
**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 28881:2022(E)

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

ISO 28881:2022

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: <ul style="list-style-type: none"> — 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.				