

# Practical Eye Protection for Glassworkers<sup>1 2</sup>

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This article provides information on eye hazards for glassworkers. It presents some technical information on radiance and filter characteristics, summarizes current research on the ocular dangers facing glassworkers, and suggests ways to minimize the risk to your eyes. Hazards connected with both furnace glass operations and torch work are considered. The operations and temperatures encountered in furnace and torch work are different, and produce different safety recommendations.

The results presented here summarize roughly 20 years of scientific study, with an emphasis on recent research. Of particular importance in this review are two studies exploring actual working conditions of glass artists (Moss & Burr, 1996; Oriowo, Chou, & Cullen, 1997).

## Chemical, Particulate, and Thermal Hazards

Glass making and working involves close contact with materials that are hazardous to the eyes even without their being hot. Fortunately, recent studies indicate that these dangers are not significantly present in current glasswork facilities (Moss & Burr, 1996, Oriowo et al, 1997). In addition, it's easy to guard against these hazards; be careful when mixing batch and charging the furnace, keep a reasonably clean studio to avoid dusts in the air, and wear eye protection to guard against flying shards from shattering glass. Beyond those simple precautions, it is the radiation from the hot glass that produces the most risk to the eyes.

## Spectral Radiation

When objects are heated, they give off radiant energy across a spectrum of wavelengths. Visible light—that which we can see—occupies the wavelengths from roughly 400 nanometers (nm) (purple), through 500 nm (green) and 600 nm (yellow) to about 750 nm (red). Radiation of shorter wavelengths (below about 400 nm) is known as *ultraviolet* (UV), while that above roughly 750 nm is called *infrared* (IR).

Glasses show differences in the spectrum of light that they radiate depending upon the temperature and the environment in which they are being heated. The two major kinds of glass that glassblowers use are borosilicate (“hard” or “Pyrex®”—Corning’s brand of

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<sup>2</sup>This is a brief version of a more complete literature review. For a free copy of that report, please contact the author. A copy may also be obtained over the World Wide Web at

<http://www.fandm.edu/Departments/psychology/eyeprotection/papers.html>

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borosilicate glass), and soda-lime ("soft") glass. The former glass is used by torch workers who heat the glass in the flame of a bench torch, while the latter is used by off-hand blowers who work from the furnace and glory hole.

When borosilicate glass is heated with the torch to its melting point, a combination of the ingredients in the glass and the gasses in the flame glow very brightly with a brilliant yellow flame with a wavelength of roughly 600 nm. This bright flame is caused by the sodium in the gas burning off and is known to lamp workers as "sodium flare." Sodium flare is so intense that it's difficult to see the glass being melted and worked; special lenses are normally used to filter out the yellow flare. At its working temperature, borosilicate glass gives off very little radiant energy in the remainder of the visible spectrum, and not much at the infrared end, either, though considerable ultraviolet radiation is produced.

Soda-lime glass shows a different pattern of emission when it is heated to a working temperature. There's a lot of ultraviolet radiation, not much in the visible range except at the upper end; the furnace and glass appear as brilliant yellow/orange/red. Beyond the visible spectrum, workable soda-lime glass radiates very intensely in the infrared range. The radiation at the two extremes, ultraviolet and infrared, can cause serious ocular damage, primarily in the lens of the eye. In the lens, heat can cause the development of cataracts or cloudy areas which can, over time, seriously interfere with vision.

## Hazards from Spectral Radiation, and How to Minimize Their Effects

Just what happens when the eye is exposed to radiation in the ultraviolet, infrared, and visible spectrum? And what can we do to guard ourselves against negative effects? The effects, and their mitigation, are different depending upon the wavelength.

### *Visible Spectrum.*

Within the visible spectrum, there's no particular visual hazard in ordinary glassworking situations. The human eye is well adapted to function in these wavelengths for long periods of time without permanent harm, so long as the intensity is not too high or for too long. The sodium flare can be disregarded as a source of eye damage. The flare is annoying to torch workers because it makes it difficult to see the work, but otherwise it poses no risk to vision. "While the production of such light can be visually distracting while working on the glass item it does not cause deleterious biological effects" (Moss & Burr, 1996, p. 6).

A suitable filter between the hot glass and the eye can eliminate sodium flare and make the glass visible. Filters are matched to tasks by evaluating their transmission of varying wavelengths. A very common (and excellent) filter for torch workers and others working with borosilicate glass is made of didymium glass. Such a glass transmits about 60-80% of the light in the 400-450 nm (purple) region, and about 90% in the infrared range (950 nm and above). But the most important feature of this filter material is in the sodium flare area (roughly 590-600 nm). There is virtually zero transmission in that region, meaning that looking through this filter will eliminate the sodium flare with very little impact on other colors. Many glasswork and safety equipment suppliers offer safety glasses with didymium filters, and they're readily available. Most torch workers probably already use such filters.

But the didymium filter's blocking of the 600 nm range is not helpful to the furnace worker since soda-lime glass in the furnace emits very little radiant energy in that region. So while a didymium filter is very useful to the torch worker whose borosilicate glass is heated with gas that exhibits sodium flare, it offers nothing to the furnace worker.

### *Ultraviolet and Infrared Radiation.*

The ends of the spectrum are another matter entirely. All types of glass generate a great deal of ultraviolet light when heated, and some of that UV radiation can be quite dangerous to the eyes. Fortunately, UV is very easy to guard against. Additionally, infrared radiation is present in all hot glass; it, too, can be hazardous.

Light entering the eyes first encounters the outer layer (the cornea), then it travels through the lens, into the vitreous matter in the center of the eye itself, finally reaching the retina at the back of the eyeball. Depending upon the wavelength of the light entering the eye, most of its radiant energy is absorbed by the cornea and lens before it reaches the vitreous and the retina. Unfortunately that energy absorbed by the cornea and lens is the cause of thermal damage to the eye, most especially causing cataracts (cloudy areas in the lens). According to Vos and van Norren (1994, 1998), the heat absorption by the cornea and its subsequent transfer of the heat to the lens is a major cause of glassblower's cataracts.

The colored iris serves primarily to expand or contract the opening into the eye—the pupil. The size of the pupil has little to do with risk, because much of the heat absorption occurs in the cornea which, being on the outside, cannot be “protected” by the pupil. Indeed, one of the major theories about ocular damage has the iris serving a critical role in absorbing IR heat and radiating it to the lens where the damage actually occurs.

The literature concerning the actual biomedical processes that cause eye damage is complex, often confusing, and sometimes contradictory. Despite that, though, the general themes of the results are clear enough:

- ◆ Exposure to infrared and ultraviolet radiation is likely to cause ocular damage, primarily from absorption of radiant energy and its subsequent transmission to the lens where cataracts are likely to form.
- ◆ The more the combined lifetime exposure to infrared and ultraviolet radiation, the greater the likelihood of ocular damage.
- ◆ The exact mechanism of the damage, its exact location, its permanence, and its severity all depend upon the specific wavelengths, intensity, duration of each exposure, and life-time total exposure, along with other factors.
- ◆ Appropriate filters and awareness of the potential hazards can minimize exposure and help to prevent nearly all damage.

### *Selecting a Filter for Soda-Lime Glass (Furnace Work)*

A shade #3 welder's goggle filters virtually all of spectrum below about 450 nm, and that above 700 nm. The light that passes the filter is in the yellow-red region of the visual range. Within that remaining yellow-red band the transmission in the visible area is cut to about 20%, meaning that the total light reaching the eyes will be greatly reduced and the overall visual scene will be dark. This is often an benefit for furnace workers; because the total brightness is reduced, it's easier to see the glass in the glory hole or furnace.

Unfortunately, because using a welding filter makes the work area appear darker, visibility at the bench or marver is reduced. Some glassworkers use this fact to rationalize not using eye protecting lenses at all. But shade #3 (and darker shade #5) filters are available in flip-up goggles, or in clip-on, flip-up “sunglass” mountings. These configurations make it simple to get the filter out of the way easily, perhaps just before withdrawing a piece from the glory hole, or maybe on the way to the bench or marver. Safety equipment suppliers can locate sources for such filter equipment.

For people who wear prescription glasses anyway, coatings can be applied directly to the corrective lenses that eliminate nearly all ultraviolet radiation. It’s also possible to have prescription lenses fit into safety glasses with a UV coating; put a clip-on, flip-up shade #3 filter on such glasses and you probably have all the ocular protection you need.

Another solution has been used at some establishments—hang a piece of shade #3 or even #5 filter material in front of the glory hole in a position so that the gaffer looks through it when reheating. This system is used in the Steuben shop at Corning Glass.

## Conclusions

The literature on eye hazards for glass workers is complicated in its details but not in its implications for eye protection—glass work can damage your vision. Protect your eyes from chemical and particulate assaults by using some form of safety glasses. Protect your eyes from infrared and ultraviolet radiation by using a filter that is appropriate to the emission of the glass you’re working. For torch workers, this will probably be a didymium filter together with ultraviolet protection. Furnace workers need to filter out both the infrared and the ultraviolet; an appropriate welder’s goggle will be satisfactory if worn faithfully. A practical solution for many furnace workers would be to put UV protection on safety glasses and add an appropriate welder’s goggle filter that can be removed or flipped up easily if desired.

## References

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