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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Test methods for electroheating installations with electron guns

Méthodes d'essai des installations électrothermiques comportant des canons à électrons

IEC 60703:2008

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60703 has been prepared by IEC technical committee 27: Industrial electroheating equipment.

This second edition cancels and replaces the first edition published in 1981 and constitutes a technical revision.

The significant changes with respect to the previous edition are as follows:

– the latest edition of IEC 60519-7 has been taken into account;
– test requirements have been completed with new items important for testing and acceptance of installations.

The text of this standard is based on the following documents:

CDV	Report on voting
27/628/CDV	27/648/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

TEST METHODS FOR ELECTROHEATING INSTALLATIONS WITH ELECTRON GUNS

1 Scope and object

This International Standard applies to electroheating installations comprising one or more electron guns as heating source.

The object of this standard is the standardization of test methods to determine the essential parameters, technical data and characteristics of electroheating installations comprising one or more electron guns.

The standard does not contain a mandatory list of tests and is not restrictive. Tests may be selected from the proposed list. The specification established by agreement between the user and the manufacturer of electroheating installations can supplement these recommendations but should not be in contradiction with them.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-841:2004, *International Electrotechnical Vocabulary (IEV) – Part 841: Industrial electroheat*

IEC 60204-1:2005, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60204-11:2000, *Safety of machinery – Electrical equipment of machines – Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*

IEC 60398:1999, *Industrial electroheating installations – General test methods*

IEC 60519-1:2004, *Safety in electroheat installations – Part 1: General requirements*

IEC 60519-7:2008, *Safety in electroheat installations – Part 7: Particular requirements for installations with electron guns*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-841, IEC 60519-7 (some of which are repeated here) and the following apply.

3.1
electron beam
electron flux emitted from one source (cathode or plasma) and moving along the exactly determined tracks at very great velocities

[IEV 841-30-01, modified]

3.2
electron (beam) gun
system of generating, forming and accelerating one or more electron beams

[IEV 841-30-08, modified]

3.3
anode (of an electron gun)
electrode capable of educing and accelerating electrons from the medium of lower conductivity

[IEV 841-22-31, modified]

3.4
cathode (of an electron gun)
electrode capable of emitting electrons from the medium of low conductivity and also of receiving positive carriers, if necessary

[IEV 841-22-32, modified]

3.5
beam accelerating voltage
potential difference between the cathode and the anode, to generate an electric field for acceleration of the electrons

[IEV 841-30-29]

3.6
high-voltage power supply
source of the acceleration voltage and of the emission current for electron guns

3.7
return conductor
electrical interconnection between the high-voltage power supply (positive pole) and anodic part of the electron gun system including the vacuum chamber around the workpiece

3.8
interlock
device that prevents activation of a piece of equipment when any form of hazard or danger exists

3.9
vacuum chamber
enclosed space of a vacuum plant constructed in such a way that it can withstand a rarefied atmosphere inside, in which the workpiece to be treated is placed

3.10
electron gun chamber
vacuum chamber in which the electron gun is located

NOTE This chamber may be separated from the workpiece by an aperture, so that between the electron gun and the workpiece a pressure difference can be established.

3.11
electron beam deflection system
electromagnetic coil or deflecting electrodes system, applied to place the beam to different working positions or move the beam over the charge heating surface

[IEV 841-30-25, modified]

3.12
electron beam bending system
electromagnetic coil or permanent magnet for changing the direction of the electron beam outside the electron gun

3.13
electron beam focusing system
electromagnetic coil, system of coils or capacitor plates for focusing the electron beam over the charge heating surface

[IEV 841-30-27, modified]

3.14
beam pattern
image created by a cyclic time function of electron beam positions or a superposition of such cycles

3.15
maximum deflection angle
angle between electron beam attitude without any deflection and at maximum activation in one direction

3.16
deflection limits
limits of a defined area that may proceed with the electron beam without danger for the equipment at reasonable power distribution

3.17
maximum deflection frequency
frequency, at which the amplitude of the deflected beam is reduced to one half in relation to a static deflection caused by the dynamic performance of the complete deflection system

3.18
beam power
product of electron beam current and acceleration voltage

3.19
cathode current
electron current flowing from cathode

NOTE 1 The electron beam current arriving at the workpiece may either be lower than the cathode current, or up to several orders of magnitude larger than the emission current if ion bombardment is also present.

NOTE 2 There is a difference between the possible emission current and the circulated current; cathode current is limited by the space charge.

3.20
rated power (of an electron gun)
product of acceleration voltage and cathode current

4 General test requirements

4.1 Test procedure

The test procedure includes tests and measurements, which can be grouped as follows:

a) Tests of auxiliary facilities (Clause 5);
b) Tests of electron gun system (Clause 6);
c) Production run tests (Clause 7).

The tests of group a) shall be finished before proceeding to the group b) tests. The test procedure shall include all relevant tests of groups a) and b). Production run tests of group c) are only recommendations, their necessity depends on the beam properties requested by the application.

4.2 Test intervals

The test procedure shall be carried out immediately

- after the erection of the electron beam gun installation,
- after general repair work,
- after an accident caused by the electron beam gun installation,
- after substantial modifications of the installation.

The test procedure shall be repeated at least once a year. A shorter period may be determined by the manufacturer or by the user of the installation.

After a repair of a single component the relevant test(s) is also required and may be limited to functionalities directly influenced by this component.

4.3 Ambient conditions

The tests shall be carried out in the ambient conditions stated in Table 1, unless other conditions are specified by the manufacturer.

Table 1 – Ambient conditions for tests

Ambient temperature	°C	Normal	20
		Minimum	15
		Maximum	40
Relative humidity	%	Maximum	85
Altitude above sea level	m	Maximum	1 000
NOTE When the ambient conditions are beyond the values listed in this table, the measured values shall be corrected in accordance with the relevant rules.			

The ambient temperature is considered as an average value. All quantities dependent on the temperature shall refer to the ambient temperature of 20 °C, the so-called reference ambient temperature.

5 Test of auxiliary facilities

5.1 Assembly check

Completeness and integrity of equipment of the electron gun installation shall be verified. Particular attention shall be given to:

- safety appliances and danger signs,
- lock-out devices,
- X-ray shields including lead glass view ports.

5.2 Test of electrical equipment

5.2.1 General

Basically, the test of electrical equipment including control system shall be carried out in accordance with IEC 60204-1, IEC 60398 and IEC 60204-11. Special test procedures for the electrical equipment for electroheat installations with electron guns are stated in the following subclauses. Special tests for electron guns and the high-voltage supply are given in Clause 6.

5.2.2 Continuity of return conductor and equipotential bonding

The return conductor and equipotential bonding shall be visually inspected for compliance with IEC 60519-1 and IEC 60519-7 and a check for tightness of the connections shall be made.

The continuity of the protective bonding and the return conductor shall be verified by injecting current of at least 10 A at 50 Hz or 60 Hz derived from an electrically separated extra low voltage source for a period of at least 10 s. Deviating from IEC 60204-1, the measured voltage drop shall not exceed 1,0 V in the case of return conductor and equipotential bonding between process chamber, electron gun and the high-voltage supply.

5.2.3 Test of safety interlocks and alarm system

The test shall be performed in accordance with IEC 60398.

Special care should be given to the interlocks for the acceleration voltage and, if it exists, to the automatic earthing system (see 6.2.1 and 6.2.2).

When testing interlocks, only the control circuits shall be live. The power circuits should be only switched on for tests of monitoring circuits, which need these voltages.

5.3 Test of liquid cooling system

The test shall be carried out in accordance with IEC 60398. If some parts and electrical devices cannot withstand 1,5 times the maximum pressure, for example double wall vacuum chambers, turbo molecular pumps and heat exchangers in electrical cabinets, they shall be bypassed or disconnected and individually tested according to manufacturer's instructions.

5.4 Test of actuation systems

The electron beam installation may be equipped with different actuation systems like compressed air, hydraulics and electric motion systems. These systems shall be tested according to the relevant standards and manufacturer's instructions. Particular attention shall be given to:

- protective devices against overload and mechanical malfunction,
- means to safeguard personnel against dangerous movements.

5.5 Vacuum test

Measurement shall be carried out using an ionization vacuum gauge when the installation is clean.

A pressure of 10^{-2} Pa or lower shall be attained in the electron gun chamber, when the cathode is cold. For this measurement, the vacuum chamber shall be separated from the gun chamber, or if not possible, the vacuum chamber shall be cleaned and no workpiece shall be placed inside the chamber.

After heating up, the cathode shall be degassed for 30 min, then a pressure of 5×10^{-2} Pa or lower shall be attained.

The required pressure for the vacuum chamber depends on the process and the kind of separation between a gun chamber and vacuum chamber. In any case, the pressure inside the gun chamber shall be below the level of 5×10^{-2} Pa also in the case of maximum specified process pressure inside the vacuum chamber.

6 Test of electron gun system

6.1 Electron gun

6.1.1 Condition of parts

The individual parts of the electron gun shall be checked regarding cleanness, tightness and adjustment according to the manufacturer's maintenance instruction. Particular care should be given to the cathode system.

6.1.2 Moveable parts

If the electron gun has any moveable parts, like for example a vario cathode or vario anode, the movement shall be checked regarding smooth running, limits and accuracy of positioning.

6.1.3 Insulation resistance tests

The insulation resistance between high voltage conductors and ground shall be measured according to Clause 19 of IEC 60204-11 (2000).

6.2 High-voltage power supply including cables

6.2.1 Earthing system

6.2.1.1 Test of earthing stick

All parts of the earthing stick, the earthing cable as well as the connections to ground and to the hooks shall be carefully inspected. Damaged parts shall be replaced, immediately.

6.2.1.2 Test of automatic earthing systems

Connection wires, contacts and control devices shall be checked visually.

Beside the test of reliable operation of each earthing device, it is also necessary to check the monitoring circuits for earth connection. For this purpose, a piece of paper is put between the contacts. The simulation of this failure may only be done as long as power circuits are switched off in a safe way.

6.2.2 Safety installation

Beside the test of reliable operation of each safety device and the right assignment, it is also necessary to check whether the monitoring circuits for redundant elements can detect a single failure. The simulation of such a failure may only be done as long as power circuits are switched off in a safe way.

6.2.3 High voltage connectors

The insulation resistance between high voltage conductors and ground shall be measured according to Clause 19 of IEC 60204-11 (2000). Connections to ground or other potentials shall be temporarily disconnected for the measurement.