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Interested committees:

Title: Draft BS ISO 23285 Agricultural machinery, tractors, and earthmoving machinery. Safety of electrical and electronic components and systems operating at 32 to 75 VDC and 21 to 50 VAC

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

DRAFT INTERNATIONAL STANDARD

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2024-03-05

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

ICS: 65.060.01; 53.100

Member bodies are requested to consult relevant national interests in ISO/TC 127/SC 3 before casting their ballot to the e-Balloting application.

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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 conducted 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).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committees ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*, in conjunction with ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 3, *Machine characteristics, electrical and electronic systems, operation and maintenance*, Working Group JWG 10, *Safety of electric drive and hybrid electronic components and systems*.

Introduction

Electrification technology can provide increased flexibility in machine 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, 0-32 V DC and 0-21 V AC. VC-B2 machines operate in the 75-1 500 V DC and 50-1 000 V AC and are covered by ISO 16230-1 for agricultural machines and ISO 14990 (all parts) for earth-moving machines. This document covers machines 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 (all parts) for agricultural machinery, ISO 26322 (all parts) for tractors used in agriculture and forestry, and ISO 20474 (all parts) for earth-moving machinery.

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 defined in ISO 12100.

Type of machinery and the extent to which hazards, hazardous situations, or hazardous events are covered are indicated in [Annex A](#) of this document.

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.

Agricultural machinery, tractors, and earth-moving machinery — Safety of electrical and electronic components and systems operating at 32 to 75 V DC and 21 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 to 60 V DC and 21 to 30 V AC) and B1 (60 to 75 V DC and 30 to 50 V AC), including waveforms synthesized by power electronic converters. This standard is limited to addressing hazards that are not as commonly found in 12 and 24 V DC systems, including those related to higher power converters and drive motors.

Although protection against electrically induced fire hazards is addressed sparingly, compliance to content of this document will have 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 implements, semi-mounted implements, and mounted implements used in or with agriculture and forestry;
- earth-moving machinery (EMM) as defined in ISO 6165 and attachments.

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

NOTE 2 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 machines 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 machines 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 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.

Even though this document addresses most hazards associated with the use of electrical systems within the voltage ranges above, 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](#).

This document is not applicable to machines 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.

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

ISO 7010, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 12100, *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 14990:2016, *(all parts), Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems*

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 17840-4, *Road vehicles — Information for first and second responders — Part 4: Propulsion energy identification*

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, *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 60947-1, *Low-Voltage Switchgear, and control gear — Part 1: General rule*

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, abbreviated terms, and acronyms

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

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

- IEC Electropedia: available at www.electropedia.org
- ISO Online browsing platform: available at www.iso.org/obp

3.1

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.

3.2

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 – to be more specific about finger accessibility]

3.3

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 – to clarify and better reflect the voltage range covered by this document.]

3.4

basic protection

protection against electric shock under fault-free conditions through the use of insulation or distance or a combination of both

[SOURCE: IEC 62477-1:2022]

3.5

conductive part

part of the machine that is capable of conducting electric current

[SOURCE: IEC 60050-195:2021, 195-01-06, modified – to make clearer]

3.6

(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 – by removing the note]

3.7

double insulation

insulation comprised of both basic and supplementary insulation types

[SOURCE: IEC 60050-195:2021, 195-06-08, modified – to make clearer]

3.8
(local) earth
(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]

3.9
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 – by replacing vehicle with machine and added option of just using chassis]

3.10
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.

3.11
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 – change term being defined from enhanced protection provision to enhanced protection]

3.12
EPB (equipotential bonding)

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 added to be specific to products within the scope of this document]

3.13
FEPB (functional-equipotential-bonding)

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]

3.14
PEPB (protective-equipotential-bonding)

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]

3.15

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.

3.16

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, 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.

3.17

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]

3.18

IP code

(degree of protection)

the 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); 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 – by adding extra context found in IEC 60529]

3.19

live part

conductor or conductive component intended to be electrically energized in normal use, including conductor when used, but not a combined EPB-neutral conductor.

Note 1 to entry: Live parts include negative and neutral conductors on a DC system connected galvanically to the chassis.

[SOURCE: IEC 60050-195:2021, 195-02-19, modified – to clarify and better reflect needs of this document]

3.20

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.

3.21

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 6469-3:2018/AMD 1:2021, 3.26]

3.22

mobile machinery

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

3.23

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]

3.24

nominal voltage

suitable approximate value of the voltage used to designate and identify a component, device, equipment, or system

Note 1 to entry: The nominal value is generally a rounded value.

[SOURCE: IEC 60050-151:2001, 151-16-09, modified – to address voltage in particular.]

3.25

pollution degree

numeral characterizing expected pollution of the micro-environment

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

3.26

power supply

provision of electrical energy from a source

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

3.27

protective barrier

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

[SOURCE: IEC 60050-195:2021, 195-06-15, modified – to clarify directionality.]

3.28**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 – to clarify and better reflect needs of this document]

3.29**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]

3.30**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]

3.31**RCD (residual current device)**

a mechanical switching device designed to make, carry, and break currents under normal service conditions and to cause the opening of the contacts 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.

[SOURCE: IEC 60050-442:2014, 442-05-02, modified – added a note]

3.32**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 several layers which cannot be tested 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]

3.33**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]

3.34

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]

3.35

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 – to by adding note to clarify]

3.36

VC (voltage class)

classification of an electric component or circuit according to its *maximum working voltage* ([3.21](#))

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 [5.1.2](#).

[SOURCE: ISO 6469-3:2018, 3.36]

3.37

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 dry 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 [5.10](#).

3.38 Abbreviations and acronyms

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 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
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 ACrms
VC-A	$0 < U \leq 60$	$0 < U \leq 30$
VC-A1	$0 < U \leq 32$	$0 < U \leq 21$
VC-A2	$32 < U \leq 60$	$21 < U \leq 30$
VC-B	$60 < U \leq 1\,500$	$30 < U \leq 1\,000$
VC-B1	$60 < U \leq 75$	$30 < U \leq 50$
VC-B2	$75 < U \leq 1\,500$	$50 < U \leq 1\,000$
VC-C	$1\,500 < U \leq 36\text{ kV}$	$1\,000 < U \leq 36\text{ kV}$
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 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 standard.

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 machinery manufacturer. Unless specified elsewhere in this document, the electrical system or its components shall comply with to the environmental effects requirements of ISO 15003 for agricultural tractors and machinery and ISO 19014-3 for EMM.