

THE UNIVERSITY OF MANITOBA

**LASER SAFE WORK PROCEDURES
FOR THE DEPARTMENT OF MECHANICAL AND MANUFACTURING LOW-SPEED
WINDTUNNEL LABORATORY
E1-409**

Prepared by:
Patrick Fleming
Department of Mechanical & Manufacturing Engineering

Reviewed and Approved by:
Mr. P. Krueger, Laser Safety Contact
Dr. N. Popplewell, Designated Owner by:
Dr. D. Kuhn, Department Head
January 13, 2009
Updated July 13, 2009

EMERGENCY CONTACT INFORMATION:

Environmental Health and Safety Office: 474-6633

Emergency Fire Contact: 474-8566

**24 Hr Security Services (In case of fire after hours): 474-9341 or 555
or #555 from MTS / ROGERS Cell Phone**

Security Services (Non-Emergency): 474-9312

TABLE OF CONTENTS

	Page
1 LASER SAFETY	1
1.1 Laser-controlled area in E1-409 and windtunnel test section	1
2 LASER DESCRIPTIONS	2
2.1 Continuous INNOVA® 70C Series Ion Laser	2
2.2 Pulsed New Wave Research Inc. Gemini-PIV Nd:YAG Laser	3
2.2.1 Gemini-PIV Nd:YAG Laser Operation	3
3 DETAILS OF THE FLOW-VISUALISATION AND PIV TECHNIQUES	6
3.1 Overview and Additional Safe Work Procedures for Seeding Airflow	6
3.2 Beam-Path Control for Laser and Sheet-Forming Optics	7
3.2.1 Continuous INNOVA® 70C Series Ion Laser	7
3.2.2 Pulsed New Wave Research Inc. Gemini-PIV Nd:YAG Laser	7
4 LASER SAFETY EQUIPMENT AND DEVICES	8
4.1 Laser Safety Eyewear	8
4.1.1 Continuous INNOVA® 70C Series Ion Laser	8
4.1.2 Pulsed New Wave Research Inc. Gemini-PIV Nd:YAG Laser	8
4.2 Laser Safety Notices, Curtain, Interlocks, and Warning Light	9
4.3 Panic Button and Emergency Disconnect Switch for the Coherent Laser	9
5 LASER SAFE WORK PROCEDURES	10
5.1 Laser Control Keys	10
5.2 Laser Start-Up	10
5.3 Laser Alignment	11
5.4 Normal Laser Operation	11
5.5 Laser Shutdown	12
5.6 Storage of Laser Control Keys, Safety Goggles, Smoke Detector Cover, Safe Work Operating Procedures, and PIV Acknowledgment Form	12
5.7 Emergency	13
6 REFERENCES	14
APPENDIX A: SUMMARY OF HAZARDS: RISK ASSESSMENT AND CONTROL MEASURES	15
APPENDIX B: LASER OPERATORS	24

1 LASER SAFETY

High-power Class IV lasers can cause serious injuries if improperly operated. The following safety procedures have been prepared in accordance with the University of Manitoba's existing laser safety guidelines [1] to ensure safe laser operation while performing both airflow visualisation studies and particle-image velocimetry (PIV) experiments in room E1-409. Specific details regarding the safety devices, as well as the continuous and pulsed lasers used in the low-speed windtunnel laboratory (E1-409) are included. When any laser is in use, all operators and observers present in the laser-controlled area are to have already read and signed the University of Manitoba's Laser Safety Information, as well as thoroughly read the INNOVA[®] 70C Series Ion Laser and New Ware Research Inc. Tempest and Gemini PIV Nd:YAG Laser Manuals [2, 3] and safe work procedures included herein. A brief description of the windtunnel test section and laser-controlled area in room E1-409 is provided below. A hazard and risk assessment and summary of control measures are presented in Appendix A for compliance with Manitoba Workplace Safety and Health Regulations. A current list of trained laser operators allowed in the laser-controlled area in E1-409 while any laser is in use is presented in Appendix B.

1.1 Laser-controlled area in E1-409 and windtunnel test section

The laser controlled area in E1-409 encompasses the entire windtunnel and is defined by the laboratory's sheetrock walls and a laser safety barrier. The side profile of the low-speed windtunnel in room E1-409 is shown in Figure 1.1. The tunnel's test section, where all laser-based tests are performed, measures approximately 53 cm high, 76 cm wide, and 183 cm long. The test section is constructed of plywood and features optical access on three sides. The windtunnel components adjacent to the lower test section are a wooden contraction cone and a

fiberglass diffuser. For both flow visualisation studies and PIV experiments in the test section, a horizontal, laser light sheet is transmitted into the test section through the section's side access panel. Upon exiting the test section area, the laser sheet is terminated on the opposite side of the test section using a common black cloth material.

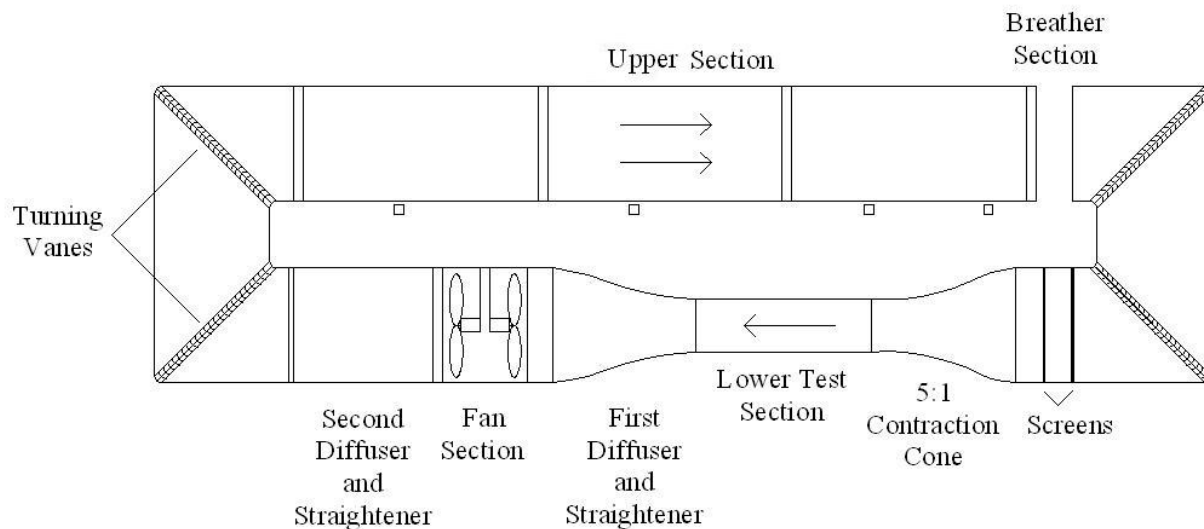


Figure 1.1. Side profile of the low-speed windtunnel in room E1-409.

2 LASER DESCRIPTIONS

2.1 Continuous INNOVA® 70C Series Ion Laser

An INNOVA I-70C-5 Argon Ion laser manufactured by Coherent Inc. is used for flow visualisation studies in the laser-controlled area in room E1-409. The laser will only be used in the laser-controlled area in room E1-409, and is capable of various modes of operation including continuous output wavelengths between 457.9 and 528.7 nm, at power levels ranging from 0 - 6 Watts. In addition, the laser is powered from a 208V AC, three-phase grounded electricity source and requires continuous cooling water when in operation. Please refer to the INNOVA® 70C Series Ion Laser Manual [2] for further specifications as well as detailed maintenance and alignment procedures.

2.2 Pulsed New Wave Research Inc. Gemini-PIV Nd:YAG Laser

For PIV experiments, a Gemini-PIV Nd:YAG laser system manufactured by New Wave Research Inc. is used in the laser-controlled area in room E1-409. The laser system consists of two power supply units connected to a combined head unit with an umbilical cord. The laser system will only be used in the laser-controlled area in room E1-409, and produces two consecutive pulses of 532nm light, at a frequency of 1-15 Hz with a maximum power level of 500 mJ per 5ns pulse. In addition, the laser is powered from a 120V AC, single phase grounded electricity source and features a sealed, internal cooling system that uses distilled water. Please refer to the New Wave Research Inc. Tempest and Gemini PIV Nd:YAG Laser Manual [3] for further specifications as well as proper operating, maintenance, and alignment procedures.

2.2.1 Gemini-PIV Nd:YAG Laser Operation

Specific details on the operation of the Gemini-PIV Nd:YAG Laser are found in the New Wave Research Inc. Tempest and Gemini PIV Nd:YAG Laser Manual [3], included in this safe work procedure. A summary of the laser's general operating controls using the laser system's two control boxes is presented below as a general overview. There are seven control adjustment on each box:

1. The **FLASHLAMP** knob. This knob controls the intensity of the flashlamp, and ultimately, the intensity of the laser emission. The laser system cannot be started unless the **FLASHLAMP** knobs are in the **MIN** position. Also, note the **FLASHLAMP** knobs are not identically calibrated. For the same intensity for each laser pulse, the knobs must be set to different positions.

2. The **REP RATE** knob, located just beneath the **REP RATE** display. This adjustment controls the pulse frequency of the Nd:YAG laser when operating in **VAR** mode. For operation with the Flow Manager software, this knob has no useful function.
3. The **REP RATE MODE** knob, located to the right of the **REP RATE** knob. This adjustment determines the mode that the laser will be fired. For operation with the Flow Manager software, use **FIXED**.
4. The **STOP** button. This button ceases operation of the corresponding laser pulse. Remember, there are two laser pulses; to stop the laser entirely, the **STOP** buttons on both control boxes must be pressed.
5. The **STANDBY** button. This button enables laser emission, providing the **FLASHLAMP** knob is set to **MIN**.
6. The **FIRE** button. This is only used when operating the laser independently of the Flow Manager software.
7. The **ATTENUATOR** knob (only on "A" box). This is an electronic attenuator that reduces the overall intensity of the laser emission. The attenuator has the same effect as turning down the **FLASHLAMP** knob on both laser control boxes.

In addition to the general Gemini-PIV operation controls noted above, a copy of the ACKNOWLEDGMENT form found on the following page will be completed for all laser operators and included in this safe work procedure.

ACKNOWLEDGMENT

I acknowledge having completely read and understood the PIV Nd:Yag Laser Protocol package. I will follow the procedure correctly at all times, and will act in a manner that protects the safety of myself and those around me.

If I have questions on any matter, I also acknowledge that I may contact my supervisor or the Environmental Health & Safety office for clarification.

EMPLOYEE OR STUDENT SIGNATURE

DATE

EMPLOYEE OR STUDENT NAME

SUPERVISOR SIGNATURE

DATE

SUPERVISOR NAME

3 DETAILS OF THE FLOW-VISUALISATION AND PIV TECHNIQUES

3.1 Overview and Additional Safe Work Procedures for Seeding Airflow

Both a laser-based flow visualisation and a PIV system involves five general components: a camera, seeding generator, dispenser, laser, and sheet-forming optics [4, 5]. For both cases, the windtunnel airflow is seeded with an aerosol composed of di-ethyl hexyl sebacate (DEHS) oil droplets having a diameter of about $1\mu\text{m}$. The oil droplets can be illuminated in the test-section using a thin laser sheet and photographed using a camera. For a flow visualisation study, the laser sheet is continuous light, while for a PIV experiment, the light sheet is pulsed at a constant frequency. DEHS oil the most common seeding particles used in air particle image-velocimetry (PIV) and laser-Doppler anemometry (LDA) techniques [6]. The oil is also useful for performing flow visualisation studies. DEHS is odourless, non-toxic, and not known to pose health risks [7], although inhalation should be avoided as the oil is non-soluble in water [6]. While seeding the airflow in the windtunnel, aerosol may become noticeable in the laser-controlled area if the windtunnel's breather section is left open. Safety precautions involving a new exhaust system for the tunnel's breather section are presently being tested. In any case where DEHS aerosol does become noticeable outside the windtunnel in the laser-controlled area, respirators will be used by all persons present. To prevent any chance of the DEHS aerosol triggering a false fire alarm, a smoke detector cover will also be used in the laser-controlled area for the duration of any laser-based experiment or study.

3.2 Beam-Path Control for Laser and Sheet-Forming Optics

3.2.1 Continuous INNOVA® 70C Series Ion Laser

The beam delivery path from the Coherent laser head through the sheet-forming optics will be covered with a black, non-reflective metal shroud to control the beam in case a large misalignment should occur and create reflections towards the operator. The laser operator and observers in the laser-controlled area will be located away from the Coherent laser head output at all times when the laser is in operation to avoid direct exposure to the beam. The output of the sheet-forming optics will also be placed as close as possible to the test-section to minimise reflections. The path of the continuous laser sheet will be terminated on the far side of the test-section with a black cloth material.

3.2.2 Pulsed New Wave Research Inc. Gemini-PIV Nd:YAG Laser

The beam delivery path and sheet forming optics for the Gemini PIV laser system are contained and sealed in the system's main head unit. When the Gemini PIV laser system is operated in normal operation, the laser operator and observers in the laser-controlled area will be located away from the laser head output at all times to avoid direct exposure to the beam. As in the case of the Coherent laser, the output of the laser system's main head unit will also be placed as close as possible to the test-section to minimise reflections. The path of the pulsed laser sheet will be terminated on the far side of the test-section with a black cloth material.

4 LASER SAFETY EQUIPMENT AND DEVICES

4.1 Laser Safety Eyewear

4.1.1 Continuous INNOVA® 70C Series Ion Laser

The laser safety eyewear listed in Appendix A, having a sufficient optical density (OD) in the wavelength range from 457.9 to 528.7 nm, will be worn by all persons present in the laser-controlled area during the operation of the continuous Coherent laser. To determine a suitable optical density, especially for the case of extended testing, the guidelines provided by Laservision [8] will be consulted and strictly followed.

4.1.2 Pulsed New Wave Research Inc. Gemini-PIV Nd:YAG Laser

The laser safety eyewear listed in Appendix A, having a sufficient optical density (OD) in the 532nm wavelength, will be worn by all persons present in the laser-controlled area during the operation of the pulsed New Wave Gemini PIV laser system. As above, to determine a suitable optical density for protection from a pulsed laser, the guidelines provided by Laservision [8] will be consulted and strictly followed.

4.2 Laser Safety Notices, Curtain, Interlocks, and Warning Light

The laser-controlled area in room E1-409 has been designed with several safety features. Laser safety warning signs in accordance with ANSI Z136.1 are posted outside the laser-controlled area and the laboratory entryway. When a laser is in use, a warning light outside the laser controlled area is also illuminated to notify other occupants in the laboratory who are outside the laser-controlled area. All entryways and exits of the laser-controlled area are equipped with interlocks to the laser in use, and ensures that if a person tries to leave or enter the area when a laser is in use, any laser output will be instantly terminated.

4.3 Panic Button and Emergency Disconnect Switch for the Coherent Laser

The interlock system for both lasers used in E1-409 also includes a portable red, mushroom-shaped panic button in case of emergency. For the Coherent laser, a stationary disconnect switch for the laser's supply electricity is also present near the laser's power supply. While performing any laser-based experiments, the panic button will be located directly next to the laser operator and the windtunnel test-section in case of emergencies. The panic button acts similarly to the doorway interlocks and terminates the laser output when pressed. The disconnect switch for the Coherent laser's electricity is permanently located above the laser's power supply and its electricity outlet. When the switch's large red handle is set to the 'OFF' position, the Coherent laser's three-phase electricity source is disconnected.

5 LASER SAFE WORK PROCEDURES

5.1 Laser Control Keys

Both the Coherent and Gemini PIV lasers cannot be operated without first turning on the lasers' power supplies with the appropriate laser control key. When a laser is not in use, the lasers' control keys will be stored in a locked chest in room E1-421, along with laser safety goggles and the smoke detector cover for room E1-409. The laser operators listed in Appendix B and Mr. K. Tarte, the laboratory technician, will be the only persons that have access to laser control keys, safety goggles, and smoke detector covers.

5.2 Laser Start-Up

Before turning on any laser with the its control key, the laser operator will ensure that the following conditions have been met:

1. The laser safety curtain is properly closed.
2. All persons in the laser-controlled area are wearing appropriate laser safety goggles and are located behind the laser output.
3. The laser aperture is closed.
4. For the Coherent laser, ensure that the cooling water is turned on.

Once a laser power supply is turned on with the control key, the laser's remote control and display lights will be checked for error messages. If the remote control reports proper operation, the laser head can be turned on or set to fire at the lowest possible power level. Note that for the Coherent laser, before the laser head is energised, there is a 50 second delay which is displayed on the Coherent laser's remote control display.

5.3 Laser Alignment

When aligning a laser's head or sheet-forming optics, the laser operator will use appropriate laser safety alignment eyewear having an optical density rating of 1.0 at 514 nm for the Coherent laser and 1-2 at 532 nm for the Gemini PIV laser. Jewelry, watches, and other reflective articles will be removed from the alignment area to prevent unanticipated reflections towards the operator or observers. Before beginning the alignment procedure, the area forward of the alignment area and laser head will also be examined for reflective materials and removed to prevent reflections. Alignment will be performed on the lowest possible power level and the procedures in the INNOVA[®] 70C Series Ion Laser and New Ware Research Inc. Tempest and Gemini PIV Nd:YAG Laser Manuals [2, 3] will be strictly followed. The laser panic button will be located directly next to the laser operator at all times during any alignment procedure.

5.4 Normal Laser Operation

During normal operation of any laser-based experiment, all occupants in the laser-controlled area will be located away from the laser head and the laser will be set to the lowest power level required. If possible, the laser in use will always be kept below eye-level of a person sitting. No one will enter or leave the laser-controlled area while a laser is in normal operation unless an emergency should arise. The laser panic button will be located next to the laser operator at all times during normal operation.

When a laser operator is working alone in the laser-controlled area for several hours at a time, prior arrangements will be made with a designated safety contact person who will check in every hour to ensure the general safety of the operator. The safety contact person will have

emergency contact information for the environmental health and safety office and security services in case the laser operator cannot be reached by phone or in person.

5.5 Laser Shutdown

The Coherent and Gemini PIV laser heads can be shutdown or de-energised by using their respective laser remote control. Once de-energised, the following actions will be taken:

1. The laser head aperture will be closed.
2. In the case of Coherent laser, the cooling water will remain on until the laser's head and power supply have had sufficient time to cool down to a safe level.
3. The laser control keys and safety goggles will be returned to the designated locked storage chest in room E1-421.
4. The smoke detector cover will be removed as soon as the laboratory's exhaust system has evacuated any aerosol in the windtunnel. The smoke detector cover will be returned to the designated locked storage chest in room E1-421.

5.6 Storage of Laser Control Keys, Safety Goggles, Smoke Detector Cover, Safe Work Operating Procedures, and PIV Acknowledgment Form

As noted above, whenever either the Coherent or Gemini PIV lasers are not in use, the laser control keys, safety goggles, and smoke detector cover will be safely stored in a locked chest in room E1-421. The operators listed in Appendix B as well as Mr. K. Tarte will be the only persons with access to the locked chest.

A copy of the laser safety operating procedures for room E1-409, as well as both laser operators manuals, the University of Manitoba's Laser Safety Information, and signed forms will be stored in a clearly marked binder next to the telephone in room E1-409.

5.7 Emergency

In case a laser-related emergency situation should arise, the Environmental Health and Safety Office will be contacted as soon as possible at **474-6633** or **555** after hours. A phone is located outside the laser-controlled area in room E1-409. A red emergency telephone is also located in the stairwell outside of the double-doors of room E1-409. If the Coherent laser must be shutdown for an emergency, the laser operator and observers will leave the cooling water on. Turning the Coherent laser's cooling water off immediately following shutdown may damage the laser.

In case of an emergency fire, fire extinguishers are located next to the sink and double doors in the laser-controlled area, and next to the single entranceway of the laboratory. A first-aid kit is also located next the phone outside the laser-controlled area in room E1-409. Additional emergency contacts are listed below in case of emergency.

Emergency (off Campus): 4 - 911

Dr. Neil Popplewell - 9888 Designate Owner

Mr. Paul Krueger - 8823 Laser Safety Contact

Dr. David Kuhn - 9803 Owner, Department Head

6 REFERENCES

- [1] University of Manitoba, “*Laser Safety Information*,” [Online], 2008. Available: http://www.umanitoba.ca/admin/human_resources/ehso/media/Laser_Safety_EHS_O_March_19_08.pdf [December 2008].
- [2] Coherent Inc., “*Operators Manual INNOVA[®] 70C Series Ion Laser*,” Santa Clara, 1999.
- [3] New Wave Research Inc., “*Operators Manual New Wave Research, Inc. Tempest and Gemini PIV Nd:YAG Lasers*,” Fremont, CA, 2000.
- [4] Yang, W.J., *Handbook of Flow Visualization: A Practical Approach*, Taylor and Francis Inc. (CRC Press), 1989.
- [5] Mejia, K.M. and Jorgens, C.J. “Conceptual Design of a Laser Light Sheet Flow Visualization System for a Pressurized, Low Speed Wind Tunnel,” *22nd International Congress on Instrumentation in Aerospace Simulation Facilities*, p.1-13, 2007.
- [6] Raffel, M., Willert, C., and Kompenhans, J., *Particle Image Velocimetry: A Practical Guide*, Springer, 1998.
- [7] Alfa Aesar, “*Material Safety Data Sheet*,” [Online], 2008. Available: http://www.alfa.com/MSDSPDF/English_/A16049.pdf [January 12, 2008].
- [8] Lavision, “*Laser Safety Filter Guide*,” [Online], 2008. Available: http://www.lasersafety.com/guide_detail.cfm?market=5&catid=8&guide_id=4 [January 12, 2008].

APPENDIX A: SUMMARY OF HAZARDS: RISK ASSESSMENT AND CONTROL MEASURES

A.1 Lasers

LASER DESCRIPTION	TYPE	CLASS
COHERENT INNOVA I-70C-5	ARGON-ION CONTINUOUS WAVE	IV
U OF M #	WAVE LENGTH	MAXIMUM POWER
L-4-F-003	457.9-528.7 nm	6 WATTS
BUILDING	ROOM#	FACILITY
EITC	E1-409	WIND TUNNEL
LASER DESCRIPTION	TYPE	CLASS
New Wave Research Gemini PIV Laser	Nd:YAG	IV
U OF M #	WAVE LENGTH	MAXIMUM POWER
L-4-F-002	532 nm	500 mJ / 5ns
BUILDING	ROOM#	FACILITY
EITC	E1-409	WIND TUNNEL

A.2 Responsibility for Implementing Control Measures

POSITION	NAME	APPLICABILITY
DEPARTMENT HEAD	DR. DAVID KUHN	YES
DEPARTMENTAL OWNER	DR. NEIL POPPLEWELL	YES, DESIGNATE
LASER OPERATORS	SEE APPENDIX B	YES
OTHER OCCUPANTS	SEE APPENDIX B	NO

A.3 Hazards

HAZARD (CONTROLLED AREA)	RISKS	CONTROL MEASURES
DIRECT LASER RADIATION, DIFFUSE AND SPECULAR REFLECTIONS FROM CLASS 4 LASER		LASER-CONTROLLED AREA AS PER ANSI Z136.1-2007: DEFINED AS THE FLOOR SPACE WITHIN E1-409 EAST OF THE LASER CONTROLLED AREA BARRIER (NOMINAL HAZARD ZONE) WARNING SIGNAGE: WARNING SIGN ON E1-409 SOUTH ENTRANCE DOOR, ADDITIONAL WARNING SIGN ON LASER-CONTROLLED AREA BARRIER INSIDE E1-409 WARNING LIGHTS: AMBER STROBE LIGHT LOCATED ON THE OUTSIDE OF LASER-CONTROLLED AREA BARRIER ACTIVATES WHEN LASER CONTROL UNIT IS TURNED ON ENGINEERED. ENTRY CONTROL: NON-DEFEATABLE, INTERLOCKED WITH LASER ENGINEERED.

		EMERGENCY EXITING: THROUGH E1-409 EAST DOOR, EXIT ONLY INTERLOCKED WITH LASER THROUGH LASER-CONTROLLED AREA BARRIER - CURTAIN ON ROLLER TRACK INTERLOCKED WITH LASER- EXITS TO E1 409 SOUTH DOOR ENGINEERED. EMERGENCY LASER SHUTDOWN: MOVEABLE, RED MUSHROOM SHAPED “PANIC BUTTON” ENGINEERED. PROTECTIVE EYEWARE: ALL PERSONS IN LASER-CONTROLLED AREA DURING OPERATION HAVE APPROPRIATE EYEWARE PROCEDURAL MAXIMUM OCCUPANCY: 2 GOGGLE/SPECTACLE SPECIFICATIONS, 1. GLENDALE LASER-GARD ARGON OD > 7 190-520 nm OD > 4.5 520-532 nm OD > 9 5000-11000 nm 2. LSR - GREEN GARD CO2 LGW LUY05 MODEL 3901 OD > 9 190-520 nm OD > 4.5 520-532 nm OD > 7 5000-11000 nm
--	--	--

		LASER KEY CONTROL: ACCESS CONTROL: ONLY TRAINED STAFF ARE PERMITTED IN THE LASER-CONTROLLED AREA DURING OPERATION PROCEDURAL TRAINED STAFF-EHSO LASER SAFETY INFORMATION PPT COMPLETED AND STORED WITH SAFE OPERATING PROCEDURES NEXT TO TELEPHONE IN E1-409 (SEE APPENDIX B FOR LIST) FOR PROTECTION OF ANCILLARY STAFF (UNTRAINED) SIGNAGE, KEY CONTROL, STROBE LIGHT, ENTRY INTERLOCK SAFE WORK PROCEDURES (SWPS): COPY LOCATED NEXT TO TELEPHONE IN E1-409 WITH EMERGENCY CONTACT INFORMATION UNATTENDED OPERATION IS PROHIBITED
--	--	--

HAZARD (LASER AND BEAM DELIVERY)	RISKS	CONTROL MEASURES
DIRECT LASER RADIATION, DIFFUSE AND SPECULAR REFLECTIONS FROM CLASS 4 LASER	MEDIUM TO HIGH POTENTIAL FOR EYE AND/OR SKIN DAMAGE	GENERAL: LASER AND BEAM PATH LOCATED BELOW EYE LEVEL WHEN SITTING. ACTIVATION WARNING LIGHT BECOMES ENERGISED WHEN LASER KEY IS TURNED TO THE 'ON' POSITION ENGINEERED. LASER APERTURE CLOSED BEFORE TURNING LASER ON PROCEDURAL AREA IN FRONT OF LASER OUTPUT IS EXAMINED FOR POTENTIAL REFLECTIVE SURFACES, JEWELRY AND OTHER REFLECTIVE ARTICLES ARE REMOVED BEFORE STARTING ALIGNMENT PROCESS PROCEDURAL RESTRICTIONS ON MOVEMENT OF EXTREMITIES IN VICINITY OF BEAM PATH PROCEDURAL DURING ALIGNMENT: ALL PROCEDURAL USE OF ALIGNMENT GOGGLES, OD 1-2 LOWEST POSSIBLE POWER LEVEL USED OPTICAL COMPONENTS SEMI PERMANENT MOUNTING PANIC BUTTON LOCATED DIRECTLY NEXT TO LASER OPERATOR WHILE PERFORMING ALIGNMENT PROCEDURES

		DURING OPERATION: ALL PROCEDURAL PROTECTIVE SHROUD MADE OF BLACK NON-REFLECTIVE METAL USED TO PROTECT OCCUPANTS FROM UNEXPECTED REFLECTIONS IN BEAM DELIVERY FOR COHERENT LASER BLACK BEAM STOP-CURTAIN-MATERIAL USED ON ADJACENT SIDE OF WINDTUNNEL TEST SECTION TO CONTAIN LASER BEAM AND REFLECTIONS INSIDE THE TEST SECTION LASER OUTPUT POWER SET TO LOWEST LEVEL REQUIRED
--	--	--

HAZARD (APPLICATION)	RISKS	CONTROL MEASURES
AIRFLOW VISUALIZATION AND PIV - CAMERA VIEWING ILLUMINATED AEROSOLS	THE APPLICATION DOES NOT CREATE ANY ADDITIONAL RISKS FOR OCCUPANTS DAMAGE TO CCD FROM INTENSE LIGHT	AEROSOL CONTROL COVERED UNDER NON BEAM HAZARDS ORIGINAL EQUIPMENT MANUFACTURE'S RECOMMENDATIONS WILL BE FOLLOWED INCLUDING THE USE OF FILTERS TO PREVENT EQUIPMENT DAMAGE
HAZARD (NON BEAM)	RISKS	CONTROL MEASURES
ELECTRICAL / FLOOD	208V 60 AMP 3 PH POWER SUPPLY AND COOLING WATER SUPPLY TO LASER- LOW POTENTIAL FOR WATER LEAKAGE TO CONTACT HIGH POWER 120 V 10 AMP 1 PH POWER SUPPLY AND COOLING WATER SUPPLY TO LASER- LOW POTENTIAL FOR WATER LEAKAGE TO CONTACT HIGH POWER	CSA APPROVED GROUNDED ELECTRICAL SERVICE WITH WATER RESISTANT CONNECTION. ENGINEERED. FLOOR LEVEL DRAIN IN VICINITY OF LASER ENGINEERED. CSA APPROVED GROUNDED ELECTRICAL SERVICE. ENGINEERED. ELECTRICAL EXTENSION CORDS STORED OFF THE FLOOR IN VICINITY OF LASER PROCEDURAL.

FIRE: CEILING SMOKE DETECTORS COVERED DURING TUNNEL OPERATION	WIND TUNNEL CONSTRUCTED FROM WOOD WITH GLASS AND ACRYLIC WINDOW FOR CONTINUOUS LASER OUTPUTS ABOVE 0.5 WATTS - LOW TO MEDIUM POTENTIAL TO START A FIRE	SPRINKLERS ABOVE TUNNEL (HEAT SENSING) ENGINEERED. CONTROLLED AREA BARRIER AT LASER LEVEL CONSTRUCTED FROM NON FLAMMABLE SILICON RUBBER IMPREGNATED FIBERGLASS WELDING BLANKET, GALVANIZED STEEL STRUCTURAL MEMBERS AND STEEL SHEETING COATED WITH BLACK HIGH TEMPERATURE PAINT ENGINEERED. ALL BUILDING WALLS SHEETROCK ENGINEERED. FIRE EXTINGUISHERS FOR LOCAL CONTROL, LOCATED NEXT TO THE SINK AND DOUBLE-DOORS INSIDE LASER CONTROLLED AREA, AND NEXT TO SINGLE DOOR OF LABORATORY PROCEDURAL
NOISE	NOISE LEVEL OF HYDRAULIC MOTOR ON WIND TUNNEL FAN - HIGH POTENTIAL FOR HEARING DAMAGE	USE OF HEARING PROTECTION DURING TUNNEL OPERATION PROCEDURAL
AIR QUALITY	LEAKAGE OF SEEDING AEROSOLS FROM WIND TUNNEL STREAM-MEDIUM POTENTIAL FOR INHALATION OF NON-TOXIC, NON WATER SOLUBLE OIL (IRRITANT) MEDIUM POTENTIAL FOR ACTIVATING SMOKE ALARM	MANUALLY CONTROLLED IN-DUCT FANS MOVE AEROSOL/AIR MIXTURES FROM LEAKAGE AREAS THROUGH FLEXIBLE DUCTING TO BUILDING EXHAUST CANOPY. ENGINEERED RESPIRATOR USE PROCEDURAL COVER SMOKE DETECTORS DURING TESTING PROCEDURAL

TRIPPING	DRAIN LINES FROM LASER CROSS WALKWAY TO FLOOR DRAIN- HIGH POTENTIAL POWER CORDS FROM ELECTRICAL SERVICE TO LASER CONTROL TO LASER	BRIDGE PLATE USED TO COVER DRAIN LINES AND PREVENT TRIPPING HAZARD ENGINEERED LAYOUT / COIL AWAY FROM WALKWAY- UNDER TABLES PROCEDURAL
		Template by P. Krueger, MME Departmental Laser Safety Contact, January 2009

APPENDIX B: LASER OPERATORS

NAME:	OFFICE	CONTACT	READ AND SIGNED EHSO LASER SAFETY INFORMATION	READ COHERENT AND GEMINI PIV OPERATOR'S MANUAL AND E1-409 SAFE WORK OPERATING PROCEDURES
Patrick Fleming	E1-421A	474-8463	x	x
Darryl Stoyko	E1-421A	474-8463	x	
Vance Stoyko	E1-421A	474-8463		