



BSI Standards Publication

Spray booths for organic coating material - Safety requirements

National foreword

This British Standard is the UK implementation of EN 16985:2018. It supersedes BS EN 12215:2004+A1:2009, BS EN 12981:2005+A1:2009 and BS EN 13355:2004+A1:2009, which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/3/8, Thermoprocessing equipment - Safety.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Spray booths for organic coating material - Safety requirements

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Lackierkabinen für organische Beschichtungsstoffe - Sicherheitsanforderungen

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Contents

Page

European foreword	6
1 Scope.....	8
2 Normative references.....	9
3 Terms, definitions, variables and abbreviations	11
3.1 Terms and definitions	11
3.2 Variables	15
3.3 Abbreviations.....	17
4 Safety requirements and/or -measures	18
4.1 General.....	18
4.2 Mechanical.....	18
4.2.1 Moving or rotating elements	18
4.2.2 Falling objects	18
4.2.3 Height from the ground	19
4.2.4 Slippery surface.....	19
4.3 Electrical	19
4.4 Thermal.....	19
4.5 Noise	19
4.6 Radiation.....	20
4.7 Contact with and inhalation of hazardous material.....	21
4.7.1 General.....	21
4.7.2 Automatic application.....	22
4.7.3 Manual application.....	22
4.8 Fire	26
4.8.1 General.....	26
4.8.2 Spray booth construction.....	27
4.8.3 Filter media.....	27
4.8.4 Fire detection	27
4.8.5 Fire extinguishing equipment.....	28
4.9 Explosion.....	28
4.9.1 General.....	28
4.9.2 Spray booth for liquid coating material.....	29
4.9.3 Spray booth for powder coating material.....	31
4.10 Safety devices and control systems.....	34
4.11 Trapping.....	36
4.11.1 General.....	36
4.11.2 Manual spray booth	36
4.11.3 Automatic spray booth.....	37
4.12 Ergonomics.....	37
4.12.1 General.....	37
4.12.2 Access	37
4.12.3 Working area	37
4.12.4 Climatic environment.....	37
4.12.5 Luminous environment	38
4.12.6 Maintenance	38
4.13 Environment in which the machinery is used	38

5	Verification of the safety requirements	38
6	Information for use	44
6.1	General	44
6.2	Instruction handbook	44
6.2.1	General	44
6.2.2	Information related to installation	45
6.2.3	Information related to operation	46
6.2.4	Information related to maintenance	46
6.3	Marking	47
	Annex A (informative) Hazards	49
	Annex B (informative) Examples of classification of hazardous zones.....	53
B.1	Example 1	53
B.2	Example 2	54
B.3	Example 3	56
B.4	Example 4	58
B.5	Example 5	60
B.6	Example 6	62
	Annex C (normative) Calculated average concentration of flammable substances	65
C.1	General	65
C.2	Spray booths for liquid coating material containing organic solvents	65
C.2.1	General	65
C.2.2	Example for the calculation of concentration of flammable substances on the basis of a given air flow velocity (manual spray booth)	65
C.2.3	Example for the calculation of required minimum fresh air flow (automatic spray booth).....	66
C.3	Spray booths for organic powder coating material.....	67
C.3.1	General	67
C.3.2	Example for the calculation of coating powder concentration	67
C.3.3	Example for the calculation of maximum coating powder input	68
C.4	Filters for powder coating booths	69
C.4.1	General	69
C.4.2	Example for the calculation of coating powder concentration in the clean air part of the filter.....	69
	Annex D (normative) Air flow velocity measurement.....	71
D.1	Measurement equipment	71
D.2	Measurement procedure	71
D.2.1	Measurement conditions	71
D.2.2	Air flow velocity components.....	71
D.3	Measurement points.....	72

D.3.1	Vertically ventilated spray booth (liquid and powder, internal working area)	72
D.3.2	Vertically ventilated spray booth with designated workpiece (liquid and powder, internal working area).....	73
D.3.3	Vertically ventilated segmented spray booth.....	73
D.3.4	Horizontally ventilated spray booth (liquid and powder)	75
D.3.5	Openings of a spray booth	76
D.3.6	Summary of air flow velocity parameters.....	76
Annex E (informative) Ignitability of water-based paint		79
Annex F (normative) Energy-efficiency and reduction of environmental impact.....		80
F.1	General.....	80
F.2	Spray booths for liquid coating material.....	80
F.2.1	Acquisition	80
F.2.2	Production.....	80
F.2.3	Use	80
F.2.3.1	Input	80
F.2.3.1.1	Material.....	80
F.2.3.1.2	Water	80
F.2.3.1.3	Energy.....	81
F.2.3.2	Output	81
F.2.3.2.1	Emissions to air.....	81
F.2.3.2.2	Waste	81
F.2.3.2.3	Noise.....	81
F.2.4	End of life	82
F.3	Spray booths for powder coating.....	82
F.3.1	Acquisition	82
F.3.2	Production.....	82
F.3.3	Use	82
F.3.3.1	Input	82
F.3.3.2	Output	82
F.3.3.2.1	Emissions to air.....	82
F.3.3.2.2	Waste	82
F.3.3.2.3	Noise.....	82
F.3.4	End of Life	83
Annex G (informative) Examples for safety related controls.....		84
G.1	General.....	84
G.2	Interlocking of forced ventilation system with interface to spray application.....	84

Annex H (informative) Determination of the spray booth clearance time using smoke.....	86
H.1 General	86
H.2 Procedure	86
Annex I (informative) Estimation of the spray booth purge time	87
I.1 General	87
I.2 Example.....	87
Annex J (informative) Examples for ventilation of spray booths with working pits.....	89
J.1 Ventilation of working pits	89
J.2 Measurement of air flow velocity in working pits	93
Annex ZA (informative) Relationship between this European Standard and the essential requirements of Directive 2006/42/EC aimed to be covered.....	95
Bibliography	98

European foreword

This document (EN 16985:2018) has been prepared by Technical Committee CEN/TC 271 “Surface treatment equipment - safety”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2019, and conflicting national standards shall be withdrawn at the latest by June 2019.

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

This document supersedes EN 12215:2004+A1:2009, EN 12981:2005+A1:2009 and EN 13355:2004+A1:2009.

In comparison with the previous edition the following technical modifications have been made:

- a) The 3 European Standards EN 12215:2004+A1:2009, EN 12981:2005+A1:2009 and EN 13355:2004+A1:2009 have been merged into this European standard;
- b) The scope has not been changed, but the limits of a spray booth have been defined by specifying the interfaces to ancillary machinery, to clarify the scope;
- c) 4.2.2 Falling objects, has been introduced;
- d) 4.2.3 Height from the ground, has been introduced;
- e) 4.7 Contact with and inhalation of hazardous material, has been revised;
- f) 4.7.3.3.4 Segmented spray booths, has been introduced;
- g) 4.8 Fire, has been revised;
- h) 4.9 Explosion, has been revised;
- i) 4.10 Safety devices and control systems, has been revised;
- j) 4.11 Trapping, has been introduced;
- k) 4.12 Ergonomics, has been introduced;
- l) 4.13 Environment in which the machinery is used, has been introduced;
- m) The list of hazards has been moved to new Annex A (informative);
- n) Examples of classification of hazardous zones have been moved to new Annex B (informative);
- o) Calculations for explosive atmosphere have been moved to new Annex C (normative);
- p) Calculation for powder filters has been introduced (Annex C.4);
- q) Requirements for air flow velocity measurement have been clarified and moved to new Annex D (normative);

- r) Information on ignitability of water-based paint has been introduced in new Annex E (informative);
- s) Annex F (normative) on Energy-efficiency and reduction of environmental impact has been introduced;
- t) Annex G (informative) with examples for safety related controls has been introduced;
- u) Annex H (informative) on a procedure for the determination of the spray booth clearance time using smoke has been introduced;
- v) Annex I (informative) with an example for the estimation of the spray booth purge time has been introduced;
- w) Annex J (informative) with examples for ventilation of spray booths with working pits has been introduced.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of the EU Directive 2006/42/EC.

For relationship with the EU Directive, see informative Annex ZA, which is an integral part of this document.

NOTE Although a spray booth, as an integral whole, formally does not fall under the scope of the ATEX Directive 2014/34/EU, the standard is based upon a fundamental risk analysis according to this directive.

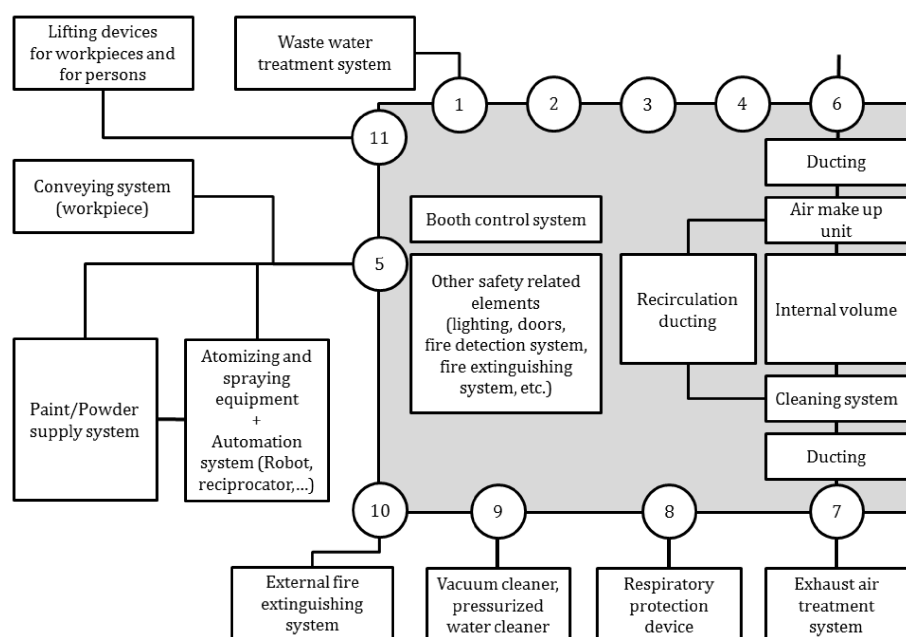
According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard deals with all significant hazards, hazardous situations and hazardous events relevant to spray booths for the application of organic liquid and powder coating materials, when they are used as intended and under the conditions foreseen by the manufacturer, including reasonably foreseeable misuse.

See Annex A for significant hazards.

Interfaces between spray booths and other machinery used in coating application are given in Figure 1.



Key



spray booth

- | | |
|----|--|
| 1 | water output connector |
| 2 | connector to electric power supply |
| 3 | water input connector |
| 4 | connector to pressurized air supply |
| 5 | interface of control system |
| 6 | fresh air supply |
| 7 | connector to exhaust air treatment system |
| 8 | connector to RPD air supply |
| 9 | booth cleaning system connector |
| 10 | connection to external fire extinguishing system |
| 11 | connection to lifting device |

Figure 1 — Interfaces of a spray booth to ancillary machinery

The specific significant risks related to the use of this machinery with foodstuff and pharmaceutical products are not dealt with in this standard.

The specific significant risks related to drying operation of combined spraying and drying booths are not dealt with in this standard, but in EN 1539:2015.

This European Standard is not applicable to:

- spaces for application of organic coating material consisting only of an extraction wall;
- platforms attached to spray booths (e.g. for touch-up jobs);
- flock booths (see EN 50223:2015);
- spray booths with airflow from vertical inlet to horizontal extraction or from horizontal inlet to vertical extraction.

This European Standard is not applicable to machinery manufactured before the date of its publication as European Standard.

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. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 525:2009, *Non-domestic direct gas-fired forced convection air heaters for space heating not exceeding a net heat input of 300 kW*

EN 547-1:1996+A1:2008, *Safety of machinery — Human body measurements — Part 1: Principles for determining the dimensions required for openings for whole body access into machinery*

EN 746-1:1997+A1:2009, *Industrial thermoprocessing equipment — Part 1: Common safety requirements for industrial thermoprocessing equipment*

EN 746-2:2010, *Industrial thermoprocessing equipment — Part 2: Safety requirements for combustion and fuel handling systems*

EN 1127-1:2011, *Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology*

EN 1539:2015, *Dryers and ovens, in which flammable substances are released — Safety requirements*

EN 12198-1:2000+A1:2008, *Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 1: General principles*

EN 12198-2:2002+A1:2008, *Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 2: Radiation emission measurement procedure*

EN 12464-1:2011, *Light and lighting — Lighting of work places — Part 1: Indoor work places*

EN 14373:2005, *Explosion suppression systems*

EN 14462:2015, *Surface treatment equipment — Noise test code for surface treatment equipment including its ancillary handling equipment — Accuracy grades 2 and 3*

EN 14491:2012, *Dust explosion venting protective systems*

EN 14986:2017, *Design of fans working in potentially explosive atmospheres*

EN 15089:2009, *Explosion isolation systems*

EN 16447:2014, *Explosion isolation flap valves*

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 50176:2009, *Stationary electrostatic application equipment for ignitable liquid coating material — Safety requirements*

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

EN 60204-1:2006, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2005)*

EN 60519-1:2015, *Safety in installations for electroheating and electromagnetic processing — Part 1: General requirements (IEC 60519-1:2015)*

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

EN 61496-1:2013, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests (IEC 61496-1:2012)*

EN 61496-2:2013, *Safety of machinery — Electro-sensitive protective equipment — Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs) (IEC 61496-2:2013)*

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

EN ISO 13732-1:2008, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces (ISO 13732-1:2006)*

EN ISO 13856-1:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors (ISO 13856-1:2013)*

EN ISO 13857:2008, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2008)*

EN ISO 13849-1:2015, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2015)*

EN ISO 14119:2013, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection (ISO 14119:2013)*

EN ISO 14120:2015, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards (ISO 14120:2015)*

EN ISO 14122-1:2016, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means and general requirements of access (ISO 14122-1:2016)*

EN ISO 14122-2:2016, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways (ISO 14122-2:2016)*

EN ISO 14122-3:2016, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails (ISO 14122-3:2016)*

EN ISO 14122-4:2016, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders (ISO 14122-4:2016)*

EN ISO 19353:2016, *Safety of machinery — Fire prevention and fire protection (ISO 19353:2015)*

EN ISO 80079-36:2016, *Explosive atmospheres — Part 36: Non-electrical equipment for explosive atmospheres — Basic method and requirements (ISO 80079-36:2016)*

3 Terms, definitions, variables and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100:2010 and the following apply.

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

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

3.1.1

spray booth

rigid structure, limited by walls, forming a partially or fully enclosed volume for the controlled processing of spray application of organic coating material

3.1.1.1

spray booth for powder coating material

spray booth designated for the application of powder coating material

3.1.1.2

spray booth for liquid coating material

spray booth designated for the application of liquid coating material

3.1.1.3

manual spray booth

spray booth designated for the manual application of coating material

3.1.1.4

automatic spray booth

spray booth designated for the automated application of coating material

3.1.1.5

segmented spray booth

spray booth with interdependent ventilated zones

3.1.2

forced ventilation

technical ventilation consisting of one or more of the following systems:

- fresh air supply system;
- air recirculation system;
- air exhaust system

3.1.3

exhaust air cleaning system

system which removes overspray from the exhaust air

Note 1 to entry: Solvents are not removed from the exhaust air by the exhaust air cleaning system.

3.1.4

powder recovery system

system which separates powder overspray from the exhaust air

3.1.4.1

open powder recovery system

powder separator open to the coating area

3.1.4.2

enclosed powder recovery system

enclosed powder separator (e.g. filter and/or cyclone) connected by ductwork to the coating area of the spray booth

3.1.5

working area

area of the spray booth, designated as operator working position for manual coating operation

3.1.5.1

internal working area

working area inside of a spray booth (see Figure 2)

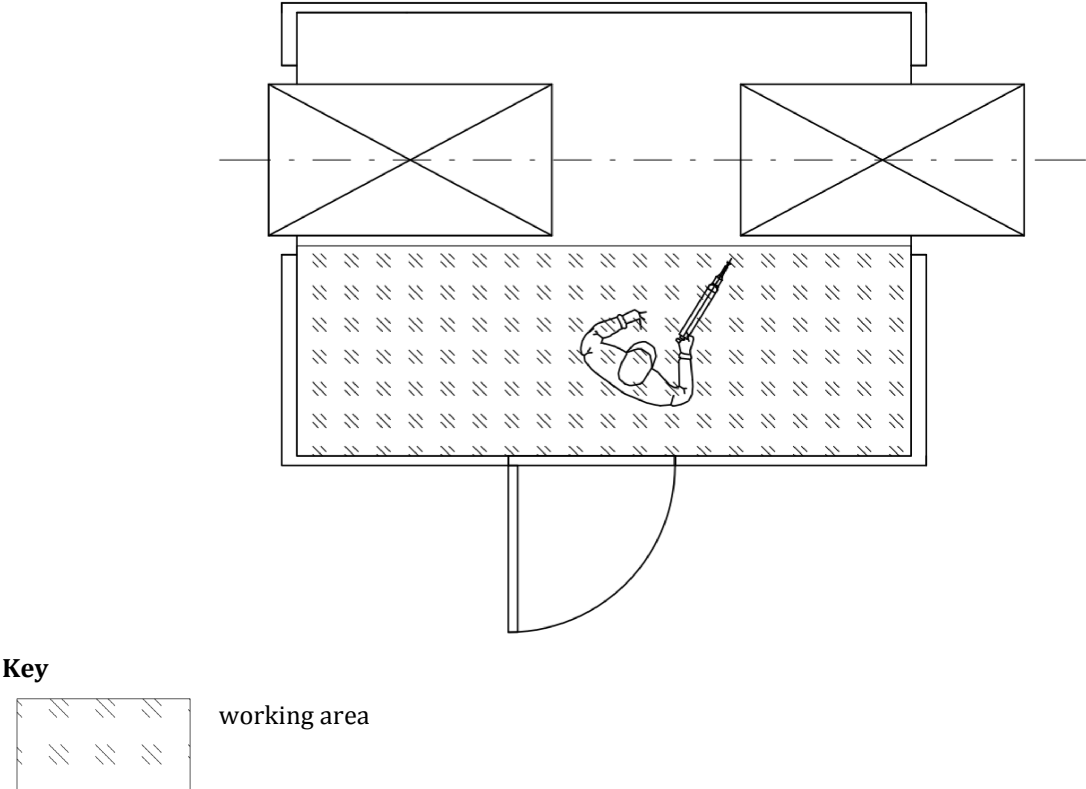


Figure 2 — Internal working area

3.1.5.2
working pit

internal working area located below floor level (see Figure 3)

Note 1 to entry: Working pits are used e.g. for the coating of heavy goods vehicle chassis.

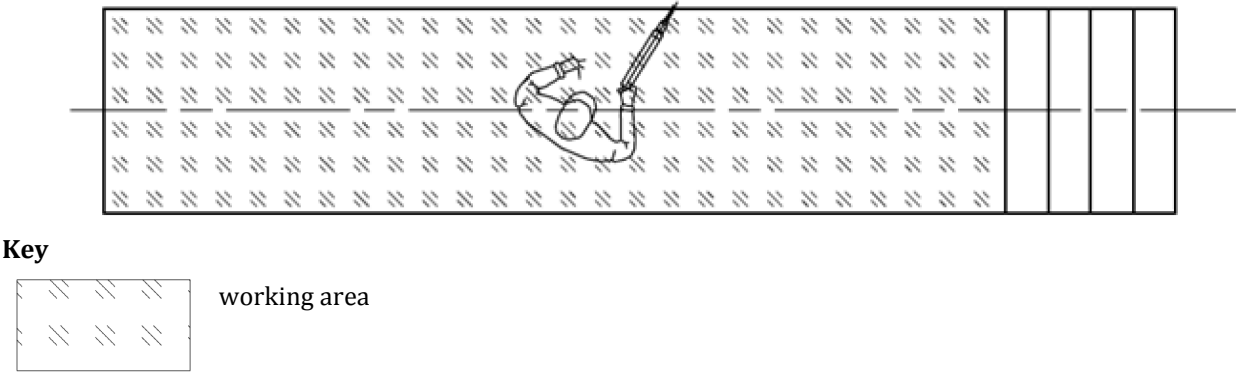
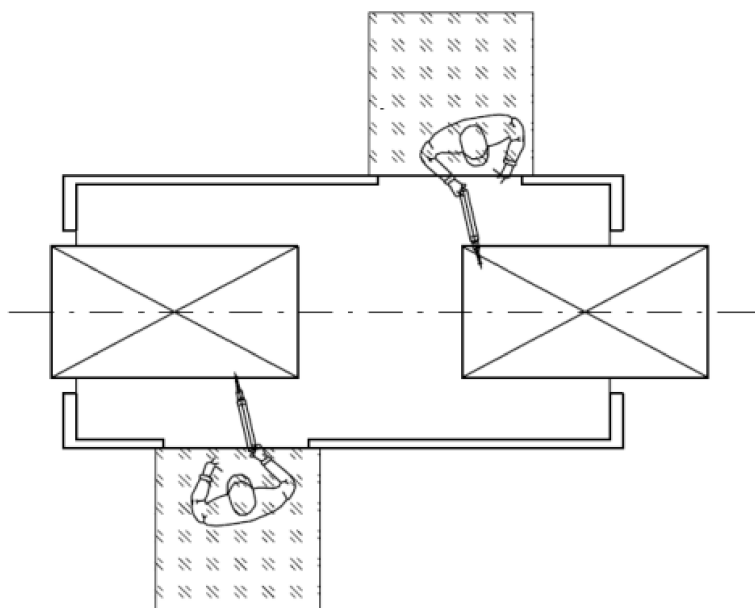


Figure 3 — Pit working area

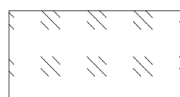
3.1.5.3

external working area

working area outside of a spray booth (see Figure 4)



Key



working area

Figure 4 — External working area

3.1.6

fresh air

air drawn from a clean source inside or outside of the building into the spray booth

3.1.7

clearance time

time required to clear the internal volume of a fully enclosed spray booth from smoke by forced ventilation

Note 1 to entry: See Annex H.

3.1.8

purge time

time required to achieve a non-hazardous atmosphere in the spray booth after spraying process is stopped and when ventilation is operating in spraying conditions. Typically, time after which the concentration of hazardous substances in the spray booth is below exposure limit value

Note 1 to entry: Exposure limit values are subject to national regulation.

3.1.9**back-up filter**

filter unit for powder recovery

- located in clean air part downstream of the separator;
- usually fitted with differential pressure monitoring;
- to prevent discharge of powder to the environment

3.1.10**internal volume of spray booth**

space limited by the interior walls, plane of the openings, floor and ceiling of the spray booth

3.2 Variables

Variables used in this standard are given in Table 1.

Table 1 — Variables used in this standard

Variable	Definition	Dimension
A	Area of the measurement plane	m^2
$\bar{C}_{Liquid}$	Average concentration of flammable solvents (in air) in the spray booth	g / m^3
$\bar{C}_{Powder}$	Average concentration of flammable coating powder (in air) in the spray booth	g / m^3
$\bar{C}_{Clean}$	Average concentration of flammable coating powder behind filter medium	mg / m^3
$\bar{C}_{LEL, Liquid}$	Average concentration of flammable solvents (in air) in the spray booth as a percentage of LEL	%
$\bar{C}_{LEL, Powder}$	Average concentration of flammable coating powder (in air) in the spray booth as a percentage of LEL	%
$\bar{C}_{LEL, max}$	Maximum average concentration (design value) as a percentage of LEL	%
C_{LV}	Exposure limit value of hazardous substance	g / m^3
$\bar{C}_{max}$	Maximum average concentration (design value)	g / m^3
$\bar{C}(t)$	Average concentration of hazardous material in the spray booth at time t	g / m^3
$\bar{C}(t_0)$	Average concentration of hazardous material in the spray booth at stop of spray process	g / m^3
$\bar{C}(t_p)$	Average concentration of hazardous material in the spray booth after purge time t_p is over	g / m^3
$\bar{e}_{rfm}$	Average penetration of filter medium (suppliers certificate)	%

e_s	Recovery efficiency of pre-separator given by manufacturer (e.g. for cyclone typically between 90 % and 95 %)	%
e_t	Transfer efficiency of powder coating process	%
k_1	Mass percentage of flammable solvents content in the liquid organic coating material at spraying conditions	%
k_2	Estimated percentage of flammable solvents evaporated inside the spray booth. For common spray application the value is 80 %.	%
k_3	Inhomogeneity factor taking into account the concentration inhomogeneity throughout the spray booth and, in particular, the high concentration between spray gun and workpiece and its vicinity. The range is from 1 to 5. For common spray application the value is 3. For highly defined (automatic) spray processes a lower value can be chosen	dimensionless
k_4	Mass percentage of hazardous material content in the liquid organic coating material at spraying conditions	%
k_5	Estimated percentage of hazardous material emitted inside the spray booth	%
l	Length	m
LEL_{Liquid}	Lower explosion limit of solvents mixtures at 293 K. If the component parts of the solvents mixtures are known, but the LEL of the mixture is unknown, then the LEL of the solvent component with the lowest value should be taken. If the data are not available, then the value of 40 g/m ³ shall be used.	g / m^3
LEL_{Powder}	Lower explosion limit of a combustible coating powder-air mixture. If the data are not available, then the value of 20 g/m ³ shall be used.	g / m^3
$M_{applied}$	Quantity of organic coating powder sprayed for coating of one workpiece	g
$\dot{M}_{clean}$	Mass flow rate of organic coating powder in the clean air part of the recovery system	g / h
$\dot{M}_{crude}$	Mass flow rate of organic coating powder in the powder laden air part of the recovery system	g / h
$\dot{M}_{max, Liquid}$	Maximum mass input of flammable liquid coating material sprayed per hour	g / h
$\dot{M}_{max, Powder}$	Maximum mass input of flammable coating powder sprayed in the spray booth per hour	g / h
$M_{workpiece}$	Quantity of organic coating powder deposited on the workpiece	g
Q_{min}	Minimum fresh air volume flow required	m^3/h
Q_{op}	Operational airflow for coating process	m^3/h
t	Time	h
t_0	Start time for determination of purge time	dimensionless

t_p	Purge time	s
$\bar{v}$	Average air flow velocity	m/s
V	Internal volume of the spray booth	m^3
w	Width	m

3.3 Abbreviations

Abbreviations used in this standard are given in Table 2.

Table 2 — Abbreviations used in this standard

Abbreviation	Description
A-L	Electrostatic spraying system of type A for liquid coating material (see EN 50176:2009)
A-P	Electrostatic spraying system of type A for powder coating material (see EN 50177:2009)
B-L	Electrostatic spraying system of type B for liquid coating material (see EN 50176:2009)
B-P	Electrostatic spraying system of type B for powder coating material (see EN 50177:2009)
C-L	Electrostatic spraying system of type C for liquid coating material (see EN 50176:2009)
C-P	Electrostatic spraying system of type C for powder coating material (see EN 50177:2009)
D-L	Electrostatic spraying system of type D for liquid coating material (see EN 50176:2009)
H ₂ O	Water
IR	Infrared
LM	Liquid organic phase, mainly consisting of higher glycol esters in mixture with max. 1:1 propanol
ORG	Solid organic phase, mainly consisting of binder and pigments
PPE	Personal protective equipment
PL	Performance level of a safety related control
PLC	Programmable logic controller
PL _r	Required Performance level of a safety related control
RPD	Respiratory protective device
UV	Ultraviolet

4 Safety requirements and/or -measures

4.1 General

Spray booths shall comply with the safety requirements and/or protective measures of Clause 4. In addition, spray booths shall be designed according to the principles of EN ISO 12100:2010 for relevant but not significant hazards (for instance sharp edges), which are not dealt with by this standard.

The safety requirements defined in this standard override the requirements defined for minimizing energy usage and environmental impact (see Annex F).

4.2 Mechanical

4.2.1 Moving or rotating elements

Hazards by shearing, crushing or drawing-in by movements of machine parts and equipment shall be prevented by design. Access to dangerous moving parts shall be prevented. This can be achieved by

- fitting fixed guards

and/or

- fitting one of the following devices interlocked with the hazardous movement
 - movable guards, see EN ISO 14120:2015;
 - active opto-electronic protective devices, see EN 61496-1:2013 and EN 61496-2:2013;
 - pressure sensitive protective devices (mats and floors), see EN ISO 13856-1:2013.

NOTE 1 For fans fixed guards have been proven to be effective.

Fixed guards that shall be demounted by the user, e.g. for maintenance and cleaning purposes, shall be fitted with fixing elements remaining attached to the machine or to the guard when the guard is removed, e.g. captive screws. See also 6.2.4 l).

If access for maintenance or other reasons is foreseen to be frequent, i.e. more than once per shift, interlocked movable guards shall be used. If it is possible to reach moving parts before they have stopped, the guard shall be interlocked with guard locking. See EN ISO 14119:2013.

Requirements for safety functions are given in Table 5 (see 4.10).

Safety distances to dangerous moving parts shall be ensured (see EN ISO 13857:2008).

NOTE 2 For conveyors see EN 619:2002+A1:2010.

NOTE 3 For robots see EN ISO 10218-2:2011.

NOTE 4 For power operated doors for persons see EN 12433-1:1999, EN 12433-2:1999, EN 12453:2017, EN 12635:2002+A1:2008 and EN 12978:2003+A1:2009.

NOTE 5 For lifting tables see EN 1570-1:2011+A1:2014.

4.2.2 Falling objects

Information shall be given on the fixing of workpieces, see 6.2.3 h).

4.2.3 Height from the ground

Guard rails shall be installed between working areas at different levels (e.g. working platforms), see EN ISO 14122-3:2016. Pits shall be equipped with a fall protection device for operators. Where fixed guards interfere with the spraying process or movement of the workpieces, means of fixing PPE against falling shall be installed and information on PPE against falling from height shall be given, see 6.2.3 i).

Walkways and filter support gratings which can be stepped on, shall be designed for a minimum operating load of 2 kN/m² and minimum concentrated load of 1,5 kN/(200 mm x 200 mm), see EN ISO 14122-2:2016.

If access at a height (e.g. on top of a booth) is required (e.g. for maintenance or servicing) guards or measures for safe access shall be installed.

4.2.4 Slippery surface

Floor gratings, platforms, steps and other walkways shall be designed according to EN ISO 14122-2:2016, EN ISO 14122-3:2016, EN ISO 14122-4:2016.

If the floor is made of detachable elements:

- any hazardous horizontal movement of these elements shall be prevented e.g. by fasteners and/or frames;
- it shall be possible to inspect fixings in order to detect any corrosion or any hazardous loosening or change of position of clamps.

Information on cleaning and maintenance shall be given in the information for use, see 6.2.4.

4.3 Electrical

The electrical equipment shall comply with EN 60204-1:2006. All conductive parts shall be earthed at equal potential. The insulation of electrical equipment shall be resistant against solvents and other fluids. Electrical equipment shall be protected against outside mechanical influence.

For electro-heating installations the requirements of EN 60519-1:2015 apply.

Electrostatic discharges of more than 350 mJ shall be avoided.

Floors of working areas shall have a resistance to earth of less than 100 MΩ.

An interface shall be provided to enable the interlocking of movable guards or means of access with the high voltage supply of electrostatic application systems (see EN 50176:2009, EN 50177:2009).

NOTE See EN 50348:2010, EN 50050-1:2013, EN 50050-2:2013, EN 50059:2018, EN 50176:2009 and EN 50177:2009 for requirements against electrical shock caused by electrostatic application equipment.

4.4 Thermal

Contact with hot surfaces shall be avoided by insulation or fixed guards, see EN ISO 13732-1:2008.

For combined spraying and drying booths the requirements of EN 1539:2015 apply during drying operation.

4.5 Noise

By design and construction, the emission of airborne noise shall be minimized. Technical progress and the availability of means for noise reduction, in particular at source, shall be taken into account.

NOTE 1 EN ISO 11688-1:2009 gives general technical information on widely recognized technical rules and means for design and construction of low-noise machinery.

NOTE 2 EN ISO 11688-2:2000 gives useful information on noise generation mechanisms in machinery and equipment.

Typical sources of airborne noise for spray booths are:

- fans and pumps;
- scrubber systems;
- leakage in the forced ventilation system, especially where the static pressure/vacuum is higher than 500 Pa;
- air flow velocity in the ducting system;
- pneumatically operated cleaning system for automatic spray booths for powder coating material;
- filter cleaning system.

NOTE 3 Applicators can be relevant sources of noise (see EN 1953:2013).

Typical measures for reduction of noise emission are:

- minimize leakage of the forced ventilation system;
- minimize pressure loss (e.g. by design of the plenum);
- avoid imbalance of fan impeller;
- choice of fan speed according to most favourable noise curves;
- design ducting with minimum bend radius of $1,5 \times$ diameter of duct;
- minimize air flow velocity in the air ducting;
- avoid propagation of vibrations and resonances to the structure;
- design ducting with sound decoupling;
- application of sound damping material;
- installation on anti-vibration support.

The determination, declaration and verification of airborne noise emission levels of spray booths shall be carried out according to EN 14462:2015.

The noise emission values according to EN 14462:2015 shall be indicated in the information for use, see 6.2.1 e).

4.6 Radiation

By design and construction, the exposure to radiation shall be minimized for combined spraying and drying booths equipped with IR or UV radiation sources for drying. The requirements of EN 1539:2015 apply for drying related aspects.

Hazardous emission of radiation into the working area shall be prevented by shielding (e.g. mechanical shutters).

NOTE EN 12198-3:2002+A1:2008 deals with a design strategy to reduce the flow of radiation by attenuation or screening.

Exposure to hazardous radiation shall be prevented by interlocking with guard locking of means of access with measures against hazardous emission from the radiation source. Requirements for safety functions are given in Table 5 (see 4.10).

The risks of hazards by radiation shall be assessed according to EN 12198-1:2000+A1:2008. The spray booth shall be classified into a radiation emission category according to EN 12198-1:2000+A1:2008. The classification shall be based on measuring according to EN 12198-2:2002+A1:2008 and/or prediction of emission of radiation.

The radiation emission values according to EN 12198-2:2002+A1:2008 and the marking according to EN 12198-1:2000+A1:2008 shall be given in the information for use, see 6.2.1 g) and 6.3 n).

4.7 Contact with and inhalation of hazardous material

4.7.1 General

4.7.1.1 Ventilation

Spray booths shall be designed to prevent escape of air containing vapours, aerosols or coating powder to avoid generation of an atmosphere with hazardous concentrations of material in the workshop.

Exhaust air from spray booths for liquid coating material shall be discharged to atmosphere.

External air intake and exhaust ducts shall be designed and positioned to avoid recirculation of polluted air. The dominant wind direction at the site of installation shall be taken into account.

The filter media of the powder recovery system shall ensure that the residual powder concentration in air recirculated into the building is below 10 % of exposure limits.

NOTE Exposure limit values, requirements for air-recirculation inside a building and emissions to atmosphere are subject to national regulation.

4.7.1.2 Direct heating systems

Direct heating systems shall

- comply with EN 746-1:1997+A1:2009, EN 746-2:2010 and EN 525:2009;
- be interlocked with the forced ventilation system. Requirements for safety functions are given in Table 5 (see 4.10);
- only be able to operate, when the forced ventilation of the spray booth is active.

4.7.1.3 Drying systems

For combined spraying and drying booths the requirements of EN 1539:2015 apply for drying related aspects.

4.7.1.4 Microbiological

Ventilation, filtration and scrubber systems shall be designed and constructed in such a way that

- the material used for construction is neither emitting substances hazardous to health, nor can it serve as nutritive medium for microorganisms in intended humid areas;

- construction material, surface engineering and geometrical shaping of system components avoid adhesion and deposit of matter, which can serve as nutritive medium for microorganisms;
- effective droplet separators are installed;
- water cannot stagnate in the system;
- water-bearing components can be drained as completely as possible;
- generation of damp areas outside of intended wet area (e.g. air humidifier, cooler with dehumidification) is prevented;
- regular inspections and maintenance (i.e. cleaning) are enabled, see 6.2.4 k).

4.7.2 Automatic application

4.7.2.1 General

Means of access shall be equipped with interlocking and guard locking, to prevent access during application of coating material and the subsequent purge time (see Annex I). An interface shall be provided to enable the interlocking of means of access with the spray application system. Requirements for safety functions are given in Table 5 (see 4.10).

It shall be possible to purge automatic spray booths, to ensure safe access by personnel for adjustment, maintenance and verification of machinery.

For required information on the use of PPE and procedures for safe access to the spray booth, see 6.2.3 h) and 6.2.3 i).

4.7.2.2 Air flow direction

At openings the airflow direction shall be from outside to inside.

4.7.2.3 Air flow velocity

For openings designated to manual spray application from an external working area, the air flow velocity in the measurement plane of these openings shall be at least

- 0,4 m/s in average and 0,3 m/s as minimum value in vertically ventilated spray booths;
- 0,5 m/s in average and 0,4 m/s as minimum value in horizontally ventilated spray booths;

for the empty spray booth.

For other openings (e.g. for loading of workpieces or conveyor systems) the air flow velocity at the centre of the measurement plane shall be at least 0,4 m/s for the empty spray booth.

4.7.3 Manual application

4.7.3.1 General

Contact with and inhalation of hazardous material sprayed shall be reduced by forced ventilation as far as possible. The airflow direction shall keep hazardous material (paint, solvents, coating powder) away from the breathing zone of the operator. This shall be achieved by the spray booth design and may be supported by e.g.

- means to rotate workpieces;

- optimizing of airflow direction to the work situation.

The spray booth shall be designed to operate with fresh air only.

The airflow over the whole working area should be as homogeneous as possible to minimize eddies within the spray booth. This may be achieved by:

- plenum construction;
- removing obstacles which influence the airflow;
- measures to direct the airflow;
- homogeneous distribution of air temperature within the spray booth (e.g. by installing the fan downstream of heating system);
- increasing the internal height of vertically ventilated spray booth;
- measures to avoid heating of spray booth walls;
- provisions for the positioning of workpieces to reduce the disturbance of the airflow.

The homogeneous airflow can be disrupted by operators, workpieces, the conveyor and the process of spray application.

The required airflow

- for spray booths for liquid coating material is calculated by

$$Q_{min} = \bar{v} \cdot w \cdot l$$

- for spray booths for powder coating material is calculated by

$$Q_{min} = \bar{v} \cdot A$$

The required airflow shall be monitored. An interface shall be provided to enable the interlocking of the forced ventilation and the spray application system. The spray application system shall only be able to operate when the forced ventilation is in operation and the airflow requirements are met. The forced ventilation shall not be switched off before the purge time (see Annex I) is over.

Requirements for safety functions are given in Table 5 (see 4.10).

Enclosed spray booths shall be designed to operate under non-positive internal air pressure.

Additional use of PPE including RPD, see 6.2.3 i) may be required.

NOTE 1 The requirement to use PPE/RPD for manual paint spray application of hazardous substances (e.g. isocyanates), is subject to national regulation for occupational safety.

If respiratory protection is required, means of connecting RPD to a supply of breathable air shall be provided for the designated number of operators. The connecting device shall have no negative influence on the quality and quantity of the breathable air supplied.

It shall be possible to purge manual spray booths, to allow removal of the RPD under safe condition.

For required information on the use of PPE, see 6.2.3 i) and 6.2.4 g).

The ventilation strategy for a working pit in a spray booth shall be determined by risk assessment. See Annex J for examples of ventilation of spray booths with a working pit.

In spray booths, the concentration of combustion gases from direct heating systems shall be below the exposure limits.

NOTE 2 Exposure limits are subject to national regulation.

4.7.3.2 Air flow direction

For vertically ventilated spray booths, the airflow direction shall be downwards.

The influence of hot surfaces (e.g. hot workpieces) shall be taken into account.

At openings the airflow direction shall be from outside to inside.

For open fronted spray booths, the airflow direction shall be horizontal.

For open top spray booths, the airflow direction shall be vertical.

If the operator has to move around a workpiece, the ventilation shall be vertical.

Spray booths with working pits shall be ventilated vertically. The airflow direction in the pit, upward or downward, shall be selected to minimize hazardous material in the breathing zone of the operator. This can be achieved by considering workpiece geometry and pit dimensions.

4.7.3.3 Air flow velocity

4.7.3.3.1 General

The air flow velocity criteria (see 4.7.3.3.2 and 4.7.3.3.3) shall be fulfilled in the working area for the empty spray booth.

For vertically ventilated spray booths for designated workpieces with

- a length of more than 6 m (e.g. container or wagon) and
- a coverage of at least 40 % of the air flow measurement plane

the air flow velocity criteria may be fulfilled for the loaded spray booth. Coating of smaller workpieces shall be excluded from the intended use of these spray booths, see 6.2.1 d), 6.2.3 g) and 6.3 j).

Dampers shall be accessible and easy to clean, see 6.2.4 i).

In segmented spray booths, the air flow velocity criteria shall be fulfilled in active segments.

4.7.3.3.2 Application of liquid coating material

The air flow velocity in the measurement plane in vertically ventilated spray booths shall be at least 0,3 m/s in average and 0,25 m/s as minimum value.

The air flow velocity in the measurement plane in horizontally ventilated spray booths shall be at least 0,5 m/s in average and 0,4 m/s as minimum value.

For openings designated to manual spray application from an external working area, the air flow velocity in the measurement plane of these openings shall be at least

- 0,4 m/s in average and 0,3 m/s as minimum value in vertically ventilated spray booths;
- 0,5 m/s in average and 0,4 m/s as minimum value in horizontally ventilated spray booths;

for the empty spray booth.

For other openings (e.g. for loading of workpieces or conveyor systems) the air flow velocity at the centre of the measurement plane shall be at least 0,4 m/s for the empty spray booth.

See Annex D for measurement requirements.

4.7.3.3.3 Application of powder coating material

For internal working areas, the air flow velocity in the measurement plane shall be at least:

- 0,3 m/s in average and 0,25 m/s as minimum value for vertically ventilated spray booths; and
- 0,5 m/s in average and 0,4 m/s as minimum value for horizontally ventilated spray booths.

For openings designated to manual spray application from an external working area, the air flow velocity in the measurement plane of these openings shall be at least

- 0,4 m/s in average and 0,3 m/s as minimum value in vertically ventilated spray booths;
- 0,5 m/s in average and 0,4 m/s as minimum value in horizontally ventilated spray booths;

for the empty spray booth.

For other openings (e.g. for loading of workpieces or conveyor systems) the air flow velocity at the centre of the measurement plane shall be at least 0,4 m/s for the empty spray booth.

See Annex D for measurement requirements.

4.7.3.3.4 Segmented spray booths

In segmented spray booths, the air flow velocity criteria given in 4.7.3.3.2 shall be fulfilled in the working area. To ensure sufficient airflow in the working area, the central and the adjacent segments shall be active.

NOTE 1 A common length of a segment is ≥ 3 m.

The switching between active segments shall be triggered by the position of the operator(s), see Figure 5. Therefore the position of every operator shall be determined, e.g. by radio-transmitters or video signal. The working area shall follow the operator(s) with a delay of less than 3 s.

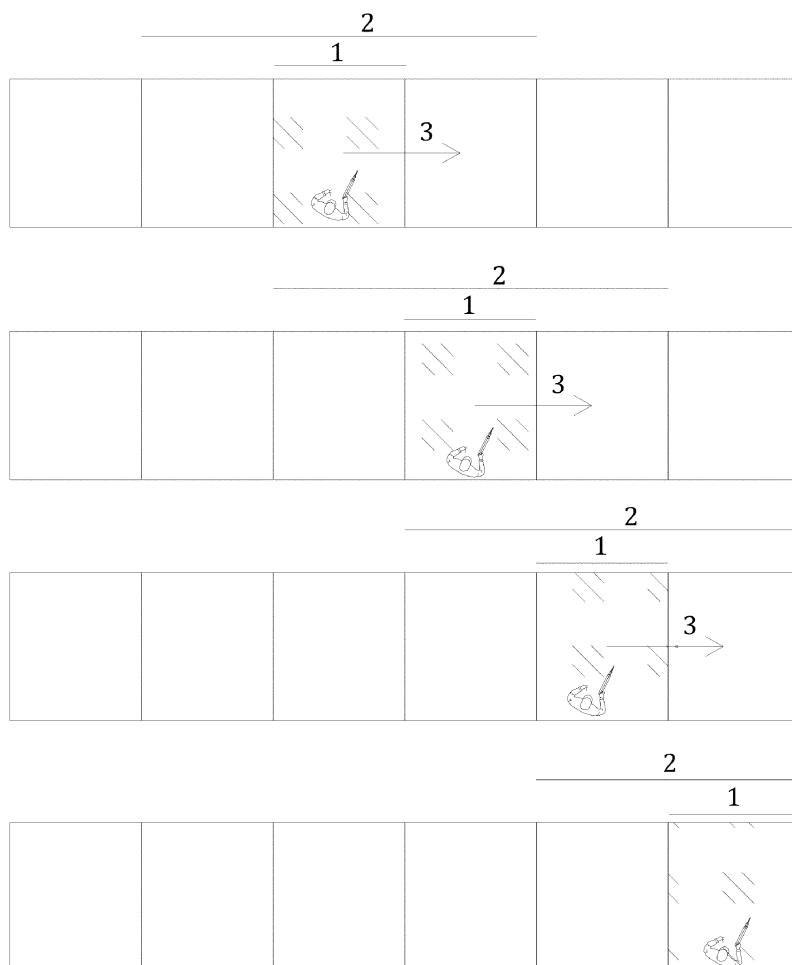
An interface shall be provided to enable the interlocking of the forced ventilation of active segments and the application system. The application system shall not be able to operate if the air flow velocity requirements in the active segments are not met.

Requirements for safety functions are given in Table 5 (see 4.10).

Dampers shall be accessible and easy to clean, see 6.2.4 i).

NOTE 2 Operation of the segments rely on damper operation.

Information on the time to establish a stable airflow in active segments shall be given in the information for use, see 6.2.1 m).

**Key**

- 1  working area
- 2 active segments
- 3 movement of operator

Figure 5 — Switching of active segments**4.8 Fire****4.8.1 General**

The fire load inside the spray booth shall be minimized by design and construction, maintenance and operation procedures.

The selection of the construction material shall be carried out by risk analysis according to EN ISO 19353:2016. If non-combustible material is not applicable hardly flammable material should be used.

NOTE Non-combustible or hardly flammable construction elements of buildings are classified as A1, A2 or B in EN 13501-1:2007+A1:2009.

4.8.2 Spray booth construction

Structural support elements of spray booths

- for liquid coating material shall be non-combustible;

NOTE 1 Non-combustible construction elements of buildings are classified as A1 in EN 13501-1:2007+A1:2009.

- for powder coating material shall be at least hardly flammable and in case of fire, shall emit as little smoke as possible;

NOTE 2 Hardly flammable construction elements of buildings are classified as B in EN 13501-1:2007+A1:2009.

- shall maintain structural stability of the spray booth for the time needed for escape in event of fire. The estimation of the escape time shall be related to the foreseeable worst case (e.g. operator escape from lifting devices).

NOTE 3 Fire resistance of construction elements of buildings are classified in EN 13501-2:2016.

All other construction material (e.g. insulation material of sandwich elements) shall be:

- hardly flammable or non-combustible. In case of fire, hardly flammable material shall emit as little smoke as possible;
- securely and rigidly fastened.

The interior surface of the spray booth shall be as smooth as possible to minimize deposition of coating material and facilitate cleaning.

Information on how to reduce the risk of fire shall be given, see 6.2.1 h)1), 6.2.1 j), 6.2.1 l), 6.2.3 b), 6.2.3 d), 6.2.3 e) and 6.2.4 i).

4.8.3 Filter media

Final downstream inlet air filter media shall be manufactured from non-combustible or hardly flammable material. In case of fire, hardly flammable material shall emit as little smoke as possible.

NOTE Non-combustible or hardly flammable construction elements of buildings are classified as A1, A2 or B in EN 13501-1:2007+A1:2009.

For the first exhaust filtration stage, the filter media for liquid coating material shall be manufactured from at least hardly flammable material. In case of fire, hardly flammable material shall emit as little smoke as possible.

4.8.4 Fire detection

A fire detection system shall be installed in:

- automatic spray booths for liquid coating material;
- spray booths for powder coating material with closed air cleaning or closed recovery systems.

The fire detection system shall:

- have a response time of less than 0,5 s;
- be designed and constructed to operate under spray booth conditions;

- be positioned adequately (e.g. to avoid interference with paint-spray).

The fire detection system shall be interlocked with

- the forced ventilation. The forced ventilation shall be stopped when a fire is detected;
- fire dampers, when present. Fire dampers shall be closed when a fire is detected.

An interface shall be provided to enable the interlocking of the fire detection system with

- the high voltage supply of electrostatic application systems (see EN 50176:2009, EN 50177:2009). The high voltage supply shall be cut off when a fire is detected;
- the spray application. The spray application shall not be able to operate when a fire is detected.

The fire detection system shall initiate an audible and visible alarm when a fire is detected.

Requirements for safety functions are given in Table 5 (see 4.10).

4.8.5 Fire extinguishing equipment

All spray booths for liquid coating material with fire detection systems shall be equipped with either

- an interface for the safe exchange of signals to suitable fire extinguishing systems or
- a suitable fire extinguishing system.

The technical emergency safety measures, described in 4.8.4., shall be in force before triggering the extinguishing equipment. If the extinguishing agent concentration is not hazardous for the operators, the technical emergency safety measures, described in 4.8.4., can be triggered at the same time as the fire extinguishing system.

All spray booths without fire detection system should be equipped with manual fire extinguishers. Information shall be given in the information for use, see 6.2.1 m).

NOTE 1 Provision for use of manual fire extinguishing equipment is subject to national regulation for occupational safety.

NOTE 2 Local fire extinguishing may be required for electrostatic application equipment (e.g. EN 50176:2009). These fire extinguishing systems are part of the application system.

See 4.9.3.3 for requirements for the protection of spray booths for powder coating material.

4.9 Explosion

4.9.1 General

Spray booths shall be equipped with forced ventilation to limit the concentration of flammable substances below the specified percentage of LEL.

The required air flow shall be monitored.

An interface shall be provided to enable the interlocking of the forced ventilation with

- the spray application and
- the high voltage supply of electrostatic application equipment.

Requirements for safety functions are given in Table 5 (see 4.10).

4.9.2 Spray booth for liquid coating material

4.9.2.1 Limitation of flammable solvent vapour concentration

The flammable substances concentration shall be limited to:

- 50 % of LEL for automatic spray booths;
- 25 % of LEL for manual spray booths.

The flammable substances concentration and the fresh air flow required for explosion protection shall be calculated according to Annex C.

NOTE National regulations may require lower flammable concentration limits for manual spray booths.

If the LEL of solvents is unknown, a value of 40 g/m³ shall be used.

Working pits shall be ventilated to avoid accumulation of solvents in the pit.

4.9.2.2 Ignition sources

Ignition sources shall be avoided in spray booths for liquid coating applications. Installed equipment, components and protection systems shall, dependent on the calculated concentration, fulfil the categories specified in Table 3.

NOTE Hazardous areas are classified in terms of zones on the basis of frequency and duration of the occurrence of an explosive atmosphere (see Annex B).

An interface shall be provided to enable the interlocking of electrical equipment and heating devices which do not comply with the requirements of Table 3 with the spray application system. The spray application system shall not be able to operate if

- this electrical equipment is live;
- the surface temperature of heating devices is higher than the admissible temperature (see EN 1127-1:2011).

Requirements for safety functions are given in Table 5 (see 4.10).