Appendix 6. Laser control measures: additional requirements for specific High Risk laser activities

A6.1 Open Beam Work

A6.1.1 The following initial safety checks for open beam work should be considered for inclusion in the Standing Orders for work with unenclosed High Risk laser beams.

Before releasing High Risk laser beams:

- Beam paths should be inspected for any objects that should not be there and any beam line components that may have been displaced or misaligned.
- Any screens/enclosures or beam stops that have been removed should be replaced.
- All optics should be checked for damage, and the stability of optics mounts verified prior to operation of laser.
- Check that only authorized people are in the area.
- Check that everyone in the area is wearing appropriate laser safety eyewear.
- Give prior warning that the laser beam is about to be launched.

A6.1.2 Beam alignment of open beam paths is the most common cause of laser eye injuries. The following guidelines should be considered for inclusion in the Standing Orders.

- Only suitably trained and authorised Laser Nominated Persons may carry out alignment.
- Alignment should be carried out with one or at most two authorised laser operators. All other persons should be excluded from the room during this procedure.
- Watches, bracelets and other reflective jewellery should be removed.
- Appropriate laser safety eyewear to be worn.
- Initial alignment should be at the lowest possible power, preferably Class 2 or Class 1, by attenuating the laser or by use of an alignment laser.
- Analyze each and every optical element in the beam path for stray reflections and install suitable beam blocks. (The blocks must be stable, preferably locked to the table.)
- Restricted access, unauthorized personnel must be excluded from the room or area.

- Under no circumstances must direct viewing of the laser beam be attempted even if the beam has been attenuated. The use of a video camera for remote viewing should be considered.
- Alignment with a higher power beam should be carried out using laser safety eyewear. The table below gives examples of suitable techniques.

Wavelength range	**Techniques for beam position detection with the operator using laser safety eyewear**
Visible only	Introduce an attenuator to reduce accessible emission to Class 3R or below. Protective eyewear can then be removed. Alternatively wear laser alignment eyewear.
UV and/or Visible	Use fluorescent card (e.g. impregnate paper with dye, mark target with highlighter ink): fluorescence at shifted wavelength can be seen through protective eyewear. Attenuate the beam and use a CCD camera
Infrared only	Options include: ➢ liquid crystal paper, which changes colour when heated ➢ heat sensitive fax/chart recorder paper ➢ fluorescent-coated blocks illuminated with UV lamps ➢ for near infrared, phosphor or scintillation cards ➢ attenuate the beam and use a CCD camera ➢ simple detector in conjunction with an aperture (or a position sensitive centroid or quadrant detector) to locate the centre of the beam.
Single Pulse lasers	Use black coated or lithographic paper; the coating is ablated by the more powerful pulsed lasers.
Any wavelengths	Use a collinear low power visible cw laser for principal alignment. Introduce variable (iris) diaphragms to aid alignment.
'All' visible wavelengths	Multi-wavelength alignment may have to be carried out without laser safety eyewear, as it would otherwise be impossible to visualise the laser beam on a card.

A6.1.3 Where the alignment technique requires one person controlling release of the laser hazard (e.g. by blocking and unblocking the laser beam) while another (or others) view the beam, the latter should be provided with a fail-safe engineered means (e.g. a key control or a hand held button on a flying lead operating a simple external shutter) to prevent unintentional activation of the laser hazard.

A6.1.4 Where the alignment requires the simultaneous presence of open beam Class 3B and/or 4 laser beams for which there is no suitable eye protection available with sufficient visible transmission (such situations occur, for example, with (i) 'white light' laser beams and (ii) generally where there are at discrete wavelengths at both ends of the visible spectrum), the following steps must be taken:

- Consider complete enclosure, using cameras and motorized controllers for beam alignment.
- If open beam work is inevitable, then: (i) expose the minimum number of wavelengths and use eyewear that protects against the most powerful of the exposed beam(s); and (ii) Use of an optical filter in the beam path to select only a single or narrow wavelength range (e.g. for 'white light' laser beams consider the use of an acousto-optic tuneable filter).
- Consider the feasibility of using 'night vision' eyewear.
- Implement strict administrative control of reflecting surfaces and use optical mounts that prevent excessive angular adjustment, especially in the vertical plane.
- All optical mounts and tools (screwdrivers etc) should have matt surfaces.
- The operator(s) when making adjustments must exercise extra caution.

A6.2 Maintenance and service of laser equipment

A6.2.1 Maintenance of laser equipment

The following precautions should be considered for inclusion in the Standing Orders.

- Before commencing the maintenance, the manual for the laser system should be consulted, to identify the recommended procedure.
- In the case of anything other than routine maintenance, and/or when the laser manual does not give a procedure, the advice of the equipment supplier should be sought. Some procedures may go beyond the competence of the laser user.
- The risks associated with the procedure should be assessed, the control measures reviewed, and the conclusions recorded. In the case of some regular maintenance procedures there may be an existing

protocol that is suitable and sufficient.

- Maintenance involving the alignment of a laser beam inside a laser enclosure, for instance introducing the pump laser into a frequency mixing crystal, can lead to an increased risk of laser radiation exposure. A risk assessment for the procedure must be carried out.

A6.2.2 Service using external contractors

A6.2.2.1 Contractors must supply a method statement for approval before work can proceed. Key considerations in assessing the method statement include:

- If the alignment procedure is followed, are there any foreseeable circumstances where an accident could happen?
- Is the method of alignment clear and unambiguous?
- Does the procedure require the service engineer to remove laser safety eyewear? If so, is this justified and what safeguards are put in place to compensate? (These should be specific activities with no freedom of choice, only specific instructions).
- Are others (e.g. spectators) within the vicinity at risk?

N.B. The host organization retains a duty of care for all work on site even if waivers are given by the contractor.

A6.2.2.2 Before permitting an external laser service engineer to conduct service work on site the responsible LRO must:

- Be satisfied that the person conducting the servicing is competent.
- Establish the boundaries of the hazard area and ensure the provision of appropriate PPE (laser safety eyewear etc.) for those in the area, and the means by which other personnel will be excluded.
- Review the hazards to be exposed and the procedures to be followed during servicing activities. This review should place particular emphasis on beam control and termination (e.g. large area beam stops), beam visualisation techniques for alignment, and the transfer of control, especially where servicing takes place at a point remote from the equipment controls.
- Review emergency procedures, including how the equipment would be isolated if there is a risk of injury from electrical or mechanical hazards, or how a fire would be extinguished if there are open Class 4 laser beams. This may involve the presence of a company employee (perhaps the LRO) during the servicing, and the safety of that employee must then also be considered.
- Review isolation procedures (e.g. Lock-Out-Tag-Out (LOTO)) for times when the service engineer may wish to leave the area.
- Review the safety of the proposed service activity (i.e. are the measures proposed in the risk assessment and method statement adequate?)

A6.2.2.3 The LRO must issue a Permit to Work before work is allowed to proceed.

A6.2.2.4 The LRO must impose a system of work for handing over the equipment to a service engineer and accepting it back when the work is completed.

A6.2.2.5 After completion of the work the LRO must check:

- that the equipment has been restored to normal operation and is safe to use.
- that overrides and tools have been removed and protective covers replaced.
- that temporary warning signs have been taken down.
- That the log book for the equipment records the servicing operation, what was done and any consequent changes to the performance of the laser product.

A6.2.3 Temporary set-ups

Subject to a risk assessment evaluation the following relaxations to the control measures may be applied to laser enclosures erected for service activities. Such temporary set-ups may also be used for maintenance and trials/demonstrations involving High Risk and Embedded lasers products.

A6.2.3.1 High Risk lasers may be operated outside a DLA provided that a temporary laser hazard area is established with screens, coupled with laser warning signs and lights.

A6.2.3.2 Warning signs and lights may be used in place of interlocks to control access to the laser hazard area.

A6.3 Outdoor Laser Use

A6.3.1 Risk assessment

A6.3.1.1 A risk assessment must be made before Class 1M , Class 2M, Class 3B or Class 4 lasers are used outdoors.

A6.3.1.2 The risk assessment must include an estimate of:

- The ENOHD for the ‘raw’ laser beam.
- The potential of visible laser beams to dazzle or distract spectators and those working at heights or driving vehicles (e.g. motor vehicles, aircraft).
- The potential for eye or skin injury from High Risk laser beams, including specular reflections.
- The potential injury from diffuse reflections from Class 4 laser beams, including back reflections in the case of beams propagating through fog and rain.

A6.3.2 Approval

A6.3.2.1 The OLRO must be provided with the following documentation/information:

- A risk assessment.
- A statement on the purpose and duration of the outdoor work.

- A description of the means of defining and enforcing the boundaries of the hazard control area (i.e. the area within which the Class 1AEL or MPE, as appropriate, can be exceeded) for spectators and other persons present.
- The means by which the laser will be fixed in position and the beam manipulated, and any limitations placed upon the pointing of the laser beam.
- The means of protecting people within the hazard area

A6.3.2.2 The OLRO and Director must approve the risk assessment before outdoor laser work is allowed to commence.

A6.3.2.3 For laser displays and shows guidance can be found in IEC 60825 Part 3 and the Health and Safety Executive Guidance Note HS(G)95. If applicable the requirements of HS(G)95 must be complied with and any statutory notifications must be made.

6.4 Working with optical fibre systems

Guidance on fibre optic laser work can be found in IEC 60825 Part 2.'Safety of optical fibre communication systems' though the standard strictly only applies to extended Class 1 communications systems.

Optical fibres carrying laser radiation normally provide a complete enclosure of the radiation, and so prevent access to it. However, if a fibre is disconnected or a fibre break occurs, hazardous levels of laser exposure can be present. IEC 60825 Part 2 introduces the concept of Hazard Levels, corresponding exactly to the classification scheme for lasers. This scheme is particularly useful for dealing with servicing of extended optical communication systems that may be driven by Class 3B or 4 lasers but are essentially closed Class 1 systems in normal operation.

Good practice (all lasers)

A6.4.1 Do not stare with unprotected eyes or with any unapproved collimating device at the fibre ends or connector faces.

A6.4.2 Do not cleave ribbon fibres or use ribbon splicers without first assessing the hazard of exposure to multiple laser outputs.

A6.4.3 Do cover the output ends of fibres, either individually or collectively, when they are not in use.

A6.4.4 Do, when using optical test cords, connect the optical power source last and disconnect it first.

A6.4.5 Do dispose of fibre off-cuts (sharps) in an approved container.

High Risk lasers

A6.4.6 Before connecting High Risk laser test equipment assess the potential hazard at other points of access to the optical fibre system and either block the open ends or take appropriate action to prevent access.

A6.4.7 Optical fibre in mixed service conduits must be protected and clearly distinguished from electrical and other service cabling.