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## Safety of thermal cutting machines

*Sécurité des machines de coupage thermique*

ICS 25.160.10

### ISO/CEN PARALLEL PROCESSING

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO-lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five-month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.

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Case postale 56 • CH-1211 Geneva 20  
Tel. + 41 22 749 01 11  
Fax + 41 22 749 09 47  
E-mail [copyright@iso.org](mailto:copyright@iso.org)  
Web [www.iso.org](http://www.iso.org)

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## Foreword

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

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

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

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

ISO 17916 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 9, and by Technical Committee CEN/TC 121, *Welding* in collaboration.

## Introduction

ISO 17916 has been created in recognition of the particular hazards that are presented by thermal cutting machines.

ISO 17916 is a type-C standard as outlined in ISO 12100.

When provisions of a type-C standard are different from those which are stated in type-A or type-B standards, the provisions of the type-C standard will take precedence over the provisions of the other standards for machines that have been designed and built in accordance with the provisions of the type-C standard.

The machinery concerned and the extent to which hazards, hazardous situations and events are covered are indicated in the Scope of this part of ISO 17916.

Hazards associated with thermal cutting machines are well recognized, but the sources of the hazards are frequently unique to a particular thermal cutting system. The number and type(s) of hazard(s) is(are) directly related to the nature of the thermal cutting process and the complexity of the installation. The risks associated with these hazards vary with the type of equipment used, its purpose, and the way in which it is installed, programmed, operated and maintained.

**NOTE** Not all of the hazards identified by ISO 17916 apply to every thermal cutting machine, nor will the level of risk associated with a given hazardous situation be the same from thermal cutting machine to thermal cutting machine. Consequently, the safety requirements, or the protective measures, or both, can vary from what is specified in this standard. A risk assessment can be conducted to determine what the protective measures should be.

ISO 17916 is not applicable to thermal cutting machines that were manufactured prior to its publication date.

# Safety of thermal cutting machines

## 1 Scope

This standard specifies the safety requirements and measures for machinery covering design, construction, production, transport, installation, operation, maintenance and putting out of service.

This standard applies to machinery using thermal cutting and or marking processes such as oxy-fuel, plasma arc. This standard applies to machinery the basis of which is either designed as open gantry, cantilever machine or the track of which is incorporated in the cutting table. This standard applies to any machine regardless of work piece or how the work piece is supported .

This document does not cover design standards for specific tools, e.g. oxy-fuel hose standards, electrical requirements for plasma power supplies. Most tools used on thermal cutting machines have specific design standards.

Risks arising from thermal cutting tools may be covered by related standards.

Risks arising from laser radiation, except those caused by position indicating lasers, are not covered by this standard. Those risks are covered by ISO 11553.

Machines that combine thermal processes with other processes (e.g. grinding, drilling, milling etc.) are only partly covered. Risks arising from these other processes may be covered by related standards.

## 2 Normative references

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

ISO 3821, *Gas welding equipment — Rubber hoses for welding, cutting and allied processes*

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

IEC 62079, *Preparations of instructions - structuring, content and presentation*

ISO/DIS 15012-4, *Health and safety in welding and allied processes — Equipment for capture and separation of welding fume — Part 4: General requirements for welding fume separation equipment* <sup>1)</sup> IEC 60974-8, *Arc welding equipment — Part 8 Gas consoles for welding and plasma cutting systems*

ISO 11553-1, *Safety of machinery — Laser processing machines — Part 1 General safety requirements*

ISO 15667, *Acoustics — Guidelines for noise control by enclosures and cabins*

IEC 60825-1, *Safety of Laser Products -Part 1: Equipment Classifications Requirement*

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

ISO14122-1:2001, *Safety of machinery. Permanent means of access to machinery. Part 1: Choice of fixed means of access between two levels*

1) This standard is currently under development.

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1 thermal cutting**  
cutting process that uses heat of different sources to melt or oxidize the material and a high speed jet to remove the liquid material

**3.2 tool**  
any component to carry out a working process

Note 1 to entry: Working processes are for example cutting or marking.

**3.3 aggregate**  
unit that carries one or more tools and which is used to position the tools relatively to each other and/or to adjust the bevel angle of the tool(s)

**3.4 cutting table**  
support for the work piece to be cut

**3.4.1 dry cutting table**  
cutting table not filled with water

**3.4.2 water table**  
cutting table filled with water

Note 1 to entry: The work piece may be placed under, on or above the water. The water catches most of the exhaust gases and dust generated by the cutting process

**3.5 exhaust unit**  
unit to exhaust dust and exhaust gases generated by the cutting process

**3.6 marking process**  
method for applying markings on the surface of the work piece

**3.7 movement envelope**  
area which can be reached by a moveable part of the machine

**3.8 oxy-fuel cutting**  
thermal cutting process using an oxygen/fuel gas flame to heat up the material to its ignition temperature and an oxygen jet to oxidize and remove the material

**3.9 plasma cutting**  
thermal cutting process using a constricted arc to heat up the material and a high velocity gas jet of ionized gas to remove the molten material

**3.10****positioning laser**

laser pointer to indicate the exact position of the machine

**3.11****section**

segment

partition of the cutting table

Note 1 to entry: Sections are used to make exhausting more efficient. Flaps in each section allow the exhaust system to open the suction only to the currently active cutting area.

**3.12****time weighted average****TWA**

a quantitative average which is determined from the measurement of a sample, which has been taken over a known time interval, multiplied by the desired time interval expression and divided by the total time of over which the sample was obtained

Note 1 to entry: For occupational exposure a working shift of eight hours is commonly used as the averaging time. Values are typically expressed as a concentration of a contaminant in air, or decibels, in the case of noise exposure.

**3.13****working area**

area where operation of cutting/marking tool is intended by design and/or manufacturer's specifications

**3.14****overall system stopping performance**

time interval between the actuation of the sensing function and the termination of the hazardous machine function

**4 Significant hazards**

The listed hazards, see Table A.1, assume foreseeable access from all directions, as well as unexpected start-up. Risks to both, the operators and other persons who can have access to the danger zones are identified, taking into account hazards that can occur under various conditions (e.g. commissioning, set-up, production, maintenance, repair, decommissioning) during the life of the machine. The assessment includes an analysis of the effect of failure in the control system. Following the intended use of the machine which includes maintenance, setting and cleaning, the reasonably foreseeable misuse, the identification of the significant hazards associated with the machine, and risks shall be evaluated.

For identification and evaluation of hazards ISO 12100 applies.

**5 Safety requirements and protective measures****5.1 General**

Machines covered by this standard shall meet the safety requirements listed hereafter.

With regard to hazards not covered by this standard, these machines shall be designed in compliance with the principles given in ISO 12100.

Machines, covered by this standard, shall be equipped with protective devices shown in the table 1, column 2.

Machines not requiring access to the movement range during operation (e.g. because they have construction-related short operating cycles, or the cutting table of which is not suited for access due to its design) do not require protective devices against collision with the gantry in the movement range.

5.2 List of safety requirements

Table 1 — List of safety requirements and /or protective measures and their verification procedures for cutting machines using thermal cutting processes.

| Hazards              | Safety Requirements and/or Protective Measures  | Verification             |
|----------------------|---|--------------------------|
| <p>1. Mechanical</p> | <p><b>1.1. Risk of collision between the operator and the machine while the operator is on the ground</b></p> <p><b>1.1.1. Collision when the operator is unimpeded by obstacles</b></p> <p><b>1.1.1.1. General</b></p> <p>The following conditions shall be fulfilled in case of collisions with the body:</p> <p>force <math>F &lt; 150N</math><br/>                     energy <math>E &lt; 10 J</math><br/>                     pressure <math>p &lt; 50 N/cm^2</math></p> <p><b>1.1.1.2. Relative speed of the machine to the operator <math>\leq 15</math> m/min</b></p> <p>The conditions described in 1.1.1 are met with a use of a bumper that is able to compress at least 4 mm (e.g. human tissue) and the collision area <math>&gt; 3cm^2</math>.</p> <p><b>1.1.1.3. Relative speed of the machine to the operator <math>&gt;15</math> m/min</b></p> <p>The conditions described in 1.1.1.1 are met using some of the measures below:</p> <p>bumper to safely remove the operator out of the danger zone fulfilling the conditions of 1.1.1.1</p> <p>bumper which activates an emergency stop. The stroke shall be greater than the overall system stopping performance. This bumper shall function without exceeding the conditions described in 1.1.1.1. The required performance level is C as described in ISO 13849.</p> <p>emergency trip wire which activates an emergency stop. The stroke shall be greater than the overall system stopping performance. This emergency trip wire shall function without exceeding the conditions described in 1.1.1.1. The required performance level is C as described in ISO 13849-1.</p> <p>light barrier which activates an emergency stop. The distance between the light barrier and the hazard shall be greater than the overall system stopping performance. The required performance level is C as described in ISO 13849-1.</p> | <p>Visual inspection</p> |



| Hazards | Safety Requirements and/or Protective Measures   | Verification |
|---------|--|--------------|
|         | <p><b>1.1.2. Collision when the operator is impeded by obstacles</b></p> <p>The conditions described in 1.1.1.1 are met using some of the measures below:</p> <p>light barrier which activates an emergency stop. The distance between the light barrier and the hazard shall be greater than the overall system stopping performance. The required performance level is D as described in ISO 13849-1.</p> <p>bumper which activates an emergency stop. The stroke shall be greater than the overall system stopping performance. This bumper shall function without exceeding the conditions described in 1.1.1.1. The required performance level is D as described in ISO 13849-1.</p> <p>In the case where a foreign object is present in the rail mounting fasteners of a machine (e.g. a foot is trapped) the gantry bridge will have a safety device installed to detect its presence and activate an emergency stop. This safety device shall function without exceeding the conditions described in 1.1.1.1. The required performance level is D as described in ISO 13849-1.</p> <p>Due to the nature of thermal cutting machines the associated risks are less than other machinery e.g. presses and shears, As such ISO 13855 does not apply.</p> <p>NOTE 1: Due to the variable thickness of work pieces, the lower limit of protective devices used may be set to 50 mm plus the maximum thickness of the work piece specified in the machine documentation, measured from the table. This applies to specified material thicknesses &gt; 130mm. Otherwise the lower limit of the protective devices shall start at ≤ 180mm above the table. (An example is given in Annex D).</p> <p>NOTE 2: For protective devices listed above, it is taken into account that due to their physical properties, the working processes of the machines are very striking and easily recognizable. It can therefore be assumed that the risks arising from the cutting process cannot be overlooked. In conjunction with the low speeds of movement in nearly all potential risky situations an avoiding of the hazard is possible.</p> |              |

| Hazards | Safety Requirements and/or Protective Measures   | Verification                             |
|---------|--|--|
|         | <p><b>1.2. Risk while stepping/standing on the cutting table</b></p> <p>To avoid falling while stepping on the table, e.g. for marking and picking up parts, an adequate ascent support shall be available.</p> <p>To avoid injuries while walking on the table safe walking areas shall be (temporarily) installable, e.g. plates.</p> <p>This does not apply to tables which are not able to carry a person. In this case signs on the machine and the safety instructions in the manual shall point out not to step on the table.</p> <p>Suitable personal protective equipment shall be utilized when a worker is standing on a cutting table or working on elevated platforms not designed for human occupancy.</p> <p>Additional requirements for while the machine is in operation</p> <p>The conditions described in 1.1.1 shall be met using some of the measures below:</p> <ul style="list-style-type: none"> <li>— bumper which activates an emergency stop. The stroke shall be greater than the overall system stopping performance. This bumper shall function without exceeding the conditions described in 1.1.1. The required performance level is D as described in ISO 13849-1.</li> <li>— light barrier which activates an emergency stop. The distance between the light barrier and the hazard shall be greater than the overall system stopping performance. The required performance level is D as described in ISO 13849-1.</li> </ul> | <p>Visual inspection</p>                 |
|         | <p><b>1.3. Outside the machine</b></p> <p>Protections against unauthorised persons are required according to the respective national regulations in force.</p> <p>The safety area to the outer machine movement envelope shall be installed according to ISO 13854 and ISO 13857.</p> <p>This safety area shall be defined in the manufacturer's instructions. Safety devices shall be designed according to ISO 12100.</p> <p>To allow the operator sufficient access to the machine in normal operation a clearance of 500 mm from the machine movement envelope shall be kept free of obstructions.</p> <p>An automatic monitoring system is not required.</p> <p>If the safety area cannot be designed around the equipment by the manufacturer or established by the installer due to site specific restraints, then the requirements specified in Table 1, 1.1 shall be met.</p>   | <p>Measurement<br/>Visual inspection</p> |

| Hazards                          | Safety Requirements and/or Protective Measures  | Verification                           |
|----------------------------------|---|--|
|                                  | <p><b>1.4. Interlocking</b></p> <p>Movements of the machine/aggregates are only allowed as long as the protective devices, according to 1.1, are in position or activated. If for reasons of maintenance, service or setting protective devices are disabled or removed, machine movements without enabling device are allowed up to a maximum speed of 6 m/min. Rotating aggregates are limited to a speed that the circumferential speed does not exceed 6m/min. This speed is not acceptable if rotating tools (e.g. brushes, grinders, drills, milling tools etc.) are in active use.</p> <p>Higher speed during service, maintenance or setting is permitted only in connection with:</p> <ul style="list-style-type: none"> <li>— a hold-to-run control device</li> <li>— an electronic hand wheel</li> <li>— a manual data entry followed by a cycle starting command</li> </ul> <p>The required performance level is D as described in ISO 13849-1.</p> | <p>Measurement<br/>Functional test</p> |
|                                  | <p><b>1.5. End Stops</b></p> <p>In all directions of movement, end stops shall be provided to safely stop the machine movement. If mechanical end stops are used, these end stops shall be designed in a way that crushing between the end stop and other components of the machine is avoided.</p>   | <p>Visual inspection</p>               |
|                                  | <p><b>1.6. Falling objects - Push out of work pieces</b></p> <p>Collision of the tool(s) with tilted parts may cause wedging or pushing out work pieces. Appropriate measures shall be provided to avoid such critical situations (e.g. by force limited assembly of the tool carrier)</p>  | <p>Visual inspection</p>               |
| <p><b>2. Electrical</b></p>      | <p><b>2.1. Direct Contact</b></p> <p>The entire electrical equipment of a machine shall be designed according to IEC 60204-1.</p> <p>Warning signs close to each of the plasma torches shall indicate that it is mandatory to switch off the plasma power source before any activities at the torch.</p>  | <p>Visual inspection</p>               |
|                                  | <p><b>2.2. Indirect Contact</b></p> <p>The entire electrical equipment of a machine shall be designed according to IEC 60204-1.</p> <p>Warning signs close to each of the plasma torches shall indicate that it is mandatory to switch off the plasma power source before any activities at the torch.</p>  | <p>Visual inspection</p>               |
|                                  | <p><b>2.3. Protection against electric shock on the Work Piece</b></p> <p>Appropriate measures to ensure sufficient grounding of the work piece shall be provided with the machine. If a sufficient grounding cannot be ensured automatically, additional devices (e.g. clamps) shall be used.</p>  | <p>Visual inspection</p>               |
| <p><b>3. Thermal Hazards</b></p> | <p><b>3.1. Contact with the hot Work Piece</b></p> <p>To avoid burns with the hot work piece, personal protective equipment shall be worn. Signs on the machine and safety instructions in the manual shall point to the obligation to wear personal protective equipment.</p>  | <p>Visual inspection</p>               |