Laser Pointers

The misuse of laser pointers (sometimes referred to as laser pens) reported in the press has generated public concern over the safety of these devices. The following provides basic information on the properties of laser radiation, the different laser Classes and summarises the HPA position on the issue of the safety of laser pointers. The advice from the HPA takes account of the current British Standard for laser safety, and the technically equivalent European and International Standards. NRPB (now the Radiation Protection Division of the HPA) was involved in the initial development of these Standards and currently provides input to the British Standards Institution and International Electrotechnical Commission Technical Committees responsible for maintaining these documents.

NRPB provided advice to the Department of Trade and Industry concerning the safety of hand-held laser pointers and the optical hazards posed by the use of these products.

Laser radiation

Lasers are devices which produce radiation with unique properties. It is these properties that distinguish laser radiation from the radiation produced by more familiar sources such as the sun or the common household electric light bulb. When the radiation emitted by a source can be detected by the eye and produces a sensation of vision, it is referred to as light. An electric light bulb produces radiation comprising many different wavelengths, perceived as white light, and emits fairly equally in all directions. The radiation produced is said to be highly divergent, i.e. the light spreads out rapidly as the observer moves away from the bulb. It is this property which allows the illumination of large areas using a single light bulb. In contrast a laser will produce radiation over a very narrow wavelength band, so narrow that the laser is referred to as a monochromatic or single wavelength source. If the laser emits in the visible region then the radiation is perceived as a single colour. The wavelength of light is usually measured in nanometres, or one-thousand-millionth of a metre and is abbreviated to “nm”. The laser also produces a very narrow beam which diverges, or spreads out, very little with increasing distance from the source. This low divergence property means that the laser output is highly directional, forming a pencil-like beam that will still appear as a small spot when shone against a surface, even at large distances (i.e. 100 metres plus). A consequence of this is that high power devices can present a hazard over considerable distances. When considering the safety implications of the laser beam an important parameter is the amount of power in the beam divided by the cross-sectional area of the beam. This is called the irradiance and is usually quoted in watts per square metre or W m⁻².

Laser pointers

Laser pointers have been used as presentational aids by professional trainers for a number of years, with no reported incidents in the UK. They are usually portable, low powered, battery operated, hand held laser devices. Commonly available laser pointers generally emit red coloured light (wavelengths between 630 and 670 nm), although more expensive devices are available which emit green coloured light (532 nm). The response of the human eye is wavelength dependent and peaks at around 550 nm, the response decreasing as either end of the visible spectrum is approached (400 nm to 780 nm). As a result, if laser pointers are compared at three different wavelengths (670 nm, 635 nm and 532 nm) but at the same radiant power, the brightness as perceived by the eye will be approximately in the ratios 1 : 10 : 30. Laser pointers emitting light with the laser wavelength which is closer to the eye’s peak response are therefore capable of producing the adequate visual stimulus at lower radiant powers.

Laser pointers can be pen shaped, and these are the type usually marketed for professional use (figure 1). Devices intended for the novelty market can be of different shapes. These novelty laser pointers may also contain either interchangeable effects heads (figure 2) or have an integral selector control (figure 3). They are commonly supplied as key rings.
Laser safety standards

Laser pointers sold in the UK should be classified in accordance with the current British Standard1 on laser safety. This document specifies requirements for the manufacturers of laser products to ensure that the risk of accidental exposure is minimised through the use of engineering control features and product labelling, and by specifying minimum requirements for the supply of product information to allow for its safe use. The Standard also contains advice to the user of laser products in terms of procedural controls and Class-specific training requirements. In the USA there is a Federal Performance Standard for Laser Products2 which has similar requirements, but there are differences between these two documents. This is discussed below (see Laser Classes).

If product mislabelling is suspected, or there is doubt over the classification of a product then measurements should be carried out in accordance with the requirements of the British Standard to determine the actual laser Class to which the device should be assigned. A visual inspection of a laser product or its laser output will not provide any indication of the appropriate Class for the device.

The British Standard sets out seven Classes of laser, these are Class 1, Class 1M, Class 2, Class 2M, Class 3R, Class 3B and Class 4. The higher the Class number, the greater the laser radiation hazard posed by the laser. Class 4 lasers are high power devices, usually needing a mains power supply. Class 4 lasers are used for specific applications in research, medicine and industry. They are also used in the entertainment industry. Class 4 lasers are not designed to be used as laser pointers.

The classification system uses the concept of an Accessible Emission Limit (AEL). An AEL is the maximum value of accessible laser radiation that an individual may be exposed to during the operation of a laser. The AEL values are in turn based on Maximum Permissible Exposure (MPE) levels. An MPE is a level of laser exposure which it is believed an individual could be exposed to without incurring an injury. An MPE may therefore be considered as a maximum safe level of exposure. MPE levels are specified for both the eye and skin as a function of the wavelength of the laser radiation and the duration of exposure. These MPE values are internationally agreed.

A laser is assigned to a particular Class when the measured emission level exceeds the AEL for all lower laser Classes but does not exceed the AEL for the Class assigned. For example, a laser will be assigned as a Class 3R laser product when the maximum measured accessible emission level exceeds Class 1, Class 1M, Class 2 and Class 2M AEL values but does not exceed the Class 3R AEL. Once a laser has been assigned to a particular Class there are other requirements prescribed in the British Standard which should be met. These will include product labelling and customer information, and may include specific engineering control features to be incorporated in the laser product depending upon the Class assigned. A summary of the laser Classes is given below.

Laser Classes

The following laser classification scheme is taken from the International Electrotechnical Commission IEC 60825-1 Edition 1.2, August 20013 standard. This was adopted in Europe as EN 60825-1+A11+A2+A1, July 20024 and subsequently in the UK as BS EN 60825-1: 1994 incorporating Amendment Numbers 1, 2 and 3, September 20021.

**Class 1**

Class 1 lasers are products where the radiant power of the laser beam accessible (the accessible emission) is always below the Maximum Permissible Exposure value. Therefore, for Class 1 lasers the output power is below the level at which it is believed eye damage will occur. Exposure to the beam of a Class 1 laser will not result in eye injury. Class 1 lasers may therefore be considered safe. However, Class 1 laser products may contain laser systems of a higher Class but there are adequate engineering control measures to ensure that access to the beam is not reasonably likely. Examples of such products include laser printers and compact disc players.

**Class 1M**

Class 1M lasers are products which produce either a highly divergent beam or a large diameter beam. Therefore, only a small part of the whole laser beam can enter the eye. However, these laser products can be harmful to the eye if the beam is viewed using magnifying optical instruments. Some of the lasers used for fibre-optic communication systems are Class 1M laser products.
Class 2

Class 2 lasers are limited to a maximum output power of 1 milliwatt or one thousandth of a watt (abbreviated to mW) and the beam must have a wavelength between 400 and 700 nm. A person receiving an eye exposure from a Class 2 laser beam, either accidentally or as a result of someone else’s deliberate action (misuse) will be protected from injury by their own natural aversion response. This is a natural involuntary response which causes the individual to blink and avert their head thereby terminating the eye exposure. Repeated, deliberate exposure to the laser beam may not be safe. Some laser pointers and barcode scanners are Class 2 laser products.

Class 2M

Class 2M lasers are products which produce either a highly divergent beam or a large diameter beam in the wavelength range 400 to 700 nm. Therefore, only a small part of the whole laser beam can enter the eye and this is limited to 1 mW, similar to a Class 2 laser product. However, these products can be harmful to the eye if the beam is viewed using magnifying optical instruments or for long periods of time. Some lasers used for civil engineering applications, such as level and orientation instruments are Class 2M laser products.

Class 3R

Class 3R lasers are higher powered devices than Class 1 and Class 2 and may have a maximum output power of 5 mW or 5 times the Accessible Emission Limit (AEL) for a Class 1 product. The laser beams from these products exceed the maximum permissible exposure for accidental viewing and can potentially cause eye injuries.

This Class, which was introduced into the British Standard with Amendment 3, replaces the former Class 3A and the low power part of Class 3B. Class 3A had the additional requirement that the irradiance of the laser beam should not exceed 25 W m-2. The effect of the irradiance limit was to restrict the power admitted to a fully dilated human eye (taken as a 7 mm acceptance aperture) to 1 mW. As such, accidental exposure to a Class 3A laser beam was no more hazardous than accidental exposure to a Class 2 laser beam. An individual accidentally exposed would be protected from injury by their natural aversion response. Class 3A laser pointers were, however, potentially hazardous when viewed with an optical aid such as binoculars and were therefore not suitable for the general consumer.

To satisfy the irradiance criteria, a laser pointer with an output power greater than 1 mW would have to produce an expanded beam to reduce the irradiance below 25 W m-2. As the characteristic feature of a laser pointer is the small spot produced by the narrow beam, expanding the beam area to satisfy the irradiance criteria effectively destroys this useful property. It was therefore extremely unlikely that a laser pointer with a power output in excess of 1 mW would satisfy the Class 3A AEL criterion. Therefore, in general, laser pointers were either Class 1, Class 2 or Class 3B products. The former Class 3B laser pointers, which did not exceed 5 mW, are now Class 3R.

The American Standard does not have the Class 3A irradiance criteria previously specified in the British Standard. Therefore, a correctly classified American Class IIIA laser pointer would have become Class 3B device when classified against the British Standard. The use of Roman numerals should indicate that the product has been classified in accordance with the American Standard. In practice, examples occur where an inappropriate 3A label has been substituted for the IIIA label. All of the American IIIA laser products will now be Class 3R under the British Standard.

Examples of Class 3R products include some laser pointers and some alignment products used for home improvement work.

Class 3B

Class 3B lasers may have an output power of up to 500 mW (half a watt). Class 3B lasers may have sufficient power to cause an eye injury, both from the direct beam and from reflections. The higher the output power of the device the greater the risk of injury. Class 3B lasers are therefore considered hazardous to the eye. However, the extent and severity of any eye injury arising from an exposure to the laser beam of a Class 3B laser will depend upon several factors including the radiant power entering the eye and the duration of the exposure. Examples of Class 3B products include lasers used for physiotherapy treatments and many research lasers.

Class 4

Class 4 lasers have an output power greater than 500 mW (half a watt). There is no upper restriction on output power. Class 4 lasers are capable of causing injury to both the eye and skin and will also present a fire hazard if sufficiently high output powers are used. Lasers used for many laser displays, laser surgery and cutting metals may be Class 4 products.

Use of lasers and training

The British Standard provides advice on the use of lasers for demonstrations, displays and exhibition and states that only Class 1 or Class 2 devices should be used in unsupervised areas unless under the control of experienced well-trained operators. Laser pointers used by, for example, professional lecturers in the workplace are considered to fall
under this category. Minimum training requirements are specified for operators using lasers of a higher Class for these purposes due to the risk of eye injury. Such training should include guidance to the user on the risks from the laser beam and advice not to point the beam at anyone.

**Laser pointers currently available on the market**

The HPA Radiation Protection Division has examined many laser pointers available to the general public in order to assess their laser Class and have found a significant proportion of these products to be Class 3R lasers and several Class 3B. The body's natural aversion responses are unlikely to provide adequate protection from eye injury for Class 3B laser pointers.

Green laser pointers have given a particular cause for concern. Many of these are not even suitable for professional use because they cause afterimages in people viewing the beam on a projection screen. Those close to the screen may also experience a grey 'comet tail' following the beam as it is moved across the screen. Some of these green laser pointers produce beams that consist of a series of bursts (or pulses) of light with high peak powers in each pulse. The manufacturers often quote average power, which gives a misleading indication of the risk. Because of the way the green beam is generated, there may also be other, invisible, laser beams emitted. Specialist equipment is needed to identify these problems.

Although the risk of a permanent eye injury from a laser pointer may be small, an individual receiving even a transient eye exposure from a laser pointer will experience a bright flash, a dazzling effect, which is likely to cause distraction and temporary loss of vision in the affected eye and possibly after-images. The time taken to recover from these effects will vary for different individuals and will also be dependent on the ambient light level at the time of exposure. Medical attention should only be sought if after-images persist for hours, or if a disturbance in reading vision is apparent.

Many of the laser pointers assessed by the HPA were either incorrectly labelled or not labelled at all. It was also unusual to find any information on laser safety or warnings on the implications of potential misuse supplied with the products.

**HPA advice**

The HPA considers the professional use of a Class 1 or Class 2 laser pointer as a training aid in the workplace to be justified, and regards these Classes of laser product as being generally adequate for such use. The use of Class 3R laser pointers up to 5 mW may be justified for some applications in the workplace where the user has received adequate training.

The HPA advises that the sale of laser products to the general public for use as laser pointers should be restricted to Class 1 or Class 2 devices which should be classified in accordance with the requirements of the current British Standard and should be sold with sufficient accompanying information to enable the user to operate the product in a safe manner. Toys should be Class 1 or of such low output that they do not need to be classified.

After seeking advice from NRPB (now the Radiation Protection Division of the HPA) the Department of Trade and Industry urged Trading Standards Authorities to use their existing powers under the General Product Safety Regulations 2005 5 to remove laser pointers of a Class higher than Class 2 (as defined in the British Standard) from the general market. Such devices are too powerful for general use as laser pointers and present an unacceptable risk in the hands of the consumer because they may cause eye injury in normal reasonably foreseeable use.

**References**


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