Re-Refined Engine Oil Bottoms
Asphalt Binder Specifications

* Pre-
  * Strategic Highway Research Program

* Post-
  * SHRP
  * PG- Specifications
How Asphalt Behaves

- Behaviour Depends on
  - Temperature
  - Time of Loading
  - Changes with Age
Penetration

* 25C
* Unaged
Viscosity

* 60°C
* Unaged
Post-SHRP

- Performance Grade
  - Physical Properties (Stiffness)
- Different Temperatures
  - Rutting
  - Fatigue
  - Low Temperature Cracking
Post-SHRP

- Considers Aging
  - Short Term (construction)
  - Long Term (in-service)
- Does not Consider Physical Hardening
  - Observable in binder
  - No clear link to mixture
Post-SHRP

* “Blind” to modifiers
  * SBS?
  * SBR?
  * Plastic?
  * Etc.
Reaction to “Blindness”

- Supplementary Tests
  - Elastic Recovery
  - Toughness

- “political” decisions
User Producer Groups

- Result of SHRP
- Patterned after
  - Pacific Coast Conference on Asphalt
  - (1956)
FHWA Expert Task Groups

- Asphalt Binder
- Asphalt Mixture

- Provide technical guidance to AASHTO
- Identify research needs
Poly-phosphoric Acid

2004 North Central User Producer Group

Use was identified
“Are you getting acid in your asphalt?”
“Better check!”
“and ban use”
Acid in Asphalt??

* False modifier
  * Way to fool the test.
* Neutralized by limestone
* Neutralizes anti-strip
  * Especially lime
Stripping Failure
Poly-phosphoric Acid

- Chemical Modifier
- Not New
  - 20 or more years(?)
FHWA Technical Brief

- What is PPA?
- How used?
- Mix performance
  - Moisture damage
  - Limestone aggregate
  - Field performance
Summary of findings
Asphalt Institute IS-220
  Polyphosphoric Acid Modification of Asphalt
AAPT Symposium (2010)
TRB Circular E-C160 (2012)
Re-Refined Engine Oil Residue

* Vacuum Tower Bottoms
* Engine Oil Residue
* Waste Engine Oil
Today “is” 2004

Do you have recycled engine oil in your asphalt?
Causes Cracking

* “Accelerated aging”
* “Projects failing in cracking”
* “Low stiffness binders are bad”
* “Adding used engine oil can’t be a good thing”
2010 Hesp

ZN identified

Pavement Performance

15 poor had ZN

11 good did not have ZN
2011 Hesp
- Oxidative aging of asphalt binders
- Increased oxidation
- Metal catalysts
2012 d’Angelo

- Multiple asphalt binders
- Multiple asphalt extenders
- Addition rates up to 20%
- Extended PAV aging
- No accelerated aging rate
2013 d’Angelo

Asphalt Mixture

Fatigue

Low temperature cracking

Performance equal or better
2014 Hesp

* 15% addition

* Extended aging

* Greater loss of phase angle
Resolution

November 21, 2014

Whereas

REOB in some asphalt

Limited research on performance

Some member states have banned
Resolved that SOM
  * Identify research
  * Identify method of detection
  * Determine use
  * Recommend additional research
Objective Introduction to a Heated Topic

• The Asphalt Institute supports the responsible modification of asphalt materials for improved performance and better life cycle costs, but does not endorse any specific or proprietary form of modification.
  o Currently no official written guidance on the use of REOB.

• Asphalt Institute has developed information/guidance documents and reported on studies regarding some modification types.
  o PPA,
  o Sulphur Extended Asphalt,
  o PMA

Mark Buncher to Mix ETG, September 2014
Task Force Formed

• Technical Advisory Committee formed REOB Task Force
  - Asphalt Institute (3 members)
  - Refiners (3 members)
  - Suppliers (4 members)
  - Additive suppliers (2 members)
  - REOB suppliers (4 members)

Mark Buncher to Mix ETG, September 2014
Objectives

- Learn more about REOB materials,
  - Processing,
  - Effects / benefits of use and
  - Best practices
Objectives

- Recommend action for AI that could include:
  - sponsoring a symposium
  - conducting research
  - developing information/guidance on REOB residue modification that could be similar to IS-220 for PPA modification
    - Synthesize the literature
    - laying out benefits, concerns, best practices
    - help agencies make educated decisions

Mark Buncher to Mix ETG, September 2014
Cooperative Study
FHWA Turner Fairbank

- Request to DOTs for samples
- More than 1000 received
  - Not a representative sample
- More than 20 percent have VTAE
  - Elevated levels of Zinc
Cooperative Study

* Illinois DOT Mix Design
* PG 58-28 binders
  * Without VTAE
  * With VTAE
Research Objective

- Chemical Analysis
  - Neat Asphalt Binder
  - Binder with Asphalt Extender
- Mix Performance
  - TSR
  - Hamburg
  - E* and FN
Asphalt Binder Formulation

- PG 64-22 base asphalt
- PG 52-28 (80%) plus PG 64-22 (20%)
- Asphalt Extender (9%) plus PG 64-22 (91%)
Performance Grading

<table>
<thead>
<tr>
<th>Asphalt Sample</th>
<th>PG 58-28 Neat</th>
<th>PG 58-28 VTB</th>
<th>PG 64-22 Neat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Binder DSR, ºC</td>
<td>58.6</td>
<td>59.2</td>
<td>66.7</td>
</tr>
<tr>
<td>RTFO Mass Loss, %</td>
<td>-0.094</td>
<td>-0.154</td>
<td>0.040</td>
</tr>
<tr>
<td>RTFO Binder DSR, G*/sin(delta), KPa</td>
<td>2.35 @58°C</td>
<td>3.07 @58°C</td>
<td>3.20 @64°C</td>
</tr>
<tr>
<td>RTFO Binder DSR, ºC</td>
<td>58.5</td>
<td>60.6</td>
<td>67.0</td>
</tr>
<tr>
<td>BBR Stiffness, -18ºC, MPa</td>
<td>227</td>
<td>137</td>
<td>187</td>
</tr>
<tr>
<td>BBR m-value, -18ºC</td>
<td>0.323 @-18°C</td>
<td>0.313 @-18°C</td>
<td>0.327 @-12°C</td>
</tr>
<tr>
<td>Estimated PG</td>
<td>PG 58-30</td>
<td>PG 60-29</td>
<td>PG 67-24</td>
</tr>
<tr>
<td>Actual PG</td>
<td>PG 58-28</td>
<td>PG 58-28</td>
<td>PG 64-22</td>
</tr>
</tbody>
</table>
# Identification of Metals

<table>
<thead>
<tr>
<th>Sample</th>
<th>PG 58 -28 Neat</th>
<th>PG 58-28 RVTB</th>
<th>PG 64 -22 Neat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Element</strong></td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
</tr>
<tr>
<td>Ca</td>
<td>24</td>
<td>729</td>
<td>32</td>
</tr>
<tr>
<td>Na</td>
<td>390</td>
<td>680</td>
<td>450</td>
</tr>
<tr>
<td>P</td>
<td>18</td>
<td>324</td>
<td>4.8</td>
</tr>
<tr>
<td>Zn</td>
<td>41</td>
<td>377</td>
<td>39</td>
</tr>
<tr>
<td>Fe</td>
<td>38</td>
<td>131</td>
<td>29</td>
</tr>
</tbody>
</table>
Polycyclic Aromatic Compound Testing

- PAC related to
  - Environment and health concerns
- PAC includes
  - two fused benzene rings to six benzene rings
  - 40 compounds
Polycyclic Aromatic Compounds

![Bar chart showing PAC levels in different asphalt types]

- **PG 58-28 Neat**: 40 mg/kg
- **PG 58-28 Asphalt Extender**: 55 mg/kg
- **PG 64-22**: 45 mg/kg
Polycyclic Aromatic Compounds

PAC, mg/kg

- PG 58-28 Neat
- PG 58-28 Asphalt Extender
- PG 64-22
- High PAC

Graph showing the Polycyclic Aromatic Compounds (PAC) content in different asphalt binders and an asphalt extender.
**“Gradation Analysis” of molecules**

![Molecular Weight Chart](chart.png)

- **Original**
- **RTFO Aged**
- **PAV Aged**

**GPC Testing Results (Aging)**

- **PG 58-28 Neat**
- **PG 58-28 Asphalt Extender**
- **PG 64-22**
GPC Testing Results (Aging)

- PG 58-28 Neat
- PG 58-28 Asphalt Extender
- PG 64-22

Molecular Weight

- Original
- RTFO Aged
- PAV Aged
GPC Testing Results (Aging)

Molecular Weight

- Original
- RTFO Aged
- PAV Aged

PG 58-28 Neat
PG 58-28 Asphalt Extender
PG 64-22
Volumetric Design Results

* RAP Binder Replacement
  * 20%

* Air Voids
  * 4.0%

* VMA
  * 15.0%
## Mix Design Results

<table>
<thead>
<tr>
<th>Mix</th>
<th>Total AC (%)</th>
<th>Avg. Voids</th>
<th>VMA</th>
<th>CM 16</th>
<th>FM 20</th>
<th>FM 02</th>
<th>Min Fill</th>
<th>+ 3/8&quot; FRAP</th>
<th>- 3/8&quot; FRAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 58-28 Neat</td>
<td>6.1</td>
<td>3.8</td>
<td>15.2</td>
<td>43.8</td>
<td>25.7</td>
<td>5.0</td>
<td>0.5</td>
<td>1.6</td>
<td>23.4</td>
</tr>
<tr>
<td>PG 58-28 VTB</td>
<td>6.1</td>
<td>4.0</td>
<td>15.0</td>
<td>43.8</td>
<td>23.7</td>
<td>5.0</td>
<td>0.5</td>
<td>1.6</td>
<td>25.4</td>
</tr>
</tbody>
</table>
Air Voids
  * 7.0 +/- 0.5%

PG 58-28 Neat
  * 131.8 psi    104.2 psi    TSR = 0.79

PG 58-28 Asphalt Extender
  * 110.6 psi    99.5 psi    TSR = 0.90
Hamburg Rut Test

![Graph showing measured rut depth (mm) vs. number of passes. The graph includes lines for 58-28 Neat Average, 58-28 VTB Average, and Failure Criteria. The y-axis represents measured rut depth in millimeters, ranging from 0 to 14, and the x-axis represents number of passes, ranging from 0 to 7500.]
Dynamic Modulus

Dynamic Modulus @ 10Hz

- PG 58-28 Neat 4C
- PG 58-28 VTB 4C
- PG 58-28 Neat 30C
- PG 58-28 VTB 30C
- PG 58-28 Neat 40C
- PG 58-28 VTB 40C

Dynamic E-Modulus (MPa)
Conclusions

* Metals (zinc) can be used to identify Asphalt Extender
* Polycyclic Aromatic Compounds considerably below high level
* No significant difference in molecular weight
Conclusion, cont’d

* Same grade for
  * 9% Asphalt Extender
  * 80% PG 52-28
Conclusions, cont’d

* Tensile Strength Ratio
  * Better for PG 58-28 Asphalt Extender

* Rutting Resistance
  * Same for Asphalt Extender Binder and Neat Binder

* Stiffness
  * Same for both mixes
Conclusions, cont’d

- Asphalt Binders Similar
- Mixtures Perform Similarly

- To be “Done”
  - Extended Aging
  - Fatigue Cracking
  - Low Temperature Cracking
Road to the Future

- AASHTO
- FHWA
- Asphalt Institute
- Expert Task Groups
  - Asphalt Binder
  - Asphalt Mixture
Final Thoughts

Working Together
We Find the Answers
THANK YOU