DGUV Test
Prüf- und Zertifizierungsstelle
Elektrotechnik
Fachbereich Energie Textil
Elektro Medienerzeugnisse

Translation

Principles of testing and certification of wireless control equipment subject to safety requirements of machinery

Status as of: 2020-03

Principles of testing
Wireless control equipment
subject to safety requirements
GS-ET-07 E

GS-ET 07 E

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Preliminary remarks

These Principles of testing serve as verification that the requirements of the German Product Safety Act (ProdSG) and, in particular, the 1st and 9th provisions of ProdSG have been complied with in conjunction with DIN EN 62745:2017-12.

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 the tests conducted by the testing and certification body of the committee for electrical engineering in DGUV TEST.

These Principles of testing supplement the functional aspects of DIN EN 62745: 2017-12 for wireless control equipment through additional requirements necessary for ready-to-use products.

These Principles of testing also include additional requirements for two special primary applications (crane, industrial robot).

The respective valid regulations must be applied for other special applications (e.g. forestry and agricultural machinery).

testing and certification of wireless control equipment subject to safety requirements of machinery

Changes with respect to Edition 2010-03:

- **Fundamental revision**
- **Integration of DIN EN 62745: 2017-12**
- **Adaptation to current standards**

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.

Table of Contents

1 General

1.1 Scope of application

These Principles apply to the testing of wireless control equipment used for communicating between the operator's control unit and the machinery's control system for the transmission of safety-relevant control commands to the machinery corresponding to directive 2006/42/EC.

1.2 Test specifications

Where dated references are made to normative documents, these Principles of testing will reference the test procedures stipulated precisely in the sections of those standards.

Applicable standards

DIN EN 50178 1998-04	Electronic equipment for use in power installations
DIN EN 14492-2 2019-09	Power driven winches and hoists – Part 2: Power driven hoists
DIN EN 60068-2-6 (VDE 0468-2-6)	Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)
DIN EN 60068-2-27 (VDE 0468-2-27) 2010-02	Environmental testing - Part 2-27: Tests – Test Ea and guidance: Shocks
DIN EN 60068-2-31 (VDE 0468-2-31)	Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for
2009-04	equipment-type specimens
DIN EN 60068-2-64 (VDE 0468-2-64) 2009-04	Environmental testing - Part 2-64: Test method Test Fh: Vibration, broadband noise (digitally regulated) and guidance
DIN EN 60068-2-75 (VDE 0468-2-75) 2015-08	Environmental testing – Part 2 – 75: Tests – Test Fh: Hammer tests
DIN EN 60068-2-78 2014-02	Environmental testing – Part 2 – 78: Tests – Test (VDE 0468-2-78) Cab: Damp heat, steady state
DIN EN 60204-1 (VDE 0113-1) 2019-06	Safety of machinery – Electrical Electrical equipment of machines - Part 1: General requirements
DIN EN 60335-2-29 (VDE 0700-29) 2019-06	Safety of electronic equipment for Household and similar electrical appliances – Part 2-29: Particular requirements for battery chargers

DIN EN 60529 2014-09	Degree of protection provided by enclosures (IP code)
DIN EN 60695-2-11 (VDE 0471-2-11)	Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – 2014-11 Glow-wire flammability test method for end products
DIN EN 60947-1 (VDE 0660-100) 2015-09	Low-voltage switchgear and controlgear – Part 1: General requirements
DIN EN 60947-5-1 (VDE 0660-200) 2018-03	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – electromechanical control circuit devices
DIN EN 61326-3-1 (VDE 0843-20-3-1) 2018-04 intended General	Electrical equipment for measurement, control, and laboratory use EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment to perform safety-related functions (functional safety) − industrial applications
DIN EN 62745 2017-12	Safety of machinery – Requirements for wireless control systems on machinery
DIN EN ISO 12100 2011-03	Safety of machinery – General principles for design Risk assessment and risk reduction
DIN EN ISO 13849-1 2016-06	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
DIN EN ISO 13849-2 2013-02	Safety of machinery – Safety – related parts of control systems – Part 2: Validation
DIN EN ISO 13850 2016-05	Safety of machinery – Emergency – Stop function – Principles for design

Standards applicable specifically for industrial cranes

DIN EN 60204-32 (VDE 0113-32) 2009-03	Safety of machinery – Electrical Electrical equipment of machines – Part 32: Requirements for hoisting machines
DIN EN 13135 2018-08	Cranes - Safety - Design – Requirements for equipment
DIN EN 13557 2009-07	Cranes - Controls and control stations

Standards applicable specifically for industrial cranes

DIN EN ISO 10218 -1 2012-01	Safety requirements for industrial robots Part 1: Robots
DIN EN ISO 10218 -2 2012-06	Safety requirements for industrial robots Part 2: Robot systems

1.3 Validity

GS-ET-07, Principles of testing, Edition 2020-03 is to be applied as of 01 May 2020 and replaces Edition 2010-03.

2 Terms

2.1 Wireless control equipment

Wireless control equipment incorporates devices used for the transmission of control commands, e.g. through radio or optical radiation. It is comprised of remote stations and base stations.

2.2 Remote station

Integral part of a wireless control system, serving the operator as an interface to the wireless control system.

2.3 Base station

Integral part of a wireless control system, providing an interface between the wireless control and other components of the machine control system.

2.4 Output interface

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

2.5 Secondary battery

An arrangement of secondary cells, ready for use as an electrical power source, characterised by its voltage rating, size, connection scheme, capacity, and performance level.

Note: This includes one cell storage batteries.

3 Test documentation to be submitted

3.1 Technical documents

The information for commissioning, connection and operation of the wireless control unit 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:

- Operating instructions
- Functional description including block diagram
- Circuit diagram, wiring diagram, circuit board layout
- Specification of the safety functions with stipulation of the category, PL in accordance with DIN EN ISO 13849-1
- Software documentation
- Parts lists and data sheets
- Installation and connection instructions
- EU Declaration of Conformity
- Sales literature
- PAH – Self-disclosure

The testing facility can request further documentation if deemed necessary.

3.2 Prototype

The number of test specimens to be submitted will be determined by the testing facility. As a rule, at least two unit prototypes must be made available. The testing facility can request additional prototypes if deemed necessary.

4 Requirements and tests

4.1 General test requirements

Wireless control equipment must satisfy all the requirements below 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 specimen should be used.

Fulfilment of broader manufacturer specifications must be verified separately.

These 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	The wireless control unit must still function as intended during and after its exposure to operational demands.
B	The wireless control unit 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 unit may be achieved automatically or through explicit release, depending on its use.
C	The wireless control unit must enter the safe state and remain in the safe state during and after its exposure to operational demands. The restoration of normal operation is initiated 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 specimen must function according to the manufacturer's technical operating data throughout the test under the ambient conditions set forth in Table 2.

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

Table 2: General ambient conditions

All tests shall be carried out only after the steady-state temperature has been attained. It can be assumed that this has been attained when the change in test specimen temperature is less than 2 K/h.

4.2 User Information

4.2.1 Operating instructions

For testing, the equipment shall be accompanied by a German version of the Operating instructions incorporating the information necessary for proper identification, transport, installation, operation, maintenance, decommissioning, and disposal.

The language version(s), for which the manufacturer assumes responsibility, shall be annotated „Original Operating Instructions“. Each additional translation shall be annotated „Translation of the Original Operating Instructions“.
These must conform to the basic requirements for design and structure according to

DIN EN ISO 12100, Sec. 6.4.5.

The information included therein must conform to DIN EN 62745, Sec. 6.2.

Moreover, the following information should be provided:

- Intended proper usage and reasonably foreseeable faulty application thereof
- Type designation
- Information regarding the qualification of personnel for parameterization
- Anticipated short-circuit or over-current protection devices, if applicable
- 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 for the various individual components, as necessary
- Specification of the rated insulation voltage and degree of contamination
- Specification of the conventional thermal current (Ithe) or (Ith), or of the summation current (normally only relevant for base stations)
- Specification of the parameters for the wireless transmission system (e.g. frequency, output power)
- Specification of the base station conductor type (rigid, multi-strand or fine-strand), the smallest and largest conductor cross-sections for which the connections are suitable and the number of simultaneously connectable conductors, if necessary
  Information regarding the connection cables used (ambient conditions)

- Information regarding possible residual hazards
- System fault characteristics
- Information regarding differentiation between electrical circuitry for safety-related applications and electrical circuitry for reporting applications
- Information regarding the response time in a fault-free and in a faulty state
- Designation of utilization category and rated operating currents for the rated operating voltages
- Information regarding cleaning, maintenance and, if applicable, repair and required replacement parts
- Information regarding disposal
- The EC Declaration of Conformity or a document rendering the content of the EC Declaration of Conformity.
- Warning: When a wireless control unit is put into service, it must be ensured that it does not interfere with other local systems or that these systems do not interfere with it. (DIN EN 13557)
- Note: When integrating an Emergency-Stop command device into the remote station of the wireless control equipment, caution must be taken to ensure potential confusion is avoided between operative and non-operative Emergency-Stop devices. (DIN EN 13850, Sec. 4.3.8)
- Operating instructions must include the information necessary for using the radio equipment as properly intended. This encompasses a description of the accessories, components, and software, where appropriate, used to facilitate proper operation of the radio equipment. These Operating instructions, safety information and all markings must be clear, easily understood, and legible.

Furthermore, if the radio equipment normally emits radio waves, the following information must be included:

a. The frequency range or ranges, within which the radio equipment is to be operated.

b. The maximum radiated output power in the frequency range or ranges, within which the radio equipment is to be operated.

Additional information regarding charging equipment:

Relevant information according to DIN EN 60335-2-29, Sec. 7.12, including a reference to DIN EN 60335-1, Sec. 7.12 (Inscriptions and instructions; operating instructions).

Additional warnings regarding the use of storage batteries:

* Unused storage batteries should be kept away from paper-clips, coins, keys, nails, screws, or other small metal objects, which may cause bridging of the contacts.

* Improper usage may result in fluid leakage from the battery. Avoid physical contact with this fluid. Rinse with water in the event of inadvertent contact and seek medical assistance if fluid gets into the eyes. ***(DIN VDE 0740-1)***

The following information must be provided, if applicable:

- Keep small cells and batteries that can be swallowed out of the reach of children.
- Ingesting the battery may result in burning, perforation of soft tissue and can be fatal. Severe burns can occur within 2h after ingestion.
- Seek medical assistance immediately in the event a cell or a battery has been swallowed.

Additional information regarding radio systems (apply RED Directive - 2014/53/EU):

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

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

4.2.2 Sales literature

If sales literature is available for the wireless control equipment, the information therein must not be in contradiction to the Operating instructions.

Sales literature shall not supplant the Operating instructions in whole or in part. (Machinery Directive 2006/42/EC, Annex I)

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

4.2.3 Inscriptions and markings

Information in accordance with DIN EN 62745, Sections 5.2 and 7 must be specified at the respective station.

All inscriptions and markings must be legible and permanently applied.

In addition, the following minimum information must be rendered on the remote station type plate;

- Company name and full address of the manufacturer and its representatives, if applicable
- Design series or type designation
- Serial number, if applicable
- Designation of the safety component (e.g. radio control system; remote station)
- Year of manufacture
- CE-marking
- Type of current
- Operating current
- For equipment with Protection class II: graphic symbols according to IEC 60417, graphic symbol No.: 5172
- In addition, the following minimum information must be rendered on the base station type plate:
- Company name and full address of the manufacturer and its representatives, if applicable
- Design series or type designation
- Serial number, if applicable
- Designation of the safety component (e.g. radio control system; base station)
- Year of manufacture
- CE-marking
- Type of current, number of phases and frequency, if applicable
- Operating current
- For equipment with Protection class II: graphic symbols according to IEC 60417, graphic symbol No.: 5172

For charging units:

Relevant unit information according to DIN EN 60335-2-29, Sec. 7, including a reference to DIN EN 60335-1, Sec. 7.

Additional information regarding radio systems with the RED Directive (2014/53/EU) applied:

- CE-marking accompanied by the identification number of the notified body in accordance with the RED Directive (2014/53/EU)

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

Electric/electronic equipment shall contain the following additional 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 protection device current and tripping characteristics must be specified next to the device holder.

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

Test: Check for completeness, correctness and consistency of the information.

4.2.3.1 Size of inscriptions and markings

The inscriptions/markings must be clearly legible (e.g. with a minimum font height = 2 mm with good contrast) and durable.

Test: Visual inspection.

4.2.3.2 Durability

The inscriptions/markings must be durable.

Test: Rubbing test (rub using two cotton cloths, one soaked in water and the other in a test fluid*) for 15 s each).

The inscriptions/markings must remain clearly legible following the test. It must not be possible to easily remove any labels, nor should they be wrinkled or creased.

*)The chemical product with the trade name "n-Hexan for analysis", which fulfils the requirements for the test fluid defined in DIN EN 60335-1 and DIN EN 62368-1, should be used as test fluid.

4.3 Requirements for the external assembly

4.3.1 Control actuators and display elements

Push-buttons, display lights and displays must conform to the requirements of DIN EN 60204-1, Sections 10.2 to 10.6, the Emergency-Stop device (if available) must conform to the requirements of DIN EN ISO 13850, Section 4.3.

Note: Supplemental information regarding the subject „Active/inactive Emergency-Stop“ can be found in the IFA position paper in German: *The use of illumination to differentiate between active and inactive Emergency-Stop.*

The switching ON of the remote station must be displayed on the unit and must not introduce hazardous movements, even when other control actuators have already been activated. ***(DIN EN 13557; DIN EN 60204-32)***

Each remote station must have the capability of recognizing the machinery to which the remote station is assigned. ***(DIN EN 60204)***

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

Control actuators used for machine movement must automatically return to their basic position when released. Control actuators must be designed or protected in such a manner that, if exposed to a potential hazard, their intended output can only be achieved through deliberate actuation. ***(Machinery Directive, Sec. 1.2.2)***

Test: Visual inspection; functional test

Tip test:

The wireless control equipment is in an operationally ready state. The remote station shall be tipped onto the control actuator surface three times from every possible position.

During the tip test, no hazardous movements shall be induced

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 may be initiated only upon renewed command input. (C.2.4, 5.1.6, DIN EN 13557)

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

Movement must not be initiated upon restoration of the radio link. This shall be possible only upon renewed command input out of the neutral position

(This means the base station should have received at least one data telegram without a work command). The same applies with a power interruption to the remote and base stations, as well as when resetting the Emergency-Stop command device.

4.3.2 External materials and properties

Materials containing substances harmful to health may not be used on any part of the remote station that an operator's skin is regularly exposed to during operation.

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

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

Apply the procedure in accordance with the German Product Safety Commission GS specification, AfPS GS 2019: 01 PAK to check the amount of polycyclic aromatic hydrocarbon (PAH).

Where function allows, components subject to physical contact should have no sharp corners, edges or abrasive surfaces that can cause injury.

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

Test: Handling and visual inspection.

4.3.3 Ergonomics

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

Control lever:

- Forwards and rearwards: 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 grasped or moved solely by the whole hand.
- Sidewards 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
- 10 N for holding force in the "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 the remote station is stored for 2 hours at the highest or lowest temperature within the operating temperature range prescribed by the manufacturer. This operating temperature range must lie between at least 0°C and +40°C. Following the respective storage period, actuating forces are measured on each control actuator using a force-measuring device.

Measurement at the control actuator must take place within 1 minute after the unit is removed from the climatic exposure test cabinet and shall replicate regular actuation with respect to direction and point of application. Between any further measurements, the test specimen must be stored at the appropriate temperature for at least 15 minutes. Measured actuation forces must not exceed the prescribed limit forces.

The exposure of operating personnel to stress, fatigue and harmful physical strain with proper usage must be reduced to the lowest possible level, with consideration given to ergonomic principles.

Criteria:

- That part of the wireless control unit intended to be held by hand must feature an ergonomic contour.
- Edges, corners, and rough surfaces must be avoided.
- Operating personnel must not fatigue when carrying a remote station over a lengthy period of time. A carrying aid should be provided for carrying remote stations weighing more than 500 g.
- The remote station together with the carrying aid must not exceed a maximum weight of 3 kg.
- Safe operation of the control actuator using one hand per actuator must be warranted without having to set down the mobile remote station.
- The remote station must be designed in such a manner that an unintentional change in position is not possible when it is being set down.

Test: Handling; weight measurement.

4.3.4 Measures against unauthorized use

Where the prevention of unauthorized usage is of concern, the remote station must be outfitted with a means of ensuring such unauthorized usage is not possible (e.g. key lock, access code).

(DIN EN 62745, Sec 4.2.2)

Test: Visual inspection, check of effectiveness.

4.4 Environmental requirements

Wireless control equipment must possess sufficient resistance against environmental influences.

This should be verified using the tests described below.

Furthermore, subsequent to completing the individual tests according to Sections 4.4.1 and 4.4.2, the following criteria must be fulfilled:

1. It must not have become possible to touch live components.
2. The effectiveness of insulated lining and separators must not be impaired.
3. The test specimen must still provide a level of protection against the infiltration of dust, solid foreign objects and water corresponding to specifications in the Operating instructions.

Test: Visual inspection.

4.4.1 Mechanical strength

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

Test according to Sections 4.4.1.1 to 4.4.1.4

Component test	Parameters
I. Continuous vibration: Test standard Frequency range Amplitude Frequency cycle count Tuning speed	 DIN EN 60068-2-6 10 - 150 Hz ± 1 Hz (0.35 mm/5 g) ± 15 % at the control point 20 1 octave/min Testing is to be carried out in all three axes
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 Type of shock 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 In all 6 directions

Table 3: Minimum requirements for vibration and mechanical stress

4.4.1.1 Resistance to shock

This requirement applies to the base and remote stations used in wireless control equipment.

Three blows of 0.7 J (Nm) shall be applied at what is considered to be the most critical point, using an impact testing device according to DIN EN 60068-2-75, Sec. 6, whereby particular attention should be paid to the insulating materials used to shroud live 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 operating temperature. Shock test within 1 min. after removal from the climatic exposure test cabinet. Subsequent to testing, the evaluation criteria must have been fulfilled according to Sec. 4.4.

4.4.1.2 Resistance to vibration

Both the base station as well as the remote station are to be exposed to mechanical vibrations according to Table 3; I while in operationally-ready state and in their potential mounted or deployed positions.

The wireless control unit must fulfil evaluation criteria A during the test according to Table 1. Control actuators are not activated during the test. Subsequent to each test in the corresponding position, evaluation criteria A must have been fulfilled according to Table 1 with activation of each control actuator.

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 and after testing, a change in the Emergency-Stop command device switching state is not permitted. Subsequent to testing, the evaluation criteria A for the Emergency-Stop function must have been fulfilled in the corresponding position.

Additionally, the evaluation criteria must have been fulfilled according to Sec. 4.4.

4.4.1.3 Resistance to impact / Continuous shocks/ individual shocks:

Both the base station and the remote station are to be exposed to individual shocks in accordance with the parameters of Table 3; II.

Both the base station and the remote station 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 shock or continuous shock test in the corresponding position, the base station must fulfil evaluation criteria B according to Table 1.

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

All control actuators must still function properly following exposure to 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 and after testing, a change in the Emergency-Stop command device switching state is not permitted. Subsequent to testing, the evaluation criteria A for the Emergency-Stop function must have been fulfilled in the corresponding position.

Subsequent to testing, the evaluation criteria must have been fulfilled according to Sec. 4.4.

4.4.1.4 Resistance to breakage

The test shall be carried out on remote stations in accordance with the provisions of DIN EN 60068-2-31, Procedure 1 – Free-falling. The drop height will depend on manufacturer specifications, but must be at least 1000 mm.

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

Test: According to DIN EN 60068-2-31; Procedure 1, Free-falling. During the test, the device is in an operating state.

During and after the test, the wireless control unit must have fulfilled at least evaluation criteria C according to Table 1 or have been so severely damaged that it is no longer operational.

Additionally, the evaluation criteria must have been fulfilled according to Sec. 4.4.

4.4.2 Climatic conditions

Wireless control equipment (remote/base station) 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 referenced above.

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

a. When operating wireless control equipment under the conditions established in Sec. 4.1.1, an A-Test* must be carried out for a duration of at least 1h. The B-Test* must be carried out subsequently.

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 0.5 h. The 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. At the same time, 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. The B-Test* must be carried out subsequently.

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. The B-Test* must be carried out subsequently.

In addition to the A- and B-Tests*, the criteria according to Sec. 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 base station with manual introduction at the remote station

4.5 Protection class

Wireless control equipment (remote/base station) must at least conform to Protection class IP 54 (enclosure category 1; DIN EN 60529, Sec. 13.4) when installed and ready for operation.

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

Different protection classes may apply due to differing placement options for the remote and base stations. If it is foreseen that the unit will be subsequently installed in an enclosure (e.g. control cabinet or control panel), the unit must conform to at least Protection class IP 2X.

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

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

4.6 Electric/ electronic equipment requirements

4.6.1 Supply voltage

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

Test: In accordance with DIN EN 60204-1, Sec. 4.3

During and after the test, the wireless control unit must have fulfilled evaluation criteria A according to Table 1.

The remote station power supply must be capable of being removed or detached by hand (without the aid of tools).

Test: Visual inspection; functional test

4.6.2 Thermal load capacity of insulating materialsInsulating materials must be sufficiently resistant to heat and fire.

Test: In accordance with DIN EN 60695-2-11.

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

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

Unattended operation is assumed for the base station. Attended operation and power supplied through storage batteries are assumed for the remote station. If appropriate protective measures are integrated into the remote station storage batteries, the heat-filament temperature can be reduced to 550°C.

4.6.3 Air gaps and creepage distances

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

Test: Measurement of air gaps and creepage distances.

4.6.4 Verification of adherence to temperature-rise limits

Wireless control equipment must fulfil the requirements related to the heating of component parts in accordance with DIN EN 60947-1, Sec. 7.2.2 (with Tables 2 and 3).

Test: Temperature-rise testing is to be carried out in accordance with DIN EN 60947-1, Sec. 8.3.3.3. Specification of the conventional thermal current or of the maximum summation current must be considered.

For analysis of temperature rise, the upper ambient temperature of the wireless control equipment corresponding to manufacturer specifications in the Operating instructions shall apply as a basis, albeit at least 40 °C.

If temperature-rise testing is carried out at room temperature, the temperature rise ascertained must be increased by the amount of the temperature difference between upper ambient temperature (manufacturer’s specifications) and room temperature.

4.6.5 Protection against electric shock

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

Test: Review of the technical documents and comparison with the prototype. Measurement of inlet openings and distances from voltages hazardous to the touch, or measurement of leakage current and residual voltage, as necessary.

4.6.6 Over-current protection

Wireless control equipment must be outfitted with suitable protection of the electric equipment against over-current according to DIN EN 60204-1, Sec. 7.2.

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

4.6.7 Dielectric strength

Mains powered remote or base stations must be stored at a moist heat level (T = 40°C ± 2°C; RH = 93% ± 3%) for 96 hours according to DIN EN 60068-2-78.

Following exposure, the insulation must fulfil dielectric strength requirements in accordance with DIN EN 50178.

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

4.6.8 Insulation resistance

The insulation resistance between the main circuit conductors and the protective conductor system must be sufficiently high when the remote or base stations are powered by the mains.

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

4.6.9 Making- and breaking-capacity

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

Test: Testing is carried out according to DIN EN 60947-5-1, Sec. 8.3.3.5 making- and breaking-capacity). Subsequent to each test, an evaluation and a voltage test are to be performed according to DIN EN 60947-5-1 Sec. 8.3.3.5.6.

4.6.10 Conductors, cables and lines

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

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

Electrical equipment wiring must be rendered according to the requirements of DIN EN 60204-1, Sec. 13.

The electric connections of electronic components must be rendered in accordance with DIN EN 50178, Sec. 7.1.10.

Removable plug connections are to be coded in such a manner that the risk of swapping lines is excluded, insofar as a swap could create a hazard for persons or operating materials. 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 realized 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 part of the wireless control equipment, the requirements of DIN EN 60204-1, Sec. 8.2 must be fulfilled.

Test: Visual inspection of the model and a check of the protective ground system continuous connection according to DIN EN 60204-1, Sec. 8.2.

4.6.11 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.

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

4.6.12 Short-circuit current

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

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

4.6.13 Component assembly

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

Connections must be secured to prevent unintentional loosening.

Electrical connection terminals and junctions must be designed in such a manner that the projected reliability during the life span of the electronic equipment is preserved. The anticipated 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 DIN EN 50178, Sec. A 7.1.8, Requirements for electrical connections) and fulfilment of the tests according to Sec. 4.4 of these Principles of testing.

4.6.14 Fault characteristics

DIN EN 62745, Sec. 4.6 is to be applied.

Test: Validation according to DIN EN ISO 13849-2

4.6.15 Additional requirements for semiconductor-output circuit elements

Semiconductor output circuit elements must fulfil the requirements of

DIN EN 60947-5-1, Annex H.

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

4.6.16 Response time of safety-related commands

Normal operation:

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

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 base station within the time specified by the manufacturer following a corresponding command initiated at the remote station.

Test: Measurement of the response time as prescribed by the manufacturer.

4.6.17 Charging devices for secondary batteries

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

Air gaps and creep age distances are to be measured according to over-voltage category II and contamination level 2.

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

4.7 EMC and radio transmission requirements

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

Wireless control equipment must additionally fulfil the requirements of the RED Directive (2014/53/EU).

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

Verification from a notified body related to the fulfilment of the RED Directive (2014/53/EU).

Additional tests of EMC in accordance with EN 300220-2 or EN 301489*

* Selection of the respective relevant standard must be considered.

4.8 Functional aspects

4.8.1 Prevention of unintentional commands

Measures must be taken to ensure that control commands:

- will affect only the intended base station or remote station (e.g. utilization of address codes);
- will introduce only the intended functions at the base station or remote station.

Such measures must be protected against accidental or inadvertent modification.

When malfunction or fault is detected, all safety-related outputs must be directed into the OFF state with appropriate safety integrity.

Where hardware switches (e.g. DIP switch) are used for device addressing, it may be necessary to implement additional measures (e.g. parity checks) in order to fulfil the requirements in the event of a malfunction.

Test: Functional analysis

4.8.2 Serial data transmission

Serial data transmissions must be in line with the conditions according to DIN EN 62745, Sec. 4.3.

Test: Estimation of the probability of residual error and rate of residual error of data transfer in accordance with the methods described in DIN EN 62745, Sec. 4.3.

As an alternative, the probability of residual error can also be estimated in accordance with DIN EN 61784-3: 2017-09, Sec. 5.8.

4.8.3 Structure and display of communication transfers

The structure and display of communication transmissions must be in line with the conditions according to DIN EN 62745, Sec. 4.5.

Test: Functional analysis

4.8.4 Stop function/resetting the stop function on wireless control equipment

The stop function and resetting of the stop function must conform to the requirements of DIN EN 62745, Sections 4.7 and 4.8.

Test: Functional analysis

4.8.5 Interruption of transmissions from a remote station

If signal transmission interruptions are tolerated, the time frame duration of the maximum interruption must be prescribed by the manufacturer. The maximum time frame duration shall be determined in accordance with the risk assessment. If the maximum time frame is exceeded, then an automatic stop must be initiated.

Test: Measurement of the time from the transmission interruption to initiation of the stop command.

4.8.6 Self-locking control functions

If self-locking control functions are available, they must conform to the requirements of DIN EN 62745, Sec. 4.10.

Test: Compare the functions with the specifications in the Operating instructions.

4.8.7 Characteristics in the event of energy loss

Wireless control equipment must conform to the requirements of DIN EN 62745, Sec. 4.11.

Test: Functional analysis

4.8.8 Multiple remote stations

If the wireless control equipment is comprised of multiple remote stations, the requirements of DIN EN 62745, Sec. 4.12 must be fulfilled.

Test: Functional analysis

4.8.9 Multiple base stations

If the wireless control equipment is comprised of multiple base stations, the requirements of DIN EN 62745, Sec. 4.13 must be fulfilled.

Test: Functional analysis

4.8.10 Log-out of wireless control equipment

If a log-out mode is foreseen that provides for the machine control to be switched from one wireless control unit to another without initiating the OFF state at the base station, the requirements of DIN EN 62745, Sec. 4.14 must be fulfilled.

Test: Functional analysis

4.8.11 Configuration protection

Configuration protection must conform to the requirements of DIN EN 62745,

Sec. 4.15.

Test: Functional analysis

4.9 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 no adverse effects for humans exist.

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

4.10 Security

If a risk related to (IT-) Security is identified in the risk assessment, then the Principles of testing: GS-IFA-M24 „Principles of testing and certification of security aspects related to the functional safety of industrial automation systems“ should be applied.

5 Component testing at manufacturer facilities

The manufacturer on each completely assembled wireless control unit must carry out tests 5.1 and 5.2 below.

Test: Review of the test instructions, etc.

5.1 Functional test

All safety-related functions are to be tested for proper function by manually actuating 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 associated operating device will be identified.

5.2 Test of the protective conductor current path

Insofar as relevant, the following test of protective conductor system consistency should be carried out on the base station 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 every protective conductor system, with the current ranging between a minimum of 0.2 A and approximately 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 not recommended to use a PELV-supply, as this type of supply can cause misleading results. The measured resistance must fall within a range anticipated for 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 Principles of testing, the following describes necessary divergences or additional requirements and tests for this scope of application.

4.3.4 Measures against unauthorised use

In addition, the remote station must not transmit as long as the means for preventing unauthorized use are activated (DIN EN 60204-32, Sec. 9.2.7).

4.4.1.2 Resistance to vibration

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

The base station must not be susceptible to broadband noise.

Test: Test Fh according to DIN EN 60068-2-64 must be carried out on the base station (DIN EN 13557, Sec. C7).

Prior to testing, a visual examination and functional test must be carried out in order to determine proper condition.

The wireless control unit is in an operationally ready state.

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

The base station is to be attached according to manufacturer specifications.

Load exposure:

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

Single-point regulation

Test frequency range:

5 - 100 Hz

Acceleration spectral density:

1 $(m/s^2)^2/Hz$ (also equates to 1 m^2/s^3)

Type of acceleration spectrum:

Straight,horizontal course of the acceleration spectral density

Duration of exposure:

30 min +5% in all three axes

The wireless control unit must fulfil evaluation criteria A during the test according to Table 1. Control actuators are not activated during the test. Subsequent to each test in the corresponding position, evaluation criteria A must have been fulfilled according to Table 1 with activation of each control actuators.

Additionally, the criteria must have been fulfilled according to Sec. 4.1.5.

4.6.11 Suitability of structural elements/components used

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

- DIN EN 60204-32, Sec. 4.2.2 (Selection of power contactors)

4.8 Functional aspects

4.8.4 Stop function/resetting the stop function on wireless control equipment

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

- Control category of the stop function in wireless control equipment for crane control systems: at least PL c and category 3, in accordance with DIN EN ISO 13849-1; also refer to DIN EN 60204-32, Sec. 9.2.7.3,
- DIN EN 13557, Sec. C.3.1 and DIN EN 14492-2: 2019-09
- DIN EN 13557, Sec. C.3.2 (Run-down time for crane movement with invalid data frames); also refer to DIN EN 60204-32, Sec. 9.2.7.3
- DIN EN 13557, Sec. C.3.3 (Crane shutdown following the stop function); also refer to DIN EN 60204-32, Sec. 9.2.7.3
- DIN EN 13557, Sec. C.3.4, (Shutdown category for cranes following Emergency-Stop actuation); also refer to DIN EN 60204-32, Sec. 9.2.7.3.
- The response time must not exceed 550 ms from the shutdown command. (DIN EN 60204-32, Sec 9.2.7.3)
- Resetting of the stop function must not initiate a restart.
- (DIN EN 60204-32, Sec 9.2.7.3)

4.8.12 Functional requirements for crane applications

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

- -DIN EN 13557, Sec. C.2.3 (Actuation of the crane switch); also refer to DIN EN 60204-32, Sec. 9.2.7.2
- -DIN EN 13557, Sec. C.2.5 (Requirements for current-free crane switches);
- also refer to (DIN EN 60204-32, Sec 9.2.7.2
- -DIN EN 13557, Sec. C.4.2 (Transmission reliability); also refer to DIN EN 60204-32, Sec. 9.2.7.4
- -DIN EN 13557, Sec. C.6 (Requirements for a remote station with declining voltage in vicinity of a crane)
- The wireless control equipment must initiate an automatic de-energising of the crane switch if a malfunction is detected in the wireless control unit. *(DIN EN 60204-32, Sec 9.2.7.3)*
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Annex 2

Special safety requirements for wireless control equipment on industrial robots

Insofar as not otherwise described in the basic relevant requirements of these Principles of testing, DIN EN ISO 10218-1, Sec. 5.8 and DIN EN ISO 10218-2, Sec. 5.7 apply.

Test: In accordance with DIN EN ISO 10218-1, Sec. 5.8 and DIN EN ISO 10218-2, Sec. 5.7.

Annex 3

Information regarding contract preparation

DGUV Test Prüf- und Zertifizierungsstelle Elektrotechnik Fachbereich Energie Textil Elektro Medienerzeugnisse	Information regarding contract preparation **- Wireless control equipment -**	Company:

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}]	

DGUV Test Prüf- und Zertifizierungsstelle Elektrotechnik Fachbereich Energie Textil Elektro Medienerzeugnisse	Information regarding contract preparation **- Wireless control equipment -**	Company:

EMC-Tests

Testing in accordance with DIN EN 61326-3-1 ***Verification of compliance with the RED Directive (2014/53/EU)***	Yes ☐ / No ☐ 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…	*attached*	*will be submitted*
Electromagnetic compatibility	☐	by
Switch-ON/switch-OFF capacity of the safety-related shutdown devices	☐	by
Conditional short-circuit current for 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