LED area lighting to reduce glare for roof-bolter operators

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To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

Researchers from the U.S. National Institute for Occupational Safety and Health (NIOSH) developed the Saturn light that significantly improves illumination for roof-bolting machine operators while reducing glare. The existing roof-bolter lighting was the baseline and was compared to the Saturn at 100, 75 and 50 percent intensities. Discomfort glare and disability glare were measured by the De Boer rating scale and the Mars Letter Contrast sensitivity test, respectively. Thirty study participants were tested. Discomfort glare was reduced at least three levels with the Saturn luminaire. Visibility levels were four to 6.5 times better with the Saturn than with the baseline. The Saturn design is freely available for commercialization.

Introduction

Accident data indicate that operating the roof bolter is a leading cause of machine-related injuries in mining [1]. The operational hazards of a roof-bolter machine include relatively poor visibility due to low ambient light levels and low contrast levels. Excessive glare is another visibility hazard and is a frequent complaint among roof-bolter operators. It is primarily due to the high luminance contrast between the background and high-intensity luminance of the luminaires mounted on the roof bolter. A high luminance contrast can result in discomfort glare, a loss or reduction in visibility, or both [2].

NIOSH researchers have developed the Saturn LED light to address these concerns, and the design documentation is freely available for downloading [3]. The Saturn was designed to improve floor illumination for detecting trip hazards and to reduce glare that has been historically problematic on roof bolters. The first objective was achieved with up to a 48 percent reduction in average trip detection time compared to the standard lighting on a roof bolter [4]. More importantly, the Saturn trip object miss rates were < 0.5 percent for all age groups in contrast to those of the standard lighting, which ranged from 32.5 percent for the youngest group to 50.4 percent for the oldest group [4]. Therefore, the present study's primary objective was to determine if the Saturn can reduce discomfort and disability glare. The second objective was to determine if varying the Saturn intensity results in differences in discomfort and disability glare.

Methods

The roof bolter's compact fluorescent lamp (CFL) luminaires with amber polycarbonate globes served as the baseline and were compared to the Saturn luminaire at 100, 75 and 50 percent intensities (Fig. 1). The study was conducted in two phases: phase 1 at the middle of the roof bolter, and phase 2 at the front. The De Boer scale was used to rate discomfort glare, and the Mars Letter Contrast Sensitivity test to rate disability glare. Of the 30 participants, 10 were in each of the three age groups: young, 18–25 years old; middle, 40–50 years old; oldest, older than 50 years old.

Results and discussion

For phase 1, no statistically significant differences existed among the luminaires for discomfort or disability glare; thus, the Saturn does not appear to reduce glare at this middle location. The median De Boer rating was 8 (better than satisfactory) for the CFL and the Saturn at 100 and 75 percent, and 7 (satisfactory) for the Saturn at 50 percent.

For the phase 2 location at the front, statistically significant differences existed among the luminaires for discomfort glare. The median De Boer rating was 5 (just acceptable) for the CFL, and ranged between 8 and 9 for all Saturn intensities with no significant differences among the Saturn intensities. For disability glare, age and luminaire were significant. Post hoc analysis on age showed that the results for both the younger and middle groups were significantly different from the older group, but the difference between the younger group and the middle group was not significant. Disability glare was the worst with the CFL for all age groups and decreased as the Saturn intensities decreased.

Additional analysis of the visibility level (VL) was conducted, given phase 2 data were significant. The worst VL was 2 for the CFL and 8, 12 and 13 (best) for the Saturn at 100, 75 and 50 percent, respectively, indicating the Saturn reduced glare without sacrificing visibility.

The phase 1 and 2 results differ because the luminaire mounting locations differed, resulting in varying levels of illuminance direct to the eyes. For phase 1, the CFL average eye illuminance was 5.3 lux and the Saturn luminaires ranged from 8.1 to 12.0 lux. For phase 2, the CFL average

eye illuminance was 25.1 lux; the Saturn luminaires ranged from 0.6 to 1.2 lux, thus enabling significant glare reduction.

Conclusions and summary

Overall, the Saturn luminaires performed significantly better relative to discomfort and disability glare and visual performance than the CFL luminaires at the phase 2 location of the roof bolter; thus, the first study objective to determine if the Saturn luminaires could reduce discomfort and disability glare was achieved. The second objective to determine if there are differences among the Saturn luminaires was also achieved.

Among the Saturn luminaires, the Saturn at 50 percent enabled the least amount of disability glare and the highest visibility level at the phase 2 location, so it appears that the Saturn at 50 percent would be the most desirable luminaire in terms of reducing glare. Note that the phase 1 data analysis indicated no significant differences among the Saturn luminaires and the CFL lighting condition with respect to discomfort and disability glare because glare was not an issue at the phase 1 location. ■

Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention. Mention of any company or product does not constitute endorsement by NIOSH.

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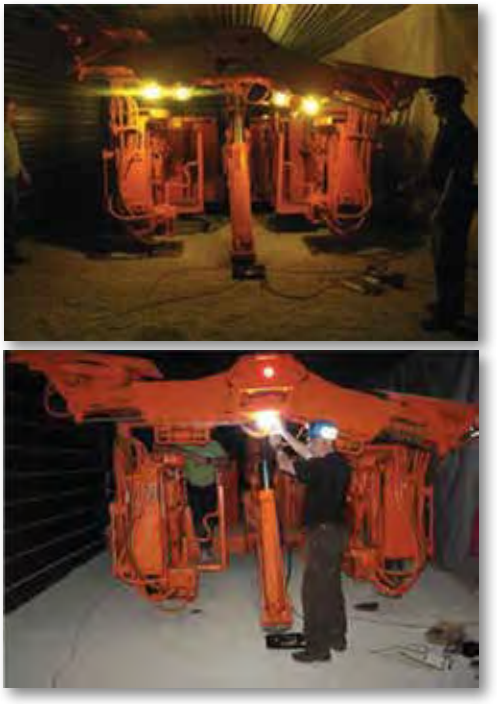

Fig. 1 Roof-bolter front illuminated with (a) CFL luminaires and (b) Saturn luminaire at 100 percent.

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Numerical investigation of the effect of a novel wet scrubber on dust reduction in an underground coal mine

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Special Extended Abstract

Controlling dust generation and keeping it below permissible limits to meet federal dust standards at the working face of a room-and-pillar coal mine is a challenge for a mine operator. With the recent changes in federal dust regulations requiring lower worker exposure, maintaining compliance has become increasingly difficult. The current most effective