**Handheld Laser Device Appendix**

**Introduction**

The purpose of this appendix is to draw attention to the hazards related to Class 3B and Class 4 Handheld Laser Devices (HLD). Depending on the application and the location/operating conditions significant hazards can be present. This appendix describes both the areas of hazards as well as protective measures.

This document deals with the specific hazards resulting from laser radiation arising in HLD operation, when they are used as intended and under condition of misuse which are reasonably foreseeable.

Some examples of applications and potential safety issues are:

**Cutting:**

Direct beam: the beam can propagate through cutting kerf or (at the end of the sheet/cut) propagate past the work piece, even when the HLD is equipped with a touch control.

Reflected beam: if the energy coupling efficiency of the laser beam to the processing material is poor, too much beam energy can be reflected (specular or scattered).

**Surface operations** (Cleaning, heat-treatment, coating):

Direct beam: the beam can propagate past the work piece (especially near edges); if the HLD is free hand-held, in accidental situation the beam can propagate everywhere.

**Welding:**

Direct beam: the direct beam can propagate through gaps (e.g., butt welding)

Reflected beam: if the energy coupling efficiency of the laser beam to the processing material is poor, too much beam energy can be reflected (e.g., T-joint, corner joint),

Forensics:

Mobile Finger Print detector used at crime scenes

### **General**

Laser radiation hazards can originate both from direct and reflected laser beams, which may cause eye and skin injuries.

The normal use for operation, maintenance, and servicing as well as malfunction and reasonably foreseeable fault conditions shall be considered for risk assessment and protection against laser radiation hazards.

Several factors affect the energy coupling efficiency of laser beam to the processing material. They can be laser related (wavelength, incident angle, and polarization) and material related (material reflectivity, surface roughness, oxide layer, and surface pollution).

Due to a possible large NOHZ, especially in free workspace and surroundings applications without barriers or shielding the laser workplace with appropriate laser guards, the personnel inside the NOHZ can be endangered by the laser radiation.

Possible emission sources of unintended direct laser beams, specular reflection and scatter radiation during operation, maintenance and servicing are including but not limited to in the following:

## **Hazards related to the use of HLD**

The particular hazards related to HLD depend decisively on the application, operating conditions and the persons those who operate the HLD and the location the HLD is used

### Unauthorized operation

The persons those who operate the HLD shall be trained and authorized.

The following hazards are related to operators of HLDs:

1. unauthorized start-up or operation;
2. insufficient training for the drivers or operators;
3. accidental restoration of energy supply after an interruption;
4. accidental starting or continued operation.
5. forget to wear appropriate protection personal equipment (PPE).

### Improper movement

The following hazards are related to improper movement:

1. movement without all parts in safe position;
2. insufficient ability of HLD to be slowed down or to be stopped;
3. excessive speed of moving parts in HLD;
4. lack of smooth movement due to entanglement (e.g., fibre optic cable);
5. fall from height (e.g., fiber, e-cable).

### **Unshielded application of HLD in open workspace and surroundings**

With HLD is often difficult to shield the process zone completely.

The following hazards are related to unshielded applications:

1. misdirection of the laser beam or the wrong positioning and orientation of workpiece;

## unauthorized personnel enter location without giving a notice

## **Hazards by disregarding ergonomic principles**

The following are related with hazards by disregarding ergonomic principles:

1. improper design or location of indicators and visual displays units;
2. inadequate consideration of human anatomy and movement of operators;
3. tough or painful repetitive activity;
4. unhealthy postures or excessive effort.
	1. Inherent hazards

The following hazards can emanate from a HLD:

1. Eye hazards
2. Skin hazards
3. mechanical hazards;
4. electrical hazards;
5. thermal hazards;
6. fume hazards;
7. fire hazards;
8. vibration hazards;
* chemicals;
* ~~toxic fumes;~~
* obstacles;
* explosive materials;
* non-ionizing radiation;
1. Danger due to the broadband wavelengths of the process radiation, which can also be re-emitted;
2. low-frequency electromagnetic radiation;
3. radio frequency electromagnetic radiation;
	1. Hazards induced by external effects

Deterioration or fluctuation of environmental conditions in which the HLD operates can interfere the normal operation of the HLD and can induce malfunction of the HLD or its key component devices thus giving rise to hazardous conditions and/or making intervention necessary within the laser hazard area or other hazard areas.

Additional parameters and events that can be the causes of the environmental interferences include:

1. temperature;
2. humidity;
3. external shock/vibration;
4. vapours, dust or gases from the environment;
5. electromagnetic-interference;
6. lightning strike;
7. source voltage interruption/fluctuation;
8. insufficient hardware/software compatibility and integrity;
9. HLD capable of being separated or disconnected from the external laser device that is located remotely from the laser device.
10. non-observance of interface specification (including power limits, control signals);
11. Contamination e.g., use in a reactor radiation area.
	1. Confined space

A compact HLD, or a hand-held or hand-operated processing head can be used in the confined spaces, additional hazards can be constituted by:

1. concentration of harmful substances in the air;
2. enrichment of process gases (nitrogen, argon, helium, oxygen) in the air;
3. oxygen depletion;
4. electrical current;
5. increased radiation hazard through direct as well as directly or diffusely reflected laser radiation;
6. increased tripping and impact (mechanical shock) hazard.
	1. Working at heights

An integrated compact HLD or a compact hand-held or hand-operated laser processing head as a component device of an extended HLD can be used at heights:

1. falling objects;
2. fall of the user;
3. possibility to bring a laser beam above peripheral protection.
	1. Environmental effects

Hazards can directly affect the user due to the operating environmental conditions. This applies in particular when HHLDs are used outdoors.

This includes the following environmental effects due to:

1. temperature (cold, heat);
2. humidity (rain, fog, hail);
3. mechanical effects (vibration, wind pressure);
4. electromagnetic effects (lightning strike);
5. visibility (sunlight, lighting);
6. inhalation;
7. ingestion;
8. evacuation.

Second hazards, which are caused by laser beam/material interaction, such as sparks, the generation of hazardous substances (fumes, vapours, gases), fire/explosion risks or the generation of secondary radiation, e.g. bright light and ultraviolet (UV) light.

**Recommended Control Measures**

Setup a laser controlled area (LCA)

Door interlock at the entry of LCA, when practical

Operated by a “Deadman” switch/Emergency Stop button

Key switch of the equipment

Safety design of the HLD trigger

Safety design of preventing HLD shooting laser into free space accidentally

Laser Protective Eyewear

Clothing/gloves

Warning labels/alarm light at the entry of LCA

Warning labels/status light on HLD Ventilation controls

Flammable material control

**The following requirements shall be met:**

1. risk assessment shall be performed;
2. unauthorized human access to laser hazard area shall be prevented by engineering controls.
3. if access cannot be prevented, exposure above the ocular MPE shall be eliminated by use of safeguards and complementary protective measures.
4. inform of the user in the instructions that the HLDs shall only be operated by trained and authorized persons.

NOTE 1 The same protective device may be used to provide simultaneous protection against more than one hazard.

HLDs shall be designed and constructed with the verification of risk assessment to ensure that all reasonably foreseeable hazards and reasonably foreseeable fault conditions including the possibility of accidental misdirection of the laser beam are identified and, if necessary, corrective measures have been taken.

Laser radiation emitted from the HLDs shall be protected by relevant safety measures (e.g., laser guards, screens, Personal Protective Equipment) in such a way that the beam irradiance or radiant exposure by direct laser beam as well as reflected beam and scattered radiation including secondary radiation from irradiated materials does not exceed relevant MPEs for the eye and skin.

### **A. 8 Protection during operation and maintenance**

In the laser hazard area, human exposure shall be limited during operation and maintenance to levels of laser radiation not exceeding the Maximum Permissible Exposure (MPE) limits.

If the exposure cannot be limited by safeguards and complementary engineering protective measures, the user shall be informed in the instructions about the use of administrative measures or the use of Personal Protective Equipment (for example laser protective eyewear, helmet and clothing).

### **A.9 Protection during service**

During servicing it shall be ensured that only authorized persons are allowed access to zones exposed to levels of laser radiation that exceed MPE values for Class 3B and Class 4 HLDs shall therefore be designed, and appropriate safety measures and risk reduction measures provided, with respect to the following four situations listed in order of preference.

1. servicing takes place with laser emission switched off;
2. servicing takes place in laser hazard area to which unauthorized human access is controlled in the same manner as during production (e.g., interlocked cover);

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

#### **A.10 Beam delivery system**

All beam delivery systems including beam-guiding devices and beam-shaping devices (e.g., laser processing heads) which are incorporated in HLDs shall require a tool for disconnection to be interlocked (e.g., against disconnection or opening the access panels) to prevent access to hazardous laser radiation generated due to the disconnection or the interruption of interlocking.

The HLD shall be switched off or the laser radiation from the HLD shall be shut off in the appropriate area of interface prior to the disconnection or opening of components or access panels incorporated in the beam delivery systems (e.g., to inspect or adjust the optical components).

Appropriate engineering measure shall be ensured so that no hazardous laser emission is emitted from the beam delivery system before the specified laser beam exit aperture for laser processing.

To avoid unintended emission of laser radiation out of the beam delivery system following features shall be implemented:

* connector to laser system: safety position switches or contacts for the safety control respectively;
* laser fiber: control means for fiber breakage and unacceptable temperature rise (both integrated into the safety control);
* connector to laser processing head HLD: safety position switches or contacts for the safety control respectively.

Collimating and focusing optical elements in the HLD:

* withstanding of HLD housing for at least 10 s (acc. to IEC 60825-4, corresponding to T3, continuous monitoring by observation) and manual laser stop;
* control means for an unintended misguided beam (elements out of alignment), e.g., or unacceptable temperature rise of HLD housing (both integrated into the safety control), e.g., by monitor diodes, thermocouples.

Scanning optics: controlled operation of the scanner, malfunctions (defect/stoppage) shall lead to a laser stop.

1. **11 INFORMATIVE REFERENCES**

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

ISO 11553-2 Safety of machinery-Laser processing machines- Part 2 Safety Requirements for hand-held laser processing devices

ANSI B11.0 Safety if Machinery

ANSI/AWS Z 49.1 Safety in Cutting, Welding, and Allied Processes

DGUV Information 203-093 Guidance for risk assessment in the operation of open laser beams I facilities for materials processing that are hand-held

“Handguided laser systems for new applications in material processing” H.Haferkamp, M.Goede, A. Ostendorf, M.Drugalla, O.Berend, and C.Schmid; ICALEO 2001

“Technical safety measures for the safe use of hand-held laser processing devices” Thomas Puester, Juergen Walter, Michael Hustedt, and Volker Wesling: Journal of Laser Applications (2012)