BS ISO 14990-3:2016

BSI Standards Publication

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

Part 3: Particular requirements for self-powered machines

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National foreword

This British Standard is the UK implementation of ISO 14990-3:2016.

The UK participation in its preparation was entrusted to Technical Committee B/513/1, Earth moving machinery (International).

A list of organizations represented on this committee can be obtained on request to its secretary.

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INTERNATIONAL STANDARD

ISO 14990-3

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2016-11-01

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

Part 3: Particular requirements for self-powered machines

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

Partie 3: Exigences particulières pour les machines auto-alimentées

Reference number
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Foreword

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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.

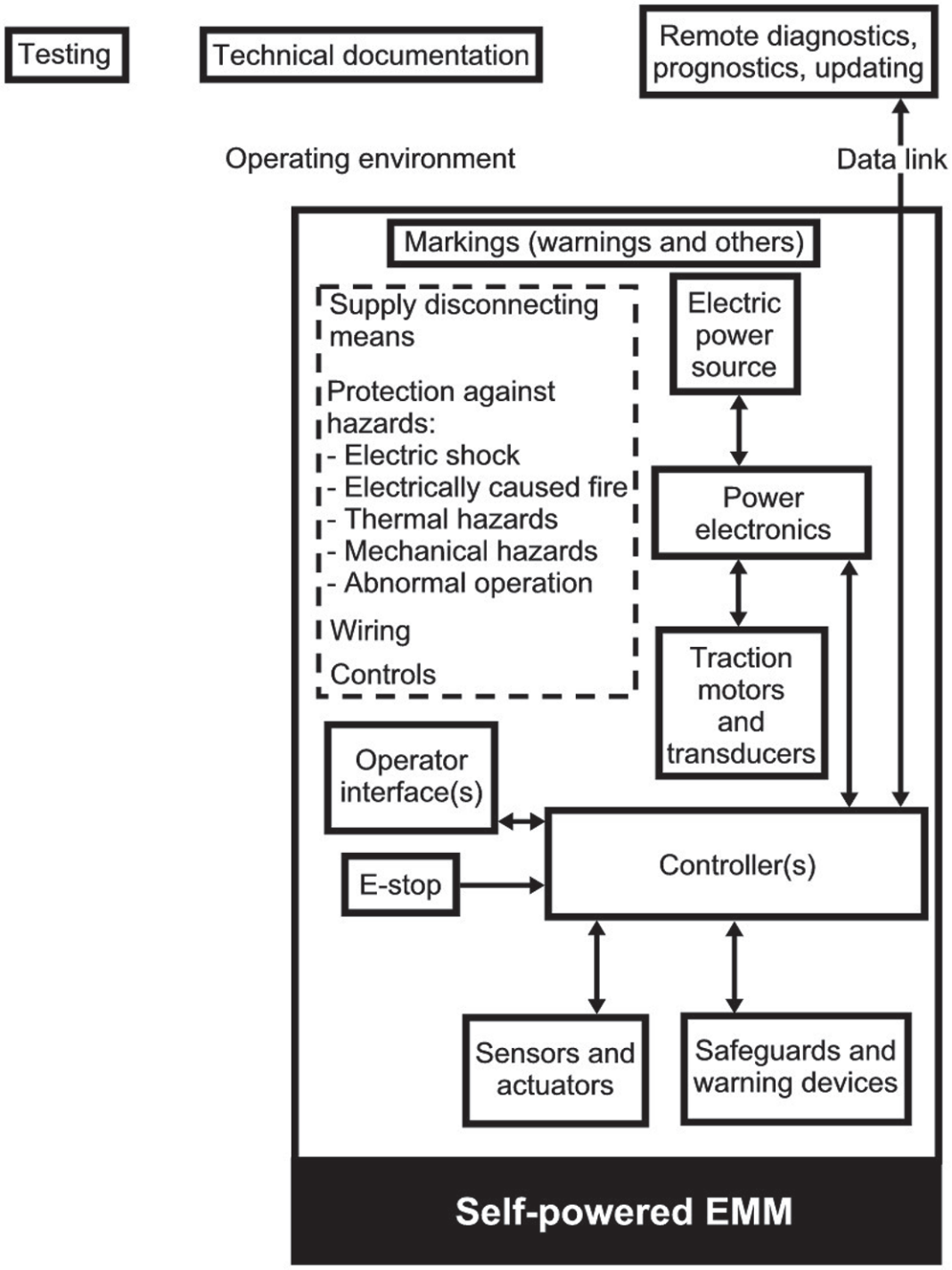

Figure 1 — Block diagram of a typical machine

INTERNATIONAL STANDARD ISO 14990-3:2016(E)

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

Part 3: Particular requirements for self-powered machines

1 Scope

This document specifies the particular safety requirements for the electrical equipment and its components incorporated in self-powered (utilizing on-board electric power sources) 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 externally-powered machines are given in ISO 14990-2. It is possible to have an EMM that is 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 14990-2 is also applicable.

NOTE For machines intended to be operated on-road, automotive standard ISO 6469 and/or UN ECE R100 may provide useful guidance. See Annex B for a comparison of requirements.

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 14990-2, *Earth-moving machinery — Electrical safety of machines utilizing electric drives or related components and systems — Part 2: Particular requirements for externally-powered machines*

3 Terms and definitions

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

For supply systems such as onboard generators, supply voltage limits are not applicable, provided that the equipment is designed to operate correctly from the supply voltage source.

5 Protection against electric shock hazards

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

5.1 See Figure 2 for an example of equipotential bonding for electrical equipment of a self-powered EMM.

5.2 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.

Alternatively, each protective conductor connecting point on a self-powered machine may be marked or labelled as such using the symbol IEC 60417-5020[2)].

5.3 On self-powered machines, the protective conductors, the conductive structural parts of the electrical equipment, and those extraneous conductive parts which form the structure of the machine shall all be connected to a protective bonding terminal to provide protection against electric shock. Where a self-powered machine is also capable of being connected to an external incoming power supply, this protective bonding terminal shall be the connection point for the external protective conductor.

When the supply of electrical energy is self-contained within mobile equipment, and when there is no external supply connected (for example when an on-board battery charger is not connected), there is no need to connect such equipment to an external protective conductor.

6 Protection against electrical fire hazards

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

1) Online database: available at http://www.graphical-symbols.info/

2) Online database: available at http://www.graphical-symbols.info/

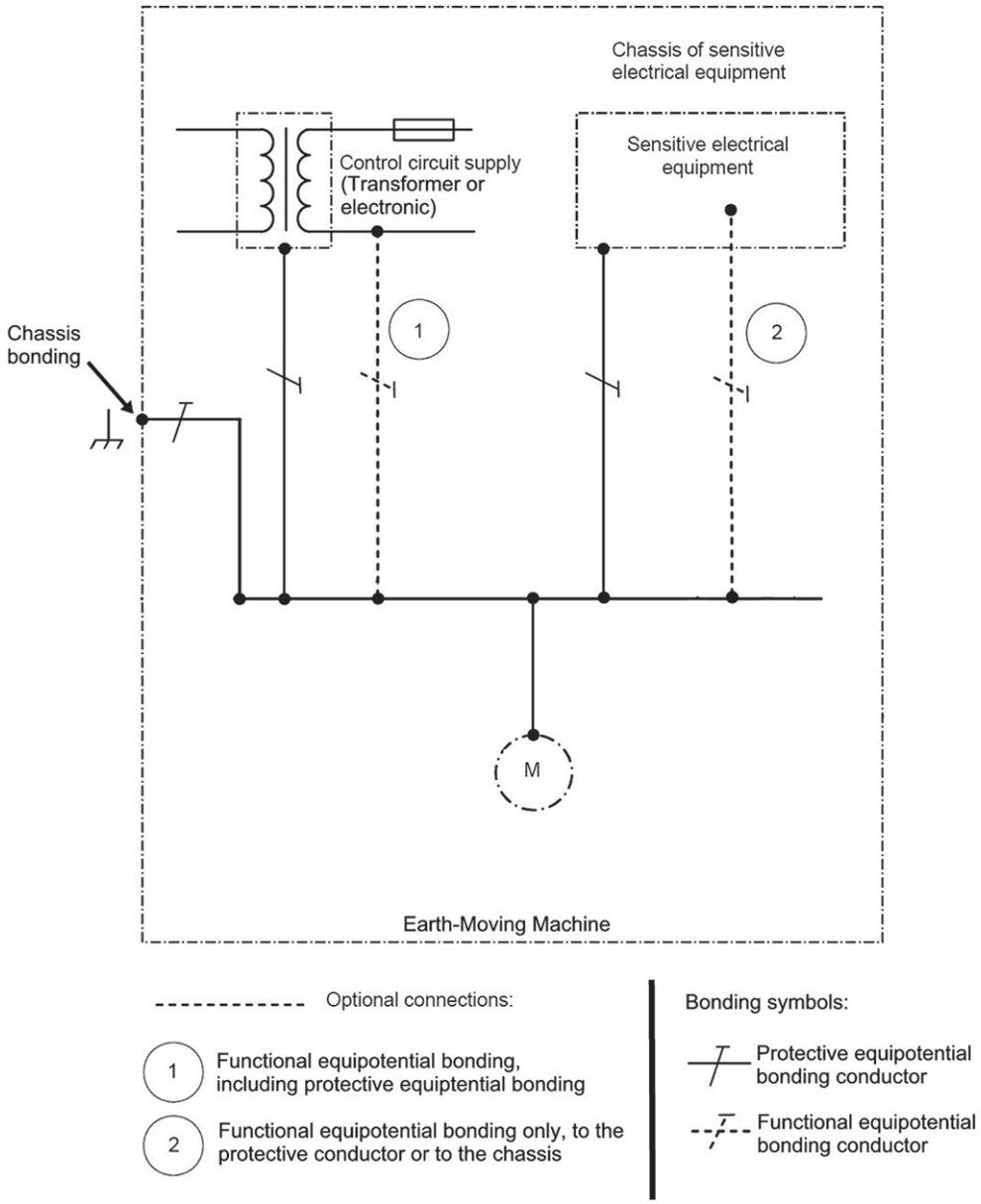

Figure 2 — Example of equipotential bonding for self-powered EMMs

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 Overcurrent protection (OCP)

Overcurrent protection by means of automatic engine shutoff is permitted if the I^2t ratings of conductors and components are not exceeded.

10 Electric power source

The requirements of ISO 14990-1:2016, Clause 10 shall apply except as modified in this clause.

There shall be a means of disconnecting or removing the power source from the rest of the low voltage system.

— An engine key switch or engine stop feature together with a lockable battery disconnect is sufficient for removing a generator power source.

— For low-voltage batteries, a switch, relay, plug, connector, or equivalent shall be provided. The device shall be located as close to the source as is practical. It shall be possible to remove power without exposing a service person to live low voltage parts.

11 Wiring

The requirements of ISO 14990-1:2016, Clause 11 shall apply.

12 Electric motors

The requirements of ISO 14990-1:2016, Clause 12 shall apply.

13 Non-motor loads

The requirements of ISO 14990-1:2016, Clause 13 shall apply.

14 Controls

The requirements of ISO 14990-1:2016, Clause 14 shall apply.

15 Manuals and documentation

15.1 General

The requirements of ISO 14990-1:2016, Clause 15 shall apply except as modified by this clause.

15.2 Information to be provided

Manufacturers shall provide adequate instructions to ensure power supply compatibility for external charging systems. External charging systems are outside the scope of this standard.

16 Marking

16.1 General

The requirements of ISO 14990-1:2016, Clause 16 shall apply except as modified by this clause.

16.2 Marking of equipment

For equipment having chassis leakage currents greater than 10 mA AC or DC, a warning marking shall be provided adjacent to the PE terminal, and where necessary on the nameplate of the electrical equipment. The warning shall include information about the leakage current and the minimum cross-sectional area of the external protective conductor.

17 Tests

The requirements of ISO 14990-1:2016, Clause 17 shall apply.

Annex A
(informative)

Enquiry form for electrical equipment of self-powered machines

It is recommended that the prospective user of the equipment provide the information indicated by the table below. This information will be helpful toward an agreement between the user and supplier. Such an agreement facilitates proper design and use of the electrical equipment of the machine by covering basic facts of the application and additional user requirements.

Responses may necessarily refer to additional documents.

Item of information	Response
Date	
Quotation number, order number, etc.	
Name of manufacturer/supplier	
Name of purchaser/end user	
Type of machine	
1. Special concerns	
1.1 a) Will the machine be used in production or processing of explosive or flammable materials?	Yes/No
b) If yes, the specific nature of the materials	
1.2 a) Might the machine be used in explosive or flammable atmospheres?	Yes/No
b) If yes, the specific nature of the atmospheres	
1.3 a) Are any materials to be worked by the machine likely to give rise to special hazards?	Yes/No
b) If yes, specify the nature of the materials and hazards.	
1.4 a) Will the machine be used in mines?	Yes/No
b) If yes, specify the type of mine and material mined.	
1.5 Might the machine be exposed to more severe conditions during transportation or storage (e.g. temperatures beyond the normal operating range, etc.)	
1.6 Indicate any special limitations on the transport of the machine to the worksite	
1.7 Indicate any special aspect to facilitate maintenance and repair	
1.8 Indicate any special aspect to improve reliability and ease of operation	
2. Operating environment	
2.1 Indicate the worst-case EMC environment (note likely sources of interference)	
2.2 Maximum altitude	
2.3 Ambient temperature range	
2.4 Humidity range	
2.5 Special conditions (e.g. high dust level, very wet, corrosive atmosphere, etc.)	
2.6 Will the machine be used a) outdoors only?	Yes/No
b) indoors or within enclosed areas?	Yes/No
2.7 Will the machine be exposed to radiation?	Yes/No
2.8 Indicate the electrical competence of persons who would have access to the interior of electrical enclosures during normal use of the machine (untrained, instructed, skilled, etc.)	
2.9 Can safe access into electrical enclosures be reasonably ensured if such enclosures are supplied with removable keys or special tools to open them?	Yes/No

Item of information	Response
2.10 a) Is a particular degree of protection (sealing) desired for electrical and control enclosures?	
b) If so, specify.	
3. Controls	
3.1 If wireless controls will be used, what is the desired time delay before automatic machine shutdown is initiated in the absence of control signal?	
3.2 Are special colours desired for any operating controls? (e.g. such as may be in use on existing machines)	
3.3 Special environmental requirements	
3.4 Any special conditions relating to control devices, visual indicators, and displays?	
4. Miscellaneous electrical	
4.1 a) If convenience socket-outlets are to be provided, is a particular type desired?	Yes/No
b) If yes, what type?	
4.2 Are convenience socket-outlets to be provided with residual current protective devices (RCD)?	Yes/No
4.3 If there is a preferred or maximum voltage for lighting circuits, specify	
4.4 Special safety requirements, e.g.: Fire suppression system is required	
5. Markings	
5.1 a) Is a third-party certification mark desired?	Yes/No
b) If yes, specify.	
5.2 Specify any special markings to be placed on electrical equipment	
5.3 Specify the language to be used in markings	
6. Technical documentation	
6.1 Specify the language to be used in technical documentation	
6.2 Specify the media to be used for technical documentation (e.g. print, CD, DVD, etc.)	
6.3 Is a certificate of operating tests to be provided?	Yes/No

Annex B
(informative)

Comparison of selected requirements of ISO 14990, UN ECE R100 and ISO 6469-3

The purpose of Table B.1 is to promote sharing of technology with the automotive industry by showing commonalities and differences between the standards used.

NOTE The comparison given by Table B.1 does not include every requirement.

In the automotive industry, IT electrical systems are widely used. To enable sharing of technology, IT system design is a method permitted in ISO 14990-1:2016, 5.9.

Requirements such as maximum leakage current limits and protective equipotential bonding of all exposed metals are not realistic requirements for EMMs. Alternative methods for protecting the operator and bystanders are provided in ISO 14990.

Table B.1 — Comparison of selected requirements of ISO 14990, UN ECE R100 and ISO 6469-3

Topic	ISO 14990		UN ECE R100:2011[14]		ISO 6469-3:2011	
	Section	Requirement	Section	Requirement	Section	Requirement
Voltage scope	Clause 1	50 V–36 kV AC at any frequency 75 V– 36 kV DC pulsating DC at any rate	2	30–1 000 V AC 60–1 500 V DC No frequency range specified	Clause 1	30–1 000 V AC 60–1 500 V DC No frequency range specified
Power source	Clause 1	self-powered	1	Self-powered (mains only for charging)		Self-powered (mains only for charging)
Components	ISO 14990-1:2016, 4.4	Conform to IEC International Standards	None	None	7.8	conform to IEC 60664 or pass hipot
EMC	ISO 14990-1:2016, 4.5.1	ISO 15998 recommended	None	None	None	None
Ambient temperature	ISO 14990-1:2016, 4.5.1	Recommended: (–25 to +70 OC)	None	None	Clause 4	None (as specified by mfr)
Ambient humidity	ISO 14990-1:2016, 4.5.1	Recommended: (30–95 % RH)	None	None	Clause 4	None (as specified by mfr)
Vibration	ISO 14990-1:2016, 4.5.1	ISO 15998 recommended	None	None	None	None
Operating altitude	ISO 14990-1:2016, 4.5.3	Up to 1000 m	None	None	Clause 4	None (as specified by mfr)
Enclosure (not in cab) IP rating	ISO 14990-1:2016, 4.5.4 and 14.6.3	– "Shall be adequate"[a] – Minimum = IP 22 for controlgear	5.1.1.2	IPXXB	7.6.2	IPXXB
Disconnection of power	ISO 14990-1:2016, 10.1 ISO 14990-3:2016, 10.1.1	required Engine stop acceptable. required disconnect characteristics battery disconnect required	None	none	7.3.4	Optional. ("May be de-energized as a protection measure") No requirements as to how or when de-energization is to be accomplished.

[a] Air-cooled resister grids shall only be required to meet a minimum of IP2X or IPXXB, provided they do not create hazardous conditions in the installed position when exposed to rain or dust. (If IP2X or IPXXB are not practical, it is also acceptable to use the crushing requirement dimensions found in ISO 3457:2003, 10.7.) Normal cleaning procedures shall be specified in the operator manual if necessary to prevent fire.

Table B.1 *(continued)*

Topic	ISO 14990		UN ECE R100:2011[14]		ISO 6469-3:2011	
	Section	Requirement	Section	Requirement	Section	Requirement
Prevention of unexpected startup	ISO 14990-1:2016, 10.2	Required	None	None	None	None
Protection against electric shock hazards	ISO 14990-1:2016, Clause 5	By enclosures or by insulation or by residual voltage protection or by barriers or by placing out of reach or by class II design or by automatic disconnection or by PELV	5.1	by enclosures or by insulation or — by barriers or — by class II design or — —	Clause 7	By enclosures or by insulation or — by barriers or — by class II design or — —
Overcurrent protection/equipment protection	ISO 14990-1:2016, 9.2 ISO 14990-3:2016, 9.2.7	– Where required – OCPs – Motors – Over temperature – Overspeed – Earth or chassis fault – Overvoltage Engine shutoff acceptable if coordinated with i^2t	None	None	None	None

[a] Air-cooled resister grids shall only be required to meet a minimum of IP2X or IPXXB, provided they do not create hazardous conditions in the installed position when exposed to rain or dust. (If IP2X or IPXXB are not practical, it is also acceptable to use the crushing requirement dimensions found in ISO 3457:2003, 10.7.) Normal cleaning procedures shall be specified in the operator manual if necessary to prevent fire.

Table B.1 *(continued)*

Topic	ISO 14990		UN ECE R100:2011[14]		ISO 6469-3:2011	
	Section	Requirement	Section	Requirement	Section	Requirement
Equipotential bonding	ISO 14990-1:2016, 5.10 ISO 14990-3:2016, 5.10.2.6 and 5.10.2.7	– Protective conductors – Bonding circuit – Connections – High leakage currents – Functional bonding Marking required A central (main) bonding terminal is required	5.1.2.1	"Exposed conductive parts…shall be galvanically connected securely to the electrical chassis by connection with electrical wire or ground cable, or by welding, or by connection using bolts, etc."	7.9	"All components forming the potential equalization current path (conductors, connections) shall withstand the maximum current in a single-failure situation."
Controls	ISO 14990-1:2016, Clause 14	– Control circuit supply/ protection – Interlocks – Functions in event of failure – Operator interface – Controlgear – Enclosures – Access	None	None	None	None
Conductors and cables	ISO 14990-1:2016, 11.1 to 11.6	– Conductors – Conductor/cable insulation – Flexing, winding, tensioning	None	None	None	None

[a] Air-cooled resister grids shall only be required to meet a minimum of IP2X or IPXXB, provided they do not create hazardous conditions in the installed position when exposed to rain or dust. (If IP2X or IPXXB are not practical, it is also acceptable to use the crushing requirement dimensions found in ISO 3457:2003, 10.7.) Normal cleaning procedures shall be specified in the operator manual if necessary to prevent fire.

Table B.1 *(continued)*

Topic	ISO 14990		UN ECE R100:2011[14]		ISO 6469-3:2011	
	Section	Requirement	Section	Requirement	Section	Requirement
Wiring	ISO 14990-1:2016, 11.7 to 11.11	– Connections – Runs/routing – Identification of wires (including orange identification) – Flexing – Concealed and exposed – Plug/socket combinations – Breakdown for shipping – Ducts, boxes, conduits	5.1.1.5.3	Orange identification	6.2	Orange identification
Electric motors and generators	ISO 14990-1:2016, Clause 12	– Conform to IEC 60034 – Overcurrent, overload, overspeed – General design/selection criteria	None	None	None	None
Non-motor loads	ISO 14990-1:2016, Clause 13	– Overcurrent protection required	None	None	None	None

[a] Air-cooled resister grids shall only be required to meet a minimum of IP2X or IPXXB, provided they do not create hazardous conditions in the installed position when exposed to rain or dust. (If IP2X or IPXXB are not practical, it is also acceptable to use the crushing requirement dimensions found in ISO 3457:2003, 10.7.) Normal cleaning procedures shall be specified in the operator manual if necessary to prevent fire.

Table B.1 *(continued)*

Topic	ISO 14990		UN ECE R100:2011[14]		ISO 6469-3:2011	
	Section	Requirement	Section	Requirement	Section	Requirement
Marking	ISO 14990-1:2016, Clause 16 ISO 14990-3:2016, 16.4	Symbols specified for – shock hazard – hot surface – magnetic field – arc flash/blast residual voltage warning nameplate requirements marking required if leakage > 10 mA AC or DC	5.1.1.5.1	Shock hazard symbol	Clause 6	Shock hazard symbol
Manuals and technical documentation	ISO 14990-1:2016, Clause 15 of Part 1	– list of information items to be provided – required items in operator and service manuals	None	None	None	None
[a] Air-cooled resister grids shall only be required to meet a minimum of IP2X or IPXXB, provided they do not create hazardous conditions in the installed position when exposed to rain or dust. (If IP2X or IPXXB are not practical, it is also acceptable to use the crushing requirement dimensions found in ISO 3457:2003, 10.7.) Normal cleaning procedures shall be specified in the operator manual if necessary to prevent fire.						

Table B.1 *(continued)*

Topic	ISO 14990		UN ECE R100:2011[14]		ISO 6469-3:2011	
	Section	Requirement	Section	Requirement	Section	Requirement
Tests	ISO 14990-1:2016, Clause 17	– Automatic disconnection	—	—	—	—
		– Bonding continuity (pass = meet calculated range)	5.1.2.2	< 0,1Ω	7.9	≤ 0,1 Ω
			5.1.3.2	100 Ω/V DC, 500 Ω/V AC	7.7, 8.2	100 Ω/V DC, 500 Ω/V AC
		– Insulation resistance (pass = ≥ 1 MΩ)	—	—	8.3.3.2	For self-powered
			5.1.1.3	≤ 60 V DC or 30 V AC within 1 s	8.3.3.3	(pass = no breakdown for highest expected voltage)
		– Hipot (pass = no break-down for greater of 2x supply or 1 000 V)			7.3.4	For plug-in
						(Pass = no breakdown for $2U$ + 1 000 V for basic insulation, $2U$ + 3 250 V for double insulation)
		– Residual voltage (pass = < 60 V within 10 s)				No test is specified, but the requirement is stated that decay shall be < 30 V AC or 60 V DC (decay time to be specified by mfr.

[a] Air-cooled resister grids shall only be required to meet a minimum of IP2X or IPXXB, provided they do not create hazardous conditions in the installed position when exposed to rain or dust. (If IP2X or IPXXB are not practical, it is also acceptable to use the crushing requirement dimensions found in ISO 3457:2003, 10.7.) Normal cleaning procedures shall be specified in the operator manual if necessary to prevent fire.

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[1] ISO 3457:2003, *Earth-moving machinery — Guards — Definitions and requirements*

[2] ISO 6469-1, *Electrically propelled road vehicles — Safety specifications — Part 1: On-board rechargeable energy storage system (RESS)*

[3] ISO 6469-2, *Electrically propelled road vehicles — Safety specifications — Part 2: Vehicle operational safety means and protection against failures*

[4] ISO 6469-3:2011, *Electrically propelled road vehicles — Safety specifications — Part 3: Protection of persons against electric shock*

[5] ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

[6] ISO 13766, *Earth-moving machinery — Electromagnetic compatibility*

[7] ISO 15998, *Earth-moving machinery — Machine-control systems (MCS) using electronic components — Performance criteria and tests for functional safety*

[8] ISO 20474 (all parts), *Earth-moving machinery — Safety*

[9] IEC 60034 (all parts), *Rotating electrical machines*

[10] IEC 60204-1:2009, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

[11] IEC 60204-11, *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*

[12] IEC 60417-DB, *Graphical symbols for use on equipment*

[13] IEC 60664 (all parts), *Insulation coordination for equipment within low-voltage systems*

[14] UN ECE R100:2011, *Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train*

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