behavior,
f) electrical properties,
g) signal processing times, cycle times, and
h) interfaces, communication protocols.

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

4.2.5 Operating instructions, operating manual

(1) The operating instructions or the operating manual for the module shall normally contain instructions and information on:

a) mounting and installation,
b) commissioning,
c) adjustment,
d) special accessories,
e) maintenance, and
f) packaging and storage.

(2) Superordinate operating instructions may be compiled in a system operating instruction.

4.2.6 Hardware documents for modules with discrete components

(1) The circuit diagram shall depict all components of the module and their interconnections.

(2) The parts list shall list all mechanical and electrical components of the module that are necessary to be able to evaluate the function of the module.

(3) The positioning plan of the components shall depict the arrangement of the components and the layout of their interconnections.

4.2.7 Hardware documentation for modules with highly integrated components

(1) The connection diagram shall depict all electrical and data-specific connections of the module.

(2) All configuration and identification documents required for the identification of the device shall be submitted. All hardware and software components and the associated tools shall be listed in these documents which shall also indicate the revision level of the individual document.

4.2.8 Software Documents

(1) The development process of the software shall be substantiated by software documents.

Note:
These documents can be, e.g.,

a) technical specification,
b) procedure specification,
c) specification of development steps
d) shop documents,
e) test documentation and
f) documents regarding configuration management.

(2) The structure, programming sequence and temporal behavior of the software shall be described.

(3) The possibilities for the configuration and parameterization of the modules shall be specified as well as the software tools available for these tasks.

(4) The conditions and procedures to be observed during configuration and parameterization shall be described.

(5) The specification of the interfaces to other modules or systems shall be submitted, and the data transferred through these interfaces shall be specified.

Note:
The requirements for the system environment are based on these data.

(6) In the case of pre-fabricated software, the procedure for its qualification or the procedure for demonstrating its suitability shall be described together with the results.

(7) The possibilities for protecting the software against manipulations and the possibilities for identifying, initiating alarms and documenting such software manipulations shall be described.

4.2.9 Documents with respect to the self-monitoring mechanisms

Documents describing the self-monitoring mechanisms implemented for the hardware and the software shall be submitted. The behavior of the module in response to an actuation of the monitoring or error-handling routines shall be described.

4.3 Determination of Reliability Data

4.3.1 General Requirements

(1) Reliability data shall be determined on the basis of the documents to be submitted as specified in Sections 4.2.3 and 4.2.6 through 4.2.9.

(2) The failure rates of the modules shall be determined for the conditions of specified normal operation.

(3) The failure effects of the module and the associated failure rate shall normally be specified. An experimental determination of failure rates is permissible.

(4) If the failure effects must be known for only a certain number of functional units, it shall be demonstrated that even a failure of the remaining functional units cannot have any reactive effects on the functional units examined.

(5) The procedures used for determining the reliability data of the hardware and software components shall be specified.

Note:
Professional experts cannot yet present certifiable quantitative reliability data for software. Therefore, the reliability of the software for electrical devices must be determined quantitatively in the course of the type approval test of the electrical devices.

4.3.2 Determination of failure rates on the basis of operating experience

(1) If the failure rates for devices or components can be determined with sufficient statistical accuracy on the basis of the evaluation of operating experience, then an evaluation of operating experience shall be given preference over a theoretical determination of the failure rates.

(2) The determination of failure rates for newly developed or modified modules shall be based on the failure rates of comparable modules or functional units, provided, the comparable modules or functional units have accumulated at least 10^7 operating hours and at least ten pieces of the modules or functional units have been in operation under comparable operating conditions for two years. Modules or functional units are considered to be comparable if

a) comparable types of the electrical component,

b) comparable structural elements, and

c) similar design principles

have been used and

d) similar ambient conditions for the components

have been specified.

(3) The following data to be acquired over the last two years shall be presented for the comparable modules and functional units:

a) annual number of units delivered,

b) total number of units delivered,

c) estimated number of modules or functional units in operation,

d) annual number of repairs performed in the manufacturing plant,

e) estimated annual number of repairs performed outside of the manufacturing plant,

f) estimated annual number of failed modules or functional units that but were not repaired.

(4) With regard to comparable modules or functional units, the failure effects, the causes of failure and the evaluation of these causes shall be provided for those modules or functional units that were returned to the manufacturing plant.

(5) The mean failure rate and the associated confidence range shall be specified with a certainty of 95 %.

4.3.3 Determination of failure rates for the module hardware on the basis of failure effect analyses

(1) The failure effects to be specified shall normally be the physical effects that a failed component has on the function of the module.

(2) The analysis procedure, the extent of the analysis and the auxiliary means employed shall be substantiated.

4.4 Critical Load Analysis

(1) Proof shall be presented that the components and their electrical connections will not be subjected to any static and dynamic loads greater than the permissible limit values.

(2) Proof shall be presented that the function of the modules is ensured taking the tolerances of the components into account. In this context, the effects of component tolerances on the specified characteristics of the modules shall be investigated for selected component combinations relevant to the function.

(3) The proof may be based on experimental or analytical procedures.

4.5 Test Instructions for the Physical Tests

(1) The test instructions shall describe the type of tests, the test parameters and their physical values, the testing equipment and the test procedure (sequence and extent of the test steps).

(2) The individual test cases and test conditions for the physical test of the test modules shall be specified.

Note:
Certain test cases can only be performed on a functional unit.

4.6 Preparation and Examination of the Documents

(1) Documents shall be prepared for the theoretical examinations specified in Sections 4.2 through 4.5. These documents shall normally be checked by an authorized expert (under Sec. 20 Atomic Energy Act).

(2) The documents specified in Sections 4.2 through 4.5 shall be checked, specifically, with regard to completeness, mutual consistency, and functional design of the modules.

5 Physical Tests

5.1 General Requirements

(1) A test program comprising the test schedule and the test instructions shall be prepared for the physical tests and shall be specified in coordination with the authorized expert (under Sec. 20 Atomic Energy Act)

(2) The test schedule shall specify the procedures and equipment to be employed during the test.

(3) The test instructions shall specify the objectives and boundary conditions of the tests as well as the underlying technical standards.

(4) When performing the physical tests, higher loadings may be employed than those specified in Section 5 of this safety standard.

(5) The physical tests shall basically be performed by a plant expert. An external certified test organization may also perform these tests, provided, they are so commissioned by the plant expert.

(6) The physical tests shall be performed at a test location which, with respect to quality of the test facilities and measuring instrumentation, is suited to meet the test requirements under this safety standard.

5.2 Test Modules

(1) Three factory tested modules of a single type or production batch (type series) shall be selected for the type approval test. The test modules shall cover the entire spectrum of the characteristics to be demonstrated for the specific type or production batch (type series).

(2) Each of the test modules shall be marked accordingly.

(3) The test modules may be selected from the pilot series.

(4) A summary account of the history of each of the test modules shall be prepared.

Note:
The summary account contains, e.g., fabrication place, fabrication date, factory testing office, factory tests an date performed, storage periods and possible additional loadings of the test module encountered prior to the type approval test.

(5) A visual inspection (identity check) shall be performed to assure that the test module corresponds to the fabrication documents listed in the index of engineering documents.

(6) The test module shall be examined with regard to workmanlike fabrication.

Note:
This may be an examination regarding, e.g., cleanness, proper soldering, positioning of the components, transportation damages.

(7) One test module shall remain available for further testing up to at least one year after the successful conclusion of the type approval test.

5.3 Functional Tests

(1) The functioning of the module as specified in the data sheet shall be demonstrated. This requires combining the following test parameters within the range limits and with the input signal forms specified in the data sheet:

a) input signal,

b) output load,

c) ambient temperature,

d) auxiliary power supply, and

e) electrical characteristics.

The number of combinations shall be specified within the framework the theoretical examination of the module.

(2) In case modules whose function can be altered by an operating mode selector (e.g., by internal or external circuitry), the test shall normally be extended to all operating modes.

(3) The specified characteristics of software based modules shall be tested. This shall include the interaction of hardware and software components of the test modules, the interfaces with adjacent modules, the processor loading, the bus loading, the shut-down and start-up behavior of the processor.

5.4 Electromagnetic Compatibility (EMC) Tests

(1) It shall be demonstrated that the functionality of the test module is not impaired by the loading from electromagnetic fields to which the test module, in accordance with the data sheet, may be subjected during transportation, storage and operation.

(2) The disturbance resistance shall be demonstrated to be in accordance with the data sheet.

(3) The interference radiation emitted from the test module shall be measured and compared to the corresponding value specified in the data sheet.

(4) The tests shall be performed at the nominal values of the test parameters specified in Section 5.3 para. 1. It is not required to consider a combination of the different interference effects.

(5) If the data sheet does not contain specifications regarding a permissible loading of the test object from electromagnetic fields, then the disturbance resistance of, and the interference radiation emitted from, the test object shall be demonstrated as specified under para. 6.

(6) These tests shall normally demonstrate the electromagnetic disturbance resistance of the test module against interference from those line- and field-oriented interference parameters that must be considered at the final location of the module during operation. The minimum required interference test parameters shall be those specified in the generic EMC standard regarding EMC immunity for industrial environments, DIN EN 61000-6-2. Additionally, the specifications in the standards for specific EMC products or product families (e.g., DIN EN 61326) may be taken into consideration, provided, these do not permit lesser degrees of accuracy than the specifications in the generic EMC standard, DIN EN 61000-6-2. In addition, this test shall normally demonstrate that, both, the line- and the field-oriented electromagnetic interference radiation emitted from the test module do not exceed the limit values specified in the generic EMC standard for emitted interference radiation, DIN EN 61000-6-4. Here also, the specifications in standards for specific EMC products or product families (e.g., DIN EN 61326) may be taken into consideration, provided, these do not permit higher limit values than those specified in the generic EMC standard, DIN EN 61000-6-4. In addition to the requirements specified in the generic EMC standard for emitted interference radiation, DIN EN 61000-6-4, it shall also be demonstrated that the limit values for line-oriented interference parameters are not exceeded at the signal and control connections.

5.5 Interim Functional Tests

(1) The interim functional tests shall be performed in the course of the physical tests at specific hold points. Selected individual test steps shall be carried out with one value each for the auxiliary power supply, the output load and the ambient temperature, and in only one operating mode of the test module.

Note:
Preferably, this would involve a reduced test of

a) the logical function,
b) the signal propagation delay, and
c) the characteristic.

(2) Neither electric interferences nor electromagnetic effects have to be considered in these tests.

5.6 Monitoring of the Function

(1) When performing the physical test specified in Sections 5.4, 5.7 and 5.8 the function of the test module shall be monitored.

(2) Function monitoring shall be performed for one set of values for the test parameters and at only one operating mode of the test module.

(3) The function monitoring shall be performed such that even brief functional failures of the test module can be detected.

5.7 Climatic Tests

5.7.1 General requirements

(1) It shall be demonstrated that the functionality of the test module is not impaired by the ambient conditions to which the test module, as specified in the data sheet, may be subjected during transportation, storage and operation.

(2) The test module shall be subjected to the climatic loading in its unpacked state and in its operating position.

(3) If the data sheet does not contain the characteristic values relating to the following climatic tests, the tests specified in Sections 5.7.2 through 5.7.6 shall be performed with the values specified in those sections.

(4) After the climatic loading, visual inspections and interim functional tests shall be performed.

5.7.2 Constant cold. after a rapid temperature change

Note:
This test demonstrates the suitability of the module for transportation or storage at low temperatures. The requirements for performing this test are specified in DIN EN 60068-2-1 (Test Aa).

(1) The test module being at room temperature shall be placed in the test chamber which shall normally be at the lowest permissible storage temperature (T_{min}) as specified in the data sheet. If the data sheet does not specify a corresponding value, T_{min} = - 25 °C shall be used.

(2) The test module in its inoperative state shall normally be subjected to a temperature $T_{min} \pm 3$ K for 24 hours.

5.7.3 Constant dry heat, after a rapid temperature change

Note:
This test demonstrates the suitability of the module for transportation or storage in dry heat. The requirements for performing this test are specified in DIN EN 60068-2-2 (Test Ba).

(1) The test module being at room temperature shall be placed in the test chamber which shall normally be at the maximum permissible storage temperature (T_{max}) as specified in the data sheet. If the data sheet does not specify a corresponding value, T_{max} = 85 °C shall be used.

(2) The test module being in its inoperative state shall normally be subjected to a temperature of $T_{max} \pm 2$ K for 24 hours.

5.7.4 Constant humid heat

Note:
This test demonstrates the suitability of the module for storage or operation in humid heat without condensation. The requirements for performing this test are specified in DIN EN 60068-2-78 (Test of Ca).

(1) If the data sheet does not specify corresponding values, the test module shall be subjected to the following loads:

a) temperature: 40 °C ± 2 K,

b) relative humidity: $(93\ ^{+2}_{-3})$ %,

c) duration: 48 hours,

d) operating status: test module not in operation.

(2) Following an interim functional test the test module shall be subjected to the following loads:

a) temperature: 40 °C ± 2 K,

b) relative humidity: $(93\ ^{+2}_{-3})$ %,

c) duration: 24 hours,

d) operating status: test module in operation with a cyclic variation of the supply voltage between U_{max} and U_{min} after every six hours of the test. During changeover of the supply voltage, intermediate values of the supply voltage as specified in the data sheet are permissible.

5.7.5 Cyclic humid heat

Note:
This test demonstrates the suitability of the module for storage in high humidity and with temperature changes and including condensation. The requirements for performing this test are specified in DIN EN 60068-2-30 (Test Db).

The test module shall normally be tested with the test module not in operation. If the data sheet does not specify corresponding values, the test module shall be subjected to the following loads:

a) The initial temperature of the test module shall be matched to the initial temperature of the test chamber, 25 °C ± 3 K (cf. **Figure 5-1**).

b) The relative humidity in the test chamber shall then be increased to at least 95 % while the temperature is maintained at 25 °C ± 3 K.

c) Upon reaching this humidity level (start of the test), the temperature in the test chamber shall be steadily raised to 55 °C ± 2 K within (3 ± 0.5) hours. During the temperature rise, the relative humidity shall be at least 95 %; it may drop to 90 % in the last 15 minutes.

Note:
In the case of test modules with a very small temperature time constant, condensation will only occur if the relative humidity is very close to 100 %.

d) The maximum temperature shall be maintained for a period of (9 ± 0.5) hours at a relative humidity of (93 ± 3) %. During subsequent cooling, the rate of temperature change in the first 1.5 hours shall average 10 K/h. Within the next 1.5 to 4.5 hours, the temperature of the test chamber shall be lowered to 25 °C ± 3 K.

e) During the cooling off period, the relative humidity should not fall below 85 %. However, in the first 15 minutes it may drop down to 70 %.

f) Subsequently, and until the end of the test period of 24 hours, the temperature shall be kept at 25 °C ± 3 K and the relative humidity above 95 %.

5.7.6 Cyclic dry heat (long-term test)

Note:
This test demonstrates the suitability of the module with regard to specified normal operation. The requirements for performing this test are specified in DIN EN 60068-2-14 (Tests Nb) and in DIN EN 60068-2-33.

(1) The initial temperature of the test module shall be matched to the initial temperature of the test chamber, 25 °C ± 3 K.

(2) The temperature of the test chamber shall, subsequently, be increased within one hour to the maximum permissible ambient temperature (T_{max}) as specified in the data sheet for operation of the test module. If the data sheet does specify a corresponding value, T_{max} = 70 °C shall be used.

(3) The test module shall then be subjected to the following cyclic test conditions:

a) The cycle duration shall be 24 hours.

b) The loading duration in each cycle shall normally be at least 20 hours at the higher temperature (T_{max}) and at least 2 hours at the lower temperature 25 °C ± 3 K.

c) The test module shall be in operation with a cyclic variation of the supply voltage between U_{max} and U_{min} after every 24 hours in the course of the test. During changeover of the supply voltage, intermediate values of the supply voltage as specified in the data sheet are permissible.

d) The test duration shall be 1000 hours.

5.8 Tests with Mechanical Loadings

5.8.1 General requirements

(1) It shall be demonstrated through tests that the functional capability of the test module is not impaired by those me-

chanical loads that are permissible during transportation and operation in accordance with the data sheet.

(2) The test module shall be subjected to the loads in its unpacked state.

(3) The tests related to operation shall be performed on a test module that is mounted in the test facility in the manner specified in the module documentation for the final location of the module (e.g., in the module assembly frame).

(4) Visual inspections and interim functional tests shall normally be performed before and after each type of loading.

(5) When changing from one type of loading to another, it is permissible to perform only a single interim functional test. In this context, the test module may remain mounted in the test facility.

(6) When testing the test module in operation, the function shall be monitored.

5.8.2 Resistance to vibration in the frequency range between 5 Hz and 35 Hz

Note:
This test demonstrates the resistance of the module to vibrations in the frequency range between 5 Hz and 35 Hz, e.g., due to seismic events. The requirements for performing this test are specified in DIN EN 60068-2-6 (Test Fc).

(1) If the data sheet does not specify otherwise, the tests shall normally be performed with the deflection amplitude (maximum value) and the acceleration amplitude specified in para. 2.

(2) The test shall normally be performed with a sinusoidal loading and a smooth change of frequency as follows:

a) deflection amplitude:	(10 ± 2.5) mm,
b) acceleration amplitude:	(1 ± 0.2) · 9.81 m/s²,
c) rate of change:	1 octave/min,
d) duration per main axis:	1 cycle,
e) operating status:	test module in operation.

5.8.3 Resistance to vibrations in the frequency range between 5 Hz and 100 Hz

Note:
This test demonstrates the resistance of the module to vibrations in the frequency range between 5 Hz and 100 Hz, e.g., due to plane crash. The requirements for performing this test are specified in DIN EN 60068-2-6 (Test Fc).

(1) If the data sheet does not specify otherwise, the tests shall normally be performed with the deflection amplitude and the acceleration amplitude specified in para. 2.

(2) The test should be performed with a sinusoidal loading and a smooth change of frequency as follows:

a) deflection amplitude:	(10 ± 2.5) mm,
b) acceleration amplitude:	(2 ± 0.4) · 9.81 m/s²,
c) rate of change:	smaller than or equal to 10 octaves/min,
d) duration per main axis:	1 cycle,
e) operating status:	test module in operation.

5.8.4 Shock Test

Note:
This test demonstrates the suitability of the module for transportation. The requirements for performing this test are specified in DIN EN 60068-2-27 (Test Ea).

(1) If the data sheet does not specify otherwise, the tests shall normally be performed with the acceleration amplitude and the duration specified in para. 2.

(2) This test shall normally be performed with a sinusoidal, saw-tooth or trapezoidal shaped shock and an individual shock actuation as follows:

a) acceleration amplitude:	30 · 9.81 m/s²,
b) duration:	11 ms,
c) number of shocks in each direction:	3,
d) total number of shocks:	18,
e) operating status:	test module not in operation.

5.9 Behavior of the Test Module upon Plugging and Unplugging

(1) If the electrical input and output circuitry or the signal connections are designed as plug-in connectors and an unplugging of the connectors is permitted, then the behavior of the test module shall be tested by plugging and unplugging the connectors.

(2) This test step shall be repeated ten times.

5.10 Sequence of the Physical Tests

(1) The physical tests shall normally be performed in the following sequence:

a) visual inspection of the test module as specified in Section 5.2 para. 5,

b) functional tests as specified in Section 5.3,

c) behavior of the test module upon plugging and unplugging as specified in Section 5.9,

d) climatic tests as specified in Section 5.7,

e) tests with mechanical loadings as specified in Section 5.8, and

f) functional tests specified in Section 5.3.

(2) The electromagnetic compatibility tests specified in Section 5.4 may be performed independently from the sequence of the other physical tests.

5.11 Measures in the Event of Failures During the Physical Tests

If a failure occurs, the time of the failure and its effects shall be determined. An investigation report shall be prepared containing details of the investigation performed and a statement on the determined cause of failure. If the investigation reveals the presence of a common-mode failure, appropriate improvement measures shall be taken. The extent to which the type approval test must be repeated shall be specified in cooperation with the authorized expert (under Sec. 20 Atomic Energy Act).If the failure is not a common-mode type, the tests specified in Section 5.2 para. 5 and Section 5.3 shall be repeated after repairing the test module, and type testing shall be continued after repeating the test step that had been interrupted.

6 Criteria for a Successful Type Approval Test

The type approval test is considered as successfully passed if the theoretical examination specified und Sections 4.2 through 4.5 gave no cause for concern and the functional

capability has been demonstrated by the physical test specified in Sections 5.5 through 5.11.

7 Test Documentation

7.1 Documentation of the Theoretical Examinations

(1) The documentation of the theoretical examinations shall include the following records:

a) module documents specified in Section 4.2 together with the stated opinion of the authorized expert (under Sec. 20 Atomic Energy Act) with respect to these documents,

b) reliability data specified in Section 4.3 with the stated opinion of the authorized expert (under Sec. 20 Atomic Energy Act) with respect to these reliability data,

c) critical load analysis specified in Section 4.4 with the stated opinion of the authorized expert (under Sec. 20 Atomic Energy Act) with respect to this critical load analysis,

d) test instructions for the physical tests specified in Section 4.5 with the stated opinion of the authorized expert (under Sec. 20 Atomic Energy Act) with respect to the test instructions.

(2) The results of the stated opinions shall be summarized in test certifications.

7.2 Documentation of the Physical Tests

(1) A test record shall be prepared for each test step and this test record shall contain the following information:

a) identification number of the test record,

b) module type and module designation including state of modification,

c) identity of the test module,

d) manufacturer of the test module,

e) test step,

f) test assembly, test equipment, test facility,

g) number of measurement value tables,

h) test result,

i) place and date, and

k) organization, name and signature of the tester.

(2) The test record shall specify any failures, visible defects and damages that occurred during the test step.

(3) The measurement values shall be listed in measurement value tables which shall normally list the required values including the permissible deviations.

(4) The results of the tests shall be summarized in test certifications.

7.3 Test Report

(1) The theoretical examinations and physical tests performed and the test results shall be compiled in a test report.

(2) If the test modules are selected from a production batch (type series), the selection criteria shall be specified and substantiated.

(3) Possible application restrictions and special application areas shall be specified.

Note:
This also includes comments with regard to system tests to be performed at a later date.

7.4 Test Certificate

(1) The test certificate shall contain information on the following:

a) identification number of the certificate,

b) module type and module designation including state of modification,

c) list of the test records,

d) manufacturer of the tested module,

e) identification of the test instruction,

f) test result,

g) place and date, and

h) organization, name and signature of the tester and the experts.

(2) Several test certificates may be combined in one comprehensive test certificate.

(3) The test certificate shall remain valid for newly fabricated components, provided, it is regularly confirmed in three-year time intervals, e.g., by quality audits in accordance with safety standard KTA 3507, that no modifications have been applied to the module that would influence the tested characteristics documented in the test certificate (including the test report).

7.5 Storage Location and Duration

Requirements regarding storage and archiving of the test documentation are specified in safety standard KTA 1404.

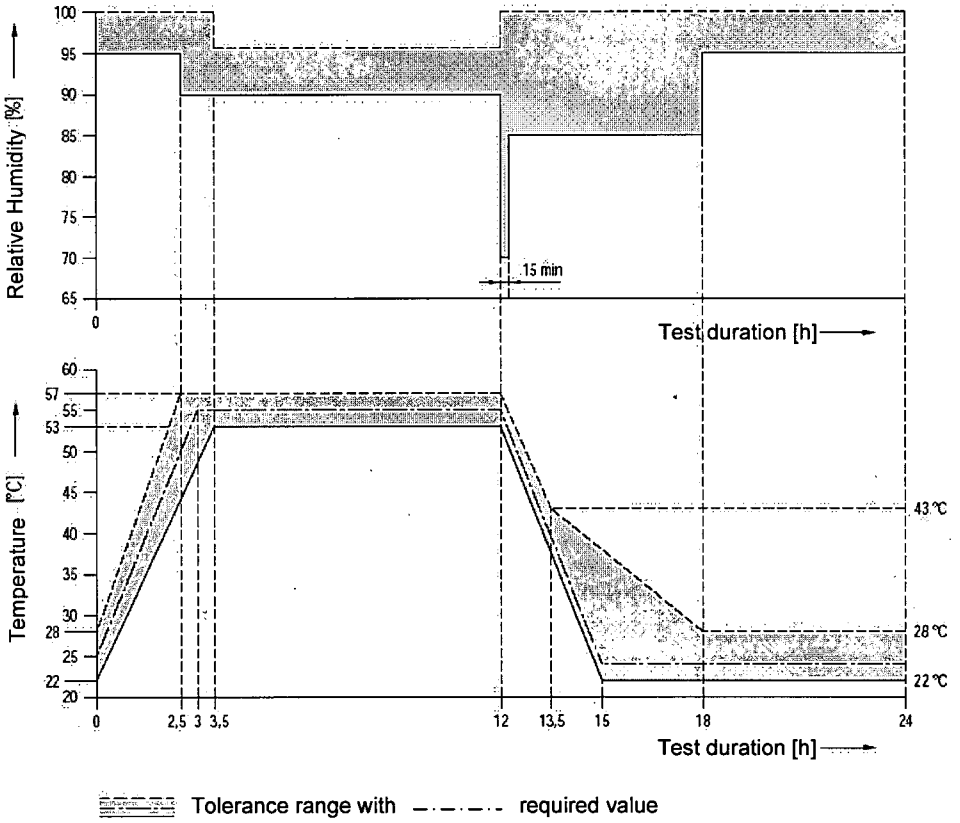

Figure 5-1: Time history of relative humidity and temperature during the climate test specified in Section 5.7.5

Appendix A

Regulations Referred to in this Safety Standard

Regulations referred to in this 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.

Atomic Energy Act		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act) of December 23, 1959 (BGBl I, p. 814) in the version of July 15, 1985 (BGBl I, p. 1565), most recently changed by Act of August 12, 2005 (BGBl I, p. 2365)
KTA 1404	(2001-06)	Documentation during the construction and operation of nuclear power plants
KTA 3501	(1985-06)	Reactor protection system and monitoring equipment of the safety system
KTA 3507	(2002-06)	Factory tests, post-repair tests and demonstration of successful service for the instrumentation and control equipment of the safety system
DIN EN 61000-6-2	(2002-08)	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments (IEC 61000-6-2:2005); German version EN 61000-6-2:2005
DIN EN 61000-6-4	(2002-08)	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards; Emission standard for industrial environments (IEC 61000-6-4:1997, modified); German version EN 61000-6-4:2001
DIN IEC 61226	(2005-09)	Nuclear power plants - Instrumentation and control systems important to safety - Classification of instrumentation and control functions (IEC 61226:2005)
DIN EN 61326	(2004-05)	Electrical equipment for measurement, control and laboratory use - EMC requirements (IEC 61326:1997 + IEC 61326/A1:1998 + IEC 61326-1/A2:2000 + Appendices E & F of IEC 61326:2002 + Corrigendum: 2002); German version EN 61326:1997 + EN 61326/A1:1998 + EN 61326/A2:2001 + EN 61236/A3:2003 / Attention: DIN EN (2002-03) is also still applicable until 2006-10-01

Appendix B (informative)

System Standards of DIN Regarding Computer Based Instrumentation and Control Systems Relevant to Safety

DIN IEC 60780	(2000-12)	Nuclear power plants - Electrical equipment of the safety system - Qualification (IEC 60780:1998)
DIN IEC 60880	(2004-07 draft)	Nuclear power plants - I&C systems important to safety - Software aspects for computer-based systems performing category A functions (IEC 45A/523/CD:2003)
DIN EN 60068-2-1	(1995-03)	Environmental testing - Part 2: Tests; tests A: Cold (IEC 60068-2-1:1990 + A1:1993 + A2:1994); German version EN 60068-2-1:1993 + A1:1993 + A2:1994
DIN EN 60068-2-2	(1994-08)	Basic environmental testing procedures - Part 2: Tests; tests B: Dry heat (IEC 60068-2-2:1974 + IEC 68-2-2A:1976 + A1:1993); German version EN 60068-2-2:1993 + A1:1993
DIN EN 60068-2-6	(1996-05)	Environmental testing - Part 2: Tests; test Fc: Vibration (sinusoidal) (IEC 60068-2-6:1995 + Corrigendum 1995); German version EN 60068-2-6:1995
DIN EN 60068-2-27	(1995-03)	Basic environmental testing procedures - Part 2: Tests; test Ea and guidance: Shock (IEC 60068-2-27:1987); German version EN 60068-2-27:1993
DIN EN 60068-2-30	(2000-03)	Environmental testing - Part 2: Tests - Test Db and Guideline damp heat, cyclic (12 h + 12 h cycle) (IEC 60068-2-30:1980 + A1:1985); German version EN 60068-2-30:1999
DIN EN 60068-2-33	(2000-09)	Environmental testing - Part 2: Tests; guidance on change of temperature tests (IEC 60068-2-33:1971 + A1:1978); German version EN 6068-2-33:1999
DIN EN 60068-2-78	(2002-09)	Environmental testing - Part 2-78: Tests; Test Cab: Damp heat, steady state (IEC 60068-2-78:2001); German version EN 60068-2-78:2001
DIN EN 61000-4-5	(2001-12)	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques; Surge immunity test (IEC 61000-4-5:1995 + A1:2000); German version EN 61000-4-5:1995 + A1:2001 (VDE 0847 Parts 4-5)
DIN EN 61131-1	(2004-03)	Programmable controllers - Part 1: General information (IEC 61131-1:2003); German version EN 61131-1:2003
DIN EN 61131-2	(2004-02)	Programmable controllers - Part 2: Equipment requirements and tests (IEC 61131-2:2003); German version EN 61131-2:2003
DIN EN 61508-3	(2002-12)	Functional safety of electrical / electronic / programmable electronic safety-related systems - Part 2: Requirements for electrical / electronic / programmable electronic safety-related systems (IEC 61508-2:2000); German version EN 61508-2:2001
DIN EN 61508-4	(2002-11)	Functional safety of electrical / electronic / programmable electronic safety-related systems - Part 4: Definitions and abbreviations German version EN 61508-4:2001
DIN IEC 61513	(2002-10)	Nuclear power plants - Instrumentation and control for systems important to safety - General requirements for systems (IEC 61513:2001) (VDE 0491 Part 2)