Traffic Safety Facts
Vehicle Safety Research Notes

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Study of Present-Day LED Brightness and Corresponding Rear Signaling Concepts (LED Optimization)

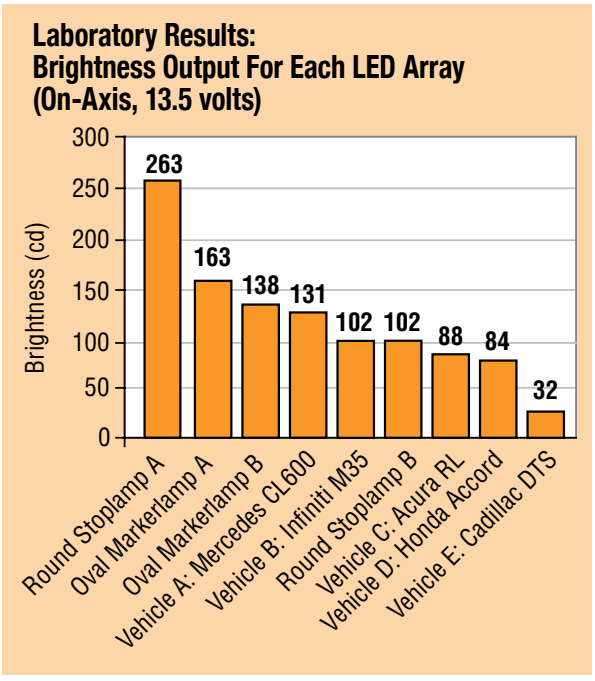
Crash database studies have shown that more than 29 percent of all crashes are rear-end crashes. These types of crashes often result from a failure to respond (or delays in responding) to a stopped or decelerating lead vehicle (NHTSA, 2005). The work described here is part of a larger program of research intended to develop and evaluate rear signaling applications designed to reduce the frequency and severity of rear-end crashes by redirecting drivers' visual attention to the forward roadway (for cases involving a distracted driver), and/or increasing the saliency or meaningfulness of the brake signal (for attentive drivers).

The purpose of this research study was to develop optimized rear brake lighting signal configurations using present-day lighting assemblies, but with LED technology. Work under this study included a laboratory component to quantify the brightness levels of various LED lamps, and a data collection component using human participants intended to determine optimum flash frequencies, brightness levels, and signal patterns (e.g., simultaneous versus alternating flashing).

Laboratory Study

The laboratory study characterized the on-axis brightness (illuminance) and beam width of a sample of existing, commercially available automotive LED light arrays from production vehicles and marker light assemblies ordinarily used on heavy vehicles (two of the LED arrays are pictured). The lettered stoplamps in the chart represent heavy-vehicle marker lamps; additional detail regarding these lamps and model numbers are available in the full report.

Results showed that, in general, those units with the highest number of LEDs and least dispersion beam have the greatest brightness, or on-axis output. This suggests that to achieve even greater output, the number of LEDs should be increased or the lamp units should be "ganged." As shown in the bar graph below, the units with the highest output are lamps ordinarily used on heavy vehicles, the highest being the round stop lamp A (pictured to the right).



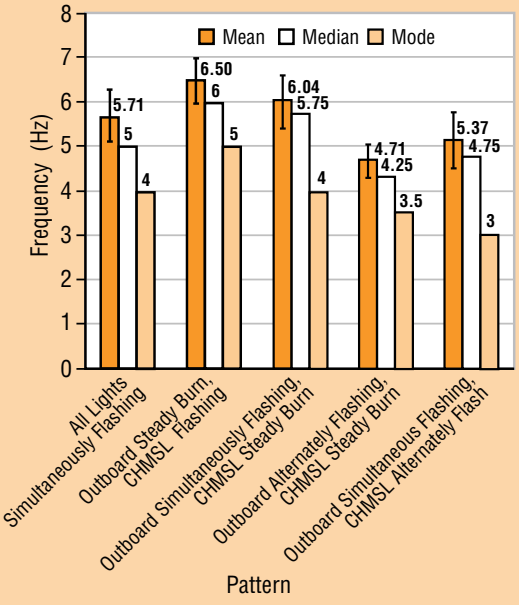
Rear Vehicle Applique

Compared with the results of earlier tests of enhanced rear signals with very high brightness levels (1376 cd), the LED assemblies evaluated here are much below this. However, it should be possible to compete favorably with the incandescent units (at least, on axis) by using multiple units.

LED Frequency Optimization Study

Lighting assemblies were developed and testing conducted in order to identify the most attention-getting signal pattern frequencies (signal flashing rates). This study included 12 naïve participants, each of whom was presented with a variety of different flash patterns and was asked to adjust the frequency for each pattern using the "method of limits" (ascending and descending trials) to determine the most attention-getting frequency pattern. The experimental setup used a full-size appliqué of the rear of a vehicle. Lamps (corresponding to Round stop lamp A, the highest output lamp tested in the above study) were mounted in arrays in the three locations on the appliqué (for the two outboard lights and the center high-mounted stop lamp, known as CHMSL). Therefore, the test apparatus was developed using the concept of multiple round lamps in order to obtain high brightness levels.

Frequency Results by Pattern for LED Optimization Study



Each participant selected "the optimum frequency" for each of 5 patterns based on what they judged to be the most attention-getting flash frequency. As shown to the left, optimum frequencies ranged from 4.25 to 6.5 Hz (mean/median values). Subsequent testing to characterize attention-getting used these optimum values to tune the flash frequencies for each pattern.

One important finding is that the optimum flash frequencies for LED-enhanced brake signal lights are slightly higher than for incandescent lamps. This appears to occur because there is no trade-off of desired frequency and rise/fall times for LEDs, which are relatively instantaneous.

LED Attention-Getting Study

A follow-on study was conducted in order to validate these optimum frequencies as well as capture attention-getting ratings for a broader range of signal patterns. A separate group of 14 naïve participants was recruited for this study. Each participant was provided with the frequency-optimized patterns derived from the results of the previous study, and was asked to rate attention-getting (and glare) of each configuration while looking directly at the display board as well as when looking away (glancing 30 degrees off-angle).

Results indicate that the first two patterns (on the left in the figure) are rated to be significantly more attention-getting from the last two patterns (on the right in the figure).

Clearly, the steady burn and flashing CHMSL with steady outboard are not as good as the outboard simultaneous flashing with CHMSL alternating flashing, and all simultaneously flashing. It appears that flashing and pattern affect the results. The best configurations for future testing therefore appear to be those in which the outboard lamps flash, either alternately or simultaneously.

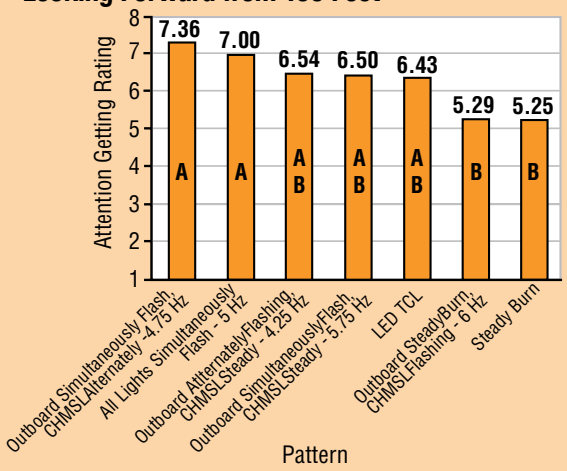
Conclusions

It appears that present-day LED lamps are capable of competing with incandescent lamps in terms of attention-getting by using multiple units or assemblies along with narrow beam widths. This research demonstrated that flashing all lights simultaneously or alternately flashing is a promising signal for use in enhanced brake light applications.

References

Wierwille, W. W., Lee, S. E., & DeHart, M. C. (2005). Enhanced Rear Lighting and Signal Systems: Project Final Report Emphasizing Task 3 Results: Test Road Experiment on Imminent Warning Rear Lighting and Signaling, Report No. DOT HS 809 864. Washington, DC: National Highway Traffic Safety Administration.

Mean Attention Getting Ratings by Pattern Looking Forward from 100 Feet



This Vehicle Safety Research Note is a summary of the technical research report: *Evaluation of Enhanced Brake Lights Using Surrogate Safety Metrics. Task 1 Report: Further Characterization and Development of Rear Brake Light Signals.* Report No. DOT HS 811 127. Washington, DC: National Highway Traffic Safety Administration. This report can be downloaded free of cost on the Vehicle Safety Research section of NHTSA's Web site (www.nhtsa.gov).

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