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

## D6417, D5133 (GI), D5800, D6335 (TEOST), D7097(MTEOS), D6082, D874 and D7528 (ROBO)

October 2022

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# B0.07 Bench Testing Executive Summary

- D5133 (Gelation Index)
  - Zero operationally invalid tests this period compared to 17 tests in the previous period.
- D6335 (TEOST)
  - TMC Memorandum 21-044, updating targets for reference oil 75-1 was issued 11/3/2021
  - Fail rate for TEOST doubled with respect to previous six-month period.

# B0.07 Bench Testing Executive Summary

- D6082 (High Temperature Foam) and D874 (Sulfated Ash)
  - For the second consecutive 6-month period, there were no tests which failed to meet acceptance criteria for both these test types.
- D7528 (ROBO)
  - Long term (very linear) mild severity trend, as evidenced in the Cusum plot, may indicate that targets may not be correct.
  - Information letter 21-01, allowing an option to use dilute nitrogen dioxide in air was issued 11/3/21
- D5800 (NOACK)
  - Slight leveling of CUSUM slope this period. Long-term severity trend (severe) in the CUSUM plots was a topic of discussion at the Surveillance Panel meeting in October. The panel decided that a target change wasn't appropriate and that the severe trend abating may be due to more D procedure rigs as well as a difference in lab/rig make up.

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# Calibrated Labs and Stands*

(change shown in parentheses)

| Test | Labs | Stands |
|---|---|---|
| D6417 | 7 (0) | 9 (0) |
| D5800 | 10 (+1) | 25 (+4) |
| D5133 (GI) | 8 (+3) | 49 (+4) |
| D6335 (TEOST) | 8 (0) | 13 (+1) |
| D7097 (MTEOS) | 8 (0) | 40 (+3) |
| D6082 | 6 (+2) | 7 (+2) |
| D874 | 4 (+1) | -- |
| D7528 (ROBO) | 7 (+1) | 9 (–18) |

*As of
9/30/2022

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# D02.B0.07
# TMC Monitored Tests

## ASTM D 6417

April 1, 2022 – September 30, 2022

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# D6417: Estimation of Engine Oil Volatility by Capillary GC

| Test Status | Validity Code | No. Tests |
|---|---|---|
| Acceptable Calibration Test | AC | 18 |
| Failed Calibration Test | OC | 1 |
| **Total** | | **19** |

Number of Labs Reporting Data: 7
Fail Rate of Operationally Valid Tests: 5%

# D6417: Estimation of Engine Oil Volatility by Capillary GC

| Statistically Unacceptable Tests (OC) | No. Of Tests |
|---|---|
| Volatility Loss Mild | 1 |
| Volatility Loss Severe | 0 |

- There were no operationally invalid tests reported this period

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

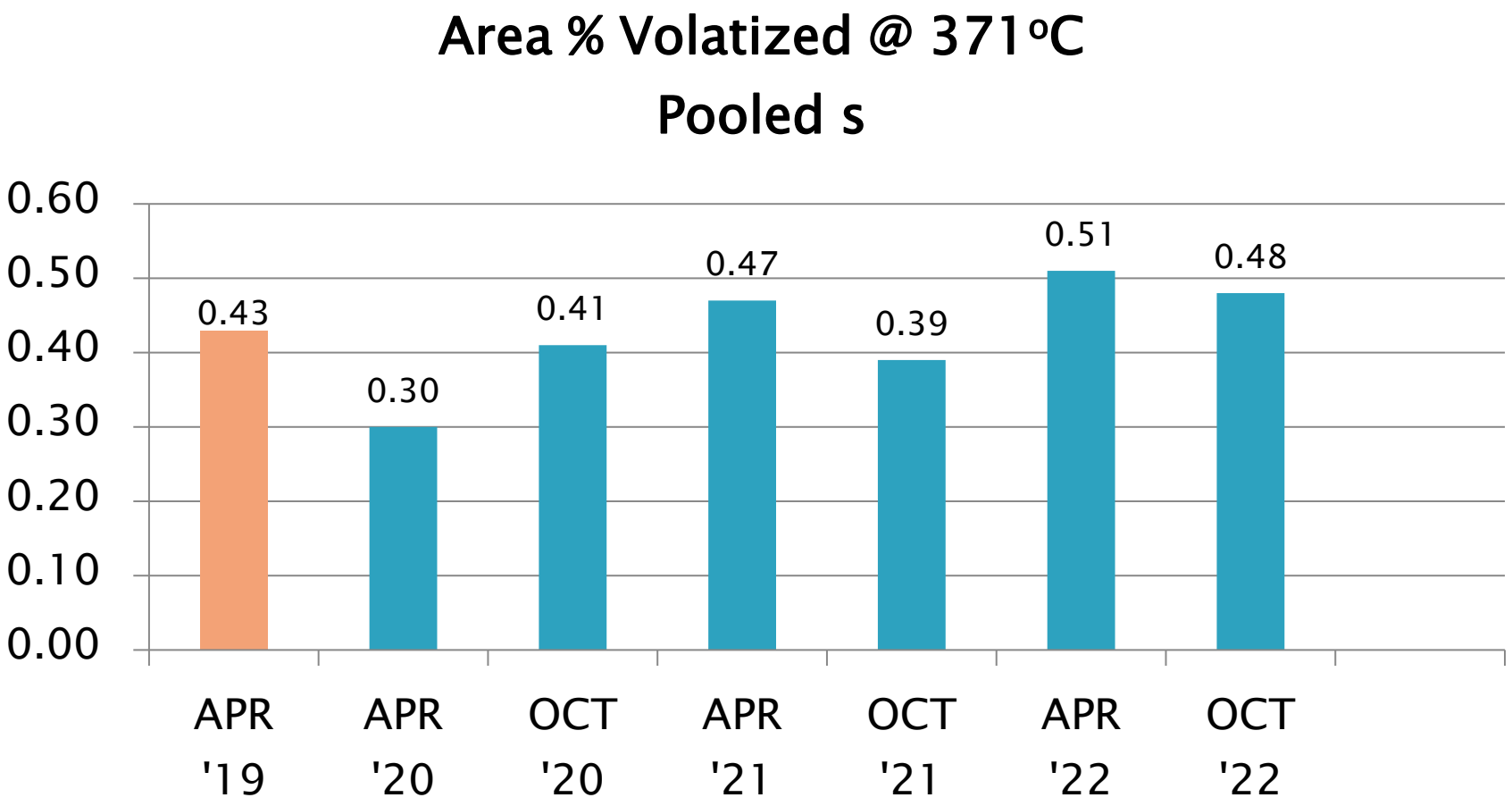
# D6417: Estimation of Engine Oil Volatility by Capillary GC

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*<br>4/1/20 through 9/30/20* | 16<br>14 | 13<br>11 | 0.41<br>0.31 | -0.34<br>0.01 |
| 10/1/20 through 3/31/21*<br>10/1/20 through 3/31/21* | 21<br>19 | 18<br>16 | 0.47<br>0.37 | -0.81<br>-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 |

*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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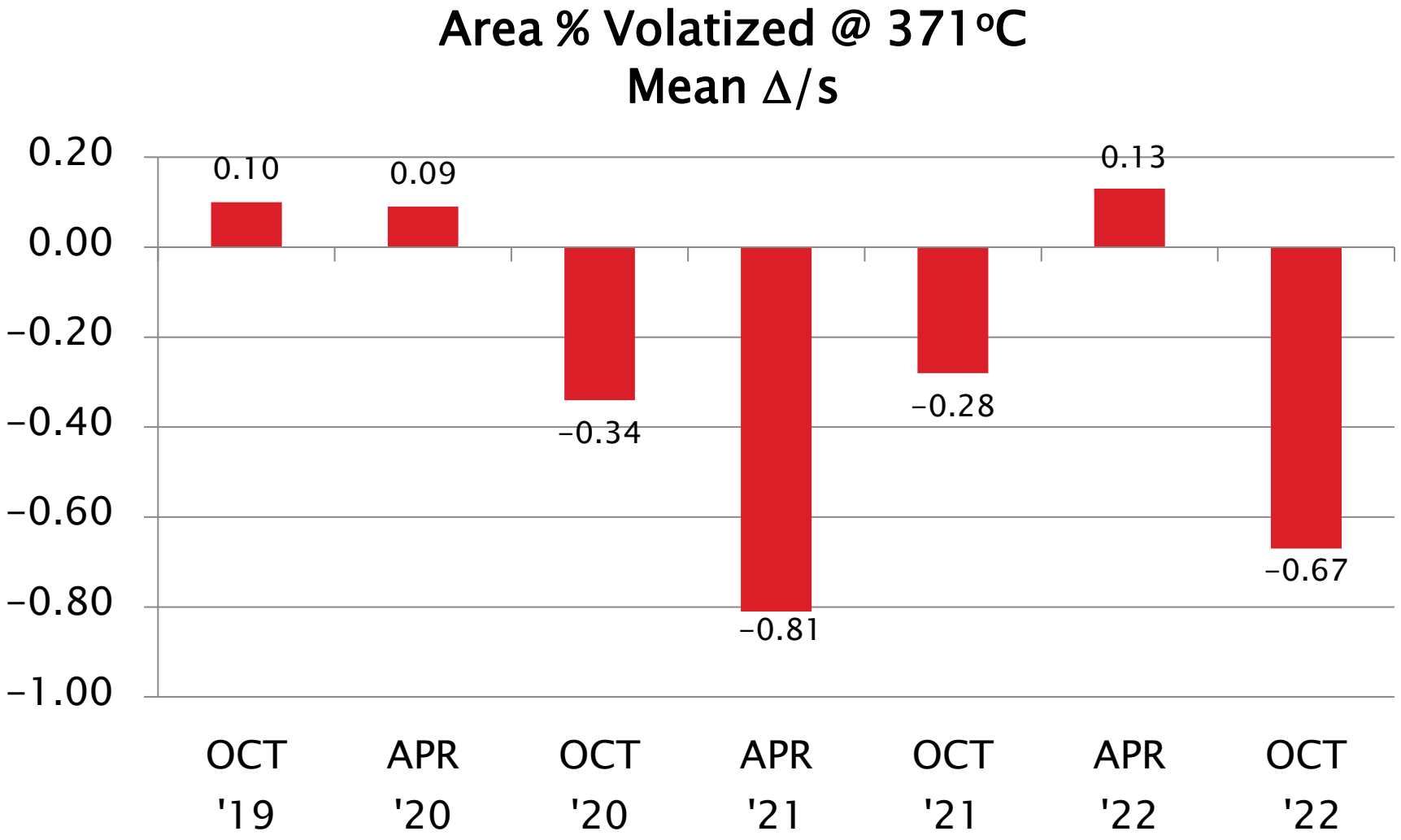
# D6417 Severity Estimates

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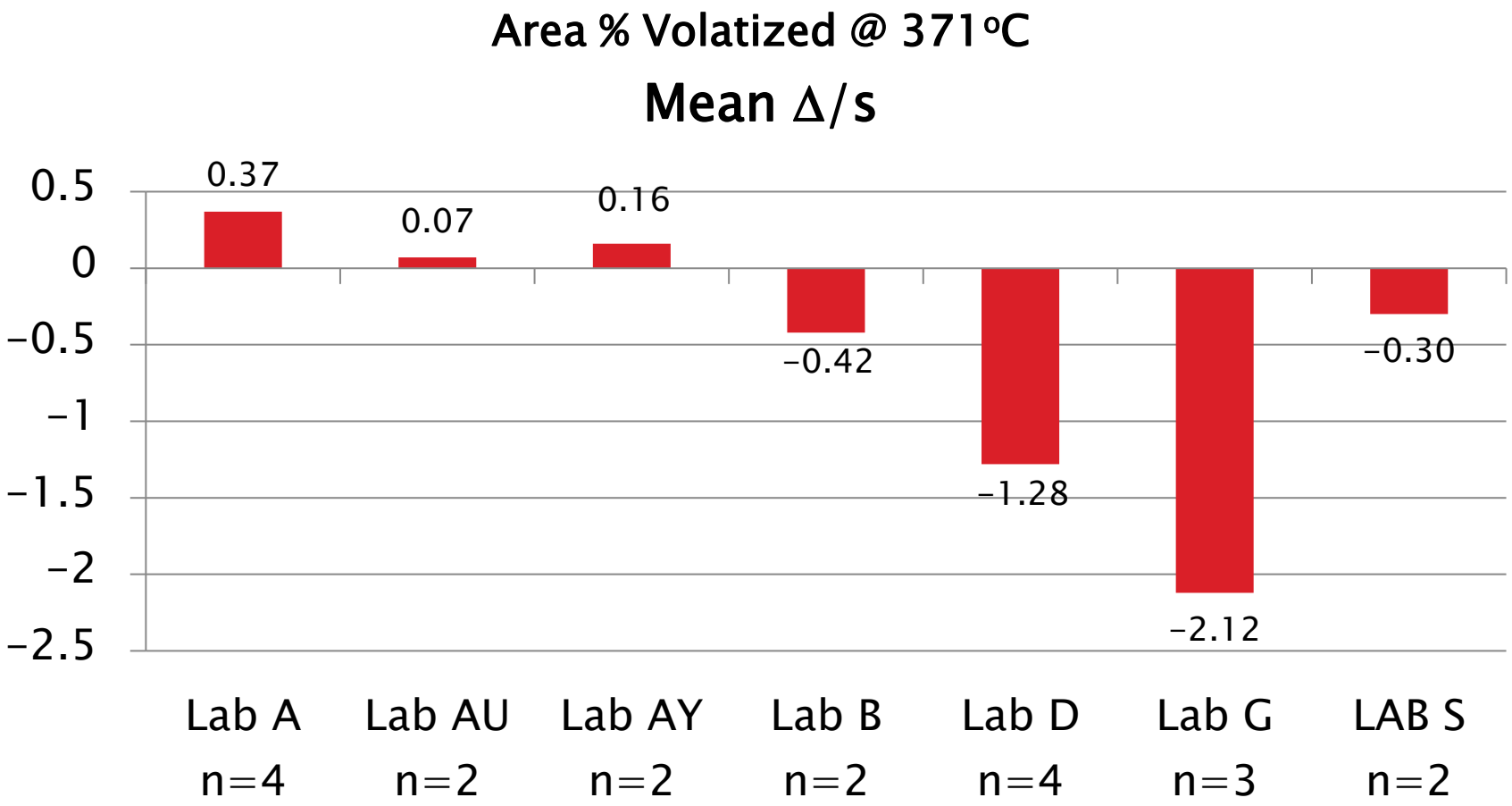
# D6417 Lab Severity Estimates

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# D6417: Estimation of Engine Oil Volatility by Capillary GC

- Precision (Pooled s) has slightly improved this period relative to previous period and historical rates.
- Performance (Mean Δ/s) has fallen to -0.67 s, mild and further from target compared to prior reporting period.
- CUSUM severity plot trending mild.

# D6417 VOLATILITY BY GC INDUSTRY OPERATIONALLY VALID DATA

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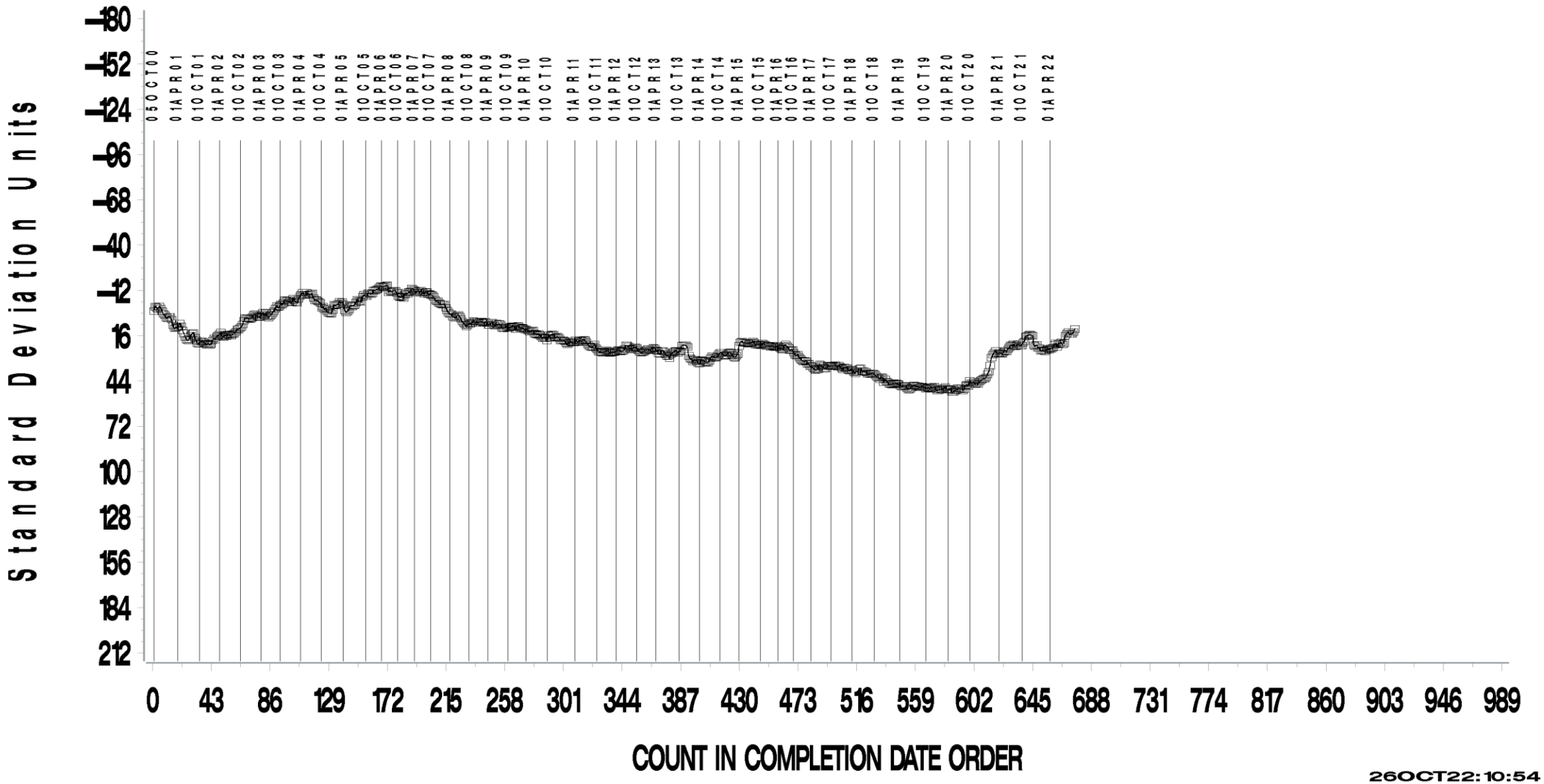
## SAMPLE AREA % VOLATIZED

CUSUM Severity Analysis

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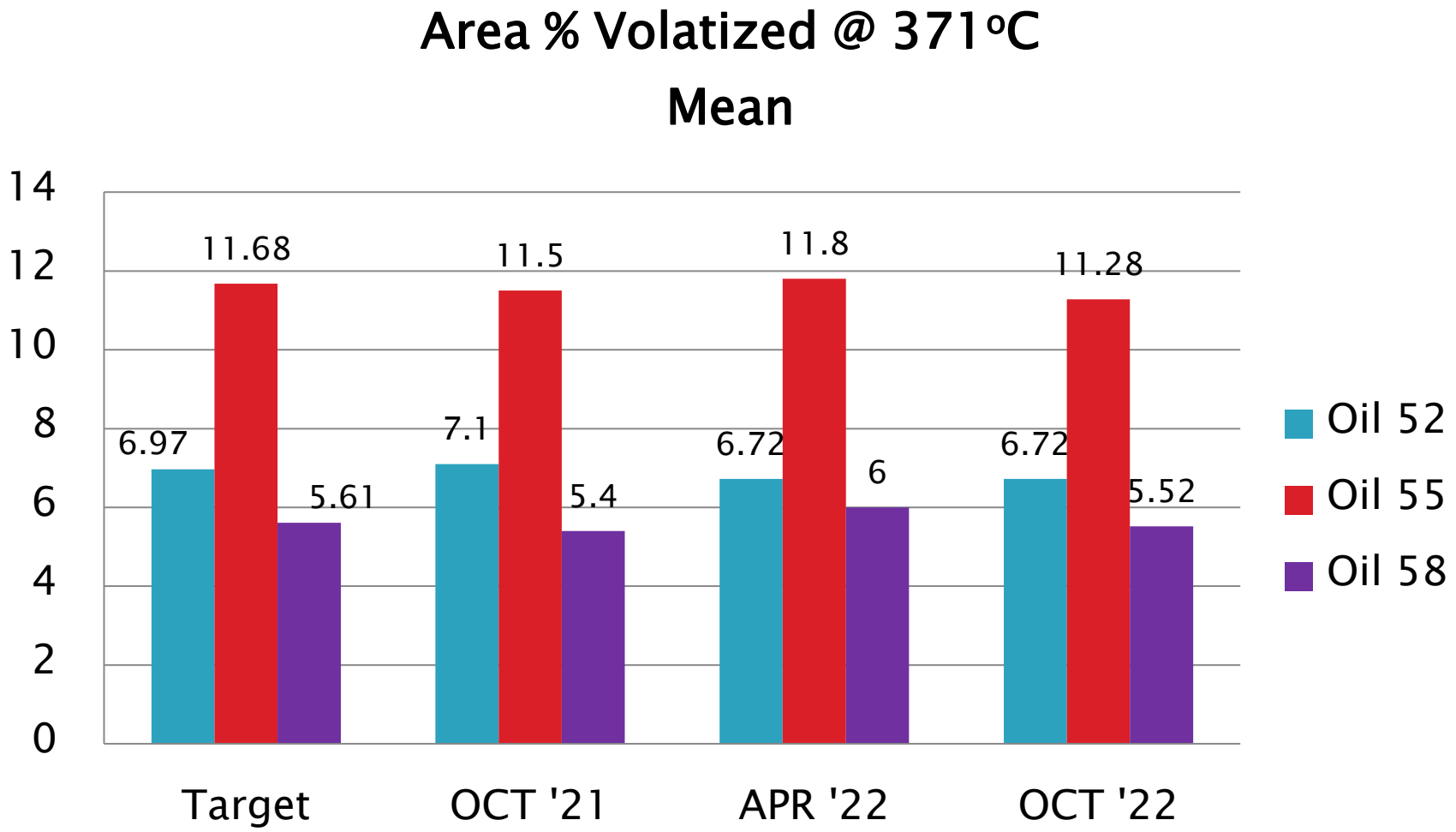
# D6417 Performance by Oil

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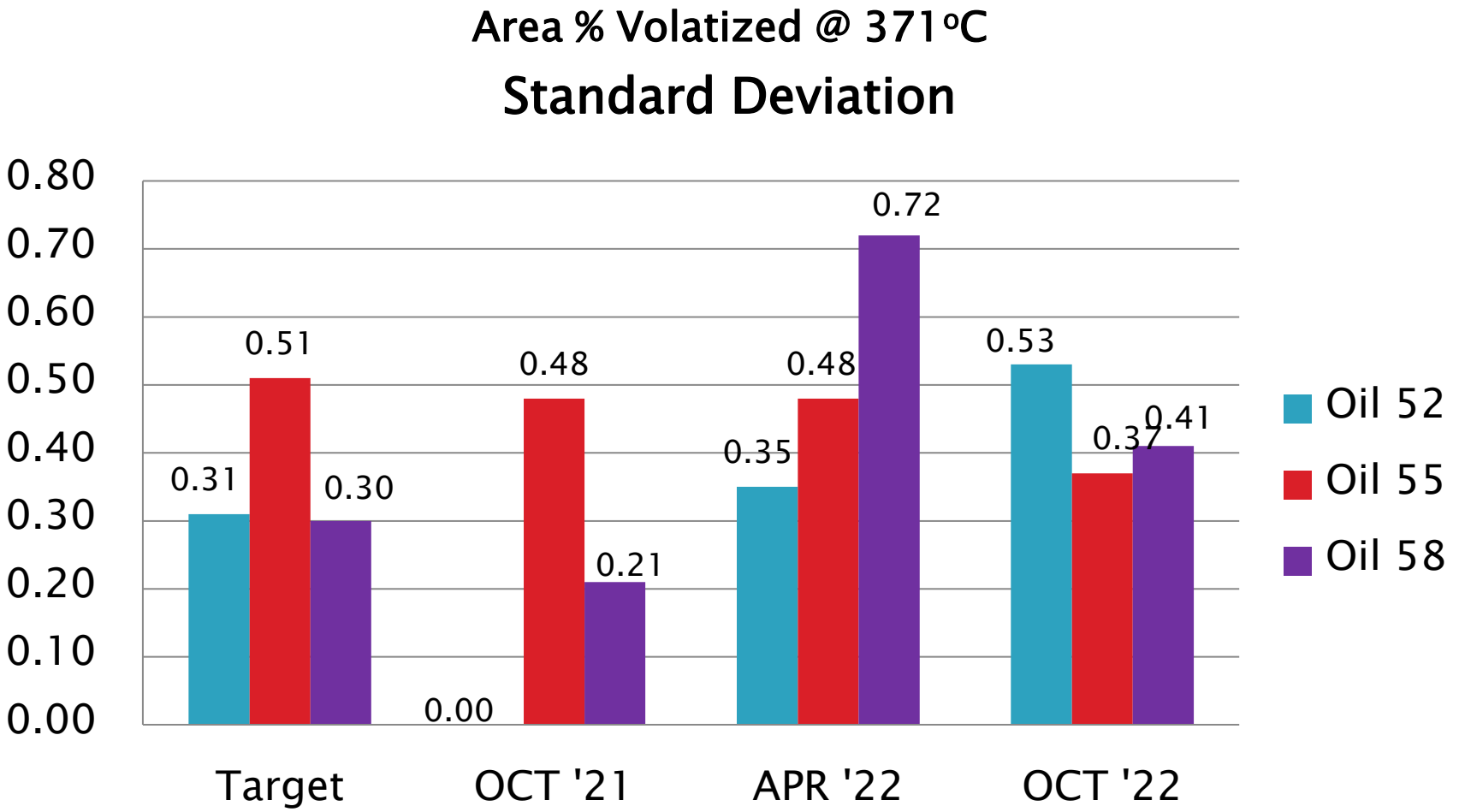
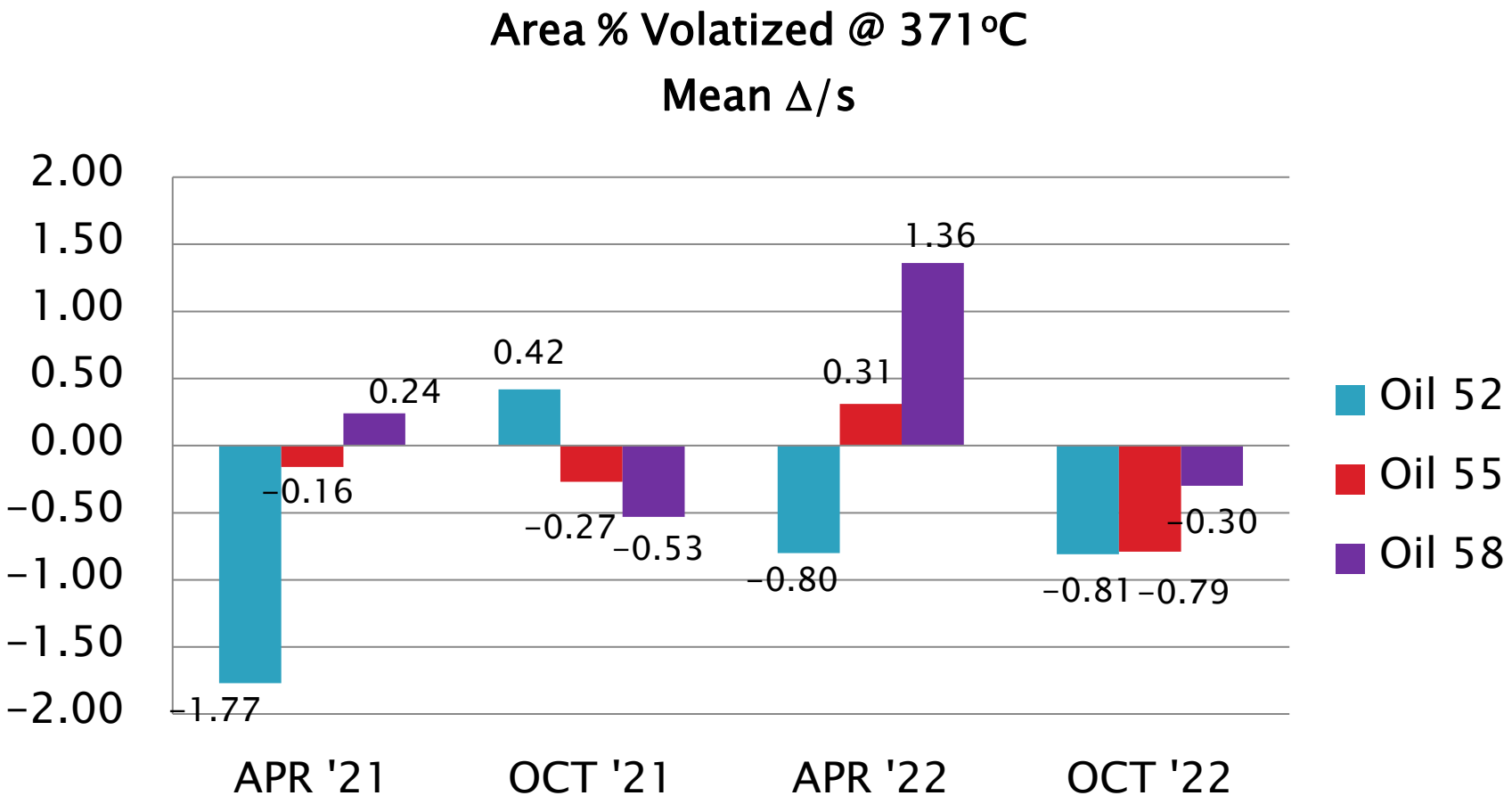
# D6417 Performance by Oil



# D6417 Performance by Oil

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# D02.B0.07
# TMC Monitored Tests

## ASTM D 5800

April 1, 2022 – September 30, 2022

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# D5800: Evaporation Loss of Lubricating Oil by Noack Method

| Test Status | Validity Code | No. Tests |
|---|---|---|
| Acceptable Calibration Test | AC | 132 |
| Failed Calibration Test | OC | 4 |
| Operationally Invalidated by Lab | LC | 2 |
| **Total** | | **138** |

Number of Labs Reporting Data: 9
Fail Rate of Operationally Valid Tests: 3%

# D5800: Evaporation Loss of Lubricating Oil by Noack Method

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

- The 4 OC tests were on four different rigs at 4 labs..
- No operationally valid tests exceed ±3 s this period.

# D5800: Evaporation Loss of Lubricating Oil by Noack Method

- Two operationally invalid calibration runs were reported this period:
  - One test was invalid due to failed QC result performed on the day of calibration (LC)
  - One test where the test sample was run at an incorrect temperature. (LC)

- 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 | 135 | 133 | 0.0469 | -0.10 |

[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: Evaporation Loss of Lubricating Oil by Noack Method

## Performance Comparison by Procedure & Model

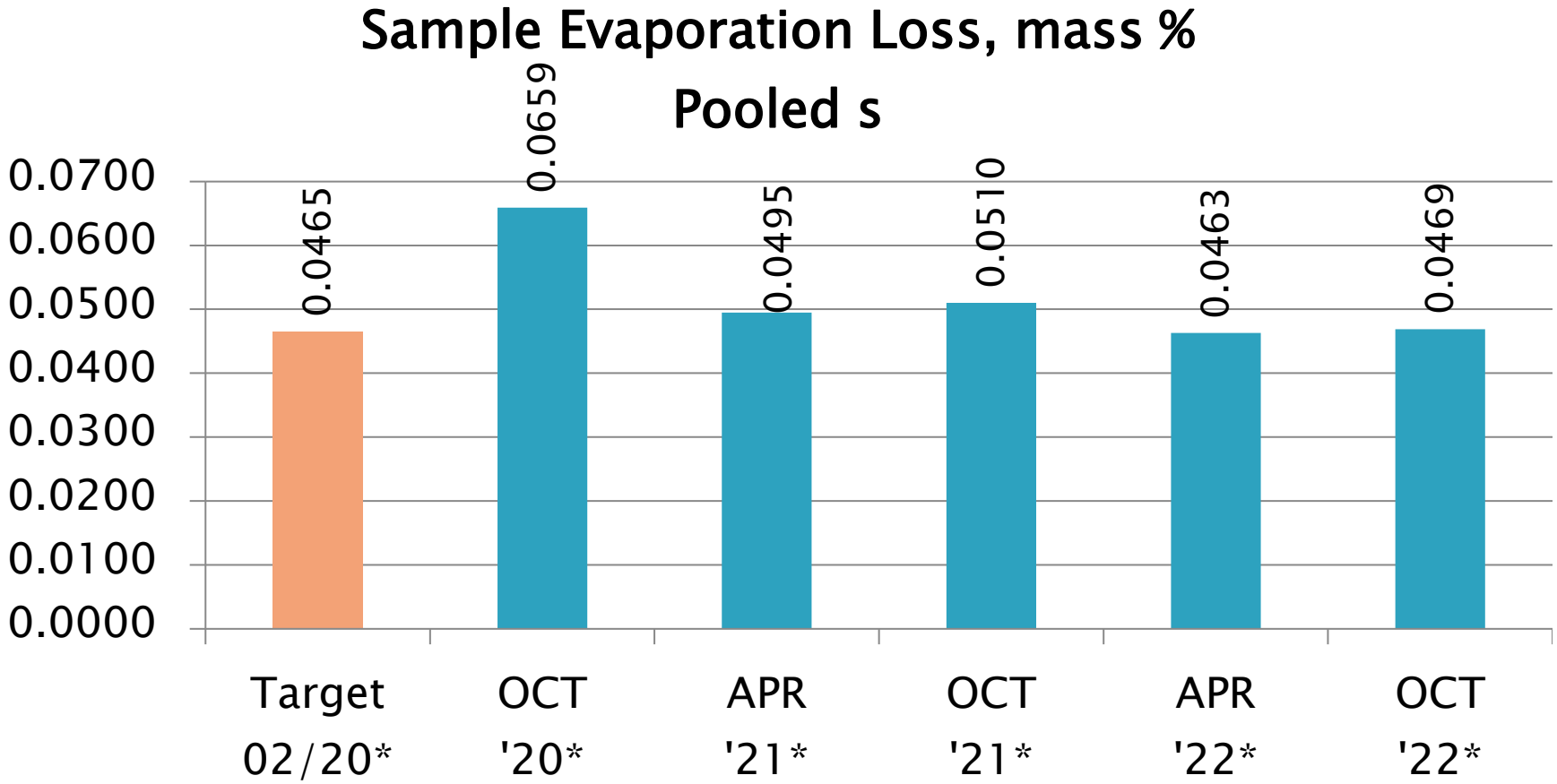
### Sample Evaporation Loss, Mass %

| Procedure | n | df | Pooled s | Mean Δ/s |
|---|---|---|---|---|
| Procedure B | 82 | 79 | 0.0414 | 0.17 |
| Procedure C | No Procedure C tests reported this period. | | | |
| Procedure D | 54 | 51 | 0.0411 | -0.50 |

| Model | n | df | Pooled s | Mean Δ/s |
|---|---|---|---|---|
| NCK2 | 5 | 2 | 0.0085 | 0.26 |
| NCK25G | 77 | 74 | 0.0424 | 0.16 |
| NS2 | 54 | 51 | 0.0411 | -0.50 |

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

# 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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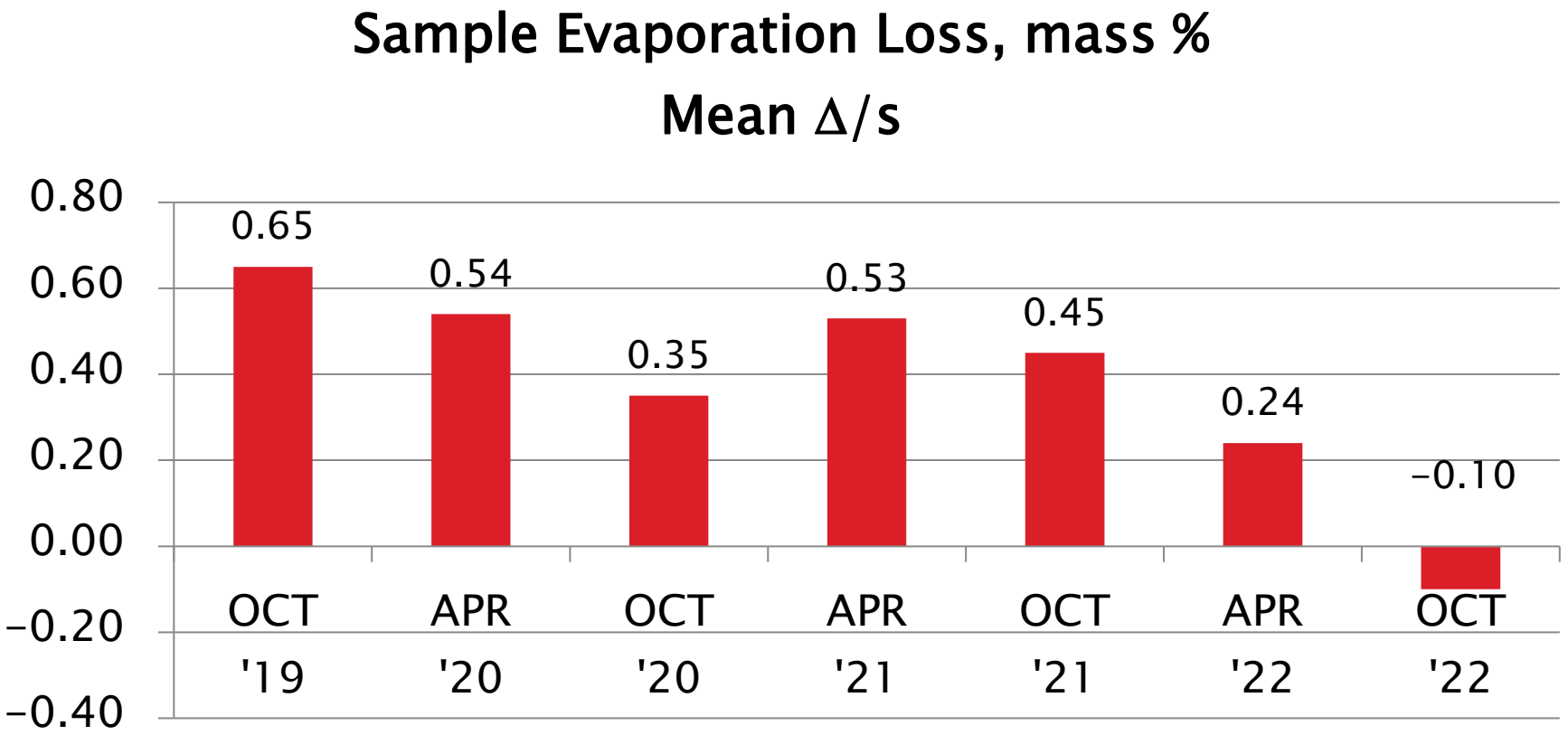
# D5800 Severity Estimates

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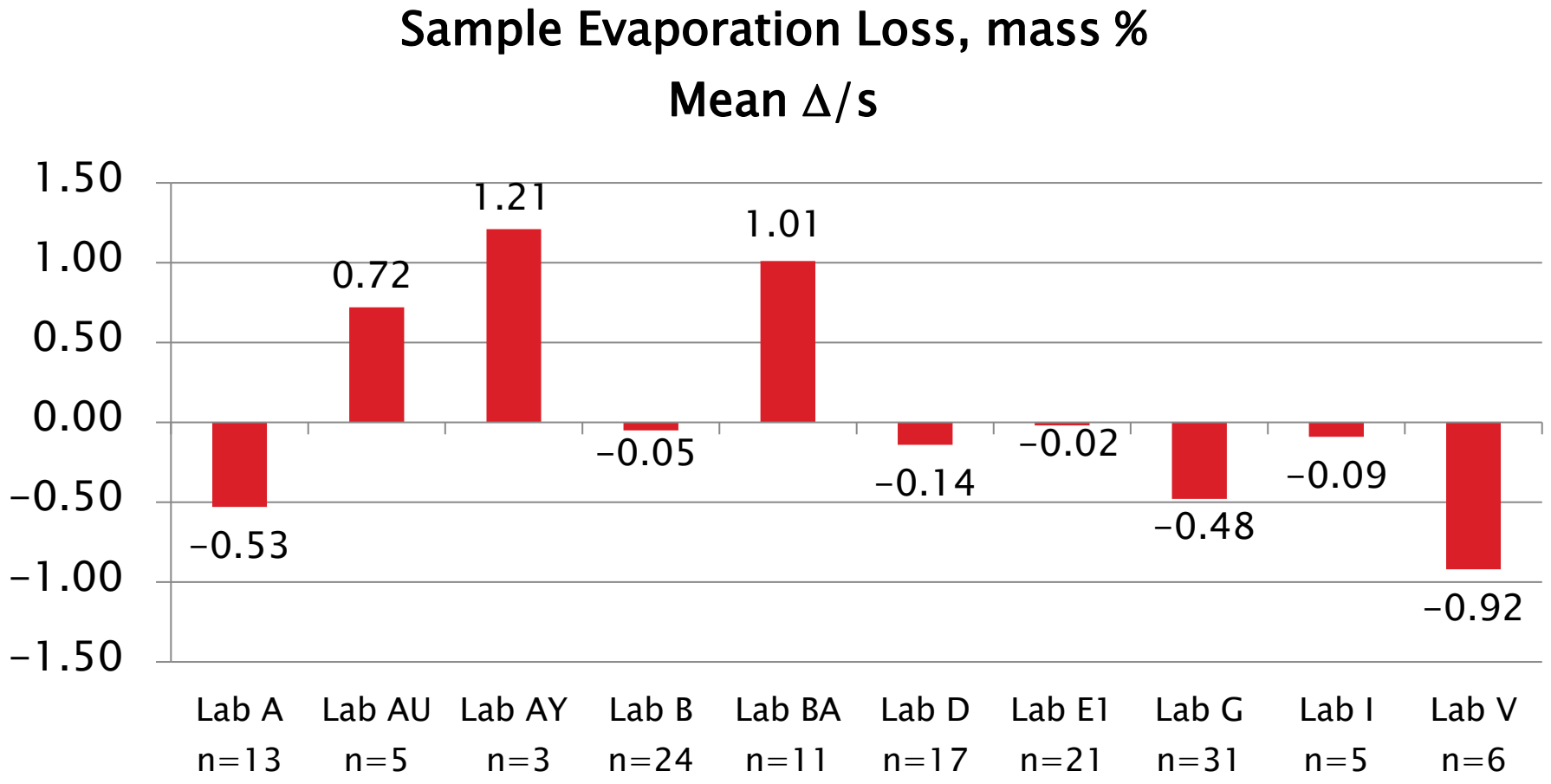
# D5800 Lab Severity Estimates



# D5800: Evaporation Loss of Lubricating Oil by Noack Method

- Precision (Pooled s) is comparable to target precision (in natural log transformed units).
  - Compares well to prior periods
- Performance (Mean Δ/s) is -0.10 s mild.
  - Procedure B rigs are trending 0.17 s severe while Procedure D rigs are trending -0.50 s mild.
- CUSUM severity plots shows a return to near target performance Procedure D tests have been trending mild for the past few periods while the long-term severe trend with Procedure B tests has lessened. The industry EWMA Control chart is currently in control.

# D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

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## EVAPORATION LOSS, MASS%

CUSUM Severity Analysis


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# D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

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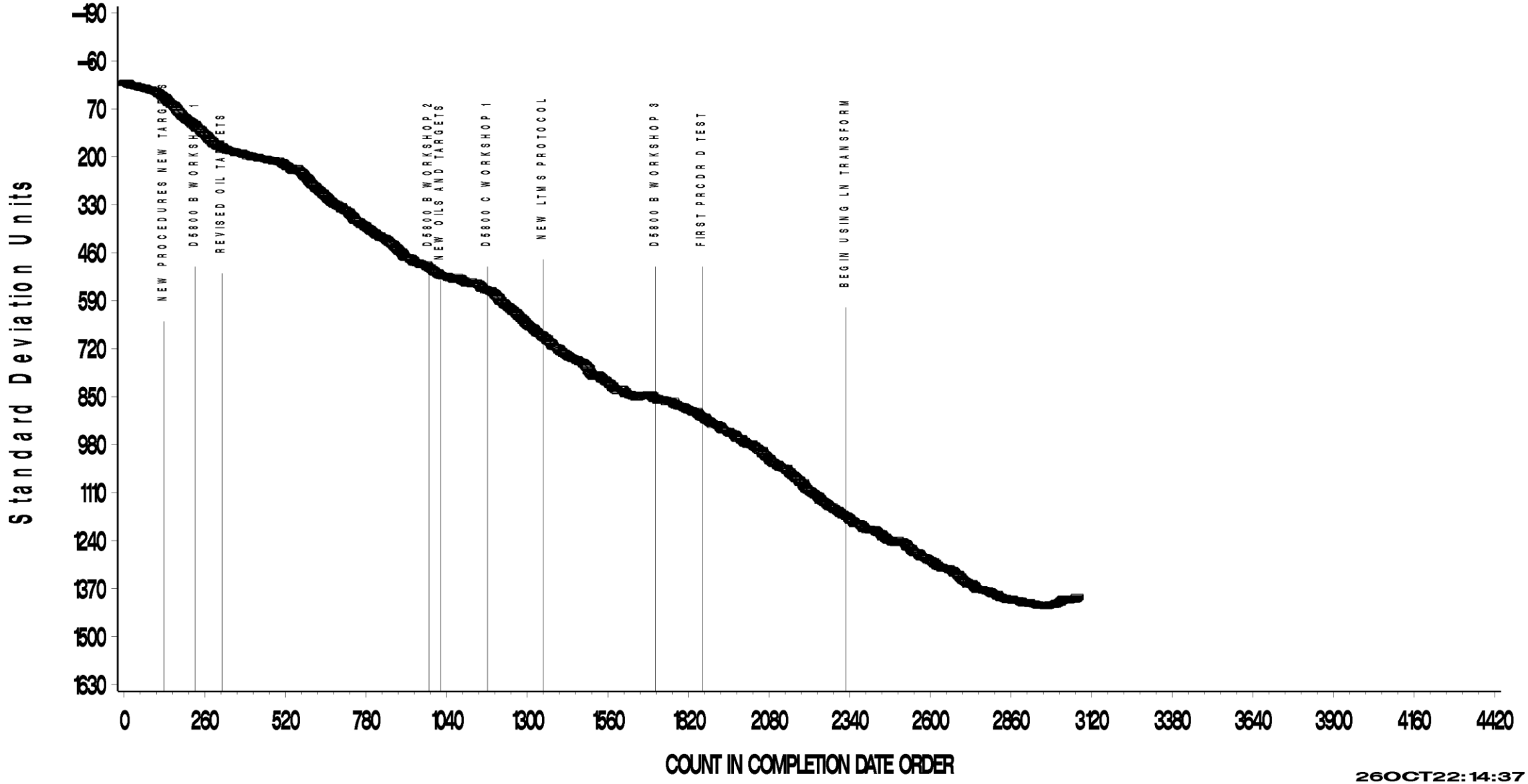
## EVAPORATION LOSS, MASS%

CUSUM Severity Analysis

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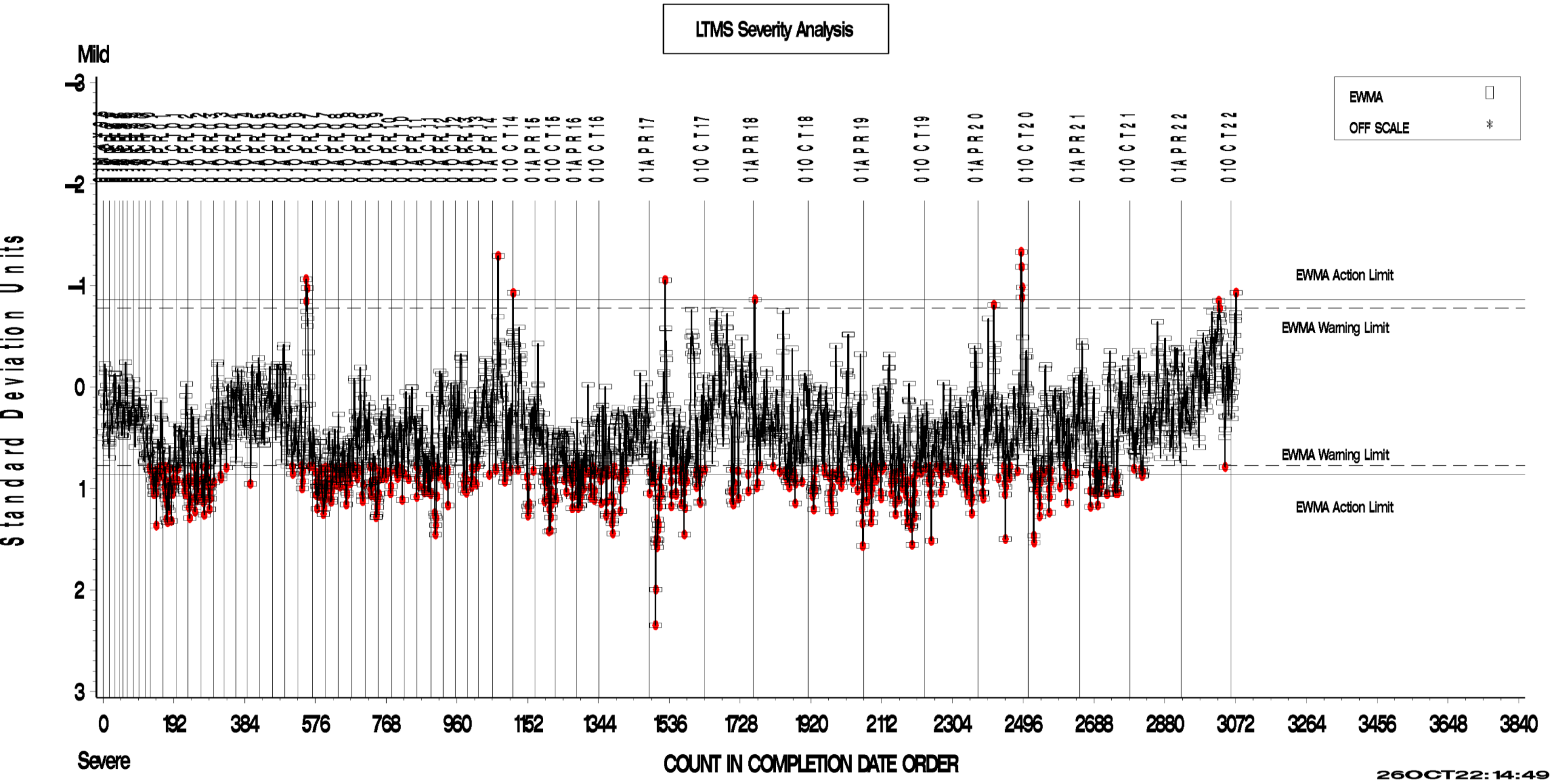
# D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

## EVAPORATION LOSS, MASS%

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# D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
## Procedure B
## EVAPORATION LOSS, MASS%

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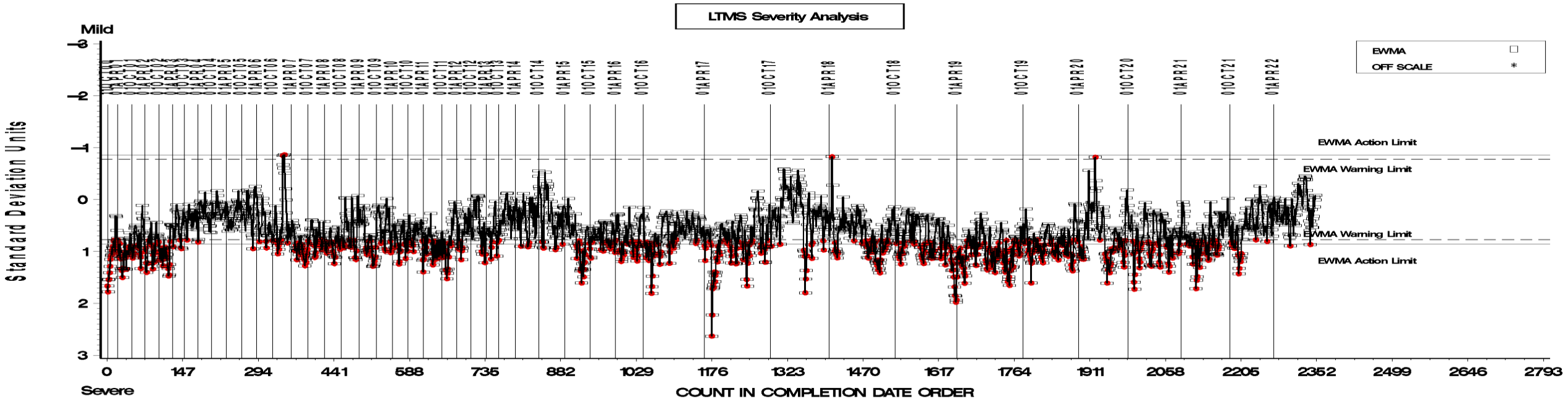


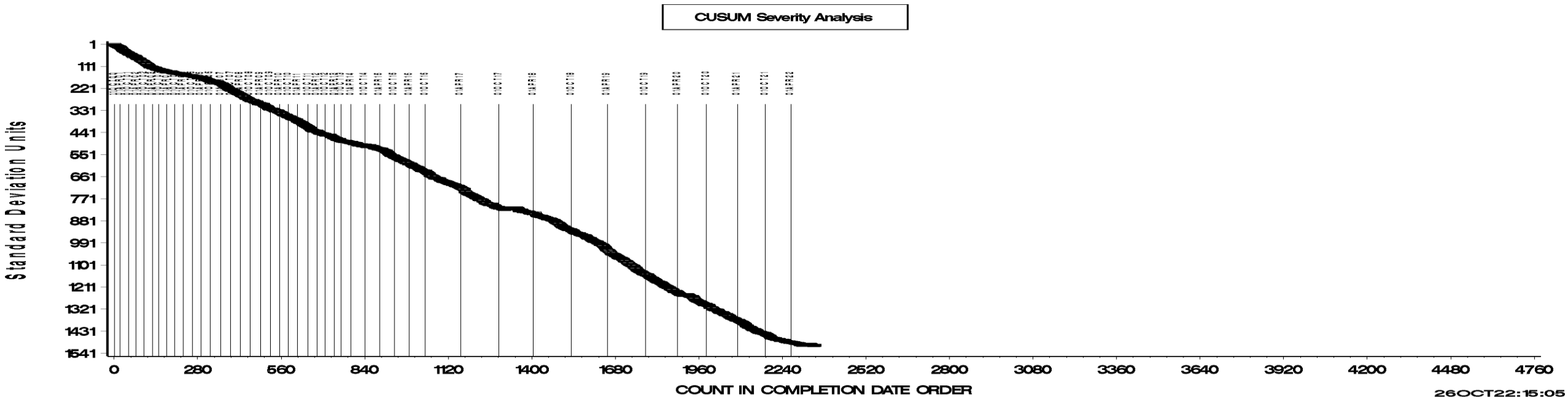

# D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
## Procedure D results only
## EVAPORATION LOSS, MASS%

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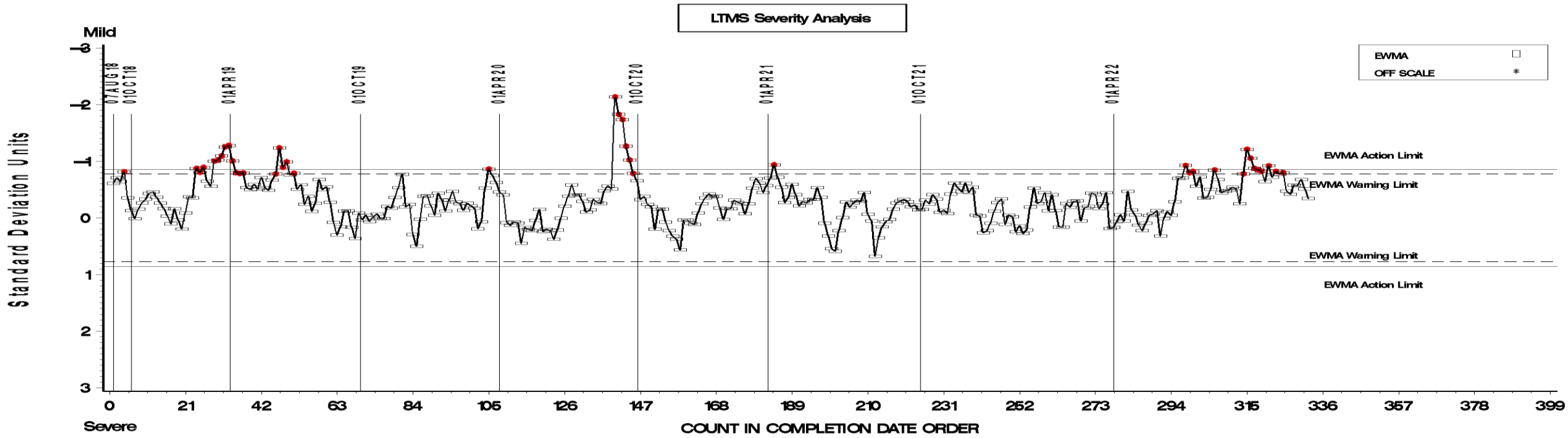
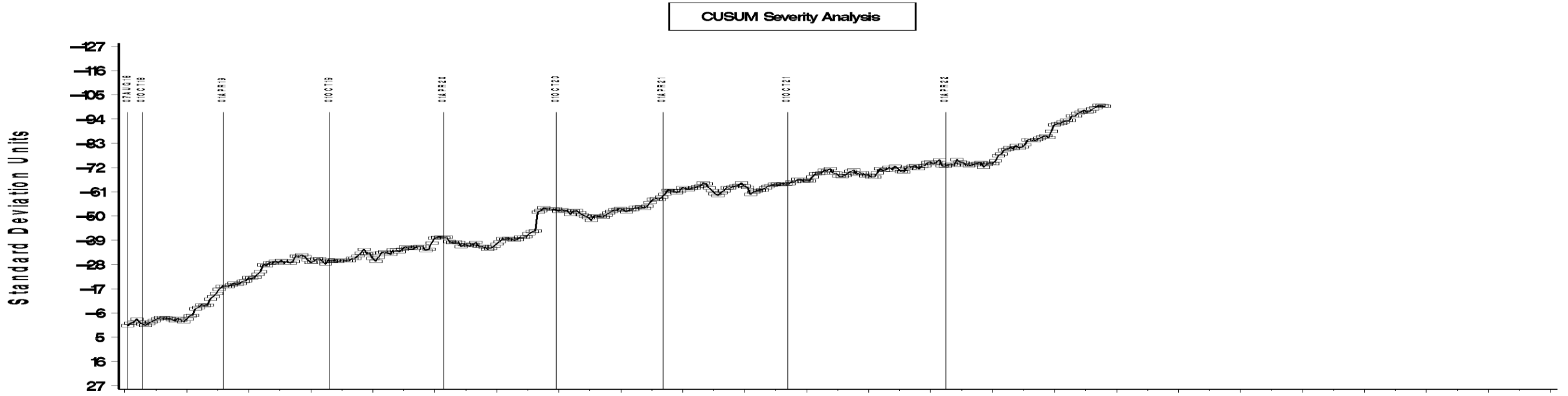
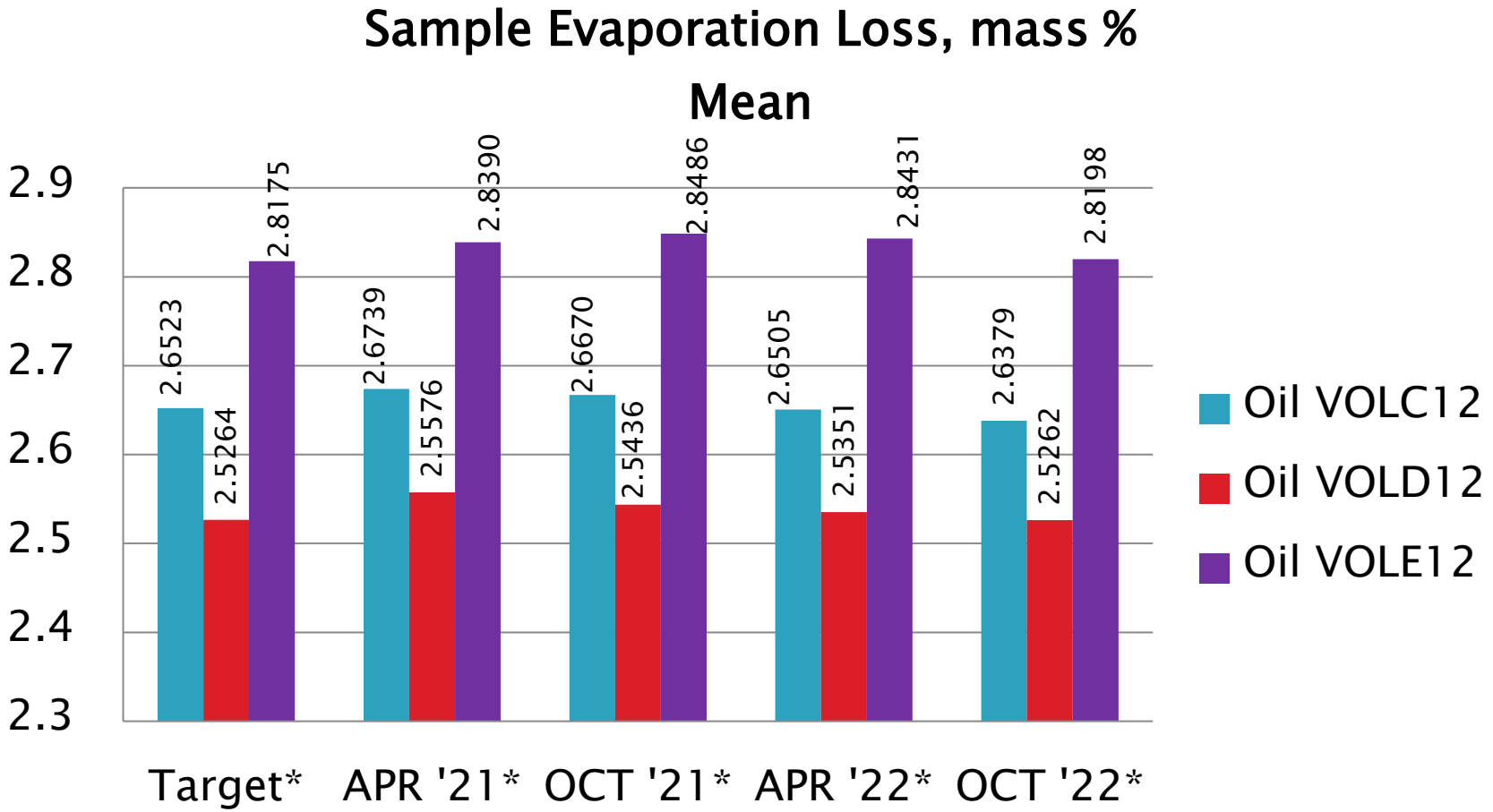


# D5800 Performance by Oil




*Results transformed to natural log per updated LTMS 20200207

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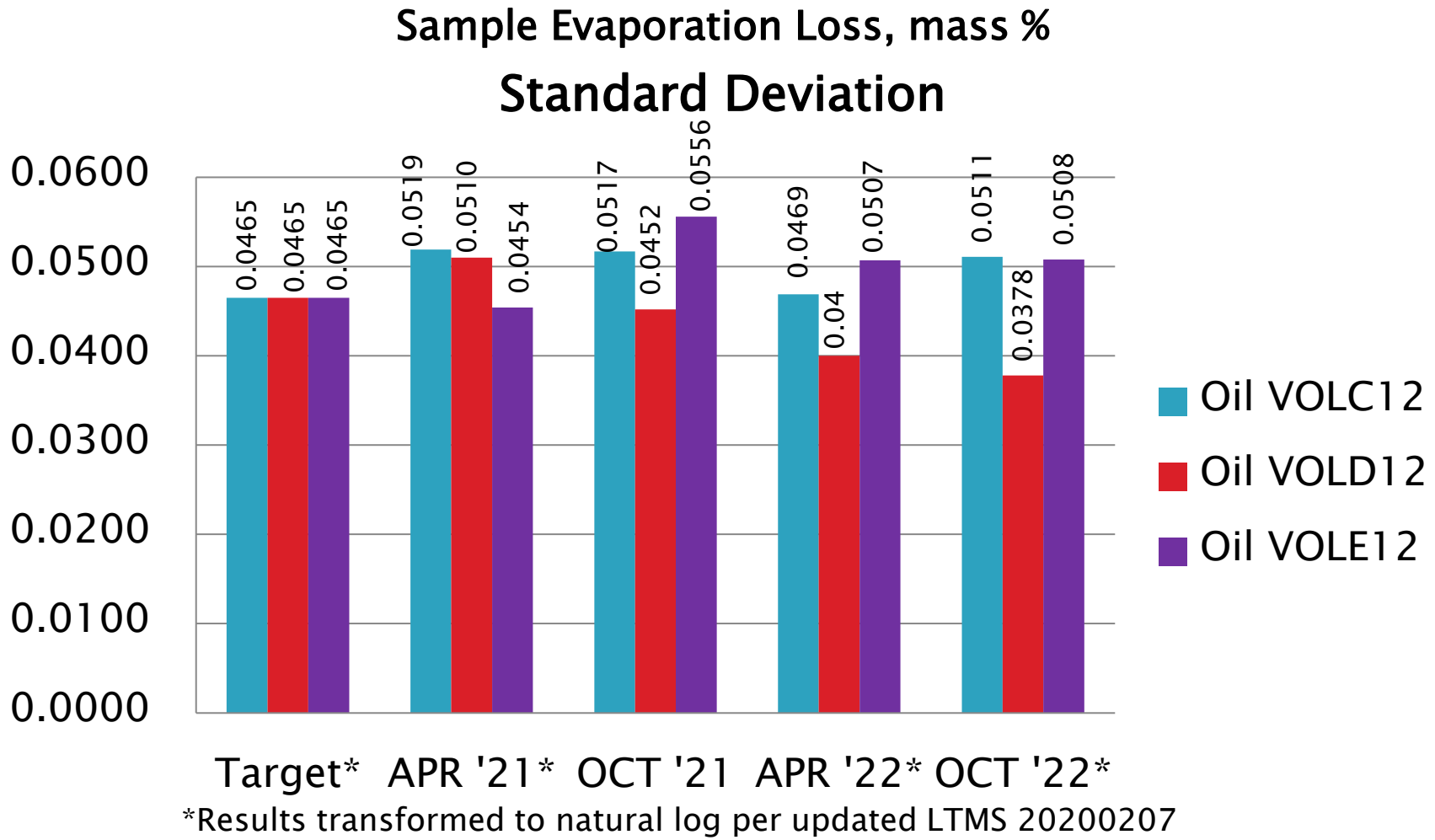
# D5800 Performance by Oil




*Results transformed to natural log per updated LTMS 20200207

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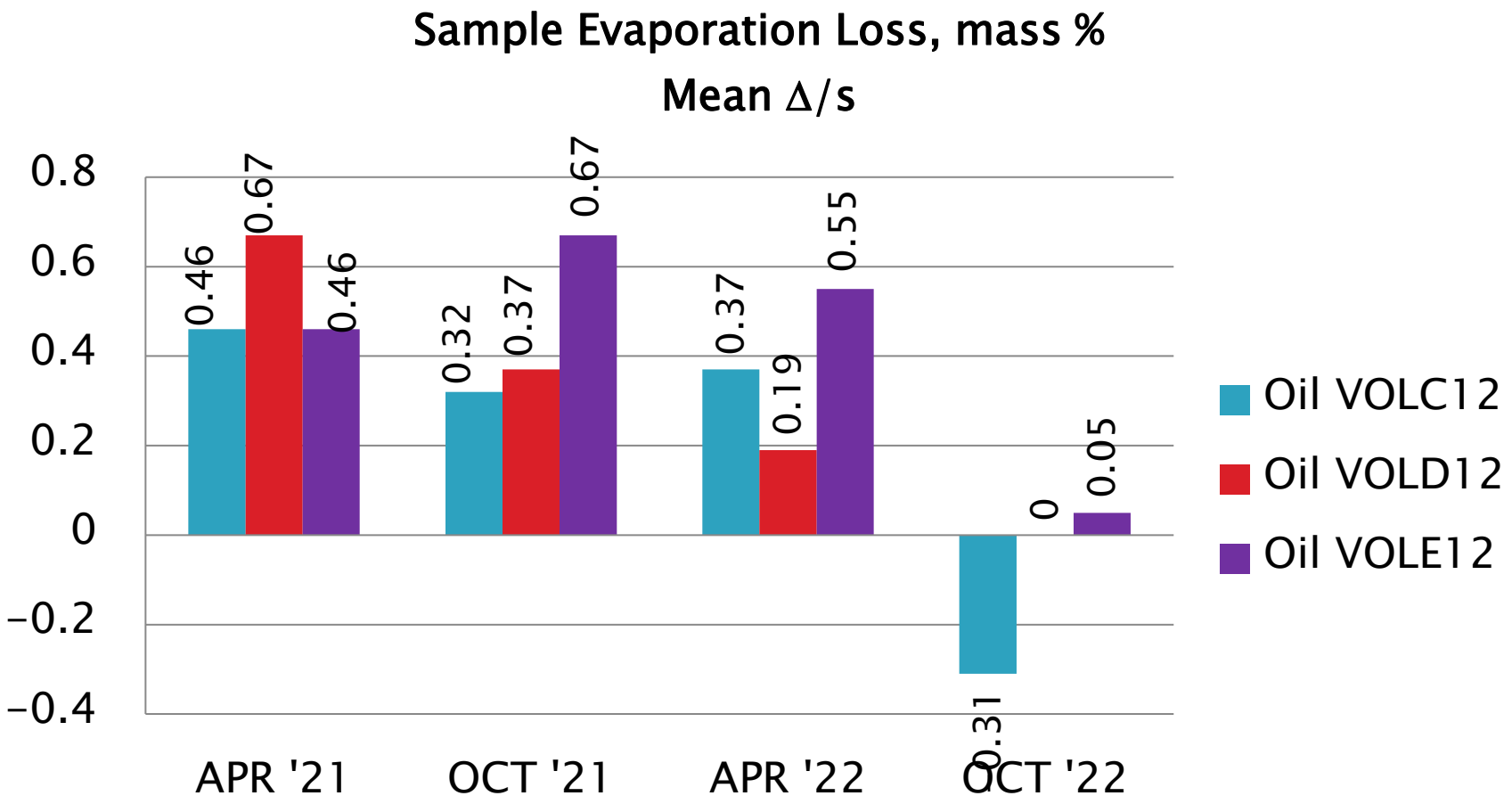
# D5800 Performance by Oil

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# TMC Monitored Tests

## ASTM D 5133

April 1, 2022 – September 30, 2022

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# D5133: Gelation Index

| Test Status | Validity Code | No. Tests |
|---|---|---|
| Acceptable Calibration Test | AC | 53 |
| Failed Calibration Test | OC | 4 |
| Operationally Invalidated by Lab | LC, LS, XC, XS | 0 |
| Operationally Invalidated After Initially Reported as Valid | RC/RS | 0 |
| Acceptable Discrimination Tests | AS | 1 |
| Failed Discrimination Tests | OS | 0 |
| **Total** | | **58** |

Number of Labs Reporting Data: 9
(only 8 labs with chartable results this period)
Fail Rate of Operationally Valid Calibration Tests: 6.9%
Fail Rate of Operationally Valid Discrimination Tests: 0%

# D5133: Gelation Index

| Statistically Unacceptable Calibration Tests (OC) | No. Of Tests |
|---|---|
| Gelation Index Mild | 1 |
| Gelation Index Severe | 3 |

- Of the 4 OC tests:
  - One was -4.5455 s from target
  - One between +3-4 s from targets
  - One between +4-5 s from targets
  - One greater than +5 s from targets (5.1471)

# D5133: Gelation Index

| Tests Excluded From Statistics (Operationally or Otherwise) | Validity Code | No. Tests |
|---|---|---|
| | | |
| Total | | 0* |

*There were no invalid tests this report period compared to 17 invalidated tests last period.

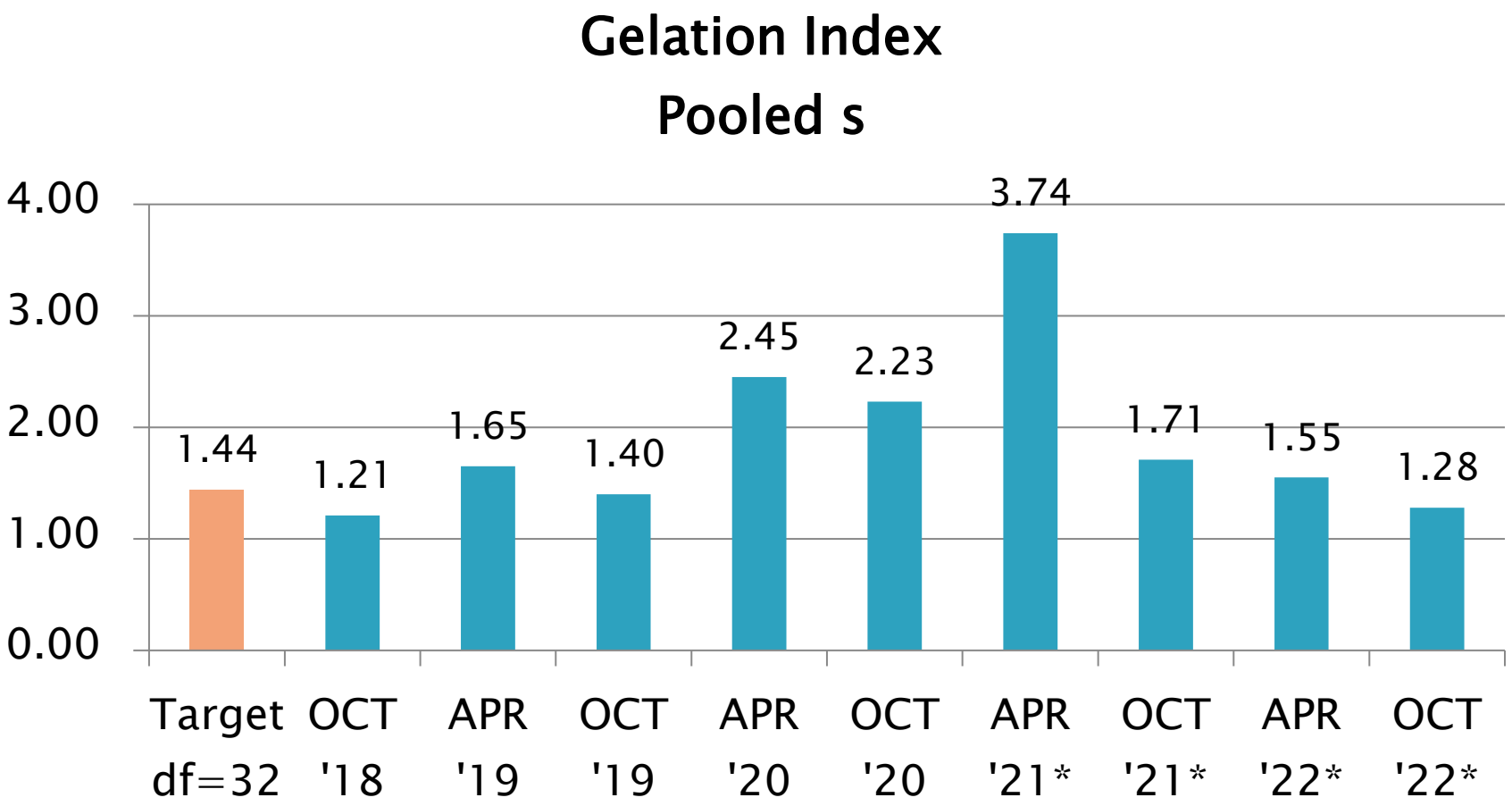
# D5133: Gelation Index

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 |

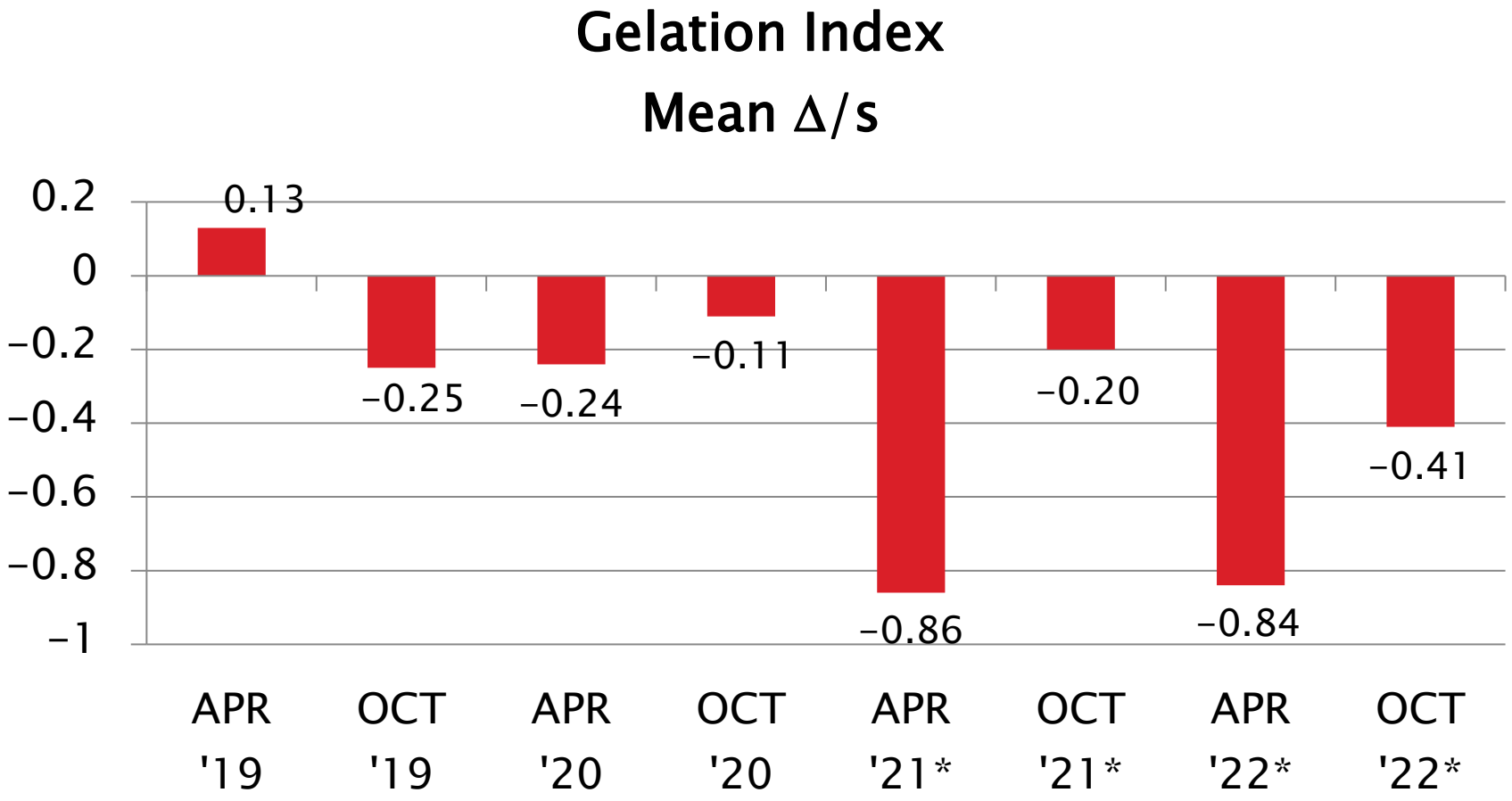
[1]Target precision updated to current reference oils GIA17 and 1009 only
[2]Changed from bath to head-based monitoring scheme 10/1/20

# D5133 Precision Estimates



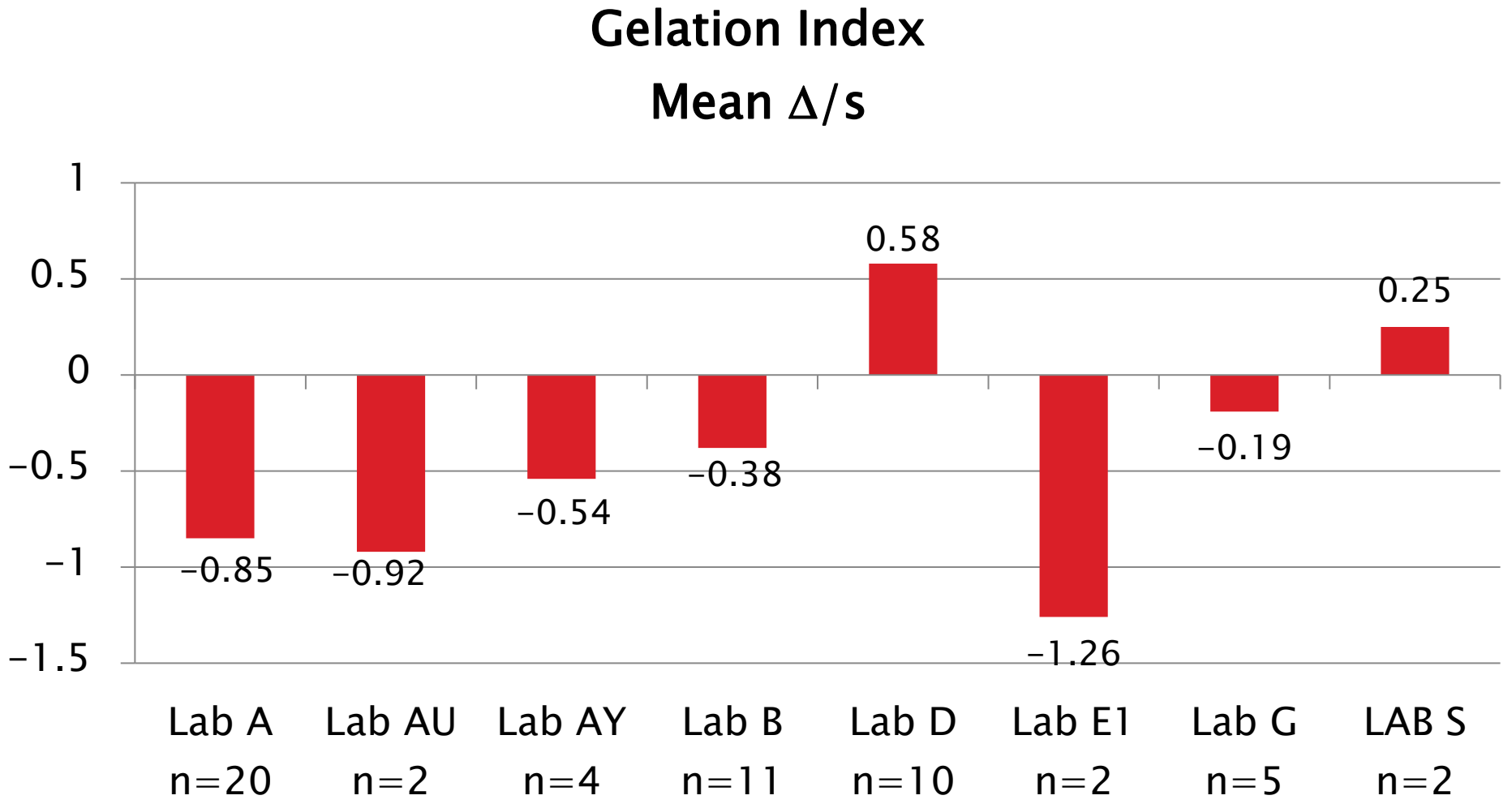

*Changed from bath to head-based monitoring scheme

# D5133 Severity Estimates




*Changed from bath to head-based monitoring scheme

# D5133 Lab Severity Estimates



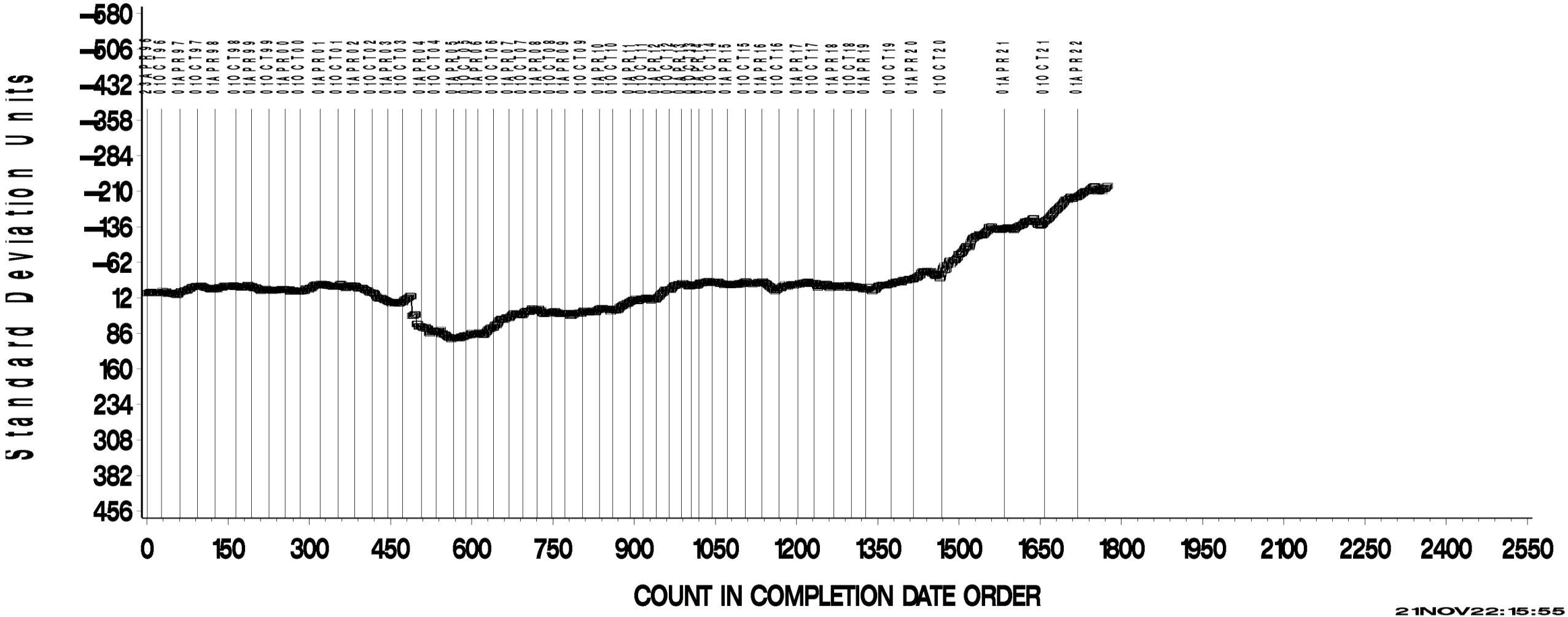
# D5133: Gelation Index

- Fail rate of operationally valid tests is 6.9% this period
  - Compared to 12.3% fail rate last period
  - There were no reported fails on operationally valid discrimination runs
  - Historic period fail rates have ranged between 6% and 26%
- Precision (Pooled s) is slightly more precise than last period
  - Comparable to updated target precision
- Performance (Mean Δ/s) is -0.41 s mild but closer to target
  - Six of Eight labs reporting mild of target
- A round robin was completed to evaluate a calibration oil that performs closer to the GF-5/6 pass/fail limit of 12 GI
  - GIC18 was voted into rotation by the Surveillance Panel
  - Replaces oil 58 that was reclassified as a discrimination oil

# D5133 GELATION INDEX INDUSTRY OPERATIONALLY VALID DATA

## GELATION INDEX

CUSUM Severity Analysis

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# D5133 GELATION INDEX INDUSTRY OPERATIONALLY VALID DATA

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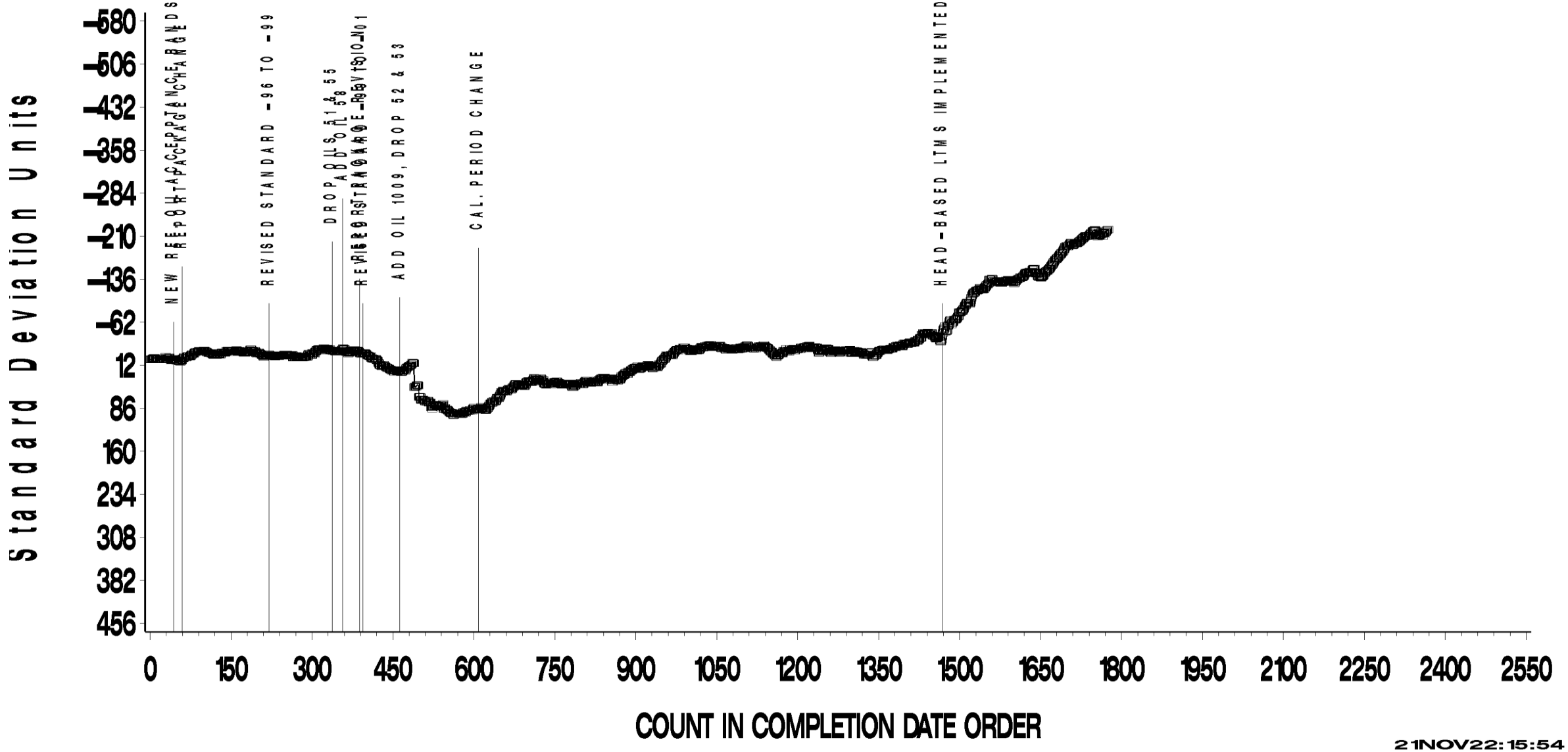
## GELATION INDEX

CUSUM Severity Analysis

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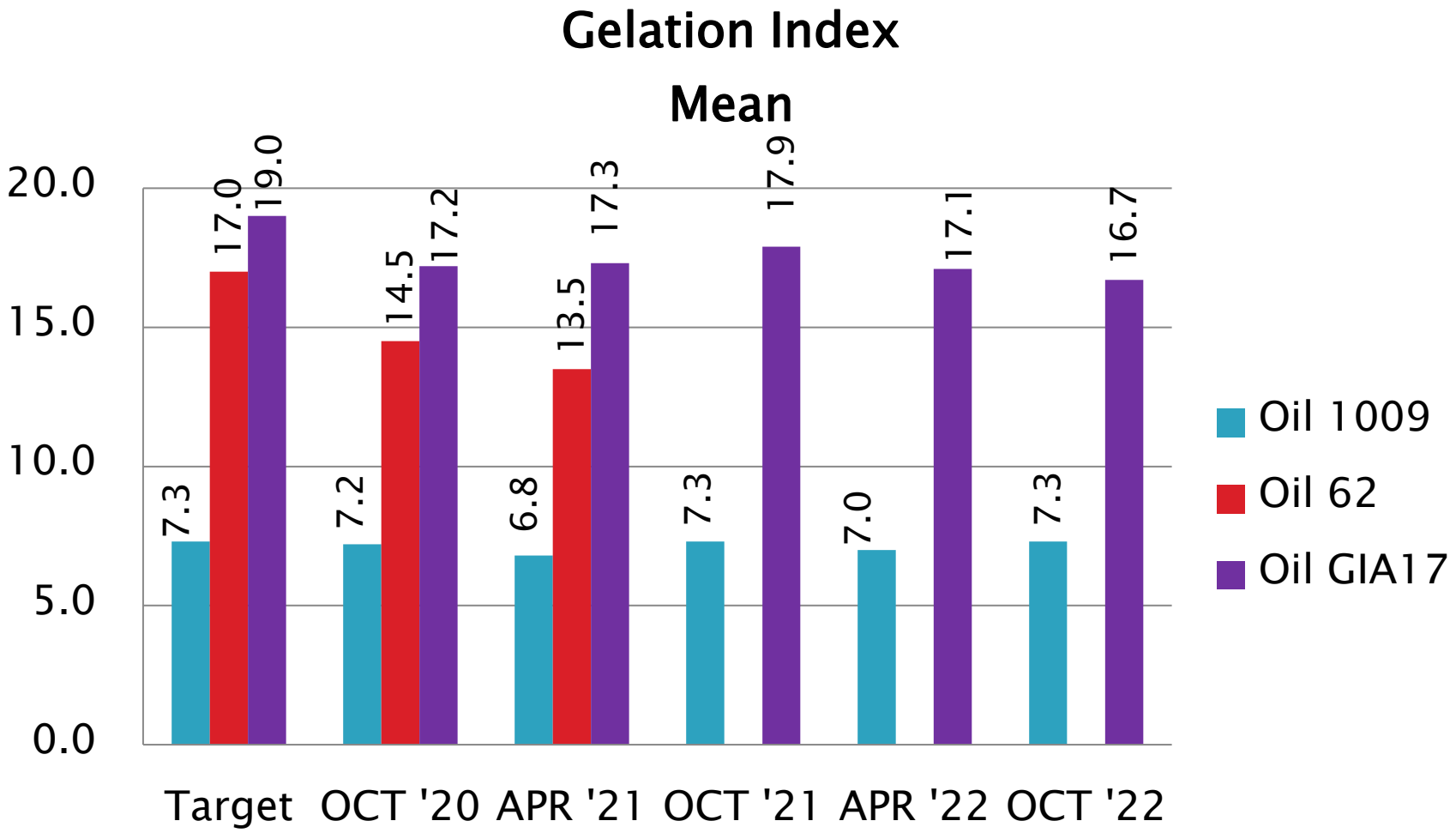
# D5133 Performance by Oil

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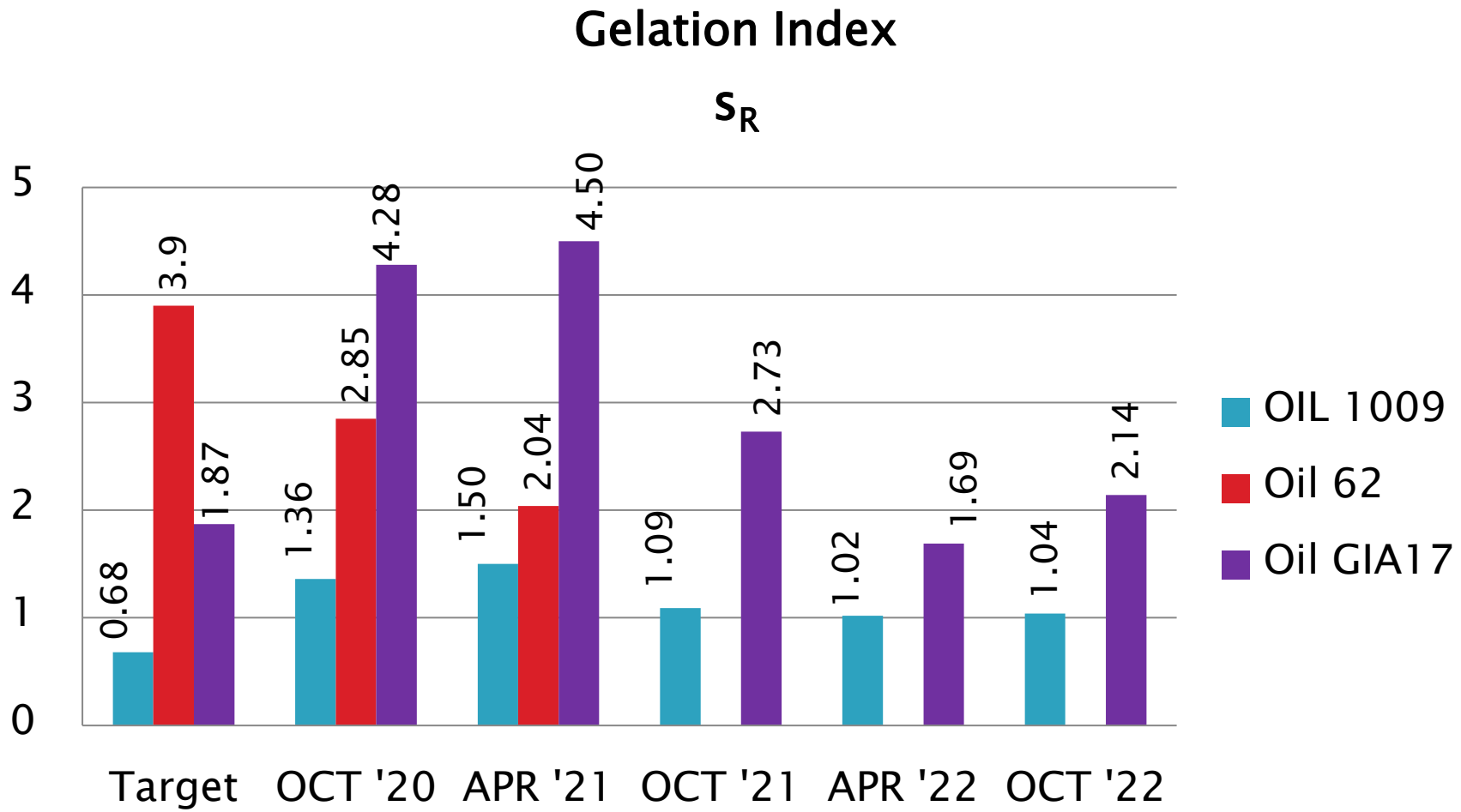
# D5133 Performance by Oil

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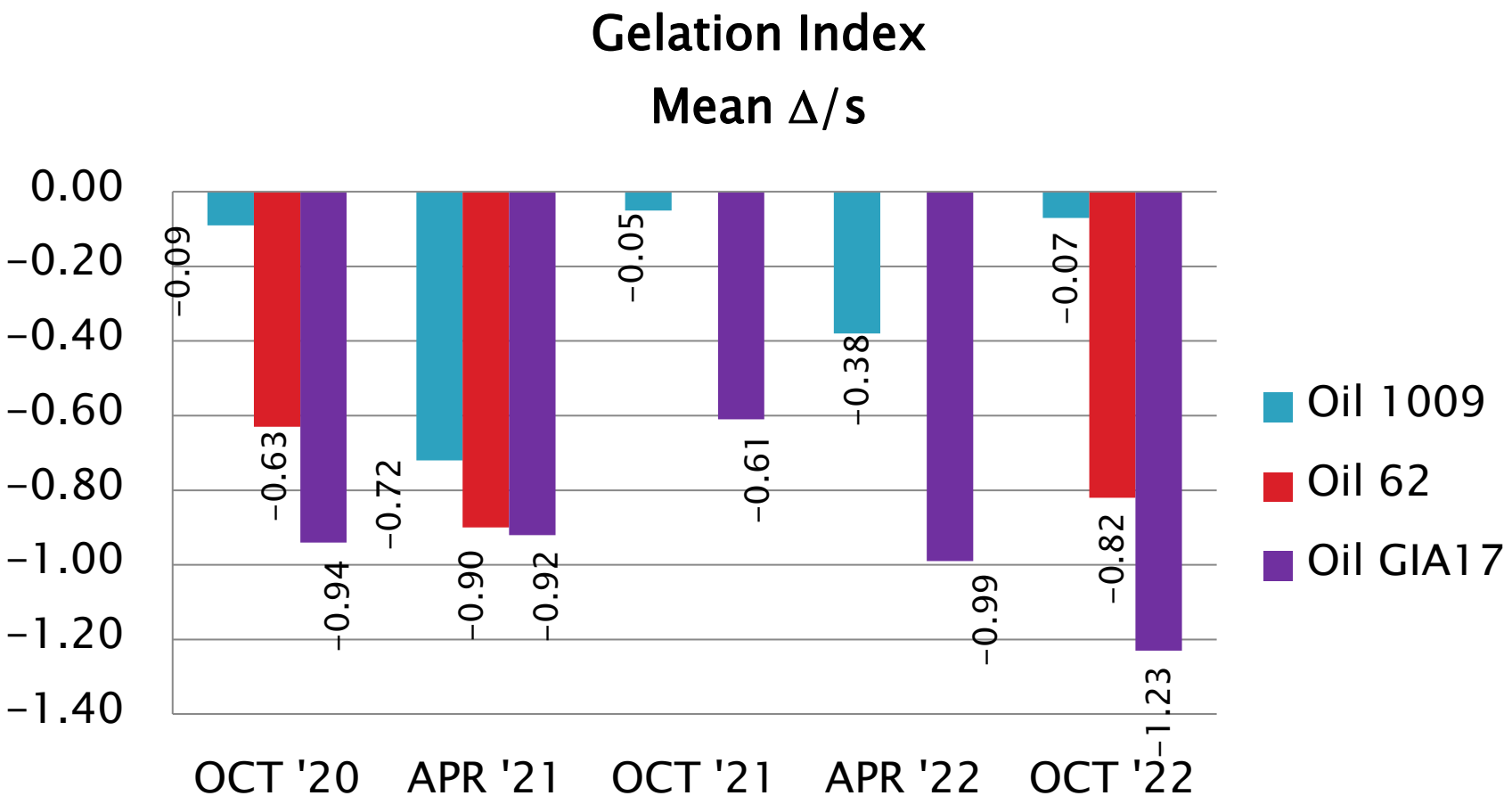
# D5133 Performance by Oil

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# TMC Monitored Tests

## ASTM D 6335

April 1, 2022 – September 30, 2022

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# D6335: Deposits by TEOST-33C

| Test Status | Validity Code | No. Tests |
|---|---|---|
| Acceptable Calibration Test | AC | 25 |
| Failed Calibration Test | OC | 4 |
| Operationally Invalidated by Lab | LC, XC | 0 |
| **Total** | | **29** |

Number of Labs Reporting Data: 8
Fail Rate of Operationally Valid Tests: 13.8%

# D6335: Deposits by TEOST-33C

| Statistically Unacceptable Tests (OC) | No. Of Tests |
|---|---|
| Total Deposits Severe | 4 |

- The four statistically unacceptable results this period were multiple fails on two stands (stands D3 and G4; all four results severe of target).
- There were no operationally invalid tests reported this period.
- TMC Memo 21-044 issued November 3, 2021, updating targets for reference oil 75-1.

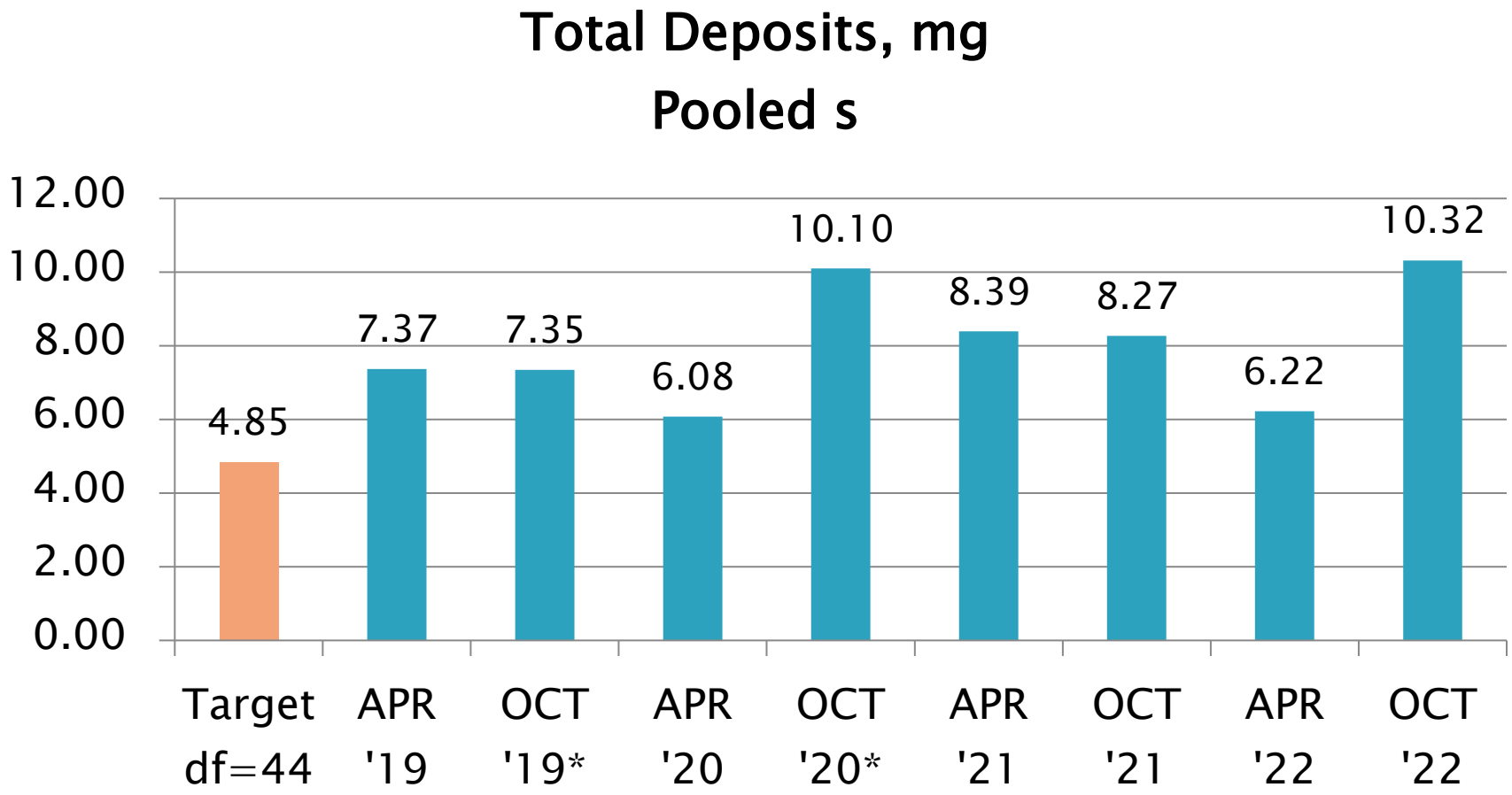
# D6335: Deposits by TEOST-33C

## 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 |

[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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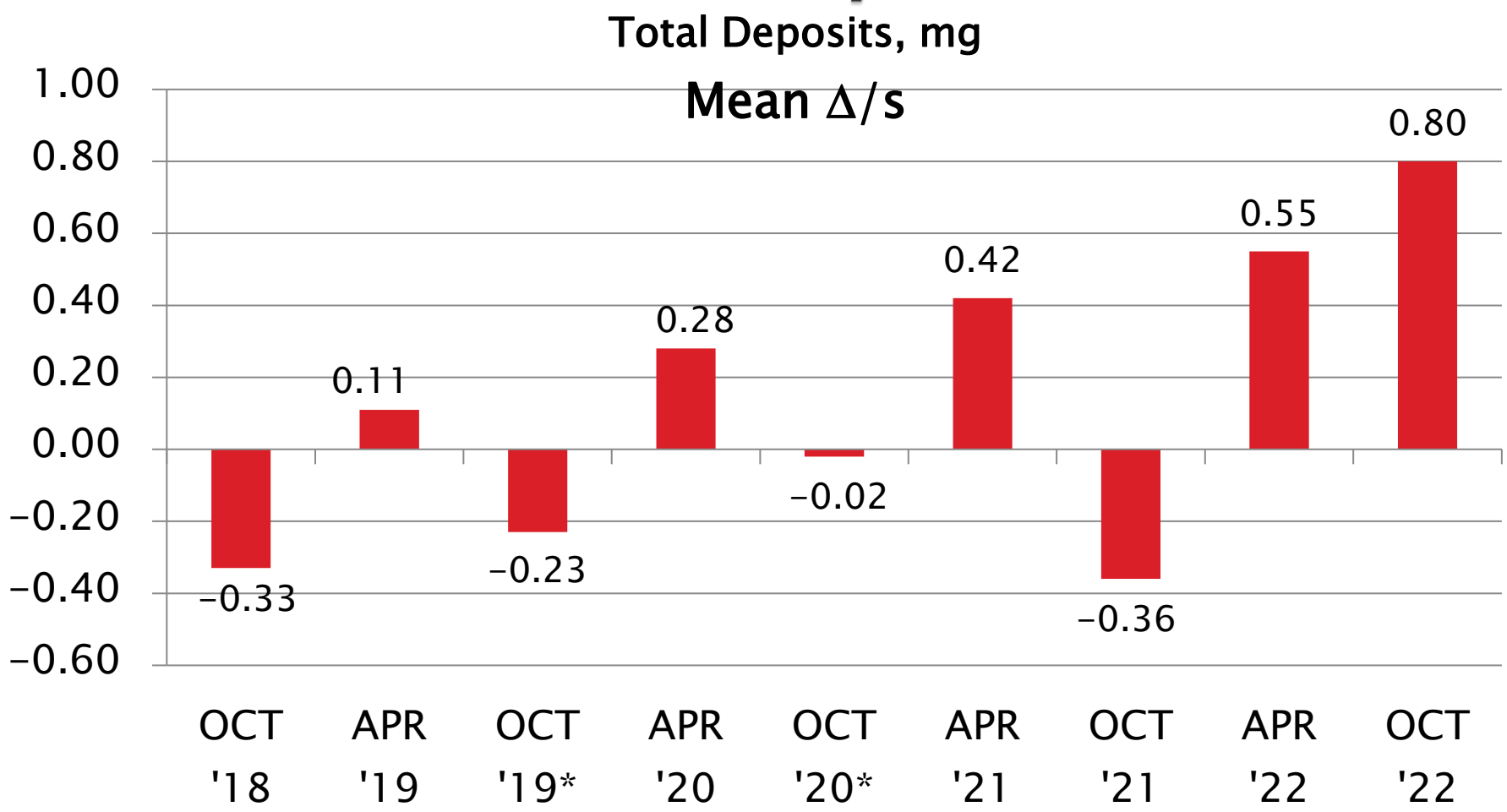
# D6335 Severity Estimates

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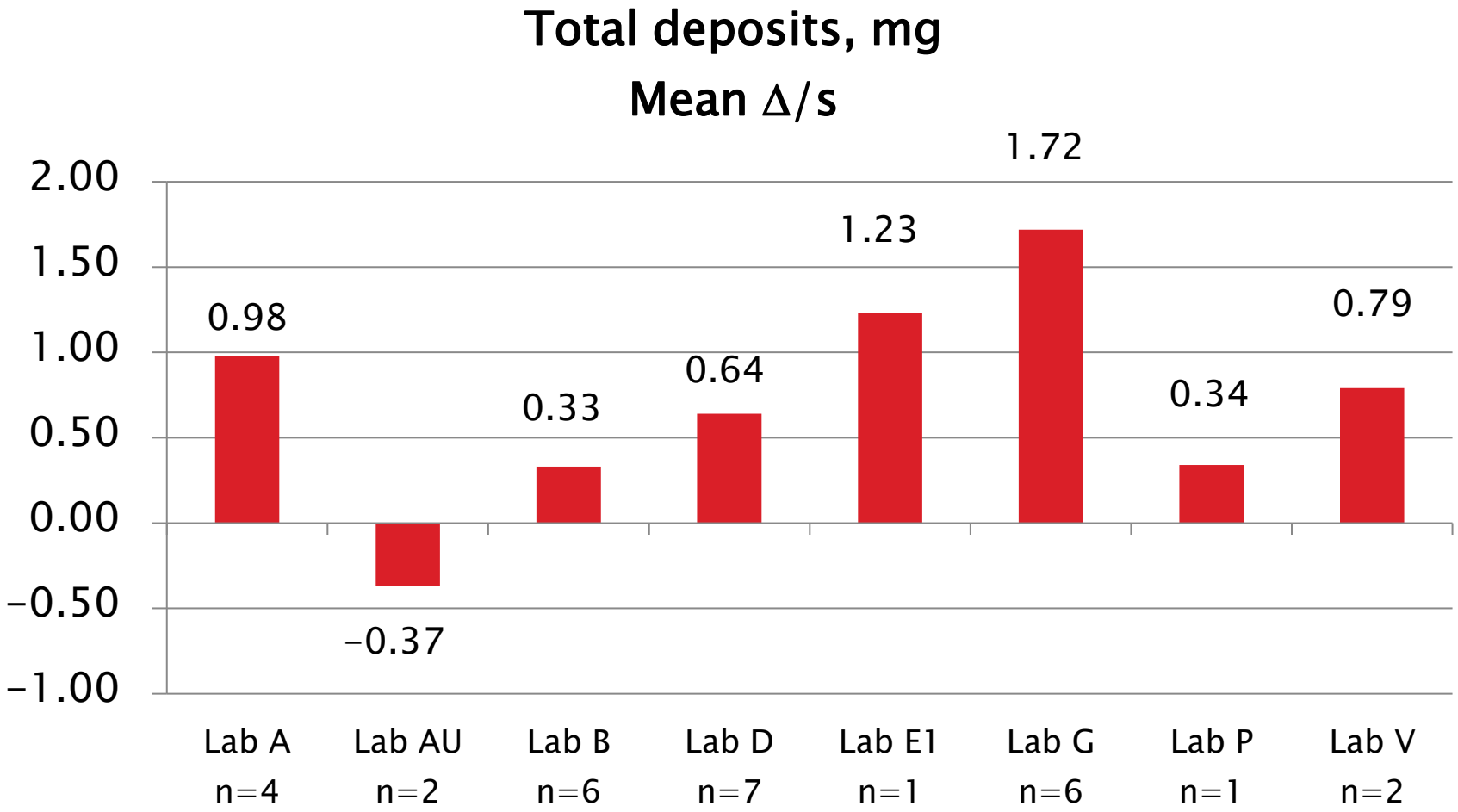
# D6335 Lab Severity Estimates

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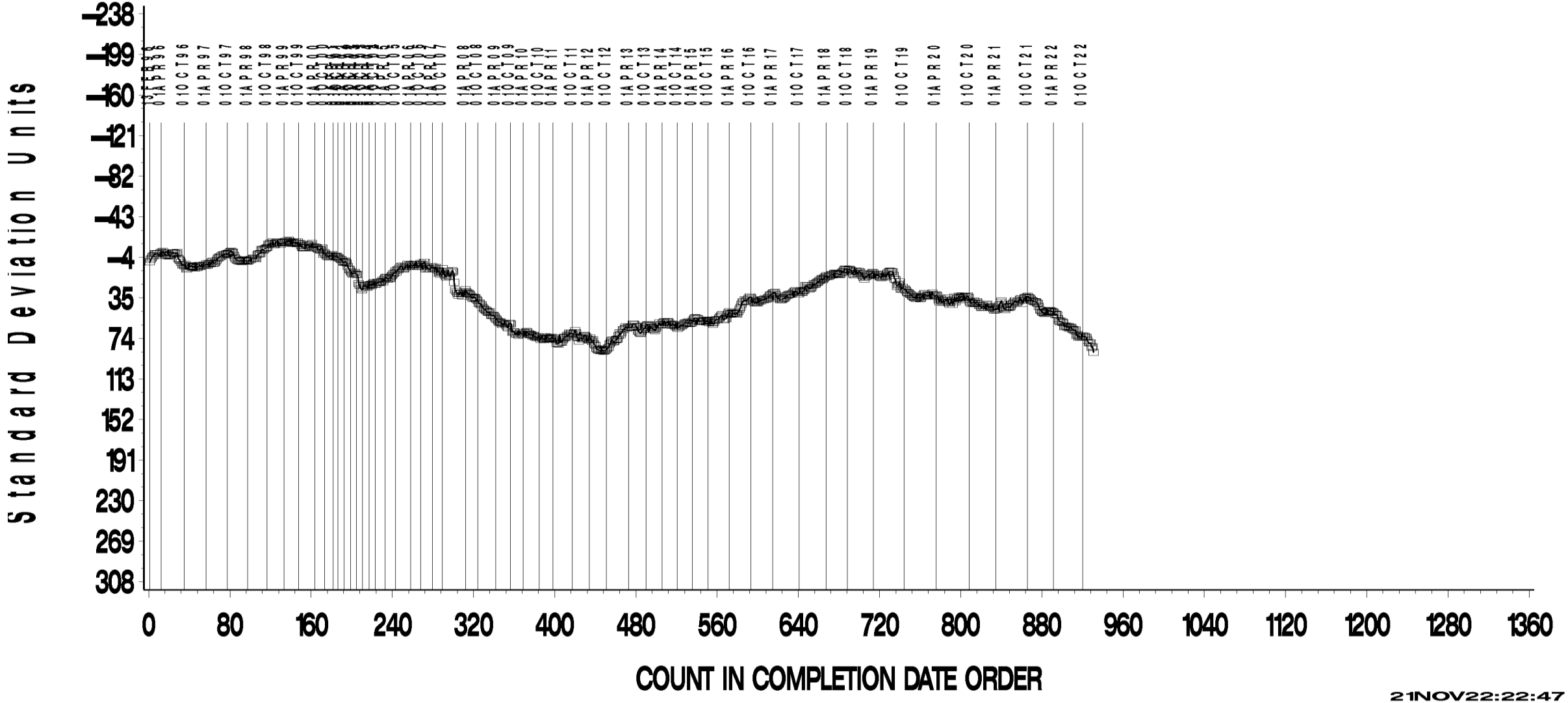
# D6335: Deposits by TEOST-33C

- Precision (Pooled s) is poorer when compared to the previous period and is larger (more imprecise) compared to all historical rates going back 3.5 years (to APR '19)
  - Less precise than target precision
    - There were no tests reported using oil 75
- Performance (Mean Δ/s) is 0.80 s severe this period (compared to 0.55 s severe last period)
- Period fail rate of 13.8% on tests reported as operationally valid
  - Fail rate has almost doubled (13.8% vs 7.0%) when compared to previous six-month report period.
  - All on Rod Batch N
  - Two Units had all four fails
- All tests this period report using Rod Batch M or N.

# TEOST —33C INDUSTRY OPERATIONALLY VALID DATA

## TOTAL DEPOSITS MG

CUSUM Severity Analysis

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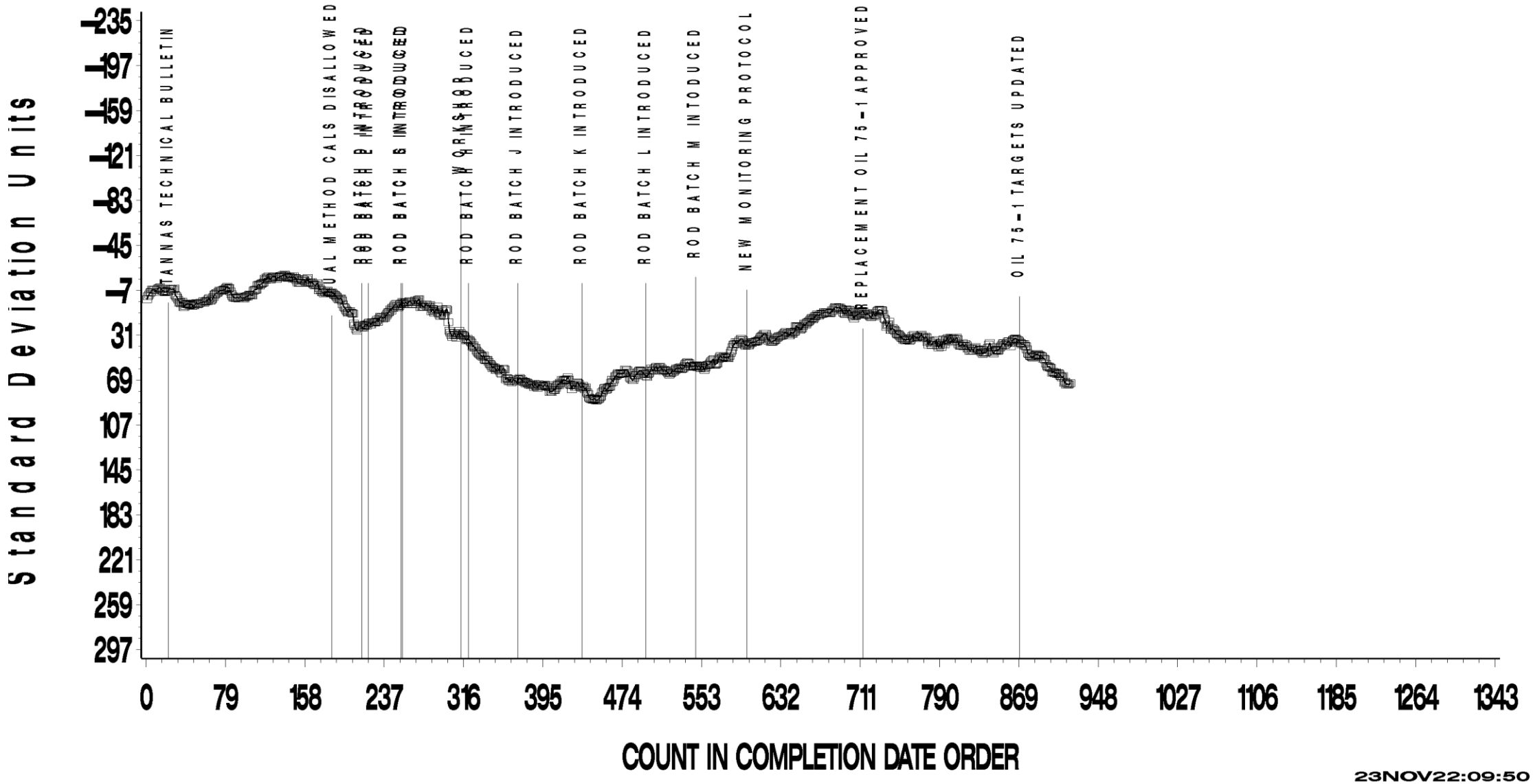
TEOST —33C INDUSTRY OPERATIONALLY VALID DATA

TOTAL DEPOSITS MG

CUSUM Severity Analysis

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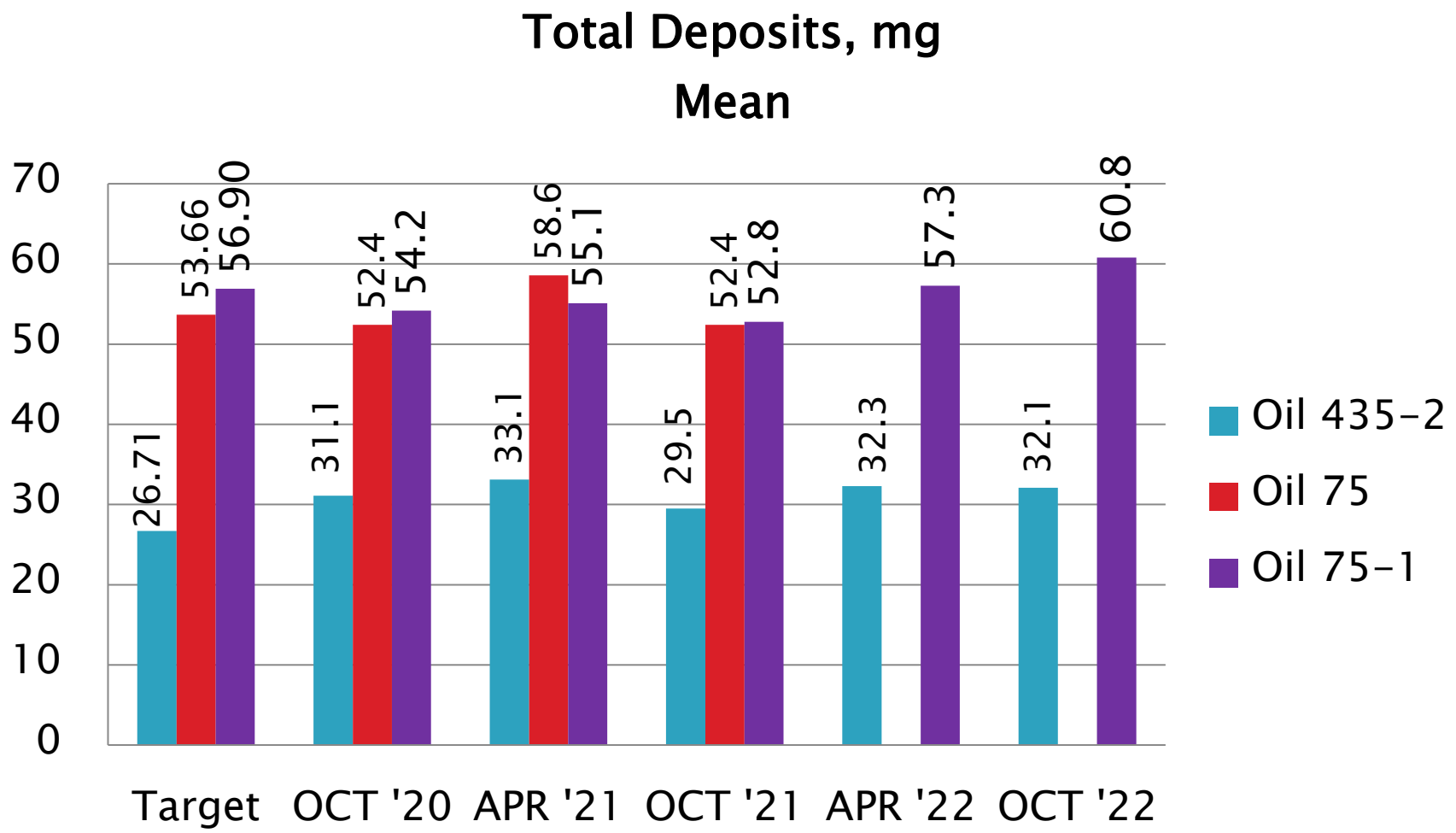
# D6335 Performance by Oil

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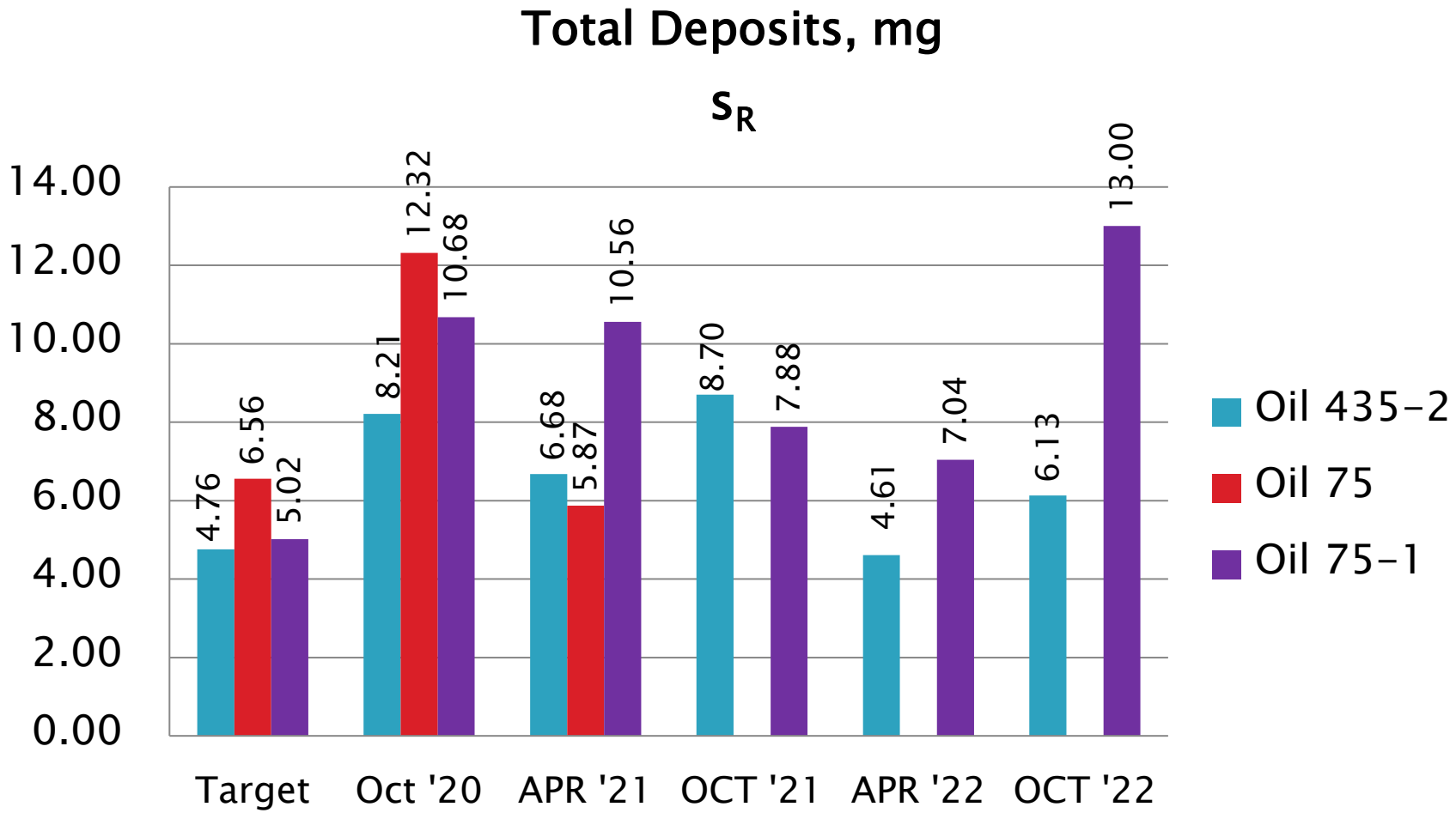
# D6335 Performance by Oil

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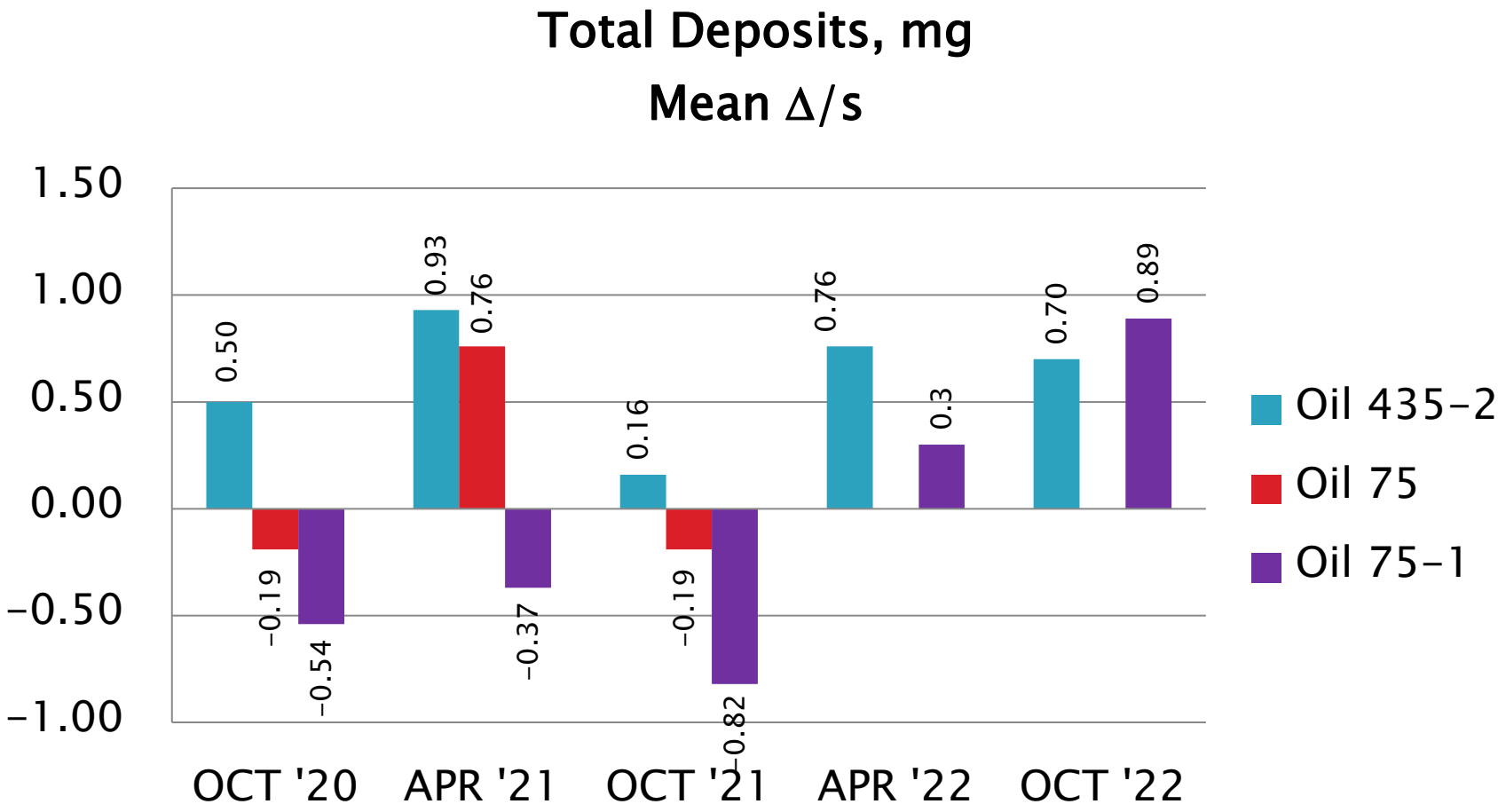
# D6335 Performance by Oil

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# D02.B0.07
# TMC Monitored Tests

## ASTM D 7097

April 1, 2022 – September 30, 2022

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# D7097: Deposits by MHT TEOST

| Test Status | Validity Code | No. Tests |
|---|---|---|
| Acceptable Calibration Test | AC | 66 |
| Failed Calibration Test | OC | 11 |
| Operationally Invalidated by Lab | LC | 3 |
| Operationally Invalidated After Initially Reported as Valid | RC | 0 |
| Instrument Shakedown Run | NI | 3 |
| **Total** | | **83** |

Number of Labs Reporting Data: 8
Fail Rate of Operationally Valid Tests: 14%

# D7097: Deposits by MHT TEOST

| Statistically Unacceptable Tests (OC) | No. Of Tests |
|---|---|
| Total Deposits Mild | 0 |
| Total Deposits Severe | 11 |

# D7097: Deposits by MHT TEOST Summary of Invalid Tests

| Operationally Invalid Tests | Validity Code | No. Of Tests |
|---|---|---|
| Catalyst Weight ratio incorrect | LC | 3 |
| | | |

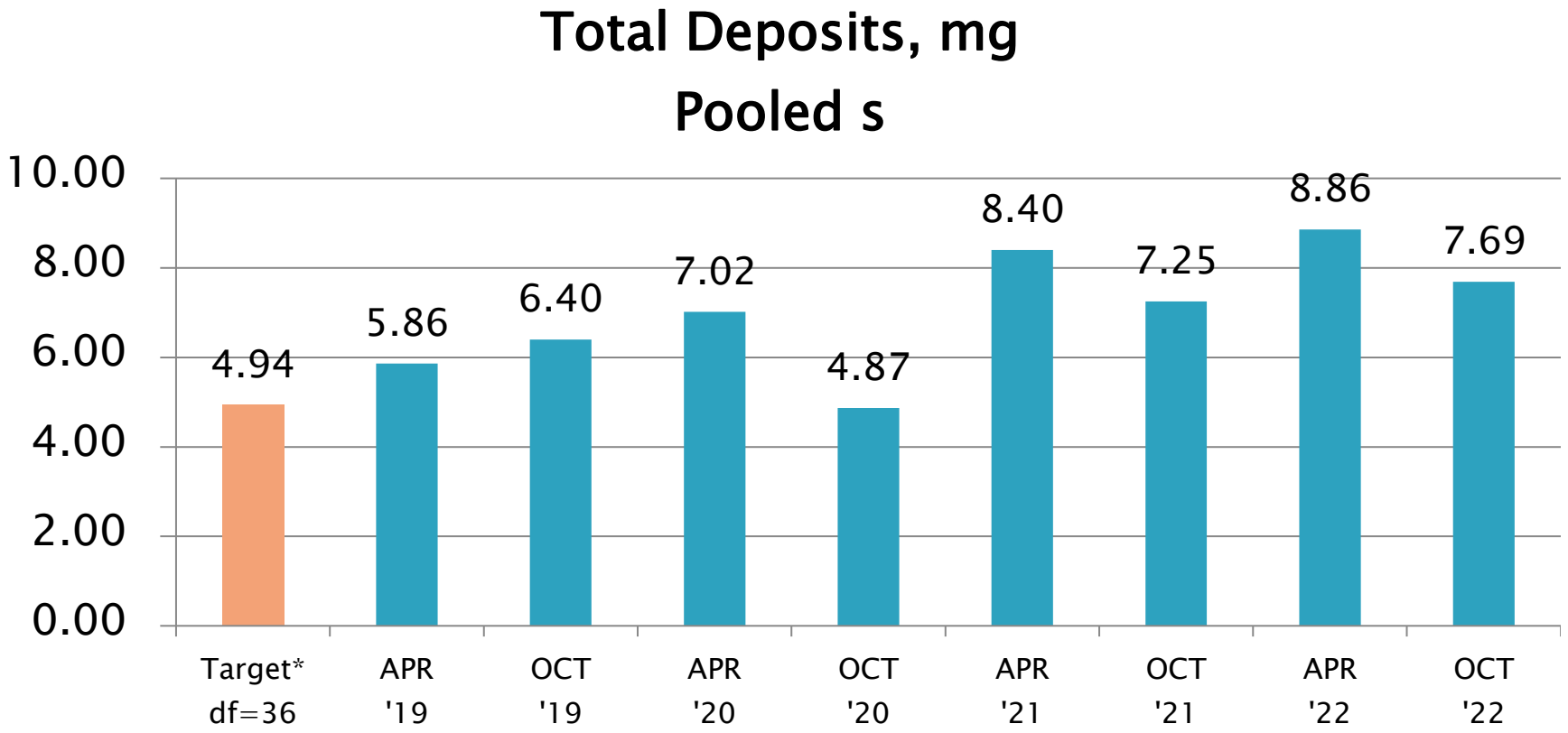
# D7097: Deposits by MHT TEOST

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 |

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

# D7097 Precision Estimates




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

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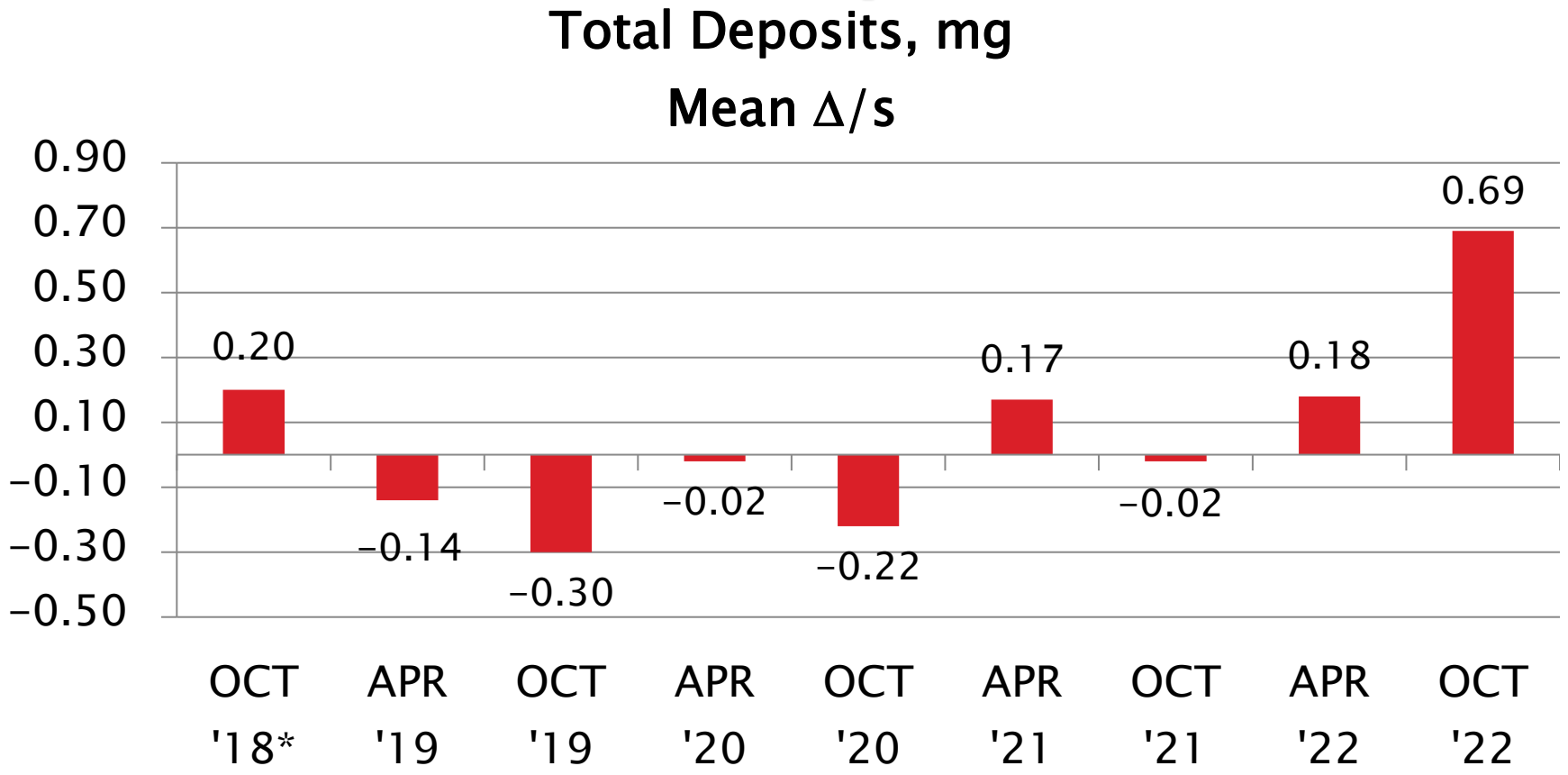
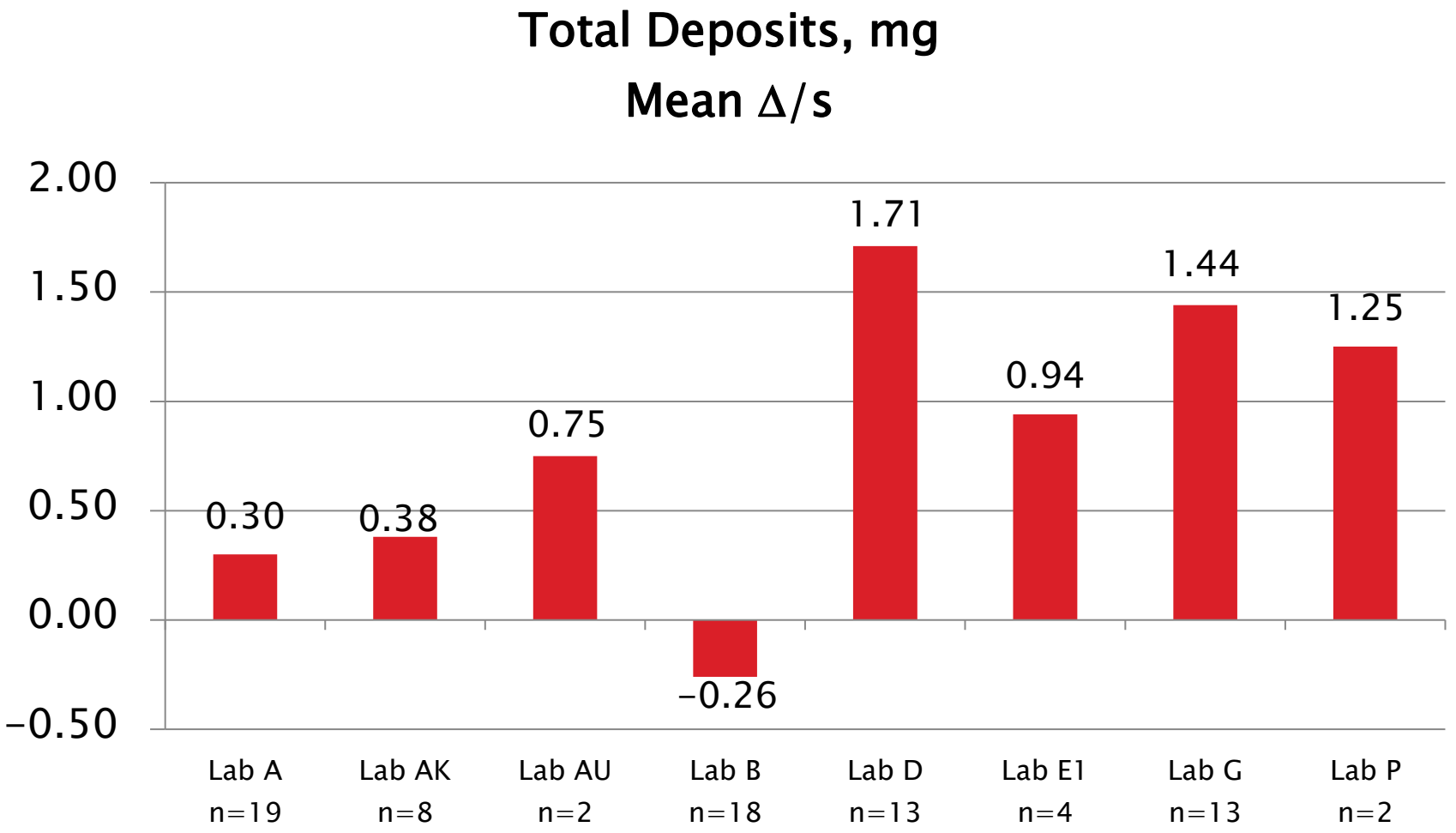
# D7097 Severity Estimates




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

# D7097 Lab Severity Estimates

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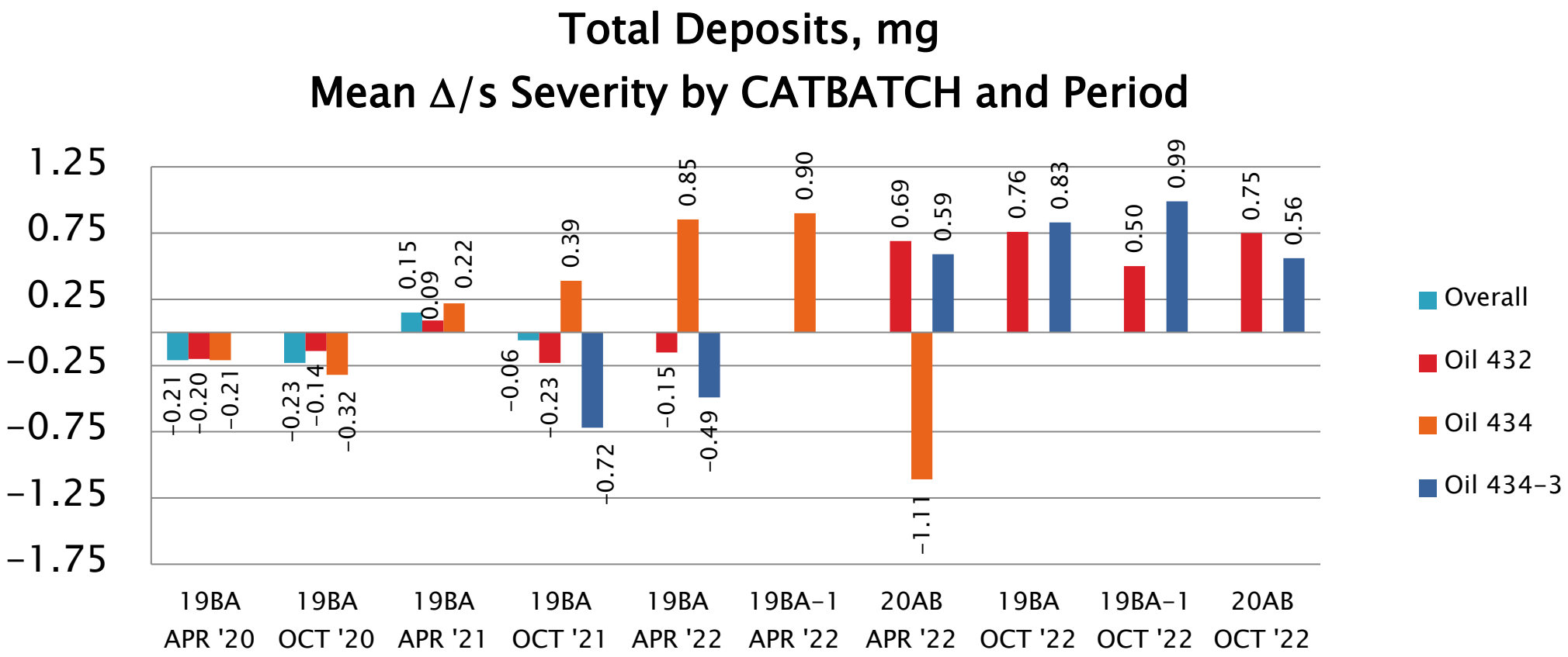
# D7097: Deposits by MHT TEOST

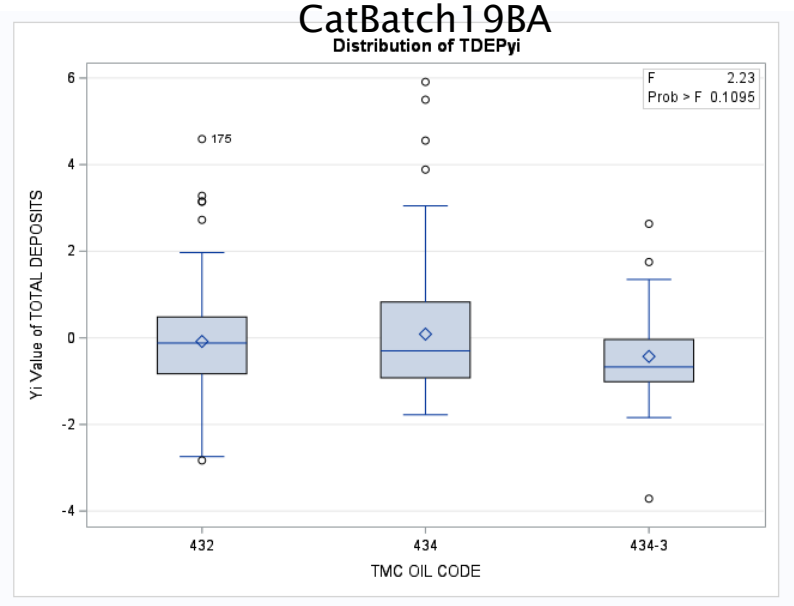


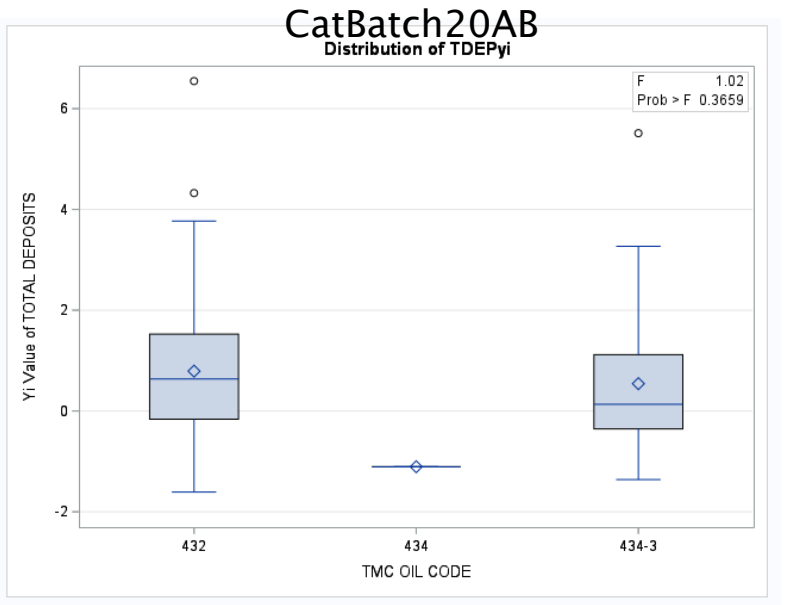
# D7097: Deposits by MHT TEOST

- Precision (Pooled s) remains high, but did move closer to target in this reporting period
  - Very nearly matching precision from one year ago
- Performance (Mean Δ/s) has moved significantly more severe (+0.69 s)
- All operationally valid tests this period report using Rod Batches M or N (new).
- All operationally valid calibration tests this period report using Catalyst Batch 1 19BA (n=7) 19BA-1 (n=2) or 20AB (n=74)

# D7097: Deposits by MHT TEOST

- Overall severity on catalyst batch 19BA (n=344) appears to be on target for oils 432, 434 and 434-3 (Yi = -0.04).
- Overall severity on catalyst batch 20AB (n=95) appears to be slightly severe of target for oils 432, 434 and 434-3 (Yi = 0.65)

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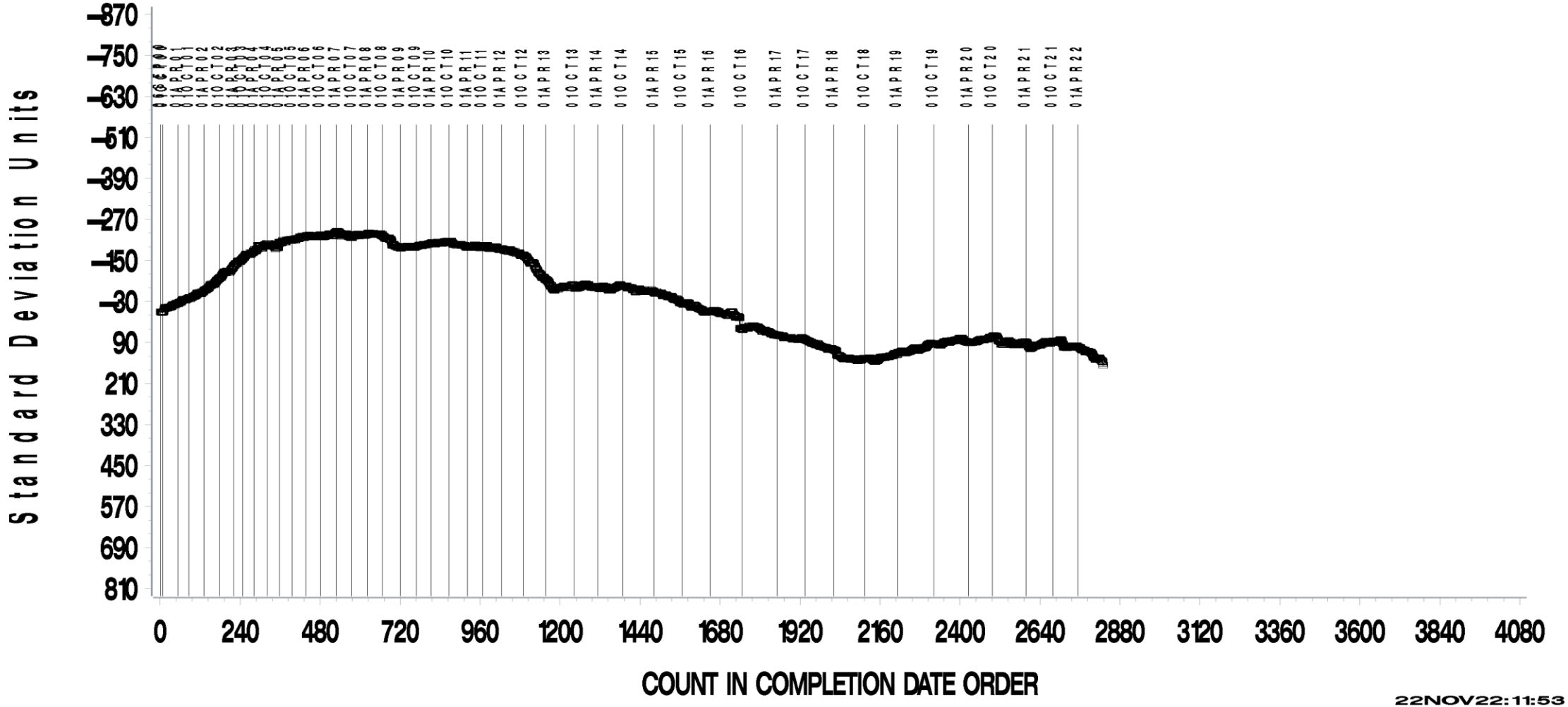
# MHT—4 TEOST INDUSTRY OPERATIONALLY VALID DATA

## TOTAL DEPOSITS MG

CUSUM Severity Analysis

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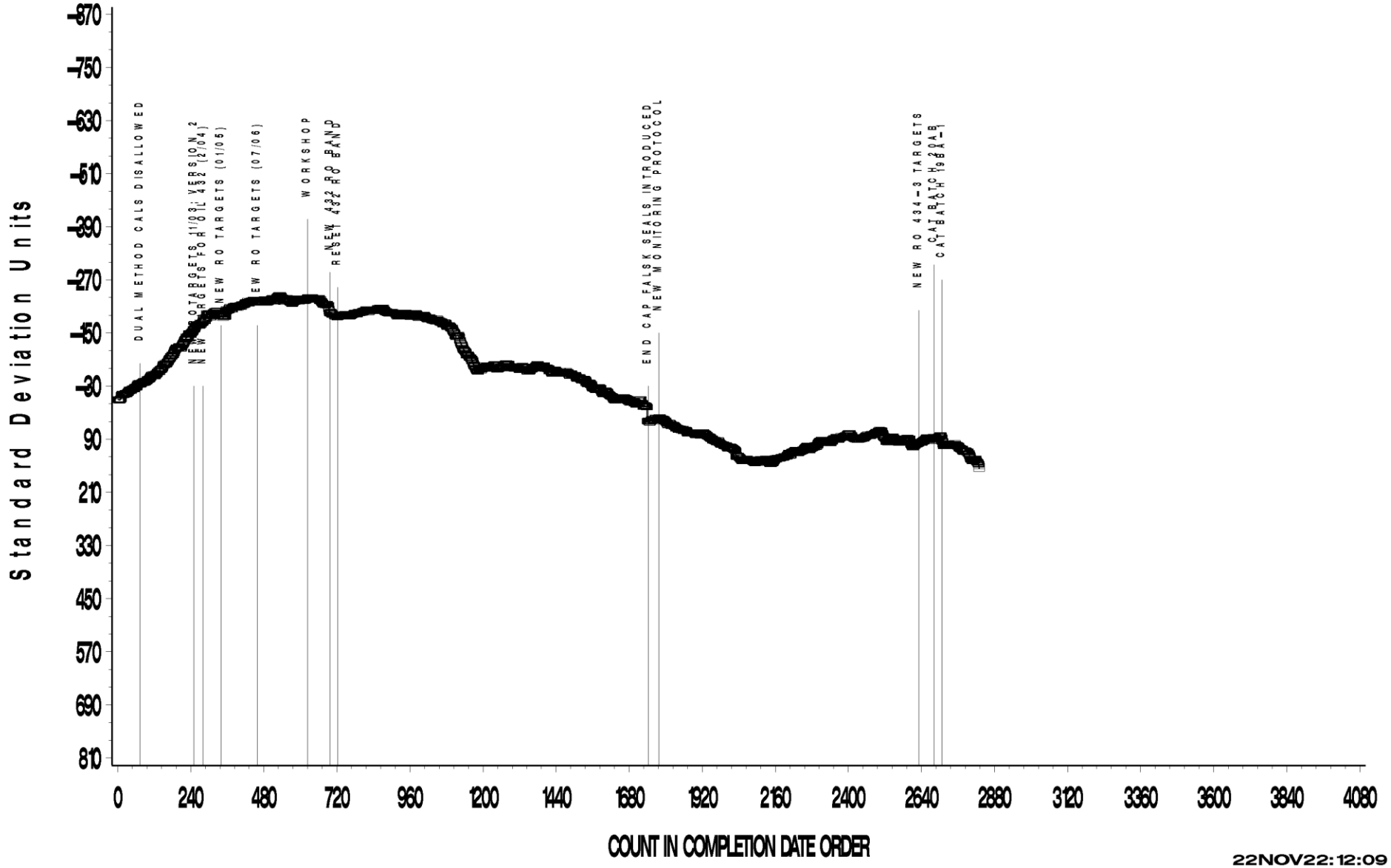
# MHT—4 TEOST INDUSTRY OPERATIONALLY VALID DATA

## TOTAL DEPOSITS MG

CUSUM Severity Analysis

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# MHT—4 TEOST INDUSTRY OPERATIONALLY VALID DATA

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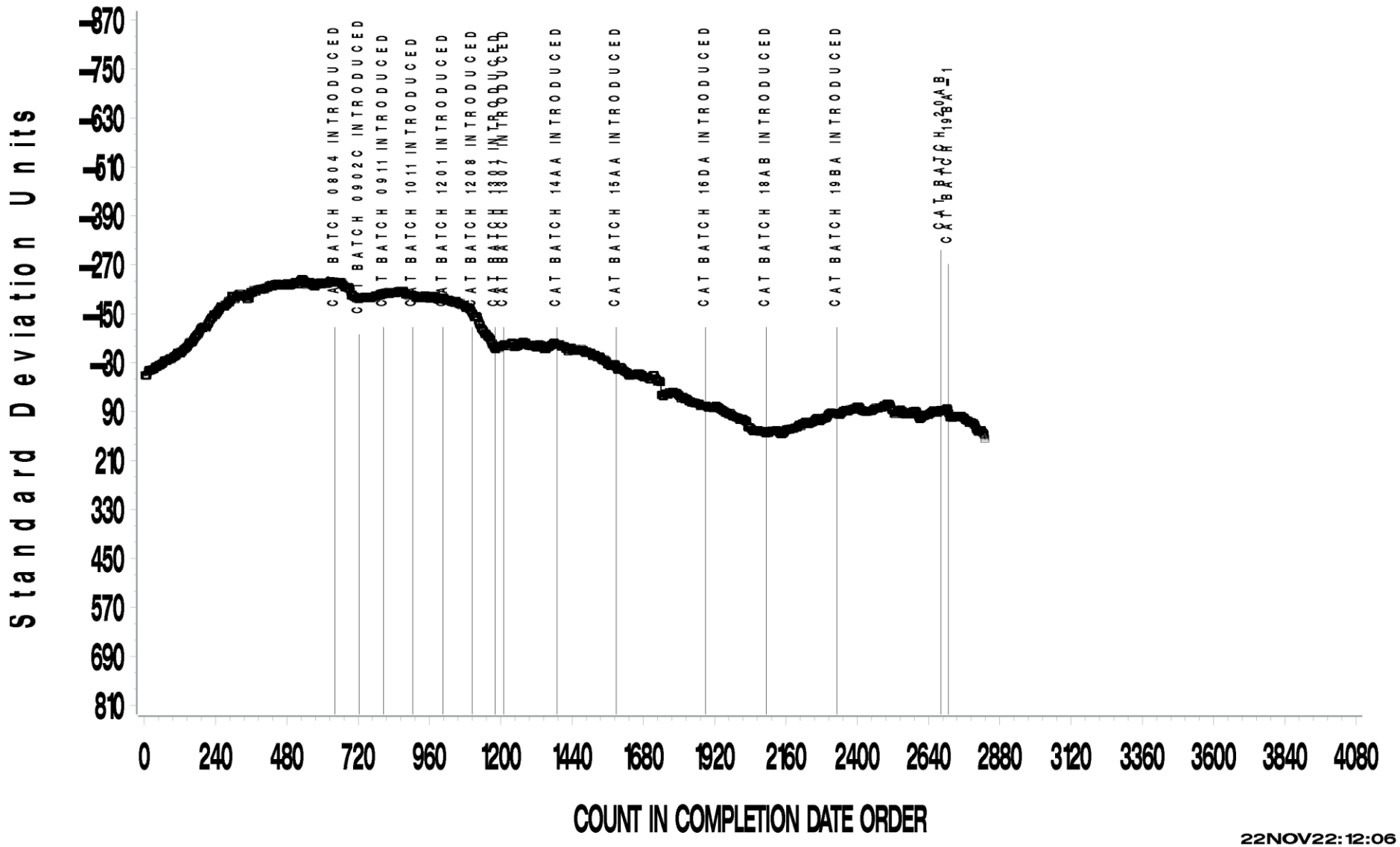
## TOTAL DEPOSITS MG

CUSUM Severity Analysis

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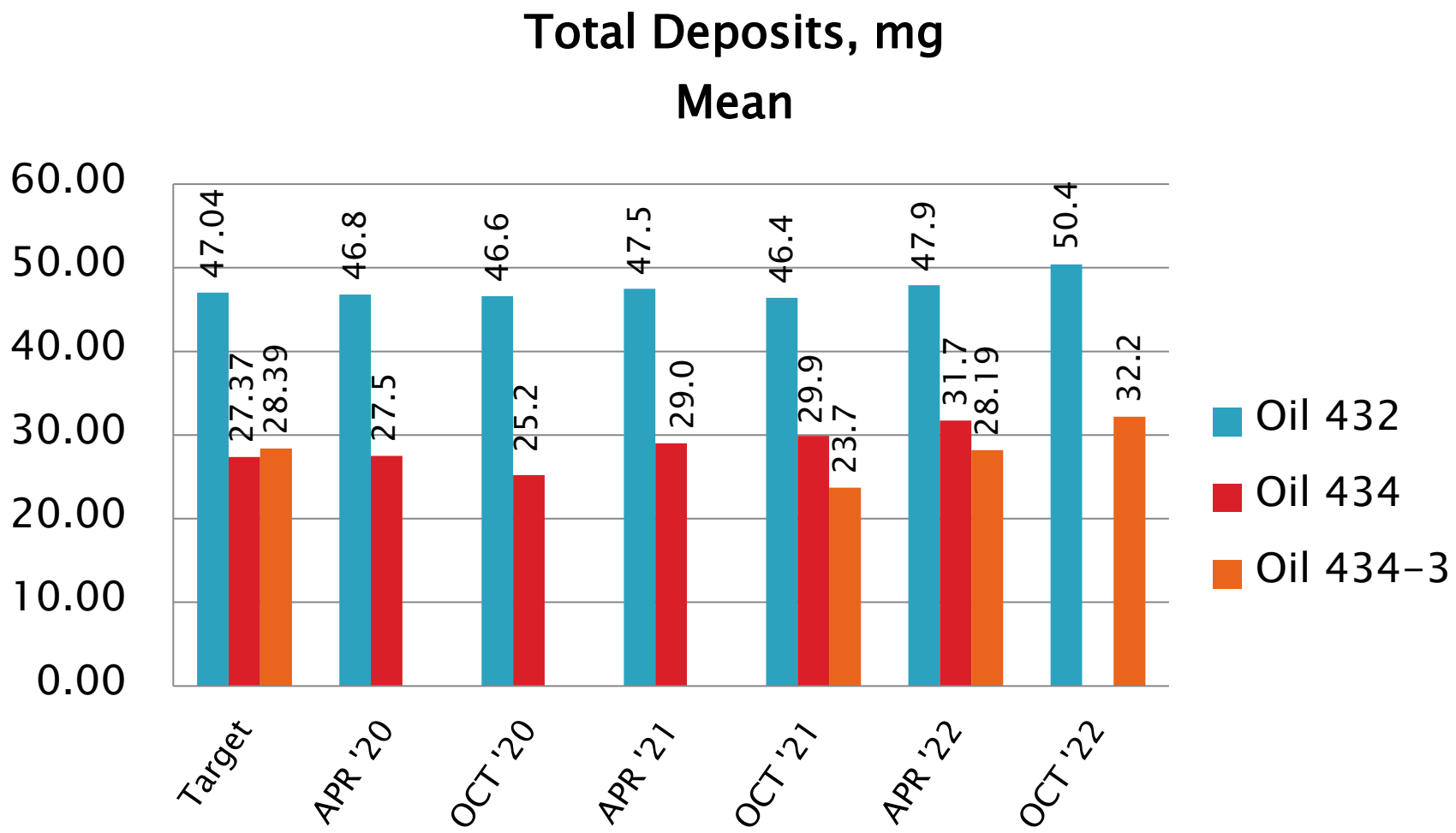
# D7097 Performance by Oil

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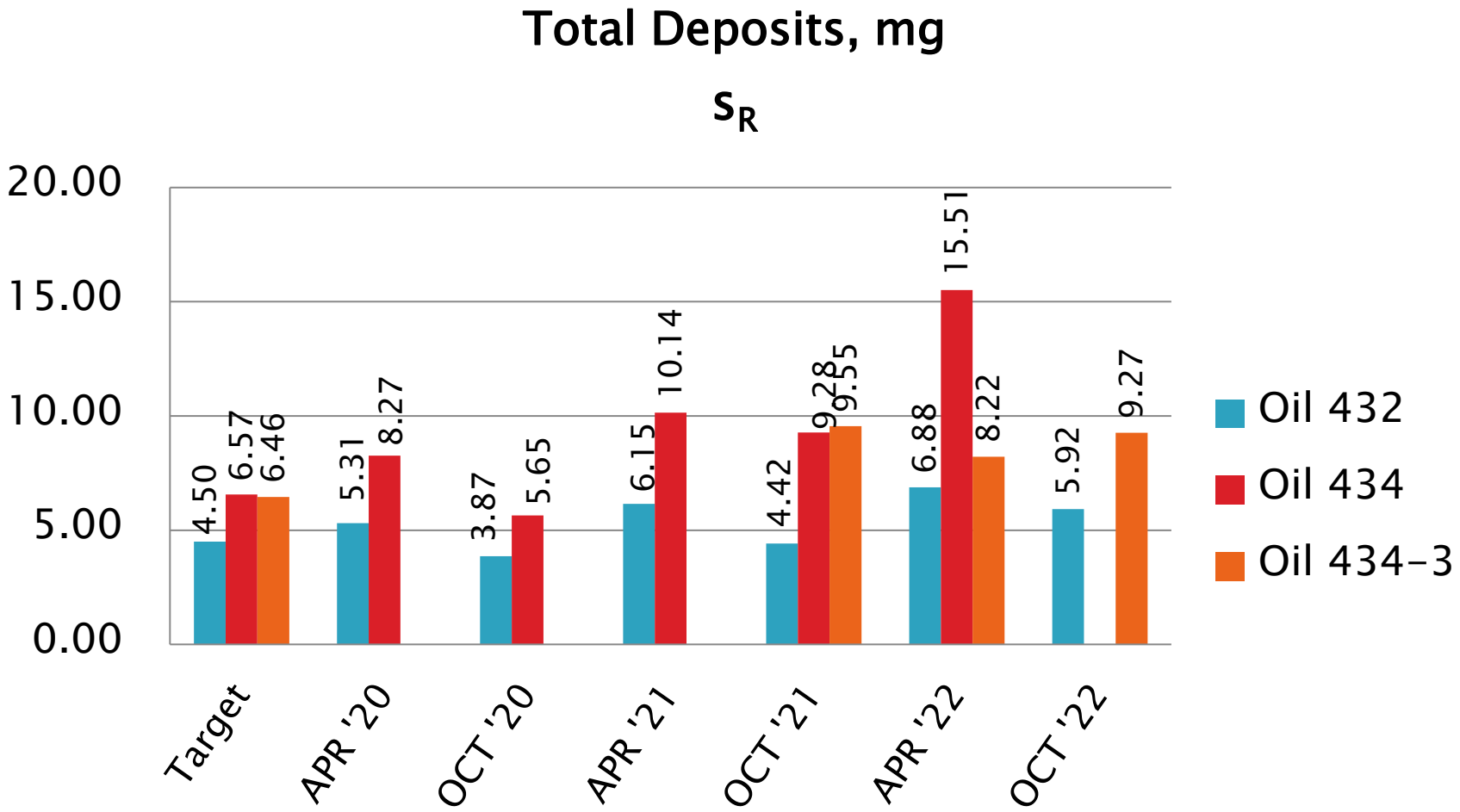
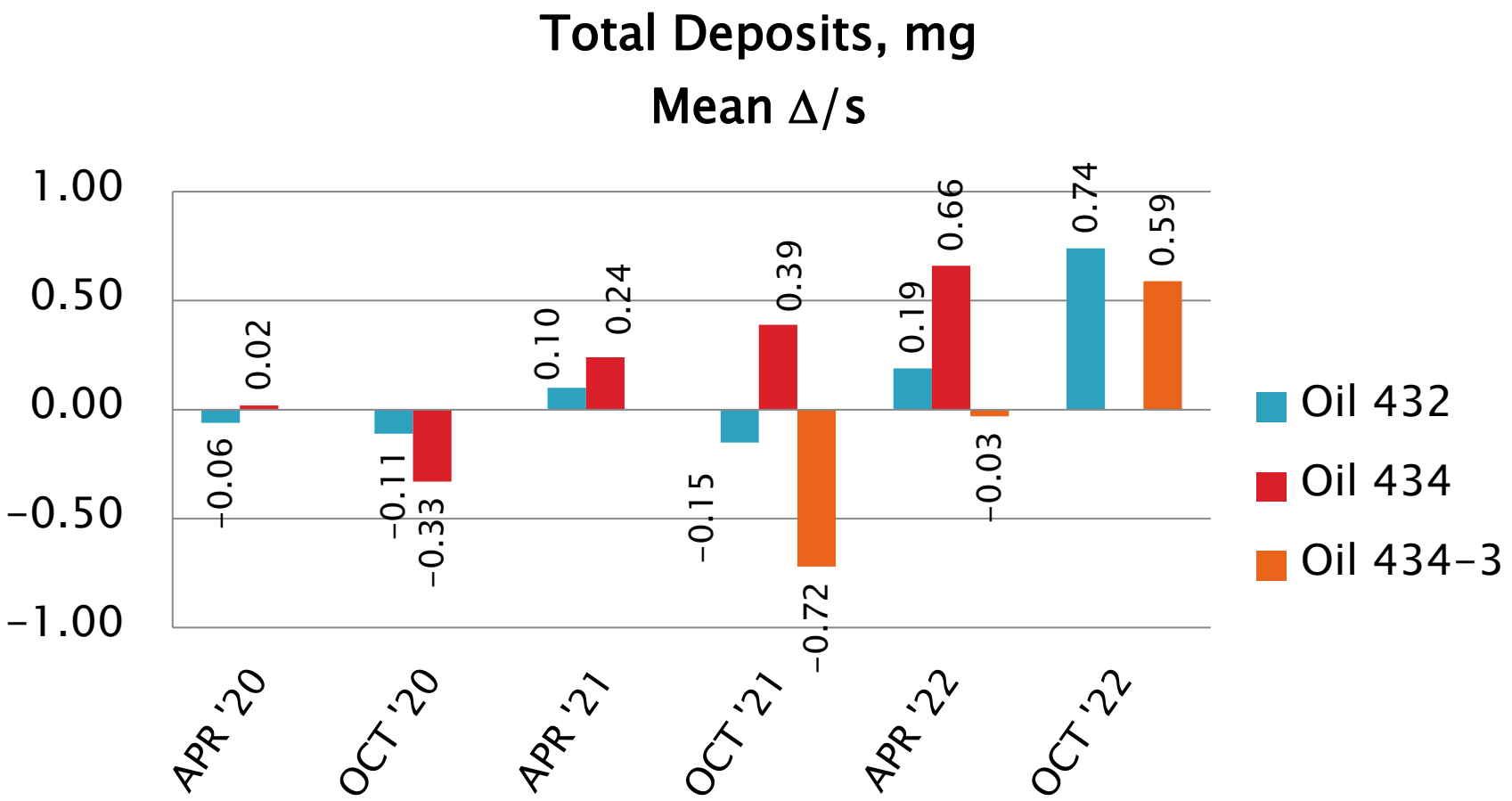
# D7097: Deposits by MHT TEOST



# D7097: Deposits by MHT TEOST

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# D02.B0.07
# TMC Monitored Tests

## ASTM D 6082

April 1, 2022 – September 30, 2022

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# D6082: High Temperature Foam

| Test Status | Validity Code | No. Tests |
|---|---|---|
| Acceptable Calibration Test | AC | 15 |
| Acceptable Discrimination Test | AS | 7 |
| Operationally Invalid, Reported as Valid | RC | 1 |
| **Total** | | **23** |

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 was one operationally invalid result this report period.
- There were no statistically unacceptable results this report period.

# D6082: High Temperature Foam

Period Precision and Severity Estimates

| Foam Tendency, ml | n | df | Pooled s | Mean Δ/s |
|---|---|---|---|---|
| Targets updated 20201001[1] | 18 | 17 | 9 | ----- |
| 4/1/18 through 9/30/18 | 14 | 13 | 9 | -0.07 |
| 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 |

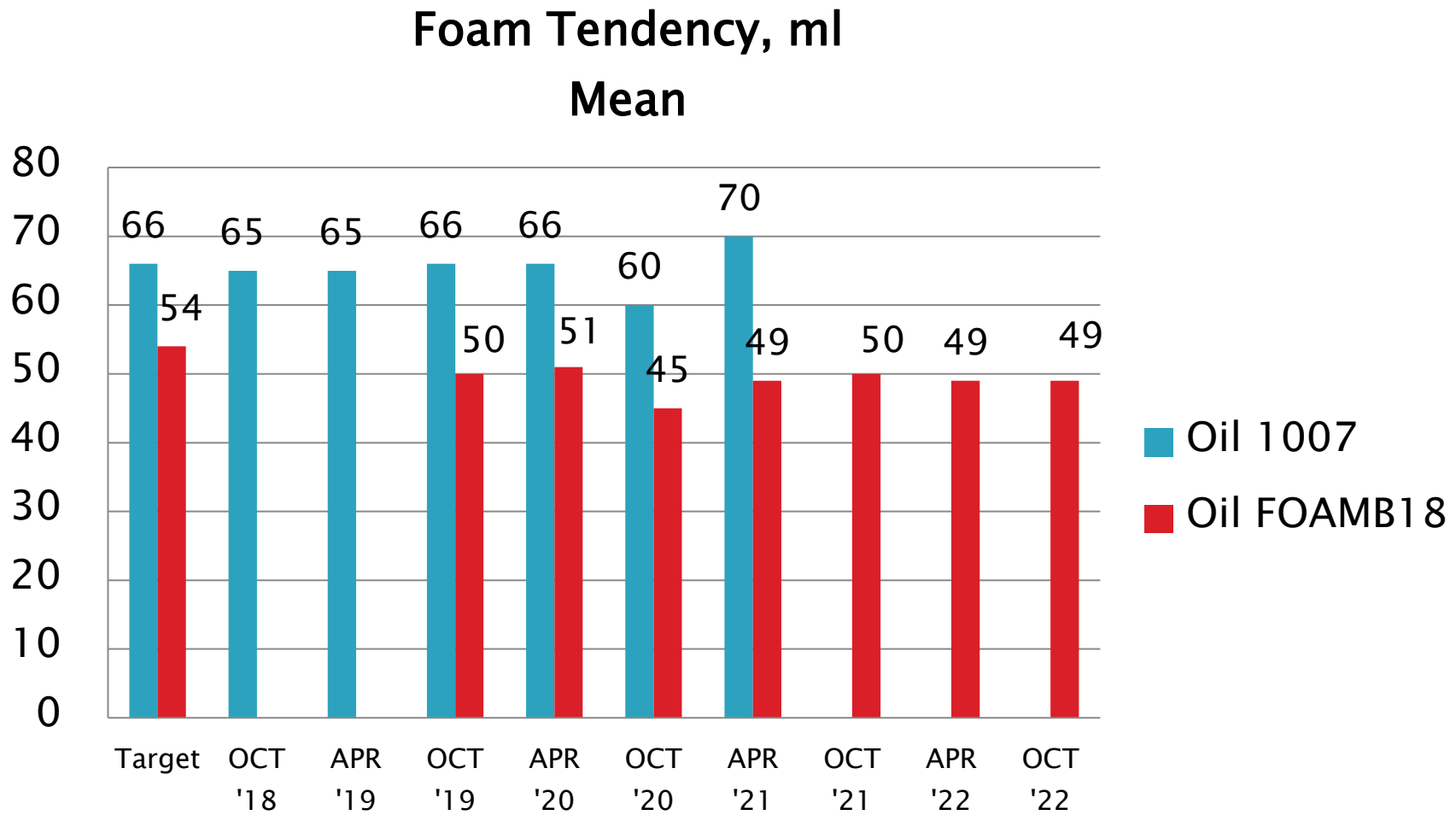
[1]Target precision updated to current reference oil FOAMB18

# D6082: High Temperature Foam

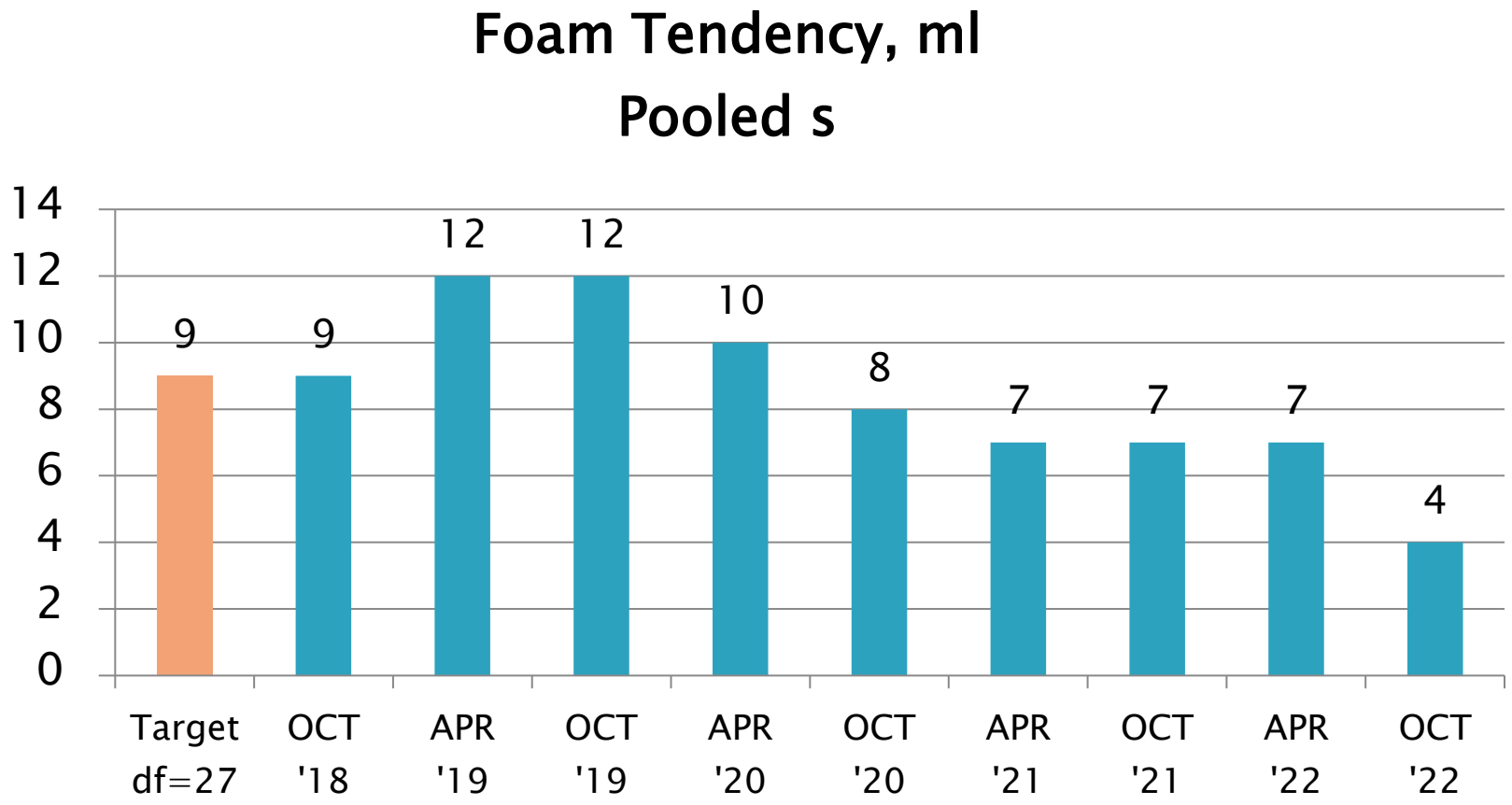
Period Precision and Severity Estimates

| Foam Stability @ 1 min, ml | n | Mean | s |
|---|---|---|---|
| Current Targets | 18 | 0.00 | 0.00 |
| 4/1/18 through 9/30/18 | 14 | No non-zero occurrences | |
| 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 | |

# D6082 Performance by Oil



# D6082: High Temperature Foam

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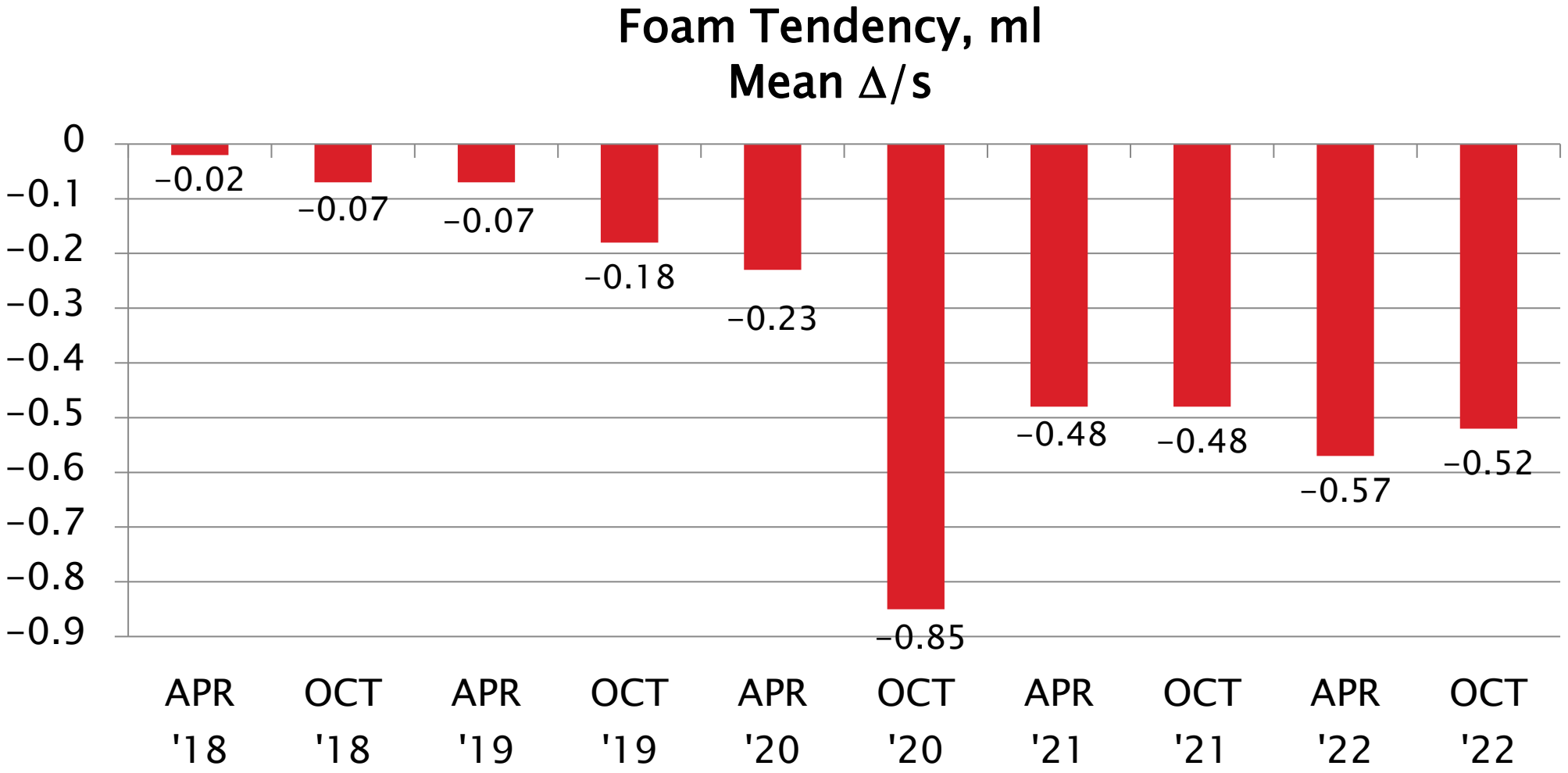
# D6082: High Temperature Foam

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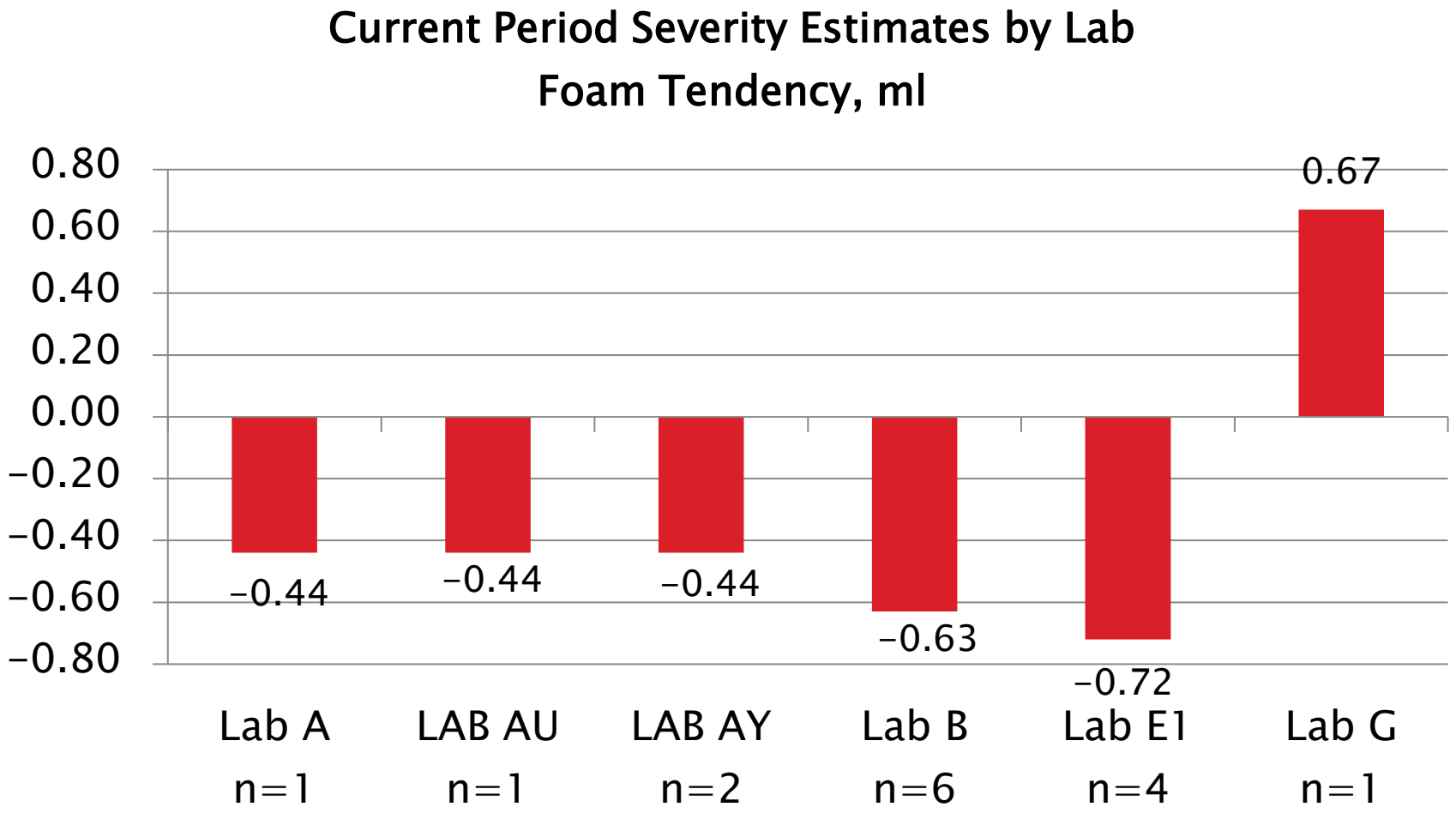
# D6082: High Temperature Foam

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# D6082: High Temperature Foam

- Foam Tendency Precision (Pooled s) is the same as last period
  - More precise than oil FOAMB18 target precision
    - Oil 1007 has been completely consumed. Third consecutive report period where all reference tests were conducted only on replacement oil FOAMB18.
- Performance (Mean Δ/s) is -0.52s mild
  - Three consistent periods of -0.5s 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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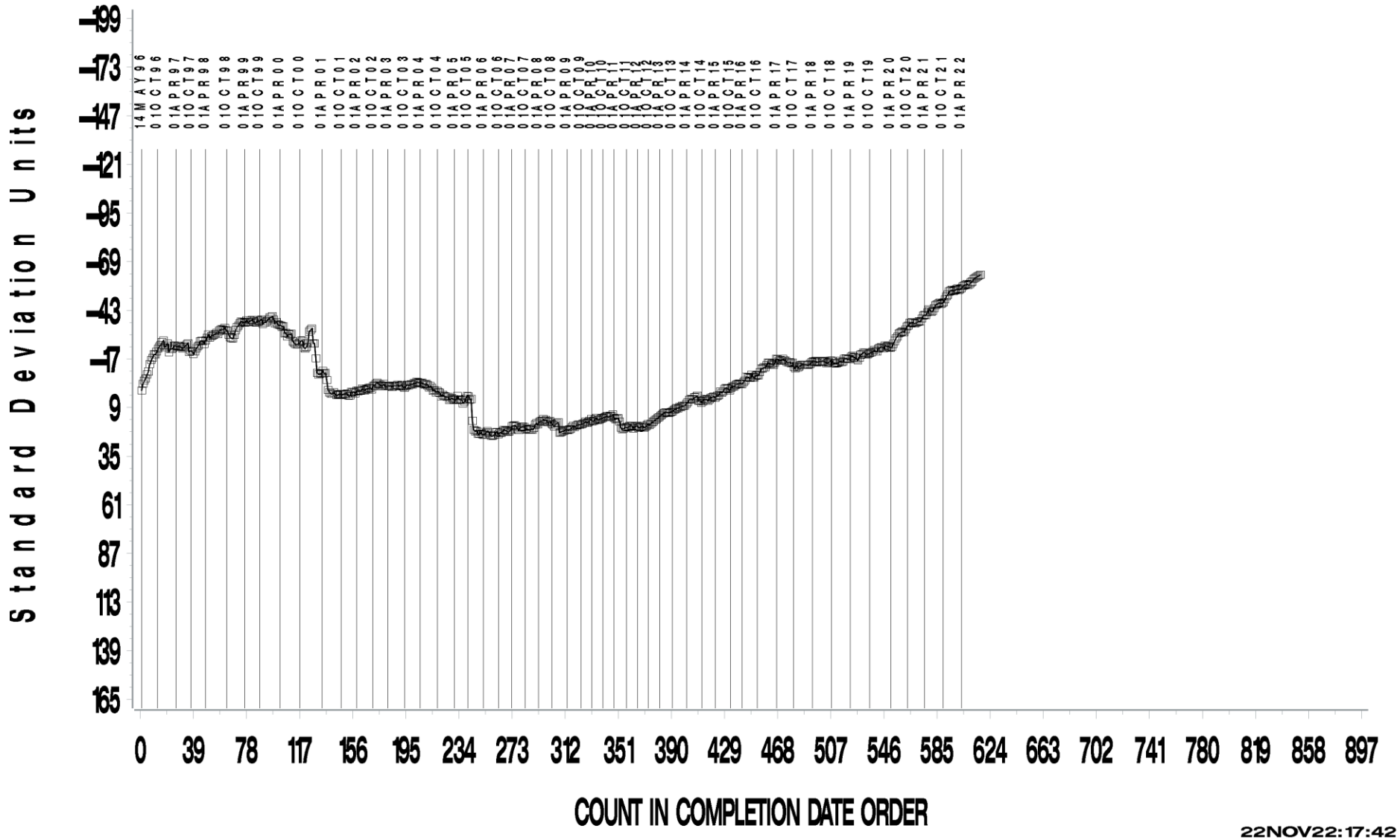
## FOAM TENDENCY

CUSUM Severity Analysis

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# D6082 HIGH TEMPERATURE FOAM INDUSTRY OPERATIONALLY VALID DA
## OIL FOAMB18 DATA ONLY
## FOAM TENDENCY

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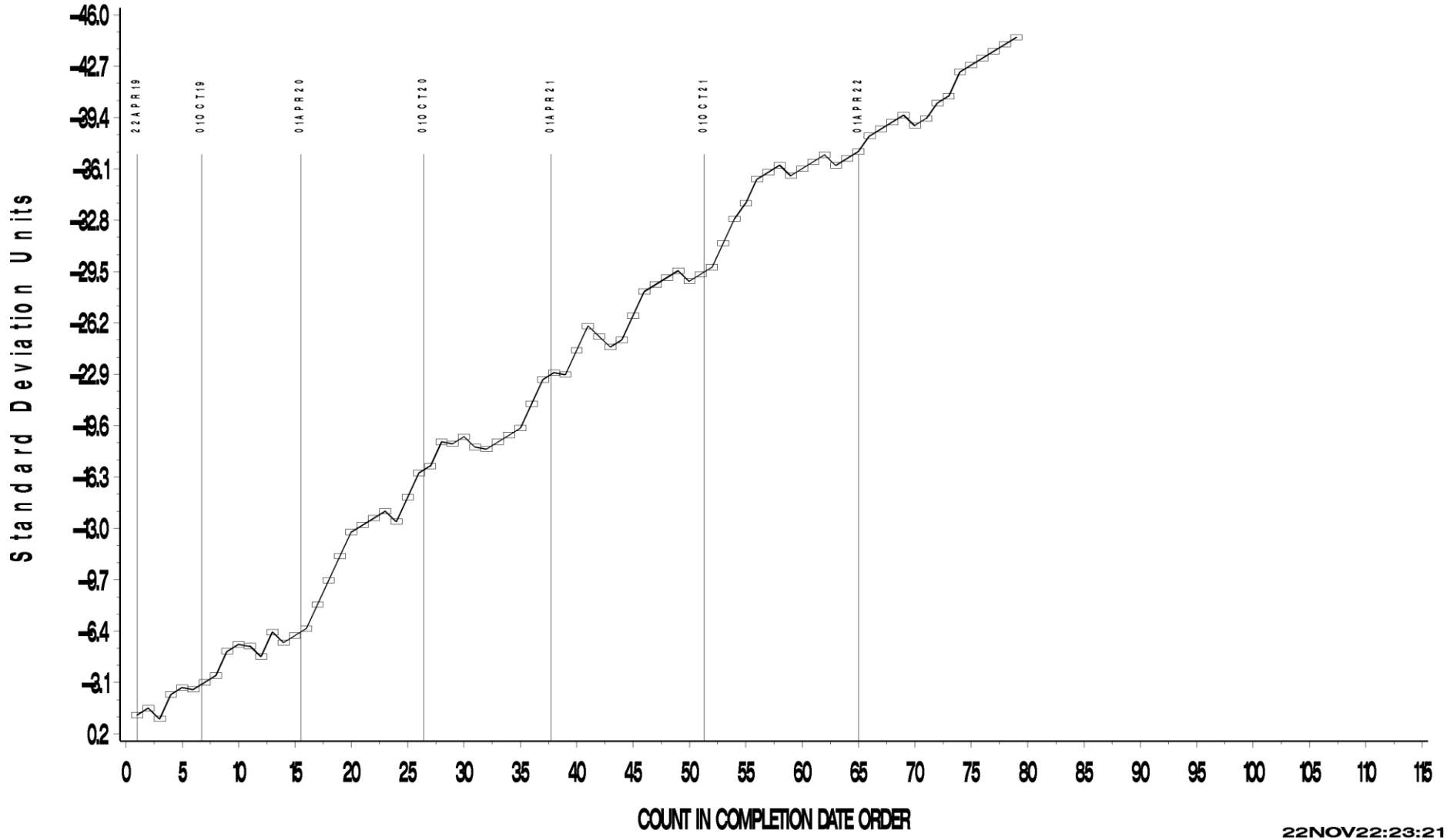
CUSUM Severity Analysis

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# D02.B0.07
# TMC Monitored Tests

## ASTM D 874

April 1, 2022 – September 30, 2022

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# D874: Sulfated Ash

| Test Status | Validity Code | No. Tests |
|---|---|---|
| Acceptable Calibration Test | AC | 8 |
| **Total** | | **8** |

Number of Labs Reporting Data: 4
Fail Rate of Operationally Valid Tests: 0%

# D874: Sulfated Ash

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

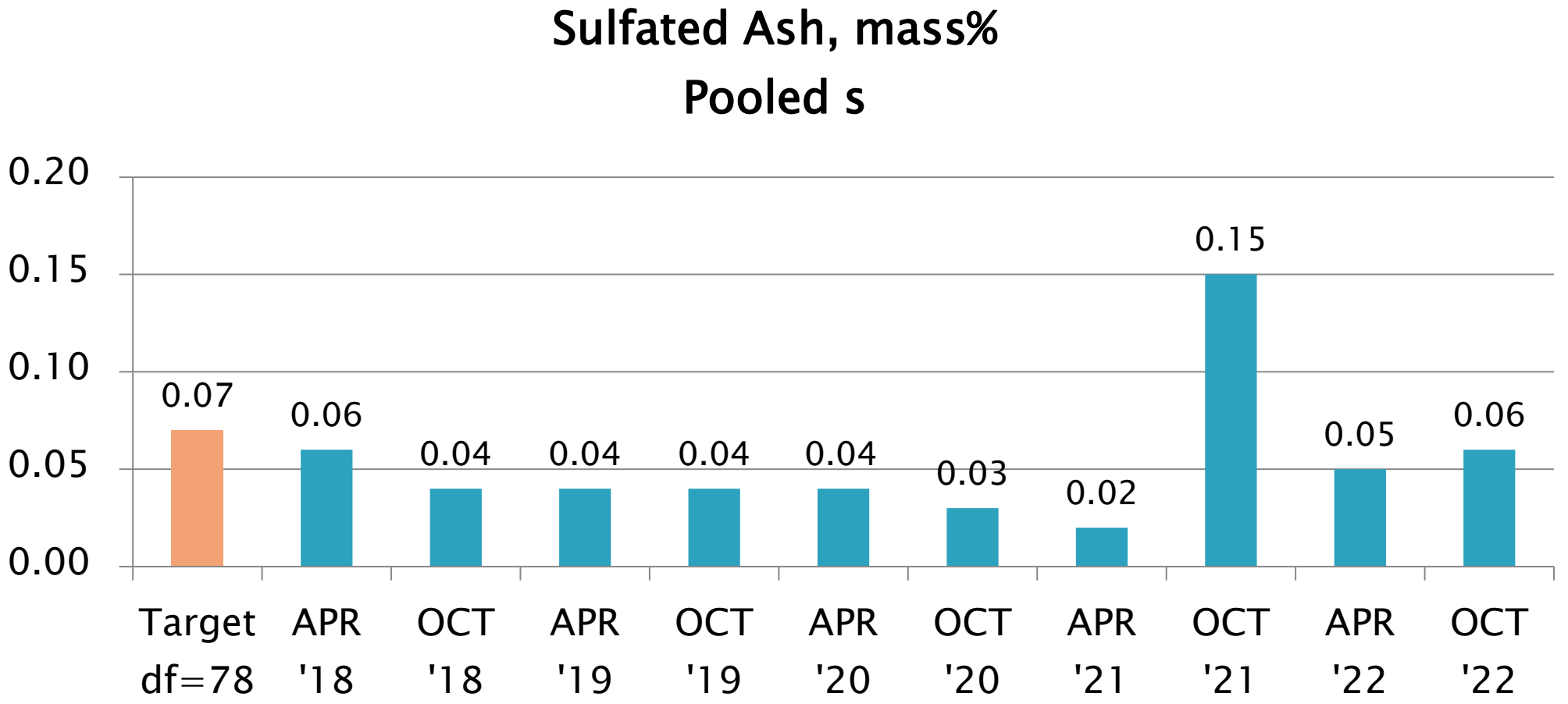
- No operationally invalid or statistically unacceptable tests this report period.

# D874: Sulfated Ash

Period Precision and Severity Estimates

| Total Deposits, mg | n | df | Pooled s | Mean Δ/s |
|---|---|---|---|---|
| Current Targets | 81 | 78 | 0.07 | ----- |
| 4/1/18 through 9/30/18 | 8 | 5 | 0.04 | -0.22 |
| 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 |

# D874: Sulfated Ash

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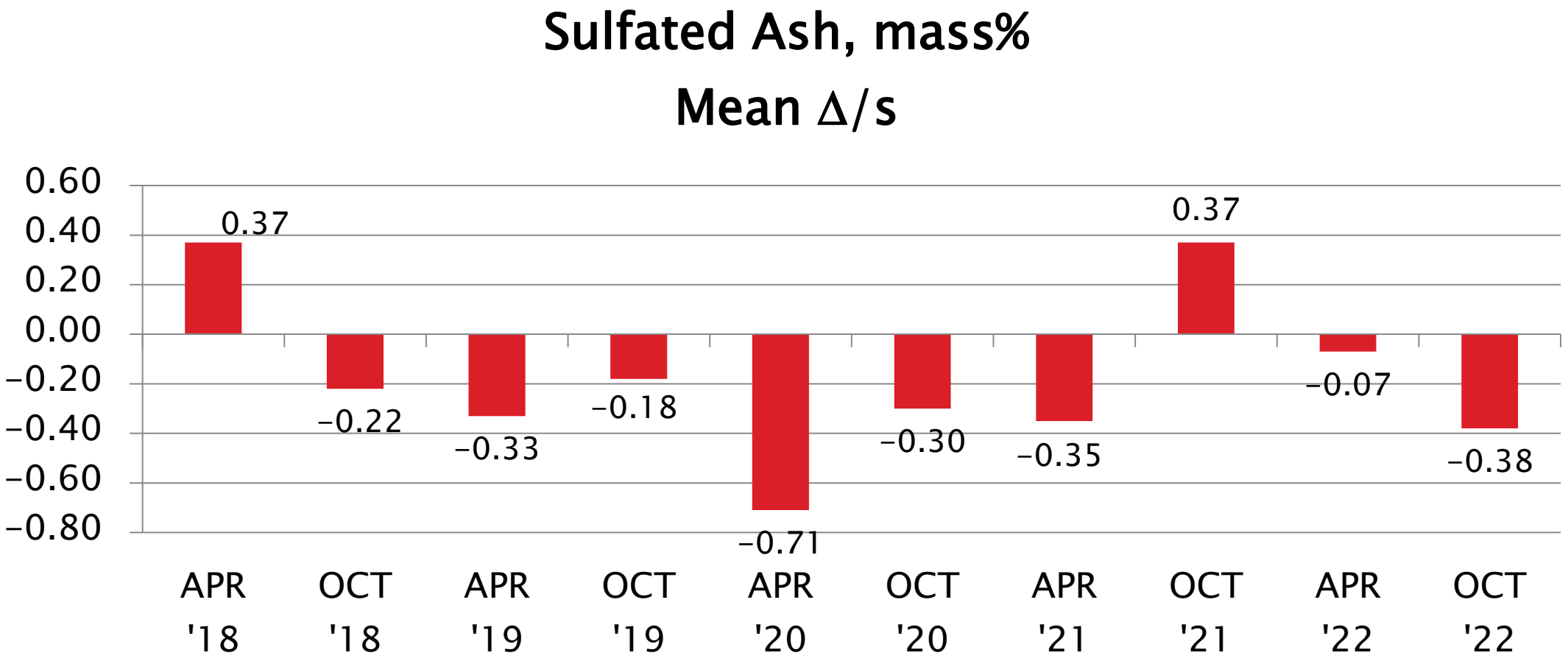
# D874: Sulfated Ash

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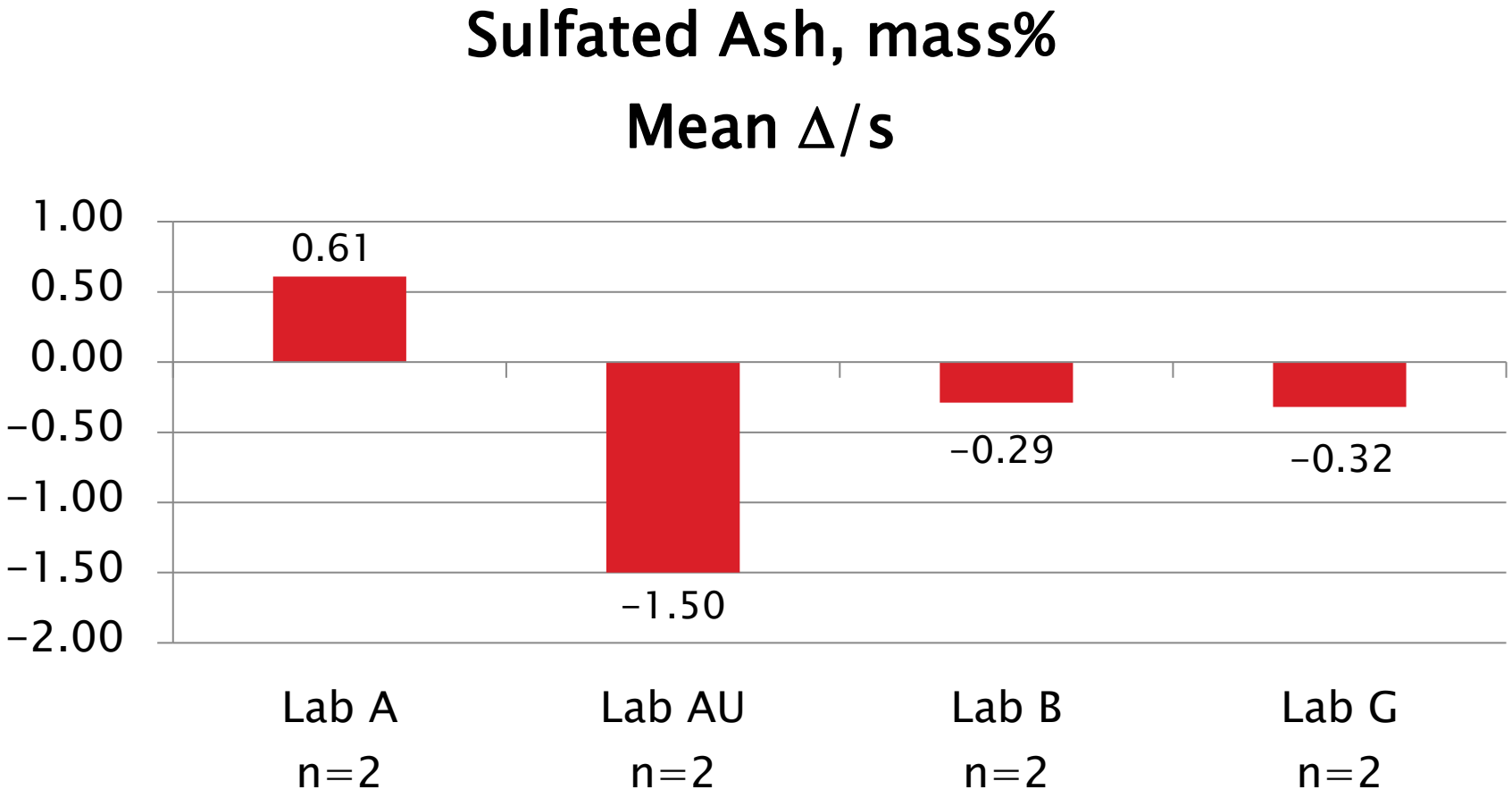
# D874: Sulfated Ash

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# D874: Sulfated Ash

- Precision (Pooled s) is almost identical with respect to the previous period and is in line with historical estimates
- Performance (Mean $\Delta/s$) has regressed to -0.38 s

# D874 INDUSTRY OPERATIONALLY VALID DATA

## TEST SAMPLE PERCENT SULFATED ASH

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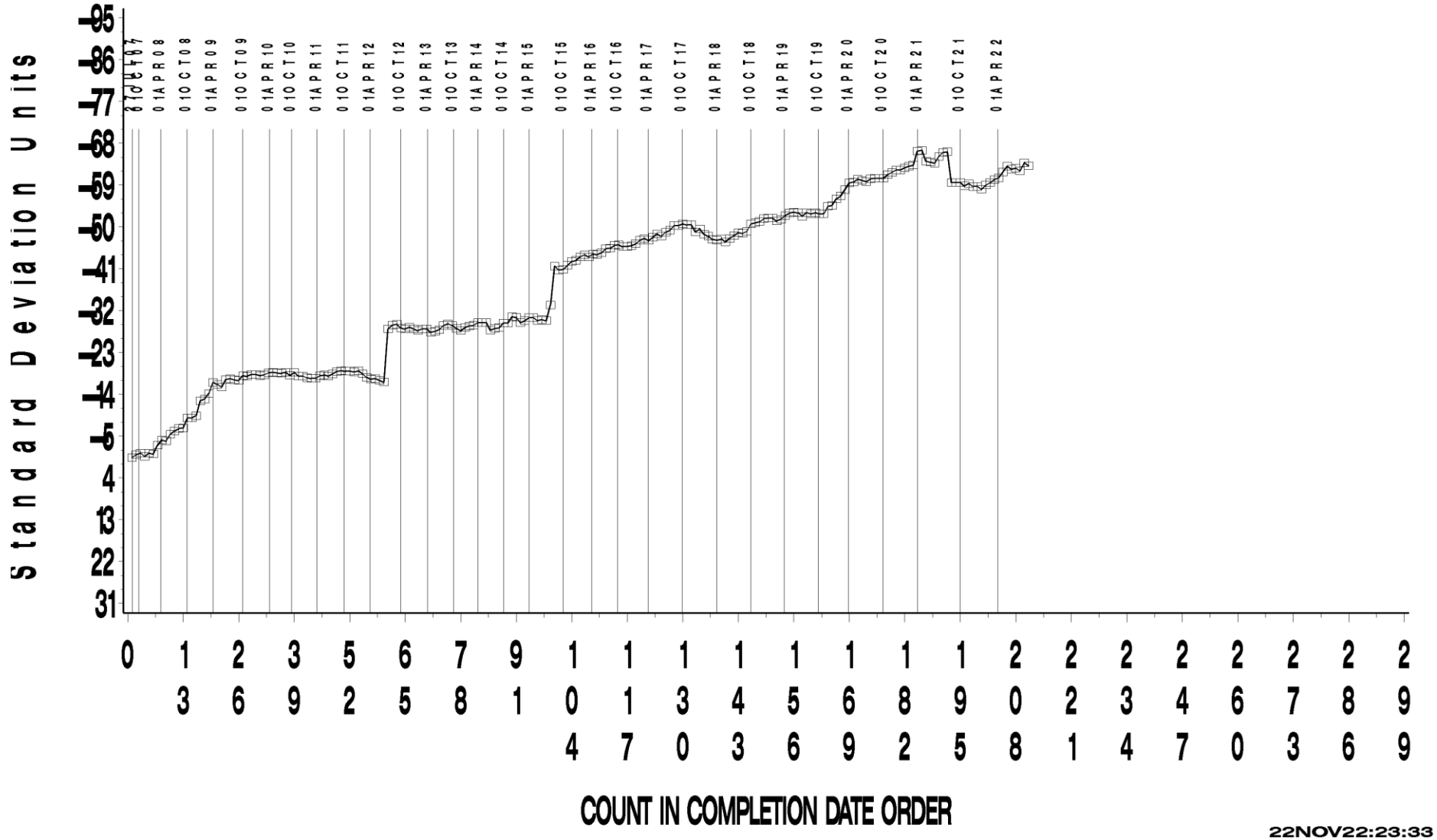
CUSUM Severity Analysis

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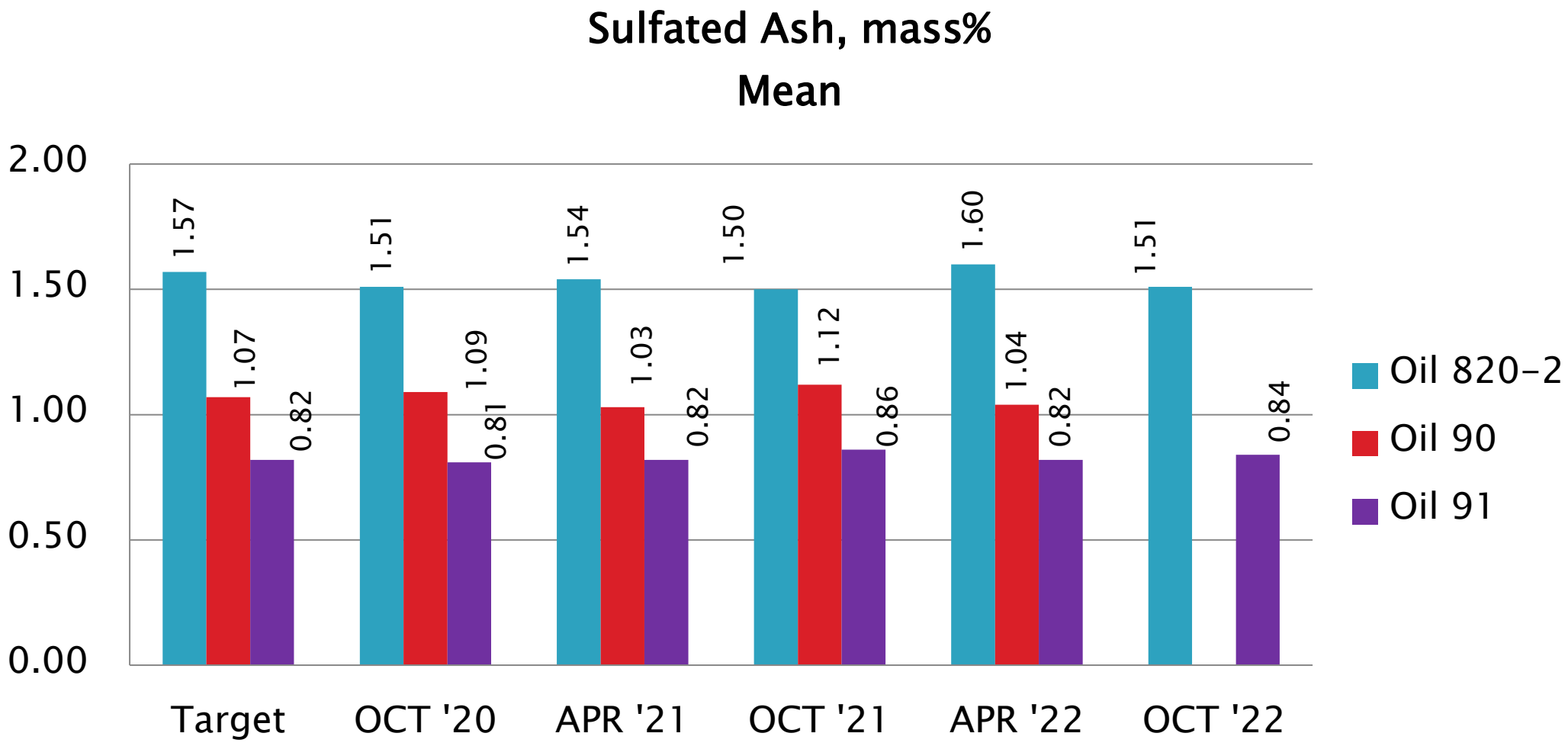
# D874: Sulfated Ash

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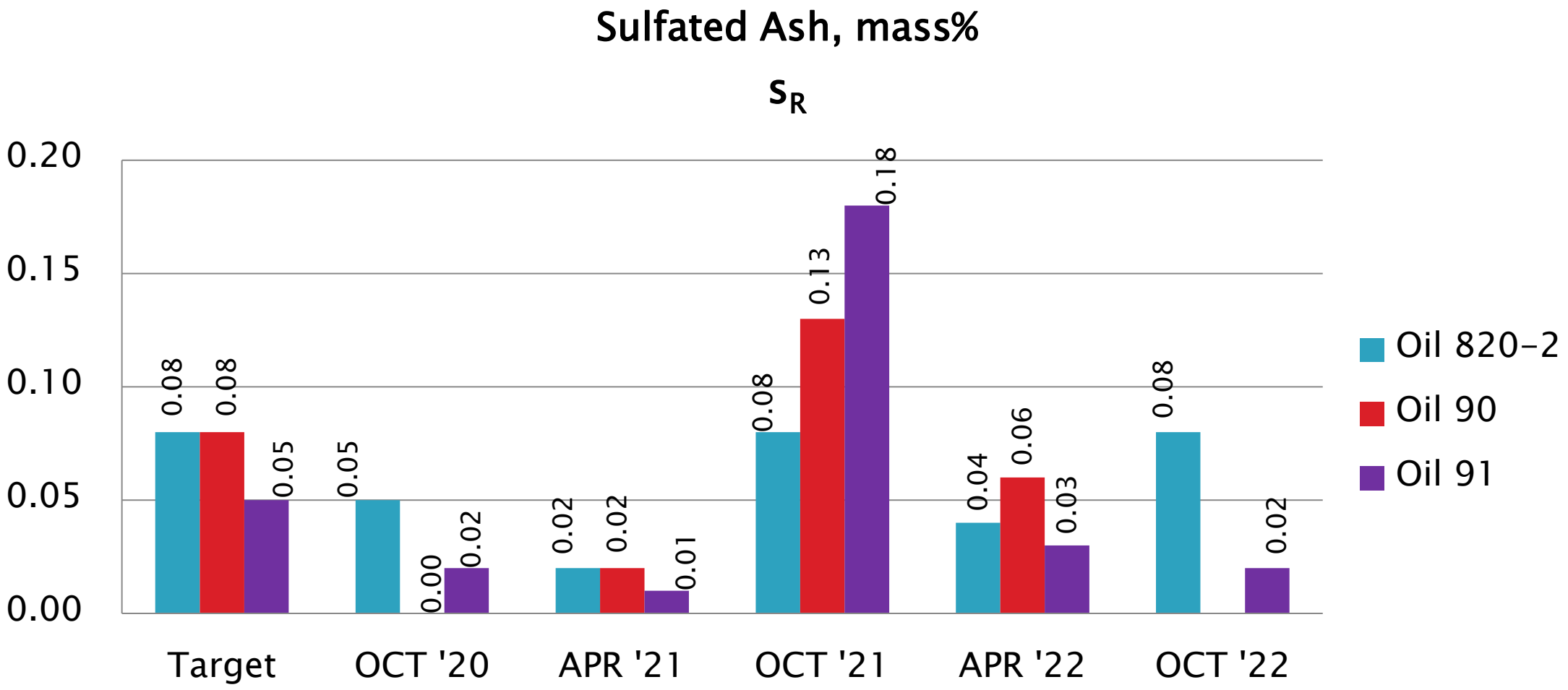
# D874: Sulfated Ash

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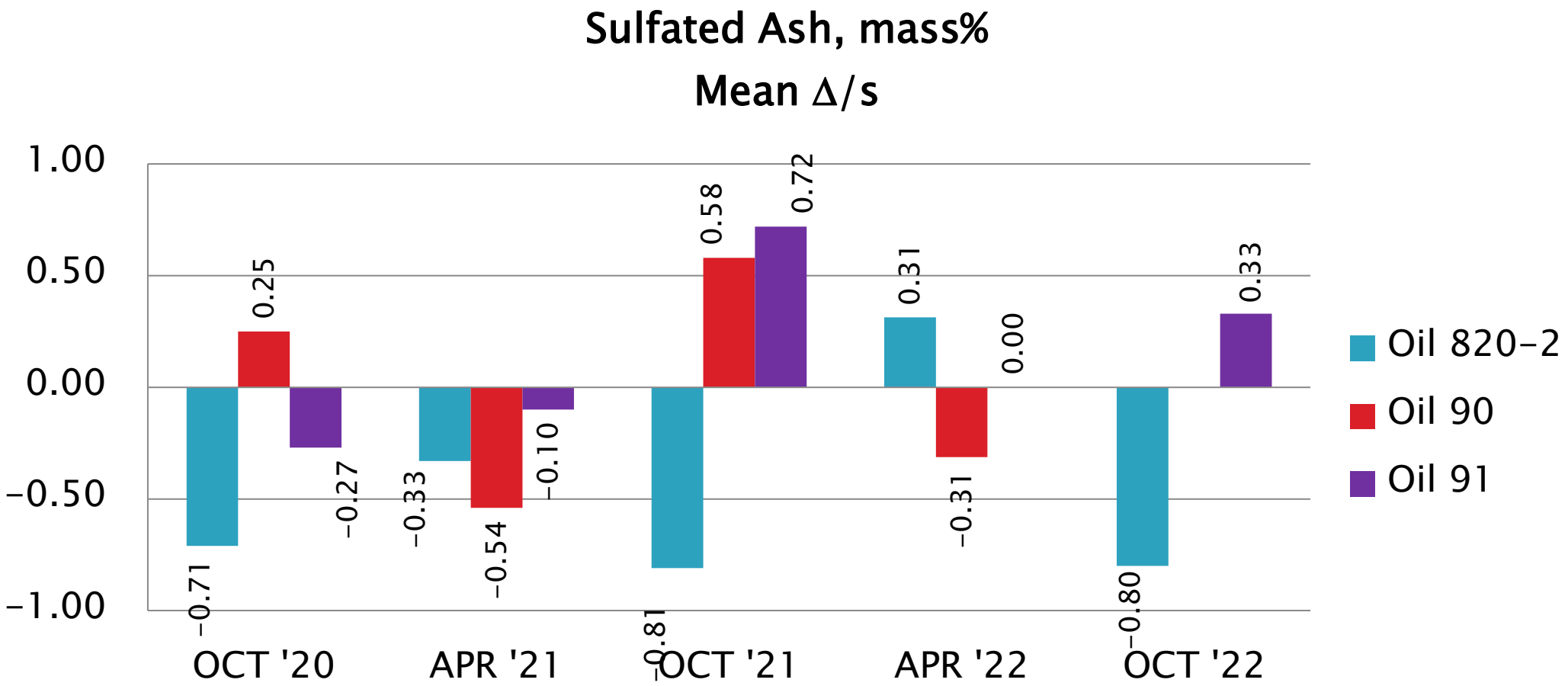
# D874: Sulfated Ash

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# D02.B0.07
# TMC Monitored Tests

## ASTM D 7528

April 1, 2022 – September 30, 2022

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# D7528: Oxidation by ROBO

| Test Status | Validity Code | No. Tests |
|---|---|---|
| Acceptable Calibration Test | AC | 95 |
| Failed Calibration Test | OC | 10 |
| Operationally Invalidated by Lab | LC, XC | 5 |
| Operationally Invalidated After Initially Reported as Valid | RC | 2 |
| **Total** | | **112** |

Number of Labs Reporting Data: 10
Fail Rate of Operationally Valid Tests: 11%

# D7528: Oxidation by ROBO

| Statistically Unacceptable Tests (OC) | No. Of Tests |
|---|---|
| Natural Log (MRV Viscosity) Mild | 7 |
| Natural Log (MRV Viscosity) Severe | 3 |
| **Total** | **10** |

- Information Letter 21-1 was issued 11/3/21 and added an option to use dilute nitrogen dioxide in air

# D7528: Oxidation by ROBO

## Operationally Invalid Calibration Tests

| Test Status | Cause | # |
|---|---|---|
| Invalid | Yield stress >35kPa | 4 |
| Aborted | Vacuum Pump Failure | 1 |
| Aborted | Electric Supply Failure | 1 |
| Aborted | Lost Sample | 1 |
| **Totals** | | **7** |

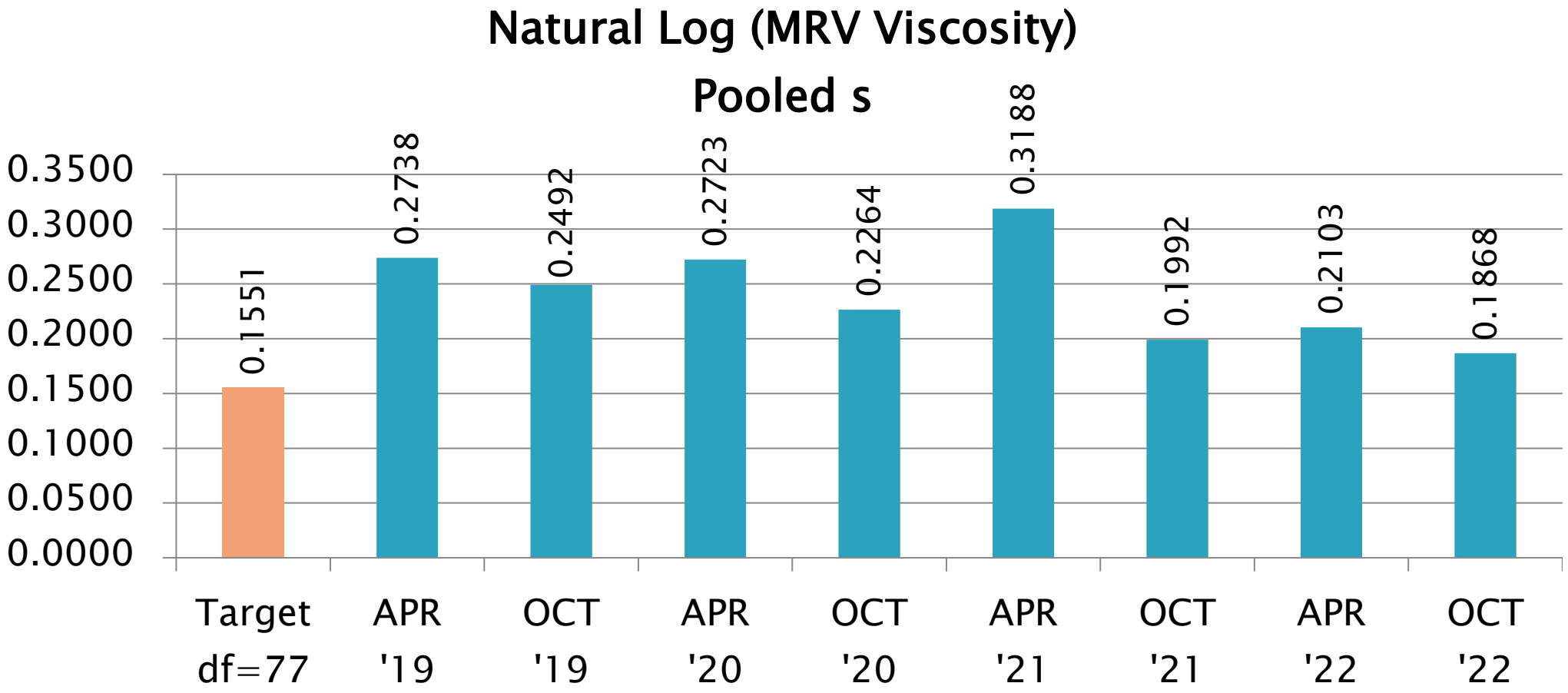
# D7528: Oxidation by ROBO

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 |

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

# D7528: Oxidation by ROBO

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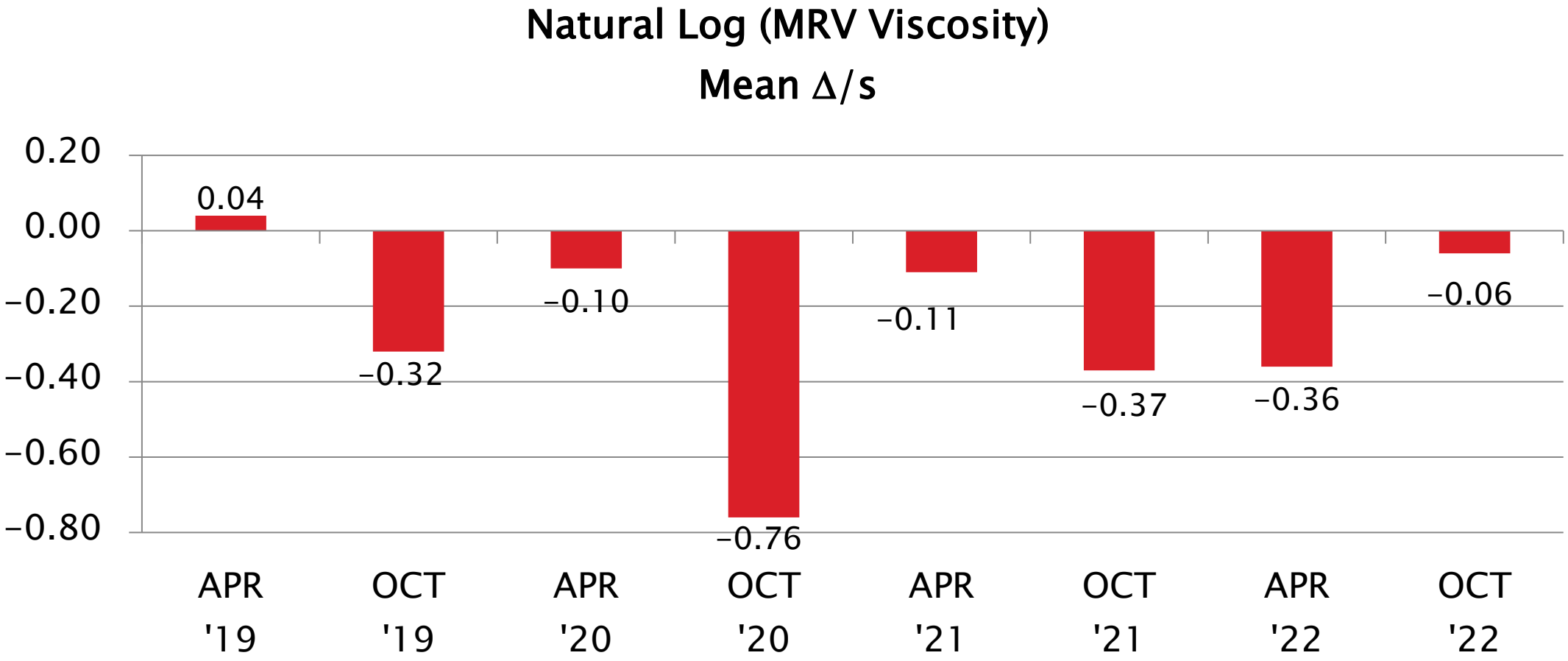
# D7528: Oxidation by ROBO

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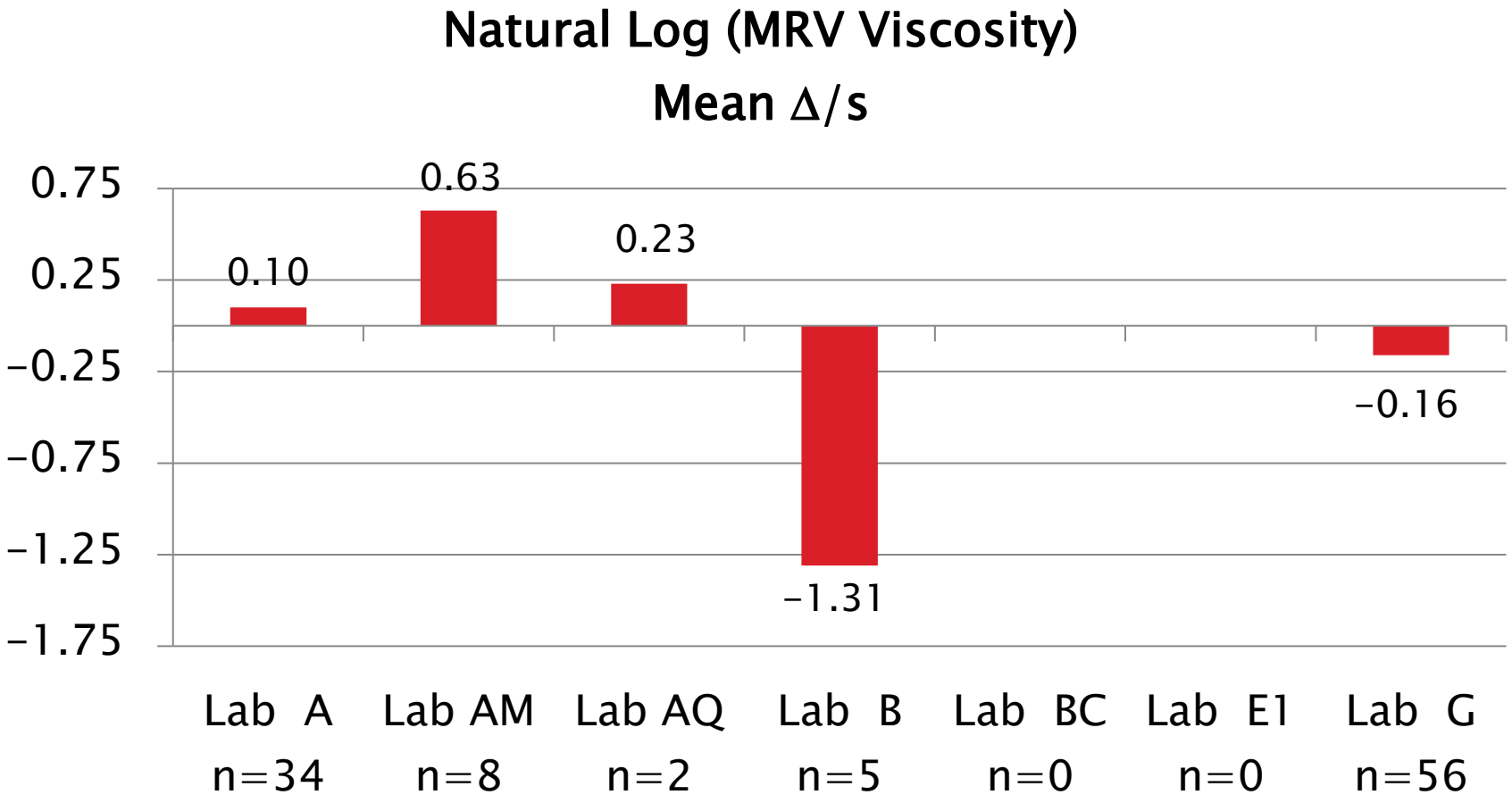
# D7528: Oxidation by ROBO



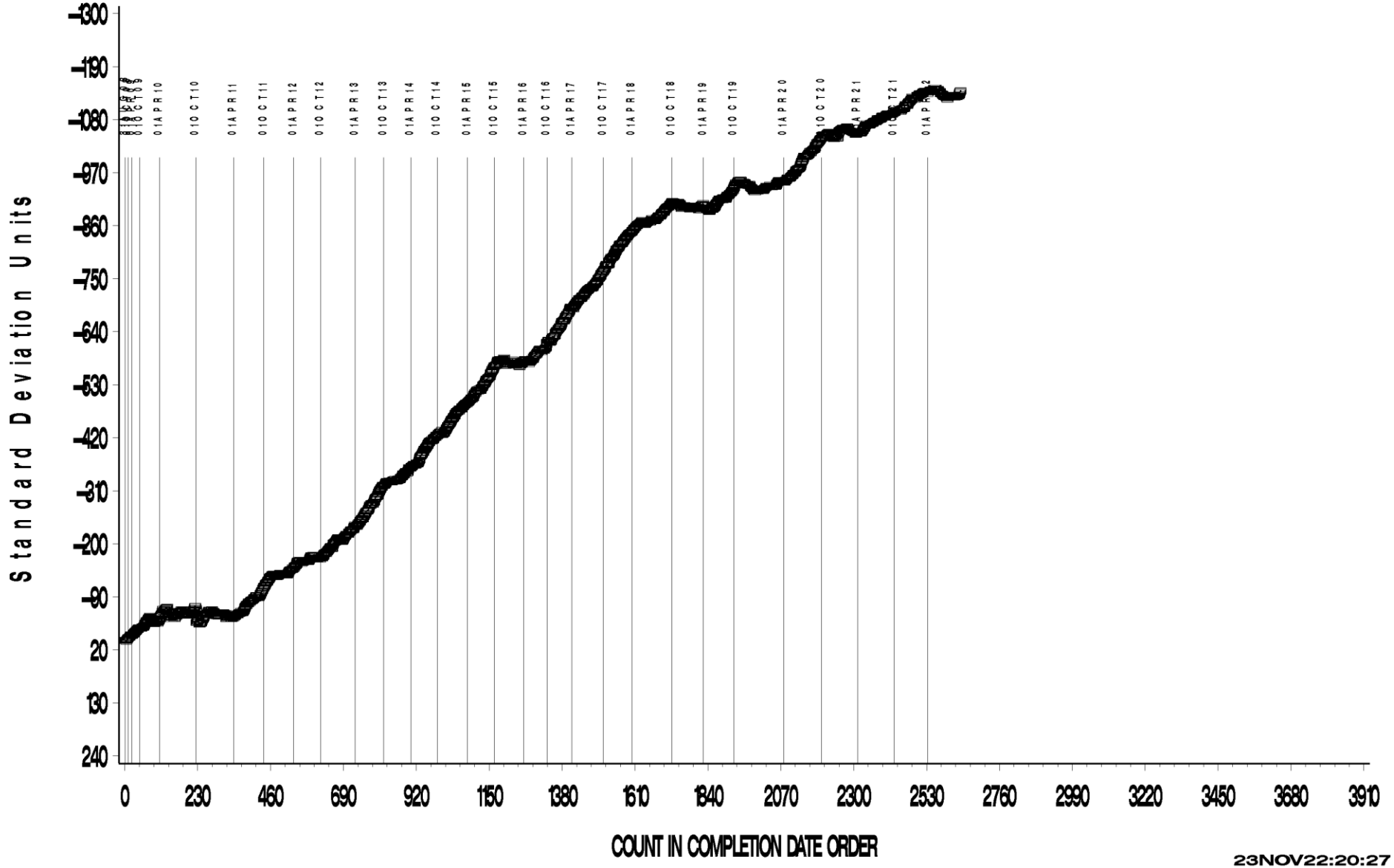
# D7528: Oxidation by ROBO

- Precision (Pooled s) is comparable to recent report periods but directionally better when compared to target precision
- Severity (Mean $\Delta$/s) is -0.06 s mild for this report period
- CUSUM severity plot shows long term mild trend of varying levels
- Two labs did not report any runs this period

# ROBO TEST INDUSTRY OPERATIONALLY VALID DATA

## AGED OIL MRV APPARENT VISCOSITY

CUSUM Severity Analysis

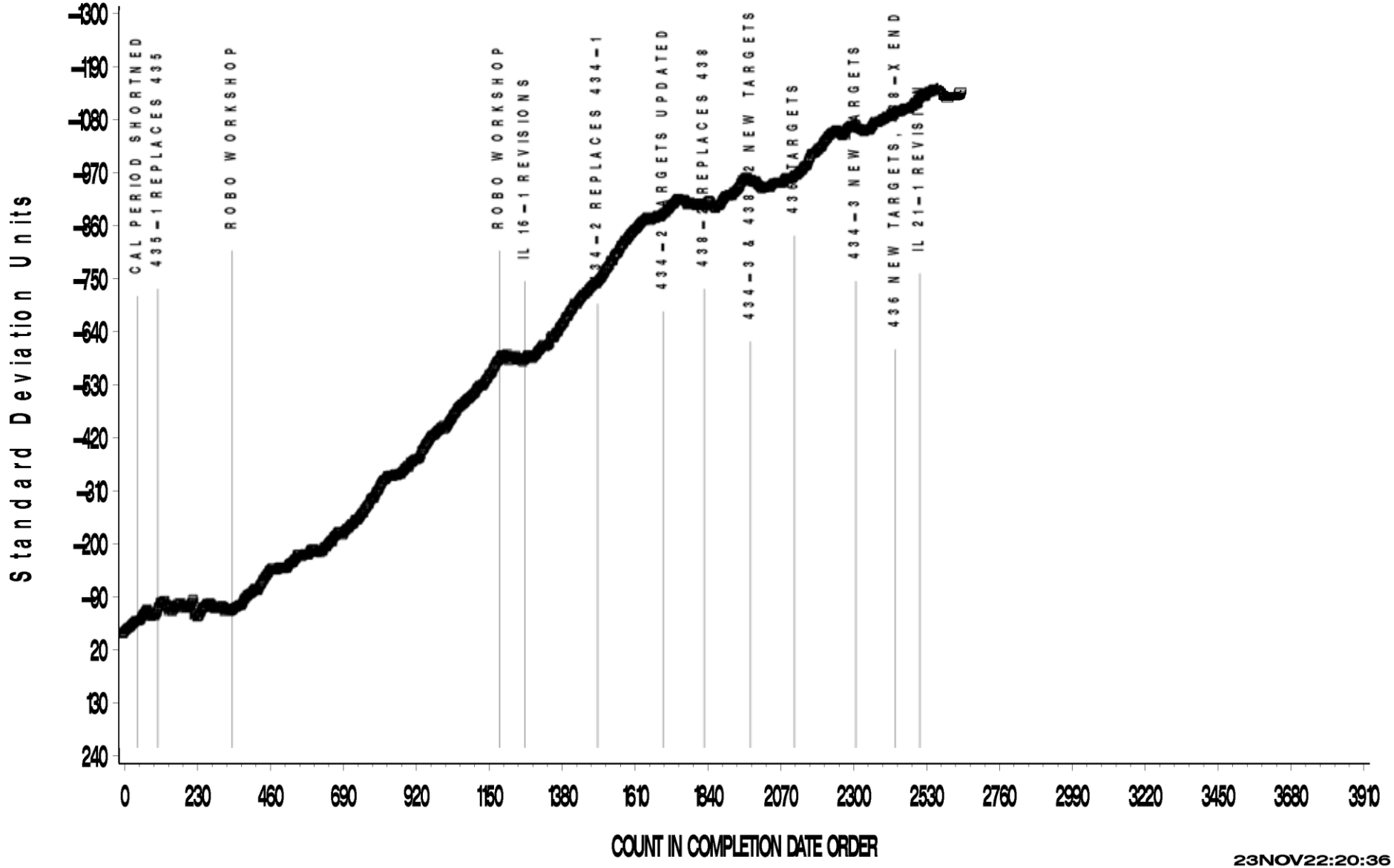



23NOV22:20:27

# ROBO TEST INDUSTRY OPERATIONALLY VALID DATA

## AGED OIL MRV APPARENT VISCOSITY

CUSUM Severity Analysis

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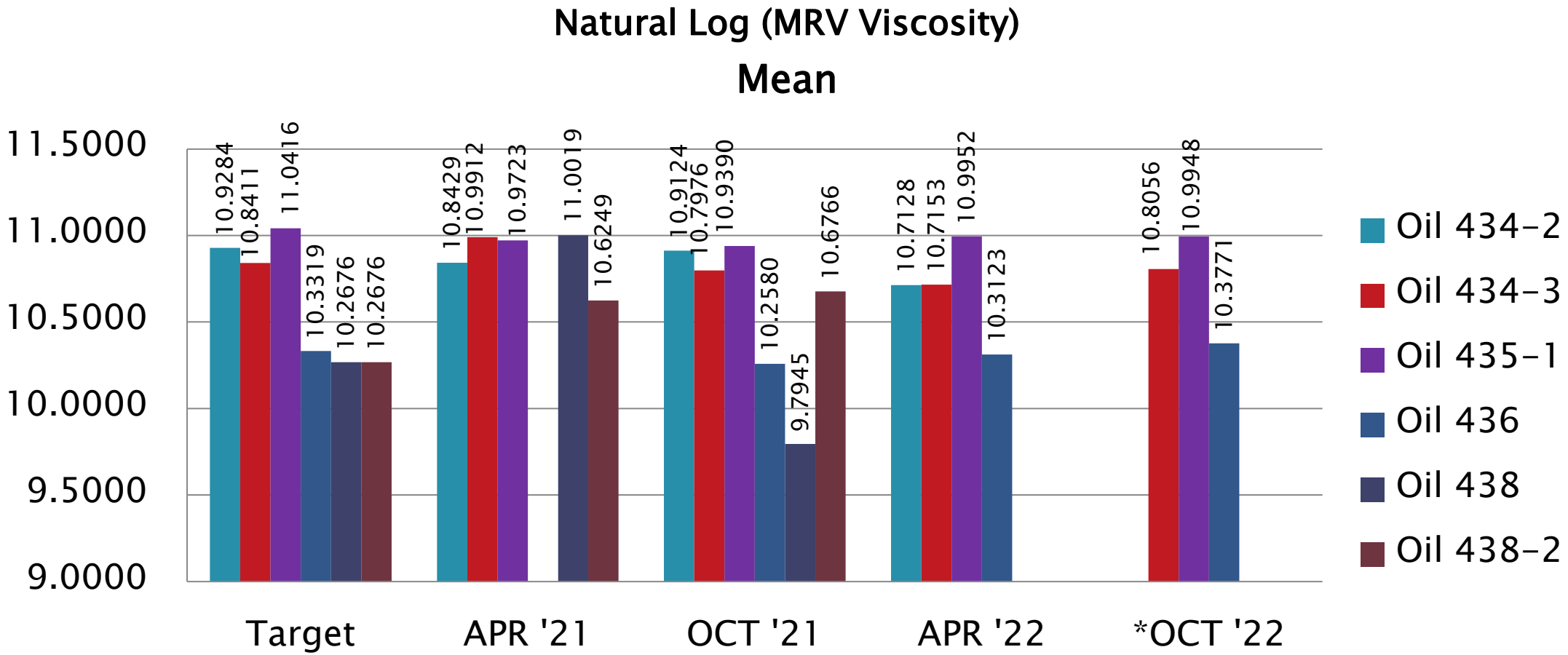
# D7528: Oxidation by ROBO




*Single Oil 434-2 Run Not Included in this Analysis

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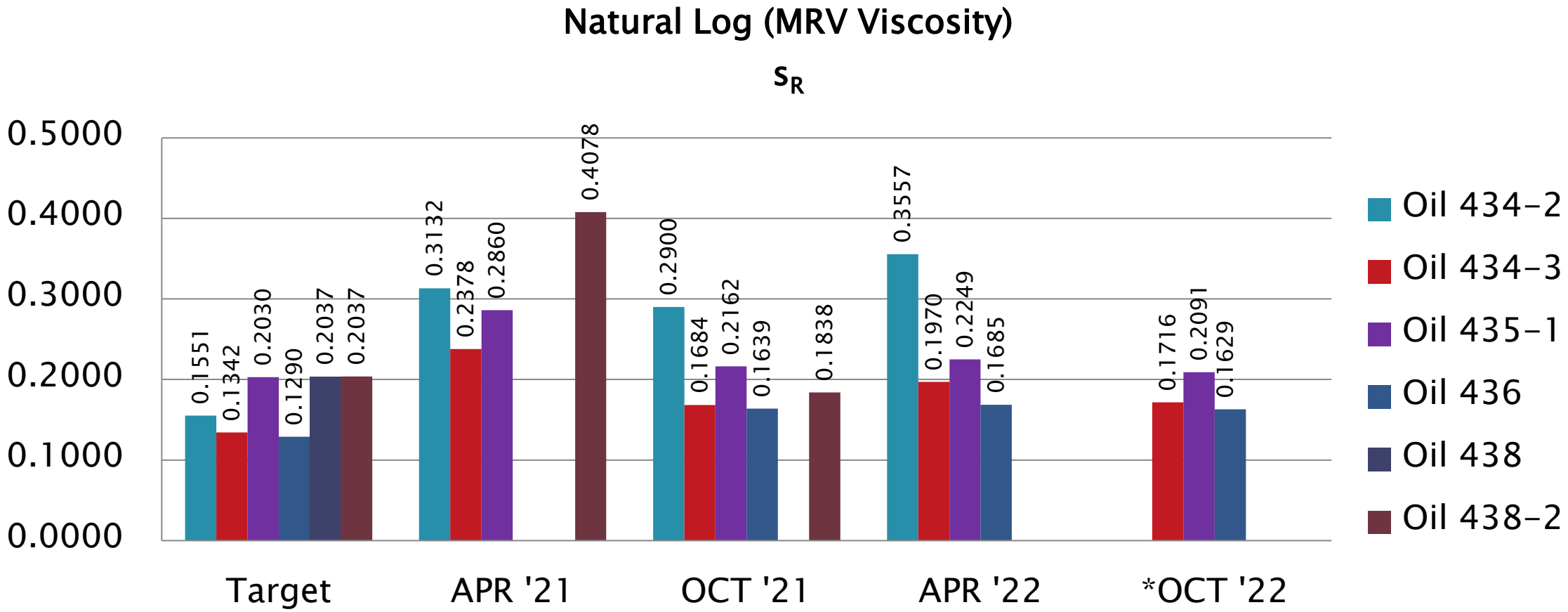
# D7528: Oxidation by ROBO




*Single Oil 434-2 Run Not Included in this Analysis

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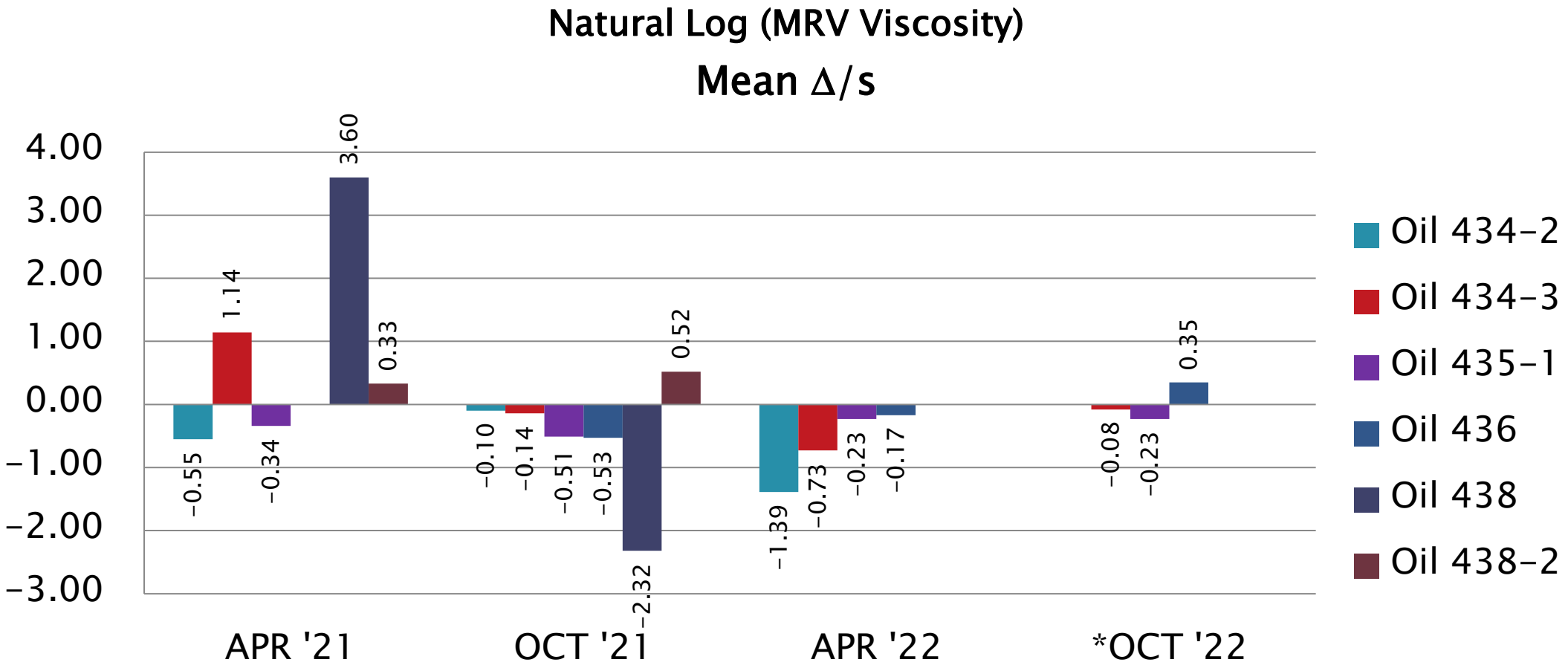
# D7528: Oxidation by ROBO




*Single Oil 434-2 Run Not Included in this Analysis

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# Reference Oil Inventory

As of 9/30/2022

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# Reference Oil Inventory

## D5800

| Oil | Year Rec'd By TMC[A] | Tests | TMC Inventory, gallons | Gallons Shipped last 6 months |
|---|---|---|---|---|
| VOLC12 | 2013 | D5800 | 24.6 | 2.2 |
| VOLD12 | 2013 | D5800 | 25.2 | 2.4 |
| VOLE12 | 2013 | D5800 | 22.8 | 2.1 |
| VOLD18 | 2018 | D5800QC | 832 | 82 |

[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 |
|---|---|---|---|---|
| 52 | 1995 | D6417 | 59.4 | 0.02 |
| 55 | 1995 | D6417 | 65.9 | 0.03 |
| 58 | 1998 | D6417, D6417QC, GI | 111.3 | 0.2 |
| GIA17 | 2017 | GI | 6.3 | 2.0 |
| GIC18 | 2018 | GI | 9.2 | 0.6 |
| 1009 | 2002 | GI | 35.7 | 0.2 |

[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 |
|---|---|---|---|---|
| 432 | 1998 | MTEOS | 102.0 | 0.4 |
| 75-1 | 2016 | TEOST | 3.2 | 1.1 |
| 435-2[B] | 2010 | TEOST | 35.4 | 1.0 |
| 434-3[B] | 2017 | ROBO/MTEOS | 28.3 | 3.2 |
| 435-1 | 2008 | ROBO | 336.8 | 11.3 |
| 436[B] | 2014 | ROBO | 39.9 | 1.2 |

[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 |
|---|---|---|---|---|
| FOAMB18 | 2018 | D6082 | 79.3 | 3.0 |
| 66 | 2002 | D6082 | 71.9 | 1.0 |
| 820-2 | 2001 | D874 | 3.3 | 0.1 |
| 90 | 2005 | D874/D874QC | 6.9 | 4.8 |
| 91 | 2006 | D874 | 3.10 | 0.1 |

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

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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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