**Laser Usage Form Guidance Document**

The State of Montana, through OSHA regulations, has adopted ANSI Z136 standards for the safe use of lasers in educational and research activities. The engineering, administrative and procedural safety controls that have been deemed a status of “*shall”* in these regulations are as follows:

Engineering Controls (Class 3B and 4)

* Protective housing or LSO approved alternative controls
* Interlocks on removable protective housing
* Service access panel
* Ensure viewing limited < MPE (Maximum Permissible Exposure)
* Fully/Limited Open Beam Path NHZ (Nominal Hazard Zone) analysis

Engineering Controls (Class 4 only)

* Area warning device
* Laser radiation emission warning
* Class 4 laser controlled area
* Entryway controls

Administrative and Procedural Controls (Class 3B and 4)

* Output emission limitations (LSO determination)
* Education and training
* Authorized personnel
* Indoor laser controlled area
* Outdoor control measures
* Alignment procedures

Administrative and Procedural Controls (Class 4 only)

* Standard operating procedures
* Class 4 laser controlled area
* Spectators
* Laser eye protection

To ensure that our laser safety program meets these requirements a laser usage form is required for laser operation at MSU. Guidance on best practices for laser alignment and standard operating procedures for class 4 lasers is provided in this document. This is an excellent resource for filling out a laser usage form that meets MSU’s laser safety program requirements.

**Laser Beam Alignment Best Practices**

Laser beam alignment requires work with an open beam and involves directing the beam toward a series of reflective or partially reflective surfaces, such as mirrors or lenses, so that the beam follows some predetermined path. With respect to the laser, alignments may be internal or external.

Internal alignments are those occurring within the laser cavity or head and often place the worker at increased risk of electrical accidents as well as beam exposure. The need for internal alignments arises most often because of problems associated with beam mode or power.

External alignments are those that occur from the laser’s end window to some terminal target (beam stop). In between these two locations may be a number of optical components (optics) arrayed in configurations that may be simple (few optics) or quite complex (many optics, multiple tables, extends outside primary area/room, etc.). The need for external alignments occurs because of requirements for an initial setup, reconfiguration of the optical setup, or replacement of components in the open beam path.

External alignments include optical table (bench top), laser-to-fiber port, fiber port-to-fiber port, free-space delivery, beam-to-sensor (receiver), and laser therapy. The following suggested alignment practices are a compilation of generally work practices that reduce the potential for overexposure to laser radiation. These practices are most generally applicable to external alignments on the optical table.

**Suggested Alignment Practices**

1. Perform alignments with a colleague or “buddy”;
2. Review alignment operating procedures with your buddy;
3. Identify equipment and materials necessary to perform alignment safely;
4. View beams indirectly: remote viewing, thermal paper, ceramic discs, IR/UV viewing scopes, paper business or non-glossy 3 x 5 inch cards, phosphor-viewing cards;
	* 1. Make sure viewing cards have diffusing surfaces;
		2. Cover the face of cards with specular surfaces with clear, matte-finish tape;
		3. If fluorescent viewing cards need optical charging, have a UV lamp on hand;
		4. Make sure conversion wavelengths are visible through protective eyewear;
5. Tools, targets, beam stops/blocks, power meter/detector, beam profiling system, curtain, signage, caution tape;
6. Make sure tools or items used in an around the beam path have non-reflective, diffusing surfaces at the wavelength(s) to be aligned;
7. Personal protective equipment (PPE): alignment eyewear, operational power eyewear, faces shields for scattered UV, skin protection as necessary;
8. Pay attention to housekeeping; make sure the immediate work area/bench top/optical table is free from opportunistic specular (mirror-like) reflectors that are not needed for alignment (e.g., glass bottles, razor blades, forceps, screw drivers, optical posts, photographic paper, plastic, dye cells, etc.);
9. Remove jewelry (from hands, wrist, ankles, ears, and neck) that may be reflectors and are electrically conductive. If jewelry (e.g., wedding bands) is not easily removed, cover with multiple layers of electrical tape. Remove tie tacks or tie clasps and neckties. Remove materials in shirt pockets that could fall into the beam path;
10. Isolate and demarcate the area to avoid distractions and minimize the hazard to others;
11. If Class-IV, open-beam system, make sure exterior warning signs / indicators are functioning;
12. If embedded high-power laser, establish temporary laser controlled area;
13. Restricted to authorized and trained individuals;
14. Use beam blocking barrier or laser curtain to contain beam;
15. Cover windows or viewing ports that are within the controlled area;
16. Use “Notice” and “Danger” signs per ANSI Z136.1;
17. Confine the beam to the optical table or bench top;
18. If multiple lasers are located on the same optical table or adjacent optical tables, physically isolate lasers with a barrier curtain;
19. Make sure that the beam shutter is closed or a beam block is in front of the end window. Make sure beam block is securely mounted;
20. If the primary laser is optically pumped by another laser and alignment of the pump beam is necessary, block the primary beam to limit potential multi-wavelength exposure and eyewear concerns. Align the pump beam then replace the beam enclosure in the pump-to-laser-beam path;
21. Prepare the beam delivery system: remove beam tubes or other parts of the protective housing as necessary, including extended sections that may be covered by beam tubes or bellows. Check all optics (mirrors, lenses, filters, polarizers, expanders, etc.)and optomechanical components (base plates, post holders and fasteners, mirror mounts, etc.) ensuring they are currently aligned (for changes / additions to an existing alignment) and securely mounted;
22. If the beam path to be aligned is located in multiple rooms, locate a beam block in the beam path between the rooms, and align the beam path in one room, then the other. If line of sight with buddies in other rooms is blocked, use two-way, real-time communications. Be patient at each step.
23. Use the minimum beam power / energy for as many alignment steps as possible or use a low-power coaxial laser beam for path simulation;
	* 1. Use a class 1 or 2 laser for alignment when possible
		2. For CW lasers with adjustable power, adjust the power to a minimum stable level;
		3. For pulsed lasers, use single pulses and / or reduce pump power;
		4. For Q-switched lasers, turn off the Q-switch and operate in low-power, CW mode;
		5. In some cases, power-reducing (e.g., neutral density) filters may be used during alignment;
		6. Ensure that you have protective eyewear with the appropriate value of optical density for the beam power. Using high OD eyewear that is suitable for normal operations with low-power, alignment beams is a formula for failure as is wearing low OD, alignment eyewear for high-power beams;
24. Proceed with system alignment:
	1. Wear laser protective eyewear to view diffuse reflections from viewing devices (e.g., UV or IR viewing scopes);
	2. Never view laser beams directly unless the scenario has been specifically approved by a knowledgeable laser safety officer (LSO);
	3. Perform the “rough” or “coarse” alignment with the beam blocked. Beam blocks should be highly absorbing, non-reflecting materials / designs;
	4. As you progress down the optical path, place beam blocks behind optics to be adjusted to stop errant (stray) beams;
	5. When using viewing aids to visualize the beam, reach into the beam path slowly and deliberately with the card slightly angled so you can see the diffuse reflection. Alternately, fix the car in the beam path. Adjust the optic so that the beam strikes the card just in front of the surface of the component;
	6. If the beam path changes elevation (+Z), be aware of the increased potential for vertical reflections;
	7. Close the shutter or insert the beam block during adjustments; re-secure the optics making sure components are properly located/adjusted;
	8. Be aware of the potential for errant reflections (stray beams) from components such as polarizers and dielectric mirrors. Check for stray beams at each step and again after completing all alignment steps;
	9. If the alignment has been performed at lower power or with a low-power collinear beam but final steps will be performed at operational power levels, be sure and change to the appropriate eyewear for the high-power beam;
	10. Communicate with your buddy at all times (e.g., during change of process step or before removal of protective eyewear;
	11. Restore the system to normal operational mode (pay attention to the protective housing, interlock switches, and shutters) and verify normal operation.

**Class 4 LASER SOP Guidelines**

The ANSI Z136.1 standard for the safe use of lasers requires a written standard operating procedure (SOP) for activities requiring access to class 4 laser beams. An SOP for laser equipment is usually a concise document that gives general safety guidelines instead of specific, step-by-step instructions. Additional guidance for the below sections prompted in the laser usage form is provided below.

**Hazards**

Consider eye and skin hazards from direct or scattered radiation, electrical, chemical, and any other recognized hazards associated with the laser. For each hazard present, consider how that hazard will be mitigated. For each hazard listed, briefly state the control measures to be used.

**Preparation of the Laboratory Environment**

Consider the preparation of the laboratory for usage. This should include:

1. How unauthorized users will be prevented from accessing the laboratory while the laser is in operation. This should include both procedures and physical barriers such as locked doors with restricted key access to AUs only.
2. The use of an area warning device to indicate that a class 4 laser is in use such as a blinking light accompanied by signage indicating operation of a class 4 laser when the light is blinking.
3. Removal of reflective surfaces, jewelry
4. Housekeeping aspects such as removal of unnecessary items from the usage area and ensuring that cables and cords do not present a trip hazard
5. Ensuring that there is protective housing for electrical hazards prior to energizing the system
6. Placement of protective housing and/or laser curtains for protection from direct or scattered beam paths.

**Personnel Protective Equipment**

The appropriate eye ware for each laser is identified outside of the class 4 laser SOP portion of the laser usage form. The use of appropriate eye ware should be indicated in this section of the SOP as well as the location that eye ware is stored. A convenient online tool for the calculation of the recommended eye ware optical density for a specific laser can be found here: <https://www.lia.org/evaluator/od.php>

**Personnel Allowed in the NHZ**

Procedures must be in place to prevent unauthorized users from entering during operation. An authorized user must have the following qualifications:

1. Are listed as authorized users on the laser usage form
2. Successfully completed general laser safety training on D2L.
3. Successfully completed laboratory specific laser safety training, which includes a signed and dated record of completion on the laser usage form.

**Operating Procedures**

This section should identify general safety guidelines for the safe operation of a class 4 laser. Safety during the following steps should be considered:

1. During startup
2. Due to particular system settings
3. During data collection

**Shutdown Procedures**

This section should identify general safety guidelines for the safe shutdown of a class 4 laser. Safety during the following steps should be considered:

1. During shutdown
2. Storage of PPE
3. Turning off area warning devices

**Emergency Procedures**

This section should describe actions to be taken during the event of an emergency. This should include:

1. List potential emergencies and corresponding actions
2. Describe specific rescue/evacuation procedures
3. Emergency contacts