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TECHNICAL SPECIFICATION

Energy efficiency in electroheating installations

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FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62796, which is a technical specification, has been prepared by IEC technical committee 27: Industrial electroheating and electromagnetic processing.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
27/882/DTS	27/903/RVC

Full information on the voting for the approval of this technical specification 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

- transformed into an International Standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This Technical Specification (TS) was prepared by a working group of IEC TC 27, whose overall intent was to develop guidelines for the classification of industrial electroheating systems, which allow for the determination of the performance/efficiency of a given system and a comparison with other systems of that class.

The initial technical considerations suggested that TC 27 should at first limit its focus on determination of energy consumption for a defined output of processed workload. The next step should then be consideration of performance characteristics influencing the energy efficiency, such as metallurgical or thermal processing particulars. However, during the course of the work, it turned out that comparisons of performance can best be made by specifying different workloads for different kinds of comparisons.

Measurements of efficiencies are split into two main categories: electrical-only and of the electroheating in normal operation. The latter has a relationship to other performance aspects which are also dealt with.

Testing requires specification limits on workload and three kinds are defined:

– normal workloads – i.e. such within the specifications provided by the manufacturer;
– dummy workloads – artificial items specially designed to very efficiently absorb the available output power without being processed or modified as the normal workload, and by that promoting the accuracy of enthalpy increase measurements;
– performance test workloads – artificial or partially artificial workloads specially designed for discrimination of processing results.

The TS provides general methods for determination of the efficiency of electroheating systems and is intended to assist in creating a consistent terminology and structure in various TC 27 test standards dealing with specific equipment types. The TS material is to be covered by the future third edition of IEC 60398 [3][1].

1 Numbers in square brackets refer to the Bibliography.

ENERGY EFFICIENCY IN ELECTROHEATING INSTALLATIONS

1 Scope and object

This Technical Specification is applicable to industrial electroheating installations using electric energy as input, alone or in combination with other kinds of energy. However, external combustible fuel energy input is not dealt with, and all considerations begin at the electric only mains frequency source to which the installation is connected. Any external voltage transformation from the supply network to the plant into a special voltage which is fed into the installation is not dealt with in this Technical Specification, since it is not considered a responsibility of the manufacturer of the installation.

The object of this Technical Specification is to provide methods for determination of the efficiency of a given system as well as enabling comparisons with other equipment using the same principle for processing of the workload.

For satisfactory comparisons to be possible, differences in end product quality and influences of environmental factors on heat recovery are included.

Heat recovery aspects are dealt with but limited to the temperature changes, the specific heat capacity characteristics, and the physical properties of the usually fluidic substance obtained from the installation and employed for energy recovery use. Conversion into mechanical energy is dealt with.

Adaptation to the needs of operation and performance management as might be necessary for the implementation or application of smart grid technologies, is addressed but no test methods are given.

A guideline is provided for the development of the detailed electroheating efficiency tests for the particular test method standards. The different principles of electroheating for processing a workload, and types of equipment, are given in Clause 1 of IEC 60519-1:2010.

If energy from combustible gases or liquids is used in addition to electric energy, the measurement and calculation of the energy efficiency contribution of combustion in the installation are made according to the relevant ISO standards. These may deal with the electric energy input in other ways than in this Technical Specification.

NOTE The relevant standards in the ISO 13579 series are listed in the Bibliography [4 – 7].

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 60519-1:2010, *Safety in electroheating installations – Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, terms and definitions given in IEC 60519-1:2010 and the following apply.

NOTE General definitions are given in IEC 60050, International Electrotechnical Vocabulary [1]. Terms relating to industrial electroheat are defined in IEC 60050-841.

3.1 General concepts

3.1.1
enthalpy increase
sum of energy added through heating of an object and the mechanical work of expansion of it done in pushing against the ambient (atmospheric) pressure

Note 1 to entry: The energy of the mechanical work of expansion is stored in the surroundings and can be recovered if the system collapses back to its initial state.

3.1.2
exergy
maximum fraction of energy in a system including a medium at an initial temperature T_1 which can be converted into useful work during a process at the end of which the system temperature is T_0

Note 1 to entry: This is the theoretical quantity related to the endoreversible thermal efficiency of a heat engine.

3.1.3
heat engine
system that performs the conversion of thermal energy into mechanical work by bringing a working medium from a high temperature state to a lower temperature state

Note 1 to entry: In the context of this document, the mechanical work is either used directly with an external generator to create electricity, or with a second external heat engine operating in the heating mode for increasing the temperature of a part of the hot medium, for further use.

3.1.4
energy recoverability
usefulness of a hot substance obtained in or from a process for providing energy back into the process or to an external purpose

Note 1 to entry: The usefulness depends on the temperature and ease of handling of the hot substance, and on the temperature of the recipient.

Note 2 to entry: Transformation into mechanical energy by heat engines is a separate item.

Note 3 to entry: Transformation into chemical energy is not included.

Note 4 to entry: Any heat of combustion of the substance is excluded.

3.2 Equipment, operations and workloads

3.2.1
ambient conditions
environmental conditions
characteristics of the environment which may affect performance of a device or system

EXAMPLE Pressure, temperature, humidity, radiation, vibration.

3.2.2
equipment capacity
measure of the production rate capability of equipment in normal operation

EXAMPLE Flow, mass or volume.

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

3.2.3
equipment class
group within a type of equipment, using the same principle for processing of the workload and the size of this as well as the equipment capacity

Note 1 to entry: An example of type is equipment for induction heating, and a class example is such equipment for metal wire heating in a specified capacity interval, using medium frequency.

3.2.4
efficiency, <of an electroheating installation>
ratio of the usable enthalpy increase in the workload to the electric energy supplied to it at the location of the equipment, during a cycle of batch operation or stationary operation during a suitable time period for measurements

[SOURCE: IEC 60050-841:2004, 841-22-70, modified – Enthalpy increase in the workload is specified instead of useful energy, and measurement time limits have been added.]

3.2.5
performance, <of an electroheating installation>
degree to which the intended functions, including energy or power consumption and output as well as the result of the treatment of the workload are accomplished

3.2.6
end product quality
degree to which a set of inherent characteristics of a processed workload fulfils requirements

3.2.7
power factor
under periodic conditions, ratio of the absolute value of the active power P to the apparent power S

Note 1 to entry: This is applied to the supply network under normal operation.

[SOURCE: IEC/TS 62257-12-1:2007 [2], 3.4, modified – Note 1 to entry has been added.]

3.2.8
cold start-up
process by which the equipment is energised into hot standby operation from the cold state, including all other start-up operations which enable the equipment to run under normal operation

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, see 6.1.

3.2.9
holding power
electric power consumption during which the workload is kept in the treatment chamber 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: This mode of operation is not applicable for certain types of electroheating equipment.

3.2.10
hot standby operation
mode of operation of the installation occurring immediately after normal operation

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

3.2.11
normal operation
range of output settings with the normal workload in allowable working conditions of the equipment, as specified in the manufacturer's documentation

3.2.12
normal workload
object being processed at nominal output power, as specified in the manufacturer's documentation

Note 1 to entry: The workload is called charge in some electroheating contexts.

Note 2 to entry: The workload includes any container, holder or other device necessary for the processing and which is directly or indirectly subjected to the output power. The processed object/material as such is also called load.

3.2.13
dummy workload
artificial item with known thermal properties, designed for accurate enthalpy increase measurements by absorbing the available output power

3.2.14
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 General aspects of energy efficiency measurements in electroheating

4.1 General

Clause 4 deals with the instrumentation and some general non-electric factors connected with energy efficiency measurements. Clause 5 deals with the requirements for comparative testing, Clause 6 with measurements of electric power and ancillary energy factors, and Clause 7 with the measurements of efficiencies.

4.2 Instrumentation

Electric instruments shall be of class 2 or better. Other instrumentation shall allow measurement inaccuracies of maximally 2 %, with the exception of measurements of quantities having only a small influence on the overall power/energy data, and for workload enthalpy increase.

It may be unavoidable to accept inaccuracies exceeding 2 % of the enthalpy increase under conditions addressed in 4.4 and 4.5, as well as for large solid workloads. Specifications on instrumentation and accuracy requirements on those quantities shall be stated in the test method standard for the particular type of equipment.

4.3 Ambient conditions and initial temperature of the workload

Ambient conditions, in particular the temperature, will influence the energy efficiency, and even more so the need for integrated or ancillary cooling or preheating equipment. The energy recoverability is also affected.

Installations of the same type and class may thus be different depending on the specified ambient conditions, in particular with regard to the limits of specified ambient temperature at nominal power operation. Also the initial temperature of the workload is important in many cases and its variations shall be considered. Satisfactory comparison of installations requires specification and report of these variations and of the ambient conditions throughout the tests.