
**Earth-moving machinery — Safety
requirements for remote operator control**

Engins de terrassement — Exigences de sécurité pour la commande à distance utilisée par l'opérateur

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Foreword

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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 15817 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*.

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Earth-moving machinery — Safety requirements for remote operator control

1 Scope

This International Standard specifies the safety requirements for wireless and/or wired remote control systems, used on earth-moving machinery as defined in ISO 6165.

It does not apply to autonomous control systems that enable a machine to work without the assistance of an operator, but rather is applicable to machines controlled remotely by an operator. This International Standard does not apply to the remote control of attachments on non-remote controlled machines.

This International Standard does not specify performance criteria for the remote control system. Where “wireless control” or “wired control” features as a subclause title, the provisions of that subclause are applicable to the corresponding control only.

2 Normative references

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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 3450, *Earth-moving machinery — Braking systems of rubber-tyred machines — Systems and performance requirements and test procedures*

ISO 5006-1, *Earth-moving machinery — Operator's field of view — Part 1: Test method*

ISO 6165, *Earth-moving machinery — Basic types — Vocabulary*

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

ISO 6405-2, *Earth-moving machinery — Symbols for operator controls and other displays — Part 2: Specific symbols for machines, equipment and accessories*

ISO 9244, *Earth-moving machinery — Safety signs and hazard pictorials — General principles*

ISO 10265, *Earth-moving machinery — Crawler machines — Performance requirements and test procedures for braking systems*

ISO 13766, *Earth-moving machinery — Electromagnetic compatibility*

ISO 15998, *Earth-moving machinery — Machine-control systems (MCS) using electronic components — Performance criteria and tests for functional safety¹⁾*

ISO 17063, *Earth-moving machinery — Braking systems of pedestrian-controlled machines — Performance requirements and test procedures*

1) To be published.

IEC 60068-2-32, *Basic environment testing procedures — Part 2: Tests — Test Ed: Free fall*

IEC 60204-1:2000, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

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

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

3 Terms and definitions

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

3.1 remote control
remote operator control
control of a machine by wireless or wired transmission of signals from a remote control box not located on the machine to a receiving unit located on the machine

3.2 remote control system
system for transmitting operational information or control to a remote-controlled machine

NOTE It consists of a remote control box and a receiving unit.

3.3 remote-controlled operation
operation of a machine by an operator distant from the machine

3.4 remote control box
device with controls to actuate all needed operating functions for control of the machine from a distant place

NOTE The signals are transmitted between the remote control box and the receiving unit.

3.5 receiving unit
device located on the machine to receive signals emitted from the remote control box and to process these signals into machine operating orders

NOTE It consists of following elements:

- receiving element that receive signals from the remote control box;
- monitoring element for confirming signals;
- output intersection element that drives the control devices of the machine.

The receiving unit may also include means of return signal transmission for confirmation.

3.6 control cable
electric wire for transmitting signals between the remote-control box and the receiving unit

3.7 hazard zone
area defined by the manufacturer of the machine and by the use of the machine where potential for injury might exist due to movement of the machine and its application

4 Requirements for remote operator control

4.1 General requirements

4.1.1 Design

Remote control systems shall be designed so that all remote-controlled machine operations stop and remain stationary in a safe manner for any of the following conditions:

- a) when the controls are not activated;
- b) when the power supply of the remote control system is interrupted;
- c) when the communication between the remote control box and receiving unit is interrupted;
- d) loss of power at the machine that interrupts any part of the remote control system, or
- e) loss of signal.

4.1.2 Wireless control

When the location of the machine operated by wireless remote operator control is such that the machine is out of remote control communication range, the machine remote-controlled operation shall stop and remain stationary in a safe manner.

If there are several machines equipped with a wireless remote control system working in close proximity, each remote control system shall have means to indicate to the operator the corresponding controlled machine prior to the start of the remote operation.

It is recommended that a special lamp control (e.g. the yellow/amber beacon at the operator position referenced in 4.10) be used to identify the corresponding machine when the operator starts remote-controlled operation.

4.2 Signal reliability

The signal transmission system shall have an error-detection and/or -correction system to prevent the machine controls from being actuated by false signals resulting from burst levels of electro-magnetic radiation, temporary signal loss, remote control box malfunction, etc. The data communication protocol shall guarantee integrity of the communication link and of the data being transmitted. In the event of the integrity being unable to be verified, the machine shall come to an immediate stop in a safe manner.

The remote control system shall meet the electromagnetic compatibility requirements of ISO 13766.

4.3 Remote control box

4.3.1 Design

A machine shall only be able to be remote controlled from one remote control box at a time except for emergency stops.

The remote control box shall be equipped with a device or means to control access such as a key switch or access code for activation/deactivation of the remote controls.

By design, the remote control box shall minimize the restriction to the machine operator's freedom of movement.

4.3.2 Controls

4.3.2.1 Neutral position

All controls on the remote control box shall return to their neutral position when the operator releases them. And when the controls are in their neutral position, the resulting machine action shall be same as the action when the corresponding controls on the machine itself are in the neutral position.

Where fixed detent position(s) are provided for machine and/or attachment (tool) controls, the functions activated by a detent position may be able to be maintained, even if the operator releases all other controls, except when the resulting machine function(s) are potentially hazardous.

4.3.2.2 Marking

The controls on the remote control box shall have clearly marked directional orientation and directions of movement for the machine and its equipment/attachment consistent with the control markings on the machine, if the machine is so equipped (see ISO 6405-1 and ISO 6405-2).

4.3.2.3 Protection against unintended actuation

The controls on the remote control box shall be so arranged, deactivated or guarded to protect against unintended action. A means shall be provided to guard against actuation in case the remote control box falls from the operator's hands or the operator falls while holding the remote control box.

A means shall be provided to disable the controls on the remote control box in the deactivated mode for protection against unauthorized actuation.

4.3.2.4 Brake/stopping function

The machine shall be held in the standstill position (at maximum slope as specified by the manufacturer) when the remote controls for travelling are in the neutral position. Braking systems of remote-controlled machines shall comply with ISO 3450, ISO 10265 or ISO 17063.

4.3.2.5 Priority of controls at the operator's station

Generally, direct controls at the operator's station, if equipped, shall have priority over remote operator controls. See 4.6 for selection of controls.

4.4 Wired control

It shall be possible for the operator to control the machine from a position outside of the hazard zone.

The control cable shall be sufficient in length and flexibility to allow the operator to maintain an operating position outside the hazard zone. With regard to pulling forces, the flexible electrical cables and fittings used in cable-connected consoles shall comply with the requirements of IEC 60204-1:2000, 14.4.2 and 14.4.3.

Excessive tension on the control cable shall not cause actuation of the controls.

4.5 Stop control

4.5.1 General

A stop control shall be present on the remote control box and on the machine.

Activation of the stop control shall immediately stop all hazardous machine movement in a safe manner.

4.5.2 Characteristics

It shall not be possible to restore the operation of a machine until the stop control has been manually reset.

Where several stop controls are provided, the operation of a machine shall not be restored until all stop controls previously operated or activated have been reset.

4.5.3 Stop control button

Stop control shall generally be obtained by a push-button. Either the device or its marking shall be red in colour (see IEC 60947-5-1).

The background around the stop control shall be of a contrasting colour.

The stop control button shall apply fail-safe design.

4.5.4 Machine

A remote-controlled machine should be equipped with a stop control button or other means that can be activated by a person standing at ground level out of the path of forward travel of the machine.

4.6 Selecting switch

If the machine can also be controlled with controls on the machine (direct control), a selecting switch shall be located at the operator's station on the machine for selecting direct or remote control.

The control selection (direct or remote control) shall only be possible by use of a key-switch, access code or a switch in a lockable cab.

4.7 Impacts, shocks and vibrations

By design, operational impacts of the remote control box and the receiving unit shall not cause inadvertent machine movement.

The remote control box shall withstand the following tests:

- free fall test according to IEC 60068-2-32;
- shock test (15 g shock load for 11 ms) according to ISO 15998

The receiving unit shall withstand the vibration test, according to ISO 15998.

4.8 Environmental protection

4.8.1 Remote control box

The environmental protection of the remote control box shall be IP 65 (see IEC 60529).

4.8.2 Receiving unit

The degree of protection is based on the location for the installation of the receiving unit. IP 54 shall be met if the receiving unit is located inside the cab or a similar location; in all other cases, IP 65 shall be applied.