::Laser Law::

For further information please refer to: http://www.hse.gov.uk/lau/lacs/index.htm

Radiation safety of lasers used for display purposes
Introduction:

1. This circular should be read in conjunction with circular number 60/2 which deals with general aspects of laser safety. the reader is also referred to HSE guidance document hs(g)95 - the radiation safety of lasers used for display purposes' which gives comprehensive information about the safety assessment of display laser installations.

What types of laser are in use at display venues?

2. The following types and classes of laser are in widespread use. hs(g)95, appendix b gives more information about these laser types.

(i) helium-neon - class 2 and class 3a used with scanning optics to produce time-varying geometrical patterns on screens. many proprietary systems are available which have output powers up to around 5 milliwatts. their main application is in discotheques and night clubs.

(ii) argon-ion - class 3b (typically 100-200 milliwatts) or class 4 (typically 1 -10 watts)

This type of laser is used at venues where green or blue light of high power is required. they are widely used at pop/rock concerts to produce scanning or fan-shaped beams and can be coupled to special optical systems to generate animation and sign-writing on screens. their use in discotheques and clubs is on the increase.

(iii) krypton-ion - class 4 (typically 1-10 watts). these produce a red light and are favoured at venues where high power is required. they are therefore commonly used in outdoor applications.

(iv) mixed gas lasers - class 4 (typically 1-20 watts) this type of laser represents the state-of-the-art in entertainments applications and, although very expensive, are now the mainstay in outdoor laser shows and in many night clubs and discotheques. they have similar output powers to argon and krypton designs and, like these, use a gas discharge tube containing a low pressure mixture of argon and krypton gas as the laser medium. their main advantage over other gas lasers is that they emit light at a number of wavelengths (in the red, blue and green parts of the spectrum) which, with suitable filtration and mixing, allows any visible colour to be projected into the venue.

The use of this type of laser is now commonplace at large indoor and outdoor venues and, as prices fall in real terms over the coming years, they will doubtless become the laser of choice for most users.

(v) copper vapour - class 4 (typically tens of watts) these very high power lasers are currently only used in outdoor applications. their very high power and low divergence make them eminently suited to large-scale spectacular displays at concerts and large civic events. at present these designs are difficult to maintain and operate and they are expensive to purchase. for the time being, this has meant that their use is not widespread but this may change as technology improves. since this type of laser emits high frequency pulses of very high peak power rather than a continuous emission (so-called continuous wave - cw), assessment of their viewing safety is a very difficult, specialist task. they are therefore not suitable for audience scanning applications.

What are the hazards of display lasers?

3. Most laser systems used for display purposes exceed class 1 or 2 criteria as defined in the current British Standard (BS EN60825-1:1994 amendment 2). many are class 4 and are capable of causing skin burn and eye damage, especially the retina. laser-induced damage to the retina is always permanent.

4. eye injury thresholds depend upon a number of factors and not just upon beam power density (irradiance); exposure duration and viewing condition are equally important. class 4 lasers are capable of causing eye damage in all types of viewing condition; that is, during direct ocular, specular reflection and, in some instances, diffuse reflection viewing conditions. the very low divergence typical of the output from a display laser system means that a stationary laser beam may remain hazardous for distances up to several hundred meters. in the case of multi-watt lasers, this distance may be over 1 km.

Reflection hazards

6. Specular reflections occur at smooth, shiny surfaces such as mirrors. rough surfaces, such as masonery and air contaminants such as smoke and dust, produce diffuse reflections and scatter. see hs(g)95, appendix a for more information on these terms. specular reflections can be just as hazardous as the primary laser beam. diffuse reflections by contrast are much less hazardous because the surface irregularities that cause them destroy beam coherence and cause scatter. consequently, the eye is exposed to reduced power density and forms an extended image on the retina that, in most exposure circumstances, is less hazardous.

Scanning hazards

6. Laser emission scanning is normally produced by a pair of galvanometer mounted mirrors oscillating at right angles to each other. scanning device control is normally effected by some form of programmable controller although, in some installations, it is achieved manually.

7. Scanning applications present a special viewing condition whereby a continuous wave (cw) emission is perceived as a series of pulses as it passes rapidly across the eye. scanning frequency is therefore an important determinant of injury threshold and, as such, requires careful evaluation before a scanned display can be considered safe to view.

8. Scanned emissions pose less risk of eye damage than static emissions because beam movement reduces exposure time. but hazardous exposure can still arise if accessible emissions are not properly evaluated: especially if fault conditions arise and scanning patterns unexpectedly change. it should never be assumed that, because a hazardous cw emission is being scanned at high frequency across a display area, it will be safe to view.

Venue hazards

9. Hazardous exposure to laser emissions may occur in a variety of circumstances; by direct exposure to the beam emitted at the laser aperture itself or from beams produced by external optical components such as mirrors. the existence of unexpected reflective surfaces should also not be overlooked.

10. Indoor displays, such as those at discotheques and night clubs, may present a risk of unexpected laser reflection from ornamental mirrors or tiles, or from conventional lighting rigs.

11. In outdoor displays, powerful lasers may be directed towards occupied buildings or at people and traffic on overhead flyovers and walkways etc. all these possibilities should be carefully assessed before an outdoor display is allowed to take place.

12. In outdoor displays remember that, even when accessible emissions are considered to be below the applicable maximum permissible exposure value (mpe), the presence of a laser emission may still cause distraction to people unaware that a display is taking place. for example, unexpected laser emission may dazzle or disorientate motorists and aircraft pilots. there is also the risk of interference with air traffic control navigational lights and traffic signals on roads and railways. all these factors should be assessed before an outdoor display is allowed to take place.

Assessing the hazards

13. The current British Standard requires displays that take place in unsupervised areas to comply with class 1 or 2 criteria but, although this is good advice, the standard does not indicate how such compliance is to be demonstrated.

14. The usefulness of classification criteria to indicate exposure hazards from large and highly configurable display laser installations is limited. the accessible emission, upon which classification is always based, may be so venue specific and alterable by the installer or user at the time of commissioning that classification becomes not only difficult but also less relevant than the direct use of mpe values. this is especially true of scanned emissions where the constraining mpe value is the most restrictive of mpe values obtained from three separate assessments. consequently, display installation safety assessment should always place greater emphasis upon mpe considerations than on getting the installation classification right.

15. The aim of safety assessment is to provide assurance that emissions produced during a display can not lead to personal exposure above the applicable mpe value for both normal operation and following fault conditions. for more information about the criteria to be used in display laser safety assessment, you should read chapter 4 of hs(g)95.

Enforcement approach

16. The key to safe operation of a display laser installation is completion of an adequate, venue specific risk assessment (referred to as the safety assessment in hs(g)95). the competence of laser operators and the installer and equipment maintenance procedures also have important roles to play in the safety assurance of display laser installations.

17. Display laser safety assessment becomes a very complex matter for installations that are designed to scan audiences with class 4 laser products. enforcement officers should therefore seek expert assistance if they are in any doubt about the extent to which laser operating employers and installers have complied with the guidance given in hs(g)95.

18. Safety assessments should meet the following general guidelines:

(i) emissions intended for viewing should be safe and without risk to health.

(ii) the applicable mpe value should not be exceeded following personal exposure up to the maximum time for which an emission could remain accessible. see table 1 of hs(g)95 for more information on how to decide upon the applicable mpe value.

(iii) emissions that are not intended to be viewed, ie. all those that are potentially hazardous, should be physically inaccessible.

(iv) if requirement (iii) is impracticable, reliance may be placed upon administrative controls, provided that they ensure that hazardous exposure will not occur. such controls include the demarcation of laser hazard areas by means of fencing (e.g. rope barriers) in conjunction with warning signs, and invigilation by installation operators.

(v) reasonably foreseeable installation fault conditions, particularly scanning failure, should not lead to personal exposure above the applicable mpe value.

(vi) potentially hazardous unexpected exposure situations, e.g. the sudden appearance of unauthorised people at hazardous viewing locations, or audience unruliness, should be identified so that everything reasonably practicable may be done to reduce their likelihood.

(vii) with the exception of prescription lenses, due account should be taken of the effect of viewing aids upon the appropriate value of the mpe in circumstances where these are likely to be used.

(viii) evaluation of emissions having a diameter greater than that of the relevant limiting aperture, should take account of any variation in intensity with position within the beam: the limiting aperture should always be placed where the greatest emission occurs. nb. the british standard specifies a limiting aperture of 7 mm.

19. It is good practice for the safety assessment to be fully documented and auditable so that it can be checked by the user, an appointed consultant and, when requested, by the relevant enforcement authority. the decision tree in figure 7 of hs(g)95 sets out the principles upon which a robust safety assessment should be based.

20. Requests for specialist advice and joint visits should be forwarded to the area enforcement liaison officer (elo) who will, where appropriate, transmit the request to the appropriate hse regional support group (rsg).