Statistical Approach to DSR-PAV Test Improvement

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Sarnia Technology Applications & Research

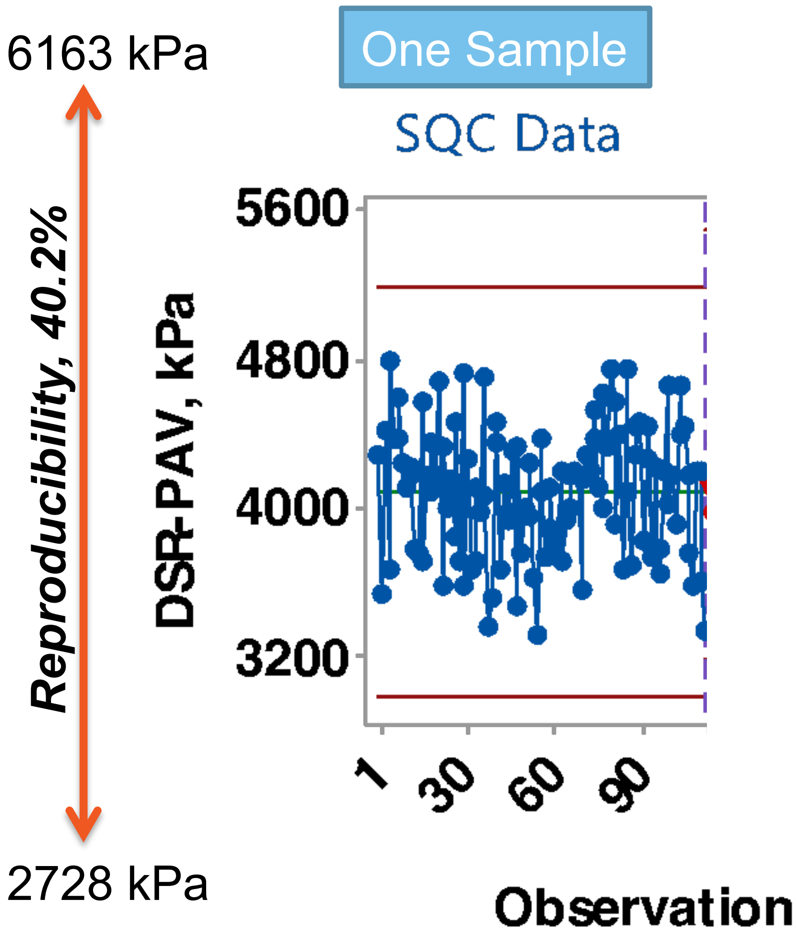
Select Correct Glasses for Observation

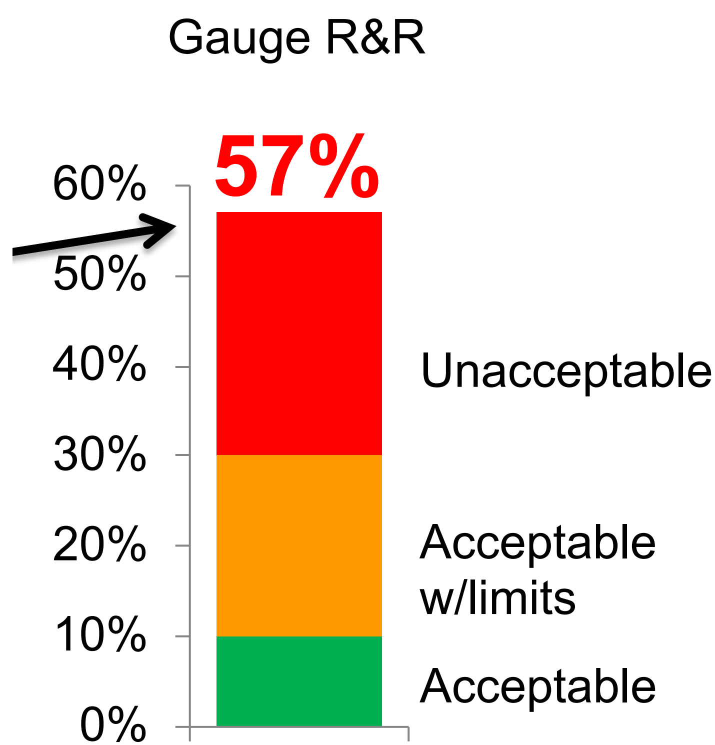
"The observation is only as good as the measurement method"

Poor Test Resolution→ Increased Cost

- Representation (Pass or Fail?)
- Feedstock management
- Production/quality control
- Logistics

Case for Action: DSR-PAV Is Too Variable





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Approach to DSR-PAV Variability Improvement

- Sample RTFO & PAV aging shown insignificant to DSR-PAV variability
- Study focused on DSR test improvement

Focus of this presentation

1. Sample preparation
   - Direct pour
   - Plates at 46 °C
2. Trimming & gap setting
   - Plates at 46 °C
3. Conditioning
   - Fixed cooling rate
   - Fixed wait time

- Review setting in T315 for contributions to variability
- Test variables in Statistical Design of Experiment

Statistical Design of Experiment (DoE)

- DoE = a powerful approach to maximize output at minimized effort
- A number of possibly interdependent factors or variables is studied
- The tests are strategically selected to represent each factor equally

Following variables were standardized prior to applying DoE:

- Large volume of QC sample PAV residue (PG 64-22, 25 °C test T.)
- Modern, Peltier cooled, base DSR instrument
- Sample aliquot, container size, oven preheat (temperature & time)
- Loading, trimming, gap temperature = 46 °C
- Trimming technique & tool
- Cooling rate to test temperature, isothermal time prior to test

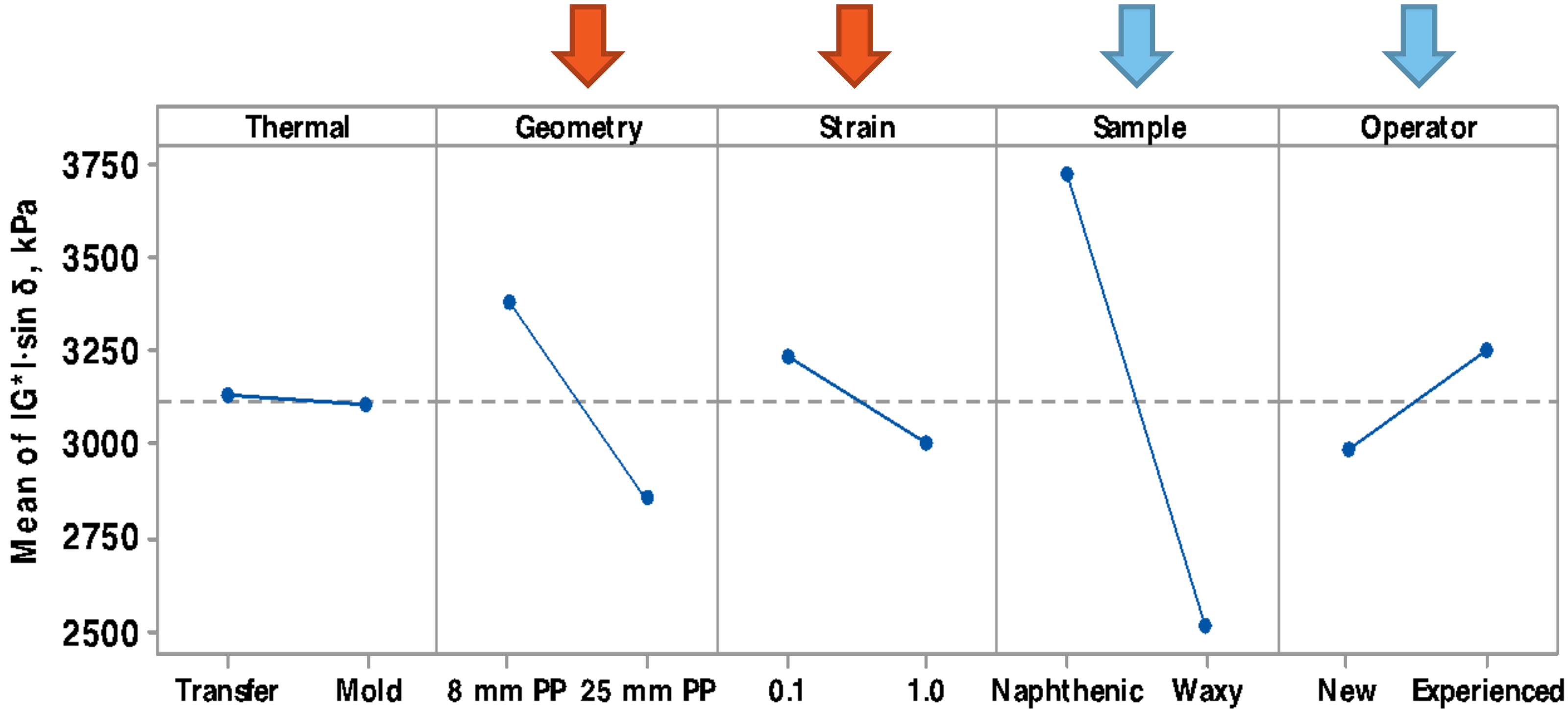
DoE Factors and Levels

Factor	+1	−1	Reason
Thermal	Direct Transfer	Mold	Use of molds, 46 °C loading T
Geometry	8 mm PP* 2 mm gap	25 mm PP* 1 mm gap	Simple shear, trimming
Strain (%)	0.1	1	Linear viscoelasticity
Sample	Naphthenic	Waxy	Hardening tendency
Operator	New	Experienced	Experience

- 5 factors at 2 levels total 2^5 or 32 individual test settings
- Test matrix was generated and randomized using Minitab® software
- Each setting was repeated four times to calculate standard deviation
- Half design (16 settings) found to be statistically significant in identifying contributors to test variability

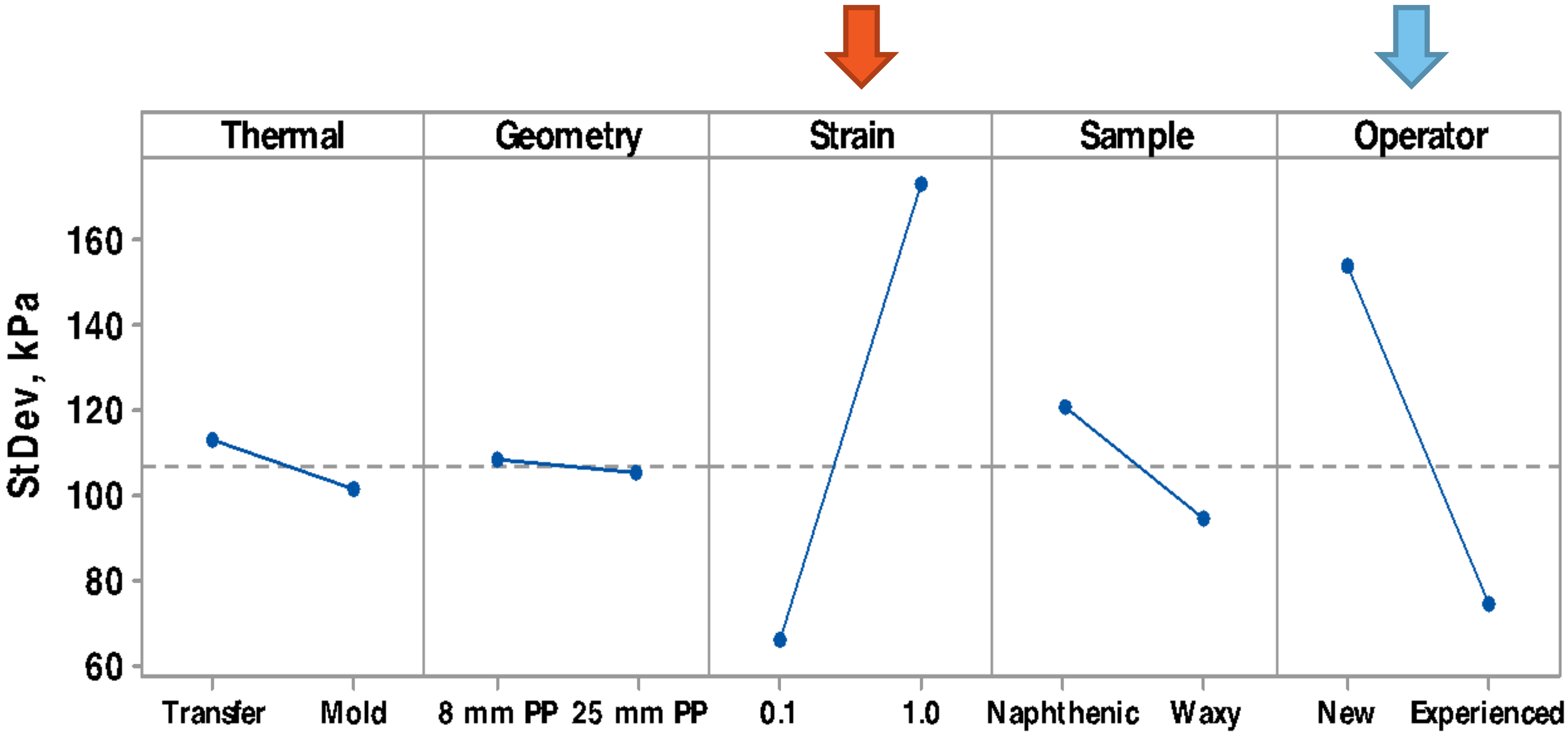
**Parallel plates*

Strain & Geometry Impact Result **Magnitude**



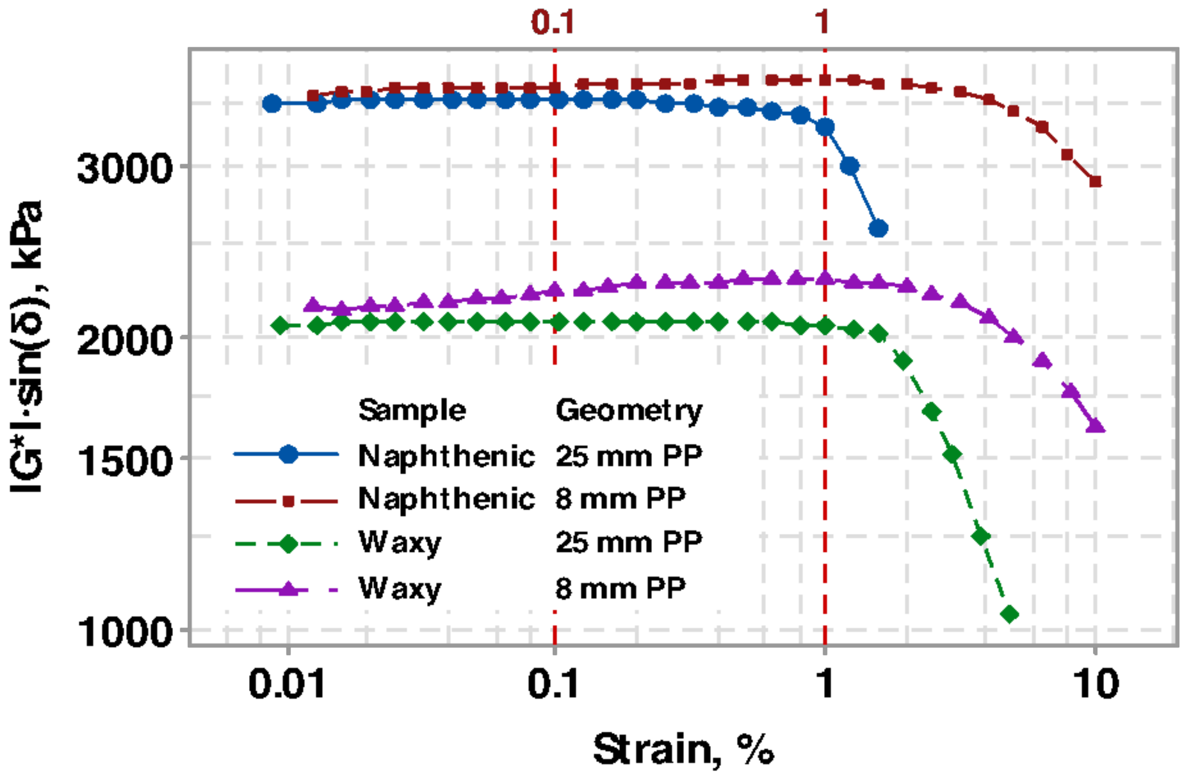
- Each point represents a mean of half of the 64 total experiments
- Two geometries provide different result

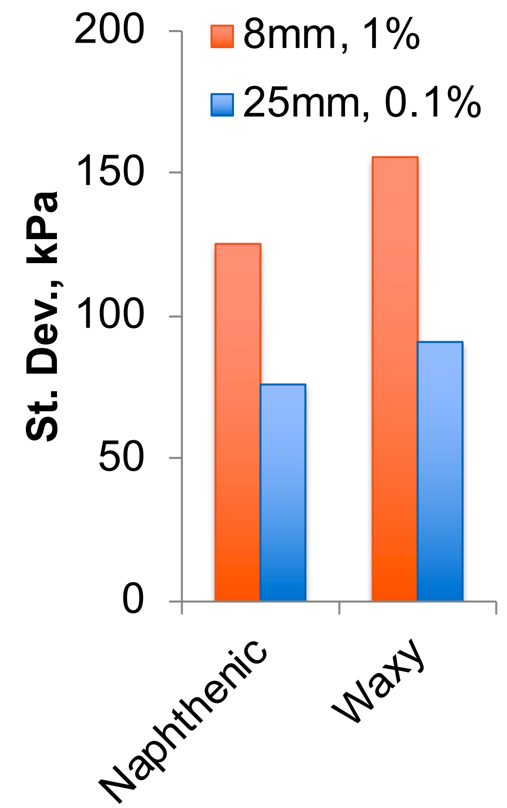
Strain = Major Factor Affecting **Variability**



Linear Viscoelasticity Challenged at 1% Strain

- 8PP: modulus increases with strain likely due to edge effect
- Strain below 0.1 % desirable





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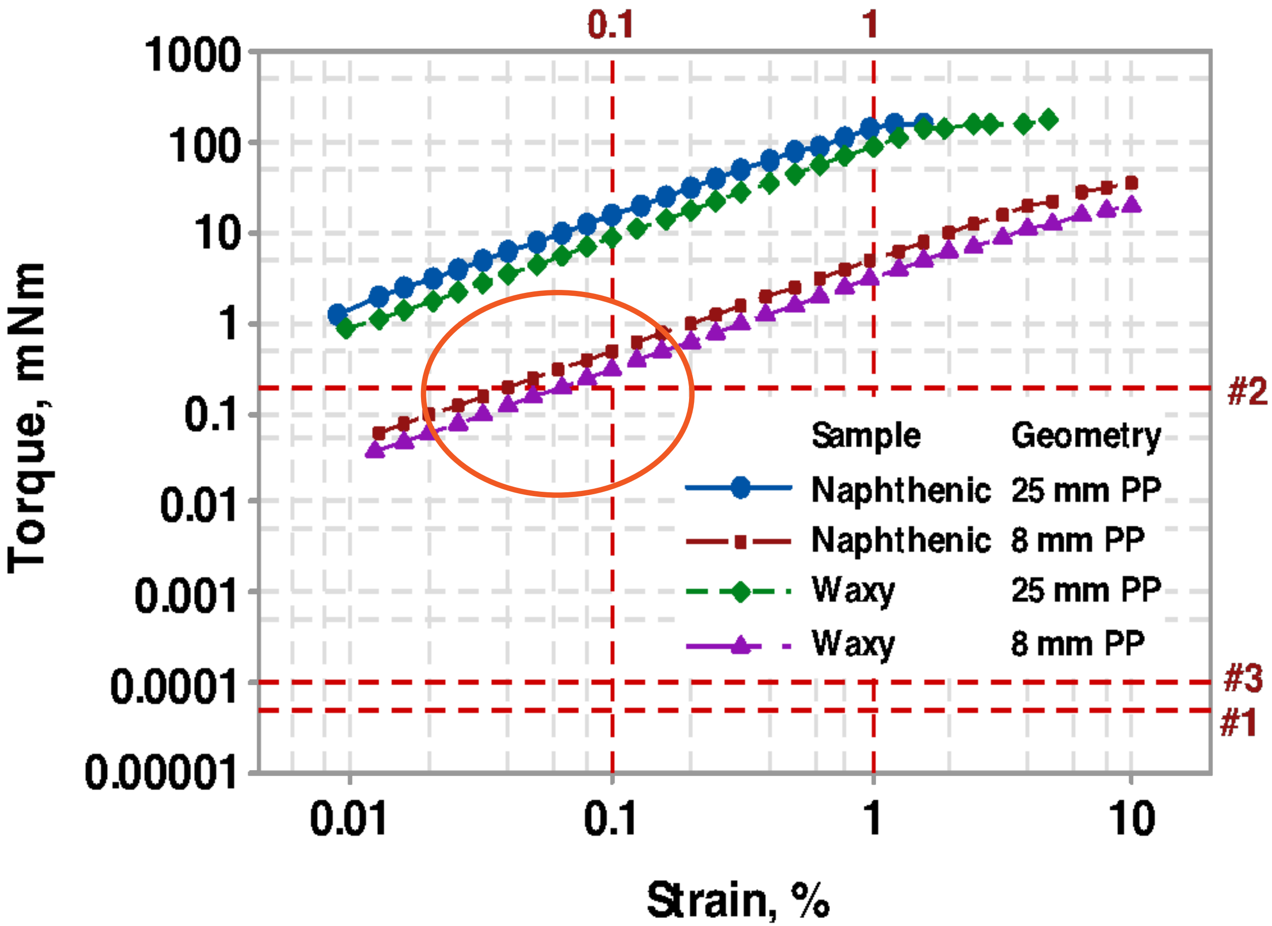
High Test Strain & 8 mm Plates = Artifact of 1990s DSR Capability



1993 instrument min. torque

2008, 2014 instruments min. torque

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Conclusions

1. DSR-PAV test is not able to distinguish quality easily
2. High test variability is partly driven by a test method
3. Lower strain & higher plate diameter-to-gap ratio is desirable

Recommendation:

1. Adopt 0.1% (or lower) strain and 25 mm PP for DSR-PAV test
2. Increase specification limit (e.g. to 6000 kPa) to ensure DSR (Original/RTFO) & BBR (m or S) are PG limiting specifications

Output:

- Improved asphalt production without impact to performance

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Question & Comments?

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Appendix

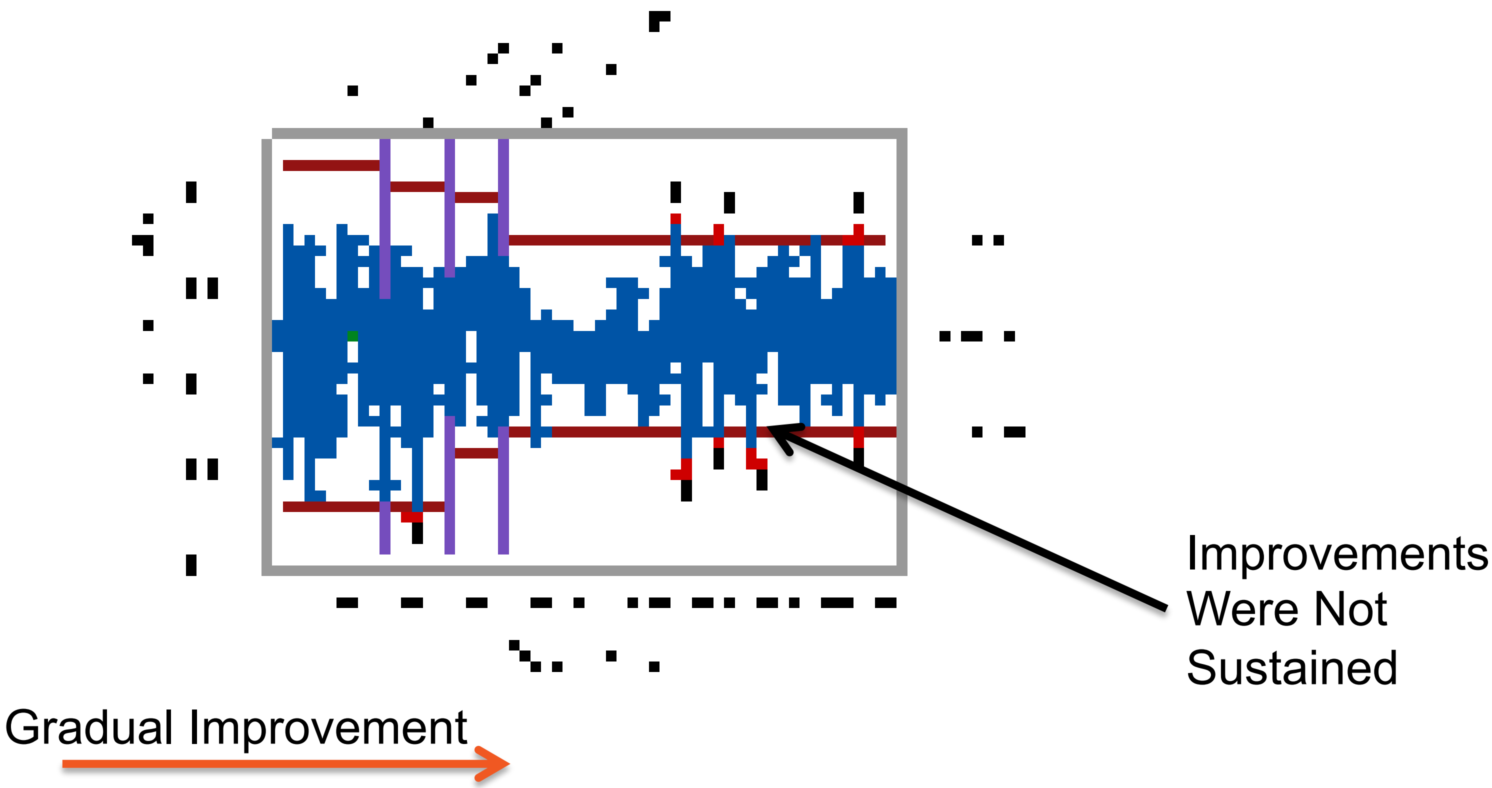
Lean Six Sigma

- Lean Six Sigma offers a powerful approach to continuous improvement

- DMAIC approach & numerous tools ranging from brainstorming & mind mapping to design of experiments & statistical analysis were utilized

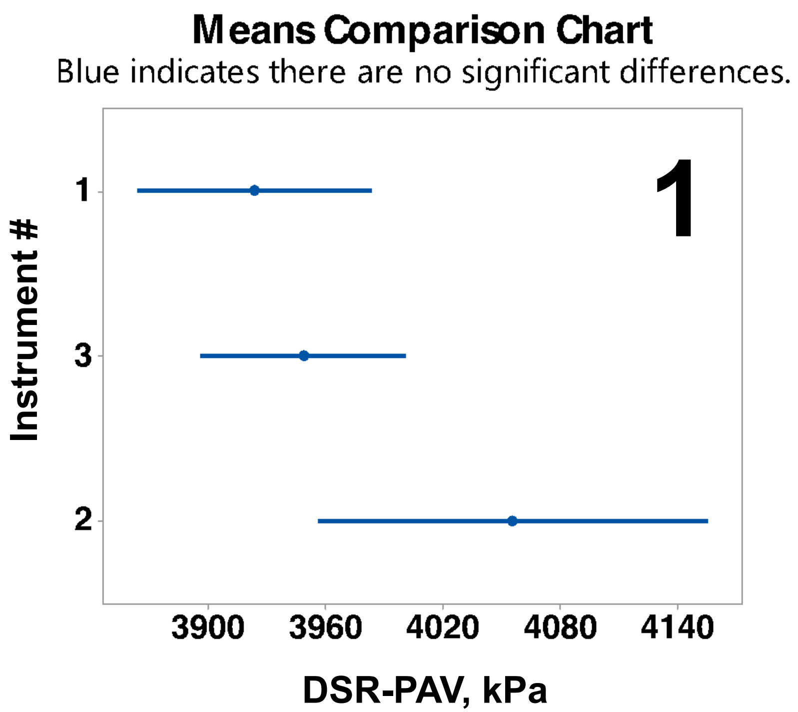
Standardizing Sample Management

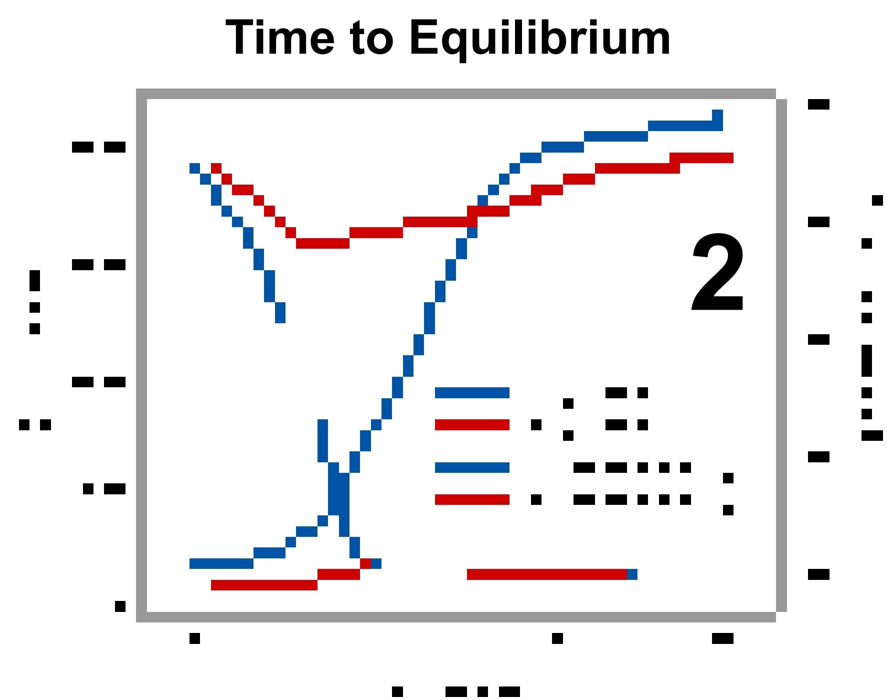
1. Wait Time = silicon mold time standardized at 10 minutes
2. Gap Temperature = Sample load, gap setting, trimming done at 46 °C
3. Direct Transfer = molds discontinued, hot asphalt transferred to plates



Time to Thermal Equilibrium in DSR

1. No significant difference among 3 instruments ($n > 30$ datapoints)
2. Minor increase (sample dependent) due to hardening
   - 10-25 min wait time increased modulus by ~5%





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