INS AND OUTS OF USING RECYCLED TIRE RUBBER AT YOUR ASPHALT PLANT

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- Tom Rosenmayer & Silpara Technologies
- Doug Carlson & Liberty Tire
- Bob McGennis & Holly Frontier

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Thank You to…

- Recycled tire rubber
- Ground tire rubber
- Crumb rubber
- Asphalt rubber
- Rubber modified asphalt
- Arizona Style
- Dry
- Wet
- Terminal blend …

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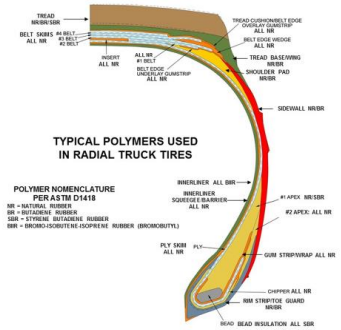
It's a Jungle Out There

Tires

- Steel
- Textile
- Rubber



Tire Rubber

- Can be up to up to 10 or more specific compounds in a single tire
- Compounds based on blends of
  - Natural rubber (polyisoprene) NR
  - Co-polymer Styrene-butadiene SBR
  - Polybutadiene BR
  - Co-polymer butyl-isoprene IIR
- Rubber compounds contain these polymers with fillers and other ingredients
- Consistency ensured through ISO Quality Systems including feedstock specification, vendor selection, testing, and traceability.

Ambient Ground Tire Rubber

Scrap tire processing is a multi-step and *iterative process*:

- Rough shred to tear the structure of the tire apart
  - takes a whole tire to large chunks (12"+ in size)
- Secondary shred for sizing
  - normally 4-8" pieces
- Initial granulation for steel removal
  - typically 1" minus creates 99.9% wire free rubber and clean steel
- This 1" minus product is the "feedstock" for **crumb rubber** production
  - **crumb rubber** is the commonly used term for GTR

Ambient Ground Tire Rubber

There are three methodologies for making ambient GTR/crumb rubber:

Crackermill process: two large cylinders, side by side turning into each other with the rubber forced between the cylinders. Each cylinder is corrugated and the rubber is **torn** apart by being forced through the "gap" between the cylinders.

Granulation process: high RPM rotor with blade-holders with "fly" knives mounted on the rotor rotating inside a cutting chamber with stationary/static knives mounted in the chamber. The rubber is **cut** by the knives until it is small enough to fit through the screens that form the only exit from the machine.

Micromill process: used for finer grind (smaller sizes); the input rubber (normally 10 mesh) is mixed with a liquid to form a slurry and then forced through an abrasive disc and torn in smaller sizes.

Ambient Ground Tire Rubber

Crackermill process:

- coarsest surface morphology (comparable sizing) due to tearing
  - action (25%+ more than granulation at comparable sizes)
- higher temperatures in processing (typically 150F+)
- more variability in sizing of output
- product sizing controlled externally by screening
- most mills optimized for 16 mesh (highest thruputs) and maximum size
  - reduction is 40mesh (typical gapping between rolls is 4 thousandths

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Crackermill

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Crackermill

Ambient Ground Tire Rubber

Granulation process:

- middle of road on surface morphology vs. cracker mill and cryo (same sizing)
- most conformity in sizing (narrowest size distribution curve)
  - sized in machine vs outside
- powderizers (smallest of generally used granulators) optimized for -8 mesh
  - machines are generally gapped to 5-7 thousandths
- product moved by air and generally processed at <100F

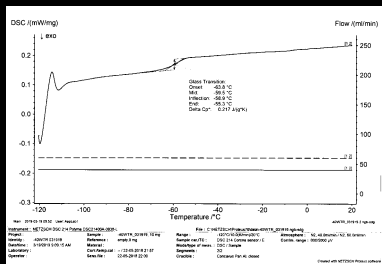
Ambient Ground Tire Rubber

Micromill process:

- Least "in-use" of all the ambient processes
  - environmental issues
  - high cost/low thruput
- Capable of finer GTR /crumb than other ambient processes (40 and 80 mesh)
  - optimized for a -40 mesh

Cryogenic Ground Tire Rubber

The point of cryogenic processing is to lower the temperature of the rubber to below its glass-transition point, thus making it temporarily brittle and easy to fracture into fine particles.



Cryogenic Ground Tire Rubber

Hammer Mills

- Cryo "cheese grater" forces material through screen openings
- Small to medium size
- Versatile – can handle a wide variety of materials
- Inefficient for rubber due to shear heat

Impact Mill

- Turbine with "large" gap relies on impact not shear, i.e.
  - "Beer bottle thrown at a brick wall"
  - "Frozen chicken through a jet engine"
- Tiny to large (milligrams to tons/hour)
- Produces a broad particle size distribution
- For rubber: post-mill screening into various fractions 50-500 microns
  - 50-200 microns (~60%) for tire rubber and specialty markets (>500,000,000 tires made)
  - 200-500 microns for RMA (30-40 mesh – skewed small)
- Efficient for rubber (below Tg)
  - Some adiabatic compression but no shear heat

Ambient Ground Tire Rubber

Surface Morphology:

Cryo:

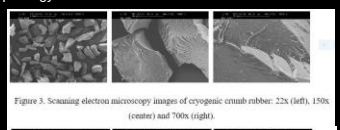


Figure 3. Scanning electron microscopy images of cryogenic crumb rubber: 22x (left), 150x (center) and 700x (right).

Crackermill:

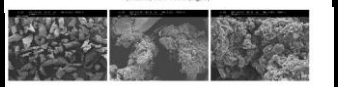


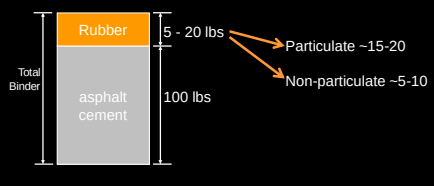
Figure 4. Scanning electron microscopy images of ambient crumb rubber: 22x (left), 150x (center) and 700x (right).

Rubber Modified Asphalt Binder Systems

- Particulate System
  - ASTM D6114 – "blend of paving grade asphalt cements, ground recycled tire rubber…interacted…hot…swelling…"
  - this is "asphalt rubber"
  - aka, "Arizona" Process, "McDowell" Process
  - typically blended on-site at HMA mixing facility, sometimes in a terminal
- Non-Particulate System
  - "terminal blended" rubberized asphalt
  - aka "TR" products

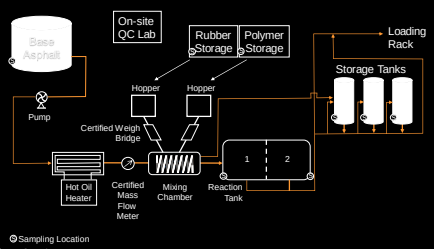
How much rubber?

- 5 - 20% rubber by weight asphalt cement depending on type of system



Asphalt Rubber Manufacture

(Terminal Environment-Hybrid System)



Courtesy of Bob McGennis

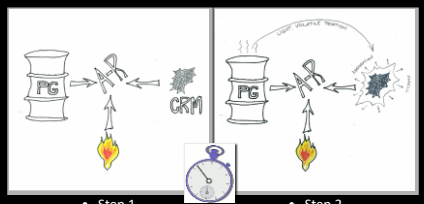
Typical Manufacturing Parameters (Particulate Systems)

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

Courtesy of Bob McGennis

The Reaction Process

(Theory of AR Particulate Manufacture)



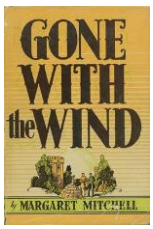
- Step 1
- Step 2

Courtesy of Bob McGennis

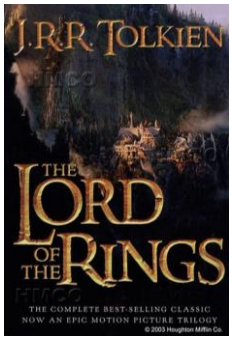
Non-Particulate Systems

- Smooth and homogeneous
  - almost completely soluble in TCE
- Terminal blended means not blended at HMA facility
  - rubber processing is sometimes proprietary
- Most often contains co-modifier
  - typically 1-3% SBS
- Low viscosity relative to traditional AR
- Looks and behaves like polymer modified asphalt
- Applications
  - just about every type of HMA
  - hot applied chip seals

Courtesy of Bob McGennis



Books that Took Longer to Write than RTR Best Practices



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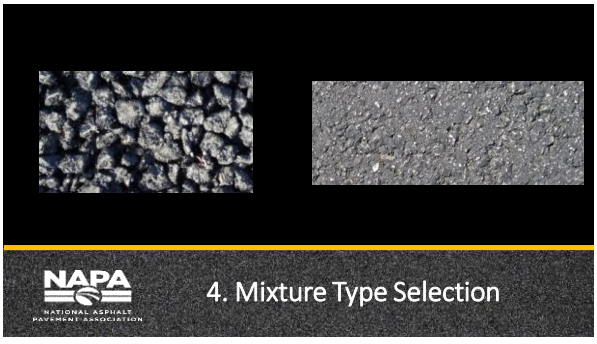

5. Mixture Design Impacts

6. How Much is Enough?

7. Is it Compatible?

8. Impact on Lab QC

9. Impact on Field QC

10. Will it Perform?

Some Statistics for You

- 2-inch lift of HMA = 2000 tires/lane mile
- Chip seal = 500 tires/lane mile
- 10 million tires recycled into paving annually

Source: Rubber Pavements Association

Societal Benefits of Asphalt Rubber

- Noise Reduction (~85% compared with PCC)
  - reduced need for sound walls
- Consumes a post consumer product
  - 5% of roads paved with AR would use all scrap tires
- Keeps tires out of landfills
- Eliminates tire fires
- Eliminates breeding place for mosquitos

Source: Rubber Pavements Association

Engineering Benefits of Asphalt Rubber

- Enhanced fatigue life
  - reduced pavement thickness (maybe)
- Enhanced HMA strength/stability
- Crack mitigation
- Retards aging (maybe)

Thank you!

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Questions?

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