

Translation

Principles of testing and certification of wireless control equipment for machinery safety requirements
Status as of 2010-03

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These principles will be revised and supplemented periodically in consideration of knowledge gained in the area of occupational health and safety, as well as technical progress. The most recent edition shall always be binding for tests conducted by the testing and certification department of the committee for electrical engineering, with a transition period of 6 months.

Because of its adaptation to directive 2006/42/EC, however, this test principle is obligatory as of the date of issue.

Changes with respect to the previous document (2008-08):

- Editorial changes; specifications in Sections 3.1, 4.1.2.1, 4.1.3, 4.1.4.1, 4.1.6, 4.1.9, 5.1
- Change to the notes in Section 4.1.4.1
- Change to the frequency range (with limitations) in table 3 corresponding to new findings
- Evaluation criteria adapted for continuous and single shock tests
- Adaptation of Sections 4.1.8, 4.1.9, Annex 1 to current standards
- Adaptation of Section 4.1.9 and Annex 1 to the revised Section 9.2.7 „Wireless control“ from DIN EN 60204-32 (2009-03)
- Adaptation to directive 2006/42/EC in Section 4.1.2.1 Annex 4, specifications incorporated for contract preparation

Highlighted notes in italics following the requirements serve merely to indicate the source of information or reference.

This is the English translation of the German test principle. The German original version is obligatory.

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1 General

1.1 Scope

These principles of testing apply to wireless control equipment used for the transmission of safety-relevant commands on machinery corresponding to directive 2006/42/EC. They are not valid for use within the scope of directive 94/9/EC (ATEX).

Note: Wireless controlling devices may contain electromechanical and/or electronic and/or programmable electronic components for the provision of control commands.

2 Terms

2.1 Wireless control equipment

Wireless control equipment comprises devices for the transmission of control commands, e.g. through radio or optical radiation. The equipment is comprised of control units and receivers.

2.2 Control unit

Control units are devices that transmit signals to the receiver upon actuation of the command device.

The Control unit is comprised of:

- Command devices
- Casing
- Signal processor
- Transmitter
- Electrical supply

Note: A device can function simultaneously as a control unit and a receiver if bidirectional communication is provided for.

2.3 Receiver

Receivers are devices for receiving signals and converting these into commands.

The Receiver is comprised of:

- Receiving component
- Casing

- Signal processor
- Output interface
- Electrical supply

Note: A device can function simultaneously as a control unit and a receiver if bidirectional communication is provided for.

2.4 Output interface

That part of the wireless control equipment connected with the machine control, and which changes status when a command device on the control unit is properly actuated. This can take place, for example, via OSSD's or via a safe bus interface.

3 Documents and test objects for submission

3.1 Technical documents

The information for commissioning, connection and operation of the wireless control equipment must be provided in form of drawings, circuit diagrams, tables, descriptions and user information.

The following documents must be submitted in German language for the technical test:

- Instruction manual
- Functional description including block diagram
- Circuit diagram
- Specification of the safety requirements with designation of the SILCL and PFH_D according to DIN EN 62061 and/ or categories PL and MTTF_D according to DIN EN ISO 13849-1
- Connection diagram, which provides for the complete tracing of electric equipment circuitry, e.g. circuit board layout, wiring diagram, list of components
- Installation and connection instructions
- EC Declaration of Conformity (with reference to the relevant directives)
- Sales literature

The testing facility can request further documents if necessary.

3.2 Test objects

The testing facility can request further documents if necessary. As a rule, at least two unit prototypes must be made available.

4 Type test (basic requirements)

4.1 General test requirements

Wireless control equipment must satisfy all of the following requirements as well as the special requirements of Annex 1ff, as necessary. The test sequence must be chosen in such a manner that earlier tests do not influence the results of subsequent tests. In case of doubt, a separate test object should be used.

Fulfilment of farther reaching manufacturer specifications must be verified separately.

The evaluation criteria have been established according to Table 1 for a functional evaluation during and/or after the test. Further evaluation criteria are to be established for individual tests where expedient.

Evaluation criteria	Description
A	Wireless control equipment must still function as intended during and after its exposure to operational demands.
B	Wireless control equipment must still function as intended after being exposed to operational demands. A hazardous condition must not be induced during the test. Restart of the wireless control equipment may be achieved automatically or through an explicit release, depending on its use.
C	Wireless control equipment runs to the safe state and remains in the safe state during and after its exposure to operational demands. Restoration of intended operation takes place through user intervention. E.g. through setting/control elements, or mains OFF/ mains ON.

Table 1: Testing evaluation criteria

4.1.1 General test conditions

If not otherwise specified, the test object must function according to the manufacturer's technical operating data throughout the test under the ambient conditions set forth in Table 2.

Ambient condition	Range
Temperature	Room temperature 20 ±5 °C
Relative atmospheric humidity	25 % to 75 %
Air pressure	86 kPa to 106 kPa

Table 2: General ambient conditions

The fault-free functioning of the test object must be ascertained at the beginning of each test.

All measurements must be taken after the steady-state temperature has been reached. It can be assumed that this has been achieved when the increase or decrease in the test object temperature is less than 2 K/h.

4.1.2 User information

4.1.2.1 Instruction manual

A German version of the instruction manual for the devices must be supplied for the test to ensure proper connection, commissioning and operation.

The language version(s), for which the manufacturer assumes responsibility, shall be annotated „Original instruction manual“. Each additional translation shall be annotated „Translation of the original instruction manual“. (***Machinery Directive 2006/42/EC, Annex I***)

These must conform to the basic requirements for design and construction according to **Sections 6.5.2 and 6.5.3, DIN EN ISO 12100-2: 2004.**

The instruction manual shall contain at least:

- Intended proper usage and reasonably foreseeable faulty application thereof
- Manufacturer's name (trade name, mark of origin) and full address

- Type designation
- General description of the equipment
- Rated operating voltage specifying voltage type and frequency (if differing from 50 Hz)
- Specification of device power-/ current consumption
- Information regarding emitted radiation
- Designation of category, PL, SILCL and/or safety integrity regarding the standard used
- Description of control actuators and functions
- Specification of the delay time for the safety related output interface (e.g. contacts)
(DIN EN 13557)
- Specifications for parameterization, if necessary for address entry (e.g. in case of replacement), configuration or programming, insofar as required, and for qualification of the operative personnel
- Anticipated short-circuit or overcurrent protection devices, if applicable
- Specifications regarding ambient conditions
- Information regarding improper usage and operating conditions
- Information regarding weight, storage and transport conditions
- Information regarding device assembly, connection and commissioning
- Designation of protection class; stipulated separately as necessary for the various individual components
- Specification of the rated insulation voltage and degree of contamination
- Specification of the conventional thermal current (I_{the}) or (I_{th}), or of the summation current (normally only relevant for receiver units).

- Specification of the parameters for the wireless transmission system
- Information regarding the conductor type (rigid, multi-strand or fine-strand), the smallest and largest conductor cross-sections for which the connections are suitable and, if necessary, the number of simultaneously connectable conductors
- Information regarding the connection cables used (ambient conditions)
- Information regarding possible residual hazards
- Information regarding fault characteristics
- Information regarding differentiation between electrical circuitry for safety-related applications and electrical circuitry for reporting applications
- Designation of utilization category and rated operating currents for the rated operating voltages
- Information regarding cleaning, maintenance and, if applicable, repairs and required replacement parts
- Information regarding disposal
- The EC Declaration of Conformity or a document reflecting the EC Declaration of Conformity
- **Warning:** When wireless control equipment is put into service, it must be warranted that it does not interfere with other local systems or that these systems do not interfere with it. (*DIN EN 13557*)
- **Warning regarding the integration of an emergency-stop command device into the wireless control equipment controller:** If the wireless control equipment with an integrated emergency-stop command device is out of service, it must be ensured that potential confusion between operative and non-operative emergency-stop devices is prevented. (*DIN EN 13850, Section 4.1.1*)

- **Additional information regarding charging equipment:**

Relevant specifications according to Section 7.12, DIN EN 60335-2-29: 2005, including reference to Section 7.12 (inscriptions and instructions; instruction manual) in DIN EN 60335-1: 2007.

- **Additional warnings regarding the use of storage batteries:**

- * Storage batteries should be recharged only with charging units recommended or provided by the manufacturer.
- * Unused storage batteries should be kept away from paperclips, coins, keys, nails, screws or other small metal objects, which may cause bridging of the contacts.
- * Use only those storage batteries prescribed for the devices (battery technology and type)
- Improper usage may result in liquid leakage from the battery. Avoid physical contact. Rinse with water in the event of inadvertent contact and seek medical assistance if the liquid gets into the eyes. (*DIN VDE 0740-1*)

Additional information regarding radio systems (with application of R&TTE-RL 1999/5/EC):

Information regarding the member state or the geographic area of a member state, in which usage the device is intended.

Test: Review of the technical documents submitted; check for completeness, correctness and consistency.

4.1.2.2 Sales literature

If sales literature is available for the wireless controlling device, it must not be in contradiction to the instruction manual.

The sales literature shall not supplant the instruction manual in whole or in part.

(Machinery Directive 2006/42/EC, Annex I)

Test: Review of the sales literature submitted; check for completeness, correctness and consistency.

4.1.3 Labelling and markings

All labels and markings must be clear with obvious formulation. A control unit must be marked in such a manner that its allocation to the controller operated unit is recognizable.

A type plate must be present on the control unit containing at least the following information:

- Company name
 - Designation of the safety component (e.g. radio control system; transmitter)
 - Type designation or production series
 - Serial number, as appropriate
 - Year of manufacture
 - CE-marking
 - Rated voltage, current type *
 - Operating current *
 - For equipment with Protection class II: graphic symbols according to IEC 60417, graphic symbol No.: 5172 *
 - Transmission frequency/range
- * Only for mains-operated controlling devices

A type plate must be present on the receiver containing at least the following information:

- Company name and full address of the manufacturer and representatives, accordingly
- Designation of the safety component (e.g. radio control system; receiver)
- Type designation or production series
- Serial number, as appropriate
- Year of manufacture
- CE-marking
- Rated voltage, current type, number of phases and frequency, as necessary
- Operating current
- Receiver frequency/range
- For equipment with Protection class II: graphic symbols according to IEC 60417, graphic symbol No.: 5172 *

For charging units:

Relevant equipment specifications according to Section 7.12, DIN EN 60335-2-29: 2005, including reference to Section 7.12 (inscriptions and instructions; instruction manual) in DIN EN 60335-1: 2007

For storage batteries:

Nominal voltage

Markings and address of the manufacturer

Type designation

For radio systems with application of R&TTE-RL 1999/5/EC:

If necessary, device classification labelling as well as identification number of the notified body, if applicable, according to directive 1999/5/EC (R&TTE)

On the packaging: Information regarding the member state or the geographic area of a member state, in which usage the device is intended.

Electric/electronic equipment shall additionally contain the following information:

Every connection must be clearly and distinctly identifiable with suitable markings affixed on it or in its immediate vicinity.

For circuit protectors, the nominal current and protection device tripping characteristics must be specified next to the protection device bracket.

Each protective conductor connection point must be marked as such using the symbol corresponding to IEC 60417, graphic symbol No. 5019.

Test: Visual inspection.

4.1.3.1 Size of graphic symbols, lettering and digits

The size of graphic symbols, lettering and digits must be at least 2 mm.

Test: Visual inspection /measurement of inscriptions or type plate.

4.1.3.2 Durability

Inscriptions must be durable.

Test: Gently rub using two cotton cloths, one soaked in water and the other in benzene, for 15 s each. The markings must remain clearly legible, while the marking label must remain firmly affixed to the unit.

Benzene with properties according to DIN EN 60950-1: 2006, Section 1.7.11

4.1.4 Requirements for external construction

4.1.4.1 Control actuators and display elements

Push-buttons, display lights and displays must conform to the requirements of Sections 10.2 to 10.6, the emergency-stop device (if available) must conform to the requirements of Section 10.7, DIN EN 60204-1: 2007.

The emergency-stop device control actuator (if available) should be preferably designed as a palm- or mushroom-shaped push-button.

Switching of the control unit ON must be displayed on the device and must not introduce hazardous movements with regard to control actuators that have already been activated. (*DIN EN 13557; DIN EN 60204-32*)

Each control unit must have the capability of recognizing the machinery assigned to it. (*DIN EN 60204*)

Assigned movements and functions must be obvious with relation to the markings on the control actuator.

Machine movement-related control actuators must automatically return to their initial setting when released.

Control actuators must be designed or protected in such a manner that, if exposed to a potential hazard, its intended effect can only be achieved through deliberate actuation. (*Machinery Directive, Section 1.2.2*)

Test: Visual inspection; functional test.

Tip test: The wireless control equipment is in an operationally ready state. The control unit shall be tipped onto the control actuator surface three times from each possible position.

During the tip test, a signal change must not occur on the receiver.

Note: A change in the emergency-stop signal in a safe direction is acceptable.

In order to prevent unintentional machinery movement following a functional interruption or subsequent to resetting an emergency-stop command device, movement must be initiated only upon renewed command input. **(C.2.4, 5.1.6, DIN EN 13557)**

Test: Each control actuator is taken out of the neutral position in-turn and held in this position. The radio link is interrupted.

Movement must not be initiated upon restoration of the radio link. This must be possible only upon renewed command input from the neutral position (meaning the receiver should have received at least one data telegram without a work command). The same applies with a power interruption to a control unit or receiver, as well when resetting an emergency-stop command device.

4.1.4.1.1 External materials and properties

No materials containing substances harmful to health may be used on any part of the control unit that comes in regular contact with the operator's skin.
(Machinery Directive 2006/42/EC, Annex I)

Test: Review of the safety data sheets for the materials used.

Use the procedure according to ZEK 01.2-08 to check the amount of polycyclic aromatic hydrocarbon (PAH).

Unit components accessible by hand must have no sharp corners or edges, or abrasive surfaces that can lead to injuries. **(Machinery Directive 2006/42/EC, Annex I)**

Test: Handling and visual inspection.

4.1.4.1.2 Ergonomics

Actuation forces required for control actuators must not exceed the following values:

Control lever:

- Forwards and backwards: between 5N and 60 N. If finger-actuation is foreseen for the control lever, the actuating force shall not exceed 20 N. The actuating force may increase to 60 N if the control lever is to be clasped or moved solely by hand.
- Sideways to the left or right: between 5N and 20N. A maximum actuating force of 40N is acceptable for control levers on control stations exposed to considerable acceleration forces.

Push-buttons, except for buttons used for shutdown in case of emergency and push-buttons used to directly switch on power:

- 10 N for finger- or thumb-actuation
- 10N for holding force on „ON“-position with stepped switching push-buttons (*DIN EN 13557*)

Test: Measurement of actuation forces takes place within the temperature range prescribed by the manufacturer. Testing should take place after 2 hours storage of the control unit at the highest or lowest temperature within the temperature range prescribed by the manufacturer. This temperature range must be at least between 0°C and +40°C. Following the respective storage period, actuating forces are measured on each control actuator using a force measuring device.

Measurement of each control actuator must take place within 1 minute after its removal from the climatic exposure test cabinet and shall replicate regular actuation with respect to direction and point of application. The test object must be stored at the appropriate temperature for at least 15 minutes between any follow-on measurements. Measured actuation forces must not exceed the prescribed limit forces.

Exposure of operating personnel to disturbance, fatigue and harmful physical stress during intended usage must be reduced to the lowest possible level in consideration of ergonomic principles.

Criteria:

- Ergonomic handheld component contour of the wireless control equipment
- Avoidance of edges, corners and rough surfaces
- The lengthy carrying of a control unit must not fatigue operating personnel. A handle should be provided for carrying control units weighing more than 500g.
- The control unit being carried must not exceed a maximum weight of 3 kg in connection with the carrying aid.
- Safe control actuator operation, with one hand per actuator, must be warranted without having to set down the mobile control unit. Where necessary, the use of gloves should be taken into consideration.

The control unit must be designed in such a manner that an unintentional change in position when being set down is not possible.

Test: Handling; weight measurement.

4.1.4.1.3 Measures against unauthorised use

Measures must be foreseen for the wireless control equipment's control unit to prevent the unauthorized execution of dangerous movements.

Test: Visual inspection, check of effectiveness.

4.1.5 Environmental requirements

Wireless control equipment must possess sufficient resistance against environmental influences.

This should be verified using the tests described below.

Furthermore, the following criteria must be fulfilled after the individual tests according to Sections 4.1.5.1 and 4.1.5.2:

1. It must not be possible to physically touch active components.
2. The effectiveness of insulated lining and separators must not be impaired.
3. The test object must be provided a degree of protection against the infiltration of dust, solid foreign objects and water corresponding to user information specifications.

Test: Visual inspection.

4.1.5.1 Mechanical strength

Wireless control equipment must possess sufficient mechanical strength with respect to expected operational demands when used as intended, such as jolting, shock or impact.

Test in accordance with Sections 4.1.5.1.1 - 4.1.5.1.4.

Component test		Notes
I. Continuous vibration: Test standard Frequency range Amplitude Frequency cycle count Tuning speed	DIN EN 60068-2-6 10-150 Hz \pm 1 Hz 0.35 mm/5 g \pm 15% at the control point 20 1 octave/min	If the receiver manufacturer dictates that it is to be deployed only at those locations where there is no direct exposure to machine vibration, then the upper frequency of 55 Hz applies.
II. Individual shock: Test standard Type of shock Shock amplitude Shock duration Number of shocks	DIN EN 60068-2-27 Half-sine wave 30 g 11 ms 3 per axis	in all 6 directions
III. Continuous shock: Test standard Shock form Shock amplitude Shock duration Shock sequence Number of shocks	DIN EN 60068-2-27 Half-sine wave 10 g 16 ms (1-3)/s 1000 \pm 10	In all 6 directions

Table 3: Minimum requirements for vibration and shock loading

4.1.5.1.1 Resistance to shock

This requirement applies to both wireless control equipment receivers as well as control units.

The position considered to be the most critical point is exposed to three blows at 0.7 J (Nm) using an impact test device according to DIN EN 60068-2-75:1998, Section 5. Particular attention must be afforded the insulating material covering active components.

Test: In accordance with DIN EN 60068-2-75; Ehb test; with spring hammer, performed after 2 hours of storage at the manufacturer's specified minimum application temperature. Shock test within 1 min. after being taken out of the climatic exposure test cabinet.

The criteria according to Section 4.1.5 must have been complied with upon completion of the test.

4.1.5.1.2 Resistance to vibration

The receiver and the control unit are to be exposed to mechanical vibrations according to Table 3, I while in operationally-ready states in their potential mounted or deployed positions.

Wireless control equipment must fulfil evaluation criteria A according to Table 1 during the test. Control actuators are not activated during the test. After each test in the corresponding position, evaluation criteria A must be fulfilled with activation of all control actuators according to Table 1.

If an emergency-stop command device is available, the entire test must also be performed according to table 3, I with the emergency-stop command device actuated.

During the test, a change in the emergency-stop command device switching status is not permitted. Evaluation criteria A for the emergency-stop function must be fulfilled upon completion of each test in the corresponding position.

Additionally, all criteria according to Section 4.1.5 must be complied with.

4.1.5.1.3 Resistance to impact

Continuous shocks/ individual shocks:

The receiver and the control unit are to be exposed to individual shocks in accordance with the parameters of Table 3, II.

The receiver and the control unit are to be exposed to continuous shocks in accordance with the parameters of Table 3, III while in operationally-ready state.

The control actuators must not be activated during the respective tests.

During and after each individual or continuous shock test in the corresponding position, the receiver must fulfil evaluation criteria B according to Table 1.

During each individual or continuous shock test in the corresponding position, the control unit must at least fulfil evaluation criteria C according to Table 1.

All control actuators must still function properly following application of the respective load.

If an emergency-stop command device is available, the entire test must be carried out according to Table 3, II or III, with the emergency-stop command device actuated.

During the test, a change in the emergency-stop command device switching status is not permitted. Evaluation criteria A for the emergency-stop function must have been fulfilled by the end of each test in the corresponding position.

The criteria according to Section 4.1.5 must have been complied with upon completion of the test.

4.1.5.1.4 Resistance to dropping

The test shall be carried out on mobile control units in accordance to the provisions of DIN EN 60068-2-31, procedure 1 – Free-falling, from a drop height of 1000 mm.

Two drop tests are to be carried out from each usable position.

Test: According to DIN EN 60068-2-31; procedure 1, Free-falling.

The device is active during the test.

During and after the test, the wireless control equipment must have fulfilled at least criteria C according to Table 1. Additionally, the criteria according to Section 4.1.5 must be complied with.

4.1.5.2 Climatic conditions

Wireless control equipment (control unit/ receiver) must function properly within the operating temperature range as prescribed by the manufacturer.

The minimum operating temperature range must be at least between 0 °C to +40 °C.

Test: The following test sequences must be carried out within the temperature range prescribed by the manufacturer. In so doing, the prescribed temperature range must possess at least the reference values as prescribed for the minimum operating temperature range indicated above.

Wireless control equipment must be subjected to the following test sequences:

- a) For operation of wireless control equipment under the conditions established in 4.1.1, an A-Test* must be carried out for a duration of at least 1h. A B-Test* must be subsequently carried out.
- b) The ambient temperature must be increased to the highest ambient temperature at a maximum rate of 0.6 °C/min. An A-Test* must be carried out during this period.

- c) An A-Test* must be carried out at highest ambient temperature for a duration of at least 1h. The relative humidity must be increased to 95% during this period and maintained at this value for at least for 0.5h. A B-Test* must be carried out subsequent to the A-Test*.
- d) The ambient temperature must be reduced at a maximum rate of 0.6°C/min until a temperature of 20°C has been reached. In so doing, a relative humidity of 95% should be maintained. An A-Test* must be carried out during this period.
- e) The ambient temperature must be reduced at a maximum rate of 0.6°C/min, without condensation occurring, until the lowest ambient temperature has been reached. An A-Test* must be carried out during this period
- f) An A-Test* must be carried out at lowest ambient temperature for a duration of at least 1h. A B-Test* must be subsequently carried out.
- g) The ambient temperature must be increased at a maximum rate of 0.6°C/min to the value established in 4.1.1. An A-Test* must be carried out during this period.
- h) An A-Test* must be carried at the temperature established in 4.1.1 for a duration of at least 1h. A B-Test* must be subsequently carried out.

In addition to the A- and B-Tests*, the criteria according to Section 4.1.5 must be complied with.

* A-Test: the wireless controller remains in an operationally ready state without command input.

* B-Test: proper output of all potential commands at the receiver with manual introduction at the control unit.

4.1.6 Protection class

Wireless control equipment (control unit / receiver), when installed and ready for operation, must be consistent with Protection class IP 54 (casing category 1; DIN EN 60529: 2000, Section 13.4).

A higher protection class may be necessary, depending on the respective particular range of applications.

Different protection classes may apply due to differing placement of the control unit and receiver. If the equipment is designated for subsequent casing installation (e.g. control cabinet or control panel), the equipment must at least fulfil Protection class IP 2X.

Test: Protection class test according to DIN EN 60529. The test must be conducted in an operationally ready state (meaning storage batteries or attachable accessories must be connected. Casings and battery compartment covers must be closed).

Subsequent to the respective individual test, the wireless control equipment must work as intended and the prescribed evaluation criteria must be fulfilled according to DIN EN 60529 consistent with the specific protection class.

4.1.7 Requirements concerning electric/ electronic equipment

4.1.7.1 Supply voltage

Wireless control equipment must operate fault-free according to the requirements of Section 4.3, DIN EN 60204-1: 2007.

Test: According to Section 4.3, DIN EN 60204-1: 2007.

Wireless control equipment must fulfil evaluation criteria A in Table 1 both during and subsequent to the test.

The power supply to the control unit must be capable of being removed or separated by hand (without the aid of tools). (**9.2.7.1, DIN EN 60204-1**)

Test: Visual inspection, functional test.

4.1.7.2 Thermal load capacity of insulating materials

Insulating materials must be sufficiently resistant to heat and fire.

Test: DIN EN 60695-2-11 shall apply.

Insulating materials used on the receiver (affix current-conducting components of the casing and elements in position) must be tested at a heat-filament temperature of 850 °C.

Insulating materials used on the control unit (affix current-conducting components of the casing and elements in position) must be tested at a heat-filament temperature of 650 °C.

Unsupervised operation is prescribed for the receiver. Supervised operation and a power supply through the use of batteries/ storage batteries are prescribed for the control unit. If appropriate protective measures are integrated for the batteries/ storage batteries, the heat-filament temperature can be reduced to 550 °C.

4.1.7.3 Air gaps and creepage distances

Air gaps and creepage distances are to be determined according to DIN EN 50178. For devices connected with the mains, overvoltage category III and contamination level 2 apply.

Test: Measurement of air gaps and creepage distances.

4.1.7.4 Verification of adherence to excess temperature limits

Wireless control equipment must conform to the requirements related to the heating of unit parts according to Section 7.2.2, DIN EN 60947-1: 2008 (with Tables 2 and 3).

Test: A heating test is to be carried out in accordance with Section 8.3.3.3, DIN EN 60947-1: 2008. Specification of the conventional thermal current or of the maximum summation current must be considered.

For analysis of temperature increase, the upper ambient temperature of the wireless control equipment corresponding to manufacturer specifications in the user manual, however at least 40 °C, shall apply as a basis.

If a heating test is carried out at room temperature, the temperature increase ascertained must be increased by the amount of the temperature difference between upper ambient temperature (manufacturer's specifications) and room temperature.

4.1.7.5 Protection against electric shock

Wireless control equipment must provide for the protection of persons against electric shock, including measures according to Section 6.2 (Protection against direct physical contact), 6.3 (Protection for indirect physical contact) or 6.4 (Protection through PELV), DIN EN 60204-1: 2007:

- against direct physical contact
- with indirect physical contact

Test: Review of the technical documents and comparison with the prototype or, as necessary, measurement of inlet openings and clearances to voltage hazardous to physical contact, residual voltage.

4.1.7.6 Over-current protection

Wireless control equipment must possess suitable elements for the protection of the electric equipment against over-current according to Section 7.2, DIN EN 60204-1: 2007.

Test: Review of the technical documents and comparison with the prototype.

4.1.7.7 Dielectric strength

Mains powered control units and receivers must be stored according to DIN EN 60068-2-78 at a moist heat level ($T = 40^{\circ}\text{C} \pm 2^{\circ}\text{C}$; rel.Hu. = $93\% \pm 3\%$) for 96 hours. Subsequent to load application, the insulation must fulfil dielectric strength requirements in accordance with DIN EN 50178.

Test: Carry out a voltage test according to Section 9.4.5.2, DIN EN 50178: 1998 (insulation test with AC- or DC-voltage).

4.1.7.8 Insulation resistance

Insulation resistance between the main circuit conductors and the protective conductor system must be sufficiently high for mains powered control units and receivers.

Test: Test at a DC-voltage of 500 V. Insulation resistance must not be less than 1 MOhm.

4.1.7.9 Making- and breaking capacity

The requirements of Section 7.2.4 of DIN EN 60947-5-1: 2005 (switch ON and switch OFF for common or uncommon load conditions) must be complied with by the receiver output circuit elements.

Test: Testing is carried out according to Section 8.3.3.5 of DIN EN 60947-5-1: 2005 (making- and breaking capacity). Subsequent to each test, an evaluation and a voltage test are to be performed according to Section 8.3.3.5.5 of DIN EN 60947-5-1: 2005.

4.1.7.10 Conductors, cables and lines

Conductors, cables and lines must conform to the requirements of Sections 12.1-12.6.2, DIN EN 60204-1: 2007.

Test: Inspection of the prototype and, as necessary, comparison with component data-sheets; temperature measurement.

The wiring of electrical equipment must be carried out according to the requirements of Section 13, DIN EN 60204-1: 2007.

The electric connections of electronic components must be accomplished according to Section 7.1.10, DIN EN 50178.

Removable plug connections are to be coded in such a manner that the risk of swapping lines is excluded, insofar as the swap creates a hazard for operating materials or persons. If a protective earth conductor connection is required, it must not be removed before any active conductors have been interrupted and the active conductors must not be connected prior to the protective earth conductor. **(7.1.9, DIN EN 50178)**

The interior component and assembly wiring must be designed in such a manner that neither mechanical influence nor breakage, slackening or loosening of a conductor will lead to a reduction in the effectiveness of the insulation for providing safe isolation to the point that it no longer fulfils the requirements of the basic insulation. **(5.2.18.6, DIN EN 50178)**

Test: Visual inspection of wiring and connections.

If, for functional reasons, a protective ground or potential equalization system is built into parts of the wireless control equipment, the requirements of Section 8.2 or 8.3, DIN EN 60204-1: 2007, must be fulfilled.

Test: Visual inspection of the model and a check of the protective ground system continuous connection according to Section 18.2, DIN EN 60204-1: 2007.

4.1.7.11 Suitability of structural elements/components used

Electrical/ electronic components and operating materials must be suitable for their intended application and correspond to applicable standards, if these exist.

Note: Charging devices according to DIN EN 60950-1 may not be suitable for industrial use.

Test: Check of the corresponding data sheets or calculate, as necessary.

4.1.7.12 Short-circuit currents

The receiver of the wireless control equipment must withstand the loads caused by short circuits at the OSSD's.

Test: Testing is carried out according to Section 8.3.4 or, when a semiconductor output switching element is used, in accordance with Section H 8.6 of DIN EN 60947-5-1: 2005.

4.1.7.13 Installation of structural elements

Printed circuit board material is to be made of glass fibre reinforced epoxy resin or an equivalent material. Appropriate corrosion protection must be available.

Connections should be secured to prevent unintentional loosening.

Electrical connection terminals and junctions must be designed in such a manner that the expected reliability during the life span of the electronic equipment is maintained. The expected conditions normally encountered during operation, such as corrosion, shock, heating and seepage of the operating substances must be considered.
(DIN EN 50178)

Test: Visual inspection (consideration given to Section A 7.1.8, DIN EN 50178: 1998, Requirements for electrical connections) and fulfilment of the tests according to Section 4.1.5 of the Principles of Testing.

4.1.7.14 Actions in the event of failure

A check should be made to determine whether the category and PL, as prescribed in the user manual, correspond to the requirements of DIN EN ISO 13849-1 or whether the SILCL and PFH_D, as prescribed, correspond to DIN EN 62061.

Test: Validation according to DIN EN ISO 13849-2 or DIN EN 62061.

4.1.7.15 Additional requirements for semiconductor output circuit elements

Semiconductor output circuit elements must fulfil the requirements of Annex H, DIN EN 60947-5-1: 2005.

Test: According to Section H8, DIN EN 60947-5-1:2005.

4.1.7.16 Response time of safety related commands

Normal operation:

In fault-free condition, all safety-related information must be issued by the receiver within the time specified by the manufacturer following a corresponding command input to the control unit.

In case of failure:

In case of failure (e.g.: component defect or transmission line disturbance) all safety-related information must be issued by the receiver within the time specified by the manufacturer following a corresponding command initiated at the control unit.

Test: Measurement of the response time as set forth by the manufacturer.

4.1.7.17 Charging devices for storage batteries

In battery operated control units, built in and external charging devices must correspond to DIN EN 60335-2-29.

Air gaps and creepage distances are to be measured according to overvoltage category II and contamination level 2.

Test: Carry out the applicable test according to DIN EN 60335-2-29.

4.1.8 EMC and radio transmission requirements

Wireless control equipment must satisfy the requirements for electromagnetic compatibility according to Section 7.3, DIN EN 60947-1: 2008, Environment A, as well as the requirements of DIN EN 61326-3-1: 2008 for safety-relevant electronic equipment.

Wireless control equipment must additionally fulfil the requirements of directive 1999/5/EC (R&TTE).

Test: In accordance with Section 8.4, DIN EN 60947-1: 2008 and, if applicable, in accordance with DIN EN 61326-3-1: 2008.

Verification by the manufacturer or, if necessary to comply with the R&TTE-directive, a designated body related to the fulfilment of directive 1999/5/EC (R&TTE). Additional tests of EMC in accordance with EN 300 220-2 or EN 301 489 *

** Selection of the respective relevant standard must be considered.*

4.1.9 Functional aspects

4.1.9.1 General requirements

Changes to transmission parameters by unauthorized persons must be prevented by suitable measures.

Modification of the operating voltage beyond the admissible tolerance range must not cause a hazardous situation. If one or more potentially hazardous movements are to be carried out using the control unit, a visual or audible warning signal must be issued if the operating voltage exceeds or falls short of the admissible tolerance range. Under these circumstances, the control unit must remain functional for at least 30 s so the operator is able to properly shutdown the machine. **(DIN EN 60204-1)**

If the transmitter battery voltage drops to such a low level that reliable transmission is no longer warranted, the transmitter must initiate a category 0 or 1 shutdown and issue no further data telegram until the transmitter is switched ON once again. **(Section 9.2.7.6, DIN EN 60204-32; BGR 149)**

With multiple control units controlling the same machinery in the wireless control equipment, measures must be taken to ensure release of only one control unit at a time. A display of which control unit is controlling the machinery must be provided at an appropriate location as identified by risk assessment.

Exception: An operative command for initiating shutdown must be possible from each control unit if this measure is identified by the machinery risk assessment.
(DIN EN 13557, DIN EN 60204-1 and -32)

In those locations where multiple control units in the wireless control equipment are used to operate at the same machinery, provisions must be made to allow for the control command to be transferred from one control unit to another. Activation of the second control unit for the purpose of transferring the control command must be possible only after transmission of a command for movement stoppage and shutdown of the active control unit. **(C.5.1, DIN EN 13557; DIN EN 60204-32)**

Means must be provided for operating multiple pairs of control units/ receivers within range of a control unit without resulting in an unintentional influence between them. The equipment must be protected against accidental or unintentional transfers (mix-up).
(C.5.2, C.5.3, DIN EN 13557; DIN EN 60204-32)

Suitable measures must be provided to protect against externally induced changes to the standardized data transmission process.

Each receiver must convert only those signals into control commands, which have been transmitted from its dedicated control unit based on address allocation. **(BGR 149, DIN EN 60204-1 and -32)**

The allocation of address characteristics must be monitored and administered by the manufacturer. **(BGR 149)**

In certain cases, the manufacturer can allocate address contingents. Acceptance of addresses other than the contingents must be blocked by the equipment. The distinct assignment of transmitter to receiver must be warranted through an allocation process (e.g. pairing). The respective address contingent must apply to only specific wireless control equipment. Address input must be protected by suitable means (e.g. assignment of a password during initialization or equivalent measures) and must be undertaken only by qualified personnel.

Data frames must be transmitted repeatedly during operation.

The receiver must transmit an output control signal only when it has correctly received data frames with the proper address and the respective command. **(DIN EN 13557, DIN EN 60204-1 and -32)**

If an error occurs in the control unit, which changes the address characteristics, it must not be possible to establish a new valid address. **(BGR 149)**

During signal transmission, the receiver shall check to determine if the delay between two valid messages exceeds a prescribed value. If this is the case, failure of the safety-related transmission should be assumed. In such a case, the OSSD's must take over the safety-related status (Time-out).

Test: Functional analysis; measurement of reaction times; review of instruction manual.

If the equipment for control unit localization is available, the manufacturer's specifications must be checked with regard to localization equipment measurement uncertainty. **(DIN EN 60204-1, Section. 9.2.7.2, last sentence)**

Test: Review of the manufacturer's specifications through functional analysis or functional test dependent upon the functioning principle.

The transmission system must have the provision for ensuring the transmission of safety-related messages according to the security level stipulated for the system (see GS-ET-26 (05.2002), Section 3).

Test: Assessment of the data transfer residual error probability and residual error rate according to the methods described in GS-ET-26 (05.2002). Other methods can be used if they are comparable and at least equivalent in quality.

4.1.9.2 Shutdown/Shutdown in case of emergency

The command for shutdown must have priority over the command for start-up of the machinery **(Annex I, 2006/42/EC)**. Function reset for shutdown must not introduce a hazardous situation.

A separate and clearly identifiable device must be available on each control unit, capable of issuing an immediate command to initiate one of the stop-functions for any potentially hazardous situation according to Section 9.2.5.3, DIN EN 60204-1: 2007 (pursuant the risk assessment).

Equipment for execution of an emergency-stop command may be available (see Section 4.1.1; DIN EN ISO 13850: 2008). If this is the case, the requirements of Section 9.2.5.4.1 and 9.2.5.4.2; DIN EN 60204-1: 2007 must be fulfilled.

Explanation of emergency-stop approval in wireless control equipment:

Contrary to the current provision in DIN EN 60204-1 and -32 that an emergency-stop function for wireless control equipment is not admissible, Section 4.1.1, DIN EN ISO 13850: 2008 should be called upon for evaluation regarding approval of the emergency-stop device during potential isolation.

According to present information, DIN EN 60204-1 should be supplemented to account for emergency-stop approval in wireless control equipment. (DIN EN ISO 13850, DIN EN ISO 10218-1)

Test: Functional analysis; measurement of reaction times.

4.1.10 Radiated emission

Undesirable radiated emissions (e.g. artificial optical and electromagnetic radiation) from wireless control equipment must be excluded or reduced to a level that adverse effects for humans do not exist.

Test: Review of the technical documentation or, as necessary, measurement of radiation intensity.

5 Component testing at manufacturer facilities

Tests 5.1 to 5.2 below must be carried out by the manufacturer on each completely assembled wireless control unit.

Test: Review of the test instructions, etc.

5.1 Functional test:

All safety-related functions are to be tested for proper functioning through manual actuation of the corresponding operating component. Test results must be documented. Alternative measures for manual actuation are permitted if it can be guaranteed that an improper function related to the corresponding operating component can be identified.

5.2 Test of the protective conductor current path:

Insofar as relevant, the following test related to protective conductor system consistency should be carried out on both the control unit as well as on the receiver of each wireless control unit.

The resistance of each protective conductor system must be measured between the PE-clamps and relevant points, which are part of each protective conductor system, with a current between at least 0.2 A and approx. 10 A. This current should be taken from an electrically isolated supply with a maximum open circuit voltage of AC 24 V or DC 24 V. It is recommended to not use a PELV-supply, as this type of supply can cause misleading results. The measured resistance must be within a range corresponding to the length, cross-section and material of the respective protective conductor(s). The results must be documented.

Annex 1 Special safety requirements for wireless control equipment on cranes

In addition to the relevant basic requirements of these testing principles, the following describes necessary divergences or additional requirements and tests for this area of application.

4.1.4.1.3 Measures against unauthorised use

In addition, the control unit must not transmit as long as the means for preventing unauthorized use are activated. (**Section 9.2.7, DIN EN 60204-32**)

4.1.5.1.2 Resistance to vibration

The following requirements must be fulfilled in addition to the basic requirements:

The receiver must not be susceptible to broadband noise.

Test: Test Fh from DIN EN 60068-2-64 must be carried out on the receiver.
(**Section C7, DIN EN 13557**)

Prior to testing, a visual examination and functional test with regard to proper condition must be carried out.

The wireless control equipment is in an operationally ready state.

The test shall be carried out with the testing severity according to DIN EN 60068-2-64 using following parameters:

The receiver is to be attached according to manufacturer's specifications.

Load application according to:

No inspection of the vibration response and no monitoring of the lateral motion.

Single-point control

Test frequency range: 5 - 100 Hz

Acceleration spectral density: 1 (m/s²)²/Hz (also equates to 1 m²/s³)

Type of acceleration spectrum:

Straight, horizontal course of the acceleration spectral density

Duration of load: 30 min +/-5% in all three axes

Wireless control equipment must fulfil assessment criterion A according to Table 1 throughout the test. Control actuators will not be activated during the test. Following each test in the corresponding position, assessment criterion A according to Table 1 must have been fulfilled with activation of each control actuator.

Additionally, the criteria according to Section 4.1.5 must be complied with.

4.1.6.11 Suitability of components used

The following requirements must be fulfilled in addition to the basic requirements:

- Section 4.2.2, DIN EN 60204-32 (selection of the power contactors)

4.1.9 Functional aspects

4.1.9.1 General requirements

The following requirements must be fulfilled in addition to the basic requirements:

- Section C.2.3, DIN EN 13557 (operation of the crane switch); also see Section 9.2.7.2, DIN EN 60204-32
- Section C.2.5, DIN EN 13557 (requirements for current-free crane switches); also see Section 9.2.7.2, DIN EN 60204-32
- Section C.4.2, DIN EN 13557 (transmission reliability); also see Section 9.2.7.4, DIN EN 60204-32
- Section C.6, DIN EN 13557 (requirements for a control unit with declining voltage in the area of cranes)

Wireless control equipment must initiate the automatic de-energising of the crane switch if a defect is discovered in the wireless control equipment. (**Section 9.2.7.3, DIN EN 60204-32**)

4.1.9.2 Shutdown/Shutdown in case of emergency

The following requirements must be fulfilled in addition to the basic requirements:

- Control category of the shutdown function in wireless control equipment for crane controls: at least PL c and category 3, according to DIN EN ISO 13849-1; also see Section 9.2.7.3, DIN EN 60204-32: 2009 and Section C.3.1, DIN EN 13557: 2009 and Section 5.2.5, DIN EN 14492-2:2007
- Section C.3.2, DIN EN 13557: 2009 (Run-down time for crane movement with invalid data frames); also see Section 9.2.7.3, DIN EN 60204-32: 2009
- Section C.3.3, DIN EN 13557: 2009 (Crane switch OFF following the shutdown function); also see Section 9.2.7.3, DIN EN 60204-32: 2009
- Section C.3.4, DIN EN 13557: 2009 (Shutdown category for cranes following emergency-stop); also see Section 9.2.7.3, DIN EN 60204-32: 2009
- The response time must not exceed 550ms from the shutdown command.
(Section 9.2.7.3, DIN EN 60204-32)
- Resetting of the shutdown function must not initiate a restart.
(Section 9.2.7.3, DIN EN 60204-32)

Annex 2 Special safety requirements for wireless control equipment on industrial robots

Explanation of emergency-stop approval in wireless control equipment:

Contrary to the current provision in DIN EN 60204-1 that an emergency-stop function for wireless control equipment is not admissible, Section 4.1.1, DIN EN ISO 13850: 2008 should be called upon for evaluation regarding approval of the emergency-stop device during potential isolation.

According to present information, DIN EN 60204-1 should be supplemented to account for emergency-stop approval in wireless control equipment.

Additional requirements are not specified at this time.

Annex 3 Technical rules

1.0 Applicable standards

DIN EN 50178 (VDE 0160)	Electronic equipment for use in power installations
DIN EN 60204-1 (DIN VDE 0113-1)	Safety of machinery- Electrical equipment of machines Part 1: General requirements
DIN EN 60335-2-29 (VDE 0700-29)	Household and similar electrical appliances - Safety - Part 2-29: Particular requirements for battery chargers
DIN EN 60947-1 (VDE 0660-100)	Low voltage switchgear and control gear; Part 1: General rules
DIN EN 60947-5-1 (VDE 0660-200)	Low voltage switchgear and control gear; Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
DIN EN 62061 (VDE 0113-50)	Safety of machinery- Functional safety of safety related electrical,electronic and programmable electronic control systems
DIN EN ISO 13849-1	Safety of machinery; Safety-related parts of control systems Part 1: General principles for design
DIN EN ISO 13849-2	Safety of machinery; Safety related parts of control systems Part 2: Validation
DIN EN ISO 13850	Safety of machinery; Emergency-Stop - Principles for design

2.0 Special applicable standards for cranes

DIN EN 60204-32 Safety of machinery - Electrical equipment of machines
(VDE 0113-32) Part 32: Requirements for hoisting machines


DIN EN 13135-1 Cranes - Equipment - Part 1: Electrotechnical equipment

DIN EN 13557 Cranes - Controls and control stations

3.0 Special applicable standards for industrial robots

DIN EN ISO 10218-1 Robots for industrial environments - Safety requirements -
Part 1: Robot ISO 10218-1

Annex 4 Specifications for contract preparation

 DGUV Test Prüf- und Zertifizierungsstelle Fachausschuss Elektrotechnik	Specifications for contract preparation - Wireless control equipment -	Company:
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Product identification information

Product nomenclature

Type

 Product variants available? yes / no

 Variant matrix attached? yes / no
Test specification(s) and parameters to be used according to test specification(s)
Testing in accordance with DIN EN ISO 13849-1 yes / no

Category

PL

 MTTF_d in [a]

 DC / DC_{avg} in [%]

CCF in [points]

Service life in [years]

 Mean operating duration d_{op} in [days/years]

 Mean operating duration h_{op} in [hours/days]

 Cycle time t_{cycle} in [s⁻¹]

Testing in accordance with DIN EN 62061 yes / no

SILCL

Service life in [years]

Hardware fault-tolerance

 DC / DC_{avg} in [%]

SFF in [%]

 PFH_d in [h⁻¹]

EMC-Tests

Testing in accordance with DIN EN 61326-3-1

yes / no

Verification via directive 1999/5/EC (R&TTE)

yes / no

Documentation to be submitted

attached

will be submitted

Operating/Installation manual/connection guide

by

Sales literature

by

Circuit diagram(s)
Functional description

by

Printed circuit board-layout(s)

by

Declaration of Conformity

by

Parts list(s)

by

Component failure rate (if available)

by

Single fault analysis, e.g. FMEA

by

Fault combination analysis, e.g. FTA

by

Documentation of software according to Principles of Testing

by

not applicable

Test reports provided by external accredited test bodies for...

Electromagnetic compatibility

by

attached

will be submitted

Switch-ON/switch-OFF capacity of the safety-related shutdown devices

by

Contingent short-circuit current from safety-related shutdown devices

by

Test reports provided for tests performed under special agreement for...

attached

will be submitted

by

by

Note: In the interest of prompt order processing, it is essential that the information above be provided in its entirety!

Date

Name

Signature