

Asphalt Rubber



Understanding Modified Asphalt Binder Technology
Workshop

Julie Kliewer, PhD, PE

Objectives

- ▶ Understand what differentiates the different types of asphalt rubber materials
- ▶ Know ADOT specification philosophy as applied to asphalt rubber
- ▶ Know what affects the final properties of asphalt rubber
- ▶ Know asphalt rubber specification tests and their purpose

What is Crumb Rubber Modified Asphalt

- ▶ No easy answer
 - diverse recycled rubber sources
 - diverse processes and technologies
 - diverse opinions and perceptions
 - a moving target
- ▶ Sort of like “what is polymer modified asphalt”

Overview of CRM Technology

Material

Process

Technology

Product

Crumb
Rubber

Wet

On-site blend

Terminal blend

Other

Modified
Binder

Dry

Plus Ride

Generic

Others

Rubber
Aggregate

**Let's focus
on binders
modified
with rubber...**



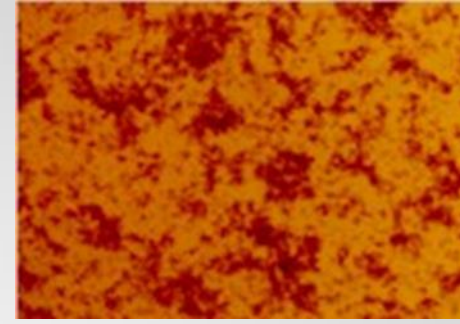
Asphalt Rubber Binder

- ▶ ASTM D6114 – blend of paving grade asphalt cements, ground recycled tire (vulcanized) rubber and other additives for use as a binder in pavement construction; rubber is blended/interacted in hot asphalt cement sufficiently to cause swelling of the rubber particles prior to use...this is “asphalt rubber”
 - traditional wet process AR such as used by ADOT, COP, MAG, BIA, etc.
 - historically blended on-site, occasionally in a terminal
- ▶ Terminal blended rubberized asphalt
 - aka “TR” products

Rubber in Asphalt Systems

- ▶ Rubber as an asphalt binder modifier
- ▶ Particulate systems (non-homogeneous)
 - ADOT Section 1009 (COP, MAG, etc.) for HMA or chip seals
 - ~20% rubber in paving asphalt
 - Polymer Modified Asphalt Rubber (PMAR) for chip seals
 - 15% ADOT Ty B rubber + 2-3% SBS in PG 64-16
 - Rubber Asphalt Binder (RAB) for chip seals or HMA
 - 10% #30 rubber + 2-3% SBS in PG 64-16
- ▶ Non-Particulate systems (homogeneous)
 - ADOT PG 76-22TR+ for HMA
 - 8-10% rubber + 1-3% SBS
 - AC-15-5TR (ADOT PG 64-28 TR+) for chip seals
 - 5% rubber + 1-3% SBS

Additives



- ▶ Used in conjunction with crumb rubber to facilitate manufacture or performance
 - Polymers – high temperature performance
 - Anti-stripping agents/coating enhancers – mitigate moisture damage, ravelling
 - Extender Oils – facilitates rubber/asphalt reaction; aromatic oils help compatibilize rubber and asphalt
 - High Natural Rubber – fatigue performance, high temperature performance

ADOT Asphalt Rubber (Section 1009)

- ▶ Use PG asphalt cement
 - CRA Ty 1: PG 64-16 desert
 - CRA Ty 2: PG 58-22 mid-zone
 - CRA Ty 3: PG 52-28 alpine
- ▶ Crumb rubber
 - Ty A: chip seal (deleted from ADOT specs)
 - Ty B: hot mix

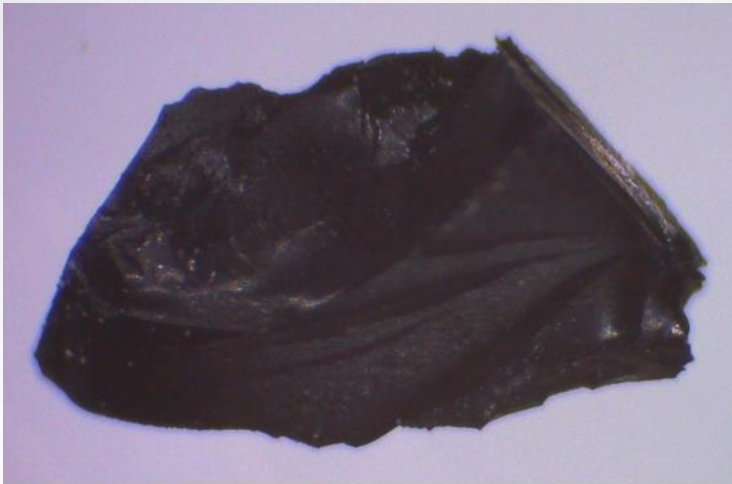
ADOT Asphalt Rubber Specs

Property	CRA 1	CRA 2	CRA 3
Grade of AC	PG 64-16	PG 58-22	PG 52-28
Rotational Vis, 350 F, Pa-S	1.5 – 4.0	1.5 – 4.0	1.5 – 4.0
Pen @ 39.2 F, dmm, min	10	15	25
Softening Point, C	57	54	52
Resilience @ 77 F, % min	25	20	15

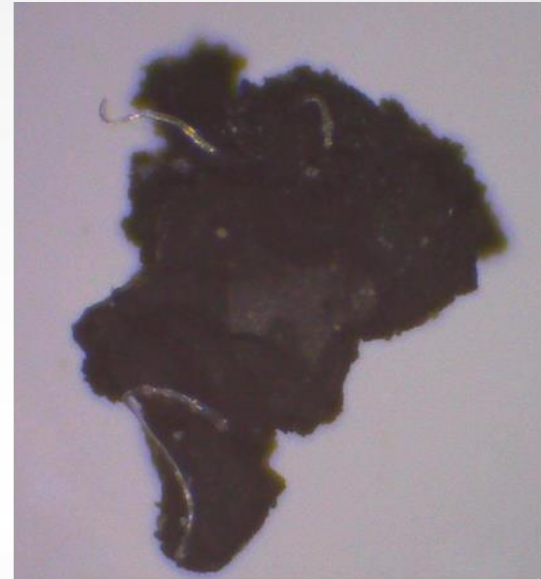
ADOT Rubber Specs

Sieve Size	Type A	Type B
No. 8	100	
No. 10	95 - 100	100
No. 16	0 - 10	75 - 95
No. 30		30 - 60
No. 50		5 - 30
No. 200		0 - 5

Rubber Grinding Methods



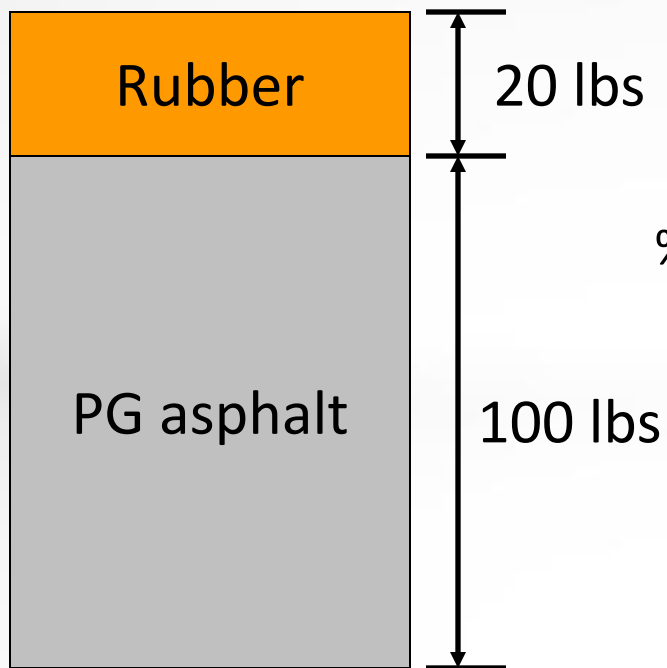
“cryo” grind



“ambient” grind

ADOT Proportions

- ▶ Minimum 20% rubber by weight asphalt cement



$$\% \text{ rubber} = (20/100) \times 100\% = 20\%$$

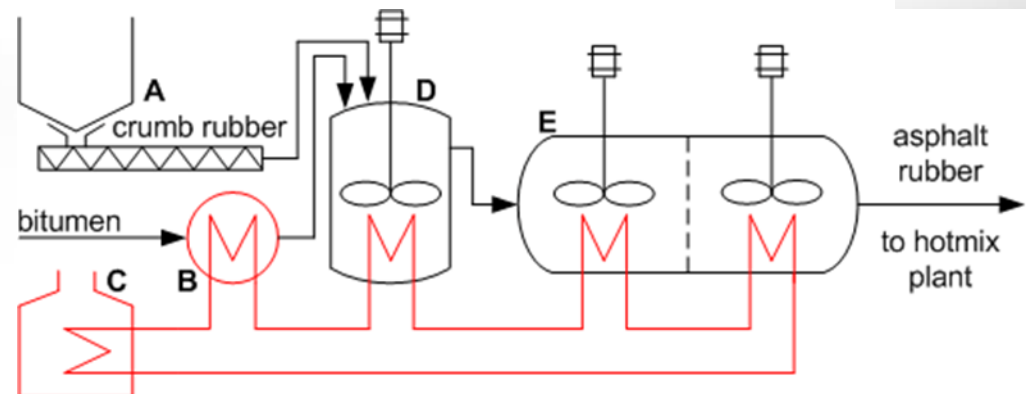
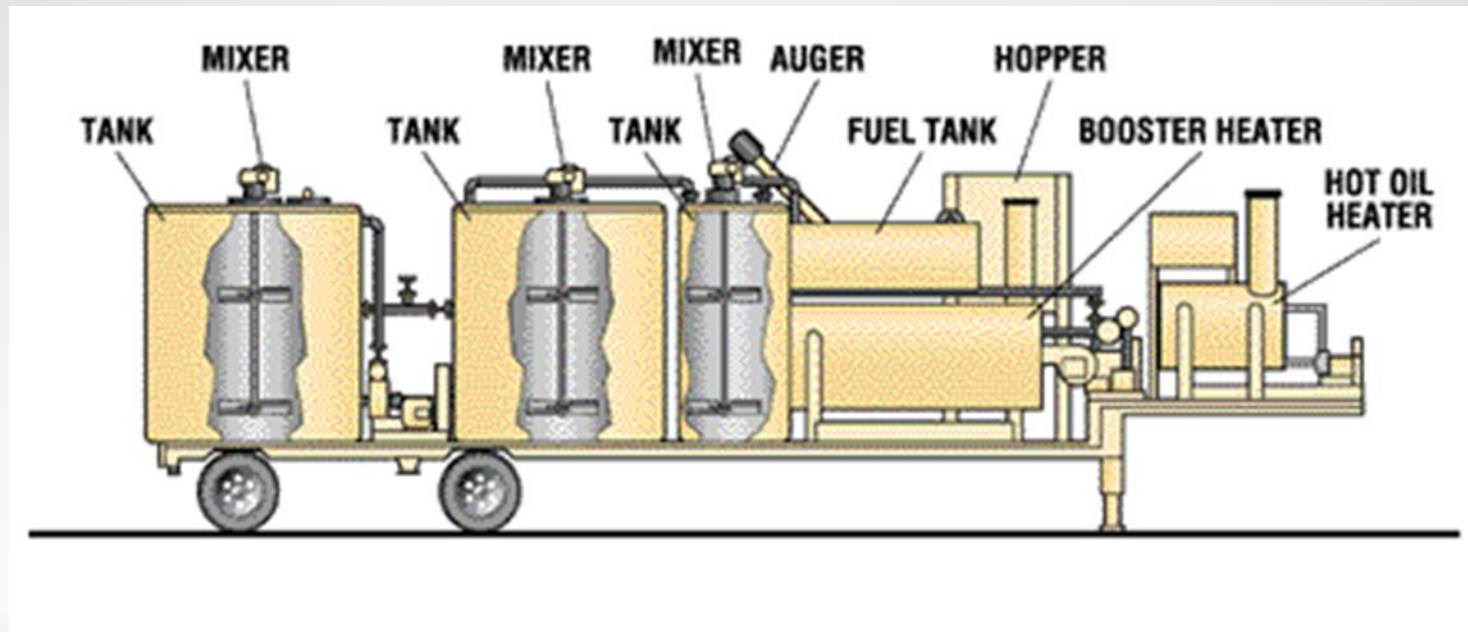
or

$$\% \text{ rubber} = (20/(20+100)) \times 100\% = 16.7\%$$

Rubber Blending Systems



Rubber Blending Systems



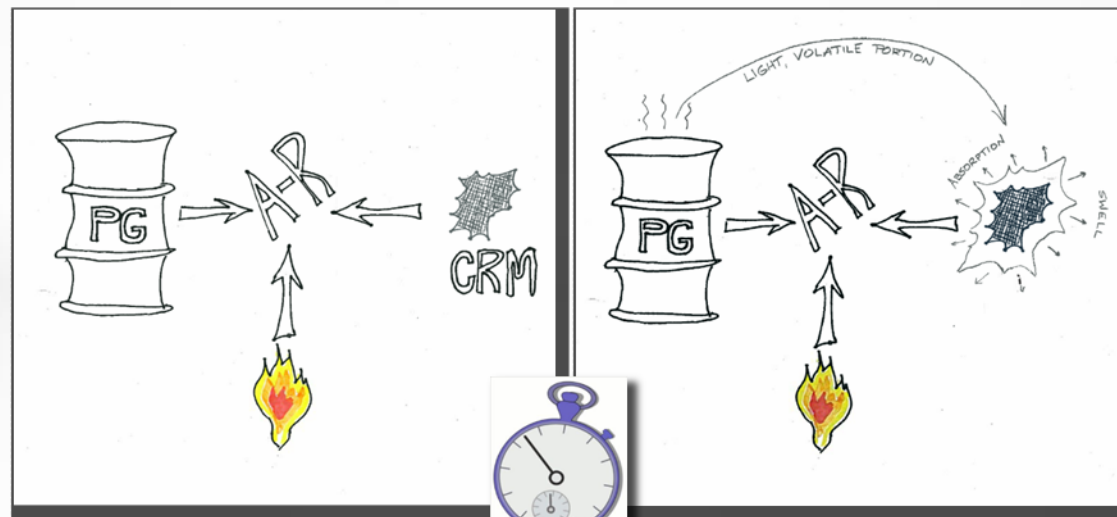
Manufacturing Parameters

- ▶ Mixing
 - 350° – 400° F binder when rubber added
 - react 325° – 375° F for 1 hour
 - test rotational vis
- ▶ Handling
 - thorough agitation
 - 325° – 375° during mix production
 - Max hold time 10 hrs above 325° F
 - only 1 cool/reheat cycle allowed
 - max 4 days above 250° F allowed

The Reaction Process

(Theory of AR Manufacture)

- ▶ During the reaction period
 - light fractions migrate from asphalt to rubber
 - rubber particles swell (4x original size)
 - viscosity of asphalt increases



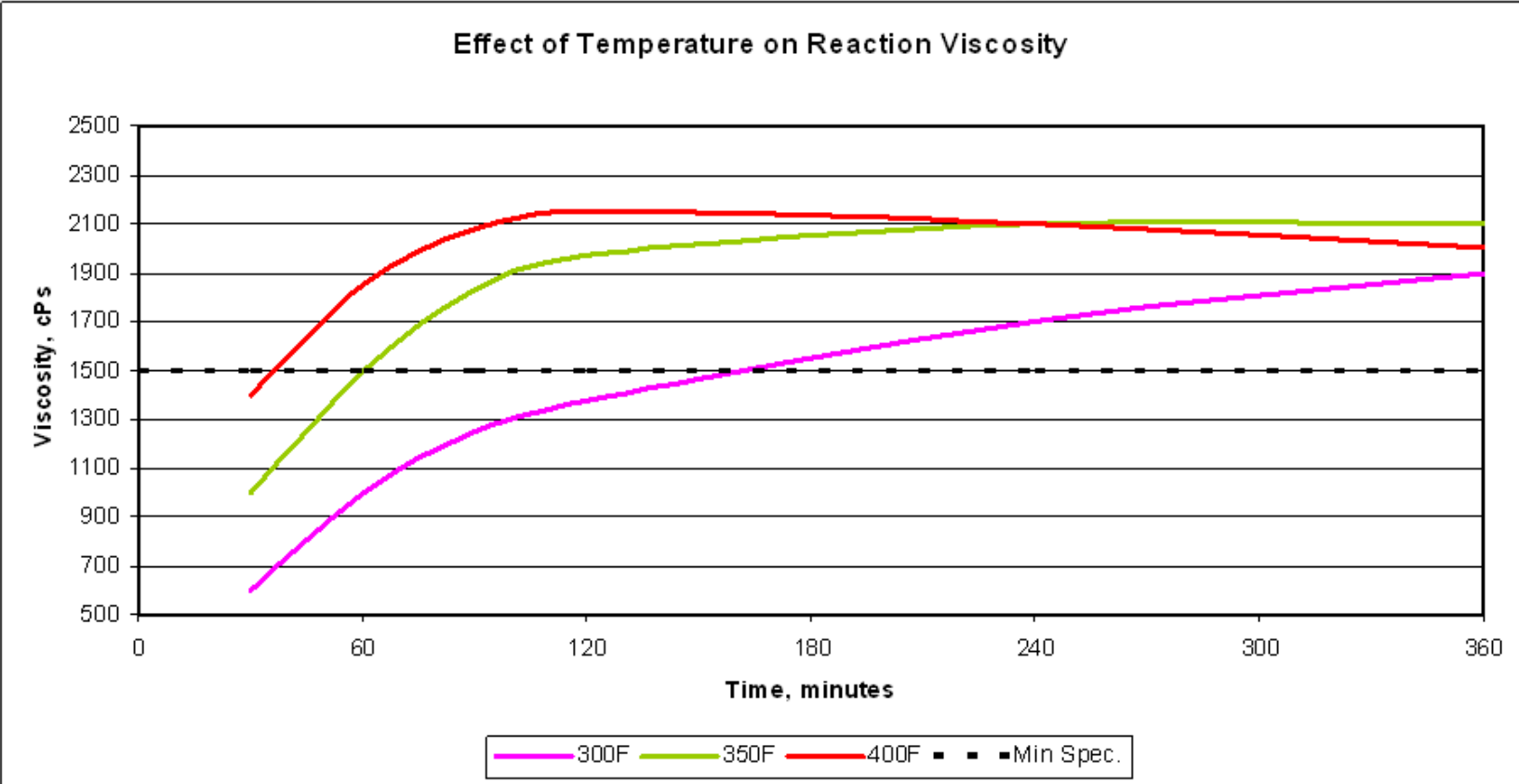
• Step 1

• Step 2

Binder Design (aka “Blend Profile”)

- ▶ Confirm the reaction process
 - blend time
 - blend temperature
 - compatibility of components
- ▶ Determine specification compliance
- ▶ Final binder properties depend on
 - Asphalt source and grade
 - Rubber source
 - Amount of rubber
 - Gradation of rubber
 - Interaction time and temperature

Temperature Effects



Blend Profile 17% rubber

Test Performed	Minutes of Reaction					Specified Limits
	60	90	240	360	1440	
Viscosity, Haake at 177°C, Pa-s	2.0	2.4	2.6	2.7	1.8	1.5-4.0
Resilience at 25°C, % Rebound (ASTM D3407)	30		34		32	30 Minimum
Ring & Ball Softening Point, °F (ASTM D36)	149.0	141.0	138.0	136.5	134.5	135 Minimum
Needle Penetration at 4°C, 200g, 60 sec., 1/10mm (ASTM D5)	21		22		26	10 Minimum

Blend Profile 18% rubber

Test Performed	Minutes of Reaction					Specified Limits
	60	90	240	360	1440	
Viscosity, Haake at 177°C, Pa-s	2.7	2.8	2.8	2.8	2.0	1.5-4.0
Resilience at 25°C, % Rebound (ASTM D3407)	34		36		32	30 Minimum
Ring & Ball Softening Point, °F (ASTM D36)	150.0	150.5	152.5	154.5	145.0	135 Minimum
Needle Penetration at 4°C, 200g, 60 sec., 1/10mm (ASTM D5)	22		24		26	10 Minimum

Blend Profile 19% rubber

Test Performed	Minutes of Reaction					Specified Limits
	60	90	240	360	1440	
Viscosity, Haake at 177°C, Pa-s	3.6	3.5	3.3	3.3	2.4	1.5-4.0
Resilience at 25°C, % Rebound (ASTM D3407)	39		38		34	25 Minimum
Ring & Ball Softening Point, °F (ASTM D36)	158.0	157.0	157.0	155.0	150.0	130 Minimum
Needle Penetration at 4°C, 200g, 60 sec., 1/10mm (ASTM D5)	22		24		26	10 Minimum

Viscosity

- ▶ Purpose
 - evaluate extent binder/rubber reaction
 - high temp handling characteristics



Resilience

- ▶ Purpose
 - measures elastic properties of binder



Softening Point

- ▶ Purpose
 - evaluate high pavement temp stiffness



“Terminal Blended”

Rubberized Asphalt ~~Asphalt Rubber~~

- ▶ Polar opposite of traditional asphalt rubber ala ASTM D6114
 - smooth and homogeneous
- ▶ Developed in Texas by Wright Asphalt Products
 - TRMAC® product platform
- ▶ Terminal blended means not on-site blended
- ▶ Non-particulate system
 - almost completely soluble in TCE
 - 5 to 10% rubber (ADOT min. 8%)
 - typically 1-3% SBS (ADOT min. 2%)
- ▶ Low viscosity relative to traditional AR
- ▶ Looks and behaves like polymer modified asphalt
- ▶ Applications
 - just about every type of HMA
 - hot applied chip seals

Terminal Blended Rubberized Asphalt

- ▶ Specified in ADOT Section 1005
 - Meet requirements of AASHTO M320 PG 76-22
 - Plus
 - Solubility $\geq 97.5\%$
 - Elastic Recovery (10° C) $\geq 55\%$
 - Softening Point $\geq 60^\circ$ C
 - Phase Angle @ 76° C $\leq 75^\circ$

For more information

- ▶ [http://rubberpavements.org/Library Information/AR Std Practice Guide Second Edition 20121001.pdf](http://rubberpavements.org/Library%20Information/AR%20Std%20Practice%20Guide%20Second%20Edition%2020121001.pdf)
- ▶ <http://www.wrightasphalt.com/>