Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3503 (2015-11)

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

(Typprüfung von elektrischen Baugruppen der Sicherheitsleittechnik)

The previous version of this safety standard was issued in 2005-11

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

Editor:
KTA-Geschaeftsstelle
c/o Bundesamt fuer kerntechnische Entsorgungssicherheit (BfE)
Willy-Brandt-Str. 5 • 38226 Salzgitter • Germany
Telephone +49 (0) 30 18333-1621 • Telefax +49 (0) 30 18333-1625

KTA SAFETY STANDARD

November 2015	**Type Testing of Electrical Modules for the Instrumentation and Control System Important to Safety**	KTA 3503

Previous versions of this safety standard: 1982-06 (BAnz No. 173 of September 17)
1986-11 (BAnz No. 93a of May 20, 1987)
2005-11 (BAnz No. 101a of May 31, 2006)

Contents

Basic Principles 5
1 Scope 5
2 Definitions 5
3 Testing Procedures 5
4 Theoretical Examinations 5
4.1 Extent of the Theoretical Examinations 5
4.2 Engineering Documents of the Modules 6
4.3 Determination of Reliability Data 7
4.4 Critical Load Analysis 7
4.5 Test Instructions for the Physical Tests 7
4.6 Preparation and Examination of the Documents 7
5 Physical Tests 8
5.1 General Requirements 8
5.2 Test Objects 8
5.3 Functional Tests 8
5.4 Interim Functional Tests 8
5.5 Monitoring of the Function 8
5.6 Electromagnetic Compatibility (EMC) Tests 8
5.7 Climatic Tests 9
5.8 Tests with Mechanical Loadings 10
5.9 Behavior of the Test Object upon Plugging Procedures 10
5.10 Sequence of the Physical Tests 10
5.11 Required Measures in Case of Failures During Physical Tests 11
6 Criteria for a Successful Type Approval Test 11
7 Test Documentation 11
7.1 Documentation of the Theoretical Examinations 11
7.2 Documentation of the Physical Tests 11
7.3 Test Report 11
7.4 Test Certificate 11
7.5 Storage Location and Storage Duration 11
Appendix A Regulations Referred to in the Present Safety Standard 13
Appendix B (informative) DIN Standards Pertaining to Instrumentation and Control Systems Important to Safety 14

PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 35-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in the Federal Gazette (Bundesanzeiger) of January 08, 2016. Copies of the German version may be mail-ordered through the Wolters Kluwer Deutschland GmbH (info@wolterskluwer.de). Downloads of the English translations are available at the KTA website (http://www.kta-gs.de).

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

KTA-Geschaeftsstelle c/o BfE, Willy-Brandt-Str. 5, D-38226 Salzgitter, Germany or kta-gs@bfe.bund.de

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 permissible. 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 AtG and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and in the SiAnf-Interpretations.

(2) Based on the SiAnf and the SiAnf-Interpretations, the modules required to be subjected to type testing in accordance with the present safety standard are specified in safety standard KTA 3501.

(3) In the present safety standard, it is presumed that conventional requirements and technical standards (e.g., Accident Protection Requirements, DIN-Standards, VDE-Regulations) are adhered to under consideration of the safety-related requirements specific to nuclear power plants.

(4) Type tests are performed by authorized experts to evaluate whether the modules are in accordance with the data sheet specifications and the specified characteristics.

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

(6) Requirements regarding the certification of satisfactory service life are specified in safety standard KTA 3507.

(7) Requirements regarding quality assurance, management systems and documentation are specified in safety standards KTA 1401, KTA 1402, KTA 1404, KTA 3506 and KTA 3507.

1 Scope

This safety standard applies to the type testing of electrical modules of the instrumentation and control system important to safety in accordance with safety standard KTA 3501.

2 Definitions

(1) Functional unit

A functional unit is a unit under observation delimited within the system by its task and operating principle.

Note:

A functional unit may be realized structurally within a module or within an agglomeration of multiple modules, or may be realized as a part of a module.

(2) Module

A module is an arrangement of components or subunits that performs a specific function.

Note:

Modules are comprised of hardware and possibly software. An I & C module is a replaceable device with a standardized interface. A differentiation is made between:

a) modules comprised of discrete non-programmable components or subunits,

b) modules comprised of at least one discrete programmable component (e.g., field-programmable gate arrays (FPGA), programmable logic devices (PLD) and application-specific integrated circuits (ASIC)) and

c) computer-based modules comprised of at least one processor or controller.

(3) Type approval test

A type approval test is the test of representative test objects of a fabrication series (type series) regarding the characteristics specified in the data sheet and in the description of functionality.

(4) Authorized expert

An authorized expert is a qualified person or organization consulted by the nuclear licensing or supervisory authority based on Sec. 20 AtG.

3 Testing Procedures

(1) The type approval test 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 for the type approval test, provided, the safety-related requirements of the present safety standard are fulfilled.

(3) In the case of computer-based modules or those with programmable components, the software and its quality characteristics shall be tested within the framework of the theoretical examinations specified under Section 4.2, and the function of the module shall be tested within the framework of the physical tests.

Note:

The different requirements for testing software and its quality characteristics for modules required to perform Cat A and Cat B instrumentation and control functions are specified in safety standard KTA 3501.

(4) The employed interfaces of the modules shall be subjected to the same requirements that are valid for the individual modules to be tested.

(5) Any modifications on type-tested modules shall be tested in accordance with the basic principles of the present safety standard. These tests may be theoretical examinations or physical tests or a combination of these test procedures. In the case of physical tests, the number of test objects specified in Section 5.2 may be reduced, provided, a prior agreement was reached with the authorized expert.

4 Theoretical Examinations

4.1 Extent of the Theoretical Examinations

(1) The theoretical examinations shall comprise an examination of the engineering documents of the modules specified in Section 4.2, of the certifications to be submitted as specified in Sections 4.3 through 4.4, and also of the test instructions and the test program specified in Section 4.5.

(2) The suitability of the quality assurance measures applied within the framework of the module fabrication shall be assessed during type testing. The quality assurance measures applied

shall normally be comprehensibly documented in the form of audit reports regarding the quality audits performed, e.g., in accordance with safety standards KTA 3507 or KTA 1401. If the audit reports are not sufficient, then the required quality certifications shall be produced within the framework of type testing.

Notes:

(1) KTA 3501 specifies that the quality of fabrication and design shall meet Level B in accordance with DIN EN 61192-1. In addition to Level B of DIN EN 61192-1, safety standard KTA 3501 also cites Class 2 of IPC-A-610.

(2) Section 9 of DIN EN 60987 specifies requirements for the fabrication that are comparable to those in DIN EN 61192-1 and IPC A 610.

4.2 Engineering Documents of the Modules

4.2.1 General requirements

The respective engineering documents shall contain information on the manufacturer, the type and state of modification of the module. These documents shall comprise the documents specified in Sections 4.2.2 through 4.2.8.

N o t e :

Due to the growing degree of integration of the modules, the extent and degree of detail of the documents to be submitted shall be established in agreement with the authorized expert

4.2.2 Index of engineering documents

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

4.2.3 Description of functionality

The description of functionality shall provide information on the range of application, the task and the mode of operation of the module including those of its interfaces.

4.2.4 Data sheet

(1) The data sheet shall contain all data including the permissible range of application as well as the tolerances characterizing the module type.

N o t e :

The data sheet shall contain, e.g., the following data:

a) input parameters,
b) output parameters,
c) auxiliary power supply,
d) ambient conditions,
e) signal transfer behavior,
f) electrical characteristics,
g) electromagnetic compatibility / stress
h) signal processing times, cycle times, and
i) interfaces, communication logs.

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

4.2.5 Operating instructions, technical manuals

(1) The operating instructions or the technical manuals shall normally contain instructions and information on:

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

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

4.2.6 Hardware documents

(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 their reliability and function. The parts list shall basically contain all relevant technical data for the components. Alternatively, the relevant technical data for components may be made available by referencing additional documents (e.g., the data sheet).

(3) The position diagram of components shall show the components and the arrangement of their connections,

(4) In the case of computer-based modules or modules with programmable components, the data sheets of the programmable components including the data-technological connections shall be submitted.

(5) The configuration and identification documents required for proper identification of the modules shall be submitted. In the case of computer-based modules or modules with programmable components, the hardware and software components as well as the software tools shall be listed together with the respective versions.

(6) If the fabrication anticipates variants of assembly by the installation of equivalent components, these shall be specified in the parts list and considered in the type approval tests. Provided, the variant components are truly equivalent, a theoretical analysis of the equivalency may be sufficient.

4.2.7 Software documents

(1) The development process of the software of computer-based modules and the development process of programmable components shall be substantiated by technical documents.

N o t e :

These documents can be, e.g.:

a) requirement specification,
b) tender specification,
c) performance specification,
d) development documentation including documentation of tools for new developments and modifications,
e) test documentation including information on the range covered by the tests,
f) configuration management in accordance with safety standard KTA 3506.

(2) The structure, program sequence and temporal behavior of the software for computer-based modules and modules with programmable components 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) A specification of the interfaces to other modules or systems shall be submitted and the data to be transferred via these interfaces shall be specified.

N o t e :

The requirements for the system environment (e.g., measures to prevent or control consequential failures) are based on these data.

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

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

4.2.8 Documents with respect to the self-monitoring mechanisms

(1) Documents regarding the implemented self-monitoring mechanisms of the hardware and the software shall be submitted. These documents shall comprise at least:

a) the specification of the self-monitoring mechanism for detecting a malfunction as well as the response tolerance with respect to failures of the module and their interfaces,

b) the specification of the behavior of the module in response to an actuation by the surveillance routine (error-handling routine),

c) an analysis of the implemented self-monitoring mechanisms of the modules regarding the covered range of surveillance of the functions important to safety (Sec. 5.1 of safety standard KTA 3506).

(2) The documents shall be such that they enable the verification of the effectiveness of the self-monitoring mechanisms.

4.3 Determination of Reliability Data

4.3.1 General requirements

(1) The reliability data shall be determined based on the documents to be submitted as specified in Sections 4.2.

(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 rates shall normally be specified (e.g., by a Failure Mode and Effect Analysis – FMEA). An experimental determination of the 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 the remaining functional units, even if they would fail, cannot affect the functional units examined.

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

Note:

So far, the professional world has no accepted procedures for determining quantitative reliability data for software. Therefore, the reliability of software must be determined qualitatively during type testing.

4.3.2 Determining failure rates for the hardware of modules based on operatiional experience

(1) If the failure rates for modules or components can be determined with sufficient statistical accuracy based on the evaluation of operating experience, then the 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 may be based on the failure rates of comparable modules, provided, these comparable modules have accumulated at least 10^7 operating hours and at least ten of these modules have been in operation under comparable operating condition for two years. The average failure rates and associated range of confidence shall be specified for a significance of 95 % by the Chi-square distribution. Modules or functional units shall be comparable in at least the following aspects:

a) electrical components,

b) structural elements,

c) firmware,

d) data file for programming components (e.g., in the case of field-programmable gate arrays (FPGA), programmable logic devices (PLD), application-specific integrated circuits (ASIC)),

e) design principles, and

f) ambient conditions.

(3) For the comparable modules or functional units, the following data shall be acquired over the recent two years and shall be submitted:

a) annual number of modules supplied,

b) total number of modules supplied,

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, and

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

(4) For the comparable modules, the failure effects, the failure causes and the assessment of these causes shall be provided for those modules that were returned to the manufacturing plant.

4.3.3 Determination of failure rates based on failure effect analyses for the hardware of modules

(1) The failure effects to be specified shall normally be the physical effects that component failures had 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 static and dynamic loads greater than the permissible limit values.

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

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

4.5 Test Instructions for the Physical Tests

(1) The test instructions shall describe the kind of tests, the test parameters and their physical values, the test facilities and the test procedure (sequence and extent of the testing steps), as well as the acceptance criteria for a successful test.

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

(3) The modules containing a communication bus shall be subjected to an integration test that takes the functionally relevant system environment into consideration. Regarding the integration test the following information shall be available:

a) test specification,

b) acceptance criteria for the integration test,

c) version and configuration of the system used,

d) required tools and operating media, and

e) functional characteristics of the module to be tested.

Note:

Additional information regarding the integration test are contained in DIN 61508-3, DIN EN 61513 and DIN EN 60880.

4.6 Preparation and Examination of the Documents

(1) Documents shall be prepared for the theoretical examination as specified in Sections 4.2 through 4.5. These documents shall normally be checked by an authorized expert.

(2) The documents specified in Sections 4.2 through 4.5 shall be checked, specifically, regarding completeness and mutual consistency, and regarding a functionally correct design of the module.

5 Physical Tests

5.1 General Requirements

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

(2) The test schedule shall specify the procedures and test 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 under Sections 5.6 through 5.9.

(5) The physical tests should be performed by a works inspector. It is also permissible to have the physical tests be performed by a suitable test organization.

(6) The physical tests shall be performed at a test location which is suited regarding the quality of the test facility and measuring instrumentation.

5.2 Test Objects

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

(2) Each of the test objects shall be unambiguously marked.

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

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

Note:

The summary account contains, e.g., place and date of fabrication, factory testing office, factory tests and the date they were performed, periods of storage, and possible additional loadings of the test object encountered prior to type testing.

(5) An identity check of the test object shall be performed to assure that it corresponds to the manufacturing documents listed in the index of engineering documents.

(6) The test object shall be examined regarding professional execution of fabrication.

Note:

(1) This may be an examination regarding, e.g., cleanness, proper soldering, positioning of the components, transportation damages.

(2) . In addition to Level B of DIN EN 61192-1, the IPC A 610 Class 2 can also be used here.

(7) The test objects shall normally remain available for further testing up to at least three years after the successful conclusion of the type approval test.

5.3 Functional Tests

(1) The function 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 conditions,
d) auxiliary power supply, and
e) electrical characteristics.

The number of combinations shall be specified within the framework of the theoretical examination of the module specified under Section 4.5.

(2) Additionally, the characteristics of the modules specified in the respective engineering documents shall be tested.

Note:

In the case of computer-based or programmable modules, this includes, e.g., the interaction of hardware and software components of the test object, the interfaces with adjacent modules, the processor loading, the bus loading, the processor shut-down and start-up behavior, the self-monitoring and failure behavior.

(3) In the case of modules whose function can be modified by an operating mode selector (e.g., by internal or external circuitry), the test shall normally comprise all operating modes.

5.4 Interim Functional Tests

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

Note:

Here, a reduced test

a) of the logical function,
b) the signal transit time and
c) the characteristic

is preferably intended.

(2) In these tests, neither electric interferences nor electromagnetic effects need to be considered.

5.5 Monitoring of the Function

(1) During the physical tests specified in Sections 5.6, 5.7 and 5.8 when the test objects are in operation, proper functioning of the test object shall be monitored.

(2) The monitoring may be performed at a typical value of the test parameters and a typical operating mode.

(3) Monitoring of the function shall be performed such that even short-duration functional failures of the test object are detected.

5.6 Electromagnetic Compatibility (EMC) Tests

(1) It shall be demonstrated that the functional capability of the test object is not impermissibly impaired by the line-conducted or field-conducted electromagnetic interferences specified in the data sheet.

(2) The interference radiation emitted from the test object shall not exceed the corresponding values specified in the data sheet.

(3) The tests shall be performed at the typical 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.

Note:

The severity levels for testing and the limit values are specified in, e.g., the generic EMC standards DIN EN 61000-6-2 and DIN EN 61000-6-4.

(4) In addition to the requirements of the generic EMC standard for emitted electromagnetic interference, DIN EN 61000-6-4, compliance with the limit values for line conducted electromagnetic interference specified in the data sheet shall also be demonstrated for signal and control connections.

N o t e s :

(1) Additional information is presented in VdTÜV Report 45 “Proof of electromagnetic compatibility within the framework of the nuclear licensing and surveillance procedure”.

(2) With regard to the evaluation of the measurement results of the demonstration of suitability, it is useful to include the auxiliary measurement means used (e.g., network model, test probe, current transformer) and, if applicable, the transformation calculation of network impedance from, e.g., dB(µV) to dB(µA), shall be specified in the data sheet or the test report.

5.7 Climatic Tests

5.7.1 General requirements

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

(2) The test object shall be unpacked and in its operating position when being subjected to the climatic loading.

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

(4) Visual inspections and interim functional tests shall be performed after the climatic loading.

5.7.2 Constant cold, after a temperature change

(1) This test shall demonstrate the suitability of the module for transportation or storage at low temperatures.

N o t e :

The requirements for performing this test are specified in DIN EN 60068-2-1 (Test Ab).

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

(3) The non-operating test object shall normally be subjected to a temperature of T_{min} ± 3 K for a duration of 24 hours.

5.7.3 Constant dry heat, after a temperature change

(1) This test shall demonstrate the suitability of the module for transportation or storage in dry heat.

N o t e :

The requirements for performing this test are specified in DIN EN 60068-2-2 (Test Bb).

(2) The test object being at room temperature, it 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, a T_{max} = 85 °C shall be used.

(3) The non-operating test object shall normally be subjected to a temperature of T_{max} ± 2 K for a duration of 24 hours.

5.7.4 Constant damp heat

(1) This test shall demonstrate the suitability of the module for storage or operation in damp heat without condensation.

N o t e :

The requirements for performing this test are specified in DIN EN 60068-2-78 (Test Ca).

(2) The test object shall be subjected to the maximum relative humidity as specified in the data sheet. If the data sheet does not specify corresponding values, the test shall be performed with the following ambient conditions:

a) temperature: 40 °C ± 2 K,

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

(3) The non-operating test object shall normally be subjected to this ambient condition for a duration of 48 hours.

(4) Following an interim functional test, the test object shall be re-subjected to the loading under para. (2) as follows:

a) duration: 24 hours,

b) operating condition: test object 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 specified in the data sheet are permissible.

5.7.5 Cyclic damp heat

(1) This test shall demonstrate the suitability of the module for storage in high humidity with temperature changes and condensation.

N o t e :

The requirements for performing this test are specified in DIN E 60068-2-30 (Test Db).

(2) The test object shall normally be tested with it being in its non-operating condition. If the data sheet does not specify corresponding values, the test object shall be subjected to the following loads:

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

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

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

N o t e :

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

d) The upper temperature shall be maintained for a period of (9 ± 0.5) hours at a relative humidity of (93 ± 3) %. During the subsequent cooling-off period, 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 reduced to 25 °C ± 3 K.

e) During the cooling-off period, the relative humidity shall normally not fall below 95 %.

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 greater than 95 %.

5.7.6 Cyclic dry heat (long-term test)

(1) This test shall demonstrate the suitability of the module for the condition of specified normal operation.

N o t e :

The requirements for performing this test are specified in DIN EN 60068-2-14 (Test Nb).

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

(3) 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 the operating test object. If the data sheet does not specify a corresponding value, a T_{max} = 70 °C shall be used.

(4) The test object shall then be subjected to the following cyclic test conditions:

a) The duration of each cycle shall be 24 hours.
b) The loading duration in each cycle shall normally be at least 20 hours at the upper temperature, T_{max} ± 2 K, and at least 2 hours at the lower temperature 25 °C ± 3 K.
c) The test object shall be in operation with a cyclic variation of the supply voltage between U_{max} and U_{min} after every 24 hours of the test. During changeover of the supply voltage, intermediate values of the supply voltage specified in the data sheet are permissible.
d) The overall test duration shall be 1000 hours.

5.8 Tests with Mechanical Loadings

5.8.1 General requirements

(1) Tests shall be performed that demonstrate that the functional capability of the test object is not impermissibly impaired by those mechanical loads that are permissible during transportation and operation in accordance with the data sheet.

N o t e :

Sections 5.8.2 through 5.8.4 do not address any continuous mechanical loadings specific to actual operation.

(2) The test object shall be unpacked when being subjected to the mechanical loading.

(3) For tests related to operation, the test object shall be mounted in the test facility in the manner specified in the respective engineering documents for the final location of the module (e.g., in the module rack).

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

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

5.8.2 Resistance to vibrations in the frequency range from 5 Hz to 35 Hz

(1) This test shall demonstrate the resistance of the module to vibrations in the frequency range from 5 Hz to 35 Hz caused by, e.g., seismic events.

N o t e :

Requirements for performing this test are specified in DIN EN 60068-2-6 (Test Fc).

(2) If the data sheet does not specify otherwise, this test shall normally be performed with the deflection amplitude specified in para. (3) up to a transition frequency in accordance with DIN EN 60068-2-6 and shall then be continued with the acceleration amplitude specified in para. (3).

(3) This 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) *x* 9.81 m/s²,
c) rate of change: 1 octave/min,
d) duration per main axis: 1 cycle, and
e) operating condition: test object in operation.

5.8.3 Resistance to vibrations in the frequency range from 5 Hz to 100 Hz

(1) This test shall demonstrate the resistance of the module to vibrations in the frequency range from 5 Hz to 100 Hz caused by, e.g., a plane crash.

N o t e :

The requirements for performing this test are specified in DIN EN 60068-2-6 (Test Fc).

(2) If the data sheet does not specify otherwise, this test shall normally be performed with the deflection amplitude specified in para. (3) up to a transition frequency in accordance with DIN EN 60068-2-6 and shall then be continued with the acceleration amplitude specified in para. (3).

(3) This 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: (2 ± 0.4) *x* 9.81 m/s²,
c) rate of change: ≤ 10 octaves/min,
d) duration per main axis: 1 cycle,
e) operating condition: test object in operation.

5.8.4 Shock test

(1) This test shall demonstrate the suitability of the module for transportation.

N o t e :

The requirements for performing this test are specified in DIN EN 60068-2-27 (Test Ea).

(2) If the data sheet does not specify otherwise, the test shall normally be performed with the acceleration amplitude and for an effective duration as specified in para. (3).

(3) This test shall normally be performed with an individual shock actuation either by a sinusoidal, saw-tooth or trapezoidal shock shape as follows:

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

5.9 Behavior of the Test Object upon Plugging Procedures

(1) If the electrical input and output circuits or the signal connections are designed as plug-in connectors and an unplugging of the connectors is permitted, then the behavior of the test object 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 of those modules which do not need to be resistant to the ambient conditions from a design basis accident shall normally be performed in the following sequence:

a) visual inspection of the test object as specified in Section 5.2 para. (5),
b) functional tests as specified in Section 5.3,

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

d) climatic tests as specified in Section 5.7,

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

f) functional tests as specified in Section 5.3.

(2) The electromagnetic compatibility tests specified in Section 5.6 may be performed independently from the sequence of the other physical tests.

5.11 Required Measures in Case of Failures During Physical Tests

If a failure occurs, the time of failure and the failure effects shall be determined. An investigation report shall be prepared containing details regarding the investigation performed and a statement about the determined cause of failure. If the investigation reveals the presence of a common-cause failure, appropriate improvement measures shall be taken. The extent to which the type approval test must be repeated shall be specified in coordination with the authorized expert. If the failure is not a common-cause type, the tests specified in Section 5.2 para. (5) and Section 5.3 shall be repeated after repairing the test object, and the test steps of the type approval test shall be continued after repeating the interrupted test step.

6 Criteria for a Successful Type Approval Test

The type approval test is considered as being successfully passed if the theoretical examination specified in Section 4 gives no cause for concern, and if the functional capability has been demonstrated by the physical tests specified in Section 5.

7 Test Documentation

7.1 Documentation of the Theoretical Examinations

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

a) engineering documents as specified in Section 4.2 together with the respective written opinion of the authorized expert,

b) reliability data as specified in Section 4.3 together with the respective written opinion of the authorized expert,

c) critical load analysis as specified in Section 4.4 together with the respective written opinion of the authorized expert,

d) test instructions for the physical tests as specified in Section 4. together with the respective written opinion of the authorized expert, and

e) statement of the authorized expert regarding the fabrication quality as specified in Section 4.1 para. (2).

(2) The results of the written opinions shall be documented in the test report specified in Section 7.3.

7.2 Documentation of the Physical Tests

(1) Each test step shall be documented by a test record which shall contain the following information:

a) identification number of the test record,

b) module type and designation including state of modification,

c) identity of the test object,

d) manufacturer of the test object,

e) test step

f) test assembly, auxiliary test equipment, test facility,

g) recorded measurement values,

h) test results,

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 together with the required values and permissible deviations in a form suited to enable a proper assessment,

(4) The results of the tests shall be summarized in the test report specified in Section 7.3.

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 objects are selected from a production batch (type series), the selection criteria shall be specified and assessed.

(3) Possible application restrictions shall be specified.

Note:

This also includes comments regarding any operation-specific system tests to be performed at a later date.

7.4 Test Certificate

(1) The theoretical examinations and physical tests and the test results shall be summarily recorded in a test certificate that shall contain the following information:

a) identification number of the test certificate,

b) module type and designation including state of modification,

c) test regulations,

d) manufacturer of the tested module,

e) test report,

f) test result,

g) place and date, and

h) organization, name and signature of the person issuing the test certificate.

(2) It is permissible to combine several test certificates in one comprehensive test certificate.

(3) The test certificate shall remain valid for newly fabricated modules, provided, it is regularly confirmed in three-year intervals, e.g., by quality audits in accordance with safety standard KTA 3507, that no modifications have been applied regarding the test certificate (including the test report) that in any way affect the tested characteristics. Alternatively, this confirmation may be replaced by design reviews within the framework of procurement.

7.5 Storage Location and Storage Duration

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

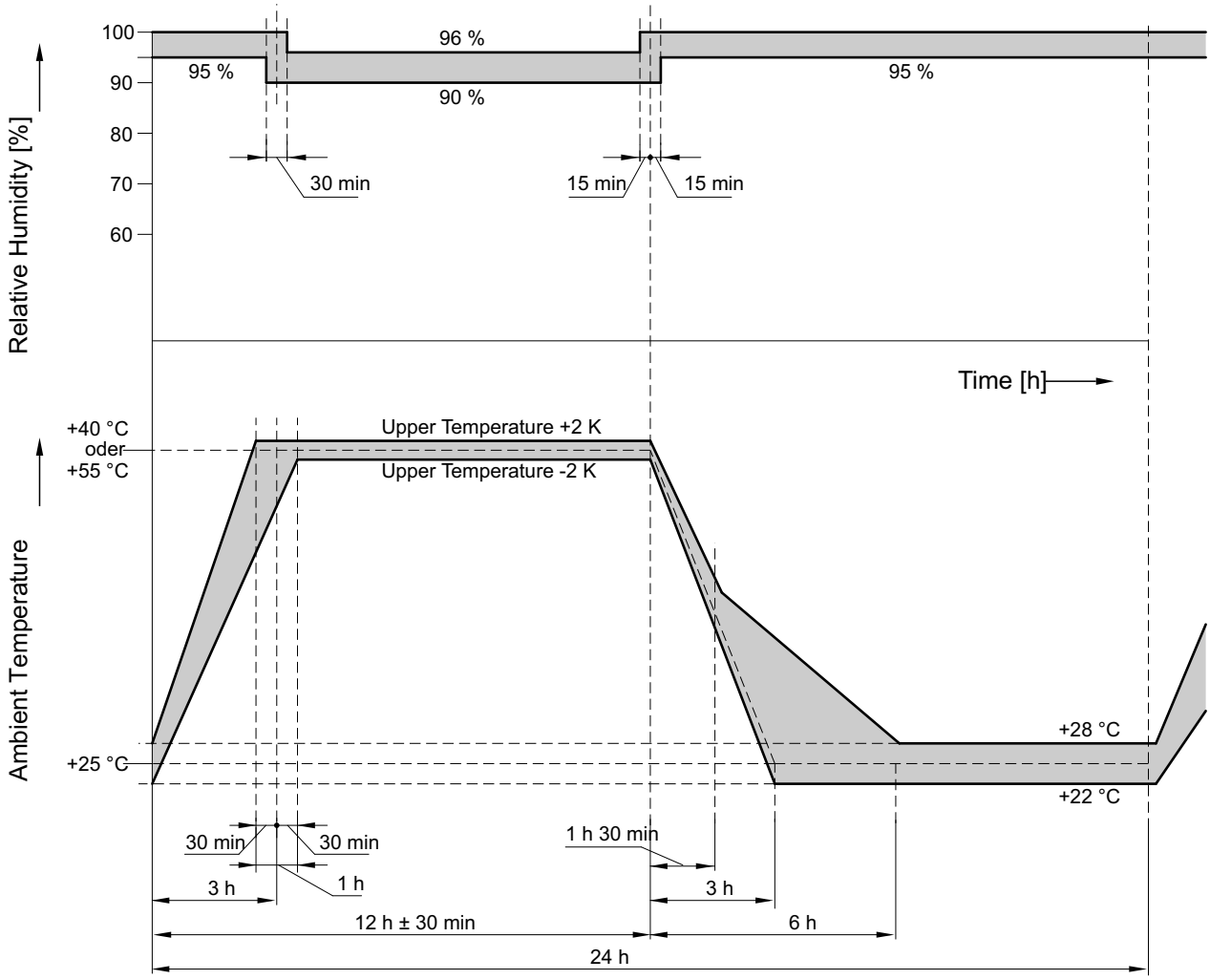

Figure 5-1: Temporal sequence of the relative humidity and temperature during the climate test specified in Section 5.7.5

Appendix A

Regulations Referred to in the Present Safety Standard

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

AtG		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act – AtG) of December 23, 1959, revised version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Article 307 of the Act of August 31, 2015 (BGBl. I 2015, No. 35, p. 1474)
StrlSchV		Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance – StrlSchV) of July 20, 2001 (BGBl. I, p. 1714; 2002 I, p. 1459), most recently changed by Article 5 of the Act of December 11, 2014 (BGBl. I, p. 2010)
SiAnf	(2015-03)	Safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B2)
SiAnf-Interpretations	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B3)
KTA 1401	(2013-11)	General requirements regarding quality assurance
KTA 1402	(2012-11)	Integrated management systems for the safe operation of nuclear power plants
KTA 1403	(2010-11)	Ageing management in nuclear power plants
KTA 1404	(2013-11)	Documentation during the construction and operation of nuclear power plants
KTA 3501	(2015-11)	Reactor protection system and monitoring equipment of the safety system
KTA 3505	(2015-11)	Type testing of measuring sensors and transducers for the instrumentation and control system important to safety
KTA 3506	(2012-11)	System testing of the instrumentation and control equipment important to safety of nuclear power plants
KTA 3507	(2014-11)	Factory tests, post-repair tests and certified satisfactory service life of modules and devices of the instrumentation and control system important to safety
DIN EN 60068-2-1 (VDE 0468-2-1)	(2008-01)	Environmental testing - Part 2-1: Tests - Test A: Cold (IEC 60068-2-1:2007); German version EN 60068-2-1:2007
DIN EN 60068-2-2 (VDE 0468-2-2)	(2008-05)	Environmental testing - Part 2-2: Tests - Test B: Dry heat (IEC 60068-2-2:2007); German version EN 60068-2-2:2007
DIN EN 60068-2-6 (VDE 0468-2-6)	(2008-10)	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal) (IEC 60068-2-6:2007); German version EN 60068-2-6:2008
DIN EN 60068-2-14 (VDE 0468-2-14)	(2010-04)	Environmental testing - Part 2-14: Tests - Test N: Change of temperature (IEC 60068-2-14:2009); German version EN 60068-2-14:2009
DIN EN 60068-2-27 (VDE 0468-2-27)	(2010-02)	Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock (IEC 60068-2-27:2008); German version EN 60068-2-27:2009
DIN EN 60068-2-30	(2006-06)	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle) (IEC 60068-2-30:2005); German version EN 60068-2-30:2005
DIN EN 60068-2-78	(2014-02)	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state (IEC 60068-2-78:2012); German version EN 60068-2-78:2013
DIN EN 60880 (VDE 0491-3-2)	(2010-03)	Nuclear power plants - Instrumentation and control systems important to safety - Software aspects for computer-based systems performing category A functions (IEC 60880:2006); German version EN 60880:2009
DIN EN 60987 (VDE 0491-3-1)	(2015-06)	Nuclear power plants - Instrumentation and control important to safety - Hardware design requirements for computer-based systems (IEC 60987:2007 + A1:2013); German version EN 60987:2015

DIN EN 61000-6-2 (VDE 0839-6-2)	(2006-03)	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 61000-6-2 (VDE 0839-6-2) Corrigendum	(2011-06)	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments (IEC 61000-6-2:2005); German version EN 61000-6-2:2005, Corrigendum to DIN EN 61000-6-2 (VDE 0839-6-2):2006-03; German version CENELEC-Cor. :2005 to EN 61000-6-2:2005
DIN EN 61000-6-4 (VDE 0839-6-4)	(2011-09)	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments (IEC 61000-6-4:2006 + A1:2010); German version EN 61000-6-4:2007 + A1:2011
DIN EN 61192-1	(2003-11)	Workmanship requirements for soldered electronic assemblies - Part 1: General (IEC 61192-1:2003); German version EN 61192-1:2003
DIN EN 61508-2 (VDE 0803-2)	(2011-02)	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems (IEC 61508-2:2010); German version EN 61508-2:2010
DIN EN 61508-3 (VDE 0803-3)	(2011-02)	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 3: Software requirements (IEC 61508-3:2010); German version EN 61508-3:2010
DIN EN 61513 (VDE 0491-2)	(2013-09)	Nuclear power plants - Instrumentation and control important to safety - General requirements for systems (IEC 61513:2011); German version EN 61513:2013

Appendix B (informative)

DIN Standards Pertaining to Instrumentation and Control Systems Important to Safety

DIN IEC 60780	(2000-12)	Nuclear power plants - Electrical equipment of the safety system - Qualification (IEC 60780:1998)
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 (VDE 0411-500)	(2008-04)	Programmable controllers - Part 2: Equipment requirements and tests (IEC 61131-2:2007); German version EN 61131-2:2007