Identifying Wet Retroreflectivity Levels for Pavement Markings

What Was the Need?
Drivers depend upon pavement markings to give them a continuous stream of information as they navigate the roadway. Centerlines and edge line markings delineate the vehicle lane for drivers, while other markings such as stop bars and railway crossings alert drivers to safety and other road environment issues.

Pavement markings must be readily visible to drivers during the day, at night and in all weather conditions, including adverse weather such as rain. Visibility is especially necessary in rural areas with sparse or no road lighting. Markings in good condition provide adequate delineation in dry nighttime conditions, but their visibility is generally reduced in wet-night conditions. Poor delineation of the roadway can confuse drivers and increase the risk of run-off-road crashes.

MnDOT did not have quantitative performance standards for pavement marking wet retroreflectivity. Both MnDOT and local agencies across the state wanted research to investigate and establish wet retroreflectivity performance levels that would eventually become specifications for contracts that included wet-reflective pavement markings.

What Was Our Goal?
The main objective of this project was to establish quantitative pavement marking retroreflectivity performance levels—both initial and maintained—that would be included in MnDOT pavement marking specifications for contractors. Researchers also needed to determine drivers’ visibility needs: the minimum pavement marking brightness drivers need to see the markings in advance (called preview time) in wet-night conditions.

What Did We Do?
To determine effective initial and maintained wet retroreflectivity performance levels of pavement markings, researchers conducted the following investigations:

- **Comprehensive review of past research literature.** To evaluate data and previous research methods, investigators examined publications that addressed retroreflectivity measurement, visibility, durability and safety.

- **Human factors study.** Forty-three participants evaluated the visual quality of 20 different pavement marking samples in dry and continuous wet-night conditions on a closed test track facility. Using three 2015 Ford Explorers, researchers drove each participant around the half-dry, half-wet track in night conditions. The wet portion simulated 1.5 inches of rain per hour (a heavy rain). Participants averaged approximately 60 years of age; slightly more than one-half of the participants were 65 years or older. Each completed a demographic survey and visual acuity test.

- **Retroreflected light measurements.** Researchers used a portable retroreflectometer to measure the retroreflected light of samples used on the track, measured as a coefficient of retroreflected luminance and expressed as millicandelas per square
meter per lux (mcd/m²/lux). Researchers tested wet and dry markings using ASTM procedures.

• **Comparison of the new human factors data to literature review results and other DOT data.** Researchers examined drivers’ visibility requirements in conjunction with the measured continuous wet retroreflectivity of the pavement markings. These data allowed researchers to determine the minimum level of continuous wet retroreflectivity that would be required to meet driver visibility needs in wet-night conditions. The minimum driver needs were coupled with continuous wet retroreflectivity degradation models and a desired service life to establish initial continuous wet retroreflectivity levels.

What Was the Result?
Using the information gathered from the human factors closed track testing, previous research and MnDOT data, researchers determined that pavement markings must have at least a continuous wet retroreflective luminance level of 50 mcd/m²/lux to be adequately visible in wet-night conditions. Agencies may use this level as a minimum performance measure for in-place wet-reflective markings.

After discussing rates of marking luminance degradation with MnDOT and pavement marking manufacturers, researchers selected an initial continuous wet retroreflectivity value of 200 mcd/m²/lux for new pavement marking installations. This value would yield a service life of about four years before degrading to the minimum continuous wet retroreflectivity level of 50 mcd/m²/lux.

Researchers developed recommendations with values for pavement marking wet-night retroreflectivity that MnDOT will include in standards and specifications for roadway pavement markings.

What’s Next?
This is an innovative first step in research intended to obtain more quantitative data regarding pavement marking retroreflectivity, effectiveness and service life. MnDOT will install wet-reflective pavement markings with an initial continuous wet retroreflectivity target value of 200 mcd/m²/lux on selected corridors on the state highway system to evaluate the initial performance and service life in real-world conditions. This effort will allow MnDOT to determine the longevity of wet-reflective pavement markings before the wet continuous retroreflectivity approaches 50 mcd/m²/lux. Results from this and future projects will allow agencies to make informed, data-based decisions regarding product selection, installation and maintenance of wet-reflective pavement marking materials.