

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.
 - a. View beams indirectly: remote viewing, thermal paper, ceramic discs, IR/UV viewing scopes, paper business or 3x5 inch cards, phosphor-viewing cards.
 - Make sure viewing cards have diffusing surfaces.
 - Cover the face of cards with specular surfaces with clear, matte-finish tape.
 - If fluorescent viewing cards need optical charging, have a UV lamp on hand.
 - Make sure conversion wavelengths are visible through protective eyewear.
 - b. Tools, targets, beam stops/blocks, power meter/detector, beam profiling system, curtain, signage, caution tape.
 - c. Make sure tools or items used in an around the beam path have non-reflective, diffusing surfaces at the wavelength(s) to be aligned.
 - d. Personal protective equipment (PPE): alignment eyewear, operational power eyewear, faces shields for scattered UV, skin protection as necessary.
- 4 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.).

5 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.

6 Isolate and demarcate the area to avoid distractions and minimize the hazard to others.

- a. If Class-IV, open-beam system, make sure exterior warning signs / indicators are functioning.
- b. If embedded high-power laser, establish temporary laser controlled area.
 - Restricted to authorized and trained individuals.
 - Use beam blocking barrier or laser curtain to contain beam.
 - Cover windows or viewing ports that are within the controlled area.
 - Use "Notice" and "Danger" signs per ANSI Z136.1.
- c. Confine the beam to the optical table or bench top.
- d. If multiple lasers are located on the same optical table or adjacent optical tables, physically isolate lasers with a barrier curtain.

7 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.

8 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.

9 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.

10 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.

11. Use the minimum beam power / energy for as many alignment steps as possible or use a low-power coaxial laser beam for path simulation.

- a. For CW lasers with adjustable power, adjust the power to a minimum stable level.
- b. For pulsed lasers, use single pulses and / or reduce pump power.
- c. For Q-switched lasers, turn off the Q-switch and operate in low-power, CW mode.
- d. In some cases, power-reducing (e.g., neutral density) filters may be used during alignment.
- e. 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.

12. Proceed with system alignment:

- a. Wear laser protective eyewear to view diffuse reflections from viewing devices (e.g., UV or IR viewing scopes).
- b. Never view laser beams directly unless the scenario has been specifically approved by a knowledgeable laser safety officer (LSO).
- c. Perform the “rough” or “coarse” alignment with the beam blocked. Beam blocks should be highly absorbing, non-reflecting materials / designs.
- d. As you progress down the optical path, place beam blocks behind optics to be adjusted to stop errant (stray) beams.
- e. 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 card in the beam path. Adjust the optic so that the beam strikes the card just in front of the surface of the component.
- f. If the beam path changes elevation (+Z), be aware of the increased potential for vertical reflections.
- g. Close the shutter or insert the beam block during adjustments; re-secure the optics making sure components are properly located/adjusted.
- h. 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.
- i. 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.
- k. Communicate with your buddy at all times (e.g., during change of process step or before removal of protective eyewear).

Restore the system to normal operational mode (pay attention to the protective housing, interlock switches, and shutters) and verify normal operation.