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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Safety of machinery – Requirements for cableless control systems of machinery

Sécurité des machines – Exigences pour les systèmes de commande sans fil des machines

IEC 62745:2017-01(en-fr)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SAFETY OF MACHINERY – REQUIREMENTS FOR CABLELESS CONTROL SYSTEMS OF MACHINERY

FOREWORD

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The text of this standard is based on the following documents:

FDIS	Report on voting
44/783/FDIS	44/785/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,
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INTRODUCTION

Cableless control systems (CCS) are increasingly being used to provide an operator interface on a wide range of machinery. The functionality of a CCS and the way in which it interfaces with the overall machine control system can therefore affect the safety of the machinery.

IEC 62745 specifies requirements for the functionality of a CCS that is interfaced with or is part of a machine control system for use as an operator control station on a machine.

The extent to which the functionality of a CCS is relied upon to minimise risk on a machine is a key selection criterion. It is therefore important to select a CCS that provides suitable control functions with an appropriate safety integrity in accordance with the risk assessment at the machine.

In some particular applications, the requirements for a CCS can exceed those specified in this document.

SAFETY OF MACHINERY – REQUIREMENTS FOR CABLELESS CONTROL SYSTEMS OF MACHINERY

1 Scope

This standard specifies requirements for the functionality and interfacing of cableless (for example, radio, infra-red) control systems that provide communication between operator control station(s) and the control system of a machine. Specific requirements are included for such operator control stations that are portable by the operator.

NOTE The part of the cableless control system that is used as an operator control station is sometimes referred to as the 'transmitter' and the part that interfaces with the machine control system is sometimes referred to as the 'receiver'. However, to take account of the possibility of bi-directional communication, this standard refers to these individual parts as the 'remote station' and the 'base station' respectively.

This document does not deal with cableless communication between parts of a machine(s) that are not operator control stations.

This document is not intended to specify all of the requirements that are necessary for the design and construction of a cableless control system. For example, it does not specify communication protocols, frequency or bandwidth aspects, nor the full range of constructional requirements such as impact resistance, ingress protection, electromagnetic compatibility, etc.

The provisions of this document are intended to be applied in addition to the requirements for electrical equipment in the IEC 60204-1.

This document is a type-B2 standard as stated in ISO 12100.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-31:2008, *Environmental testing – Part 2-31: Tests – Test Ec – Rough handling shocks, primarily for equipment-type specimens*

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

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60947-5-5, *Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function*

IEC 62061, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*

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

ISO 13849-2, *Safety of machinery – Safety-related parts of control systems – Part 2: Validation*

ISO 13850, *Safety of machinery – Emergency stop function– Principles for design*

3 Terms, definitions and abbreviations

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

For an alphabetical list of definitions, see Table 1.

For list of abbreviations see Table 2.

Table 1 – Alphabetical list of definitions

Term	Definition number
active stop	3.17
address code	3.7
automatic stop (ATS)	3.19
base station	3.13
cableless control	3.1
cableless control system (CCS)	3.2
disabling of a remote station	3.22
error detection code	3.9
frame	3.6
Hamming distance	3.11
manual stop	3.20
neutral frame	3.10
OFF-state	3.15
operating command signal	3.8
operator control station	3.5
passive stop	3.18
receiver	3.3
remote station	3.12
safety-related stop function	3.16
stop output	3.14
transmitter	3.4
valid signal	3.21

Table 2 – Abbreviations

Term	Abbreviation
automatic stop (4.7.3.5)	ATS
cableless control system (3.2)	CCS
emergency stop (4.7.3.4)	EMS
general safe stop (4.7.3.3)	GSS

3.1
cableless control
transmission of the machine operator's commands without any wired connection

3.2
cableless control system
CCS
system consisting of at least one remote station and one base station, which uses cableless control to transmit commands between them

3.3
receiver
part of a cableless control system which receives frames from a transmitter

3.4
transmitter
part of a cableless control system which sends frames to a receiver

3.5
operator control station
assembly of one or more control actuators (part of a device to which an external manual action is to be applied) fixed on the same panel or located in the same enclosure

Note 1 to entry: An operator control station can also contain related equipment, for example, potentiometers, signal lamps, instruments, display devices, etc.

3.6
frame
"package" of information exchanged between a remote station and a base station, and consisting of, for example:

a) address code;

b) operating commands;

c) error detection code;

d) other commands, signals or information

Note 1 to entry: A "frame" is sometimes referred to as a "telegram" or "message".

3.7
address code
part of a frame that enables a base station or a remote station to recognise frames that are intended to convey commands to it

Note 1 to entry: The base station or remote station respond to commands that are recognised as having the relevant address code.

3.8
operating command signal
control signal that is intended to initiate, modify or maintain a machine function

3.9
error detection code
additional information added to each frame to enable the detection of transmission errors

3.10
neutral frame
frame in which all operating command signals are in a state such that when it is received at the base station it does not activate any outputs intended for control of hazardous operations of the machine

Note 1 to entry: Neutral frames can be used to maintain communication (i.e. a valid signal) between a transmitter and receiver, for example to preclude automatic initiation of the stop function at a machine.

Note 2 to entry: Neutral frame transmission is intended to prevent hazardous operations of the machine resulting from establishment or re-establishment of communication.

Note 3 to entry: Neutral frames can contain data, for example parameterisation data, and commands that are not intended to cause hazardous operations of the machine.

3.11
Hamming distance
number of bit positions in which two frames of the same length differ from each other

3.12
remote station
part of a cableless control system via which an operator interfaces with the cableless control system

Note 1 to entry: The remote station of a cableless control system is sometimes referred to as a “transmitter”, but a remote station that is part of a bi-directional cableless control system will incorporate both a transmitter and a receiver.

Note 2 to entry: The remote station forms the operator control station of a cableless control system.

Note 3 to entry: The remote station can be portable (by the operator), mobile (e.g. installed separately from the machine on a vehicle or trolley) or fixed (e.g. installed on or near to the machine).

3.13
base station

part of the cableless control system that interfaces with the machine control system

Note 1 to entry: The base station of a cableless control system is sometimes referred to as a “receiver”, but a base station that is part of a bi-directional cableless control system will incorporate both a receiver and a transmitter.

Note 2 to entry: The base station may be installed on static or mobile machinery.

Note 3 to entry: The base station is not necessarily a discrete physical entity, but it includes all of the components that fulfill the requirements specified in this standard for the base station.

3.14
stop output
output circuit of the base station that interfaces with the control system of the machine to initiate a stop function

Note 1 to entry: Stop outputs can be safety-related or non-safety-related. See also Table 3.

Note 2 to entry: Interfaces to field bus part of a CCS base station can also be considered as an output circuit.

3.15
OFF-state
state of safety-related stop output(s) of the base station, which is intended to be used to initiate one or more stop functions of a machine

3.16
safety-related stop function
stop function provided by the CCS that results in an OFF-state and whose failure can result in an immediate increase of the risk(s)

3.17
active stop
stop resulting from transmission of a stop signal from the remote station to the base station

3.18
passive stop
safety-related stop resulting from absence of a valid signal at the base station

Note 1 to entry: A passive stop can be initiated by, for example, an out of range condition, battery failure, electromagnetic interference.

3.19
automatic stop
safety-related stop initiated without manual actuation of a device by an operator

3.20
manual stop
stop initiated by actuation of a device by an operator

3.21
valid signal
any received frame, including a neutral frame, that is accepted by the error checking routines of the receiver and contains the relevant address code for the receiver

3.22
disabling of a remote station
deliberate operation that renders a remote station incapable of sending signals to the base station

4 Functional requirements

4.1 General

Figure 1 illustrates an example of the main elements of a CCS and its interaction with the machine control system.

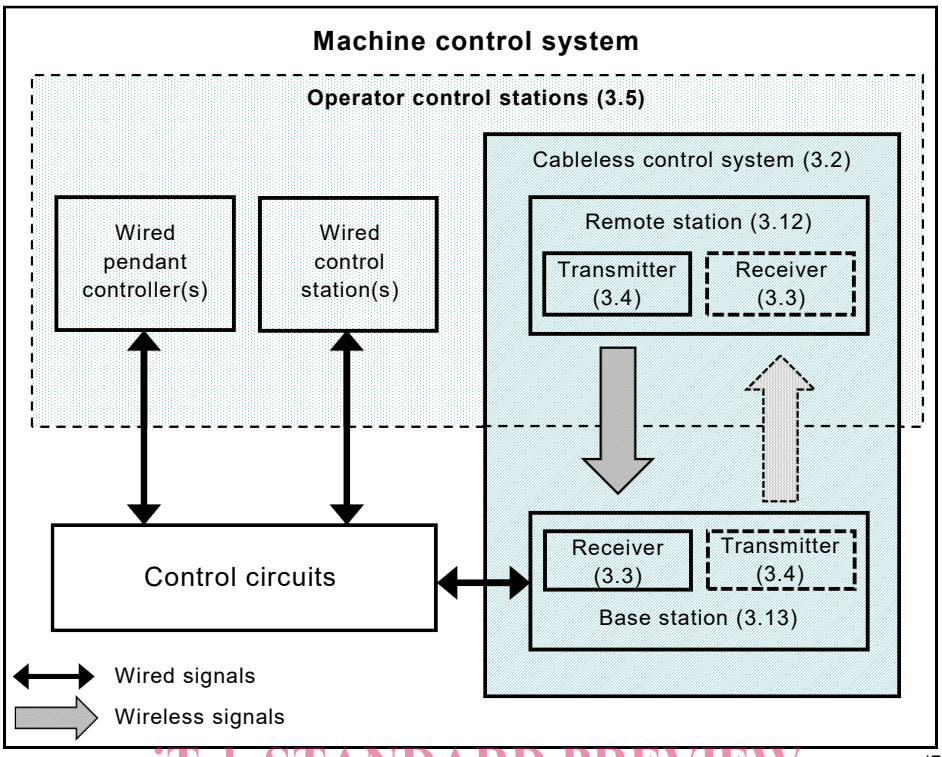

Figure 1 – Block diagram example of a cableless control system and its interaction with the machine control system

NOTE The references to IEC 60204-1 in this standard could have corresponding requirements in other relevant parts of IEC 60204 series.

4.2 Operational preventions

4.2.1 Prevention of inadvertent actuation

The remote station and its control actuators shall be designed and arranged so as to minimise the possibility of inadvertent actuation (for example, caused by dropping to the floor or striking an obstruction, failure of electronics) generating an unintended hazardous command.

4.2.2 Prevention of unauthorised operation

Where prevention of unauthorised operation of the CCS is required, remote stations shall be provided with means to prevent unauthorised use (for example, key-operated switch, access code).

4.2.3 Prevention of unintended commands

Measures shall be taken to ensure that operating command signals:

- affect only the intended base station or remote station (for example, using address code);
- initiate only the intended functions in that base station or remote station.

Such measures shall be resistant to accidental or unintentional change.

Upon detection of malfunction or faults, all relevant safety-related output shall be controlled to OFF-state with an appropriate safety integrity.

Where hardware switches (for example, DIP) are used for device addressing, additional measures such as parity checking may be necessary to fulfil the requirements in case of a fault.

NOTE Typical methods include factory-set coding, which are more robust than user-configurable methods because they cannot be defeated (either intentionally or inadvertently) by the user.

4.3 Serial data transfer

The serial data transfer shall satisfy one of the following requirements:

- means shall be provided that ensure the probability of an erroneous frame being received undetected, $R(P_e)$, is less than 1×10^{-8}, given an input bit error probability of $P_e = 10^{-3}$, if no better input bit error probability can be proven, or
- the Hamming distance shall be either 4 or the total number of bits in a frame divided by 20, whichever is greater.

NOTE 1 An input bit error probability of $P_e = 10^{-3}$ can be assumed as typical estimate for a wireless channel disturbed by Additive White Gaussian Noise (AWGN) and electromagnetic interference (EMI).

NOTE 2 IEC 60870-5-1 defines a set of possible transmission frame formats.

NOTE 3 Increasing the reliability of serial data transmission only reduces the possibility of errors than can be occurring in the transmission media.

In addition for safety-related functions of a CCS the residual error probability Λ of undetected error per hour shall be less than 1 % of the specified PFHD value for the respective function of the CCS. Residual probability of undetected error per hour Λ shall be calculated by:

$$\Lambda(P_e) = R(P_e) \times v \times b \text{ [1/h]}$$

where:

$\Lambda(P_e)$: residual probability of undetected error per hour in relation to the input bit error probability

$R(P_e)$: residual probability of undetected error per frame in relation to the input bit error probability

P_e: input error probability. If no better input bit error probability can be proven, $P_e = 1 \times 10^{-3}$ applies

v: maximum number of safety-related messages per hour

b: maximum number of listening base stations

NOTE 4 For a definition of PFH_D see IEC 62061 or ISO 13849-1.

NOTE 5 $\Lambda(P_e)$ calculation is based on IEC 61784-3; this approach is valid for cyclic transmission of safety-related messages.

NOTE 6 When using CRC as hash-function, Equation (B.3) or (B.4) from IEC 61784-3:2016 can be applied in order to determine $R(P_e)$ with an input bit error probability of $P_e = 1 \times 10^{-3}$.

The CCS can be equipped with indicator of transmission reliability.

NOTE 7 It is not necessary to provide a separate warning indicator for each condition that can affect transmission reliability.

4.4 Removal of remote station transmission

Means shall be provided to readily stop transmission from the remote station. This shall be achieved by one or more of the following:

- a device that interrupts the power supply of transmission for the remote station, where such a device shall have direct opening action (see IEC 60947-5-1:2016, Annex K), or
- removal of the battery without the use of a tool, or
- a dedicated transmission removal function in accordance with IEC 61508, IEC 62061 or ISO 13849-1 and ISO 13849-2, with an integrity in accordance with 4.7.2.

NOTE A passive stop will result from the removal of transmission power.