Emulsion Technology Trends

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Note: For narration of this presentation, click here to visit AMAP's technical library to download the PowerPoint show file.

Presentation Outline

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- Introduction of polymers used in asphalt emulsions
- Current testing of modified residues
- New test procedures for getting emulsion residues
- Trends in emulsion and residue testing

Polymers in Asphalt Emulsion Production

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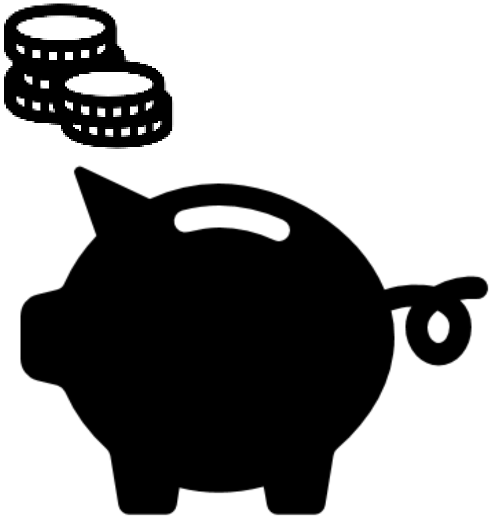
Polymer Modified Asphalt Emulsions Practical Benefits

- **Overall improvement in performance + durability**
- **Reduced life cycle cost**
  - **preventive maintenance**



Polymers for Asphalt Emulsion Modification

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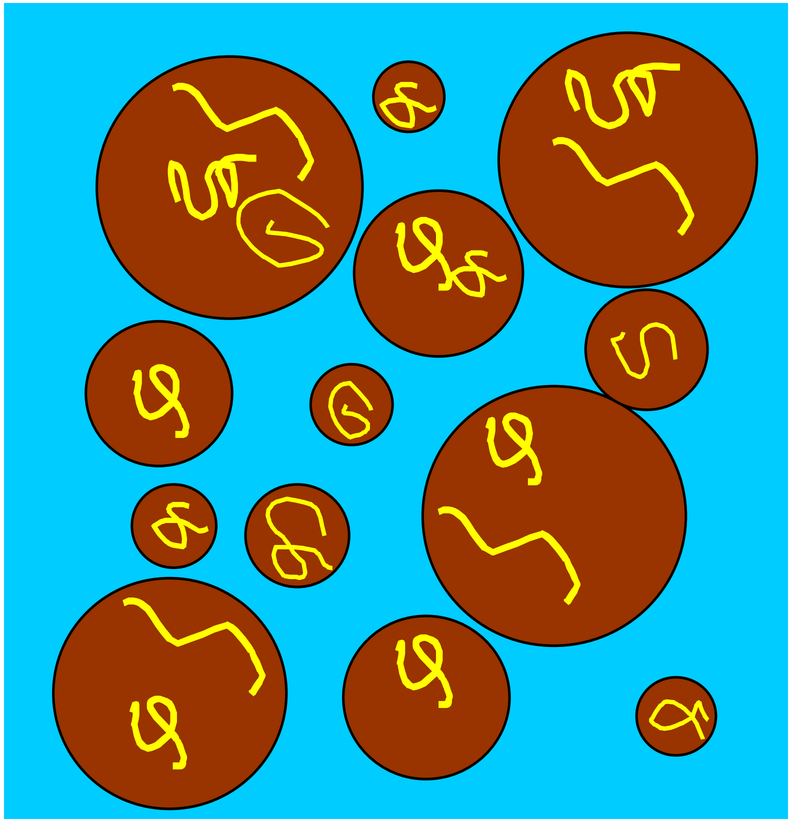
- **Dry**
  - SBS or SB
  - EVA
  - GTR or Crumb Rubber
- **Latex**
  - SBR
  - Neoprene
  - Natural Latex
  - Acrylics

5

Polymer Modification of Asphalt Emulsions

- **Emulsify polymer mod. asphalt**
  - "Pre-modified" emulsion
  - Polymers – SBS, SB-, EVA
  - Higher mod. asphalt viscosity
    - higher asphalt + mill temp.
  - Exit temp. > 100ºC
  - Heat exchanger, back press.
- **Polymer inside asphalt droplet**



Polymer Modification of Asphalt Emulsions

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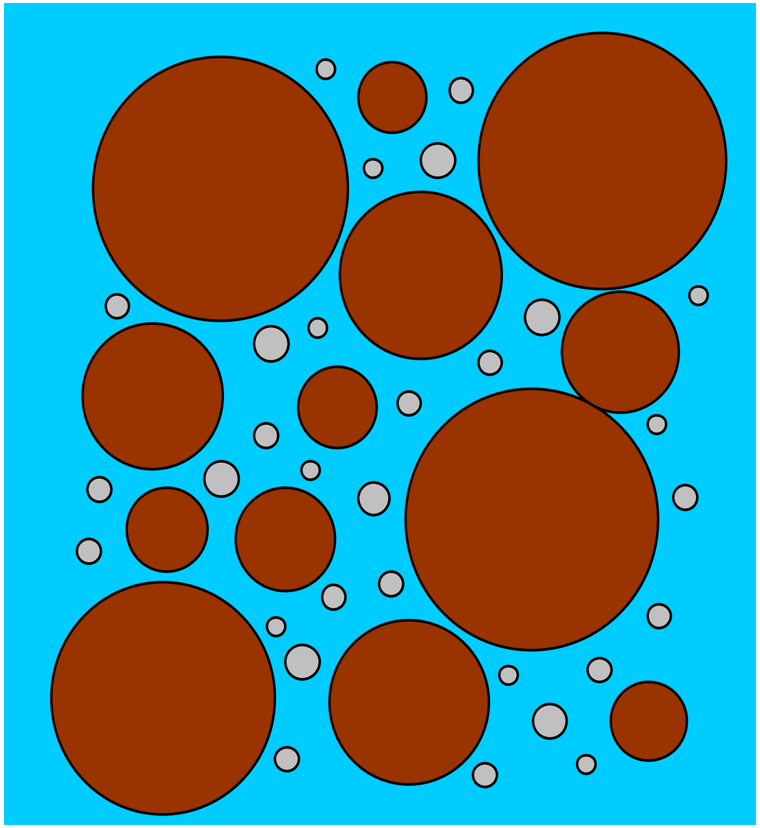
- **Add latex external to asphalt**
  - Methods
    - soap batching
    - co-milling – asphalt or soap
    - post addition
  - Polymers – SBR, Natural latex, Neoprene
  - Lower asphalt viscosity
  - No special mill, handling



- **Polymer in water phase**
- **Continuous polymer film formation on curing**

Residue Evaluation – Polymer Modified Asphalt vs. Latex Modified Emulsions

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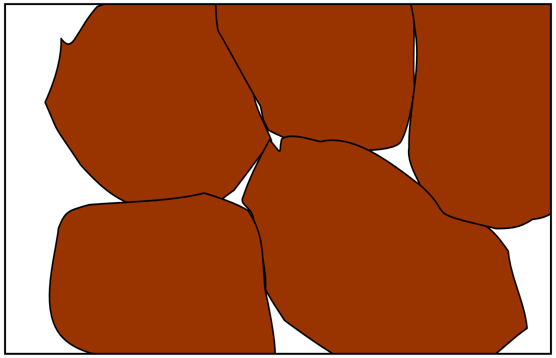
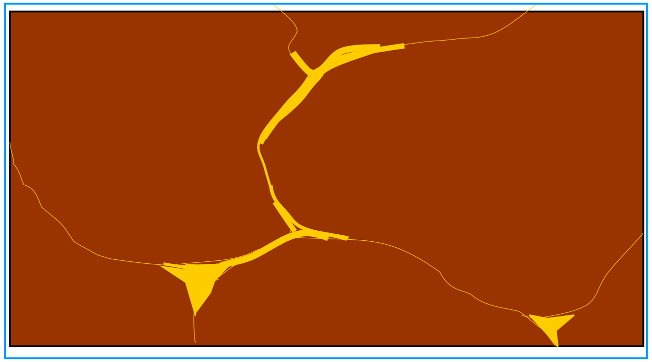
Dried emulsion residues (coalesced asphalt particles)

Neat asphalt



Latex modified emulsion



Emulsion of polymer modified asphalt

Asphalt rheology only

Improved binder properties
- Improved low temperature fatigue properties
- Reduced rutting at high temperature
- Improved early strength development

8

Current Testing of Modified Residues

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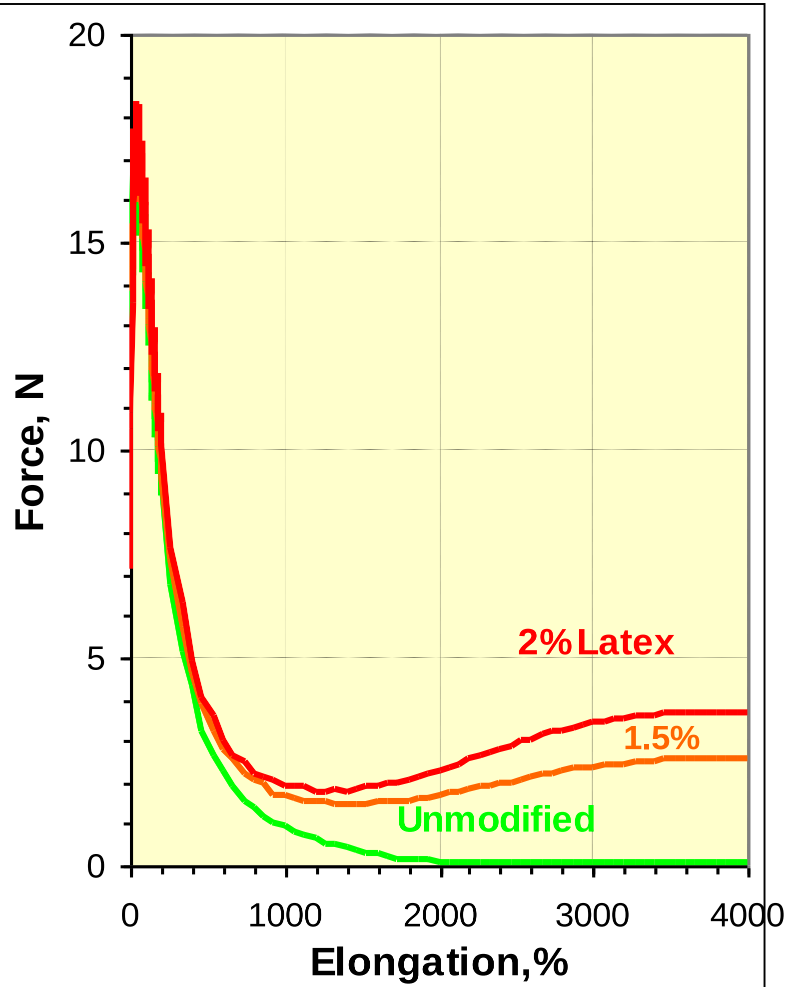
Traditional Testing

- **Force Ductility**
- **Softening Point**
- **Toughness/Tenacity**
- **Torsional Recovery**
- **Elastic Recovery**

Force Ductility



- **Stress-Strain measurement**
  - Easier temp. to measure stress and strain
    - large elongation at break
- **Faster elongation rate⇒Stronger elastic contribution**
  - Time-temp superposition
- **Elongation (Strain) = Permanent Deformation**
  - Area under the curve ∝ Total Energy Dissipated
  - Large Area = More work needed to make a permanent deformation = Less permanent deformation per traffic loading?
- **Does not represent traffic load**
  - Too high elongation
  - Cold Fracture<Temperature<Fatigue

New test procedures for getting emulsion residues

Creativity is problem solving with relevance and novelty.
Anonymous

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Residue Recovery

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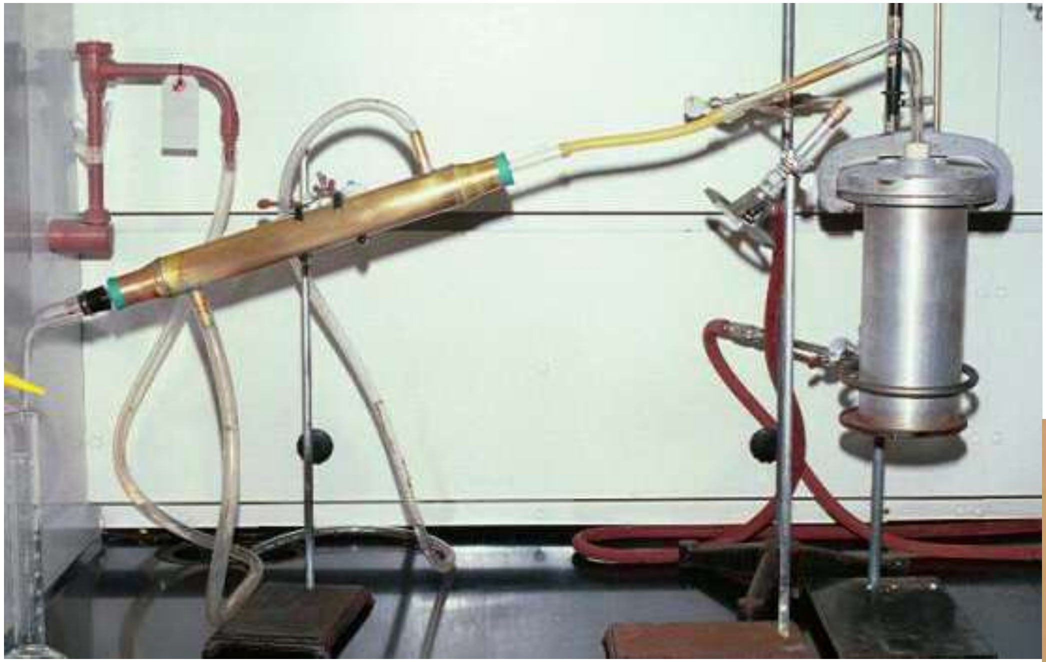

Residue Recovery by Distillation

Residue Recovery by Low Temperature Evaporation

Recovery Methods
(High Temperature)

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- **Distillation Recovery procedures**
  - **Modified ASTM D6997 to 350ºF or 400ºF with hold times either 15 or 20 minutes for modified emulsions**
  - **Temperatures can effect the polymers**
- **High Temperature Evaporative procedures > 275ºF**
- **Much higher than pavement temperatures that the emulsions see during application or service life**
- **Polymers can change or degrade in some of the high temperature recovery techniques**

Recovery Method Trends (Low Temperature)

- **AASHTO R78**
  - **Method A – 24 hour ambient/24 hour 60°C**
  - **Method B – 6 hour at 60°C**
- **ASTM Methods**
  - **D7497 – similar to AASHTO R78 method A**
  - **D7944 – similar to method B, but 3 hours in vacuum oven**
- **All methods use drawdown on silicone mats for ease of residue removal**

Trends in Emulsion Residue Testing

Ash Content vs. Solubility
Various methods in using the DSR for emulsion residues
Sweep test comparison
Tackiness Test
High float residues

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Ash Content test for emulsion residues

- **Solubility test does not work well with modified emulsion residues.**
  - Plugs filter due to polymer swell
  - Solubility test was not designed for polymer systems
- **Ash content test performs well on all emulsion residues, whether they are modified or not**
  - ASTM Standard D8078
- **Getting rid of solubility will remove a chlorinated solvent from some laboratories**

Examples of Ash Content vs. Solubility

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- One agency uses solubility for unmodified emulsion residues and ash content for modified emulsion residues
  - Solubility of 97.5% minimum for unmodified emulsion residues
  - Ash content of 0.2% maximum for modified emulsion residues

- Example of solubility not working
  - Agency specification requiring minimums of 8% GTR and 2% SBS for a modified asphalt
  - Specification of 97.5% minimum solubility
    - How can this possibly be met?

Trends in Emulsion Residue Testing

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DSR Testing as viscosity alternative – Comparing residue recovery

SHRP TEST REPORT FORM		SHRP SPECS			
Sample #			*7527*	*7528*	*7529*
Recovery Method			**LTR-A**	**LTR-B**	**LTR-BV**
Tests on unaged material:	**°C**	**Spec Limit**			
Phase Angle (delta)	58		75.3	74.9	76.9
G*/sin delta @ 10 rad/sec,kPa	58	1.0 min.	11.32	13.24	7.61
Phase Angle (delta)	64		77.6	77.2	78.4
G*/sin delta @ 10 rad/sec,kPa	64	1.0 min.	5.50	6.39	3.75
Phase Angle (delta)	70		79.3	78.8	79.2
G*/sin delta @ 10 rad/sec,kPa	70	1.0 min.	2.75	3.22	1.94
Phase Angle (delta)	76		80.3	79.7	79.4
G*/sin delta @ 10 rad/sec,kPa	76	1.0 min.	1.43	1.69	1.05
Phase Angle (delta)	82		80.5	79.8	79.1
G*/sin delta @ 10 rad/sec,kPa	82	1.0 min.	0.79	0.94	0.60
SHRP Grade			**79.6**	**81.3**	**76.5**

Similar Polymer – Micro-surfacing Residue

DSR Testing as viscosity alternative – Comparing residue recovery

AASHTO Method A and B along with 350ºF Distillation

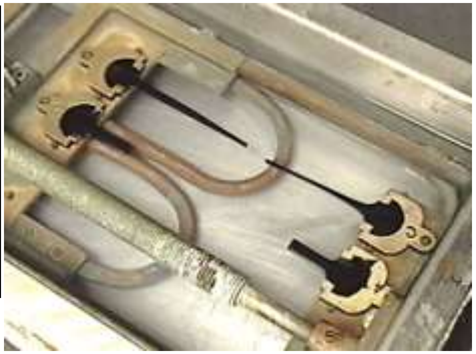
			24h air dry 24h 60C oven		thin film 6h 60C oven		ASTM 6997 20 min hold	
SHRP TEST REPORT FORM		**SHRP SPECS**						
Modifier			Polymer A	Polymer B	Polymer A	Polymer B	Polymer A	Polymer B
Tests on unaged material:	**°C**	**Spec Limit**	**AUT-W301**	**Aut W 414**				
Phase Angle (delta)	52		73.4	61.2	72.1	61.8	68.8	66.0
G*/sin delta @ 10 rad/sec,kPa	52	1.0 min.	7.77	7.85	9.38	6.05	5.76	2.98
Phase Angle (delta)	58		75.4	61.8	74.3	62.9	69.6	66.9
G*/sin delta @ 10 rad/sec,kPa	58	1.0 min.	4.04	4.32	4.73	3.27	2.98	1.63
Phase Angle (delta)	64		76.9	63.2	75.7	64.7	69.9	57.9
G*/sin delta @ 10 rad/sec,kPa	64	1.0 min.	2.14	2.47	2.50	1.83	1.65	0.90
Phase Angle (delta)	70		77.7	65.2	76.2	67.0	69.7	
G*/sin delta @ 10 rad/sec,kPa	70	1.0 min.	1.18	1.40	1.37	1.04	0.98	
Phase Angle (delta)	76		77.8	68.0	75.9	69.8		
G*/sin delta @ 10 rad/sec,kPa	76	1.0 min.	0.68	0.81	0.79	0.61		

Two different polymers – chip seal emulsion residue

DSR Testing – Polymer comparison
Elastic Recovery and Sweep Testing

Elastic Recovery @10ºC – 350ºF Distillation Residue

SAMPLE #	AUT- W	Reference	*Polymer A*	*Polymer B*
ER 10C SS 20cm 5mn, %	103	D113 Mod	70.0	78.8
ER 10C SS 20cm 5mn, %	103	D113 Mod	70.0	78.8
ER 10C SS 20cm 5mn, %	103	D113 Mod	70.0	77.5
AVG			**70.0**	**78.3**



Sweep Testing @35ºC

Sweep Testing			Polymer A	Polymer B
Mass loss % - **2.0** hours	D-7000 - mod		12.05	28.09
Mass loss % - **2.0** hours	D-7000 - mod		20.36	28.32
AVG			**16.2**	**28.2**

Mass loss % - **1.0** hour	D-7000 - mod	**44.8**	**44.6**

DSR Testing on Scrub Seal Residues

SHRP TEST REPORT FORM		SHRP SPECS		
Base Asphalt			Blend	Blend
Grade			81.2/18.2	81.2/18.2
Modifier			**Polymer A**	**Polymer B**
% Modifier			3.5	3.5
Tests on unaged material:	°C	Spec Limit		
Phase Angle (delta)	46		80.3	78.7
G*/sin delta @ 10 rad/sec,kPa	46	1.0 min.	5.08	4.21
Phase Angle (delta)	52		78.8	78.7
G*/sin delta @ 10 rad/sec,kPa	52	1.0 min.	2.29	1.92
Phase Angle (delta)	58		79.0	77.7
G*/sin delta @ 10 rad/sec,kPa	58	1.0 min.	1.11	0.98
Phase Angle (delta)	64		78.0	
G*/sin delta @ 10 rad/sec,kPa	64	1.0 min.	0.58	

Two Different Polymers – LTR - A

DSR Testing for Tackiness

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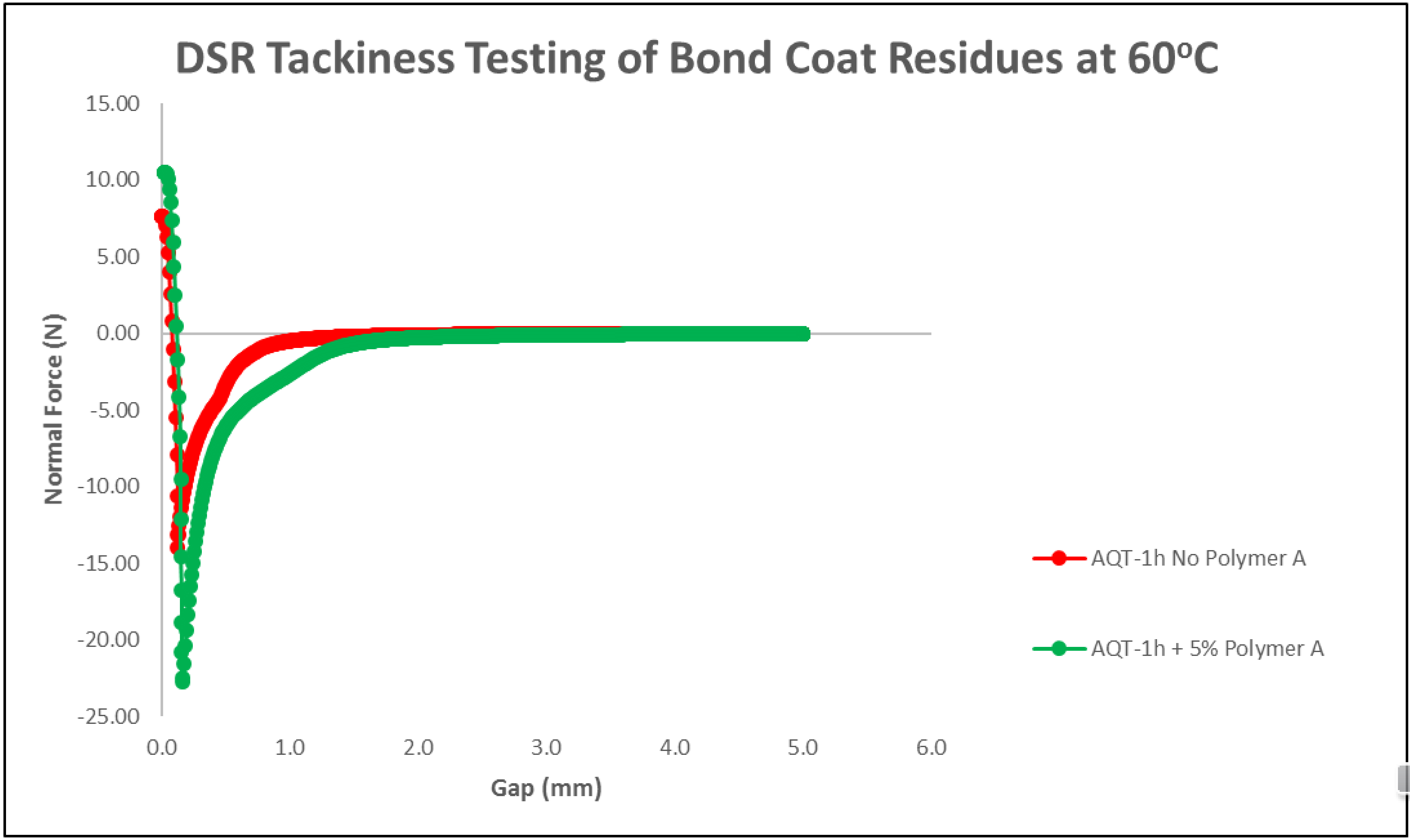
ASTM Procedure in the balloting process



High Float Emulsion Distillation (Al Tube)

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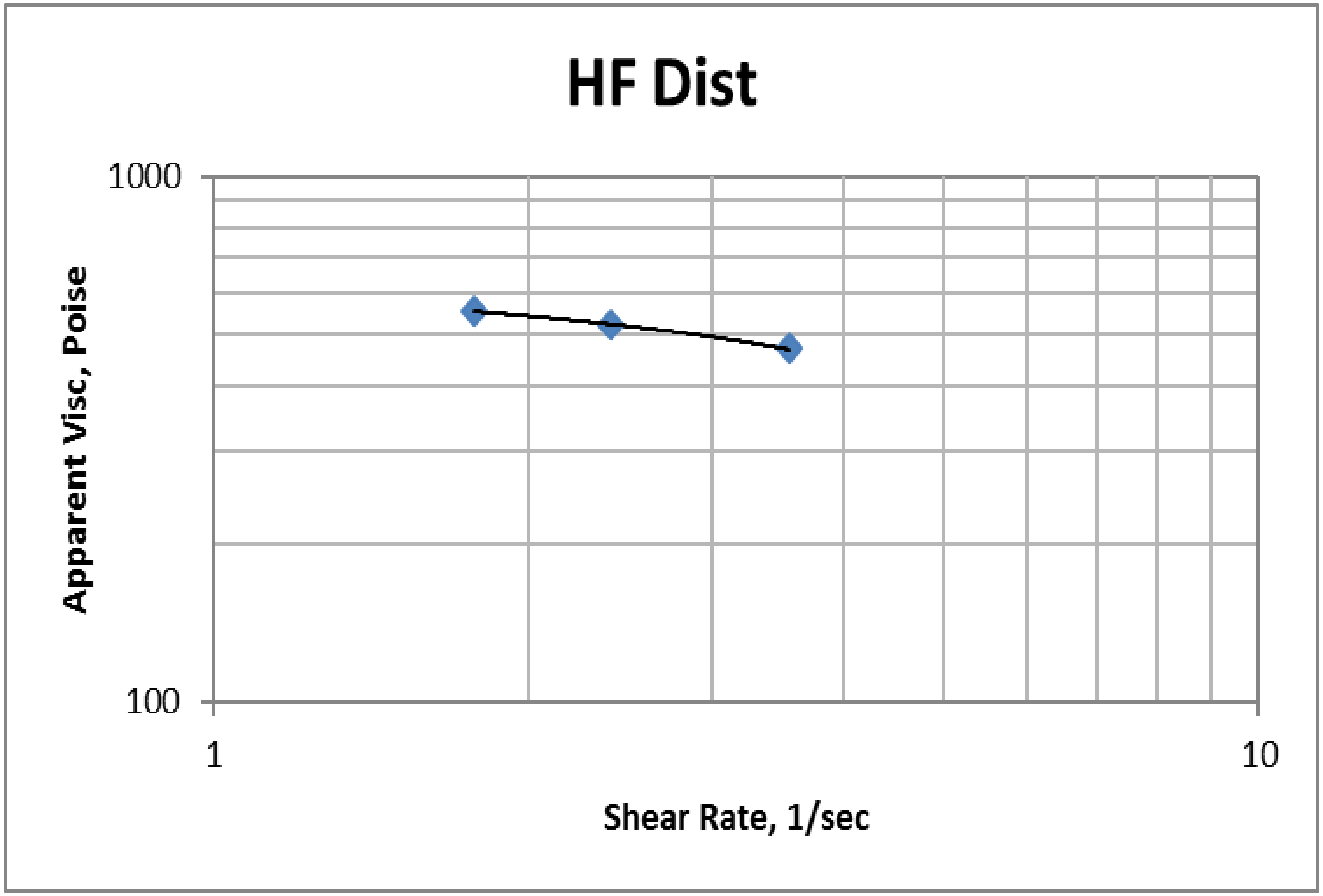
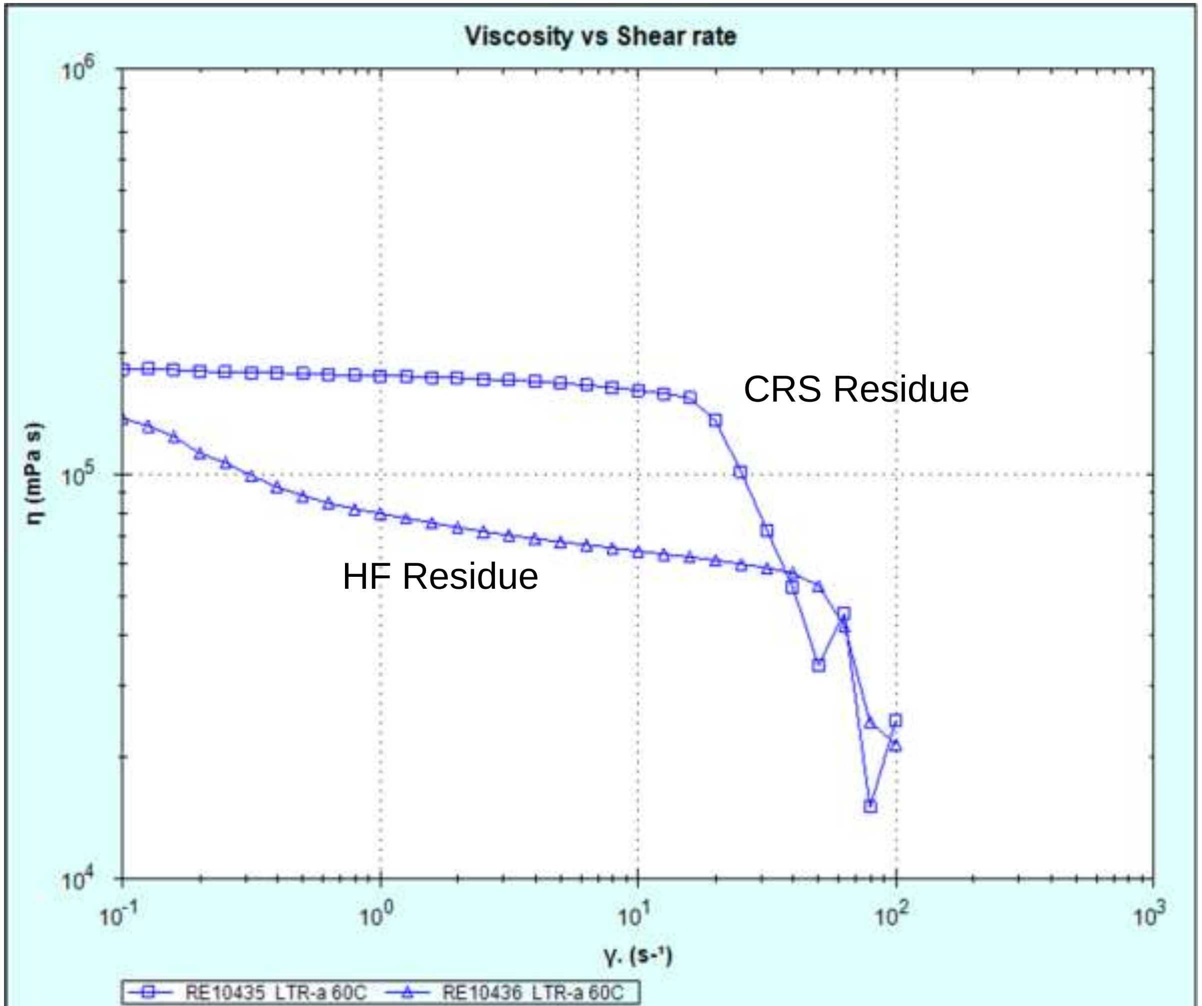


DSR Testing – Comparing CRS and HF Residues (LTR-A or D7497)



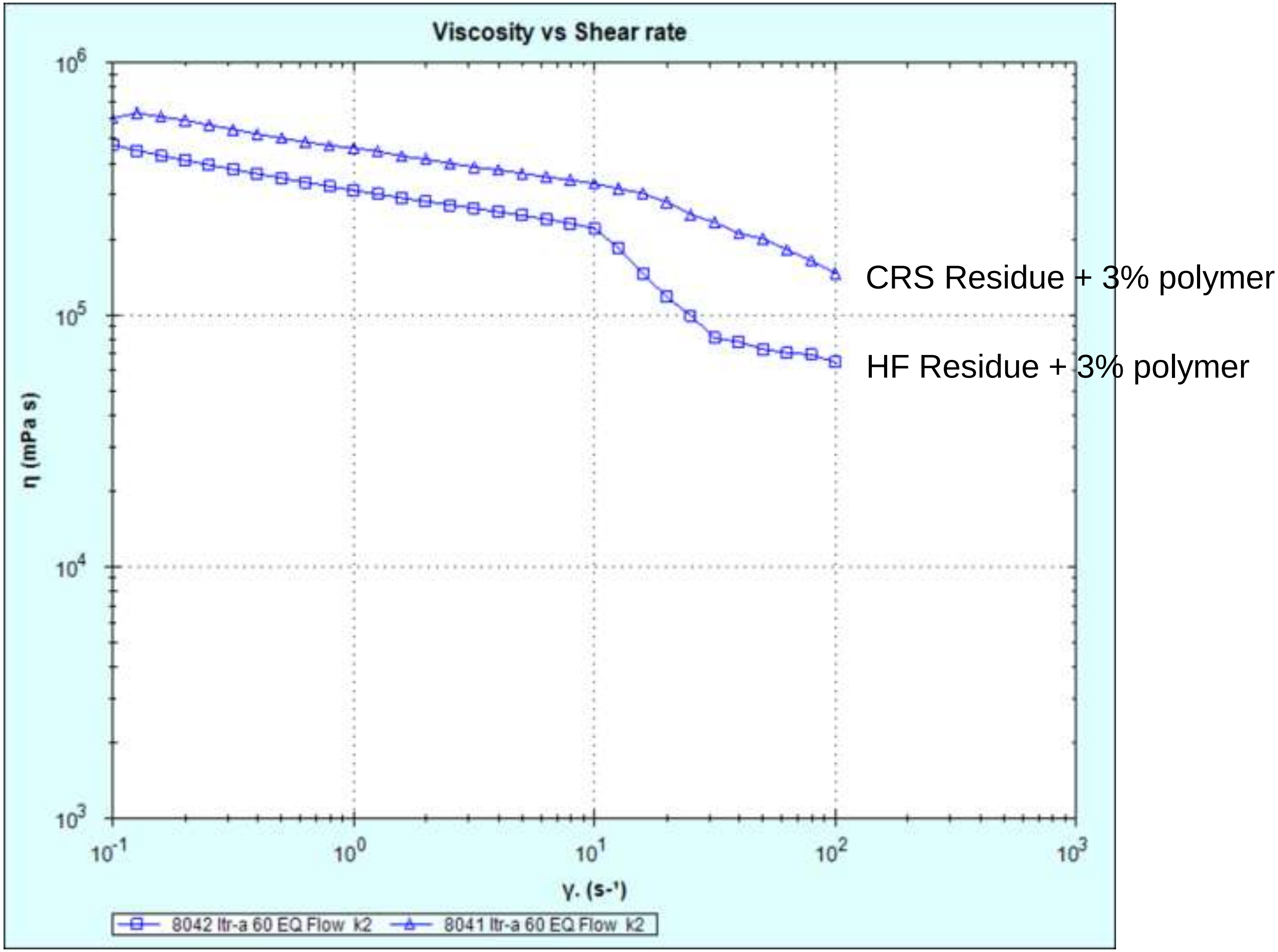
CRS Before

CRS After

HF Before

HF After

DSR Testing – Comparing Modified CRS and HF Residues (LTR-A or D7497)



Questions?

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Bill Kirk – BASF Charlotte Technical Center
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We cannot solve our problems with the same level of thinking that created them.
Albert Einstein