

MME Standard Operating Procedure (SOP)

Name	<ul style="list-style-type: none"> LW50A Nd:YAG Pulsed Welding Laser
Description	<ul style="list-style-type: none"> Laser in enclosure with safety interlocks
Location	<ul style="list-style-type: none"> Building: Engineering 3, Room: 2103B
SOP Creation Date	<ul style="list-style-type: none"> 2015-04-23
SOP Created By	<ul style="list-style-type: none"> Boyd Panton
SOP Revision Date	<ul style="list-style-type: none"> N/A
SOP Revised By	<ul style="list-style-type: none"> N/A
SOP Location	<ul style="list-style-type: none"> https://uwaterloo.ca/centre-advanced-materials-joining/safety-first/standard-operating-procedures
Manual Location	<ul style="list-style-type: none"> lsd.miyachiamerica.com
Equipment Owner	<ul style="list-style-type: none"> Prof. Y. Norman Zhou
Authorized Trainers	<ul style="list-style-type: none"> Boyd Panton Andrew Michael
Support Technicians	<ul style="list-style-type: none"> No Technician assigned Contact Amada Miyachi America Inc.



Significant Hazards	<ul style="list-style-type: none"> The laser is housed in and enclosure with safety interlocks that ensure that when the enclosure is open the laser cannot fire, so no contact between the operator and laser can occur Non-beam hazards <ul style="list-style-type: none"> Fire and explosion (class 4 lasers able to ignite combustible materials; keep laser work cell clean). Electrical (high voltage power supplies, and large capacitors) X-Y-Z axis motion system; crush hazards Sheet Metals edges and sharp wires; cut hazards Compressed gases <ul style="list-style-type: none"> High pressure vessels Valve failure Noise (Laser, chillers, gas jets, parts handling, process interaction are all noise sources)
Administrative Controls	<ul style="list-style-type: none"> The laser equipment can be used during: Monday to Friday 9.00 AM to 6.00 PM. Authorized personnel: Boyd Panton (x. 36963), Andrew Michael. Only authorized personnel shall operate, maintain or service the laser. Service personnel shall comply with control procedures.
Engineering Controls	<ul style="list-style-type: none"> The laser and workspace are housed in protective cells. <ul style="list-style-type: none"> There are interlocks on the doors into the work cell The viewports into the work cell are impenetrable to the laser energy The laser is monitored and fired from a remote location (outside of the work cell) <ul style="list-style-type: none"> Service access panels are interlocked and require a tool for removal. Emergency stop/panic button A key-controlled master switch is provided.

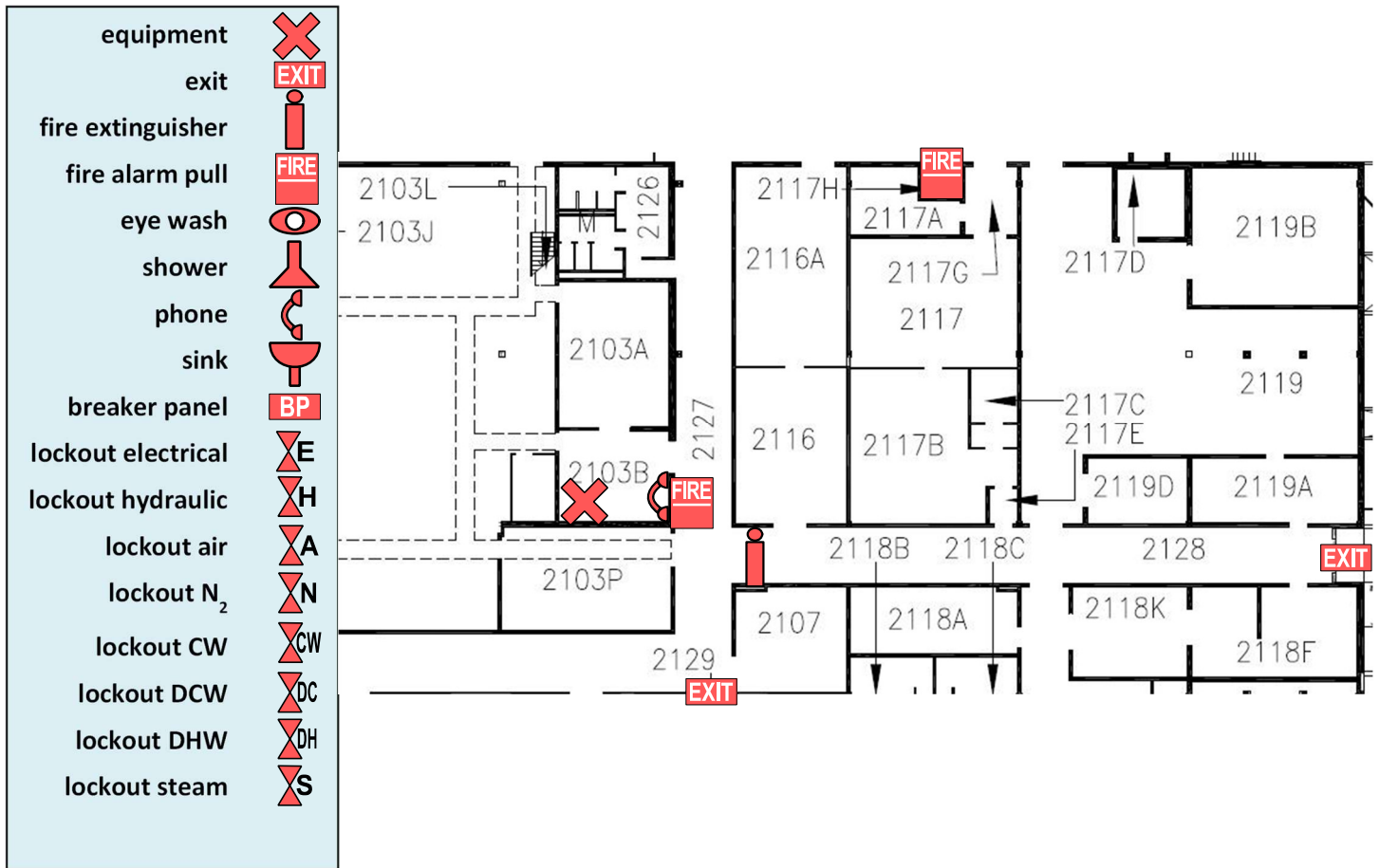
PPE Required

- No Personal Protective Equipment is required to operate the equipment
 - The engineering controls ensure that the operator is never in direct contact with the laser energy
- Protective eye goggles are required for safely maintaining the system
- Factors in selecting appropriate eyewear:
 - Laser power and /or pulse energy
 - Wavelength(s) of laser output
 - Maximum permissible exposure
 - Optical density requirement of eyewear filters at laser output wavelength
 - Visible light transmission requirement and assessment of the effect of the eyewear on the ability to perform tasks while wearing the eyewear

Wavelength (s) or wavelength range (nm)	Power (W)	Eyewear optical density required
1064	5000	7+

<p>Relevant Standards and Codes</p>	<ul style="list-style-type: none"> • The guidance on best practice in the use of lasers is given in: <ul style="list-style-type: none"> ○ ANSI Z136.1 “American National Standard for Safe Use of Lasers” ○ IEC 60825-1 “Safety of laser products – Part 1: Equipment classification and requirements”. ○ CAN/CSA E 60825-1 ○ U. S. O. S. H. A. regulations ○ U. S. CDRH Laser product performance requirements ○ U. S. ANSI B 11.21 “Machine Tools Using Lasers for Processing Materials – Safety Requirements for Design, Construction, Care, and Use” ○ Ontario Ministry of Labour follows ANSI Z136.1 ○ ANSI Z136.1 “American National Standard for Safe Use of Lasers” <ul style="list-style-type: none"> ▪ Maintained and published by Laser Institute of America (www.laserinstitute.org) ▪ Principle U. S. laser safety standard for laser users ▪ Goal: to harmonize with international (IEC) standard ▪ Changes for the 2007 version of the ANSI Z136 standard <ul style="list-style-type: none"> • Changes to classifications (harmonize with IEC specs.) • Increase duties of Laser Safety Officer ○ U. S. O. S. H. A. regulations <ul style="list-style-type: none"> ▪ Inspectors may cite ANSI Z136.1 under General duty clause ▪ General industry standards <ul style="list-style-type: none"> • 29 CFR 1910.132 – general requirement for PPE • 29 CFR 1910.133 – eye and face protection • 29 CFR 1910.134 – respiratory protection • 29 CFR 1910.147 – lock out/ tag out • www.osha0slc.gov/SLTC/laserhazards/ ○ U. S. ANSI B11.31 (2006) “Machine Tools-Safety Requirements for Machine Tools Using Lasers for Processing Materials” <ul style="list-style-type: none"> ▪ Scope: This standard applies to machine tools using laser radiation to process materials. It describes the hazards generated by such machines and states the protective measures to be incorporated into such machines. The standard also contains the description of information required to be provided by suppliers and users of such equipment. ▪ Sponsored by: AMT – The Association for Manufacturing Technology ▪ www.nssn.org, search standards for ANSI B11.21
<p>Relevant MSDS</p>	<p>All MSDSs can be found at msds.mme.uwaterloo.ca</p> <ul style="list-style-type: none"> • Acetone • Ethanol • Deionized water • Compressed argon

<p>Accident Procedure</p>	<ul style="list-style-type: none"> • All accidents/exposures are to be reported to your supervisor as soon as possible. • Compressed argon leakage from cylinder → Call UW Police 519-888-4911 or X. 22222. • For treatment of all other injuries, proceed to: <ul style="list-style-type: none"> ○ Department first aid kit in E3 – 2108H ○ Health Services for first aid services (519-888-4096, X. 84096) ○ UW Police assists if the above services are not available (519-888-4911, X. 22222) • See Safety Posters in this lab
<p>Emergency Shutdown Procedure</p>	<ul style="list-style-type: none"> • Personnel Injury: <ul style="list-style-type: none"> ○ Turn off the laser system with the "Emergency Button" or power switch. ○ Call 911 and inform the dispatcher to advise medical personnel that the accident involved lasers. ○ Contact Health Services – first aid services available → 519-888-4096 or Ext. 84096. ○ UW Police – assists if the above services are not available → 519-888-4911 or Ext. 22222. ○ Complete incident report. • Fire: <ul style="list-style-type: none"> ○ Turn off the laser system with the "Emergency Button" or power switch. ○ Evacuate area as stated in your Building Emergency Plan. ○ Active wall mounted fire alarm pull station located at exits. ○ Call 911 for medical assistance (Ambulance). If using a cell/mobile call UW Police at 519-888-4911. ○ Report any information about fire to UW Police and Fire Department.



Pre-start Checklist

Before starting the equipment:

- Inspect chiller and laser for leaks
- Have the Ophyr power meter on hand
- Ensure space around laser and interior of laser workspace are clean
- Be familiar about panic button/Emergency Stop
- Master Switch (operated by key)
- Main power switch
- Details operating procedures
- Emergency contact information (UW Police, Health Services, Safety Officer)

Start-up Procedure: Power Up

- Turn on the Nd:YAG chiller.
- Turn on Unitek Precision System Keypad which is found near the chiller
- Turn on LW50A power supply by the main power switch found on the front face.
- Switch the Shutter Control to on.
- Open Argon gas valve completely
- Turn on TV, Colorado Video system, and, if needed, the computer.
- After shutter control system ready light (Indicating High Voltage) is lit continue to Laser Power Tracking

Start-up Procedure: Power Tracking

- Place the Ophir Vega power meter next to the actuated table in the laser chamber.
- Plug the serial port into the power meter and plug the power in the power meter.
- Turn on the power meter.
- Set the readings to Joules and the range to 6 J.

NOTE: All initial readings are done at a low power to ensure that the damage is minimized if the improper fiber is selected.

NOTE: Make note of the laser fiber used and the lens used.

- Center power sensor below the laser lens. Place the aluminum plate underneath the sensor.
- Articulate the laser in the Z axis by selecting the up and down arrows of the right directional pad on the laser controller. Bring the laser all the way down to the laser meter.

NOTE: Although the green button allows for large rates of movement, use it only after ensuring that the laser will not clash with the meter.

- Center laser in the sensor by using the left directional pad buttons.

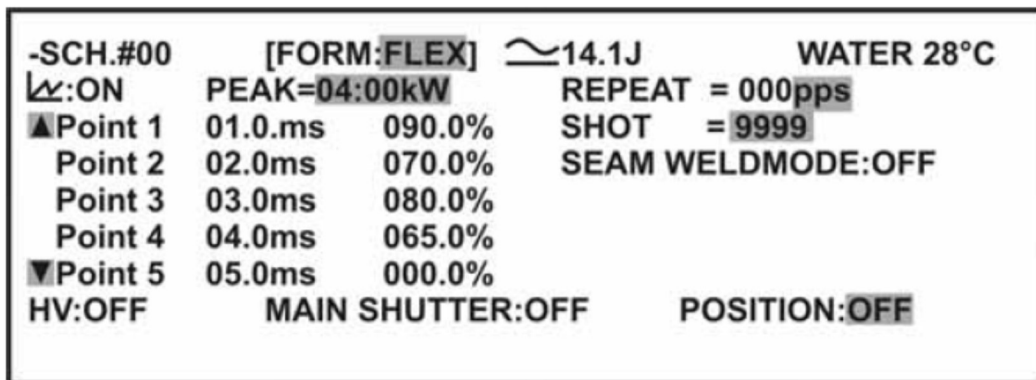
NOTE: The sense of the left directional pad buttons are reversed. Pressing right will move the table left, vice versa.

- Previous to closing the door, ensure that the fiber you will select is the one that is installed in the columnator.
- Close doors
- Ensure the laser control button, the yellow button, is off. Otherwise the computer will have control.
- In the Status Screen, select the proper fiber is on and the mirror is on. All others should be off. After ensuring that the fiber that is selected on the YAG Laser Controller, ensure that the main shutter is on.

NOTE: Mirror 2 is a fixed position laser so is permanently on unless Mirror 1 is switched on. For using the second fiber, just ensure that fiber 2 is on

NOTE: If the menu item is switched without pressing enter it will not be selected. One way to ensure all the selections are correct is to cycle through all the menus and return to the current menu screen to ensure the proper selection.

- Press Menu on the laser controller until you reach the Schedule screen, see Figure 1



-SCH.#00	[FORM:FLEX]	≈14.1J	WATER 28°C
⏏:ON	PEAK=04:00kW	REPEAT = 000pps	
▲Point 1	01.0.ms	090.0%	SHOT = 9999
Point 2	02.0ms	070.0%	SEAM WELDMODE:OFF
Point 3	03.0ms	080.0%	
Point 4	04.0ms	065.0%	
▼Point 5	05.0ms	000.0%	
HV:OFF	MAIN SHUTTER:OFF	POSITION:OFF	

Figure 1: Example of Schedule Screen

- In the Schedule Menu, select the following:
 - Schedule # 00
 - Schedule 00 should be reserved for laser power testing.
 - Peak: 00.50 kW
 - Form: Flex
 - Form flex allows for non-conventional waveforms to be defined over twenty segments.

- Point 1: 00.0 ms and 100%
- Point 2: 01.0 ms and 100%
- Point 3-20: 00.0 ms and 0%
- Repeat: 0 pps
- Shot: 0
- Seam WeldMode: Off

- Look at the Graph, to ensure that the waveform that is shown is correct. It can be shown by selecting the little graph symbol underneath the schedule
- Cycle through all menus to ensure that the proper fiber and mirror is selected, and schedule settings are selected.
- Turn on the aiming beam to ensure that the correct fibre and mirror combination have been selected and are the same as the installed fibre.
- Fire the laser 1 time and see if the power meter measures any energy. If it does then the fibre was installed and selected properly
- Fire laser ten times, record results of the controller and of the Vega Power meter output and the Miyachi reported output. If the output flashes that indicates that the proper fiber has been selected.
- Put the recorded values in the excel file on the computer in the lab
- Compare the values to the average of previous trials. If it is out of the standard deviation then examine the system for issues.
- Repeat the measurement procedure for the working laser pulse profile that will be used.
- If the powers are within the standard deviation of the previous measurements than continue to the remainder of the startup procedure. If they are not, then examine the system for issues.

Start-up Procedure: Wire Rig Mounting and Wire Preparation

- Place the wire actuator rig in the location specified by the red marks and bolt down.
- Line up the wire holding fixture final roller underneath the wire actuator wheel and affix to the table with the four bolts.
- Put springs on using the pins and screws available.
- Attach gas lines and minimize number of kinks and bends.
- Using a kimwipe, clean etched wire in acetone, ethanol, and then DI water.

NOTE: The acetone removes any chemicals on the wire. The ethanol removes the acetone. The water ensures everything is clean.

- Put wire through the between the two closest rollers ensuring the wire is in the little roller notch shown.
- Feed wire through the laser opening to the next rollers.
- Put wire through the rollers ensuring that the wire is in the little notch.
- Bring wire to final rollers and while actuating the wire rig, left and right directional buttons on the right directional pad of the keypad, push the wire until the wire catches on the actuator.
- Feed enough wire so that the actuator can move the wire properly.

Start-up Procedure: Laser Spot Reticle Location Verification

- Place burn paper on the fixture that you will be using.
- Focus camera on paper by articulating the table and laser in X, Y, and Z axes.
- Select the laser position on the controller. On the TV, the display of the laser spot is shown. Bring the laser until it is in focus and move slightly above to ensure that laser focal point occurs above part and fixture rather than in it. Use the aiming beam to ensure the laser is focused: when the aiming beam is the smallest diameter the laser is focused.
- Set to the 00 low power schedule. Fire laser.
- Position yourself so that parallax of the TV is minimized and verify that the spot is at the correct place on the TV.
- If spot is not centred, use ethanol on a kimwipe and remove spot and remark the screen with a marker. Repeat step 5 until aligned.

Start-up Procedure: Motion Planner Using Correct Fibre

- Previous to starting to process wires, check that the program selected uses the proper fiber. If this is not checked the fibre could be damaged
- Place burn paper on the fixture that you will be using.
- Focus camera on paper by articulating the table and laser in X, Y, and Z axes.
- Select the laser position on the controller. On the TV, the display of the laser spot is shown. Bring the laser until it is in focus and move slightly above to ensure that laser focus occurs above part and fixture rather than in it.
- Afterwards, press the laser control button, the yellow button on the keypad, to allow the computer to control the laser.
- After running Motion Planner on the computer using Andie BWH, which was copied from the initial file, press r4 to run the wire processing program.
- Enter the information prompted by the program.

NOTE: When entering items into the program, ensure to put the prefix of exclamation mark and apostrophe (!') before the number.

- After the program has run, ensure that the laser fired on the burn paper, which ensures that the proper laser fiber was selected by the program.

Operating Procedure

- Turn on the Nd:YAG chiller.
- After doing the check for using a motion planner program, take off the laser position control by turning off the laser control, the yellow button.
- Move laser so that the reticle is lined up with the middle of the laser fixture hole and in the middle of the wire.
- Select the laser position on the controller. On the TV, the display of the laser spot is shown. Bring the laser until it is in focus and move slightly above to ensure that laser focus occurs above part and fixture rather than in it.
- Close door, turn on the gas, blue button on keypad, and ensure that the flowmeter reads 20 c.f.m. on the argon gauge (Or what is appropriate for the fixture that is being used).
- Leave argon on for two minutes to ensure that the wire will not oxidize.
- Turn on yellow button to relinquish control to the PC.
- After running Motion Planner on the computer using Andie BWH, which was copied from the initial file, press r4 to run the wire processing program.

- Enter the information prompted by the program.

NOTE: When entering items into the program, ensure to put the prefix of exclamation mark and apostrophe (!') before the number. Previous to pressing enter after pulses wait for the argon fill time to reach 2 minutes.

NOTE: In order to speed up laser use, insert the laser wait time into the program

- After the two minutes are up, press enter to run the program.

Some Useful Commands:

If you lose control of the laser:

- Kill Program: *!k*
- Type and press enter to shut argon off: *!out.17-0*
- Use a dummy program to regain control by typing: *r5* and enter *!'* multiple times

Shutdown Procedure

- Turn off TV, Colorado Video system, and the computer.
- Close Argon gas valve completely
- Switch the Shutter Control to off.
- Turn off LW50A power supply by the main power switch found on the front face.
- Turn off Unitek Precision System Keypad which is found near the chiller
- Turn off the Nd:YAG chiller.

Clean-up

The clean-up procedures are as follows:

- Clean-up the working table after each weld; any kind of dirt, weld deposits.
- Use the log book located in the cabinet to document weekly/bi-weekly/monthly clean-up operation.
- All waste should be transferred to the Environmental Safety Facility (ESF) located at ESC Room 150

Lockout

- Notify all affected workers
- Put a sign on the door to the lab
- Ensure each person in the room has the laser safety goggles
- Machine equipment shutdown and isolation (place locks and tags on the switches and valves to prevent their use).
- The tagger shall ensure that the lockout/tagout is effective. After the shutter is lifted and tagged, the outrigger cover can be removed. The initial verification of this lockout shall be performed while wearing laser goggles to verify complete closure of the shutter.
- When the work is completed, ensure that all employees are clear before removing the locks and tags, energizing equipment, or opening valves.
- Release from lockout / tagout

Maintenance and Repair

Major maintenance or issues must be investigated and performed by the authorized trainers.
If tasks are beyond the competence of the trainers then Miyachi should be contacted.

The following procedure must be followed during maintenance and repair:

- Maintain regular log book/schedule for maintenance/repair.
- Check the laser working envelope regularly, and reposition the limit switch.
- Refer to the manual during maintenance/repair as listed in “Relevant Standards and Codes” section