Asphalt Emulsion Residue Recovery: State of the State

Andrew Braham, P.E.
Assistant Professor
University of Arkansas
Wednesday, February 24, 2016
Asphalt Emulsion Recovery

- Significance
- History
- The current standard
- Newer developments

(www.pavementinteractive.org)
Significance

• In-service asphalt emulsion applications designed for binder residue only
• Must develop ways to simulate evaporation of water, breaking of emulsion in the laboratory – this allows for:
  • Determination of amount of asphalt (non-water) phase
  • Further testing of residue
• Do not want to damage/change residue during recovery
• Various stages of interest for residue
Stages of interest

- Time = 0: initial residue binder immediately after water evaporation
- Time = 1 year: stabilized binder with no volatile fractions (for fluxing)
- Time = 2-5 years: mature binder after several years of service
- Time = 7-10 years: long-term field performance
Asphalt Emulsion Recovery

- Significance
- History
- The current standard
- Newer developments

(heartlandasphaltmaterials.com)
History

- Transportation Research Circular E-C122 (October 2007)
- Various recovery methods
  - Evaporation: lower temperature, higher surface area heating
  - Boiling: higher temperature, lower surface area heating
  - Chemically

Can google: trb ec122
Evaporation

- EN 13074: 1 day ambient, 1 day 122°F; 0.039 in. thick
- EN 14895: 1 day ambient, 1 day 122°F, 1 day 185°F; 0.039 in. thick
- NF T66-031 (French): 14 days 122°F; 0.039 in. thick
- Weathering rack: 50 g samples, thin film oven pans, 2-7 days at ambient
- Dehydrator: 10 g samples, thin film oven pans, 1-3 days at ~160°F

Want to prevent skin from forming
Thin film oven pan – same as PAV pan

(pavementinteractive.org)
Boiling

- ASTM D6997/EN 1431: 200 g in distillation tower, 500°F for 15 minutes
  - Obtain aqueous phase and volatile fractions
  - Have been reduced to 350 and 400°F to reduce damage to polymers
  - Vacuum distillation further reduces temperature to 275°F
- ASTM D6934/Spanish NLT-147: 50 g emulsion in 600-ml beaker, 325°F for two hours
- Belgian 08-34: 1 L emulsion in 2 L beaker, 325°F until all water gone
Standard distillation method for emulsified asphalts
Chemical

- Ethanol precipitation
  - Partial to complete separation of emulsifier, complete separation of water
  - Ethanol added to emulsion, asphalt “lump” forms, lump compressed, rinsed, and dried at 284°F until no more air bubbles
- Stirred air flow test with nitrogen (SAFT with nitrogen)
  - SAFT test setup with nitrogen instead of air
  - 300 g sample at 219°F, 1 hour
Stirred air-flow test apparatus
General pros and cons

- Evaporation – least damaging to base binder; longer recovery times
- Boiling – larger residue samples; can damage binder, polymers, additives
- Chemically – short recovery time; but need additional materials
- Some of these pros and cons can be seen visually
Ultraviolet microscope observation

(a) Initial SBS modified binder
(b) Evaporation (1 day 122°F, 1 day 185°F)
(c) Boiling (1 L emulsion, 325°F)
(d) Pressure aging vessel (PAV)

(the width of the photo is equivalent to about 250 µm)
Asphalt Emulsion Recovery

• Significance
• History
• The current standard
• Newer developments
The current standard

• Transportation Research Circular E-C182 (January 2013)


• Three sections of particular interest
  • Asphalt Emulsion Residue Recovery Update
  • Development of New Viscosity and Residue Recovery Standards at ASTM International
  • Techniques for Accelerating Recovery of Asphalt Emulsion Residues at 60°C (140°F)
Asphalt Emulsion Residue Recovery Update

- Challenges with use of latex and polymers
- Moving away from higher temperature (350 – 500°F) to lower temperature (140°F)
- Want to mimic field applications temperatures as closely as possible
- Two recently approved techniques highlighted
  - AASHTO PP72 Method A (from EN 13074) – essentially identical to ASTM D7497
  - AASHTO PP72 Method B (from TxDOT)
AASHTO PP72 Method A

- 1.5 – 2.0 kg/m² - similar thickness to chip seal application
- Silicone mat
- 24 hours at 77°F then 24 hours at 140°F
- Reduce skin formation
AASHTO PP72 Method B

- 0.015 in. thickness – similar to fog seal/tack coat application
- Silicone mat
- 6 hours at 140°F
New Viscosity and Residue Recovery Standards

- Utilizes Moisture Analyzer Balance (MAB)
- 4 grams of emulsified asphalt
- 325°F → 20 minutes; 212°F → 90 minutes
- Can place asphalt emulsion directly on silicon mold for DSR Superpave binder testing
- Promising results to date, more validation needed
Moisture Analyzer Balance: ASTM D7404
Techniques for Accelerating Recovery of Asphalt Emulsion Residues at 60°C (140°F)

- 140°F with vacuum for three hours
- Looking to minimize oxidation due to force draft air over large surface
- Hydrochloric acid (often in higher percentage than emulsifier) can stiffen asphalt – increased influence with forced draft air
- Promising results to date, more validation needed
Sample in vacuum oven

(E-C182)
Asphalt Emulsion Recovery

- Significance
- History
- The current standard
- Newer developments
University of Wisconsin, 2012

- Utilized ASTM D7497 Method B for residue
- 0.015 in. thickness, 140°F in forced-draft oven for six hours
- Selected over ASTM D7497 Method A to reduce amount of curing time required
- Stated “further research is needed to evaluate reproducibility of ASTM D7497 Method B’s residue recovery method”
- In 2013 – bumped oven temperature up to 158°F: no adverse effects
Western Research Institute, 2013

- Compared AASHTO PP72 Method B to Simple Aging Test (SAT)
  - AASHTO PP72 Method: 0.015 in. thickness, 6 hours at 140°F
- Two forms of Simple Aging Test (SAT)
  - Emulsion placed on SAT plate to obtain 0.015 in. residue, then
    - a) placed in force draft oven, 6 hours at 140°F
    - b) placed PAV aging for 8 hours at 20 atm
- SAT softer than AASHTO PP72 residues at lower temperatures, but reversed at intermediate temperatures
Texas A&M, 2013

- Utilized AASTHO PP72 for residue
  - 0.015 in. thickness, 6 hours at 140°F
- Recovery time shorter than Method A
- Less oxidation in residues by Method B from Fourier transform infrared spectra analysis
- Similar water removal between Methods A and B
Western Research Institute, 2014

- Three methods utilized “industry’s struggle to develop standard method”
  - AASTHO PP72 for residue, 0.015 in. thickness, 6 hours at 140°F
  - SAT plates – 0.015 in., 140°C for two hours at 0.74 atm vacuum (PAV = 20 atm)
  - SAT plates – forced draft oven at 140°C for six hours
- Each method removed adequate quantity of water
- “More time in oven may be necessary to ensure ruggedness for all asphalt emulsions”
Louisiana Tech, 2015

- Five recovery methods explored
  - ASTM D7497 – 0.059 in. thick, 24 hours 77°F, 24 hours 140°F
  - ASTM D6934 – 50 g, 2 hours 325°F, stirred, 1 hours 325°F
  - AASHTO TP 72 Method B - 0.015 in. thick, silicone mat, 6 hours 140°F
  - Vacuum drying method - 0.059 in. thick, 3 hours 140°F, 0.06 atm (PAV = 20 atm)
  - Field curing method – outside, 0.059 in. thick, 48 hours (sun, 78.8°F, 58% humidity)
- Vacuum “most efficient low temperature evaporation method”
Asphalt Emulsion Recovery – summary

- Time – want to minimize recovery time
- Money – equipment needs
- Temperature – balancing speed versus residue integrity
- Thickness – higher surface area desired to decrease time
- Plate surface – silicon mat or metal?
- Pressure – is pressure necessary?
University of Arkansas

Andrew Braham, P.E.
Assistant Professor
4190 Bell Engineering Center, Fayetteville, AR 72701
afbraham@uark.edu
479-575-6028
www.andrewbraham.com