International Standard

ISO 11553-2

Safety of machinery — Laser processing machines —

Part 2: Safety requirements for hand-held or hand-operated laser processing machines

Sécurité des machines — Machines à laser —

Partie 2: Exigences de sécurité pour machines à laser portatives ou actionnées manuellement

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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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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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 172, *Optics and photonics*, Subcommittee SC 9, *Laser and electro-optical systems*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 123, *Lasers and photonics*,in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement) and with IEC/TC 76, *Optical radiation safety and laser equipment*.

This second edition cancels and replaces the first edition (ISO 11553-2:2007), which has been technically revised.

The main changes are as follows:

a) The document was changed to type-C standard;

b) added dates to references in the whole document and main body of the text;

c) several terms and definitions were modified or newly added;

d) the covered hazards as well as the requirements concerning the hazards were added in more detail;

e) Clause 4 was rewrote with new structure, the Table 1 was newly added, serving to list the significant hazards and hazardous situations;

f) Table 2 was newly added in Clause 4, serving to list the further hazards and hazardous situations;

g) Clause 5 was rewrote with new structure. Table 3 was newly added in Clause 5 to describe the work place safety for HLM;

h) Several subclauses of Clause 5 were rewrote with more detail;

i) Table 3 was modified in Clause 6.

j) Several subclauses of Clause 7 were added with more information;

k) several subclause headings were modified and several technical requirements were amended;

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l) some of the lists were renumbered;

m) previous Annex B was deleted, and example of risk assessment for HLM was added as Annex B;

n) new Annex C, Annex D, Annex E, Annex F, Annex G and Annex H were added.

A list of all parts in the ISO 11553 series can be found on the ISO website/IEC website.

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.

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Introduction

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

This document is of relevance particularly for the following stakeholder groups representing the market players with regards to machinery safety:

a) hand-held or hand-operated laser processing machines (HLMs) manufacturers (small, medium and large enterprises); including manufacturers of sub/part machines such as devices or devices assembly related to laser radiation, as well as system integrators (small, medium, and large enterprises);

   NOTE Devices or device assemblies include, but are not limited to, those for: guiding; shaping, delivery, protective, locking, control, enabling, limiting, impeding, switching, exhaust, stop, loading/feeding, scanning and warning devices.

b) health and safety bodies (regulators, accident prevention organizations, 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:

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

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

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

f) consumers (in case of machinery intended for use by consumers);

g) bystanders.

The above-mentioned stakeholder groups have been given the possibility to participate in 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.

The purpose of this document is to prevent serious and irreversible injuries to persons and damage to property

— by listing potential hazards generated by hand-held or hand-operated laser processing machines;

— by describing the risk assessment procedure for all relevant hazards;

— by specifying safety measures and verification procedures 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 user so that they can establish proper procedures and precautions at the workplace.

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Safety of machinery — Laser processing machines —

Part 2: Safety requirements for hand-held or hand-operated laser processing machines

1 Scope

This document deals with all significant hazards, hazardous situations or hazardous events relevant to hand-held or hand-operated laser processing machines (HLMs), when they are used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer. HLM is the machine, as defined in ISO 11553-1:2020, 3.7, in which laser radiation is generated, where the laser provides sufficient energy/power to 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 material processing.

This document defines general design requirements of HLM. HLM includes the laser device, beam-guiding device (e.g. mirror, fibre, lenses), beam-shaping device (e.g. telescope, focusing), and controls. The laser assembly as an integral part of the HLM or only the laser processing head is hand-held or hand-operated during the laser material processing.

This document does not apply

— to laser processing machines which are remotely controlled by a manual controller (hand-operated controller), such as joy sticks, keyboard, etc., without touching a workpiece or a part mechanically connected with the laser material processing head by using the hand(s) of the operator (user)

— to laser processing machines without a drive system which may not belong to machinery. And the laser processing apparatus without moving parts, which may not be considered as machinery in “Type C standard”.

  — to medical or cosmetic applications for the treatment of living human or animal tissue;

  — to weapon applications, (e.g. such as with regard to military applications, direct close combat.)

NOTE “hand-operated laser processing machine” is synonymous with “hand-guided laser processing machine” in this document. Hand-operated laser processing machines often use manual force reduction means such as wheels, supports, etc., for manual positioning of the laser processing heads or the workpieces.

It is applicable to HLMs using laser radiation to process materials.

The purpose of this document is to draw attention to the hazards related to HLMs and to prevent personal injury. Depending on the application and the location/operating conditions of HLMs, a number of different significant hazards can arise. This document describes both the areas of hazards analysis and risk assessment as well as protective measures.

Requirements dealing with noise as a hazard are covered by ISO 11553-3:2013.

This document does not apply to laser products or equipment manufactured solely or expressly for applications which are excluded from the Scope of ISO 11553-1:2020. This document is not applicable for HLMs which have been manufactured before the date of publication of this standard.

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HLMs include the following types:

a) HLMs which are designed as all-in-one laser assembly including the beam delivery/forming(shaping) system and optional features such as gas nozzles, material (e.g. powder, wire) feed system;

b) HLMs where the relevant devices are connected by a beam guidance system (e.g. optical fibre) and power/control cables to an external laser assembly device and which includes only the beam delivery/ forming(shaping) system and optional features such as gas nozzles, material (e.g. powder, wire) feed system;

c) laser processing machines where the workpiece is manually moved under/relative to the laser beam (see informative Annex A).

The intended use of HLMs covers both:

d) movement of elements or workpieces by hand to be processed under/relatively to stationary laser beams as shielded , and

e) movement of the laser processing head (beam shaping device) by hand to move laser beam(s) over or relative to elements or workpieces to be processed.

Laser processing machines, where laser processing is performed with hand-held or hand-operated workpieces outside the fixed (neither hand-held nor hand-operated by the operator or user) laser processing machines are out of the scope of this document. Such a fixed laser processing machine is to be covered by ISO 11553-1:2020.

HLMs are intended for the industrial use and can be only operated by trained and authorized personnel in indoor and/or outdoor environments/locations (e.g. cleaning of facades, statues).

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 3864-1:2011, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 6385:2016, *Ergonomics principles in the design of work systems*

ISO 11145:2018, *Optics and photonics — Lasers and laser-related equipment — Vocabulary and symbols*

ISO 11553-1:2020, *Safety of machinery — Laser processing machines — Part 1: Laser safety requirements*

ISO 11553-3:2013, *Safety of machinery — Laser processing machines — Part 3: Noise reduction and noise measurement methods for laser processing machines and hand-held processing devices and associated auxiliary equipment (accuracy grade 2)*

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

ISO 13732-1:2006, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces*

ISO 13849-1:2023, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

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

ISO 13851:2019, *Safety of machinery — Two-hand control devices — Principles for design and selection*

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

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ISO 14119:2024, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

ISO 16321-1:2022, *Eye and face protection for occupational use - Part 1: General requirements*

ISO 16321-2:2021, *Eye and face protection for occupational use — Part 2: Additional requirements for protectors used during welding and related techniques*

ISO 21904-1:2020, *Health and safety in welding and allied processes — Equipment for capture and separation of welding fume — Part 1: General requirements*

ISO 20607:2019, *Safety of machinery — Instruction handbook — General drafting principles*

ISO 26800:2011, *Ergonomics — General approach, principles and concepts*

IEC 60204-1:2016/AMD1:2021, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60364-1:2025, *Low-voltage electrical installations— Part 1: Fundamental principles, assessment of general characteristics, and definitions*

IEC 60529:1989/AMD1:1999+AMD2:2013, *Degrees of protection provided by enclosures (IP Code)*

IEC 60825-1:2014, *Safety of laser products — Part 1: Equipment classification and requirements*

IEC 60825-4:2022, *Safety of laser products — Part 4: Laser guards*

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

IEC 61000-6-3:2020, *Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for equipment in residential environments*

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

IEC 61000-6-7:2014, *Electromagnetic compatibility (EMC) - Part 6-7: Generic standards - Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations*

IEC 62061:2021+AMD1:2024, *Safety of machinery — Functional safety of safety-related control systems*

ISO 19818-1:2021, *Eye and face protection — Protection against laser radiation — Part 1: Requirements and test methods*

IEC 61326-1:2020, *Electrical equipment for measurement, control and laboratory use –EMC requirements –Part 1: General requirements*

EN 1005-1:2001+AMD1:2008, *Safety of machinery - Human physical performance - Part 1: Terms and definitions*

EN 1005-2:2003+AMD1:2008, *Safety of machinery Human physical performance Part 2: Manual handling of machinery and component parts of machinery*

EN 1005-3:2002+AMD1:2008, *Safety of Machinery - Human Physical Performance - Part 3: Recommended Force Limits for Machinery Operation*

EN 1005-4:2005+AMD1:2008, *Safety of machinery - Human physical performance - Part 4: Evaluation of working postures and movements in relation to machinery*

EN 1005-5:2007+AMD1:2008, *Safety of machinery - Human physical performance - Part 5: Risk assessment for repetitive handling at high frequency*

IEC 60974-5:2019, *Arc welding equipment - Part 5: Wire feeders*

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

ISO 9355-2:1999, *Ergonomic requirements for the design of displays and control actuators - Part 2: Displays*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145:2018, ISO 11553-1:2020, ISO 12100:2010, ISO 13849-1:2023, IEC 60825-1:2014, IEC 60825-4:2022 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
confined space
working area surrounded on all sides, or for the most part, by 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

3.2
disposal unit
equipment that captures and removes effluents and/or chemical pollutants (e.g. fumes, gases) and/or by products during laser material processing passing these on for filtration

EXAMPLE Capture devices, pipes, filtration systems, ventilation systems.

3.3
hazard area
danger zone
any space within and/or around machinery in which a person can be exposed to a hazard

Note 1 to entry: There may be several hazard areas (danger zones) on the same workplace depending on the types of hazards and relevant safety control measures against the hazards.

Note 2 to entry: For “laser hazard area”, see 3.6.

Note 3 to entry: Hazard area (danger zone) is not synonymous to “laser hazard area” and “nominal ocular hazard area (NOHA)”.

[SOURCE: ISO 12100:2010, 3.11, modified — the term "hazard zone" was changed to "hazard area" and "danger zone", Note 1 to entry, Note 2 to entry and Note 3 to entry were added.]

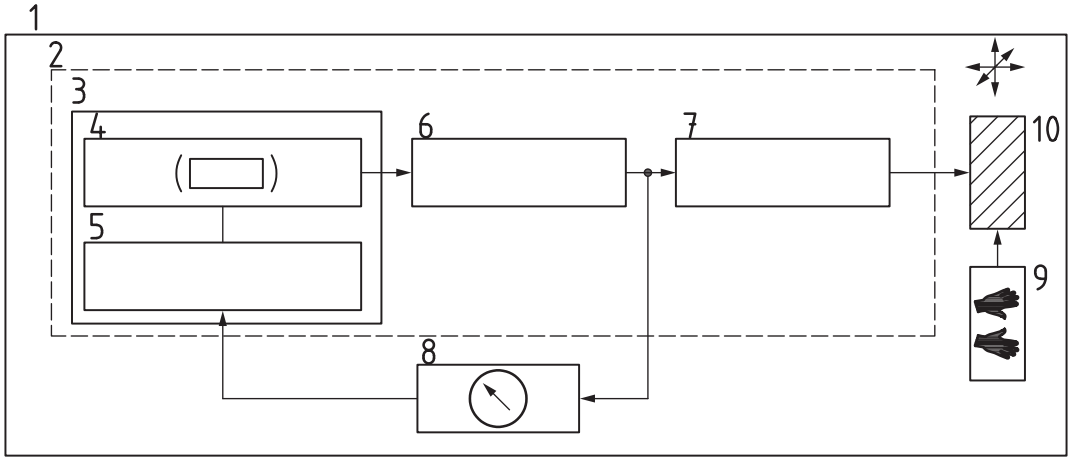
3.4
hand-held or hand operated laser processing machine
HLM
machine in which laser radiation is generated, together with essential additional facilities (e.g. cooling, power and gas supply) that are necessary to operate the laser, where the laser provides sufficient energy/power to melt, evaporate or cause a phase transition in a part of the workpiece and where the laser beam or workpiece to be processed is guided manually or hand-held during the laser material processing

Note 1 to entry: Generally, HLM can be divided in two representative types (Type 1 HLM and Type 2 HLM) (for examples see Annex A):

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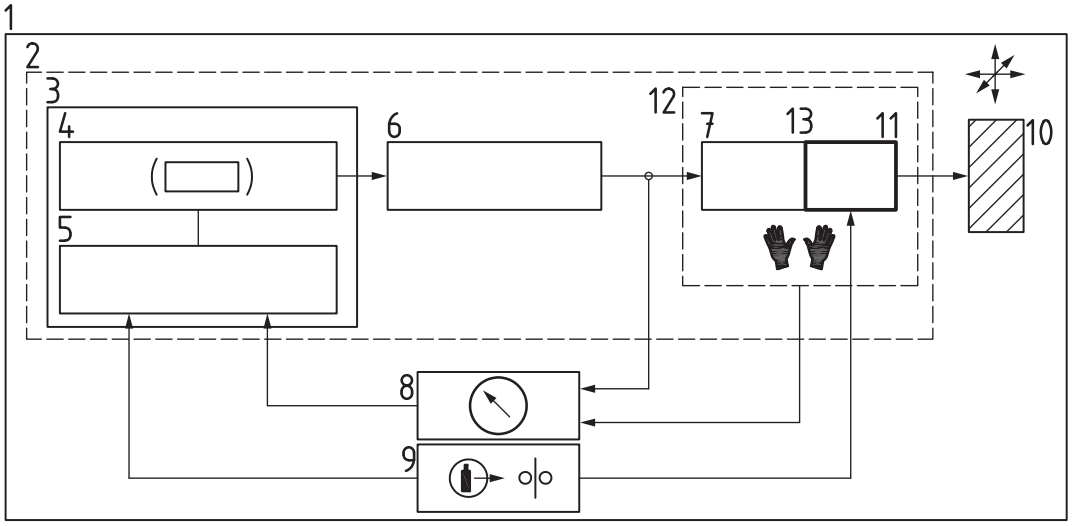
3.4.1
Type 1 HLM
HLM equipped with a fixed laser assembly, where the workpiece is manually guided or manually positioned relative to the laser processing head (beam shaping device) (for examples see Annex A),

3.4.2
Type 2 HLM
HLM equipped with a hand-held or hand-guided laser head (HLH) where the laser processing head is connected to a remotely located (i.e. external) laser device via a beam delivery system (e.g. fibre optical cable) or where the laser source is integral part of the hand-held device (for examples see Annex A).



a) HLM Type1: Hand-held, hand guided workpiece

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b) HLM Type2: Hand-held, hand guided laser head (HLH)

Key

1	laser unit (HLM)
2	laser assembly
3	laser device
4	laser
5	supply (power, cooling, gas)
6	beam-guiding (mirrors, fibres, lenses)
7	beam-shaping device (telescope, focusing, wobbling)
8	measurement systems and control systems, including safety related parts of control systems (SRP/CS)
9	hands of operator
10	workpiece
11	nozzle, feeder (gas/wire/powder), feed drive support, sensors/controls for contact or distance to workpiece
12	hand-held, hand-guided laser head (HLH)
13	Feeding devices (wire, gas, if applicable)

NOTE 1 This example is taken from materials processing.

NOTE 2 Laser unit (HLM), one or more laser assemblies together with handling units, measurement systems and control systems.

NOTE 3 The safety equipment that is usually required is not illustrated here.

NOTE 4 Indication hand-held, hand-guided 

Figure 1 — Illustration of the terms laser, laser device, laser assembly, laser unit, HLH and HLM

3.5
hand-held or hand-guided laser head
HLH
component, which is hand-held or hand guided and contains the laser output/aperture

Note 1 to entry: The HLH can be equipped via an optical fibre with an external laser source or contain the laser system itself, which can be positioned or guided on the work piece surface or in a certain distance to the workpiece. Usually HLM comprises a housing/enclosure with optical elements for beam guidance and shaping, the operating elements, controls and indication elements (e.g. warning LED).

Note 2 to entry: The HLH can further comprise nozzle, feeder (gas/wire/powder), feed drive support, sensors/controls for contact or distance to workpiece, capturing device for fume and gas emissions.

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Note 3 to entry: Depending on the equipment, the HLH can also be connected with feeding devices for wire, gas, cooling water, etc.

3.6
laser hazard area
area in which the laser radiation exposure of the eye and/or the skin exceeds the respective maximum permissible exposure values (MPEs), including the possibility of accidental misdirection of the laser beam

Note 1 to entry: To avoid ambiguities, information whether the laser hazard area is based on the eye or the skin MPEs can be added.

Note 2 to entry: See 3.10 for nominal ocular hazard area.

[SOURCE: IEC 60825-1:2014, 3.47, modified — "laser radiation" was added before exposure and "see nominal ocular hazard area" was exchanged by "including the possibility of accidental misdirection of the laser beam" Note 2 to entry was added.]

3.7
laser system
laser in combination with an appropriate laser energy source with or without additional incorporated components

[SOURCE: IEC 60825-1:2014, 3.51, modified — Note 1 to entry was added.]

Note 1 to entry: See Figure 1.

3.8
laser assembly
laser system together with specific, normally optical, mechanical and/or electrical system components for beam handling and forming

[SOURCE: ISO 11145:2018, 3.19.7, modified — “laser device” was replaced by “laser system”, included “normally” and “beam guiding and beam shaping” was changed to “beam handling and forming”; Note 1 to entry was replaced.]

Note 1 to entry: See Figure 1.

3.9
laser device
device where the laser radiation is generated, together with essential additional facilities (e.g. cooling supply, power supply and gas supply) that are necessary to operate the laser

[SOURCE: ISO 11145:2018, 3.19.6, modified — "apparatus including the laser" was changed in the definition to "device where the laser radiation is generated"; Note 1 to entry was replaced.]

Note 1 to entry: See Figure 1.

3.10
nominal ocular hazard area
NOHA
area within which the beam irradiance or radiant exposure exceeds the appropriate corneal maximum permissible exposure (MPE), including the possibility of accidental misdirection of the laser beam

Note 1 to entry: If the NOHA includes the possibility of viewing through optical aids, this is termed as the “extended NOHA (ENOHA)”.

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3.11
nominal ocular hazard distance
NOHD
distance from the output aperture beyond which the beam irradiance or radiant exposure remains below the appropriate corneal maximum permissible exposure (MPE)

Note 1 to entry: If the NOHD includes the possibility of viewing through optical aids, this is termed as the "extended NOHD (ENOHD)".

3.12
nominal skin hazard area
NSHA
area within which the beam irradiance or radiant exposure exceeds the appropriate maximum permissible exposure (MPE) for the skin, including the possibility of accidental misdirection of the laser beam

3.13
nominal skin hazard distance
NSHD
distance from the output aperture beyond which the beam irradiance or radiant exposure remains below the appropriate maximum permissible exposure (MPE) for the skin

3.14
nominal hazard zone
NHZ
space within which the level of the direct, reflected, or scattered radiation may exceed the applicable MPE

[SOURCE: ANSI Z136.1:2022, modified — "and where exposure levels beyond the boundary of the nominal hazard zone are below the applicable MPE" was deleted.]

Note 1 to entry: It is the largest area between NSHA and ENOHA if the NOHA includes the possibility of viewing through optical aids.

3.15
supply unit
all devices that provide the process energies and operating material supply, direct to the point of action and are absolutely necessary for the operation of HLM

EXAMPLE Cooling system, power and gas supply.

4 List of significant hazards

4.1 General

The list of hazards and hazardous situations in Table 1 is the result of task and hazard identification determined by the risk assessment carried out in accordance with ISO 12100:2010, Clause 4 for HLMs covered by the scope of this document. The safety requirements and risk reduction measures in Clause 5 and the verification of safety requirements and measures in Clause 6 are based on this risk assessment and deal with the identified hazards by either eliminating them or reducing the risks they generate.

NOTE For an example of risk assessment for HLM, see Annex B.

4.2 Main hazards

Laser radiation is the physical type of energy transfer in which laser material processing is carried out with a HLM. To process materials, the irradiance or the radiant exposure applied needs to reach such orders of magnitude, that several hazards can arise:

a) primary hazards by the laser beam, include the direct laser beam, specular reflected laser beam and/or scattered laser beam;

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