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Oprichter van Laprocon

Keurmeester van  
laserlaswerkplekken

**Hoe ziet een veilige  
laserlaswerkplek eruit?**

**LAPROCON**

# Laser safety

## Handheld laser welding



**Kennisdeeldag Laserlassen / Nieuwegein**

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## Ingenieurs & Adviesbureau

Laser safety technology

Fume Extraction & Filter technology

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### Laser technology

- welding, cutting, drilling, scribing/engraving, ablating, cladding, cleaning, measuring, repairing
- product development, process integration, laser system integration

### Laser safety products & services

- Risk and hazard assessments
  - Equipment / European directives:
    - Machinery, Low Voltage directive, General Product Safety, Medical Devices
  - Work environment
    - Arbo-wet (NL) / Welzijnswet (B) / Arbeitssicherheit (D)
- Laser product en machine classification (laser class 1, 1M, 1C, 2, 2M, 3R, 3B en 4)
- American FDA/CDRH registration (export into the US / US customs demand)
- Laser safety training and instruction (in collaboration with 'Mikrocentrum Opleidingen & Advies')
- Laser Safety Officer (LSO) / all services)
- Laser safety products
- Extraction and filtration systems
- Certification & enforcement



# Content

## Introduction handheld laser welding

- Equipment examples
- EU health and safety regulations
- CE Declaration of conformity

## Hazard and risk assessment

- Laser hazard distance
- Damage threshold values / eye and skin
- Laser product classes

## Laser safety precautions

- Engineering solutions
- Administrative procedures
- Personal protective equipment

## What will be your plan of action?



## LASER CLASSES IN ACCORDANCE WITH EN 60825-1

Class	Description
1	Accessible laser radiation is harmless
1M	Accessible laser radiation is harmless without optical instruments (magnifying glass, telescopes)
2	Accessible laser radiation in the visible spectrum (400 nm to 700 nm), is harmless when exposure to it is brief
2M	Like class 2, without optical instruments (magnifying glass, telescopes)
3R	Laser radiation dangerous for the eye
3B	Laser radiation dangerous for the eye, in some cases also for the skin
4	Laser radiation very dangerous for the eye and dangerous for the skin, danger of fire and explosion

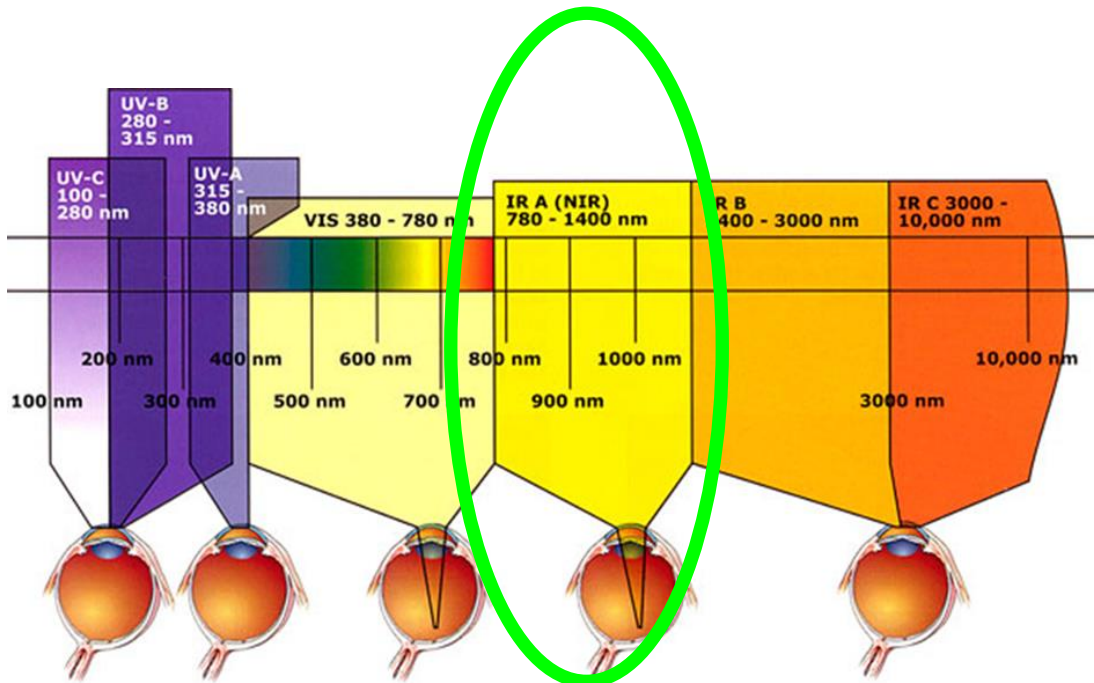
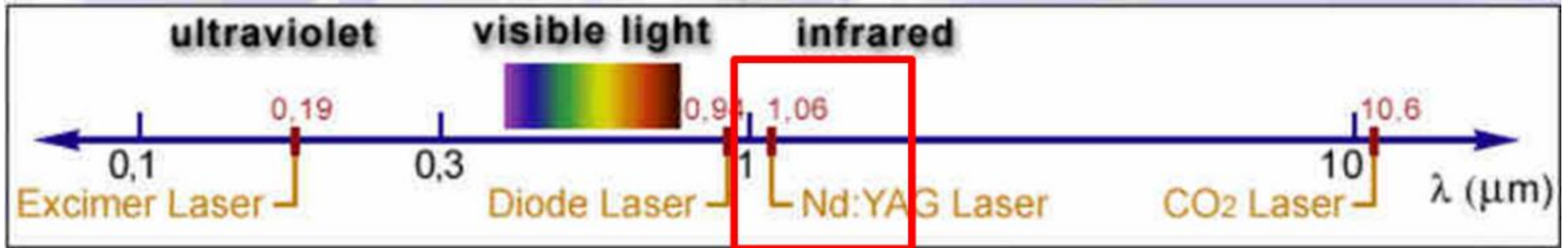
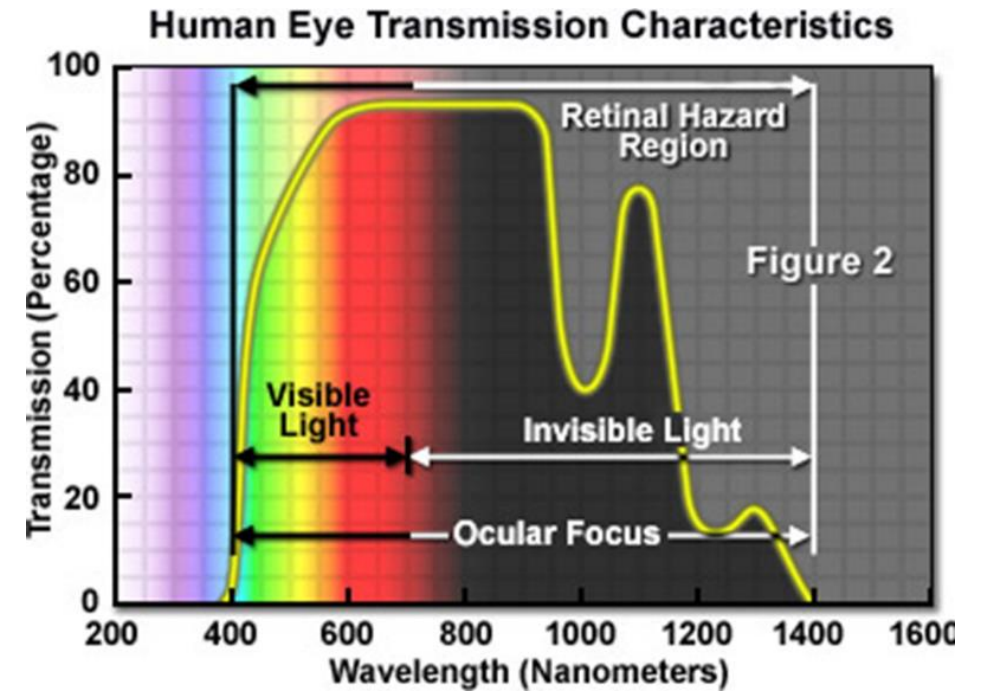


Figure 9. The above table shows the depth of penetration of electromagnetic radiation in the human eye.



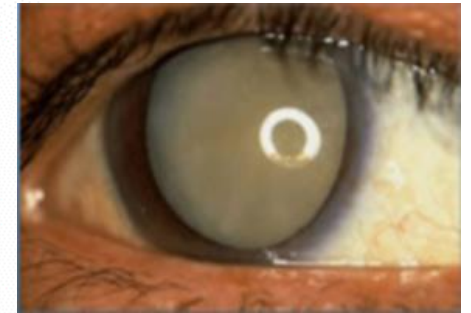


**Table D.1 – Summary of pathological effects associated with excessive exposure to light**

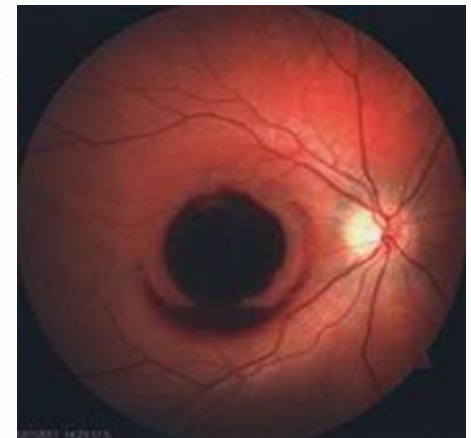
CIE spectral region <sup>a</sup>	Eye	Skin
Ultra-violet C (180 nm to 280 nm)	Photokeratitis	Erythema (sunburn)
Ultra-violet B (280 nm to 315 nm)		Accelerated skin ageing process Increased pigmentation
Ultra-violet A (315 nm to 400 nm)	Photochemical cataract	Pigment darkening Photosensitive reactions
Visible (400 nm to 780 nm)	Photochemical and thermal retinal injury	Skin burn
Infra-red A (780 nm to 1 400 nm)	Cataract, retinal burn	Skin burn
Infra-red B (1,4 µm to 3,0 µm)	Aqueous flare, cataract, corneal burn	
Infra-red C (3,0 µm to 1 mm)	Corneal burn only	

<sup>a</sup> The spectral regions defined by the CIE are short-hand notations useful in describing biological effects and may not agree perfectly with spectral breakpoints in the MPE Tables A.1 to A.3.

Cataracts  
(780 – 1400 nm)

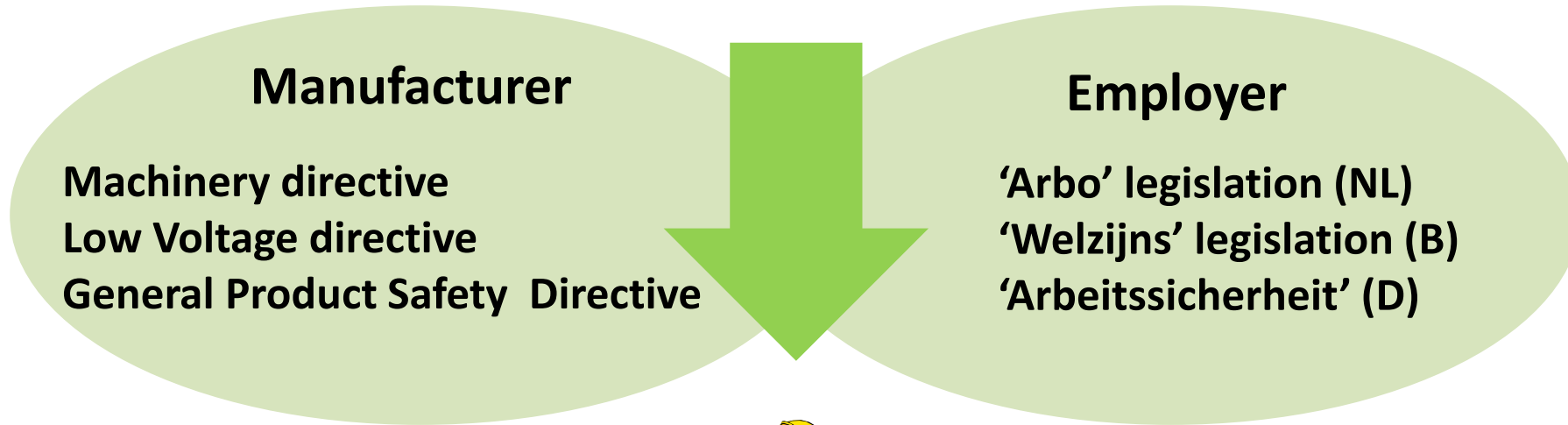


Retinal burn  
(780 – 1400 nm)



## Safe equipment

## Safe work environment



## Work-environment



## Safe work environment

### European Union:

DIRECTIVE 2006/25/EC

On the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation) - laser radiation included.

**Creating and maintaining a laser safe work environment!**

<b>Machinery Directive</b>	<b>2006/42/EC</b>
<b>Low Voltage Directive</b>	<b>2014/35/EU</b>
<b>General Product safety Directive</b>	<b>2001/95/EC</b>

## Some examples / list is not complete

- IEC-EN 60825 part 1-17 / Laser safety standard
- ISO 11252  
Lasers and laser-related equipment –  
Laser device - Minimum requirements for documentation
- EN-ISO 11553-1  
Safety of machinery - Laser processing machines –  
Part 1: General safety requirements
- EN-ISO 11553-2  
Safety of machinery - Laser processing machines –  
Part 2: Safety requirements for hand-held laser processing devices
- EN 12254  
Screens for laser working places - Safety requirements and testing
- EN 207  
Personal eye-protection - Filters and eye-protectors against laser radiation (laser eye-protectors)

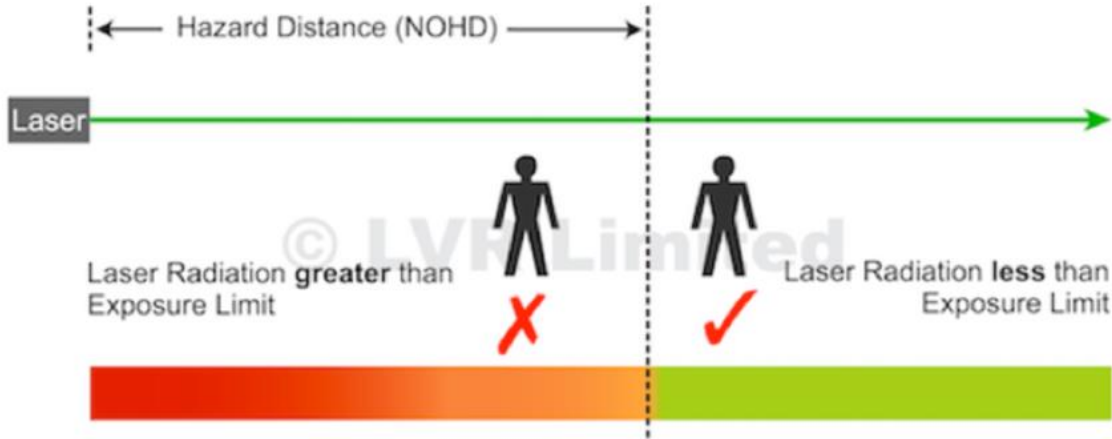


# Manufacturer / Supplier / Importer / Employer responsible & liable

Table F.2 – Summary of manufacturer's requirements (1 of 2)

Requirements subclause	Classification						
	Class 1*	Class 1M	Class 2	Class 2M	Class 3R	Class 3B	Class 4
Description of hazard class Annex C	Safe under reasonably foreseeable conditions	As for Class 1 except may be hazardous if user employs optics	Low power; eye protection normally afforded by aversion & active responses	As for Class 2 except may be more hazardous if user employs optics	Direct intrabeam viewing may be hazardous	Direct intrabeam viewing normally hazardous	High power; diffuse reflections may be hazardous
Protective housing 6.2	Required for each laser product; limits access necessary for performance of functions of the products						
Safety interlock in protective housing 6.3	Designed to prevent removal of the panel until accessible emission values are below that for Class 3R				Designed to prevent removal of the panel until accessible emission values are below that for Class 3B or 3R for some products		
Remote Interlock 6.4	Not required					Permits easy addition of external interlock in laser installation. Not required for some products in Class 3B	
Manual Reset 6.5	Not required						Requires manual reset if power interrupted or remote interlock is actuated
Key control 6.6	Not required					Laser inoperative when key is removed	
Emission warning device 6.7	Not required				Gives audible or visible warning when laser is switched on or if capacitor bank of pulsed laser is being charged. For Class 3R, only applies if invisible radiation is emitted		
Attenuator 6.8	Not required					Gives means to temporarily block beam	
Control locations 6.9	Not required				Controls so located that there is no danger of exposure to AEL above Classes 1 or 2 when adjustments are made		
Viewing optics 6.10	Not required		Emission from all viewing systems shall be below Class 1M AEL				
Scanning 6.11	Scan failure shall not cause product to exceed its classification						

# Nominal Ocular Hazard Distance (NOHD)



Nominal Ocular Hazard Distance (NOHD)



Lens diameter 10 mm

Beam diameter  
Appr. 8 mm

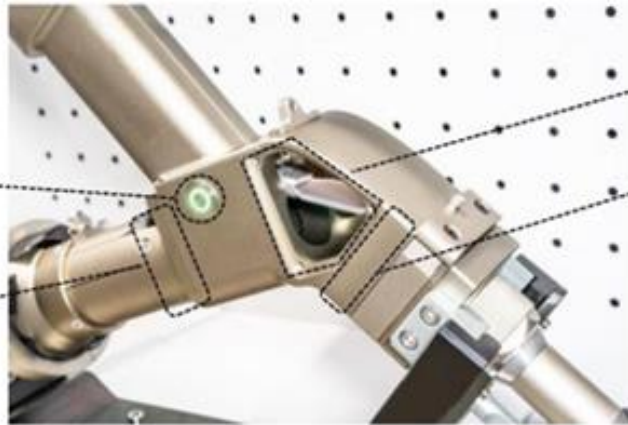
Focal distance 150 mm



The angle  $\theta$  is appr.  $3^\circ$

Beveiligingsknop

Collimerende lens

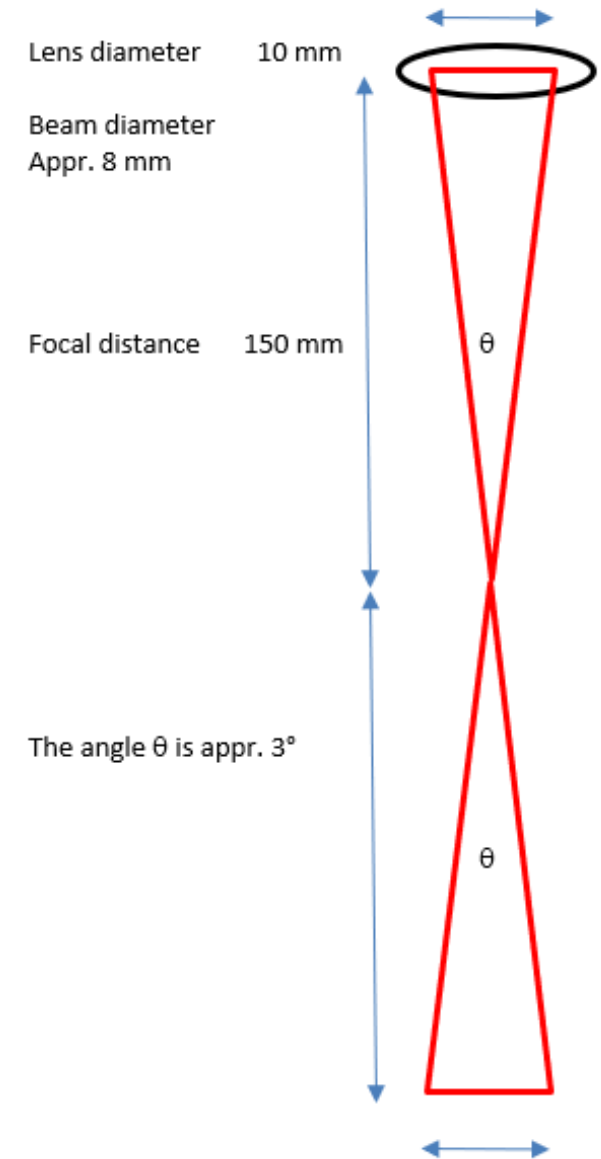


Hoeklens

Convergerende lens

# Nominal Ocular Hazard Distance (NOHD)

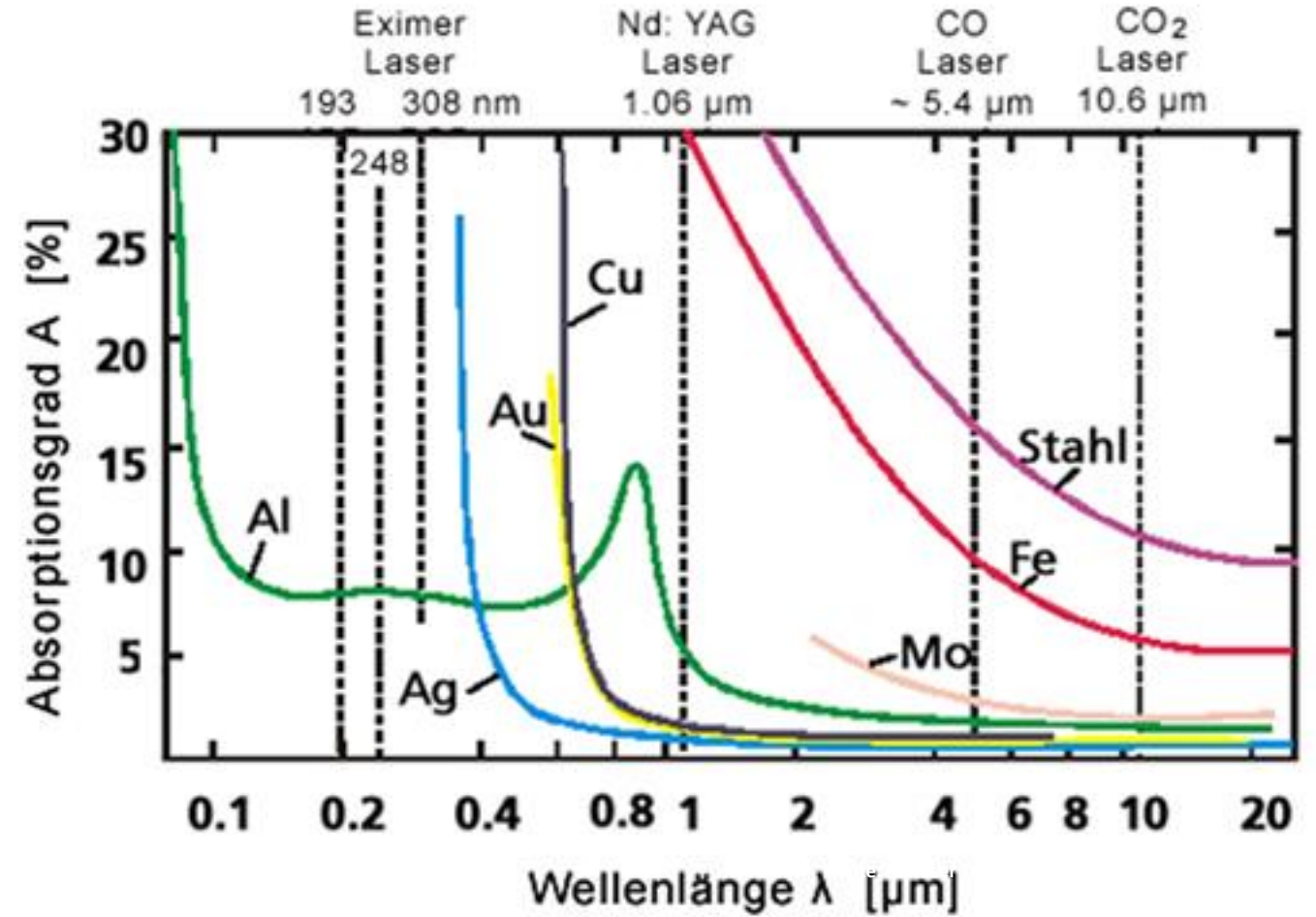
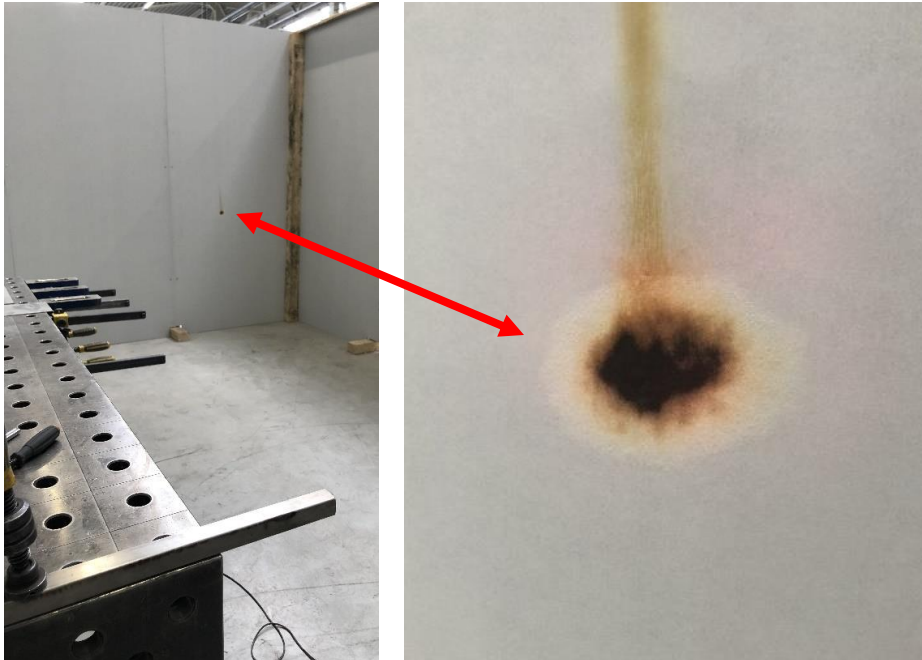
Laser Beam Wavelength	1070 nm	▶
Exposure to Beam Time Frame	30000 s	▶
Laser Output Power	1500 W	▶
Axis 1 Laser Beam Diameter (d63)	0.5 mm	▶
Axis 2 Laser Beam Diameter (d63)	0.5 mm	▶
Axis 1 Beam Divergence (d63)	3 °	▶
Axis 2 Beam Divergence (d63)	3 °	▶
Laser to Target Distance	1 m	▶



Limiting MPE	50 W/m <sup>2</sup>	MPE Limit Aperture	7 mm
Accessible Emission	683 kW/m <sup>2</sup>	ExNOHD Aperture	50 mm
MPE Excess	13700	Skin Aperture	3.5 mm
Class 1 AEL Excess	769000	Skin Limit MPE	10 kW/m <sup>2</sup>
Test Class	4	Skin AEL	683 kW/m <sup>2</sup>
Class Time Base	100 s	Skin MPE Excess	68.3
Beam Irradiance	683 kW/m <sup>2</sup>	N.O.H.D.	118.1 m
Radiant Exposure	20.5 GJ/m <sup>2</sup>	Extended NOHD	843.7 m
Axis 1 Spot Size (1/e)	52.9 mm	Axis 2 Spot Size (1/e)	52.9 mm

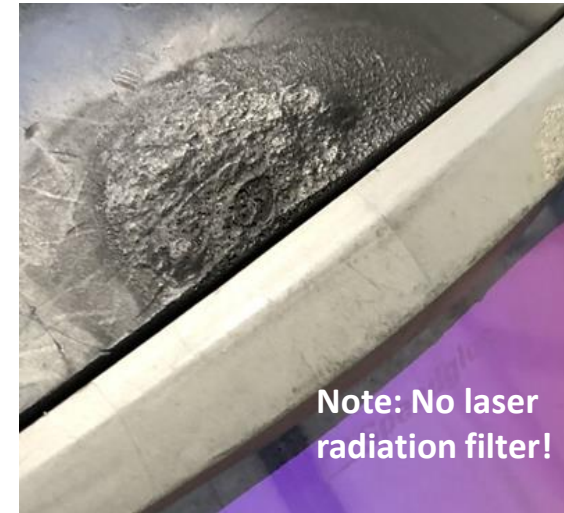
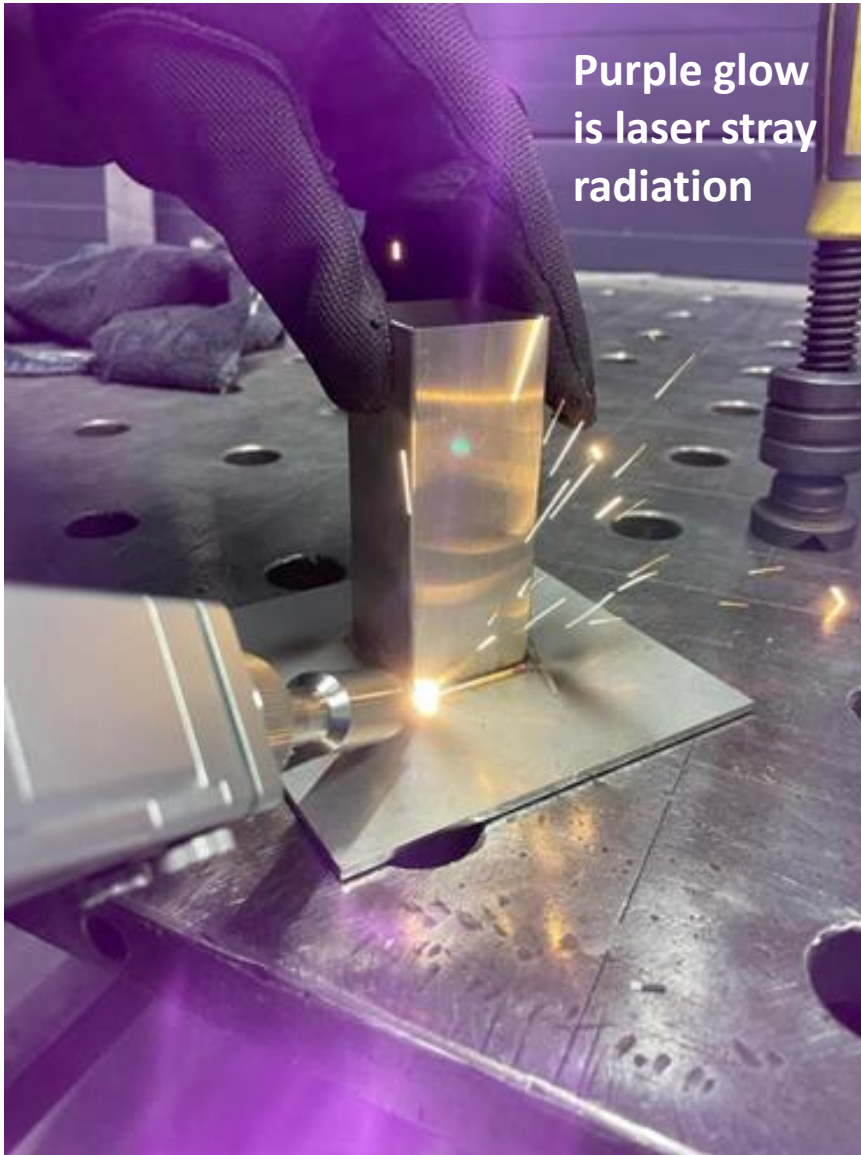
MPE Maximum Permissible Exposure = Damage threshold value

# Nominal Ocular Hazard Distance (NOHD)





# Nominal Ocular Hazard Distance (NOHD)





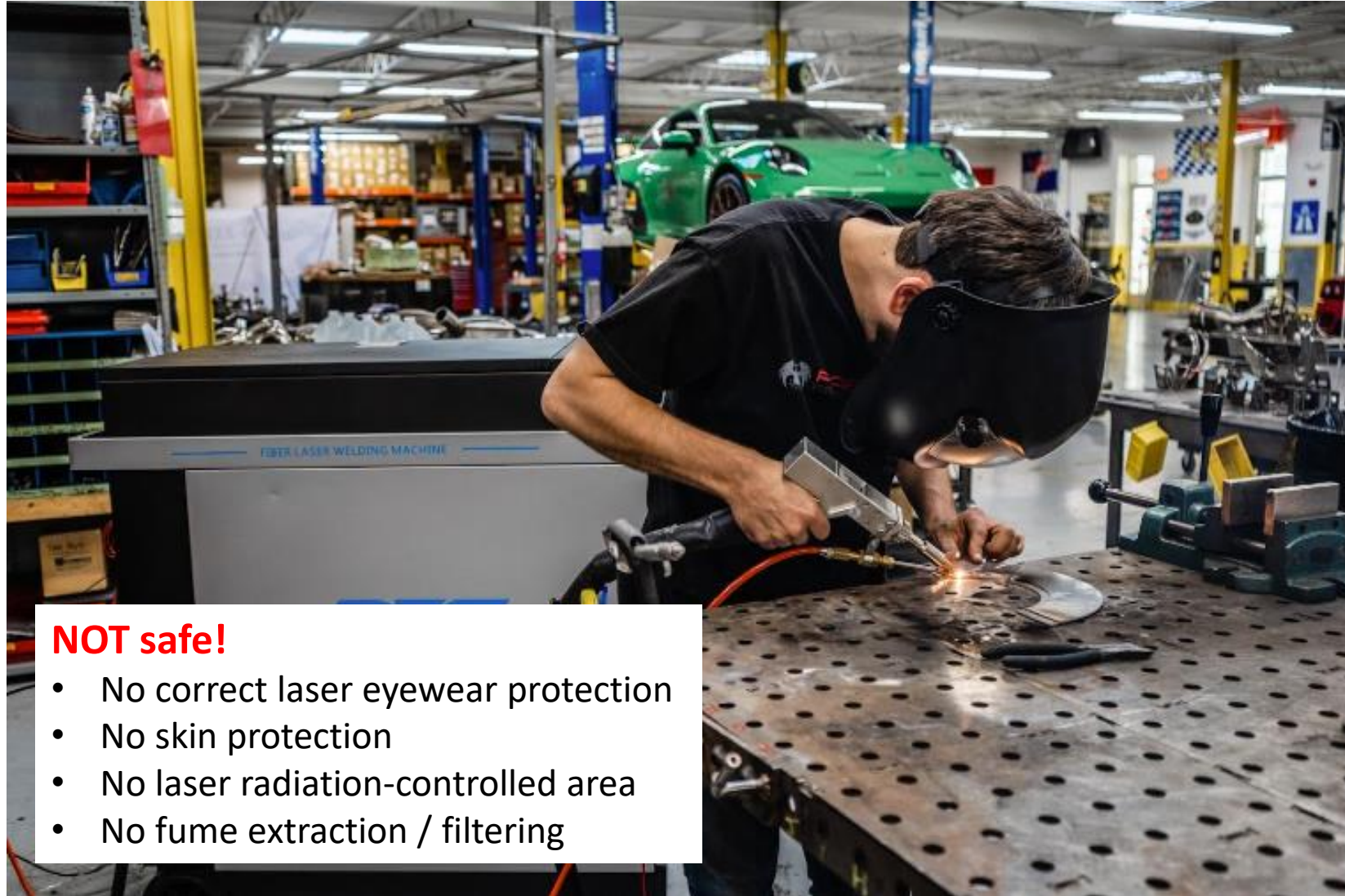
## Laser safety precautions

Laser radiation escaping from the backside of weld/melt pool....

**Look at the coffee cup!**

Courtesy - VLH Welding Group B.V.

## Executing laser hazard & risk assessment



### **NOT safe!**

- No correct laser eyewear protection
- No skin protection
- No laser radiation-controlled area
- No fume extraction / filtering

## Control measures

- **Engineering Controls** Laser system, workroom
- **Administrative Procedures** Laser Safety Procedure
- **Personal Protective Equipment** Laser safety eyewear

**Laser stray radiation safe?  
No top / no ceiling**



Courtesy – CEPRO



Courtesy – WE-Metal

## Laser filter windows | Laser protective windows

WAVELENGTH (NM)	OD	EN 207 OPERATING MODE / TESTED PROTECTION LEVEL
960 - <1030	(OD7+)	D LB6 + IRM LB7
1030 - 1400	(OD8+)	D LB6 + IRM LB8

### DIN EN 60825-4

840-3000nm | 40,7 kW/m<sup>2</sup> | T3 | t<sub>max</sub> = 63s

840-3000nm | 18,1 kW/m<sup>2</sup> | T2 | t<sub>max</sub> = 105s

5200-14700nm | 50,9 kW/m<sup>2</sup> | T2 | t<sub>max</sub> = 105s

**Visible light transmission**      **16 %**

Thickness 3 mm



## Administrative Procedures

- Executing laser hazard & risk assessment
- Authorised laser welder
  - Laser safety training and instruction
- Laser Safety Procedure
  - Stand Operation Procedure
  - Stainless steel, aluminium - ‘reflections’
  - Who is present in the close vicinity (‘NOHD’)?
  - Closing of visors (of the MIG/TIG welding hoods / outside the laser welding area)



Dr. E.M. Burns pioneer in the development of laser safety regulations, earns the nickname "Lefty."



## Lasermet



### Passive ALF Interlocked Laser Welding Helmet

#### Interlocked Laser Safety Helmet for Hand-held Laser Welding

Designed specifically to protect welders from stray laser radiation, the interlocked helmet design requires the helmet to be properly worn with the visor closed before firing the laser.

- Protection from laser radiation
- Passive laser filter protection
- Integrate with Laser Safety Interlock® Systems



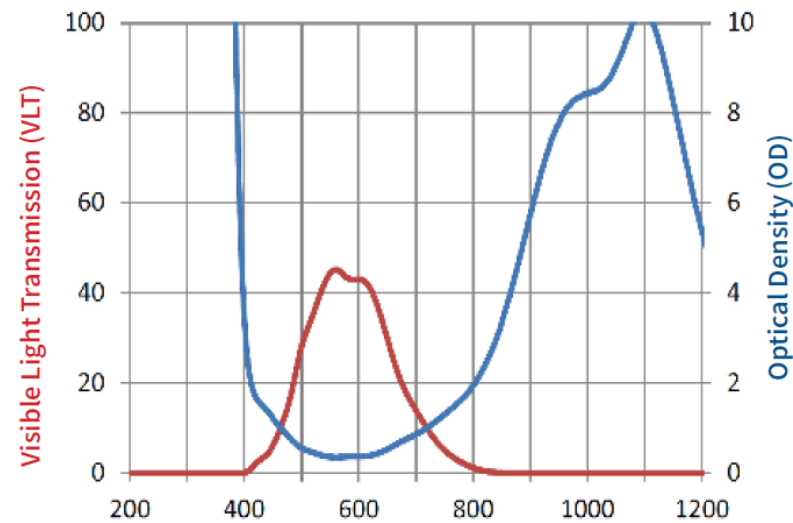
ICS-9 Interlock® Controller



## Univet



EN207:2009 +AC:2011, EN207:2017	
180-315	D LB8 + IR LB4
>315-380	D LB4 + IR LB6 + M LB6Y
915-1180	D LB6 + IR LB7
2720-2940	DI LB4
5000-11000	DI LB3
EN 12254: 2010 +AC:2011	
D AB8 + IR AB3	180 - 315
D AB5 + IR AB6 + M AB6Y	>315-380
D AB5 + IR AB7	915 - 1180
D AB2	2720 - 2940
D AB2 + I AB3	5000 - 11000







This is NOT laser safety eyewear!



LB-Rating Specs (EN 207) <sup>a</sup>
190 to 315 nm (D LB8 + IR LB4 + M LB6Y)
>315 to 425 nm (DIRM LB5)
790 to <808 nm (DIRM LB3)
808 to 840 nm (DIRM LB4)
>840 to 950 nm (DIRM LB5)
>950 to 1080 nm (D LB6 + IRM LB7 <sup>b</sup> )
>1080 to 1090 nm (DIRM LB5)



## What will be your plan of action?

### Reliable hand-held laser welding equipment supplier

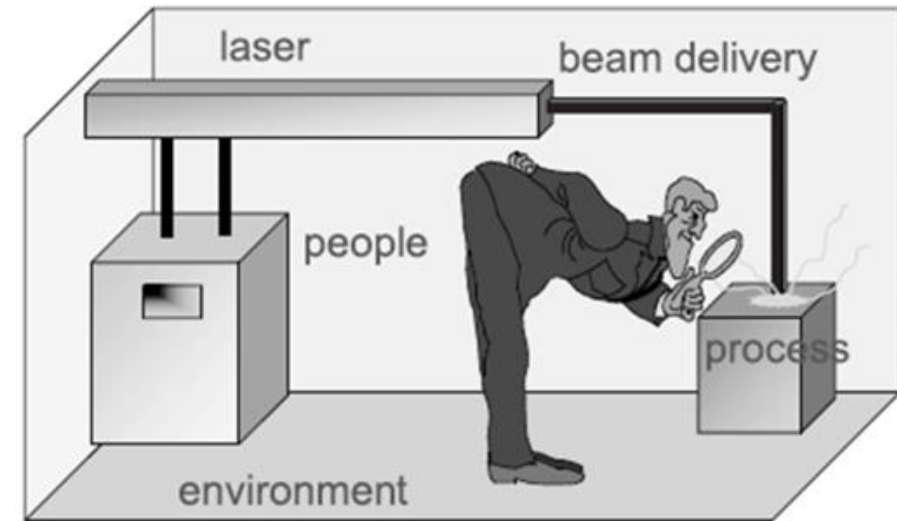
- CE Declaration of conformity

### Execute laser hazard and risk assessment

- Laser welding process location
- Employees involved

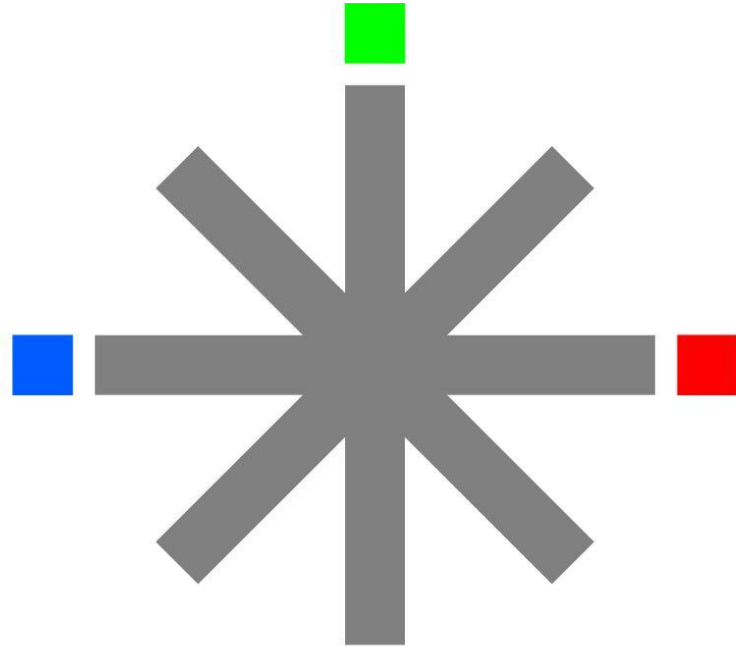
### Laser safety precautions

- Engineering solutions
- Administrative procedures
- Personal protective equipment



Representation of complete hazard evaluation approach.





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