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Test Monitoring Center

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ASTM D02.B0.07 Semi-Annual Report Bench Test Monitoring

D874 (SASH), D5133 (GI), D5800 (NOACK), D6082 (HT
FOAM), D6335 (TEOST), D6417 (GC VOL), D6557 (BRT),
D6594 (HTCBT), D6794 (EOWT), D6795 (EOFT),
D7097(MTEOS), D7216 (EOEC/LDEOC) and D7528 (ROBO)

April 1, 2024 – September 30, 2024

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Section	Topic		
Summary Items	Executive	Reference Oil Inventories	Additional Information
Test Area Status	TEST	LABS*	STANDS*
Sulfated Ash	D874	5 (+0)	N/A
Gelation Index (GI)	D5133	9 (+0)	42 (+0)
NOACK Volatility	D5800	14 (+0)	39 (+2)
High Temp Foam	D6082	7 (+0)	9 (-2)
TEOST	D6335	9 (+0)	14 (+0)
GC Volatility	D6417	7 (+0)	10 (+0)
* Between 4/1/2024 and 9/30/2024			

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Section	Topic		
Test Area Status (cont.)	TEST	LABS*	STANDS*
Ball Rust Test (BRT)	D6557	5 (+0)	5 (+0)
HTCBT	D6594	10 (+2)	26 (+3)
EOWT	D6794	5 (-1)	N/A
EOFT	D6795	5 (-1)	N/A
MTEOS	D7097	11 (+1)	35 (-2)
EOEC Elast. Compat.	D7216-E	8 (+1)	N/A
LDEOC Elast. Compat.	D7216-L	7 (-1)	N/A
ROBO	D7528	6 (+1)	28 (+1)
* Between 4/1/2024 and 9/30/2024			

B0.07 Bench Testing Executive Summary

- ▶ [D874](#) (Sulfated Ash)

- ▶ For the sixth consecutive 6-month period, there were no tests which failed to meet acceptance criteria for D874. Reference test results continue trending mild. Reference Oil 92 has been exclusively assigned to labs to generate test results to establish final acceptance bands.

- ▶ [D5133](#) (Gelation Index)

- ▶ Number of Labs/Units running GI is the same as last period. Final Acceptance Bands for Reference Oil GIC18 was established and approved by Surveillance Panel in May .

- ▶ [D5800](#) (NOACK)

- ▶ Fourteen labs (and two new stands) had successful calibrations this semester. Several EWMA alarms this semester – all severe.

B0.07 Bench Testing Executive Summary

- ▶ [D6082](#) (High Temperature Foam)
 - ▶ New FOAMB18 Acceptance Targets were established and approved by Surveillance Panel in June 2024.
- ▶ [D6335](#) (TEOST)
 - ▶ Test fail rate at 22.0% was similar to last semester (23.5%). Reference Oil 75-2 has replaced batch 75-1 with the same Acceptance Band range.
- ▶ [D6417](#) (GC Volatility)
 - ▶ Precision and Performance running on-target with no calibration fails this semester.
- ▶ [D6557](#) (BRT)
 - ▶ A lot of activity in BRT this semester. A Round Robin was conducted on new ball bearing Batch E. SP voted to accept the new ball bearings with existing Acceptance Band Ranges. Reference Oils 86, 87 and 820-1 were suspended from assignments at some point during the semester. At this time, only RO 1006 is being assigned for calibration tests.

B0.07 Bench Testing Executive Summary

▶ D6594 (HTCBT)

- ▶ Two labs (three stands) have come back on-line this semester. Some labs have now moved on to Batch P coupons after a Round Robin was completed on Batch p coupons to establish initial Targets and Acceptance Ranges.

▶ D6794 (EOWT)

- ▶ Change in Flowrate Average (CIFA) continues to trend severe for all water treat rates except 0.6% which is on-target this semester. Reference Oil 79 has approximately three semesters of inventory available.

▶ D6795 (EOFT)

- ▶ Change in Flow Average (CIFA) is trending severe with a very consistent CUSUM slope over the past 4 years. Reference Oil 79 has approximately three semesters of inventory available.

B0.07 Bench Testing Executive Summary

▶ D7097 (MTEOS)

- ▶ Precision regressed moving back to 7.57 s, as did Performance moving back to 0.43 s this period. All operationally valid tests this period report using Rod Batch N. Many labs have now moved to Catalyst Batch 23AB, but some labs are still using Catalyst Batch 20AB. No labs used Catalyst Batch 19BA.

▶ D7216 EOEC / D7216 LDEOC

- ▶ All calibrations are using Ref Oil SL-107. Surveillance Panel has agreed to resume Adjustment Factors for EOEC. In preparation for the new HNBR elastomer for EOEC, a Round Robin is being conducted to establish targets and acceptance bands. For LDEOC, four new elastomers have been identified for GF-7 and calibrated tests are available for scheduling through TMC.

▶ D7528 (ROBO)

- ▶ Precision fell slightly to 0.19 (target 0.15). Performance moved very mild (-0.72) the mildest Performance has been in several years. One lab came back on-line after not having a calibration status last semester.

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D02.B0.07

TMC Monitored Tests



ASTM D 874

Sulfated Ash

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D874	5 (+0)	N/A
*As of 9/30/2024		

D874: Sulfated Ash

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	9
Total		9

Number of Labs Reporting Data: 5
Fail Rate of Operationally Valid Tests: 0%

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D874: Sulfated Ash

Statistically Unacceptable Tests (OC)	No. Of Tests
No Failed tests	0

- No operationally invalid or statistically unacceptable tests this report period.

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D874: Sulfated Ash

Period Precision and Severity Estimates

Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Current Targets	81	78	0.07	-----
10/1/19 through 3/31/20	7	4	0.04	-0.71
4/1/20 through 9/30/20	8	5	0.03	-0.30
10/1/20 through 3/31/21	8	5	0.02	-0.35
4/1/21 through 9/30/21	10	7	0.15	0.37
10/1/21 through 3/31/22	9	6	0.05	-0.07
4/1/22 through 9/30/22	8	6	0.06	-0.38
10/1/22 through 3/31/23	11	8	0.04	-0.71
4/1/23 through 9/30/23	10	7	0.04	-0.46
10/1/23 through 3/31/24	11	8	0.02	-0.47
10/1/23 through 3/31/24	9	7	0.04	-0.45

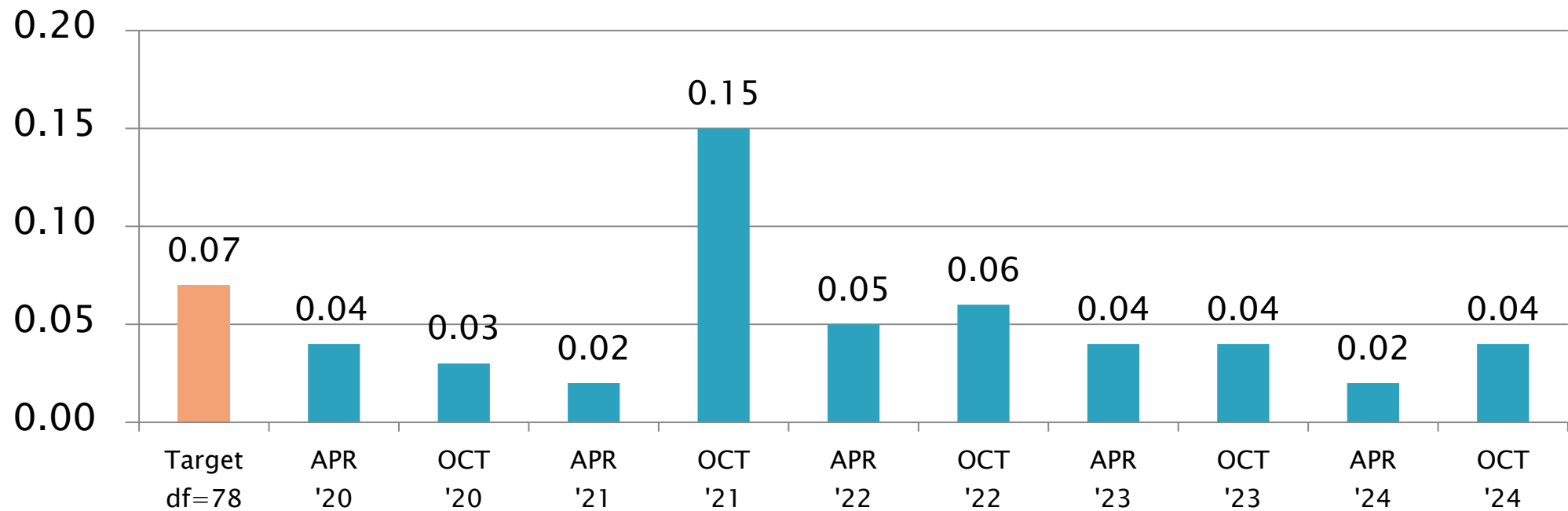
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D874: Sulfated Ash

Sulfated Ash, mass%
Pooled s



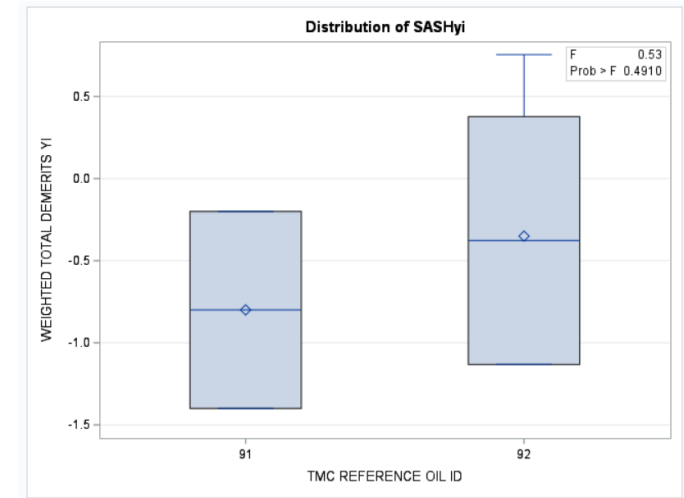
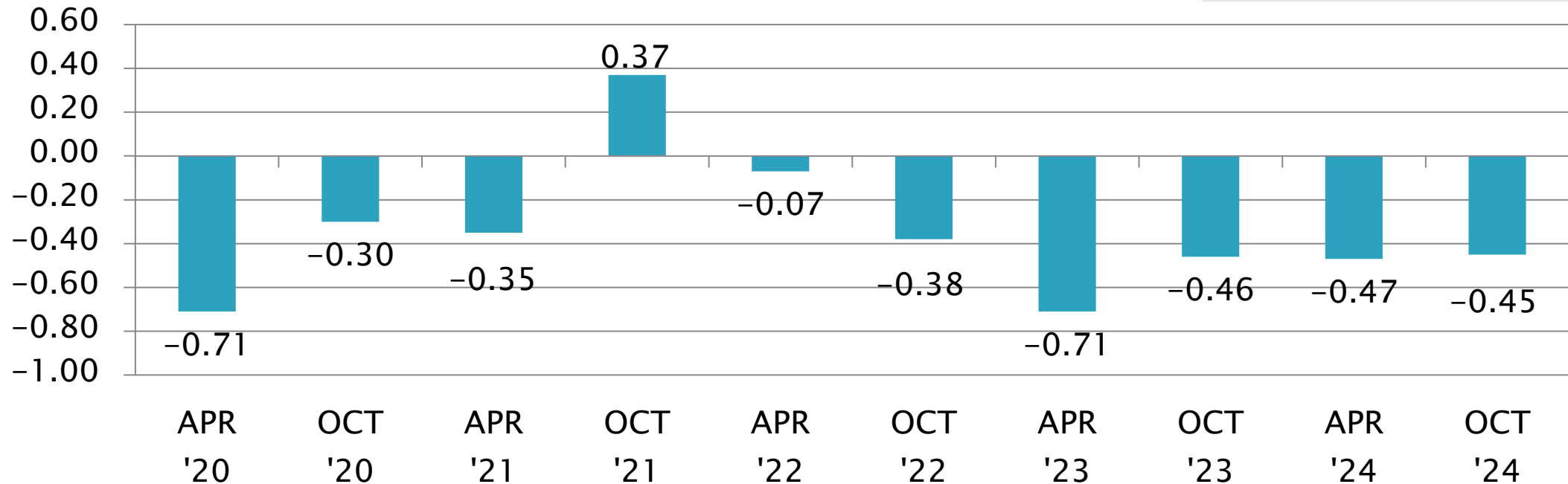
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D874: Sulfated Ash

Sulfated Ash, mass%
Mean Δ/s



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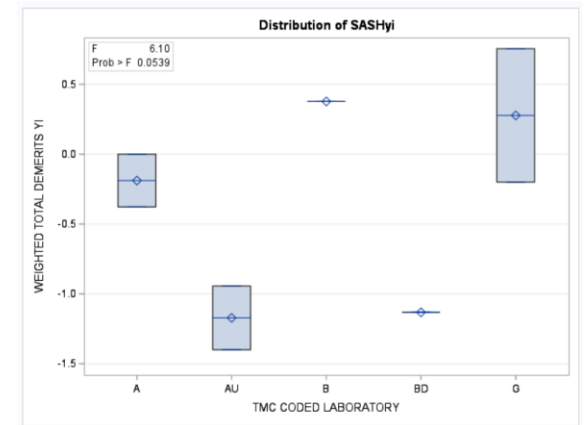
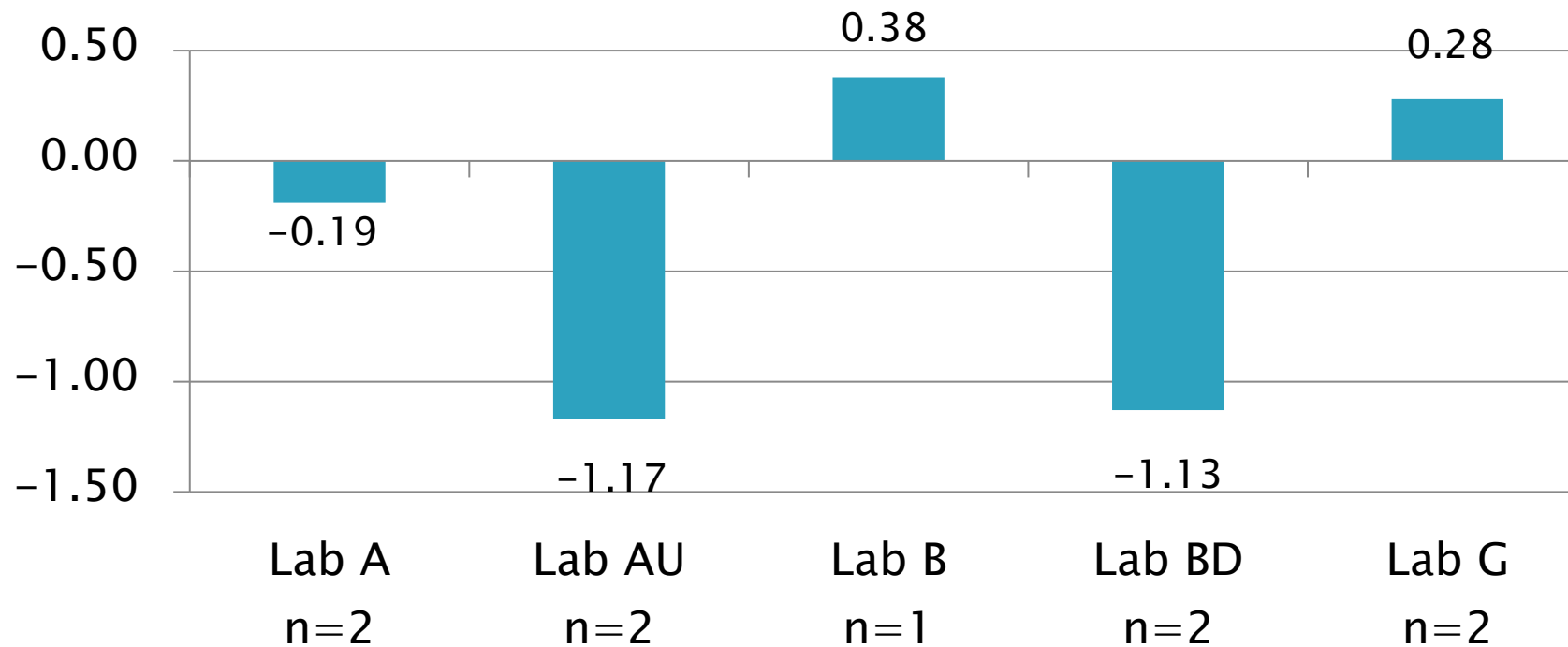
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D874: Sulfated Ash

Sulfated Ash, mass%

Mean Δ/s



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D874 (Sulfated Ash) Status

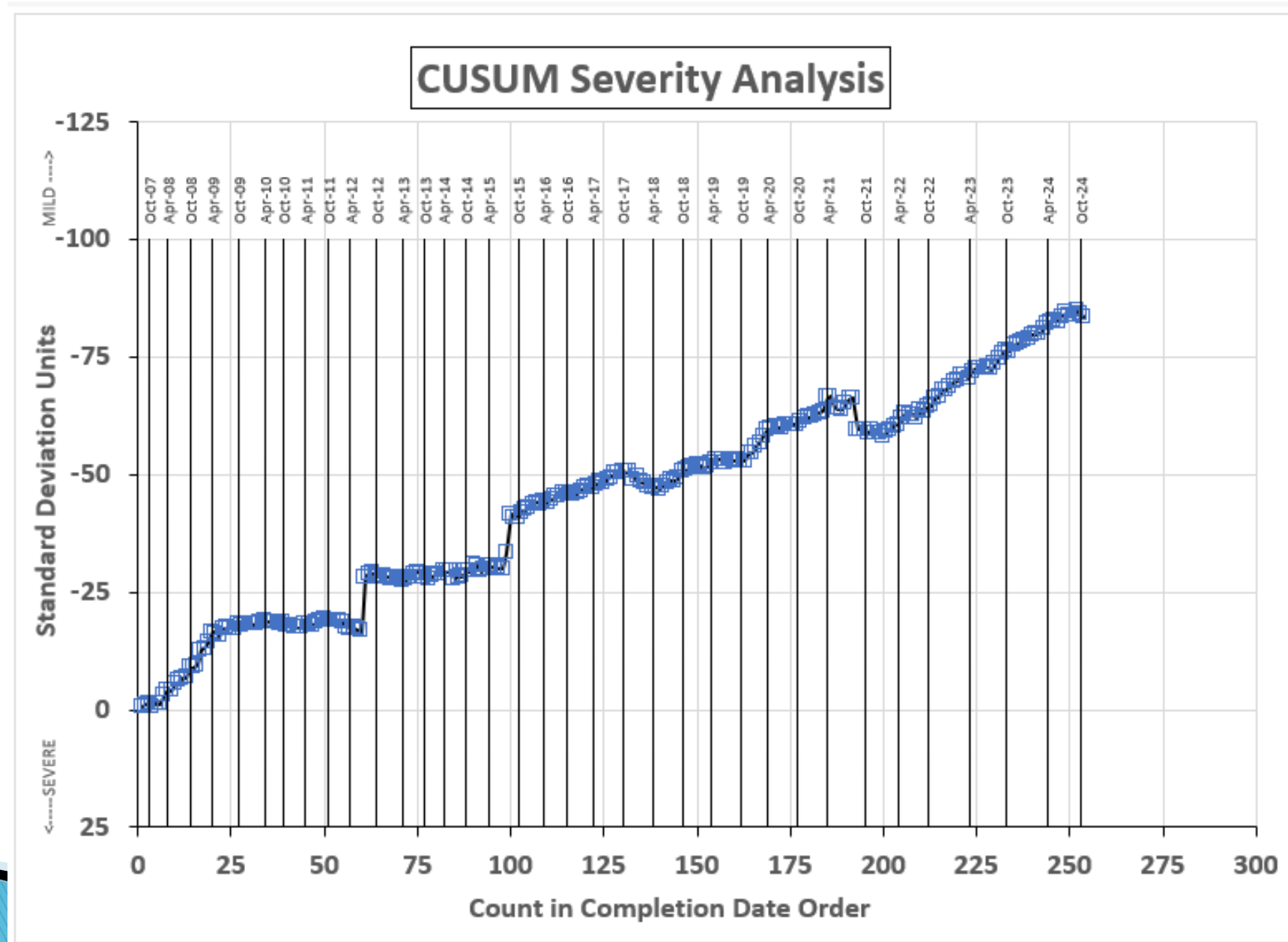
- ▶ Precision (Pooled s) has moved back slightly to 0.04.
- ▶ Performance (Mean Δ/s) has remained steady at -0.45 s
- ▶ Reference Oil 90 only being used for D874 Daily QC.
- ▶ Reference Oil 92 is being assigned to all labs for every calibration test so that targets can be updated within the next year.

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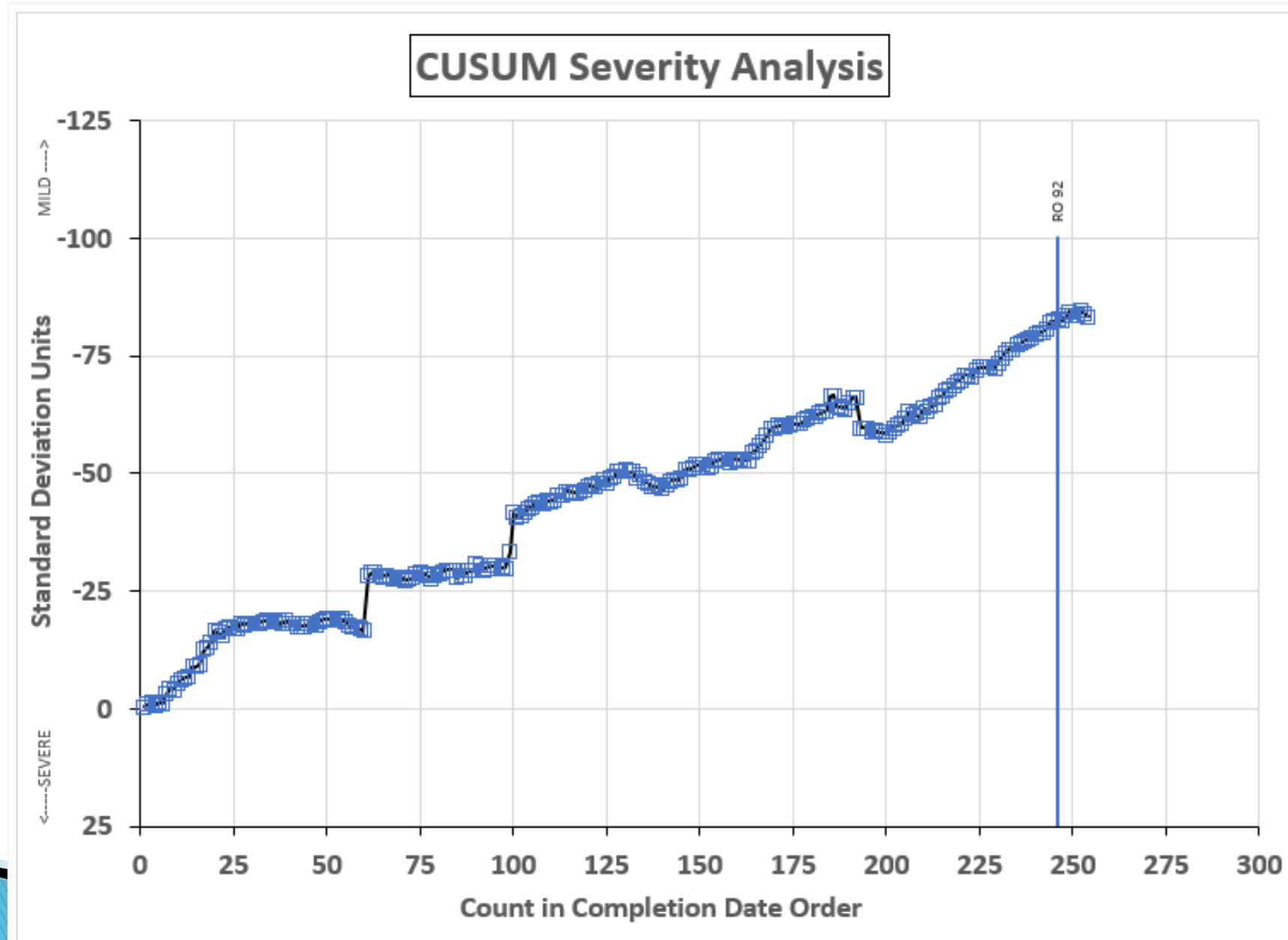
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TEST SAMPLE PERCENT SULFATED ASH

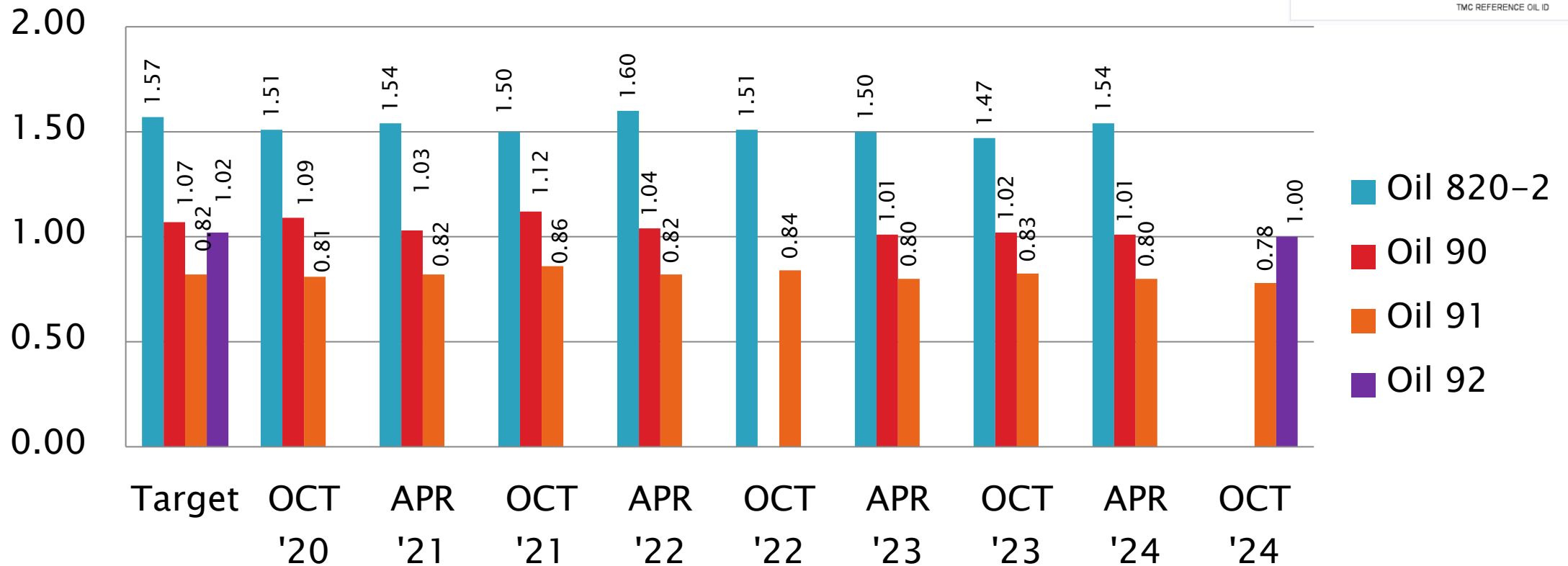
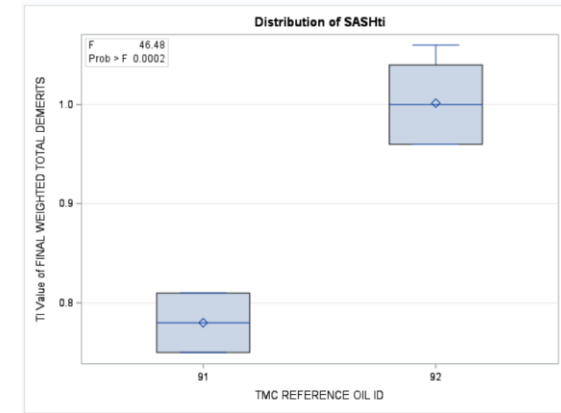


TEST SAMPLE PERCENT SULFATED ASH



D874: Sulfated Ash

Sulfated Ash, mass%
Mean



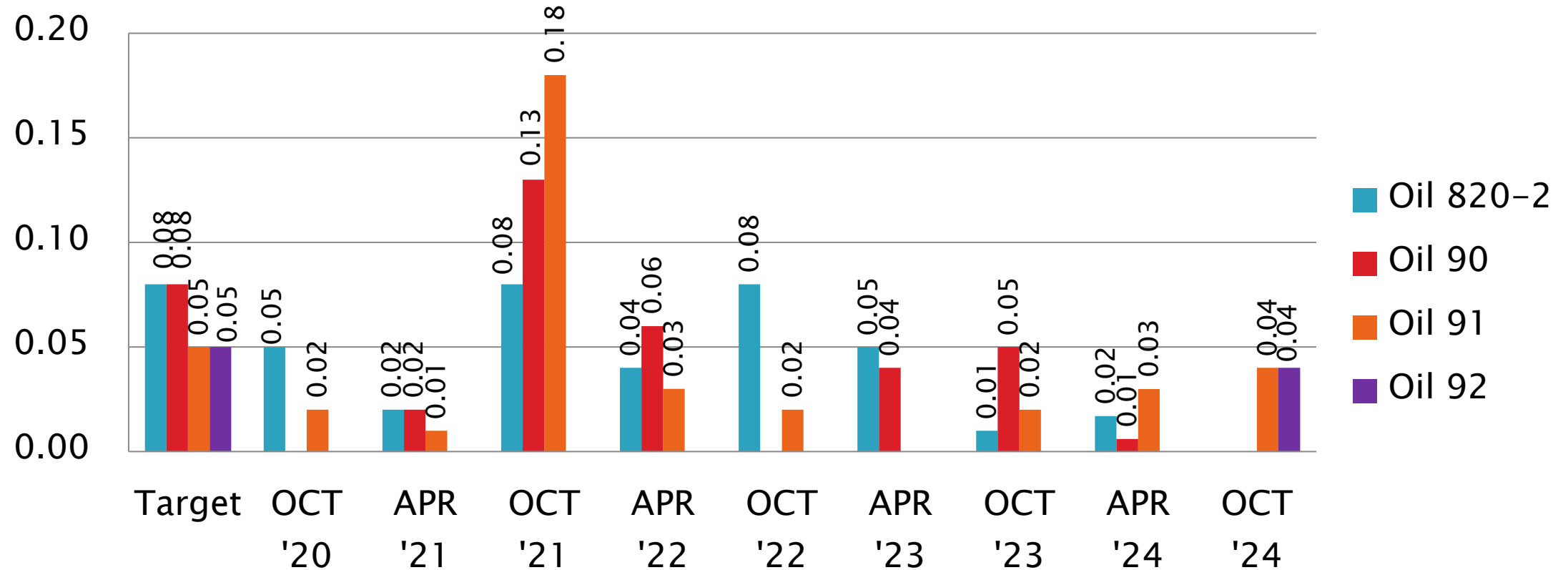
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D874: Sulfated Ash

Sulfated Ash, mass%
Standard Deviation



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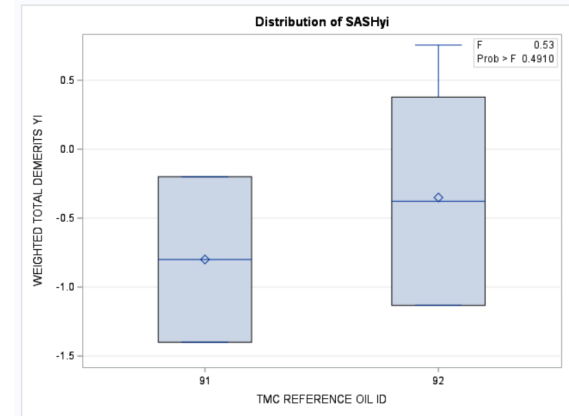
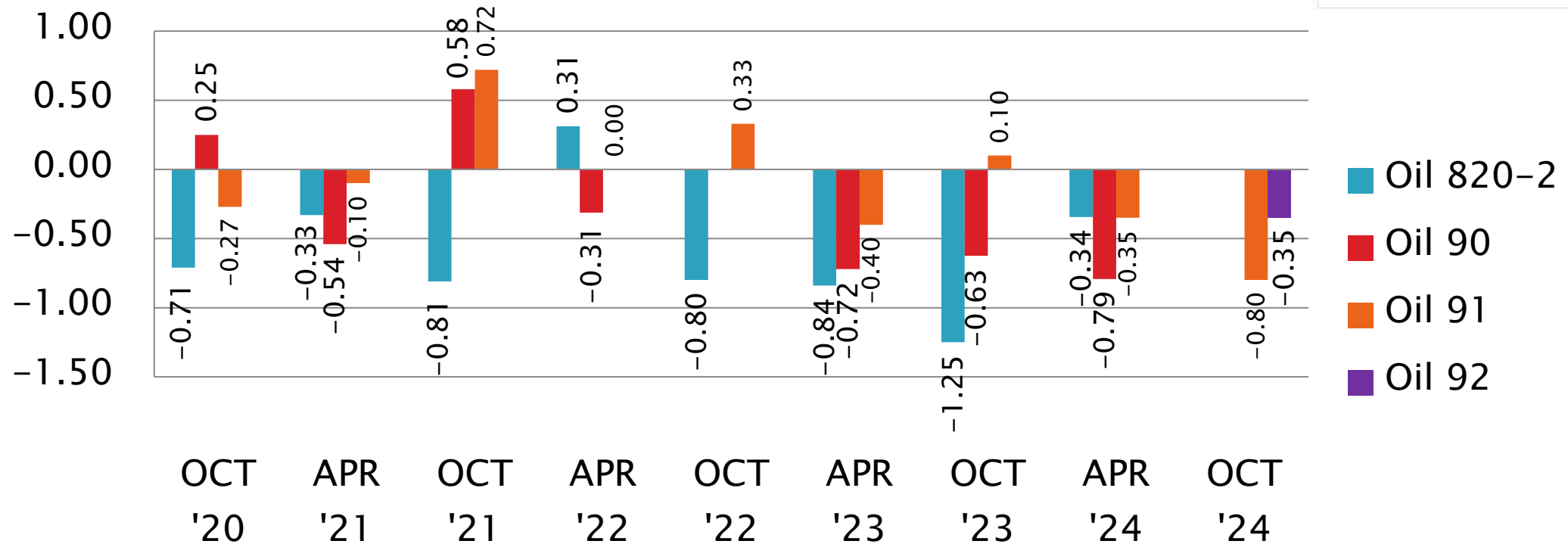


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D874: Sulfated Ash

Sulfated Ash, mass%

Mean Δ/s



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Reference Oil Inventory

D874

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
820-2	2001	D874	5.99	0.02	5+ years
90 ^B	2005	D874QC	2.49	1.32	1.5 years
91	2006	D874	2.98	0.01	5+ years
92	2020	D874	52.52	0.05	5+ years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B Reference Oil 90 is now only used for D874QC Samples (1L sizes)

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TMC Monitored Tests



ASTM D 5133

Gelation Index (GI)

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual Report)

Test	Labs	Stands
D5133	9 (+0)	42 (+0)
*As of 9/30/2024		

D5133: Gelation Index

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	50
Failed Calibration Test	OC	12
Operationally Invalidated by Lab	LC / LS / LN / XC / XS	6
Operationally Invalidated After Initially Reported as Valid	RC/RS	0
Acceptable Discrimination Tests	AS	23
Failed Discrimination Tests	OS	0
Informational Runs	NN / MN	18
Total		109

Number of Labs Reporting Data: 9 (previous 9)
Fail Rate of Operationally Valid Calibration Tests: 19.4 % (previous 14.0%)
Fail Rate of Operationally Valid Discrimination Tests: 0.0 % (previous 0%)

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D5133: Gelation Index

Statistically Unacceptable Calibration Tests (OC)	No. Of Tests
Gelation Index Severe	1
Gelation Index Mild	11
Total	12

- Of the TWELVE “OC” tests
 - 7–GIC 18
 - 5–GIA 17
 - 0–1009
- Four between -1.96 and -3.0 sd from target
- One between $+1.96$ and $+3.0$ sd from target
- Seven greater than -3.0 sd from target

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D5133: Gelation Index

Statistically Unacceptable Discrimination Tests (OS)	No. Of Tests
Gelation Index Severe (> 7.2)	0
Total	0

- There were no (ZERO) Failing Discrimination Runs this Semester

D5133: Gelation Index

Tests Excluded From Statistics (Operationally or Otherwise)	Validity Code	No. Tests
Invalidated Runs	LC, LS, LN, RC, RS	5
Aborted Runs	XC, XS	1
Informational Runs (Acceptable Result)	NN	16
Informational Runs (Unacceptable Result)	MN	2
Total		24

- FIVE Invalidated Run (Contamination, Temp Control, Nitrogen Supply Interruption)
- ONE Aborted Run (Power Outage)
- EIGHTEEN requests for Informational (non-blind) runs

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D5133: Gelation Index

Period Precision and Severity Estimates

Gelation Index	n	df	Pooled s	Mean Δ/s
Targets Updated 20201001 ¹	34	32	1.44	-----
10/1/19 through 3/31/20	41	37	2.45	-0.24
4/1/20 through 9/30/20	52	48	2.23	-0.11
10/1/20 through 3/31/21 ²	116	113	3.74	-0.86
4/1/21 through 9/30/21	75	73	1.71	-0.20
10/1/21 through 3/31/22	61	59	1.55	-0.84
4/1/22 through 9/30/22	57	55	1.28	-0.41
10/1/22 through 3/31/23	84	80	3.83	-0.08
4/1/23 through 9/30/23	62	59	1.34	-0.21
10/1/23 through 3/31/24	57	54	1.64	-0.03
4/1/24 through 9/30/24	62	59	2.09	-0.92

¹Target precision based upon GIA17 and 1009 reference oils 10/1/2020

²Changed from bath to head-based monitoring scheme 10/1/2020

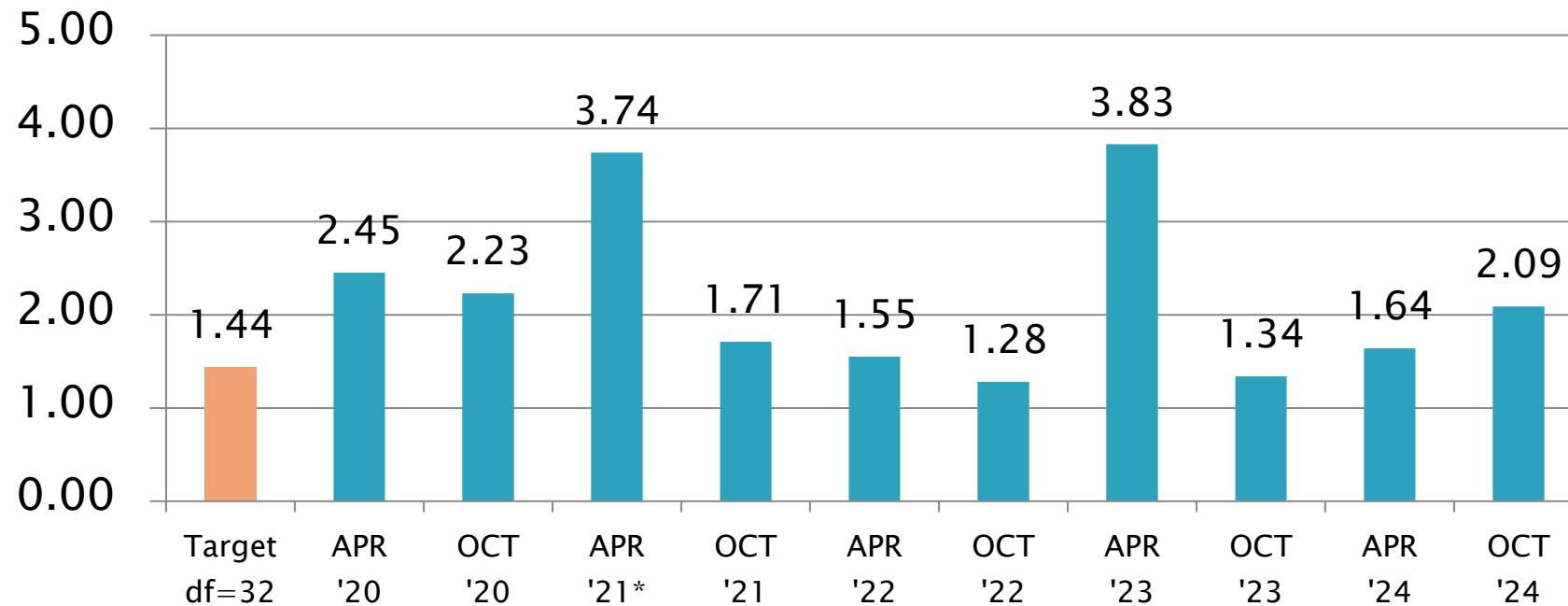
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D5133 Precision Estimates

Gelation Index Pooled s



*Changed from bath to head-based monitoring scheme

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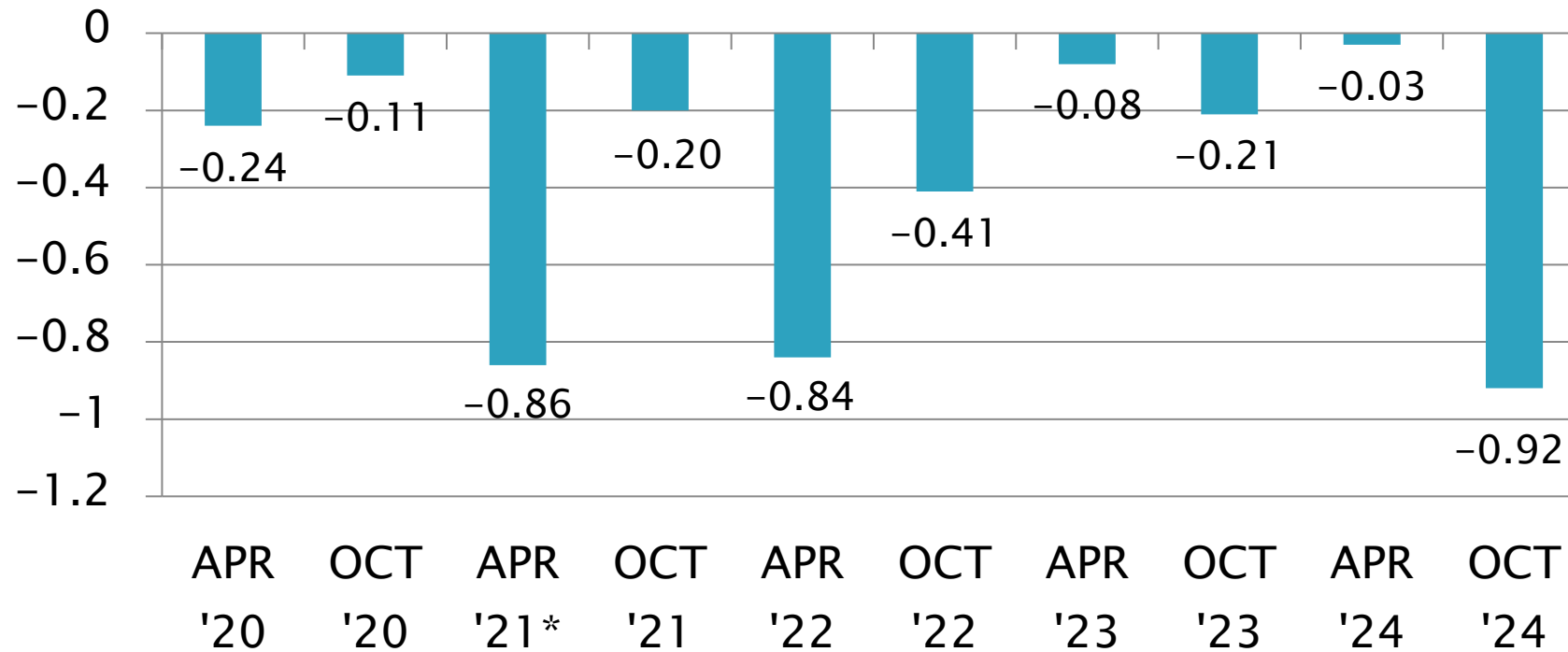
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D5133 Severity Estimates

Gelation Index

Mean Δ/s



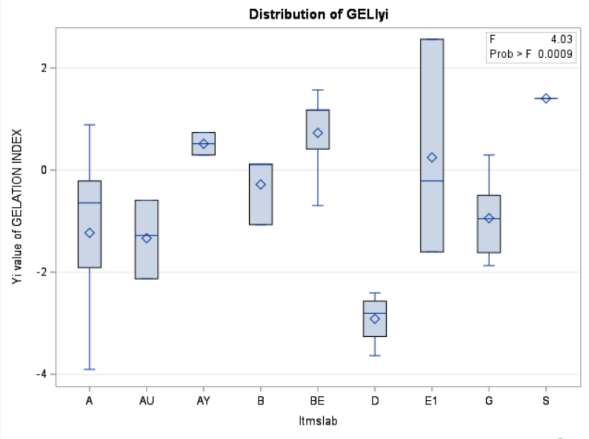
*Changed from bath to head-based monitoring scheme

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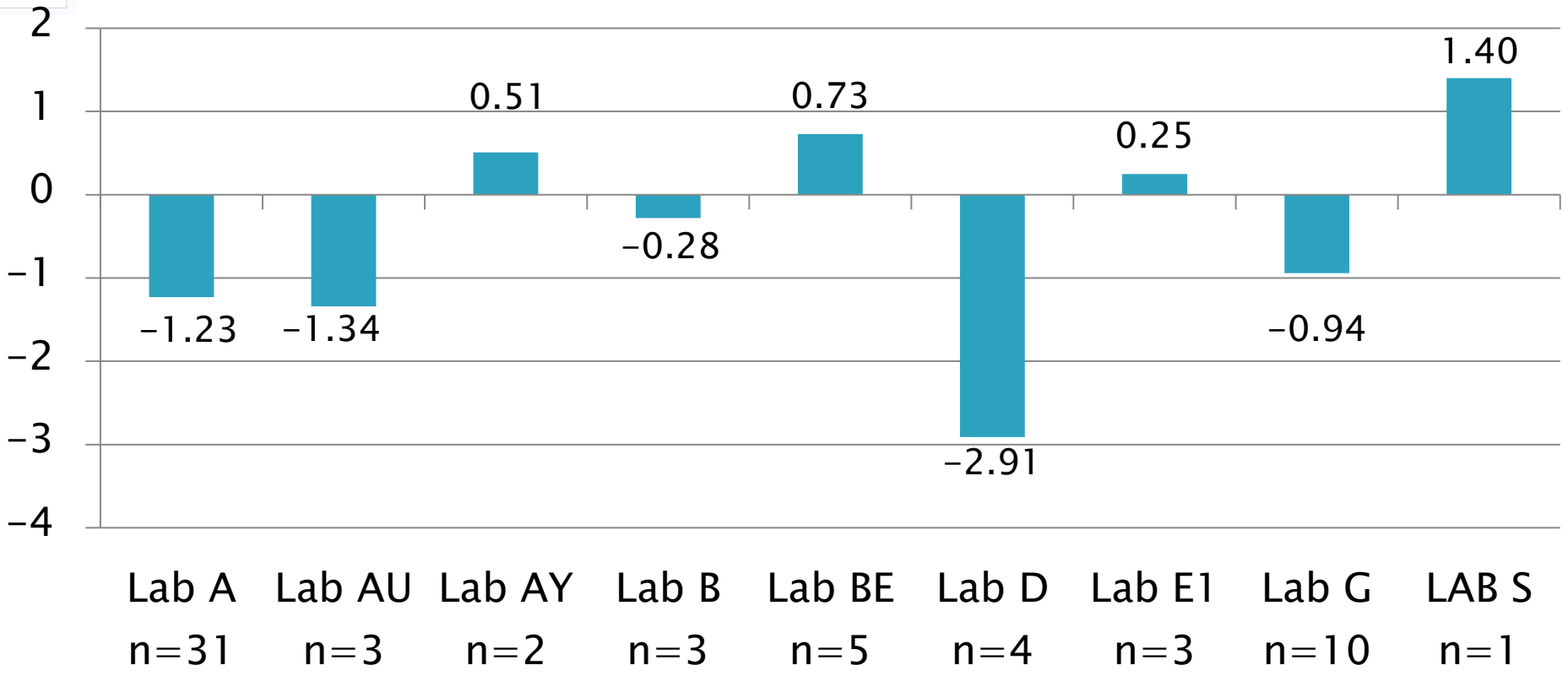
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D5133 Lab Severity Estimates

Gelation Index

Mean Δ/s



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D5133: Gelation Index

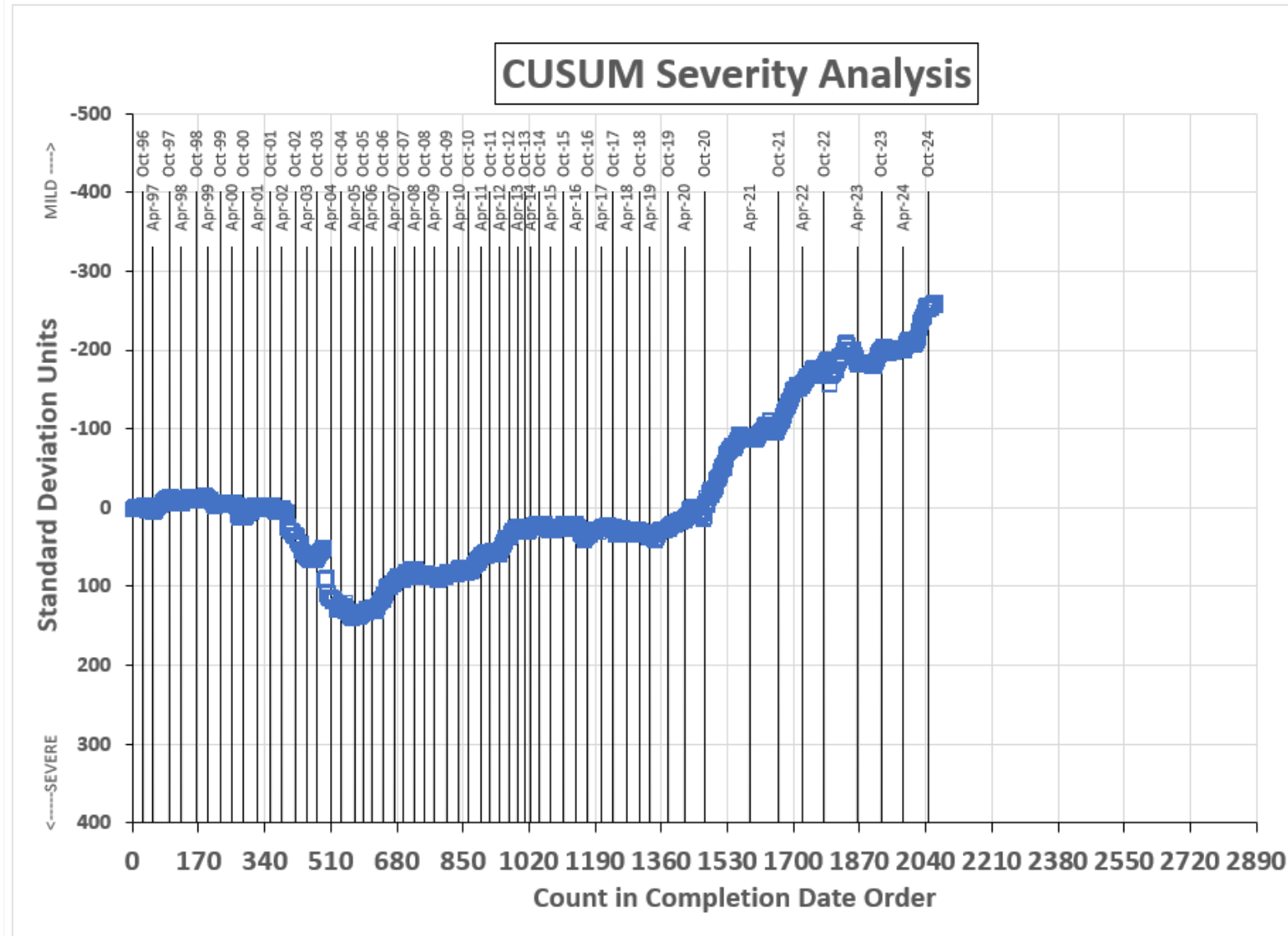
- Fail rate of operationally valid tests rose to 19.4%
 - Fail rate last period was 14%
- No (ZERO) operationally valid discrimination runs failed this period
 - Four discrimination runs failed last period
- Precision (Pooled s) increased to 2.09 and is now well above target (1.44).
- Performance (Mean Δ/s) shows that the testing is running mild at -0.92 s
- Final Acceptance Limits for Reference Oil GIC18 were approved by the Surveillance Panel on 5/21/2024

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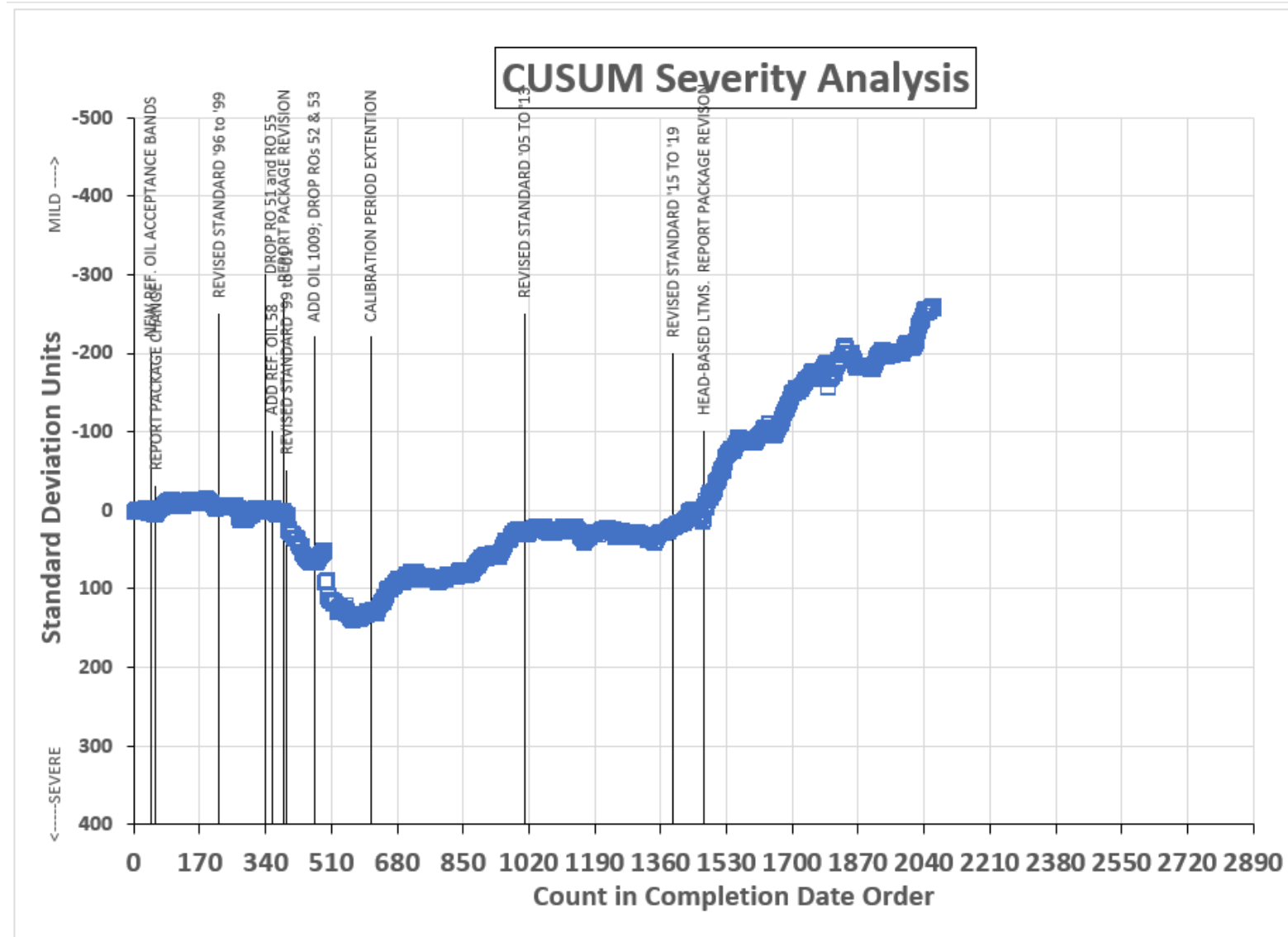


GELATION INDEX



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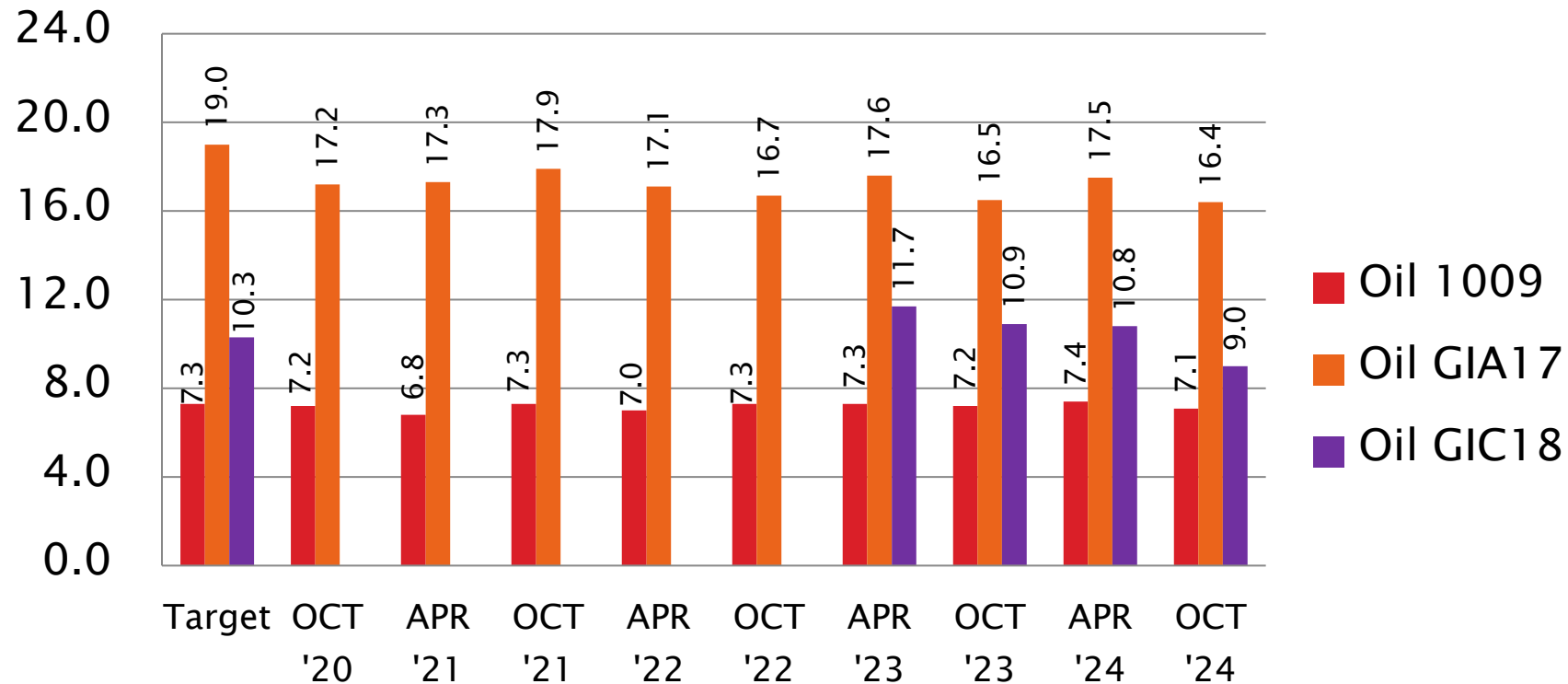
GELATION INDEX



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D5133 Performance by Oil

Gelation Index
Mean



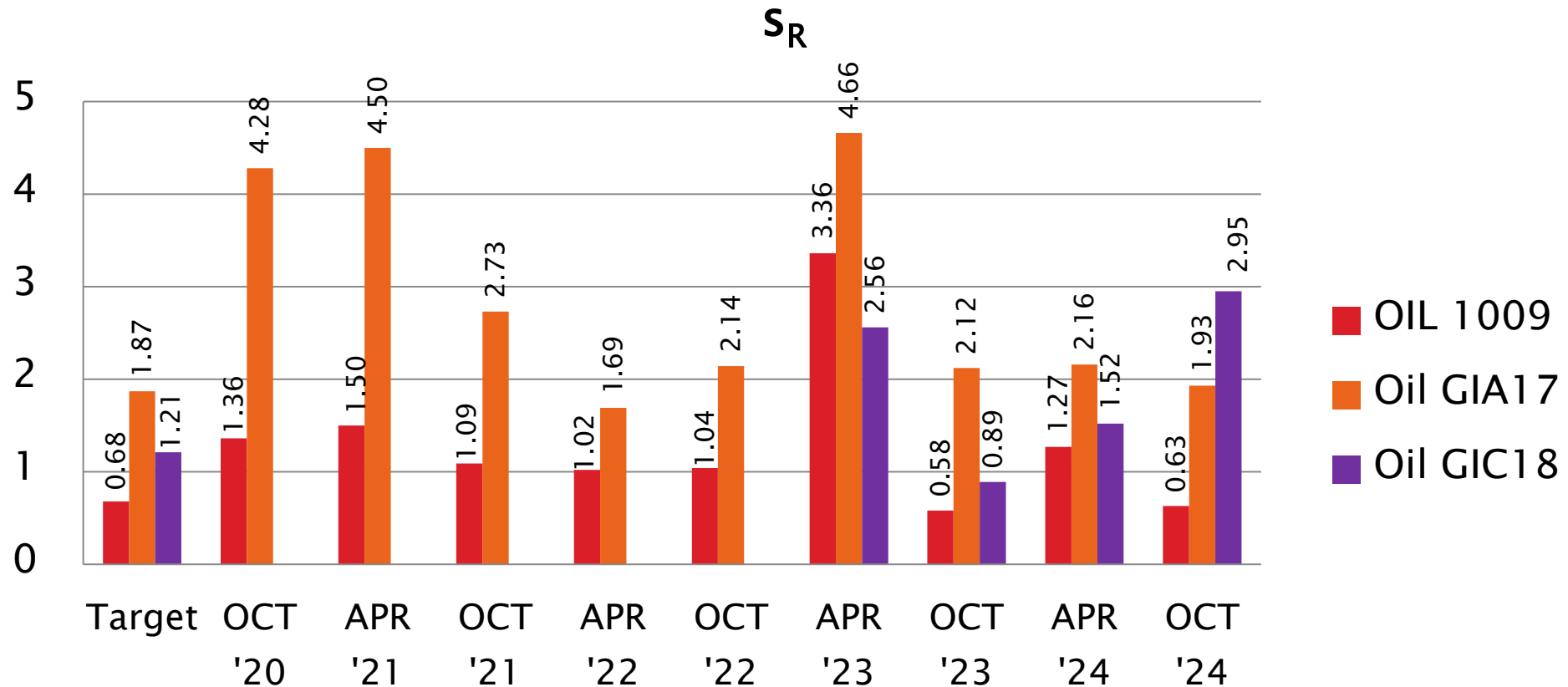
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D5133 Performance by Oil

Gelation Index

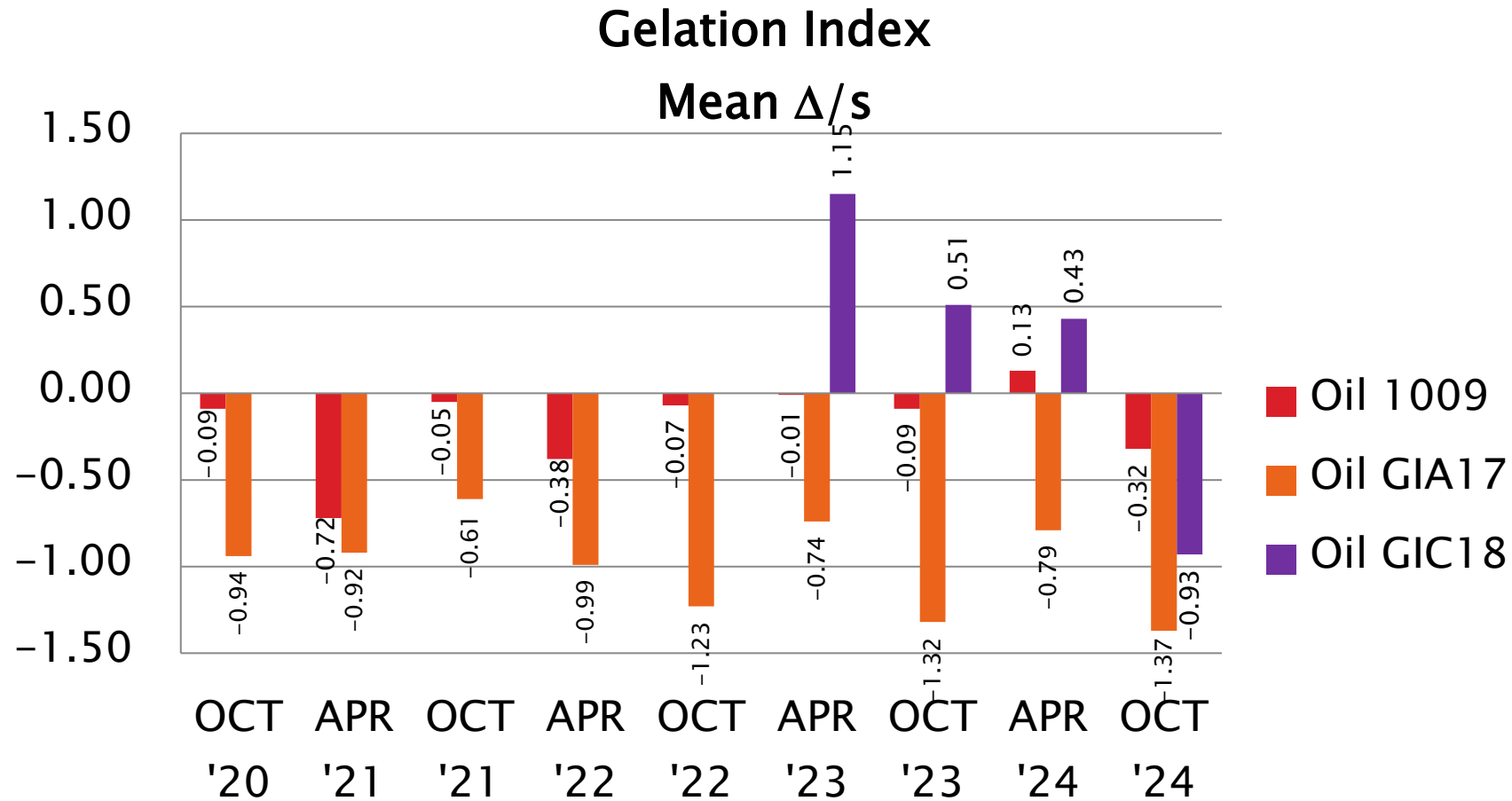


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D5133 Performance by Oil

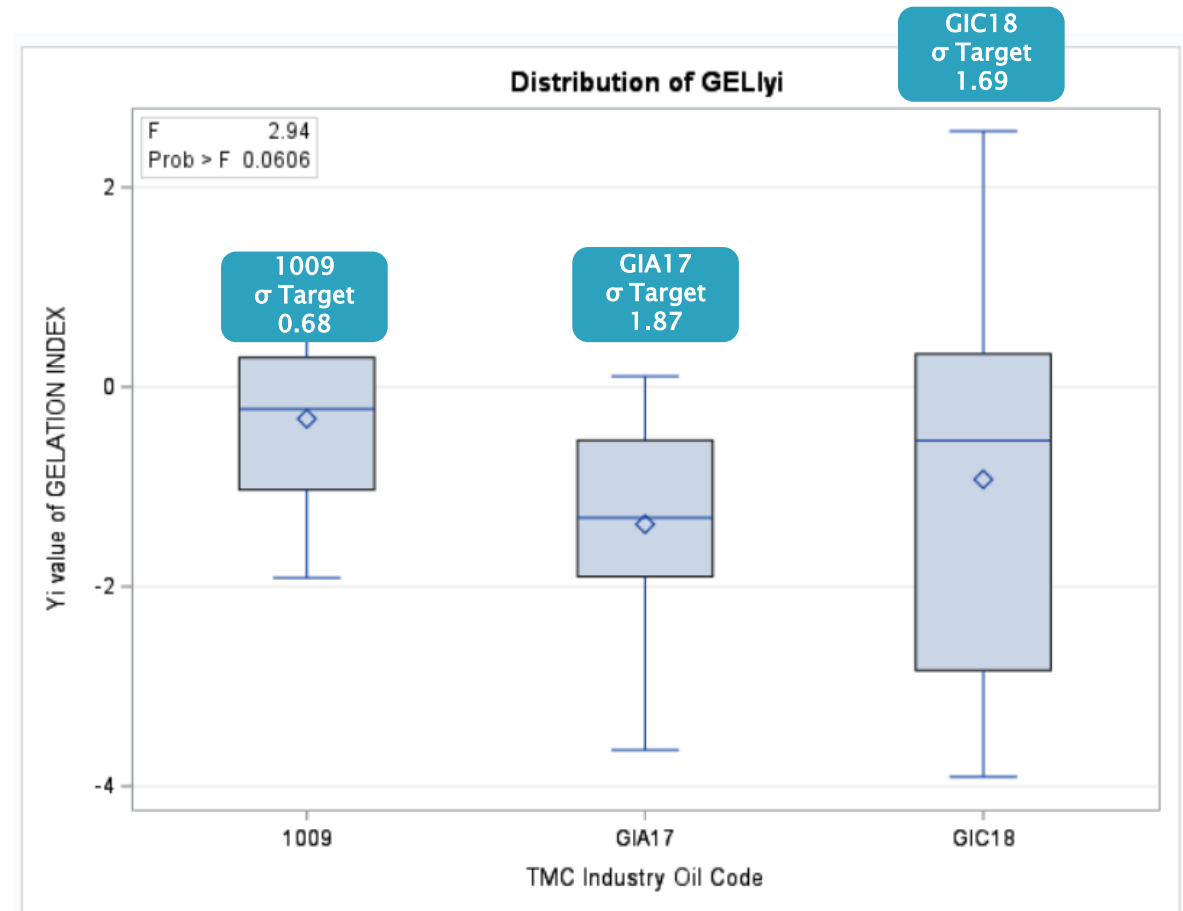
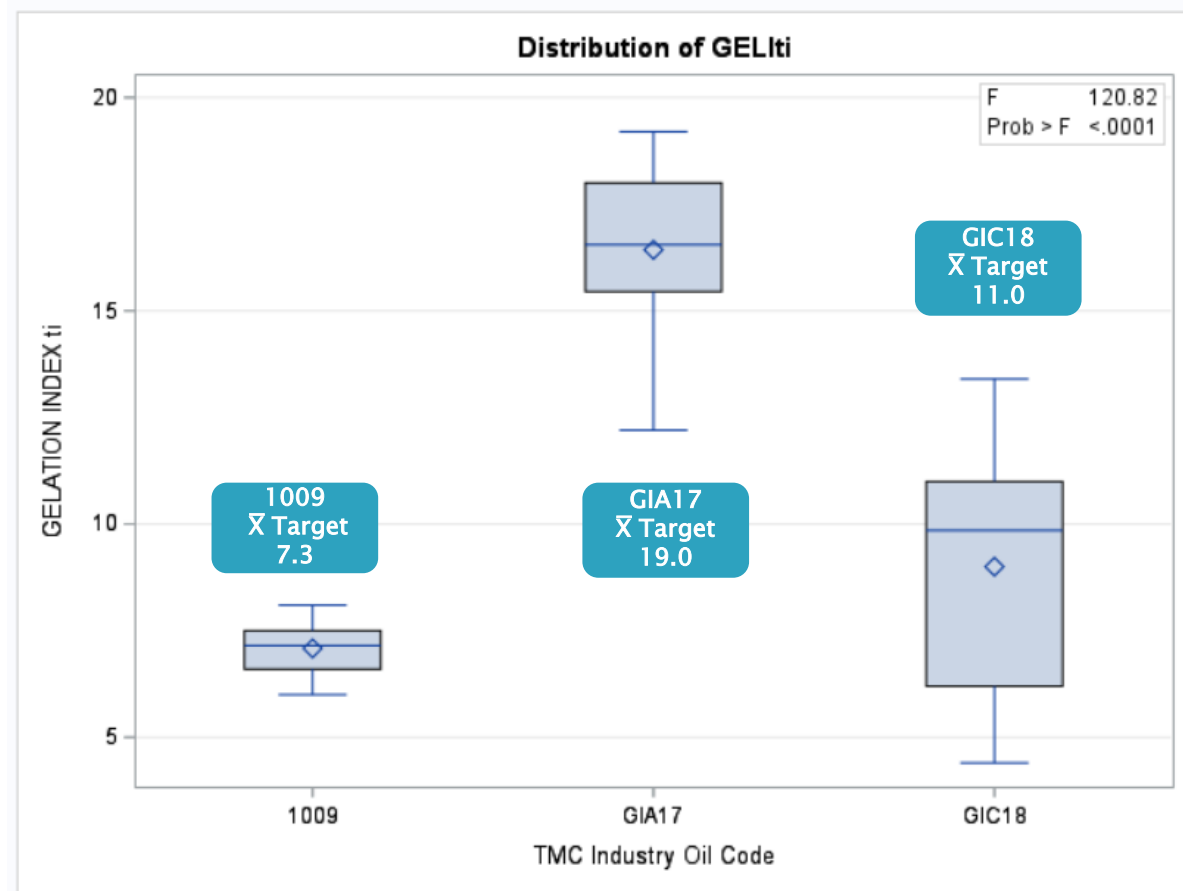


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ASTM D5133 (GI): OCT23 – MAR24 Results



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Reference Oil Inventory

GI (D5133)

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
58 ^B	1998	GI	110.19	0.31	5+ years
GIA17	2017	GI	5.31	0.22	5+ years
GIC18	2018	GI	7.96	0.19	5+ years
1009	2002	GI	33.41	0.17	5+ years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B Reference Oil 58 is used in multiple Bench Test Areas.

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D02.B0.07

TMC Monitored Tests



ASTM D 5800

NOACK Volatility

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual Report)

Test	Labs	Stands
D5800	14 (+0)	39 (+2)
*Between 4/1/2024 and 9/30/2024		

D5800: Evaporation Loss of Lubricating Oil by Noack Method

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	185
Failed Calibration Test	OC	4
Operationally Invalidated by TMC	RC	3
Aborted Test	XC	1
Acceptable Shakedown Run	NN	0
Unacceptable Shakedown Run	MN	0
Total		193

Number of Labs Reporting Data: 14
Fail Rate of Operationally Valid Tests: 2.12% (last Semester 5.75%)

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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Statistically Unacceptable Tests (OC)	No. Of Tests
Ei Level 3 Alarm Severe	2
Ei Level 3 Alarm Mild	1
Zi Level 2 Severity Alarm Severe	1
Zi Level 2 Severity Alarm Mild	0

- The FOUR OC tests were on four different rigs at four different labs.
- ZERO (!) operationally valid tests exceeded ± 3.0 s this period.

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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Failed (OC) Details	Procedure	Model	No. Tests
Zi Level 2 Alarm: Rig (D3) Severe	B	NCK25G	1
Ei Level 3 Alarm Severe: Rig (D5) too imprecise to predict SA	D	NS2	1
Ei Level 3 Alarm Severe: Rig (E1 7) too imprecise to predict SA	D	NS2	1
Ei Level 3 Alarm Mild: Rig (B9) too imprecise to predict SA	B	NCK25G	1
Total			4
Fail Rate of Operationally Valid Tests: 2.12%			

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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Operationally Invalid Tests (LC, RC)

Two different labs had invalidated calibration runs this period

- Two tests were invalidated by TMC due to DAILY QC Out of Range
- One test was invalidated by TMC due to not having a DAILY QC Result

D5800 Technical Memos

No D5800 technical memos were issued by the TMC this period.

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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Period Precision and Severity Estimates

Sample Evaporation Loss, mass %	n	df	Pooled s	Mean Δ/s
Targets Effective 02/07/20 ¹	78	75	0.0465	-----
10/1/19 through 3/31/20 ¹	146	143	0.0503	0.54
4/1/20 through 9/30/20 ¹	136	133	0.0659	0.35
10/1/20 through 3/31/21 ¹	140	137	0.0495	0.53
4/1/21 through 9/30/21 ¹	136	133	0.0510	0.45
10/1/21 through 3/31/22 ¹	139	136	0.0463	0.24
4/1/22 through 9/30/22 ¹	136	133	0.0469	-0.10
10/1/2022 through 3/31/23 ¹	136	133	0.0545	-0.15
4/1/2023 through 9/30/23 ¹	169	166	0.0586	0.33
10/1/2023 through 3/31/24 ¹	174	171	0.0576	0.37
4/1/2024 through 9/30/24 ¹	189	187	0.0551	0.23
¹ Began monitoring natural log transformed test results on 20200207 making logarithmic scale changes for target and period precision estimates starting April 2020 report period				

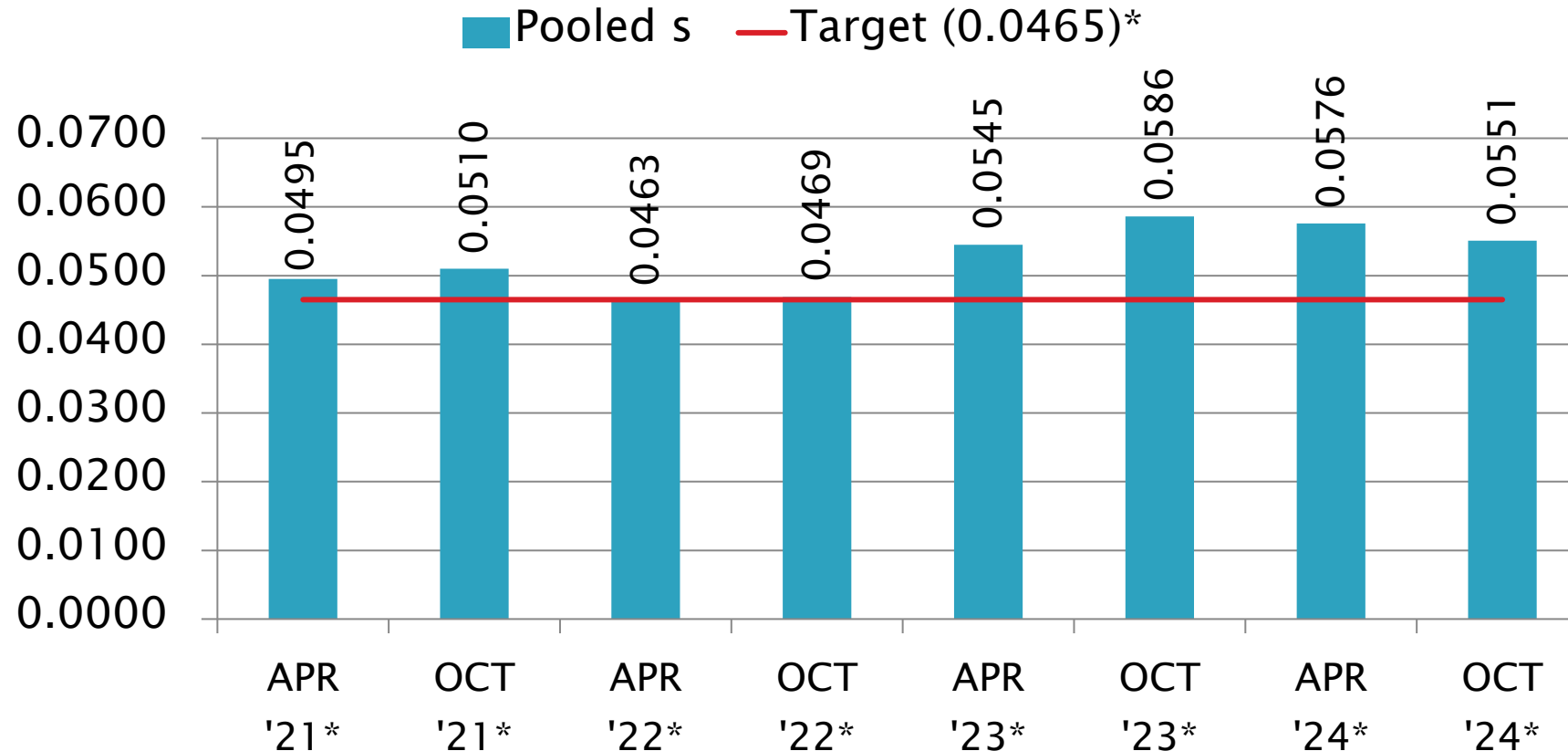
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D5800 Precision Estimates

Sample Evaporation Loss, mass %



*Began monitoring natural log transformed test results on 20200207 making logarithmic scale changes for target and period precision estimates starting April 2020 report period.

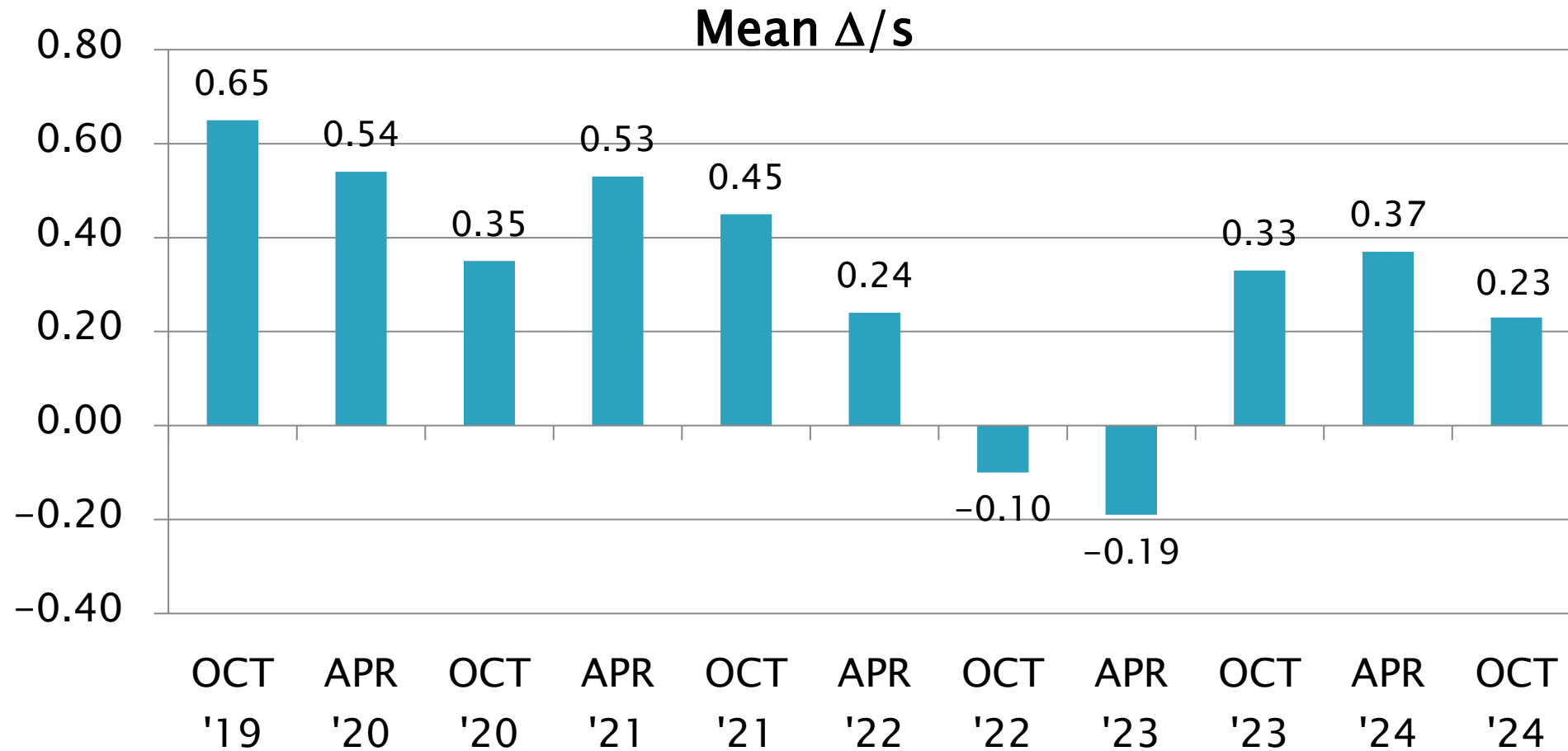
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D5800 Severity Estimates

Sample Evaporation Loss, mass %



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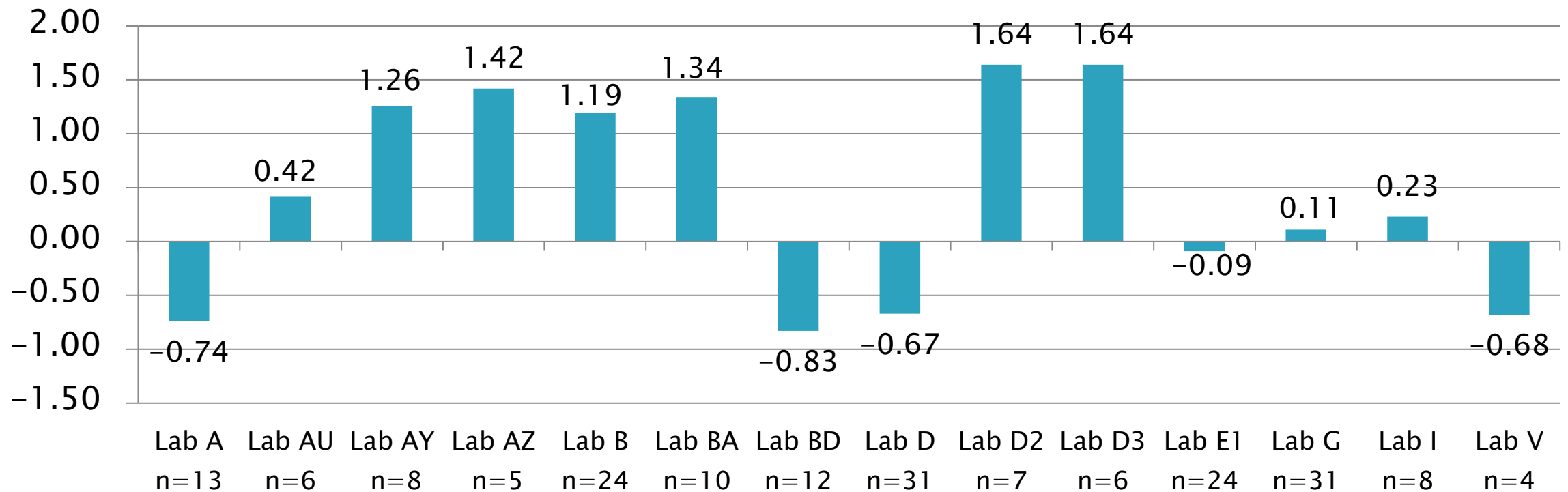
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D5800 Lab Severity Estimates

Sample Evaporation Loss, mass %

Mean Δ/s



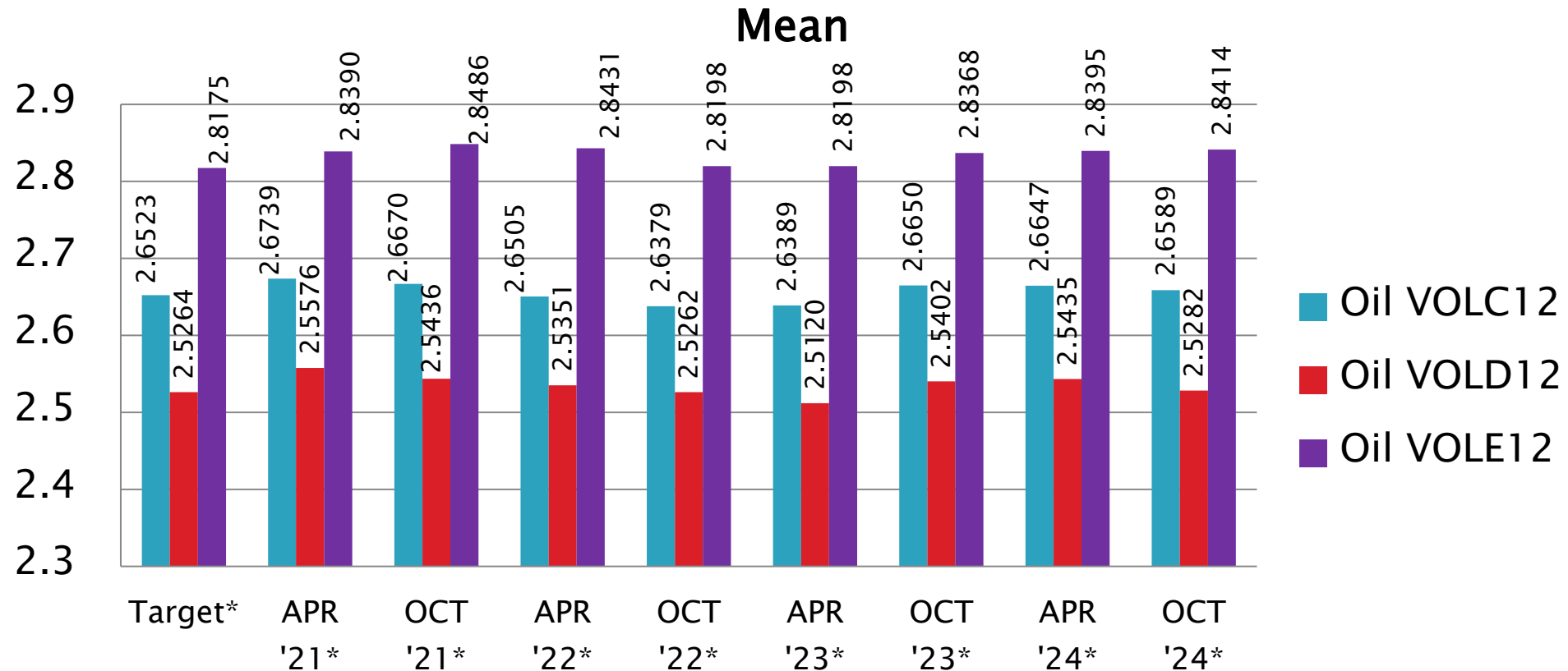
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D5800 Performance by Oil

Sample Evaporation Loss, mass %



*Results transformed to natural log per updated LTMS 20200207

April 1, 2024 – September 30, 2024

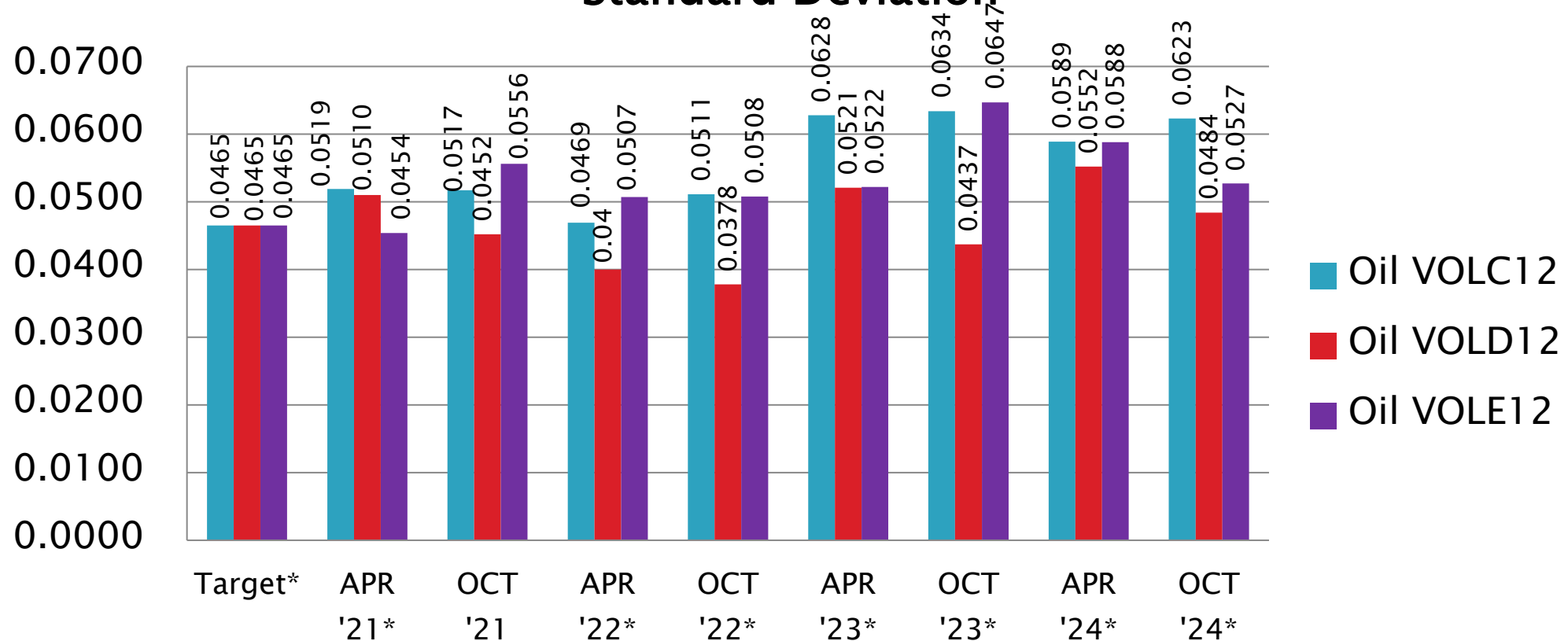
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D5800 Performance by Oil

Sample Evaporation Loss, mass %

Standard Deviation



*Results transformed to natural log per updated LTMS 20200207

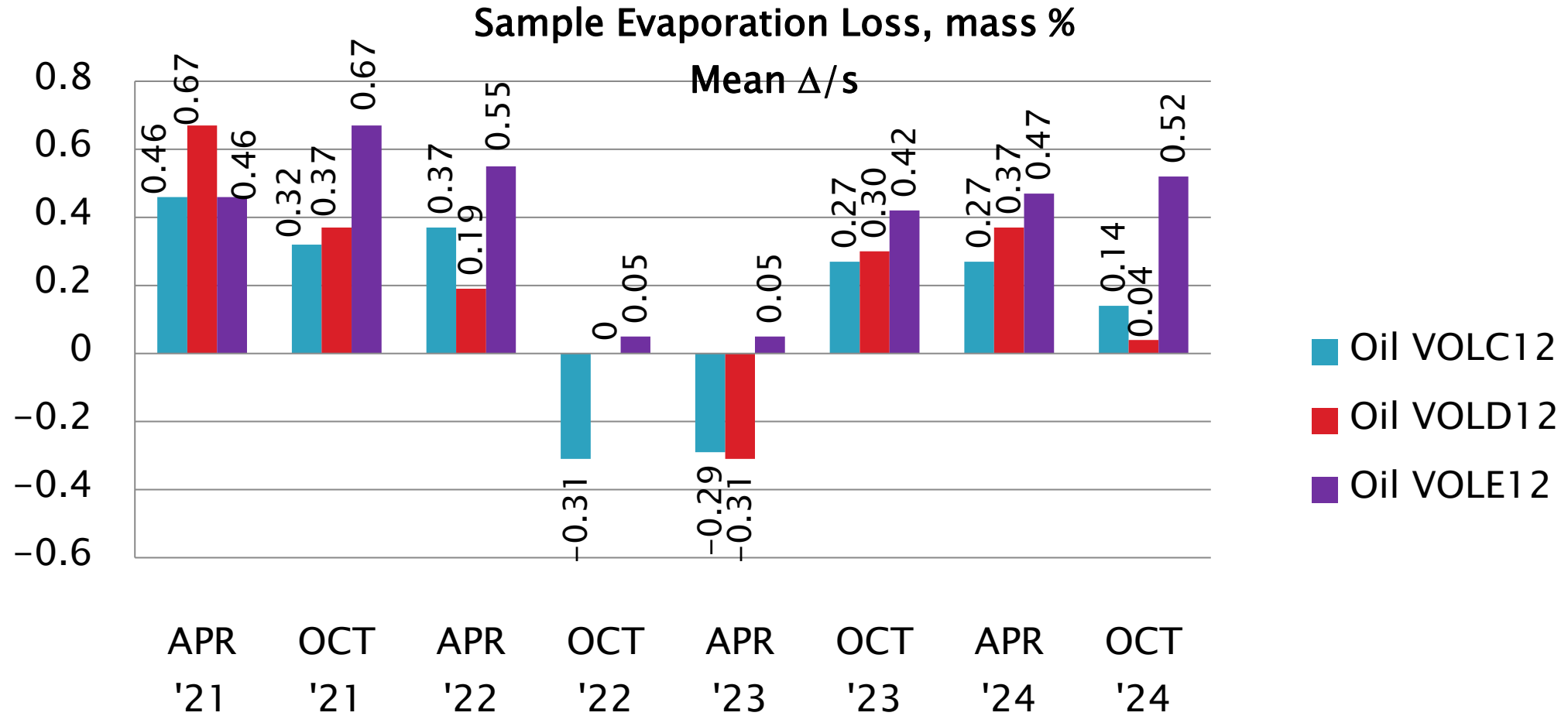
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D5800 Performance by Oil



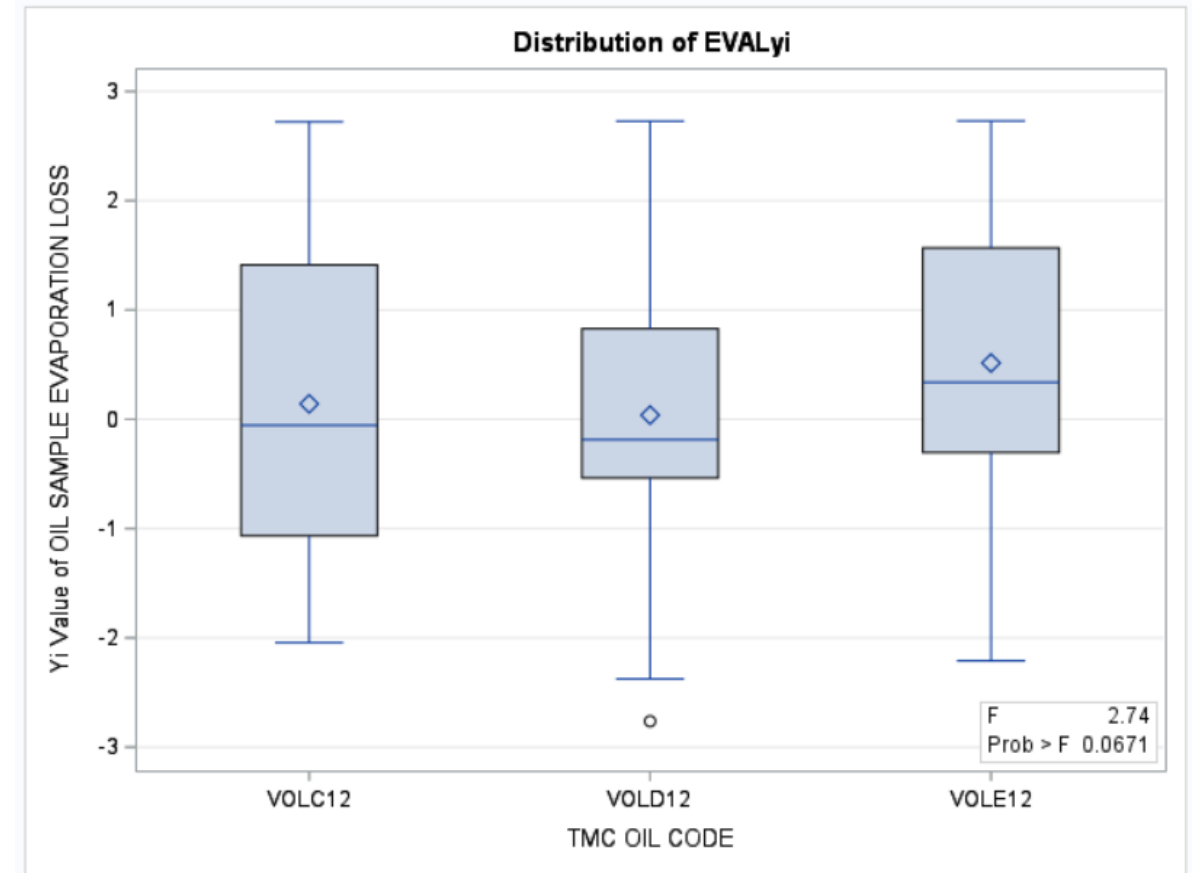
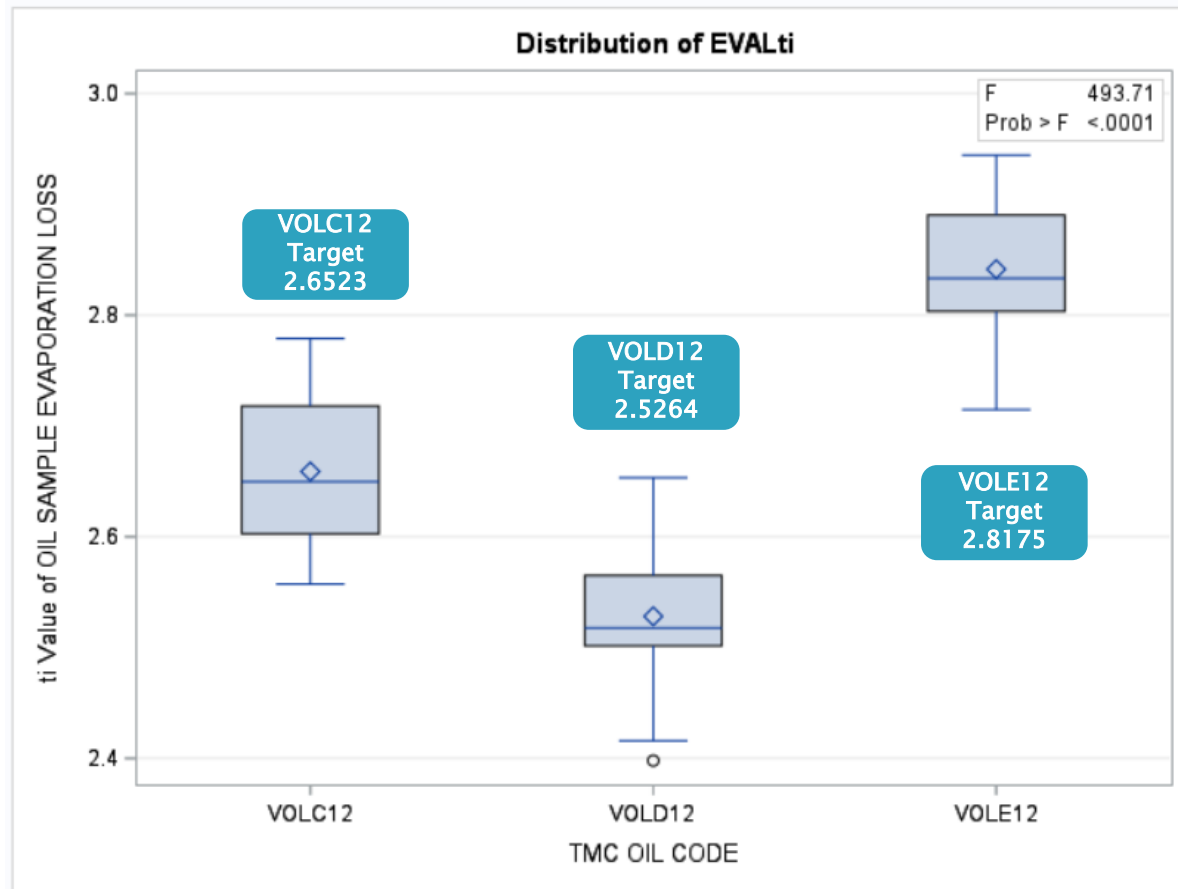
April 1, 2024 – September 30, 2024

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ALL

All Procedures: APR24 – SEP24 Results



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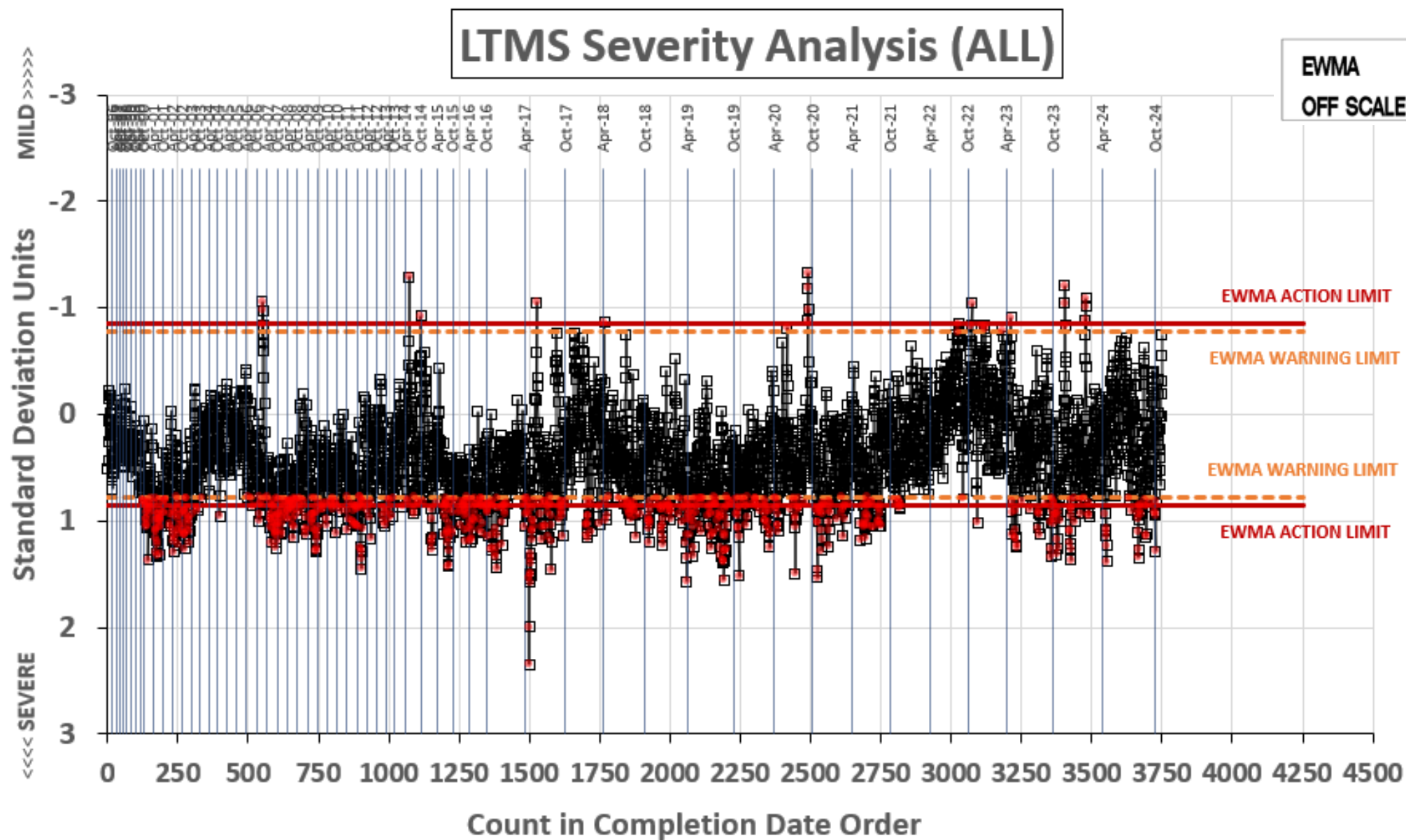
Test Monitoring Center
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ALL

D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

EVAPORATION LOSS, MASS%

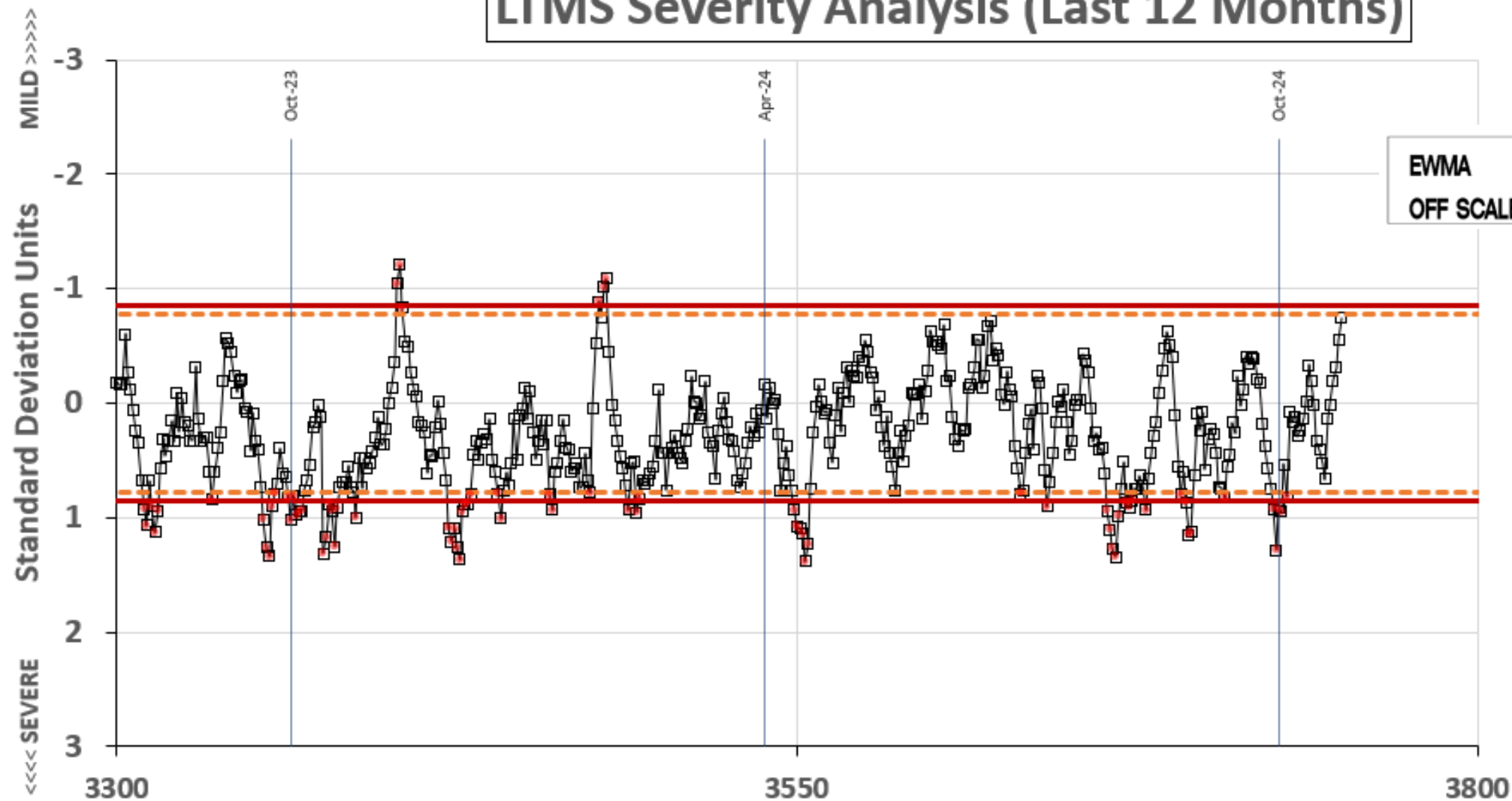


ALL

D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

EVAPORATION LOSS, MASS%

LTMS Severity Analysis (Last 12 Months)

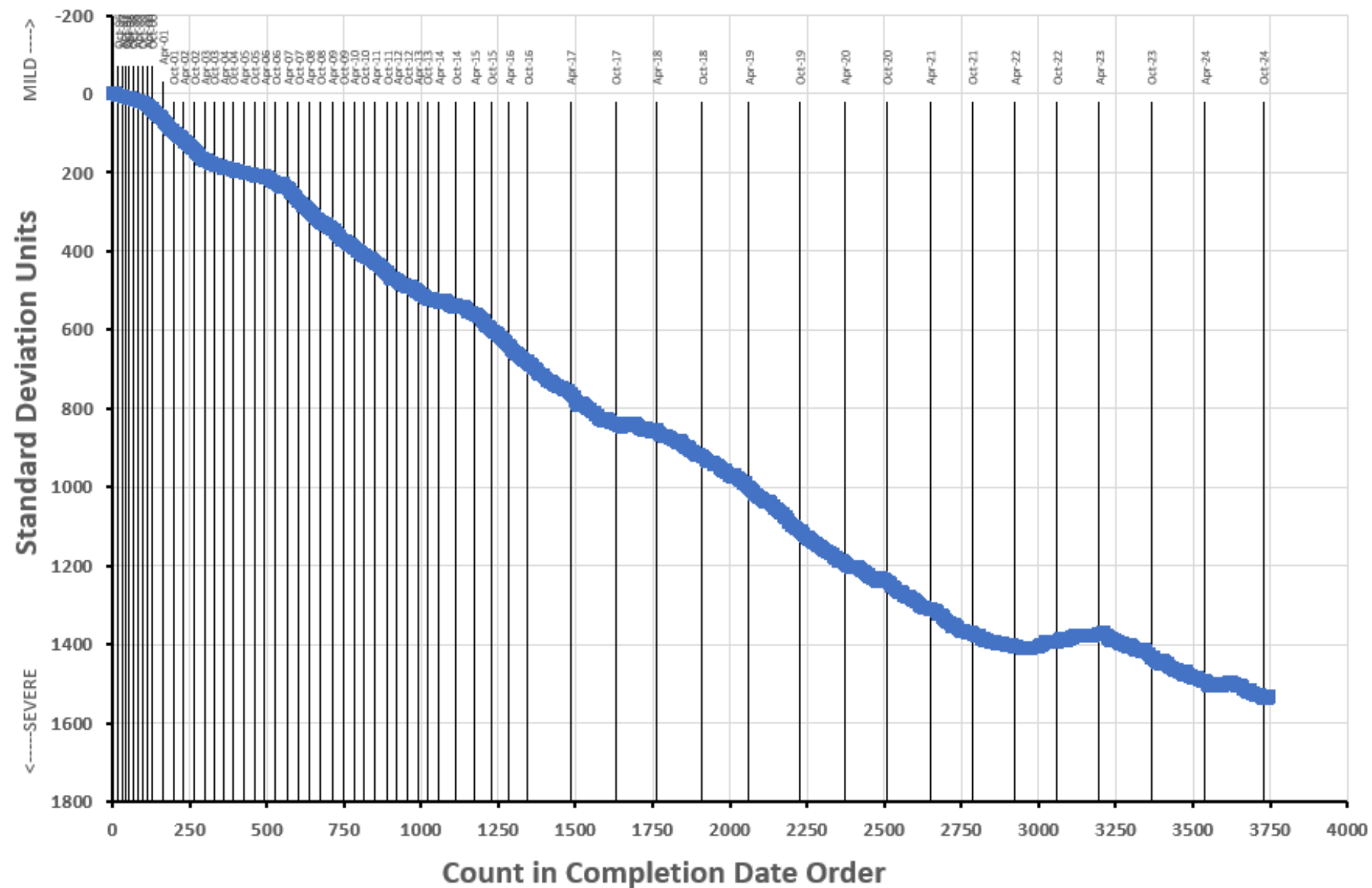


Count in Completion Date Order

ALL

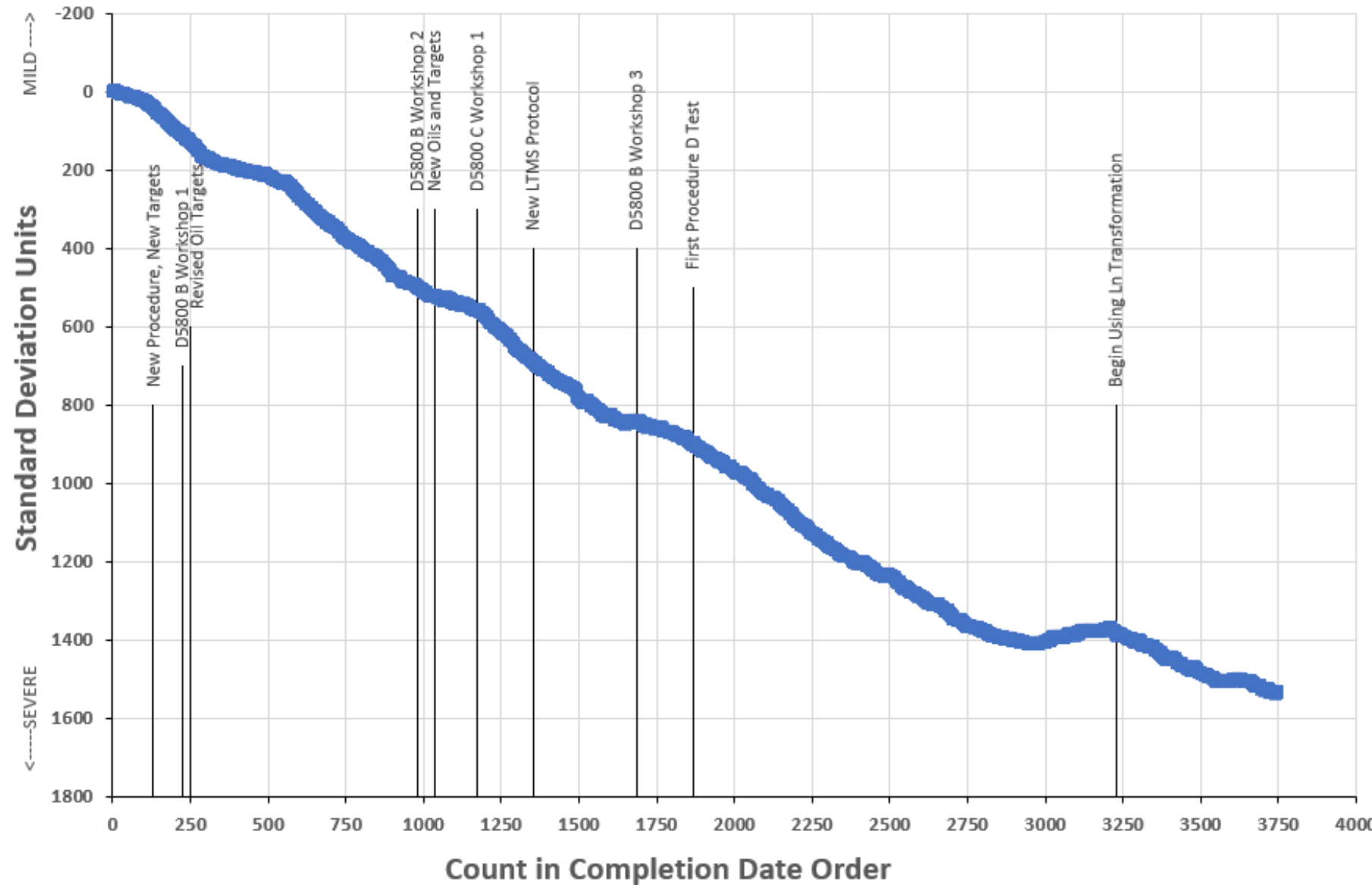
EVAPORATION LOSS, MASS%

CUSUM Severity Analysis



ALL

EVAPORATION LOSS, MASS%

CUSUM Severity Analysis

D5800: Evaporation Loss of Lubricating Oil by Noack Method and Rig Model

Performance Comparison
Sample Evaporation Loss, Mass %

Procedure	n	df	Pooled s	Mean Δ/s
Procedure B (NCK2, NCK25G)	103	100	0.0399	0.96
Procedure D (NS2)	86	83	0.0373	-0.64

Model	n	df	Pooled s	Mean Δ/s
NCK2 (B)	6	3	0.0191	-0.04
NCK25G (B)	97	94	0.0392	1.02
NS2 (D)	86	83	0.0373	-0.64

1 (+0) Procedure B NCK2 Rig
23 (+1) Procedure B NCK25G Rigs
15 (+1) Procedure D NS2 Rigs

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D5800: Evaporation Loss of Lubricating Oil by Noack Method: Industry Procedure B

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	101
Failed Calibration Test	OC	2
Total		103

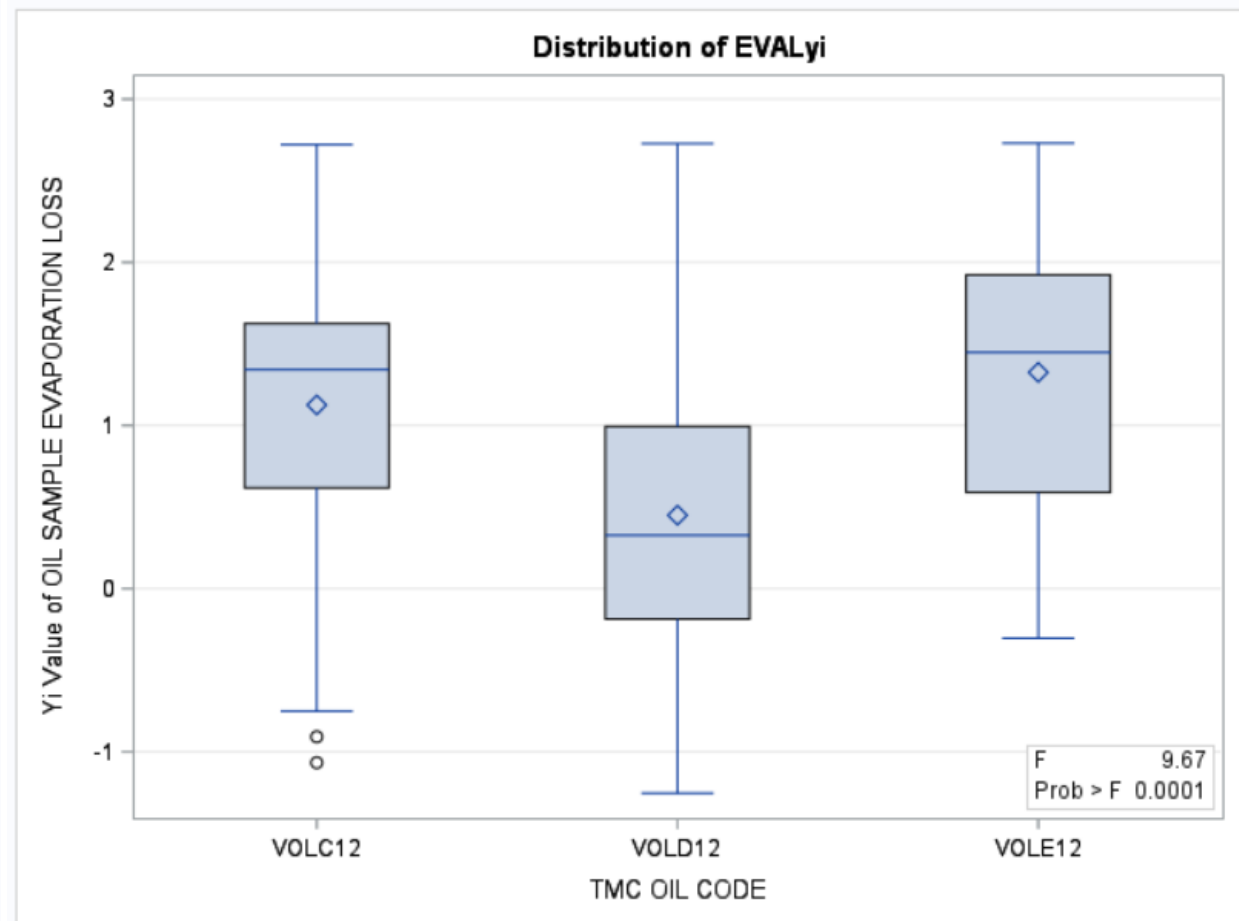
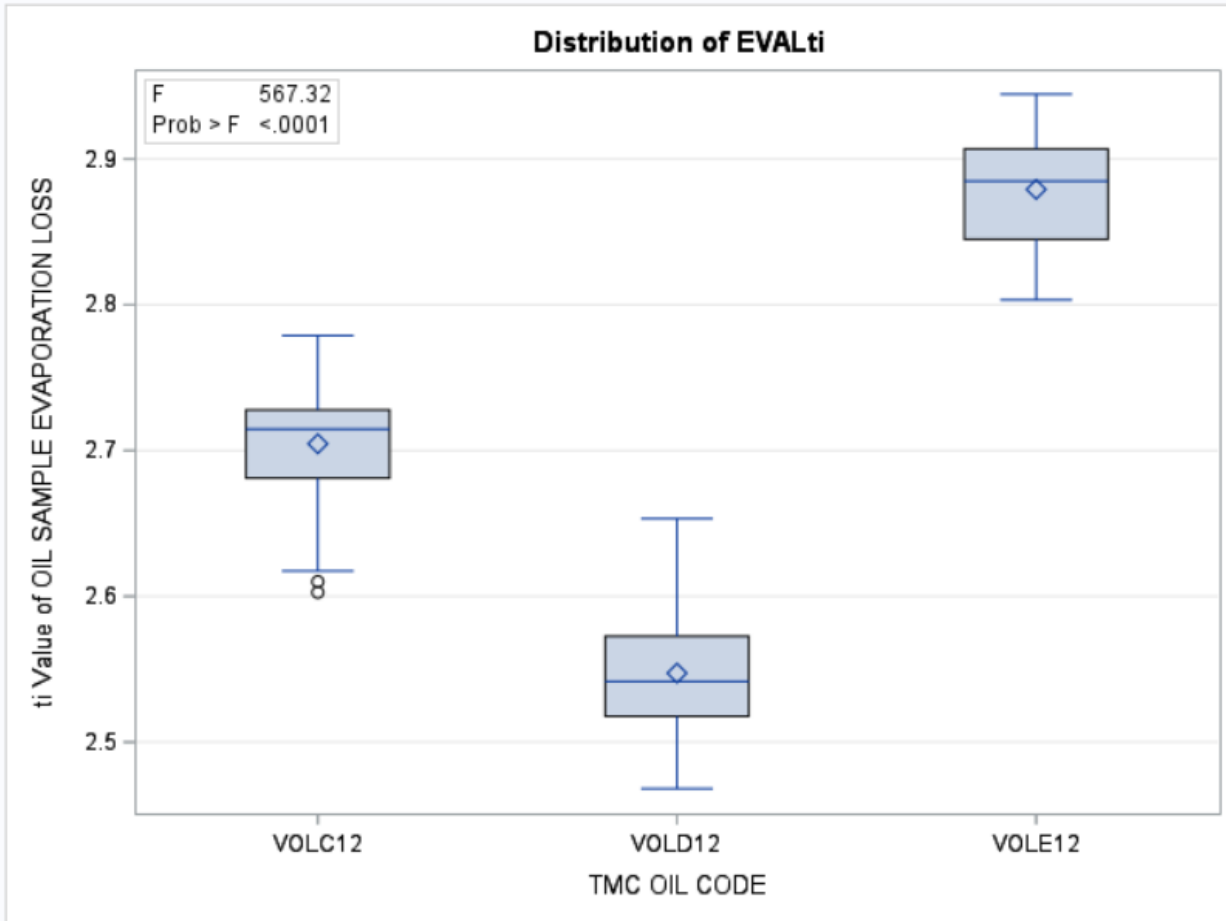
Number of Labs Reporting Data: 10
Fail Rate of Operationally Valid Tests: 1.94%

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Procedure B: APR2024 – SEP2024 Results



April 1, 2024 – September 30, 2024

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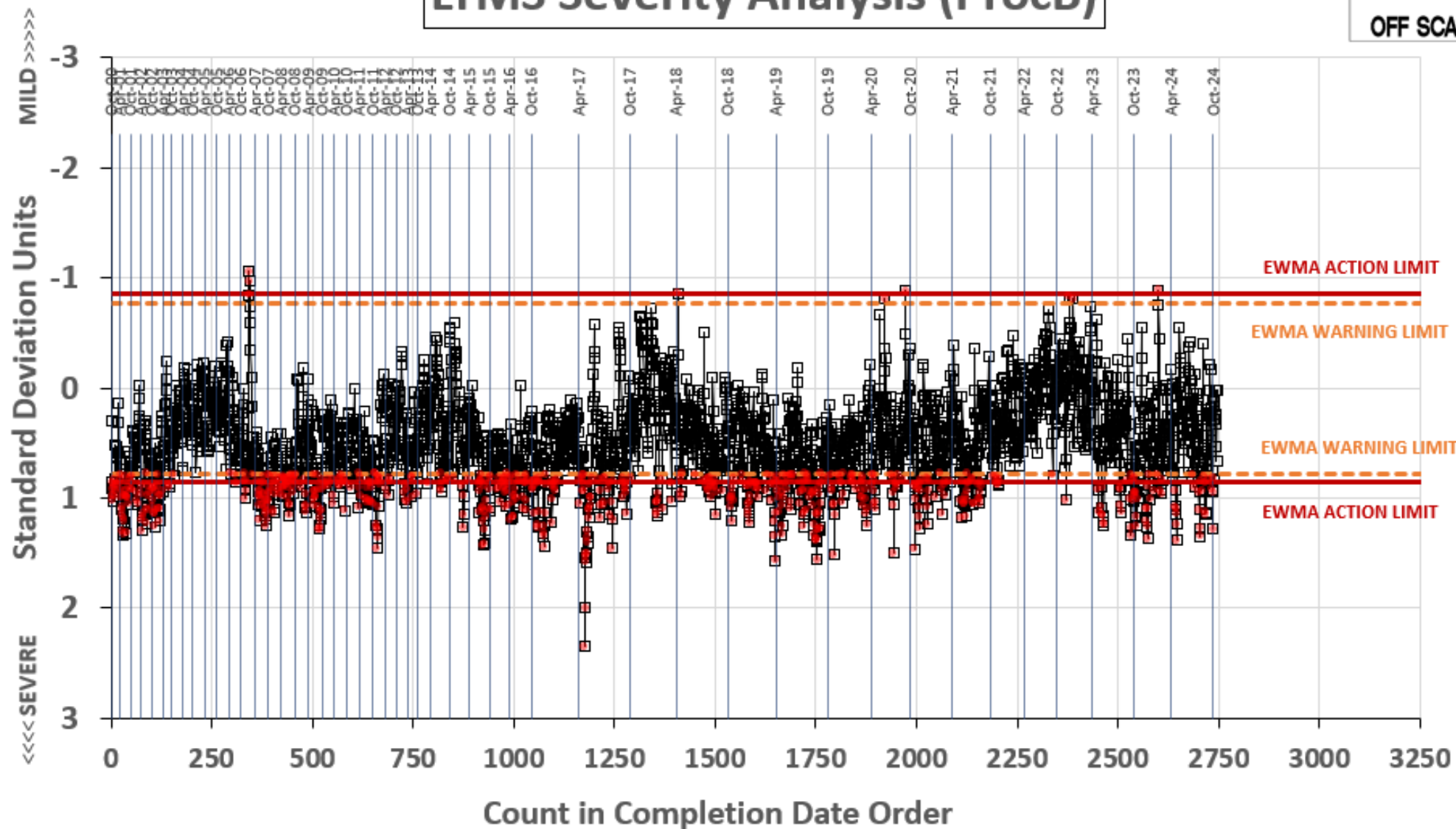
B only

D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
PROCEDURE B ONLY
EVAPORATION LOSS, MASS%



LTMS Severity Analysis (ProcB)

EWMA
OFF SCALE

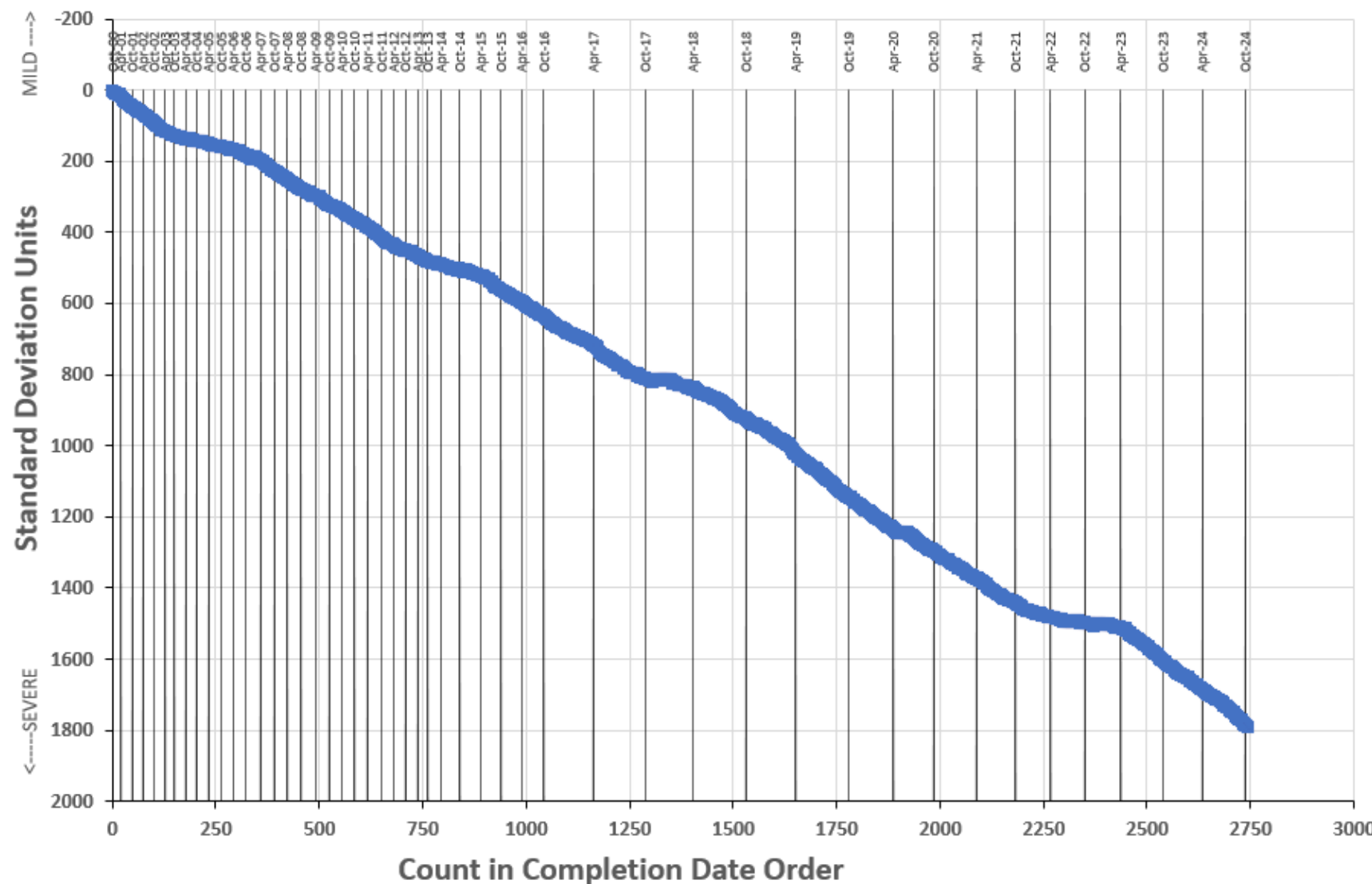


B only

**D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
PROCEDURE B ONLY
EVAPORATION LOSS, MASS%**



Procedure B CUSUM Severity Analysis



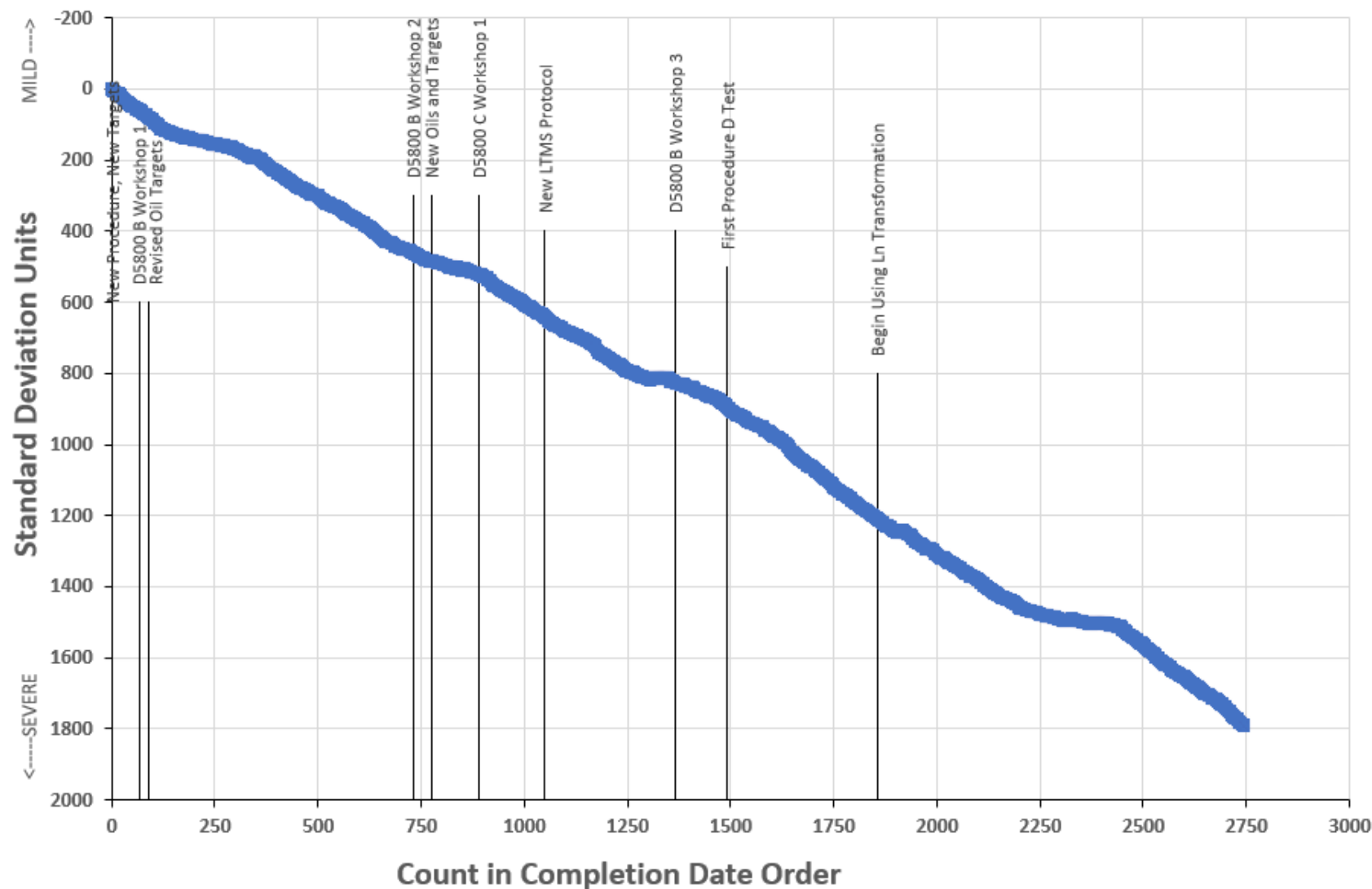
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B only

**D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
PROCEDURE B ONLY
EVAPORATION LOSS, MASS%**



Procedure B CUSUM Severity Analysis



D5800: Evaporation Loss of Lubricating Oil by Noack Method: Industry Procedure D (NS2)

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	84
Failed Calibration Test	OC	2
Total		86

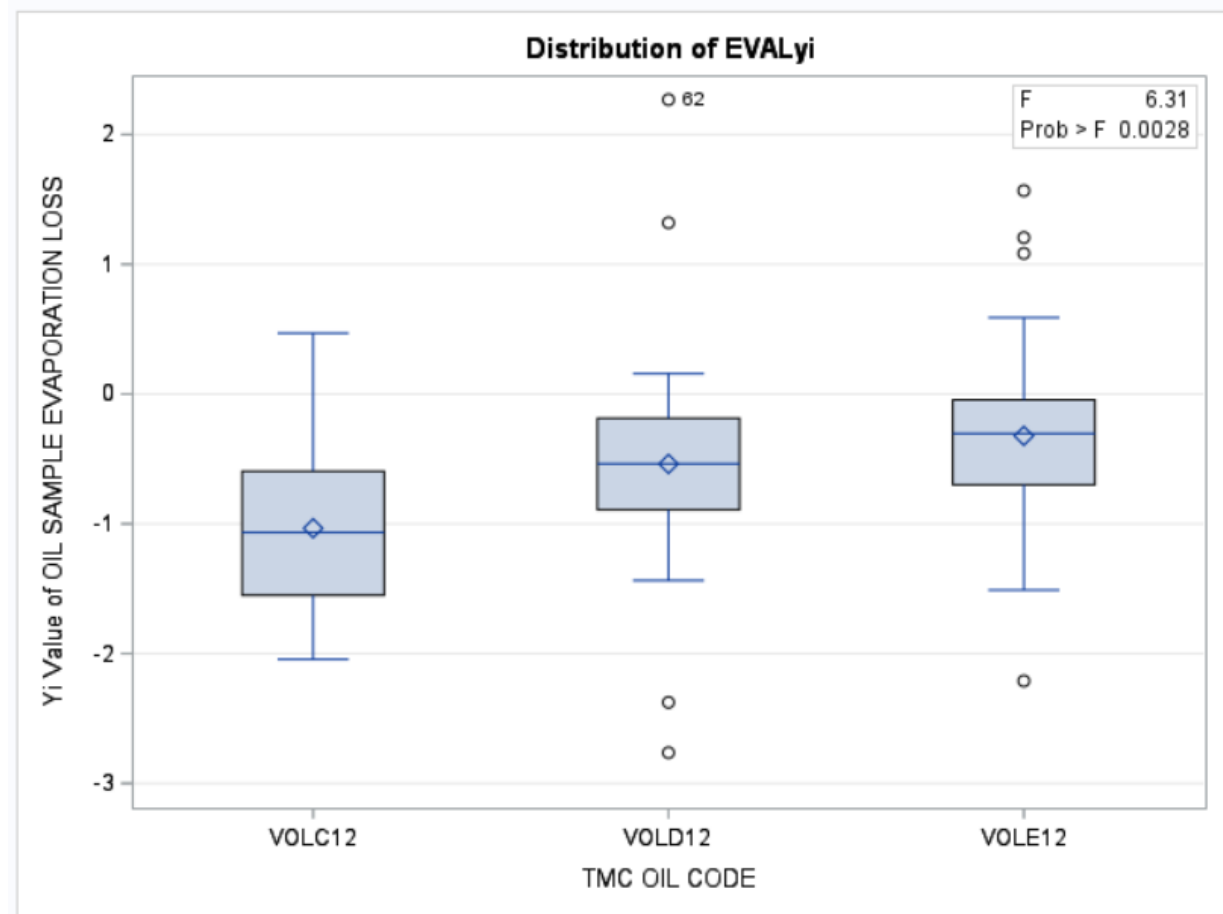
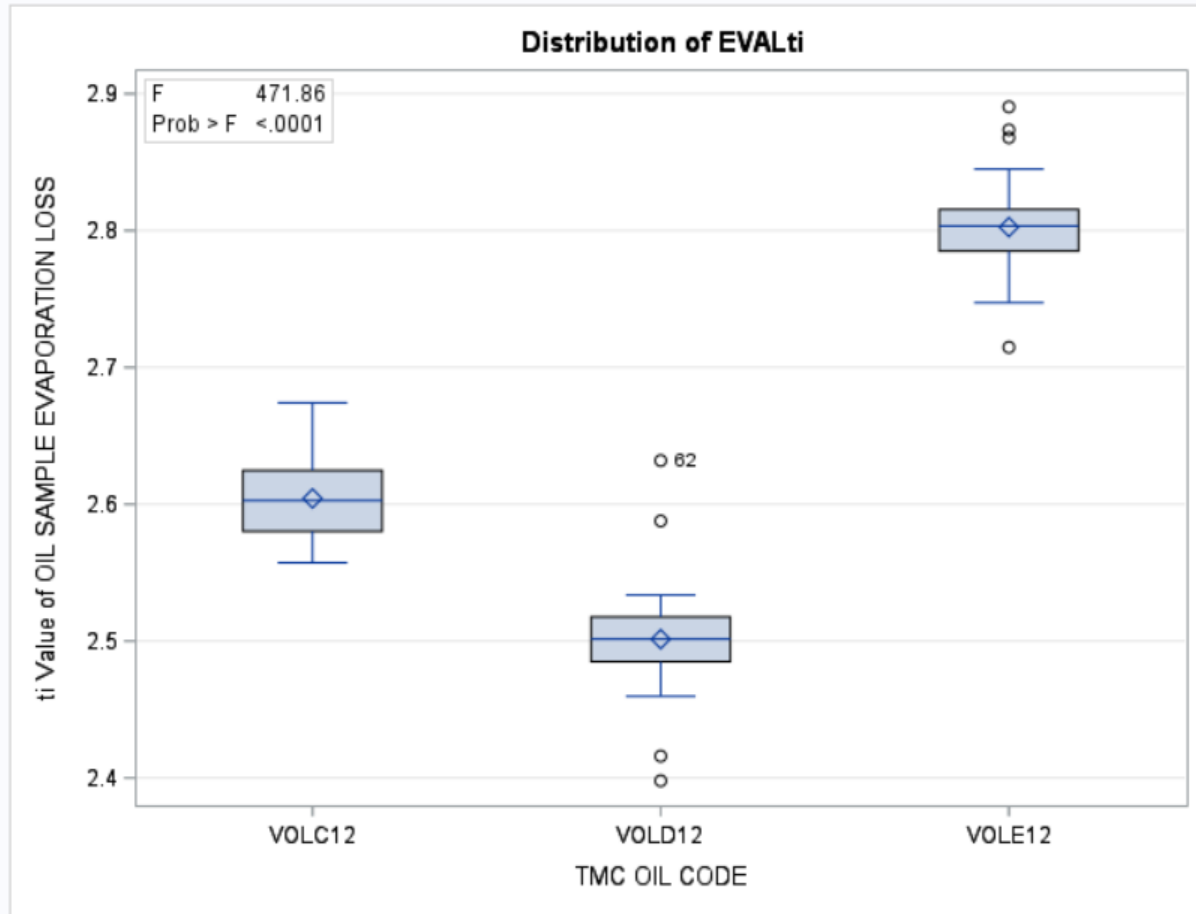
Number of Labs Reporting Data: 6
Fail Rate of Operationally Valid Tests: 2.32%

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Procedure D (NS2): APR2024 – SEP2024 Results



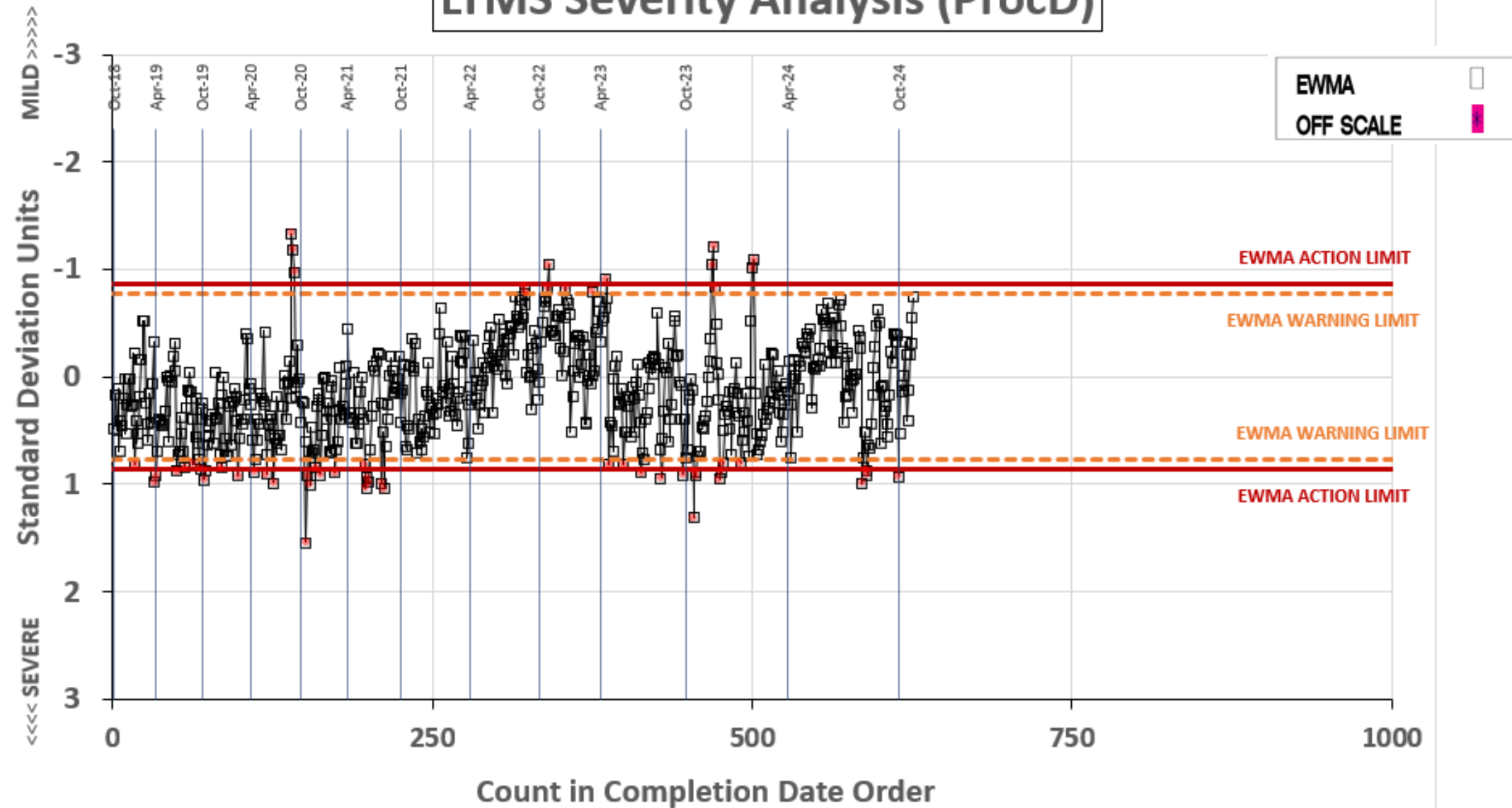
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D only
(NS2)Procedure D Only
EVAPORATION LOSS, MASS%

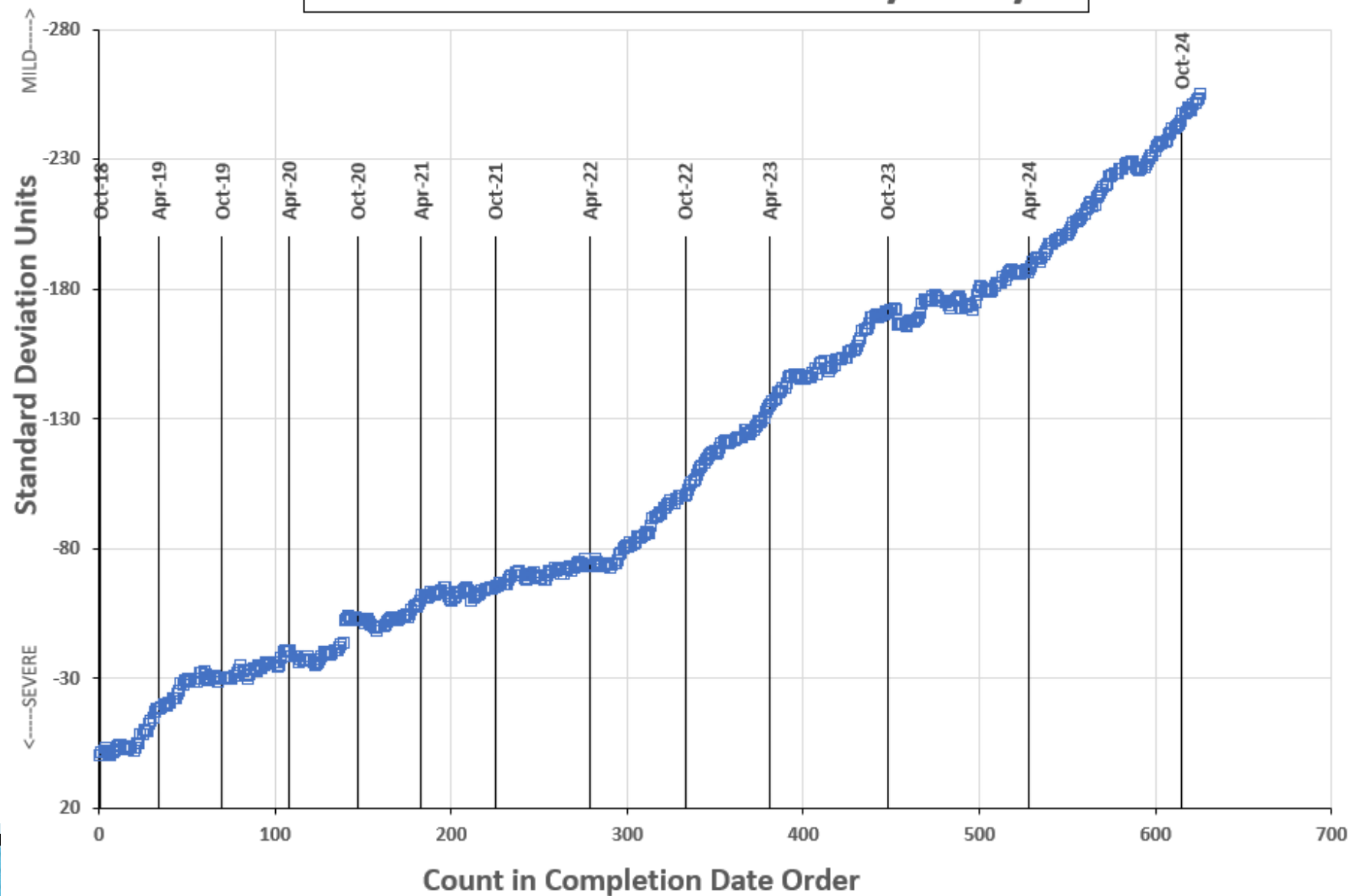
LTMS Severity Analysis (ProcD)



D only
(NS2)

Procedure D Only
EVAPORATION LOSS, MASS%

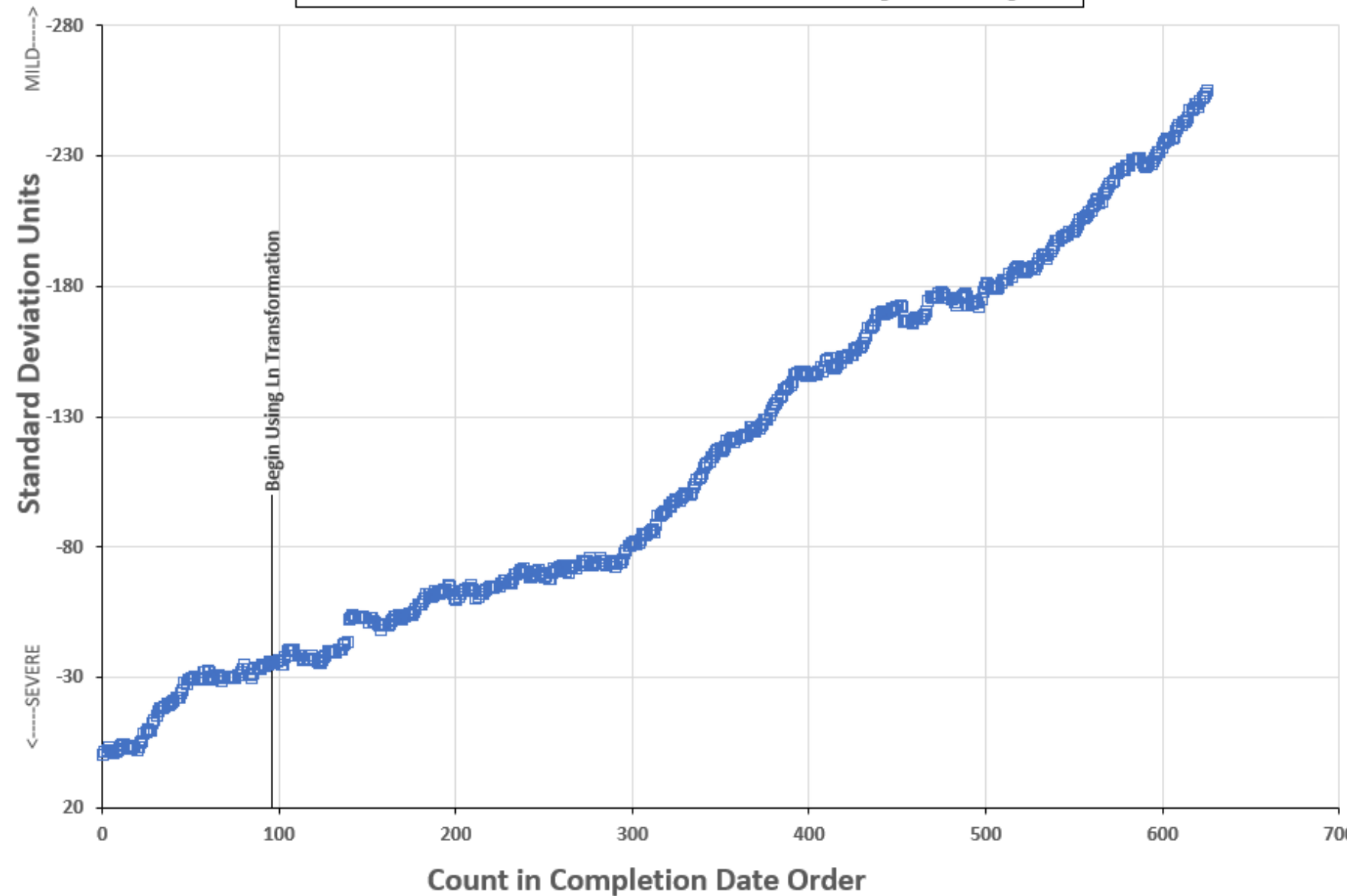
Procedure D CUSUM Severity Analysis



D only
(NS2)

Procedure D Only
EVAPORATION LOSS, MASS%

Procedure D CUSUM Severity Analysis



D5800: Evaporation Loss of Lubricating Oil by Noack Method: Industry Model NCK2

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	6
Failed Calibration Test	OC	0
Total		6

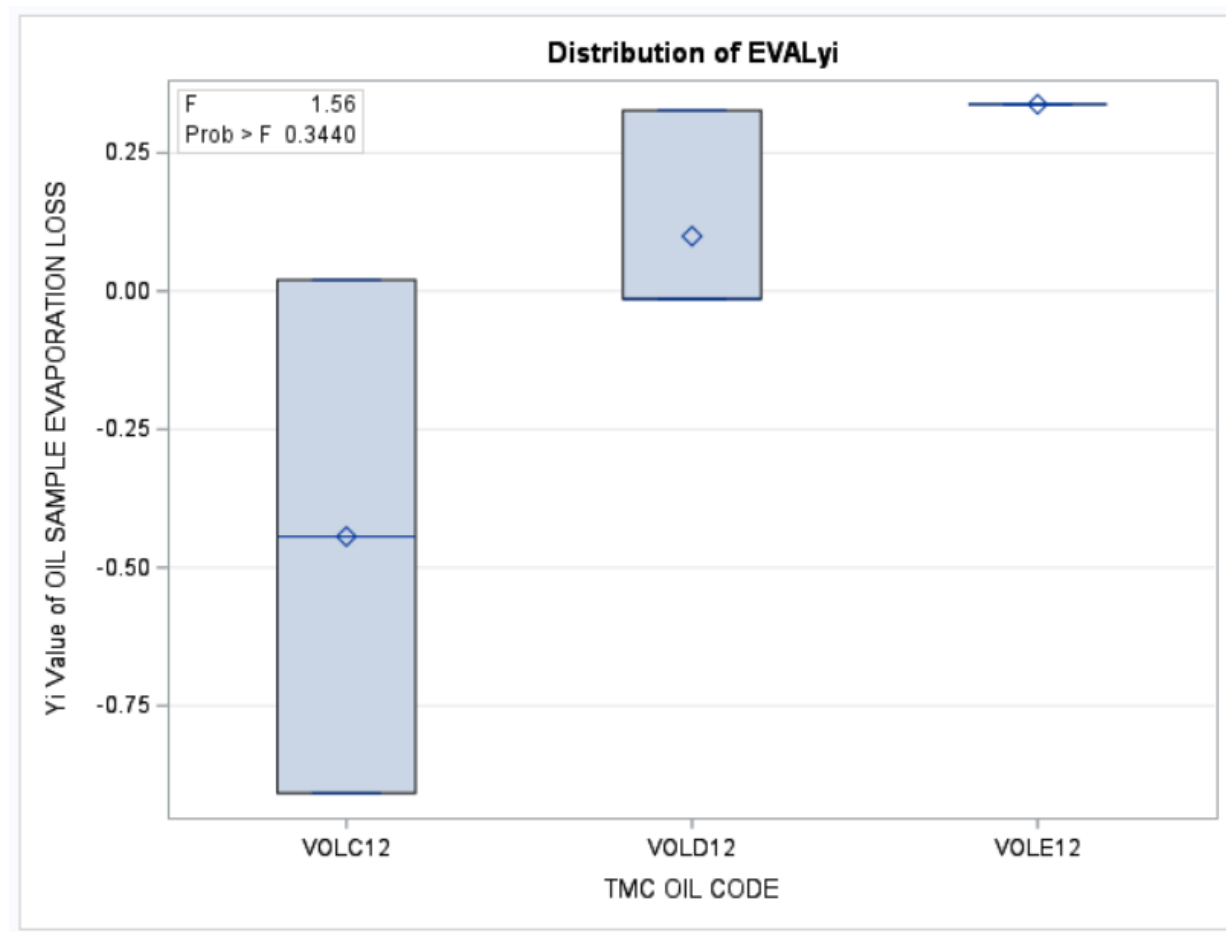
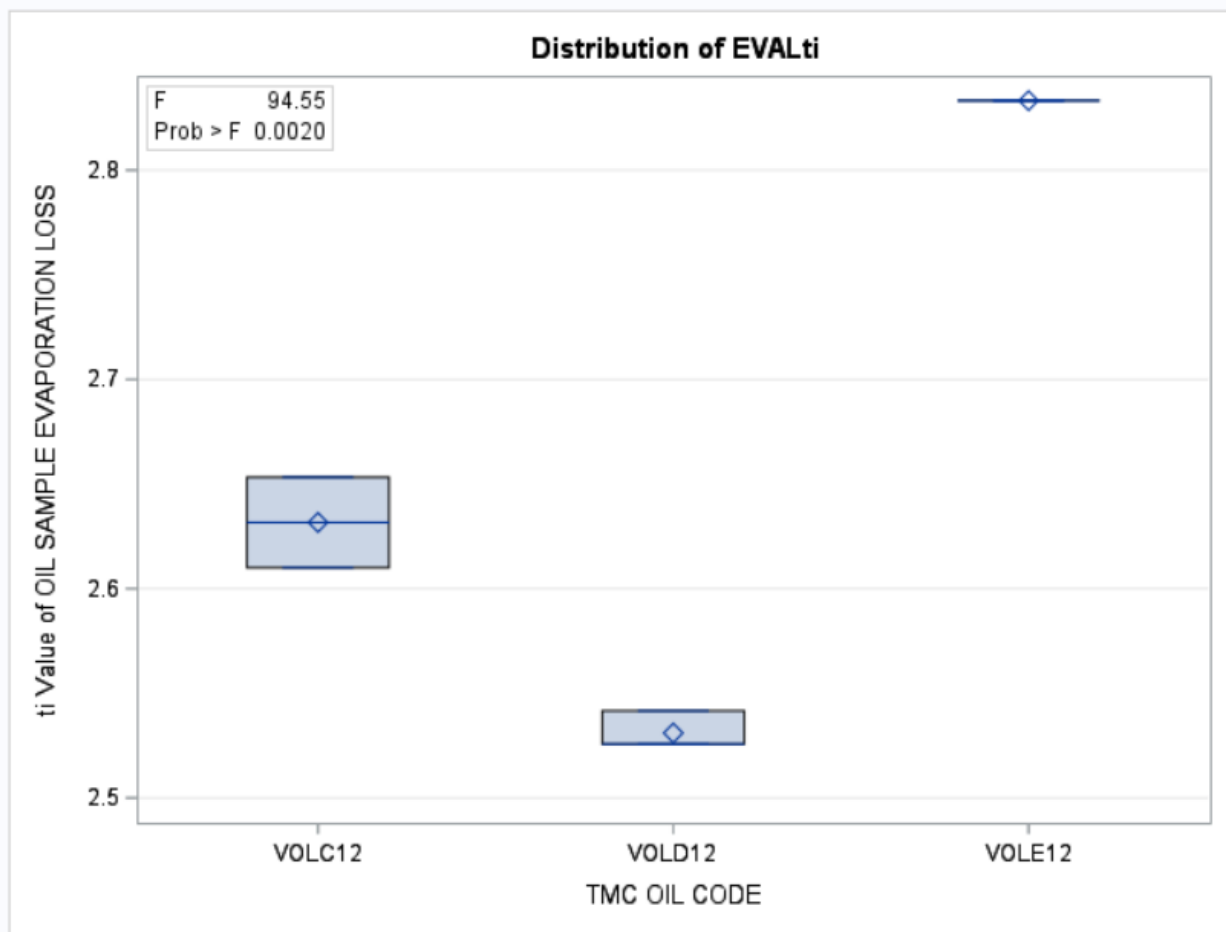
Number of Labs Reporting Data: 1
Fail Rate of Operationally Valid Tests: 0.0 %

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MODEL NCK2: APR2024 – SEP2024 Results



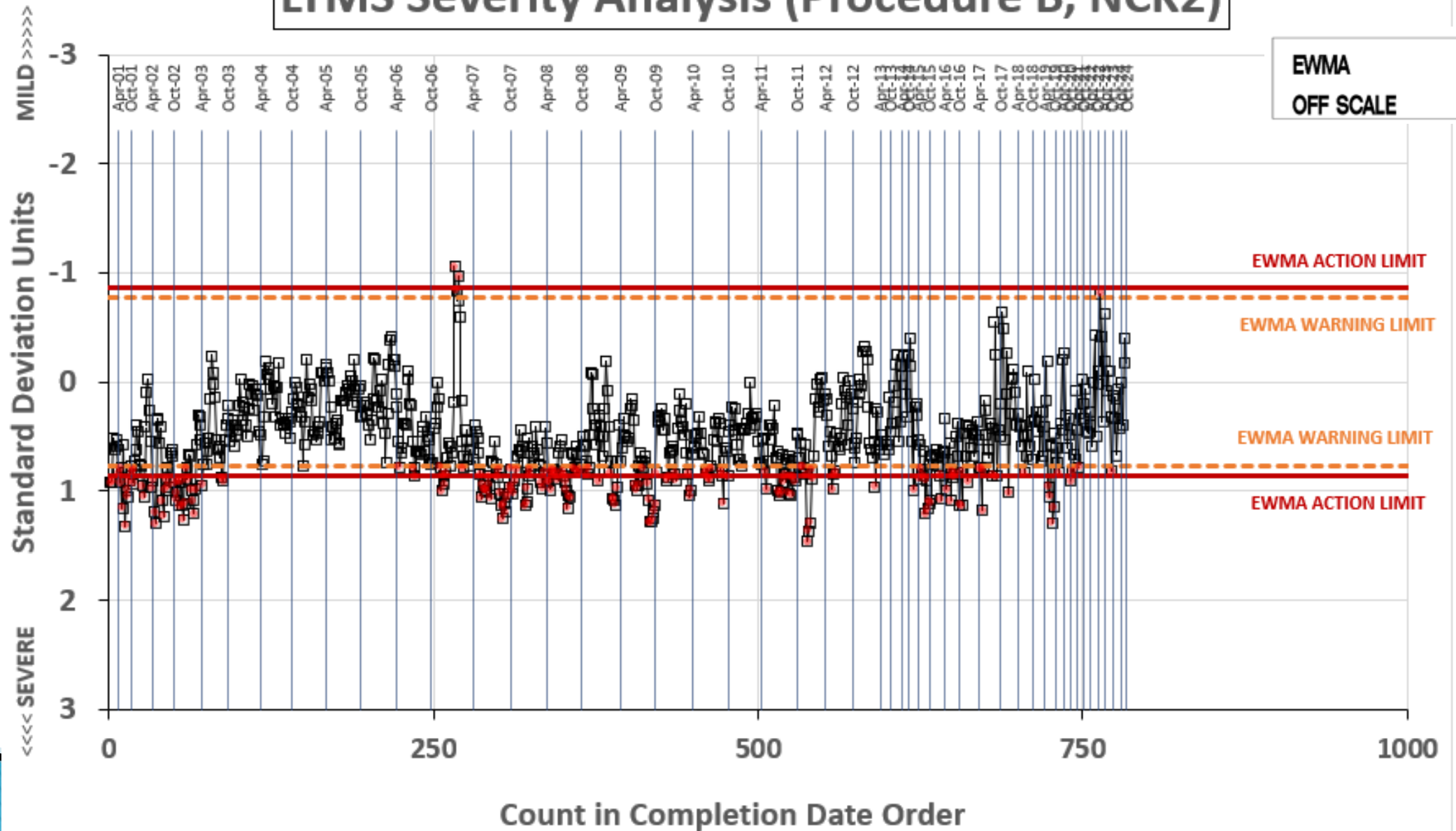
April 1, 2024 – September 30, 2024

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NCK2
only

LTMS Severity Analysis (Procedure B, NCK2)

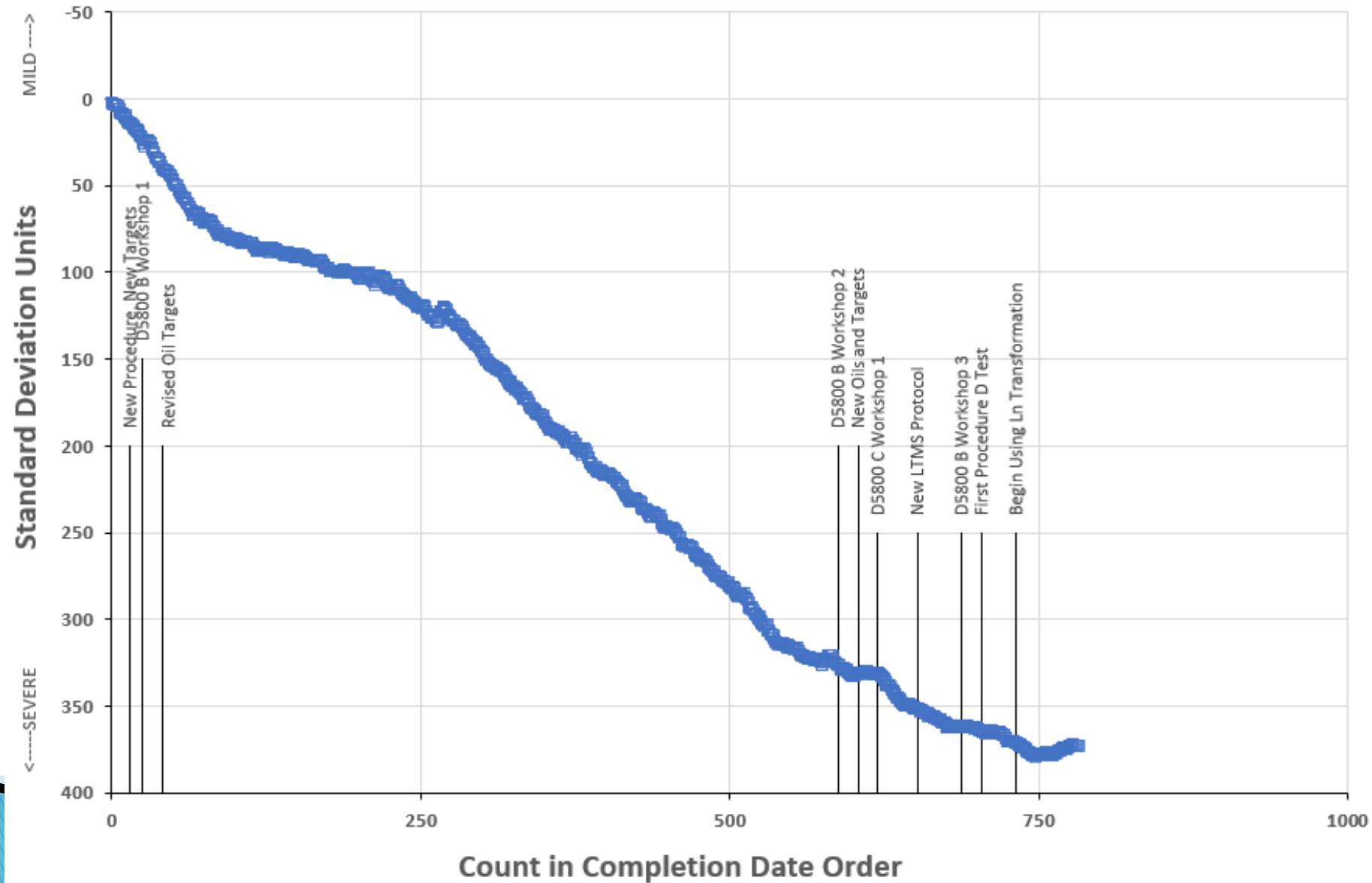


MODEL NCK2 ONLY
EVAPORATION LOSS, MASS%

The graph displays the distribution of COVID-19 cases based on their completion date order. The x-axis represents the 'Count in Completion Date Order' from 0 to 1000. The y-axis represents 'Standard Deviation Units' from -50 to 400, with 'MILD' cases at the top and 'SEVERE' cases at the bottom. The data points are blue circles connected by a blue line. The distribution is roughly bell-shaped, peaking around count 250. The y-axis is labeled 'MILD' at the top and 'SEVERE' at the bottom.

NCK2
only

Procedure B (NCK2) CUSUM Severity Analysis



D5800: Evaporation Loss of Lubricating Oil by Noack Method: Industry Model NCK25G

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	95
Failed Calibration Test	OC	2
Total		97

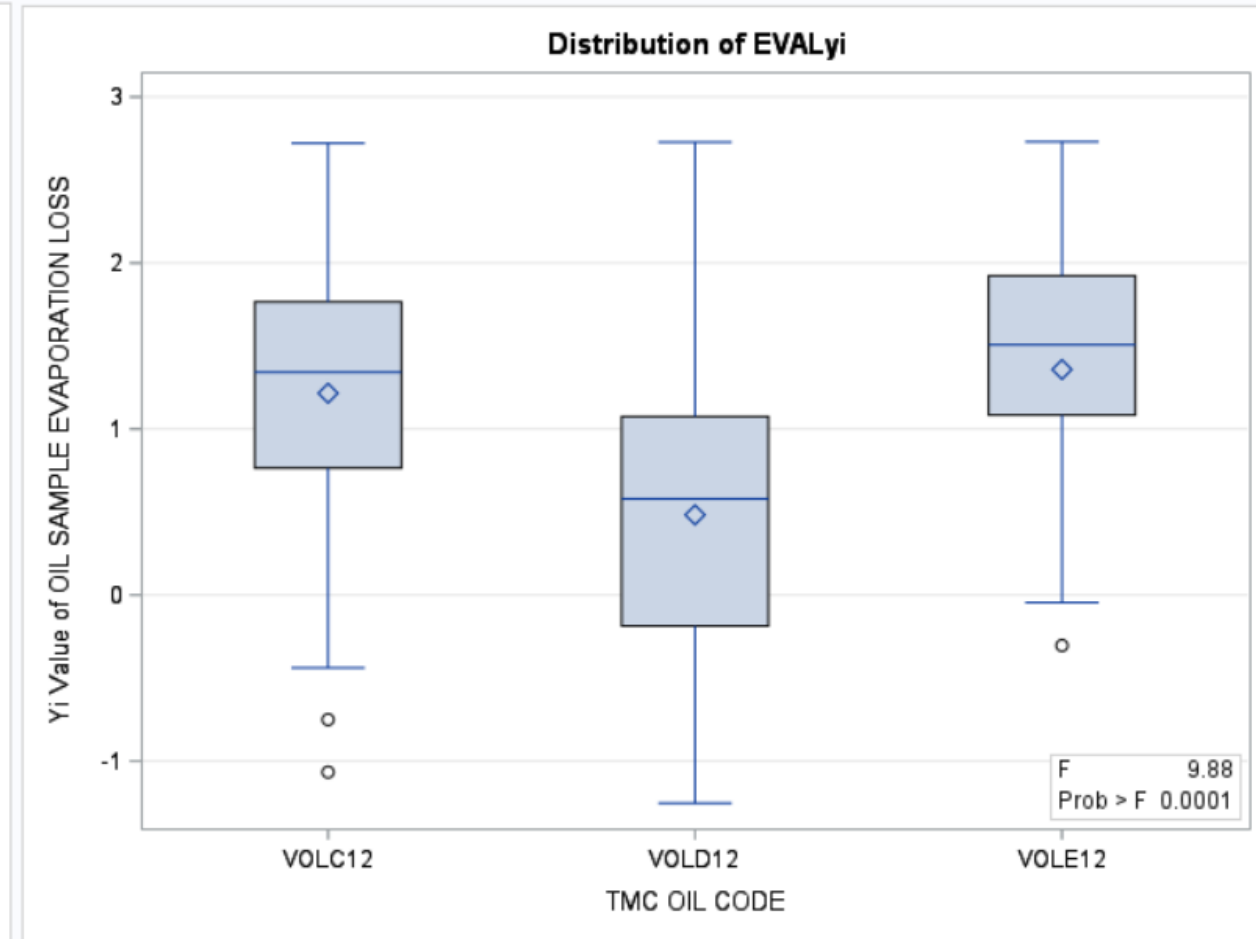
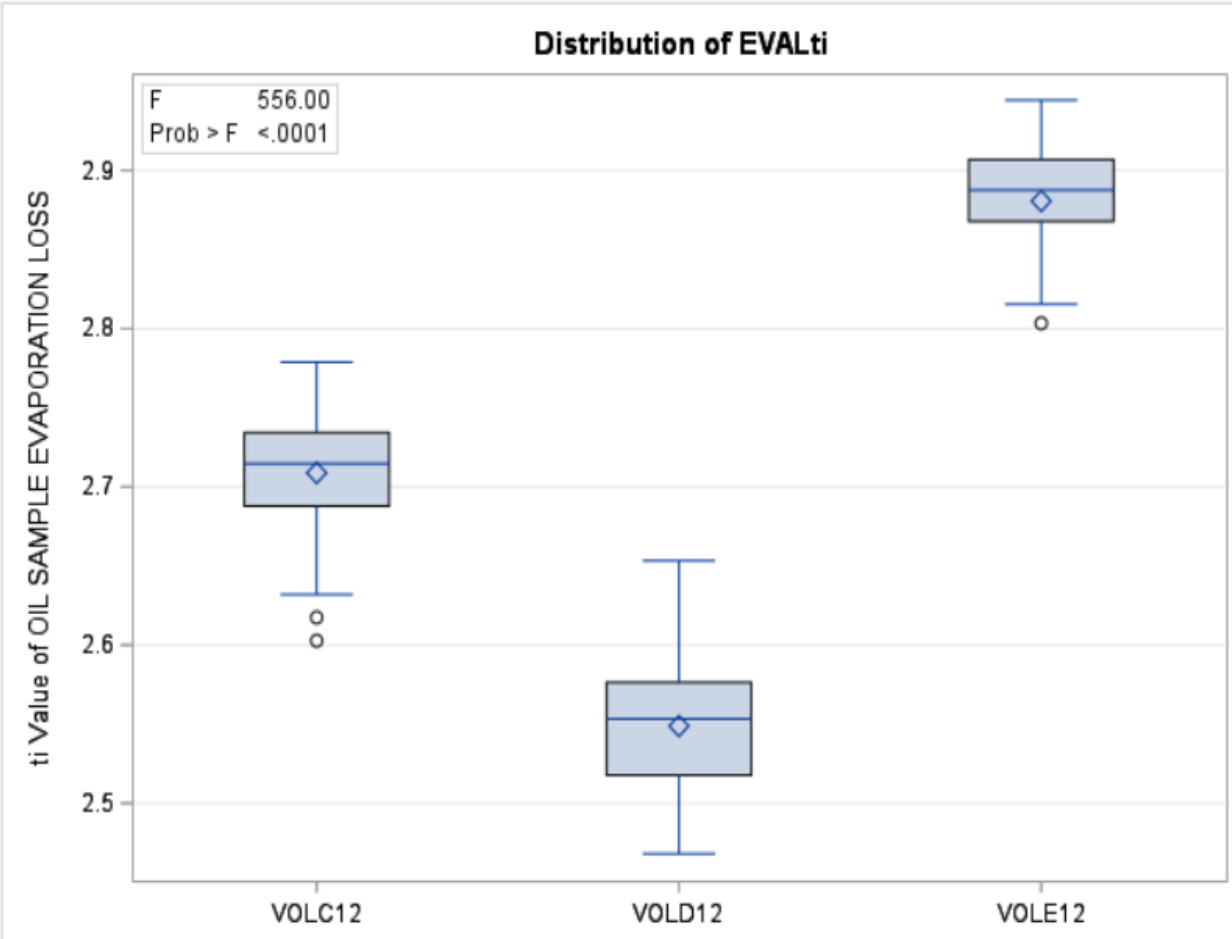
Number of Labs Reporting Data: 10
Fail Rate of Operationally Valid Tests: 2.06%

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MODEL NCK25G: APR2024 – SEP2024 Results



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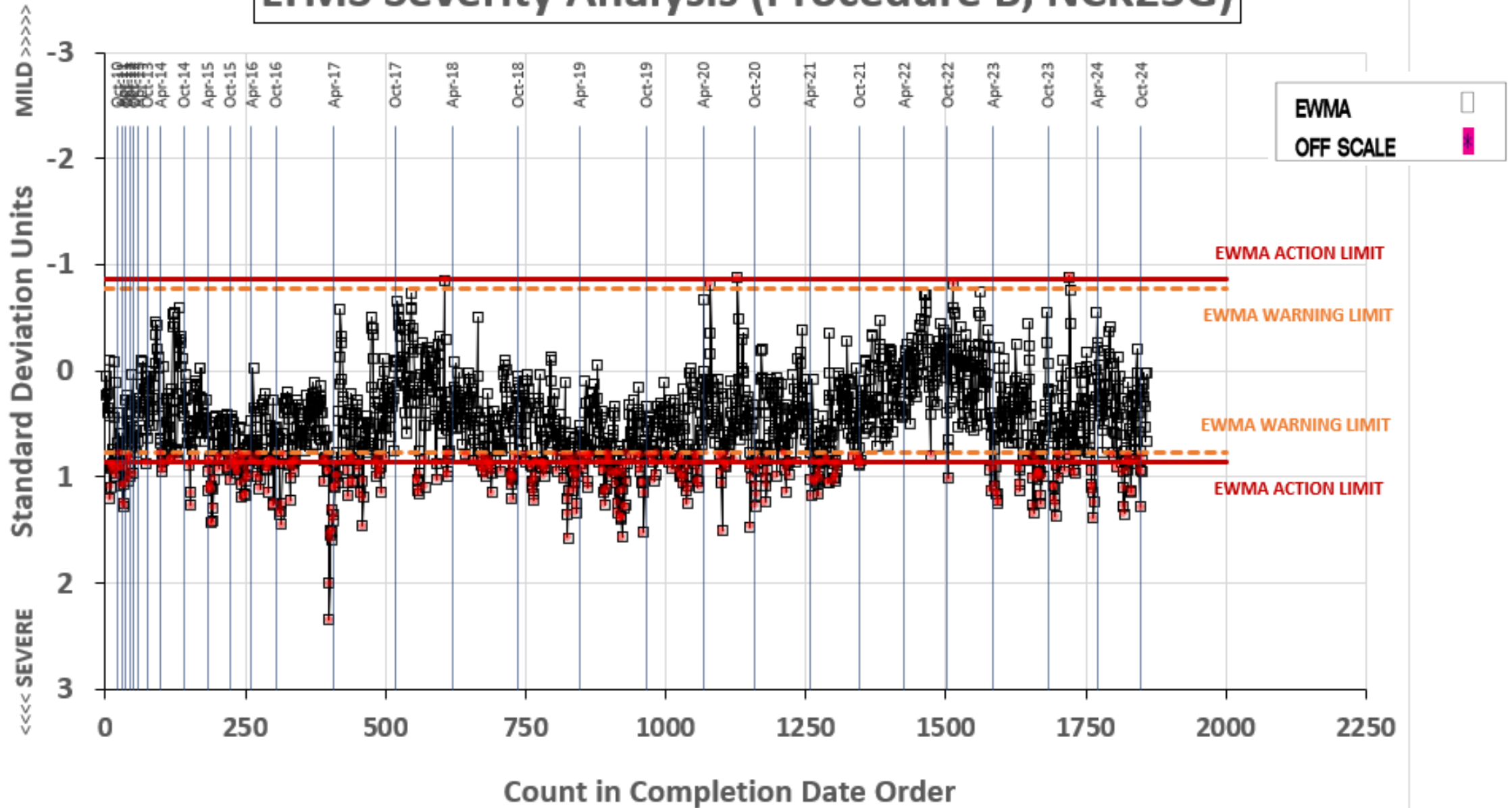
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NCK25G
only

MODEL NCK25G ONLY
EVAPORATION LOSS, MASS%

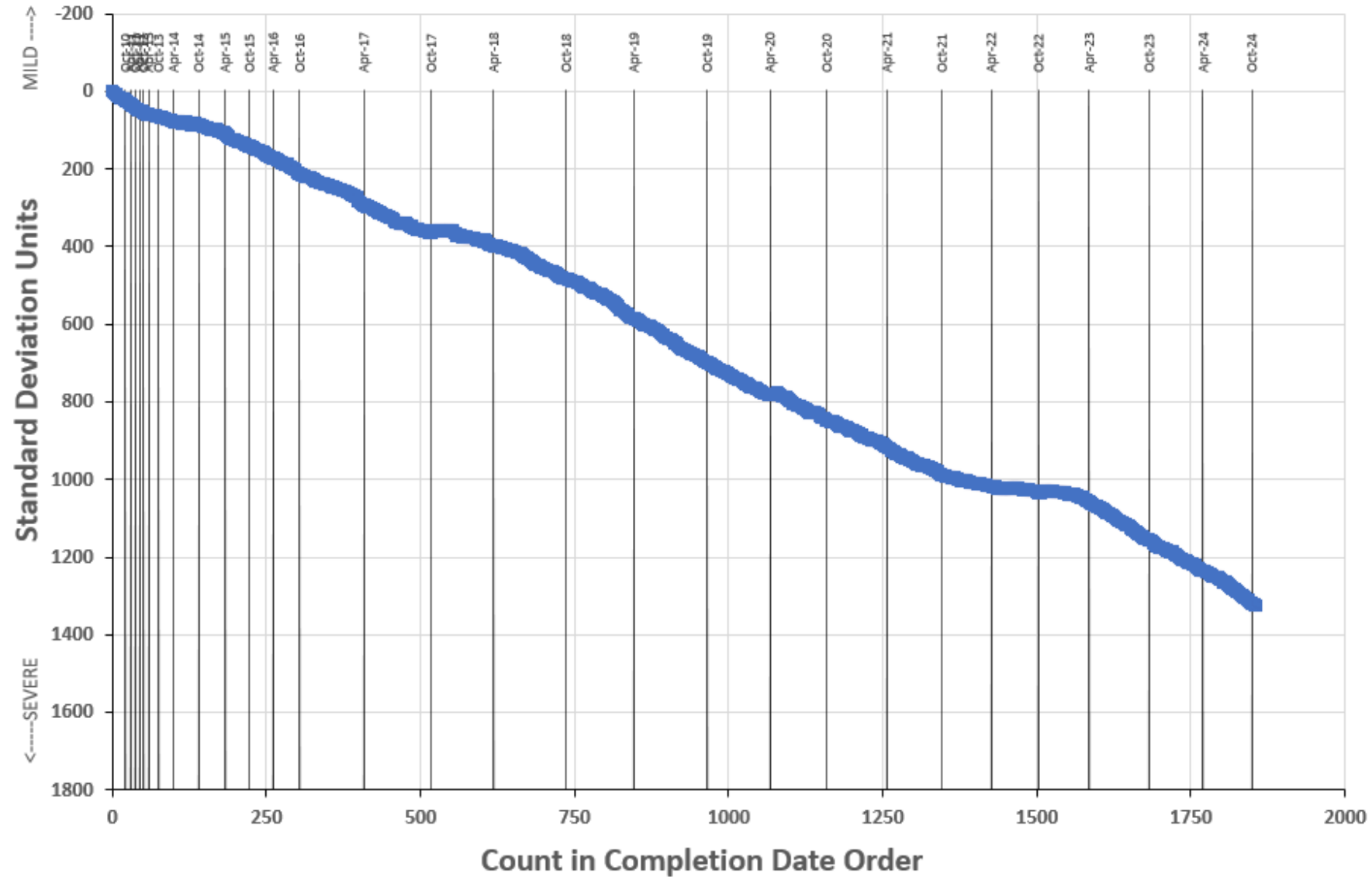
LTMS Severity Analysis (Procedure B, NCK25G)



NCK25G
only

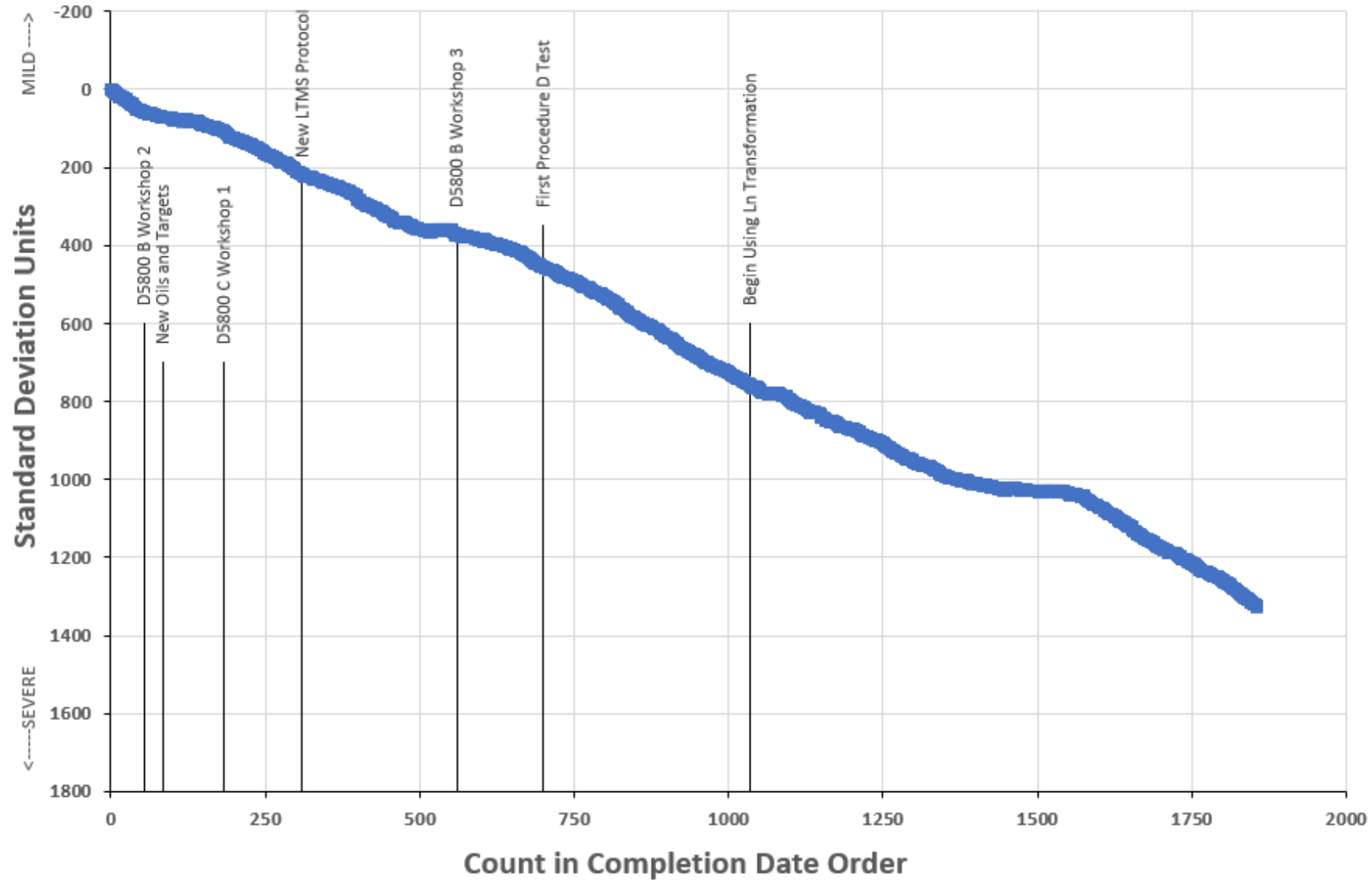
MODEL NCK25G ONLY
EVAPORATION LOSS, MASS%

Procedure B (NCK25G) CUSUM Severity Analysis



NCK25G
only

Procedure B (NCK25G) CUSUM Severity Analysis



Reference Oil Inventory

D5800

Oil	Year Rec'd By TMC ⁴	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
VOLC12	2013	D5800	18.7	1.5	5+ years
VOLD12	2013	D5800	16.8	1.4	5+ years
VOLE12	2013	D5800	14.5	1.5	5+ years
VOLD18	2018	D5800QC	562	52	5+ years

⁴ Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

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D5800: Evaporation Loss of Lubricating Oil by Noack Method: Semester Summary

Precision (Pooled s) improved moving (again) slightly towards target this semester.

Performance (Mean Δ/s) continues to be severe at +0.23 s.

- Procedure B rigs continue to trend severe (+0.96 s) while Procedure D rigs continue to trend mild (-0.64 s).

The industry EWMA Control Chart had several Warning Alarms last semester, all of which were SEVERE warning alarms.

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D02.B0.07

TMC Monitored Tests



ASTM D 6082

High Temperature Foam

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6082	7 (+0)	9 (-2)
*Between 4/1/2024 and 9/30/2024		

D6082: High Temperature Foam

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	17
Failed Calibration Test	OC	1
Acceptable Discrimination Test	AS	6
Operationally Invalid, Reported as Valid	RC, RS	0
Operationally Invalid, Reported by Lab	LC, LS	0
Informational Run (Valid)	NN	2
Aborted Tests	XC, XS	0
Total		26

Number of Labs Reporting Data: 7
Fail Rate of Operationally Valid Calibration Tests: 5.6%

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D6082: High Temperature Foam

Statistically Unacceptable Tests (OC, OS)	No. Of Tests
Foam Tendency Mild	1
Foam Tendency Severe	0
Total	1

- All severe oil discrimination runs (on TMC oil 66) reported this period demonstrated acceptable discrimination.
 - Discrimination runs are not evaluated for overall period precision or severity due to poor test precision above 100 ml foam tendency.
- There was ONE statistically unacceptable calibration test this period.

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D6082: High Temperature Foam

Operationally Unacceptable Tests (RS, LC, LS, XC, XS)	No. Of Tests
Total	0

- There were ZERO operationally invalid results this report period.

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D6082: High Temperature Foam

Informational Runs (MN, NN)	No. Of Tests
Non-blind Informational run on-target and valid (NN)	2
Non-blind Informational run invalid (MN)	0
Total	0

- There were TWO Informational results this report period.

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D6082: High Temperature Foam

Period Precision and Severity Estimates

Foam Tendency, ml	n	df	Pooled s	Mean Δ/s
Targets updated 20201001 ¹	18	17	9	-----
4/1/20 through 9/30/20	13	11	8	-0.85
10/1/20 through 3/31/21	12	10	7	-0.48
4/1/21 through 9/30/21	14	13	7	-0.48
10/1/21 through 3/31/22	13	12	7	-0.57
4/1/22 through 9/30/22	15	14	4	-0.52
10/1/22 through 3/31/23	16	15	10	-0.69
4/1/23 through 9/30/23	14	13	4	-0.68
10/1/23 through 3/31/24	19	18	10	-0.62
4/1/24 through 9/30/24	18	17	13	-0.01

¹Target precision updated to current reference oil FOAMB18

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D6082: High Temperature Foam

Period Precision and Severity Estimates

Foam Stability @ 1 min, ml	n	Mean	s
Current Targets	18	0.00	0.00
4/1/20 through 9/30/20	13	No non-zero occurrences	
10/1/20 through 3/31/21	12	No non-zero occurrences	
4/1/21 through 9/30/21	14	No non-zero occurrences	
10/1/21 through 3/31/22	13	No non-zero occurrences	
4/1/22 through 9/30/22	15	No non-zero occurrences	
10/1/22 through 3/31/23	16	No non-zero occurrences	
4/1/23 through 9/30/23	14	No non-zero occurrences	
10/1/23 through 3/31/24	19	No non-zero occurrences	
4/1/24 through 9/30/24	18	No non-zero occurrences	

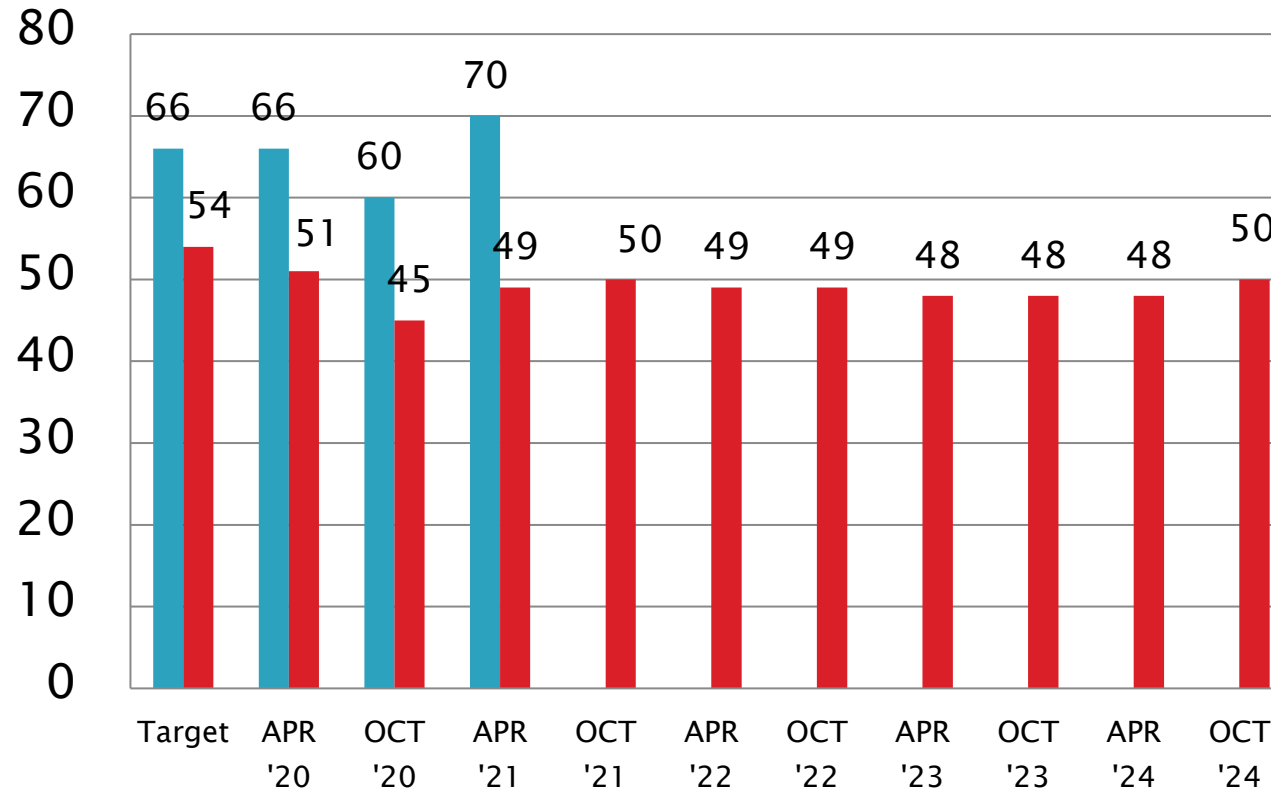
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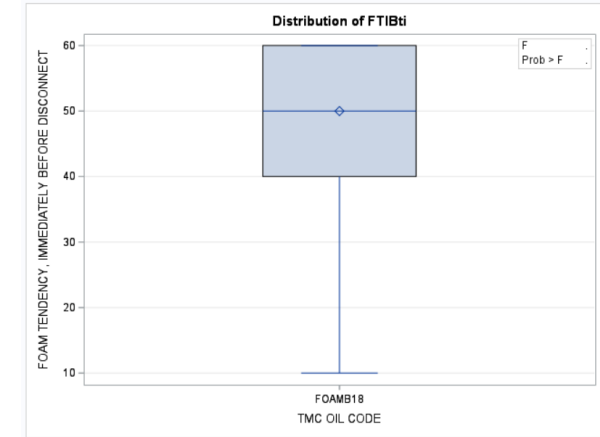


D6082 Performance by Oil

Foam Tendency, ml
Mean



Oil 1007
Oil FOAMB18



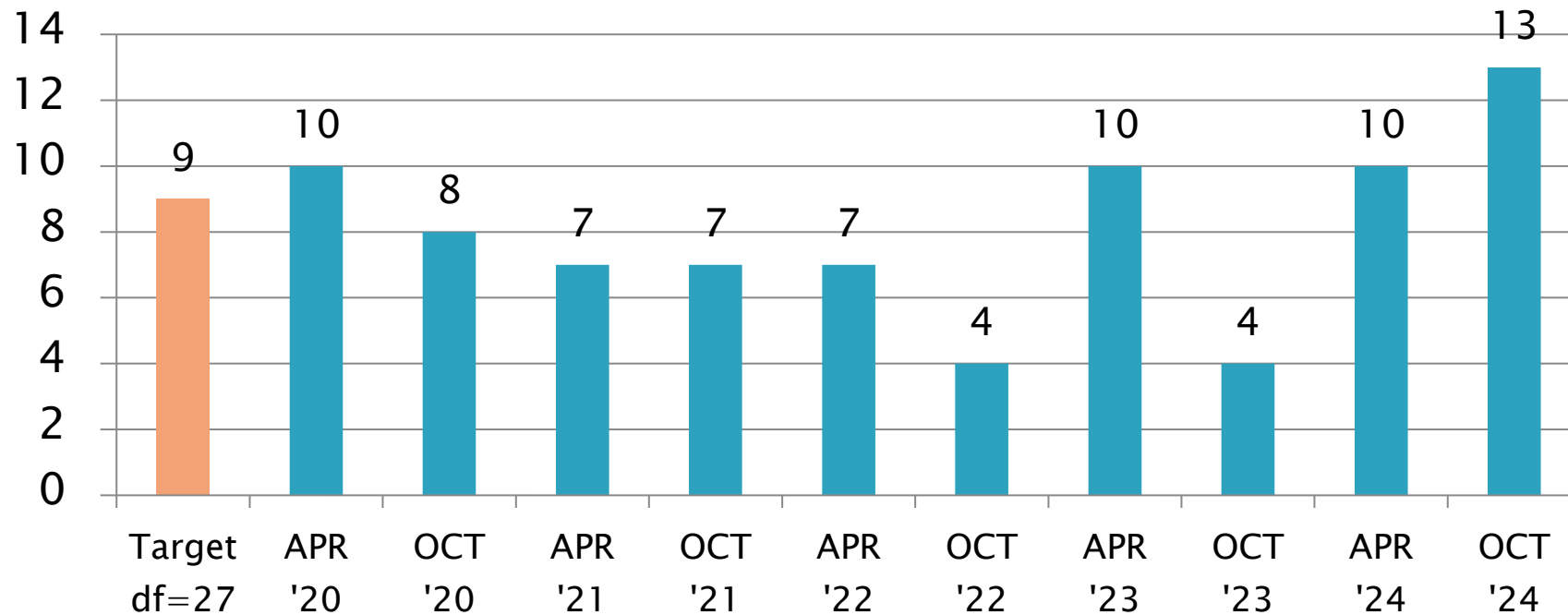
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D6082: High Temperature Foam

Foam Tendency, ml
Pooled s



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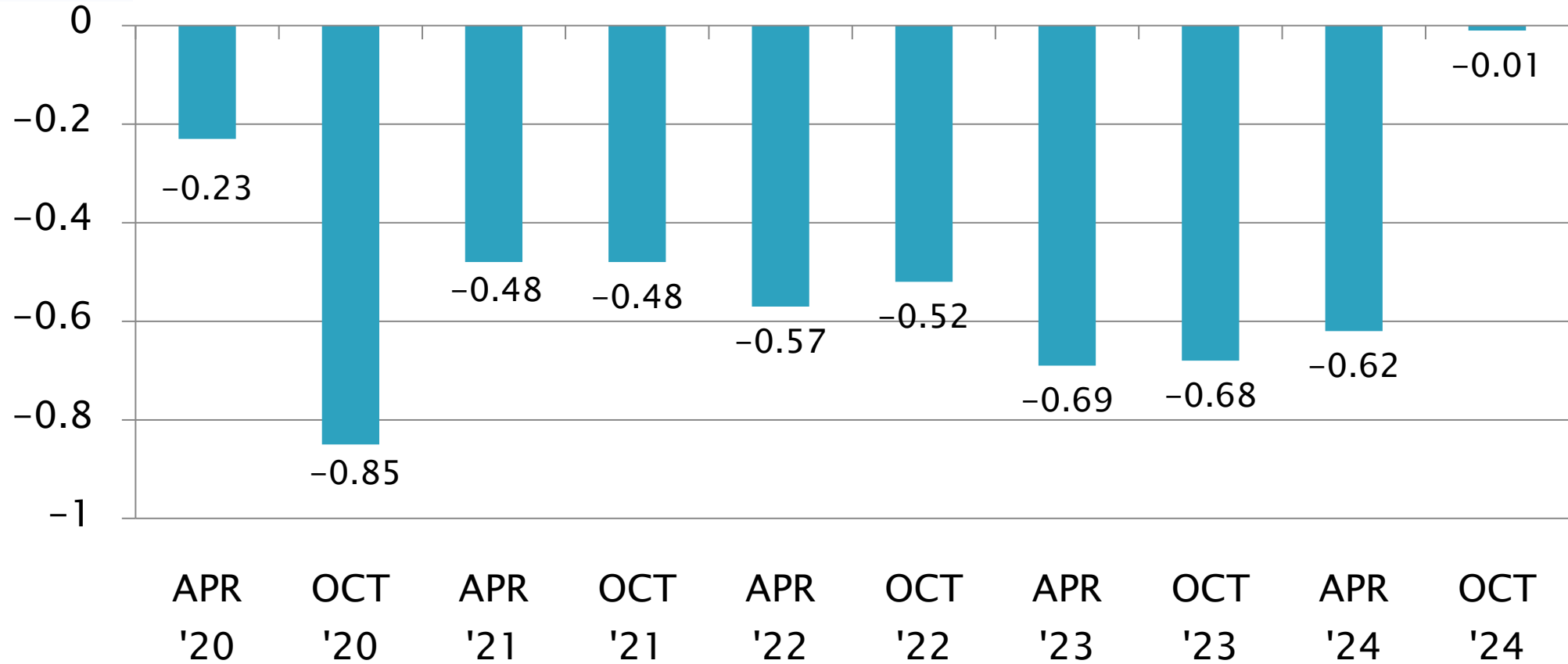
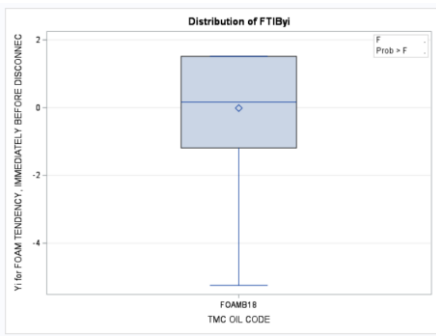
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D6082: High Temperature Foam

Foam Tendency, ml
Mean Δ/s



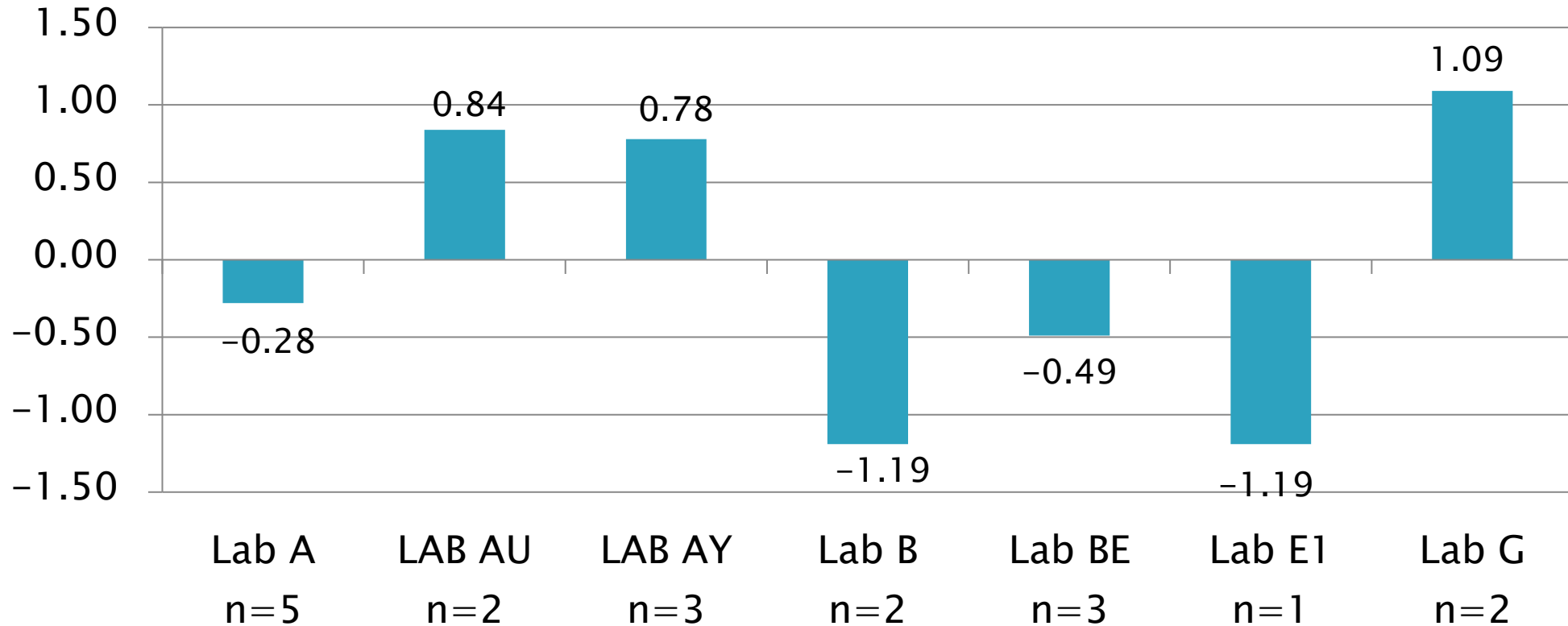
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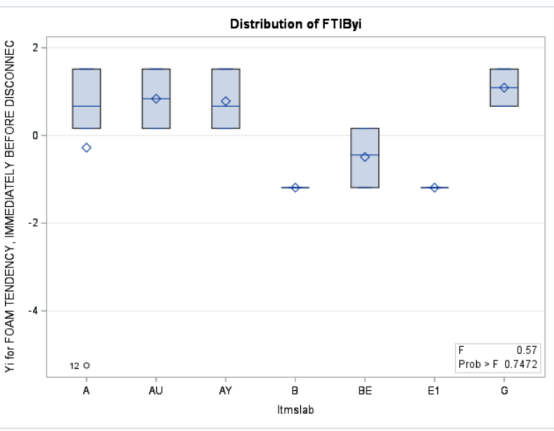
D6082: High Temperature Foam

Current Period Severity Estimates by Lab
Foam Tendency, ml



April 1, 2024 - September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



D6082: High Temperature Foam

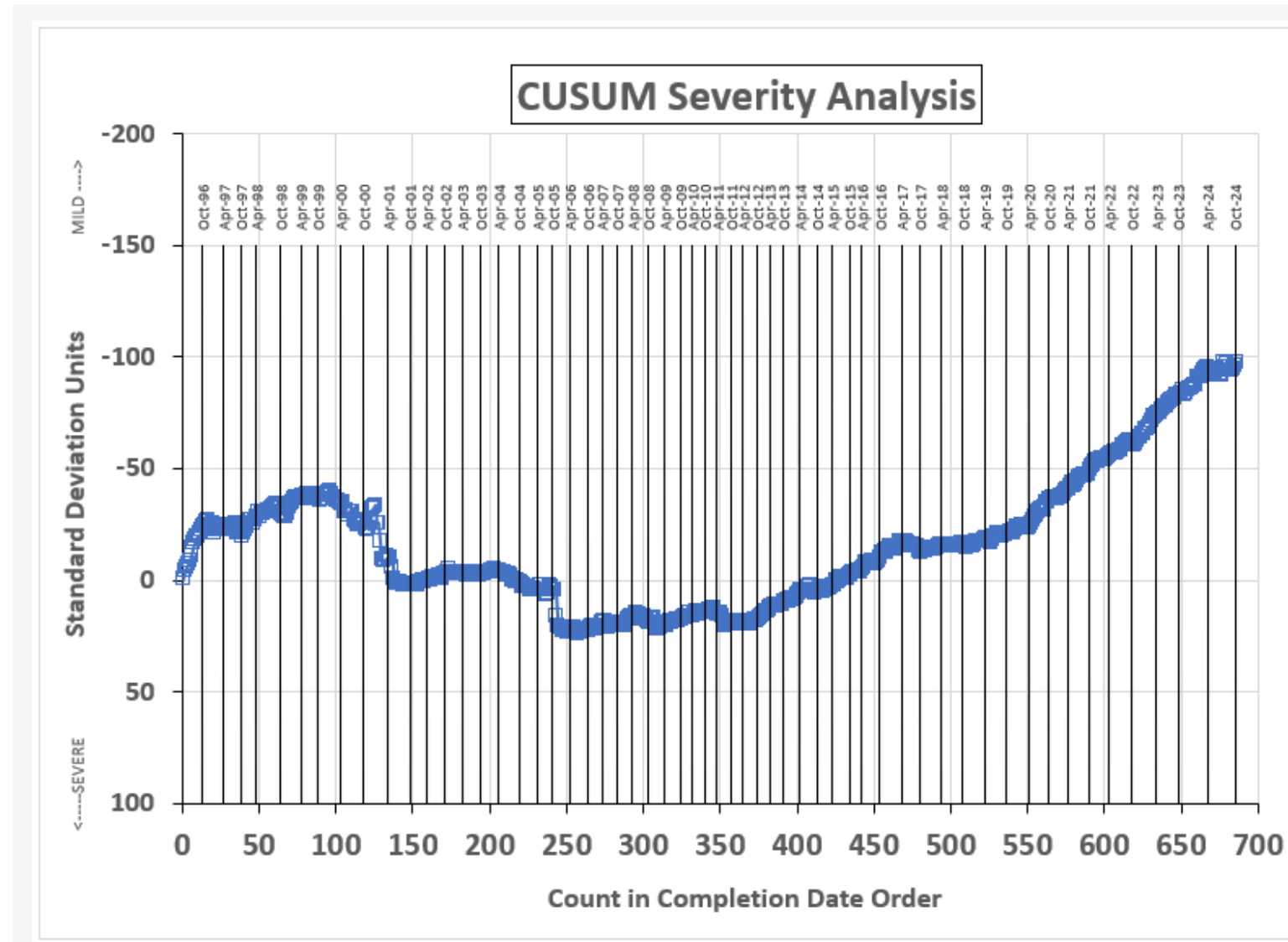
- ▶ Foam Tendency Precision (Pooled s) has fallen further back (to 13) this semester. Previous semester Precision was 10.
- ▶ Performance (Mean Δ/s) has improved to $-0.01s$.
- ▶ NEW FOAMB18 final targets, based upon 131 data points, were approved by the Surveillance Panel in June.
- ▶ No non-zero occurrences of Foam Stability
- ▶ All SIX severe oil discrimination runs (on TMC oil 66) demonstrated acceptable discrimination on foam tendency (>100 ml).

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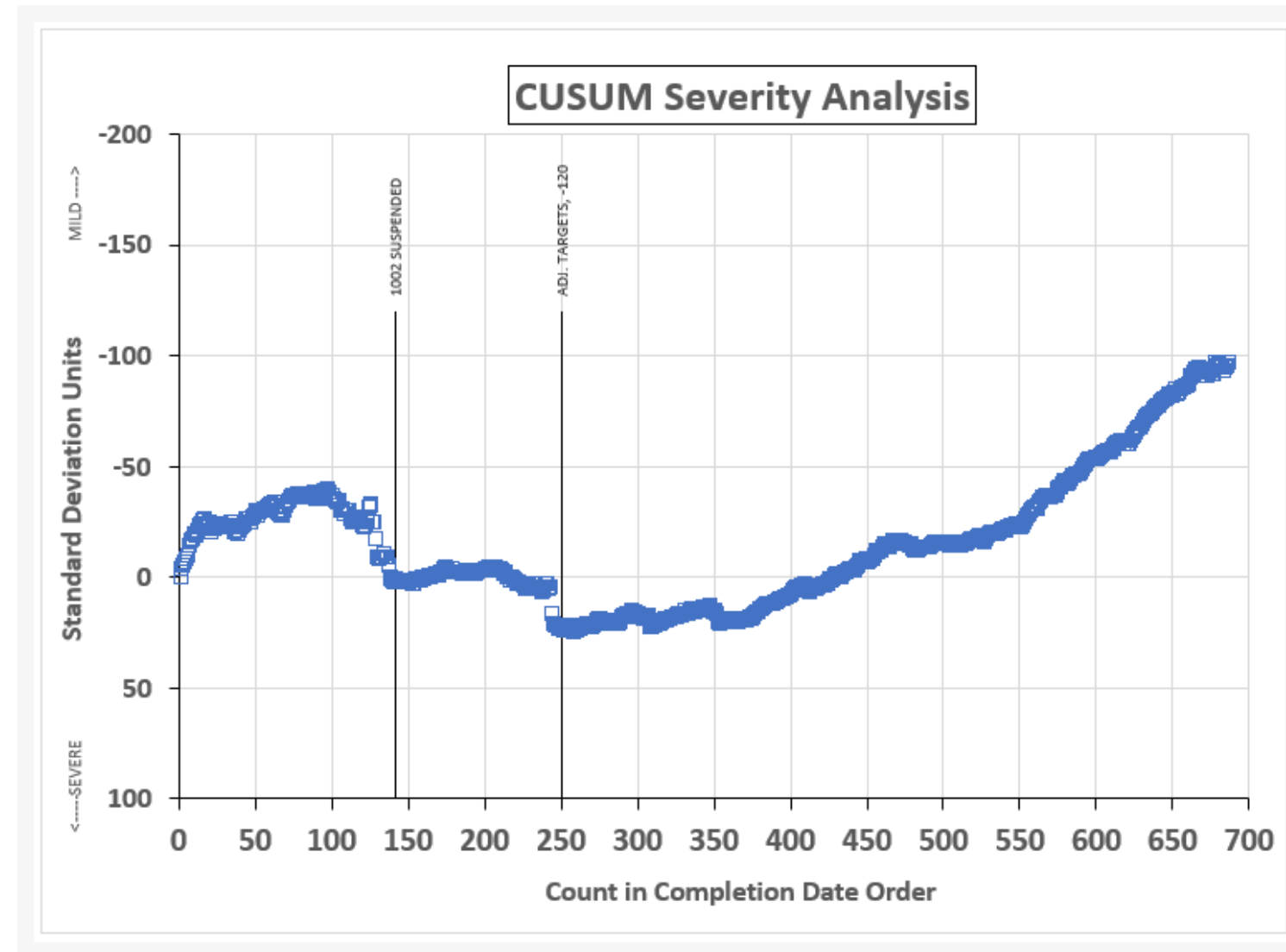


FOAM TENDENCY



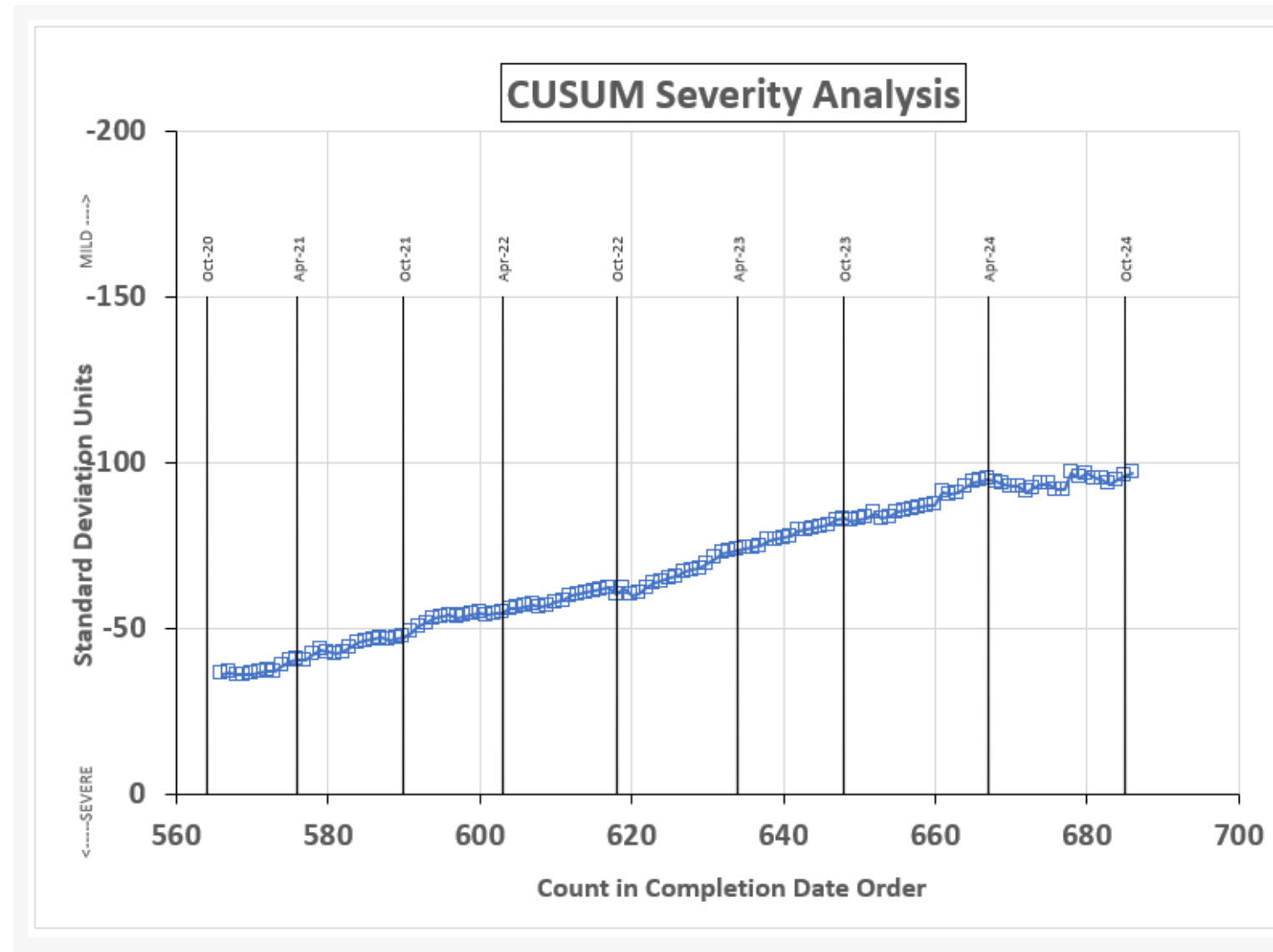
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FOAM TENDENCY



April 1, 2024 – September 30, 2024

Last 120 Data Points
FOAM TENDENCY



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Reference Oil Inventory

D6082

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
FOAMB18	2018	D6082	68.29	2.77	5+ years
66	2002	D6082	66.73	0.97	5+ years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B D874QC Samples (1L sizes) could quickly deplete Reference Oil 90 availability.

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D02.B0.07

TMC Monitored Tests



ASTM D 6335

TEOST

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6335	9 (+0)	14 (+0)
*As of 9/30/2024		

D6335: Deposits by TEOST-33C

Test Status	Validity Code	No. Tests
Acceptable Calibration Tests	AC	32
Failed Calibration Tests	OC	9
Operationally Invalid or Aborted by Lab	LC, XC	1
Informational Run (In Range)	NN	3
Informational Run (Out of Range)	MN	7
Total		52

Number of Labs Reporting Data: 9 (9 Labs Last Period)
Fail Rate of Operationally Valid Tests: 22.0% (23.5% Last Period)

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D6335: Deposits by TEOST-33C

Statistically Unacceptable Tests (OC)	No. Of Tests
Total Deposits Severe	8
Total Deposits Mild	1
Total	9
Operationally Invalid Tests (LC, RC, XC)	No. Of Tests
Power Failure (aborted run)	1
Total	1

- RO reblend 75-2 approved for use with current RO 75-1 acceptance range.

D6335: Deposits by TEOST-33C

Period Precision and Severity Estimates

Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Updated Targets 20201001 ¹	46	44	4.85	-----
10/1/20 through 3/31/21	26	23	8.39	0.42
4/1/21 through 9/30/21	31	28	8.27	-0.36
10/1/21 through 3/31/22	27	25	6.22	0.55
4/1/22 through 9/30/22	29	27	10.32	0.80
10/1/22 through 3/31/23	35	33	8.53	0.84
4/1/23 through 9/30/23	30	28	6.57	0.03
10/1/23 through 3/31/24	34	32	6.19	0.63
4/1/24 through 9/30/24	41	39	8.58	0.84

¹Target precision updated to include only current oils 75-1 and 435-2

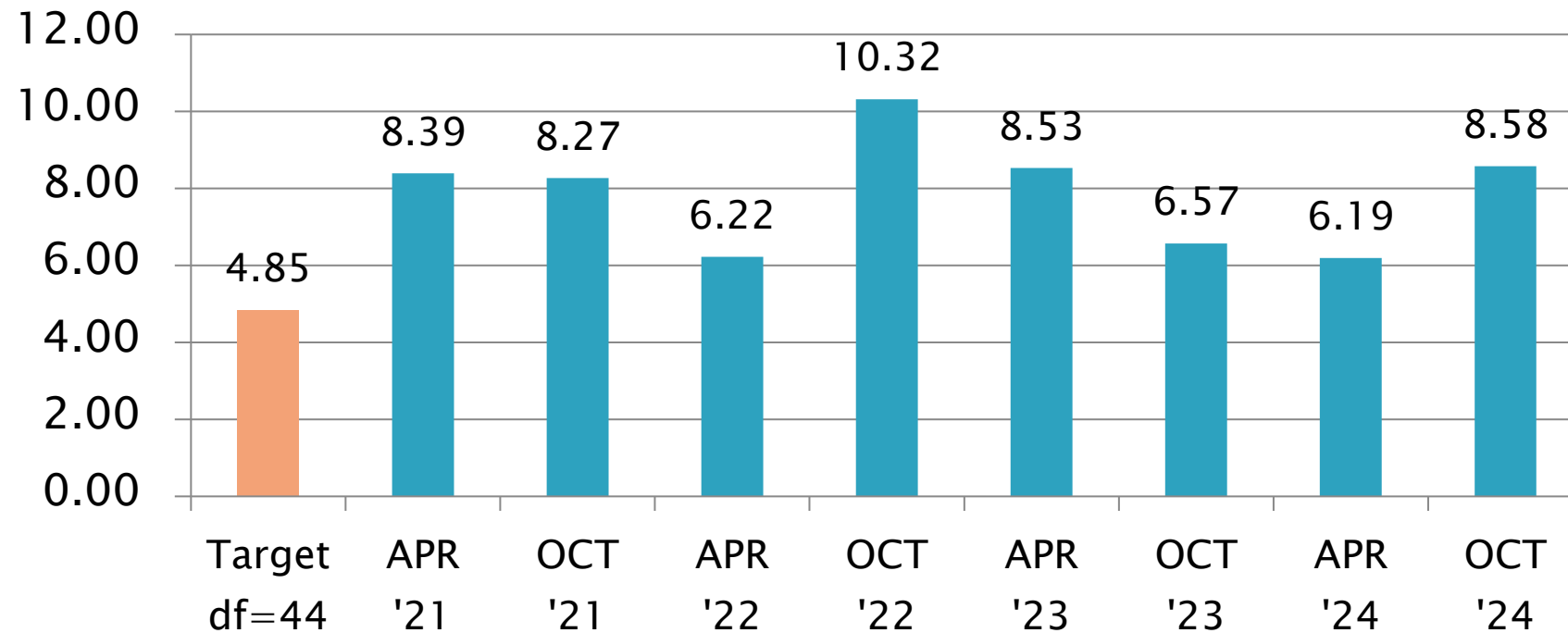
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D6335 Precision Estimates

Total Deposits, mg
Pooled s

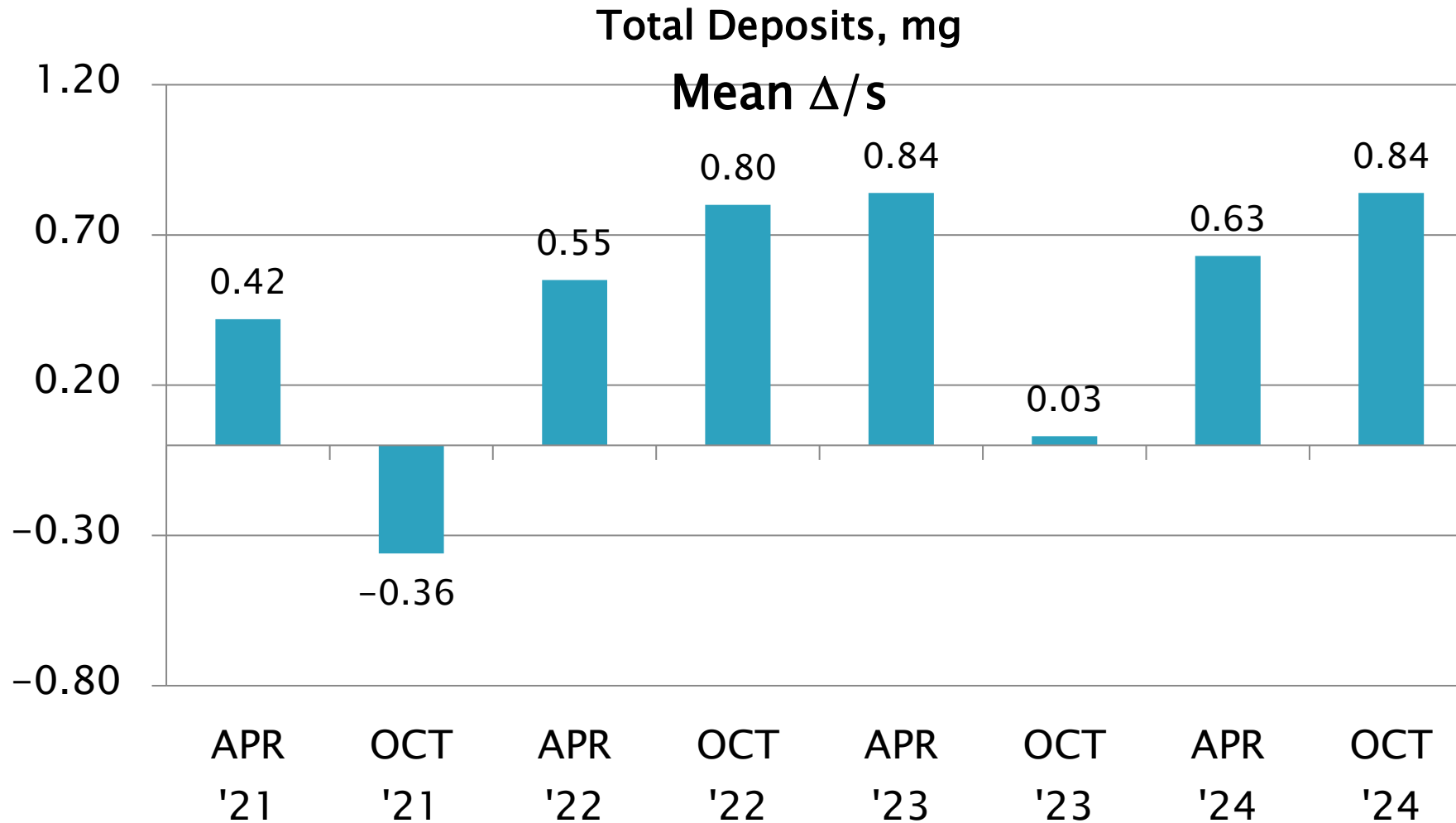


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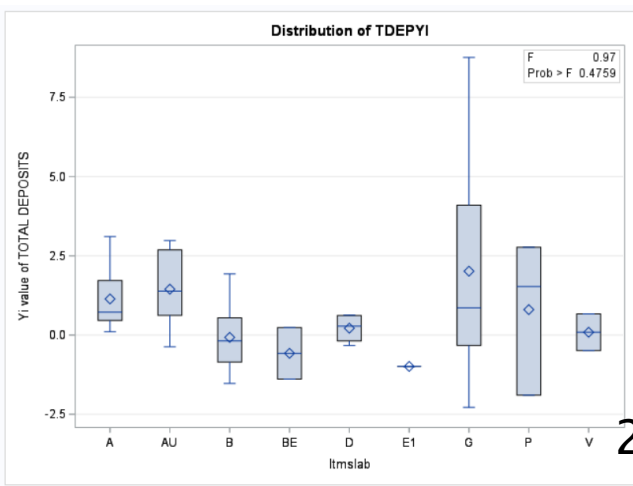
D6335 Severity Estimates



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Test Monitoring Center
<https://www.astmtmc.org>

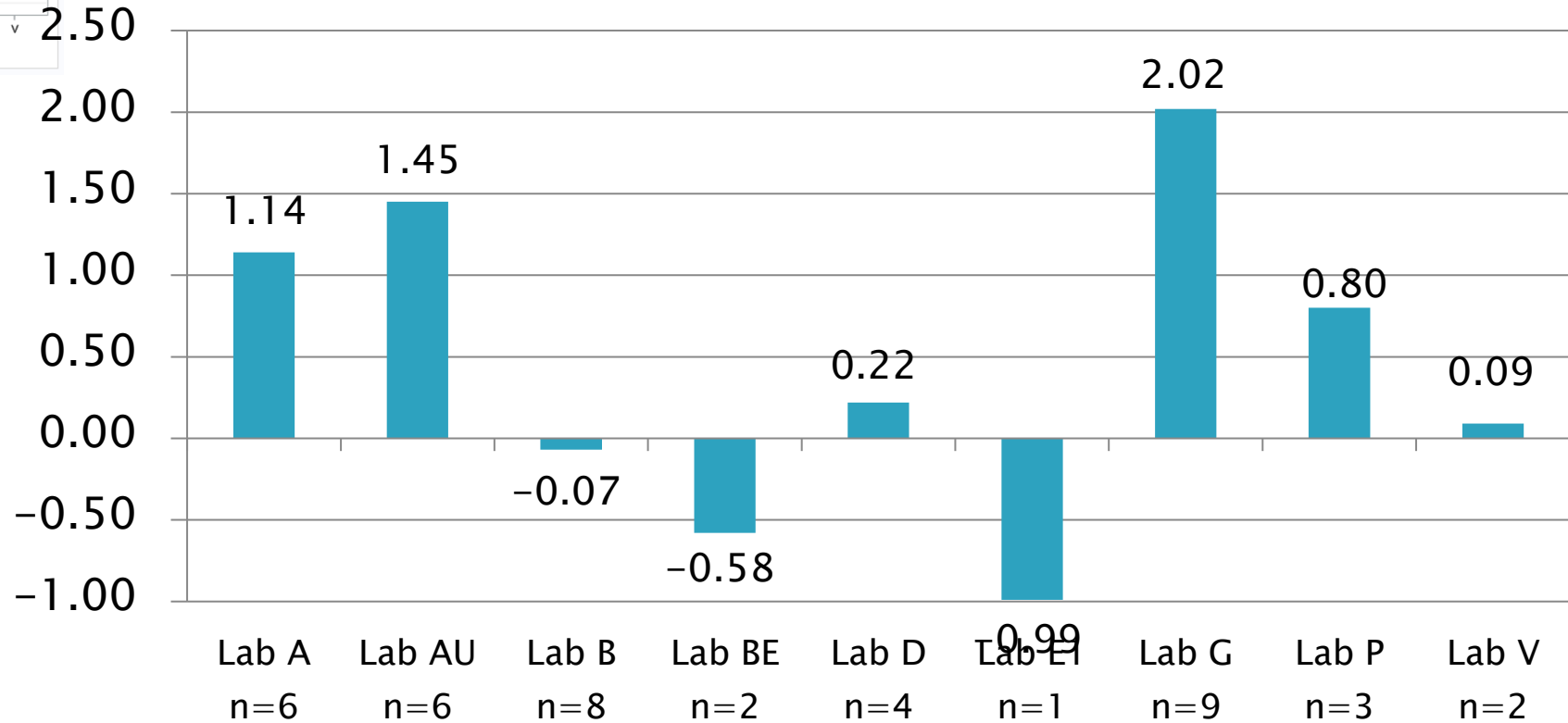




D6335 Lab Severity Estimates

Total deposits, mg

Mean Δ/s



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D6335: Deposits by TEOST-33C

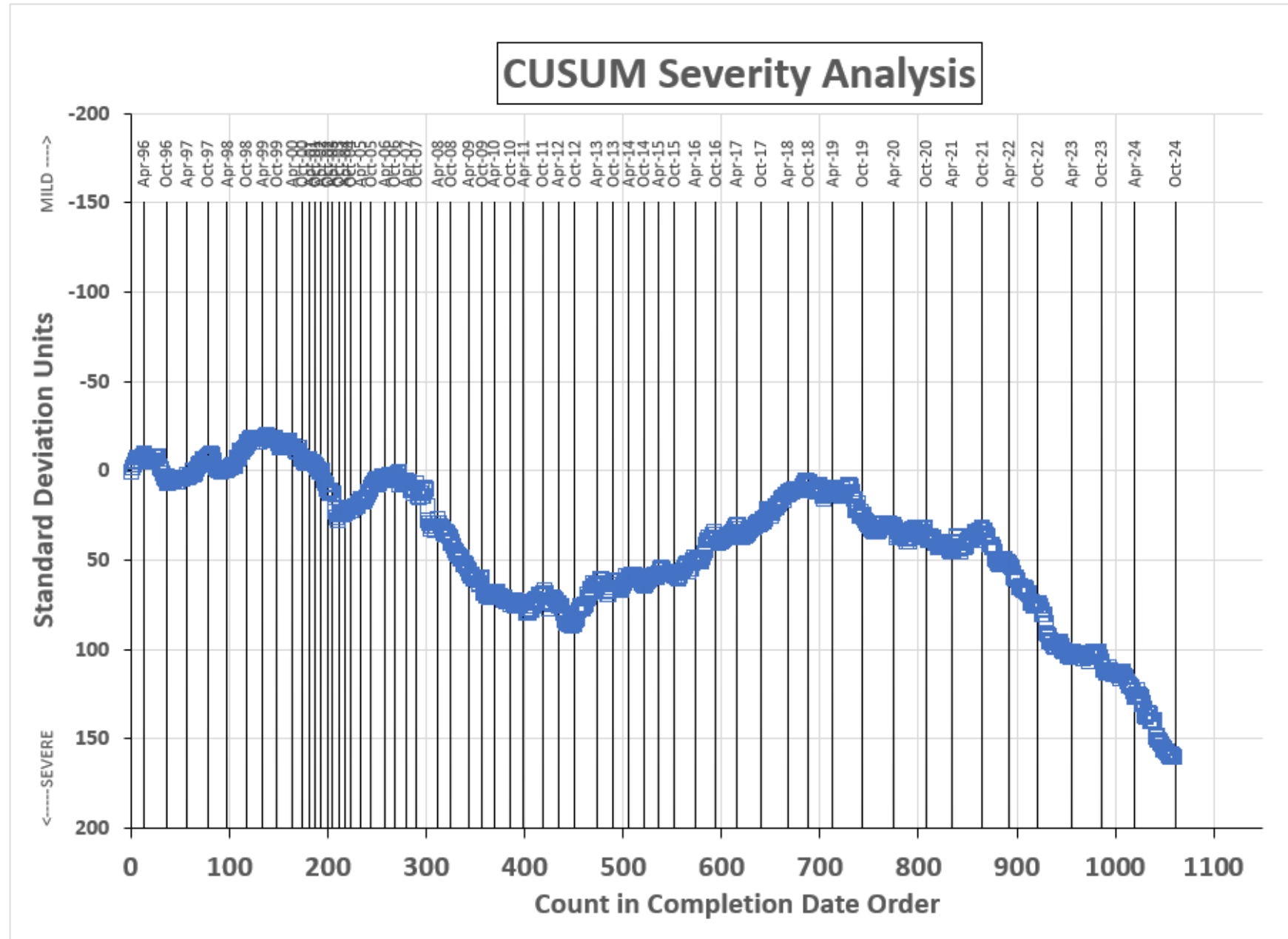
- Precision (Pooled s) regressed away from target for the first time in five reporting semesters
- Performance (Mean Δ/s) also regressed to a severe 0.84 s this period (0.63 s last semester)
- Fail rate (22.0%) this semester remained comparable to fail rate from last semester (23.5%).
- All tests this period report used Rod Batch N.
- Reblend RO 75-2 has replaced batch 75-1. Surveillance Panel voted to carry-forward the existing acceptance range for 75-2.

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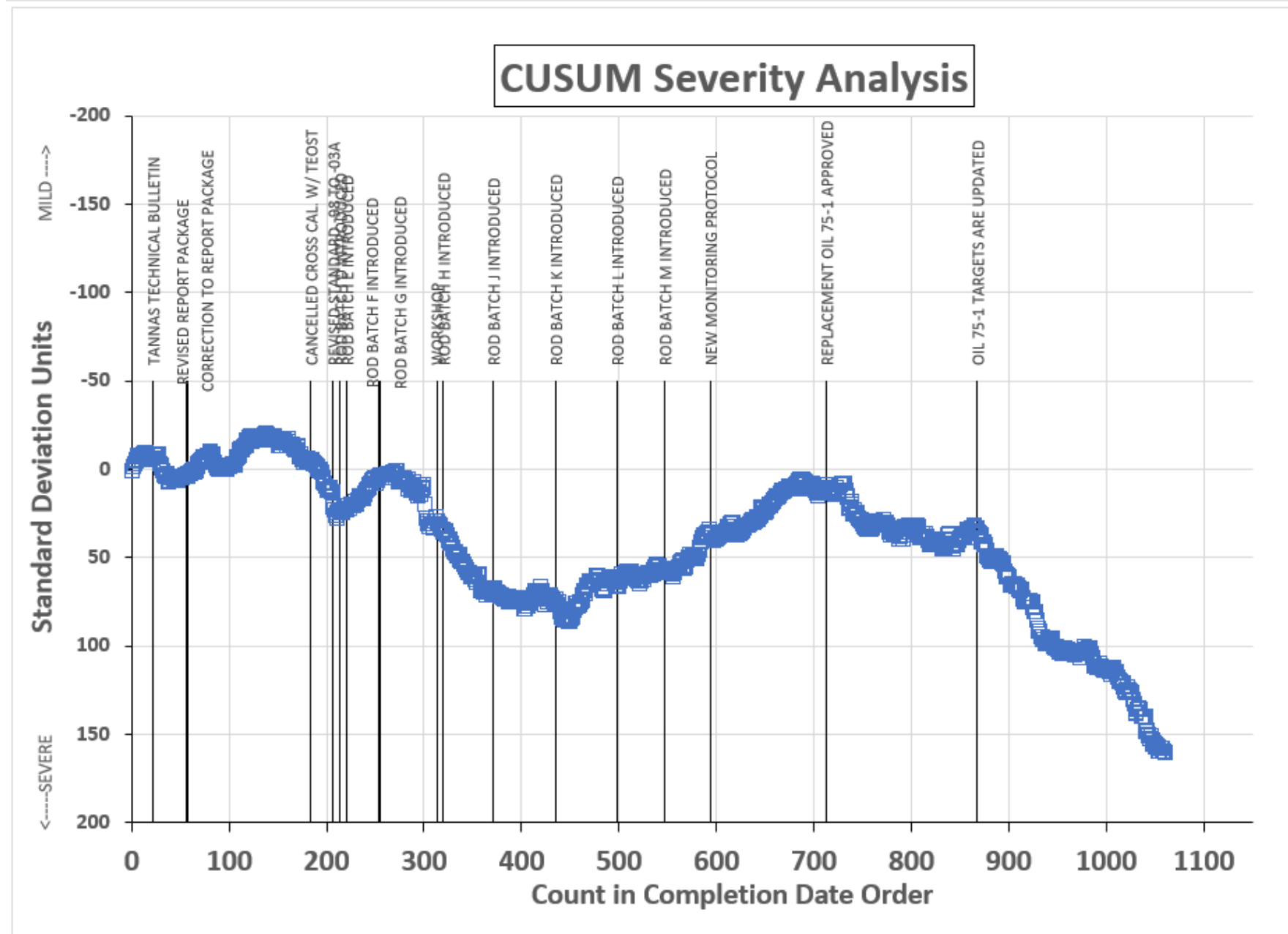
Test Monitoring Center
<https://www.astmtmc.org>

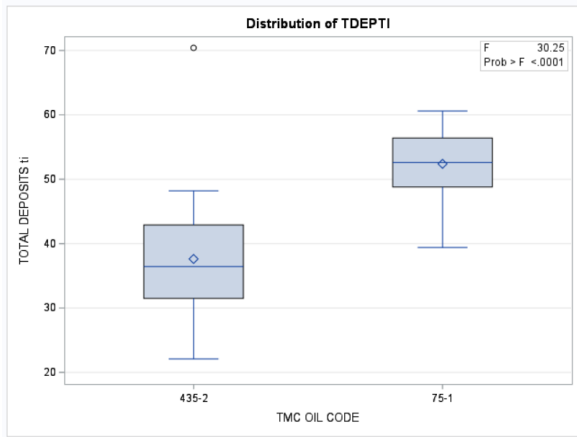


TOTAL DEPOSITS MG



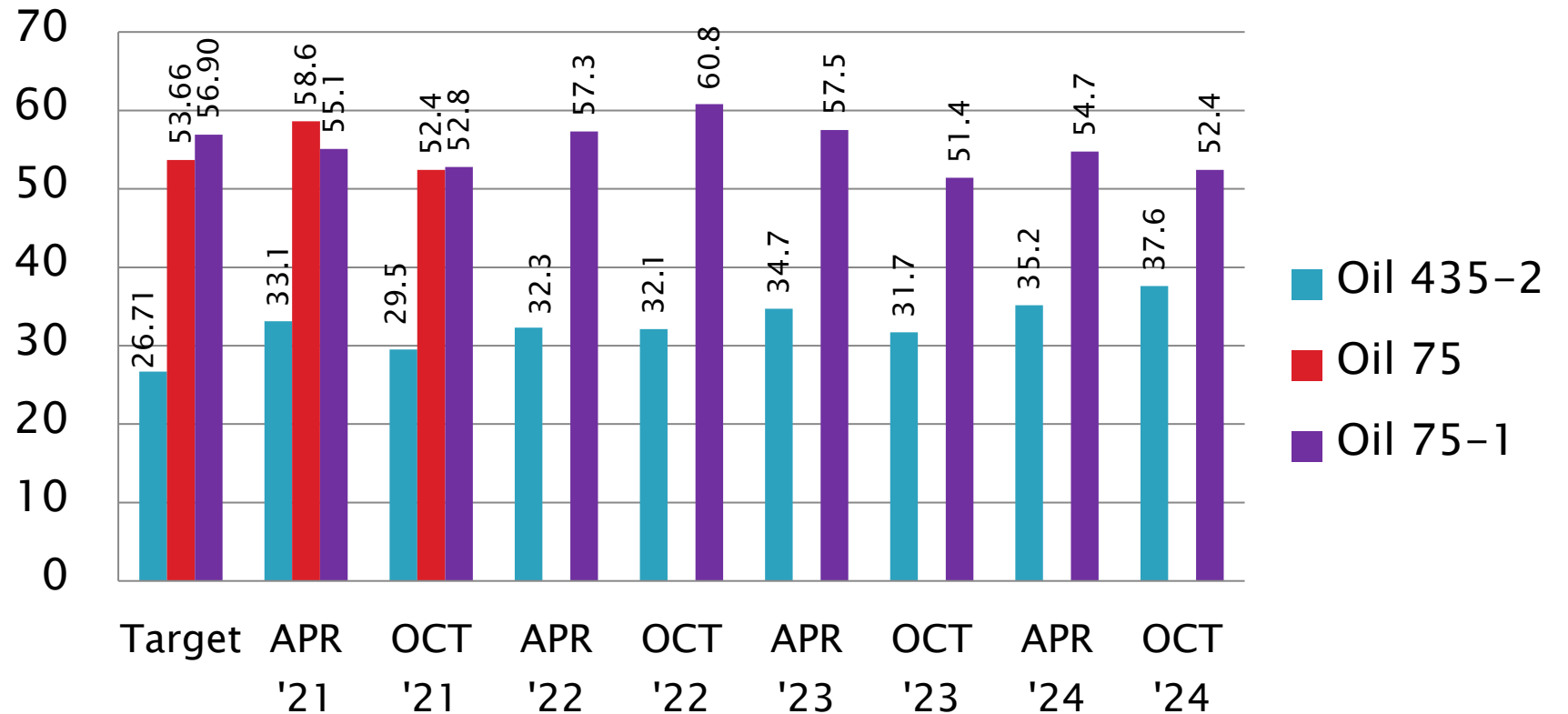
TOTAL DEPOSITS MG





D6335 Performance by Oil

Total Deposits, mg
Mean

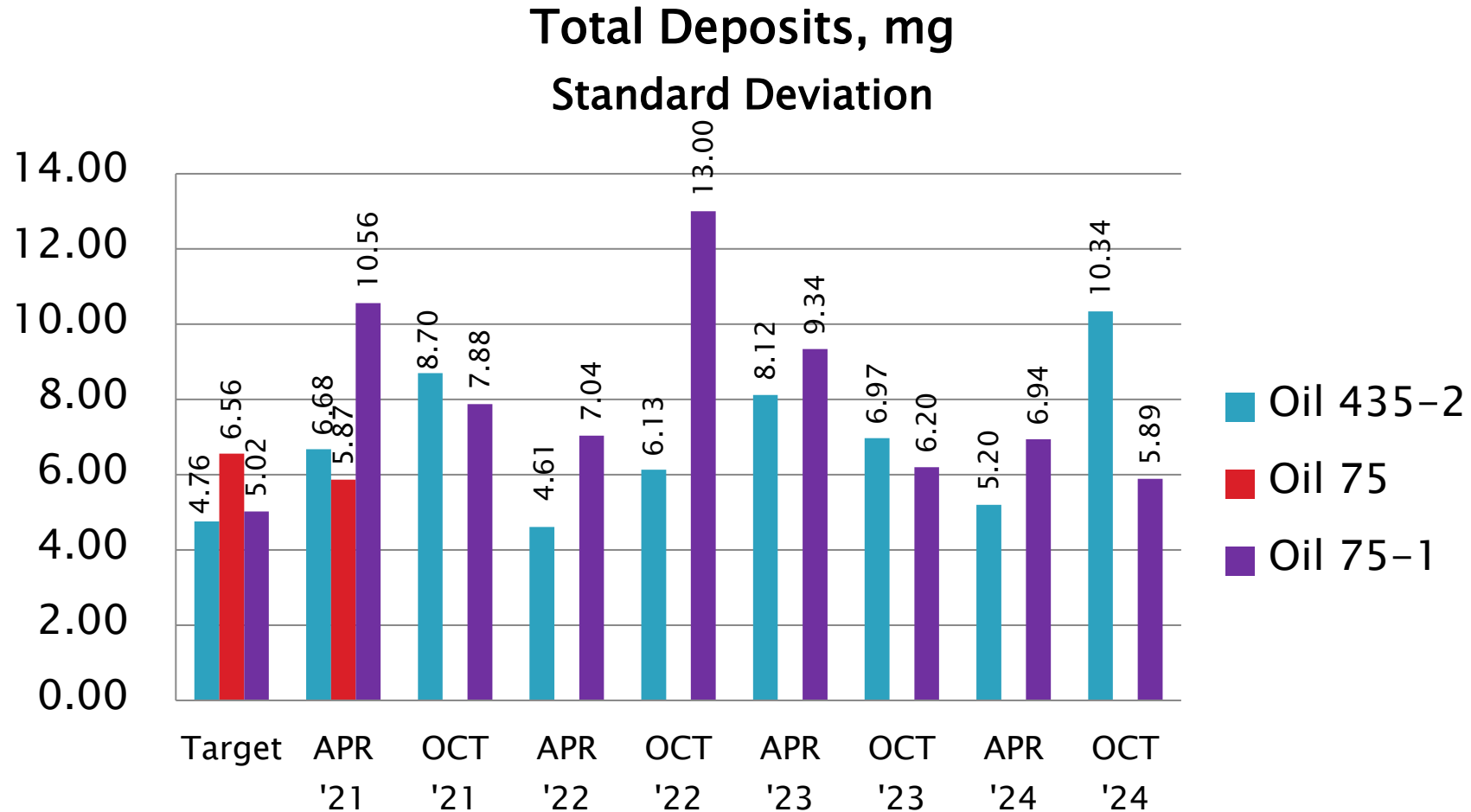


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D6335 Performance by Oil



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D6335 Performance by Oil

Total Deposits, mg

Mean Δ/s

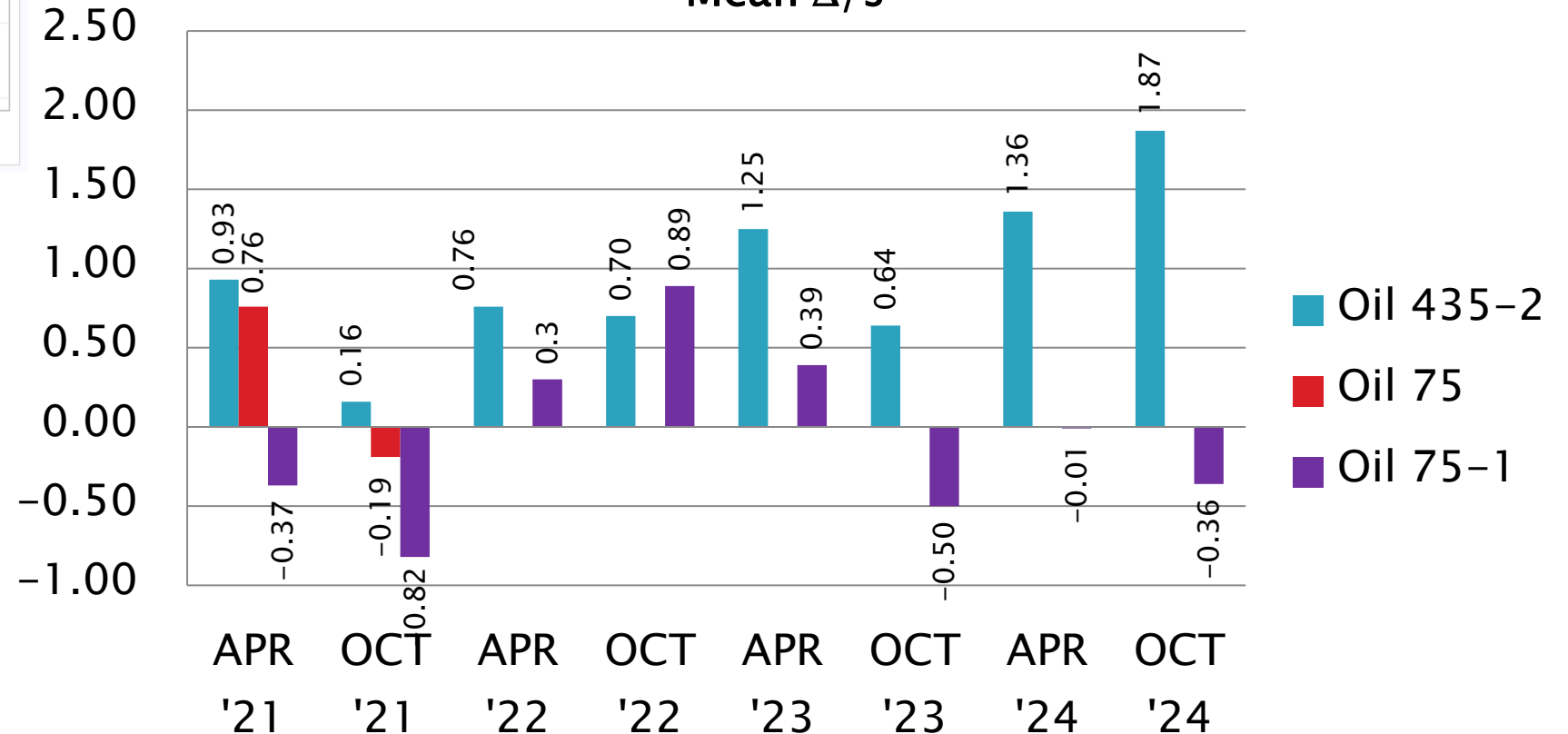
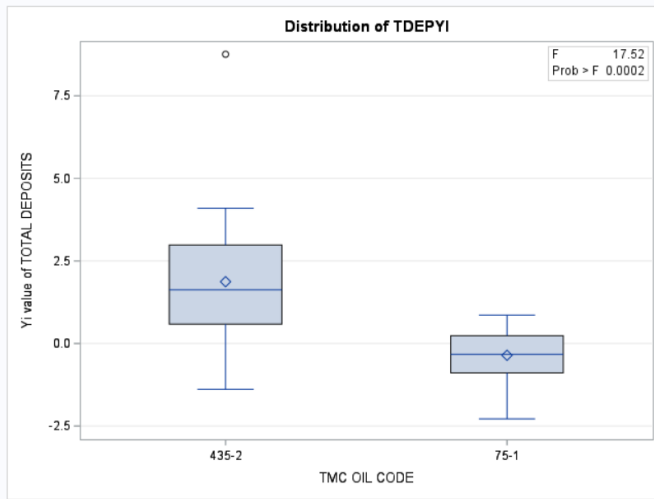


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Reference Oil Inventory

TEOST

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
75-1	2016	TEOST	0.00	1.22	None
75-2	2024	TEOST	7.27	1.03	5+ years
435-2 ^B	2010	TEOST	32.39	1.00	5+ years
434-3 ^B	2017	TEOST	14.68	3.71	~2 years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B Multi-test oil; estimated aliquot reserved for bench testing.

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Test Monitoring Center
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D02.B0.07

TMC Monitored Tests



ASTM D 6417

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6417	7 (+0)	10 (+0)
*Between 4/1/2024 and 9/30/2024		

D6417: Estimation of Engine Oil Volatility by Capillary GC

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	19
Failed Calibration Test	OC	0
Acceptable Shakedown Runs	NN	1
Total		20

Number of Labs Reporting Data: 7
Fail Rate of Operationally Valid Tests: 0%

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Test Monitoring Center
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D6417: Estimation of Engine Oil Volatility by Capillary GC

Statistically Unacceptable Tests (OC)	No. Of Tests
Volatility Loss Mild	0
Volatility Loss Severe	0

Operationally Invalid Tests (LC)	No. Of Tests
Daily QC was out of range (Severe)	0

- No D6417 TMC technical updates were issued this report period.

D6417: Estimation of Engine Oil Volatility by Capillary GC

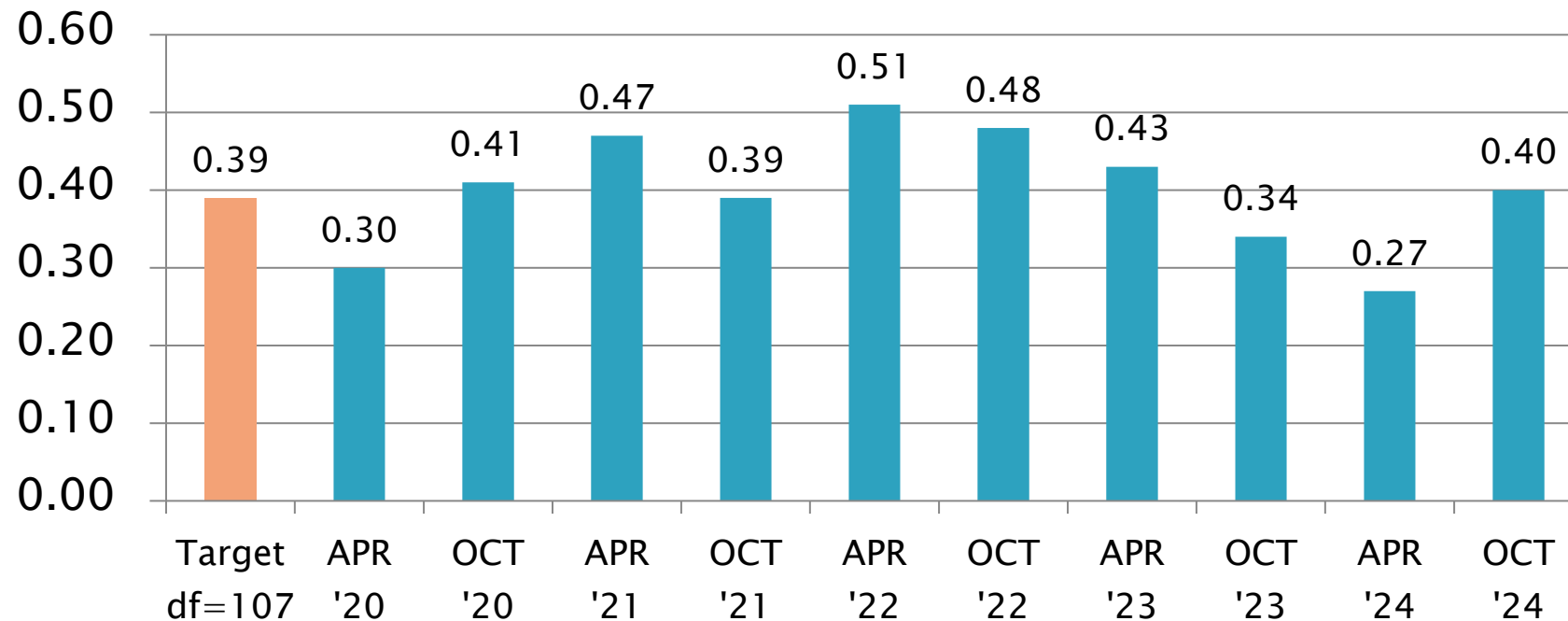
Period Precision and Severity Estimates

Area % Volatized @ 371°C	n	df	Pooled s	Mean Δ/s
Initial Selected Oils from RR	54	51	0.39	-----
4/1/20 through 9/30/20*	16	13	0.41	-0.34
4/1/20 through 9/30/20*	14	11	0.31	0.01
10/1/20 through 3/31/21*	21	18	0.47	-0.81
10/1/20 through 3/31/21*	19	16	0.37	-0.43
4/1/21 through 9/30/21	17	14	0.39	-0.28
10/1/21 through 3/31/22	20	17	0.51	0.13
4/1/22 through 9/30/22	19	16	0.48	-0.67
10/1/22 through 3/31/23	18	15	0.43	0.41
4/1/23 through 9/30/23	16	13	0.34	-0.02
10/1/23 through 3/31/24	18	15	0.27	0.25
4/1/24 through 9/30/24	20	17	0.40	-0.02

*Period statistics with two mild results from rigs D5/D6 included and excluded (operational problem suspected but lab never confirmed)

D6417 Precision Estimates

Area % Volatized @ 371°C
Pooled s



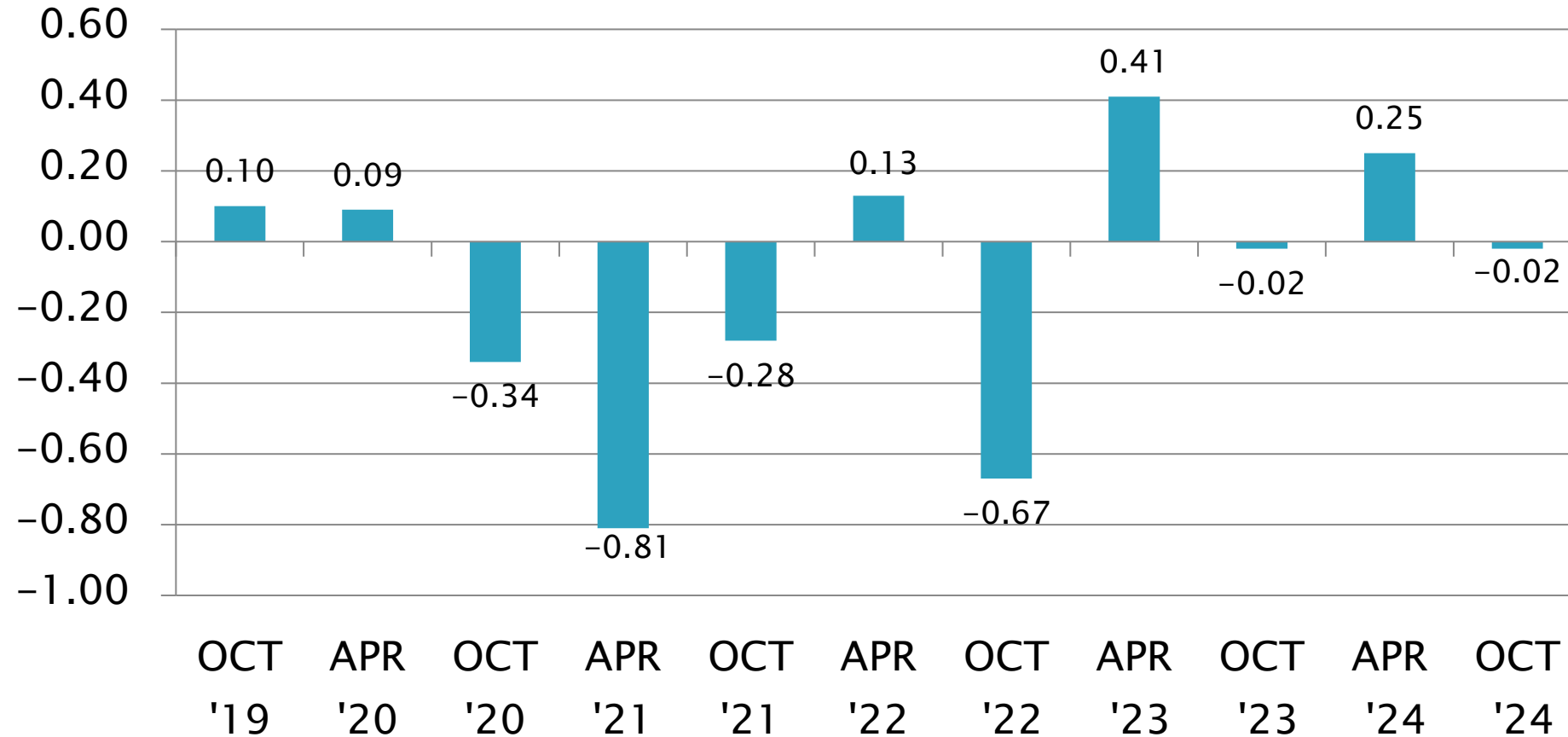
April 1, 2024 – September 30, 2024

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D6417 Severity Estimates

Area % Volatized @ 371°C
Mean Δ/s



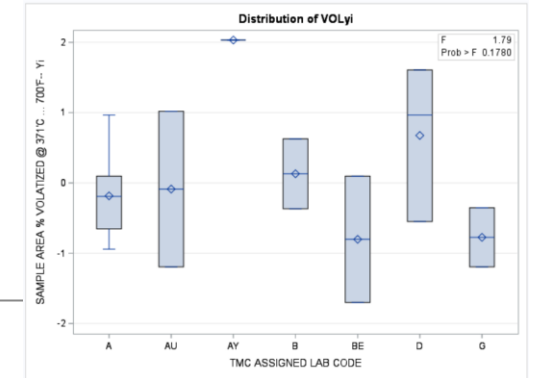
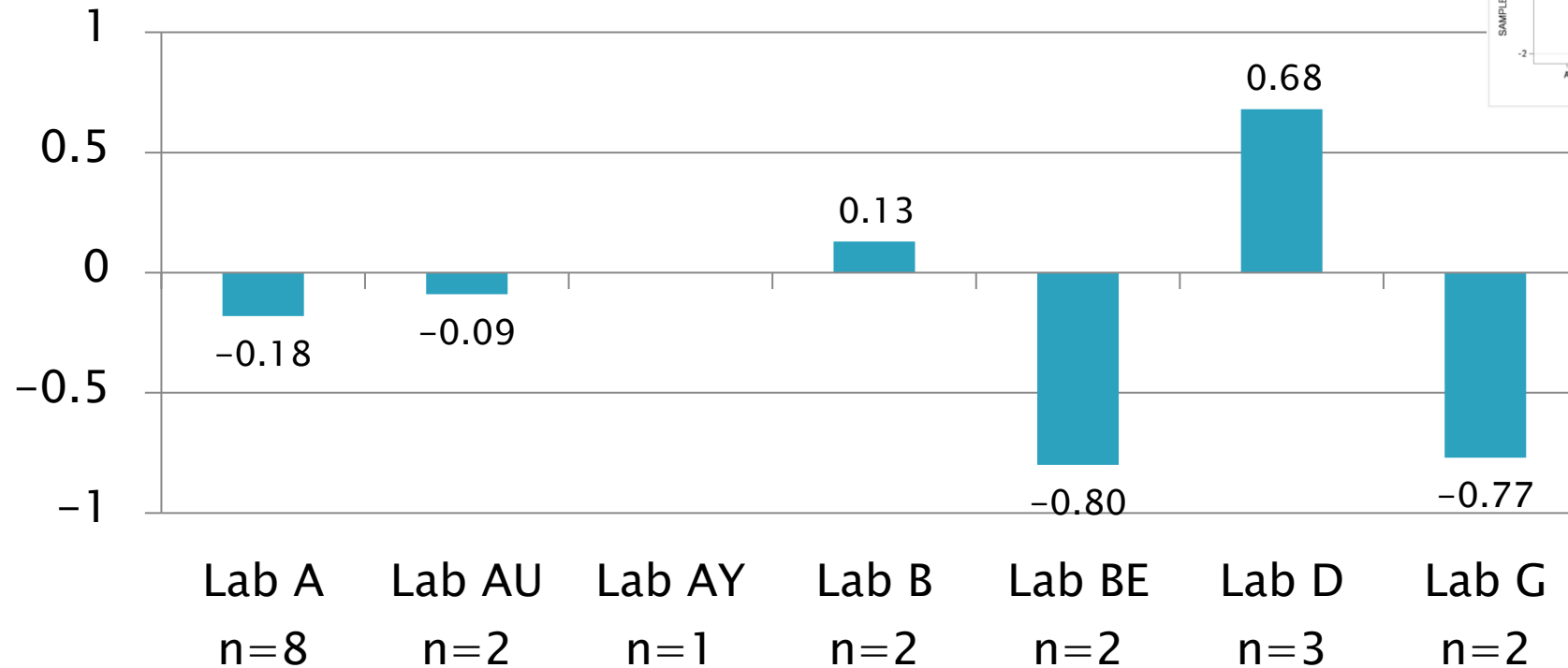
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D6417 Lab Severity Estimates

Area % Volatized @ 371°C
Mean Δ/s



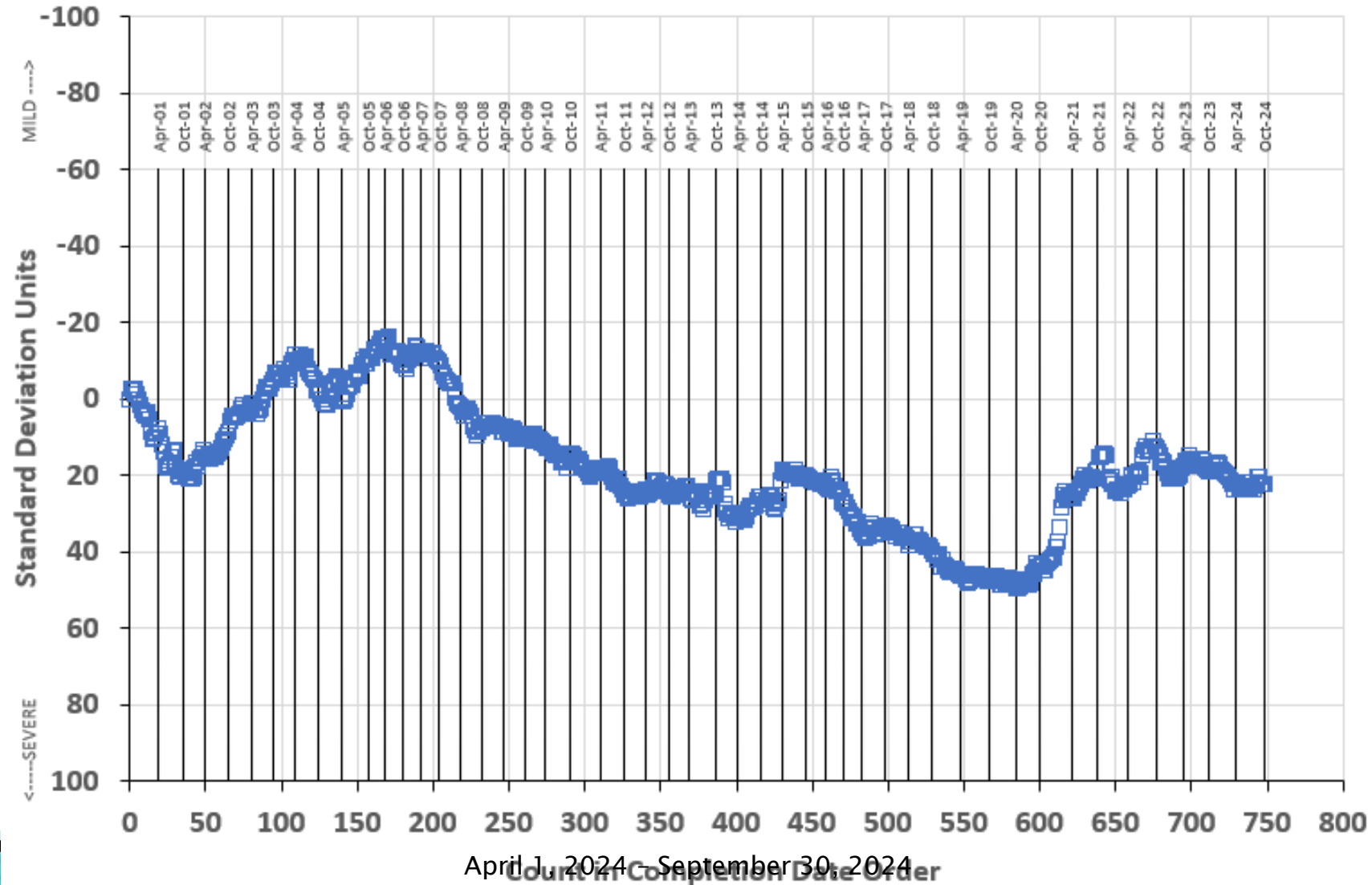
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SAMPLE AREA % VOLATIZED

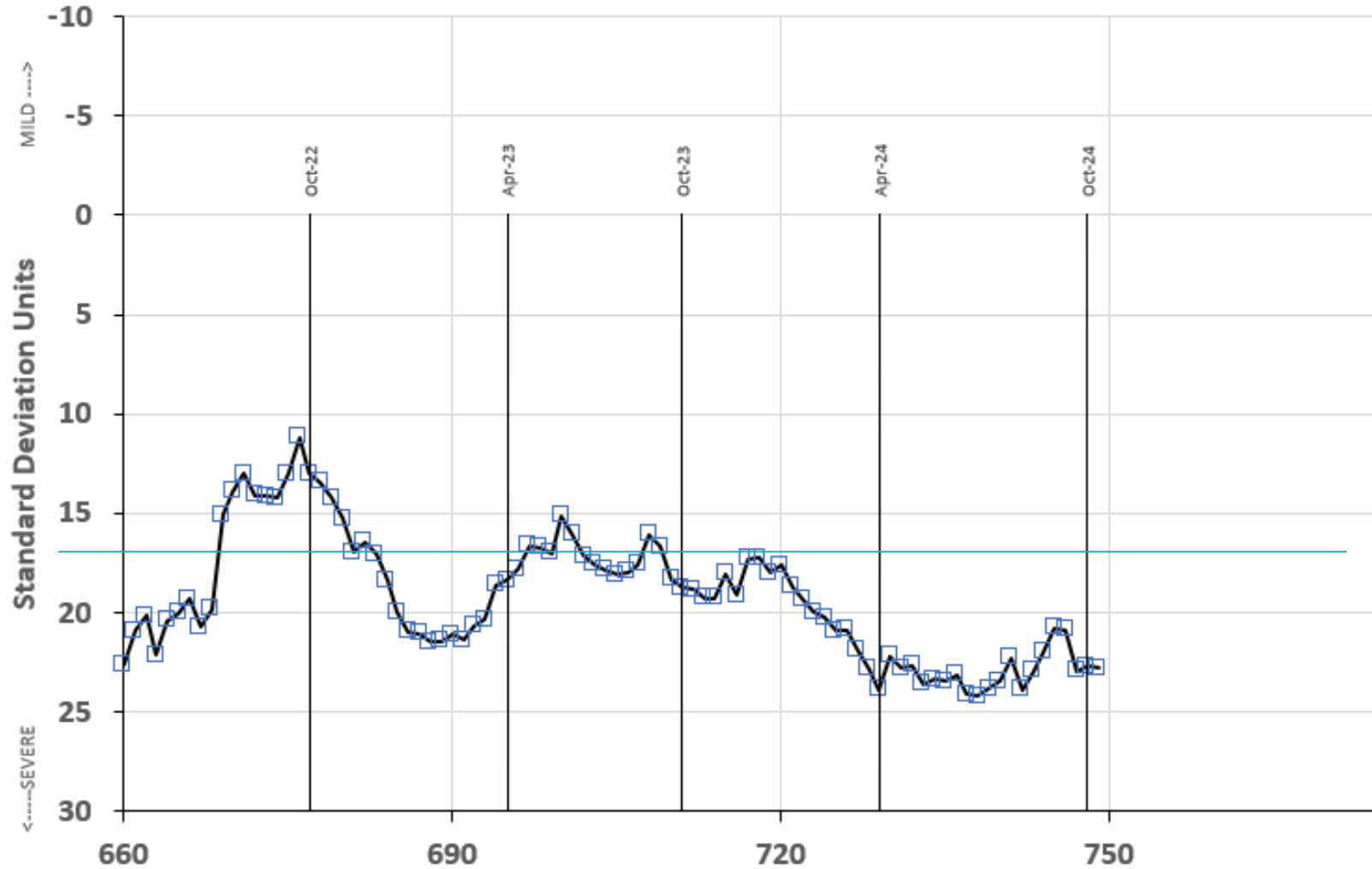
CUSUM Severity Analysis



April 1, 2024 – September 30, 2024

D6417 VOLATILITY BY GC INDUSTRY OPERATIONALLY VALID DATA
LAST 90 Points
SAMPLE AREA % VOLATIZED

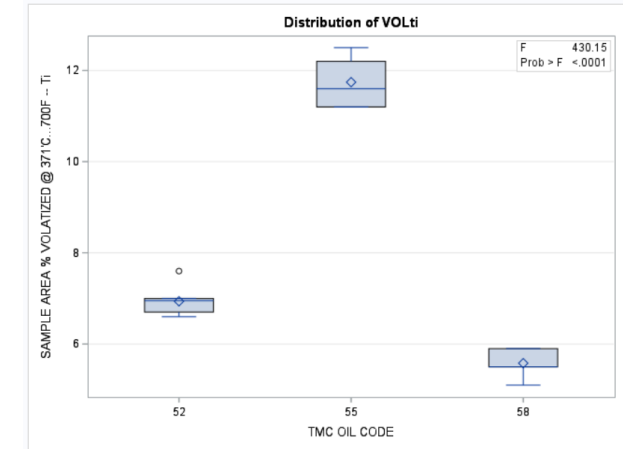
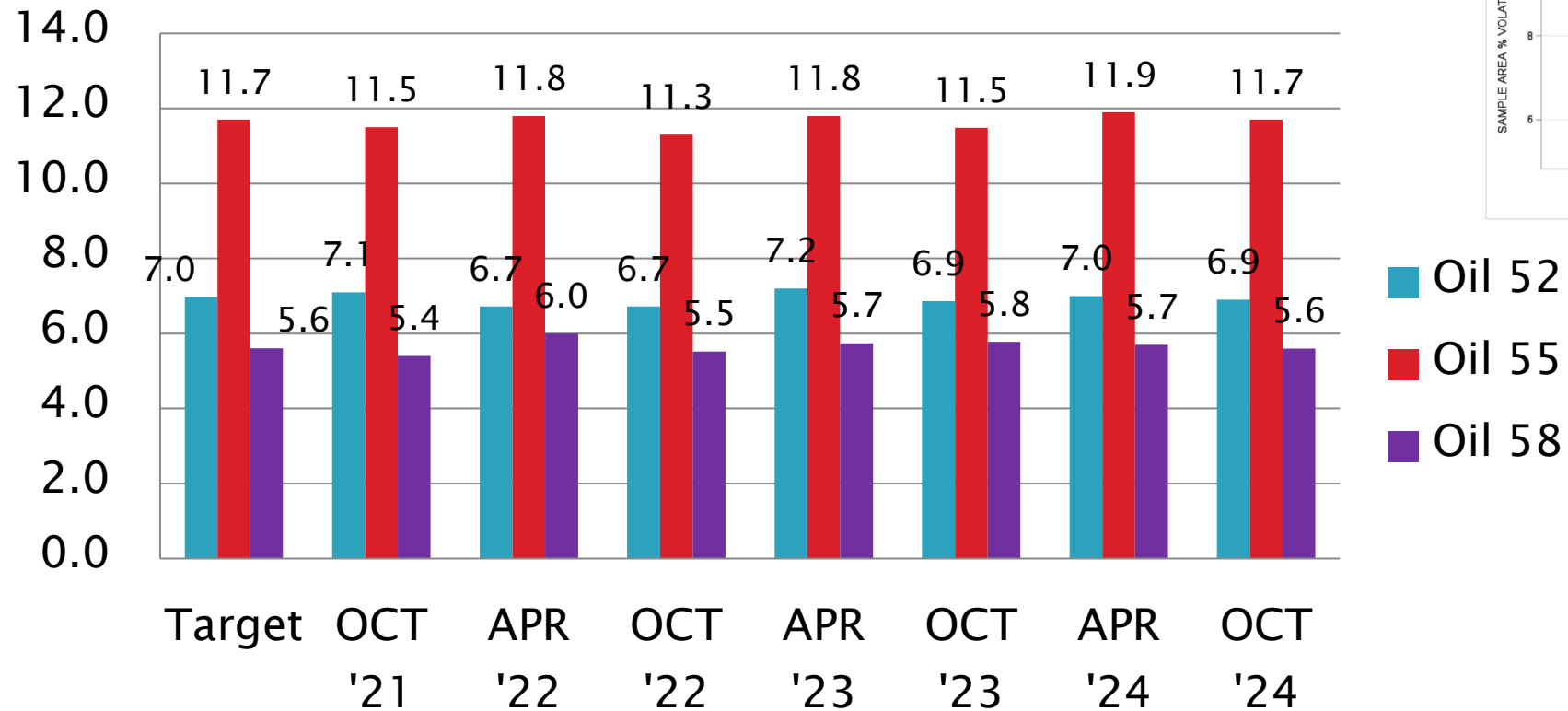
CUSUM Severity Analysis



Count in Completion Date Order
April 1, 2024 - September 30, 2024

D6417 Performance by Oil

Area % Volatized @ 371°C
Mean



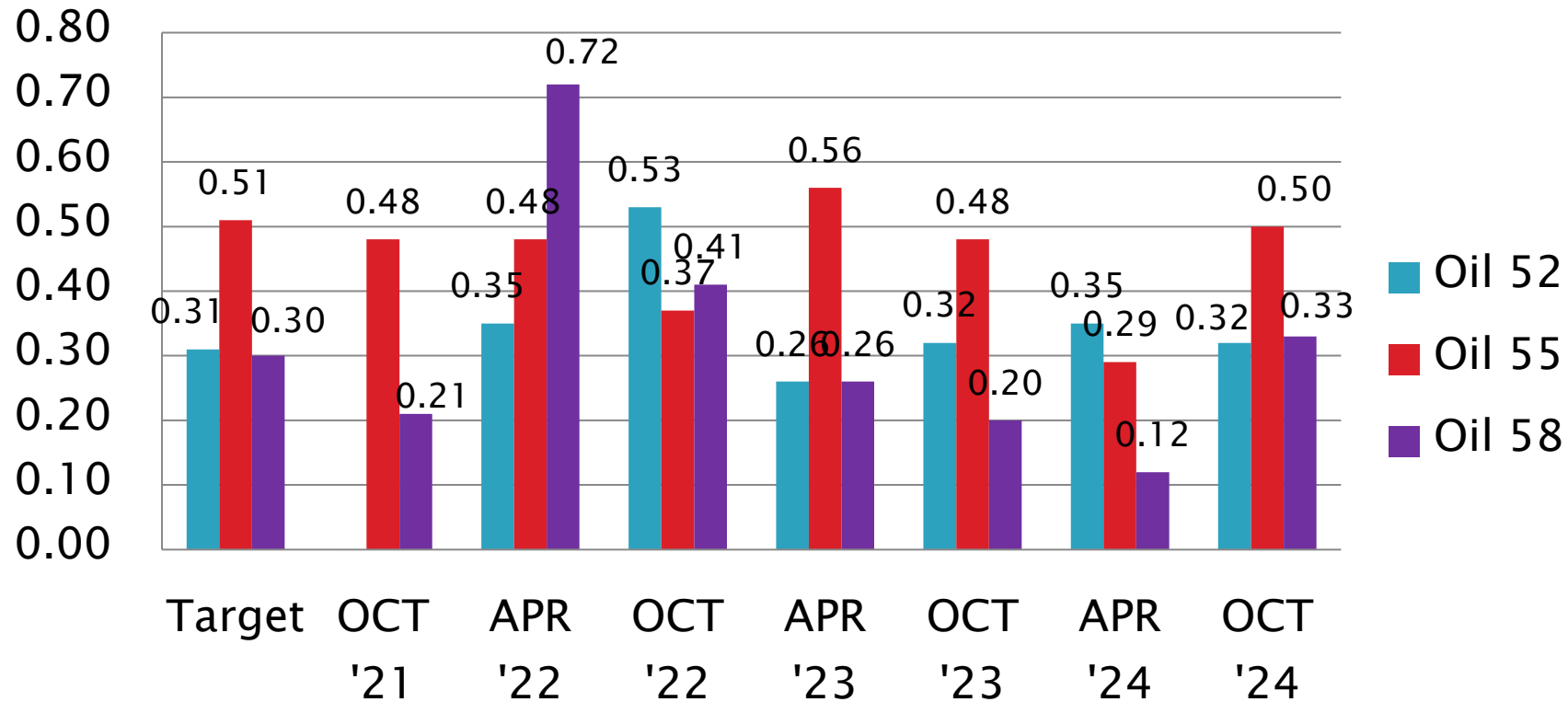
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D6417 Performance by Oil

Area % Volatized @ 371°C
Standard Deviation



April 1, 2024 – September 30, 2024

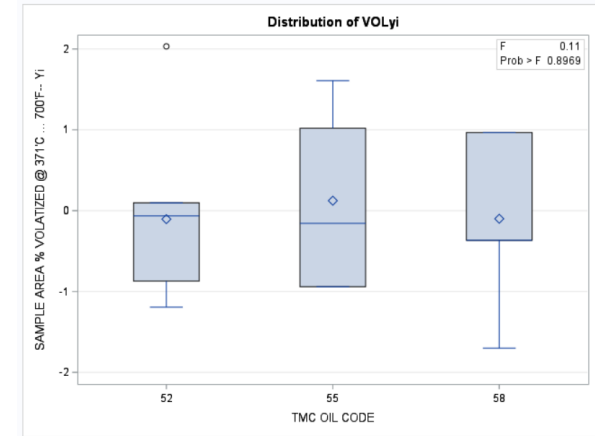
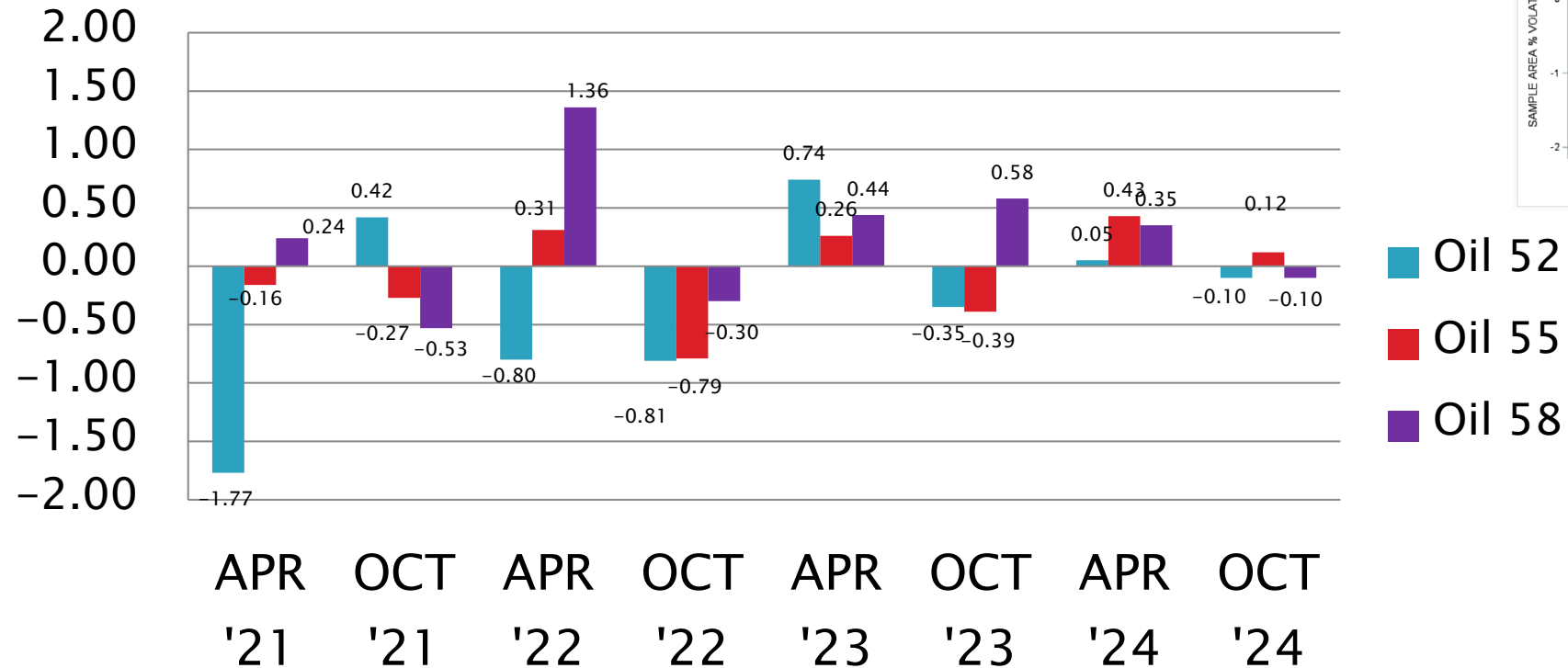
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D6417 Performance by Oil

Area % Volatized @ 371°C
Mean Δ/s



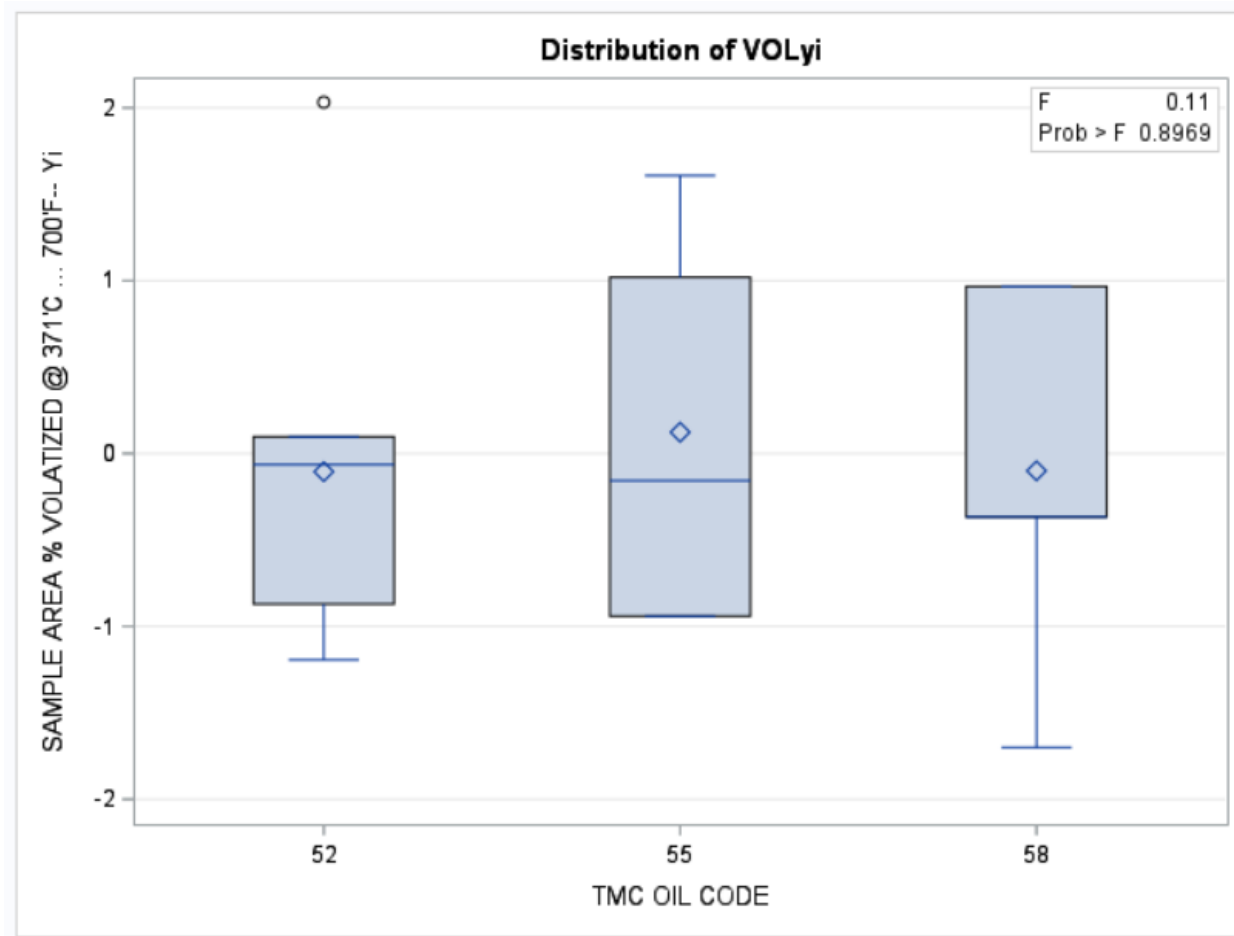
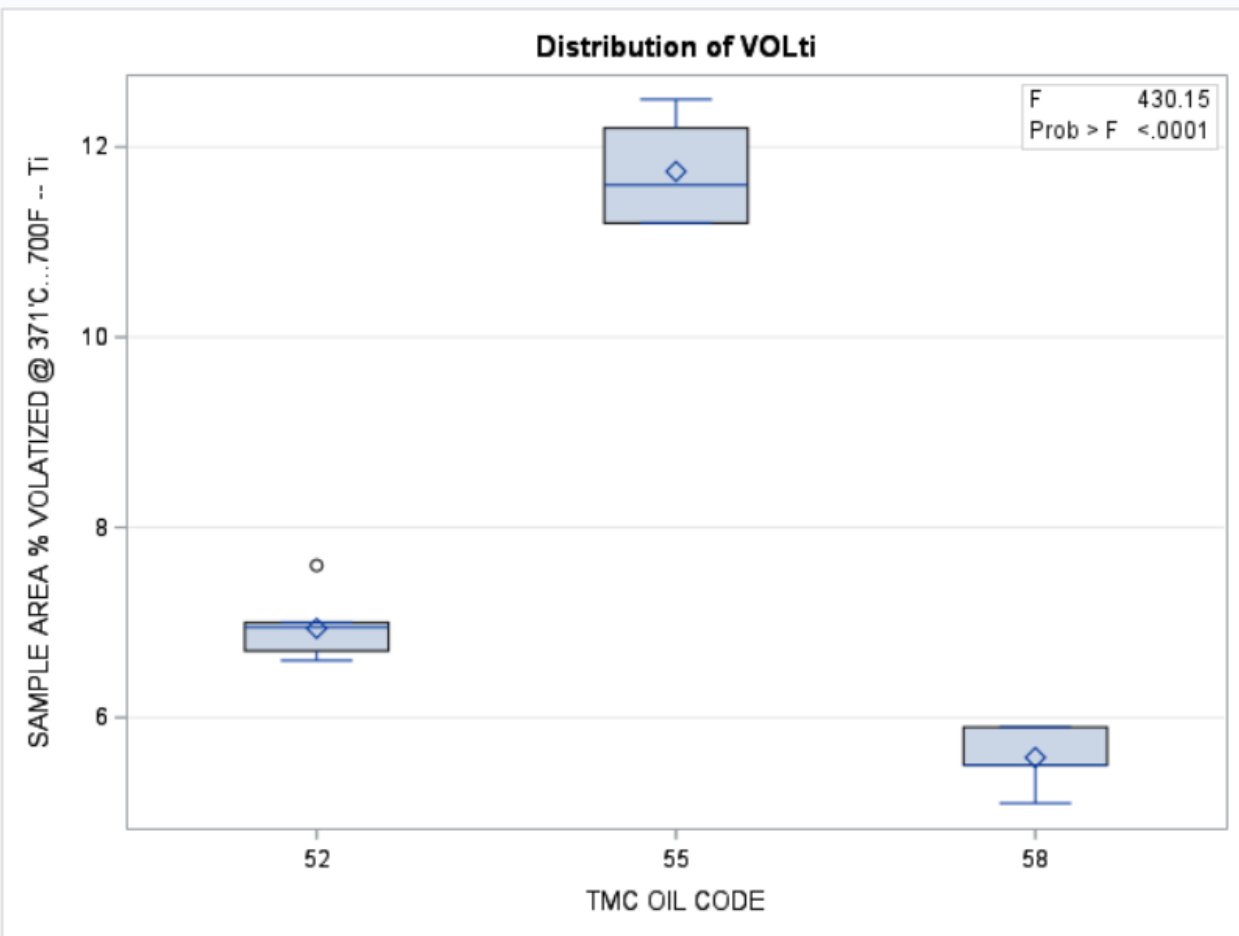
April 1, 2024 – September 30, 2024

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D6417 Performance by Oil



April 1, 2024 – September 30, 2024

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Reference Oil Inventory

D6417

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
52 ^B	1995	D6417	59.37	<0.01	5+ years
55	1995	D6417	65.89	<0.01	5+ years
58	1998	D6417, D6417QC	110.19	<0.01	5+ years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B Reference Oil 58 is used in multiple Bench Test Areas.

April 1, 2024 – September 30, 2024

Test Monitoring Center
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D6417: Estimation of Engine Oil Volatility by Capillary GC

- ▶ Precision (Pooled s) continues to be remarkably consistent and almost exactly on target this past semester.
- ▶ Performance (Mean Δ/s) also reflects that the test is exactly on target.
- ▶ CUSUM severity flattened out this semester

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D02.B0.07

TMC Monitored Tests



ASTM D 6557

Ball Rust Test (BRT)

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6557	5 (+0)	5 (+0)
*As of 9/30/2024		

BRT Test Activity*

Test Status	Validity Code	Number of Tests
Acceptable Calibration Test	AC	153
Failed Calibration Test	OC	13
Operationally Invalid	LC, RC, LS, RS	0
Aborted Run	XC, XS	3
Batch E Ball Bearing Round Robin Testing	NN	35
Shakedown Run (Result Within Acceptance Band)	NN	14
Shakedown Run (Result Outside Acceptance Band)	MN	11
Total		229

- 5 labs reported data

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Test Monitoring Center
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BRT Failed Tests

Failed Parameter (OC)	Number of Tests
Severe (low) Average Gray Value	9
Mild (high) Average Gray Value	4
Total	13

RO 82-1	FOUR Mild Tests
RO 86	FIVE Severe Tests
RO 87	TWO Severe Tests
RO 1006	TWO Severe Tests

April 1, 2024 – September 30, 2024

Test Monitoring Center
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BRT Failed Tests (OC) by Lab

Failed Parameter	LTMS Lab					#
	A	B	D	G	L	
Severe Average Gray Value	3	1	2	3	0	9
Mild Average Gray Value	3	0	0	1	0	4
Total	6	1	2	4	0	13

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Test Monitoring Center
<https://www.astmtmc.org>



BRT Lost Tests*

Failed Parameter (LC, RC, XC)	Number of Tests
Aborted due to Pump Failure (XC)	1
Aborted due to Shaker-Table Failure (XC)	1
Aborted due to Power Outage (XC)	1
Total	3

*Invalid (LC, RC) and Aborted (XC) calibration tests

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Test Monitoring Center
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BRT Lost Tests by Lab

Cause	LTMS Lab					#
	A	B	D	G	L	
Pump Failure	0	0	1	0	0	1
Shaker-Table	0	0	1	0	0	1
Power Outage	0	1	0	0	0	1
Total	0	1	2	0	0	3

April 1, 2024 – September 30, 2024

Test Monitoring Center
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BRT (D6557) Rust Protection Test

Period Precision and Severity Estimates

Average Gray Value	n	df	Pooled s	Mean Δ/s
10/1/20 through 3/31/21	171	168	13.58	-0.01
4/1/21 through 9/30/21	191	188	11.27	-0.20
10/1/21 through 3/31/22	141	138	16.28	0.12
4/1/22 through 9/30/22	154	151	21.10	-0.29
10/1/22 through 3/31/23	165	162	15.56	-0.17
4/1/23 through 9/30/23	171	168	17.56	0.34
10/1/23 through 3/31/24	183	179	13.75	0.32
4/1/24 through 9/30/24	166	162	14.41	-0.07

*Period statistics for all Valid Reference Oil Results (pooled)

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BRT Test Severity

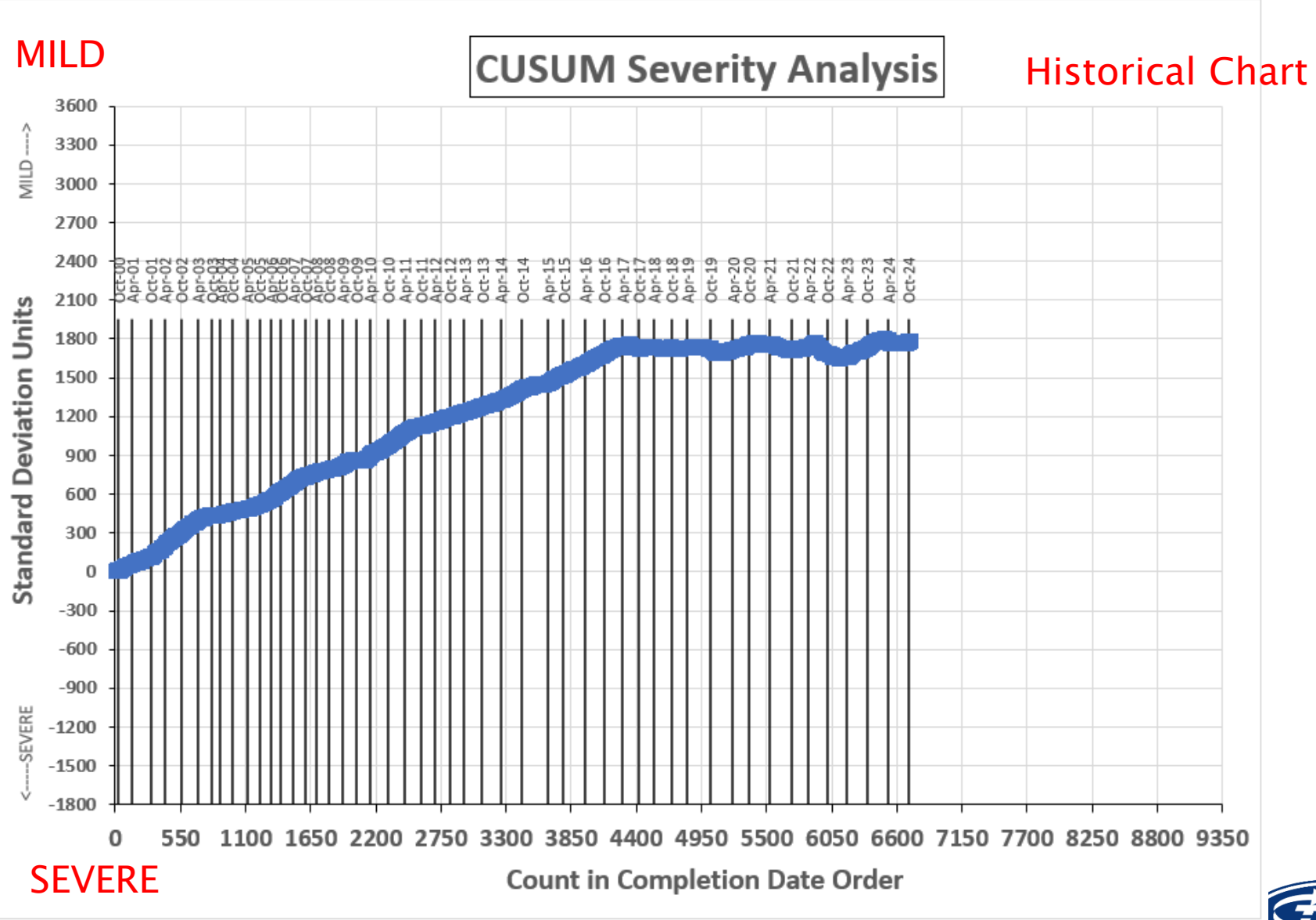
- ▶ With the suspension of Reference Oils 86 and 87 due to severe test results, most data was generated on Reference Oil 1006 (High Reference Oil) and Reference Oil 82-1 (Low Reference Oil). However, Reference Oil 82-1 started to show a mild trend, and it was subsequently also removed from assignment rotation leaving only Reference Oil 1006 available for assignments.
- ▶ Ball Bearing Batch E was tested to determine if it could be a replacement for current Ball Bearing Batch D. Data supported the replacement and Batch E Ball Bearings are now being used in the BRT with no change from the current Acceptance Bands for Reference Oils 1006 and 82-1. A follow-up Round Robin with RO's 86 and 87 with Ball Bearing Batch E has just recently started.

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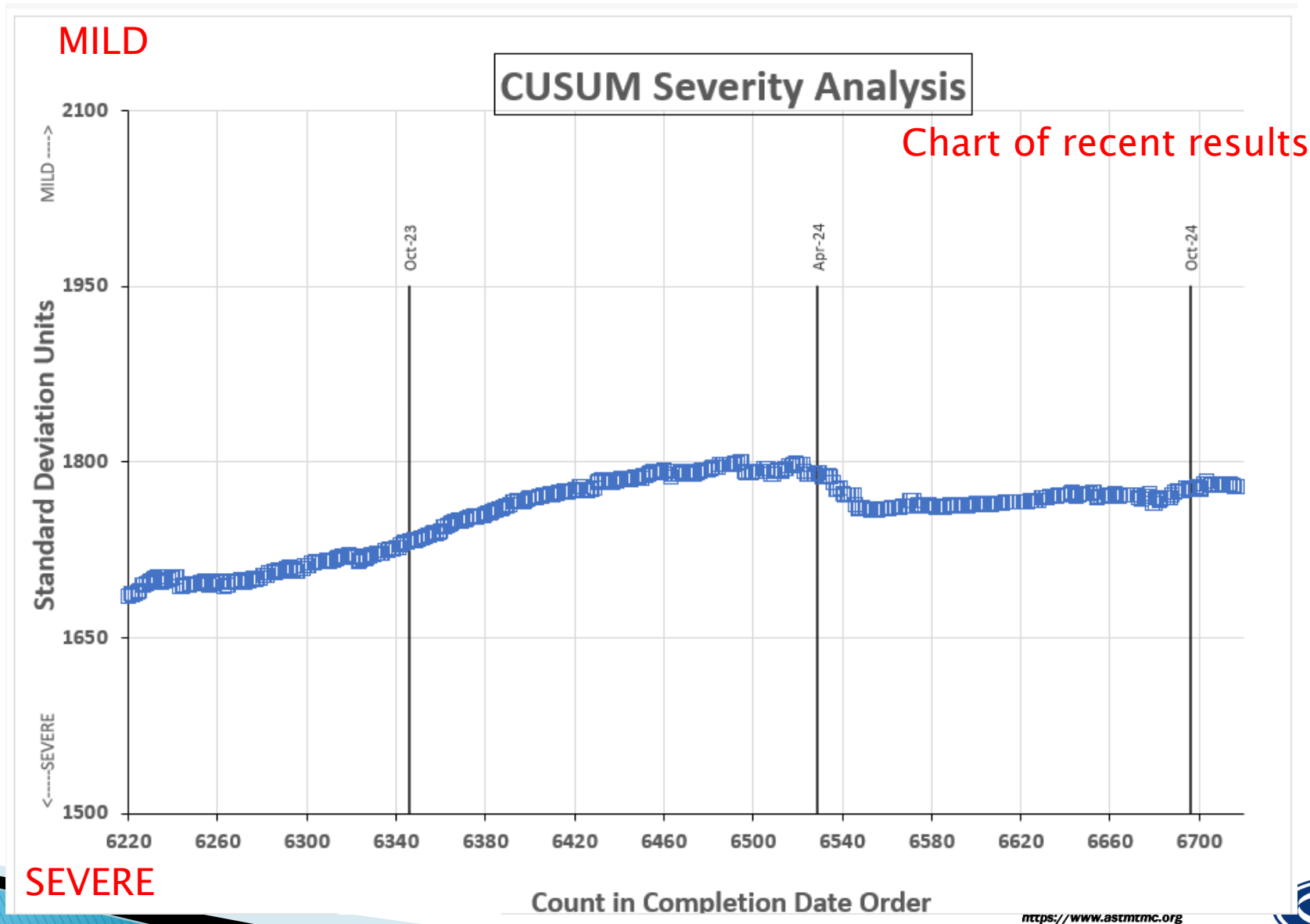
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REFERENCE AVERAGE GRAY VALUE

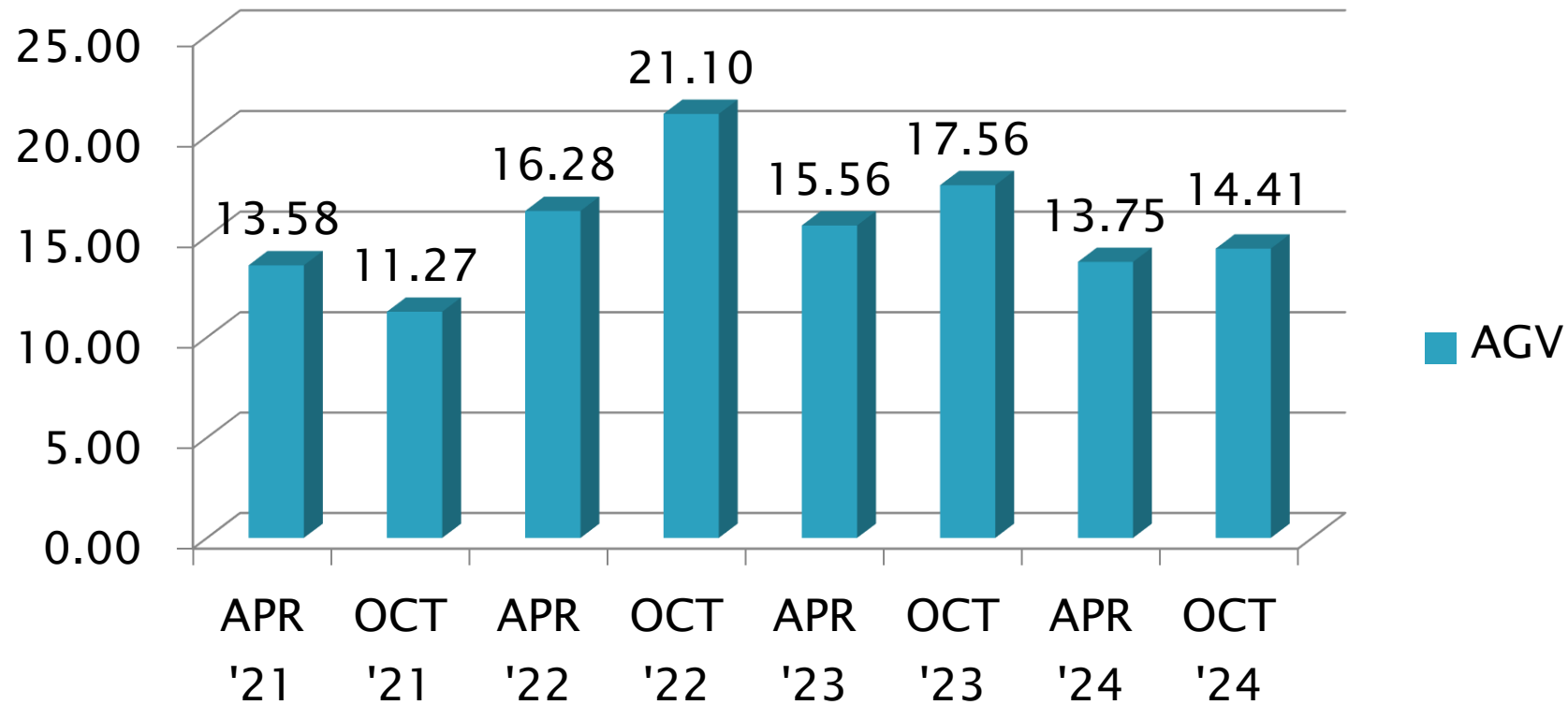


BALL RUST TEST INDUSTRY OPERATIONALLY VALID DATA
Last 500 Points
REFERENCE AVERAGE GRAY VALUE



BRT Precision (Pooled s) Estimates

AGV

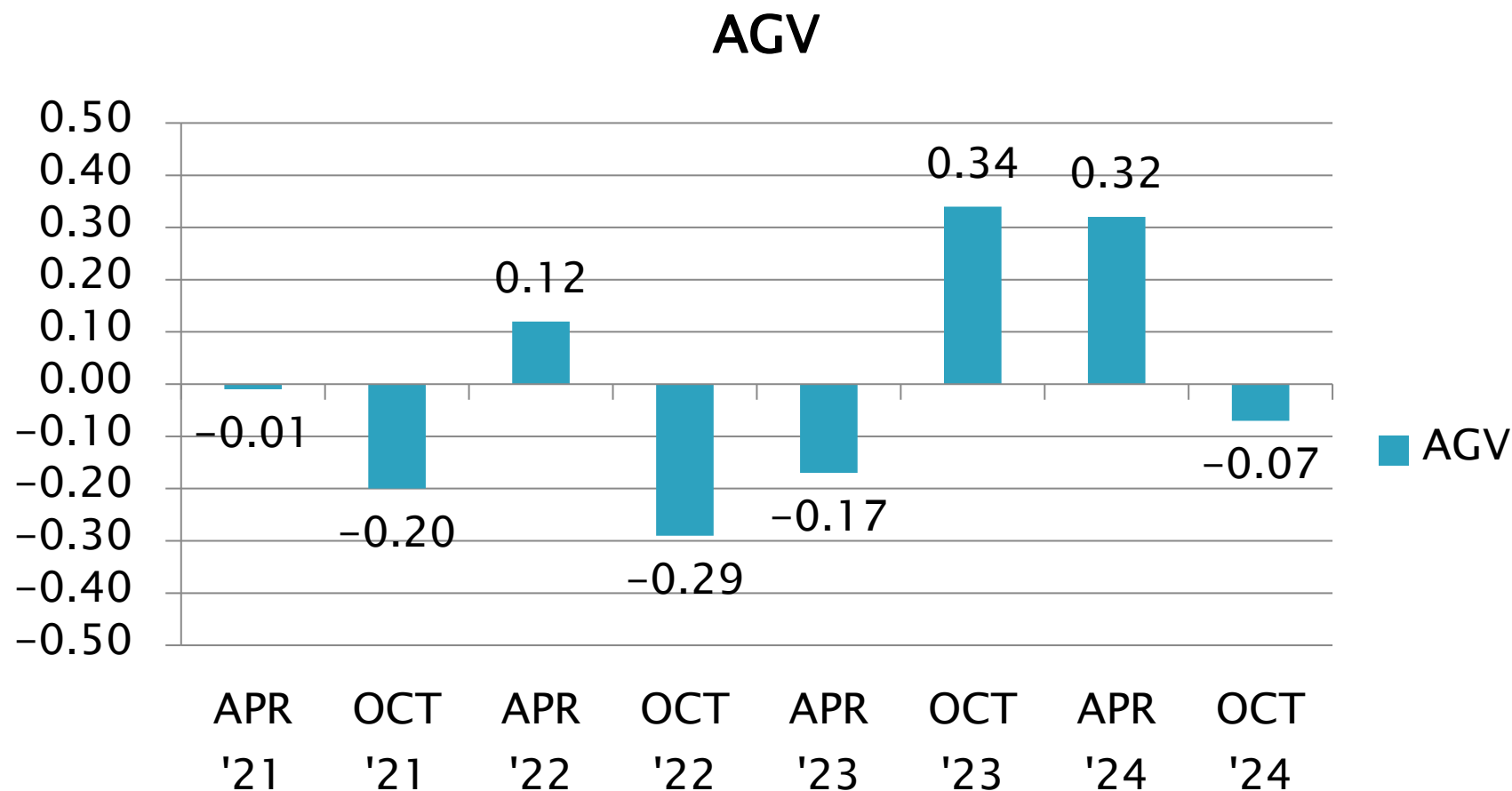


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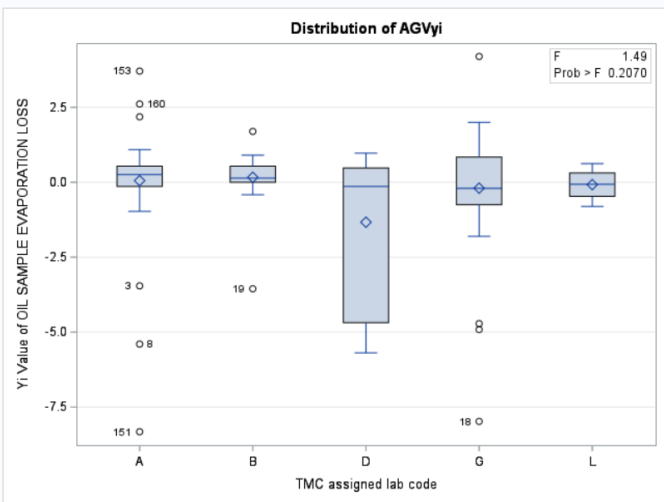
BRT Performance (Mean Δ/s) Estimates



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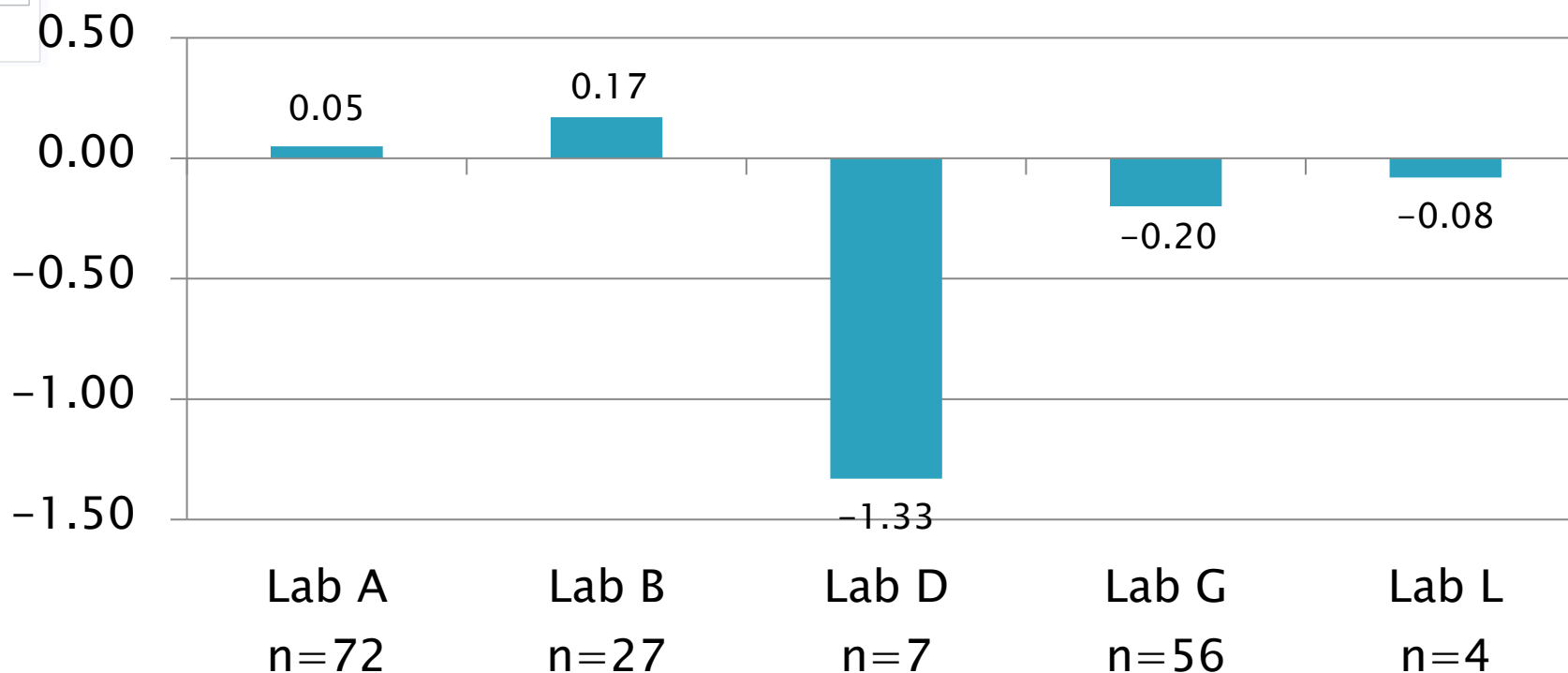
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BRT Lab Severity Estimates

AGV
Mean Δ/s



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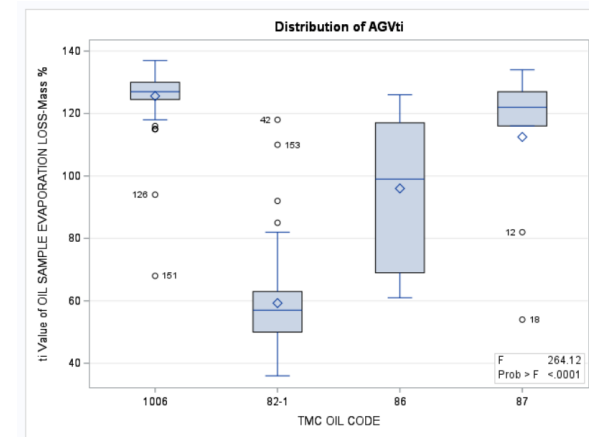
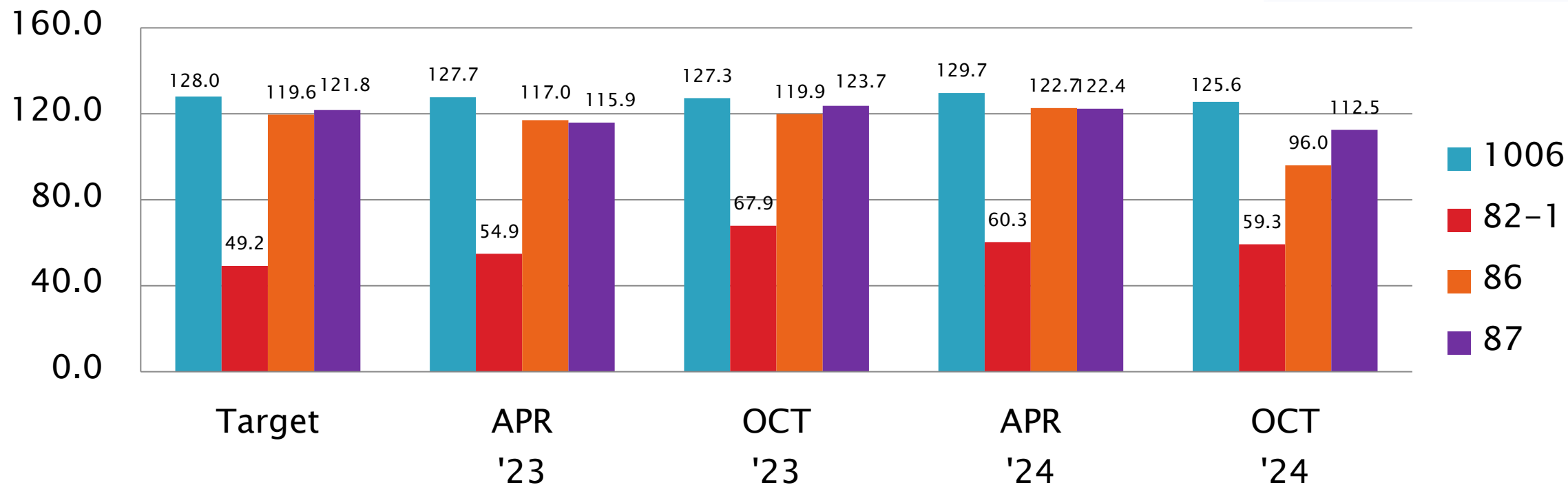
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BRT Performance by OIL

Average Gray Value Mean



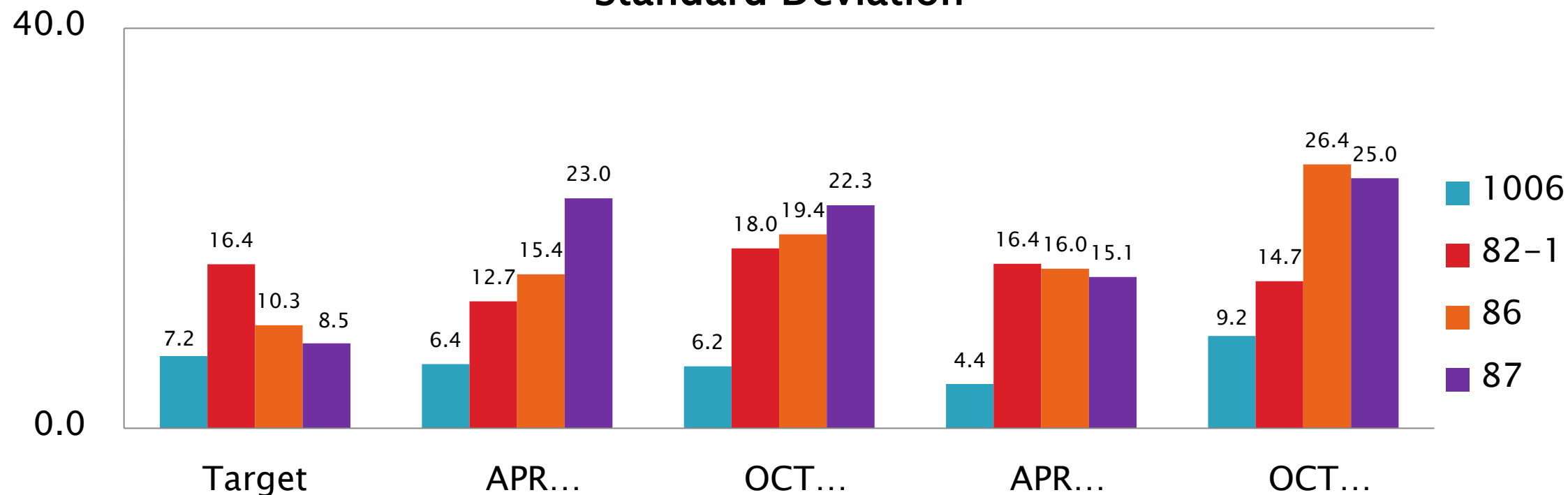
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BRT Performance by OIL

Average Gray Value
Standard Deviation

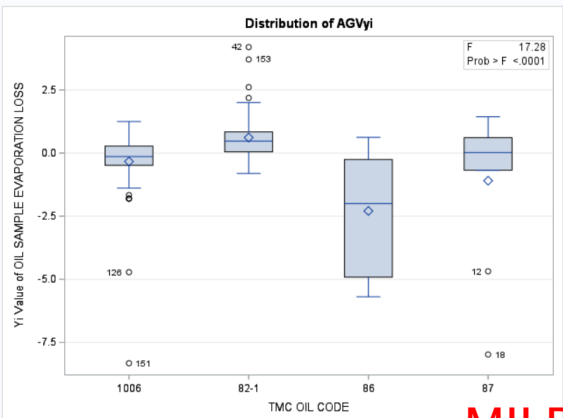


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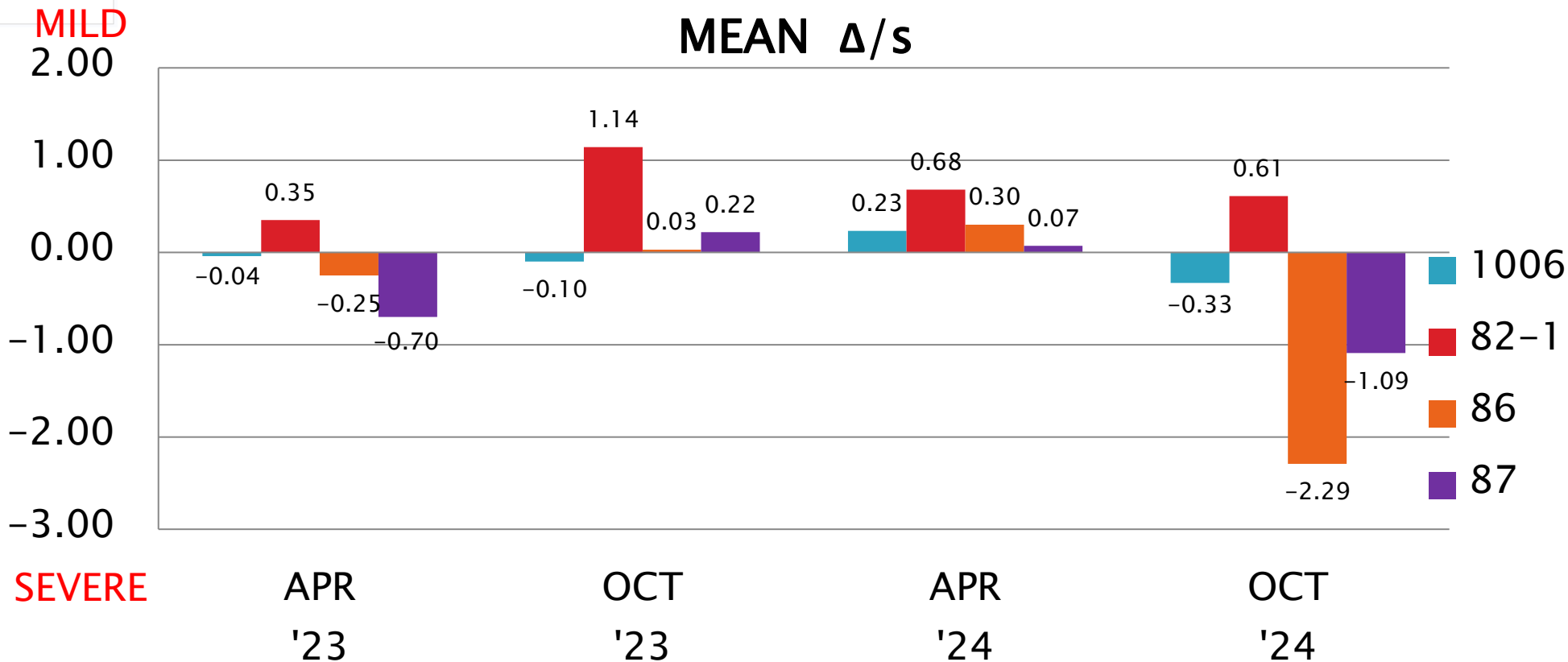


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BRT Performance by OIL

Average Gray Value
MEAN Δ/s



April 1, 2024 – September 30, 2024

Information Letters & Memos*

Test	Date	IL / Memo	Topic
BRT	20240503	Mem24-016	Suspension of assignments of Reference Oils 86 and 87
BRT	20240914	Mem24-025	TMC Investigation of Reference Oil 86 and 87 Performance

*Available from TMC Website

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Test Monitoring Center
<https://www.astmtmc.org>



Reference Oil Inventory Estimated Life

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Total Assignments ¹ made over Semester	Estimated Life
1006	27.66	1.24	98	5+ years
82-1	0.5	1.0	108	< 1 year
86	49.0	0.1	17	5+ years
87	92.9	0.1	11	5+ years

¹– Includes Informational (i.e. “Shakedown”) run assignments

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D02.B0.07

TMC Monitored Tests



ASTM D 6594

High Temperature Corrosion Bench Test (HTCBT)

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report in parentheses)

Test	Labs	Stands
D6594	10 (+2)	26 (+3)
*As of 9/30/2024		

HTCBT Test Activity*

Test Status	Validity Code	Number of Tests
Acceptable Calibration Test	AC	223
Failed Calibration Test	OC	21 ¹
Operationally Invalid, by lab	LC	3
Aborted Calibration Test	XC	0
Information Run in Range	NN	1
Information Run out of Range	MN	5
Total		253

10 labs reported data (2 more from previous semester)

¹ An increase of 1 from previous semester

April 1, 2024 – September 30, 2024

Test Monitoring Center
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HTCBT Failed Tests

Failed Parameter	Number of Tests
Lead Concentration Severe	3
Lead Concentration Mild	6
Copper Concentration Severe	5
Copper Concentration Mild	3
Lead and Copper Concentrations (both) Severe	2
Copper Mild and Lead Severe	2
Total	21

NOTE: Of the 20 failing tests
8 (38.1%) were on runs with 1005-5 Reference Oil
1 (4.8%) were on runs with 44-4 Reference Oil
12 (57.1%) were on runs with 44-5 Reference Oil

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Test Monitoring Center
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HTCBT Failed Tests by Lab

Failed Parameter	LTMS Lab										#
	A	L	G	I	V	BB	BC	B	P	BE	
Lead Concentration Severe	0	0	1	1	1	0	0	0	0	0	3
Lead Concentration Mild	0	0	6	0	0	0	0	0	0	0	6
Copper Concentration Severe	0	0	3	0	0	0	0	0	0	2	5
Copper Concentration Mild	0	0	3	0	0	0	0	0	0	0	3
Lead and Copper Concentrations (both) Severe	0	0	1	0	0	0	0	0	0	1	2
Copper Mild and Lead Severe	0	1	1	0	0	0	0	0	0	0	2
Total	0	1	15	1	1	0	0	0	0	3	21

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Test Monitoring Center
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HTCBT Lost Tests*

Status (LC, XC)	Cause	#
Invalid	Test contaminated with water from condenser	1
Invalid	Technician Training Run	1
Invalid	Unknown Black Contamination on Coupon	1
Total		3

*Invalid or Aborted calibration tests

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Test Monitoring Center
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HTCBT Lost Tests by Lab

Failed Parameter (LC, XC)	LTMS Lab										#
	A	L	G	I	V	BB	BC	B	P	BE	
Test contaminated with water from condenser	0	0	0	0	1	0	0	0	0	0	1
Technician Training Run	1	0	0	0	0	0	0	0	0	0	1
Unknown Black Contamination on Coupon	1	0	0	0	0	0	0	0	0	0	1
Total	2	0	0	0	1	0	0	0	0	0	3

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HTCBT Test Status

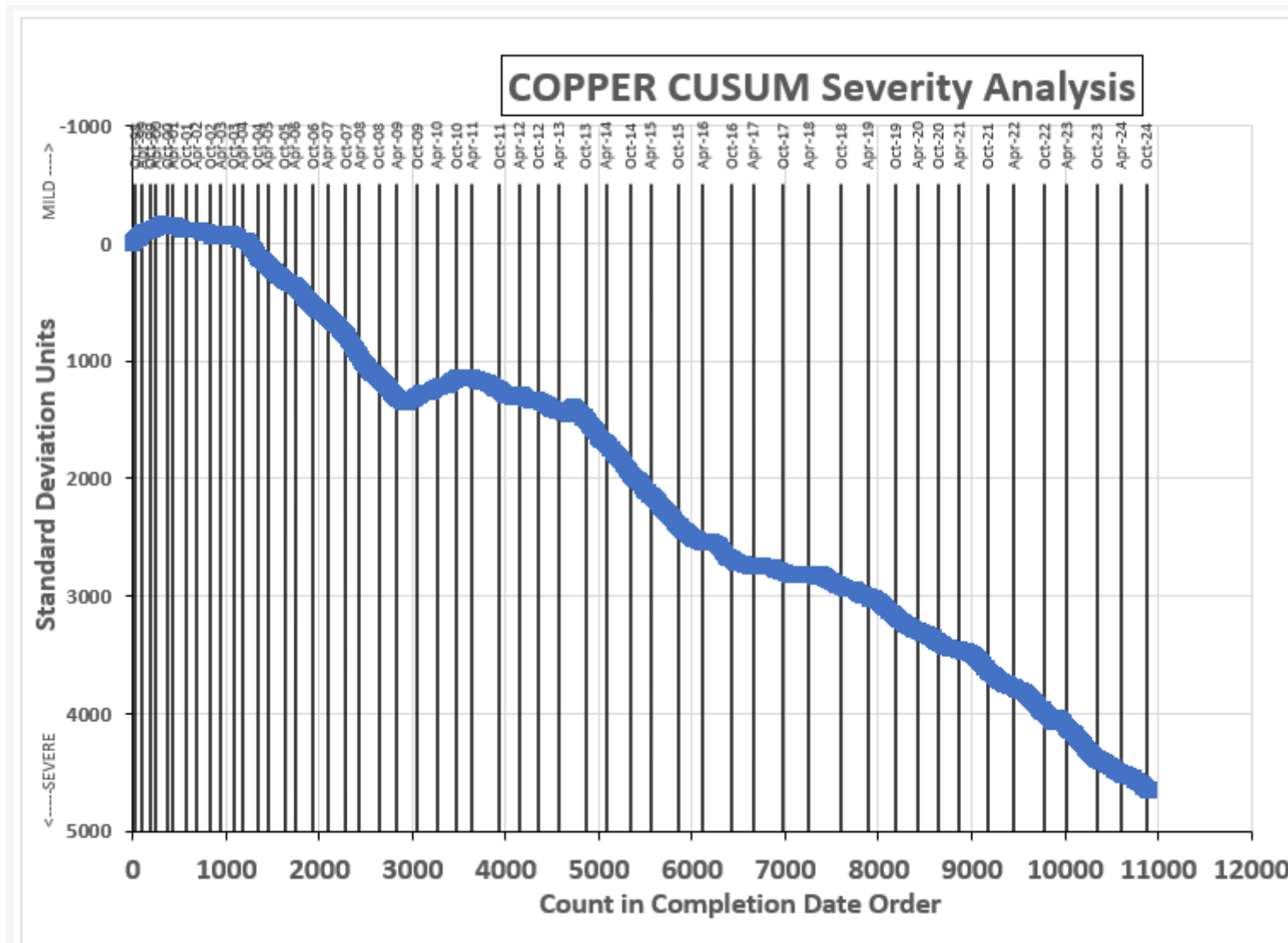
- ▶ Labs now using Batch P coupons. Pass/Fail limits were kept at current ranges for RO's 1005-5, 44-5.
- ▶ Few TESTKEYs of Reference Oil 44-4 remaining at labs. Most labs now using Reference Oil 44-5.
- ▶ Two labs resumed testing, and three more stands were calibrated this semester

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COPPER CHANGE (ppm)



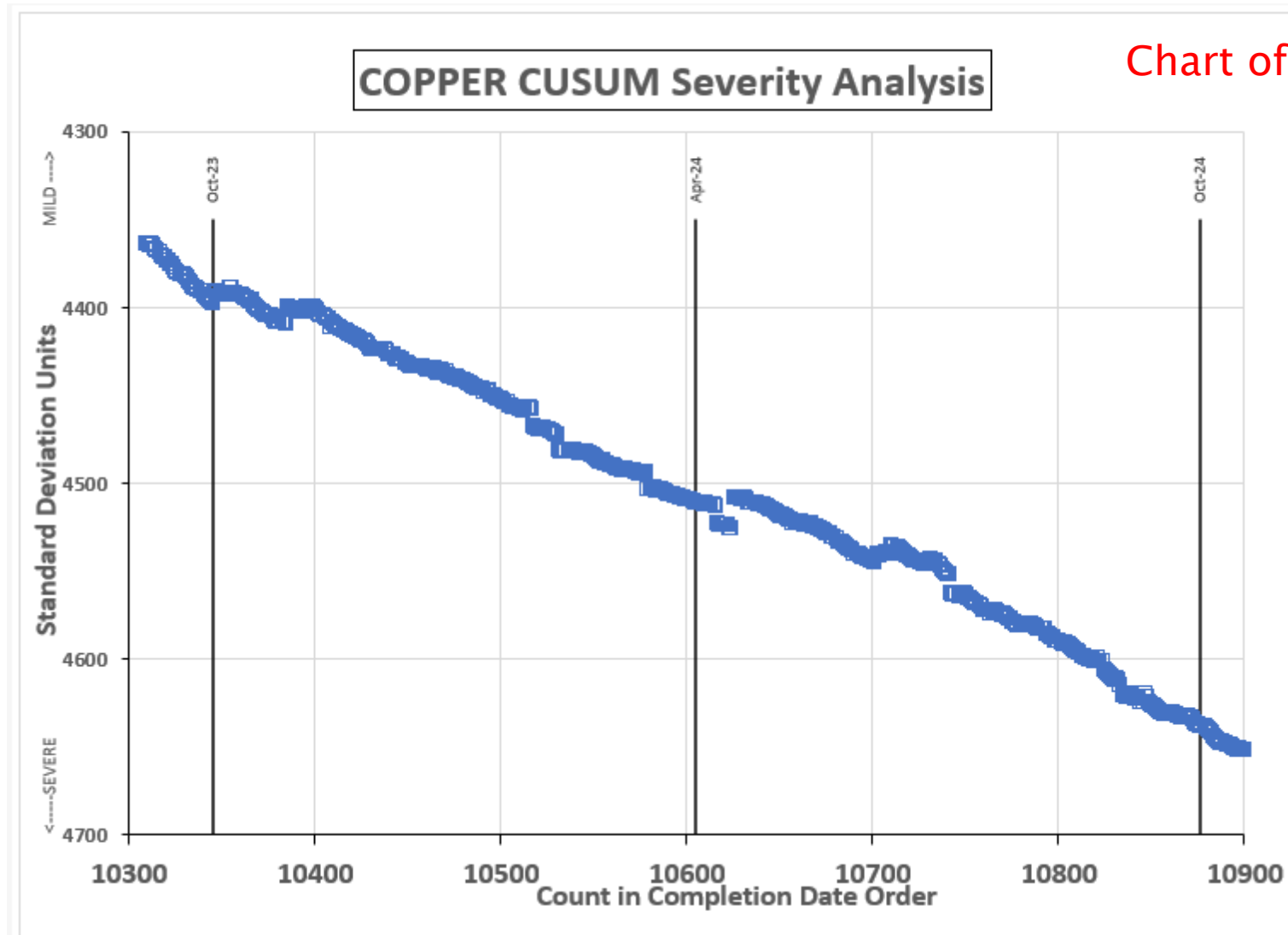
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HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
LAST 600 DATA POINTS
COPPER CHANGE (ppm)



Chart of recent results

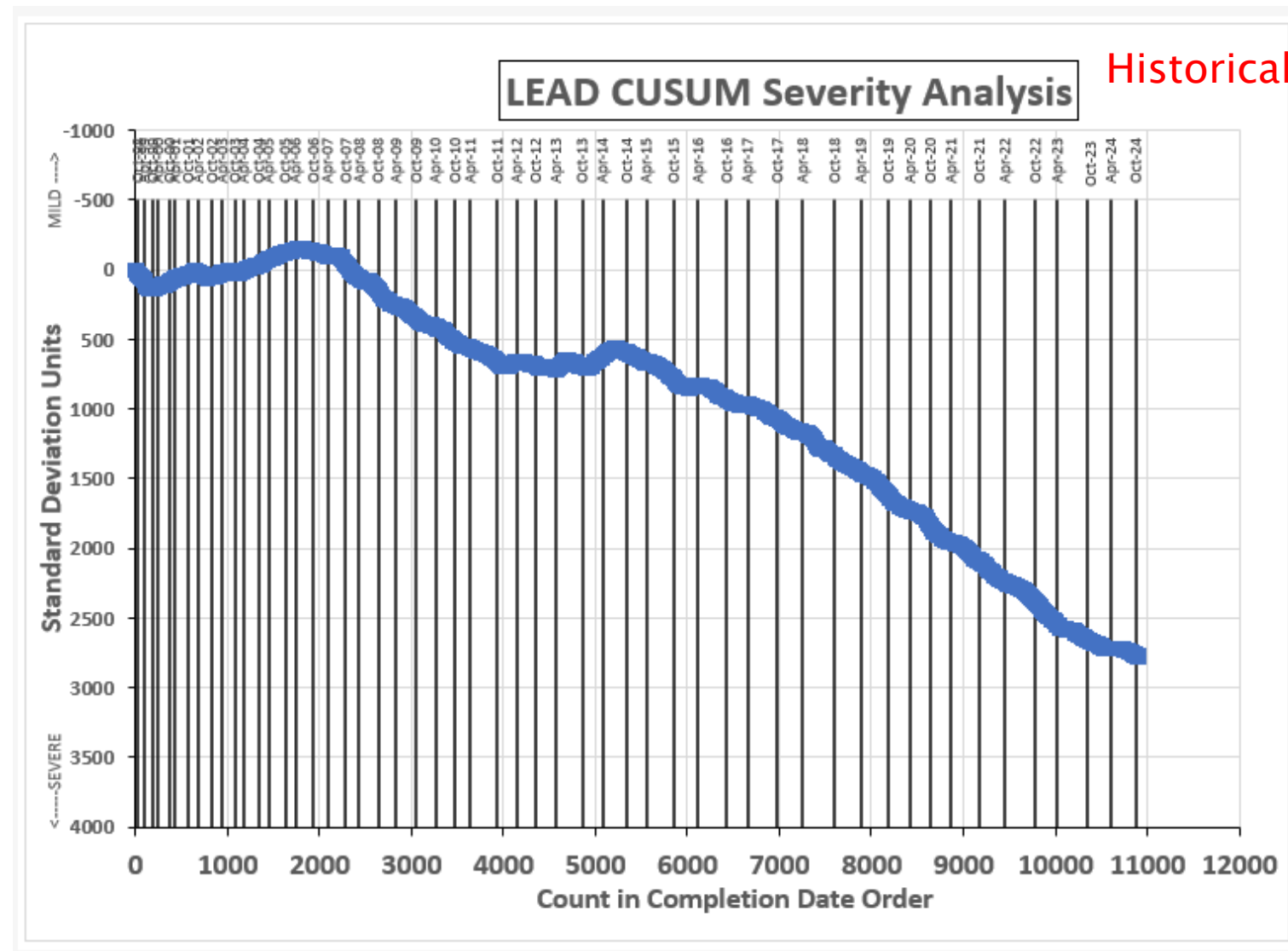


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Test Monitoring Center
<https://www.astmtmc.org>



LEAD CHANGE (ppm)



April 1, 2024 – September 30, 2024

HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
LAST 600 DATA POINTS
LEAD CHANGE (ppm)

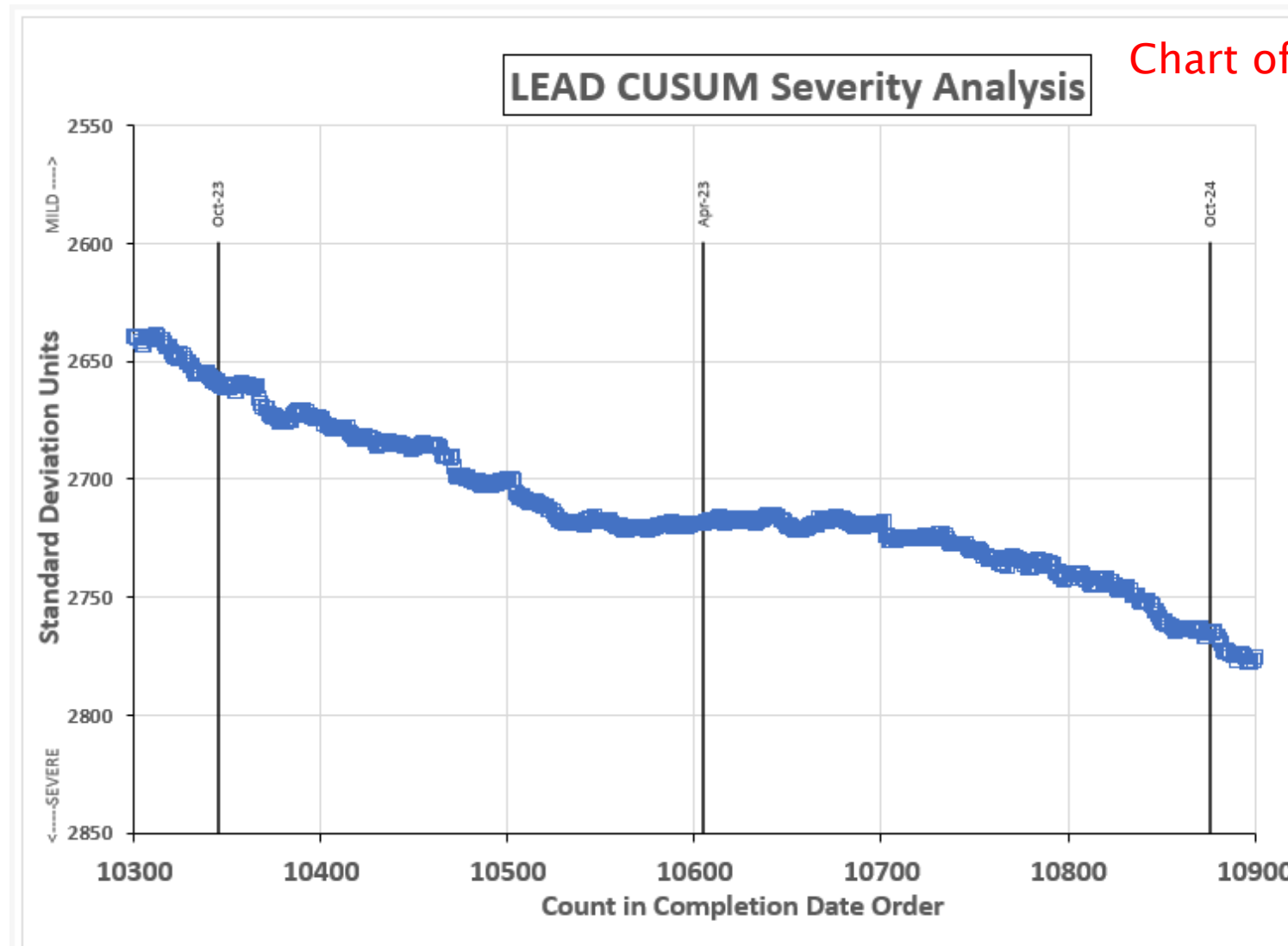


Chart of recent results

April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>

HTCBT (D6594): High Temperature Corrosion Bench Test

Period Precision and Severity Estimates: Copper Change

Date Range	n	df	Pooled s	Mean Δ/s
10/1/21 through 3/31/22	305	302	0.31	0.53
4/1/22 through 9/30/22	306	303	0.33	0.63
10/1/22 through 3/31/23	263	260	0.66	0.57
4/1/23 through 9/30/23	296	293	0.34	0.87
10/1/23 through 3/31/24	287	284	0.44	0.39
4/1/24 through 9/30/24	244	241	0.38	0.53

*Period statistics for all Valid Reference Oil Results (pooled)

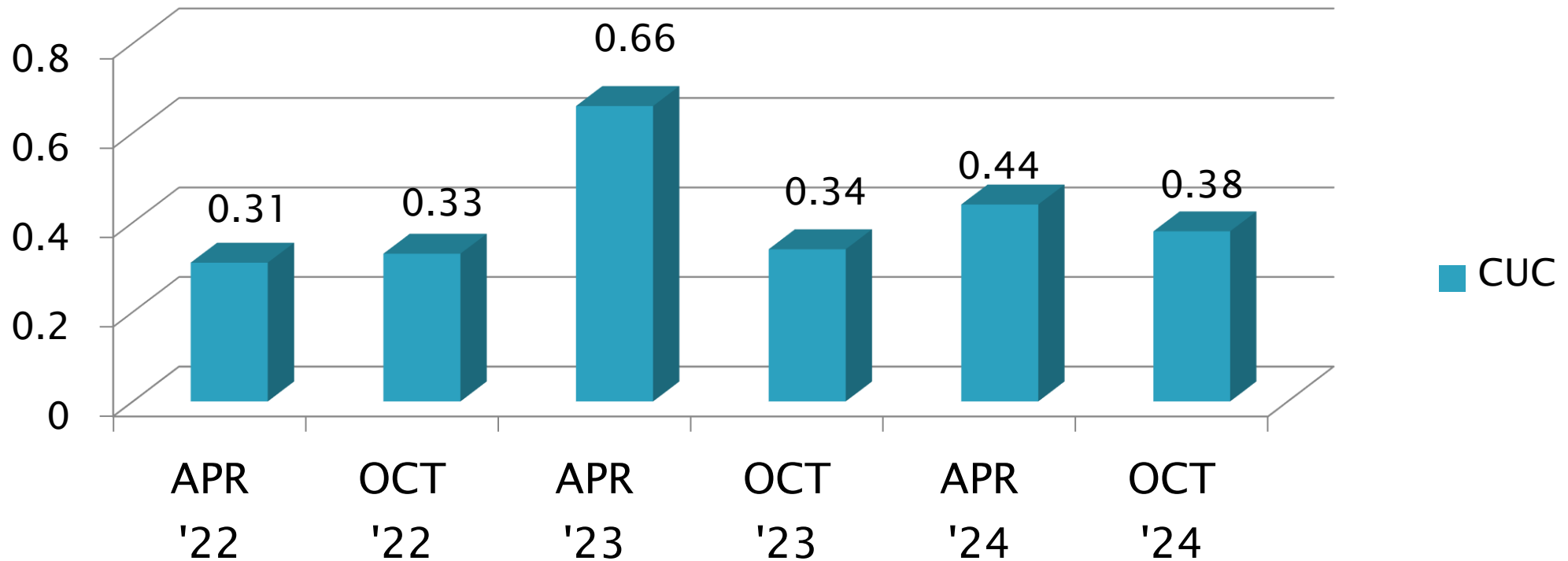
April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



HTCBT Precision (Pooled s) Estimates

COPPER CHANGE



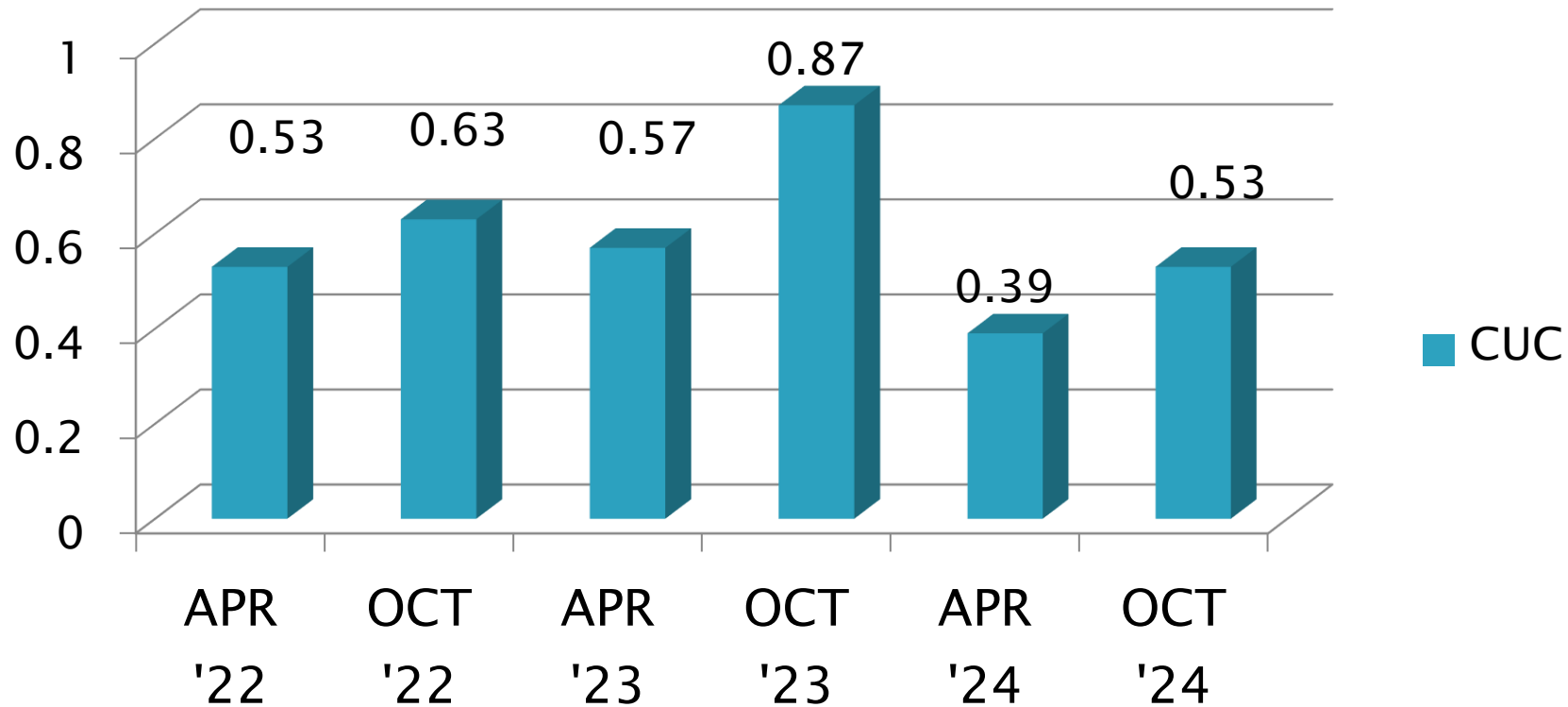
April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



HTCBT Performance (mean Δ/s) Estimates

COPPER CHANGE



April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



HTCBT (D6594): High Temperature Corrosion Bench Test

Period Precision and Severity Estimates: Lead Change

Average Gray Value	n	df	Pooled s	Mean Δ/s
10/1/21 through 3/31/22	305	302	8.20	0.55
4/1/22 through 9/30/22	306	303	5.72	0.43
10/1/22 through 3/31/23	263	260	11.6	0.69
4/1/23 through 9/30/23	296	293	6.91	0.31
10/1/23 through 3/31/24	287	284	6.89	0.20
4/1/24 through 9/30/24	244	241	7.29	0.20

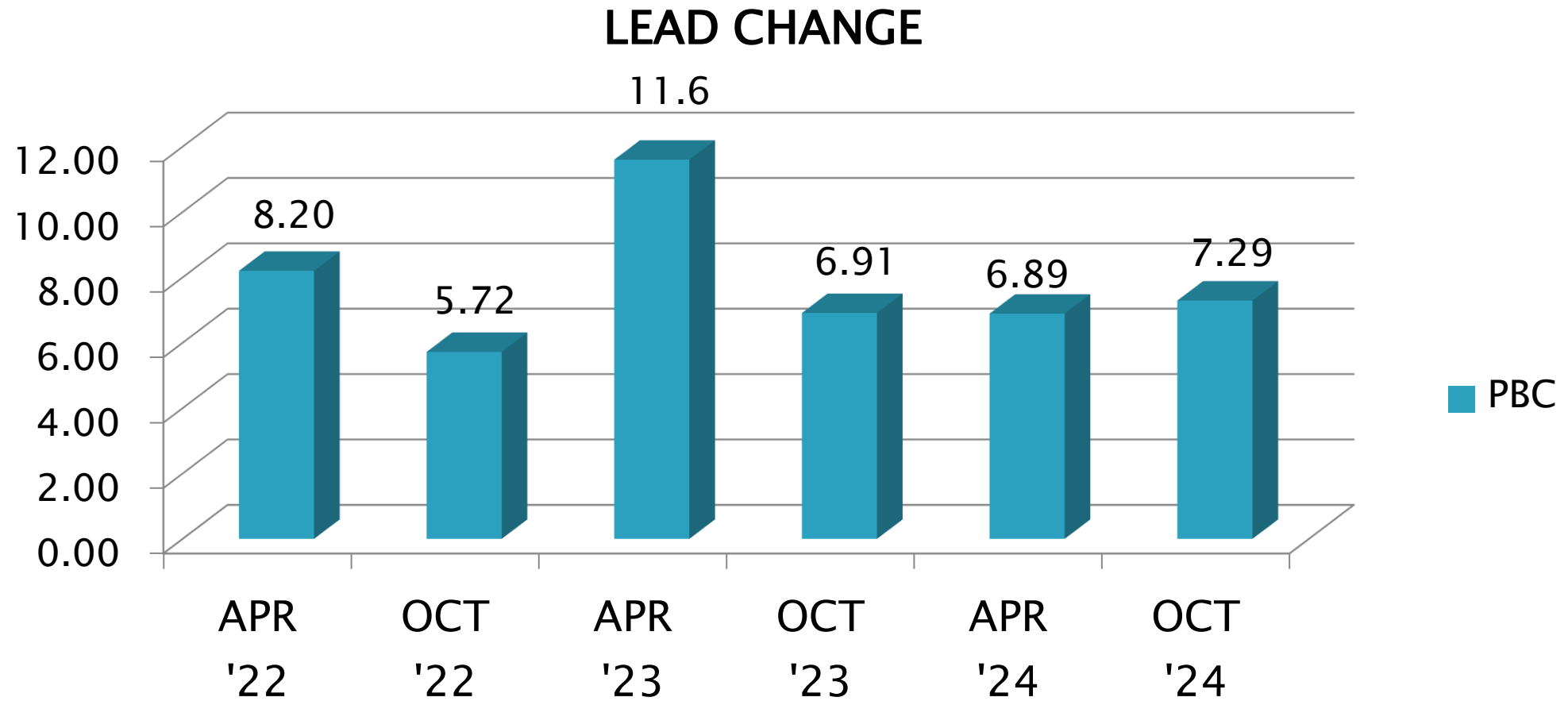
*Period statistics for all Valid Reference Oil Results (pooled)

April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



HTCBT Precision (Pooled s) Estimates

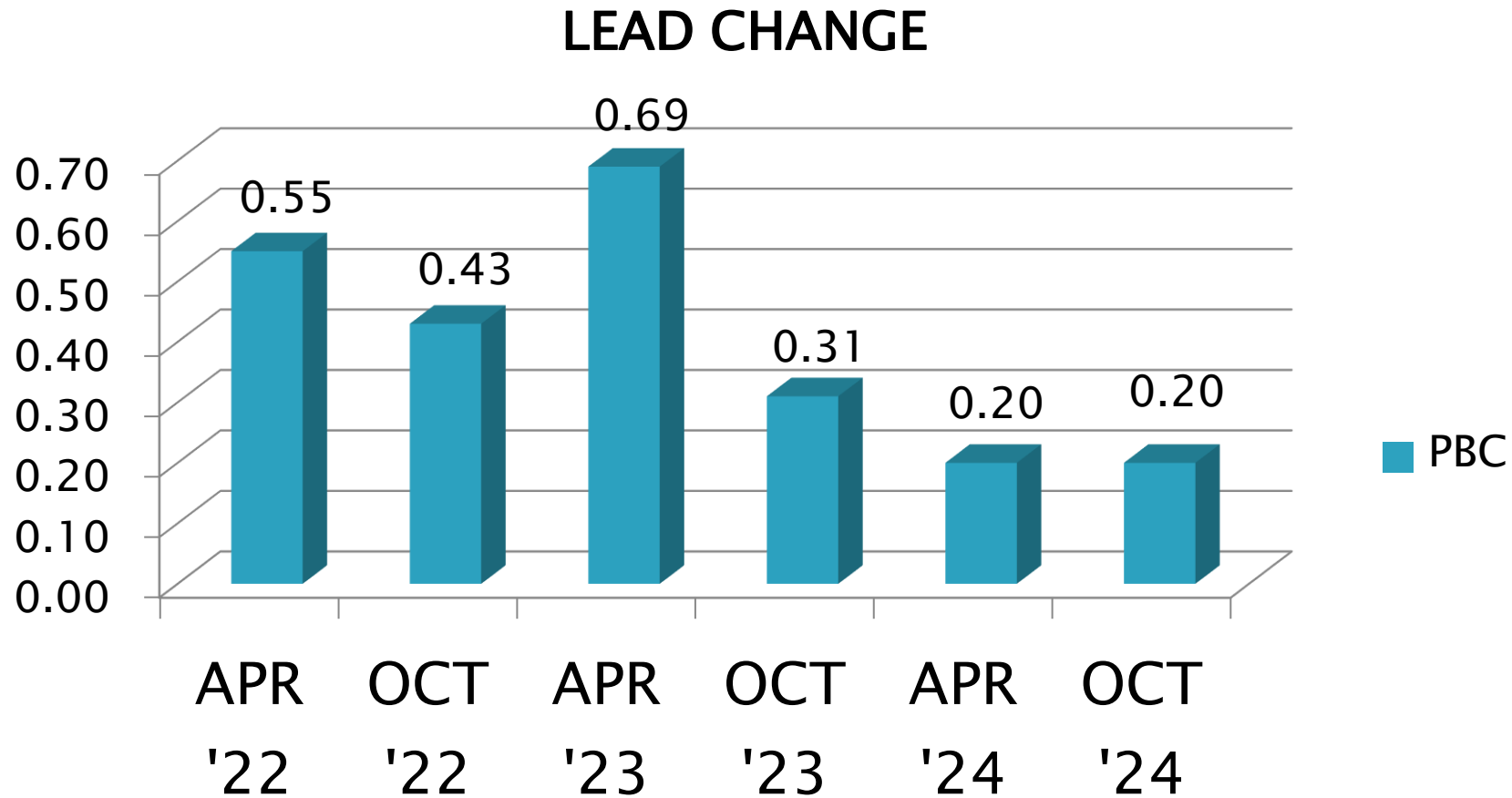


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Test Monitoring Center
<https://www.astmtmc.org>



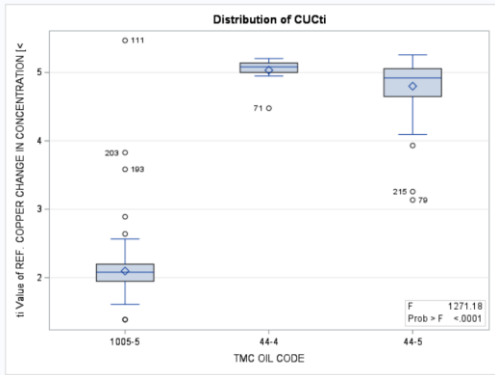
HTCBBT Performance (mean Δ/s) Estimates



April 1, 2024 – September 30, 2024

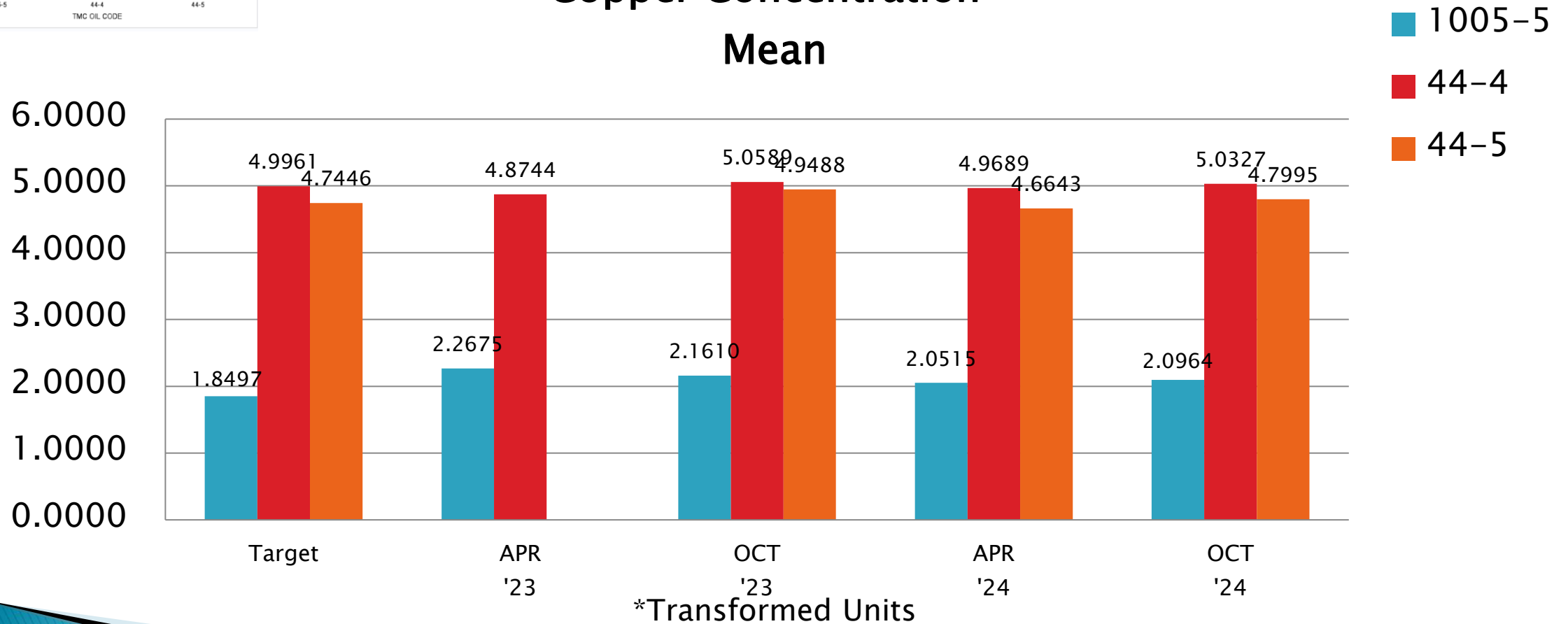
Test Monitoring Center
<https://www.astmtmc.org>





HTCBT Performance by OIL

Copper Concentration* Mean



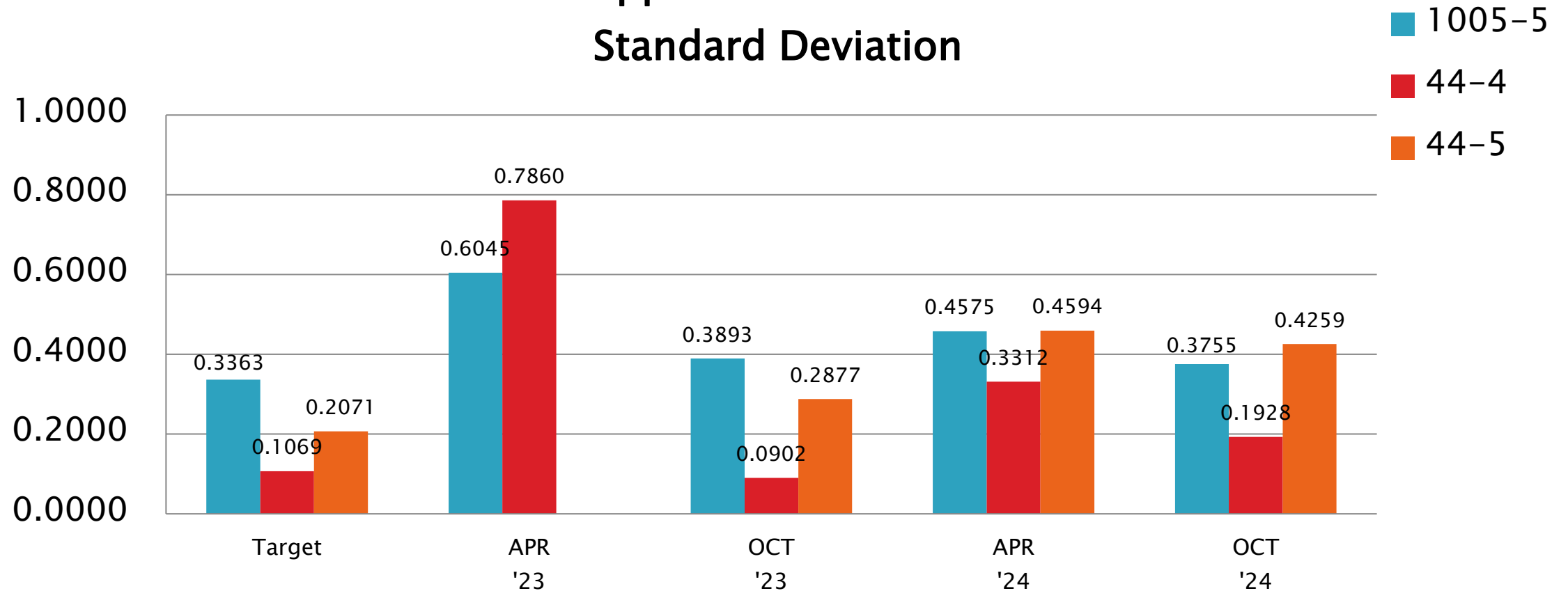
April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



HTCBT Performance by OIL

Copper Concentration Standard Deviation



April 1, 2024 – September 30, 2024

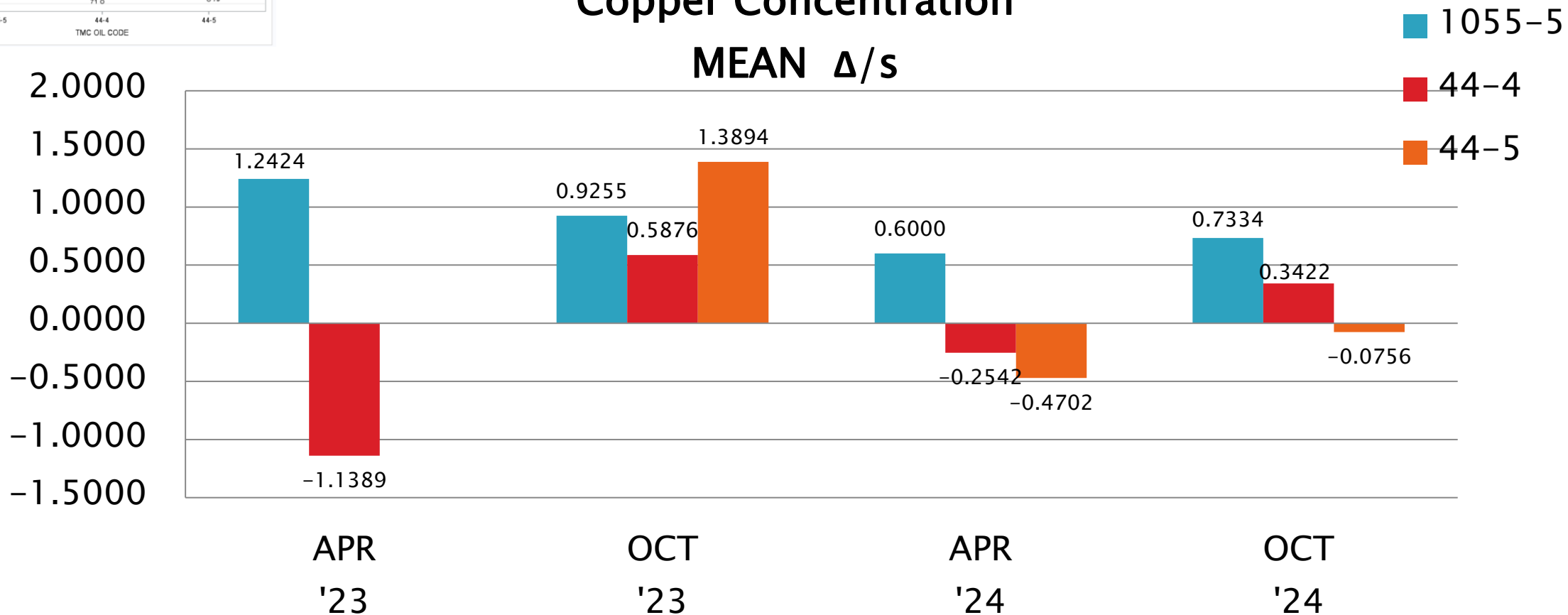
Test Monitoring Center
<https://www.astmtmc.org>



HTCBT Performance by OIL

Copper Concentration

MEAN Δ/s

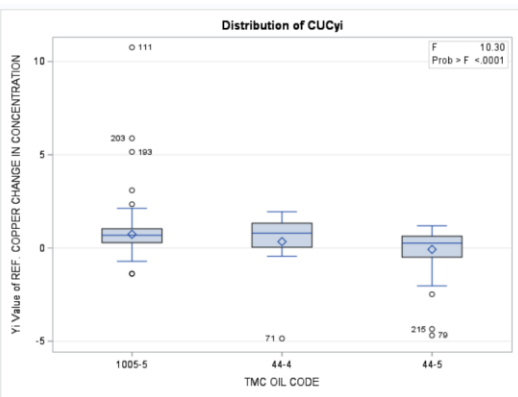


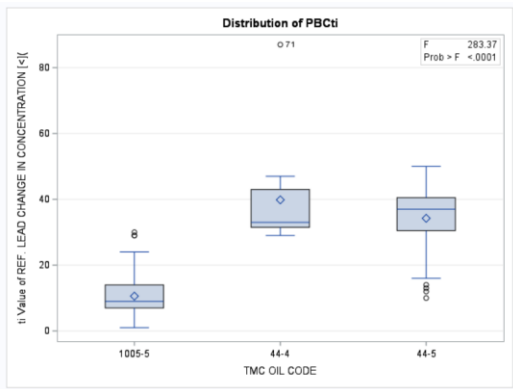
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Test Monitoring Center
<https://www.astmtmc.org>



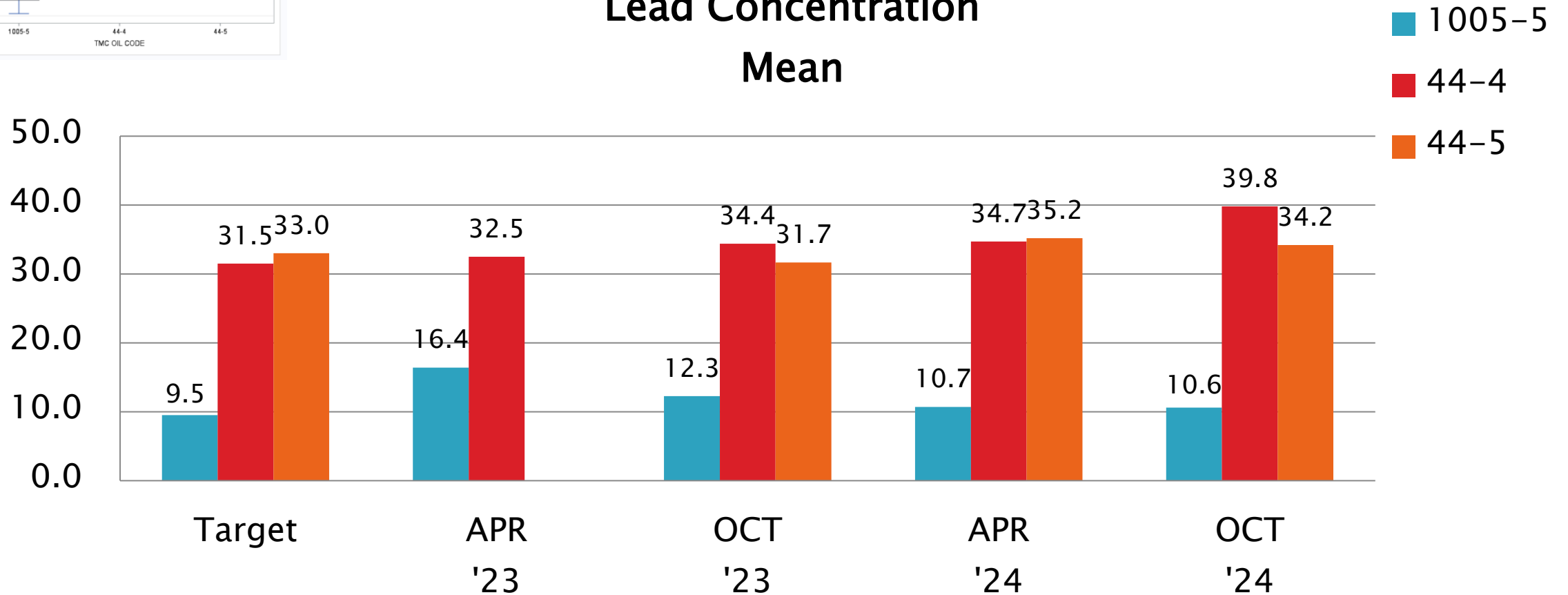
A Program of ASTM International





HTCBT Performance by OIL

Lead Concentration Mean



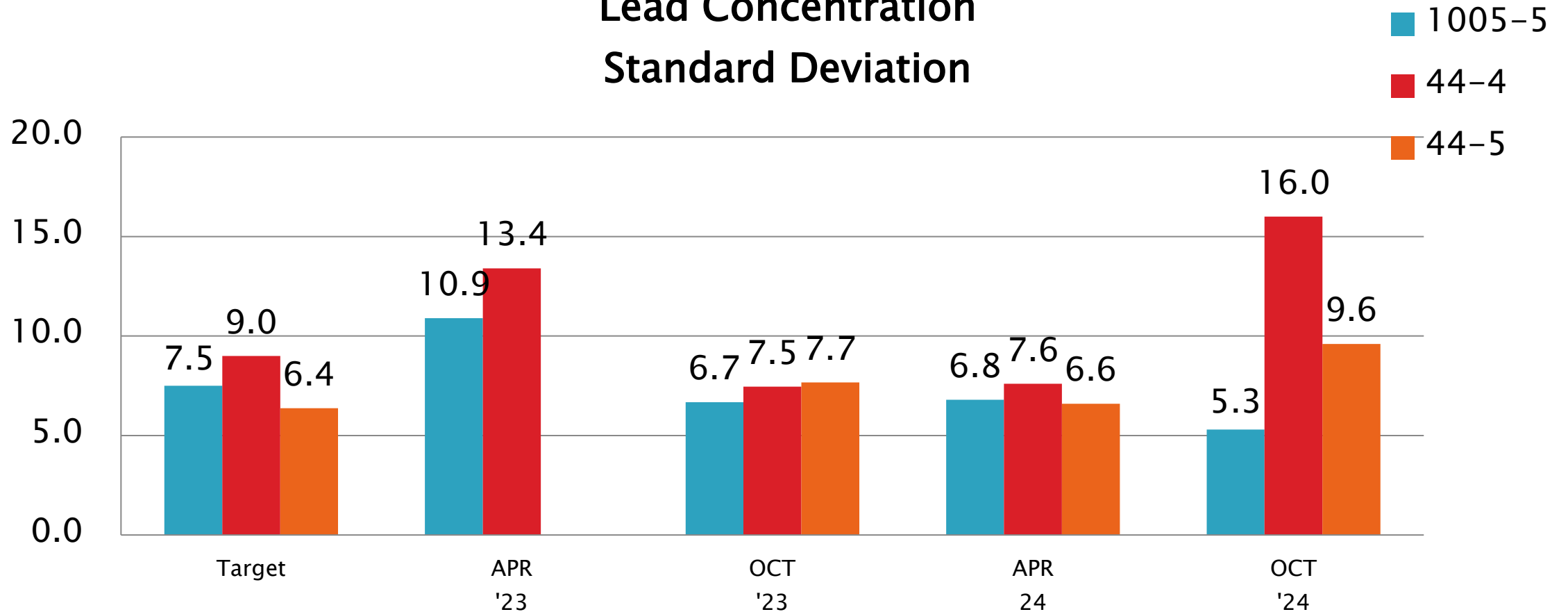
April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



HTCBT Performance by OIL

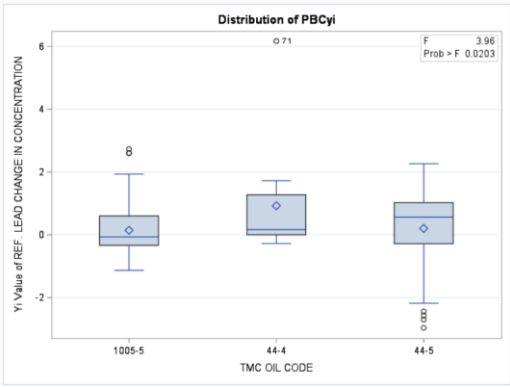
Lead Concentration
Standard Deviation



April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>

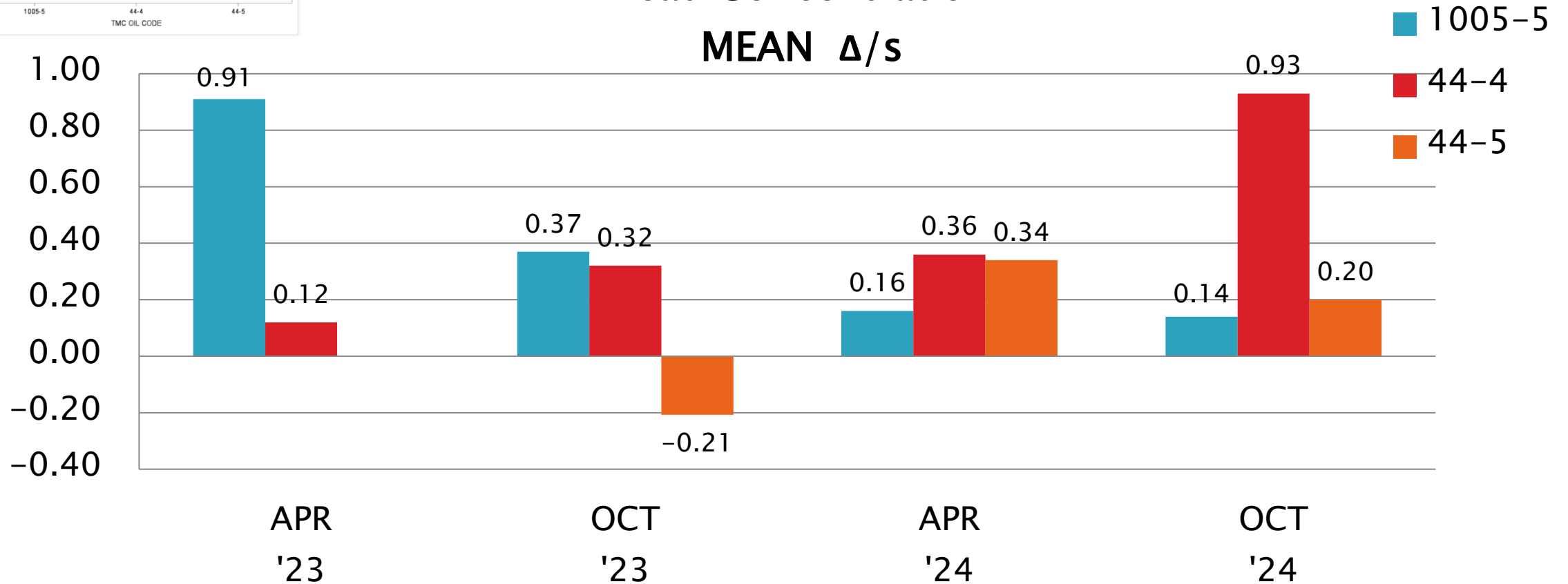




HTCBT Performance by OIL

Lead Concentration

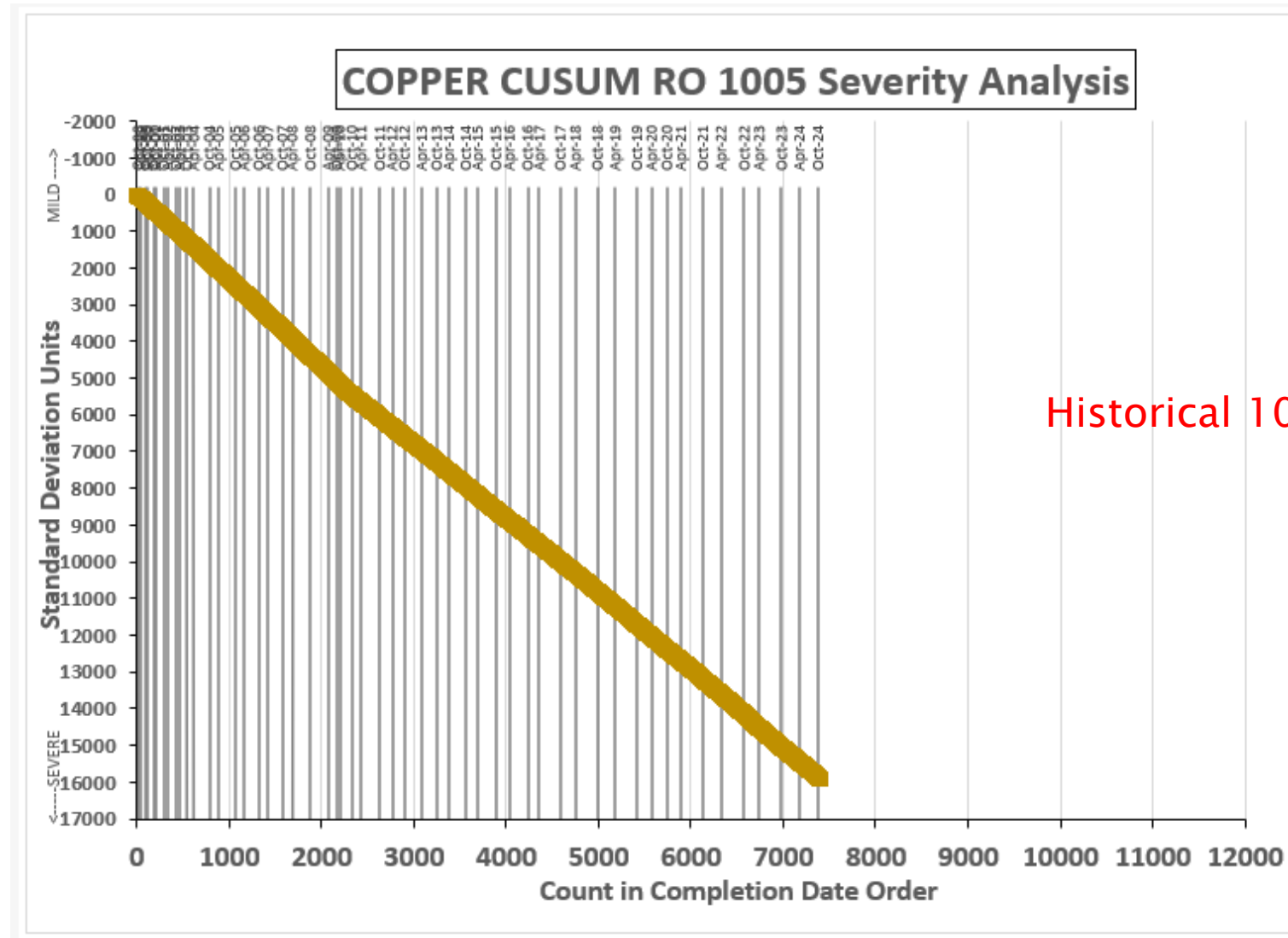
MEAN Δ/s



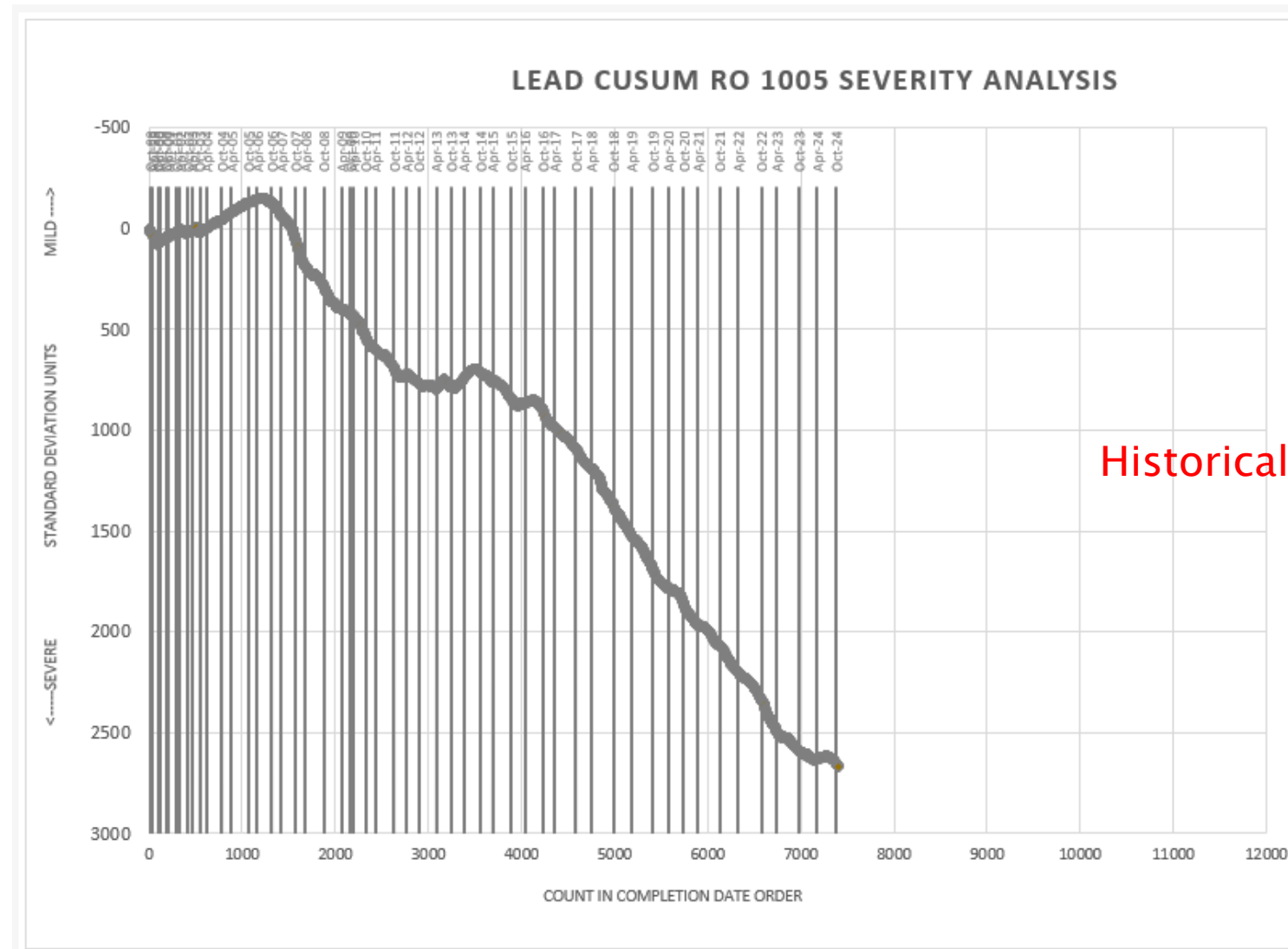
April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



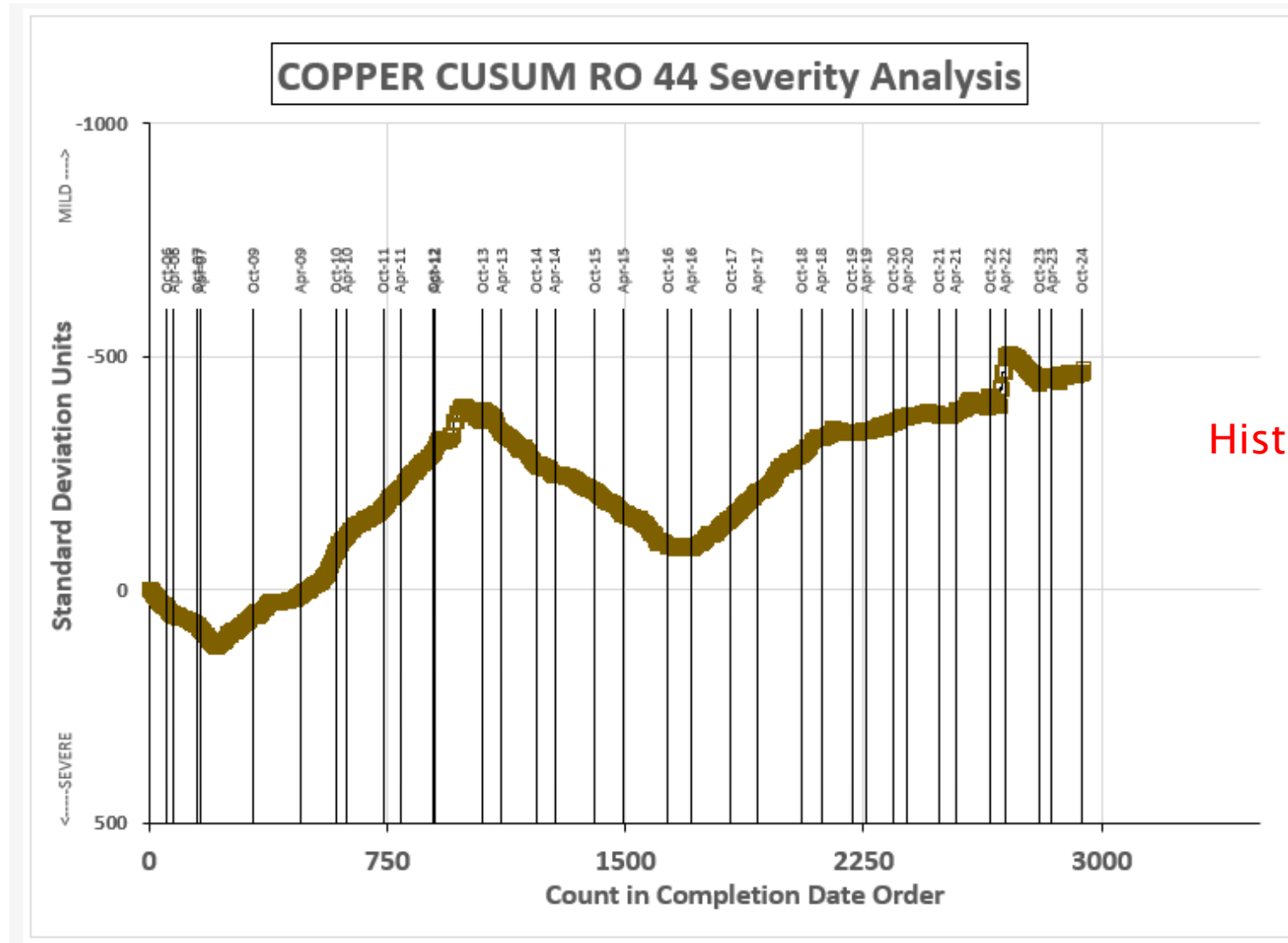


Historical 1005-x Chart



Historical 1005-x Chart

HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Oil 44 → Only
COPPER CHANGE (ppm)

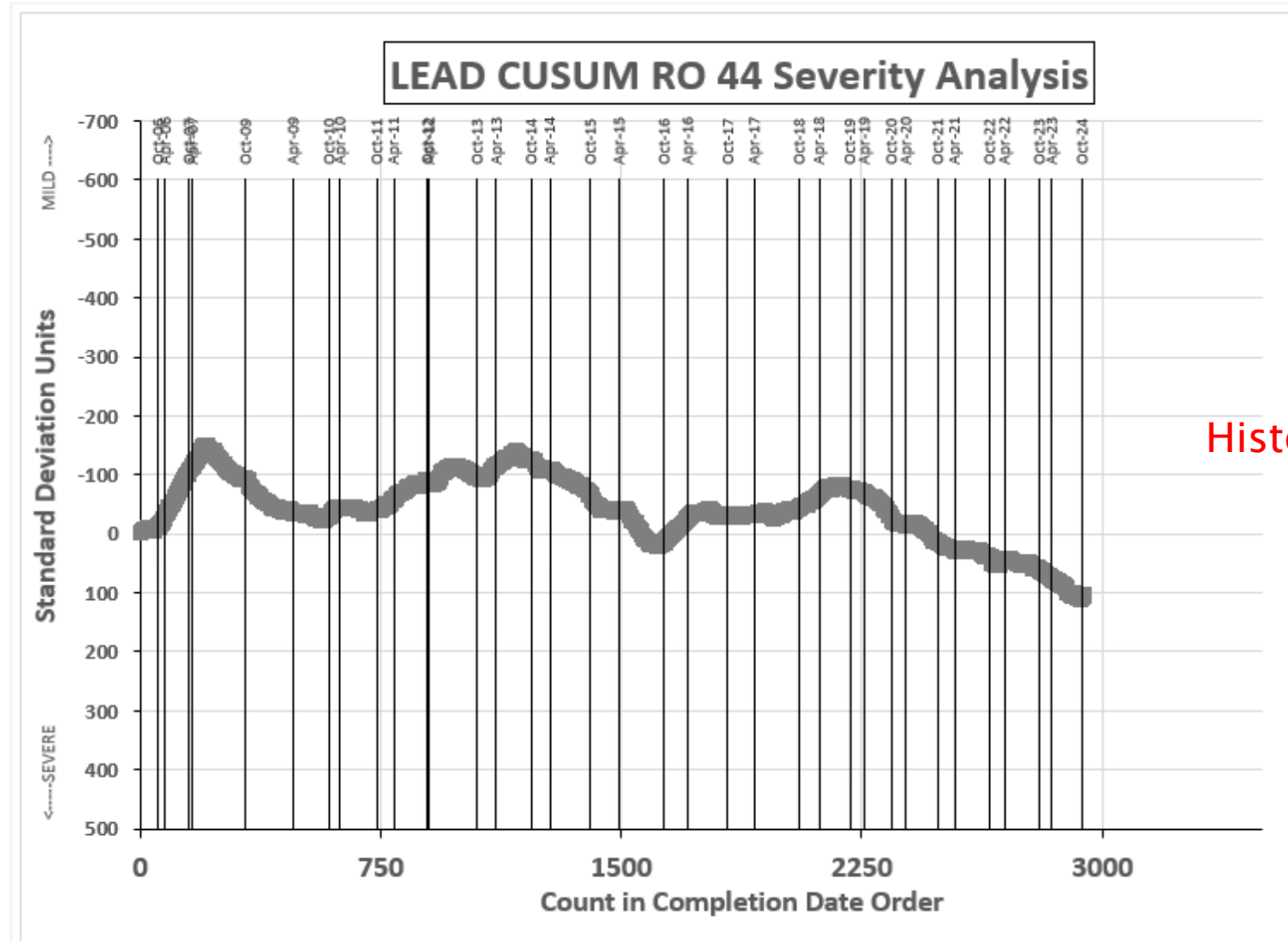


Historical 44-x Chart

April 1, 2024 - September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>





Historical 44-x Chart

Information Letters and Memos*

Test	Date	IL/Memo	Topic
HTCBT			

No new Information Letters or Memos issued this semester.

*Available from TMC Website

April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



Reference Oil Inventory Estimated Life

D6594

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Lab Assignments Made	Estimated Life
44-4	1.8	0.0	11	N/A
44-5	47.5	4.5	59	5+ year
1005-5	29.0 (Reserved drum - Additional oil available at the TMC)	5.9	186	5+ years

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D02.B0.07

TMC Monitored Tests



ASTM D 6794

Engine Oil Water Tolerance (EOWT)

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6794	5 (-1)	N/A
*As of 9/30/2024		

EOWT Test Activity by Treat Rate

Test Status	Validity Code	Number of Tests by Water Treat Rate				Total
		0.6%	1.0%	2.0%	3.0%	
Acceptable Calibration Test	AC	170	170	170	169	679
Failed Calibration Test	OC	0	1	3	2	6
Acceptable Information Run	NN	0	0	0	0	0
Unacceptable Information Run	MN	0	0	0	0	0
Invalid Calibration Test	LC, RC	1	1	0	0	2
Aborted Calibration Test	XC	1	1	1	2	5
Total		172	173	174	173	692

- 5 labs reported data

April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



EOWT Test Activity by Reference Oil*

Test Status	Validity Code	Number of Tests by Reference Oil		Total
		77-3	79	
Acceptable Calibration Test	AC	336	343	679
Failed Calibration Test	OC	6	0	6
Acceptable Informational Test	NN	0	0	0
Unacceptable Informational Test	MN	0	0	0
Invalid Calibration Test	LC, RC	0	2	2
Aborted Calibration Test	XC	4	1	5
Total		346	346	692

- No Informational runs requested this semester

April 1, 2024 – September 30, 2024

Test Monitoring Center
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EOWT Failed Tests

Failed Parameter (OC)	Number of Tests				Total
	0.6%	1.0%	2.0%	3.0%	
Severe Change in Flowrate	0	0	2	0	2
Mild Change in Flowrate	0	1	1	2	4
Total	0	1	3	2	6

April 1, 2024 – September 30, 2024

Test Monitoring Center
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EOWT Failed Tests by Lab

Failed Parameter (OC)	LTMS Lab						#
	A	B	BE	G	I	L	
Severe Change in Flowrate	2	N/A	0	0	0	0	2
Mild Change in Flowrate	2	N/A	0	2	0	0	4
Total	4	N/A	0	2	0	0	6

April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



EOWT Lost Calibration Tests*

Cause	Number of Tests				#
	0.6%	1.0%	2.0%	3.0%	
Samples stored in oven too long	1	1	1	1	4
Results not recorded	0	0	0	1	1
Wrong Test Oil (LC)	1	1	0	0	2
Total	2	2	1	2	7

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Test Monitoring Center
<https://www.astmtmc.org>



D6794: EOWT

Period Precision and Severity Estimates

Change in Filtration Rate	H ₂ O %	n	df	Pooled s	Mean Δ/s
4/1/24 through 9/30/24	ALL	693	691	3.81	0.34
4/1/24 through 9/30/24	0.6	172	170	3.61	0.04
4/1/24 through 9/30/24	1.0	173	171	3.69	0.24
4/1/24 through 9/30/24	2.0	175	173	3.43	0.42
4/1/24 through 9/30/24	3.0	173	171	3.21	0.64

April 1, 2024 – September 30, 2024

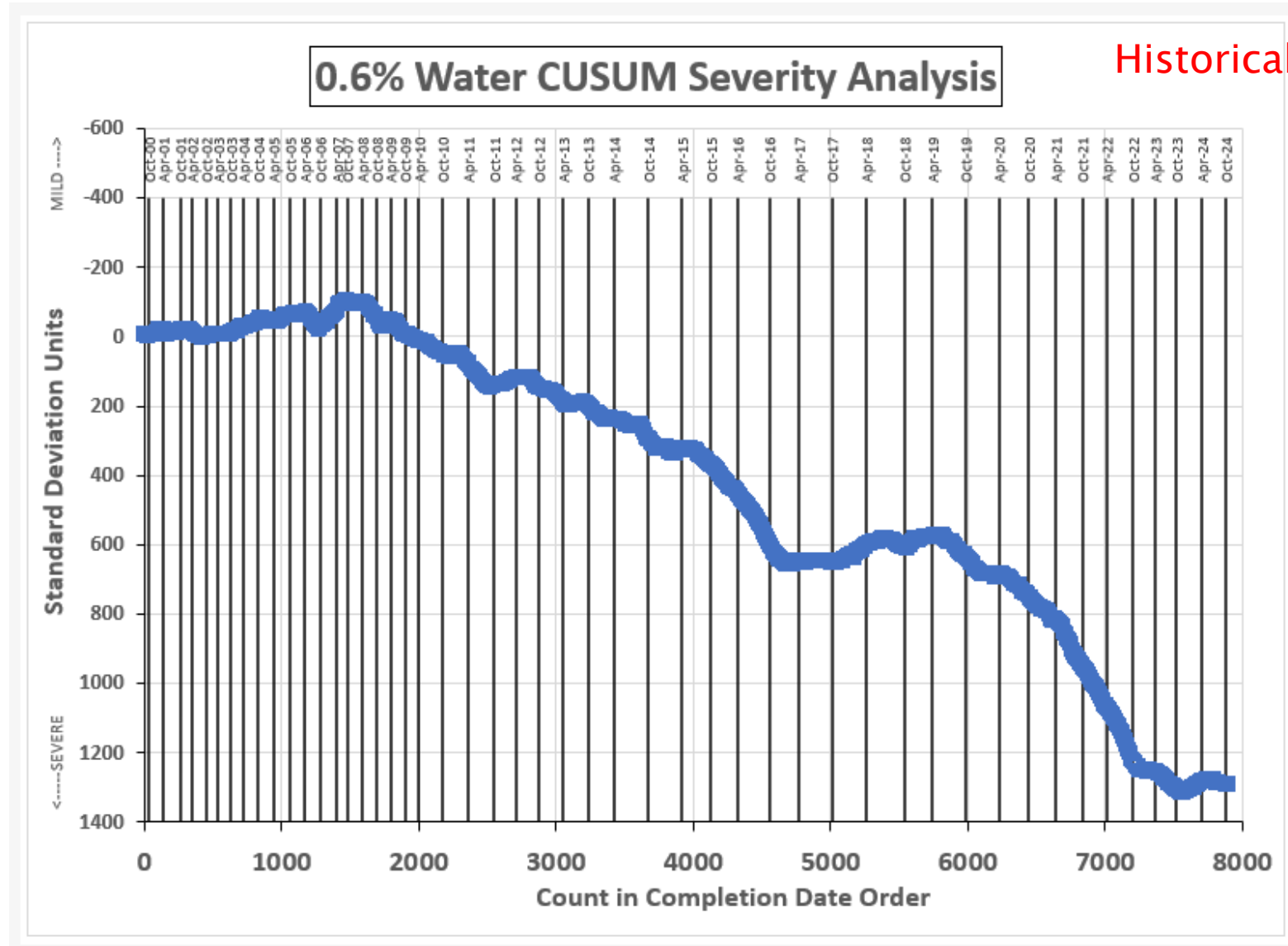
Test Monitoring Center
<https://www.astmtmc.org>



EOWT Test Severity

- ▶ Change in Flowrate Average (CIFA) continues to trend severe for all water treat rates except for 0.6% which is on target at 0.04 s this semester.
- ▶ Reference Oil 79 has less than 2 years of availability based upon consumption rate from last two semesters. Reference Oil 79 is also used in the EOFT (and is the single Reference Oil for that Bench Test).

Historical Chart



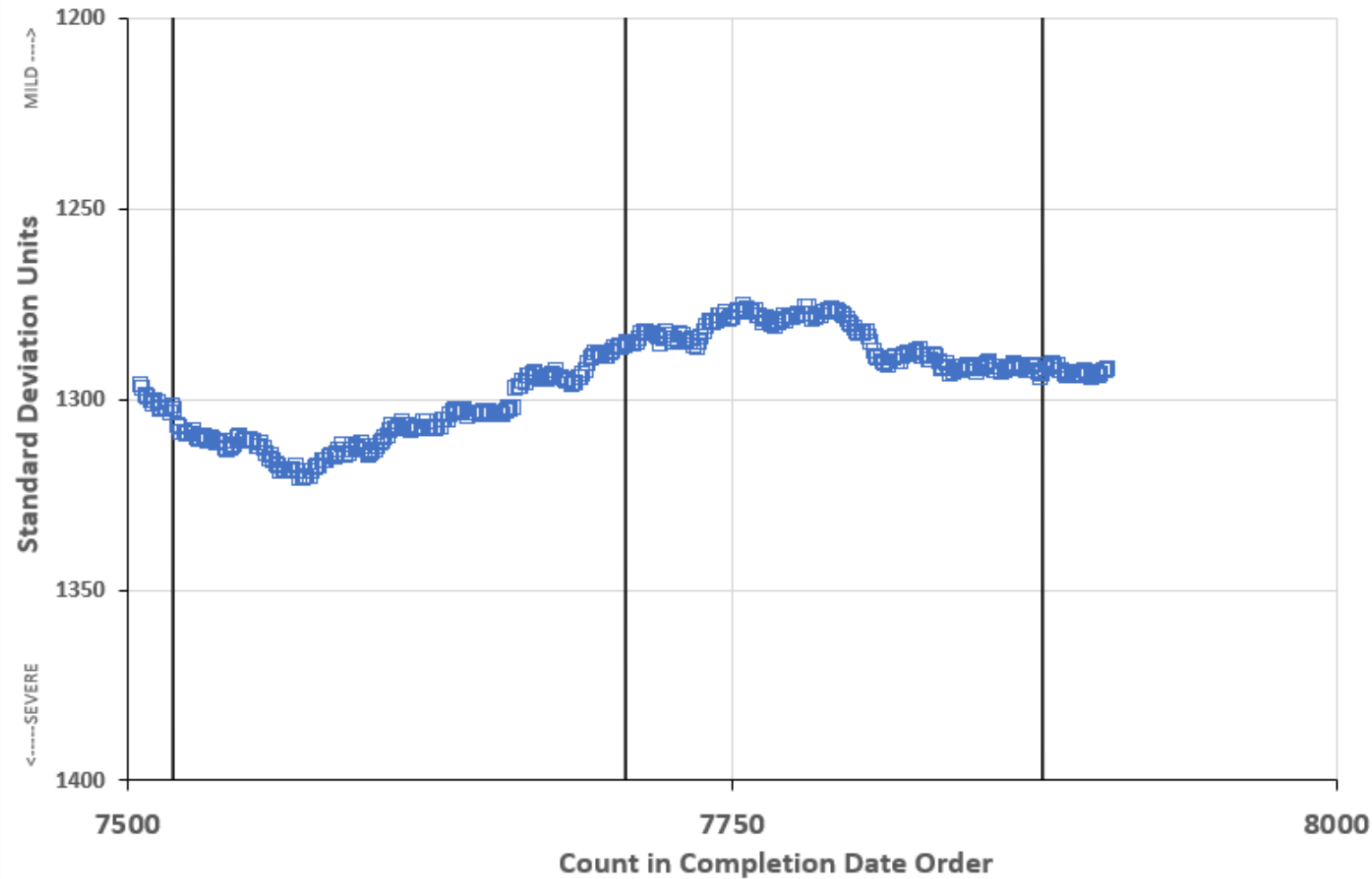
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Test Monitoring Center
<https://www.astmtmc.org>

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 0.6% Water Treat Rate (Last 400 Data Points)
20 —25 ML CHANGE IN FLOWRATE AVG.

0.6% Water CUSUM Severity Analysis

Chart of recent results

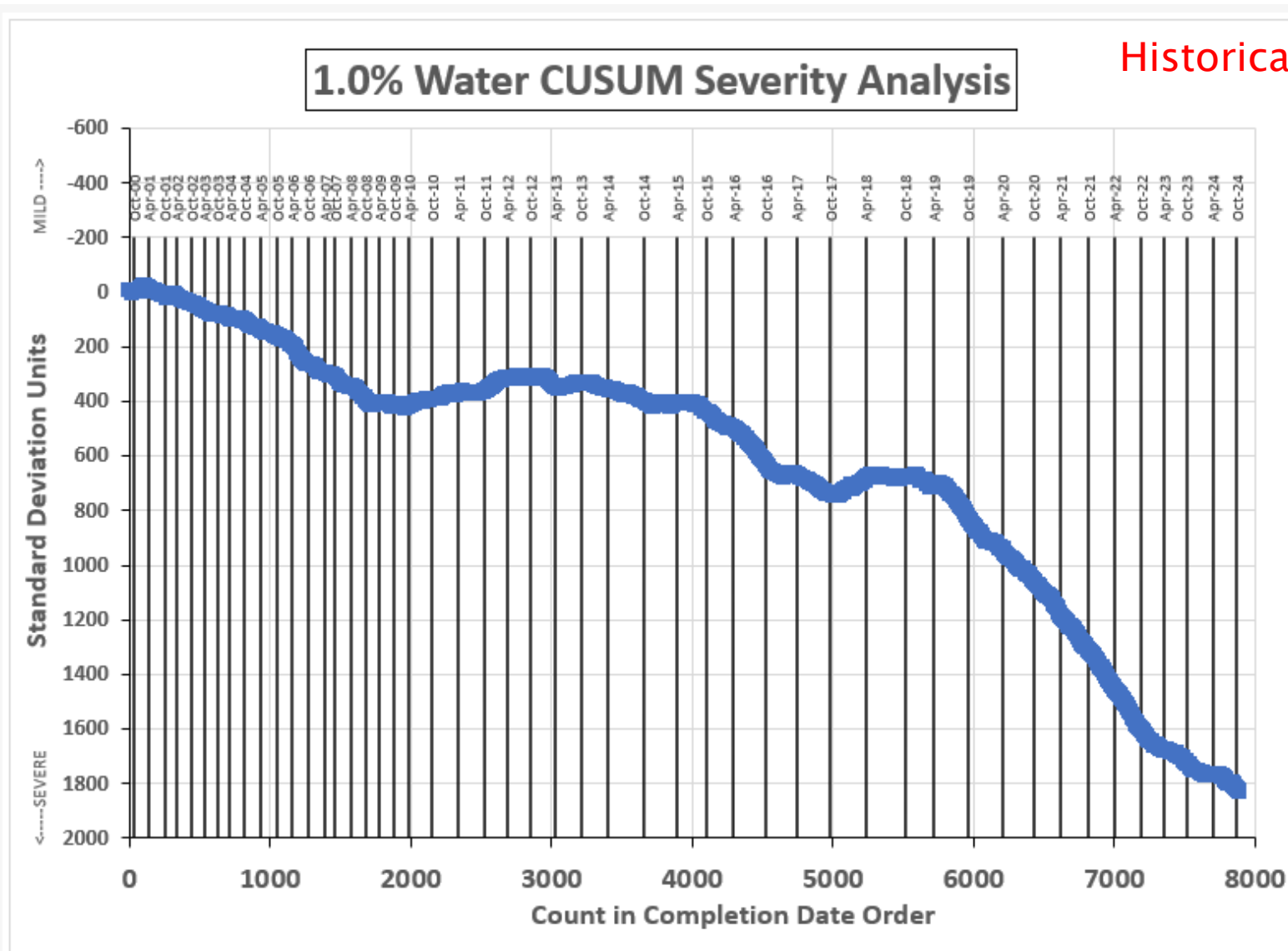


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Test Monitoring Center
<https://www.astmtmc.org>

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 1.0% Water Treat Rate
20 —25 ML CHANGE IN FLOWRATE AVG.

Historical Chart



April 1, 2024 – September 30, 2024

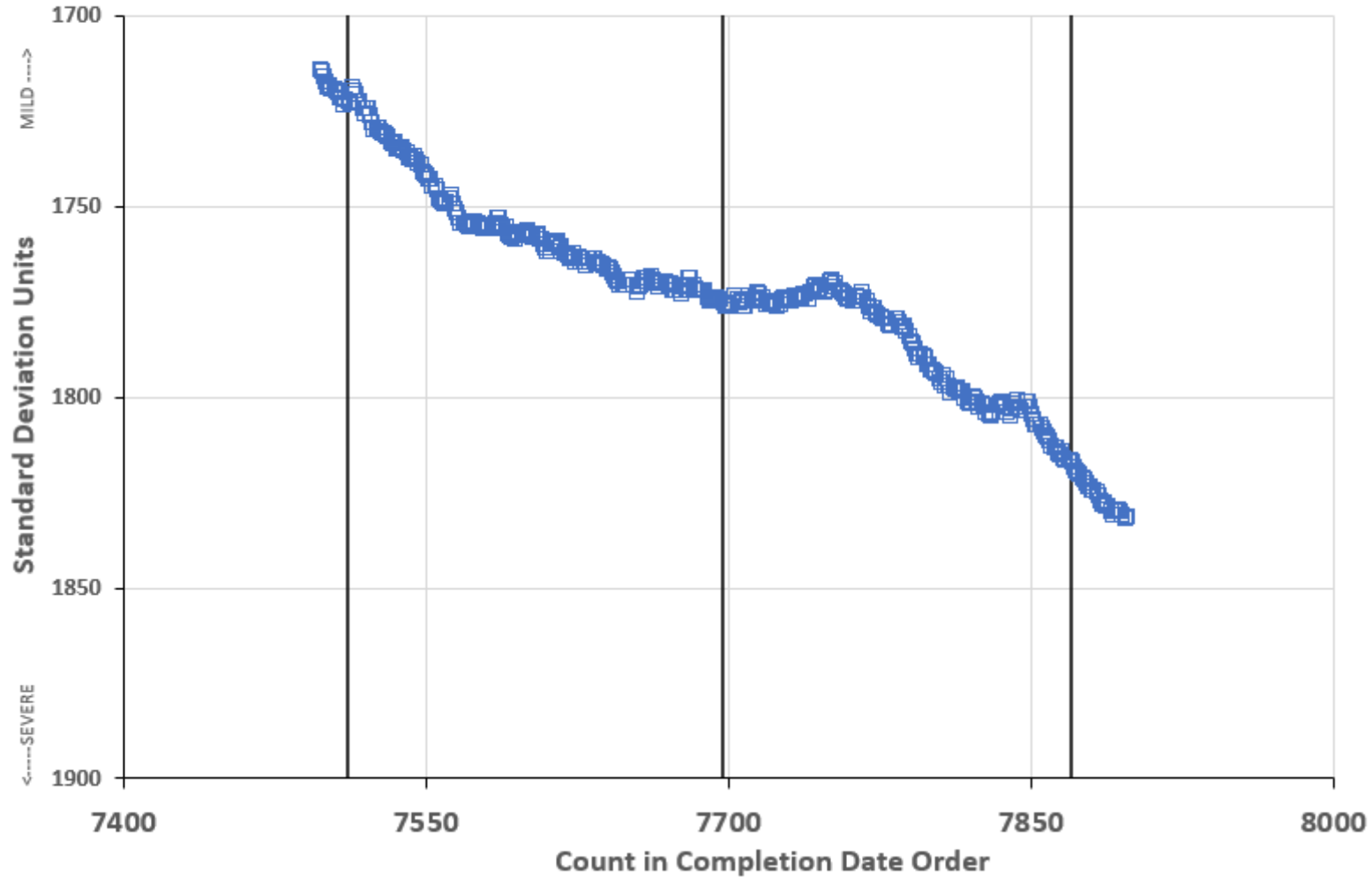
Test Monitoring Center
<https://www.astmtmc.org>

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 1.0% Water Treat Rate (Last 400 Data Points)
20 —25 ML CHANGE IN FLOWRATE AVG.



1.0% Water CUSUM Severity Analysis

Chart of recent results



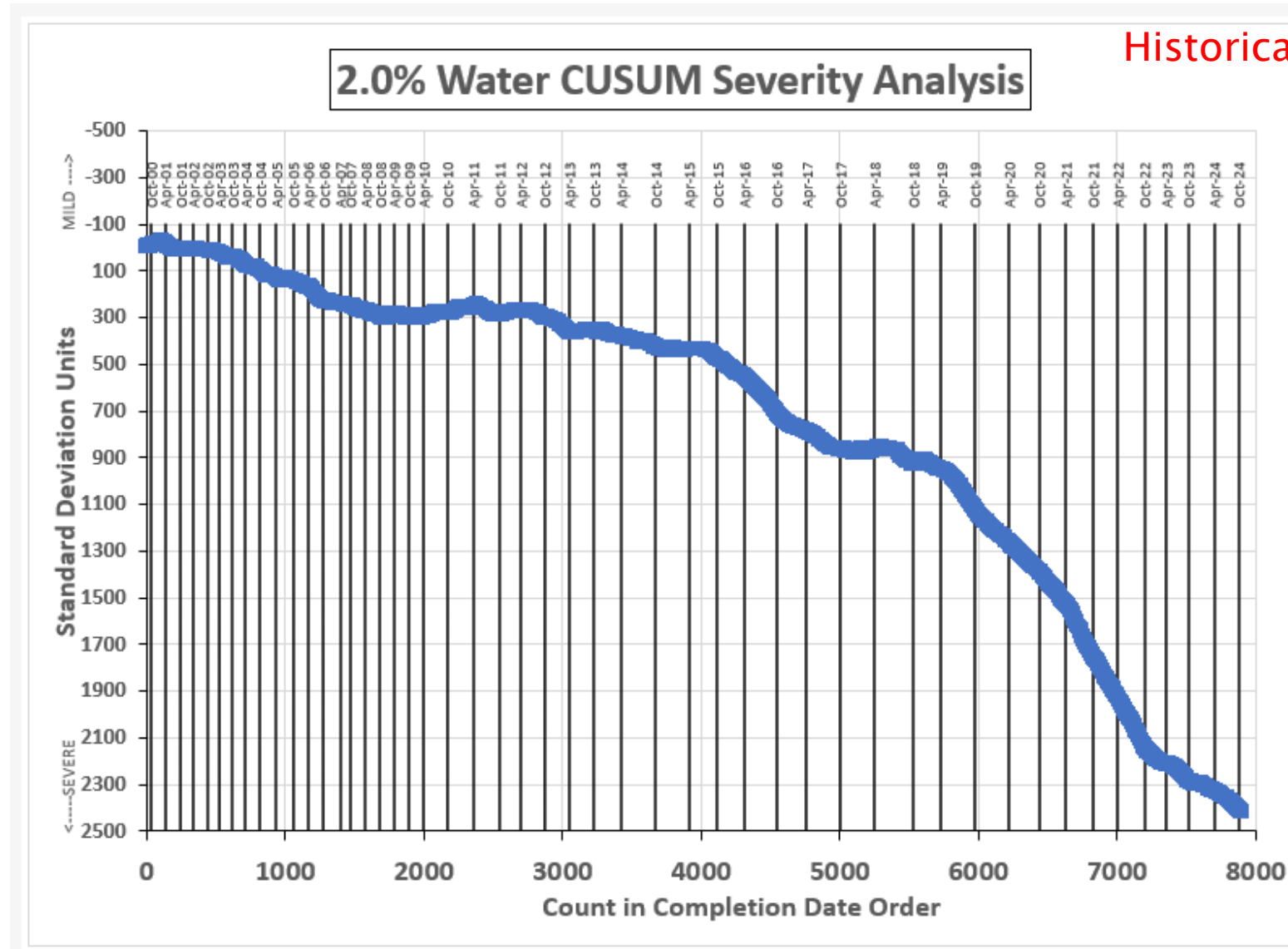
April 1, 2024 - September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



EWOT INDUSTRY OPERATIONALLY VALID DATA
CFA 2.0% Water Treat Rate
20 —25 ML CHANGE IN FLOWRATE AVG.

Historical Chart

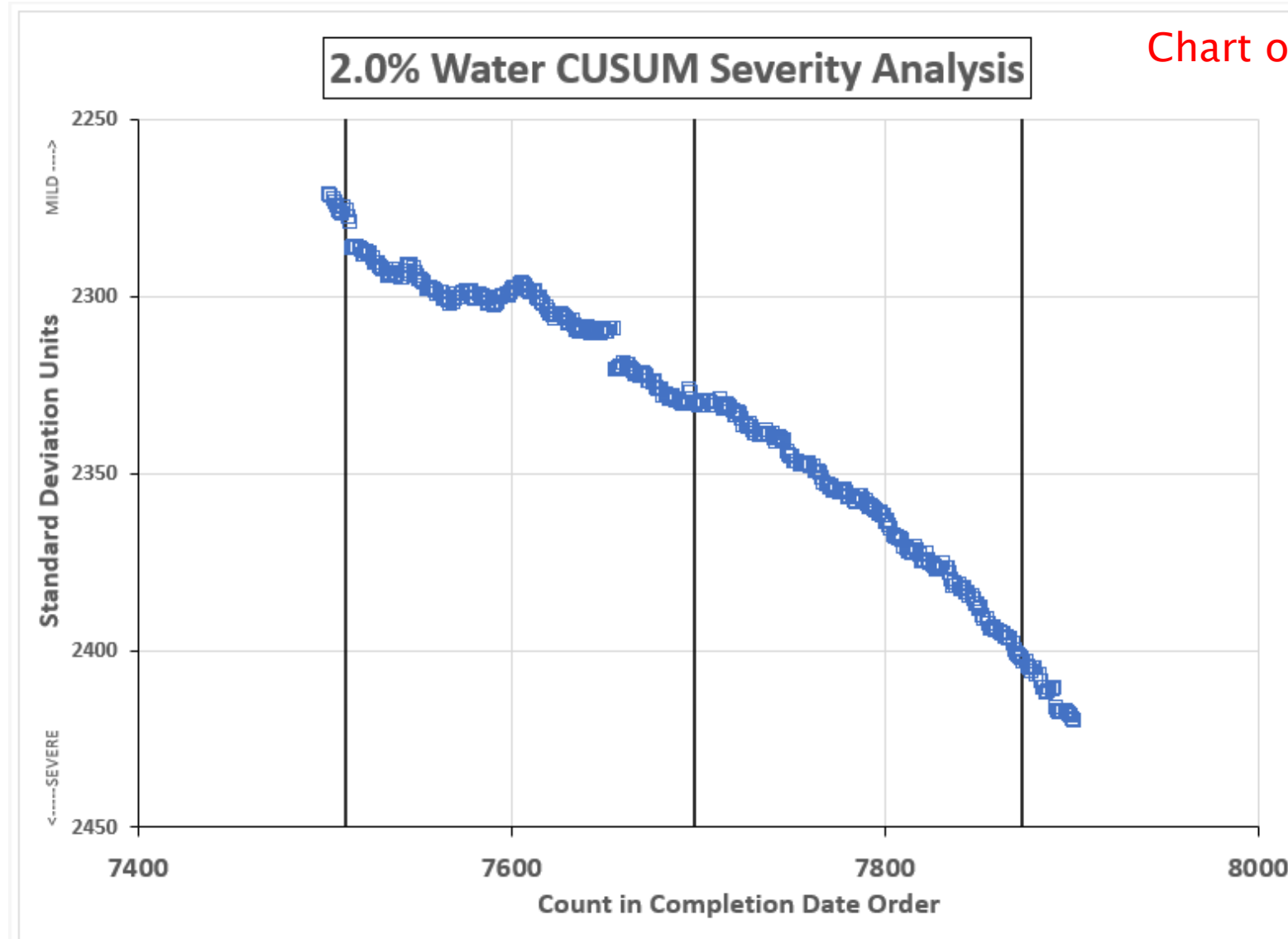


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EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 2.0% Water Treat Rate (Last 400 Data Points)
20 —25 ML CHANGE IN FLOWRATE AVG.



Chart of recent results

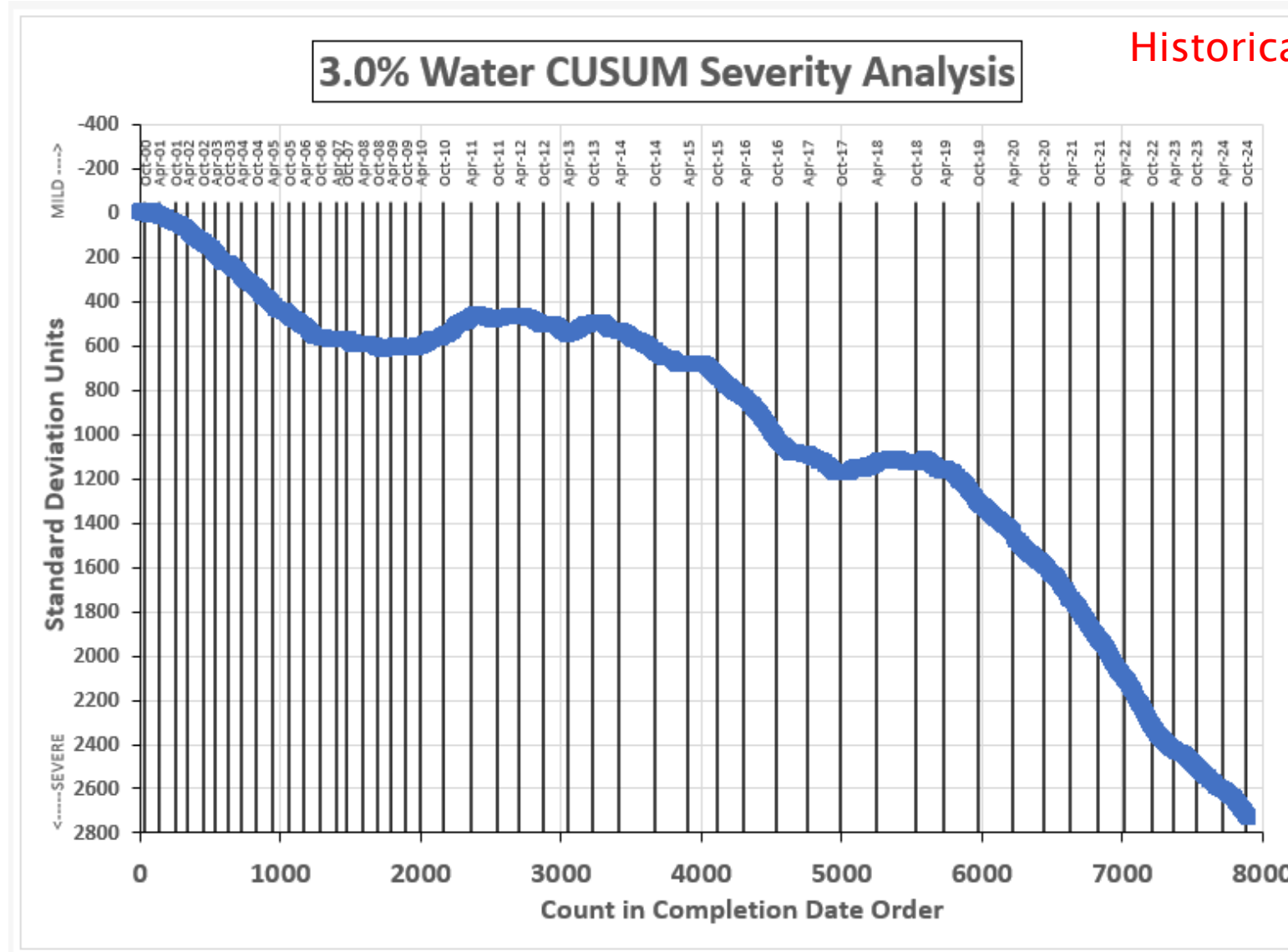


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<https://www.astmtmc.org>



Historical Chart



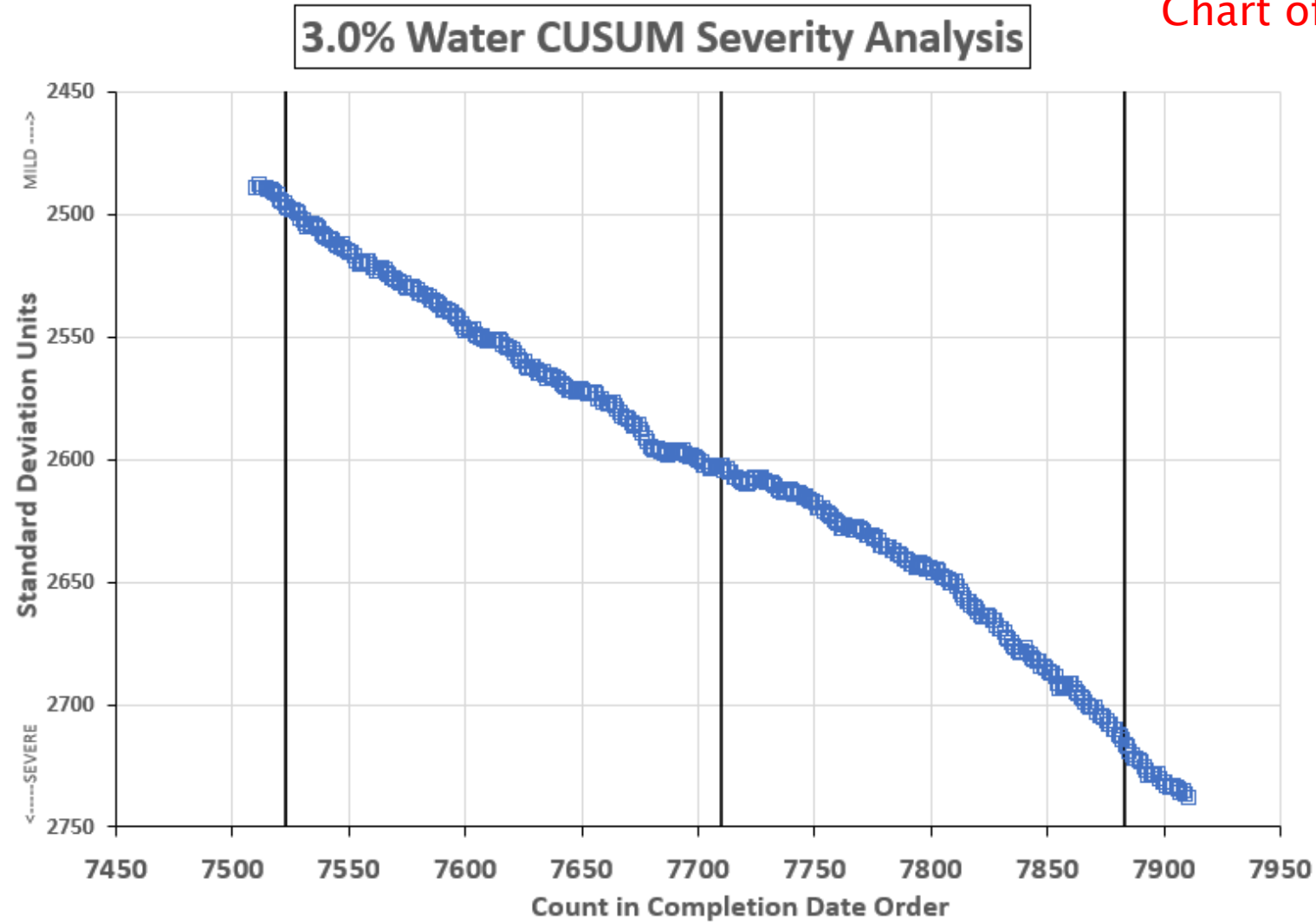
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Test Monitoring Center
<https://www.astmtmc.org>

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 3.0% Water Treat Rate (Last 400 Data Points)
20 —25 ML CHANGE IN FLOWRATE AVG.



Chart of recent results

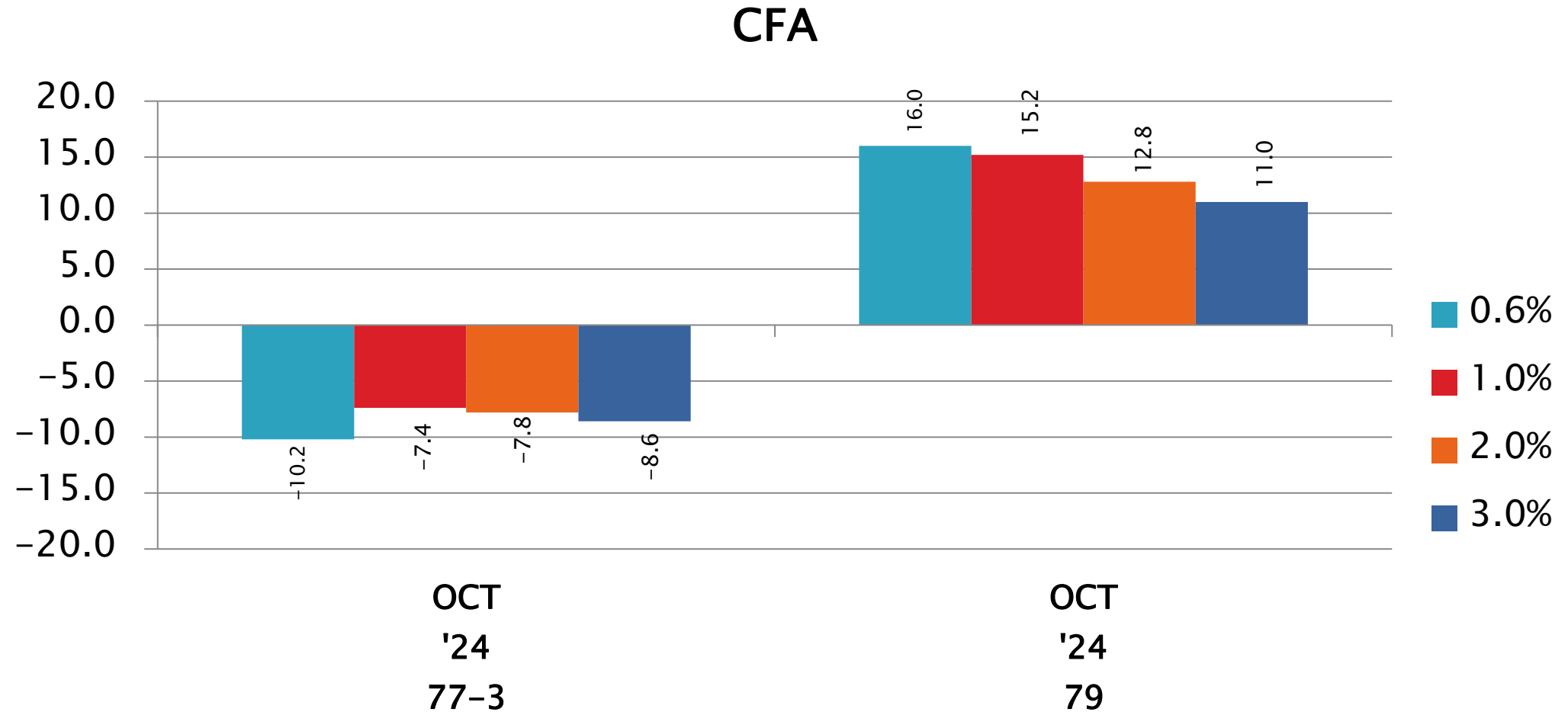


April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



EOWT MEAN CFA's (%) by Reference Oil



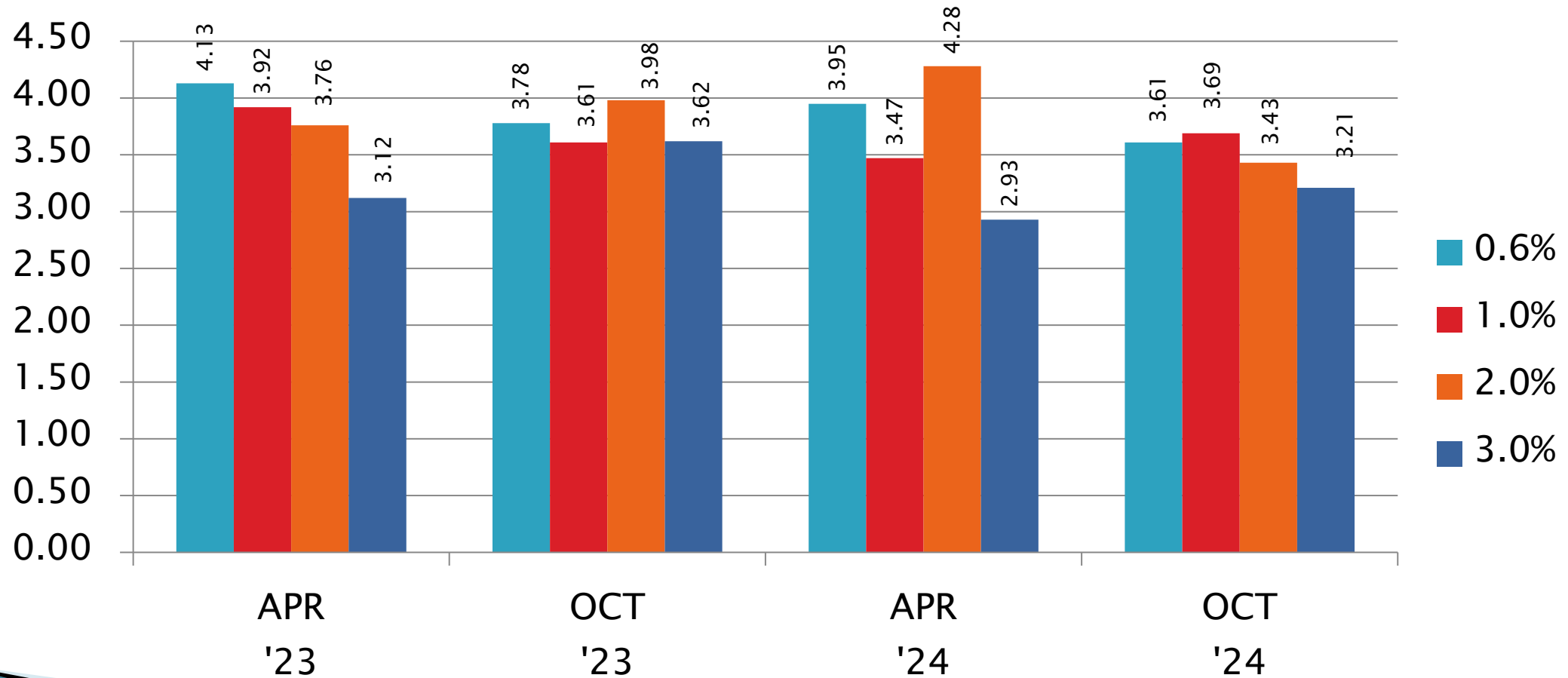
April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



EOWT Precision (Pooled s) Estimates

CFA



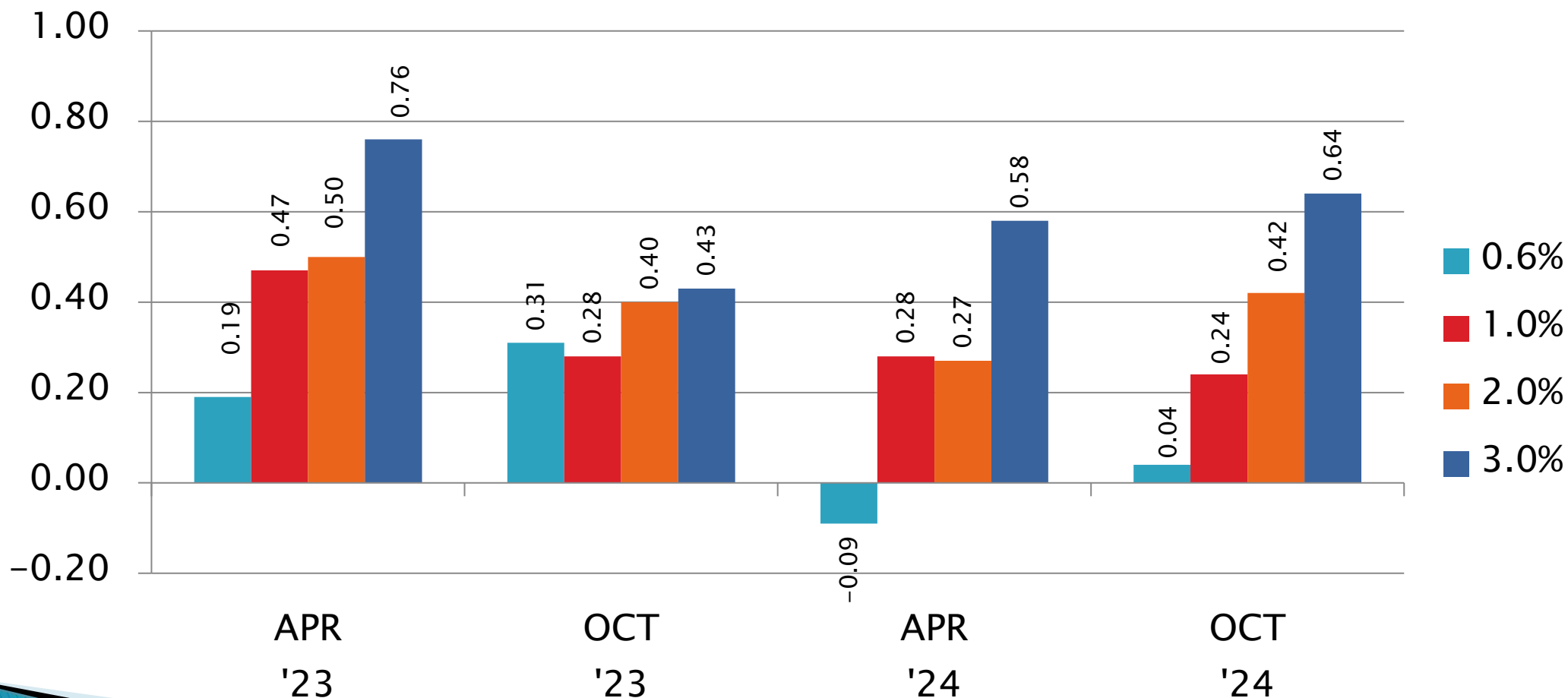
April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



EOWT Performance (Mean Δ/s) Estimates

CFA

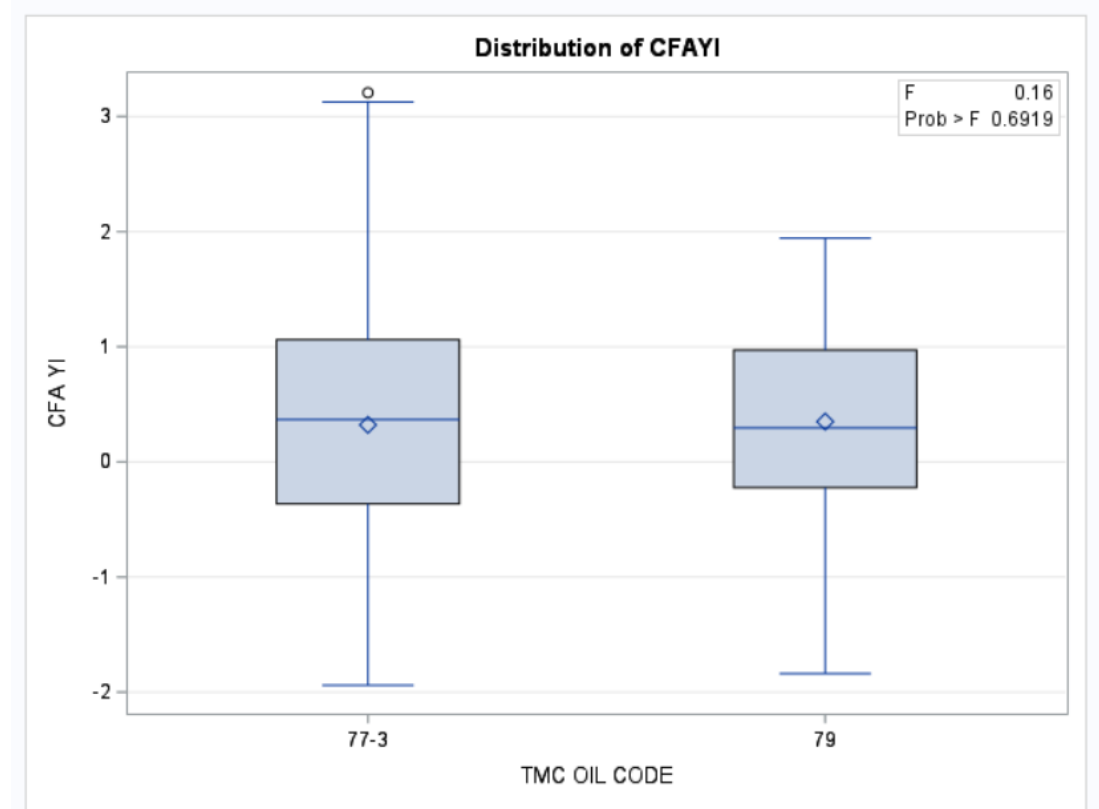
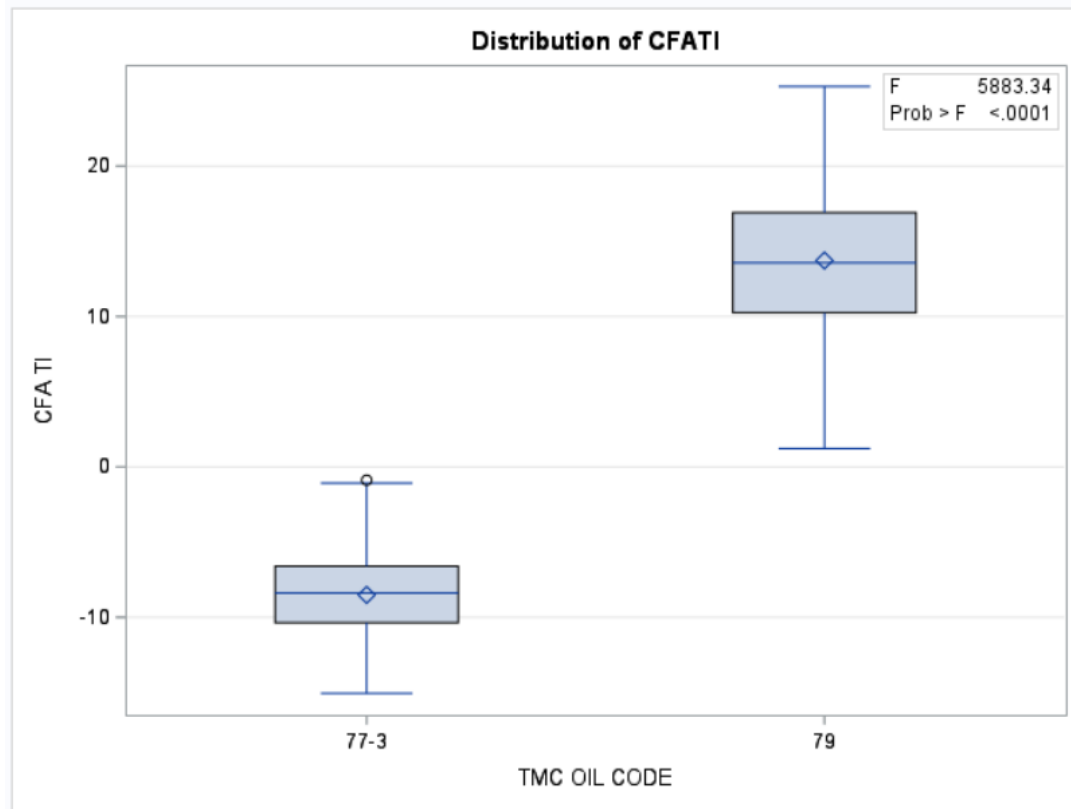


April 1, 2024 – September 30, 2024

Test Monitoring Center
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EOWT Results by Reference Oil: All Water Levels

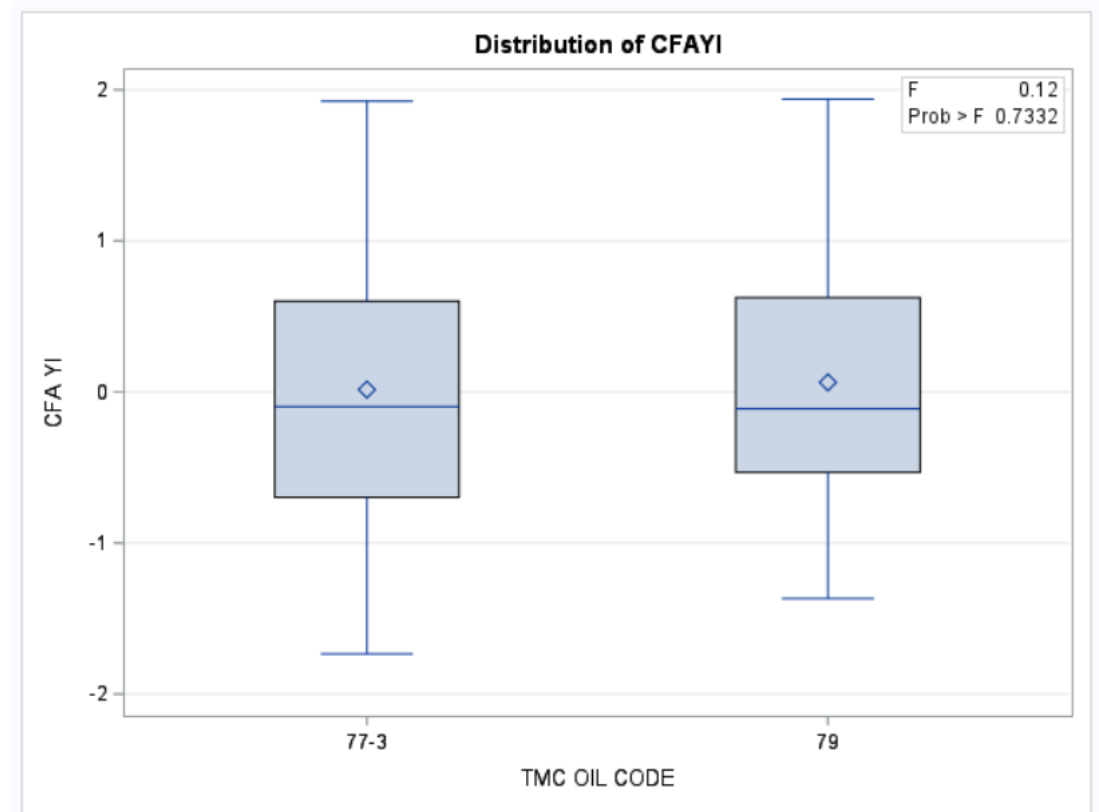
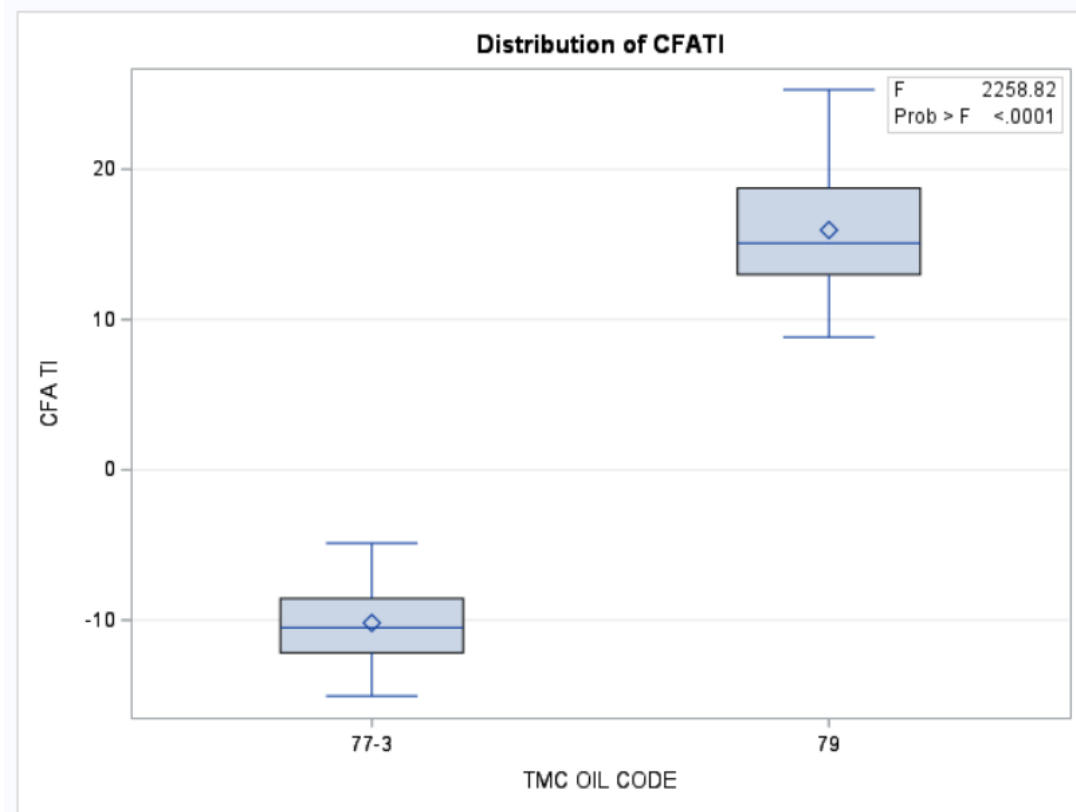


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Test Monitoring Center
<https://www.astmtmc.org>



EOWT 0.6% Results by Reference Oil

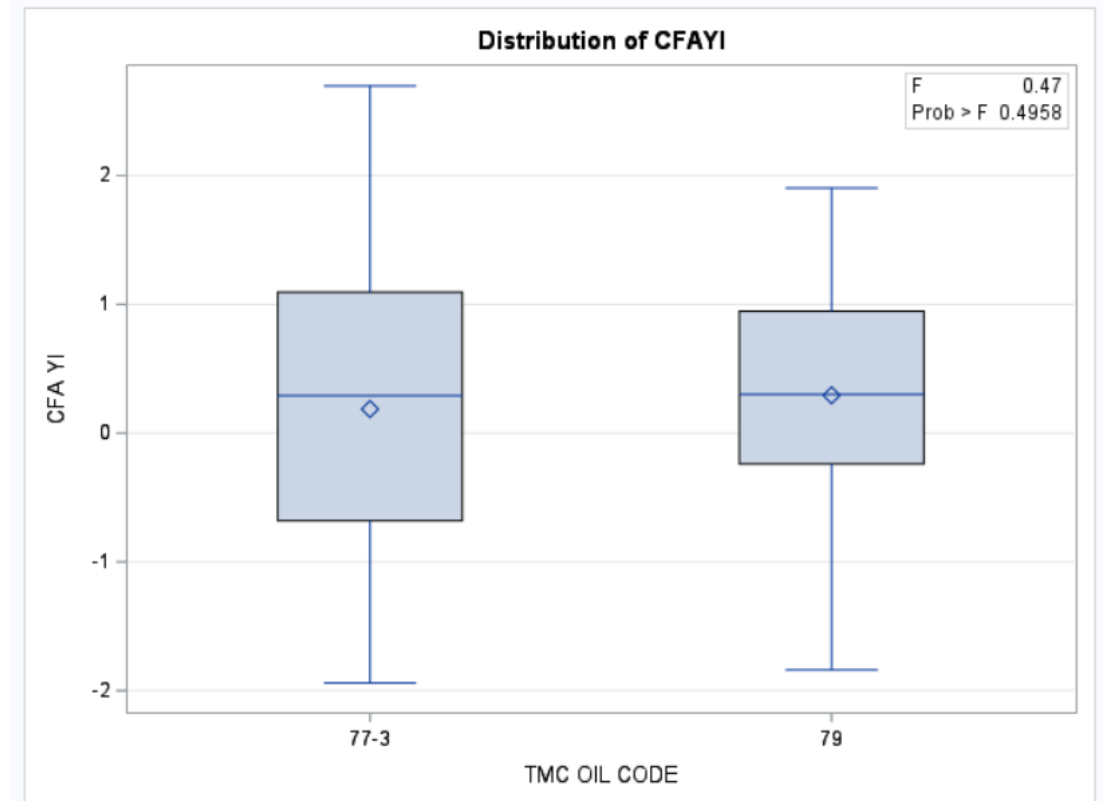
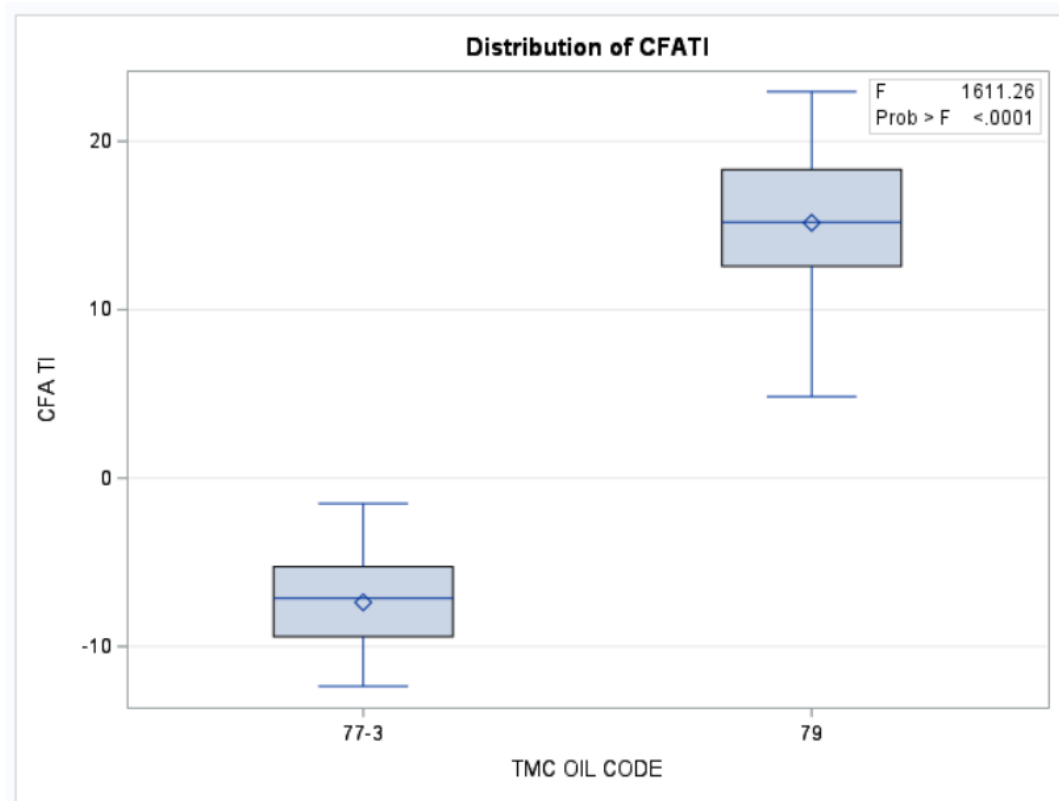


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Test Monitoring Center
<https://www.astmtmc.org>



EOWT 1.0% Results by Reference Oil

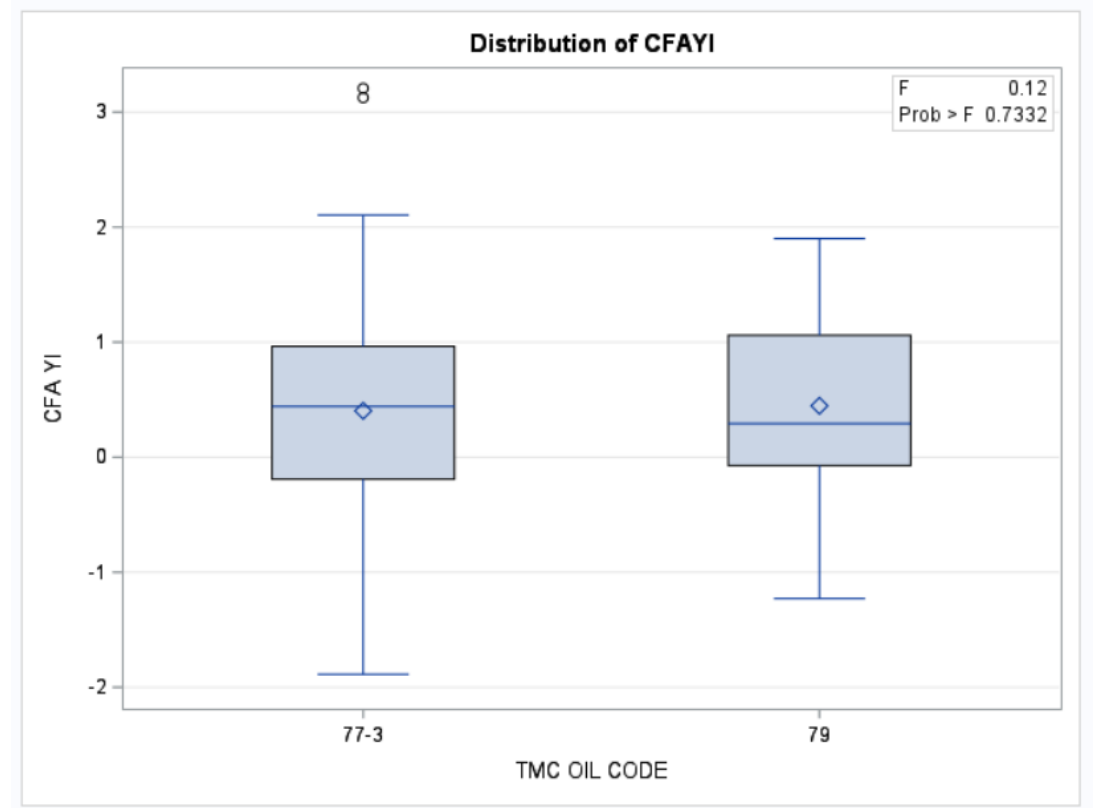
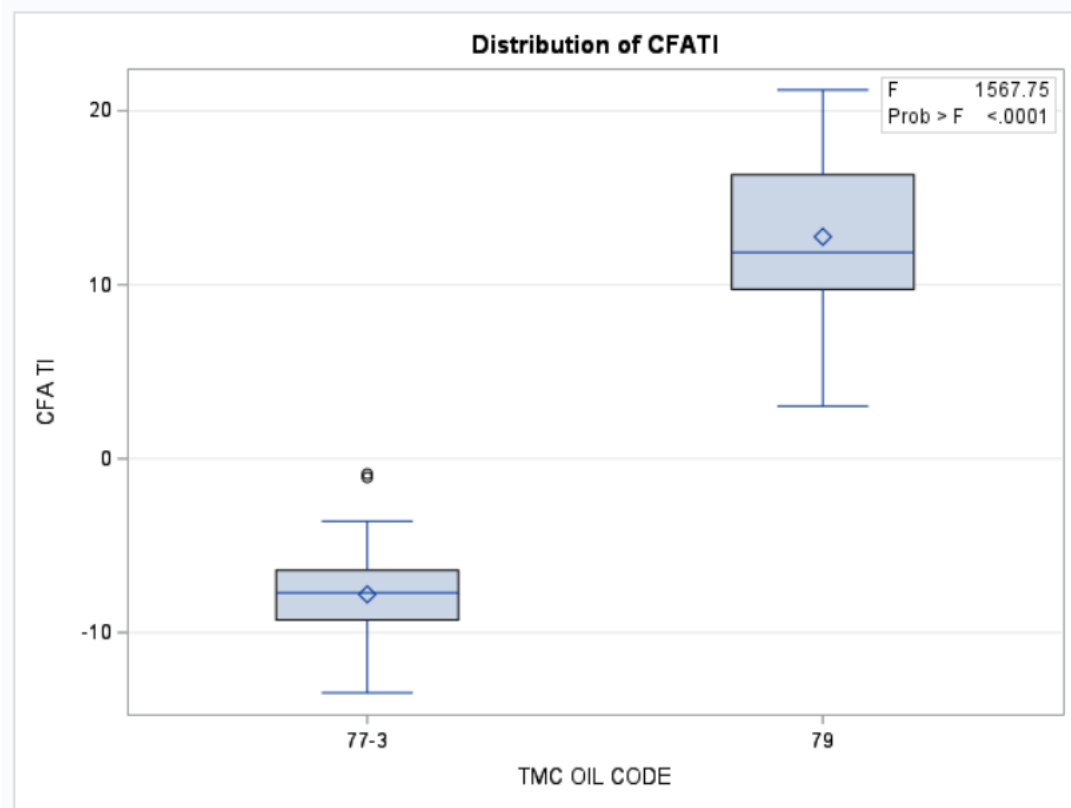


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Test Monitoring Center
<https://www.astmtmc.org>



EOWT 2.0% Results by Reference Oil

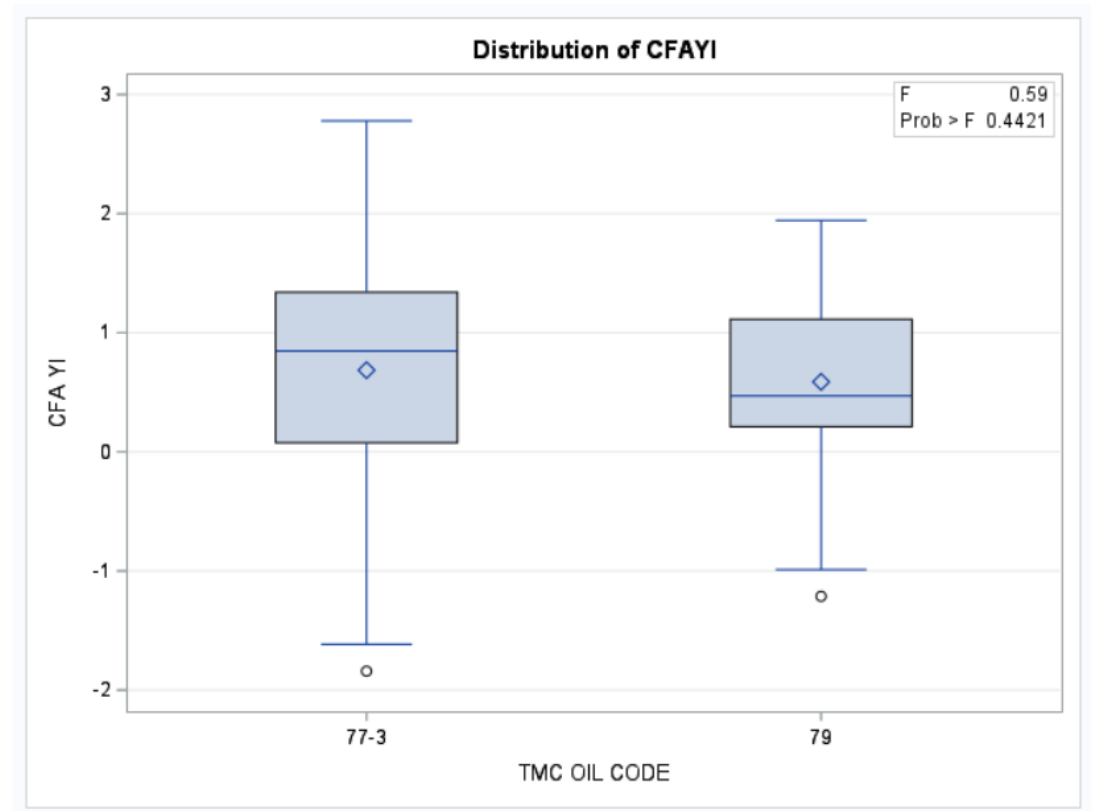
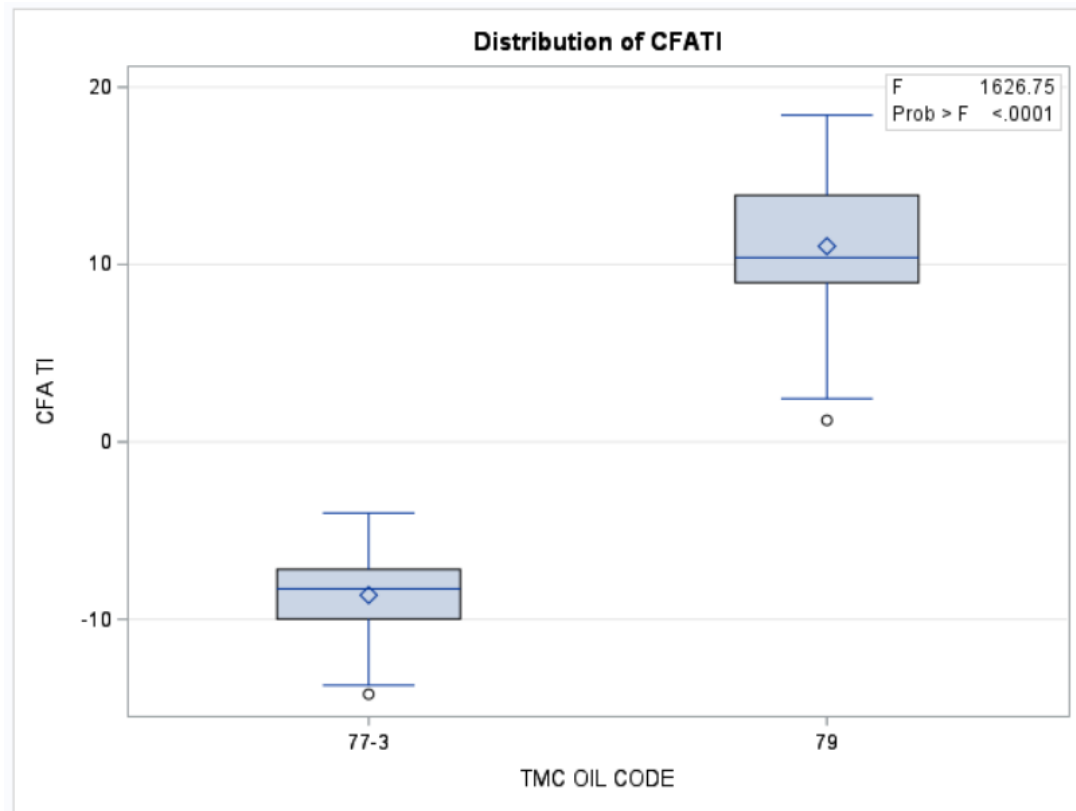


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Test Monitoring Center
<https://www.astmtmc.org>



EOWT 3.0% Results by Reference Oil



April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



Information Letters*

Test	Date	IL	Topic
			No new information letters this period.

*Available from TMC Website

April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



Reference Oil Inventory Estimated Life

EOWT & EOFT

Oil	TMC Inventory (gallons)	TEST	Total Assignments made over Semester	Volume of Samples Assigned (Gallons)	Estimated Life ¹
77-3	374.3	EOWT	338	27.2	5+ years
79	112.4	EOWT	338	27.2	~1.5 years
		EOFT	125	10.1	

1 –Based upon Sample Assignment Rate from past 6 months.

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D02.B0.07

TMC Monitored Tests



ASTM D 6795

Engine Oil Filterability Test (EOFT)

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6795	5 (-1)	N/A
*As of 9/30/2024		

EOFT Test Activity*

Test Status	Validity Code	Number of Tests
Acceptable Calibration Test	AC	130
Failed Calibration Test	OC	0
Aborted Calibration Test	XC	1
Acceptable Shakedown Run	NN	0
Unacceptable/Aborted Shakedown Run	MN / XN	0
Total		131

- 100% Acceptable Calibration (AC) Testing Rate
 - 5 labs reported data this semester

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Test Monitoring Center
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EOFT Failed Tests

Failed Parameter	Number of Tests
Change in Flow Average (CIFA) Severe	0
Change in Flow Average (CIFA) Mild	0
Total	0

April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



EOFT Failed Tests by Lab

Failed Parameter	LTMS Lab						#
	A	B	G	I	L	BE	
Change in Flow Average (CIFA) Severe	0	N/A	0	0	0	0	0
Change in Flow Average (CIFA) Mild	0	N/A	0	0	0	0	0
Totals	0	N/A	0	0	0	0	0

April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



EOFT Lost Tests*

Status	Cause	No. of Tests
Invalid (L,R)		0
Aborted (X)	TESTKEY opened, insufficient volume to begin test	1
Total		1

*Invalid and aborted calibration tests

April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>



EOFT Information/Shakedown Tests

Informational / Shakedown Results	Number of Tests
None	0
Total	0

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Test Monitoring Center
<https://www.astmtmc.org>



EOFT Test Severity

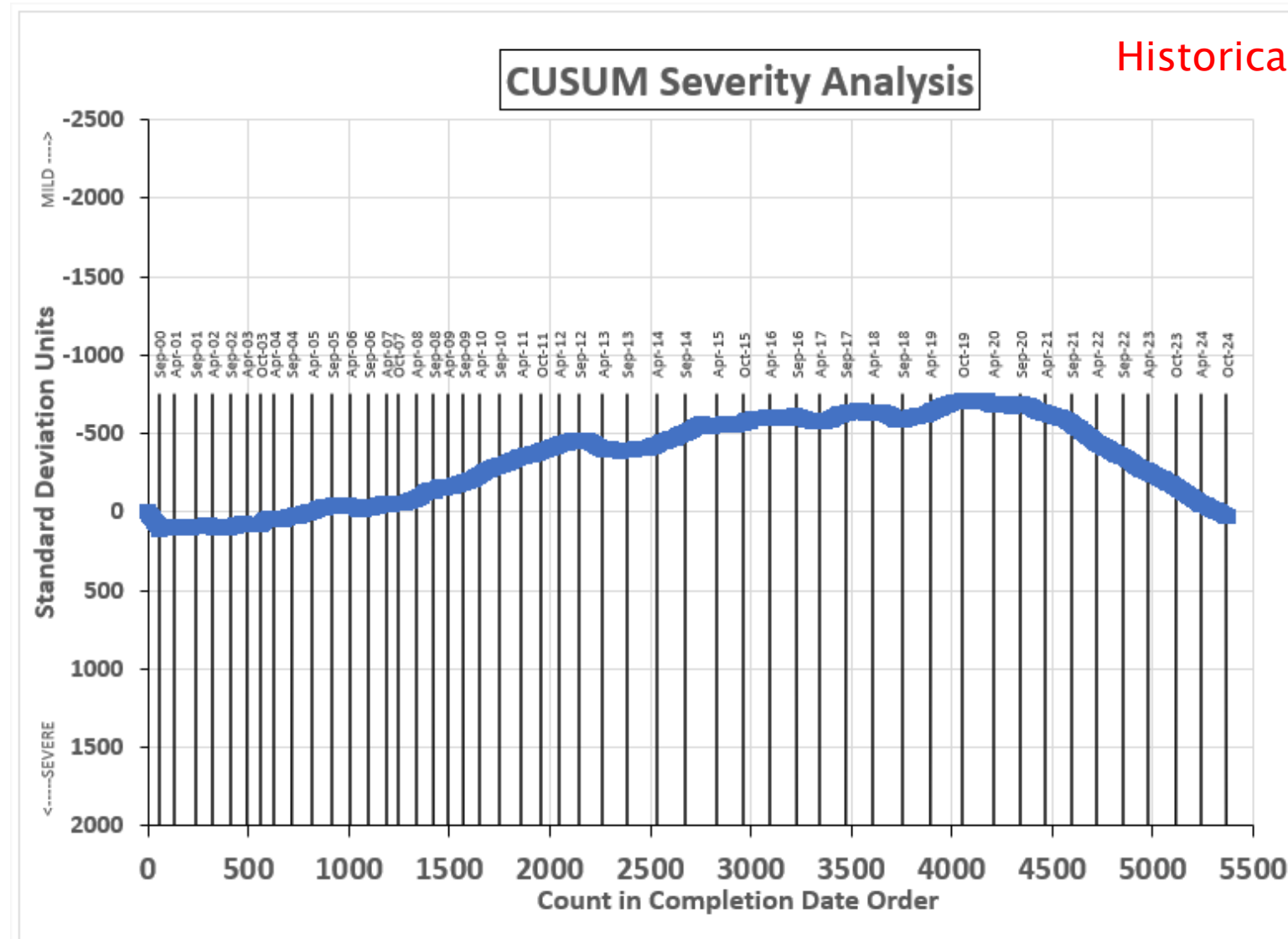
- ▶ Change in Flow Average (CIFA) is trending severe with a very consistent CUSUM slope over the past 4 years.
- ▶ Precision (Pooled s) is on target at 4.51 s
- ▶ Performance (Mean Δ/s) remains severe but steady around 0.7 for the last eight semesters.

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Test Monitoring Center
<https://www.astmtmc.org>

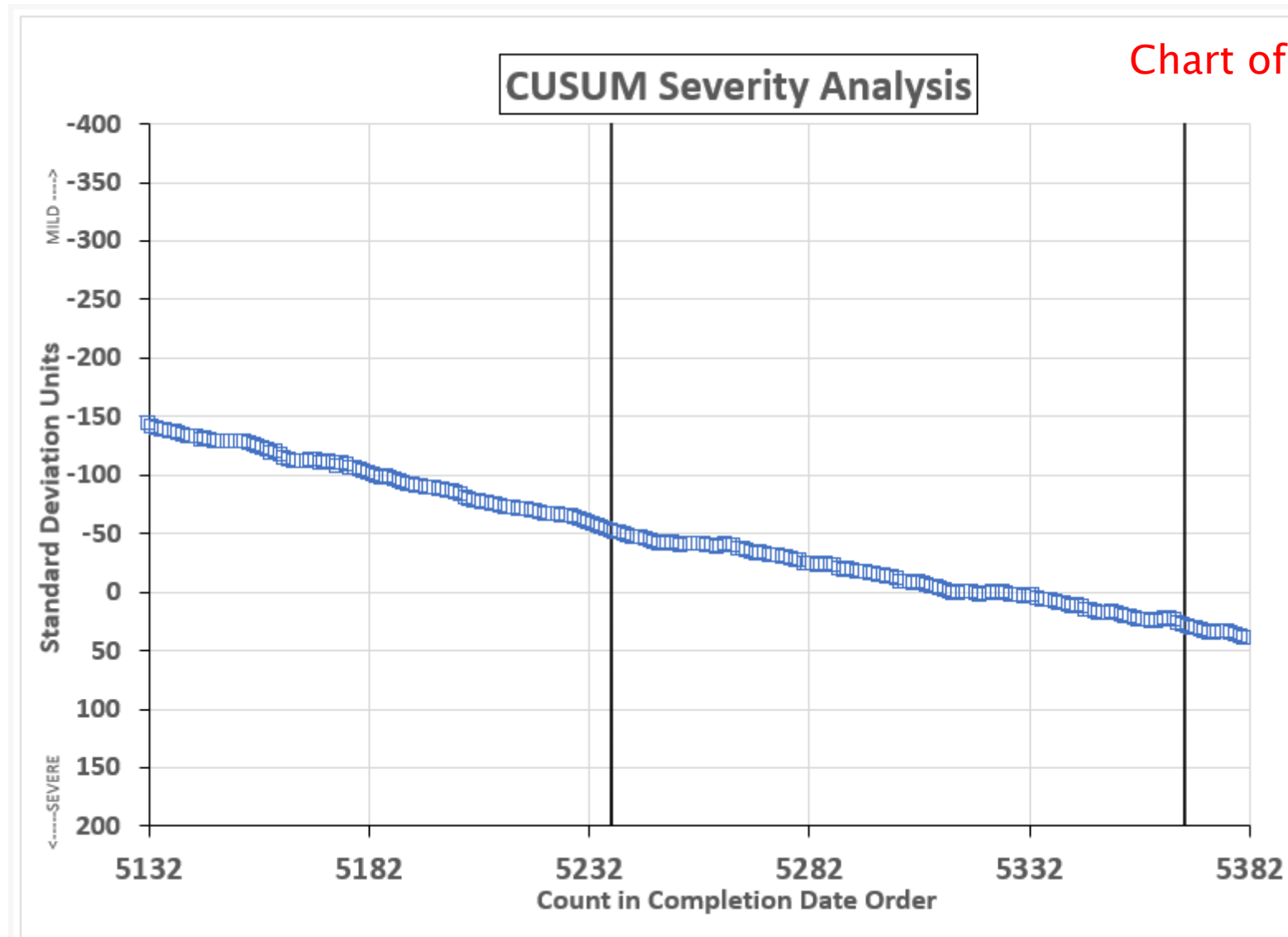


20 —25 ML CHANGE IN FLOWRATE AVERAGE (%)



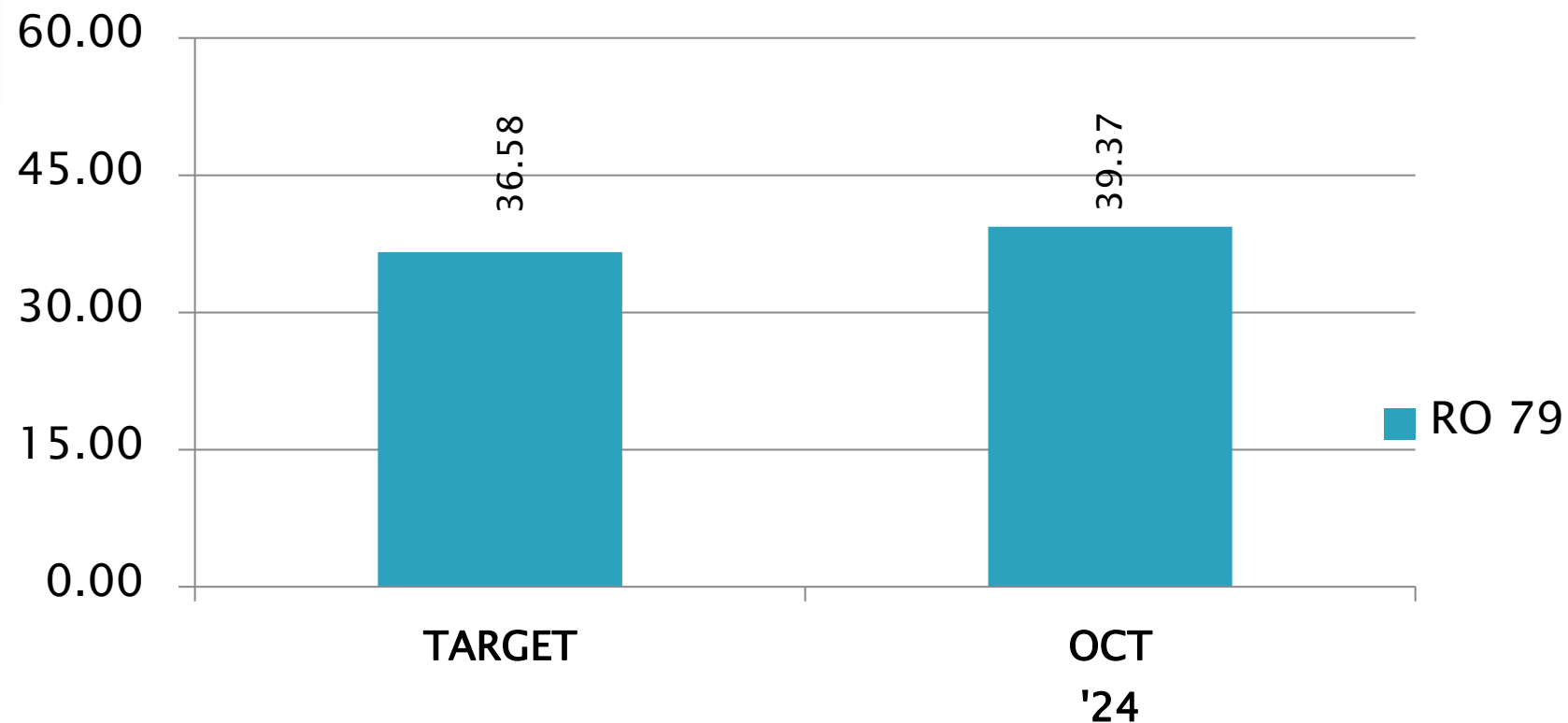
EOFT INDUSTRY OPERATIONALLY VALID DATA
Last 250 Data Points
20 —25 ML CHANGE IN FLOWRATE AVERAGE (%)

Chart of recent results

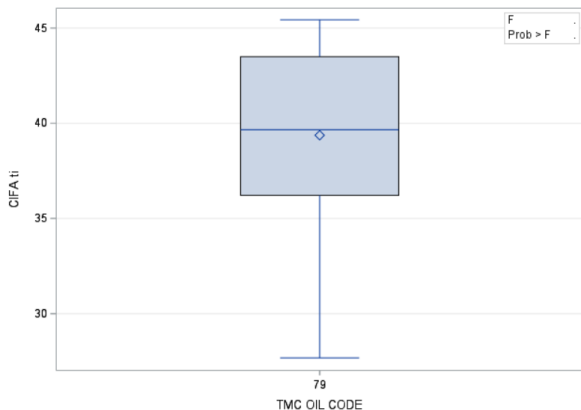


EOFT MEAN CFA's (%)

CFA



Distribution of CIFAti



April 1, 2024 – September 30, 2024

Test Monitoring Center
<https://www.astmtmc.org>

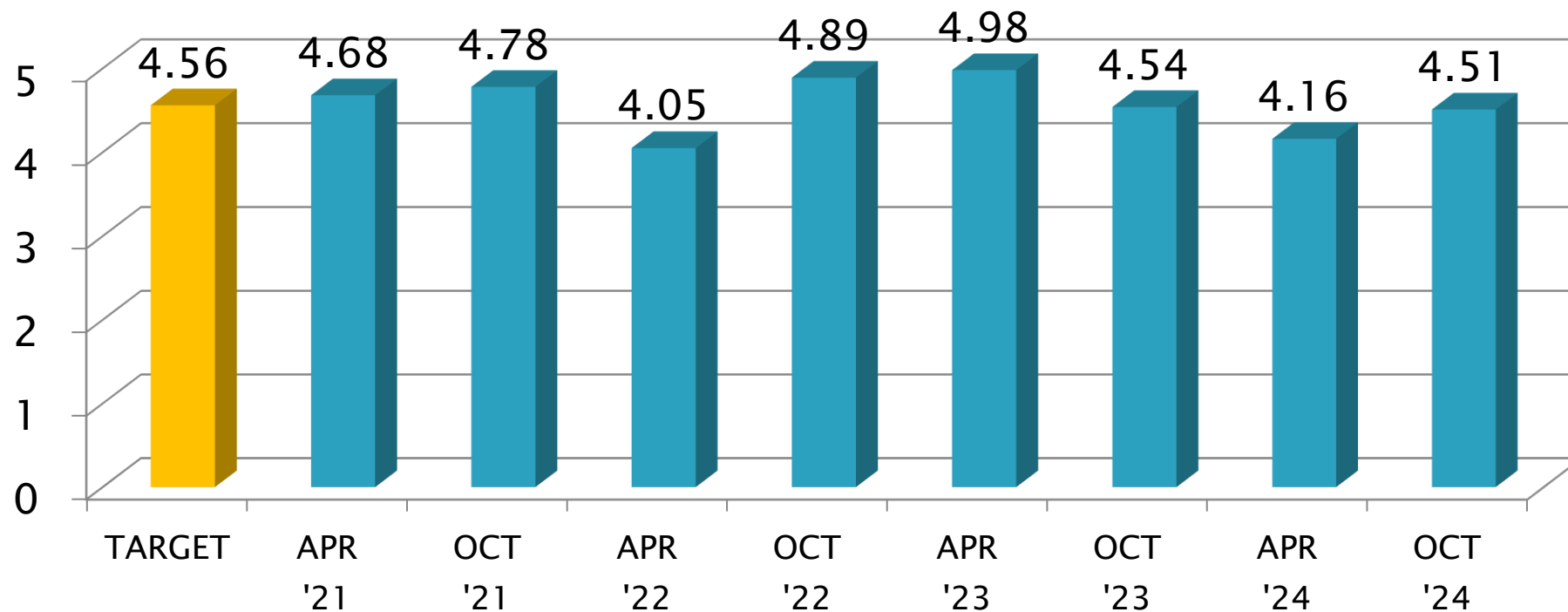


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EOFT Precision Estimates

CIFA

Pooled s

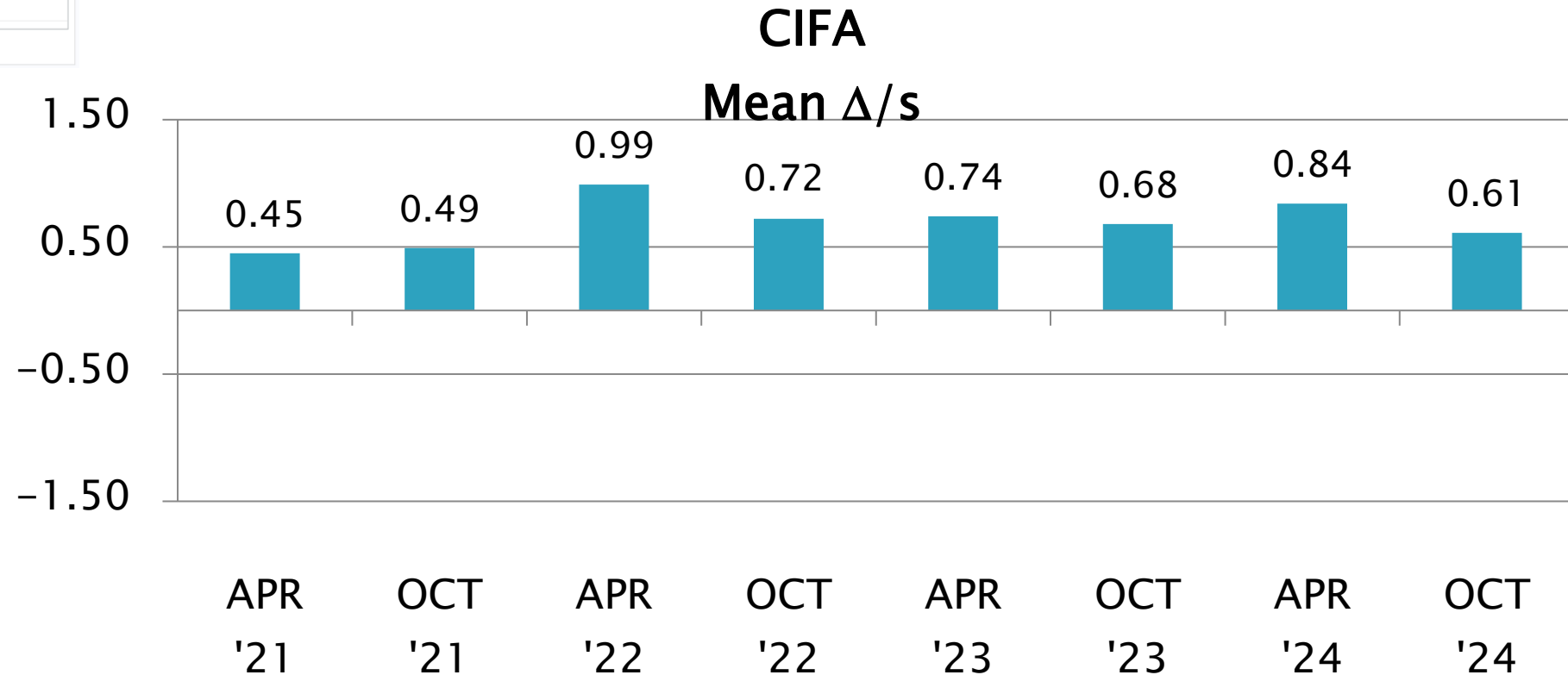
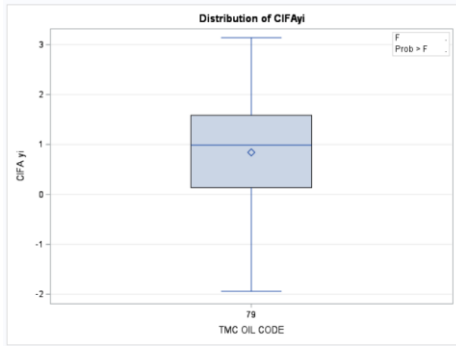


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Test Monitoring Center
<https://www.astmtmc.org>



EOFT Severity Estimates



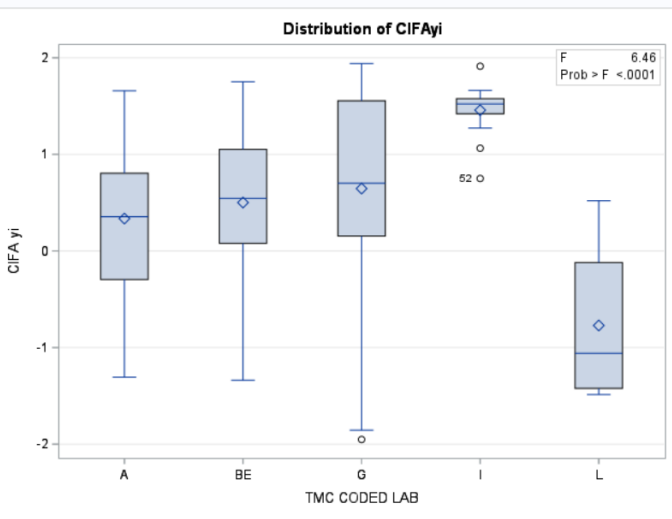
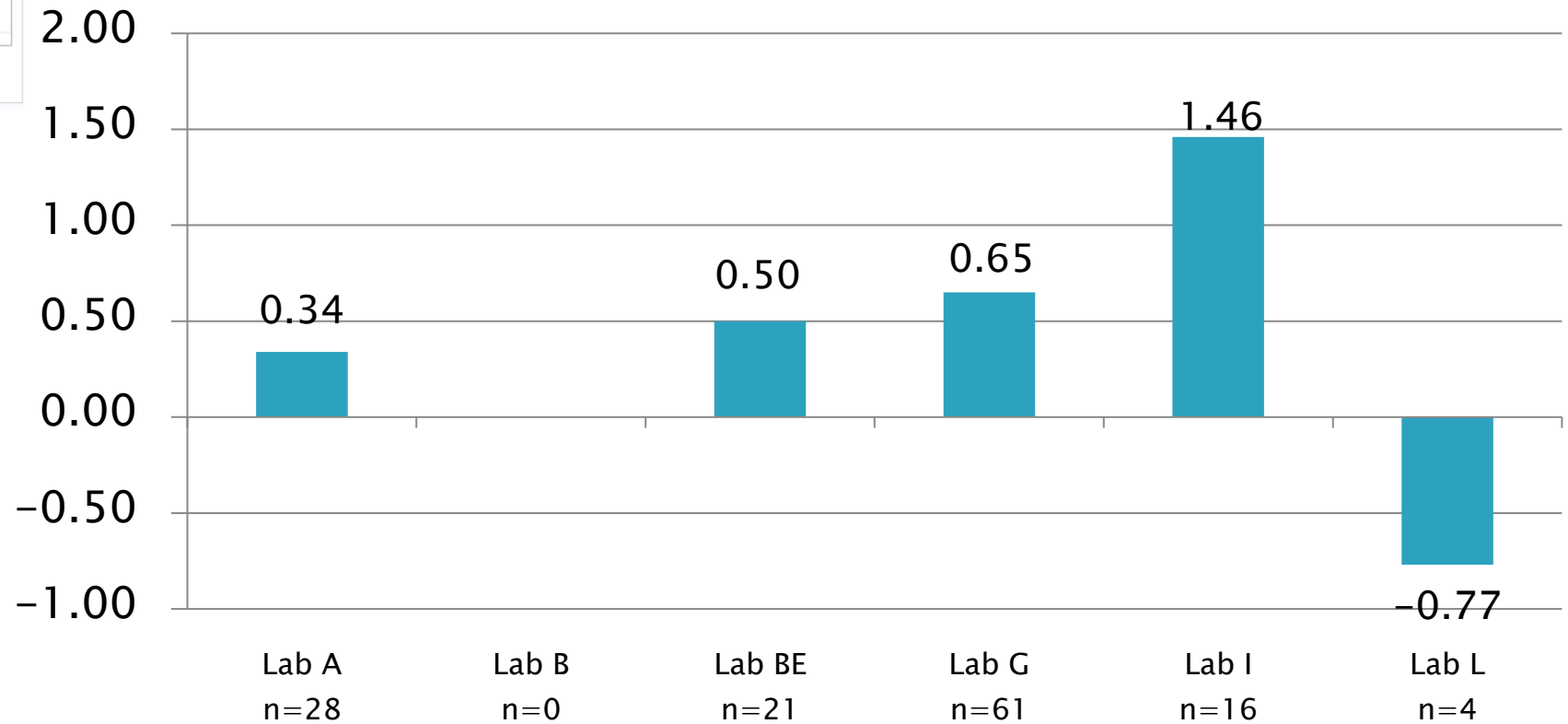
April 1, 2024 – September 30, 2024

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EOFT Lab Severity Estimates

CIFA
Mean Δ/s



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Information Letters*

Test	Date	IL	Topic
			No new information letters this period.

*Available from TMC Website

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Reference Oil Inventory Estimated Life

EOWT & EOFT

Oil	TMC Inventory (gallons)	TEST	Total Assignments made over Semester	Volume of Samples Assigned (Gallons)	Estimated Life ¹
77-3	374.3	EOWT	338	27.2	5+ years
79	112.4	EOWT	338	27.2	~1.5 years
		EOFT	125	10.1	

1 –Based upon Sample Assignment Rate from past 6 months.

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D02.B0.07

TMC Monitored Tests



ASTM D 7097

Medium High Temperature TEOST (MTEOS)

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D7097	11 (+1)	35 (-2)
*As of 9/30/2024		

D7097: Deposits by MTEOS

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	66
Failed Calibration Test	OC	10
Operationally Invalidated by Lab	LC	2
Operationally Invalidated by TMC	RC	2
Operationally Invalid (Aborted)	XC	1
Acceptable Informational Run	NN	4
Unacceptable Informational Run	MN	0
Total		85

Number of Labs Reporting Data: 11 (+1)

Fail Rate of Operationally Valid Tests: 13.2% (7.7% last period)

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D7097: Deposits by MTEOS

Statistically Unacceptable Tests (OC)	No. Of Tests
Total Deposits Severe	9
Total Deposits Mild	1
Total	10

THREE Labs had OC results.

April 1, 2024 – September 30, 2024

Test Monitoring Center
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D7097: Deposits by MTEOS

Summary of Invalid Tests

Operationally Invalid Tests (LC, RC, XC)	Validity Code	No. Of Tests
Aborted by Lab. Starting Rod Weight Missing	XC	1
Wrong Catalyst Concentration Used in Calcs	RC	2
Electrical Issue	LC	2
Total		5

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Test Monitoring Center
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D7097: Deposits by MTEOS

Summary of Informational Tests

Informational / Shakedown Tests (NN, MN)	Validity Code	No. Of Tests
Shakedown run, Deposits in Range	NN	4
Shakedown run, Deposits not in Range (Severe)	MN	0
Total		4

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D7097: Deposits by MTEOS

Period Precision and Severity Estimates

Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Current Targets 9/30/2021 ¹	38	36	4.94	-----
10/1/19 through 3/31/20	103	101	7.02	-0.02
4/1/20 through 9/30/20	72	70	4.87	-0.22
10/1/20 through 3/31/21	101	99	8.40	0.17
4/1/21 through 9/30/21	81	78	7.25	-0.02
10/1/21 through 3/31/22	75	73	8.86	0.18
4/1/22 through 9/30/22	77	75	7.69	0.69
10/1/22 through 3/31/23	67	65	7.03	0.41
4/1/22 through 9/30/23	74	71	7.42	0.31
10/1/23 through 3/31/24	65	62	6.04	0.19
4/1/24 through 9/30/24	76	73	7.57	0.43

¹Target precision updated to reference oils 432 and 434-3 preliminary

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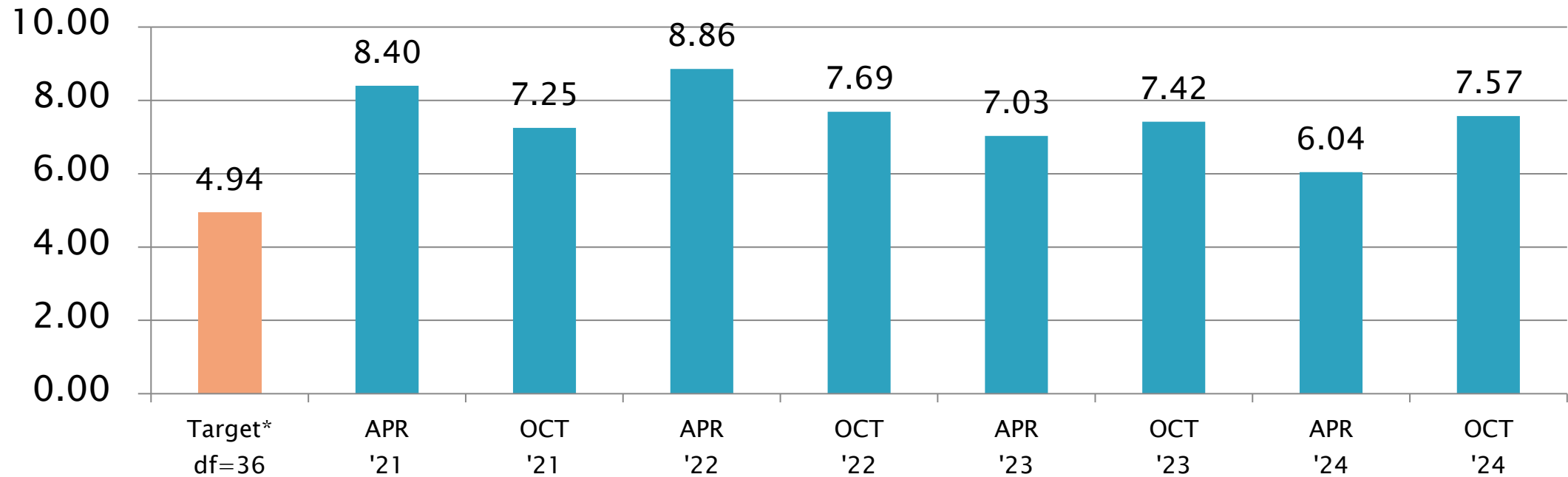
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D7097 Precision Estimates

Total Deposits, mg

Pooled s



*Target precision updated to reference oils 432 and 434-3 preliminary

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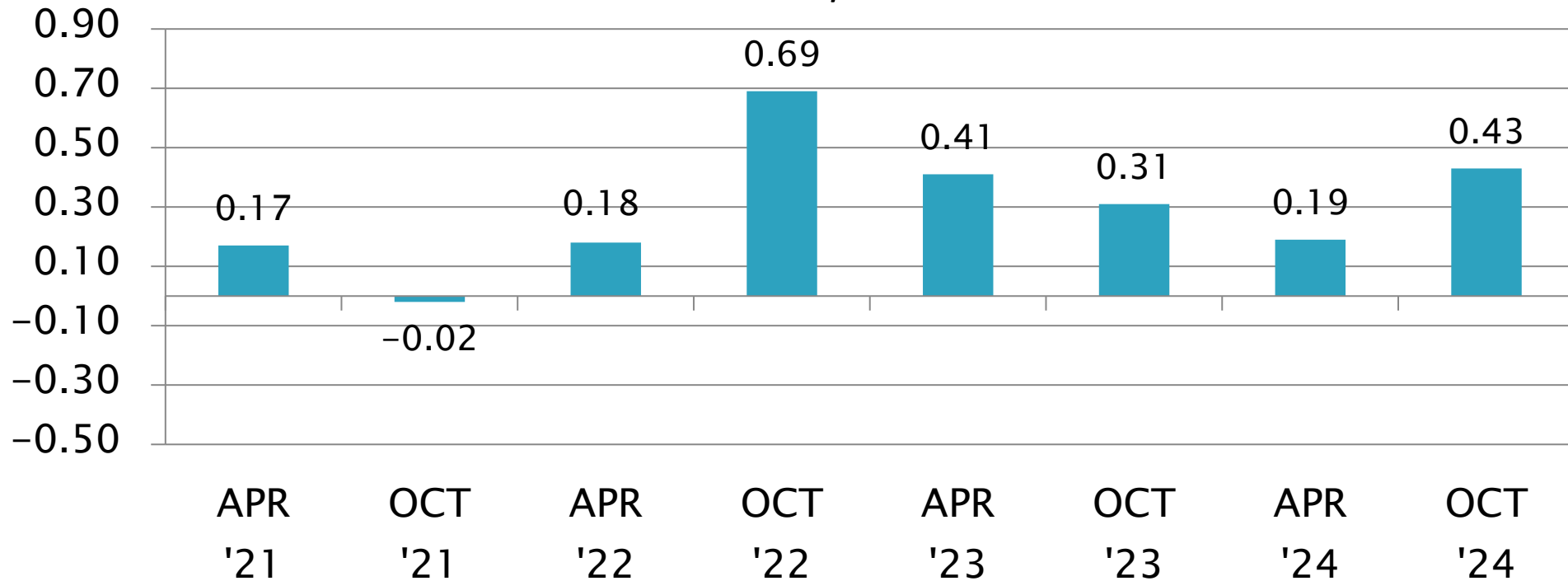
Test Monitoring Center
<https://www.astmtmc.org>



D7097 Severity Estimates

Total Deposits, mg

Mean Δ/s



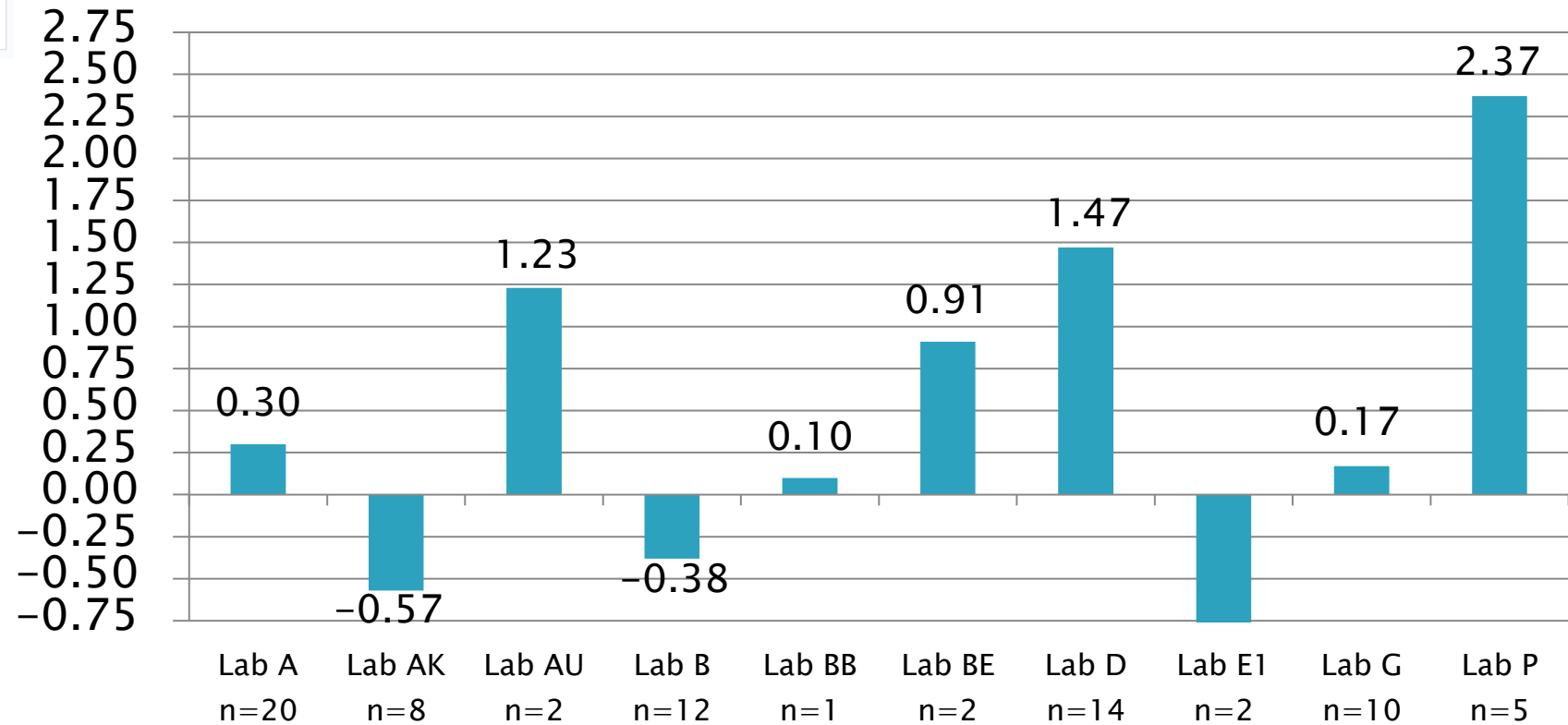
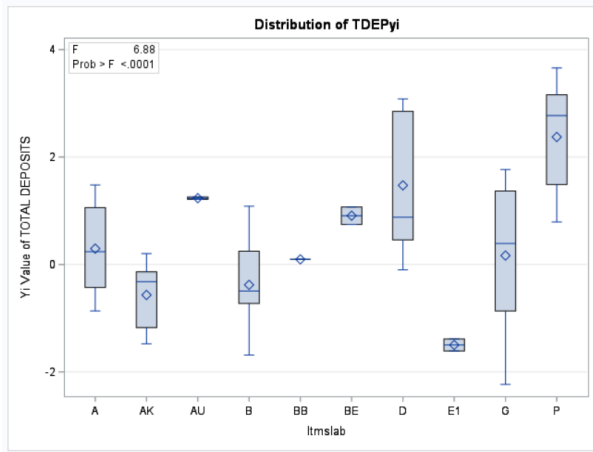
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D7097 Lab Severity Estimates

Total Deposits, mg
Mean Δ/s



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D7097: Deposits by MTEOS

- ▶ Precision (Pooled s) regressed back to 7.57 s this reporting period
- ▶ Performance (Mean Δ/s) has also regressed, moving from 0.19 s back up to 0.43 s this semester.
- ▶ All operationally valid tests this period report using Rod Batch N ($n = 76$ valid calibration runs).
- ▶ Most operationally valid calibration tests this period report using Catalyst Batch 23AB ($n=51$). Some runs used Catalyst Batch 20AB ($n=25$).
 - No runs used Catalyst Batch 19BA this semester

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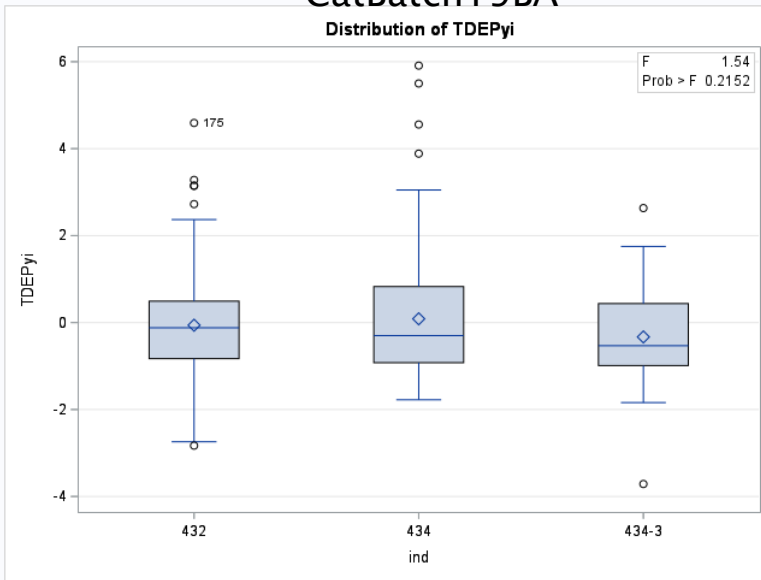
Test Monitoring Center
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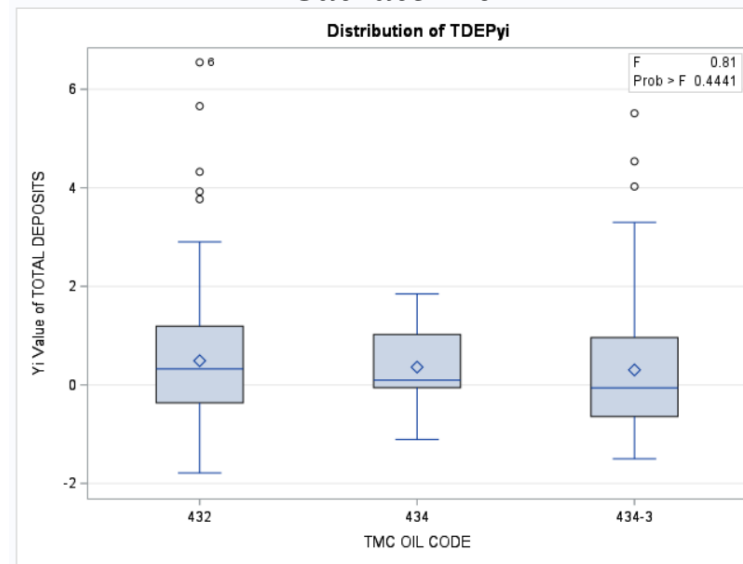
D7097: Deposits by MHT TEOST

- ▶ No new runs on catalyst batch 19BA this semester
 - Total Runs and Y_i statistic for batch 19BA remain at $n=349$, $Y_i = -0.02$.
- ▶ Severity on catalyst batch 20AB ($n=319$) appears to be slightly severe of target for oils 432, 434 and 434-3 Performance ($Y_i = 0.40$) has not changed since APR '24 report ($Y_i = 0.40$).
- ▶ New catalyst batch 23AB now has 58 runs. Performance has improved since the APR '24 report. ($Y_i = 0.53$ OCT '24; $Y_i=1.39$ APR '24)

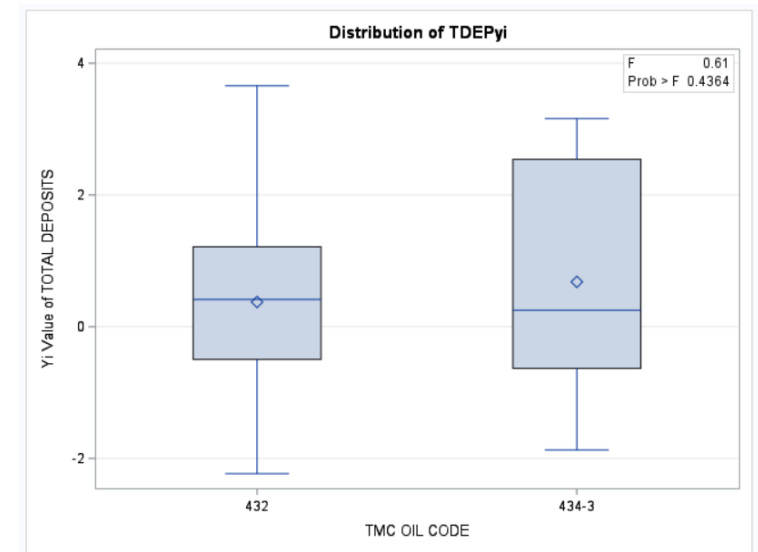
CatBatch19BA



CatBatch20AB



CatBatch23AB



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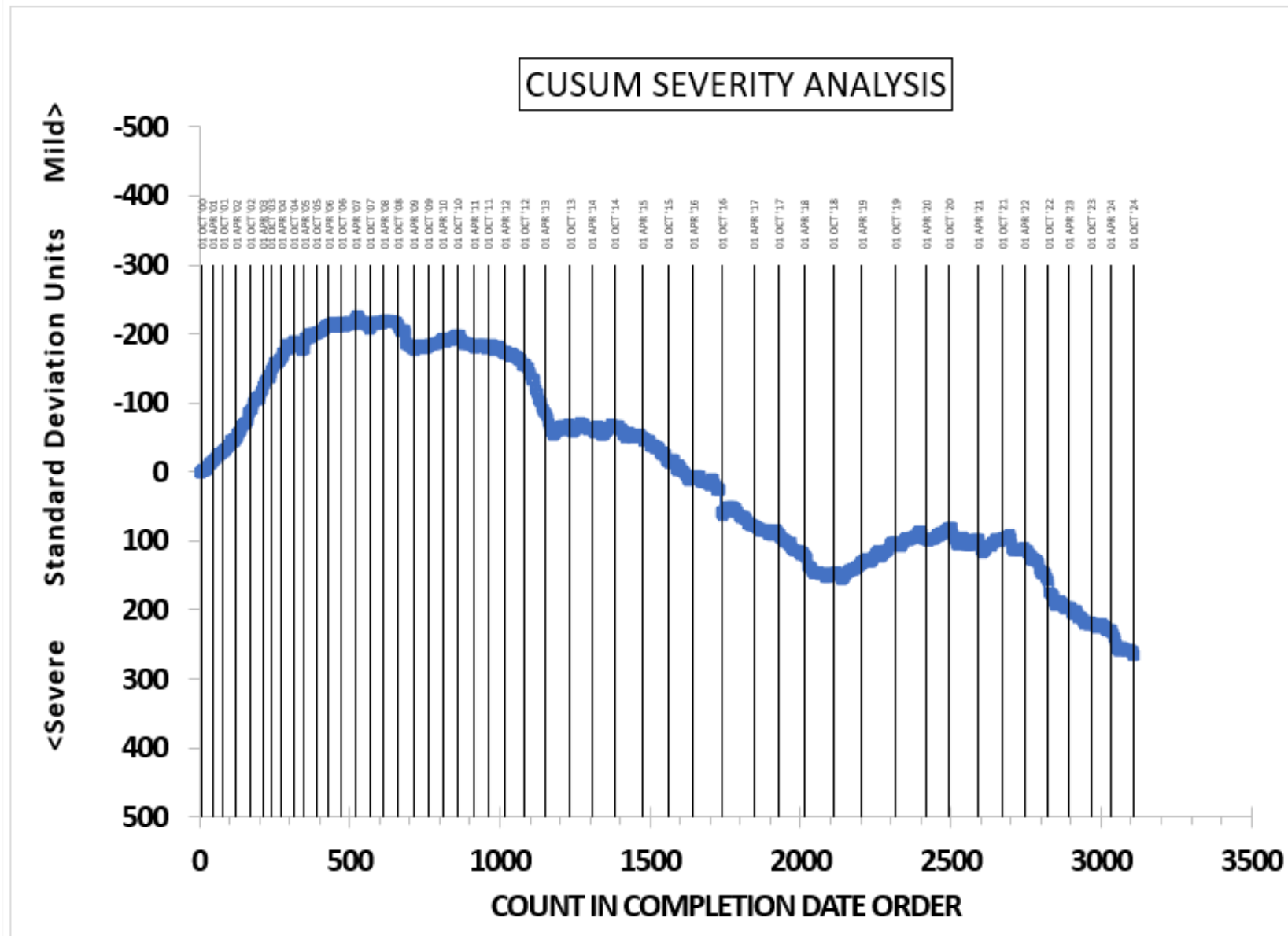
Test Monitoring Center
<https://www.astmtmc.org>



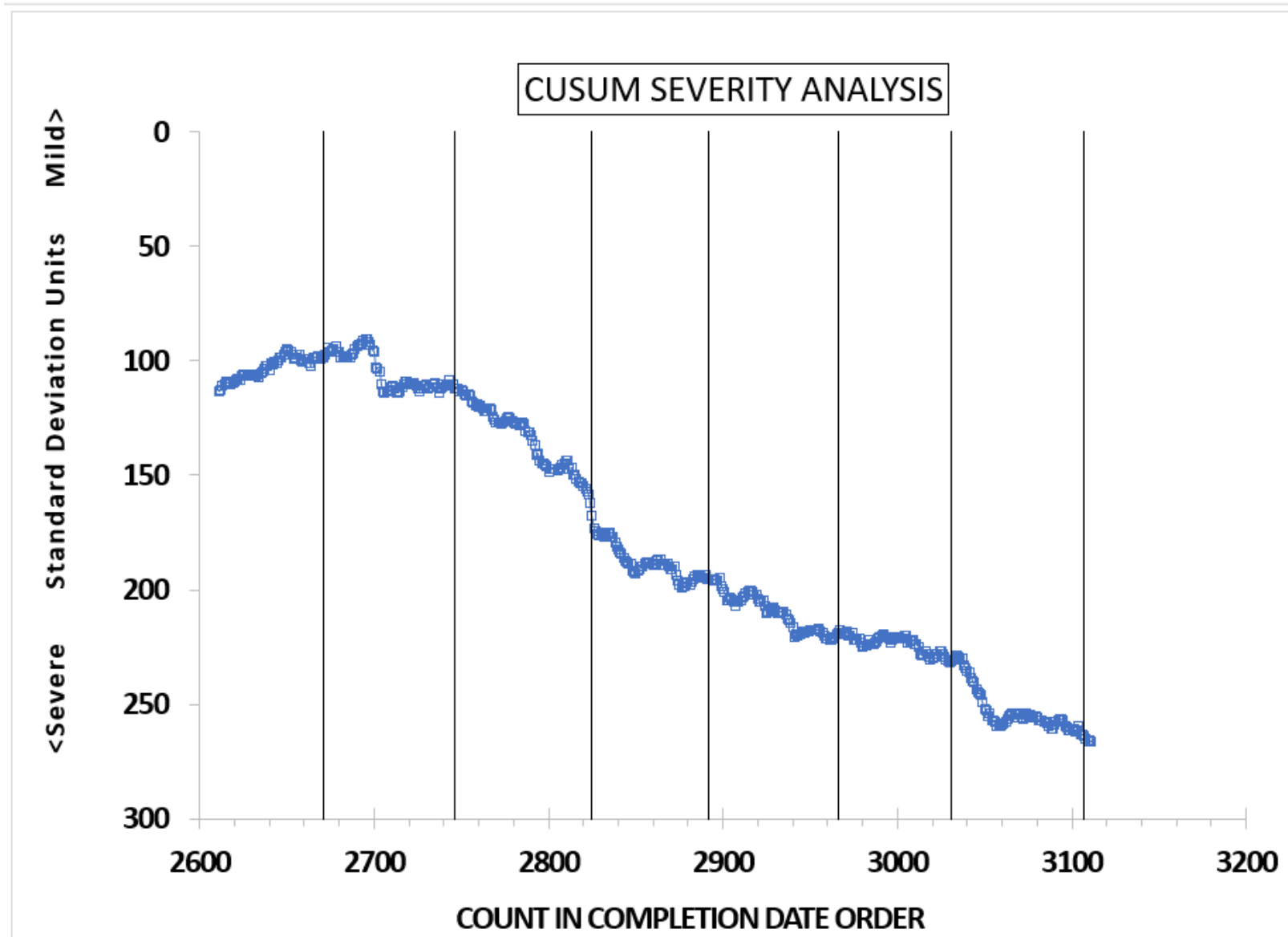
MHT-4 TEOST INDUSTRY OPERATIONALLY VALID DATA

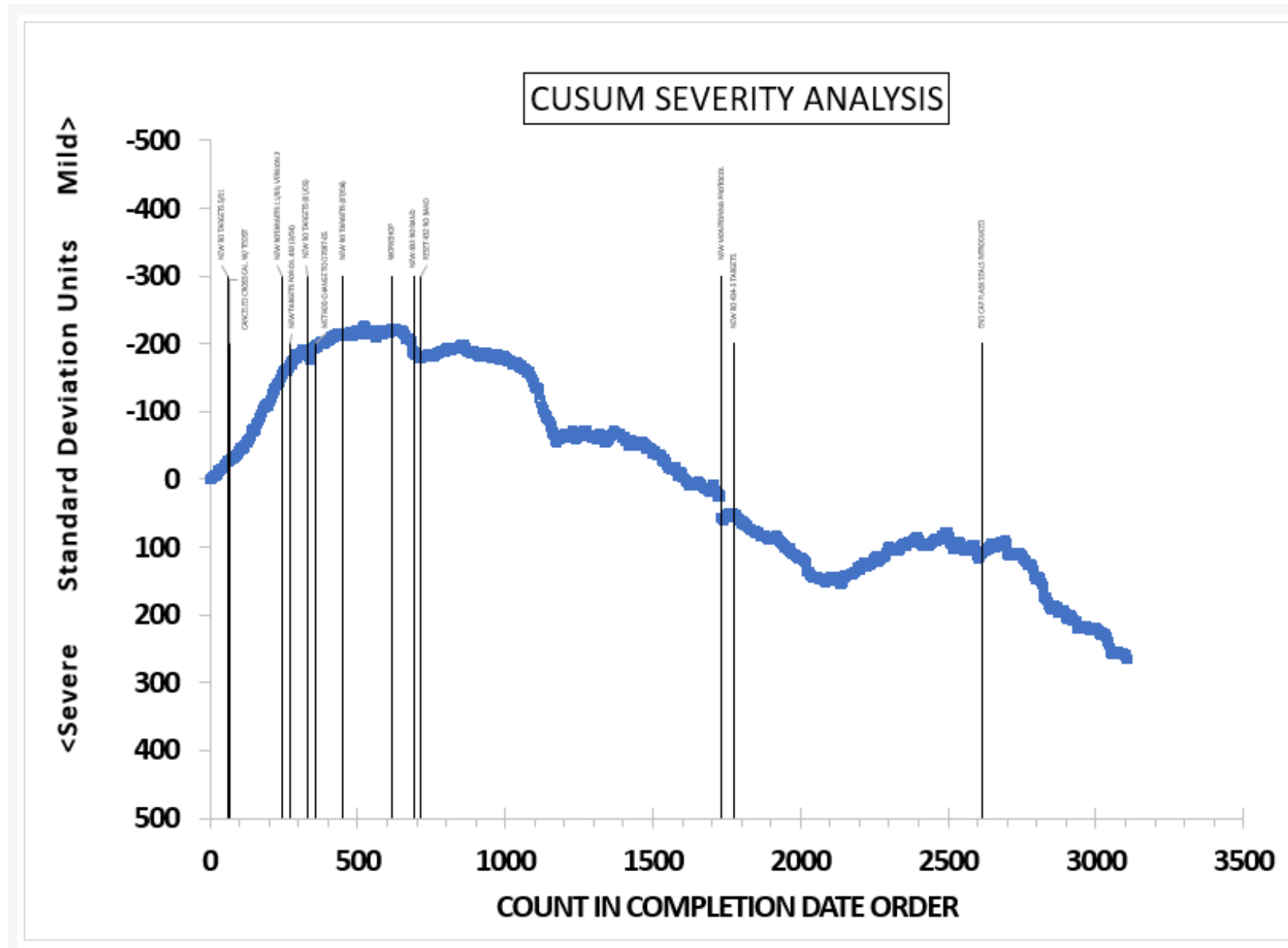


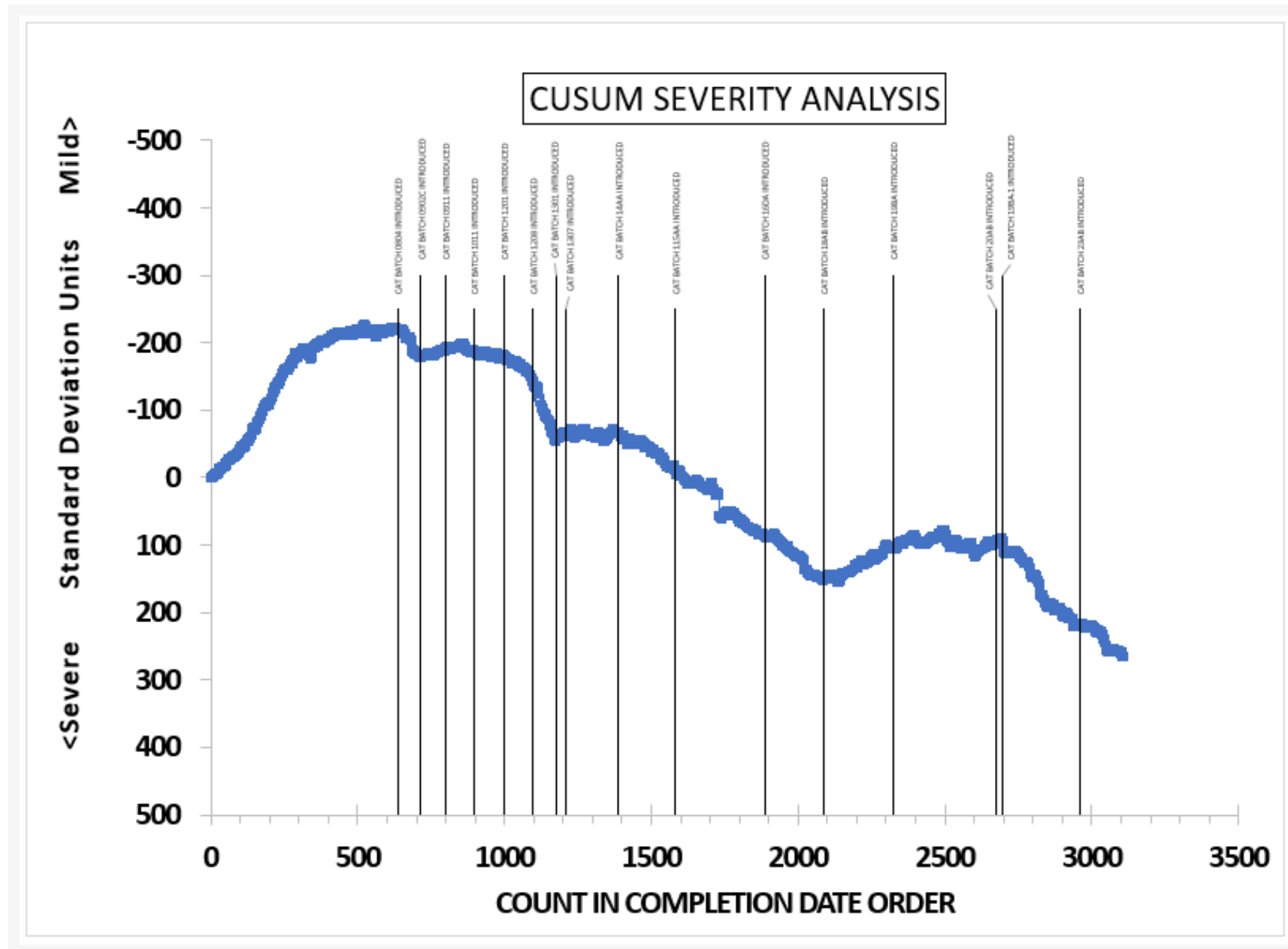
TOTAL DEPOSITS MG



MHT-4 TEOST INDUSTRY OPERATIONALLY VALID DATA
Last 500 Points
TOTAL DEPOSITS MG



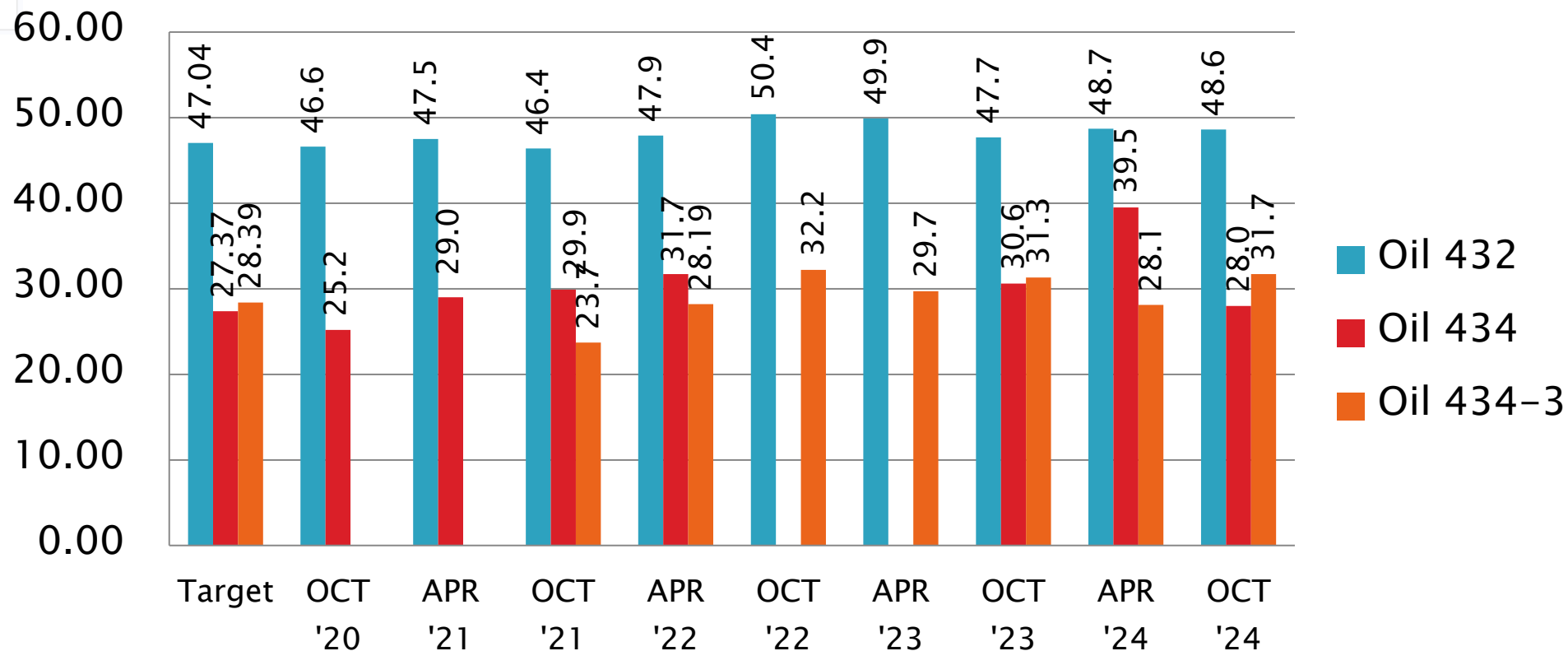
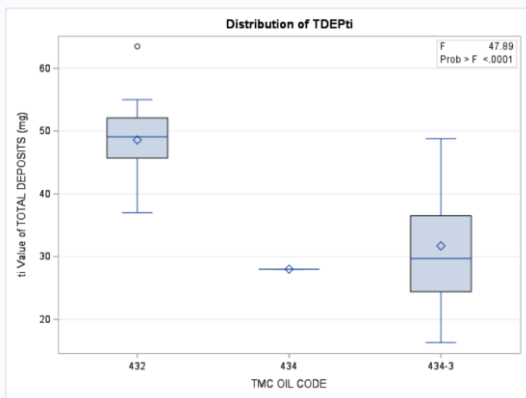






D7097 Performance by Oil

Total Deposits, mg
Mean



*Only a single RO 434 run for APR'24 and OCT'24.

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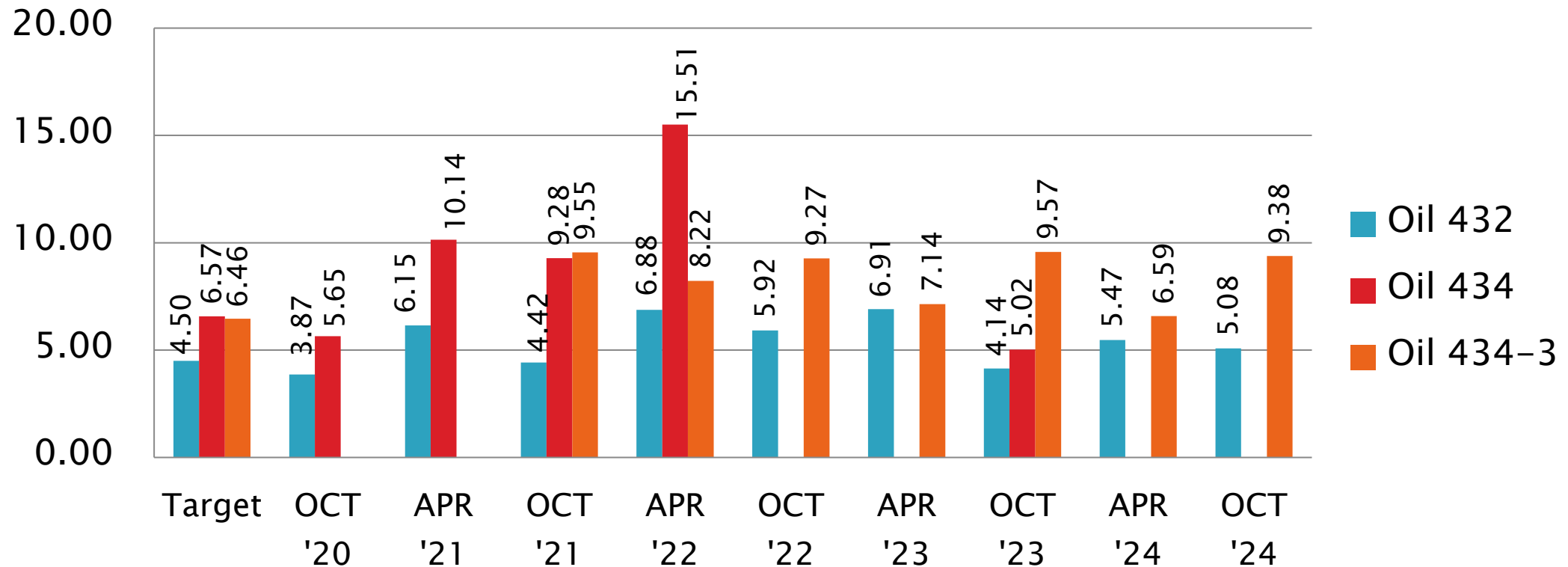
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D7097: Deposits by MHT TEOST

Total Deposits, mg

S_R



*Only single RO 434 runs. No StDEV result available for APR'24 and OCT'24.

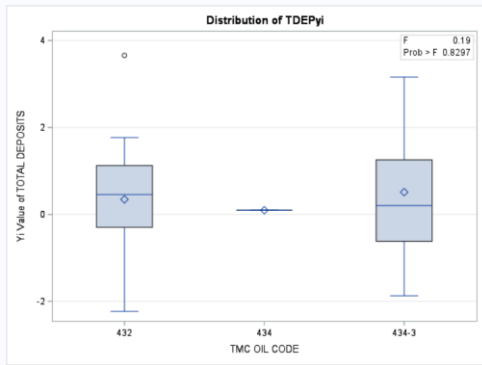
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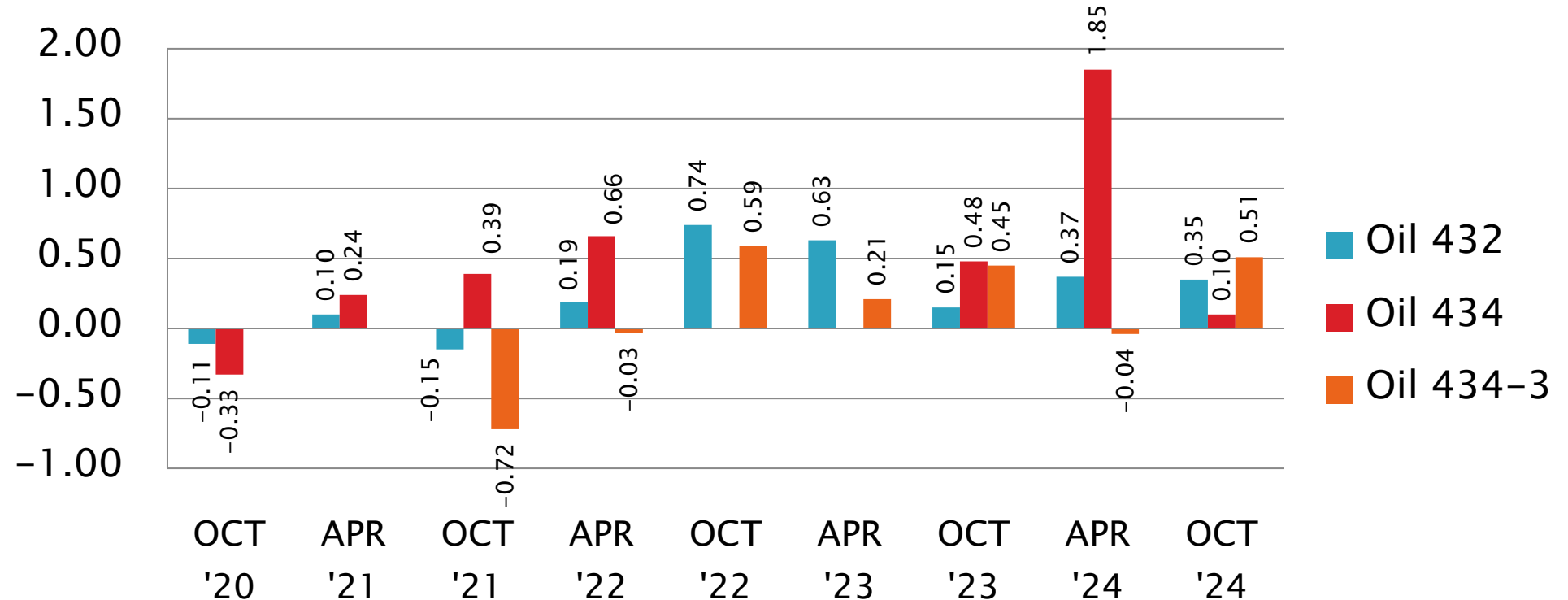


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D7097: Deposits by MHT TEOST



Total Deposits, mg
Mean Δ/s



*Only a single RO 434 run for APR'24 and OCT'24.

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Reference Oil Inventory

MTEOS

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
432	1998	MTEOS	101.29	0.23	5+ years
434-3 ^B	2017	MTEOS	14.68	3.71	2 years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B Multi-test oil; estimated supply of drum reserved for bench testing – other drums available.

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D02.B0.07

TMC Monitored Tests



ASTM D 7216

Engine Oil Elastomer Compatibility (EOEC/LDEOC)

April 1, 2024 – September 30, 2024



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ASTM Reference Testing Semi-Annual Report D7216 EOEC

April 1, 2024 – September 30, 2024

ASTM D 7216

Engine Oil Elastomer Compatibility

EOEC (Heavy-Duty)	
OHT PART NUMBER	BATCH CODE
OHTEOEC-NBR-A	31
OHTEOEC-ACM-B	33
OHTEOEC-FKM-A	31
OHTEOEC-MAC-A	24
OHTLDEOC-VMQ1-A	42
OHTLDEOC-HNBR1-A	32

Calibrated Labs and Stands¹

(change since last Semi-Annual report)

Test	Labs	Stands
D7216 EOEC	8 ² (+1)	N/A

¹ As of 9/30/2024

² SEVEN Labs ran EOECV

EOEC Test Activity*

Test Status		Fluoroelast.	Nitrile	Polyacrylate	Silicone	Ethylene Acrylate	Total
LABS		8	8	8	8	7	
Acceptable Calibration Test	AC	69	84	71	61	65	350
Failed Calibration Test	OC	0	1	1	1	2	5
Operationally Invalid, by lab	LC	0	1	0	0	0	1
Operationally Invalid, by TMC	RC	0	0	0	0	0	0
Aborted	XC	0	0	1	1	0	2
Total		69	86	73	63	67	358

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EOEC Failed Calibration Tests*

Cause	Elastomer	No. of Tests
HARDNESS (MILD)	1 – MAC	1
TENSILE STRENGTH (SEVERE)	1 – NBR, 1 – MAC	2
VOLUME & HARDNESS (MILD)	1 – VMQ	1
ELONGATION (SEVERE)	1 – ACM	1
Total		5

* FIVE failing calibration tests from TWO different labs

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EOEC Lost Tests*

Validity	Cause	No. of Tests
XC	Aborted Test Bath Temperature Issues	1
XC	Aborted Test Broken Glass Found in Tube	1
LC	Test Ran on Wrong Elastomer Type	1
LC	Lab Reported Invalid (no data or details)	1
Total		4

*Invalid and aborted calibration tests

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EOEC Test Severity

Fluoroelastomer (FKM)

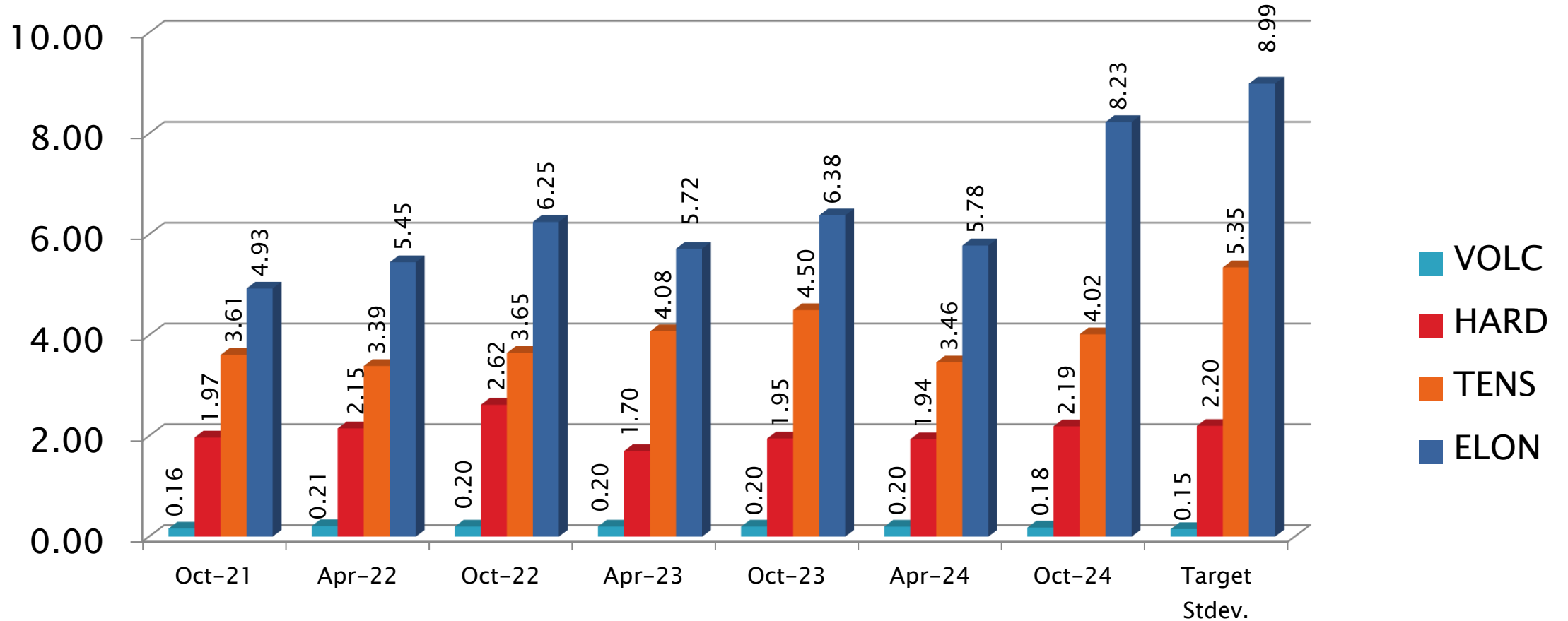
Parameter	Period Mean Δ/s	Status
Volume Change	0.1488	Slightly Severe
Points Hardness Change	0.1597	Slightly Severe
Tensile Strength Change	0.3670	Severe
Elongation Change	-0.3456	Mild

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EOEC Precision (Pooled s) Estimates: Fluoroelastomer



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EOEC Precision Estimates by Lab: FKM

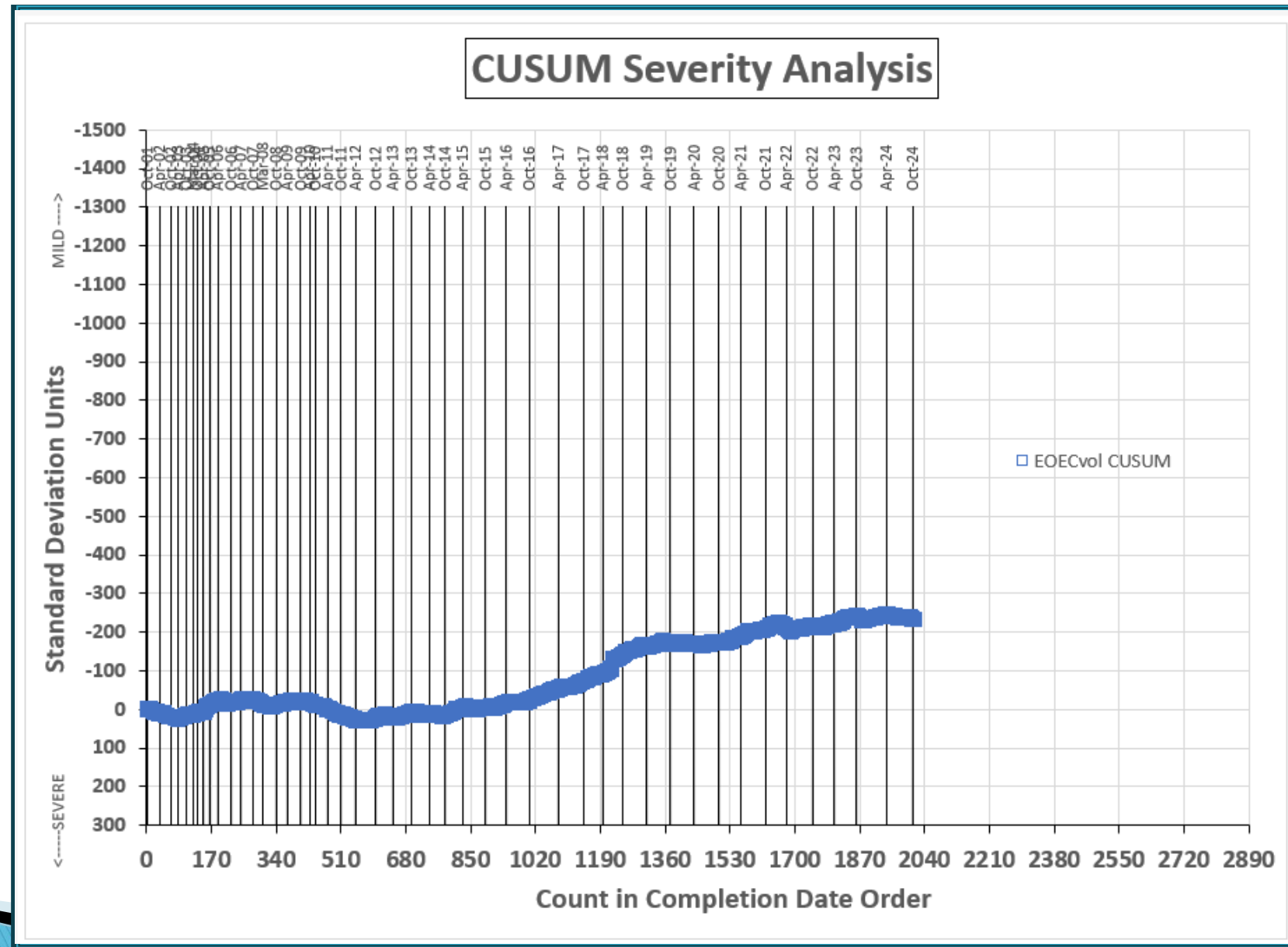
Test Parameter	Statistic	LTMS Lab							
		A	B	BB	G	I	L	P	V
	n=	26	8	1	21	8	2	2	1
Volume	Mean	0.3604	0.4612	0.48	0.5195	0.6400	0.4300	0.5550	0.3400
	Pooled s	0.1311	0.2413	n/a	0.1272	0.2266	0.0141	0.1485	n/a
	Mean /s	-0.5379	0.1436	0.2703	0.5373	1.351	-0.0676	0.7770	-0.6757
Hardness	Mean	9.462	9.500	6.00	6.048	9.500	8.500	10.00	11.00
	Pooled s	0.8114	0.9258	n/a	2.312	1.309	0.7071	1.414	n/a
	Mean /s	0.6462	0.6636	-0.9273	-0.9056	0.6636	0.2091	0.8909	1.3454
Tensile Strength	Mean	-72.41	-71.52	-66.8	-66.54	-65.40	-69.25	-66.70	-71.40
	Pooled s	1.859	1.670	n/a	4.283	1.510	0.3536	3.536	n/a
	Mean /s	-0.2040	-0.0383	0.8449	0.8929	1.107	0.3869	0.8636	-0.0150
Elongation	Mean	-68.45	-64.55	-63.8	-53.26	-56.34	-66.40	-57.55	-72.70
	Pooled s	2.827	2.480	n/a	7.408	2.338	3.536	5.728	n/a
	Mean /s	-1.019	-0.6752	-0.5918	0.5810	0.2383	-0.8810	0.1034	-1.582

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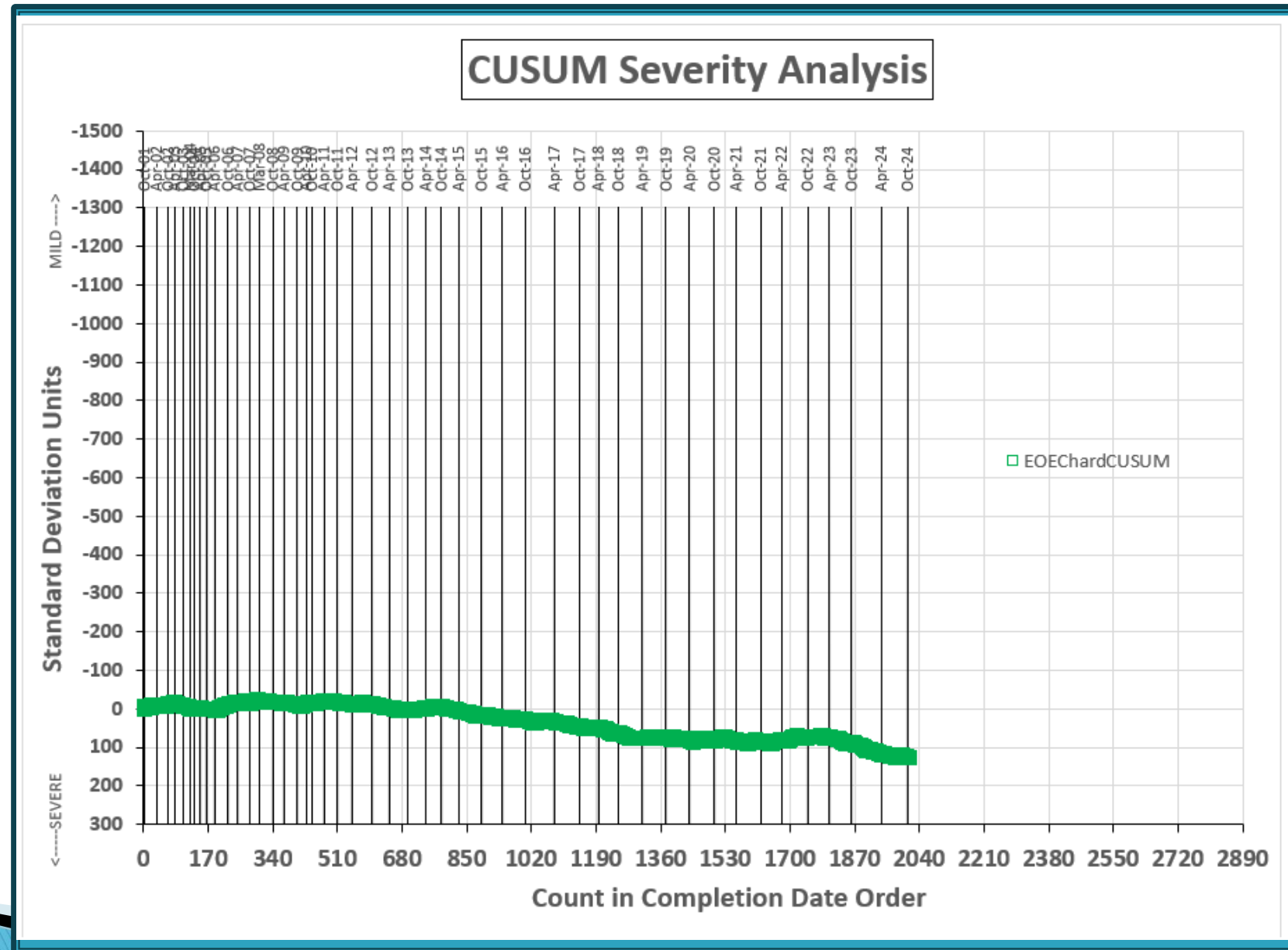
Test Monitoring Center
<https://www.astmtmc.org>



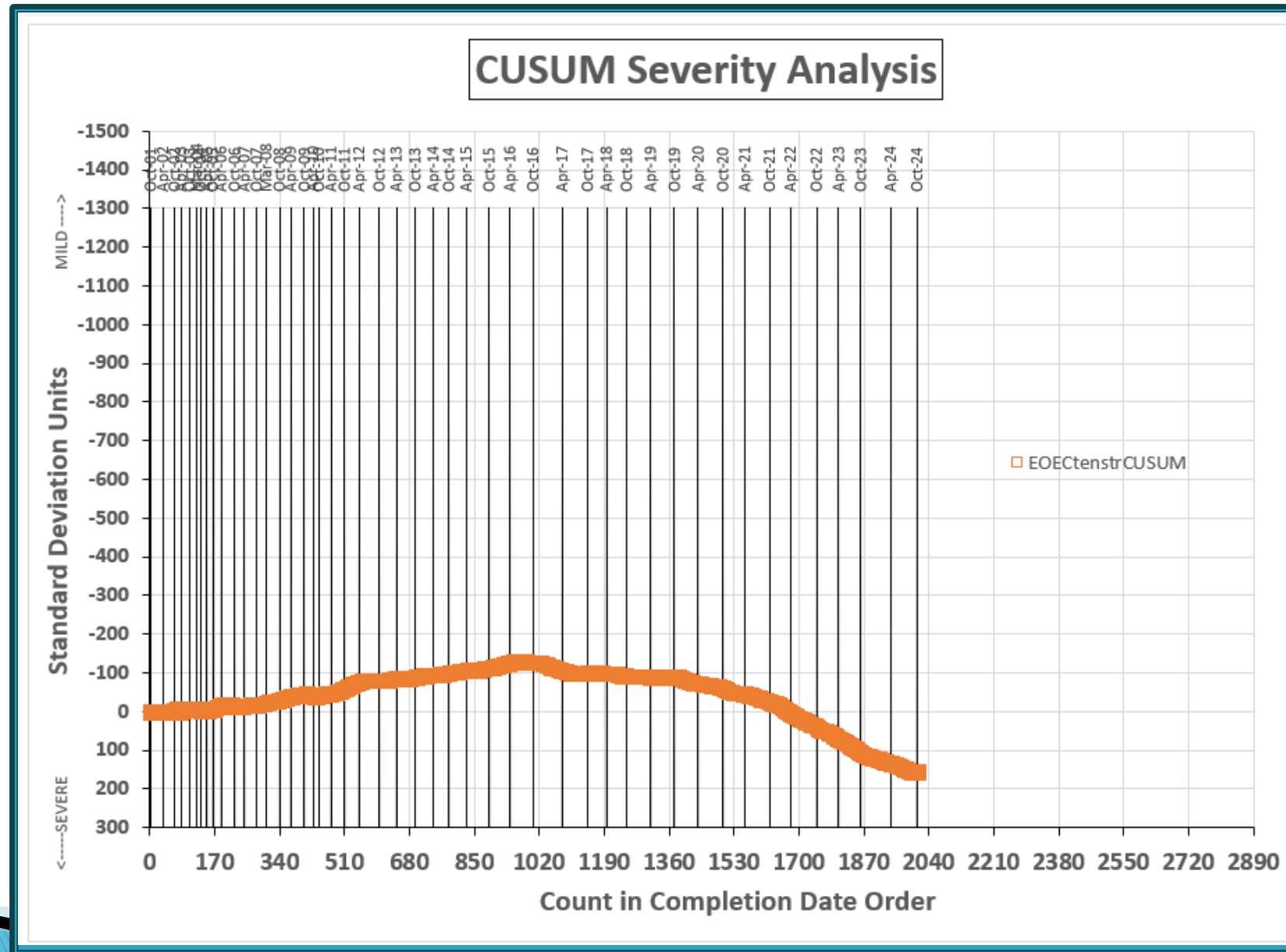
FLUOROELASTOMER VOLUME CHANGE CORRECTED AVERAGE



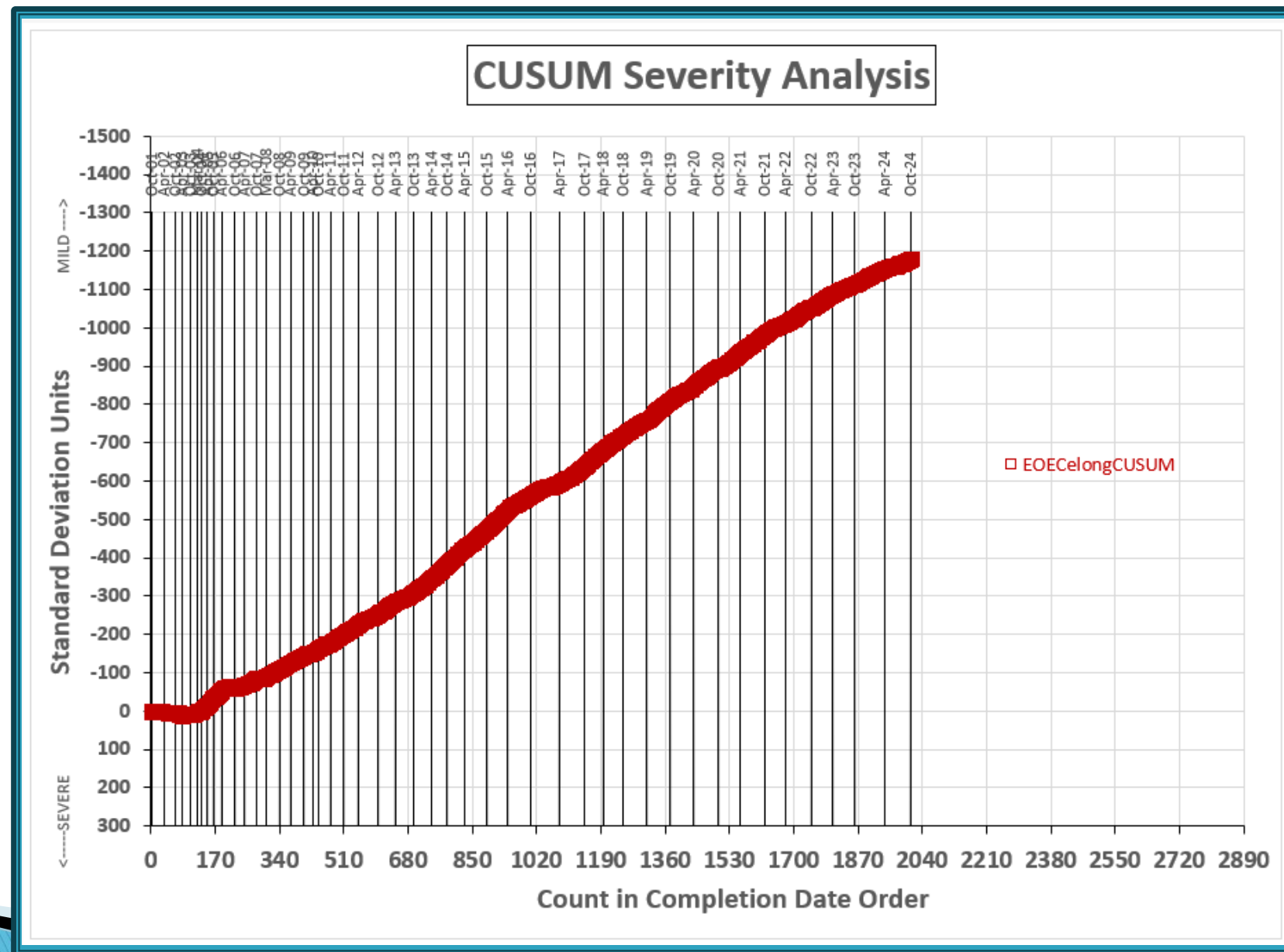
FLUOROELASTOMER PTS HARDNESS CHANGE CORRECTED AVG



FLUOROELASTOMER TENS STRENGTH CHANGE CORRECTED AVG



FLUOROELASTOMER ELONGATION CHANGE CORRECTED AVG



EOEC Test Severity

Nitrile (NBR)

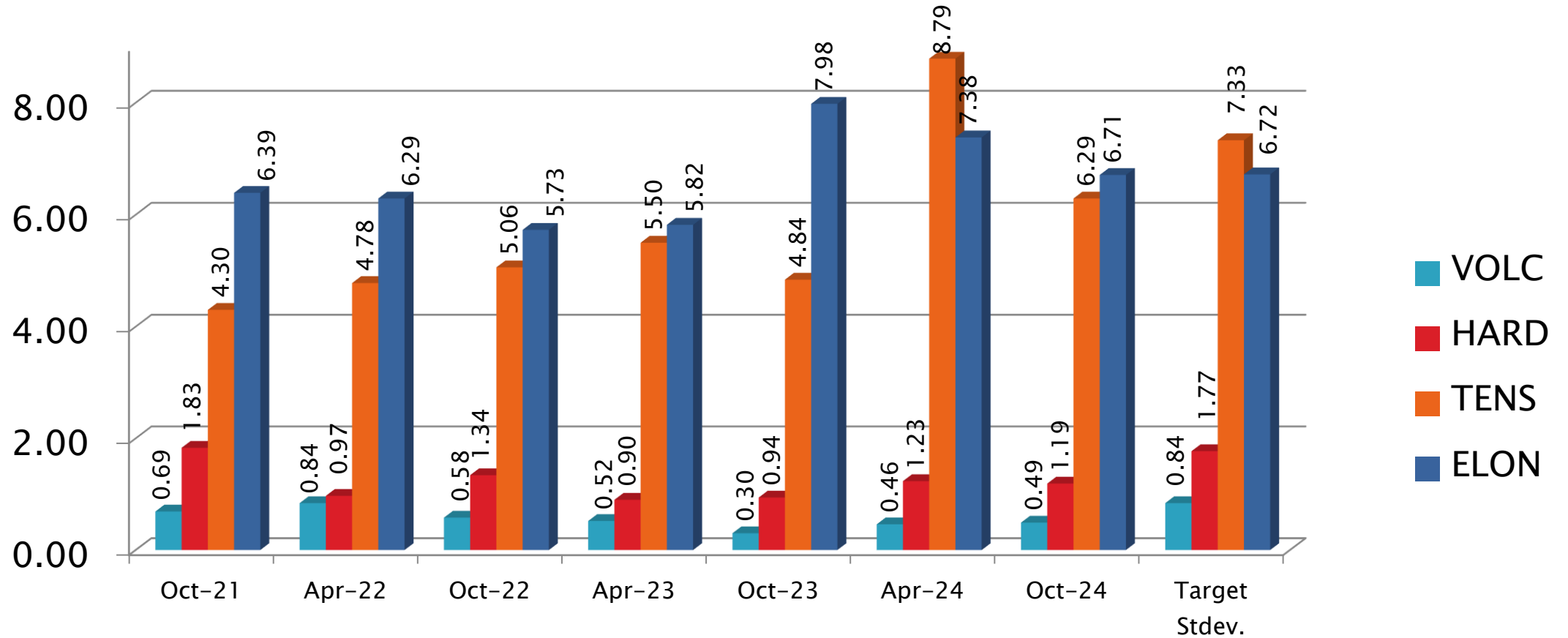
Parameter	Period Mean Δ/s	Status
Volume Change	0.2090	Slightly Severe
Points Hardness Change	0.7464	Severe
Tensile Strength Change	-1.0884	Very Mild
Elongation Change	-0.1854	Slightly Mild

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EOEC Precision Estimates – Nitrile



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EOEC Precision Estimates by Lab: NBR

Test Parameter	Statistic	LTMS Lab							
		A	B	BB	G	I	L	P	V
	n=	30	8	1	22	14	2	5	3
Volume	Mean	1.873	2.166	1.820	1.6332	2.235	2.043	2.036	1.957
	Pooled s	0.4206	0.5030	n/a	0.3155	0.7370	0.2721	0.2784	0.2108
	Mean /s	0.1583	0.5074	0.0952	-0.1272	0.5893	0.3611	0.3524	0.2579
Hardness	Mean	3.100	3.625	5.000	2.5455	3.857	3.000	3.400	2.667
	Pooled s	0.9223	0.9161	n/a	1.4712	1.027	1.000	0.8944	1.528
	Mean /s	0.7175	1.014	1.791	0.4042	1.145	0.6610	0.8870	0.4727
Tensile Strength	Mean	-5.260	-4.950	-10.90	-9.332	-1.393	-2.200	2.040	-5.267
	Pooled s	6.429	3.217	n/a	6.748	2.499	2.443	5.302	3.802
	Mean /s	-1.100	-1.057	-1.869	-1.655	-0.5720	-0.6821	-0.1037	-1.101
Elongation	Mean	-37.10	-33.51	-35.00	-34.22	-32.34	-36.93	-31.88	-37.53
	Pooled s	3.857	3.143	n/a	10.78	5.272	7.575	3.905	2.043
	Mean /s	-0.507	0.0264	-0.1949	-0.0793	0.2005	-0.4826	0.2693	-0.5719

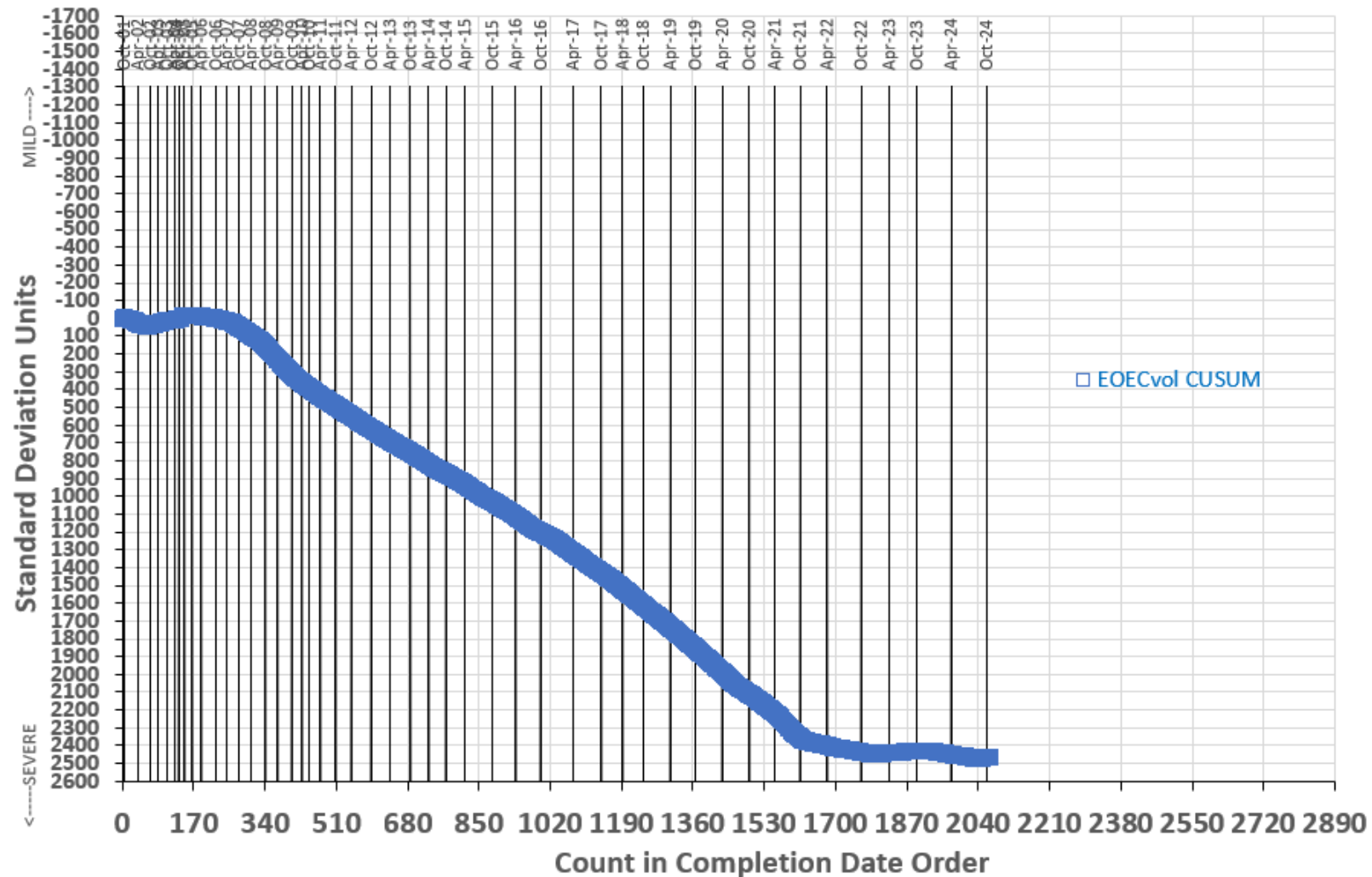
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Test Monitoring Center
<https://www.astmtmc.org>



REFERENCE NITRILE VOLUME CHANGE CORRECTED AVERAGE

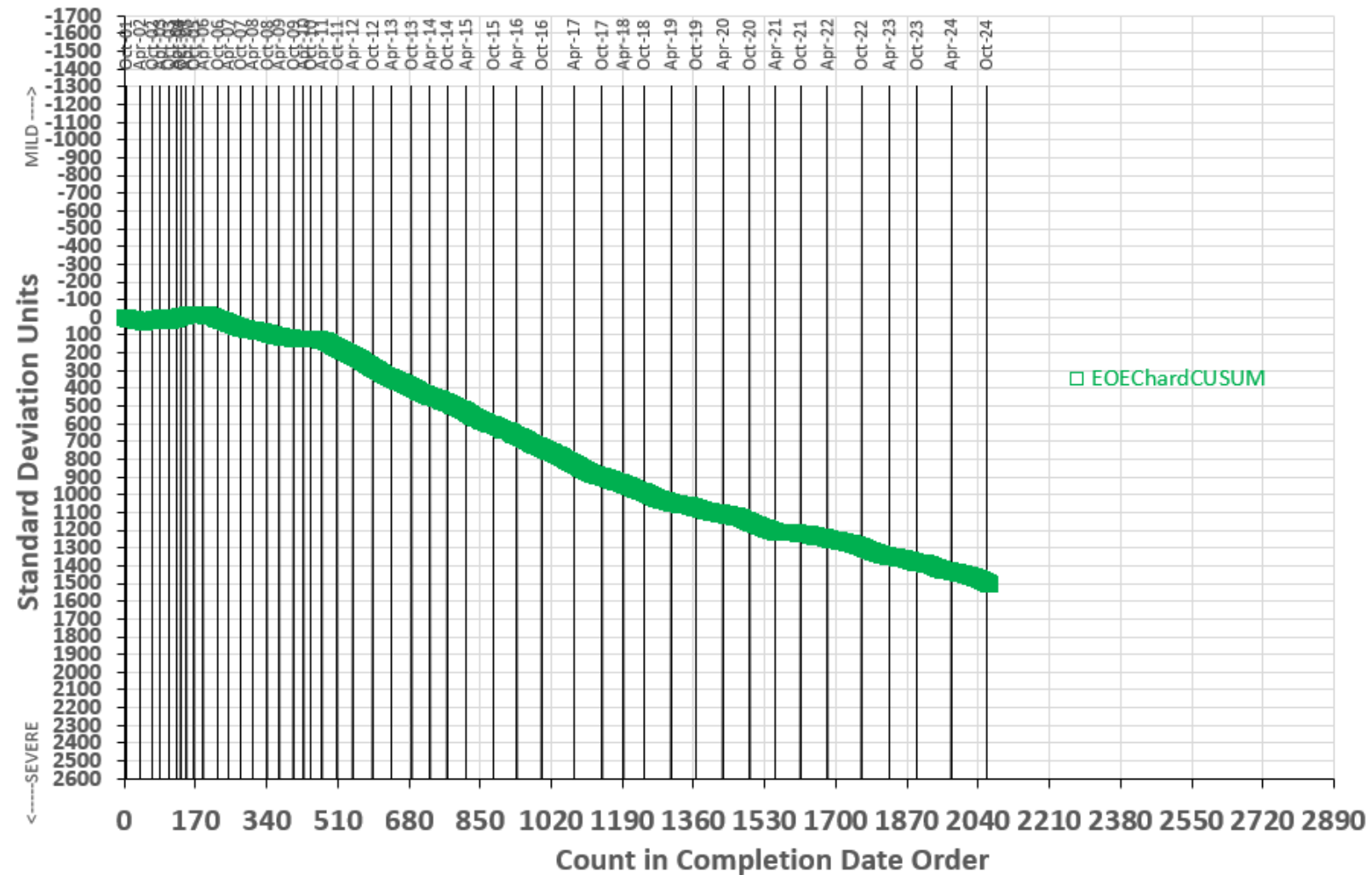
CUSUM Severity Analysis



EOECvol CUSUM

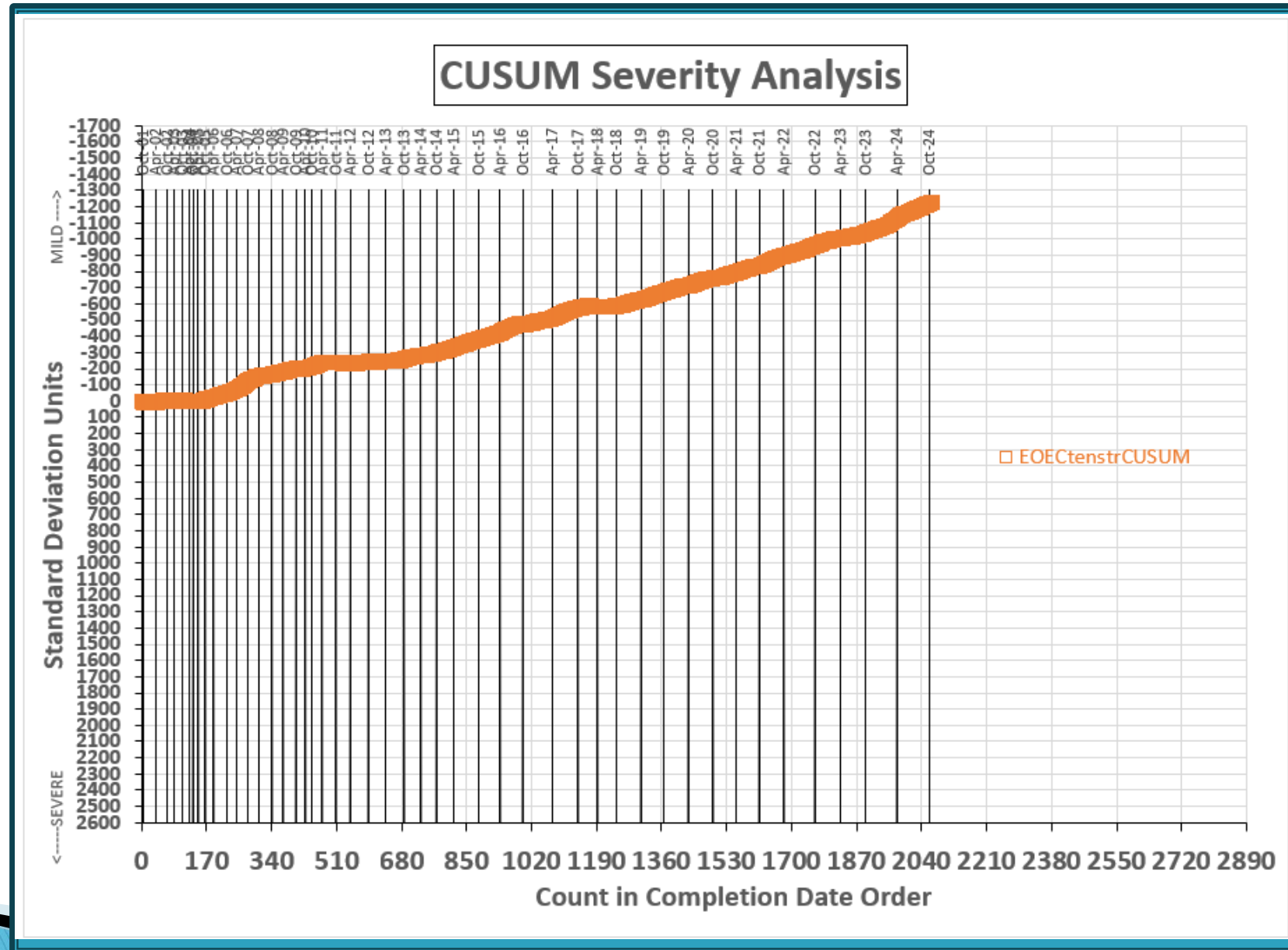
REFERENCE NITRILE PTS HARD CHANGE CORRECTED AVG

CUSUM Severity Analysis

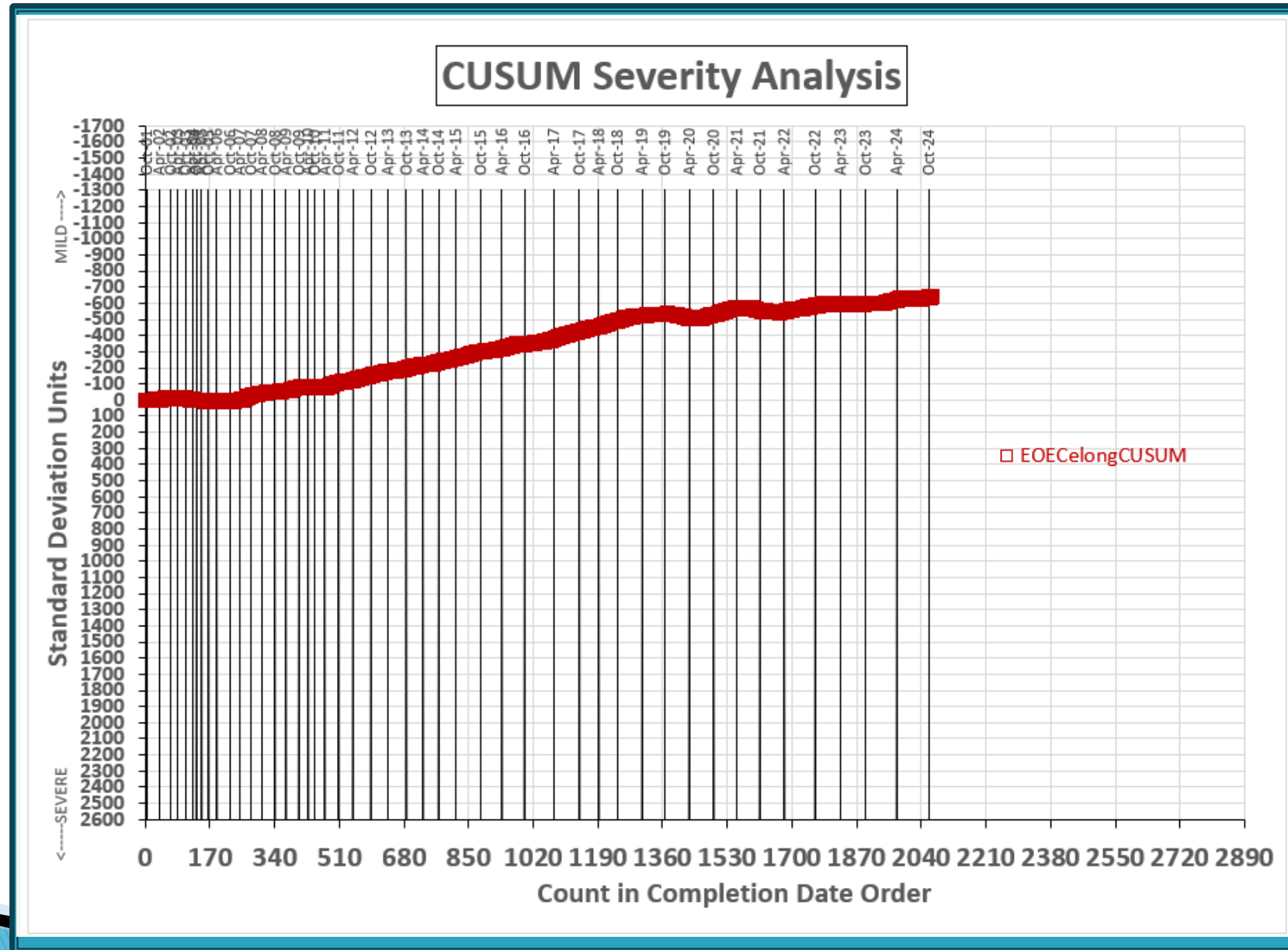


□ EOEChardCUSUM

REF NITRILE TENS STRENGTH CHANGE CORRECTED AVG



REF NITRILE ELONGATION CHANGE CORRECTED AVERAGE



EOEC Test Severity

Polyacrylate (ACM)

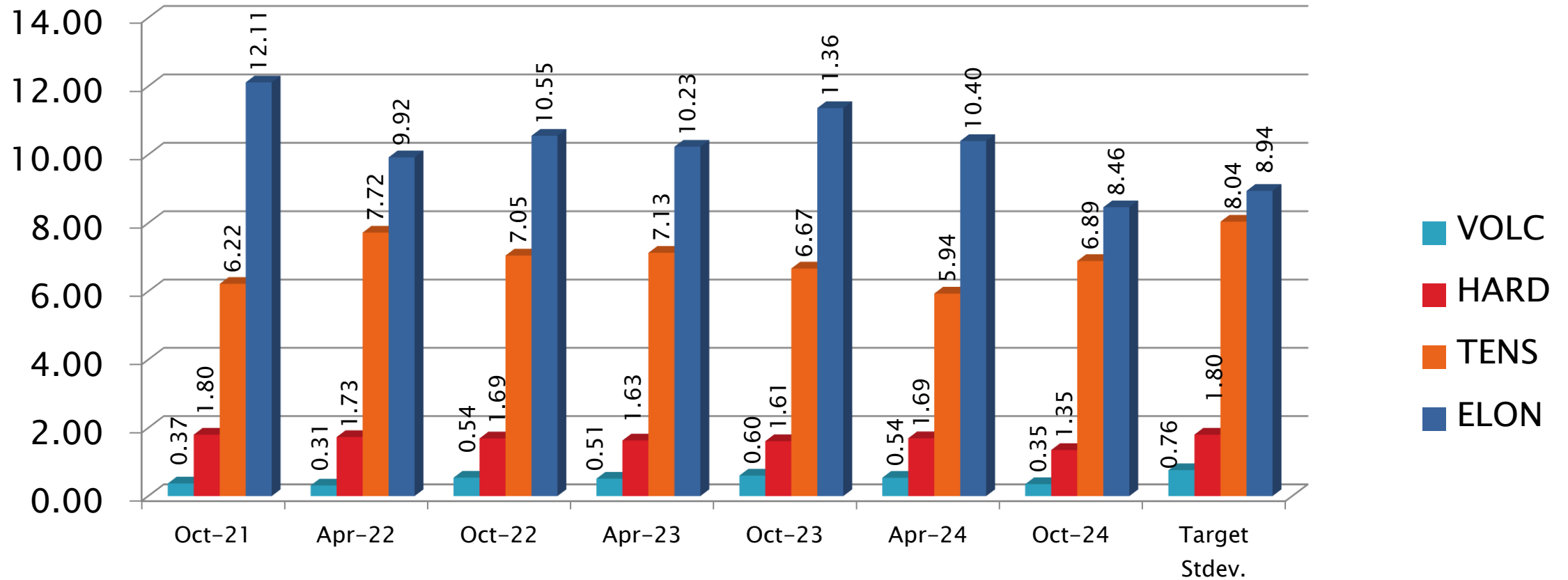
Parameter	Period Mean Δ/s	Status
Volume Change	2.26	Severe
Points Hardness Change	-1.25	Mild
Tensile Strength Change	0.52	Severe
Elongation Change	0.75	Severe

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Test Monitoring Center
<https://www.astmtmc.org>



EOEC Precision Estimates – Polyacrylate



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<https://www.astmtmc.org>



EOEC Precision Estimates by Lab: ACM

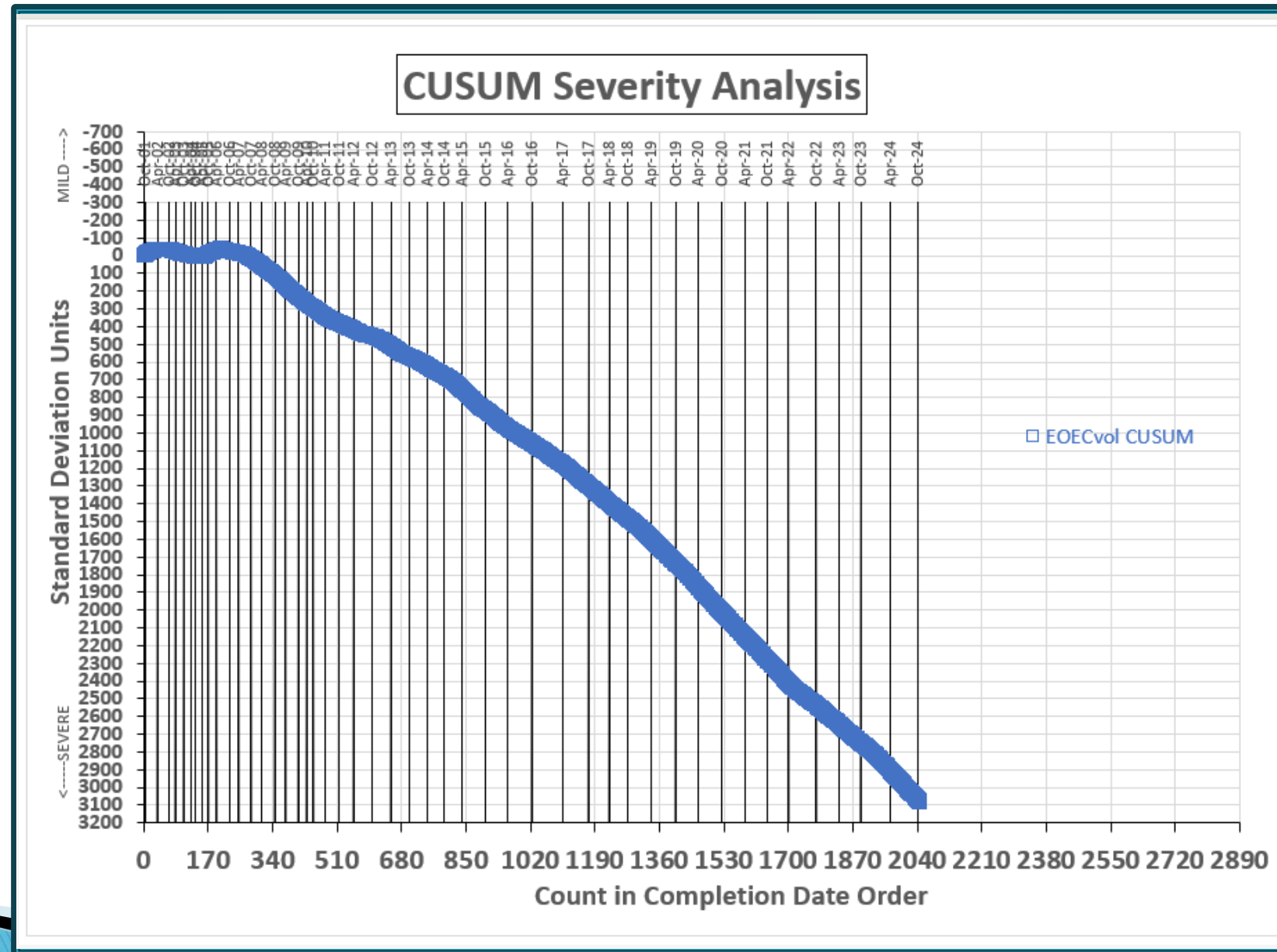
Test Parameter	Statistic	LTMS Lab							
		A	B	BB	G	I	L	P	V
	n=	26	8	1	23	8	2	2	2
Volume	Mean	1.917	2.030	1.460	1.881	2.156	1.340	2.040	1.680
	Pooled s	0.1676	0.1355	n/a	0.4611	0.5026	0	0.0424	0.1556
	Mean /s	2.260	2.408	1.658	2.212	2.574	1.500	2.421	1.947
Hardness	Mean	-3.000	-2.625	0.000	-2.087	-0.8750	-1.000	0	-3.500
	Pooled s	0.8485	0.5175	n/a	1.443	0.9910	1.414	1.414	0.7071
	Mean /s	-1.661	-1.453	0.0056	-1.154	-0.4806	-0.5500	0.0056	-1.939
Tensile Strength	Mean	5.677	7.050	-0.7000	1.204	6.7000	2.800	9.450	8.150
	Pooled s	5.076	2.986	n/a	9.687	3.020	4.525	4.172	2.899
	Mean /s	0.6613	0.8321	-0.1318	0.1050	0.7886	0.3035	1.131	0.9689
Elongation	Mean	-15.90	-14.06	-11.50	-15.99	-20.36	-13.10	-14.20	-10.40
	Pooled s	9.313	3.912	n/a	9.758	6.827	6.930	6.647	1.273
	Mean /s	0.7468	0.9527	1.2394	0.7375	0.2480	1.060	0.9374	1.362

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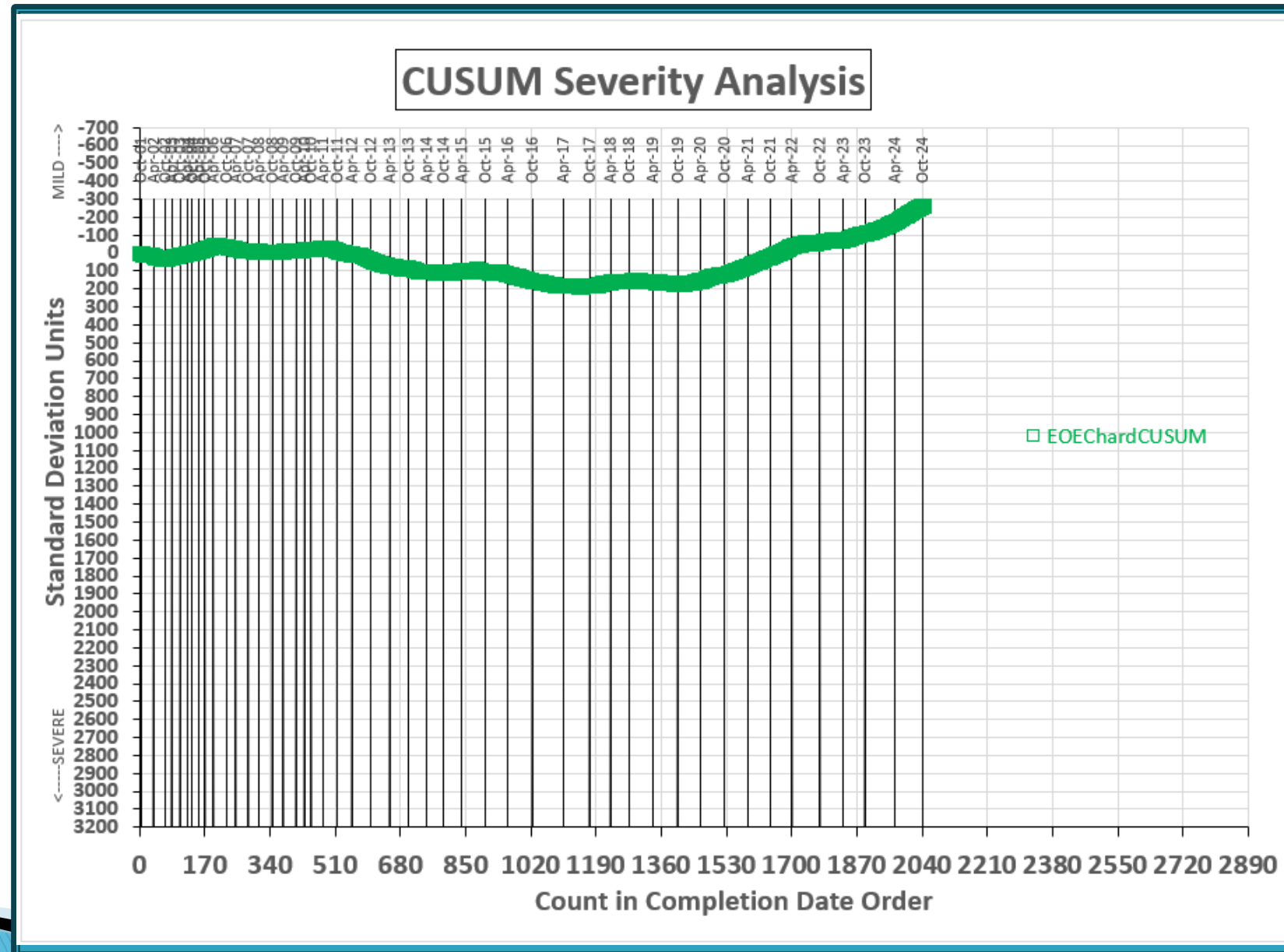
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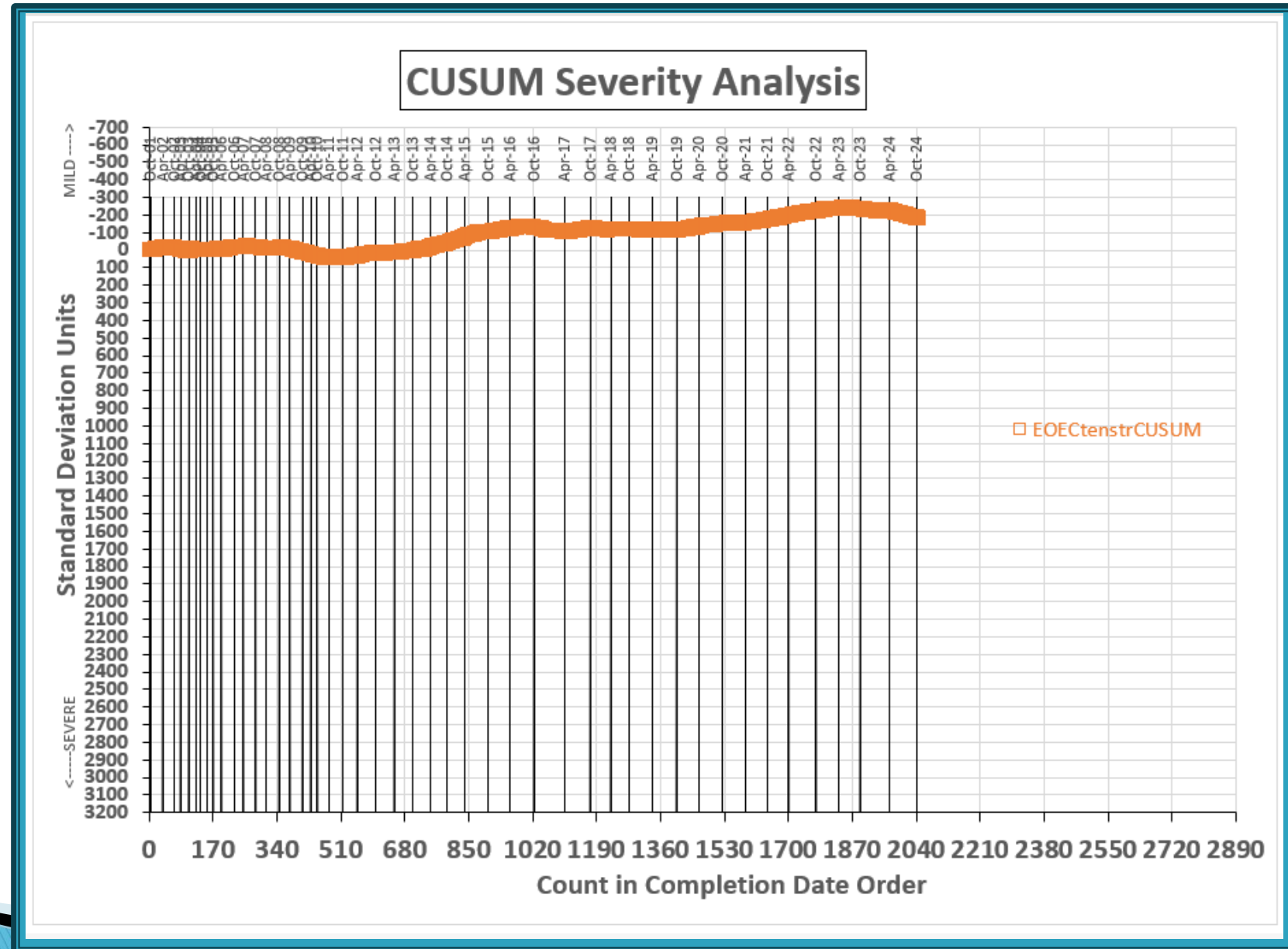
REFERENCE POLYACRYLATE VOLUME CHANGE CORRECTED AVG



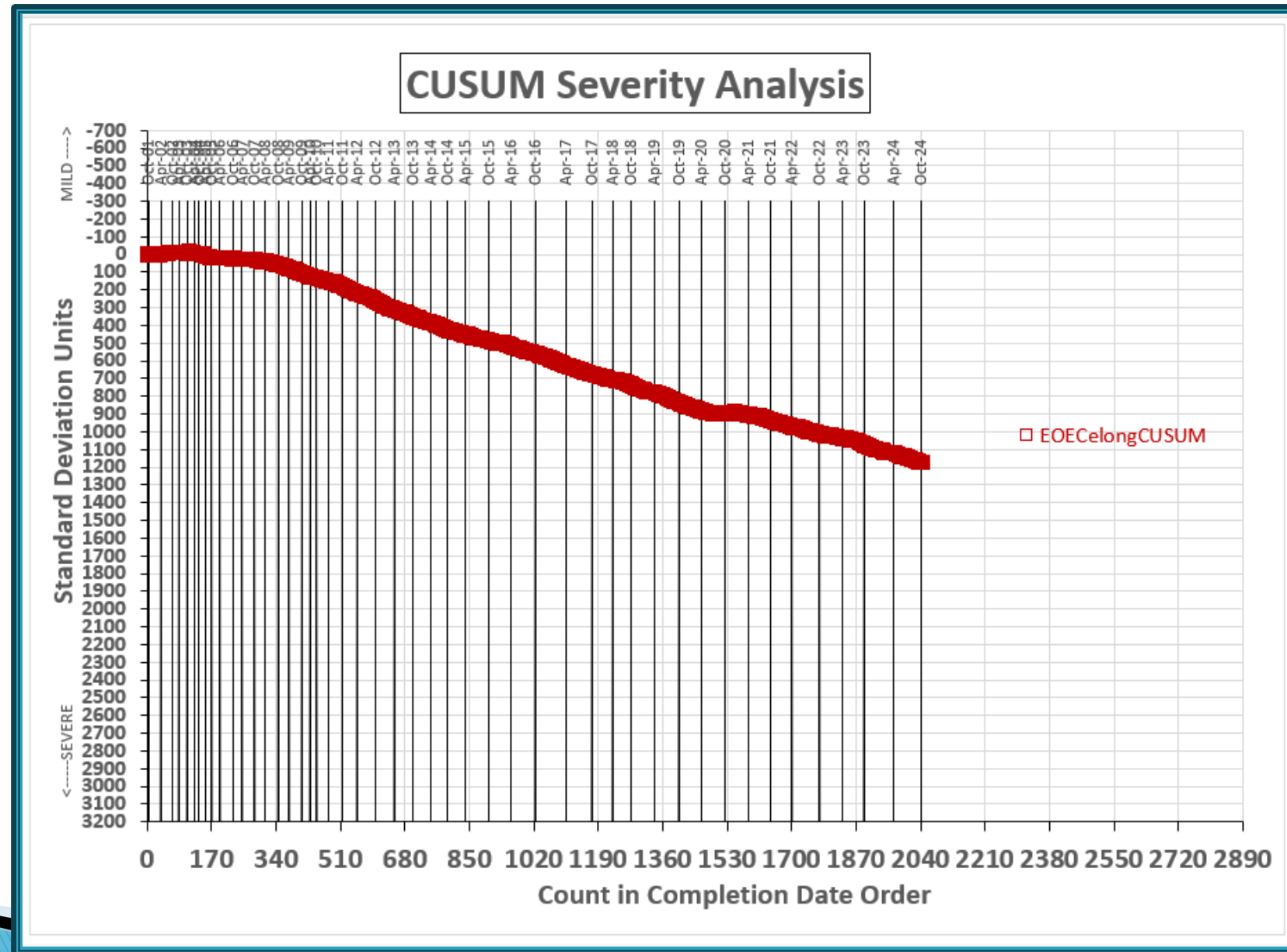
REF POLYACRYLATE PTS HARD CHANGE CORRECTED AVG



REF POLYACRYLATE TENS STRNGTH CHANGE CORRECTED AVG



REF POLYACRYLATE ELONGATION CHANGE CORRECTED AVG



EOEC Test Severity

Silicone (VMQ)

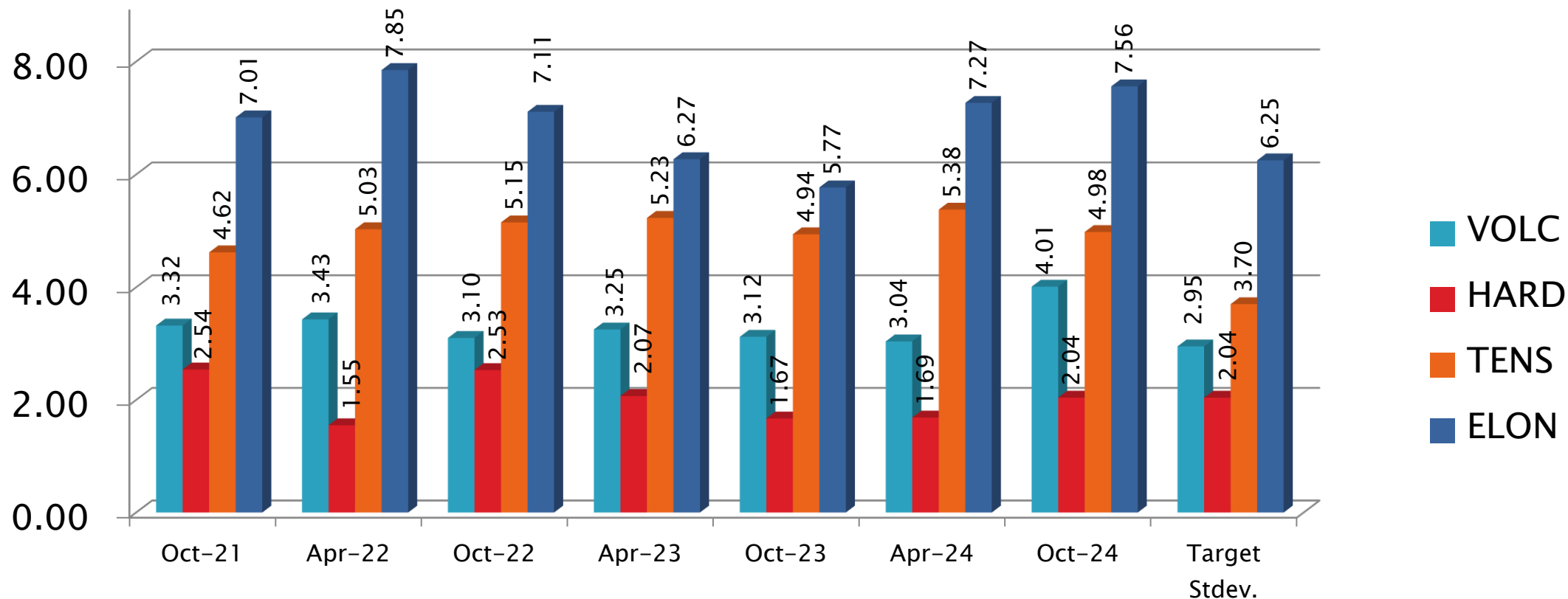
Parameter	Period Mean Δ/s	Status
Volume Change	0.5556	Severe
Points Hardness Change	-0.6789	Mild
Tensile Strength Change	0.0553	On-Target
Elongation Change	-0.2418	Mild

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EOEC Precision Estimates – Silicone



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EOEC Precision Estimates by Lab: VMQ

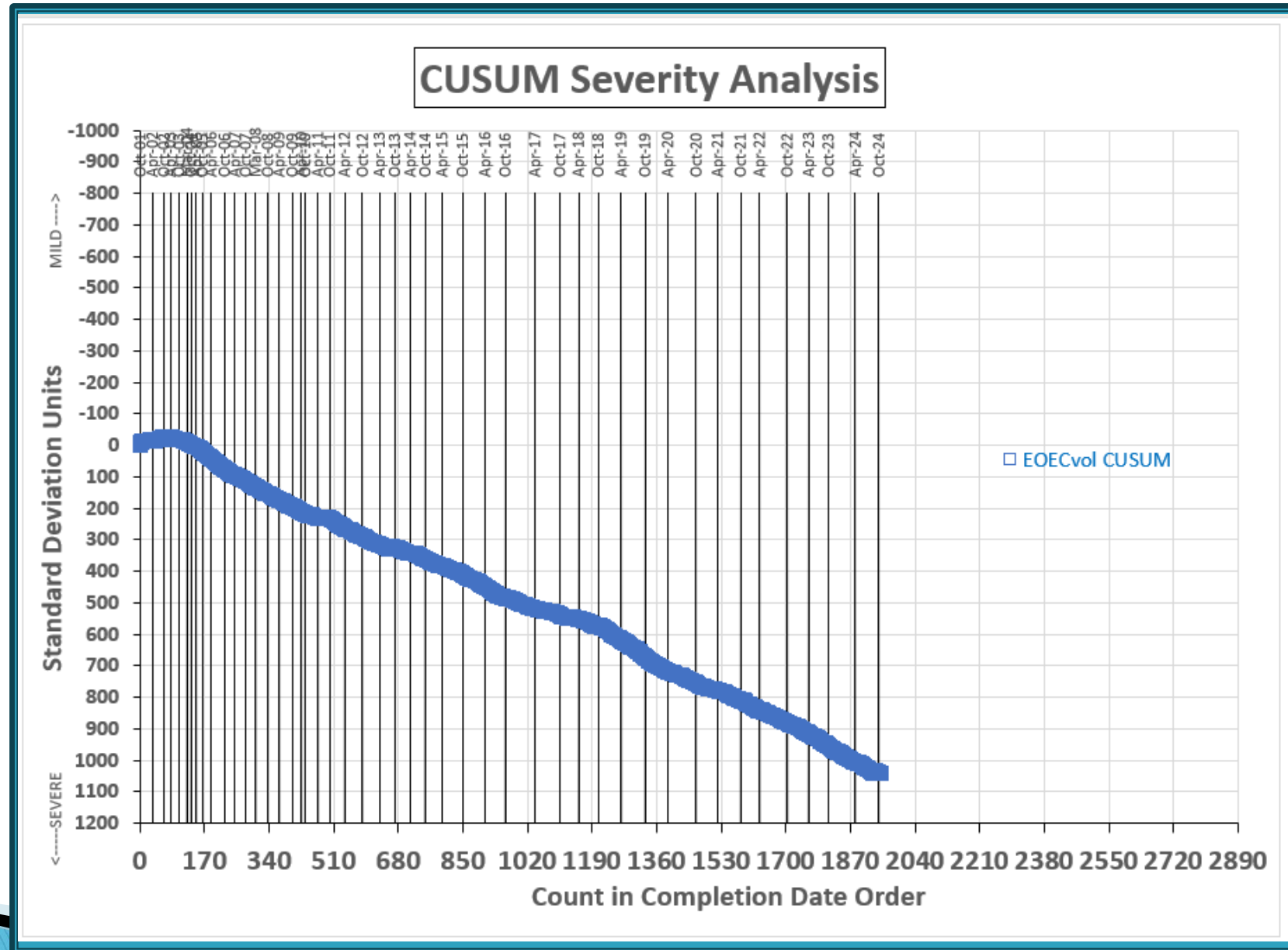
Test Parameter	Statistic	LTMS Lab							
		A	B	BB	G	I	L	P	V
	n=	21	7	1	21	7	2	2	1
Volume	Mean	33.78	34.81	10.58	35.62	32.03	31.90	32.13	32.26
	Pooled s	0.6405	1.821	n/a	3.799	0.9662	1.745	1.584	n/a
	Mean /s	0.5549	0.8954	-7.319	1.169	-0.0484	-0.090	-0.0136	0.0305
Hardness	Mean	-23.38	-23.29	-15.00	-24.00	-22.00	-17.00	-23.50	-22.00
	Pooled s	0.9207	1.112	n/a	1.517	1.291	0.000	2.121	n/a
	Mean /s	-0.8338	-0.7871	3.275	-1.137	-0.157	2.294	-0.8922	-0.1569
Tensile Strength	Mean	-32.89	-30.33	-29.80	-36.22	-32.86	-29.85	-31.15	-34.50
	Pooled s	5.021	3.374	n/a	5.467	2.333	0.3536	4.7376	n/a
	Mean /s	0.2336	0.925	1.068	-0.6673	0.2413	1.054	0.7027	-0.2027
Elongation	Mean	-26.75	-22.44	-18.50	-29.36	-23.46	-21.25	-20.60	-30.00
	Pooled s	4.724	3.134	n/a	10.55	5.317	2.192	4.808	n/a
	Mean /s	-0.3108	0.3787	1.010	-0.7283	0.2165	0.5696	0.6736	-0.8304

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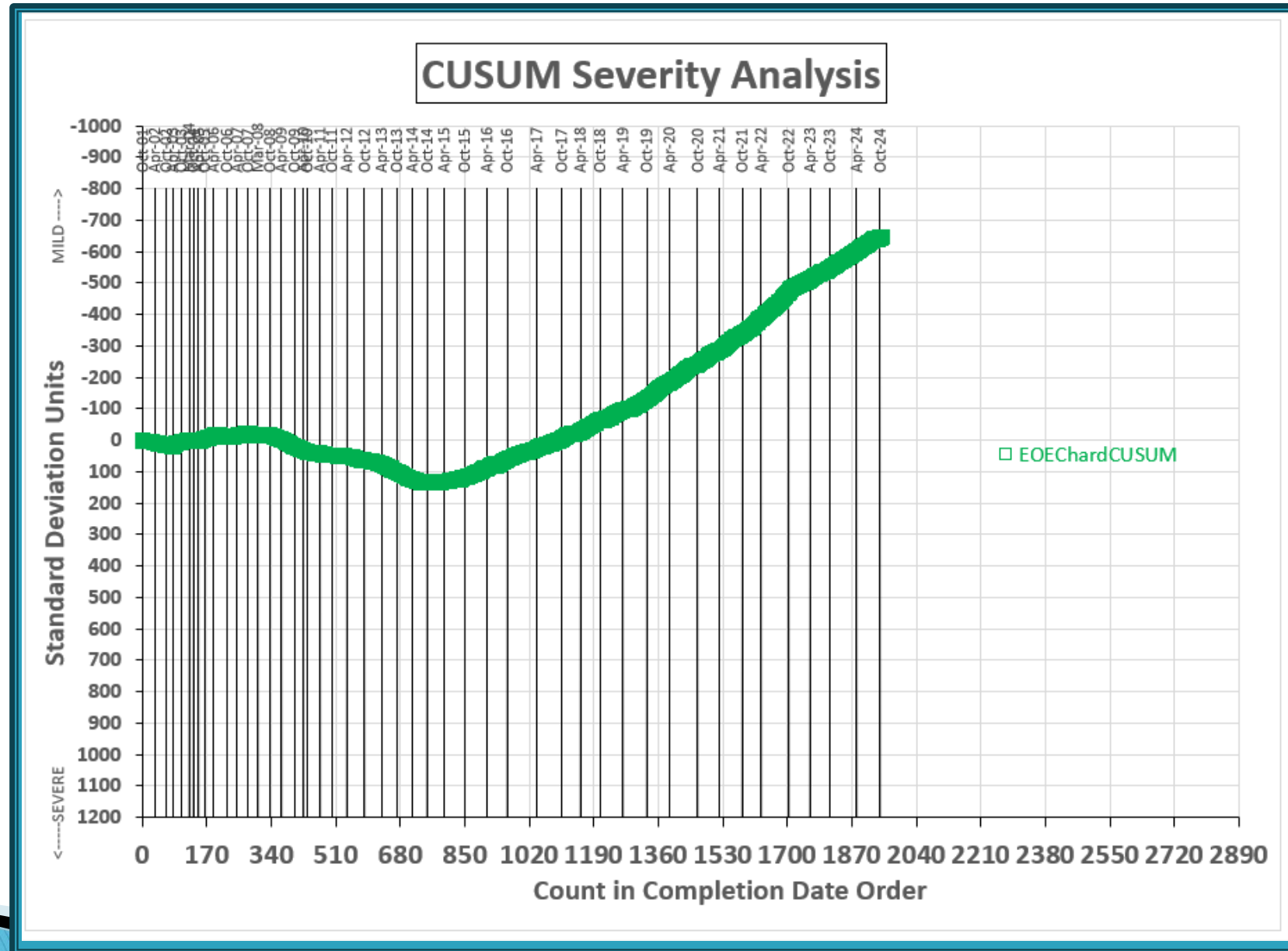
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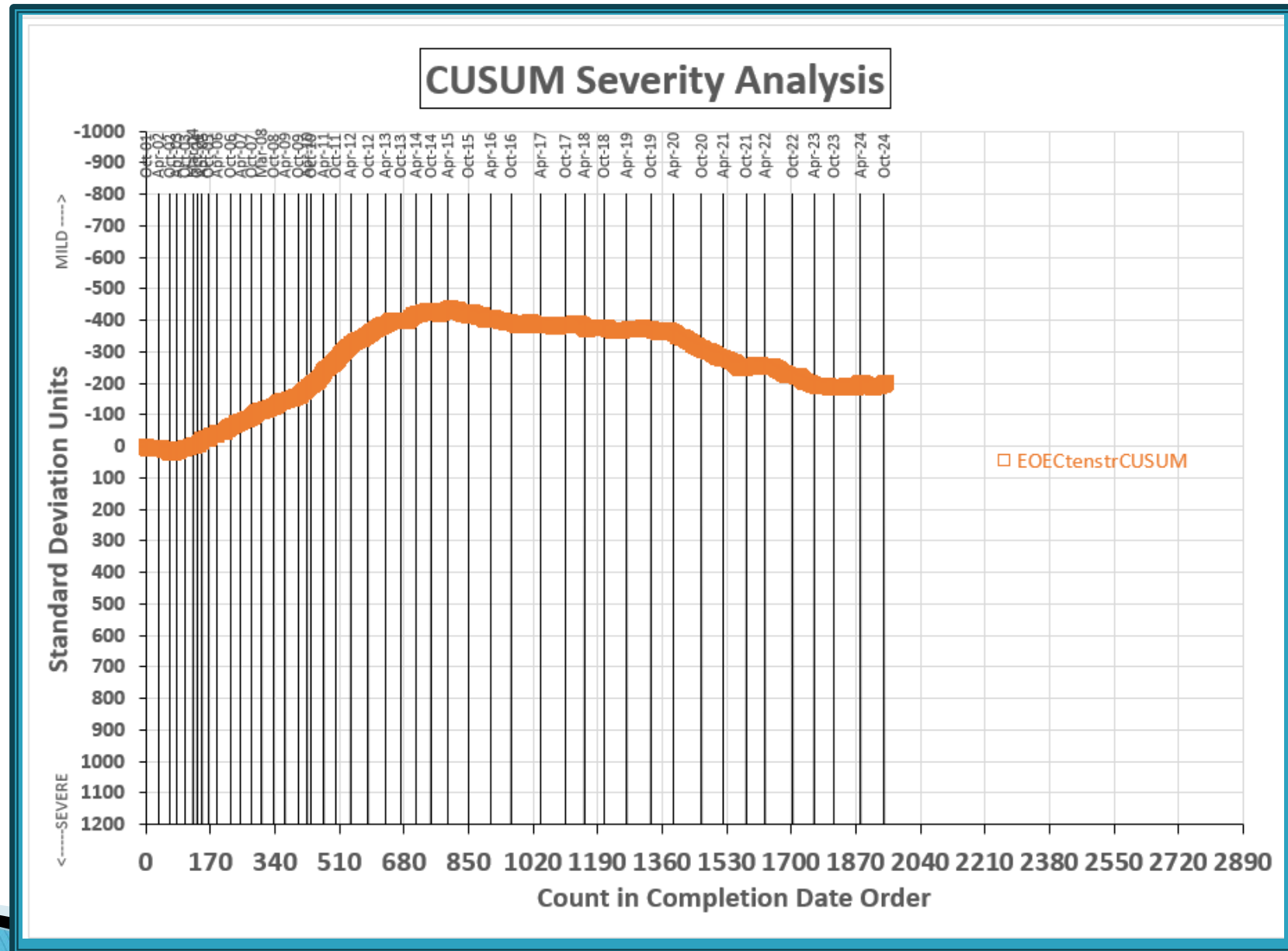
REFERENCE SILICON VOLUME CHANGE CORRECTED AVG



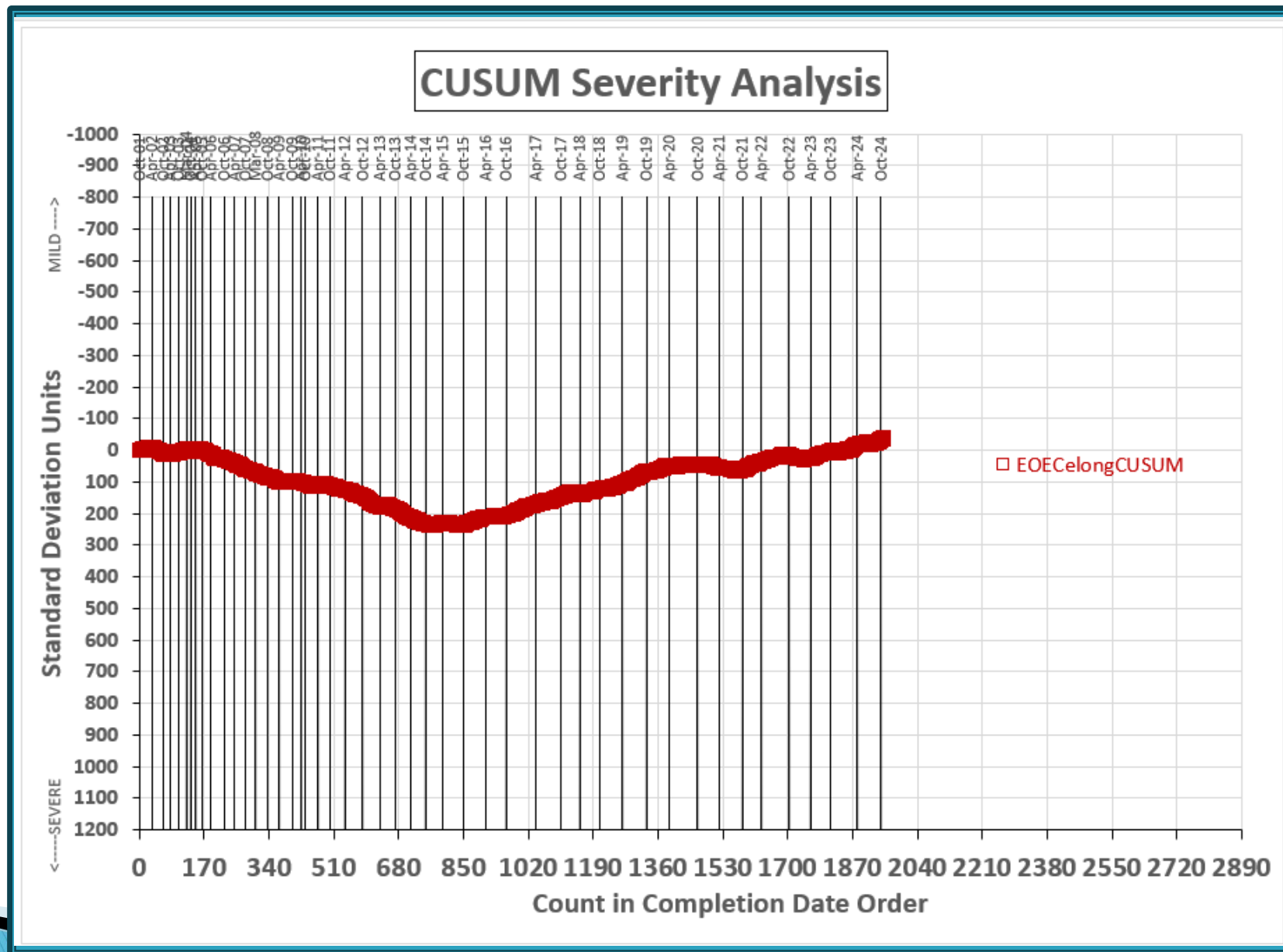
REFERENCE SILICON PTS HARD CHANGE CORRECTED AVG



REF SILICON TENSILE STRENGTH CHANGE CORRECTED AVG



REF SILICON ELONGATION CHANGE CORRECTED AVG



EOEC Test Severity

Ethylene Acrylate “VAMAC” (MAC)

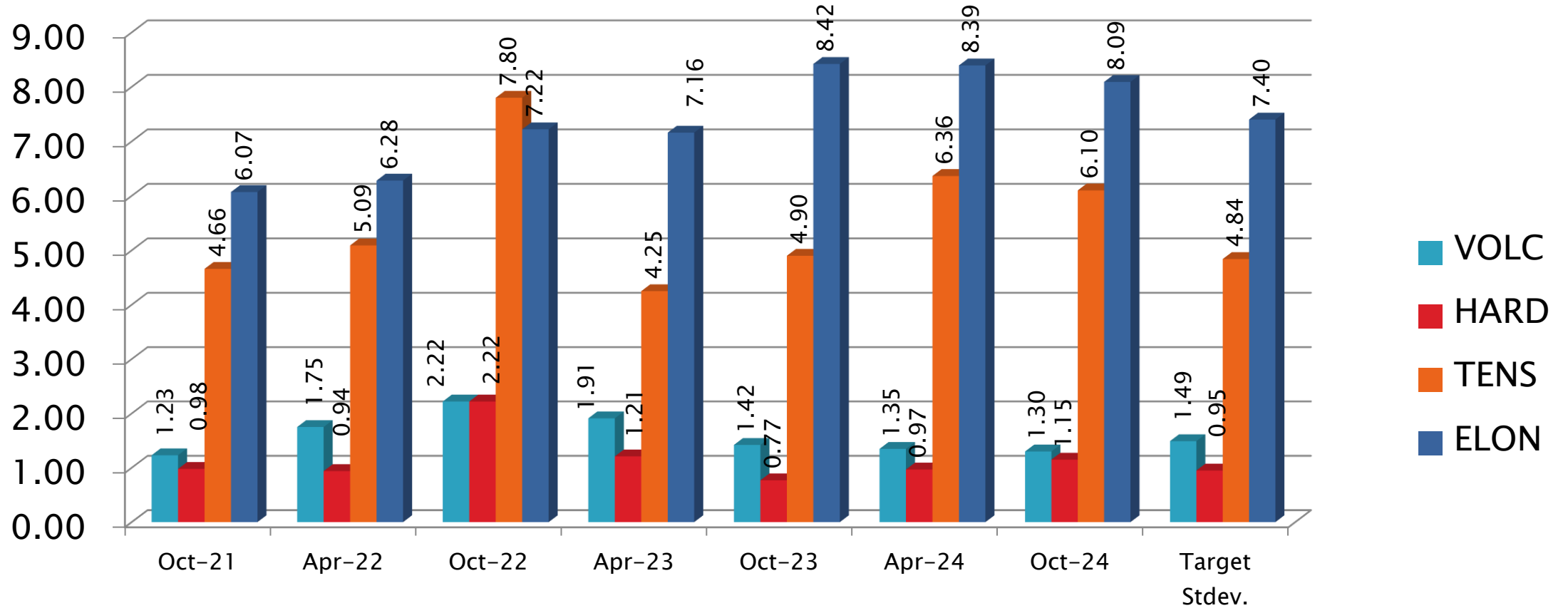
Parameter	Period Mean Δ/s	Status
Volume Change	0.7352	Severe
Points Hardness Change	-0.8301	Mild
Tensile Strength Change	-0.4992	Mild
Elongation Change	-0.1605	Slightly Mild

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EOEC Precision Estimates – VAMAC



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EOEC Precision Estimates by Lab: MAC

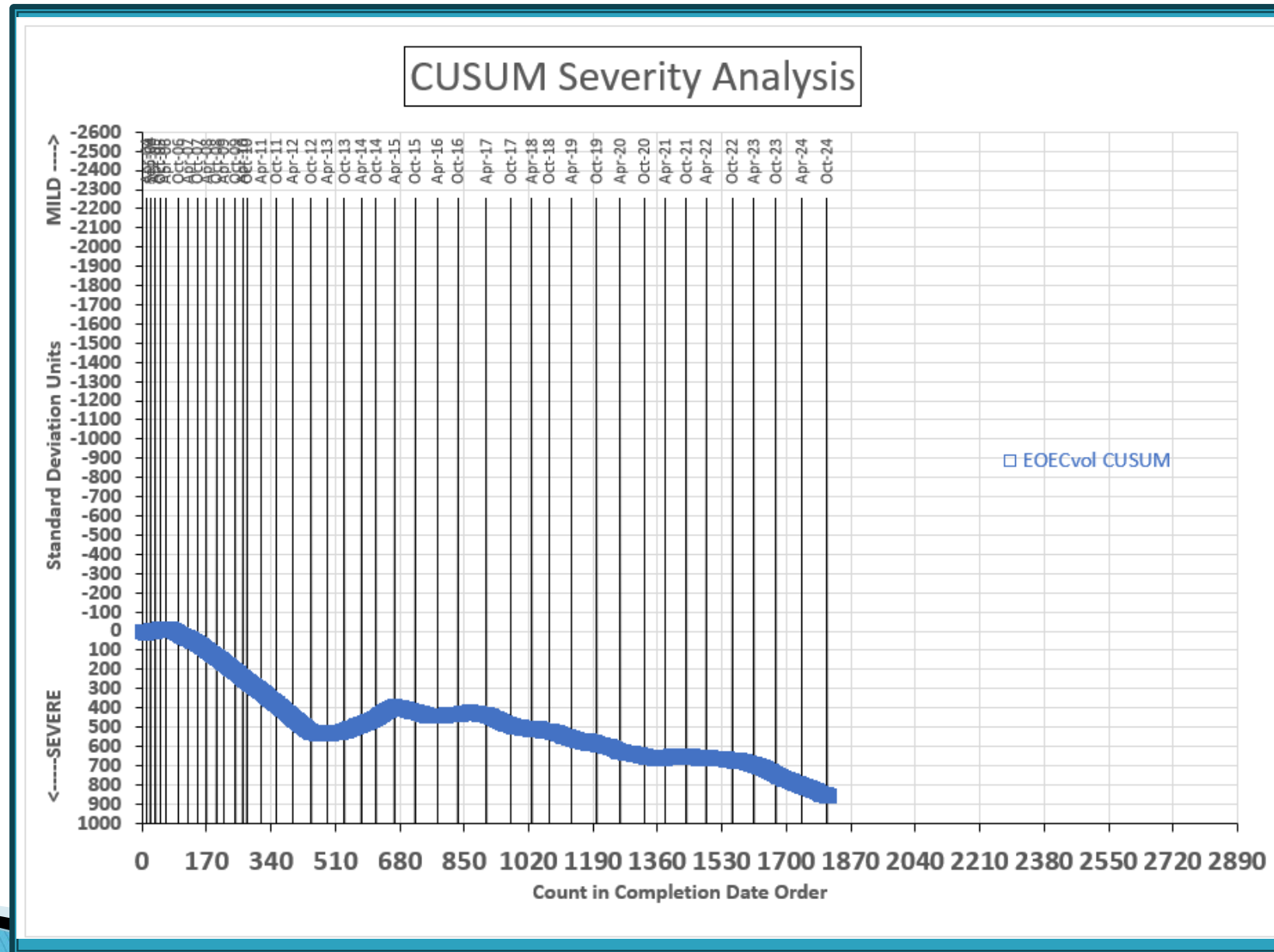
Test Parameter	Statistic	LTMS Lab							
		A	B	BB	G	I	L	P	V
	n=	25	8	0	21	8	3	1	1
Volume	Mean	19.25	19.71		20.51	19.41	17.74	20.97	16.43
	Pooled s	0.8932	0.4172		1.462	0.8490	0.2887	n/a	n/a
	Mean /s	0.4743	0.7878		1.326	0.5831	-0.5391	1.631	-1.416
Hardness	Mean	-8.720	-8.750		-7.905	-7.375	-7.333	-10.00	-9.000
	Pooled s	0.8907	0.7071		1.375	0.7440	0.5774	n/a	n/a
	Mean /s	-1.305	-1.337		-0.4471	0.1105	0.1544	-2.653	-1.600
Tensile Strength	Mean	-19.84	-20.95		-17.124	-12.99	-7.567	-20.10	-19.10
	Pooled s	5.398	1.932		6.631	4.581	1.665	n/a	n/a
	Mean /s	-0.9318	-1.161		-0.3706	0.4840	1.604	-0.9855	-0.7789
Elongation	Mean	-36.30	-36.96		-35.18	-39.52	-29.37	-39.40	-36.20
	Pooled s	5.813	2.897		12.23	4.211	5.960	n/a	n/a
	Mean /s	-0.1816	-0.2706		-0.0292	-0.6169	0.7559	-0.6000	-0.1676

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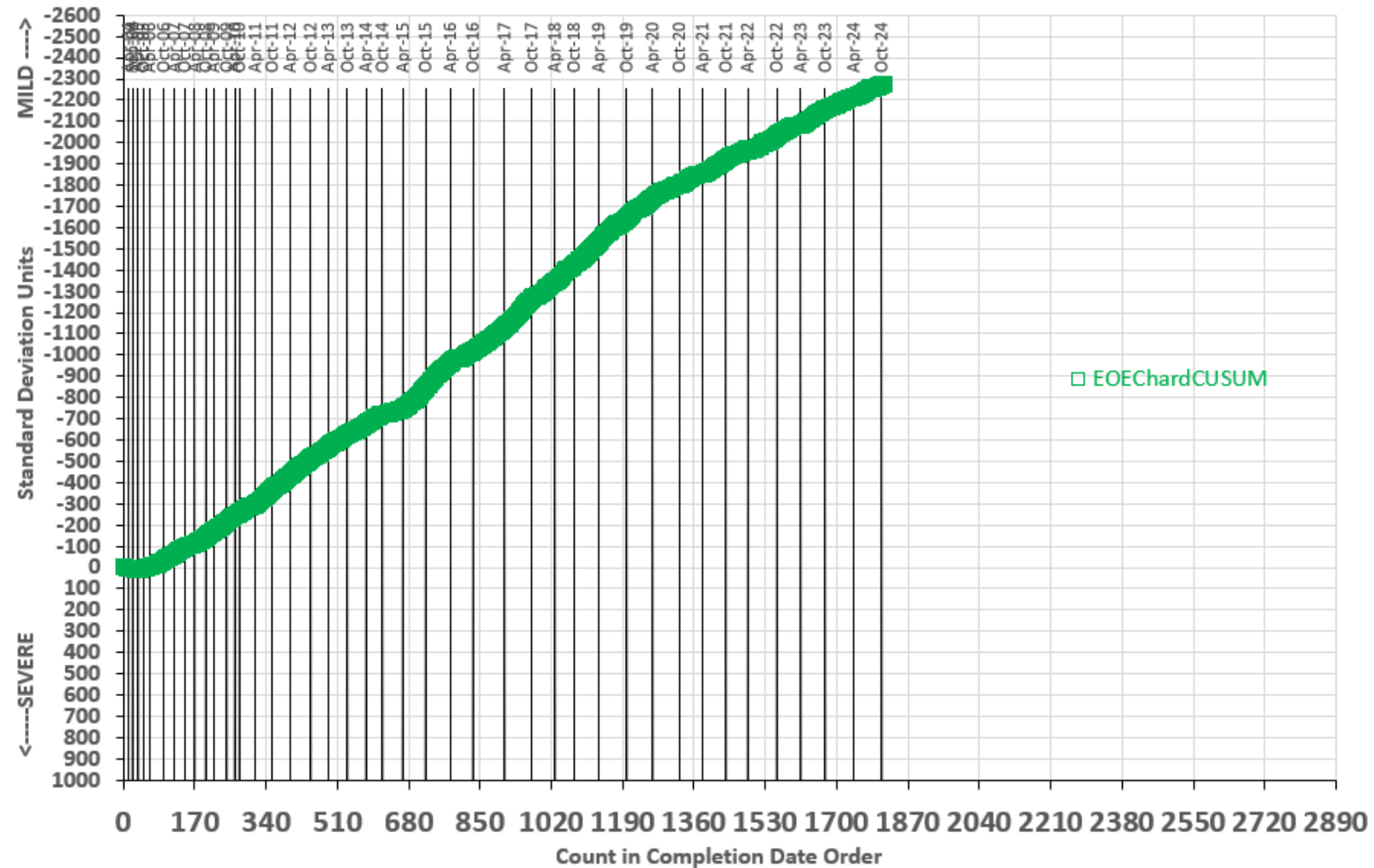


REFERENCE VAMAC G VOLUME CHANGE CORRECTED AVERAGE

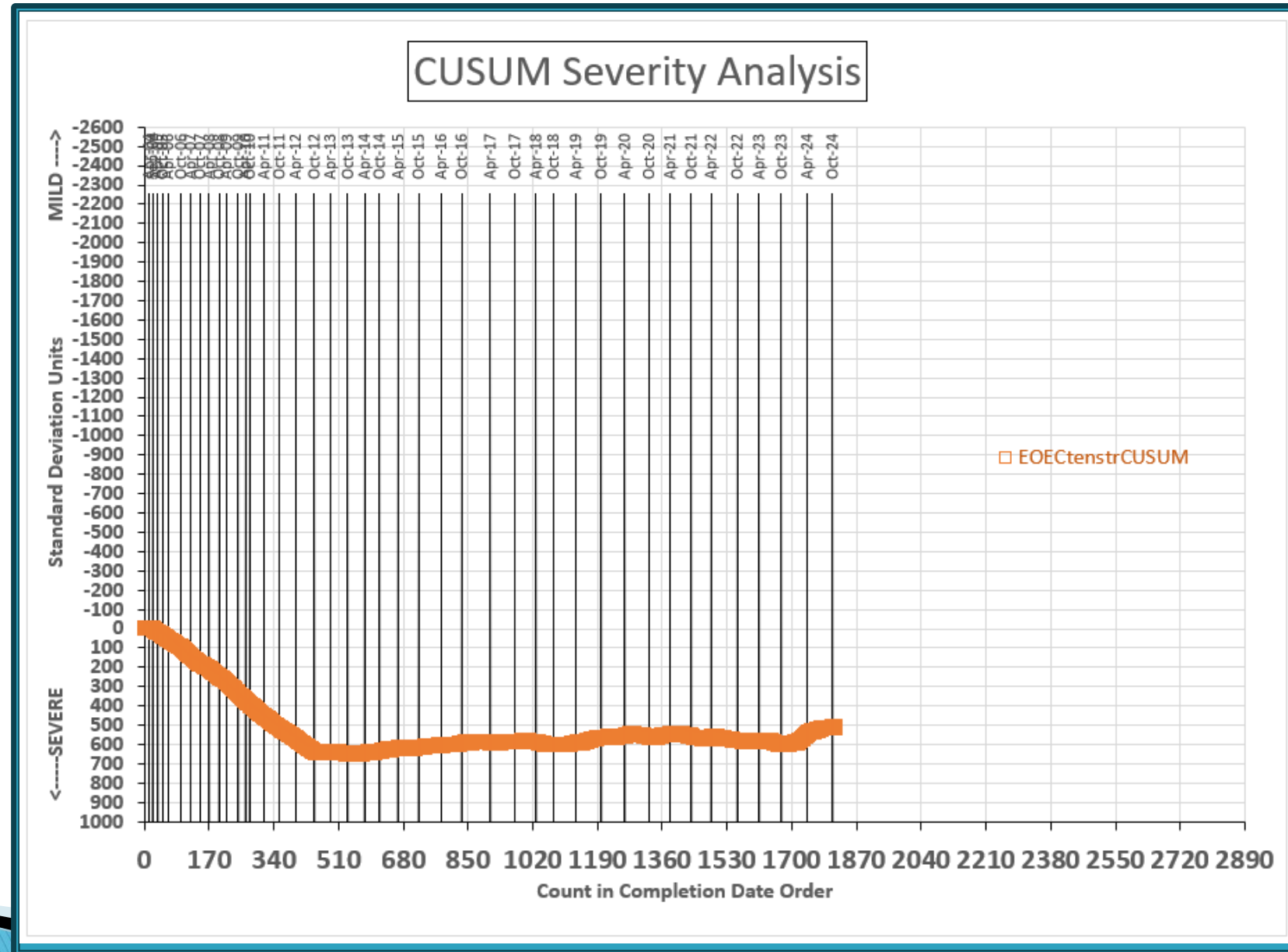


REF VAMAC G POINTS HARDNESS CHANGE CORRECTED AVG

CUSUM Severity Analysis

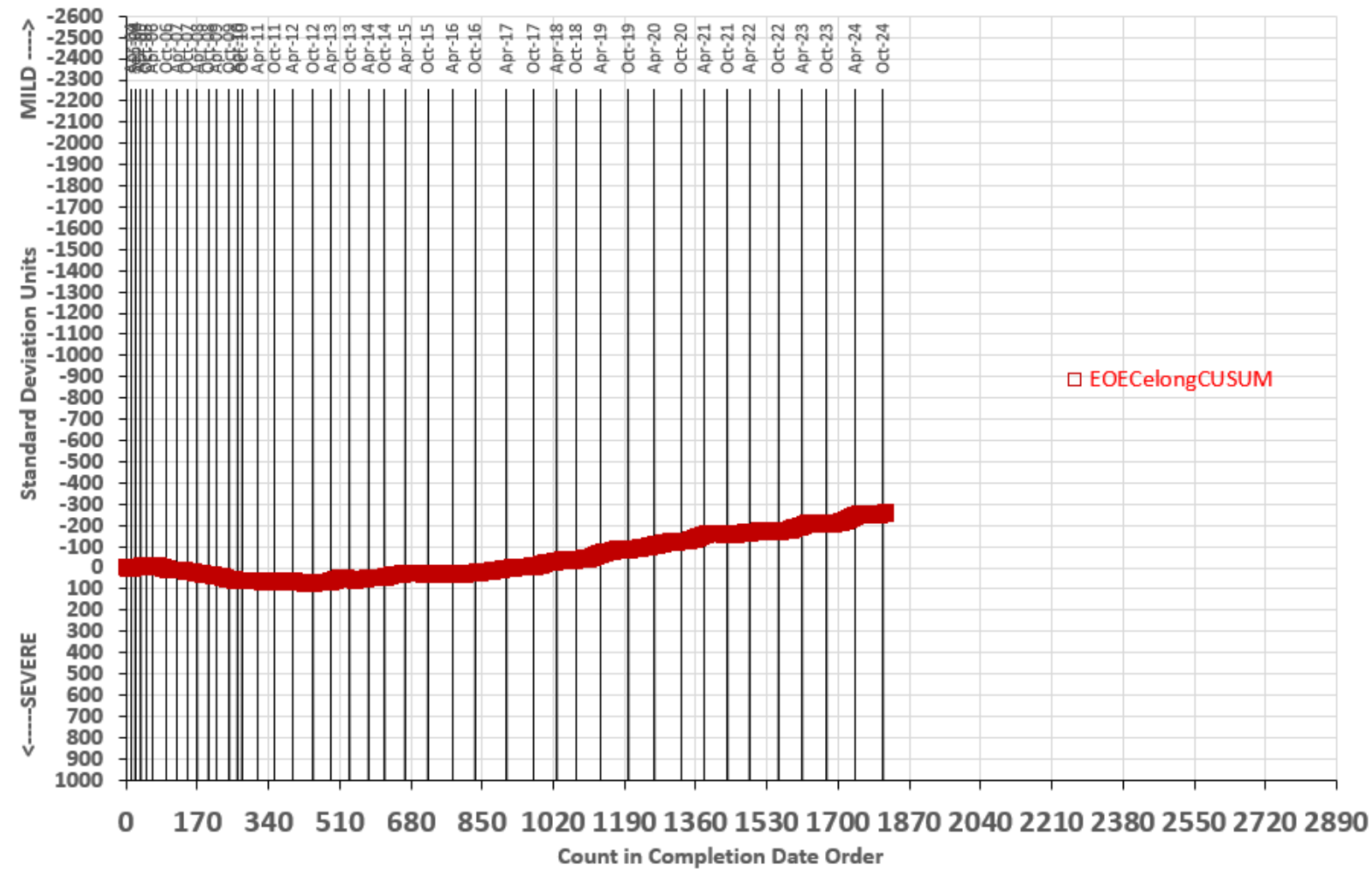


REF VAMAC G TENSILE STRENGTH CHANGE CORRECTED AVG



REF VAMAC G ELONGATION CHANGE CORRECTED AVG

CUSUM Severity Analysis



□ EOElongCUSUM

Information Letters & Technical Updates*

Test	Date	IL or Memo Number	Topic
EOEC	20241031	IL24-01	Adjusted Specification Limits for EOEC D7216 Tests added to EOEC IL folder

*Available from TMC Website

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Reference Oil Inventory Estimated Life

EOEC & LDEOC

Oil	TMC Inventory Gallons	Gallons Shipped Past 6 Months	Estimated Life ^C
SL107 ^{A, B}	1482	260	3 years

^A TMC Inventory is used across several test methods

^B SL107 has fully replaced oil 1006; Oil 1006 is no longer used as an EOEC Reference Fluid

^C Use Rate of SL107 will accelerate due to addition of five new Elastomers to D7216:
FOUR: ILSAC GF-7
ONE: PC-12

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ASTM Reference Testing Semi-Annual Report D7216 LDEOC

April 1, 2024 to September 30, 2024

ASTM D 7216

Engine Oil Elastomer Compatibility

LDEOC (Light-Duty)	
OHT PART NUMBER	BATCH CODE
OHTLDEOC-HNBR1-A	32
OHTLDEOC-FKM1-A	30
OHTLDEOC-ACM1-B	26
OHTLDEOC-VMQ1-A	42
OHTLDEOC-AEM1-B	32
OHTLDEOC-ACM2-A	1
OHTLDEOC-AEM2-A	1
OHTLDEOC-FKM3-A	1
OHTLDEOC-AEM3-A	1

LDEOC Test Activity

Test Status		Ethylene Acrylate	Fluoroelast.	Nitrile	Polyacrylate	Silicone	Total
LABS		7	7	7	7	7	
Acceptable Calibration Test	AC	75	82	75	81	86	399
Failed Calibration Test	OC	7	0	6	0	2	15
Operationally Invalid, by lab	LC	0	1	0	1	0	2
Operationally Invalid, by TMC	RC	0	0	0	0	0	0
Aborted	XC	0	0	0	0	1	1
Acceptable Informational Run	NN	0	0	0	0	0	0
Unacceptable Informational Run	MN	0	0	0	0	0	0
Total		82	83	81	82	89	417

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LDEOC Test Activity

Test Status		Ethylene Acrylate 2	Ethylene Acrylate 3	Fluoroelast.3	Polyacrylate2	Total
LABS		4	4	4	4	
Acceptable Calibration Test	AC	24	26	28	24	102
Failed Calibration Test	OC	1	0	0	2	3
Operationally Invalid, by lab	LC	2	0	0	1	3
Operationally Invalid, by TMC	RC	0	0	0	0	0
Aborted	XC	0	0	0	0	0
Acceptable Informational Run	NN	0	0	0	0	0
Unacceptable Informational Run	MN	0	0	0	0	0
Total		27	26	28	27	108

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Calibrated Labs and Stands¹

(change shown in parentheses)

Test	Labs	Stands
D7216 LDEOC	7 ² (-1)	N/A

¹ As of 9/30/2024

² Only FOUR labs ran all 9 elastomer types

LDEOC Failing Calibration (OC) Tests

Cause	Elastomer	#
TENSILE STRENGTH (MILD)	2-AEM1, 1-ACM2	3
VOLUME (MILD)	3-AEM1	3
HARDNESS (MILD)	2-HNBR1,	2
TENSILE STRENGTH (SEVERE)	1-AEM1, 1-AEM2, 1-HNBR1, 1-ACM2, 2-VMQ1	6
HARDNESS (SEVERE)	1-AEM1, 3-HNBR1	4
Total		18

There were EIGHTEEN failing LDEOC Calibration Tests reported this period from FOUR different labs.

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LDEOC Lost Tests

Validity	Cause	No. of Tests
LC	WRONG ELASTOMER USED (FKM1)	1
LC	SAMPLES REMOVED FROM BATH TOO SOON	1
LC	SAMPLES DISPOSED BEFORE DATA TAKEN	3
XC	TEMPERATURE CONTROLLER FAILURE (VMQ1)	1
Total		6

*Invalid (LC,RC) and Aborted (XC) calibration tests

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LDEOC Test Severity

Ethylene Acrylate (AEM1)

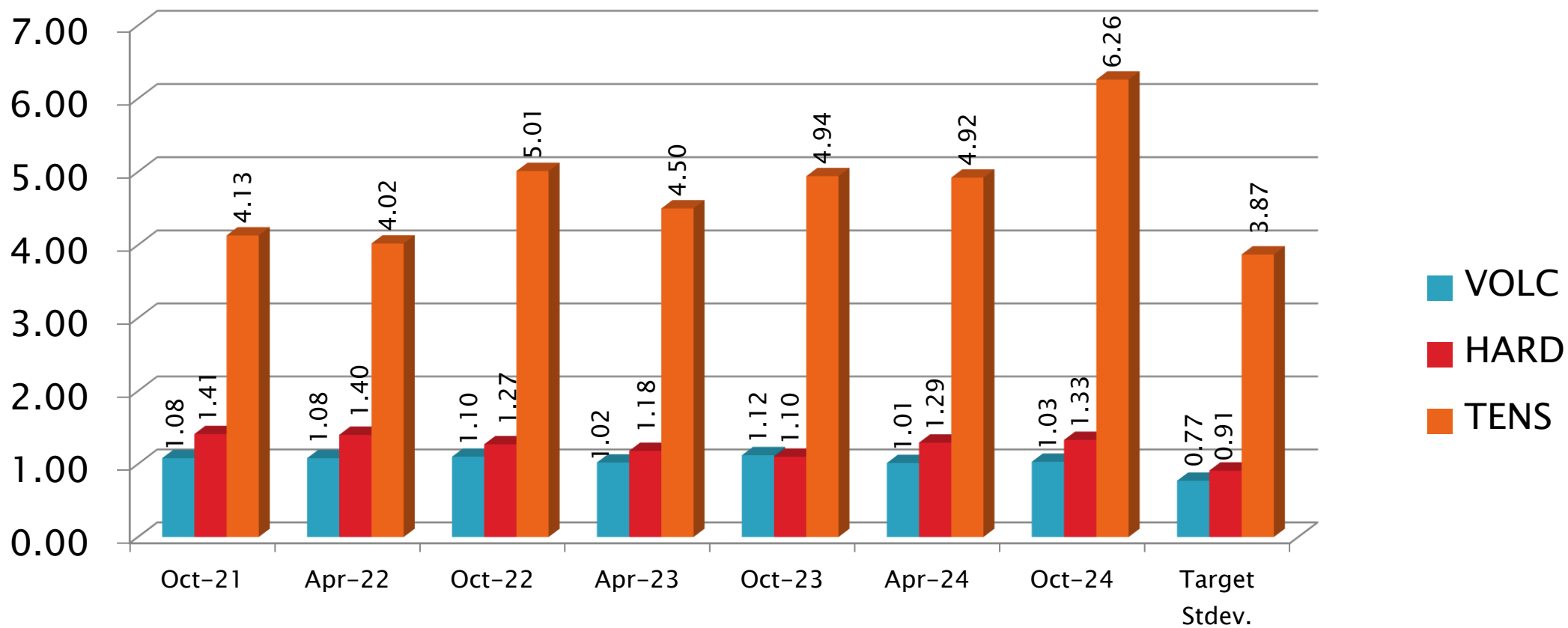
Parameter	Period Mean Δ/s	Status
Volume Change	-1.1136	Mild
Points Hardness Change	-0.0555	Slightly Mild
Tensile Strength Change	0.4146	Severe

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LDEOC Precision Estimates – Ethylene Acrylate



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LDEOC Precision Estimates by Lab: AEM1

Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	28	6	0	25	14	2	4	3
Volume	Mean	22.53	23.83		24.21	23.49	23.57	23.23	22.04
	Pooled s	0.3583	0.1614		0.9083	1.128	0.1838	0.3221	0.5372
	Mean /s	-2.174	-0.4827		0.0161	-0.9184	-0.8182	-1.256	-2.810
Hardness	Mean	-13.04	-13.00		-13.00	-11.86	-12.00	-12.75	-13.00
	Pooled s	1.347	0.8944		1.607	0.7703	0.000	0.9574	1.000
	Mean /s	-0.3359	-0.2967		-0.2967	0.9592	0.8022	-0.0220	-0.2967
Tensile Strength	Mean	-14.75	-22.45		-16.30	-11.40	-13.80	-16.65	-13.47
	Pooled s	4.988	1.350		0.7407	6.495	6.364	1.555	0.8083
	Mean /s	0.5400	-1.450		0.1406	1.406	0.7855	0.0491	0.8717

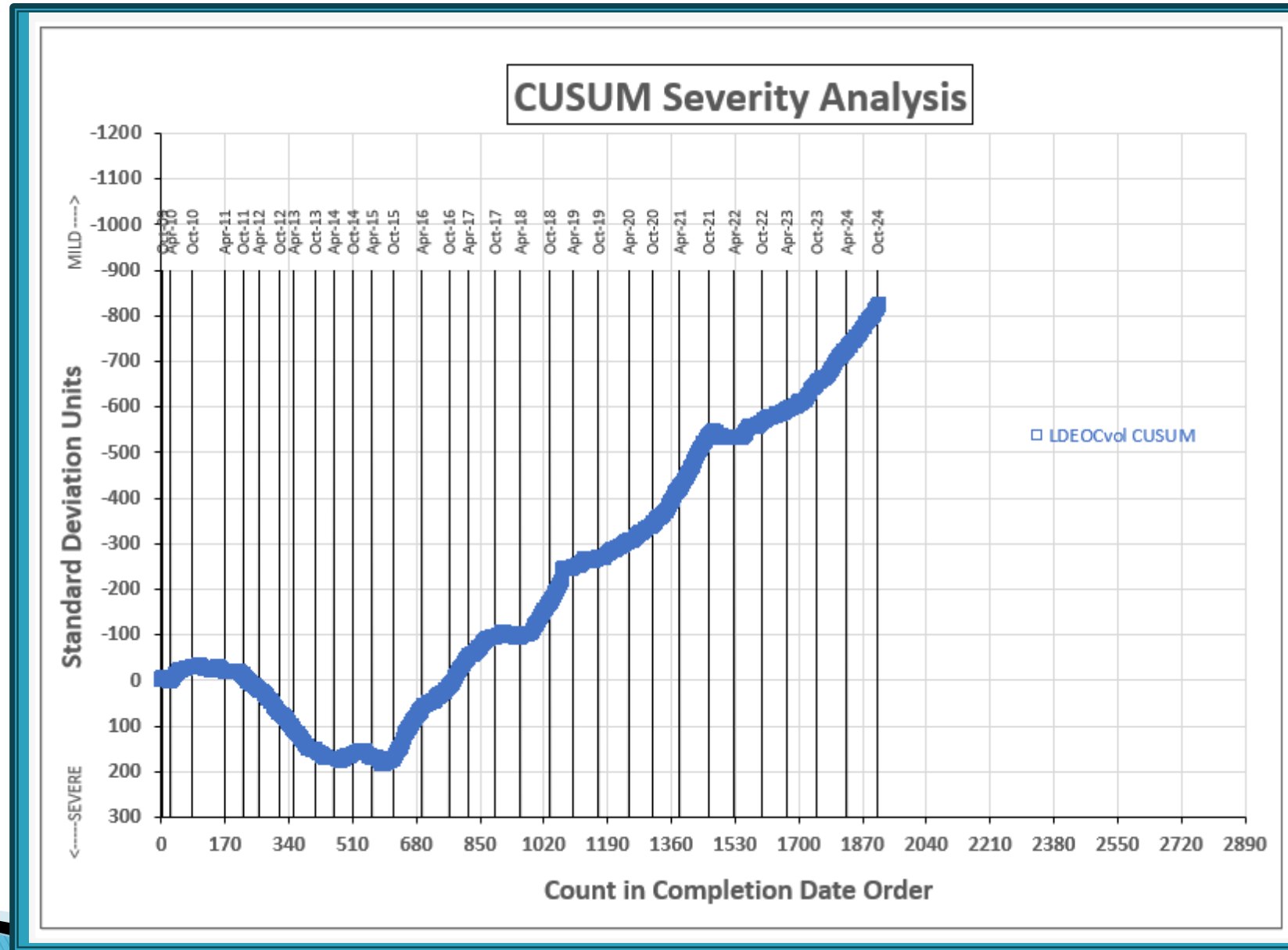
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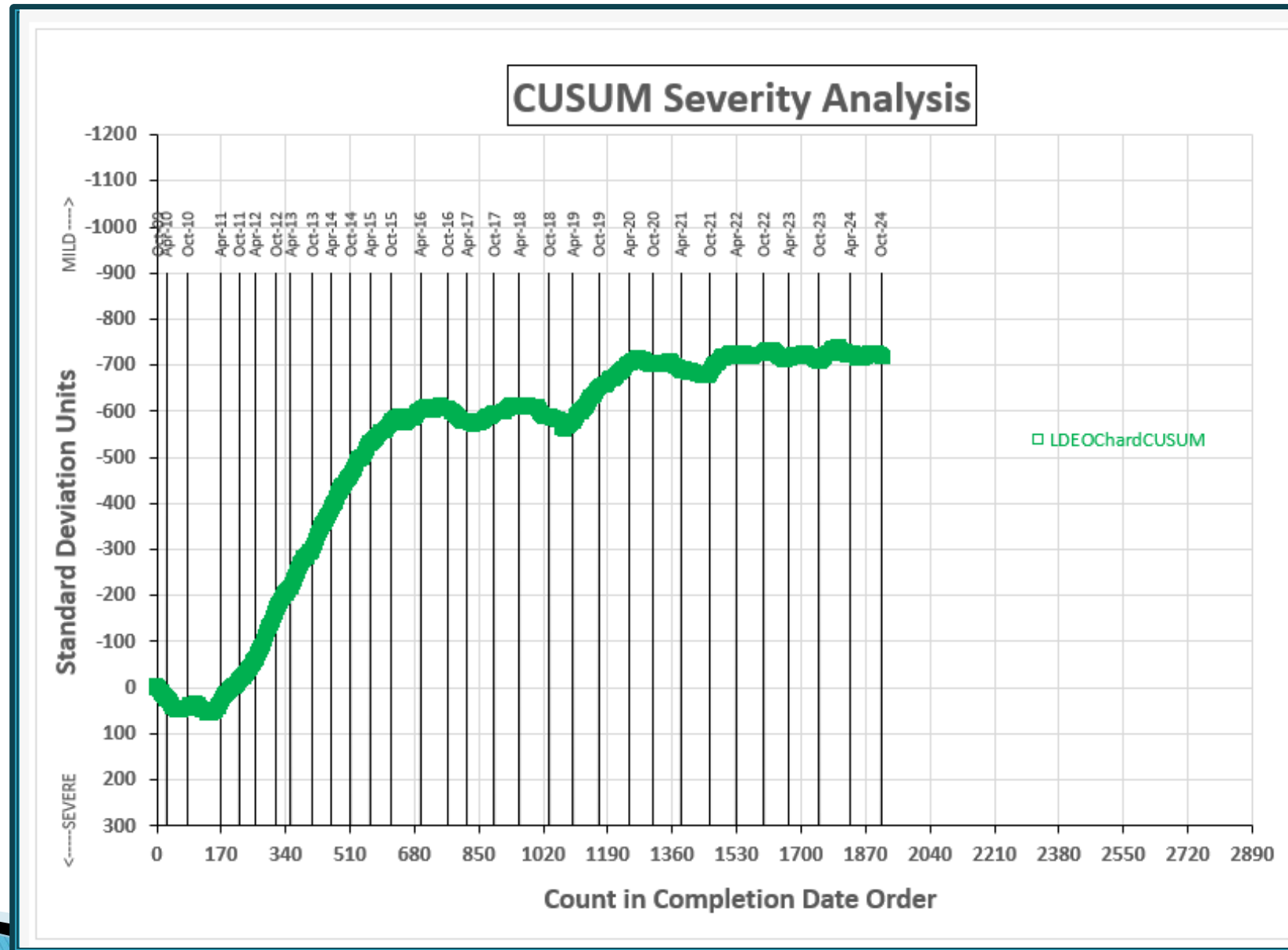
LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA

ETHYLENE ACRYLATE VOLUME CHANGE FINAL



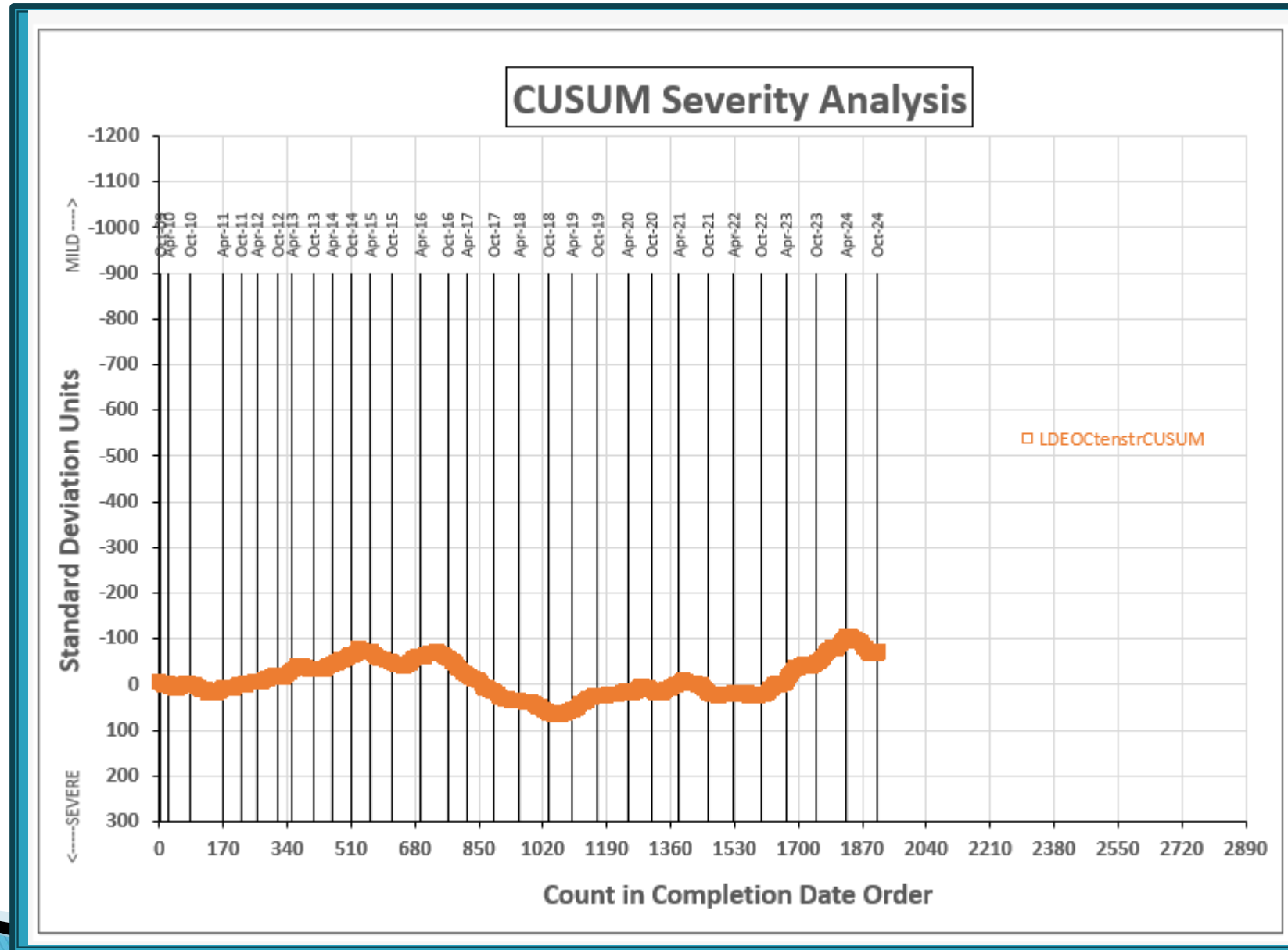
LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA

ETHYLENE ACRYLATE HARDNESS CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA

ETHYLENE ACRYLATE TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Ethylene Acrylate (AEM2)

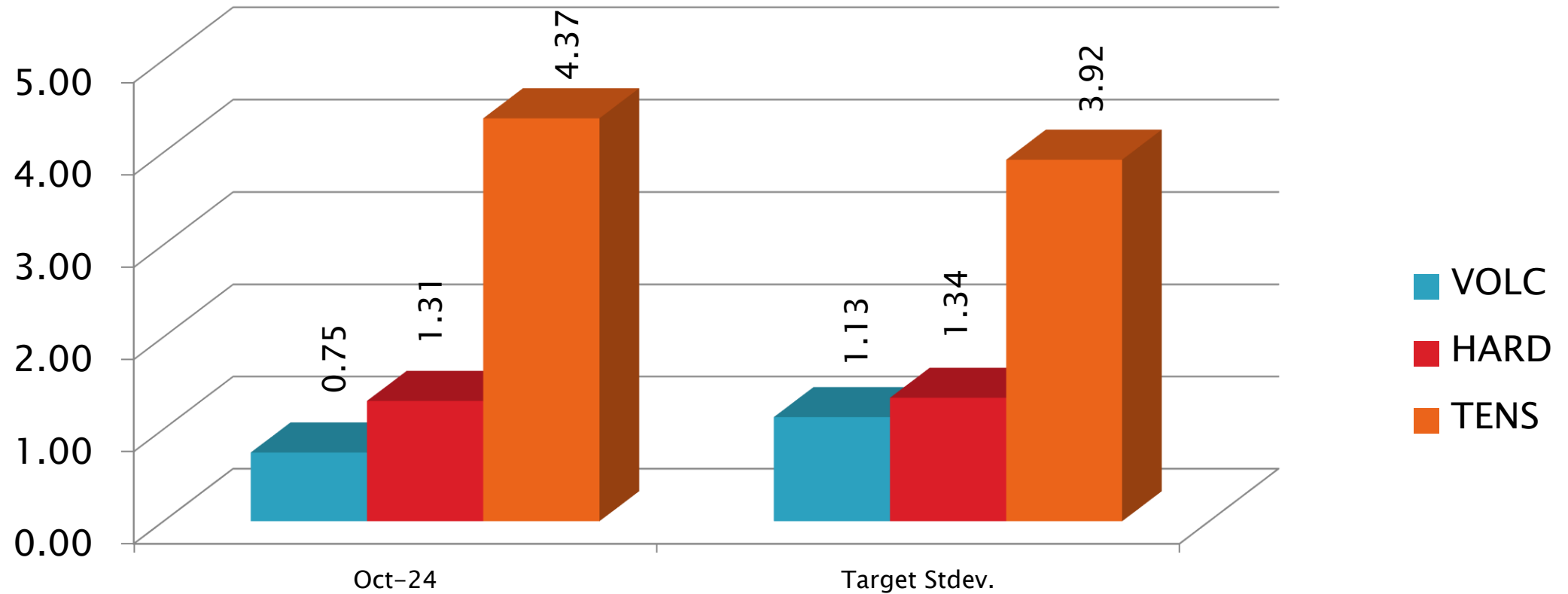
Parameter	Period Mean Δ/s	Status
Volume Change	-0.1080	Slightly Mild
Points Hardness Change	-0.8955	Mild
Tensile Strength Change	0.0658	On-Target

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LDEOC Precision Estimates – Ethylene Acrylate 2



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LDEOC Precision Estimates by Lab: AEM2

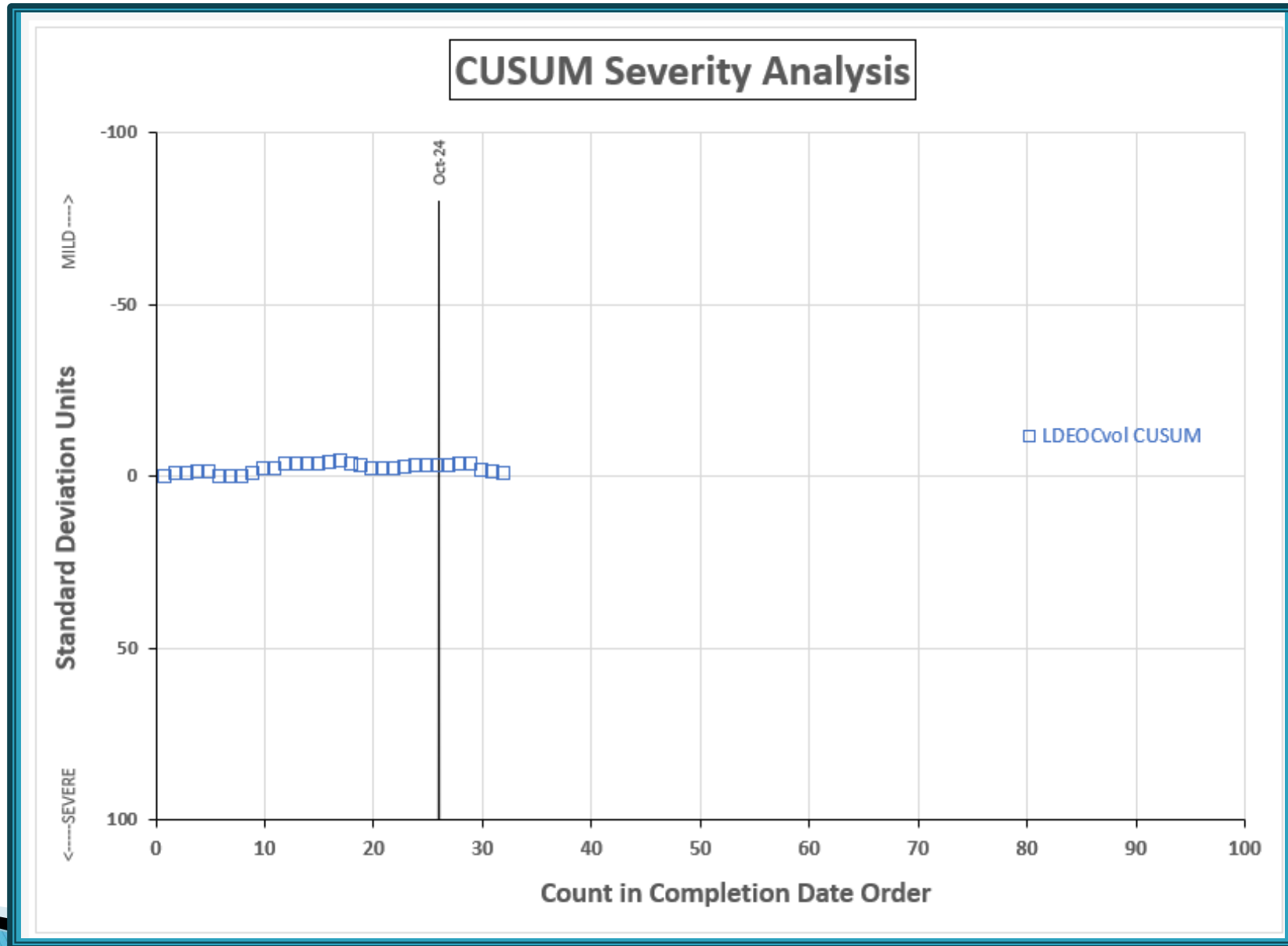
Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	18	1	0	2	0	0	0	4
Volume	Mean	20.94	21.76		20.51				20.46
	Pooled s	0.6171	n/a		1.853				0.7403
	Mean /s	-0.0393	0.6903		-0.4159				-0.4624
Hardness	Mean	-9.056	-9.000		-7.500				-9.250
	Pooled s	0.7254	n/a		4.950				0.9574
	Mean /s	-0.9668	-0.9254		0.1940				-1.112
Tensile Strength	Mean	-41.14	-47.20		-42.40				-42.80
	Pooled s	3.550	n/a		0.7071				8.199
	Mean /s	0.2208	-1.324		-0.0995				-0.2015

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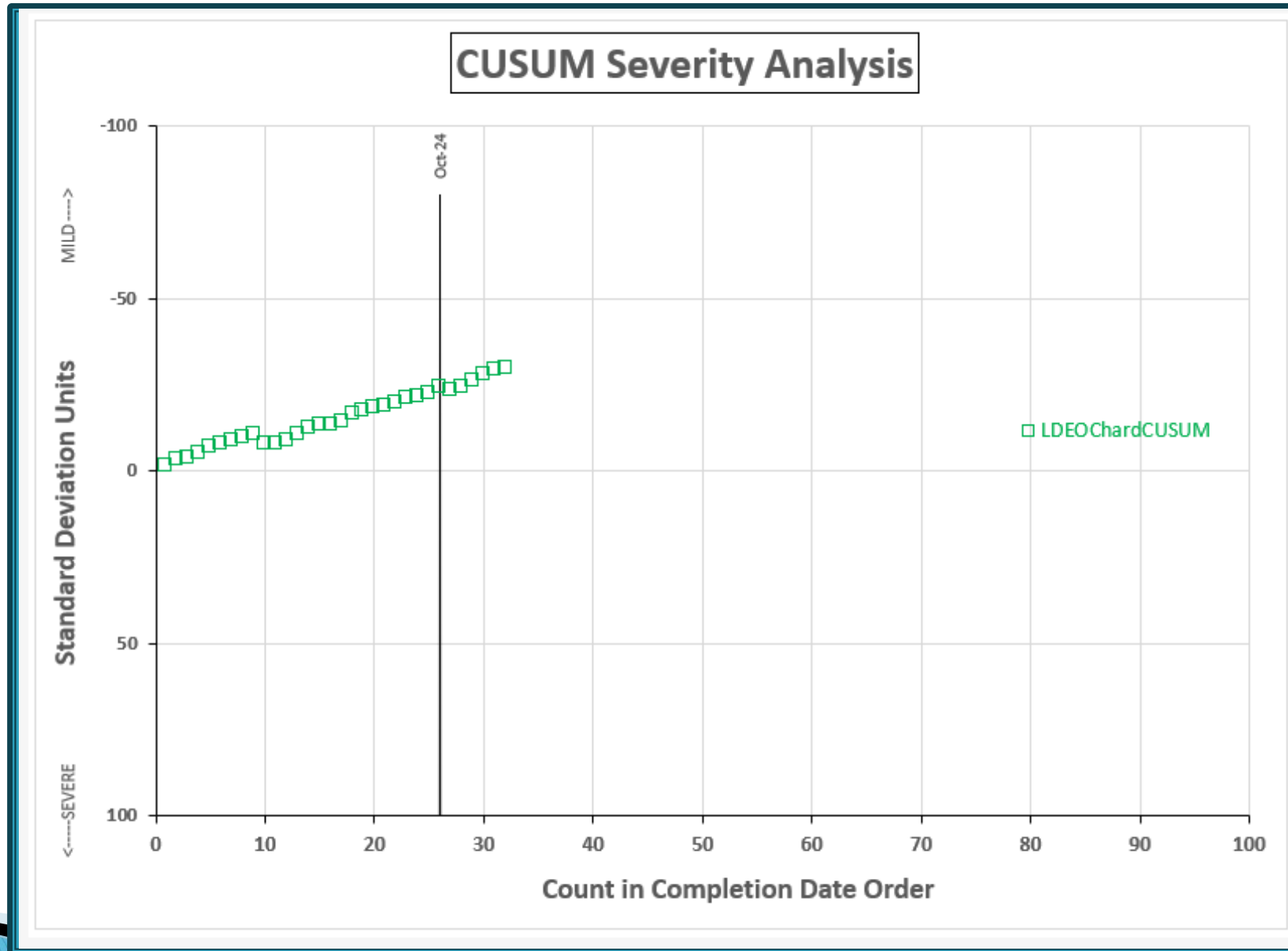
Test Monitoring Center
<https://www.astmtmc.org>



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA
ETHYLENE ACRYLATE-2 VOLUME CHANGE FINAL

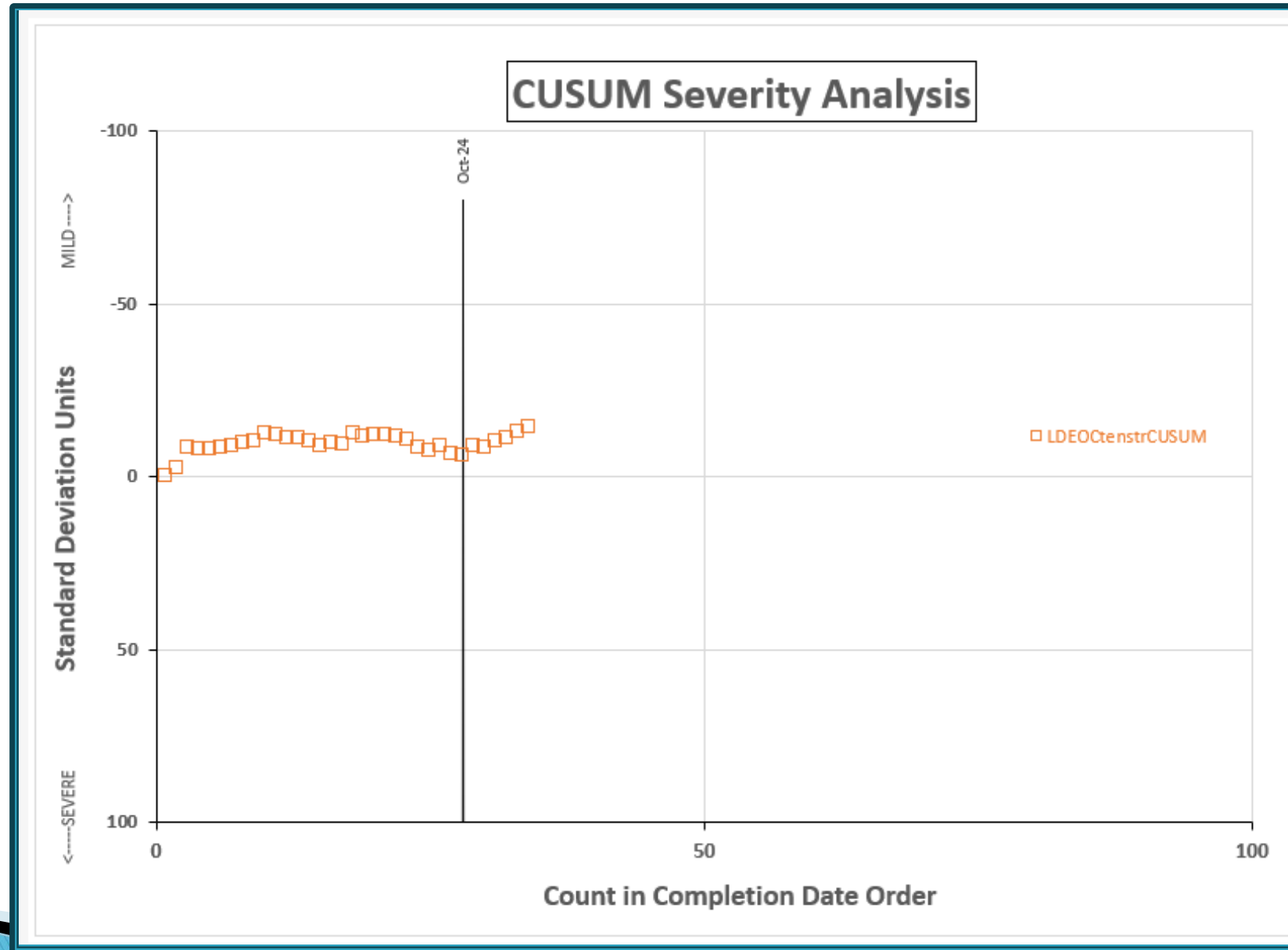


LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA
ETHYLENE ACRYLATE-2 HARDNESS CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA

ETHYLENE ACRYLATE-2 TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Ethylene Acrylate (AEM3)

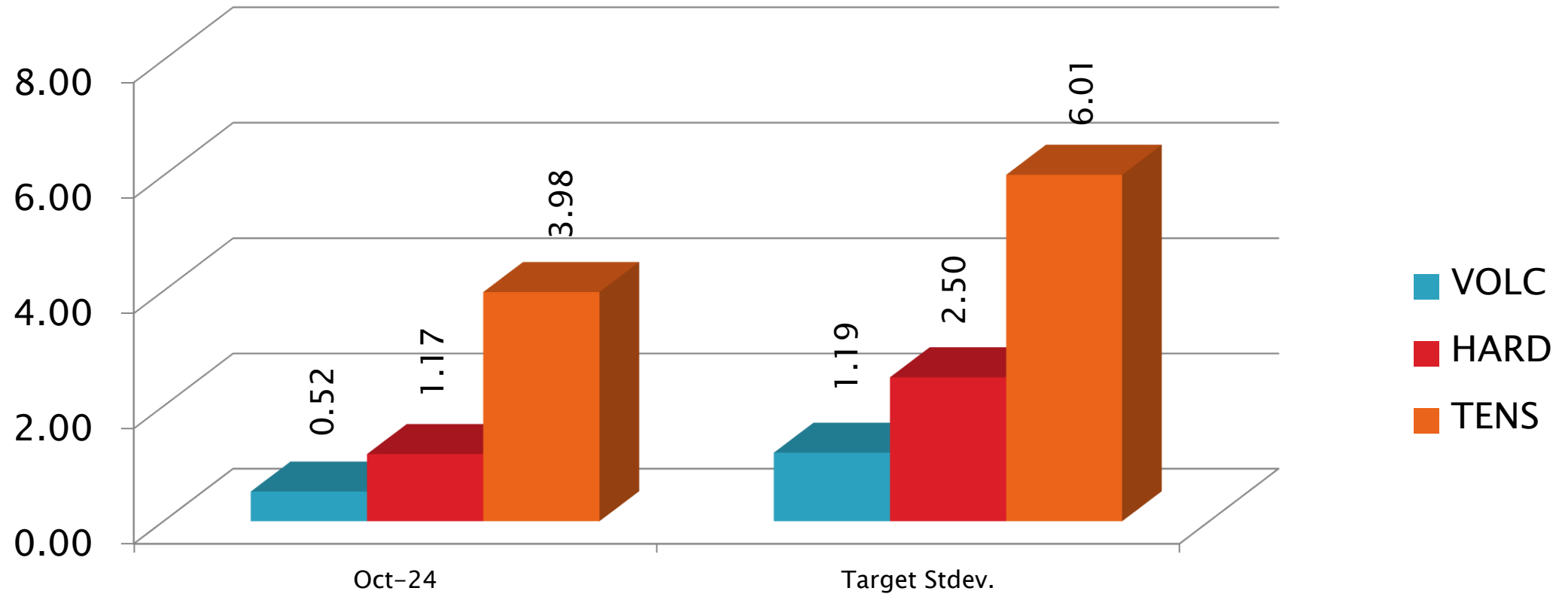
Parameter	Period Mean Δ/s	Status
Volume Change	-0.0310	On-Target
Points Hardness Change	0.1760	Slightly Severe
Tensile Strength Change	-0.0325	On-Target

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LDEOC Precision Estimates – Ethylene Acrylate 3



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LDEOC Precision Estimates by Lab: AEM3

Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	19	1	0	2	0	0	0	4
Volume	Mean	8.197	8.580		9.25				7.872
	Pooled s	0.4308	n/a		0.2404				0.4061
	Mean /s	-0.0694	0.2521		0.8151				-0.3424
Hardness	Mean	-0.1053	0.0000		-2.000				1.500
	Pooled s	0.8753	n/a		0.0000				1.000
	Mean /s	0.1339	0.1760		-0.6240				0.7760
Tensile Strength	Mean	-38.49	-42.80		-40.30				-35.70
	Pooled s	3.590	n/a		2.823				5.771
	Mean /s	-0.0532	-0.7704		-0.3544				0.4110

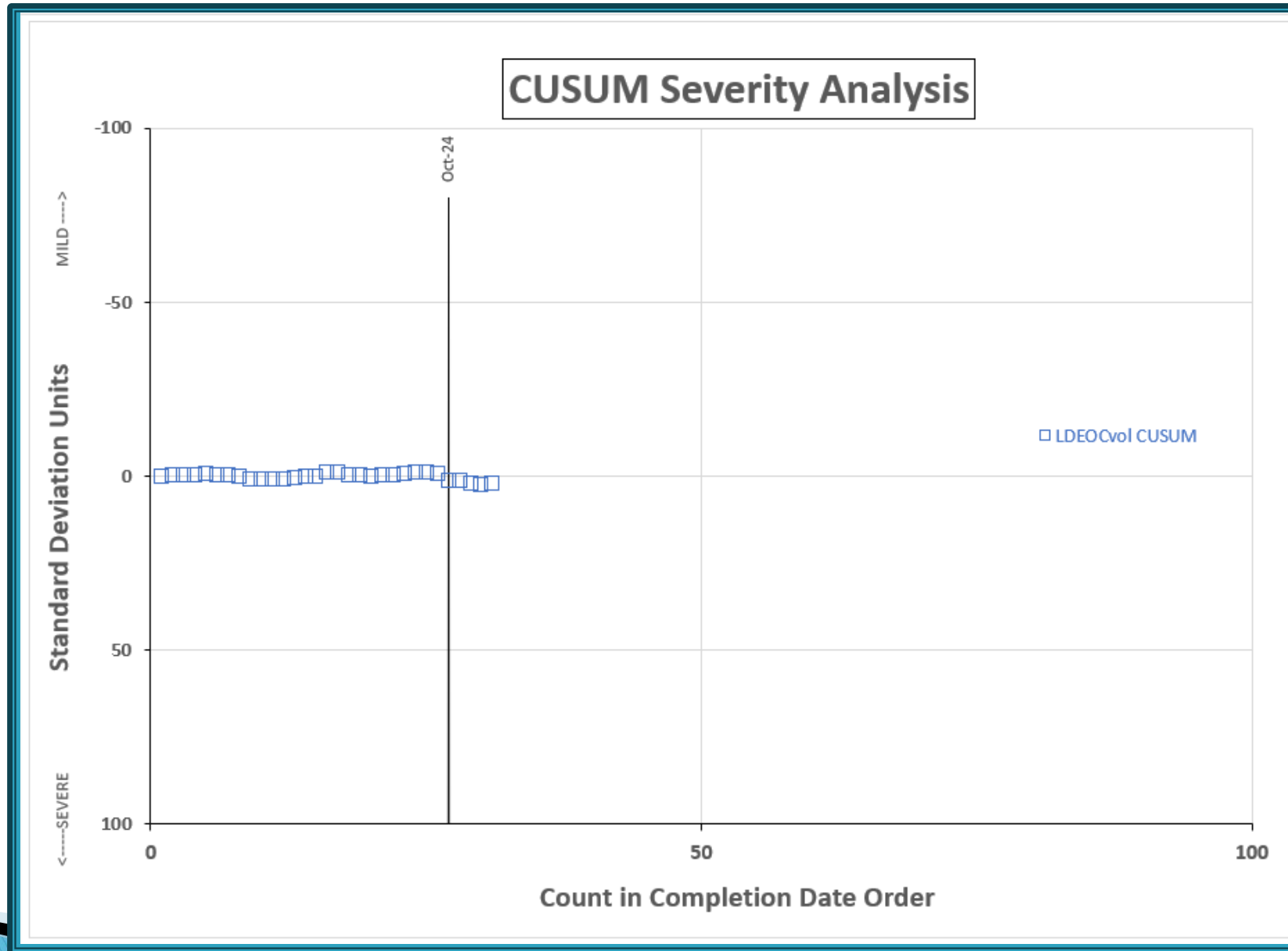
April 1, 2024 – September 30, 2024

Test Monitoring Center
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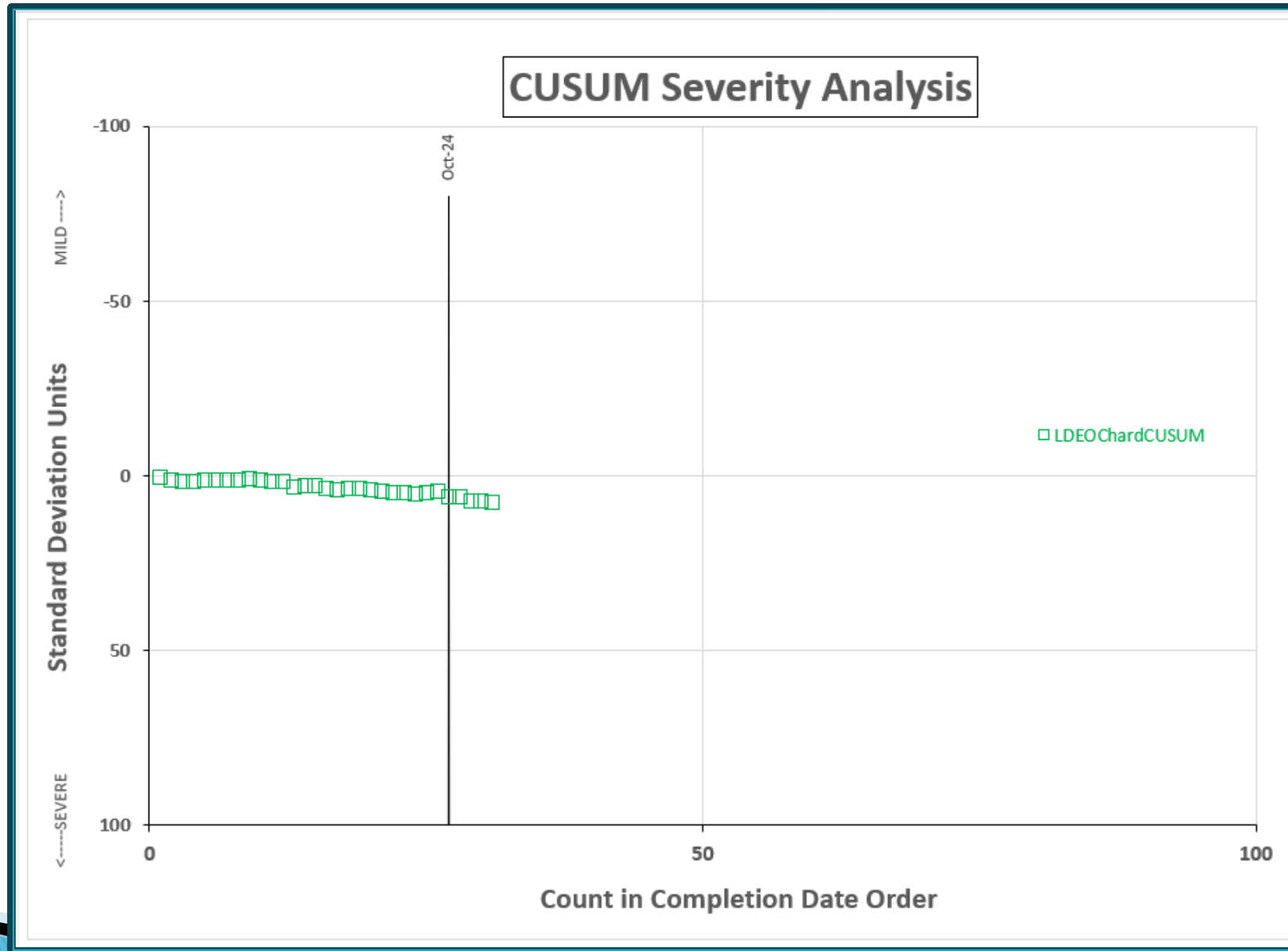


LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA

ETHYLENE ACRYLATE-3 VOLUME CHANGE FINAL

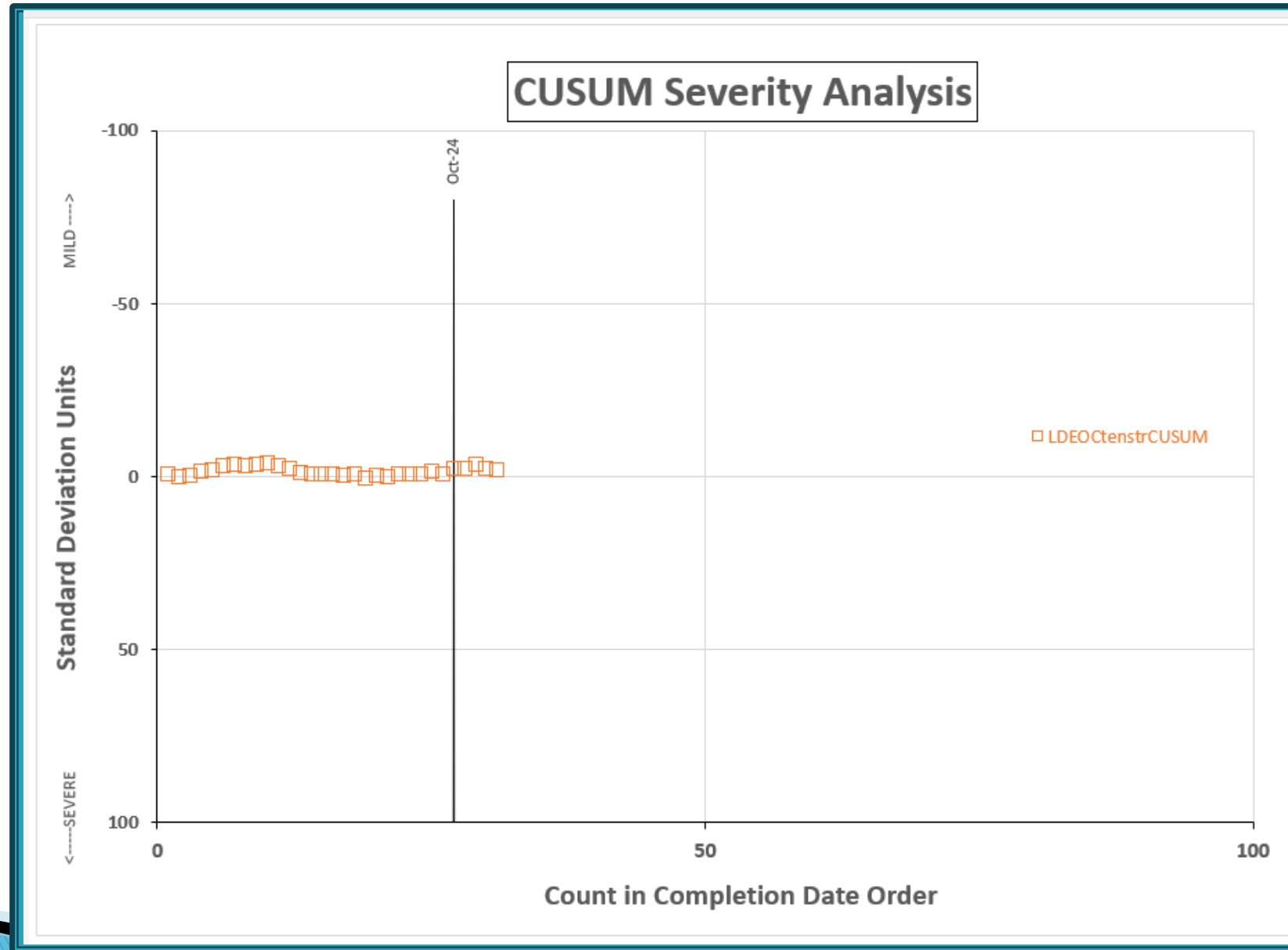


LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA
ETHYLENE ACRYLATE-3 HARDNESS CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA

ETHYLENE ACRYLATE-3 TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Fluoroelastomer (FKM1)

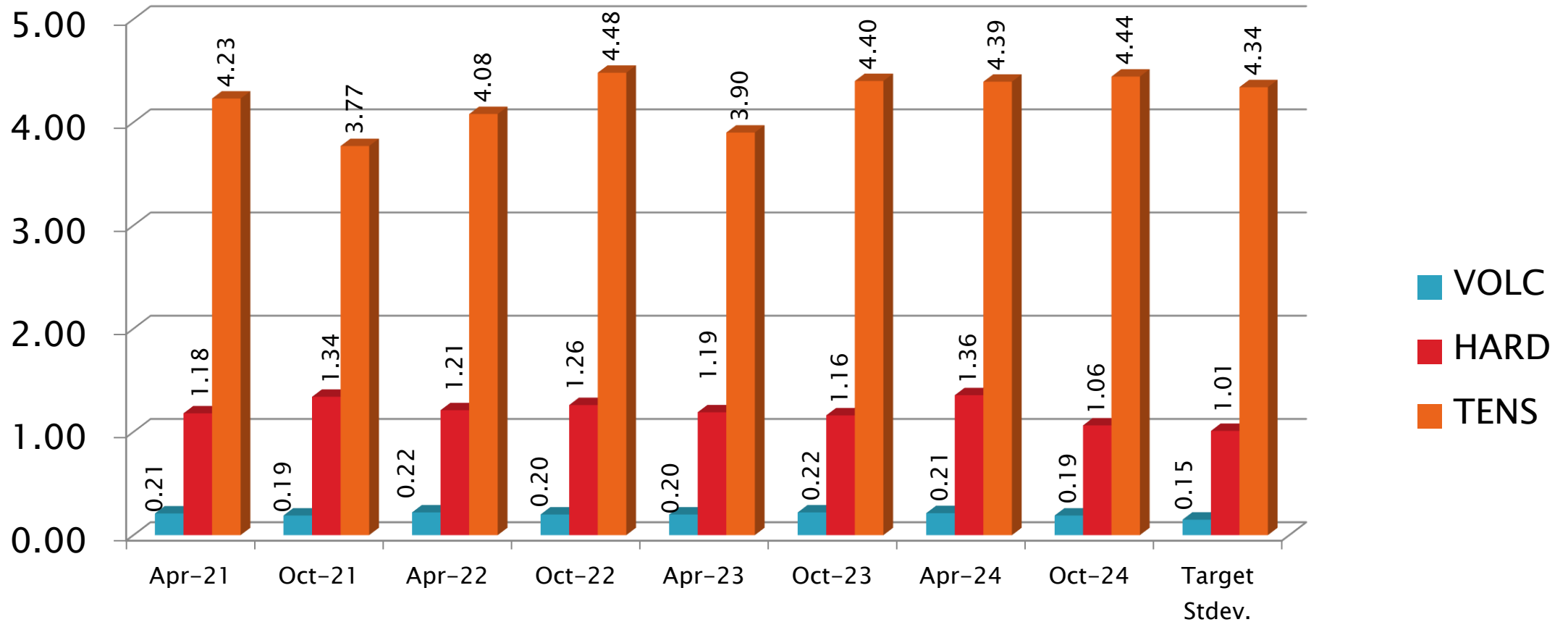
Parameter	Period Mean Δ/s	Status
Volume Change	-0.8772	Mild
Points Hardness Change	0.0338	On-Target
Tensile Strength Change	0.4018	Severe

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LDEOC Precision Estimates – Fluoroelastomer



*One 1006 reference oil result not included in this table

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LDEOC Precision Estimates by Lab: FKM1

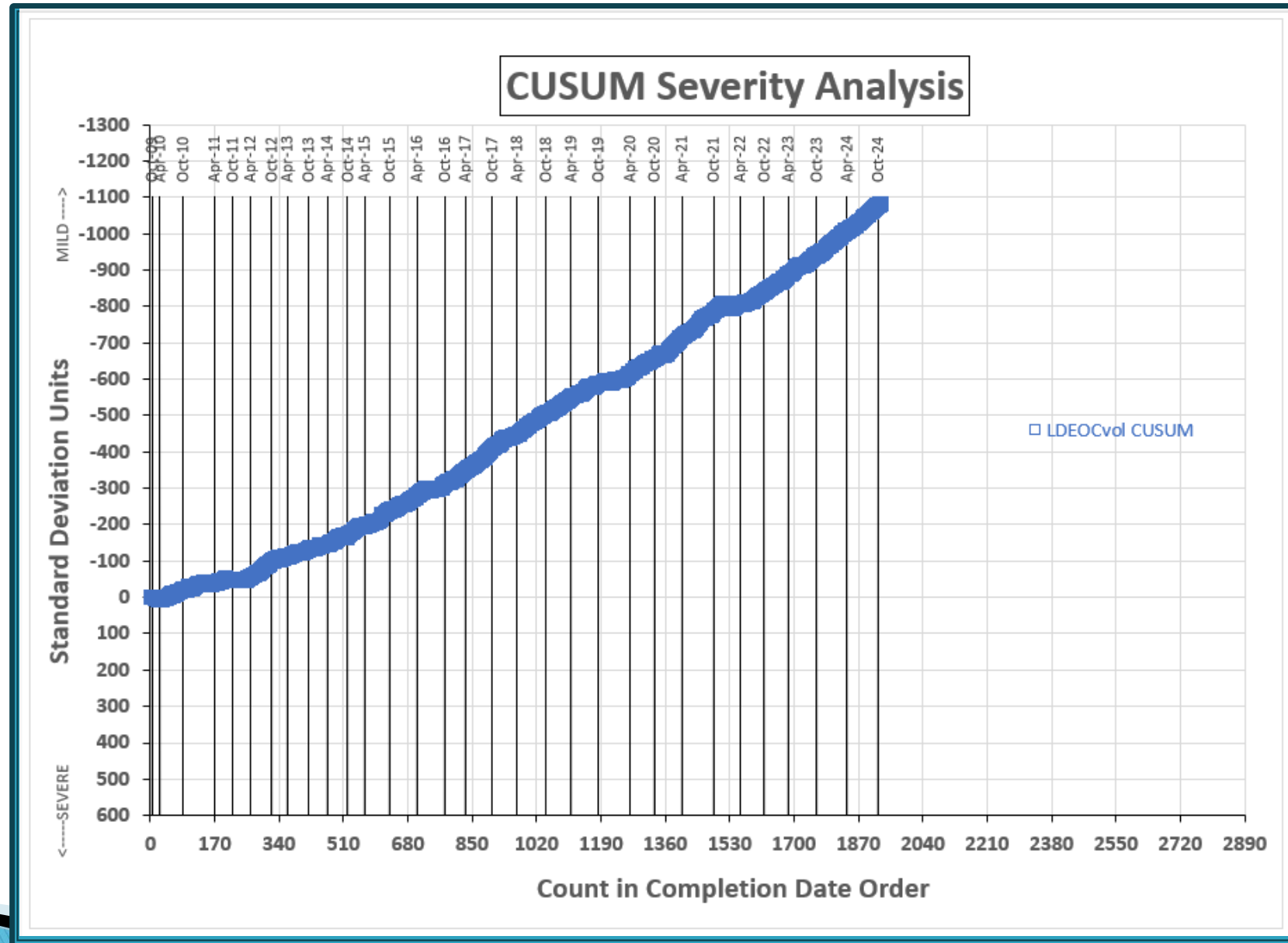
Test Parameter	Statistic	LTMS Lab*							
		A	B	E	G	I	L	P	V
	n=	25	6	0	25	13	3	4	6
Volume	Mean	0.4992	0.4683		0.5252	0.8362	0.4900	0.3300	0.4817
	Pooled s	0.1035	0.0783		0.1245	0.2449	0.0100	0.1472	0.1034
	Mean /s	-1.205	-1.411		-1.032	1.041	-1.267	-2.333	-1.322
Hardness	Mean	4.200	4.000		3.800	3.692	4.667	4.750	5.667
	Pooled s	0.8165	0.8944		1.258	0.4804	1.155	0.9574	0.8165
	Mean /s	0.0990	-0.0990		-0.2970	-0.4037	0.5611	0.6436	1.551
Tensile Strength	Mean	-57.68	-56.58		-55.60	-48.56	-56.77	-54.85	-61.87
	Pooled s	2.904	1.250		3.641	1.891	1.358	2.127	1.491
	Mean /s	-0.0645	0.1882		0.4138	2.037	0.1459	0.5876	-1.029

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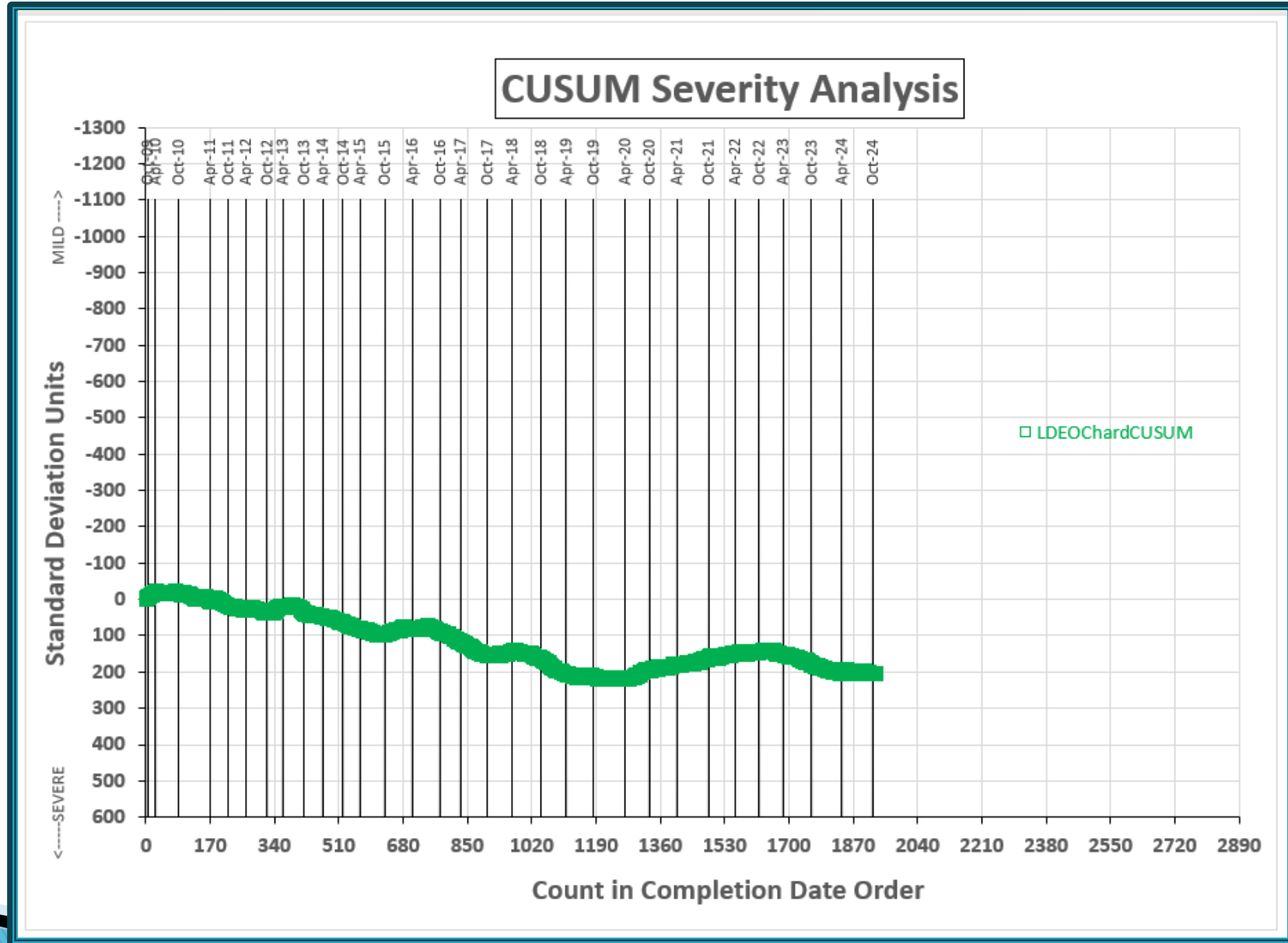
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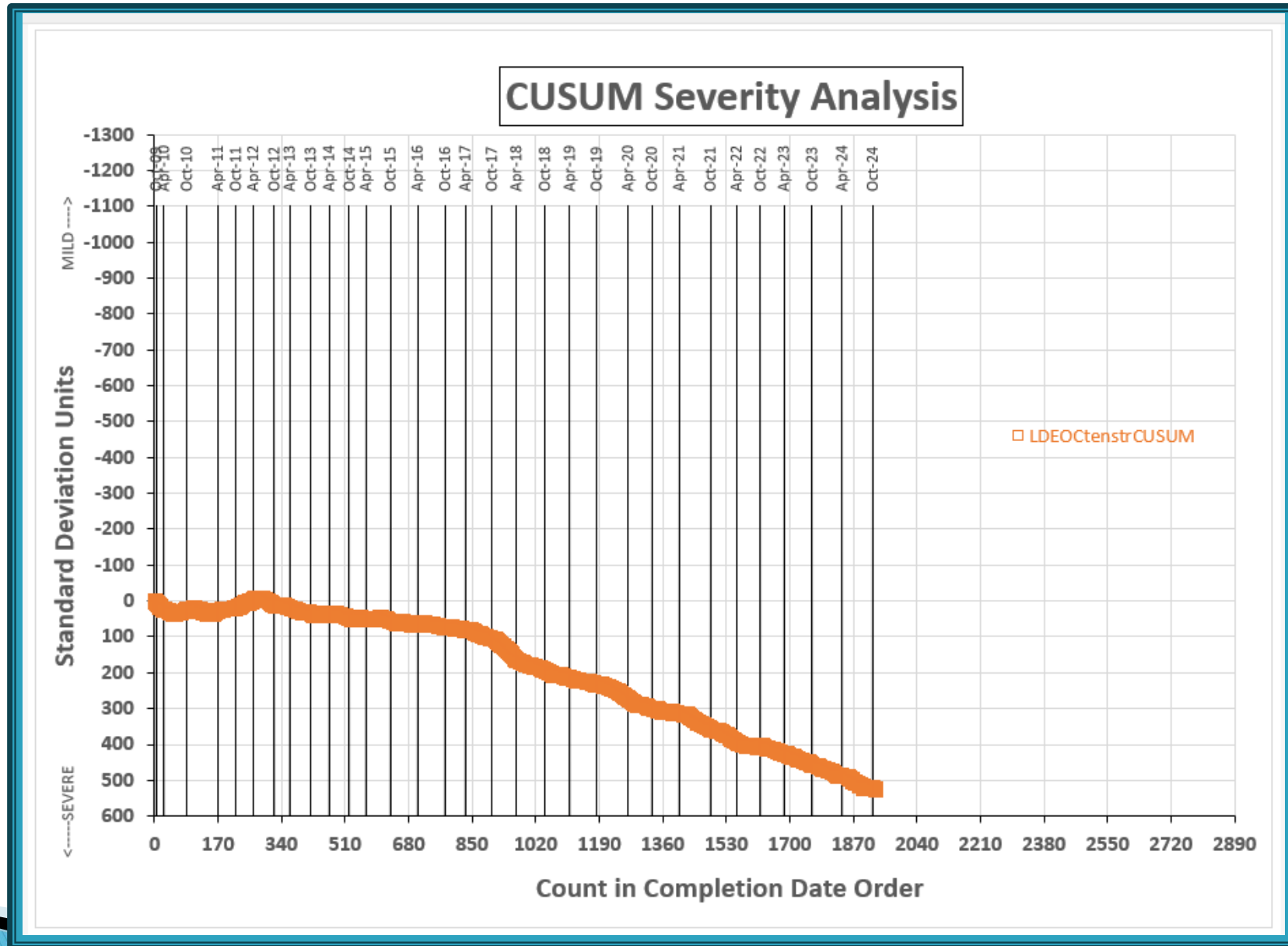
LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA FLUOROELASTOMER VOLUME CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA FLUOROELASTOMER HARDNESS CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA FLUOROELASTOMER TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Fluoroelastomer (FKM3)

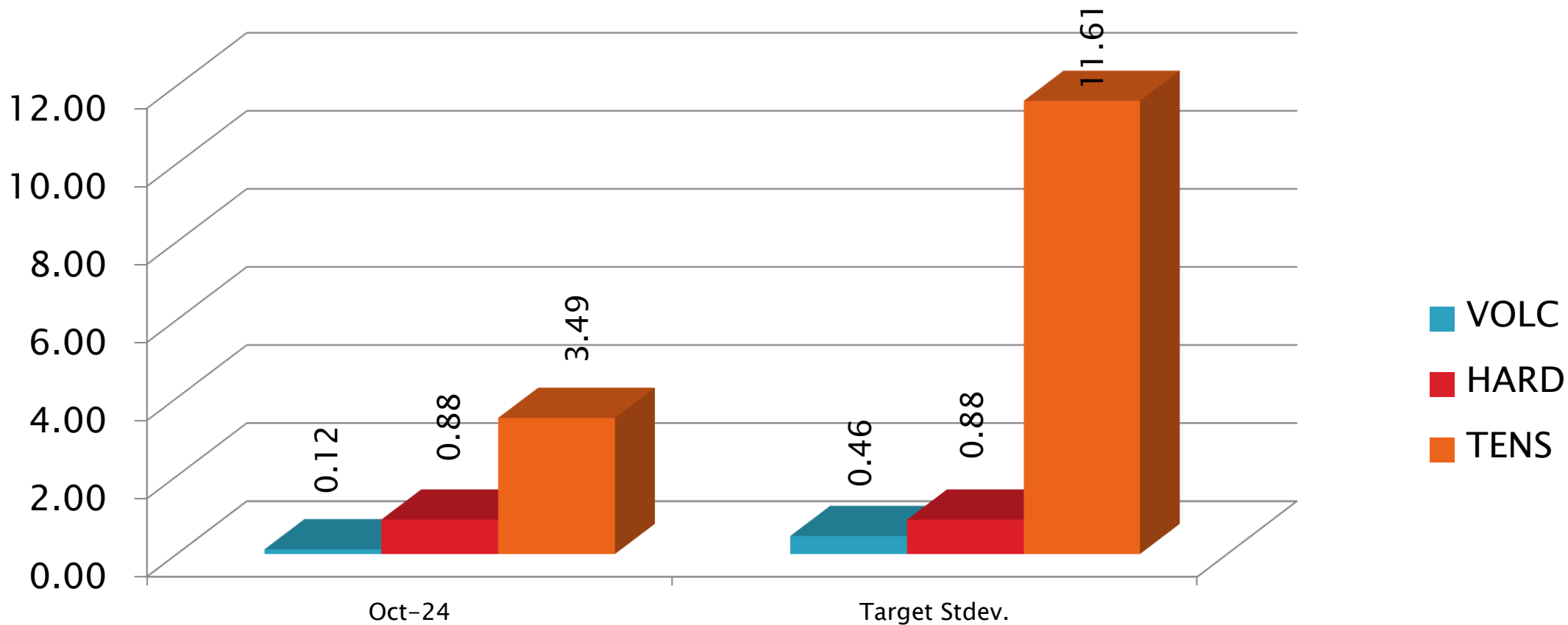
Parameter	Period Mean Δ/s	Status
Volume Change	-0.0994	On-Target
Points Hardness Change	-0.0406	On-Target
Tensile Strength Change	-0.5687	Mild

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LDEOC Precision Estimates – Fluoroelastomer3



*One 1006 reference oil result not included in this table

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LDEOC Precision Estimates by Lab: FKM3

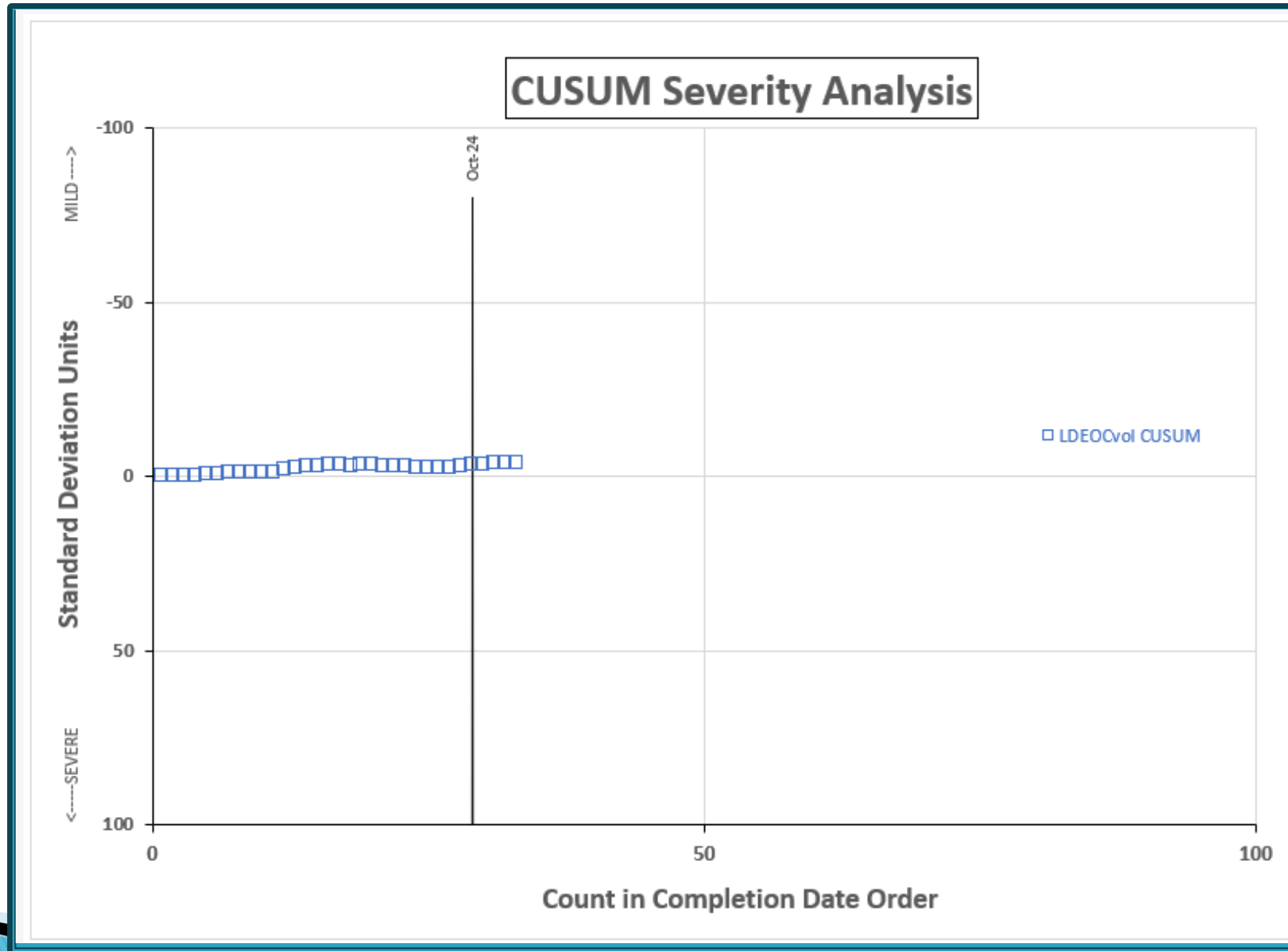
Test Parameter	Statistic	LTMS Lab*							
		A	B	E	G	I	L	P	V
	n=	20	1	0	3	0	0	0	4
Volume	Mean	0.7215	0.7600		0.6067				0.6775
	Pooled s	0.1245	n/a		0.1332				0.0881
	Mean /s	-0.0620	0.0217		-0.3116				-0.1576
Hardness	Mean	4.000	4.000		3.000				4.500
	Pooled s	0.5620	n/a		1.000				1.732
	Mean /s	0.000	0.000		-1.136				0.5682
Tensile Strength	Mean	-57.18	-56.90		-51.07				-60.55
	Pooled s	2.572	n/a		4.579				1.112
	Mean /s	-0.5844	-0.5607		-0.0582				-0.8751

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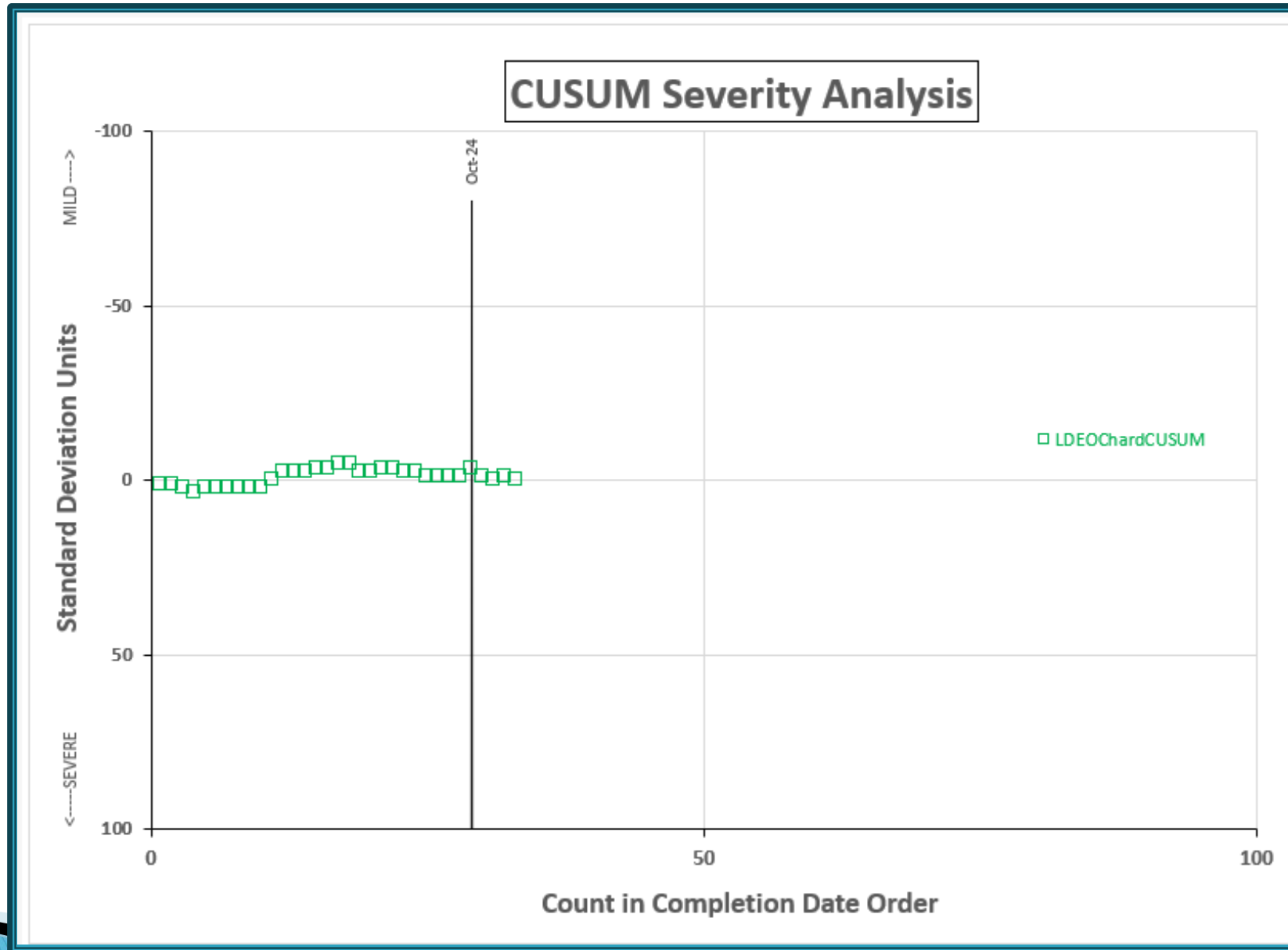
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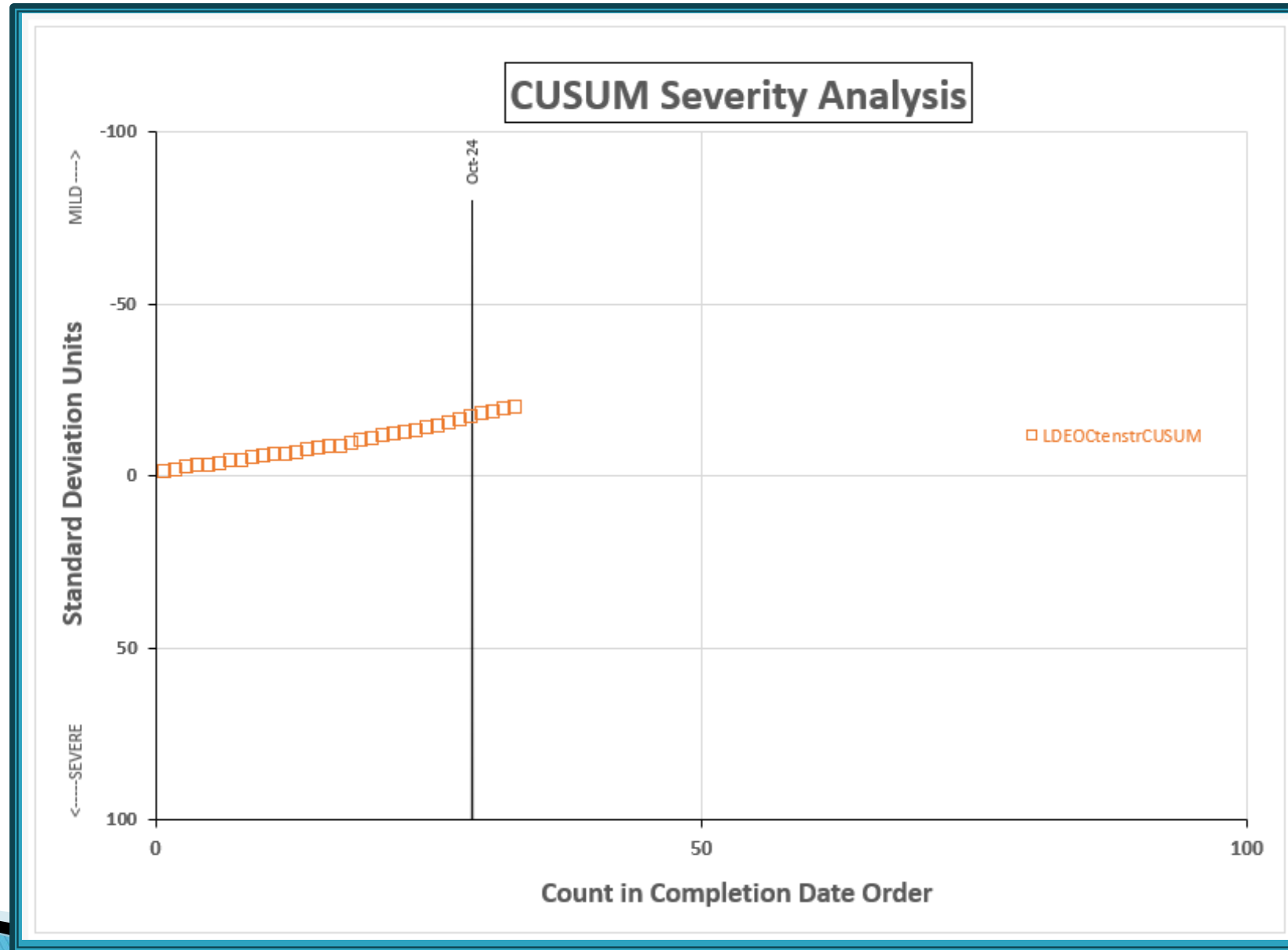
LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA FLUOROELASTOMER-3 VOLUME CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA FLUOROELASTOMER-3 HARDNESS CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA FLUOROELASTOMER-3 TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Nitrile (NBR1)

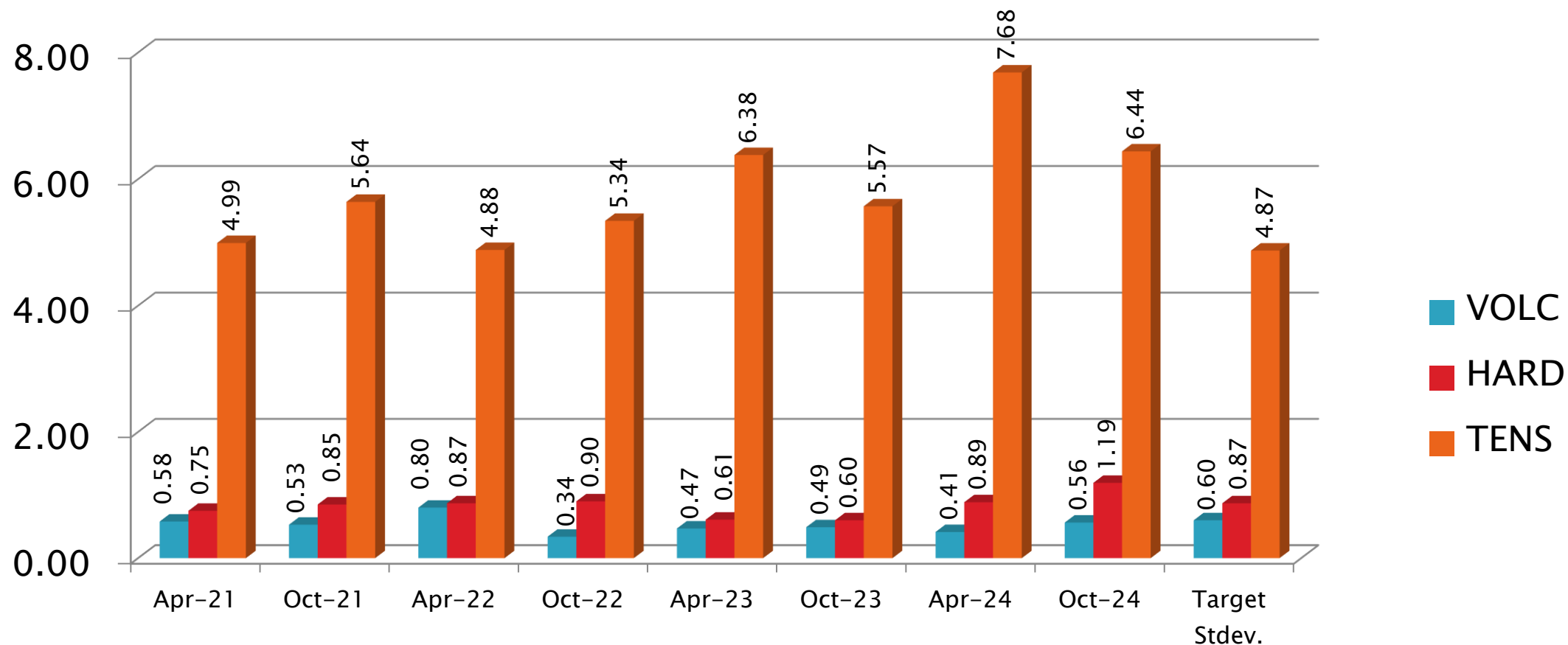
Parameter	Period Mean Δ/s	Status
Volume Change	1.0922	Severe
Points Hardness Change	-0.8148	Mild
Tensile Strength Change	-0.6816	Mild

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LDEOC Precision Estimates – Nitrile



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LDEOC Precision Estimates by Lab: NBR1

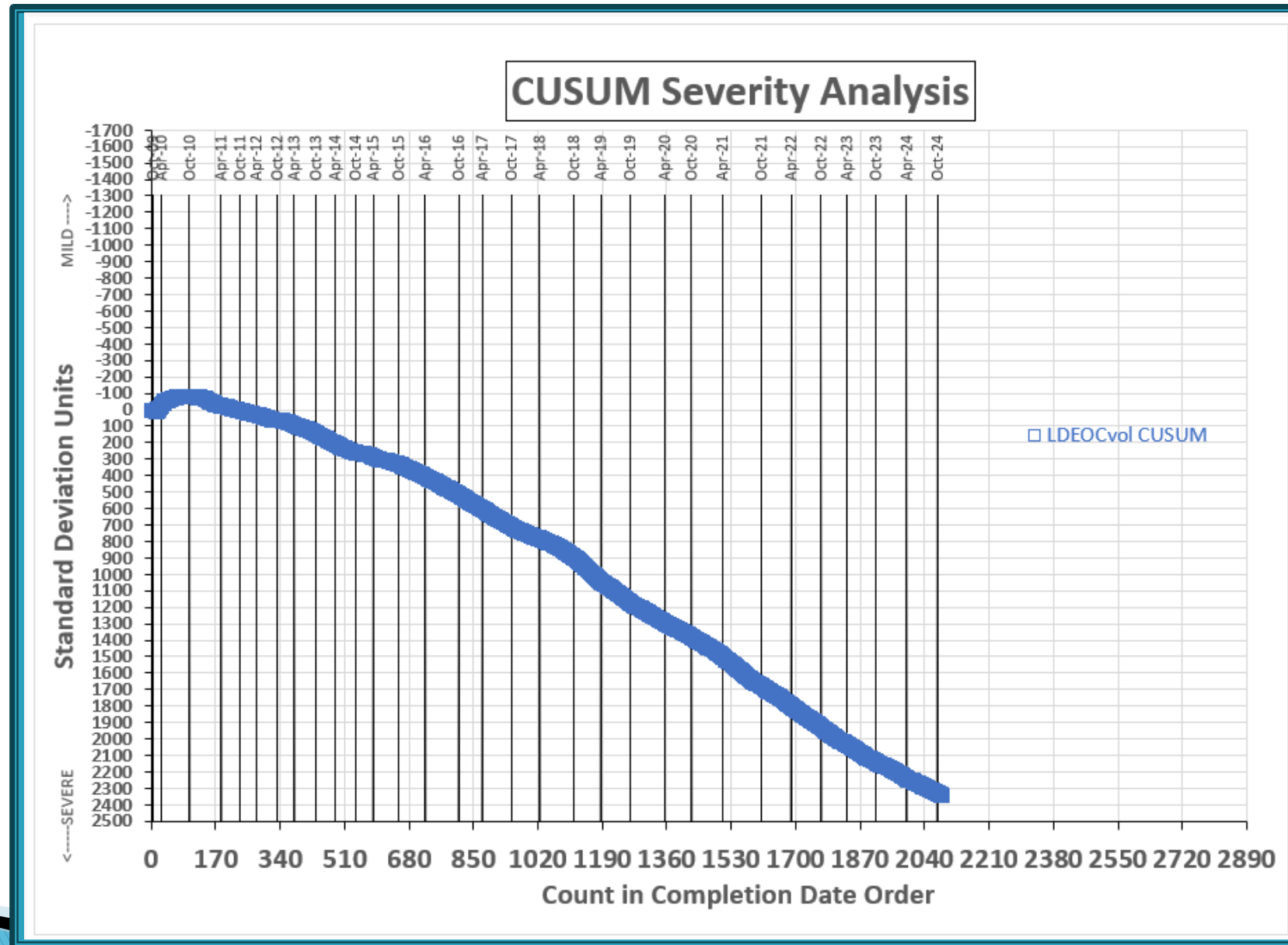
Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	29	6	0	25	14	1	3	3
Volume	Mean	1.122	1.210		0.8244	0.8421	1.370	0.8967	0.9167
	Pooled s	0.2082	0.1724		0.6447	0.9511	n/a	0.3889	0.2026
	Mean /s	1.336	1.483		0.8407	0.8702	1.750	0.9611	0.9944
Hardness	Mean	-2.344	-1.500		-1.440	-1.929	-2.000	-2.000	-1.667
	Pooled s	0.5526	0.8367		1.850	0.6157	n/a	1.000	0.5774
	Mean /s	-1.339	-0.3678		-0.2989	-0.8604	-0.9425	-0.9425	-0.5594
Tensile Strength	Mean	1.117	1.417		5.016	2.014	2.300	1.367	4.600
	Pooled s	5.939	2.679		8.994	2.584	n/a	1.320	3.219
	Mean /s	-0.996	-0.9350		-0.1959	-0.8123	-0.7536	-0.945	-0.2813

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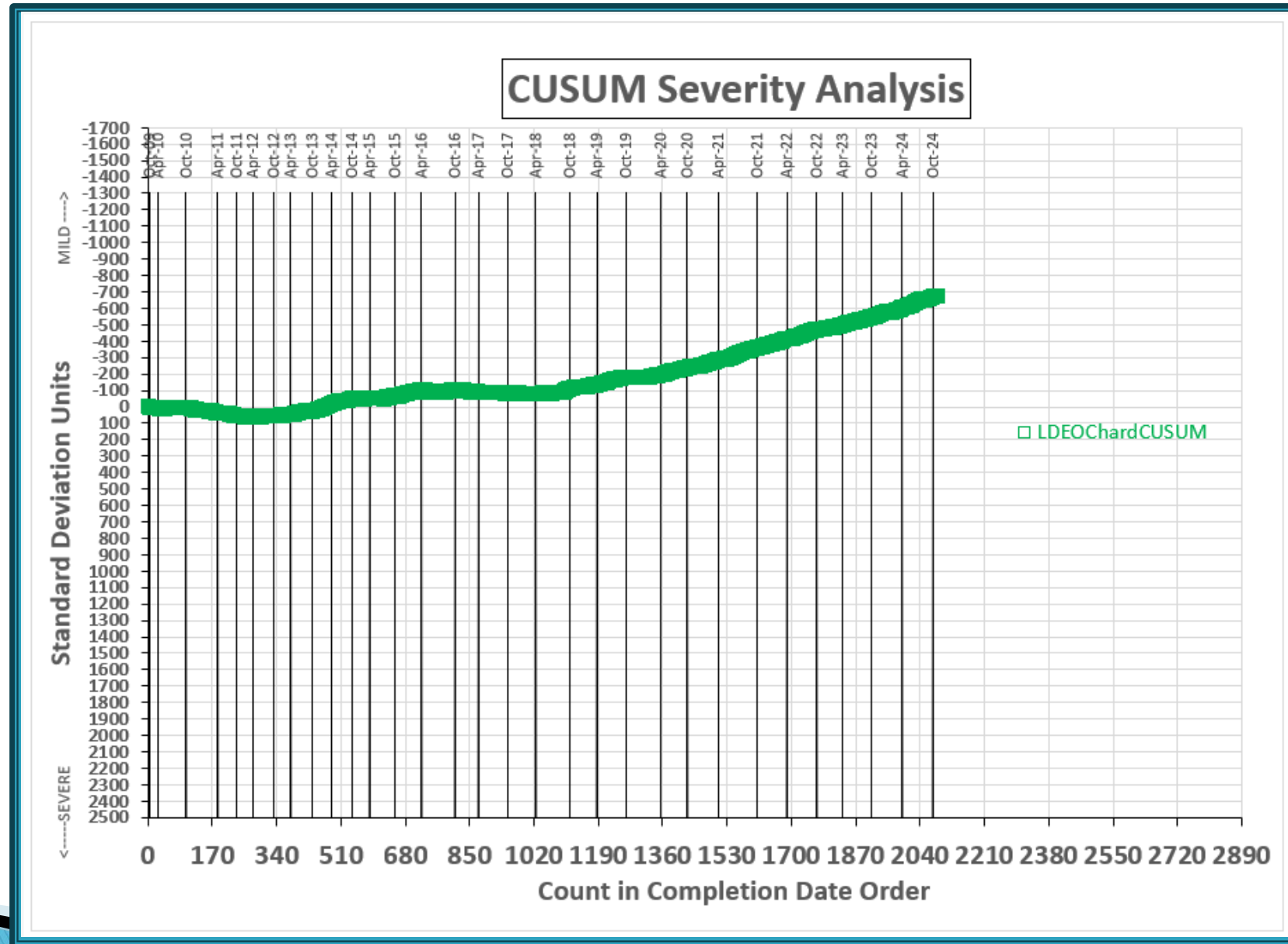
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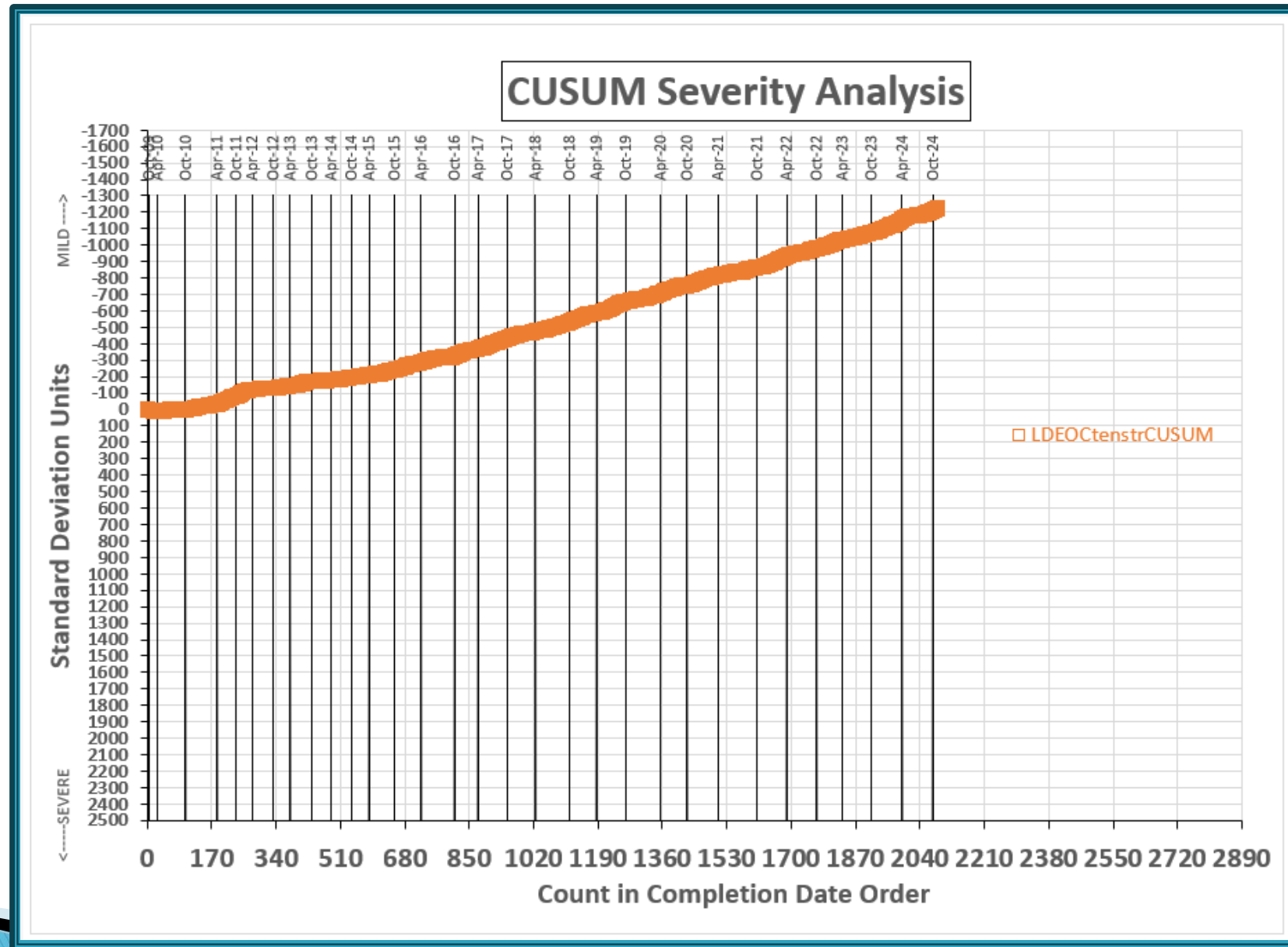
REFERENCE NITRILE VOLUME CHANGE FINAL



REF NITRILE POINTS HARDNESS CHANGE AVERAGE



REF NITRILE TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Polyacrylate (ACM1)

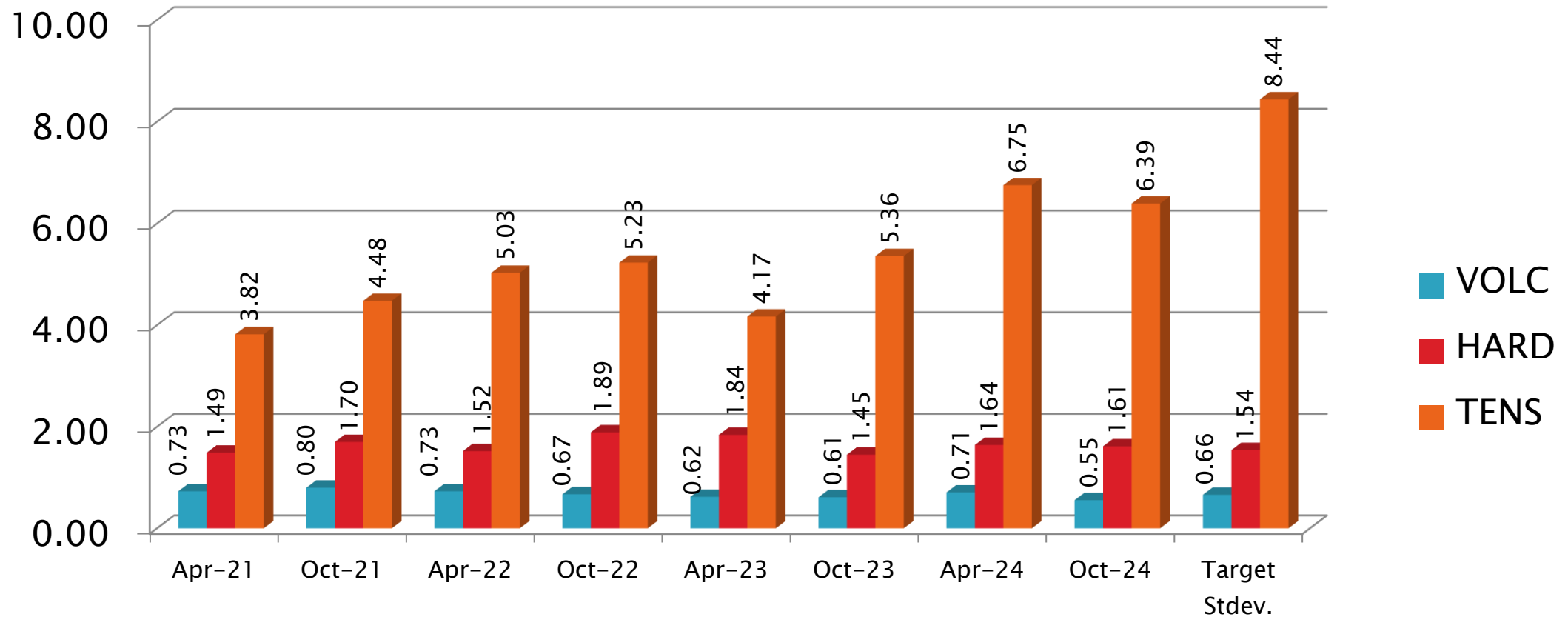
Parameter	Period Mean Δ/s	Status
Volume Change	-0.4080	Mild
Points Hardness Change	-1.3147	Mild
Tensile Strength Change	-0.4496	Mild

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LDEOC Precision Estimates – Polyacrylate



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LDEOC Precision Estimates by Lab: ACM1

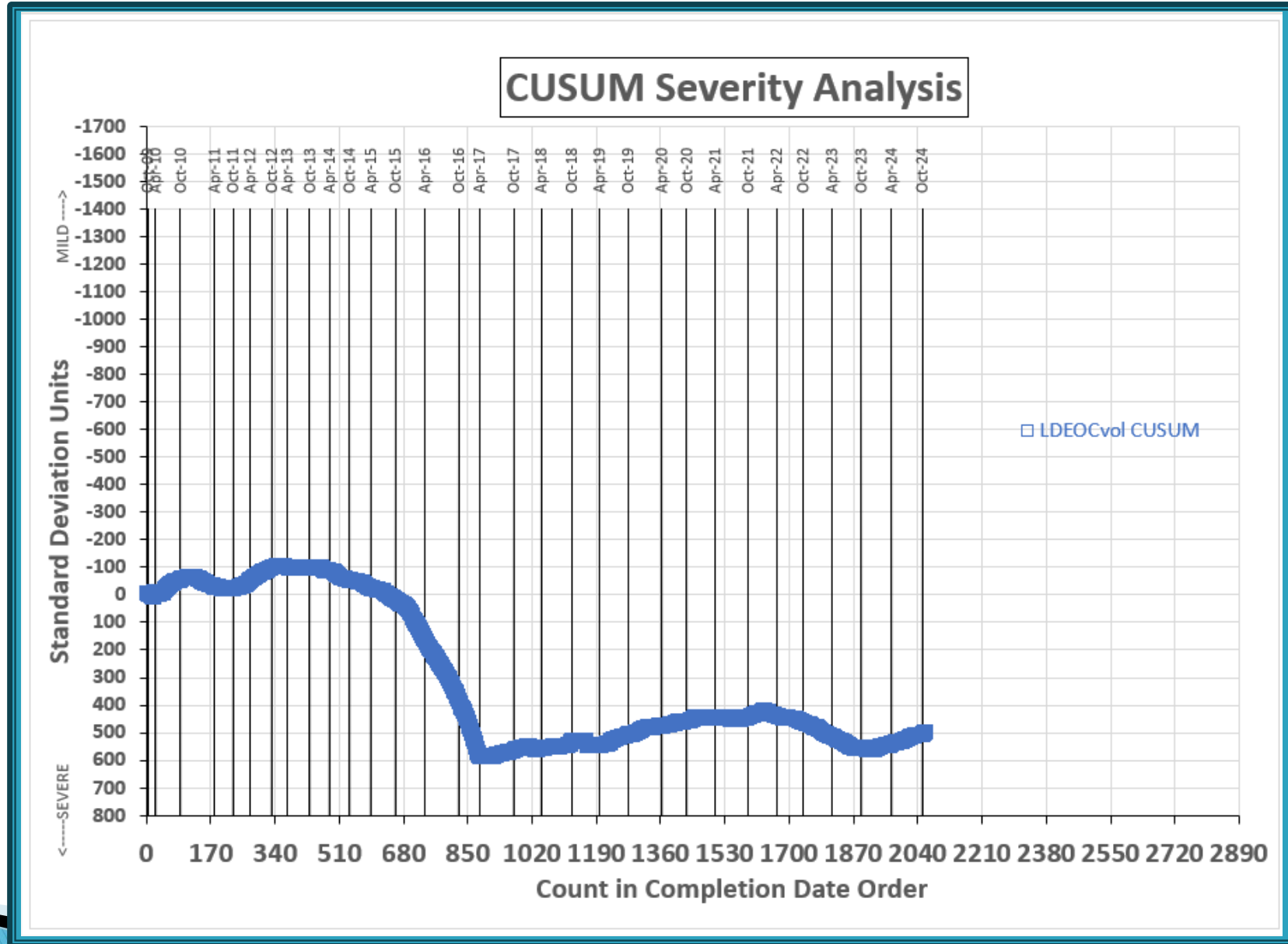
Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	26	7	0	25	14	2	4	3
Volume	Mean	1.540	2.204		1.854	1.901	2.105	1.890	1.343
	Pooled s	0.2347	0.3929		0.3910	1.044	0.0919	0.118	0.4062
	Mean /s	-0.7727	0.2338		-0.2970	-0.2251	0.0833	-0.2424	-1.071
Hardness	Mean	-3.192	-1.857		-2.200	-1.000	-2.500	-0.2500	-3.333
	Pooled s	0.8010	1.464		2.041	0.6794	0.7071	1.500	0.5574
	Mean /s	-1.937	-1.070		-1.292	-0.5130	-1.487	-0.0260	-2.028
Tensile Strength	Mean	-0.9115	-0.7143		-1.836	-1.736	0.1000	-1.675	2.333
	Pooled s	5.951	2.406		8.934	5.131	2.687	2.380	1.724
	Mean /s	-0.4137	-0.3903		-0.5232	-0.5113	-0.2938	-0.5041	-0.0292

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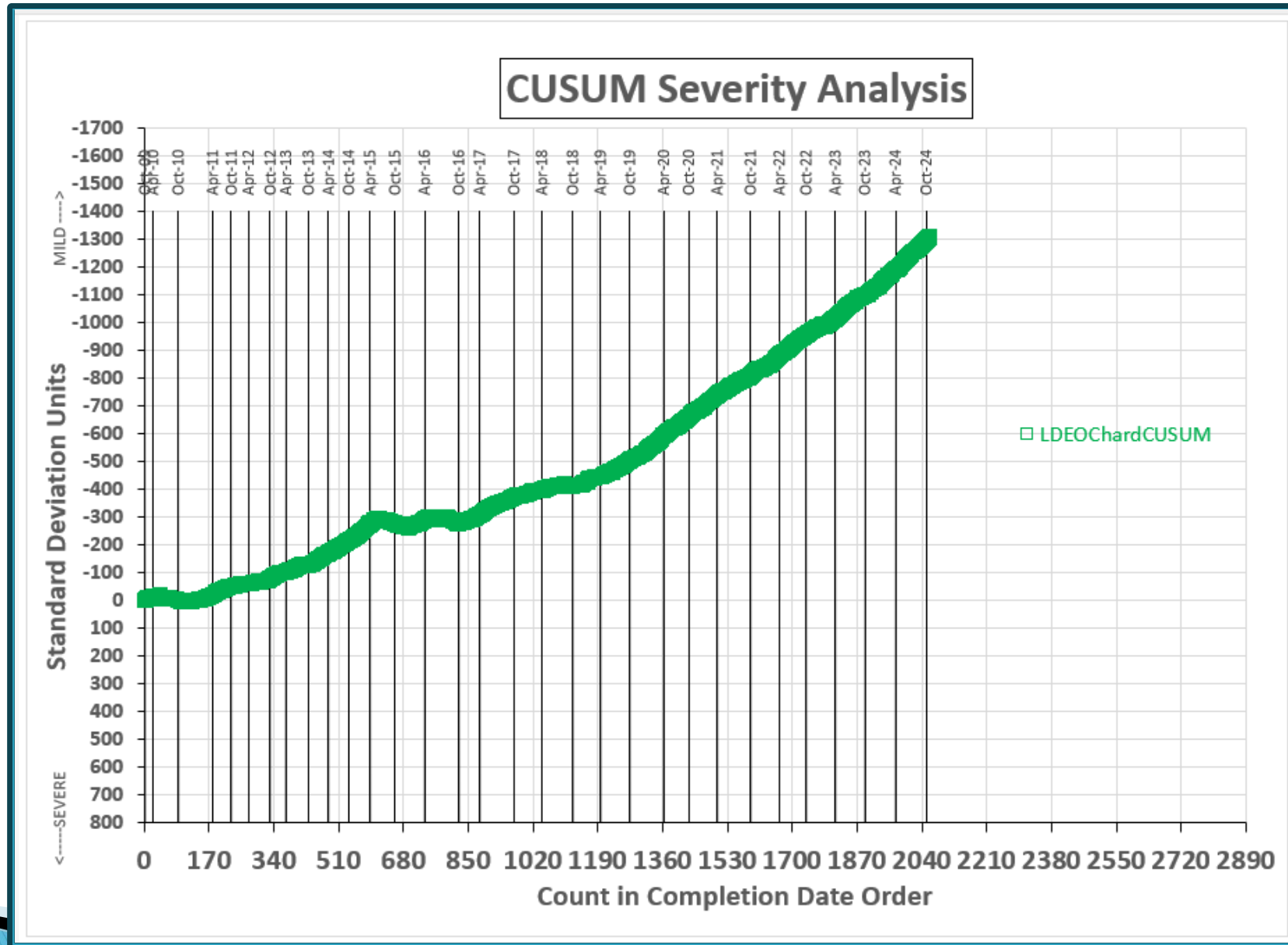
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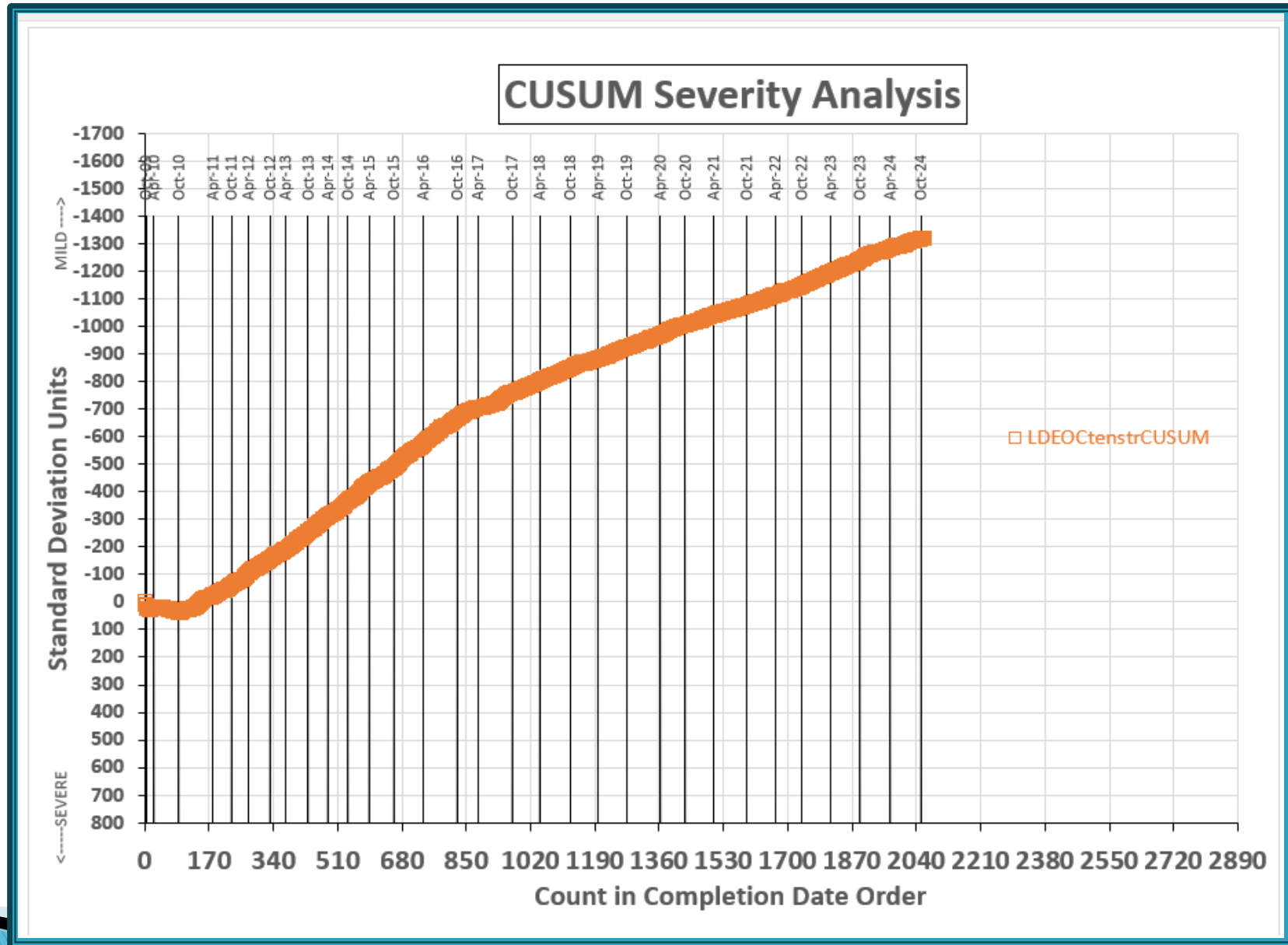
LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA POLYACRYLATE VOLUME CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA POLYACRYLATE HARDNESS CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA POLYACRYLATE TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Polyacrylate (ACM2)

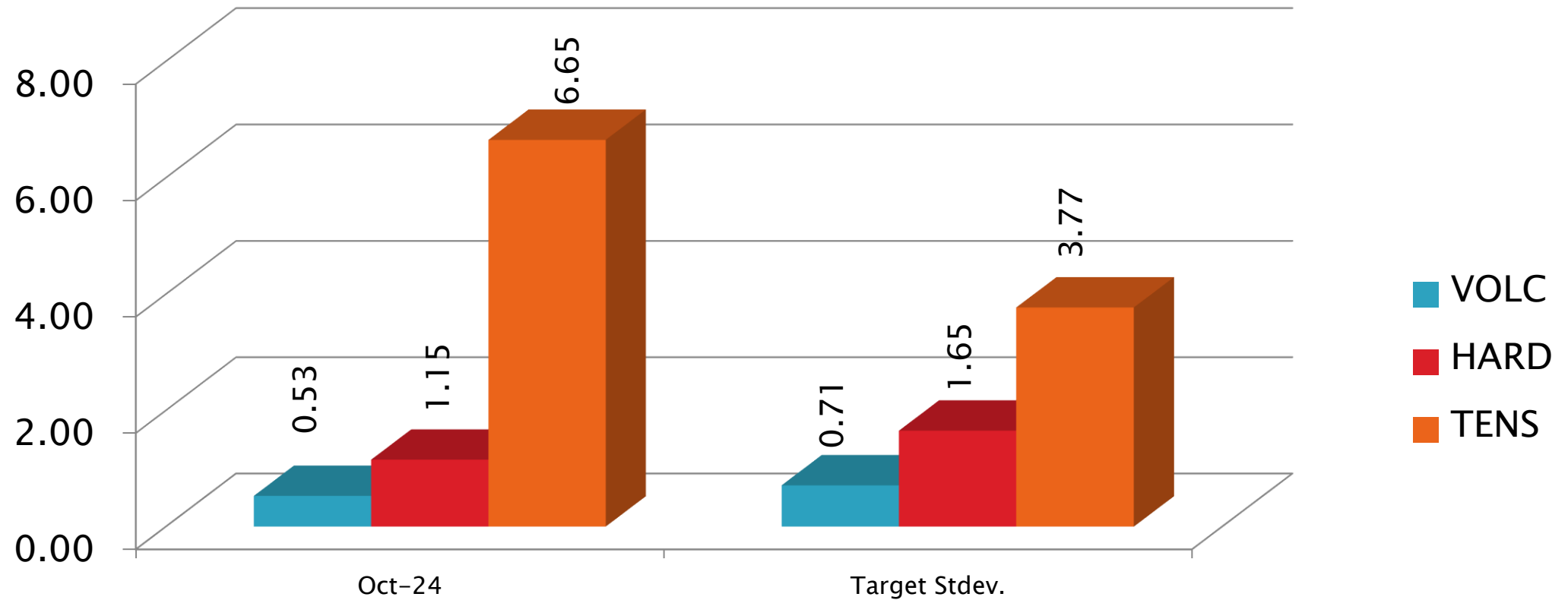
Parameter	Period Mean Δ/s	Status
Volume Change	0.0672	On-Target
Points Hardness Change	-1.3207	Mild
Tensile Strength Change	-0.2438	Mild

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LDEOC Precision Estimates – Polyacrylate2



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LDEOC Precision Estimates by Lab: ACM2

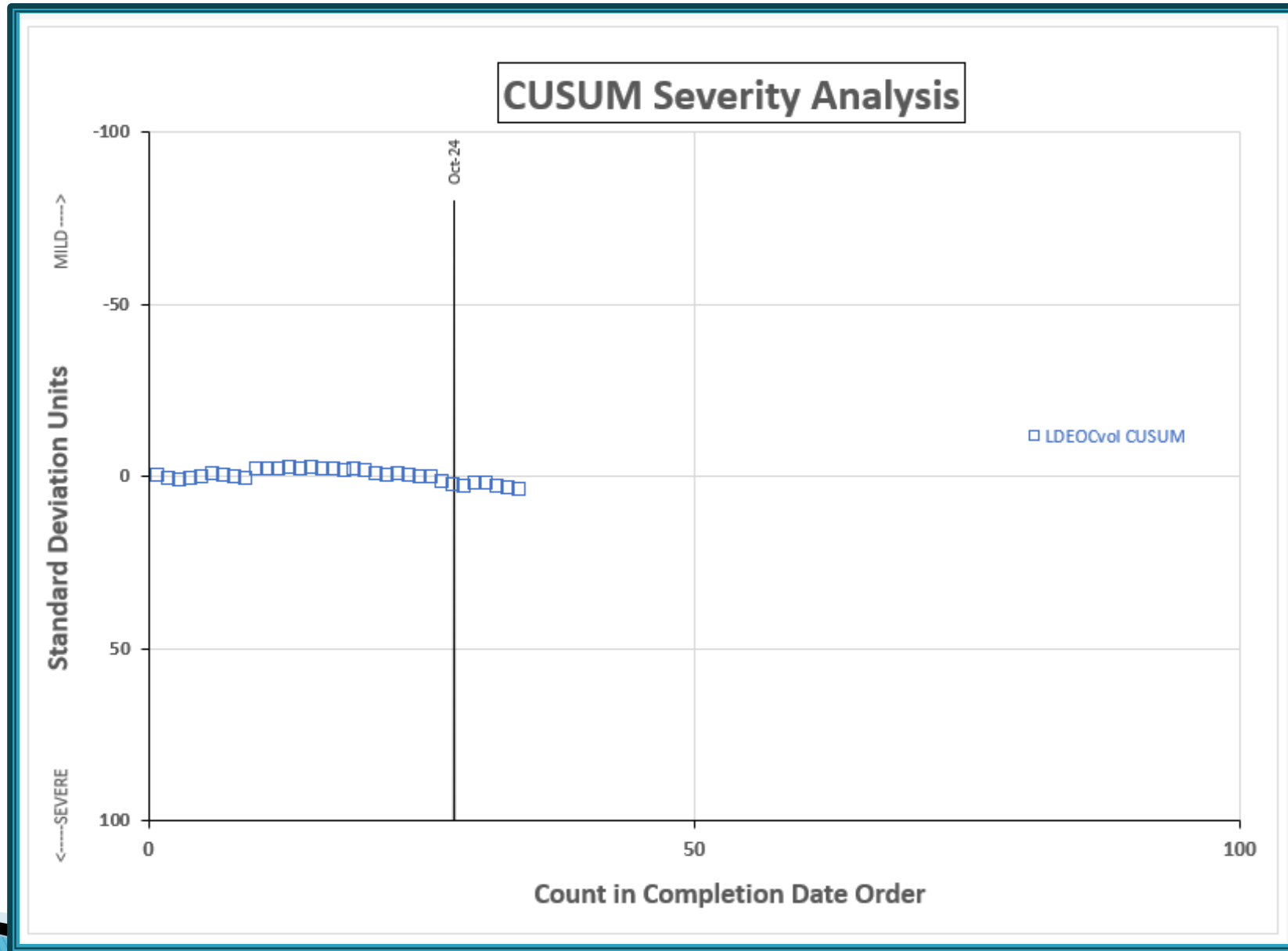
Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	18	1	0	3	0	0	0	4
Volume	Mean	11.03	11.68		10.737				10.86
	Pooled s	0.2793	n/a		1.502				0.3480
	Mean /s	0.1182	1.028		-0.300				-0.1268
Hardness	Mean	-4.556	-4.000		-2.333				-4.500
	Pooled s	0.8556	n/a		1.155				1.291
	Mean /s	-1.494	-1.158		-0.1475				-1.461
Tensile Strength	Mean	-14.79	-15.10		-17.80				-13.95
	Pooled s	6.478	n/a		11.51				5.724
	Mean /s	-0.1827	-0.2652		-0.9814				0.0340

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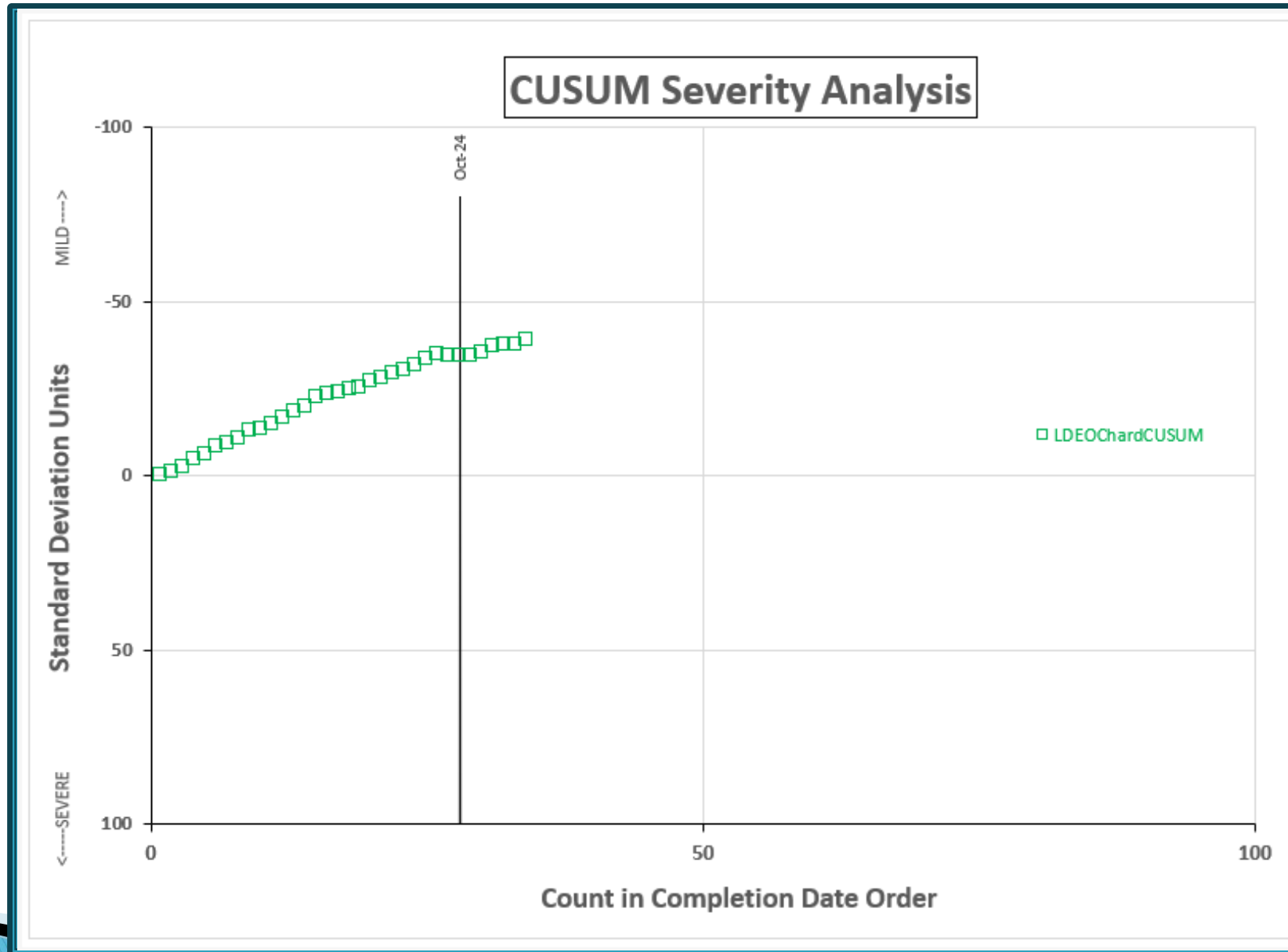
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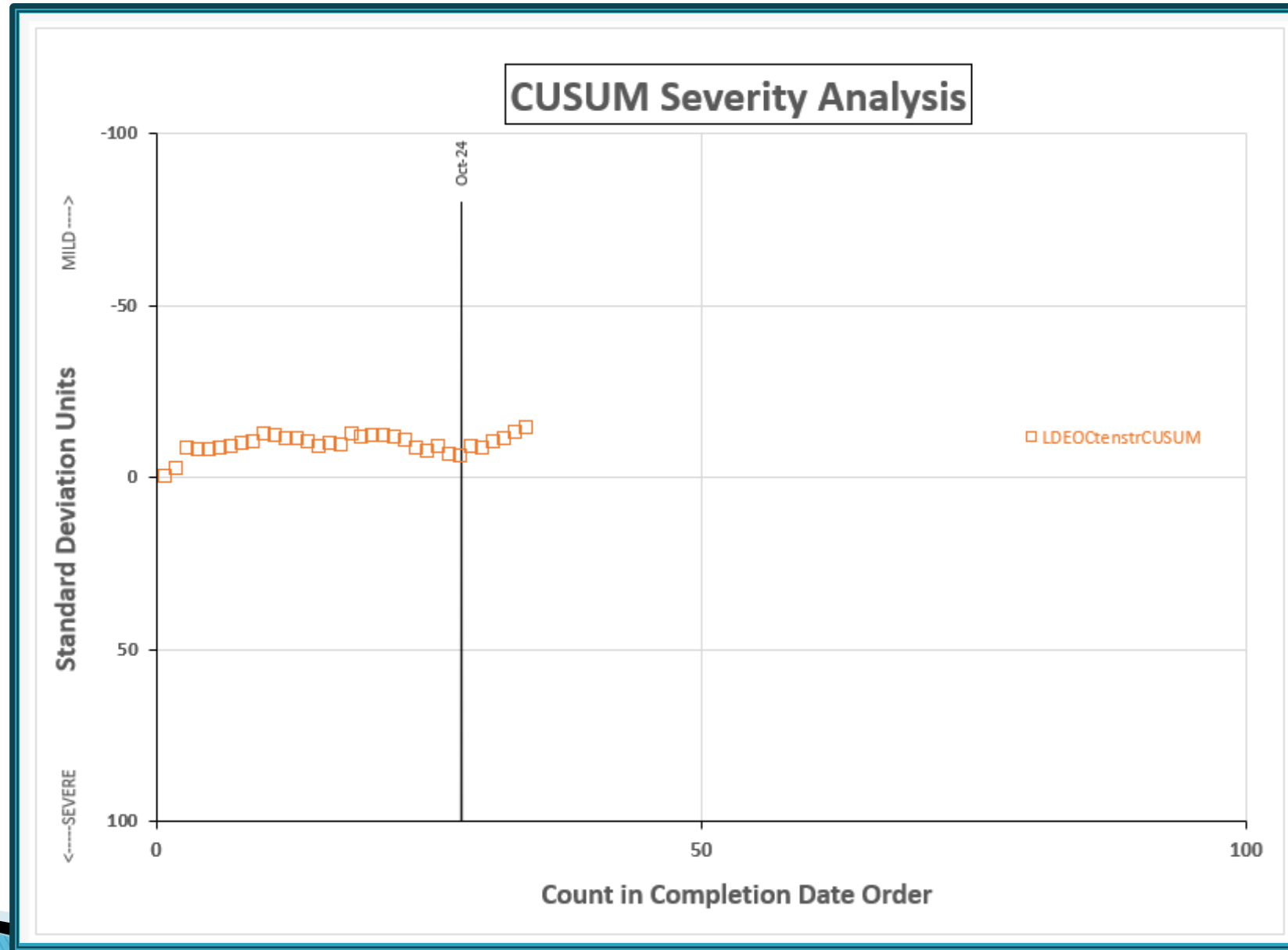
LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA POLYACRULATE-2 VOLUME CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA POLYACRYLATE-2 HARDNESS CHANGE FINAL



LDEOC – ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA POLYACRYLATE-2 TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Silicone (VMQ1)

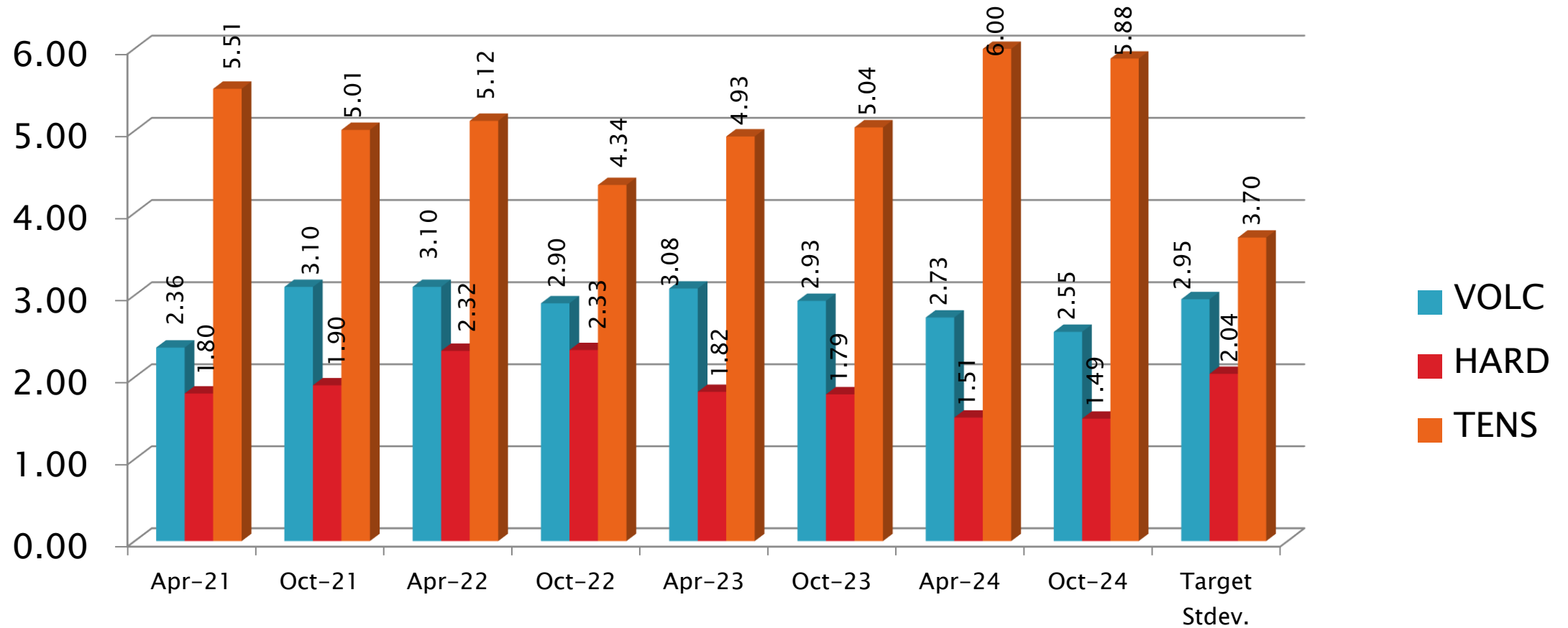
Parameter	Period Mean Δ /s	Status
Volume Change	0.5778	Severe
Points Hardness Change	-0.6582	Mild
Tensile Strength Change	0.1318	Slightly Severe

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LDEOC Precision Estimates – Silicone



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LDEOC Precision Estimates by Lab: VQM1

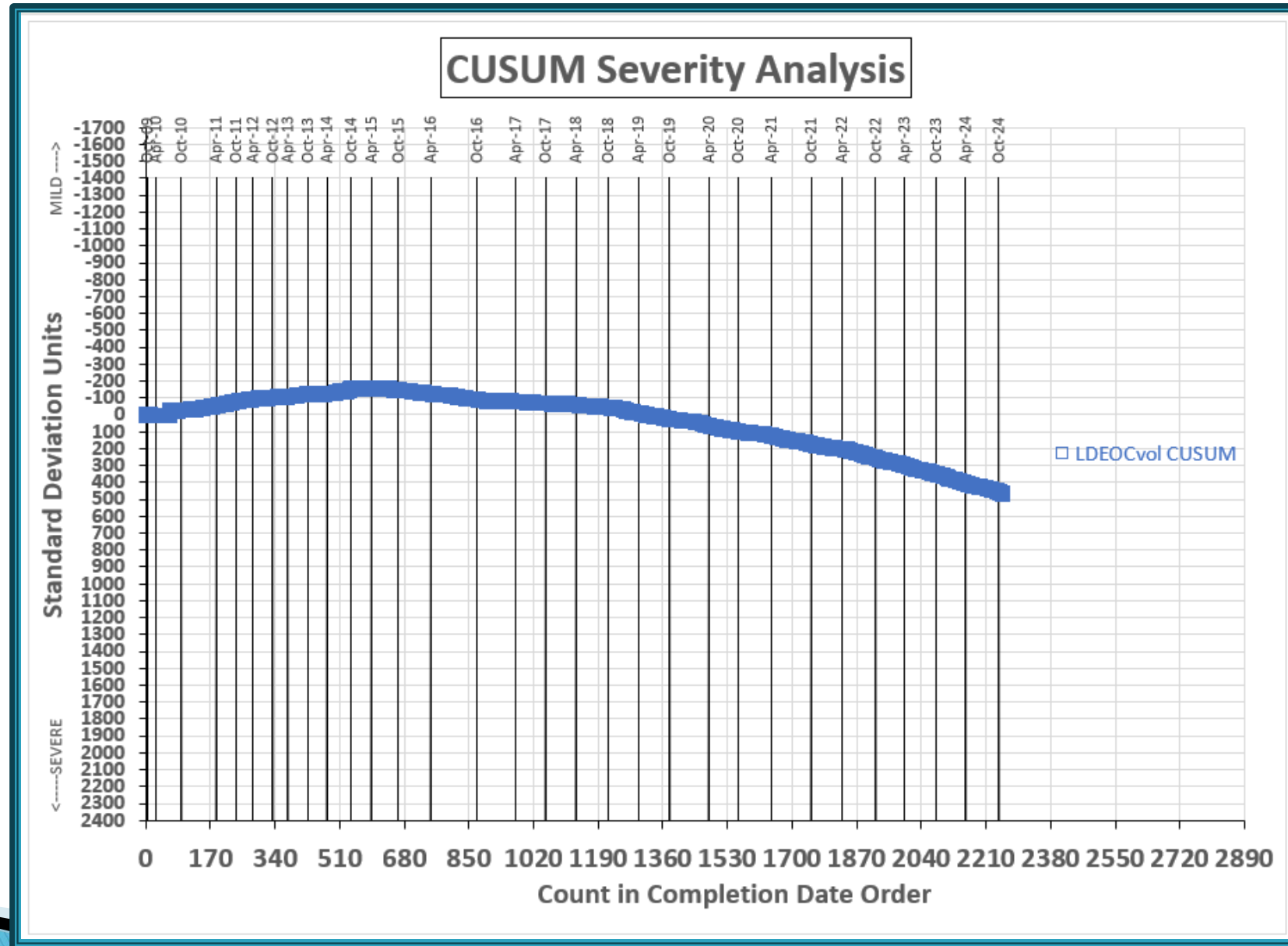
Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	29	6	0	25	14	3	5	6
Volume	Mean	33.75	34.22		36.33	30.33	30.85	33.99	33.60
	Pooled s	0.5547	1.412		2.447	1.754	1.5316	0.8590	0.5773
	Mean /s	0.5352	0.6955		1.409	-0.6223	-0.4475	0.6169	0.4830
Hardness	Mean	-23.28	-23.50		-23.72	-22.36	-17.33	-23.40	-22.50
	Pooled s	0.9598	0.5477		1.137	0.8419	0.5774	0.5477	0.8367
	Mean /s	-0.7822	-0.8922		-1.000	-0.3319	2.130	-0.8431	-0.4020
Tensile Strength	Mean	-32.46	-29.00		-35.81	-31.89	-29.07	-38.80	-31.50
	Pooled s	5.311	3.336		6.693	4.287	3.326	5.612	5.599
	Mean /s	0.3500	1.284		-0.5562	0.5019	1.266	-1.365	0.6081

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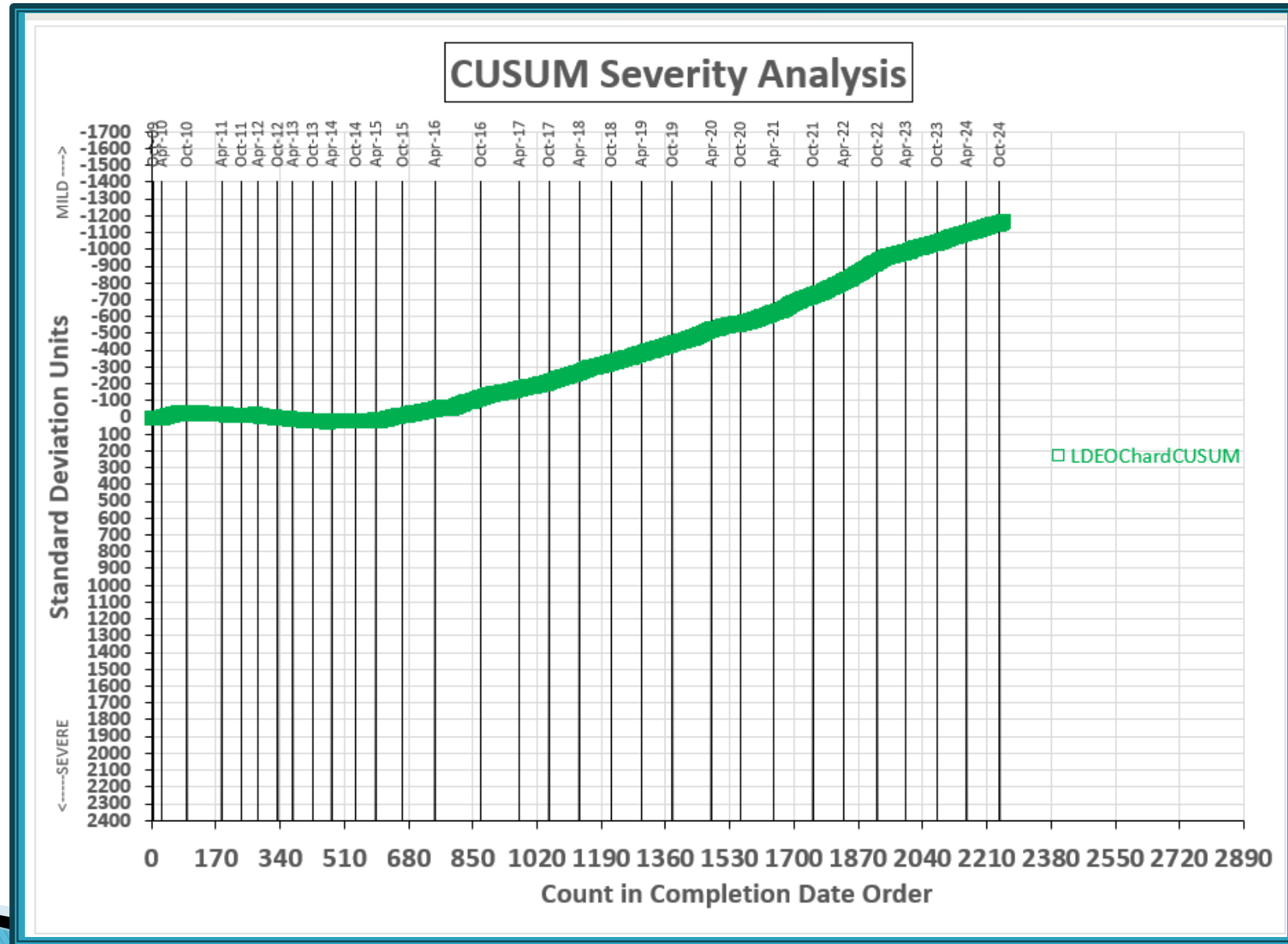
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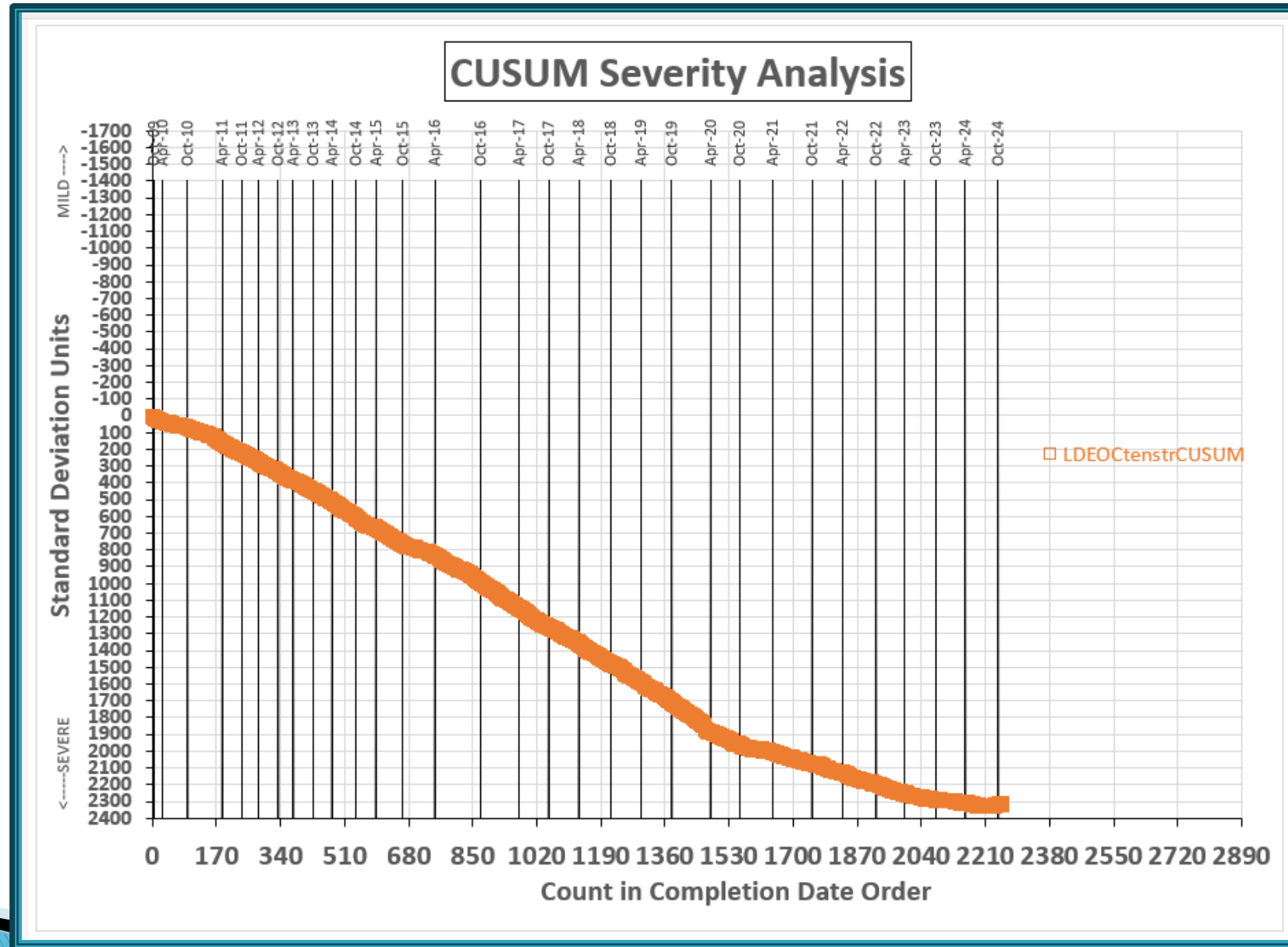
REFERENCE SILICON VOLUME CHANGE FINAL



REFERENCE SILICON POINTS HARDNESS FINAL



REF SILICON TENSILE STRENGTH CHANGE FINAL



Information Letters & Technical Updates*

Test	Date	IL or Memo Number	Topic
LDEOC	20240424	LDEOC-20231005	Report Package Revision Notice – addition of 4 new elastomers.

*Available from TMC Website

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Reference Oil Inventory Estimated Life

EOEC & LDEOC

Oil	TMC Inventory Gallons	Gallons Shipped Past 6 Months	Estimated Life ^C
SL107 ^{A, B}	1482	260	3 years

^A TMC Inventory is used across several test methods

^B SL107 has fully replaced oil 1006; Oil 1006 is no longer used as an LDEOC Reference Fluid

^C Use Rate of SL107 will accelerate due to addition of five new Elastomers to D7216:
FOUR: ILSAC GF-7
ONE: PC-12

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D02.B0.07

TMC Monitored Tests



ASTM D 7528

ROBO

April 1, 2024 – September 30, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D7528	6 (+1)	28 (+1)
*As of 9/30/2024		

D7528: Oxidation by ROBO

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	81
Failed Calibration Test	OC	11
Operationally Invalidated by Lab	LC, XC	9
Operationally Invalidated After Initially Reported as Valid	RC	0
Total		101

Number of Labs Reporting Data: 6
Fail Rate of Operationally Valid Tests: 12.0% (7.7% last period)

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D7528: Oxidation by ROBO

Statistically Unacceptable Tests (OC)	No. Of Tests
Natural Log (MRV Viscosity) Severe	0
Natural Log (MRV Viscosity) Mild	11
Total	11

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D7528: ROBO Failed Tests by Lab

Failed Parameter	LTMS Lab				Number of Tests
	B	BC	AQ	G	
Natural Log (MRV Viscosity) Severe	0	0	0	0	0
Natural Log (MRV Viscosity) Mild	4	1	1	5	11
Total	4	1	1	5	11

- SIX different units from FOUR different labs reported failing calibration tests

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D7528: Oxidation by ROBO

Operationally Invalid (LC, RC) or Aborted (XC) Calibration Tests

Test Status	Cause	No. of Tests
Invalidated by Lab (LC)	NO2 Feed Rate Incorrect	2
Invalidated by Lab (LC)	Insufficient Sample to run MRV	1
Invalidated by Lab (LC)	Incorrect Parameter Settings	1
Aborted Test (XC)	Test Temperature off Spec	4
Aborted Test (XC)	Excess NO2 delivered	1
Totals		9

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D7528: Oxidation by ROBO

Period Precision and Severity Estimates

Natural Log (MRV Viscosity)	n	df	Pooled s	Mean Δ/s
Targets Updated 20211021 ¹	80	77	0.1551	-----
4/1/19 through 9/30/19	95	91	0.2492	-0.32
10/1/19 through 3/31/20	158	153	0.2723	-0.10
4/1/20 through 9/30/20	119	113	0.2264	-0.76
10/1/20 through 3/31/21	113	108	0.3188	-0.11
4/1/21 through 9/30/21	116	110	0.1992	-0.37
10/1/21 through 3/31/22	106	102	0.2103	-0.36
4/1/22 through 9/30/22	105	101	0.1868	-0.06
10/1/22 through 3/31/23	94	91	0.2000	0.11
4/1/23 through 9/30/23	103	100	0.1990	-0.11
10/1/23 through 3/31/24	91	88	0.1741	-0.12
4/1/24 through 9/30/24	92	88	0.1893	-0.72

¹Updated targets to include latest primary reference oils 434-3, 435-1 and 436

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D7528: Oxidation by ROBO

NO ₂ Delivery Mechanism	Number of Total Tests	Number Of AC Tests	Pass Rate (%)	Number of Labs	Number of Rigs	LAB ID's
Dilute	37	33	89.2	2	14	G, AM
Liquid	55	48	87.3	5	16	A, AQ, B, BC, G
BOTH (Totals)	92	81	88.0	6*	30	A, AM, AQ, B, BC, G

*One lab is conducting tests with both NO₂ delivery methods.

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D7528: Oxidation by ROBO

Precision, Performance (Mean Δ/s) by Lab and NO₂ Delivery Mechanism

NO ₂ Delivery		Ref Oil 434-2	Ref Oil 434-3	Ref Oil 435-1	Ref Oil 436	TOTAL
Dilute	No. of Runs	0	12	15	10	37
	Mean		10.7509	10.9625	10.2760	10.7083
	Pooled s		0.1684	0.2052	0.1696	0.1847
	Mean Δ/s		-0.48	-0.39	-0.43	-0.43
Liquid	No. of Runs	2	15	26	12	55
	Mean	10.5687	10.6149	10.8848	10.2904	10.6700
	Pooled s	0.0036	0.2751	0.1493	0.1332	0.1885
	Mean Δ/s	-2.32	-1.46	-0.77	-0.32	-0.92
BOTH	No. of Runs	2	27	41	22	92
	Mean	10.5687	10.6754	10.9132	10.2838	10.6854
	Pooled s	0.0036	0.2378	0.1735	0.1472	0.1893
	Mean Δ/s	-2.32	-1.02	-0.63	-0.37	-0.72

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D7528: Oxidation by ROBO

Period Performance (Mean Δ/s) by Lab and NO₂ Delivery Mechanism

NO ₂ Delivery Mechanism	LAB A (all L)	LAB AM (all D)	LAB AQ (all L)	LAB B (all L)	LAB BC (all L)	LAB G (mix)
Dilute	n = 0	n = 5	n = 0	n = 0	n = 0	n = 32
	N/A	0.16	N/A	N/A	N/A	-0.52
Liquid	n = 31	n = 0	n = 3	n = 8	n = 3	n = 10
	-0.61	N/A	-2.85	-1.50	-1.81	-0.57
BOTH	n = 31	n = 5	n = 3	n = 8	n = 3	n = 42
	-0.61	0.16	-2.85	-1.50	-1.81	-0.53

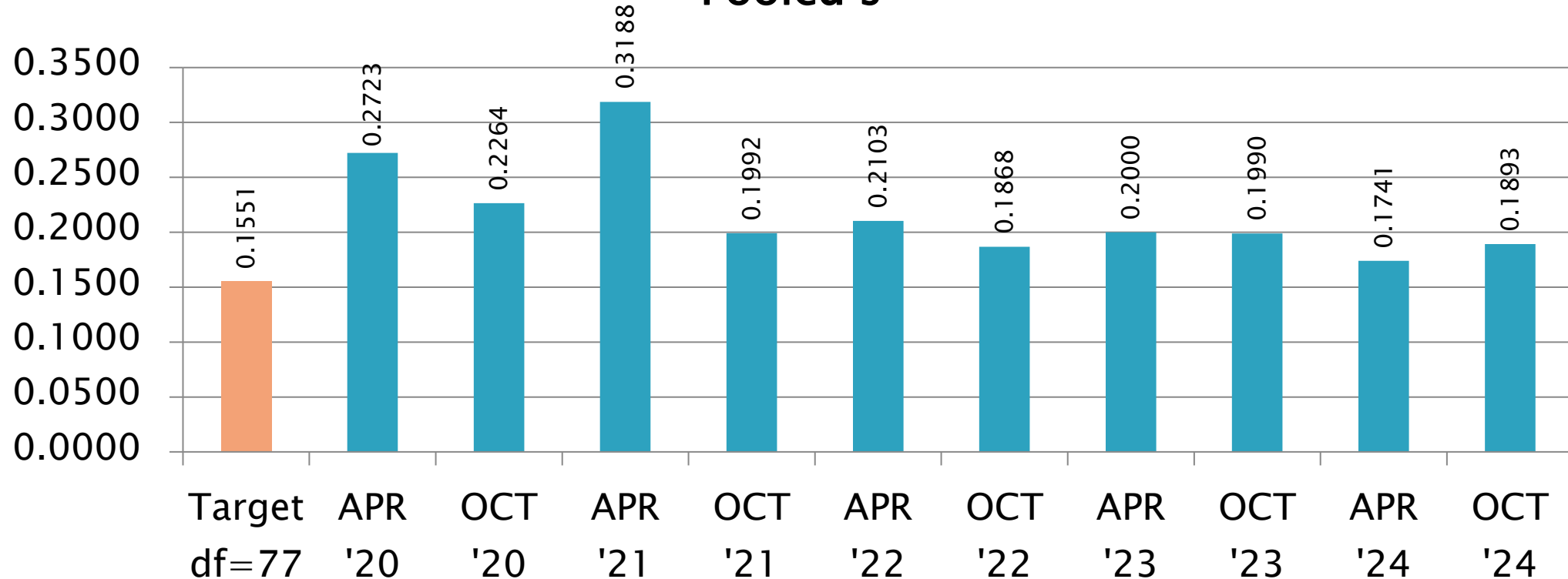
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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity) Pooled s



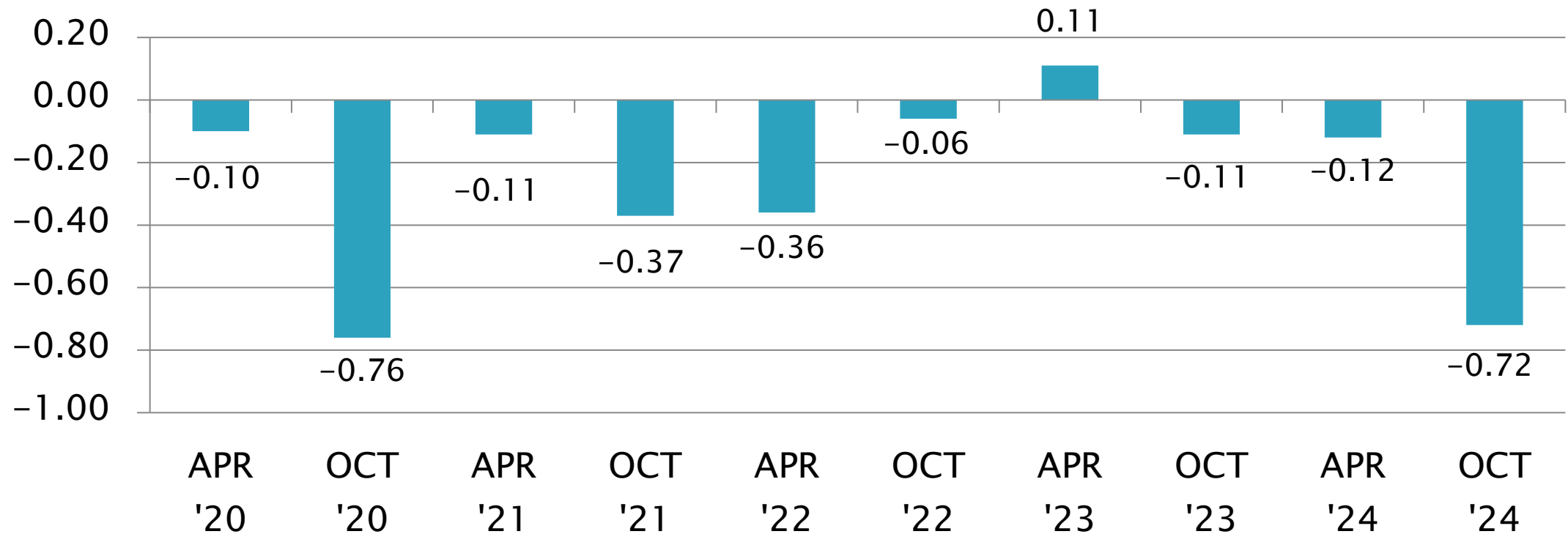
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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)
Mean Δ/s

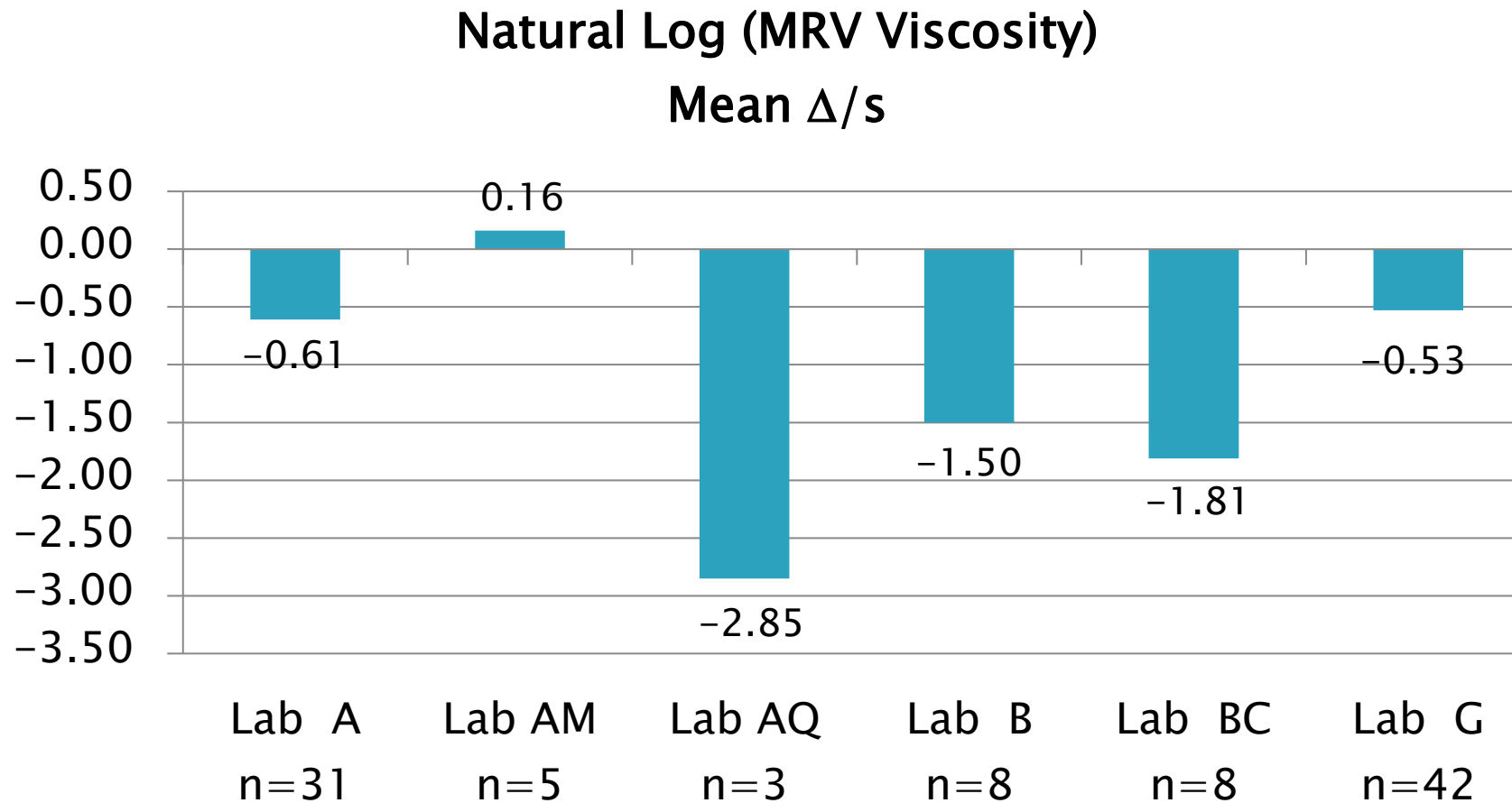


April 1, 2024 – September 30, 2024

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D7528: Oxidation by ROBO



April 1, 2024 – September 30, 2024

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D7528: Oxidation by ROBO

- ▶ Precision (Pooled s) fell back to 0.19 and is further from target (0.15).
- ▶ Severity (Mean Δ/s) has gone very mild at -0.72. The test has not had a Severity this mild in four years.
- ▶ CUSUM plots confirm the strong trend in mild test severity.
- ▶ A historical lab came back on-line this semester and number of calibrated stands increased by one since last semester.

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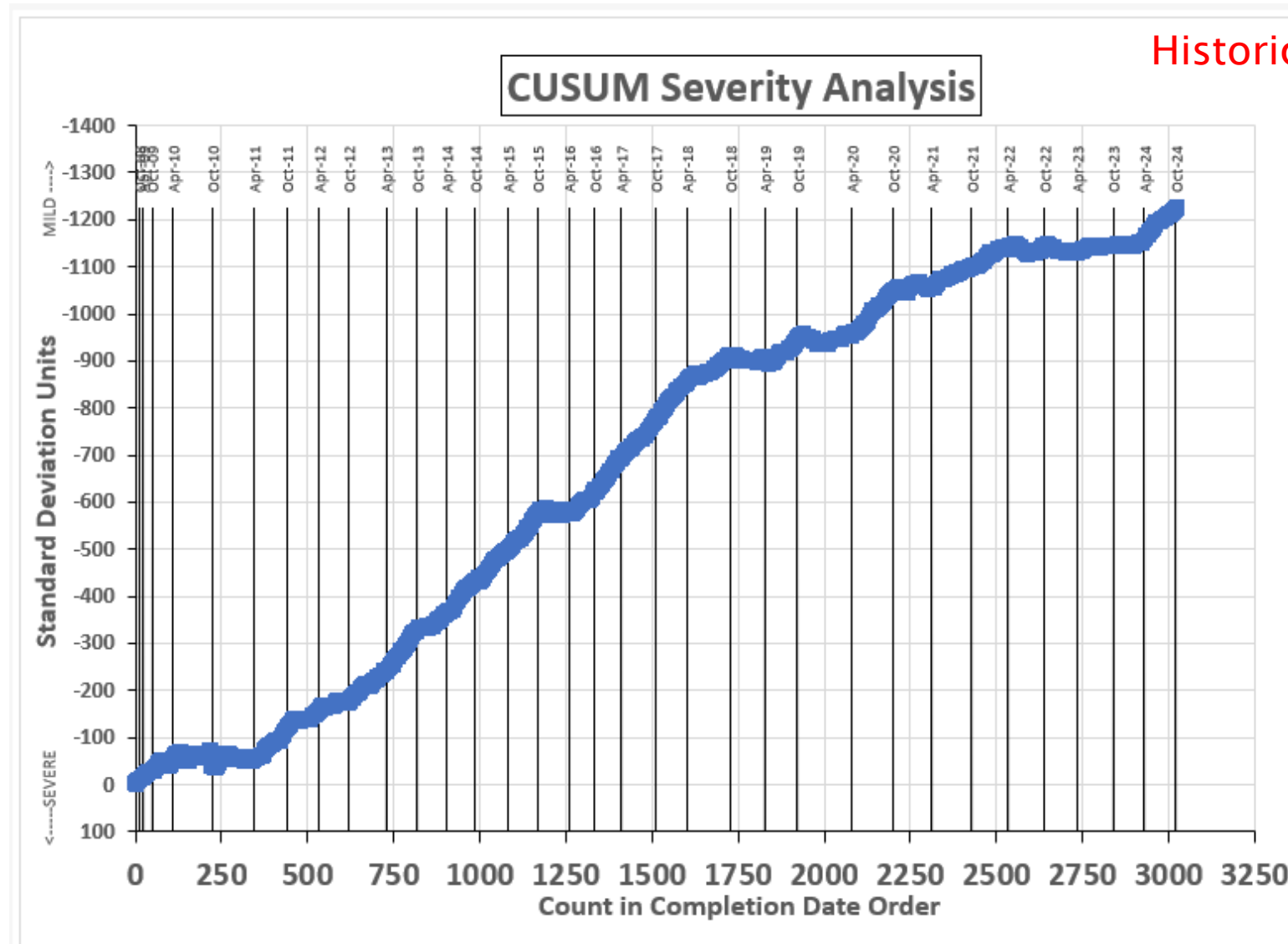
Test Monitoring Center
<https://www.astmtmc.org>



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AGED OIL MRV APPARENT VISCOSITY

Historical Chart



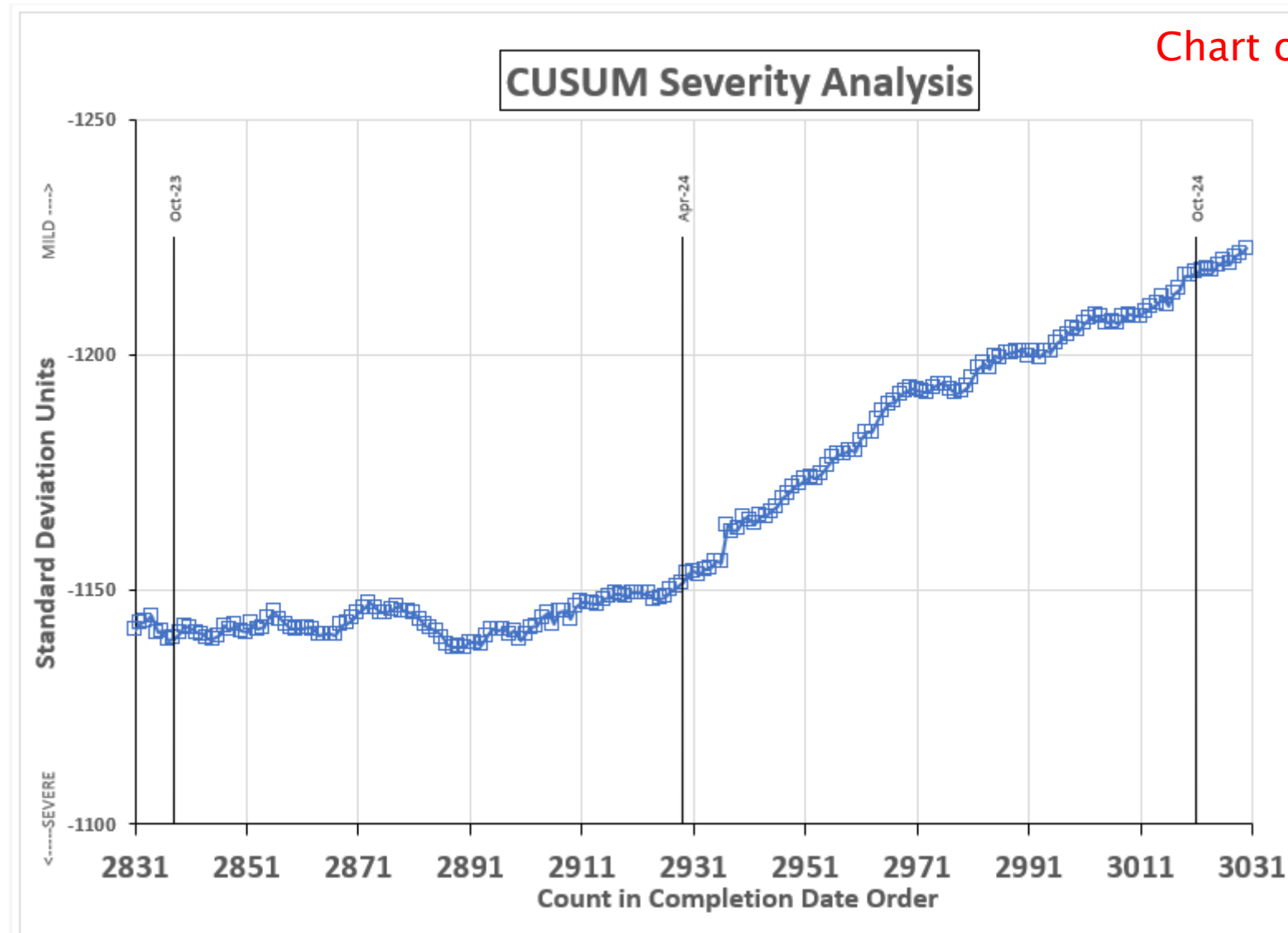
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Last 200 Data Points

AGED OIL MRV APPARENT VISCOSITY

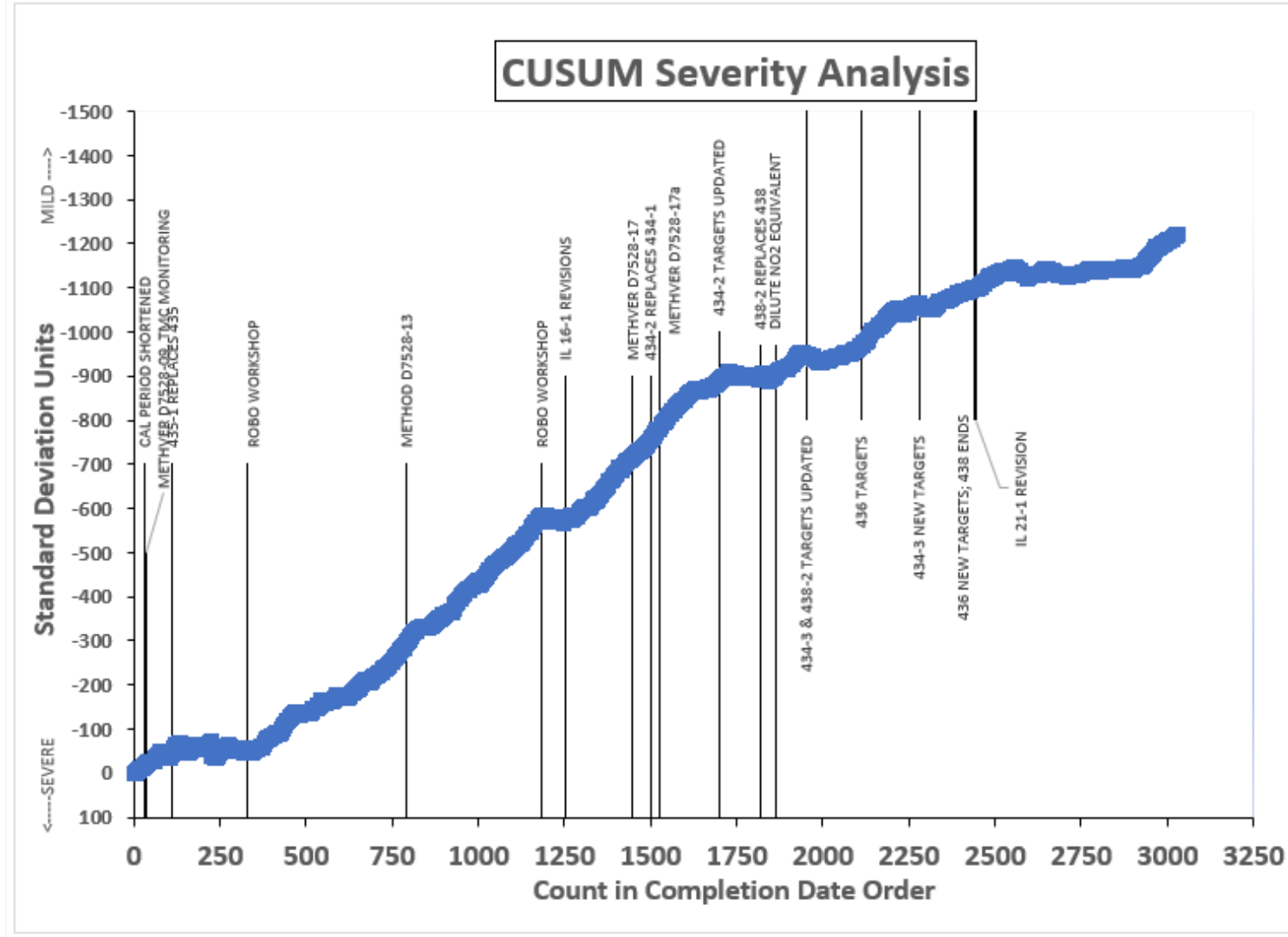
Chart of recent results



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AGED OIL MRV APPARENT VISCOSITY



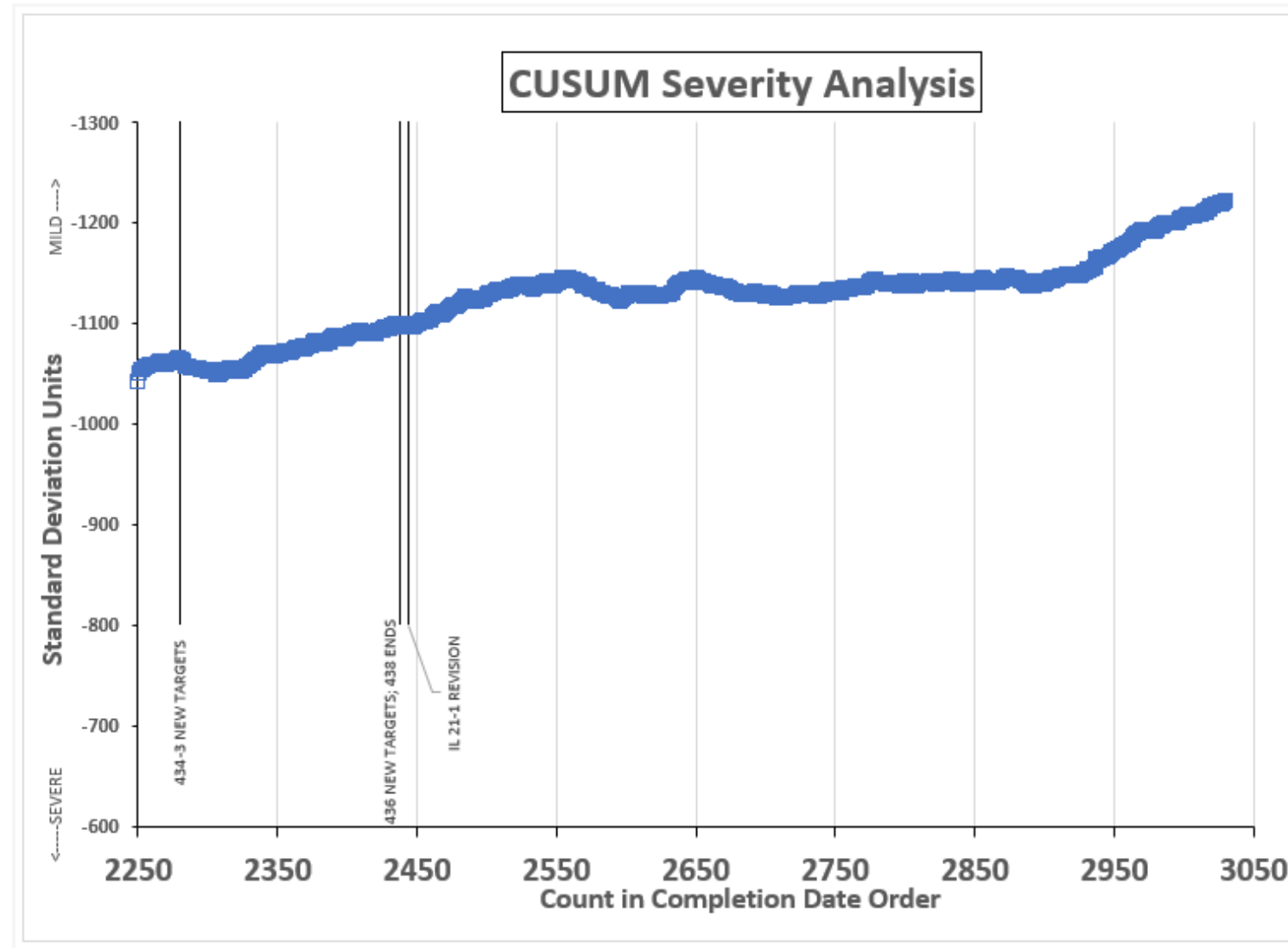
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ROBO TEST INDUSTRY OPERATIONALLY VALID DATA

Last 750 Data Points

AGED OIL MRV APPARENT VISCOSITY



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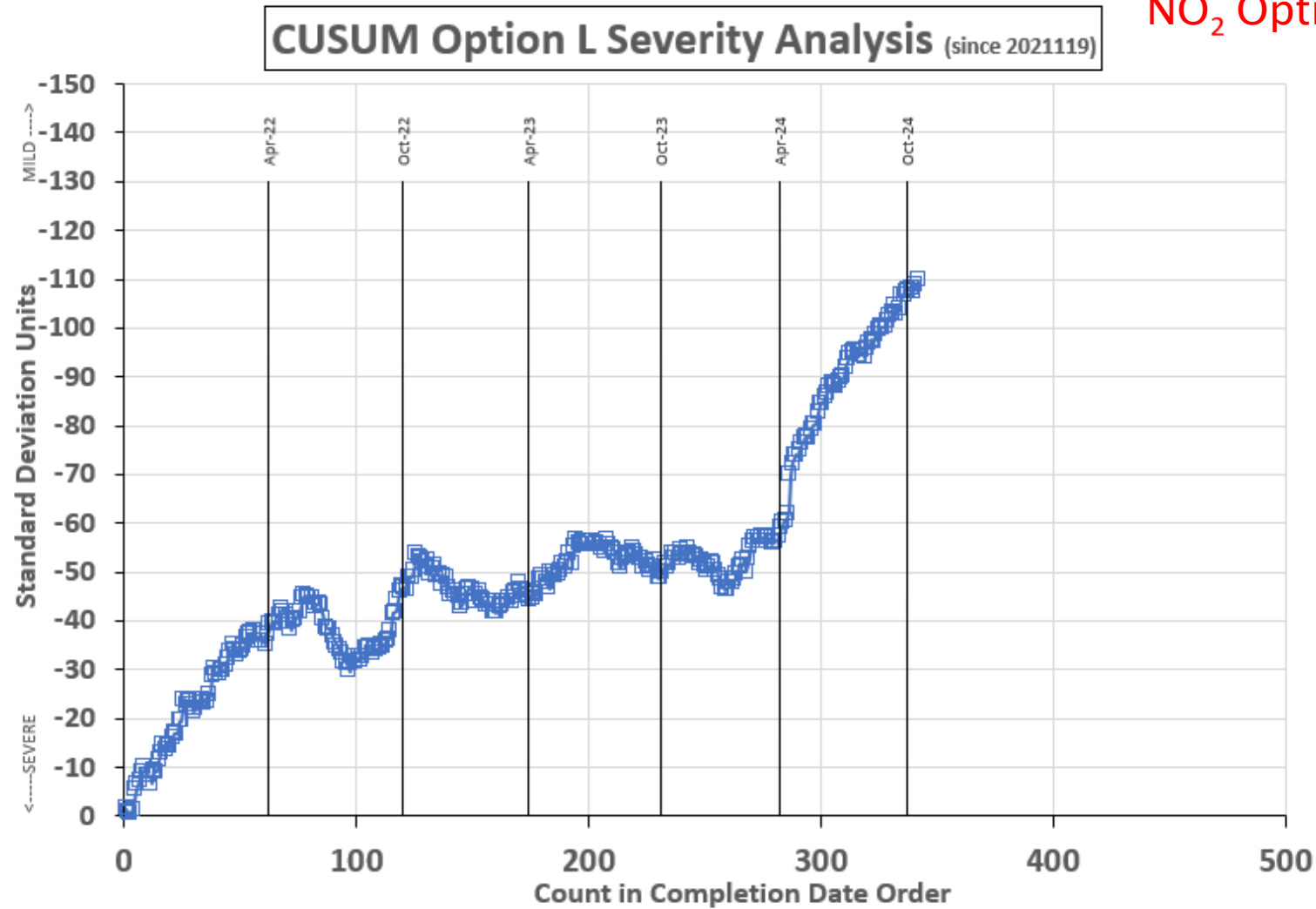
Test Monitoring Center
<https://www.astmtmc.org>



ROBO TEST INDUSTRY OPERATIONALLY VALID DATA
NO₂ Option L ONLY
AGED OIL MRV APPARENT VISCOSITY



NO₂ Option L Chart

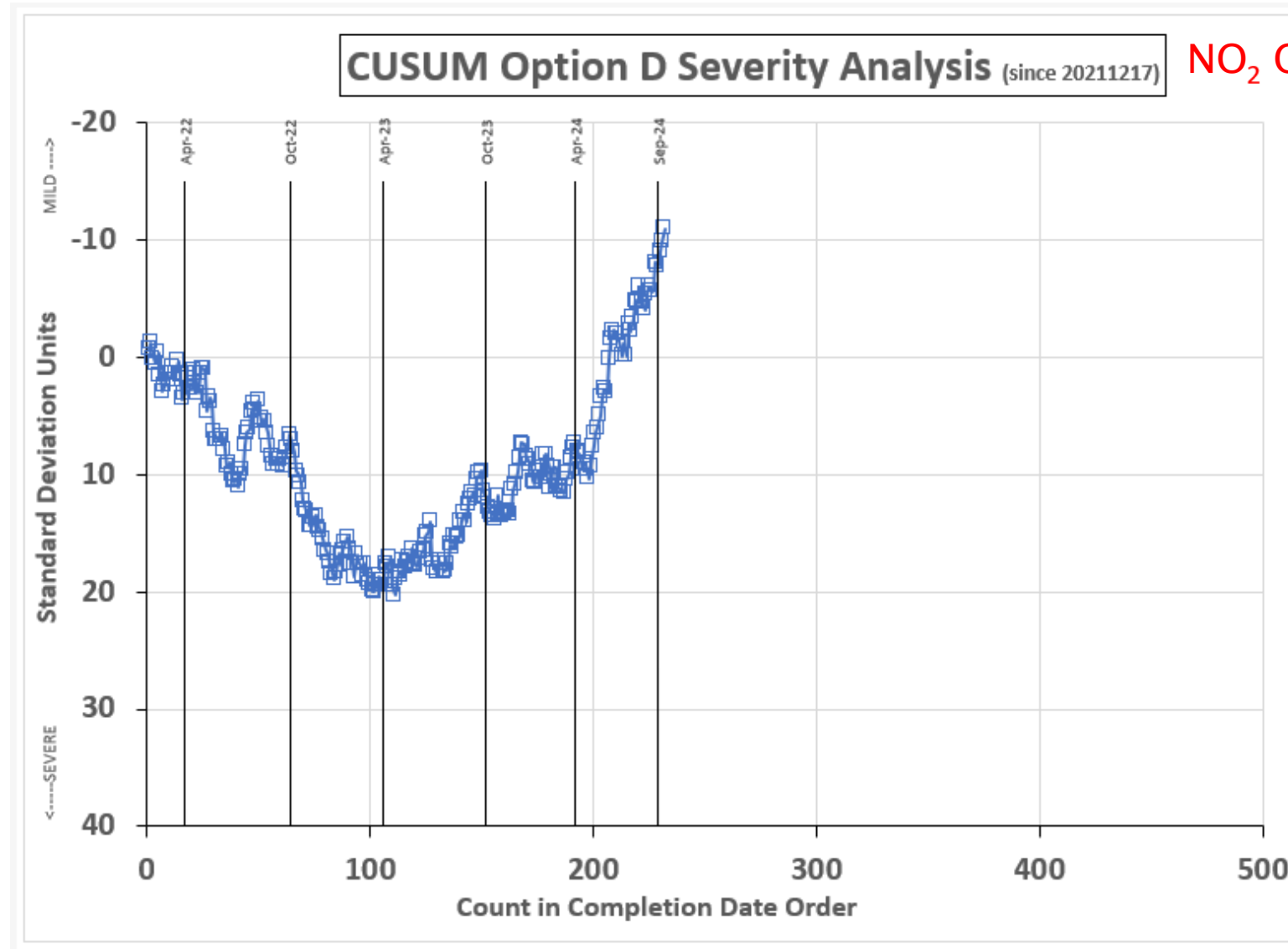


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Test Monitoring Center
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ROBO TEST INDUSTRY OPERATIONALLY VALID DATA
NO₂ Option D ONLY
AGED OIL MRV APPARENT VISCOSITY



NO₂ Option D Chart

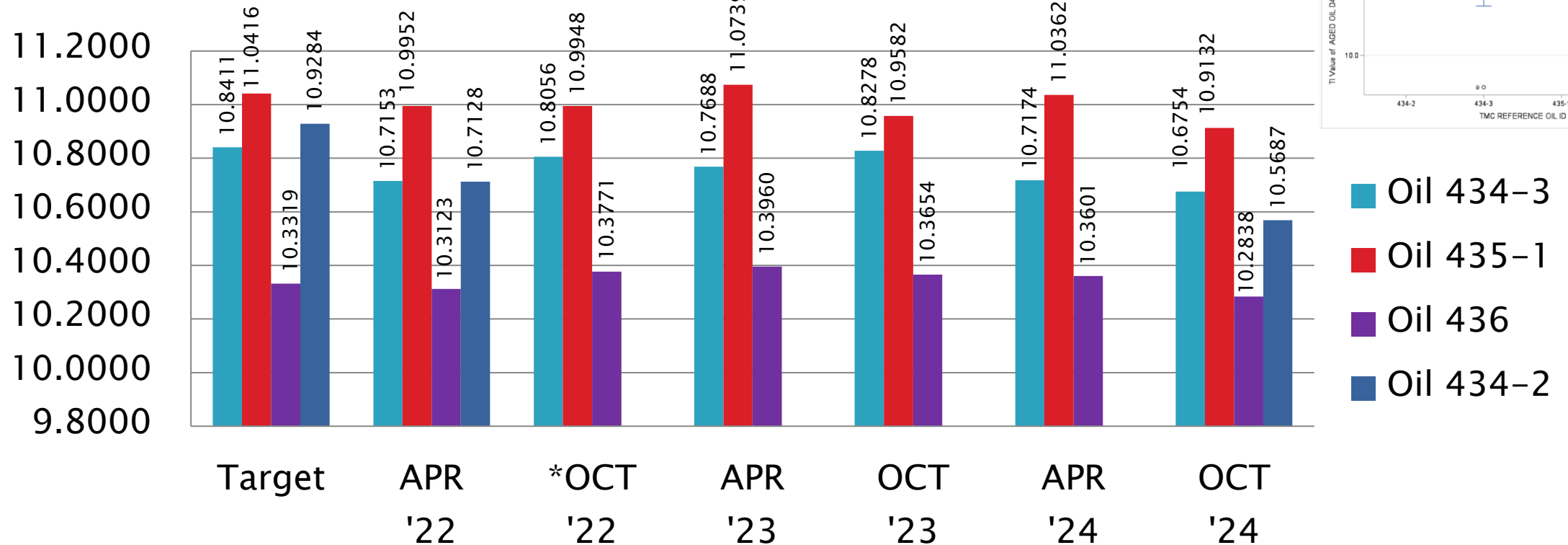
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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)
Mean



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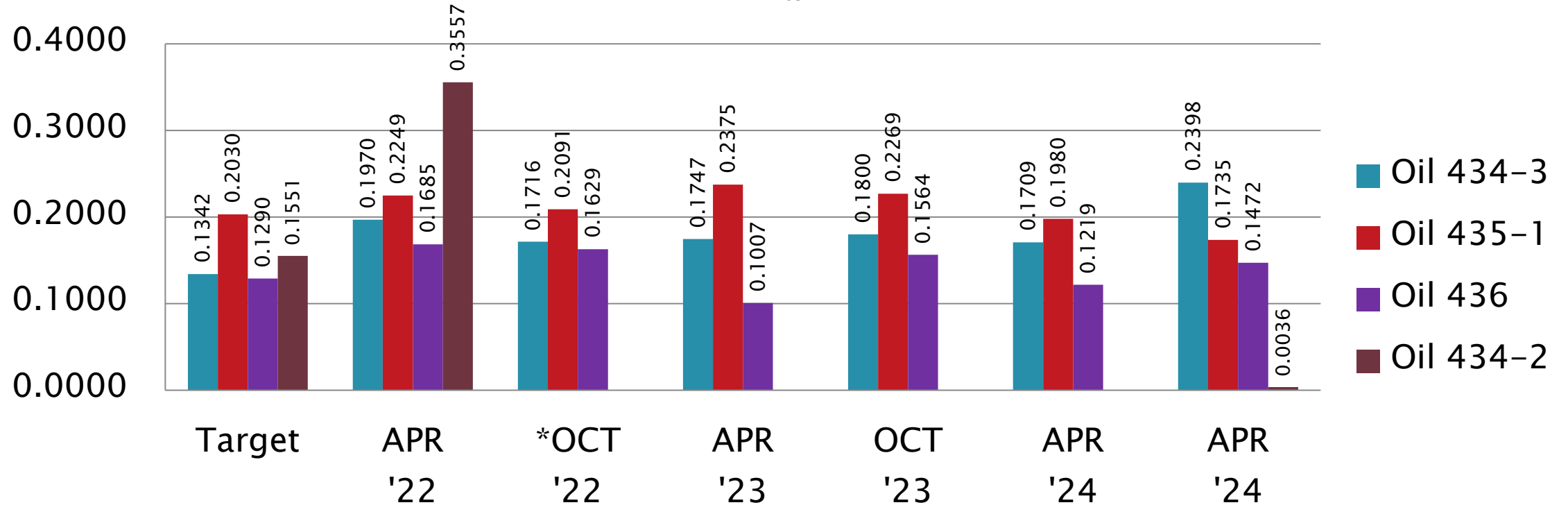


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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)

S_R



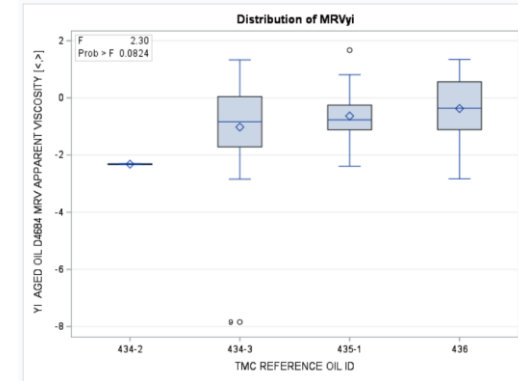
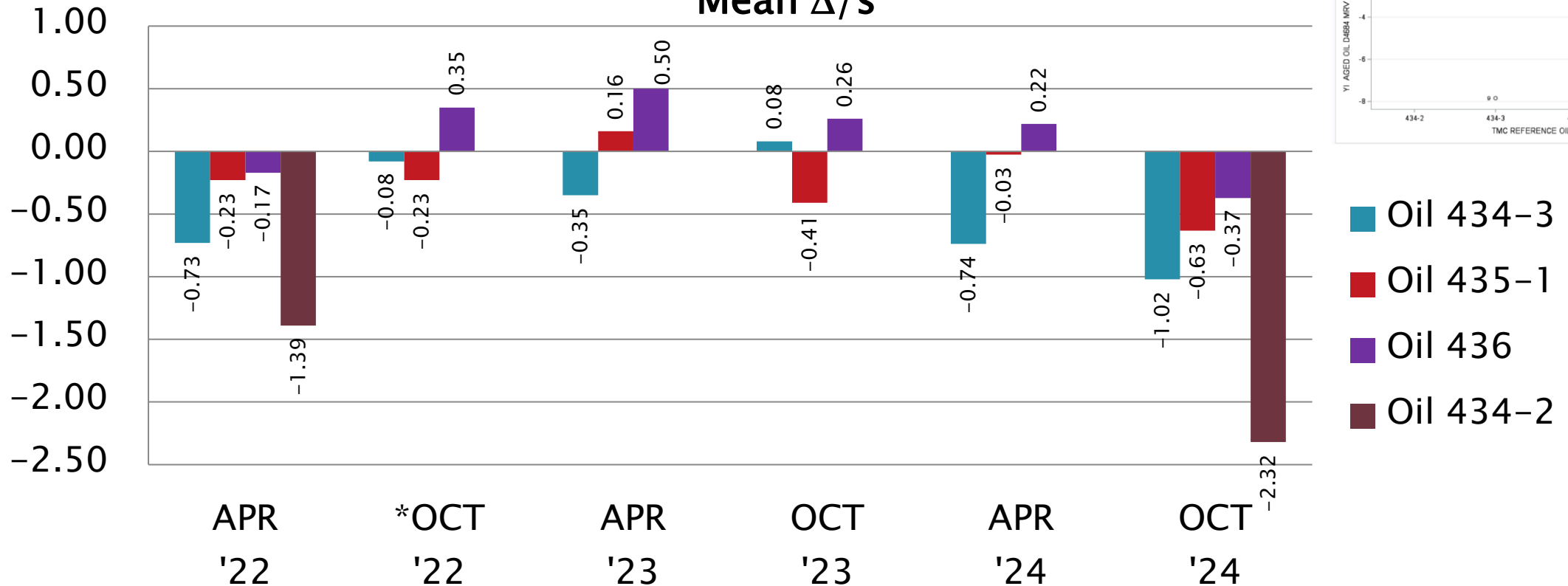
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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)
Mean Δ/s



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Reference Oil Inventory

ROBO

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
434-3 ^B	2017	ROBO	14.68	3.44	2 years
435-1	2008	ROBO	40.63	6.07	4 years
436 ^B	2014	ROBO	32.27	1.30	5+ years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B Multi-test oil; estimated aliquot reserved for bench testing.

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Reference Oil Inventory



As of 9/30/2024

Reference Oil Inventory: September 2024

Original Blend	Section	Oil	Tests	Year	Blend Quantity	TMC Inventory	Estimated Life
44	BENCH	44-5	D6594	2022	54	47.5	> 5
52	BENCH	52	D6417	1995	100	59.4	> 5
55	BENCH	55	D6417	1995	100	65.9	> 5
58	BENCH	58	D6417, D6417QC, GI	1998	159	110.2	> 5
66	BENCH	66	D6082	2002	108	67.7	> 5
75	BENCH	75-2	TEOST	2024	8	7.27	> 5
77	BENCH	77-3	EOWT	2015	900	374.3	> 5
79	BENCH	79	EOFT, EOWT	2014	1026	112.4	1.5
82	BENCH	82-1	BRT	2008	10	0.5	< 1
86	BENCH	86	BRT	2017	54	49	> 5
87	BENCH	87	BRT	2017	98	92.9	> 5
90	BENCH	90	D874QC	2005	49.5	2.49	1.5
91	BENCH	91	D874	2006	5	2.98	> 5
92	BENCH	92	D874	2020	52	52.52	> 5
432	BENCH	432	MTEOS	1998	207	101.29	> 5
434	BENCH	434-3	TEOST, ROBO	2017	55	14.68	2
435	BENCH	435-1	ROBO	2008	55	40.63	4
435	BENCH	435-2	TEOST	2010	550	32.39	> 5
436	BENCH	436	ROBO	2014	55	32.27	> 5
820	BENCH	820-2	D874	2001	55	5.99	> 5
1005	BENCH	1005-5	D6594	2015	55	29.0	> 5
1006	BENCH	1006	BRT	1996	55	27.66	> 5
1009	BENCH	1009	GI	2002	55	33.41	> 5
FOAMB18	BENCH	FOAM18B	D6082	2018	102	68.29	> 5
GIA17	BENCH	GIA17	GI	2017	10	5.31	> 5
GIC18	BENCH	GIC18	GI	2018	10	7.96	> 5
SL107	BENCH	SL107	EOEC, LDEOC	2019	3868	1482	3.5
VOLC12	BENCH	VOLC12	D5800	2013	55	18.2	> 5
VOLD12	BENCH	VOLD12	D5800	2013	55	16.8	> 5
VOLD18	BENCH	VOLD18	D5800QC	2018	1092	562	> 5
VOLE12	BENCH	VOLE12	D5800	2012	55	14.5	> 5

Additional Information

Additional Information

- ▶ Available on the TMC's Website:
 - Lubricant Test Monitoring System (LTMS) Document
 - CUSUM Severity Plots
 - Reference Data, Period Statistics and Timelines
 - Information Letters and Technical Memos
 - Report Forms & Data Dictionaries
 - Online Store, and more...

- ▶ www.astmtmc.org

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