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**Automatic electrostatic application systems for ignitable liquid
coating materials - Safety requirements**

Systèmes automatiques d'application électrostatique de
matériaux de revêtement inflammables - Exigences de
sécurité

Automatische elektrostatische Beschichtungssysteme für
entzündbare Beschichtungsstoffe -
Sicherheitsanforderungen

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European foreword

This document (EN 50176:2025) has been prepared by CLC/SC 31-8 "Electrostatic painting and finishing equipment" of CLC/TC 31 "Electrical apparatus for potentially explosive atmospheres".

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2026-02-28
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2028-02-29

This document supersedes EN 50176:2009 and all of its amendments and corrigenda (if any).

The significant technical changes between this document and EN 50176:2009 are given in Annex G, Table G.1.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a standardization request addressed to CENELEC by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annexes ZZA and ZZB, which are integral parts of this document.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Introduction

During the electrostatic coating process, the ignitable liquid coating material is transported to a spraying device where it is atomised by mechanical forces and/or by the influence of an electric field. The generated spray cloud is charged by high voltage of some 10 kV, is attracted by and is applied to the earthed workpiece.

Spray clouds which are not applied to the workpiece (overspray) are removed by a suction device or by other means.

The coating material is cured at room temperature or by heating.

1 Scope

1.1 This document specifies the electrical requirements for the design of automatic electrostatic application systems for liquid coating materials which can be ignited in an atomised state, used within a temperature range from 5 °C to 40 °C.

This document considers automatic electrostatic application systems for processing ignitable liquid coating materials, where the conductivity of the complete system is limited up to 50 nS/cm. Together with additional measures like e.g. potential separation systems, these requirements can also be applied to ignitable liquid coating materials, where the conductivity of the complete system is limited up to 2 000 µS/cm.

Ignition hazards related to the generated explosive atmosphere and the protection of persons against electric shock are considered.

1.2 This document specifies

- requirements for an interface to machinery according to EN 16985:2018,
- additional requirements for machinery covered by EN 1953:2025 and EN 12621:2025.

1.3 This document also specifies requirements for a safe operation of electrostatic application systems, including the electrical installation. The requirements consider both the processing of coating materials and the cleaning and purge processes.

1.4 This document applies to three types of spraying systems; see 5.1.1.

Spraying systems are classified as equipment of group II, category 2G (for intended use in zone 1 or zone 2) or category 3G (for intended use in zone 2).

Only electrostatic spraying systems operating with a d.c. sinusoidal ripple of not more than 10 % of the r.m.s. value are considered.

1.5 For electrostatic application systems used in food and pharmaceutical industry, additional requirements may apply.

1.6 This document does not apply to

- potential separation systems;
- selection, installation and application of other electrical and non-electrical equipment in areas with explosion hazard, see EN 60079-14:2014 and EN 16985:2018;
- quality assurance systems for electrostatic spraying equipment (see EN ISO/IEC 80079-34:2020, ZB.11).

2 Normative references

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

EN 1149-5:2018, *Protective clothing - Electrostatic properties - Part 5: Material performance and design requirements*

EN 1953:2025, *Application equipment for coating materials - Safety requirements*

EN 12621:2025, *Machinery for supply and circulation of liquid coating materials - Safety requirements*

EN 16985:2018, *Spray booths for organic coating material - Safety requirements*

EN 50050-1:2013, *Electrostatic hand-held spraying equipment - Safety requirements - Part 1: Hand-held spraying equipment for ignitable liquid coating materials*

EN 50050-2:2013, *Electrostatic hand-held spraying equipment - Safety requirements - Part 2: Hand-held spraying equipment for ignitable coating powder*

EN 50050-3:2013, *Electrostatic hand-held spraying equipment - Safety requirements - Part 3: Hand-held spraying equipment for ignitable flock*

EN 50059:2025, *Hand-held electrostatic application equipment for non-ignitable liquid coating materials — Safety requirements*

EN 50177:2009,¹ *Stationary electrostatic application equipment for ignitable coating powders - Safety requirements*

EN 50223:2015, *Stationary electrostatic application equipment for ignitable flock material - Safety requirements*

EN 50348:2010,² *Stationary electrostatic application equipment for non-ignitable liquid coating material - Safety requirements*

EN 60204-1:2018, *Safety of machinery - Electrical equipment of machines - Part 1: General requirements (IEC 60204-1:2016, modified)*

EN 60529:1991, *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*

EN 61340-4-1:2004,³ *Electrostatics - Part 4-1: Standard test methods for specific applications - Electrical resistance of floor coverings and installed floors*

EN ISO 12100:2010, *Safety of machinery - General principles for design - Risk assessment and risk reduction (ISO 12100:2010)*

EN ISO 13849-1:2023, *Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2023)*

EN ISO 20344:2021, *Personal protective equipment - Test methods for footwear (ISO 20344:2021)*

IEC 60479-1:2018, *Effects of current on human beings and livestock — Part 1: General aspects*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available <https://www.electropedia.org/>

¹ As impacted by EN 50177:2009/A1:2012.

² As impacted by EN 50348:2010/COR1:2010.

³ As impacted by EN 61340-4-1:2004/A1:2015.

3.1.1

application system

automatic electrostatic application system in which the spraying device is either fixed stationary (EXAMPLE 1: on supports) or is guided by reciprocators (EXAMPLE 2: robots) and operated automatically, which in general comprises the following:

- spraying system;
- fire extinguishing system;
- coating material supply system

3.1.2

spraying system

devices for application of liquid coating material by means of electrostatic charge and generally comprises the following:

- spraying device;
- high voltage electrode, if applicable;
- high-voltage supply system;
- housing;
- exchangeable attachment parts;
- battery unit (integrated fixedly, or attached), if applicable;
- control system

Note 1 to entry: The term 'spraying system' is a synonym to the terms 'applicator' of EN 50050-1:2013 and 'application equipment' of EN 1953:2025.

Note 2 to entry: The high-voltage supply system can be an integral part of the control system.

3.1.3

spraying device

device with outlet opening of coating material for atomising, high-voltage electrode for charging the coating material and, if applicable, supplying atomising air and horn/shaping air

Note 1 to entry: Typical designs are nozzles or rotating discs, or bell-shaped devices.

Note 2 to entry: The high-voltage electrode can be a needle or a solid part which is on high-voltage potential.

3.1.4**high-voltage supply system**

system, which in general comprises the following:

- low-voltage section with devices for switching on and off the high-voltage supply system and for adjustment, control, regulation, limitation and monitoring of current and voltage, as well as the required connecting cables;
- high-voltage generator;
- high-voltage switching device;
- high-voltage cable;
- high-voltage plug-and-socket connector

3.1.5**control system**

device generally having the following functions for adjustment, control, regulating, limitation and monitoring of, for instance, the spraying system and the high voltage supply system

Note 1 to entry: A combination of the control system and the high voltage supply system according to 3.1.4 is possible.

3.1.6**connecting cable**

electric cable connected to the applicator or charging device for coating material

3.1.7**high voltage electrode**

conductive part in the form of a needle or a solid part, which is under high voltage and serves for direct or indirect charging of the coating material

3.1.8**coating material supply system**

system, comprising components for supplying the spraying system with coating material, which in general comprises the following:

- pressurized or depressurised containers;
- pumps;
- controllers and valves;
- dosing and mixing devices for coating materials;
- ducts and hoses;
- charging device for liquid coating material

3.1.9**earthing system**

system for earthing the spraying system permanently

3.1.10**hazardous discharge**

discharge which generates the hazard of ignition of explosive mixtures or of electric shock

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3.1.11

workpiece

article to which the coating material is applied

3.1.12

non-ignitable liquid coating materials

substances, especially varnishes which cannot be ignited in sprayed state

Note 1 to entry: A formula for the estimation of ignitability on the basis of the composition of the coating material is given in Annex F.

3.1.13

ignitable liquid coating materials

sprayed materials, especially varnishes which can be ignited in sprayed state and react in the form of an explosion

Note 1 to entry: A formula for the estimation of ignitability on the basis of the composition of the coating material is given in Annex F.

3.1.14

explosive atmosphere

mixture of air, under atmospheric conditions, and ignitable substances in the form of gas, vapour, mist, powder or flock, in such proportions that it can be ignited by effective ignition sources, such as excessive temperature, arcs or sparks

Note 1 to entry: See EN 1127-1:2019.

3.1.15

dissipative footwear

footwear that has a resistance to earth via its sole which is low enough to prevent the build-up of electrostatic charges capable to produce a hazardous discharge

Note 1 to entry: See EN ISO 20344:2021.

Note 2 to entry: A required electric insulating resistance to prevent electric shocks is not contradictory to this definition.

3.1.16

protective clothing

clothing that has a resistance to earth which is low enough to prevent the build-up of electrostatic charges capable to produce a hazardous discharge

Note 1 to entry: See EN 1149-5:2018.

Note 2 to entry: A required electric insulating resistance to prevent electric shocks is not contradictory to this definition.

3.1.17

dissipative floor

floor that has a resistance to earth which is low enough to prevent the build-up of electrostatic charges capable of producing a hazardous discharge

3.1.18

constant-voltage mode

closed control circuit system with direct feedback of the actual value of the high voltage to a control system, and during the mode of which the adjusted high voltage is maintained constant up to the performance limit of the high-voltage supply system, independent of the variable operational current

3.1.19**voltage-controlled mode**

open control circuit system without feedback of the high voltage, and during the mode of which the high voltage is adjusted generally at a defined operational current; the high voltage is not maintained constant by a control system, but it varies depending on the operational current and the on-load behaviour of the high-voltage supply system

3.1.20**constant-current mode**

closed control circuit system with direct feedback of the actual value of the operating current to a control system; the operational current is maintained constant, and the high voltage varies load-dependently between a minimum and a maximum value defined by the process

3.1.21**current-controlled mode**

closed control circuit system with direct feedback of the actual value of the operating current and the actual value of the high voltage to a control system; the operating current is controlled, the high voltage varies load-dependently between a minimum and a maximum value defined by the process

3.1.22**operational current**

current which flows within the high-voltage circuit during failure-free operation

3.1.23**overcurrent**

current occurring during a malfunction, exceeding the operational current of the high-voltage circuit and giving rise to expect that in voltage-controlled and constant-voltage operation hazardous discharges or arcs between high-voltage parts and earthed parts of the plant could occur in case the safety distance drops below the permissible limit

3.1.24**maximum admissible operating voltage**

voltage of the high-voltage circuit giving rise to expect that hazardous discharges or arcs could occur between high-voltage parts and earthed parts of the plant

3.1.25**minimum voltage**

voltage of the high-voltage circuit giving rise to expect that in constant-current mode hazardous discharges or arcs could occur between high-voltage parts and earthed parts of the plant, in case the safety distance drops below the permissible limit

3.1.26**lowering or shut off threshold**

limit value for current $I_{\bar{a}}$ or voltage U_{min}

3.1.27**locally acting fire extinguishing system**

system which protects the hazardous area between spraying system and workpiece / the cleaning device

3.1.28**cleaning device**

equipment for outside cleaning of the spraying device

3.1.29**exchangeable attachment parts**

nozzles, bells/discs, extensions, angular pieces, electron and ion absorber and discharge electrodes if applicable

3.1.30**maximum surface temperature**

highest temperature which is attained in service under the most adverse conditions (but within the specified tolerances) by any part or surface of Ex Equipment

3.1.31**routine test**

test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

3.1.32**type test**

test of one or more devices made to a certain design to show that the design meets certain specifications

3.2 List of symbols

U_{max}	Maximum output voltage of the high-voltage generator
I_{max}	Maximum output current of the high-voltage generator
$I_{B\ rms}$	Body current (r.m.s.) flowing from the hand to both feet
$I_{C\ (p)}$	Peak-current value generated by a discharge provoked from the application system
$\int i(t)dt$	Integral of time-dependent current
C	Capacitance
U	Voltage
t_i	Pulse duration in which the peak-current value $I_{C\ (p)}$ is reduced to 5 % of its value
$U_{C\ (p)}$	Peak-voltage value of a discharge measured from the oscilloscope
R_{Shunt}	Resistance of the shunt in Ω
F_{CT}	Factor of the current transformer in V/A
F_{AT}	Factor of the attenuator
$I_{\bar{u}}$	Overcurrent
U_{app}	Maximum admissible operating voltage
U_{min}	Minimum voltage
Q	Transferred charge
W	Energy

4 Hazards**4.1 Explosion hazards**

An explosion hazard is present, if

- the concentration of sprayed ignitable liquid coating materials in air is within the explosion limits,
- an ignition source of appropriate energy for this explosive atmosphere is present.

An explosion can be prevented if one condition is avoided. Because it is very difficult to exclude the possibility of ignitable discharges completely, the focus should be the prevention of ignitable concentrations of explosive atmosphere.

NOTE If an explosive mixture of coating materials and air is trapped in a closed room, the damaging effects of an explosion could be increased due to the increase in pressure.

Electric ignition sources are an electric arc or a spark.

4.2 Electric hazards

Electric shock (by direct or indirect contact) may be generated, for instance, by contact with

- live parts, which are not insulated for operational reasons,
- conductive parts, which are not under hazardous voltage during normal operation, but in case of failure,
- insulated live parts whose insulation is insufficient or has been damaged due to mechanical, thermal, chemical or other influences

Inadequate earthing may occur, for instance, due to

- faulty connections to the protective earthing system,
- a too high resistance to earth (e.g. due to contamination by coating materials).

Electrical hazards may occur, for instance, if hazardous malfunctions (e.g. shortcut of electronic safety circuits, of access guards to hazardous areas or of warning devices) occur due to interferences of the high-voltage supply system and the components of control and safety systems.

Hazardous electrostatic discharges could be generated, for instance, by non-earthed conductive components or by large insulating surfaces, especially if they are backed with conductive material.

5 Requirements for application systems

5.1 Requirements for spraying systems depending on the type

5.1.1 General

Depending on the hazards that can occur, spraying systems are categorized in three types according to Table 1.

Table 1 — Spraying systems for ignitable liquid coating materials – Fields of application

Types ("L" for liquid coating materials)	Hazard by ignitable discharge	Hazard by electric shock	Related to areas of Figure 1
L-1	No	No	I
L-2	Yes	No	I
L-3	Yes	Yes	II or III
NOTE 1 Hazards listed in the table are adequately prevented by applying this standard.			
NOTE 2 The type L-1 can be compared to the type A-L, the type L-2 to the type B-L, Type L-3 corresponds to the types C-L and D-L of EN 50176:2009.			

The requirements related to the different types are listed in Table 2.

Table 2 — Requirements for spraying systems depending on the type

Types	Requirements of the cited clause					
	5.1.2	5.1.3	5.1.4	5.1.5	5.1.6.1	5.1.6.2
L-1	yes	no	yes ^a	no	no	no
L-2	no	yes	yes	yes	yes	no
L-3	no	yes	yes	yes	no	yes
^a fulfilled by design and construction.						

5.1.2 Requirements for ignition protection

Spraying systems shall be designed and constructed to ensure

- a maximum transferred charge $Q \leq 60$ nC generated by parts of conductive or dissipative materials (e.g. electrodes), and
- a maximum transferred charge $Q \leq 90$ nC generated by parts of insulating materials (e.g. housings) or
- a maximum discharge energy $W \leq 0,24$ mJ generated by parts of all types of materials.

NOTE For further information see CLC/TR 60079-32-1:2018 [8] and [20].

5.1.3 Prevention of hazardous discharges

5.1.3.1 General

Hazardous discharges shall be prevented by

- measures according to 5.1.3.2 for constant-voltage or voltage-controlled operating mode
- or
- measures according to 5.1.3.3 for constant-current or current-controlled operating mode.

For category 3G devices, a hazardous discharge shall be prevented during normal operation. For this reason, measures of 5.1.3.2 or 5.1.3.3 shall avoid hazardous discharges after the first discharge.

For category 2G devices, a hazardous discharge shall be prevented during normal operation and in fault conditions (e.g. failure of disconnection). Measures of 5.1.3.2 or 5.1.3.3 shall avoid any hazardous discharge in the test procedure according to Annex E.

5.1.3.2 Constant-voltage mode and voltage-controlled mode

For constant-voltage mode and voltage-controlled mode, a hazardous discharge is prevented by lowering or shut off the high voltage in case of overcurrent I_0 .

The threshold value shall be defined with consideration of the operational and local conditions and shall be monitored automatically.

NOTE In general, an overcurrent I_0 for operational currents of less than 200 μ A up to 200 % or for operational currents of more than 200 μ A up to 150 % is suitable.

If the threshold value I_0 is set too high, a hazardous discharge between parts under high voltage and earthed parts could occur. This should be of special consideration in case of series connexion of high impedance resistance within the high-voltage circuit.

5.1.3.3 Constant-current mode and current-controlled mode

For constant-current mode and current-controlled mode, a hazardous discharge is prevented by lowering or shut off the high voltage when undercutting the defined minimum output value of high-voltage U_{\min} .

The threshold value shall be defined with consideration of the operational and local conditions and shall be monitored automatically.

NOTE 1 In general a value of the minimum voltage U_{\min} of 20 % to 50 % below the value of the output high-voltage for the failure-free normal operation is suitable.

NOTE 2 If the threshold value U_{\min} is set too low, a hazardous discharge between parts under high-voltage and earthed parts could occur.

Hazardous discharges between high-voltage parts and earth potential shall be prevented by limiting the maximum admissible operation voltage U_{app} .

5.1.4 Prevention of hazardous discharges during rinsing and cleaning processes

5.1.4.1 Automatic cleaning without cleaning devices

During the rinsing and cleaning process with ignitable liquids under high voltage twice the value of the minimum distance to the earthed parts (see 5.2.5) shall be observed.

Values of safe distances between the live parts and the earthed parts shall be given in the information for use, see 7.2.2.

5.1.4.2 Automatic cleaning with cleaning devices

Before starting the cleaning process with ignitable liquids in cleaning devices with atomiser (e.g. bell cleaners), all parts of the spraying systems shall be discharged below values given in 5.1.2, or to a voltage of 1,25 kV at most.

5.1.4.3 Manual cleaning

An interface shall be provided to allow the interlocking, if necessary with guard locking, of means of access to the spray booth with the high voltage supply.

If it is possible to start manual cleaning of live parts before the limits given in 5.1.2 or a voltage of 1,25 kV are undercut, a signal shall be provided to activate the guard locking until the spraying systems are discharged below the limits.

5.1.5 Automatic fire extinguishing system

5.1.5.1 General

Based on a risk assessment it shall be decided, which fire extinguishing system shall be installed:

- a locally acting fire extinguishing system and/or
- a fire extinguishing system for the spray booth interior.

The installed system shall be actuated immediately in case of a fire.

5.1.5.2 Interface to locally acting fire extinguishing system

An interface shall be provided to allow the interlocking of the fire detection system with the locally acting fire extinguishing system. Based on a risk assessment the coating material supply, the cleaning liquid supply, the high-voltage supply, the horn/shaping air, and the atomizing air shall be interrupted.

NOTE Fire detection systems, see EN 16985:2018.

5.1.5.3 Interface to fire extinguishing system for the spray booth interior

An interface shall be provided to allow the interlocking of the fire detection system with the fire extinguishing system for the spray booth interior and the high-voltage supply. Based on a risk assessment the coating material supply, the cleaning liquid supply, the horn/shaping air, and the atomizing air shall be interrupted.

NOTE Fire detection systems, see EN 16985:2018.

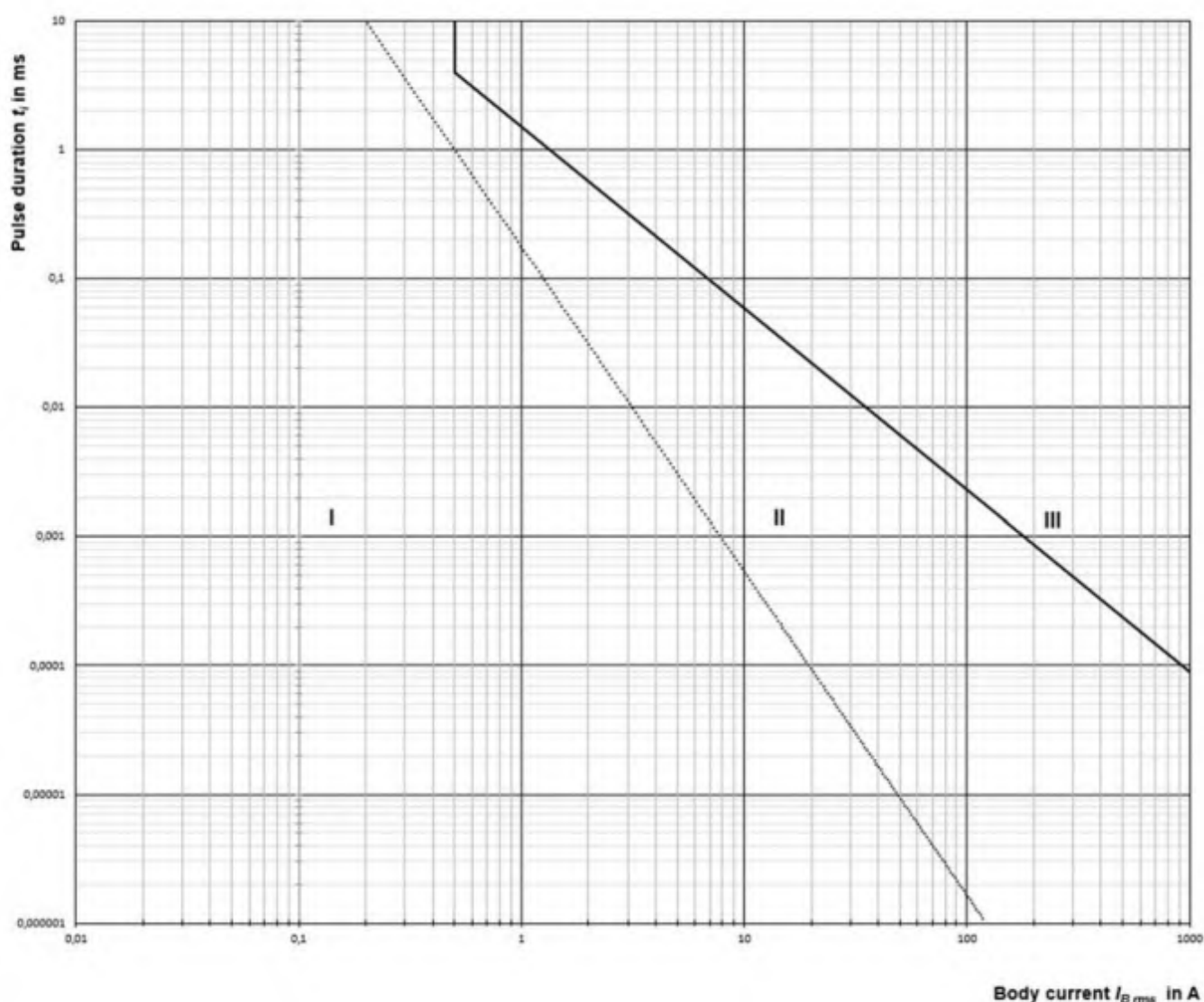
5.1.6 Prevention of electric shock

5.1.6.1 Undercutting the limits of electric shock

For undercutting the limits of electric shock, spraying systems shall be designed such that

- in case of a long contact (>1 s) of the user with live parts or charged passive parts, the current flowing through the user does not exceed the value of 25 mA d.c., and
- in the case of a discharge to the user with a pulse duration t_i shorter than 10 ms from live parts or charged passive parts, the body current $I_{B\ rms}$ and the pulse duration t_i of the discharge are within area I of Figure 1.

NOTE Discharges between 10 ms and 1 s do not occur at spraying systems.



Key

Area Effect on human body

- I no risk of strong muscular reactions (safety limit)
- II no risk of ventricular fibrillation
- III increasing risk of ventricular fibrillation

NOTE 1 Analysis of electrical accidents led to the result that the risk of ventricular fibrillation is especially present for long-term longitudinal flow (from the hands to the feet). These findings are considered for the calculation of the effective value of the current.

NOTE 2 Areas I to III are based on the areas DC-2 to DC-4 defined in IEC 60479-1:2018 and extrapolated to shorter pulse durations.

Figure 1 — Pulse duration - body current, risk of muscular reactions and ventricular fibrillation

5.1.6.2 Prevention of contact with live parts

An interface shall be provided to allow the interlocking, if necessary with guard locking, of means of access to hazardous areas (i.e. spray booth). Following signals shall be provided:

- for moveable guards a signal to activate the guard locking until the spraying systems are discharged below the limits and/or
- for permanent openings a signal to allow the interlocking of protective devices (e.g. light curtains, pressure-sensitive mats) with the high voltage supply.

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Requirements of the control system, depending on the values of the body current $I_{B\ rms}$ and the pulse duration t_i are within area II or III of Figure 1, are given in 5.4.1.

The time needed to discharge the system shall be given in the information for use, see 7.2.2.

Information on measures to prevent charging of persons or objects by the present electric field shall be given in the instruction manual, see 7.2.

5.1.7 Limiting parts

In order to fulfil 5.1.2 or 5.1.6.1 a proven hardware solution may be considered: electric limiting parts shall consist of at least two zener diodes, resistors or equivalent parts (e.g. power semiconductors). These parts shall be loaded to no more than two-thirds of the maximum valued rates. To ensure the required reliability of all electrical limiting parts, the spraying system shall

- withstand a short-circuit between the high voltage electrode and earth for 5 min. The housing of the spraying system shall remain without any hazardous damages, and the degree of protection of the control system given in 5.4.2 shall be maintained, or
- be switched off automatically in case of a short-circuit in no more than 1 s.

5.2 Requirements for all types of spraying systems**5.2.1 General**

Spraying systems shall fulfil the respective requirements of EN 1953:2025.

The values of the maximum high voltage and the maximum short-circuit current of spraying systems shall be defined by the manufacturer.

5.2.2 Reliability

Components determining the ignition safety shall be constructed, located, and built-in, that the safety of electrostatic spraying systems is not affected.

NOTE Examples of components determining the ignition safety are spraying devices, earthing cables, resistors, and other electronic components.

Insulating materials of parts under high voltage shall be designed in compliance with the conditions for operation, transport, and storage.

The live parts of the spraying device shall be designed in such a way to prevent occurrence of hazardous discharges within 90 min. under maximum high voltage.

5.2.3 Connection of cables under high voltage

Electrical connecting cables shall be mechanically secured to the applicator or associated equipment, e.g. screwed on or secured with bayonet fitting or similar device.

5.2.4 High-voltage cable

The high-voltage cable shall be designed in such a way that no breakdown occurs.

5.2.5 Minimum distances to live parts

The minimum distance in air between the live parts and the earthed parts shall not be less than 0,25 cm/kV. These minimum distances are not applicable both for the distance between the electrostatic spraying device and the workpiece (with the exception of systems according to 5.1.4.1), and the design-specific distances of the spraying devices.

Values of minimum distances between the live parts and the earthed parts shall be given in the information for use, see 7.2.2.

NOTE Possible occurrence of surface discharges at the spraying device can influence the safe distances.

5.2.6 Electrical safety

The electric equipment of the spraying system not related to the high-voltage system shall comply with EN 60204-1:2018.

5.2.7 Bonding to earth potential

Spraying systems shall have an earth connection. The connection shall be designed in mechanically secured way that prevents loosening. Detachable earth connections shall be marked clearly.

All conductive and dissipative parts of the spraying system which are not at high voltage potential shall be bonded to earth potential with a resistance of $\leq 1 \text{ M}\Omega$. Bonding to earth potential of conductive and dissipative parts inside the spraying system can be neglected if hazardous discharges have been prevented by design. Conductive and dissipative parts connected to measuring and control circuits shall be bonded to earth potential with a resistance of $\leq 100 \text{ M}\Omega$. This does not apply to the high-voltage path, which may be bonded to earth potential via a high-voltage resistor in order to measure and / or permanently discharge the high voltage.

NOTE High-voltage resistors used in this field typically have a resistance from $1 \text{ G}\Omega$ to $10 \text{ G}\Omega$.

5.2.8 Safeguard against unauthorised switch-on

The high-voltage supply shall be safeguarded against unauthorised switch-on.

Switch-off shall be possible at any time.

NOTE Examples for safeguards against unauthorised switch-on are key switches or hardware and software authorization.

5.2.9 Safeguard against modification of safety relevant parameters

The high-voltage supply and the spraying system shall be safeguarded against an unauthorised modification of safety relevant parameters (e.g. switch-off limits, maximum operating voltage).

NOTE Safety against unauthorised modification of safety relevant parameters is ensured by, for instance, safeguarded control cabinets or software authorisations.

5.3 Requirements for the coating material supply system

5.3.1 General

Coating material supply systems shall fulfil the requirements of EN 12621:2025.

5.3.2 Requirements for ignition protection

Parts of the coating material supply systems for type L-1 spraying system located in explosion-hazardous areas shall fulfil the same requirements for ignition protection as the spraying system under all operating conditions, see Table 2.

NOTE Conductive or dissipative liquids (e.g. cleaning liquids) could lead to hazardous discharges.

5.3.3 Prevention of hazardous discharges

Parts of the coating material supply system under high voltage of type L-2 and L-3 spraying systems shall

- fulfil the requirements in 5.1.3 and
- have a minimum separation distance through air of $0,25 \text{ cm/kV}$ to the earth potential.

NOTE Possible occurrence of surface discharges at the coating material supply system can influence the minimum distances.

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For closed electrical operation sites containing the coating material supply system under high voltage for type L-3 spraying systems requirements of 5.1.6.2 apply.

Coating material supply systems operating at high voltage and connected to type L-3 spraying systems shall be designed to enable the discharge of the whole system within 2 min. after turning off the main switch of the spraying system. After discharging the limit values of 5.1.6.1 shall be fulfilled.

5.3.4 Conductive and dissipative parts

If conductive or dissipative parts are used for the coating material supply system under high voltage, these parts shall be bonded to earth potential according to 5.2.7 or shall be connected to the high voltage supply in such a way that their potential is permanently identical with that of the spraying system. The equipotential bonding shall be done by means of a discrete electrical conductor.

5.3.5 Hoses of coating material supply under high voltage

Hoses of the coating material supply shall be

- made of insulating material;
- designed in such a way that no breakdown according to 6.3.5 occurs, with the exception of hoses laid in areas with high voltage that are at the same potential as the coating material inside the hose;
- mechanically secured to the applicator or associated equipment, e.g. screwed on or secured with bayonet fitting or similar device.

NOTE Hoses of coating material supply under high voltage can be shielded or unshielded.

5.3.6 Cleaning of coating material supply pipes and hoses

Hazardous discharges during cleaning of coating material supply pipes and hoses shall be avoided by

- measures to keep the coating material supply system on the same potential as the spraying system or
- fulfilling the requirements of 5.1.4.3.

5.3.7 Other insulating parts under high voltage

Other insulating parts under high voltage (e.g. vessels, housing) shall withstand a voltage of $1,5 U_{\max}$ by design (e.g. avoidance of breakdown).

5.4 Requirements for the control system**5.4.1 General**

Safety related control systems shall be designed in accordance with EN ISO 13849-1:2023.

Depending on the type, the minimum requirements for control systems of spraying systems are given in Table 3.

EN 16985:2018 defines higher requirements for control systems with reference to EN 50176:2009.

Table 3 — Requirements for safety functions of spraying systems

Safety function	Clause	PL ^a
Limitation of maximum transferred charge or maximum discharge energy by hard- and software	5.1.2	c ^b
Lowering or shut off of high voltage in constant-voltage mode and voltage-controlled mode	5.1.3.2	a ^c or c
Lowering or shut off of high voltage in constant-current and current-controlled mode	5.1.3.3	
Limitation of the maximum admissible operating voltage	5.1.3.3	
Cleaning process – without cleaning device Observing the safe distance	5.1.4.1	a ^a or c
Cleaning process – with cleaning device Interlocking of cleaning process with discharge function	5.1.4.2	c
Cleaning process – manual cleaning Interface to allow the interlocking of cleaning process with discharge function, or with access, with guard locking if applicable	5.1.4.3	c
Interlocking of the fire detection system with the locally acting fire extinguishing system, and if applicable, with the coating material supply, the cleaning liquid supply, the high-voltage supply, the horn/shaping air and the atomizing air	5.1.5.2	c
Interlocking of the fire detection system with the fire extinguishing system for the spray booth interior and the high-voltage supply, and if applicable with the coating material supply, the cleaning liquid supply, the horn/shaping air and the atomizing air	5.1.5.3	d
Interface to allow the interlocking of access points inside the spray booth with the high-voltage supply, with guard locking if applicable	5.1.6.2	Area II: b Area III: d
Interface to allow the interlocking of means of access to a closed electrical operation site, to exposed parts of the spraying system and to the coating material supply system under high voltage		
^a see EN ISO 13849-1:2023		
^b not required for L-1 and L-2 spraying systems with limiting parts according 5.1.7		
^c PL is sufficient, if an interlocking of forced ventilation and high voltage supply system according EN 16985:2018, 4.9.1 and Table 5, is installed		

5.4.2 Requirements for control systems of category 3G

Control systems, which are designed as equipment of category 3G, shall have at least a degree of protection provided by enclosure of IP 54 according to EN 60529:1991¹ and the maximum surface temperature.

6 Tests

6.1 Tests depending on the type of spraying systems

6.1.1 General

Tests of this clause shall be carried out depending on the type of the spraying systems and the related subclauses according to Table 2.

6.1.2 Test of transferred charge or discharge energy

The limit values of the maximum transferred charge according to Annex A or the maximum discharge energy according to Annex B shall be verified by measurement.

The test procedure according Annex A shall be used preferentially.

This is a type test.

6.1.3 Hazardous discharges

6.1.3.1 General

Tests of this clause shall be carried out depending on the selected mode of the spraying system.

6.1.3.2 Verification of the threshold value of overcurrent $I_{\bar{U}}$

The lowering or shut off procedure of the high voltage carried out with the threshold value of $I_{\bar{U}}$ shall be checked by passing the tests defined in Annex E.

This type test is also to be performed as routine test.

6.1.3.3 Verification of the threshold value of minimum output high voltage U_{\min}

The lowering or shut off procedure of the high voltage carried out with the threshold value of U_{\min} shall be checked by passing the tests defined in Annex E.

This type test is also to be performed as routine test.

6.1.4 Hazardous discharges during rinsing and cleaning processes

6.1.4.1 Automatic cleaning without cleaning devices

The value of the safe distance to the earth potential shall be measured.

This type test is also to be performed as routine test.

6.1.4.2 Automatic cleaning with cleaning devices

The limit values shall be verified by measurement of the maximum transferred charge according to Annex A, evaluation of the maximum discharge energy according to Annex B or measurement of the residual voltage.

This type test is also to be performed as routine test.

6.1.4.3 Manual cleaning

The interlocking shall be checked by functional test and by verification of the documentation.

The time of the guard locking shall be verified by measurement of the maximum transferred charge according to Annex A, measurement of the maximum discharge energy according to Annex B or measurement of the residual voltage.

This type test is also to be performed as routine test.

6.1.5 Automatic fire extinguishing system

6.1.5.1 General

It shall be verified if a locally acting fire extinguishing system and/or a fire extinguishing system for the spray booth interior is installed.

This type test is also to be performed as routine test.

6.1.5.2 Interface to locally acting fire extinguishing system

The interlocking of the fire detection system with the locally acting fire extinguishing system shall be checked by functional test. If applicable, the interruption of the coating material supply, the cleaning liquid supply, the high-voltage supply, the horn/shaping air, and the atomizing air shall be checked by functional test.

This type test is also to be performed as routine test.

6.1.5.3 Interface to fire extinguishing system for the spray booth interior

The interlocking of the fire detection system with the fire extinguishing system for the spray booth interior and the high-voltage supply shall be checked by functional test. If applicable, the interruption of the coating material supply, the cleaning liquid supply, the horn/shaping air, and the atomizing air shall be checked by functional test.

This type test is also to be performed as routine test.

6.1.6 Prevention of electric shock

6.1.6.1 Undercutting the limits of electric shock

The current shall be measured with a μ -ampere meter/m-ampere meter, from the end of the high-voltage electrode or of the nozzle or of the bell/disc or of conductive and dissipative parts of the spraying system against earth potential.

Compliance with the area I of Figure 1 shall be tested by measuring the peak current value $I_{C(p)}$ and the time period of the discharge and evaluation of the body current $I_{B\text{ rms}}$ and the pulse duration t_i according to Annex C.

This is a type test.

6.1.6.2 Prevention of contact with live parts

All safety functions described in 5.1.6.2 shall be checked by functional test and by verification of the documentation.

Safety measures at other openings allowing contact with live parts shall be checked by functional test and by verification of the documentation.

This type test is also to be performed as routine test.

6.1.7 Test of limiting parts

Requirements on limiting parts shall be verified by measurement and check of the documentation.

If the switch-off function is enabled, the switch-off time shall be measured in accordance with 5.1.7.

This is a type test.

6.2 Tests for all types of spraying systems

6.2.1 General

Compliance to EN 1953:2025 shall be evaluated by test procedures described in that standard.

The maximum high voltage shall be measured without any load at the end of one high-voltage electrode at the spraying device. Here, further high-voltage electrodes shall be sealed with high-voltage insulation kit, if necessary.

The maximum short-circuit current shall be measured with a μ -ampere meter/m-ampere meter, from the end of the high-voltage electrode or of the nozzle or of the bell/disc or of conductive parts of the spraying system against earth potential. The duration of the test shall be at least 5 min.

This is a type test.

6.2.2 Test of the reliability

The test shall be carried out for 90 min. at U_{\max} . During the test corona current at the high-voltage electrode shall be suppressed, e.g. by means of an insulating moulding material. All parts of the spraying system at earth potential during normal operation shall be earthed during the test. The test is passed if no hazardous discharges can be detected by measurement and visual inspection.

This is a type test.

6.2.3 Tests of connection of electrical cables

Connections of electrical cables shall be checked by visual inspection and review of documentation.

This is a type test.

6.2.4 Tests of the high-voltage cables

A sample of the high-voltage cable of at least 2,5 m shall be raised to a voltage of $1,2 U_{\max}$ for a duration of 24 h, the electrically conductive shield of the cable shall be earthed. $80 \text{ cm} \pm 5 \text{ cm}$ of the shielding shall be removed at each end of the cable.

If the cable does not have an electrically conductive shield, a sample cable, at least 2,5 m in length, shall be placed on an earthed metal plate. A test voltage of $1,2 U_{\max}$ shall be applied for 24 h. Alternatively the test shall be carried out in an earthed water bath.

The duration of 24 h shall alternatively be replaced by 4 sessions with a duration of 7 h each and a break of less than 24 h in between.

This is a type test.

6.2.5 Minimum distances of live parts

The values of the minimum distances of live parts to the earth potential shall be measured.

This type test is also to be performed as routine test.

6.2.6 Electrical safety

Measures of the electrical safety shall be checked by measurement and documentation.

This is a type test.

6.2.7 Test of bonding to earth potential

Bonding to earth potential shall be proven by measurement and verified by visual inspection and check of the documentation. The resistance shall be measured using e.g. a Megohmmeter/Insulation Resistance Tester with a measurement voltage up to 1 000 V.

This type test is also to be performed as routine test.

6.2.8 Safeguard against unauthorised switch-on

The safeguard against unauthorised switch-on shall be checked by functional test and documentation.

The switch-off at any time shall be checked by functional test.

This is a type test.

6.2.9 Safeguard against modification of safety relevant parameters

The safeguard against modification of safety relevant parameters shall be checked by functional test and documentation.

This is a type test.

6.3 Test of the coating material supply system

6.3.1 General

Compliance with EN 12621:2025 shall be evaluated by test procedures described in that standard.

6.3.2 Tests of ignition protection

For tests of coating material supply system for type L-1 spraying systems see 6.1.2.

This is a type test.

6.3.3 Tests of measures preventing hazardous discharges

For tests of coating material supply system see 6.1.3.

The discharging of the complete coating material supply system operating at high voltage and connected to type L-3 spraying systems shall be tested according to Annex A or C.

This type test is also to be performed as routine test.

6.3.4 Test of conductive and dissipative parts

Bonding to earth potential shall be tested according to 6.2.7.

Equipotential bonding between high voltage supply system and the coating material supply system shall be verified by measurement. A discrete electrical conductor shall be verified by visual inspection, measurement and check of documentation.

This type test is also to be performed as routine test.

6.3.5 Test of the coating material supply hose with coating material under high voltage

The specific d.c. resistance of the insulating material shall be verified by check of the documentation.

Material supply hoses with earthed shielding shall be proven by measurement and verified by check of the documentation.

A sample of the hose of at least 2,5 m shall be filled with tap water or another conductor at ambient temperature. The tap water or the conductor inside the hose shall be raised to a voltage of $1,2 U_{\max}$ for a duration of 24 h; the electrically conductive shield of the hose shall be earthed. $80 \text{ cm} \pm 5 \text{ cm}$ of the shielding shall be removed at each end of the hose.

If the supply hose does not have an electrically conductive shield, a sample of at least 2,5 m in length shall be placed on an earthed metal plate. A test voltage of $1,2 U_{\max}$ shall be applied to the tap water or to the conductor for 24 h. Alternatively the test shall be carried out in an earthed water bath.

The duration of 24 h shall alternatively be replaced by 4 sessions with a duration of 7 h each and a break of less than 24 h in between.

The fixing of the material supply hose under high voltage shall be checked by visual inspection and review of documentation.

This is a type test.

6.3.6 Tests of safety of cleaning procedure

Measures to keep the coating material supply system on the same potential as the spraying system shall be verified by measurement.

Measures according 5.1.4.3 shall be checked according to 6.1.4.3.

This type test is also to be performed as routine test.

6.3.7 Test of other insulating parts under high voltage

The properties of other insulating parts under high voltage shall be verified by check of design and documentation.

This is a type test.

6.4 Test of the control system

6.4.1 General

Depending on the type of spraying systems, the required PL's for the safety functions of the control system shall be checked by functional test and documentation.

The functionality of the interfaces shall be verified by functional test and check of documentation.

This type test is also to be performed as routine test.

6.4.2 Test for control systems of category 3G

For control systems, which are designed as equipment of category 3G, compliance with the degree of protection provided by enclosure of IP 54 in accordance with EN 60529:1991¹ shall be verified.

This is a type test.

7 Information for use

7.1 General

In addition to the requirements of EN 1953:2025, Clause 6 and EN 12621:2025, Clause 6, the manufacturer shall provide information for use for all application systems.

The information for use shall comply with the requirements in EN ISO 12100:2010, Clause 6, especially 6.4.5 "Accompanying documents (in particular — instruction handbook)" and 6.4.4 "Markings, signs (pictograms) and written warnings".

7.2 Instruction for use

7.2.1 General

Every automatic electrostatic application system shall be accompanied by an instruction manual according to EN ISO 12100:2010.

NOTE The instruction manual can be written in a general comprehensible, illustrated, or symbolic language.

The manufacturer shall provide information for use for all application systems given in EN 1953:2025, Clause 6 and EN 12621:2025, Clause 6. In addition, the instruction manual shall indicate the type(s) of the electrostatic application system given in Table 1 and the information given in Table 4.

The instruction manual shall contain the admissible combinations of devices, including the indication of the admissible exchangeable attachment parts.

The instruction manual shall contain a list of safety relevant spare and wear parts.

7.2.2 Information on installation

The following information shall be given:

- spraying systems shall be used only in spraying areas according to EN 16985:2018, or under equivalent ventilation conditions. Additional requirements apply:
 - an optical signal indicating connection to high voltage at doors and openings of spray booths allowing access to or contact with live parts is recommended;

- openings of spray booths allowing contact with or proximity to live parts, which are not safeguarded by interlocking, shall be closed and shall only be opened with a key or a tool;
- hazardous discharges with respect to the type of spraying system used shall be avoided on insulating surfaces of the spray booth, e.g. walls, covers, plates and labels;
- all conductive and dissipative components, e.g. floors, walls, ceilings, protective gratings, conveying system, jigs, or construction elements inside the spray booth shall be connected to the equipotential bonding, except for the parts under high voltage for operational reasons. The leakage resistance shall not exceed 1 MΩ. The resistance shall be measured using a Megohmmeter/Insulation Resistance Tester with a measurement voltage up to 1 000 V. The construction of the jigs shall ensure the earthing of the workpieces during the application process;
- spraying systems and coating material supply systems at high voltage potential shall be operated in combination with conductive or dissipative floors tested in accordance with EN 61340-4-1:2004.
- the standards of all spraying systems / applicators that are compatible with the control system, see 7.3.6;
- description of the operational limitations of equipment marked with "X", for instance
 - for spraying devices: "The spraying system may only operate as Type L-1 up to a current of 100 μA and a voltage up to 80 kV. For higher values of currents and/or voltage the spraying system operates as a Type L-2",
 - for control systems: "The control system may only operate in the constant-current operation mode "I-constant" with the shutdown threshold U_{min} ";
- if applicable the discharge time according to 5.1.6.2;
- if applicable the values of safe distances between the live parts and the earthed parts, see 5.1.4.1 and 5.2.4.

7.2.3 Information on operation

The instruction manual shall contain at least the following additional information:

- operating of application system by competent persons;
- settings required for a correct operation of the application system;
- the maximum conductivity in μS/cm and/or nS/cm of the ignitable liquid coating materials, thinner, cleaning or rinsing liquids that can be processed with the spraying system and the coating material supply system;
- specific requirements for the painting process with regard to avoid hazardous charging of workpieces made of insulating material (e.g. bonding to ground via liquid film of paint);
- dissipative footwear to be used by the operator shall comply with EN ISO 20344:2021, the measured insulation resistance shall not exceed 100 MΩ;
- protective clothing, including gloves, shall comply with EN 1149-5:2018, the measured insulation resistance shall not exceed 100 MΩ;
- daily visual check of damages and contamination at spraying systems;
- prohibition of usage of damaged spraying systems;
- prohibition of usage by operators with active body aids, e.g. cardiac pacemaker, insulin pump.

7.2.4 Cleaning, maintenance, and corrective maintenance

The manufacturer shall provide comprehensive information on cleaning and maintenance. The stationary electrostatic spraying device shall be maintained regularly according to the instructions of the manufacturer. The instruction manual shall contain the following information:

- during cleaning, maintenance, and corrective maintenance all energy supply shall be disconnected;
- spare parts and wear parts generally have safety relevant properties;
- worn parts shall be replaced immediately;
- use only electrically conductive container for cleaning liquids; the containers shall be earthed;
- non-ignitable cleaning agents shall be preferred;
- appropriate measures shall ensure that the resistance to earth of the suspending point of the workpiece shall not exceed 1 MΩ. The resistance shall be measured using a Megohmmeter/Insulation Resistance Tester with a measurement voltage up to 1 000 V;
- if workpieces are earthed by conductive transport devices (e.g. jigs, hooks), these devices shall be cleaned to remove insulating layers of coating materials, or shall be designed such that generation of insulating layers are prevented.

7.2.5 Periodic inspections

The periodic inspections depend on the operational and local conditions. For all tests in Table 4 an interval of one year is recommended.

NOTE An automatic monitoring is considered to be equivalent.

Table 4 — Periodic inspections

Subclause	Reference
6.1.3	Prevention of hazardous discharges
6.1.3.2	Check of the lowering or shut off procedure of the high voltage with the threshold value of $I_{\text{Ü}}$
6.1.3.3	Check of the lowering or shut off procedure of the high voltage with the threshold value of U_{min}
6.1.4	Prevention of hazardous discharges during rinsing and cleaning processes
6.1.4.1	Measurement of safe distance to the earthed parts during automatic cleaning without cleaning devices
6.1.4.2	Measurement of maximum transferred charge or discharge energy or residual voltage of the spraying system
6.1.4.3	Test of interlocking of means of access to the spray booth with the high voltage supply Verification of time of guard locking if installed Measurement of maximum transferred charge or discharge energy or residual voltage of the spraying system
6.1.5	Fire extinguishing system
6.1.5.1	Verification of installation of locally acting fire extinguishing system and/or a fire extinguishing system for the spray booth interior

Subclause	Reference
6.1.5.2	Test of interlocking of the fire detection system with the locally acting fire extinguishing system If applicable, test of interruption of the coating material supply, the cleaning liquid supply, the high-voltage supply, the horn/shaping air, and the atomizing air
6.1.5.3	Test of interlocking of the fire detection system with the fire extinguishing system for the spray booth interior and the high-voltage supply If applicable, test of interruption of the coating material supply, the cleaning liquid supply, the horn/shaping air, and the atomizing air
6.1.6	Prevention of electric shock
6.1.6.2	Test of interlocking, if installed with guard locking, of means of access to hazardous areas (i.e. spray booth) Measurement of discharge time of the system Check of measures to prevent charging of persons or objects by the present electric field
6.2	Common safety requirements
6.2.5	Measurement of safe distance between live parts and earthed parts
6.2.6	Test according to EN 60204-1:2018
6.2.7	Test of bonding to earth potential
6.2.8	Functional test of safeguard against unauthorised switch-on of the switch
6.2.9	Functional test of safeguard against modification of safety relevant parameters
6.3	Coating material supply system
6.3.3	See 6.1.3.2 and 6.1.3.3
6.3.4	Check of discrete electrical conductor by visual inspection. Measurement of equipotential bonding of conductive and dissipative parts
6.3.6	Tests of measures to keep the coating material supply system on the same potential as the spraying system safety during cleaning procedure or See 6.1.4.3
6.4	Control systems
6.4.1	Test of all safety functions installed

7.3 Marking

7.3.1 General


Marking is subject to the relevant European directives.

In addition to the legal marking and the marking according to EN 1953:2025, the following information shall be provided for spraying system.

7.3.2 Spraying devices as equipment of category 3G

The marking of spraying devices as equipment of category 3G shall include:

— type of system according Table 1;

— ;

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- “II” for the equipment group;
- “3” for the equipment category;
- “G” for gas explosion protection;
- “Ex EN 50176”;
- “IIA” for the explosion group;
- “T” for the maximum surface temperature;
- if Specific Conditions of Use apply, the symbol “X” shall be placed after the certificate reference, if any;
- rated output voltage;
- rated output current.

NOTE According to this document, IIA means that paint formulations and formulations of solvents which do not predominantly contain constituents of substances of explosion group IIB can also be assigned to explosion group IIA and can be operated together with the spraying systems of this document.

7.3.3 Spraying devices as equipment of category 2G

In deviation to 7.3.2 the marking of spraying devices as equipment of category 2G shall include:

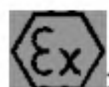
- The name or mark of the notified body, as well as the reference to the test certificate. These indications shall be preferably given in the following form: Year of issue (XX), the word ATEX followed by the consecutive number of the year (YYYY);
- “2G” for the equipment category.

NOTE An example of the marking of spraying devices as equipment of category 2G is given in 7.3.7

7.3.4 Control systems as safety, controlling or regulating device connected to products of category 2G

The marking of control systems as safety, controlling or regulating device connected to products of category 2G shall include:

- The name or mark of the notified body, as well as the reference to the test certificate. These indications shall be preferably given in the following form: Year of issue (XX), the word ATEX followed by the consecutive number of the year (YYYY);



- “II” for the equipment group;
- “(2)” for the equipment category;
- “G” for gas explosion protection;
- “[Ex EN 50176]”;
- the wording “admissible combinations of devices, see information for use”
- range of input voltages and whether a.c. or d.c.;

- range of input frequency;
- input power;
- rated output voltage;
- rated output current.

NOTE An example of the marking of control systems as safety, controlling or regulating device connected to products of category 2G is given in 7.3.8

7.3.5 Control systems as equipment of category 3G connected to products of category 2G

In deviation to 7.3.4 the marking of control systems as equipment of category 3G connected to products of category 2G shall include:

- “3 (2)G” for the equipment category;
- “Ex EN 50176”;
- “IIA” for the explosion group;
- if Specific Conditions of Use apply, the symbol “X” shall be placed after the certificate reference, if any.

NOTE 1 According to this document, IIA means that paint formulations and formulations of solvents which do not predominantly contain constituents of substances of explosion group IIB can also be assigned to explosion group IIA and can be operated together with the spraying systems of this document.

NOTE 2 An example of the marking of control systems as equipment of category 3G connected to products of category 2G is given in 7.3.9

7.3.6 Multiple marking of the control systems

If more than one of the standards EN 50050-1:2013, EN 50050-2:2013, EN 50050-3:2013, EN 50059:2025, EN 50176:2024, EN 50177:2009¹, EN 50223:2015, EN 50348:2010¹ are applicable to the control system, the marking of the control system shall be changed as follows:

Replace

- “EN 50176”

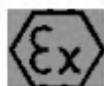
with

- “EN 50zzz”.


The instruction manual shall list the standards of all spraying systems / applicators that are compatible with the control system; “zzz” stands for the last three digits of all relevant standards.

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7.3.7 Example for marking of spraying device as equipment of category 2G (informative)

Name or registered trademark and address of the manufacturer			
Type L-2	production number	123456	year of manufacturing
	serial number	123456	2024
II 2G Ex EN 50176 IIA T6 X	N.A. XX/ATEX/YYYY		
output voltage [kV]	output current [µA]		
N.A. = Name or sign of the responsible notified body.			

7.3.8 Example for marking of control systems as safety, controlling or regulating device connected to products of category 2G (informative)

Name or registered trademark and address of the manufacturer			
*Admissible combinations of devices, see information for use			
	production number	123456	year of manufacturing
	serial number	123456	2024
II (2)G [Ex] EN 50zzz*	N.A. XX/ATEX/YYYY		
input voltage [V]	input frequency [Hz]	output voltage [V/kV]	
input power [W]		output current [µA]	
N.A. = Name or sign of the responsible notified body.			

7.3.9 Example for marking of control systems as equipment of category 3G connected to products of category 2G (informative)

Name or registered trademark and address of the manufacturer			
*Admissible combinations of devices, see information for use			
	production number	123456	year of manufacturing
	serial number	123456	2024
II (2)G Ex EN 50zzz* IIA T6	N.A. XX/ATEX/YYYY		
input voltage [V]	input frequency [Hz]	output voltage [V/kV]	
input power [W]		output current [µA]	
N.A. = Name or sign of the responsible notified body.			

7.3.10 Warning sign

A warning sign shall be placed at a noticeable place on the spraying system with following content: "Usage prohibited for operators with active body aids, e. g. cardiac pacemaker, insulin pump"

Annex A (normative)

Test of ignition protection for L-1 spraying systems including parts of the coating material supply system

A.1 Preliminary tests

During all tests of Annex A, Annex B, Annex C and Annex E, the values of the outlet high voltage and outlet current shall be set to the maximum values. The required relevant operational parameters shall be documented (e.g. supply voltage).

Before the tests of Annex A, Annex B or Annex C are carried out, a preliminary test with a conductive, earthed rod shall be carried out on the spraying system and the coating material supply system ready for operation and active high voltage. The aim of the preliminary test is to identify the critical parts of the spraying system and the coating material supply system with the strongest discharges to the rod or, for L-1 spraying systems including parts of the coating material supply system, a hand-held coulombmeter, which are operating in the hazardous area with potentially explosive atmosphere or where live parts or charged passive parts are accessible.

The preliminary test shall be carried out under conditions described in Annex A, Annex B, or Annex C but outside an ignition vessel and without test gas mixture.

The preliminary test shall be carried out with the coating material supply system and the spraying device with exchangeable attachment parts. The conductive, earthed rod or the parts of the spraying system and the coating material supply system shall be dynamically approached to each other several times. The critical parts at which the strongest discharges towards the rod occur visibly and audibly shall be determined qualitatively.

Alternatively, for L-1 spraying systems including parts of the coating material supply system, a quantitative preliminary test shall be carried out with a hand-held coulombmeter. The transferred charges resulting from the provoked discharges from the spraying system and the coating material supply system to the coulombmeter.

The coulombmeter used for the measurement shall have a 25 mm diameter ball electrode to provoke and detect the discharges. The evaluation of the transferred charge shall be based on Formula (A.1) or (A.2) with indication of the polarity. The measuring range shall be from ≤ 9 nC to ≥ 210 nC. The measured values shall be evaluated and displayed with an uncertainty of $\leq \pm 5$ % but not more accurate than ± 3 nC and with one decimal place. An earthing cable attached to the outside of the coulombmeter leads directly to the equipotential bonding rail of the measurement location.

$$Q = \int i(t) dt \quad (A.1)$$

$$Q = C \cdot U \quad (A.2)$$

A.2 General

Measurement shall be carried out at a relative humidity of ≤ 50 % and at a temperature of (22 ± 5) °C. The influence of the air pressure on the measurements can be neglected.

The test for ignition protection is carried out with a shunt and an oscilloscope. The transferred charges resulting from the provoked discharges from the spraying system and coating material supply system to the shunt will be measured with an oscilloscope. The discharge shall be measurable in the form of a non-oscillating pulse and related to a discharge curve of a capacitor discharge (RC-circuit).

NOTE 1 Oscillating pulse indicate a faulty construction, insufficient bandwidth of the shunt, double shielded coaxial cable and / or oscilloscope.

The shunt used for measurement shall be designed coaxially with at least three symmetrically arranged resistors and shall be equipped with a ball electrode having 25 mm in diameter. The resistances of the shunt shall be

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determined with an uncertainty of $\leq 2,5\%$ and shall be indicated to the third decimal place. The system consisting of shunt and double shielded coaxial cable shall ensure a limit frequency of ≥ 500 MHz. An earth cable attached to the outside of the shunt leads directly to the earth potential of the equipotential bonding rail of the test facility.

NOTE 2 In general, the shunt has a resistance between 0,100 Ω and 0,500 Ω .

The oscilloscope used for measurement shall record the measurements with ≥ 1 GS/s (gigasamples per second) and with a bandwidth of ≥ 300 MHz. The d.c. amplification of the oscilloscope shall have an uncertainty of $\leq 2\%$. The stability of the time base shall be ≤ 20 ppm related to a time interval of 1 ms. Prior to the measurements, the zero line of the oscilloscope shall be set so that the zero-point noise is as low as possible and evenly scattered around the zero line. The zero integral $\int U dt$ forms a value of $< 1,5$ nV s and the total discharge will be recorded on the screen of the oscilloscope. The entire measurement system for recording the discharge shall be aligned to 50 Ohm.

NOTE 3 Standard values for adjustment of the oscilloscope are in a range of 20 mV/div to 1 V/div, between 20 ns/div and 100 ns/div; for the zero integral at ± 100 pV s or less. The entire measurement system is usually operated with 50 Ohm input impedance at the oscilloscope.

All parts of the spraying system and the material supply system identified as critical in the preliminary test which are operating in potentially explosive atmospheres, as well as the spraying device together with exchangeable attachment parts shall be tested. For tests with exchangeable attachment parts, the smallest and largest parts shall be used.

The spraying system and the coating material supply system for coating materials with a conductivity up to 50 nS/cm shall be tested without liquid coating material or water.

The spraying system and the coating material supply system for coating materials with a conductivity higher than 50 nS/cm shall be tested as follows:

The coating material supply system shall be filled up to the nozzle of the spraying device bubble-free with saltwater with a conductivity of $2\,750\ \mu\text{S}/\text{cm} \pm 250\ \mu\text{S}/\text{cm}$.

NOTE 4 The conductivity of the test fluid is higher than the maximum allowable value of $2\,000\ \mu\text{S}/\text{cm}$ in this document for safety reasons.

During the test under high voltage, the nozzle of the spraying device shall be kept closed (stagnant medium), or, if no high voltage is otherwise released, shall be kept open (flowing medium). The tests shall be carried out with the implementation of the coating material supply system (in the arrangement / laying of hoses in particular), which leads to the highest possible electrical capacitance of the system. Tests shall be performed in the most unfavourable configurations in terms of length and diameter of coating material supply hoses (original parts) permitted by the manufacturer, which leads to the highest electrical capacitance and the lowest electrical resistance in these hoses to the spraying device.

The maximum values shall be set in case of adjustable high voltage and adjustable output current.

During the test with active high voltage, the critical parts or ball electrode shall be brought in the most unfavourable angle and velocity dynamically nearer to each other. The periodic discharges provoked by this process will be measured by the oscilloscope as integral $\int U dt$. Over 5 min > 100 discharges shall be provoked quickly in a consecutive way for each configuration of the spraying system and the coating material supply system and the integral is recorded in nV s. The maximum transferred charge Q of the spraying system and the coating material supply system results from the absolute maximum value of the integral divided by the resistance of the shunt (in Ω) according to the following relationship: $Q = |\int i(t)dt| = 1/R |\int u(t)dt|$.

The test will be considered to be successful, if the absolute values of the maximum transferred charge Q do not exceed the limit values given in 5.1.2.

The uncertainties for this measurement method are considered appropriately by the limit values for the maximum transferred charge.

Annex B (normative)

Ignition test within the gas mixture for L-1 spraying systems including parts of the coating material supply system

B.1 Preliminary tests

See Annex A, A.1.

B.2 General

The ignition test of spraying system and the coating material supply system for ignitable liquid coating materials shall be performed with a combustible test gas mixture having a minimum ignition energy of 0,24 mJ.

NOTE 1 A minimum ignition energy of 0,24 mJ is given by a test gas mixture of propane and air containing $(5,25 \pm 0,25)$ vol % propane N35 with a purity of 99,95 vol % at (22 ± 5) °C, a relative humidity ≤ 3 % in a pressure range of 800 hPa to 1 100 hPa.

NOTE 2 For the preparation of the test gas mixture, calibrated mass flow controllers (MFCs) or equivalent calibrated devices with an accuracy of < 1 % and an appropriate mixing section have proven to be suitable.

The ignition test shall be carried out with active high voltage in an ignition vessel made of insulating, transparent material on the spraying system and the coating material supply system ready for operation.

In the case of a statically filled ignition vessel, a test cycle lasts 5 min and is carried out four times, each time using a new test gas mixture.

For dynamically filled ignition vessels where the test gas mixture is passed continuously and laminarly through the ignition vessel, the duration of the entire test is 20 min. In this case the test is carried out without interruption.

All parts of the spraying system in combination with the coating material supply system identified as critical in the preliminary test which are operating in potentially explosive atmospheres, as well as the spraying device together with exchangeable attachment parts shall be tested (see Figure B.1). For tests with exchangeable attachment parts, the smallest and largest parts shall be used.

The spraying system and the coating material supply system for coating materials with a conductivity up to 50 nS/cm shall be tested without liquid coating material or water.

The spraying system and the coating material supply system for coating materials with a conductivity higher than 50 nS/cm shall be tested as follows:

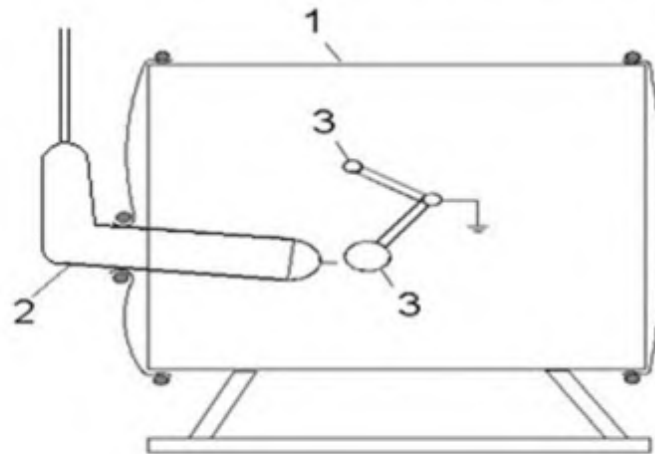
The coating material supply system shall be filled up to the nozzle of the spraying device bubble-free with saltwater with a conductivity of $2\,750\ \mu\text{S}/\text{cm} \pm 250\ \mu\text{S}/\text{cm}$.

NOTE 3 The conductivity of the test fluid is higher than the maximum allowable value of 2 000 $\mu\text{S}/\text{cm}$ in this document for safety reasons.

During the test under high voltage, the nozzle of the spraying device shall be kept closed (stagnant medium) without escape of water and pressurized air. The tests shall be carried out with the implementation of the coating material supply system (in the arrangement / laying of hoses in particular), which leads to the highest possible electrical capacitance of the system. Tests shall be performed in the most unfavourable configurations in terms of length and diameter of coating material supply hoses (original parts) permitted by the manufacturer, which leads to the highest electrical capacitance and the lowest electrical resistance in these hoses to the spraying device.

B.3 Preparations

For adjustable output high voltage and adjustable output current, the highest values shall be set.



Key

- 1 ignition vessel
- 2 critical parts of the electrostatic spraying system
- 3 grounded metal spheres with Ø 10 mm and Ø 25 mm

Figure B.1 — Example of a test arrangement

B.4 Test

The test of the critical parts of the spraying system and the coating material supply system is carried out with active high voltage in an ignition vessel filled with the test gas mixture. Dilution of the test gas mixture during the test shall be avoided. The critical parts of the spraying system and the coating material supply system shall be dynamically approached one after the other to the two grounded metal spheres with diameters of 10 mm and 25 mm. This causes periodic discharges to the grounded metal spheres. For each configuration ≥ 100 discharges shall be provoked within 5 min.

B.5 Result

The test is passed if the explosive test gas mixture is not ignited.

Annex C (normative)

Compliance with area I for L-2 spraying systems including parts of the coating material supply system

C.1 Preliminary tests

See Annex A, A.1.

C.2 General

Measurement shall be carried out at a relative humidity of $\leq 50\%$ and at a temperature of $(22 \pm 5)^\circ\text{C}$. The influence of the air pressure on the measurements can be neglected.

The measurement of a discharge with the peak current value $I_{C(p)}$ and the pulse duration t_i shall be carried out with a suitable test setup. Suitable are e.g.

- a shunt, double shielded coaxial cable and oscilloscope; or
- a current transformer, double shielded coaxial cable, if necessary, with an attenuator and an oscilloscope.

The discharge shall be measurable in the form of a non-oscillating pulse and related to a discharge curve of a capacitor discharge (RC-circuit).

NOTE 1 Oscillating pulse indicates a faulty construction, insufficient bandwidth of the shunt, double shielded coaxial cable, attenuator, current transformer and / or oscilloscope.

The discharges shall be provoked from the spraying system and the coating material supply system under high voltage to a ball electrode having 25 mm in diameter which is joined with a low-inductance connection cable (stranded wire) having a wire cross section $A \geq 6 \text{ mm}^2$ to ground potential via a low-inductance high voltage 500 Ω resistor with sufficient electric strength (e.g. $U_{max} = 40 \text{ kV}$, $P = 3 \text{ W}$).

NOTE 2 The resistance of the used low-inductance high voltage 500 Ω resistor is the resistance for the current path "hand to hand" and lower than the lowest resistance for the current path "hand to both feet" with 50 k Ω . Due the possible of the current path "hand to hand" in case of failure and for safety reasons the 500 Ω resistor will be used.

The shunt used for measurement shall be designed coaxially with at least three symmetrically arranged resistors. The resistances of the shunt shall be determined with three decimal places and an uncertainty of $\leq 2,5\%$.

NOTE 3 In general, the shunt has a resistance between 0,100 Ω and 0,500 Ω .

The current transformer shall have a bandwidth $\geq 100 \text{ MHz}$, a theoretical rise time $< 2 \text{ ns}$ and a peak current of $\geq 1\,000 \text{ A}$.

NOTE 4 Measurements have shown that a current transformer with a bandwidth of $\geq 200 \text{ MHz}$ a theoretical rise time less than 2 ns and a peak current of $\geq 1\,000 \text{ A}$, if necessary, in combination with an attenuator with a division ratio of 10:1 and a bandwidth of 100 MHz, can be used.

NOTE 5 Current transformers and shunts are available in different designs. Ring forms were built around the path to earth; integrated forms are built into the path to earth.

The attenuator used for measurement shall have a division ratio of $\geq 10:1$ with a bandwidth $\geq 100 \text{ MHz}$.

The oscilloscope used for measurement shall record the measurements with $\geq 1 \text{ GS/s}$ (gigasamples per second) and with a bandwidth of $\geq 300 \text{ MHz}$. The d.c. amplification of the oscilloscope shall have an uncertainty

of $\leq 2\%$. The stability of the time base shall be ≤ 20 ppm related to a time interval of 1 ms. Prior to the measurements, the zero line of the oscilloscope shall be set so that the zero-point noise is as low as possible and evenly scattered around the zero line. The pre-trigger of the oscilloscope shall be set in such a way that the peak current value $I_{C(p)}$ and the pulse duration t_i will be displayed on the screen. The entire measurement system for recording the discharge shall be aligned to 50 Ohm.

NOTE 6 Standard values for adjustment of the oscilloscope are in a range of 20 mV/div to 1 V/div, between 1 μ s/div and 200 μ s/div. The entire measurement system is usually operated with 50 Ohm input impedance at the oscilloscope.

All parts of the spraying system in combination with the coating material supply system identified as critical in the preliminary test which are operating in the hazardous area where live parts or charged passive parts are accessible, as well as the spraying device together with exchangeable attachment parts shall be tested. For tests with exchangeable attachment parts, the smallest and largest parts shall be used.

The spraying system and the coating material supply system for coating materials with a conductivity up to 50 nS/cm shall be tested without liquid coating material or water.

The spraying system and the coating material supply system for coating materials with a conductivity higher than 50 nS/cm shall be tested as follows:

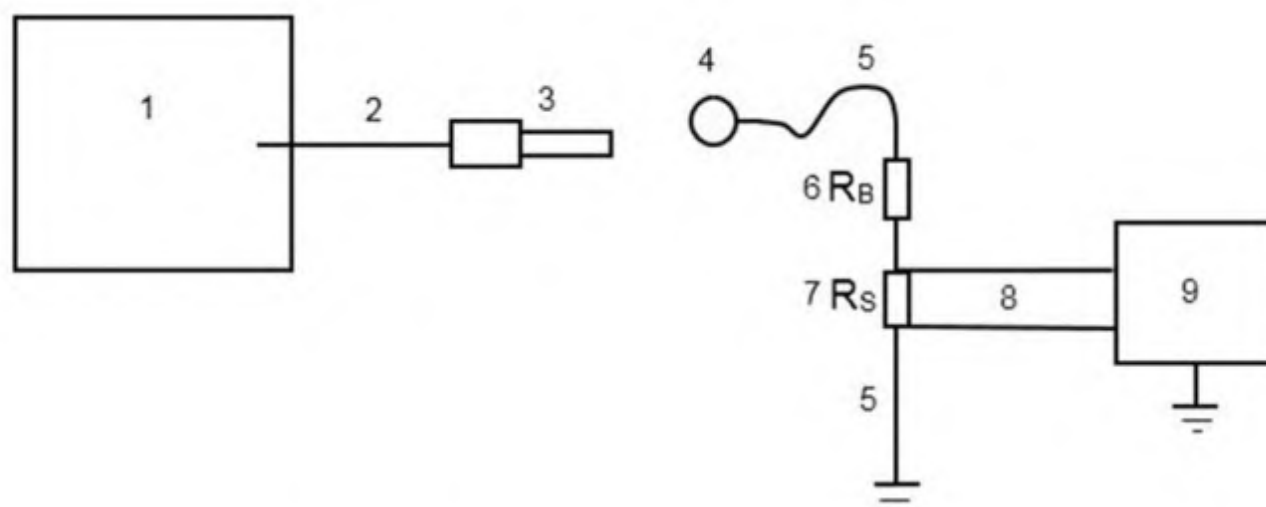
The coating material supply system shall be filled up to the nozzle of the spraying device bubble-free with saltwater with a conductivity of $2\,750\ \mu\text{S}/\text{cm} \pm 250\ \mu\text{S}/\text{cm}$.

NOTE 7 The conductivity of the test fluid is higher than the maximum allowable value of 2 000 $\mu\text{S}/\text{cm}$ in this document for safety reasons.

During the test under high voltage, the nozzle of the spraying device shall be kept closed (stagnant medium) without escape of water and pressurized air or if no high voltage is otherwise released, kept open (flowing medium) with escape of water and with pressurized air. The tests shall be carried out with the implementation of the coating material supply system (in the arrangement / laying of hoses in particular), which leads to the highest possible electrical capacitance of the system. Tests shall be performed in the most unfavourable configurations in terms of length and diameter of coating material supply hoses (original parts) permitted by the manufacturer, which leads to the highest electrical capacitance and the lowest electrical resistance in these hoses to the spraying device.

The maximum values shall be set in case of adjustable outlet high voltage and adjustable outlet current.

Figure C.1 and Figure C.2 show the equivalent circuit diagrams of the described measurement systems.

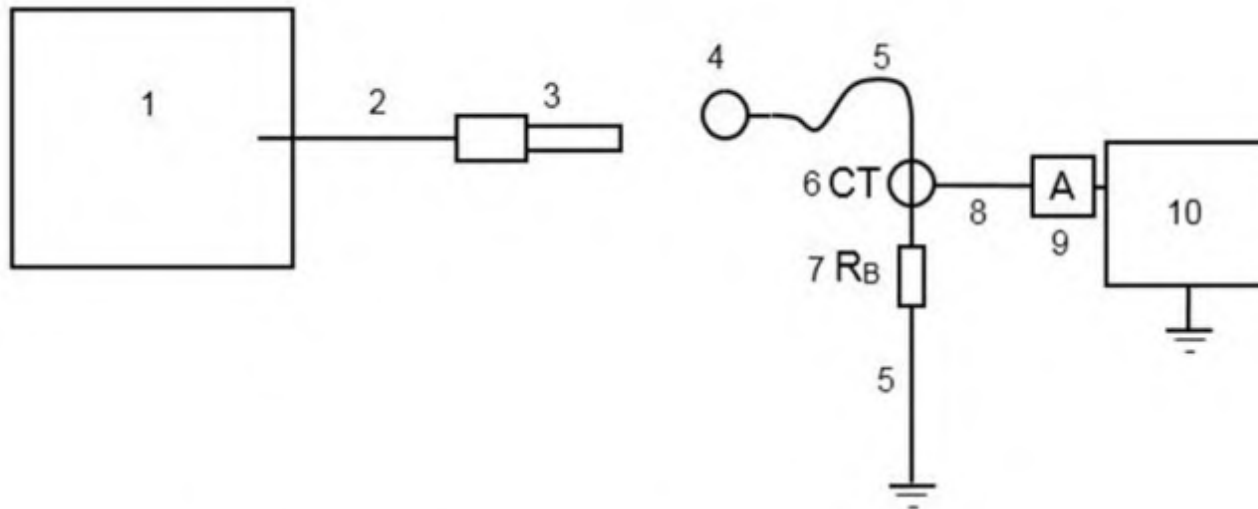
**Key**

1	coating material supply system (salt-water, lacquer)	= EUT
2	coating material supply hose	
3	spraying system	
4	ball electrode (Ø 25 mm)	
5	connection cable $A \geq 6 \text{ mm}^2$ (stranded wire)	
6	low-inductance high-voltage resistor (500 Ω)	
7	shunt resistor (e.g. 0,200 Ω)	
8	coaxial cable (e.g. double shielded BNC cable)	
9	oscilloscope	

NOTE 1 Use either Figure C.1 or Figure C.2.

NOTE 2 EUT: equipment under test.

Figure C.1 — Equivalent circuit diagram with shunt and oscilloscope

**Key**

1	coating material supply system (salt-water, lacquer)	= EUT
2	coating material supply hose	
3	spraying system	
4	ball electrode (Ø 25 mm)	
5	connection cable $A \geq 6 \text{ mm}^2$ (stranded wire)	
6	current transformer	
7	low-inductance high-voltage resistor (500 Ω)	
8	coaxial cable (e.g. double shielded BNC cable)	
9	attenuator (optional)	
10	oscilloscope	

NOTE 1 Use either Figure C.1 or Figure C.2.

NOTE 2 EUT: equipment under test.

Figure C.2 — Equivalent circuit diagram with current transformer and oscilloscope

During the test with active high voltage, the critical parts or ball electrode shall be brought in the most unfavourable angle and velocity dynamically nearer to each other. The discharges shall be recorded separately by the oscilloscope. For each configuration of the spraying system and the coating material supply system ≥ 25 discharges shall be recorded and evaluated.

The values $I_{C(p)}$ and t_i shall be determined in the plot of discharge as defined in Figure C.3. t_i is defined as the time period, in which the peak current value $I_{C(p)}$ is dropped to 5 % of its value.

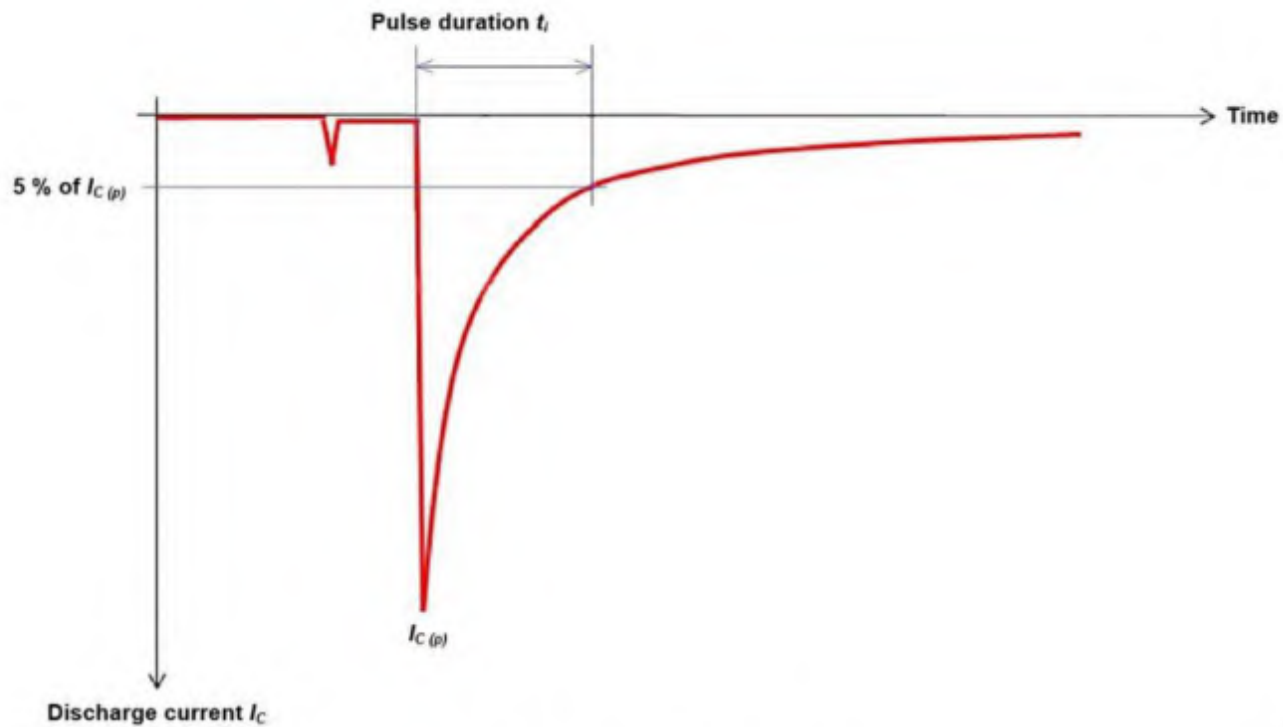


Figure C.3 — Schematic discharge curve

The discharge current $I_{B\ rms}$ shall be calculated:

$$I_{B\ rms} = \frac{F x I_{C(p)}}{\sqrt{6}} = 0,408 x I_{C(p)} \quad (C.1)$$

F is the factor for the electrical potential of the heart describing the hazards for the body caused by electrical current due to the current path in accordance with IEC 60479-1:2018. The current path “hand to both feet” is relevant for this document with $F = 1,0$.

NOTE 8 Annex D shows an example of the measurement procedure and the calculation.

The readings of $I_{C(p)}$ at the oscilloscope depends from the measurement method used.

For the measurement method shunt and oscilloscope use Formula (C.2):

$$I_{C(p)} = \frac{U_{C(p)}}{R_{Shunt}} \quad (C.2)$$

For the measurement method current transformer and oscilloscope use Formula (C.3):

$$I_{C(p)} = \frac{U_{C(p)}}{F_{CT}} \quad (C.3)$$

For the measurement method current transformer, attenuator and oscilloscope use Formula (C.4):

$$I_{C(p)} = \frac{U_{C(p)} x F_{AT}}{F_{CT}} \quad (C.4)$$

The test will be considered to be successful, if the body current $I_{B\ rms}$ of a discharge with the peak current value $I_{C(p)}$ and the pulse duration t_i after evaluation does not exceed area I of Figure 1 (see 5.1.6.1).

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The uncertainties for this measurement and evaluation method are considered appropriately by the boundary of area I in Figure 1.

During testing multiple discharges can occur. Metrological investigations have shown that the maximum discharge currents are in multiple discharges significantly lower than in a single discharge, and that the amplitude of the successive discharges permanently decreases. Therefore, only the current strongest individual discharges are used for evaluation.

Annex D (informative)

Example for discharge measurement

Figure D.1 shows an example of a discharge plot, measured with equipment described in Annex C. Before the actual measurement starts, it is recommended to provoke a couple of discharges at different time bases to find the optimal settings of the oscilloscope for reading $I_{C(p)}$ and t_i .

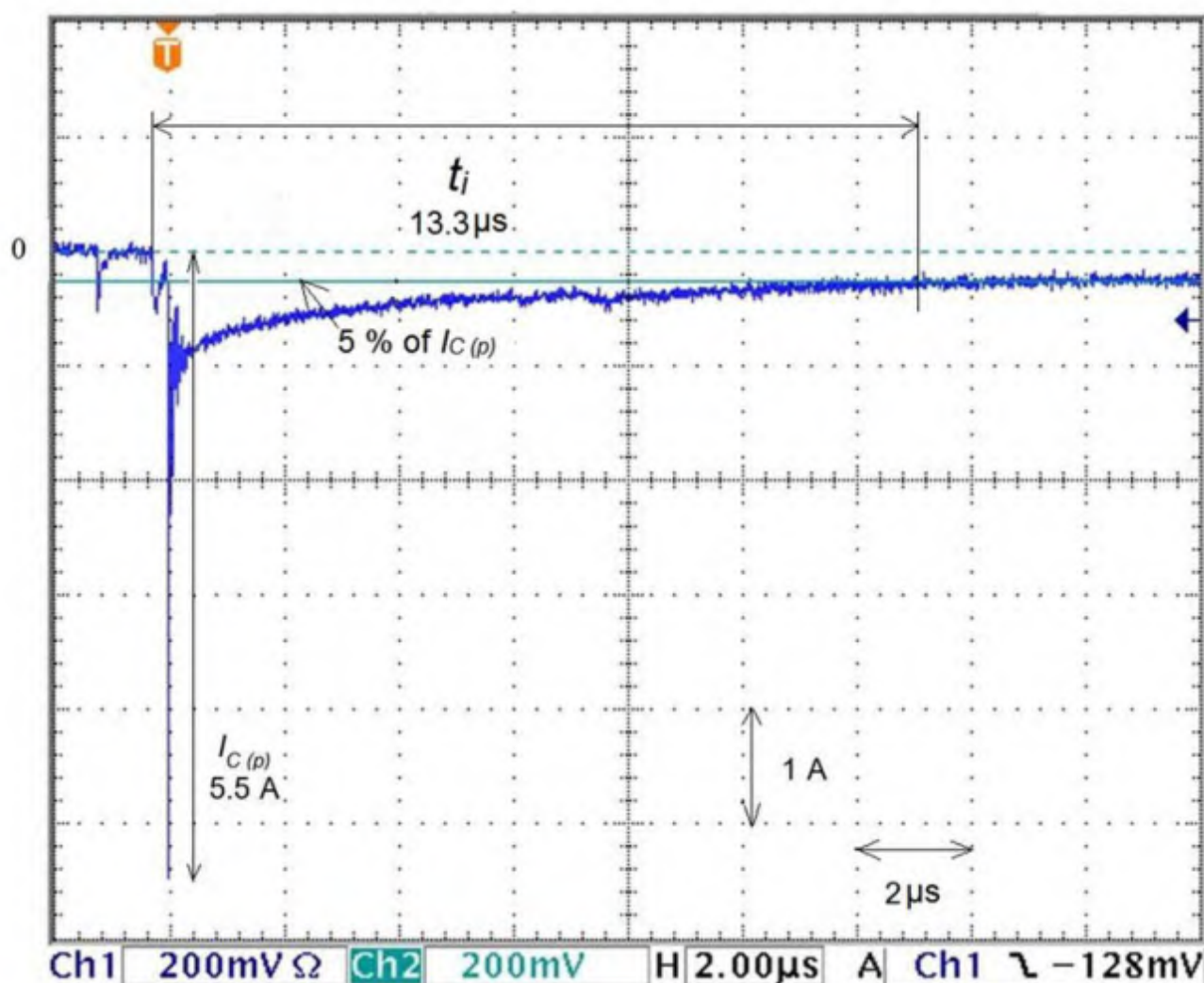


Figure D.1 — Discharge plot

Measurement with shunt and oscilloscope

Oscilloscope $U = 200 \text{ mV/Div}$

Oscilloscope: time
base = 2 μs/Div

Shunt: $R_{\text{Shunt}} = 200 \text{ mΩ}$

$$\text{Oscilloscope: } \frac{I}{\text{Div}} = \frac{U}{R_{\text{Shunt}}} = 1 \text{ A/Div}$$

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Measurement with current transformer and oscilloscope

Oscilloscope U = 200 mV/Div

Oscilloscope: time base = 2 μ s/Div

$$\text{Oscilloscope: } \frac{I}{\text{Div}} = \frac{U}{F_{CT}} = 1 \text{ A/Div}$$

Factor current transformer:

$$F_{CT} = 0,2 \text{ V/A}$$

Measurement with current transformer, attenuator and oscilloscope

Oscilloscope U = 200 mV/Div

Oscilloscope: time base = 2 μ s/Div

$$\text{Oscilloscope: } \frac{I}{\text{Div}} = \frac{U \times F_{AT}}{F_{CT}} = 1 \text{ A/Div}$$

Factor attenuator: $F_{AT} = 10:1$

Factor current transformer:

$$F_{CT} = 2 \text{ V/A}$$

Evaluation procedure:

- 1) Calculate the value of $I_{C(p)}$ by using the Formulas (C.2), (C.3) or (C.4) and read the value of $t_i: I_{C(p)} = 5,5 \text{ A}$ and $t_i = 13,3 \mu\text{s}$
- 2) Calculation according to Formula (C.1): $I_{B \text{ rms}} = I_{C(p)} \times 0,408 = 5,5 \text{ A} \times 0,408 = 2,245 \text{ A}$
- 3) Plot values (2,245 A; 13,3 μ s) into diagram Figure 1.

Check if the resulting point is in area I, if yes: Test passed.

Annex E (normative)

Test procedure for the prevention of hazardous discharges of spraying systems including parts of coating material supply system

Each spraying system shall be tested individually at the operating site.

The test shall be carried out under operational ambient conditions. During the test no explosive atmosphere shall be present. The ambient conditions (temperature, relative humidity and air pressure) shall be recorded in the test protocol.

For category 3G systems, the test shall be carried out by using an earthed, conductive rod which is passed nearby the high-voltage parts in a quick and continuous movement provoking a flashover. The test shall be carried out five times per system and shall be recorded. All test shall result in a safe lowering or shut off. After the lowering or shut off, no further discharge shall occur between the parts under high voltage and the earthing rod when passed nearby again.

The test of category 2G spraying systems shall be carried out with a device shown in Figure E.1 and Figure E.2. The motion of the electrodes in relation to each other shall be linear to the centrelines and shall not be influenced directly or indirectly by other objects.

NOTE 1 For the test it is of no importance which electrode is moved.

The test of parts of coating material supply systems which are in connection with category 2G spraying systems shall be carried out accordingly in a suitable manner.

Dimensions in millimetres

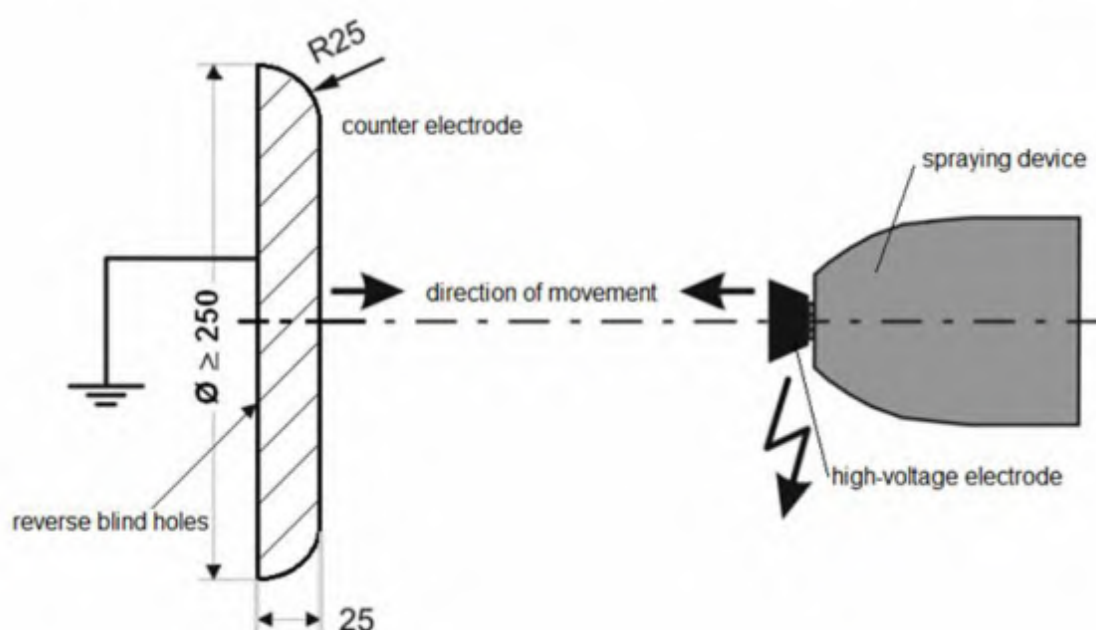


Figure E.1 — Test assembly of spraying system with direct charging

Dimensions in millimetres

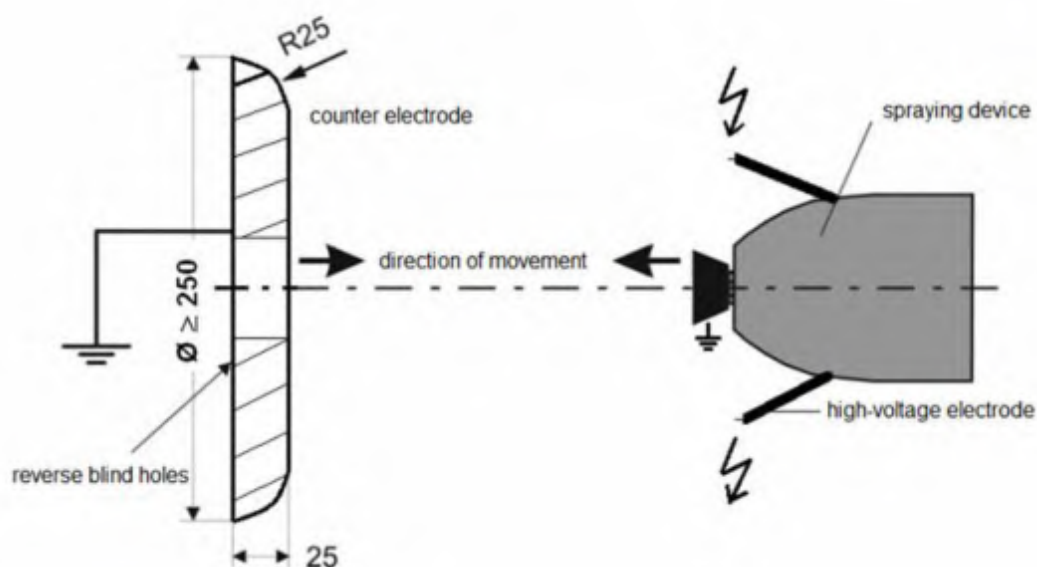


Figure E.2 — Test assembly of spraying system with external charging

In the start position, the distance between the electrodes shall be at least 0,5 cm/kV. The output voltage shall be the maximum admissible operational voltage.

During the test, the approach speed between the electrode under high voltage and the earthed electrode shall correspond to 1,2 times the maximum admissible speed of motion of the spraying device during spraying process determined by the manufacturer, but at least 500 mm/s.

Both electrodes shall be approximated up to about 1 cm. For spraying systems with external charging, a hole in the middle of the counter electrode for the passage of the bell could be required, see Figure E.2.

The diameter of the counter electrode shall be 100 mm greater than the diameter of the bell (contact charging), or at least 100 mm greater than the imaginary circle running through the electrode tips (in case of external charging), at least 250 mm.

The test shall be carried out five times for each spraying system and shall be recorded. In all cases, a safe lowering or shut off of the high voltage shall take place before the first discharge. A discharge between the electrodes shall not occur after disconnection.

NOTE 2 In the sense of this test requirement a discharge is a visible and audible spark between the electrodes.

Annex F (informative)

Ignitability of liquid coating materials

F.1 General

The fire and explosion protection of spraying systems can be facilitated considerably when processing liquid coating materials with a low portion of solvents and a high flash point (generally water-based paints), provided that the spray cloud of the liquid coating materials are considered to be non-ignitable. Substantial research has shown that the ignitability of spray clouds depends on the composition of the liquid coating materials made mainly of water, solvents, and solids.

The following classification has been established:

F.2 Non-ignitable liquid coating materials

Coating materials of this group have the following composition:

$$[\% \text{H}_2\text{O}] > 1,70 \times [\% \text{LM}] + 0,96 \times [\% \text{ORG}], \text{ (all in \% by weight)}$$

where

- H₂O: water;
- LM: the entire liquid phase, including liquids with flash points above 60 °C and those liquids not listed in the safety data sheet, in which case the entire liquid phase is ignitable in the sprayed state;
- ORG: solid phase which is ignitable in the sprayed state (ignitable inorganic or ignitable organic solids) including the solids which have an ignitable inorganic or ignitable organic coating.

Non-ignitable liquid coating materials act like water in the liquid phase and in the sprayed state. If the rinsing and thinner liquids correspond to this category, too, no explosion protection is necessary.

Coating materials of this group are classified as being non-ignitable liquid coating material.

F.3 Ignitable liquid coating materials

Coating materials which do not satisfy the criteria of “non-ignitable”.

Coating materials of this group are classified as being ignitable liquid coating material.

Annex G (informative)

Significant technical changes between this document and EN 50176:2009

Table G.1 — Significant technical changes with respect to EN 50176:2009

Significant changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
Modification of the title of the document	-	X	-	-
Normative references updated	2	X	-	-
New arrangement and new designation of the types of spray systems	5.1.1	-	X	-
New arrangement and amendments of the requirements for automatic electrostatic application systems for ignitable liquid coating materials	5.1	-	X	-
Definition of requirements for safety functions	5.4.1	-	X	-
New arrangement and amendment of tests for automatic electrostatic application systems for ignitable liquid coating materials	6	-	X	-
New arrangement and extension of the information for use	7.1, 7.2	X	-	-
Definition of requirements for periodic inspections	7.2.5	-	X	-
Clarification of marking	7.3	X	-	-
Introduction of the normative Annex A "Test of ignition protection for L-1 spraying systems including parts of the coating material supply system"	Annex A	-	X	-
Introduction of the normative Annex B "Ignition test within the gas mixture for L-1 spraying systems including parts of the coating material supply system"	Annex B	X	-	-
Introduction of the normative Annex C "Compliance with area I for L-2 spraying systems including parts of the coating material supply system"	Annex C	-	X	-
Introduction of the informative Annex D "Example for discharge measurement"	Annex D	-	X	-
introduction of the normative Annex E "Test procedure for the prevention of hazardous discharges of spraying systems including parts of coating material supply system"	Annex E	X	-	-
Introduction of the revised informative Annex F "Ignitability of coating materials"	Annex F	X	-	-
NOTE This list includes the significant technical changes but it is not an exhaustive list of all modifications from the previous version.				

Annex ZZA (informative)

Relationship between this European Standard and the essential requirements of Directive 2006/42/EC aimed to be covered

This European Standard has been prepared under a Commission's standardization request "M/396 Mandate to CEN and CENELEC for Standardisation in the field of machinery" to provide one voluntary means of conforming to essential requirements of Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast).

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

Table ZZA.1 — Correspondence between this European Standard and Annex I of Directive 2006/42/EC

The relevant Essential Requirements of Directive 2006/42/EC	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
1.1.2 (a)	5, 6, 7	
1.1.2 (c)	5, 6, 7	
1.1.2 (d)	5, 6, 7	
1.1.2 (e)	5, 6, 7	
1.1.3. Materials and products	5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.4, 5.3.6, 7.2.3, 7.2.4	
1.1.5. Design of machinery to facilitate its handling	5.2.2, 5.3.1	
1.2.1. Safety and reliability of control systems	5.1.2, 5.1.3, 5.1.4, 5.1.5.2, 5.1.5.3, 5.1.6.2, 5.1.7, 5.2.1, 5.2.2, 5.3.3, 5.4.1	
1.2.2. Control devices	5.2.6, 5.3.1	
1.2.3. Starting	5.2.6, 5.3.1	
1.2.4.1. Normal stop	5.2.6, 5.2.9	
1.2.4.2. Operational stop	5.2.6, 5.2.9	
1.2.4.3. Emergency stop	5.2.6	
1.2.6. Failure of the power supply	5.2.6	
1.3.1. Risk of loss of stability	5.3.1	
1.3.2. Risk of break-up during operation	5.2.1, 5.3.1	
1.3.3 Risk of falling or ejected objects	5.2.1, 5.3.1	
1.3.7. Risks related to moving parts	5.2.1, 5.3.1	

The relevant Essential Requirements of Directive 2006/42/EC	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
1.3.8.1. Moving transmission parts	5.2.1, 5.3.1	
1.3.8.2. Moving parts involved in the process	5.2.1, 5.3.1	
1.3.9. Risks of uncontrolled movements	5.3.1	
1.4.1. General requirements for guards and protective devices	5.1.4.3, 5.1.6.2, 5.2.1, 5.3.1, 5.3.3	
1.4.2.1. Fixed guards	5.3.1, 5.5.3	
1.4.2.2 Interlocking movable guards	5.1.4.3, 5.1.6.2, 5.3.1	
1.5.1. Electricity supply	5.1.6, 5.2.2, 5.2.3, 5.2.5, 5.3.1, 5.3.3, 5.3.4, 5.4.2	
1.5.2. Static electricity	5.1.2, 5.1.3.2, 5.1.3.3, 5.1.4.2, 5.1.4.3, 5.1.6.1, 5.1.7, 5.2.1, 5.2.2, 5.2.3, 5.2.5, 5.3, 5.4.1, 7.2.2, 7.2.3, 7.2.4, 7.2.5	
1.5.3. Energy supply other than electricity	5.2.1, 5.3.1	
1.5.4. Errors of fitting	5.2.1, 5.3.1	
1.5.5. Extreme temperatures	5.2.1, 5.3.1	
1.5.6. Fire	5.1.2, 5.1.3.2, 5.1.3.3, 5.1.4, 5.1.5, 5.1.7, 5.2.1, 5.2.4, 5.2.5, 5.2.6, 5.3, 5.4.1, 7.2.2	
1.5.7. Explosion	5.1.2, 5.1.3.2, 5.1.3.3, 5.1.4, 5.1.5, 5.1.7, 5.2.1, 5.2.4, 5.2.5, 5.2.6, 5.3, 5.4.1, 7.2.2	
1.5.8. Noise	5.2.1, 5.3.1	
1.5.13. Emissions of hazardous materials and substances	5.2.1, 5.2.2, 5.3.1, 5.3.4	
1.5.15. Risk of slipping, tripping or falling	5.3.1	
1.6.1. Machinery maintenance	5.2.1, 5.3.1, 7.2.4	
1.6.2. Access to operating positions and servicing points	5.3.1	
1.6.3. Isolation of energy sources	5.2.1, 5.2.5, 5.2.7, 5.3.1,	
1.6.4. Operator intervention	5.2.1, 5.3.1, 7.2.3, 7.2.4	
1.6.5. Cleaning of internal parts	5.3.1, 7.2.4	
1.7.1.1. Information and warnings on the machinery	5.2.1, 5.3.1, 7.1, 7.3.2, 7.3.5	
1.7.1.2. Warning devices	5.3.1, 7.2.2	

The relevant Essential Requirements of Directive 2006/42/EC	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
1.7.2. Warning of residual risks	5.3.1, 7.3.10	
1.7.3. Marking of machinery	5.2.1, 7.3.1, 7.3.2, 7.3.3, 7.3.4, 7.3.5, 7.3.6	
1.7.4. Instructions	5.2.1, 5.3.1, 7.2.1	
1.7.4.2. Contents of the instructions	5.2.1, 5.3.1, 7.2.2, 7.2.3, 7.2.4, 7.2.5	
1.7.4.3. Sales literature	5.2.1, 5.3.1	

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

Annex ZZB (informative)

Relationship between this European standard and the essential Health and Safety Requirements of Directive 2014/34/EU⁴ aimed to be covered

This European Standard has been prepared under a Commission's standardization request as regards equipment and protective systems intended for use in potentially explosive atmospheres in support of Directive 2014/34/EU "M/596 C(2023)4798 final" to provide one voluntary means of conforming to the essential health and safety requirements of Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast).

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZZB.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding essential health and safety requirements of that Directive and associated EFTA regulations.

Table ZZB.1 — Correspondence between this European Standard and Annex II of Directive 2014/34/EU [2014 OJ L96]

Essential health and safety requirements of Directive 2014/34/EU	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
1.0.1	5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.1.5, 5.1.7, 5.2, 5.3, 5.4, 7.2, 7.3.1, 7.3.2, 7.3.3, 7.3.4, 7.3.5, 7.3.6	
1.0.2	5.1.1, 5.1.3, 5.1.7, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.4.1	
1.0.3	1.1, 1.4, 5.2.1, 5.2.3, 5.3.1, 5.3.4, Annex A, Annex B, Annex C, Annex E	
1.0.4	1.1, 5.2.1, 5.3.1	
1.0.5	7.3.1, 7.3.2, 7.3.3, 7.3.4, 7.3.5, 7.3.6	
1.0.6	5.2.1, 5.3.1, 7.2	
1.1.1	5.2.1, 5.3.1	
1.1.3	5.2.1, 5.3.1	
1.2.1	5.1.7, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.4	
1.2.3	5.2.1, 5.2.2, 5.3.5, 5.4.2	
1.2.7	5.1.5, 5.1.6, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8, 5.2.9, 5.3.1, 5.3.3, 5.4.1, 5.4.2, 7.2	

⁴ OJ L 96, 29.3.2014, p. 309–356

Essential health and safety requirements of Directive 2014/34/EU	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
1.2.8	5.2.1, 5.3.1	
1.3.1	5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.1.7, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8, 5.2.9, 5.3, 5.4, 7.2	
1.3.2	5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.1.7, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8, 5.2.9, 5.3, 5.4, 7.2	
1.3.3	5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8, 5.2.9, 5.3.1, 5.3.4, 7.2.2, 7.2.3, 7.2.4, 7.2.5	
1.3.4	5.2.1, 5.3.1	
1.4.1	5.2.2, 5.2.3, 5.2.6, 5.3.1	
1.4.2	5.2.1, 5.2.2, 5.2.3, 5.2.6, 5.2.7, 5.3.1	
1.5.1	5.3.1, 5.4.1	
1.5.3	5.2.6	
1.5.8	5.3.1, 5.4.1	
1.6.1	5.2.6	
1.6.2	5.2.6, 5.3.3	
1.6.3	5.2.6, 5.3.1	
1.6.4	5.2.3, 5.2.6, 5.3.1	
2.2.1.1	5.1.2, 5.1.3, 5.1.4, 5.1.7, 5.2, 5.3, 5.4	
2.2.1.2	5.2.1, 5.3.1	
2.3.1.1	5.1.2, 5.1.3, 5.1.4, 5.1.7, 5.2, 5.3, 5.4	
2.3.1.2	5.2.1, 5.3.1	

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