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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Installations for electroheating and electromagnetic processing – General performance test methods

Installations pour traitement électrothermique et électromagnétique – Méthodes générales d'essai de fonctionnement

IEC 60398:2015-04(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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INSTALLATIONS FOR ELECTROHEATING AND ELECTROMAGNETIC PROCESSING – GENERAL PERFORMANCE TEST METHODS

FOREWORD

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International Standard IEC 60398 has been prepared by IEC technical committee 27: Industrial electroheating and electromagnetic processing.

This third edition cancels and replaces the second edition of IEC 60398 published in 1999 and the first edition of IEC TS 62796 published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- the title and scope of the standard have been expanded to include installations and equipment for electromagnetic processing of materials;
- the requirements have been restructured;

- tests concerning safety have been moved to IEC 60519-1[1];
- new tests and clauses addressing energy efficiency considerations have been added;
- a new annex placing this standard in the context of energy efficiency assessment as developed by ISO and IEC has been added;
- new annexes addressing visual display of data, estimation of energy use and energy recoverability of fluids have been added.

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

FDIS	Report on voting
27/949/FDIS	27/952/RVD

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 stability 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- withdrawn,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.

[1] Fifth edition to be published.

INTRODUCTION

Designing equipment for electroheating (EH) or for electromagnetic processing of materials (EPM) is a complex task. The manufacturer of the installation or equipment usually needs to fulfil the following requirements, which come from different sources and are quite often in this order of priorities:

a) to enable the intended process and make the installation to work properly;

b) to be cost effective during design and manufacturing;

c) to ensure that the equipment is safe to use in the sense of providing freedom from unacceptable risk of physical injury or damage to the health of the operator (safety in the narrower sense of ISO 12100:2010);

d) to prove that the equipment is cost effective to operate and uses sufficiently small amounts of energy, material and other resources;

e) to ensure that the equipment is safe to use in the sense of providing freedom from unacceptable risk or physical injury or damage to the health of people, or damage to property or the environment (adding other safety aims to c) and in the much broader definition of safety according to ISO/IEC Guide 51).

It is usually part of the proprietary knowledge of the manufacturer or user of the equipment, to make it cost effective or enabling intended processes with a benefit. IEC 60519-1:— assists with achieving safety in the ISO 12100:2010 sense. The focus of this standard is on basic requirements for measuring instrumentation and test methods concerned with energy and resource efficiency, performance of the intended process and assessing cost of ownership for installations and equipment for EH and EPM.

INSTALLATIONS FOR ELECTROHEATING AND ELECTROMAGNETIC PROCESSING – GENERAL PERFORMANCE TEST METHODS

1 Scope

This International Standard specifies the basic test procedures, conditions and methods for establishing the main performance parameters and the main operational characteristics of industrial installations and equipment intended for electroheating (EH) or electromagnetic processing of materials (EPM).

Measurements and tests that are solely used for the verification of safety requirements of equipment for EH or for EPM are outside the scope of this standard and are covered by the IEC 60519 series.

This standard is applicable for the commissioning, verification of design improvements or for energy related tasks including benchmarking with respect to energy use or energy efficiency, establishing of an energy baseline, and labelling. Some concepts from this standard can directly be used as key performance indicators.

Detailed tests for specific types of EH or EPM equipment and installations are beyond the scope of this standard and are provided in particular test standards for EH or EPM equipment. This standard is intended as general reference for all future test standards applicable to particular EH or EPM equipment or installations.

This standard includes the concept and material presented in IEC TS 62796 on energy efficiency dealing with the electrical and processing parts of the equipment, as well as the overall performance.

2 Normative references

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

IEC 60519-1:—[2], *Safety in installations for electroheating and electromagnetic processing – Part 1: General Requirements*

ISO/IEC 13273-1[3], *Energy efficiency and renewable energy sources – Common international terminology – Part 1: Energy Efficiency*

ISO/IEC Guide 99, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

ISO 50001:2011, *Energy management systems – Requirements with guidance for use*

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2 Fifth edition to be published.

3 To be published.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60519-1, ISO/IEC 13273-1, ISO 50001, ISO/IEC Guide 99, as well as the following apply.

NOTE General definitions are given in the International Electrotechnical Vocabulary, IEC 60050. Terms relating to industrial electroheating are defined in IEC 60050-841.

3.1 General

3.1.1
energy using system
physical item or organization with defined system boundaries, using energy

Note 1 to entry: An energy using system can be a plant, a process, part of a process, a building, a part of a building, a machine, equipment, a product, etc.

[SOURCE: ISO/IEC 13273-1:—, 3.1.11, modified – Original cross-references have been deleted.]

3.1.2
system boundary
physical or site limits and/or organizational limits as defined by the organization for a stated purpose

EXAMPLE A process; a group of processes; a site; an entire organization; multiple sites under the control of an organization.

Note 1 to entry: The stated purpose could be for a management system, or for the boundaries of an energy assessment or for the boundaries of a specific measurement and verification activity.

[SOURCE: ISO/IEC 13273-1:—, 3.3.2, modified – "M&V" has been replaced by full term in Note 1 to entry.]

3.1.3
equipment category
group within a type of equipment, using the same principle for processing of the workload

Note 1 to entry: A category can be further divided with respect to the size or the capacity of equipment.

Note 2 to entry: An example of type is equipment for induction heating, and an example of category is such equipment for metal wire heating in a specified capacity interval, using medium frequency.

3.1.4
equipment capacity
measure of the production rate capability of equipment in normal operation

EXAMPLE Flow, mass or volume.

Note 1 to entry: The capacity does not refer to the volume of the working space.

3.1.5
intended workload quality
degree to which a set of inherent characteristics of a processed workload fulfils requirements

Note 1 to entry: Workload that does not attain the intended workload quality is regarded as scrap or undergoes rework.

3.1.6
processing range, <of EH or EPM installation>
range between an upper and a lower limit of set parameters between which the processed workload exhibits the intended workload quality

3.2 Energy efficiency

3.2.1
energy efficiency
ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy

EXAMPLE Conversion efficiency; energy required/energy used; output/input; theoretical energy used to operate/energy used to operate.

Note 1 to entry: Both input and output need to be clearly specified in quantity and quality, and be measurable.

[SOURCE: ISO 50001:2011, 3.8]

3.2.2
energy intensity
quotient describing the total amount of energy necessary to generate a unit of output, activity, economic value, or service

EXAMPLE Gigajoule per euro of GDP (gross domestic product); Gigajoule per unit of turnover.

[SOURCE: ISO/IEC 13273-1:—, 3.1.16 modified – Original cross references have been deleted.]

3.2.3
specific energy consumption
quotient describing the total amount of energy necessary to generate a unit of output, activity, or service

EXAMPLE Gigajoule (GJ) per tonne of steel, annual kilowatt hour (kWh) per square metre (m^2), litres (l) of fuel per kilometre (km), etc.

[SOURCE: ISO/IEC 13273-1:—, 3.1.17 modified – Original cross references have been deleted.]

3.2.4
heating efficiency, <of EH or EPM equipment>
ratio of the usable enthalpy increase in the workload to the electric energy supplied to it during a cycle of batch operation or stationary operation

3.3 States and parts

3.3.1
cold start-up
process by which the equipment is energised into hot standby operation from the cold state

Note 1 to entry: This mode of operation applies to cases where there is a significant energy consumption needed for obtaining a state of the equipment allowing the actual processing of the workload.

3.3.2
holding power
electric power consumed for keeping the workload in the processing chamber or zone at a specified temperature

Note 1 to entry: The temperature is typically maintained during a time intended to equalize the workload temperature.

Note 2 to entry: Holding power is not applicable for all EH or EPM equipment.

3.3.3
hot standby operation
mode of operation of the installation occurring immediately after normal operation

Note 1 to entry: This mode of operation of the installation is with its hot state remaining, without workload, and with the means of operation ready for prompt normal operation.

3.3.4
shut-down operation
process by which the installation is de-energised safely into the cold state

3.3.5
port, <entrance or exit>
opening in the processing chamber or enclosure through which the workload moves

3.3.6
means of access
structural feature of the EH or EPM installation which can be opened or removed without the use of a tool to provide access to the installation

3.4 Workload

3.4.1
intended workload
normal workload
object intended to be processed as specified in the manufacturer's documentation

Note 1 to entry: The intended workload includes any container, holder or other device necessary for the processing and which is directly or indirectly subjected to the output power.

3.4.2
dummy workload
artificial workload with known thermal properties, designed for accurate enthalpy increase measurements by absorbing the available output power

3.4.3
performance test workload
artificial or partially artificial workload designed for discrimination of processing results

Note 1 to entry: Examples of such results are relative slag content, relative or absolute areas or volumes of unsatisfactorily processed material.

4 Basic provisions for testing and test conditions

4.1 Aim of testing

This standard provides tests concerning

– the outcome of the process,
– service performance or intended workload quality,
– energy use of the system,
– other resource use.

In all cases, the definition of the system boundaries is mandated and shall be documented.

The specific outcome of the process, the expected workload quality and the minimum service performance after processing are usually defined by the manufacturer and user.

NOTE Details can be beyond the scope of this standard or even particular test standards for EH or EPM equipment.

This standard determines all general tests necessary to assess the energy use of the system, which provide basic data for

a) determining energy intensity or specific energy use as agreed on by the manufacturer and user,

b) energy efficiency related services like comparing, labelling or classification (see Annex A),

c) determining energy performance indicators (see Annex A) or

d) tests related to energy management according to ISO 50001.

Additional tests may be specified in the commissioning and operation manuals issued by the manufacturer or may be agreed between the manufacturer and user.

4.2 Communication of test results

Data generated during the measurements or tests defined in this standard can be used for many different purposes or services. Some of these services come with their own defined minimum requirements for the amount and depth of documentation and their requirements on communication.

This standard provides minimum requirements for documentation with each single test enabling use and reuse of data for different purposes. Only well-documented data is trustworthy and enables comparison in time or between different installations.

Annex B provides information on how data can be visualised.

4.3 Boundaries of the energy using system for testing

4.3.1 General considerations

The following basic rules apply:

– All energy uses being part of electric energy generation or transport to the installation are excluded.

– All energy uses being part of the installation or being necessary for the intended process of the installation are included.

The following energy uses of the intended process shall be considered:

a) Energy of compression or decompression of steam, air or any other gas shall be included in the calculations of used and lost energy.

b) Exo- or endothermic chemical energy involving any reactive gases in the processing of the workload shall be included.

c) Energy used for cooling action by any excess reactive and/or inert gases in the processing of the workload shall be included.

d) Energy used for cooling of the processed workload to ambient temperature, or as preparation for further treatment as part of normal operation shall be included, but stated separately in the calculation of used and lost energy. If a part of this thermal energy is transferred back into the installation or process, this recycling of thermal energy shall be reported separately, to allow comparisons with other installations in the same category not having this feature. Thermal energy used outside the process shall not be included in reporting (see Annex D).

4.3.2 Batch type installations

Batch type installations are characterised by a discontinuous processing, where the intended process happens at a specific treatment position or inside a processing chamber. If there are means of access, these are opened and a workload is placed inside a processing chamber of the installation and then undergoes normal operation. The means of access are then reopened and the workload is removed from this processing chamber and the installation either goes into hot standby operation with closed means of access, or the process is directly restarted with another workload after replacement of the workload.

Normal operation includes a processing phase in the operation cycle and can also include one or more of the following sub-processes in this cycle:

– closing and opening of means of access;
– pressurising of the processing chamber;
– movement or transport of the workload, this includes for example rotation or wobbling movement during operation;
– holding the workload at a specified temperature for a specified time;
– introducing reactive or protective gases into the processing chamber, including deposition processes;
– free or forced cooling of the workload, for example, if cooling is necessary to avoid damage or boiling by exposing the hot workload to ambient atmosphere.

The energy used to perform these sub-processes shall be included. The spatial boundary of the installation with respect to the process is defined by

a) an entrance port position where the workload is placed prior to normal operation or the equipment, which transports the workload into a processing chamber or position; such equipment is a part of the installation and its energy use is included;
b) an exit port position where the workload is placed after normal operation for removal, or the equipment, which moves the workload out of a processing chamber or position; such equipment is a part of the installation and its energy use is included;
c) the energy use of all equipment in between, including for example all switchgear, pumps, and cooling means necessary for the processing.

NOTE In equipment utilising non-atmospheric pressure or other atmospheres than air, the boundary between the EH or EPM installation and any other installation is typically a valve; a load lock – consisting of two valves and used for the transfer of workload between different atmospheres – will usually be part of the EH or EPM installation.

The cycle of batch operation relevant for measurement shall begin after hot standby operation.

4.3.3 Continuous type installations

Continuous type installations are characterised by a continuous or semi-continuous processing. The workload is conveyed through the processing region of the installation, which can be a processing chamber of the installation during normal operation. The processing occurs at consecutive positions inside the installation as the workload is transported through it – for example in roll to roll operations or in sheet feed installations. Most installations go into standby operation when no workload is conveyed; this can be a hot standby for many thermal processes.

The normal operation includes a processing phase and can include one or more of the following sub-processes, which occur at different and typically separated spatial positions inside the installation,

– holding the workload at a specified temperature;
– introducing reactive or protective gases, including deposition processes;
– free or forced cooling of the workload, for example if cooling is necessary to avoid damage by exposing the hot workload to ambient atmosphere.

The energy used to perform these sub-processes shall be included only if it is necessary to cool or depressurise the workload in an integral part of the installation. The boundary of the installation is then defined by

a) the entrance and exit ports;
b) all equipment in between, including for example all switchgear, pumps, cooling means necessary for operation of the installation.

The energy consumption of transport or roll handling in stand-alone installations is included in the used energy. It shall be stated separately in the calculations.

4.4 General requirements for testing

The relevant safety requirements and the manufacturer's instructions shall be observed during all tests, to ensure safety.

The characteristics and parameters defined in Clause 8 shall be tested in the hot state of an EH or EPM installation

– during commissioning,
– when the installation is ready for normal operation,
– at regular intervals as specified by the manufacturer,
– following maintenance or
– after modifications.

The operator responsible for performing the measurements or tests shall be sufficiently trained to make accurate tests and have sufficient time and resources at hand to perform measurements and tests as intended and indicated in this standard.

4.5 Operating conditions during tests

Operating conditions during tests shall be in the range of normal operation conditions and thus reflect the manufacturer's intended use of the installation while excluding extreme usage patterns, deliberate misuse or unauthorized modifications of the installation or its operating parameters.

4.6 Environmental conditions during tests

All tests shall be performed

– under standardised environmental conditions, at ambient temperature in the range between 5 °C and 40 °C, relative air humidity of less than 95 %, at less than 1 000 m altitude above the sea level, or
– at the place of use of the installation under the available and specified environmental conditions there.

The environmental conditions shall not exceed those defined for the intended use of the installation. All environmental conditions affecting measurement results shall be monitored during the tests and shall be reported. This includes

a) temperature and humidity in the air inlet region to the processing chamber, if relevant;
b) temperature and humidity of cooling air drawn into the installation;
c) exhaust air temperature and humidity, if relevant for the energy balance calculations;
d) temperature of the workload when entering the installation;
e) moisture or solvent content of the workload when entering the installation, if applicable.

4.7 Supply voltage

The supply voltage shall not exceed the limits defined for the intended use.

NOTE The rated supply voltage range is specified by agreement between the manufacturer and user. A common range is a deviation not exceeding ± 10 % from nominal, as this is the range defined by IEC 60038.

The supply voltage to the installation shall be monitored during the tests.