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Second edition
Deuxième édition
2007-06

Safety in electroheat installations –

Part 11:
Particular requirements for installations using the effect of electromagnetic forces on liquid metals

Sécurité dans les installations électrothermiques –

Partie 11:

Exigences particulières pour les installations utilisant l'effet des forces électromagnétiques sur les métaux liquides

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY IN ELECTROHEAT INSTALLATIONS –

Part 11: Particular requirements for installations using the effect of electromagnetic forces on liquid metals

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 60519-11 has been prepared by IEC technical committee 27: Industrial electroheating equipment.

This second edition cancels and replaces the first edition published in 1997 and constitutes a technical revision. The significant changes with respect to the previous edition are as follows:

- the latest editions of IEC 60519-1:2003 and IEC 60519-3:2005 have been taken into account;
- definitions have been brought into line with the second edition of IEC 60050-841:2004.

This standard is to be used in conjunction with IEC 60519-1:2003. It is intended to specify particular requirements for installations using the effect of electromagnetic forces on liquid metals.

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

FDIS	Report on voting
27/577/FDIS	27/585/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 list of all parts of the IEC 60519 series, under the general title *Safety in electroheat installations*, can be found on the IEC website.

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.

SAFETY IN ELECTROHEAT INSTALLATIONS –

Part 11: Particular requirements for installations using the effect of electromagnetic forces on liquid metals

1 Scope

This part of IEC 60519 applies to installations predominantly using the effect of electromagnetic forces on liquid metals:

- installations for electromagnetic (induction) stirring or transport of liquid metals at low frequencies;
- installations that influence the pouring process by an electromagnetic field;
- parts directly affected by the electromagnetic stirring, transport or pouring installation.

Examples of application:

- stirring devices for casting machines, arc furnaces, ladles, etc.;
- transport of liquid metal for emptying or filling furnaces, launders or moulds;
- devices to transport liquid metal with simultaneous proportioning of the transported quantity, for example, for filling diecasting machines;
- influencing the ingot surface or the pouring stream enhancing crystallization by means of an electromagnetic field during continuous casting;
- sealing of mechanical gaps of melt vessels, for example, in vertical galvanizing line.

This standard consists of

- requirements common to installations using the effect of electromagnetic forces on liquid metals;
- specific requirements for electromagnetic pouring equipment (Annex A);
- specific requirements for electromagnetic equipment with lining (Annex B).

NOTE When applying IEC 60519-1 in conjunction with this standard, the terms "electroheat installation" or "electroheat device" should be replaced by the term "installation using the effect of electromagnetic forces on liquid metals".

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 – Part 841: Industrial electroheat*

IEC 60110-1:1998, *Power capacitors for induction heating installations – Part 1: General*

IEC 60143-1:2004, *Series capacitors for power systems – Part 1: General*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60519-1:2003, *Safety in electroheat installations – Part 1: General requirements*

CISPR 11, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in IEC 60519-1 and IEC 60050-841 (some of which are repeated here), as well as the following apply.

3.1
installation using the effect of electromagnetic forces on liquid metals
installation composed of the inductor and the electric and mechanical equipment used to exercise an intended effect of electromagnetic forces on liquid metals

3.2
electromagnetic stirring of liquid metals
procedure to achieve stirring motion in liquid metals by using an electromagnetic field

[IEV 841-27-24, modified]

3.3
electromagnetic transport of liquid metals
procedure to move liquid metals in a defined direction using an electromagnetic field

[IEV 841-27-25, modified]

3.4
electromagnetic casting of liquid metals
procedure to shape the liquid metal stream or to influence its surface quality after pouring by the use of an electromagnetic field

[IEV 841-27-26]

3.5
enhancing crystallization of liquid metal in electromagnetic fields
procedure to shape a form and structure of metal crystals in an electromagnetic field

[IEV 841-27-27]

3.6
inductor
part of an installation (for example, coil(s)) using the effect of electromagnetic forces on liquid metals which produces the electromagnetic field to yield the required electrodynamic force

NOTE Inductor is defined in IEV 841-27-47, but for the purpose of this standard this more specific definition is needed.

4 Inductor

4.1 Inductors with high power ratings may be equipped with yokes (coil flux guides) to guide the magnetic flux outside the induction coil(s) to reduce stray fields possibly heating the surrounding metal structure.

The design of these yokes should take care of the risk of them being excessively heated by eddy currents.

4.2 Where the inductor or parts of it are intended to be replaced due to wear or exchanged to meet a new production requirement, the manufacturer's instructions shall be followed.

4.3 Should the effect of cooling of the inductor become insufficient and cause danger to personnel or damage to essential parts of the equipment, an alarm signal shall be given and the power switched off automatically.

In the case where a sudden interruption of power could cause a possible hazard to personnel, due to liquid metal splashes, a controllable reduction of power is recommended.

4.4 For installations using the effect of electromagnetic forces on liquid metals with forced cooled inductors having a charge and/or lining of high heat capacity, it is advisable to have an emergency supply for cooling the coil(s) and, where applicable, the conveying equipment until the hot charge has been removed and until the lining has cooled to a safe temperature.

4.5 The design of the inductor shall take into account the concentrated electromagnetic forces due to the high values of low-frequency current in the coil(s) that can produce vibrations and local field concentrations.

4.6 The inductor shall be designed and manufactured so as to meet the difficult operational and environmental requirements, for example, the presence of water spray, steam and heat radiation.

4.7 Design of components in the vicinity of the inductor shall take into account the influence of electromagnetic fields. Apart from suitable material and shape, further measures can be required such as screening, insulation, forced cooling and avoidance of closed metallic loops in order to keep the electromagnetic and thermal influences within admissible limits.

5 Capacitors

5.1 This clause deals with power capacitors. Other capacitors, for example, installed in control circuits, are covered by 6.2.4 of IEC 60519-1.

5.2 All necessary precautions shall be taken to rapidly discharge capacitors which could be dangerous to touch after they have been switched off.

A warning notice shall be displayed in a visible position stating that the discharge shall be effected before touching the capacitors.

5.3 For capacitors permanently connected in parallel to an inductor or a transformer, the discharge device may be dispensed with.

Where capacitors connected in parallel to an inductor or a transformer are disconnected only in the off-load condition, the discharge device may be dispensed with, providing a sufficient time delay occurs for the discharge between switching off the supply and opening the capacitor switch.

If there is a risk of d.c. charging, the discharge device is indispensable.

5.4 Capacitors that are switched on load or connected via external fuses shall have discharge facilities.

5.5 Information on the requirements for the discharge of series connected capacitors is given in 6.8, 6.9 and 6.10 of IEC 60110-1 and in 5.1 of IEC 60143-1.

5.6 The terminals of capacitors with internally series-connected elements shall be short-circuited before being disconnected.

NOTE Although a discharge device has operated, a residual charge may sometimes remain at the interconnections of series-connected capacitors due to blown fuses, interrupted internal connections, differences of the capacitance values or dielectric recharging from d.c. components of the previous charge.

5.7 Capacitors in installations without electronic power control shall be connected via protective devices. Where internal fuses are employed, external means of protection can be dispensed with.

5.8 Where capacitors are liquid-cooled, the provision given in 6.2.8 of IEC 60519-1 shall apply.

6 Mains-frequency power sources

In the case of mains-frequency power sources which feed a single-phase load from a three-phase supply and which employ capacitors and reactors to keep the three line currents in reasonable balance, series resonance causing overvoltages liable to impair safety may occur if the phase connection common to the capacitors and reactors of the balancing circuit becomes open-circuited, for example, by a blown fuse or a defective contactor in the line.

For such conditions measures shall be provided to disconnect the supply, for example, overvoltage tripping of the supply circuit-breaker.

Contactors which control the three-phase supply to the reactor-capacitor combination shall be designed to ensure that the contact connected to the common point of the reactor and capacitor closes earlier when switching on and opens later when switching off.

Design shall take care of the risk of possible harmonic currents absorbed from the supply system due to parallel resonance.

7 Solid-state frequency converters

7.1 Solid-state frequency converters shall be protected at the input terminals to prevent transient overvoltages, which may occur during switching operations on the supply side, ensuring that safety is maintained.

7.2 Solid-state frequency converters shall have fast-acting overvoltage and overcurrent protection.

7.3 Additional measures shall be taken to avoid the occurrence of dangerous transient voltages due to rapid changes of load power.

7.4 Hazards that may occur to personnel in case of a fault due to stored energy shall be avoided by suitable measures.

8 Switchgear

8.1 Design of the switchgear operated off-load shall take into account the time behaviour of the converters, reactances (transformers and reactors) and capacitors.

8.2 Design of switchgear shall take into account not only the fundamental component of the current, but also the harmonics which may occur.

8.3 When switching capacitors on-load, the following points among others shall be considered when a switching device or method is chosen.

- When switching on, high current peaks at high frequency may occur.
- When switching off, dangerous levels of overvoltage as a result of restriking of the switching device shall be avoided.

9 Cables, wires and busbars

9.1 Cables, wires and busbars shall be so dimensioned and arranged that inadmissible heating is avoided, taking into account the magnitude and frequency of their current loadings.

NOTE Tables of cable current carrying values relevant for mains frequency (50 Hz/60 Hz) are generally not applicable for installations working at higher frequencies.

In the case of parallel connections, care shall be taken to avoid over-heating of individual conductors due to unequal sharing of current.

Care shall be taken to avoid excessive heating of neighbouring constructions by stray fields.

9.2 Where cables, wires or busbars are force cooled, the provisions given in 6.2.8, 6.6.1 and 6.6.2 of IEC 60519-1 shall apply.

9.3 The individual overcurrent protection devices of the installation may be dispensed with for internal connections between components such as converters, transformers, capacitors, switchgear, inductors and contact systems, provided such connections are short-circuit and earth-leakage proof.

NOTE This is deemed to be the case with cables or arrangements of solid wires or single cores where contact with one another (also with earthed parts) is prevented by using sufficient clearances, spacers or insulating shims, by laying the conductors in separate conduits of insulating material or by using cables or wires that are considered to be short-circuit proof by their design.

The short-circuit strength mentioned above may be dispensed with for medium- and high-frequency installations if sufficient short-circuit protection is ensured by the design of the frequency converter, for example, solid-state equipment.

The design shall take care to avoid excessive internal over-currents.

9.4 Cables and wires, which are part of the heating section, are normally provided with an insulation that shall resist high mechanical and thermal stresses. In the majority of cases this insulation is insufficient for protection against electric shock. For this reason measures shall be taken for the prevention of inadvertent contact with these cables and wires during operation, if the permissible touch voltage (13.1.1) is exceeded.

9.5 When choosing cables or leads to feed the inductor, the effect of heat radiation and the presence of water or steam shall be taken into account. There may be a need for special measures to protect them, for example, screening, forced cooling or casings.

10 Liquid cooling

Subclause 6.6 of IEC 60519-1 applies with the following additional requirements.

10.1 In textile-reinforced hoses, moisture is likely to creep along the textile reinforcement creating potential differences between the reinforcement and the coolant, possibly overstressing the electrical insulation of the hose.

This shall be taken into account in the choice of material and the arrangement of hoses.

10.2 Certain liquid-cooled components (for example, inductors with water-cooled housing, ceramic capacitors, water jackets of electronic tubes) are extremely sensitive to pressure. Deviating from the requirements of 6.6.4 of IEC 60519-1, they shall withstand the rated service pressure only. Their water connections, however, shall withstand 1,5 times the rated service pressure.

Pressure peaks potentially caused by switching valves shall be taken into account.

10.3 Cooling below dew point shall be avoided as it can cause condensation, for example, at the coil of the inductor and its terminals possibly leading to a short circuit.

10.4 Water used for cooling of live parts and magnetic cores shall be of particularly high quality and shall not contain dirt and/or ferromagnetic particles.

10.5 When opening the cooling circuit, for example, when changing the inductor, care shall be taken to avoid any contamination of the water.

10.6 Where the water cooling is employed to dissipate the electrical losses and, in addition, to protect the inductor and/or the cables or leads against radiated heat from the charge, the flow of water shall remain even with the electric power switched off until there is no longer a heat hazard.

11 Rating plate

Clause 15 of IEC 60519-1 applies with the following additional requirements.