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

D874, D5133 (GI), D5800, D6082, D6335 (TEOST), D6417, D6557 (BRT), D6594 (HTCBT), D6794 (EOWT), D6795 (EOFT), D7097(MTEOS), and D7528 (ROBO)

October 2022 – March 31, 2023

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Section	Topic		
Test Area Status (cont.)	TEST	LABS*	STANDS*
Ball Rust Test (BRT)	D6557	5 (–1)	5 (–2)
HTCBT	D6594	10 (+0)	30 (–2)
EOWT	D6794	6 (+1)	N/A
EOFT	D6795	6 (+0)	N/A
MTEOS	D7097	10 (+2)	26 (–4)
EOEC Elast. Compat.	D7216-E	6 (–2)	N/A
LDEOC Elast. Compat.	D7216-L	8 (+0)	N/A
ROBO	D7528	5 (–2)	29 (+20)
* As of 3/31/2023			

B0.07 Bench Testing Executive Summary

- D874 (Sulfated Ash)
- For the third consecutive 6-month period, there were no tests which failed to meet acceptance criteria for D874. Reference test results still trending mild.
- D5133 (Gelation Index)
- Six new Units became calibrated with the addition of a new GI testing lab this period. Also new was GIC18, a Reference Oil with a performance target close to the Pass/Fail limit of 12.
- D5800 (NOACK)
- CUSUM slope continued turning towards MILD after leveling off in the previous semester. Long-term severity trend (severe) in the CUSUM plots was a topic of discussion at the Surveillance Panel meeting in October. At this meeting, the panel concluded that a target change was not appropriate (at that time) but warranted a deeper investigation of test results by Procedure and/or by Model. Since the October Surveillance Panel meeting, it does appear that the severe trend abating is due to more D procedure rigs which are running on the MILD side of target while the B procedure rigs have moved back towards on-target (away from running on the SEVERE side of target).

B0.07 Bench Testing Executive Summary

- D6082 (High Temperature Foam)
- For the Third consecutive 6-month period, there were no tests which failed to meet acceptance criteria for HT Foam calibration testing.
- D6335 (TEOST)
- For the second consecutive semester, test fail rates have climbed by approximately 7% (20% fail rate for APR '23). Precision is running severe.
- Fail rate for TEOST doubled with respect to previous six-month period.
- D6417 (GC Volatility)
- No failing Calibration Runs in this period for the seven labs that have nine instruments.
- D6557 (BRT)
- Average Gray Value (AGV) continues to trend slightly severe this semester after a MILD Peak last period. But overall, CUSUM has been relatively "flat" for the past six years (since April 2017)

B0.07 Bench Testing Executive Summary

- D6594 (HTCBT)
- Copper and Lead concentrations are both trending severe. Some labs had test results with extremely large variance from expected means. These results have raised concerns and generated requests to understand if this is a lab or industry issue. Previous Surveillance Panel Chairperson (M. Lopez) is no longer available. The SP will need to identify a replacement for Mr. Lopez.
- D6794 (EOWT)
- Change in flowrate continues to trend severe for all water treat rates, however the severe trends are abating, especially for the 0.6% testing which showed a significant flattening of its CUSUM plot in the second half of this reporting period.
- D6795 (EOFT)
- Change in Flow Average (CIFA) is trending severe with a very consistent CUSUM slope over the past two years.

B0.07 Bench Testing Executive Summary

- D7097 (MTEOS)
- Precision (Pooled s) remains high, but did move closer to target in this reporting period and Performance (Mean Δ/s) has improved, moving from 0.69 s down to 0.41 s
- D7216 (EOEC/LDOEC)
- Supply of 1006 Ref Oil has been completely exhausted. All tests now use Ref Oil SL-107. Surveillance Panel has agreed to resume Adjustment Factors for EOEC. Several labs participated in Round Robin tests of ACM1 batch 25 vs batch 26 to understand what would be the result of returning to a previous manufacturing method for the Polyacrylate elastomer. TMC will officially monitor the EOEC/LDEOC bench tests, adding a section to LTMS.
- D7528 (ROBO)
- Long term (very linear) mild severity trend in CUSUM plotting now appears to be leveling off and the Surveillance Panel is seeking to understand if this trend may be a result of a recent change to the test procedure which allows the use of pre-diluted NO_2. The ROBO Surveillance Pane; thanks Justin Mills for many years of service as Chairperson and welcome's new Chairperson Maddie Dellinger.

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TMC Monitored Tests

ASTM D 874

Sulfated Ash

October 1, 2022 – March 31, 2023

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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D874	5 (+1)	N/A
*As of 3/31/2023		

D874: Sulfated Ash

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	11
Total		**11**

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

D874: Sulfated Ash

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

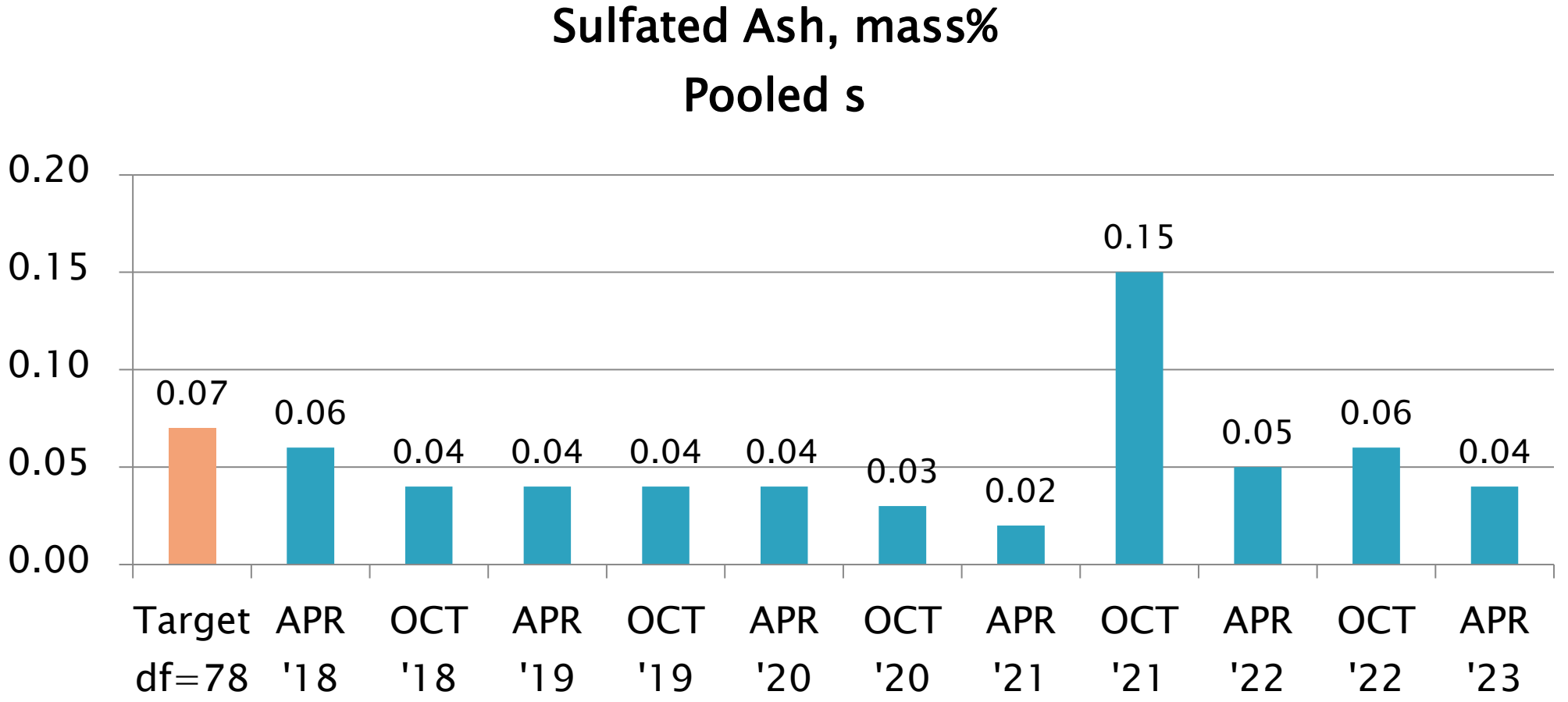
- No operationally invalid or statistically unacceptable tests this report period.

D874: Sulfated Ash

Period Precision and Severity Estimates

Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Current Targets	81	78	0.07	-----
10/1/18 through 3/31/19	8	5	0.04	-0.33
4/1/19 through 9/30/19	8	5	0.04	-0.18
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

D874: Sulfated Ash



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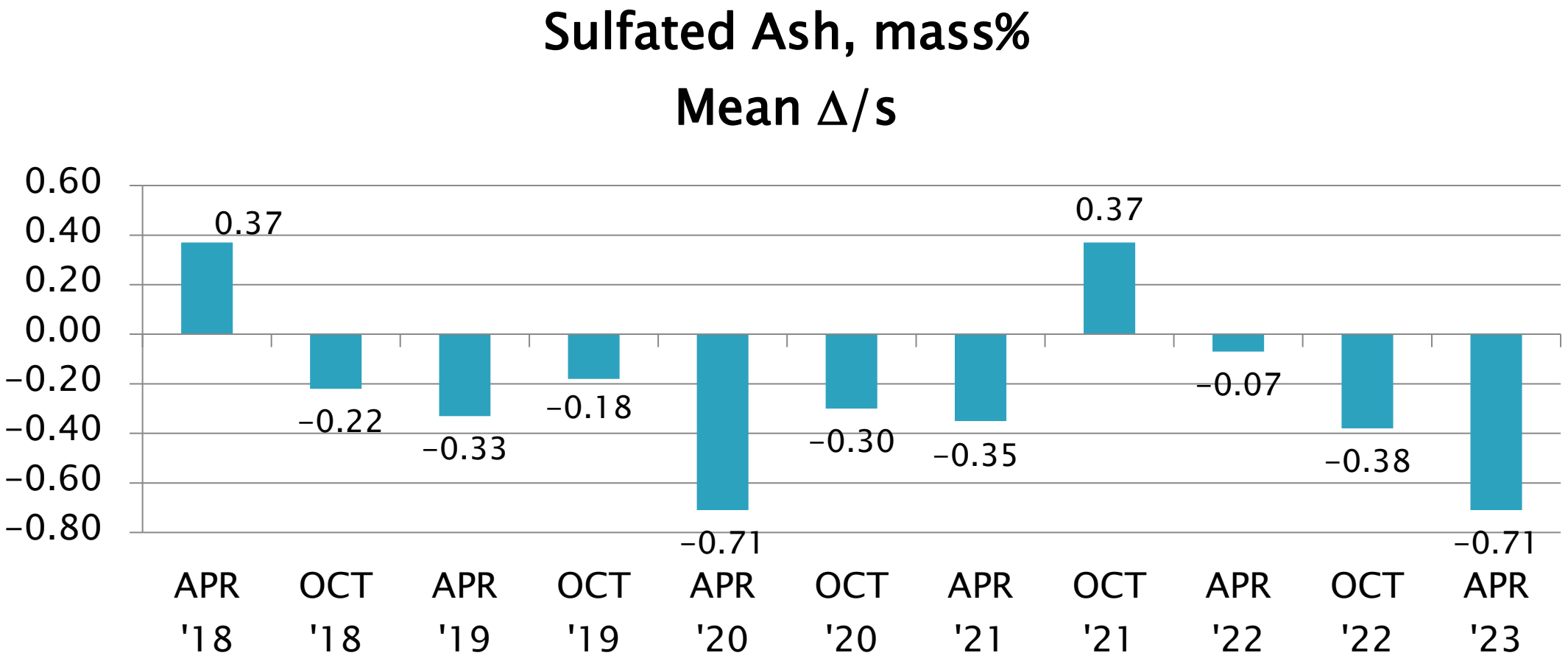
D874: Sulfated Ash



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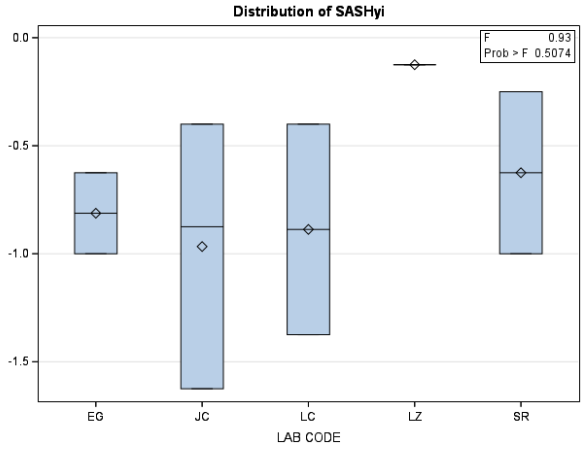
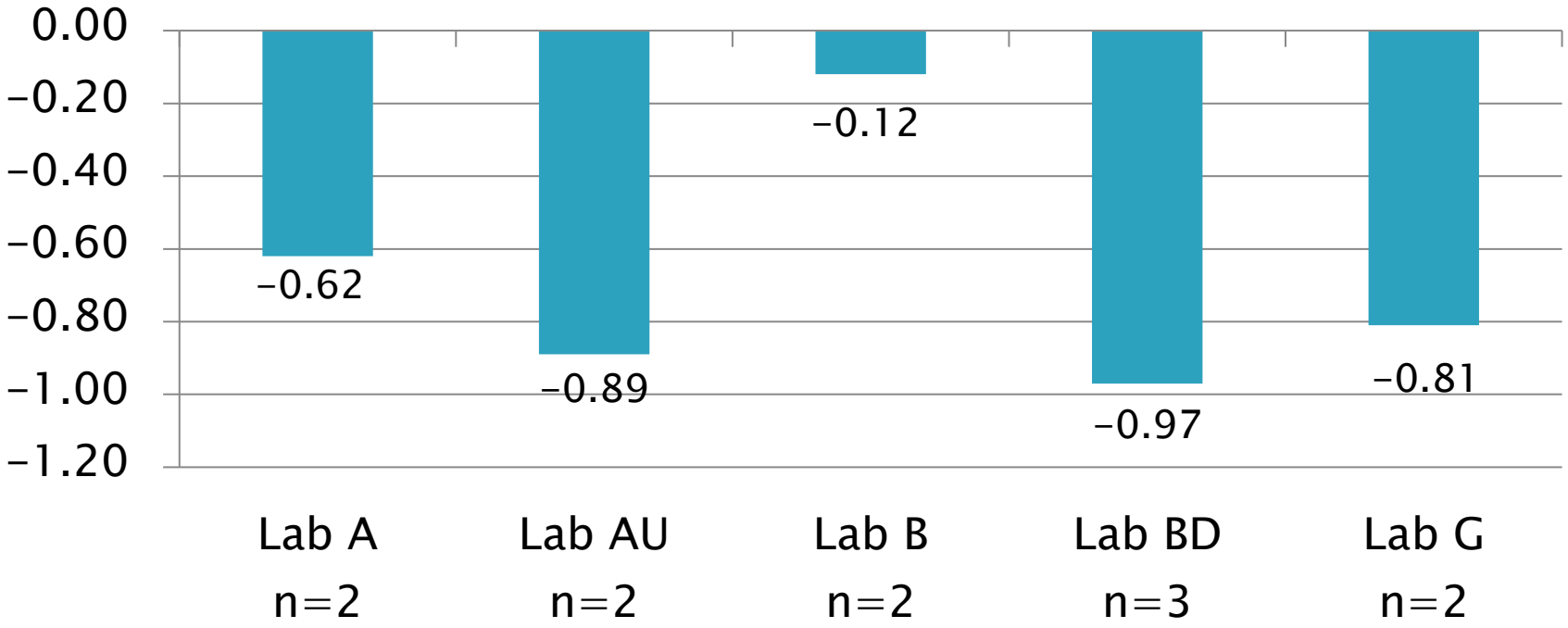
D874: Sulfated Ash



Sulfated Ash, mass%

Mean Δ/s



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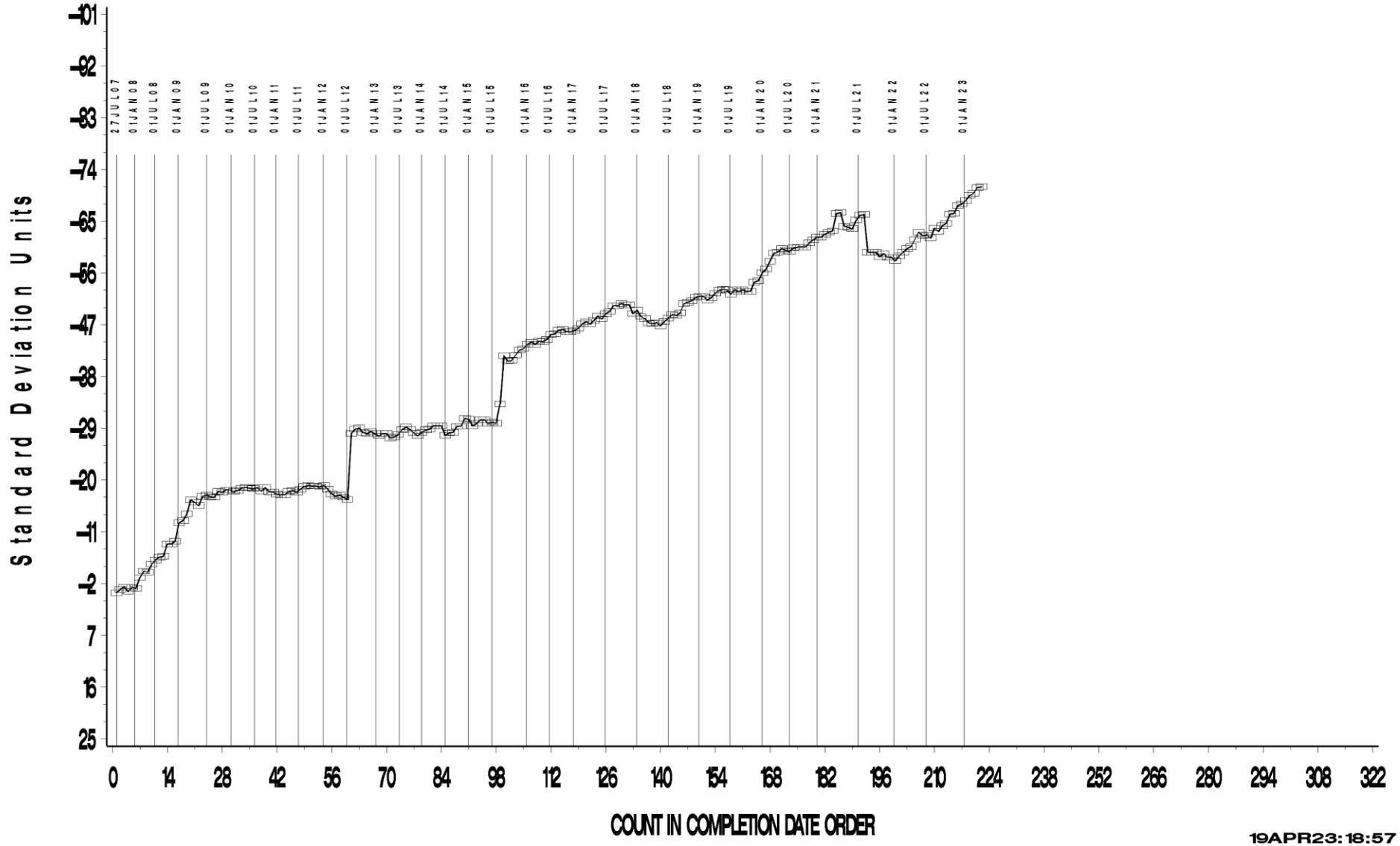
D874: Sulfated Ash

- Precision (Pooled s) is almost identical with respect to the previous period and is in line with most historical estimates
- Performance (Mean Δ/s) has further regressed to -0.71 s

D874 INDUSTRY OPERATIONALLY VALID DATA

TEST SAMPLE PERCENT SULFATED ASH

CUSUM Severity Analysis



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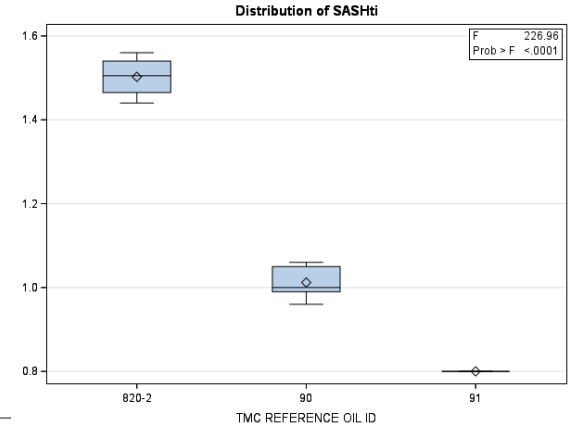
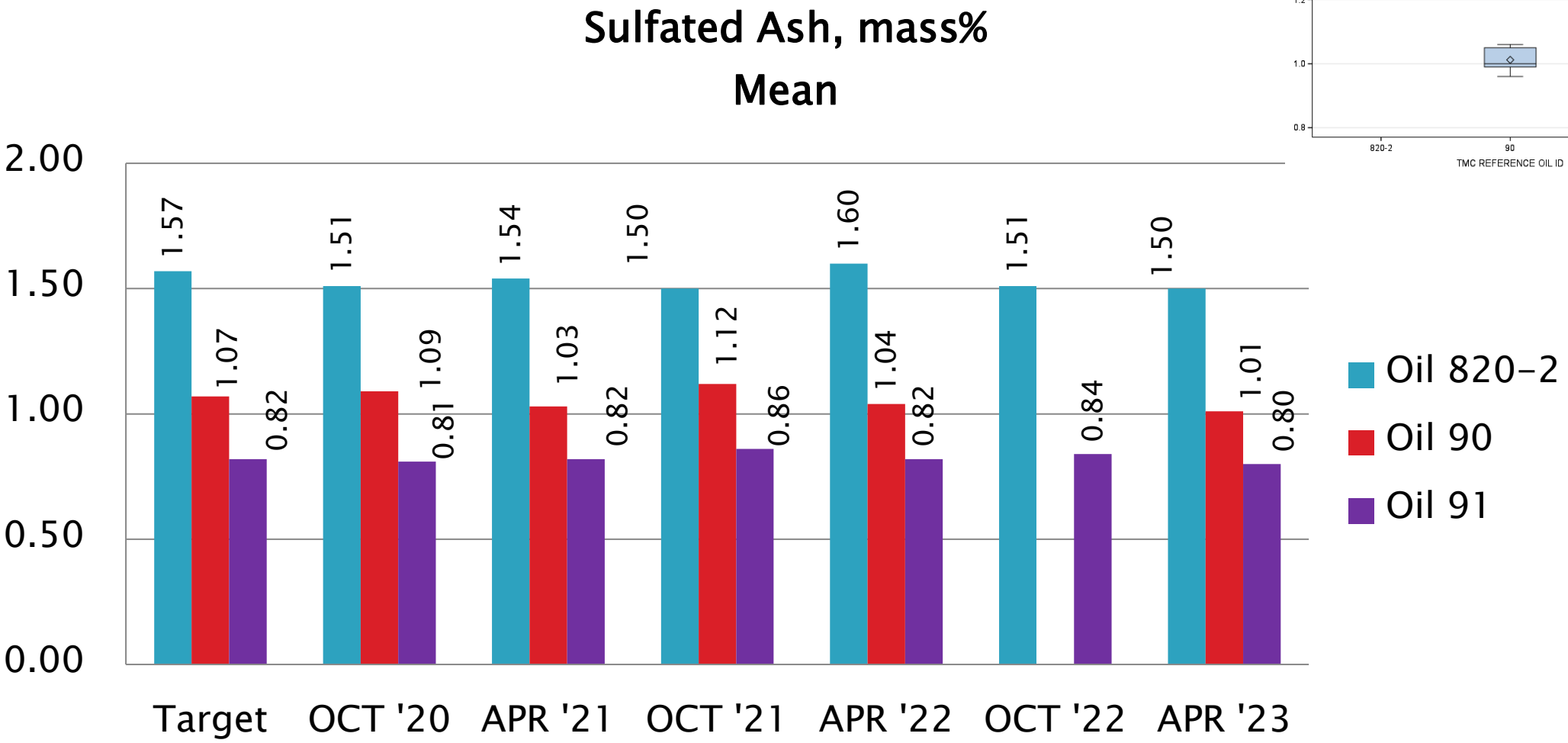
D874: Sulfated Ash





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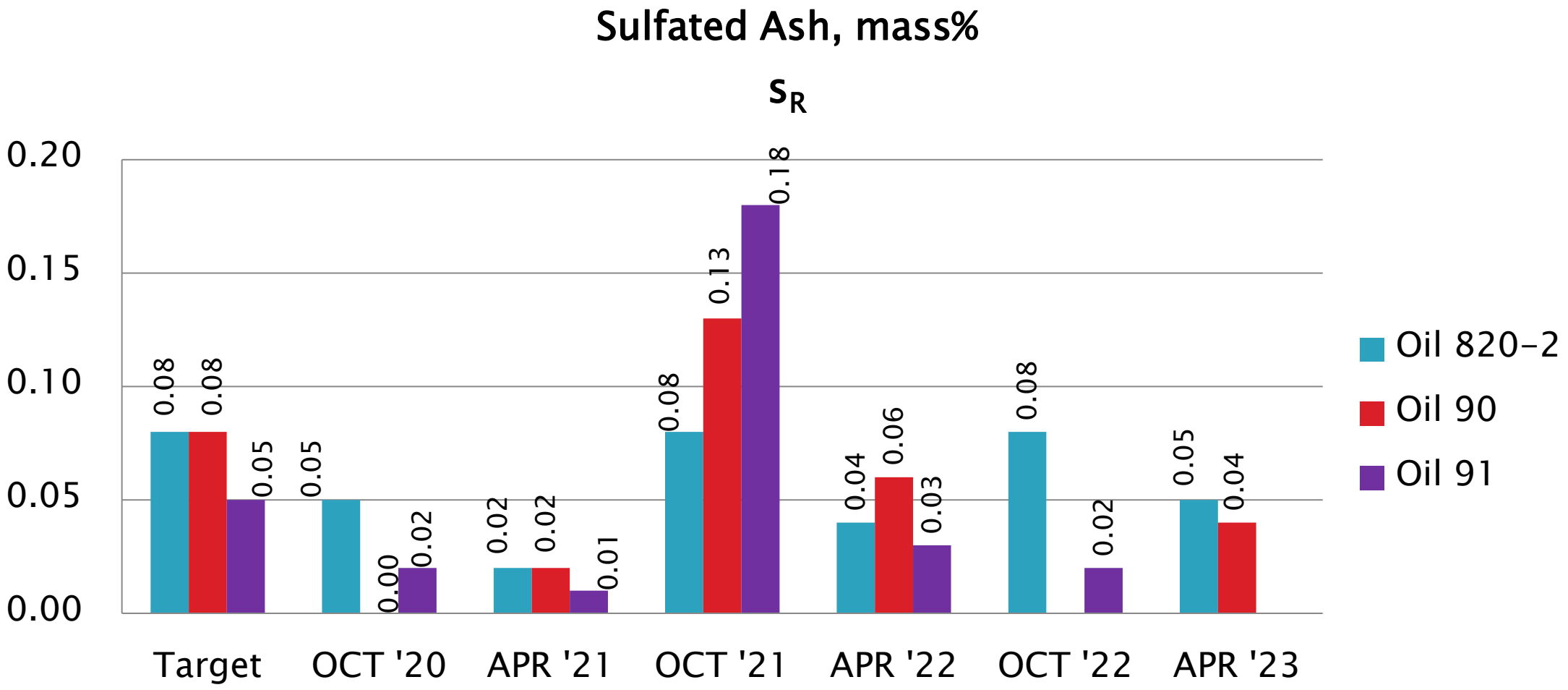
D874: Sulfated Ash



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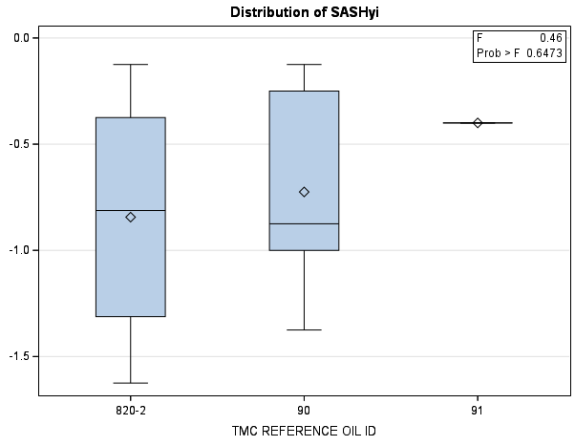
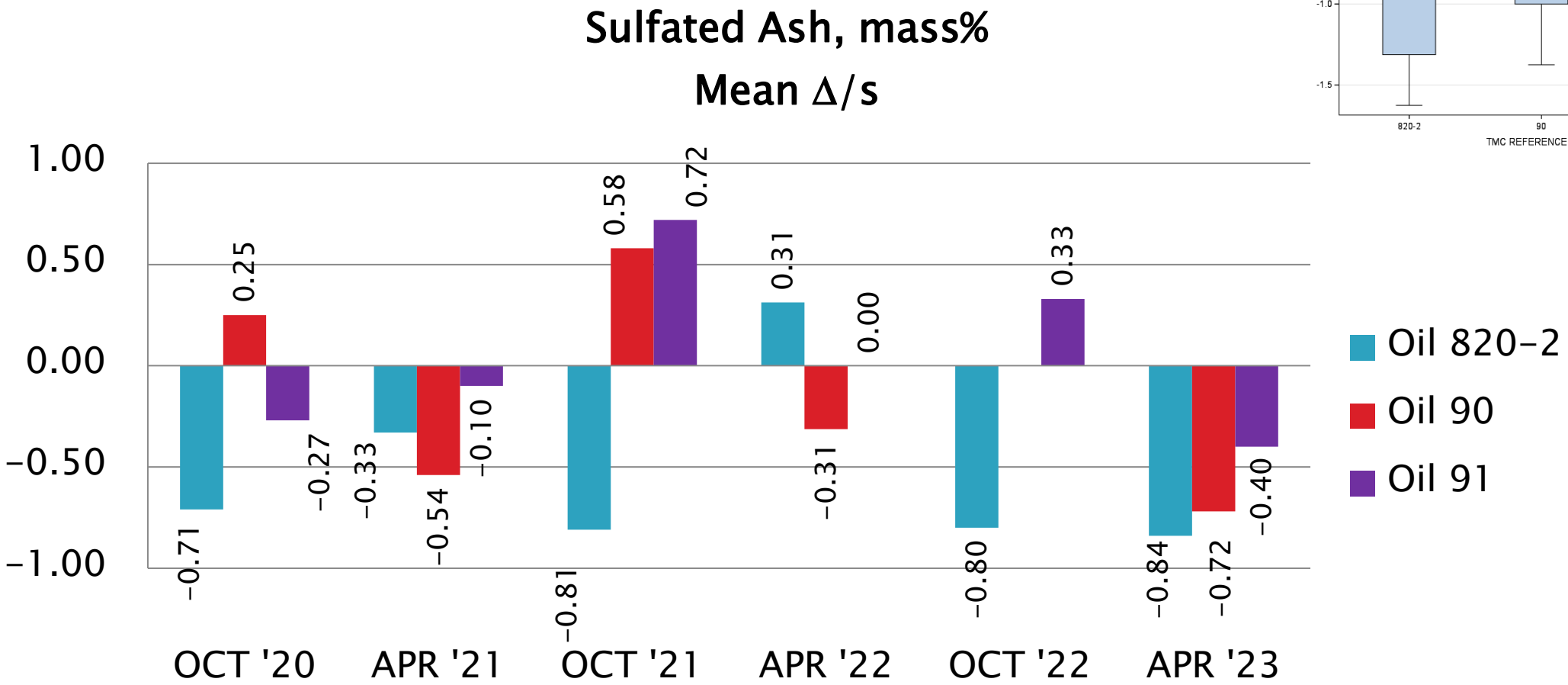
D874: Sulfated Ash





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D02.B0.07
TMC Monitored Tests

ASTM D 5133

Gelation Index (GI)

October 1, 2022 – March 31, 2023

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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D5133	9 (+1)	55 (+6)
*As of 3/31/2023		

D5133: Gelation Index

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	70
Failed Calibration Test	OC	14
Operationally Invalidated by Lab	LC / LS / XC / XS	4
Operationally Invalidated After Initially Reported as Valid	RC/RS	0
Acceptable Discrimination Tests	AS	45
Failed Discrimination Tests	OS	8
Informational Runs	NN / MN	3
Total		**144**

Number of Labs Reporting Data: 9
Fail Rate of Operationally Valid Calibration Tests: 17% (previous 6.9%)
Fail Rate of Operationally Valid Discrimination Tests: 15% (previous 0%)

D5133: Gelation Index

Statistically Unacceptable Calibration Tests (OC)	No. Of Tests
Gelation Index Mild	7
Gelation Index Severe	7
Total	**14**

- Of the 14 OC tests
  - 7-GIC18 (New Reference Oil added to the Rotation)
  - 5-GIA17
  - 2-1009
- Three greater than -6.5 s from targets (-10.735 s largest)
- Four between -2 and -6.5 s from targets
- Four between +2 and +6.5 s from targets
- Three greater than +6.5 s from targets (22.2059 s largest)

D5133: Gelation Index

Statistically Unacceptable Discrimination Tests (OS)	No. Of Tests
Gelation Index Severe	8
Total	**8**

- Eight Failing Discrimination Runs
  - Three different Test Labs
  - Seven different Test Heads

D5133: Gelation Index

Tests Excluded From Statistics (Operationally or Otherwise)	Validity Code	No. Tests
Invalidated Runs	LC, LS, RC, RS	6
Aborted Runs	XC, XS	0
Informational Runs	MN, NN	3
Total		**9**

- Two Tests (2 x LC) lost due to Computer Error
- Four Tests (2 x LC; 2 x LS) lost due to Improper Leveling
- No (0) aborted runs this period
- Three requests for Informational (non-blind) runs

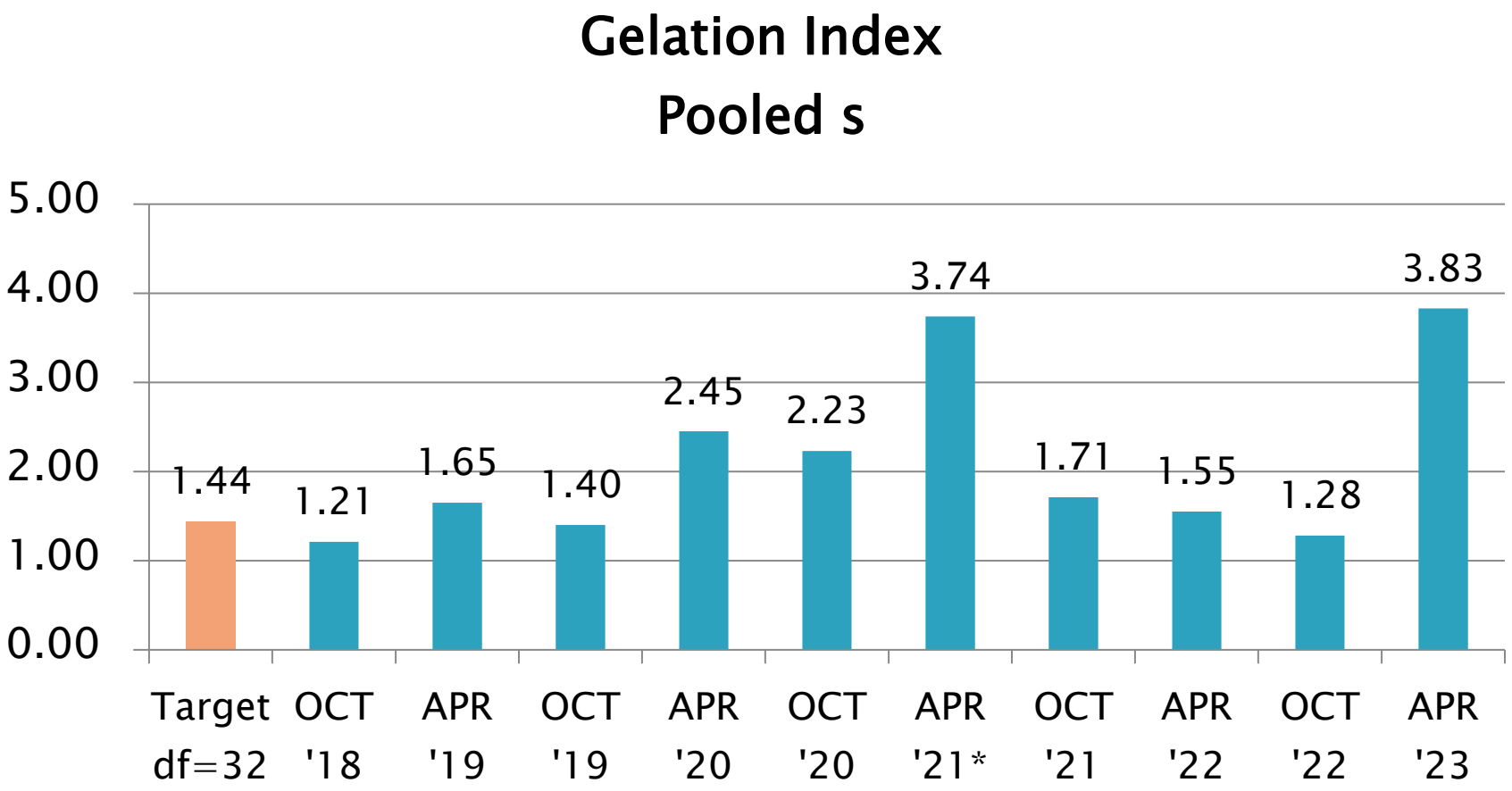
D5133: Gelation Index

Period Precision and Severity Estimates

Gelation Index	n	df	Pooled s	Mean Δ/s
Targets Updated 20201001[1]	34	32	1.44	-----
10/1/18 through 3/31/19	27	24	1.65	0.13
4/1/19 through 9/30/19	47	44	1.40	-0.25
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

[1]Target precision updated to current reference oils GIA17 and 1009 only
[2]Changed from bath to head-based monitoring scheme 10/1/20

D5133 Precision Estimates



*Changed from bath to head-based monitoring scheme

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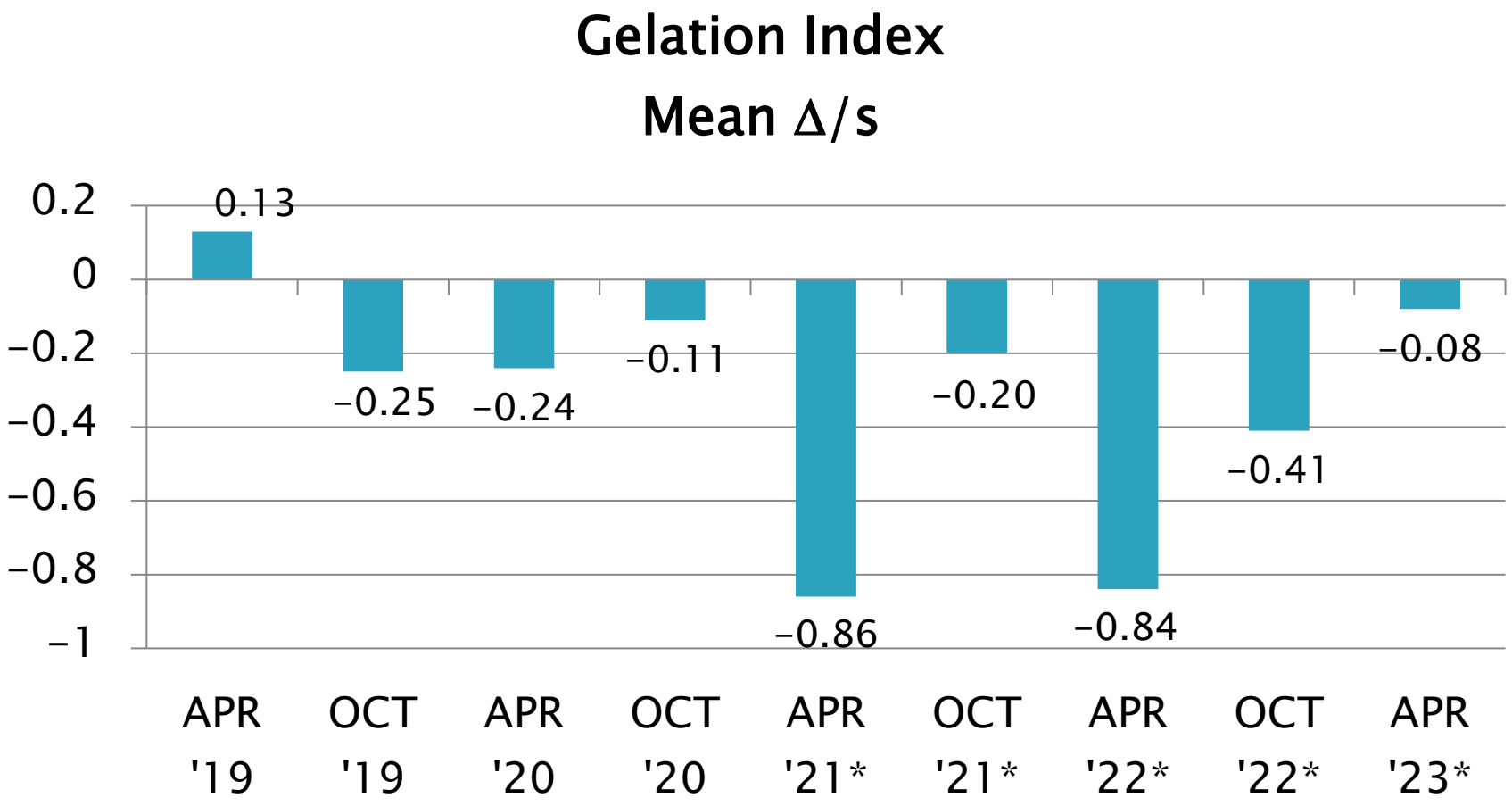
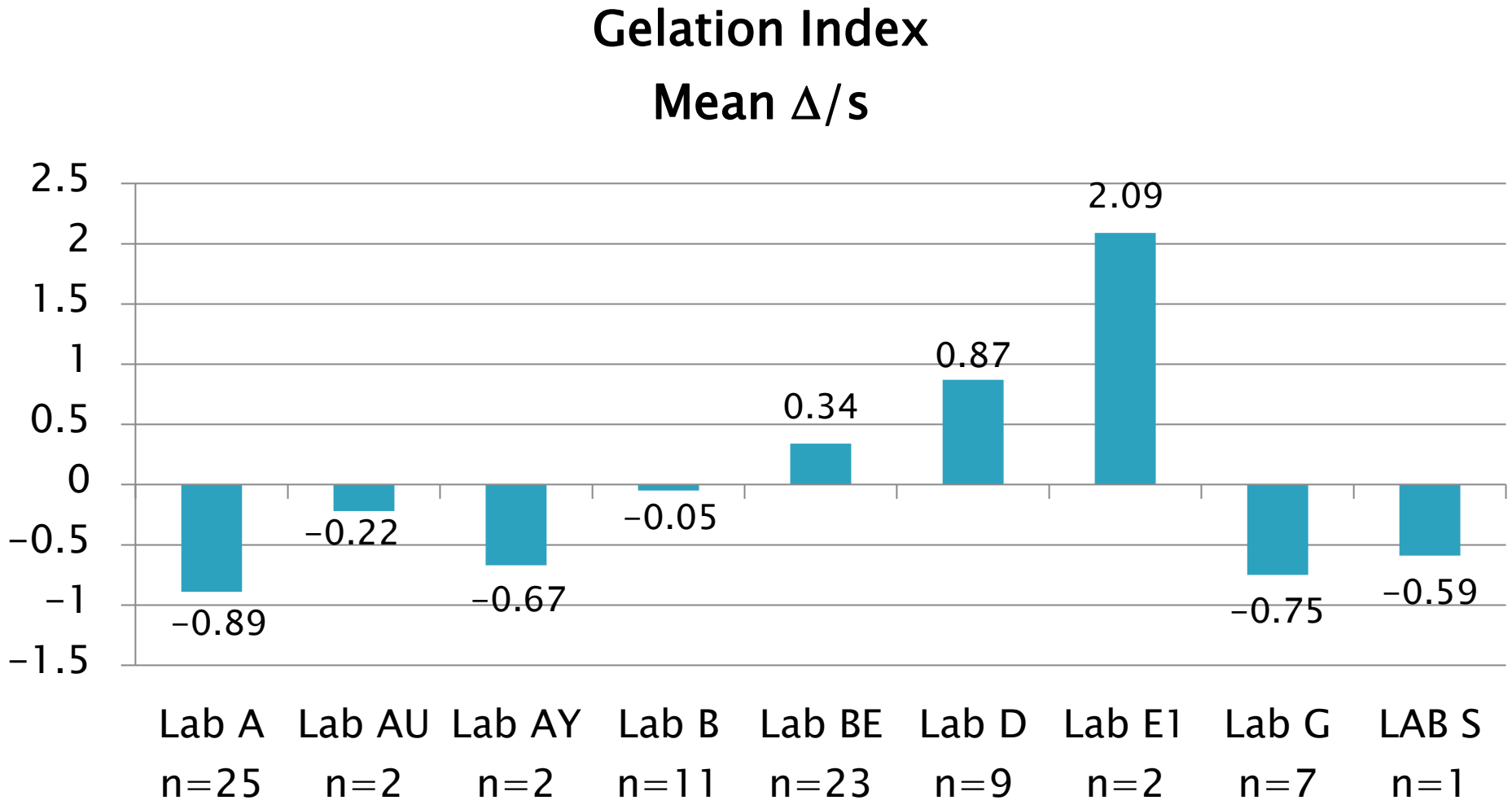
D5133 Severity Estimates



*Changed from bath to head-based monitoring scheme

D5133 Lab Severity Estimates



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D5133: Gelation Index

- Fail rate of operationally valid tests is 17% this period
  - Compared to 6.9% fail rate last period
    - Fail rate of operationally valid discrimination runs is 15% this period
  - Historic period fail rates have ranged between 6% and 26%
- Precision (Pooled s) is much less precise than last period
  - Several valid calibration attempts were >> 3s off target
- Performance (Mean Δ/s) is -0.08 s mild and closer to target
  - Six of Nine labs reporting mild of target
- GIC18, a new Reference Oil, was incorporated into the calibration testing rotation this period
  - 19 GIC18 Tests were completed this semester (6 Labs)
  - GIC18 targets will be revisited after completion of 30 tests
  - Replaces oil 58 that was reclassified as a discrimination oil

D5133 GELATION INDEX INDUSTRY OPERATIONALLY VALID DATA

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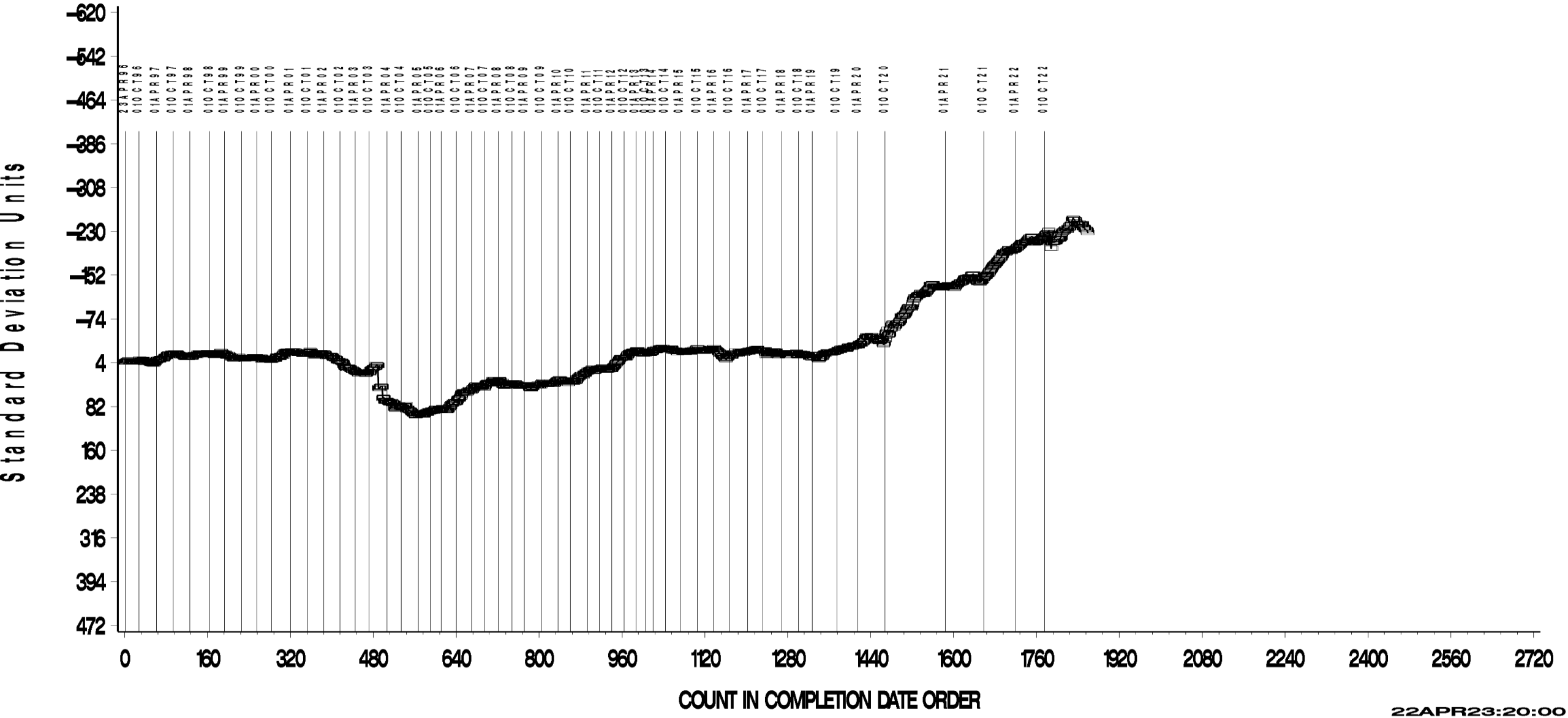
GELATION INDEX

CUSUM Severity Analysis



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D5133 GELATION INDEX INDUSTRY OPERATIONALLY VALID DATA

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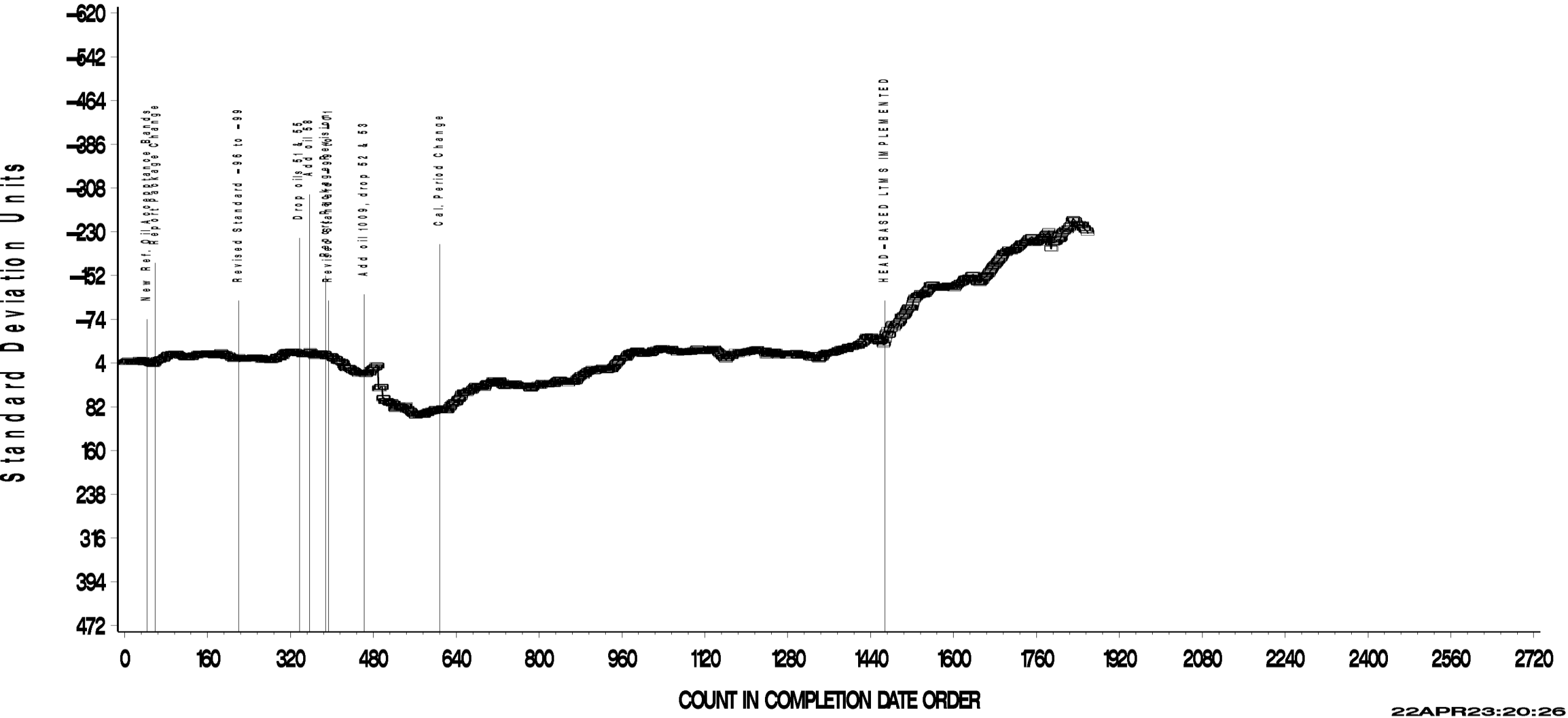
GELATION INDEX

CUSUM Severity Analysis



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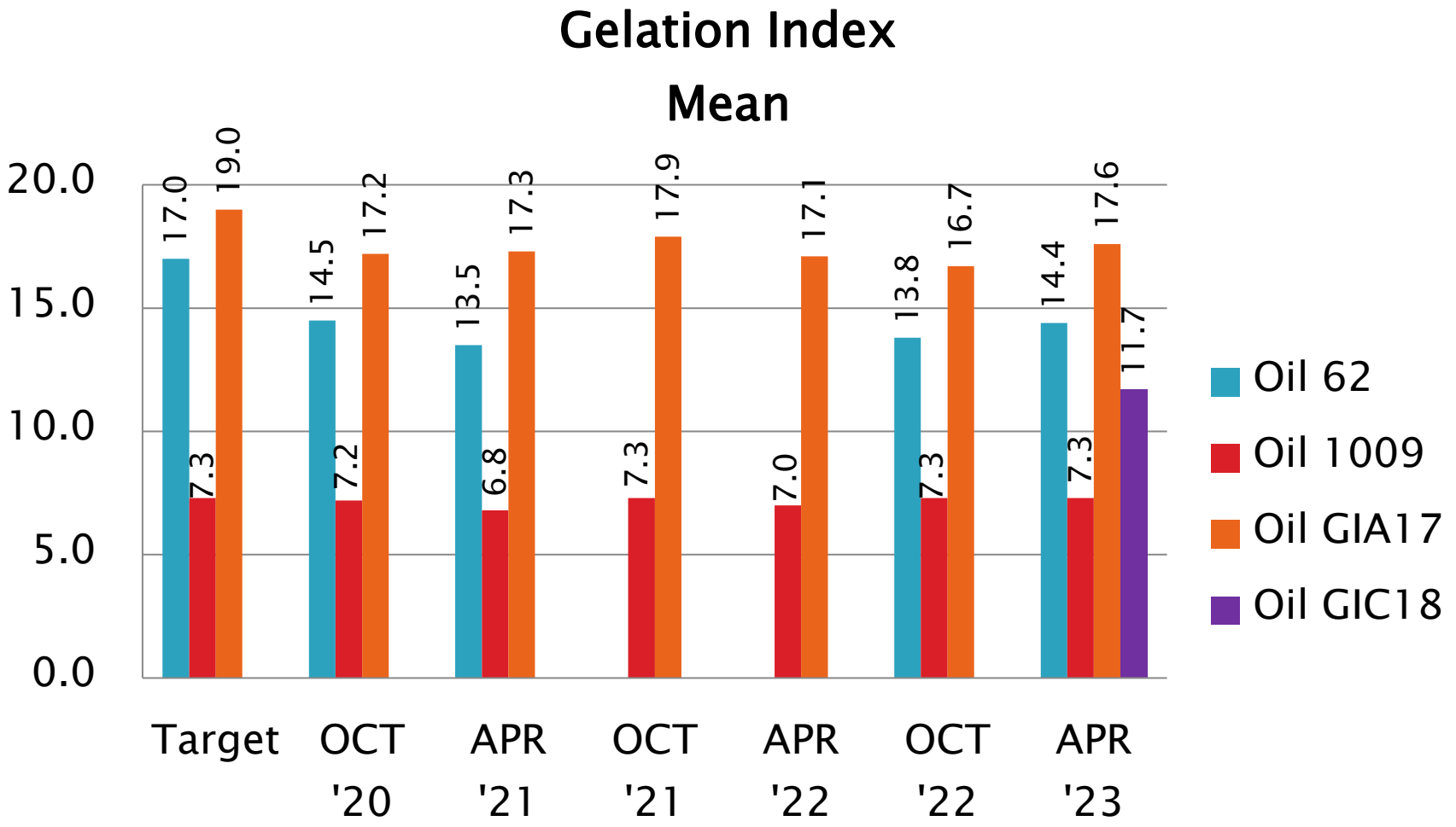
D5133 Performance by Oil



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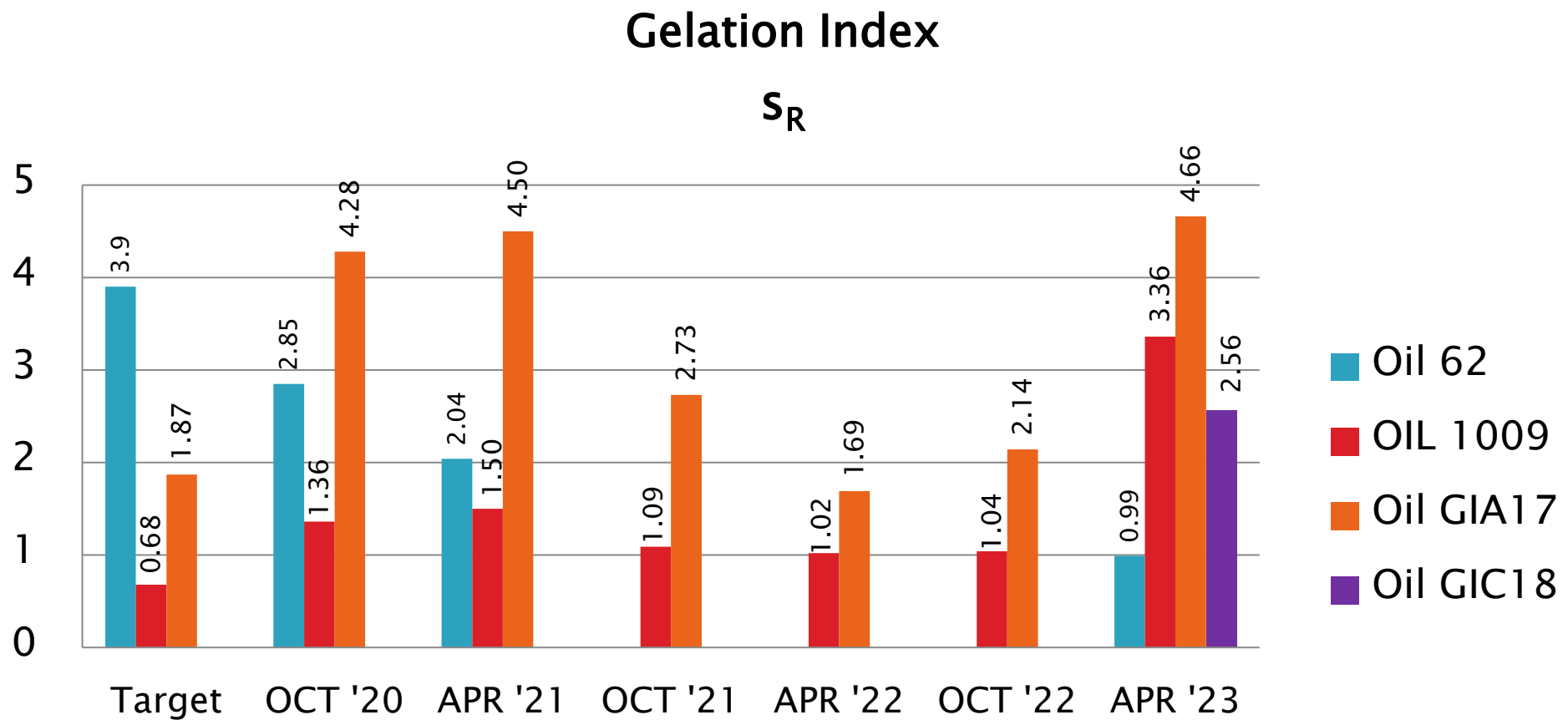
D5133 Performance by Oil



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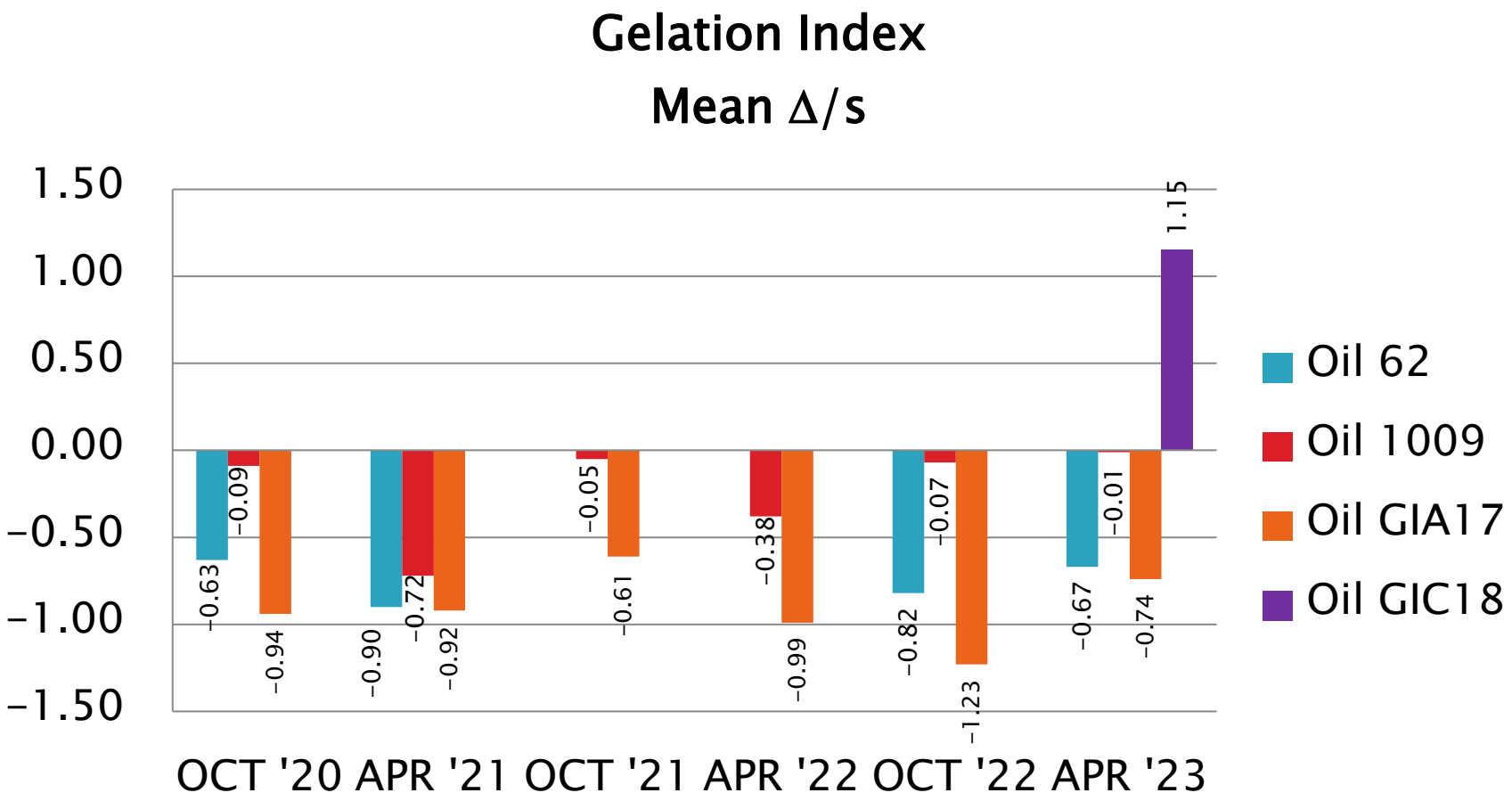
D5133 Performance by Oil



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TMC Monitored Tests

ASTM D 5800

NOACK Volatility

October 1, 2022 – March 31, 2023

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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D5800	11 (+1)	25 (+0)
*As of 3/31/2023		

D5800: Evaporation Loss of Lubricating Oil by Noack Method

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	130
Failed Calibration Test	OC	6
Operationally Invalidated by Lab	LC	2
Total		**138**

Number of Labs Reporting Data: 11
Fail Rate of Operationally Valid Tests: 4.3%

D5800: Evaporation Loss of Lubricating Oil by Noack Method

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

- The 6 OC tests were on four different rigs at 3 labs..
- No operationally valid tests have exceeded ±3 s for last two test periods.

D5800: Evaporation Loss of Lubricating Oil by Noack Method

Failed (OC) Details	Procedure	Model	No. Tests
Zi Level 2 Alarm: Rig (BD1*) too Severe	B	NCK25G	1
Zi Level 2 Alarm: Rig (BD1*) too Severe	B	NCK25G	1
Ei Level 3 Alarm: Rig (B6) too imprecise to predict SA	B	NCK25G	1
Ei Level 3 Alarm: Rig (B7) too imprecise to predict SA	B	NCK25G	1
Ei Level 3 Alarm: Rig (D7) too imprecise to predict SA	D	NS2	1
Ei Level 3 Alarm: Rig (D7) too imprecise to predict SA	D	NS2	1
Total			6
Fail Rate of Operationally Valid Tests: 4.3%			
*BD1 is a new rig that has not yet achieved calibration status.			

D5800: Evaporation Loss of Lubricating Oil by Noack Method

Operationally Invalid Tests (LC)

Two operationally invalid calibration runs were reported this period

- Both tests were lost due to faulty thermocouple. (LC)

D5800 Technical Memos

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

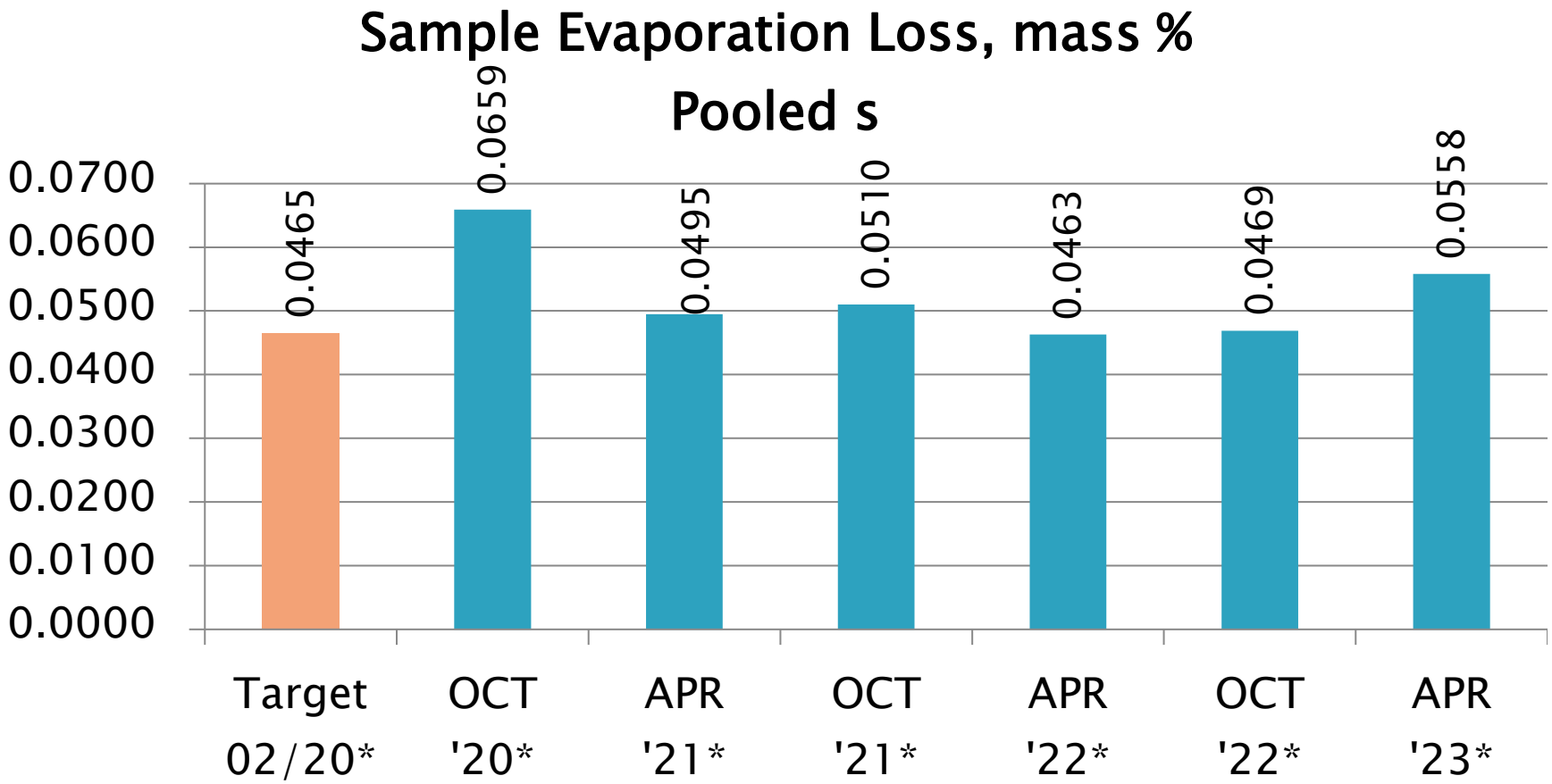
D5800: Evaporation Loss of Lubricating Oil by Noack Method

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	-----
4/1/19 through 9/30/19	164	161	0.81	0.65
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	139	136	0.0463	0.24
4/1/22 through 9/30/22	136	133	0.0469	-0.10
10/1/2022 through 3/31/23	136	133	0.0545	-0.15

[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

D5800 Precision Estimates



*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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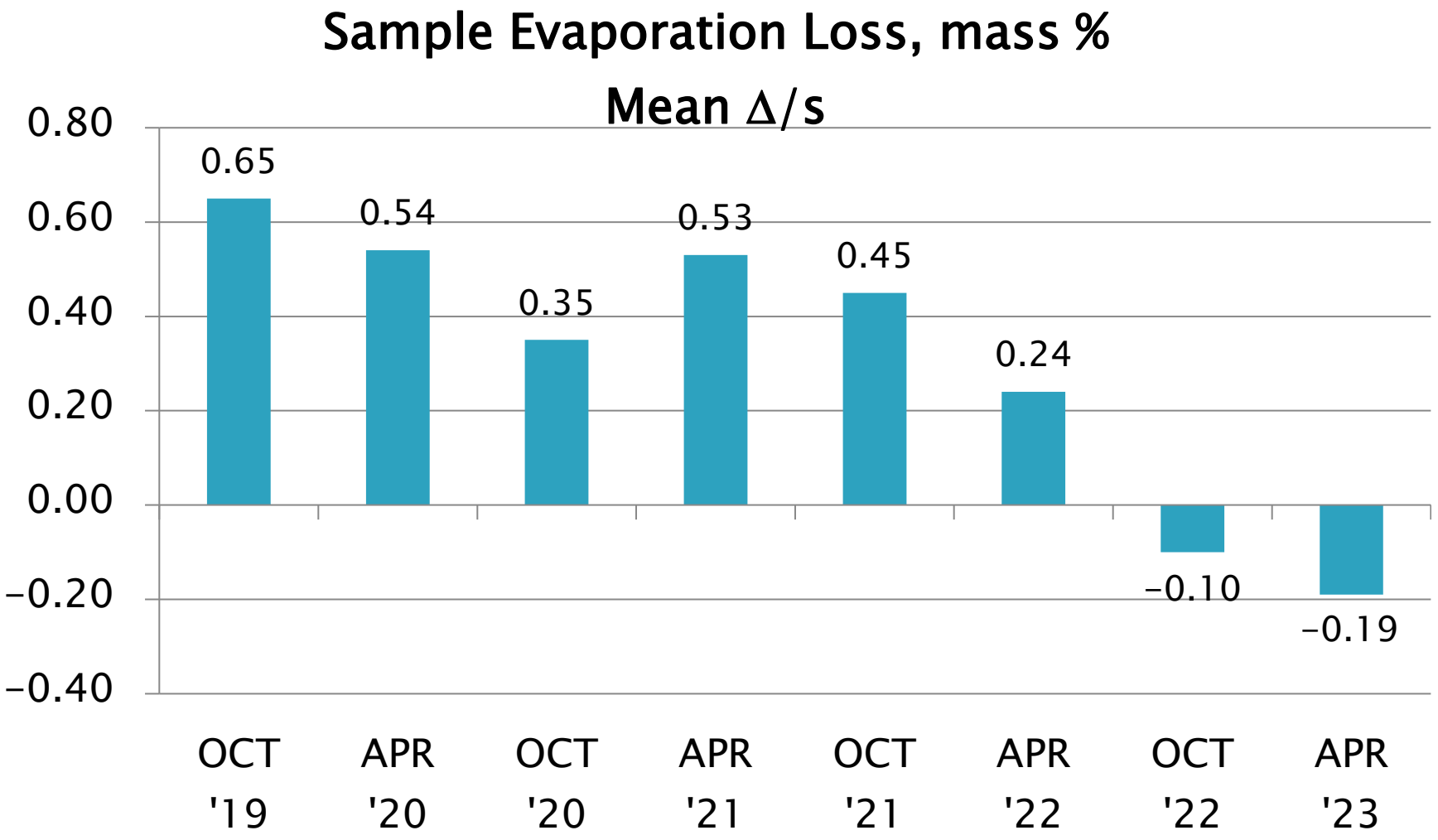
D5800 Severity Estimates



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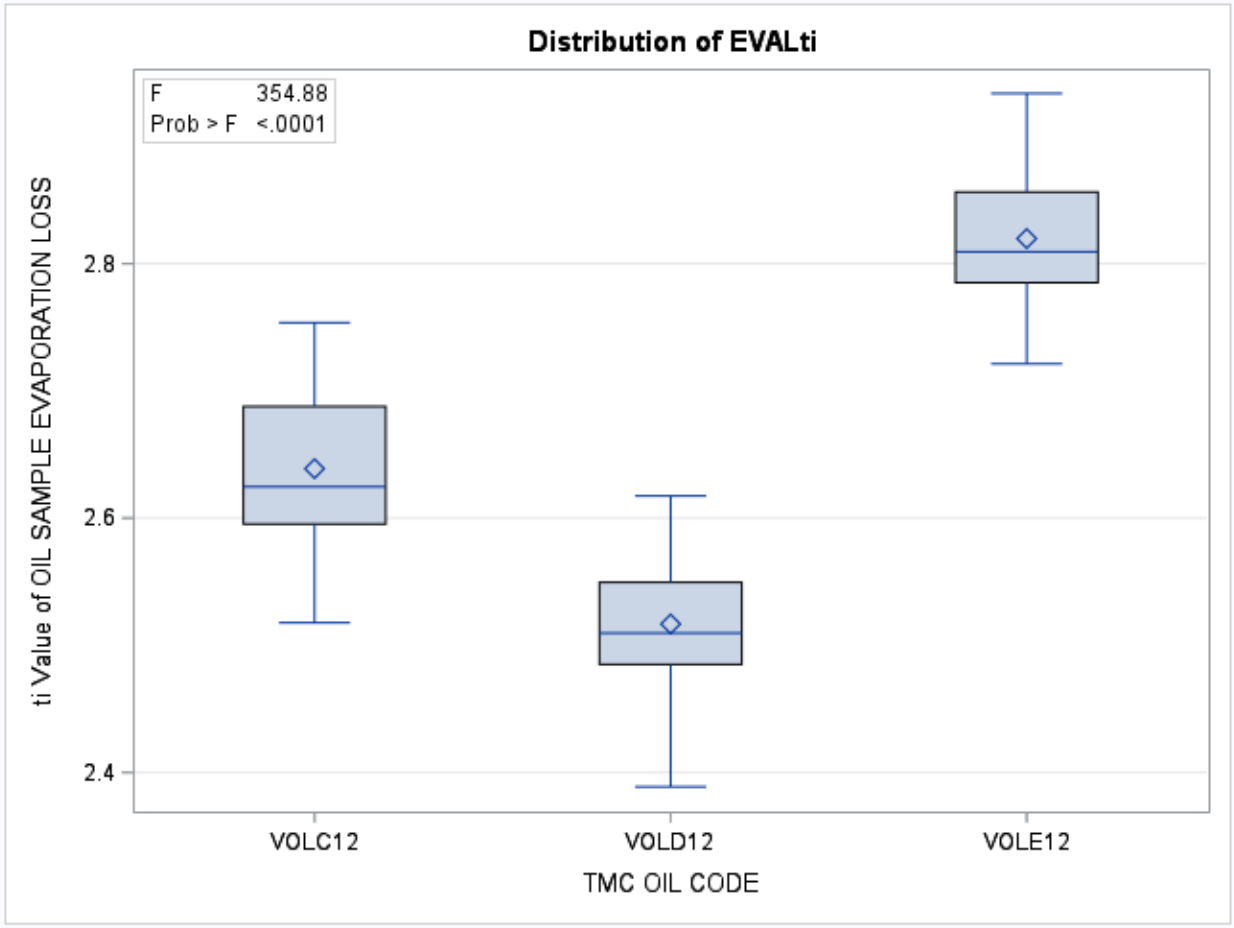
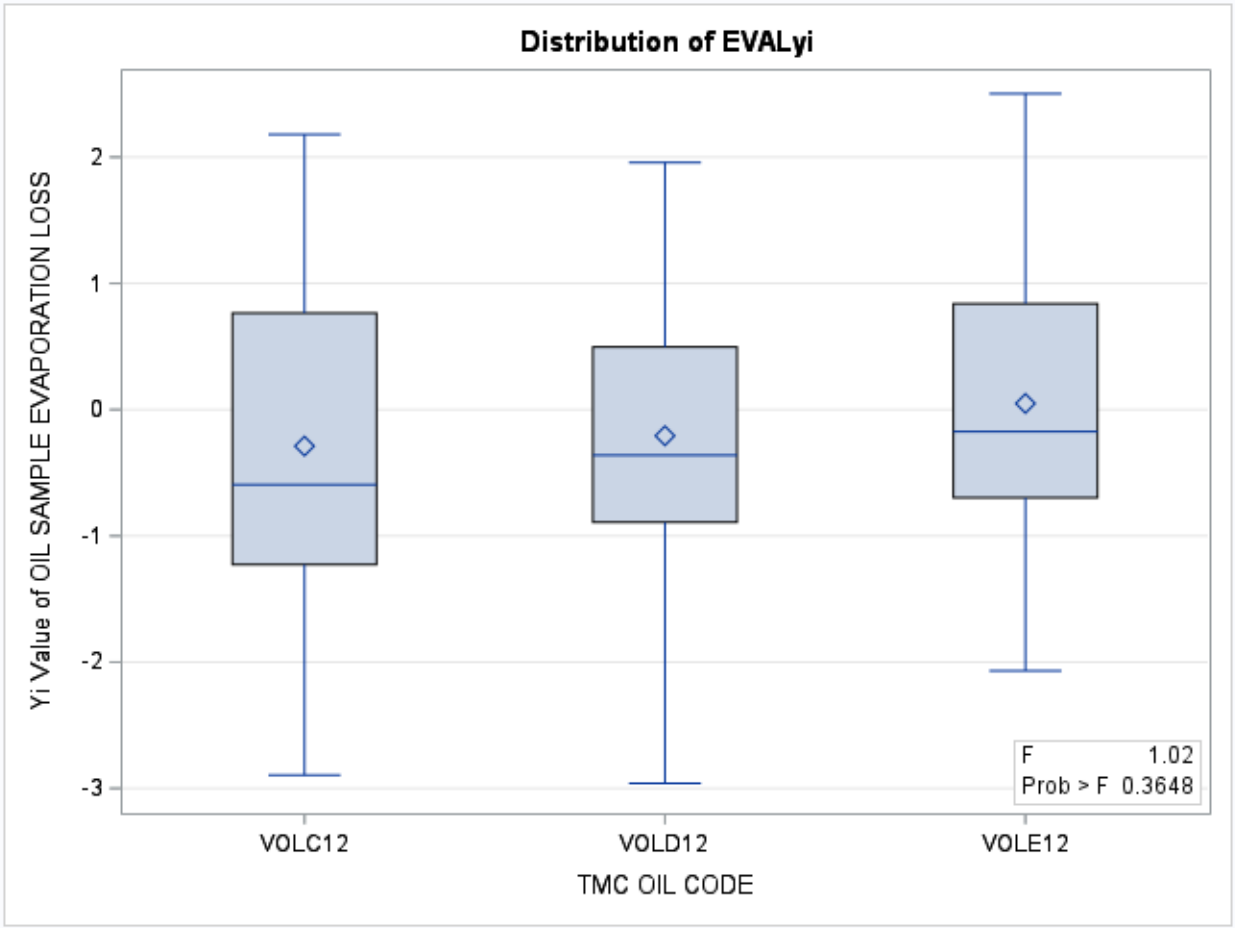
All Procedures: Oct22 – Mar23 Results





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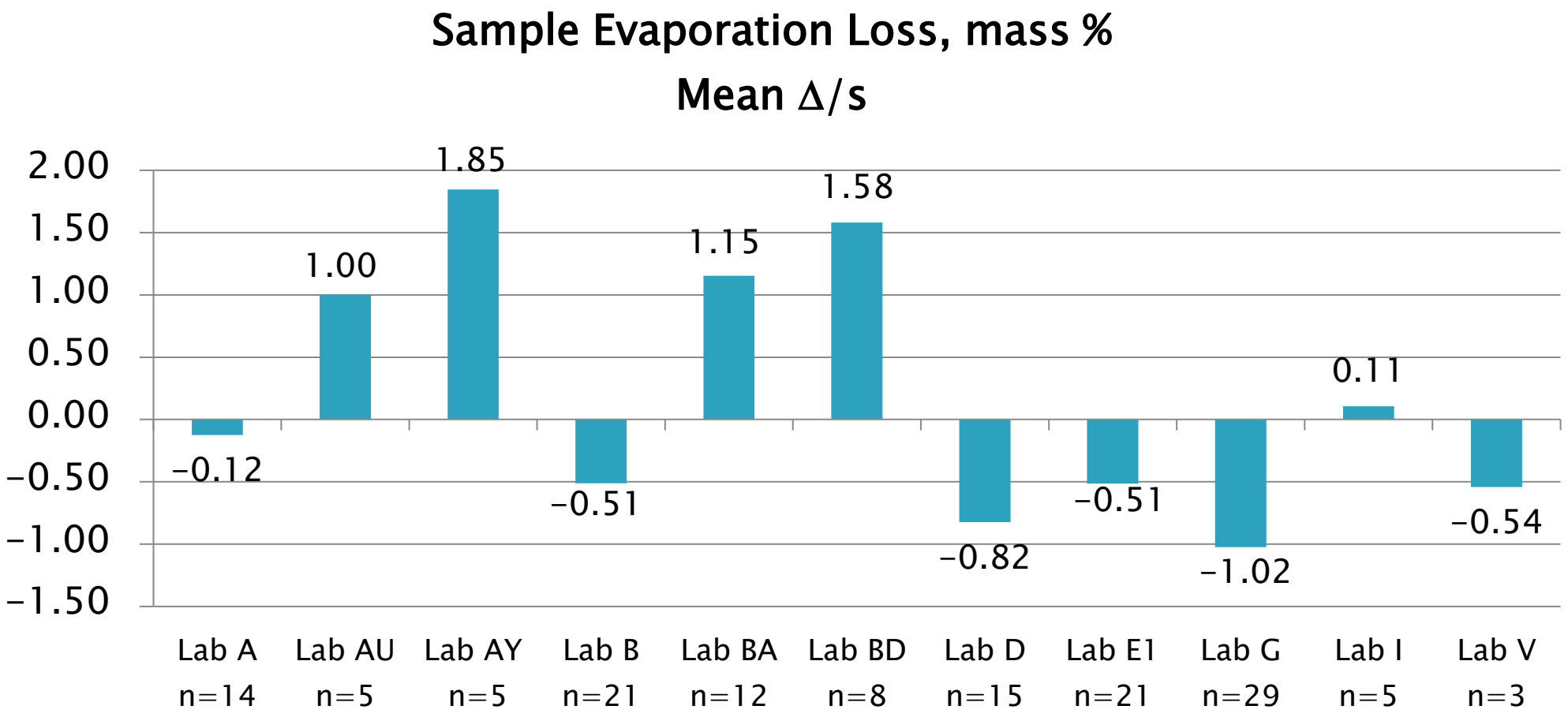
D5800 Lab Severity Estimates



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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Performance Comparison by Procedure & Model

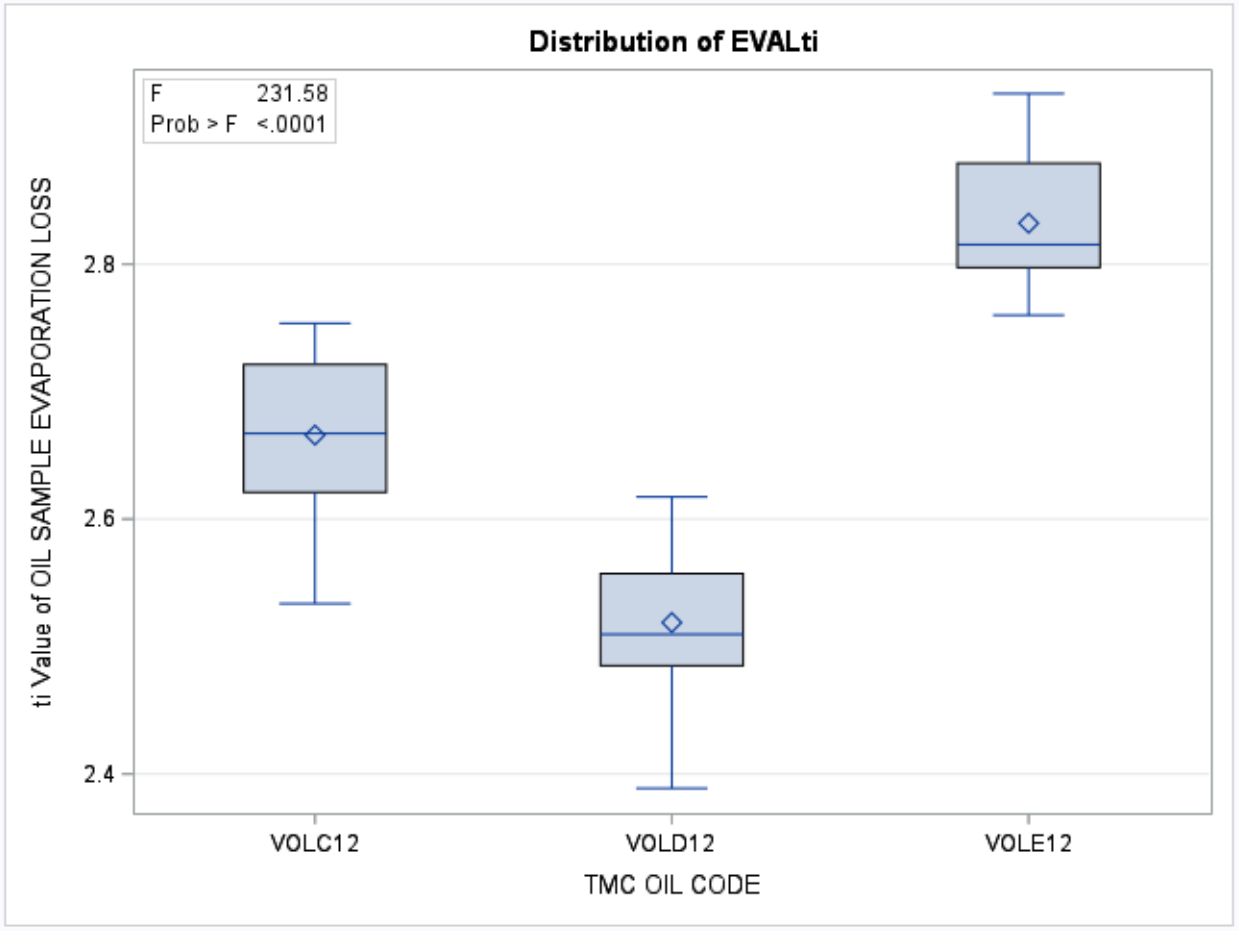
Sample Evaporation Loss, Mass %

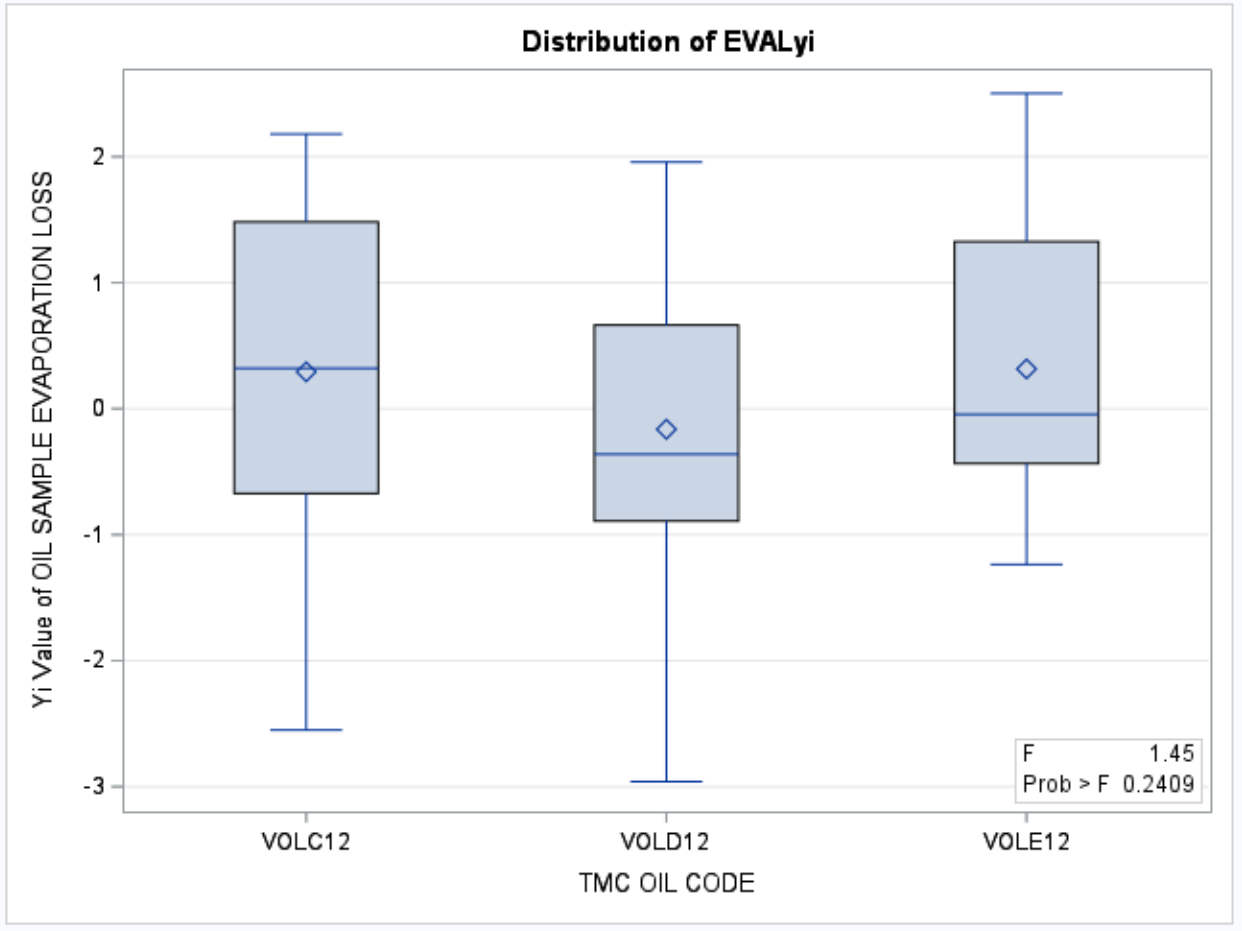
Procedure	n	df	Pooled s	Mean Δ/s
Procedure B	87	85	0.0564	0.15
Procedure C	No Procedure C tests reported this period.			
Procedure D	49	47	0.0405	-0.78

Model	n	df	Pooled s	Mean Δ/s
NCK2	6	3	0.0151	-0.45
NCK25G	82	79	0.0579	0.19
NS2	48	45	0.0350	-0.70

1 Procedure B NCK2 Rig
15 Procedure B NCK25G Rigs
9 Procedure D NS2 Rigs

Procedure B: Oct22 – Mar23 Results





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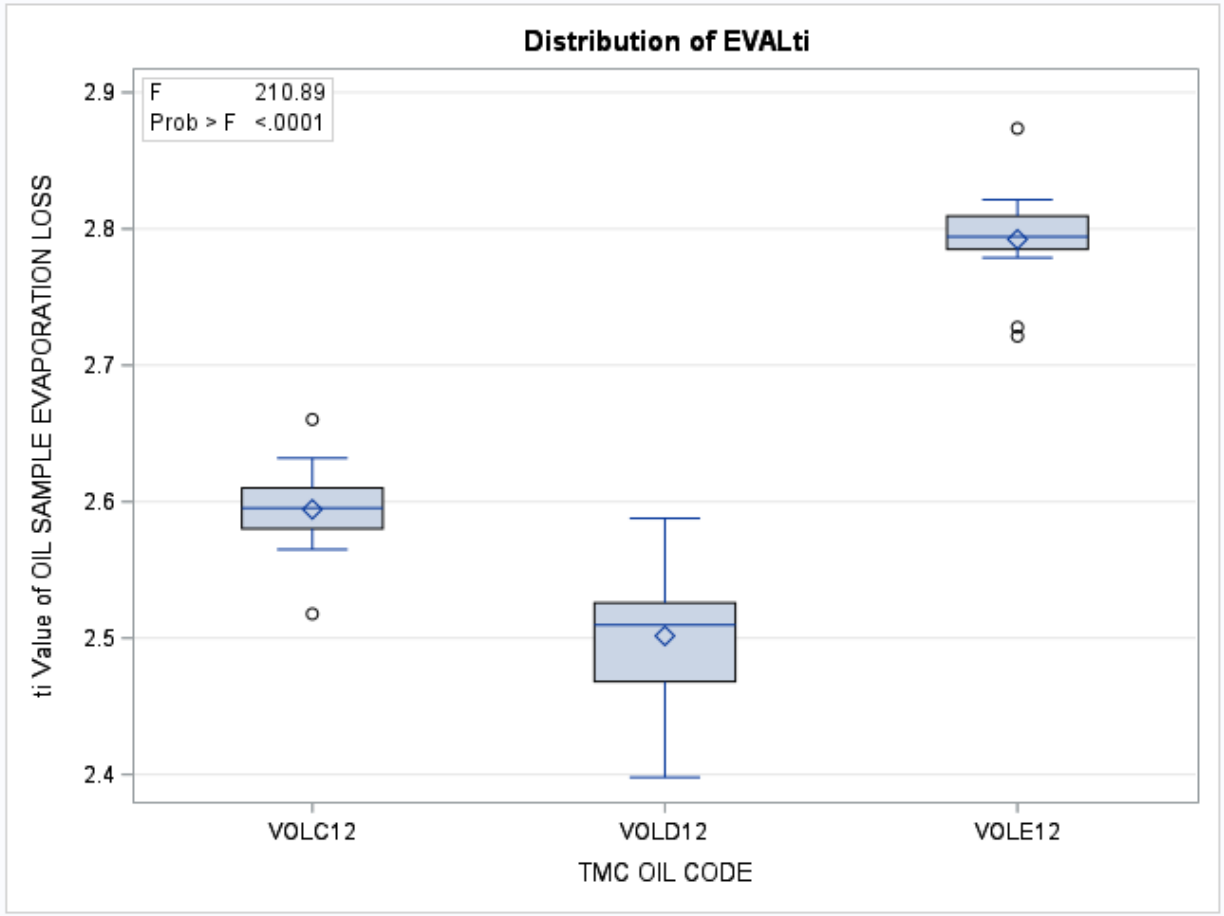
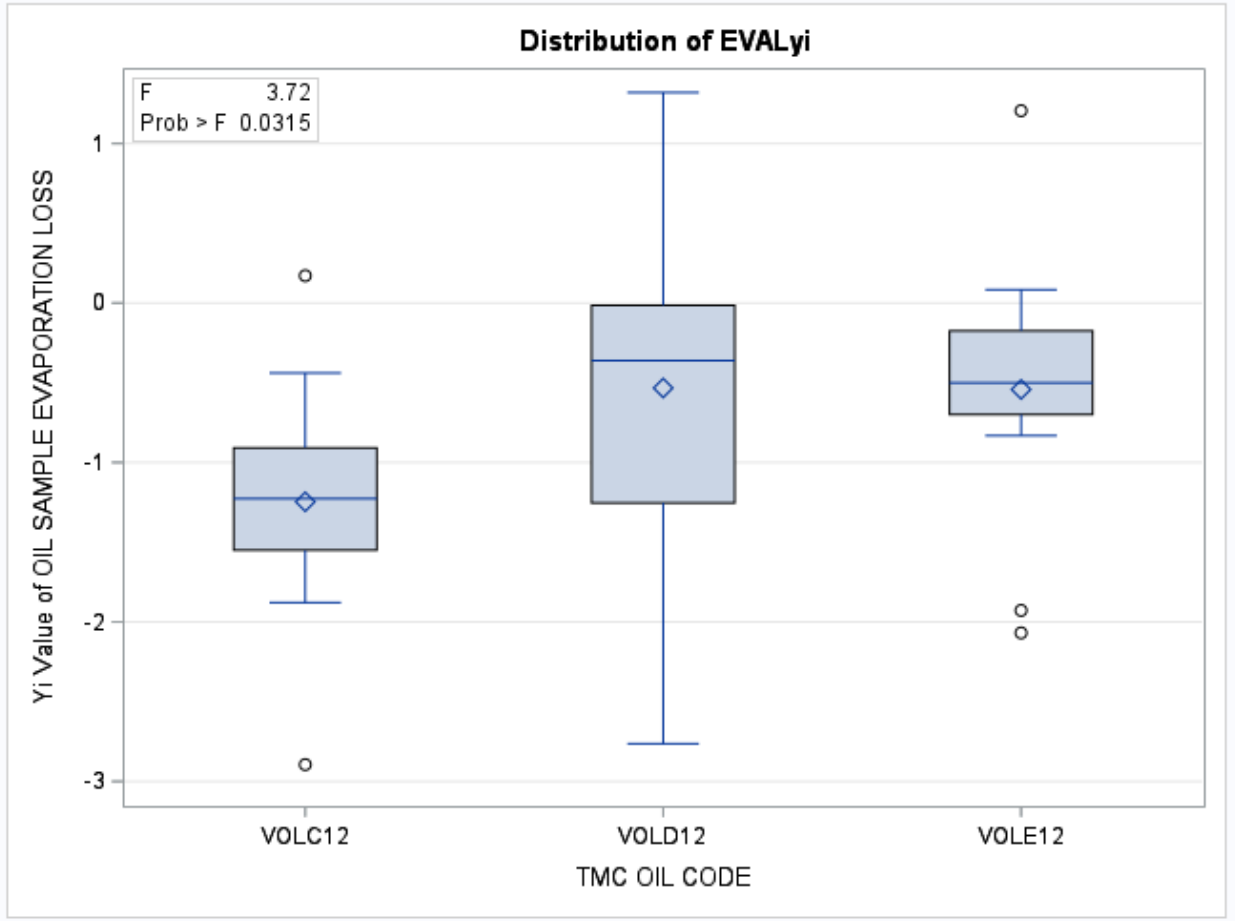
Procedure D: Oct22 – Mar23 Results





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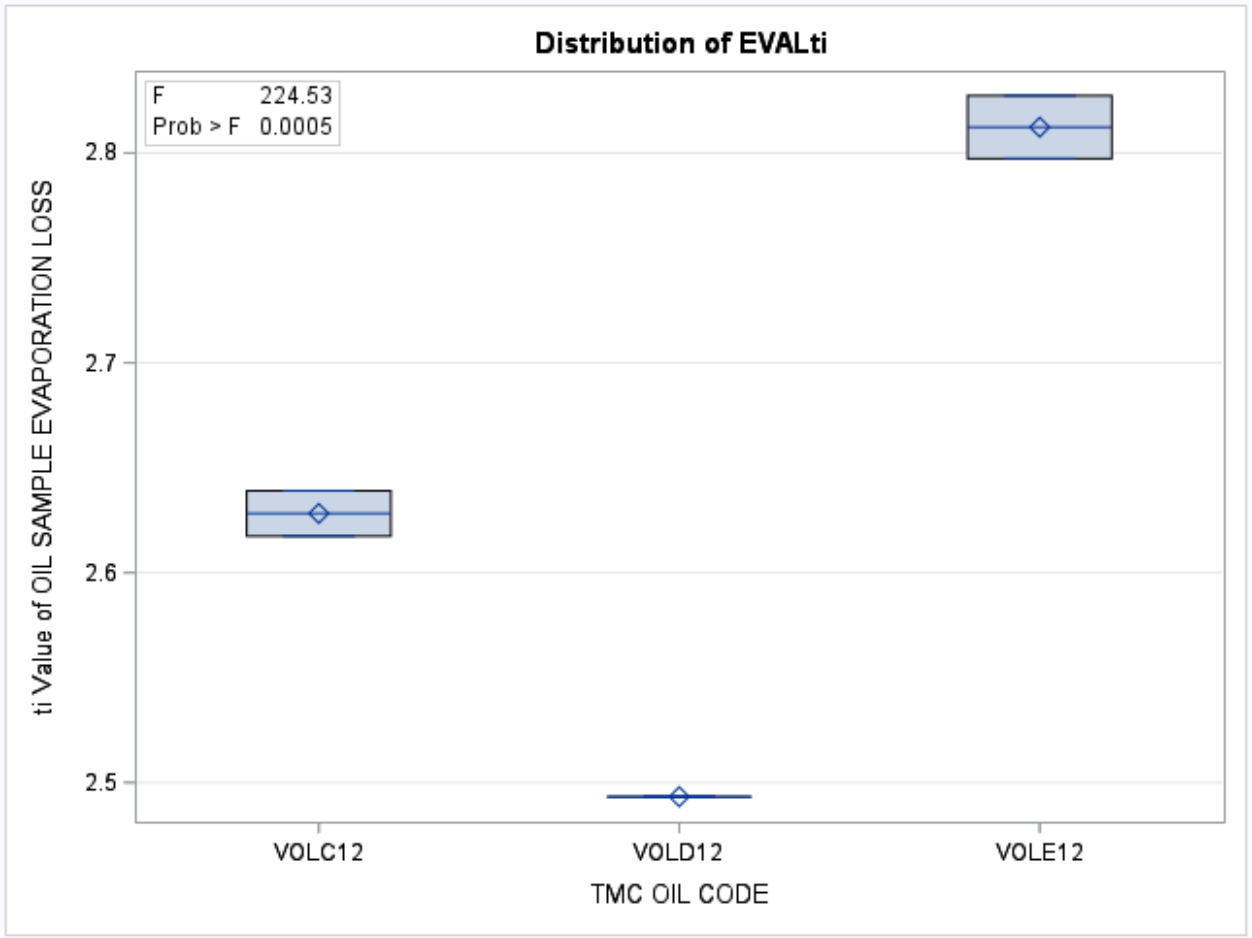
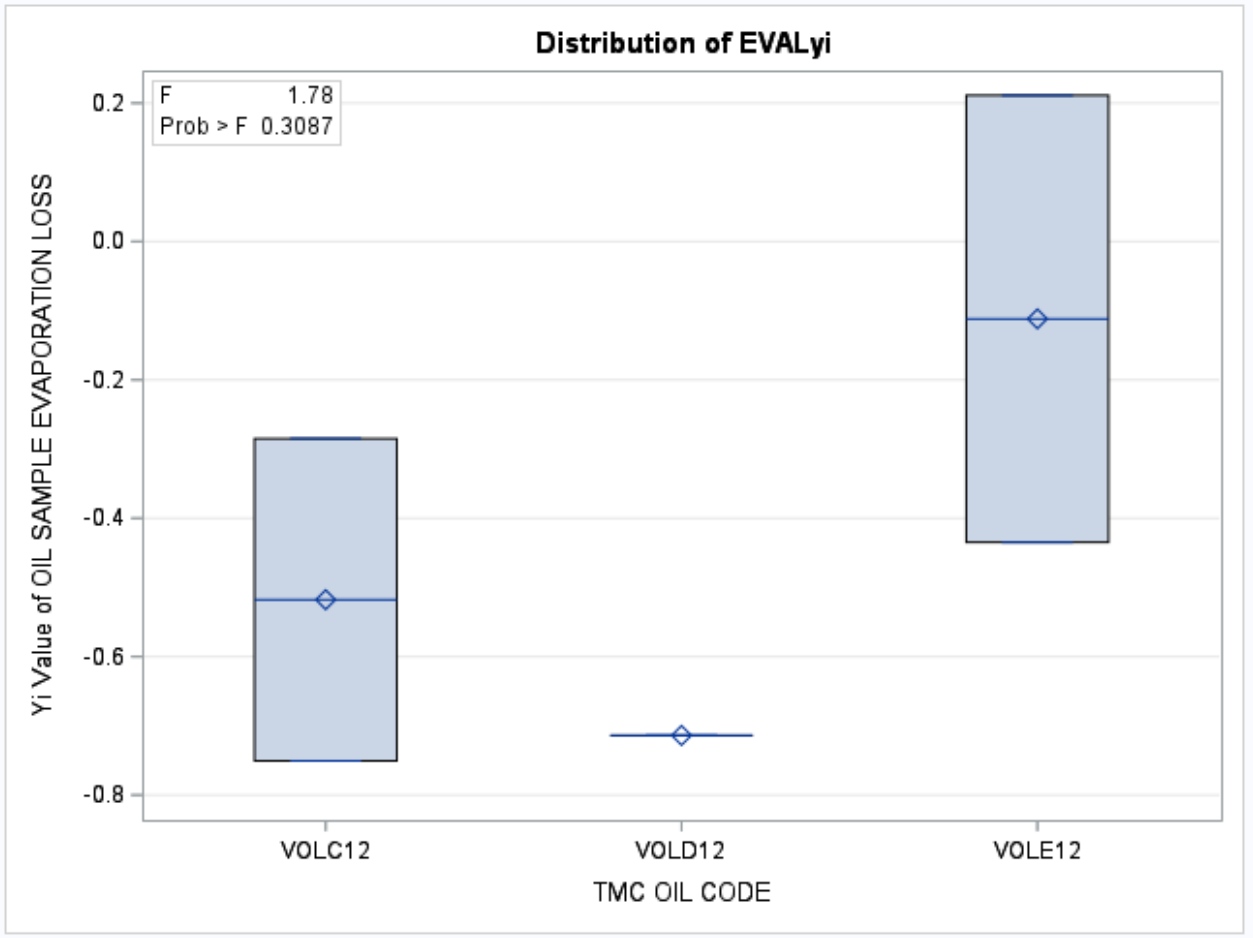
MODEL NCK2: Oct22 – Mar23 Results





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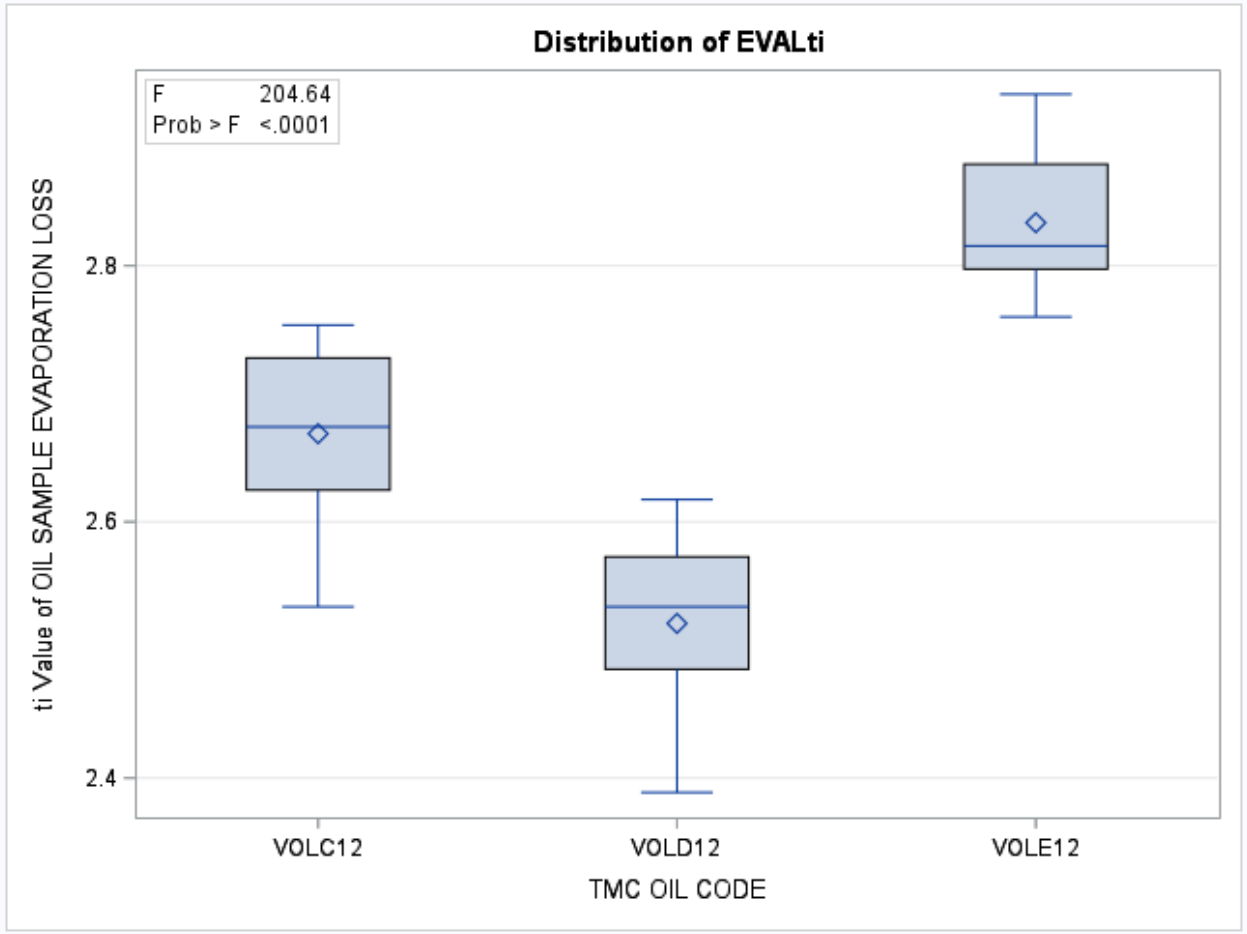
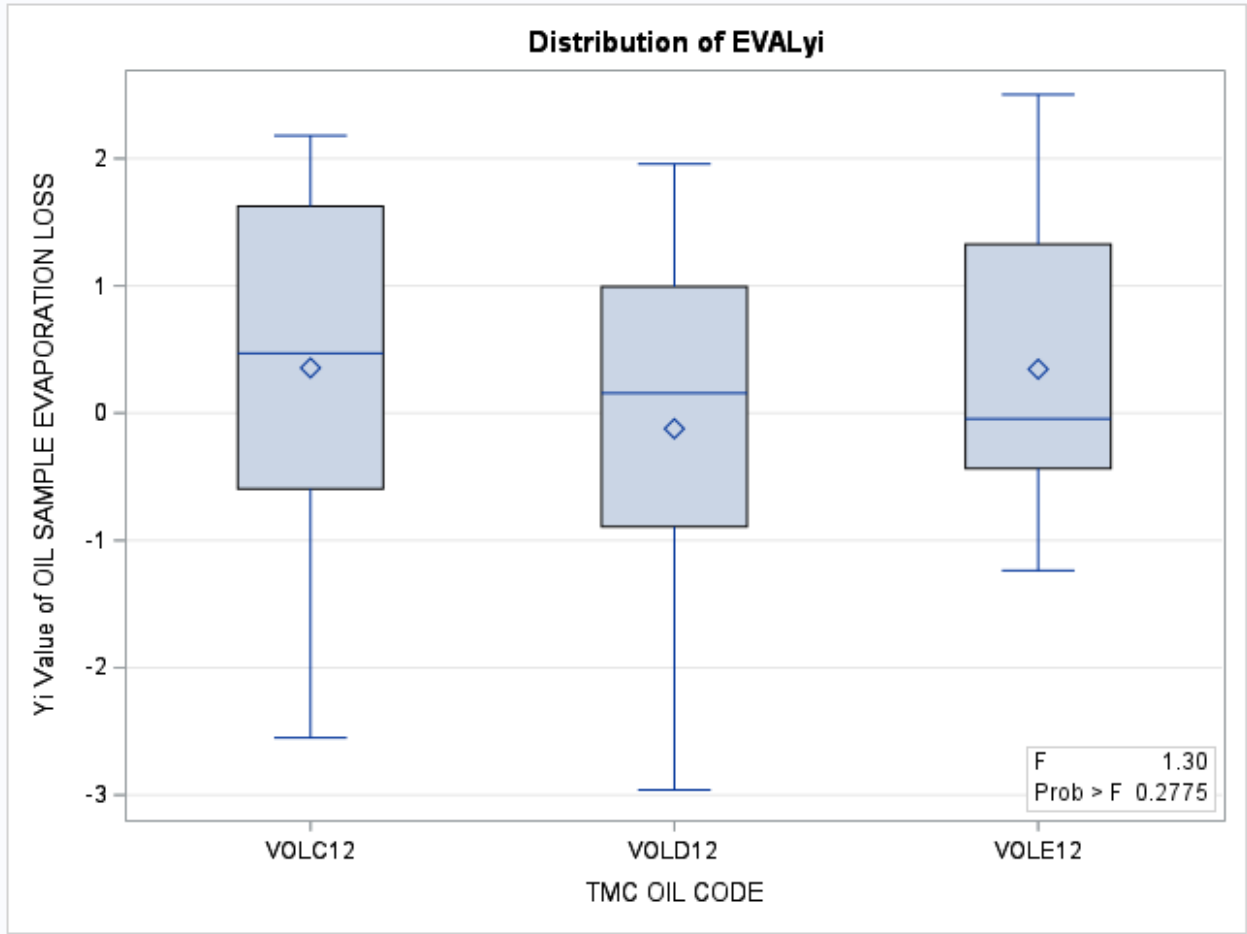
MODEL NCK25G: Oct22 – Mar23 Results





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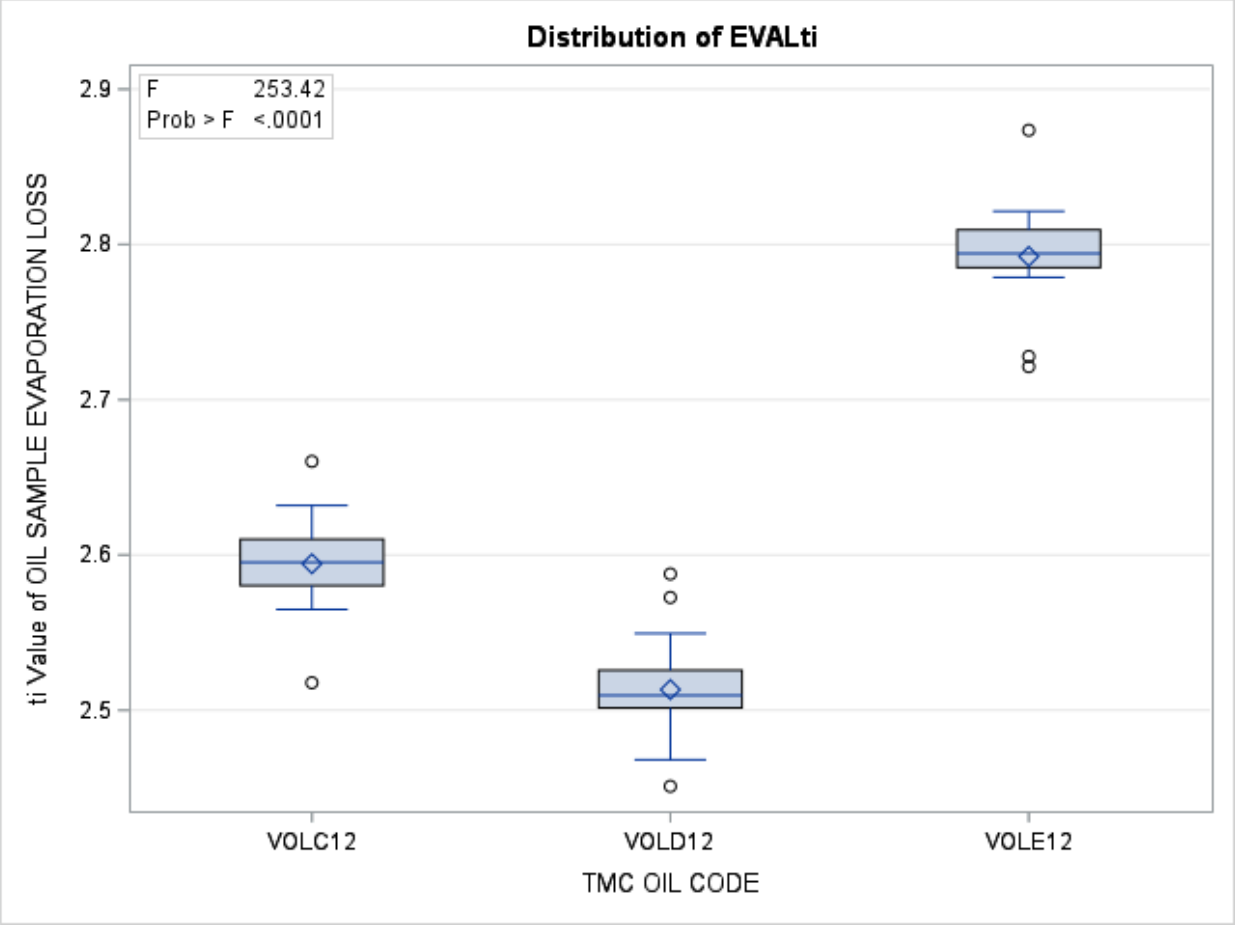
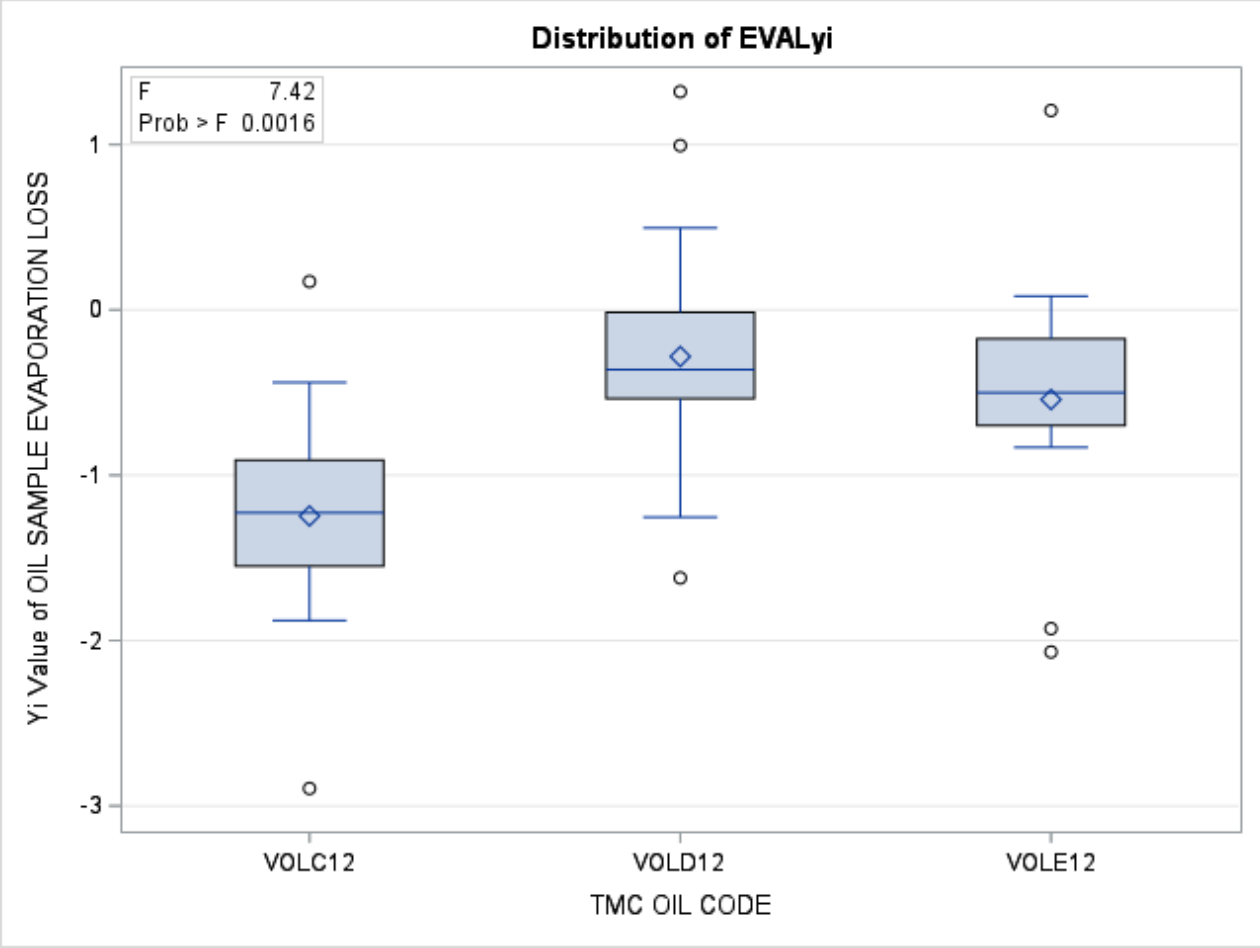
MODEL NS2: Oct22 – Mar23 Results





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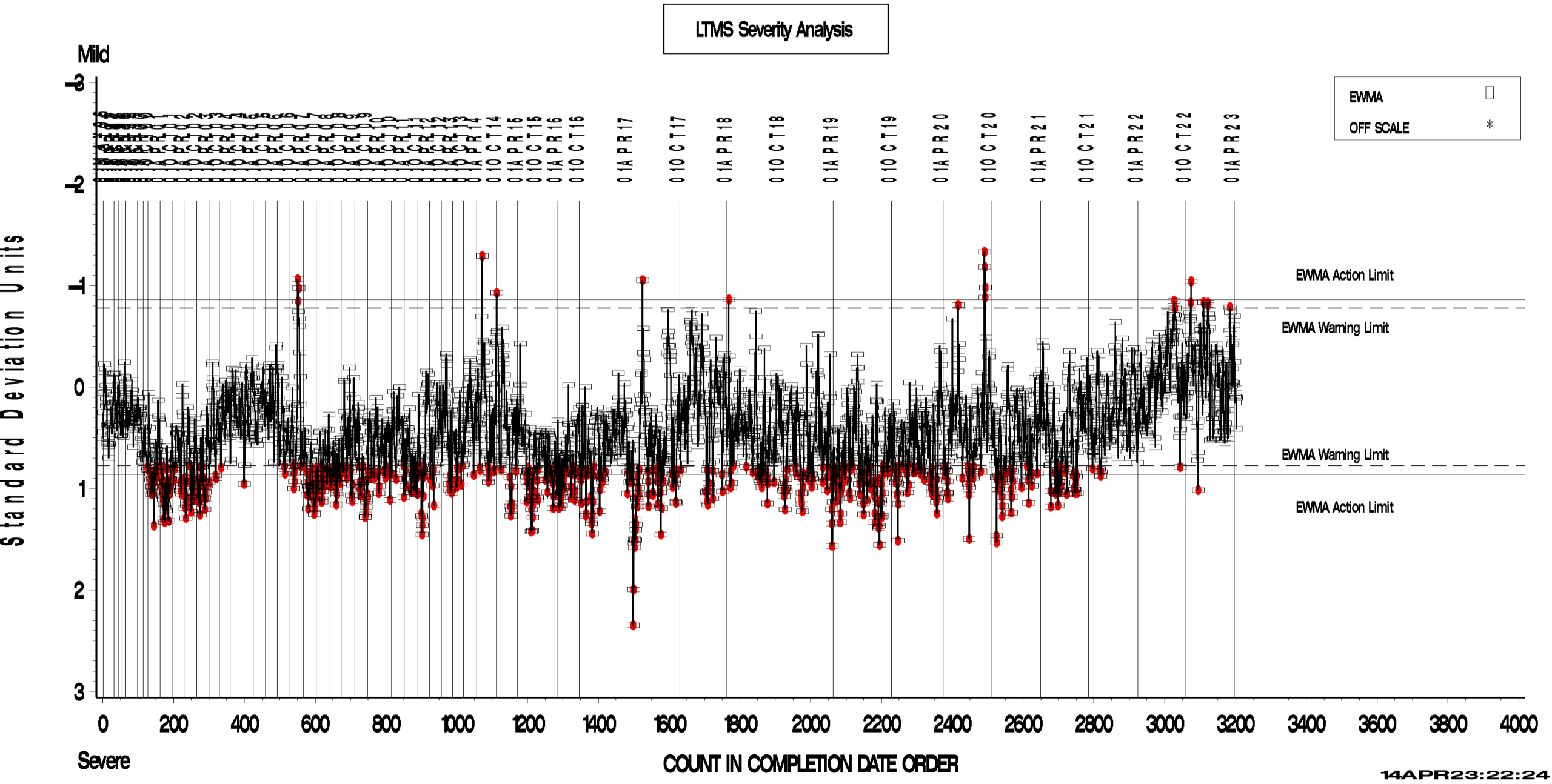
D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

ALL

EVAPORATION LOSS, MASS%



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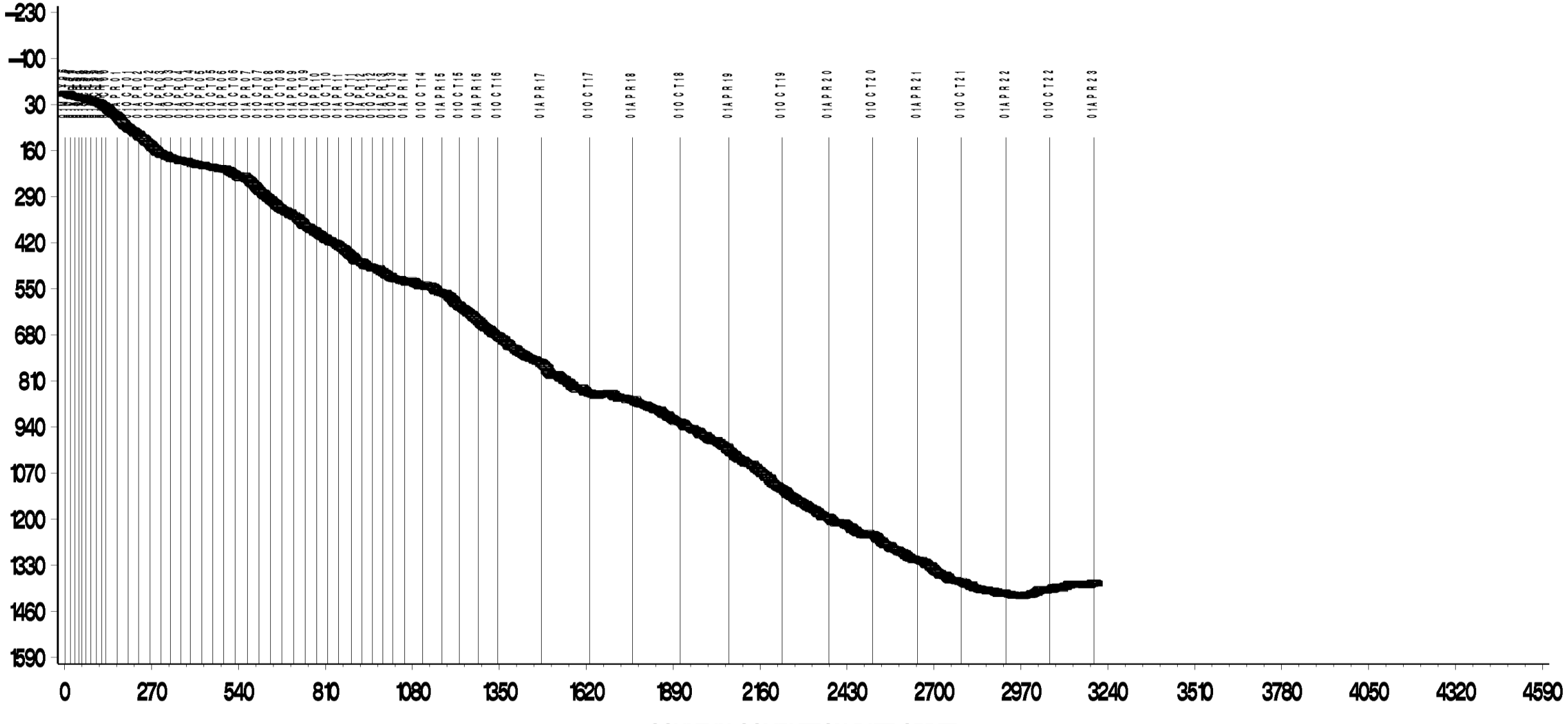
D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

ALL

EVAPORATION LOSS, MASS%

CUSUM Severity Analysis



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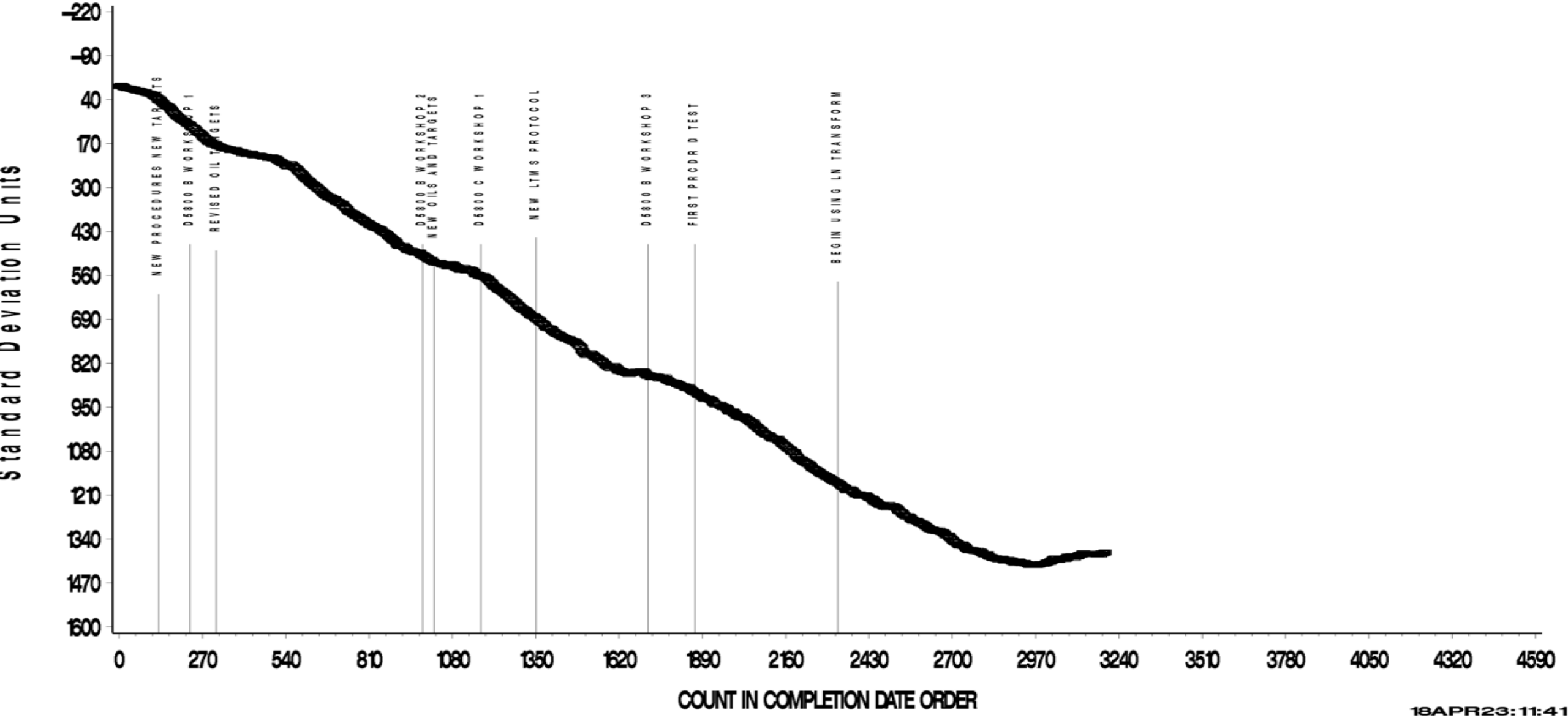
D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

ALL

EVAPORATION LOSS, MASS%

CUSUM Severity Analysis



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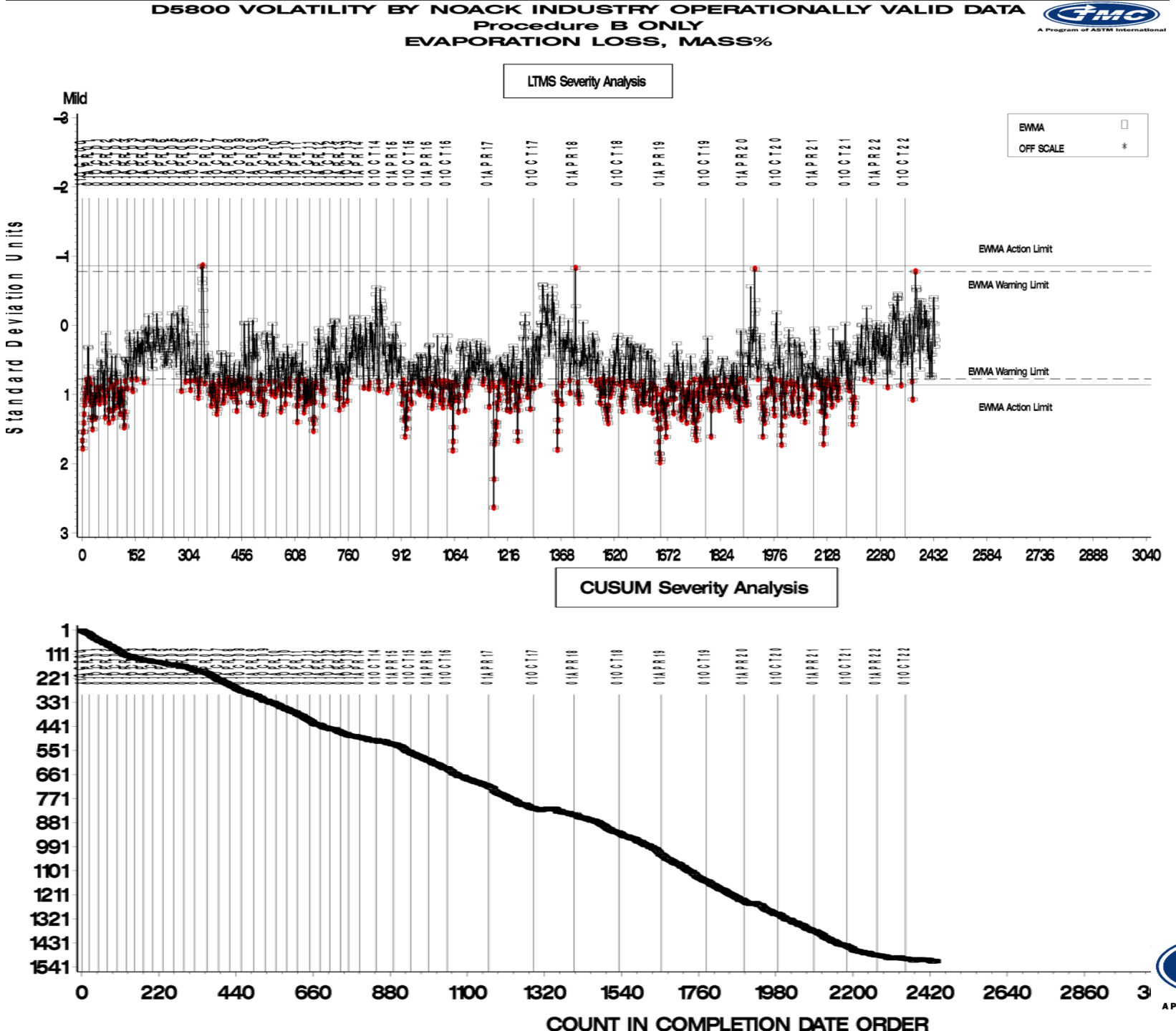
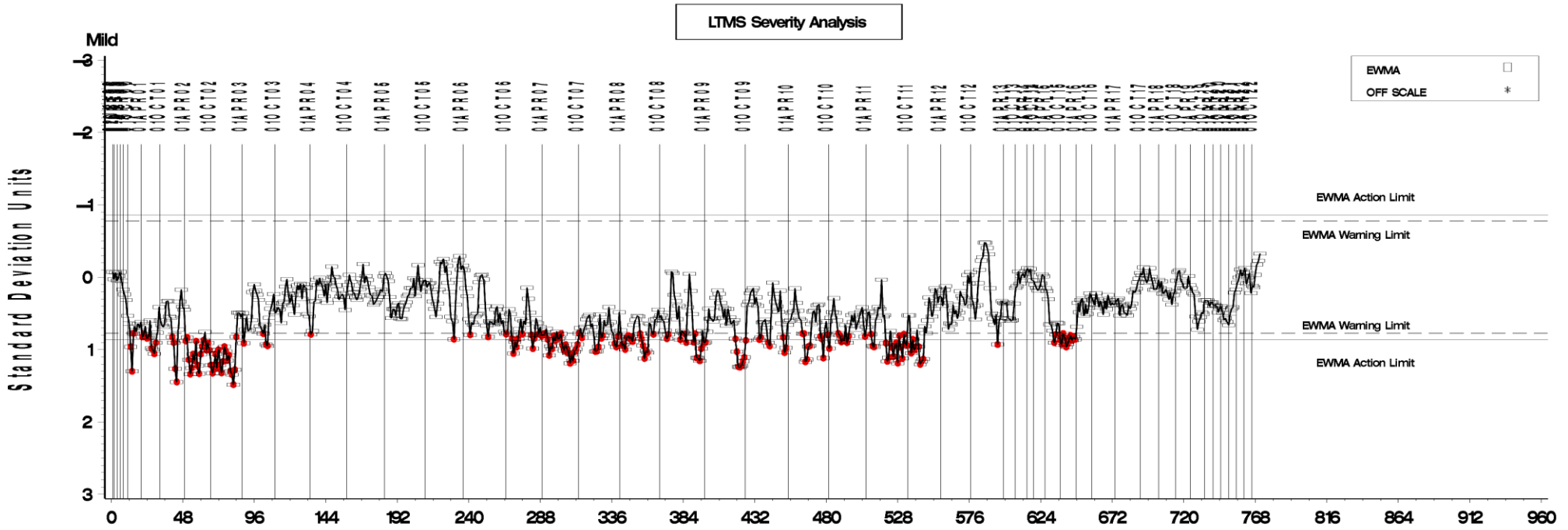
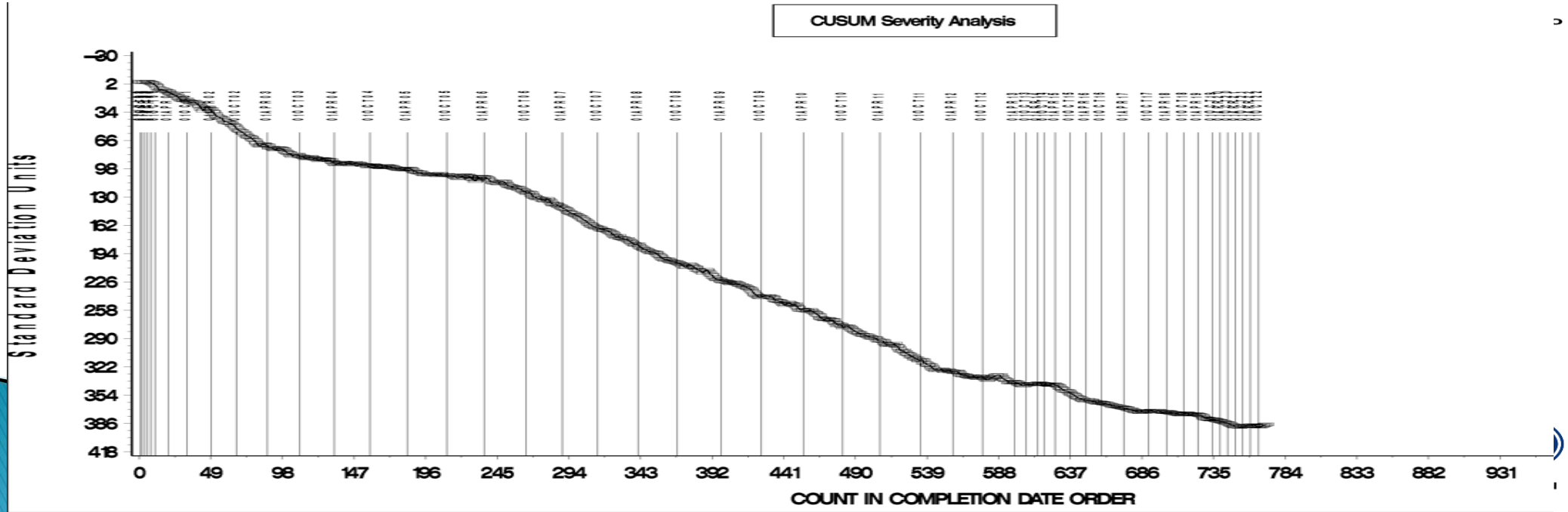
B only


D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
Procedure B ONLY
EVAPORATION LOSS, MASS%
LTMS Severity Analysis
Mild
Standard Deviation Units
EWMA
OFF SCALE
EWMA Action Limit
EWMA Warning Limit
EWMA Warning Limit
EWMA Action Limit
CUSUM Severity Analysis
Standard Deviation Units
COUNT IN COMPLETION DATE ORDER

NCK2 only

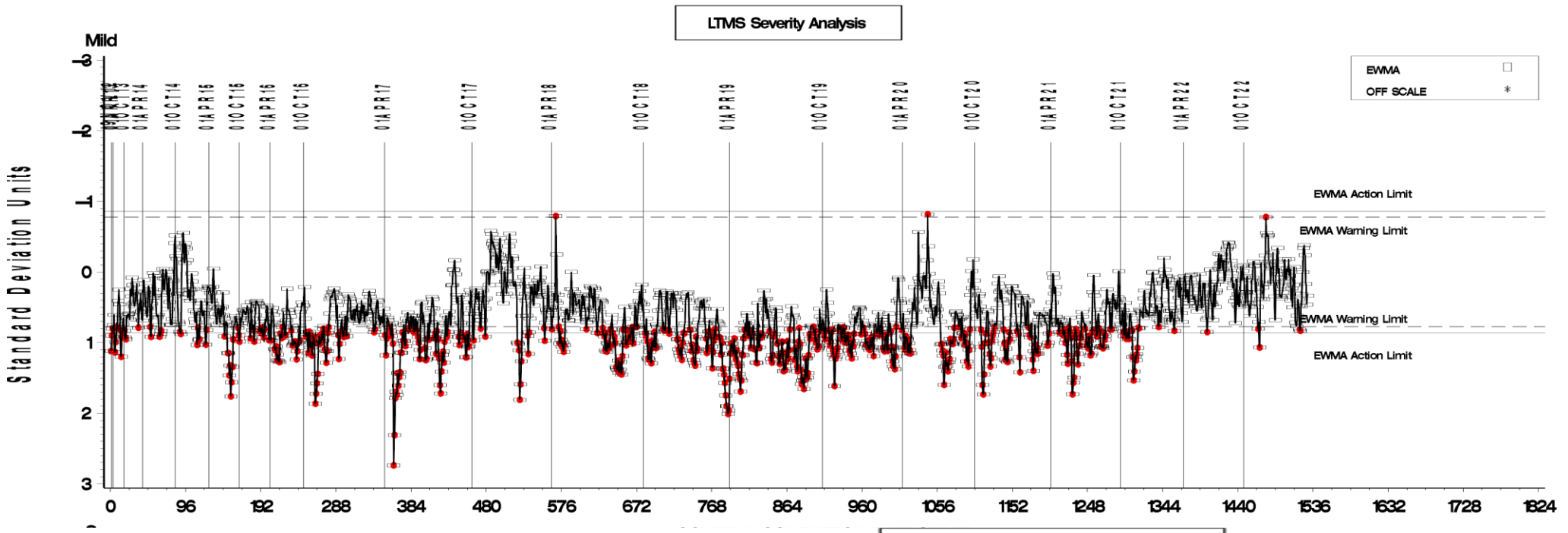
D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
NCK2 ONLY
EVAPORATION LOSS, MASS%

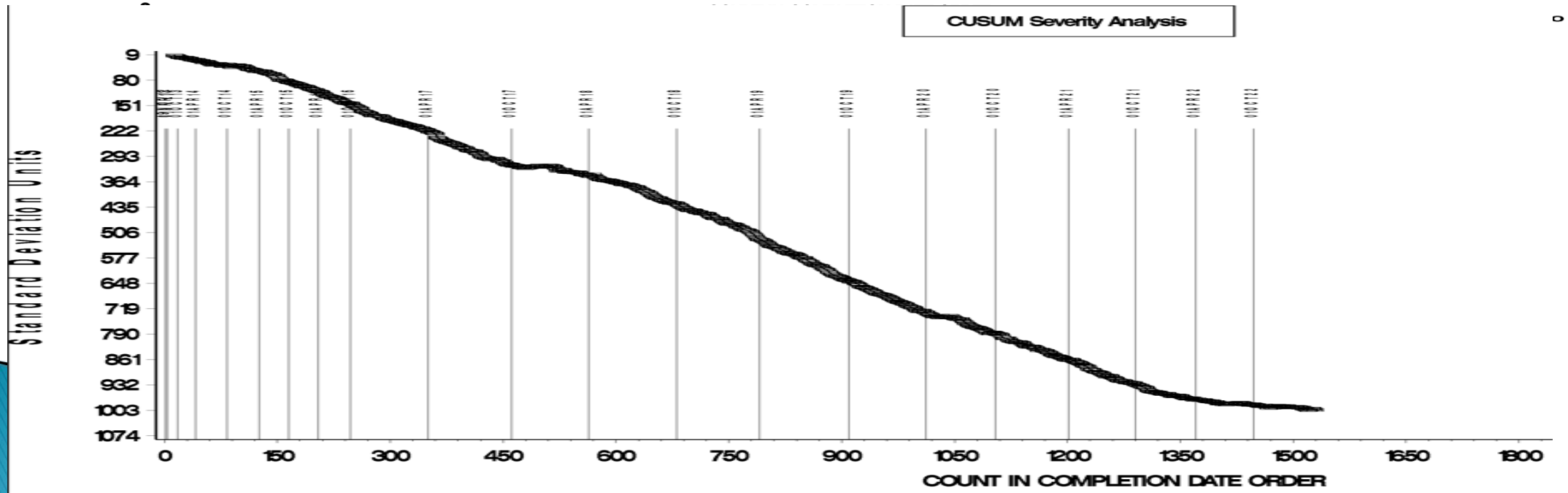




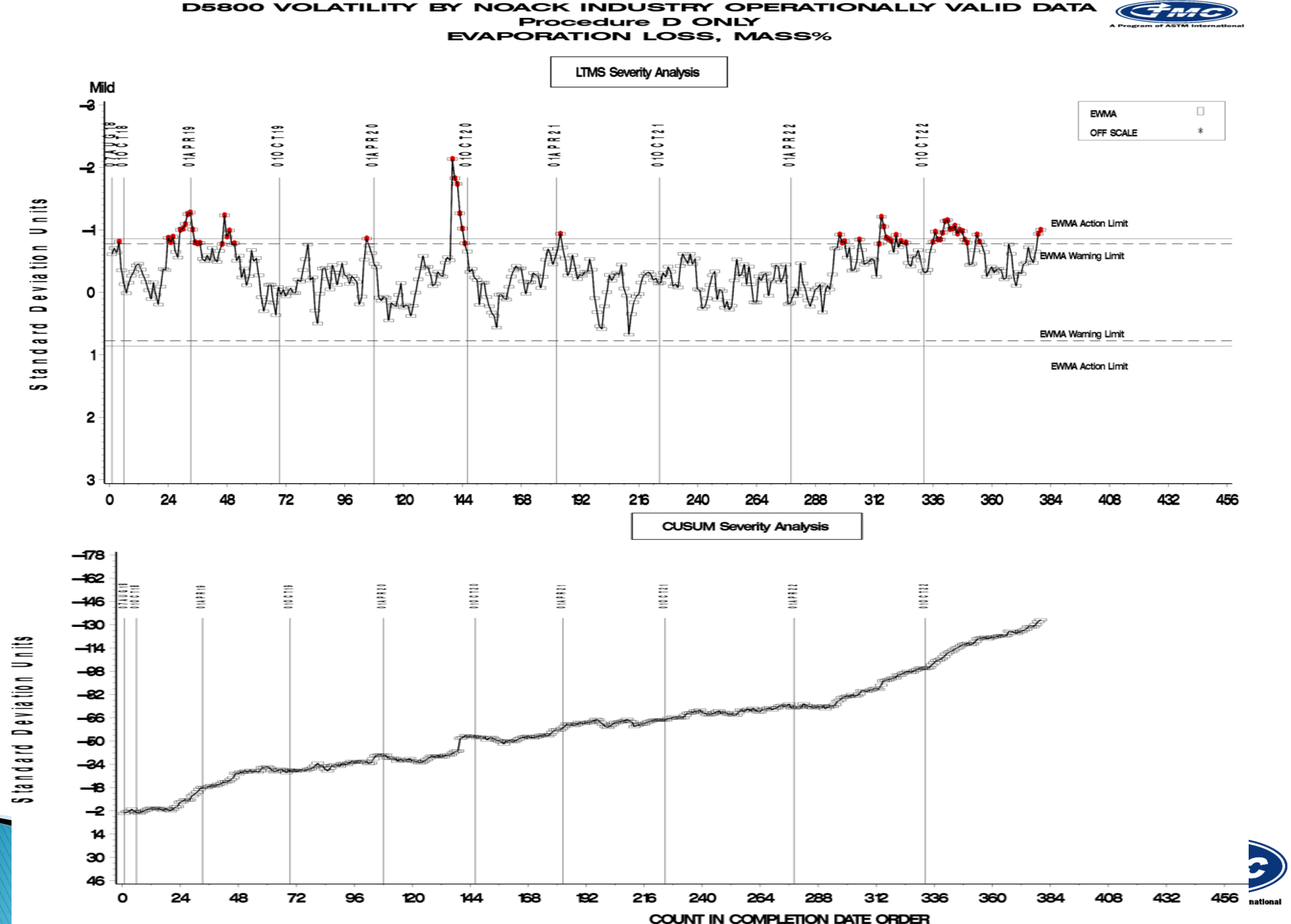
NCK25 G only

D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
NCK25G ONLY
EVAPORATION LOSS, MASS%

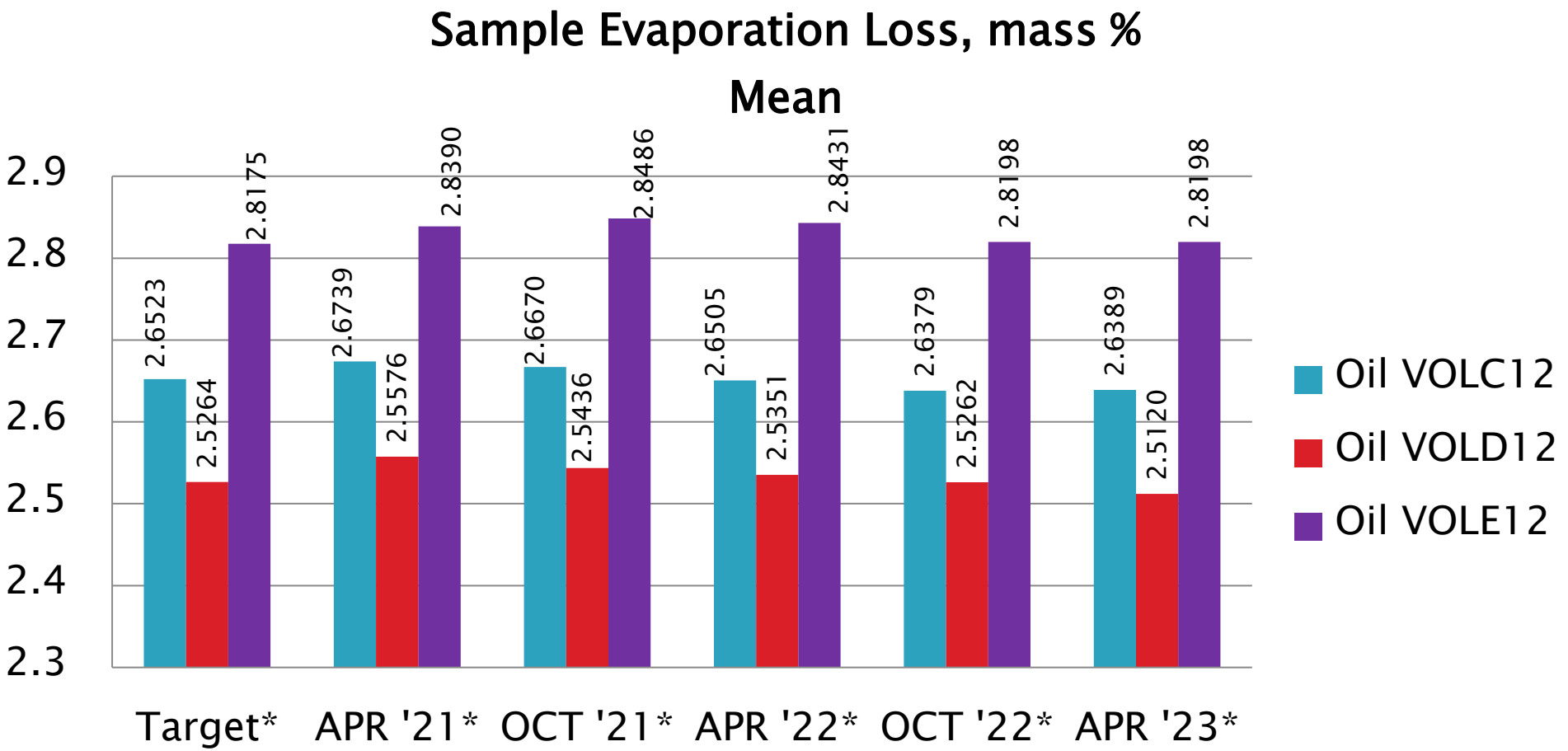




D only (NS2)


D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
Procedure D ONLY
EVAPORATION LOSS, MASS%
LTMS Severity Analysis
Mild
Standard Deviation Units
EWMA
OFF SCALE
EWMA Action Limit
EWMA Warning Limit
EWMA Warning Limit
EWMA Action Limit
CUSUM Severity Analysis
Standard Deviation Units
COUNT IN COMPLETION DATE ORDER

D5800 Performance by Oil



*Results transformed to natural log per updated LTMS 20200207

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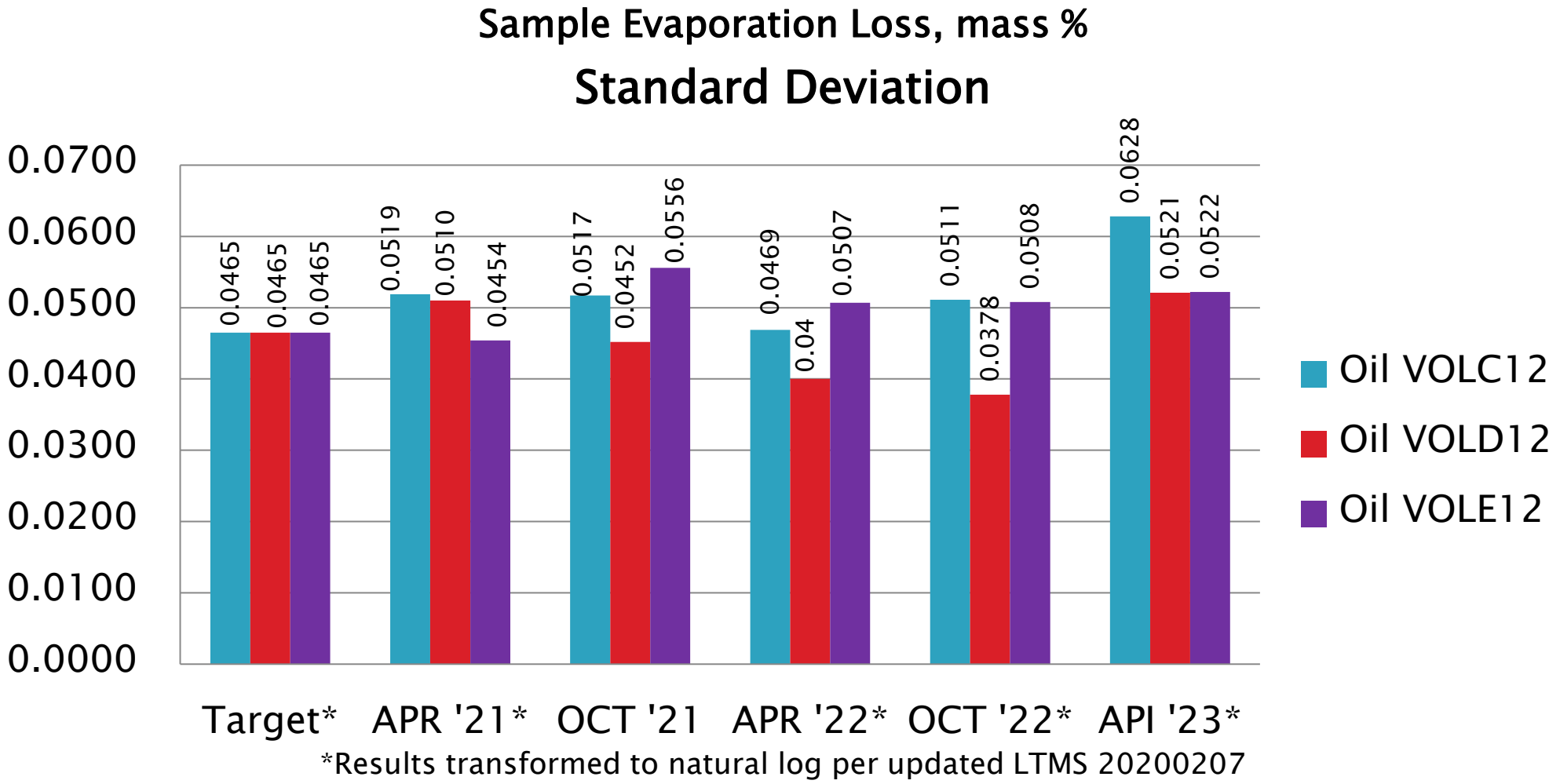
D5800 Performance by Oil



*Results transformed to natural log per updated LTMS 20200207

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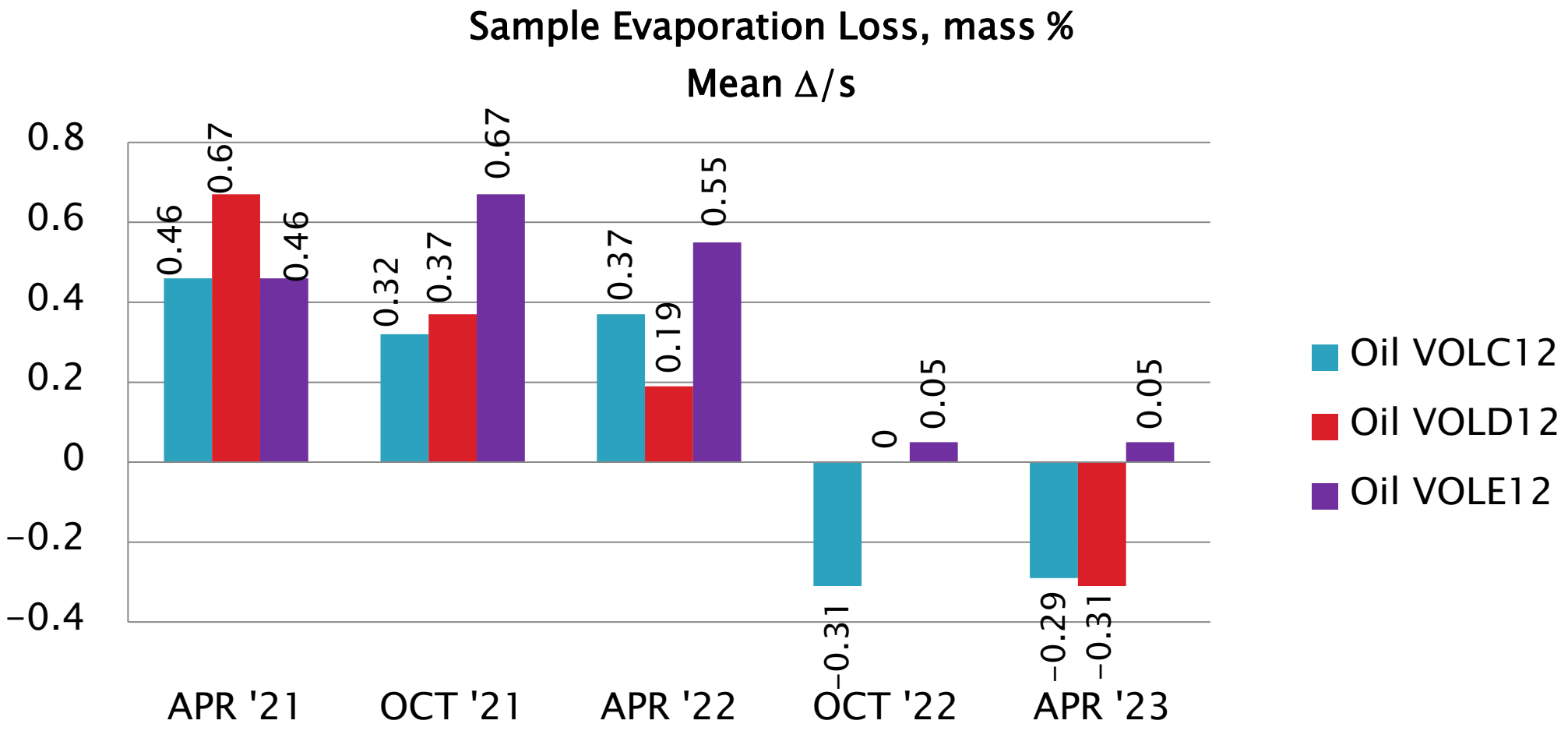
D5800 Performance by Oil



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

Precision (Pooled s) remains comparable to target precision (in natural log transformed units), but slightly higher than previous semester.

- Performance (Mean Δ/s) continues to move mild, falling from −0.10 s to −0.19 s in the past six months.
  - Procedure B rigs continue to trend slightly severe (0.17 s) while Procedure D rigs continue to trend mild (−0.78 s).
- CUSUM plot shows a reversing of the severe trend that the test has seen for many semesters and now shows a relatively flat line. This is due to mild test results from Procedure D units and Procedure B units coming out of a severe trend to be mostly on-target. The industry EWMA Control chart is currently in control.

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D02.B0.07
TMC Monitored Tests

ASTM D 6082

High Temperature Foam

October 1, 2022 – March 31, 2023

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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D6082	7 (+1)	8 (+1)
*As of 3/31/2023		

D6082: High Temperature Foam

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	16
Acceptable Discrimination Test	AS	7
Operationally Invalid, Reported as Valid	RC	1
Operationally Invalid, Reported by Lab	LC	1
Informational Run (Valid)	NN	4
Informational Run (Invalid)	LN	1
Total		**30**

Number of Labs Reporting Data: 6
Fail Rate of Operationally Valid Calibration Tests: 0%

D6082: High Temperature Foam

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

- 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 were no statistically unacceptable results this report period.

D6082: High Temperature Foam

Operationally Unacceptable Tests (RC, LC)	No. Of Tests
No Option A (RC; Originally reported as Valid)	1
No Option A (LC; Lab reported as Invalid)	1
Total	**2**

- There were two operationally invalid results this report period.
- There were no statistically unacceptable results this report period.

D6082: High Temperature Foam

Informational Runs (MN, NN, LN)	No. Of Tests
Non-blind Informational run on-target and valid (NN)	4
Non-blind Informational run invalid (LN)	1
Total	**5**

- There were four valid Informational results this report period.
- There was one Informational invalid result due to lost sample.

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	-----
10/1/18 through 3/31/19	14	13	12	-0.07
4/1/19 through 9/30/19	14	12	12	-0.18
10/1/19 through 3/31/20	15	13	10	-0.23
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

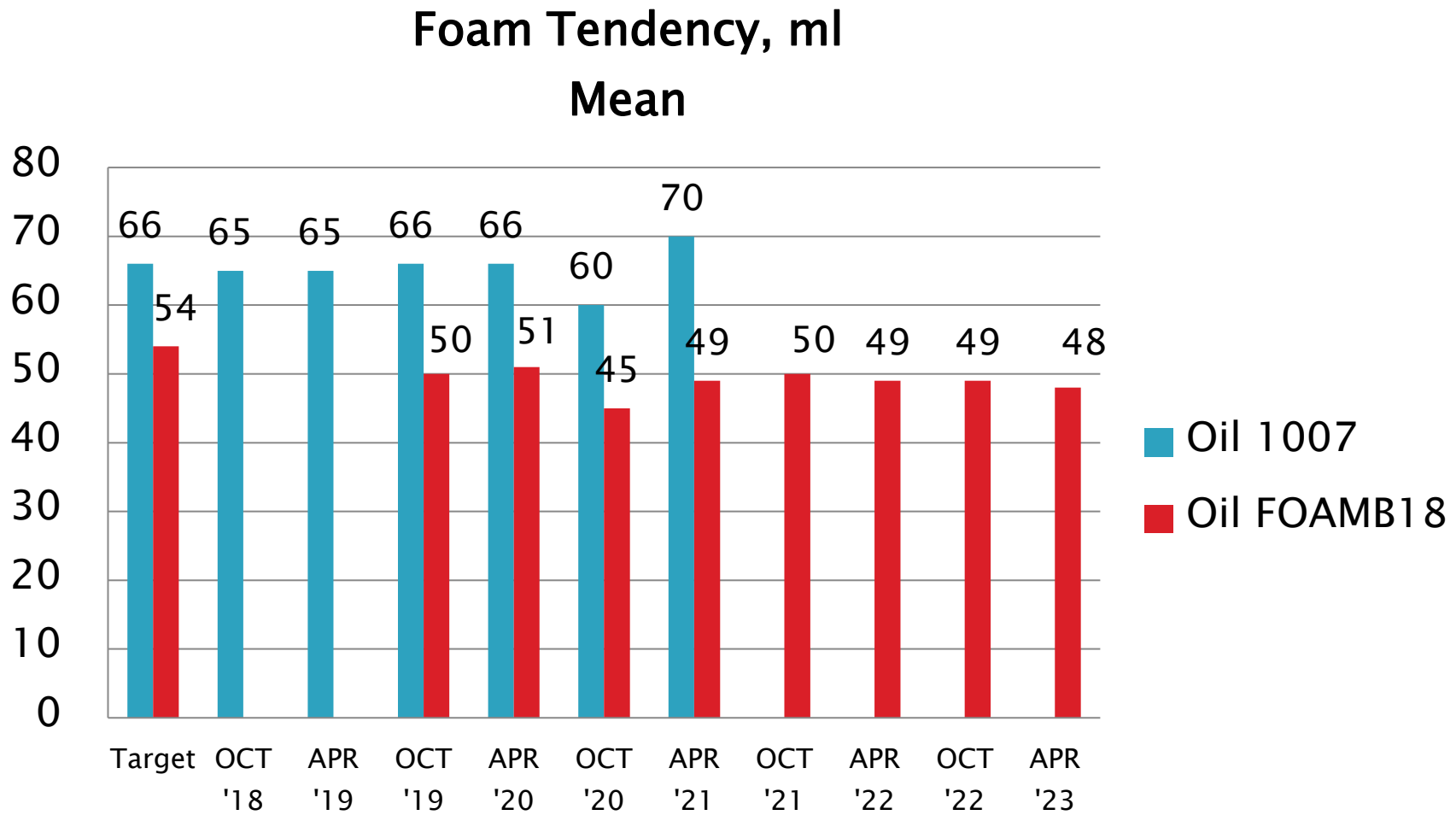
[1]Target precision updated to current reference oil FOAMB18

D6082: High Temperature Foam

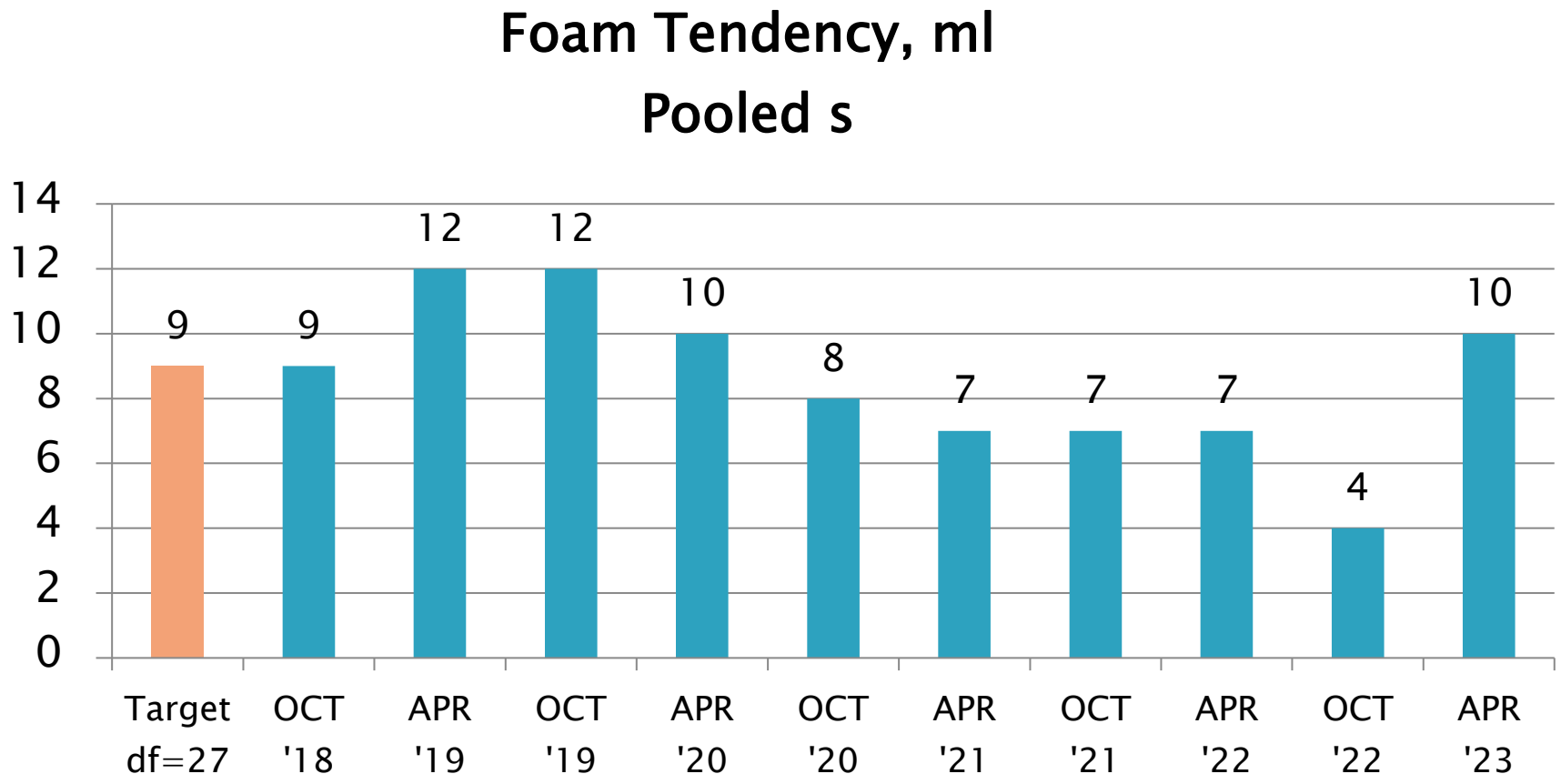
Period Precision and Severity Estimates

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

D6082 Performance by Oil



D6082: High Temperature Foam



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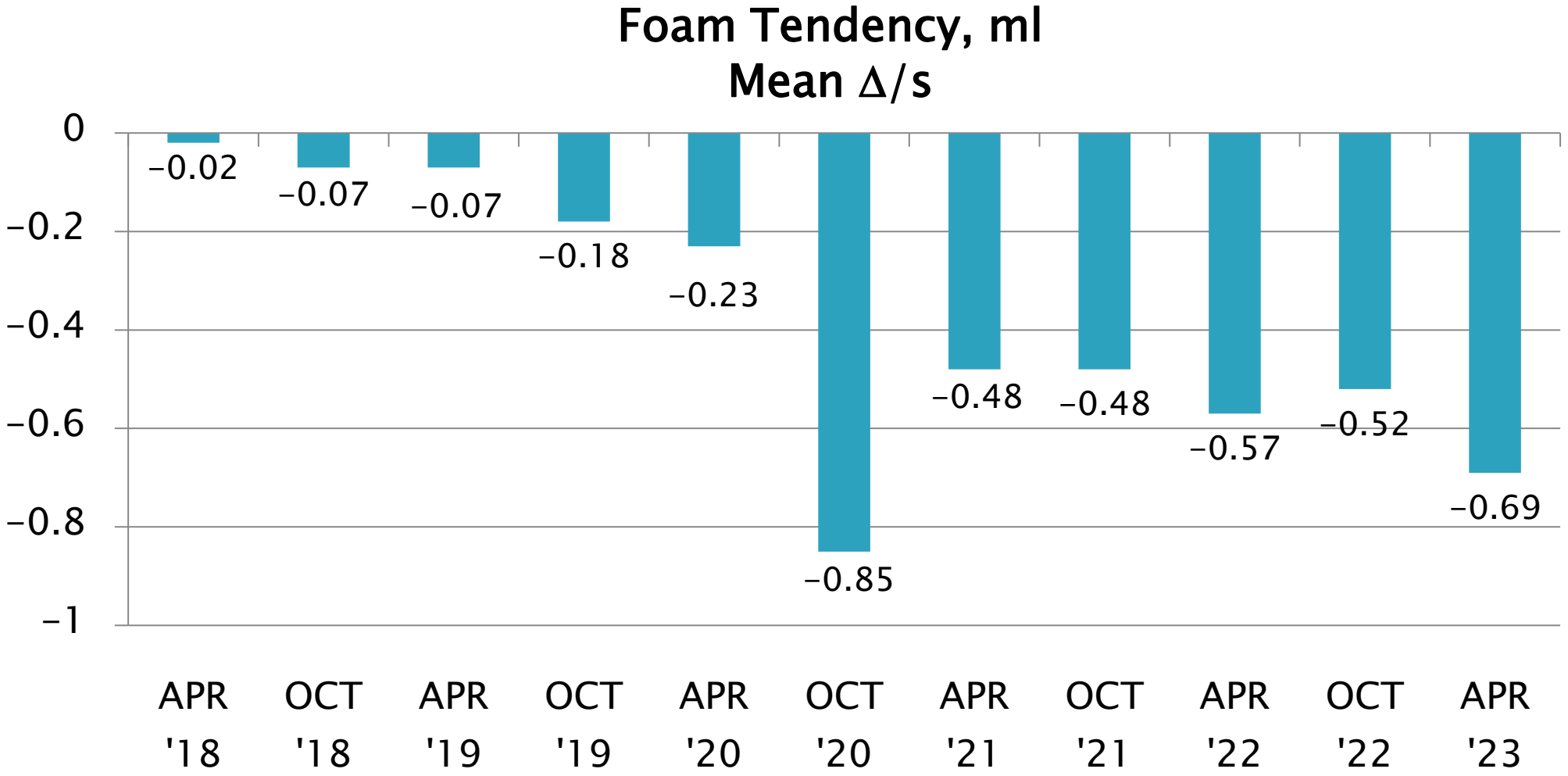
D6082: High Temperature Foam



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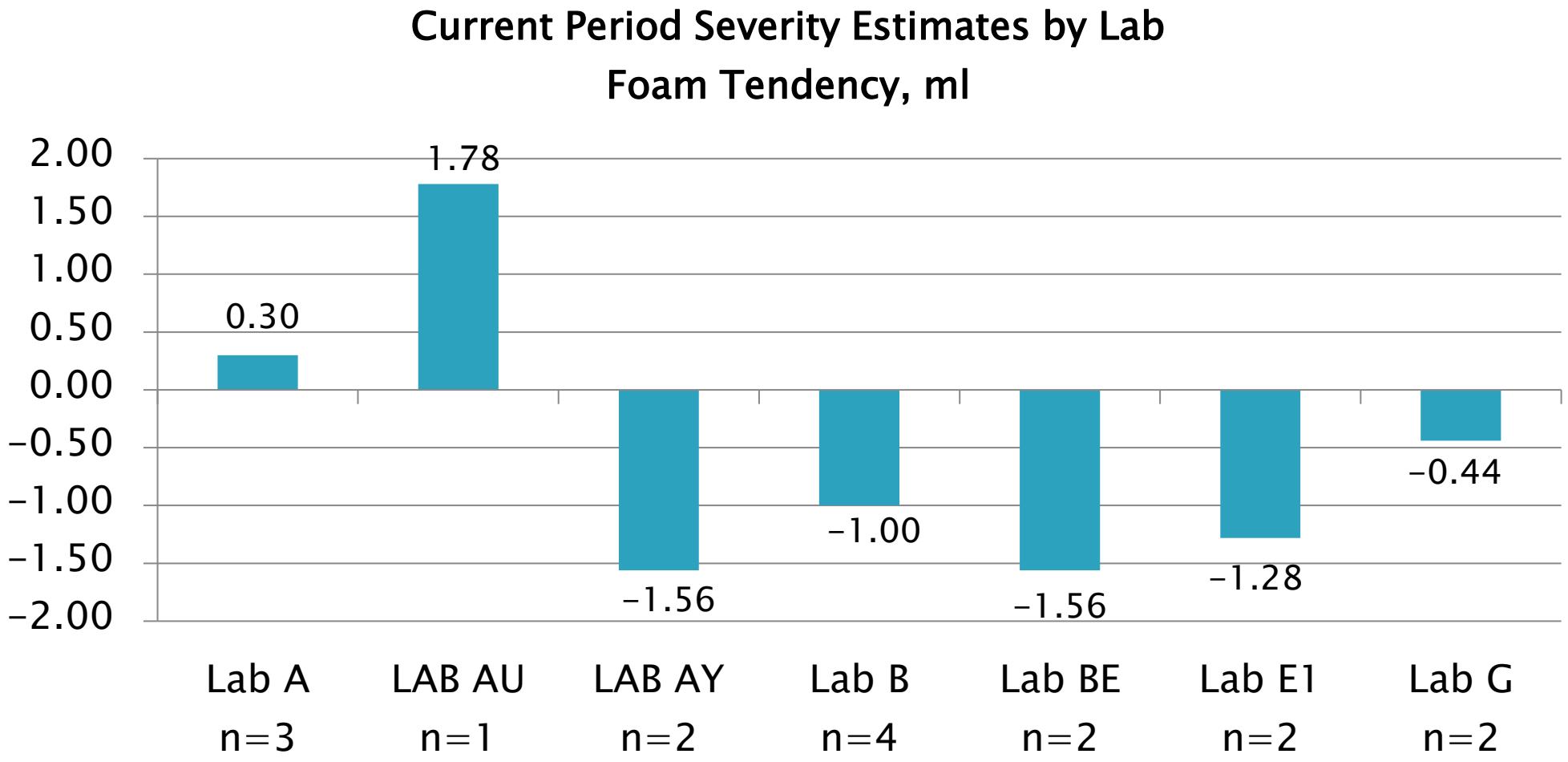
D6082: High Temperature Foam



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D6082: High Temperature Foam

- Foam Tendency Precision (Pooled s) is higher than last period but on-target
  - More precise than oil FOAMB18 target precision
    - Oil 1007 has been completely consumed. Fourth consecutive report period where all reference tests were conducted only on replacement oil FOAMB18.
- Performance (Mean Δ/s) is -0.69s mild
  - Fourth consecutive period of -0.5+ s mild performance with FOAMB18.
    - Target performance, set on 18 runs in a RR, may need revisited.
- No non-zero occurrences of Foam Stability
- All seven severe oil discrimination runs (on TMC oil 66) demonstrated acceptable discrimination on foam tendency (>100 ml).

D6082 HIGH TEMPERATURE FOAM INDUSTRY OPERATIONALLY VALID DA

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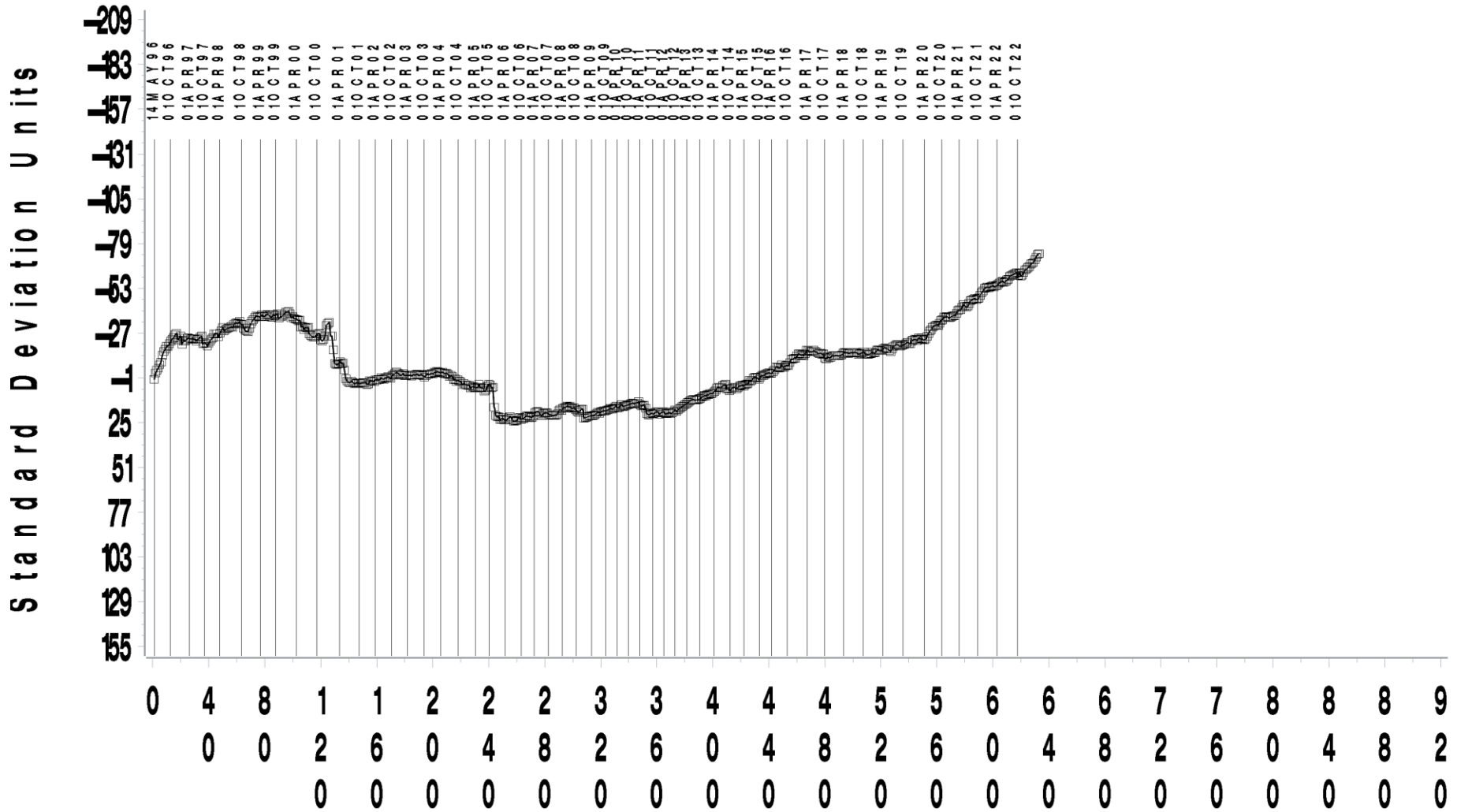
FOAM TENDENCY

CUSUM Severity Analysis



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D6082 HIGH TEMPERATURE FOAM INDUSTRY OPERATIONALLY VALID DA
LAST 120 POINTS
FOAM TENDENCY

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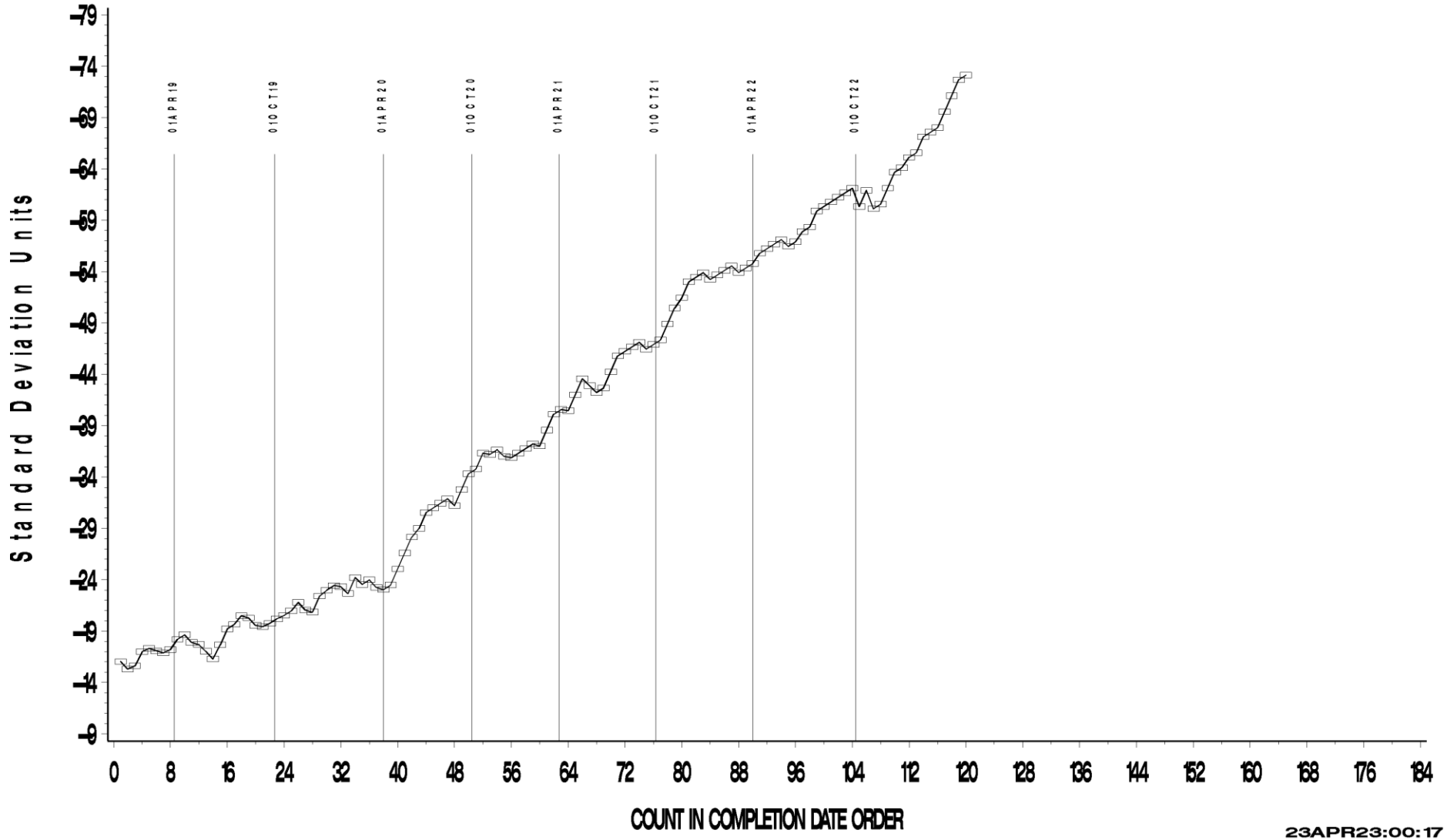
CUSUM Severity Analysis



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D02.B0.07
TMC Monitored Tests

ASTM D 6335

TEOST

October 1, 2022 – March 31, 2023

Test Monitoring Center
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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D6335	8 (+0)	13 (+0)
*As of 3/31/2023		

D6335: Deposits by TEOST-33C

Test Status	Validity Code	No. Tests
Acceptable Calibration Tests	AC	28
Failed Calibration Tests	OC	7
Acceptable Discrimination Tests	AS	1
Acceptable Non-Blind / Informational Runs	NI, NN	6
Operationally Invalidated by Lab	LC	3
Total		**45**

Number of Labs Reporting Data: 8 (8 Labs Last Period)
Fail Rate of Operationally Valid Tests: 20.0% (13.8% Last Period)

D6335: Deposits by TEOST-33C

Statistically Unacceptable Tests (OC)	No. Of Tests
Total Deposits Severe	7

- The seven (7) statistically unacceptable results this period were fails on four stands (A1, G3, G4 and P1); all seven results severe of target.
- There were three operationally invalid tests reported this period.
  - One (1) Wrong Sample Ran by Lab
  - One (1) Lab had faulty Pump
  - One (1) Wrong Sample Batch Delivered to Lab
- No new Information Letters or Memos in the past year

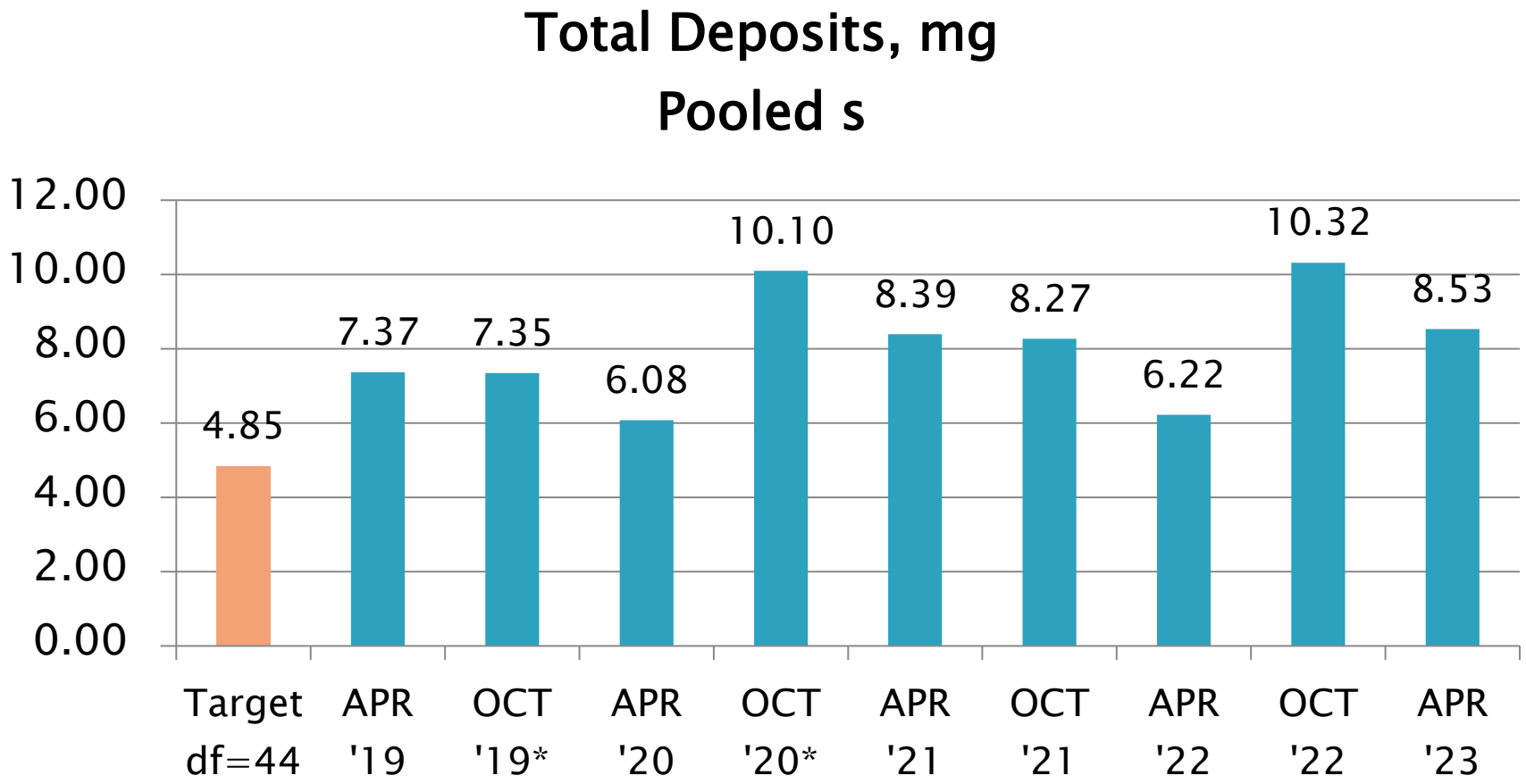
D6335: Deposits by TEOST-33C

Period Precision and Severity Estimates

Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Updated Targets 20201001[1]	46	44	4.85	-----
4/1/17 through 9/30/19[2]	30	28	12.66	0.47
4/1/17 through 9/30/19[2]	26	24	7.35	-0.23
10/1/19 through 3/31/20	32	30	6.08	0.28
4/1/20 through 9/30/20[3]	33	30	11.44	0.02
4/1/20 through 9/30/20[3]	26	23	10.10	-0.02
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

[1]Target precision updated to include only current oils 75-1 and 435-2
[2]Four consecutive OC results on same rig included and excluded.
[3]Rig with six OC results included and excluded.

D6335 Precision Estimates



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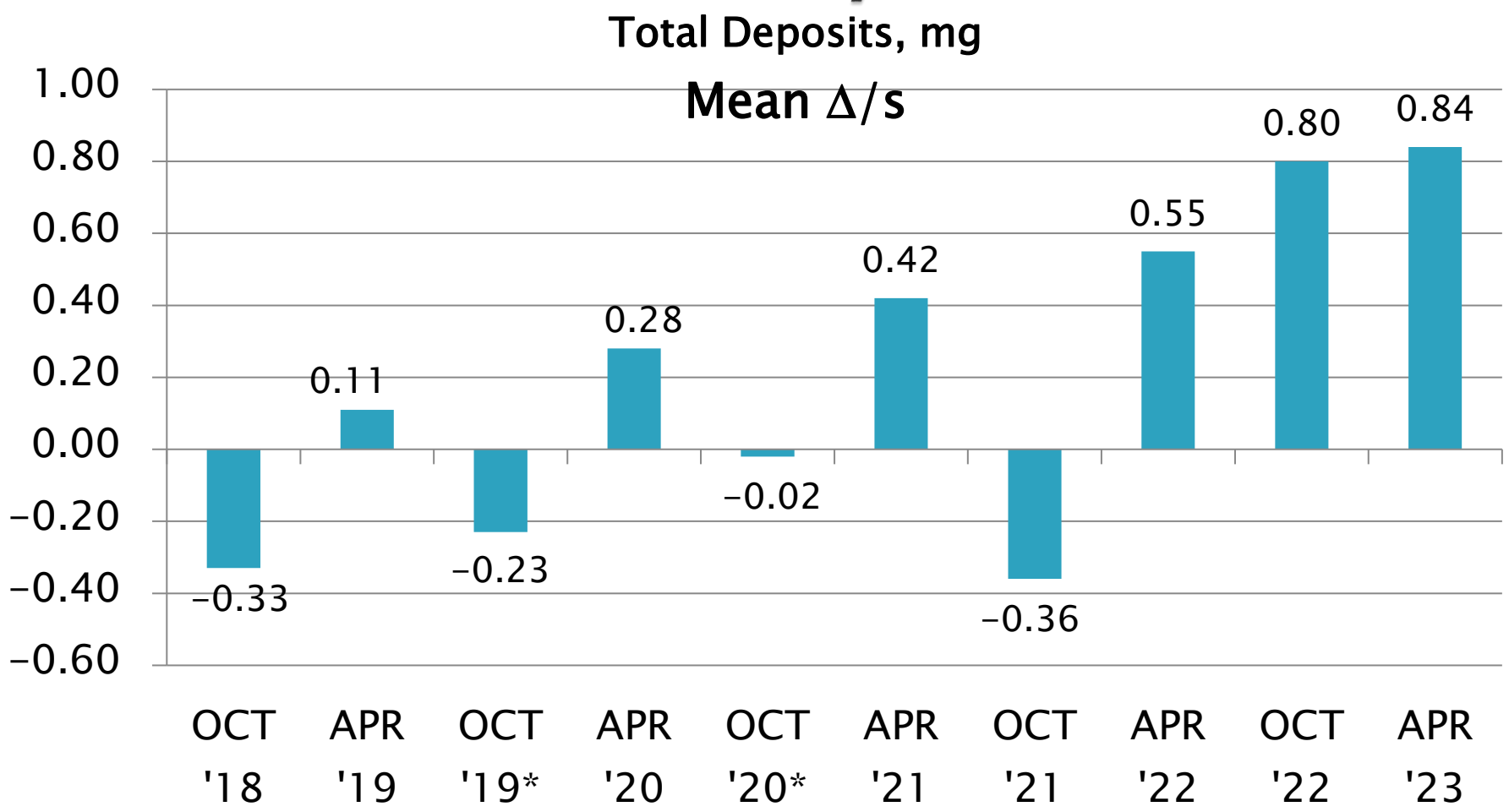
D6335 Severity Estimates



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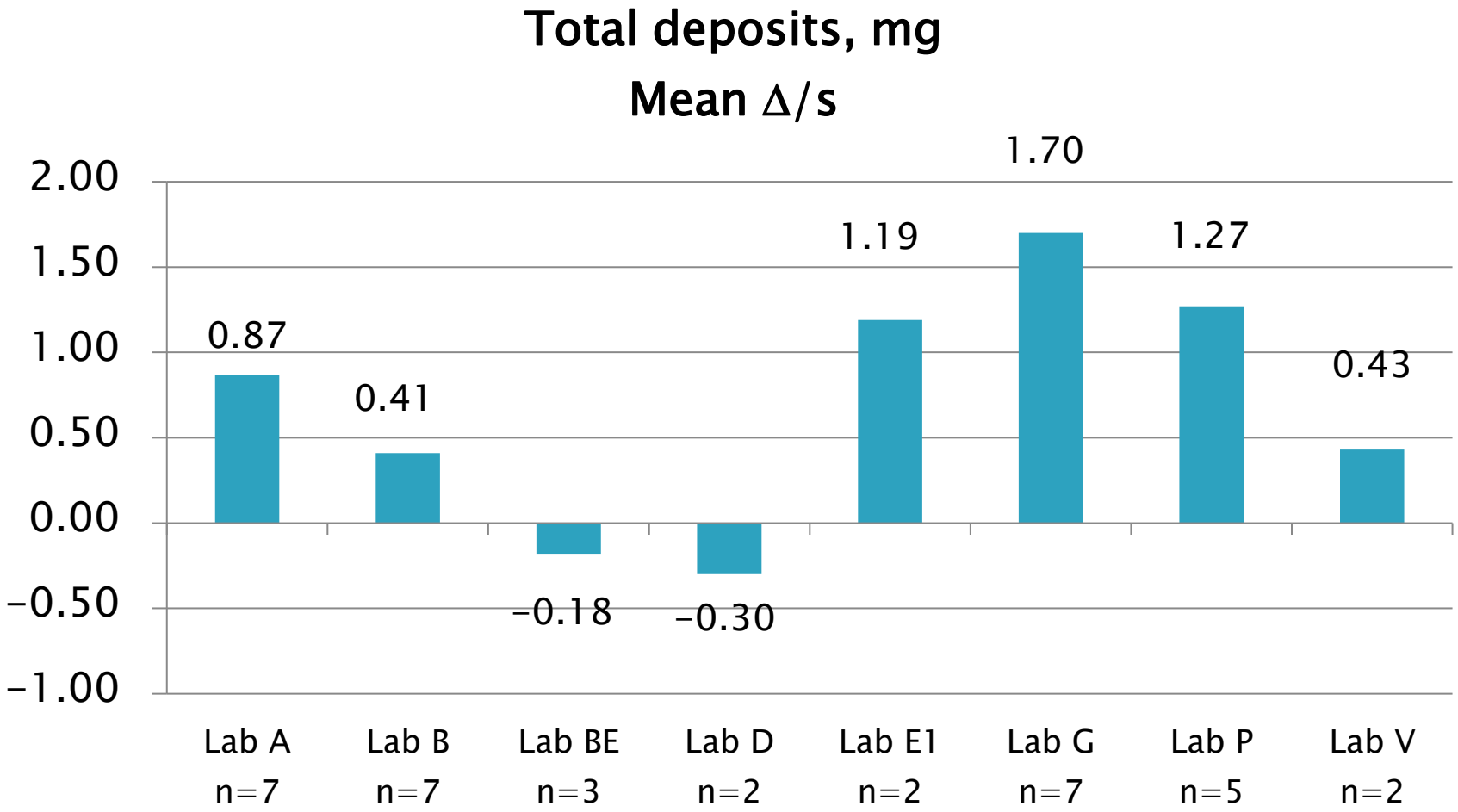
D6335 Lab Severity Estimates



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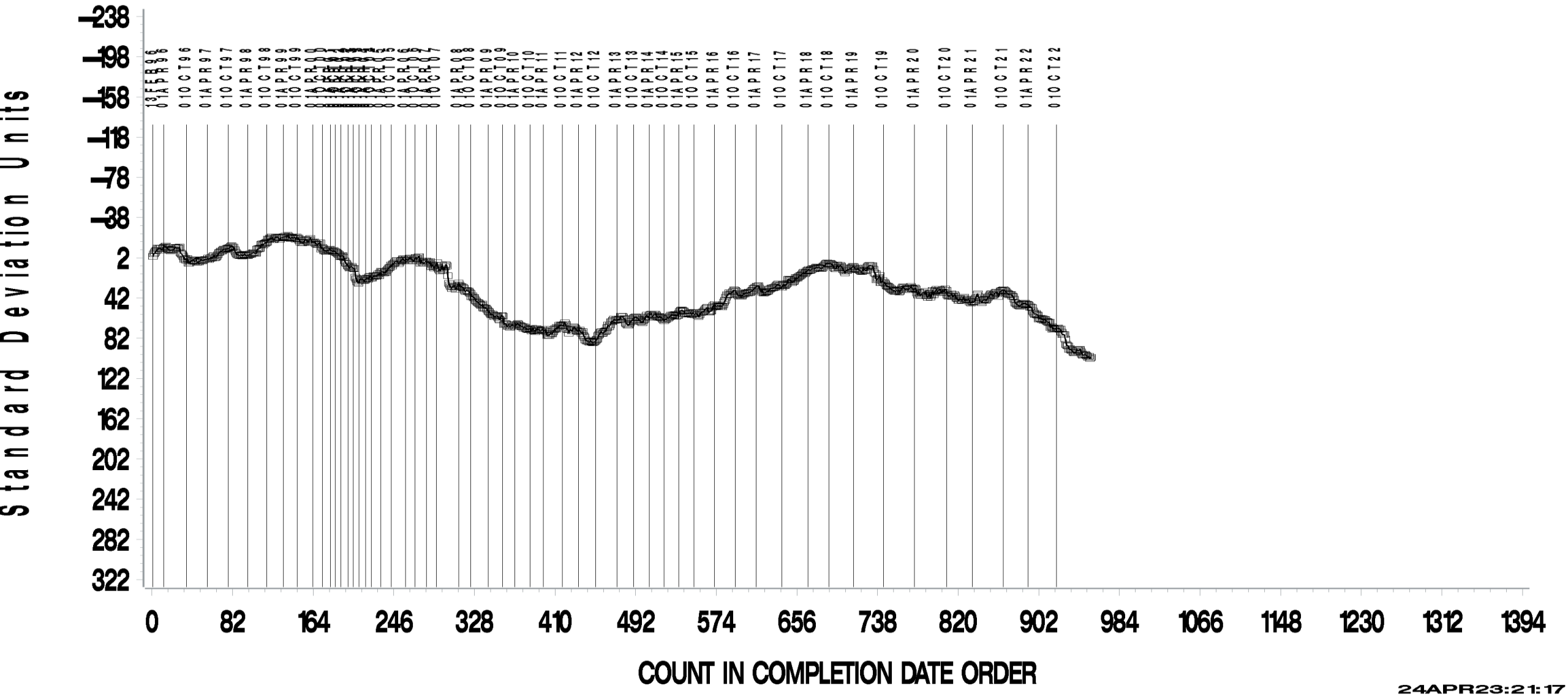
D6335: Deposits by TEOST-33C

- Precision (Pooled s) is better when compared to the previous period (8.53 vs 10.32 in OCT '22)
  - There were no tests reported using oil 75 for 3rd consecutive period
- Performance (Mean Δ/s) is 0.84 s severe this period (comparable to 0.80 s last period)
- Period fail rate of 20% on tests reported as operationally valid
  - Fail rate continues to climb (7.0% -> 13.8% -> 20%) when compared to last two six-month reporting periods.
  - All on Rod Batch N
  - Four Units had Seven fails from Three labs
- All tests this period report using Rod Batch M (n=2) or N (n=33).

TEOST —33C INDUSTRY OPERATIONALLY VALID DATA

TOTAL DEPOSITS MG

CUSUM Severity Analysis



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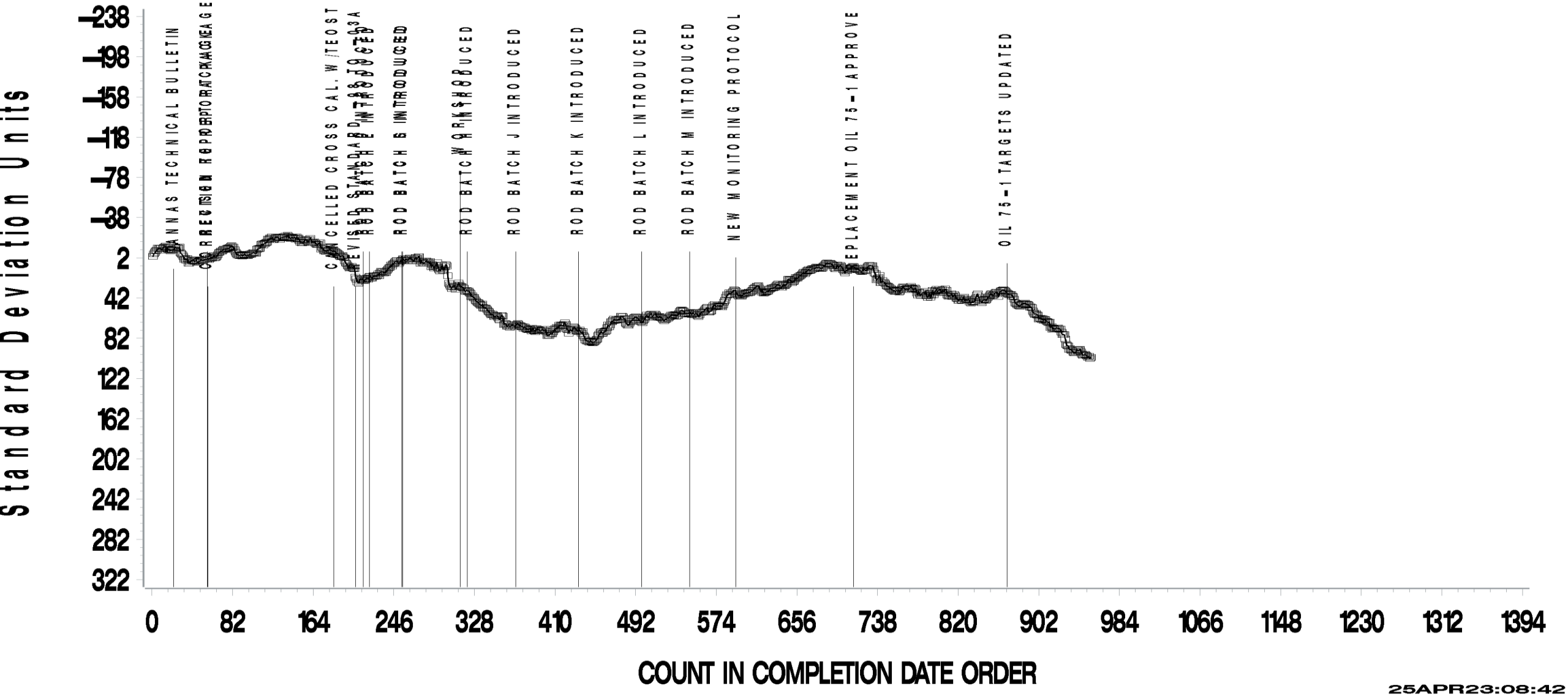
TEOST —33C INDUSTRY OPERATIONALLY VALID DATA

TOTAL DEPOSITS MG

CUSUM Severity Analysis



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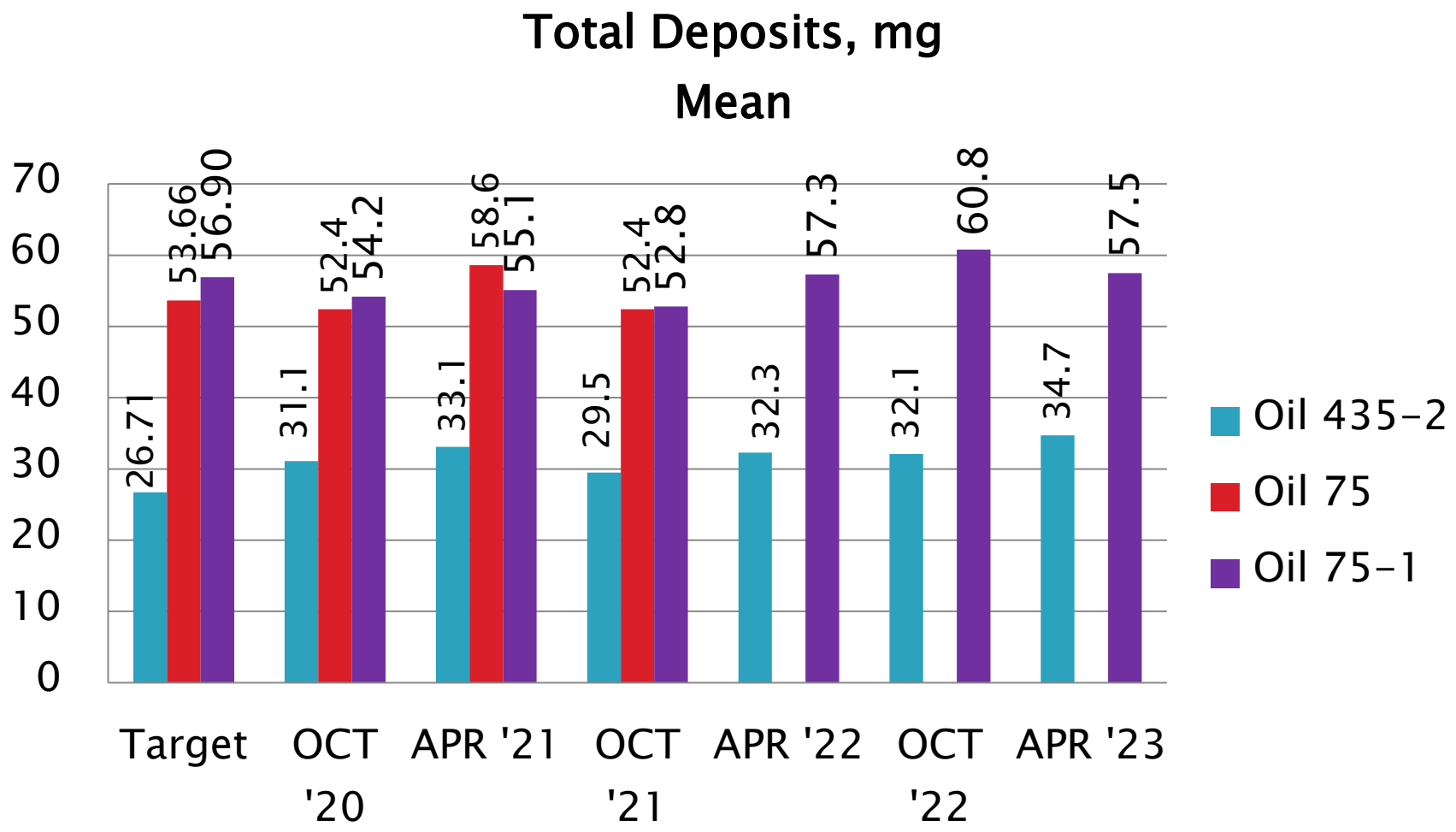
D6335 Performance by Oil



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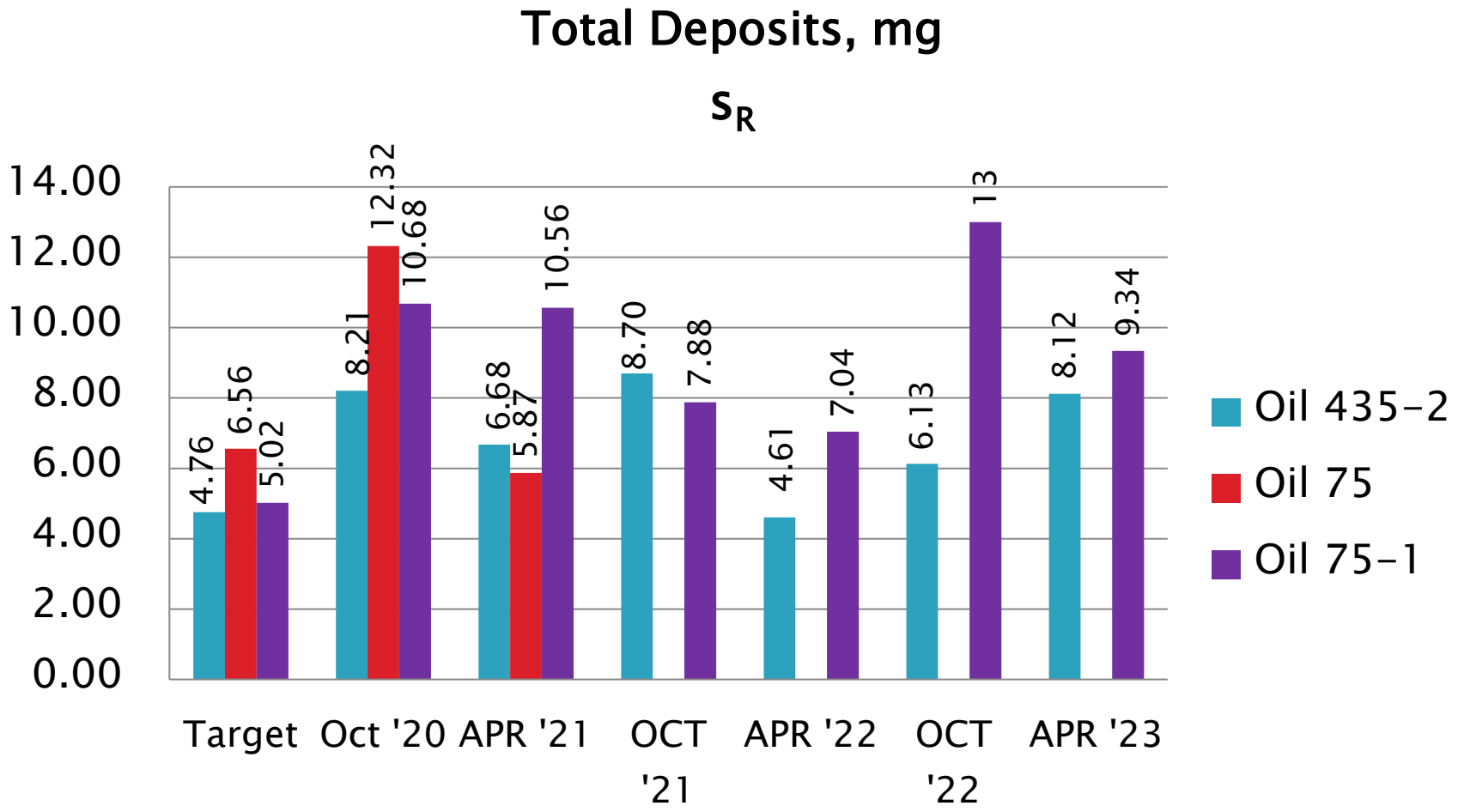
D6335 Performance by Oil



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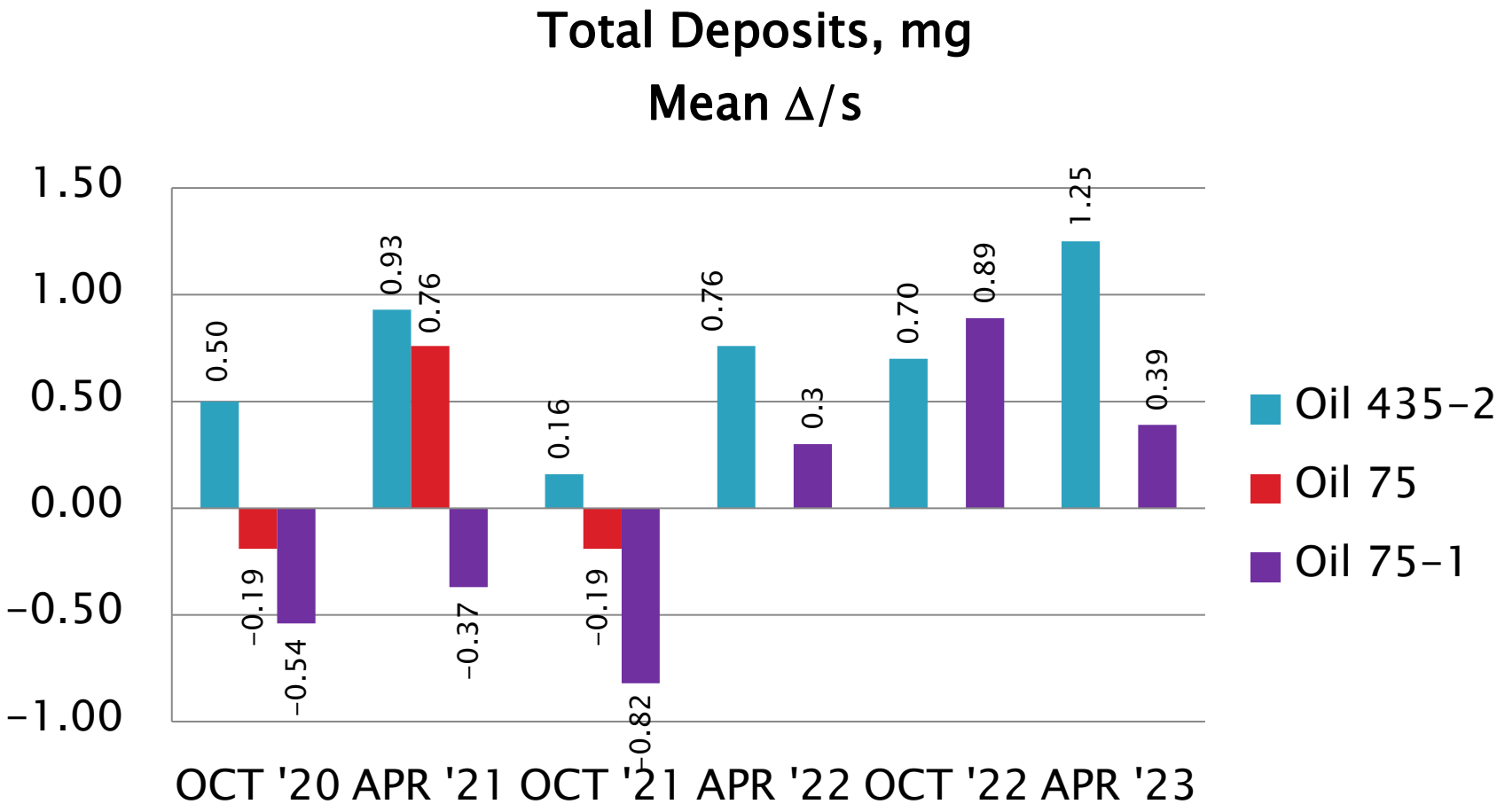
D6335 Performance by Oil



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D02.B0.07
TMC Monitored Tests

» ASTM D 6417

October 1, 2022 – March 31, 2023

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TMC
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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D6417	7 (+0)	9 (+0)
*As of 3/31/2023		

D6417: Estimation of Engine Oil Volatility by Capillary GC

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	18
Failed Calibration Test	OC	0
Total		**18**

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

D6417: Estimation of Engine Oil Volatility by Capillary GC

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

- There were no statistically invalid tests reported this period
- There were no operationally invalid tests reported this period
- No D6417 TMC technical updates were issued this report period.

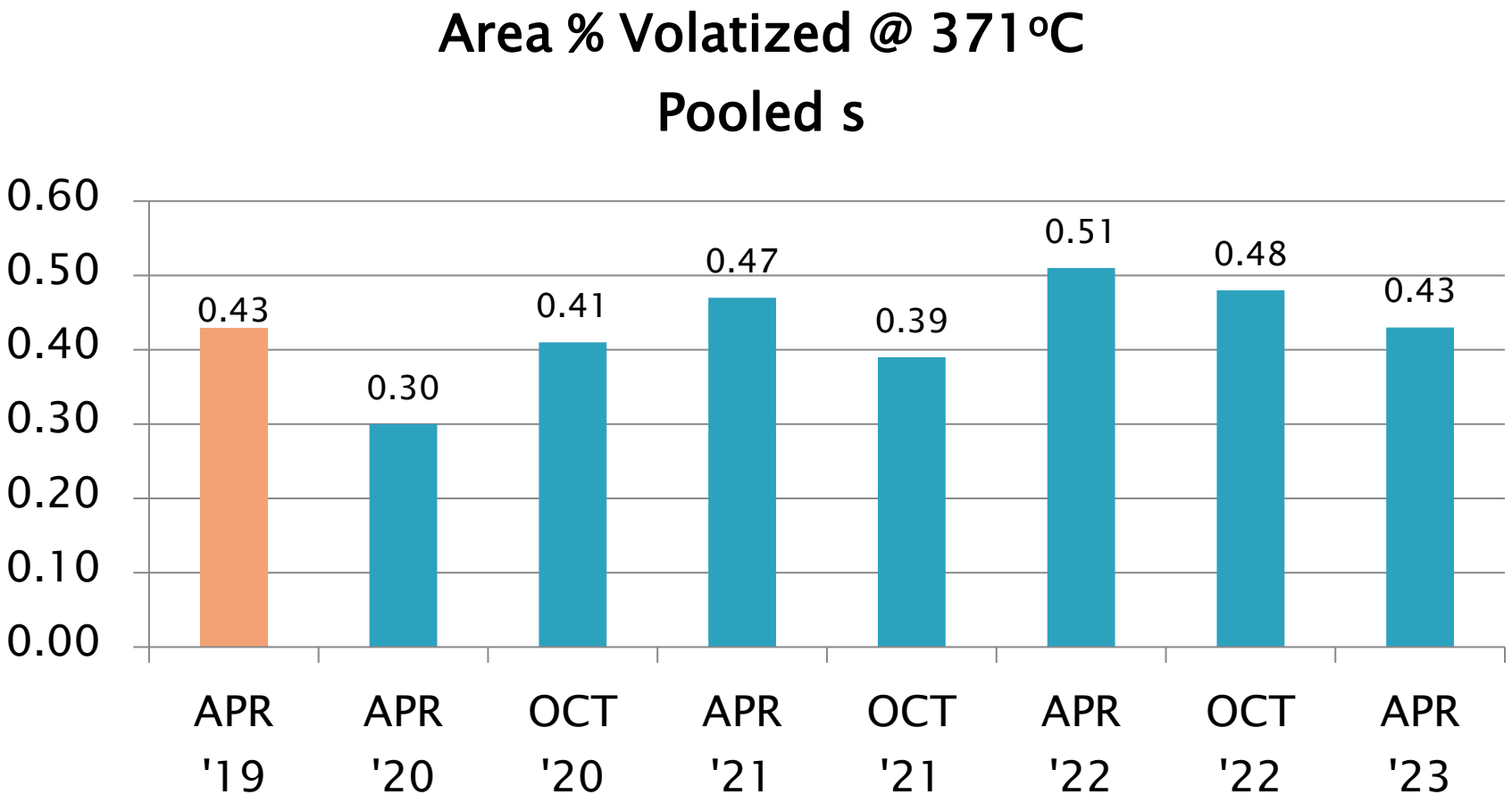
D6417: Estimation of Engine Oil Volatility by Capillary GC

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	-----
10/1/19 through 3/31/20	17	14	0.30	0.09
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

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

D6417 Precision Estimates



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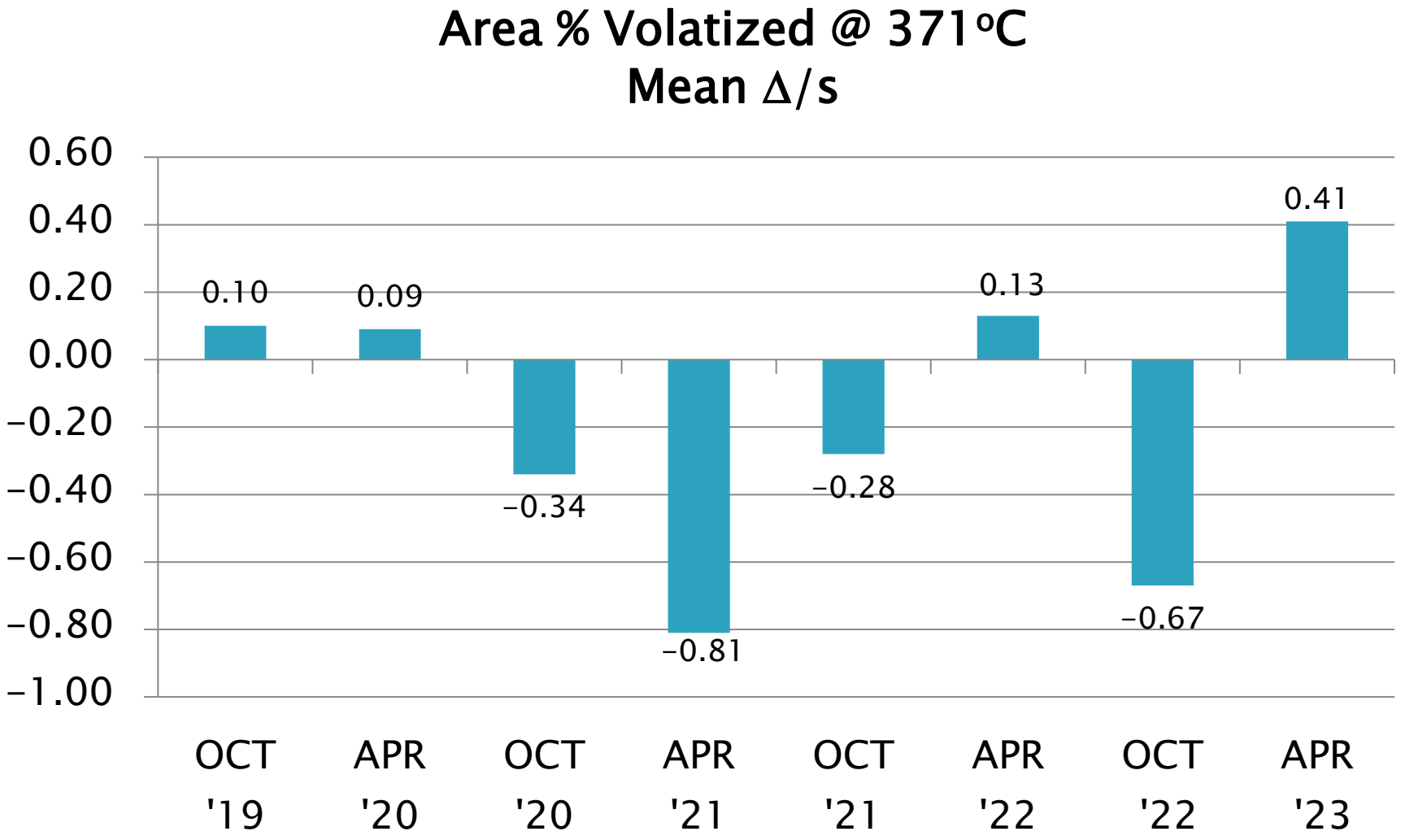
D6417 Severity Estimates



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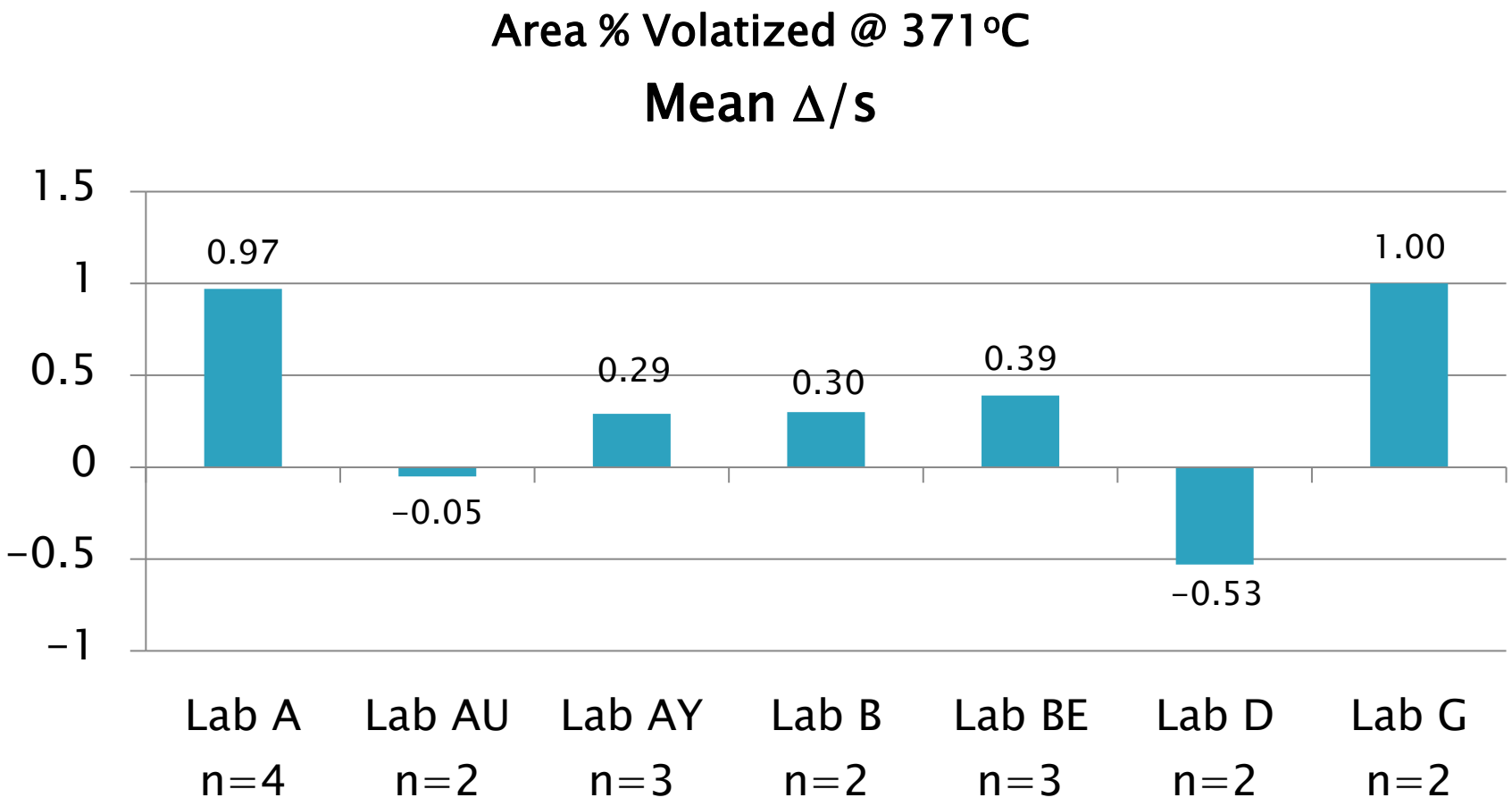
D6417 Lab Severity Estimates



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D6417: Estimation of Engine Oil Volatility by Capillary GC

- Precision (Pooled s) has been very consistent over the past 6 semesters.
- Performance (Mean Δ/s) has flipped to +0.41 s severe but closer to target compared to prior reporting period (-0.67 s).
- CUSUM severity plot is currently in a MILD trend but has been relatively “flat” for the past three semesters, circling around CUSUM value of 19.7 during this time.

D6417 VOLATILITY BY GC INDUSTRY OPERATIONALLY VALID DATA

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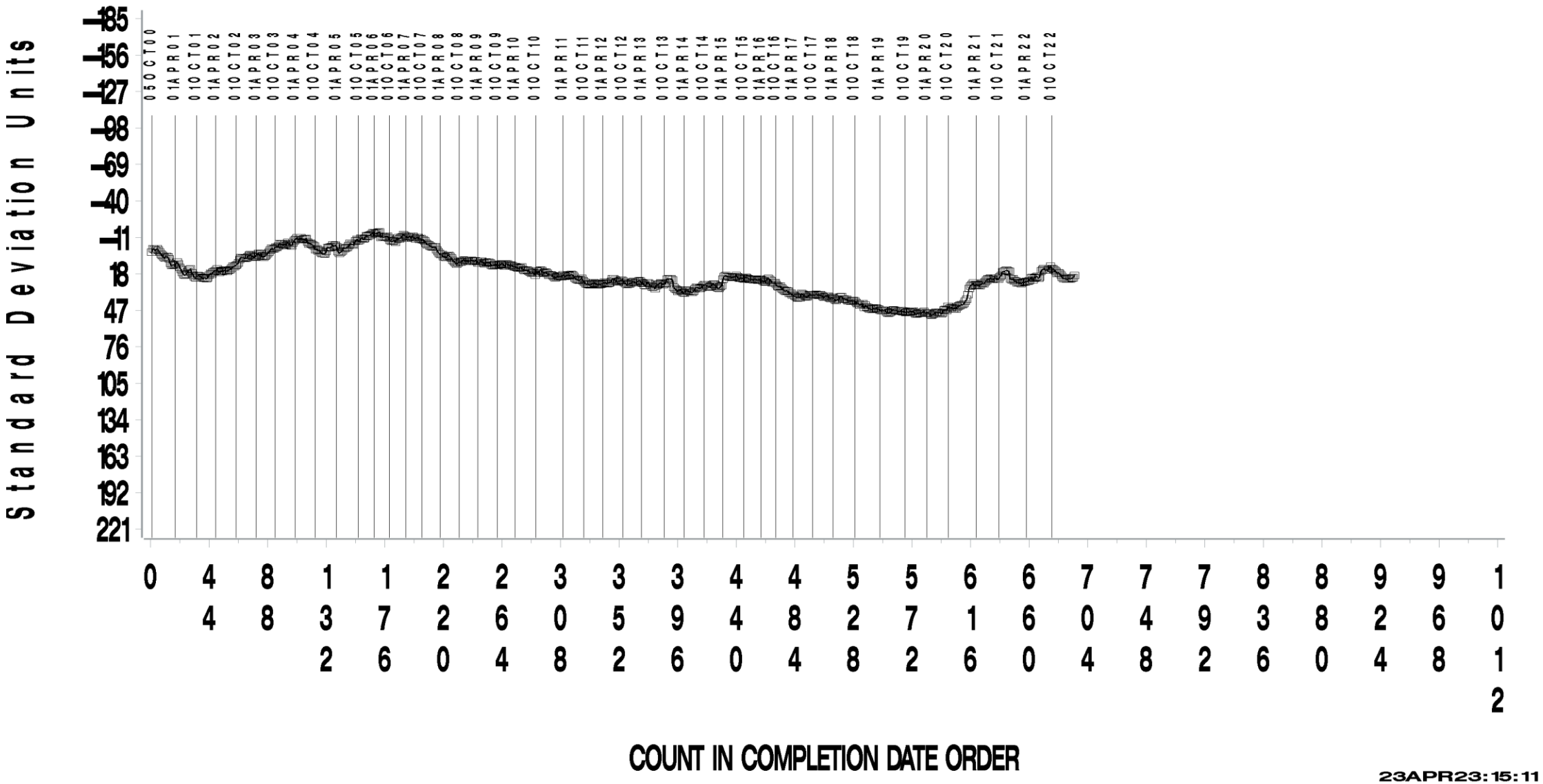
SAMPLE AREA % VOLATIZED

CUSUM Severity Analysis



23APR23:15:11

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

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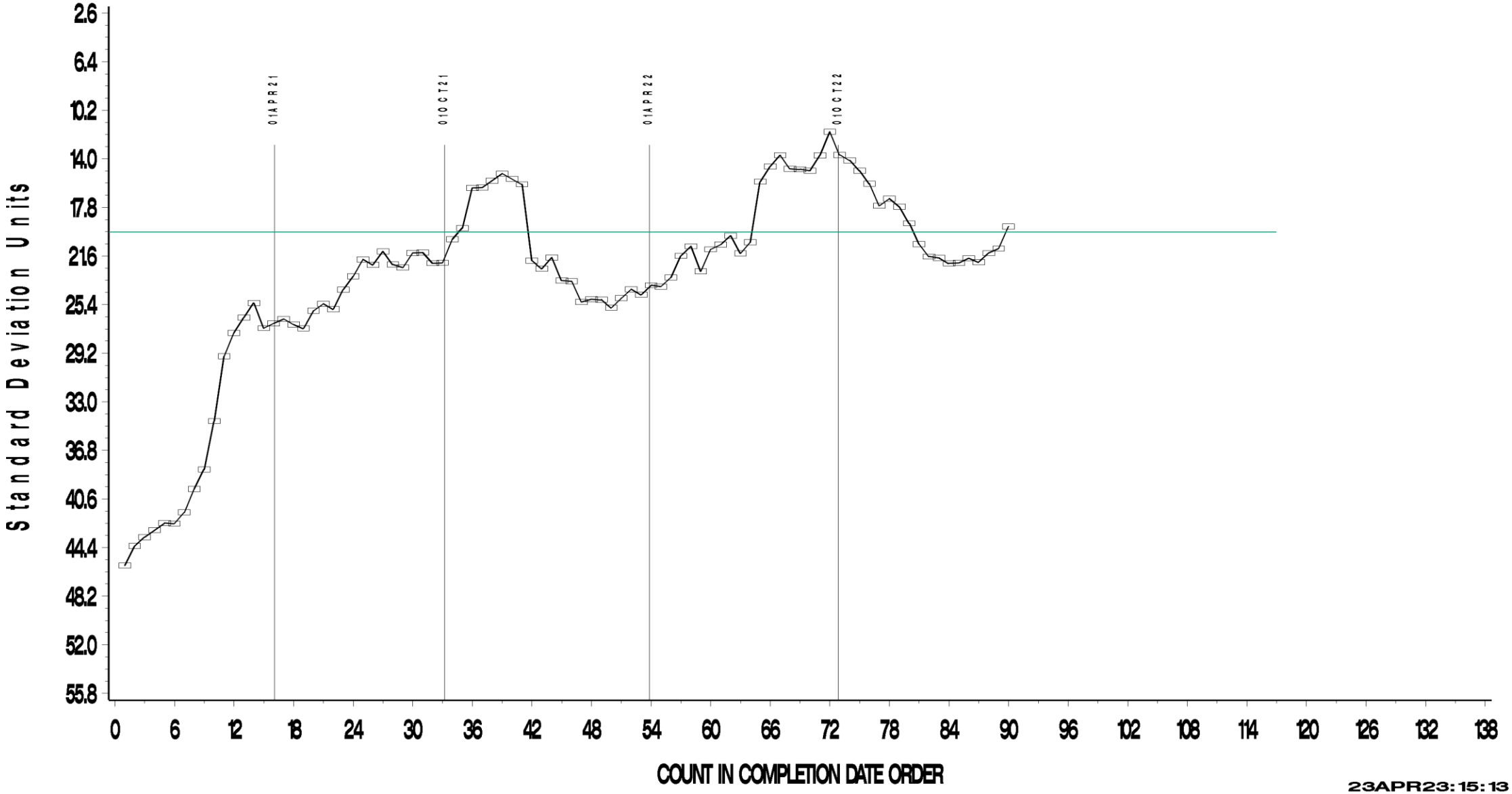
CUSUM Severity Analysis



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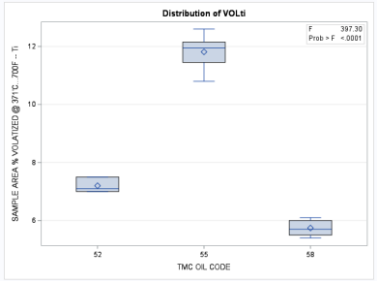
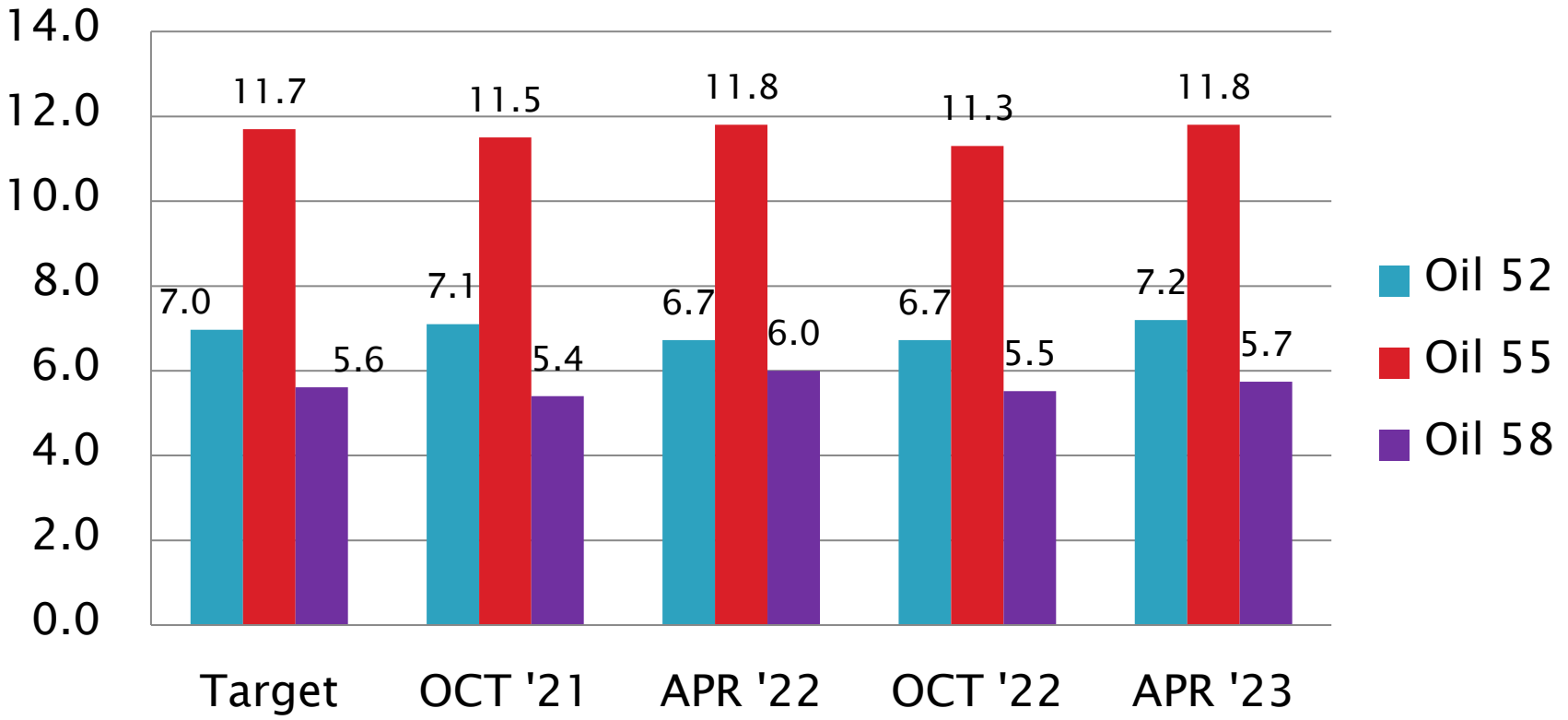
D6417 Performance by Oil



Area % Volatized @ 371°C

Mean



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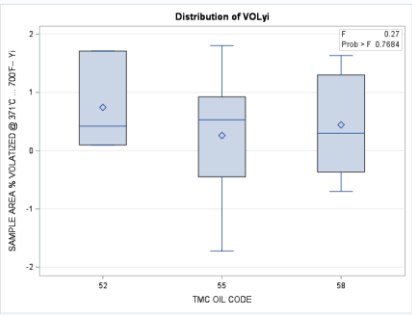
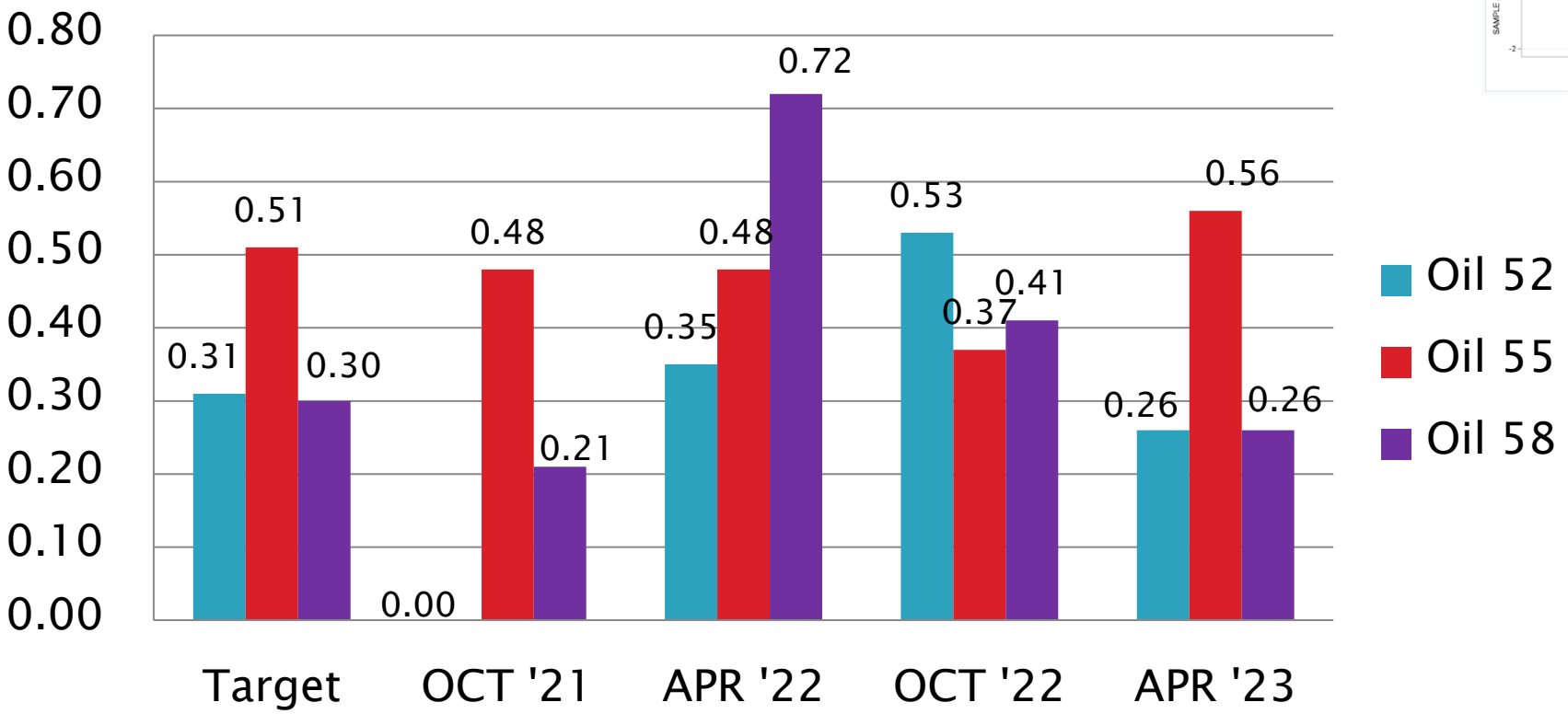
D6417 Performance by Oil



Area % Volatized @ 371°C

Standard Deviation



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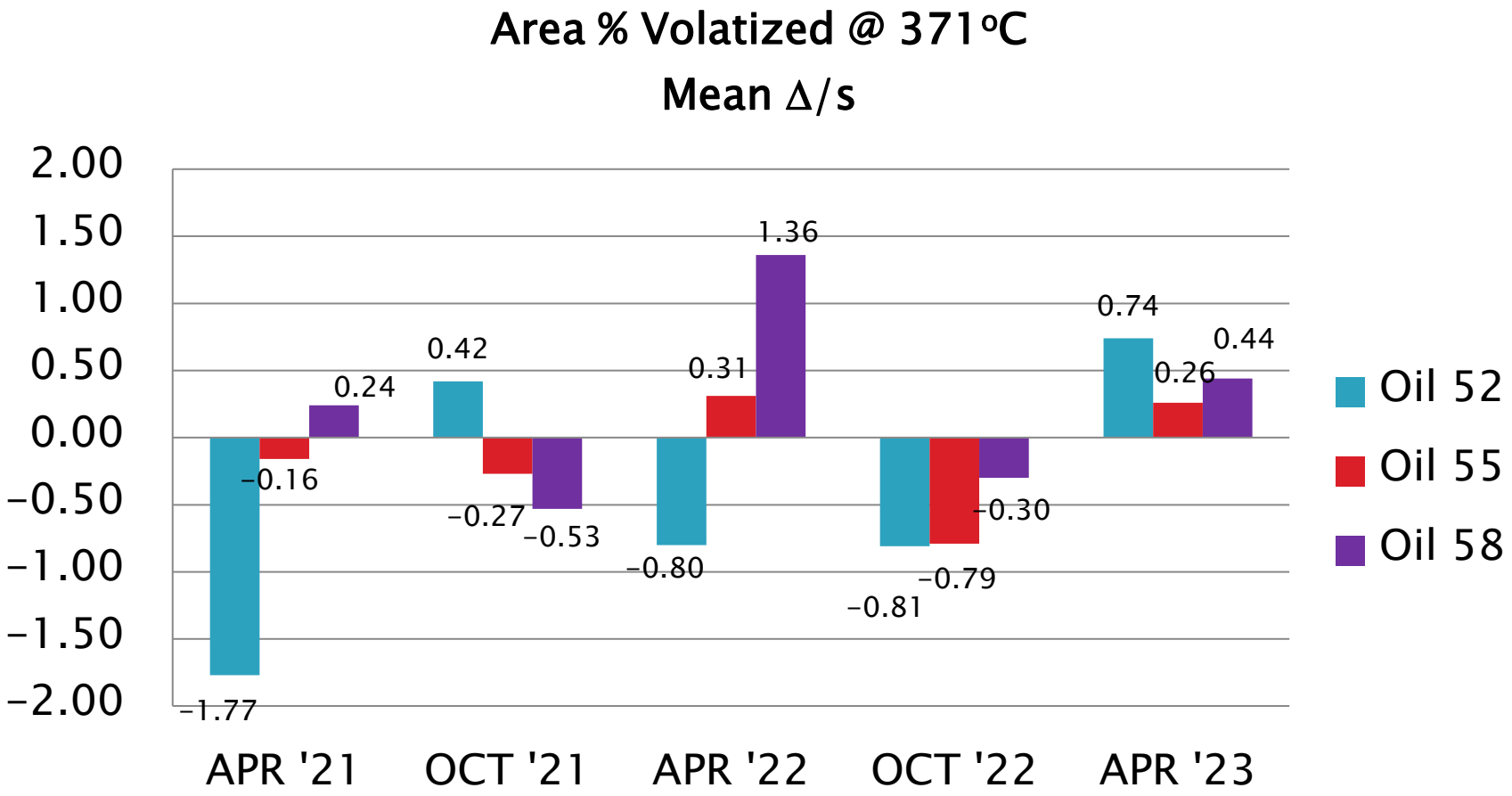
D6417 Performance by Oil



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D02.B0.07
TMC Monitored Tests

ASTM D 6557

Ball Rust Test (BRT)

October 1, 2022 – March 31, 2023

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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D6557	5 (–1)	5 (–2)
*As of 3/31/2023		

BRT Test Activity*

Test Status	Validity Code	Number of Tests
Acceptable Calibration Test	AC	154
Failed Calibration Test	OC	13
Operationally Invalid, by Lab	LC	16
Aborted Calibration Run	XC	2
Acceptable Shakedown Run	NN	2
Unacceptable Shakedown Run	MN	4
Total		**191**

- 5 labs reported data

*April 1, 2022 – September 30, 2022

BRT Failed Tests

Failed Parameter (OC)	Number of Tests
Severe Average Gray Value	13
Mild Average Gray Value	0
Total	**13**

Failed Parameter (MN)	Number of Tests
Severe Average Gray Value	2
AGV Difference between tubes > 15	2
Total	**4**

BRT Failed Tests (OC) by Lab

Failed Parameter	LTMS Lab					#
	A	B	D	G	L	
Severe Average Gray Value	2	2	1	8	0	13
Mild Average Gray Value	0	0	0	0	0	0
Total	2	2	1	8	0	13

BRT Lost Tests*

Failed Parameter (LC, XC)	Number of Tests
Acid Batch Off-Spec (LC)	15
Shaker Table Malfunction (LC)	1
Acid Injector Malfunction (XC)	1
Sample Leak (XC)	1
Total	**18**

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

BRT Lost Tests by Lab

Cause	LTMS Lab					#
	A	B	D	G	L	
Acid Batch Off-Spec	4	0	0	11	0	15
Acid Injector Malfunction	0	0	0	1	0	1
Sample Leak	0	0	0	1	0	1
Shaker Table Malfunction	1	0	0	0	0	1
Total	**5**	**0**	**0**	**13**	**0**	**18**

BRT Test Severity

- Average Gray Value (AGV) continues to trend slightly severe this semester after a MILD Peak last period. But overall, CUSUM has been relatively “flat” for the past six years (since April 2017).

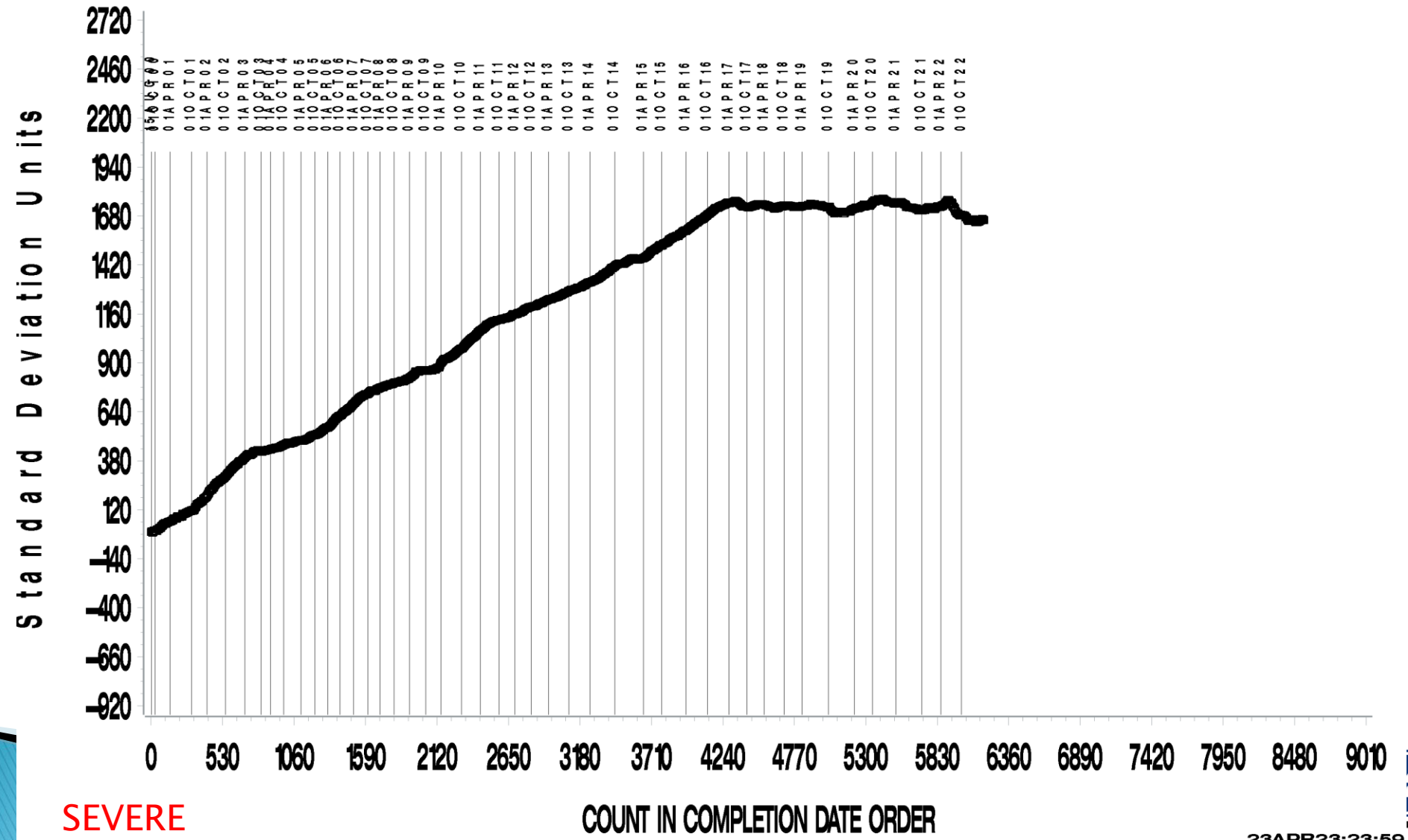
BALL RUST TEST INDUSTRY OPERATIONALLY VALID DATA

REFERENCE AVERAGE GRAY VALUE

MILD

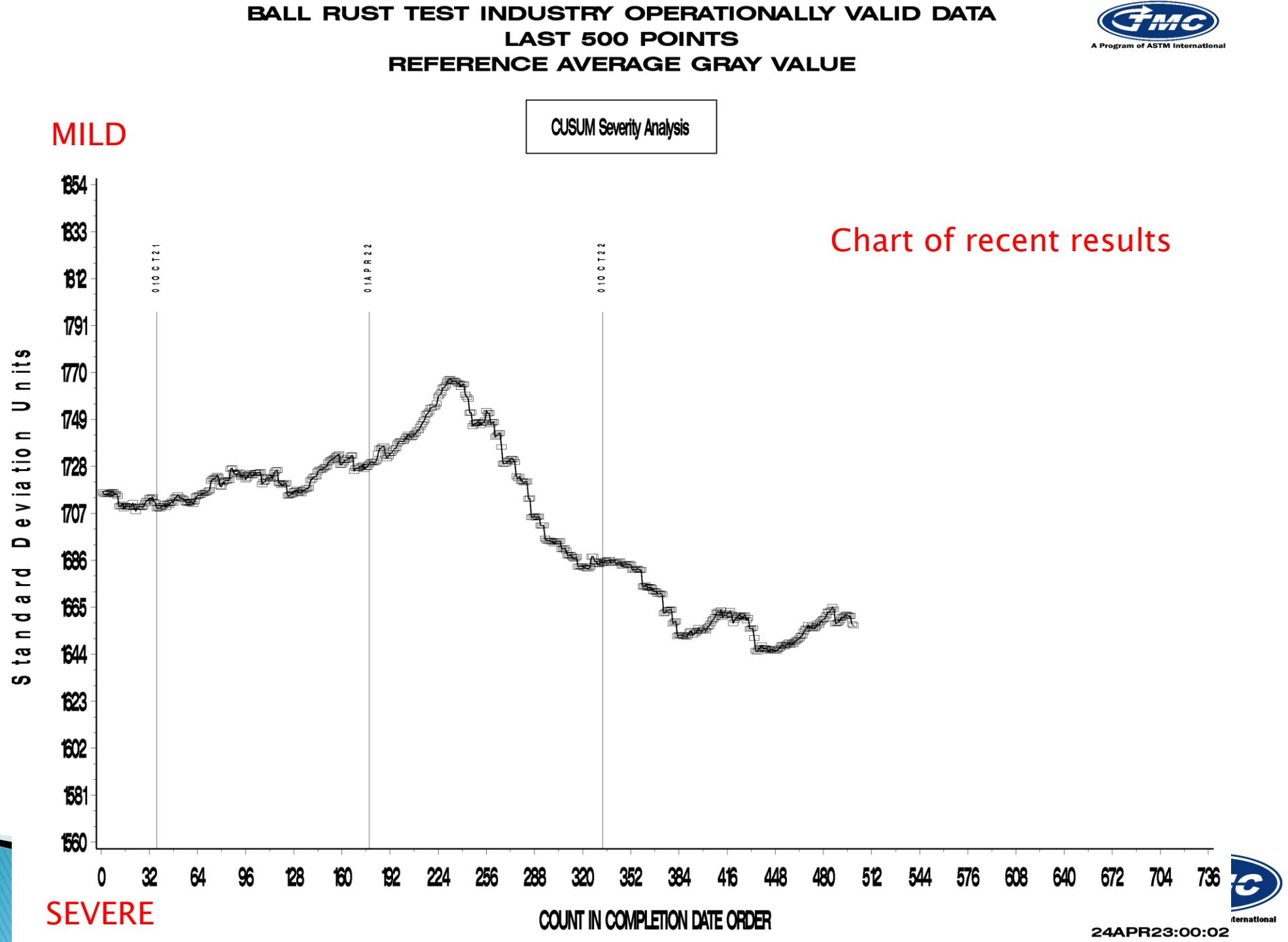
CUSUM Severity Analysis

Historical Chart

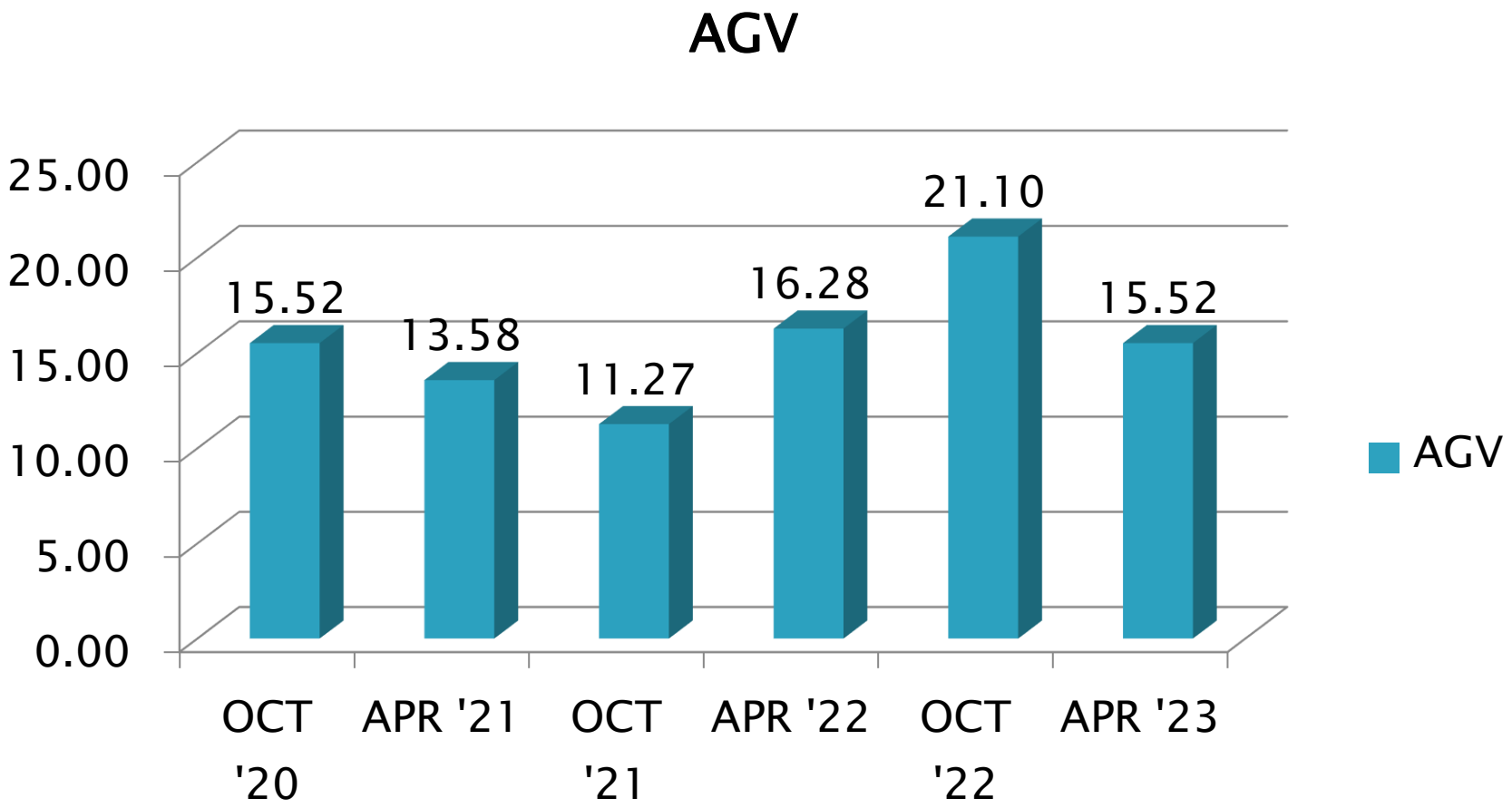


SEVERE

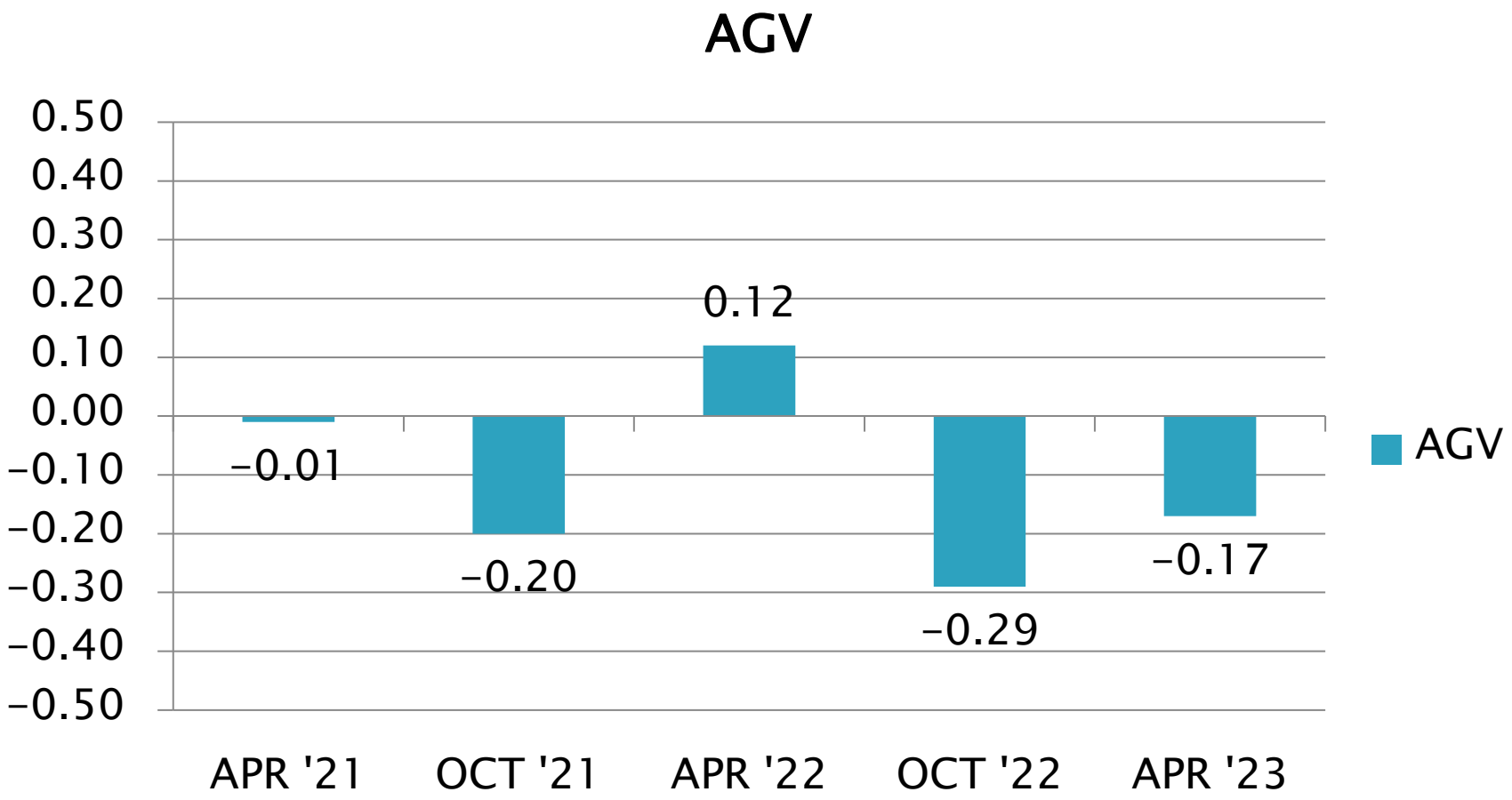
23APR23:23:59


BALL RUST TEST INDUSTRY OPERATIONALLY VALID DATA
LAST 500 POINTS
REFERENCE AVERAGE GRAY VALUE
A Program of ASTM International
MILD
CUSUM Severity Analysis
Chart of recent results
Standard Deviation Units
1854
1833
1812
1791
1770
1749
1728
1707
1686
1665
1644
1623
1602
1581
1560
01OCT21
01APR22
01OCT22
0
32
64
96
128
160
192
224
256
288
320
352
384
416
448
480
512
544
576
608
640
672
704
736
COUNT IN COMPLETION DATE ORDER
SEVERE
24APR23:00:02

BRT Precision (Pooled s) Estimates



BRT Performance (Mean Δ/s) Estimates



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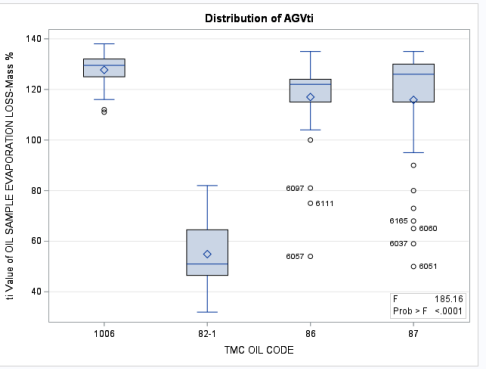
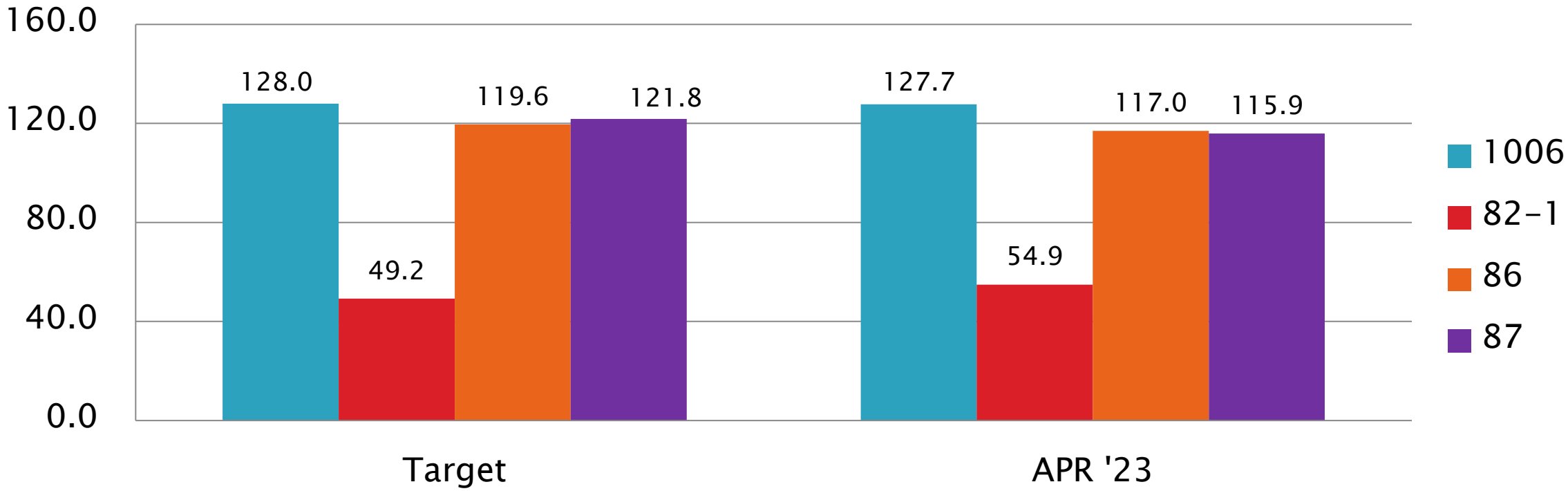
BRT Performance by OIL



Average Gray Value
Mean



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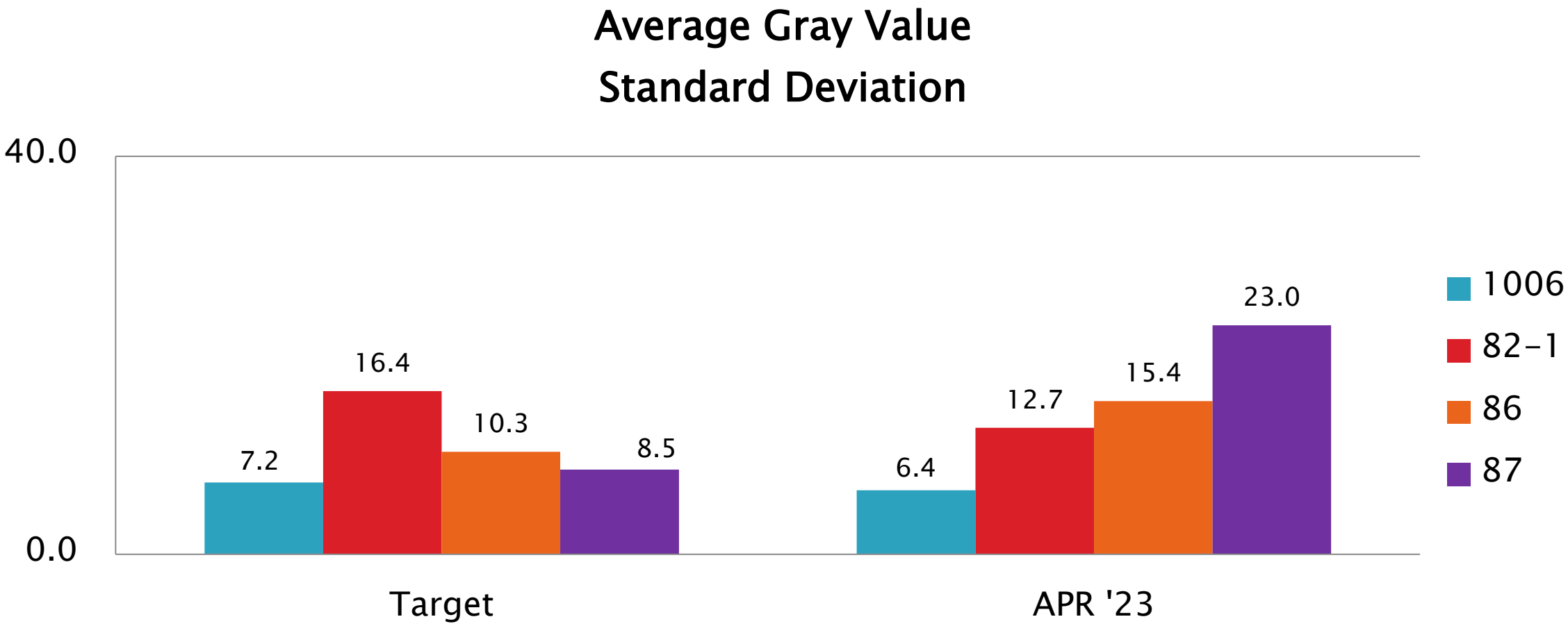
BRT Performance by OIL



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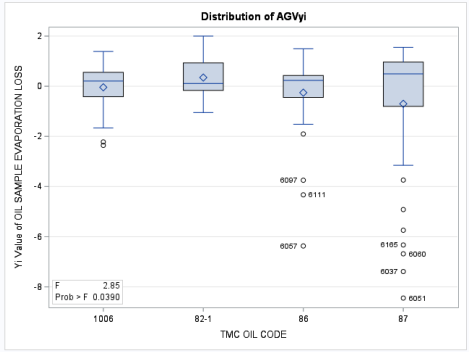
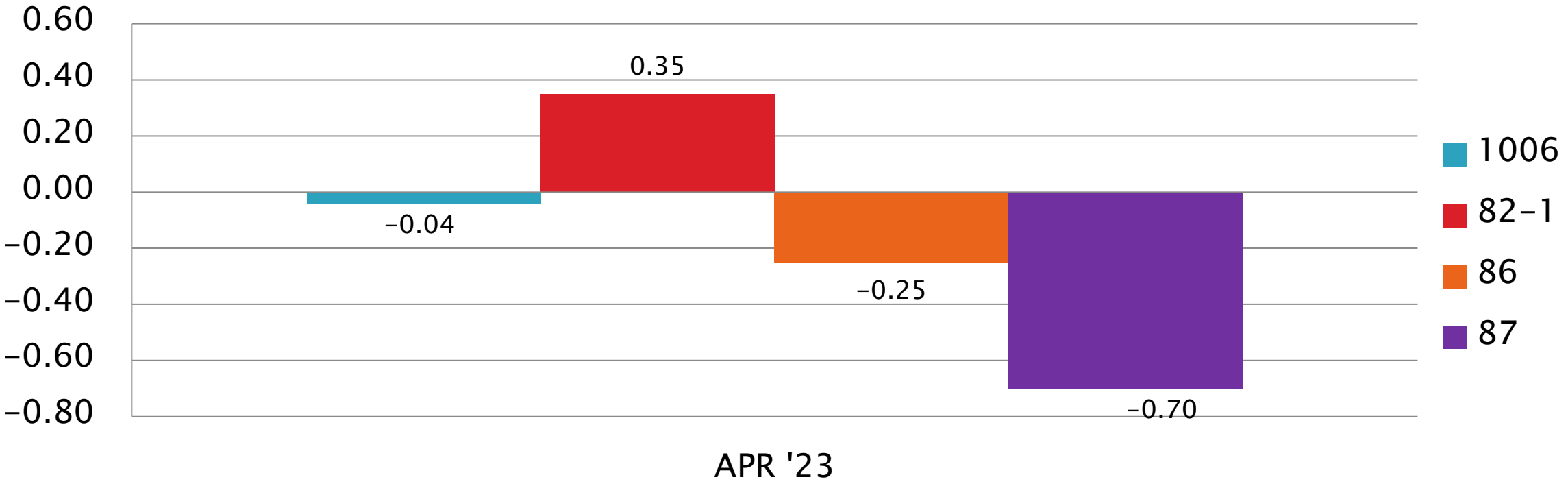
BRT Performance by OIL



Average Gray Value

MEAN Δ/s



APR '23

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Information Letters*

Test	Date	IL	Topic
			No new information letters this period.

*Available from TMC Website

Reference Oil Inventory Estimated Life

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Lab Inventory (samples)	Estimated Life
1006	29.7	0.3	28	5+ years
82-1	2.3	0.2	32	3 years
86	50.1	0.2	26	5+ years
87	93.9	0.2	29	5+ years

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D02.B0.07
TMC Monitored Tests

ASTM D 6594

High Temperature Corrosion Bench Test (HTCBT)

October 1, 2022 – March 31, 2023

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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D6594	10 (+0)	30 (–2)
*As of 3/31/2023		

HTCBT Test Activity*

Test Status	Validity Code	Number of Tests
Acceptable Calibration Test	AC	239
Failed Calibration Test	OC	23**
Operationally Invalid, by lab	LC	3
Aborted Calibration Test	XC	1
Acceptable Shakedown Run	NN	16
Unacceptable Shakedown Run	MN	15
Total		**297**

10 labs reported data
**23 (up from 16 previous semester).

*April 1, 2022 – September 30, 2022

HTCBT Failed Tests

Failed Parameter	Number of Tests
Lead Concentration Severe	8
Lead Concentration Mild	1
Copper Concentration Severe	4
Copper Concentration Mild	1
Lead and Copper Concentrations (both) Severe	6
Lead and Copper Concentrations (both) Mild	3
Total	**23**

HTCBT Failed Tests by Lab

Failed Parameter	LTMS Lab										#
	A	L	G	I	V	BB	BC	B	P	BE	
Lead Concentration Severe	1	0	2	4	1	0	0	0	0	0	8
Lead Concentration Mild	0	0	0	0	0	0	0	0	0	1	1
Copper Concentration Severe	0	0	0	4	0	0	0	0	0	0	4
Copper Concentration Mild	0	0	0	1	0	0	0	0	0	0	1
Lead & Copper Concentrations Severe	1	0	0	2	1	0	1	0	0	1	6
Lead & Copper Concentrations Mild	0	0	0	0	0	0	0	0	0	3	3
Total	**2**	**0**	**2**	**11**	**2**	**0**	**1**	**0**	**0**	**5**	**23**

HTCBT Lost Tests*

Status	Cause	#
Invalid	Temperature Bath / Heater Malfunction	3
Invalid	Air Flow Malfunction	1
Total		**4**

*Invalid or Aborted calibration tests

HTCBT Lost Tests by Lab

Failed Parameter	LTMS Lab										#
	A	L	G	I	V	BB	BC	B	P	BE	
Temperature Bath / Heater Malfunction	0	0	0	2	0	0	0	0	0	1	3
Air Flow Malfunction	0	0	1	0	0	0	0	0	0	0	1
Total	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**4**

HTCBT Test Severity

- Copper concentration trending severe
- Lead concentration trending severe
- Some labs had test results with extremely large variance from expected means. These "outlier" (?) results have raised concerns and requests to understand if this is a lab or industry issue.
  - New Chairperson for HTCBT Surveillance Panel needs to be identified

HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA

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COPPER CHANGE (ppm)

CUSUM Severity Analysis

Historical Chart

25APR23:21:15

HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Last 600 Points ONLY
COPPER CHANGE (ppm)

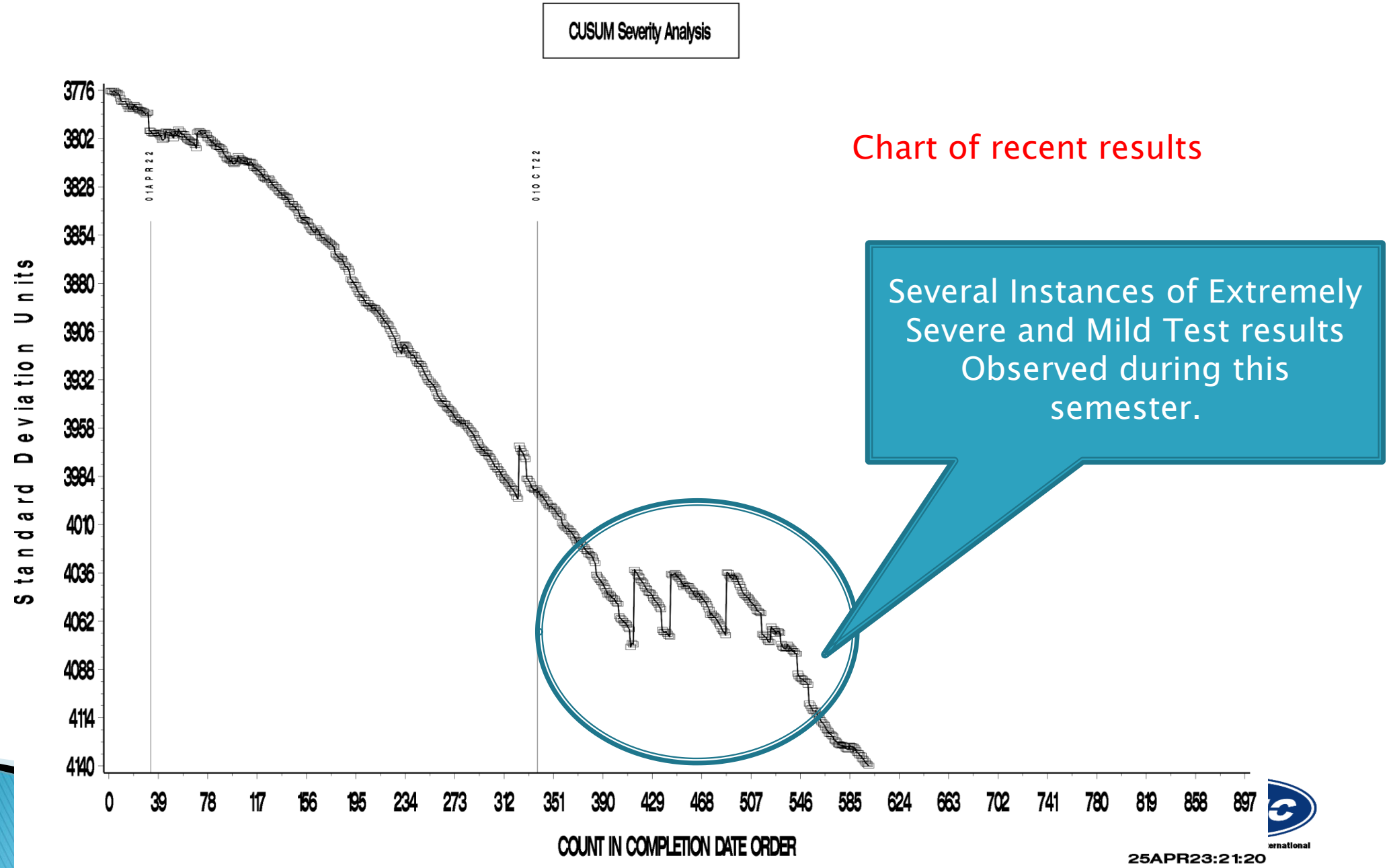

Chart of recent results

Several Instances of Extremely Severe and Mild Test results Observed during this semester.

HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA

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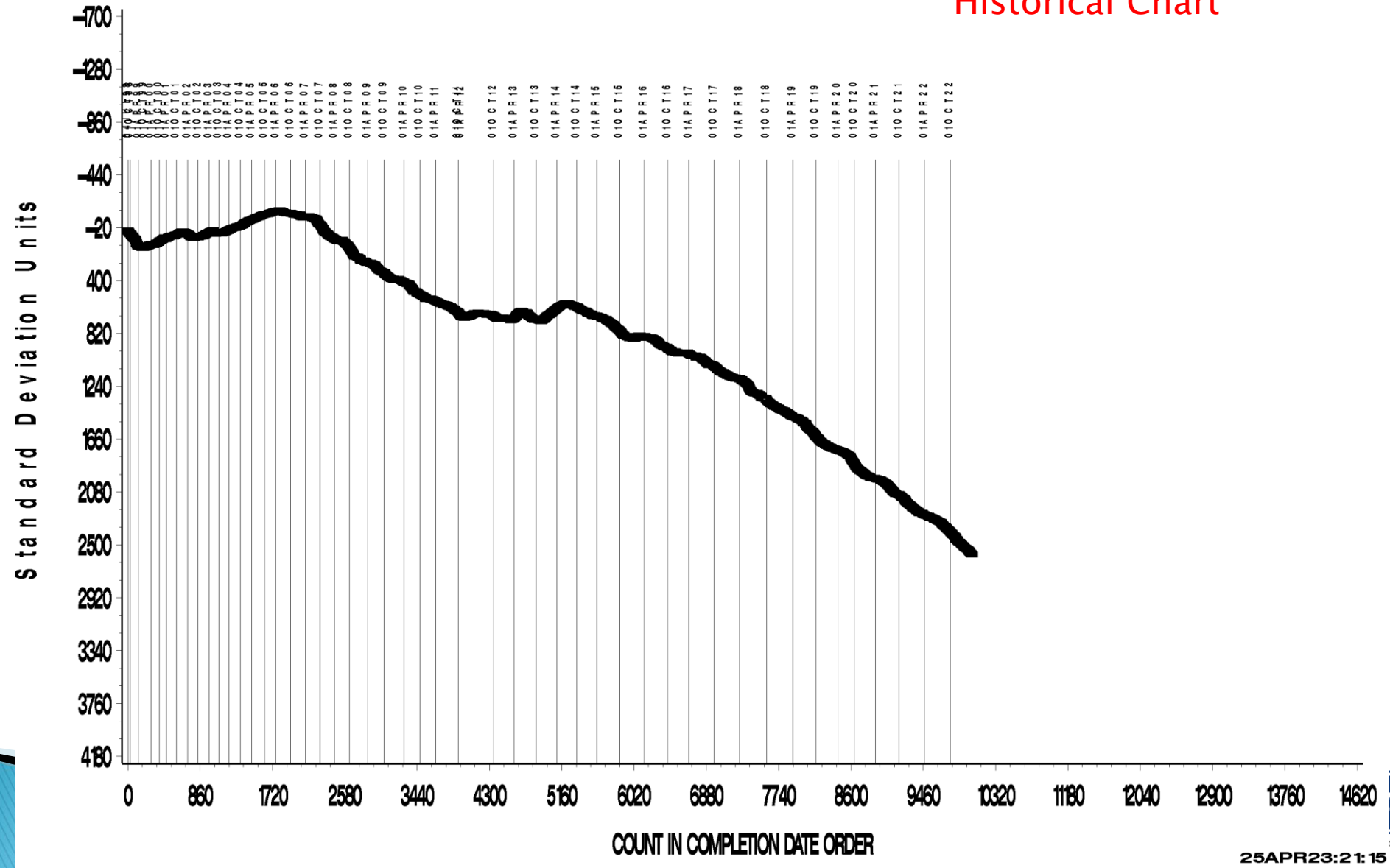
LEAD CHANGE (ppm)

CUSUM Severity Analysis

Historical Chart



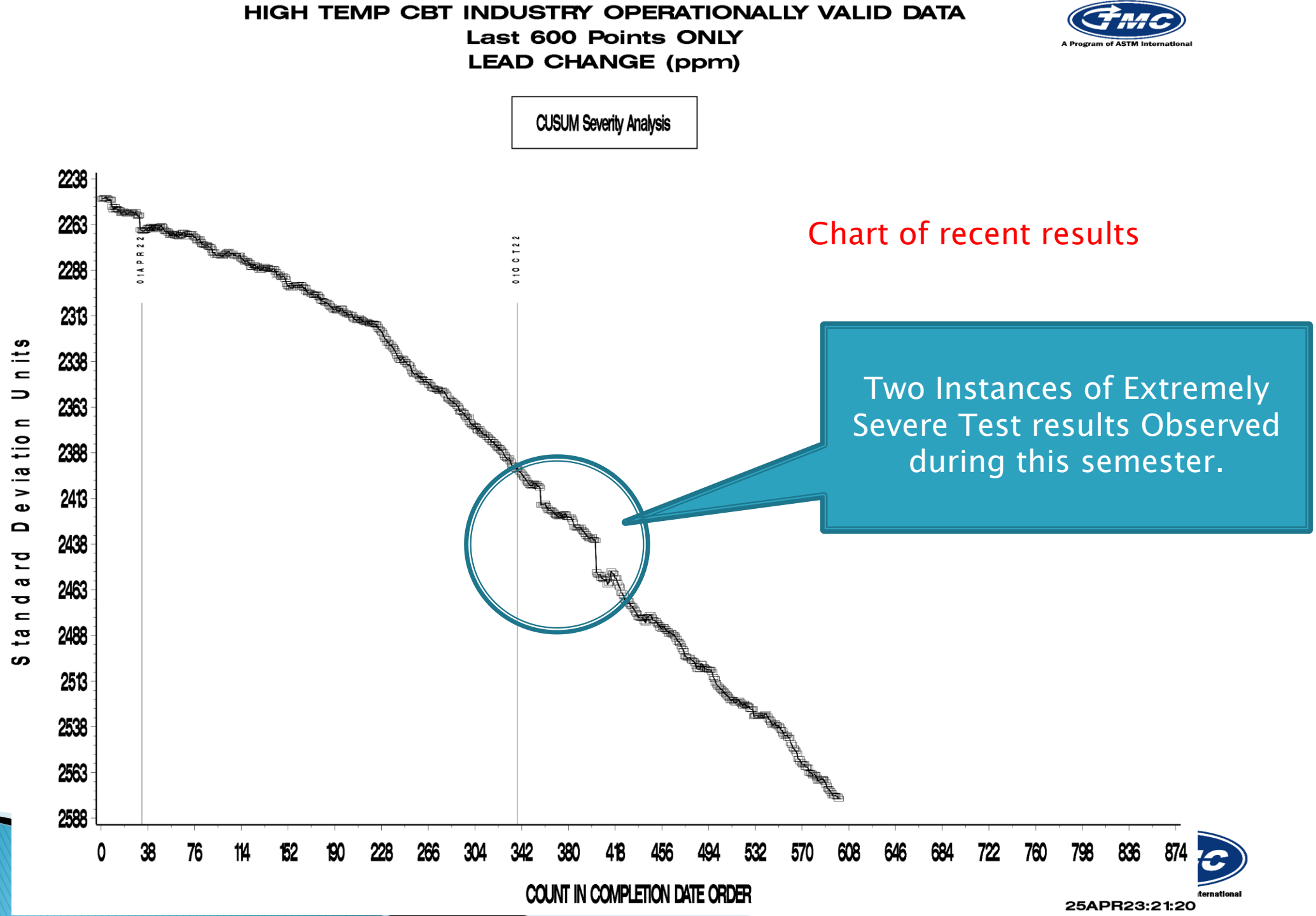
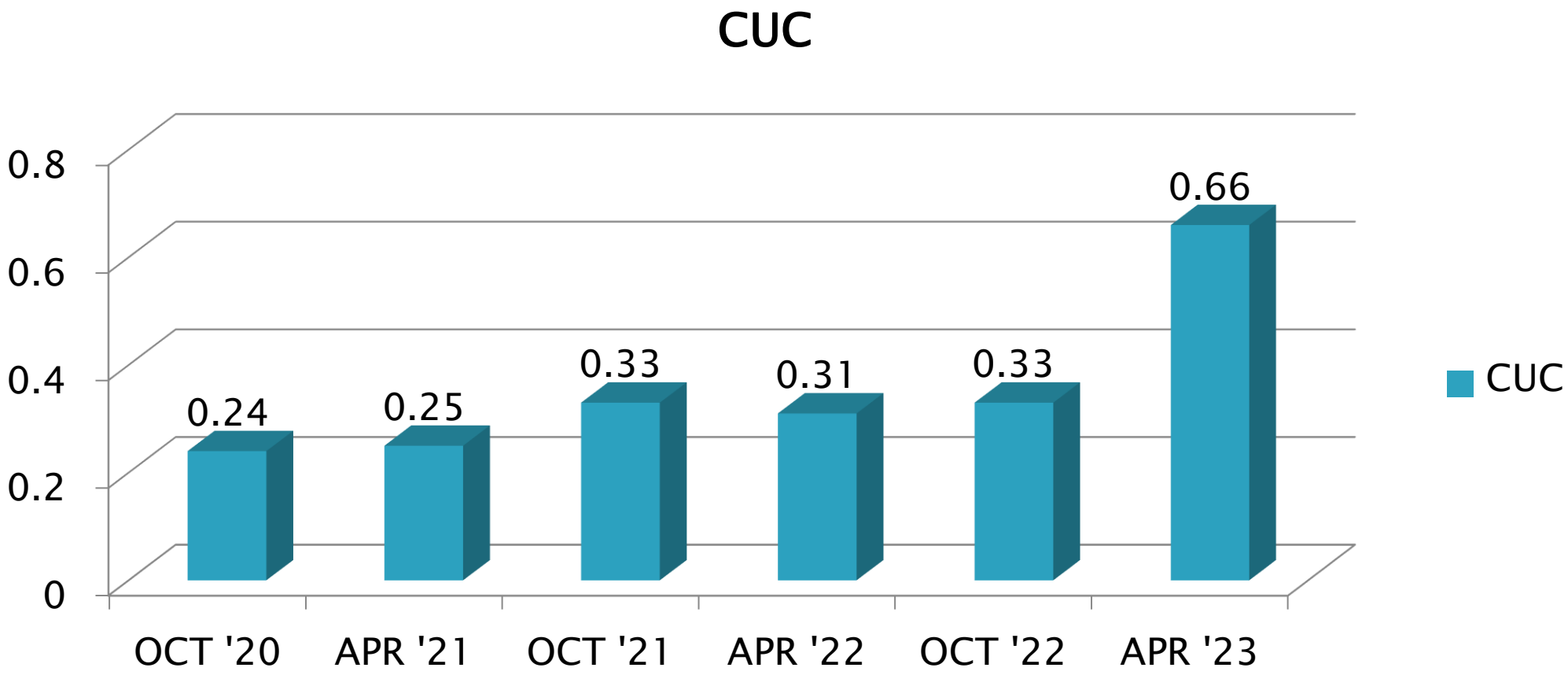


Chart of recent results

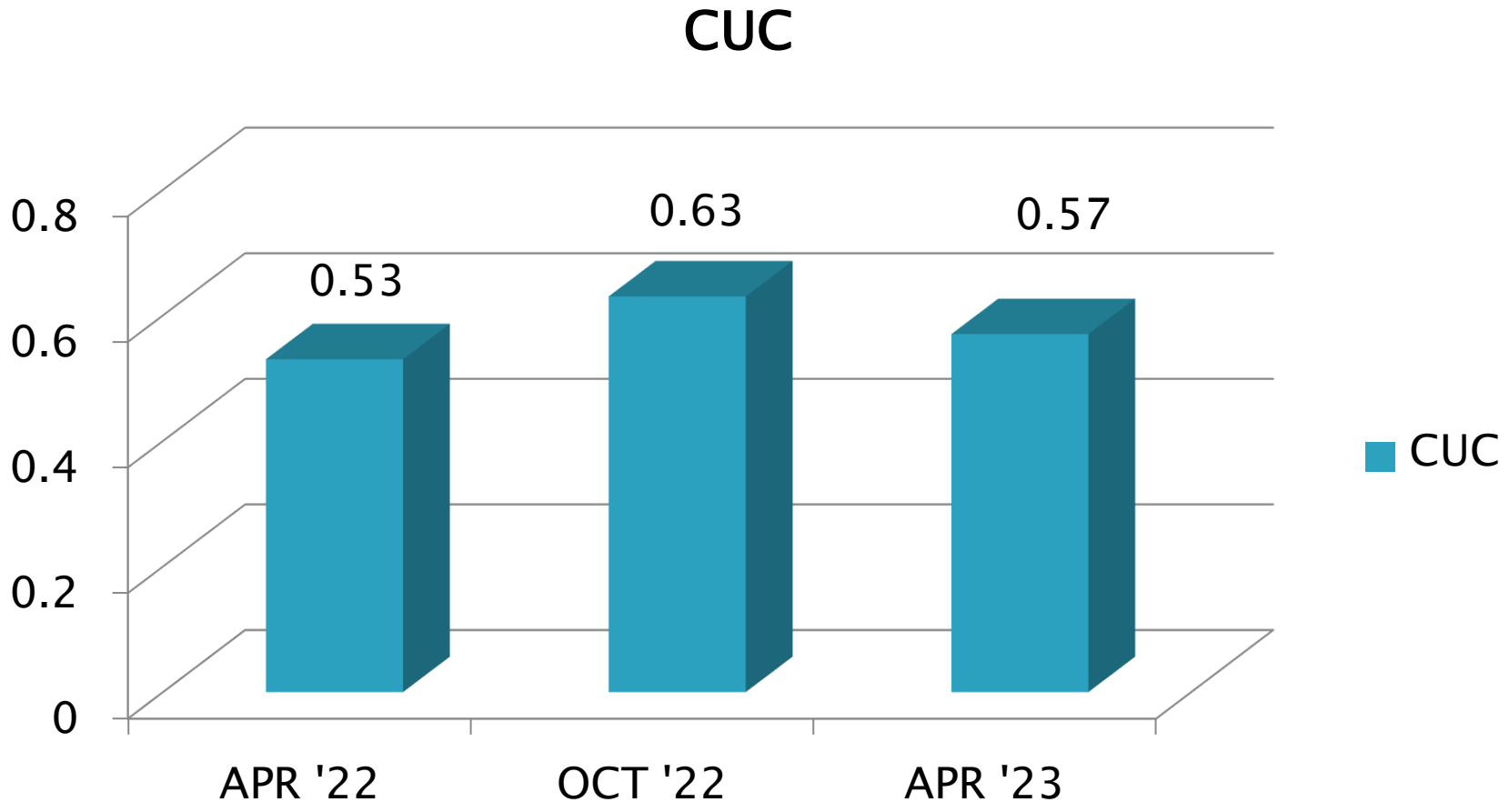
Two Instances of Extremely Severe Test results Observed during this semester.

HTCBT Precision (Pooled s) Estimates

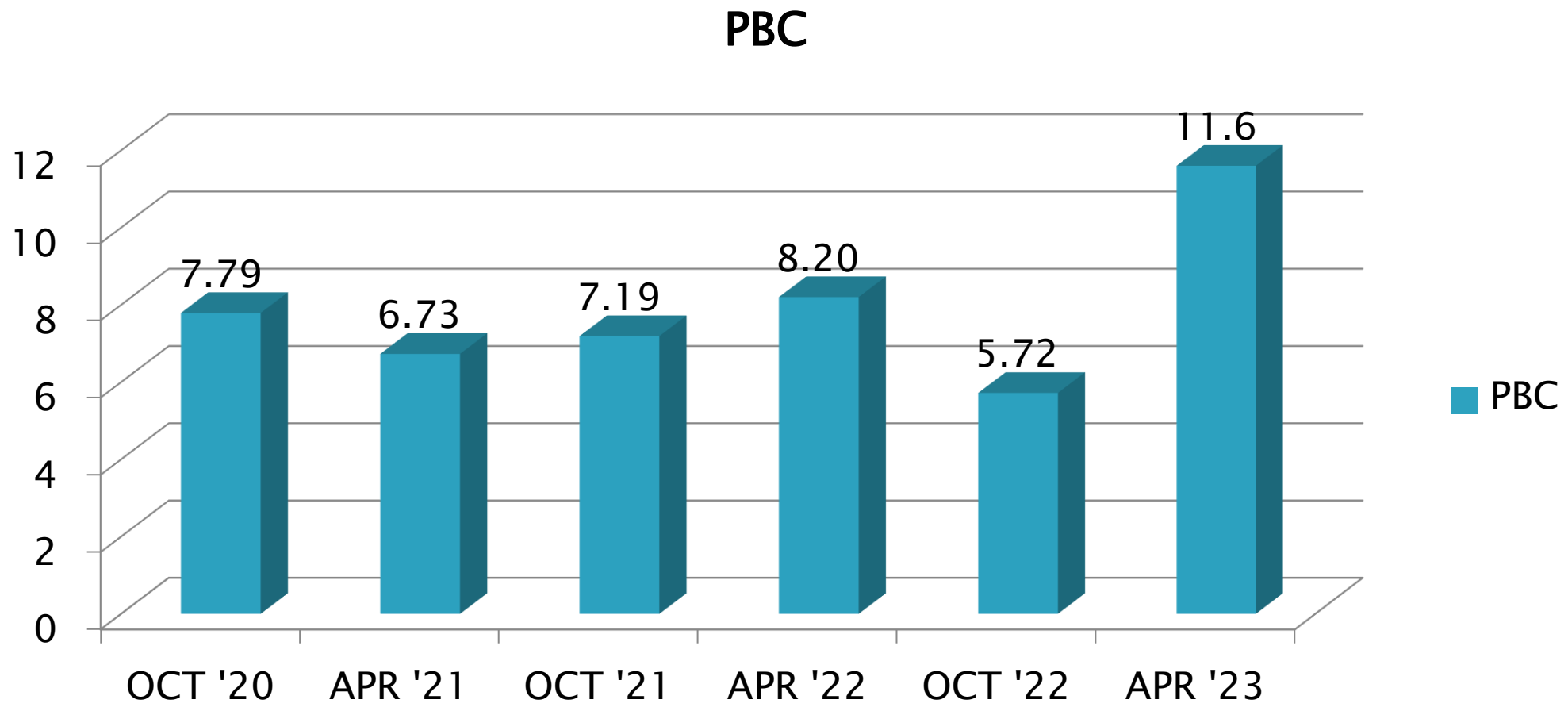


CUC Standard Deviation results ranged from -40.2 (Oil 44-4) to + 11.3 (Oil 1005-5). Significant deviations from the expected targets are impacting the plot summaries.

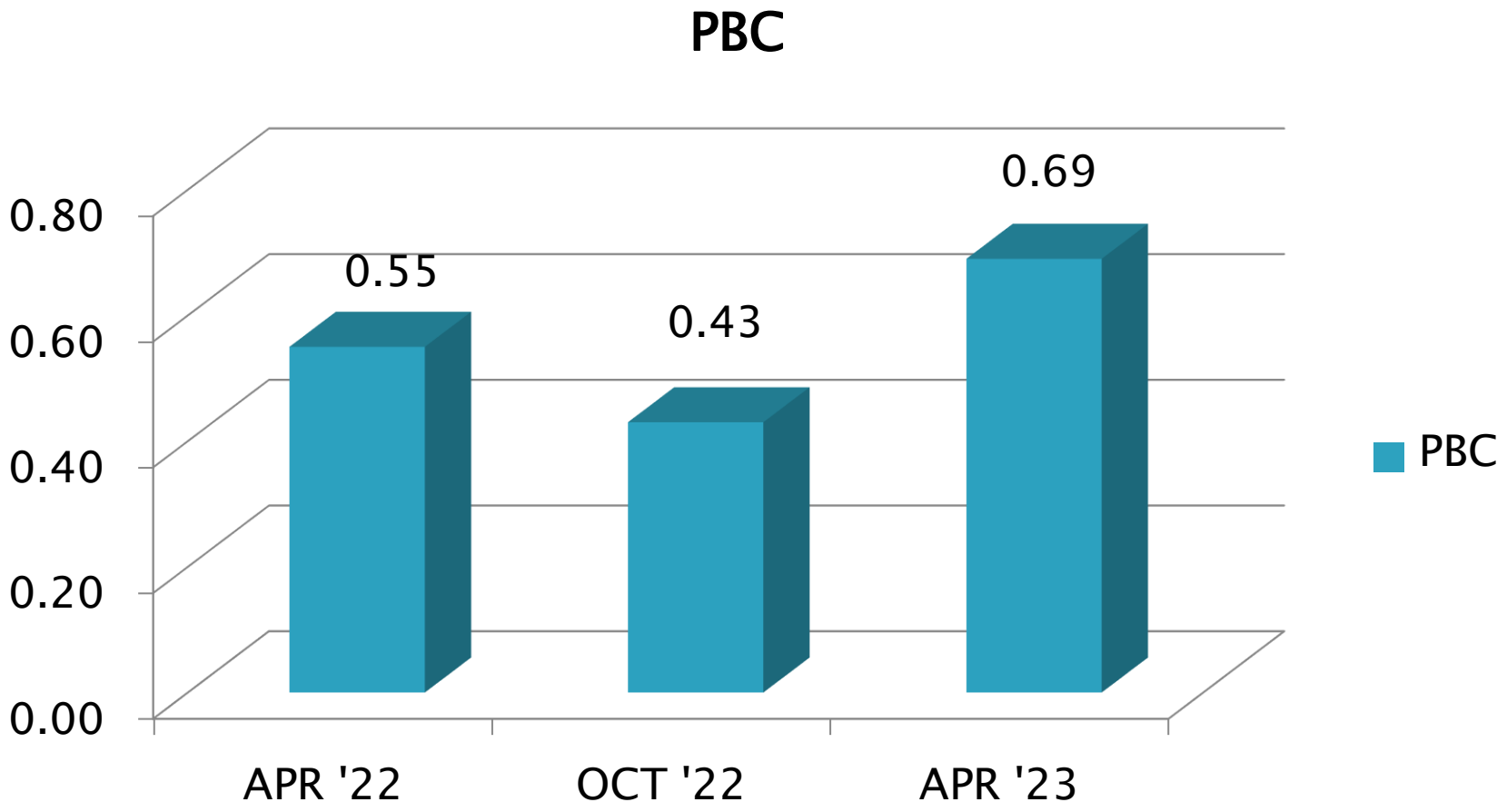
HTCBT Performance (mean Δ/s) Estimates



HTCBT Precision (Pooled s) Estimates



HTCBT Performance (mean Δ/s) Estimates



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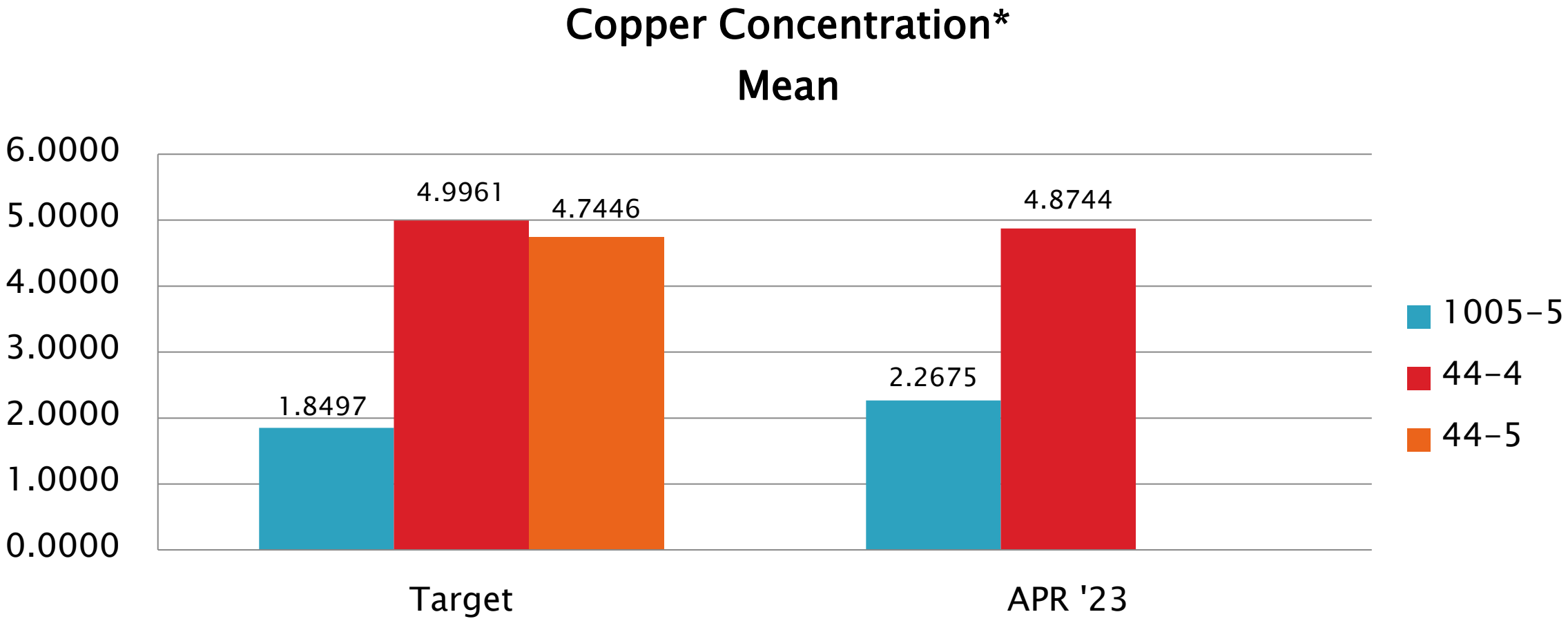
HTCBT Performance by OIL



*Transformed Units

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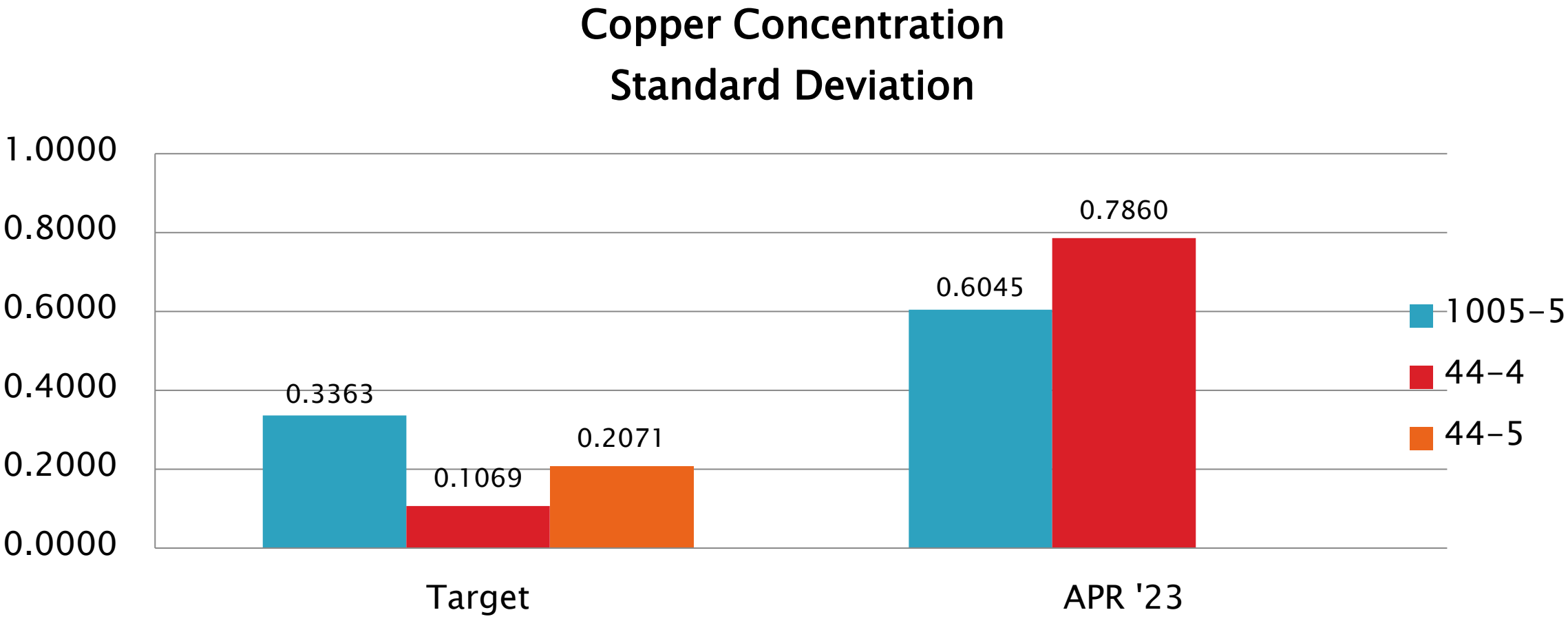
HTCBT Performance by OIL



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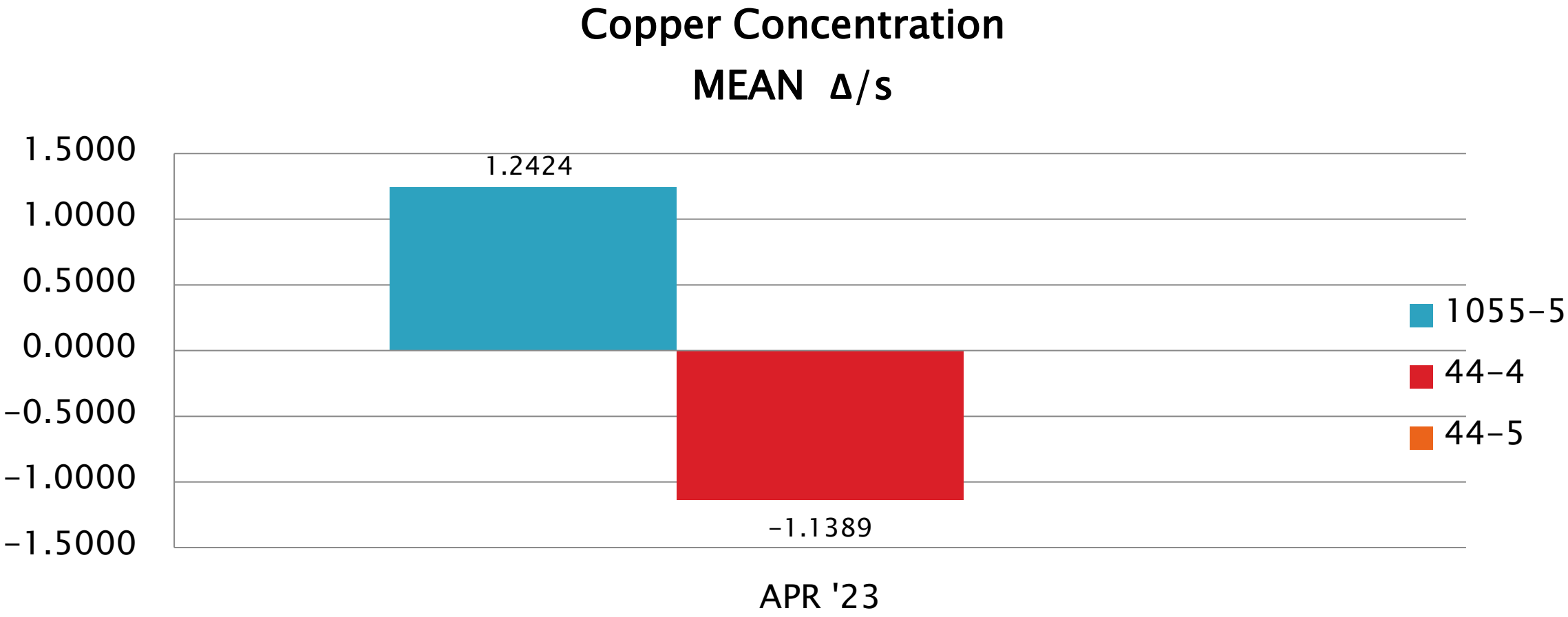
HTCBT Performance by OIL



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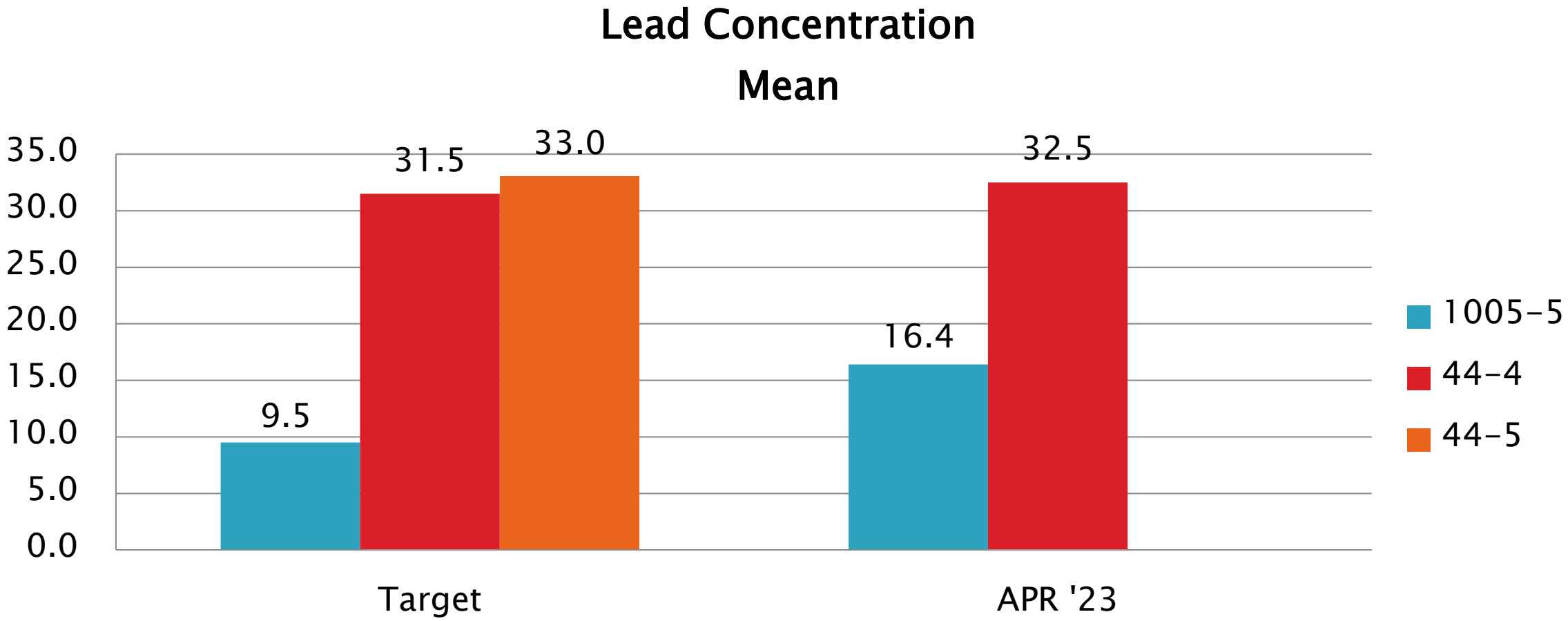
HTCBT Performance by OIL



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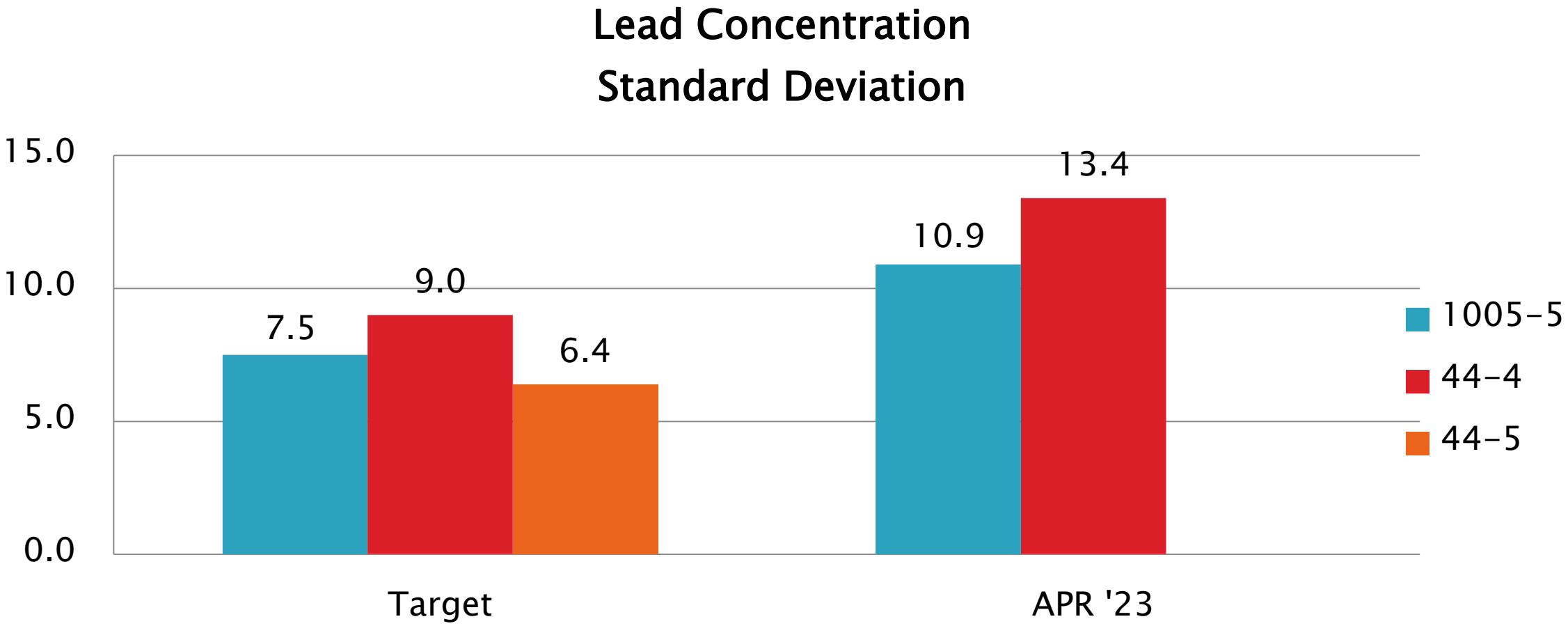
HTCBT Performance by OIL



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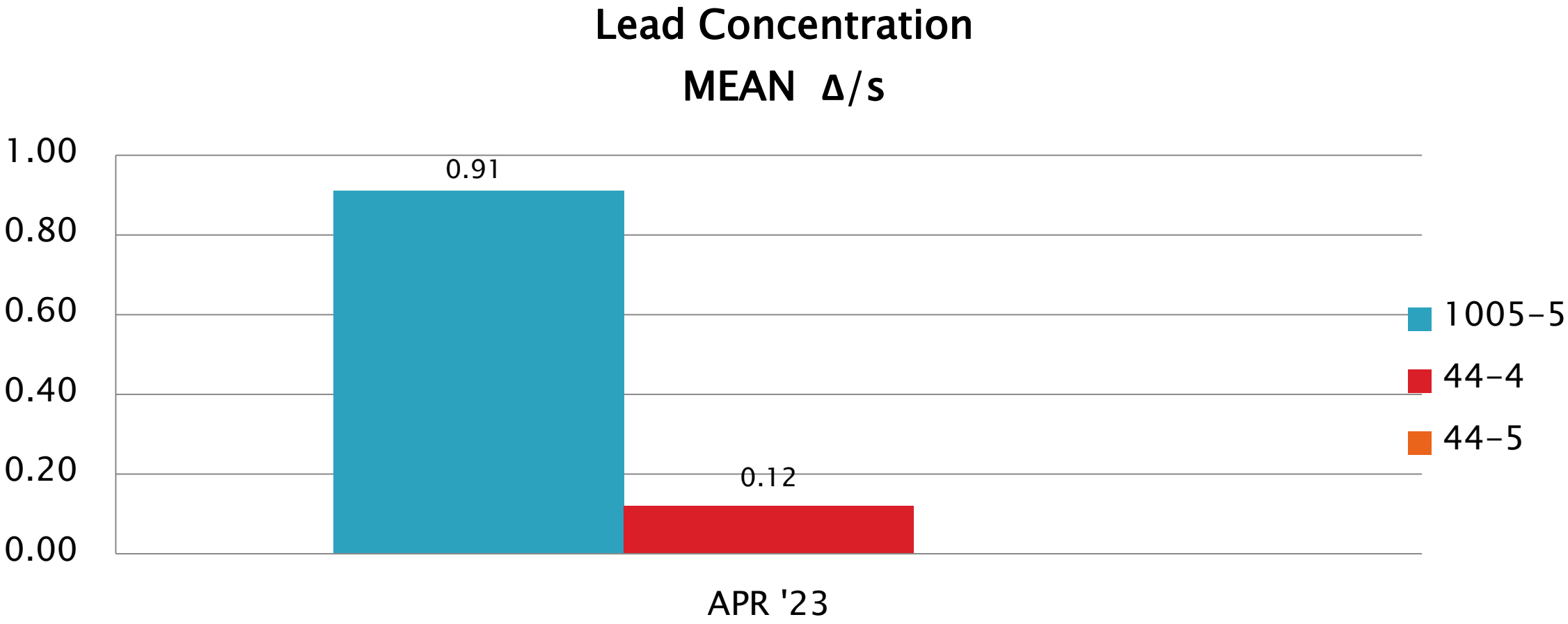
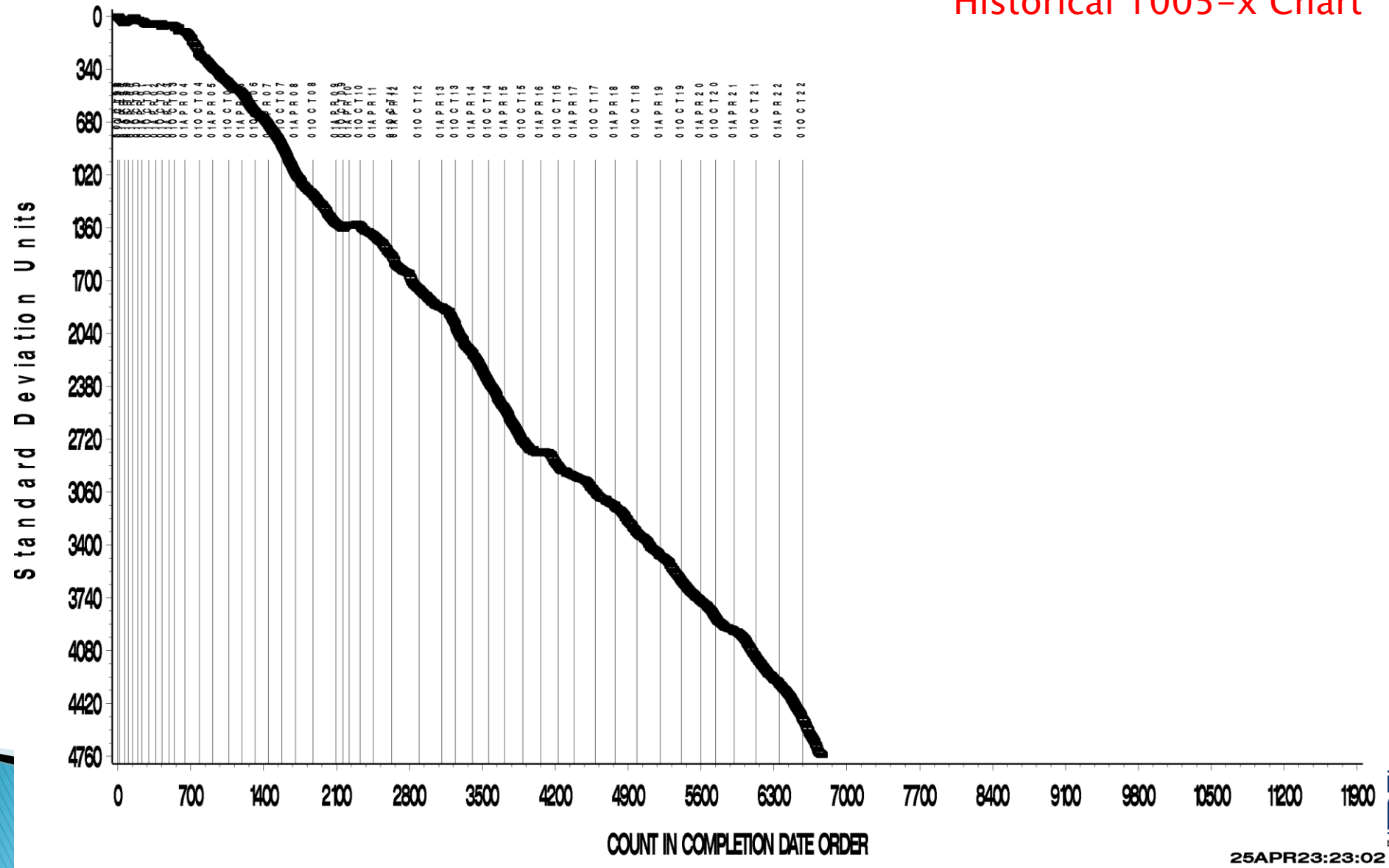
HTCBT Performance by OIL



HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Oil 1005 –x ONLY
COPPER CHANGE (ppm)

CUSUM Severity Analysis

Historical 1005-x Chart

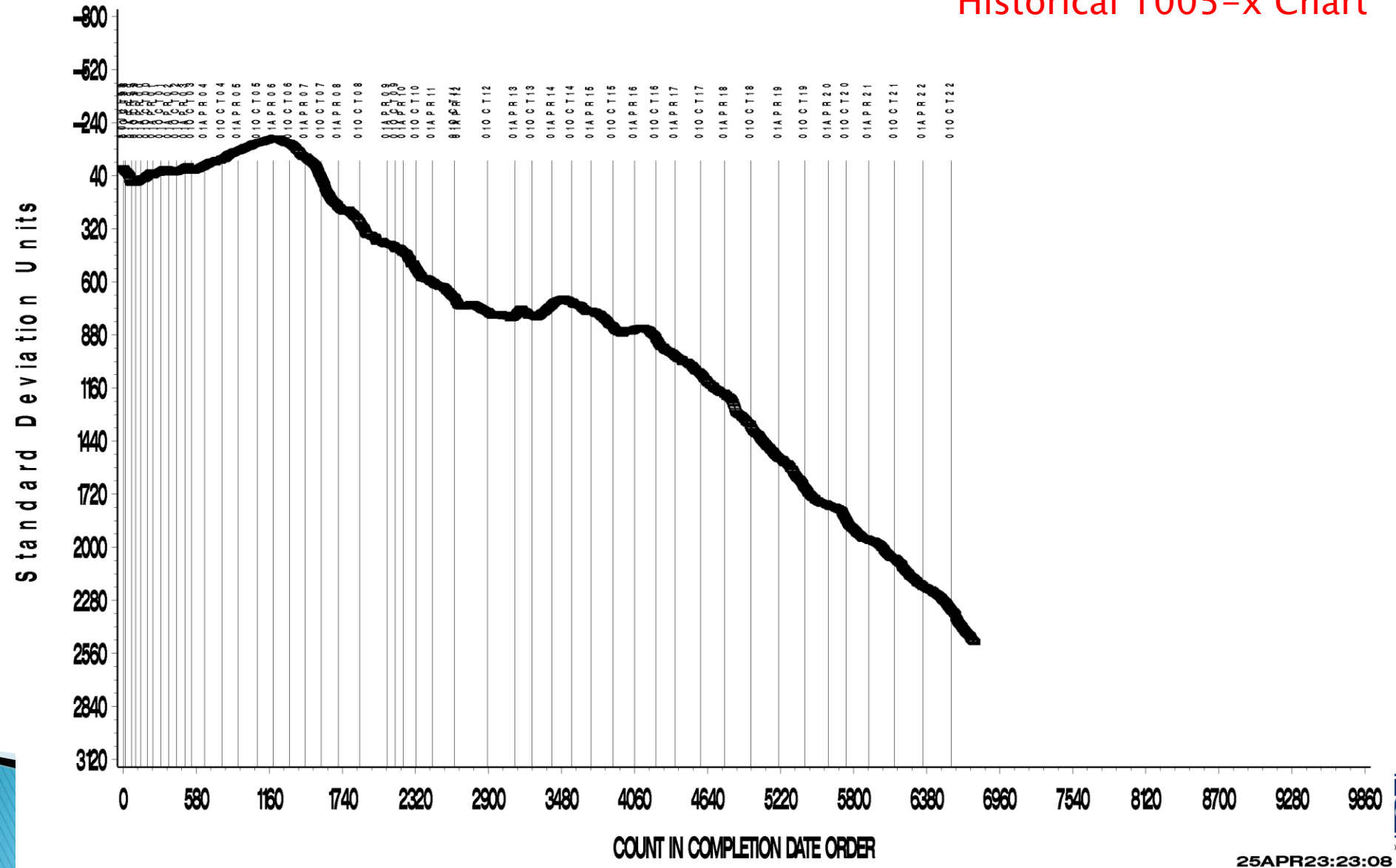


25APR23:23:02

HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Oil 1005 –x ONLY
LEAD CHANGE (ppm)

CUSUM Severity Analysis

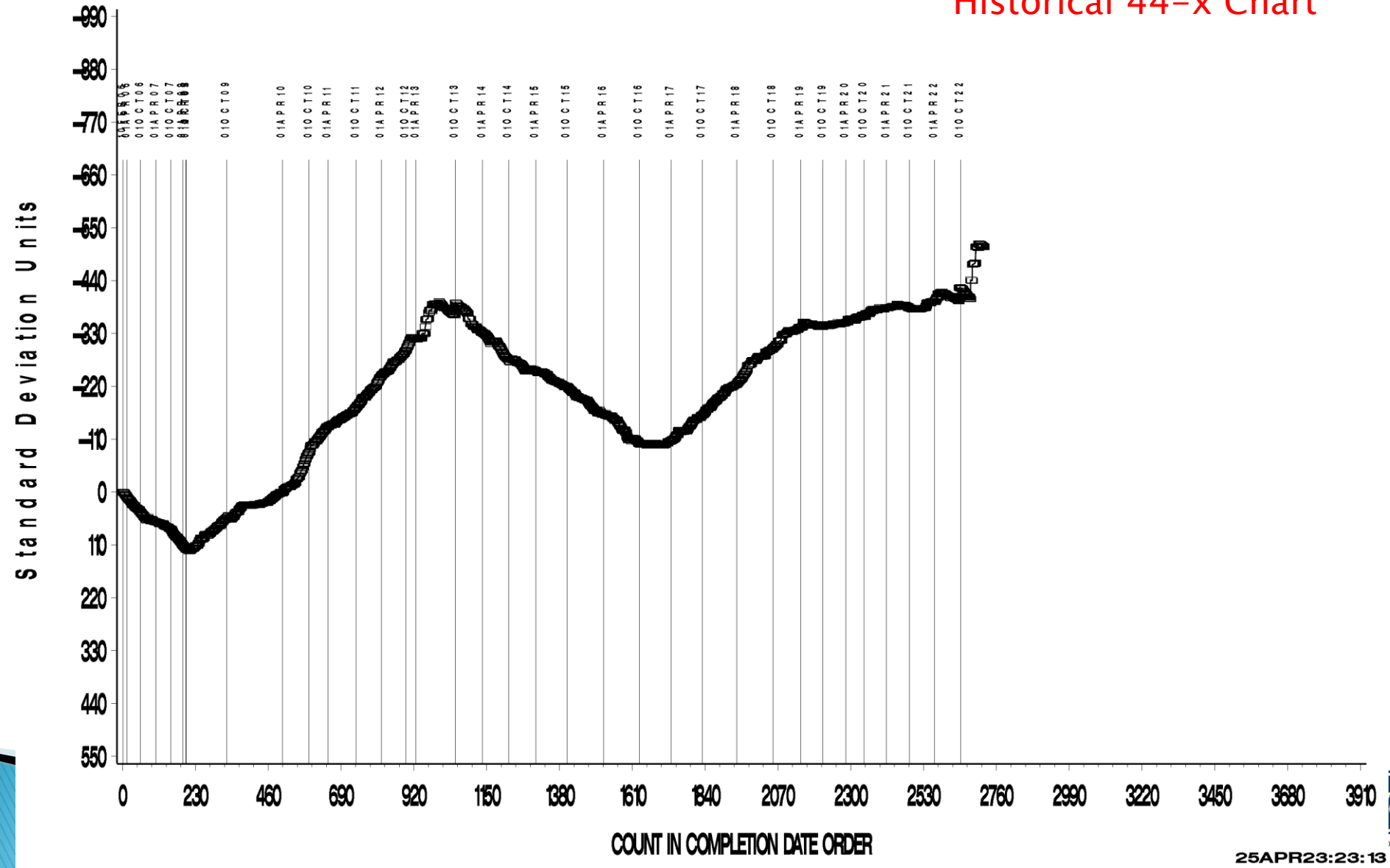
Historical 1005-x Chart



HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Oil 44 –x ONLY
COPPER CHANGE (ppm)

CUSUM Severity Analysis

Historical 44-x Chart

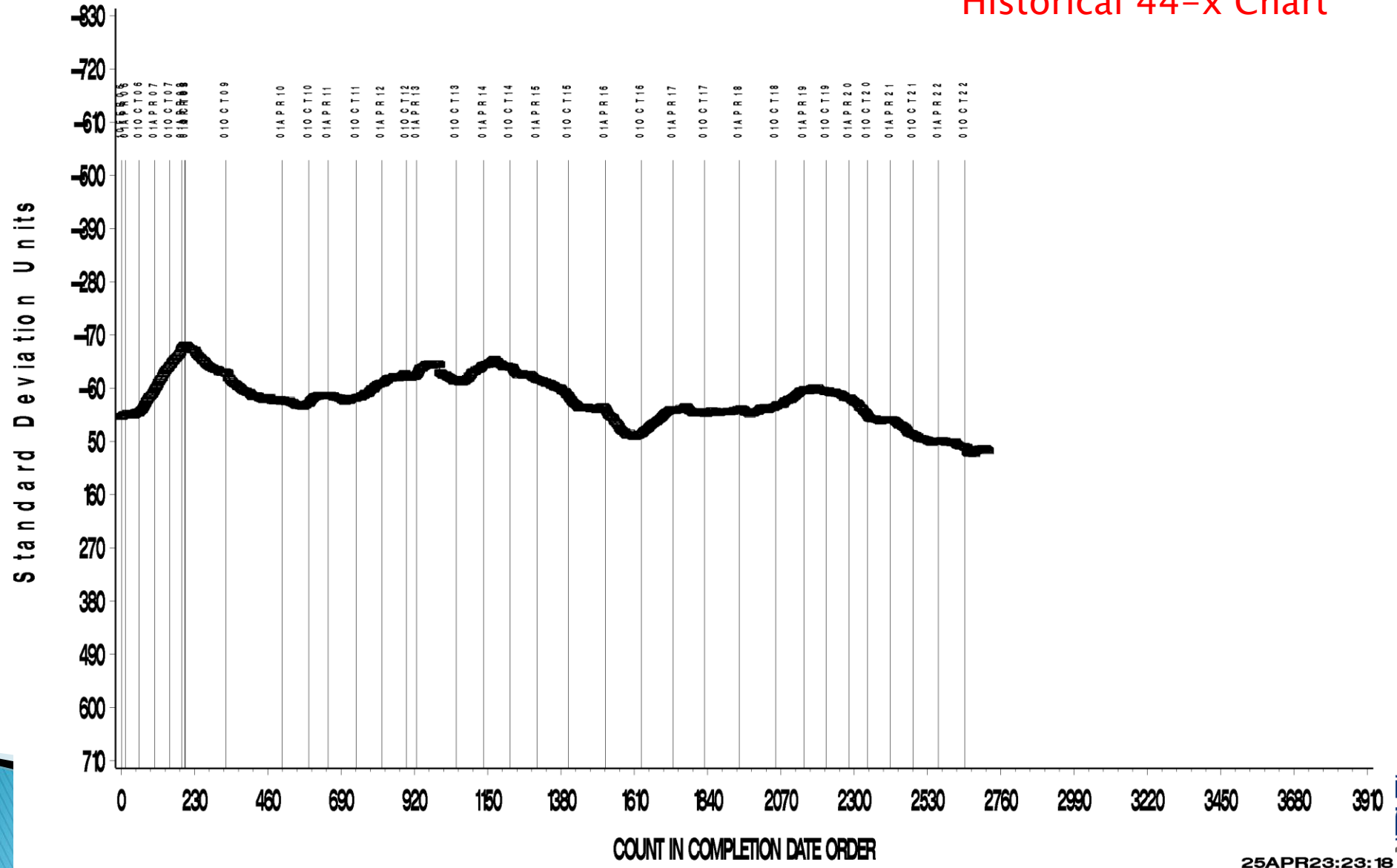


25APR23:23:13

HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Oil 44 –x ONLY
LEAD CHANGE (ppm)

CUSUM Severity Analysis

Historical 44-x Chart



25APR23:23:18

Information Letters*

Test	Date	IL	Topic
			No information letters this period.

*Available from TMC Website

Reference Oil Inventory Estimated Life

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Lab Inventory (samples)	Estimated Life
44-4	3.7	3.2	96	<1 year
44-5	53	0.4	13	>5 year
1005-5	49.9 (Reserved drum – Additional oil available at the TMC)	6.7	202	>5 years

Oil 44-5 Batch has been approved for use by the surveillance panel. TMC has shipped some blind coded 44-5 TESTKEYs to labs and will begin to assign these samples when Batch 44-4 TESTKEYs have been consumed.

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D02.B0.07
TMC Monitored Tests

ASTM D 6794

Engine Oil Water Tolerance (EOWT)

October 1, 2022 – March 31, 2023

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

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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D6794	6 (+1)	N/A
*As of 3/31/2023		

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	159	159	158	158	634
Failed Calibration Test	OC	1	2	0	0	3
Acceptable Information Run	NN	0	0	9	0	9
Unacceptable Information Run	MN	0	0	3	0	3
Aborted Calibration Test	XC	3	4	3	4	14
Total		**163**	**165**	**173**	**162**	**663**

- 6 labs reported data

April 1, 2022 – September 30, 2022

EOWT Test Activity by Reference Oil*

Test Status	Validity Code	Number of Tests by Reference Oil		Total
		79	77-3	
Acceptable Calibration Test	AC	321	313	634
Failed Calibration Test	OC	0	3	3
Acceptable Informational Test	NN	6	3	9
Unacceptable Informational Test	MN	0	3	3
Aborted Calibration	XC	8	6	14
Total		**335**	**328**	**663**

- One (1) Lab requested all 12 Informational runs

April 1, 2022 – September 30, 2022

EOWT Failed Tests

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

April 1, 2022 – September 30, 2022

EOWT Failed Tests by Lab

Failed Parameter (OC)	LTMS Lab						#
	A	B	BE	G	I	L	
Severe Change in Flowrate	0	0	3	0	0	0	**3**
Mild Change in Flowrate	0	0	0	0	0	0	**0**
Total	**0**	**0**	**3**	**0**	**0**	**0**	3

April 1, 2022 – September 30, 2022

EOWT Lost Calibration Tests*

Cause	Number of Tests				#
	0.6%	1.0%	2.0%	3.0%	
Incorrect sample preparation	3	3	3	4	13
Operator Error	0	1	0	0	1
Total	**3**	**4**	**3**	**4**	**14**

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

April 1, 2022 – September 30, 2022

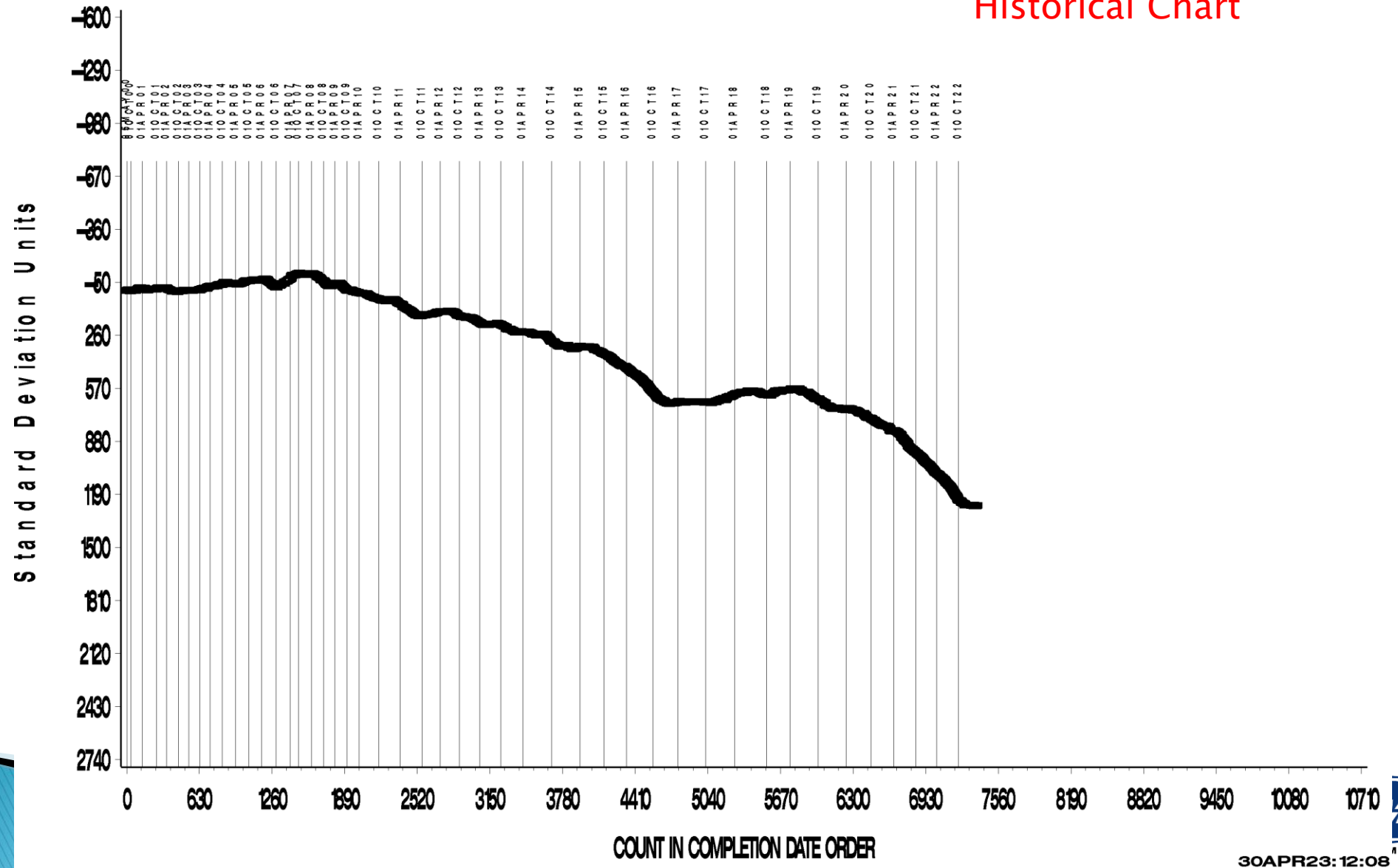
EOWT Test Severity

- Change in flowrate continues to trend severe for all water treat rates, however the severe trends are abating, especially for the 0.6% testing which showed a significant flattening of its CUSUM plot in the second half of this reporting period.

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 0.6% WATER TREAT RATE
20 —25 ML CHANGE IN FLOWRATE AVG.

CUSUM Severity Analysis

Historical Chart



30APR23:12:08

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 0.6% WATER TREAT RATE; Last 400
20 —25 ML CHANGE IN FLOWRATE AVG.

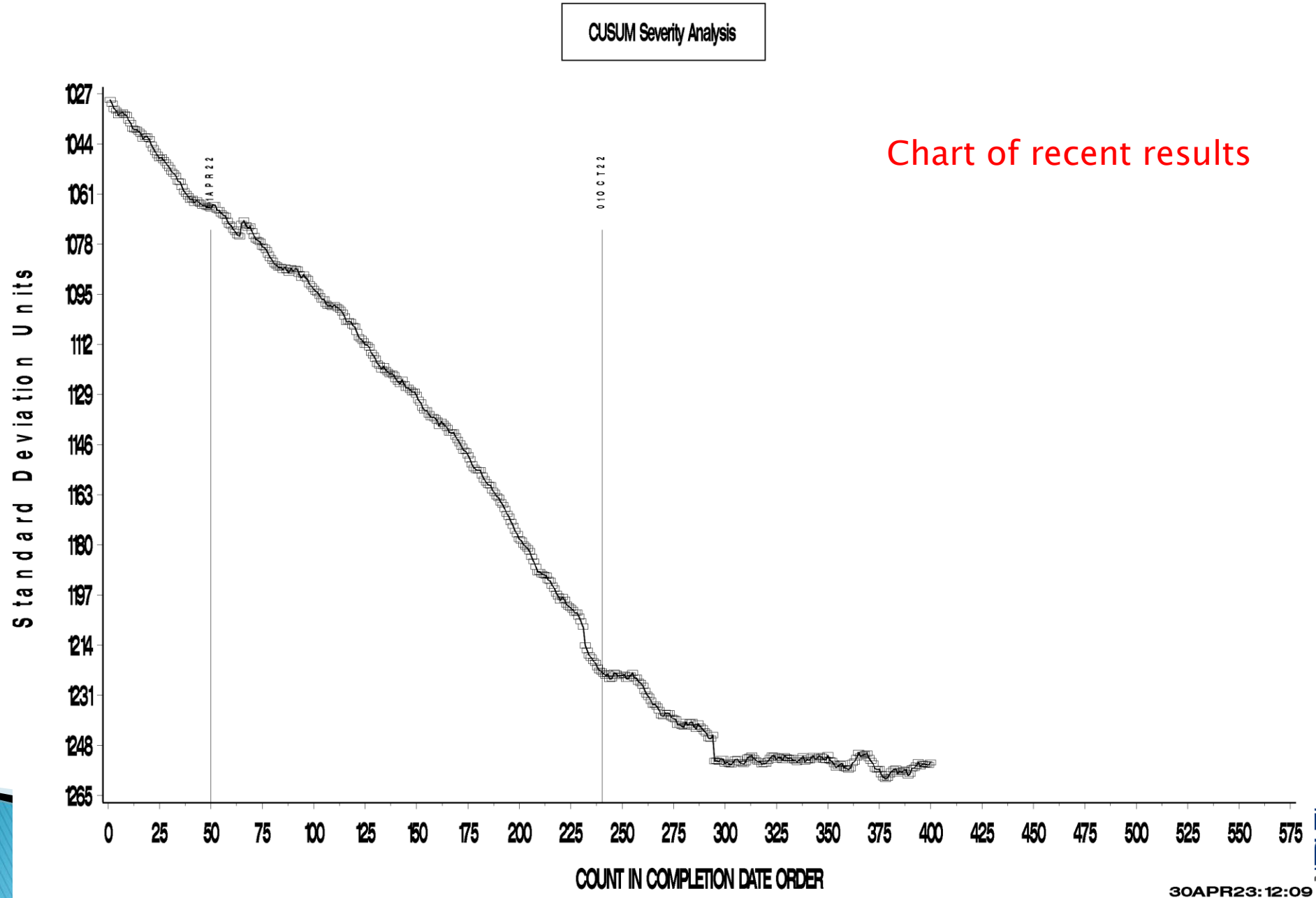
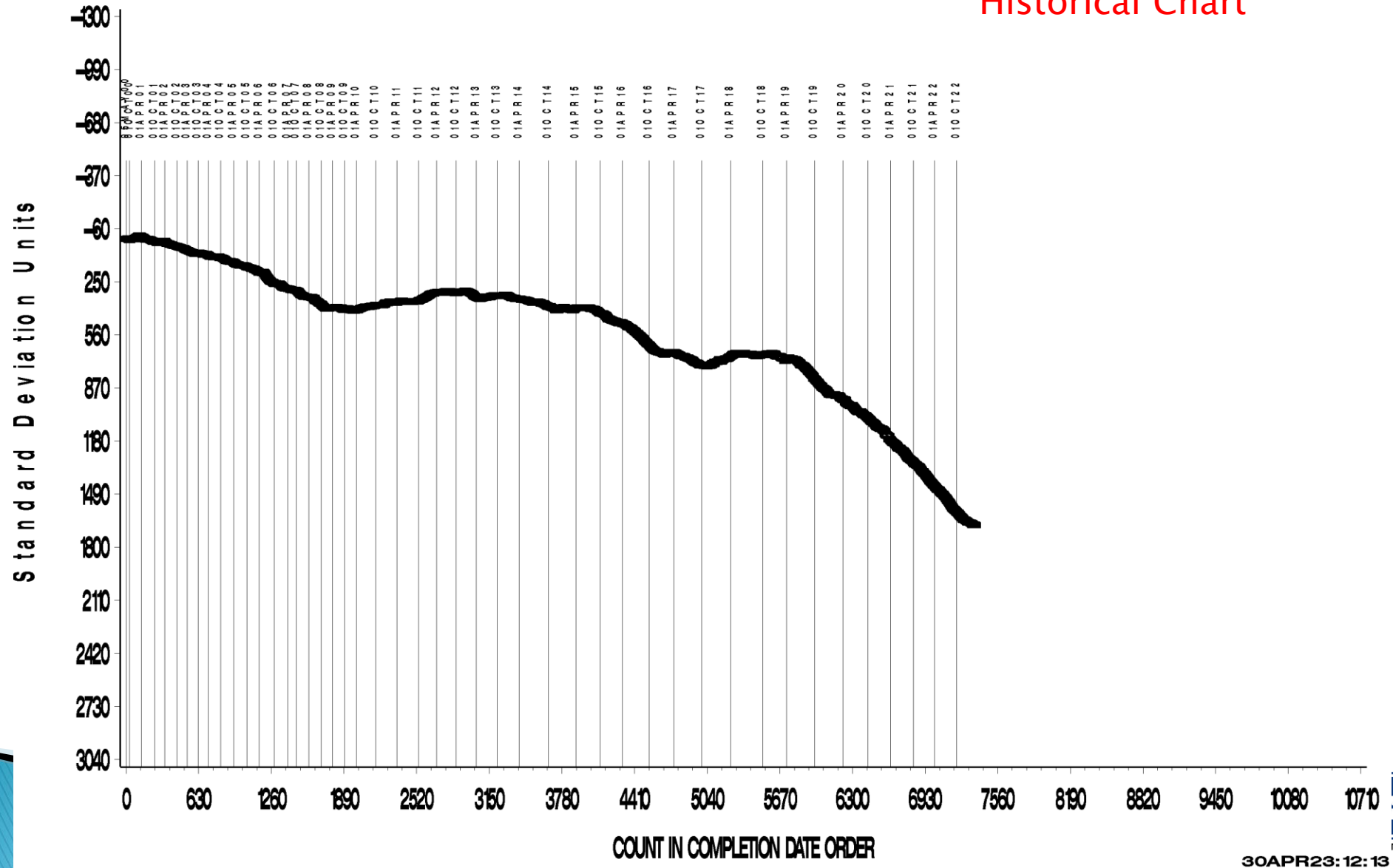


Chart of recent results

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 1.0% WATER TREAT RATE
20 —25 ML CHANGE IN FLOWRATE AVG.

CUSUM Severity Analysis

Historical Chart



EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 1.0% WATER TREAT RATE: Last 400
20 —25 ML CHANGE IN FLOWRATE AVG.

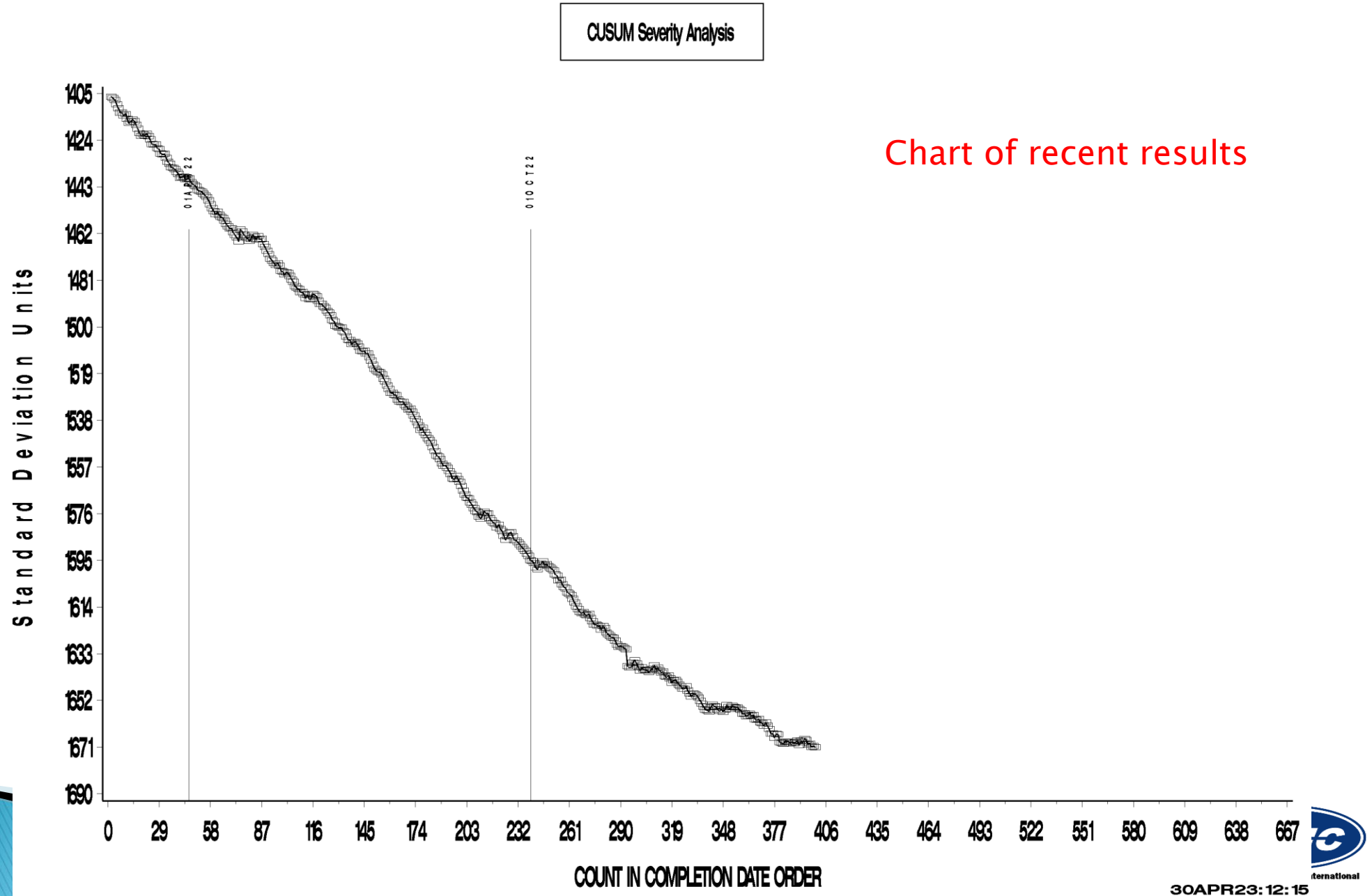
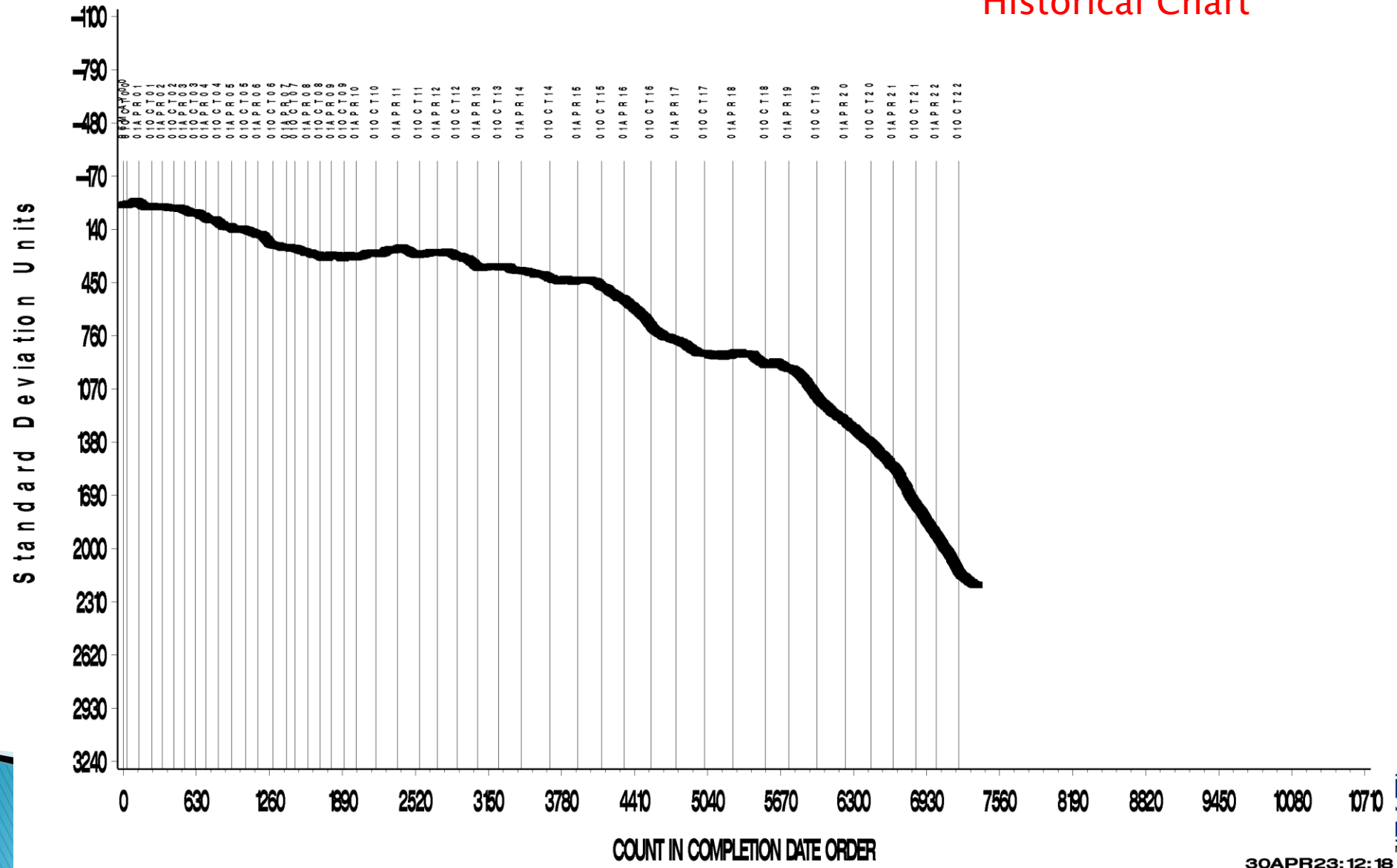


Chart of recent results

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 2.0% WATER TREAT RATE
20 —25 ML CHANGE IN FLOWRATE AVG.

CUSUM Severity Analysis

Historical Chart



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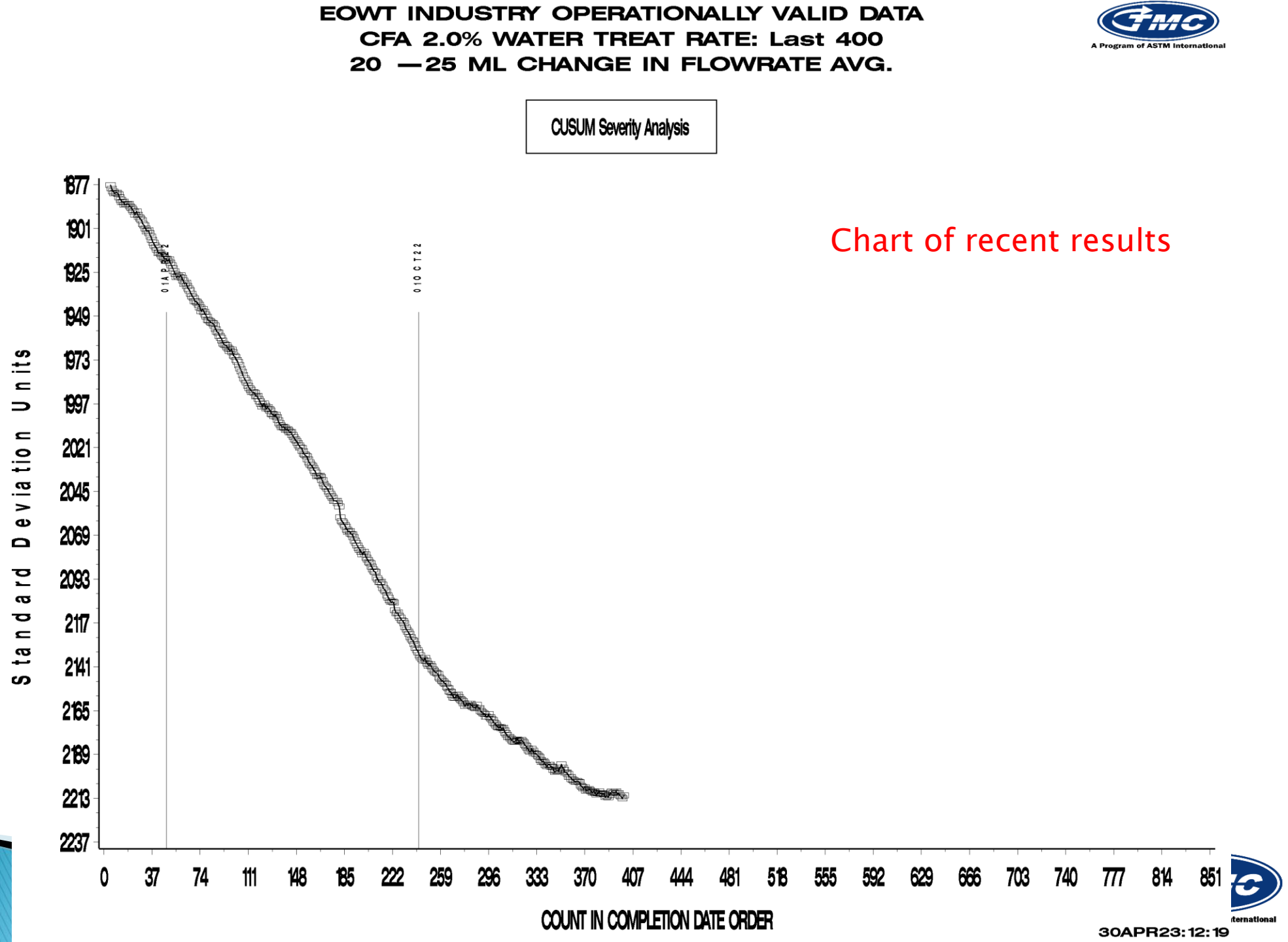
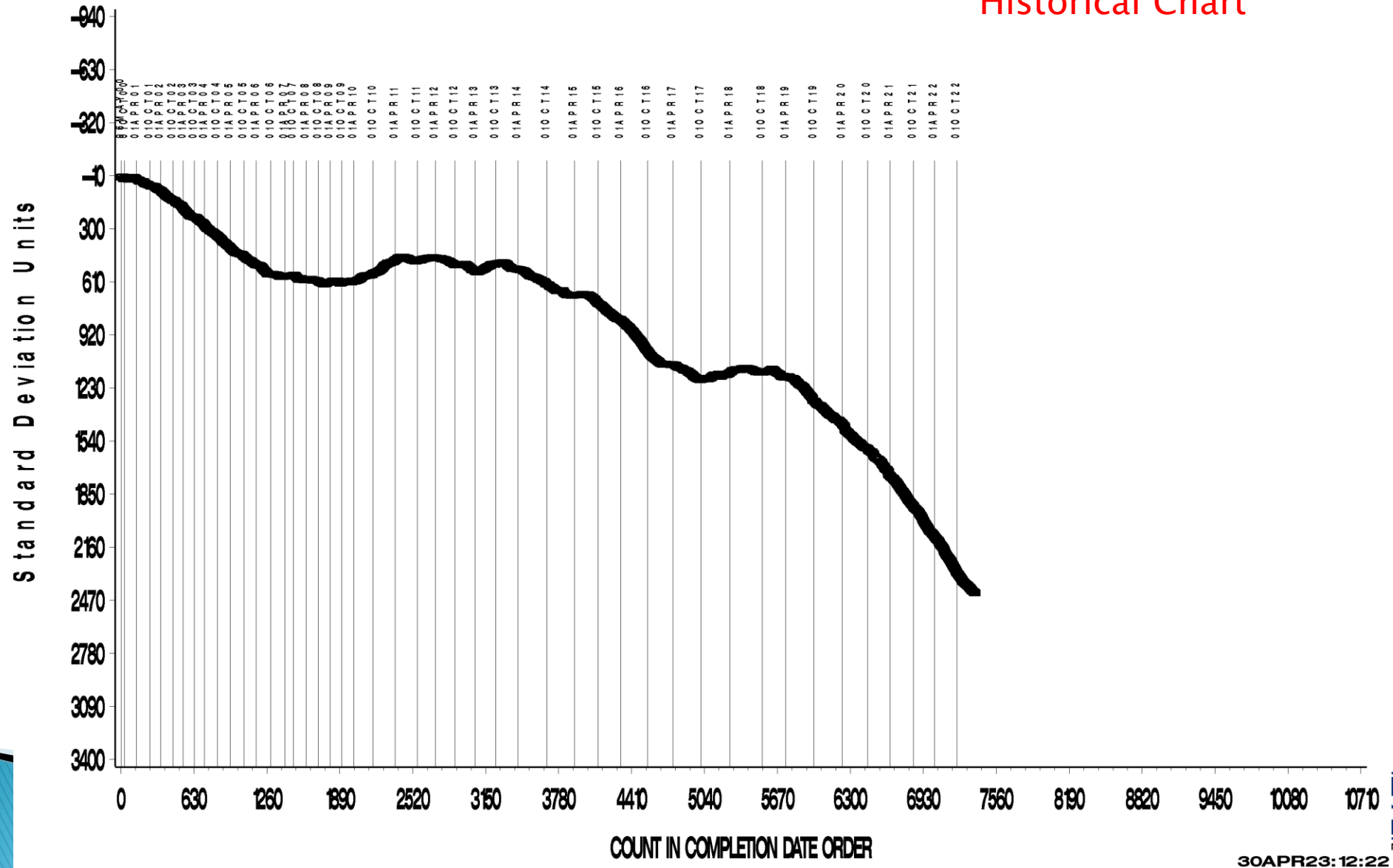


Chart of recent results

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 3.0% WATER TREAT RATE
20 —25 ML CHANGE IN FLOWRATE AVG.

CUSUM Severity Analysis

Historical Chart



30APR23:12:22

EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 3.0% WATER TREAT RATE: Last 400
20 —25 ML CHANGE IN FLOWRATE AVG.

CUSUM Severity Analysis

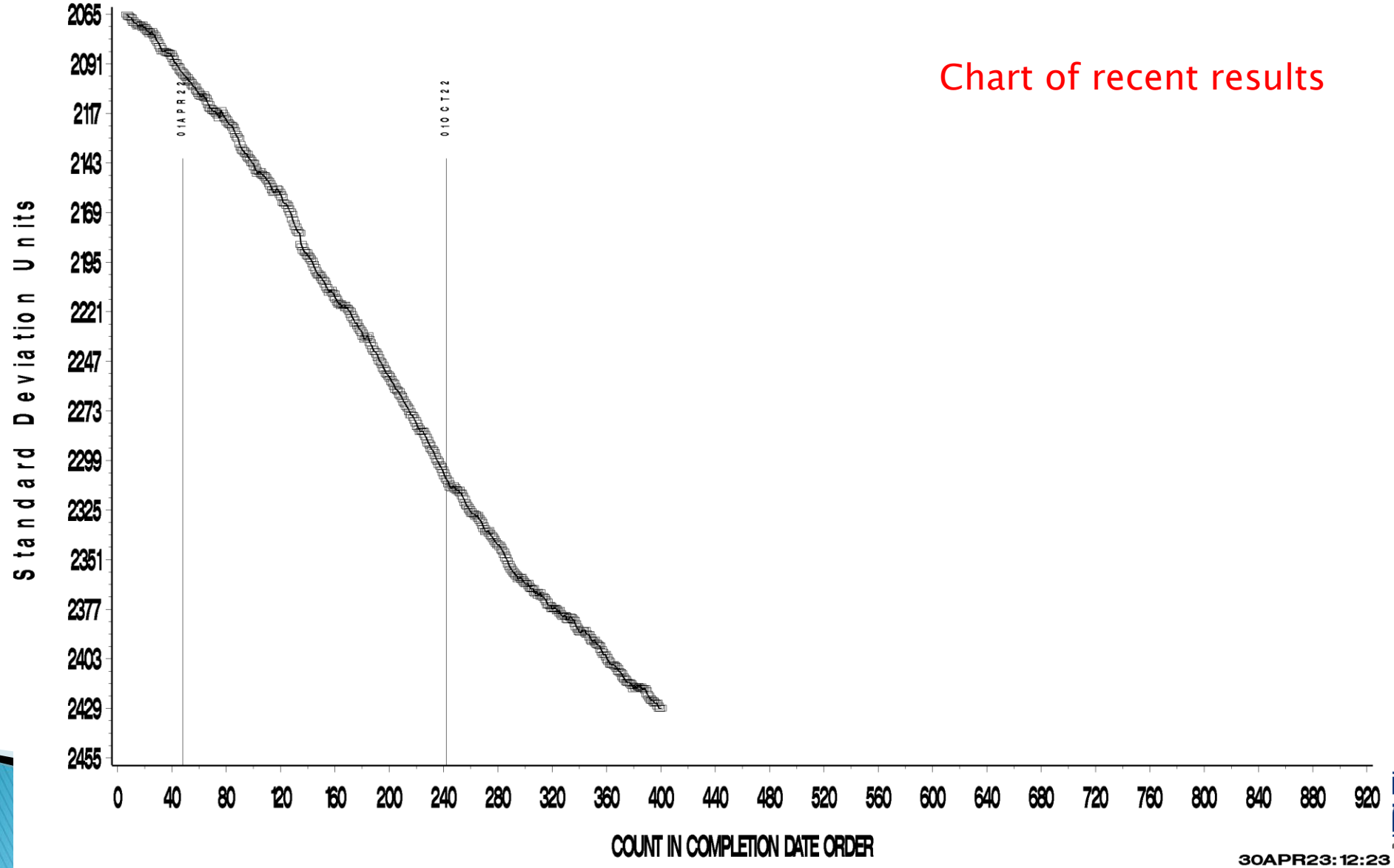
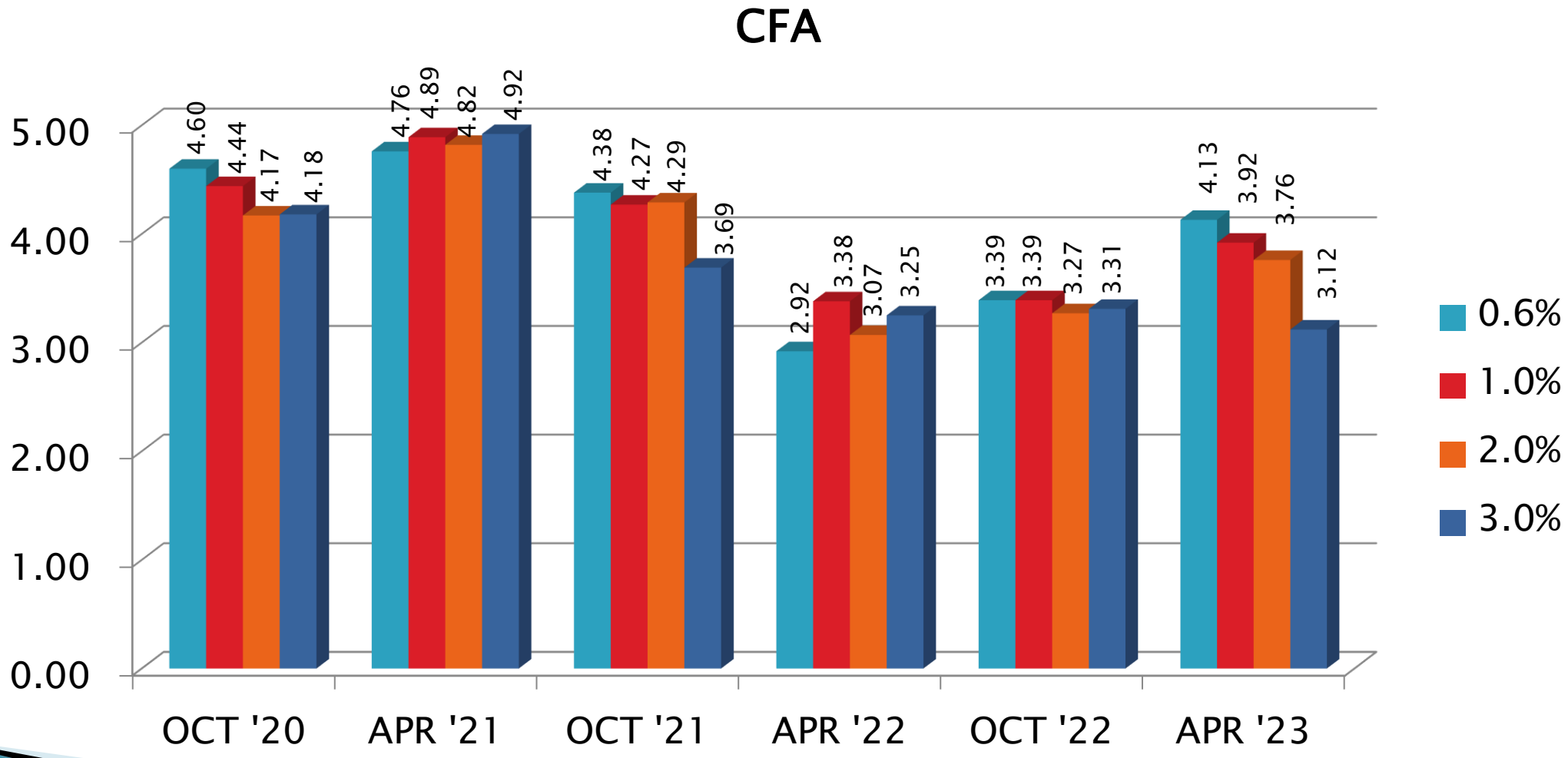


Chart of recent results

30APR23:12:23

EOWT Precision (Pooled s) Estimates



April 1, 2022 – September 30, 2022

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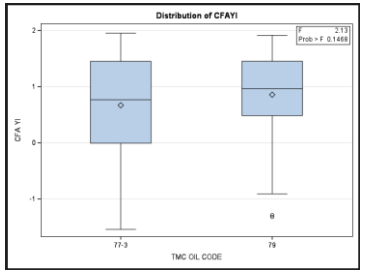
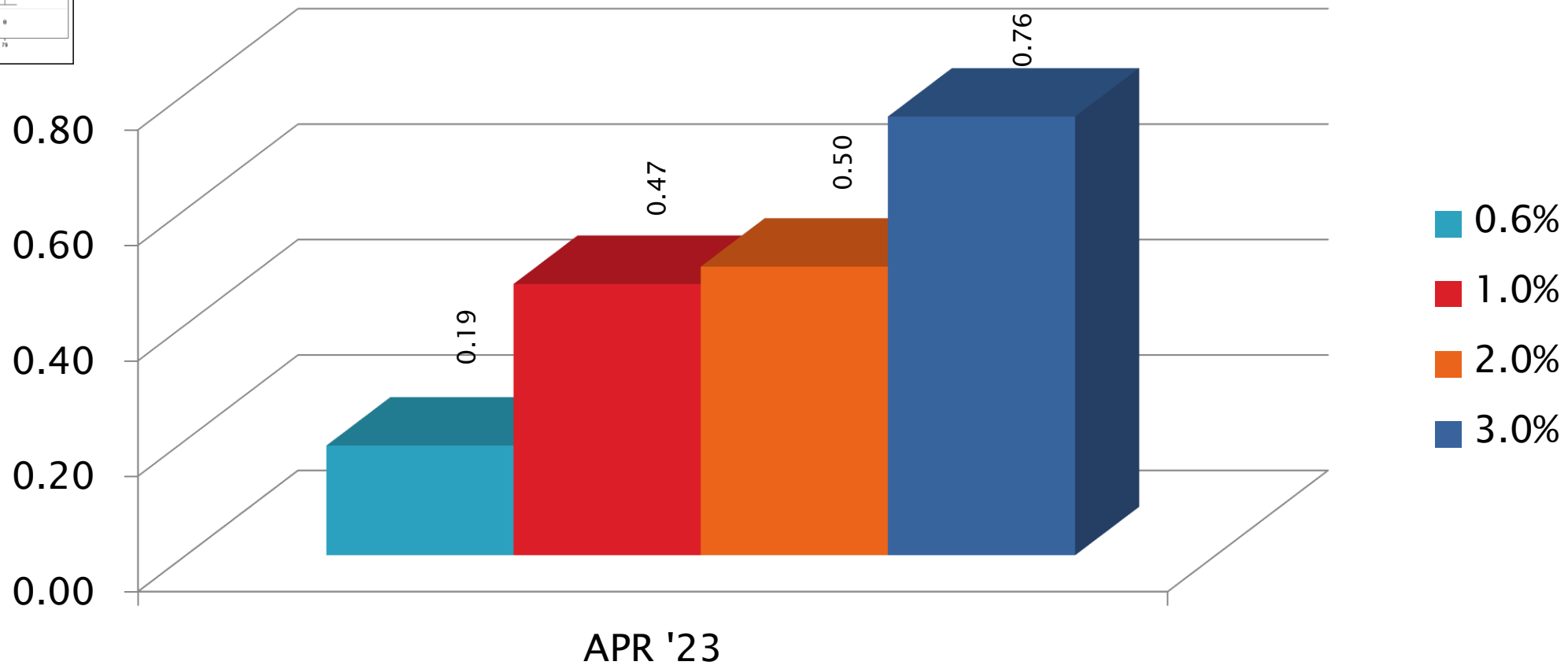
EOWT Performance (Mean Δ/s) Estimates





April 1, 2022 – September 30, 2022

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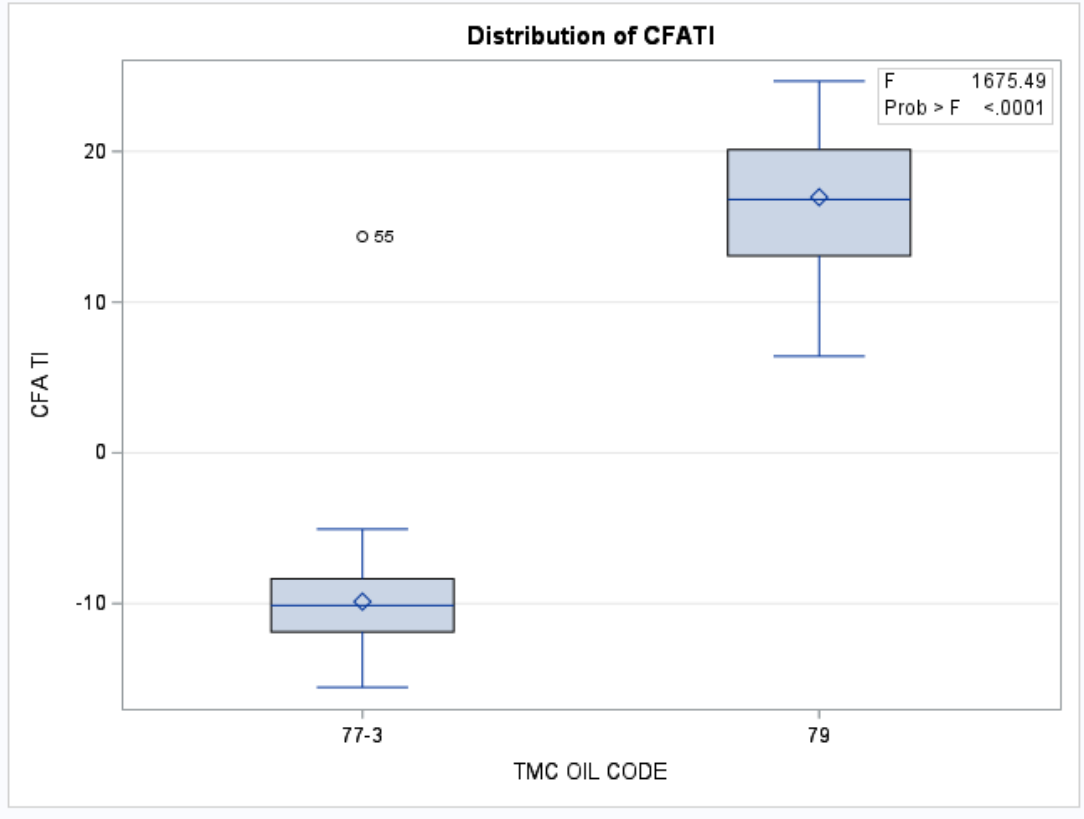
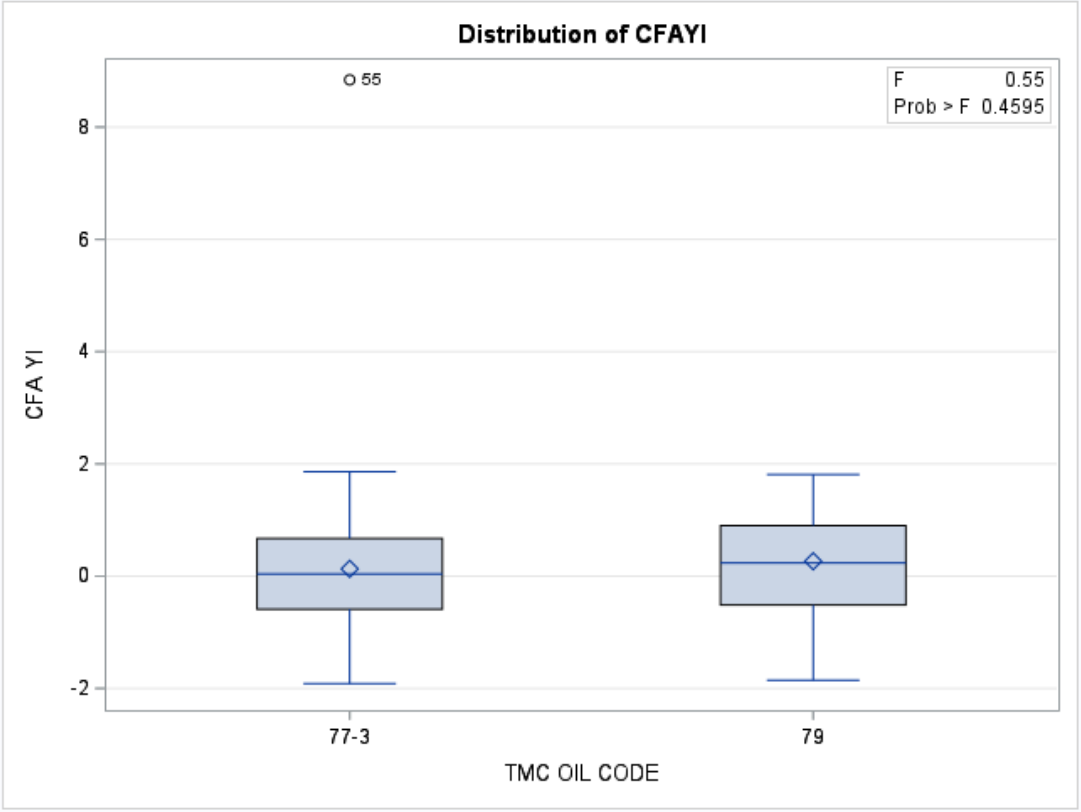
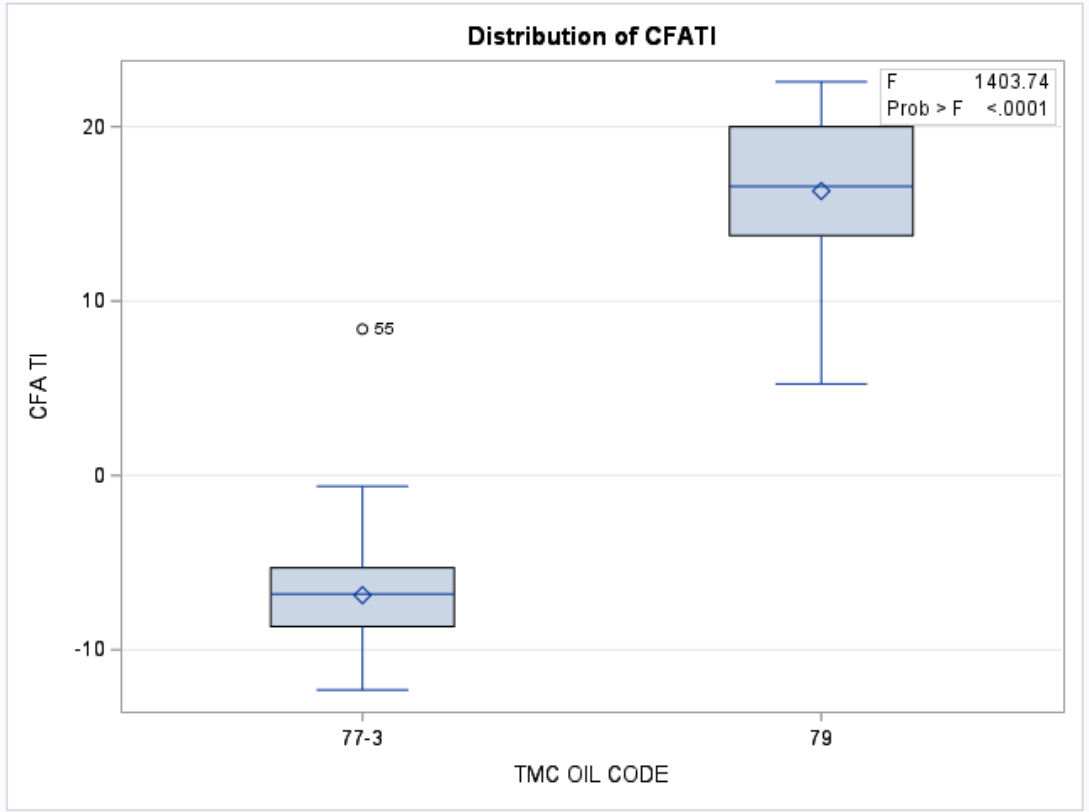
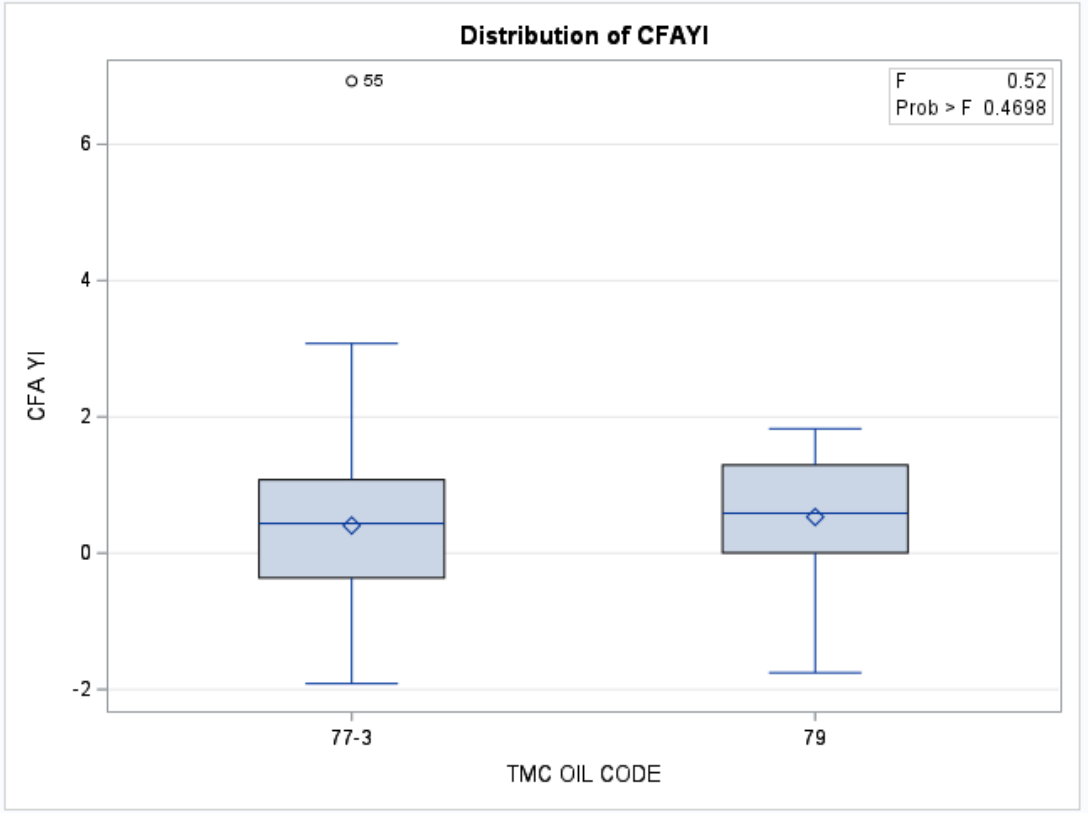
EOWT 0.6% Results by Reference Oil





EOWT 1.0% Results by Reference Oil





April 1, 2022 – September 30, 2022

Test Monitoring Center
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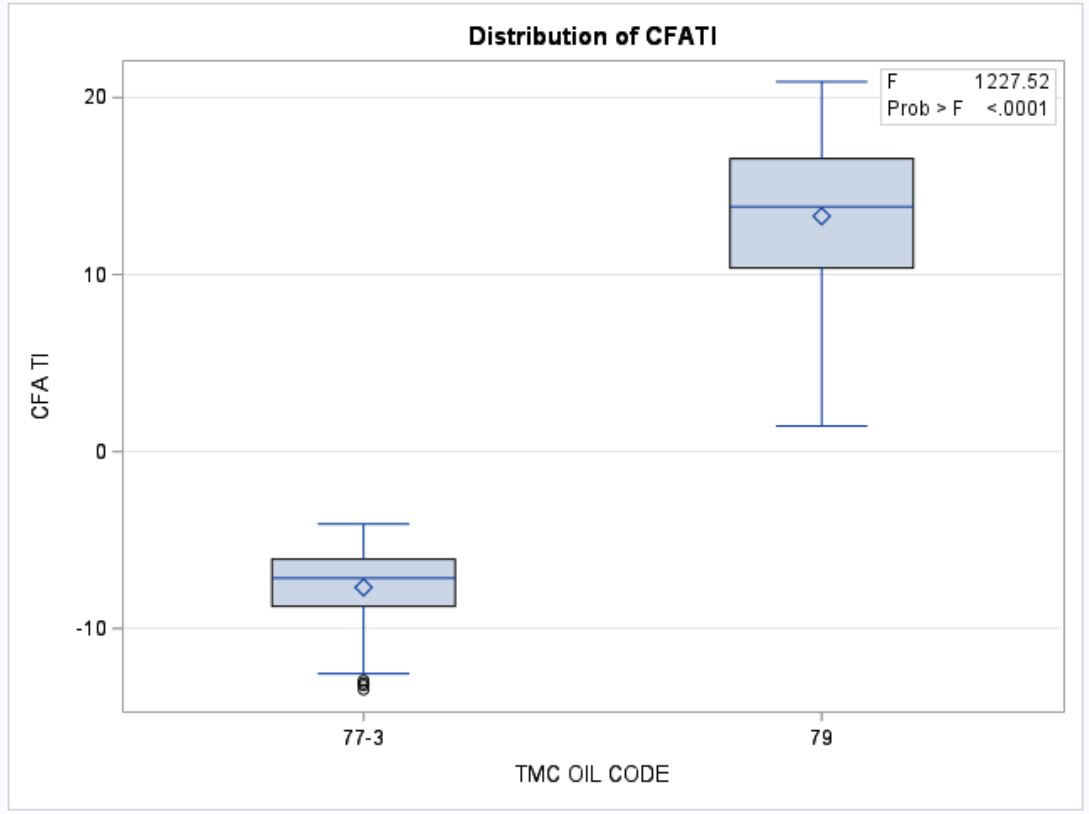
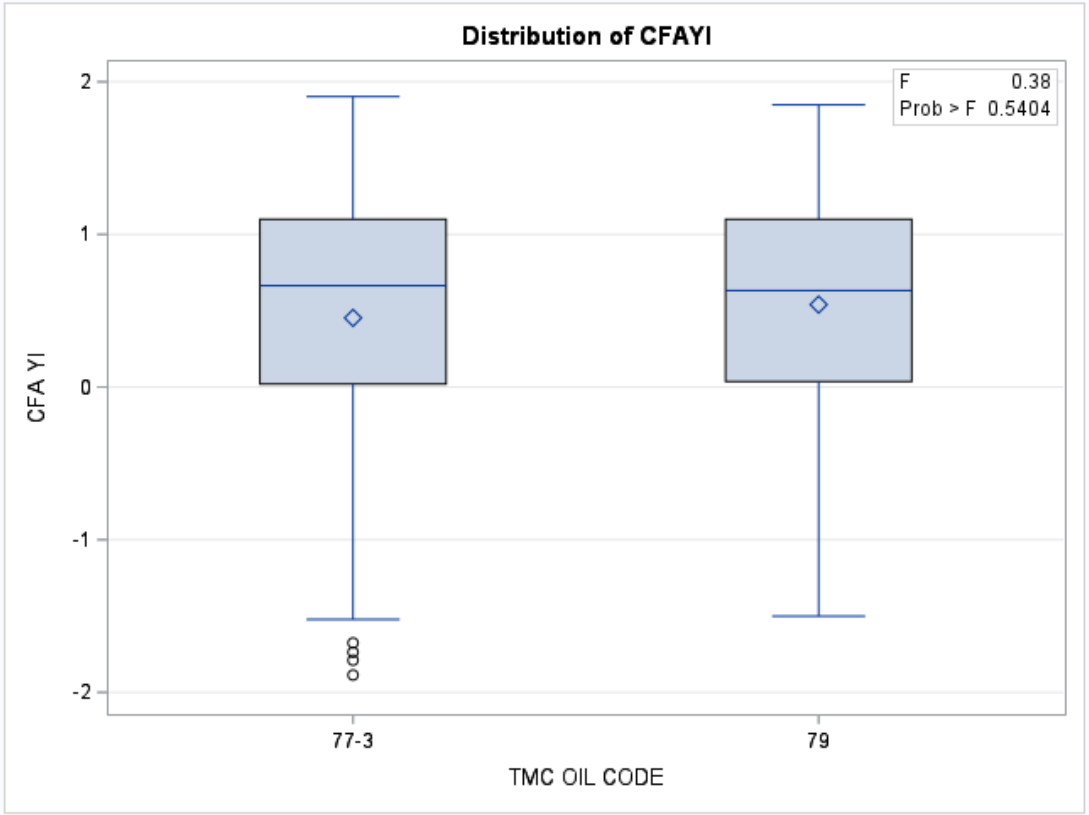
EOWT 2.0% Results by Reference Oil





April 1, 2022 – September 30, 2022

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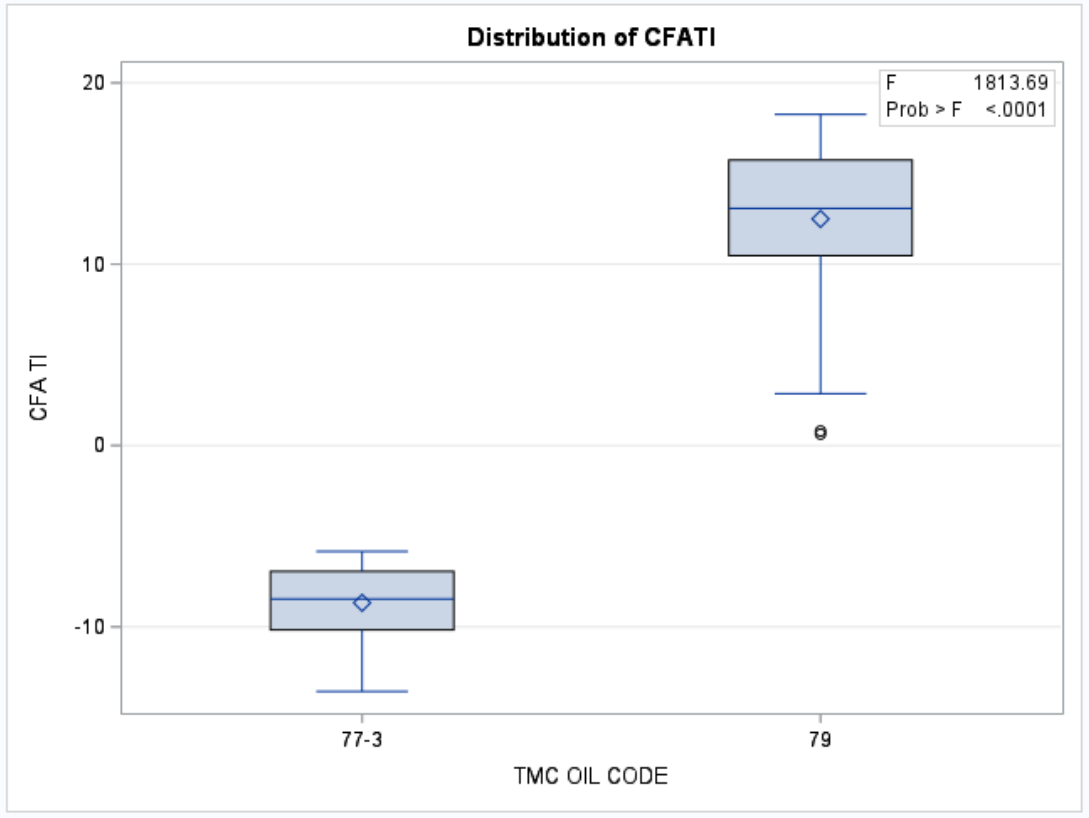
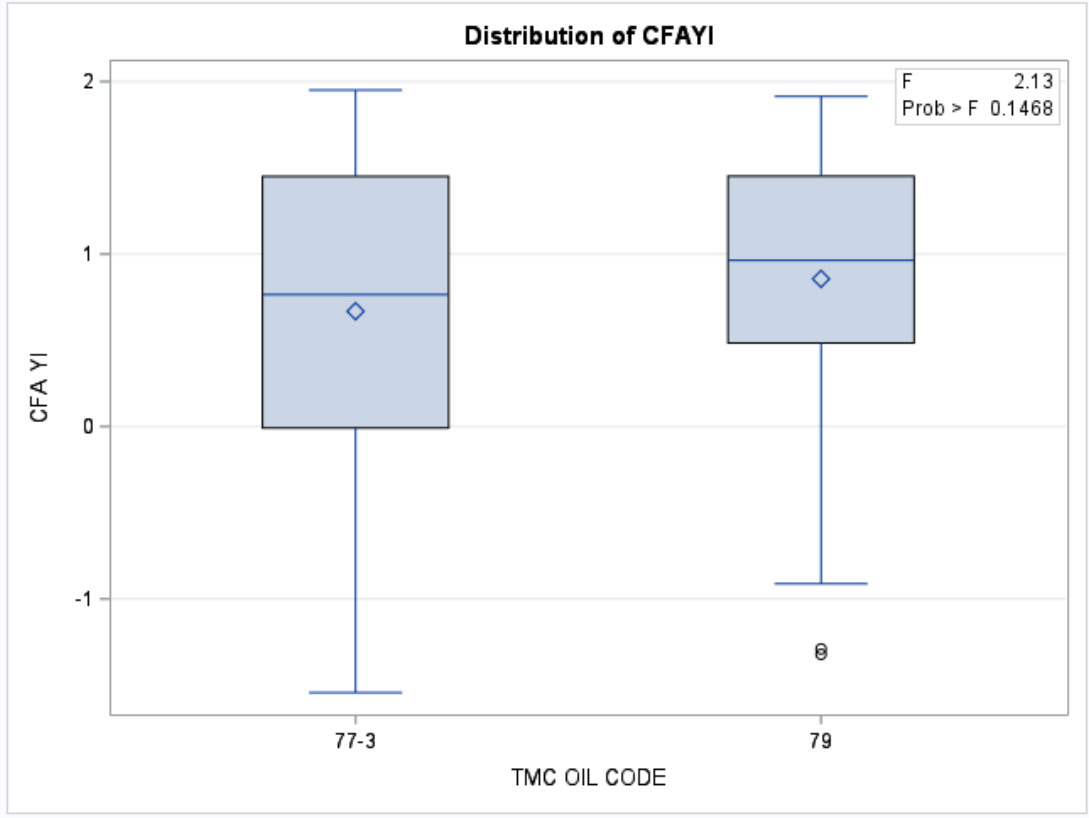
EOWT 3.0% Results by Reference Oil





April 1, 2022 – September 30, 2022

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Information Letters*

Test	Date	IL	Topic
			No new information letters this period.

*Available from TMC Website

Reference Oil Inventory Estimated Life EOWT

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Lab Inventory (samples)	Estimated Life*
77-3	465.5	26.2	325	5+ years
79	240.2	26.3	327	3.7 years

*Based upon Sample Shipping Rate from past 6 months.

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D02.B0.07
TMC Monitored Tests

ASTM D 6795

Engine Oil Filterability Test (EOFT)

October 1, 2022 – March 31, 2023

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

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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D6795	6 (+0)	N/A
*As of 3/31/2023		

EOFT Test Activity*

Test Status	Validity Code	Number of Tests
Acceptable Calibration Test	AC	122
Failed Calibration Test	OC	2
Aborted Calibration Test	XC	0
Acceptable Shakedown Run	NN	0
Unacceptable/Aborted Shakedown Run	MN / XN	0
Total		**124**

- 98.4% Acceptable Calibration (AC) Testing Rate
  - 6 labs reported data this semester

*April 1, 2022 – September 30, 2022

EOFT Failed Tests

Failed Parameter	Number of Tests
Change in Flow Average (CIFA) Severe	2
Change in Flow Average (CIFA) Mild	0
Total	**2**

- The two fails were from two different test labs.

EOFT Failed Tests by Lab

Failed Parameter	LTMS Lab						#
	A	B	G	I	L	BE	
Change in Flow Average (CIFA) Severe	1	0	1	0	0	0	2
Totals	**1**	**0**	**1**	**0**	**0**	**0**	**2**

EOFT Lost Tests*

Status	Cause	No. of Tests
Invalid (L,R)		0
Aborted (X)		0
Total		**0**

*Invalid and aborted calibration tests

EOFT Information/Shakedown Tests

Informational / Shakedown Results	Number of Tests
None	0
Total	0

EOFT Test Severity

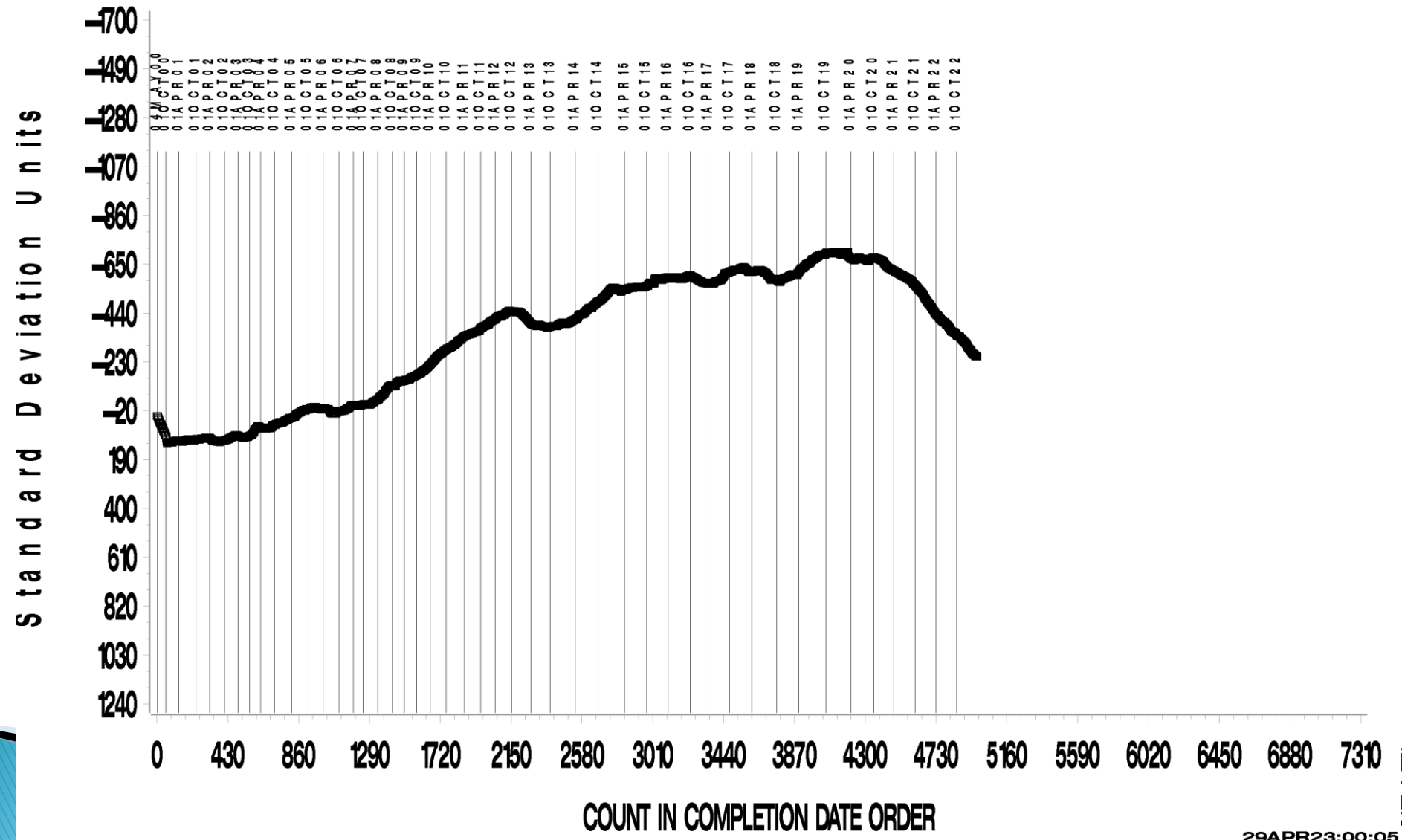
- Change in Flow Average (CIFA) is trending severe with a very consistent CUSUM slope over the past two years.

EOFT INDUSTRY OPERATIONALLY VALID DATA

20 —25 ML CHANGE IN FLOWRATE AVERAGE (%)

CUSUM Severity Analysis

Historical Chart



29APR23:00:05

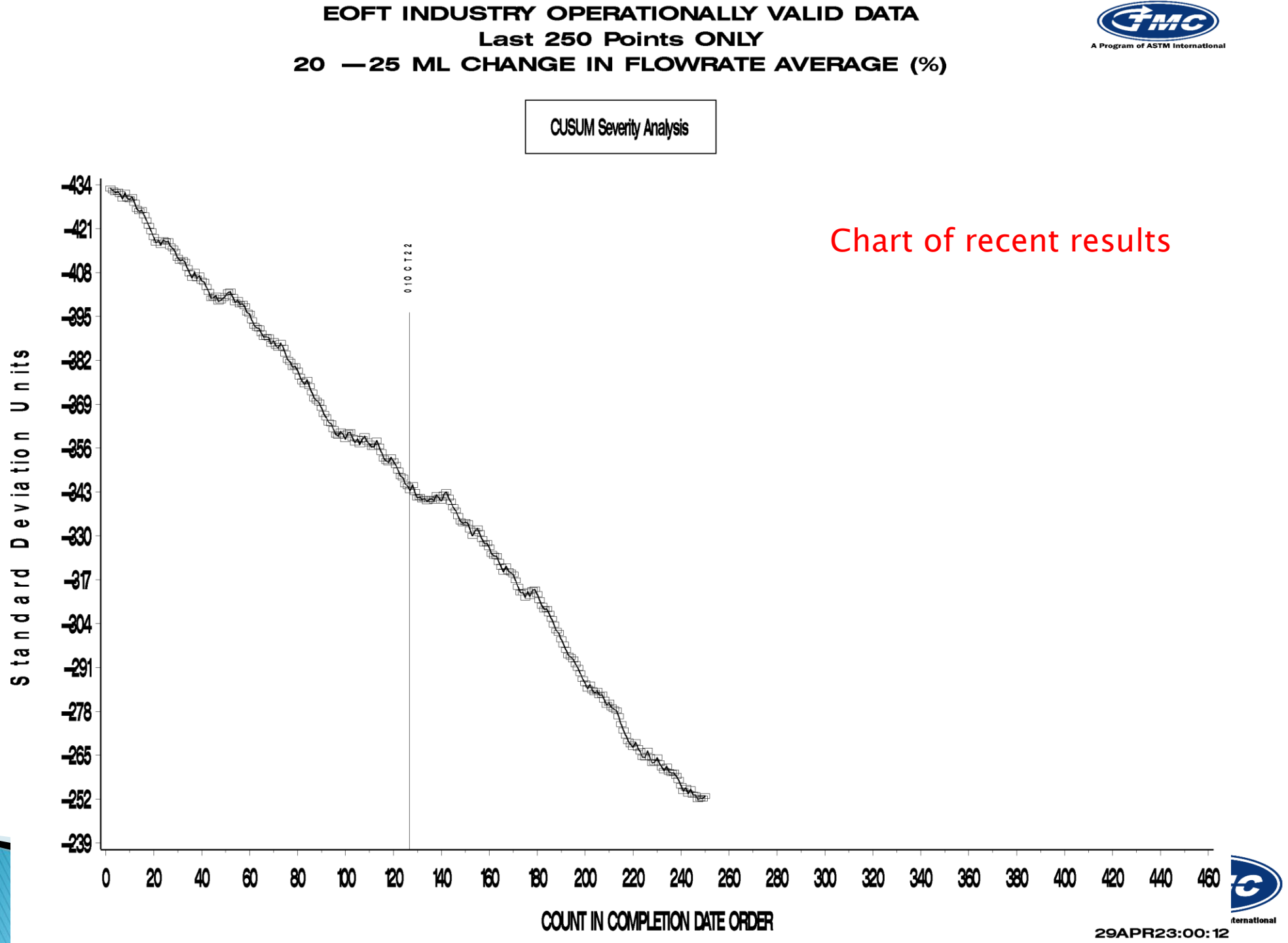
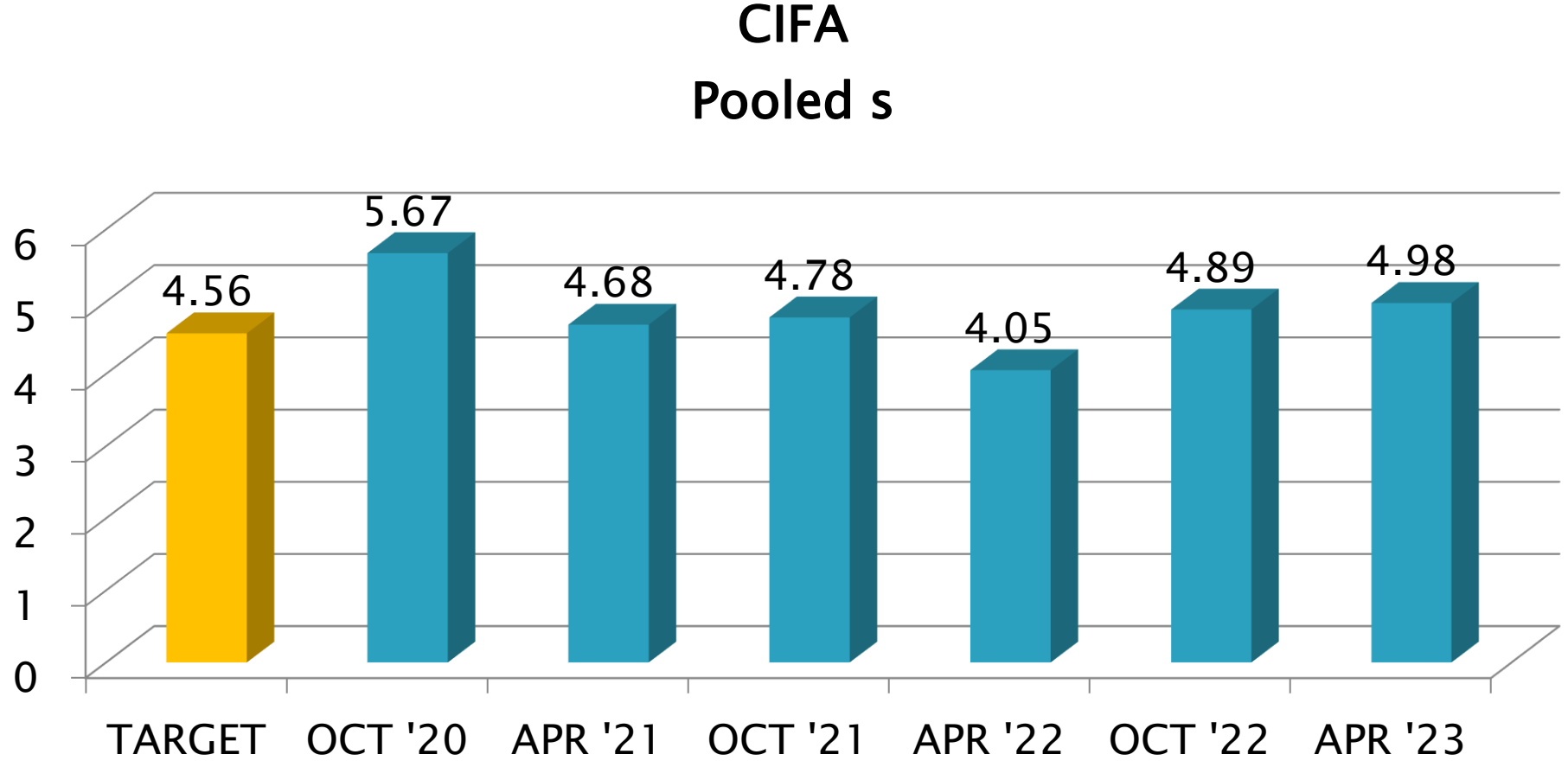
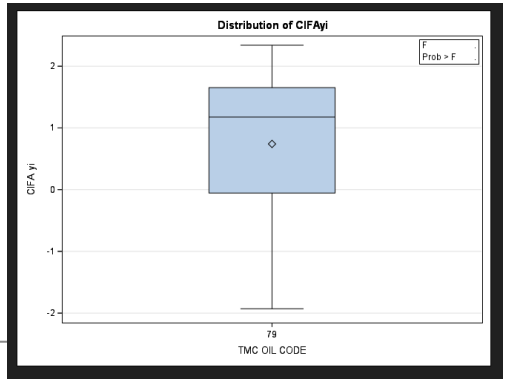


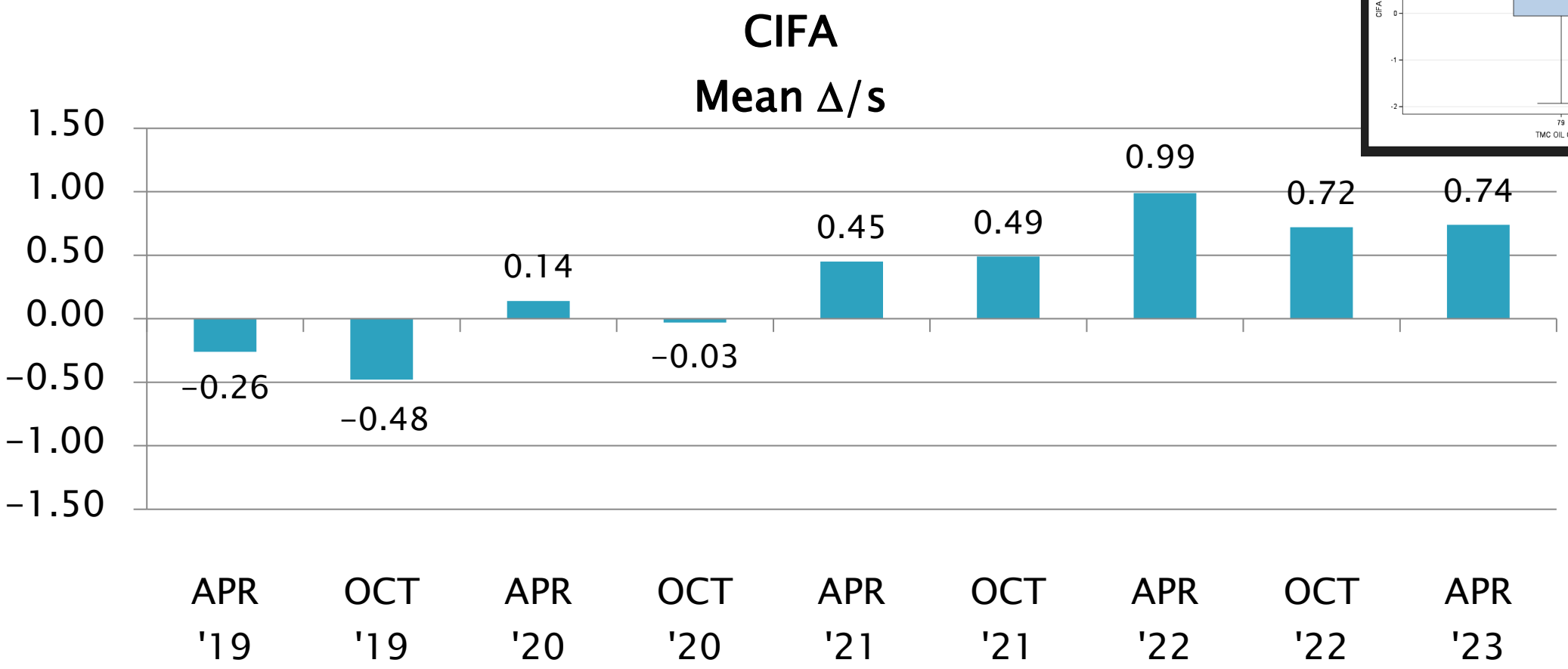
Chart of recent results

EOFT Precision Estimates



EOFT Severity Estimates





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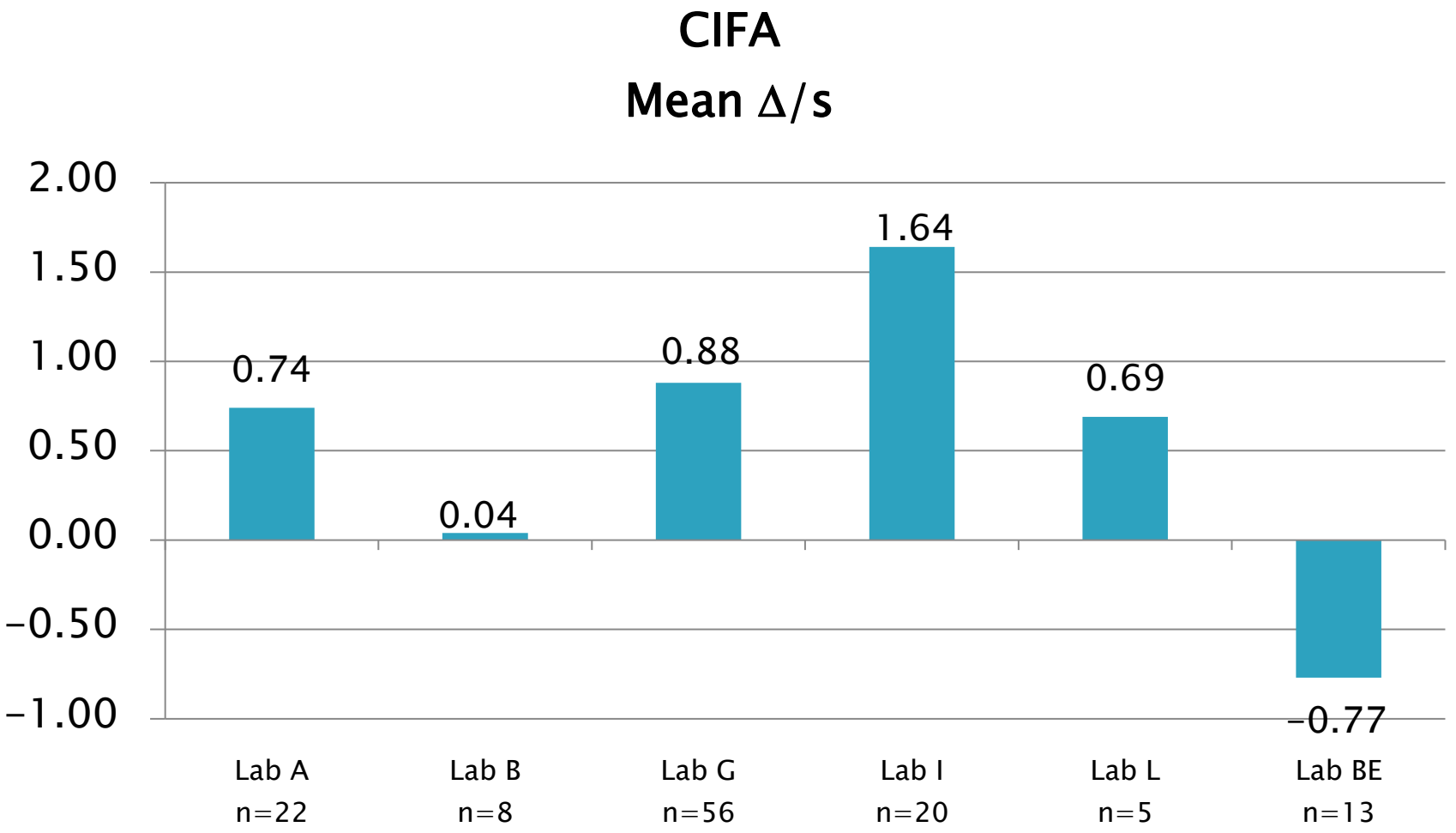
EOFT Lab Severity Estimates



Test Monitoring Center
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Information Letters*

Test	Date	IL	Topic
			No new information letters this period.

*Available from TMC Website

Reference Oil Inventory Estimated Life EOFT

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Lab Inventory (samples)	Estimated Life
79	240.2	31.4	128	2.5 years

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D02.B0.07
TMC Monitored Tests

ASTM D 7097

Medium High Temperature TEOST (MTEOS)

October 1, 2022 – March 31, 2023

Test Monitoring Center
https://www.astmtmc.org
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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D7097	10 (+2)	36 (–4)
*As of 3/31/2023		

D7097: Deposits by MTEOS

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	61
Failed Calibration Test	OC	6
Operationally Invalidated by Lab	LC	5
Operationally Invalidated After Initially Reported as Valid	RC	1
Acceptable Informational Run	NN	1
Unacceptable Informational Run	MN	2
Total		**76**

Number of Labs Reporting Data: 10 (+2)
Fail Rate of Operationally Valid Tests: 9%

D7097: Deposits by MTEOS

Statistically Unacceptable Tests (OC)	No. Of Tests
Total Deposits Mild	0
Total Deposits Severe	6
Total	**6**

Three Labs had OC results.

D7097: Deposits by MTEOS
Summary of Invalid Tests

Operationally Invalid Tests (LC, RC)	Validity Code	No. Of Tests
Compressor Failure	LC	2
Initial Rod Weight not Recorded	LC	2
Sample Contaminated	LC	1
Catalyst Weight Out of Range	RC	1
Total		6

D7097: Deposits by MTEOS
Summary of Informational Tests

Informational / Shakedown Tests (NN, MN)	Validity Code	No. Of Tests
Shakedown run, Deposits in Range	NN	1
Shakedown run, Deposits not in Range (Severe)	MN	2
Total		**3**

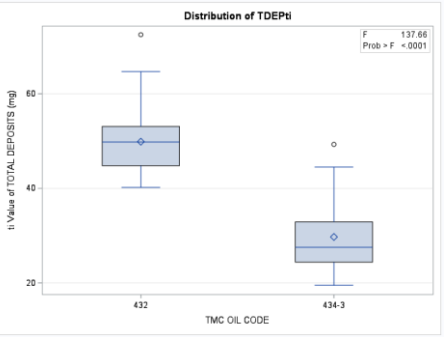
D7097: Deposits by MTEOS

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	-----
10/1/18 through 3/31/19	97	95	5.86	-0.14
4/1/19 through 9/30/19	109	107	6.40	-0.30
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

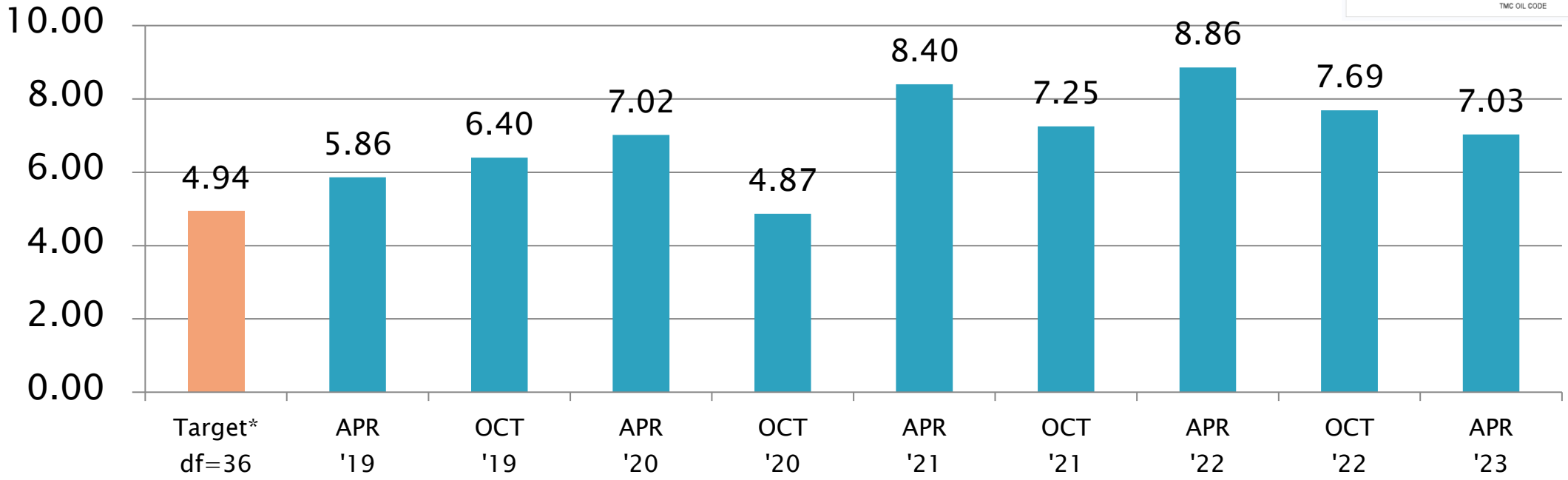
[1]Target precision updated to reference oils 432 and 434-3 preliminary

D7097 Precision Estimates



Total Deposits, mg

Pooled s



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

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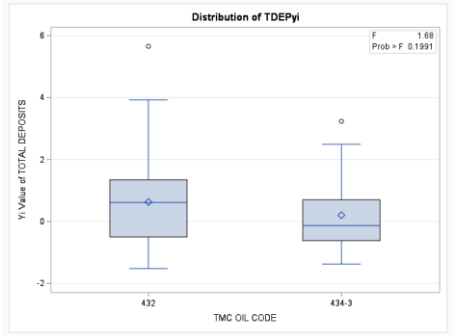
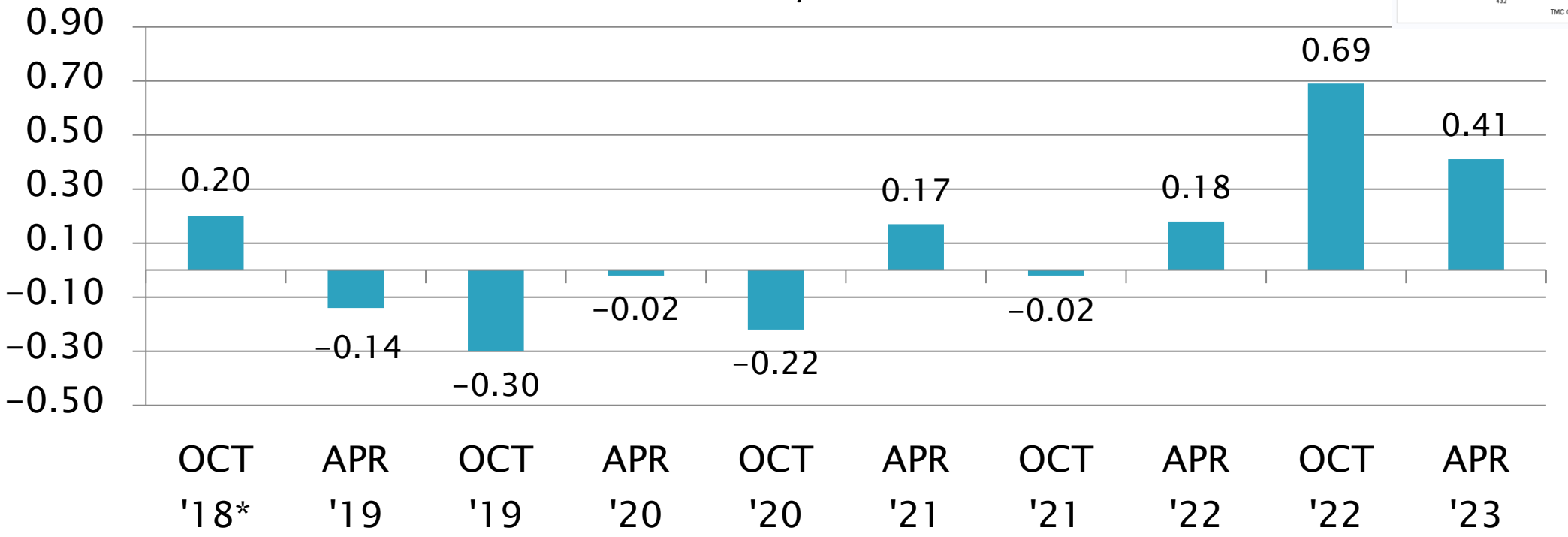
D7097 Severity Estimates



Total Deposits, mg

Mean Δ/s



*One severe OC test from instrument G5 excluded (8.9 s)

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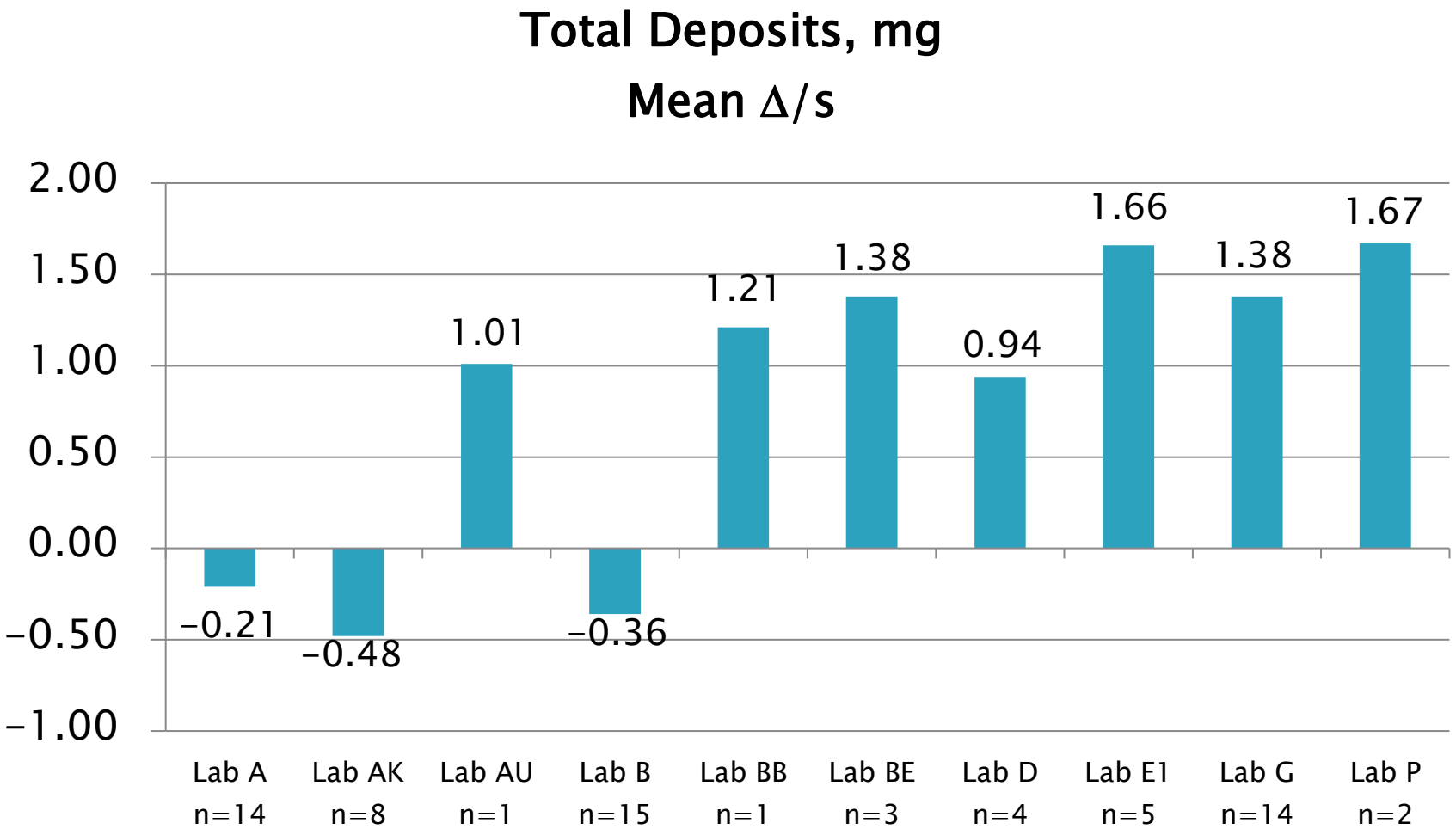
D7097 Lab Severity Estimates



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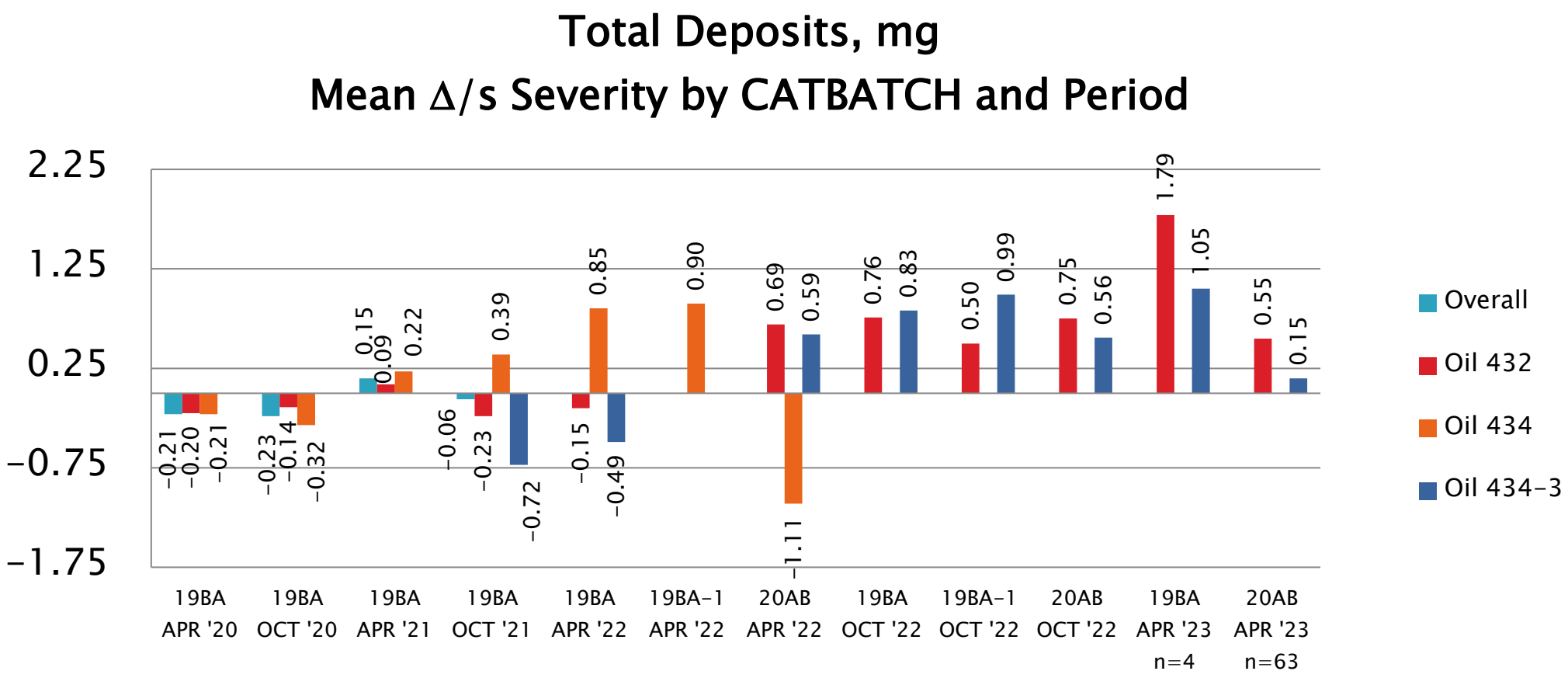
D7097: Deposits by MTEOS



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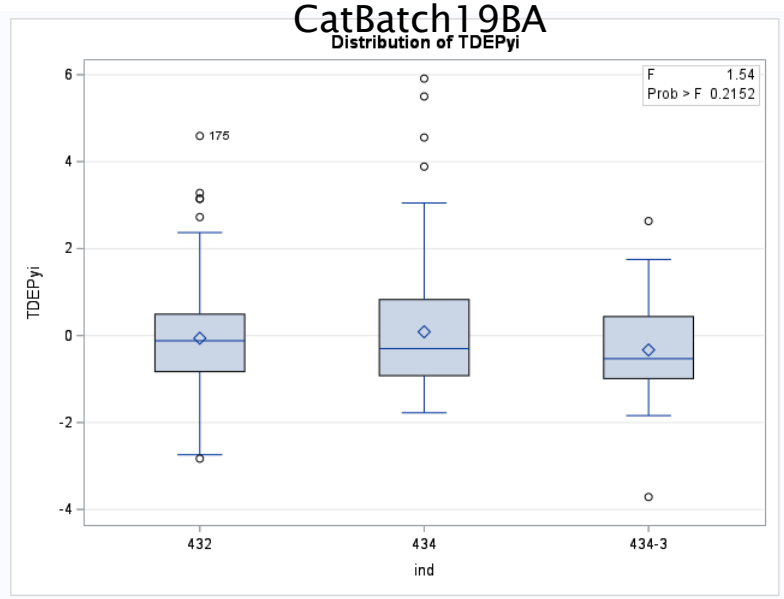
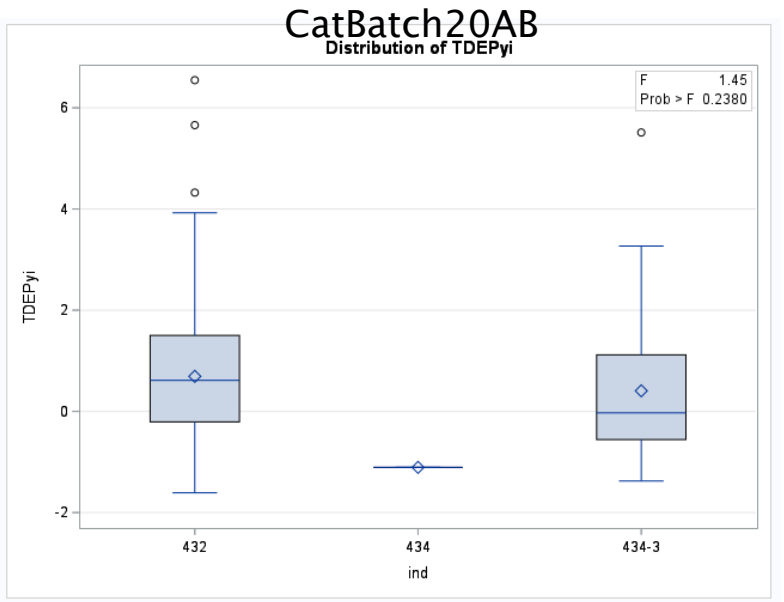
D7097: Deposits by MTEOS

- Precision (Pooled s) remains high, but did move closer to target in this reporting period
  - Best precision result since October 2020
- Performance (Mean Δ/s) has improved, moving from 0.69 s down to 0.41 s
- All operationally valid tests this period report using Rod Batches M (n=2) or N (n=65).
- All operationally valid calibration tests this period report using Catalyst Batch 19BA (n=4) or 20AB (n=63)

D7097: Deposits by MHT TEOST

- Overall severity on catalyst batch 19BA (n=348) appears to be on target for oils 432, 434 and 434-3 (Yi = -0.02).
- Overall severity on catalyst batch 20AB (n=160) appears to be slightly severe of target for oils 432, 434 and 434-3 (Yi = 0.54), but improving from severity at previous report (Yi = 0.65)





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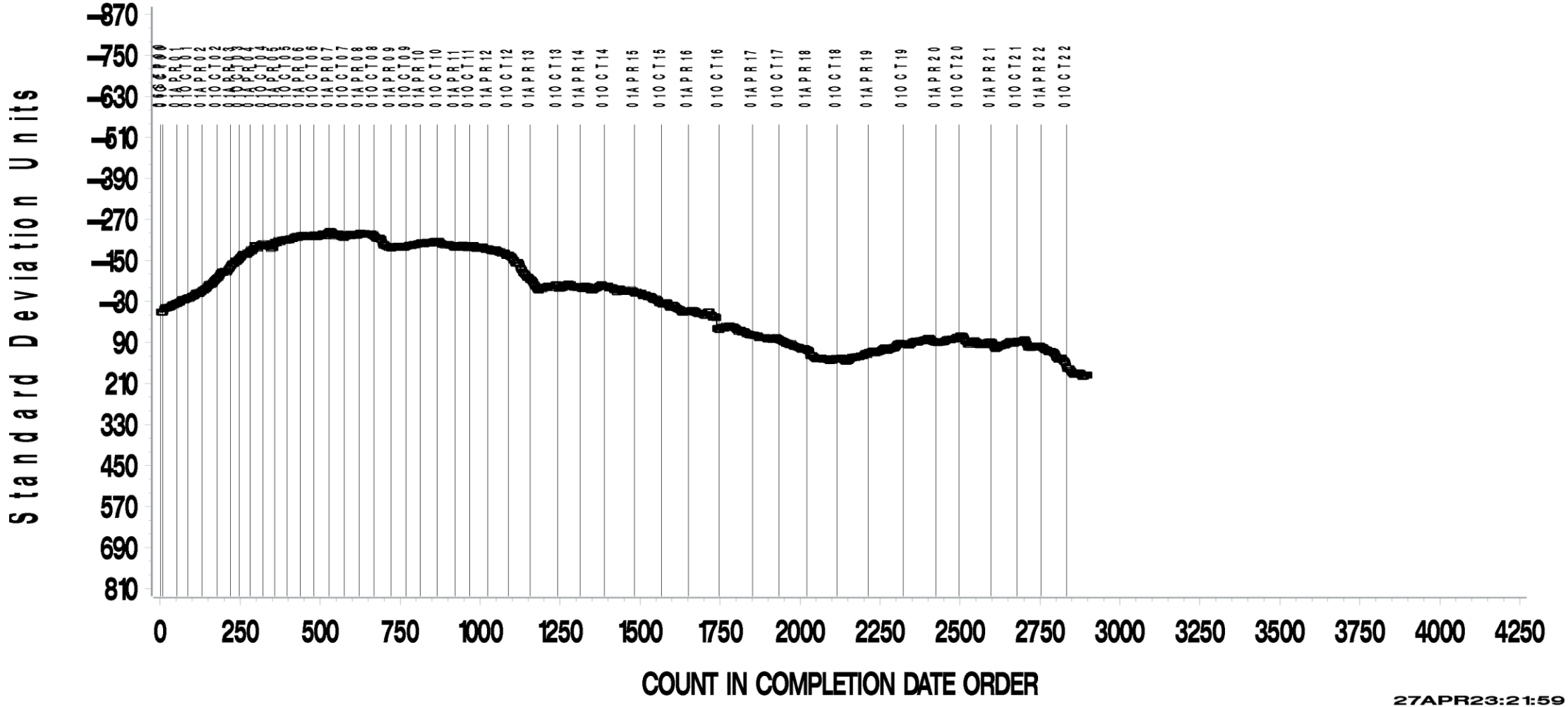
MHT—4 TEOST INDUSTRY OPERATIONALLY VALID DATA

TOTAL DEPOSITS MG

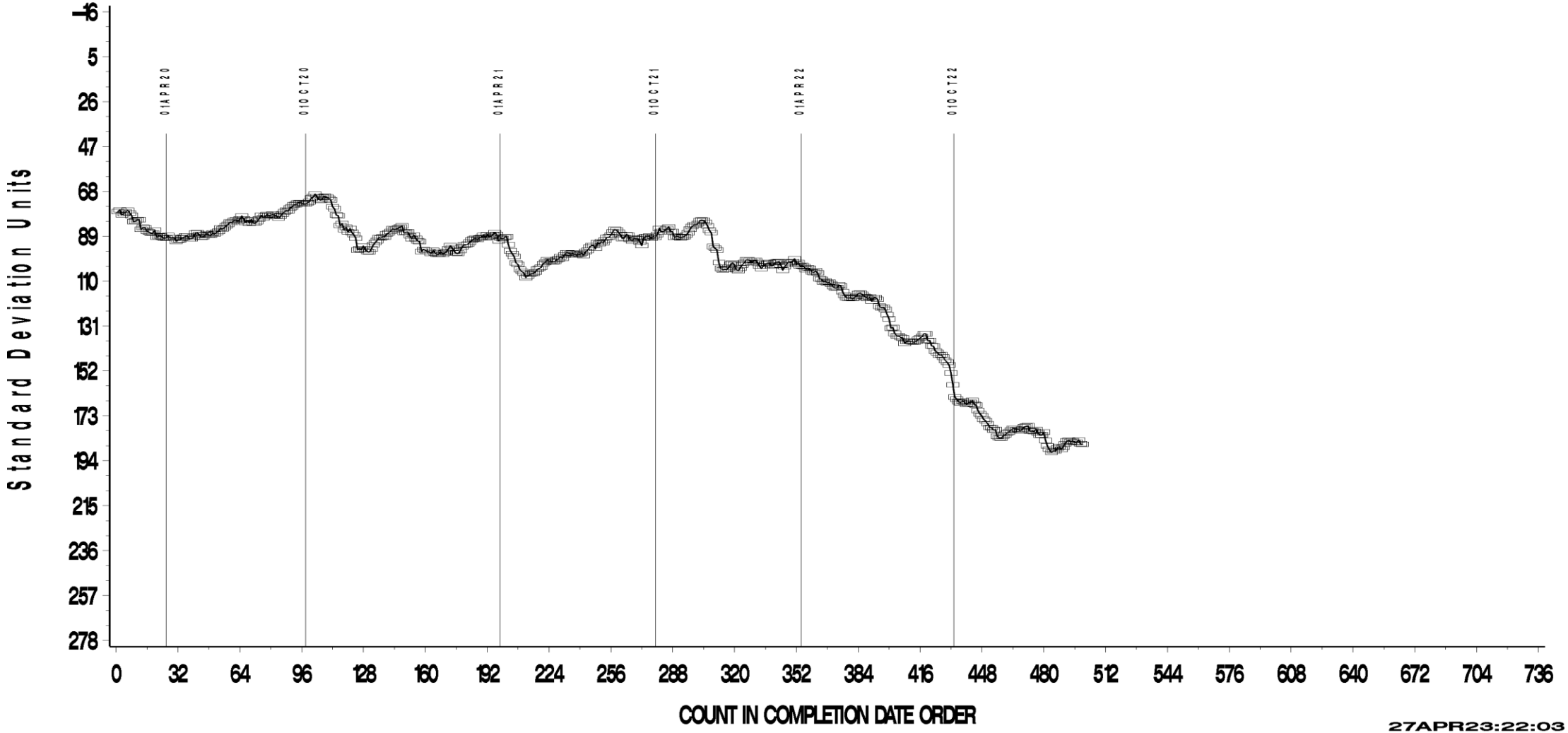
CUSUM Severity Analysis



27APR23:21:59

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

CUSUM Severity Analysis

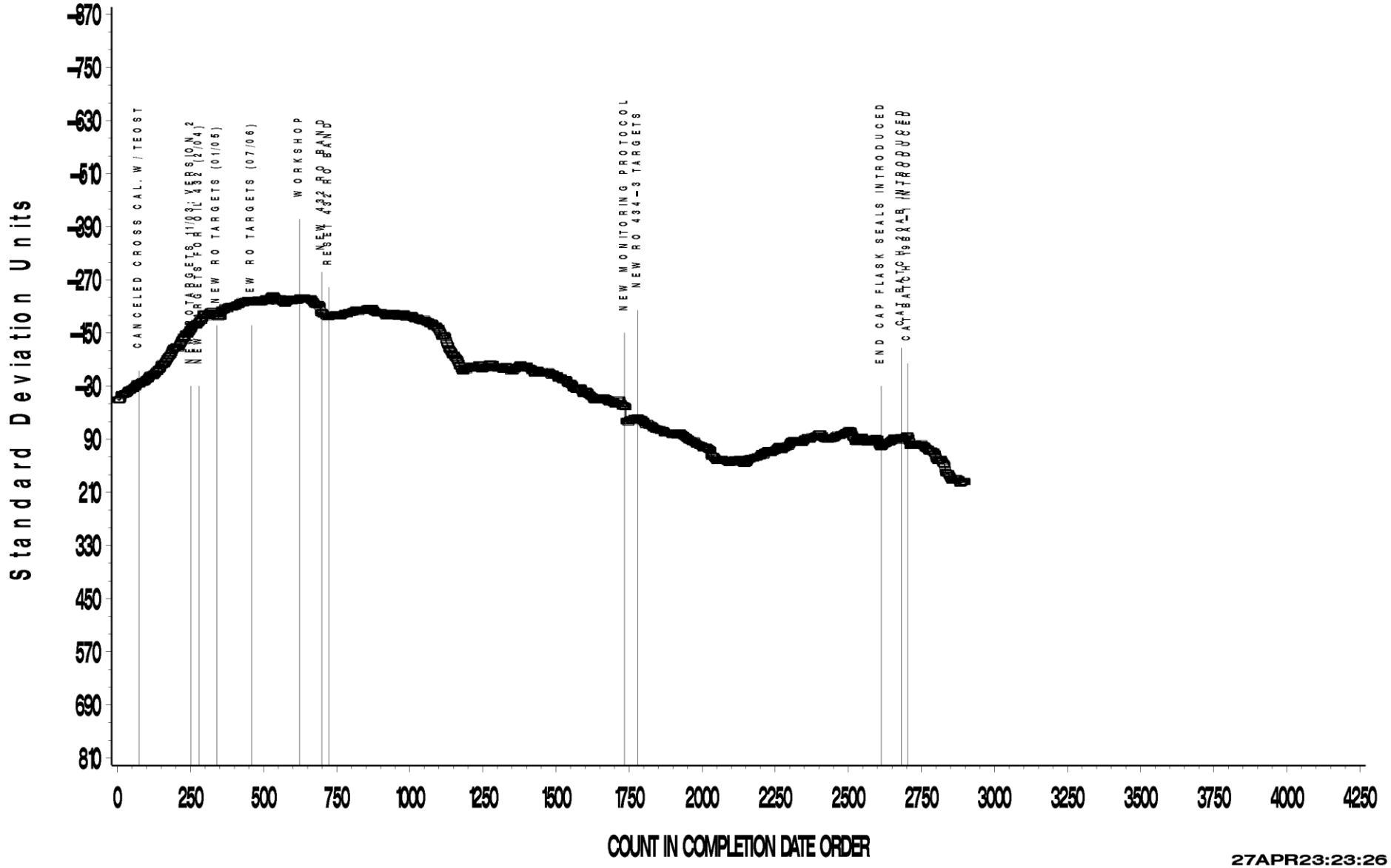


27APR23:22:03

MHT—4 TEOST INDUSTRY OPERATIONALLY VALID DATA

TOTAL DEPOSITS MG

CUSUM Severity Analysis



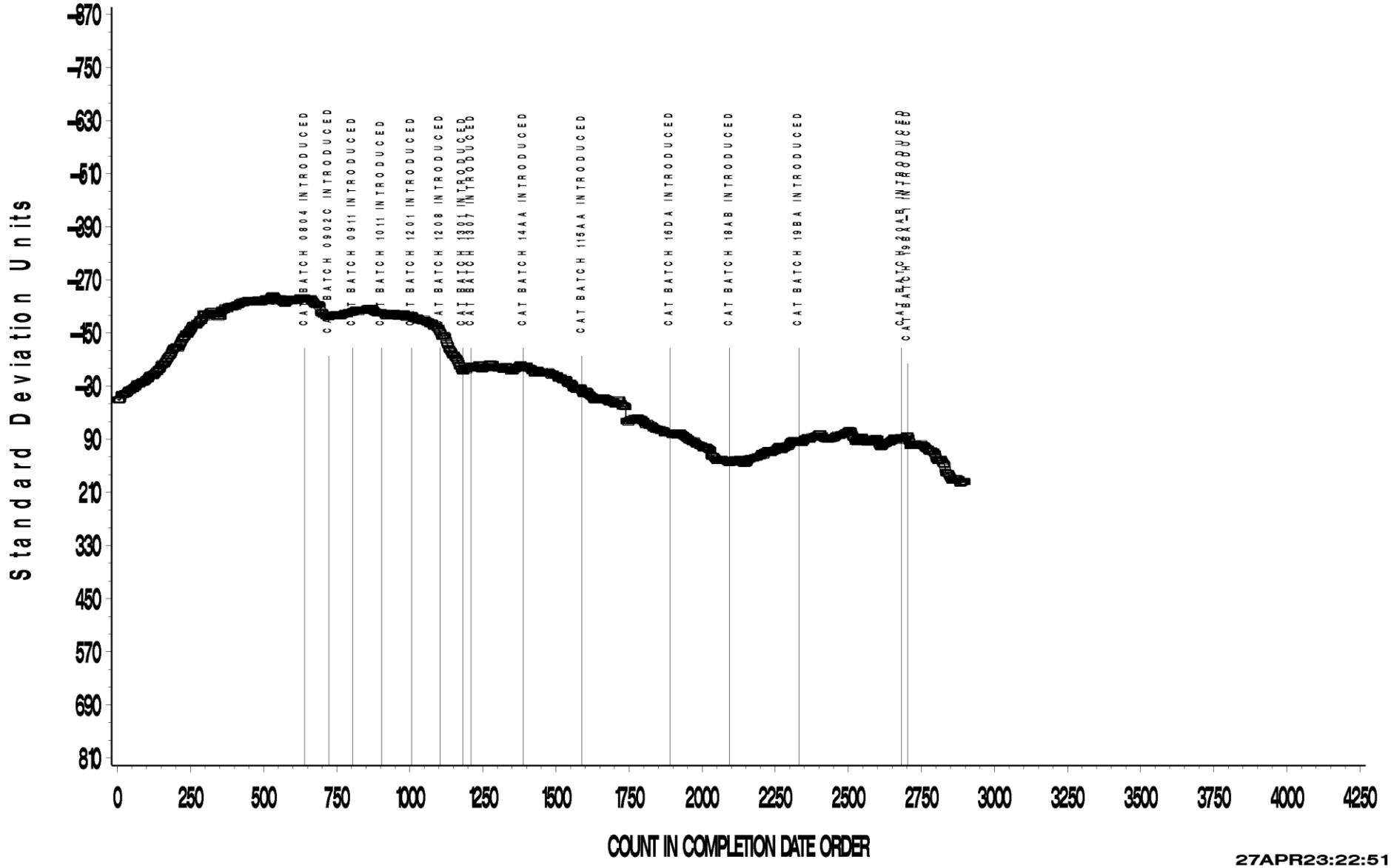
27APR23:23:26

MHT—4 TEOST INDUSTRY OPERATIONALLY VALID DATA

CATALYST BATCH

TOTAL DEPOSITS MG

CUSUM Severity Analysis



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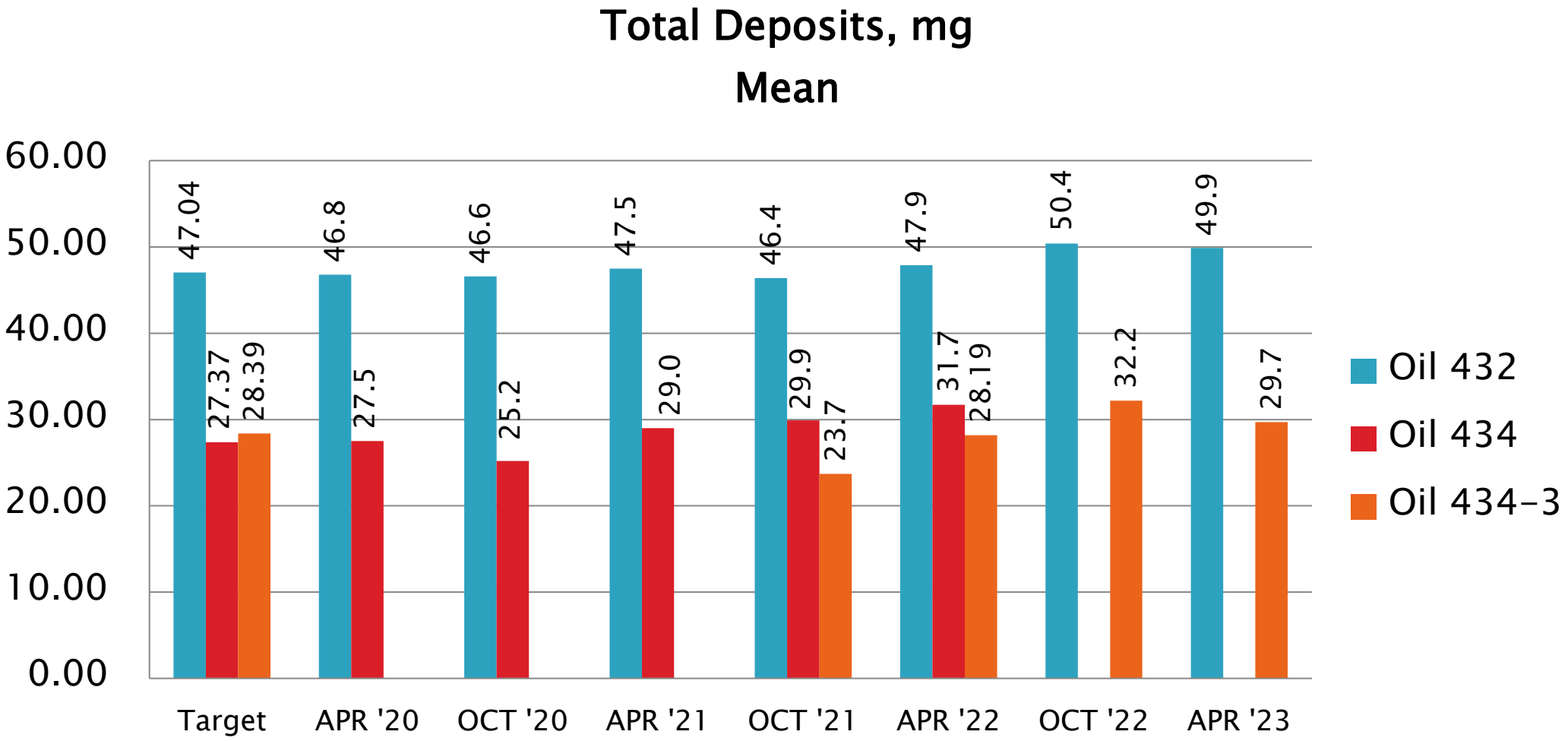
D7097 Performance by Oil



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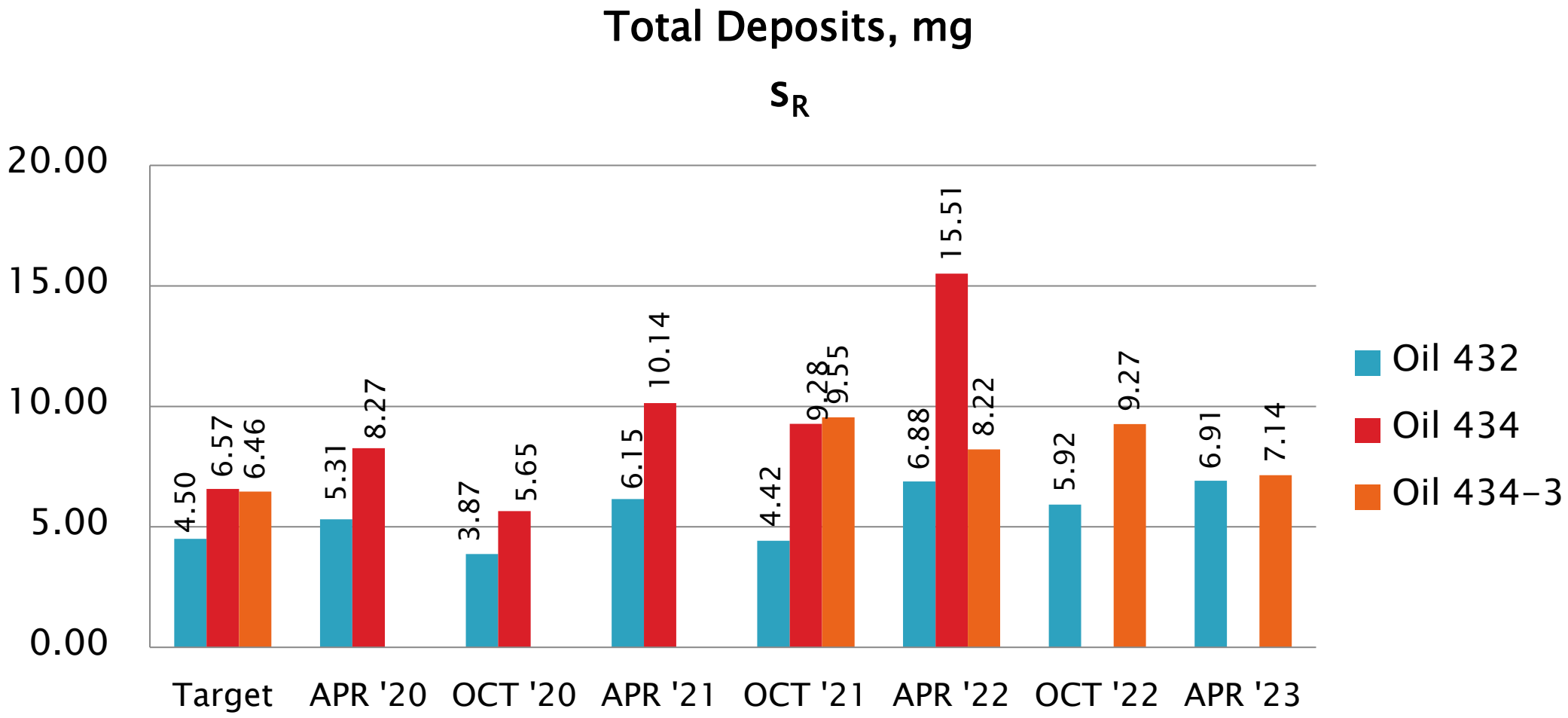
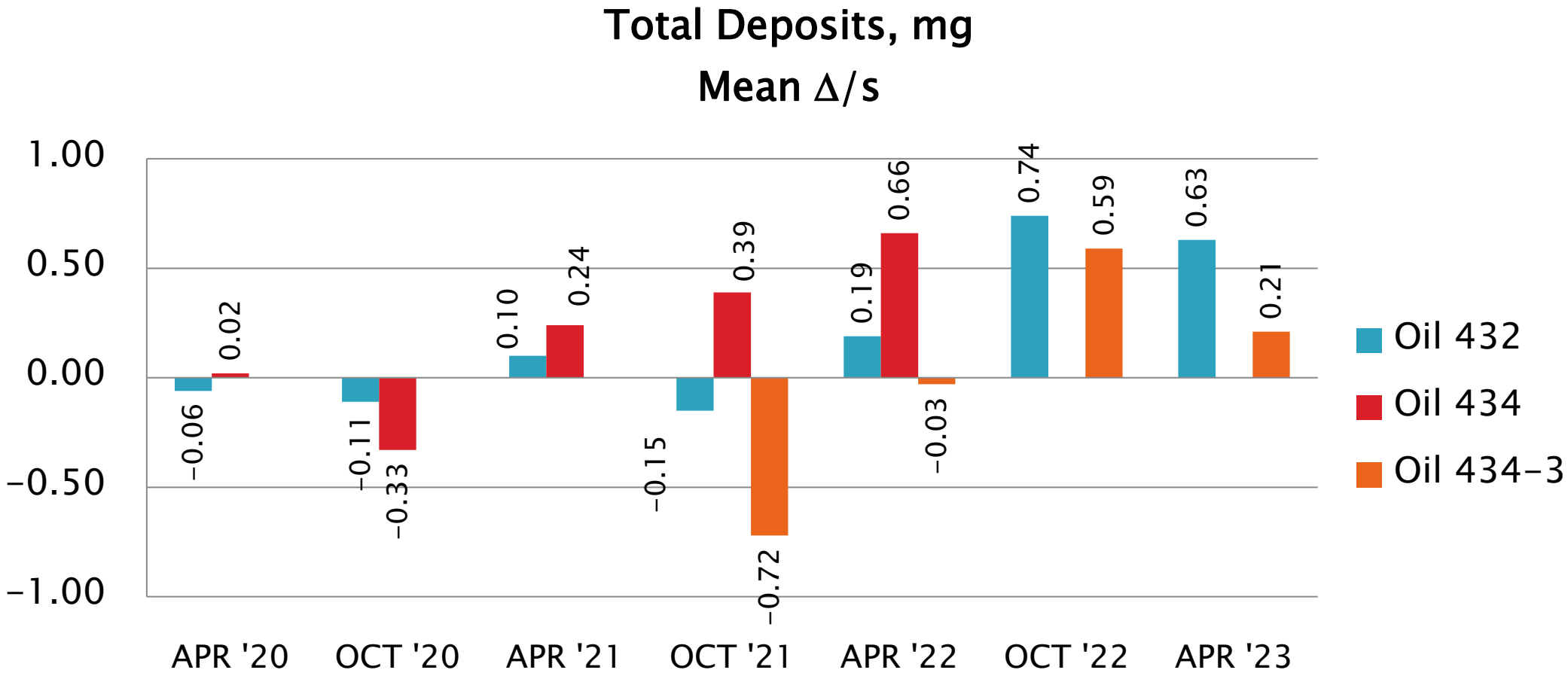
D7097: Deposits by MHT TEOST



D7097: Deposits by MHT TEOST



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D02.B0.07
TMC Monitored Tests

ASTM D 7216

Engine Oil Elastomer Compatibility (EOEC/HDEOC)

October 1, 2022 – March 31, 2023

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ASTM Reference Testing Semi-Annual Report D7216 EOEC

October 1, 2022 – March 31, 2023

ASTM D 7216

Engine Oil Elastomer Compatibility (EOEC/HDEOC)

OHT CURRENT ELASTOMER BATCH CODES FOR ASTM D7216

AS OF: 3/9/2023

EOEC (PC 9)	
OHT PART NUMBER	**BATCH CODE**
OHTPC9-NBR-1	29
OHTPC9-ACM-2	31
OHTPC9-FKM-1	30
OHTPC9-MAC-1	23

LDEOC (J2643)	
OHT PART NUMBER	**BATCH CODE**
OHTJ2643-HNBR-1	30
OHTJ2643-FKM-1	28
OHTJ2643-ACM-2	25
OHTJ2643-VMQ-1	40
OHTJ2643-AEM-2	30

Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D7216	6 (–2)	N/A
*As of 3/31/2023		

EOEC Test Activity*

Test Status		Fluoroelast.	Nitrile	Polyacrylate	Silicone	VAMAC	Total
Acceptable Calibration Test	AC	58	67	61	56	55	297
Failed Calibration Test	OC	0	0	0	0	2	2
Operationally Invalid, by lab	LC	0	4	0	0	0	4
Operationally Invalid, by TMC	RC	0	0	0	0	0	0
Aborted	XC	0	0	0	0	0	0
Total		**58**	**71**	**61**	**56**	**57**	**303**

*October 1, 2022 – March 31, 2023

EOEC Failed Calibration Tests*

Cause	Elastomer	No. of Tests
Tensile Strength Change (MILD)	EOECV	1
Volume Change (MILD)	EOECV	1
Total		**2**

*Two failing calibration tests, one (each) reported by two different labs

EOEC Lost Tests*

Validity	Cause	No. of Tests
LC	Wrong Temperature	1
LC	Wrong Elastomer Material	1
LC	Sample Lost	2
Total		**4**

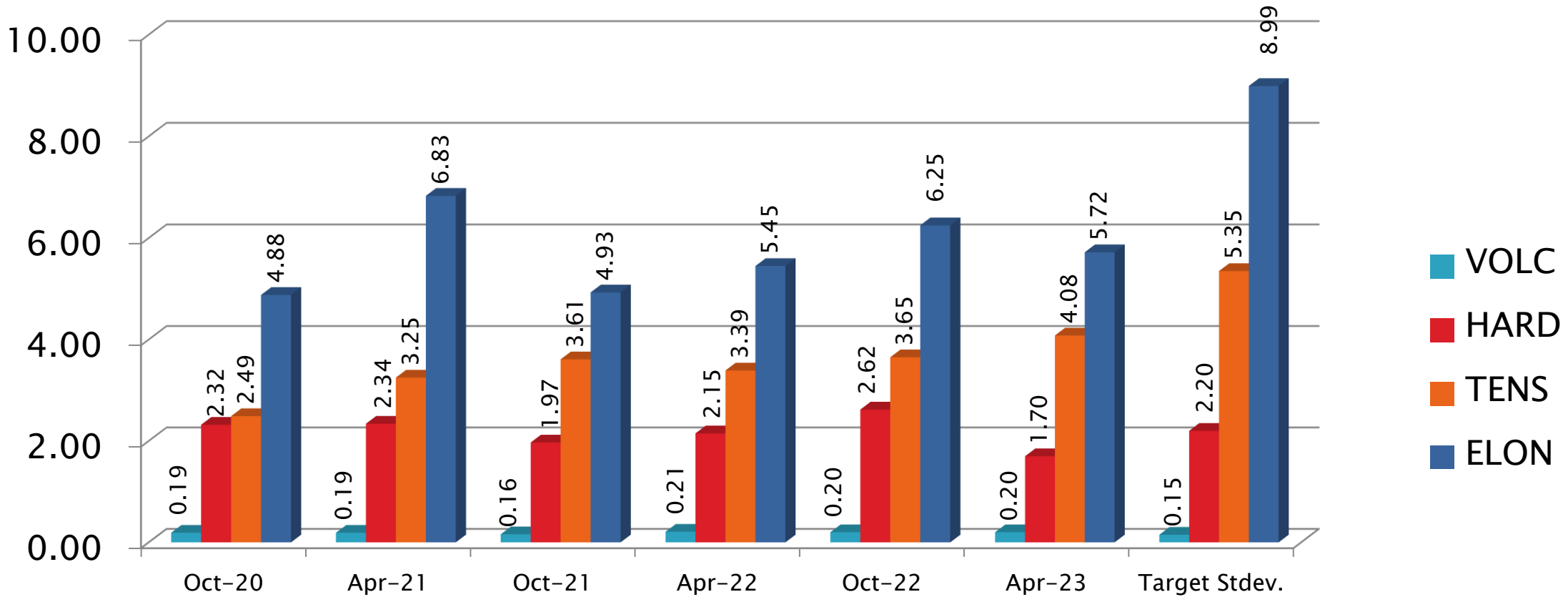
*Invalid and aborted calibration tests

EOEC Test Severity

Fluoroelastomer (FKM)

Parameter	Period Mean Δ/s	Status
Volume Change	-0.04	On-Target
Points Hardness Change	0.00	On-Target
Tensile Strength Change	0.57	Severe
Elongation Change	-0.58	Mild

EOEC Precision (Pooled s) Estimates: Fluoroelastomer



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EOEC Precision Estimates by Lab: FKM

Test Parameter	Statistic	LTMS Lab				
		A	B	L	I	G
	n=	19	3	4	14	18
Volume	Mean	0.37	0.39	0.35	0.61	0.39
	Pooled s	0.10	0.08	0.05	0.30	0.14
	Mean /s	-0.46	-0.34	-0.61	1.12	-0.32
Hardness	Mean	8.89	9.67	8.25	7.71	7.06
	Pooled s	1.15	1.15	1.26	1.44	1.95
	Mean /s	0.39	0.74	0.1	-0.15	-0.45
Tensile Strength	Mean	-70.8	-72.3	-70.4	-65.4	-66.7
	Pooled s	1.93	2.14	1.78	0.69	4.44
	Mean /s	0.09	-0.19	0.17	1.10	0.87
Elongation	Mean	-67.8	-66.2	-68.1	-58.3	-62.3
	Pooled s	2.69	1.51	1.42	6.27	4.53
	Mean /s	-1.04	-0.86	-1.07	0.02	-0.42

EOEC — FLUOROELASTOMER INDUSTRY OPERATIONALLY VALID DATA

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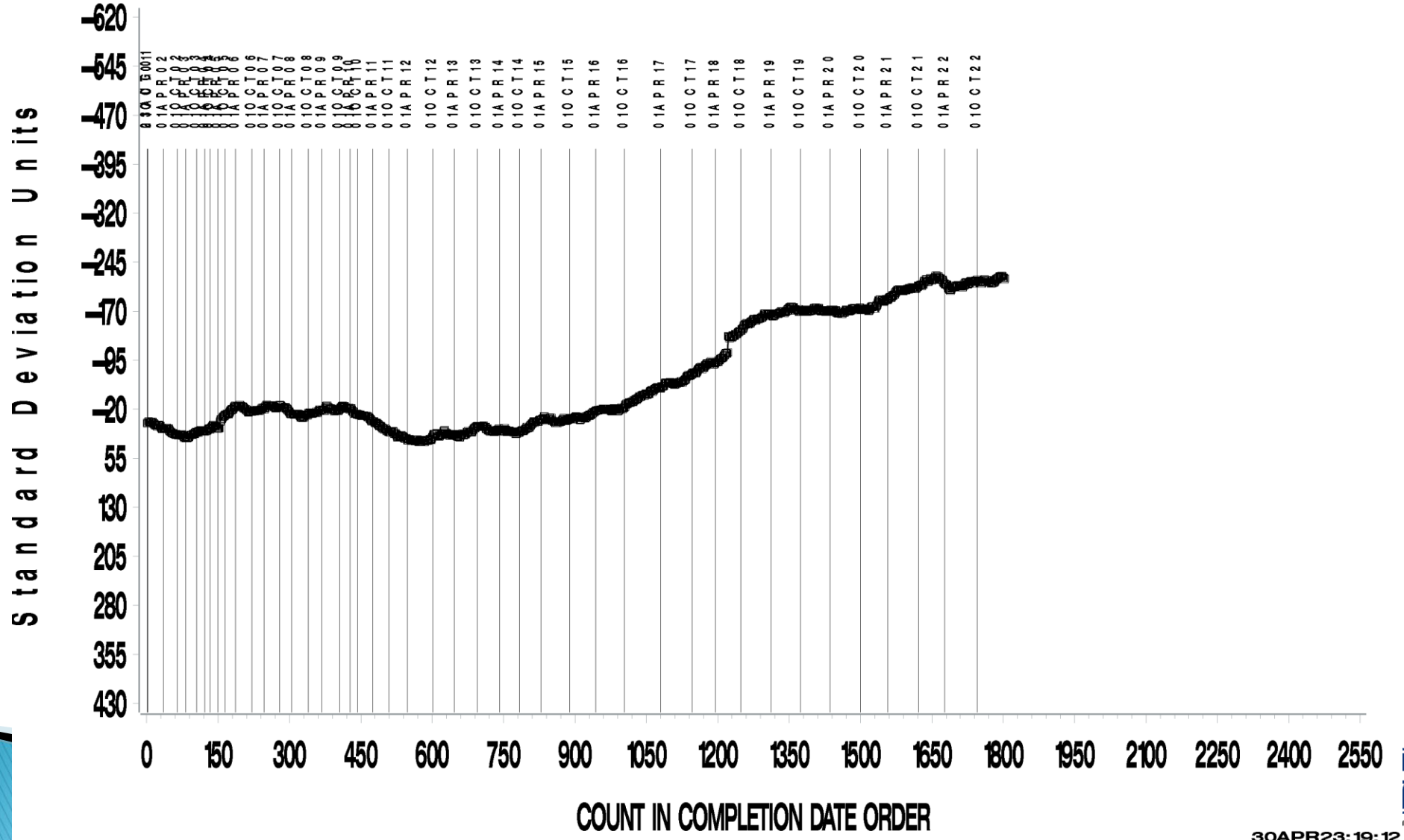
FLUOROELASTOMER VOLUME CHANGE CORRECTED AVERAGE

CUSUM Severity Analysis



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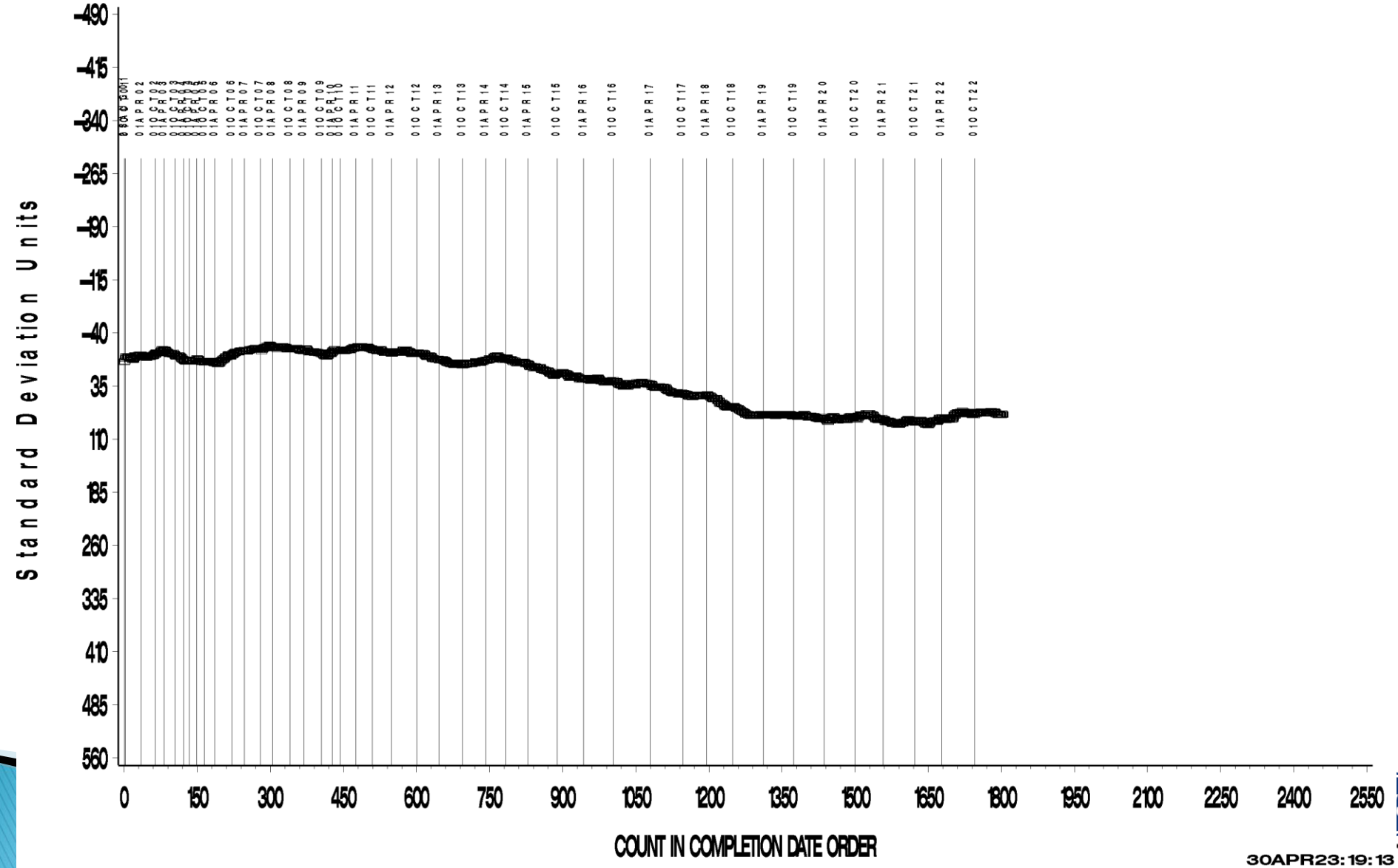
FLUOROELASTOMER PTS HARDNESS CHANGE CORRECTED AVG

CUSUM Severity Analysis



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EOEC — FLUOROELASTOMER INDUSTRY OPERATIONALLY VALID DATA

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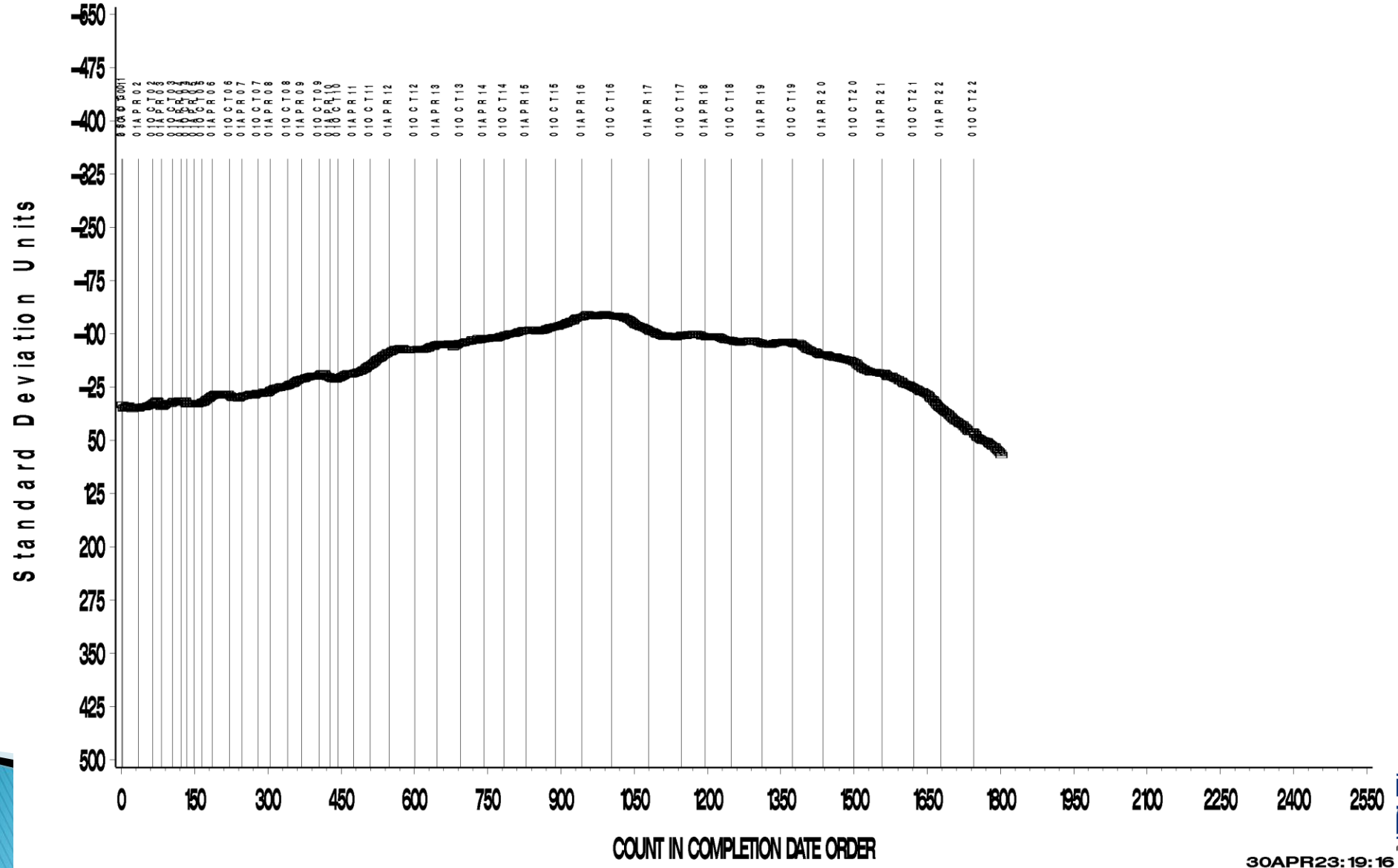
FLUOROELASTOMER TENS STRENGTH CHANGE CORRECTED AVG

CUSUM Severity Analysis



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EOEC — FLUOROELASTOMER INDUSTRY OPERATIONALLY VALID DATA

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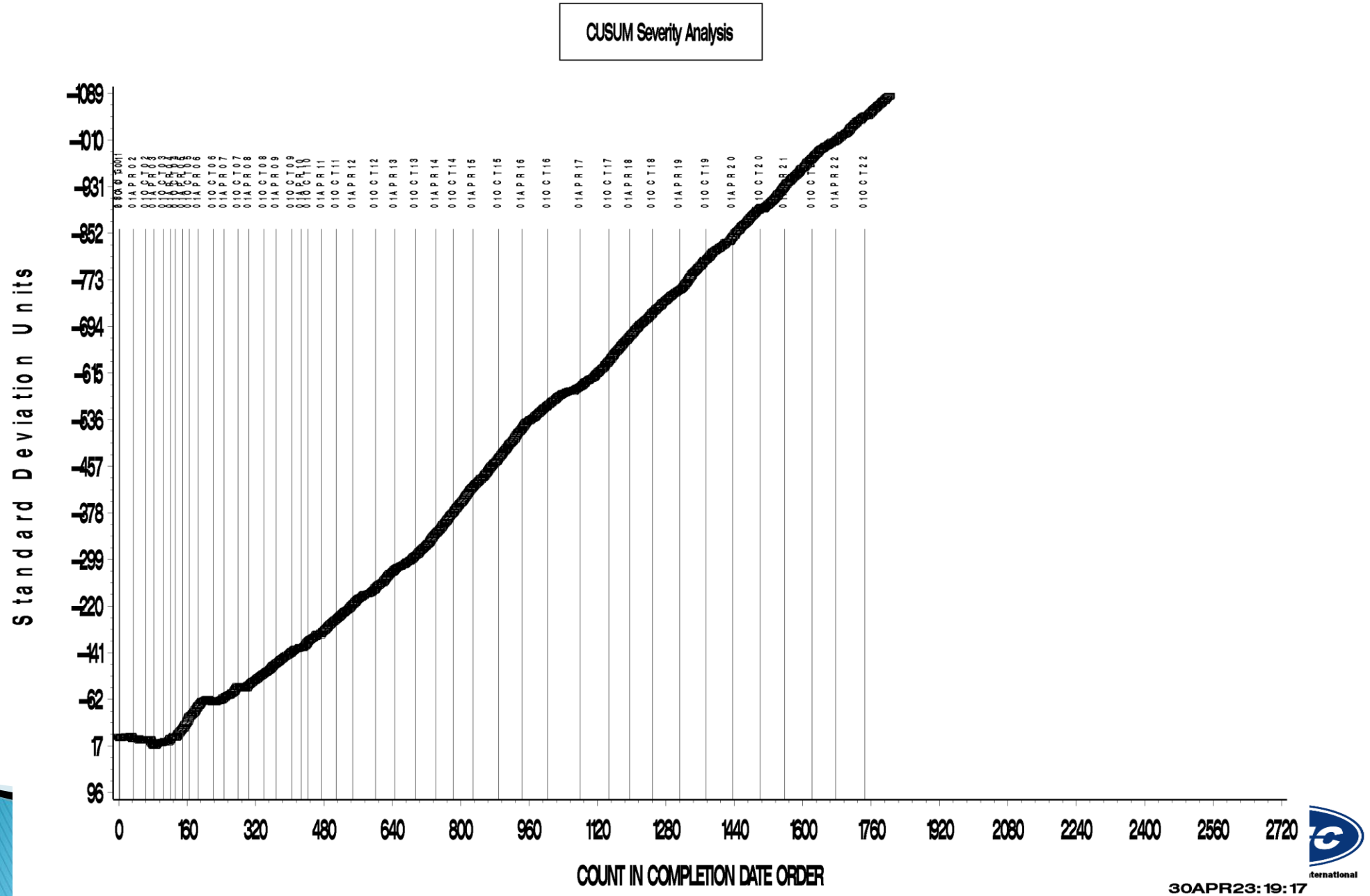
FLUOROELASTOMER ELONGATION CHANGE CORRECTED AVG



EOEC Test Severity

Nitrile (NBR)

Parameter	Period Mean Δ/s	Status
Volume Change	0.06	On-Target
Points Hardness Change	0.83	Severe
Tensile Strength Change	-0.68	Mild
Elongation Change	-0.15	Slightly Mild

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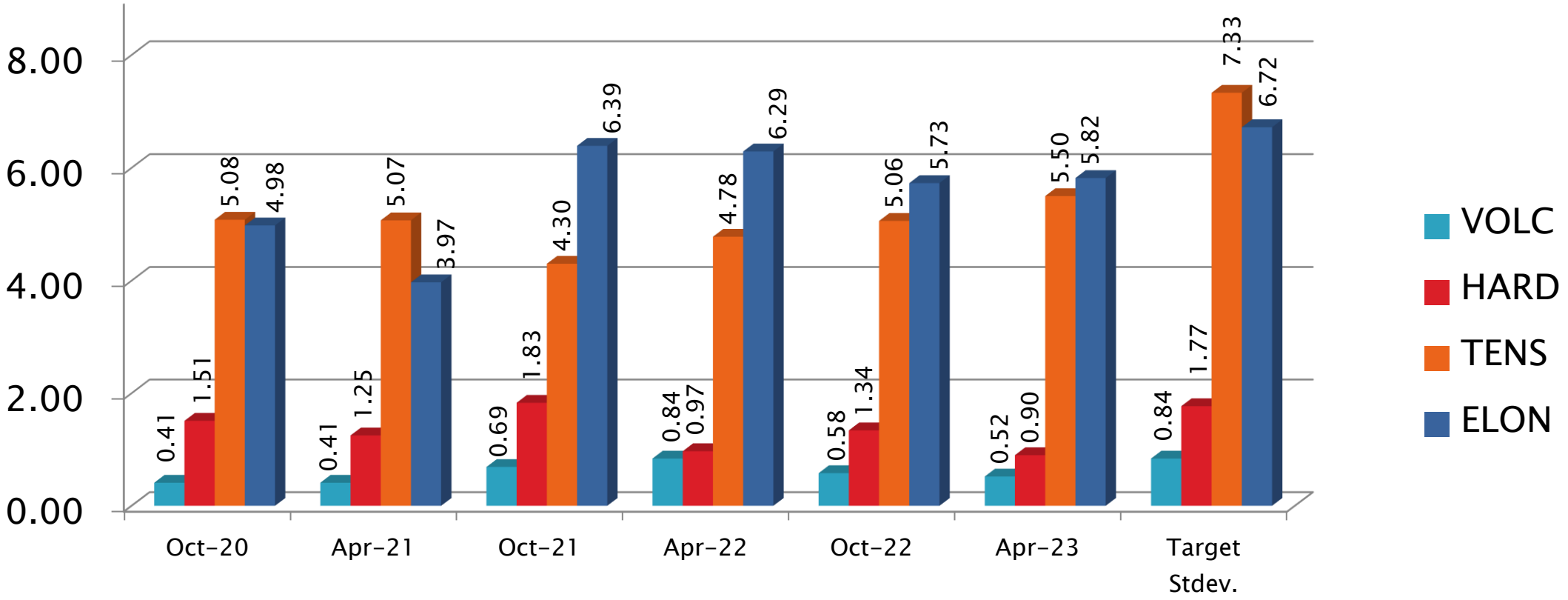
EOEC Precision Estimates – Nitrile



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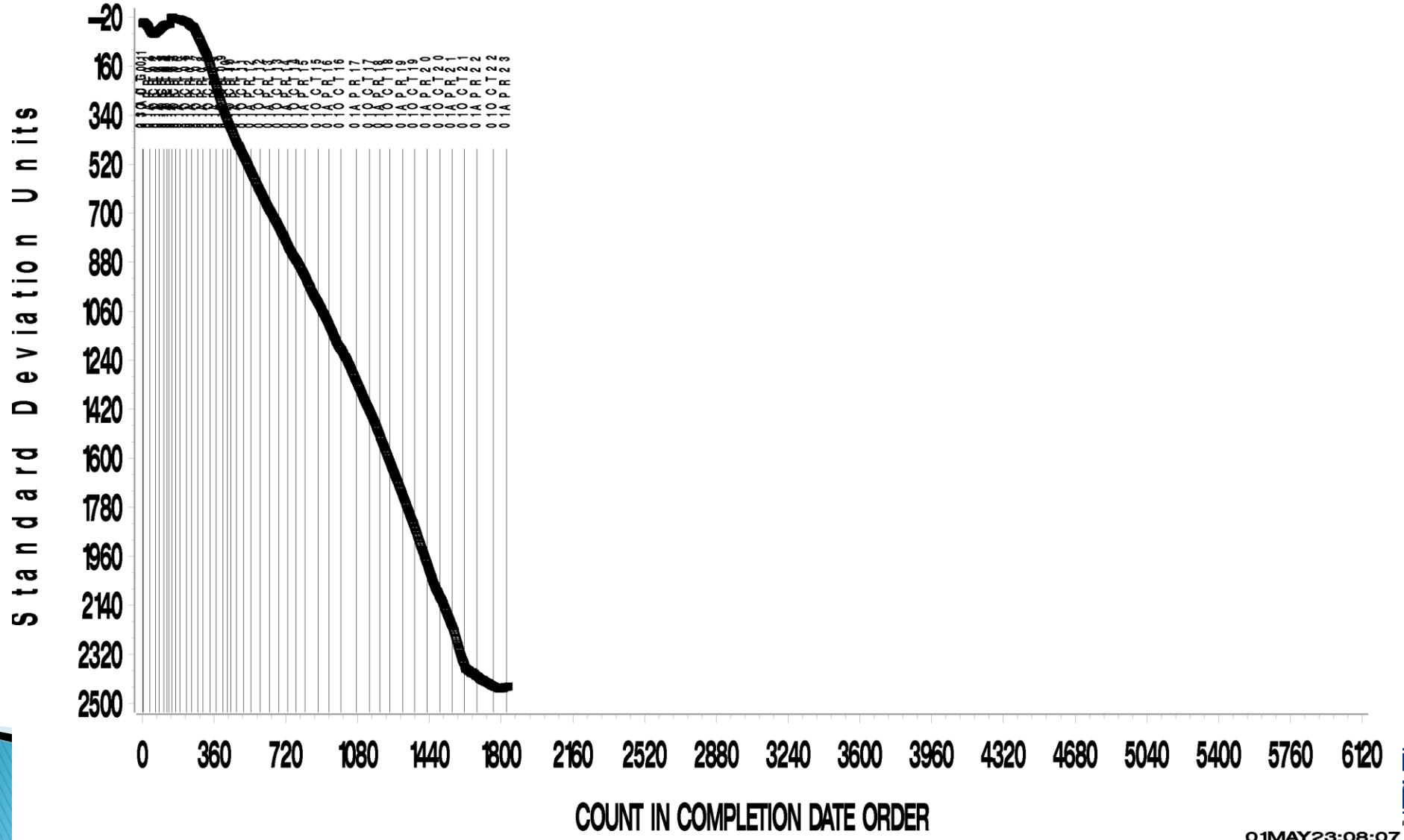
EOEC Precision Estimates by Lab: NBR

Test Parameter	Statistic	LTMS Lab				
		A	B	L	I	G
	n=	24	3	4	16	20
Volume	Mean	1.93	2.36	1.49	2.02	1.42
	Pooled s	0.31	0.27	0.09	0.51	0.56
	Mean /s	0.23	0.73	-0.30	0.33	-0.38
Hardness	Mean	3.08	3.67	3.00	3.12	3.70
	Pooled s	0.72	1.15	0.82	0.72	1.13
	Mean /s	0.71	1.04	0.66	0.73	1.06
Tensile Strength	Mean	-0.16	-7.43	2.12	-1.94	-4.76
	Pooled s	4.75	3.14	3.92	2.66	6.94
	Mean /s	-0.40	-1.40	-0.09	-0.64	-1.03
Elongation	Mean	-34.7	-37.6	-34.3	-37.5	-32.2
	Pooled s	4.19	0.44	1.64	3.43	8.50
	Mean /s	-0.15	-0.58	-0.91	-0.56	0.22

EOEC —NITRILE INDUSTRY OPERATIONALLY VALID DATA

REFERENCE NITRILE VOLUME CHANGE CORRECTED AVERAGE

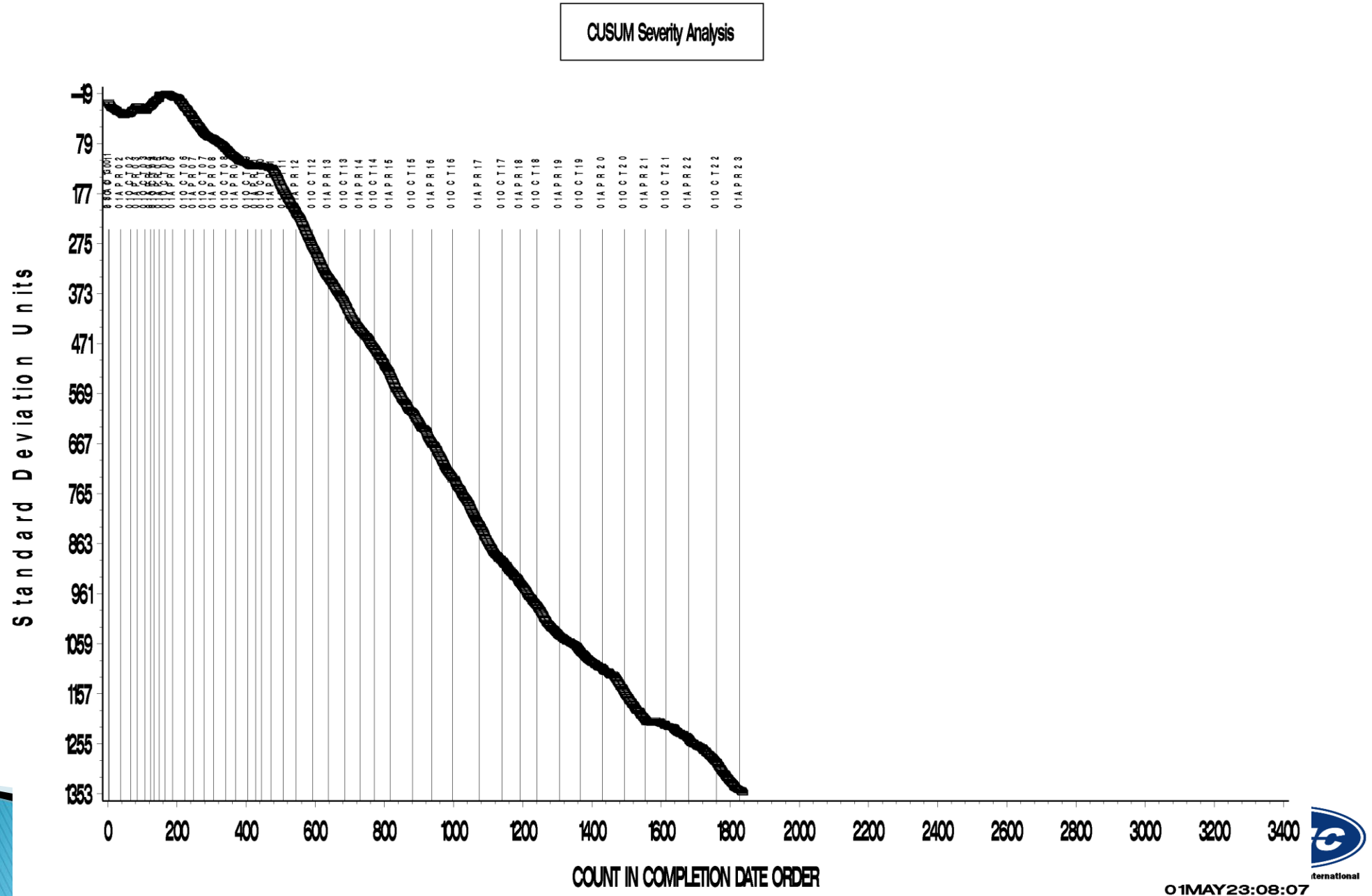
CUSUM Severity Analysis



01MAY23:08:07

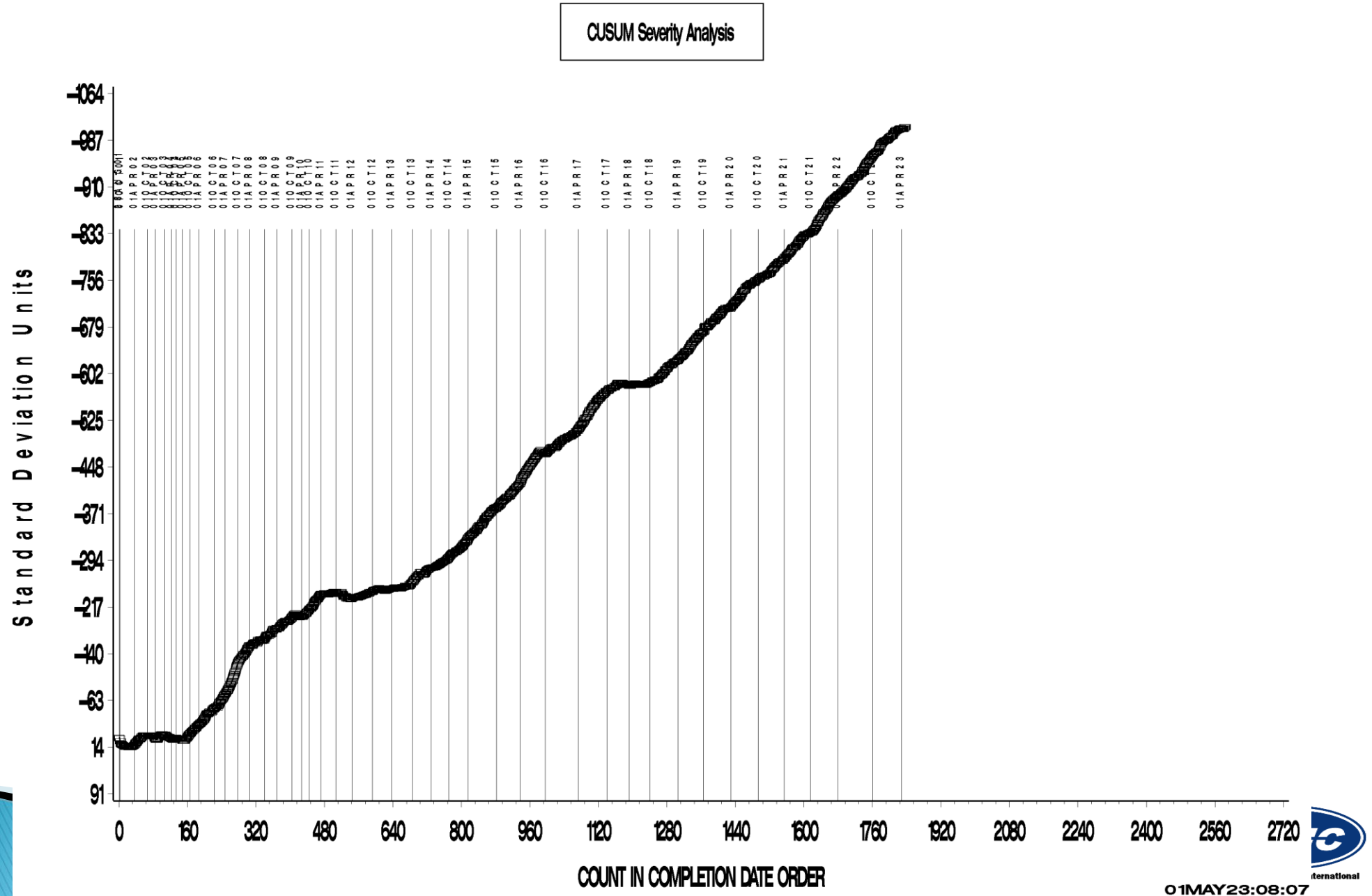
EOEC —NITRILE INDUSTRY OPERATIONALLY VALID DATA

REFERENCE NITRILE PTS HARD CHANGE CORRECTED AVG



EOEC —NITRILE INDUSTRY OPERATIONALLY VALID DATA

REF NITRILE TENS STRENGTH CHANGE CORRECTED AVG



EOEC —NITRILE INDUSTRY OPERATIONALLY VALID DATA

REF NITRILE ELONGATION CHANGE CORRECTED AVERAGE

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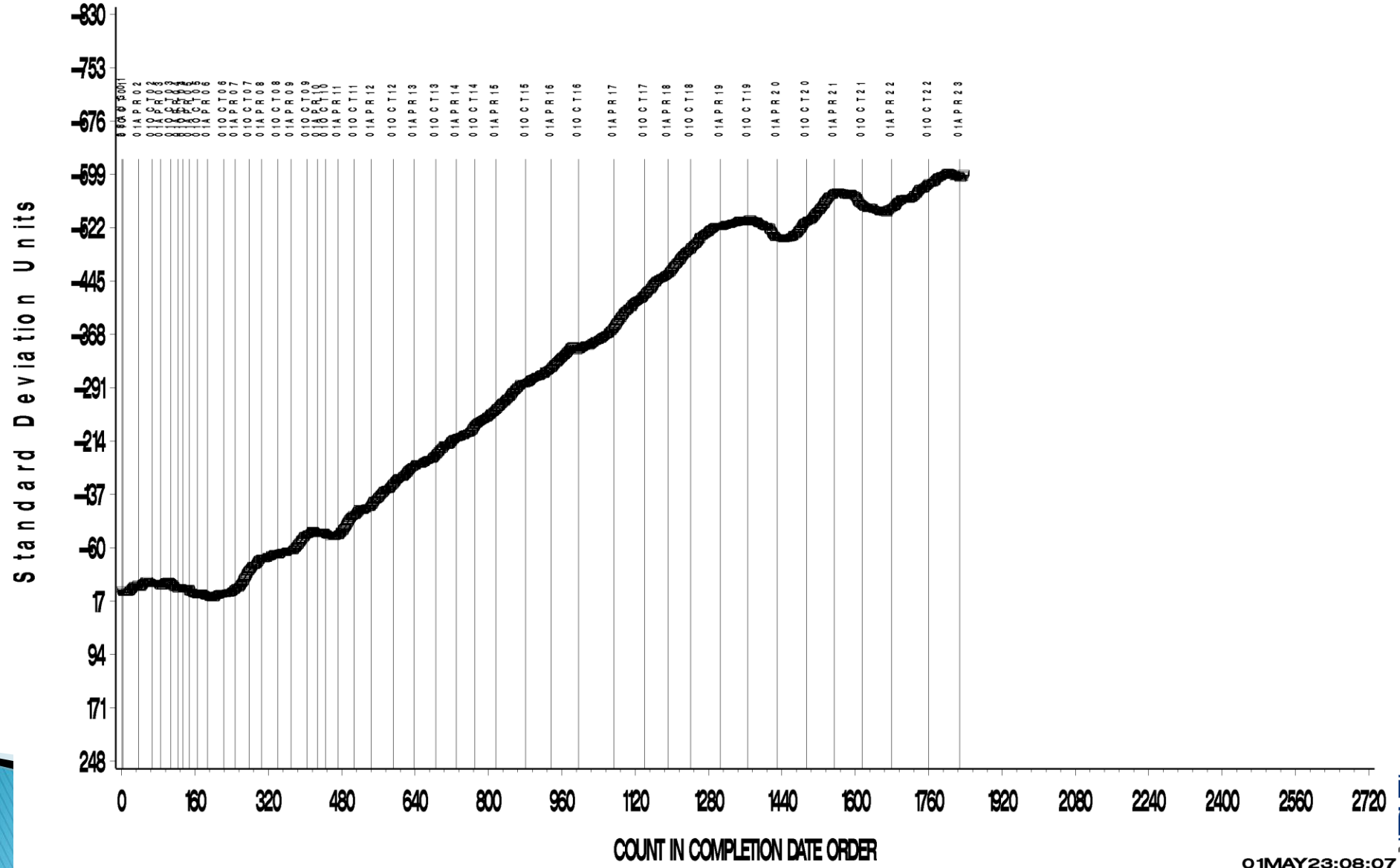
CUSUM Severity Analysis



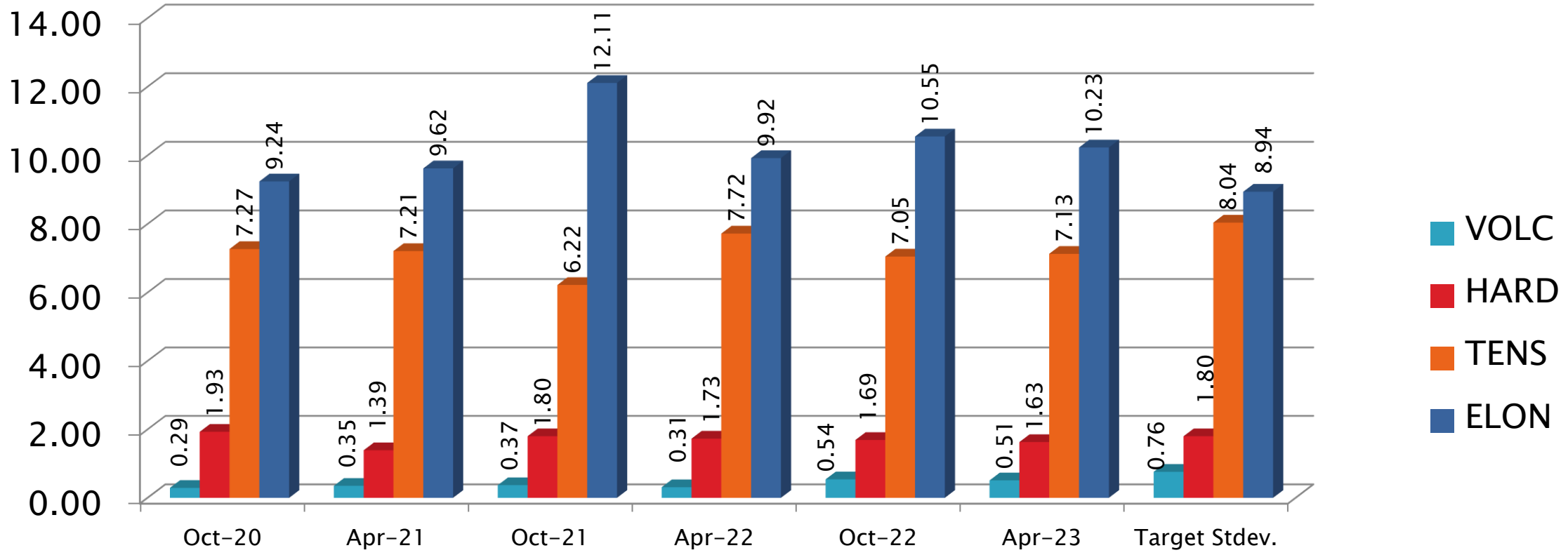
01MAY23:08:07

EOEC Test Severity

Polyacrylate (ACM)

Parameter	Period Mean Δ/s	Status
Volume Change	1.81	Severe
Points Hardness Change	-0.21	Mild
Tensile Strength Change	-0.26	Mild
Elongation Change	0.33	Severe

EOEC Precision Estimates – Polyacrylate



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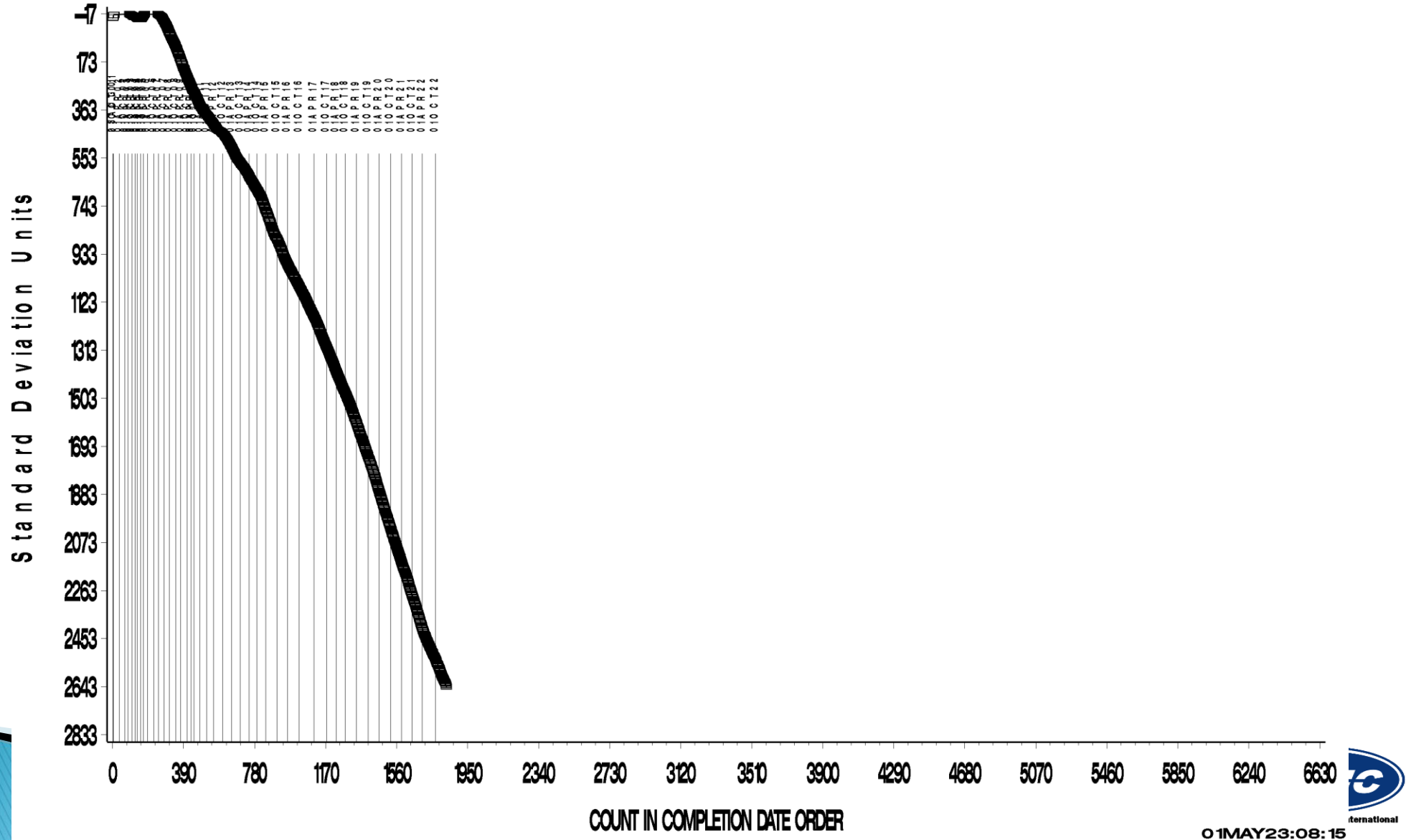
EOEC Precision Estimates by Lab: ACM

Test Parameter	Statistic	LTMS Lab				
		A	B	L	I	G
	n=	20	2	4	15	20
Volume	Mean	1.35	1.51	1.60	1.99	1.49
	Pooled s	0.21	0.20	0.48	0.66	0.46
	Mean /s	1.51	1.72	1.84	2.36	1.70
Hardness	Mean	-0.55	-1.00	-1.00	-0.67	-0.30
	Pooled s	1.15	1.41	0.82	1.10	2.39
	Mean /s	-0.30	-0.55	-0.55	-0.03	-0.16
Tensile Strength	Mean	-1.80	0.80	-3.50	-1.25	-1.84
	Pooled s	6.58	2.12	6.48	7.26	8.37
	Mean /s	-0.27	0.05	-0.48	-0.20	-0.27
Elongation	Mean	-21.8	-15.6	-13.5	-23.2	-16.3
	Pooled s	11.05	11.95	10.70	6.70	10.63
	Mean /s	0.08	0.79	1.01	-0.07	0.70

EOEC —POLYACRYLATE INDUSTRY OPERATIONALLY VALID DATA

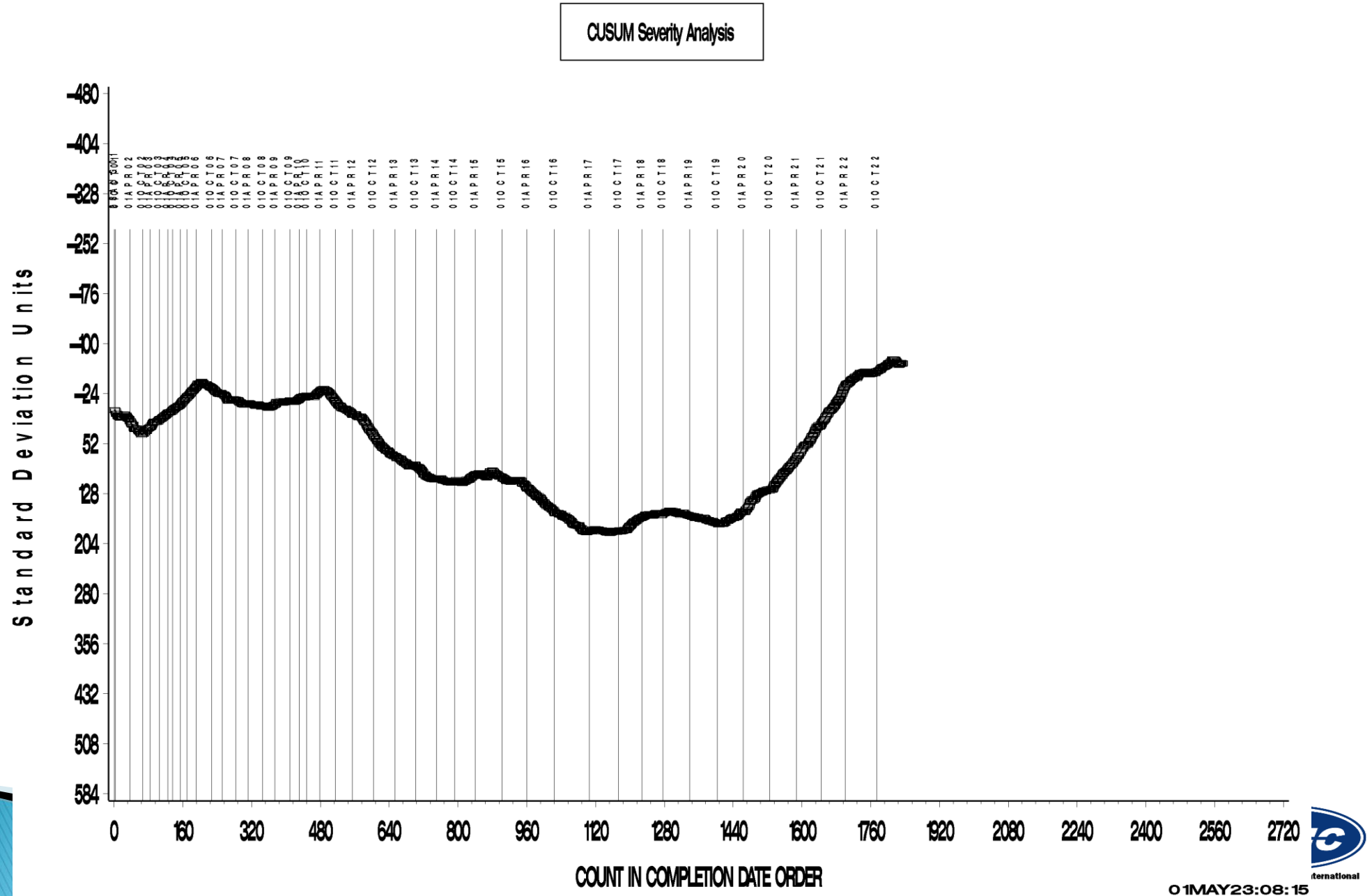
REFERENCE POLYACRYLATE VOLUME CHANGE CORRECTED AVG

CUSUM Severity Analysis



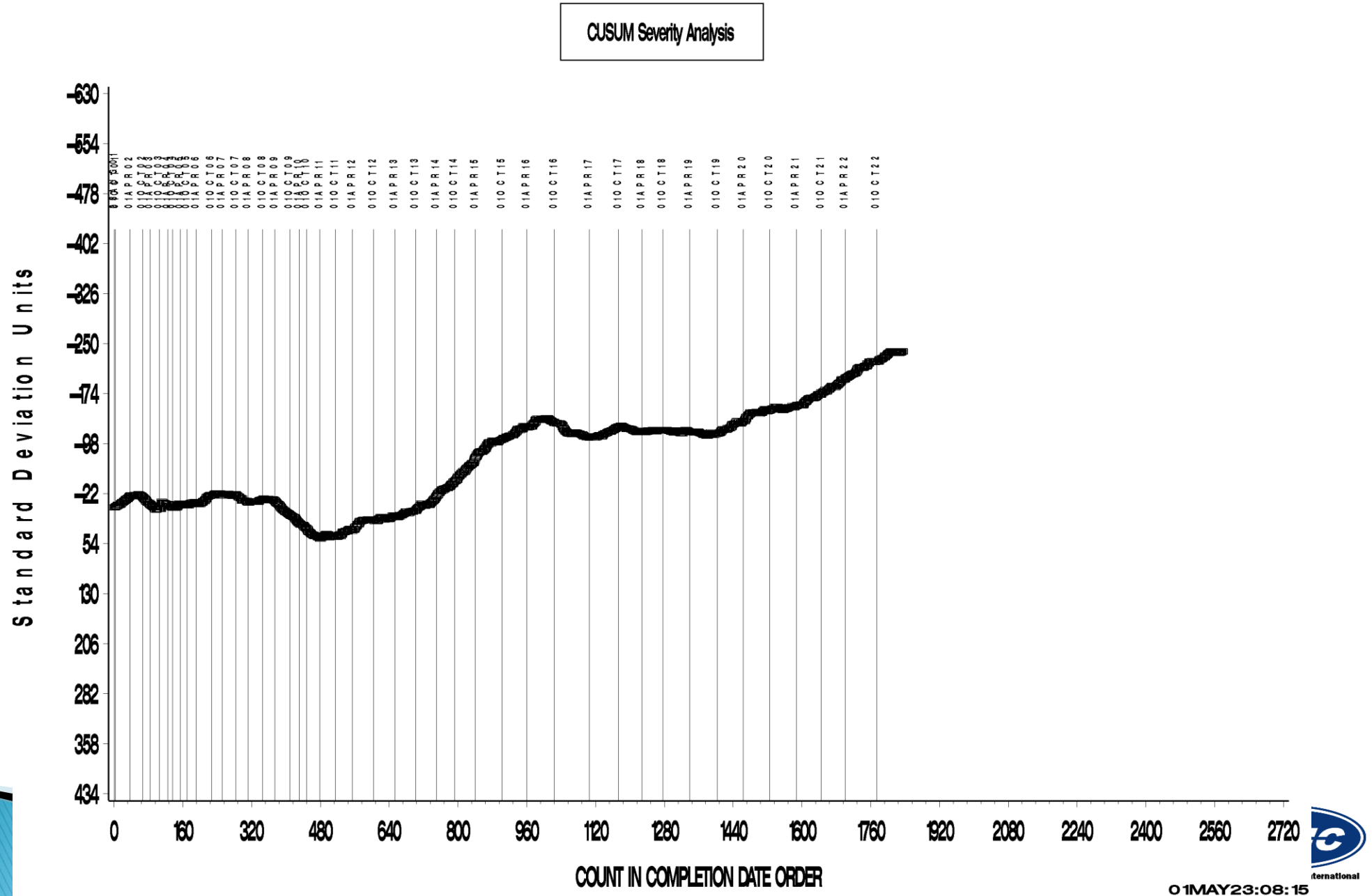
EOEC —POLYACRYLATE INDUSTRY OPERATIONALLY VALID DATA

REF POLYACRYLATE PTS HARD CHANGE CORRECTED AVG



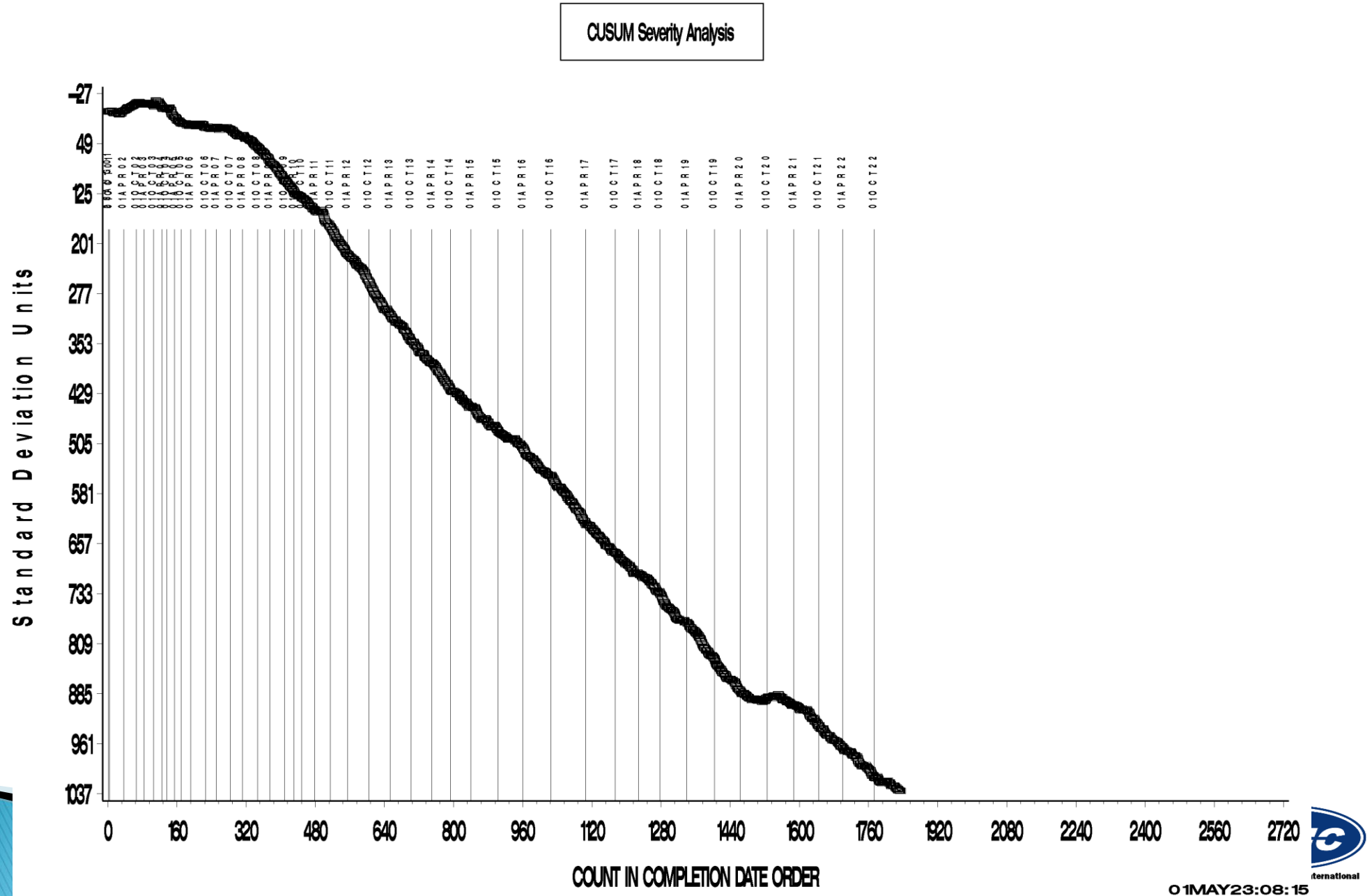
EOEC —POLYACRYLATE INDUSTRY OPERATIONALLY VALID DATA

REF POLYACRYLATE TENS STRNGTH CHANGE CORRECTED AVG



EOEC —POLYACRYLATE INDUSTRY OPERATIONALLY VALID DATA

REF POLYACRYLATE ELONGATION CHANGE CORRECTED AVG

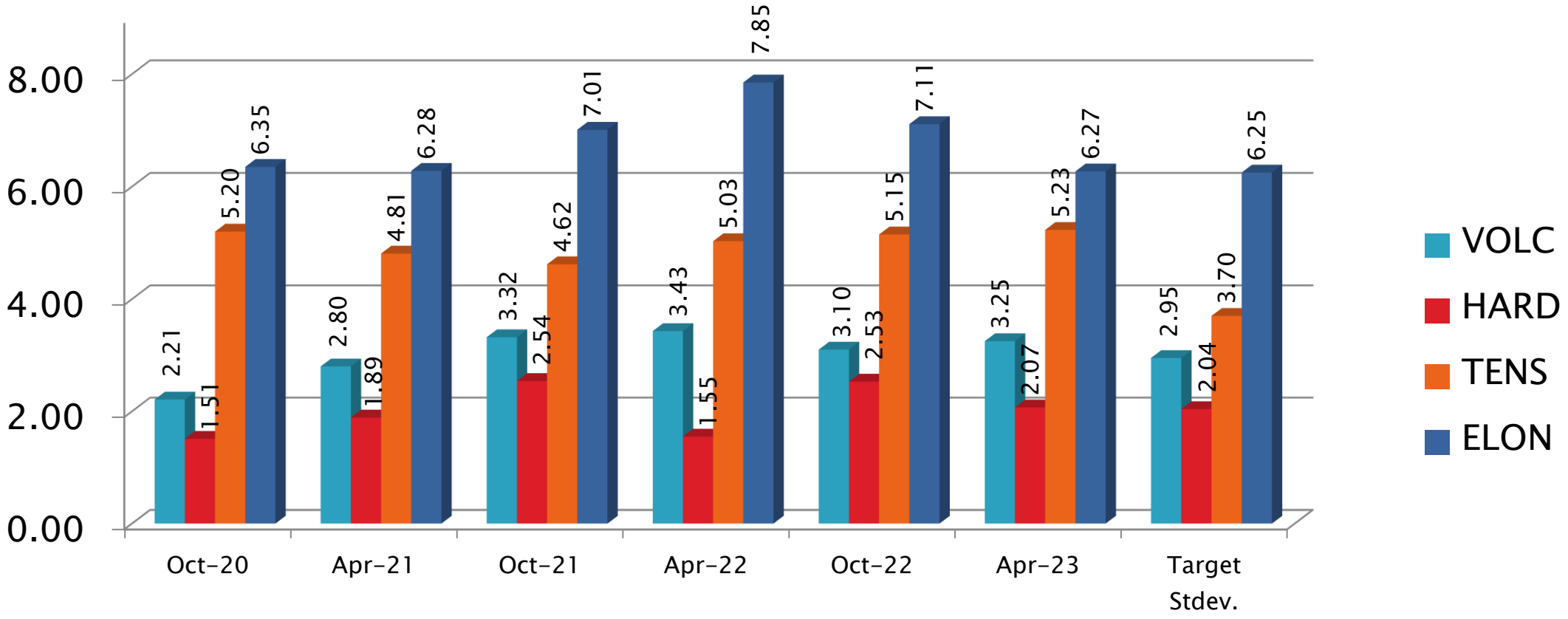


EOEC Test Severity

Silicone (VMQ)

Parameter	Period Mean Δ/s	Status
Volume Change	0.61	Severe
Points Hardness Change	-0.72	Mild
Tensile Strength Change	0.52	Severe
Elongation Change	0.22	Severe

EOEC Precision Estimates – Silicone



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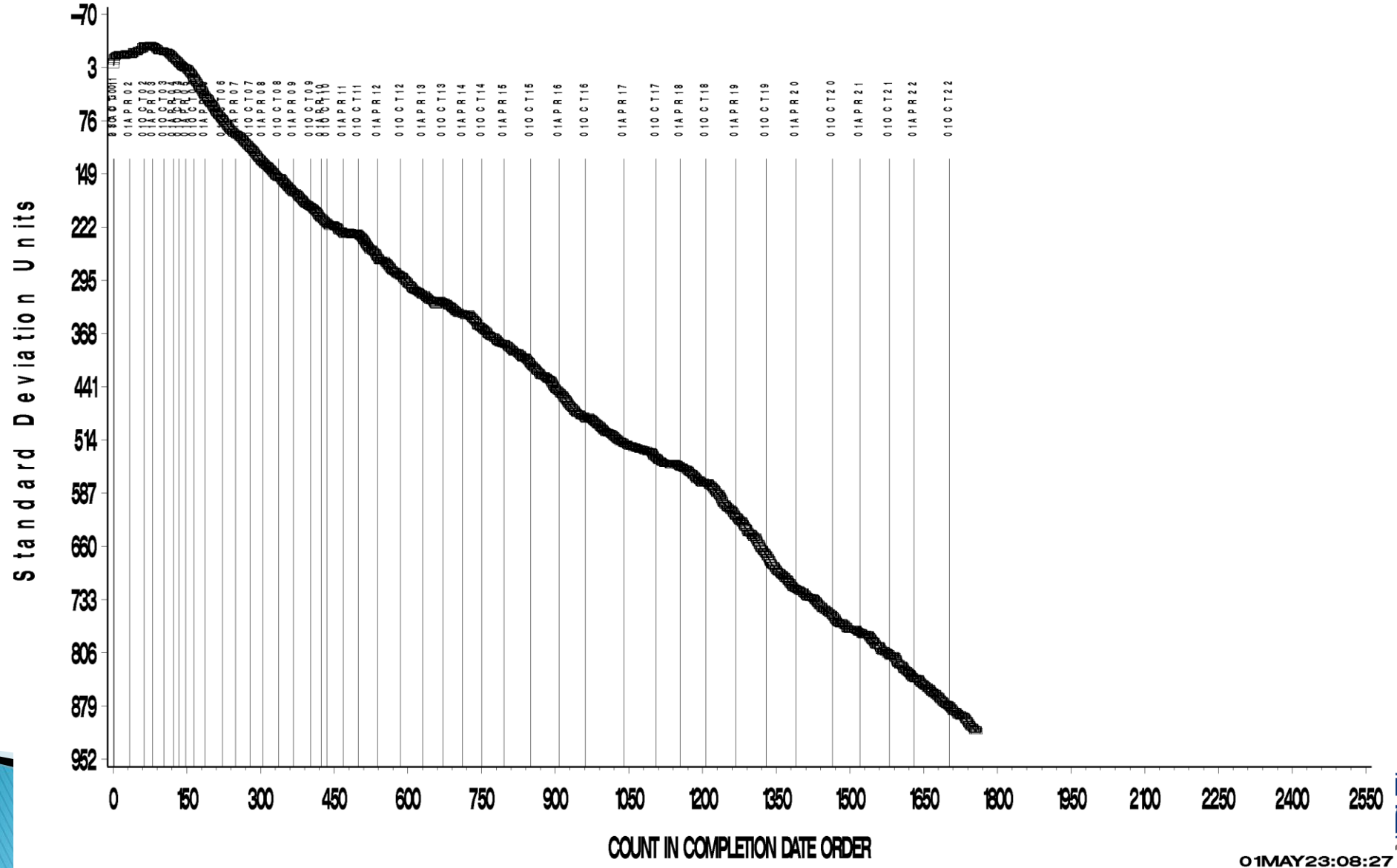
EOEC Precision Estimates by Lab: VMQ

Test Parameter	Statistic	LTMS Lab					
		A	B	L	I	G	V
	n=	17	3	4	14	16	2
Volume	Mean	33.3	33.2	29.2	31.6	38.3	32.4
	Pooled s	1.65	0.81	1.29	1.06	1.51	0.01
	Mean /s	0.40	0.36	-1.00	-0.20	2.07	0.06
Hardness	Mean	-24.5	-23.7	-18.8	-22.4	-23.2	-24.0
	Pooled s	1.33	1.15	0.50	1.65	1.84	0
	Mean /s	-1.37	-0.97	1.44	-0.37	-0.77	-1.14
Tensile Strength	Mean	-28.4	-27.8	-31.4	-37.3	-32.5	-24.0
	Pooled s	3.15	5.46	0.78	3.16	4.88	1.77
	Mean /s	1.44	1.60	0.64	-0.97	0.33	2.62
Elongation	Mean	-23.9	-17.1	-18.6	-24.0	-25.2	-21.7
	Pooled s	2.66	5.97	3.31	5.80	9.06	1.27
	Mean /s	0.15	1.23	1.00	0.13	-0.06	0.50

EOEC —SILICONE INDUSTRY OPERATIONALLY VALID DATA

REFERENCE SILICON VOLUME CHANGE CORRECTED AVG

CUSUM Severity Analysis



EOEC —SILICONE INDUSTRY OPERATIONALLY VALID DATA

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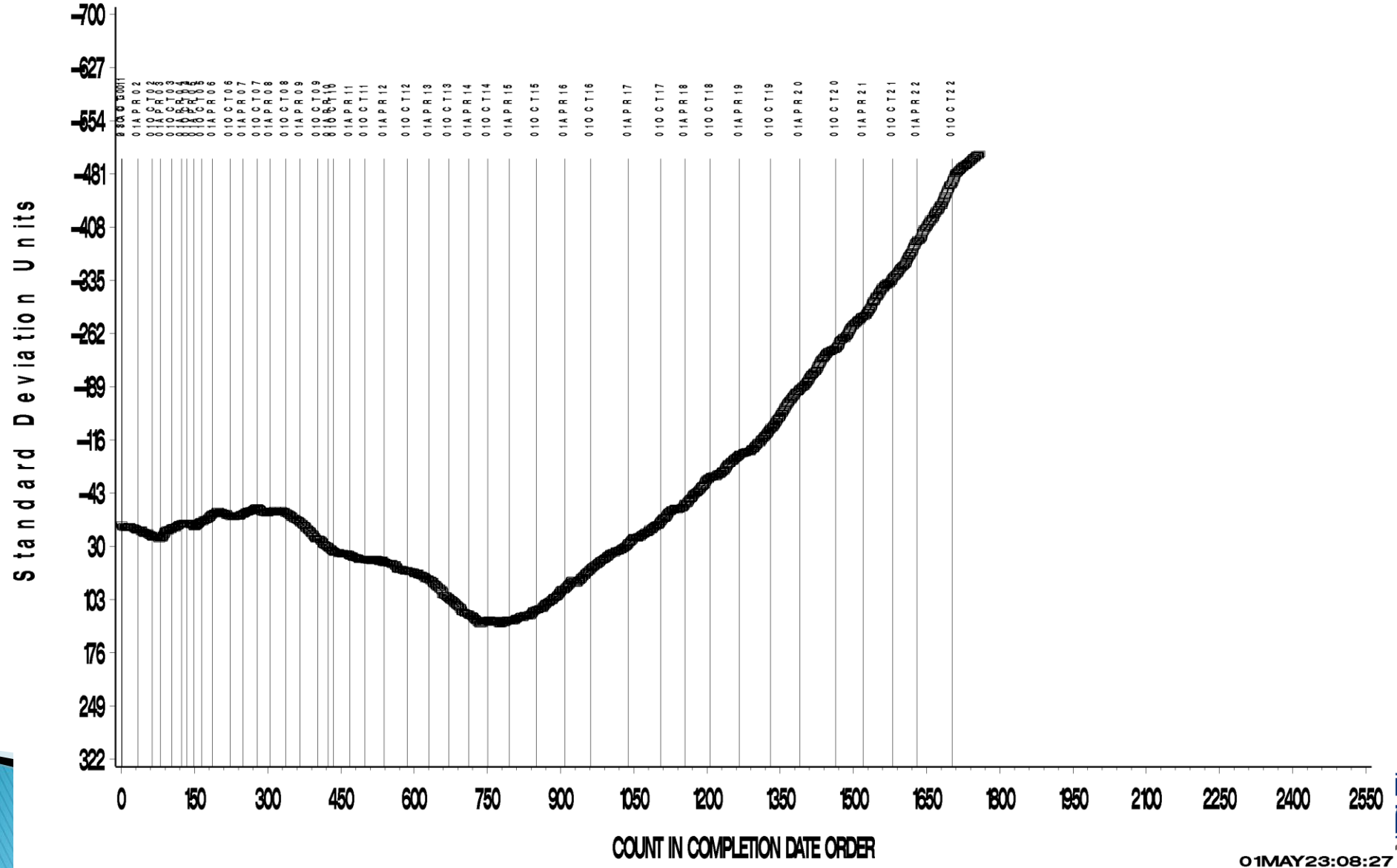
CUSUM Severity Analysis



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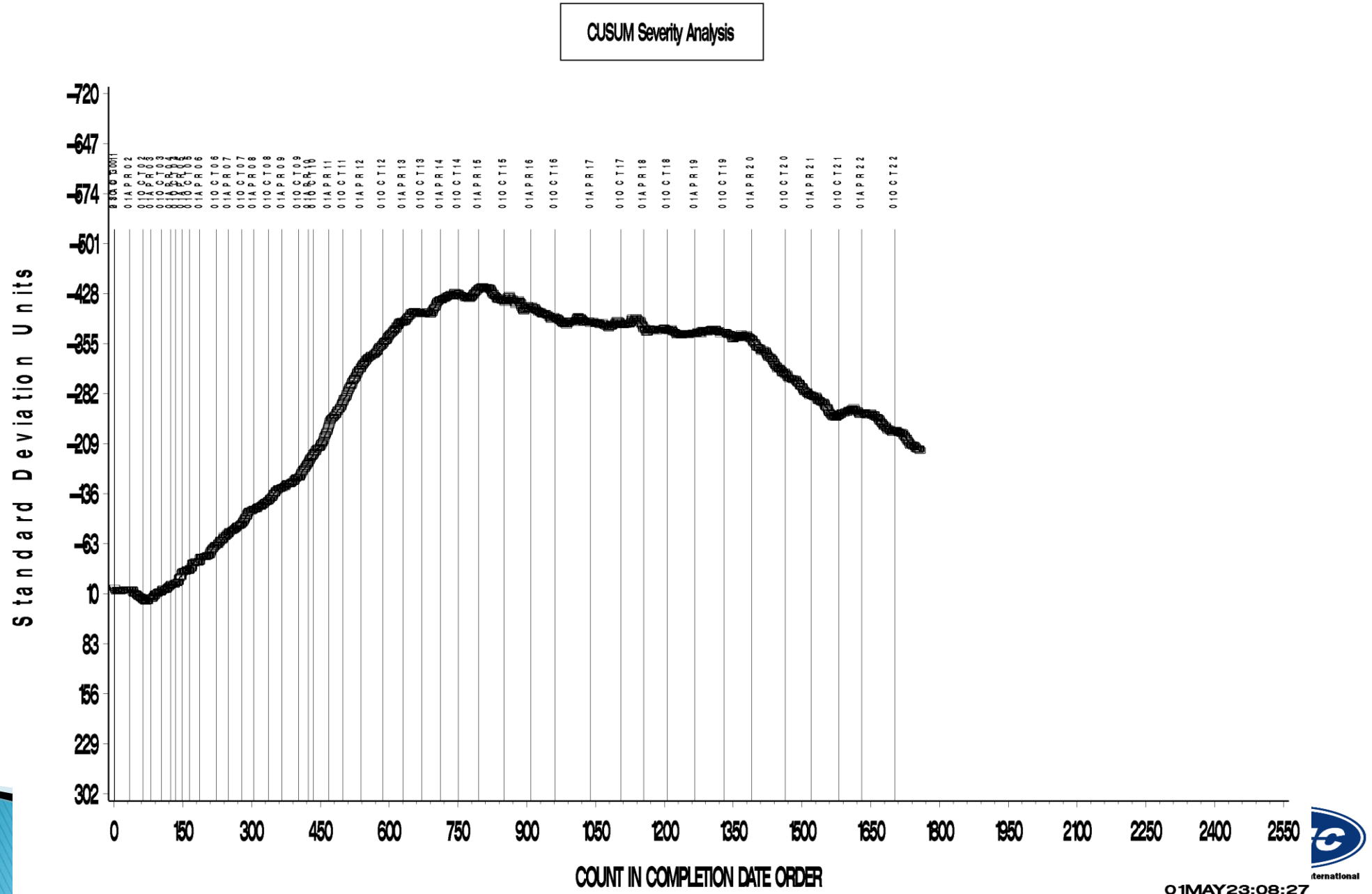
EOEC —SILICONE INDUSTRY OPERATIONALLY VALID DATA

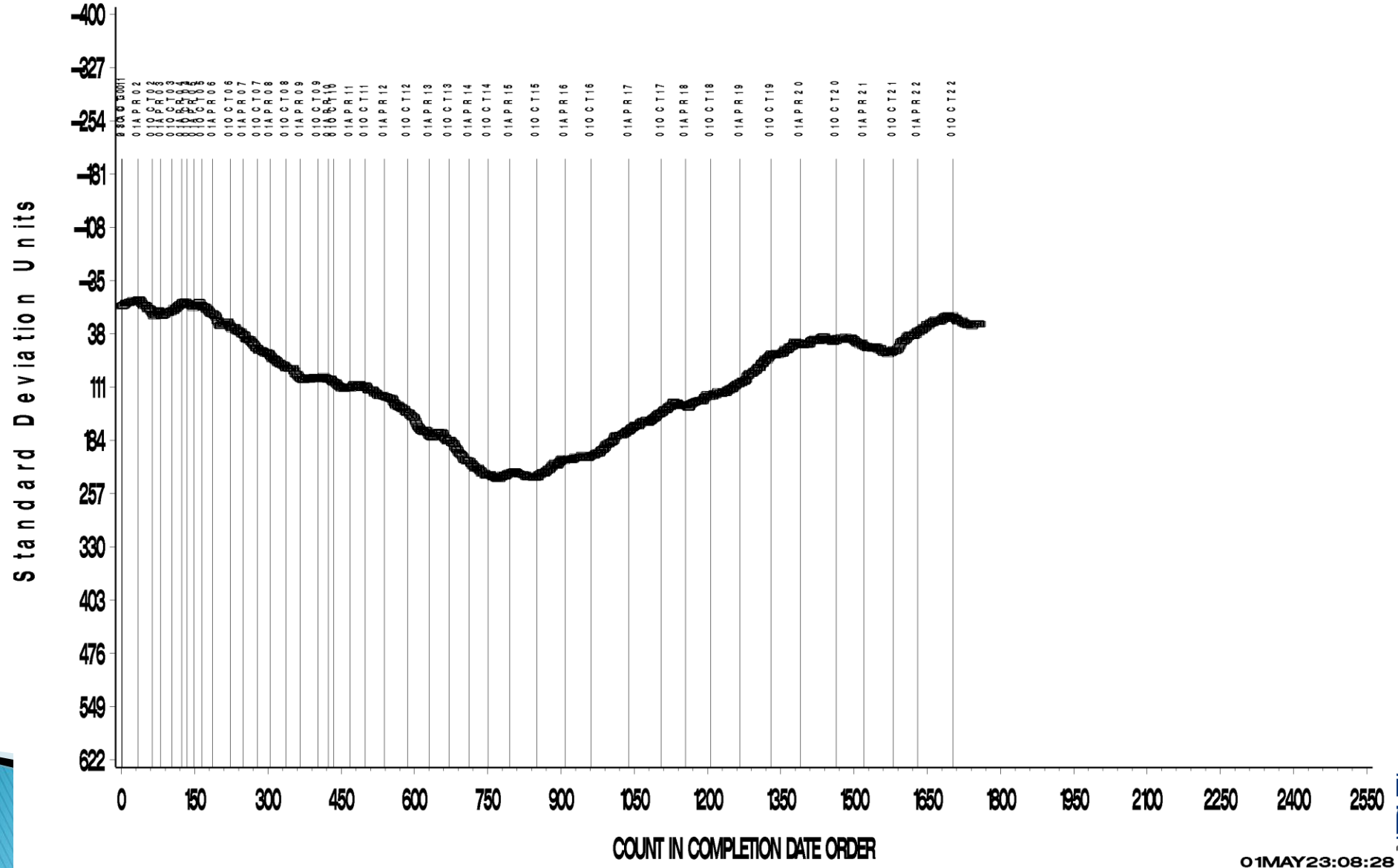
REF SILICON TENSILE STRENGTH CHANGE CORRECTED AVG



EOEC —SILICONE INDUSTRY OPERATIONALLY VALID DATA

REF SILICON ELONGATION CHANGE CORRECTED AVG

CUSUM Severity Analysis



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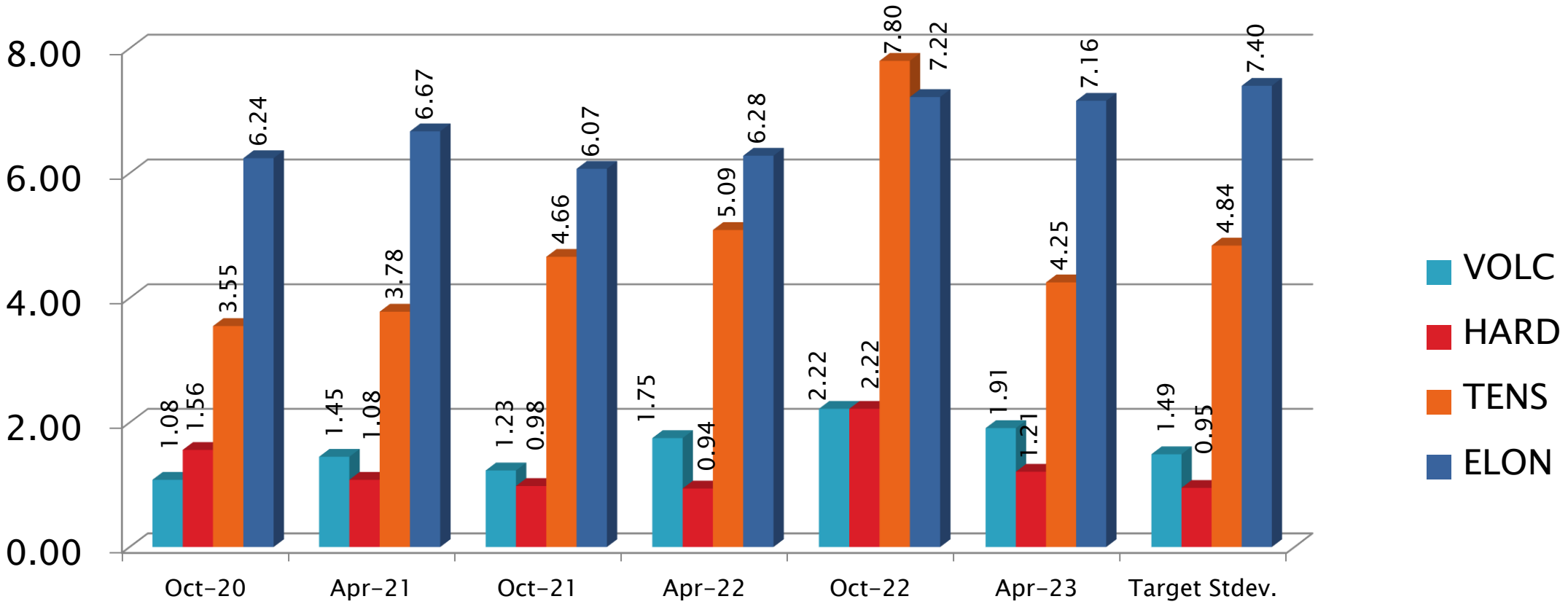
EOEC Test Severity

VAMAC (MAC)

Parameter	Period Mean Δ/s	Status
Volume Change	0.40	Severe
Points Hardness Change	-0.88	Mild
Tensile Strength Change	0.05	On-Target
Elongation Change	-0.40	Mild

EOEC Precision Estimates – VAMAC



October 1, 2022 – March 31, 2023

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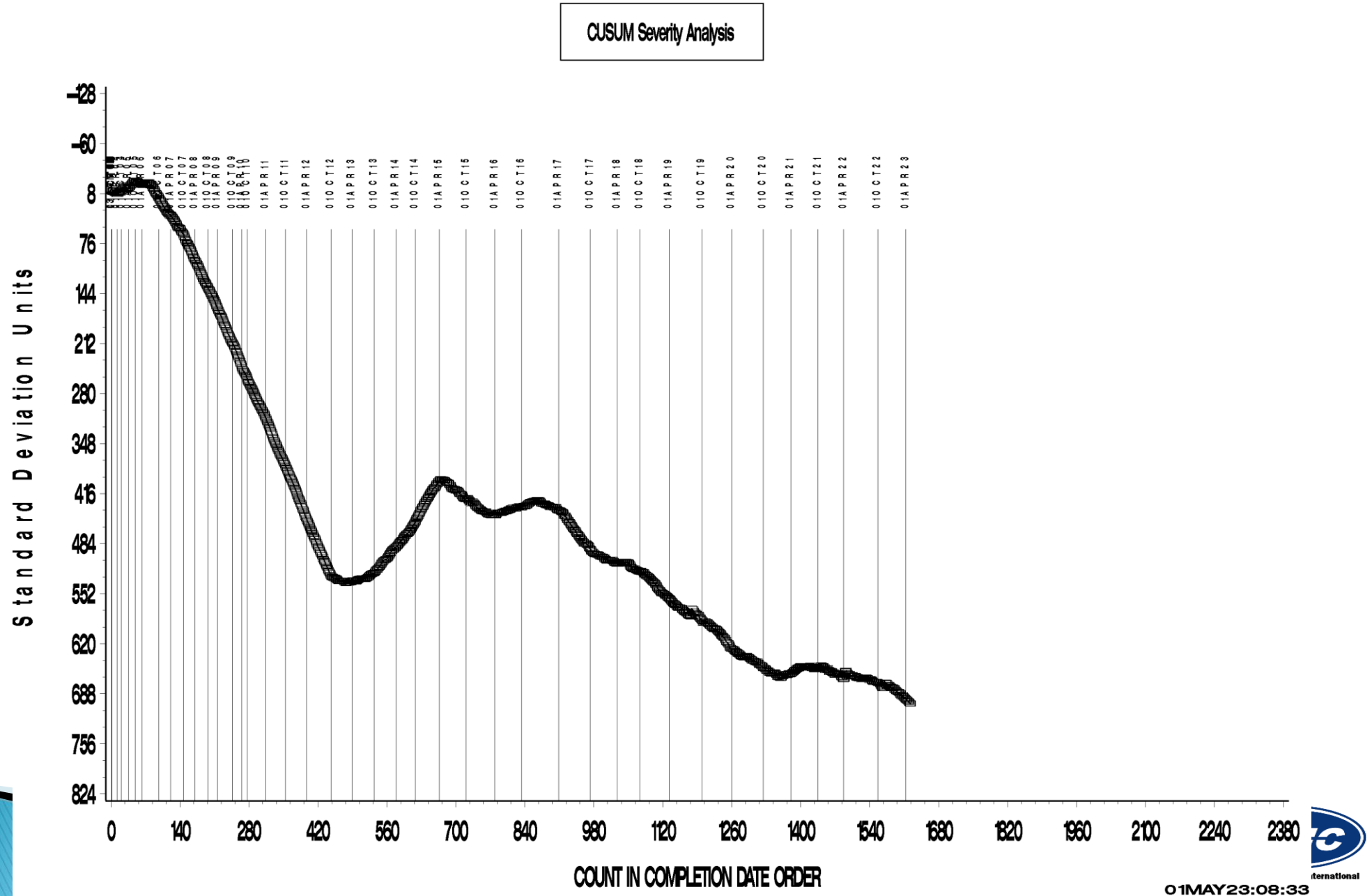
EOEC Precision Estimates by Lab: MAC

Test Parameter	Statistic	LTMS Lab				
		A	B	L	I	G
	n=	19	3	4	14	17
Volume	Mean	18.8	18.9	17.5	19.6	19.5
	Pooled s	0.41	0.39	0.40	0.77	3.31
	Mean /s	0.18	0.25	-0.67	0.71	0.66
Hardness	Mean	-8.79	-9.00	-6.50	-8.57	-7.88
	Pooled s	1.08	1.00	0.58	0.85	1.27
	Mean /s	-1.38	-1.60	1.03	-1.15	-0.42
Tensile Strength	Mean	-13.3	-16.4	-18.0	-14.8	-16.3
	Pooled s	5.08	4.24	2.34	3.28	3.81
	Mean /s	0.41	-0.23	-0.55	0.10	-0.20
Elongation	Mean	-38.3	0.88	-38.0	-41.9	-33.6
	Pooled s	4.98	-41.3	2.43	3.28	10.26
	Mean /s	-0.46	1.50	-0.40	-0.94	0.18

EOEC —VAMAC INDUSTRY OPERATIONALLY VALID DATA

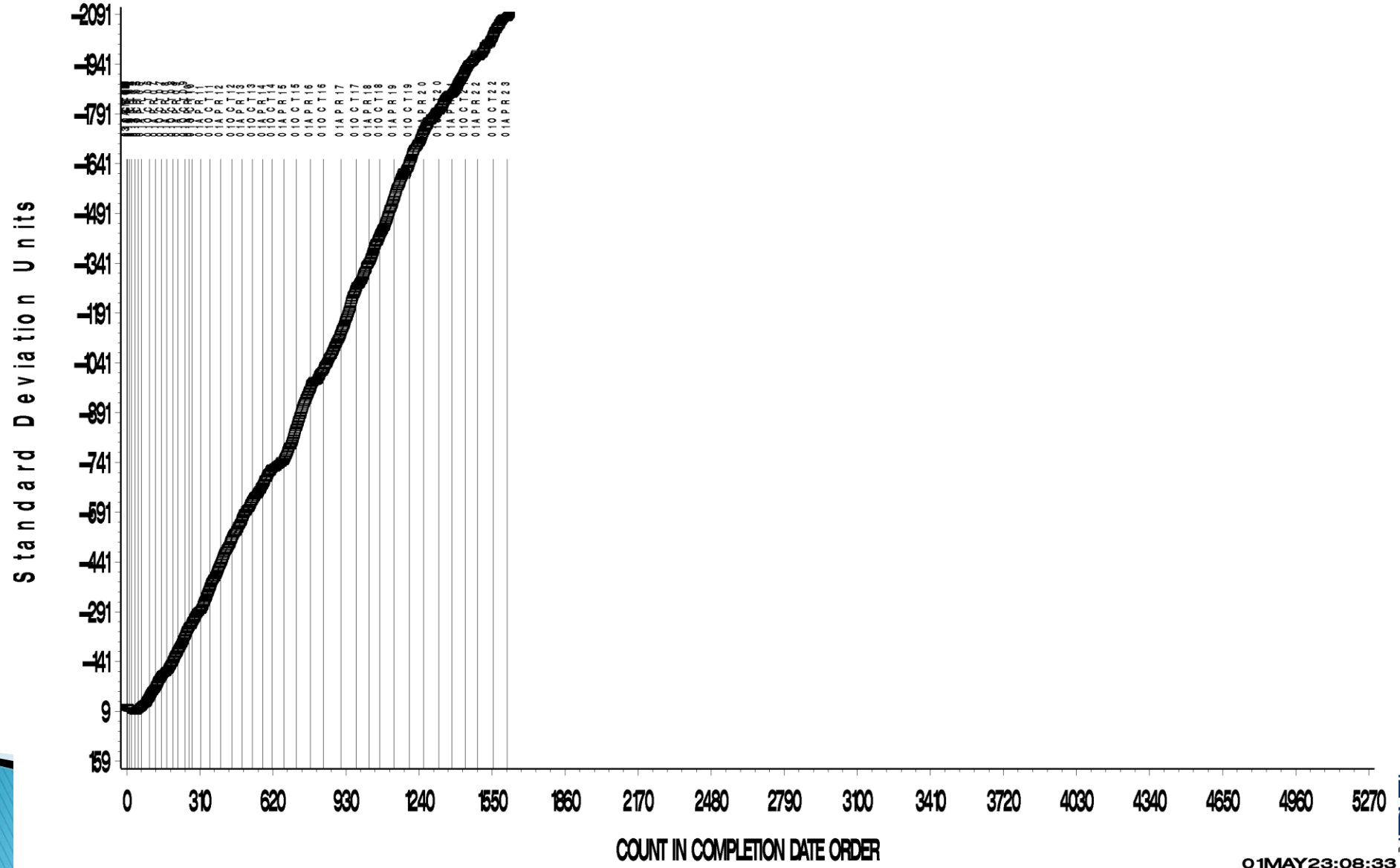
REFERENCE VAMAC G VOLUME CHANGE CORRECTED AVERAGE



EOEC —VAMAC INDUSTRY OPERATIONALLY VALID DATA

REF VAMAC G POINTS HARDNESS CHANGE CORRECTED AVG

CUSUM Severity Analysis



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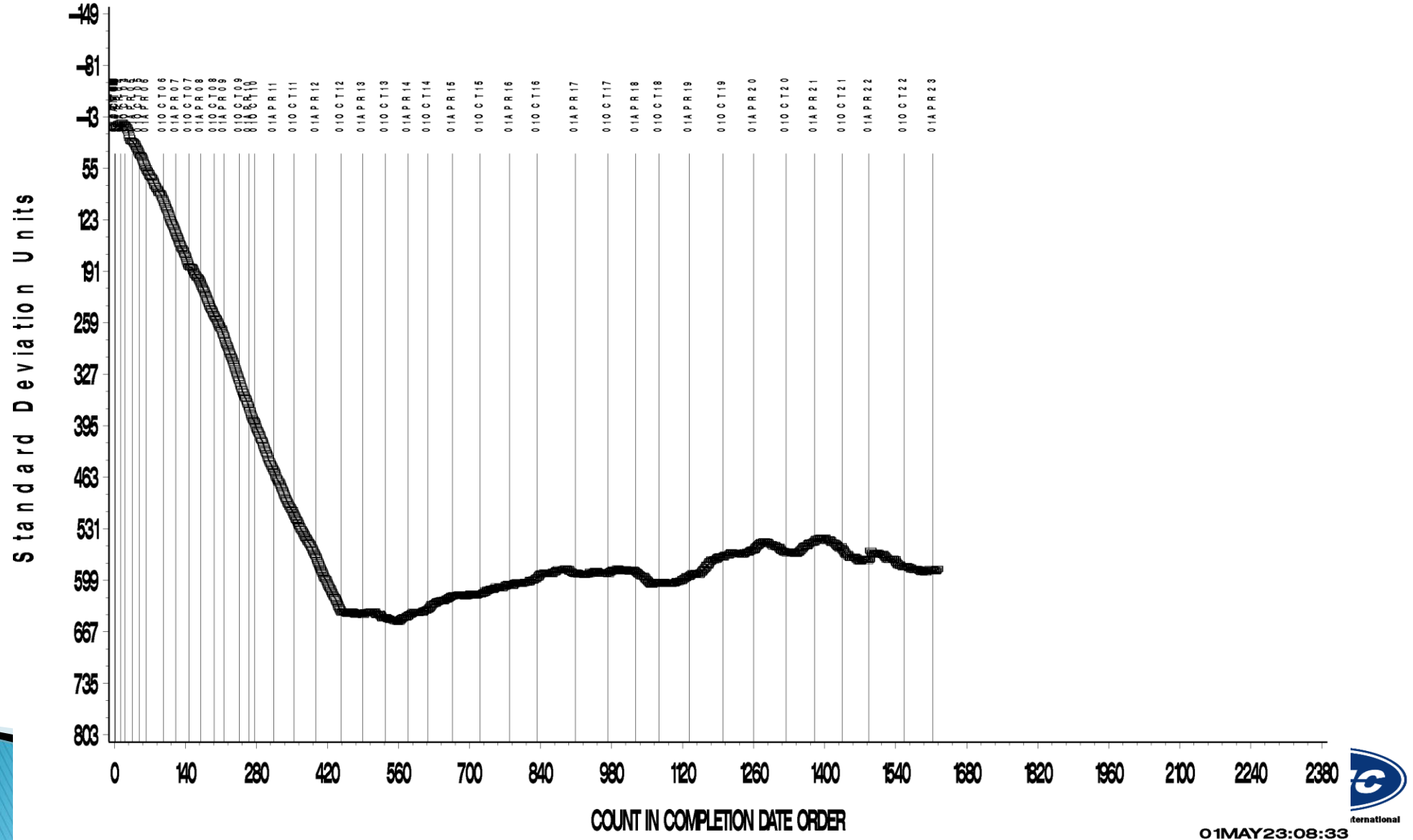
EOEC —VAMAC INDUSTRY OPERATIONALLY VALID DATA

REF VAMAC G TENSILE STRENGTH CHANGE CORRECTED AVG

CUSUM Severity Analysis



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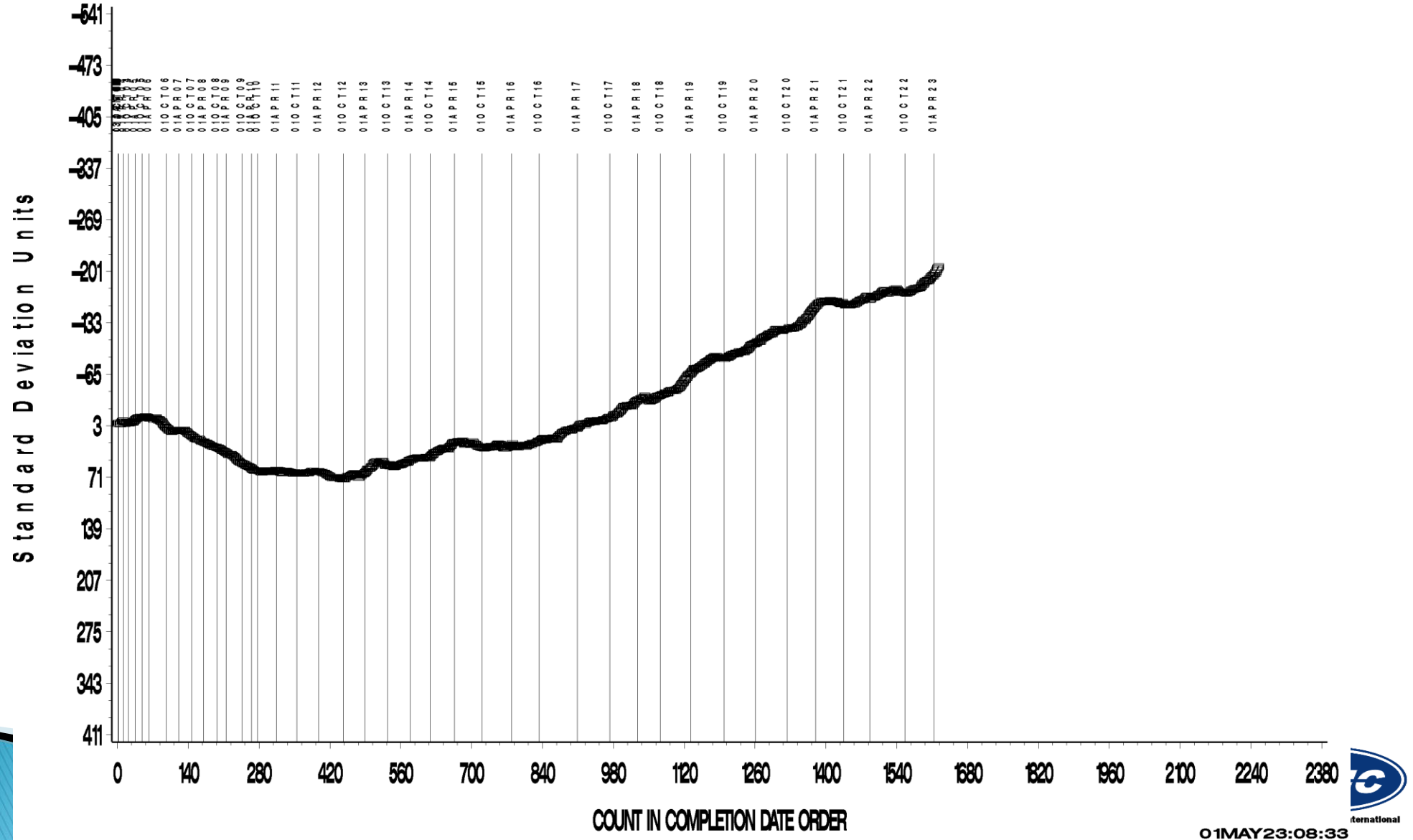
EOEC —VAMAC INDUSTRY OPERATIONALLY VALID DATA

REF VAMAC G ELONGATION CHANGE CORRECTED AVG

CUSUM Severity Analysis



Information Letters & Technical Updates*

Test	Date	IL or Memo Number	Topic
EOEC	20230118	M23-002*	Elastomer SP Votes to Eliminate the use of 1006 Reference Oil

*Available from TMC Website

Reference Oil Inventory Estimated Life EOEC/LDEOC

Oil	TMC Inventory Gallons	Gallons Shipped Past 12 Months	Estimated Life
SL107[A, B]	2174	198	3.7 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

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ASTM Reference Testing Semi-Annual Report D7216 LDEOC

October 1, 2022 to March 31, 2023

ASTM D 7216

Engine Oil Elastomer Compatibility (EOEC/HDEOC)

OHT CURRENT ELASTOMER BATCH CODES FOR ASTM D7216

AS OF: 3/9/2023

EOEC (PC 9)	
OHT PART NUMBER	**BATCH CODE**
OHTPC9-NBR-1	29
OHTPC9-ACM-2	31
OHTPC9-FKM-1	30
OHTPC9-MAC-1	23

LDEOC (J2643)	
OHT PART NUMBER	**BATCH CODE**
OHTJ2643-HNBR-1	30
OHTJ2643-FKM-1	28
OHTJ2643-ACM-2	25
OHTJ2643-VMQ-1	40
OHTJ2643-AEM-2	30

LDEOC Test Activity*

Test Status		Ethylene Acrylate	Fluoroelast.	Nitrile	Polyacrylate	Silicone	Total
Acceptable Calibration Test	AC	66	63	68	76	75	**348**
Failed Calibration Test	OC	0	0	0	0	0	**0**
Operationally Invalid, by lab	LC	0	0	0	1	1	**2**
Operationally Invalid, by TMC	RC	0	0	0	0	0	**0**
Aborted	XC	0	0	0	0	0	**0**
Industry Information Runs	NI	0	0	0	10	0	**10**
Total		**66**	**63**	**68**	**87**	**76**	**360**

*October 1, 2022 – March 31, 2023

Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D7216	8 (+0)	N/A
*As of 3/31/2023		

LDEOC Failing Calibration (OC) Tests*

Validity	Cause	#
OC		
OC		
OC		
Total		**0**

*Invalid and aborted calibration tests

No Failing LDEOC Calibration Tests were reported this period.

LDEOC Lost Tests*

Validity	Cause	No. of Tests
LC	Sample Lost	1
LC	Heating Bath Failure	1
Total		**2**

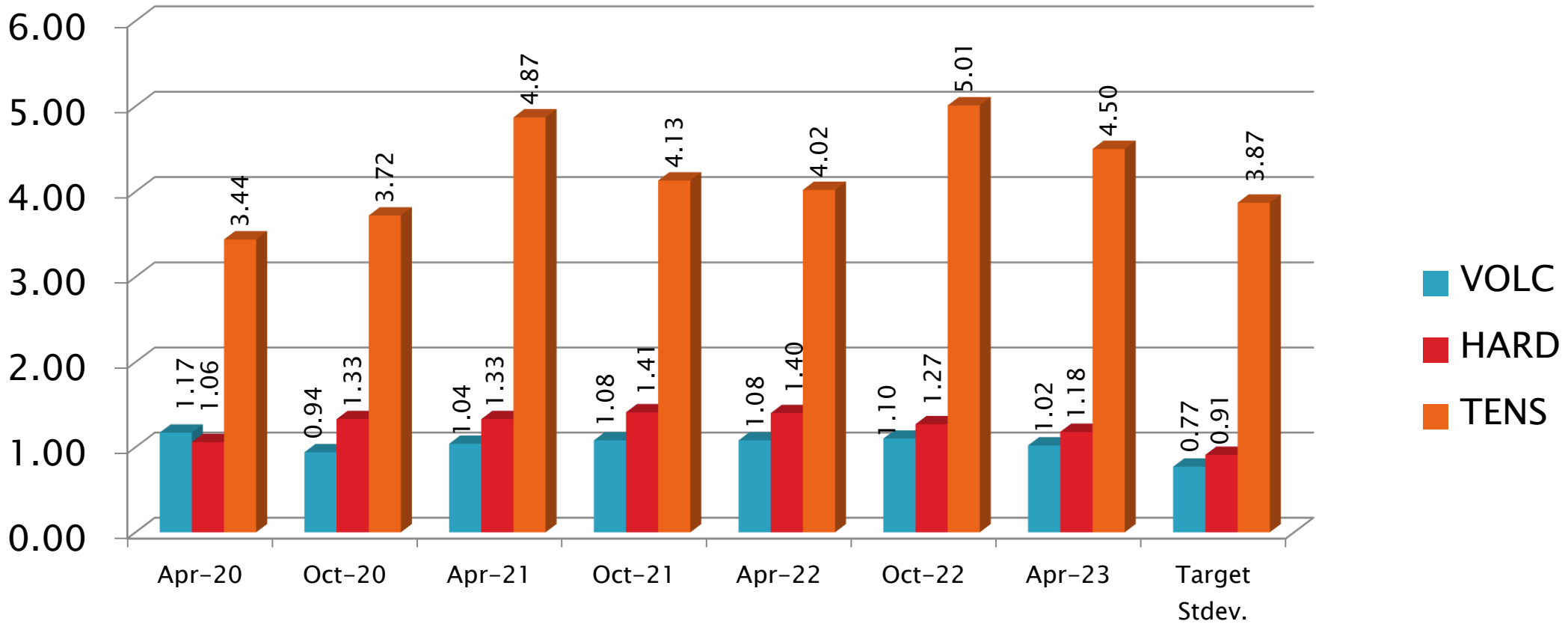
*Invalid and aborted calibration tests

LDEOC Test Severity

Ethylene Acrylate (AEM1)

Parameter	Period Mean Δ/s	Status
Volume Change	-0.39	Mild
Points Hardness Change	0.14	Severe
Tensile Strength Change	-0.38	Mild

LDEOC Precision Estimates – Ethylene Acrylate



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LDEOC Precision Estimates by Lab: AEM1

Test Parameter	Statistic	LTMS Lab					
		A	B	L	I	P	G
	n=	23	5	3	10	3	22
Volume	Mean	23.2	23.7	22.4	24.6	23.4	24.6
	Pooled s	0.36	0.56	0.28	1.11	0.64	0.91
	Mean /s	-1.27	-0.63	-2.29	0.50	-1.10	0.52
Hardness	Mean	-13.1	-13.4	-11.7	-12.0	-12.3	-12.3
	Pooled s	0.97	0.55	1.15	1.05	1.53	1.25
	Mean /s	-0.44	-0.73	1.17	0.80	0.44	0.45
Tensile Strength	Mean	-18.2	-18.9	-10.5	-19.9	-22.5	-18.2
	Pooled s	3.25	2.43	5.05	4.34	5.01	4.99
	Mean /s	-0.34	-0.54	1.64	-0.79	-1.47	-0.34

LDEOC —ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA

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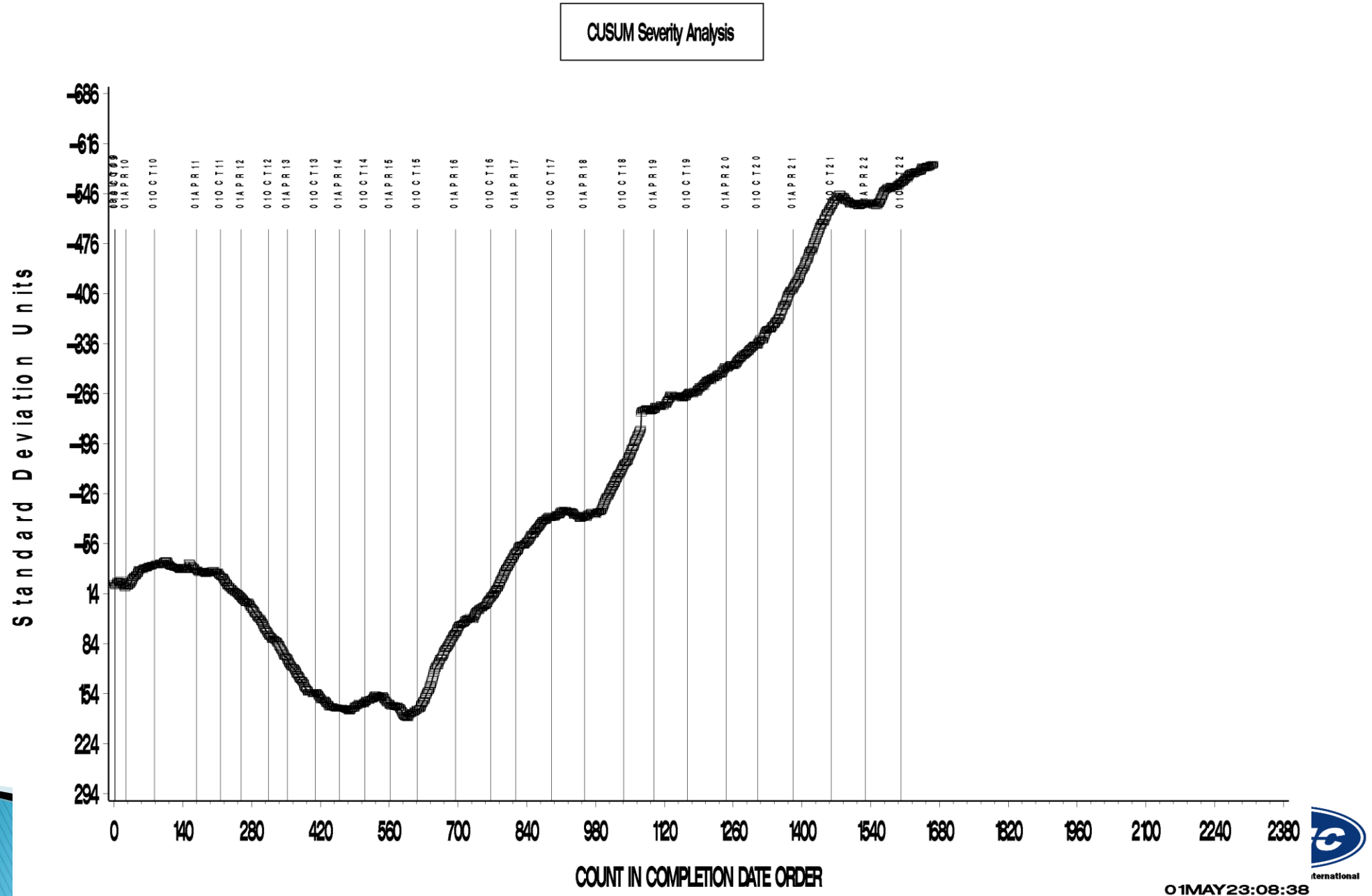
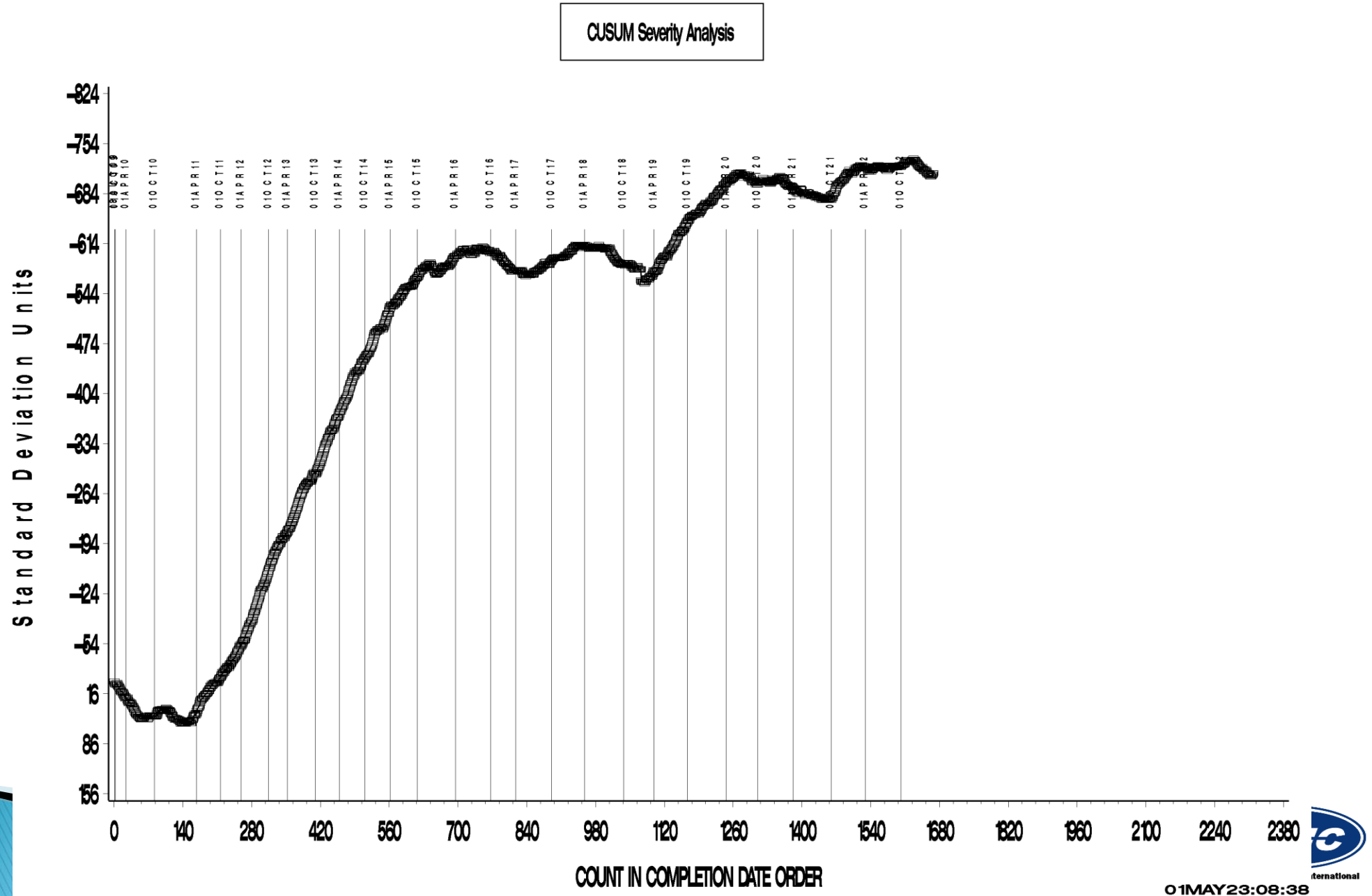
REF ETH ACRYLATE VOLUME CHANGE FINAL



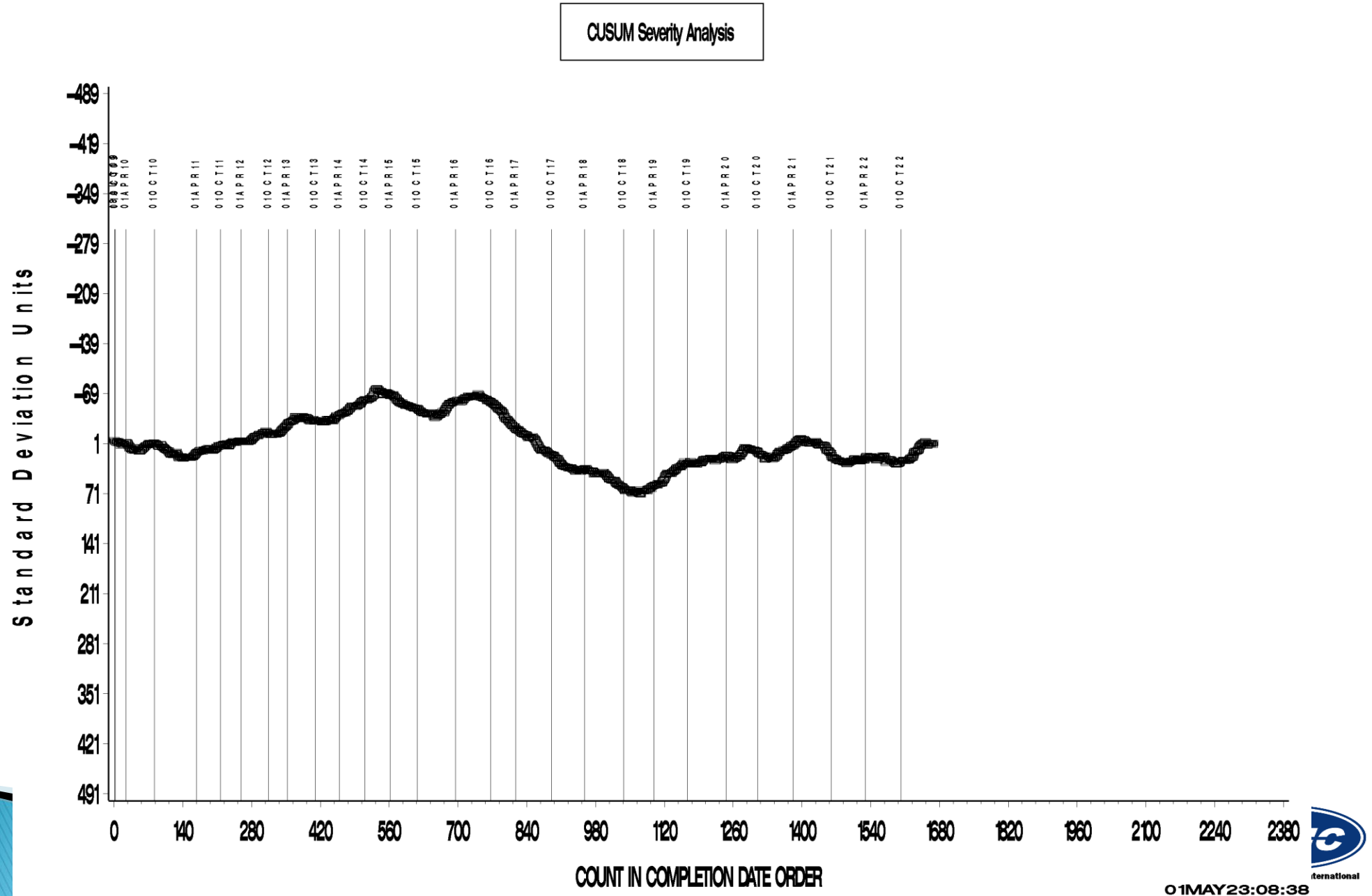
LDEOC —ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA

REF ETH ACRYLATE POINTS HARDNESS CHANGE FINAL



LDEOC —ETHYLENE ACRYLATE INDUSTRY OPERATIONALLY VALID DATA

REF ETH ACRYLATE TENSILE STRENGTH CHANGE FINAL

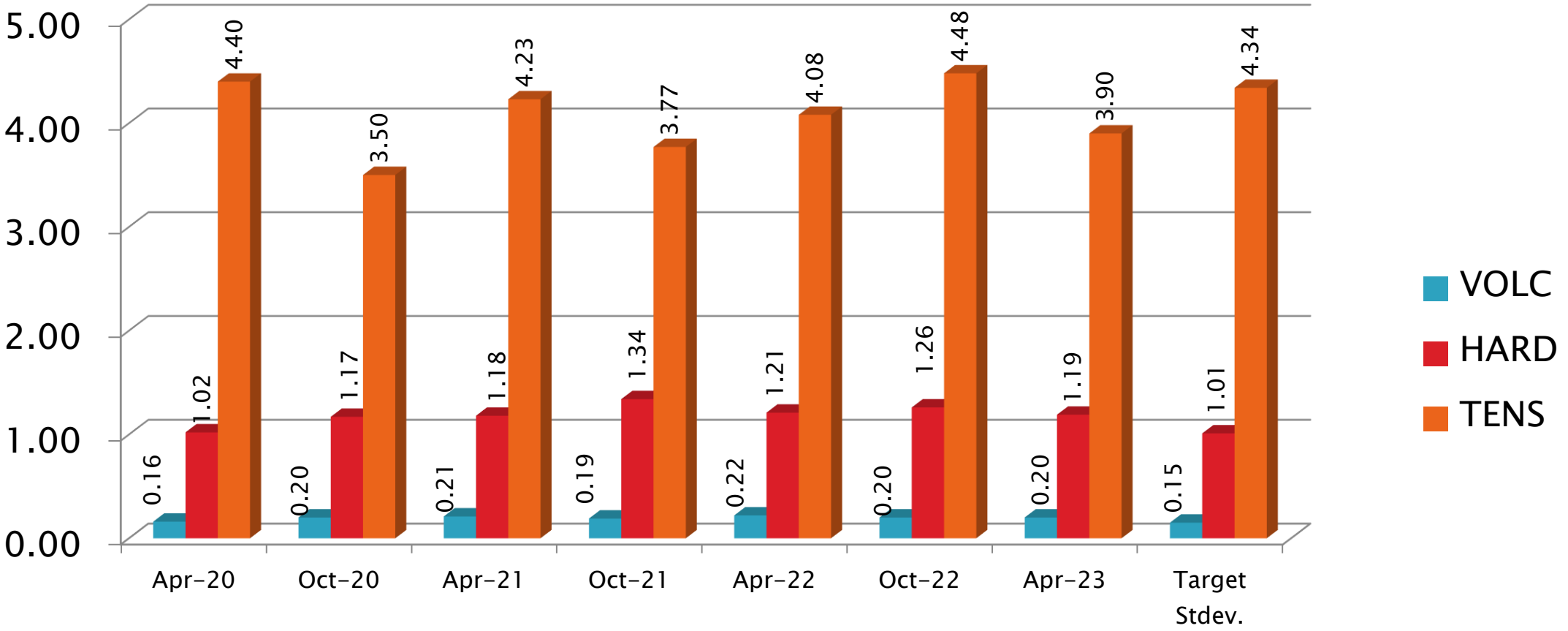


LDEOC Test Severity

Fluoroelastomer (FKM1)

Parameter	Period Mean Δ/s	Status
Volume Change	-0.75	Mild
Points Hardness Change	0.06	On-target
Tensile Strength Change	0.31	Severe

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	L	I	P	G
	n=	20	6	3	10	3	21
Volume	Mean	0.48	0.51	0.41	0.71	0.50	0.63
	Pooled s	0.13	0.02	0.04	0.26	0.04	0.22
	Mean /s	-1.31	-1.13	-1.82	0.21	-1.18	-0.36
Hardness	Mean	4.65	4.17	4.00	4.50	5.00	3.43
	Pooled s	0.81	0.41	1.00	1.08	1.00	1.43
	Mean /s	0.54	0.07	-0.10	0.40	0.89	-0.66
Tensile Strength	Mean	-58.6	-58.8	-58.9	-51.9	-57.0	-54.3
	Pooled s	2.27	1.66	1.04	1.93	0.91	4.24
	Mean /s	-0.27	-0.31	-0.35	1.27	0.08	0.71

LDEOC —FLUOROELASTOMER INDUSTRY OPERATIONALLY VALID DATA

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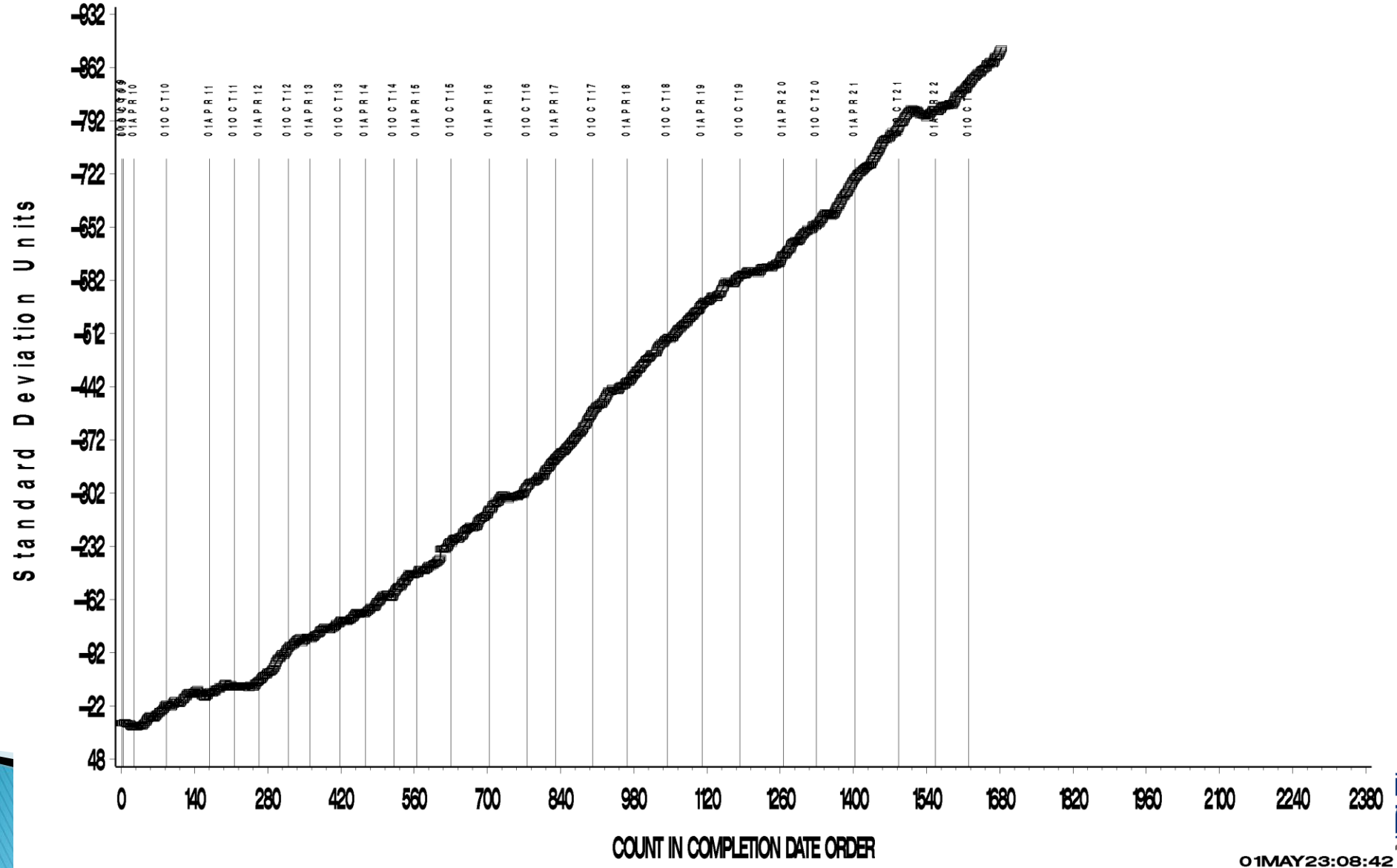
REF FLUOROELASTOMER VOLUME CHANGE FINAL

CUSUM Severity Analysis



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LDEOC —FLUOROELASTOMER INDUSTRY OPERATIONALLY VALID DATA

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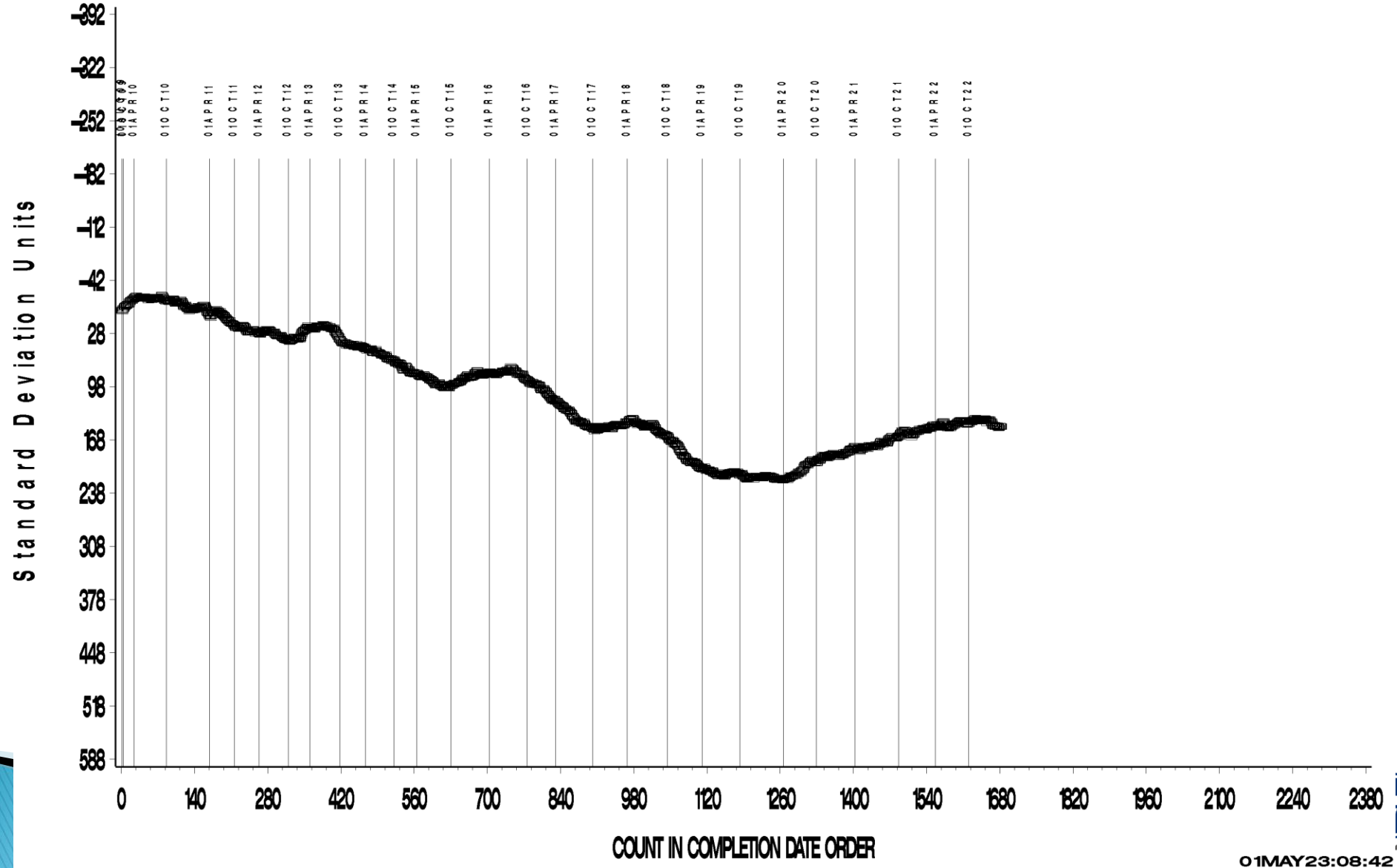
REF FLUORO POINTS HARDNESS CHANGE FINAL

CUSUM Severity Analysis



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LDEOC —FLUOROELASTOMER INDUSTRY OPERATIONALLY VALID DATA

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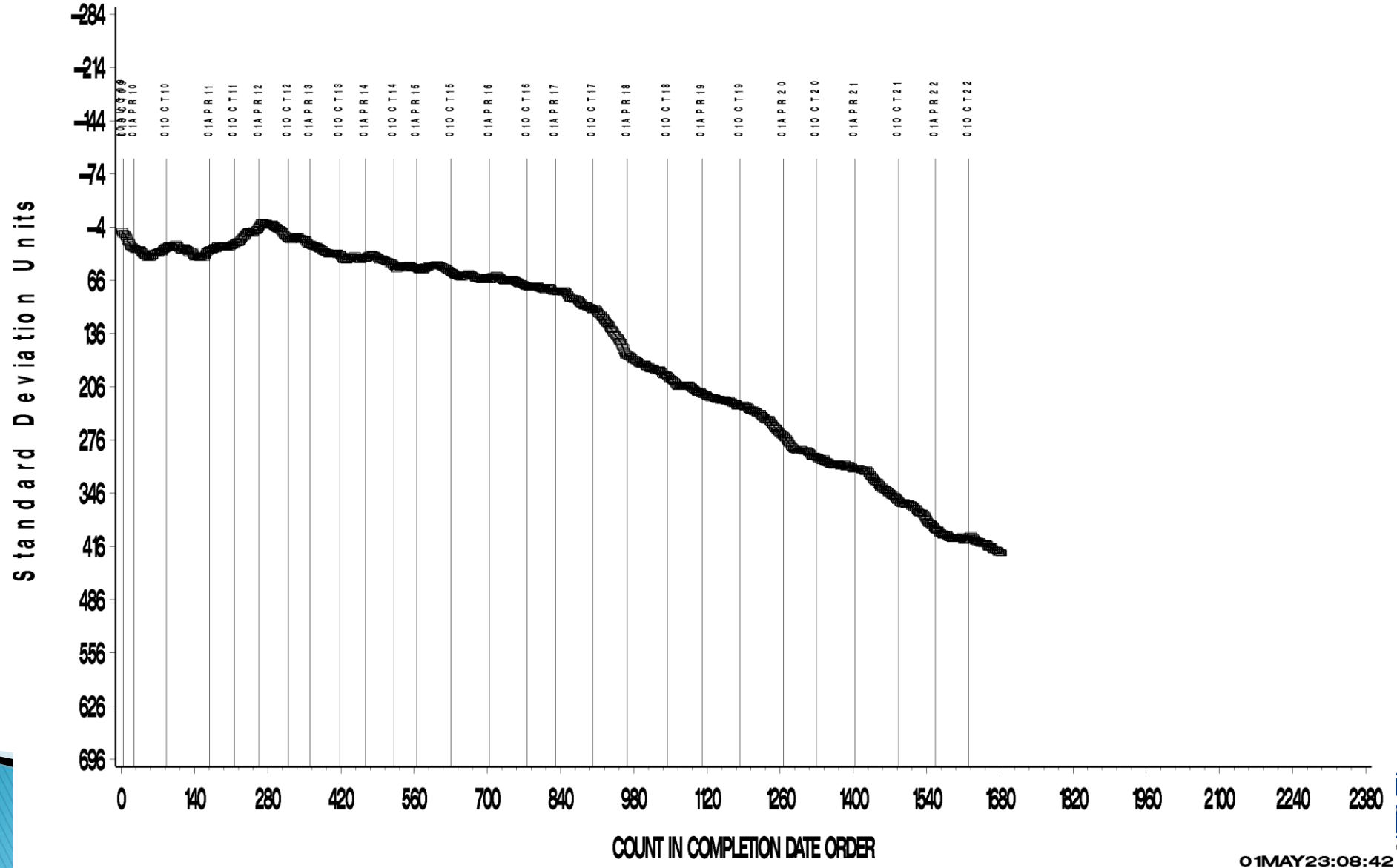
REF FLUORO TENSILE STRENGTH CHANGE AVERAGE

CUSUM Severity Analysis



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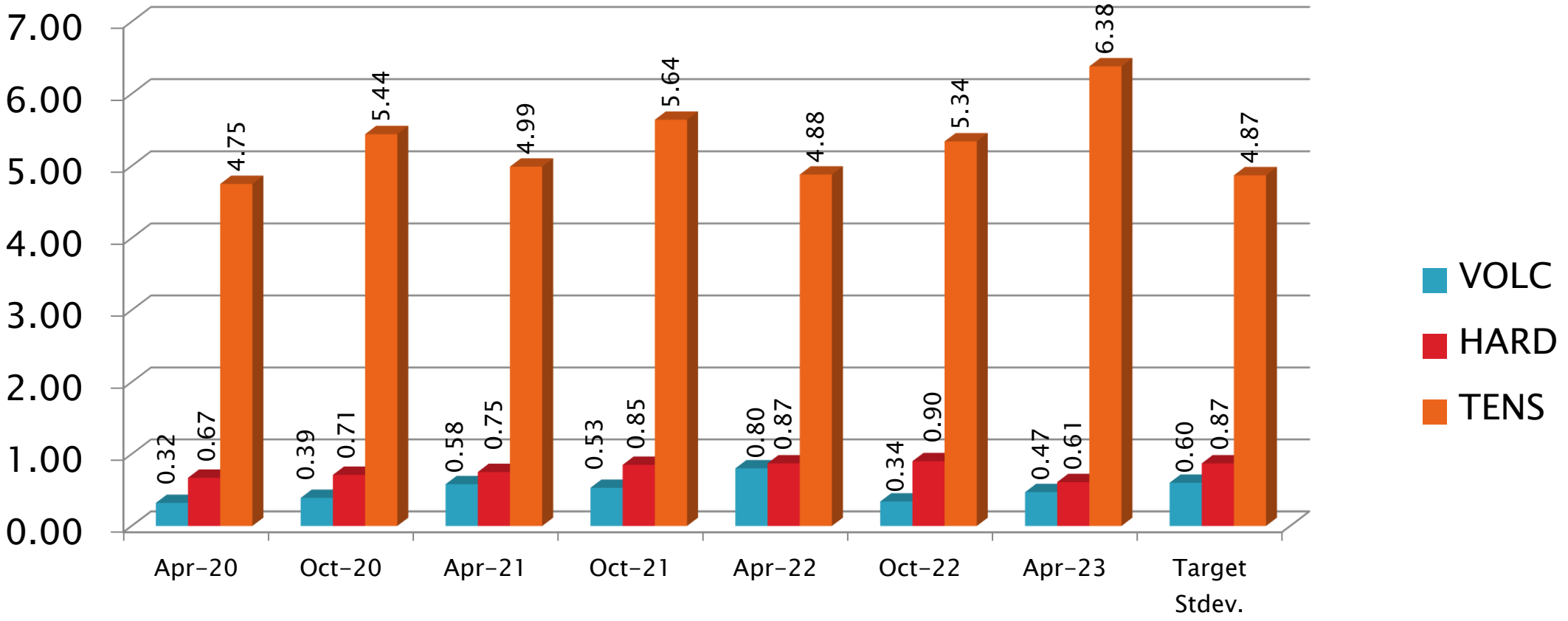
LDEOC Test Severity

Nitrile (NBR1)

Parameter	Period Mean Δ/s	Status
Volume Change	1.55	Severe
Points Hardness Change	-0.42	Mild
Tensile Strength Change	-0.75	Mild

LDEOC Precision Estimates – Nitrile



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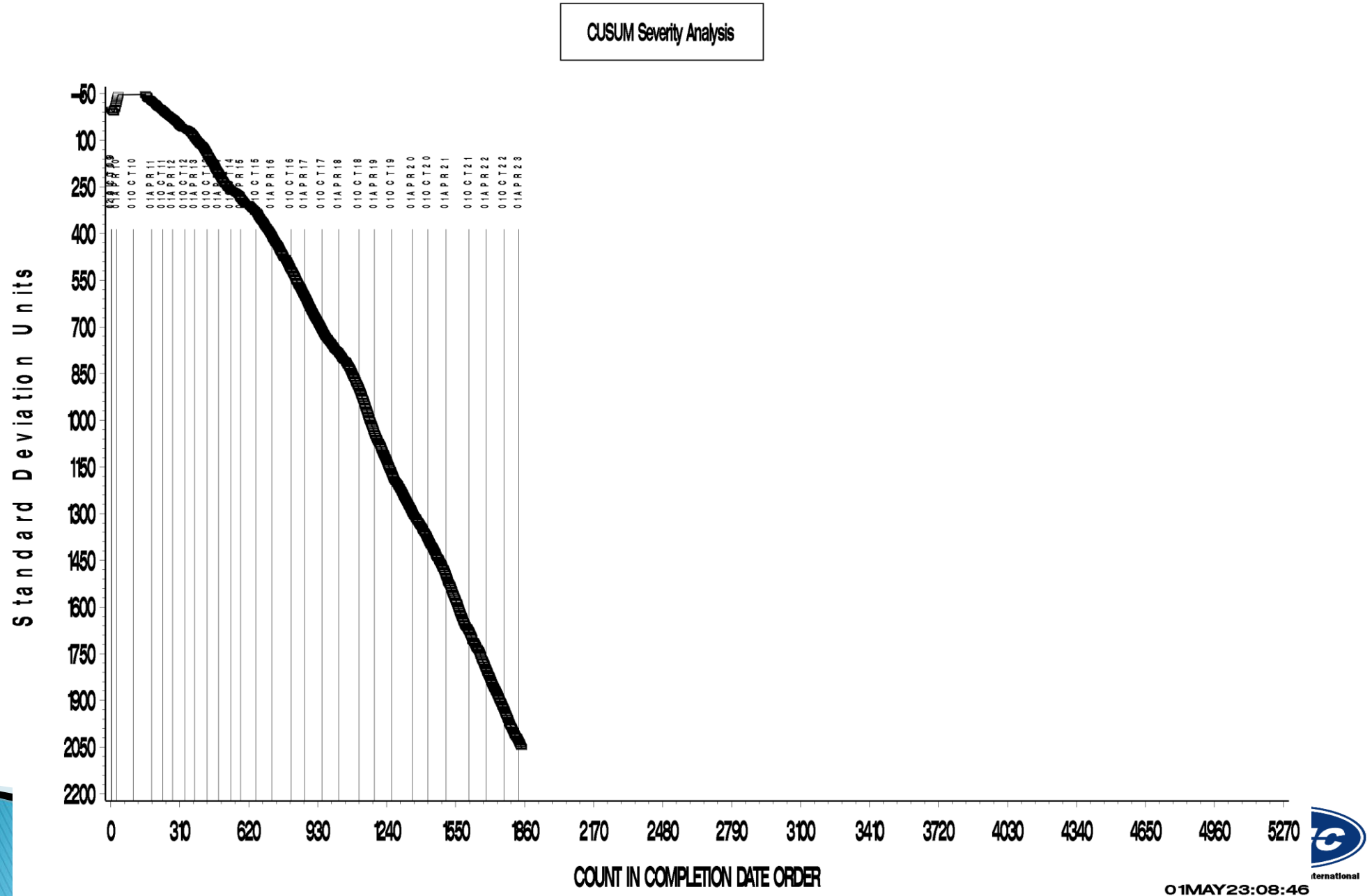
LDEOC Precision Estimates by Lab: NBR1

Test Parameter	Statistic	LTMS Lab						
		V	A	B	L	I	P	G
	n=	2	23	5	3	10	3	22
Volume	Mean	1.51	1.26	1.27	1.28	1.56	1.14	1.08
	Pooled s	0	0.18	0.22	0.13	0.66	0.09	0.63
	Mean /s	1.98	1.58	1.58	1.60	2.06	1.37	1.26
Hardness	Mean	-2.00	-1.65	-1.80	-1.33	-1.10	-1.33	-1.59
	Pooled s	0	0.57	0.45	0.58	0.74	0.58	0.59
	Mean /s	-0.94	-0.54	-0.71	-0.18	0.92	-0.18	-0.47
Tensile Strength	Mean	-0.70	0.64	0.52	-3.53	2.96	-0.17	5.59
	Pooled s	8.77	4.63	3.02	0.21	3.63	1.85	8.60
	Mean /s	-1.37	-1.09	-1.12	-1.95	-0.62	-1.26	-0.08

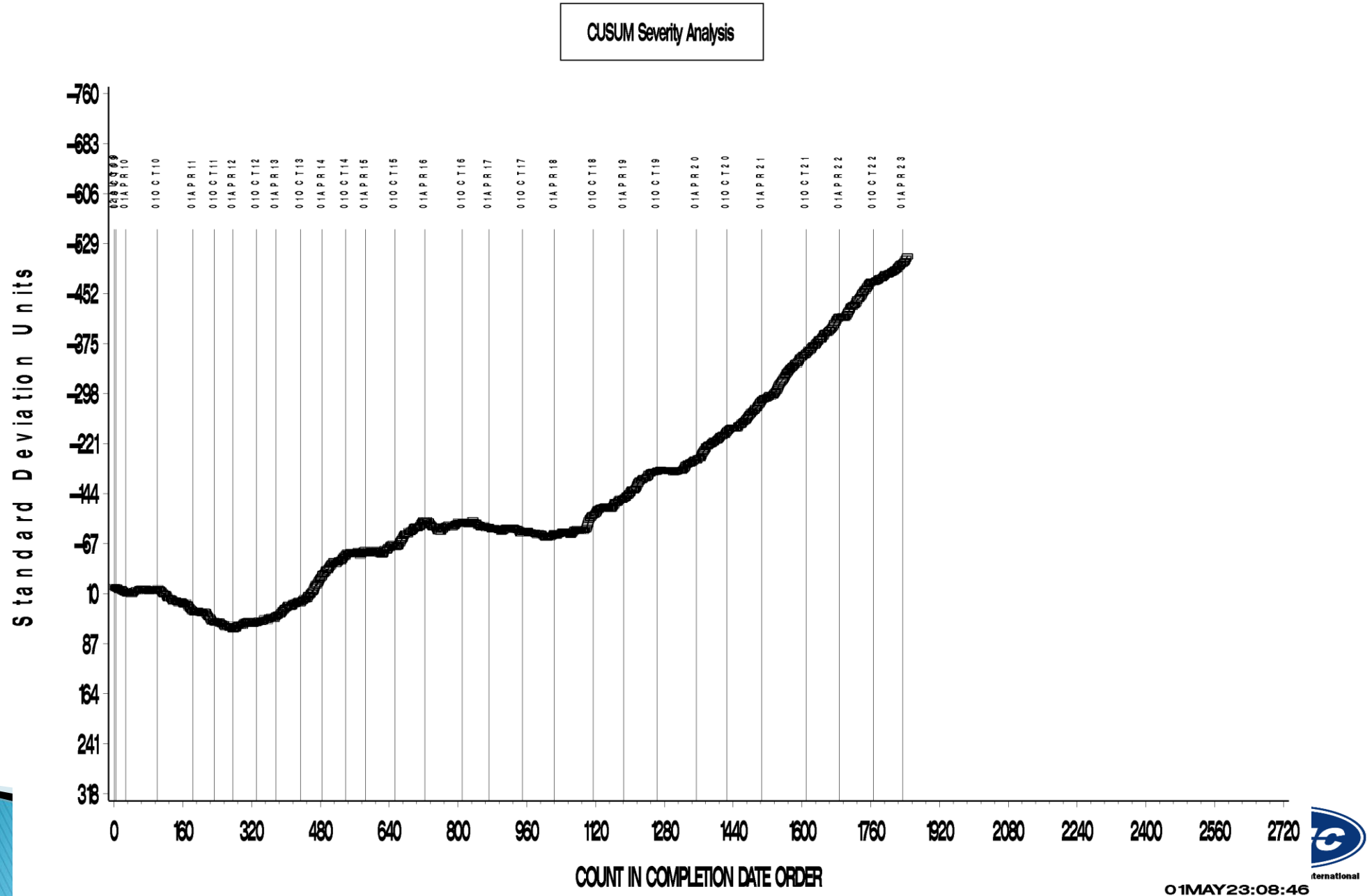
LDEOC —NITRILE INDUSTRY OPERATIONALLY VALID DATA

REFERENCE NITRILE VOLUME CHANGE FINAL



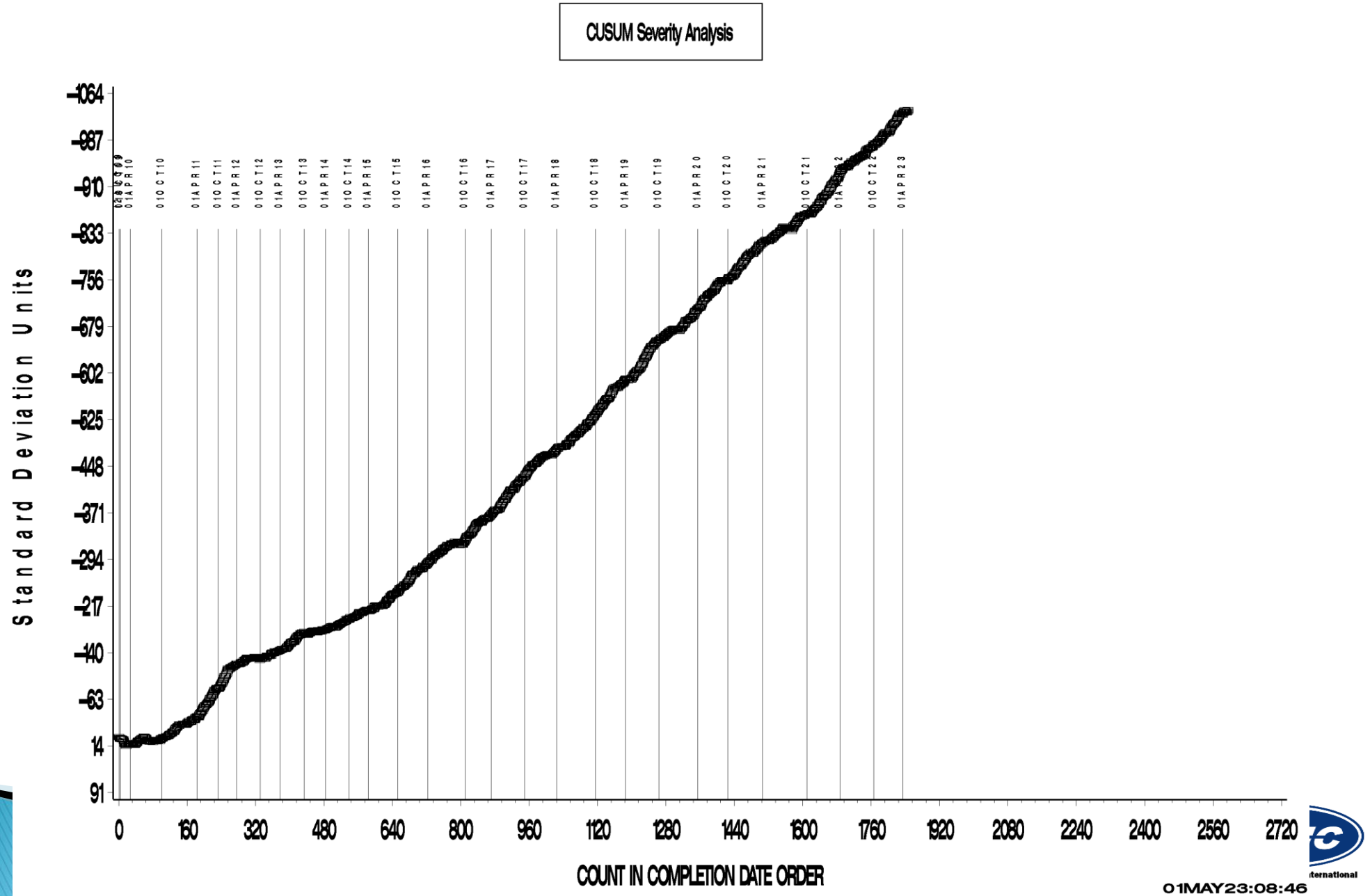
LDEOC —NITRILE INDUSTRY OPERATIONALLY VALID DATA

REF NITRILE POINTS HARDNESS CHANGE AVERAGE



LDEOC —NITRILE INDUSTRY OPERATIONALLY VALID DATA

REF NITRILE TENSILE STRENGTH CHANGE FINAL

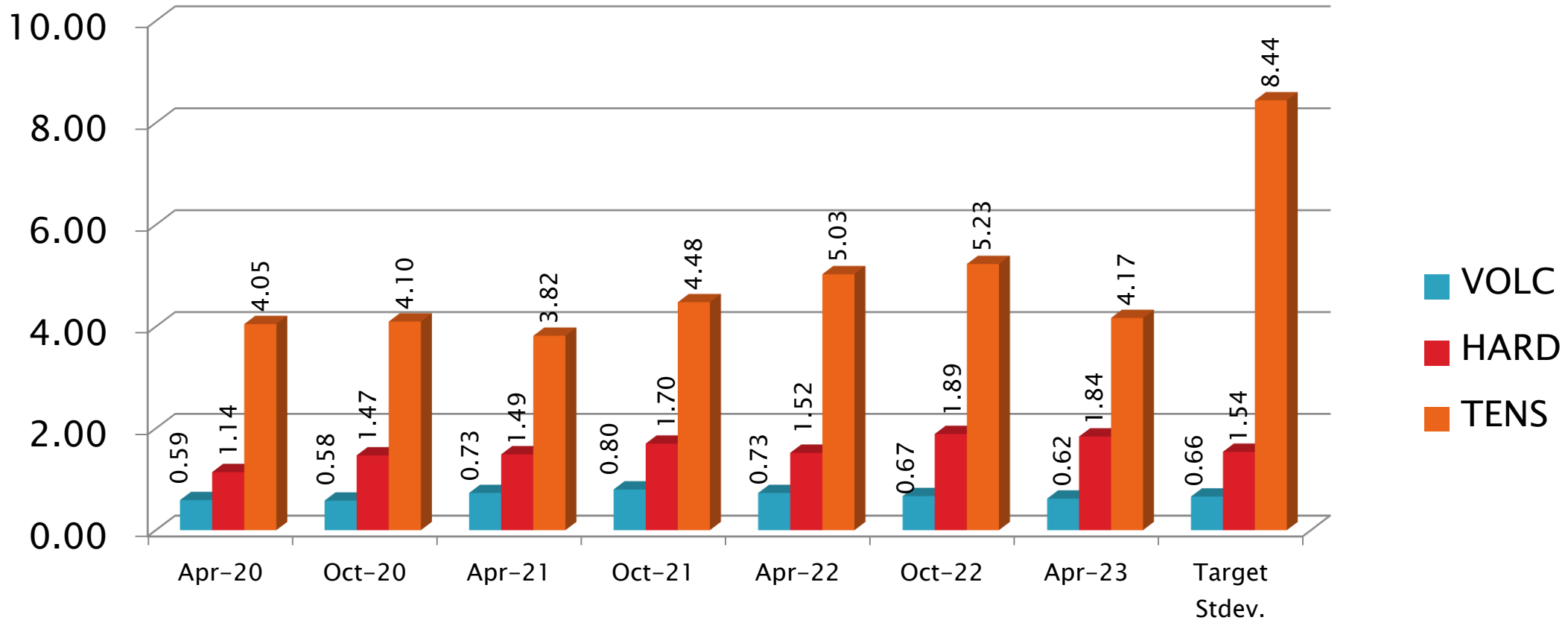


LDEOC Test Severity

Polyacrylate (ACM1)

Parameter	Period Mean Δ/s	Status
Volume Change	0.68	Severe
Points Hardness Change	-0.76	Mild
Tensile Strength Change	-0.64	Mild

LDEOC Precision Estimates – Polyacrylate



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LDEOC Precision Estimates by Lab: ACM1

Test Parameter	Statistic	LTMS Lab							
		E	V	A	B	L	I	P	G
	n=	2	2	23	7	3	12	3	24
Volume	Mean	2.47	1.76	2.42	2.07	2.07	3.35	2.50	2.39
	Pooled s	0.04	0.24	0.26	0.56	0.16	0.72	0.39	0.58
	Mean /s	0.64	-0.44	0.56	0.03	0.02	1.97	0.69	0.51
Hardness	Mean	-1.50	-2.50	-2.39	-2.86	-2.00	-0.50	0.33	-0.46
	Pooled s	0.71	0.71	0.94	0.90	1.00	1.57	1.53	2.22
	Mean /s	-0.84	-1.49	-1.41	-1.72	-1.16	-0.19	0.35	-0.16
Tensile Strength	Mean	0.35	0.40	-2.68	-1.77	-2.60	-3.66	-4.53	-3.23
	Pooled s	1.91	0.57	3.68	1.74	3.27	2.88	2.37	5.86
	Mean /s	-0.26	-0.26	-0.62	-0.52	-0.61	-0.74	-0.84	-0.69

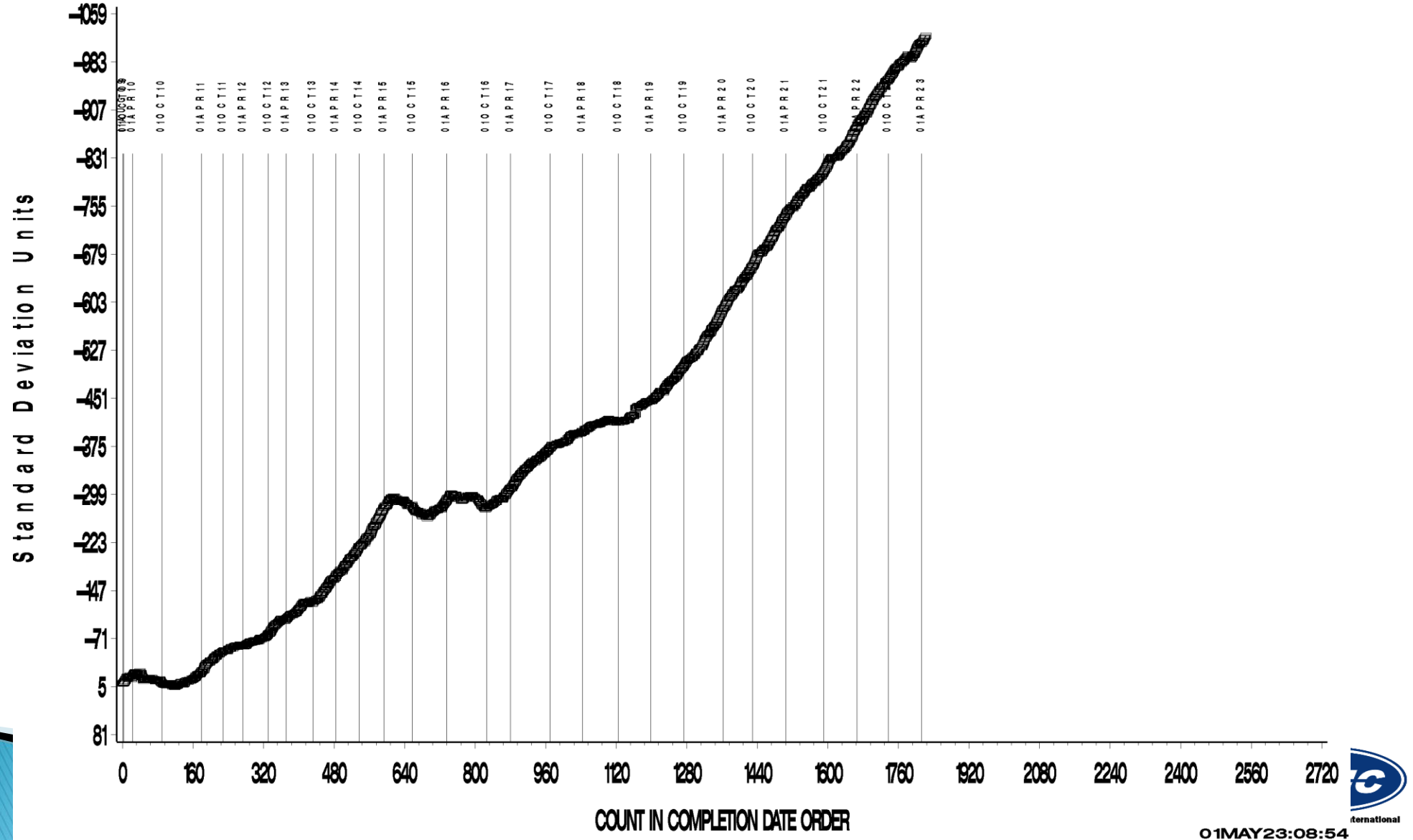
LDEOC — POLYACRYLATE INDUSTRY OPERATIONALLY VALID DATA

REF POLYACRYLATE VOLUME CHANGE FINAL

LDEOC — POLYACRYLATE INDUSTRY OPERATIONALLY VALID DATA

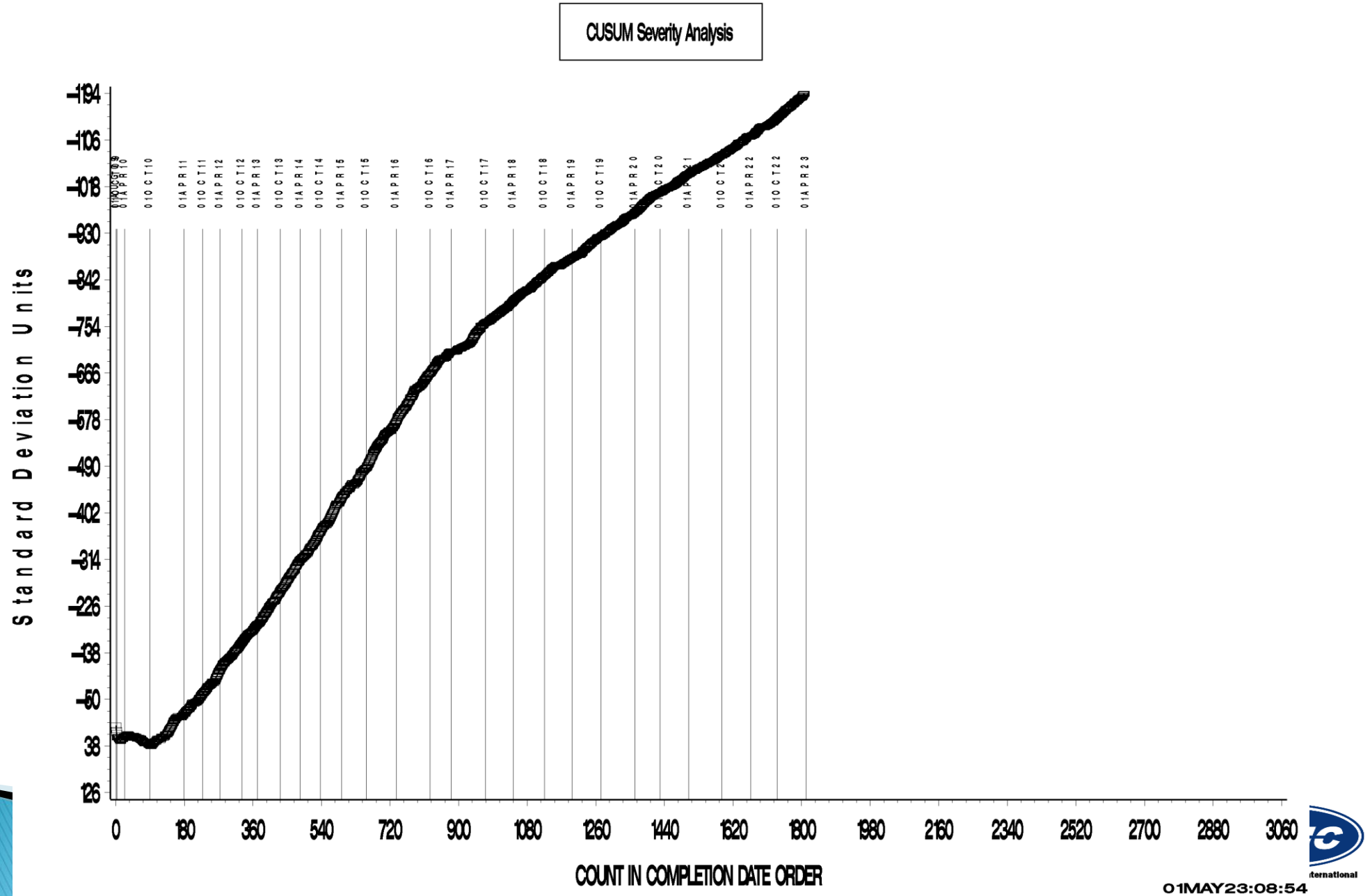
REF POLYACRYLATE POINTS HARDNESS CHG FINAL

CUSUM Severity Analysis



LDEOC — POLYACRYLATE INDUSTRY OPERATIONALLY VALID DATA

REF POLYACRYLATE TENSILE STRENGTH CHG FINAL

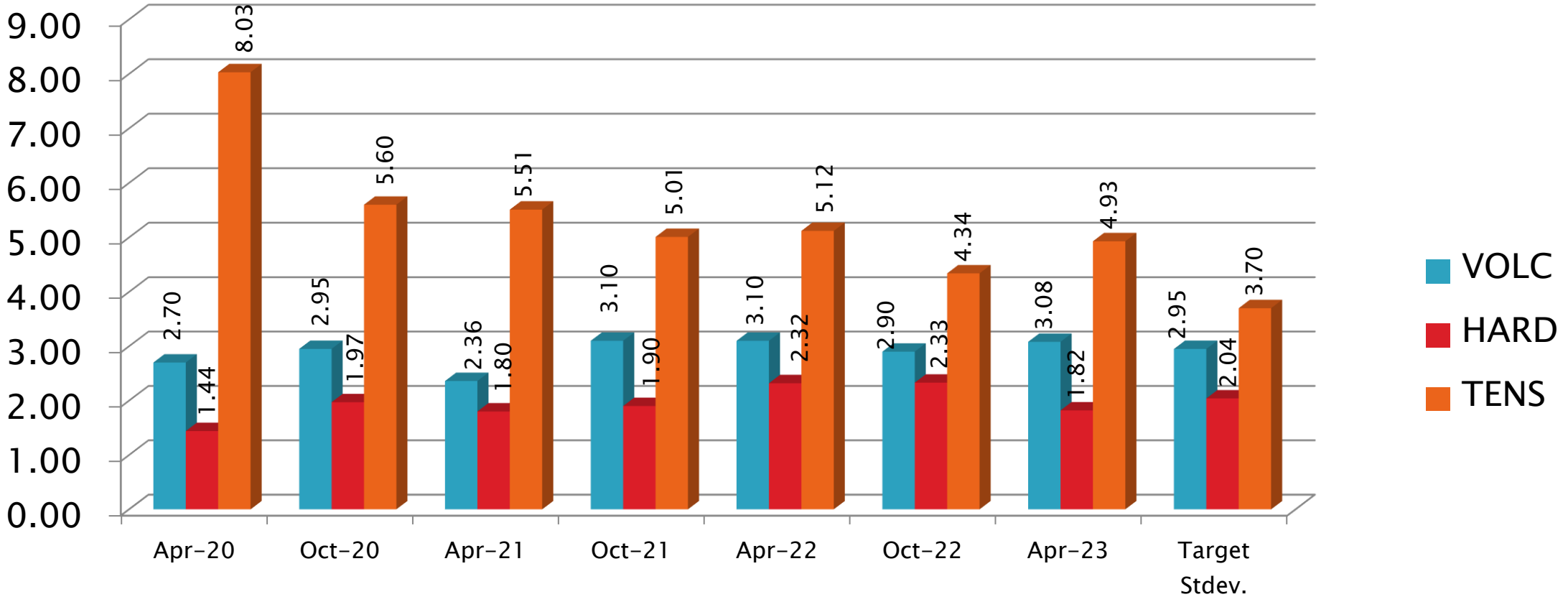


LDEOC Test Severity

Silicone (VMQ1)

Parameter	Period Mean Δ/s	Status
Volume Change	0.58	Severe
Points Hardness Change	-0.84	Mild
Tensile Strength Change	0.73	Severe

LDEOC Precision Estimates – Silicone



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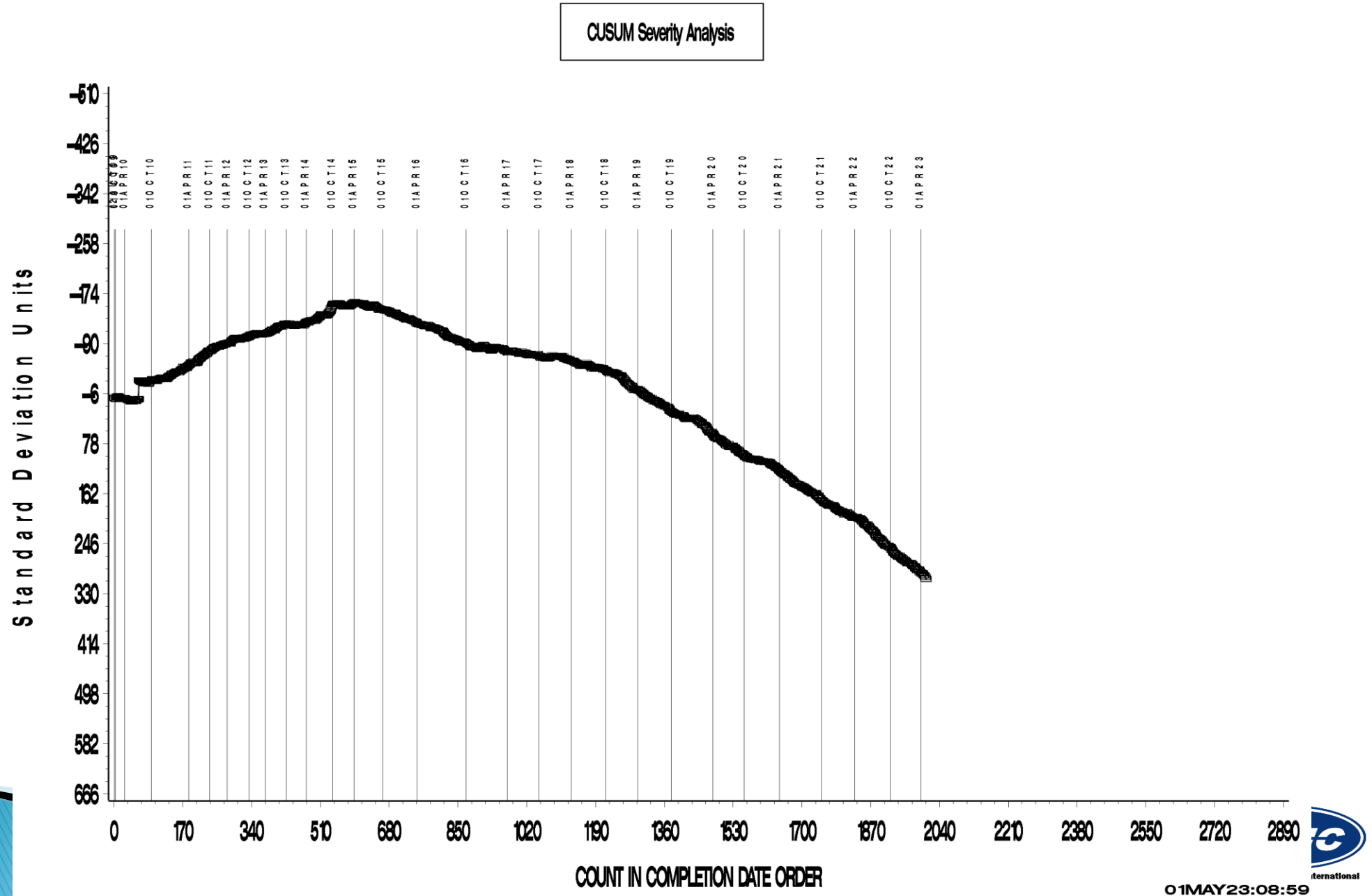
LDEOC Precision Estimates by Lab: VQM1

Test Parameter	Statistic	LTMS Lab						
		V	A	B	L	I	P	G
	n=	5	28	5	3	10	3	21
Volume	Mean	33.2	33.3	32.7	30.0	30.6	33.2	37.3
	Pooled s	0.43	1.32	0.78	0.50	1.49	0.09	3.15
	Mean /s	0.35	0.37	0.19	-0.73	-0.55	0.37	1.75
Hardness	Mean	-24.8	-24.4	-23.2	-18.7	-21.6	-23.7	-23.3
	Pooled s	0.45	1.34	1.10	0.58	1.17	1.55	1.42
	Mean /s	-1.53	-1.31	-0.74	1.48	0.04	-0.97	-0.79
Tensile Strength	Mean	-29.9	-28.2	-27.7	-30.4	-34.2	-34.6	-34.1
	Pooled s	8.09	2.80	2.01	3.11	4.04	3.96	4.92
	Mean /s	1.03	1.51	1.64	0.91	-0.12	-0.23	-0.09

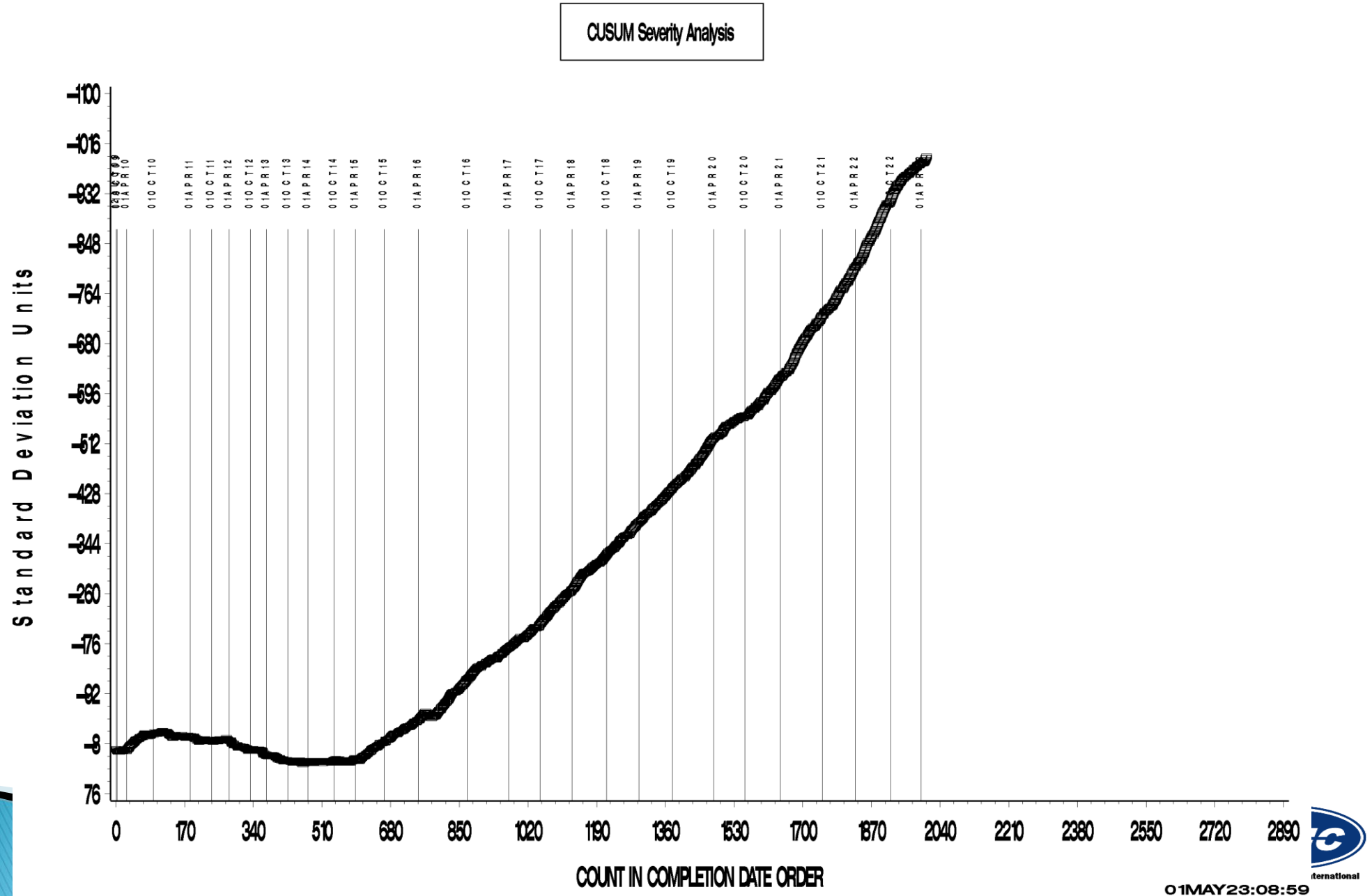
LDEOC —SILICONE INDUSTRY OPERATIONALLY VALID DATA

REFERENCE SILICON VOLUME CHANGE FINAL



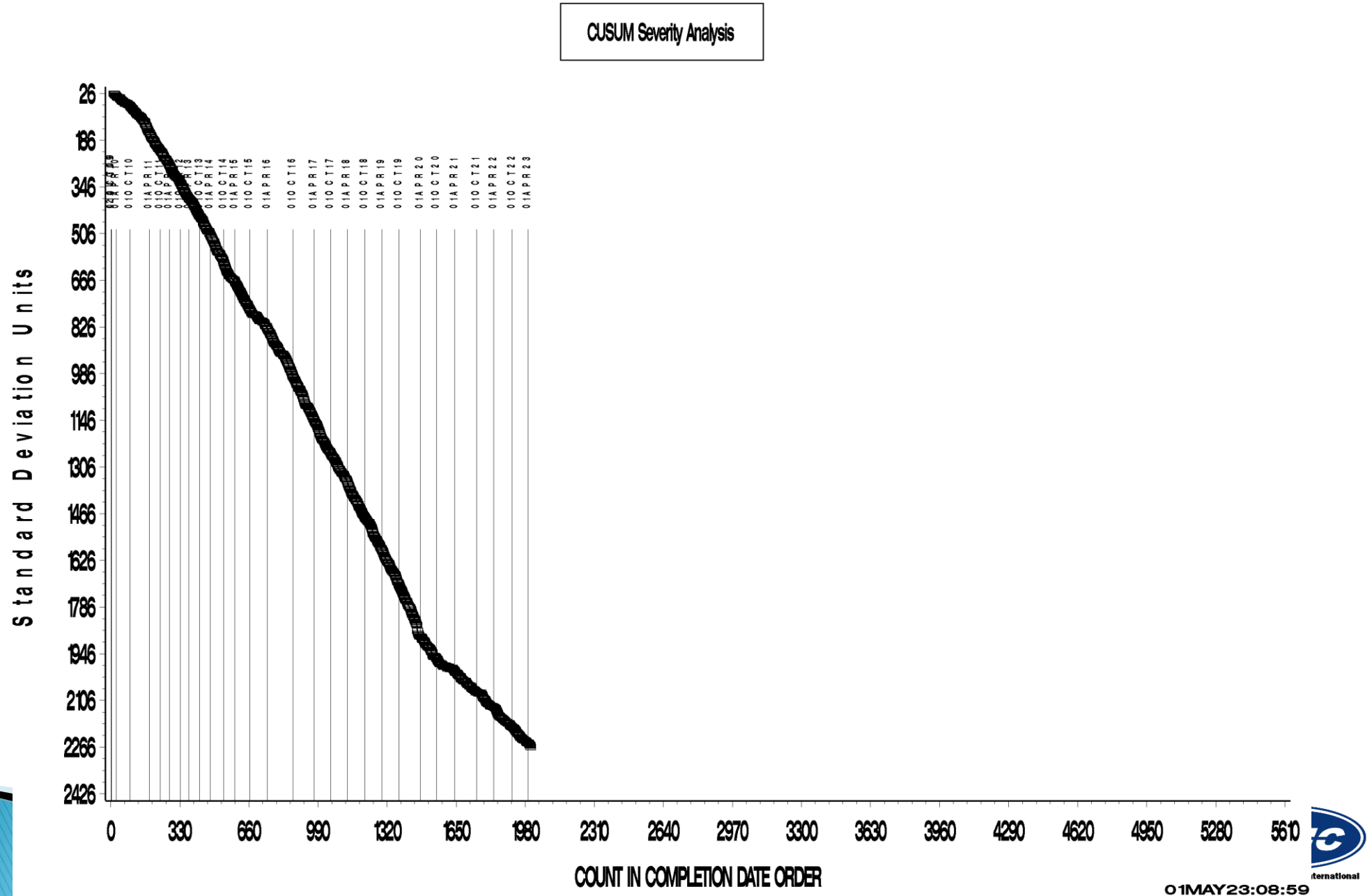
LDEOC —SILICONE INDUSTRY OPERATIONALLY VALID DATA

REFERENCE SILICON POINTS HARDNESS FINAL



LDEOC —SILICONE INDUSTRY OPERATIONALLY VALID DATA

REF SILICON TENSILE STRENGTH CHANGE FINAL



Information Letters & Technical Updates*

Test	Date	IL or Memo Number	Topic
LDEOC	20230118	M23-002*	Elastomer SP Votes to Eliminate the use of 1006 Reference Oil

*Available from TMC Website

Reference Oil Inventory Estimated Life EOEC/LDEOC

Oil	TMC Inventory Gallons	Gallons Shipped Past 12 Months	Estimated Life
SL107[A, B]	2174	198	3.7 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

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D02.B0.07
TMC Monitored Tests

ASTM D 7528

ROBO

October 1, 2022 – March 31, 2023

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Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D7528	5 (–2)	29 (+20)
*As of 3/31/2023		

D7528: Oxidation by ROBO

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	87
Failed Calibration Test	OC	7
Operationally Invalidated by Lab	LC, XC	1
Operationally Invalidated After Initially Reported as Valid	RC	3
Total		**98**

Number of Labs Reporting Data: 5
Fail Rate of Operationally Valid Tests: 7.4%

D7528: Oxidation by ROBO

Statistically Unacceptable Tests (OC)	No. Of Tests
Natural Log (MRV Viscosity) Mild	3
Natural Log (MRV Viscosity) Severe	4
Total	**7**

- Information Letter 21-1 was issued 3 November 2021 and added an option to use dilute nitrogen dioxide in air

D7528: ROBO Failed Tests by Lab

Failed Parameter	LTMS Lab					Number of Tests
	A	BC	AQ	G	AM	
Natural Log (MRV Viscosity) Severe	3	0	1	0	0	4
Natural Log (MRV Viscosity) Mild	2	0	1	0	0	3
Total	**5**	**0**	**2**	**0**	**0**	**7**

- Six different units from two different labs reported failing calibration tests

D7528: Oxidation by ROBO

Operationally Invalid or Aborted Calibration Tests

Test Status	Cause	No. of Tests
Invalidated by Lab (LC)	Yield stress >35kPa (Not RO 434-3)	1
Invalidated by TMC (RC)	Yield stress >35kPa (Not RO 434-3)	3
Totals		**4**

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	-----
10/1/18 through 3/31/19	100	96	0.2738	0.04
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

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

October 1, 2022 – March 31, 2023

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	40	40	100	2	14	G,AM
Liquid	54	47	87	4	16	A,AQ,BC,G
BOTH (Totals)	**94**	**87**	**92.6**	**5***	**29****	**A, AM, AQ, BC, G**

*One lab is conducting tests with both NO_2 delivery methods.
**One unit reported one single failing test result and is not in calibration.

D7528: Oxidation by ROBO

Precision, Performance (Mean Δ/s) by Lab and NO_2 Delivery Mechanism

NO_2 Delivery		Reference Oil 434-3	Reference Oil 435-1	Reference Oil 436	TOTAL
Dilute	No. of Runs	11	22	7	40
	Mean	10.7338	11.1550	10.4058	10.9081
	Pooled s	0.1209	0.1536	0.0395	0.1327
	Mean Δ/s	-0.60	0.56	0.57	0.24
Liquid	No. of Runs	12	28	14	54
	Mean	10.8010	11.0102	10.3911	10.8032
	Pooled s	0.2131	0.2729	0.1217	0.2302
	Mean Δ/s	-0.12	-0.15	0.46	0.01
BOTH	No. of Runs	23	50	21	94
	Mean	10.7688	11.0739	10.3960	10.8478
	Pooled s	0.1747	0.2375	0.1007	0.2000
	Mean Δ/s	-0.35	0.16	0.50	0.11

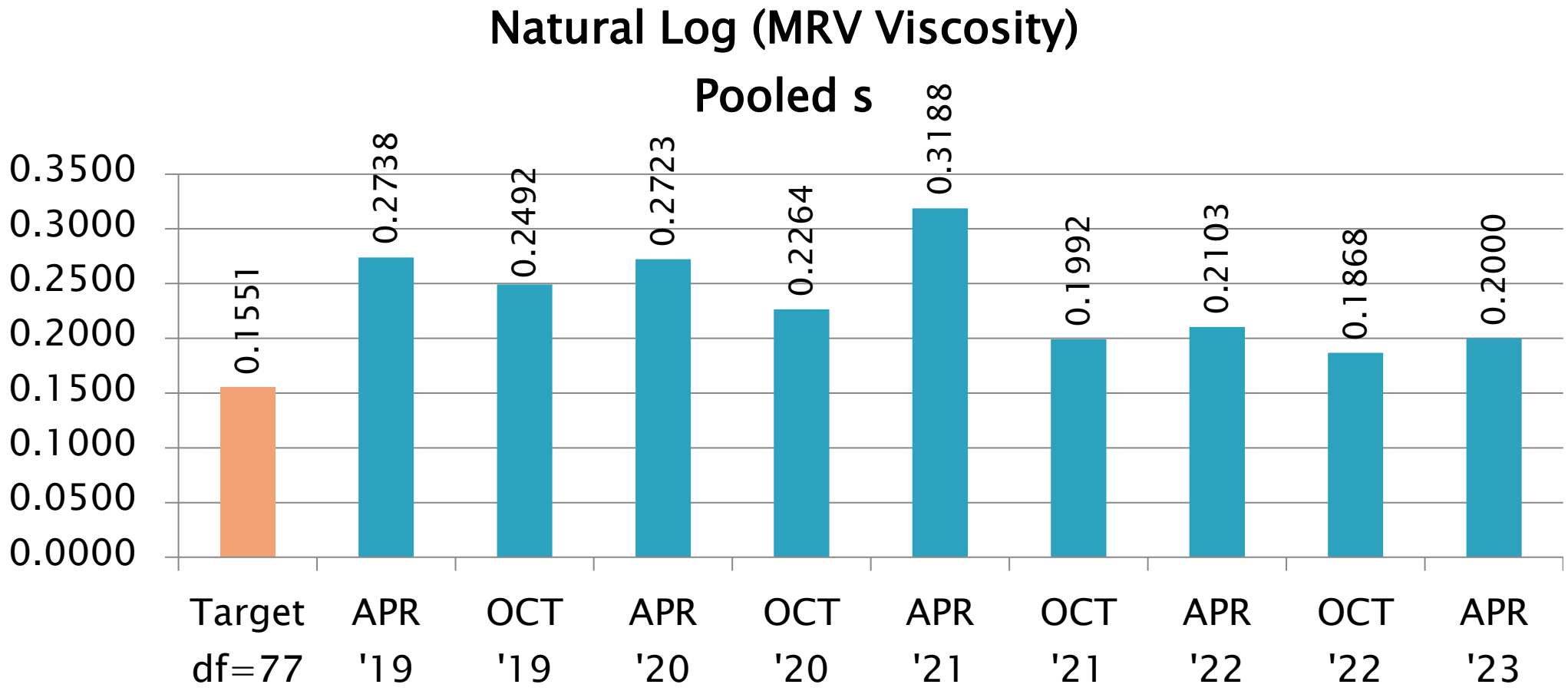
D7528: Oxidation by ROBO

Period Performance (Mean Δ/s) by Lab and NO_2 Delivery Mechanism

NO_2 Delivery Mechanism	LAB A (all L)	LAB AM (all D)	LAB AQ (all L)	LAB BC (all L)	LAB G (mix)
Dilute	n = 0	n = 7	n = 0	n = 0	n = 33
	N/A	0.39	N/A	N/A	0.21
Liquid	n = 35	n =0	n = 7	n = 4	n = 8
	0.33	N/A	-0.53	-0.22	-0.76
BOTH	**n = 35**	**n = 7**	**n =7**	**n = 4**	**n = 41**
	0.33	**0.39**	**-0.53**	**-0.22**	**0.02**

October 1, 2022 – March 31, 2023

D7528: Oxidation by ROBO



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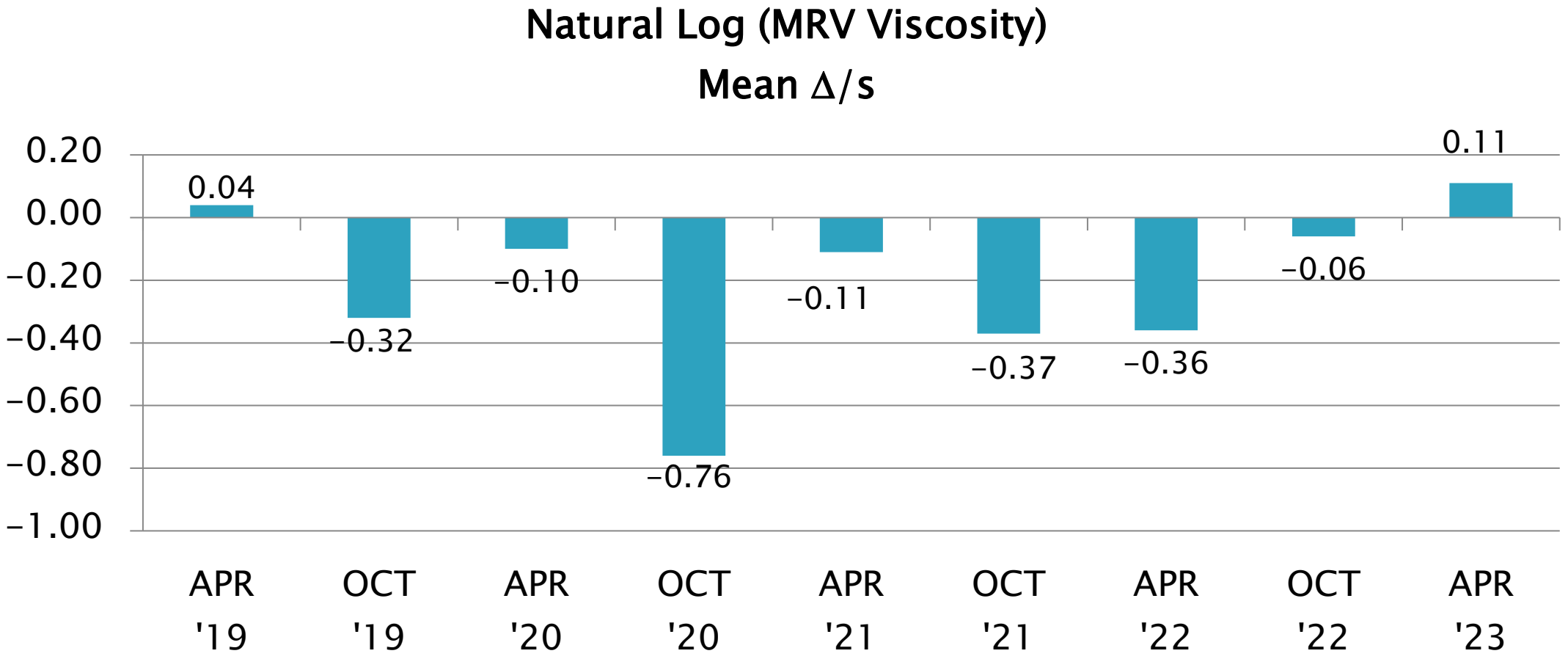
D7528: Oxidation by ROBO



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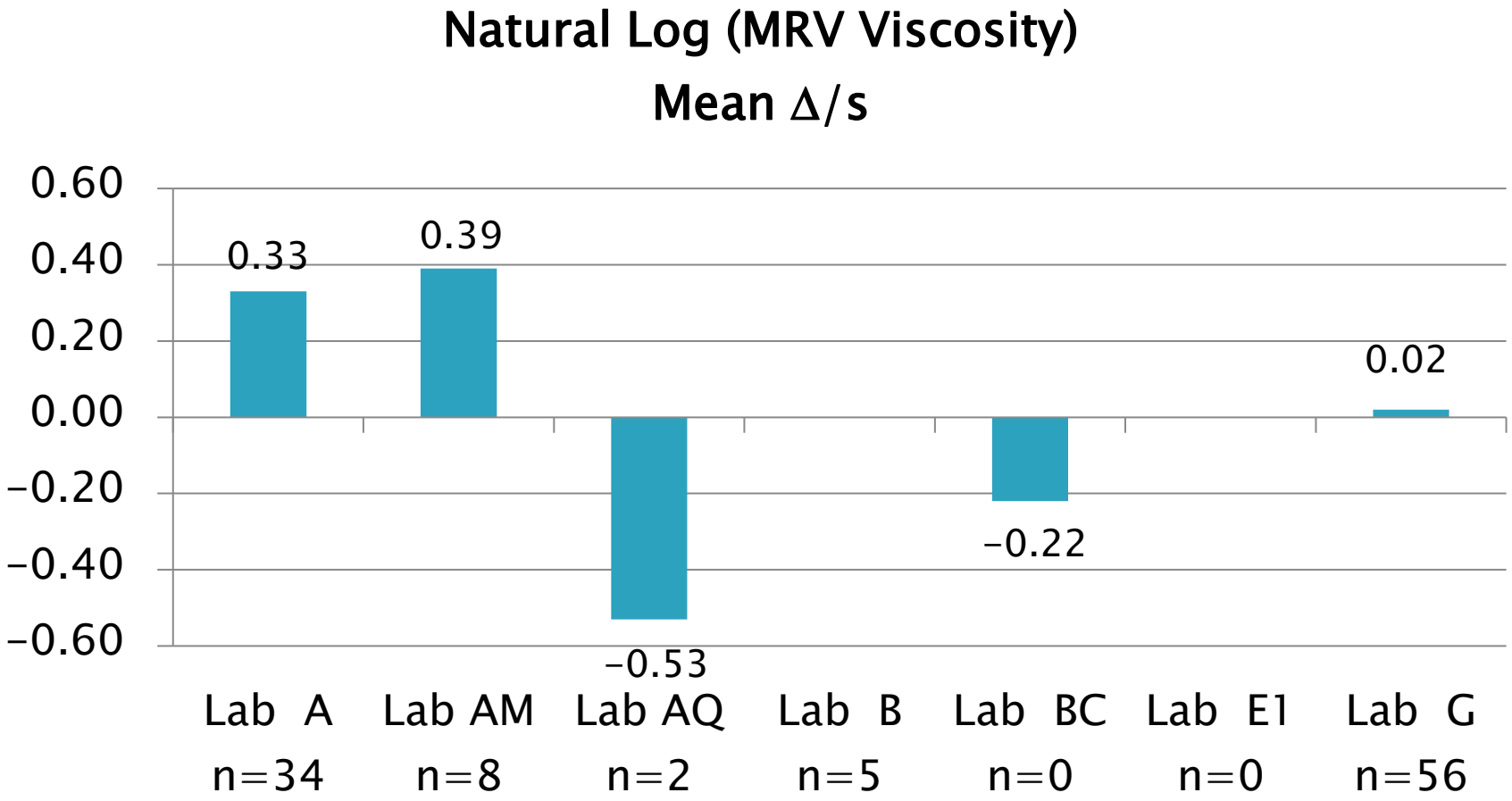
D7528: Oxidation by ROBO



D7528: Oxidation by ROBO

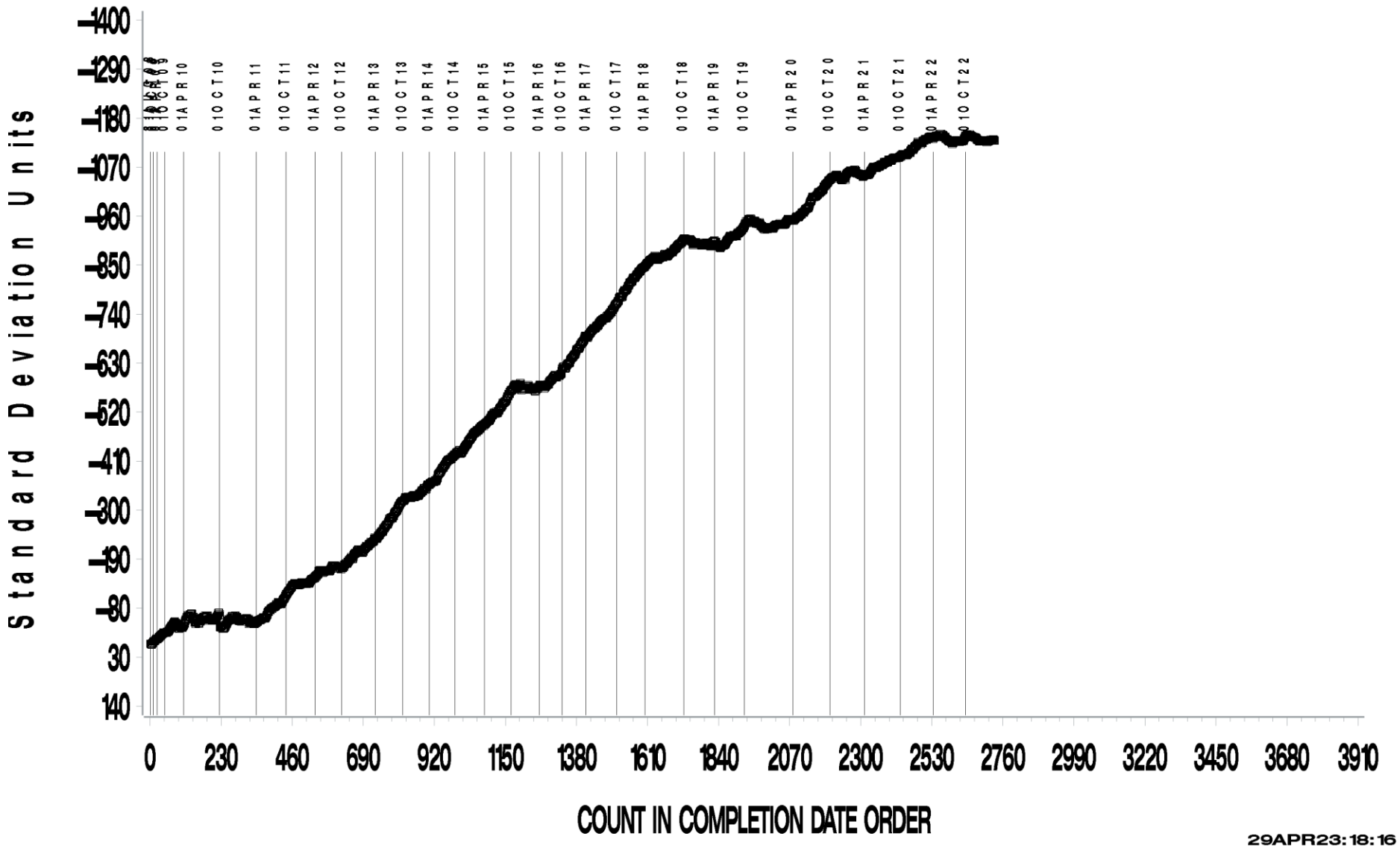
- Precision (Pooled s) has been consistently right around 0.20 for the past four semesters and about 0.05 units higher than target (0.15).
- Severity (Mean Δ/s) has moved to severe (+0.11) for the first time since April 2019
- CUSUM severity plot shows a second consecutive period of relatively 'flat' CUSUM after many periods of trending Mild.
- Two labs did not report any runs this period

ROBO TEST INDUSTRY OPERATIONALLY VALID DATA

AGED OIL MRV APPARENT VISCOSITY

CUSUM Severity Analysis

Historical Chart



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ROBO TEST INDUSTRY OPERATIONALLY VALID DATA
Last 200 Points ONLY
AGED OIL MRV APPARENT VISCOSITY

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CUSUM Severity Analysis

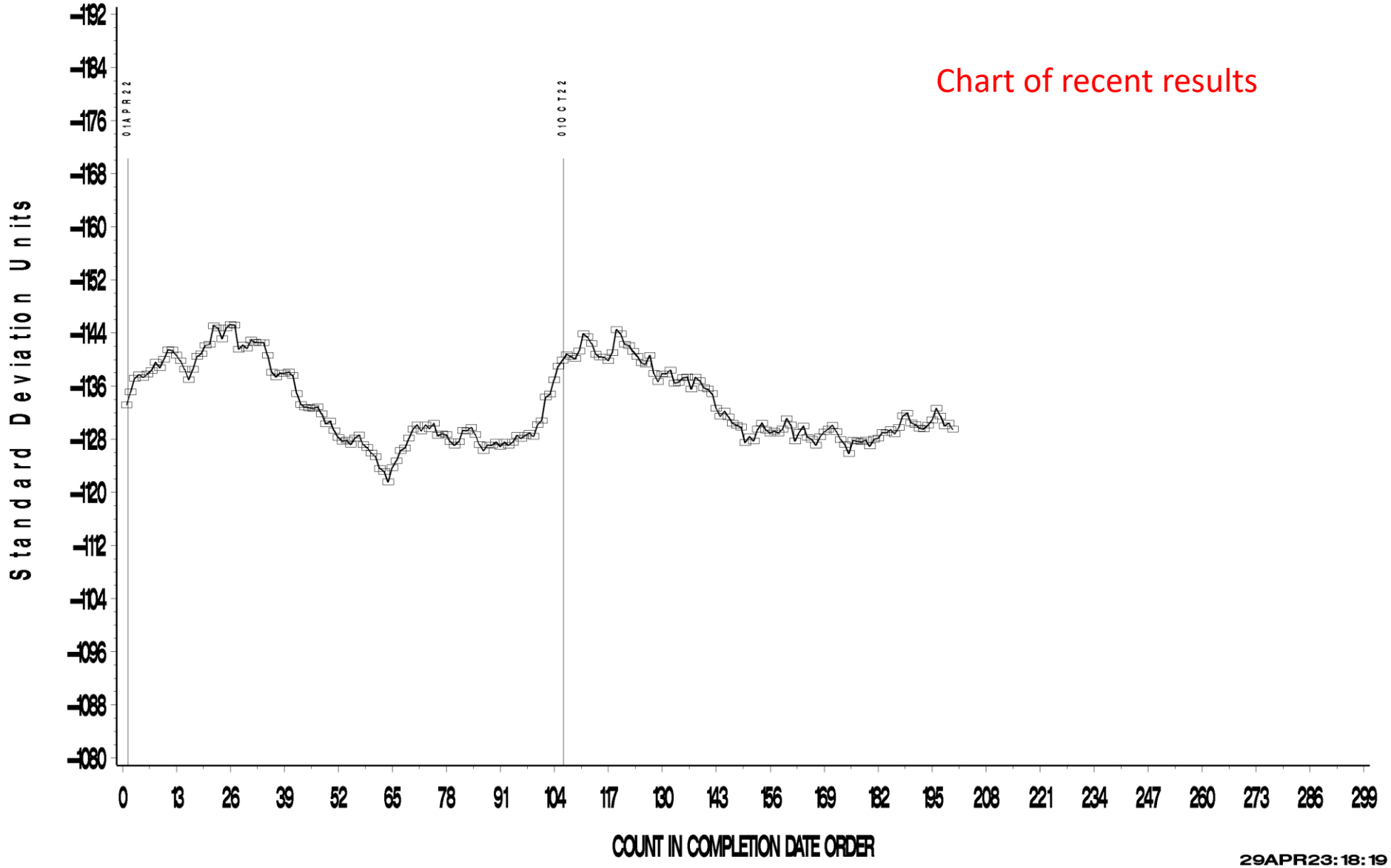

Chart of recent results

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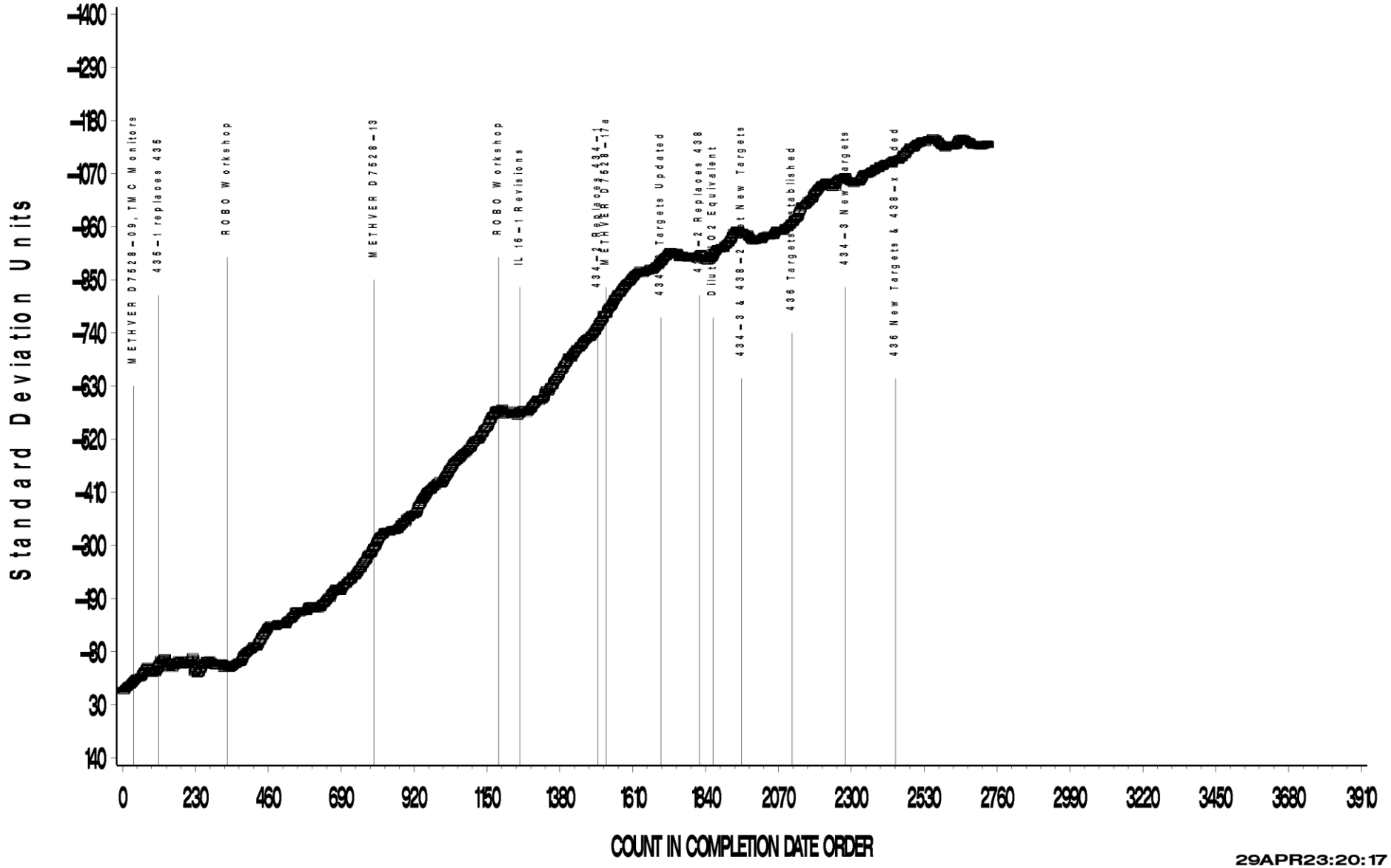
ROBO TEST INDUSTRY OPERATIONALLY VALID DATA

AGED OIL MRV APPARENT VISCOSITY

CUSUM Severity Analysis



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ROBO TEST INDUSTRY OPERATIONALLY VALID DATA
Last 750 Points ONLY
AGED OIL MRV APPARENT VISCOSITY

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CUSUM Severity Analysis

29APR23:20:19

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

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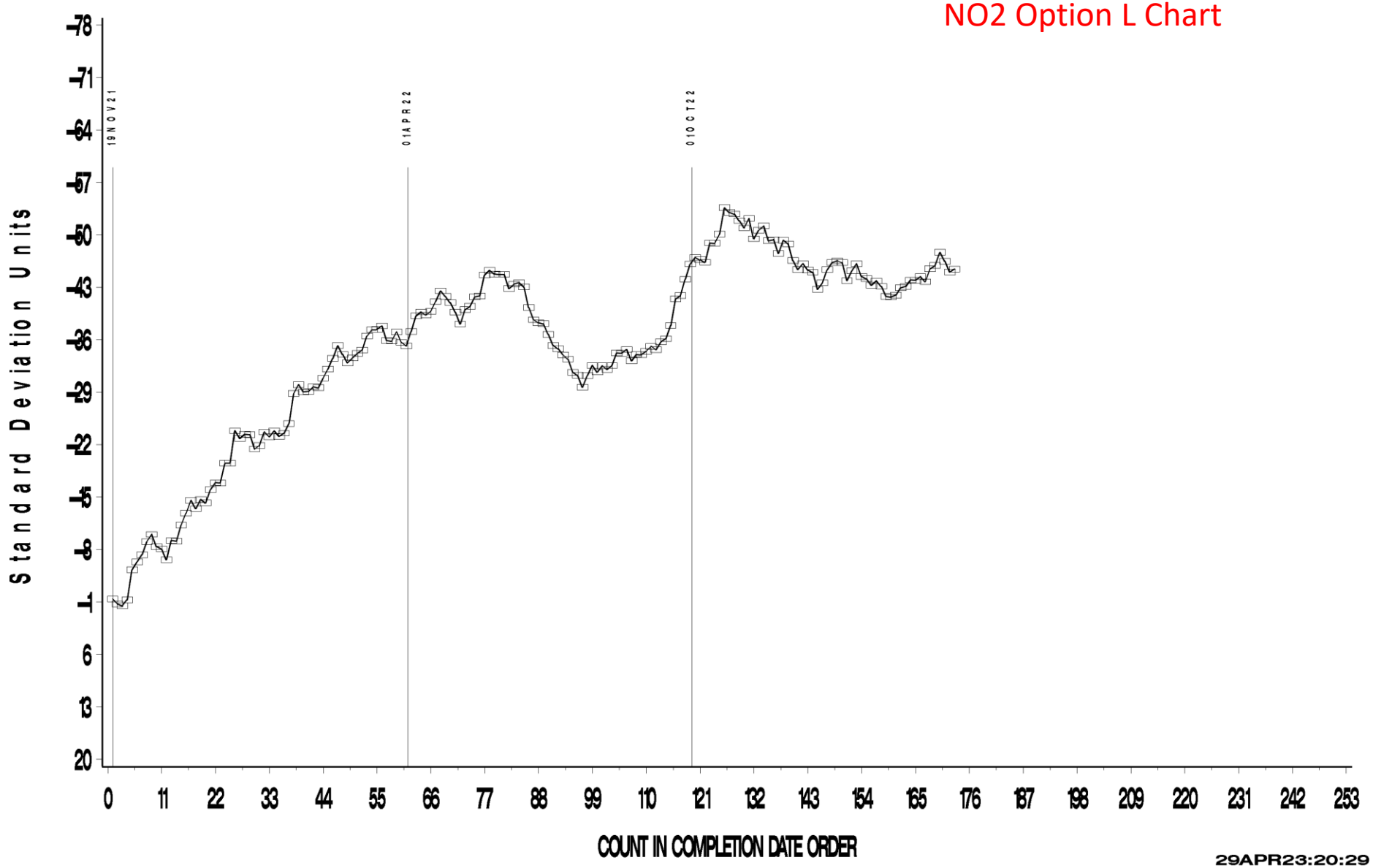
CUSUM Severity Analysis

NO2 Option L Chart



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

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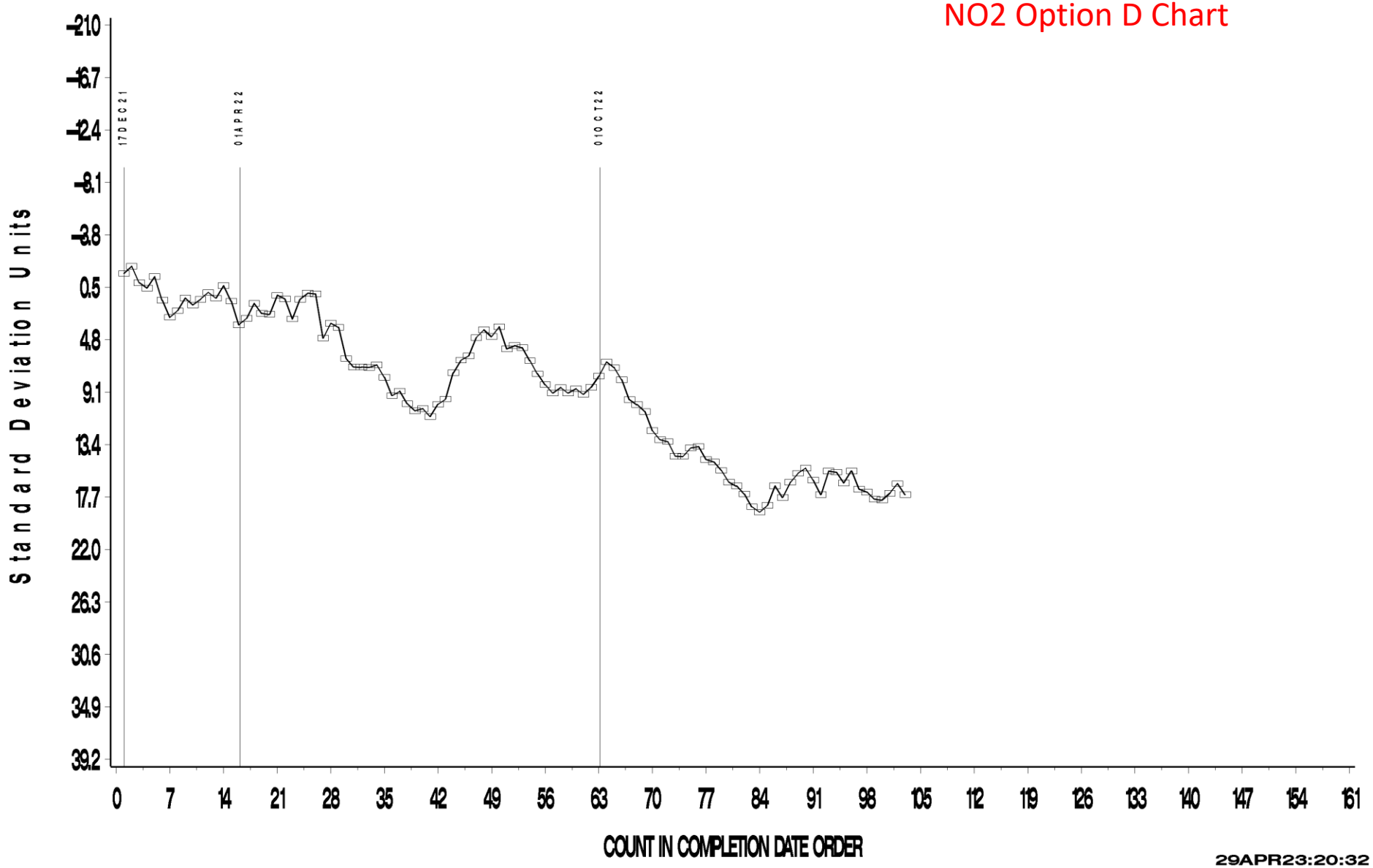
CUSUM Severity Analysis

NO2 Option D Chart



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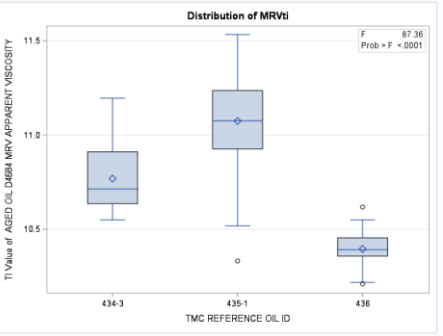
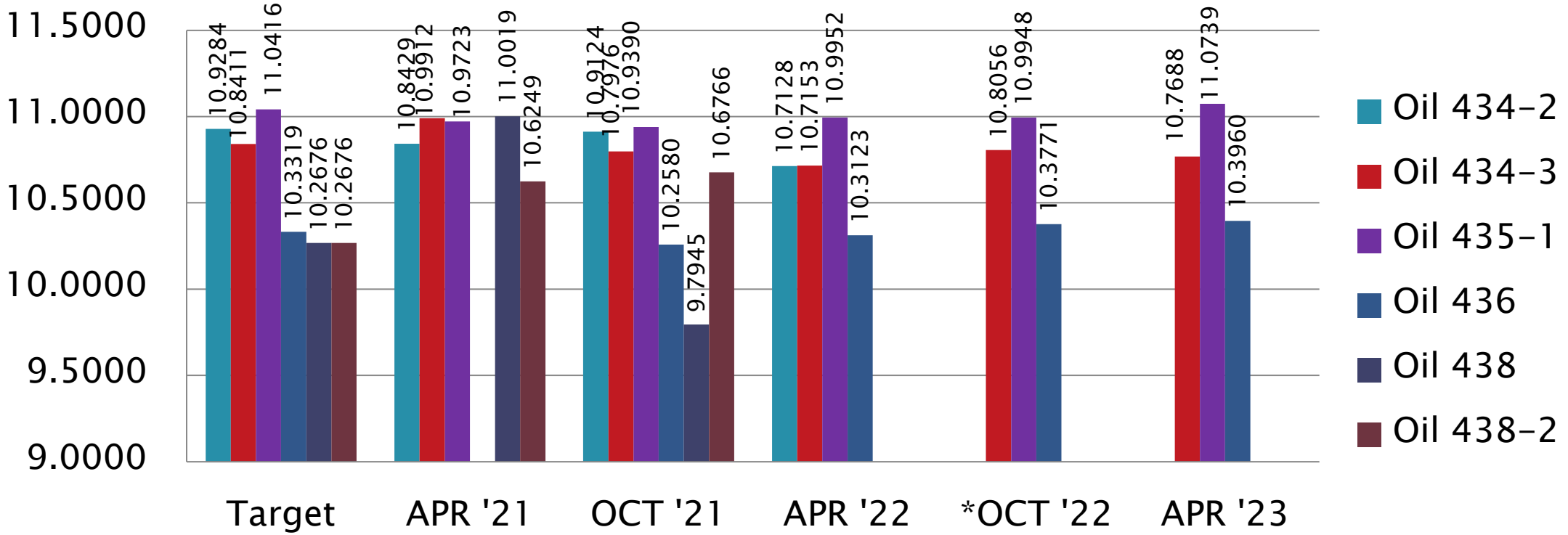
D7528: Oxidation by ROBO



Natural Log (MRV Viscosity)

Mean



* SINGLE OIL 434-2 RUN NOT INCLUDED IN THIS ANALYSIS

October 1, 2022 – March 31, 2023

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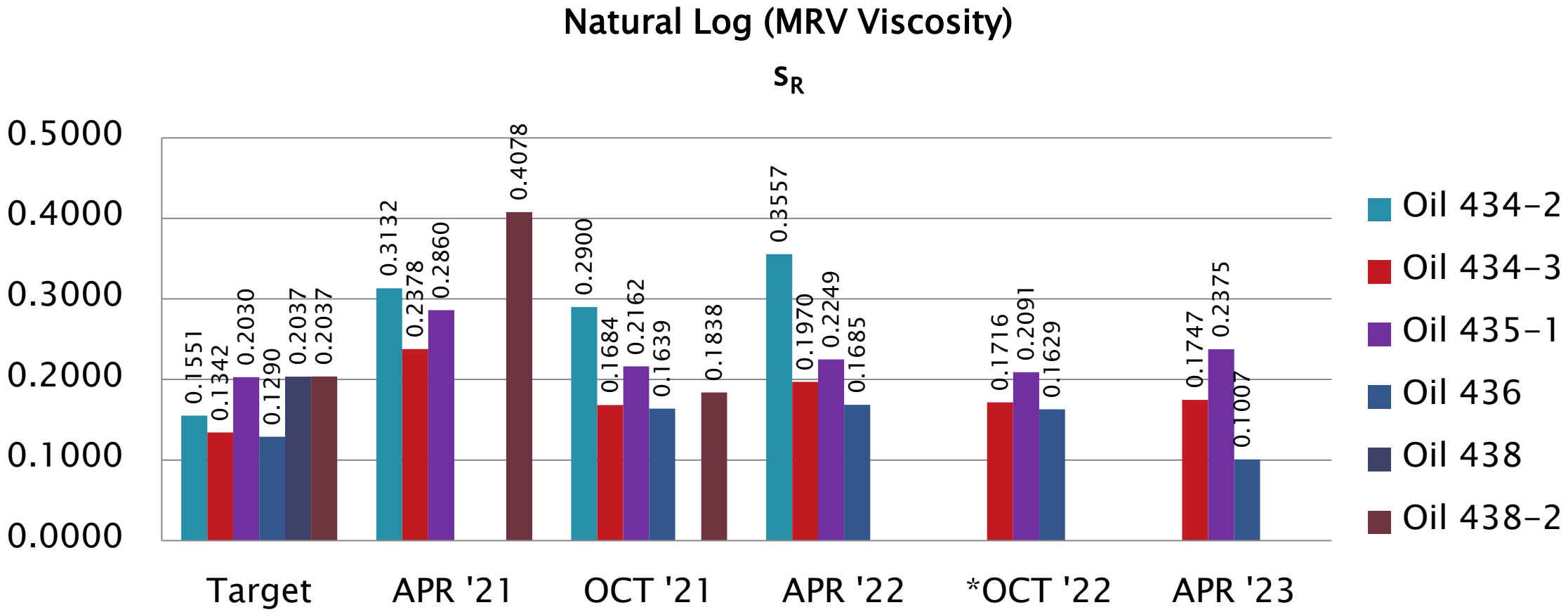
D7528: Oxidation by ROBO



* SINGLE OIL 434-2 RUN NOT INCLUDED IN THIS ANALYSIS

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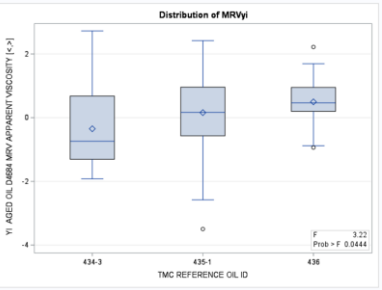
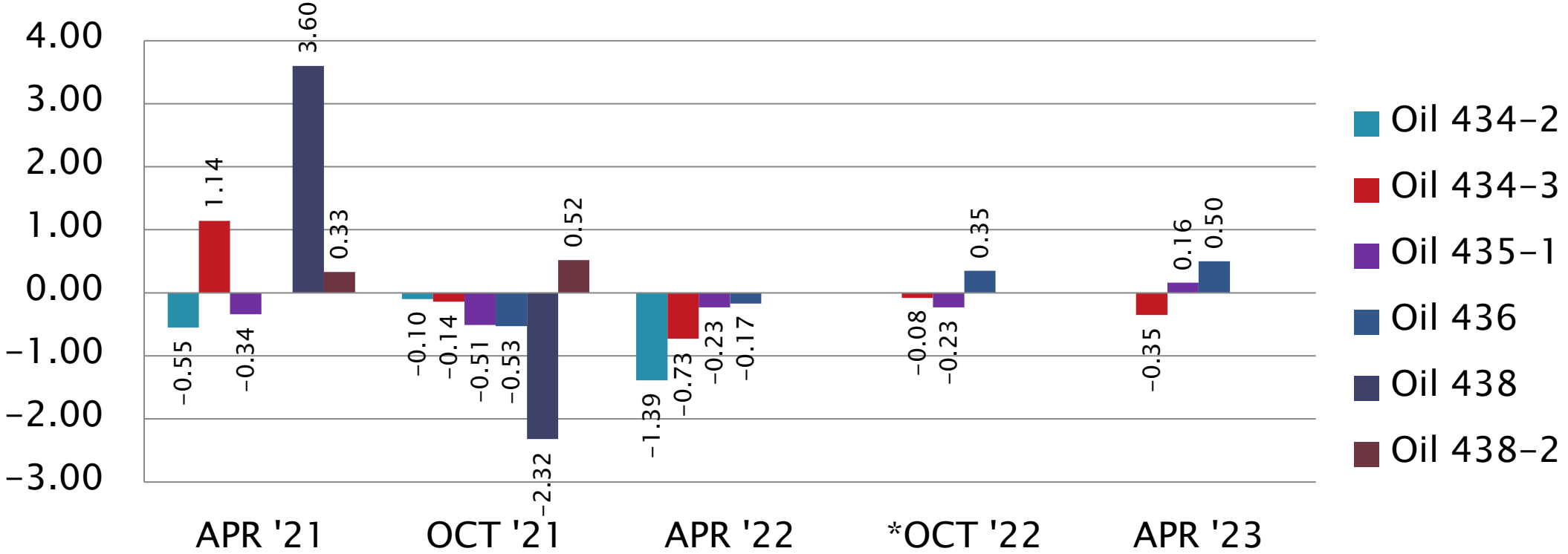
D7528: Oxidation by ROBO



Natural Log (MRV Viscosity)

Mean Δ/s



* SINGLE OIL 434-2 RUN NOT INCLUDED IN THIS ANALYSIS

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Reference Oil Inventory

As of 3/31/2023

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Reference Oil Inventory

D5800

Oil	Year Rec'd By TMC[A]	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
VOLC12	2013	D5800	23.2	1.4	5+ years
VOLD12	2013	D5800	21.3	3.9	5+ years
VOLE12	2013	D5800	19.2	3.6	5+ years
VOLD18	2018	D5800QC	706	126	5+ years

[A] The integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

Reference Oil Inventory

D6417, GI

Oil	Year Rec'd By TMC[A]	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
52	1995	D6417	59.4	0.02	5+ years
55	1995	D6417	65.9	0.03	5+ years
58	1998	D6417, D6417QC, GI	111.0	0.3	5+ years
GIA17	2017	GI	6.2	0.1	5+ years
GIC18	2018	GI	8.7	0.5	5+ years
1009	2002	GI	35.6	0.1	5+ years

[A] The integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

Reference Oil Inventory

TEOST, MTEOS & ROBO

Oil	Year Rec'd By TMC[A]	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
432	1998	MTEOS	101.9	0.1	5+ years
75-1	2016	TEOST	2.6	0.6	1.5 years
435-2[B]	2010	TEOST	34.6	0.8	5+ years
434-3[B]	2017	25.0	28.3	3.3	5+ years
435-1	2008	ROBO	339.3	7.2	5+ years
436[B]	2014	ROBO	38.8	1.1	5+ years

[A]The 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.

Reference Oil Inventory

D6082 & D874

Oil	Year Rec'd By TMC[A]	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
FOAMB18	2018	D6082	78.3	1.9	5+ years
66	2002	D6082	71.9	1.5	5+ years
820-2	2001	D874	3.3	0.03	5+ years
90[B]	2005	D874/D874QC	6.9	2.0	2 years
91	2006	D874	3.10	0.03	5+ years

[A] The 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.

Reference Oil Inventory Estimated Life EOWT

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Lab Inventory (samples)	Estimated Life*
77-3	465.5	26.2	325	5+ years
79	240.2	26.3	327	3.7 years

*Based upon Sample Shipping Rate from past 6 months.

Reference Oil Inventory Estimated Life EOFT

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Lab Inventory (samples)	Estimated Life
79	240.2	31.4	128	2.5 years

Reference Oil Inventory Estimated Life EOEC/LDEOC

Oil	TMC Inventory Gallons	Gallons Shipped Past 12 Months	Estimated Life
SL107[A, B]	2174	198	3.7 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

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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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