Achieving Sustainability Goals with Warm Mix Asphalt

NEAUPG 2022 – Albany, NY
November 3, 2022
Agenda

Ingevity Overview
Past & Present Use of Warm Mix Asphalt
Benefits of Lower Production Temps
Meeting Contractor Needs with Data
Path Forward
PURIFYING, PROTECTING AND ENHANCING EVERYDAY LIFE

COATINGS
Performance-driven industrial coatings

AGRICULTURAL INGREDIENTS
Plant-based crop protection and plant health applications

DISPERGANTS
Materials for batteries and textile dyes

ASPHALT PAVING
Emissions reducing asphalt paving, recycling and rehabilitation technologies

LUBRICANTS
Additives for cutting auto and aerospace parts

RENEWABLE ENERGY AND FUEL
Natural gas engine solution for all fuel trucks powered by RNG

ADHESIVES
For bio-based packaging, footwear, apparel, electronics and EV battery padding

OILFIELD
High performance solutions for drilling, stimulation and production

AUTOMOTIVE EMISSION CAPTURE
Internal combustion engine gasoline vapor emission control

POLYURETHANE MATERIALS
Durable auto protection, wearable apparel and wheel technology

PROCESS PURIFICATION
Wood-based food, chemical and water purification solutions

RUBBER
Renewably sourced synthetics, rubber materials

SAFETY ROAD STRIPING
Reflective safety road markings

BIOPLASTICS
High performance, fully biodegradable plastics

INKS
Bio-based resins for printing inks
Brief History of WMA
NAPA Survey on WMA Usage

WMA technology is in ≈50% of our asphalt tonnage.

BUT... is it really WMA if we haven’t reduced temps?
NAPA Survey on WMA Usage

Percentage of WMA Placed by Technology Type

- Production Plant Foaming
- Chemical Additive
- Organic Additive
- Additive Foaming

Data taken from NAPA’s “Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage: 2019”

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<tr>
<td>Production Plant Foaming</td>
<td>83</td>
<td>92</td>
<td>95.4</td>
<td>88.3</td>
<td>87</td>
<td>84.5</td>
<td>72</td>
<td>76.9</td>
<td>64.7</td>
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<td>1</td>
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<td>25.2</td>
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<td>32.2</td>
<td>34.3</td>
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<tr>
<td>Organic Additive</td>
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<td>1</td>
<td>0.3</td>
<td>0.2</td>
<td>0</td>
<td>0.5</td>
<td>0.7</td>
<td>1.9</td>
<td>3.1</td>
<td>1.8</td>
<td>0.7</td>
<td>1.6</td>
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Current Use of WMA

• Cheap Insurance
• Improved compaction
  • Density bonus
  • Reduce rollers
• Cold Weather Paving
  • Start earlier – pave longer
• Long Haul – Better Silo Storage
• Reduced Absorption – Lower AC Content
• Liquid Anti-Strip and Lime replacement
• Increased recycle usage – improved workability
• Decrease mix temperature
  • Reduced thermal segregation
  • Longer binder life
  • Reduced fuel consumption
  • Reduced emissions
  • BMD
Benefits of Lower Production Temperatures
Binder Mass Loss vs RTFO Temperatures

Asphalt Binder Mass Loss

RTFO Conditioning Temp, F

- PG 64-22 J
- PG 64-22 F
- PG 58-28 F

Binder Mass Loss vs RTFO Temperatures

PG 64-22 WMA Range
PG Low Temp After Extended Aging

- 20 Hr PAV is common aging limit for PG specifications
- PG 64-22 RTFO 350F is out of spec after 20 Hr PAV
- Reducing RTFO 50F still meets spec after 60 Hrs
IdealCT Results – SC

Mean(CT Index) vs. Mix Type

HMA Mix Temp = 320F
HMA Comp Temp = 300F
WMA Mix Temp = 260F
WMA Comp Temp = 240F

CT Index

HMA – Lime: 38.4
HMA – Chemical Additive: 93.1
HMA – LAS: 64.3
WMA – Chemical Additive: 140.0
Field Data – Louisiana Field Density Study

Field Density – Cores

Semi-Circular Bend Test Results, 25°C
ASTM D8044 – Field Cores

LWT Test Results, 50°C
AASHTO T 324

Binder Course
Wearing Course

Moises Akentuna, Louay N. Mohammad, Minkyum Kim, Samuel B. Cooper, III., Samuel B. Cooper, Jr., Ph.D., P.E, Improving Durability of Asphalt Pavements in Louisiana through Increased In-Place Field Density, 99th TRB Annual Meeting January 12 – 16, 2020 Washington, D.C.
Recovered Binder Data (Florida)

Extracted Binder Grading Low Temperature WMA (Florida)

- RTFO PG-XX (0 hr PAV)
- Low PG-YY (20 hr PAV)
- Low PG-YY (40 hr PAV)
- Low PG-YY (60 hr PAV)

PG Grade (°C)

- HMA 325 °F
- WMA 275 °F
- WMA 250 °F
Observed vs Predicted WMA Field Performance

Based on field observations, there was a 92% decrease in crack area (%) in the Evotherm Pavement compared to the Control.

Predicted data shows a 25% decrease in damage area (%) in the Evotherm Pavement compared to Control.

- Wang, Yizhuang; Norouzi, Amirhossein; and Kim, Richard. Y. Comparison of Fatigue Cracking Performance of Asphalt Pavements Predicted by Pavement ME and LVECD Programs. Transportation Research Record 2590, 2016.
Meeting Industry Goals with Data
Our Industry Needs Leaders…
Improved Air Quality with WMA

325° HMA

275° HMA
Quantifying Emissions Reductions with True WMA

- Run #1 AVG 305F Mix Temp
- Run #2 280F AVG Mix Temp
- Run #3 260F AVG Mix Temp
- Run #4 325F AVG Mix Temp
Evotherm WMA Plant Fugitive Emissions Data

Project Details from Contractor (Utah)
- 360 Tons/hr run rate
- Gencor Counter Flow Drum
- 15% RAP Content

Project Details from Contractor (Florida)
- 200 Tons/hr run rate
- Astec Double Barrel Green
- 40% RAP Content

Project Details from Contractor (Virginia)
- 290 Tons/hr run rate
- Astec Double Barrel Green
- 30% RAP Content

<table>
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<tr>
<th>Auger Box</th>
<th>Hopper</th>
<th>Screed</th>
<th>Silo #2</th>
<th>Silo #3</th>
<th>Top of Silo</th>
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<tr>
<td>315°F</td>
<td>&gt; 260°F</td>
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<tr>
<td>325°F</td>
<td>&gt; 275°F</td>
<td>&gt; 265°F</td>
<td>&gt; 250°F</td>
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<tr>
<th>Auger Box</th>
<th>Hopper</th>
<th>Screed</th>
<th>Silo Left</th>
<th>Silo Right</th>
<th>Top of Silo</th>
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<tbody>
<tr>
<td>310°F</td>
<td>&gt; 285°F</td>
<td>&gt; 260°F</td>
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% Reduction in Fugitive Emissions (PM2.5) Using WMA

<table>
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<tr>
<th>Concentration (PPM)</th>
<th>0%</th>
<th>-20%</th>
<th>-40%</th>
<th>-60%</th>
<th>-80%</th>
<th>-100%</th>
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<tr>
<td>315°F</td>
<td>-98%</td>
<td>-92%</td>
<td>-97%</td>
<td>-71%</td>
<td>-76%</td>
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<tr>
<td>325°F</td>
<td>-95%</td>
<td>-99%</td>
<td>-97%</td>
<td>-93%</td>
<td>-90%</td>
<td>-96%</td>
</tr>
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<td>-95%</td>
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<td>-96%</td>
<td></td>
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- Auger Box
- Hopper
- Screed
- Silo #2
- Silo #3
- Top of Silo
Evotherm WMA Plant Stack Emissions Data

Input Data from Contractor (Utah)
- 360 Tons/hr run rate
- Gencor Counter Flow Drum
- 15% RAP Content

Input Data from Contractor (Florida)
- 200 Tons/hr run rate
- Astec Double Barrel Green
- 40% RAP Content

Input Data from Contractor (Ohio)
- 240 Tons/hr run rate
- Astec Double Barrel
- 20% RAP Content

Stack Emissions Data:

Utah:
- PM: 11.6% decrease
- CO: 9.9% decrease
- NOX: 0.5% increase
- VOC: 4.8% decrease
- CO2: 2.7% decrease

Florida:
- PM: -12% decrease
- CO: 17% decrease
- NOX: 70% decrease
- VOC: 9% decrease
- CO2: 33% decrease

Ohio:
- PM: -17% decrease
- CO: -79% decrease
- NOX: -28% decrease
- VOC: -33% decrease
- CO2: -88% decrease
Blue Smoke Mitigation:

Costs:

Blue Smoke Recovery Systems: $750,000-$2M for the system per mix plant and approximately $30-$50K/year in parts, labor and energy costs.

Evotherm at Low Temps:

Approx. $1.00-$1.25 per mix ton (before value of fuel savings and other economic benefits)
Hazard Mitigation

OSHA Hazard Mitigation "Hierarchy of Control"
Evotherm WMA Plant Fugitive Emissions Data

2022

Project details from Contractor (New York)

- 225 Tons/hr run rate
- Astec Double Barrel
- 20% RAP Content

Comparison of HMA and WMA Particulate Matter (PM10) Emissions for 1-Hour Run at Top of Silo

Percent Reduction Fugitive Emissions from HMA - Top of Silo

PM1.0
- 325°F: -16%
- 275°F: 76%
- 255°F: 99%

PM2.5
- 325°F: -41%
- 275°F: -94%
- 255°F: -99%

PM10
- 325°F: -82%
- 275°F: -94%
- 255°F: -99%
Evotherm WMA Plant Fuel Consumption Data

Note: Natural gas fuel $9.00/MMBtu assumption

**Utah Contractor**
- 360 Tons/hr
- Gencor Counter Flow
- 15% RAP
- 250k Mix Tons/yr
- $147.5k Savings (single plant) running at 260°F

**Florida Contractor**
- 200 Tons/hr
- Astec Double Barrel
- 40% RAP
- 150k Mix Tons/yr
- $61.5k Savings (single plant) running at 265°F

**Virginia Contractor**
- 290 Tons/hr
- Astec Double Barrel
- 30% RAP Content
- 250k Mix Tons/yr
- $107.5k Savings (single plant) running at 260°F

**Illinois Contractor**
- 300 Tons/hr
- Gencor Counter Flow
- 40% RAP Content
- 350k Mix Tons/yr
- $101.5k Savings (single plant) running at 275°F
What’s the Path Forward
Ingevity EPDs for Chemical WMA Additives

Ingevity
Warm Mix Asphalt Additive, Warm Mix Asphalt Chemical Additive, Warm Mix Asphalt Chemical Package, Liquid Anti-Strip, Compaction Aid

Environmental Product Declaration

Product
Evotherm P25

Self-declared core EPD based on the EN15804:2012 + A2

Issue Date 7/1/2022
Valid until 7/1/2027
Collection period 2021

Company
Ingevity Corporation 5295 Virginia Avenue North Charleston, SC 29406 U.S.A.
www.ingevity.com +1 800-458-4034

DEMONSTRATION OF VERIFICATION
EN15804:2012+A2 serves as core PCR
Third party verification of the declaration, according to ISO 14025

Internal Third party verifier
External The Right Environmental Ltd.

Environmental Product Declaration

Product
Evotherm M1

Self-declared core EPD based on the EN15804:2012 + A2

Issue Date 12/3/2021
Valid until 12/1/2026
Collection period 2020

Company
Ingevity Corporation 5295 Virginia Avenue North Charleston, SC 29406 U.S.A.
www.ingevity.com +1 800-458-4034

DEMONSTRATION OF VERIFICATION
EN15804:2012+A2 serves as core PCR
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CO2 Reduction – Path to Zero

CO₂e Reduction (%) for WMA Technology

- HMA: >285°F, <10%
- Foam: 250 - 280°F, 15-30%
- Zero Water: 230 - 260°F, 25-40%
- Chemical WMA: 190 - 220°F, 40-50%
- CCPR: <100°F, 40-60%
- CIR: <100°F, 75-90%
**Agency Options**

**Incentive Specifications**
- $1/ton Bonus < 290° Production Temperature
- $2/ton Bonus < 270° Production Temperature

**WMA Temperature Specifications**
- Road Owner Specifies Max Production Temperature

**Line Item Pay**
- DOT pays for WMA as a separate line item.
  - Similar model to asphalt binder in SC or LAS in TN

**Specifications**
True WMA Is Good For Our…

- People
- Planet
- Performance
- Profitability
Thank you!

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