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Machine tools — Safety — Electrical discharge machines

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

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 10, *Safety*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 143, *Machine tools — Safety*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 28881:2013), which has been technically revised. It also incorporates the Technical Corrigendum ISO 28881:2013/Cor.1:2013.

The main changes are as follows:

— the service mode has been introduced;

— Annex C has been rewritten.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

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

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organisations, market surveillance etc.)

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e. g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

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

In addition, electrical discharge machining (EDM) equipment and EDM systems are intended to be designed according to the principles of ISO 12100:2010 for hazards which are not dealt with in this document.

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

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

Machine tools — Safety — Electrical discharge machines

1 Scope

This document specifies safety requirements and/or protective measures applicable to EDM equipment and EDM systems intended to be adopted by persons undertaking their design, construction, installation and/or supply, 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.

This document also includes information to be provided by the manufacturer to the user.

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

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

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

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 document defines required performance level and safety categories of the safety-related parts of the control system for EDM equipment and EDM systems as defined in ISO 13849-1:2015.

2 Normative references

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

ISO 3746:2010, *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 4413:2010, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 4414:2010, *Pneumatic fluid power — General rules and safety requirements for systems and their components*

ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 7010:2019/Amd.2:2020, *Graphical symbols — Safety colours and safety signs — Registered safety signs/ — Amendment 2*

ISO 9355-1:1999, *Ergonomic requirements for the design of displays and control actuators — Part 1: Human interactions with displays and control actuators*

ISO 9355-3:2006, *Ergonomic requirements for the design of displays and control actuators — Part 3: Control actuators*

ISO 11201:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections*

ISO 11202:2010, *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 11202:2010/Amd.1:2020, *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/ — Amendment 1*

ISO/TR 11688-1:1995, *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*

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

ISO 13849-2:2012, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

ISO 13850:2015, *Safety of machinery — Emergency stop function — Principles for design*

ISO 13854:2017, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

ISO 13855:2010, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

ISO 13857:2019, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

ISO 14118:2017, *Safety of machinery — Prevention of unexpected start-up*

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

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

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

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

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

ISO 14123-1:2015, *Safety of machinery — Reduction of risks to health resulting from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers*

IEC 60204-1:2016, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60529:1989/AMD2:2013/COR:2019, *Degrees of protection provided by enclosures (IP Code)*

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices (RLV Redline version)*

IEC 61000-6-2:2016, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

IEC 61000-6-4:2018, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments*

IEC 61310-1:2007, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*

IEC 61310-2:2007, *Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*

IEC 61558-1:2017, *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*

IEC 62226-1:2005, *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*

IEC 62226-2-1:2005, *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*

IEC 62226-3-1:2007/A1:2017, *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*

IEC 62311:2020, *Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz)*

EN 2:1992, *Classification of fires*

EN 54-1:2021, *Fire detection and fire alarm systems — Part 1: Introduction*

EN 614-1:2006+A1:2009, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles*

EN 614-2:2000+A1:2008, *Safety of machinery — Ergonomic design principles — Part 2: Interactions between the design of machinery and work tasks*

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

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

EN 12198-3:2002+A1:2008, *Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 3: Reduction of radiation by attenuation or screening*

EN 55011:2016, *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 13849-1:2015 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
electrical discharge machining
EDM
any machining process based on spark erosion

3.2
EDM process
removal of material in dielectric fluid by electrical 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.

3.3
EDM equipment
machine tool that includes all the necessary units for the process of *EDM* (3.1)

EXAMPLE *Generator* (3.20), *control circuits* (3.8) and *dielectric fluid container* (3.17).

3.4
EDM system
assembly of *EDM equipment* (3.3) and other machines or devices, which are arranged, linked and controlled to function as an integrated whole

3.5
EDM die sinking
removal of material by spark erosion with a formed or bar-shape electrode to produce various shapes in the workpiece

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

3.6
EDM drilling
removal of material by spark erosion with a tubular electrode to produce straight holes in the workpiece

3.7
EDM wire cutting
removal of material by spark erosion with a wire electrode to produce prismatic shapes in the workpiece

3.8
control circuit
<machine> circuit used for the control, including monitoring, of the machine

Note 1 to entry: For electrical equipment, see IEC 60204-1:2016, 3.1.10.

3.9
machine control system
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 13849-1:2015, 3.1.32

3.10
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 2806:1994, 2.1.1, 2.1.22]

3.11
electronic handwheel
manually operated control device that initiates and maintains an axis movement by pulse generation input to the *numerical control* (3.10) during its rotation

3.12
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]

3.13
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]

3.14
dielectric fluid
<EDM process> non-conductive medium to improve the discharge effect, evacuate debris and cool the workpiece/electrode

3.15
flammable dielectric fluid
dielectric fluid (3.14) used in *EDM* (3.1), characterized by its relative ease of ignition and relative ability to sustain combustion

3.16
flash point
minimum temperature at which the *dielectric fluid* (3.14) used in the sinking *EDM* (3.1) gives off sufficient combustible gas or vapour to ignite and sustain combustion

3.17
dielectric fluid container
tank system to keep the *dielectric fluid* (3.14) in a condition suitable for *EDM* (3.1)

EXAMPLE Filtering and cooling.

3.18
work tank
<EDM equipment> unit surrounding the *work area* (3.19) to contain the *dielectric fluid* (3.14) for *EDM processes* (3.2)

3.19
work area
<EDM equipment> space within the envelope of the machine where the *EDM process* (3.2) can take place (inside and around the *work tank* (3.18))

3.20
generator
unit to convert the electrical power supplied to the *EDM equipment* (3.3) and *EDM system* (3.4) for the purpose of being used for spark erosion processing

3.21
electrical machining power
electrical power supplied to the *EDM equipment* (3.3) and *EDM system* (3.4) transformed by the *generator* (3.20) in specific electric energy, supplied as a tool to the sinker/wire electrode and the workpiece, to perform machining by electro-thermal material removal

3.22
electrode changer
<EDM equipment> mechanism integrated with the machine to supply an electrode to the machine, 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.

3.23
workpiece changer
<EDM equipment> mechanism forming part of the machine to supply a workpiece or pallet to the machine, in exchange for another workpiece or pallet

Note 1 to entry: The workpiece changer/pallet changer is designed to enable an operator to load/unload the workpiece or pallet to the magazine from outside of the *work area* (3.19).

3.24
operating mode
possible mode for use of the machine

3.24.1
automatic mode
MO 1: Automatic
mode for use under *numerical control* (3.10) 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.

3.24.2
setting mode
MO 2: Setting
mode for use without *electrical machining power* (3.21), 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* (3.23), 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).

3.24.3
discharge alignment mode
MO 3: Manual intervention
mode for use for specific alignment with the electrical discharge on and with the guards of *EDM equipment* (3.3) temporarily open and alternative safety measures activated

EXAMPLE Exhaust air extraction adjustment, vertical wire alignment, *dielectric fluid* (3.14) flushing adjustment and visual machining inspection.

3.24.4
service mode
MO service
mode for service and maintenance tasks

Note 1 to entry: In MO service, the machining of a workpiece is not allowed.

EXAMPLE Axis calibration, for example, by laser, *generator* (3.20) calibration, repeatability test.

3.25
performance level
PL
discrete level used to specify the ability of safety-related parts of *control systems* (3.9) to perform a safety function under reasonably foreseeable conditions

[SOURCE: ISO 13849-1:2015, 3.9]

3.26
electro-magnetic compatibility
EMC
ability of *EDM equipment* (3.3) and *EDM systems* (3.4) to function satisfactorily in their electro-magnetic environment without introducing intolerable electro-magnetic disturbances to anything in that environment

3.27
shielding
mechanical barrier or enclosure of conductive material intended to attenuate the emission/penetration of a varying electro-magnetic field into an assigned region

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 document, identified by risk assessment as significant for this type of machinery, and which require action to eliminate or reduce the risk.

The manufacturer shall perform a risk assessment to ensure that any other risk (not covered in this clause) is considered.

NOTE 1 The purpose of risk assessment is to identify hazards, and to 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 document. 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 14121-2:2012).

The list of hazards given in Table 1 is the result of a risk assessment carried out for all EDM equipment covered by this document. 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, 3.23 and 3.24) for both spark erosion with automatic mode and operations requiring intervention (e.g. setting, maintenance and repair).

The significant hazards covered by this document 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 (included in waste disposal, used filters, used dielectric fluid, electrodes and sludges);

— electro-magnetic emissions (radiated and conducted); see IEC 61000-6-2:2016 EMC for immunity and IEC 61000-6-4:2018 EMC for emission.

NOTE 3 The general word electrode is used on the document to reference the work tool of the machine. This is the name for the work tool in EDM die sinking and EDM drilling machines, in EDM wire cutting machines the work tool is named wire.

Table 1 — List of significant hazards and major sources of these hazards associated with electrical discharge machines

No.[a]	Hazard type	Hazardous situation action	Activity	Danger zone	Reference to Table 3
1	**Mechanical hazards**				
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	A1, A2, A3, A8
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

[a] This list is derived from ISO 12100:2010, Table B.1.

Table 1 *(continued)*

No.[a]	Hazard type	Hazardous situation action	Activity	Danger zone	Reference to Table 3
2	**Electrical hazards**				
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
3	**Thermal hazards (not relevant to EDM)**				
4	**Noise hazards**				
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
5	**Vibration hazards (not relevant to EDM)**				
6	**Radiation hazards**				
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	**Materials/substances hazards**				
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	**Ergonomic hazards**				
8.1	Specific requirements resulting from neglect of ergonomic principles	Ergonomic hazards including unhealthy posture and/ or excessive effort including the design of machines in accordance with ergonomic principles	During loading and unloading of electrode or workpiece on the EDM equipment and EDM system	At operator's position	F1
9	**Hazards associated with the environment in which the machine is used**				
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

[a] This list is derived from ISO 12100:2010, Table B.1.

Table 1 *(continued)*

No.[a]	Hazard type	Hazardous situation action	Activity	Danger zone	Reference to Table 3
10	**Combination of hazards**				
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

[a] 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 document.

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 13849-1:2015. Therefore, reliability requirements for safety functions are defined as performance levels in accordance with ISO 13849-1:2015 (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 document, 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 13849-1:2015. If the safety function, when activated, initiates a category 2 stop in accordance with IEC 60204-1:2016, 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 14118:2017.

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 13849-1:2015, as listed in Table 2. (See Annex A, Figure A.5)

Table 2 — Required performance level (PL_r) of safety-related parts of the control system for EDM equipment and EDM systems

Safety functions	Subclause in this document	Required performance level, PL_r ISO 13849-1:2015	Reference to Table 3
— Movement control by means of hold-to-run control device or electronic handwheel	5.3.2.2	PL_r b	A3
— Movement control with safely monitored reduced speed	5.3.2.2	PL_r c	A3
— Interlocking function of movable guards of tool changer/ magazine	5.3.2.2	Cat. 3, PL_r c	A1, A2, A3, B2
— Safe operating stop (SOS) function in accordance with IEC 61800-5-2:2007	5.4.1	Cat. 2, PL_r c	B6
— Start, stop and automatic restart function of machining	5.4.1	PL_r b	E3
— Interlocking function of movable guards of the EDM equipment	[a]	Cat. 3, PL_r c	A1, A2, A3, B2
— Movement control and/or electrical machining power control by means of enabling device	5.3.2.2 5.3.2.3	Cat. 3, PL_r c	A3
— Time limit function for discharge alignment mode	5.3.2.3	PL_r c	A1, A2, A3, B2
— Mode selection function	5.3.1	PL_r c	
— Emergency stop function	5.4.2	Cat. 3, PL_r c	
— Enabling device function	5.3.2.2 5.3.2.3	Cat. 3, PL_r c	A3
— Monitoring function of level and temperature of flammable dielectric fluid	[b]	PL_r c	D6, D7, D8
— Fire detection function	[b]	PL_r c	D10

[a] Interlocking function of movable guards, electro-sensitive protective equipment (ESPE) or other safety equipment of EDM equipment with hazardous movements and voltage applied to electrodes >25 V-a.c. or >60 V-d.c. (using a safety source in accordance with IEC 61558-1:2017).

[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 13849-2:2012).

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 (e.g. access code), which restrict the use of certain modes to certain operators (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, 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 60204-1:2016, 9.2.3.5.

5.3.2 Protective measures relating to operating modes

5.3.2.1 Automatic mode (MO 1: Automatic)

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).

Movements only associated with loading/unloading of tools/workpieces in Automatic mode with guards open shall be possible with specific requirements stated in 5.3.2.2.

5.3.2.2 Setting mode (MO 2: Setting)

In the setting mode, voltage applied to electrodes, which can be touched, shall be limited to ≤25 V a.c. or ≤60 V d.c., in accordance with IEC 60204-1:2016, 6.4.1 (using a safety source in accordance with IEC 61558-1:2017).

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 ≤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 hazard zone (e.g. light curtain, laser scanner, two-hand control device).

The stop resulting from the release of the enabling device shall be safe operating stop (SOS) in accordance with IEC 61800-5-2:2007, 4.2.3.1. The minimum distance in accordance with ISO 13855:2010 shall be maintained.

For rotating axes with speed up to 50 rpm 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 rpm are not permitted.

5.3.2.3 Discharge alignment mode (MO 3: Manual intervention)

Use of the EDM equipment for specific alignment operation (e.g. vertical wire alignment, adjustment of the exhaust air extraction, dielectric fluid flushing adjustment and visual machining inspection) with the guards open and voltage applied to electrodes 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 (Manual intervention during automatic operation):

   — 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 5 min and visual and audible alarm signal (after this time, the discharge alignment mode is automatically quitted);

   — press the button of the one-hand operation-enabling device and keep it pressed during discharge alignment mode. Stop all machining operation when the button is released;

— open the guards to operate the discharge alignment operations (adjustment of the exhaust air extraction, dielectric fluid flushing adjustment and visual machining inspection, etc.);

— after a maximum of 5 min, the machine operation shall stop 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 5 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 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 5 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 pressed during discharge alignment mode;

— perform the discharge alignment operation (e.g. vertical wire alignment, adjustment of the exhaust air extraction, dielectric fluid flushing adjustment and visual machining inspection) by tilting or feeding;

— release the enabling device after alignment operation;

— after a maximum of 5 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 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).

5.3.2.4 Service mode (MO Service)

If MO Service is provided the following rules shall be applied.

MO service shall only be provided for service staff, trained in accordance with the information given by the instruction's manual (see 6.3). This mode of operation is intended for service tasks, such as troubleshooting, calibration measurement, diagnostic and checking of machine functions.

a) General:

1) The selection of MO service shall be carried out either using a key switch or equivalent means (e.g. access code), which restrict the use to service staff, trained and authorized by the machine manufacturer. As long as the MO service is selected, no other mode of operation shall be selectable.

   The service device may be replaced by other selection means limiting application of MO service to the persons mentioned above:

2) manual operation shall be possible under the conditions in 5.3.2.2;

3) according to the risk assessment, additional safety measures can be necessary, such as secondary guards, barriers, or screens, in connection with warning signs;

4) pneumatic or hydraulic movements of machine parts shall be initiated and maintained with an enabling device together with a start button.

b) This mode enables restricted automatic functionality of the machine with the movable guards open. The restrictions are the following:

1) machining of a workpiece shall not be possible in MO service;

2) each axes speed shall not exceed 2 m/min and shall be monitored;

3) continued moving cycles can be possible (e.g. repeatability test);

4) switching on of the generator (see 3.20) for calibration purpose can be possible. In case using flammable dielectric fluid, keep the fire detection function activated to stop electrical discharge in case of fire ignition. If spark erosion work is done, the axis movement shall be controlled through;

— single axis movement, or

— (hand-operated) hold-to-run control, or

— (hand-operated) enabling device, together with a start button, or

— other equivalent measures (e.g. light curtain, laser scanner, two-hand control device).

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 60204-1:2016, 9.2.3.4.2, ISO 12100:2010, 6.3.5.2, and ISO 13850:2015.

The emergency stop functions shall be of stop category 1 in accordance with IEC 60204-1:2016, 9.2.2, and shall switch off electrical 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 electrical discharge drilling machines), stop category 0 according to IEC 60204-1:2016, 9.2.2, 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; 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, and

— by analysis of documentation (e.g. circuit or functional diagram, information for use).

The standards in the 5th column of Table 3 shall be followed.

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

	Hazard	Safety requirements and/or protective measures	Verification	Relevant reference
A[a]	**Mechanical hazards**			
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 13857:2019 ISO 13854:2017
		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	ISO 14120:2015, 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 Figure A.9.	By testing and visual inspection	ISO 13857:2019 ISO 13854:2017
		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	ISO 13854:2017 ISO 13857:2019 ISO 14120:2015, 3.3 and 3.5 ISO 14119:2013
		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 Table 2), e.g. switch off electrical machining power and hazardous movement.	By testing and visual inspection and by analysis of documentation	IEC 60204-1:2016, 9.3.6 ISO 14118:2017

[a] See Table 1.

Table 3 *(continued)*

	Hazard	Safety requirements and/or protective measures	Verification	Relevant reference
		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 Table 2).	By testing and visual inspection and by analysis of documentation	ISO 14118:2017, 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	ISO 14119:2013 IEC 60204-1:2016, 5.4 and 9.3.1
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	ISO 14120:2015 ISO 13855:2010 ISO 14119:2013
		A3.1.2 Opening the guard of the electrode/workpiece changer shall prevent automatic changing movement or magazine movement. As a schematic example, see Figures A.7 and A.8.	By testing and visual inspection	
		A3.1.3 The movement of the electrode/workpiece changer in setting mode shall be possible under the conditions mentioned in 5.3.2.2 only.	By testing and visual inspection	ISO 13857:2019 IEC 60204-1:2016, 9.3.6 and 9.2.3.7
		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 standards (e.g. prevention of residual pressure).	By testing and visual inspection	ISO 14120:2015 ISO 4413:2010 ISO 4414:2010
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	ISO 14119:2013

[a] See Table 1.

Table 3 *(continued)*

	Hazard	Safety requirements and/or protective measures	Verification	Relevant reference
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	
		A6.1.2 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 14122-1:2016 ISO 14122-2:2016 ISO 14122-3:2016
		A6.1.3 The instruction handbook shall include requirements on appropriate footwear [see 6.3.2.2 b) 2] and/or location of non-slip surfaces around the machine [see 6.3.2.2 a) 2].	By visual inspection	
A7	Mechanical hazards associated with the failure of safety-related parts of the control circuit	EDM equipment and safety-related parts of the control system shall fulfil the required performance level PL_r, as specified in ISO 13849-1:2015 (see 5.2).	By testing and analysis of documentation	IEC 60204-1:2016, 9.4 ISO 13849-1:2015 ISO 13849-2:2012
A8	Falling down of an axis slider 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 testing and visual inspection	
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: — the hanging points for lifting up — the mass — how to move.	By analysis of documentation	
B[a]	**Electrical hazards**			
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 60204-1:2016
		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 60529:1989/AMD2:2013/COR:2019.	By visual inspection and analysis of documentation	IEC 60204-1:2016, 6.2.2 IEC 60529:1989/AMD2:2013/COR:2019

[a] See Table 1.

Table 3 *(continued)*

	Hazard	Safety requirements and/or protective measures	Verification	Relevant reference
B2	B2.1 Persons coming into contact with live parts	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 60529:1989/AMD2:2013/COR:2019.	By visual inspection and analysis of documentation	IEC 60529:1989/AMD2:2013/COR:2019
		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 60204-1:2016
		B2.1.4 The work area on the EDM equipment and EDM system 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	ISO 14119:2013
		B2.1.5 The opening of interlocking guards protecting live parts shall cut the electrical machining power in automatic mode (see Table 2).	By visual inspection and analysis of documentation	IEC 60204-1:2016 ISO 14119:2013
		B2.1.6 On EDM equipment and EDM systems when a voltage exceeding 25 V a.c. or 60 V d.c. is applied to the electrode in the work area, the interlocking guards shall be closed, with the exception of the discharge alignment mode (see 5.3.2.3).	By visual inspection and analysis of documentation	IEC 60204-1:2016 ISO 14119:2013
		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 analysis of documentation	IEC 61558-1:2017
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 60204-1:2016, 5.2, 6.3.3, 8.2, 18.2

[a] See Table 1.

Table 3 *(continued)*

	Hazard	Safety requirements and/or protective measures	Verification	Relevant reference
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 61000-6-2:2016 IEC 60204-1:2016, 4.4.2 IEC 61000-6-4:2018
B5	Hazards generated by electro-magnetic disturbances provoking risk for electrical implants in human bodies	The low-frequency electro-magnetic interferences, as well as the magnetic field, shall be measured at short distance in accordance with the relevant standards. 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	EN 55011:2016 IEC 62226-1:2005, IEC 62226–2-1:2005, IEC 62226–3-1:2007/A1:2017 IEC 62311:2020 EN 12198-1:2000+A1:2008, EN 12198–2:2002+A1:2008, EN 12198–3:2002+A1:2008 ISO 7010:2019/Amd.2:2020-W005 and ISO 7010:2019/Amd.2:2020-W006
B6	Unexpected start-up	A safe operating stop (see Table 2) shall be applied to prevent unexpected start-up.	By calculation and practical tests	IEC 61800-5-2:2007 ISO 14118:2017
C[a]	**Noise hazards**			
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. Examples of possible noise reduction measures: a) choice of low-noise machine components b) choice and design of soundproofing material; c) choice and design of low-noise transmission components, e.g. gears, pulleys, belts, bearings, clutch; d) sound deadening and vibration damping of hydraulic circuits, pump and prime mover	By measurement and analysis of documentation	ISO 3746:2010 ISO 4871:1996 ISO 11202:2010/Amd.1:2020 ISO/TR 11688-1:1995 Annex B

[a] See Table 1.

Table 3 *(continued)*

	Hazard	Safety requirements and/or protective measures	Verification	Relevant reference
D[a]	**Hazards generated by materials and substances (and their constituent elements) processed or used by the machinery**			
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 Figure A.3.).	By testing and analysis of documentation	ISO 14123-1:2015
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	ISO 14119:2013
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 fluid flash point	EDM equipment shall be designed for use with dielectric fluids having a flash point of at least 60 °C. See Annex C for fire protection codes for special regional cases.	By analysis of documentation	
D6	Dielectric fluid temperature rise	EDM equipment using flammable dielectric fluids shall have two independently operating temperature-detecting systems, switching off electrical machining power whenever the dielectric fluid temperature within the work tank exceeds 50 °C. In this case, temperature increase shall be indicated. As a schematic example, see Figures A.5 and A.6. See Annex C for fire protection codes for special regional cases. 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	
D7	Insufficient dielectric fluid level	Where flammable dielectric fluids are used, the depth at which the electrical 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. In the case where the processing current value is large, dielectric level should be kept higher (e.g. 100 mm or more). See Annex C for fire protection codes for special regional cases.	By testing and analysis of documentation	

[a] See Table 1.

Table 3 *(continued)*

	Hazard	Safety requirements and/or protective measures	Verification	Relevant reference
D8	Dielectric fluid level drop	EDM equipment using flammable dielectric fluids shall have two independently operating dielectric fluid level detecting systems, switching off electrical machining power whenever the dielectric fluid 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 electrical 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 detection 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 2:1992 EN 54-1:2021
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. by mist, missing barriers or leakage of dielectric fluid from the work tank). All components of the dielectric fluid system (e.g. dielectric fluid container, work tanks, filling/emptying system) as well as the exhaust air extraction system shall be manufactured in non-flammable materials.	By testing and visual inspection and by analysis of documentation	EN 2:1992
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 61000-6-2:2016 IEC 60204-1:2016, 4.4.2

[a] See Table 1.

Table 3 *(continued)*

	Hazard	Safety requirements and/or protective measures	Verification	Relevant reference
E[a]	**Hazards generated by power failure and restoration**			
E1	Failure of electrical power supply	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 — clamping systems, — electrode or workpiece changer, — dielectric fluid container, — position of axis, and — fire detection system shall be maintained by either mechanical retaining devices (e.g. spring-loaded locking devices) or uninterrupted power supply.	By testing and analysis of documentation	IEC 60204-1:2016, 7.5
E2	Pressure failure	If safety-related functions are relying on hydraulic or pneumatic systems, the EDM equipment shall stop in case of pressure loss or fluctuation (e.g. over pressure). During the time of pressure failure, the equipment shall remain stopped. The integrity of safety features of devices such as — clamping systems, — electrode or workpiece changer, — dielectric fluid container, — position of axis, and — fire detection system 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 or redundant pressure supply).	By testing and analysis of documentation	ISO 4413:2010 ISO 4414:2010
E3	Failure due to recovery of the power supply	To prevent dangerous situations for the operator and the equipment or process such as — position loss and — data loss due to failure of the power supply, the integrity of the safety-related functions shall be monitored and confirmed before automatic restart is allowed.	By testing and analysis of documentation	IEC 60204-1:2016, 7.5
F[a]	**Hazards generated by neglecting ergonomic principles**			
F1	Neglect of ergonomic principles	EDM equipment and EDM systems shall be designed according to ergonomic principles to prevent significant ergonomic hazards.	By visual inspection and analysis of documentation	EN 614-1:2006+A1:2009 EN 614-2:2000+A1:2008
F2	Design, location or identification of control devices	Control devices shall be positioned to ensure visibility of the dangerous zone an identified clearly	By visual inspection and analysis of documentation	ISO 9355-1:1999 ISO 9355-3:2006

[a] See Table 1.

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 61310-1:2007 and IEC 61310-2:2007.

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 "electrical 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) for its safe use:

- the machine shall be provided with appropriate marking to indicate residual risks;
- where flammable dielectric fluid is used on the EDM equipment and EDM system, this shall be indicated with warning/information symbols (according to Table 3);
- 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.

NOTE 1 ISO 7010:2019/Amd.2:2020 is used as base reference for markings to indicate residual risks.

NOTE 2 The mandatory marking for Europe is the CE marking.

6.3 Instruction handbook

6.3.1 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.

If the machine provides the service mode (MO service) in accordance with 5.3.2.4, the manufacturer of the machine shall specify the following information in the instruction handbook:

- the details of the application(s) of MO service;

— the required skills and the skill level for the operator(s) to operate MO service; and

— tools and work holding devices (if applicable) to be removed.

6.3.2 Special recommendations for EDM site preparation

6.3.2.1 General

An instruction handbook in accordance with ISO 12100:2010, 6.4.5 completed with the specific information for the stated machine, shall be provided with the machine.

The instructions for use shall provide all necessary information regarding transport, assembly/disassembly, operation, setting, maintenance, cleaning, etc., to train or qualify the staff sufficiently in intended and safe use of the machine.

The instruction handbook shall specify that it is essential that operators be adequately trained in the safe use, adjustment and operation of the machine. At least the following information shall be given:

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 requirements, waste disposal and special EMC site requirements;

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);

— a declaration shall be made concerning the airborne noise emission, using the dual-number form of presentation described in ISO 4871:1996;

— 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 exhaust air extraction system (as a schematic example, see Figure A.3);

   5) instructions for troubleshooting 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, troubleshooting 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 electrical discharge 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 a 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 appropriate method for lifting or moving);

12) instructions to regularly check the correct function of the customers' exhaust air extraction 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 in order for users to prevent the spreading of fire by distribution of fluid;

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 account of:

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 sensor 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 (e.g. bacterial) hazards.

6.3.2.7 Electro-magnetic emissions (EMC)

The information shall state that:

a) metal connections of external devices, such as filter systems or 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;

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

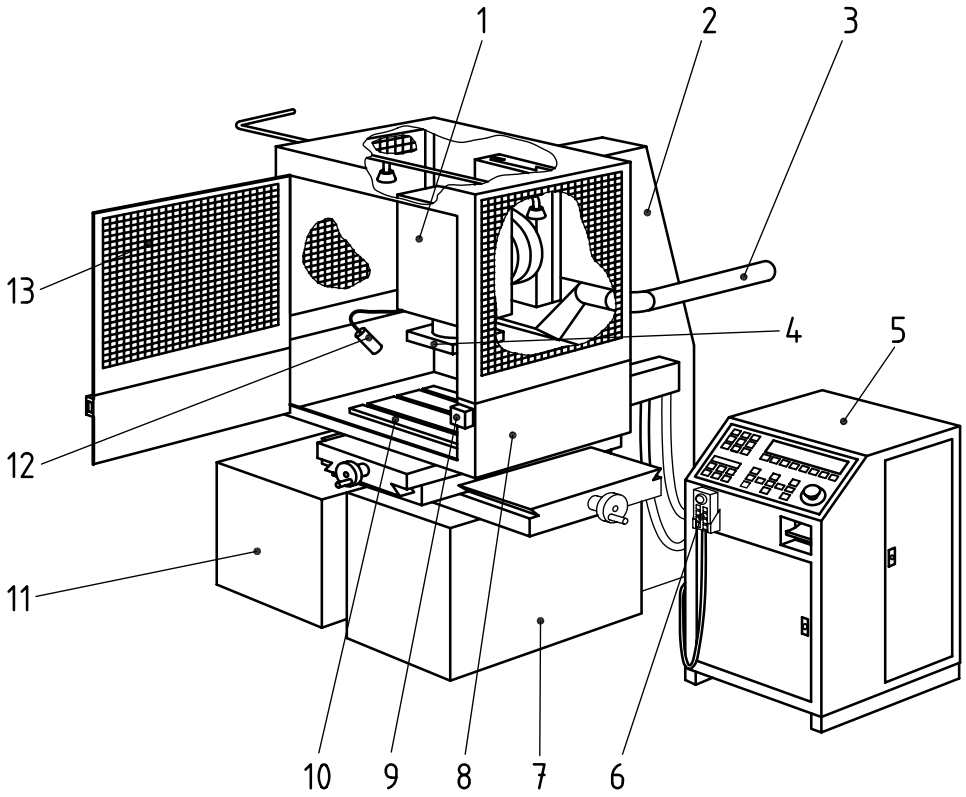
The operating conditions of the machinery during measurement and the measuring methods used shall be described.

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

A noise emission declaration shall be provided (see Annex B).

Annex A
(informative)

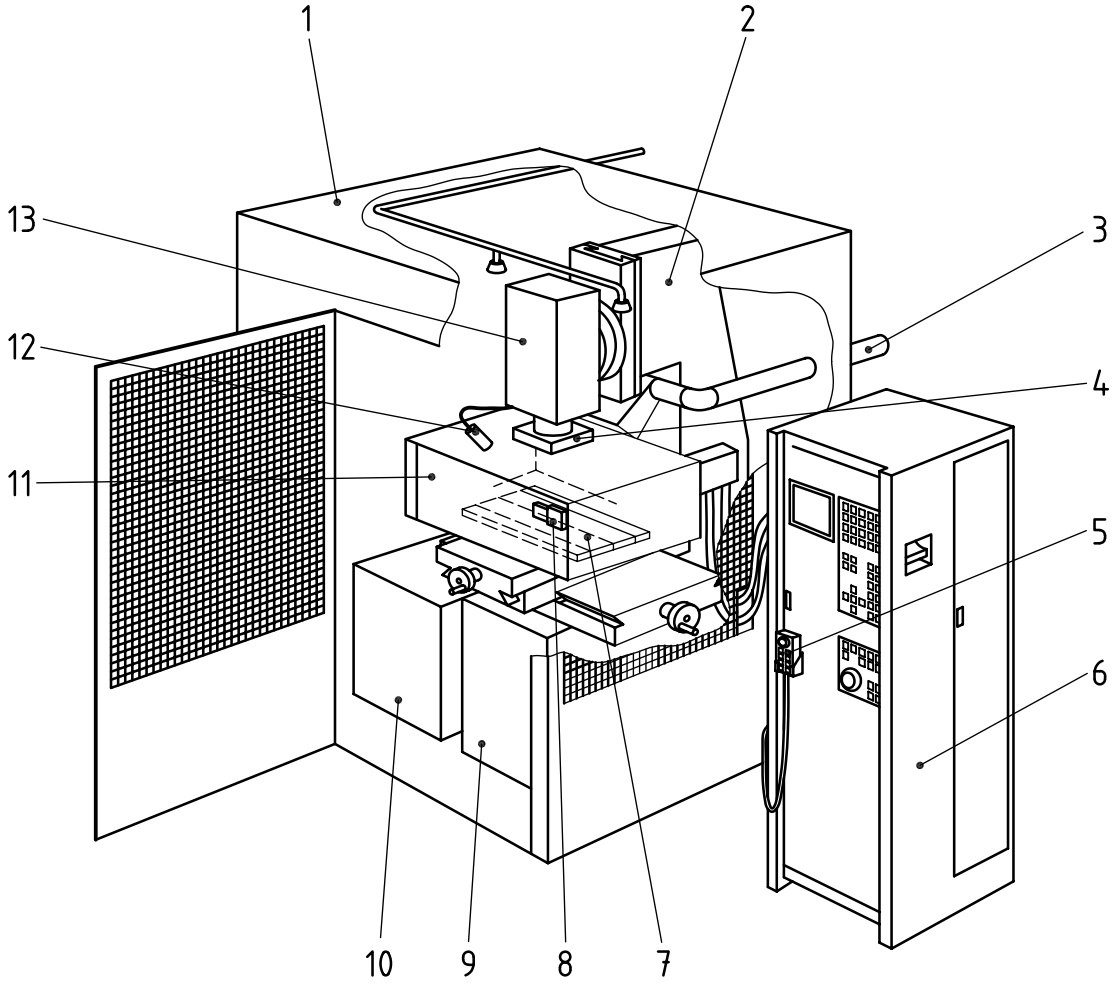
Examples and schematic diagrams



Key

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

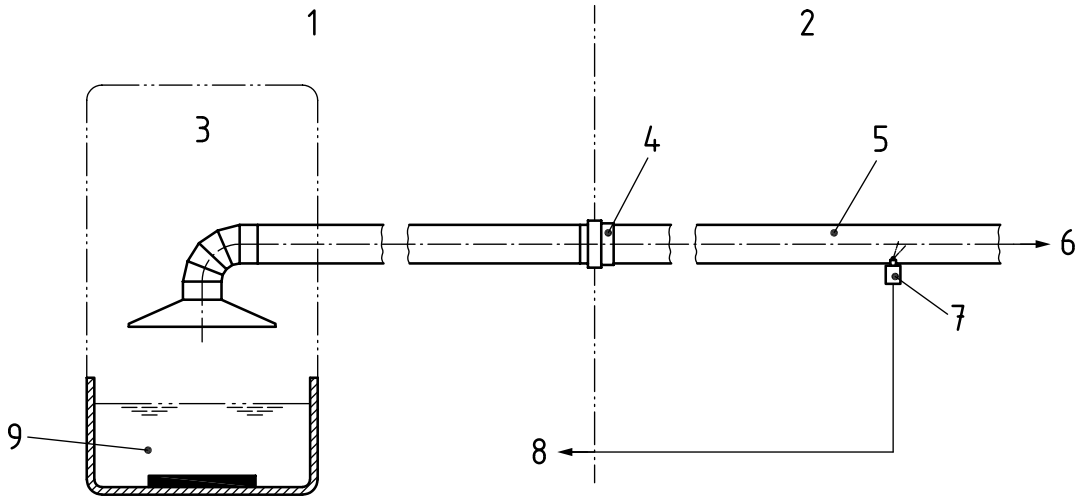
Figure A.1 — EMC shielding, fire detection and exhaust air extraction — Schematic example of work area shielding



Key

1 EMC enclosure
2 machine column
3 exhaust air extraction
4 electrode holder
5 portable control station
6 electrical cabinet (generator)
7 work table
8 interlocking device
9 machine frame
10 flammable dielectric fluid container
11 work tank
12 fire detector
13 machining head

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



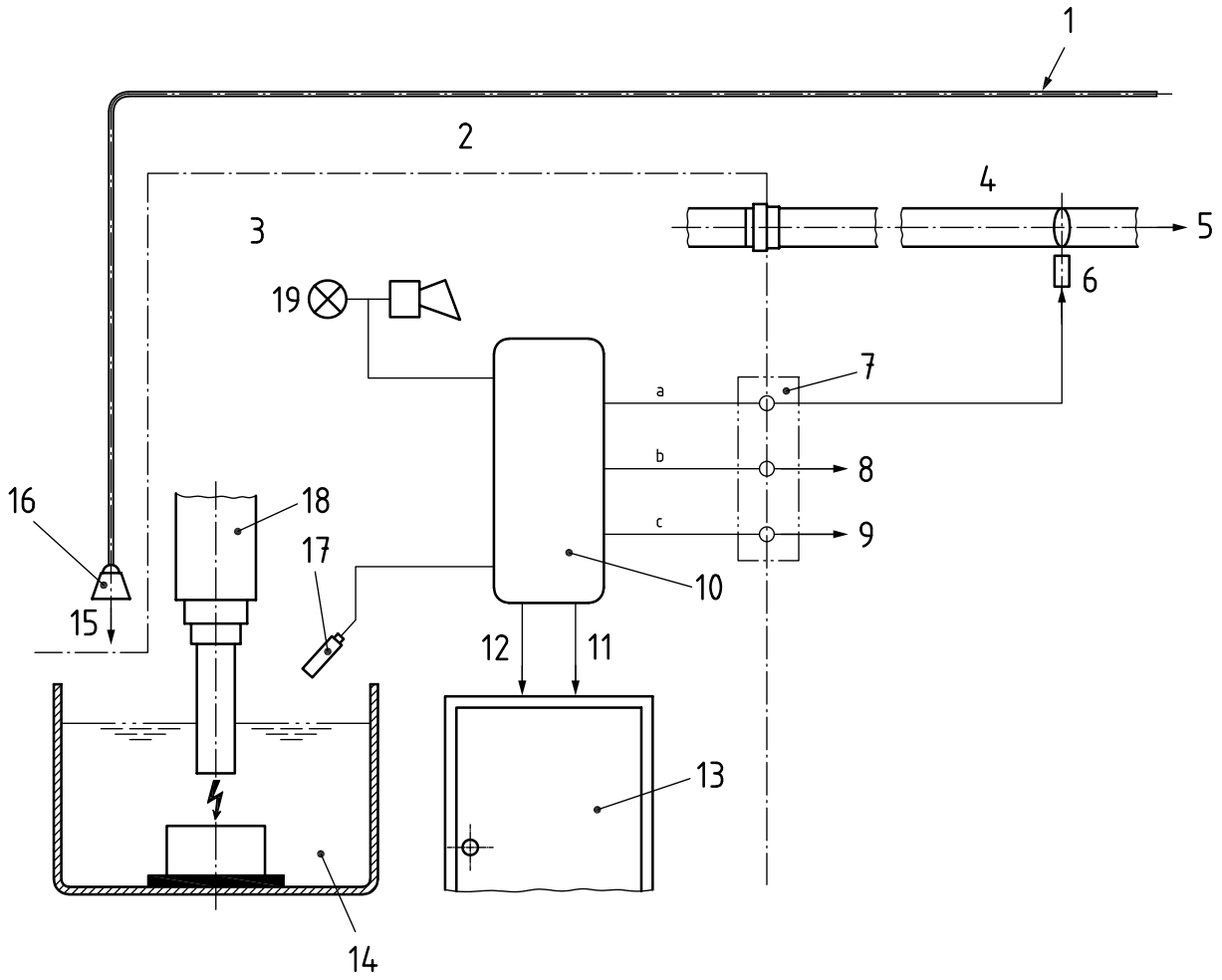
Key

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

Information for user:

— minimum and maximum air flow [m^3/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		

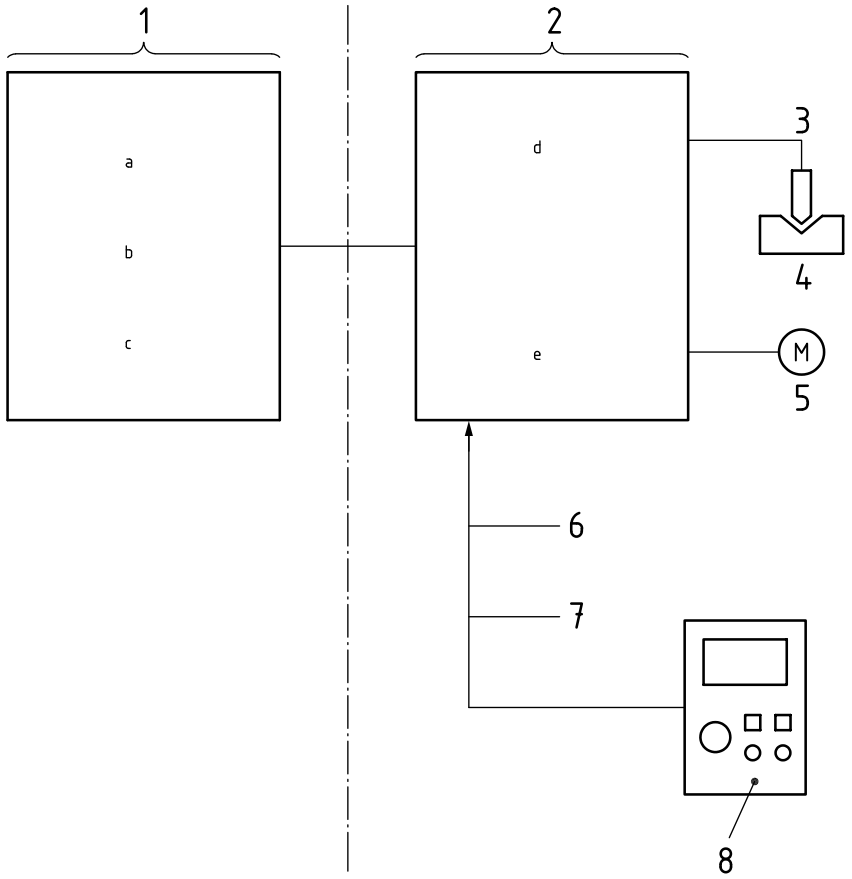
—·—·— borderline between responsibility area of the user (2) and responsibility area of the manufacturer (3)

[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.

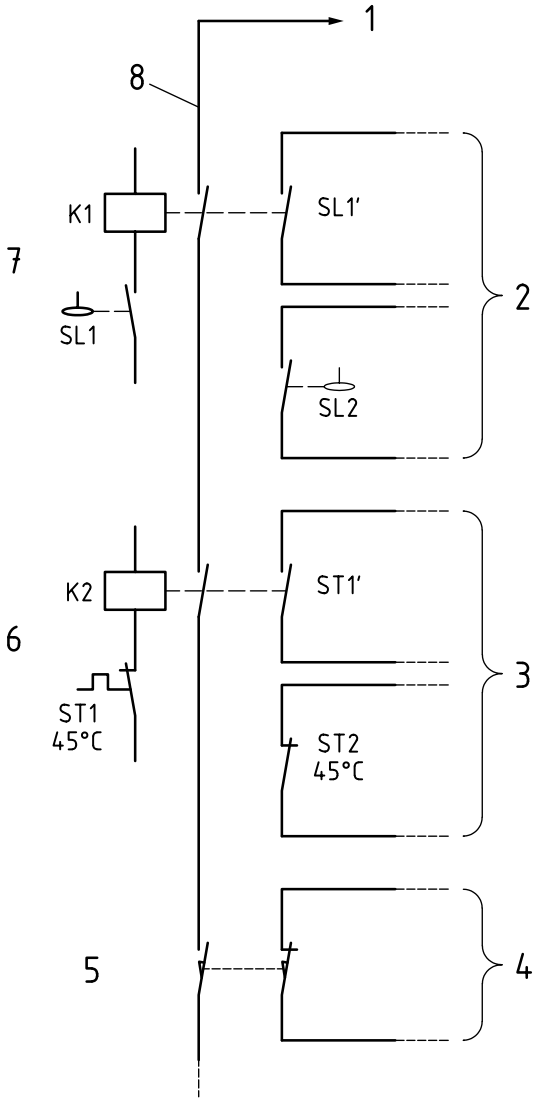
[c] Fire detection.

[d] Electrical machining power.

[e] Motion.

Opening of a guard or failure in dielectric fluid level or temperature monitoring devices shall stop motion and electrical 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.

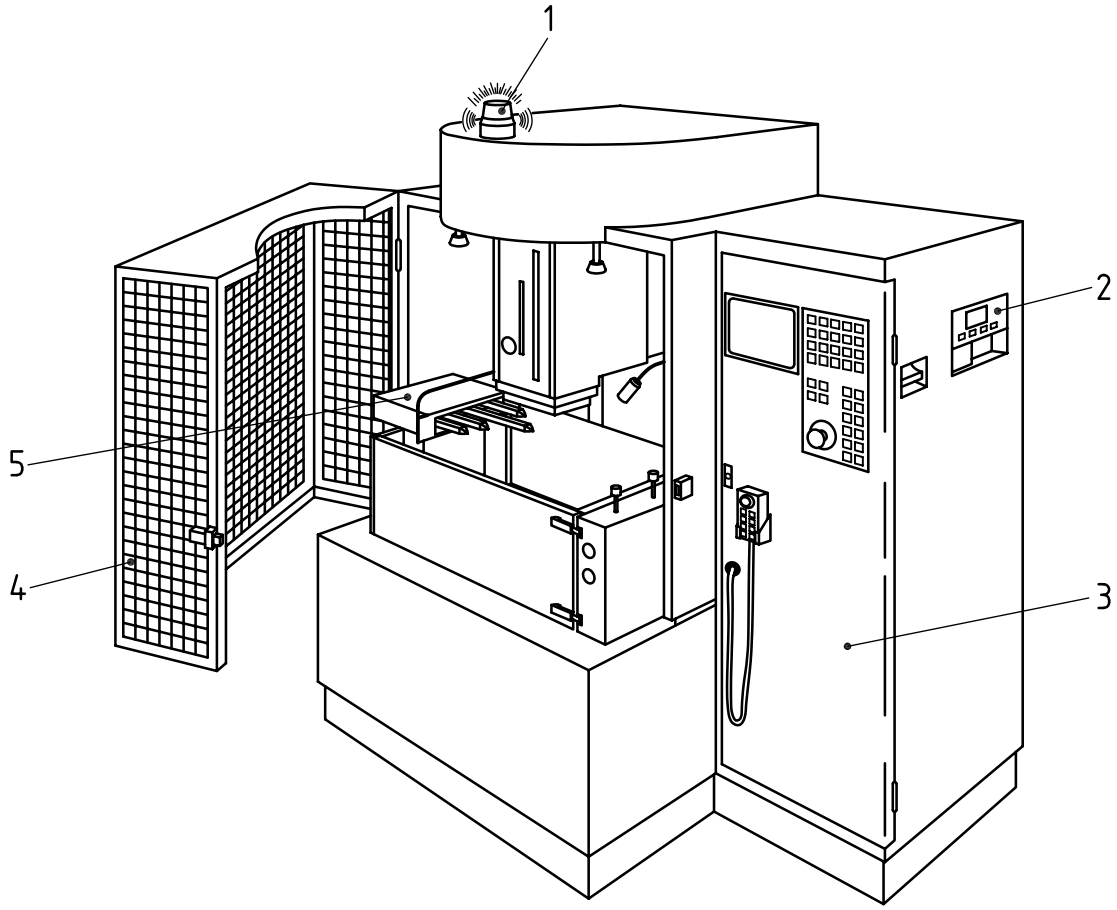
NOTE 2 Relays K1 and K2 are with forcibly guided contacts (IEC 60947-5-1:2016, Annex L).

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 electrical machining power (ISO 13849-2:2012).

NOTE 4 Contacts SL1′/SL2 as well as ST1′/ST2 are monitored for fault detection, according to ISO 13849-2:2012, 9.2.4.

NOTE 5 See Table C.1 for other threshold limit values of dielectric fluid temperature and level.

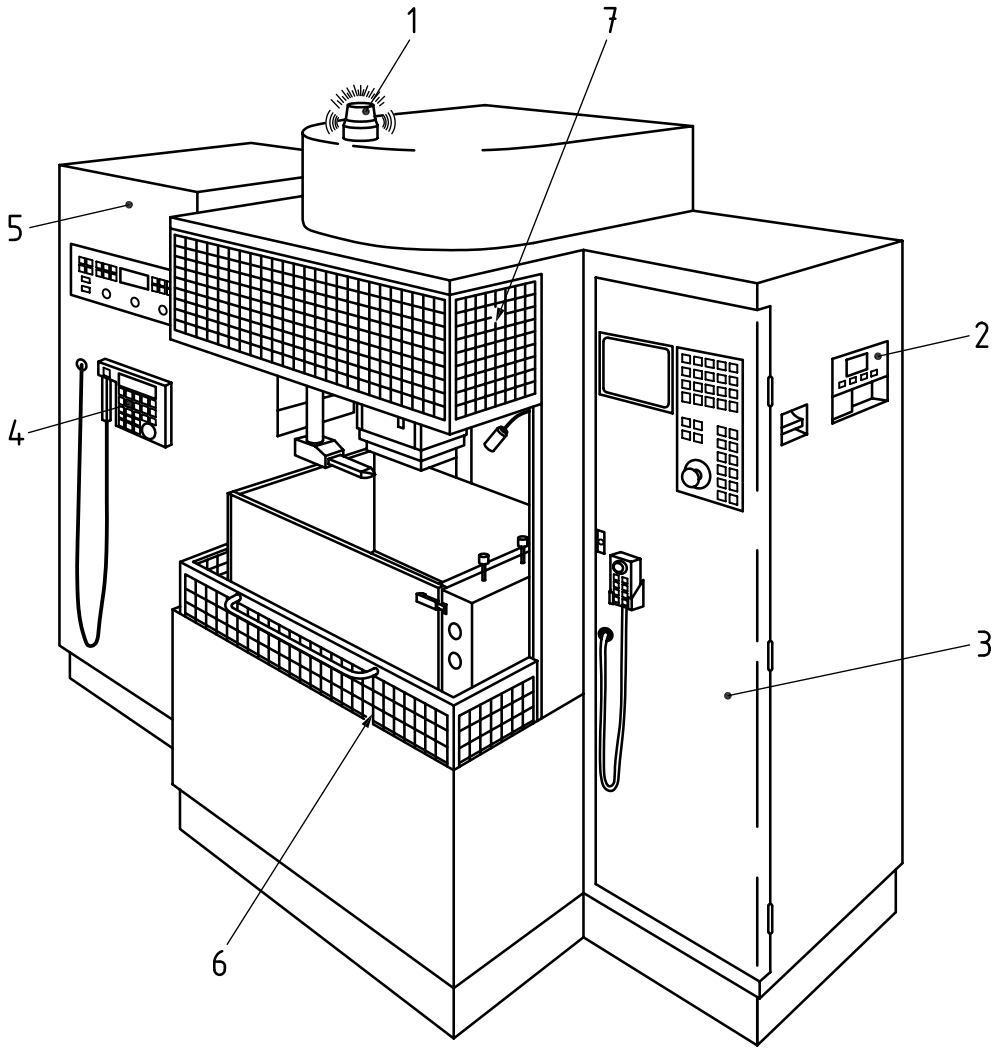
Figure A.6 — Example of redundancy in monitoring level and temperature of flammable dielectric fluid



Key

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

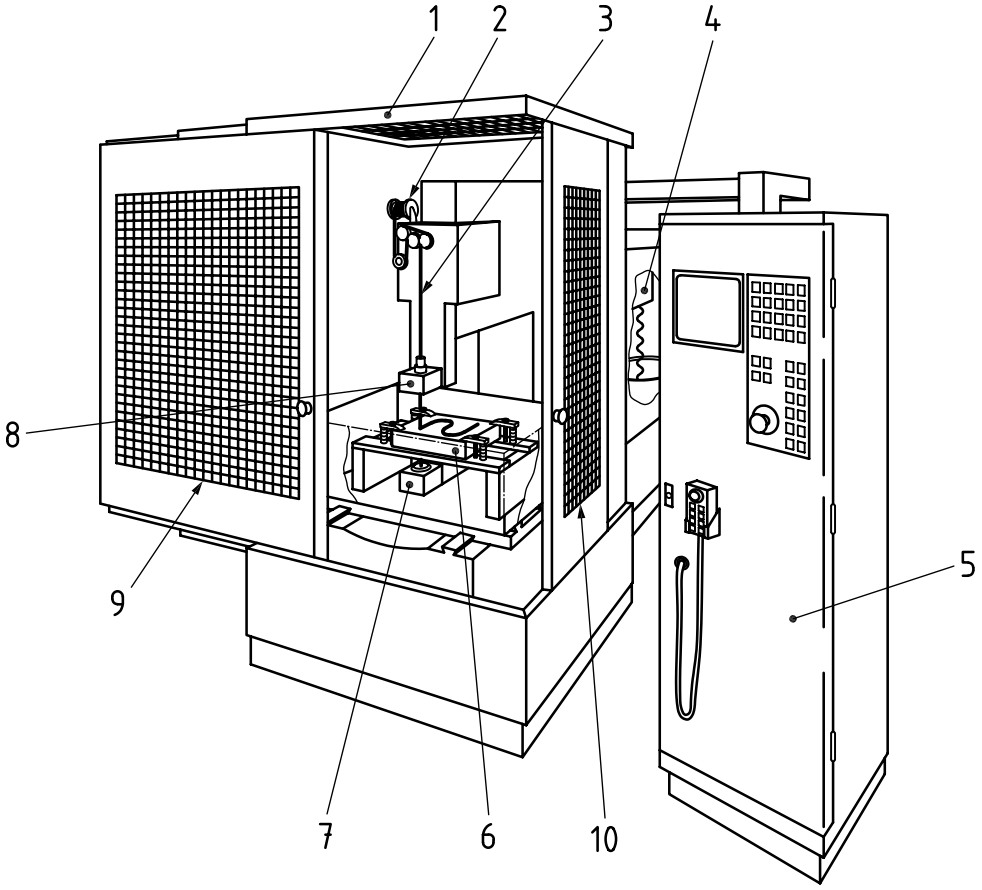
Figure A.7 — Die sinking machine with linear electrode changer



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 test code

B.1 General

This noise test code specifies all the information necessary to carry out efficiently and under standardized conditions the determination, declaration and verification of the noise emission values of electrical discharge machine.

The determination of these values is necessary for:

— manufactures to declare the noise emitted;

— comparing the noise emitted by machines in the family concerned;

— purpose of noise control at source at the design stage.

It specifies the noise measurement methods, mounting and operating conditions (see B.4 and B.5) for the test.

The use of this test code ensured the reproducibility of the measurements and the comparability of the noise emission values within specified limits determined by the grade of accuracy of the basic measurement methods used.

The noise measurement, grade 2 (engineering grade) is preferred with the benefit of having a lower uncertainty, but grade 3 (survey grade) is allowed if it is justified that no grade 2 method is applicable.

B.2 Determination of the A-weighted sound power level

A-weighted emission sound power level for electrical discharge machine family is below 80 dB therefore this measurement is not required

B.3 Determination of the A-weighted emission sound pressure level at workstation

B.3.1 Basic standards and measurement procedure

The determination of the A-weighted emission sound pressure level shall be carried out using one of the standards:

— for grade 2 measurement;

  — ISO 11201:2010 with grade 2 accuracy; or

  — ISO 11202:2010 with grade 2 accuracy; and

— for grade 3 measurement;

  — ISO 11202:2010 with grade 3 accuracy.

NOTE Useful information about the various methods for measuring the A-weighted emission sound pressure level at workstations can be found in ISO 11200:2014.

B.3.2 Measurement time interval

The measurement time interval at each microphone position shall be at least 10 s.

B.3.3 Position of microphones at workstation

The determination of the A-weighted emission sound pressure level shall be carried out at all designated operator's positions defined by the manufacturer in the instruction handbook following the specifications in the basic standards listed in B.3.1.

Where the workstations are undefined or cannot be defined, A-weighted emission sound pressure levels shall be determined at height of 1,55 ± 0,075 m at the following positions:

— in front of the main control panel; and

— in front of the work tank, at a horizontal distance of 1 m from the external boundary of the work tank.

The position and value of the maximum A-weighted emission sound pressure shall be recorded, reported and declared.

B.3.4 Measurement uncertainty

In the current absence of data for uncertainty contributions and possible correlations between input quantities, the following values shall be used:

a) If a grade 2 (engineering) method is used, the standard deviation of reproducibility for A-weighted levels is 1,5 dB, resulting in a measurement uncertainty, *K*, of 2,5 dB if the operating conditions of the machine are stable, which is normally the case for Electrical Discharge Machine.

b) If a grade 3 (survey) method is used, the standard deviation of reproducibility for A-weighted levels is 2,5 dB, resulting in a measurement uncertainty, *K*, of 4 dB if the operating conditions of the machine are stable, which is normally the case for Electrical Discharge Machine.

These values are taken from the basic standards and are upper values. Manufactures may aim at high stability of the machine mounting and operating condition given in B.4 and B.5 in order to achieve a total standard deviation that is close to the standard deviation of reproducibility.

NOTE Detailed information about uncertainty is given in ISO 11201:2010, Clause 11 and ISO 11202:2010, Clause 12 (see also ISO 4871:1996).

B.4 Mounting conditions

The machine shall be mounted according to the manufacturer's instructions.

B.5 Operating conditions

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 if present, e.g. electrode changer and workpiece changer.

B.6 Information to be recorded

The information to be recorded includes the information to be recorded as specified in the basic standards used and all of the technical requirements of this noise test code. Any deviation from this noise test code or from the basic standards on which it is based are to be recorded together with the technical justification for such deviations.

B.7 Information to be recorded

The information to be included in the test report is at least that which is required to prepare a noise emission declaration or to verify the declared values. Thus, as a minimum the following information shall be included:

— reference to this noise test code and to the basic standards used;

— description of the electrical discharge machine;

— description of the mounting and operating conditions;

— the noise emission values obtained.

It shall be confirmed that all requirements of the noise test code have been fulfilled. If this is not the case, any unfulfilled requirements shall be identified. Deviations from the requirements shall be stated and technical justification for the deviations shall be given.

B.8 Declaration and verification of noise emission values

B.8.1 General and content

The declaration of the noise emission value shall be a dual number declaration according to ISO 4871:1996.

The instruction handbook shall include a declaration regarding noise emissions, established on the basis of measurements in accordance with this noise test code and made either on the actual machine in question or on a technically comparable machines, which is representative of the machine to be produced with regards to the noise sources and the applied means for noise reduction.

The declaration shall contain the following.

1) the A-weighted emission sound pressure level, L_{pA}, at all workstations and the associated uncertainty, K_{pA}. Where the workstations are undefined or cannot be defined the position and value of the maximum A-weighted emission sound pressure level shall be indicated;

2) a statement of the measuring method used, including the grade of accuracy and the operating conditions applied during the test; if accuracy grade 3 is used, the reason why grade 2 was not applicable;

   NOTE Possible reasons for not applying grade 2 can be, for example, background noise was present and could not be reduced sufficiently (at operator positions for emission sound pressure), or safety reason preventing the microphone position to be used.

3) the following statement: "If the declared emission values are to be verified, measurements shall be made using the same method and the same operating and mounting conditions as those declared.";

4) the following warning: "WARNING: The noise emission values given are only valid if the same operating and mounting conditions are applied. Other operating and mounting conditions, e.g. a different work process, can lead to higher noise emission with the risk of underestimation.";

5) the following warning: "WARNING: The noise emission values given are not exposure levels. While there is a correlation between emission and exposure levels, noise emission values cannot be used

to reliably determine whether or not further precautions are required. Factors that influence the actual level of exposure include the actual work process, characteristics of the work room and other adjacent sources of noise operation.".

The noise declaration shall clearly indicate deviations from this noise test code, if any.

If undertaken, the verification of declared values of noise emission shall be carried out according to ISO 4871:1996, 6.2, by using the same mounting and operating conditions as those used for the initial determination of noise emission values.

The same information on noise emission as that given in the instructions shall be given in the sales literature providing performance data too.

B.8.2 Example of noise emission declaration

Table B.1 shows an example of the noise emission for Electrical Discharge Machine.

Information and noise emission values that are relevant to the machine in question and to the operating conditions and measurements methods used shall be inserted in the grey areas. Italics indicate option to be chosen and/or filled in. Instructions in brackets shall be followed and deleted before issuing the declaration.

Table B.1 — Example of the noise emission declaration

(Designation of the machine type tested)			
Declared dual-number noise emission values in accordance with ISO 4871:1996	**Idle**	**Preparation**	**Erosion**
A-weighted emission sound pressure level, L_{pA}, in dB at operator position A	Xx	Xx	Xx
A-weighted emission sound pressure level, L_{pA}, in dB at operator position B *(if there is more than 1 operator position)*	xx	xx	xx
Uncertainty, *KpA* in dB *(2, 5if grade 2 is used, 4 if grade 3 is used)*	2,5 / 4	2,5 / 5	2,5 / 4
Measurement made in accordance with ISO 28881:2022, Annex B, using: — for emission sound pressure: *ISO 1120_:2010 with accuracy grade _. (write which standard was used, see B.3.1)* (if relevant, insert this Note) *NOTE Measurements of the emission sound pressure level with accuracy grade 2 was not possible because* _____			
Operating condition during measurements: *(add information on set-up, tools, workpieces and operation of the machine during measurement)*			
If the declared emission values are to be verified, measurements shall be made using the same method and the same operating and mounting conditions as those declared.			
WARNING: The noise emission values given are only valid if the same operating and mounting conditions are applied. Other operating and mounting conditions, e.g. a different work process, can lead to higher noise emission with the risk of underestimation.			
WARNING: The noise emission values given are not exposure levels. While there is a correlation between emission and exposure levels, noise emission values cannot be used to reliably determine whether or not further precautions are required. Factors that influence the actual level of exposure include the actual work process, characteristics of the work room and other adjacent sources of noise operation.			

Annex C
(informative)

Fire protection codes for special regional cases

C.1 Fire protection codes

C.1.1 General

This annex describes the provisions in MAS 810:2017, which are currently valid in Japan, as an example of the fire protection codes for special regional cases.

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

Refer to the Fire Service Act in cases in which the quantity of dielectric fluid exceeds specified limits. The Act stipulates regulations for storage environments and other aspects.

NOTE These standards provide relevant clauses of the template ordinance for provisions concerning the structure or the operation of EDM. Fire prevention ordinances established by prefectures, municipalities, and public institutions can stipulate more detailed regulations.

C.2 Structural standard

C.2.1 Dielectric fluid and dielectric fluid container

The dielectric fluid and dielectric fluid container should comply with the following requirements and or measures.

a) dielectric fluid having a flash point of more than or equal to 70 °C should be used. The dielectric fluid temperature should not exceed 60 °C (see Table C.1).

b) dielectric fluid container should comply with the following requirements:

   1) the dielectric fluid container should be made of steel having a thickness of more than or equal to 3,2 mm (2,3 mm or greater when the dielectric fluid container capacity is below 400 l) or material having equivalent or superior mechanical properties. This should not apply to dielectric fluid containers which are integrated into EDM equipment in order to store dielectric fluid sufficient to circulate in the work tank, and is made of grey cast iron of mechanical properties equivalent or superior to FC300 (see JIS G 5501:1995);

   2) dielectric fluid containers should neither leak nor deform during a water-filling test (see C.4);

   3) the surface should be treated with a rustproof treatment unless the container is made of stainless steel or other corrosion resistant material;

4) dielectric fluid containers should have a structure to prevent falls in the event of an earthquake and so on.

c) The dielectric fluid piping should comply with the following requirements:

1) the pipes should have sufficient strength for the given installation conditions and operating environment. The pipes should withstand water-pressure test (including tests using non-flammable dielectric fluid or non-flammable gas) at pressures equal to or greater than 1,5 times the maximum working pressure;

2) the pipes should not be easily degraded by dielectric fluid;

3) the pipes should not be easily deformed when exposed to heat in the event of fire unless the pipes are installed in areas where they will not be subject to the effects of heat in the event of fire;

4) the outer surfaces of the pipes should be treated with a rustproof treatment unless the pipes will not rust under the installation conditions.

d) The work tank should by with following requirements:

1) work tanks should be made of a non-flammable, oil resistance, and crack resistance material;

2) dielectric fluid level should be adjustable to prevent overflows;

3) Significantly uneven temperature distribution in the work tank should be considered, for example, the dielectric fluid circulation;

4) Door(s) of the work tank should prevent unintended opening;

5) if hazardous gases can be retained inside the work tank, the work tank should incorporate measures to prevent concentration of hazardous gases (e.g. natural ventilation through venting openings or forced ventilation);

6) the work tank should have a structure to prevent dielectric fluid levels from exceeding the maximum dielectric fluid level.

e) EDM equipment should be equipped with a structure to reduce or function to control increases in dielectric fluid temperature in accordance with the maximum power used for machining processes.

C.2.2 Equipment for each safety measures

The following equipment should be provided:

a) dielectric fluid temperature detecting equipment: This equipment should be capable of automatically and immediately stopping machining whenever dielectric fluid temperatures in areas other than the discharge area of the work tank exceed the maximum allowable dielectric fluid temperature. The temperature should be detected at the appropriate point of the work tank. The maximum allowable dielectric fluid temperature should be equal to or less than 60 °C.

b) dielectric fluid level detecting equipment: This equipment be capable of automatically and immediately stopping machining whenever dielectric fluid level drops below a pre-set level (including sloshing by e.g. an earthquake) to keep an appropriate distance between the discharge area and dielectric fluid surface. The dielectric fluid pumps should also be stopped. This function should not override.

c) detecting equipment for abnormal machining: This equipment should be capable of automatically and immediately stopping machining when the equipment detects the abnormal machining due to the carbon material build up between the tool electrode and a workpiece or other factors.

C.2.3 Automatic fire extinguisher

An automatic fire extinguisher should be capable of automatically detecting fire immediately upon the ignition of dielectric fluid, automatically spraying of fire extinguishing agent (e.g. powder, aqueous film-forming foam) over the entire work tank, extinguishing the fire, and sounding an audible alarm. If an automatic fire extinguisher is activated then all power supplies — for instance (e.g. electric, pneumatic, hydraulic) should be interrupted and a signal to close the exhaust system should be generated.

The detecting system and fire extinguishing agent should be the following requirements:

a) detecting system: It should sense temperature or flame. If it is a system for detecting temperature, it should start at a work temperature of less than or equal to 75 °C;

b) fire extinguishing agent: Fire extinguishing agent should have enough ability and speed for oil fire, and should prevent re-ignition of the fire;

c) the main part of automatic fire extinguisher should be made of non-flammable or flame-retardant materials resistant to fire extinguishing agent and also be corrosion-resistant;

d) stored amount of the fire-extinguishing agent should be enough for the shape of the EDM equipment work tank and the area of the exposed oil surface.

Table C.1 — Threshold limit values

Threshold limit value for environmental temperature ≤35 °C	**This document**	**Japan** **MAS 810:2017**	**China** **GB 13567:1998**
Flash point of the dielectric fluid	≥60 °C	≥70 °C	≥70 °C
Dielectric fluid temperature detecting level	≤50 °C	≤60 °C	≤60 °C
Dielectric fluid level detecting level	≥40 mm	≥50 mm	≥50 mm
Fire extinguisher detecting temperature	—	≤75 °C	Required in 5.6.3 GB

C.2.4 Markings, signs, written warnings and instruction handbook

a) Markings for operating instructions for safety

Markings showing the following instructions for safety during operation should be attached to the EDM equipment:

1) type of dielectric fluid, volume (e.g. dielectric fluid level), and precautions regarding dielectric fluid leaks;

2) instructions to use dielectric fluid with a flash point of more than or equal 70 °C;

3) instructions to set the maximum allowable dielectric fluid temperature of less than or equal to 60 °C:

4) warning prohibiting use of fire;

5) other relevant information;

In addition, marking showing the following instructions should be attached to an appropriate location on the automatic fire extinguisher;

i) type and volume (l) or weight (kg) of fire extinguishing agent;

ii) maximum protective coverage (m^2);

iii) discharge time;

iv) detector type and its working temperature;

v) Number and locations of detectors and nozzles;

vi) Year and month of construction;

vii) serial number;

viii) model number;

ix) other relevant information;

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 Operating standard

C.3.1 Type and level of dielectric fluid

a) dielectric 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. The level of fluid should be as high as possible, and at least 50 mm above the upper surface of the workpiece. In the case where the processing current value is large, dielectric level should be kept higher (e.g. 100 mm or more).

C.3.2 Equipment for safety measure and their operation

Where using EDM equipment, equipment described in C.2, such as dielectric fluid temperature detecting equipment, fluid level detecting equipment, detecting 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) dielectric fluid temperature detecting equipment: this equipment should be capable of automatically and immediately stopping machining whenever dielectric fluid temperatures in areas other than the discharge area of the work tank exceed the maximum allowable dielectric fluid temperature. The temperature should be detected at the appropriate point of the work tank. The maximum allowable dielectric fluid temperature should be equal to or less than 60 °C.

b) dielectric fluid level detecting equipment: this equipment allows the setting of optimum fluid levels based on the workpiece. The equipment automatically and immediately switches off the discharge power if fluid levels fall below the level set to maintain a minimum safe distance between the discharge area and the dielectric fluid surface (including the effects of potential sloshing in the event of an earthquake). The level of dielectric fluids should be higher than 50 mm above the upper surface of the workpiece.

c) detecting equipment for abnormal machining: this equipment automatically and immediately stops machining if the equipment detects the abnormal machining due to carbon material build-up between the tool electrode and a workpiece or other factors.

d) Automatic fire extinguisher: this equipment should be capable of automatically detecting fire immediately upon the ignition of dielectric fluid, automatically spraying of fire extinguishing agent over the entire work tank, extinguishing the fire, and activating an alarm. The position, direction,

and/or other conditions of the spray nozzle should remain at the position and in the orientation prescribed.

C.3.3 Maintenance and inspection

a) For inspection (daily inspection), Check the following items before the start of the job:

   1) Noise, vibration, pressure, etc. of dielectric fluid container;

   2) Volume, level, temperature and leakage of dielectric fluid;

   3) conditions of fixing of electrode and workpiece;

   4) confirmation of function of each piece of safety equipment;

   5) clogging of dielectric fluid filter.

b) for periodic inspection:

   1) the function of dielectric fluid temperature detecting equipment should be confirmed more than once every six months at the designated temperature (60 °C or less), and;

   2) inspect the automatic fire extinguisher periodically as follows. in particular, ensure adequate periodic maintenance:

      i) more than once every six months for a check of the appearance (e.g. damage of splashing nozzle, piping, detector and wiring);

      ii) at least once a year for functional check (excluding automatic spraying of fire extinguishing agent);

      iii) at least once every five years for detailed check (including replacement of fire extinguishing agent).

   If there are the extinguisher manufacturer's instructions (such as inspection time, replacement time, inspection cycle, fire extinguishing agent and parts requiring inspection / replacement, product life, etc.), it should be respected.

   3) clean and remove flammable deposits in the EDM equipment, exhaust air extraction, and near the machine to prevent the fire spreading.

C.3.4 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;

c) Fire extinguisher(s) on EDM equipment using flammable dielectric fluid should be set to automatic fire detection and extinguishing operation;

d) if an exhaust air extraction system is installed, the areas where gas flows should be made of non-flammable materials to prevent fire spread.

C.3.5 Special attention to be paid during machining

a) Warning prohibiting non-submerged machining: Non-submerged machining is not allowed because EDM machining with dielectric fluid ejecting to the workpiece can provoke fire ignition (see Figure C.1);

b) Machining near dielectric fluid surface: Particular attention should be paid to the manner of fixing and positioning of the fixture so as not to discharge near the dielectric fluid surface; dielectric fluid level should be kept more than 50 mm higher than the upper level of the workpiece (see Figures C.2, C.3 and C.8);

c) Monitoring automatic machining: It should be arranged to have personnel who can implement appropriate actions to prevent fire hazards present for safety reasons during automatic machining regardless of the kind of safety equipment available;

d) The following are examples of actual fire hazards relevant to EDM equipment using flammable dielectric fluid, and care should be taken not to process under such conditions:

   1) processing by spraying the processing liquid without dipping the workpiece (see Figure C.1);

   2) machining of the workpiece with inappropriate height compared with the depth of the work tank. The level of the dielectric fluid should be higher than 50 mm above the upper surface of the workpiece (see Figure C.2);

   3) machining without enough depth of dielectric fluid in spite of sufficient volume of the work tank (see Figure C.3);

   4) discharge between electrode and workpiece fixture; discharge at unexpected area and near the surface of the dielectric fluid (see Figure C.4);

   5) discharge between power cables with broken electric shield and workpiece fixture (see Figure C.5);

   6) discharge between electrode and fixture where electrode falls off its fixture (see Figure C.6);

   7) discharge at dielectric fluid surface where there is growth of carbide because of abnormal discharge (see Figure C.7);

   8) unintended lowering of dielectric fluid level (see Figure C.8);

   9) discharge between the electrode and flushing nozzle (see Figure C.9).

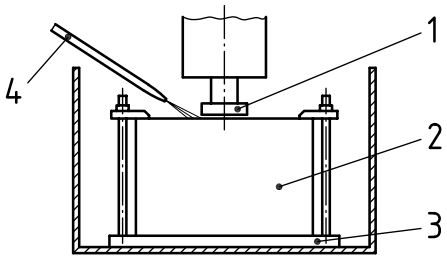
C.3.6 Examples of the risk of fire ignition in EDM process

NOTE Figures C.1 to C.9 show possible hazardous situations. It is expected that special attention be paid to prevent fire ignition.

C.3.6.1 Danger zone No. 1

Discharge area: Nearby electrode, lateral flushing nozzle and work table.

Hazard risk: ignition where machining with ejection of dielectric fluid, without the workpiece being submerged.



Key

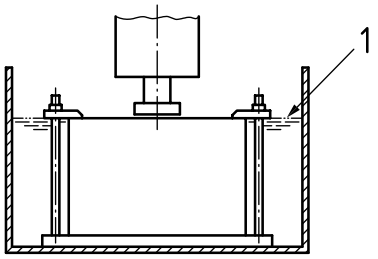
1 electrode
2 workpiece not submerged
3 work table
4 flushing nozzle

Figure C.1 — Danger zone No. 1

C.3.6.2 Danger zone No. 2

Discharge area: Nearby dielectric fluid level.

Hazard risk: machining of the workpiece with inappropriate height compared with the depth of the work tank. The level of dielectric fluid should be higher than 50 mm over the upper surface of the workpiece.



Key

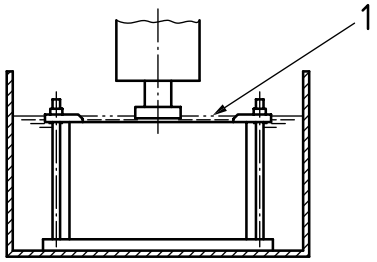
1 dielectric fluid not covering the workpiece

Figure C.2 — Danger zone No. 2

C.3.6.3 Danger zone No. 3

Discharge area: Nearby dielectric fluid level.

Hazard risk: machining without enough depth of dielectric fluid despite sufficient volume of the work tank.



Key

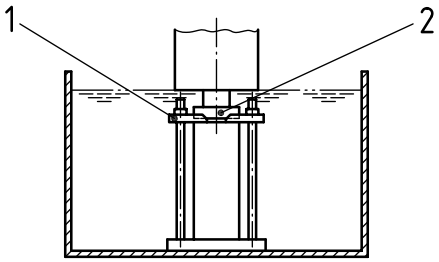
1 insufficient dielectric fluid level

Figure C.3 — Danger zone No. 3

C.3.6.4 Danger zone No. 4

Discharge area: Workpiece fixture.

Hazard risk: risk of discharge between electrode and workpiece fixture. Discharge at unexpected area near the surface of the dielectric fluid.



Key

1 workpiece fixture

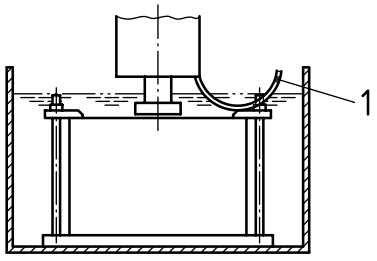
2 electrode

Figure C.4 — Danger zone No. 4

C.3.6.5 Danger zone No. 5

Discharge area: Power cable.

Hazard risk: risk of discharge between power cables with broken electric shield and workpiece fixture.



Key

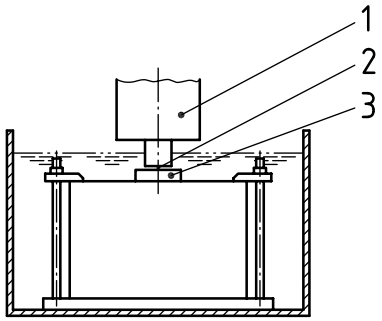
1 power cable

Figure C.5 — Danger zone No. 5

C.3.6.6 Danger zone No. 6

Discharge area: Electrode fixture on its holder.

Hazard risk: risk of power discharge between the electrode and its holder whenever the electrode falls off the fixture.



Key

1 electrode holder

2 electrode

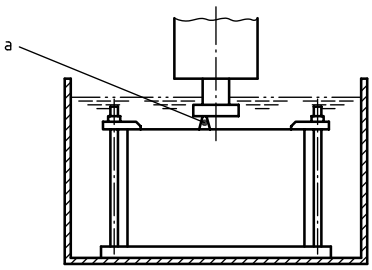
3 assembly of electrode to electrode holder deficient (risk of discharge between fixture and electrode)

Figure C.6 — Danger zone No. 6

C.3.6.7 Danger zone No. 7

Discharge area: Growth of carbide.

Hazard risk: risk of discharge at the surface of the dielectric fluid by the growth of carbide by abnormal discharge.



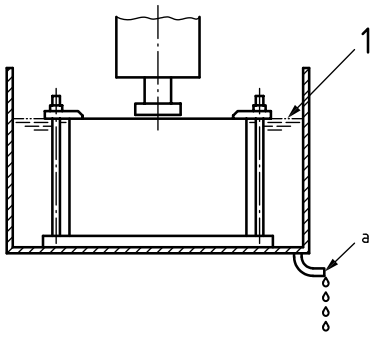
[a] Growth of carbon (risk of fire hazard at the top of the dielectric fluid).

Figure C.7 — Danger zone No. 7

C.3.6.8 Danger zone No. 8

Discharge area: Insufficient dielectric level.

Hazard risk: unintended lowering of dielectric fluid level.



Key

1 dielectric fluid drops

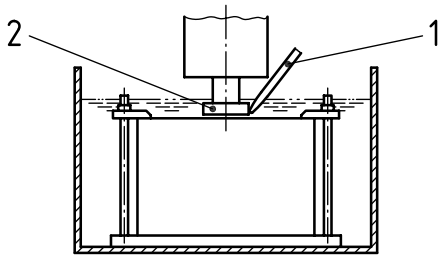
[a] Leakage of dielectric fluid can provoke unexpected lowering.

Figure C.8 — Danger zone No. 8

C.3.6.9 Danger zone No. 9

Discharge area: Electrically conducting flushing nozzles.

Hazard risk: risk of discharge between electrode and flushing nozzle.



Key

1 flushing nozzle (electrically conducting nozzle contacts the electrode)

2 electrode

Figure C.9 — Danger zone No. 9

C.4 Voluntary hydrostatic test

C.4.1 Test apparatus

The following should be the apparatus of the voluntary hydrostatic test:

a) sheet metal tank to contain the dielectric fluid for the EDM equipment and EDM system;

b) tank of capacity less than 2 000 l (a tank of more than or equal to 2 000 l can be subject to fire prevention regulations.)

C.4.2 Testing procedure

Perform a voluntary hydrostatic test as follows:

a) the test should be implemented after completing the welding of every part to the tank, and before coating and/or painting;

b) the tank should be fully filled with water, kept for 10 min, and confirmed by visual check for leakage;

c) next, the tank should be checked visually for leakage, using hammering along the welding lines.

C.4.3 Determination

The tank is judged conformant to the test if no leaks occur during the test as described in C.4.2.

C.4.4 Report of the test result and storage

The following items should be recorded and kept by the manufacturer as a result of the voluntary hydrostatic test:

a) test method (according to MAS810-2017);

b) test pressure (atmospheric pressure);

c) tank capacity (see C.4.5.3);

d) tank size (maximum internal dimension of the tank: length, width and height);

e) material and wall thickness;

f) date of test;

g) serial number;

any number which designates the tested tank can be used. The number should be the same as the one used for the test proof label of voluntary hydrostatic test, or certificate of voluntary hydrostatic test;

h) the name of the company or body actually performing the test;

i) the name of the individual performing the test.

NOTE The size and the format of the test record can be arbitrary.

C.4.5 Information to be labelled on and/or attached to the dielectric fluid container

C.4.5.1 General

The following materials should be labelled and/or attached to the tank, conforming to the voluntary hydrostatic test:

a) test proof label of voluntary hydrostatic test: attached to the tank itself;

b) certificate of voluntary hydrostatic test: to be handled as a document attached to EDM equipment;

c) calculation result of tank capacity: attached to the certificate of voluntary hydrostatic test;

d) drawing of the sheet metal tank: attached to the certificate of voluntary hydrostatic test.

C.4.5.2 Test proof label of voluntary hydrostatic test

The test proof label of voluntary hydrostatic testing shows that the tank conforms to the voluntary hydrostatic testing, and it should be attached to the tank itself:

a) the contents of the test proof label of voluntary hydrostatic testing are:

   1) test method (according to MAS 810:2017);

   2) test pressure (atmospheric pressure);

3) tank capacity (C_t);

4) date of the test;

5) serial number. Any number which designates the tested tank can be used. That number should be the same as the one used for the certificate of voluntary hydrostatic test;

6) the name of the company;

b) the material and labels should withstand oily conditions;

c) the test proof label of voluntary hydrostatic test should be attached to the tank itself. The labelling technique should withstand oily conditions.

C.4.5.3 Certificate of voluntary hydrostatic test

A certificate of voluntary hydrostatic test should be prepared for the document reported to the local fire prevention authority by the user of the EDM equipment and EDM system. It should be attached to the EDM equipment and EDM system or the dielectric fluid container.

a) Contents of certificate of voluntary hydrostatic testing:

1) test method (according by MAS810-2017);

2) test pressure (atmospheric pressure);

3) tank capacity;

4) tank size;

5) material and wall thickness;

6) date of the test;

7) serial number. Any number which designates the tested tank can be used. That number should be the same as the one used for the test proof label of voluntary hydrostatic test;

8) name of the company.

b) The size of the certificate should be A4.

C.4.5.4 Calculation result of tank capacity

The result of calculations of tank capacity should be attached to the certificate of voluntary hydrostatic test since it is the basis of tank capacity described on the test proof label (of voluntary hydrostatic test) and certificate of voluntary hydrostatic test.

a) The tank capacity, C_t, is calculated with:

1) Formula (C.1):

$$C_t = C_{tot} - C_{vac} \tag{C.1}$$

where

C_{tot} is the total capacity;

C_{vac} is the vacant capacity.

2) tank size: the maximum values of internal size (length × width × height) should be described as tank size;

3) total tank capacity ($C_{t,tot}$): the capacity when the tank is fully filled with water (100 %). It is calculated with the internal size of the tank;

4) vacant capacity, calculated with Formula (C.2):

$$C_{vac} - C_{t,tot} - C_t \quad \text{(C.2)}$$

5) vacant ratio (C_{vr}), calculated with Formula (C.3):

$$C_{vr} = \frac{C_{vac}}{C_{t,tot}} \times 100 \quad \text{(C.3)}$$

The total capacity and tank capacity should be set to induce a vacant ratio in 5 % to 10 %.

b) The size of the calculation result should be A4.

C.4.5.5 Tank diagram

An illustration or a drawing of the tank should be attached to the certificate of voluntary hydrostatic test since it is the basis of the calculation of tank capacity.

NOTE The size and format of the drawing of the tank can be arbitrary.

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