

Guidance on the application of remote controls for lifting machines

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1.0 Introduction

In recent years, the use of remote controls for cranes and hoists has become increasingly popular, and with good reason. In addition to offering most of the advantages of pendant controls, they also give the operator greater freedom of movement. This can enhance productivity and may, in some circumstances, be a safer option.

Many new cranes and hoists are supplied with remote controls and they are an increasingly popular choice when modernising existing cranes. This guidance is intended to provide those who specify, install and use remote controls with an overview of the relevant European legislation, standards and current good practice. **It is not intended to be a comprehensive guide, but rather to serve as a starting point.**

Throughout this guidance, reference is made to various other documents. For convenience, these are listed with their full titles and status in a bibliography at the end.

2.0 European legislation and standards

In legislation and standards remote controls are usually referred to as cable-less controllers. There are variations in the capability of the products on the market, and therefore choices to be made when selecting a product for a particular application. As with many situations where there is a choice, there can be a downside if the wrong decision is made, particularly if the safety performance of an application is compromised. It is therefore essential that users and installers have a clear understanding of how they function and how they should be installed, maintained and operated.

Firstly, it must be understood that most cable-less controllers on the market are multipurpose, i.e. they can be used to control a wide variety of equipment, not just lifting machines. Prior to the introduction of the Radio Equipment Directive 2014/53/EU in 2013, systems marketed within Europe were required to be CE marked and to have an EC Declaration of Conformity (DoC) indicating which Directives the CE mark relates to. For cable-less controllers operating by radio, the DoC referred to the Radio Equipment and Telecommunications Terminal Equipment Directive (99/5/EC), which covered the frequency range 9kHz to 3,000GHz. Commonly reference would also have been made to the Low Voltage Directive (2006/95/EC) and the Electromagnetic Compatibility Directive (2004/108/EC), although Directive 99/5/EC includes requirements for electrical safety and electromagnetic compatibility by cross references to them. The important point to understand is that these Directives do not address functional safety.

On the 13th June 2017 a change in legislation meant that it is now a mandatory requirement for manufacturers of radio control equipment to comply with the Radio Equipment Directive 2014/53/EU (RED). This legislation also requires CE marking and a EC Declaration of Conformity, but in this case the DOC should contain a list of the applicable harmonised standards and EU directives, such as directives 2011/65/EU RoHS and 2006/42/EC Machinery.

2.1 Key legislative changes enforced by RED.

When new legislation is implemented it is important to note that the new requirements do not apply to equipment placed on the market prior to changes. Therefore, in the case of RED it does not apply to any equipment that was manufactured and placed on the market prior 12th June 2017.

Manufacturers of radio equipment are legally responsible for ensuring that their products comply with all the applicable directives and standards. To confirm that they have fulfilled their legal obligations they are required to supply an EC Declaration of Conformity. If they have not manufactured to a harmonised standard then the declaration of conformity would need to include the details of the third party notified body used to verify compliance of the equipment. For further guidance on conformity assessment refer to page 24 of the guidance to RED at the following link;

<https://ec.europa.eu/docsroom/documents/33162>.

2.2 Exclusions from RED

The Radio equipment directive details various forms of radio equipment that is excluded from its scope. The following lists those exclusions that are relevant to the lifting equipment industry. For further guidance on these and other exemptions please refer to the guide to the RED at the following link:

<https://ec.europa.eu/docsroom/documents/33162>

2.2.1 Marine Equipment

Equipment within the scope of Directive 2014/90/EU is excluded from RED. Directive 2014/90/EU covers equipment which has to be carried on ships which are subject to International Maritime Organisation (IMO) Conventions e.g. Safety of Life at Sea (SOLAS).

2.2.2 Non-radio products which function with radio equipment/electrical and electronic equipment with non-electrical products.

The RED is applicable to the combination of the radio equipment and the non-radio product as a whole only if the radio equipment is:

- Incorporated into the non-radio product; and
- Permanently affixed to the non-radio product.

Hence if the radio equipment is incorporated in a fixed and permanent way in the non-radio product at the moment of its placing on the EU market (i.e. in such a way that it cannot be easily accessed and readily removed), as specified above, this product is deemed to be a single product.

In other cases, the radio equipment and the non-radio product are considered as separate finished products and only the radio equipment is subject to RED. For example, if radio equipment is connected to the machinery via a plug-in connection which is covered by standards, the machinery and the radio equipment remain to separate products. Therefore the radio equipment would be covered by RED and the Machinery under the Machinery Directive 2006/42/EC, plus any other applicable directives.

2.2.3 Infrared devices IR.

IR devices operating in the IR spectrum below 3,000 GHz are within scope of RED. However, those that operate above 3,000 GHz do not fall under the RED.

2.2.4 Antennas

There are two forms of antennas, active and passive. Active antennas are supplied with one or more active electronic components, such as diodes and transistors, that interact with the RF-signal. All other antennas are generally considered as passive types.

Passive antennas are not covered by RED if placed on the market as a single commercial unit, whereas active antennas are covered. However, a radio equipment with antenna is subject to all the requirements of RED.

2.2.5 Fixed Installations

Fixed installations are not regulated under RED and there are two types of fixed installations as follows:

- Fixed installations as defined and described in the EMCD, i.e., which are unique in their build up;
- Installations built up of mass-market equipment but are fixed in the sense that they are permanent in their place.

Refer to RED guidance for further information on each;

<https://ec.europa.eu/docsroom/documents/33162>

In addition to the manufacturers obligations, RED also places a duty on those involved with the installation, retrofitting, procurement and distribution to only use compliant radio equipment. They fulfil this obligation by ensuring that the correct certification is issued with the product.

For further information refer to the guidance to the application of the Radio Equipment Directive using the following link:

<https://ec.europa.eu/docsroom/documents/33162>

3.0 Functional safety

Functional safety relates to that aspect of risk reduction associated with the correct functioning of a control system. Factors that influence the functional safety performance of a control system include its ability to avoid, tolerate and detect faults, which is influenced by component reliability, system architecture, and avoidance of systematic errors.

Cranes and other lifting machines are within the scope of the Machinery Directive 2006/42/EC. The Machinery Directive includes specific “Essential Health and Safety Requirements” (EHSRs) that relate to functional safety, and several harmonised standards have been developed to provide methods for designing control systems so that the functional safety performance satisfies these requirements. A harmonised standard provides a method of satisfying particular “Essential Requirements” of a European Directive. Compliance with it grants a presumption of conformity with the essential requirements within its scope.

There are three levels of harmonised standards that apply to the Machinery Directive. Type A deal with basic safety of all types of machinery. Type B deal with particular safety aspects and safeguards. Type C are specific to particular types of machinery and are generally developed by tailoring the requirements of Type A and Type B standards to the particular machine. Functional safety is one aspect of a machine’s safety performance, and so the relevant harmonised standards are at the Type B level.

4.0 Similarities and differences with pendant controllers

A cableless controller has some similarities with a pendant controller. The commands are generated in the same way by using actuators such as buttons or joysticks on the operator station and the base station responds by switching a corresponding output to the various motions. The requirements for these common aspects are exactly the same. For example, the need for electrical and mechanical interlocks to prevent the ‘up’ and ‘down’ motions being energised simultaneously.

The big difference lies in the connection between the actuators and the outputs. Whereas conventional pendant controllers use simple hard-wired connections, the cable-less controller involves highly complex electronics. By its very nature, wireless communication is more open to interference and corruption. It is therefore imperative that cable-less controllers are designed and tested in accordance with a suitable methodology, such as that offered by the relevant standards.

To communicate a command by a cable-less control system requires the following:

- (1) operation of the actuator on the operator station
- (2) encoding of the actuator command
- (3) transmission of the encoded command
- (4) reception by base station of encoded command
- (5) de-coding the received command
- (6) switching the appropriate output

The cable-less controller must be designed so that for each of these actions there are sufficient checks to detect, and if necessary prevent, any corruption of the command. For example, the code for a particular command will be a digital string or ‘telegram’. It may suffer some corruption in transmission but, if it is sufficiently complex and sufficiently distinct from the other command codes, it can still be read and correctly interpreted. If the extent of corruption is such that it cannot be read, then the system must fail to safety. A higher level of integrity can be achieved if each command is transmitted by two independent signals and received by two independent receivers and de-coders and then compared.

5.0 Essential Health and Safety Requirements

The EHSRs of the Machinery Directive include, in section 1.2.1, requirements for control system safety and reliability, and its behaviour in the event of a failure.

The Machinery Directive also states that “For cable-less control, an automatic stop must be activated when correct control signals are not received, including loss of communication.”

These “functional safety” EHSRs are addressed by following three Type B harmonised standards:

- EN ISO 13849-1 - Safety of machinery – Safety-related parts of control systems – General principles for design

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

For additional information about these standards, refer to Annex 1.

6.0 Specific requirements for cable-less controllers

For lifting machines, specific requirements for cable-less controllers can be found in the following harmonised standards:

- EN 60204-32 Safety of machinery – Electrical equipment of machines – Part 32: Requirement for hoisting machines.
- EN 13557 Cranes – Control and control stations.
- EN 15011 Cranes – Bridge and Gantry cranes.

These standards have a wide scope, covering many type of cranes, hoists and winches. They set out requirements for the overall control systems and control stations of cranes, hoists and winches, and include specific requirements for their cable-less control aspects. Some of these requirements for cable-less control are referred to within Type C product standards for particular types of lifting equipment.

A cable-less controller that complies with relevant parts of these harmonised standards should, in those aspects covered by their scopes, support the machine's conformity with the Machinery Directive. So, when selecting a cable-less controller for use on a lifting machine, in addition to the CE marking, compliance with these harmonised standards is also relevant. If a cable-less controller does not comply with these harmonised standards, then conformity with the Machinery Directive cannot be presumed and additional work is required to demonstrate conformity.

7.0 Emergency stop devices

With few exceptions, the Machinery Directive requires machines to be equipped with one or more emergency stop devices that enable actual or impending danger to be averted. Relevant harmonised standards for the Machinery Directive, such as the EN 60204 series and EN ISO 13850 (Safety of machinery – Emergency stop – Principles for design) reflect this requirement.

EN 60204-32 requires a separate and clearly identifiable means of initiating an emergency stop function. It also refers to those situations when a stop function must be automatically initiated, such as when a fault has been detected or when no valid signal has been detected within a specified time.

Clause 9.2.7.3 of EN 60204-32 states;

'A cableless control system shall automatically initiate the stopping of the hoisting machine by de-energizing the crane-switch in the following situations:

- When a fault is detected in the cableless control system;
- When a valid signal has not been detected for a period of 0.5 s, except when a hoisting machine is executing a pre-programmed task taking it outside the range of the cableless control where no hazardous situation can occur. For those applications where 0.5 s is too short, this value may be extended up to a maximum of 2 s. the foreseen usage of the hoisting machine shall be evaluated to ensure that additional risks do not result from this extension of the time value. The de-energizing of the crane-switch may be delayed for a maximum of 5 min provided that the initiation of stopping is assured by monitoring the state of the control system.'

Annex C of EN 13557 contains specific requirements for the cable-less controller's stop function, stating that it is a safety-related part of the control system and, as such, shall be designed to category 3 and performance level = c, or higher (pl=d or pl=e). In effect this means using well-tries safety principles, that a single fault in any part shall not lead to the loss of the safety function and whenever reasonably practicable, single faults shall be detected at or before the next demand upon the safety function.

An emergency stop actuator on a pendant controlled lifting machine is a red button which, when pressed, latches in and de-energises the main contactor that supplies power for all motions of the lifting machine. It must be re-set before the pendant control becomes active again. Although the stop facility

on a cable-less control normally works in the same way, EN 60204:32 specifically prohibits this from being labelled or marked as an emergency stop.

This constraint is because the Machinery Directive requires emergency stop devices to be clearly identifiable, clearly visible and quickly accessible. Whilst these criteria would generally be satisfied from the perspective of an operator who is in possession of the control station, its portability may mean that this is not the case when other persons and situations are considered.

There are potentially several situations in which the stop facility would not be considered adequate in an emergency. For example, the control station may not be available to the person who needs to initiate an emergency stop if:

- (1) the operator drops it or leaves it unattended or;
- (2) the person, being someone other than the operator, is unable to locate it.

Clause 9.2.7 of EN 60204-32 requires you to address the hazards that arise when the operator control station is dropped and isn't immediately retrievable. In this situation, other means to stop the hoisting machine shall be provided within the working area of the operator.

When the control station has been installed on an overhead bridge or a gantry crane. This potentially hazardous situation can be avoided by following the provisions given in clause 5.3.5.3 of EN 15011.

'Devices shall also be provided in the following locations to stop the appropriate motions:

- On the crane structure at ground level on both sides or at each corner of a cabin-controlled gantry crane;
- In the machinery room;
- Any other location based on risk assessment.

Emergency stop devices located at control stations shall be of the palm or mushroom-headed push-button self-latching type complying with the provisions of EN 60947-5-5. The type of emergency stop devices for other locations shall be selected so as to achieve easy identification and access to them, and to avoid unintentional actuation.

Where the cable less control station is the only place of control on an overhead bridge crane, an emergency stop actuator in addition to the stop button on the cable less control is not required, provided all the following conditions apply:

- It is ensured that a lost cableless control station cannot send any run command;
- There are no operator access ways on the crane;
- The crane runway has no access facilities'.

In a situation where there are several machines operating in the same area, the lack of association between a cable-less control station and its associated machine could result in the wrong emergency stop being pressed, or the emergency stop on an inactive control station being pressed. In an emergency situation it is natural for someone to reach for the nearest emergency stop.

With a pendant controlled crane, the location of the pendant's emergency stop is always obvious and therefore meets the criteria of being clearly identifiable, clearly visible and quickly accessible. However, because an emergency stop device on a cable-less control station might not meet these criteria, it will be necessary to provide another emergency stop facility at an appropriate location.

For simple installations, this should not be a problem. An emergency stop button located in a prominent and accessible position can interrupt the power supply to the crane or hoist. The situation becomes more complex if the crane can travel a long distance, or if there are several cranes sharing the same down shop power feed system. In the former case, emergency stop buttons may be required at several locations to ensure that they are readily accessible. In the latter case, activating the emergency stop would stop all of the cranes. If there are several cranes each with independent power feed systems, it might also be difficult to identify which emergency stop applies to which crane. It is therefore not possible

to give general guidance on how best to provide the emergency stop facility as each installation will have to be individually risk assessed.

Many cable-less controls are configured to keep the main contactor energised for a certain period of time after each motion command. This is to avoid excessive operations of the main contactor, which will remain energised until:

- (1) the operator presses the stop button or;
- (2) no valid signal is being detected (e.g. due to loss or corruption) or;
- (3) a set time has elapsed since the last motion command.

Note 1: The appropriate time limit can be found in clause 9.2.7.3 of EN 60204-32 see above.

This configuration means that, until the main contactor is de-energised, a malfunction in the electronics of the cable-less controller could result in an unwanted motion command. So, if for some reason the control station is left unattended before the main contactor has de-energised, then the availability of a separate, clearly identifiable, clearly visible and quickly accessible hard-wired, emergency stop facility is highly appropriate.

8.0 Reducing dependency on a separate emergency stop

There are measures which can be taken to lessen the dependency upon a separate emergency stop. Some of these relate to features of the control station, whilst others relate to aspects of user management.

The controls for a lifting machine should be of the 'hold to run' type. Therefore, in the event of a malfunction, the first action for the operator is to release the control. If that is not effective, the second is to activate the emergency stop button.

The situations which can lead to the control station being unavailable can be addressed as follows:

Control features

- (1) The control station can be fitted with a neck strap to prevent it being dropped accidentally.
- (2) The control station can be fitted with an isolating key lock to prevent unauthorised use. This can be of the 'pull out' type which will automatically de-energise the main contactor. If the key is attached to the operator by a lanyard, this ensures the main contactor is always de-energised before the control station is left unattended. It also gives additional security if the control station is accidentally dropped.
- (3) The control station can have a separate 'hold to run' button which holds in the main contactor. This requires two-handed operation but will automatically de-energise the main contactor when the control station is left unattended. If fitted, this facility should have the same level of integrity as the emergency stop, i.e. a single fault shall not lead to loss of safety function and, whenever reasonably practicable, shall be detected at or before the next demand on the safety function.

User management

- (1) The user should ensure that the system is properly maintained, particularly the control station. Wear or damage to the seals around buttons or joysticks and damage to the casing enable dirt, water and other contaminants to enter which can cause false commands.
- (2) There should be a designated storage place for the control station when not in use.
- (3) Operators should be trained in good practice particularly:
 - (a) ensuring that the battery has adequate charge;
 - (b) use of the neck strap to prevent accidentally dropping the control station;
 - (c) use of the key lock and lanyard if provided;
 - (d) ensuring that the main contactor is always de-energised before leaving the control station unattended;
 - (e) ensuring that the control station is always returned to the designated storage place when not in use.

9.0 Installation on existing cranes and other safety issues

There are several other safety issues relevant to remote controls. In particular these relate to installing them on existing cranes, training and maintenance

Installation on existing cranes

(1) The whole machine should be risk assessed prior to installing a cable-less control system to ensure that the use of a cable-less controller will not impact on the safe use of the machine, or its electrical control system. There can be cases where the original control system has a built-in safety feature and fitting a cable-less control system in place of the pendant can disable this function, unless the remote system also has this feature available.

(2) Addendum wiring diagrams should be produced to ensure that a complete record of the electrical system on the lifting machine is held in the technical file. A copy of the wiring diagram should be available in the control panel of the machine.

(3) In accordance with appropriate standards, a warning beacon or sounder must be fitted to the lifting machine, indicating when the lifting machine is under cable-less control.

(4) Direction legends should be clear and unambiguous using a compass rose with corresponding legends, or coloured direction arrows on both the control station and the crane, gantry or runway. Simple white and black direction arrows on the control station are potentially dangerous in the event of an emergency.

Training

Training in the use of the system should be provided for all lifting machine operators including those who may already be trained in pendant control.

Maintenance

The control station should be disabled during any maintenance work, by the removal of the key, unless the maintenance engineer requires the use of it. In this case it should be kept under the engineer's control.

10.0 Conclusions

Clearly there are some significant issues to address when specifying, installing or using remote controls for cranes or hoists. However, by selecting a system with the necessary facilities and level of security, installing it in accordance with the harmonised standards to ensure an adequate level of functional safety, and applying best practice when operating and maintaining it, the full advantages of cable-less control can be obtained with few, if any, disadvantages.

Annex 1 – Additional information about the Type B harmonised standards

In terms of the stop function EN ISO 13849 ranks functional safety capability in terms of 5 “Performance Levels” (PLa - PLe), each of which corresponds to a range of probability of dangerous failure per hour and as a minimum requires at least Cat.3 pl=c.

EN 62061, which is the European approval of IEC 62061, is the machinery sector implementation of the IEC 61508 functional safety standard. As with its IEC 61508 parent standard, it also ranks functional safety capability in terms of a “Safety Integrity Levels” (SILs), which correspond to a range of probability of dangerous failure per hour. However, unlike IEC 61508, the scope of EN 62061 is restricted to the range SIL1 to SIL3, because the level of risk reduction associated with SIL 4 is beyond typical machinery applications.

It is recommended that, designers of safety related control systems of machinery should be apply either EN ISO 13849-1 or EN 62061. Regardless of which standard is applied, the methodology follows broadly similar stages. For example, the required safety functions must firstly be identified, and the amount of risk reduction that each is required to provide must be determined. The safety-related control system should then be designed in accordance with the integrity requirements of the safety functions that it implements.

A safety function can be considered as a function of a machine whose failure can result in an immediate increase in risk. For example, safety-related stopping or prevention of unexpected start-up of a machine are typical safety functions. As the consequences of a safety function failure can vary, such as across different applications, then so will the its required integrity. The degree of component reliability, system architecture, and avoidance of systematic errors associated with the safety-related control system will vary accordingly.