ODOT's Look at Thermal Segregation with PAVE-IR

Ohio Asphalt Paving Conference

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Introduction

- The Problem with Segregation
- How did we get here?
- What is Pave-IR?
- Research Projects
- Project Data
- Conclusions
- Future Projects

Thank You!!

- Angela Desimone – ODOT Intern
- Dave Powers – Asphalt Materials Engineer
- ODOT – Office of Research & Development
- Shelly Company
- Kokosing Construction

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The Problem!

TABLE 29 Summary of the influence of segregation on mixture properties

Mixture Property	Percent of Non-Segregated Mix Property by Level of Segregation Δ AV 2%-4.5%	Δ AV 4.5%-6.5%	Δ AV > 6.5%
	Fine	Low	Medium	High
Permeability	Increased slightly	Increasing with level of coarse segregation		
Resilient Modulus	Little or slightly increasing stiffness	80 to 90%	70 to 80%	50 to 70%
Dynamic Modulus	Little or slightly increasing stiffness	80 to 90%	70 to 80%	50 to 70%
Dry Tensile Strength	110%	90 to 100%	50 to 80%	30 to 50%
Wet Tensile Strength	80 to 90%	75%	50%	30%
Low Temperature Tensile Stress	No conclusions due to test method difficulties			
Loss of Fatigue Life when Segregation in Upper Lifts, %	Not Estimated	38%	80%	99%
Rutting Potential	Not strongly influenced by gradation segregation until a high level of segregation is seen			

[2]*NCHRP 441 – Segregation in Hot-Mix Asphalt Pavements*

How Did We Get Here??

The Problem:

"Segregation creates non-uniform mixes that do not conform to the original job mix formula in gradation or asphalt content. The resulting pavement exhibits poor structural and textural characteristics, provides poor performance and durability, and has a shorter life expectancy and higher maintenance costs." [1]

- Segregation has been noted as problem in asphalt pavements for over 50 years.
- Current identification methods for segregation are very subjective.
- 1998 Washington DOT looks at Thermal Segregation and Density Differentials.
- 2000 NCHRP 411 Segregation in HMA Pavements
- 2002 TTI research concludes with development of Pave-IR system.
- 2004 Texas DOT standard specs requires Thermal Profiles for asphalt paving.
- 2011 ODOT demos Pave-IR on US-24 with Gerken Paving
- 2012 ODOT Pilots Pave-IR

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What is PAVE-IR?

- Thermal imaging system to collect continuous real time temperature data from asphalt paving projects.
- Utilizes non-contact infrared temperature sensors
- GNSS receiver to collect geographic position data.
- Odometer to record paving speed, stop, and distance information.

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PAVE-IR Pilot Methodology

Goal: Evaluate the Pave-IR system for determining segregation and the anticipated temperature ranges for typical paving operations.

- 150ft thermal profiles
- Corresponding density profiles with nuclear/electronic density gauge.
- Collect data in all temp. diff. ranges
  - $\Delta T < 25°F$
  - $25°F < \Delta T < 50°F$
  - $\Delta T > 50°F$

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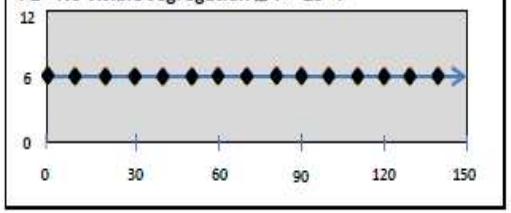
HMA DENSITY PROFILE DATA

Project (C/R/S) / No.:	Date:
Contractor:	Paver Info:
Technician:	Transfer Device: Y or N Type:
Mix Type:	No. Trucks:
Thickness:	Haul Distance:
Existing Surf.:	Roller Info:
JMF #:	Gauge #:

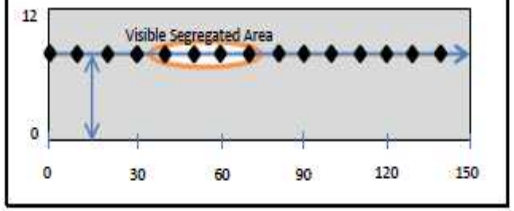
Longitudinal Profile Information						Density Reading (PCF) / Longitudinal Profile Location (ft)													
No.	Begin Sta:	End Sta:	Offset	Profile Type		D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}
1					Density															
					Location															
2					Density															
					Location															
3					Density															
					Location															
4					Density															
					Location															
5					Density															
					Location															
6					Density															
					Location															
7					Density															
					Location															
8					Density															
					Location															

Comments:

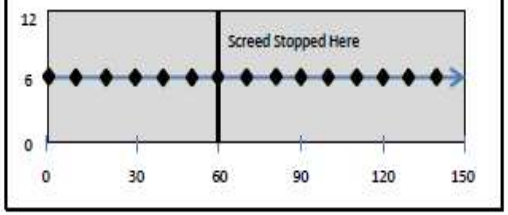
P1 - No visible segregation Δ T < 25° F (Control)
P2 - No visible segregation Δ T > 25° F



P3 - Visible segregation



P4 - Paver Stop > 2 min.



Projects?

- Project 74-12 / US32 Pike County
  - Contractor: Shelly Co.
  - 1.5” - 12.5 mm
  - 1.75” – 19.0 mm
  - MS4 Transfer Device
- Project 508-11 / US32 Adams County
  - Contractor: Shelly Co.
  - 1.5” - 12.5 mm
  - 1.75” – 19.0 mm
  - MS4 Transfer Device
- Project 3011-11/ I-71 Morrow County
  - Contractor: Kokosing Construction
  - 1.75” – 19.0 mm, MS4 Transfer Device
  - 6” – 302 Asphalt Base

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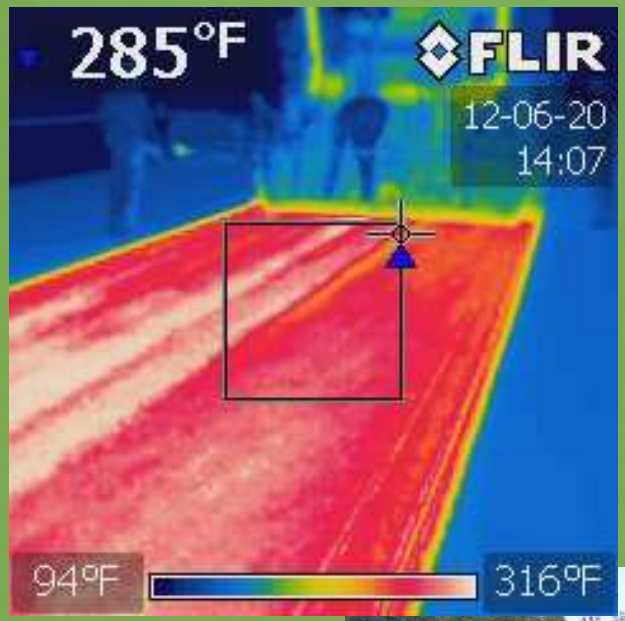
US32 – Pike County
Project 74-12



Pay Factor Information:

19.0mm Avg. Core Density = 93.9%

12.5mm Avg. Core Density = 93.6%

88.7% of the density incentive captured

95.2% of the smoothness incentive captured

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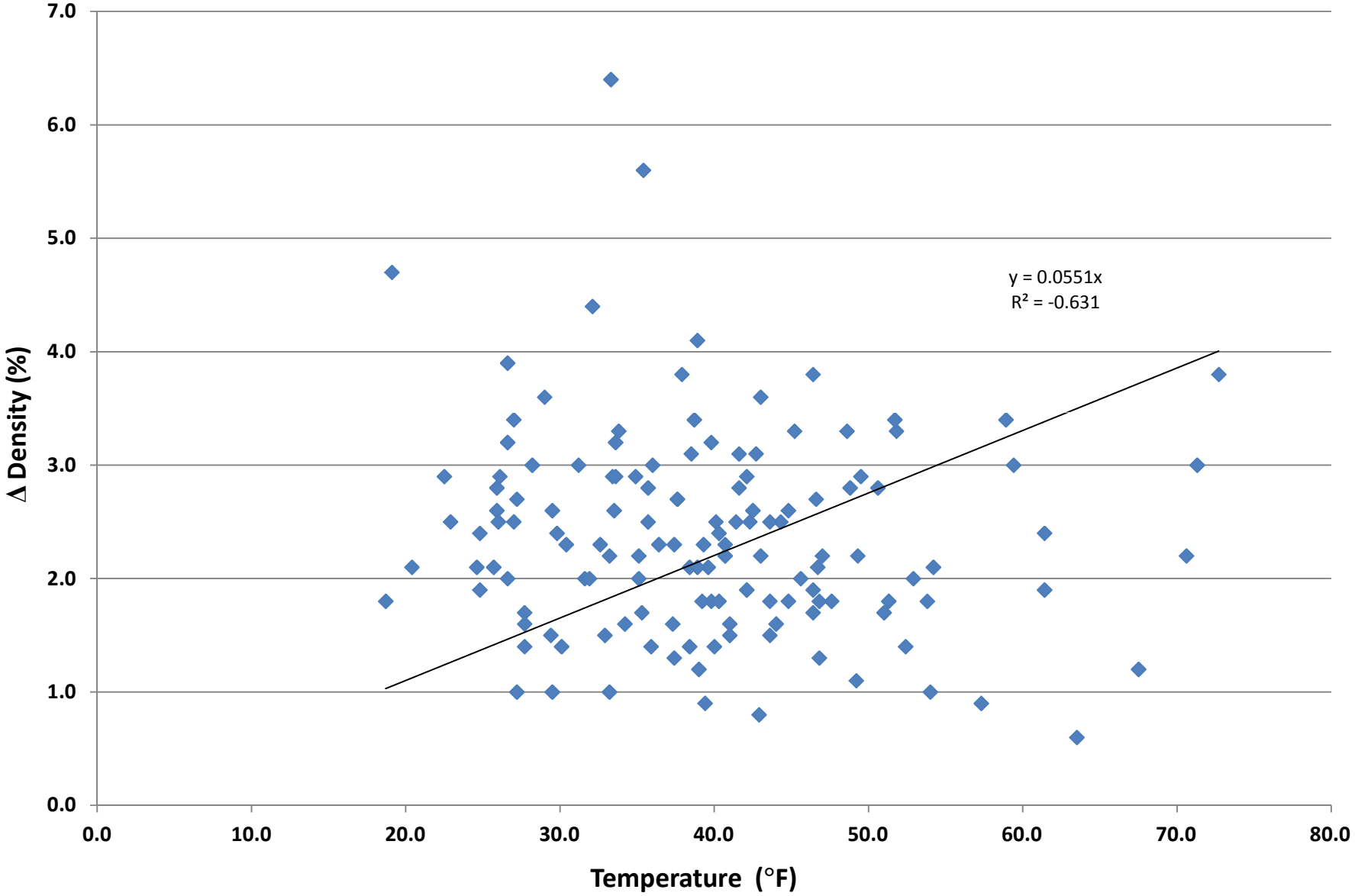
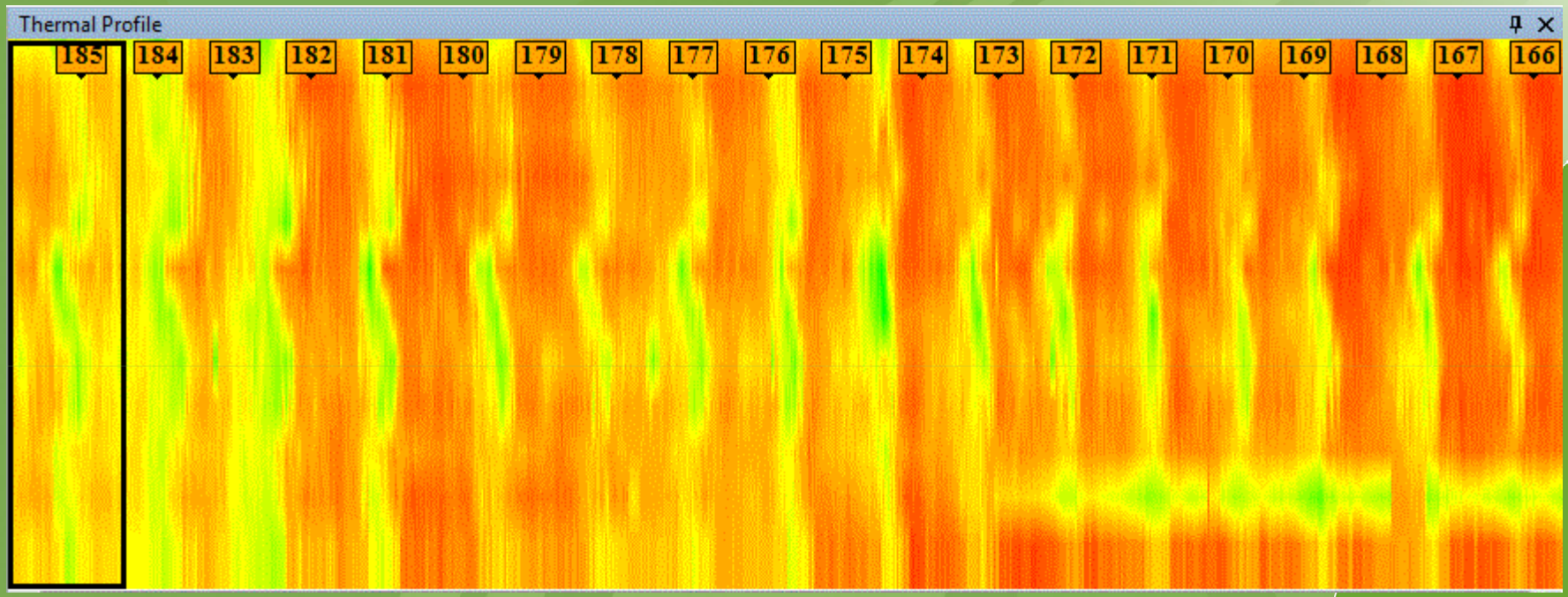
US 32 Δ Temperature vs. Δ Density



US32 – Pike County – 12.5mm



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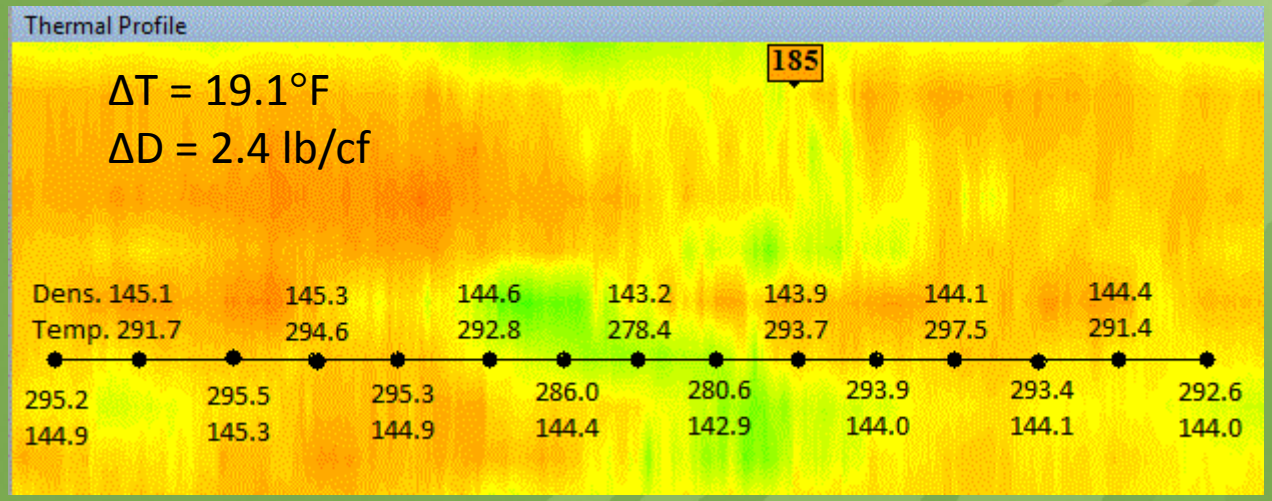
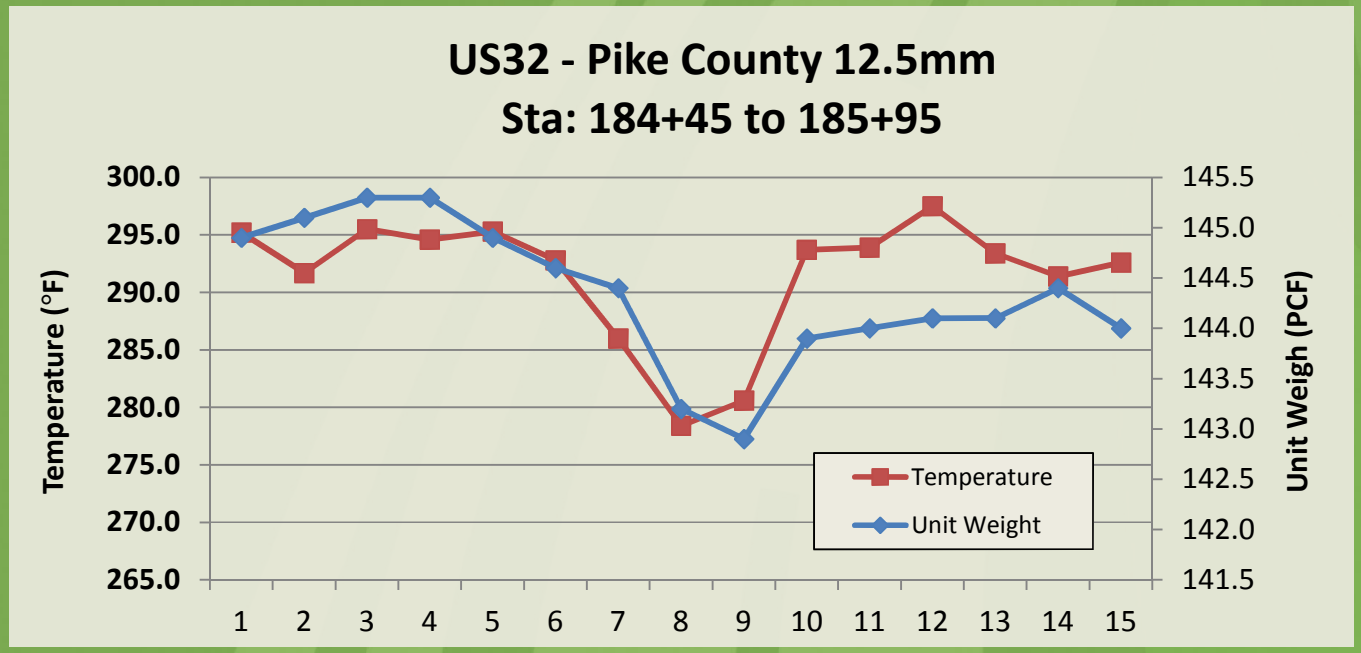
US32 – Pike County – 12.5mm





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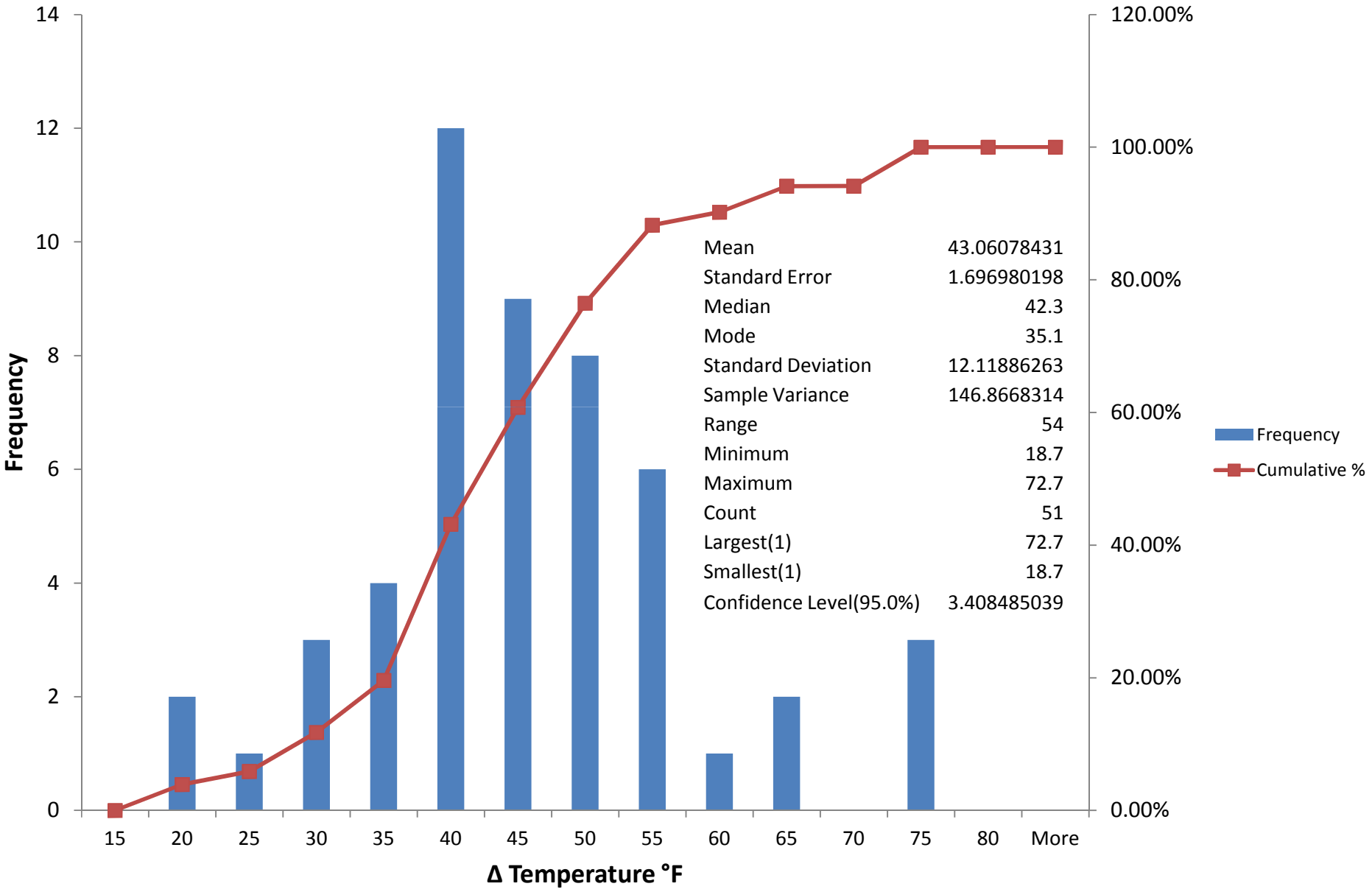
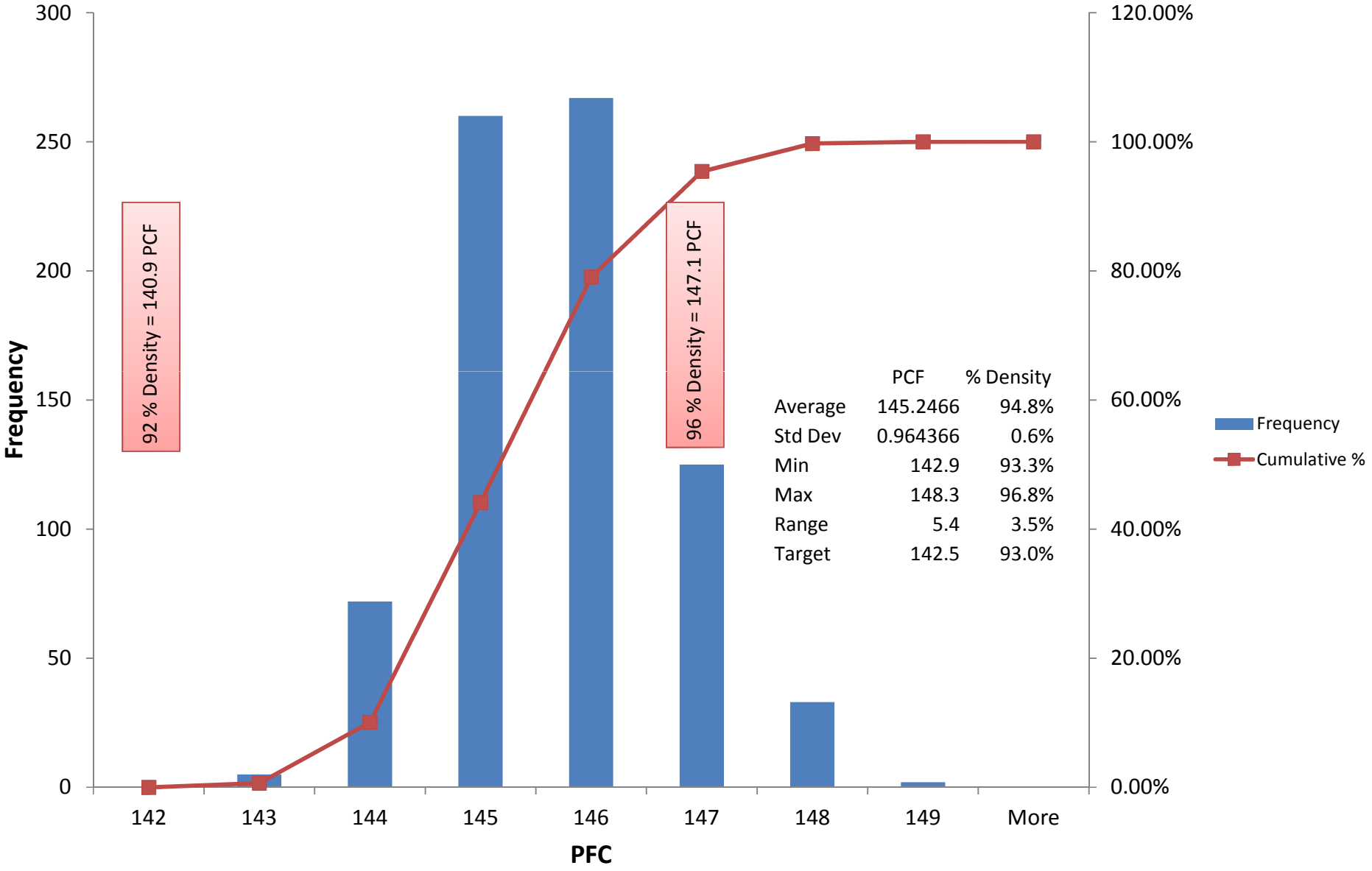
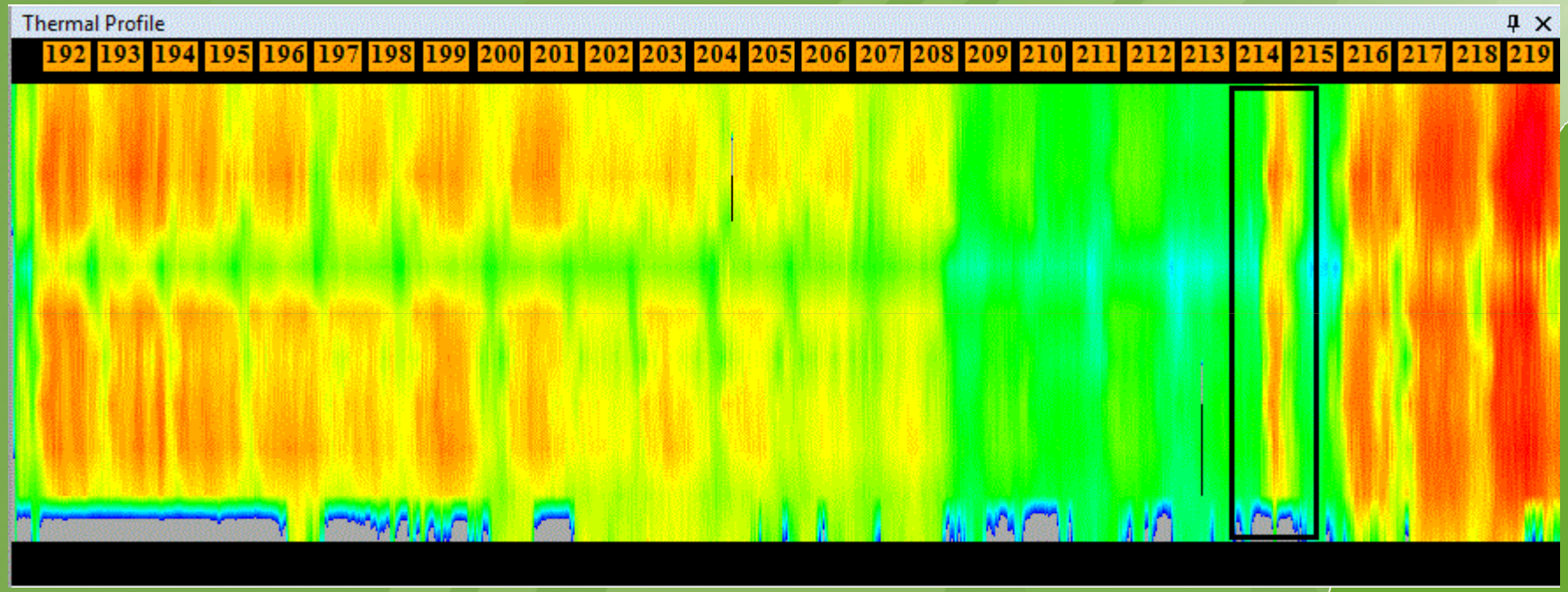
Temperature Histogram
12.5 mm US 32 - Pike County



Unit Weight Histogram
12.5 mm US 32 - Pike County



US32 – Pike County – 19.0mm



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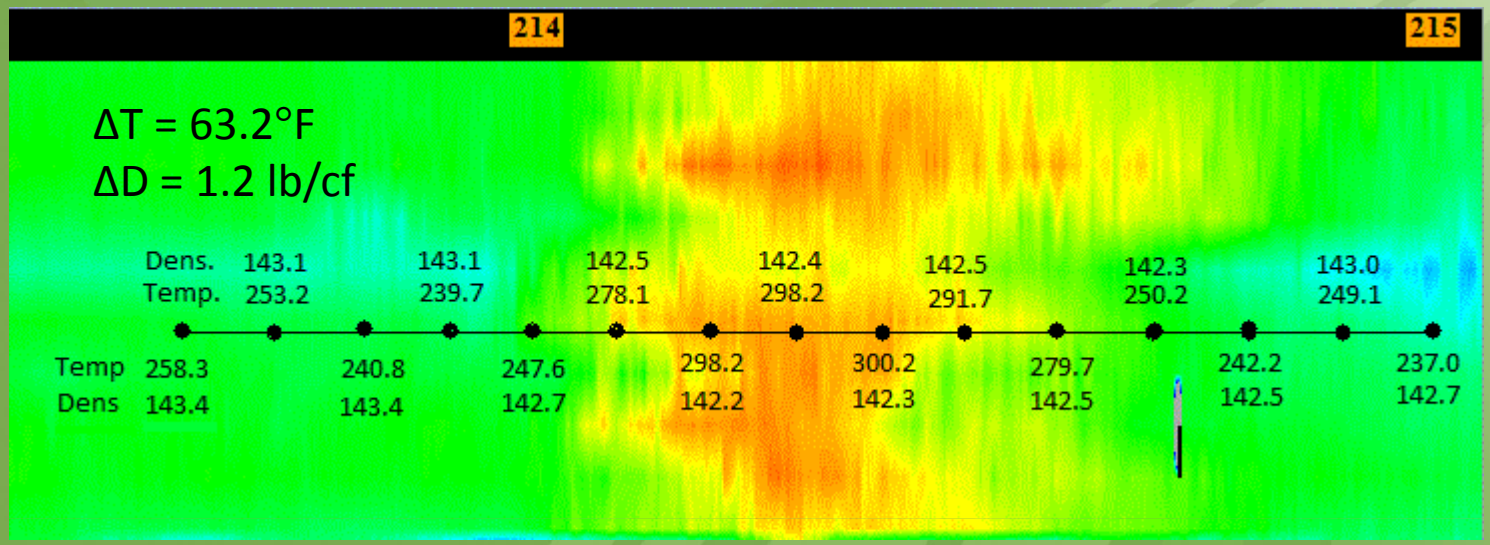
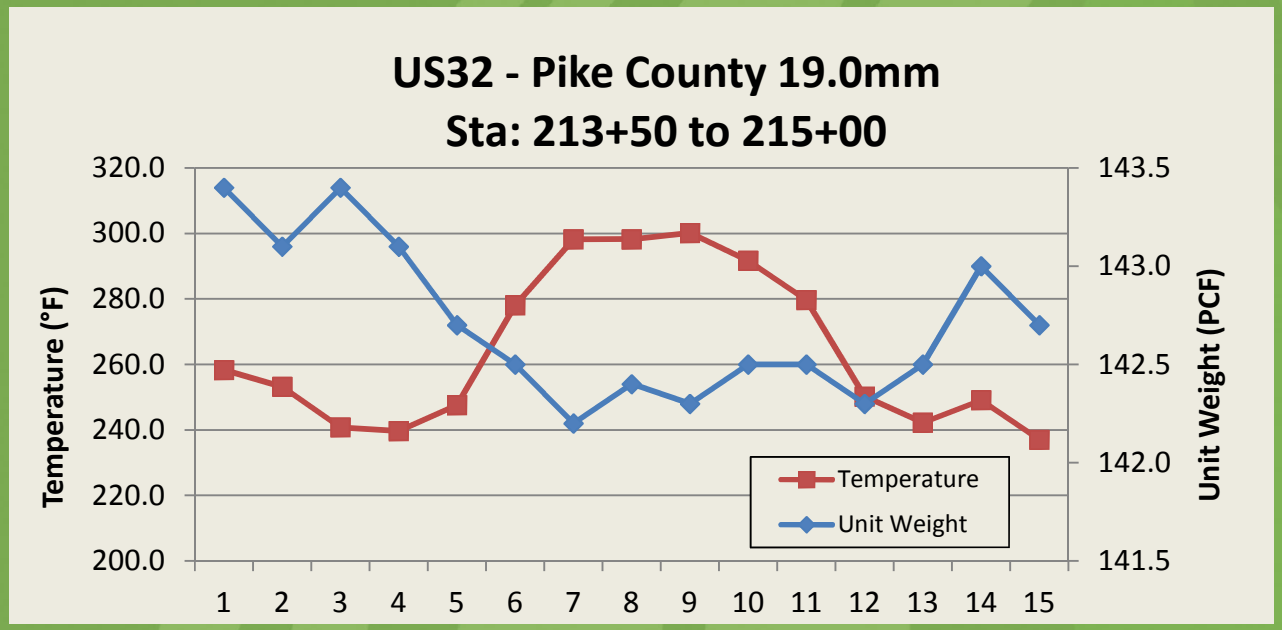
US32 – Pike County – 19.0mm





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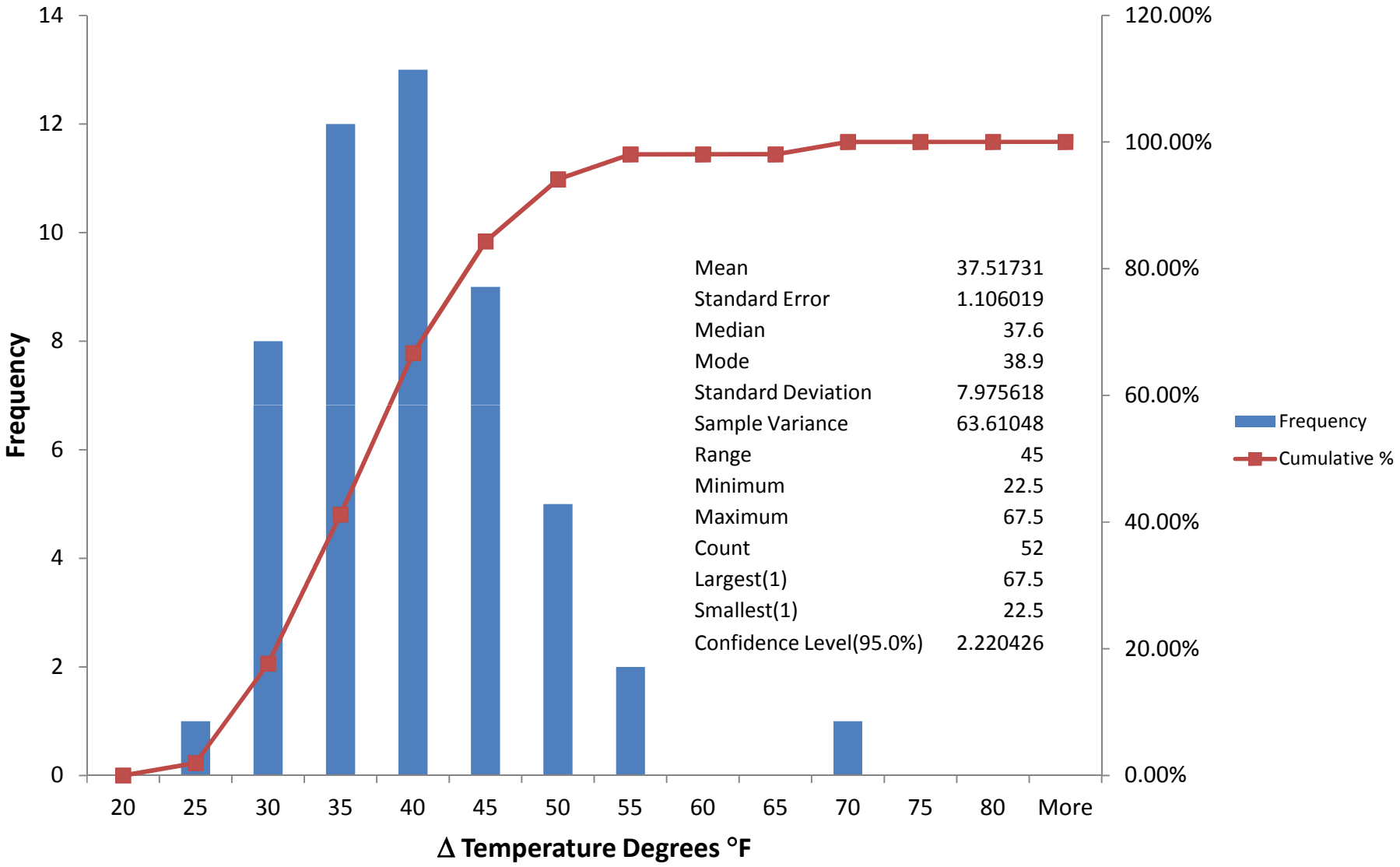
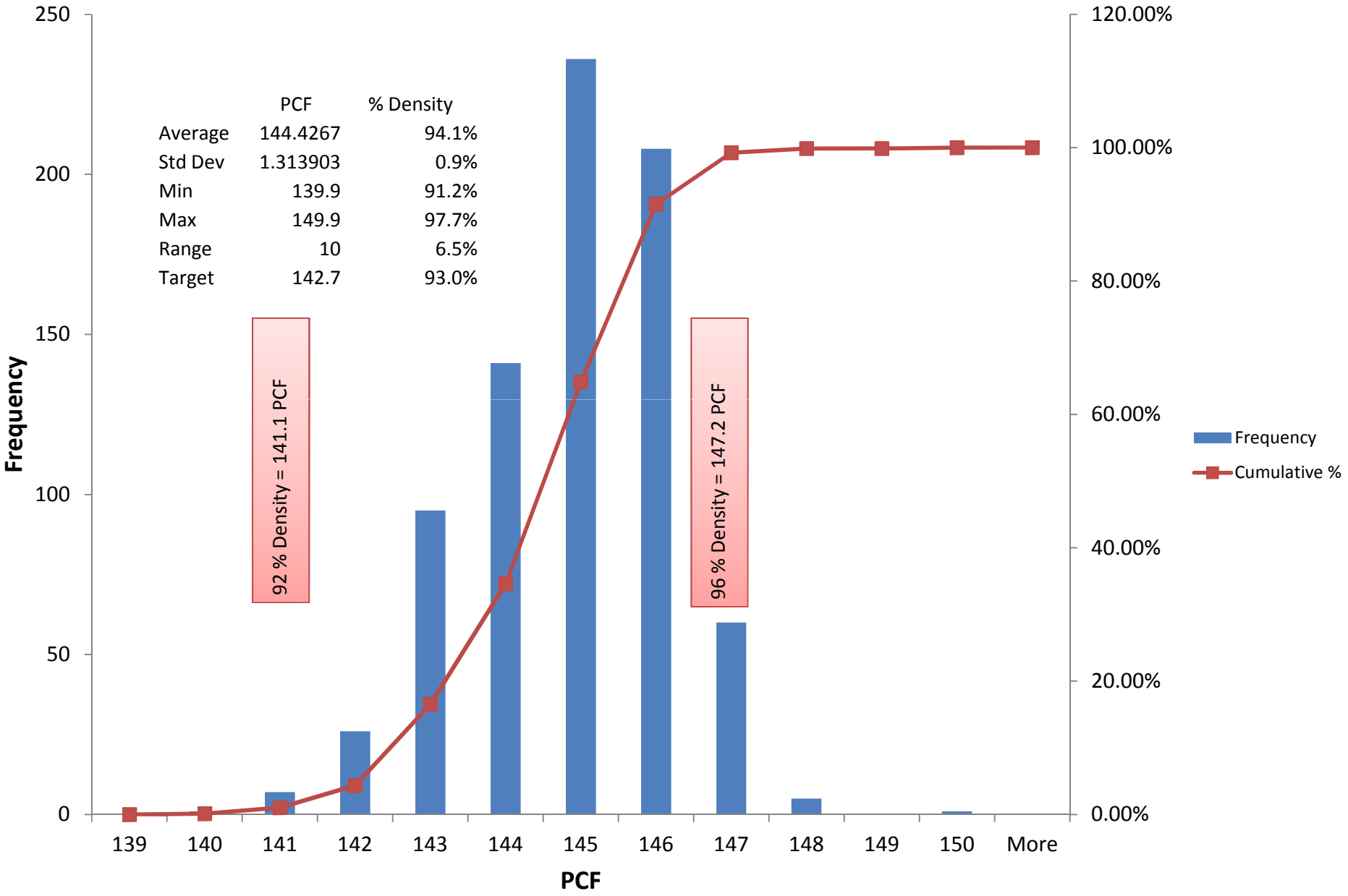
Temperature Histogram
19.0 mm US 32 - Pike County

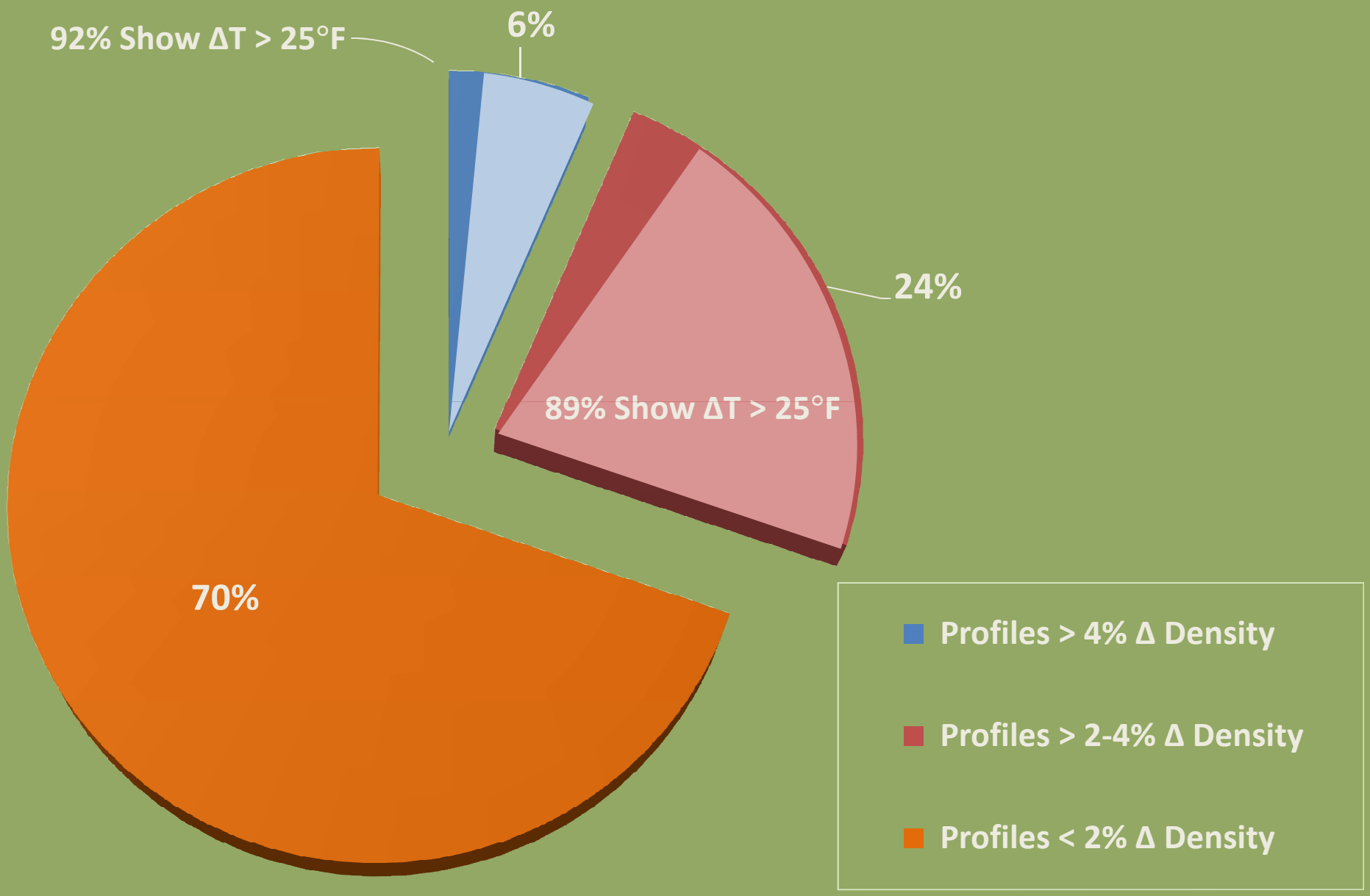


Mean	37.51731
Standard Error	1.106019
Median	37.6
Mode	38.9
Standard Deviation	7.975618
Sample Variance	63.61048
Range	45
Minimum	22.5
Maximum	67.5
Count	52
Largest(1)	67.5
Smallest(1)	22.5
Confidence Level(95.0%)	2.220426

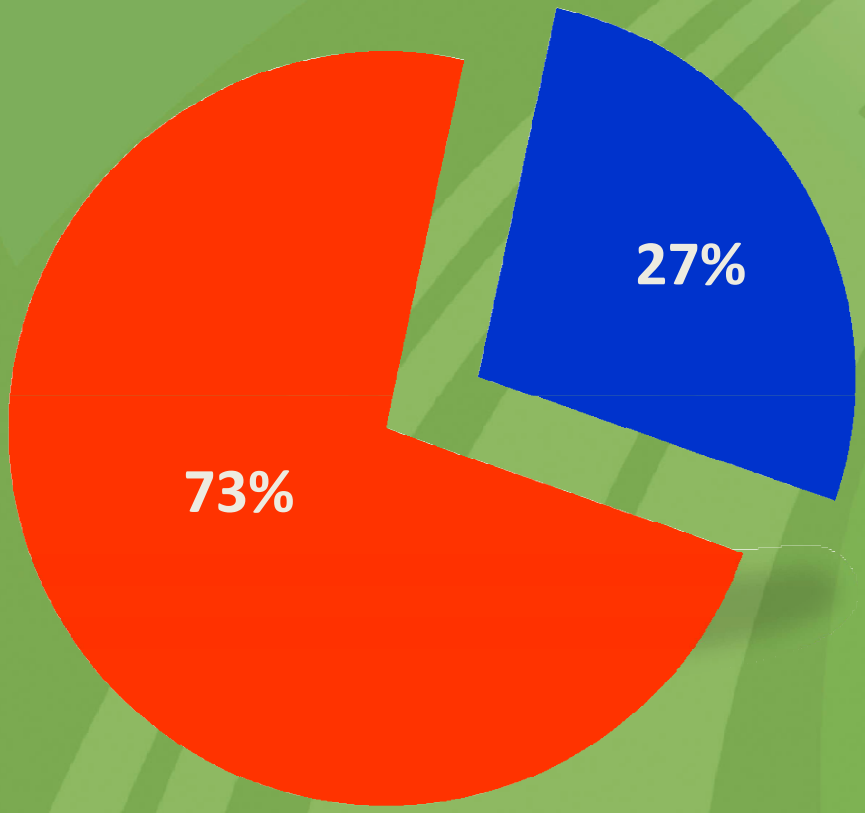
Unit Weight Histogram
19.0 mm US 32 - Pike County



Total Density Profiles



Percentage of Profiles
Δ Density <2% with ΔT<25° F



- Over 93% of the profiles density varied by less than 4% for Δ25°F or less
- Over 73% of the profiles density varied by less than 2% for Δ25°F or less

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Preliminary Conclusions

1. Thermal segregation does not always indicate density issues.
2. High density differentials indicate a high likelihood of temperature segregation.
3. Minimal thermal segregation is a strong indicator of good process quality control.
4. MS4 Device is not adequate to maintain temperature differential under 25°F.
5. We need additional data at temperature extremes to review temperature range limits.

Contractor Takeaways

Pros:

- Useful tool to track paver starts, stops and speed.
- Ability to review the mat temperature.

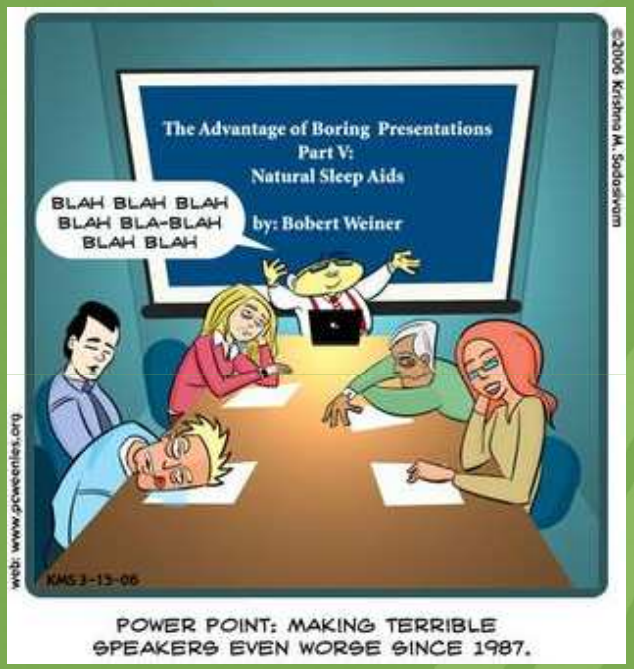
Cons:

- Concerns when paving next to guardrail about the IR beam being in the way of the screed men
- Frequent downtime
- No local manufacturer representative
- Cost
- Inability to change temperature sensors without major recalibration

Further Research for 2013

1. Obtain Data on projects utilizing end dump and Transfer Device with remix capabilities.
2. Obtain additional data at both temperature extremes.
3. Work with manufacturer to resolve equipment and software issues.

ODOT's Look at Thermal Segregation with PAVE-IR



Questions??

References

1. Joint Task Force on Segregation of Asphalt Subcommittee on Construction, *Segregation Causes and Cures for Hot Mix Asphalt* (1997)..
2. Stroup-Gardiner, M. Brown, E.R., *Report 441 Segregation in Hot-Mix Asphalt Pavements,* Washington DC (2000).

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