BS ISO 23285:2025

BSI Standards Publication

Agricultural machinery, tractors, and earth-moving machinery — Safety of electrical and electronic components and systems operating at 32 V to 75 V DC and 21 V to 50 V AC

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National foreword

This British Standard is the UK implementation of ISO 23285:2025.

The UK participation in its preparation was entrusted to Technical Committee AGE/6, Agricultural tractors and forestry machinery.

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

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Agricultural machinery, tractors, and earth-moving machinery — Safety of electrical and electronic components and systems operating at 32 V to 75 V DC and 21 V to 50 V AC

Matériel agricole, tracteurs et engins de terrassement — Sécurité des composants et systèmes électriques et électroniques fonctionnant sous 32 V à 75 V DC et 21 V à 50 V AC

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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 document 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).

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For an explanation of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*, in collaboration with ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 3, *Machine characteristics, electrical and electronic systems, operation and maintenance*.

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Introduction

Electrification technology can provide increased flexibility in mobile machinery configuration. It offers efficiency gains and enhanced power delivery options, which are not possible with current mechanical and hydraulic systems.

Traditional agricultural and earth-moving machinery electrical systems operate in VC-A1, 0 V DC to 32 V DC and 0 V AC to 21 V AC. VC-B2 mobile machinery operate in the 75 V DC to 1 500 V DC and 50 V AC to 1 000 V AC and are covered by ISO 16230-1 for agricultural machines and ISO 14990 series for earth-moving machines. This document covers mobile machinery with systems operating in VC-A2 and VC-B1 (see Table 1). Some of the content of this document is based on IEC 60204-1 and IEC 62477-1, adapted to the specific application of agricultural and earth-moving machinery. Non-electrical hazards are addressed by ISO 4254 series for agricultural machinery, ISO 26322 series for tractors used in agriculture and forestry, and ISO 20474 series for earth-moving machinery.

Even though this document addresses most hazards associated with the use of electrical systems within the voltage ranges in the scope of this document, owing to the possible presence of additional electrical hazards, conformance with it cannot be taken as an absolute guarantee of electrical safety. Areas of concern are included in the list of significant hazards found in Annex A.

Having a background in the IEC approach to electrical system safety helps the user make better decisions about the application of this document.

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

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises); and

— health and safety bodies (regulators, accident prevention organisations, market surveillance, etc.)

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, (e.g. for maintenance, small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document. The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those which are 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.

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Agricultural machinery, tractors, and earth-moving machinery — Safety of electrical and electronic components and systems operating at 32 V to 75 V DC and 21 V to 50 V AC

1 Scope

This document primarily specifies both general design requirements and guidelines for protection of operators and bystanders against electric shock and electrically induced fire, for voltage classes A2 (32 V DC to 60 V DC and 21 V AC to 30 V AC) and B1 (60 V DC to 75 V DC and 30 V AC to 50 V AC), including waveforms synthesized by power electronic converters. This document is limited to addressing hazards that are not as commonly found in 12 V DC and 24 V DC systems, including those related to higher power converters and drive motors.

NOTE 1 Although protection against electrically induced fire hazards is addressed sparingly, conformance to content of this document has the impact of reducing the occurrence and hazards associated with fire.

This document is applicable to electric systems used on:

— tractors, self-propelled ride-on machines, interchangeable towed machinery, semi-mounted implements, and mounted implements used in or with agriculture and forestry; and

— earth-moving machinery (EMM) as defined in ISO 6165 and attachments.

For mobile machinery with multiple rated voltages, with at least one system rated greater than VC-B1, this document addresses the risks associated with the interactions between VC-A2 and VC-B1 systems and those systems which are nearby and rated greater than VC-B1.

NOTE 2 Electrical safety requirements for greater than VC-B1 are described in ISO 16230-1 for agricultural machines and ISO 14990 series for earth-moving machines.

NOTE 3 Although 12 V DC and 24 V DC systems are generally below the limits of this document, meeting appropriate requirements of this document ensures that proper protection exists between the covered systems and lower voltage systems.

This document is applicable to mobile machinery that are either externally powered or self-powered or both.

Alternative safety requirements can be necessary for special equipment or components such as underground mining equipment. This document does not address the additional risks for mobile machinery operating in potentially explosive atmospheres.

This document deals with all significant hazards, hazardous situations, or hazardous events relevant within its scope (see Annex A), when the mobile machinery is used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer. It specifies appropriate technical measures for eliminating or reducing risks arising from significant hazards, hazardous situations, or hazardous events during commissioning, operation, and maintenance.

This document is not applicable to mobile machinery manufactured before the date of its publication.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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.

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ISO 6405-1:2017, *Earth-moving machinery — Symbols for operator controls and other displays — Part 1: Common symbols*

ISO 7010[1)], *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13857:2019, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

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

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

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

ISO 15003, *Agricultural engineering — Electrical and electronic equipment — Testing resistance to environmental conditions*

ISO 16230-1:2015, *Agricultural machinery and tractors — Safety of higher voltage electrical and electronic components and systems — Part 1: General requirements*

ISO 19014-3, *Earth-moving machinery — Functional safety — Part 3: Environmental performance and test requirements of electronic and electrical components used in safety-related parts of the control system*

IEC 60034-1, *Rotating electrical machines — Part 1: Rating and performance*

IEC 60204-1:2016, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60309-1, *Plugs, socket-outlets, and couplers for industrial purposes — Part 1: General requirements*

IEC 60364-5-54:2011/AMD1:2021, *Low-voltage electrical installations — Part 5-54: Selection and erection of electrical equipment — Earthing arrangements and protective conductors*

IEC 60417[1)], *Graphical symbols for use on equipment*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

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

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

IEC 61140:2016, *Protection against electric shock — Common aspects for installations and equipment*

IEC 61984, *Connectors — Safety requirements and tests*

IEC 62477-1:2022, *Safety requirements for power electronic converter systems and equipment — Part 1: General*

SAE J1614, *Wiring Distribution Systems for Off-Road, Self-Propelled Work Machines*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100 and the following apply.

1) The graphical symbol collections of ISO 7010 and IEC 60417 can be previewed and purchased on the Online Browsing Platform (OBP), www.iso.org/obp.

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

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

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

3.1.1
access system
(machine) access system
system provided on a machine for ascending from the ground or descending to the ground or for moving from one area on the machine to another area

[SOURCE: ISO 2867:2011, 3.2.1]

3.1.2
accessible conductive part
accessible part having a conductive surface that is bare or covered by an insulating layer that does not comply with the requirements of basic insulation

Note 1 to entry: An accessible conductive part is considered to be a hazardous live part if not separated from live parts by at least basic insulation.

3.1.3
accessible part
part which, as installed, can be touched by means of the jointed test finger in IEC 60529

[SOURCE: IEC 60050-442:1998, 442-01-15, modified — definition has been changed to be more specific about finger accessibility]

3.1.4
basic insulation
insulation of live parts providing protection against direct contact

Note 1 to entry: Basic insulation does not include insulation used exclusively for a functional purpose.

Note 2 to entry: The use of winding wire coatings as basic, supplementary, or reinforced insulation is restricted in some VC-B2 (and higher) standards. However, VC-A and VC-B1 are not subject to such restrictions.

[SOURCE: IEC 60050-195:2021, 195-06-06, modified — definition has been clarified and better reflect the voltage range covered by this document.]

3.1.5
basic protection
Protection against electrical shock under fault-free conditions

[SOURCE: IEC 60050-195:1998, 195-06-01]

3.1.6
conductive part
part of the machine that is capable of conducting electric current

[SOURCE: IEC 60050-195:2021, 195-01-06, modified — definition has been made clearer]

3.1.7
converter
electric energy converter
device for changing one or more characteristics associated with electric energy

Note 1 to entry: In informal usage, it is common to use the term "inverter" to mean converter, rectifier, or AC/DC or AC/AC converter. The informal meanings of "inverter" are not used in this document.

[SOURCE: IEC 60050-151:2001, 151-13-36, modified — Note has been removed and replaced by a new Note.]

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3.1.8
double insulation
insulation comprised of both basic and supplementary insulation types

[SOURCE: IEC 60050-195:2021, 195-06-08, modified — definition has been made clearer]

3.1.9
earth
local earth
ground, US
local ground, US
part of the Earth which is in electric contact with an earth electrode and whose electric potential is not necessarily equal to zero

[SOURCE: IEC 60050-195:2021, 195-01-03]

3.1.10
electric chassis
chassis
conductive parts of a machine that are electrically connected and whose potential is taken as reference

[SOURCE: ISO 6469-4:2015, 3.5, modified — replaced "vehicle" with "machine" and added option of just using chassis]

3.1.11
enclosure
part providing protection of equipment against certain external influences and protection against direct contact in any direction

Note 1 to entry: Enclosures provide protection of persons against access to hazardous parts, and also protect enclosed devices from the environment.

3.1.12
enhanced protection
protective provision having a reliability of protection not less than that provided by two independent protective provisions

[SOURCE: IEC 60050-195:2021, 195-06-27, modified — original term was enhanced protection provision]

3.1.13
equipotential bonding
EPB
set of electric connections intended to achieve equipotentiality between conductive parts

Note 1 to entry: In standards referenced by this document and elsewhere, earth, earthed and earthing are often used to designate the equivalent of EPB. However, for mobile equipment it is often impractical and unnecessary to create an EPB connection to the actual earth, rather the frame of the machinery or other metallic components are often used for protection against shock.

[SOURCE: IEC 60050-195:2021, 195-01-10, modified — note to entry has been added]

3.1.14
functional-equipotential-bonding
FEPB
equipotential bonding for the reasons other than electrical shock, fire, and arc flash safety

Note 1 to entry: In this definition ‘other than electrical shock, fire, and arc flash safety’ is most typically the use of EPB to reduce electromagnetic interference and transient impact on control system functionality.

[SOURCE: IEC 60050-195:2021, 195-01-16, modified — to clarify electrical safety meaning within the definition]

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3.1.15
protective-equipotential-bonding
PEPB
equipotential bonding for the purposes of electrical shock, fire, and arc flash safety

Note 1 to entry: In this definition 'electrical shock, fire and arc flash safety' most typically is the prevention of shock or fires by use of EPB to maintain low touch currents during a fault condition or to provide a low resistance current path facilitating effective OCP operation.

[SOURCE: IEC 60050-195:2021, 195-01-15, modified — to clarify electrical safety meaning within the definition]

3.1.16
fault
system, device, or component unable to perform a required function, excluding both human error and the inability to perform a required function during preventive maintenance or other planned action

Note 1 to entry: A fault is often the result of a failure but can exist without prior failure.

Note 2 to entry: A fault is not the operator ignoring a warning sign. 'Ignoring' is equivalent to human error for the purposes of this definition.

3.1.17
I^2t
current squared multiplied times the time
electrical quantity used to determine energy through a protective device, such as a circuit breaker or fuse, where I = current and t = time

Note 1 to entry: The excess heat generated in the protected conductors, is approximately proportional to the current squared times the duration of the overload.

3.1.18
interchangeable towed machinery
machine which is designed to be towed by a tractor and changes or adds to its functions

Note 1 to entry: It may include a load platform designed and constructed to receive any tools and appliances needed for those purposes, and to store temporarily any materials produced or needed during work.

Note 2 to entry: Any vehicle intended to be towed by a tractor and permanently incorporating an implement or designed to process materials shall be considered interchangeable towed machinery if the ratio of the technically permissible gross mass to the unladen mass of that vehicle is less than 3,0.

[SOURCE: ISO 12934:2021, 3.1.3]

3.1.19
IP code
degree of protection
extent of protection provided by an enclosure against access to hazardous parts, against egress of solid foreign objects and/or against ingress of water and verified by standardized test methods, related to preventing contact with live parts of a back-of-hand test (IPXXA), test finger (IPXXB), a test rod (IPXXC), or a test wire (IPXXD), which is also an indication of protection degrees related to the ingress of water and dust through enclosures (e.g. IPX3 by water spray, IPX5 by a water jet, IPX7 by short term immersion, IPX8 by continuous immersion, or IP6X for dust)

Note 1 to entry: IP degrees of protection are defined in IEC 60529.

[SOURCE: IEC 60529:1989+AMD 1:1999+AMD 2:2023, modified — added extra context found in IEC 60529]

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3.1.20
live part
conductor or conductive component intended to be electrically energized in normal use, but not a combined EPB-neutral conductor

Note 1 to entry: Unless meeting all requirements of an EPB conductor, negative and neutral conductors are considered live on a system even though they can be connected galvanically to the chassis. EPB conductors have additional requirements for fault conditions and durability, which extend beyond a simple neutral or negative conductor.

3.1.21
lockout
lockout device
placement of an energy-isolating device, in accordance with an established procedure, ensuring that the energy-isolating device and the equipment being controlled cannot be operated until the device is removed

Note 1 to entry: A lockout device is any device that uses positive means, such as a lock, to hold an energy-isolating device in a safe position, thereby preventing the energizing of machinery or equipment.

3.1.22
maximum working voltage
highest value of AC voltage (rms) or of DC voltage that can occur under any normal operating conditions according to the manufacturer's specifications, disregarding transients, and ripple

[SOURCE: ISO 6469-3:2021, 3.26]

3.1.23
mobile machinery
tractors, self-propelled ride-on machines, *interchangeable towed machinery* (3.1.18), semi-mounted implements, and mounted implements used in agriculture and forestry which also applies to earth-moving machinery (EMM), as defined in ISO 6165

3.1.24
neutral conductor
conductor electrically connected to the neutral point and capable of contributing to the distribution of electrical energy

[SOURCE: IEC 60050-195:2021, 195-02-06]

3.1.25
pollution degree
numeral characterizing expected pollution of the micro-environment

[SOURCE: IEC 60050-581:2008, 581-21-07, modified — to eliminate irrelevant note]

3.1.26
power supply
provision of electrical energy from a source

[SOURCE: IEC 60050 151-13-75:2001]

3.1.27
protective barrier
part providing protection against direct contact from any usual direction of access

[SOURCE: IEC 60050-195:2021, 195-06-15, modified — directionality has been clarified.]

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3.1.28
protective impedance
impedance connected between hazardous live parts and accessible conductive parts, of such value that the touch current, in normal use and under likely fault conditions, is limited to a safe value, and which is so constructed that its ability is maintained throughout the life of the equipment

[SOURCE: IEC 60050-442:1998, 442-40-24, modified — definition has been clarified to better reflect needs of this document]

3.1.29
rated voltage
value of the voltage assigned by the manufacturer to a component, device, or equipment and to which operation and performance characteristics are referred

Note 1 to entry: It is possible for equipment to have more than one rated voltage value or to have a rated voltage range.

Note 2 to entry: For three-phase power supply, the line-to-line voltage applies.

[SOURCE: IEC 60050-442:2014, 442-09-10, modified — to clarify and better reflect needs of this document]

3.1.30
rated voltage range
voltage range as declared by the manufacturer expressed by its lower and upper rated voltages

[SOURCE: IEC 60050-151:2001, 151-16-49]

3.1.31
residual current device
RCD
switching device designed to make, carry, and break currents under normal service conditions and to cause the opening of the circuit when the residual current attains a given value under specified conditions

Note 1 to entry: A residual current device can be a combination of various separate elements designed to detect and evaluate the residual current and to make and break current. A current sensing circuit combined with a control system utilizing software can be used to meet the requirements of an RCD.

[SOURCE: IEC 60050-442:2014, 442-05-02, modified — added a note and removed mechanical and contact from definition]

3.1.32
reinforced insulation
insulation system applied to live parts which provides protection against direct contact equivalent to double insulation

Note 1 to entry: Reinforced insulation can be comprised of one, two or more layers which in some cases can be difficult to test individually as basic insulation or supplementary insulation.

[SOURCE: IEC 60050-195:2021, 195-06-09, modified — to clarify and better reflect needs of this document]

3.1.33
single fault condition
condition in which there is a fault of a single protection (but not a reinforced protection) or of a single component or a device

Note 1 to entry: If a single fault condition results in one or more other fault conditions, all are considered as one single fault condition.

Note 2 to entry: A single fault definition does not include operator error. Operator error for example includes intentionally removing a barrier with tools, ignoring safety signs, or intentionally contacting two separate exposed terminals.

[SOURCE: IEC 60050-903:2013, 903-01-15, modified — to clarify and better reflect needs of this document]

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3.1.34
supplementary insulation
independent insulation applied in addition to basic insulation, in order to provide protection against electric shock in the event of a failure of the basic insulation

[SOURCE: IEC 60050-195:2021, 195-06-07, modified — to clarify and better reflect needs of this document]

3.1.35
touch current
electric current passing through a human body or through livestock when it touches one or more accessible parts of an electrical installation or equipment

Note 1 to entry: Methods of measurement of touch current are specified in IEC 60990.

[SOURCE: IEC 60050-195:2021, 195-05-21, modified — Note to entry has been added]

3.1.36
voltage class
VC
classification of an electric component or circuit according to its *maximum working voltage* (3.1.22)

Note 1 to entry: See Table 1 for the alphanumeric code indicating a range of maximum working voltages.

Note 2 to entry: Requirements in this document are based upon VC, however those requirements can be shifted to lesser requirements based on analysis of the actual wave form and corresponding risk of injury, according to 5.2.2.

[SOURCE: ISO 6469-3:2021, 3.36]

3.1.37
wet environment
environment where equipment is likely to be exposed to rain, cleaning or splashing water

Note 1 to entry: Agricultural sites and construction sites are typically considered wet environments.

Note 2 to entry: A non-wet environment can be created if provisions are specifically made to place electrical systems or components in a location shielded from rain, cleaning or splashing water (e.g. portions of the operator's station or a walk-in electrical vault).

Note 3 to entry: Submerged components and systems are addressed separately in 5.11.

3.2 Abbreviated terms

AC	alternating current
DC	direct current
EMC	electromagnetic compatibility
EMM	earth-moving machinery
IP	The meaning of IP is found in IEC 60529, but IP is not a proper acronym in that standard. IP is related to preventing contact with live parts of a back-of-hand test (IPXXA), test finger (IPXXB), a test rod (IPXXC), or a test wire (IPXXD); also, an indication of protection degrees related to the ingress of water and dust through enclosures (e.g. IPX3 by water spray, IPX5 by a water jet, IPX7 by short term immersion, IPX8 by continuous immersion, or IP6X for dust)
OCP	overcurrent protection (e.g. a fuse, circuit breaker, or solid-state device including its control system)
PPE	personal protective equipment
PTO	power take-off

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PWM pulse width modulation

RMS root-mean-square

4 General requirements

4.1 V-model

The design methodology and layout of this document have been created in accordance with the V-model depicted in Figure B.1.

4.2 Voltages

The manufacturer shall characterize the voltages of the electrical systems. The VC are given in Table 1.

Table 1 — Voltage classes

Voltage class	Maximum working voltage	
	V DC	V AC_{rms}
VC-A	0 < U ≤ 60	0 < U ≤ 30
VC-A1	0 < U ≤ 32	0 < U ≤ 21
VC-A2	32 < U ≤ 60	21 < U ≤ 30
VC-B	60 < U ≤ 1 500	30 < U ≤ 1 000
VC-B1	60 < U ≤ 75	30 < U ≤ 50
VC-B2	75 < U ≤ 1 500	50 < U ≤ 1 000
VC-C	1 500 < U ≤ 36 kV	1 000 < U ≤ 36 kV
U = maximum working voltage		

NOTE 1 ISO 6469-3 voltage class A extends to 0 V, which is outside the scope of this document. This document splits VC-A into VC-A1 and VC-A2. VC-A1 includes 12 V DC and 24 V DC systems.

A characterization of all voltage parameters including transients shall be made to verify the proper correlated functioning of the components selected for design and field replacement.

NOTE 2 For automotive, ISO 21780 addresses 48 V DC rated components and ISO 21498-1 addresses VC-B rated components.

NOTE 3 VC-A2 and VC-B1 have no requirements to utilize isolated power systems in this document.

Voltages completely internal to an enclosure may exceed the rated voltage ranges of the circuits or components (as rated at the terminals).

4.3 Environmental and operational requirements

The requirements given in this document shall be met across the range of environmental and operational conditions for which the electrical system is rated to operate, as specified by the mobile machinery manufacturer. Unless specified elsewhere in this document, the electrical system or its components shall conform with to the environmental effects requirements of ISO 15003 for agricultural tractors and machinery and ISO 19014-3 for EMM.

Adequate protection shall be provided from penetration by moisture, dust, and debris consistent with IEC 60529 according to environment where the product is intended to be used, the pollution degrees selected and chemical compatibility of the design.

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4.4 Components and devices

Manufacturers shall ensure the components and devices of the electrical system are:

— suitable for their intended use; and

— applied within their ratings (including derating as applicable), and in accordance with the supplier's instructions.

When relevant IEC standards exist, suitability for intended use includes either conformity with the safety-related content of those standards or demonstration of a comparable level of safety (e.g. applicable parts of the IEC 60034 series for rotating electrical machinery may be applied to various types of motors.)

For chargers and other devices that are to be connected, the manufacturer shall provide instructions to only use chargers and other devices that are properly rated, compatible with the system, and compliant with relevant standards (e.g. IEC 61851 for electric charging stations). These devices shall be evaluated as part of the electrical system to ensure compatibility.

5 Protection against electric shock hazards

5.1 Overview

The approaches to protection against electric shock hazards provided by this document are based upon those of IEC 62477-1 for power converters, which are in turn based on those of IEC 61140, which provides principles of shock prevention. Adjustments to requirements are permitted for shock prevention at electrical frequencies beyond the scopes of IEC 62477-1 and IEC 61140.

NOTE Annex C provides a summary of methods in this Clause.

5.2 General

5.2.1 Fundamental requirements

Electric shock protection shall be provided against both direct contact and against indirect contact occurring under single-fault conditions.

Table C.2 summarizes the paths for the prevention of shock directly described in this document. IEC 61140:2016, Annex A provides further details and additional approaches for providing two protections against electric shock which are available to the user of the document.

5.2.2 Determination of shock protection requirements

5.2.2.1 Overview

The shock protection requirements given by this document are based on IEC 62477-1, and in some cases, consideration of ISO 6469-3.

NOTE Table C.3 summarizes the requirement differences between VC-A2 and VC-B1 using the methods in 5.2.2.2 and 5.2.2.3.

One or more of the methods in 5.2.2.2 through 5.2.2.5 shall be used to determine the shock protection requirements, based on electrical characteristics, e.g. voltage, frequency, waveform shape, as well as the environmental conditions, e.g. wet or non-wet. Since equipment in the scope of this standard is typically used in wet environments, all protection requirements starting from 5.3 through the end of this document assume a wet environment. The user shall assume a wet environment unless the design has appropriate provisions or a specific use case determination for it to be considered as a non-wet environment. See Table C.1 in Annex C for a summary of the optional methods.

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