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**Agricultural machinery and  
tractors — Safety of higher voltage  
electrical and electronic components  
and systems —**

**Part 1:  
General requirements**

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*Tracteurs et matériels agricoles — Sécurité des composants et des  
systèmes électriques et électroniques haute tension —*

*Partie 1: Exigences générales*

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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](http://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](http://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 WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 3, *Safety and comfort*.

ISO 16230 consists of the following parts, under the general title *Agricultural machinery and tractors — Safety of higher voltage electrical and electronic components and systems*:

— *Part 1: General requirements*

## Introduction

Electrification is an enabling technology regarding increased power density and greater flexibility in machine form packaging. Customer benefits are increased fuel economy through efficiency gains and enhanced power delivery options not possible with current mechanical systems.

Agricultural machinery electrical systems have traditionally been in the 12 V DC range. Electrification is introducing significantly higher voltages to the Agricultural machinery and mobile equipment sector (see scope definition) usually observed only in industrial/building applications and other transportation sectors. Increased voltage potential requires special safety considerations in this new environment.

The purpose of this standard is to provide direction on safety of electrical systems as defined in the scope (50 V AC to 1000 V AC and 75 V DC to 1500 V DC) on Agricultural machinery and tractors.

In addition, this part of ISO 16230 defines requirements that can apply to the electrical equipment of agricultural tractors and machines. Example areas include, but are not exclusive to the following:

- protection against electric shock;
- wiring practices;
- marking warning signs — safety symbols;
- operator manual considerations.

Supporting electrical equipment standards like IEC 60204-1 and ISO 6469 were considered. Additional parts of this International Standard are expected to deal with external machine interface (power distribution and communication).

This part of ISO 16230 is a type-C standard as defined in ISO 12100.

When requirements of this type-C standard are different from those stated in type-A or 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 and tractors — Safety of higher voltage electrical and electronic components and systems —

## Part 1: General requirements

### 1 Scope

This part of ISO 16230 is applicable to tractors and self-propelled ride-on machines, mounted implements, and towed implements used in agriculture and forestry. This part of ISO 16230 specifies general requirements that relate to the protection and safety of operators and bystanders on machines with on-board voltages in the range of 50 V AC to 1000 V AC and 75 V DC to 1500 V DC. This part of ISO 16230 applies to electrical equipment and parts of the electrical equipment on such machines and includes general requirements related to the protection and safety of operators, bystanders, and first responders.

This part of ISO 16230 deals with significant hazards, hazardous situations, and events, as listed in [Annex A](#), relevant to this agricultural machinery when used as intended and under the conditions of misuse foreseeable by the manufacturer during normal operation and service.

This part of ISO 16230 is not applicable to the following:

- specific design elements of external interfaces (e.g. the interface between a tractor and implement);
- externally powered equipment (e.g. line powered equipment, equipment without on-board power generation);
- purpose built forestry machines;
- stationary electrical generators.

This part of ISO 16230 is not applicable to machines which are manufactured before the date of its publication.

### 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3864-1, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

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

IEC 60204-1:2005 + AMD1:2008, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

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

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

IEC 61140:2009, *Protection against electric shock — Common aspects for installation and equipment*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

#### 3.1

##### **barrier**

part providing protection against *direct contact* (3.7) from any usual direction of access

#### 3.2

##### **basic insulation**

insulation applied to *live parts* (3.15) for protection against *direct contact* (3.7) under fault-free conditions

Note 1 to entry: Basic insulation does not necessarily include isolations used exclusively for functional purposes.

#### 3.3

##### **basic protection**

protection against *direct contact* (3.7) with *live parts* (3.15) under fault-free conditions

#### 3.4

##### **conductive part**

part capable of conducting electric current

#### 3.5

##### **connector**

assembly of contacts and housing which terminates conductors for the purpose of providing connection and disconnection to a suitable mating connector

#### 3.6

##### **creepage distance**

shortest distance along a surface of a solid insulating material between two *conductive parts* (3.4)

#### 3.7

##### **direct contact**

contact of persons with *live parts* (3.15)

#### 3.8

##### **double insulation**

insulation system comprising both *basic insulation* (3.2) and *supplementary insulation* (3.22)

#### 3.9

##### **electric shock**

physiological effect resulting from an electric current passing through a human body

#### 3.10

##### **equipotential bonding**

provision of electric connections between *conductive parts* (3.4), intended to achieve equipotentiality

#### 3.11

##### **exposed conductive part**

*conductive part* (3.4) of the electric equipment that can be touched by a test finger according to IPXXB after removing *barriers* (3.1)/enclosures that can be removed without using tools and that is not normally live, but which can become live under fault conditions

Note 1 to entry: Protection degrees (e.g. IPXXB) are defined in ISO 20653.

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**3.12**  
**higher voltage**  
**HV**

in a machine that contains systems with more than one voltage range, higher voltage refers to systems in the ranges of 50 V AC-1000 V AC and 75 V DC-1500 V DC

**3.13**  
**isolation-resistance monitoring system**

system which periodically or continuously monitors the *isolation resistance* (3.14) between *live parts* (3.15) and the electric chassis or *exposed conductive parts* (3.11)

**3.14**  
**isolation resistance**

resistance between *live parts* (3.15) of *higher voltage* (3.12) electric circuit and the electric chassis or *exposed conductive parts* (3.11) as well as the *lower voltage* (3.16) system

**3.15**  
**live part**

conductor or *conductive part* (3.4) intended to be electrically energized in normal use

**3.16**  
**lower voltage**

in a machine that contains systems with more than one voltage range, lower voltage refers to systems with maximum voltage of <50 V AC and <75 V DC

**3.17**  
**maximum fault current**

highest value of a.c. current or of d.c. current that can occur in an electric system under fault conditions according to manufacturers' specifications

**3.18**  
**potential equalization**

electric connections of *exposed conductive parts* (3.11) of the electric equipment to minimize differences in potential between these parts

**3.19**  
**protection degree**

protection provided by a *barrier* (3.1)/enclosure related to the contact with *live parts* (3.15) by a test probe, e.g. a test finger (IPXXB) or a test wire (IPXXD)

Note 1 to entry: Protection degrees (e.g. IPXXB, or IPXXD) are defined in ISO 20653.

**3.20**  
**reinforced insulation**

insulation of *live parts* (3.15) for protection against *electric shock* (3.9) equivalent to *double insulation* (3.8)

Note 1 to entry: Reinforced insulation does not imply that the insulation shall be a homogeneous piece. The reinforced insulation can comprise several layers which cannot be tested individually as supplementary or basic insulation.

**3.21**  
**socket**

*connector* (3.5) intended to mate with a plug-in device

**3.22**  
**supplementary insulation**

independent insulation applied in addition to *basic insulation* (3.2) for protection against *electric shock* (3.9) in the event of a failure of the basic insulation

### 3.23

#### VAC

AC voltage as measured using RMS (Root-Mean-Square)

### 3.24

#### wiring

system of wires providing electric circuits and including cables and *connectors* (3.5)

## 4 General requirements

### 4.1 Standards

The safety standards for tractors and agricultural machinery, e.g. ISO 4254, ISO 26322, and ISO 25119 shall be applied in addition to the requirements provided in this part of ISO 16230.

### 4.2 Component selection

Component design and selection shall follow IEC 60204:2009, 4.2.1 for major system functional components (e.g. inverter selection, etc.)

## 5 Protection of persons against electric shock

### 5.1 General

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The electrical equipment shall provide protection of persons against electric shock. Such protections shall consist of basic measures against direct contact and measures for protection under single-fault conditions (indirect contact).

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If any of the protective measures in 5.2 and 5.3 are not practical, equivalent measures from IEC 61140 or other appropriate standards can be used.

### 5.2 Protection against direct contact

The higher voltage electric system on agricultural machinery and tractors shall be designed such that a person is protected against direct contact with live parts.

The following electrical safety requirements apply to higher voltage equipment or buses in a closed vehicle system or a combination of vehicle and attachment or implement system.

#### 5.2.1 Protection measures

At least one or a combination of the following protection measures against direct contact with live parts shall be applied:

- basic insulation of live parts;
- enclosures according to 5.2.2;
- barriers, protecting against direct contact with live parts of the higher voltage system from any common direction of access.

The design of the protection measures shall also consider the connection between the vehicle and external equipment (e.g. implement, attachment, or towed machinery).

### 5.2.2 Enclosure requirements

Enclosures are deemed to meet the requirements of 5.2 if they meet one or more of the following.

- Live parts within the operator workplace shall be contained within enclosures compliant with IPXXD in accordance with IEC 60529.
- Live parts in areas other than the operator workplace shall be contained within enclosures compliant with IPXXB in accordance with IEC 60529.
- For enclosure access, it shall not be possible to open an enclosure without having to apply a tool. If a tool is not required to open the enclosure, the power supply shall automatically be switched off if a cover of the enclosure is opened.
- The voltage of the live parts becomes equal or below 60V DC or equal or below 30V AC (rms) within 5 s after disconnection of the supply voltage in accordance with IEC 60204-1.

### 5.3 Connectors

Connectors are deemed to meet the requirements of 5.2 if they meet one or more of the following.

- When able to be separated without tools, connectors inside the operator station shall comply with IPXXD, and connectors outside the operator station shall comply with IPXXB.
- They are provided with a locking mechanism and other components need to be removed with the use of tools in order to separate the connector
- The voltage of the live parts becomes equal or below 60 V DC or equal or below 30 V AC (rms) within 1 s after the connector is separated in accordance with IEC 60204-1. If time exceeds 1 s, additional switching devices or an appropriate warning device shall be applied in accordance with IEC 60204-1.

NOTE For sockets connecting the vehicle with attachments or implements, see [Clause 6](#).

### 5.4 Protection against indirect contact

#### 5.4.1 IT system

The vehicle system or a combination of vehicle and implement or machine and dedicated attachment (e.g. header) shall be designed as an IT system as defined by IEC 60364-4-41.

#### 5.4.2 General

At least one or a combination of the following measures shall be applied.

- Protective Provisions (Protection by class II construction or equivalent). To prevent the occurrence of touch voltages, the electrical installation shall meet the requirements of IEC 61140:2009, 7.3 for class II equipment or equivalent requirements of other electrical safety standards.
- Protection by electrical separation. The provisions in IEC 61140:2009, 7.3.1.2 for electrical separation shall be met.
- Protection by automatic disconnection of source. Protection by automatic disconnection shall meet the requirements for IT systems, IEC 60204-1: edition 5.1 2009, 6.3.3. This only applies to chassis faults.
- IEC 60204-1 is applicable except for interruption times.

NOTE Interruption times defined by the application.