New Asphalt Cement Parameters, Perspective & Action Plan

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MTO

Emerging, Innovative, and Practical Test Methods

- Materials Engineering and Research Office (MERO) is responsible for the development of technical policy and documentation including standards and test procedures
- MERO identified poor quality asphalt cement (AC) as one of the primary causes of the premature cracking
- Bituminous Section has implemented several emerging, innovative, and practical test methods to assess gaps not captured with current standard North American asphalt cement grading protocols used to predict pavement performance

Outline

- Asphalt Cement:
  - 2017 Parameters
  - MTO's Perspective on Changes Made
  - Action Plans
- Asphalt Mix:
  - Current Actions
  - Action Plans
- Other Action Plans
- Wrap-Up

Asphalt Cement: 2017 Parameters

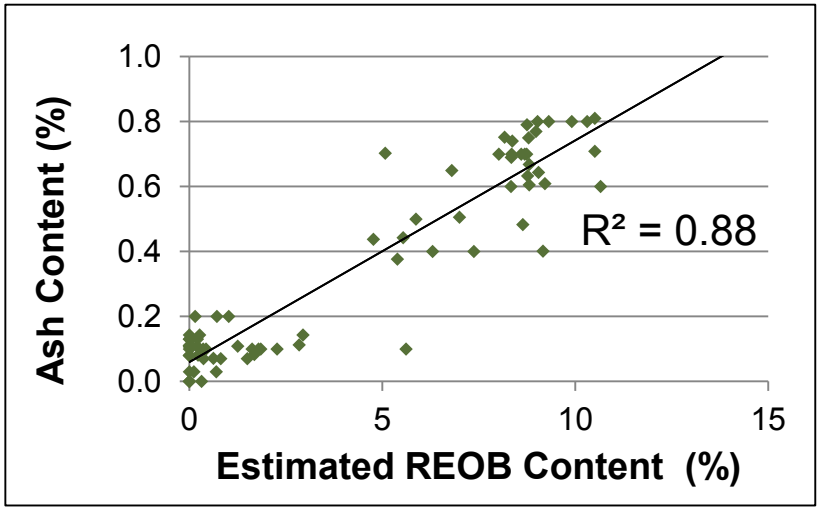
- Testing Fully Implemented in 2017:
  - Extended Bending Beam Rheometer (ExBBR) Test
  - Double Edge Notched Tension (DENT) Test
  - Ash Content Test

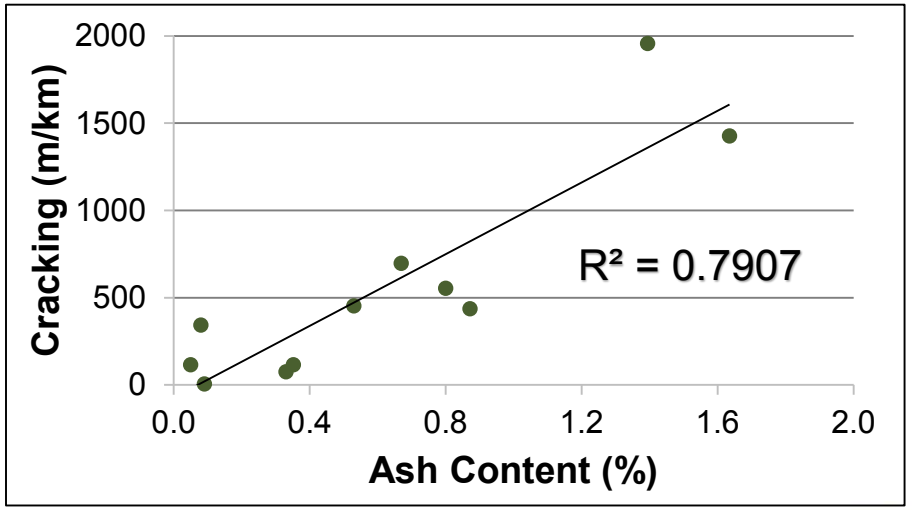
Asphalt Cement: 2017 Parameters

- DENT provides the Critical Crack Tip Opening Displacement (CTOD) that approximates strain tolerance
- Higher CTOD indicate a mix more resistant to stresses in the pavement
- ExBBR was found to be best at predicting cracking performance
- Our analysis has shown that it is important to use DENT results in conjunction with ExBBR results. To mitigate pavement cracking, both testing criteria must be met

Asphalt Cement: 2017 Parameters

- Ash Content (LS-227) (now based on ASTM D8078-16) was implemented to prevent over-modification with Re-Refined Engine Oil Bottoms (REOB)
  - Analysis of over 50 samples showed a very strong correlation between ash content and estimated REOB content
  - Limited analysis to date shows a good correlation between pavement cracking and ash content





Asphalt Cement: MTO's Perspective on Changes Made

- Changes made to paying for asphalt mix specifications in 2017 have resulted in overall improvements to in-place mix properties:
  - 0.3 % increased in mix compaction
  - 0.5 % increase in the asphalt cement in mixes
- Have seen a significant reduction in pavement cracking due to other 2017 changes:
  - improved AC quality testing requirements
  - use of RAP suspended in surface mixes, and
  - use of shingles prohibited in all mixes
- As a result we expect pavement service life to be extended by a minimum of 10%

Asphalt Cement: MTO's Perspective on Changes Made

No early premature cracking has been reported on any MTO contracts meeting the Spring 2017 asphalt cement material requirements

Asphalt Cement: Action Plans

- We feel there is value in looking at alternative tests as possible future alternatives for acceptance
- It is important to be progressive and evaluate alternative AC quality parameters.
- Next will cover the follow work being done:

- Currently:
  - Testing for Additives
  - Tightened PGAC Acceptance Tolerances
  - Ensuring Quality of Acceptance Testing
  - Additional AC Testing for Information Purposes
  - Recovered AC Grading
- Short Term:
  - Improving Grade Selection

- Future Goals

Testing for Additives

- MERO conducts X-Ray Fluorescence (XRF) and Fourier Transform Infrared Spectroscopy (FTIR) analysis on contract samples for information purposes

XRF

FTIR

Tightened PGAC Acceptance Tolerances

Category	Deviation	PGAC Requirements			
		MTO Year of Tender Opening			
		2018	2019	2020	2021+
Acceptance Criteria	below XX and	≤ 0.0 ℃	≤ 0.0 ℃	≤ 0.0 ℃	≤ 0.0 ℃
	above -YY	≤ 0.0 ℃	≤ 0.0 ℃	≤ 0.0 ℃	≤ 0.0 ℃
Minor Borderline*	below XX and	≤ 3.0 ℃	≤ 1.5 ℃	≤ 1.0 ℃	≤ 0.5 ℃
	above -YY	≤ 3.0 ℃	≤ 1.5 ℃	≤ 1.0 ℃	≤ 0.5 ℃
	Sum	≤ 3.0 ℃	N/A	N/A	N/A
Major Borderline	below XX and	≤ 3.0 ℃	≤ 3.0 ℃	≤ 1.5 ℃	≤ 1.0 ℃
	above -YY	≤ 3.0 ℃	≤ 3.0 ℃	≤ 1.5 ℃	≤ 1.0 ℃
	Sum	>3.0 ℃ & ≤ 6.0 ℃	N/A	N/A	N/A
Rejectable	below XX or	> 3.0 ℃	> 3.0 ℃	> 1.5 ℃	> 1.0 ℃
	above -YY	> 3.0 ℃	> 3.0 ℃	> 1.5 ℃	> 1.0 ℃
	Sum	> 6.0 ℃	N/A	N/A	N/A

*Considered 'Borderline' in Municipal spec

Ensuring Quality of Acceptance Testing

- Integrity of acceptance testing is maintained by MTO:
  - 3 asphalt cement test correlations are run each year on acceptance tests
  - this year, lab testing includes 20 and 40 hour PAV, Cross-over Temperature, and Low Temperature Critical Spread
  - QA and Referee laboratory must participate
  - QA and Referee laboratories with any less than satisfactory ratings must report what corrective actions have been taken to improve their testing
  - MTO pauses our use of laboratories not conducting satisfactory testing

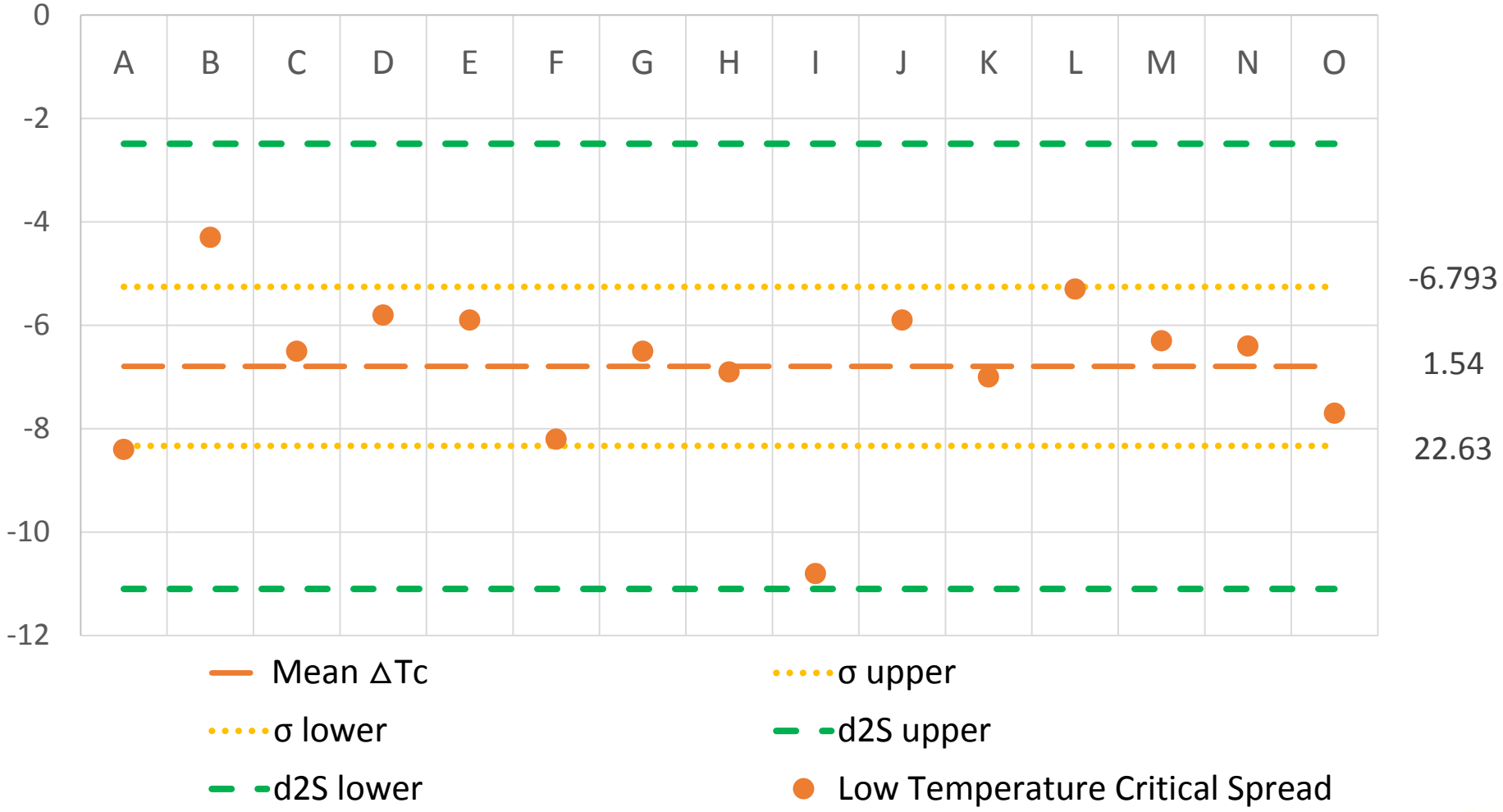
Additional AC testing for Information Purposes

- On select contracts this year on 20 and 40 hour PAV:
  - Low Temperature Critical Spread (ΔTc)
  - Cross-Over Temperature ($T_{\delta 45}$), and
  - DENT and BBR

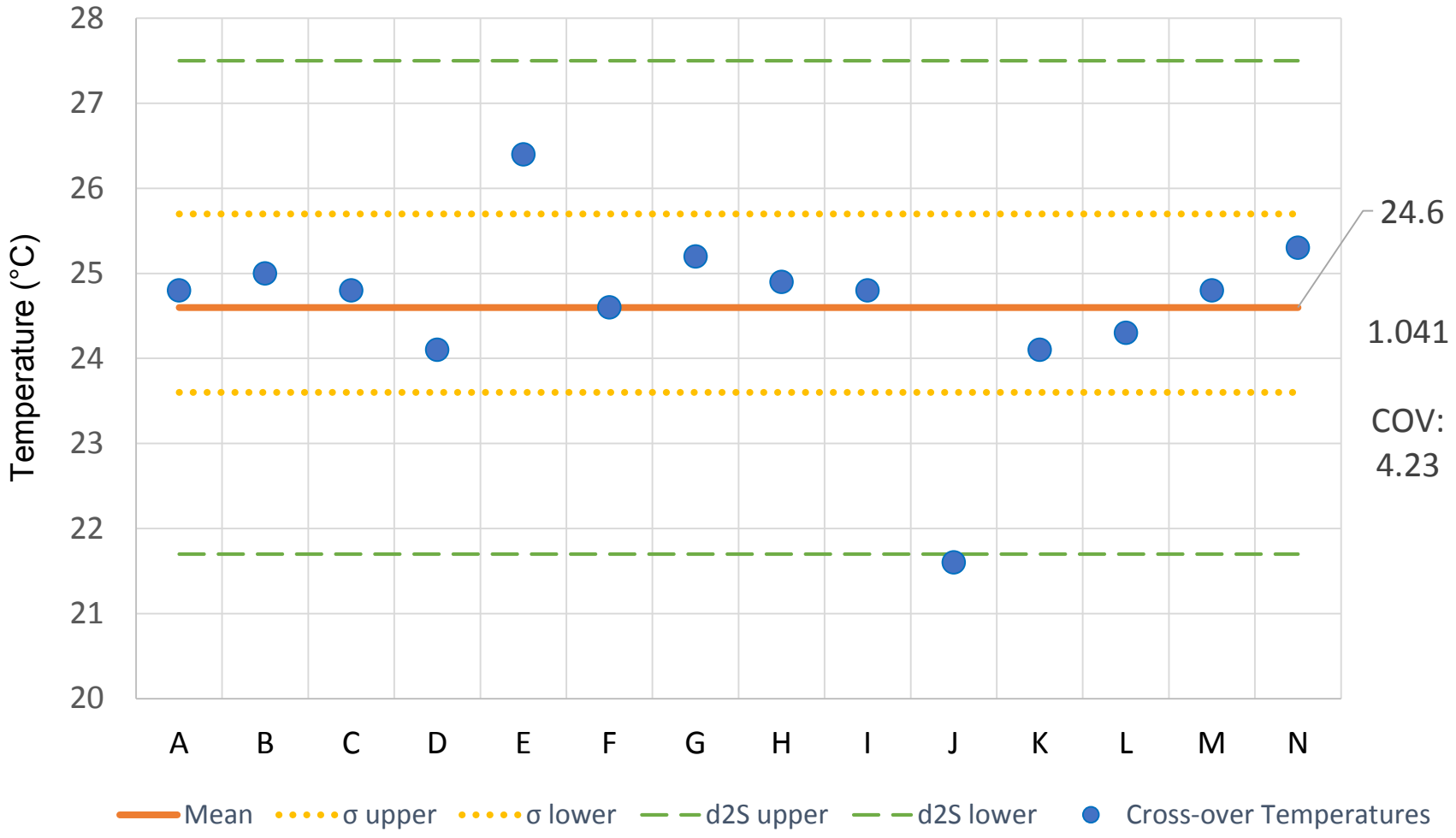
Evaluating New Tests: For Information Only on Contracts (eg. for PG XX-34)

Property and Attribute	MTO Acceptance Limits
Ash Content	≤ 0.6
Non-recoverable creep compliance (except PG 52-34)	< 4.50
Average percent recovery at 3.2kPa (except PG 52-34)	> the lesser of 55.0 or [(29.371) $(J_{nr\text{-}3.2})^{-0.2633}$]
Percent difference in non-recoverable creep compliance	For information purpose only
CTOD (except PG 52-34)	≥ 14.0
Low temperature limiting grade (except PG 52-34)	≤ -34.0
Grade Loss (except PG 52-34)	≤ 6.0
Cross-Over Temperature	**For information purpose only**
Low-Temperature Critical Spread	**For information purpose only**

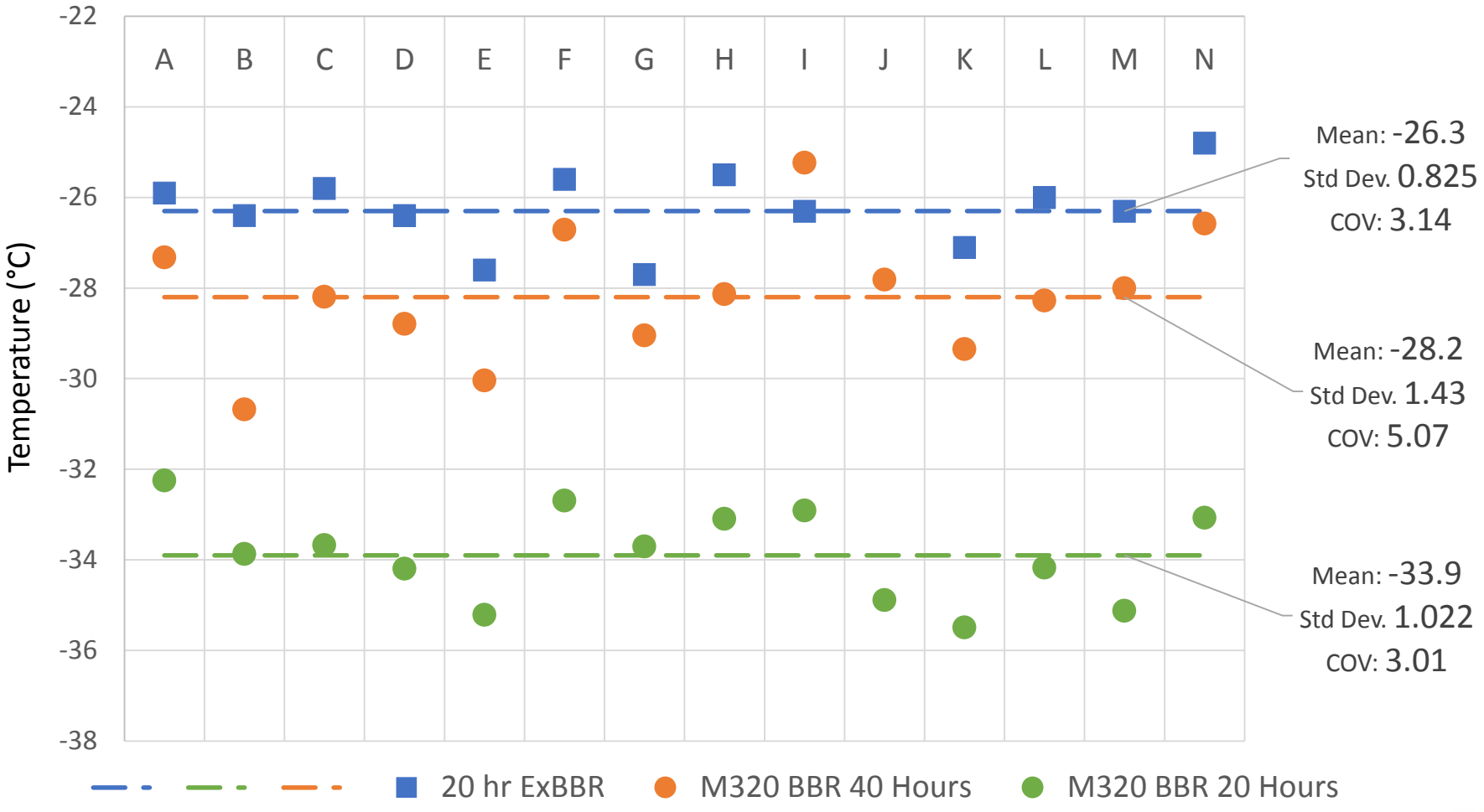
Low Temperature Critical Spread (ΔTc)



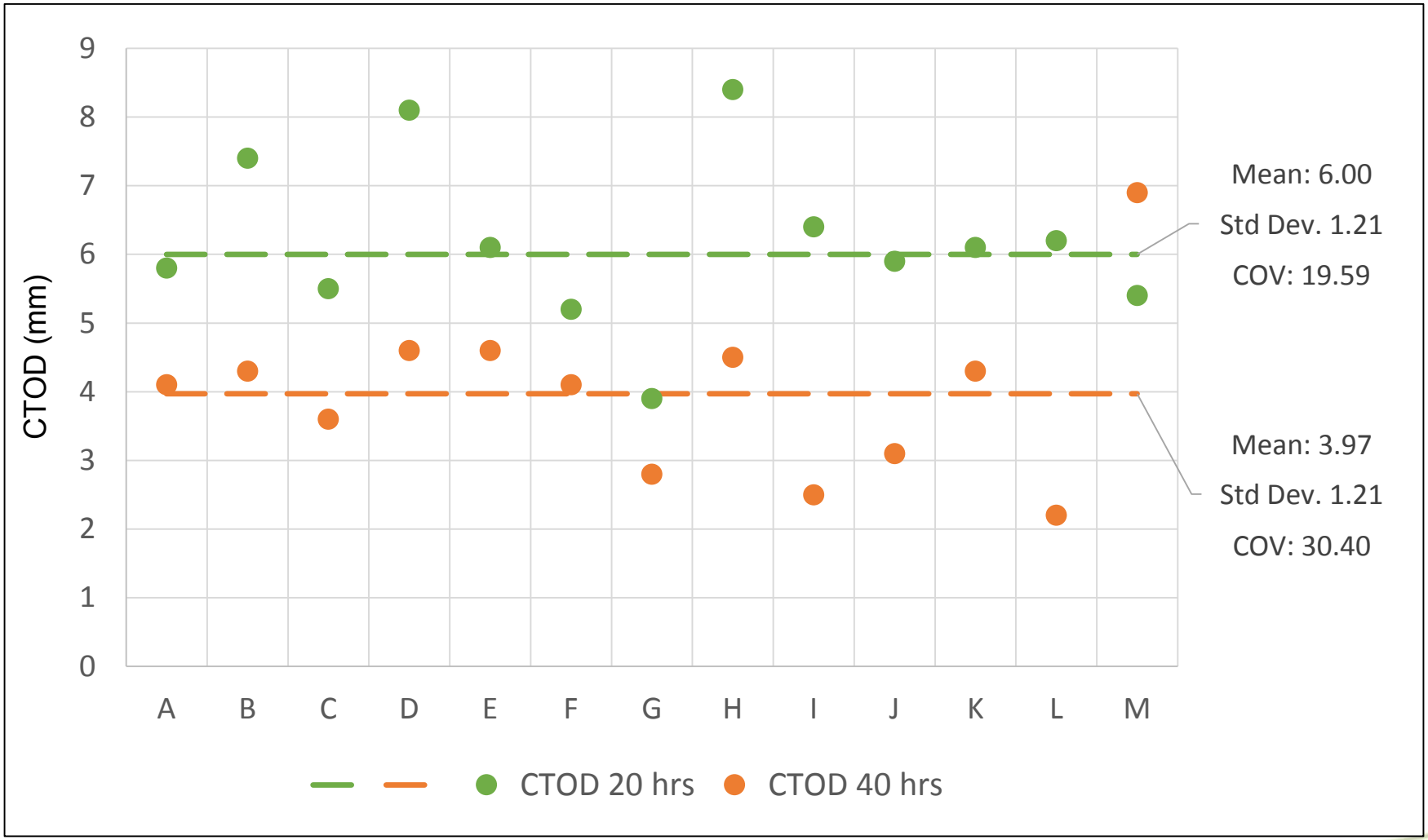
Cross-Over Temperature: Phase Angle δ=45°C



ExBBR and BBR



Critical Crack Tip Opening Displacement (CTOD)



Recovered Asphalt Cement (RAC)

LS-284 using only the Rotary evaporator. Provides LS guidance for controlling fines in recovered asphalt; solvent drip rates during recovery; and alternate vacuum measurement units

BITU0027
(111F09 M)

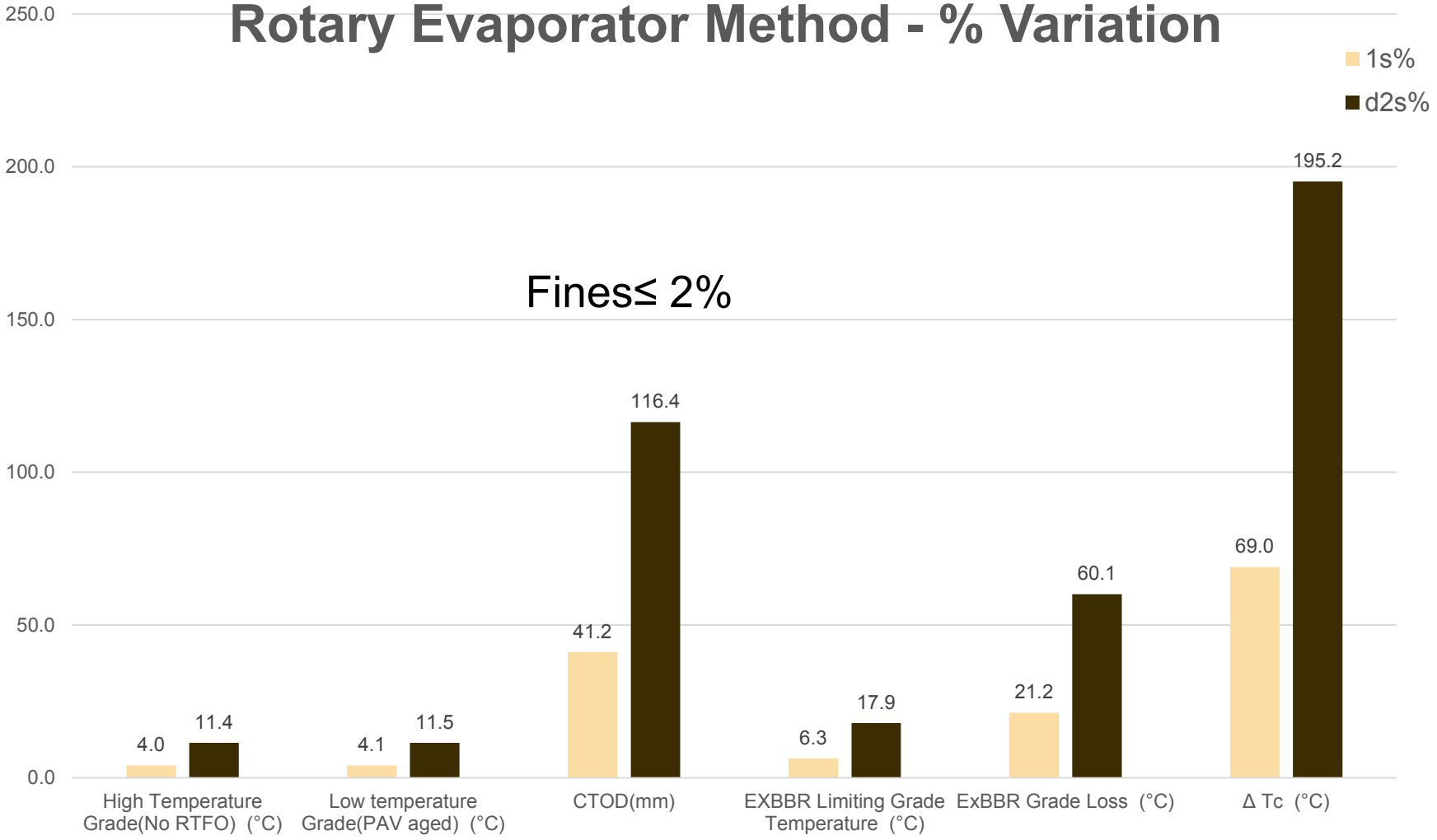
Expect on some contracts this year

Recovered Asphalt treated as RTFO residue

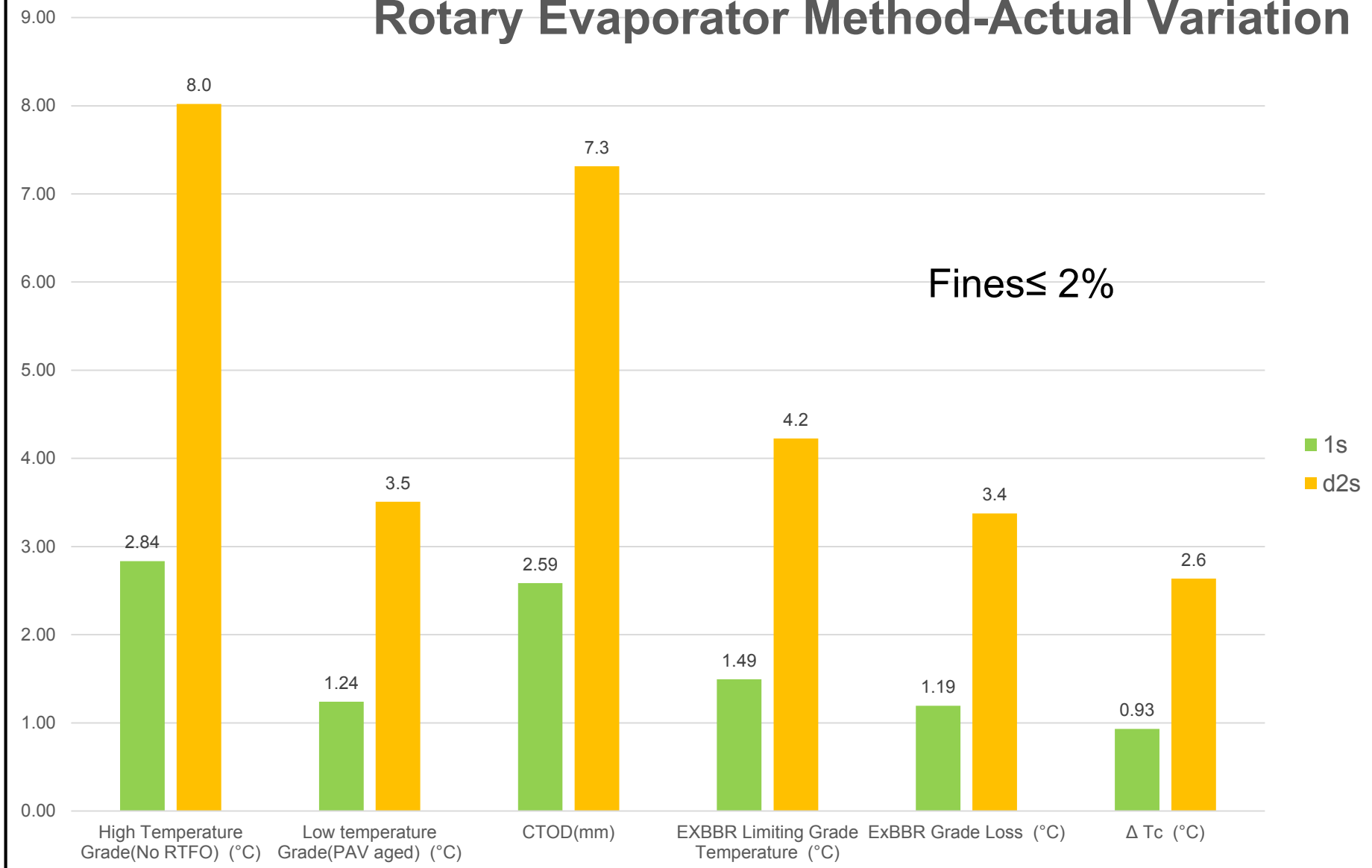
High and Low Temperature Grading for acceptance

Fines in recovered AC are limited using 1% Ash Content

2019 Recovered Asphalt Correlation-Round 1
Rotary Evaporator Method - % Variation



2019 Recovered Asphalt Correlation-Round 1
Rotary Evaporator Method-Actual Variation



Extraction and Recovery

Solvent	Energy for Boiling [kj/mole]	Boiling Point [ºC]	Flammability
Toluene	37.0	111	Flammable
TCE	34.7	87	Not flammable

ECHA EUROPEAN CHEMICALS AGENCY

https://echa.europa.eu/documents/10162/18584504/afa_tce-0024-05-aa_en.pdf

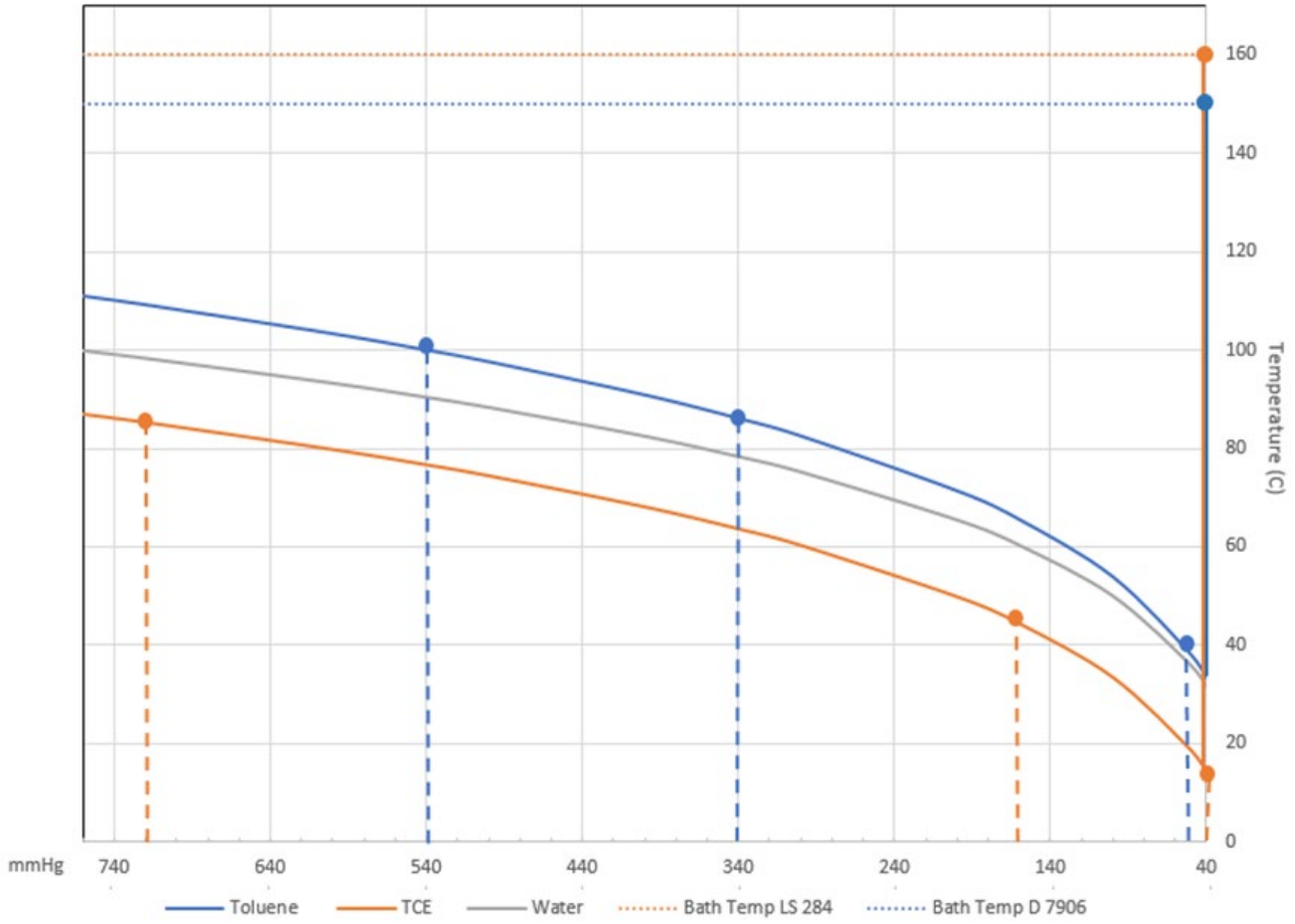
NIST National Institute of Standards and Technology U.S. Department of Commerce — NIST Chemistry WebBook, SRD 69

Extraction

Fines Removal

Recovery

Temperature during Recovery



At maximum vacuum, the temperature increases rapidly to the bath temperature

Toluene
Water
TCE

Acceptance Criteria for RAC Contracts

Category	Deviation	2018 PGAC Requirements (°C)	RAC Requirements (°C)		
			Year of Tender Opening		
			2019	2020	2021 +
Acceptance Criteria	below XX &	≤ 0.0	≤ 4.0	≤ 3.5	≤ 3.0
	above -YY	≤ 0.0	≤ 4.0	≤ 3.5	≤ 3.0
Minor Borderline	below XX &	≤ 3.0	≤ 6.0	≤ 5.0	≤ 4.0
	above -YY &	≤ 3.0	≤ 6.0	≤ 5.0	≤ 4.0
	Sum	≤ 3.0	N/A	N/A	N/A
Major Borderline	below XX &	≤ 3.0	≤ 8.0	≤ 6.0	≤ 5.0
	above -YY &	≤ 3.0	≤ 8.0	≤ 6.0	≤ 5.0
	Sum	> 3.0 & ≤ 6.0	N/A	N/A	N/A
Rejectable	below XX or	> 3.0	> 8	> 6.0	> 5.0
	above -YY or	> 3.0	> 8	> 6.0	> 5.0
	Sum	> 6.0	N/A	N/A	N/A

Improving Asphalt Grade Selection

1998

- Grade selection guidelines for MTO developed using FHWA's LTPPBind

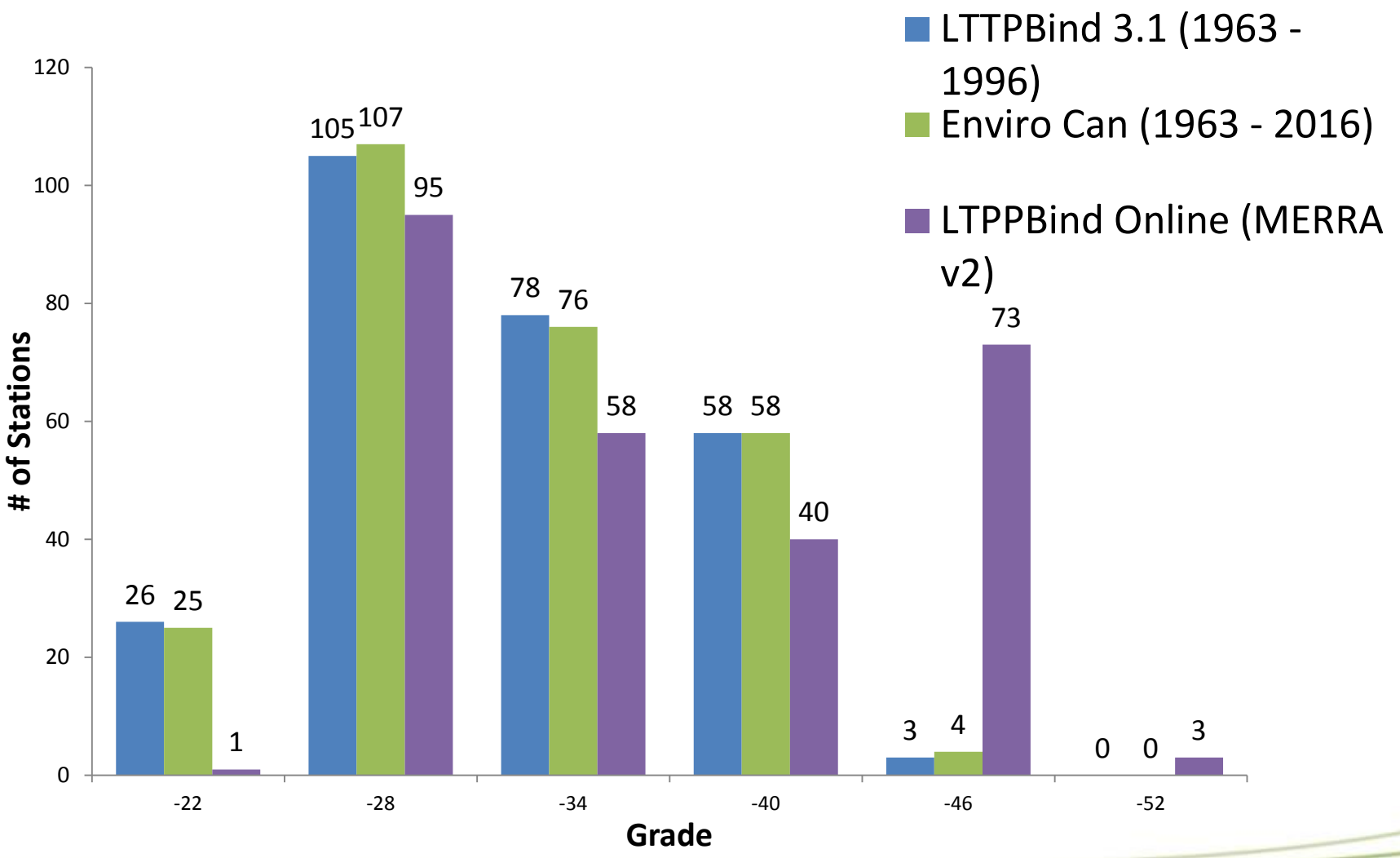
2005

- LTPPBind 3.1 (desktop)
- weather station data from 1963 - 1996

2017

- LTPPBind Online
- NASA satellite data from 1979 – present
- Temperature data is average for large grids

Comparison


LTTPBind 3.1 (1963 - 1996)
Enviro Can (1963 - 2016)
LTPPBind Online (MERRA v2)
# of Stations
120
100
80
60
40
20
0
26
25
1
105
107
95
78
76
58
58
58
40
3
4
73
0
0
3
-22
-28
-34
-40
-46
-52
Grade

Grade Selection using Environment Canada Data

- Create “BindON” from Environment Canada data
  - Use of different reliabilities
  - Use data from 1963 onwards
  - Update yearly

BindON 2019 Fill-in All Purple Cells

Pavement Location:		Latitude, Degree:	43.92	Zone:	Zone 3	Depth of Layer, mm:	0	ESALs:	< 0.3 M
		Longitude, Degree:	-79.83	Reliability %:	98%	Avg Traffic Speed:	Slow	Highway Type:	Rural Arterial
				*Refer to MTO Superpave and SMA Guide for Zone descriptions and guidance		*Standard is > 70 km/h, Slow is 20 to 70 km/h, and Standing is < 20 km/h			

Select which Stations to include in calculating the Low Temperature Grade:

Include?		Station	Distance (km)	Lowest Yearly Air Temperature , °C	Low Air Temperature Standard Deviation, °C	Elevation, m	First Year Data Available	Latest Year Data	Total Years of Data Available	Years of Missing Data
Yes	Closest Station:	Albion Field Centre	0.0	-29.6	3.7	282	1969	2001	30	3
Yes	2nd Closest Station:	Orangeville MOE	20.1	-28.5	3.8	412	1963	2015	52	1
Yes	3rd Closest Station:	Bradford Muck Research	22.1	-28.5	4.4	221	1974	1998	25	0
No	4th Closest Station:	Woodbridge	24.2	-26.6	3.9	164	1963	2005	40	3
No	5th Closest Station:	Alliston Nelson	25.7	-27.1	3.5	221	1977	2008	29	3

Base High Temperature Grade, °C:	58	Average Lowest Yearly Air Temperature, °C:	-28.9
Adjustment for Traffic, °C:	See Note 1	Low Air Temperature Standard Deviation,	4.0
Adjustment for Depth, °C:	0	Latitude, Degree:	43.92
Optional Additional Adjustment, °C: (Note 2)		Reliability %:	98%
HT Pavement Temperature, °C:	**58.0**	**LT Pavement Temperature, °C:**	**-28.6**
Recommended HT Grade:	**58**	**Recommended LT Grade:**	**-34**

Asphalt Cement: Future Goals

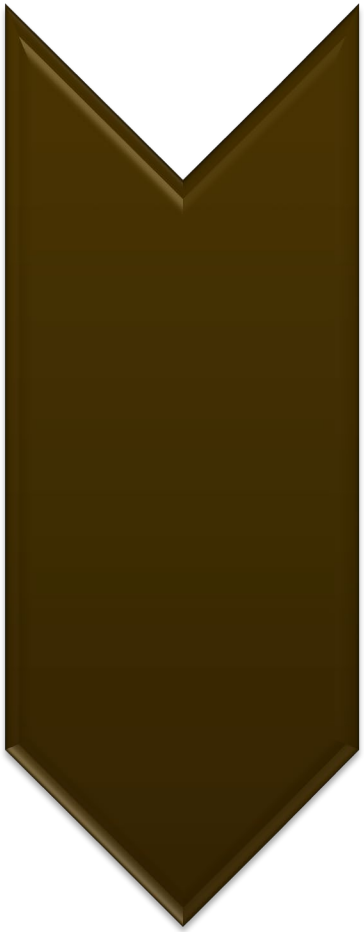
Continue to modernize asphalt testing parameters used to predict pavement performance

- Investigate other appropriate intermediate tests
- Discuss phase in of MSCR in place of bumping up high temperature grading
- Change Mass Loss requirements for softer grades of asphalt
- Additional testing of contract materials, HIIFP research by Queen's University and work by others will assist us in determining if they can replace current testing parameters with for example:
  - DENT on 40 hours PAV residue
  - Cross-Over Temperature ($T_{\delta 45}$) using DSR phase angle on 20 hours and 40 hours PAV residue (LS-319)
  - Low Temperature Critical Spread (ΔT_C) using BBR on 20 hour and 40 hour PAV residue (LS-320)

Asphalt Mix: Current Actions & Action Plans

1. Asphalt Cement Quantity
2. Longitudinal Joints
3. Improve Bond Between Lifts
4. Incentives for Low Permeability
5. Mix Performance Tests

Asphalt Cement Quantity: Current Actions



- Regression method trials with AC content selected to correspond to 3.5% air void level:
  - ➢7 trial contracts in 2019
- AC film thickness required for information on all projects
- RAP content expressed in terms of % Binder Replacement reported on mix design

Asphalt Cement Quantity: Long-term

- Investigate possible use of the following to increase effective AC content:
  - Full implementation of 3.5% air voids regression method
  - Other opportunities related to mix design and in place air voids (Superpave 5)
  - Strengthen VMA specification requirements to increase VMA (remove 0.5 allowance)
  - VMA as separate pay attribute
  - 0.2% limit on amount contractor can reduce AC content
  - Reduced tolerances on acceptance parameters
  - Lower number of gyrations for mix design (drop gyrations by 25)
  - Ensure a fine graded mix is provided when specified (more AC, better compaction, tighter less permeable surfaces)

Longitudinal Joints

Short-term

- Select contracts include edge compaction as a pay attribute with a tender opening date reduction factor (TODRF) in 2019 and 2020

Long-term

- Construct additional contracts with edge compaction as a pay attribute
- Consider phased implementation across the province

Improve Bond Between Lifts: Short-term

Completed review of other agency minimum residue requirements

Revise specifications:

Measure quantity placed	Raise requirements for residue	Penetration acceptance

Specification to be implemented in August

Improve Bond Between Lifts: Long-term

Set limits on interlayer shear strength or some other process for acceptance

Establish performance testing (i.e. Interlayer Shear Strength test)

Start measuring for information and acceptance

Incentives for Low Permeability: TRAK Compactor

Self propelled, static roller that uniformly distributes pressure with a special rubber belt over a large contact area

- Crack free, tight, and low permeability surface
- Ideal for bridge deck compaction
- No additional rollers required

Incentives for Low Permeability: Specification

Field and laboratory testing required

Expect 2019 to offer incentives for low permeability on some jobs

Say tuned - possible Pave-In in Eastern Region this summer

Mix Performance Tests

MTO is evaluating performance tests and is committed to developing acceptance criteria for post-production asphalt mix

Asphalt mix design has become more complex with the increased use of recycled materials and various additives

Superpave mix design allows the mix designer to select a mix with less asphalt cement & decreased durability

Objective is to use performance tests that provide a balance between both resistance to cracking and rutting

Mix Performance Tests

- Focusing on:
  - SCB for intermediate temperature cracking
  - DCT for low temperature cracking
  - Hamburg Wheel Track testing for rutting and moisture damage
  - Cyclic Fatigue testing also being evaluated for intermediate temperature fatigue performance

Mix Performance Tests: Short-term

- Complete testing program of mix from over 20 Ontario paving contracts, including evaluating material from poor performing roadways to establish criteria for Ontario
- Findings:
  - Carry out Hamburg Wheel Track testing at 44^0C for PG 52-XX instead of 50^oC
  - RAP mixes have lower SCB FI and DCT Fracture Energy results
  - Field cores SCB FI about twice that of gyratory samples made from loose mix samples

Mix Performance Tests: Short Term

- Survey completed of equipment used by Ontario Laboratories to be used in investigation determining impact of changing SCB test for QA/QC lab through HIIFP with U of Waterloo. Looking at using:
  - Other loading frames including Indirect Tensile Strength
  - Alternate conditioning methods
- Will investigate other emerging mix performance tests that show promise
- Phased in approach to be used starting in 2020
  - MTO expects to target 5 to 10 contracts for acceptance based on mix performance testing
  - Contractors will be encouraged to use balanced mix design

Mix Performance Tests: Long-term

Testing carried out by equipped and capable laboratories (QC/QA/Referee)

Conduct long-term aging for mix performance tests, analyze effects and establish mix performance acceptance criteria in relation to in-service pavement performance

Implement mix performance specifications on all contracts to improve quality of asphalt mixes used on Ontario's highways for acceptance

Other Action Plans

- Further explore the use of High Stiffness Base Course
- More use of SMA mixes with consideration for use as binder courses
- Explore opportunities to increase use of Warm Mix Asphalt
- Allow RAP in surface mixes with recovered AC grading for acceptance
- Explore incentives and reduced tolerances for mix and compaction criteria

Wrap-up

MTO is committed to sustainability and will continue to promote and implement innovative pavement recycling techniques

Ontario is currently using improved asphalt cement testing for acceptance and evaluating other tests for future use

MTO is actively evaluating mix tests for future performance acceptance specifications

Questions

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