The road ahead is GREEN
WMA BY WATER FOAM HAS A LARGE AND GROWING TRACK RECORD. (ASTEC DOUBLE BARREL GREEN SYSTEM ONLY)

Numerous Projects and Demos
- North Carolina
- New York
- Maine
- South Carolina
- Tennessee
- Alabama
- Texas
- Arkansas
- California
- Kentucky
- British Columbia
- France
- Russia
- Columbia
- New Mexico
- Delaware
- Cuba
- Australia
- Ontario
- Alberta
- Ohio
- Illinois
- Maryland
- Louisiana
- Florida
- Massachusetts
- Sweden
- Mississippi
- New Zealand
- Korea
- South Africa
- Kazakhstan

Approaching 400 units ... Millions of Tons... Worldwide

THERE ARE SEVERAL WMA TECHNOLOGIES.

THE BENEFITS ARE SIMILAR.

IT’S GREEN!

- 14% LESS CO2 EMISSIONS
- REDUCED VOC EMISSION
### Reduced Emissions

<table>
<thead>
<tr>
<th>Mix Temperature (°F)</th>
<th>Volatile Organic Compounds (VOC)*</th>
<th>Load-out Emissions (lb/yr)</th>
<th>Silo-filling Emissions (lb/yr)</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>325</td>
<td>7312</td>
<td>2346</td>
<td></td>
<td></td>
</tr>
<tr>
<td>275</td>
<td>2084</td>
<td>669</td>
<td></td>
<td>71.5</td>
</tr>
<tr>
<td>260</td>
<td>1430</td>
<td>459</td>
<td></td>
<td>80.4</td>
</tr>
</tbody>
</table>

* Based upon a plant producing mix at 400 TPH with a total yearly production of 600,000 tons

PRODUCES BETTER PAVEMENT.

- LESS OXIDATION OF MIX
- BETTER COMPACTION
$ IT’S GREEN! $

- USES 14% LESS FUEL
- AIDS COMPACTION
WATER FOAM WMA ADDITIVE COST ADVANTAGE

½ ¢/TON ADDITIVE COST

5 ¢ PER TRUCK LOAD

$1 FOR EVERY 400 TONS

BASED ON 0.0785 $/FT³ WATER INCLUDING SEWAGE FEE

WMA 50% RAP, Right two lanes

HMA 0% RAP, Left lane

Photo taken the day after paving was complete. Note oxidation in the HMA lane.

Main Questions That are Asked

How much water?

Where does it go?

What about mix performance?
How much water is injected?
2% by weight of virgin binder

Assuming 5%AC per ton, water injected per ton would be:
2 lb
30.7 fluid oz.
0.91 liters

How much water remains in the mix?
Voids are filled with steam at mix temperature.

Uncompacted Mix:
Voids at about 25%

Voids are the only place water can remain

Compacted Mix:
Voids at about 5%

Voids are still filled with steam at mix temperature, but the void volume has been reduced.
BEFORE COMPACTION
25% of void space, each ton can hold….

0.149 lb
2.3 fluid oz.
0.068 liters

AFTER COMPACTION
5% of void space, each ton can hold….

0.0234 lb
0.359 fluid oz.
0.011 liters

0.00117% of mix

MORE WATER DOESN’T AFFECT RETENTION.

What if we inject more water?
3%, 3.5%, 4% of the liquid AC?

REMEMBER: Water retained is a function of the volume of air voids in the mix.

Still 0.00117%
How much retained water (internal moisture) is typically allowed per mix ton?

0.5% or 10 lb is typical (total of all five containers)

0.00117% added during Green System Foaming

WHAT ABOUT MIX PERFORMANCE?

Technology Demonstration Test Results:
Nashville Area, September 2007, Limestone

- Advera WMA
- 1150 Tons Placed
- % AC 5.16 & 5.29
- % Air Voids 4.7
- Stability 1425
- TSIR 51.9%
- Density 92.5%
- Evotherm
- 700 Tons Placed
- % AC 5.14
- % Air Voids 3.5
- Stability 1285
- TSIR 65.5%
- Density 91.5%
- Astec Green System
- 775 Tons Placed
- % AC 5.19 & 5.29
- % Air Voids 4.0
- Stability 2200
- TSIR 72.3%
- Density 91.6%
- Evotherm
- 750 Tons Placed
- % AC 5.22 & 5.36
- % Air Voids 5.1
- Stability 1495
- TSIR 84.3%
- Density 91.0%
- Advera WMA
- 1150 Tons Placed
- % AC 5.16 & 5.29
- % Air Voids 4.7
- Stability 1425
- TSIR 51.9%
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NCAT Pavement Test Track

2009 Group Experiment (+)

Six-State Sponsored  WMA  Privately Sponsored

50% RAP  10 Test Sections  Data courtesy of NCAT

“Rutting” Results to Date

- Maximum deformation at 7.9mm (0.31 inches)
- Results are as expected:
  - HMA stiffer than WMA
  - RAP stiffer than Virgin

Data courtesy of NCAT
2009 Group Experiment (+)

Fatigue Performance Expectations

Foam: 2X as long
Fatigue Performance Expectations

10 Million ESALs
Equivalency line

RAP: 5.3X as long

Fatigue Performance Expectations

10 Million ESALs
Equivalency line

Foam+RAP: 12.7X as long

Production/Construction Techniques and Issues

FAQ
If some of the water remains in the mix, won’t I show a high AC content?

NO

• A small amount of water remains in the mix after compaction
• Theoretically, this could show up as AC content.
• Maximum of 0.00117% of the water remains (virgin mix)
• Beyond the measurement accuracy of AC content (typically reported to the nearest 0.1%).

Won’t the baghouse temperature be too low when with the lower mix temperature?

• Depends on a number of factors.
• Decreases BH temps about 35°F to 40°F (CF dryer) all other factors constant.
• Things go better with RAP

New ASTEC Stack Temperature Control System enables running all mixes without stack temperature problems.

Can coating be affected?

Sometimes there is a positive effect. We have never see a negative effect.

• Good coating has been observed below 200°F
• Foam has significantly improved poor coating.
Do I have to do anything special to my binder?

**NO.**

Won’t I experience a drop in mix temperature since I am adding water?

**NO.**

- Significant temperature drops during ordinary hauls in moderate weather is caused by *internal* moisture.
- Internal moisture signs: steam and water at the silo tops, water running out of the truck beds, and a drop in mix temperature (27°F per ½%).
- Water remaining in the mix post compaction is 0.00117% (0.07°F drop).

Can I run water foamed mix at higher temperatures?

**YES.**

- There is no danger in running the mix at higher temperatures.
- Mix simply remains workable for a longer period.
Can water foam WMA be stored?

YES.

- As long as the corresponding HMA may be stored
- First test was 24 hours then 48 hours
- Have stored as long as 4 days

Will rolling patterns change?

YES

- Generally, crews have been able to begin rolling immediately.
- At some locations, less rolling was required
- Experiment. Each situation is unique.

Mat does not extrude as much in the cross paving direction. Joints stand up straight.
Is handwork different than that of HMA?

- Can be different depending upon the situation
- Cold day tight quarter handwork on base mixes have become difficult on a couple of jobs
- Straight pulls never an issue

Does WMA produced water foam look different?

- Can look the same as ordinary HMA minus smoke and smell
- Can look rich (especially virgin mixes) due to film thickness increase

Won’t my water freeze when it gets cold?

- “Cold weather package” available through Astec Parts.
- Not meant for “winterizing”.
- What about anti-freeze, chlorine or other additives? Don’t do it. Clean water only.
- Some customers have had bad experiences with additives.
HOW ASTEC DOES WATER FOAMED WMA

(PROCESS - PATENTED)
(EQUIPMENT – PATENT PENDING)
WHY MULTIPLE NOZZLES?

INSPITE OF THE FORGIVING NATURE OF THE WATER FOAMING METHOD, IT CAN BE DONE WRONG BY NOT FOAMING ALL OF THE AC.

MULTIPLE NOZZLES HELP ENSURE THAT ALL OF THE AC IS FOAMED.
Actuator
Self-cleaning
All Stainless Water Injector
Field Rebuildable

Valve body
Self-cleaning pintle
Viton seat
Seat/nozzle
Viton O-ring

Generation 2.X
Foaming Chamber-Standpipe
CONFIGURATIONS

• Generation 2.0 and 2.0s
  – Double Barrel (most common)
  – Double RAP
• Generation 2.6 and 2.6s
  – Double RAP
  – Double Drum
  – Drum mix coater
  – Parallel flow
  – Batch
  – Retrofit for other manufacturer’s drums

Generation 2.0
Larger drum sizes

Generation 2.0s
Smaller drum sizes
250tph and less
Generation 2.6
Larger drum sizes

AC

Generation 2.6s
Smaller drum sizes
250tph and less

AC

Discharge Pipe
Vent Valve
Add-on AC Pump and Motor (if needed)
Suction Pipe
Spray Manifold
Green Pac™ Manifold
Spray Manifold
Discharge Pipe
Add-on AC Pump and Motor (if needed)
Suction Pipe
Spray Manifold
Green Pac™ Manifold
Green Pac™ for Batch Benefits
- Gives existing HMA Batch Plants same proven WMA capability as continuous plants.
- Retrofits to all existing plant configurations.
- Retains original weighing system components and controls.
- Retains HMA gravity feed capability
- PLC controlled, yet utilizes existing batch control regardless of its vintage.
- Utilizes field-proven, low-maintenance Generation 2.X foaming manifold hardware.
**Generation 2.6 and 2.6s Variations**

**SXS Configuration**

No valve needed - always installed horizontal.

**South Carolina Requirement**

"Moisture" loss is any of the following:

- Remaining WMA water
- Retained Moisture
- AC Light Ends

**Generation 2.6 and 2.6s Variations**

**O/U Configuration**

Two-way jacketed valve is closed when making either HMA or WMA. Valve opens when the AC is reversed for sucking back to remove AC from the supply line into the drum.

No valve needed when installed horizontal.