Wet (Retro)Reflective Pavement Markings

Update to AASHTO SCOTE
June 2016
Does it Rain in Texas?

35,000,000,000,000 gallons

- Enough to cover the entire state of Texas in 8 inches of water.
- Enough to fill up California’s 200 largest surface reservoirs 3X to capacity.

*for the month of May*
Report FHWA-SA-15-063

- MUTCD Warrants
- Effects of Marking Width
- Dry Retroreflectivity
- **Wet Retroreflectivity**
- Combined Impacts of Markers
- Marking Selection Tools
- Future of Markings

Texas A&M Transportation Institute

Synthesis of Pavement Marking Research

June 2015
Key Points from FHWA Synthesis

- Dry retro does not predict wet retro
- Wet retro depends on optics and structure
- Initial performance can be impressive
- Long-term performance remains elusive
- Innovative products being introduced every year
Looking Ahead

• More structured markings in the south
• More grooved markings in the north
• Develop RRPM guidelines that consider
  – Functional classification
  – Tangent and horizontal curve sections
  – Use of RPMs in conjunction with other types of
delineation devices, surface treatments, and lighting
  and their impacts on driver performance
  – The visibility needs of drivers 60 years or older
  – Various types of RPMs
  – Performance measures and minimum RPM
  performance level
Approach

- Research synthesis
- **Practice synthesis (i.e., survey)**
- Human Factors Study
- Visibility Modeling
- SHRP2 Analysis
- Safety Analysis
### Evaluation of Wet Retro Materials

- **Report FHWA/TX-07/5008-2**

<table>
<thead>
<tr>
<th>Marking Number</th>
<th>Marking Material</th>
<th>Detection Distance (Dry, ft)</th>
<th>Detection Distance (Wet, ft)</th>
<th>COST ($/mile/yr)</th>
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</thead>
<tbody>
<tr>
<td>8</td>
<td>Polyurea 4&quot;</td>
<td>371</td>
<td>164</td>
<td>1122</td>
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<tr>
<td>11</td>
<td>Thermo 4&quot; (Splatter)</td>
<td>308</td>
<td>156</td>
<td>1144</td>
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<td>24</td>
<td>Tape 6&quot;</td>
<td>333</td>
<td>211</td>
<td>3300</td>
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<td>34</td>
<td>Thermo 4&quot; (Flat) Type II Bead</td>
<td>265</td>
<td>139</td>
<td>475</td>
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<tr>
<td>35</td>
<td>Thermo 4&quot; (Rumble Stripe) Type II Bead</td>
<td>237</td>
<td>161</td>
<td>880</td>
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<tr>
<td>37</td>
<td>Thermo 6&quot; (Flat) Type II Bead</td>
<td>237</td>
<td>148</td>
<td>563</td>
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<tr>
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<td>Thermo 4&quot; (Flat) Type II Bead</td>
<td>229</td>
<td>150</td>
<td>475</td>
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<tr>
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<td>Thermo 4&quot; (Flat) Type III Bead</td>
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<td>169</td>
<td>475</td>
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<tr>
<td>42</td>
<td>Thermo 4&quot; (Rumble Stripe) Type III Bead</td>
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<td>160</td>
<td>880</td>
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<td>43</td>
<td>Thermo 4&quot; (Inverted Profile Transverse) 4&quot;</td>
<td>281</td>
<td>182</td>
<td>990</td>
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<td></td>
<td>RRPM Type II C-R</td>
<td>&gt; 1000</td>
<td>&gt; 550</td>
<td>74.8</td>
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</table>
ASTM Standards

- ASTM E1710 Dry Handheld Test Method
- ASTM E2177 Wet Recovery Handheld Test Method
- ASTM E2176 Wet Continuous Handheld Test Method
- ASTM E2832 Wet Continuous Handheld Test Method
- ASTM D7585 Handheld Sampling Protocol

- ASTM WK3833 Mobile Pavement Marking – Work Item
ASTM E1710

- Measurements of dry pavement marking retroreflectivity
- Defines instrument geometry
- Refers to D7585 for sampling plan
- “surface of marking shall be clean and dry”
- Includes a Precision Bias statement
- Most common Test Method
ASTM E2177

- Measurement of wet recovery (after rain)
- Currently includes option for bucket or spray method
- Includes Precision Bias statement
- Most commonly specified wet TM
ASTM E2176

- Measurement of continuously wetted pavement markings (during rain)
- Limited to markings with optics having index of refraction greater than 2.0 and structured markings having vertical surfaces \( \geq 3 \) mm
- Controversial \((\) wetting rate \( > 9 \) iph)
ASTM E2832 (replaced E2176)

- Measurement of continuously wetted pavement markings (during rain)
- Based on wetting rates of 2 inches per hour
Comparing TM Results

Test Method and Location (EL=Edgeline, LL=Laneline)

Retroreflectivity (mcd)

E1710    E2177    E2832
Comparing TM Dispersion

Average of 8 Pvmnt Mrkg systems (4 binders with 2 different optics each)

- Coefficient of Variation ($\sigma/\mu$)
- 30day
- 60day

Bar chart showing:
- DRY EL: E1710
- DRY LL: E2177
- RECOV EL: E2177
- RECOV LL: E2177
- WET EL: E2832
- WET LL: E2832
ASTM D7585

- Sampling protocol for using handheld retroreflectometers
- Evaluation techniques
  - Nighttime Visual Inspection
  - Standard Evaluation Protocol
  - Referee Evaluation Protocol
- New or in-service markings
- Published in 2010
ASTM WK3833

- In-development
- Test method for mobile pavement marking retroreflectivity measurements
Safety Evaluation

• New FHWA research
• Published in Oct 2015
• Report No. FHWA-HRT-15-085
• FHWA’s Low-Cost Safety PFS (38 states)

• What is the safety impact of upgrading typical pavement markings with wet reflective pavement markings?
Study Areas

• Freeway sections
  – Minnesota, North Carolina, Wisconsin
• Two-lane highways
  – Minnesota
• Multi-lane highways
  – Wisconsin
Products

• Minnesota (771 mi)
  – 3M
  – Epoplex

• North Carolina (95 mi)
  – Epoplex
  – 3M elements

• Wisconsin (300 mi)
  – 3M tape
## Economic Analysis

<table>
<thead>
<tr>
<th>Road Type</th>
<th>B/C Ratio</th>
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<tbody>
<tr>
<td>Freeways</td>
<td>1.45 (0.83 – 2.04)</td>
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<tr>
<td>Multilane Highways</td>
<td>5.44 (3.10 – 7.67)</td>
</tr>
</tbody>
</table>
## Crash Modification Factors

<table>
<thead>
<tr>
<th>Road Type</th>
<th>Total</th>
<th>Injury</th>
<th>ROR</th>
<th>Wet-Road</th>
<th>Nighttime</th>
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<tbody>
<tr>
<td>Freeways</td>
<td>---</td>
<td>0.881 (0.033)</td>
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<td>0.861 (0.040)</td>
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</tr>
<tr>
<td>Multilane Highways</td>
<td>0.825 (0.051)</td>
<td>0.595 (0.059)</td>
<td>0.538 (0.078)</td>
<td>0.751 (0.108)</td>
<td>0.696 (0.082)</td>
</tr>
</tbody>
</table>
Questions

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