Eye Safety for Illuminators

What Integrators, Installers, and Customers Should Know

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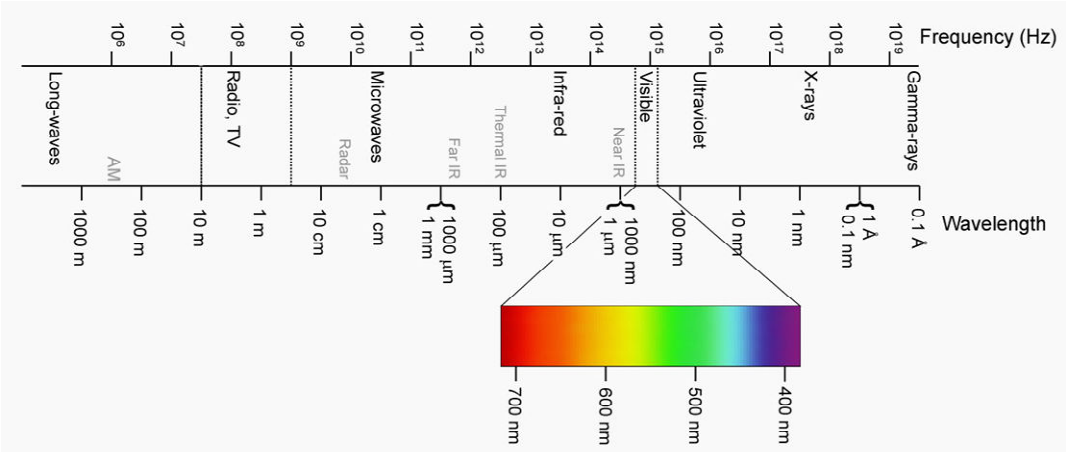
Introduction

Most people are aware that lasers can pose a safety hazard. Fewer know that non-visible radiation, such as infrared or ultraviolet light, can also be harmful to the human eye. Fewer still know that non-coherent light sources such as LEDs (Light Emitting Diodes) also have the potential to cause harm. This paper provides a brief overview of eye safety considerations as they relate to LED-based illuminator products.

Types of Electromagnetic Radiation

As we know, visible light is a form of electromagnetic radiation. Light occupies a very narrow range of wavelengths on a spectrum which spans all the way from radio waves to gamma rays. Infrared and ultraviolet light fit on either side of the visible light band. Infrared radiation can further be divided into short-wave (or near-) IR and long-wave (or far-) IR. Near-IR can be detected with conventional video security cameras. Far-IR is actually thermal radiation, requiring special thermal imaging sensors. The electromagnetic spectrum is shown in Figure 1 below.

Figure 1 - Electromagnetic Spectrum



Eye safety is mostly concerned with visible, ultraviolet, and near-infrared light. Other forms of electromagnetic radiation such as thermal, microwaves, or x-rays pose their own health risks, but these risks are not specific to the eye; they are not germane to a discussion of illuminator safety.

Damage Mechanisms

There are several ways that the eye can be damaged when exposed to high intensity light radiation, depending on which form of radiation causes the exposure. Ultraviolet light is absorbed in the cornea and lens of the eye. Prolonged exposure can result in burns and the development of cataracts. Given that video security illuminators do not use ultraviolet light, the remainder of the discussion will focus on visible and near infrared light.

White light, whether from a natural source like the sun or from artificial sources, can cause eye damage through a couple of mechanisms. The blue content of white light can cause photochemical damage to the retina, where light

triggers chemical reactions in tissue. The longer wavelengths of visible light can cause thermal damage. Here, the tissue in the eye is heated to the point where proteins are broken down (denatured). It literally "cooks" the retina.

The effects of eye damage usually do not appear until hours after the exposure. The effects are similar to watching arc welding without eye protection. Mild exposure can feel like you have sand in your eyes, severe exposure can cause temporary or permanent spot blindness.

We have a several natural protection mechanisms that minimize the potential for harm from intense visible light. Strong light reflexively causes the eye to blink, the iris to contract, and the viewer to look away. Sources of visible light that pose a serious risk must be: a) switched on quickly enough, before our natural aversion response happens; and b) powerful enough to cause damage in that short period of time. Lasers can clearly fall into this category. Most other white light sources do not.

Infrared light also can cause the same kind of thermal damage to the retina described above. While the mechanism is the same, the actual risk of accidental exposure is much greater than for visible light. The reason is that because infrared light is invisible to the human eye, none of the aversion responses are triggered. We don't blink, our irises don't contract, and we don't instinctively look away.

Imagine staring directly and continuously at the sun – it is difficult to do even if you wanted to. Now imagine that the sun's light is there, but it is barely visible to you at all – more like looking at the moon. You continue to stare at it with dilated pupils, even if this pretend sun is producing the same blinding effect on your retina as the real sun. So you can appreciate why we must be much more cautious in examining the safety issue for infrared illuminators than we do for white light illuminators.

Safety of Illuminators

Knowing that light can pose a theoretical risk of injury to the eye, the question at hand is: how safe are illuminators designed for video security? The short answer is: quite safe, provided that some common sense precautions are taken during installation. We will address these precautions later.

The first issue to resolve is safety of the public. Can we conclude that the illuminator poses no significant risk to anyone within its intended area of coverage? Remember that we are trying to shed just enough light on the subject to get a decent video image. This amount of energy is many orders of magnitude below the levels that can cause harm. It therefore poses no danger to the public – no more than if they were to look up at a street light at night.

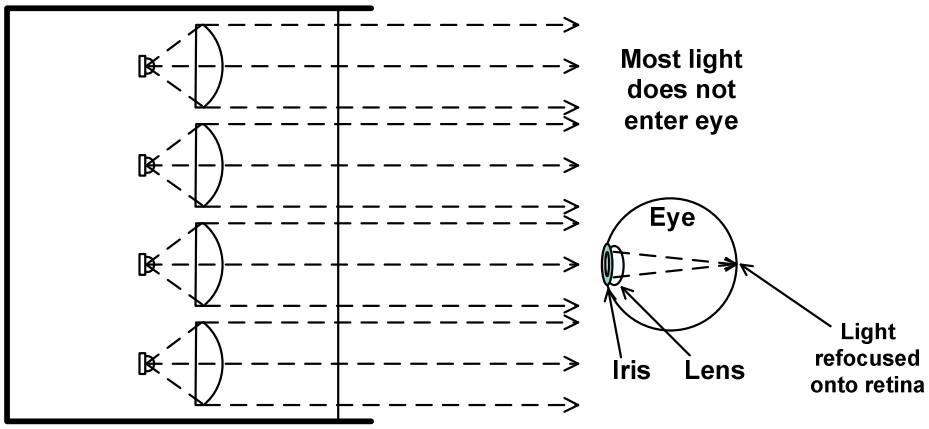
But is it possible for someone to be exposed to light from the illuminator at levels thousands, or even millions of times greater than the light levels in the intended area of coverage? Yes, if they were to look directly into the illuminator from a very close distance. Let us look more closely at this scenario.

Most applications require an illumination pattern that covers an angle that matches the field of view of the camera. We know intuitively that: a) the narrower the angle, the higher the intensity of the light; and b) for any given coverage angle, the closer you are to the illuminator, the higher the intensity of the light. So the worst-case scenario is a narrow angle or telephoto illuminator, at a very close distance. For a more rigorous discussion of this relationship, please refer to NuOptic's white paper entitled *Illumination Distance*.

Within the illuminator, the light from each LED comes from a very small and intensely bright spot. This light must be gathered and redirected (collimated) using a lens or reflector. So the light that exits the illuminator is

already spread out over the diameter of the lens or reflector. Even at a very close distance, it is only possible for a small fraction of the light from any LED to enter the eye. We don't need to be concerned about the total light output from the illuminator, only this small beam of collimated light that enters the pupil of the eye. This point is made graphically in Figure 2 below.

Figure 2 - Light Entering the Eye



The beam that enters the eye is re-focused by the lens of the eye down to a smaller spot on the retina. Depending on the specifics of the LED power and the collimating optics, prolonged exposure theoretically could result in temporary or permanent damage to that spot. Fortunately, it would take very long exposures (minutes or hours) at very close distances (inches or feet) to cause permanent damage, even with the most powerful illuminators available today.

Installation Safety

There are two circumstances under which someone may be exposed to the illuminator at very close distances. The first is if the illuminator is installed in a place where a curious bystander could look directly into it. As explained earlier, no one would stare into an energized white illuminator – not for long, anyway. However, they could very easily stare continuously into an IR illuminator and not know in was on at all. Therefore, proper installation guidelines dictate that:

- Install illuminators high, well out of reach of the public
- Make sure there are reasonable barriers to direct access by the public
- Be especially careful of the previous two guidelines when installing IR illuminators

These guidelines are prudent installation practice from the standpoint of vandal resistance as well. They are probably also consistent with placement for best video imaging – high over the scene rather than at lower angles.

The person with the greatest risk of exposure is the installer him/herself. This is the second circumstance under which someone may be exposed to the illuminator at close distances. The installer is inherently very close to the light source while wiring up, mounting, and adjusting the illuminator. Again, simple guidelines should be followed:

- Perform all mounting and electrical connection work with power disconnected at the source
- Operate from behind or to the side of the illuminator when it is powered
- If possible, work with an assistant on the ground for aiming or testing the system
- Remain especially vigilant when working with infrared illuminators

These guidelines also apply to possible service or replacement activities after installation is complete.

It is probably worth noting that a sudden white light flash from an accidentally powered illuminator poses a risk of a broken leg or arm from a fall. This risk is probably greater than that of eye damage from light exposure; much akin to an electric shock more likely resulting in a fall than in electrocution.

Industry Standards

In recent years there has been confusion and debate about the appropriate safety standard for LED-based illuminator products. Before mid 2006, LED applications were by default covered by the Laser Standard IEC-60825. Today most LED applications are covered by the Lamp Safety IEC-62471-2006. Lamp devices may also contain optical components like lenses or reflectors. The majority of modern illuminators designed for general video security fit this definition.

The standards attempt to quantify risks and working distances through a rigorous calculation of optical energy entering a 7mm pupil aperture, combined with exposure time and the biochemistry associated with specific wavelengths of light. The analysis is quite complicated, and is probably beyond the scope of most security professionals and their clients and customers.

It is quite safe to assume that we are operating well within the bounds of these standards if we follow the installation guidelines described above.

Summary

The LED technology used in modern security illuminators has made great strides in brightness and efficiency in the last several years. While they are quite powerful, they pose little risk. Common sense precautions are recommended during installation, especially for infrared illuminators. With over 20,000 IR illuminators installed each year, we are unaware of a single safety issue raised about IR used in video security systems.

Note:

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References

Eye Safety of IREDs used in Lamp Applications – Osram Application Note

IEC/EN 60825-1 (2007-03), DIN EN 60825-1 (2008-05) – *SAFETY OF LASER PRODUCTS*

IEC 62471 (CIE S009) – *Photobiological Safety of Lamps and Lamp Systems*