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**Machine tools — Safety — Electro-  
discharge machines**

*Machines-outils — Sécurité — Machines d'électro-érosion*

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Published in Switzerland

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 28881 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 10, *Safety*.

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## Introduction

This International Standard has been prepared to be a Harmonized Standard to provide one means of conforming to the Essential Safety Requirements of the Machinery Directive of the European Union and associated EFTA regulations.

This document is a type-C standard as defined in ISO 12100:2010.

The machinery concerned and the extent to which hazards, hazardous situations and events are covered are indicated in the Scope of this International Standard. In addition, electro-discharge machining (EDM) equipment and EDM systems are intended to be designed according to the principles of ISO 12100 for hazards which are not dealt with in this International Standard.

When requirements of this type-C standard are different from those which are stated in type-A or -B standards, the requirements of this type-C standard take precedence over the requirements of other standards for machines that have been designed and built according to the requirements of this type-C standard.

This International Standard defines performance level and safety categories of the safety-related parts of the control system for EDM equipment and EDM systems as defined in ISO 13849-1:2006.

The requirements of this International Standard concern designers, manufacturers, suppliers and importers of machines described in the Scope.

This International Standard also includes a list of informative items intended to be provided by the manufacturer to the user.

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# Machine tools — Safety — Electro-discharge machines

## 1 Scope

This International Standard specifies safety requirements and/or protective measures, applicable to EDM equipment and EDM systems, such as

- manually controlled EDM die sinking or EDM drilling machines,
- numerically controlled EDM die sinking or EDM drilling machines, and
- numerically controlled EDM wire cutting machines

intended to be adopted by persons undertaking the design, construction, installation and/or supply of such equipment. This International Standard also includes information to be provided by the manufacturer to the user.

This International Standard is not applicable to arc eroding and electro-chemical machining equipment.

This International Standard takes account of the precondition of the intended use as well as the reasonably foreseeable misuse, in normal workshop environments and non-explosive atmospheres, including transportation, installation, setting, maintenance, repair and dismantling for removal or disposal of EDM equipment and EDM systems.

This International Standard is also applicable to auxiliary devices essential for EDM processing.

This International Standard deals with all significant hazards, hazardous situations or hazardous events relevant to EDM equipment and EDM systems, where they are used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer (see [Clause 4](#)).

This International Standard is intended to apply to machines manufactured after the date of publication of this International Standard.

## 2 Normative references

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

ISO 3746, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

ISO 4413, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 4414, *Pneumatic fluid power — General rules and safety requirements for systems and their components*

ISO 4871, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 11202, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying approximate environmental corrections*

ISO/TR 11688-1, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning*

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

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ISO 13849-1:2006, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13849-2:2003, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

ISO 13850, *Safety of machinery — Emergency stop — Principles for design*

ISO 13855, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

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

ISO 14118, *Safety of machinery — Prevention of unexpected start-up*

ISO 14122-1, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means of access between two levels*

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

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

IEC 60204-1:2009, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments*

IEC 61310-1, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*

IEC 61310-2, *Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*

IEC 61558-1, *Safety of power transformers, power supplies, reactors and similar products — Part 1: General requirements and tests*

IEC 61800-5-2:2007, *Adjustable speed electrical power drive systems — Part 5-2: Safety requirements — Functional*

EN 2, *Classification of fires*

EN 54-1, *Fire detection and fire alarm systems — Part 1: Introduction*

EN 349, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

EN 614-1, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles*

EN 614-2, *Safety of machinery — Ergonomic design principles — Part 2: Interactions between the design of machinery and work tasks*

EN 626-1, *Safety of machinery — Reduction of risks to health from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers*

EN 953:2009, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

EN 1037:2008, *Safety of machinery — Prevention of unexpected start-up*

EN 1088, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

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

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

EN 12198-3, *Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 3: Reduction of radiation by attenuation or screening*

EN 62226-1, *Exposure to electric or magnetic fields in the low and intermediate frequency range — Methods for calculating the current density and internal electric field induced in the human body — Part 1: General*

EN 62226-2-1, *Exposure to electric or magnetic fields in the low and intermediate frequency range — Methods for calculating the current density and internal electric field induced in the human body — Part 2-1: Exposure to magnetic fields — 2D models*

EN 62226-3-1, *Exposure to electric or magnetic fields in the low and intermediate frequency range — Methods for calculating the current density and internal electric field induced in the human body — Part 3-1: Exposure to electric fields — Analytical and 2D numerical models*

EN 62311, *Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz)*

CISPR 11, *Industrial, scientific and medical equipment — Radio-frequency disturbance characteristics — Limits and methods of measurement*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100:2010 and ISO 13849-1:2006 and the following apply.

#### 3.1

##### **control circuit**

<machine> circuit used for the control, including monitoring, of the machine

Note 1 to entry: For electrical equipment, see IEC 60204-1:2009, 3.8.

#### 3.2

##### **machine control system**

system that responds to input signals from parts of machine elements, operators, external control equipment or any combination of these, and generates output signals causing a machine to behave in the intended manner, as specified in ISO 13849-1:2006, 3.1.32

#### 3.3

##### **dielectric fluid**

<EDM process> non-conductive medium to improve the discharge effect, evacuate debris and cool the workpiece/electrode

#### 3.4

##### **dielectric fluid container**

tank system to keep the dielectric fluid in a condition suitable for EDM

EXAMPLE Filtering and cooling.

#### 3.5

##### **EDM equipment**

machine tool that includes all the necessary units for the process of electro-discharge machining

EXAMPLE Generator, control circuits and dielectric fluid container.

**3.6**

**EDM system**

assembly of EDM equipment and other machines or devices, which are arranged, linked and controlled to function as an integrated whole

**3.7**

**electrode changer**

<EDM equipment> mechanism integrated with the machine to supply a previously loaded electrode in exchange for another electrode

Note 1 to entry: The changing device is expected to enable an operator to load/unload electrodes from outside of the work area.

**3.8**

**electro-discharge machining**

**EDM**

any machining process based on spark erosion

Note 1 to entry: Electro-discharge machining is generally abbreviated as "EDM".

**3.9**

**electro-magnetic compatibility**

ability of EDM equipment and EDM systems to function satisfactorily in their electro-magnetic environment without introducing intolerable electro-magnetic disturbances to anything in that environment

Note 1 to entry: Electro-magnetic compatibility is generally abbreviated as "EMC".

**3.10**

**electronic handwheel**

manually operated control device that initiates and maintains an axis movement by pulse generation input to the numerical control during its rotation

**3.11**

**enabling device**

additional manually operated device used in conjunction with a start control and which, where continuously actuated, allows a machine to function

[SOURCE: ISO 12100:2010, 3.28.2 — modified.]

**3.12**

**flammable dielectric fluid**

dielectric fluid used in EDM, characterized by its relative ease of ignition and relative ability to sustain combustion

**3.13**

**flash point**

minimum temperature at which the dielectric fluid used in die sinking electro-discharge machining gives off sufficient combustible gas or vapour to ignite and sustain combustion

**3.14**

**generator**

unit to convert the electrical power supplied to the EDM equipment and EDM system for the purpose of being used for spark erosion processing

**3.15**

**hazardous electric discharge power**

electrical energy used to perform machining by electro-thermal material removal, which exceeds a permitted level of voltage for contact with persons

**3.16****hold-to-run control device**

control device that initiates and maintains hazardous machine functions only as long as the manual control (actuator) is actuated

[SOURCE: ISO 12100:2010, 3.28.3 — modified.]

**3.17****electric machining power**

electrical power supplied to the EDM equipment and EDM system transformed by the generator in specific electric energy, supplied as a tool to the sinker/wire electrode and the workpiece, to perform machining by electro-thermal material removal

**3.18****mean time to dangerous failure****MTTF<sub>d</sub>**

expectation of the mean time to dangerous failure

[SOURCE: ISO 13849-1:2006, 3.1.25 — modified.]

**3.19****numerical control****NC****computerized numerical control****CNC**

automatic control of a process performed by a device, which makes use of numerical data introduced while the operation is in progress

[SOURCE: ISO/IEC 2806:1994, definition 2.1.1 — modified.]

**3.20****operating mode**

possible mode for use of the machine

**3.20.1****automatic mode**

mode for use under numerical control to achieve programmed sequential operation with the guards closed, until stopped by a program or an operator

Note 1 to entry: This term is equivalent to machining mode.

Note 2 to entry: For machinery having automatic setting programs, such operations are considered automatic mode.

**3.20.2****setting mode**

mode for use without electric machining power, for operations in which adjustments for the subsequent machining are performed by the operator

Note 1 to entry: Measuring cycles (e.g. touching of the workpiece with a probe or electrode), checking the movement of the workpiece and/or electrode using the electrode and/or workpiece changer, checking/optimizing the injection or suction flushing, a dry run for checking the NC program, etc. are procedures forming part of the setting mode (see [5.3.2.2](#)).

**3.20.3****discharge alignment mode**

mode for the use for specific alignment with the discharge power on and with the guards of EDM equipment temporarily open and alternative safety measures activated

EXAMPLE Exhaust air extraction adjustment, e.g. vertical wire alignment, dielectric flushing adjustment and visual machining inspection.

**3.21**  
**performance level**  
**PL**

discrete level to specify the ability of safety-related parts of control systems to perform a safety function under reasonably foreseeable conditions

[SOURCE: ISO 13849-1:2006, 3.1.23 — modified.]

**3.22**  
**shielding**

mechanical barrier or enclosure of conductive material intended to attenuate the emission/penetration of a varying electro-magnetic field into an assigned region

**3.23**  
**EDM process**

removal of material in a dielectric fluid by electro-discharges, which are separated in time and randomly distributed in space, between two electrically conductive electrodes, and where the energy in the discharge is controlled

Note 1 to entry: The two electrically conductive electrodes are the tool electrode and the workpiece electrode.

**3.24**  
**EDM die sinking**

removal of material by spark erosion to produce various shapes in the workpiece

Note 1 to entry: Shapes in the workpiece may be concave, convex and prismatic holes.

**3.25**  
**EDM drilling**

removal of material by spark erosion with a tubular electrode to produce straight holes in the workpiece

**3.26**  
**EDM wire cutting**

removal of material by spark erosion with a wire electrode to produce prismatic shapes in the workpiece

**3.27**  
**work area**

<EDM equipment> space within the envelope of the machine where the EDM process can take place

**3.28**  
**workpiece changer**

<EDM equipment> mechanism forming part of the machine to load a workpiece or pallet in exchange for another workpiece or palette previously unloaded

Note 1 to entry: The workpiece changer/palette changer is designed to enable an operator to load/unload the workpiece or palette from outside of the work area.

**3.29**  
**work tank**

<EDM equipment> unit surrounding the work area to contain the dielectric fluid for EDM processes

## 4 List of significant hazards

This clause lists all the significant hazards, hazardous situations and events, as far as they are dealt with in this International Standard, identified by risk assessment as significant for this type of machinery, and which require action to eliminate or reduce the risk.

NOTE 1 The purpose of risk assessment is to identify hazards and estimate and evaluate risk to be reduced and to transfer the remaining risk to the user (see [Clause 6](#)). There are many methods and tools available for this purpose and several are described in this International Standard. The method or tool chosen is largely a matter of industry, company or personal preference. The choice of a specific method or tool is less important than the process itself. The benefits of risk assessment come from the discipline of the process rather than the precision of the results: as long as a systematic approach is taken to get from hazard identification to risk reduction, all the elements of risk are considered (see ISO/TR 14121-2).

The list of hazards given in [Table 1](#) is the result of a risk assessment carried out for all EDM equipment covered by this International Standard. The technical measures and information for use in [Clauses 5](#) and [6](#) are based on the risk assessment and deal with the identified hazards by either eliminating them or reducing the effects of the risks they generate.

NOTE 2 The designer's attention is focused on hazards which can occur during the life of the machine. The risk assessment assumes risks to both the operator(s) and other person(s) who can have access to the hazard zone(s) for conditions of intended use, including reasonably foreseeable misuse of the machine (see ISO 12100:2010, 3.22 and 3.23) for both spark erosion with automatic mode and operations requiring intervention (e.g. setting, maintenance and repair).

The significant hazards covered by this International Standard are listed in [Table 1](#).

Particular attention is paid to hazards dealing with:

- electrical hazards (electrode voltage);
- flammable dielectric fluid (level, temperature, fire detection);
- hazardous substances (waste disposal, filters, used dielectric fluid, electrodes and sludges);
- electro-magnetic emissions (radiated and conducted); see IEC 61000-6-2 EMC for immunity and IEC 61000-6-4 EMC for emission.

**Table 1 — List of significant hazards and major sources of these hazards associated with electro-discharge machines**

No. <sup>a</sup>	Hazard type	Hazardous situation action	Activity	Danger zone	Reference to <a href="#">Table 3</a>
<b>1</b>	<b>Mechanical hazards:</b>				
1.1	Acceleration, deceleration (kinetic energy of elements in controlled or uncontrolled motion): being run over, impact	Movements of machine elements, failure of the control circuit	Setting, machining and maintenance	At and near the machine	A3 to A5

Table 1 (continued)

No. <sup>a</sup>	Hazard type	Hazardous situation action	Activity	Danger zone	Reference to Table 3
1.2	Cutting parts, sharp edges: crushing and shearing	1.2.1 Workpiece clamping	Loading/unloading, reorienting	Between clamps and workpiece	A1, A2, A3
		1.2.2 Automatic workpiece/electrode changing	Power-operated, workpiece/ electrode change	Envelope of workpiece/electrode motion	A1, A2, A3
		1.2.3 Moving parts (e.g. axes, rolling elements), failure of the control circuit	Manual operation/workpiece/electrode change	Between workpiece/electrode and machine parts	A1, A2, A3, B4
1.3	Moving and/or rotating elements: entanglement	Manual or automatic workpiece/electrode changing, spindle rotation and wire rollers rotation, failure of the control circuit	Manual or power-operated workpiece/electrode changing and spindle rotation	Between workpiece/electrode and machine parts	A1, A2, A3, B4
1.4	High-pressure: fluid injection or ejection	Hydraulic/pneumatic systems ejection, leakage, flushing and residual pressure	Setting, machining and maintenance	At and near the machine	A4
1.5	Rough, slippery surface: slipping, tripping and falling of persons (related to machinery)	Ejection or spillage of fluids and lubricants; trailing floor-mounted or loose connection cables	During and after machining and maintenance	Work tanks where whole-body access is possible, slippery floor and high working positions; area surrounding the machine	A6
1.6	Loss of stability: — unbalanced machine or parts — inappropriately fixed part of machine — lifted machine or parts by crane — transportation with overload	Impact, trapping and/or crushing by inclination and/or falling of machine	Machine assembly, transportation, installation and commissioning	At and near the machine	A9
<b>2</b>	<b>Electrical hazards:</b>				
2.1	Live parts (direct contact): electrical shocks to persons, effect on medical implants, shock	Contact with workpiece/electrode, wire/wire-path and contact with unprotected circuits	Process control, setting and maintenance	Workpiece, electrode, tooling fixture	B1, B2
2.2	Parts that become live under fault conditions (indirect contact): electrocution of persons, effect on medical implants, shock	Contact with parts of the machine which are not live during normal operation	Maintenance and service on the generator and/or the machine	At and near the machine, insulation of electrical cables and equipment	B1, B3
<b>3</b>	<b>Thermal hazards (not relevant to EDM):</b>				
<b>4</b>	<b>Noise hazards:</b>				
4.1	Manufacturing process (fluid pumps, moving and/or rotating parts, whistling pneumatics): hearing damage loss or other physiological disturbances	Emission of hazardous noise from the EDM equipment or its auxiliary devices	During operation, setting, cleaning, maintenance and repair activities	At and in the vicinity of the machine or the auxiliary devices	C1

Table 1 (continued)

No. <sup>a</sup>	Hazard type	Hazardous situation action	Activity	Danger zone	Reference to Table 3
5	<b>Vibration hazards (not relevant to EDM):</b>				
6	<b>Radiation hazards:</b>				
6.1	Electro-magnetic radiation: effect on failure of safety-related parts of the control circuit and medical implants	Hazardous radiation immediately near the work area	During operation of machine and setting	In the vicinity of the machine or the auxiliary devices	B4, B5, B6
7	<b>Materials/substances hazards:</b>				
7.1	Contact with or inhalation of harmful fluids, gases, mists and dust	Conditions near the machine caused by ejection of dielectric fluid, droplets or evaporation, mists, etc.	During the EDM process, setting, maintenance and disposal of the machine	At and near the machine	D1 to D4
7.2	Fire or explosion	Fire hazard originated by flammable gas bubbles or mist generation, long-lasting arcing condition, loss of dielectric fluid, fault of electrical or hydraulic power supply, failure of the control circuit, etc.	During the EDM process	In the work tank, the work area and near the machine	D4 to D12
8	<b>Ergonomic hazards:</b>				
8.1	Specific requirements resulting from neglect of ergonomic principles	Unhealthy posture or excessive effort including the design of machines in accordance with ergonomic principles	During loading and unloading of electrode or work-piece on the EDM equipment and EDM system	At operator's position	EN 614-1 EN 614-2
9	<b>Hazards associated with the environment in which the machine is used:</b>				
9.1	Electro-magnetic disturbances: external influences on electrical equipment	Malfunction of the machine itself or electrical equipment due to electro-magnetic disturbances, failure of the control circuit	Machine in operation, setting and maintenance	At and in the vicinity of the machine	B4
10	<b>Combination of hazards:</b>				
10.1	Failure of the external power supply and restoration of the energy supply after an interruption	Malfunction resulting from power loss on the machine itself and/or electrical/pneumatic equipment, powered clamping failures and machine elements moving and/or rotating under residual forces (e.g. inertia, gravity)	All activities at the machine	At the machine and all moving elements of the machine	E1, E2, E3
<sup>a</sup>	This list is derived from ISO 12100:2010, Table B.1.				

## 5 Safety requirements and/or protective measures

### 5.1 General requirements

EDM equipment and EDM systems shall comply with the safety requirements and/or protective measures and be verified in accordance with this clause. In addition, the equipment and systems shall be designed

in accordance with the principles of ISO 12100:2010 for relevant, but not significant, hazards, which are not dealt with by this International Standard.

An analysis of failure of machine components, including failure in the control system(s), is part of the risk assessment and guidance on this subject is given in ISO 13849-1. Therefore, reliability requirements for safety functions are defined as performance levels in accordance with ISO 13849-1 (see 5.2).

## 5.2 Safety-related parts of control systems for EDM equipment and EDM systems

- a) Safety-related hardware and software: for the purposes of this International Standard, the safety-related parts of the control system are the parts of a control system which respond to safety-related input signals and generate safety-related output signals. The safety-related parts of a control system start at the point where the safety-related input signals are initiated (including, for example, the actuator and the actuating system of the position switch) and end at the output of the power control elements (including, for example, the main contacts of a contactor). Safety functions of control systems shall be implemented using safety-related parts designed, constructed and applied in accordance with ISO 13849-1. If the safety function, when activated, initiates a category 2 stop in accordance with IEC 60204-1:2009, 9.2.2, an automatic monitoring of the category 2 stop is required to prevent unexpected start-up or axis movement in accordance with ISO 14118.
- b) Safety functions: safety-related parts of control systems implementing the safety functions shall meet the requirements for the performance level and category of ISO 13849-1, as listed in [Table 2](#). Additional information is given in [Annex D](#).

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**Table 2 — Required performance level (PL<sub>r</sub>) of safety-related parts of the control system for EDM equipment and EDM systems**

Safety functions	Reference [(sub) clause]	Required performance level, PL <sub>r</sub> ISO 13849-1:2006	Reference to Table 3
— Movement control by means of hold-to-run control device or electronic handwheel	<a href="#">5.3.2.2</a>	PL <sub>r</sub> b	A3
— Movement control with safely monitored reduced speed	<a href="#">5.3.2.2</a>	PL <sub>r</sub> c	A3
— Interlocking function of movable guards of tool changer/magazine	<a href="#">5.3.2.2</a>	Cat. 3, PL <sub>r</sub> c	A1, A2, A3, B2
— Safe operational stop (SOS) function in accordance with IEC 61800-5-2	<a href="#">5.4.1</a>	PL <sub>r</sub> c	B6
— Start, stop and automatic restart function of machining	<a href="#">5.4.1</a>	PL <sub>r</sub> b	E3
— Interlocking function of movable guards of the EDM equipment	a	Cat. 3, PL <sub>r</sub> c	A1, A2, A3, B2
— Movement control and/or electric machining power control by means of enabling device	<a href="#">5.3.2.2</a> <a href="#">5.3.2.3</a>	Cat. 3, PL <sub>r</sub> c	A3
— Time limit function for discharge alignment mode	<a href="#">5.3.2.3</a>	PL <sub>r</sub> c	A1, A2, A3, B2
— Mode selection function	<a href="#">5.3.1</a>	PL <sub>r</sub> c	
— Emergency stop function	<a href="#">5.4.2</a>	Cat. 3, PL <sub>r</sub> c	
— Enabling device function	<a href="#">5.3.2.2</a> <a href="#">5.3.2.3</a>	Cat. 3, PL <sub>r</sub> c	A3
— Monitoring function of level and temperature of flammable dielectric fluid	b	PL <sub>r</sub> c	D6, D7, D8
— Fire detection function	b	PL <sub>r</sub> c	D10

a Interlocking function of movable guards, electro-sensitive protective equipment (ESPE) or other safety equipment of EDM equipment with hazardous movements and electrical discharge power > 25 V-a.c. or > 60 V-d.c. (using a safety source in accordance with IEC 61558-1).

b The fire detection device is a protective measure, complementary to the level and temperature monitoring of flammable dielectric fluid, to prevent ignition due to human error.

The function of safety-related parts, as specified above, shall be validated by examination of circuit diagrams and practical checks (see ISO 13849-2).

## 5.3 Operating modes

### 5.3.1 Operating mode selection

The selection of the operating mode shall be carried out either using a key switch or equivalent means, which restrict the use of certain modes to certain operators. If a restriction for operators is required, an admission code to access the setting mode shall be available (see [6.3.3](#)). Mode selection shall be permitted only from outside the work area and shall not initiate start-up. The indication of the selected operating mode shall be provided (e.g. the position of the selector and the provision of an indicating light or visual display indication). Mode changes shall ensure that only one mode is active at any one time in accordance with ISO 12100:2010, 6.2.11.10, and IEC 60204-1:2009, 9.2.3.

### 5.3.2 Protective measures relating to operating modes

#### 5.3.2.1 Automatic mode

Before starting automatic operation, the mode selector shall be in the automatic mode position, the guard shall be closed and other safety devices shall be in protective conditions (e.g. guard lock and fire detection device ready where flammable dielectric fluids are used).

#### 5.3.2.2 Setting mode

In the setting mode, the electrical discharge power of parts, which can be touched, shall be limited to  $\leq 25$  V a.c. or  $\leq 60$  V d.c., in accordance with IEC 60204-1:2009, 9.2.4 (using a safety source in accordance with IEC 61558-1).

The axis movement speed shall be monitored for setting operations (e.g. measuring cycles by touching the workpiece with a probe or electrode, checking the movement of the workpiece and/or electrode using the electrode changer and/or workpiece changer, checking/optimizing the injection or suction flushing and performing a dry run to check the NC program).

With the guards open, the axis speed shall not exceed 2 m/min and shall be monitored (see [Table 2](#)). The axis movement shall be controlled through:

- (hand-operated) hold-to-run control, or
- (hand-operated) enabling device, together with a start button, or
- electronic handwheel.

For movements with axis speed  $> 2$  m/min and  $\leq 15$  m/min and the guards open, protective measures shall be available to prevent the operator or other persons having access to the EDM equipment, from entering with the upper limbs in the work area by:

- hold-to-run control device in conjunction with an enabling device (see [Table 2](#)), or
- electronic handwheel, together with an enabling device (see [Table 2](#)), or
- means to prevent reaching the danger zone (e.g. light curtain, laser scanner, two-hand control device).

The stop resulting from the release of the enabling device shall be a safe operational stop (SOS) in accordance with 4.2.3.1 of IEC 61800-5-2:2007. The minimum distance in accordance with ISO 13855 shall be maintained.

For rotating axes with speed up to 50 U/min and guards open, the rotation shall be possible only with a hand-operated enabling device.

In setting mode, axis speed  $> 15$  m/min and rotating speed  $> 50$  U/min are not permitted.

#### 5.3.2.3 Discharge alignment mode

Use of the EDM equipment for specific alignment operation (e.g. vertical wire alignment, adjustment of the exhaust air extraction, dielectric flushing adjustment and visual machining inspection) with the guards open and the electrical discharge power between 60 V d.c. and 350 V d.c. or 25 V a.c. and 100 V a.c. shall be possible with the following safety measures only.

- a) Discharge alignment mode during the automatic mode:
  - close the guards and set the key switch to automatic mode;
  - press the start button to start the automatic operation;

- set the key switch to discharge alignment mode to activate the maximum time of 2 min and visual and audible alarm signal. After this time, the discharge alignment mode shall be automatically stopped;
- press the button of the one-hand operation-enabling device and keep it depressed during discharge alignment mode;
- open the guards to operate the discharge alignment operations (vertical wire alignment, adjustment of the exhaust air extraction, dielectric flushing adjustment and visual machining inspection, etc.);
- after a maximum of 2 min, the discharge alignment mode shall be automatically stopped and the visual and audible alarm signal deactivated. To continue the stopped automatic operation, close the guards, turn the key switch back to automatic mode and press the start button again.
- if, after closing the guards, the key switch is set back to automatic mode before the 2 min elapse, the automatic operation shall continue without interruption;
- in case of discharge alignment mode on EDM equipment using flammable dielectric fluid, keep the fire detection function activated to stop electrical discharge power in case of fire ignition.

b) Discharge alignment mode during the setting mode:

- set the key switch to discharge alignment mode to activate the maximum time of 2 min and visual and audible alarm signal. After this time, the discharge alignment mode shall be automatically stopped;
- press the button of the one-hand operation-enabling device and keep it depressed during discharge alignment mode;
- perform the discharge alignment operation by tilting or feeding;
- release the enabling device after alignment work;
- after a maximum of 2 min, the discharge alignment mode shall be automatically stopped, the visual and audible alarm signal deactivated, and all operations shall be ignored by the control system;
- to continue the setting operation, turn the key switch back to setting mode;
- in case of discharge alignment mode on EDM equipment using flammable dielectric fluid, keep the fire detection function activated to stop electrical discharge power in case of fire ignition.

In the information for use, provide information about the necessity of the operator to have knowledge and instruction on the specific electrical hazard; for this reason, a relevant written authorization for working with live electrical parts shall be available (see [6.3.2.2](#)).

## 5.4 Stop functions

### 5.4.1 Operational stop

An operational stop function, which is initiated by a stop device, shall be provided for each mode of operation. Whenever the operational stop function is activated, the energy supply to axes drive motors, workpiece holding device and NC equipment does not need to be turned off (see [Figure A.5](#) and ISO 12100:2010, 6.2.11.3).

A stop device shall be near each start or hold-to-run device (see ISO 12100:2010, 6.2.11.8).

### 5.4.2 Emergency stop

The EDM equipment and EDM systems shall be provided with one or more emergency stop control devices and be in accordance with IEC 60204-1:2009, 9.2.5.4.2, ISO 12100:2010, 6.3.5.2, and ISO 13850.

The emergency stop functions shall be of category 1 in accordance with 9.2.2 of IEC 60204-1:2009, and shall switch off the electric machining power, stopping all movements of the main and auxiliary axes, and electrical, mechanical, hydraulic and pneumatic actuators.

For EDM equipment and EDM systems without numerically controlled axes (e.g. EDM equipment with single working axis, including electro-mechanical planetary motion devices or electro-discharge drilling machines), stop category 0 according to 9.2.2 of IEC 60204-1:2009 may be applied.

Emergency stop device(s) shall be provided at each working station where a hazardous situation can be recognized and prevented by the operator or other personnel, for example at the

- main control panel,
- portable control panel, if another emergency stop device cannot be reached within a distance of 900 mm (see Table 5 of ISO 13857:2008), and
- workpiece/electrode loading and unloading station, if separated from the main operator's position.

### 5.5 Specific requirements

Safety requirements and/or protective measures as needed for EDM equipment and EDM systems to prevent hazards identified in [Clause 4](#) shall be taken as defined in [Table 3](#), and verified using the procedures indicated in the verification column of [Table 3](#), with the following abbreviated phrases:

- by testing (e.g. functional or practical check);
- by measurement;
- by calculation;
- by visual inspection, if testing and calculation are not adequate;
- by analysis of documentation (e.g. circuit or functional diagram, information for use).

**Table 3 — List of safety requirements and/or protective measures and their verification procedures**

	Hazard	Safety requirement and/or protective measure	Verification	Normative reference (see <a href="#">Clause 2</a> )
<b>A<sup>a</sup></b>	<b>Mechanical hazards</b>			
A1	A1.1 Mechanical hazards (general requirements)	A1.1.1 EDM equipment shall be designed so as to avoid foreseeable mechanical hazards during intended use and reasonably foreseeable misuse.	By testing and visual inspection	ISO 13857 EN 349
		A1.1.2 Where hazardous situations cannot be prevented, fixed guards shall be used where no access to danger zones is necessary during intended use.	By testing and visual inspection	EN 953:2009, 3.2
A1	A1.2 Access to work area: crushing, shearing and entanglement	A1.2.1 Where access to wire transportation system (rollers) is required, crushing or entanglement prevention devices shall be provided, preventing access by hand (e.g. setting a block preventing nipping between rollers). For schematic example see <a href="#">Figure A.9</a> .	By testing and visual inspection	ISO 13857 EN 349
		A1.2.2 Where frequent (more than once per day) access to the work area is required, hazardous situations shall be prevented using interlocking movable guards.	By testing and visual inspection	EN 349 ISO 13857 EN 953:2009, 3.3, and EN 953:2009, 3.5 EN 1088
		A1.2.3 In automatic mode, opening of interlocking guards shall stop all current operations in order to prevent all risks within the area under protection (see corresponding safety function in <a href="#">Table 2</a> ), e.g. switch off electric machining power and hazardous movement.	By testing and visual inspection and by analysis of documentation	IEC 60204-1:2009, 9.2.4 EN 1037
		A1.2.4 As long as the interlocking guards remain open, unexpected start-up shall be prevented in all modes (see corresponding safety function in <a href="#">Table 2</a> ).	By testing and visual inspection and by analysis of documentation	EN 1037:2008, 3.2
		A1.2.5 No other hazardous machine movements shall arise from the actuation of any sensor.	By testing and visual inspection and by analysis of documentation	
A2	Mechanical hazards within the work area	On EDM equipment and EDM systems, where whole-body access to the safeguarded space (work area) through an interlocking door is foreseen (e.g. for workpiece/electrode cleaning and inspection of work progress), a device which prevents inadvertent closing of the door(s) shall be provided in order to inhibit any hazardous movements and/or actions (e.g. filling of dielectric fluid in work tank).	By testing and analysis of documentation	EN 1088 IEC 60204-1:2009, 5.4, and IEC 60204-1:2009, 9.3.1

Table 3 (continued)

	Hazard	Safety requirement and/or protective measure	Verification	Normative reference (see Clause 2)
A3	A3.1 Mechanical hazards created by transfer equipment (e.g. electrode magazine, workpiece changer and/or other changing devices)	A3.1.1 Access to hazardous movements of the tool and/or workpiece magazine shall be prevented by fixed or interlocking guards with guard locking.	By testing and visual inspection	EN 953 ISO 13855 EN 1088
A3		A3.1.2 Opening the guard of the electrode/workpiece changer shall prevent automatic changing movement or magazine movement. As a schematic example, see <a href="#">Figures A.7</a> and <a href="#">A.8</a> .	By testing and visual inspection	
A3		A3.1.3 The movement of the electrode/workpiece changer in setting mode shall be possible under the conditions mentioned in <a href="#">5.3.2.2</a> only.	By testing and visual inspection	ISO 13857 IEC 60204-1:2009, 9.2.4 and IEC 60204-1:2009, 9.2.6.1
A3		A3.1.4 While tool changing or magazine movement is in progress, opening of the door shall be inhibited by interlocking with guard locking. Access to other remaining hazards shall be prevented.	By testing and visual inspection	
A4	Falling or ejected objects or fluids	Guards shall be provided to retain the foreseeable ejection of fluid. Hydraulic and pneumatic systems shall be designed in accordance with the appropriate standard (e.g. prevention of residual pressure).	By testing and visual inspection	EN 953 ISO 4413 ISO 4414
A5	Mechanical hazards caused by escape of fluid from work tank	Door(s) of the work tank shall be locked against accidental opening.	By testing and visual inspection	EN 1088
A6	A6.1 Slip, trip and fall of persons (related to the machinery)	A6.1.1 Where a fluid system is provided, the containment of dielectric fluid shall be designed to prevent leakage and minimize splash and spray. A non-slip surface shall be provided, especially for areas where frequent access is required (such as waste removal and change of filters).	By testing and visual inspection	
A6		A6.1.2 Means of access where there is a need to enter or walk on the machine, e.g. hand holds, foot holds and, where possible, a non-slip surface shall be provided.	By visual inspection	ISO 14122-1 ISO 14122-2 ISO 14122-3
A6		A6.1.3 The instruction handbook shall include requirements on appropriate footwear [see <a href="#">6.3.2.2 b) 2</a> ] and/or location of non-slip surfaces around the machine [see <a href="#">6.3.2.2 a) 2</a> ].	By visual inspection	

Table 3 (continued)

	Hazard	Safety requirement and/or protective measure	Verification	Normative reference (see Clause 2)
A7	Mechanical hazards associated with the failure of a safety-related part of the control circuit	EDM equipment and safety-related parts of the control system shall fulfil the required performance level PL <sub>r</sub> , as specified in ISO 13849-1 (see 5.2)	By testing and analysis of documentation	IEC 60204-1:2009, 9.4 ISO 13849-1 ISO 13849-2
A8	Falling down of an axis slide due to running over the limit switch	Means shall be provided to prevent the axis sliders from being unintentionally pulled off the end of the guideways.	By visual inspection and practical tests	
A9	Instability of the equipment during assembly, installation and commissioning	In the instruction handbook and on the packaging of the equipment, there shall be clearly marked: <ul style="list-style-type: none"> <li>— the hanging points for lifting up</li> <li>— the mass</li> <li>— how to move</li> </ul>	By analysis of documentation	
<b>B</b>	<b>Electrical hazards</b>			
B1	Electrical hazards (general requirements)	The electrical equipment of the EDM equipment and EDM systems shall be designed to prevent any kind of electrical shock, which can be hazardous to persons.	By visual inspection and analysis of documentation	IEC 60204-1
B2	B2.1 Persons coming into contact with live parts	B2.1.1 Live parts shall be located inside enclosures, which provide protection to prevent direct contact. The degree of protection provided by enclosures shall be at least IP2X or IPXXB, in accordance with IEC 60529.	By visual inspection and analysis of documentation	IEC 60204-1:2009, 6.2.2 IEC 60529
B2		B2.1.2 Enclosures, including control devices (e.g. keyboards, portable control stations), shall be protected against foreseeable external influences or environmental conditions where the equipment or system is intended to operate (e.g. machining residuals, dielectric fluid). The degree of protection provided by enclosures or control devices shall be at least IP 22, in accordance with IEC 60529.	By visual inspection and analysis of documentation	IEC 60529
B2		B2.1.3 The enclosures shall be located and mounted to facilitate accessibility and the continuity of the protective bonding circuit as well as the insulation resistance shall be tested.	By visual inspection and analysis of documentation	IEC 60204-1:2009
B2		B2.1.4 The work area on the EDM equipment and EDM system, where electrical energy is used as a working tool shall be protected with interlocking guards, as specified in 5.3.2, to prevent accidental or inadvertent contact.	By visual inspection and analysis of documentation	EN 1088

Table 3 (continued)

	Hazard	Safety requirement and/or protective measure	Verification	Normative reference (see Clause 2)
B2		B2.1.5 The opening of interlocking guards protecting live parts shall cut the machining electrical discharge power off in automatic mode (see Table 2).	By visual inspection and analysis of documentation	IEC 60204-1:2009 EN 1088
B2		B2.1.6 On EDM equipment and EDM systems where electrical discharge power is used in the work area for position pick-up by contact sensing, such operations shall only be possible with interlocking guards closed, with the exception of the discharge alignment mode (see 5.3.2.3).	By visual inspection and analysis of documentation	IEC 60204-1:2009 EN 1088
B2		B2.1.7 For EDM equipment and EDM systems where position pick-up is foreseen in discharge alignment mode with interlocking guards open (e.g. small-size electrodes, fine wire), the requirements in accordance with 5.3.2.3 apply.	By visual inspection and by analysis of documentation	IEC 61558-1
B3	Persons coming into contact with parts which have become live under faulty conditions	The electrical equipment of the EDM equipment and EDM system shall be provided with the connection to the protective bonding circuit to prevent hazardous conditions for persons in the event of an insulation failure between live parts and exposed conductive parts.	By testing and measurement	IEC 60204-1:2009, 5.2, 6.3.3, 8.2, 19.2
B4	Hazards generated by electro-magnetic disturbances, provoking the failure of safety-related parts of the control circuit	Electro-magnetic immunity of the EDM equipment and EDM system against electro-magnetic disturbances (e.g. main voltage filtering, grounding, shielding, appropriate wiring of EDM equipment) shall be designed for operation in industrial environments, in accordance with EMC regulations for industrial equipment. For a schematic example, see Figures A.1 and A.2.	By measurement	IEC 61000-6-2 IEC 60204-1:2009, 4.4.2 IEC 61000-6-4
B5	Hazards generated by electro-magnetic disturbances provoking dangerous risk for electrical implants in human bodies	The low-frequency electro-magnetic interferences, as well as the magnetic radiation, shall be measured at short distance in accordance with the relevant standard. The result identifies the emission category of the EDM equipment and the respective symbols shall be applied visibly to the EDM equipment. 	By measurement and analysis of documentation	CISPR 11 EN 62226-1, EN 62226-2, EN 62226-3 EN 62311 EN 12198-1, EN 12198-2, EN 12198-3 ISO 7010:2003, Table 2, W005 and W006

Table 3 (continued)

	Hazard	Safety requirement and/or protective measure	Verification	Normative reference (see <a href="#">Clause 2</a> )
B6	Unexpected start-up	A safe operational stop (see <a href="#">5.4.1</a> ) shall be applied to prevent unexpected start-up	By calculation and practical tests	IEC 61800-5-2 EN 1037
<b>C</b>	<b>Noise hazards</b>			
C1	Hearing loss or other physiological disturbances	The EDM equipment and its auxiliary devices shall be designed to avoid hazardous noise emissions either by using low-noise components or by application of noise attenuation means.	By measurement and analysis of documentation	ISO 3746 ISO 4871 ISO 11202 ISO 11688-1 <a href="#">Annex B</a> (of this International Standard)
<b>D</b>	<b>Hazards generated by materials and substances (and their constituent elements) processed or used by the machinery</b>			
D1	General requirements	EDM equipment shall be designed to prevent leakage in order to allow the safe handling of materials in process and/or removal of dielectric fluid, filters, process residuals, sludge or any other waste.	By testing and visual inspection	
D2	Hazards from coming into contact with or inhalation of harmful gases, mist and dust	EDM equipment shall be designed to avoid contact with harmful dielectric fluid. Means shall be available to the user, as part of the EDM equipment and EDM system, to connect the local exhaust air extraction system (For a schematic example, see <a href="#">Figure A.3</a> ).	By testing and analysis of documentation	EN 626-1
D3	Contact hazards caused by escape of fluid from work tank	Door(s) of the work tank shall be locked to prevent accidental opening whenever there is dielectric fluid in the work tank	By testing and visual inspection	EN 1088
D4	Formation of gases	EDM dielectric fluid containers shall incorporate devices to prevent concentration of hazardous gases (e.g. natural ventilation through venting openings or forced ventilation). Provision shall be made to cool the dielectric fluid in relation to the maximum power supplied by the EDM equipment.	By testing and analysis of documentation	
D5	Dielectric flash point	EDM equipment shall be designed for use with dielectric fluids having a flash point of at least 60 °C. See <a href="#">Annex C</a> for fire protection codes for special regional cases.	By analysis of documentation	
D6	Dielectric temperature rise	EDM equipment using flammable dielectric fluids shall have two independently operating temperature-detecting systems, switching off the discharge power whenever the dielectric fluid temperature within the work tank exceeds 45 °C. In this case, temperature increase shall be indicated. As a schematic example, see <a href="#">Figures A.5</a> and <a href="#">A.6</a> . See <a href="#">Annex C</a> for fire protection codes for special regional cases.	By testing and analysis of documentation	

Table 3 (continued)

	Hazard	Safety requirement and/or protective measure	Verification	Normative reference (see Clause 2)
D7	Insufficient dielectric level	Where flammable dielectric fluids are used, the depth at which the electro-discharge takes place at any time shall never be less than 40 mm below the free surface of the dielectric fluid. This may be achieved using an adjustable spillway, for instance.  See Annex C for fire protection codes for special regional cases	By testing and analysis of documentation	
D8	Dielectric level drop	EDM equipment using flammable dielectric fluids shall have two independently operating dielectric fluid level detecting systems, switching off the discharge power whenever the dielectric level within the work tank drops below the pre-set level. In this case, level drop shall be indicated. As a schematic example, see Figures A.5 and A.6.	By testing and analysis of documentation	
D9	Fire ignited on the dielectric fluid surface due to material build-up between electrode and workpiece	EDM equipment using flammable dielectric fluids shall be equipped with depth monitoring provisions to switch off the electric machining power if the discharge on a material build-up exceeds the highest set discharge safety. In this case, machine stop by retraction of the electrode shall be indicated.	By testing	
D10	Fire	EDM equipment using flammable dielectric fluid shall be provided with a fire-detecting system, switching off all energy supply (e.g. electrical, pneumatic, hydraulic) and closing the related exhaust air extraction system. Activation of the system shall be indicated by audible and optical signals and shall further provide a signal either for an integrated automatic fire extinguisher or for centralized fire alarm circuits or any other action. As a schematic example, see Figures A.4 and A.5.	By testing and visual inspection and by analysis of documentation	EN 2 EN 54-1
D11	Fire spreading by flammable materials, distribution of gases and fluids	EDM equipment using flammable dielectric fluids shall, in addition to the fire detection system, be designed with special attention to the prevention of the spreading of fire (e.g. preventing ebbing started by dielectric fluid from the work tank in case of flame detection, provoking the spreading of fire by mist or due to missing barriers).  All components of the dielectric system (e.g. reservoirs, work tanks, filling/emptying system) as well as for the exhaust air extraction system shall be manufactured in non-flammable materials.	By testing and visual inspection and by analysis of documentation	EN 2
D12	Hazards generated by electro-magnetic disturbances, provoking the failure of safety-related parts of the control circuit	The safety-related parts of the temperature and level monitoring control system shall be designed to be immune against electro-magnetic disturbances.	By testing and measurement	IEC 61000-6-2 IEC 60204-1:2009, 4.4.2

Table 3 (continued)

	Hazard	Safety requirement and/or protective measure	Verification	Normative reference (see <a href="#">Clause 2</a> )
<b>E</b>	<b>Hazards generated by power failure and restoration</b>			
E1	Loss of electrical power supply	<p>In the event of voltage fluctuation or power failure, the EDM equipment shall stop. During the time of power failure, the equipment shall remain stopped. The integrity of safety features of devices such as</p> <ul style="list-style-type: none"> <li>— clamping systems,</li> <li>— electrode or workpiece changer,</li> <li>— dielectric fluid container,</li> <li>— position of axis, and</li> <li>— fire detection system</li> </ul> <p>shall be maintained by either mechanical retaining devices (e.g. spring-loaded locking devices) or uninterrupted power supply (e.g. battery back-up and redundant power supply).</p>	By testing and analysis of documentation	IEC 60204-1:2009, 7.5
E2	Pressure loss	<p>If safety-related functions are relying on hydraulic or pneumatic systems, the EDM equipment shall stop in case of pressure loss. During the time of pressure loss, the equipment shall remain stopped. The integrity of safety features of devices such as</p> <ul style="list-style-type: none"> <li>— clamping systems,</li> <li>— electrode or workpiece changer,</li> <li>— dielectric fluid container,</li> <li>— position of axis, and</li> <li>— fire detection system</li> </ul> <p>shall be maintained by either mechanical retaining devices (e.g. spring-loaded locking devices) or uninterrupted pneumatic pressure supply (e.g. pressure cartridge back-up and redundant pressure supply).</p>	By testing and analysis of documentation	ISO 4413 ISO 4414
E3	Failure due to recovery of the power supply	<p>To prevent dangerous situations for the operator and the equipment or process such as</p> <ul style="list-style-type: none"> <li>— position loss and</li> <li>— data loss</li> </ul> <p>after failure of the power supply, the integrity of the safety-related functions shall be monitored and confirmed before automatic restart is allowed.</p>	By testing and analysis of documentation	IEC 60204-1:2009, 7.5
<b>F</b>	<b>Hazards generated by neglecting ergonomic principles</b>			
F1	Neglect of ergonomic principles	EDM equipment and EDM systems shall be designed according to ergonomic principles to prevent significant ergonomic hazards.	By analysis of documentation and by visual inspection	EN 614-1 EN 614-2
a	See <a href="#">Table 1</a> .			

## 6 Information for use

### 6.1 General

Information for use refers to communication links, such as texts, words, signs, signals, symbols or diagrams, which are used separately or in combination, to convey information to the user and which shall be in accordance with ISO 12100:2010, 6.4.

The information for use shall document hazards which can occur during the life of the machine to both the operator and other persons who have access to the danger zone(s) for conditions of intended use, including reasonably foreseeable misuse of the machine (see ISO 12100:2010, 3.24) for both spark erosion with automatic mode and operations requiring intervention (e.g. setting, maintenance and repair).

### 6.2 Marking, signs and written warnings

Marking shall be in accordance with ISO 12100:2010, 6.4.4, IEC 61310-1 and IEC 61310-2.

Machinery shall bear all markings which are necessary:

- a) for its unambiguous identification:
  - the business name and full address of the manufacturer and, where applicable, the authorized representative;
  - the designation “electro-discharge machine”;
  - the series or type of machine;
  - the serial number, if any;
  - the year of construction, that is the year in which the manufacturing process is completed.
- b) in order to indicate its compliance with mandatory requirements, i.e. the mandatory marking;  
NOTE The mandatory marking for Europe is the CE marking.
- c) for its safe use:
  - the machine shall be provided with appropriate marking to indicate residual risks (see ISO 7010:2003);
  - where flammable dielectric fluid is used on the EDM equipment and EDM system, the surrounding area shall be marked with warning/information symbols (see ISO 7010:2003);
  - where personal protective equipment (e.g. glasses and gloves) shall be used to prevent skin contact with waste or other health-threatening substances, this shall be indicated with mandatory action symbols (see ISO 7010:2003).

### 6.3 Instruction handbook

#### 6.3.1 Instruction handbook — General

The instruction handbook shall provide all necessary information regarding transport, installation, operation, setting, maintenance, cleaning and disposal of the EDM equipment and EDM system, in accordance with ISO 12100:2010, 6.4.5.

## 6.3.2 Special recommendations for EDM site preparation

### 6.3.2.1 General

The instruction handbook shall remind the user to respect the regulations of local authorities for the use of EDM equipment relevant to:

- a) the handling of hazardous substances resulting from the EDM process;
- b) environmental requirements for discharge from the exhaust air extraction system in the environment;
- c) fire prevention regulations, waste disposal and special EMC site regulations;
- d) the prevention of penetration of spilled, dripped or lost dielectric fluid into the ground.

The information for use shall include, particularly, the following:

- stability during machine assembly, installation and commissioning (to describe information for use: hanging points for machine, mass of the machine and ways to move the machine);
- verification of connection of electric, hydraulic and pneumatic circuit system, based on installation instructions;
- verification of setting the protective measures;
- cut off of the electrical power to the EDM system, by switching the main switch off for longer “no machining activities” (e.g. weekend, vacation, maintenance);
- although acoustic noise of EDM equipment is not considered to be hazardous, a declaration shall be made concerning the airborne noise emission, using the dual-number form of presentation described in ISO 4871;
- information that the floor around the machine shall be a non-slip surface.

### 6.3.2.2 General safety information

- a) General safety information shall include the following:
  - 1) indication that the EDM equipment and EDM system shall not be used in explosive or potentially explosive atmospheres;
  - 2) indication that the floor area around the EDM equipment shall be kept slip-free, especially where frequent access to the machine is required;
  - 3) indication that the space around the machine is sufficient and shall be provided for operation, service and maintenance personnel;
  - 4) indication that the operation on the EDM equipment in contaminated air shall be avoided by means of the customer's air evacuation system (as a schematic example, see [Figure A.3](#));
  - 5) instructions for trouble-shooting and/or fault-finding to prevent machine parts from falling off;
  - 6) instructions to release pressure to prevent residual hydraulic or pneumatic pressure in case of service, maintenance, trouble-shooting and repair;
  - 7) instructions on the removing, handling and fitting of heavy parts for fault-finding and repair;
  - 8) instructions for use of an enabling device or other equally safe protection device for one-hand operation, to prevent the operator from coming into direct contact with hazardous electrical discharge power in discharge alignment mode;
  - 9) instructions for the operator about working with live electrical parts as well as specific risks of electrical hazards;

- 10) instructions to have written authorization for the use of EDM equipment and EDM systems;
  - 11) instructions on how to lift or move the EDM equipment and EDM system (e.g. hanging point, mass and centre of gravity, as well as exactly how to move it);
  - 12) instructions to regularly check the correct function of the customers' air evacuation system.
- b) Instructions for use of personal protective equipment shall include:
- 1) instructions for the use of appropriate insulated industrial gloves;
  - 2) instructions for the use of appropriate footwear around the machine.

#### 6.3.2.3 Power specifications

- a) Specify external power supplies (electrical, hydraulic and/or pneumatic).
- b) Specify grounding of the EDM equipment.
- c) Specify recommended cable size.

#### 6.3.2.4 Compressed air specifications

- a) Specify information on compressed air quality and connection.
- b) Specify adequate pressure range.
- c) Specify necessary flow rate.

#### 6.3.2.5 Flammable dielectric fluid

The information shall include the following:

- a) use of non-flammable materials for connections to external devices (e.g. centralized filter and/or exhaust air extraction systems);
- b) information to use barriers on customers' interfaces, to prevent the spreading of dielectric fluid fire;
- c) information on optional fire extinguishing system, which shall not damage the EDM equipment and EDM system (e.g. water as extinguishing medium because of corrosion or distribution of burning dielectric fluid);
- d) additional information regarding fire extinguishing means:
  - 1) suitable size and location of nozzles; optimized pressure for the fire extinguishing medium;
  - 2) specifications for interfacing the fire detection device of the EDM equipment with the user's fire extinguisher installation (see [Figure A.4](#));
  - 3) electrical interface.
- e) precautions to prevent fires and/or explosions with any necessary signs and/or written warnings;
- f) safety rules to minimize fire hazards:
  - 1) use of appropriate type of flammable dielectric fluids with flash point over 60 °C (see [Annex C](#) for fire protection codes for special regional cases);
  - 2) information for the user that some types of flammable dielectric fluid can be potentially dangerous on particular operations of EDM equipment and EDM systems, and that their use shall imperatively be avoided to prevent unexpected explosion hazards;
  - 3) avoidance of open flames and lights;

- 4) special precautions.
- g) specifications for interfacing the dielectric fluid cooling system with the EDM equipment, including information, such as:
  - 1) flow rate;
  - 2) heat exchange capacity;
  - 3) specification of interface;

#### 6.3.2.6 Hazardous substances

The information shall include:

- a) renewal of the ambient air in the premises taking into account:
  - 1) ventilation required for a healthy working environment;
  - 2) air recirculation device(s).
- b) specifications for connecting the EDM equipment to the user's exhaust air extraction system, including at least the following information (see [Figure A.3](#)):
  - 1) flow rate (minimum and maximum values);
  - 2) dimensions of the exhaust air extraction connection (non-flammable material).
- c) electrical connection of the air flow sensing device to ensure that the air flow stops in case of fire detection;
- d) specifications of the type and capacity of drainage installations at the site to retain escaping dielectric fluids to prevent biological hazards.

#### 6.3.2.7 Electro-magnetic emissions (EMC)

The information shall state that:

- a) metal connections of external devices, such as filter systems, exhaust air extraction systems, passing through the shielding of the equipment, shall be electrically bonded to the shield;
- b) in case of connection to a protruding cap, this bonding is not necessary.

#### 6.3.3 Special recommendations for EDM operation

The manufacturer shall provide, in particular, information on the following:

- a) indication of how the selection among the setting mode, the discharge alignment mode and the automatic mode is provided (either a key switch or other means of selection);
- b) instructions for all categories of operators working on the EDM equipment and EDM system accordingly;
- c) information for the user if the mode selection procedure is not restricted to a certain level of operator;
- d) instructions and training of employees who use or maintain the EDM equipment and EDM system. This information shall be specified for different tasks (e.g. use, inspection, maintenance);
- e) the organization of unattended operation of the EDM equipment and EDM system;
- f) the operational procedures for periodic verification (e.g. tests, cleaning, adjustments, replacements) with their frequency (e.g. daily, weekly, monthly);

- g) a list of all the activities which shall be carried out and those which should be avoided:
  - 1) requirements for the installation of external safety equipment (e.g. exhaust air extraction system, fire extinguishers, room ventilation and remote alarm signals);
  - 2) the wearing of personal protective equipment/clothing (e.g. glasses, gloves, respirator filter) and appropriate shoes (dielectric fluid resistant with non-slip soles);
  - 3) personal health measures (e.g. washing, hand creams);
  - 4) safety rules regarding electrical risks (e.g. areas, installation conditions);
  - 5) maintenance parts, change period and change instructions.
- h) existing or potential hazards caused by the waste resulting from the EDM process for which the machine is intended (waste to be considered includes used dielectric fluids, used lubricating oils, used filters, used electrodes, reservoir sludge, de-ionizing resins and worn parts);
- i) avoidance of pollution caused by leaks, overflow and inappropriate drainage;
- j) operating safety rules to prevent accidents (e.g. safe level of dielectric fluid at least 40 mm above highest discharge area and avoidance of gas pockets in hollow workpieces or tool electrodes);
- k) a reproduction of all labels, signs and written warnings used on the EDM equipment;
- l) the conditions leading to the triggering of safety devices:
  - 1) fire ignition in the work tank;
  - 2) high temperature of the dielectric fluid in the work tank;
  - 3) low level of dielectric fluid in the work tank;
  - 4) abnormal withdrawal of the electrode during machining;
- m) the nature and type of safety devices:
  - 1) visual;
  - 2) audible;
  - 3) external/remote signalling, including interface specifications;
  - 4) emergency stop;
  - 5) interlocking;
- n) the appropriate action to be taken, either manually or automatically, upon occurrence of the warning or alarm signal:
  - 1) shutting down of electrical power to the EDM equipment and EDM system;
  - 2) closing of exhaust air extraction ducts;
  - 3) closing of fluid control valves;
  - 4) use of fire extinguishers, etc.;
- o) the specifications of the spare parts to be used, where these affect the health and safety of operators.

#### 6.3.4 Noise

The following information on airborne noise emissions shall be provided:

- a) the A-weighted emission sound pressure level at workstations, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact shall be indicated;
- b) the peak C-weighted instantaneous sound pressure value at workstations, where this exceeds 63 Pa (130 dB in relation to 20  $\mu$ Pa);
- c) the A-weighted sound power level emitted by the machinery, where the A-weighted emission sound pressure level at workstations exceeds 80 dB(A).

These values shall be either those actually measured for the machinery in question or those established on the basis of measurements taken for technically comparable machinery, which is representative of the machinery to be produced.

Whenever sound emission values are indicated, the measurement uncertainties shall be specified.

The operating conditions of the machinery during measurement and the measuring methods used shall be described.

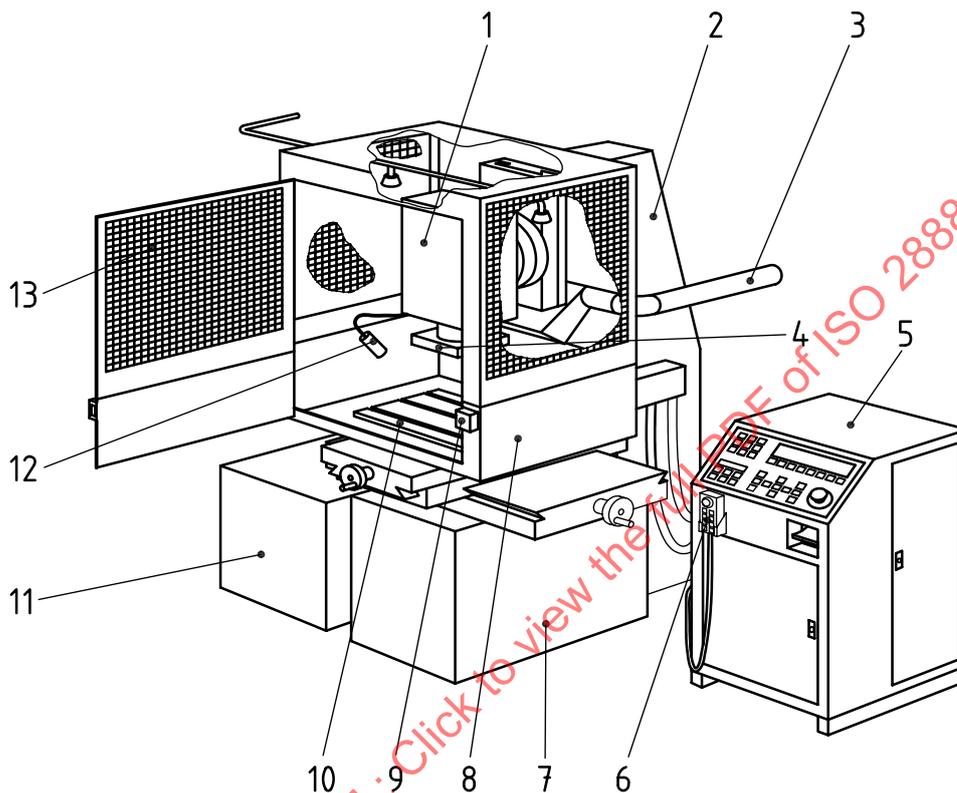
The position and value of the maximum sound pressure shall be indicated.

The declaration shall be accompanied by a statement of the measuring method used and the operating conditions applied during the test and values for uncertainty,  $K$ , using the dual-number form of declaration according to the dual-number form of ISO 4871.

See [Annex B](#).

## Annex A (informative)

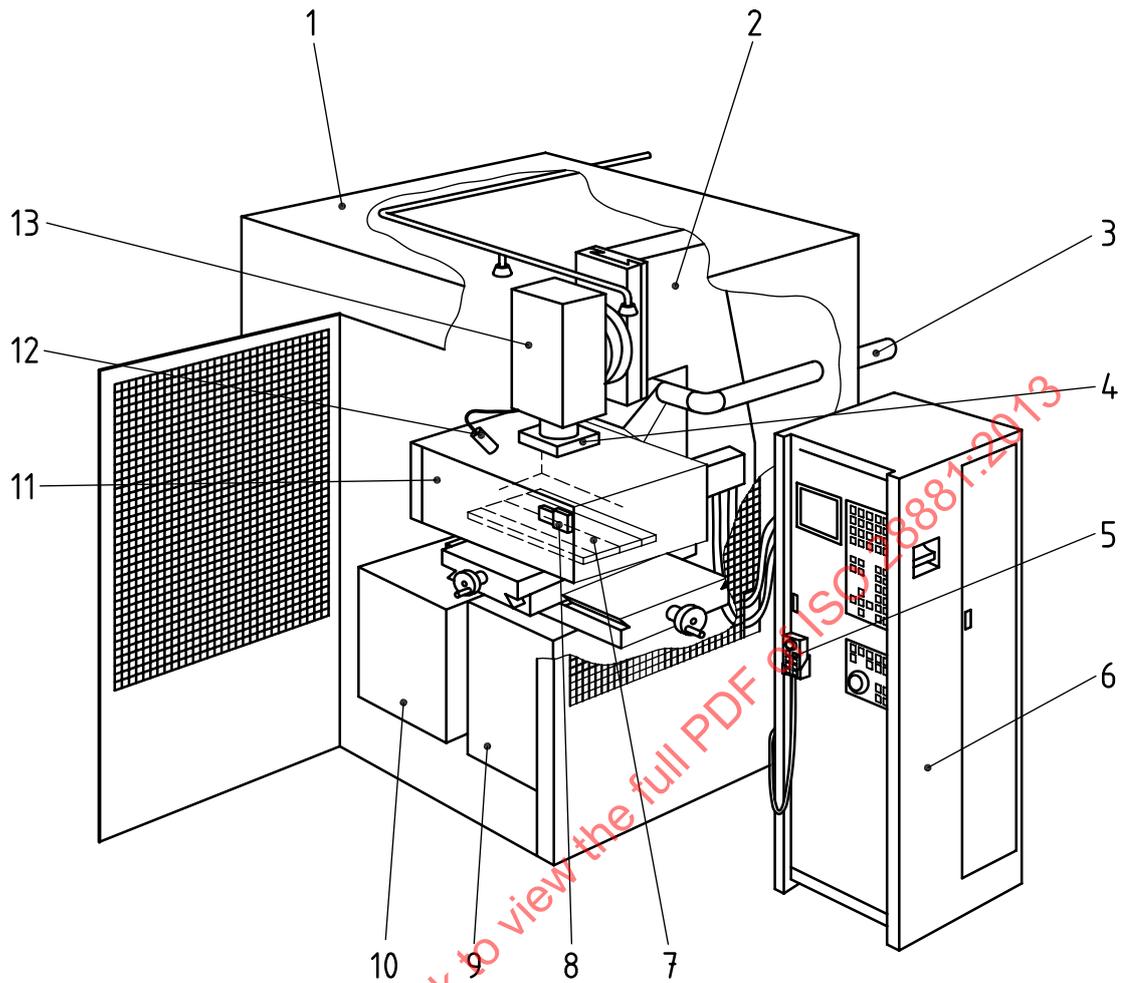
### Examples and schematic diagrams



#### Key

- |   |                                |    |   |
|---|--------------------------------|----|---|
| 1 | machining head                 | 9  | door security system  |
| 2 | machine column                 | 10 | work table  |
| 3 | exhaust air extraction         | 11 | flammable dielectric fluid container  |
| 4 | electrode holder               | 12 | fire detector   |
| 5 | electrical cabinet (generator) | 13 | shielding of work area (Faraday cage) (guard against direct contact can be combined with shielding for EMC) |
| 6 | portable control station       |    |   |

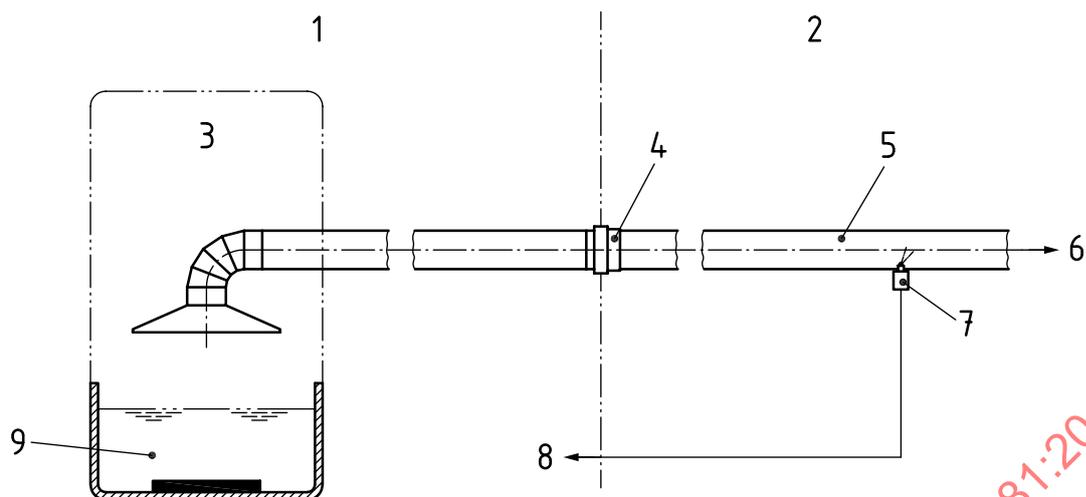
**Figure A.1 — EMC shielding, fire detection and exhaust air extraction — Schematic example of work area shielding**



**Key**

- |   |                                |    |                                      |
|---|--------------------------------|----|--------------------------------------|
| 1 | EMC enclosure                  | 7  | work table                           |
| 2 | machine column                 | 8  | door security system                 |
| 3 | exhaust air extraction         | 9  | machine frame                        |
| 4 | electrode holder               | 10 | flammable dielectric fluid container |
| 5 | portable control station       | 11 | work tank                            |
| 6 | electrical cabinet (generator) | 12 | fire detector                        |

**Figure A.2 — EMC shielding, fire detection and exhaust air extraction — Schematic example of EDM equipment shielding**



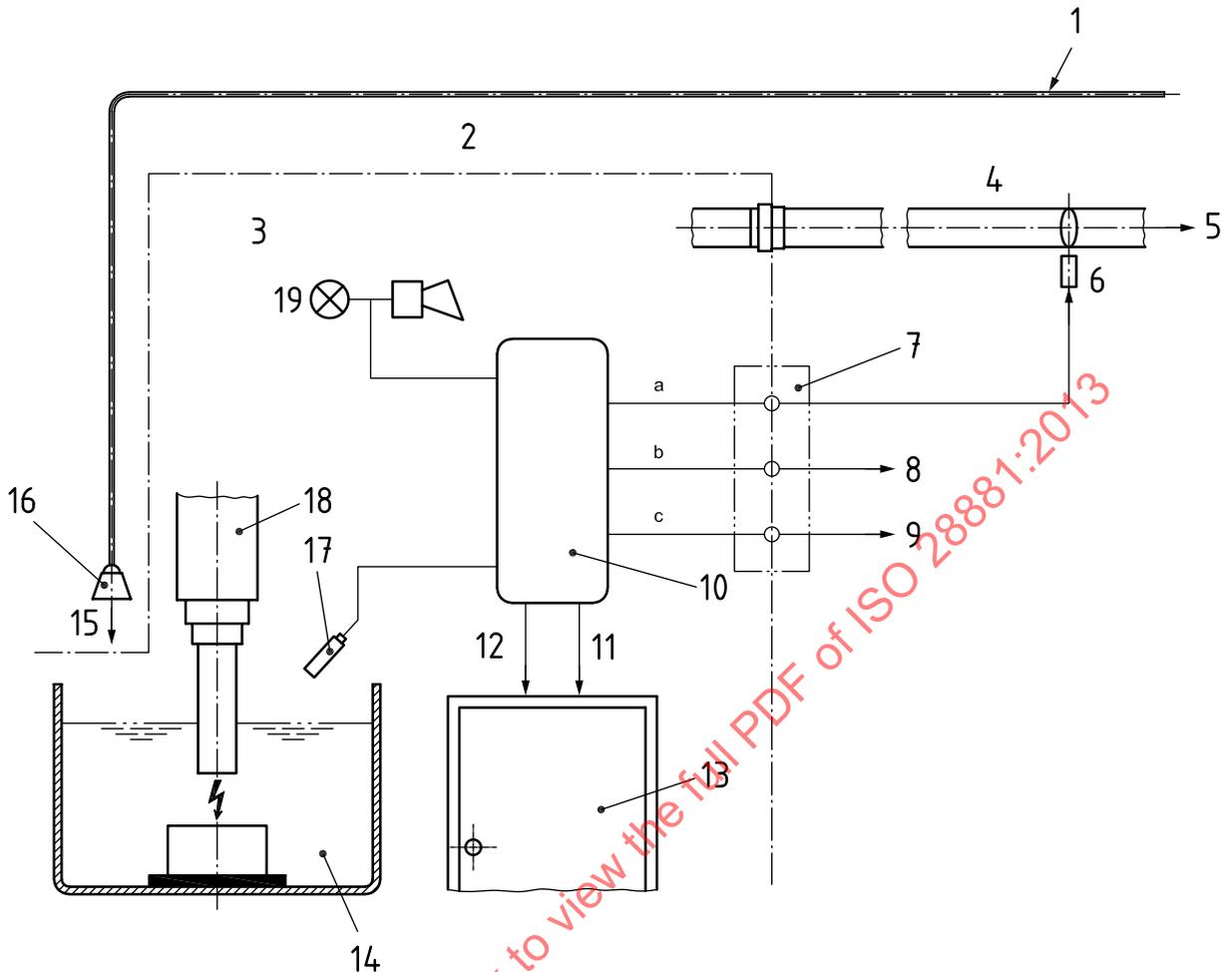
**Key**

- |   |                               |   |  |
|---|-------------------------------|---|--|
| 1 | manufacturer                  | 6 | air aspiration                                       |
| 2 | user                          | 7 | air flow sensor                                      |
| 3 | exhaust air extraction device | 8 | signal to prevent machining if insufficient air flow |
| 4 | connection device             | 9 | work tank with flammable dielectric fluid            |
| 5 | exhaust air extraction system |   |  |

**Information for user:**

- minimum and maximum air flow [m<sup>3</sup>/h];
- diameter for connecting exhaust system [mm];
- electrical interface of air flow sensor.

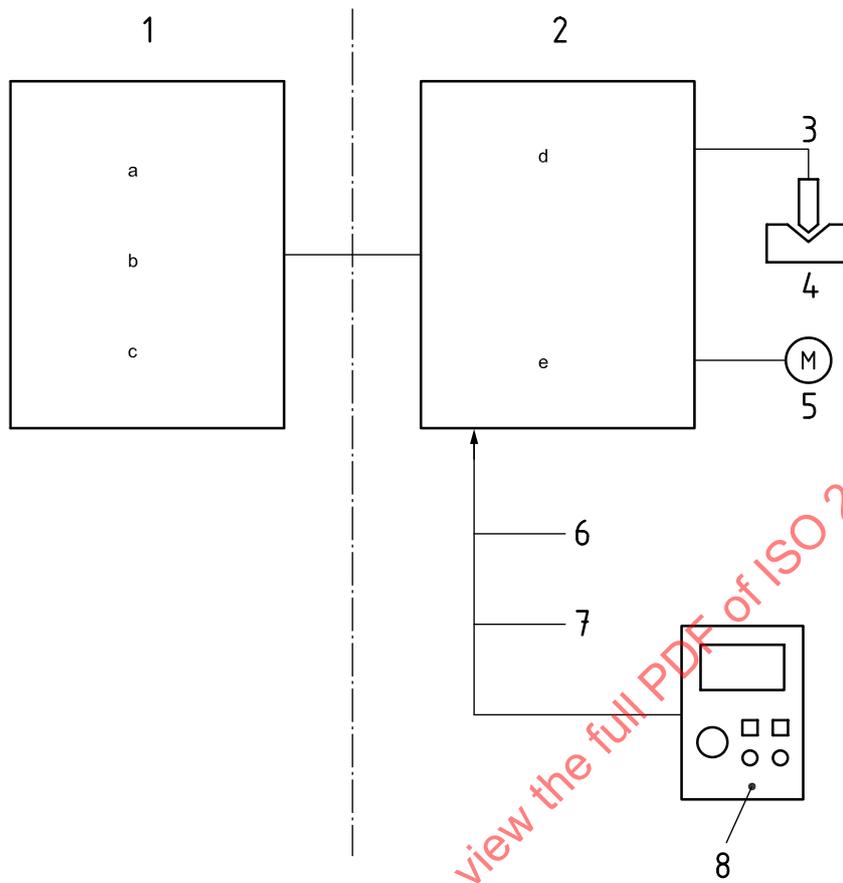
**Figure A.3 — Exhaust air extraction (interfacing schematic)**



**Key**

- |    |                                |    |   |
|----|--------------------------------|----|---|
| 1  | fire extinguishing medium      | 11 | fire detection device OK  |
| 2  | user                           | 12 | stop machining signal (can be used to disable total energy supply to the machine) |
| 3  | manufacturer                   | 13 | electrical cabinet (generator)  |
| 4  | exhaust air extraction system  | 14 | work tank with flammable dielectric fluid   |
| 5  | air aspiration                 | 15 | mist spray  |
| 6  | valve shutter device (barrier) | 16 | nozzle  |
| 7  | emergency outputs              | 17 | fire detector   |
| 8  | extinguisher(s) triggering     | 18 | machining head  |
| 9  | remote fire alarm              | 19 | local fire alarm  |
| 10 | fire detection device          |    |   |
- borderline between responsibility area of the user (2) and responsibility area of the manufacturer (3)
- a Output signal for optional valve shutter device.  
 b Output signal to trigger the optional automatic fire extinguishing device.  
 c Output signal for remote fire alarm.

**Figure A.4 — Fire detection system (interfacing schematic)**

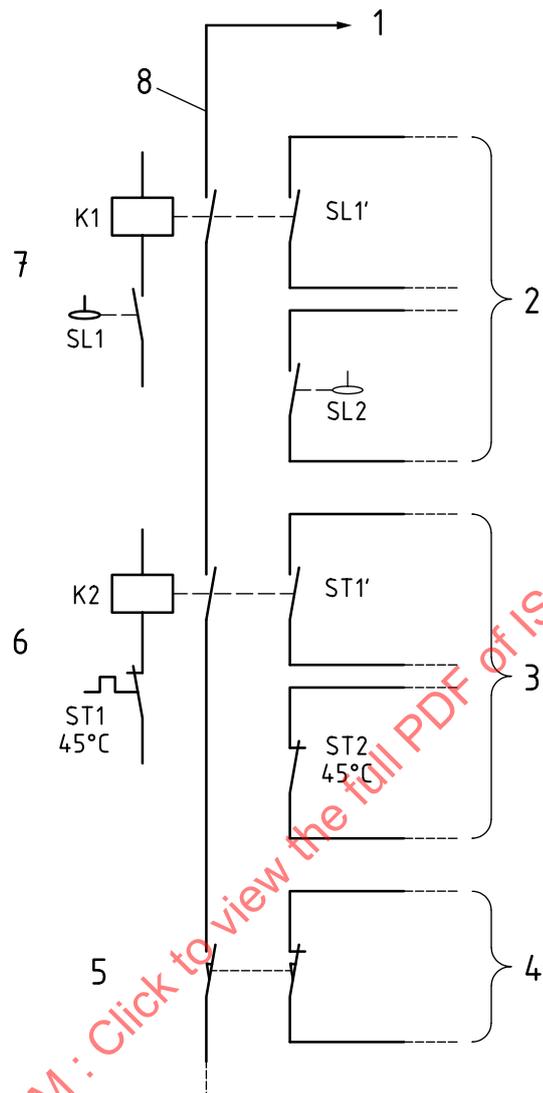


**Key**

- |   |   |   |   |
|---|---|---|---|
| 1 | primary circuits: complete stop of machinery          | 5 | axes  |
| 2 | secondary circuits: machinery suspension (idle state) | 6 | guards interlocking                               |
| 3 | electrode   | 7 | dielectric fluid level and temperature monitoring |
| 4 | workpiece   | 8 | operator interface with operational stop function |
| a | Machine on/off.                                       |   |   |
| b | Emergency stop.                                       |   |   |
| c | Fire detection.                                       |   |   |
| d | Electrical machining power.                           |   |   |
| e | Motion.   |   |   |

Opening of a guard or failure in dielectric fluid level or temperature monitoring devices shall stop motion and electric machining power, and put the machine in an idle state with error messages.

**Figure A.5 — Example of a circuit diagram for the safety functions of an EDM equipment**



**Key**

- |   |   |   |   |
|---|---|---|---|
| 1 | machine stop signal (hardware)  | 5 | guards monitoring                       |
| 2 | machine stop signal and level error message SL1, SL2 (software)       | 6 | dielectric fluid temperature monitoring |
| 3 | machine stop signal and temperature error message ST1, ST2 (software) | 7 | dielectric fluid level monitoring       |
| 4 | guard open message (software)   | 8 | safety loop (hardware)                  |

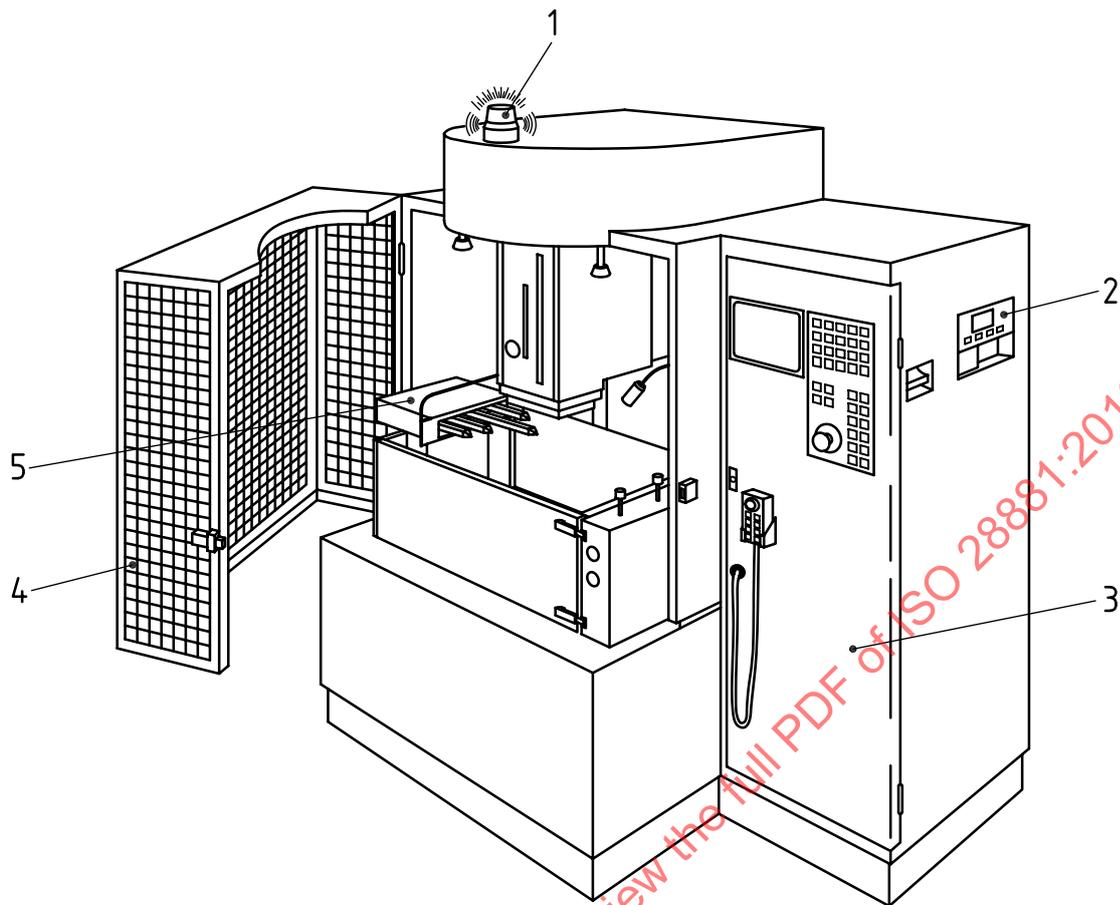
NOTE 1 Fluid temperature control devices can be located in a place where they sense the highest temperature of the dielectric fluid.

NOTE 2 Relays K1 and K2 are with forcibly guided contacts.

NOTE 3 The operation (opening) of SL1' and SL2 is checked each time the work tank is drained. If either device (SL1' or SL2) fails to operate, it is not possible to switch on the electric machining power (ISO 13849-2).

NOTE 4 Contacts SL1'/SL2 as well as ST1'/ST2 are monitored for fault detection, according to ISO 13849-2:2003, 6.2.4.

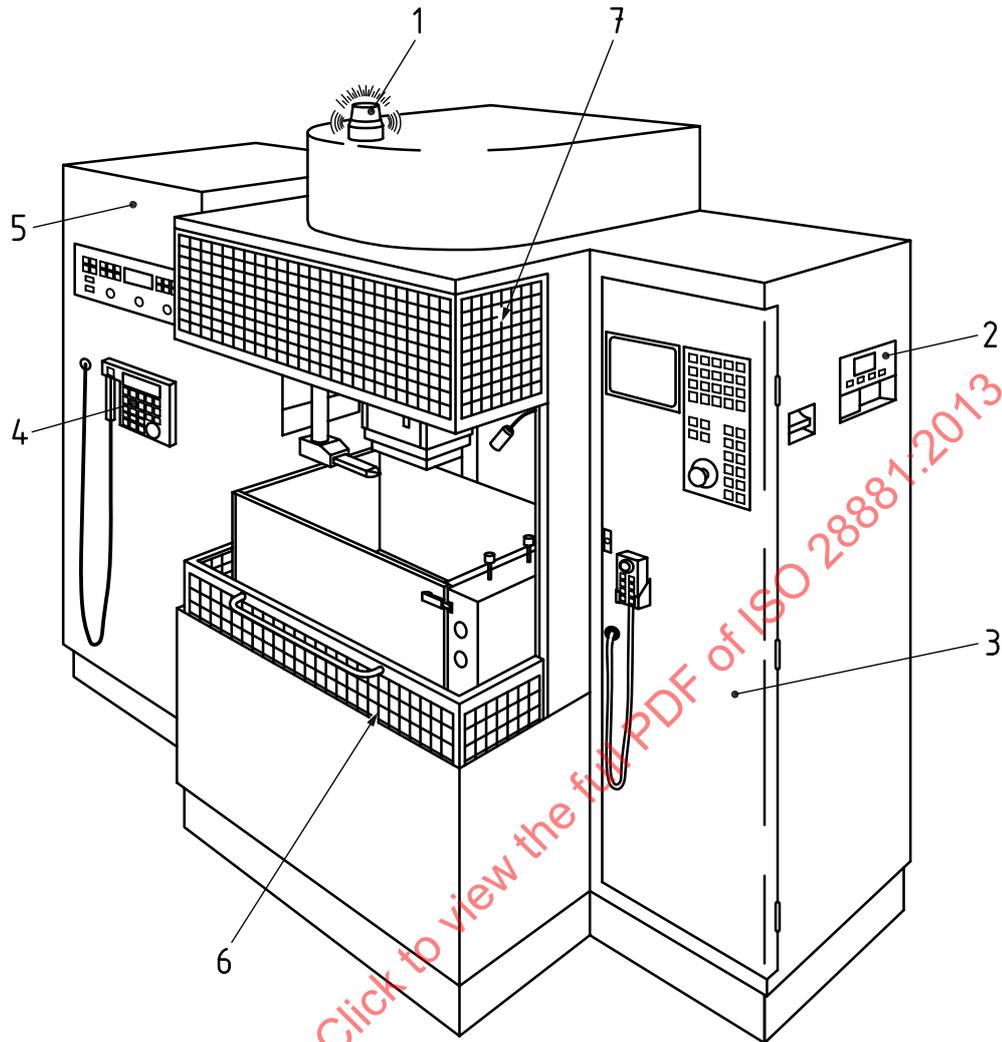
**Figure A.6 — Example of redundancy in monitoring level and temperature of flammable dielectric fluid**



**Key**

- 1 local fire alarm
- 2 fire detection device
- 3 electrical cabinet (generator)
- 4 interlocking shielded guard
- 5 linear electrode changer

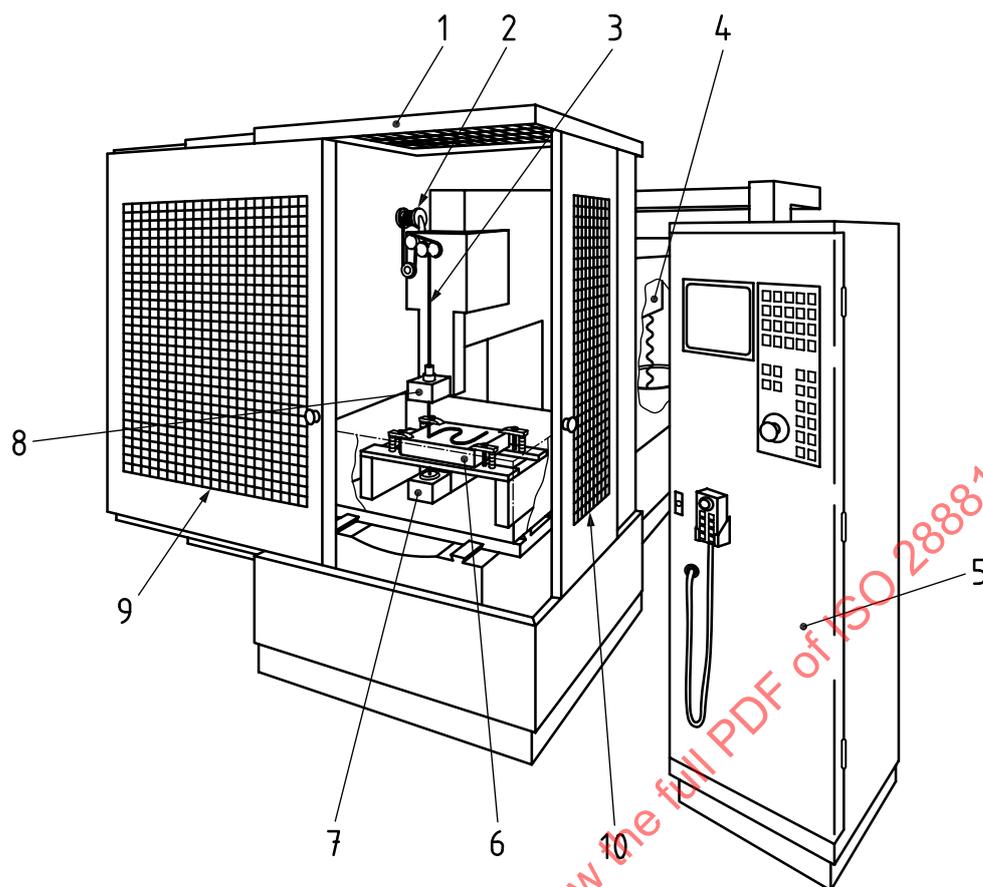
**Figure A.7 — Die sinking machine with linear electrode changer**



**Key**

- 1 local fire alarm
- 2 fire detection device
- 3 electrical cabinet (generator)
- 4 robot pendant
- 5 robot
- 6 interlocking guard
- 7 fixed guards

**Figure A.8 — Die sinking machine with robot**



**Key**

- |   |                                 |    |                    |
|---|---------------------------------|----|--------------------|
| 1 | shielded enclosure with door(s) | 6  | workpiece          |
| 2 | wire supply spool               | 7  | lower wire guide   |
| 3 | wire electrode                  | 8  | upper wire guide   |
| 4 | wire evacuation                 | 9  | interlocking guard |
| 5 | electrical cabinet (generator)  | 10 | fixed guards       |

**Figure A.9 — Wire cutting machine**

## Annex B (normative)

### Noise-emission measurements

The operating conditions for noise measurement shall include:

- a) idle running;
- b) work preparation (e.g. axis positioning, program check, flushing check and automatic wire threading);
- c) EDM process in maximum removal conditions, e.g. full power die sinking, high-speed wire cutting, cutting with high-pressure flushing and other type of machining process where the equipment is emitting acoustic noise;
- d) operation of automatic changing devices, e.g. electrode changer and workpiece changer.

Installation and operating conditions of the equipment shall conform to the manufacturer's instructions for the determination of the emission of sound pressure levels of the equipment.

The emission of sound pressure levels of the equipment shall be measured using ISO 11202, taking into account that:

- the environmental indicator,  $K_{2A}$ , shall be equal to or less than 4 dB;
- the difference between the background sound pressure level and the equipment sound pressure level at each measuring point shall be equal to or greater than 6 dB.

A declaration shall be made about the airborne noise emissions measured, indicating the methods used and the operating conditions applied during the test, as well as the values for uncertainty  $K$  (see ISO 4871).

The noise declaration shall be accompanied by the following statement:

"The figures quoted are emission levels and are not necessarily safe working levels. While there is a correlation between the emission and exposure levels, this cannot be used reliably to determine whether or not further precautions are required. Factors that influence the actual level of exposure of the manpower include the characteristics of the work room, the other sources of noise, etc., for example the number of machines and other adjacent processes, and the length of time during which the operator is exposed to the noise. Also the permissible exposure level can vary from country to country. This information, however, will enable the user of the equipment to make a better evaluation of the hazard and the risk."

If it is necessary to determine the sound power level as well as the emission sound pressure level, this shall be done in accordance with ISO 3746, using the same operating conditions as those given above.

## Annex C (informative)

### Fire protection codes for special regional cases

#### C.1 Fire protection codes

##### C.1.1 General

In the case of regions having existing national standards or regulations referring to fire hazards, these should to be respected.

For example, the fire protection codes in MAS 810:1996 are valid in Japan.

##### C.1.2 Objective

Fire protection codes serve to prevent fire hazards caused by EDM and ensure the safety of the operator through the use of relevant structural standards and operational standards, which explain how to use the machine properly.

##### C.1.3 Application

Fire protection codes should be applied to EDM equipment which use flammable dielectric fluid.

##### C.1.4 Relation to the fire prevention regulations

Fire prevention regulations should be obeyed notwithstanding this International Standard.

#### C.2 Structural standard

##### C.2.1 Dielectric fluid and dielectric fluid container

- a) Dielectric fluid for EDM: dielectric fluid having a flash point of more than or equal to 70 °C should be used.
- b) Dielectric fluid container: a dielectric fluid container should be made of steel having a thickness of more than or equal to 3,2 mm or such metal having the same or larger strength. It should be airtight and should not allow leakage or be damaged in waterproof testing.
- c) Piping connecting dielectric fluid container and work tank: the pipes should be made of metal and should withstand waterproof testing at a pressure of more than or equal to 1,5 times the normally used maximum pressure.

##### C.2.2 Equipment for each safety measure

- a) Fluid temperature sensing equipment: the designated temperature should be a maximum of 60 °C. In the case of dielectric fluid temperature exceeding the value, the process should be stopped.
- b) Fluid level sensing equipment: the appropriate fluid level should be set according to workpiece height. In the case of falling below this level, the process as well as pumps should be stopped. This function should not be deactivated.
- c) Sensing equipment for abnormal machining: in cases where carbon material is expanding, the process should be stopped.

### C.2.3 Automatic fire extinguisher

An automatic fire extinguisher should be able to not only automatically sense fire ignition caused by dielectric fluid, automatically splash extinguishing material all over the work tank and extinguish fires, but also cut power for electro-discharge, stop pumps for dielectric fluid and sound an alarm.

The sensing system and extinguishing materials should have the following characteristics.

- a) It should sense temperature or flame. If it is a system for sensing temperature, it should start at a work temperature of less than or equal to 75 °C.
- b) Fire extinguishing material should have enough ability and speed for oil fire, and should prevent re-ignition of the fire.

**Table C.1 — Threshold limit values**

Threshold limit value for environmental temperature $\leq 35$ °C	This International Standard	Japan MAS 810 :1996	China GB 13567 :1998
Flash point of the dielectric fluid	> 60 °C (+15 °C)	> 70 °C (+10 °C)	> 70 °C (+10 °C)
Dielectric fluid temperature sensing level	<< 45 °C	< 60 °C	< 60 °C
Dielectric fluid level sensing level	> 40 mm.	> 50 mm.	> 50 mm.
Fire extinguisher sensing temperature	–	< 75 °C	Required in 5.6.3 GB

### C.2.4 Labelling

- a) Plate for operating instructions for safety: a plate showing the following instructions for safety during operation should be attached to EDM equipment:
  - 1) points and methods for daily checks;
  - 2) measures for direct electric shock (positions that should not be touched, etc.);
  - 3) type and volume (fluid level) of dielectric fluid; caution for fluid leakage;
  - 4) necessary instructions for safety during process.
- b) Instruction handbook: the following should be described:
  - 1) application of installation of EDM equipment relevant to the local fire station;
  - 2) items listed in C.3.

## C.3 Operation standard

### C.3.1 General

The following should be obeyed where using EDM equipment.

### C.3.2 Type and level of dielectric fluid

- a) Fluid having a flash point of more than or equal to 70 °C should be used.
- b) The level of fluid should be as high as possible, and at least 50 mm above the upper surface of the workpiece.

### C.3.3 Equipment for each safety measure and operation

Where using EDM equipment, equipment described in C.2, such as fluid temperature sensing equipment, fluid level sensing equipment, sensing equipment for abnormal machining and automatic fire extinguishers should be provided.

For machines having such equipment, these pieces of equipment should not be taken out or modified.

The following is information on the functions of the equipment and precautions for operation of the equipment.

- a) Fluid temperature sensing equipment: this equipment should be able to immediately stop machining whenever the temperature of dielectric fluid exceeds the designated value. The designated temperature should be equal to or less than 60 °C.
- b) Fluid level sensing equipment: this equipment should be able to immediately stop machining whenever fluid level falls below the designated value. The level of fluid should be higher than 50 mm above the upper surface of the workpiece.
- c) Sensing equipment for abnormal machining: this equipment should be able to immediately stop machining whenever carbide occurs and starts to grow between the electrode and the workpiece.
- d) Automatic fire extinguisher: this equipment should be able to automatically sense fire upon ignition of dielectric fluid and automatically splash extinguishing medium all over the work tank. The position, direction and/or other conditions of the splashing nozzle should not be altered.

### C.3.4 Maintenance and inspection

- a) For inspection (daily inspection), the following items should be checked before the start of the job:
  - 1) noise, vibration, pressure, etc. of dielectric fluid container;
  - 2) volume, level, temperature and leakage of fluid;
  - 3) conditions of fixing of electrode and workpiece;
  - 4) confirmation of function of each piece of safety equipment.
- b) For periodic inspection (six months, one year and five years)
  - 1) the function of fluid temperature sensing equipment should be confirmed more than once every six months at the designated temperature, and
  - 2) it is desirable to periodically inspect the automatic fire extinguisher as follows, because appropriate maintenance is especially necessary:
    - i) more than once every six months for a check of the appearance (e.g. damage of splashing nozzle, piping, sensor and wiring);
    - ii) more than once per year for a functional check;
    - iii) more than once every five years for a detailed check (e.g. replacement of extinguishing material, such as powder and/or foam).

### C.3.5 Operating environment

The operating environment of EDM equipment should always be kept as clean as possible and the following should be taken care of.

- a) Pay attention to fire and/or high-temperature material, such as heater, welding machine and grinder; fire should not be used around EDM equipment.
- b) There should be sufficient extraction of exhaust air.