

Ref: NTU/EEE/COFT/SWP/073.00	Date of issue: 18 Aug 2017	Next review date: 18 Aug 2020
Title : Safe Work Procedure on Working on Laser (pulsed LOTIS TII laser)		
Audience : Faculty, Staff and students handling lasers in laboratories within School of Electrical and Electronics Engineering (EEE)		

1. Aim

This SWP is to ensure all personnel at work within EEE are not exposed to any radiation when using a high powered laser.

2. Scope

This SWP covers all EEE workplaces where a person is exposed or is likely to be exposed to high power laser.

3. Definitions

EEE – refers to the School of Electrical and Electronic Engineering
LSR – refers to Laboratory Safety Representative

NEA – refers to the National Environment Agency

High Powered Laser – refers to Class 3b and Class 4 lasers as listed in the Radiation Protection (Non-Ionising Radiation) Regulations

Laser work - work which involves the using, handling or any operation involved in any high powered lasers

Laser worker - any individual who is engaged in or is employed for part or whole of his working time to do radiation work

WRAS – Workplace Risk Assessment System which is the NTU web based risk assessment application used for the conduct of workplace risk assessment.

4. Responsibilities

- 4.1. Reporting Officer** – is the person whom the radiation worker reports to for work. In the scenario of a research staff and students working in a school, the Reporting Officer is usually the Project Supervisor. The Reporting Officer shall take all reasonably practicable means to ensure the safety of the radiation workers. Reasonably practicable means include, but not limited to, conduct risk assessment,

construct proper shielding, use calibrated survey meter, provide appropriate personal protective equipment, ensure wearing of personal monitoring device, and establish safety protocols using all necessary documents in according to Radiation Protection Regulations.

4.2. Equipment Owner

The high powered laser equipment owner shall ensure:

- a) The equipment possess a valid N2 licence and renewal of licence from time to time.
- b) Ensure the NTU Radiation sticker is applied and pasted on the equipment prominently.
- c) Maintain the equipment as per recommendation by the manufacturer.
- d) Ensure risk assessment and safe work procedure are established prior to the operation of the equipment.
- e) Ensure briefing or training is done to the users any laser work begins.
- f) Ensure only persons with valid N3 licence to operate the equipment.
- g) Update any required information to the School Safety Committee upon request or when equipment are no longer in used.

4.3. Laser Worker

- a) Attend all required training before operating the laser equipment. These include taking the online e-learning courses (Non-ionizing Radiation: Introduction to NIR & Local Regulations and Laser Safety Training modules) and understanding the operation of the equipment through briefing or equipment training.
- b) Ensure he/she possesses a valid N3 licence issued by NEA to operate that particular high powered laser equipment. Co-operate with RO or LSR on the licence application and renewal process.
- c) Understand the risks involved and implement all safety practices as indicated in the risk assessment, safe work procedures and operating manual.
- d) Report any abnormalities or issues to the LSR, RO or equipment owner immediately.

4.4. Laboratory Safety Representative (LSR) – is the person employed or appointed by the school or research centres / institute to ensure safety practices are carried all the times at their respective workplaces. They are required to maintain a register of all licenses required under the Regulations.

5. Safety Awareness

5.1. Ensure all appropriate personal protective equipment (PPE) must be worn at all times.

- 5.2. Wear the correct wavelength and appropriate optical density (O.D.) goggles and ensure goggles are in good condition. Defaced goggles with missing or unidentifiable wavelength/O.D. label should not be worn. All persons in the room must put on the laser goggles when the laser work is in operation.
- 5.3. When the laser is on, maintain the beam height at a level other than normal position of the eye of a person in the standing or seated position.
- 5.4. NEVER look directly into the laser beam source.
- 5.5. Always use "beam stops" to intercept laser beams. Never allow them to propagate into the laboratory area. Never walk through a laser beam.
- 5.6. Avoid flammable items along the laser path.

6. Procedure on using Laser

- 6.1. Turn on room laser interlock system.
- 6.2. Alert other users in the room.
- 6.3. Draw and enclose the working area with laser curtain.
- 6.4. Put on appropriate goggle.
- 6.5. Alignment Procedures
 - a) Housekeeping is paramount. The work area and optical table should be free from objects or surfaces that could reflect the light. (e.g. watches or jewellery)
 - b) Try to use low-power visible lasers for determining the optical path.
 - c) Make sure that beam paths are at a safe height (below eye level when in seating or standing position).
 - d) When aligning invisible beams (UV or IR) use phosphor cards or image converter viewers so that the beam can be located.
 - e) Pulsed lasers are aligned with single pulses if possible.
 - f) If the laser is equipped with Q-switched, turn off the Q-switch and use low power, or Continuous Wave (CW).
 - g) Aluminum barriers can be used to enclose the beam as much as possible.
 - h) Use beam blocks to block high-power beams,
 - i) The use of colored tape on the optical table to indicate the beam path can be very useful.
- 6.6. Laser work should not be left unattended. Ensure the door is securely locked if there is a need to leave the premises temporary.
- 6.7. Make sure the laser completely shut down after the experiment.
- 6.8. Turn off the laser interlock system. Do not mis use the laser interlock system when laser is not in operation.

7. Risks Identified

- 7.1. Eye injury due to excess light exposure
- 7.2. Skin Burn due to physical contact to laser beam.

- 7.3. Fire hazard.
- 7.4. Electrical hazard.

8. PERSONAL PROTECTIVE EQUIPMENT REQUIRED

- 8.1. Laser safety goggles (correct wavelength and appropriate O.D. goggles)
- 8.2. Enclosed shoes (to be worn at all times when in a laboratory environment).
- 8.3. Aluminium protective screens when necessary.

9. Maintenance

Renew laser license before expiry.

10. Documentation

- 10.1. EEE- SOP on Handling of High Powered Lasers NTU/EEE/SOP/022.01
- 10.2. N2 license of laser N2-01436-0070
- 10.3. N3 license of individual user N3/04777/0009

Version History

This Table below reflects the summary of changes made to the document. The full change information is indicated with yellow highlight in the document content.

Revision	Section	Details of Change	Author	Effective Date	Approved By
00	-	Initial Release	Zhang Nan	18 Aug 2017	Wei Lei



Ref: NTU/EEE/COFT/SWP/078.00	Date of issue: 14 Sept 2017	Next review date: 14 Sept 2020
Title : Safe Work Procedure on Handling of High Power CO2 Laser SYNRAD J48-1		
Audience :	Faculty, Staff and students handling High Power CO2 Laser SYNRAD J48-1 in Fiber Technology Lab, COFT, School of EEE	

1. Aim

This SWP is for safe use of High Power CO2 Laser SYNRAD J48-1 in Fiber Technology Lab, so as to prevent injury to any person and/ or cause equipment damage.

2. Scope

This SWP covers the High Power CO2 Laser SYNRAD J48-1 in Fiber Technology Lab workplaces where a person is exposed or is likely to be exposed radiation.

3. Definitions

- 3.1 **EEE** – refers to the School of Electrical and Electronic Engineering
- 3.2 **LSR** – refers to Laboratory Safety Representative
- 3.3 **Shall** – indicates an essential requirement
- 3.4 **Should** – indicates a recommendation
- 3.5 **NEA** – refers to the National Environment Agency
- 3.6 **High Powered Laser** – refers to Class 3b and Class 4 lasers as listed in the Radiation Protection (Non-Ionising Radiation) Regulations
- 3.7 **Laser worker** - any individual who is engaged in or is employed for part or whole of his working time to do radiation work
- 3.8 **WRAS** – Workplace Risk Assessment System which is the NTU web based risk assessment application used for the conduct of workplace risk assessment.

4. Responsibilities

- 4.1 **Reporting Officer** – is the person whom the laser worker reports to for work. In the scenario of a research staff and students working in a school, the Reporting Officer is usually the Project Supervisor. The Reporting Officer shall take all reasonably practicable means to ensure the safety of the High Power CO2 Laser SYNRAD J48-1 workers. Reasonably practicable means include, but not limited to, conduct risk assessment, ensure safe work procedure is established, equipment possess a valid N2 licence,

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construct proper enclosure or shielding for safe operation of High Power CO2 Laser SYNRAD J48-1, users possess a valid N3 licence to use the equipment and provide appropriate personal protective equipment (e.g. laser safety goggles).

4.2 Equipment Owner

The owner of the High Power CO2 Laser SYNRAD J48-1 shall ensure:

- a) The equipment possess a valid N2 licence and renew the licence from time to time;
- b) NTU Laser ID sticker is applied and pasted on the high powered laser equipment;
- c) Maintain the High Power CO2 Laser SYNRAD J48-1 as per recommendation from the manufacturer;
- d) Risk assessment and safe work procedure are established prior to the operation of the High Power CO2 Laser SYNRAD J48-1;
- e) Briefing or training is done to the users before authorising such use;
- f) Ensure only persons with valid N3 licence to operate the laser;
- g) Update any required information to the School Safety Committee upon request or when cease the use of the laser.

4.3 Laser Worker

- a) Attend all required training before operating the High Power CO2 Laser SYNRAD J48-1. These include taking the online e-learning courses (Non-ionizing Radiation: Introduction to NIR & Local Regulations and Laser Safety Training modules) and understanding the operation of the equipment through briefing or equipment training.
- b) Ensure he/she possesses a valid N3 licence issued by NEA to operate High Power CO2 Laser SYNRAD J48-1. Co-operate with RO or LSR on the licence application and renewal process.
- c) Understand the risks involved and implement all safety practices as indicated in the risk assessment, safe work procedures and operating manual.
- d) Report any abnormalities or issues to the LSR, RO or laser owner.

4.3.1 Apply for a license for permit to house the High Power CO2 Laser SYNRAD J48-1 in the laboratory

4.3.2 Maintain a register of the laser and all licenses required under the Regulations. This register (Appendix 1) shall be updated and send to EEE Safety Committee quarterly.

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- 4.3.3 Only authorised persons with valid N3 licence operate this laser by tagging authorised persons with valid N3 licence to individual N2 laser licence.

5. Description of SOP/SWP

The Reporting Officer shall endorse the risk assessment via the WRAS for any work which involves the use of the High Power Argon Laser COHERENT INNOVA 90V FRED performed by his staff/students. Risk assessment shall be reviewed when changes are made to the way the activity is to be carried out or as per the requirements stated in the SWP on Risk Management.

All lasers must operate within the conditions, safe limits and any other requirements stated in the Radiation Protection (Non-ionizing) Regulations 2001 and the manufacturer's manual.

Although the basic safety requirement and practices are stated in the Regulations, it is strongly recommended that the supplementary of other safety resources like the apparatus operational manual, and general practice stated in related safety books, articles and journals be referred to.

Below are the main rules of the safety practices for the High CO₂ Laser SYNRAD J48-1:

- Ensure the staff/student working with this Class 4 laser is adequately trained, and already get the N3 laser user license.
- Wear the correct wavelength and O.D. goggles and ensure goggles are in good condition. Defaced goggles with missing or unidentifiable wavelength/O.D. label should not be worn. All persons in the room must put on the laser goggles when the laser is to be operated.
- Read the laser manual carefully and strictly follow the instructions to complete the installation of the laser.
- Follow strictly the standard operation procedures to operate the High Power CO₂ Laser SYNRAD J48-1:
 1. Turn on the power supply of the CO₂ laser;
 2. Before tuning on the laser, please make sure there is not any reflected face around the laser emission side.
 3. Open the control software "WinMark" to control the laser;
 4. Switch the key to "ON" sign to turn on the laser;

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5. To end the use, switch the key to “OFF” sign to turn off the laser;
 6. Close the control software;
 7. Turn off the power supply of the CO2 laser.
- Ensure everyone in the laser area is aware that the system is being operated. The door interlock is in place and “laser on” light is on when using the laser.
 - This class 4 laser is always hazardous for the intrabeam ocular viewing even if an accidental short-time exposure occurs. Enclose and prevent unauthorized access to the room using this class 4 laser. Viewing them through optical elements with diffuse-reflecting properties is usually safe for the user.
 - NEVER, EVER LOOK INTO ANY LASER BEAM, no matter how low power or "eye safe" you may think it is.
 - Always use "beam stops" to intercept laser beams. Never allow them to propagate into the laboratory.
 - Binoculars or aiming telescopes should not be used to view direct beam or reflected beam from mirrors unless the beam intensities are greatly below the safe levels. If necessary, a filter having sufficient optical density should be placed in the optical path of telescope for such situations or adequate laser protective eye wear is worn by the operator.
 - When the High Power CO2 Laser SYNRAD J48-1 is used with certain optical elements—such as optical amplifiers, lenses, collimators, and the like—which are not supplied with the product as original accessories, or the product is integrated into a high-level system, it is strictly recommended to reclassify the final optical system in order to determine its total degree of optical radiation hazard.
 - If you suspect that you have suffered an eye injury, notify your lab staff or Reporting Officer immediately. Your ability to recover from an eye injury decreases the longer you delays treatment.

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6. Register of Authorized N3 Laser Workers in School of EEE

Name of Laboratory:	Fiber Technology Lab	Location:	S1-B4B-04
Name of LSR:		Date:	13-Sept-2017

To qualify as an authorized user, the person must possess a valid N3 license and completed both e-learning courses (Introduction to NIR & Local Regulations and the Laser Safety Training modules)

^Place a tick (✓) to tag the N3 Licensee to the N2 Licensed High Powered Laser Equipment

*Place a tick (✓) to indicate the N3 Licensee has completed the required Safety Training Modules

S/No	Name of authorized user	N3 License No.	Date of Expiry	*Introduction to NIR, Course code: OHS2NRR01	*Laser Safety Training Course code: OHS2NRL01	N2 Licence No ^							
1	Wu Zhifang	N3/04777/0004	31st Mar 2018										
2	Xu Zhilin	N3/04777/0058	31st OCT 2018										
3	Zhang Hailiang	N3/03212/0010	31st Jan 2018										
4	Zheng Yu	N3/04777/0060	30th Nov 2017										
5	Yang Jiao	N3/04777/0061	30th Nov 2017										
6	Teo Huei	N3/04777/0049	31st May 2018										
7	Zhang Nan	N3/04777/0009	31st Mar 2018										
8	Zhang Jing	N3/04777/0023	31st Mar 2019										

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9	Zhang Mengying	N3/04777/0022	31st Mar 2019														
10	Wu Peili	N3/04777/0046	31 st Jul 2018														

Version History

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Revision	Section	Details of Change	Author	Effective Date	Approved By
00	-	Initial Release	Xu Zhilin	13 Sept 2017	Shum Ping

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Ref: NTU/EEE/COFT/SWP/079.00	Date of issue: 14 Sept 2017	Next review date: 13 Sept 2020
Title : Safe Work Procedure on Handling of High Power Argon Laser COHERENT INNOVA 90V FRED		
Audience :	Faculty, Staff and students handling High Power Argon Laser COHERENT INNOVA 90V FRED in Fiber Technology Lab, COFT, School of EEE	

1. Aim

This SWP is to provide the working procedures for High Power Argon Laser COHERENT INNOVA 90V FRED in Fiber Technology Lab, so as to prevent injury to any person and/ or cause equipment damage.

2. Scope

This SWP covers the high power Argon Laser COHERENT INNOVA 90V FRED in Fiber Technology Lab workplaces where a person is exposed or is likely to be exposed radiation.

3. Definitions

- 3.1 **EEE** – refers to the School of Electrical and Electronic Engineering
- 3.2 **LSR** – refers to Laboratory Safety Representative
- 3.3 **Shall** – indicates an essential requirement
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- 3.5 **NEA** – refers to the National Environment Agency
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- 3.7 **Laser worker** - any individual who is engaged in or is employed for part or whole of his working time to do radiation work
- 3.8 **WRAS** – Workplace Risk Assessment System which is the NTU web based risk assessment application used for the conduct of workplace risk assessment.

4. Responsibilities

- 4.1 **Reporting Officer** – is the person whom the laser worker reports to for work. In the scenario of a research staff and students working in a school, the Reporting Officer is usually the Project Supervisor. The Reporting Officer shall take all reasonably practicable means to ensure the safety of the High Power Argon Laser COHERENT INNOVA 90V FRED workers. Reasonably practicable means include, but not limited to, conduct risk assessment, ensure safe work procedure is established, equipment possess a valid N2 licence, construct proper enclosure or shielding for safe operation of High Power Argon

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Laser COHERENT INNOVA 90V FRED, users possess a valid N3 licence to use the equipment and provide appropriate personal protective equipment (e.g. laser safety goggles).

4.2 Equipment Owner

The owner of the High Power Argon Laser COHERENT INNOVA 90V FRED shall ensure:

- a) The equipment possess a valid N2 licence and renew the licence from time to time;
- b) NTU Laser ID sticker is applied and pasted on the high powered laser equipment;
- c) Maintain the High Power Argon Laser COHERENT INNOVA 90V FRED as per recommendation from the manufacturer;
- d) Risk assessment and safe work procedure are established prior to the operation of the High Power Argon Laser COHERENT INNOVA 90V FRED;
- e) Briefing or training is done to the users before authorising such use;
- f) Ensure only persons with valid N3 licence to operate the laser;
- g) Update any required information to the School Safety Committee upon request or when cease the use of the laser.

4.3 Laser Worker

- a) Attend all required training before operating the High Power Argon Laser COHERENT INNOVA 90V FRED. These include taking the online e-learning courses (Non-ionizing Radiation: Introduction to NIR & Local Regulations and Laser Safety Training modules) and understanding the operation of the equipment through briefing or equipment training.
- b) Ensure he/she possesses a valid N3 licence issued by NEA to operate High Power Argon Laser COHERENT INNOVA 90V FRED. Co-operate with RO or LSR on the licence application and renewal process.
- c) Understand the risks involved and implement all safety practices as indicated in the risk assessment, safe work procedures and operating manual.
- d) Report any abnormalities or issues to the LSR, RO or laser owner.

4.3.1 Apply for a license for permit to house the High Power Argon Laser COHERENT INNOVA 90V FRED in the laboratory

4.3.2 Maintain a register of the laser and all licenses required under the Regulations. This register (Appendix 1) shall be updated and send to EEE Safety Committee quarterly.

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- 4.3.3 Only authorised persons with valid N3 licence operate this laser by tagging authorised persons with valid N3 licence to individual N2 laser licence.

5. Description of SOP/SWP

The Reporting Officer shall endorse the risk assessment via the WRAS for any work which involves the use of the High Power Argon Laser COHERENT INNOVA 90V FRED performed by his staff/students. Risk assessment shall be reviewed when changes are made to the way the activity is to be carried out or as per the requirements stated in the SWP on Risk Management.

All lasers must operate within the conditions, safe limits and any other requirements stated in the Radiation Protection (Non-ionizing) Regulations 2001 and the manufacturer's manual.

Although the basic safety requirement and practices are stated in the Regulations, it is strongly recommended that the supplementary of other safety resources like the apparatus operational manual, and general practice stated in related safety books, articles and journals be referred to.

Below are the main rules of the safety practices for the High Power Argon Laser COHERENT INNOVA 90V FRED:

- Ensure the staff/student working with this Class 3b laser is adequately trained, and already get the N3 laser user license.
- Wear the correct wavelength and O.D. goggles and ensure goggles are in good condition. Defaced goggles with missing or unidentifiable wavelength/O.D. label should not be worn. All persons in the room must put on the laser goggles when the laser is to be operated.
- Read the laser manual carefully and strictly follow the instructions to complete the installation of the laser.
- Follow strictly the standard operation procedures to operate the High Power Argon Laser COHERENT INNOVA 90V FRED:
 1. Sign in system users' LOG BOOK;
 2. Turn on the water cooling system for the laser:
 - (a) Make sure there is enough Nitrogen flow. Typically the reading is between **0.5-1.0 Bar**. User should check the gas volume left in the tank in case the gas is running out during fabrication. The typical volume should be above **20 Bar**.

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- (b) Turn Power On switch of water circulating system(Laserpure40), if there is no alarm of mal-fuction, user can go to increase the chiller water flow slowly, typically **9.5 L/min** is required.
3. Turn on the laser:
 - (a) Press on button on laser's remote control panel. There is 50 seconds of delay to laser. If user finds there is something wrong, please turn OFF the laser;
 - (b) Minimum 30 minutes is needed to let the laser system to warm up. The current is necessary to be set at operating current (typically **45.0 A**) to warm up the laser;
 - (c) Fine tune of laser cavity might be needed to get high output of **70-90 mW**. Aperture is set at **6** for our application.
4. To end the use, turn OFF the laser:
 - (a) press OFF button on the remote control panel of the laser.
 - (b) Wait about **3-5 minutes** to let the water circulating system (Laserpure40) bring the heat away from the laser system before user can turn it off.
 - (c) User can feel the temperature difference of the chiller water going into (Marked as TO LASER) and coming out (FROM LASER) of laser system. Cannot turn off water cooling system immediately after switching off the laser;
 - (d) When the heat inside the laser has been brought away by the circulating water, user then decrease the chiller water flow to ZERO slowly and press OFF button to shut down the water circulating system.
5. Sign out system users' LOG BOOK.
 - Ensure everyone in the laser area is aware that the system is being operated. The door interlock is in place and "laser on" light is on when using the laser.
 - This class 3b laser is always hazardous for the intrabeam ocular viewing even if an accidental short-time exposure occurs. Enclose and prevent unauthorized access to the room using this class 3b laser. Viewing them through optical elements with diffuse-reflecting properties is usually safe for the user.
 - NEVER, EVER LOOK INTO ANY LASER BEAM, no matter how low power or "eye safe" you may think it is.

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- Always use "beam stops" to intercept laser beams. Never allow them to propagate into the laboratory.
- Binoculars or aiming telescopes should not be used to view direct beam or reflected beam from mirrors unless the beam intensities are greatly below the safe levels. If necessary, a filter having sufficient optical density should be placed in the optical path of telescope for such situations or adequate laser protective eye wear is worn by the operator.
- When the High Power Argon Laser COHERENT INNOVA 90V FRED is used with certain optical elements—such as optical amplifiers, lenses, collimators, and the like—which are not supplied with the product as original accessories, or the product is integrated into a high-level system, it is strictly recommended to reclassify the final optical system in order to determine its total degree of optical radiation hazard.
- If you suspect that you have suffered an eye injury, notify your lab staff or Reporting Officer immediately. Your ability to recover from an eye injury decreases the longer you delays treatment.

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6. Register of Authorized N3 Laser Workers in School of EEE

Name of Laboratory:	Fiber Technology Lab	Location:	S1-B4B-04
Name of LSR:		Date:	13-Sept-2017

To qualify as an authorized user, the person must possess a valid N3 license and completed both e-learning courses (Introduction to NIR & Local Regulations and the Laser Safety Training modules)

^Place a tick (✓) to tag the N3 Licensee to the N2 Licensed High Powered Laser Equipment

*Place a tick (✓) to indicate the N3 Licensee has completed the required Safety Training Modules

S/No	Name of authorized user	N3 License No.	Date of Expiry	*Introduction to NIR, Course code: OHS2NRR01	*Laser Safety Training Course code: OHS2NRL01	N2 Licence No ^							
1	Wu Zhifang	N3/04777/0004	31st Mar 2018										
2	Xu Zhilin	N3/04777/0058	31st OCT 2018										
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