

# MME Standard Operating Procedure (SOP)

<b>Name</b>	<ul style="list-style-type: none"> <li>Fiber Laser Welder</li> </ul>
<b>Description</b>	<ul style="list-style-type: none"> <li>Ytterbium Doped Fiber, YLS-6000</li> </ul>
<b>Location</b>	<ul style="list-style-type: none"> <li>Building: E3, Room: 2116</li> </ul>
<b>SOP Creation Date</b>	<ul style="list-style-type: none"> <li>22<sup>nd</sup> April 2013</li> </ul>
<b>SOP Created By</b>	<ul style="list-style-type: none"> <li>Dulal Chandra Saha (ID# 20497839)</li> </ul>
<b>SOP Revision Date</b>	<ul style="list-style-type: none"> <li>16<sup>th</sup> March 2015</li> </ul>
<b>SOP Revised By</b>	<ul style="list-style-type: none"> <li>Dulal Chandra Saha</li> </ul>
<b>SOP Online Location</b>	<a href="https://sharepoint.uwaterloo.ca/sites/MME/Inventory">https://sharepoint.uwaterloo.ca/sites/MME/Inventory</a> <ul style="list-style-type: none"> <li></li> </ul>
<b>Equipment Owner</b>	<ul style="list-style-type: none"> <li>Professor Norman Zhou (x. 36095)</li> </ul>
<b>Authorized Trainers</b>	<ul style="list-style-type: none"> <li>Current: Dulal Chandra Saha (X. 35625), Nathan Lun (519-591-8988)</li> </ul>
<b>Support Technicians</b>	<ul style="list-style-type: none"> <li>James Merli (x. 38080)</li> <li>ITW (Panasonic for Robot) and IPG (IPG Photonics for Laser) → details contact information is in maintenance and repair section.</li> </ul>



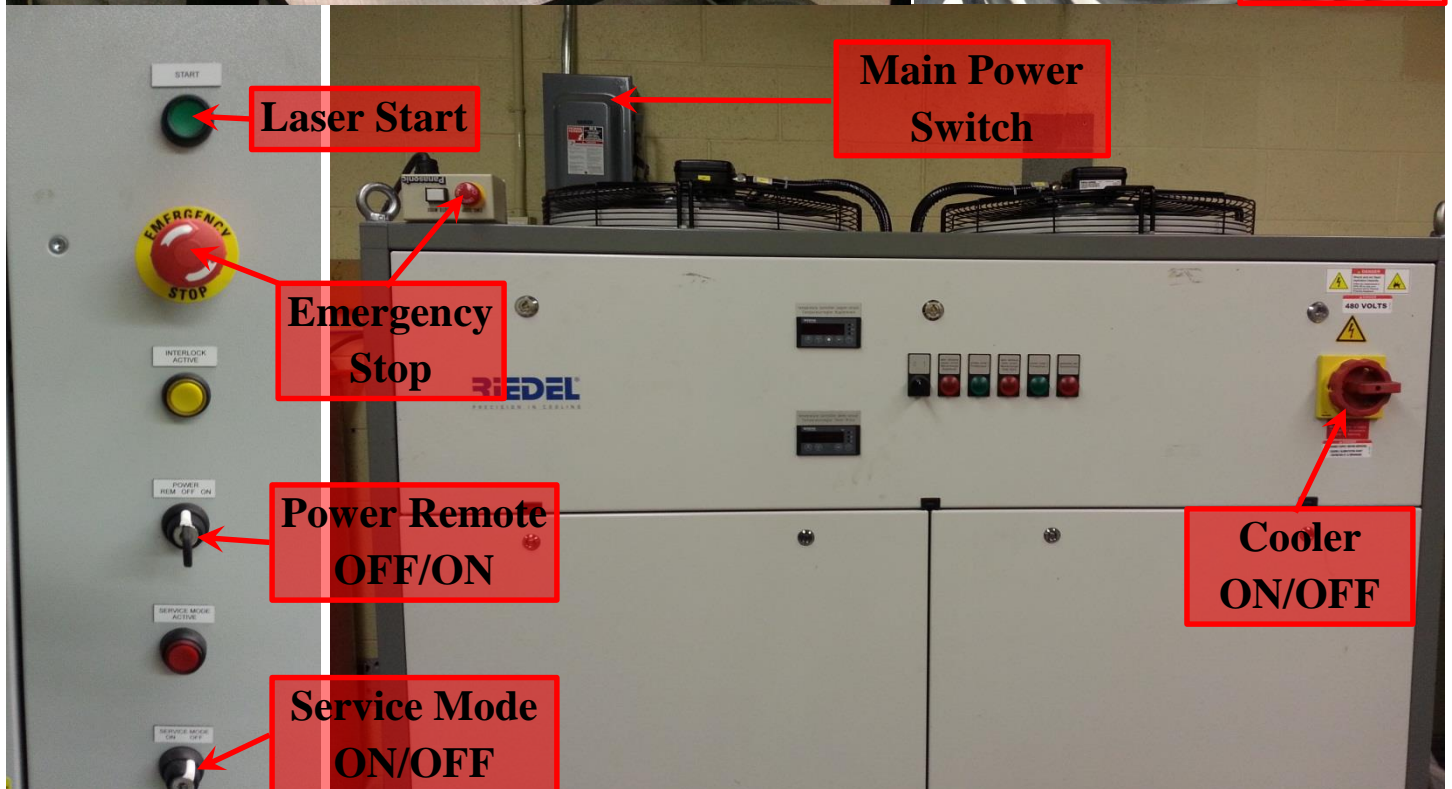
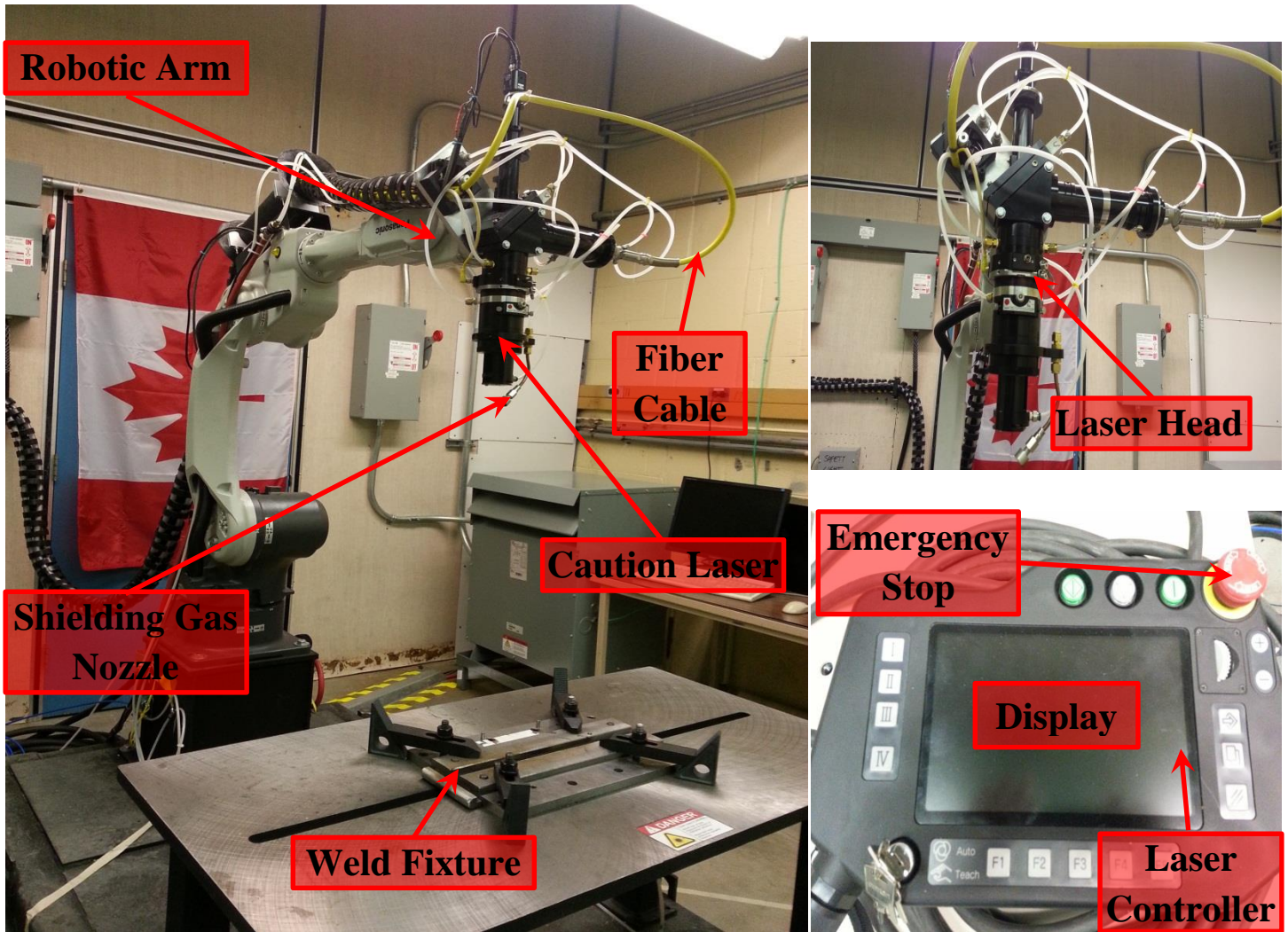
<p><b>Significant Hazards</b></p>	<ul style="list-style-type: none"> <li>• Laser radiation (wavelength 1070 nm)</li> <li>• Eyes and Skin hazards <ul style="list-style-type: none"> <li>○ Thermal (heat build-up from absorbed laser light)</li> <li>○ Photo-chemical (photon energy sufficient to cause bond breaking)</li> </ul> </li> <li>• Laser hazards to the eye <ul style="list-style-type: none"> <li>○ Visible and near IR (400 to 1400 nm)</li> <li>○ Absorbed at retina</li> <li>○ Blind spots <ul style="list-style-type: none"> <li>○ Optic disk &gt; total blindness</li> <li>○ Fovea &gt; central vision</li> <li>○ Macula &gt; color vision</li> </ul> </li> <li>○ Degraded color vision</li> <li>○ Degraded night vision</li> </ul> </li> <li>• Laser hazards to the skin (Visible to near IR) <ul style="list-style-type: none"> <li>○ Penetrates partially through skin</li> <li>○ Deep burns</li> </ul> </li> <li>• Non-beam hazards <ul style="list-style-type: none"> <li>○ Fire and explosion (class 4 lasers able to ignite combustible materials &gt;&gt; keep production area clean)</li> <li>○ Fumes (Regular maintenance and cleaning exhaust systems)</li> <li>○ Electrical (high voltage power supplies, and large capacitors)</li> <li>○ Automated laser welding (Robots &gt;&gt; crush hazards. Sheet Metals edges &gt;&gt; cut hazard)</li> <li>○ Compressed gases <ul style="list-style-type: none"> <li>○ High pressure vessels</li> <li>○ Valve failure</li> <li>○ Fire/explosion (O<sub>2</sub>)</li> </ul> </li> </ul> </li> <li>• Noise (Lasers, chillers, Gas jets, Air knives, parts handling, process interaction are all noise sources)</li> </ul>
<p><b>Administrative Controls</b></p>	<ul style="list-style-type: none"> <li>• The laser equipment can be used during: Monday to Friday 9.00AM to 6.00PM.</li> <li>• Authorized personnel: Dulal Chandra Saha (x. 35625), Nathan Lun (519-591-8988).</li> <li>• Only authorized personnel shall operate, maintain or service the laser.</li> <li>• Alignment procedures shall ensure that the MPE for the eye is not exceeded.</li> <li>• Eye protection shall be required.</li> <li>• Spectators shall be prevented from the controlled area.</li> <li>• Service personnel shall comply with control procedures.</li> <li>• The laser safety officer shall take measures to reduce output if the output is considered to be excessive.</li> </ul>

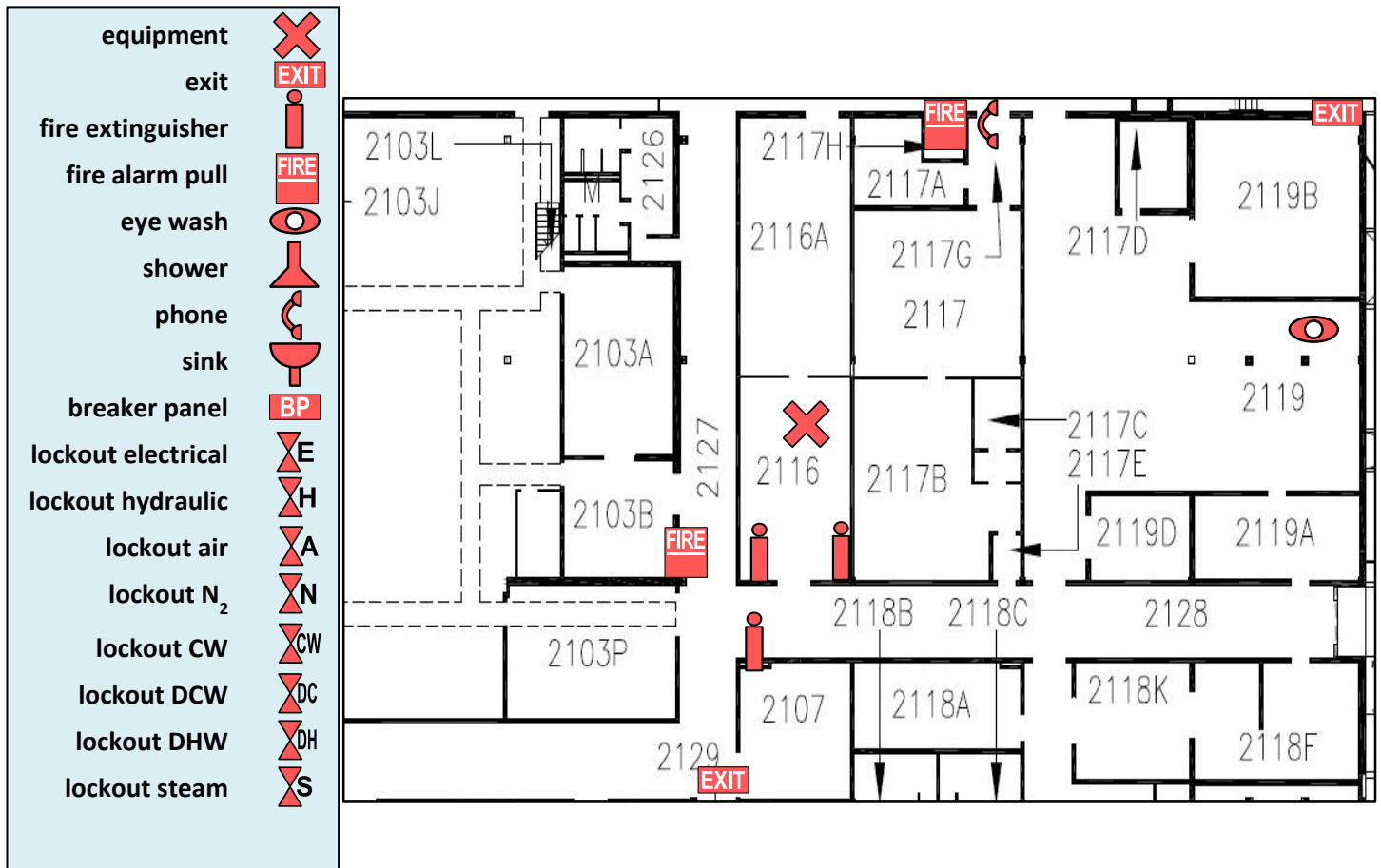
<p><b>Engineering Controls</b></p>	<ul style="list-style-type: none"> <li>• Entryway (door) interlocks</li> <li>• Emergency stop/panic button</li> <li>• Master switch (operated by key)</li> <li>• Warning signs</li> <li>• Protective housing is provided.</li> <li>• Interlocks are provided on removable parts of the housing.</li> <li>• Service access panels are interlocked or require a tool for removal.</li> <li>• A key-controlled master switch is provided.</li> <li>• When the entire beam is not enclosed, a NHZ is established.</li> <li>• A permanent beam stop or attenuator is provided.</li> <li>• An alarm, warning light, or verbal countdown is used during use or start-up of the laser.</li> <li>• The controlled areas are: <ul style="list-style-type: none"> <li>○ restricted to authorized personnel only</li> <li>○ equipped with a device that allows for deactivation of the laser or reduction of output to below the MPE</li> <li>○ designed to fulfill Class IV controlled area requirements</li> <li>○ designed with entry safety controls</li> </ul> </li> <li>• The laser is monitored and fired from a remote location.</li> </ul>						
<p><b>PPE Required</b></p>	<ul style="list-style-type: none"> <li>• Eye Protection → two eyewear goggles are available in the laser room cabinet.</li> <li>• Factors in selecting appropriate eyewear: <ul style="list-style-type: none"> <li>○ Laser power and /or pulse energy</li> <li>○ Wavelength(s) of laser output</li> <li>○ Maximum permissible exposure</li> <li>○ Optical density requirement of eyewear filters at laser output wavelength</li> <li>○ Visible light transmission requirement and assessment of the effect of the eyewear on the ability to perform tasks while wearing the eyewear</li> </ul> </li> </ul> <table border="1"> <thead> <tr> <th>Wavelength (s) or wavelength range (nm)</th> <th>Power (W)</th> <th>Eyewear optical density required</th> </tr> </thead> <tbody> <tr> <td>1070</td> <td>6000</td> <td>OD 7+</td> </tr> </tbody> </table> <ul style="list-style-type: none"> <li>• Skin Protection → to protect from laser irradiation to skin, every authorized personnel are provided an apron to wear.</li> <li>• Gloves are available in the laser room to wear during laser operation and materials handling.</li> <li>• Robot/Laser Protective Barriers → to protect from robot hit, Safety Mats are installed within the working envelope of the robot.</li> </ul>	Wavelength (s) or wavelength range (nm)	Power (W)	Eyewear optical density required	1070	6000	OD 7+
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1070	6000	OD 7+					

<p><b>Relevant Standards and Codes</b></p>	<p>The guidance on best practice in the use of lasers is given in:</p> <ul style="list-style-type: none"> <li>○ ANSI Z136.1 “American National Standard for Safe Use of Lasers”</li> <li>○ IEC 60825-1 “Safety of laser products – Part 1: Equipment classification and requirements”.</li> <li>○ CAN/CSA E 60825-1</li> <li>○ U. S. O. S. H. A. regulations</li> <li>○ U. S. CDRH Laser product performance requirements</li> <li>○ U. S. ANSI B 11.21 “Machine Tools Using Lasers for Processing Materials – Safety Requirements for Design, Construction, Care, and Use”</li> <li>○ Ontario Ministry of Labour follows ANSI Z136.1</li> <li>○ ANSI Z136.1 “American National Standard for Safe Use of Lasers” <ul style="list-style-type: none"> <li>○ Maintained and published by Laser Institute of America (<a href="http://www.laserinstitute.org">www.laserinstitute.org</a>)</li> <li>○ Principle U. S. laser safety standard for laser users</li> <li>○ Goal: to harmonize with international (IEC) standard</li> <li>○ Changes for the 2007 version of the ANSI Z136 standard <ul style="list-style-type: none"> <li>○ Changes to classifications (harmonize with IEC specs.)</li> <li>○ Increase duties of Laser Safety Officer</li> </ul> </li> </ul> </li> <li>○ U. S. O. S. H. A. regulations <ul style="list-style-type: none"> <li>○ Inspectors may cite ANSI Z136.1 under General duty clause</li> <li>○ General industry standards <ul style="list-style-type: none"> <li>○ 29 CFR 1910.132 – general requirement for PPE</li> <li>○ 29 CFR 1910.133 – eye and face protection</li> <li>○ 29 CFR 1910.134 – respiratory protection</li> <li>○ 29 CFR 1910.147 – lock out/ tag out</li> <li>○ <a href="http://www.osha0slc.gov/SLTC/laserhazards/">www.osha0slc.gov/SLTC/laserhazards/</a></li> </ul> </li> </ul> </li> <li>○ U. S. ANSI B11.31 (2006) “Machine Tools-Safety Requirements for Machine Tools Using Lasers for Processing Materials” <ul style="list-style-type: none"> <li>○ 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.</li> <li>○ Sponsored by: AMT – The Association for Manufacturing Technology</li> </ul> </li> <li>○ <a href="http://www.nssn.org">www.nssn.org</a>, search standards for ANSI B11.21</li> </ul>
<p><b>Relevant MSDS</b></p>	<ul style="list-style-type: none"> <li>● Acetone</li> <li>● Ethyl Alcohol</li> <li>● Air, Compressed</li> <li>● Argon, Compressed</li> <li>● Helium, Compressed</li> <li>● Oxygen, Compressed</li> <li>● All MSDSs can be found at <a href="https://sharepoint.uwaterloo.ca/sites/MME/MSDS">https://sharepoint.uwaterloo.ca/sites/MME/MSDS</a> that was on the template.</li> </ul>

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







**Pre-start Checklist**

The following items that needs to be inspect before working with lasers:

- Inspect whether other laser is in operation or not.
- Beware of Lasers working envelope
- Beware of Laser Enclosure Interlocks
- Laser Housing interlocks
- Remove any reflective material from beam path
- Beware of the location of fire extinguisher
- Be familiar about panic button/Emergency Stop
- Master Switch (operated by key)
- Main power switch
- Safety Mat conditions.
- Space conditions (Fumes / Vapors).
- Ensure proper ventilation.
- Safety gloves and apron.
- Correct Laser safety glasses.
- Details operating procedures
- Emergency contact information (UW Police, Health Services, Safety Officer)

**Start-up Procedure**

The following items need to be ensured before Laser operation:

- Clean the workplaces (Tables and other parts)
- Check whether cooler is working or not.
- Check the shielding gas pressure.

- Observe any kind of abnormality associated with laser or cooler.
- Position the work pieces into the weld fixture and secured properly.
- Operate Robot without Laser; and check for perfect movement of Robot arm as set-up in program.
- If everything working well then go for next step → Operation

## Operating Procedure

### Stepwise Process for Fiber Laser Welding

#### Machine Setup

1.	Wear Laser Safety Glass
2.	Turn ON chiller
3.	Turn ON Laser Power, set laser key to "Remote"
4.	Turn on Blower, and set up Ventilation; mount magnetic base clear of robot path
5.	Turn on Computer, open "Laser Net Software"
6.	Turn ON Robot Power
7.	Place the sheets in the fixture and tighten snugly
8.	Open startup program, select test mode and run startup program; wait for program holding signal.
9.	Wait for bottom stack lights to begin flashing
10.	LASER IS NOW ARMED; Laser goggles MUST be worn
11.	Open welding program (e.g. "Flying Start Hay20")
12.	Change the Parameters and locate the Laser position as well as focus using TV display.
	Set: P1: Home Position, P2: Point near start of the welding, P3: Start point
	P4: End of the welding, P5: Near P4, P6: Home Position.
13.	After focusing, Go to beginning of program and TURN ON ROBOT; CTRL (IV)
	Then follow ROBOT path, check there are no obstructions: Press (F1)
	Open Shielding Gas: F2 >> III >> You can hear the purge of shielding gas sound.
	Make sure IV is ON before welding
14.	After locating points and selecting parameters. Highlight beginning of program and SWITCH the Key from "Teach" to "AUTO MODE"
15.	Press confirm button, located outside of work envelope
16.	Stay behind the robot work envelope
17.	Run Weld wait for "Program end" signal
18.	Turn the key from "Auto Mode" to "Teach"
19.	Check that stack lights are no longer flashing
20.	Laser now dis-armed
21.	Release Dead man switch of Teach Pendant
22.	Check servo power is off; Robot should not have light on
23.	Robot Dis-armed
24.	Remove welded sample
<b>Repeat same procedure for next weld</b>	



### Shutdown Procedure

The Laser shut down procedures are as follows:

- Turn the Robot from “Auto Mode” to “Teach” mode, and keep the operating controller into safe place.
- Check that stack lights are no longer flashing.
- Close the valves of shielding gas.
- Turn the Laser mode to OFF with power key.
- Turn the laser power OFF by rotating power box counter clockwise.
- Turn OFF the cooler.
- Remove the welded parts from the weld fixture.

### 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

Lockout / tagout procedures should include:

- Notification to all affected workers
- Shutter Mechanism should be lifted to the Lockout position. The vacuum systems and the outrigger area should be isolated from the laser beams.
- The lifting of the shutter mechanism will prevent entry of laser light into the outrigger table and vacuum windows. This will make downstream vacuum systems safe from laser exposure.
- Machine equipment shutdown and isolation (place locks and tags on the switches and valves to prevent their use).
- The tagger shall ensure that the LO/TO 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

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.

Contact with suppliers and service companies for maintenance/repair:

**For Laser:**

Company: IPG Photonics Corporation

Person: Alexei Boudenkov (Field Service Engineer)

Address: #48-3265 South Millway Drive

Mississauga, ON L5L 2R3, Canada

Cellphone: (774) 200-7905

E-mail: [aboudenkov@ipgphotonics.com](mailto:aboudenkov@ipgphotonics.com)

Website: [www.ipgphotonics.com](http://www.ipgphotonics.com)