INTERNATIONAL STANDARD

ISO 14990-2

First edition
2016-11-01

Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems —

Part 2: Particular requirements for externally-powered machines

Engins de terrassement — Sécurité électrique des machines utilisant des moteurs électriques et composants et systèmes connexes —

Partie 2: Exigences particulières pour les machines à moteur externe

Reference number
ISO 14990-2:2016(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 3, *Machine characteristics, electrical and electronic systems, operation and maintenance.*

This document is intended to be used in conjunction with ISO 14990-1.

Introduction

This document is a type-C standard as defined in ISO 12100.

The machinery concerned and the extent to which hazards, hazardous situations, or hazardous events are covered are indicated in ISO 14990-1:2016, Annex A.

When requirements of this type-C standard are different from those stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

Electrification is an enabling technology providing increased flexibility in machine form packaging. Because in the past earth-moving machinery (EMM) electrical systems have predominately been in the 12–24 V DC range, two safety aspects require particular attention:

— significantly higher voltages, such as are utilized in industrial or structural applications and in other transportation sectors;

— greater available electrical energy.

Portions of this document appear to govern electrical design practices (e.g. Clauses 9, 11, 12, and 17). Their requirements are necessary because certain aspects of design cannot be separated from electrical safety.

Some of the content of this document is based on IEC 60204-1 and IEC 60204-11, adapted to the needs of earth-moving machinery. Non-electrical hazards are addressed in the ISO 20474 series.

Figure 1 is provided as an aid to the understanding of the interrelationship of the various elements of a machine and its associated equipment. Figure 1 is a block diagram of a typical machine and associated equipment showing the various elements of the electrical equipment addressed in this document.

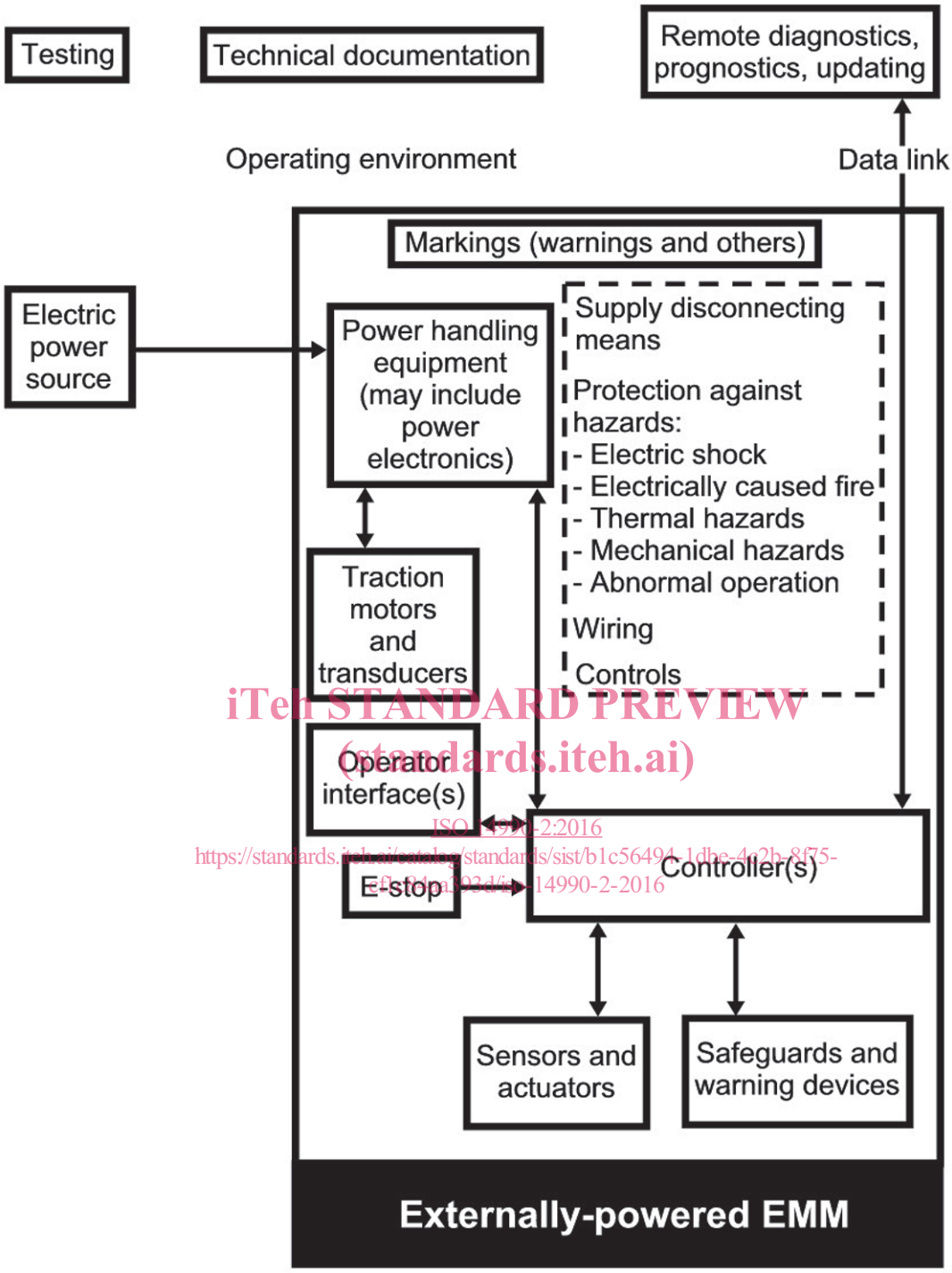

Figure 1 — Block diagram of a typical machine

Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems —

Part 2:
Particular requirements for externally-powered machines

1 Scope

This document specifies the particular safety requirements for the electrical equipment and its components incorporated in externally-powered (mains-connected, including machines powered by external dedicated generators), electrically-driven earth-moving machines (EMMs).

It is applicable to those machines using on-board voltages in the range of 50 V–36 kV AC r.m.s. at any frequency and 75 V–36 kV DC — including any repetition rate of pulsating DC — intended for outdoor use. Voltages occurring within devices are not considered to be on-board voltages and are thus not within its scope.

It is intended to be used in conjunction with ISO 14990-1, which gives general requirements for EMMs regardless of how they are powered. Requirements specific to self-powered machines are given in ISO 14990-3. However, it is possible for an EMM to be both self-powered *and* externally-powered (e.g. a battery-powered machine having a built-in charger with power supply function), in which case ISO 14990-3 is also applicable.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 14990-1:2016, *Earth-moving machinery — Electrical safety of machines utilizing electric drives or related components and systems — Part 1: General requirements*

ISO 14990-3, *Earth-moving machinery — Electrical safety of machines utilizing electric drives or related components and systems — Part 3: Particular requirements for self-powered machines*

IEC 60071-1:2006, *Insulation Coordination — Part 1: Definitions, principles and rules.* Amended by IEC 60071-1:2006/Amd. 1:2010

IEC 60364-5-52, *Low-voltage electrical installations — Part 5-52: Selection and erection of electrical equipment — Wiring systems*

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification — Identification of equipment terminals, conductor terminations and conductors*

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms, definitions and abbreviated terms given in ISO 14990-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 General requirements

4.1 General

The requirements of ISO 14990-1:2016, Clause 4, shall apply except as modified by this clause.

4.2 Special conditions

The enquiry form given in Annex A can be used as the basis for an agreement between user and supplier to address special conditions, or where certain provisions of this document might not be applicable. The waiver of any requirement shall be limited to situations not covered by this document.

4.3 Supplies

4.3.1 AC supplies

Voltage: Steady-state voltage: 0,9 to 1,1 of nominal voltage.

Frequency: 0,99 to 1,01 of nominal frequency continuously; 0,98 to 1,02 short time.

Harmonics: Harmonic distortion not exceeding 10 % of the total r.m.s. voltage between live conductors for the sum of the 2nd to the 5th harmonic. An additional 2 % of the total r.m.s. voltage between live conductors for the sum of the 6th to the 30th harmonic is permissible.

Voltage unbalance: Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in three-phase supplies exceeding 2 % of the positive sequence component.

Voltage interruption: Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle with more than 1 s between successive interruptions.

Voltage dips: Voltage dips not exceeding 20 % of the peak voltage of the supply for more than one cycle with more than 1 s between successive dips.

4.3.2 DC supplies

4.3.2.1 From batteries

Voltage: 0,85 to 1,15 of nominal voltage; 0,7 to 1,2 of nominal voltage in the case of battery-operated vehicles.

Voltage interruption: Not exceeding 5 ms.

4.3.2.2 From converting equipment

Voltage: 0,9 to 1,1 of nominal voltage.

Voltage interruption: Not exceeding 20 ms with more than 1 s between successive interruptions.

NOTE This is a variation on IEC Guide 106 for ensuring the proper operation of electronic equipment.

Ripple (peak-to-peak): Not exceeding 0,15 of nominal voltage.

5 Protection against electric shock hazards

5.1 General

The requirements of ISO 14990-1:2016, Clause 5 shall apply except as modified by this clause.

5.1.1 See Figure 2 for an example of equipotential bonding for electrical equipment of an externally-powered EMM.

5.1.2 For EMM where the connection to the earthing system (machine bonding conductor) is provided solely by flexible cables, the continuity of the protective conductor shall be ensured by appropriate design of the cable. Where there is a possibility that the cable and hence the machine bonding conductor could become damaged (e.g. a trailing cable dragged on the ground), the continuity of the protective bonding circuit shall be monitored. The supply to the electrical equipment of the machine or to the relevant part of the machine shall be switched off whenever

— loss of continuity of the protective bonding circuit is detected, or

— failure of the monitoring means occurs.

Exception: Maintenance operations involving devices such as battery chargers, block heaters and similar devices, and GFCI/RCD protected circuits.

5.1.3 Each protective conductor connecting point on a machine shall be marked or labelled as such using the symbol IEC 60417-5019[1)] or with the letters "PE", or by use of the bicolour combination GREEN-AND-YELLOW, or by any combination of these. The graphical symbol is preferred.

5.2 Guidance for type of neutral earthing system

For high-voltage equipment, the following general limitations for different voltage ranges and lengths of supply cable apply.

a) **Direct earthing of the neutral**

Only appropriate for system voltages less than 2 kV, (automatic disconnection of supply is always required).

b) **Low impedance earthing of the neutral**

May be appropriate for system voltages up to 36 kV and cable length up to 4 km (automatic disconnection of supply is normally necessary).

c) **Isolated or high impedance earthing of the neutral**

Appropriate for system voltages up to 36 kV and cable length up to 8 km, with the permissible cable length depending upon the capacitive reactance of all cables connected to the supply (automatic disconnection of supply is not normally necessary).

1) ISO Online browsing platform: available at http://www.iso.org/obp. Search using 5019.

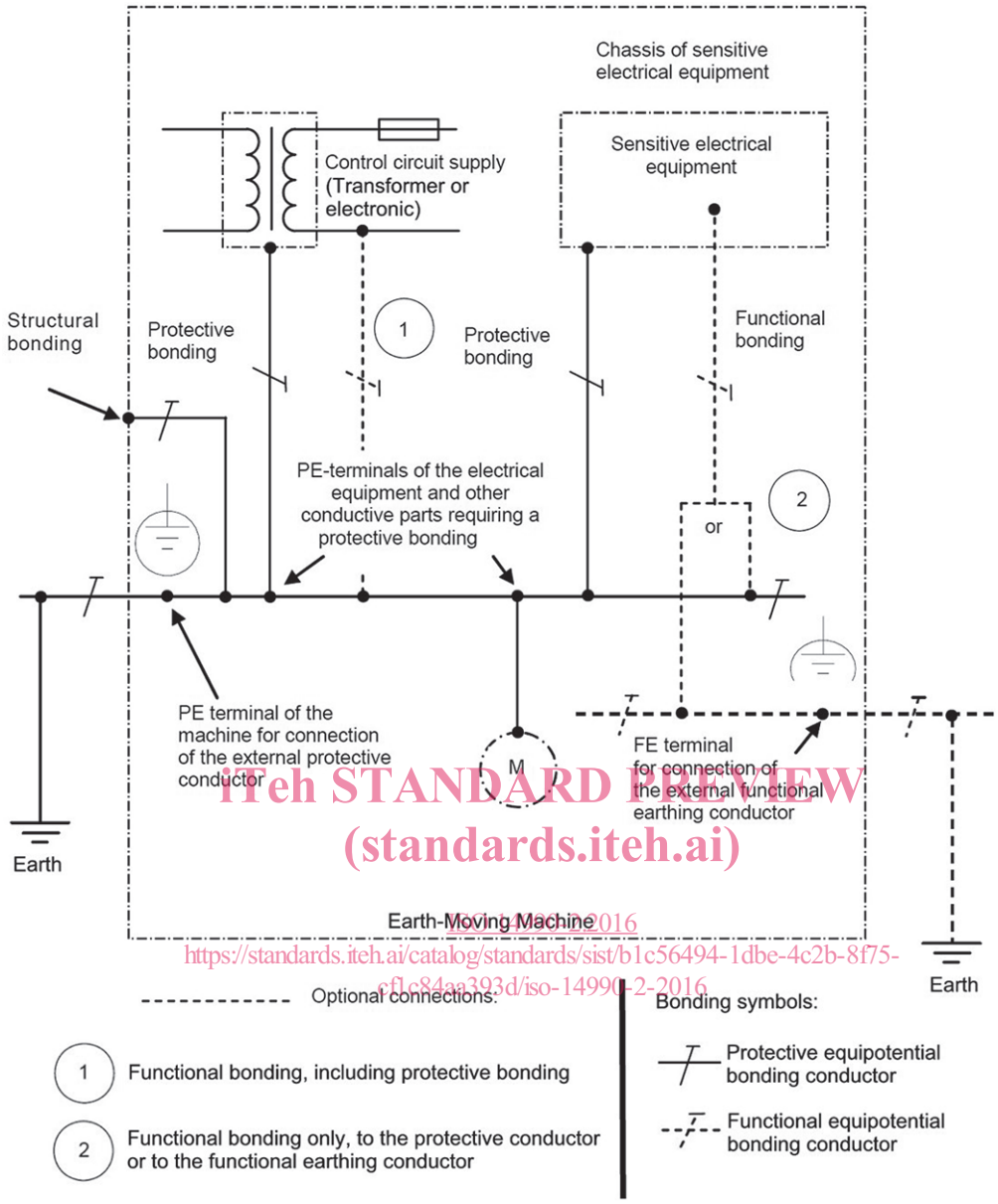

Figure 2 — Example of equipotential bonding for externally-powered EMM
(based on IEC 60204–1: 2009, Figure 2)

6 Protection against electrical fire hazards

The requirements of ISO 14990-1:2016, Clause 6 shall apply.

7 Protection against thermal hazards

The requirements of ISO 14990-1:2016, Clause 7 shall apply.

8 Protection against mechanical hazards

The requirements of ISO 14990-1:2016, Clause 8 shall apply.

9 Protection against abnormal operation hazards

9.1 General

The requirements of ISO 14990-1:2016, Clause 9 shall apply except as modified by this clause.

9.2 Supply conductors

Unless otherwise specified by the user, the supplier of the electrical equipment is not responsible for providing the overcurrent protective device for the supply conductors to the electrical equipment.

The supplier of the electrical equipment shall state on the installation diagram the data necessary for selecting the overcurrent protective device.

9.3 Socket outlets

Overcurrent protection shall be provided in the unearthed live conductors of each circuit feeding general-purpose socket outlets intended primarily for supplying power to maintenance equipment.

9.4 Protection against supply interruption or voltage reduction and subsequent restoration

Where a supply interruption or a voltage reduction can cause a hazardous situation, damage to the machine, or to the work in progress, undervoltage protection shall be provided by, for example, shutting down the machine at a predetermined voltage level.

Where the operation of the machine can allow for an interruption or a reduction of the voltage for a short time period, delayed undervoltage protection may be provided. The operation of the undervoltage device shall not impair the operation of any stopping control of the machine.

Upon restoration of the voltage or upon switching on the incoming supply, automatic or unexpected restarting of the machine shall be prevented where such a restart can cause a hazardous situation.

Where only a part of the machine or of the group of machines working together in a coordinated manner is affected by the voltage reduction or supply interruption, the undervoltage protection shall initiate appropriate control responses to ensure coordination.

9.5 Phase sequence protection

Where an incorrect phase sequence of the supply voltage can cause a hazardous situation or damage to the machine, protection shall be provided.

NOTE Conditions of use that can lead to an incorrect phase sequence include

— a machine transferred from one supply to another,

— a mobile machine with a facility for connection to an external power supply,

— supply cable repairs.

9.6 Protection against overvoltages due to lightning and to switching surges

Protective devices can be provided to protect against the effects of overvoltages due to lightning or to switching surges. If provided,

— devices for the suppression of overvoltages due to lightning shall be connected to the incoming terminals of the supply disconnecting device;

