LASER SHOW: SAFETY DATA SHEET & RISK ASSESSMENT

1. Identify the hazards

The following table lists the sorts of harm which can result from exposure to lasers.

CIE Spectral region[a]	Eye	Skin	
Ultra-violet C (180nm to 280nm)	Photokeratitis	Erythema (sunburn) Accelerated skin ageing Increased pigmentation	
Ultra-violet B (280nm to 315nm)			
Utra-violet A (315nm to 400nm)	Photochemical cataract	Pigment darkening Photosensitive reactions	Skin burn
Visible (400nm to 780nm)	Photochemical and thermal retinal injury		
Infra-red A (780nm to 1400 nm)	Cataract, retinal burn		
Infra-red B (1.4 m to 3.0 m)	Aqueous flare, cataract corneal burn		
Infra-red C (3.0 m to 1 mm)	Corneal burn only		
a The spectral regions defined by the CIE are shorthand notations useful in describing biological effects and may not agree perfectly with spectral breakpoints in the MPE tables.			

Optical Laser hazards can be quantified to some extent by using maximum permissible exposure (MPE, see later section).but laser accident statistics show that the majority of accidents are caused by other hazards such as tripping, electrocution. The following is a list of more conventional hazards that may be associated with laser equipment:

• Electrical hazards, especially from high voltage power supplies - all portable electrical equipment must be PAT tested

• Trip hazards from trailing cables and water pipes – cable runners must be used

• Leaks from water cooling – do not set up beneath air conditioning units or pipework

• Mechanical hazards from moving parts such as motorised translation stages, pumps, motors etc – do not set up or trail wire near mechanical moving parts

• Other sources of intense light from, for example, disco lighting

• Toxic chemicals – keep away from our hazardous materials or effects

• Explosion or implosion from evacuated tubes or pressurised systems

• Fire from beam contact with combustible materials – do not focus lasers on any combustible component or surface

• Hazards from coolants such as liquid nitrogen

• Formation of ozone

• Risk of asphyxiation from leaking cylinders in confined areas

For laser activities a useful way to identify all the hazards is to compartmentalise the process.

- The laser - look for all the hazards starting from the laser beam output aperture BACK to the wall socket. This could include electrical hazards from the power supply, trip hazards from the cables, beam hazards if covers are removed etc.
- The beam delivery - look for all the beam related hazards from the laser beam output aperture to the beam stop. Consider specular and diffuse reflections and the possibility of inadvertent access to the beam.
- The laser process - look for all the hazards associated with the process. Are toxic chemicals or dangerous fumes released? Can the target accidentally move?
- Environment and people – look for hazards associated with the environment or the people. Could the environment affect the safety of the laser activity, e.g. extremes of temperature, humidity etc? Could the laser activity affect the environment? Can people affect the safety? For instance an experienced researcher may put other people at risk, or alternatively can an inexperienced, or unauthorised person get access to the equipment? – mount securely on a tripod and out of reach of guests.

2. Decide who might be harmed and how.

The people who might be harmed include the users but other people as well such as clients, venue staff, function guests, other suppliers or contractors, cleaners, maintenance staff, visitors and the public must be considered.

Considering how they might be harmed must include normal operations but also situations when something has gone wrong.

3. Evaluate the risk.

Take each identified hazard and, taking into account existing controls, evaluate the risk associated with that hazard. Risk can simply be classified as high, medium or low.

4. Identify the actions to be taken.

A set of actions must be produced which will remove the hazards completely or reduce the risks to an acceptable level. High risks should take priority, followed by medium and low. Someone responsible for carrying out the actions and a date for completion must be identified.

5. Record the assessment.

The risk assessments must be written up as evidence of the fact it has been done (for audits) but more importantly as a means of reference for anyone working with or associated with the laser or laser application.

Laser Safety

The Responsible Use of Lasers in Entertainment Venues

The following information provides a simple introduction to the issues surrounding the installation and use of lasers in the entertainment industry. It should be used to assist in the risk assessment process when designing a laser display for public viewing. Only those hazards associated with the laser beam itself will be considered: no guidance is given on related issues such as training, manual handling, working at heights or electrical safety. This information is not intended to replace the existing guidance (see further advice section).

Classes of laser

Lasers are usually referred to by their class, the class of a laser is dependant on its power output and associated hazards. The current classifications set out in the British Standard can be simplified as follows:

Class 1	Low powered, safe for viewing under all conditions
Class 1M	Low powered, safe for viewing with the naked eye
Class 2	Low powered, normal blink reflex should be sufficient to prevent eye damage
Class 2M	Low powered, normal blink reflex should be sufficient to prevent eye damage when viewed with the naked eye
Class 3R	Potentially harmful to sight
Class 3B	Potentially harmful to sight (reflections may also be hazardous)
Class 4	Always hazardous to eyes and for higher powers could cause skin-burns or pose a fire risk if the laser beam is projected onto flammable materials

What risks are associated with lasers?

A laser beam is a very narrow, intense light source that can be focussed by the eye in such a way that the retina is exposed to a power density up to 100,000 times greater than that of the laser emitter. If this occurs, sections of the retina can be heated by the laser energy. This heating effect can permanently damage the retina of the eye causing impairment of vision and in severe cases total blindness.

Setting up the Instrument

Lasers often comprise three main parts: a laser; a control unit (often a DMX controller or computer) and an effects head or table. When setting up a laser it is important to consider the following issues:

- The control unit for a laser should be positioned so that the operator can at all times observe the display in progress. This will allow any potential problems to be identified quickly and the appropriate action taken.
- In the event of an emergency it should always be possible to switch off the laser quickly. The ideal way to achieve this is by routing the power cable through a switchbox unit. Alternative solutions include a single switch or computer key that will allow the power to the unit to be switched off with a single press. The emergency cut-off (or power supply switch) should be easily accessible and all laser operators should be familiar with the shutdown procedure.
- It is good practise to man the control unit for a laser display at all times when the display is in use. The operator should be provided with adequate training to ensure they are aware of the possible hazards associated with lasers.
- The control unit should be equipped with a security device to prevent unauthorised people (in particular members of the public) from interfering with the laser display. This can be achieved using a key switch or (if a computer is being used) a password that must be input to prevent any settings from being changed, alternatively, isolate power to laser equipment when not present and check for tampering on return.
- Once in position, it is vital that the laser emitter remains in the same place. Even a small shift in the emitter's position could dramatically change the angle of the laser beam. The best way to prevent this is to ensure the laser is fixed firmly in position preferably in an area where it is unlikely to be disturbed.
- Interlocking devices are designed to switch off the laser in the event of mechanical component failure. When a laser display relies on individual mechanical components, such devices should always be present to help reduce risks from such failure.
- Many laser displays make use of reflective surfaces such as mirrors to produce beam sculptures and other visual effects. Once again, a small change in the position of a reflector can cause a huge shift in the direction of the laser beam. As with the emitter itself, any reflectors used as part of a display must be rigidly mounted such that they cannot be moved accidentally or by unauthorised personnel.

Choosing a Display Area

The display area

A laser display should always take place within a specific area. For lasers of class 2 and above, the laser emitter should be positioned so that no member of the audience can be exposed to hazardous laser emissions. This can be achieved using the following guidelines:

- The laser beam or effect should be at a height of at least three metres above floor level in any area where a member of the public could gain access (this includes any areas of raised seating).

Or

- The laser beam or effect should be separated by a distance of at least two and a half metres (horizontally) from any area where a member of the public could gain access. A physical barrier should be used to prevent access in this case

Special attention should be paid to venues with balconies, camera or lighting positions or windows leading into occupied areas as lasers projecting into these areas may put venue personnel at risk. Special care should be taken when planning an outdoor display. It is also important to take into account any reflective surfaces already present in a venue such as metal fittings, trusses, mirrors or windows as these may have an effect on where a laser beam is directed.

Scanning the audience (class 2, 3 or 4)

Under controlled conditions it is permissible to scan near the audience with the effects generated using lasers. When audience scanning is desirable it is doubly important that the laser installation is supervised by a trained operator. The maximum power output of any class 2, 3 or 4 laser used for audience scanning should always be approved by a professional laser inspector before the effect is used in public. Single laser beams should never be projected into occupied areas. Audience scanning with the primary beam from the effects head would rarely, if ever be acceptable.

Masking

When a laser show includes scanning near an audience, an opaque mask (usually made of metal) can be fitted to the edges of the laser aperture to ensure that in the event of a component failure inside the laser, the laser emissions cannot be project into areas other than the display area.

Assessing the Risk

The risk assessment

The most important part of any laser installation is the risk assessment. In many cases the use of lasers is subject to approval from the local authority and a well written risk assessment is often the key to this. The aim of the risk assessment should be to assess the proposed installation critically, looking at all the potential hazards no matter how unlikely they may seem. This provides assurance that even if something unexpected were to happen during a show nobody will be exposed to potentially hazardous laser emissions. It should always be remembered that members of the public can be relied upon to be unpredictable (particularly in crowded entertainment venues). This is especially true if members of the audience might be under the influence of alcohol or drugs (prescribed or otherwise) because not only will their behaviour be less easy to predict, their natural blink reflex may be impaired.

Risk assessments should always be fully documented so they can be inspected by the operator, venue staff and licensing authority. The following information should be included in the risk assessment:

- The type of laser and its power output in watts (or milliwatts)
- Details of safety devices and procedures
- The number and type of effects being used
- The display area (preferably include a diagram)
- The name and contact details of the person responsible for the display

Specific effects

A separate risk assessment should be performed for each type of effect used during the show although it is not necessary to do a separate assessment for a large number of similar effects (such as different graphics or text) as long as the display area, power output and type of laser emission does not vary.

For further advice and guidance consult the following sources:

- HS(G)95 The Radiation Safety of Lasers Used for Display Purposes
- BS EN 60825-1: 1994 incorporating Amendment Numbers 1, 2 and 3, September 2002
- Health and Safety at Work etc Act, 1974