DERMA-LASE
LASER & IPL TRAINING

A BRIEF GUIDE TO

Laser Safety

FOR LASER & IPL USERS

In clinical and aesthetic settings
(based on UK regulations)

Lasers can be potentially dangerous to both the skin and the eyes.

This brief guide will help you stay safe.

MIKE MURPHY
Laser Protection Adviser

ALSP
THE ASSOCIATION OF LASER SAFETY PROFESSIONALS

Mike is a certificated and Committee member of the ALSP.
However, this booklet is not ‘endorsed’ by the Association.

For more information please visit our web site at www.LaserProtectionAdviser.com

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INTRODUCTION

Lasers can be very useful tools in aesthetics, cosmetics and medical applications. But they are also potentially very dangerous, particularly to the eyes - not only of the laser operator, but also to anyone else within the 'hazard zone'.

This short booklet will explain some of the more important points which ALL laser users must be familiar with, to ensure a safe and efficient laser environment.

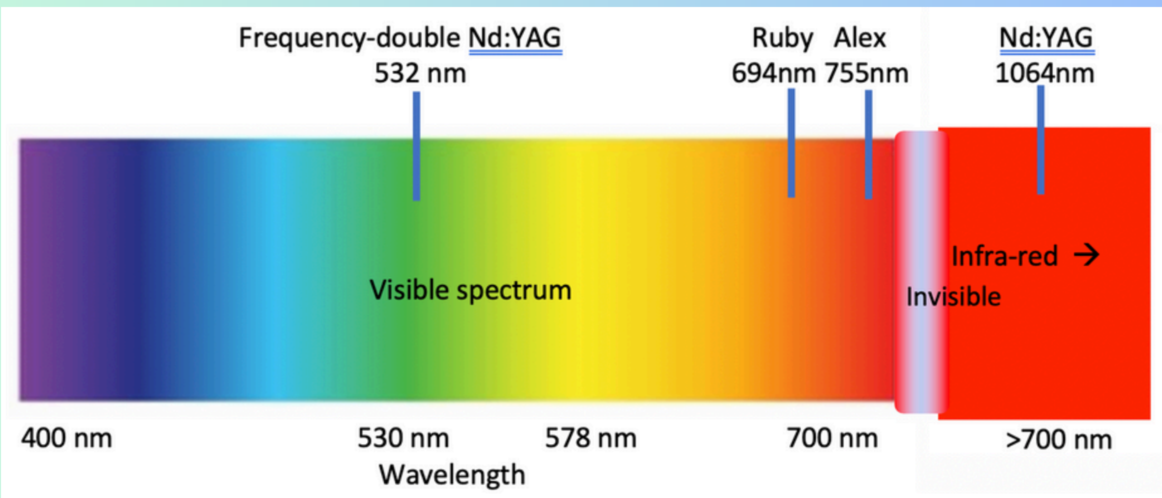
The international hazard symbol for a laser in operation

All laser and IPL systems are essentially light sources. The range of wavelengths (colours) they output is huge from ultra-violet through the visible spectrum up to infra-red energy. Some of these wavelengths are invisible but can be felt as heat (infra-red) while the UV light may stimulate melanocytes in the skin to induce a tan, or cellular damage.

Some of these wavelengths can pose a potential hazard to the skin or eyes. In this section we will examine these hazards:

Ultraviolet Light

The UV region spans from around 20nm to around 390nm in wavelength. The high energy of this high frequency light leads to chemical reactions in some materials, hence plastics and some cable sheaths deteriorate due to UV exposure. Similarly, it is the high energy of the photons in this light that damages our skin on sunny days, and not the infrared light that we feel as heat.



Visible Light

The wavelength range of visible light is from around 390nm up to around 780nm. A precise definition is not really possible because different people can different ranges of this spectrum.

Visible Light Spectral Band Designation:

Colour of Light Wavelength range (approximately):

Violet - 390 nm to 440 nm
Indigo - 440 nm to 460 nm
Blue - 460 nm to 490 nm
Green - 490 nm to 575 nm
Yellow - 575 nm to 596 nm
Orange - 596 nm to 620 nm
Red - 620 nm to 780 nm

Note: the visible wavelength range is defined as 400 nm to 780 nm in the British laser safety specification BS EN 60825-1:2014, with this range reduced to 400 nm to 700 nm (see page 7).

Infrared Light

The infrared light region extends from a wavelength of 780 nm up to 1 mm. This region is further sub-divided into the near infrared (so-called because it is near to the visible light we are most familiar with), the intermediate infrared, the far infrared and the extreme infrared.

Infrared Light Spectral Band Designation:

Designation Wavelength:

Near infrared - 780 nm to 3000 nm
Intermediate infrared - 3000 nm to 6000 nm
Far infrared - 6000 nm to 15000 nm
Extreme infrared - 15000 nm to 1 mm

Although infrared light is outside our visible region, we can still detect infrared radiation as heat. The radiant heat from the sun, fires, light bulbs and some people is infrared.

All substances emit infrared radiation to a degree depending on their temperature. Luckily, the level of emission from objects at room temperature is low, and we can use infrared signals for such things as TV remote controls without the arrival of a cup coffee leading to interference.

LASER CLASSIFICATION

As found in the Medical/Aesthetic Laser Standard BS EN 60601-2-22

Safety precautions, including eye protection, flammability, reflection, and administrative control measures, are determined by the classification of the laser, which must be included by the manufacturer on the device and aperture labels. Current classifications have been adopted by the IEC as follows:

- Class 1: safe under every conceivable condition of use;
- Class 1M: safe for viewing without optical aids, but potentially hazardous with magnification aids (microscopes, loupes, binoculars, etc.);
- Class1C: these lasers are designed for use when in contact with the skin. They are deemed eye-safe in this working mode.
- Class 2: Visible wavelengths (400-700 nm) safe if viewed for less than 0.25 seconds;
- Class 2M: Visible wavelengths (400-700 nm) not safe with optical viewing aids;

All of the above lasers output less than 1 mW of power.

*

- Class 3R: Marginally unsafe for intrabeam viewing of visible light beams with diameters >7 mm.

All Class 3R lasers visible output up to 5 mW of visible power.

*

- Class 3B: Unsafe for intra-beam viewing, causing skin and eye injury from direct but not necessarily diffuse energy;

All Class 3B lasers output up to 500 mW of power.

*

- Class 4: High power causing skin and eye injury from direct and reflected energy.

All Class 4 lasers range from 500 mW to millions of watts!

Note that the above power outputs relate to the “average” power and not the “peak” powers, which can be huge for nano- and picosecond lasers.

LASER SAFETY GLASSES

Why are they so important?

We only have one pair of eyes, so we must look after them. Many lasers can generate damage in both the retinas and/or the lenses of our eyes, depending on their wavelength.

What do the markings on laser glasses mean?

Laser safety glasses must show information on what they are supposed to protect your eyes against. This must include the wavelength(s) and the protection levels. These are to ensure that your eyes are fully and properly protected during laser procedures.

This section explains the markings you should see on your laser safety glasses. Note that these markings will vary according to your local country regulations. The markings described here are for the UK.

The information in this section can be found in more detail in the **European Standard EN207:2017** which conforms to the CE's Personal Protective Equipment Directive (PPE). All laser safety eyewear must conform with this Directive and must be CE marked in Europe, and UKCA marked in the UK (this Mark will replace the CE Mark).

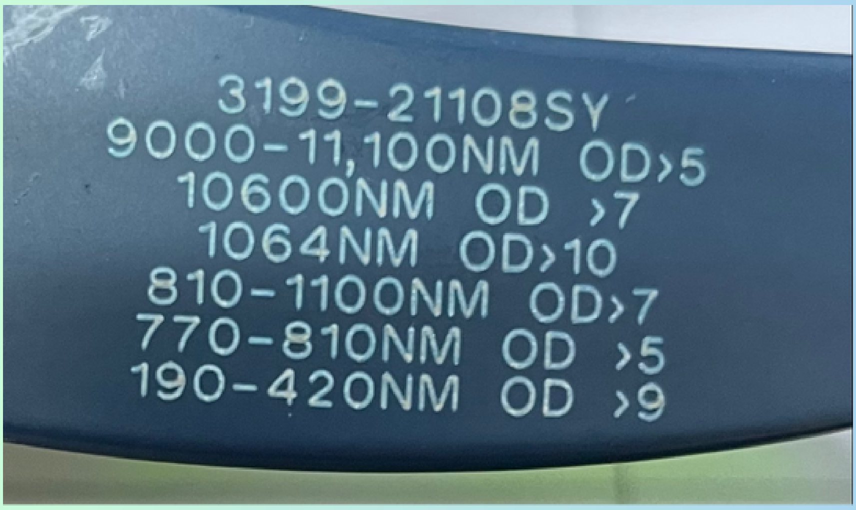
On most laser safety glasses you will find two sets of marking (see photo below):

In this section I will briefly describe the meanings of this information. For the full breakdown, please read <u>my blog post here</u>.

One set will usually describe the wavelength and optical density ranges. The other set will describe the protection according to the pulsewidths and material damage thresholds. The below above shows the wavelength range on the left, with the optical densities (OD) on the right.

The top line – “3199-21108SY” – is a reference number by the manufacturers. It has nothing to do with the safety information.

The next line – “9000-11,100NM   OD>5” – shows that the range of wavelengths from 9000 to 11,100 nanometres is protected to an optical density exceeding 5. This means that the protection level is 10 5 which is 100,000 (i.e. 1 with five zeroes after it!).

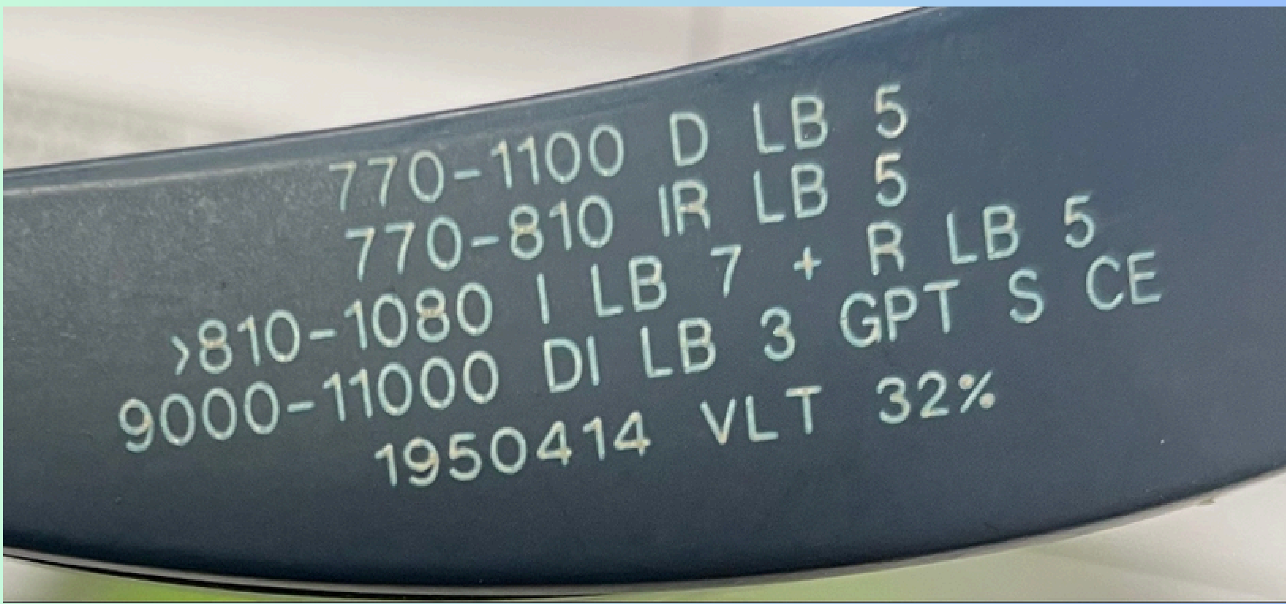


So, this means is that if you were to fire 100,000 Watts of laser power, within this range of wavelengths, into the filter part, then only 1 Watt would emerge from the other side, towards the eye. In other words, the reduction in power transmission is 100,000 to 1. (Actually, since the specification states OD>5 this indicates that the protection level is higher than 100,000 to 1).

Please visit my blog to see the rest of this description.

In summary, this information is relatively simple. It shows the wavelength(s) and the corresponding optical densities. An understanding of it may save your eyesight!

The information in the next photo gives us more useful information.



The data above conform to the EN207:2017 standard. They use various letters to denote pulsewidths and the maximum energy/power densities which these glasses can withstand.

To explain these markings, I will first describe the meanings of the letters:

D – continuous wave beam (CW) – the output represents an average power,

I – Pulsed laser with a pulsewidth greater than 1 microsecond and less than 250 milliseconds,

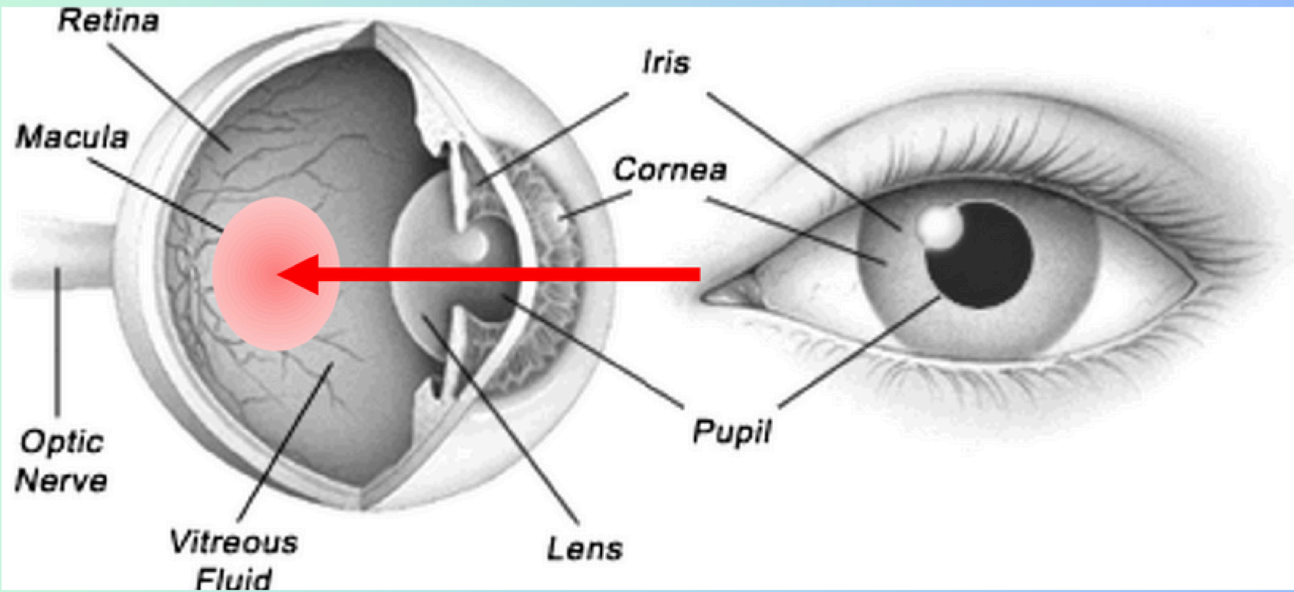
R – Pulsed laser with a pulsewidth greater than 1 nanosecond and less than 1 microsecond,

M – Pulsed laser with a pulsewidth less than 1 nanosecond

The '**DIRM**' letters describe the pulsewidth of the laser.

LB – this refers to the maximum energy or power density that these glasses can withstand if hit directly with a beam of laser energy. This is a protection rating which protects both the operator's eyes and the filter in the glasses.

The information in the next photo gives us more useful information.



The numbers after the 'LB' are similar to the optical density (OD) numbers above, but they don't mean the same thing. The numbers against the LB rating must be found from a table in the EN 207 standard.

The optical density of the glasses does not take into account the damage threshold of the filter (and the frame), whereas the LB number does. EN207 dictates that the filter and frame must be able to maintain sufficient eye protection for 5 seconds of continuous power or 50 pulses of energy from a pulsed laser.

The optical density will always be higher than the LB number for any given wavelength range. So, safety glasses with an LB of 6, means that the optical density (which protects the user's eyes) is always greater than 6.

In the above photo, the first line is – "770-1100 D LB 5" – this means that these glasses offer a protection, in the wavelength range 770 to 1100nm, from continuous wave beams (D) with an LB of 5, indicating an optical density greater than 5.

The “VLT” refers visible light transmission which is the amount of visible light that passes through the filter. In this case it is 32% which means that 32% of the room’s ambient light can pass through. The higher this number is the more ‘background’ light is available for you to see the patient. If this number is low, then you might need additional lighting to see your patient’s skin and reactions properly.

Summary

Understanding this information will keep you safe, in particular, your eyes. You only have one pair of eyes – look after them!!!

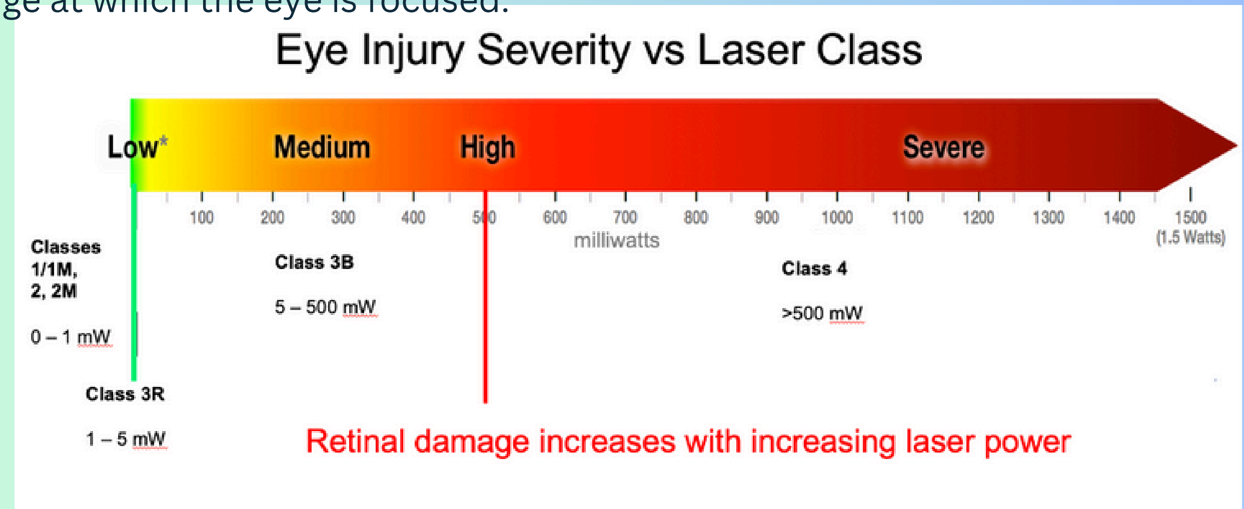
Please note that laser safety glasses are NOT interchangeable - they can only be used for the laser(s) they are prescribed for.

EYE DAMAGE

As a light sensing organ, the eye is specially adapted to collect, transmit and absorb visible light. It is this focusing of the light, efficient absorption at the back of the eye, and the general requirement for defect free optical surfaces at the front of the eye that result in the risk to the eye being somewhat higher than for the skin.

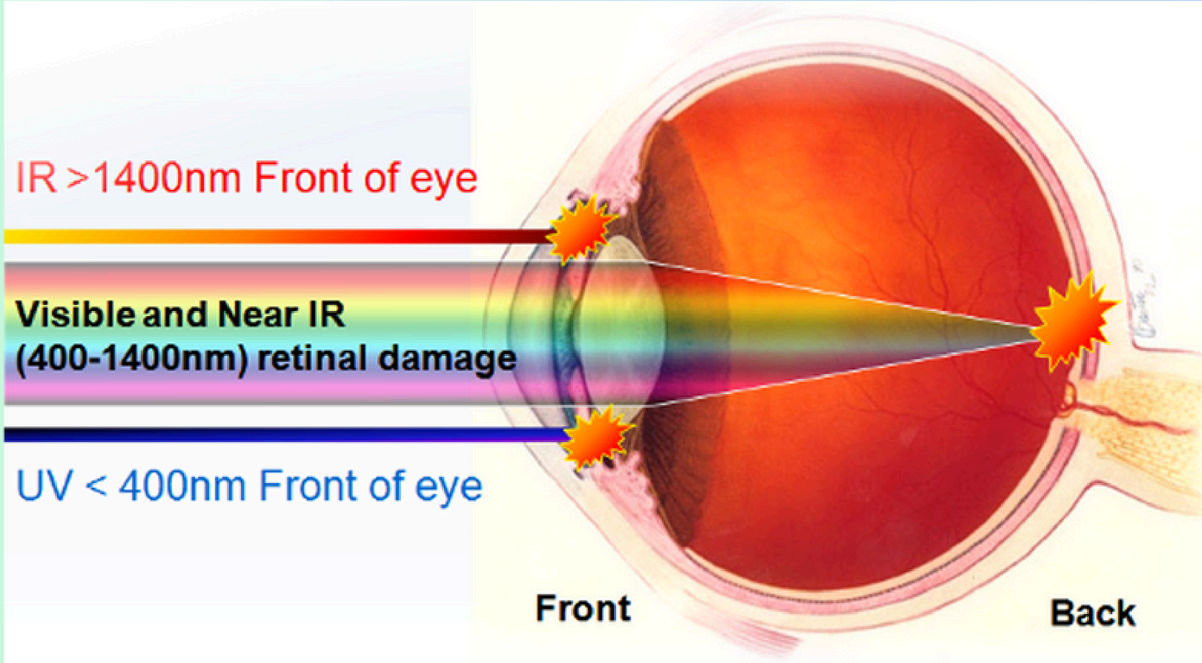
The retina is the most vulnerable part of the eye because visible and near infra-red are transmitted by the cornea and focused onto the retina where the energy is absorbed in an area that may be as small as 10μm in diameter if the beam is highly collimated. The radiant exposure at the retina can be half a million times greater than at the cornea. The minimum image size on the retina of a highly collimated beam depends on the wavelength of the laser radiation and the range at which the eye is focused.

The retina is not at risk from radiation in the ultra-violet and far infra-red parts of the spectrum. The long wavelength infra-red radiation is absorbed in the transparent ocular media and sufficient heat may be generated to damage the cornea and or the lens. Intermediate exposure levels of ultra-violet radiation may cause significant injury to the cornea. The minimum image size on the retina of a highly collimated beam depends on the wavelength of the laser radiation and the range at which the eye is focused.



All laser eyewear must meet the requirements of BS EN 207:2017 and be properly marked, otherwise they are most likely not legal for use with lasers (in most countries).

It should be noted that eye damage can accumulate over time. If using a relatively low powered laser on the skin, the reflections may not appear to be hazardous - especially if an invisible wavelength is used (1064nm). The damage may not be apparent for some years but can lead to permanent and/or partial loss of vision.



The site of damage depends on the wavelength of the incident or reflected light beam:

Light in the visible to **near infrared** spectrum (i.e. 400 - 1400 nm) can primarily cause damage to the iris and retina. Retinal damage may result in scotoma (blind spot in the fovea). This wave band is also known as the "retinal hazard region".

Light in the **ultraviolet** (290 - 400 nm) or **far infrared** (1400 - 10,600 nm) spectrum can cause damage to the cornea and/or to the lens, whereas **visible and near infra-red** light (400nm to 1400nm) can cause retinal damage from focused spot of light

In the visible and near infra-red wavelengths the cornea, lens and vitreous humour are all considered transparent. The threshold for damage at these wavelengths is generally lower than for longer wavelengths though, since these wavelengths are focused to form a higher intensity spot at the retina, which can lead to permanent damage.

Many lasers used in skin applications operate in the region 400 to 1400nm. Hence, damage to the retina is likely if the proper safety glasses are not worn. Laser safety glasses cannot be ‘swapped’ between lasers - they are designed for specific wavelengths and output powers.

Please be sure you are using the correct glasses for each laser you work with.

LASER ROOM

Your laser room must be safe

To ensure a safe, working environment, your laser room must comply with a number of safey recommendations:

Firstly, it is paramount that no laser light can escape from the room. Nobody outside of the room will be wearing the appropriate safety glasses!

All points of access to the room should be locked from the inside to prevent unauthorised entry;

The number of reflective objects (mirrors and chrome ornaments, etc.) should be kept to a minimum. Mirrors may be covered using a towel or suitable cloths/blinds during laser procedures;

There MUST be a suitable warning sign on every access door. They don't need to light up, but they must be very visible and clear;

The room should contain all the relevant safety equipment and operational gear - safety glasses, manuals, protocols, Local Rules and the emergency plan.

Emergency Plan

You should have an emergency plan in the event of any unexpected situations, such as medical emergencies, fits, laser eye exposure etc. It is always better to have such plans created in advance.

If a patient is exposed to a significant amount of laser energy and eye damage is suspected, take information about the laser used. Otherwise, the emergency personnel will not know what they're dealing with!

LOCAL RULES

This is a document prepared by an LPA which sets out the Laser/IPL safety hazards, risks and required controls. The Local Rules should include:

Hazards associated with lasers/IPL
Controlled and safe access
Authorised users' responsibilities
Methods of safe working
Safety checks
Normal operating procedures
Personal protective equipment (eyewear)
Prevention of use by unauthorised personnel
Adverse incident procedures

There will typically be one set of Local Rules for each treatment room and/or each laser device.

Local Rules should be drawn up only by certificated LPAs. There are currently two recognised LPA certification organisations in the UK:

The 'Association of Laser Safety Professionals' (ALSP) who may be found at:

LaserProtectionAdviser.com

and the:

'RPA2000' which may be found at:

RPA2000.org.uk

If you require the services of an LPA in your facility, please ensure that they are currently registered with one of the above organisations.

LASER REGULATIONS AND STANDARDS

THE BS EN 60825-1:2014 LASER SAFETY STANDARD
THE BS EN 60601-2-22:2020 PARTICULAR REQUIREMENTS FOR BASIC SAFETY AND ESSENTIAL PERFORMANCE OF SURGICAL, COSMETIC, THERAPEUTIC AND DIAGNOSTIC LASER EQUIPMENT

This section describes how a laser sources is classified in accordance with the main international standard on laser safety - BS EN60825-1:2014, and the medical/cosmetic laser standard - BS EN 60601-2-22:2020.

Specific details and instructions on how a laser is to be classified according to the Laser Safety Standard BS EN 60825-1:2014 are contained in the standard, along with the somewhat complex set of restrictions and conditions to be applied in various circumstances.

Laser Regulations and Standards

The Laser Safety Standard **BS EN-60601-2-22** covers the types of controls that are needed with medical/cosmetic lasers to protect the laser user.

The onus on the laser user is to reduce or eliminate the hazard posed by the laser in a considered, systematic manner. It may, therefore, not be necessary to implement all of the recommended control measures. For example, if a control measure reduces the laser radiation hazard to the MPE level (see page 21) or below, then it may not be necessary to adopt further control measures.

The **BS EN 207:2017** standard applies to safety glasses filters and associated equipment designed for the purposes of eye protection against laser radiation in the wavelength range 180nm to 1mm. By design the eye protectors made to this standard will reduce the irradiance (power density) to below the calculated MPE level for direct exposure to the laser beam.

TRAINING

For Laser/IPL safety management purposes, the **Laser Protection Supervisor** and all operators should receive training covering the following areas:

- Characteristics of light
- Device malfunction
- Equipment management
- Effects of light energy on:
  - eyes
  - skin
  - body tissues
- Safety management:
  - Local Rules
  - Controlled areas
  - Minimising risks
  - Adverse incidents

Training is typically supplied as a mixture of equipment supplier's training and 'Core of Knowledge' Laser/IPL safety training, usually supplied by an LPA. This initial training should then be supplemented with regular updates and other relevant training such as First Aid and Fire Safety.

Core of Knowledge

The document '**Guidance on the safe use of lasers in medical and dental practice**' was first published in 1984 by the Medical Devices Agency. This was replaced by the MHRA with a new document entitled "**Lasers, IPL Systems and LEDs: guidance for safe use in medical, surgical, dental and aesthetic practices**" in September 2015. Amongst other requirements, this guidance document requires operators of laser/IPL devices to have a '**Core of Knowledge**' in laser/IPL safety. The guidance defines what must be included in this 'core of knowledge'.

Most insurance companies require laser users to update their 'Core of Knowledge' every three or four years - please check with your insurance company to be sure you are compliant.

RISK ASSESSMENT

It is very important to carry out a risk assessment within your laser centre to ensure the safety of staff and customers.

Risk can be broken down into two components:

Risk = Likelihood X Severity

where the 'likelihood' is the probability that an event may occur and the 'severity' is a measure of how much damage may occur if the event does happen.

For example, if you walk into a room and trip over an electrical cable then the severity depends on what you may fall onto. If it's a big, comfy bed or sofa, then the severity is low.

If, however, you were to fall into a glass table, then the severity is much higher and may lead to hospitalisation!

Below is a 'Risk Matrix' which shows how the product of likelihood and severity may be used to determine the risk from 'low' to 'high'.

	Severity (S)				
Likelihood (L)	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

High
Medium
Low

Your LPA will carry out a Risk Assessment as part of their laser safety assessment.

IMPORTANT CONSIDERATIONS

MPE

MPE - Maximum Permissible Emission. This is the maximum power, or energy, density which is considered to be safe, to the human eye, and skin, for any given wavelength - i.e. negligible likelihood of tissue damage.

AEL

The **AEL - Accessible Emission Level** - is the maximum laser energy or power which any individual may be exposed to, from a laser system. Often, the AEL is a product of the MPE and the maximum diameter of the human pupil (around 7 mm). So, if the MPE for a laser system is 5 J/cm^2, then its AEL will be approximately 35 J/cm^2. But this also depends on the Class of the laser too.

Nominal Ocular Hazard Distance

The '**Nominal Ocular Hazard Distance**' (or 'Nominal Hazard Zone' as it is often referred to) is the region around any laser system which is deemed to be 'unsafe', particularly to the eyes. The laser output within this zone may exceed the MPE for that wavelength. Hence, safety glasses **must be worn** while within this region.

All of the information contained in this booklet will be found in any decent Core of Knowledge course. If you need any further information, I recommend you take one of these courses (from a properly qualified expert, of course!)

IPL SYSTEMS

BS EN 60601-2-57 Standard

Firstly, we must be clear that IPL devices are NOT lasers. They are systems which generate intense, pulsed light. But this light is not like a laser beam in that it is not monochromatic, highly coherent or minimally divergent. As such, IPL devices are classified under the Risk Group (RG) scheme.

Instead, IPL devices generate quite ordinary light, except that it may be fairly intense, in that each pulse can contain a significant amount of energy. This makes it useful for various aesthetic applications such as the removal of hair, blood vessels, benign pigmentation and skin rejuvenation.

IPL devices must be classified by their ‘risk group’ as determined by the risk of eye or skin damage based on the wavelength range and power output of the device. Most professional IPL device are typically in Risk Group 3.

However, the intensity of these devices can be quite significant. They, therefore, pose a potential ocular hazard to users and patients/clients alike. Consequently, we must protect our eye, as with lasers, using the correct eyewear. As with lasers, there is a Standard - the **BS EN 60601-2-57** - which must be followed to ensure proper protection of eyes.

Most IPL safety glasses are available in either Shade 3 or Shade 5. We recommend the use of **Shade 3 for the IPL operator**, and Shade 5 for the patients/clients.

The current safety standard for IPL protective glasses is the BS EN 60601-2-57. Similar to laser safety eyewear, requirements for IPL eyewear are different for operator and client, depending on the area of treatment:

- Operators: distance for calculations of accidental exposure is 10cm
- Clients undergoing treatment away from the face: distance for calculations of accidental exposure is 10cm
- Clients undergoing treatment near the face: distance for calculations of accidental exposure is 1cm

MISCELLANEOUS

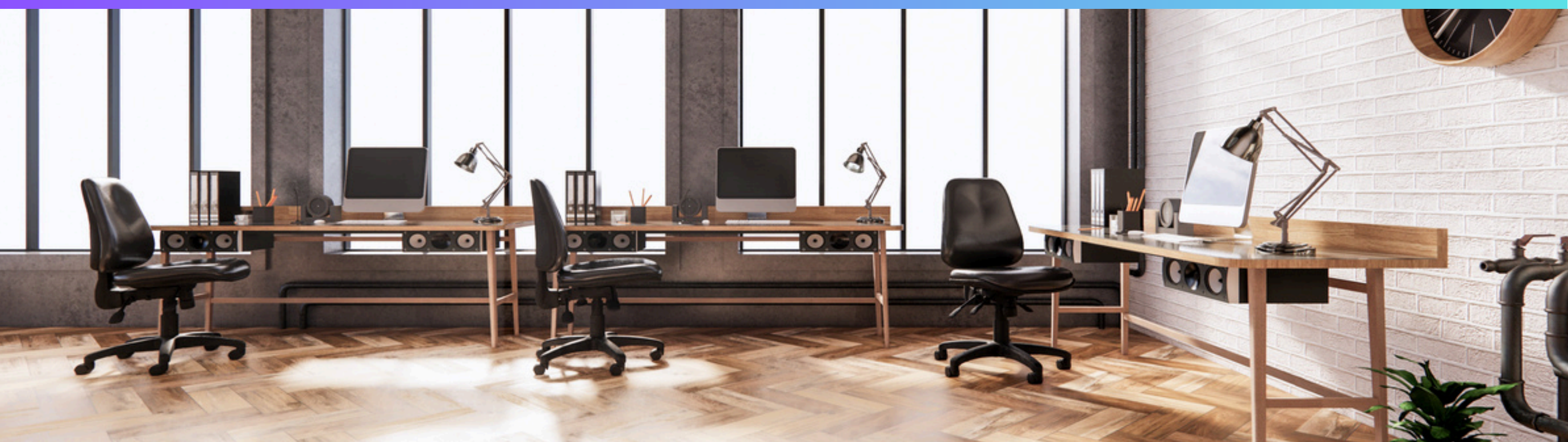
Laser Hazard Control Measures

There is a lot to consider when thinking about laser safety - risks, hazards and control measures. These are all discussed at this website (scan QR code). I recommend visiting this site for much more information.

BMLA Essential Standards

The BMLA issued their 'Essential Standards' which outlines the more important standards which should be followed for best clinical practice. This document, which is free, is an excellent source of very useful information and guidance. I highly recommend you obtain/download a copy and read it thoroughly.

You can find it here:



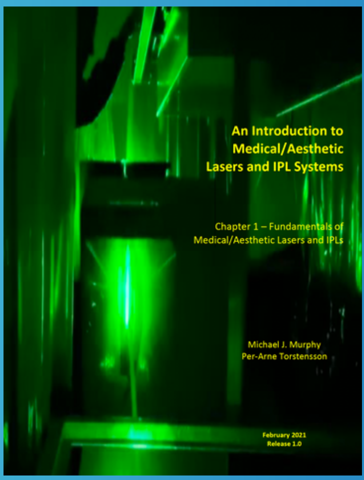
CONTACT INFORMATION

MikeMurphyLPA@gmail.com

www.LaserProtectionAdviser.com

www.MikeMurphyBlog.com

This is my book on the fundamentals of lasers and IPLs currently used in various areas of aesthetics and medicine.

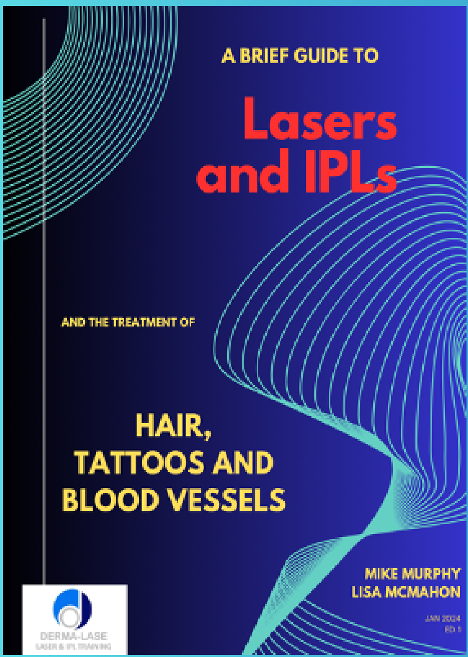


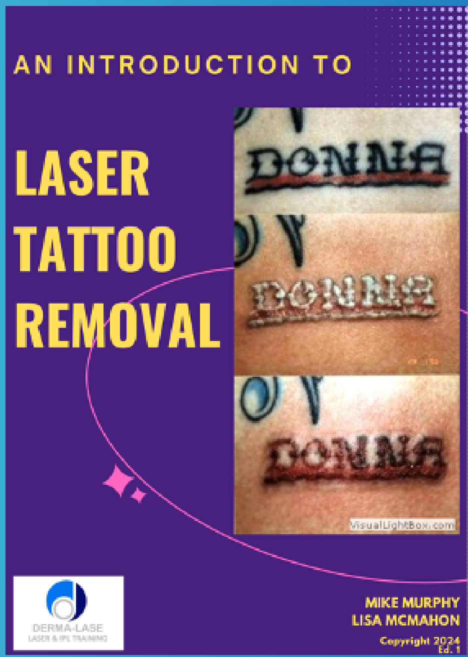
Many thanks to our Consulting Editor, Mike Regan for his very helpful assistance in writing this booklet

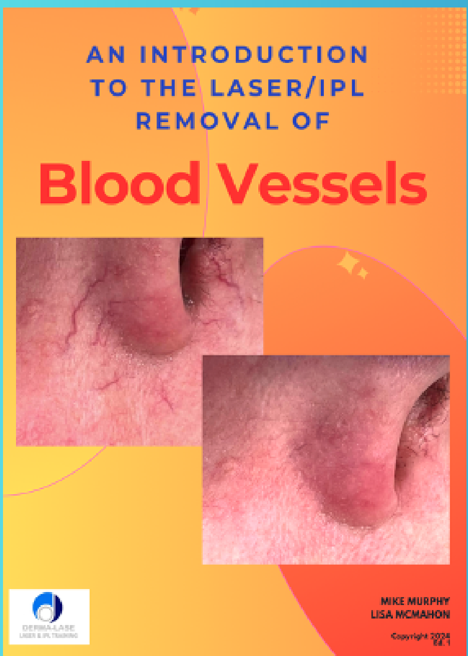
ALSP

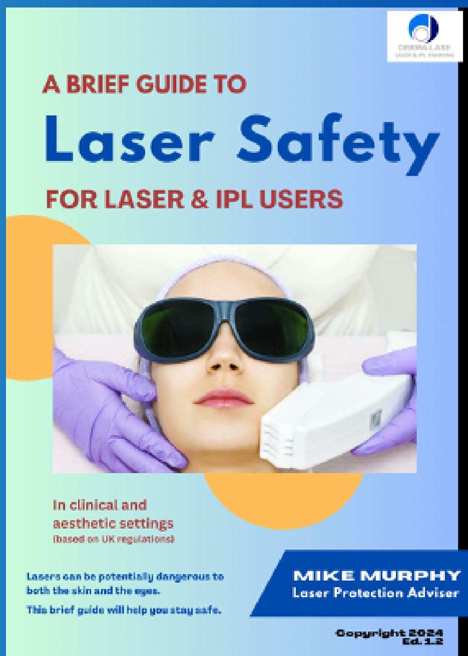
THE ASSOCIATION OF LASER SAFETY PROFESSIONALS

Other booklets by Mike Murphy:









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