

Preliminary Energy and Emissions Data from U.S. WMA Projects

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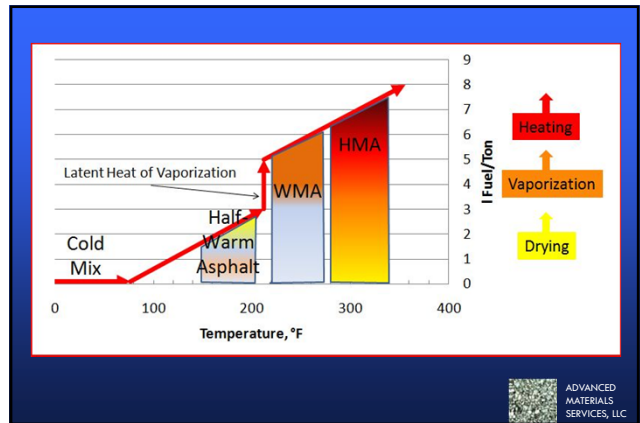
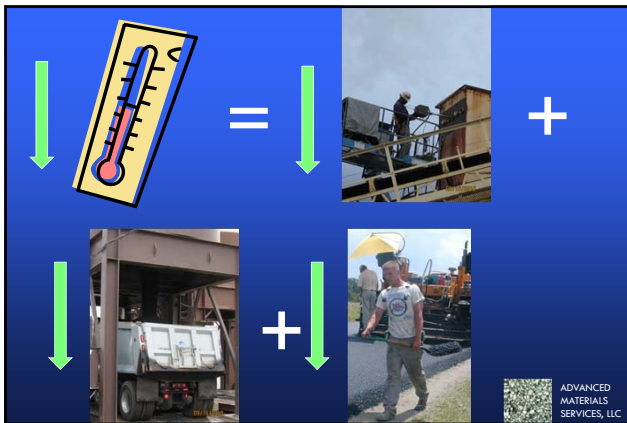
Why Warm Mix Asphalt?



Research by Stroup-Gardiner and Lange at AU Indicates increased emissions with increased temp.

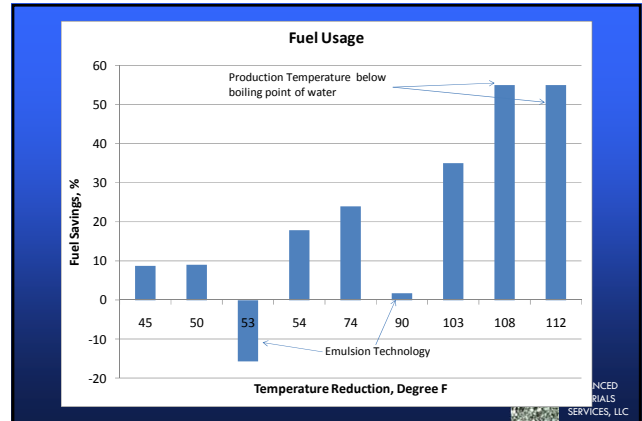
Why Warm Mix Asphalt?

- NAPA has worked to continually reduce the environmental impact of, and worker exposure from the production and placement of asphalt pavements:
 - Wet scrubbers and later baghouse filtration to reduce particulate emissions,
 - Reclaiming and recycling,
 - Engineering controls for highway class pavers,
 - Diamond achievement commendation, and
 - Warm Mix Asphalt (WMA)



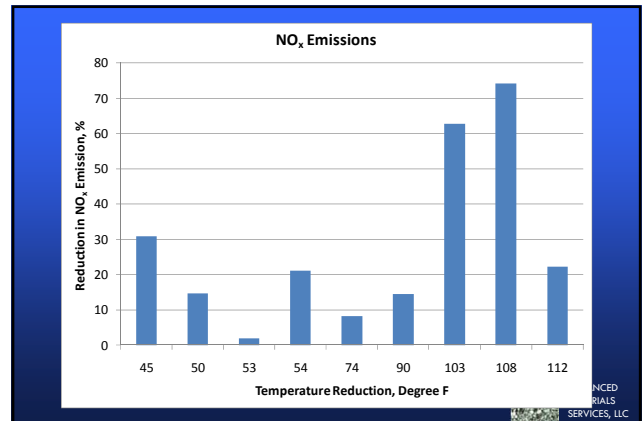
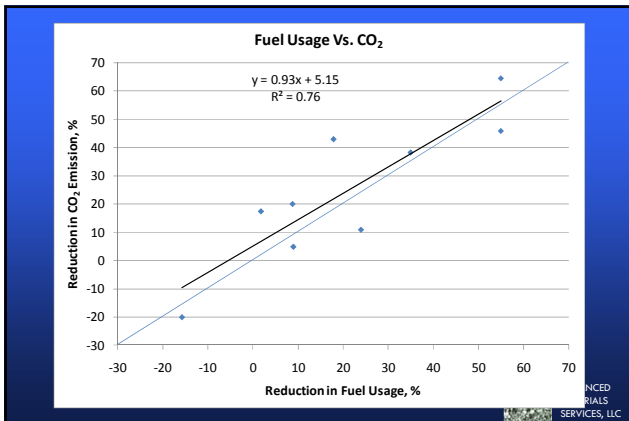
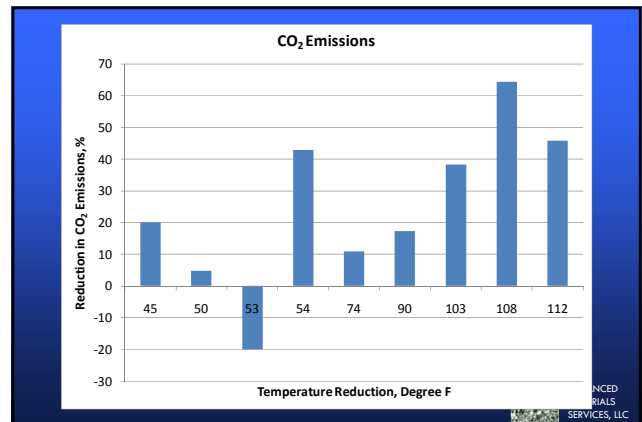
Fuel Savings – From Literature

- Comparative fuel usage reported for 15 projects representing six WMA technologies
- Theoretical calculations indicate a 50°F reduction in production temperature should result in an 11% reduction in fuel usage
- Observed savings ranged from a 15.4% increase to 77% reduction, with an average savings of 24%
- Heat losses and other inefficiencies believed to account for increased savings over theoretical calculations



Stack Emissions – From Literature

- Stack emissions data identified for 21 (18 obtained) projects in four countries representing six WMA technologies
 - Data collected varies
 - Data quality varies
 - Inconsistent reporting: stack concentration lbs/hour
- CO₂ generally reduced
- NO_x reduced in all cases
- SO₂ and VOCs both increased and decreased



The following data from NCHRP 9-47A is preliminary



NCHRP 9-47A Sites to Date



Rapid River, MI

Advera™ WMA



Evotherm™ 3G



Rapid River, MI Fuel Savings

Mix	Avg. Production Temperature, F	Avg. BTU/ton	% Savings
HMA	303	0.285	NA
Advera™ WMA	262	0.237	16.9
Evotherm 3G	272	0.248	13.1



Rapid River, MI Stack Emissions - % Reduction

Emission	Advera™ WMA	Evotherm 3G
Condensables, lb/hr	83	67
CO ₂ , %	11	6
CO, lb/ton	49	+53
SO ₂ , lb/ton	57	58
NO _x , lb/ton	11	1
VOC, lb/ton	47	45
Formaldehyde, lb/ton	37	36



Griffith, IN

Gencor Ultrafoam GX2 "Green Machine"



Wax



Griffith, IN Fuel Savings

Mix	Avg. Production Temperature, F	Avg. BTU/ton	% Savings
HMA	300	0.23	NA
Ultrafoam GX2	277	0.21	8
Evotherm DAT	256	0.20	15
Wax	268	0.15	35



Griffith, IN Electrical Usage

Mix	Avg. Production Temperature, F	Drum, amps	Drag Slat, amps
HMA	300	37	81
Ultrafoam GX2	277	39	87
Evotherm DAT	256	40	91
Wax	268	40	89



Worker Exposure – Literature Review

- Identified four industrial hygiene studies on WMA in U.S. representing four technologies
- WMA results in reductions in TPM and BSM
- Results for BSM below detectable limits in many cases



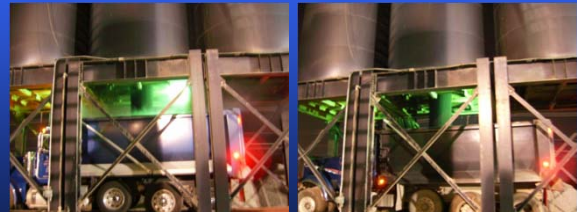
TPM = total particulate matter
BSM = benzene soluble matter



Reduced Fugitive Emissions

HMA at 330 °F

WMA at 255 °F



Reduced or eliminated fugitive emissions and odor!



Summary



Burner Tuning

- Burner tuning at one NCHRP 9-47A site resulted in an 18 percent savings for HMA!
- Incomplete burner combustion suspected for two WMA projects which used recycled oil
- Elevated levels of CO and VOCs can indicate incomplete combustion
- Stack emissions data indicate examples of improperly tuned burners
- WMA mixes may be more sensitive to resulting fuel contamination based on laboratory performance tests



Summary

- NCHRP 9-47A data indicates WMA use resulted in fuel savings of 8-35%
- There is evidence that electrical usage increases slightly
- Stack emissions indicate condensables, NO_x, and VOC's always lower. Other emissions generally reduced
- Worker exposure generally low, further reductions with WMA



Other Benefits

- Compaction aid
- Cold-weather paving
- Longer haul distances
- Use of higher percentages of RAP
- Less restriction, potentially more production in non-attainment areas
- Specific pavement rehabilitations
- Allow wasted baghouse fines to be made into a slurry



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