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| **Date:** (1)**X/Y/ZZZZ** | **Assessed by:** (2)**A. L. User** | **Validated by:** (3)PI/managerLaser safety advisor | **Location:** (4)**Lab 001, Building A** | **Assessment ref no** (5)**V1** | **Review date:** (6)Annually, or at change of use |
| **Approval of open beam work by Head of Department/ Director of Institute:** (7)**Name: ………..……………………………….Signature:……** **………………** |
| **Task and Environment :** (8)Laser flash photolysis of photochemical reactions using Edinburgh Instruments LP980 Transient Absorption Spectrometer with an Ekspla NT342B laser. The spectrometer has a number of accessories including a TgK stopped–flow (rapid mixing) and Oxford instruments cryostat which fit with custom-fitted lids to the sample chamberThe experiment is sat on a waist-high table with clear access around 3 sides. A free-standing power supply unit (PSU) is connected to laser head by umbilical. Ancillary electronic equipment also located on table for optical measurements, temperature control, data analysis, etc.The laser outputs are directed to the spectrometer via fixed height steering mirrors and prisms. The optics are contained in a black anodized aluminium enclosure. The beams from this enclosure are directed via short (<5 cm) beam tube into a fully enclosed prism which directs the beam via a shutter into the spectrometer. If all covers are in places there are no open beams. |
| **Justification for open beam work:** (9)Open beam work is only undertaken for very infrequent alignment / maintenance purposes (0-4 times/year), and only by highly trained personnel. The optics require complex (multi-axis) fine adjustments which cannot be automated due to insufficient space in this commercially produced system. There are limited possible procedures, which are detailed in the associated Scheme of Work, which aims to provide strict guidance on the best practice during this work to reduce risks. Open beam work will only take place during normal working hours (i.e. 8 am to 6 pm, Monday - Friday). |
| **Details of Laser(s) used, including ELV/MPE calculations:** (10)Class 4 laser system, Ekspla NT342B laser, comprising a Q-switched Nd:YAG laser and optical parametric oscillator (OPO) in one compact housing. Outputs, at a 10 Hz repetition rate, with FWHM beam diameter of ~5 mm (1/e diameter 5.9 mm), are:355 nm (5-7 ns pulse duration, 100 mJ / 1 W)SH output 210 – 410 nm (3-5 ns pulse duration, <7.5 mJ),OPO signal 410 – 710 nm (3-5 ns pulse duration, <34 mJ), Not used: OPO idler 710 – 2600 nm (3-5 ns pulse duration, < 11 mJ)The hazards posed by the lasers in this system have been assessed by calculating the maximum permissible exposure (MPE) according to PD IEC TR 60825-14:2022, the exposure limit values (ELV) according to Directive 2006/25/EC. 355 nm pump:In this case the ocular and skin ELV/MPE values are the same =8.4 J m-2 , the most restrictive of:[ELV/MPE]single (exposure time = pulse duration = 5-7 ns) = C1 J m-2 = 5.6x103 t0.25 = 47.1 – 51.2 J m-2 [ELV/MPE]average (average over the assumed max. exposure duration t=100 s (10 to 102) N=1000 pulses) = 104 /1000 = 10 J m-2[ELV/MPE]train (single x C5) = 47.1 – 51.2 x (1000-0.25) = 8.4 – 9.1 J m-2Eye limiting aperture, DL = 3.5 mm (ELV) or 1 mm (MPE), Skin limiting aperture, DL = 3.5 mm1/e beam diameter is larger than DL in all cases and should be used to calculate beam area = 1.02x10-5 m2 Laser energy density = 100 mJ/1.02x10-5 m2 = 9804 J m-2 . **Laser output at 355 nm exceeds eye and skin ELV/MPE by a factor of 1171**210 – 302 nm SH output:In this case the ocular and skin ELV/MPE values are the same =0.03 J m-2, the most restrictive of:[ELV/MPE]single (exposure time = pulse duration = 3-5 ns)= 30 J m-2[ELV/MPE]average (average over the assumed max. exposure duration t=100 s (10 to 102) N=1000 pulses) = 30 /1000 = 0.03 J m-2[ELV/MPE]train (single x C5) = 30 x (1000-0.25) = 5.3 J m-2Eye limiting aperture, DL = 3.5 mm (ELV) or 1 mm (MPE), Skin limiting aperture, DL = 3.5 mm1/e beam diameter is larger than DL in all cases and should be used to calculate beam area = 1.02x10-5 m2 Laser energy density = 7.5 mJ/1.02x10-5 m2 = 735 J m-2 . **Laser output at 210-302 nm exceeds eye and skin ELV/MPE by a factor of 24510**303 nm SH output:In this case the ocular and skin ELV/MPE values are the same ELV/MPE =0.04 J m-2, the most restrictive of:[MPE]single (exposure time = pulse duration = 3-5 ns, >T1 (2.5 ns) so use C2) = 39.8 J m-2[ELV]single (exposure time = pulse duration = 3-5 ns) = 40 J m-2[MPE]average (average over the assumed max. exposure duration t=100 s (10 to 102) N=1000 pulses) = C2 /1000 = 0.0398 J m-2[ELV]average (average over the assumed max. exposure duration t=100 s (10 to 102) N=1000 pulses) = 40 /1000 = 0.04 J m-2[MPE]train (single x 1) = 39.8 J m-2[ELV]train (single x C5) C5 = 1) = 40 J m-2Eye limiting aperture, DL = 3.5 mm (ELV) or 1 mm (MPE), Skin limiting aperture, DL = 3.5 mm1/e beam diameter is larger than DL in all cases and should be used to calculate beam area = 1.02x10-5 m2 Laser energy density = 7.5 mJ/1.02x10-5 m2 = 735 J m-2 . **Laser output at 303 nm exceeds eye and skin ELV/MPE by a factor of 18382**304 – 315 nm SH output:In this case the ocular and skin ELV/MPE values are the same ELV/MPE =0.06 J m-2, the most restrictive of:[MPE/ELV]single (exposure time = pulse duration = 3-5 ns <T1) = 5.6x103 t0.25 = 41.4 – 47.1 J m-2[MPE]average (average over the assumed max. exposure dur. t=100 s (10 to 102) N=1000 pulses) = C2 /1000 = 63.1 – 10000 /1000 = 0.063 - 10 J m-2[ELV]average (average over the assumed max. exposure duration t=100 s (10 to 102) N=1000 pulses) = 60 – 6.3 x103 1000 = 0.06 – 6.3 J m-2[ELV/MPE]train (single x C5) = 41.4 – 47.1 x (1) = 41.4 – 47.1 J m-2Eye limiting aperture, DL = 3.5 mm (ELV) or 1 mm (MPE), Skin limiting aperture, DL = 3.5 mm1/e beam diameter is larger than DL in all cases and should be used to calculate beam area = 1.02x10-5 m2 Laser energy density = 7.5 mJ/1.02x10-5 m2 = 735 J m-2 . **Laser output at 304-315 nm exceeds eye and skin ELV/MPE by a factor of 12255**315 to 400 nm SH output:In this case the ocular and skin ELV/MPE values are the same ELV/MPE =7.4 J m-2, the most restrictive of:[ELV/MPE]single (exposure time = pulse duration = 3-5 ns) = 5.6x103 t0.25 = 41.4 – 47.1 J m-2[ELV/MPE]average (average over the assumed max. exposure duration t=100 s (10 to 102) N=1000 pulses) = 104 /1000 = 10 J m-2[ELV/MPE]train (single x C5) = 41.4 – 47.1 x (1000-0.25) = 7.4 – 8.4 J m-2Eye limiting aperture, DL = 3.5 mm (ELV) or 1 mm (MPE), Skin limiting aperture, DL = 3.5 mm1/e beam diameter is larger than DL in all cases and should be used to calculate beam area = 1.02x10-5 m2 Laser energy density = 7.5 mJ/1.02x10-5 m2 = 735 J m-2 . **Laser output at 315-400 nm exceeds eye and skin ELV/MPE by a factor of 100**400 – 700 nm OPO signal (SH signal 400-410):Ocular ELV/MPE =2x10-3 J m-2, the most restrictive of:[ELV]single (exposure time = pulse duration = 2-6 ns) = 5x10-3 J m-2[MPE]single (exposure time = pulse duration = 2-6 ns) = 2x10-3 J m-2[ELV/MPE]average (average over the assumed max. exposure duration, t =0.25s (1-3 to 10), N=25 pulses) = 18t0.75 = 6.36/ 25 =0.25 J m-2[ELV]train (single x C5) C5 = 0.25-0.25) = 2.2 x 10-3 J m-2[MPE]train (single x 1) = 2x10-3 J m-2Eye limiting aperture, DL = 7 mm, DL is larger than 1/e beam diameter and should be used to calculate beam area = 3.85x10-5 m2 Laser energy density = 34 mJ/3.85x10-5 m2 = 883 J m-2 . **Laser output at 400-700 nm exceeds eye ELV/MPE by a factor of 441558**Skin ELV/MPE =20 J m-2, the most restrictive of:[ELV/MPE]single (exposure time = pulse duration = 2-6 ns) = 200 J m-2[ELV/MPE]average (av. over the assumed max. exposure duration, t=10 s (10 to 102) N=1000 pulses) = 2000 W m-2 /1000 = 2 W m-2 x 10s = 20 J m-2[ELV/MPE]train (single x C5) = 200 x (1000-0.25) = 35.6 J m-2Skin DL = 3.5 mm, 1/e beam diameter is larger than DL and should be used to calculate beam area = 1.02x10-5 m2 Laser energy density = 34 mJ/1.02x10-5 m2 = 3333 J m-2 . **Laser output at 400-700 nm exceeds = skin ELV/MPE by a factor of 167** |
| **Provided PPE, including calculated eyewear requirements:** (11)Safety goggles available cover laser output at reduced power intensities – see below and Scheme of Work for details. Condition and cleanliness of the eyewear will be checked prior to each usage, and condition logged at regular intervals in eyewear condition log (kept near eyewear storage). NoIR ARG (D 180-315 nm L7, R 180-315 nm L4, D>315-532 nm L4, IR >315-532 nm L6) NoIR DBY (D 180-315 nm L7, R 180-315 nm L4, D>315-534 nm L4, IRM 315-534 L6, D 920-1064 nm L5, IRM 920-1064nm L6, IR 980-1064nm L7) Nitrile gloves are also provided to protect the users hands from exposure to ultraviolet radiation.

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| **Wavelength** | Output parameters(all 1/e diameter of 5.9 mm, 10 Hz rep. rate) | Eyewear Requirement (BS EN:207) | Eyewear (ARG and DBY) Rating | **Energy Limitations of eyewear** |
| **355 nm (pump)** | 100 mJ >4 ns pulse duration | DLB5 RLB7 | DLB4 RLB6 | **15 mJ** |
| **210 – 315 nm (SH output)** | <7.5 mJ, >3 ns pulse duration | DLB8 RLB2 | DL7 RL4 | **3.1 mJ** |
| **315 – 410 nm (SH output)** | <7.5 mJ, >3 ns pulse duration | DLB4 RLB6 | DL4 RL6  | **full output** |
| **410 – 534 nm (OPO signal)** | <30 mJ, >3 ns pulse duration | DLB4 RLB7  | DLB5 RLB6  | **5.8 mJ** |

**NO OPEN BEAM WORK: >534 nm** |

| **Activity** (12) | **Hazard** (13) | **Who might be harmed** (14) | **Existing measures to control risk** (15) | **Risk rating** (16) | **Result** (17) |
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| Use of Class 4 laser | 1. High voltages within laser head and power supply2. Water cooling – risk of leaking 3. Trip hazard from water pipe and electrical cables.4. Fire hazard - The laser beams are intense enough to burn absorbing surfaces5. Class 4 beam hazard - Laser radiation from a Class 4 laser is extremely hazardous to the eyes and skin.  | 1. All2. All3. All4. All5. All | 1. All electrical equipment will be PAT tested. Laser head cover is interlocked, although interlocks can be overridden for alignment. Circuits with high voltage are closed by additional cover inside of the laser and are inaccessible in normal operation. The power supply covers are fixed and should not be removed.2. The flashlamps are cooled by a circulating water system built into the power supply. Water pipes are clamped and should be checked before use. Any power sockets are raised from floor level.3. All cables are secured and water pipe is located out of the way. 4. Care should be taken if using alignment or business cards to locate and realign the laser beams.5. The laser can only be switched by authorised users by a key which is kept in a key safe in the lab. The key code is only in possession of the authorised users listed in the local rules. Beams within the laser head are fully enclosed in a metal housing which is interlocked to prevent the laser from operating when the cover is removed. The interlock should not be defeated except by qualified service personnel (with additional risk assessment). An emission indicator (amber light) gives a visible signal when the laser is switched on or any capacitor banks contain charge. There is an emergency switch on the front of the power supply which will cut power to the entire laser. When the laser is in use the “Laser On” light outside the door will be switched on. During normal operation the beam is fully enclosed in metal enclosures. The beam routing enclosure lid is fixed in place with security screws. The routing prism/experimental shutter cover is fixed in place with numerous small screws. Mounting brackets secure it, and the interlock shutter, in place on the table. The experimental case has a number of removable lids which are interlocked to a shutter placed between the experimental shutter and the experimental case. All access lids are labelled with appropriate warning signs.Open beams are not accessible without security screw driver and/or interlock override key which will be kept separately to the laser key, only authorised personnel will know of their location (and existence). All users will attend laser awareness course (THS42e), and be fully trained as documented on form LS3. | 1. Low2. Low3. Low4. Low5. Medium | 1. A2. A3. A4. A5. A |
| Open beam work with Class 4 laser | 6. Class 4 beam hazard - Laser radiation from a Class 4 laser is extremely hazardous to the eyes and skin.  | 6. Authorised Users | 6. Only authorised and fully trained personnel may perform open beam work. Open beam work is only undertaken for very infrequent alignment / maintenance purposes (0-4 times/year). If any beam routing or other optical manipulation occurs which involves the removal of the enclosure covers or beam tubes then a chain, with a DANGER Open Laser Beams KNOCK & WAIT“ sign is placed across the doorway.Laser goggles and beam stops must be used during aligning / maintenance and the lowest possible power used at all times up to the maxima stated below (the laser body contains inbuilt attenuators, software controlled for the OPO, manual control for the 355 nm).See ELV/MPE calculations above– it is not possible to practically reduce the power to below the calculated thresholds. | 6. High | 6. A |
| Use of spectrometer | 7. Laser beams (see above) within the sample chamber.8. Chemicals in sample9. High voltage applied to PMT10. Stopped-flow accessory11. Cryostat accessory(Liquid Nitrogen – risk of cold burns and asphyxiation from excess N2 gas in lab)12. Pulsed arc lamp for optical measurements |  | 7. Enclosed and interlocked chamber under normal operating conditions - See section above.8. Separate COSHH forms required.9. Correct connectors and cables used. High voltage is generated within the PMT housing and the external supply cable carries 12V and 5V.10. The stopped-flow instrument mixes small volumes of sample (<10 ml), any spills are cleaned up immediately and electrical connections are kept well clear of area.The cell is temperature controlled using a recirculating thermostatically controlled water bath/pump. The reservoir is placed under the optical table and plastic tubing to/from the instrument is securely connected. All mains extension sockets must be raised above floor level to remove the risk of electrocution that may arise from the combination of leaking cooling water and electricity supplies. Ensure that all moving parts are not impeded by anything (i.e. hands/fingers). All users fully trained by competent personnel. All stopped-flows are fully maintained in accordance with manufacturer’s instructions. Their servicing and repair is carried out by the manufacturer or by suitably qualified personnel.11. Cryostat and vacuum pump to be fully maintained in accordance with manufacturer’s instructions. Servicing and repair to be carried out by the manufacturer or by suitably qualified personnel. All vacuum seals, O-rings and windows ensured clean and all connections tight to maintain high vacuum. Howie-style laboratory coat, safety visor and BS EN 511 compliant gloves (low temperature, long cuffs) to be used when filling cryostat, always from an approved cryogenic dewar.12. Light is enclosed and directed to sample via a shutter, all within main spectrometer housing. | 7. Med8. Low9. Med10. Low11. Med12. Low | 7. A8. A9. A10.A11. A12.A |
| General lab use | 13. Low oxygen - stopped flow attachment with pressurised N2 gas, and liquid N2 for cryostat.14. Stool and computer15. Electrical hazards from ancillary equipment16. Injury from trips and falls due to trailing electrical cables17. Lone working |  | 13. A low oxygen monitor is present in the room with external and internal alarms. Gas for stopped-flow provided via regulator. Correct connectors and pipes used, the flow rate is kept as low as possible and turned off when not in use. 14. Computer only used for data logging, stool set so that users head is NOT at beam height15. Equipment will be PAT tested. The laser table is connected to an earthing point.16. A policy of good housekeeping is encouraged and cable guides / covers are used.17. All lab use is compliant with local policy on lone working. Normal work hours are 8 am to 6 pm Monday to Friday. If working alone within normal hours in the lab then a ‘buddy system’ must be in place with contact once per hour.Open beam work is not permitted outside of normal working hours. | 13. Med14. Low15. Low16. Low17. Low | 13. A14. A15. A16. A17. A |

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| **Action plan** (18) |
| **Ref No** | **Further action required** | **Action by whom** | **Action by when** | **Done** |
|  | Note 1: To switch between OPO output and 355 nm output a flip mirror needs to be flipped in the beam routing enclosure. Only Seniro Technical Staff (X and Y) may do this (when the laser is turned off). If it turns out this happens frequently (>1/month) then a motorized flip mount will be installed.Note 2: It is expected that infrequent alignment (<twice a year) with open beams will be necessary. If it turns out that alignment is required more frequently motorized mirror mounts and beam cameras will be installed. |  |  |  |
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**Notes to accompany Laser Risk Assessment Form**

This form is adapted from the one recommended by Safety Services, and used on the University’s risk assessment training courses. It is strongly suggested that you use it for all new assessments, and when existing assessments are being substantially revised. However, its use is not compulsory. Providing the assessor addresses the same issues, alternative layouts may be used.

1. **Date** : Insert date that assessment form is completed. The assessment must be valid on that day, and subsequent days, unless circumstances change and amendments are necessary.
2. **Assessed by** : Insert the name and signature of the assessor. The assessor should have completed the Laser Safety Awareness course THS42e and Advanced Laser Safety Awareness course THS43e. General guidance on completing risk assessments can be found on the safety services website: https://www.healthandsafety.manchester.ac.uk/toolkits/ra/
3. **Checked/Validated by** :

 **Checked by** : Insert the name and signature of someone in a position to check that the assessment has been carried out by a competent person who can identify hazards and assess risk, and that the control measures are reasonable and in place. The checker will normally be a line manager, supervisor, principal investigator, etc.

 **Validated by** : Insert the name and signature of your Local Laser Safety Advisor (or their designated deputy), they will need to check that your safety calculations and control measures are adequate.

1. **Location** : insert details of the exact location, ie building, floor, room or laboratory etc. If off-campus, provide information about expected location(s) or attach itinerary.
2. **Assessment ref no** : use this to insert any local tracking references used by the school or administrative directorate.
3. **Review date** : insert details of when the assessment will be reviewed as a matter of routine. Usually this is for 1 years’ time, but might be less for a short programme of work. Note that any assessment must be reviewed if there are any significant changes – to the work activity etc.
4. **Approval of open beam work :** Where open beam work with class 3B and 4 lasers is essential, it must be signed off by the Head of School/ Department/ Institute.
5. **Task**: insert a brief summary of the task, eg research project [title] involving the use of X equipment.
6. **Justification for open beam work:** where open beam work with class 3B and 4 lasers is essential, it must be robustly justified
7. **Details of Laser(s) used, including ELV/MPE calculations:** include make, model and other details of the laser system(s) in use, including wavelength, power, energy, pulse duration and beam size where known. This is also the place to include details of ELV/MPE calculations. If the calculations are extensive (covering multiple wavelengths etc.) then the results can be summarised here and given in full in a separate referenced document.
8. **Provided PPE, including calculated eyewear requirements:** list what PPE is available, and summarise what eyewear your calculations have specified. If the eyewear available does not match that specified then clearly state what wavelength/energy rages are covered. Also include here plan for how eyewear condition will be checked regularly and monitored/recorded.
9. **Activity** : use the column to describe each separate activity covered by the assessment. The number of rows is unlimited. For example activities might include: in one particular lab or for one particular project might include: Use of Lasers, Open beam work, Experimental process, Lone Working, General lab use, Use of substances hazardous to health, etc
10. **Hazard** : for each activity, list the hazards. Remember to look at hazards that are not immediately obvious. The same activity might well have several hazards associated with it. For example ‘Use of lasers’ would include personnel exposure to beam (from the laser output), fire (from high power beams) , electrical (from power supplies), water leaks (from cooling systems), trip hazards (from cables), irritants (from laser cutting). The ‘Open beam work’ hazard would personnel exposure to beam during alignment.

Assessment of simple chemical risks (eg use of cleaning chemicals in accordance with the instructions on the bottle) may be recorded here. More complex COSHH assessments eg for laboratory processes, should be recorded on the specific COSHH forms.

Describe how harm might come about, eg an obstruction or wet patch on an exit route is a hazard that might cause a trip and fall; use of electrical equipment might give rise to a risk of electric shock; use of a ultraviolet light source could burn eyes or skin.

1. **Who might be harmed**: insert everyone who might be affected by the activity and specify groups particularly at risk. Remember those who are not immediately involved in the work, including cleaners, young persons on work experience, maintenance contractors, Estates personnel carrying out routine maintenance and other work. Remember also that the risks for different groups will vary. Eg someone who needs to repair a laser may need to expose the beam path more than users of the laser would do. Vulnerable groups could include children on organised visits, someone who is pregnant, or employees and students with known disabilities or health conditions (this is not a definitive list).
2. **Existing measures to control the risk** : list all measures that already mitigate the risk. For example, in normal operation the risk of exposure to beam has been mitigated by fully enclosing the system, and interlocking to the laser output any access panels. For exposure to beam during alignment extra precautions would be needed, access controls, further training, appropriate PPE etc.
3. **Risk Rating** : the simplest form of risk assessment is to rate the remaining risk as high, medium or low, depending on how likely the activity is to cause harm and how serious that harm might be.

 The risk is **LOW** - if it is most unlikely that harm would arise under the controlled conditions listed, and even if exposure occurred, the injury would be relatively slight.

 The risk is **MEDIUM** - if it is more likely that harm might actually occur and the outcome could be more serious (eg some time off work, or a minor physical injury.

 The risk is **HIGH** - if injury is likely to arise (eg there have been previous incidents, the situation “looks like an accident waiting to happen”) and that injury might be serious (broken bones, trip to the hospital, loss of consciousness), or even a fatality.

1. **Result** : this stage of assessment is often overlooked, but is probably the most important. Assigning a number or rating to a risk does not mean that the risk is necessarily adequately controlled. The options for this column are:

 **T = trivial risk**. Use for very low risk activities to show that you have correctly identified a hazard, but that in the particular circumstances, the risk is insignificant.

 **A = adequately controlled, no further action necessary.** If your control measures lead you to conclude that the risk is low, and that all legislative requirements have been met (and University policies complied with), then insert A in this column.

 **N = not adequately controlled, actions required**. Sometimes, particularly when setting up new procedures or adapting existing processes, the risk assessment might identify that the risk is high or medium when it is capable of being reduced by methods that are reasonably practicable. In these cases, an action plan is required. The plan should list the actions necessary, who they are to be carried out by, a date for completing the actions, and a signature box for the assessor to sign off that the action(s) has been satisfactorily completed. Some action plans will be complex documents; others may be one or two actions that can be completed with a short timescale.

 **U = unable to decide. Further information required.** Use this designation if the assessor is unable to complete any of the boxes, for any reason. Sometimes, additional information can be obtained readily (eg from equipment or chemicals suppliers, specialist University advisors) but sometimes detailed and prolonged enquiries might be required. Eg is someone is moving a research programme from a research establishment overseas where health and safety legislation is very different from that in the UK.

 **For T and A results**, the assessment is complete.

 **For N or U results**, more work is required before the assessment can be signed off.

(18) **Action Plan**. Include details of any actions necessary in order to meet the requirements of the information in Section 11 ‘Existing measures to control the risk’. Identify someone who will be responsible for ensuring the action is taken and the date by which this should be completed. Put the date when the action has been completed in the final column.