# Monitoring Oxidation Signals of Asphalt Pavement Surfaces by Portable Infrared Spectroscopy: in-situ testing of % RAP in HMA

Dr. Delmar Salomon
Dr. Iliya Yut*
Pavement Preservation Systems, LLC
*Senior Consultant

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# Outline

Oxidation as major factor of HMA pavement deterioration

Need for quick field indicator of oxidation level of an HMA

Laboratory studies of oxidation of asphalt by FT-IR
Well known

SHRP 2 advances in field applications of portable FT_IR

Nondestructive testing of oxidation levels in HMA by FT-IR

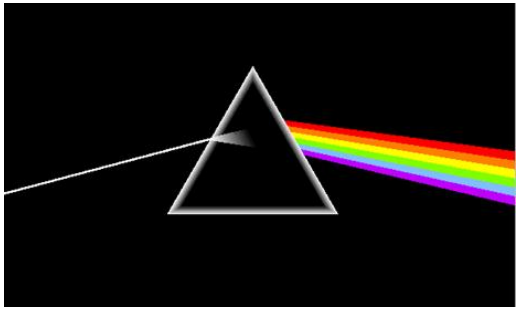
Proposed AASHTO Standard Practice on measuring oxidation in HMA by FT-IR

Use of Portable Infrared Spectroscopy for :
in-situ testing of RAP

Potential of incorporating in-situ pavement oxidation index into PMS

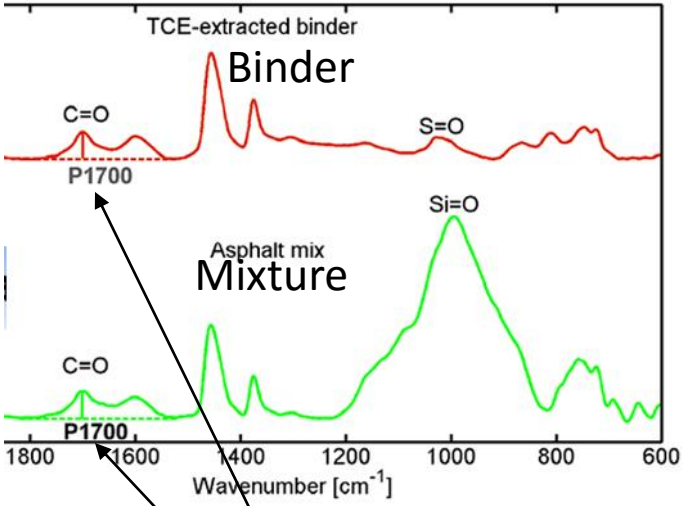
# Infrared Spectroscopic Methods

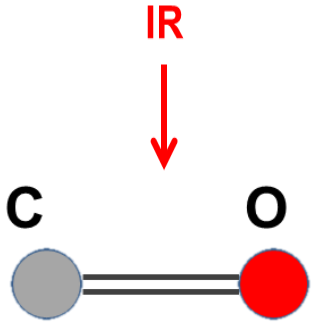
## Fourier-Transform Infra-Red (FTIR) Spectroscopy



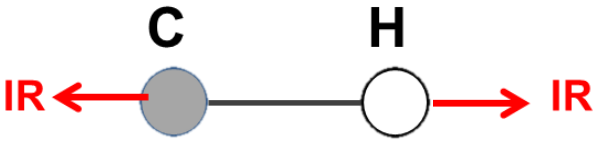
What is there ?

How much of it in there?




Bending vibration




Stretching vibration

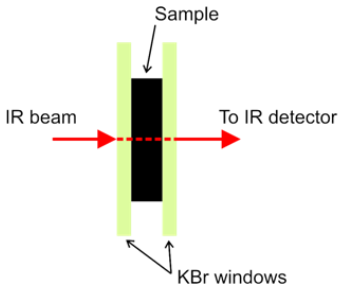
**"Oxidation Signal"**
**From binder and mixture**

# Evolution of FT-IR Sampling Modes in Asphalt Studies

## Transmission (since 1960s and SHRP – 1980s)

**Destructive**

1. Dissolve sample
2. Prepare KBr pellets
3. Place sample into a cell

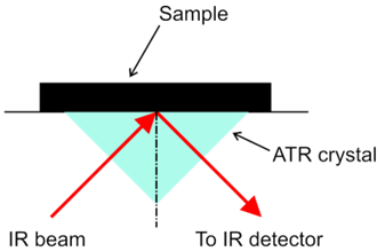


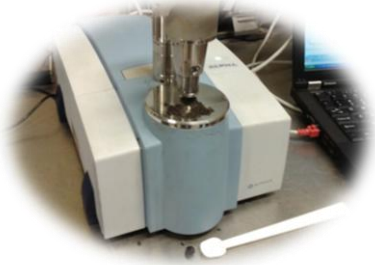

## Attenuated Total Reflection (ATR) (1990s and SHRP2 2009-2014)

**Non-invasive for binders**

**Mildly invasive for mixtures**

1. Sieve or drill
2. Bring sample to instrument



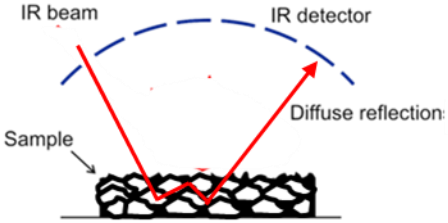



## Hand-Held Diffuse Reflection (DR) – This study (Idaho 2015)

**(a.k.a. Portable Infrared Spectrometer, or PIRS)**

**Non -destructive (point-and-shoot)**

1. Bring instrument to sample




# First Demonstration Study - Idaho

**Monitoring the consistency of HMA/RAP samples and in-place Pavement using a Portable Infrared Spectroscopy Device (PIRS)**

## Objectives:

1. Evaluate PIRS capability of estimating %RAP.
2. Provide recommendations for use of PIRS on future paving projects.

| Select projects | Collect materials | Mix calibration samples | Measure oxidation in mixes | Analyze data |
|---|---|---|---|---|
| Low RAP<br>Medium RAP<br>High RAP | Virgin binder<br>Virgin agg.<br>RAP | Vary %RAP<br>(0-**15**-30-100)<br>(0-25-**50**-100) | Lab (calibration)<br>Plant, pavement (validation) | Variability<br>Agreement between lab, plant, and pavement<br>Influencing factors |

**Compare with Field results and Develop Recommendations**

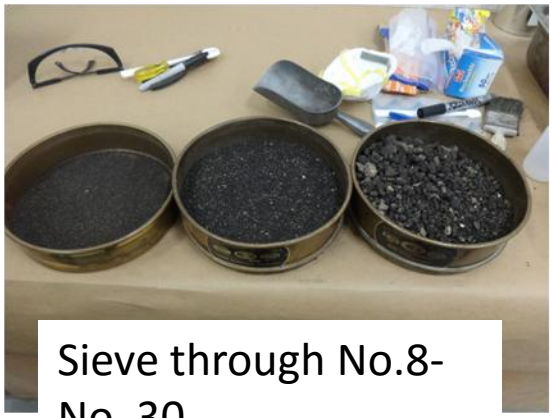
# First Demonstration Study - Idaho

## 3 Projects and Materials – Mix Designs

| Mix Design | Project 1 | Project 2 | Project 3 |
|---|---|---|---|
| **Project ID** | "Karcher" | "Fruitland" | "Lewiston" |
| **Location** | Nampa, ID | Nampa, ID | Lewiston, ID |
| **Traffic Level [ESAL]** | 1 - 10 mln | 1 – 10 mln | 10 – 30 mln |
| **NMAS** | 12.5 mm | 12.5 mm | 12.5 mm |
| **Target PG** | 70-28 | 70-28 | 76-28 |
| **RAP [by agg.]** | 17% | 54% | 45%<br>(40% mill + 5% pit) |
| **Adjusted virgin PG** | 70-28 | 52-34 | 70-34 |
| **Target $P_b$** | 5.3 | 5.3 | 5.6 |
| **RAP $P_b$** | 5.3 | 5.2 | **6.0** |
| **RAP PG (est.)** | Unknown | PG 88-XX | PG 76(82)-XX<br>(mill) |
| **Antistrip** | 0.5% | 0.5% | 0.75% |

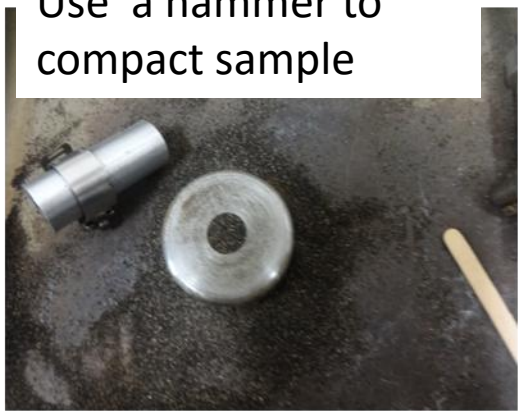
# First Implementation Study - Idaho

## Lab mix sample processing for PIRS scanning



Sieve through No.8-No. 30

Fill sampling cylinder



Use a hammer to compact sample

## Plant mix sample processing for PIRS scanning

# Example of Sampling cylinder with compacted HMA

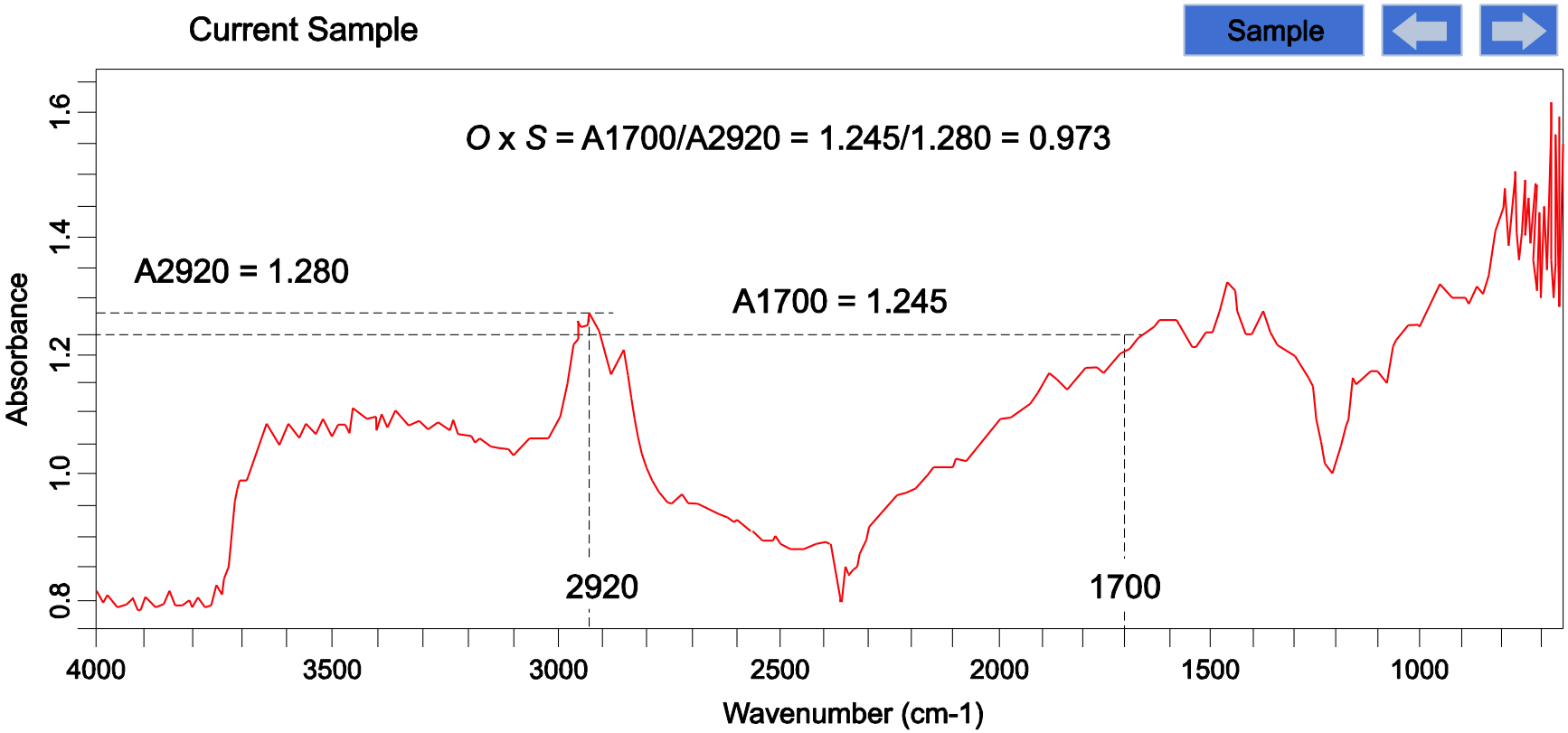
D= ½ “ X L= 2 “

# Testing in the Field
# (PIRS pavement monitoring)



# IR scans and oxidation signals

**Calculation of Oxidation Signal from an absorbance spectrum of an asphalt mix sample.**



# First Demonstration Study - Idaho

## Laboratory Results for RAP-HMA mixtures

**Objective of analysis**: Evaluate compliance with Beer Law (BL)

$$OxS(a*A+b*B) = a*OxS(A)+(1-a)*OxS(B)$$

BL Measured

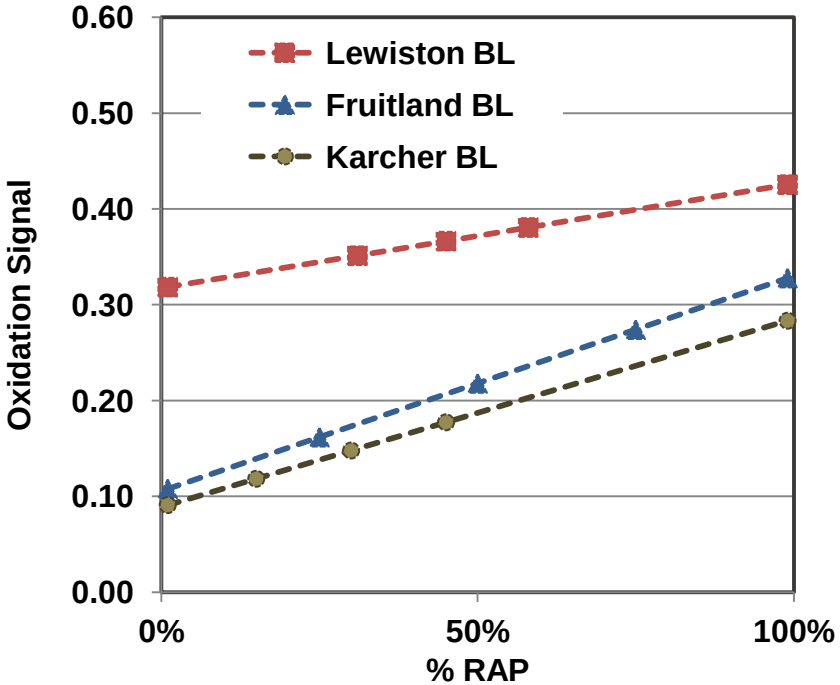
*A = pure RAP (100%RAP)*
*B =virgin mixture (0%RAP)*
*a = %RAP*
*b = %virgin mix*
*a + b=100%*

If Meas. = BL then full blending

If Meas. < BL then partial blending

If Meas. > BL then
%RAP incorrect or sample overheated

**Ideal Calibration Line**

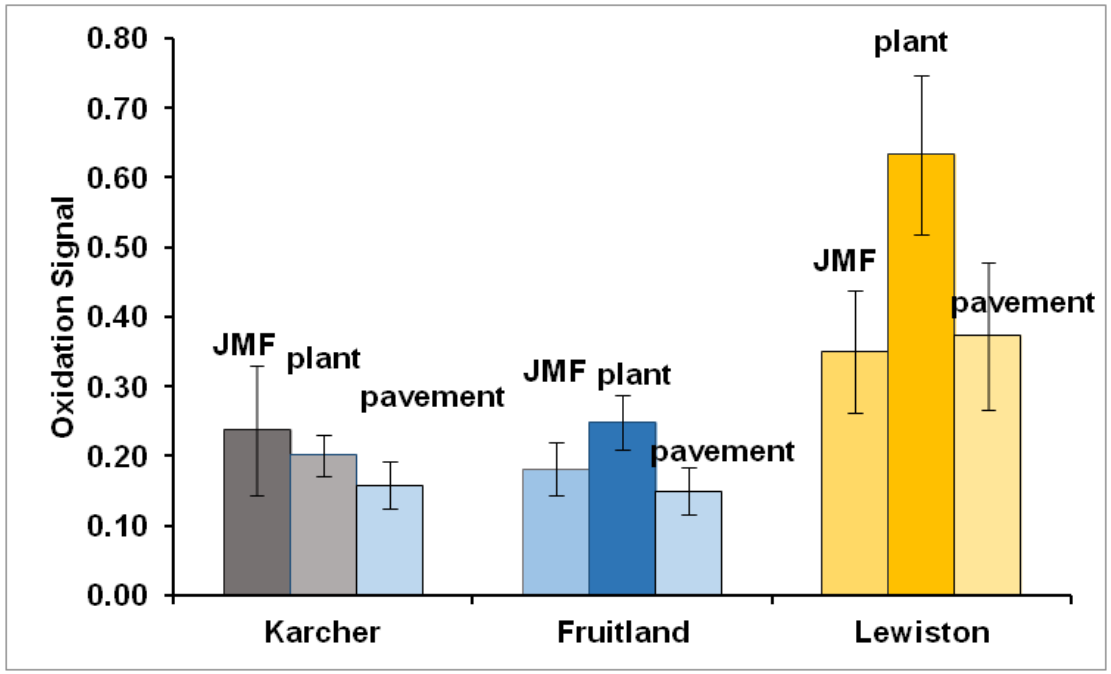


# First Demonstration Study - Idaho

## Laboratory Calibration Curves for RAP-HMA

**Objective of analysis:**

**2. Detect deviation of plant and pavement samples from the JMF**




**Results:**

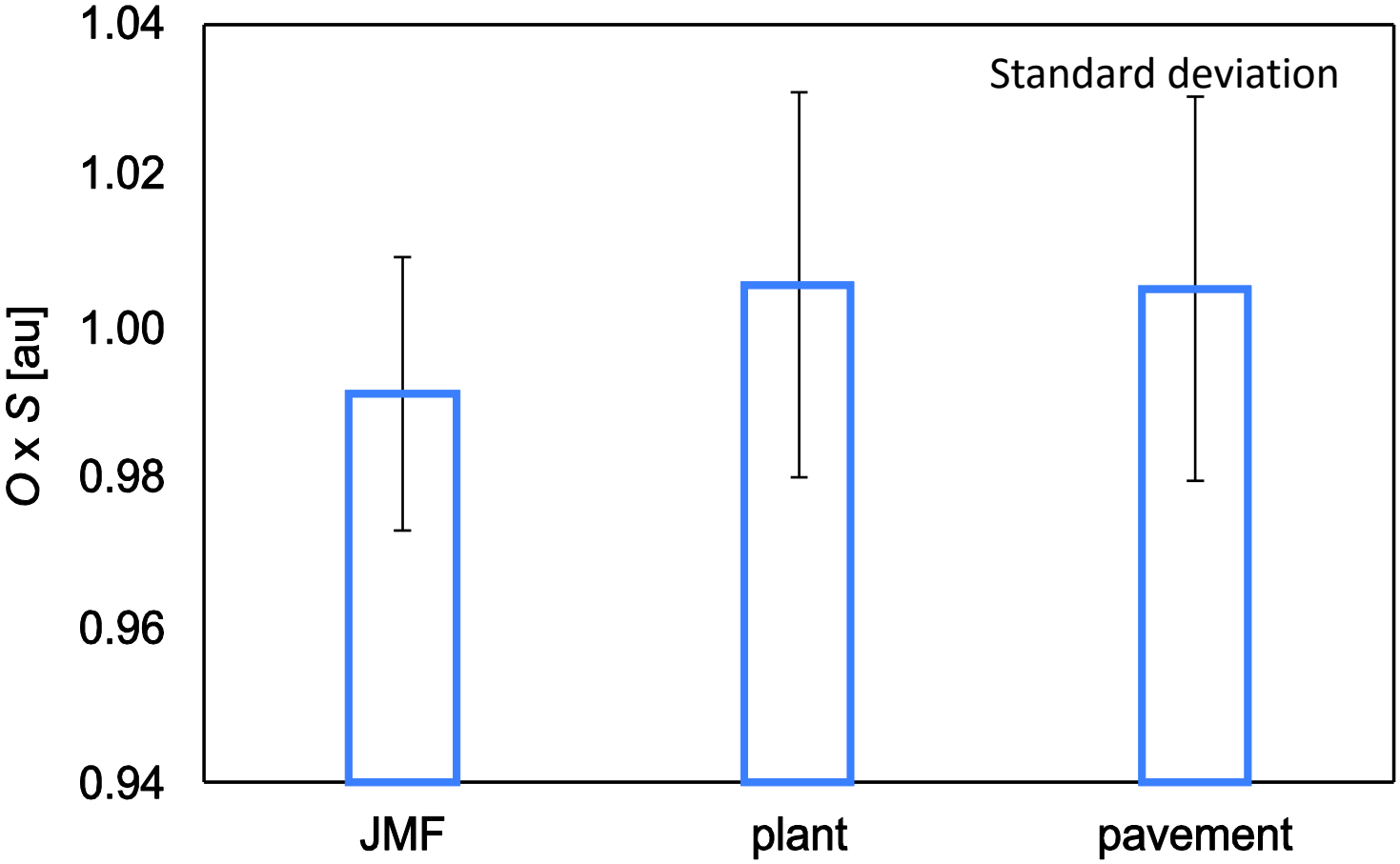
✓All pavement measurements remained within 1 st.d. from JMF

✓Plant signals were higher than pavement ones.

✓Lewiston plant sample may be not representative (night time paving)

# Example of Comparison of oxidation signals from JMF, HMA plant and in-place pavement

Mean and  and standard deviation; the error bars are one standard deviation from  the mean of five samples



# Standard Method of Test for (proposed Provisional Standard)

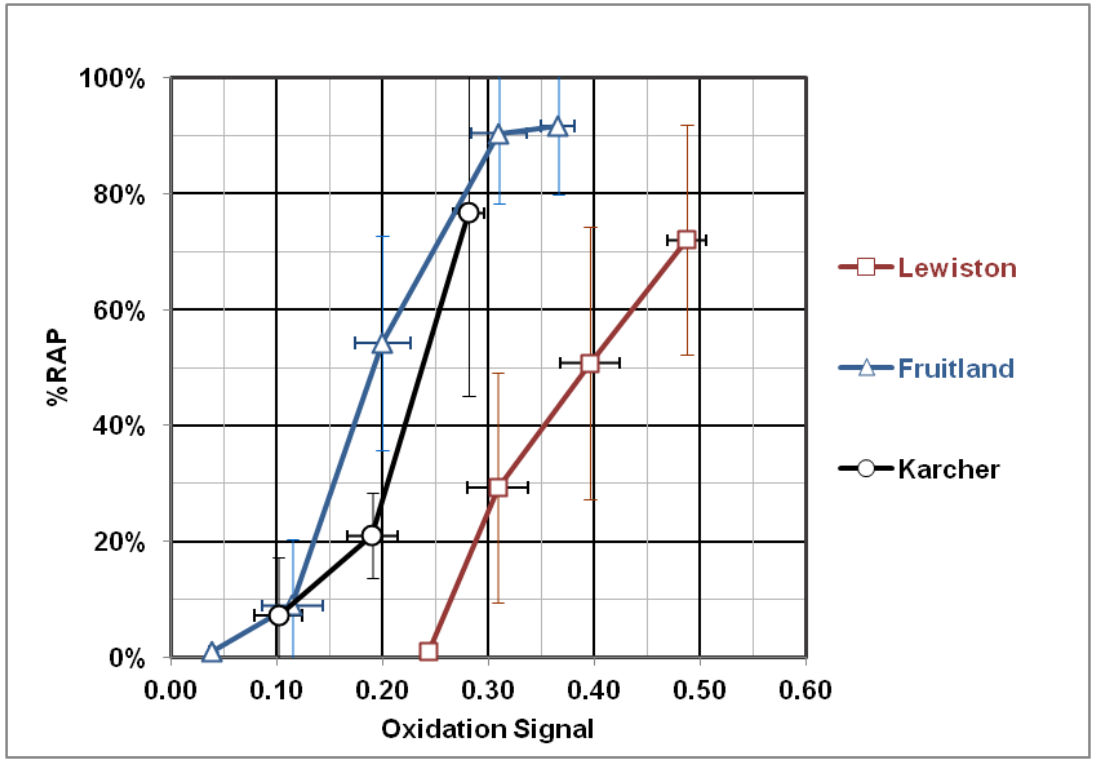
## Evaluation of Oxidation Level of Asphalt Mixtures by a Portable Infrared Spectrometer

# First Demonstration Study - Idaho

## What have we learned about RAP-HMA?

✓On average, every 20% RAP to 0.1 unit Ox.Signal with St.d. = 10% RAP

✓%RAP in HMA can be determined with 82% reliability based on no-RAP and 100% RAP measurements



# Draft AASHTO Standard – FTIR on RAP

- Was developed by SRHP2 R06B research team for aged asphalts.
- Was modified for RAP and submitted to AASHTO TS-2a by PPS, LLC
- **Scope:**
  - ✓ Covers semi-quantitative evaluation of the oxidation level in HMA.
  - ✓ Based on the quantitative analysis of ATR or DR infrared spectrum.
  - ✓ Sample is obtained from the pavement surface.
  - ✓ Sample may be modified by adding RAP and/or RAS.
  - ✓ Oxidation level in the samples is calculated based on the intensity of the signal associated with carbonyl content.

**The oxidation signal from pavement surface is compared with predetermined signals from JMF and plant samples.**

**Testing frequency of threshold is established by an agency based on a pilot study.**

# Acknowledgements

Pavement Preservation, LLC thanks the Idaho Transportation Department for sponsoring this project.

# For further information:

delmar@technopave.com