



EVOTHERM

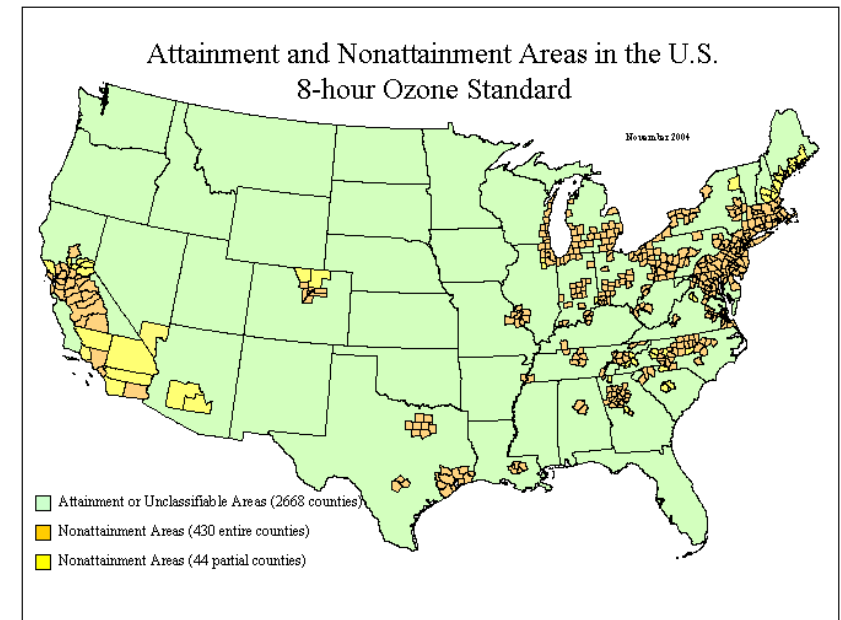
WARM MIX ASPHALT TECHNOLOGY

**Asphalt Institute Spring Meeting
April 20, 2006**

WHY SO MUCH INTEREST IN WARM MIX ASPHALT?

- Kyoto Treaty
- IARC
- PAH & Naphthalene Emissions
- Particulate Emissions
- Increased Activism

- Rising Energy Costs
- Higher Temperature Trends
- Regulatory & Permitting
- Odors



WARM MIX ASPHALT

Benefits

- **Reduced fuel usage**
- **Decreased stack emissions**
- **Reduced fumes and odor at paver**
- **Easier permitting**
- **Extended haul distances**
- **Quicker return to traffic**

- **Longer binder life**
- **Improved compaction**
- **Expanded season**
- **Improved thin-lift capabilities**
- **Higher RAP usage**

WARM MIX TECHNOLOGIES

Sasobit® – Sasol Intl.

Aspha-min® – Eurovia/Hubbard

WAM Foam® – Shell/ Kolo Veidekke

Low-energy Asphalt – Fairco

Evotherm™ – MeadWestvaco

New Technologies?

WHAT IS EVOTHERM?

Technology Highlights

Evotherm™ — MWV Asphalt Innovations

- Emulsion-based (high-residue ~ 70%)
- Chemical package of surfactants for coating and compactability, adhesion promoters for moisture resistance, and emulsification agents
- $T_{mix} = 185 - 240^{\circ}\text{F}$ *
- First test section constructed in Nov. 2003
- Openly available to end-users; no license

*Temperature range of work
since 2003: $154 - 300^{\circ}\text{F}$

EVOTHERM

Trials to Date

<u>Location</u>	<u>Aggregate</u>	<u>Binder</u>
Jo'burg, S.A.	9.5 mm Andesite	60/70 pen
Wichita, KS	9.5 mm Limestone	PG 58-22
Durban, S.A.	9.5 mm Dolerite	80/100 pen
Indianapolis, IN	12.5 mm Dolomite, 10% RAP	PG 64-22
Aurora, ON	HL8 & HL3 Limestone	PG 58-28
Kansas City, MO	12.5 mm Limestone	PG 64-22
Beijing, China	12.5 mm Limestone	AC20
Calgary, AB	20 mm Silicate	120/150 pen
Greenich, NY	12.5 NY Type 6	AC20
Remara, ON	HL4 Limestone	PG 58-28
NCAT Test Track	9.5 & 19 mm Limestone	PG 64-22/76-22
San Antonio, TX	12.5 mm Limestone	PG 64-22/84-22
St. Louis, MO	9.5 NMAS Trap rock, 10% RAP	PG 70-22
Milwaukee, WI	9.5 NMAS mixed, 15% RAP	PG 64-28
London, ON	HL8 Limestone	PG 58-28
Shanghai, China	9.5 NMAS mixed	AC13
Beijing, China	13.2 Limestone	AC16

EVOTHERM TRIALS TO DATE

Trials Show Broad Scope

- **Wide range of dense-graded aggregates**
Limestone and dolomites to high-quartz andesite
RAP (15% in the field; 100% in the lab)
- **Wide range of binders**
From 120/150 pen-graded to PG84-22 PMAC
- **Wide range of production operations**
Continuous parallel and counterflow drum plants
Batch plants with pug mills and one Dilman plant
- **Wide range of laydown and compaction equipment**
Lifts from 0.75 to 3+ inches
Truck discharge of mix and shuttle buggy
Compaction: 1) steel vibe, 2) pneumatic 3) steel static
- **Trial sections subject to widely varying climatic conditions**

EVOTHERM TRIALS TO DATE

Focus on Four Trial Sections

<u>Location</u>	<u>Aggregate</u>	<u>Binder</u>
London, ON	HL8 Limestone	PG58-28
Remara, ON	HL4 Limestone	PG58-28
Aurora, ON	HL8 & HL3 Limestone	PG58-28
Indianapolis, IN	12.5 mm Dolomite/RAP	PG64-22
NCAT Test Track	9.5 & 19 mm Limestone	PG64-22/76-22



Highlights of these trials:

- Fuel usage reduced by over 50%
- Reduced gas and particulate emissions at the plant
- Reduced fumes at the paver by over 40%
- SHRP and Marshall lab designs feasible

McASPHALT EVOTHERM

Ramara Project, Oct. 5, 2005



- HMA control compared to Evotharm
- Two-ton batch plant with dry collector
- Stack emissions monitored
- HL4 limestone surface lift

RAMARA (TORONTO) DEMO: Production and Fuel Savings

**Evotherm
T mix =
90 - 120°C**



**Fuel usage
reduced
by 55%**

	<u>Fuel (L)</u>			<u>Mix (ton)</u>	<u>L / ton</u>
	<u>init.</u>	<u>final</u>	<u>total</u>		
HMA Control	39605	28547	11058	973	11.4
Evotherm	28547	25348	3199	615	5.2

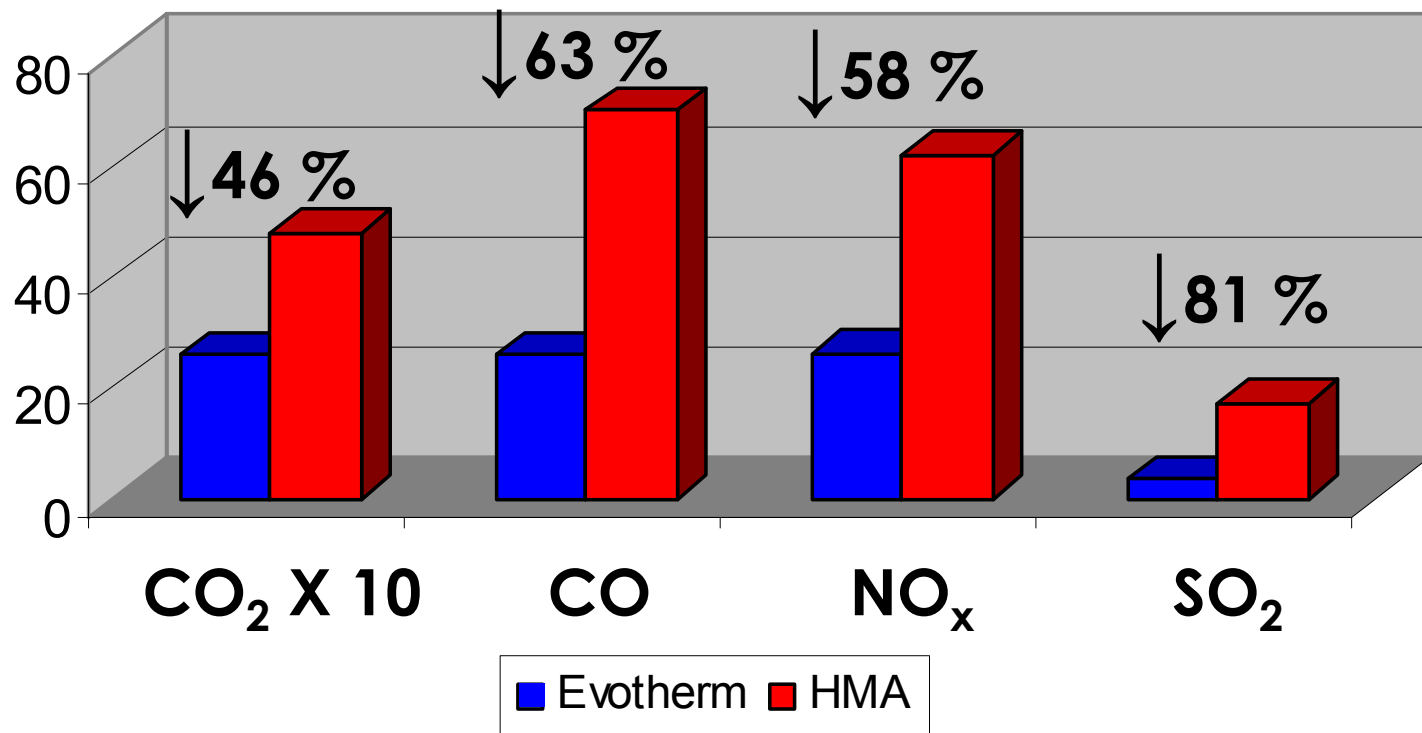
RAMARA DEMONSTRATION

Truck Samples

	HMA	EVO THERM WARM MIX ASPHALT TECHNOLOGY
Mix Temperature (°C)	150	120
Compaction (°C)	138	90
Binder Content (%)	5.0	5.0 (7.3)
Bulk Relative Density	2.383	2.386
Air Voids (%)	4.3	4.1
VMA (%)	15.0	14.8
Stability (N @ 60°C)	9295	9636
Flow Index	9.0	8.6

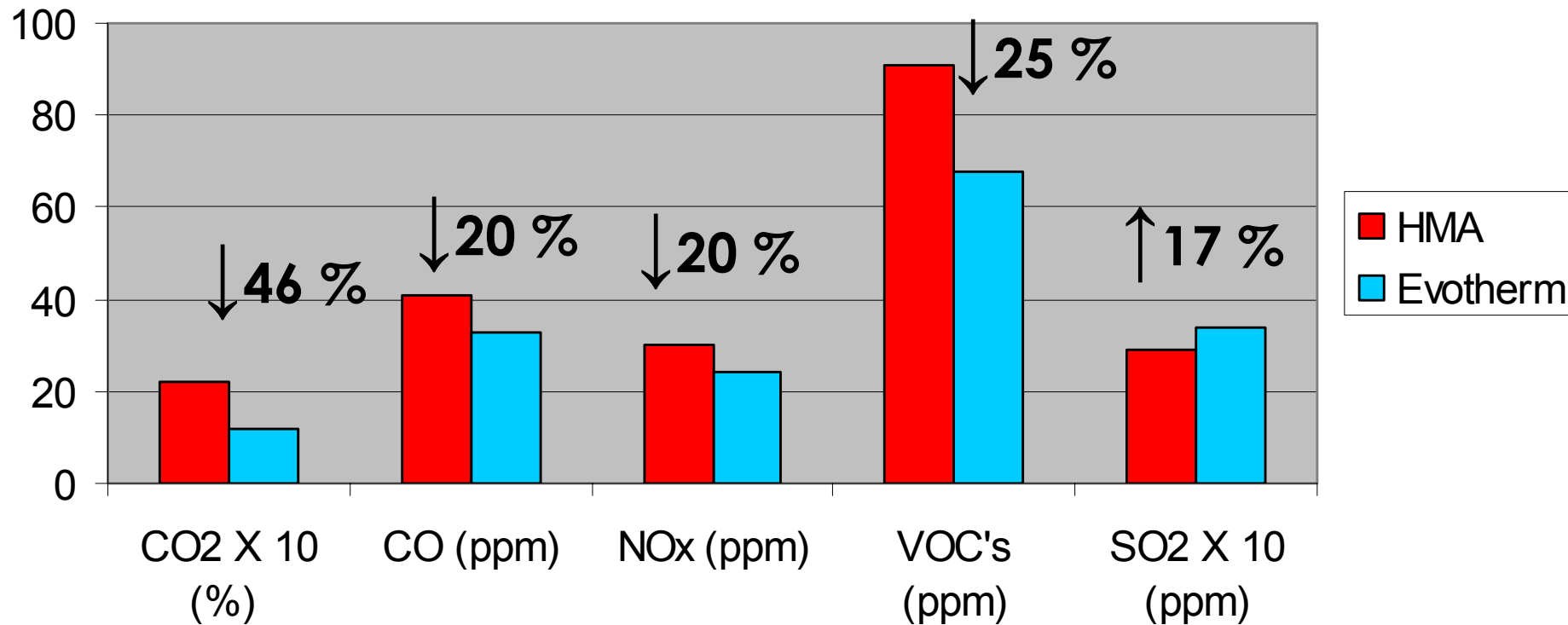
STACK EMISSIONS

Evotherm Lower than HMA Control



STACK EMISSIONS

Evotherm Lower than HMA Control



London, June 13, 2006

ORTECH
Environmental

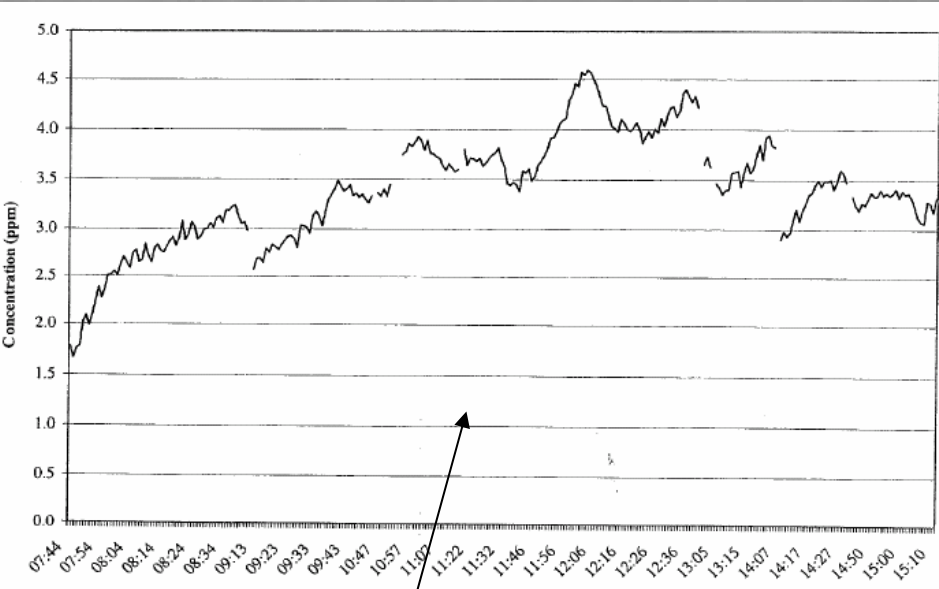
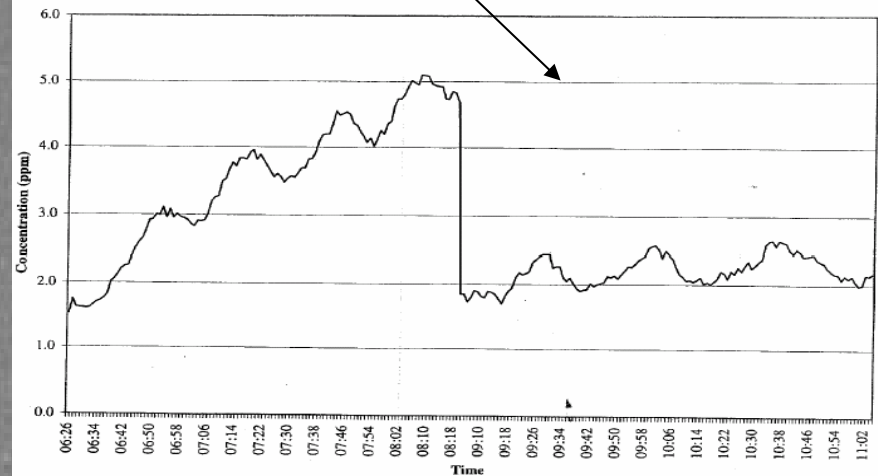
SO₂ readings were unsteady during the HMA production.

STACK EMISSIONS

Discontinuities and Irregularities

Sulfur dioxide readings during HMA production showed irregularities

WMA run was interrupted repeatedly to produce HMA for another job.



RAMARA DEMONSTRATION

Construction



In-place densities reached 94% Gmm using 3 passes each steel vibe breakdown, pneumatic, and steel finishing

McASPHALT – MILLER

Aurora Project: Fuel Consumption

	Average gas consumed (m ³ / ton)
HMA Control	10
Evotherm	2.3



McASPHALT - MILLER HL8 and HL3 Mix Designs

<u>MATERIAL</u>	<u>SOURCE</u>	<u>HL8</u>	<u>HL3</u>
19.0-mm Clear Stone	Carden	24.3	-
9.5-mm Stone	Carden	24.3	43.6
Asphalt Sand	CBM	30.9	-
Asphalt Sand	LaFarge	-	36.7
Unwashed Screenings	Carden	20.6	19.7
AC (PG58-28)	McAsphalt	4.7	5.0
Evotharm Emulsion	McAsphalt	6.8	7.3

McASPHALT - MILLER

Aurora, Canada, Aug. 8

**HL8
Tmix at
the
hopper:
95°C**



**Base stab'd
with 2.5%
foamed
PG58-28 &
1.0% cement**

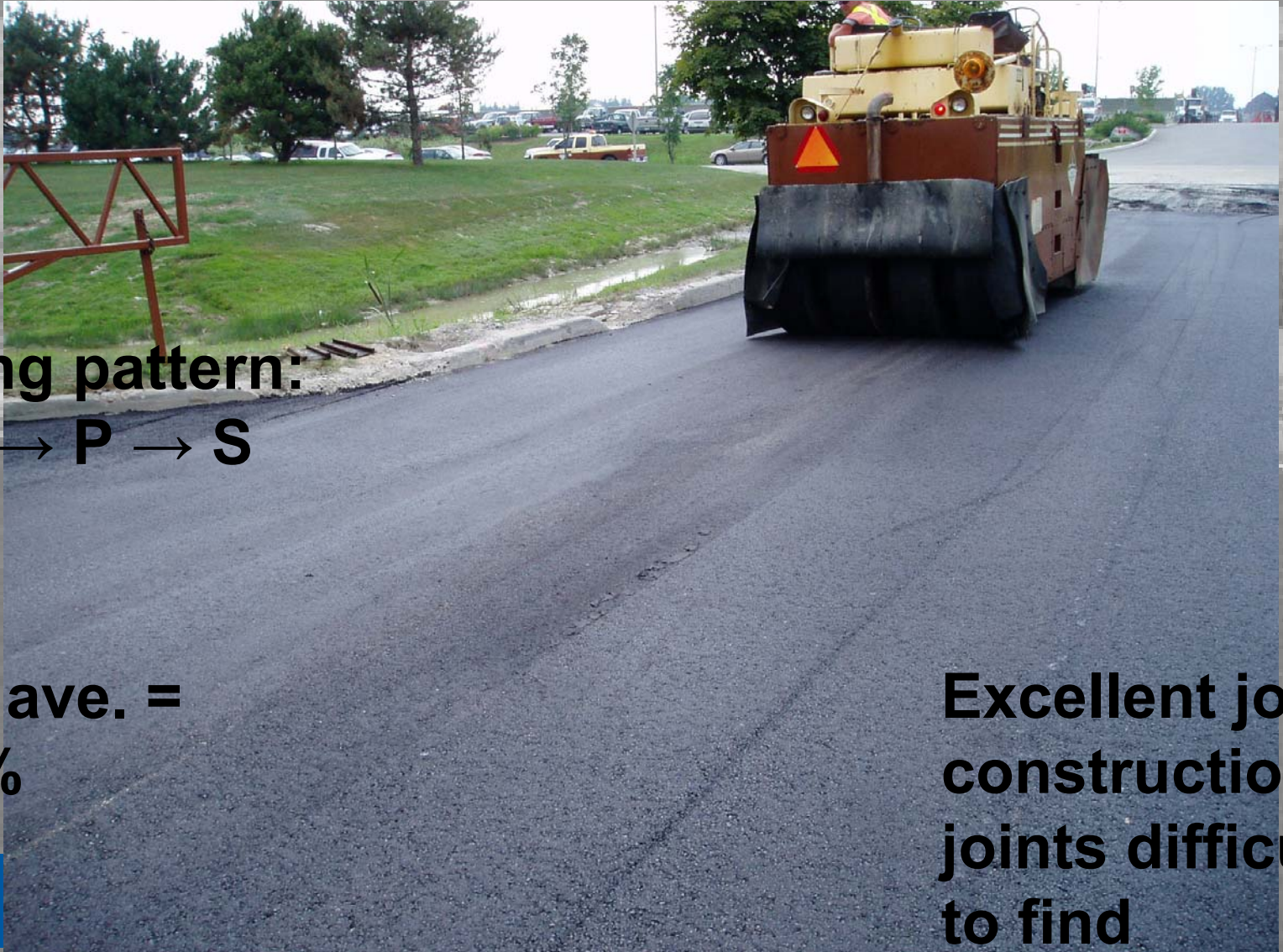
McASPHALT - MILLER

Aurora, Canada, Aug. 8

**HL3
Surface
Mix:
85-
95°C**



McASPHALT EVOTHERM HL3 Mix Overlay on HL8



**Rolling pattern:
Svib → P → S**

**Gmb ave. =
94.6%**

**Excellent joint
construction;
joints difficult
to find**

EVOT

WARM MIX ASPHALT TECHNOLOGY

McASPHALT - MILLER Aurora Project



Finished job

**2000 tons per day
since Aug. 8. '05**



To date, performing well

HERITAGE - MILESTONE

Indianapolis, Jul. 6, 2005



**Drum
mixer**

**Drum
drier**



HERITAGE – MILESTONE

Indianapolis, Jul. 6, 2005



HERITAGE - MILESTONE

Indianapolis, Jul. 6, 2005

JMF: 12.5 mm NMA5 Dolomite with 15% RAP

	Evo therm Lab		HMA lab
PG64-22 (% w/w mix)	5.0	5.0	5.0
Emulsion	7.1	7.1	--
Mix Temp. (°F)	158	203	300
% Gmm N _{-initial} (8)	84.8	84.7	85.5
N _{-design} (100)	94.8	94.5	95.1
N _{-max} (160)	96.1	95.8	96.4
Wet psi	74.8	101.6	141.6
Dry psi	82.7	107.7	151.7
TSR %	90.4	94.4	93.3

Evo**therm** showed properties similar to HMA control.

HERITAGE - MILESTONE

Indianapolis, Jul. 6, 2005



	HMA	EVO THERM WARM MIX ASPHALT TECHNOLOGY
Agg. Temp. (°F) in the drum	400	300
Mix Temp. (°F) at the discharge chute	310	210

No production problems in
this or any trial.

HERITAGE – MILESTONE

Indianapolis, Jul. 6, 2005

Moisture caused no baghouse issues....



during 680 tons of production.

HERITAGE - MILESTONE

Indianapolis, Jul. 6, 2005

EVO THERM

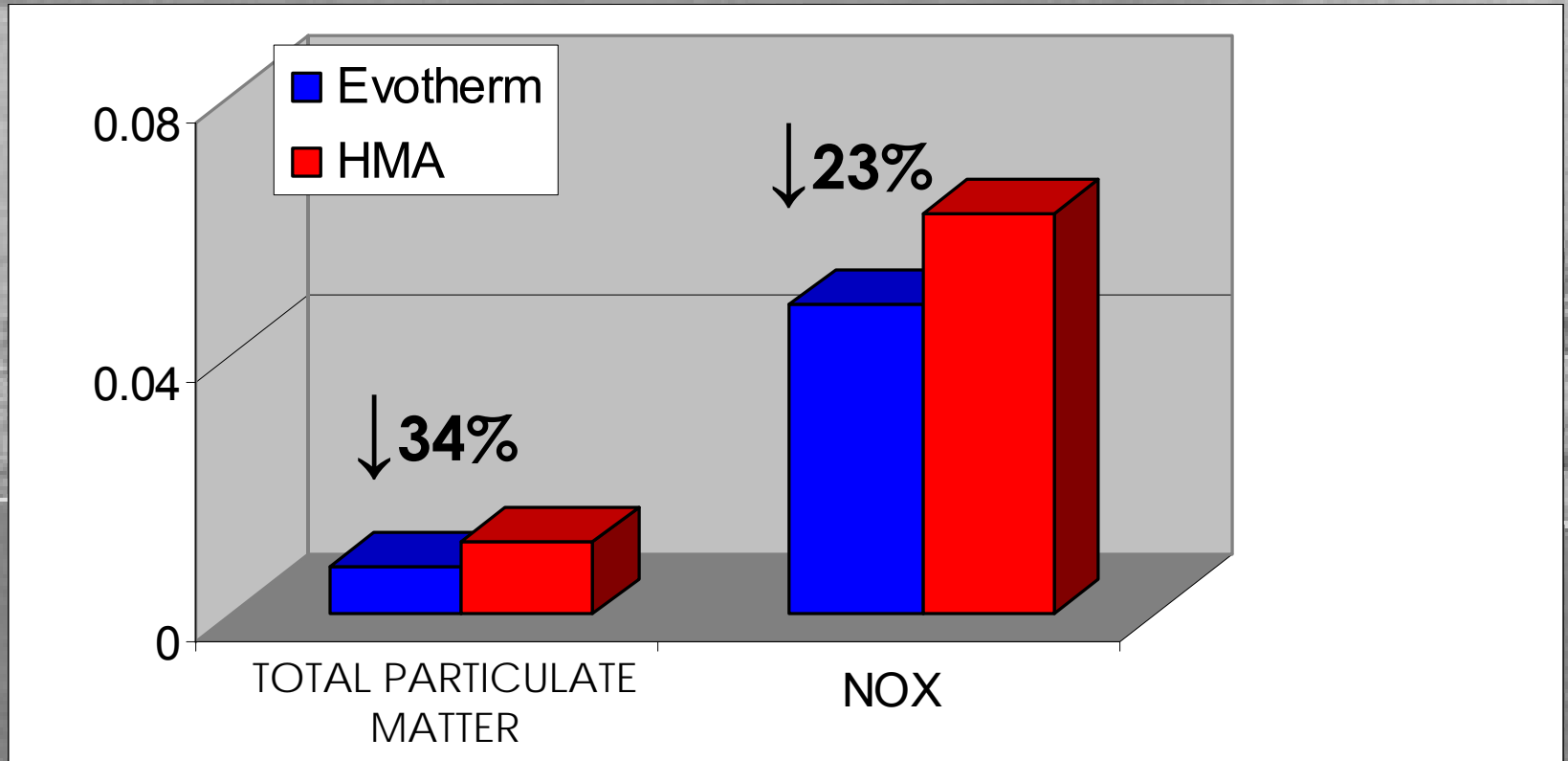
Hot Mix



EVO THERM
WARM MIX ASPHALT TECHNOLOGY

Typical temperature reductions around 100°F.

STACK EMISSIONS REDUCED COMPARED TO HMA CONTROLS

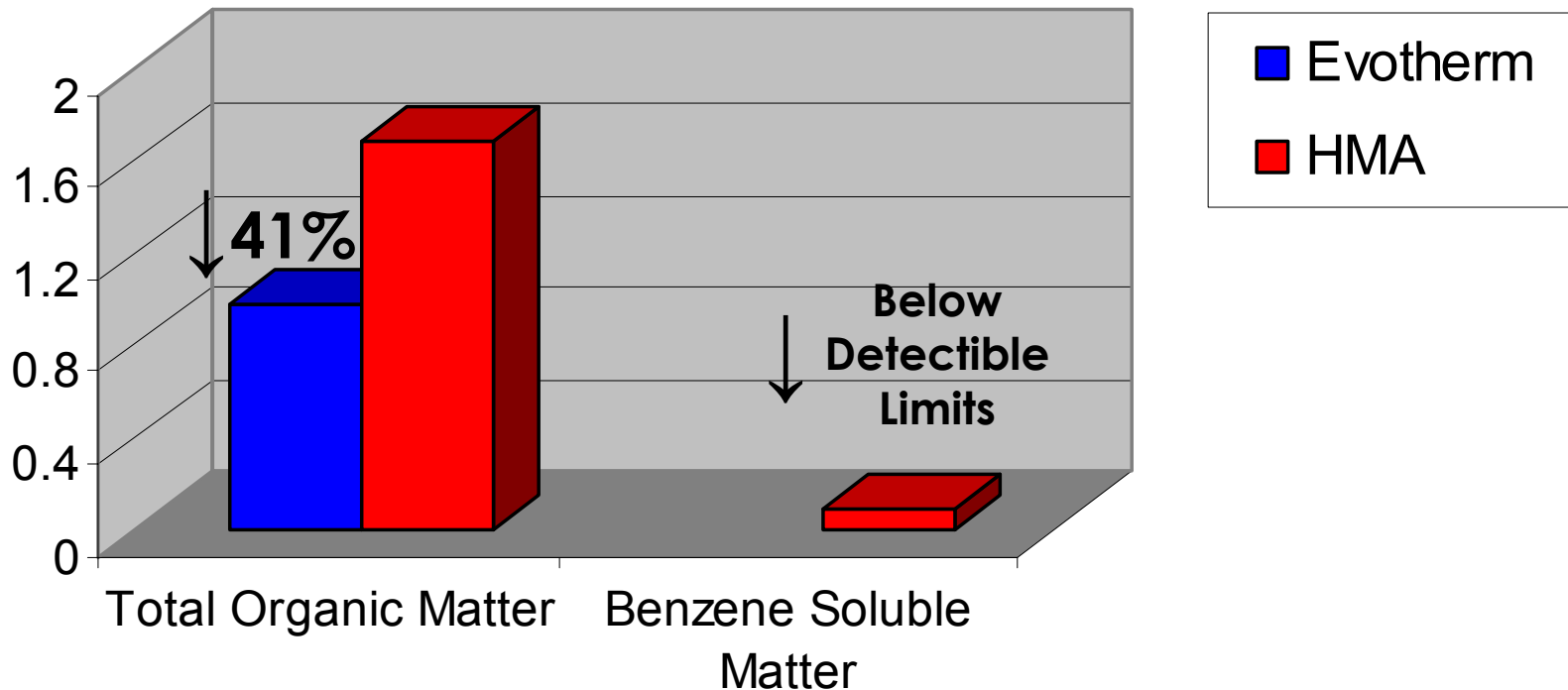


Particulate matter includes micron-size mineral particles and asphaltene aerosols that may add to smog.

ATP, Inc.

Indianapolis, Indiana, July 6, 2005

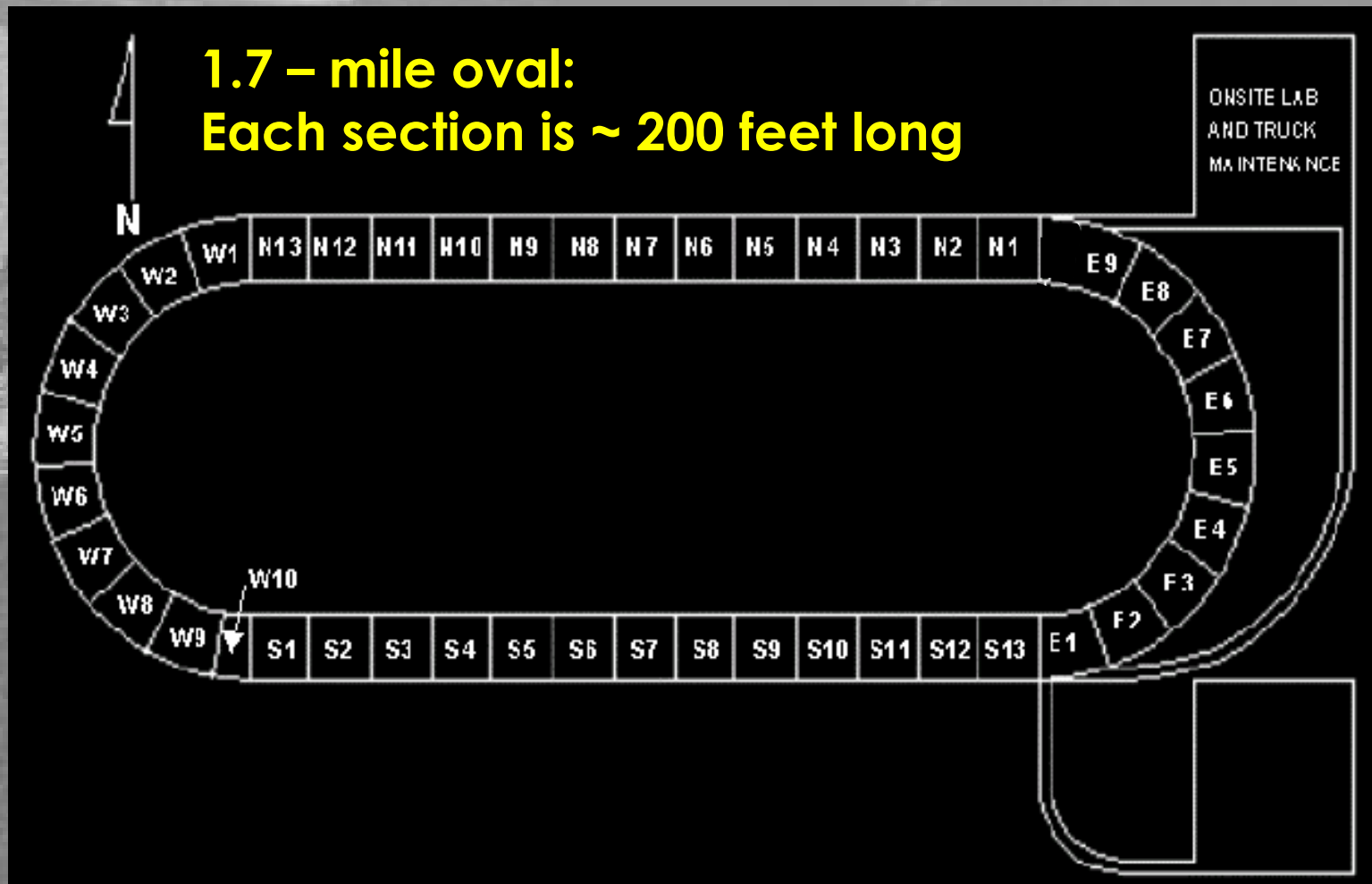
FUMES AT PAVER REDUCED COMPARED TO HMA CONTROLS



Data collected from 10 filter cassettes placed on workers at the paver. Impact of lower temperatures on odor reduction is significant.

NCAT TEST TRACK

Auburn, Alabama



NCAT TEST TRACK

Cross-section of E9, N1, and N2

N2

N1

E9

← 9.5 mm NMAS →

HMA Control PG 67-22

Evotherm PG 67-22

Evotherm PG 67-22

+ 2% Latex

T = 240-280°F

T = 185-205°F

T = 220-225°F

**19.0 mm NMAS w/
Evotherm PG 67-22
T = 220-225°F**

**19.0 mm NMAS w/
Evotherm PG 67-22
T = 220-225°F**

**N_{design} = 80
for all mixes**

NCAT TEST TRACK

Production

Mix Produced 7:00 PM



Mix Loaded out 1:30 PM – next day



**Mix held in
silo at 240°F
overnight**

Mix Placed at 3:15 PM



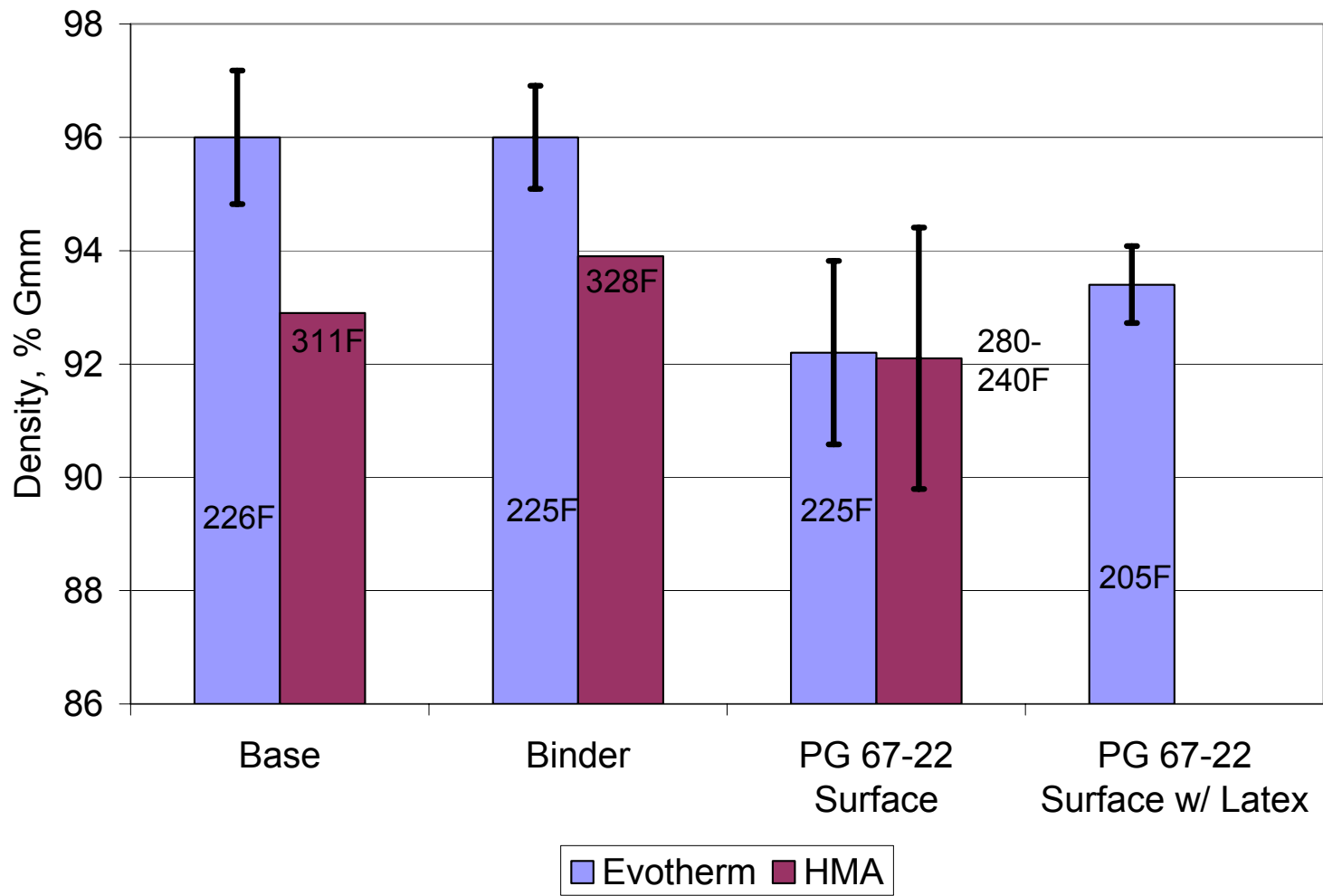
Traffic Returned at 5:00 PM



NCAT Test Track

NCAT TEST TRACK

Pavement Densities



NCAT TEST TRACK



NCAT TEST TRACK

Auburn, Alabama



NCAT TEST TRACK

DEFORMATION (RUTTING in mm) AFTER **600,000** ESALS:

1.1 mm

N2

0.9 mm

N1

0.9 mm

E9

1"	HMA Control PG 67-22	Evotherm PG 67-22 + 2% Latex	Evotherm PG 67-22
2"	19.0 mm NMAS w/ Evotherm PG 67-22		N _{design} = 80 for all mixes
2"	19.0 mm NMAS w/ Evotherm PG 67-22		

To remain through
Next 10MM ESAL's

WARM MIX ASPHALT: 2006 and Beyond

- Specifications for warm mix technology
- Binder recovery and testing methods
- More test sections to be constructed
- Other mix types to be evaluated
- Refinement and evolution to the next generation of chemistry and process technology



THANK YOU

McASPHALT EVOTHERM

HL8 Binder Layer Truck Samples

<u>Truck</u>	<u>JMF</u>	<u>2</u>	<u>5</u>
Residual AC, %	4.7	5.03	4.89
% Moisture in mix	-	0.3	0.24
Maximum density	2.501	2.478	2.476
% Air voids	3.8	4.23	4.68
Film thickness, μm	8.31	8.68	8.67
Marshall stability, N	9400	10163	8541
Flow	8.5	10.2	8.5
TSR%	-	-	73.2
Pen of recovered binder	80	105	108

Drop in penetration is 10-15%, compared to 30% for HMA control

McASPHALT - MILLER

HL3 Surface Mix Truck Samples

	<u>JMF</u>	<u>Ave. 3 samples</u>
Residual AC, %	5.0	5.12 ± 0.10
% Moisture in mix	-	0.35 ± 0.10
Maximum density	2.483	2.466 ± 0.002
% Air voids	4.27	3.80 ± 0.48
Film thickness, μm	8.99	8.37 ± 0.52
Marshall stability, N	9250	10030 ± 1010
Flow	8.5	9.3 ± 0.53
TSR%	-	82
Pen of recovered binder	80	104 ± 6