

## The Potential Ocular Hazards of LED Emitters

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Questions have arisen as to whether laser or incoherent radiation exposure limits (ELs) should be applied to LED emitters. Based upon current exposure limits from the International Commission on Non-Ionizing Radiation Protection (ICNIRP), most LEDs - particularly surface-emitting LEDs — pose no clear hazard to the eye. Current surface-emitting LEDs produce exposure levels at the retina which are less than 1% of the levels that are known to cause retinal injury even when the LEDs are viewed at extremely close distances (e.g., at 10 cm) (Sliney and Wolbarsht 1980). At typical viewing distances of 0.5 to 2 m, the levels are less than 0.1% of retinal injury levels. Even lengthy exposures of the cornea and lens of the eye pose no hazards whatsoever. From a safety standpoint, LEDs have been treated both as lasers (e.g., in IEC standard 60825-1-2001 and in ANSI Z-136.2-1997, and as lamps (CIE 1998; ANSI/IESNA 1996). Because of some confusion relating to the actual risk, ICNIRP organized a panel of experts to review the potential hazards of current diode emitters and they reported their findings in 1999 (ICNIRP, 1999). This task group noted that laser diodes are constructed with miniature resonant cavities with gain, produce a very narrow spectral bandwidth, can generally achieve shorter pulse durations, are not limited in radiance, and can emit much higher radiant powers than LEDs. Light-emitting diodes of low to moderate brightness (luminance) are used in many types of visual displays, as indicator lights and many related products. Higher power LEDs and IREDs are used as signal lamps and in a wide variety of domestic and industrial products, and can compete with laser diodes in limited optical communications systems, i.e., in local-area networks (LANs). They are generally not competitive with laser diodes because of their radiance limitations. These differences in output characteristics define both their uses and their potential eye hazards. Most current LEDs--and all surface emitting LEDs--have very limited radiance and do not pose any realistic eye hazard, despite the fact that they have been included in some laser safety standards in the past few years (IEC, 2001).

After a careful review of all possible emission characteristics of surface-emitting LEDs and IREDs, the ICNIRP concluded that these would be judged safe by applying the ICNIRP Exposure Limits (ELs) for incoherent radiation. This conclusion applies as well if one follows the recommendations of CIE TC 6-38 (Lamp Safety) for realistic viewing conditions. This conclusion applies to any LED device which does not have optical gain. Only as a result of applying extraordinarily "worst-case" assumptions and simplifications that are built into some current product safety standards, can anyone arrive at the conclusion that an LED or IRED poses a retinal hazard. On the other hand, the use of laser ELs and IEC 60825-1 measurement techniques to evaluate LEDs could result in an understatement of the lenticular risk if the source is very large and the lens becomes overheated. Thus, the ICNIRP recommended that safety evaluations and related measurement procedures for LEDs follow the guidelines for incoherent sources (ICNIRP 1997). This approach provides the most accurate assessment of incoherent sources without problems originating from certain underlying assumptions about lasers that remain incorporated into the limits developed for collimated laser beams. They also concluded that diode lasers and VCSELs be treated in all safety evaluations and safety standards as lasers.

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