

**Injector Test Stand Laser Interlock Operating Procedures**  
**Test Lab Building 58 room 127**

In October 2006, the injector test stand was outfitted with a new laser interlock system. The system provides secure access control, time delay startup, audible and visual warnings. The system exceeds the requirements of both ANSI Z136.1-2000 and Article 330 of NFPA 70E. The system is based on the Laser Safety Systems™ 2380 series laser room interlock controls available from <http://www.LaserSafetySystems.com>

The following is a brief overview of the individual operational components:



The Laser Warning module provides an audible warning of changing laser state and a visual indication of the present interlock setting (it is effectively a “quad-lume” indicator). The test cave is using class 1 enclosures around the class 4 lasers, so the warning module is configured for the following display modes:

1. Laser Safe and interlock ready to arm: Green LED’s are lit solid.
2. Laser Interlock Crashed by a crash switch: Green LED’s are flashing.
3. Laser On, but beam is contained within the class 1 enclosure: Green LED’s are off and the international yellow laser warning symbol is illuminated solid yellow.
4. Laser On, Class 4 beam is exposed (Alignment mode): The yellow laser symbol is a flashing strobe.

An audible tone is sounded when operational modes are changed. An increasing frequency tone indicates the interlock system is changing to a state of higher safety concern. A dropping frequency tone indicates the interlock system is dropping to a safer control state. There are warning modules installed outside both injector test cave doors.



The Interlock Control module allows arming and safe disarming of the interlock system. The arming switch is illuminated yellow when the system is armed. The green switch is illuminated when the system is “safe”. When the system is “crashed” by an interlock violation or crash switch, the green switch is not illuminated.

It is important to note that the green switch is the primary method to be used to drop the system to the safe mode. Crash switches are only to be used in emergency situations or during periodic safety interlock verification tests.



The Emergency Crash module is located on both sides of the two access doors to the injector test stand test cave (4 modules total). It serves the function of rapidly dropping the laser interlock to a crashed safe mode. It also serves as a primary means of removing power to the magnetic locks on the access doors in the event of an emergency. Additional crash switches may be located at the laser tables if desired. The crash switch is a “maintained” mushroom (Pushlock Turn Reset type) Non-Illuminated Emergency Stop switch.



The Alignment Control module allows positive control over the interlock state for the laser table enclosure. If the switch is in the “normal mode” position, removal of the top cover of the laser table enclosure will immediately trip the laser interlock. If the switch is placed in “alignment” mode, the laser warning modules will change to alignment “strobe” mode and provide the audible warning of the change of state. The magnetic door locks will also energize at this time. All personnel in the laser area are required to don laser eyewear and the top cover of the laser table enclosure may be removed without tripping the laser interlock.

There are two LED indicators on the alignment control module. The green indicator on the left shows the status of the enclosure limit switches. When lit, the enclosure lid is securely closed. It is important to ensure the switches are closed before returning the control switch from alignment to normal mode, otherwise the laser interlock will trip off. The high intensity orange LED is illuminated when the module is in alignment mode. (Note: Our alignment module has a toggle switch in lieu of a key switch)



The Access control keypad module permits authorized laser worker entry into the laser area when the magnetic locks are energized during alignment mode. The visual strobe from the warning module reminds the worker that laser eyewear is required. There are multiple combination sets permitted so we can program a temporary code for student access. The code can be deactivated after the student has completed his/her experiment. This is a vital safety protocol because the laser table optical layout may have changed significantly for a new experiment. The control keypad provides audible and visual indication of the lock state. The door opening time allowed is adjustable via the keypad using a master programming code.



The magnetic lock release module is located at the interior of the laser area to allow routine exit requests when the maglock is energized. A momentary push of the button will release the maglock for the time period specified in the access control keypad module.

The system also permits the installation of a floor switch pad that would automatically unlock the maglock when approaching the door, but we find the push-to-exit button to be sufficient for our needs.

Additional Comments: The test cave smoke detector / fire alarm system ties into the laser interlock system. Activation of the smoke detector will trip the interlock system and permanently unlock magnetic locks. The interlock system warning modules will flash green to indicate a crash of the system. The system cannot be rearmed until the trouble light is reset on the building fire alarm control panel.

### **Normal Operating procedures:**

1. If system is crashed as indicated by flashing green lights on the warning modules, check all crash switches to ensure that they are not in the depressed position. The switches can be reset to their normal position by rotating clockwise about 1/8<sup>th</sup> of a turn. The switch will spring out to the normal position if it was depressed. In addition to the crash switches, the laser table enclosure may not be closed, thus forcing a crash of the system. Check that the green indicator on the alignment mode module is lit. If the system is still in a crash mode, the only remaining culprit is the building fire alarm system. The trouble light must be reset on the building fire alarm control panel.
2. To arm system: Ensure green indicator is lit solid on the interlock control module. Press the yellow “set interlock” button. You will hear the warning modules indicate the change of state. After a time delay of approximately 10 seconds, the main interlock control relay for the laser interlock (or shutter interlock) will activate. Lasers or shutters attached to the main interlock control relay may then be activated.
3. To change to alignment mode: Ensure all personnel in area are authorized laser workers and have donned required laser eyewear. Close doors to test cave and take the alignment mode switch to alignment mode. The magnetic locks will energize on all access doors. Strobes will remain flashing outside the doors during alignment mode. The laser table cover may now be removed to access beams for alignment.
4. To change to normal mode from alignment mode: Replace cover on laser table and ensure that the green LED on the alignment mode module is lit. The alignment mode

switch can then be placed in the normal mode position. All door maglocks will de-energize and the warning modules will change to solid yellow.

5. To drop the laser interlock to safe mode: Press the green button on the laser interlock control module.

### **Emergency Operating Procedures:**

Any crash button can be depressed at any time to secure the laser interlock and the magnetic door locks. **If the emergency is due to Accidental Eye Exposure: Immediate medical attention is required whether injury is apparent or not. If possible, the individual should remain in the upright position during transport to medical services.**

Crash buttons shall not be routinely used to secure the interlock system. They should only be activated during real emergencies and during the Interlock verification checks described below.

### **Interlock verification checks:**

The interlocks system as a whole should be fully tested for functionality:

1. Every six (6) months.  
(or)
2. After any modification of the interlock system.  
(or)
3. After any failure of the interlock control functionality.

Proof of verification shall be submitted to the LSO after each event. If the event was due to an item 2 or 3 event, laser work shall be terminated until the LSO accepts and approves the verification sheet.

### **Verification procedure:**

#### **Step 1: Test of crash switches**

- a. Arm the system to the normal mode (Class 1 conditions).
- b. Depress a single crash switch and do not reset it.
- c. Ensure system has dropped to “Crashed” mode as indicated on the warning nodes (Green LED’s will be flashing).
- d. Ensure the laser interlock relay is not energized. (Laser will not start)
- e. Reset the crash button by rotating 1/8<sup>th</sup> turn clockwise.
- f. Ensure system returns to “Safe” mode as indicated on the warning nodes (Green LED’s will be on solid).
- g. Repeat steps 1a through 1f for each crash switch in the system.

#### **Step 2: Test of Laser table lid interlocks**

- a. Arm the system to the normal mode (Class 1 conditions).
- b. Do not energize lasers, (or don protective eyewear).
- c. Ensure Alignment mode switch is in normal position.
- d. Ensure Green LED on Alignment control node is lit.

- e. Lift the lid from the laser table and keep lid open.
- f. Ensure system has dropped to “Crashed” mode as indicated on the warning nodes (Green LED’s will be flashing).
- g. Ensure Green LED on Alignment control node is not lit.
- h. Ensure the laser interlock relay is not energized and laser will not start.
- i. Return lid to normal position.
- j. Ensure system returns to “Safe” mode as indicated on the warning nodes (Green LED’s will be on solid).
- k. Ensure Green LED on Alignment control node is lit.
- l. Repeat Step 2a through 2k for each laser table connected to the interlock system.

### Step 3: Smoke Detector Verification

- a. Inform proper building authority that smoke detector test will occur.
- b. Arm the system to the normal mode (Class 1 conditions).
- c. Spray test smoke at laser smoke detector for 5-10 seconds.
- d. Ensure system has dropped to “Crashed” mode as indicated on the warning nodes (Green LED’s will be flashing).
- e. Ensure the laser interlock relay is not energized. (Laser will not start)
- f. Reset the smoke detector fault on the main building fire control panel.
- g. Ensure system returns to “Safe” mode as indicated on the warning nodes (Green LED’s will be on solid).

### Step 4: Door interlock switch time delay verification

- a. Arm the system to normal mode, close doors and then raise level to alignment mode.
- b. Ensure magnetic locks activate.
- c. Push on Door to ensure magnetic locks hold with reasonable force.
- d. Test the push-to-exit function and keypad entry function.
- e. Once normal functions are verified, use the Push-to-exit button to open the door but hold door open beyond timer limit set on the keypad. (nominally 10 seconds)
- f. Ensure system drops to a “Crashed” state after time limit.
- g. Return the alignment mode switch to normal mode and ensure system indicates it is back to the normal “Safe” mode as indicated by solid Green LED’s on the warning nodes.
- h. Repeat steps 4a through 4g on other door.

### Step 5: Final Door interlock verification simulating maglock failure or forced bypass

- a. Arm the system to normal mode.
- b. Open the door undergoing test.
- c. Ensure opposite door is closed so test will only verify one door at a time.
- d. Take alignment mode switch to alignment mode.
- e. System will fail at the attempt to lock the door.
- f. The system should drop to a “crashed” mode within 2 seconds.
- g. Return the alignment mode switch to normal.
- h. Ensure the system is normal and ready to arm.
- i. Repeat step 5a through 5h on the opposite door.

**Injector Test Cave Interlock Verification Check-off sheet.**

Building 58 room 127

Date \_\_\_\_\_

Laser System Supervisor \_\_\_\_\_

Persons performing test (2 required) \_\_\_\_\_

Supporting LSOP# \_\_\_\_\_

Reason for Verification Check

- Normal 6-month cyclic check
- Work performed on the interlock system  
(Provide summary of work performed at bottom of page)
- Failure of interlock functionality  
(Provide detailed information on failure and corrective action taken at bottom of page)

**Verification:** Both persons initial each step confirming successful system response to test.

Step 1: Tests of all Crash Switches. \_\_\_\_\_

Step 2: Tests of Laser table lid interlocks. \_\_\_\_\_

Step 3: Smoke detector verification test. \_\_\_\_\_

Step 4: Door interlock switch time delay verification. \_\_\_\_\_

Step 5: Door interlock verification simulating maglock failure. \_\_\_\_\_

- § Beacons performed properly for all modes of operation \_\_\_\_\_
- § Audible warnings were provided for transitions between modes of operation \_\_\_\_\_
- § Check to see that laser light does not leave the Class 1 enclosure \_\_\_\_\_
- § Anti-restart of interlock system is functional (once crashed, interlock does not automatically re-enable) \_\_\_\_\_
- § Laser Eyewear of proper OD for relevant wavelength is available outside the laser area. \_\_\_\_\_
- § Laser Eyewear is clean and ready for use \_\_\_\_\_

Summary of Verification Check: