Comparison of worker breathing zone exposures between hot mix asphalt and warm mix asphalt applications

Anthony J. Kriech¹, Linda V. Osborn¹, Brian D. Prowell², Adam P. Redman¹, and Randy C. West³

1. Heritage Research Group, 7901 West Morris Street, Indianapolis, Indiana 46231 USA
2. Advanced Materials Services, LLC, 2515 E. Glenn Ave Suite 107, Auburn, Alabama 36830 USA
3. Auburn University, 277 Technology Parkway, Auburn, Alabama 36830 USA
Financial support (NCHRP 09-47A) grant between

- the National Center for Asphalt Technology (NCAT)
- the National Cooperative Highway Research Program (NCHRP) TRANSPORTATION RESEARCH BOARD (TRB) National Research Council
Why do we want to minimize exposures?
What are the health concerns related to exposure to asphalt fumes?

– Cancer
– Irritation
IARC Monograph Review

Volume 103 asphalt and asphalt fumes, and some heterocyclic PACs

**CLASSIFICATIONS**

1. is carcinogenic to humans

2A. is probably carcinogenic to humans

2B. is possibly carcinogenic to humans

3. is not classifiable as to carcinogenicity in humans

4. Is probably not carcinogenic to humans
RECENT CRITICAL RESEARCH

Cancer

- IARC Nested Case Control Study
- FRAUNHOFER ITEM
- API HPV Studies
  (Reproductive Toxicity)
- AI Skin-Painting Studies

Diagram:
- EPI
- INHALATION
- TOX
- SKIN
• no consistent evidence of an association between indicators of either inhalation or dermal exposure to asphalt and lung cancer risk and

• attributed increased incidence in cancer to confounding issues like smoking, exposure to coal tar etc
Animal Studies

• Skin-Painting Study
  – Paving asphalt fume condensate – negative

• Inhalation Studies
  – Negative reproductive toxicity study
  – Negative inhalation study (Fraunhofer ITEM)

• Asphalt-related **irritant effects** were observed in the nasal passages and in the lungs
Recent Studies

Irritation

• Raulf-Heimsoth et al.
  – potentially (sub-) chronic irritative inflammatory effects in the lower airways

• Tepper et al.
  – reported throat symptoms

• Norseth et al.
  – fatigue
  – reduced appetite
  – eye irritation
  – laryngeal-pharyngeal irritation
• WMA results in reductions in TP and BSF
• Results for BSF below detectable limits in most cases
• Not much available in peer reviewed publications

TP = total particulate
BSF = benzene soluble fraction
Study Objectives

• Does WMA reduce worker exposure to total organic matter (TOM) as compared to its corresponding HMA?
  – Minimize variables in field

• How many of a list of 40 PACs are present in the highest TOM samples per site?
  – List includes 9 of 14 on IARC list
Study Design
Sampling System Choice

- In US, NIOSH REL of 5 mg/m³
  - based on TPM as 15-min ceiling
- ACGIH TLV of 0.5 mg/m³
  - for bitumen fumes measured as benzene extractable inhalable particulate as an 8-hr time-weighted average
- Shown to be equivalent to BSF using NIOSH method 5042 for bitumen fumes
Summary of Existing Heritage Data

<table>
<thead>
<tr>
<th>TP</th>
<th>BSF</th>
<th>TOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.52</td>
<td>&lt;0.04</td>
<td>0.81</td>
</tr>
</tbody>
</table>
Total Organic Matter

- TOM captures ~7-10 times more VOCs than BSF
- TOM collected using sorbent tube; analyzed by gas chromatography with flame ionization detection

Charcoal plus XAD-2 resin
• Three different WMA technologies were compared to one HMA at each of two sites

Griffith, Indiana  New York, New York
WMA technologies

- BituTech PER
- Cecabase® RT
- Evotherm™ DAT
- SonneWarmix™
- Ultrafoam GX2
- Wax
Analytical PACs by GC/MS

GC/FID

• Quantifies How Much (TOM)
• Qualitatively tells you what boiling point range and may indicate confounding exposures

40 individual compounds investigated
Sample Collection
<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th>M</th>
<th>A</th>
<th>H</th>
<th>M</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1187</td>
<td>tons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>881</td>
<td>tons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>890</td>
<td>tons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1200</td>
<td>tons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 – mile stretch on Calumet Ave, Munster, IN

9-14-2010 through 9-16-2010
Biodiesel Substitute

**B-100 Biodiesel** - fatty acid methyl esters from soybeans or other plants and it contains no PACs
Worker spraying down bed of hopper with biodiesel
After fourth lane is being rolled
Different Types of Pavers Used
RESULTS
Mat Temperatures Just Behind Screed

Average Mix Temperature of Mat

Indiana Site

-12
-15
-10
126
114
111
116

New York Site

-55
-52
-44
161
106
109
117

°C
<table>
<thead>
<tr>
<th>Location</th>
<th>HMA</th>
<th>WMA-A</th>
<th>WMA-B</th>
<th>WMA-C</th>
<th>HMA</th>
<th>WMA-D</th>
<th>WMA-E</th>
<th>WMA-F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiana</td>
<td>0.32</td>
<td>0.12</td>
<td>0.34</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York</td>
<td>2.21</td>
<td>1.17</td>
<td>1.40</td>
<td>1.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
95% Confidence Interval for TOM

**IN Temp. / TOM**
- HMA Avg. = 126°C / 0.32 mg/m³
- WMA Avg. = 114°C / 0.20 mg/m³

**NY Temp. / TOM**
- HMA Avg. = 161°C / 2.21 mg/m³
- WMA Avg. = 111°C / 1.35 mg/m³

Total Organic Matter (TOM) mg/m³
22 of 40 PACs - below LOD for 8 samples (highest TOM)

- Naphthalene detected at highest concentration
- Only one 4-6 ring PAC (pyrene) detected in any of these worker BZ samples - in a HMA sample
- 9 PACs tested as part of compounds recently listed by IARC (preliminary list of agents to be reviewed for asphalt, asphalt fumes, and some heterocyclic PACs) were all below LOD
- Since only one 4-ring PAC was detected, unlikely that the five additional 6-ring IARC listed compounds excluded from this study were present
NY Binder more volatile until 457°F
Conclusions
WMA use resulted in:

- Lower application temperatures
- A 36% reduction in TOM exposures within the paving worker breathing zones
- Exposures not the same across technologies
- Asphalt source yielded very different results
- 4-6 ring PACs were not detected in any of the WMA breathing zone samples
Thanks to the NY city DOT
Thank You!