A Practical Guide to Laser Class 4 Entryway Control Requirements

Which standard to follow?

Numerous standards, directives, and guidelines have been written to promote the safe use of lasers. You may or may not fall under the jurisdiction of any particular standard, but the American legal system and insurance costs compel every facility to limit their liability through the implementation of recognized best work practices. Regardless of the liability, you should always strive to "do the right thing, because it's the right thing to do."

ANSI Z136.1 is the American National Standard for Safe Use of Lasers. Z136.1 is the parent document referenced by all other Z136 standards. The standards are developed by the ANSI Accredited Standards Committee (ASC) Z136, a collaboration of the leading experts in the field, and are considered to be the authoritative standard in the United States for safe laser operation and practices. Although the standards are not "law," compliance with the standard is often mandated by federal entities.*

In an effort to help employers implement a safe working environment for employees, OSHA offers directive STD-01-05-001, free of charge. This directive is based on the ANSI Z136.1-1986 standard. There have been significant advances in laser technology and changes to the recommended "best practices" since this standard was released 20+ years ago. Facilities are advised to purchase and adhere to the latest release of the ANSI Z136.1 standard.

This Guide compares the OSHA directive (based on the ANSI Z136.1-1986 standard) against the latest recommendations of ANSI Z136.1-2007. By comparing an older directive against a newer release, the safety trend and rationale become clear. It is not intended to be a complete resource. It is written to provide a better understanding of the reasons for entryway controls as applicable to the Class 4 laser area.

The OSHA directive is released to public domain and is available from:
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=1705

The ANSI Z136.1-2007 standard is available for purchase from several commercial sources. The ANSI Z136 secretariat and publisher is the Laser Institute of America (LIA), whose web address is: http://www.laserinstitute.org/

The ANSI Accredited Standards Committee (ASC) Z136 is comprised of leading experts from the fields of safety, medicine, education, industry, and defense. The web address is:
http://www.z136.org/

* 10CFR851.23(11) requires all Dept. of Energy contractors to comply with ANSI Z136.1-2000
http://ecfr.gpoaccess.gov

Why are entryway controls required?

The Class 4 laser area has a high potential for injury and requires a DANGER warning. The ANSI Z136.1 definition on the use of the Danger warning reads:

""DANGER" indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme conditions."

It is unfortunate that the danger symbol is overused. This leads to a false sense of the meaning and a relaxed attitude. Engineered safety entryway controls are a method of ensuring that the real danger is contained and respected. The controls limit the laser access to qualified individuals and help prevent harm to those who are not properly trained on the operation and safe use of the laser.

The Class 4 laser should be imagined as a machine in a machine shop. Just as the saw, drill, and hydraulic press require guarding mechanisms, so does the laser. The difference between those machines and the laser is the lasers ability to injure surrounding personnel from a distance. In many cases the beam is invisible. Without protection, severe physical harm could occur without warning. Even with visible beams, the light can be so intense that a blink reflex will not be fast enough to protect the eye.

Important statements directly from OSHA (STD 01-05-001)

CLASS IV: High power lasers (cw: 500 mW) are hazardous to view under any condition (directly or diffusely scattered) and are a potential fire hazard and a skin hazard. Significant controls are required of Class IV laser facilities.

The controls specified by the ANSI Z-136.1 standard have been rather universally adopted by industry, medicine and government as the "user requirements" of lasers. In general, the controls are rather easily implemented by the LSO of the facility.

The use of laser protective eyewear is mandatory with Class IV lasers. Protective eyewear shall be fabricated of plastic or glass absorption filters appropriate for the laser. All laser protective eyewear shall be clearly labeled with optical density values and wavelengths for which protection is afforded.

When are entryway controls NOT required on a Class 4 laser system?

Entryway controls are not required when there is no possibility of radiation exposure above the Maximum Permissible Exposure (MPE) threshold.

One common example is that of a Class 4 laser cutting machine with an interlocked cover that must be completely closed before laser emission can occur. This machine is guarded with appropriate limit switches on the housing. Windows on the housing are constructed from a special filter material that will block the harmful wavelengths.

What is a laser interlock?

A laser interlock is an electrical circuit connection designed to permit the rapid shutdown of the laser when triggered by a safety circuit. In some instances, e.g. when a laser has a long warm-up period, it is appropriate to use a shutter at the output of the laser as an interlock instead of actually turning off the laser.

Every commercial Class 3b and Class 4 laser sold in the United States will have an electrical interlock connection. It is mandated by the U.S. Food & Drug Administration's Center for Devices and Radiological Health (CDRH). The connection will have two terminals that need to be electrically shorted to each other. If the circuit opens, the laser will shutdown. It is unfortunate that most laser manufacturers ship the laser with this interlock connection already shorted. This often leads to a situation where the end user ignores the proper interlock configuration connection mandated by the ANSI standard.

If a laser is built from OEM parts at a facility, then the facility must ensure that adequate provisions are designed into the system for rapid safe shutdown.

There is a common misconception that the laser will provide an output signal connection that will turn on an external warning placed at the door whenever the laser is operating. Some laser manufacturers may include this as an option, but this is uncommon. The laser does not control the warning. An external safety system drives the warning and gives "permission" for the laser to run via the electrical interlock connection.

What are the Entryway Control Measures?

The pertinent text from the OSHA directive released to public domain:

From OSHA (STD 01-05-001)

ENTRYWAY CONTROL MEASURES (CLASS IV):

In addition [to the requirements for Class III laser controls], there are specific controls required at the entryway to a Class IV laser controlled area. These can be summarized as follows:

1. All personnel entering a Class IV area shall be adequately trained and provided proper laser protective eyewear.

2. All personnel shall follow all applicable administrative and procedural controls.

3. All Class IV area/entryway controls shall allow both rapid entrance and exit under all conditions.

4. The controlled area shall have a clearly marked "Panic Button" (disconnect switch) that allows rapid deactivation of the laser.

In addition, Class IV areas also require some form of area-entryway controls. In the past, doorway interlocking was customary for Class IV installations. Now, the ANSI Z-136.1 (1986) standard provides three options that allow the LSO to provide an entryway control suited for the installation.

The options include:

a. NON-DEFEATABLE ENTRYWAY CONTROLS: A non-defeatable control, such as a magnetic switch built into the entryway door which actuates a "beam off" condition when the door is opened is one option. In this case, training is required only for persons regularly working in the laser area.

b. DEFEATABLE ENTRYWAY CONTROLS: Defeatable controls may be used at an entryway, for example, during long term testing in a laser area. In this case the controls may be temporarily by-passed if it is clearly evident that there is no hazard at the point of entry. Training is required for all personnel who frequently require area entry.

c. PROCEDURAL ENTRYWAY CONTROLS: A blocking barrier, or screen, or curtain which can block or filter the laser beam at the entryway may be used inside the controlled area to prevent the laser light from exiting the area at levels above the applicable MPE level. In this case, a warning light or sound is required outside the entryway that operates when the laser is energized and operating. All personnel who work in the facility shall be appropriately trained. (See Section IX: Training)

The Entryway Control Measures listed in the OSHA directive are very similar to the present requirements listed in ANSI Z136.1-2007 Section 4.3.10.2 for the Class 4 Laser Controlled Area. Copyright limitations prevent the printing of the present ANSI standard. Key points and differences are discussed below.

Both the OSHA directive section 4 above and the present ANSI standard require a clearly marked "Panic Button". One can infer from this requirement that a Class 4 laser area cannot be operated entirely on a procedural control basis. In fact, the description of the procedural control method in Z136.1-2007 directs the reader to a figure that clearly shows two "emergency override" crash switches, one located at the entry and another at the laser table. There is an exception to this requirement when lasers are used for medical procedures. This will be described in further detail later.

The OSHA directive provides three entryway control options. The present ANSI standard similarly states: "The Class 4 laser controlled area **shall** incorporate **one** of the following alternatives":

1. **Non-Defeatable Area or Entryway Safety Controls**

2. **Defeatable Area or Entryway Safety Controls**

3. **Procedural Area or Entryway Safety Controls**

The following text will discuss these three types of approved safety control methods in order from lowest to highest level of complexity.

Procedural Area or Entryway Safety Controls

From OSHA (STD 01-05-001)

c. PROCEDURAL ENTRYWAY CONTROLS:

A blocking barrier, or screen, or curtain which can block or filter the laser beam at the entryway may be used inside the controlled area to prevent the laser light from exiting the area at levels above the applicable MPE level. In this case, a warning light or sound is required outside the entryway that operates when the laser is energized and operating. All personnel who work in the facility shall be appropriately trained. (See Section IX: Training)

The present ANSI standard is very similar to the older OSHA directive, but there are some important differences worth discussing.

The procedural method of entryway control sounds simple enough.... lighted warning, door curtains, training, no need for door interlocks. Why not just choose this method for all of your Class 4 laser areas?

The first sentence in the ANSI Z136.1 -2007 section 4.3.10.2.2 (3) describing this method states: **"Where safety latches or interlocks are not feasible or are inappropriate, for example during medical procedures, surgery, etc., the following shall apply: …."** The text then describes the procedural entryway control requirements.

This is a major change from the original recommendation in Z136.1 (1986), from which the OSHA standard was derived. Why? Presumably it was because too many facilities were using the procedural method as an excuse to "not" interlock in situations where interlocks were actually very appropriate.

The example of the surgical laser is indeed one of the few appropriate cases for the use of the procedural method. The interlock exception is being granted to lasers used in medical procedures for the following reasons:

1. No one wants to inadvertently secure a laser in the middle of a medical procedure by tripping an interlock.

2. The flow of traffic in and out of a surgical area cannot be impeded when life safety is involved, so door locks or entryway switches are inappropriate.

The Procedural Entryway Safety Control method uses the following assumptions because it is primarily intended for surgical use:

1. The laser is under the active control of an operator who can quickly secure the laser in the event of an emergency. (Supervised laser operation)

2. All personnel are adequately trained and provided with personal protective equipment upon entry.

3. The MPE is not exceeded at the entryway. Curtains, laser type, and room design are evaluated to meet this condition.

4. A visible or audible signal is provided at the entryway indicating the laser is energized and operating at Class 4 levels.

Conclusion: Other than the surgical laser situation, there are few valid scenarios that can justify the use of the procedural area or access control protocol for a Class 4 laser area. You must have a condition where "safety latches or interlocks are not feasible or are inappropriate". It is worthwhile to note that even within ANSI Z136.3 (Safe Use of Lasers in Health Care

Facilities,) sections 4.1 and 4.8 state that when a laser is not being used on a human patient, it shall be interlocked in accordance with the more stringent requirements of Z136.1.

Non-Defeatable Area or Entryway Safety Controls

From OSHA (STD 01-05-001)

a. NON-DEFEATABLE ENTRYWAY CONTROLS:

A non-defeatable control, such as a magnetic switch built into the entryway door which actuates a "beam off" condition when the door is opened is one option. In this case, training is required only for persons regularly working in the laser area.

The present ANSI standard is quite similar to this description, but adds a list of other possible "guard" devices like pressure sensitive floor mats, infrared or sonic detectors, etc. The training requirement stated above is removed. It did not make sense to say "persons regularly working". It is obvious that "anyone" working in the laser area must be trained.

Non-defeatable means “cannot be defeated.” The operation of this type of interlock is simple. Open the door and the laser turns off or the shutter closes. The OSHA description above failed to mention that the laser should NOT restart when the door is closed again without an intentional restart action. Interlocks must be failsafe and provide anti-restart. It’s really a matter of common sense. If an untrained individual opens the door, the laser trips off. If the individual then closes the door after walking into the room, it would be inappropriate for the laser to turn on again automatically.

This type of interlock is appropriate in the following situations:

1. If the laser or shutter is remotely controllable, then one can "sweep" the area clear of personnel, lock the door, arm the interlock, and remotely start the laser or open the shutter. If anyone opens the door during this interlocked condition, the laser trips off (or the shutter closes). Additional safety hardware would be necessary for this mode of operation. A crash button as well as audible and visual activation warnings on the INSIDE of the laser area are appropriate in the event that someone is accidentally in the room when the laser is remotely started. A time delay to start is also appropriate to give the room occupant time to crash the system before laser emission occurs. An interlock "set" control would be needed OUTSIDE the room for this mode of operation.

2. If the laser will be under the control of a person within the room for short experiments or procedures, the door can be closed and the laser may be

started. If the operator leaves the room, or if someone enters, the laser will trip off. In this configuration, an interlock "set" control would be needed INSIDE the room.

3. It is easy to see that a combination of these two operations is possible. A single operator could align a laser within a room, momentarily shutdown the laser and kill the interlock to leave the room. The same operator could then re-arm the interlock and remotely restart the laser. If a shutter is used for the safety interlock, the laser could stay on indefinitely.

4. The non-defeatable entryway control is often used for situations that have a Class 1 enclosure around a Class 4 laser, but require a “temporary” Class 4 laser area to be established during periods of alignment or maintenance. In this scenario, the switches that sense the Class 1 enclosure integrity are wired in parallel with the room interlock. If the enclosure is intact, the room interlock does not need to be armed and room access is not limited. If the enclosure is to be opened, the room interlock must be armed to satisfy the laser interlock and the room entry is protected.

Conclusion: The non-defeatable entryway control is useful for many laser applications. Careful planning is needed to match the laser operating requirements with working conditions. The laser can run in an unattended state without fear of unintentional exposure to unqualified individuals. One negative aspect is the system lacks the ability to enter and leave a Class 4 laser area without tripping the laser or shutter. You're either in or you're out. The non-defeatable entryway control is the ANSI preferred method of protection. It has the advantage of not requiring complex barriers or expensive laser curtains at the doorway since the door is the barrier.

Defeatable Area or Entryway Safety Controls

From OSHA (STD 01-05-001)

b. DEFEATABLE ENTRYWAY CONTROLS: Defeatable controls may be used at an entryway, for example, during long term testing in a laser area. In this case the controls may be temporarily bypassed if it is clearly evident that there is no hazard at the point of entry. Training is required for all personnel who frequently require area entry.

The present ANSI standard is very similar to the OSHA, but ANSI recommends the interlock only if non-defeatable interlocks limit the intended use of the laser or laser system. The intent of this text is clear. The preference is to recommend non-defeatable interlocks, followed by defeatable, and then as a last resort, when safety latches or interlocks are not feasible or are inappropriate, procedural.

A defeatable entryway control has the same ability to trip off the laser as the non-defeatable interlock, except authorized persons are permitted to momentarily “bypass” the trip mechanism to pass through the door. The design of this bypass

control circuit is critical and the bypass timer circuit must be fail-safe. If microprocessor controlled, the device must fail in a non-defeating manner if the microprocessor quits. Most security system keypads are not designed to this standard and have the potential to latch in the "bypassed" state.

The defeatable entryway control offers the best of both worlds. It provides unimpeded access to and from the laser area by qualified laser personnel who have been given an access code. It denies access to untrained individuals. This enhanced capability adds complexity. In order to be safe and effective, it is crucial that the level of laser radiation does not exceed the MPE at the entry point, which often requires the installation of barriers or laser curtains. The access is usually restricted by a magnetic lock. The magnetic lock is failsafe upon loss of power, but proper system design is critical to meet fire codes and emergency ingress / egress standards.

Conclusion: The defeatable entryway safety control is a wise choice when long term tests require uninterrupted beam with occasional access in and out of the room by qualified individuals. This control offers significant peace of mind to the laser system operators, the laser safety officer, and management. The laser can be left in operation for extended periods without fear of exposure to unauthorized personnel. If a laser area has multiple doors, it is recommended that one door is selected for defeatable access and the remaining doors are configured for non-defeatable operation. This is safer and more economical.

Further frank discussion about Entryway Controls:

ANSI Z136.1-2007 states: "Engineering controls (items incorporated into the laser or laser system or designed into the installation by the user) shall be given primary consideration in instituting a control measure program for limiting access to the laser radiation"

The procedural method of access control is not an engineering control and has limited applicability outside the medical field.

We often hear people say interlock systems are a nuisance.

The operation of a properly designed system is not a nuisance and can be a source of comfort and security to both the laser operator and the facility management. Fear of exposure to untrained individuals is eliminated. In addition, the psychological impact cannot be discounted. When laser workers see that the facility has invested in proper safety, the workers will tend to work in a safer manner.

Another common remark: Connecting a laser to a room interlock can place an experiment at risk when the laser or shutter inadvertently terminates the beam.

This is false. When properly designed and operated, room interlocks can be set for many months at a time. The system can provide simple access to the laser area by qualified individuals without interrupting beam to an experiment. The only events that would unexpectedly terminate a beam would be a power failure or a real potential exposure that has forced the safety action.

And to those who may complain that Interlock systems are expensive:

While you may have heard of facilities spending up to $40,000 to interlock a room, this is an extreme exception. Most labs can be configured with an interlock system meeting the ANSI Z136 requirements for much less. Depending on features required, commercial systems range from $500 up to $4000 for a typical single door lab. This small expense pales in comparison to the potential medical and punitive liability that exists in the event of an accident at a facility without ANSI compliant entryway controls.

We often hear people quote the ANSI standard and tell us about the permitted substitution of "alternate" controls if approved by the *Laser Safety Officer (LSO)*. We want to clear the air on this topic with a short Q & A as it pertains to a Class 4 laser area.

The section to which we are referring is Z136.1-2007 section 4.2. The text is identical to section 4.1.3 of the Z136.1-2000 standard.

Question #1: Who "owns" the laser hazard?

Answer: The operator who creates the laser hazard "owns" the hazard and is responsible for controlling it. It is the job of the Laser Safety Officer to ensure the laser operator has the tools, training, and procedures necessary to control the hazard and to verify that the worker has accepted the responsibility and complies with the procedures.

Question #2: Who is responsible for the hazard when the laser is running unattended?

Answer: You probably guessed it... The person who created the hazard is still responsible for controlling it. If automatic controls or the ability to remotely secure the hazard have not been implemented, the hazard is not controlled.

Question #3: Can't a laser operator simply lock the door to keep people out while the laser is running unattended?

Answer: This is **not** a recommended safety protocol. Who else has a key? Are you confident that an untrained security guard, maintenance worker, or janitor will respect your "DANGER" warning sign? What about a fireman who might be called upon to break open the door and enter the lab because of smoke or fire?

So to the final Question: Doesn't ANSI Z136.1 section 4.2 allow the Laser Safety Officer to make substitution of Alternate Control Measures for a Class 3b or Class 4 laser area?

Answer: Yes, freedom to choose is designed into the ANSI standard. This clause makes the assumption that the LSO is truly qualified to make this evaluation, and the resulting liability rests on the LSO and the facility.

There are some “non-standard” safety protocols that offer sufficient levels of protection. Justification for this mode of operation can occur when the operators are highly skilled and great care is taken to control the beam hazard.

Keep in mind that unexpected events can occur. The following are only a small sample of events that have been observed:

- Mirror coatings delaminating from the surface of the substrate;
- Dirty optics intercepting beam, leading to thermal runaway and catastrophic substrate failure;
- Loose optic mounts allowing an optic to fall into or out of a laser beam path;
- Inappropriate use of absorptive neutral-density filters. When overpowered, internal heating can melt the filter or cause it to crack in half, resulting in full power delivery downstream.

In each of these cases, beam control was unexpectedly lost. These examples are why interlocks exist and approved laser eyewear is always worn when working with class 3b or class 4 lasers.

In Conclusion:

If you ever wonder if your controls are sufficient, think about the fireman. He is not laser trained and will not be putting on the laser eyewear when he breaks down your laboratory door. If you are not present to secure the hazard, then the fireman must have a clear warning of the hazard and have a clearly marked method to secure the hazard or the hazard must automatically secure.

The ANSI Accredited Standards Committee (ASC) Z136 is a group of leading experts in the fields of lasers and laser safety. The process of writing the standard involves intense scrutiny of every clause. The Defeatable, Non-Defeatable, and Procedural Entryway Safety Controls were recommended because they are the best ways to control the laser hazard.