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Industrial trucks — Electrical requirements

Chariots de manutention — Exigences électriques

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 20898 was prepared by Technical Committee ISO/TC 110, *Industrial trucks*, Subcommittee SC 2, *Safety of powered industrial trucks*.

Industrial trucks — Electrical requirements

1 Scope

This International Standard specifies the electrical requirements for the design and manufacture of self-propelled industrial trucks including masted and variable reach rough terrain trucks (see ISO 5053:1987, 3.1.3.1.8), and tow tractors with a rated drawbar pull up to and including 20 000 N. This International Standard applies to trucks with battery voltages in accordance with ISO 1044. For additional requirements of trucks with mains power, see IEC 60204-1.

This International Standard does not apply to

— trucks used in potentially explosive atmospheres, or

— issues related to electromagnetic compatibility.

This International Standard does not repeat all the technical rules which are state of the art and which are applicable to the material used to construct the industrial truck, for which reference can be made to ISO 12100-2.

2 Normative references

The following referenced documents are indispensable for the application 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 1044, *Industrial trucks — Lead-acid traction batteries for electric trucks — Preferred voltages*

ISO 12100-2, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

ISO 14121-1, *Safety of machinery — Risk assessment — Part 1: Principles*

ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

EN 50272-3, *Safety requirements for secondary batteries and battery installations — Part 3: Traction batteries*

IEC 60204-1:2005, *Safety of machinery — Electrical equipment of machines — Part 1: General Requirements*

IEC 60947-5-1, *Low-voltage switchgear and control gear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices*

IEC 60384-14, *Fixed capacitors for use in electronic equipment — Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

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

3 Terms and definitions

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

3.1
arcing part
mechanical device that interrupts current during operation

3.2
auxiliary circuit
electrical circuit that controls lights, fans and other accessories

3.3
battery compartment
compartment on the truck that houses the battery

3.4
battery enclosure
container or tray that houses the individual cells

3.5
control circuit
electrical circuitry that controls truck movement

3.6
deactivate
make inactive or ineffective.

3.7
direct contact
contact of person with live parts

3.8
electrical enclosure
compartment on a truck that houses uninsulated live electrical components

3.9
electrical or electronic steering
system where input is not mechanically connected to output

3.10
exposed conductive part
conductive part of electrical equipment, which can be touched and which is not normally live, but which may become live under fault condition

3.11
frame fault
accidental connection of a live part to the truck structure

3.12
indirect contact
contact of persons with exposed conductive parts which have become live under fault conditions

3.13
live part
conductor or conductive part intended to be energized in normal use

3.14
nominal current
current in amperes that the electrical system is able to carry continuously without exceeding the allowable temperature indicated

3.15
nominal voltage (of the truck system)
total number of battery cells connected in series in the truck's system multiplied by the nominal cell voltage

3.16
power circuit
electrical circuitry that supplies the motors which cause truck movement, i.e. traction, steering and lifting

3.17
rated operating current
I_e
value of current which is determined by the conditions of use of the contactor

3.18
rated thermal current
I_{th}
value of current which determines the temperature rise conditions of the main circuit in the absence of any closing or opening operation of the contacts

3.19
risk of fire
any device that has a surface temperature greater than 175 °C or that emits sparks outside of its enclosure

3.20
routine test
test required for all production trucks

3.21
type test
test to verify compliance with this International Standard for each truck type

4 List of hazards

Table 1 contains all the significant hazards, hazardous situations and events, as far as they are dealt with in this International Standard, from ISO 14121-1:2007, Annex A and referenced in brackets, and are applicable in the situations described and could involve risks to persons if not addressed. The corresponding requirements offer guidance to limit the risk or reduce the hazard in each situation.

Table 1 — List of significant hazards, hazardous situations and hazardous events

Hazard		Corresponding requirements	
1	**Mechanical hazards**	5.1.11	Slack chains
	Crushing hazard (1.1)	5.1.12	Low voltage
	— between truck components	5.1.14	Controls — General
	— between truck and obstacles	5.1.15	Controls — Travel
	Impact by collision (20)	5.1.16	Controls — Load handling
	— when driven by the operator	5.1.17	Controls — Steering
	Loss of stability (18)	5.1.18	Contactors
	— from excess speed	7.1	Minimum marking electric trucks
	— from faulty battery mass	7.3	Minimum marking IC trucks
2	**Electrical hazards**	5.1.1	Traction batteries
	Electric shock (2.1)	5.1.2	Battery leads
	Overloading	5.1.3	Battery connectors
	— all voltages	5.1.4	Battery charging
		5.1.5	Emergency switching off requirements
		5.1.6	Design construction
		5.1.8	Wiring and wire construction
		5.1.9	Electrical shock protection
		5.1.13	Overcurrent protective devices
		5.2.1	Battery
		5.2.2	Circuit protection
		5.2.3	Control systems
		5.2.4	Wiring and wire construction
		5.2.5	Electrical shock protection
		6.2.1	Abnormal operation
	120 V < voltages ⩽ 240 V	5.1.1	Traction batteries
		5.1.7	Trucks with nominal voltage exceeding 120 V dc
3	**Thermal hazards**	6.2.2	Temperature
7	**Material/substance hazards**	5.1.1	Traction batteries
	Battery electrolyte	5.1.2	Battery leads
	Fire or explosion hazard (all voltages)	5.1.3	Battery connectors
		5.1.4	Battery charging
		5.1.5	Emergency switching off requirements
		5.1.6	Design construction
		6.1	Insulation resistance testing
		6.2.1	Abnormal operation

Table 1 (*continued*)

Hazard		Corresponding requirements	
		6.2.3	Arc rupture
		6.2.5	Connector testing
		6.2.6	Contactor testing
	120 V < voltages ⩽ 240 V	5.2.8	Trucks with nominal voltage exceeding 120 V dc
		7.1	Minimum marking electric trucks
		7.3	Minimum marking IC trucks
4.5	Ergonomic hazards (8)	7.1	Minimum marking electric trucks
4.5.1	Human error (8.6)	7.3	Minimum marking IC trucks
4.6	Hazards due to functional disorders (10)	5.2.13 5.2.15	Low voltage Controls — General
4.6.1	Failure of energy supply	5.2.16	Controls — Travels
4.6.2	Failure of control system	5.2.17	Controls — Load handling
4.6.3	Loss of machine stability	5.2.18	Control — Steering
		5.2.19	Contactors
		5.3.2	Circuit protection
		5.3.3	Control systems

5 Requirements

5.1 Electrical requirements for battery powered trucks

5.1.1 Traction batteries

5.1.1.1 All trucks shall be equipped with an insulated battery.

5.1.1.2 Cells assembled in metal containers shall be insulated from each other.

5.1.1.3 The cell connections shall be such that the potential between any two adjacent cells cannot be more than 24 V dc nominal.

5.1.1.4 For battery terminals, measures shall be taken to reduce risk of a connection coming loose causing arcing or overheating.

5.1.1.5 On trucks equipped with an on-board battery charger, the battery terminals shall be protected by insulating boots or covers.

Exception No. 1: A terminal that is intentionally connected to ground on the truck frame need not be provided with a boot or cover.

Exception No. 2: This requirement does not apply to on-board battery chargers complying with 5.1.1.6 equipped with a ground-fault circuit interrupter or an isolated output.

5.1.1.6 When trucks are fitted with on-board chargers the requirements in IEC 60204-1:2005, 6.3 up to and including 6.3.2, 7.2.1 and 8 up to and including 8.2 shall apply. The enclosure containing equipment connected to the mains supply shall be IPxxB of IEC 60529. However, for top surfaces the degree of protection shall be at least IPxxD.

5.1.1.7 For batteries with nominal voltages exceeding 120 V dc, the battery enclosure shall be lockable or facilities shall be provided so that the battery compartment can be secured to prevent unauthorized access to the battery if a lockable cover is not present on the battery enclosure.

5.1.1.8 For batteries with nominal voltages exceeding 120 V dc the following protective measures against indirect contact can be selected:

a) protective electrical insulation or;

b) protection by earth - free equipotential bonding or;

c) protection by automatic disconnection or signalling.

5.1.1.9 A battery enclosure where the battery nominal voltage exceeds 120 V dc shall be:

a) metal and lined with a material bonded to the metal that is impervious to the electrolyte or,

b) constructed of an insulating material.

5.1.2 Battery leads

5.1.2.1 A battery lead for battery nominal voltage up to and including 120 V dc shall be:

a) acceptable for application due to cross section of wires and thickness of insulation (see IEC 60227-1 and IEC 60245-1);

b) insulated with a suitable material rated for the temperatures and voltages of the truck;

c) resistant to the electrolyte;

d) able to withstand flexing, handling, and impact at temperatures referenced in 5.1.3.2;

e) average insulation thickness shall not be less than 1,5 mm for a wire less than or equal to 35 mm^2 and shall not be less than 2 mm for a wire greater than 35 mm^2.

5.1.2.2 A battery lead where the battery nominal voltage exceeds 120 V dc shall meet the requirements of IEC 60204-1:2005.

5.1.3 Battery connectors

5.1.3.1 If a battery connector is installed, one part of the connector shall be permanently mounted to either the truck or the battery enclosure. The length of the cable attached to the free part of the connector shall be as short as practicable, without interfering with the connector mating, operational efficiency or disconnecting operations and without placing stress on terminals and leads. (See 5.1.2.)

5.1.3.2 The battery connector shall be rated for the voltage of the battery and be designed for use in the application and shall be resistant to battery electrolyte and battery gases. Connectors shall have a minimum temperature rating of –20 °C to +90 °C and comply with the tests defined in 6.2.5.

5.1.3.3 The connector shall be designed so that opposite polarities can not be coupled together. Different operating voltages shall be indicated either by colour or by a coding device to prevent charger/battery/truck mismatch.

5.1.3.4 The half-connector connected permanently to the battery shall be protected against the accidental contact of persons with energized parts. Live parts shall be recessed from the face of the connectors. For battery voltage greater than 60 V dc, protection shall be IP2X or higher, in accordance with IEC 60529.

5.1.3.5 When the two half-connectors are coupled their enclosure shall provide a degree of protection IP23, in accordance with IEC 60529.

5.1.3.6 Any two half-connectors which may be separated by a force less than 15 N shall be equipped with a device to ensure the connection remain secure. A handle may be devised to facilitate connection or disconnection.

5.1.3.7 The connector shall meet the type test described in 6.2.5.

5.1.4 Battery charging

5.1.4.1 When external-charging supply cables are connected to the truck or to the truck battery it shall not be possible to energize the truck movement circuits. This does not apply to trucks designed for permanent charging during operation.

5.1.4.2 For nominal battery voltages exceeding 120 V dc, the charger shall be controlled via the connector auxiliary contacts or other device to prevent arcing at the connector and to ensure the charger is not energized until it is connected to the battery.

5.1.5 Emergency switching off requirements (disconnection) connections for batteries

5.1.5.1 An emergency switching off control or battery connector when used as an emergency switching off device shall be accessible to the operator in the normal operating position at all times.

5.1.5.2 The emergency switching off device shall be capable of interrupting without danger the power supplies to all moving elements. It shall be capable of interrupting the normal maximum current (including motor starting current) by one of the following methods:

a) battery connector for nominal battery voltage up to and including 120 V dc. Above 120 V dc, provision shall be made to prevent the use of the battery connector for emergency switching off purposes;

b) manually actuated power switch directly disconnecting one line of power supply;

c) manually actuated control switch disconnecting the power supply to the coil of one contactor in one line of the power supply. Simultaneously the power controller (e.g. inverter or controller for separate excited motors) shall be deactivated. In trucks driven by series-wound dc motor(s) with mechanical commutator without power controller, two independent contactors are necessary to switch off battery supply.

In the case of b) or c) they shall be a positive action type in accordance with IEC 60947-5-1 and the actuator coloured red. See also IEC 60947-3. A contrasting colour shall be used if the background is red.

It shall be possible to re-establish the power supply to the moving elements only by manual resetting of the switching off device followed by the normal operation of the controls.

5.1.5.3 If the battery connector is used as an emergency switching off system, the removable part of the connector shall have a means for disconnecting without damage to the battery connectors or cables.

When the connector is used for emergency switching off, the device shall be capable of being disconnected quickly in case of emergency and the two half-connectors shall be able to be separated easily. The maximum force to separate the two half connectors shall not exceed 150 N.

5.1.6 Design construction

5.1.6.1 Any arcing part in a power circuit shall be enclosed or installed so as to avoid the possibility of flame or molten metal causing a risk of fire.

5.1.6.2 Sparking components or components which can reach a temperature of 300 °C or more shall not be located where explosive gas/air mixtures may be present, e.g. above or close to a battery where the hydrogen concentration exceeds 4 % hydrogen by volume [lower explosion limit (LEL)] either during charging or discharging. Battery connectors shall be accepted as non-sparking components provided they are not used as an emergency switching-off device.