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BSI Standards Publication

Thermal spraying — Safety requirements for thermal spraying equipment

Part 6: Spray booth, Handling system, Dust collection, Exhaust system, Filter

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National foreword

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Thermisches Spritzen - Sicherheitsanforderungen für Einrichtungen für das thermische Spritzen - Teil 6: Spritzkabinen, Handhabungssystem, Staubsammlung, Abluftsystem, Filter

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Foreword

This document (CEN/TR 15339-6:2014) has been prepared by Technical Committee CEN/TC 240 “Thermal spraying and thermally sprayed coatings”, the secretariat of which is held by DIN.

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1 Scope

This Technical Report specifies safety requirements of machines and equipment for thermal spraying, in this case of spray booths, handling, dust collection, exhaust, and filter systems.

This Technical Report should be used in conjunction with the Technical Report CEN/TR 15339-1 which deals with general aspects for design, manufacture, and/or put into service of machines or equipment and with the responsibility to issue the CE Conformity Declaration.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 657, *Thermal spraying - Terminology, classification*

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

CEN/TR 15339-1, *Thermal spraying — Safety requirements for thermal spraying equipment — Part 1: General requirements*

EN ISO 10218-2, *Robots and robotic devices - Safety requirements for industrial robots - Part 2: Robot systems and integration (ISO 10218-2)*

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

EN ISO 15667, *Acoustics - Guidelines for noise control by enclosures and cabins (ISO 15667)*

EN ISO 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

EN 60974-10, *Arc welding equipment - Part 10: Electromagnetic compatibility (EMC) requirements*

3 Function of thermal spraying equipment for thermal spraying

3.1 General

The spraying processes are described in EN 657. Thermal spraying creates process related heat, fume, dust, radiation and high levels of noise. Therefore thermal spraying systems are usually installed in firm enclosures. They are designed to protect personnel and environment and to control and minimise the exposure of the operator and others. Dust and fume can be captured and removed safely by a suitable ventilation, exhaust and filter system and the enclosure provides a guard against mechanical, electrical, thermal and noise risks.

3.2 Function and construction of a spray cabin

3.2.1 General requirements

The spray cabin shall be designed that the noise level outside the cabin fulfils the legal requirements. Even if more than one piece of equipment is operated the total noise level in the workshop shall fulfil these requirements.

3.2.2 Features of a spray cabin

There are some different types of spray cabins available.

Usually, modularly built single wall enclosures made out of about 100 mm thick elements are used for plasma, arc and HVOF spraying processes. They consist of a solid steel sheet on the outer side and a perforate steel sheet on the side towards the noise source. The space between those sheets is filled with a non-flammable isolation material, for example with glass wool or rock wool.

Also the doors and windows shall be able to protect the outside working personnel from excessive noise, dust, gases, fumes and intensive light, IR and UV radiation. Openings needed for electrical cables, gas or water hoses, and piping for ventilation and exhausting shall be sealed, in order to avoid acoustic tunnelling and to minimise the escape of dust and vibrations.

If the roof of the spray cabin has to carry installations like ventilator, power sources or heat exchangers and/or small lifting devices or manipulating equipment have to be mounted onto the ceiling, adequate reinforcement shall be applied. Sufficient space for maintenance and a safe access to this area is required.

In the case of mechanised spraying, the operator will enter the cabin only for changing the part to be coated or for maintenance. If loading and unloading of the parts can be executed through an opening, while the spraying process is shut off, the enclosure can be built as small as possible and thus be more effective for dust extraction. For automatic processes loading and unloading may be done through a lock, while the process runs.

3.2.3 Layout for a spray cabin or a thermal spraying equipment in the workshop

Spraying equipment shall not create safety hazards for nearby processes. A spray cabin or the spraying equipment should be located close to an outside wall to facilitate easy gas supply and the installation and effectiveness of the ventilation and extraction equipment.

The workshop building should be single storey and be as spacious as possible with a high ceiling and good natural ventilation achieved by a sufficient number of air inlets, roof vents and opening doors and windows. In that way, gas accumulation can be avoided in unventilated areas overhead, such as voids above false ceilings or in voids below floor level, such as pits, service trenches, gullies or underground rooms, where gases heavier than air could accumulate. A mechanized ventilation can be necessary, in order to draw away gases heavier than air at lower height, as e. g. LPG, propane, argon.

3.2.4 Ventilation and exhausting for the spray cabin

3.2.4.1 Reasons for ventilation and exhausting

To avoid explosive gas or dust mixtures or hazardous conditions the spray cabin shall be ventilated. A suitable air change and flow in the spray cabin prevents the formation of a burnable or explosive atmosphere inside the enclosure, reduces temperature rise, serves for removing gases, fumes, dusts, further by-products and provides for a safe spraying operation. The filtration of the exhausted air and gas mixture avoids an inadmissible contamination of the environment. The national or local laws or regulations for emissions into the atmosphere shall be followed.

3.2.4.2 Ventilation of the spray cabin

The air volume needed for the ventilation of the spray cabin is given by the exhaust air volume. The design of air inlet into the spray cabin and of the exhausting shall provide an air flow in suitable flow direction and local speed. A laminar continuous air flow, which can be reached by a great number of small inlet openings equally distributed is preferred, so far as the air flow is not decisive disturbed by the spraying equipment and the manipulating system. A turbulent air flow causes swirls and low pressure areas, where dust can remain or fall out.

The ventilation capacity and speed in the cabin shall function in the sense of displacement ventilation. Capacity and speed shall serve:

— for an adequate transport of spray dusts to the exhaust system;

— to avoid too low an oxygen content by diluting the atmosphere in the cabin (e. g. in the case of cold spraying);

— to avoid unacceptable gas concentration, which can remain in dead spots;

— to maintain the air temperature in the duct in a range that the filters will not be damaged (e. g. in the case of HVOF kerosene spraying).

3.2.4.3 Exhausting the spray cabin

The exhaust volume shall be adequate for the spray process and the size and shape of the exhaust hood and the component. Table 1 includes typical values in m^3/h depending on the spray process. It should be noted that the better the exhaust hood is adjusted to the size and form of the component, the lesser are problems with remaining dust in the air and on the floor and cabin walls.

The air speed to capture the rebounding particles and those which did not meet the part should be at least 1 m/s in front of the exhaust hood.

In the case of manual spraying in a cabin an Air Change Rate (ACR), see Formula (1) of at least 60 to 180 changes per hour depending on the spraying process is recommended. The Air Change Rate is calculates as follows:

$$N = Q/Vol \quad (1)$$

Where

N number of air changes per hour

Q Volumetric flow rate of air in cubic meter per hour

Vol Space volume: length × width × height, in cubic meter

Table 1 — Exhaust volumes

Spray process	Exhaust volume min. m^3/h
Flame spraying	3 000 to 5 000
Arc spraying	8 000 to 12 000
Plasma spraying	8 000 to 10 000
HVOF (gaseous fuel)	10 000 to 12 000
HVOF (liquid fuel)	12 000 to 15 000
Cold spraying	5 000 to 15 000

Exhaust and ventilation systems will create a lower pressure in the spray cabin. This lower pressure shall not cause difficulties opening the doors while the extraction is running. An adequate air inlet shall be calculated and designed to avoid this.

The start of the spray system shall be interlocked with the exhaust system to ensure adequate extraction during spray operation.

Sometimes ventilators with two running speeds are recommended either to keep a low ventilation level mode, if the cabin door is opened for maintenance, set-up or teach-in programming or to increase the ventilator capacity in the case of emergency to avoid a dangerous or explosive atmosphere in the cabin.

The exhaust system should have a short run lengths and preferably should lead only from one or two spray equipment to each collector. The exhaust and filter system should have smooth walls inside and no dead spots where dust can accumulate. The exhaust channel should have as few bends as possible of large a radius as possible to avoid loss of pressure and gathering of dust. The recommended air speed in the duct should be between 16 m/s and 25 m/s. Accessibility for cleaning and inspection is required.

Depending on the material sprayed, additional measures shall be taken to avoid fire and explosion risks. Generally, the national or local regulations shall be fulfilled.

3.3 Equipment in the spray cabin

3.3.1 General

Often a spray cabin contains the part fixture system (turning device for spraying, turn table, automatic part changing equipment, etc.), the manipulator system to move the spray torch (industrial robot, X-Y-Z-axis manipulator system, etc.), the exhaust hood for spray dust, fume, and heat, exhaust channels, and the spray torch with its hose assembly, and devices for cooling the part.

The control panel shall be mounted outside the spray cabin for mechanised or automatic spraying, for manual spraying it can also be mounted outside, if a second person with visual contact to the spraying area is present. This person shall monitor the process and shut-off the spray system in case of emergency.

Sources of danger identified by a risk assessment shall be considered and marked, if appropriate, for example by mechanical barriers, stop devices, warning barriers, warning signs.

3.3.2 Function and description of the manipulating systems

Manipulating systems can help to increase the quality assurance and to avoid exposures of the operating personnel. They can be of:

— linear speed traverse;

— rotating tables;

— X-Y-Z-axis manipulator; or

— industrial robot type.

The safety requirements for industrial robots are specified in EN ISO 10218-2.

3.3.3 Electrical equipment and installation

Electrical Apparatus is a prime source for ignition an explosive atmosphere. The installation shall conform to the EN ISO 60204-1 and the local national regulations for electrical installations including the electromagnetic compatibility according to EN 60974-10 and to the manufacturer's instructions.

The safety relevant control loops, determined by the risk assessment, shall be developed according to EN 13849-1.

3.4 Extraction and filtering equipment

3.4.1 General

Its purpose is to collect, extract and filter the spray dust from the air, in order to remove the fine sized particles before the air is released to the atmosphere. The limiting values for emission of fine, coarse and carcinogenic dusts are specified in National Environmental Legislation. Wet extraction is not suitable for thermal spraying applications, because it is not able to meet emission reduction requirements.

3.4.2 Dry extraction

3.4.2.1 Dry working collector systems

Sprayed particles, which either miss the part or rebound from it, should be captured close to their source of creation. The extraction equipment can vary from:

— a basic hood behind the part to be coated, adequately adjusted to its shape and the local conditions and moved correspondingly with the motion of the spray torch; or

— floor extraction system ('floorwash'), which can provide a higher extraction rate of sprayed particles and better cleanliness in the spray cabin. However, the energy needed to capture and transport the particles is extremely high;

— other systems which use for example, part of the cabin wall or a combination of several systems.

The air speed shall be a minimum of 1 m/s in front of the hood. A fire trap should be mounted to prevent hot particles getting into the filter, especially if arc spraying is applied.

3.4.2.2 Dry extraction systems – filter systems

As a pre-filtering operation multi cell cyclones can be used for pre-extraction of coarse grain particles to avoid over loading or damage of the cartridge filter elements. However, they are not able to capture spray particles below 5 µm in size.

Usually, cartridge filters, which possess an efficiency of > 99%, are used. They comprise a series of filter elements folded to form a pleated material, mounted within a steel casing. Due to mounting of the elements in several rows the required filter surface can be reached and can avoid exceeding the admissible surface loading. It is recommended that the filter should be located outside the building, so that the safe opening of an explosion vent is possible.

Filtration method, exhaust air speed, and cleaning of the cartridges depend upon the spraying process and its running time. Cleaning the cartridges is carried out automatically by periodic reverse pulsing with compressed air while operating. A suitable cleaning cycle provides a suitable free filter surface at all times.

The maximum operation temperature of the filter cartridge shall be considered. Typically, this value is 60°C.

To avoid an inadmissible emission into the environment in the case of damaged or broken filter elements a pressure sensor, shall detect any alteration of pressure. Additionally, a tribo-electrical automatic filter controller should be installed to detect an increase of the dust loading in the filtered exhaust air, before a real damage of one or more filter elements occurs measures to be taken are described in 5.8.3.

4 Potential hazards

4.1 General

To ensure safe operation in a spray cabin, including manipulator systems, dust collection and exhaust systems (inside and filter outside the spray cabin), the following features are of importance for normal operations or foreseeable abnormal circumstances.

The hazards can be of the following types:

4.2 Mechanical hazards

— Exposure of persons to fast motion of manipulators (industrial robots or other handling systems) due to inadequate guards or ineffective interlocking of safely devices.

— Inadequate fixing of the spray torch or the part.

4.3 Electrical hazards

— Contact of persons with live parts, e.g. plasma spray torch during operation or ignition or wires in arc spraying.

— Contact of persons with parts which became live under faulty conditions, e. g. defective insulation of cables.

— Electrostatic charge of powder hoses due to inadequate grounding.

4.4 Thermal hazards

— Contact of persons to the spray jet or open flames.

— Contact of persons to hot surfaces, e.g. the sprayed part.

— Contact of persons to the cooling jet in case of CO_2 cooling.

4.5 Fire and explosion

— Fire by escape of combustible gases due to leaks in the piping.

— Fire by accumulation of dust in the spray cabin, the exhaust system or in the filter due to insufficient effectiveness of the extraction system or insufficient cleaning.

— Explosion by escape and accumulation of combustible gases due to leaks in the piping and insufficient ventilation.

— Explosion and fire by accumulation of dust in the exhaust system or in the filter due to too low extraction air flow or insufficient filter cleaning.

4.6 Hazards generated by noise

— Escape of excessive noise to outside the spray cabin due to ineffective insulation of the cabin walls or inadequate sealing of the cabin openings.

— Escape of excessive noise to the workplace due to insufficient design or insulation of the exhaust ducting to the filter.

4.7 Hazards generated by radiation

— Exposure to intensive UV, visible or infrared radiation due to an insufficient degree of protection by the observation windows.

— Exposure to inadmissible levels of electromagnetic fields, for details refer to EN 12198-1.

4.8 Hazards generated by spray materials and substances

— Inhalation of spray material or dust.

— Skin contact to spray material or dust.

— Escape of spray material, dusts and fume out of the spray cabin, powder feeding systems, the exhaust ducting or the filter to the environment due to deficient air tightness, broken filter elements or insufficient cleaning.

— Escape of spray material or dust to the environment by uncontrolled drain of contaminated water.

4.9 Hazards generated by neglecting ergonomic principles

— Insufficient illumination of the workplace and the inside of the spray cabin.

— Inadequate positioning of the observation windows.

— Inadequate design, location or unclear identification of displays, controls and other elements of operation.

4.10 Human error, human behaviour

— Neglecting directives, codes, regulations or the instructions of the manufacturer of the equipment.

— Neglecting the use or inadequate use of personal protection or safety interlock devices.

— To become suddenly afraid in the closed spray cabin due to a unexpected occasion or mis-function while setting-up or spraying.

4.11 Hazard of asphyxiation

— Due to an insufficient exhaust volume and inadequate dilution of gases such as Nitrogen or Argon with air the oxygen concentration in the cabin can drop below safe levels.

5 Safety requirements – protection measures

5.1 General

Specific safety requirements are to be considered:

— protection of the personnel from mechanical, electrical, and thermal hazards and from exposure to noise, dusts, fumes, and gases;

— use of efficient ventilation, exhaust and filter systems;

— use of piping and hose assemblies without leaks;

— avoidance of explosive dust gathering and gas concentration;

— avoidance of transmitted vibration.

The start of the spray system shall be interlocked with the exhaust system to ensure sufficient extraction during spray operation.

An electrical interlocking shall shut off the spray equipment, if the exhaust system fails or does not operate. In the case of emergency the electrical power supply shall be switched off, however the ventilation and exhaust systems shall still work.

In general, the sequence of measures shall be:

Substitution – enclosure – exhausting and ventilation – use of personnel protection equipment.

Suitable measures and equipment are discussed in the following chapters.

5.2 Protection measures from mechanical hazards

Electrical interlocking shall ensure that the operator can enter the spray cabin without being injured by the manipulator or by the spraying equipment.

To prevent injury to the operator during setting-up or teach-in programming, the manipulator or industrial robot shall only work using extremely reduced speed in this case; for details see EN ISO 10218-2. This shall be considered when performing the risk assessment. For details, see CEN/TR 15339-1.

To prevent injury to the operator during setting-up and to avoid damages of the spray equipment or the part adequate fixing of the torch and the part shall be designed and carried out.

Care shall be taken that lifting devices in the spray cabin cannot operate while the spraying process is running.

5.3 Protection measures from electrical shock or other injury from the energy supply

The installation shall fulfil the national regulations for electrical installations and the manufacturer’s instructions.

Electrical components, which are inside of the spray cabin, shall be protected against ingress of dust. For using electrical apparatus in an explosive gas atmosphere refer to the EN 60079 series.

To prevent injury to the operator during operation or ignition by contact with live parts, e.g. plasma spray torch or wires in arc spraying the equipment shall be safely designed and protected, where appropriate.

Regular inspection is required to ensure that cables with defective insulation will not be used to prevent injury to the operator by contact with parts which became live due to such faulty conditions.

Electrical cables should always be suitably protected from identifiable mechanical damage and mounted in a safe position, to avoid trip hazards and damage. The distance between permanent mounted electrical cables and pipes for combustible gases specified in national regulations shall be considered.

Control panels, metallic cabin walls and further metallic installations shall be earthed. Especially the powder feed hoses shall be grounded adequately to avoid electrostatic charge.

In case of an automatic process, a switch that requires the door being completely closed can stop or prevent operation of the spraying process. The necessity of installation of a fault current protection equipment is defined in EN ISO 60204-1.

5.4 Protection measures from thermal attack

To prevent the operator from injury by ejection of hot process cooling media leaks in the hoses or fittings shall be avoided. Regular inspection is required.

In case of a manual spraying process, care shall be taken that the personnel will not come into contact with the cooling device and/or the cooling jet in the case of CO_2 cooling or with the spray jet or any open flames for preheating, spraying, or fusing.

The operator shall be instructed to avoid any contact to hot surfaces, as e. g. the coated part.

5.5 Protection measures from fire and explosion

The risk of fire is given when combustible gases escape due to leaks in the piping system. Moreover, the risk rises if the ventilation in the spray cabin or in the workshop is not sufficient or such gases can accumulate in inadequately ventilated areas, as e.g. in dead spots or in channels. Thus, a regular inspection of the piping system is required.

The design of the ventilation system and the necessary air flow shall ensure that no accumulation of dust in the extraction system occurs. The filter shall have an adequate, functional and sufficiently frequently operated cleaning system for the filter elements to ensure an effective air flow and an efficient collection of the spray dust.

The risk of fire is given when metal fumes or dusts are created by thermal spraying of titanium and aluminium. Due to the low oxide content on the sprayed metal particles' surface in the case of cold spraying or plasma spraying in a vacuum chamber the particles can catch fire or explode when they come in contact with air. Thus, a sufficient ventilation system is required to avoid any accumulation.

Burning metal dust shall not be extinguished with water,. The use of powder extinguisher is recommended. The metal dust should not be swirled when extinguishing. The employer shall take care that trained personnel is available to extinguish metal burning, where appropriate.

If the risk assessment indicates the risk of fire due to thermal spraying of metals like zinc, titanium or aluminium, the equipment needs to be ingress protected (IP) against penetration of dust.

To reduce the risk of fire or explosion in the filter or in the exhaust ducts temperature switches and fire sensors should be installed, if they are not required by national or local regulations. If a fire in the filter is ignited an alarm signal shall be given inevitably, the ventilator shall be shut off, and the one way air flaps closed automatically to prevent the fire or explosion from reaching the spray cabin.

5.6 Protection measures from noise outside the spray cabin in the workshop

Due to the process related excessive noise levels (for details see Table 2) protection measures shall be considered to avoid a noise level and its duration time in the workshop above the limiting values specified in national laws or regulations. Usually, this noise exposition level is limited to 80 dB(A) for an 8 hour shift.

Table 2 — Typical noise levels for thermal spraying processes

Spray process	Noise level dB(A)
Detonation gun	145
HVOF spraying	125 to 135
Wire flame spraying	118 to 122
Powder flame spraying	90 to 125
Arc spraying	105 to 120
Atmospheric plasma spraying (APS)	110 to 125
Cold spraying	110

Preferably, the problem should be reduced at source by using the equipment with the lowest noise level capable of meeting the other technical requirements Sound absorbing equipment shall be applied to reduce escape of vibration noise for air inlet and exhaust ducting to the filter. Openings needed for power, gas or cooling media supply shall be insulated sufficiently.

The spray cabin and its doors and observation windows shall be adequately designed and effectively insulated to avoid an inadmissible noise level outside the cabin in the workshop.

If the noise level and/or the duration time exceeds the admissible limiting values outside the spray cabin, protection measures are required. The employer shall perform a noise exposure assessment, for example according to EN ISO 15667 and to national or local regulations. If it is not reasonably practicable to reduce the exposure of employees to a noise level of less than the admissible limiting value by technical or management measures the whole workshop is declared to be a noise loaded working zone. The employees working in this zone shall be provided with suitable hearing protection equipment and instructions for its use. The employer shall control its required use.

5.7 Protection measures from radiation

To protect the operator from ultraviolet, infrared and intense visible light radiated by the respective spraying process, the observation windows of the spray cabin shall be glazed with suitably filtering material to prevent injury to the operator and further personnel working outside the cabin. Regarding the different grades of semi-transparent dark welding screens, EN 169 is useful for this application.

To prevent injury to the operator and further personnel working outside close to the cabin the admissible level of Electromagnetic compatibility (EMC) required in national laws or local regulations and specified in European Standards shall be considered. Only equipment with CE Declaration shall be applied. Normally, the spray cabin built out of insulated metal elements generates an adequate screen (Faraday cage). Directives, national laws, local regulations, and further instructions of the equipment supplier shall be considered for installation and operating of the spray equipment.

5.8 Protection measures from attack by spray materials and substances

5.8.1 General

Before starting the spraying operation or entering the spray cabin the ventilation and exhaust system shall work for sufficient time to avoid an explosive atmosphere in the spray cabin.

To ensure that no explosive gas mixture will remain in the spray cabin and to minimise the gathering of dust a suitable design of extraction system shall be used.

An adequate air inlet shall be designed to create a slightly lower pressure in the spray cabin, the exhaust and ventilation system, so that dust and fume will not escape into the workshop. This lower pressure shall not create problems, when opening the cabin door.

The start of the spray system shall be interlocked with the air inlet and exhaust system to ensure that spraying can only be carried out, if the ventilation system works adequately.

If the concentration of gases, fumes, or dusts exceeds the working place limiting values counter-measures are required. In the case of protection area 3 or 4[1)] it is required to minimise the concentration level, even it is below the limiting value.

An oxygen sensor should be installed in the spray cabin to avoid any risk of asphyxiation. If CO_2 is used an additional CO_2 sensor shall be installed.

If the exposure level cannot be brought below the admissible working place limiting value for a substance by any technical measures, personnel protection equipment shall be provided and used as required in national regulations. The operator‘s exposure and the regular wearing of protection equipment shall be controlled by the employer.

5.8.2 Control of the emission into the environment

After installation and a test run of the exhaust and filter system the remaining dust content in the extracted air is to be determined after filtering. The different limiting values for particle size range, chemistries and carcinogenic dusts shall be considered. The limiting values for emission into the environment are specified in national laws or regulations. They shall not be exceeded.

5.8.3 Pressure supervising of the filter system

To avoid inadmissible emissions to the environment the filter system shall function adequately. A pressure sensor, which may give an optical or acoustic signal, shall detect an inadmissible increase of pressure or strong pressure drop in the filter. Additionally, a tribo-electrically working automatic filter controller should detect an increase of the dust loading in the filtered exhaust air, before a real damage of one or more filter elements occurs. If limiting values are exceeded the spraying process shall be shut off inevitably to avoid uncontrolled escape of dust.

If the pressure in the filter rises suddenly the explosion flap shall open immediately and the exhaust air shall be blown-off into the environment. Correct operation of this procedure shall be ensured by the equipment design and the installation.

5.8.4 Precautionary measures for air recovery back into the spray cabin or workshop

An air recovery back into the spray cabin or the workshop can be accepted only if the concentration of the transported contaminants is less than a quarter of the respective limiting value and no carcinogenic harmful substances remain in the exhaust air. In some cases the exhaust air can be used to warm up the cold inlet air by heat exchanging.

5.8.5 Cleaning the cabin

Even in the case of effective extraction, deposition of spray dust cannot be avoided completely. Dust will remain on the floor and walls of the spray cabin and the equipment inside the cabin. This dust shall be removed using certified industrial vacuum cleaners or road-sweeping machines. For dust containing carcinogenic substances only specific qualified vacuum cleaners shall be used.

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1) Protection area 3: presence of highly dangerous toxic substances; Protection area 4: presence of substances, which can create cancer or genetic changes or damage to fertility.

5.8.6 Disposal of spray dust

Usually, spray dust, which contains heavy metals (e.g. Ni, Cr, Co, Pb), captured in a filter shall be collected carefully as for extra waste. Disposal or recovery of dry spray dusts shall be handled according to national or local regulations.

5.9 Protection measures from neglecting ergonomic principles

The employer shall ensure that workplaces outside and inside the spray cabin are sufficiently illuminated.

Care shall be taken that ergonomic requirements for use of the equipment are fulfilled, such as appropriate height of the observation windows, adequate local lighting and sufficient location or identification of manual controls or displays, etc.

The design of the cabin shall ensure that the persons working inside the cabin can escape immediately in the case of danger. The escape route shall be clearly marked and the emergency door be opened immediately without use of any auxiliaries and door and route shall be safely useable.

Care shall be taken that doors, displays, controls, and other elements of operation, for example emergency stops, are adequately and clearly identified and marked.

5.10 Protection measures in the case of human error and human behaviour

The employer shall ensure that instructions from directives, codes, the operation manual and further advices of the supplier are followed. He shall provide instructions to his employees to work carefully and safely.

The employer shall provide protection equipment including special working clothes and shall supervise its use in accordance with the regulations.

5.11 Protection measures when entering the spray cabin

European Directives and laws or local regulations require a risk assessment by the manufacturer, integrator or user for such work.

The operator shall not enter the spray cabin before enough time has elapsed from the end of spraying operation for the ventilation and exhaust system to work sufficiently to clear the cabin of dust fume or asphyxiant gases. This can be ensured by a time controlled electrical interlocking between gas supply, ventilation, exhausting, and entrance. At least, this procedure shall be specified and published and distinctly visible placed on the outside of the spray cabin, if such a procedure is accepted by the national regulations.

Independent of the efficiency of the air extraction the operator shall wear suitable personal protective equipment, when entering the spray cabin for setting-up, teach-in programming, or spraying. Hearing protection and breath protection equipment or clean-air fed respirators shall be used in the case of manual spraying.

Breathing protection equipment shall be used also when filling or cleaning the powder feeder. For details see CEN/TR 15339-5.

5.12 Safety related maintenance

Maintenance of spraying equipment leads to increased reliability of spraying operations, coating quality and can often provide for the safety of the operator. Preventive maintenance programs shall be established and followed.

The following maintenance measures are recommended or required at intervals:

— inspection of any spraying equipment and the exhaust, filter and ventilation system;

— inspection of integrity of the screening against visible, IR and UV radiation;

— inspection of the function of interlocking devices;

— control of the emergency system;

— inspection for leaks in gas, water and cooling systems;

— inspection of the hoses, fittings, and cables for damages;

— inspection and calibration of the gas sensors;

— vacuum cleaning of the cabin floor, walls, ceiling, spraying equipment and other devices;

— inspection of the correct use of required personal protection equipment.

6 Requirements for manufacture, supply, operation, and maintenance

6.1 Requirements for the manufacturer

— manufacture of the equipment providing the requirements according to the EU Directives and the instructions of CEN/TR 15339-1;

— presentation of an operation and maintenance manual of the equipment.

6.2 Requirements for the integrator

— installation and putting into service providing the requirements according to the EU Directives and the instructions of CEN/TR 15339-1;

— to ensure that requirements according to Hazardous Area Classification (HAC) are followed;

— to provide the complete and correct customer instructions according to the EC guide-lines, especially to the Machine Directive 2006/42/EC;

— instruction of the operator personnel;

— leak testing.

6.3 Requirements for the user

— operation of the equipment following the requirements according to the EU Directives and the instructions of CEN/TR 15339-1;

— to ensure that distances to ignitable sources according to Hazardous Area Classification (HAC) are followed and sections remain free from such electrical equipment, which are not qualified for the use in the classified area;

— to ensure the necessary customer instructions and a legally valid EC Conformity Declaration being available;

— checking the supplied spraying equipment having no evident defects;

— training of the operator personnel;

— description of measures concerning the behaviour of the operator for setting-up, service and entering the spray cabin;

— providing for personal protection equipment and supervising its use;

— fulfilling the service plan.

7 National rules

National laws or regulations have to be considered and can be added in the prevailing national foreword of this European Technical Report, if applicable.

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