PLEXIGLASS LASER CUTTING WORKSHOP

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1. The world of the power laser (1)

"A **sharp, powerful radiation** that can drill metals. **cut plastics**". Laser machinery work plates to make the prototypes and small series objects

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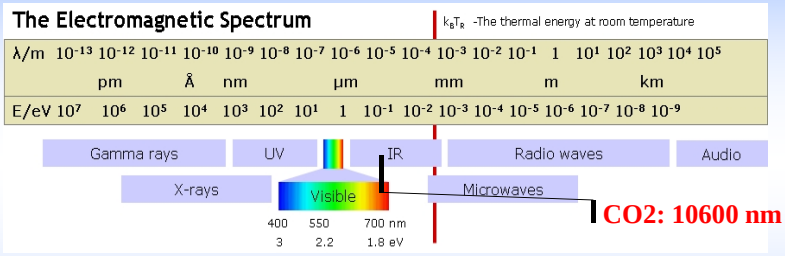
1. The world of the laser (2)

Any lasing material emits to specific vawelenght, for the safety Int.nal rules is important from **180 nm to 12000 nm.**



Some **laser** beams are **visibile**, other are in the **infrared** or in the UV. Invisible, a man has **no chance to see it in time up to the blindness**

- **CO2 laser can burn the lens, the cornea of the eye.**
- CO2 laser can hurt the skin

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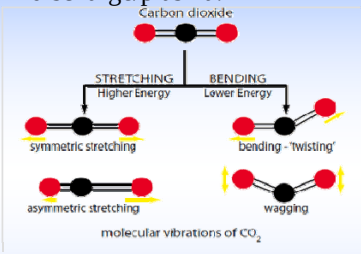
2. The world of the CO2 laser (1)

CO2 laser is a particular, where molecules vibrates pumped by electric discharge/plasma.



A mix of gases: CO2, He, Xe, N2 fill the laser, the plasma activated by H.V. Electrodes ionize CO2 to vibrate, then emit laser energy

Open flow lasers use bottles of gas, in small "sealed tecnology lasers" cathalisys clean the once filled gas.

High power (100 W is SMALL) up to 12000 Watts CW are common.

Fire hazard rises from the beam.

High voltage hazard rises from power supply

Plumes can be toxic or explosive.

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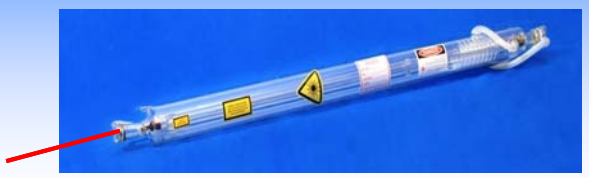
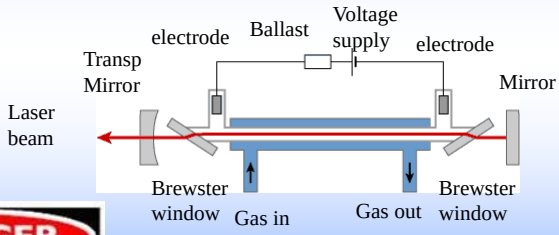
2. The world of the CO2 laser (2)

(small power-glass sealed tecnology





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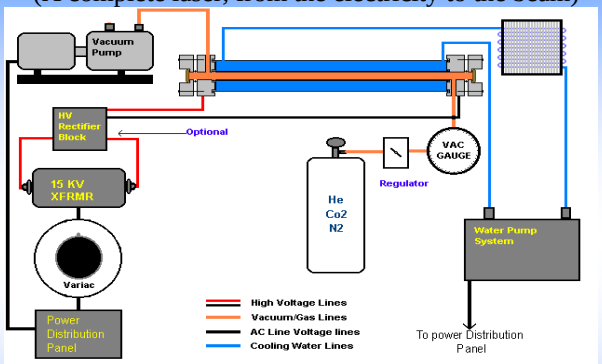
2. The world of the CO2 laser (3)

(A complete laser, from the electricity to the beam)



Dirt, smoke, particles on lenses/mirros pit the surfaces and progressively damage to very poor focusing.

It is hard to transport the CO2 beam through fibers, then is transported by:

- **dielectric or gold coated** mirrors,
- **zinc selenide (ZnSe) or diamond** windows and lenses.

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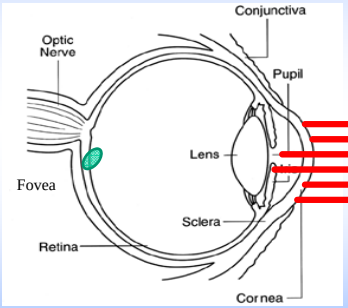
3. The EYE. The most delicate part of the body (1)

CO2 laser radiation hurts the eye. All of the eye adsorbs the radiation. First **damage occurs to cornea and to the lens**. Erithema evolves to cataract

Damages are unexpected as the radiation is invisible. The large heat involves the eye in spite of the direction.



No human reaction move the the eye in time. Burns (tenths of seconds) is possible => high risk of blindness

Shields, filters, safety glasses, upon CEI/IEC safety rules: care the protection of the people

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4. The risk classification of the laser and the Safety Rules. (1)

Lasers are classified at IEC/CEI 60825-1 Rules in accordance with the risk for the eye (and for the skin). **A CO2 laser is typically a class 4 of risk.**

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Five interesting minutes.

Please discuss about the lecture.

i.e.
. The invisible laser light,
. The high power
. The safety system…
. The electrical power system….

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5. Plexiglass laser cutting systems. (1)

The laser system shall be safe when closed, in standard working conditions.
⇒The **safety** of the system is **matter of the manufacturer** in accordance with the main reference Rules:
⇒ . CEI EN 60825-1-4; CEI CT76;
. UNI EN 207, 208 (glasses)
regarding lasers, equipmentes, room and safety courses for the personnel.

The room can be not classified, as the machine is open to class 4 just for SURVEYED maintenance operations.

BUT the access to the room is inhibited during maintenance.

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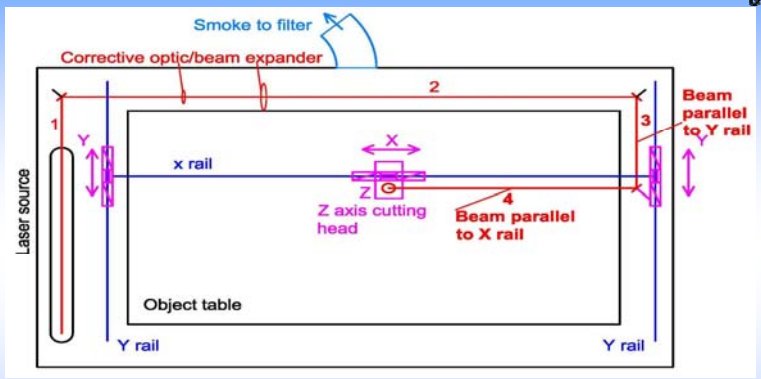
5. Plexiglass laser cutting systems. (2)



Laser generates the beam, 1,2,3,4. Mirrors 1,2,3 are fixed to the frame, mirror 4 is integral with the Y carriage, mirror Z is integral with the head.
A corrective/beam expander optics can be mounted to improve the beam quality.

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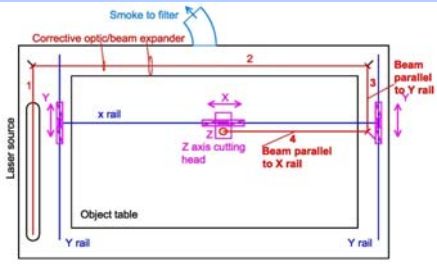
5. Plexiglass laser cutting systems. (3)



Mandatory (1):

. Beam 4 and 3 must be parallel to the rails.

. Beam must be adsorbed against non flammable objects

. plumes ash, … shall be pumped out and filtered

. Safety devices must work.

. Users, operator, technicians must be trained and authorized

. **Beware of fire hazard.** Can happen. **Oxygen increase risks**

. Ash of some materials are explosive on the filter.

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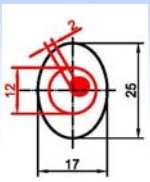
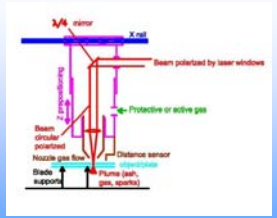
5. Plexiglass laser cutting systems. (4)



Mandatory (2):

. The beam cannot run out of the mirrors, margin shall be left.



. Head lens must be cleaned and cooled by protective gas.

. Beam shall not be focused to optics, to mirrors….

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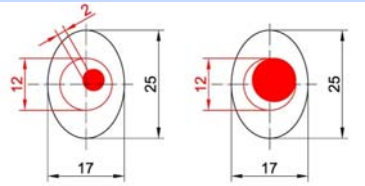
5. Plexiglass laser cutting systems. (5)



Optics best practice.

. A large, parallel beam prevents mirror and lens by optical wear.

. Absence of dust, of ash, ... prolonges their life => **Clean!**

. Avoid unnecessary cleaning of optics, general cleaning prevents wear of optics and gears

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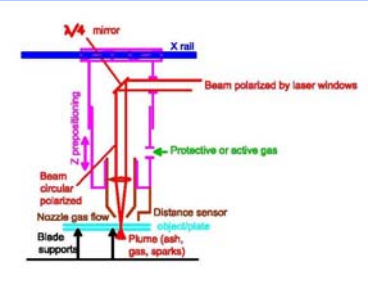
5. Plexiglass laser cutting systems. (6)



The cutting head principles (1)

. Motor-gear-move heads along the rail

. Z-control preset the coarse height of the head

. Distance sensor maintain the fine nozzle height respect the plate

. The gas flows from the nozzle to protect/clean the cut , activate if oxygen

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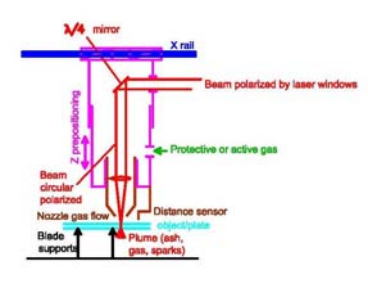
5. Plexiglass laser cutting systems. (7)



The cutting head Optics (2)
. A λ/4 mirror converts the beam to a circular polarisation for symmetrical cut.
. The lens is a Zinc-Selenide made. Focused coax to the nozzle.

. Focus preadjusted to the top of the plex plate, fine focusing upon the quality cut.
. Cut quality depends upon 60% by lens and by focus

Note. No windows, no objects on the beam after the les.

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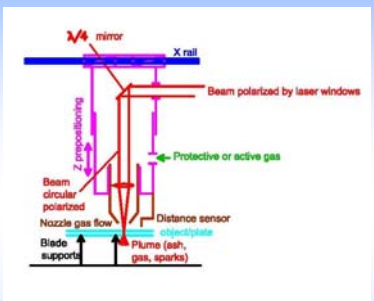
5. Plexiglass laser cutting systems. (8)



The cutting head operative (3)
. Select the lens at longest focal for the best cutting.
. Lens is disposable part, clean it, but change it when cut/focusing are poor.
.Use only **pure/absolute filtered** protective gas/air; flow before switch on the laser.

. **Plumes** shall be pumped **out** and **filtered**.
. Users, operator, technicians shall be trained and authorized.

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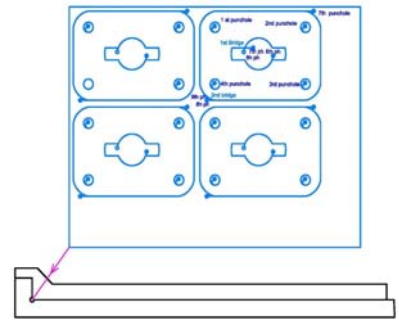
6. Plexiglass drawing and cutting. (1)



Make an axis rule, make some sharp supports.

. refer plate to zero of the rule.

. Any segment end is a discontinuity. Draw a resonable number of “segments”,

. External frame recommended to be draw, objects joined to the frame by bridges.

. Bridges be handcut at the finishing:

. Bridges can be cut by laser at 2nd run.

. Distance between pieces: approx. the thickness of the plate.

.Two pieces with common cuts are rough => evaluate if good.

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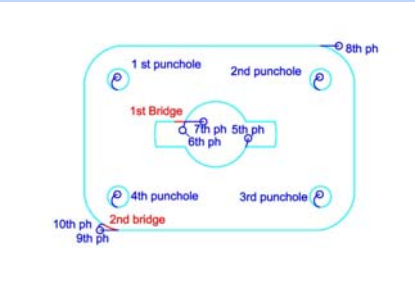
6. Plexiglass drawing and cutting. (2)



Bridges and puncholes

. 2, 4 bridges, simmetry to the center of mass. In straight line as easy to cut, near the edges improve a good finishing.

.Bridges at the end of a run.

. successive segment will start from successive punchole and track.

. Automatic punchole and starting track is fair.

. Starting track should be tangent to the curved tracks

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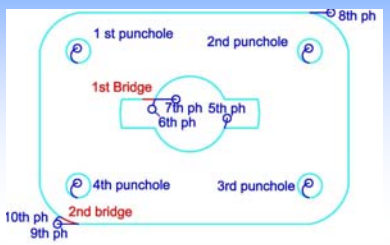
6. Plexiglass drawing and cutting. (3)



Bridges and puncholes
An example.
Guideline: start to cut internal parts, the perimetre be last; use a strategy to reduce bendings.
. 1,2,3,4 Punchole and track the 4 holes. Holes clear.
. Cut 5 Punchole to 1° bridge.
. Cut 6 Punchole to 5° punchole.
. 7 punchole to cut 1st bridge. Central hole clear.
. 8 punchole to 2° bridge.
. 9 punchole to 8 punchole
. 10 pinchole to cut 2° bridge. Part clear.

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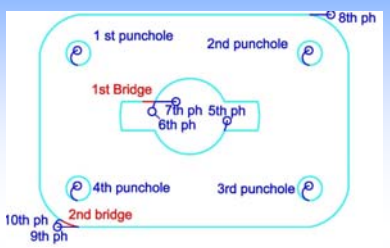
6. Plexiglass drawing and cutting. (4)



Notes:
. Plate must be grip.
. No bending, no deformation.
. Highly repetitive position.

Bridges and puncholes
Why this bridges strategy?
Guideline: Bridges hold loosing parts during the cutting.
. Bridge not necessary at track from 5, as no track from 6 done. Track from 6 incomplete until reach punchole 5, then supported by 1° bridge.
. Track from 7 cut the bridge. Minimum span.

Remark: where the x-y precision is poor, draw bridge cut 1 mm far, then smooth the small zones by hand.

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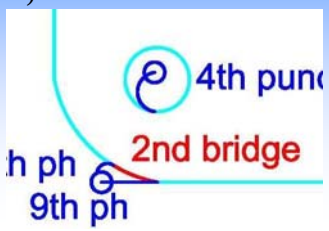
6. Plexiglass drawing and cutting. (5 7.)



Note.
. 9° punchole
usable when piece supported and frame is grip.
A new 10° punchole can be preferable.

Puncholes and start track details. Examples.
Guideline:
. punchole far from track,
. punchole track round, tangent to cutting track.
. A the end the cutting track can bend internally.
. 9th Punchole: leave enough material to hold the bridge.

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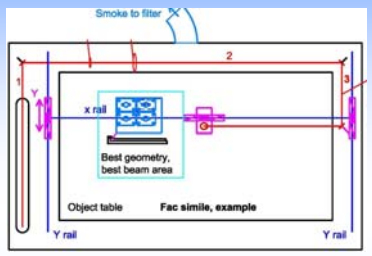
7. Plexiglass operative cutting. (1)



Positioning the plate.
. A part of the plane is optimized Use this part for precise objects, the outer space for rough cuts. This will minimize the wear.
. Refer one side of the plate to a mechanical origin and a rule.

. Repositioning the plate will be easier.
. Use supports with sharp tips, out of the beam run.
. Vacuum holders can hold the parts (far from cut track!)
. To grip the frame to the rule is useful.
. Shot first 4 marks by the laser. Useful for repositioning, evaluate scale, coarse errors, shift….

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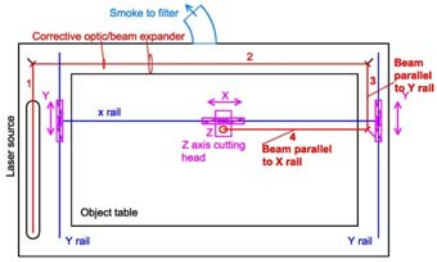
8. Cutting systems maintenance (1)



Maintenance, general.

. Follow the manufacturer instructions

. The maintenance operator is responsible of the safety. Only invited/involved perople is present, the room door locked.

. Laser hazard, then people wear safety glasses.

. He **shall** return the system **back to the operator in safety status**

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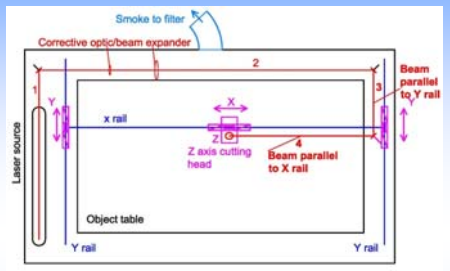
8. Cutting systems maintenance (2)



Maintenance, basic.

. Follow the manufacturer instructions

. Check, align mechanics, rails... before the beam alignment.

. Rails absolute parallel and carriages running free, No mechanical loose.

. Check and clean the hidden zones, no soak of oil, grease: goes to dirty; avoid spray oils.

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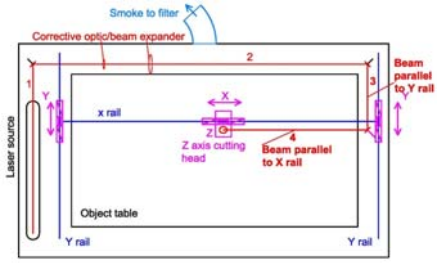
8. Cutting systems maintenance (3)



Maintenance, cleanings.
. Follow the manufacturer instructions
.use only pure products, vacuum cleaner, disposable paper
. Avoid aggressive products.
Diluents, "nitro"are banned.

. Commercial cleaners, sprays suppliers can change the mix of product and cause damages in paints, plastics, gears. Check compatibility before the use!

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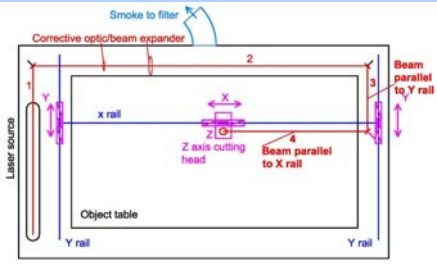
8. Cutting systems maintenance (4)



. Usually the head mirror is $\lambda/4$ to transform polarized beam to circular polarized, => avoid asymmetric thickness of the track

Beam alignement.
Do not focus the beam to the mirror, lenses, it can burn optics!
. IR sensitive card is effective to see the beam.
. The beam shall run along the paths.
. Align the centre of the beam in the half radius of the mirros.
. Parallelism within 1-3 mm of the rail is mandatory in track 3 and track 4.

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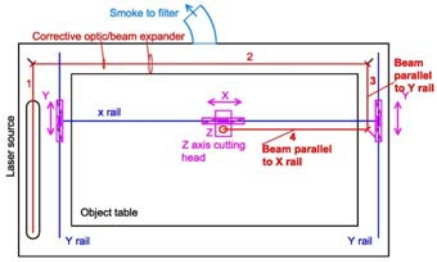
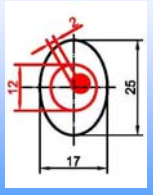
8. Cutting systems maintenance (4)



Pilot laser alignement to main beam.
Mount a sensitive card in front a mirror and shot a mark. Check and adjust the pilot beam to the mark. Align pilot laser along the laser path.
.1-2 mm max offsetting is fair.

Note. For z axis alignment remove the lens and use the card on the working plane, Flow protective gas to clean the z axis mirror.



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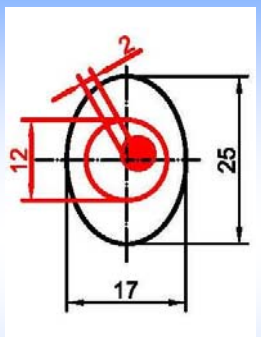
8. Cutting systems maintenance (5)



The working area of a mirror.
Mirrors oriented 45° have a net area helliptical, 70% in radius. i.e. 25x17,
.Check the beam position using the pilot, then IR card.
. Avoid peripheral positions.
. Do not paint the mirror supports. => Anodized are the best.

. Prepare some support with a clip to hold IR sensitive card along rails can be useful.

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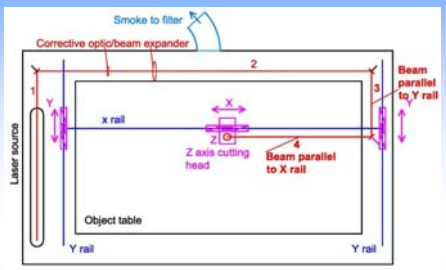
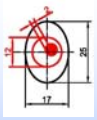
8. Cutting systems maintenance (6)





Move the head on table and check the overall alignment.

Beam alignment to x, y rails. Prerequisite: rail/ mechanics o.k. No loose gear, No loose carriages, no friction.

Set head at the centre of the table.

. Pilot laser on, adjust the laser to the first mirror pinhole.

. Repeat for any mirror.

. repeat with IR beam and IR card.

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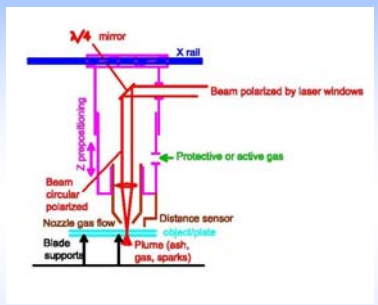
8. Cutting systems maintenance. (7)



The cutting head alignment.

. Head positioned at the centre of the table.

. Remove the lens

. Pilot laser on, adjust the z axis mirror to the beam out of the nozzle.

. Remount lens

Note. Lens compensates the small misalignments (3-5 mm out of axis)

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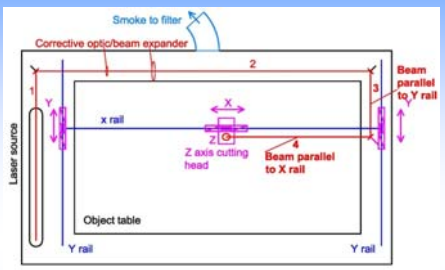
8. Cutting systems maintenance. (8)



Useful to decide the tolerance to cut bridges by laser in 2° cutting run

Fine adjust of repositioning.

. Check wear or looses of gear/road rails/screws/belt.
. Maintenance if need.
. Use slow speed cutting for top precision
. Cut, dashed line, a sample objects (cross, circle…)
. Move head far on the table,
. Cut, reverse dashed line, the same object
. compare distortion and errors.

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9. Optics maintenance (1)

Optics cleaning, mounting, dismounting.

. Block the head.
. By IR card check and save the position of the beam in front of mirrors (paper holders help)
Remove only an optic a time.
Avoid to move adj screws.

. Check the surface (microscope 10-25x): tips, clouds can be removed by analytic acetone.
. Drip acetone on disposable optic paper, wet the surface and remove the paper.
Re mount and realign one by one

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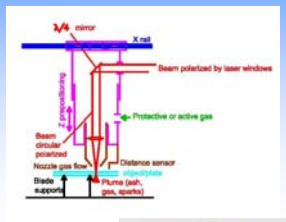
9. Optics maintenance (2)



The lens cleaning.
. Head positioned.
. Remove the lens
. Use a drop of analytic acetone on the optical paper.
Clean 2 or 3 time, check @ 10-25x; where clouds and tips remain, change the lens.
. Remount. Realignment is uncommon.

Warning. Solvent, sprays, can corrode ZnSe and have dangerous vapours.
Use only analytic grade products.

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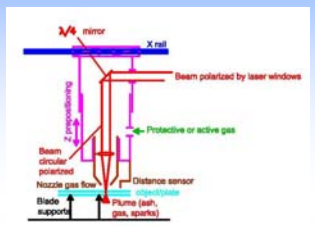
10. Gasflow maintenance (1)



Prtotective gas .
. Pure, absolute filter. NO humidity, No oil…..
. Gas piping MUST BE PURGED before mounting mirror and lens as … Particles can hit the lens, melt the beam, tips and opacity can occour.
. Protective air compressed shall be filtered, dryed, from water and from oil

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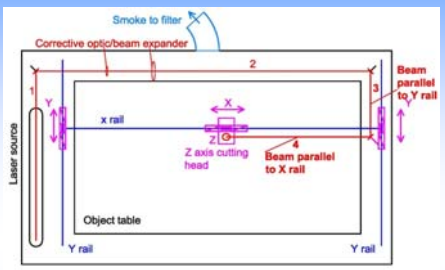
10. Gasflow maintenance (1)



Exhaust gas system.

. Sufficient flow when air sucked trough the machine gaps.

. Clean and check fan, all the piping…

. Check the filter, proper to the cut material.

. Clean or replace filter.

Note. Some material have toxic/explosive ash.
Wear protective gloves and mask.

. Explosion/fire risk increase if oxygen protective gas is uses

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11. Protective equipments and room safety. (1)

To avoid other risks general plants should be in good conditions.

. The laser machine switched on by keys (authorized by the manager)

. Avoid gaps and windows of the machine

. The cables, connectors, parts properly used;

. A labeled store to distingush materials is recommended.

Care must be taken to avoid other risks. i.e. by chemicals, biologic, x-ray.

=> Gloves, lab coats, glasses, etc. shall be available for the **specific task**.

Laser safety eye **glasses should be available at the laboratory; be used before open operate the laser**.

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11. Protective equipments and room safety. (2)

It is not a laser laboratory. Class 1 machine when closed.
Limited access during the maintenance. Lock the door.
from outdoor, opened from indoor (**emergency door** with external knob);
. **Red light outside** the door, switched on when laser is on;
. Laser hazard **warning labels**;
. Access only to **authorized persons**;
. Use proper **waste/discards containers**;
. Safety/ emergency kit available.
. Fire estiguisher availabel.

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12. "The laser accident“ (1)

. The accident is instantaneous, not necessary the laser beam or a reflection enters the field of view (side or center) the eye.
Note. A lateral beam cause accident burning the cornea.

. **As the beam is far infrared: a sensation** of seeing something **strange**, indistinct, not clear, when the eye is hit, an unfocused, foggy image occurs; intense pain may follow,

Recommended:
. **Close IMMEDIATELY both eyes AND TURN THE HEAD**;
. Look with one eye at a time, a bright wall, define the affected eye;
. Call an immediate medical check, the eye damage can be limited.

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Questions and additional information.

. Ask to the manufacturer, he is your reference for information,
. Ask to the Safety Dept. To have safety support

Tank you for your attention

last 10 minutes: question time, free questions, please.

Giorgio MAREGA

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