Thermofluids Discovery Laboratory
University of South Florida | Mechanical and Aerospace Engineering | tdlab.info

Laser Safety Guide

Class 4 CO2 laser, 10.6 um, ENG 019C

This guide collects the safety rules that apply to everyone who works in or enters the laser area of the Thermofluids Discovery Laboratory. It condenses the USF Laser Safety Manual, the ANSI Z136.1 standard and the laboratory's standard operating procedure into the parts you need day to day. It is not a substitute for the USF online laser safety training, the laser-specific training given by the PI, or the SOP you sign.

What is covered

- The laser and the people responsible for it
- Why a far-infrared Class 4 beam is dangerous
- Training and who may operate the laser
- The laser controlled area and its control measures
- Protective eyewear and other PPE
- Alignment and operating procedures
- Non-beam hazards (fire, fumes, electrical, optics)
- What to do after an exposure or near miss
- User acknowledgment

The three most common causes of laser accidents in research labs
1. Not wearing the appropriate safety eyewear.
2. Not reducing power for alignment, or an unintended power increase.
3. Stray beams left uncontained by beam stops or barriers.

Source: USF Laser Safety Manual. Every section below exists to prevent one of these.

Prepared by Dr. Ahmad Vaselbehagh, Principal Investigator | Revision 1, November 2026
Based on ANSI Z136.1-2014, the USF Laser Safety Manual and the ENG 019C laser SOP

1. The laser and the people responsible for it

Item	Detail
Laser	Coherent Diamond C-40, sealed CO_2 laser, continuous wave
Wavelength	10.6 um (10,600 nm), far infrared, invisible
Maximum output	40 W
Hazard class	Class 4 (highest). Direct, specularly reflected and diffusely reflected beams can injure the eye and skin; the beam can ignite materials.
Location	ENG 019C, Department of Mechanical and Aerospace Engineering, USF Tampa campus
Registration	Class 3B and 4 lasers must be registered with the USF Laser Safety Officer and with the Florida Department of Health, Bureau of Radiation Control (FAC 64E-4).

Laser safety contacts

Role	Name	Phone	E-mail
Laser PI	Dr. Ahmad Vaselbehagh	813-974-7664	vaselbehagh@usf.edu
Primary laser user	Ty Hagan	931-201-1843	
USF Laser Safety Officer	Adam Weaver (MDC 35)	813-974-1194, mobile 727-479-4740	aweaver@usf.edu
Medical, USF personnel	AmeriSys (24 h)	800-455-2079	
USF Workers' Compensation	Insurance Specialist	813-974-5775	melridge@usf.edu
Emergency	USF Police / 911	813-974-2628 or 911	

Who does what

Person	Responsibilities
Principal Investigator	Directly responsible for laser safety in the lab. Maintains the SOP, provides eyewear and barriers, registers the laser, trains and authorizes users, keeps training records, reports accidents to the LSO, and makes sure no one operates or modifies the laser without approval.
Laser users	Complete USF laser safety training and the lab-specific training, follow the SOP every time, use the laser only when authorized and the hazards are understood, report accidents and near misses to the PI and the LSO, and protect visitors from laser hazards.
Laser Safety Officer	Evaluates hazards, approves control measures, inspects Class 3B and 4 lasers twice a year, investigates incidents, recommends medical evaluation, and can suspend any operation that is a hazard.

2. Why this beam is dangerous

The C-40 produces a beam you cannot see, at a power that burns tissue in a fraction of a second. Four facts shape every rule in this guide.

The beam is invisible

A visible laser triggers a blink and head-turn (the aversion response) within about 0.25 s. At 10.6 um there is no such warning. You find out about an exposure when tissue heats. Treat every part of the beam path as live until it is blocked.

It burns the cornea, not the retina

Water absorbs far-infrared strongly, so a 10.6 um beam is stopped in the outer surface of the eye. The injury is a corneal burn, which is painful, can scar and can cost vision. Skin exposure causes a burn like touching a hot surface. The retinal hazard region (400 to 1400 nm) does not apply here, which is why eyewear for visible or near-infrared lasers is not automatically suitable.

The exposure limit is tiny compared with the beam

ANSI Z136.1 sets the maximum permissible exposure (MPE) for the eye and skin at 10.6 um to 0.1 W/cm^2 for a 10 s exposure. The raw 40 W beam, about 5 mm across, carries roughly 200 W/cm^2, about two thousand times the limit. Even a 1 percent reflection from a surface is still above the limit. The nominal hazard zone (NHZ), the space in which direct, reflected or scattered light exceeds the MPE, can be the whole room when the beam is open.

Metals are mirrors at this wavelength

At 10.6 um bare aluminium and copper reflect about 98 percent of the beam, steel about 95 percent. A wrench, a ruler, a watch or the bare edge of a fixture can redirect nearly the full power across the room. Keep bare metal and jewellery out of and away from the beam path.

> **Class 4 means**
> Direct beam, mirror-like (specular) reflections and scattered (diffuse) reflections can all injure the eye or skin.
> The beam can ignite paper, wood, plastics and clothing.
> Cutting or marking materials produces fumes (laser generated air contaminants).
> Operation requires an LSO-approved control plan, a written SOP, trained and authorized users and a controlled area.

3. Training and authorization

No one operates the laser, or works in ENG 019C while the beam can be exposed, until all of the following are complete. The PI keeps the records with the SOP.

1. Complete the USF online laser safety training (fundamentals, hazards, classification, control measures and PPE) and review the USF Laser Safety Manual.
2. Receive laser-specific training from the PI covering the operating and emergency procedures for this laser, specular and diffuse reflections, the eyewear and barriers in use, the exposure limits for eye and skin, the hazard evaluation of the room, and the manufacturer's safety instructions.
3. Read the SOP and sign the user review page.
4. Pass the TDLab CO_2 laser safety quiz with a score of 80 percent or more.
5. Be added to the authorized user list by the PI.

Visitors and spectators may be in the room only with an authorized operator, only after being told about the hazard, and only wearing laser eyewear whenever the beam can be exposed. Class 4 lasers are not used for demonstrations unless the LSO has approved it.

4. The laser controlled area and its control measures

The laser controlled area (LCA) is all of ENG 019C. Control measures are applied in this order of preference: engineering controls first (enclosures, barriers, beam stops, interlocks), then administrative controls (training, signs, procedures), then personal protective equipment. The LSO may approve substitutes that give equivalent protection; those are recorded in the SOP.

Controls in place in ENG 019C

Control	How it is implemented in this lab
Access	The main door is kept locked at all times. There are no door interlocks, so the lock, the sign and the warning light are the barrier. Spectators need the PI's approval to enter.
Warning sign	A laser hazard sign is posted on the access door with the class, wavelength and the PI and LSO contact details.
Warning light	A light at the door is switched on whenever the laser is in use, to alert others before they open the door.
Laser curtain	A laser-rated curtain is placed in front of the main door during operation.
Barrier panels	During operation, panels are set parallel to the beam path, between the beam and the user.
Beam stop	A beam block made of a material that withstands 40 W continuously terminates the beam. Cardboard, wood, painted panels and acrylic are not beam stops; they burn.
Bench	The laser is operated on a metal workbench to limit the fire hazard.
Beam height	The exposed beam path is kept above or below the eye level of a person standing or seated, wherever possible.
Reflective surfaces	Only diffusely reflecting materials in or near the beam path. No unnecessary tools, bare metal or jewellery near the beam.
Windows and openings	Doors, windows and portals are covered or restricted so that no laser radiation above the MPE leaves the room.
Securing the laser	When not in use the laser is locked in a cabinet and its power supply is disconnected and locked away, so it cannot be used without authorization.
Lighting	The room is kept well lit during operation. A small pupil limits the energy that can enter the eye.

Minimum requirements for any Class 4 indoor area

- Operated only by personnel trained in laser safety and in the operation of this laser.
- Under the direct supervision of someone knowledgeable in laser safety.
- Posted with the appropriate warning sign where onlookers will see it.
- A well-defined beam path, terminated in a suitable beam stop.
- Appropriate eye protection for everyone within the controlled area.
- The lowest laser power possible for alignment.

- The laser stored or disabled (key removed, power disconnected, locked) when not in use.

5. Signs and labels

The access door carries a laser hazard sign. For a Class 4 laser the signal word is WARNING (black on orange) and the sign states the class, the wavelength, the PI and LSO contact information and the precaution: *Laser radiation. Avoid eye or skin exposure to direct or scattered radiation.* The DANGER signal word is reserved for multi-kilowatt lasers; NOTICE is not allowed on a laser sign. The LSO can produce signs for the lab.

The laser housing carries the manufacturer's label with the class, wavelength and maximum output. Do not remove or deface any label. Protective eyewear is labelled with the optical density and the wavelength it protects against.

6. Protective eyewear and other PPE

Eyewear is the last line of defence, after enclosure, barriers and procedure, but it is mandatory for everyone in the room whenever the beam can be exposed. The PI provides it; the user is responsible for wearing it correctly.

Eyewear in ENG 019C	
Manufacturer	Edmund Optics
Protected wavelengths	9,000 to 11,000 nm (covers the 10.6 um CO_2 line) and 190 to 398 nm
Optical density	OD 7 at the CO_2 wavelength. The minimum required for this laser by the Z136.1 method is about OD 4; OD 7 gives a wide margin.
Storage	In the labelled case at the laser station, not loose on the bench.

Rules for eyewear

- Check the label before you put them on. The eyewear must state the OD at 10,600 nm. Glasses rated only for another wavelength may not protect you, and you cannot tell by looking.
- Ordinary safety glasses, sunglasses and prescription glasses are not laser eyewear.
- Alignment eyewear (which lets some visible beam through) is never used with this laser. The beam is invisible and high power.
- Inspect before each use for pitting, crazing, cracks, discoloration, a damaged coating, light leaks and a sound frame. Damaged eyewear is removed from service and reported to the PI.
- Clean only as the manufacturer directs. Solvents and rough wiping damage the filter.
- Eyewear protects against brief accidental exposure. It is not a licence to look into the beam.

Other protective equipment

- Long sleeves and closed shoes. No loose clothing that could enter the beam path.
- No watches, rings, bracelets or other jewellery in the controlled area.
- Laser-rated curtain and barrier panels as described in section 4.
- Fume extraction running whenever material is being cut or marked.

7. Alignment

Alignment is when most laser injuries happen, because the beam is open and attention is on the optics. Only the PI or the primary laser user performs alignment, and they follow these steps from the USF alignment guidelines.

1. Tell everyone in the room that alignment is about to start, and send out anyone who is not needed.
2. Put on laser eyewear. Remove jewellery and watches. Check that the warning light is on and the door is locked.
3. Set the laser to the lowest power that will do the job. Never align at full power.
4. Use the visible co-aligned pointer or a thermal detector card or thermal paper to locate the beam. Near-infrared viewer cards do not respond at 10.6 um. Never use your hand.
5. Block the high-power beam at the source with the shutter or a beam block except when it is needed for the step in hand.
6. Place beam blocks downstream of the optic being aligned and behind turning mirrors, so a beam that misses an optic is stopped.
7. Keep the beam below or above eye level and never bend down to look along the beam axis.
8. Locate and block every stray reflection before moving on to the next optic.
9. Confirm that every beam and reflection is terminated before returning to full power.

8. Operating procedure

Before you start

- You are on the authorized user list, and a second trained person knows you are running the laser.
- Door locked, warning light on, laser curtain across the door, barrier panels in place, beam stop in position.
- Beam path clear of bare metal, tools, paper, solvents and anything flammable. Bench clear.
- Fume extraction on. Material to be cut is identified and is on the approved list.
- Eyewear checked and on. Jewellery off. Sleeves down.
- Laser connected to its power supply only now, by an authorized user.

During operation

- Never put any part of your body in the beam path or look along the beam axis.
- Never leave the laser running unattended with the beam exposed.
- Watch for smoke or flame at the work piece. If something ignites, close the shutter or cut the power first, then deal with the fire.
- If anything unexpected happens, or you suspect a hazard, stop work, shut the beam and call the PI. The LSO can be asked for an immediate inspection.
- Do not defeat, bypass or remove any interlock, cover or guard.

Shutdown

- Close the shutter, then switch the laser off and disconnect the power supply.
- Let the laser head and work piece cool before handling.

- Return the laser and the power supply to the locked cabinet. Switch off the warning light. Return eyewear to its case.
- Record the session (date, user, power, material) in the laser log.

Emergency shutdown

Cut the power at the supply or the wall. Do not try to reach past the beam. Then follow section 10.

9. Non-beam hazards

Hazard	Control
Fire	The beam ignites paper, wood, plastics, fabric and solvents. Keep the beam path and the bench clear of combustibles, operate on the metal bench, keep a Class ABC extinguisher within reach and know where it is. Never leave a cutting job unattended.
Fumes (laser generated air contaminants)	Cutting or marking releases toxic, noxious or carcinogenic fumes depending on the material. Run the extraction for every job. Never cut PVC, vinyl or chlorinated plastics (they release hydrogen chloride), or any material you cannot identify. Keep safety data sheets for the materials you process.
Electrical	The laser and its RF power supply contain hazardous voltages. Never open the laser head or the supply. Keep liquids away. Only Coherent or a person authorized by the PI services the system.
Optics	The lens and windows are zinc selenide (ZnSe), which is toxic when powdered or burnt. Handle by the edges with gloves, never grind or sand it, and give any cracked, burnt or coated-over optic to the PI for disposal as hazardous waste.
Hot surfaces	The work piece, the beam stop and the laser head stay hot after operation. Let them cool before touching.
Compressed gas	If assist gas is used, secure the cylinder, use the correct regulator and check for leaks before each session.

10. Exposure incidents and reporting

If you think someone has been exposed to the beam

1. Shut the beam (shutter, power switch or wall supply).
2. Get the person away from the laser. For an eye exposure, do not rub the eye. For a skin burn, cool with clean water.
3. Call the PI (813-974-7664) and the USF LSO (813-974-1194, mobile 727-479-4740) right away. In a serious injury call 911 first.
4. USF personnel contact AmeriSys at 800-455-2079 (24 h) and, during working hours, the USF Workers' Compensation specialist at 813-974-5775. Non-USF personnel seek medical attention immediately.
5. Any suspected eye exposure gets an examination by an eye doctor the same day, even if it feels minor. A CO2 corneal burn feels like grit in the eye and may not show at once.
6. The laser stays off until the PI and the LSO have found the cause. Write down what happened while it is fresh.

Near misses count

A beam that went where it should not, a reflection you did not expect, a defeated guard, an eyewear failure: report these to the PI even when no one was hurt. They are how the next injury is prevented.

Notifications required by Florida law (FAC 64E-4.011)

The registrant (USF, through the LSO) must notify the Florida Department of Health by telephone at 407-297-2095:

- **Immediately** for an exposure above 100 times the MPE, any partial or total loss of sight, or a skin perforation or other serious injury.
- **Within 24 hours** for an exposure above 5 times the MPE, or second- or third-degree burns, or potential injury with partial loss of sight.
- **In writing within 30 days** for every exposure above the MPE, describing the exposure, the levels involved, the cause and the corrective steps. The exposed person receives a copy.

For this laser, five times the MPE is 0.5 W/cm^2; the raw beam is far above that, so any direct or specular exposure is reportable. Tell the LSO; the LSO handles the notification.

11. User acknowledgment

I have read this guide and the SOP for the CO_2 laser in ENG 019C, I have completed the USF laser safety training and the lab-specific training, and I will follow these procedures every time I use the laser or work in the room while it is in use.

Name (printed)	Signature	Quiz score	Date

Send a copy of the signed page to the USF Laser Safety Officer, Adam Weaver, MDC 35 (aweaver@usf.edu, fax 813-974-7091). Keep the original with the SOP in the lab.

Sources: USF Laser Safety Manual (12-1-2016) and its Appendix E alignment guidelines, Appendix F inspection checklist and Appendix G SOP for ENG 019C; ANSI Z136.1-2014 Safe Use of Lasers; Rockwell Laser Industries Laser Safety Officer course notes; Florida Administrative Code 64E-4.