

# Tech News

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## The NIOSH LED Cap Lamp Provides Improved Illumination for Greater Safety in Underground Mines



Photos by NIOSH

**Figure 1:** (Left) Illumination provided by an LED cap lamp in an underground mine. (Right) The improved illumination provided by the NIOSH-developed LED cap lamp.

### Summary

Researchers at the National Institute for Occupational Safety and Health (NIOSH) have developed an LED cap lamp that significantly improves illumination in underground mines, thereby enhancing safety by reducing injuries to miners. Providing better illumination underground improves a miner's ability to see and avoid potential hazards in the mine (see Figure 1). Results from NIOSH's scientific testing confirm that the NIOSH LED cap lamp demonstrates major improvements in trip hazard detection, peripheral motion detection of moving hazards, and reduced glare when compared to existing LED cap lamps. The NIOSH LED cap lamp design is now freely available for commercialization by cap lamp manufacturers.

### Background

Providing adequate lighting for miners to work safely is a significant challenge given that underground mines are one of the most difficult environments to illuminate. Illumination plays a critical role in an underground miner's safety because miners depend most heavily on visual cues to see fall-of-ground hazards, pinning and striking hazards from powered machinery, and slipping and tripping hazards [Cornelius et al. 1998]. Accident rates can decrease significantly when mine illumination is improved [Daly 2001]; researchers have noted that accident rates decrease as much as 60% when the overall illumination is increased [USBM 1988].

When illuminating an underground mine, age is an important factor to consider, given that the average age of the mining workforce is about 43 years [NIOSH 2012]. Age has a significant effect on one's visu-

al abilities. The physiology of the human eye degrades as a person ages, resulting in decreased visual performance. These age-related changes include reduced pupil size, yellowing of the eye lens, loss of rod photoreceptors, and increased susceptibility to glare [Harvard Women's Health Watch 2007]. Consequently, 40% less light reaches the retina of a 45-year-old person as compared to a 24-year-old [Rea 2000]. Thus, as the mining workforce ages, the need for effective underground lighting becomes even more pressing.

### Approach

To improve the illumination capability of LED cap lamps, NIOSH conducted research in two phases. Phase I focused on enhancing the color of light to improve miners' ability to see hazards, especially for older workers. NIOSH's approach was to alter the color spectrum of the cap lamp to increase the output of short

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wavelength light. The short wavelength light emitted from a cool-white LED can improve visual acuity because the human eye is more sensitive to that part of the color spectrum in lowlight mining conditions. The alternative approach would be to increase the light intensity of the cap lamp. Although this would improve the ability to see hazards, the glare would also increase, and the battery would discharge faster.

Phase II of the research focused on changing the distribution of light to increase visibility of the mine floor and of moving machinery. A single light source, along with a reflector to direct light to a circular spot, provides the typical lighting distribution from an LED cap lamp (see Figure 1, Left). This spot beam creates a tunnel vision effect that limits peripheral visibility of moving machinery. With this in mind, NIOSH designed a



**Figure 2:** *The NIOSH LED cap lamp uses multiple LEDs as the primary light source for better illumination distribution.*

cap lamp using multiple LEDs as the primary light source (see Figure 2), along with secondary totally internal reflection optics that distribute the light to specific hazardous areas within the mine (see Figure 1, Right). The cap lamp beam distribution and intensity are software controlled, enabling the flexibility of matching the cap lamp lighting to the worker's task via a push-button selection of various lighting modes (see Figure 3).

### Reported Findings

The Phase I results of enhancing the color of light to improve visual performance indicated significant improvements for people 50 or more years old. Peripheral motion detection improved by 15%, floor trip hazard detection improved by 23.7%, discomfort glare was reduced by 45%, and disability glare was reduced by 53.8% [Sammarco et al. 2010]. The Phase II results indicated a 94% faster detection rate of trip hazards and a 79% faster detection rate of peripheral motion, with no increase in glare [Reyes et al. 2011].

## For More Information

For more information on the NIOSH LED cap lamp, contact John J. Sammarco ([jsammarco@cdc.gov](mailto:jsammarco@cdc.gov)), or the NIOSH Mining program ([mining@cdc.gov](mailto:mining@cdc.gov)). The NIOSH LED cap lamp design can be downloaded at: <http://go.usa.gov/xKeRG>.

To receive NIOSH documents or for more information about occupational safety and health topics, contact: **1-800-CDC-INFO (1-800-232-4636)**, **1-888-232-6348 (TTY)**, or request information at the CDC website at [www.cdc.gov/info](http://www.cdc.gov/info), or visit the NIOSH website at [www.cdc.gov/niosh](http://www.cdc.gov/niosh).

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**Figure 3:** *The NIOSH LED cap lamp's beam distribution and intensity can be selected for various lighting needs.*

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