

KAM

I N S T R U C T I O N M A N U A L

Class 4 Laser Product Safety Guide

V E R S I O N 3 . 0

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Important Warnings

Class 4 Laser products will harm eyesight if viewed directly in the face, and is very likely to be the case even if viewed over longer distances of several tens of metres. Therefore before using the laser product you **must** familiarise yourself with its operation, and also the safety aspects that must be considered.

Laser lighting effects are quite safe to watch if installed and used correctly, and being aware of a few basic factors will help you to achieve this. This guide has been prepared to help provide a basic backgrounder to the key safety elements, and is based on current UK health and safety guidance for the use of lasers for public displays and the BS/EN60825 Standard – Safety of Laser Products.

Installation and Operation Notes

1. The laser should only be installed and operated by those that are aware of how to operate the laser, and what the various controls perform.
2. The laser should be mounted in a suitable and secure position in the venue, so that once in position, it is unlikely to be affected by unintended movement.
3. Prior to installation and operation of the laser, the paths of the beams and effects should be considered, particularly with respect to how they will touch the audience. Direct audience scanning is **not recommended** but, if desired, the laser energy in the desired effects needs to be carefully considered to decide if these are safe for direct viewing.

Introduction

Laser display units will create some of the most vivid and striking visual effects, and are often noted for how they seem to produce solid shapes that cut through the air, and pick up highly defined swirling smoke patterns. The light that is used to create these stunning effects has properties which are different from normal light and therefore specific precautions need to be taken when using lasers to ensure that the lighting effects are safe and enjoyable to view. The light power output from the kind of lasers used for lighting displays can be harmful if not properly setup or is misused. When used in accordance with the recommended safety guidelines, laser lighting effects are no more harmful than looking at any conventional lighting effect.

This guide has been put together to provide you with some background information about laser safety and guidance on the recommended safety requirements for using lasers in public places. Although this guide covers the main points to consider, when using laser effects, users are advised to familiarise themselves with other guidance, particularly that issued by the Health and Safety Executive, HS(G)95 The Radiation Safety Of Lasers Used For Display Purposes (available free for the HSE website). Attending a KAM or other laser safety training course is also highly recommended.

What is a laser?

A laser is a device that produces a special kind of light that has different properties from normal light sources. Laser light sources differ from normal light sources in that they produce very narrow and intense beams of light that can remain parallel over long distances. It is this high concentration of light that makes lasers so potentially harmful to look directly into because it will focus to the smallest possible spot on the retina, at the back of the eye.

What is a Class 4 Laser Product?

Any device that contains a laser has to be classified depending upon the amount of laser light that someone might be exposed to. During design and manufacture of the product, the manufacturer assigns the laser product to one of the specific classes defined in the Standard BS/EN60825-1 (Safety of laser products Part 1: Equipment classification and requirements). The classes range from the safest, which is Class 1, through to the most hazardous, which is Class 4. For example, CD and DVD players contain lasers to read the disk, and because they are inaccessible to people, they are classified as a Class 1 laser product. Laser pointers emit accessible power and are normally limited to being Class 2 products. Most laser lighting effects units

are Class 3B and Class 4 laser products. These two classes have the highest potential to cause harm because they emit the most powerful light beams. This is, of course, desirable and necessary for laser lighting effects! A laser device that emits more than 500mW of light will be classified as a Class 4 laser product.

Are effects from a Class 4 Laser Product safe to view?

Yes, **if used responsibly**, and in accordance with the relevant guidances issued by the Health and Safety Executive. In the simplest terms, keeping the beams and effects above the audience will not present any hazard to those viewing the show or effects. When you start to aim the laser effects down into the audience area is when it becomes harder to tell if the effects could cause harm. Very rapidly moving large and evenly scanning patterns can be acceptable at large distances, if safety calculations have been carried out. Single beams or “stop/start” effects must **never** be shone into an audience! With a Class 4 product laser lighting effect, the problem can arise if the beams or effects actually hit someone’s face. **If in any doubt, keep the effects above the audience.**

What harm can a Class 4 Laser Product cause?

Class 4 laser products can be harmful to eyesight if viewed directly, that is, the beam or effect strikes the face of a person directly and enters the eye. The actual injury that can be caused depends upon a number of factors, including how long the laser beam enters the eye for, the intensity of light - i.e. how close to the source you are, and what part of the eye it gets focused onto. The most susceptible part of the eye for damage from a laser is the internal back wall of the eyeball, known as the retina. It is this part of the eye that receives the light and converts it to signals that are sent to brain. **All** light entering the eye’s pupil gets focused onto the retina. Normal light sources such as ordinary light bulbs and regular lighting effects are normally not harmful to view because their image is spread out over a large area of the retina. A laser beam is different in that it will be focused down to very small point on the retina and can burn holes on the back of the eye, which can lead to visual impairment or permanent loss of eyesight. This process can happen in less time than it takes for a person to blink. There are no pain receptors on the retina, so the person can be unaware of any damage taking place. Damage caused to the retina is **permanent**, and can vary from almost unnoticeable loss of vision, through to total loss of sight, particularly if the damage occurs in the part of the retina that senses the central vision.

Are there any laws or licences relating to using Class 4 laser products?

There are no specific “*laser laws*” or any “*laser licences*” that anybody needs in order to own or operate a laser for lightshow use. However, there is specific guidance issued by the Health and Safety Executive in the form of a document called *HS(G)95 Radiation Safety of Lasers Used for Display Purposes*. HS(G)95 outlines a number of detailed points to consider when using lasers for lightshow purposes. **The safe use of lasers is down to the responsibility of the operator and their respect for their audience!**

Most places of public entertainment operate under a *Public Entertainments Licence*, which is issued by the Local Authority. The entertainment licence requirements will normally need to have a specific provision covering the use of lasers at the venue, where it is expected that the laser installation, (whether temporary or permanent), is to operated in compliance with the HS(G)95 laser safety guidance as part of the venue’s Public Entertainment Licence conditions.

The use of lasers, as does any other equipment used for shows, will also be covered by more general health and safety legislation, such as the *Health & Safety at Work Act*, and the *Management of Health and Safety at Work Regulations*, etc. These regulations, among other things, state that you must ensure the safety of people present at the event where the laser is used, and also that a suitable risk assessment regarding the use of laser must be carried out.

Class 4 Laser Product Features

Class 4 laser products are required to have several specific safety features as part of their design. These features are laid out in the British Standard BS/EN 60825-1 and are a requirement of the product meeting CE approvals. The important ones are listed below:-

- 1) Laser Safety Warning Labels.
- 2) Emissions Indicator.
- 3) Remote Interlock Connector.

Summary of each feature's purpose

The Class 4 laser product must contain four Warning Labels: a warning label, an explanatory label, an aperture label, and a panel label. The warning label is the starburst in the warning triangle and is intended to show that the unit contains a laser. The explanatory label indicates the Class of the product and will read:

DANGER – LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

The aperture label is located to indicate where the laser projector will emit its beams. The panel label indicates the hazard present when the unit's panels are removed and will read:

DANGER – CLASS 4 LASER RADIATION WHEN OPEN
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION

The emissions indicator is intended to show, when illuminated, that the laser is ready to produce a light output.

The Remote Interlock Connector will allow the laser to function only when the two pins are shorted together. For lightshow use it is recommended by HS(G)95 laser safety guidance laser effects should be shut down by a remote Emergency Stop switch. The remote interlock connector provides a convenient way for such a switch to be easily added to the laser system, to provide this control.

Audience Scanning

Audience Scanning is the term commonly used to describe when laser effects are being directly aimed at the viewing audience. This creates a very dramatic looking effect, as people can touch the light, and look down smoky tunnels. But because the laser light can touch or scan past people's faces, it also carries a risk that it could cause damage to people's eyesight, if they are overexposed to the laser light. For this reason any audience scanning must only be carried out after **full assessment of the hazards is carried out** with the help of power readings and/or safety software. If it can be established that the audience will not be exposed to levels above the MPE, then and only then is audience scanning acceptable.

Maximum Permissible Exposure (MPE)

The amount of laser light that a person can be exposed to without it causing harm to eyesight is known as the Maximum Permissible Exposure or MPE. These levels are defined in the British Standard BS/EN 60825-1. When people are exposed to laser light which is above the MPE, it poses a risk of causing eye damage. This should be of concern when the laser effects are viewed directly in the face or there is a chance that they could be.

How do I know what the MPE is?

Knowing what the MPE and exposure level is for a given laser effect is quite a complex and involved process to establish. It is dependent on a whole number of conditions and variables that need to be taken into account. The laser safety standard BS/EN 60825-1 contains the data required to calculate the safe levels, but it is not straightforward to interpret. Laser safety calculation software has been developed to help ease the task of establishing safe laser effects exposure.

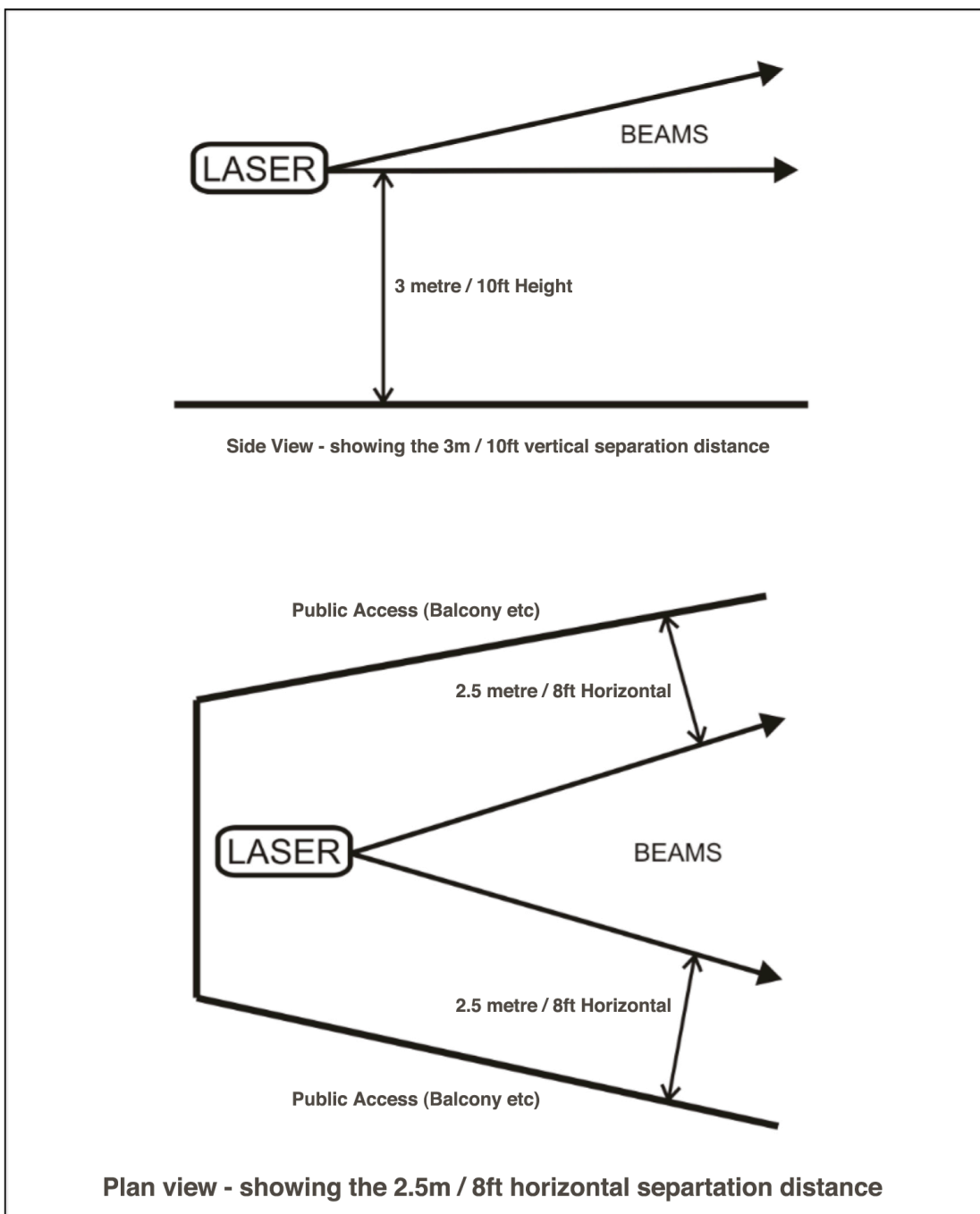
Laser Safety Officer

The BS/EN60825-1 Laser Safety Standard recommends that all establishments that use, or businesses that work with Class 4 laser products, should appoint a Laser Safety Officer (LSO). The LSO should be aware of the safety issues when using lasers, and is responsible for overseeing how the laser is used. In smaller businesses, the LSO will probably also be the installer, operator, owner, etc who should be aware of all the relevant guidelines.

Separation Distances

Health and Safety guidance states that for supervised installations, laser light above the Maximum Permissible Exposure (MPE) should not be accessible to members of the audience. It also recommends the area where the MPE may not be exceeded, extends from 3m above, and 2.5m laterally from any location in the venue where members of the public may gain access during the display. The following diagrams illustrate this.

Diagrams showing Separation Distances



Note. The 3 metre height specified is not the height of the actual projector, but it refers to the height of the laser effect. Therefore having the laser projector positioned at 3m height and aimed directly down is **not** what the guidance is saying or implying.

What types of effect are safe to scan directly at audiences?

Fast moving laser effects with evenly distributed scan patterns, such as circular tunnels are generally the safest to use. Effects such as “finger beams” or effects with pronounced bright spots in them **should not** be sent into an audience. The important thing is to be aware of the hazard distances involved. **If in any doubt – don’t audience scan!**

Hazard Distances

All display lasers have a characteristic known as the hazard distance for direct viewing (NOHD). This is distance beyond which direct viewing the laser no longer presents a hazard. At any point between the laser projector and the calculated hazard distance, it will be hazardous to view the laser directly. Viewing the laser directly from beyond the hazard distance is considered to be safe.

The worst case effect to look at directly is a static single beam, because all the light energy is concentrated into one point. The hazard distances for several different powers of Class 4 laser products are shown in the table below, to give an idea of the distances involved.

Laser Output Power	500mw	1W	1.5W
Hazard Distance (2mr)	78m	111m	136m
Hazard Distance (1mr)	156m	222m	272m

Table 1 - Static Beam Hazard Distances.

Note - The values have been calculated assuming the characteristics of a typical laser lightshow device, with a green beam and a beam spread (divergence) of 1 and 2mr (milliradians). Actual devices may differ in practice, so this table should only be used as a guide (with a “tighter” beam these distances can be up to double or more!). Details of how to calculate laser hazard distances are detailed in the British Safety Standard, and many laser safety textbooks. It is also one of the topics usually covered in laser safety courses.

It can be seen that static laser beams can remain hazardous for considerable distances, which is why projecting such effects into people’s faces is **not** recommended.

Remember, projecting these beams overhead is fine, as long as they, or any reflections, are not hitting anybody. When an effect such as a tunnel is projected, the continual scanning reduces the time the eye is directly exposed to the laser energy. These types of effect are less harmful to aim at the audience directly. The table below shows the hazard distances of a stationary circular tunnel using a 2mr divergence beam, with spreads of 50 and 25 degrees, with a scan rate of 20Hz, to give an idea of how it is reduced. Faster scan rates will give safer effects. Panning (moving around) the effect rapidly will also increase the level of safety.

Laser Output Power	500mw	1W	1.5W
Hazard Distance (50°)	37m	52m	64m
Hazard Distance (25°)	40m	57m	70m

Further Laser Safety Information and References

The Radiation Safety of Display Laser Installations HS(G)95

Published by HSE Books 1996 ISBN 0 7176 0691

Download free from: <http://www.hse.gov.uk/pubns/books/hsg95.htm>

BS/EN 60825-1: 2007 Safety of Laser Products - Part 1

Equipment classification and requirements

Website - www.bsstandards.co.uk

IEC 60825-3 Guidance for Laser Displays and Shows

Issued by International Electrotechnical Commission

Website - www.iec.ch

Health & Safety Executive

Website - www.hse.gov.uk

Laser display safety guidance page - www.hse.gov.uk/pubns/INDG224.htm

Health Protection Agency

Website - www.hpa.org.uk

Laser information page - www.hpa.org.uk/radiation/laser/index.htm

Laser FAQ page - www.hpa.org.uk/radiation/faq/laser/index.htm

Laser Show Safety Information Website

Website - www.lasershowsafety.org

Laser Safety – 480 page text book

Authors – Roy Henderson & Karl Schulmeister

Publisher – Institute of Physics Publishing (2003)

ISBN 0750308591

Laser Safety Calculation Software

LaserSafe PC Professional

G.L. Services

Free demo version available from the website – www.lasersafepc.com

Scanguard - Laser Visuals Research Limited

Website – www.laservisualsresearch.co.uk

Laser Safety Training

Kam in house client laser safety training.
Please email: lasersafety@lambapl.com for further details.

Health Protection Agency – Laser safety training courses offered.
www.hpa.org.uk/radiation/training/nir/laser_safety/index.htm

Thames Valley University – Part time course lasers in entertainment course.
www.tvu.ac.uk/prospective/pdf/LCMM_pt.pdf

Laser Visuals Research – Laser show safety training.
www.laservisualsresearch.co.uk

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