12.7.9.2 Circuit diagrams

Circuit diagrams shall be generated for each printed board assembly, and plug-in unit of the complete equipment.

Where practicable, all circuit diagrams shall be drawn so that the main sequence of events on the signal path is from left to right (and where necessary for arrangement purposes, from top to bottom).

Wherever practical, the circuit diagram for any one unit shall be completely self-contained, self-explanatory, readily related to other circuit diagrams and shall show:

— supply voltage levels and interconnections,

— connections between the low voltage circuits,

— connections between these circuits, the electronic equipment, the transducers and the controlled or monitored devices,

— earth connections of the metallic parts,

— connections between the electronic zero volt lines,

— casings and their connections,

— screened or twisted cables.

Discrete components external to a printed board assembly or plug-in unit but essential to its operation shall be shown in dotted outline on the circuit diagram and be appropriately identified.

All component symbols shall be marked with their circuit references and the nominal value of components shall be marked on the circuit diagram where the component list is not included on the same diagram.

Components with three or more connections shall have the connection points identified or marked.

The function of all controls, switches and indicating devices shall be indicated in accordance with the inscriptions marked on the equipment. The symbols for rotary controls shall be marked with an arrow indicating clockwise rotation of the spindle when viewed from the operating end.

Relays shall always be shown in the de-energized position.

12.7.9.3 Component lists

Component lists shall uniquely identify for each component its circuit reference number and the specification or part number/manufacturer indication of that component.

12.7.9.4 Component layout

Component layout drawings shall show the location of each individual component used in a printed board assembly or plug-in unit, marked with its circuit reference number, outline and polarizing details where used.

12.7.9.5 Special maintenance tool

The list, the description and references of special tools (Hardware and/or Software) associated to the electronic equipment shall be provided.

12.7.10 Documentation – Software

According to the chosen software life cycle model of 7.3.2, the supplier shall determine and list what information items are deliverable documents, intermediate deliverable, or non-deliverable; and what information items are to be archived. The list shall be laid down in the quality plan.

All identified information items (documentation) shall be according to EN 50657.

This is a preview. Click here to purchase the full publication.

At least the highly recommended (HR) documents in EN 50657:2017, Table A.1 column basic integrity shall be provided for non safety related on board equipment.

12.7.11 Documentation – System

All identified information items (documentation) shall be according to ISO/IEC/IEEE 15289:2017, Clauses 7 and 10. For each identified information item, the generic contents as specified in ISO/IEC/IEEE 15289:2017, Clause 7 shall be part of the required item content.

At least the following identified information item according to the ISO/IEC/IEEE 15289:2017, Clause 10 shall be available:

10.83	System architecture description
10.84	System element description
10.85	System requirement specification
10.88	User documentation
10.92	Validation report
10.95	Verification report

13 Testing

13.1 General

A test plan listing all the tests to be performed on the Electronic equipment and their procedures shall be written by the supplier.

All items forming a specific equipment type shall have passed the appropriate device level conformity.

The system integrator shall give the evidence to ensure all requirements are addressed providing:

a) A Type Test Report or an integration Type Test Report according to the type Test Procedure to show that all the items forming a specific equipment when integrated together are operating according to the specified functional requirements, see 4.1.

b) A Routine Test Report or an integration Routine Test Report according to the routine Test Procedure confirming that the installed equipment is ready to be brought into use.

During the type tests and routine tests, the item shall not malfunction or produce a performance which is outside its specification. The equipment should be tested in the manner in which they are expected to be used, i.e. protective covers should be in position and the equipment arranged, as nearly as possible, in the position it will occupy in actual use.

The requirements not associated with a test procedure shall be verified at the design review level. Additional requirements, acceptance criteria and the related verification/test shall be agreed between the involved parties at the tender stage.

Since some of the tests subject to agreement may be costly, it is advisable to carry out only those tests which are necessary. The user may require to witness and check the results of any tests. Arrangements for this shall be contained in the contract.

13.2 Categories of tests

13.2.1 General

There are three categories of tests:

— type tests;

— routine tests;

This is a preview. Click here to purchase the full publication.

— investigation tests.

At the time of tendering, the user shall identify any tests subject to agreement (see Table 12 - List of tests).

13.2.2 Type tests

Type tests shall be carried out to verify that a product will meet the specified requirements.

Type tests shall be performed on a single equipment of a given design and manufacturing procedure.

Equipment used for type test should be equipment already submitted to routine test procedure.

If an equipment is not identical to one tested previously the supplier shall provide documents justifying that the change does not alter the validity of existing previous report; otherwise a complete re-test or a subset of type tests shall be performed.

The Type Test sequence starts with visual inspection and a performance test. After all Type Tests have been performed the visual inspection and performance test shall be repeated.

Some or all of the type tests may be repeated from time to time on samples drawn from current production or deliveries, according to an agreement between the user and the supplier, so as to confirm that the quality of the product still meets the specified requirements.

In addition, the user may request the supplier to repeat a type test either totally or in part following:

— modification of equipment likely to affect its function or method of operation;

— failure or variations established during type or routine tests;

— resumption of production after an interruption of more than five years;

— change of manufacturing site.

The type test reports shall be produced and managed according to the implemented quality system.

Equipment used for type test shall not be delivered to the user.

13.2.3 Routine tests

Routine tests shall be performed by the supplier on each manufactured equipment. Routine tests shall be carried out to verify that the properties of a product meet the specification after the manufacturing process and correspond to those measured during the type tests. A complete routine test report shall be generated for each equipment and managed according to the implemented quality system.

13.2.4 Investigation tests

Investigation tests are intended to obtain additional information by means of reports regarding the performance of the electronic equipment outside its specified requirements. They shall be specially requested by the supplier or by the user and subjected to contract agreement.

The results of investigation tests may not be used as grounds for refusing acceptance of the equipment or to invoke penalties.

These tests are not described in this standard.

13.3 Tests summary

Table 12 lists the type and routine tests for electronic equipment; the test sequence is not mandatory. The test plan shall indicate the tests to be performed and the test sequence to be followed.

The complete test is carried out according to the test specification and the test procedure written by the supplier either for type test and for routine test.

This is a preview. Click here to purchase the full publication.

Table 12 — List of tests

	Test	Type	Routine	Test Subclause	Requirement Subclause
1	Visual inspection	M	M	13.4.1	4.1
2	Performance test	M	M	13.4.2	4.1
3	Power supply test	M	O	13.4.3	5.1
4	Insulation test	M	M	13.4.9	5.2.6
5	Low temperature storage test	O	NA	13.4.6	4.1
6	Low temperature start-up test	M	O	13.4.4	4.3.2
7	Dry heat test	M	O	13.4.5	4.3.2 and 4.3.3
8	Cyclic damp heat test (see NOTE 2)	M	O	13.4.7	4.3.2 and 4.3.7
9	Salt mist test	O	NA	13.4.10	4.4.2
10	Enclosure protection test (IP code)	O	O	13.4.12	4.1
11	EMC test	M	O	13.4.8	4.3.6
12	Vibration and shock test	M	NA	13.4.11	4.3.5
13	Equipment stress screening test	O	O	13.4.13	
14	Rapid Temperature variation test	O	NA	13.4.14	4.3.4
For the purpose of these tests ambient temperature shall be defined as 25 °C ± 10 °C. Test specification shall define performance criteria for each test.					
NOTE 1 Tests marked “M” are mandatory. Tests marked “O” are subject to contract agreement between the user and the supplier. Tests marked “NA” are not applicable. NOTE 2 For class PC1 and class PCX without coating, the cyclic damp heat test is not applicable (see 10.7, Table 10).					

13.4 Test specification

13.4.1 Visual inspection

The Visual inspection test verifies the mechanical, dimensional and appearance conformance of the Electronic Equipment; see 4.1.

The Visual inspection shall be carried out before and after tests to check whether any damage or deterioration has occurred resulting from the tests.

13.4.2 Performance test

The performance test verifies the functional requirements of the Electronic Equipment, see 4.1. The performance test is carried out according to the Performance test specification and Performance test procedure written by the supplier either for type test or for routine test.

The performance test shall be carried out at the ambient temperature.

The performance test shall consist of a comprehensive series of measurements of the characteristics of the equipment to check that its performance is in accordance with the functional requirements of the particular equipment concerned, including any special requirements of its individual specification, and general requirements of this standard.

This is a preview. Click here to purchase the full publication.

Performance test during type test could be different from performance test during routine test.

13.4.3 Power supply test

13.4.3.1 General

The test verifies the functionality of the Electronic Equipment in all the conditions foreseen for the power supply, see 5.1.

To carry out the power supply tests, EN 61000-4-29 may be used as a guide.

If the electronic equipment has a large number of similar power supply ports, which are electrically identical, then a sufficient number shall be selected to simulate actual operating conditions and to ensure that all the different types of termination are covered (e.g. 20 % of the ports or at least four ports).

Electronic equipment shall be tested, for each selected combination of test level and duration, with a sequence of 10 dips/interruptions and overvoltage with intervals of 10 s minimum and 1 min maximum (between each test event). In all cases, the voltage levels and time durations of the test waveform shall be measured with the test generator disconnected from the equipment.

13.4.3.2 Supply variations

Tests shall be performed to prove correct functioning at nominal supply voltage and at the specified upper and lower limits (see 5.1.1.2).

— DC power supply range:

  Tests shall be performed to prove correct functioning for the voltage range (see 5.1.1.3).

— DC power supply fluctuation:

  The rise/fall waveforms of the diagrams are purely indicative.

Temporary supply overvoltages shall be assumed to be generated with respect to the control system voltage supply return potential and to be present only as an increase to the level of the control system voltage, which shall be assumed to be present before and after the application of the overvoltage. Overvoltage of opposite polarity to the control of the system voltage supply need not be considered.

Overvoltage exceeding in duration or amplitude the specified voltage fluctuation shall be assumed to occur only in the case of a failure in the control system voltage supply.

Temporary supply overvoltages up to 1,4 U_n lasting no more than 0,1 s shall not cause deviation of function **(performance criterion A)**.

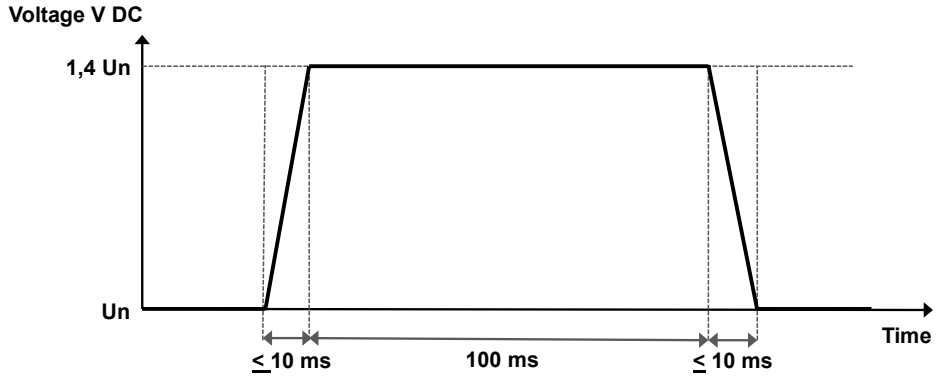

Figure 6 — Temporary supply overvoltages (a)

This is a preview. Click here to purchase the full publication.

For temporary supply overvoltages up to 1,4 U_n lasting no more than 1 s the equipment shall fulfil **performance criterion B.**

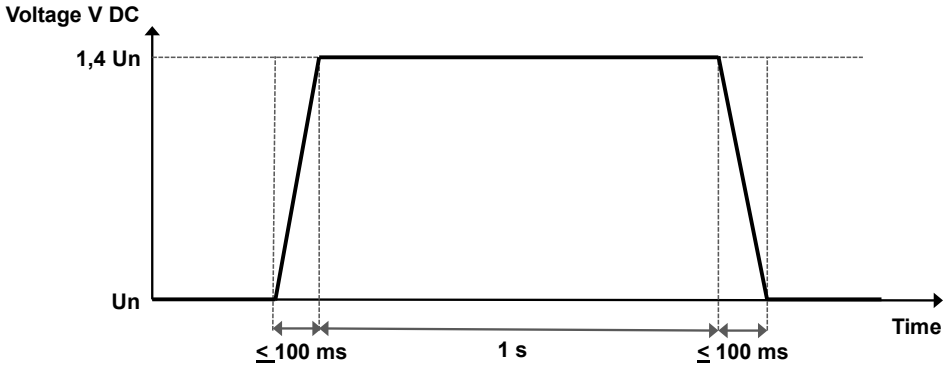

Figure 7 — Temporary supply overvoltages (b)

13.4.3.3 Temporary supply dips

Voltage dips are mainly caused by faults in the DC distribution system, or by sudden large changes of load (low impedance condition).

Temporary supply dips down to 0,6 U_n not exceeding 0,1 s shall not cause deviation of function **(performance criterion A)**.

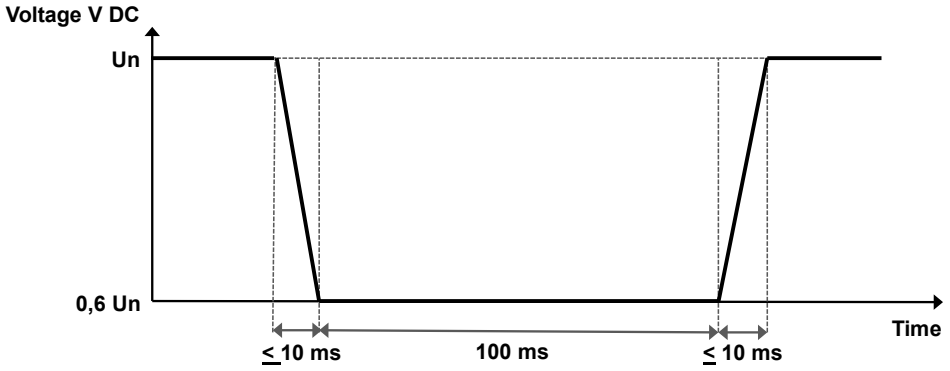

Figure 8 — Temporary supply dips

13.4.3.4 Interruptions of voltage supply

During a short interruption, the DC distribution system presents a “low impedance” (short circuit) condition due to the clearing of an overload or fault condition on the supply bus. This condition can cause reverse current (negative peak inrush current) from the load.

Regarding interruptions on supply voltage, there are three classes of equipment:

This is a preview. Click here to purchase the full publication.

Table 13 — Interruptions of voltage supply classes

Class	Requirements	Duration of the interruption time Tint (See Figure 9)
S1	No performance criterion is requested but the equipment shall continue to operate as specified after the voltage interruption.	NOTE As defined in 5.1.1.4, this test is not required.
S2	The equipment shall behave according performance criterion A.	10 ms
S3	The equipment shall behave according performance criterion A.	20 ms

For voltage interruption longer than specified within the class, equipment shall behave at minimum according performance criterion C.

Tests shall be carried out at nominal voltage.

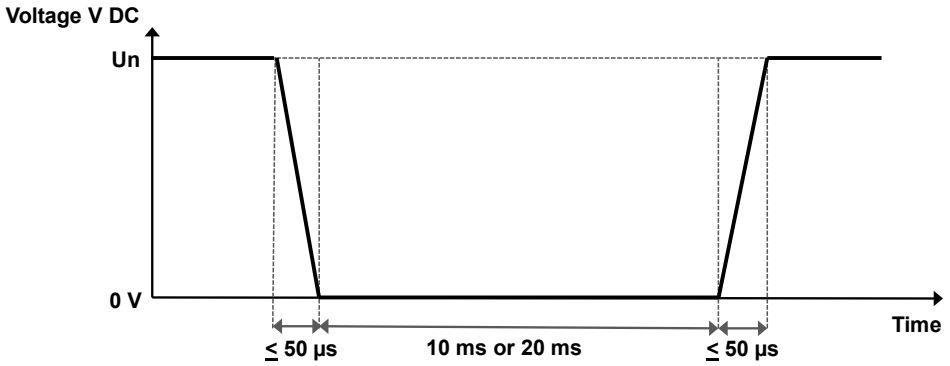

Figure 9 — Interruption of supply voltage

13.4.3.5 Supply change-over

In the case of equipment supplied with power alternatively from an accumulator battery and a DC stabilized source, the DC distribution system presents a “high impedance” condition due to switching from one source to another.

The equipment shall operate satisfactorily under the conditions stated in Subclauses 5.1.1, 5.1.1.2, 5.1.1.6 and 5.1.3.

— Class C1: at 0,6 U_n during 100 ms (without interruptions). **Performance criterion A**;

— Class C2: during a supply break of 30 ms starting at U_n **Performance criterion B**.

The supply break is an open circuit and not a short circuit (“high impedance” condition).

Unless otherwise specified, the requirements of class C1 apply to power supply only.

This is a preview. Click here to purchase the full publication.

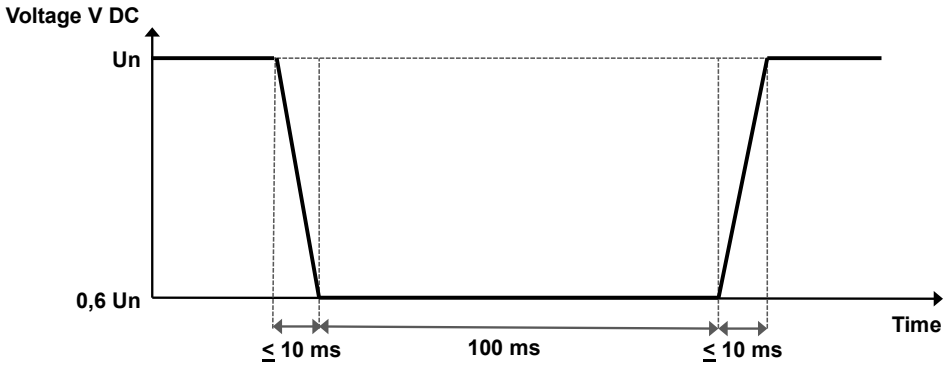

Figure 10 — Supply change-over Class C1

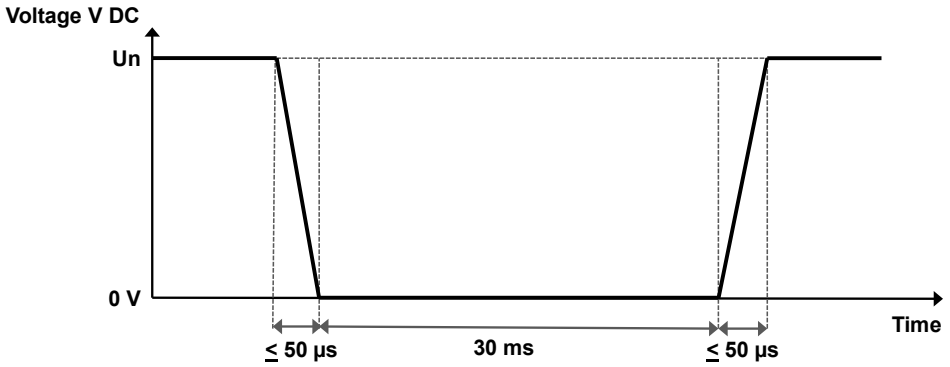

Figure 11 — Supply change-over Class C2

13.4.4 Low temperature start-up test

This test is carried out in accordance with EN 60068-2-1 (test Ad), using natural ventilation.

Equipment shall be tested according to its operating temperature class; low operating temperature (T_{TEST}) shall be taken from Table 1 of this standard.

Equipment is placed, without any voltage applied, in a test chamber.

The equipment shall be first conditioned by leaving it, after thermal stabilization of the chamber, for a sufficient period of time in which to achieve thermal stabilization. In any case, the stabilization time period shall not be less than 2 h, see Figure 12.

At the end of this period the equipment shall be switched on and a performance test shall be carried out, keeping the equipment at the low temperature.

After recovery, this operational check shall be repeated at normal room temperature.

Test acceptance requirements:

During and after the test, the equipment shall work as intended and within its specified limits (**performance criterion A**).

This is a preview. Click here to purchase the full publication.

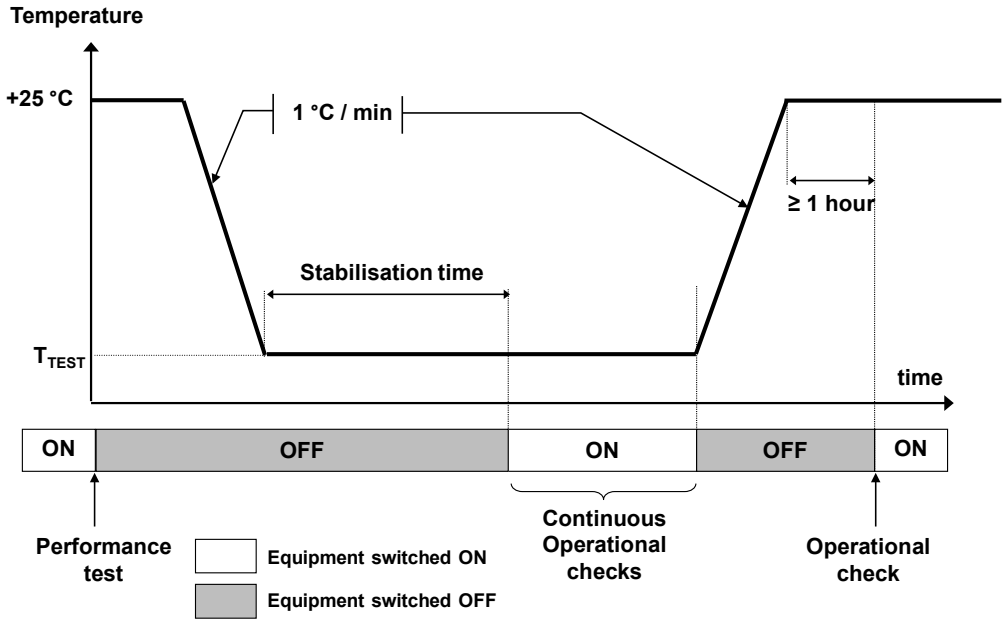

Figure 12 — Low temperature start-up test

13.4.5 Dry heat test

13.4.5.1 General

This test is carried out in accordance with EN 60068-2-2 (test Be), using natural ventilation unless a different type of cooling is normally used by or provided to the equipment. In that case, the normal configuration of the equipment shall be replicated.

The temperature value for this test is dependent of the temperature class and the switch-on extended operating temperature class of equipment under test (see Table 1 and Table 2 for details).

Equipment shall be tested according to its operating temperature class; high operating temperature shall be taken from Table 1 and Table 2.

This is a preview. Click here to purchase the full publication.

13.4.5.2 Dry heat thermal test — Cycle A

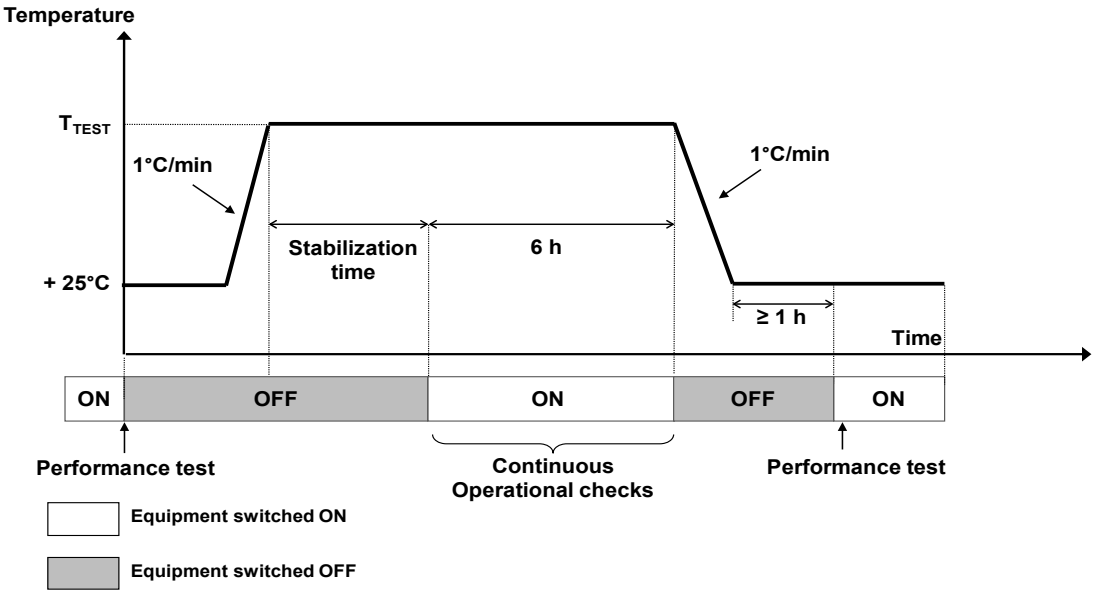

Figure 13 — Dry heat thermal test — Cycle A

The switched off equipment is placed in a chamber where the temperature is progressively raised to the maximum operating temperature (T_{TEST}) (see Figure 13).

Once the temperature of the whole equipment (internal and external) has stabilized, in any case the stabilization time shall not be less than 2 h, then the equipment is switched on and left for a time period of 6 h with continuous operational checks carried out at the maximum operating temperature (T_{TEST}).

The equipment is then allowed to cool to ambient temperature and a further performance test is carried out after the stabilization time.

Test acceptance requirements:

During and after the test, the equipment shall work as intended and within its specified limits (**performance criterion A**).

This is a preview. Click here to purchase the full publication.

13.4.5.3 Dry heat thermal test — Cycle B

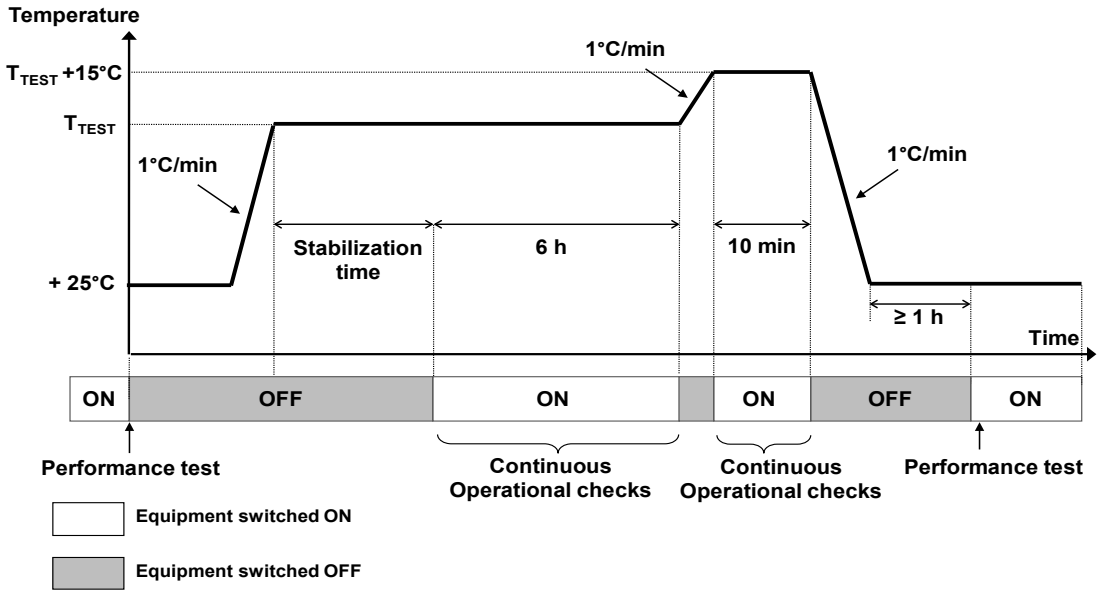

Figure 14 — Dry heat thermal test — Cycle B

The switched off equipment is placed in a chamber where the temperature is progressively raised to the maximum operating temperature (T_{TEST}) (see Figure 14).

Once the temperature of the whole equipment (internal and external) has stabilized, in any case the stabilization time shall not be less than 2 h, then the equipment is switched on and left for a time period of 6 h with continuous operational checks carried out at the maximum operating temperature (T_{TEST}).

Once this test is complete, a continuous operational check is carried out with the 10 min over-temperature value (see Figure 14 for details).

The equipment is then allowed to cool to ambient temperature and a further performance test is carried out after the stabilization time.

Test acceptance requirements:

During and after the test, the equipment shall work as intended and within its specified limits (**performance criterion A**).

This is a preview. Click here to purchase the full publication.