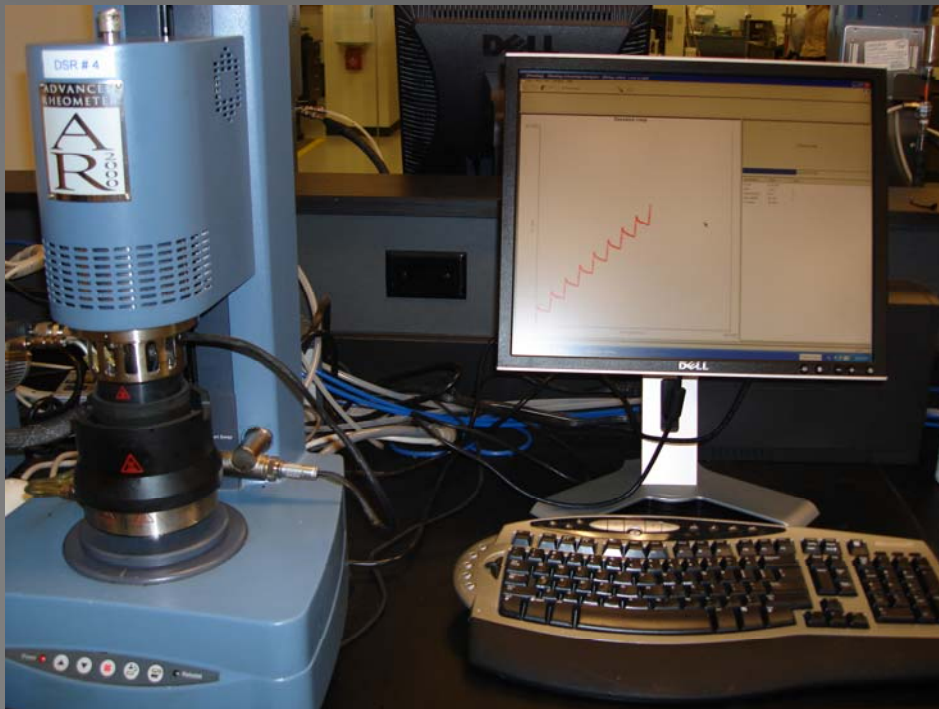




Using DSR-MSCR to Compare Emulsion Residue Recovery Methods

AEMA ITC Update of Presentation made to the TRB 2009 Annual Meeting Session 791



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Presentation Outline

- ◆ **Compare Distillation vs. Evaporation Recovery Methods**
 - Modified ASTM D6997 distillation procedure
 - BASF Oven Evaporation technique
- ◆ **Dynamic Shear Rheometer Data**
 - Original DSR and Phase Angle at various temperatures
 - Multiple Stress Creep Recovery data
- ◆ **Conclusions/Recommendations**

Distillation Procedure

◆ **Modified ASTM D6997 procedure**

- 177°C (350°F) temperature
- Hold for 20 minutes

◆ **Issues**

- Temperature is greater than the pavement temperatures
- Polymer affected by higher residue recovery temperature

Distillation Apparatus



Evaporation Procedure

◆ **BASF Procedure**

- Procedure similar to EN13074
- 60 grams in silicone mold
- 24 hours in 25°C forced air oven
- 24 hours in 60°C forced air oven
- ASTM balloted and approved (ASTM D7497)

◆ **Issues**

- 48 hours to get sample for testing
- Oven racks checked for level

Evaporation Setup



Recovery Technique Comparison

◆ **Base Asphalt Testing**

- Typical Emulsion Testing and Original DSR Testing

◆ **Residue Testing on Emulsions Manufactured from the Asphalt Bases**

- Distillation Technique
- Evaporation Technique
- Original DSR and MSCR Testing

Distillation vs. Base Asphalt Property Comparison

Traditional Emulsified Asphalt Residue Testing

Material	% Residue by Distillation (%)	Softening Point (°F)	Absolute Viscosity (Pa*s)	Penetration (dmm)
PGXX-34 (base)	x	94	38.6	301
PG58-28 (base)	x	103	131.7	136
PG64-22 (base)	x	113	302.1	73
PGXX-34 Emulsion (no latex)	64.7	93	45.2	304
PG58-28 Emulsion (no latex)	64.4	107	98.8	133
PG64-22 Emulsion (no latex)	65.9	119	261.6	75
PGXX-34 Emulsion (3.75% latex)	64.6	121	226.9	149
PG58-28 Emulsion (3.75% latex)	64.7	135	812.7	76
PG64-22 Emulsion (3.75% latex)	64.4	137	1591.5	46

Base Asphalt DSR Test Results

		Original DSR Testing on Base Asphalt							
		52°C		58°C		64°C		70°C	
Asphalt Grade	% L/P	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta
PGXX-34	0	0.9009	87.775						
PG58-28	0			1.501	86.82	0.7054	88.05		
PG64-22	0			3.1355	85.515	1.419	86.955	0.6913	88.025

Residue Comparison Distillation vs. Evaporation

Original DSR Testing on Residue from Distillation (350°F/177°C) @ 10rad/sec @ test temperature											
Emulsion	% Latex	52°C		58°C		64°C		70°C		76°C	
		g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta
PGXX-34 base	0.0	0.95985	87.39								
PG58-28 base	0.0			1.5755	85.88	0.7777	86.49				
PG64-22 base	0.0			3.6575	84.22	1.6635	85.78	0.80495	86.93		

Original DSR Testing on Residue from Evaporation (25°C 24 hour & 60°C 24 hour) @ 10rad/sec @ test temperature											
Emulsion	% L/P	52°C		58°C		64°C		70°C		76°C	
		g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta
PGXX-34 base	0.0	2.0485	84.74	0.93585	86.14						
PG58-28 base	0.0			2.408	84.92	1.119	86.45	0.546	87.55		
PG64-22 base	0.0			6.4015	82.25	2.854	84.40	1.324	86.16	0.6475	87.49

Residue Comparison vs. Base Asphalt

Original DSR Testing on Residue from Distillation (350°F/177°C) @ 10rad/sec @ test temperature											
		52°C		58°C		64°C		70°C		76°C	
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PG58-28	0			1.501	86.82	0.7054	88.05				
PG64-22	0			3.1355	85.515	1.419	86.955	0.6913	88.025		

Evaporation vs. Distillation Original DSR Results

3.75% Latex Polymer Modified Emulsion

Original DSR Testing on Residue from Evaporation (25°C 24 hour & 60°C 24 hour) @ 10rad/sec @ test temperature													
Emulsion	% LP	52°C		58°C		64°C		70°C		76°C		82°C	
		g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta
PGXX-34 base	3.75			3.283	67.79	1.913	67.96	1.174	66.98	0.772	64.70		
PG58-28 base	3.75			8.578	68.24	4.465	69.73	2.460	70.58	1.439	70.39	0.888	68.89
PG64-22 base	3.75			18.25	67.63	9.193	69.54	4.846	71.24	2.661	72.15	1.54	71.96

Original DSR Testing on Residue from Distillation (350°F/177°C) @ 10rad/sec @ test temperature													
Emulsion	% LP	52°C		58°C		64°C		70°C		76°C		82°C	
		g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta	g*/sin delta	delta
PGXX-34 base	3.75			2.354	67.09	1.3515	68.04	0.811	68.71				
PG58-28 base	3.75			5.567	68.96	2.9725	70.44	1.667	71.77	0.979	72.49		
PG64-22 base	3.75			11.26	67.64	5.890	69.05	3.210	70.74	1.806	72.31	1.067	73.23

Multiple Stress Creep Recovery Test (MSCR) Test

◆ Procedure being promoted to AASHTO

- % Recovered strain at 100 and 3200 Pa of stress
- Promoted to replace elastic recovery test

◆ Modifications for emulsion residue testing

- Tested on distillation and evaporation residue without the RTFOT aging

Multiple Stress Creep Recovery Evaporation vs. Distillation

% Recovery

Multiple Stress Creep Recovery Testing on Residue from Evaporation (25°C 24 hour & 60°C 24 hour)							
Emulsion	% Latex	58°C		64°C		70°C	
		100Pa	3200Pa	100Pa	3200Pa	100Pa	3200Pa
PGXX-34 LR	3.75	62.66	28.78				
PG58-28 LR	3.75	45.31	26.81	51.54	18.79		
PG64-22 LR	3.75			41.12	24.68	35.11	17.25

Multiple Stress Creep Recovery Testing on Residue from Distillation (177°C minute hold)							
Emulsion	% Latex	58°C		64°C		70°C	
		100Pa	3200Pa	100Pa	3200Pa	100Pa	3200Pa
PGXX-34 LR	3.75	70.21	31.67	70.09	22.79		
PG58-28 LR	3.75	48.27	27.66	47.07	19.40		
PG64-22 LR	3.75			41.8	21.57	41.14	14.22

Multiple Stress Creep Recovery Test (MSCR) Test

◆ Recent Developments

- J_{nr} – non-recoverable creep compliance
 - ◆ Determined by dividing the non-recoverable shear strain by the applied shear stress
- Promoted to eliminate grade bump for traffic levels

◆ Modifications for emulsion residue testing

- Tested on distillation and evaporation residue without the RTFOT aging

Multiple Stress Creep Recovery Test (MSCR) Test

- ◆ **Proposed specification levels for J_{nr}**
 - Standard Traffic (S) $J_{nr} \leq 4 \text{ kPa}^{-1}$
 - Heavy Traffic (H) $J_{nr} \leq 2 \text{ kPa}^{-1}$
 - Very Heavy Traffic (V) $J_{nr} \leq 1 \text{ kPa}^{-1}$
- ◆ **Very Heavy Traffic level possibly dropped to $\leq 0.5 \text{ kPa}^{-1}$**

MSCR J_{nr} Values Evaporation vs. Distillation

Multiple Stress Creep Recovery Testing on Residue from Evaporation (25°C 24 hour & 60°C 24 hour)

		58°C		64°C		70°C	
		Jnr kPa-1		Jnr kPa -1		Jnr kPa -1	
Emulsion	% Latex	.1 kPa	3.2kPa	.1 kPa	3.2kPa	.1 kPa	3.2kPa
PGXX-34 LR	3.75	0.615	1.457				
PG58-28 LR	3.75	0.568	0.892	1.110	2.298		
PG64-22 LR	3.75			0.686	0.980	1.550	2.417

Multiple Stress Creep Recovery Testing on Residue from Distillation (177°C minute hold)

		58°C		64°C		70°C	
		Jnr kPa-1		Jnr kPa -1		Jnr kPa -1	
Emulsion	% Latex	.1 kPa	3.2kPa	.1 kPa	3.2kPa	.1 kPa	3.2kPa
PGXX-34 LR	3.75	0.645	2.318	1.143	5.110		
PG58-28 LR	3.75	0.847	1.505	1.600	3.523		
PG64-22 LR	3.75			1.098	1.874	2.083	4.321

Chip Seal Emulsion Testing

Manufactured with a 3% Polymer Modified Base Asphalt

◆ **CRS-2P**

- Distillation Technique
- Evaporation Technique

◆ **HFRS-2P**

- Distillation Technique
- Evaporation Technique

Rheological Results

J_{nr} testing on Emulsions

Multiple Stress Creep Recovery Testing on Residue from Evaporation (25°C 24 hour & 60°C 24 hour)							
Emulsion	% L/P	58°C		64°C		70°C	
		Jnr kPa-1		Jnr kPa -1		Jnr kPa -1	
		.1 kPa	3.2kPa	.1 kPa	3.2kPa	.1 kPa	3.2kPa
CRS-2P (PMB2)	3.0P	0.611	0.763	1.315	2.016		
CRS-2P (CO)	3.0P	0.789	1.166	1.920	3.072		
HFRS-2P (ATX)	3.0P	1.027	1.640	1.768	3.409		
HFRS-2P (CO)	3.0P	4.489	6.595				

Multiple Stress Creep Recovery Testing on Residue from Distillation (177°C minute hold)							
Emulsion	% L/P	58°C		64°C		70°C	
		Jnr kPa-1		Jnr kPa -1		Jnr kPa -1	
		.1 kPa	3.2kPa	.1 kPa	3.2kPa	.1 kPa	3.2kPa
CRS-2P (PMB2)	3.0P	1.202	1.761	2.330	4.562		
CRS-2P (CO)	3.0P	1.613	2.396	4.056	6.248		
HFRS-2P (ATX)	3.0P	1.564	3.236	3.480	8.243		
HFRS-2P (CO)	3.0P	4.397	6.585				

Conclusions

- ◆ **Evaporation Recovery Method gives higher DSR values than distillation method even on unmodified asphalts**
- ◆ **Possible to utilize evaporative residue DSR testing to replace traditional testing such as penetration, absolute viscosity, or softening point.**
- ◆ **Questions on “performance” aspect of these changes need to be addressed**

Recommendations

- ◆ **Efforts need to be made on what are the appropriate ranges for testing parameters**
- ◆ **Understand the low temperature evaporation vs. the distillation residue differences**
- ◆ **Correlation needs to be made to performance testing based on the application (seal coat, micro-surfacing, fog seal, bond coat, etc.)**

“To educate a man in mind, and not in morals, is to educate a menace to society”

Theodore Roosevelt

Thank You



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