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Safety of machinery — Laser processing machines —

Part 2: Safety requirements for hand-held laser processing devices

Sécurité des machines — Machines à laser —

Partie 2: Exigences de sécurité pour dispositifs de traitement laser portatifs

Reference number
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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 11553-2 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 9, *Electro-optical systems*.

This first edition, together with ISO 11553-1, cancels and replaces ISO 11553:1996, which has been technically revised.

ISO 11553 consists of the following parts, under the general title *Safety of machinery — Laser processing machines*:

— *Part 1: General safety requirements*

— *Part 2: Safety requirements for hand-held laser processing devices*

Introduction

This document is a type C standard as stated in ISO 12100-1:2003.

The machinery concerned and the extent to which hazards, hazardous situations and events are covered are indicated in the scope of this document. When provisions of this type C standard are different from those which are stated in type A or B standards, the provisions of this type C standard take precedence over the provisions of the other standards, for machines that have been designed and built according to the provisions of this type C standard.

It is applicable to machines using laser radiation to process materials. The purpose of this part of ISO 11553 is to prevent injuries to persons:

— by listing potential hazards generated by machines containing lasers;

— by specifying safety measures and verifications necessary for reducing the risk caused by specific hazardous conditions;

— by providing references to pertinent standards;

— by specifying the information which is to be supplied to the users so that they can establish proper procedures and precautions.

Safety of machinery — Laser processing machines —

Part 2: Safety requirements for hand-held laser processing devices

1 Scope

This part of ISO 11553 specifies the requirements for laser processing devices, as defined in ISO 11553-1, which are hand-held or hand-operated.

The purpose of this part of ISO 11553 is to draw attention to the particular hazards related to the use of hand-held laser and hand-operated laser processing devices and to prevent personal injury. This includes both the areas of hazard analysis and risk assessment as well as protective measures.

Requirements concerning noise as a hazard are not included in this part of ISO 11553. These requirements are to be included in a subsequent amendment.

This part of ISO 11553 does not apply to laser products or equipment manufactured solely or expressly for applications which are excluded from the scope of ISO 11553-1.

2 Normative references

The following referenced documents are indispensable for the application 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 3864-1:2002, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs in workplaces and public areas*

ISO 3864-2:2004, *Graphical symbols — Safety colours and safety signs — Part 2: Design principles for product safety labels*

ISO 3864-3:2006, *Graphical symbols — Safety colours and safety signs — Part 3: Design principles for graphical symbols used in safety signs*

ISO 11145:2006, *Optics and photonics — Lasers and laser-related equipment — Vocabulary and symbols*

ISO 11252:2004, *Lasers and laser related equipment — Laser device — Minimum requirements for documentation*

ISO 11553-1:2005, *Safety of machinery — Laser processing machines — Part 1: General safety requirements*

ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

ISO 13849-1:1999, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13850:1996, *Safety of machinery — Emergency stop — Principles for design*

ISO 14118:2000, *Safety of machinery — Prevention of unexpected start-up*

ISO 14119:1998, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

IEC 60204-1:2005, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60825-1 ed. 1.2:2001, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide*

IEC/TR 60825-14:2004; *Safety of laser products — Part 14: A user's guide*

IEC 60825-4-am1:2002, *Safety of laser products — Part 4: Laser guards*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145, ISO 11553-1, ISO 12100-1, IEC 60825-4 and the following apply.

3.1
hand-held laser processing device
device in which a laser provides sufficient energy/power to melt, evaporate or cause a phase transition in a part of the workpiece and where the laser output or workpiece to be processed is guided manually or hand-held during the laser process

NOTE For the purposes of this document, the terms "hand-held" and "hand-operated" have the same meaning.

3.2
confined spaces
working areas surrounded on all sides, or for the most part, by solid walls where they, on account of their confinement or containment of materials, preparation or equipment, augment or can augment particular hazards that considerably exceed the hazard potential normally prevailing at workplaces

3.3
supply unit
all devices that provide the process energies and operating material supply, direct these energies to the point of action and are absolutely necessary for the operation of the hand-held laser processing device (e.g. cooling system, power and gas supply)

3.4
disposal units
equipment that captures and removes effluents and by-products during laser material processing passing these on for filtration (e.g. capture devices, pipes, filtration systems, ventilation systems)

4 Hazards

4.1 Inherent hazards

The following hazards (see ISO 12100-1 and ISO 12100-2) may be generated by a laser-processing device:

a) mechanical hazards;

b) electrical hazards;

c) thermal hazards;

d) vibration hazards;

e) radiation hazards; examples include:

   1) hazards generated by direct or reflected laser beams, (also take into account that radiation can occur on the back of the workpiece, e.g. when cutting or due to transparency of the workpiece),

   2) hazards generated by ionizing radiation,

   3) hazards generated by collateral (UV, microwave, etc.) radiation produced, for example, by flash lamps, discharge tubes or RF-power sources,

   4) hazards generated by secondary radiation re-emitted by targets due to beam effects (the wavelength of the re-emitted radiation may be different from that of the beam);

f) hazards generated by materials and substances; examples include:

   1) hazards due to products which are used in the laser-processing device (e.g. laser gases, laser dyes, solvents),

   2) hazards resulting from interaction between the beam and the material (e.g. fumes, particles, vapours, debris), fire or explosion,

   3) hazards from associated gases (see for example 5.4.10) used to assist laser target interactions and from any fumes that are produced; these hazards include explosion, fire, toxic effects and oxygen depletion,

   4) hazards due to the leakage of liquids (e.g. coolant);

g) hazards generated by neglecting ergonomic principles in the design of the laser-processing device.

4.2 Hazards induced by external effects (interferences)

Power conditions and the environment in which the laser-processing device operates may cause the device to malfunction thus giving rise to hazardous conditions and/or making it necessary for someone to intervene within hazard zones.

Additional environmental interferences include:

a) temperature;

b) humidity;

c) external shock/vibration;

d) vapours, dust or gases from the environment;

e) electromagnetic-interference;

f) lightning strike;

g) source voltage interruption/fluctuation;

h) insufficient hardware/software compatibility and integrity;

i) hand-held laser processing devices capable of being separated from the radiation source (see also Annex B);

j) non-observance of interface specification (including power limits, control signals).

4.3 Further hazards related to the use of hand-held laser processing devices

4.3.1 Confined rooms

Hand-held laser processing devices could be used in confined rooms. Hazards can be constituted by:

a) concentration of harmful substances in the room air;

b) enrichment of process gases (nitrogen, argon, helium, oxygen) in the room air;

c) oxygen depletion;

d) electrical current;

e) increased radiation hazard through direct as well as directly or diffusely reflected laser radiation;

f) increased tripping and impact (shock) hazard.

4.3.2 Working at heights

Hand-held laser processing devices may be used at heights above the ground or other load bearing surfaces. Hazards are:

a) falling objects;

b) fall of the user.

4.3.3 Environmental effects

Hazards that can directly affect the user due to the prevailing environmental conditions. This applies in particular when hand-held laser processing machines are used outdoors.

This includes the following environmental effects:

a) temperature (cold, heat);

b) humidity (rain, fog, hail);

c) mechanical effects (vibration, wind pressure);

d) electromagnetic effects (lightning strike);

e) visibility (sunlight, lighting).

5 Safety requirements and measures

5.1 General requirements

Machinery shall comply, as appropriate, with ISO 12100-1 or ISO 12100-2 for hazards that are not covered by this part of ISO 11553.

Manufacturers shall ensure the safety of hand-held laser processing devices by:

a) hazard identification and risk analysis;

b) implementation of safety measures;

c) verification of the implemented safety measures;

d) provision of appropriate information for the user.

Based on the hazard identification (see 5.2), appropriate safety measures shall be incorporated into the hand-held laser processing device by design and manufacture.

The following requirements shall be satisfied:

— each manufacturer shall comply with the safety requirements and measures stipulated in this clause;

— the manufacturer of a hand-held laser processing device is responsible for compliance of the complete hand-held laser processing device with the requirements, including associated components (e.g. handling unit, laser assembly).

These measures apply to all hazards specified in Clause 4 and reflect the results of hazard analysis and risk assessment. The information given in Annexes A and B should be taken into account.

5.2 Risk assessment

A risk assessment shall be performed:

a) for all phases of hand-held laser processing device ”life” (as applicable); for examples see ISO 12100-1;

b) after each modification of the hand-held laser processing device by the person or organization responsible for the modification.

A risk assessment involves a hazard identification, which includes but is not limited to:

c) hazards listed in 4.1 and 4.3;

d) danger zones, particularly those associated with

   1) the laser system,

   2) the laser beam path/propagation, beam delivery system,

   3) the process zone,

   4) interferences listed in 4.2.

The results of the risk assessment shall be duly documented.

5.3 Implementation of corrective measures

5.3.1 General requirements

Manufacturers shall ensure the safety of hand-held laser processing devices by:

— hazard analysis and risk assessment;

— integration of safety measures;

— verification of safety measures;

— provision of appropriate information for the user.

5.3.2 Protection against laser radiation hazards

5.3.2.1 General

The possibility of people being to exposed to levels of laser radiation exceeding the Maximum Permissible Exposure (MPE) limits for 3×10^4 exposure, as defined in standards IEC 60825-1 and IEC/TR 60825-14, shall be eliminated during operation.

To satisfy this, the following requirements shall be met:

a) Risk assessment shall be performed.

b) Unauthorized human access to a danger zone should be prevented by engineering controls as specified in IEC 60825-1.

c) If access cannot be prevented, exposure above the ocular MPE shall be eliminated by use of engineering or administrative controls, including Personal Protective Equipment.

   1) The design of protective devices, such as shutters, guards, beam dissipation devices, trip devices and deterring/impeding devices shall meet the requirements specified in IEC 60825-1. In cases of ambiguity or difference of interpretation between ISO 12100-1 and ISO 12100-2 and IEC 60825-1, the first two sentences of 5.3.2.1.1, 5.3.2.1.2 and 5.3.2.1.3 of ISO 11553-1:2005 shall be definitive.

   2) The same protective device may be used to provide simultaneous protection against more than one hazard.

5.3.2.2 Protection during operation

The principal danger zone is usually the process zone, but the danger zone must be defined as a result of the risk assessment. The Nominal Hazard Area (NHA) as defined in IEC/TR 60825-14 or the volumetric space is where laser radiation may exceed the MPE.

In the danger zone, human exposure shall be limited during operation to levels of laser radiation no greater than the MPE for 3×10^4 s exposure duration by use of engineering or administrative controls, including the use of Personal Protective Equipment (e.g. local protection using a protective enclosure or the provision of personal protective equipment) such as eyewear and clothing.

5.3.2.3 Protection during service

During service procedures, human access to laser radiation exceeding the Accessible Emission limit (AEL) for Class 1 is sometimes unavoidable. During servicing it shall be ensured that only authorized persons are allowed access to zones exposed to levels of laser radiation that exceed the AEL values for Class 1. Laser-processing devices shall therefore be designed and appropriate safety measures provided, with respect to the following four situations listed in order of preference.

1) Servicing takes place outside danger zones.

2) Servicing takes place in danger zones to which access is controlled in the same manner as during production (e.g. interlocked cover).

3) Servicing takes place in a danger zone (e.g. with open guards that are normally closed during production) but accessible laser radiation does not exceed the AEL for Class 1.

4) Servicing takes place in danger zones, e.g. because opening of guards (normally closed during production) is necessary. In this case, accessible laser radiation exceeds the AEL for Class 1.

The manufacturer shall indicate the class of accessible laser radiation and recommended safety procedures for each of these situations (as applicable).

When servicing hand-held laser processing devices, the laser device should be switched off. For activities (e.g. adjustment), where this is not possible, a nominal ocular hazard area should be established.

5.4 Design requirements

5.4.1 Design

The design of the hand-held laser processing devices shall take place according to ergonomic principles.

5.4.2 Protective enclosure

The technical design requirements for the protective enclosure shall be determined on the basis of risk analysis.

5.4.3 Authorizing control device

For hand-held laser processing devices connected to an external laser device via a beam delivery system, a technical device for the prevention of unauthorized operation (e.g. key-operated switch) shall be provided at the hand-held laser processing device or in the immediate vicinity of the hand-held laser processing device.

5.4.4 Emission warning device

For hand-held laser processing devices, the following radiation warning devices shall be provided in the field of vision of the operator:

Laser ready indicator:

— every hand-held laser processing device shall have a visible laser ready indicator (e.g. LED).

Indication device for laser emissions:

— in addition to the laser ready indicator, every hand-held laser processing device/laser device shall be provided with an optical and/or acoustic indication device, which indicates laser radiation emissions above Class 3R (e.g. LED).

The warning devices shall also be clearly visible when warning personal eye protection (laser eye-protectors).

5.4.5 Alignment laser

The beam power of the alignment laser (if available) shall not exceed the AEL values for Class 2 at the beam exit. The beam cross-section of the alignment laser shall have a defined position with respect to the processing laser.

5.4.6 Safety devices for scanning laser radiation

The requirements for safety devices for scanning laser radiation shall be determined by risk analysis. Areas in which radiation can exceed AEL values for Class 1 shall be designated nominal ocular hazard areas.

NOTE For hand-held laser processing devices where the laser passes freely between the beam exit aperture and target and is not enclosed, the beam propagation should be restricted with respect to the degrees of freedom (or the solid angle traversed by the laser beam) to the extent necessary for normal operation. This can take place on a software or hardware basis. The degrees of freedom should also be restricted by devices (shields in the vicinity of the beam exit, laser guards) that suppress beam propagation in specific spatial directions.

A minimum performance is that the laser shutter shall close if the intended beam scanning angle is to be exceeded.

5.4.7 Emergency stop control

An emergency stop control is required. The emergency stop control shall comply with IEC 60204-1 and ISO 13850.

The emergency stop control shall

— deactivate laser beam generation and automatically position the laser beam stop to prevent laser emission;

— deactivate the hand-held laser processing device (i.e. disconnect the power supply to the actuators and within specific time limits, as necessary for an emergency shutdown, also shut off the gas and water supply).

The emergency stop switch shall be in the form of a red pushbutton and be quickly and easily accessible and in the immediate vicinity of the user of the hand-held laser processing device.

In the case of hand-held laser processing devices connected to an external laser device via a beam delivery system and the emergency stop, unexpected start-up shall be prevented by compliance with ISO 14118.

5.4.8 Control means and circuits

5.4.8.1 General

Control means and circuits shall comply with IEC 60204-1.

The designer shall complete a risk assessment to evaluate the control system using ISO 13849-1.

NOTE Typically this would result in a safety category 3.

5.4.8.2 Start/stop controls

If a laser device is used for several hand-held laser processing devices capable of operating separately to each other, the start/stop control shall be separate for each hand-held laser processing device.

Start control: monitored start-up of the hand-held laser processing device shall be ensured.

Stop control: in the case of partly mechanized hand-held laser processing devices for supporting manual guidance or positioning, the stop control shall stop the motorized drive for feed motions and/or manipulation of the beam propagation and shaping system (beam delivery) and either isolate the laser beam or deactivate the laser beam generation.

Laser stop control: the laser stop control shall deactivate laser beam generation.

Device for control feed of motions and laser beam emission: hand-held laser processing device shall be provided with a device for monitoring feed motions (in the case of partly mechanized hand-held laser processing devices for supporting manual guidance or positioning) and laser beam emission, designed for user operation within the hazardous zone.

The following requirements apply to this device:

— The device shall be a “hold to run” control in conformity to ISO 13849-1:1999, Category 3.

— The device shall be provided with a control device with automatic reset facility designed to maintain operational laser radiation only as long as it is activated. When deactivated, it shall automatically reduce the accessible laser radiation level below the AEL values for Class 2.

If the hand-held laser processing device is controlled with this control device, all feed motions and laser beam emissions shall be controllable solely from this device.

5.4.8.3 Control and operating devices

For hand-held laser processing devices connected to an external laser device via a beam delivery system and located more than two metres away from the laser device and/or laser devices that are not quickly and easily accessible to the user, the control and operating elements shall be integrated into the hand-held laser processing device. Alternatively, for hand-held laser processing devices connected to an external laser device via a beam delivery system and/or laser devices that are not quickly and easily accessible to the user, the essential control and operating elements shall be integrated into the hand-held laser processing device. Alternatively, the control devices can also be placed in the immediate vicinity of the hand-held laser processing device or user (e.g. in a unit attached to the body of the user).

The minimum requirements relating to the essential control elements to be integrated shall be:

— shutter operation (open/close), see the requirements for 5.4.8.2;

— emergency stop button.

All other controls not safety related, e.g. parameter settings, etc., are not subject to the requirements of 5.4.8.3.

NOTE For occupational safety reasons, two-hand control devices should preferably be used (according to ISO 13851) if the beam propagation area can be accessed with one hand during normal use. The use of foot switches is recommended only in exceptional cases and these should be protected against accidental activation.

5.4.8.4 Interfaces/supply

5.4.8.4.1 General

The complete supply of the hand-held laser processing device (power, gas, water, beam delivery unit) shall be of a construction to comply with the requirements for normal use of the hand-held laser processing device, namely:

— resistance to mechanical loads;

— resistance to thermal loads;

— resistance to dust and humidity;

— resistance to laser radiation;

— other hazards.

5.4.8.4.2 Beam delivery system

For hand-held laser processing devices connected to an external laser device via a beam delivery system, the interface between the hand-held laser processing device and the beam delivery system is subject to particular requirements.

The interface shall be designed so that the beam delivery system and hand-held laser processing device match with respect to:

— optical elements;

— mechanical elements.

Beam delivery systems shall require a tool for disconnection or be interlocked to prevent access to hazardous laser radiation. The laser shall be switched off prior to laser radiation emission (in the area of the interface). It shall be ensured, by appropriate technical measures, that no laser radiation is emitted from the beam delivery system (e.g. fibre monitoring).

5.4.8.4.3 Power supply/electrical connections

The electrical equipment shall be designed in accordance with the electro-technical safety rules to prevent endangering persons.

5.4.8.4.4 Gas supply

If the hand-held laser processing device has a gas supply (e.g. for process gases), this shall be appropriately designed to prevent endangering persons.

5.4.8.4.5 Supply with liquid media

If the hand-held laser processing device is supplied with liquid media (e.g. for cooling), hazards through liquid media (operational interruptions, slipping hazard in the working area) shall be prevented by appropriate design measures.

5.4.8.5 Interlocks and guard control

When guards (in accordance with ISO 12100-2) are opened or displaced, or safety interlocks are defeated, automatic operation of the laser processing device shall be impossible.

If the design of the laser processing device requires occasional procedures to be carried out with one or more guards open (normally closed during production) and with power supplied to the device actuators, then an operating mode shall be provided to make overriding of the guard(s) possible.

The selection of this operating mode shall

— be by means of a lockable mode selector;

— automatically isolate the laser beam;

— prevent automatic operation of the laser processing device.

A key-operated switch may be used as the mode selector.

Discrete, deliberate, interlock override mechanisms on removable access panels with safety interlocks (defeatable safety interlocks) shall meet the requirements of IEC 60825-1 for such override mechanisms. This applies to hand-held laser processing device and/or in conjunction with the laser assembly.

Interlocking systems shall comply with the requirements of ISO 14119.

The operation mode selected shall be clearly signalled. After this operation mode has been selected, it shall be possible to override the beam isolation (i.e. "open" the beam stop) for service procedures.

5.4.9 Provisions for isolation of the laser beam

Isolation of the laser beam shall be achieved by blocking and/or deviating the laser beam to prevent it from entering the beam delivery system.

Beam isolation shall be accomplished using a fail-safe laser beam stop in the closed position. A key-control shall be permitted for this purpose.

Additional beam stops may be provided by the laser processing device manufacturer, for example in the following situations:

— when there are maintenance/cleaning areas present along the beam path (beam delivery system);

— when one laser device supplies more than one beam path, and there is a need for human intervention in one path while the beam is traversing one of the other paths.

5.4.10 Protection against hazards generated by materials and substances

The manufacturer shall ensure by technical measures that harmful gaseous and particulate substances generated during laser processing are removed from the working area and passed to a disposal unit. The design of the disposal unit shall be determined from the risk analysis.

NOTE 1 The capturing of hazardous substances should take place directly at the point of their occurrence.

NOTE 2 The safe removal and disposal of fumes and particulate matter from the laser processing device according to local, national or regional threshold limit values are the responsibility of the customer/user.

The manufacturer shall provide priority for suitable technical measures for protection against these hazards (see Clause 4). If the hazard is unable to be excluded by technical measures, the manufacturer shall provide the customer/user with information relating to the hazards and threshold limits for the maximum exposure (or exposure at the workplace) and, if necessary, information on appropriate personal protective equipment.

See also Annex A and Bibliography of ISO 11553-1:2005.

Due regard shall be given to the hazards from associated gases (e.g. oxygen) used to assist laser/workpiece interactions and from any fumes that are produced. Related hazards include explosion, fire, toxic effects, oxygen excess and oxygen depletion.

Additional information is given in Annex B of ISO 11553-1:2005.

6 Verification of safety requirements and measures

6.1 General conformance

General conformance with the requirements of this International Standard, particularly those clauses relating to the presence and positioning of guards and control devices, shall be confirmed by visual inspection.

Correct functioning of control devices for each product unit shall be verified according to functional tests specified by the manufacturer.

Verification procedures relating to laser radiation levels shall conform to IEC 60825-1 ed. 1.2:2001, Clause 9.

Depending on the hand-held laser processing device and particular use, it may be necessary to carry out recurring tests after certain durations of use.

6.2 Control category classification

The hand-held laser processing device shall be classified according to ISO 13849-1 in a control category relating to the safe deactivation of the device. If the hand-held laser processing device is connected to an external laser device, the control category refers to the hand-held laser processing device in conjunction with the laser device.

6.3 Laser classification

For hand-held laser processing devices connected to an external laser device, the hand-held laser processing device shall be classified in conjunction with the laser device(s) specified in the operating instructions.

Decisive for classification is the accessible laser radiation (depending on the output power and wavelength) that results in the highest possible class.

Classification shall take place for all operating states of the hand-held laser processing device:

— normal use;

— maintenance/service;

— malfunction/fault.

Classification as well as the procedures for the classification of hand-held laser processing devices shall take place in accordance with the requirements of IEC 60825-1.

7 Information for the user

7.1 Additional requirements

In addition to the requirements of IEC 60825-1, IEC 60204-1, ISO 11252 and ISO 12100-2, the following requirements shall be satisfied.

a) The manufacturer of hand-held laser processing devices that do not include a laser device (but are connected to an external laser device via beam delivery systems), shall provide the customer/user of the hand-held laser processing device with information on the interfaces and the necessary specifications of the laser device and beam delivery system (e.g. maximum output power of the laser device, optical fibre specifications).

b) The manufacturer of the hand-held laser processing device shall provide the customer/user with the associated safety-related documentation and respective data including information on normal use, foreseeable misuse, correct maintenance and servicing procedures as well as actions to be taken in the event of faults.

c) The manufacturer shall inform the user of his responsibilities with regard to the safe use of the hand-held laser processing device and provide general information.

   This includes the following areas:

   1) protection against laser radiation;

   2) protection against secondary radiation;

   3) protection against thermal radiation, hot material or slag particles;

   4) protection against hazardous substances;

   5) protection against further hazards.

The manufacturer shall make available suitable safety-related training to the user.

The manufacturer shall advise users of known potential hazards by providing a prominently placed warning statement in the user instructions and/or operator's manual.

7.2 Recommended inclusions

The following items should be considered for inclusion in the user's instructions and/or operator's manual.

a) IEC 60825-1 specifies protective measures for the primary laser radiation. The primary aim is to restrict the nominal ocular hazard area with suitable protective devices, so that the AEL for laser Class 1 is not exceeded outside this area.

   — The minimum requirement, in the case of potential exposure by a Class 3B and Class 4 product, is to wear protective laser eyewear rated for the laser power and wavelength.

b) Some operations, for example welding, may produce intense UV (in particular in connection with Argon) and/or visible radiation.

   — The minimum requirement, in the case of potential exposure to this kind of radiation is to wear appropriate protective eyewear (for example a welding mask).

c) Processing materials with hand-held laser processing devices can give rise to thermal radiation and the expulsion of hot material or slag particles, which can constitute a hazard to the user due to the short distance of the same to the process zone.

   — The minimum requirement in case of potential exposure is to wear suitable protective clothing (protective gloves, protective suit).

d) Most material processing applications produce fumes and particles. When processing metals, heavy metal vapours may be produced. These can harm body tissues and organs. When processing plastics, toxic or lethal by-products can be produced.

   — The minimum requirement, before starting the process, is to

      i) be familiar with the material to be processed, know what by-products may result, assess their risk to health and determine what precautions are necessary;

      ii) employ appropriate measures to prevent or control the risk; such measures will normally require positive exhaust of fumes from the process zone and adequate purification before exhaust gases are returned to the atmosphere away from personnel;

      iii) inform, instruct and train operators about the risks, and the precautions to be taken;

      iv) where necessary, monitor the exposure of operators and carry out an appropriate form of surveillance of their health in compliance with local regulations;

      v) consult a pertinent authority to find out what national, state and/or local regulations must be satisfied before exhaust gases are returned to the atmosphere.

e) Dangerous voltage/current is used to power the laser and its associated equipment. Power supplies can contain capacitor banks which may remain charged for some time after switching the equipment off.

   — The minimum requirements in the case of repair are to follow the rules for electrical safety practices.

f) A handling system for hand-held laser processing devices can constitute further potential hazards.

   — The minimum requirement is to provide information on special hazards (e.g. increased fire hazard, use in confined spaces) as well as the associated safety rules.

NOTE The manufacturer is the individual/organization responsible for the final modification (e.g. connection of the handling unit and laser assembly). This applies similarly when the manufacturer and customer/user are the same entity.

8 Labelling

Local or regional laws for labelling shall be adhered to.

The hand-held laser processing device shall be labelled in accordance with 6.4 of ISO 12100-1:2003, to indicate:

a) the name and address of the laser processing device manufacturer;

b) the manufacturing date;

c) the series or type of laser processing device (if appropriate) and serial number (if any).

The labels shall satisfy the following requirements:

— colours, sizes and print styles of laser radiation warning labels shall be as described in IEC 60825-1;

— in addition to the labelling required by IEC 60825-1, the laser processing device shall, after installation, carry other pertinent cautionary and warning labels (e.g. “TOXIC FUMES/PARTICLES MAY BE GENERATED BY THIS LASER-PROCESSING DEVICE”). The size and location of the labels shall be such as to make the appropriate labels legible from outside the danger zones without exposing anyone to any of the hazards listed in Clause 4.

The colour, size and print style of the labels shall comply with the requirements of ISO 3864-1, -2 and -3.

Annex A
(informative)

Risk assessment examples

Tables A.1 to A.5 contain hazard and risk assessment examples for hand-held laser processing devices. The following operating states/conditions within the useful life of a hand-held laser processing device are to be examined:

a) transport;

b) installation;

c) commissioning;

d) use:

— normal use;

— malfunction;

— improper use;

e) maintenance/servicing;

f) decommissioning.

For each operating state, possible hazards as well as protective measures shall be listed and assessed (procedures: e.g. risk chart, assessment procedure with weighted criteria).

Table A.1 — Example risk assessment chart

Operating state	**Condition/ place**	**Hazard**	**Probability of hazard occurring** (see Table A.2)	**Possible exposure time** (see Table A.3)	**Extent of damage** (see Table A.4)	**Possibility of damage/limitation** (see Table A.5)			**Risk** $R = (\Sigma A1, Ax)/x$
						Technical	Organi-zational	Perso-nal	
Cutting: Intended use	Beam penetration/ workpiece	Laser radiation	Can be expected	100 s	Permanent, serious damage to health (irreparable damage to the eyes)	Pass. screens, guards			
			(4)	(3)	(4)	(3)			
	Beam emergence fibre breakage	Laser radiation	Conceivable, but unusual	100 s	Permanent, serious damage to health (irreparable damage to the eyes)	Fibre monitoring			
			(2)	(3)	(4)	(1)			
	Polymer processing	Hazardous substances	Can be expected	30 000 s	Permanent, minor damage to health (pulmonary function impairment)	Extraction system			
			(4)	(4)	(3)	(2)			

Tables A.2 to A.5 contain examples of individual factor ratings:

Table A.2 — Probability of hazard occurring

Probability	Factor
Hardly conceivable	1
Conceivable, but unusual	2
Possible under certain condition	3
Can be expected	4
Definite occurrence	5

Table A.3 — Maximum possible exposure time

Exposure	Factor
0,25 s	1
10 s	2
100 s	3
30 000 s	4

Table A.4 — Extent of damage

Extent of damage	Factor
Minor injury (minor consequences)	1
Completely healable injury (e.g. minor burn)	2
Permanent, minor damage to health (minor retinal damage, burns)	3
Permanent, serious damage to health (e.g. loss of vision on minimum one eye, serious burns with scarring)	4
Death	5

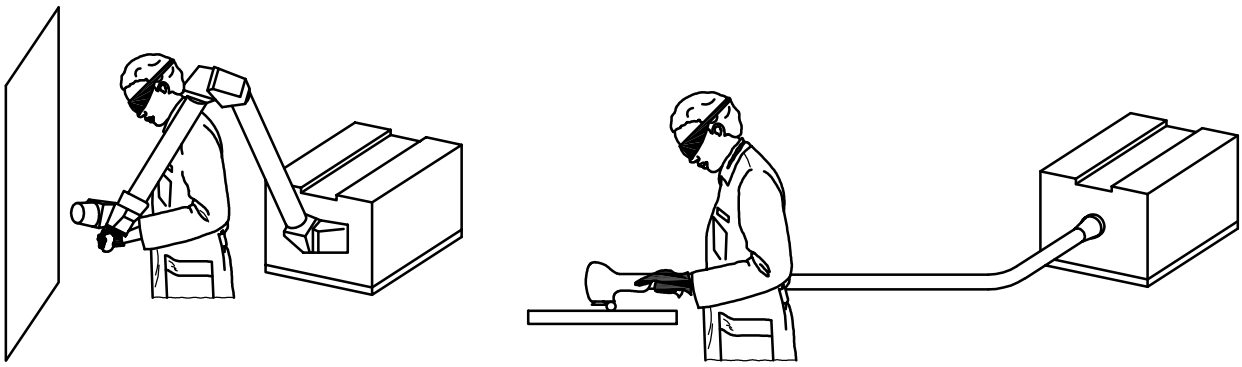
Table A.5 — Possibility of damage limitation (technical)

Possibility of damage limitation	Technical examples		Factor
	Beam delivery	Screening	
Hazard is quickly detected; measures take immediate effect Fail-safe	Encapsulated and interlocked with control monitoring	Active guard with control monitoring	1
Hazard is quickly detected; measures take immediate effect	Encapsulated and interlocked	Active guard	2
Hazard is detected in good time; measures take immediate effect	Interlocked	Passive guard in accordance with ISO 14119	3
Hazard is detected only under constant control; damage limitation possible	Open, overhead	None, enclosure of a nominal ocular area	4
Damage unavoidable	Open	None	5

Annex B
(informative)

Types of hand-held laser processing machines

B.1 Devices with hand-held handling system connected to an external laser device via a beam



a) b)

Figure B.1 — Hand-held handling system, manually positioned with or without motorized feed, laser device fixed, workpiece fixed

B.2 Hand-held laser assembly, moved relative to fixed workpiece

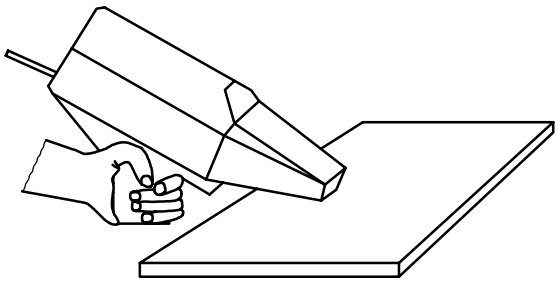


Figure B.2 — Hand-held laser assembly (laser device as an integral part of the hand-held device), manually positioned, with or without motorized feed, workpiece fixed

B.3 Fixed laser assembly, where the workpiece is moved manually relative to the beam shaping unit (processing head)

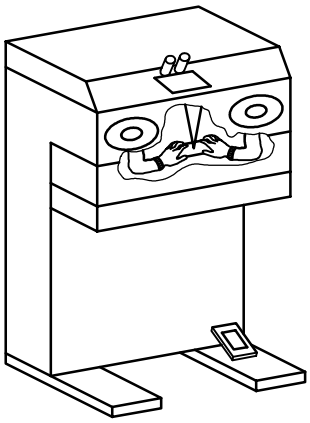


Figure B.3 — Fixed laser assembly, workpiece manually guided or manually positioned

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