APPENDIX 6 EYES

EYES—COMMONLY OCCURRING INJURIES

Could any of these apply to you or a visitor or occur in areas you manage?

Laboratories

— Eye splash, aerosols or touching eye with pathogenic material.
— Penetrating eye injury from fragments of ejected material (shattered cryo tubes).
— Cold burns from liquid nitrogen splashes.
— Penetrating chemical burns from eyes splashes or particles of corrosive agents.
— Chemical burns from corrosive fumes.
— Chemical exposure from toxic fumes.
— Allergic response after contact with allergens.
— Photokeratitis (e.g. arc eye from exposure to UV).
— Eye splash with radioactive material.
— Laser eye strikes.
— **And in the field** . . . scratches from plants, stings, bites etc.

Workshop

— Corneal scratch or penetrating eye injury from grit, projectiles or ejecta (hammering, chiselling, turning, drilling, grinding etc).
— Chemical burns (corrosives, cutting fluids etc).
— Photokeratitis (eg arc eye from welding).
— Radiant heat burns (welders flash).
— Molten metal burns.

Maintenance

— As for workshops, but greater risk as activities may be carried out in restricted or difficult conditions, or working to deadlines.
— Blunt trauma injuries (walking into head-height obstructions).
— Corneal scratch / penetrating injuries (walking into sharp objects).
— Chemical burns from disinfectants, paints, solvents, descaling chemicals etc.
— Burns from sparks.
— UV exposure.

Construction

— As for workshops and maintenance.
— Chemical burns from cement.

Kitchens

— Burns from hot fat splashes, boiling water splashes.
— Chemical burns from corrosive dishwasher reagents.

WHAT CAN HAPPEN TO EYES?

Permanent loss of sight—total or partial; temporary or permanent; disfigurement; and they are a route of exposure for infectious and toxic chemicals.

IS WEARING EYE PROTECTION MANDATORY AT THE COLLEGE?

It is mandatory in all areas where it has been identified by area risk assessment, which may include laboratories and workshops where there are chemicals, pathogens, machinery or hand tools.

WHY DON'T PEOPLE LIKE WEARING EYE PROTECTION?

Several reasons. If it is of poor optical quality, or scratched, it can tire the eyes. It may not fit the wearer correctly so cause headaches; if the wearer already needs to wear eye correction, it can cause distortions (with contact lenses), not be possible to wear except with goggles or a visor over the corrective glasses, or it may steam up.

Some people don't like to wear it because they think it unfashionable.

Some people don't wear it because they haven't been told it is necessary or why it is necessary.

In most cases, the College can accommodate more appropriate and comfortable safety eyewear, and provide prescription safety eyewear. The industry standard is to wear safety eyewear in the workplace at all times wherever the risk merits it. The College is no different—except perhaps the risks are higher because of the nature of the work (novel in many cases) and because many of the people undertaking it are students and therefore still under training.

WHAT CAN GO WRONG WITH SAFETY EYEWEAR?

Safety eyewear can be cheap or it can be very expensive; either way, if it is damaged, it may not do the job you expect it to, and fail when you need it most.

- Scratches and damage to the frame weaken its impact protection if that is what is required; removing the side pieces will increase the risk of splashes and ejecta entering the eye.
- Scratches to coated eyewear, for example in laser eye protection, can result in pin holes, and then in eye strikes.
- It may be contaminated with infectious or toxic materials, and come into contact with your breathing zone or mucous membranes.
- It may be exposed to solvents or direct sunlight, weakening the plastic.
- It may not be sufficiently impact resistant and shatter if the protection factor is exceeded.
- It may simply be the wrong specification for the task or environment, so although basic laboratory issue safety spectacles are sufficient for most laboratory work, they may not be suitable for everything. In addition, for some types of radiation, it is very important to select the correct optical properties to ensure hazardous radiation does not reach the eye. Therefore for certain activities and areas you will need to select your eyewear accordingly.
- Eye protection can be prone to misting up creating an additional hazard, in which case anti-fogging sprays or finishes may be available or ventilated models.

So careful **selection** and proper **storage** in clean areas is therefore important to protect your eyewear, your eyes and health, and your departments wallet.

STORAGE

Storage can be "permanent" i.e. at the end of the process, work day or week, or temporary, e.g. when you temporarily leave the area where safety eyewear is required.

For permanent storage, eyewear should be (washed with soapy water and rinsed, and dried with a soft cloth if dirty), returned to its original packaging materials if these are available, and the entire placed where it will not get contaminated such as a drawer or locker.

Laser eye protection —if there are several types for different wavelengths being used in the area, then there must be a means of identifying these and separating them to avoid confusion, preferably in labelled robust containers.

How to scratch your safety specs

Shared visors (eg for UV protection when working with trans-illuminators), must be stored on hooks to avoid becoming contaminated with hazardous chemicals (ie ethidium bromide residues). In addition, these should be washed with warm soapy water and dried with a soft cloth.

Temporary storage is often either on the bench (sometimes with the lens in contact with the bench) or in the lab-coat or overalls pocket, along with whatever else is in the pocket. Eyewear should never be stored in this fashion, either can lead to scratches or to contamination. It would be better to hook them onto the clothing, or even wear them on the head, or better still obtain a cord enabling the eyewear to be worn around the neck.

INSPECTION

Eyewear should be inspected for damage before use, although clearly this is more important for some activities. Laser goggles with coatings are particularly vulnerable to scratches and pinholes developing so should be inspected regularly. For example:

- Check the eyewear is appropriate for the wavelengths used.
- Check eyewear is appropriate for the power output.
- Check that the eyewear is not dirty, dusty or has broken components.
- Inspect the eyewear for scratches, pits, discolouration, coating damage and burn marks. Burn marks are a good indicator of poor beam management, intra-beam viewing or accidents.
- Ensure that the filters and frames are in good condition.
- If applicable, check the head band is still functional and replace if necessary.

SELECTION OF SAFETY EYEWEAR

This will depend on the person, the activity and the environment.

There are three types of eye protection—spectacles (with or without side pieces), goggles which may be vented or unvented, and face shields.

If the **person** already wears corrective spectacles, it may be possible for them to wear certain types of safety spectacles or goggles *over* them. However, this is not advisable for long periods as it can be extremely uncomfortable, they can steam up and scratches and poor optical quality can result in loss of concentration and loss of vision, and possibly to an accident. **Prescription safety eyewear** is available for almost every circumstance, even in bifocals and is recommended for contact lens wearers (as any splash can be compounded by the presence of the contact lens). Once you have the specification for the task and the environment, talk to your supplier and to your own optician.

Safety eyewear should be worn for many **activities**—consider the list of "Commonly occurring injuries". The following examples look at working with UV—for example when using a transilluminator, but the principles of selection are the same.

EXAMPLE 1: EYEWEAR SPECIFICATION WITH UV FILTERING PROPERTIES

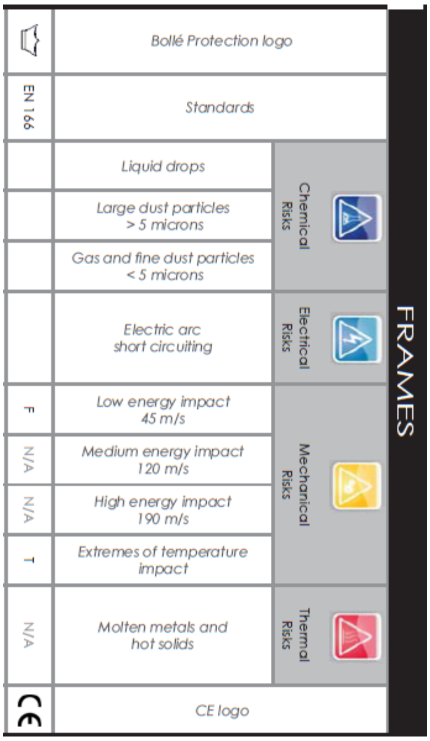
The specification illustrated in the two tables below is for a basic pair of laboratory safety spectacles, showing how the BSEN standards are separated into the *frame* properties (meets BS EN 166) and the *lens* properties.

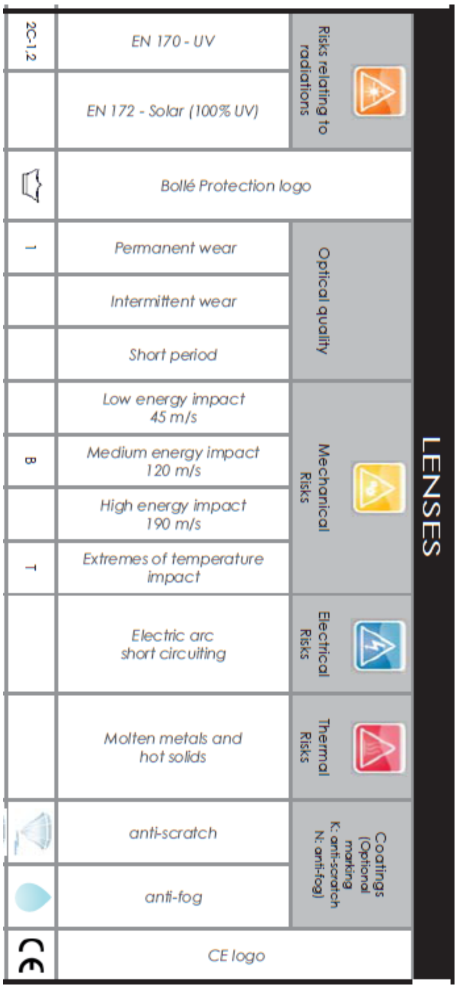
The **lens properties** are as follows:

- EN170—UV 2C-1.2: filters out UV.
- Optical quality: Class 1, suitable for permanent wear.
- Mechanical risk category B: resists medium energy impacts of 120 m/s.
- Thermal risk category T—resists extremes of temperature impact (-5 to 55°C).
- Anti-scratch and anti-fog coatings.

What is the energy impact resistance of the *frame?*

In a workshop environment, the energy impact resistance of the frame and the lens ("oculars"), may need to be greater (eg both may need to be Class B), depending on the risks.





Example 2 – a catalogue claims the following properties for its product (applies to face shields too)

EN166 1B349KN, EN170 2 -1.2

What does it mean?

1B349KN refers to EN166, the Technical Performance Standard where:

'1' denotes 'optical class 1', the highest optical class

'B' denotes 'medium energy impact resistance'

'3' denotes resistance to 'liquids (droplet or splashes)'

'4' denotes resistance to 'dust particles'

'9' denotes resistance to molten 'metal & hot solids'

'K' is optional and denotes a hard coated lens i.e. 'resistance to abrasion' by fine particles

'N' is optional and denotes 'resistance to misting'

2-1.2 refers to EN170, the Ultraviolet Standard where '2' the Code Number denotes a UV filter which may affect colour recognition

'1.2' denotes the Shade Number; in this case it indicates almost total light transmission

Where colour recognition is important, look for 3-1.2 EN170, the Ultraviolet Standard where '3' the Code Number denotes a UV filter with good colour recognition – sometimes shown as 2C

Overview of main standards relating to Eye Protection

Standards - Basic:

EN166 - Technical performance standard - The core technical standard.

EN167 - Methods for optical tests.

EN168 - Methods for tests other than optical.

Standards - Product Type:

EN169 - Filters for welding and related techniques - Transmittance requirements and recommended utilisation.

EN170 - Ultraviolet filters - Transmittance requirements and recommended utilisation.

EN171 - Infrared filters - Transmittance requirements and recommended use.

EN172 - Solar radiation filters - Sun glare filters for industrial use.

Standards - Field of Use:

Welding -

EN175 - Equipment for eye and face protection during welding and allied processes.

EN379 - Specification for welding filters with switchable and dual luminous transmittance.

SELECTION BASED ON ACTIVITY AND ENVIRONMENT

Working with UV in a laboratory with a transilluminator on the bench radiating UV upwards, can result in bad sunburn and photokeratitis if the correct PPE is not worn. There have been several instances at the this and other universities. A visor filtering UV to BS EN 170 is a prerequisite as safety spectacles and goggles will not protect the face (or the hands or wrists or other exposed skin). This is equally relevant to people with darker skin tones or who tan readily, the eyes do not become resistant to UV!

For the general laboratory environment particularly in teaching laboratories where reagents tend to be of low risk and small volume, safety spectacles should be adequate. For teaching technicians preparing teaching labs where they may handle large volumes of concentrated chemicals, safety goggles would be appropriate. In a workshop, spectacles would be required even for visitors as an incident can happen at any time to anyone; goggles and visors (face shields), may be more appropriate for the workshop staff, depending on what they were doing. The impact resistance may need to be higher then in most laboratories.

SELECTING LASER EYE PROTECTION

Choosing laser safety eye protection will need careful consideration of the specifications of the laser: operating wavelength, power, beam diameter, beam delivery system; and the work environment and tasks being undertaken. Are the requirements for beam alignment different to those for being a bystander?

This should only be done in conjunction with your supervisor and departmental laser protection officer, and if necessary with input from the supplier. Buying or borrowing the wrong specification could be costly and not protect your eyes.

The Faculty of Natural Sciences Laser User Group has produced guidance for their staff and students, which follows overleaf.

A SHORT GUIDE TO THE MARKINGS ON LASER SAFETY EYEWEAR

This guide provides a brief introduction to the selection of laser safety eyewear. For further details the reader should consult with the relevant safety standards, a book such as 'Laser Safety' by Henderson and Shulmeister (CRC Press 2003) or seek advice from their Department Laser Safety Officer or other appointed laser safety advisor.

Personal protective equipment is the last control measure in the 'hierarchy of controls' as only the wearer is protected (and protection only fully afforded if the PPE is fit for purpose, fits the user properly and is not damaged).

Introduction

There are two types of markings that can be found on laser safety eyewear: the American ANSI Z136 'OD' markings and the EU EN 207 markings. Some laser safety eyewear has only one or the other and some will have both.

When selecting laser safety eyewear, users must ensure that it has been tested and certified according to EN 207. If the eyewear does not have the EN 207 standard marking do not buy or use it.

American ANSI

Markings are of the format "$l_1 - l_2$nm OD *X*" where $l_1 - l_2$ nm is the wavelength range in nanometres and *X* is the optical density provided throughout that range. An OD of *X* provides a transmission of

$$10^{-X}$$

.

The ANSI standard only describes the amount of light transmitted by the laser safety eyewear. It does not say anything about the ability of the eyewear to survive exposure to the laser radiation.

Some eyewear will contain OD values for a range of different spectral ranges, e.g. "180-390nm + 800-818nm OD 6+" means that the eyewear provides at least OD 6 over both the ranges 180-390 nm and 800-818 nm.

EU EN 207

This standard provides information about both the optical transmission of the eyewear in particular wavelength ranges and the ability of the eyewear to withstand exposure to laser radiation.

The EN207 markings are of the form "*W* $l_1 - l_2$ L*X Y Z S*".

W is a series of letters representing the type(s) of laser radiation that the eyewear has been tested for and can be one or more of the following:

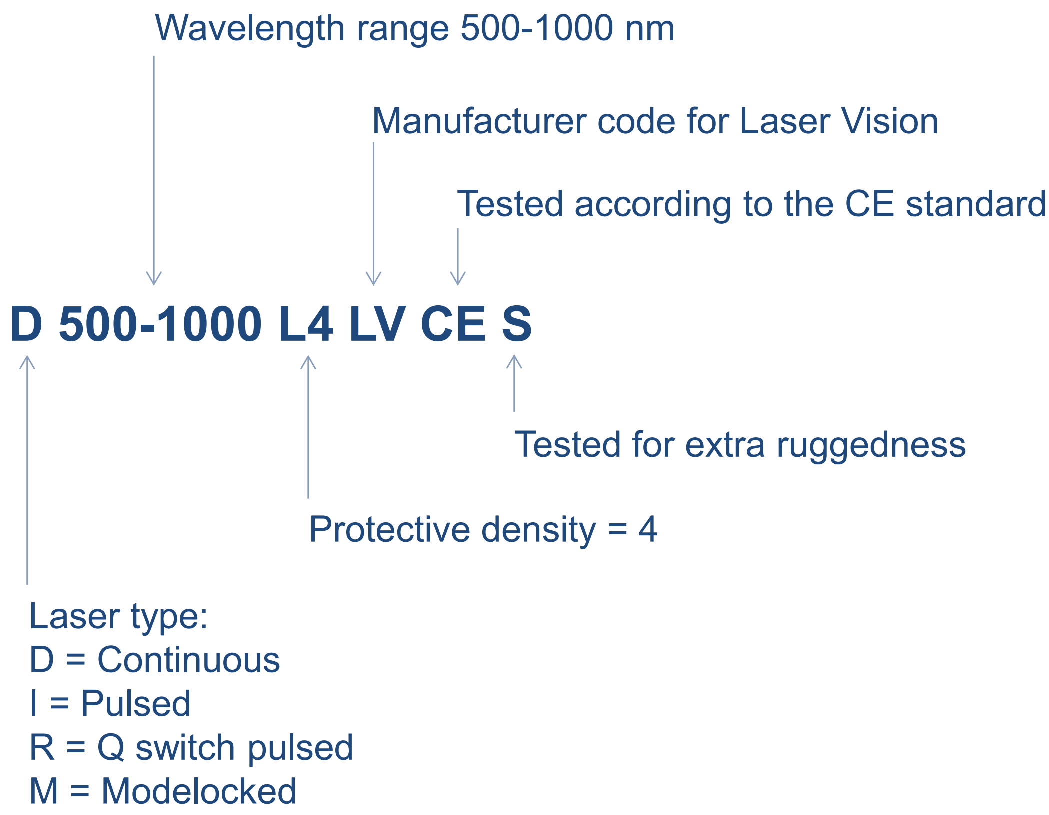
Test conditions for laser type	Typical laser type	Pulse length (s)	Number of pulses
D	Continuous Wave	10	1
I	Pulsed laser	10^{-4} to 10^{-1}	100
R	Q switch pulsed laser	10^{-9} to 10^{-7}	100
M	Mode-coupled pulsed laser	$<10^{-9}$	100

Reproduced from BS EN 207 – table 4.

$l_1 - l_2$ is the wavelength range being described and *X* refers to the level of protection provided throughout that range. The value *X* provides information on the protective density of the eyewear and combines information on both the ability of the eyewear to attenuate the laser radiation AND its ability to withstand that radiation.

Y is a series of letters giving the company that manufactured the goggles, e.g. 'NOIR' for the company NoIR or 'LV' for Laser Vision. *Z* is a series of letters providing information on the standard against which the goggles have been tested, e.g. the letters 'CE' or 'DIN CE' may appear here. The presence of the 'S' indicates that the goggles have been tested for additional ruggedness. Conversely, the absence of 'S' means that the goggles have not been tested to this additional level.

For example:



In selecting eye protection to comply with EN 207, the minimum scale number that is required is equal to log(*E*/MPE), rounded up to the next whole number. Here, *E* is the incident power (or energy) divided by the actual area of the beam, and not over the area of the limiting aperture as is required when calculating an MPE. The MPE is the maximum permissible exposure of the eye to that radiation.

The following text is based on that in the book 'Laser Safety' by Roy Henderson and Karl Schulmeister, see page 415. Consider a specific laser beam with an MPE of 100 $W.m^{-2}$ and that the maximum exposure level *E* this laser source can deliver is 100 $kW.m^{-2}$. Therefore *E* exceeds the MPE by a factor of 1000. The eye protection selected must therefore provide an attenuation factor of at least a = 1000, i.e. a transmission of 1/a = 0.001 or lower. This corresponds to a minimum OD of 3 (log a). At the same time, the eyewear must be able to withstand being potentially exposed to 100 $kW.m^{-2}$. If the eyewear provides an OD of 5, but can only withstand an exposure of 10 $kW.m^{-2}$ then it is clearly not suitable. Eyewear providing a *protective density* of L3 would be suitable, as log(100 $kW.m^{-2}$/100 $W.m^{-2}$) = 3.

Some eyewear will give markings for several spectral ranges and laser radiation types, e.g. "785-830 D L5 + I L6 800-818 D L3 + I L4" means that the eyewear provides the following protection:

	D	I	R	M
785-830 nm	L5	L6	Not suitable	Not suitable
800-818 nm	L3	L4	Not suitable	Not suitable

EU EN 208 Alignment protection laser safety eyewear

This standard governs laser safety eyewear that allows the wearer to safely view the position of a visible (400-700 nm) laser beam during beam alignment. Alignment laser safety eyewear is only intended to allow indirect viewing, e.g. of diffuse scatter from a beam alignment card, and is not intended for direct beam viewing.

In alignment laser safety eyewear, the protective density is chosen to attenuate the beam to below the MPE for an accidental exposure of 0.25 s (given by the natural blink response/aversion time), i.e. to below that of a Class 2 laser. Care must be exercised when using laser safety eyewear as a different specification will be required for each individual laser. For example, laser alignment eyewear selected for one laser would not provide adequate protection for another laser of the same wavelength but greater output power.

VLT – visible light transmission

VLT is the percentage of visible light transmitted by the eyewear and you should select eyewear that provides the required level of laser blocking and the highest possible VLT. This will provide the user with the clearest view of the task they are working on. Laser eyewear with a very low VLT may pose a safety issue in its own right as it may affect the laser user's ability to clearly see what they are doing.

Choice of laser safety eyewear

There are a range of different types of laser safety eyewear.

Blocking filter: coloured glass, coloured polymer or dielectric coating.

Coloured glass filters are robust and generally provide the highest ability to withstand exposure to laser radiation. However, they are often heavier than other types of eyewear and the frame design may restrict the peripheral vision of the user.

Coloured polymer blocking filters generally provide a lower ability to withstand laser radiation but is usually lighter and the frame designs often provide good peripheral vision.

The two above types of blocking filter generally have quite broad blocking bands and may not provide adequate protection at certain specific wavelengths or if you need protection at two or more wavelengths.

Eyewear employing dielectric coatings can provide sharper cut-off edges and blocking bands that are tailored to specific laser lines. However, the filters are often flat and this can result in laser goggle frame designs that are less comfortable to wear. This type of blocking filter is particularly susceptible to damage – if it is scratched it may provide a lower blocking of laser radiation than the value stated.

Frame type:

There are a very wide range of frame types, which can be broadly divided into 'spectacle' style and 'goggle' style, see figure below.

'Spectacle' style

'Goggle' style

The spectacle style is generally more comfortable to wear but doesn't provide guaranteed laser blocking from all directions. The goggle style does guarantee protection from all directions, but usually tends to restrict the field of view and may mist up due to condensation of perspiration.

Laser users who wear glasses to correct their vision must make sure that the laser safety eyewear is compatible with their normal glasses. Alternatively, it is possible to purchase laser safety eyewear that also provides optical correction to a specific prescription.

Other factors to be considered

Users should be aware that while wearing laser goggles warning lights may appear to be a different colour or may even appear to be ‘off’ when they are in fact ‘on’.

Users must ensure that there are sufficient storage areas for the protective eyewear they purchase. The equipment must be stored in a safe place to protect them from damage.

Users must ensure that they have sufficient cleaning materials and a system to record weekly cleaning and checks for damage of the glasses before they purchase the items.

Damaged laser safety eyewear **must** be discarded immediately.

FACE SHIELDS

Face shields permit the wearing of prescription spectacles, whilst helping protect the eyes, mouth and face from exposure to splashes of hazardous substances, such as cryogenic liquids, pathogenic and corrosive substances. Some specifications will also reduce the effect of impact (such as exploding cryogenic vials), and exposure to certain wavelengths (such as UV and ionising radiations). The specification is dependent of the risk assessment of the area which must consider all hazards, activities, and persons *in the area* as well as those relating directly to the user.

At the College, face shields are often shared amongst several users, and where this is the case, the department must ensure that someone is responsible for checking face shields are kept clean and in good condition and stored on hooks away from contaminating dusts, and to act as a focus for fault reporting and actioning repair, discard and replacement.

In addition, all users must be instructed in any limitations of the face shields—for example, one that is used for splash protection, may not be sufficiently specified for impact protection or indeed for UV filtering. There have been instances where the wrong face shield has been worn allowing UV to pass through, resulting in exposure to the face and eyes. Ideally shields should be labelled so that their purpose is clear, but labels must not obstruct the vision.

SELECTION OF FACE SHIELDS

Face shields must comply with the standards already described for eye protection (eg EN 166 for frame requirements and EN 170, the UV standard). Note that some newer models of face shields offer excellent anti-splash protection as they are shaped around the face.