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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)

April 2015

B0.07 Bench Testing Executive Summary

- D6417 (Volatility by GC)
- Less precise than last period
  - Comparable to the target precision
- Performance (Mean Δ/s) is on-target (-0.01 s)
- CUSUM plot shows variability with overall on-target performance this period following a slight mild trend last.

B0.07 Bench Testing Executive Summary

- D5800 (Volatility by Noack)
- Precision (Pooled s), at 0.80 mass %, is more precise than prior period but still less precise compared to the target precision (0.50 mass %).
- Performance (Mean Δ/s) is 0.44 s severe.
  - More severe than prior period (0.38 s)
- Fail rate of operationally valid tests (AC & OC) is 27% compared to 36% last report period.

B0.07 Bench Testing
Executive Summary

- D5800 (Volatility by Noack)
  - Comparing the past 19 months of data on the new reference oils to the prior 19 months on the old reference oils shows only a modest decrease in overall severity and somewhat worse overall precision.

B0.07 Bench Testing Executive Summary

- D5133 (Gelation Index)
  - Improved precision compared to prior period
    - More precise than target precision
  - Performance 0.12 s severe

B0.07 Bench Testing Executive Summary

- D6335 (TEOST-33C)
  - Precision (Pooled s) is more precise than prior period
    - More precise than the target precision
  - Performance (Mean Δ/s) is -0.28 s Mild
- D7097 (MHT-4 TEOST)
  - Precision (Pooled s) is more precise than prior periods
    - Less precise than target precision.
  - Performance (Mean Δ/s) is on target
    - Significant lab performance differences persist
    - Catalyst affects on oil severity are indicated
    - Overall severe performance of oil 432 (0.38 s, n=50) is nearly offset by overall mild performance of oil 434 (-0.39 s, n = 40), with mostly new CATBATCH 14AA being run this period. Similar bias to prior CATBATCH 1307.

B0.07 Bench Testing Executive Summary

- D6082 (High Temperature Foam)
  - Improved precision this period
    - More precise than target precision
  - Performance –0.26 s mild
  - All operationally valid discrimination runs demonstrated acceptable discrimination

- D874 (Sulfated Ash)
  - Period precision equal to target precision
  - Performance –0.25 s mild
  - No issues

B0.07 Bench Testing
Executive Summary

- D7528 (ROBO)
- 19% fail rate for operationally valid tests

- Precision (Pooled s) is considerably less precise than prior period
  - Less precise than target precision

- Performance (Mean Δ/s) is −0.69 s mild
  - Seven of seven labs performing overall mild

- CUSUM Severity Plot shows an ongoing overall mild trend since the 01APR11 timeline

Calibrated Labs and Stands*

Test	Labs	Stands
D6417	5	7
D5800	8	21
D5133 (GI)	4	8
D6335 (TEOST)	5	7
D7097 (MTEOS)	6	35
D6082	4	5
D874	3	--
D7528 (ROBO)	7	19

*As of 3/31/2015

D02.B0.07
TMC Monitored Tests

- October 1, 2014 –
  March 31, 2015

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D6417: Estimation of Engine Oil Volatility by Capillary GC

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	14
Failed Calibration Test	OC	0
Operationally Invalidated by Lab	LC, XC	0
Operationally Invalidated After Initially Reported as Valid	RC	1
Total		**15**

Number of Labs Reporting Data: 5
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

- Reason for single operational fail:
  - QC check sample not run on day of test

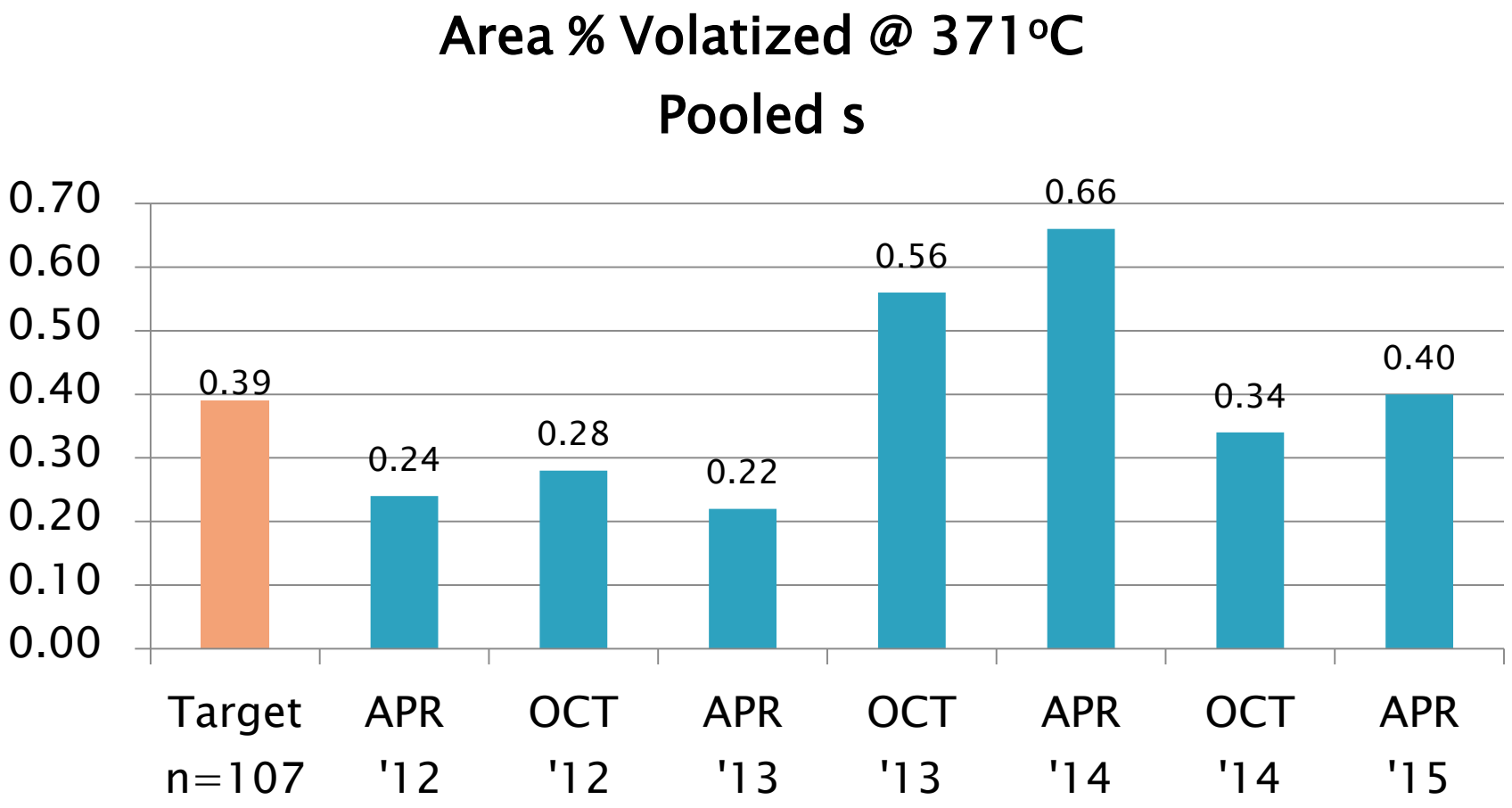
- No TMC technical updates issued this period

D6417: Estimation of Engine Oil Volatility by Capillary GC

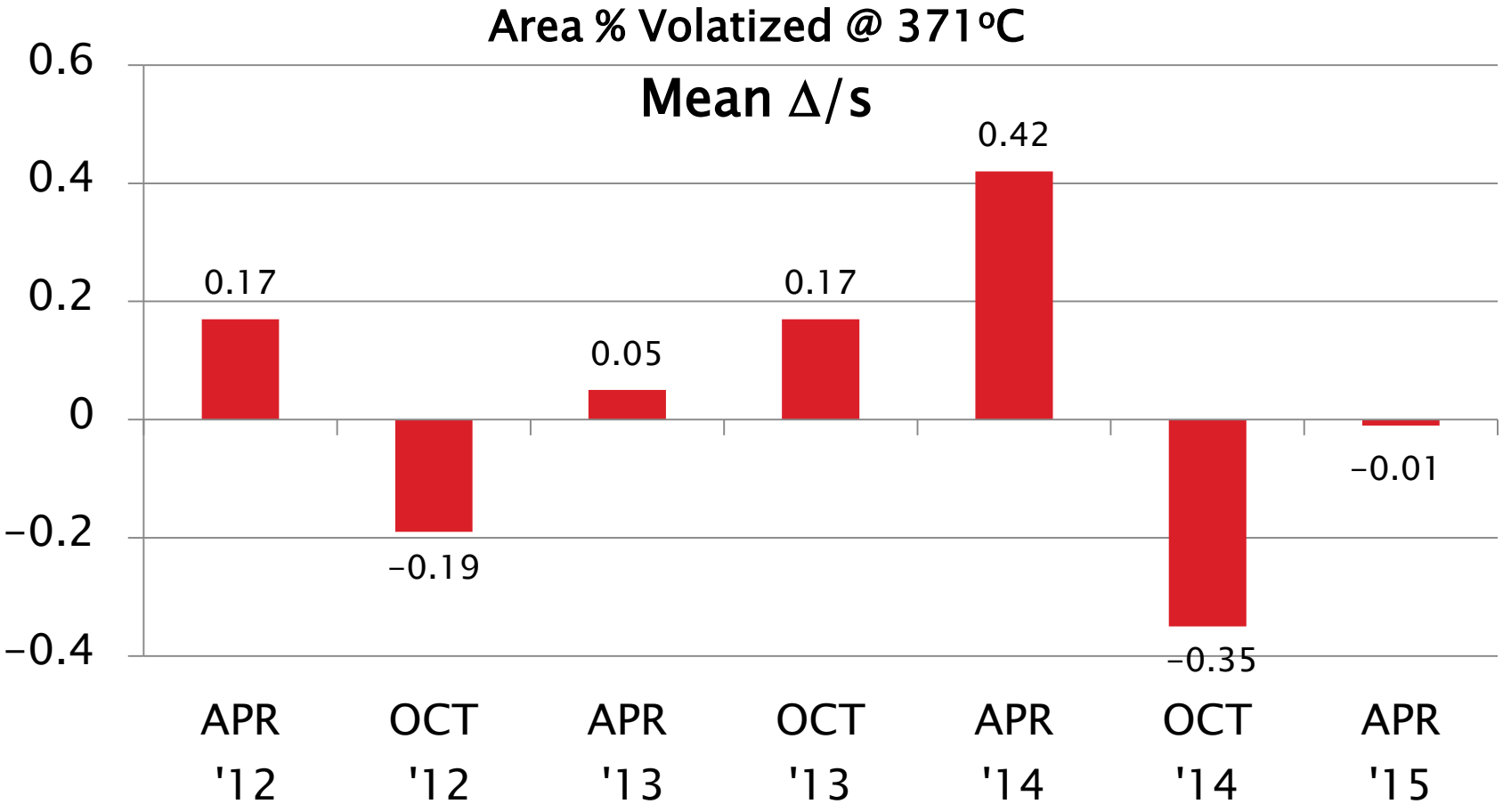
Period Precision and Severity Estimates

Area % Volatized @ 371°C	n	df	Pooled s	Mean Δ/s
Initial Selected Oils from RR	54	51	0.39	-----
10/1/11 through 3/31/12	14	11	0.24	0.17
4/1/12 through 9/30/12	15	12	0.28	-0.19
10/1/12 through 3/31/13	14	11	0.22	0.05
4/1/13 through 9/30/13	17	14	0.56	0.17
10/1/13 through 3/31/14	15	12	0.66	0.42
4/1/14 through 9/30/14	15	12	0.34	-0.35
10/1/14 through 3/31/15	14	11	0.40	-0.01

D6417 Precision Estimates



D6417 Severity Estimates

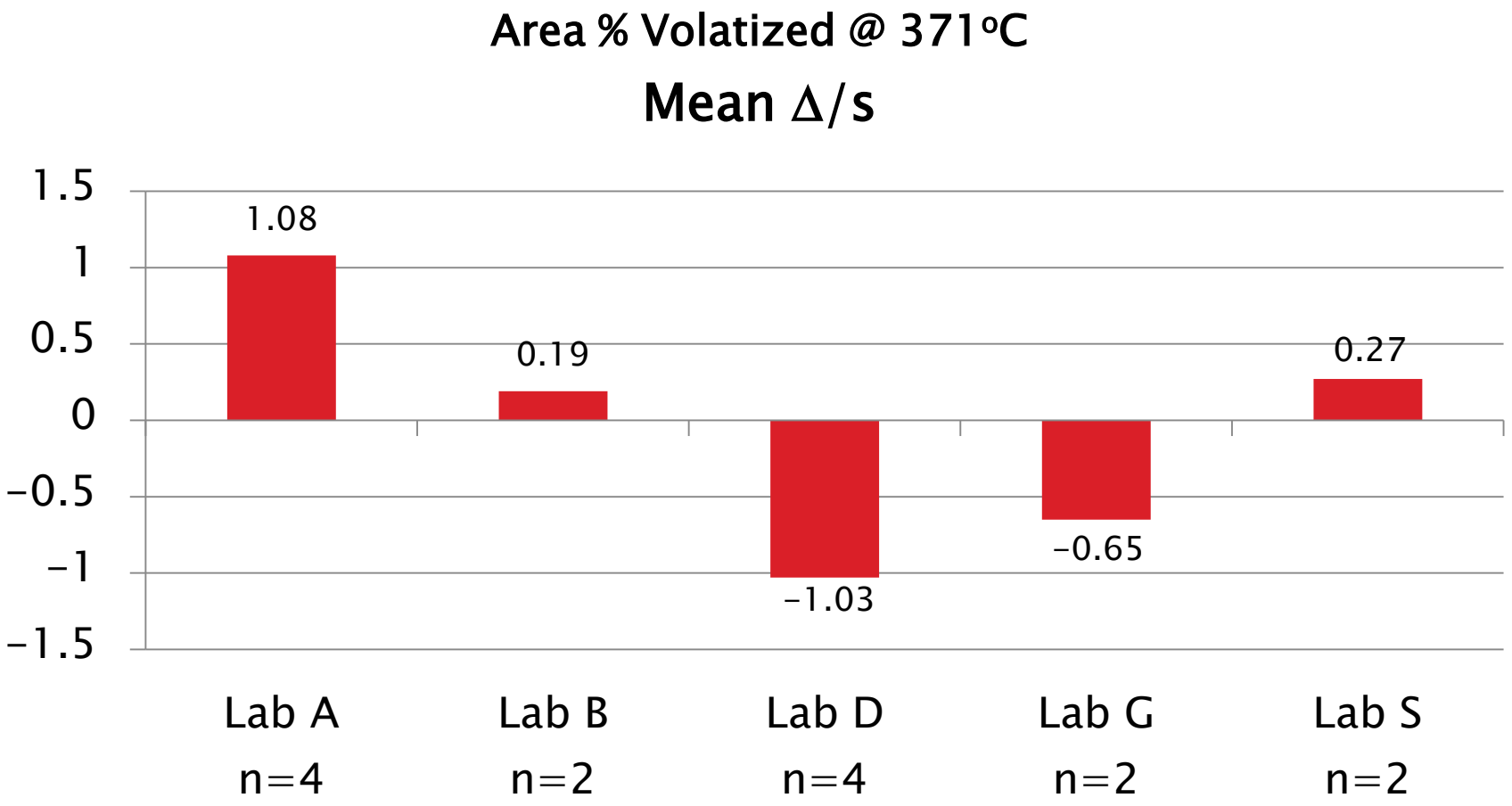


D6417: Estimation of Engine Oil Volatility by Capillary GC

Current Period Severity Estimates by Lab
Area % Volatized @ 371°C

	n	Mean Δ/s
Lab A	4	1.08
Lab B	2	0.19
Lab D	4	-1.03
Lab G	2	-0.65
Lab S	2	0.27

D6417 Lab Severity Estimates



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D6417: Estimation of Engine Oil Volatility by Capillary GC

- Precision (Pooled s) is less precise than last period
  - Comparable to the target precision
- Performance (Mean Δ/s) is on-target (-0.01 s)
- CUSUM plot shows variability with overall on-target performance this period following a slight mild trend last.
  - Lab A (1.08 s severe, n=4) nearly balances out Lab D (-1.03 s mild, n=4) in the overall mean severity estimate, which is reflected in the slightly worse overall precision this period.

D6417 VOLATILITY BY GC INDUSTRY OPERATIONALLY VALID DATA

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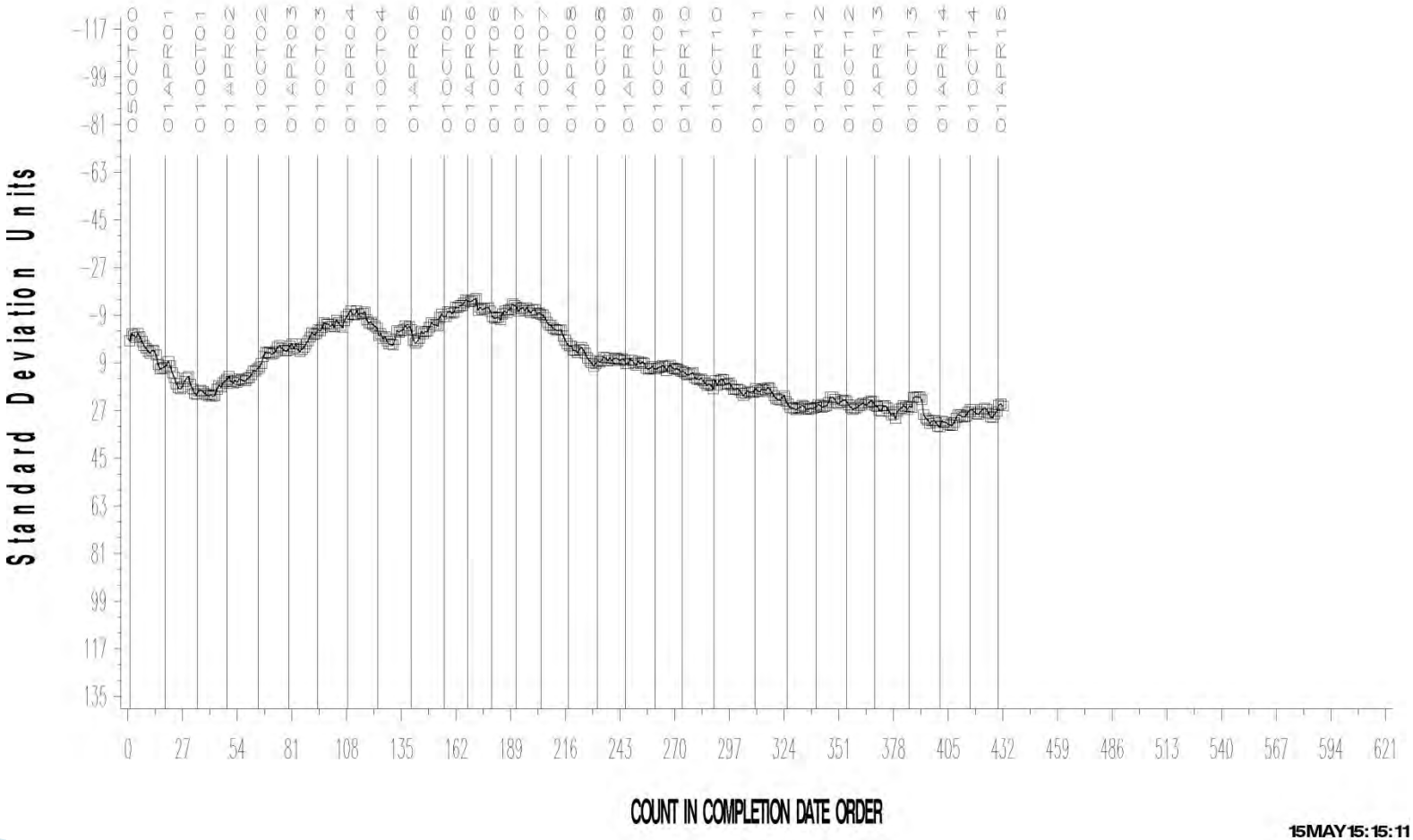
SAMPLE AREA % VOLATIZED

CUSUM Severity Analysis



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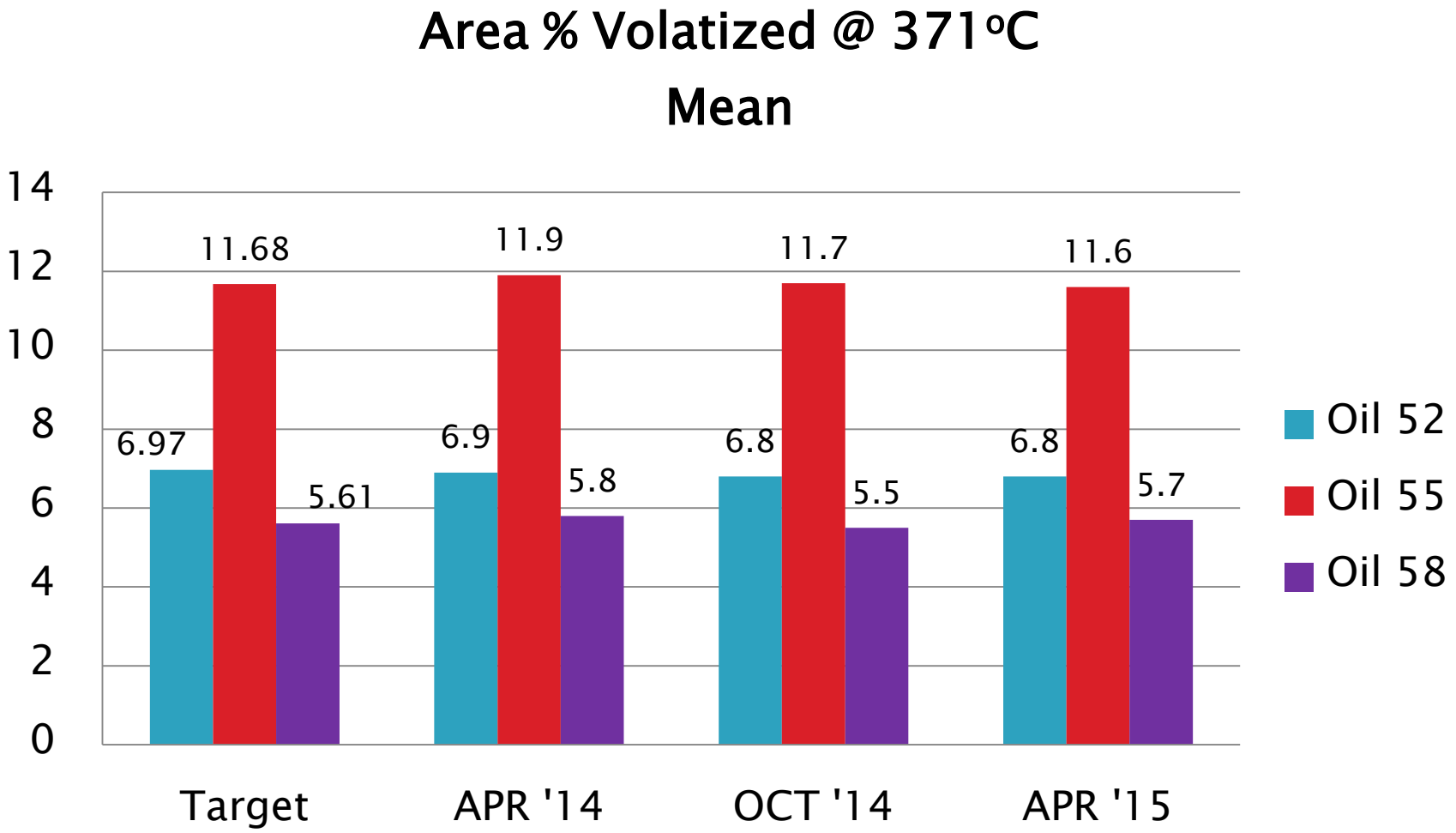
D6417: Estimation of Engine Oil Volatility by Capillary GC

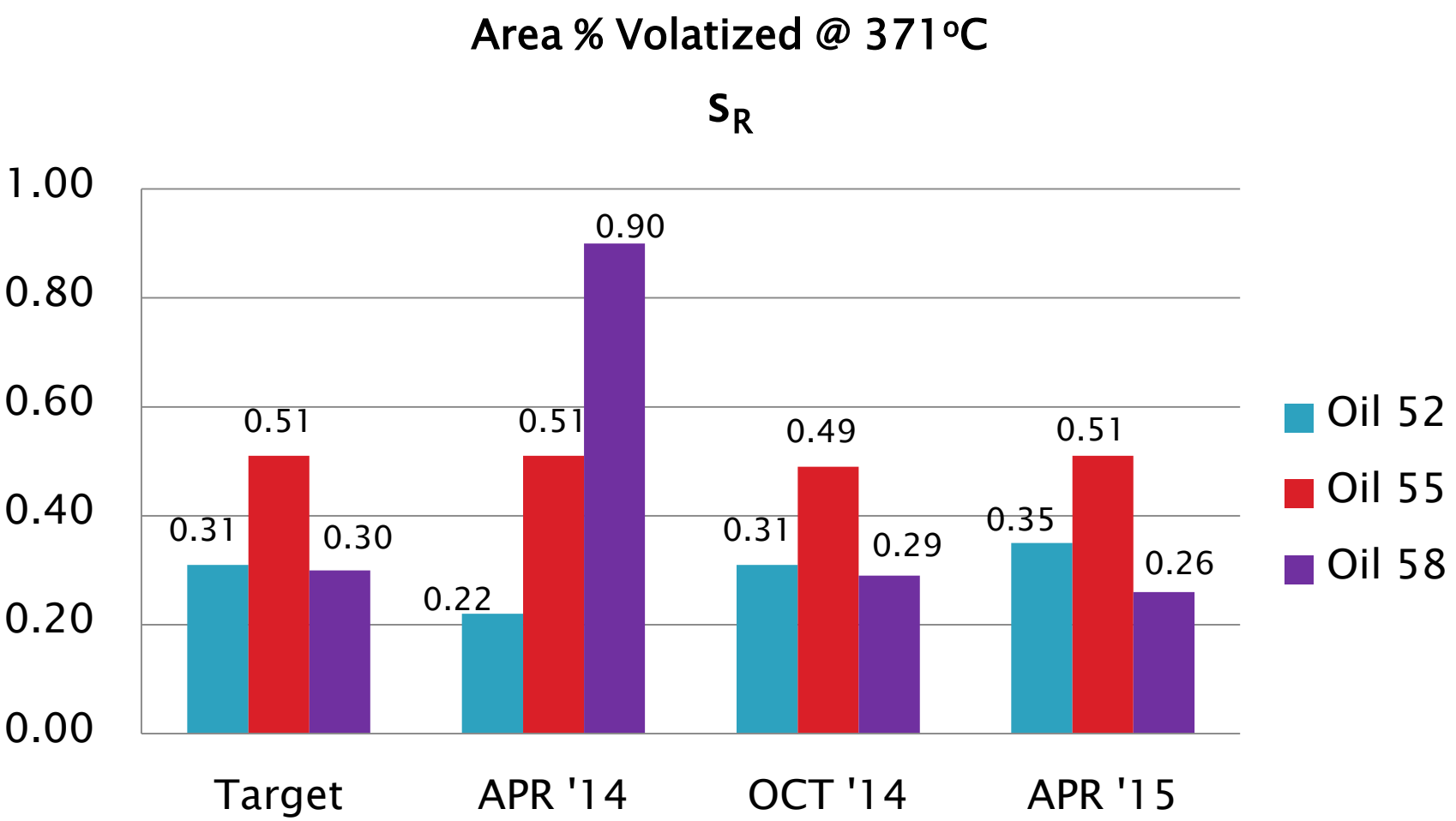
Area % Volatized @ 371°C
Performance by Oil

	Targets			10/1/13 - 3/31/14				4/1/14 - 9/30/14				10/1/14 - 3/31/15			
Oil Code	n	Mean	s_R	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s
52	18	6.97	0.31	4	6.9	0.22	-0.23	8	6.8	0.31	-0.47	2	6.8	0.35	-0.39
55	18	11.68	0.51	5	11.9	0.51	0.47	3	11.7	0.49	-0.03	6	11.6	0.51	-0.09
58	18	5.61	0.30	6	5.8	0.90	0.80	4	5.5	0.29	-0.37	6	5.7	0.26	0.19

D6417 Performance by Oil



D6417 Performance by Oil



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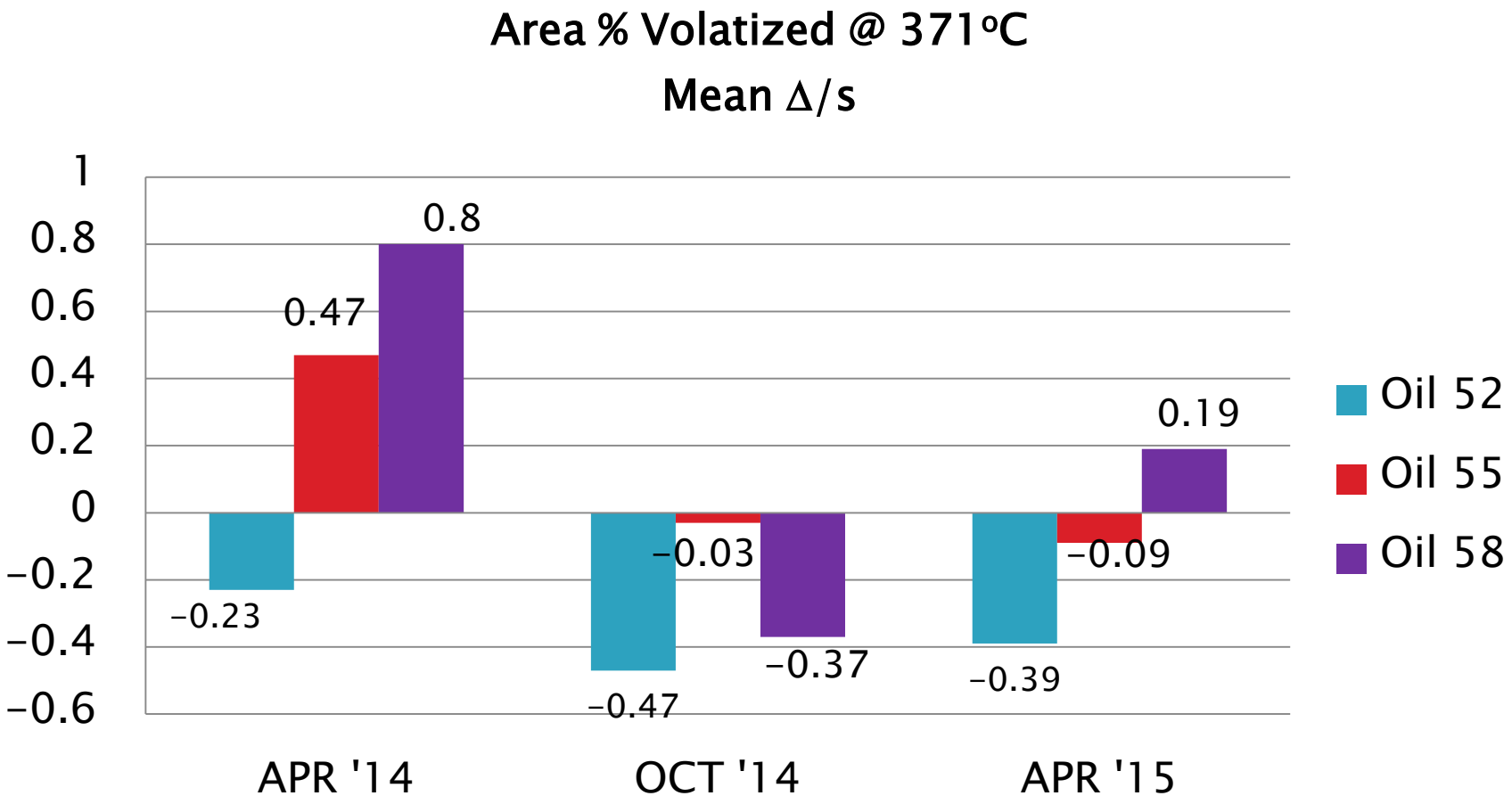
D6417 Performance by Oil



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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	44
Failed Calibration Test	OC	16
Operationally Invalidated by Lab	LC, XC	0
Operationally Invalidated After Initially Reported as Valid	RC	1
Donated Round Robin (VOLD14)	AG, RG	37
Excluded For Other Reasons	NN, LN	5
Total		**103**

Number of Labs Reporting Data: 9
Fail Rate of Operationally Valid Tests: 27%

D5800: Evaporation Loss of Lubricating Oil by Noack Method

Statistically Unacceptable Tests (OC)	No. Of Tests
Evaporation Loss Mild	6
Evaporation Loss Severe	10

- Failing results are across multiple labs, instruments and oils.
- Reason for operationally invalid results (one test):
  - Daily calibration result not in specified limits
- Labs F and J ran some non-blind instrument shakedown runs (five test total); not included in period statistics.
- Round Robin run on daily check oil VOLD14 to establish proposed performance targets; RR results not included in period statistics.

D5800: Evaporation Loss of Lubricating Oil by Noack Method

- Two technical updates were issued after the end of this report period:
  - Memo 15-005, March 10, 2015, Mandatory Daily QC Check Sample
    - TMC Oil VOLD14 was selected by panel as a mandatory daily QC check sample for D5800 procedures B & C, for TMC monitored labs, effective May 1, 2015.
  - Report Packet Revision Notice D5800-20150224, issued April 15, 2015
    - Added field FIRMWARE to data dictionary, effective May 15, 2015

D5800: Evaporation Loss of Lubricating Oil by Noack Method

- Two instruments had two consecutive failing runs, all reported as operationally valid (OC), with a passing result on the third attempt:
  - Instrument A8 (Model NCK25G), Oil VOLC12
  - Instrument V2 (Model SVT1), Oil VOLD12
- Two instruments had three consecutive failing runs, all reported as operationally valid (OC), with a passing result on the fourth attempt:
  - Instrument A7 (Model NCK25G), Oil VOLC12
  - Instrument J4 (Model NCK25G), Oil VOLC12
- Number of operationally valid results by oil:
  - VOLC12: 13 AC, 8 OC (4 mild, 4 severe)
  - VOLD12: 16 AC, 5 OC (5 mild)
  - VOLE12: 15 AC, 3 OC (2 mild, 1 severe)

D5800: Evaporation Loss of Lubricating Oil by Noack Method

Period Precision and Severity Estimates

Sample Evaporation Loss, mass %	n	df	Pooled s	Mean D/s
Targets Effective 10/1/2013	78	75	0.50	-----
10/1/11 through 3/31/12	32	29	0.78	0.54
4/1/12 through 9/30/12	33	30	0.67	0.56
10/1/12 through 3/31/13	33	30	0.79	0.43
4/1/13 through 9/30/13	30	27	0.72	0.58
10/1/13 through 3/31/14	38	34	0.59	0.37
4/1/14 through 9/30/14	55	52	1.04	0.38
10/1/14 through 3/31/15	60	57	0.80	0.44

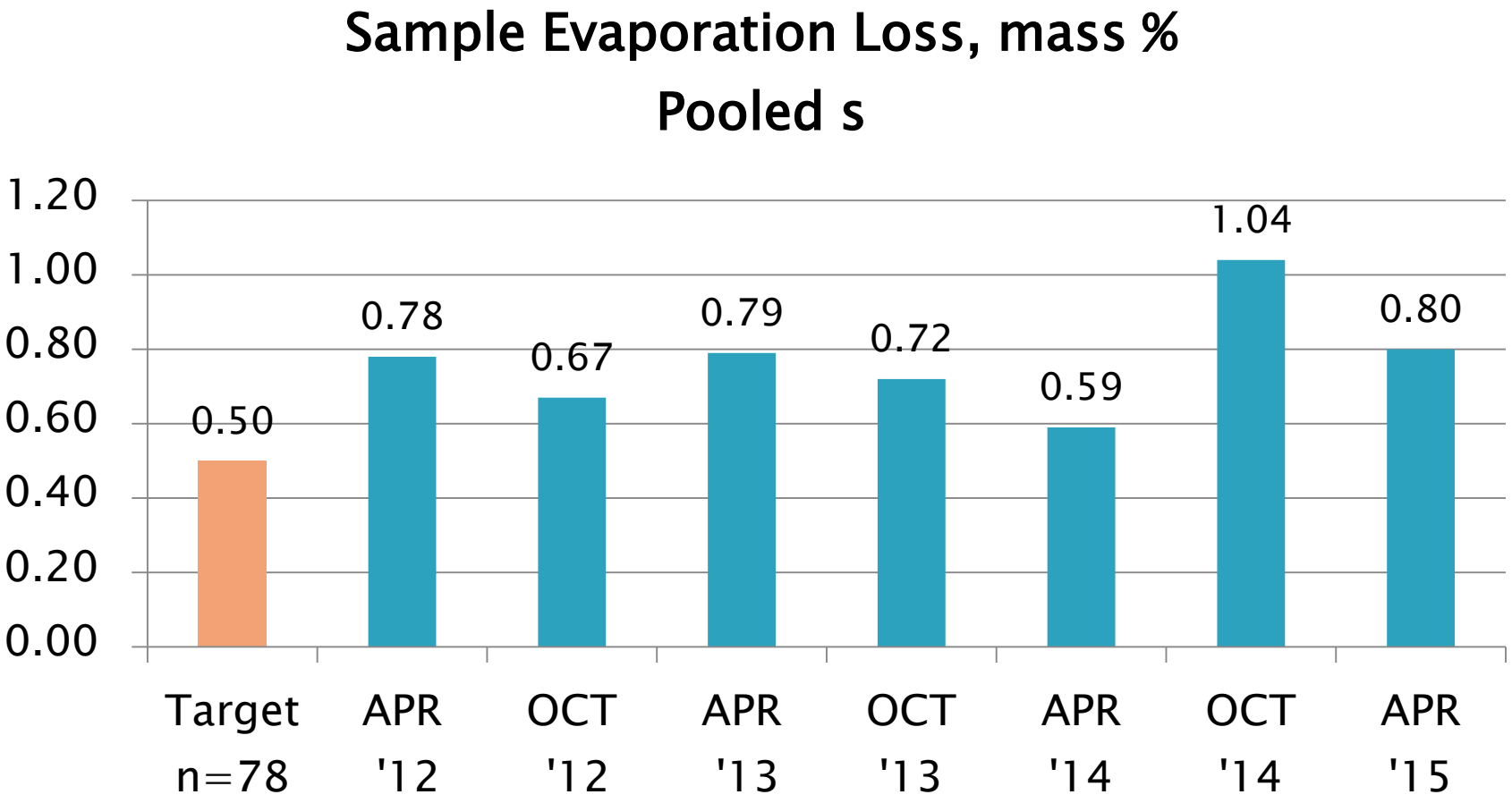
D5800: Evaporation Loss of Lubricating Oil by Noack Method

Performance Comparison by Procedure & Model
Sample Evaporation Loss, Mass %

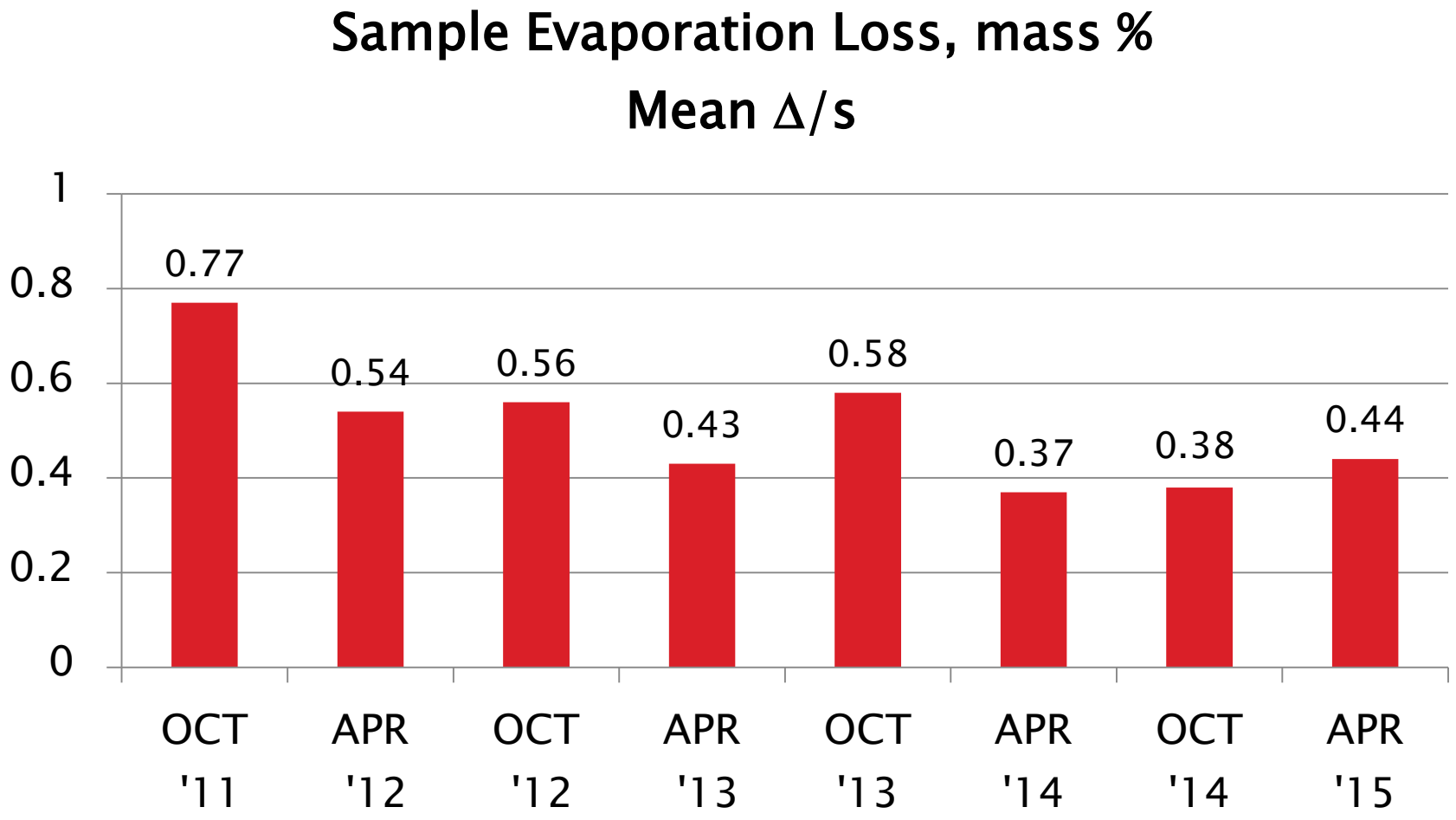
	n	df	Pooled s	Mean Δ/s
Procedure B	50	47	0.78	0.48
Procedure C	10	7	0.91	0.24

Model	n	df	Pooled s	Mean Δ/s
NCK2	7	4	0.21	0.09
NCK25G	43	40	0.84	0.55
SVT1	10	7	0.91	0.24

D5800 Precision Estimates



D5800 Severity Estimates



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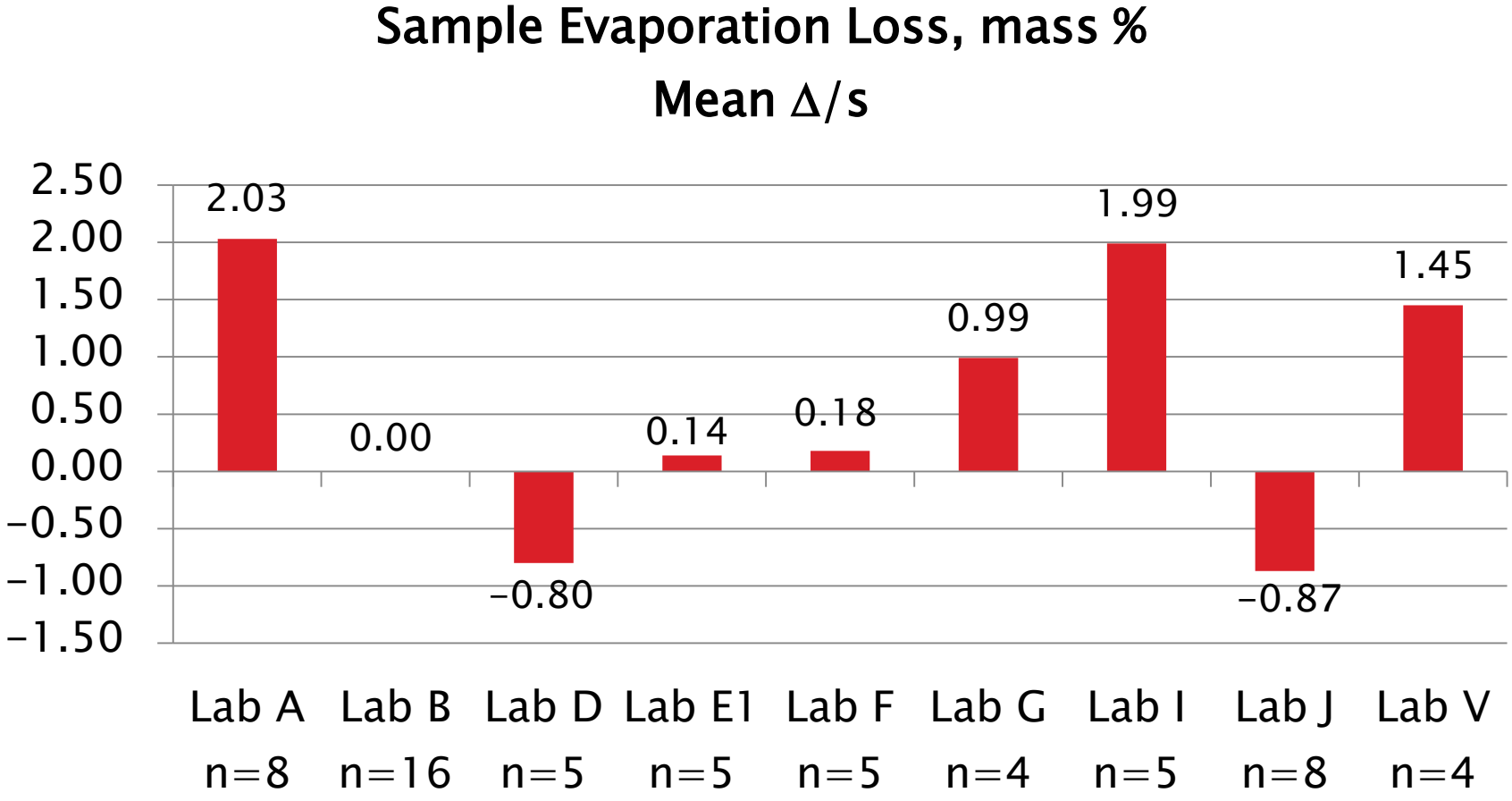
D5800: Evaporation Loss of Lubricating Oil by Noack Method

Current Period Severity Estimates by Lab
Sample Evaporation Loss, mass %

	n	Mean Δ/s
Lab A	8	2.03
Lab B	16	0.00
Lab D	5	-0.80
Lab E1	5	0.14
Lab F	5	0.18
Lab G	4	0.99
Lab I	5	1.99
Lab J	8	-0.87
Lab V	4	1.45

D5800 Lab Severity Estimates



D5800: Evaporation Loss of Lubricating Oil by Noack Method

- Precision (Pooled s), at 0.80 mass %, is more precise than prior period but still less precise compared to the target precision (0.50 mass %).
- Performance (Mean Δ/s) is 0.44 s severe.
  - More severe than prior period (0.38 s)
- Fail rate of operationally valid tests (AC & OC) is 27% compared to 36% last report period.
- Severity plot shows unexplained long-term severe trend since 01JUL06 timeline with only a modest decrease in severity following the introduction of the new reference oils (on 2013-09-17) and with comparable to worse precision.

D5800: Evaporation Loss of Lubricating Oil by Noack Method

- Comparing the overall D5800 precision and severity over the 19 months since the new reference oils were introduced to the 19 months prior on the old reference oils:

Date Range	n	df	Pooled s	Mean Δ/s
20131011 – 20150510	169	166	0.83	0.41
20120305 – 20131004	98	95	0.74	0.52

D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

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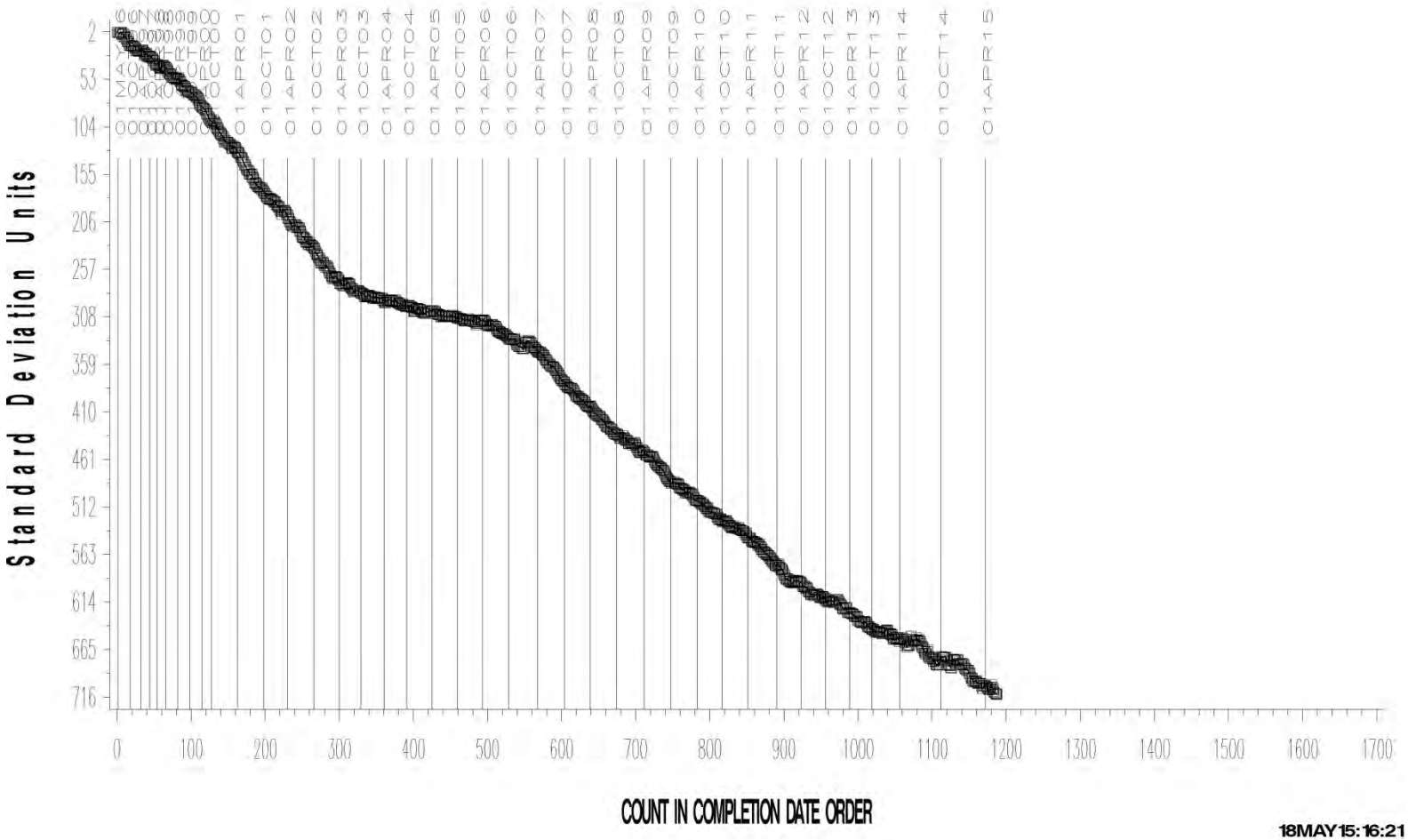
EVAPORATION LOSS, MASS%

CUSUM Severity Analysis



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D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA

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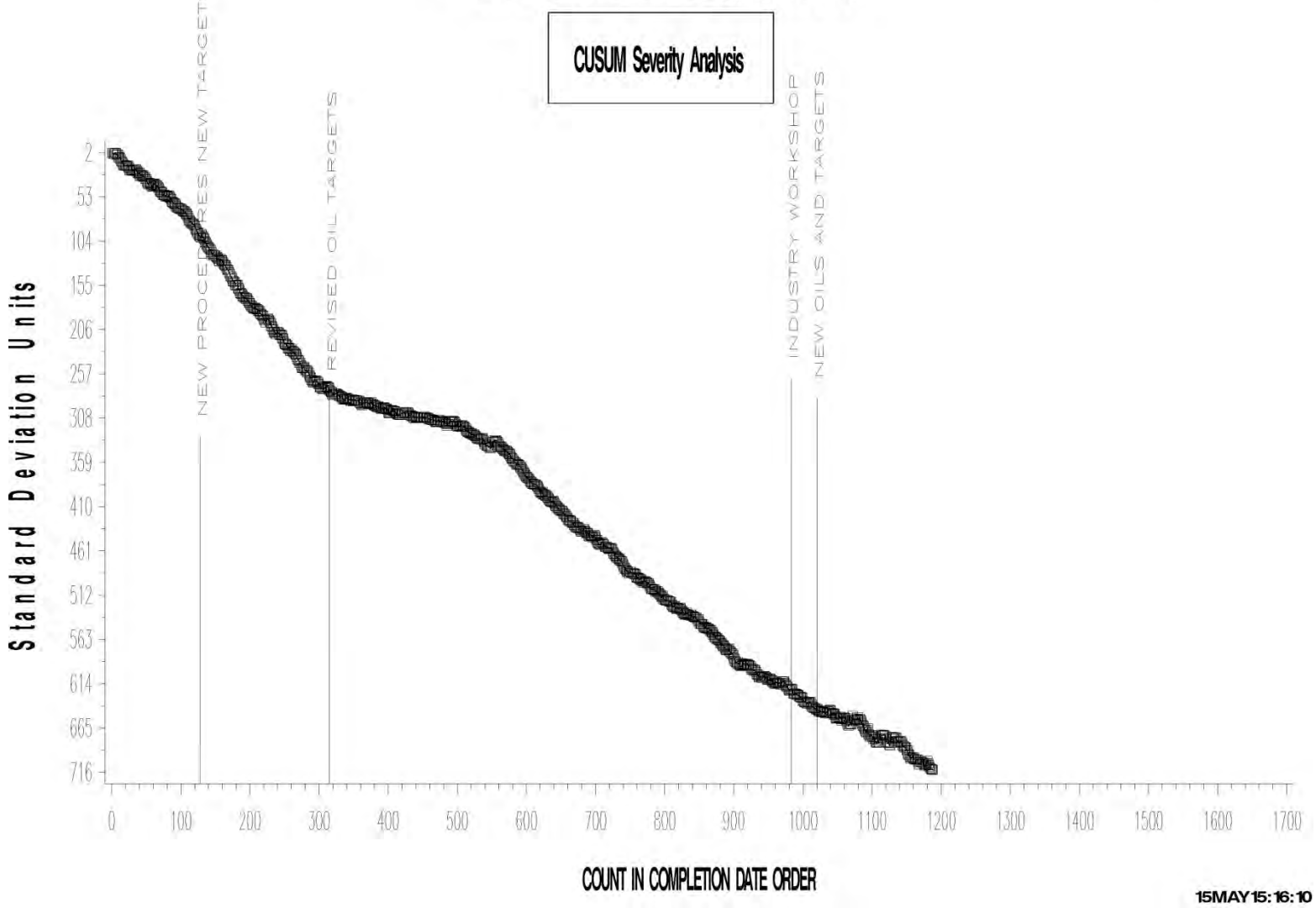
EVAPORATION LOSS, MASS%



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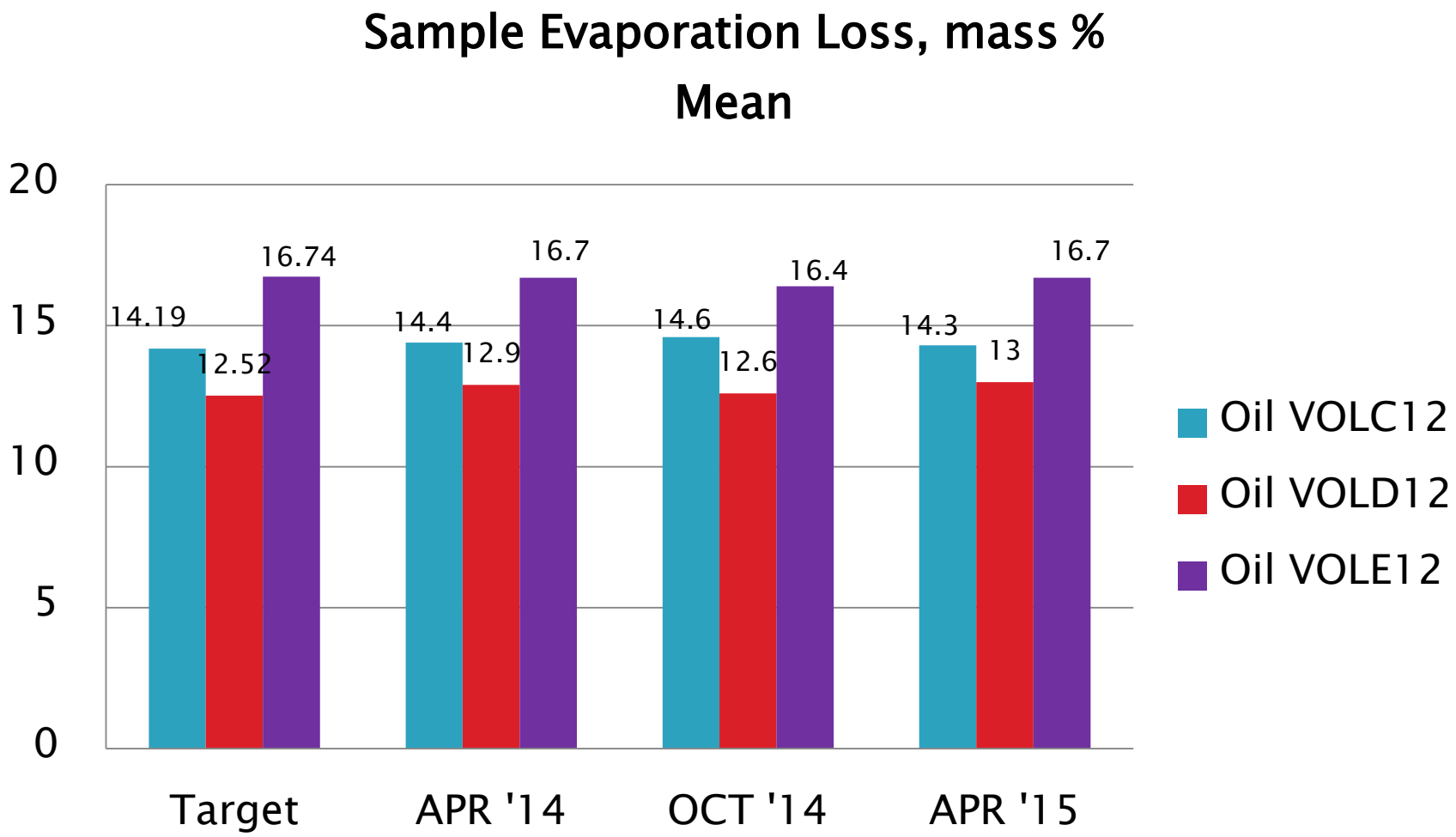
D5800: Evaporation Loss of Lubricating Oil by Noack Method

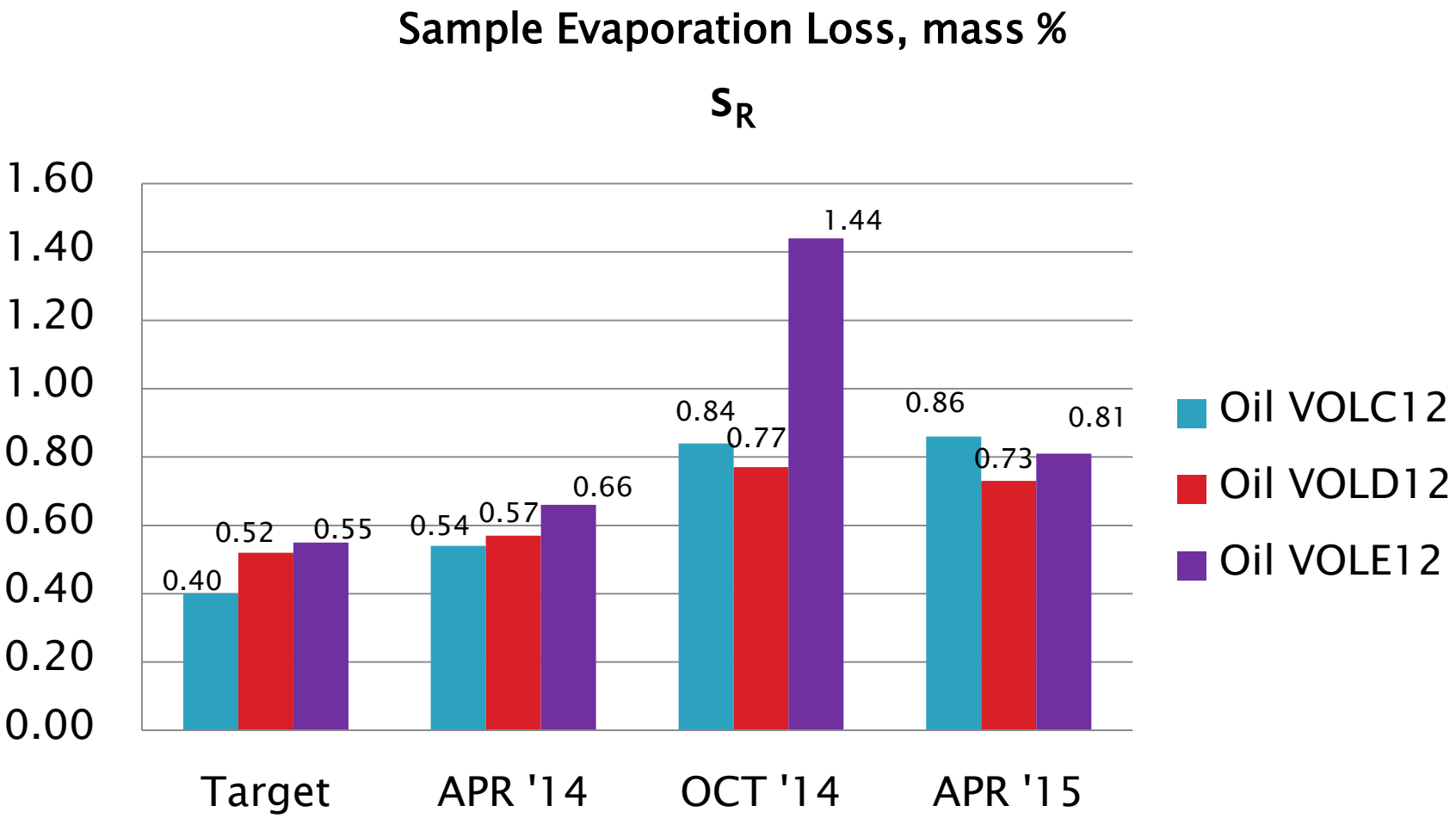
Sample Evaporation Loss, mass %
Performance by Oil

	Targets			10/1/13 – 3/31/14				4/1/134– 9/30/14				10/1/14 – 3/31/15			
Oil Code	n	Mean	s_R	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s
VOLC12	24	14.19	0.40	14	14.4	0.54	0.42	26	14.6	0.84	1.05	21	14.3	0.86	0.33
VOLD12	27	12.52	0.52	11	12.9	0.57	0.59	13	12.6	0.77	0.21	21	13.0	0.73	0.93
VOLE12	27	16.74	0.55	12	16.7	0.66	0.00	16	16.4	1.44	-0.58	18	16.7	0.81	0.00

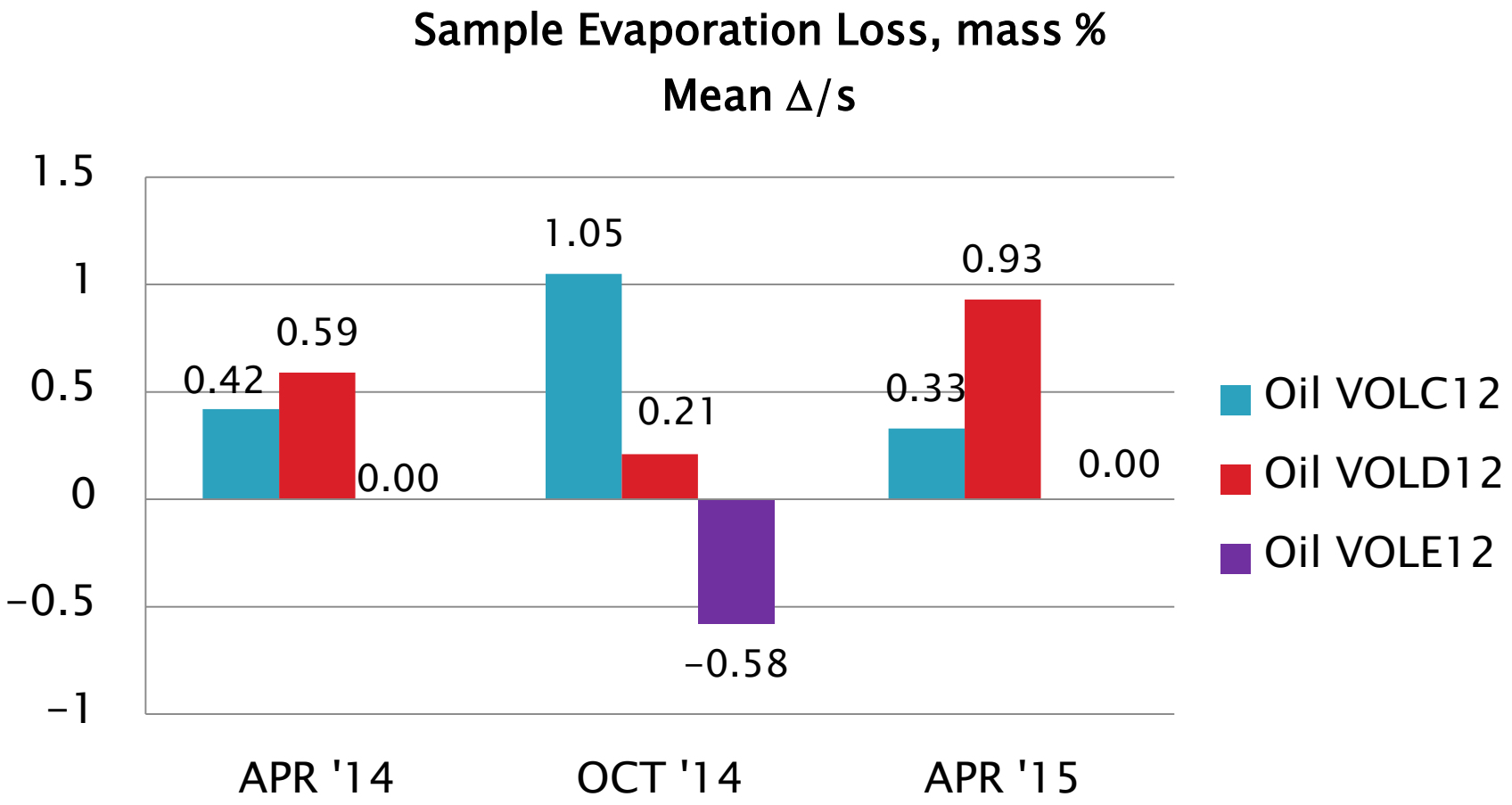
D5800 Performance by Oil



D5800 Performance by Oil



D5800 Performance by Oil



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D5133: Gelation Index

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	26
Failed Calibration Test	OC	2
Operationally Invalidated by Lab	LC, XC	0
Operationally Invalidated After Initially Reported as Valid	RC	0
Instrument Shakedown	NN, XN	2
Total		**30**

Number of Labs Reporting Data: 7

(However, only 6 labs reported calibration data; lab G ran only instrument shakedown runs that are excluded from the period statistics)

Fail Rate of Operationally Valid Tests: 7%

D5133: Gelation Index

Statistically Unacceptable Tests (OC)	No. Of Tests
Gelation Index Mild	1
Gelation Index Severe	1

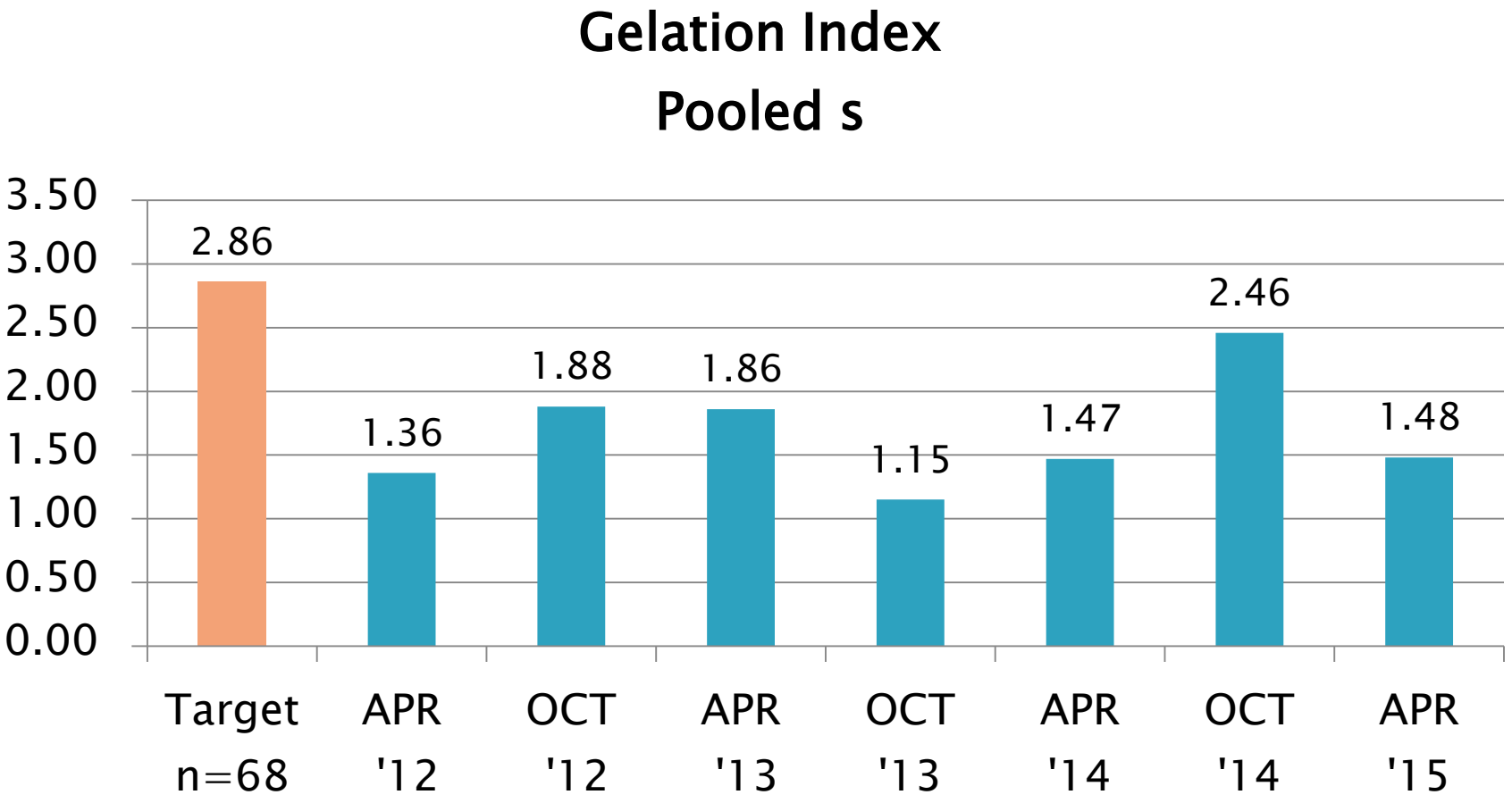
- No operationally invalid tests reported this period
- No TMC technical updates issued this period

D5133: Gelation Index

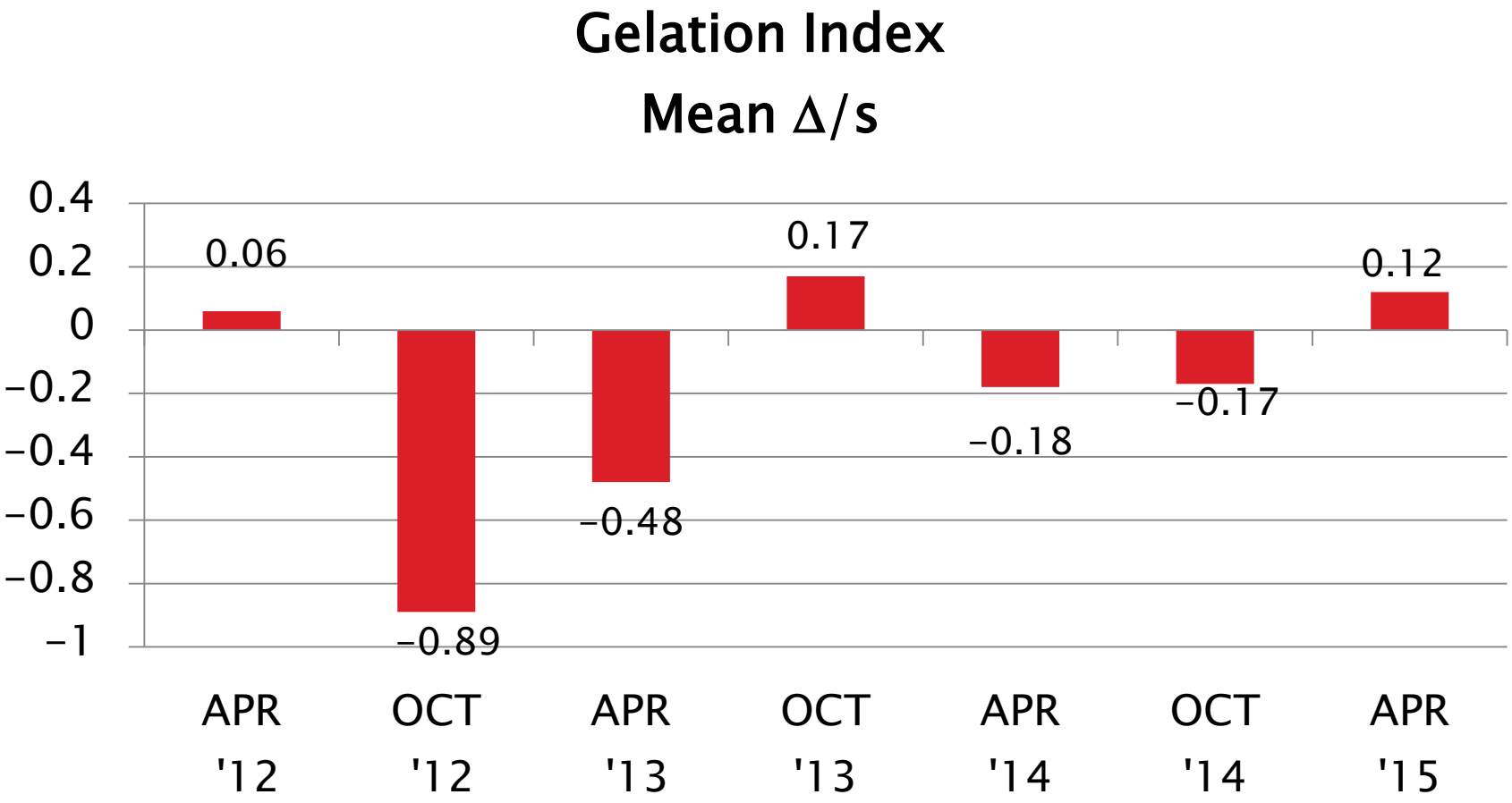
Period Precision and Severity Estimates

Gelation Index	n	df	Pooled s	Mean Δ/s
Current Targets 7/15/2003	68	65	2.86	-----
10/1/11 through 3/31/12	24	21	1.36	0.06
4/1/12 through 9/30/12	24	21	1.88	-0.89
10/1/12 through 3/31/13	22	19	1.86	-0.48
4/1/13 through 9/30/13	19	16	1.15	0.17
10/1/13 through 3/31/14	14	11	1.47	-0.18
4/1/14 through 9/30/14	24	21	2.46	-0.17
10/1/14 through 3/31/15	28	25	1.48	0.12

D5133 Precision Estimates



D5133 Severity Estimates



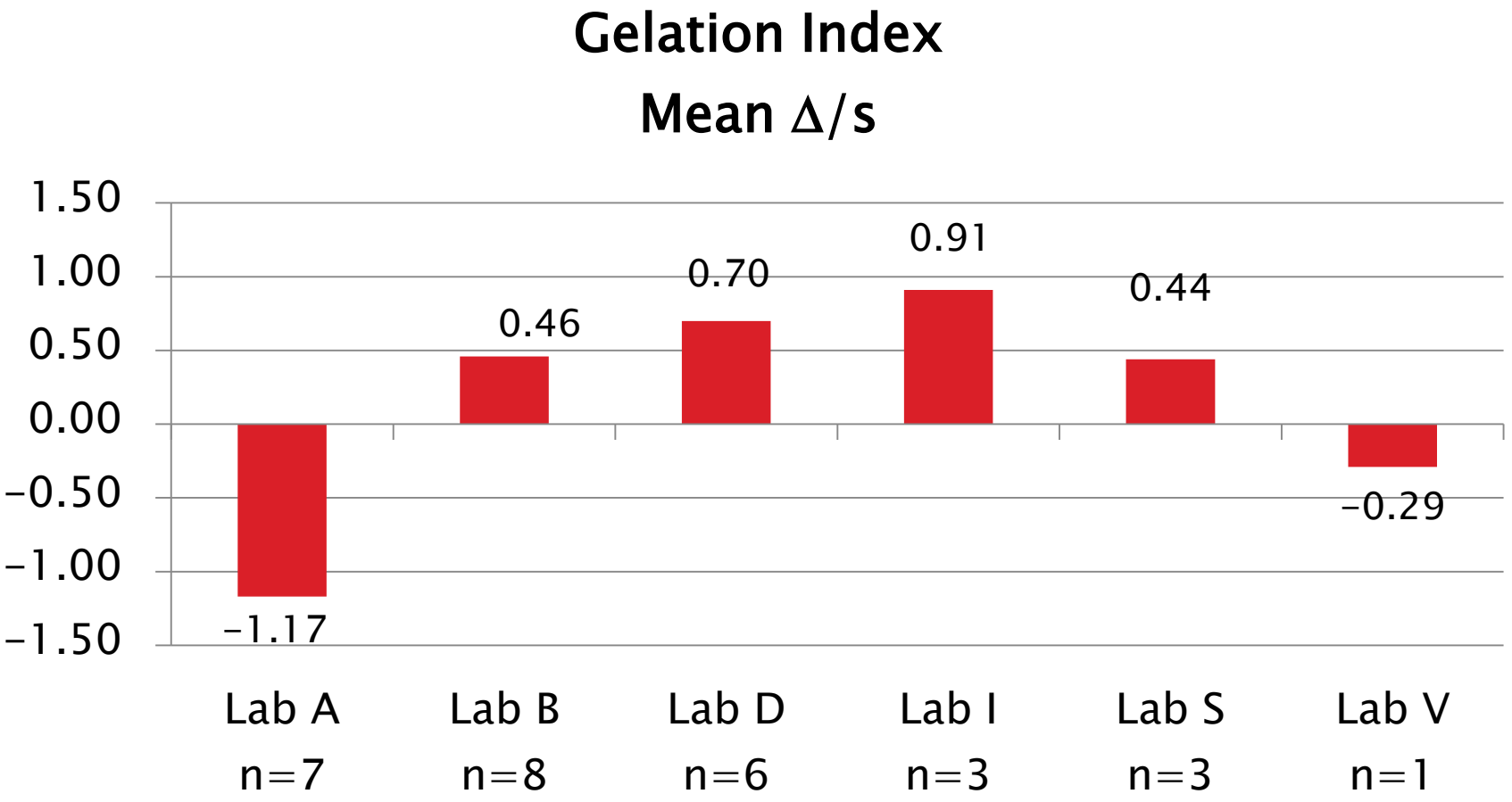
D5133: Gelation Index

Current Period Severity Estimates by Lab

Gelation Index

	n	Mean Δ/s
Lab A	7	-1.17
Lab B	8	0.46
Lab D	6	0.70
Lab I	3	0.91
Lab S	3	0.44
Lab V	1	-0.29

D5133 Lab Severity Estimates



D5133: Gelation Index

- Precision (Pooled s) is more precise than prior period and back in line with historic period values
  - More precise than target precision
- Performance (Mean Δ/s) is 0.12 s severe
  - Lab I reported a result more than 3.5 s severe as operationally valid (followed by a passing calibration)
  - Lab A reported a result more than 3 s mild as operationally valid (followed by a passing calibration)
- Reference oil 62 inventory is down to 1.2 gallons remaining (but only 0.2 gallons shipped prior 12 months).

D5133 GELATION INDEX INDUSTRY OPERATIONALLY VALID DATA

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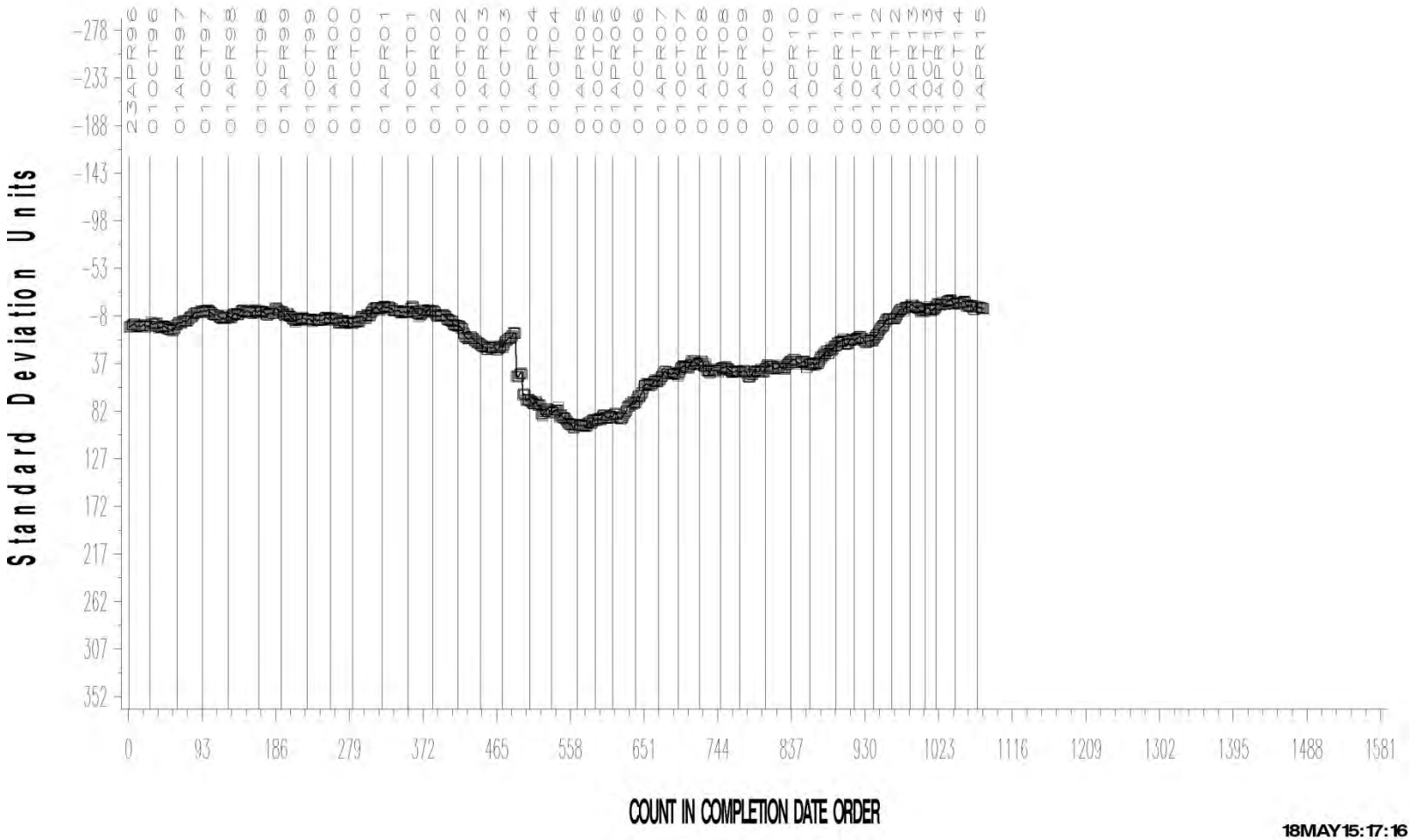
GELATION INDEX

CUSUM Severity Analysis



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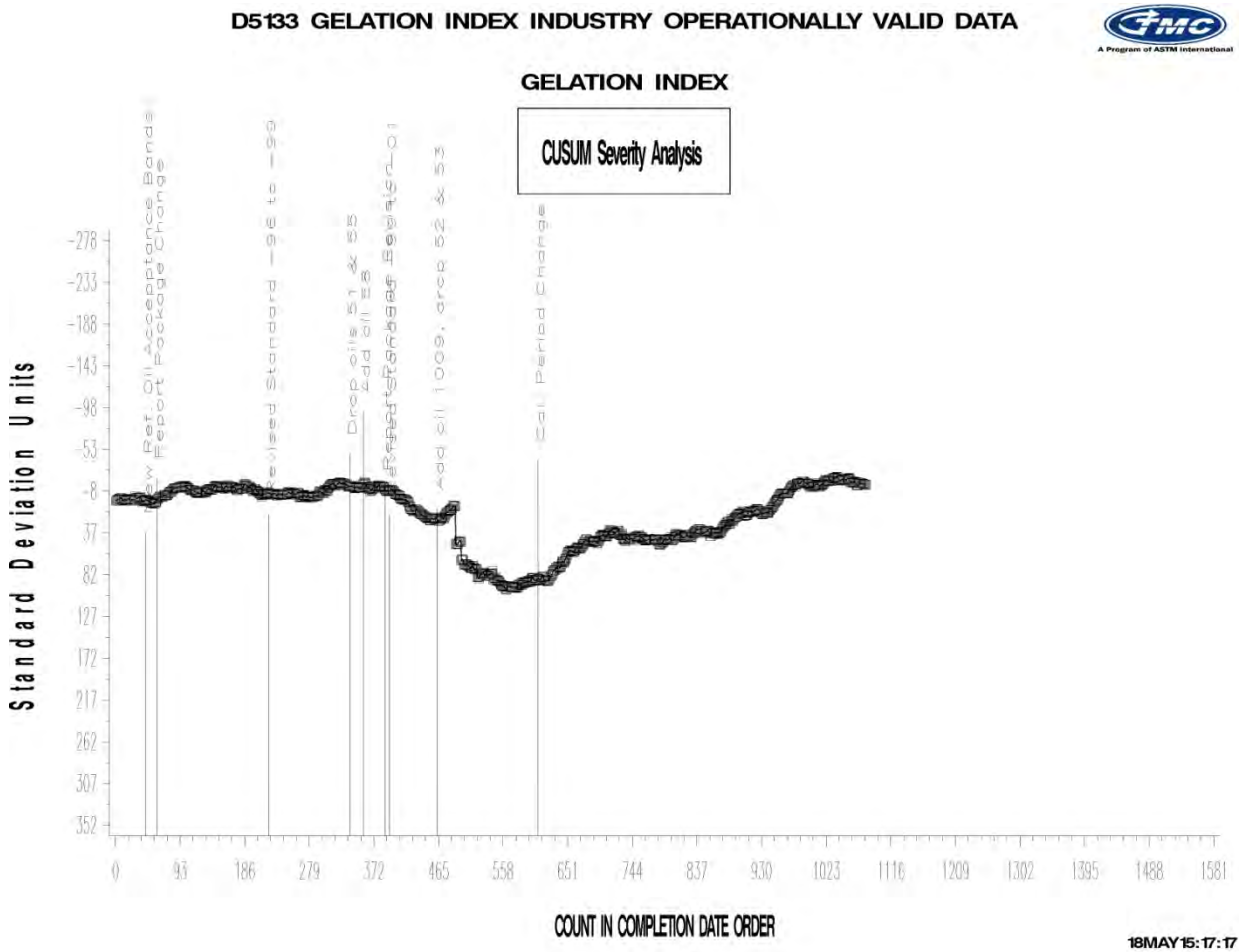
D5133: Gelation Index

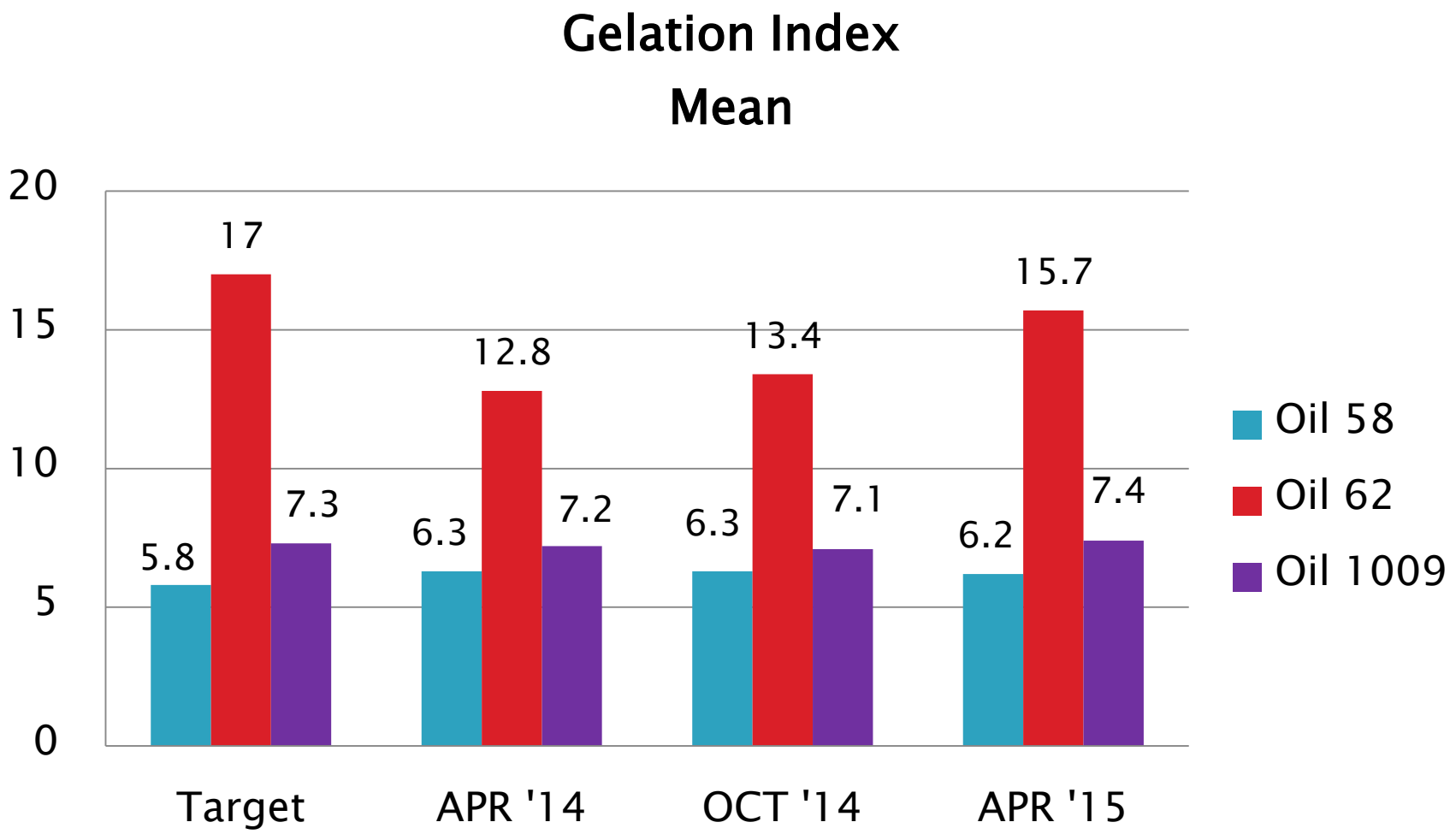


D5133 Performance by Oil

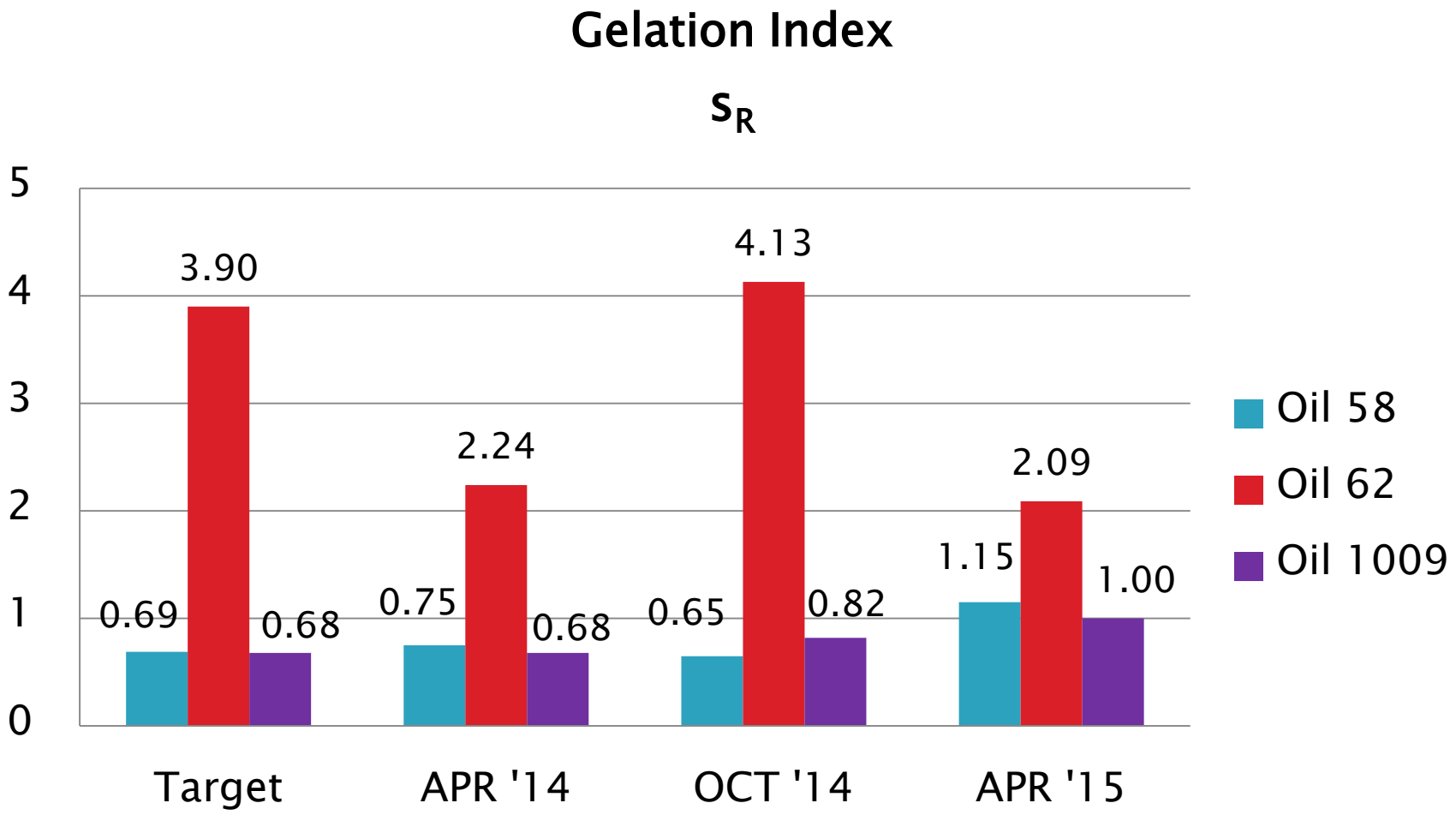
Gelation Index
Performance by Oil

	Targets			10/1/13 – 3/31/14				4/1/14 – 9/30/14				10/1/14 – 3/31/15			
Oil Code	n	Mean	s_R	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s
58	17	5.8	0.69	5	6.3	0.75	0.75	8	6.3	0.65	0.76	9	6.2	1.15	0.58
62	35	17.0	3.90	5	12.8	2.24	-1.08	8	13.4	4.13	-0.92	9	15.7	2.09	-0.34
1009	16	7.30	0.68	4	7.2	0.68	-0.22	8	7.1	0.82	-0.35	10	7.4	1.00	0.12

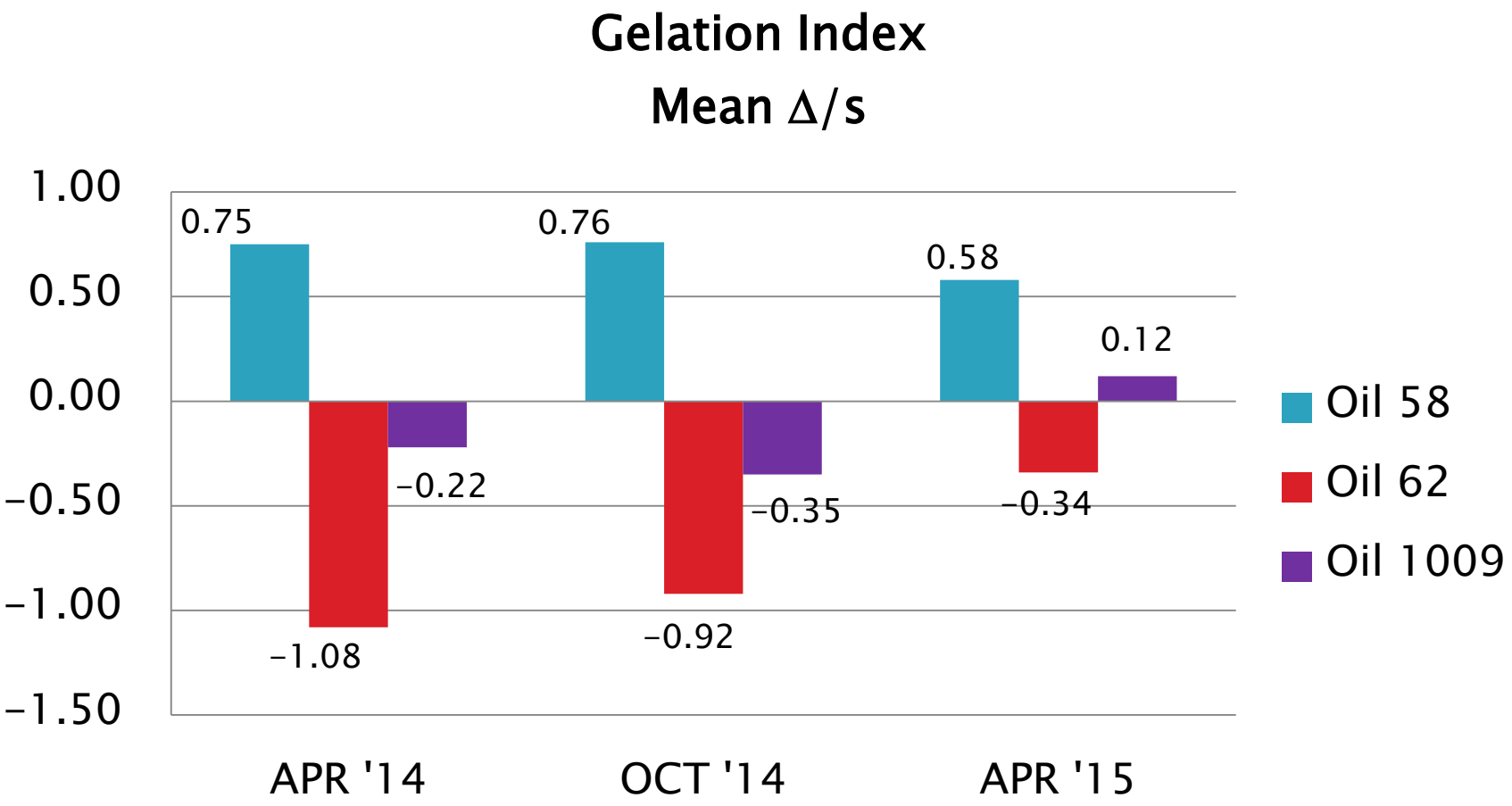
D5133 Performance by Oil



D5133 Performance by Oil



D5133 Performance by Oil



Return to Executive Summary

D6335: Deposits by TEOST-33C

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	14
Failed Calibration Test	OC	1
Operationally Invalidated by Lab	LC, XC	0
Operationally Invalidated After Initially Reported as Valid	RC	1
Total		**16**

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

D6335: Deposits by TEOST-33C

Statistically Unacceptable Tests (OC)	No. Of Tests
Total Deposits Mild	1
Total Deposits Severe	0

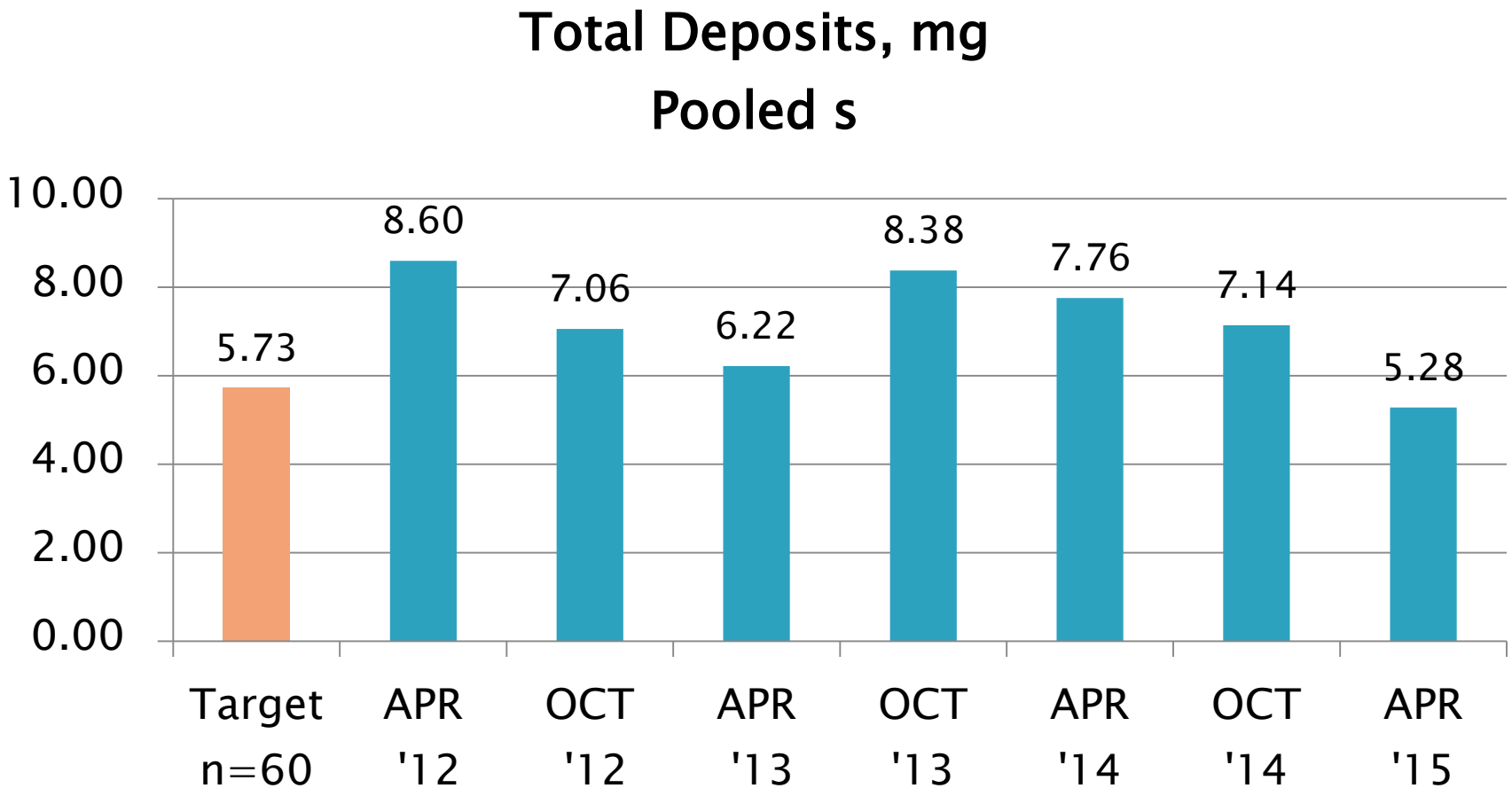
- One operationally invalid tests reported this period:
  - One invalidated (RC) due to incorrect thermocouple depth, initially reported as operationally valid but failed severe.
- No TMC technical updates issued this period

D6335: Deposits by TEOST-33C

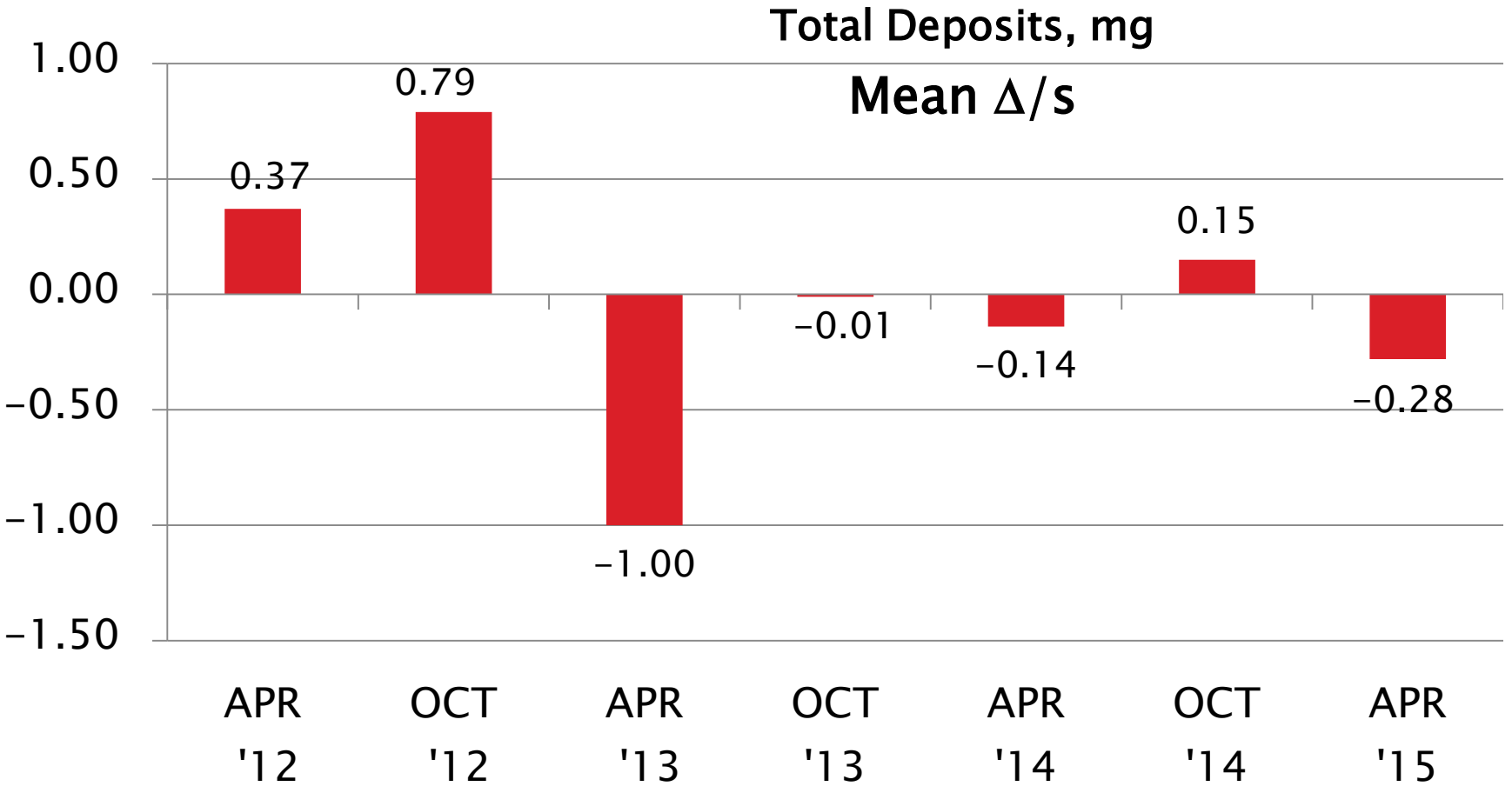
Period Precision and Severity Estimates

Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Updated Targets 20130415	60	58	5.73	-----
10/1/11 through 3/31/12	16	12	8.60	0.37
4/1/12 through 9/30/12	18	15	7.06	0.79
10/1/12 through 3/31/13	22	20	6.22	-1.00
4/1/13 through 9/30/13	17	15	8.38	-0.01
10/1/13 through 3/31/14	16	14	7.76	-0.14
4/1/14 through 9/30/14	15	13	7.14	0.15
10/1/14 through 3/31/15	15	13	5.28	-0.28

D6335 Precision Estimates



D6335 Severity Estimates

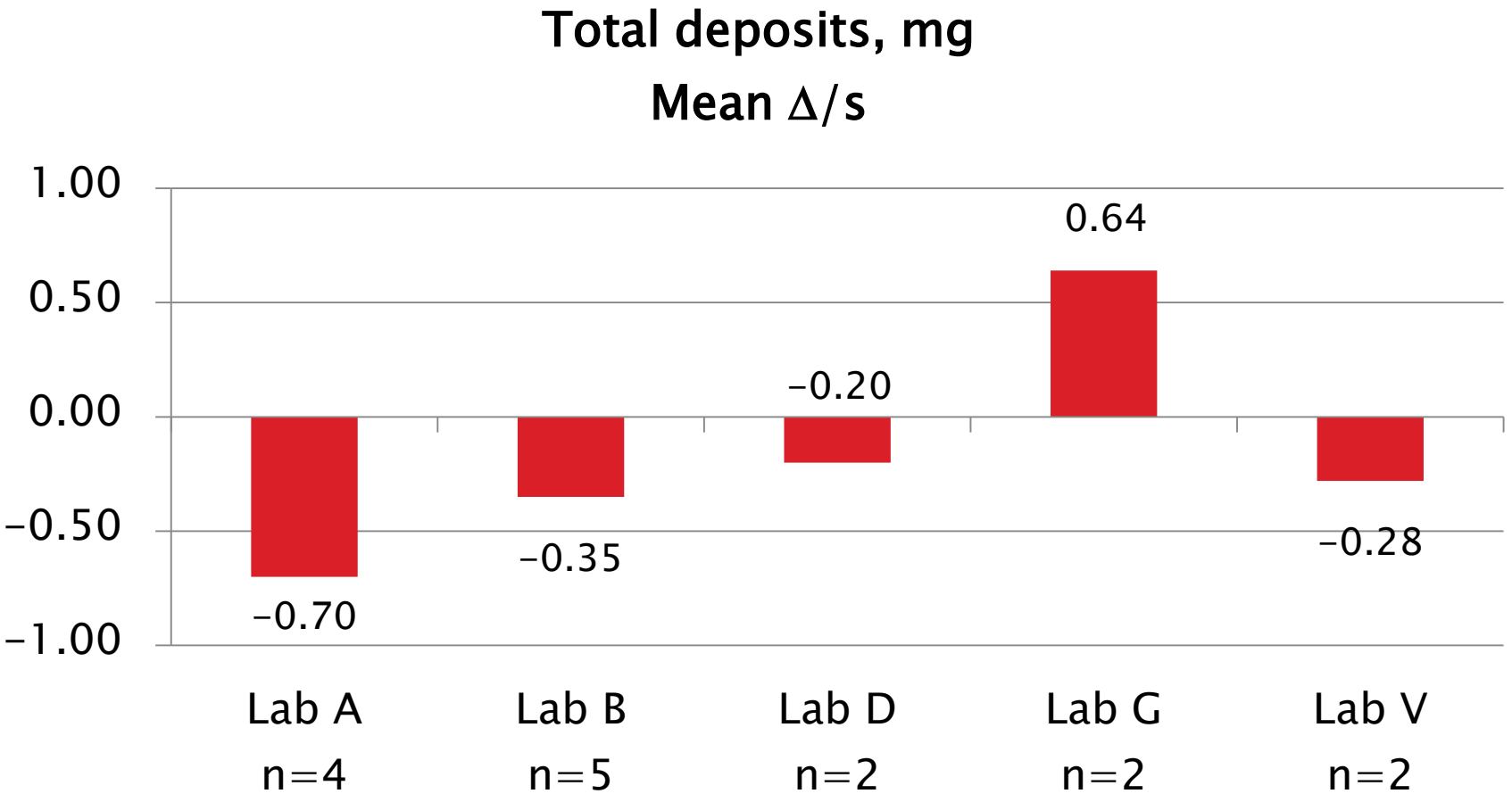


D6335: Deposits by TEOST-33C

Current Period Severity Estimates by Lab
Total Deposits, mg

	n	Mean Δ/s
Lab A	4	-0.70
Lab B	5	-0.35
Lab D	2	-0.20
Lab G	2	0.64
Lab V	2	-0.28

D6335 Lab Severity Estimates



D6335: Deposits by TEOST-33C

- Precision (Pooled s) is more precise than prior period
  - More precise than target precision for the first time in years.

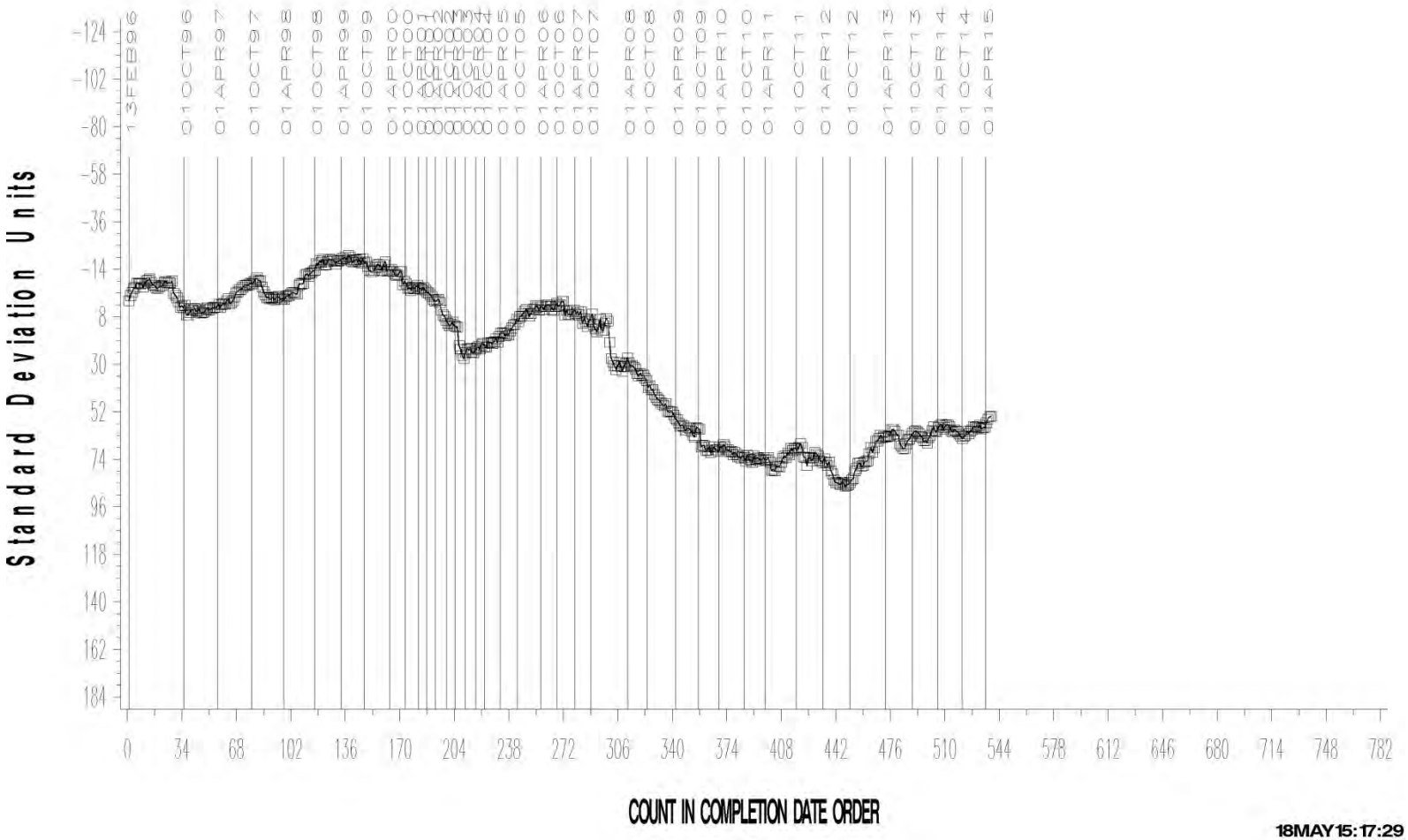
- Performance (Mean Δ/s) is -0.28 s mild
  - Oil 75 (severe oil) -0.85 s mild (n=8)
  - Oil 435-2 (mild oil) 0.37 s severe (n=7)

- All tests this period report using Rod Batches K or L

TEOST—33C INDUSTRY OPERATIONALLY VALID DATA

TOTAL DEPOSITS MG

CUSUM Severity Analysis



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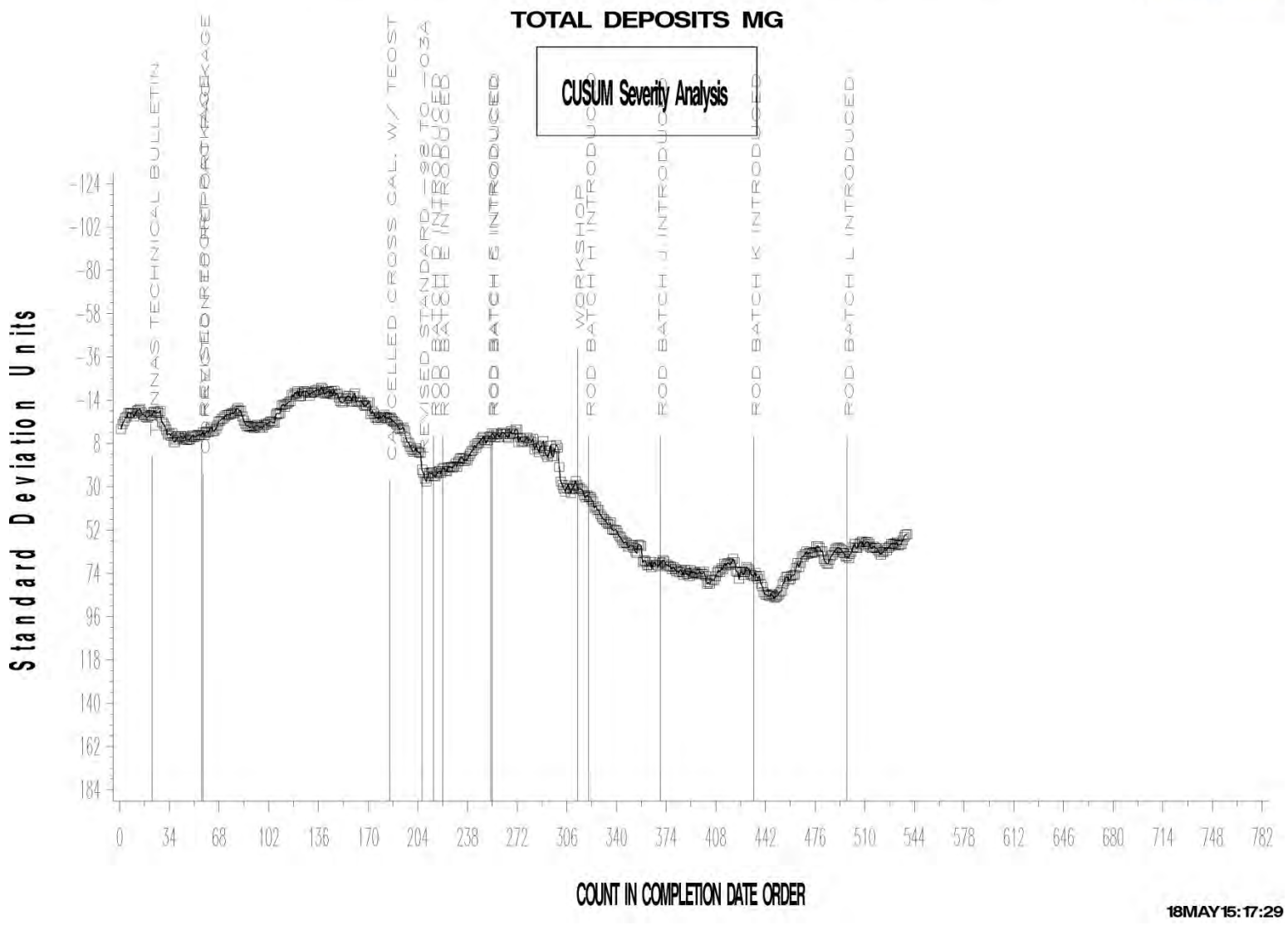
TEOST–33C INDUSTRY OPERATIONALLY VALID DATA



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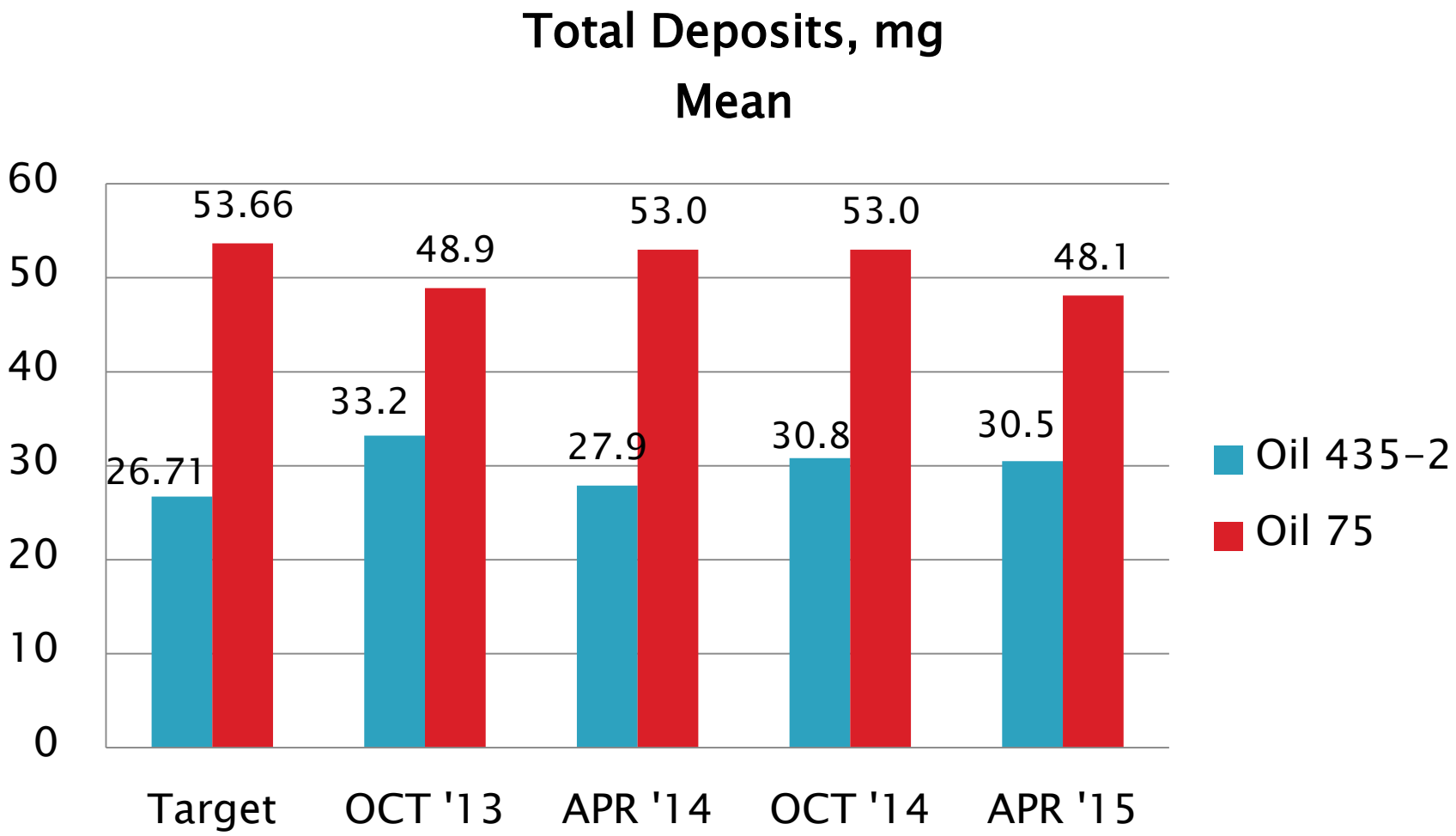
D6335 Performance by Oil

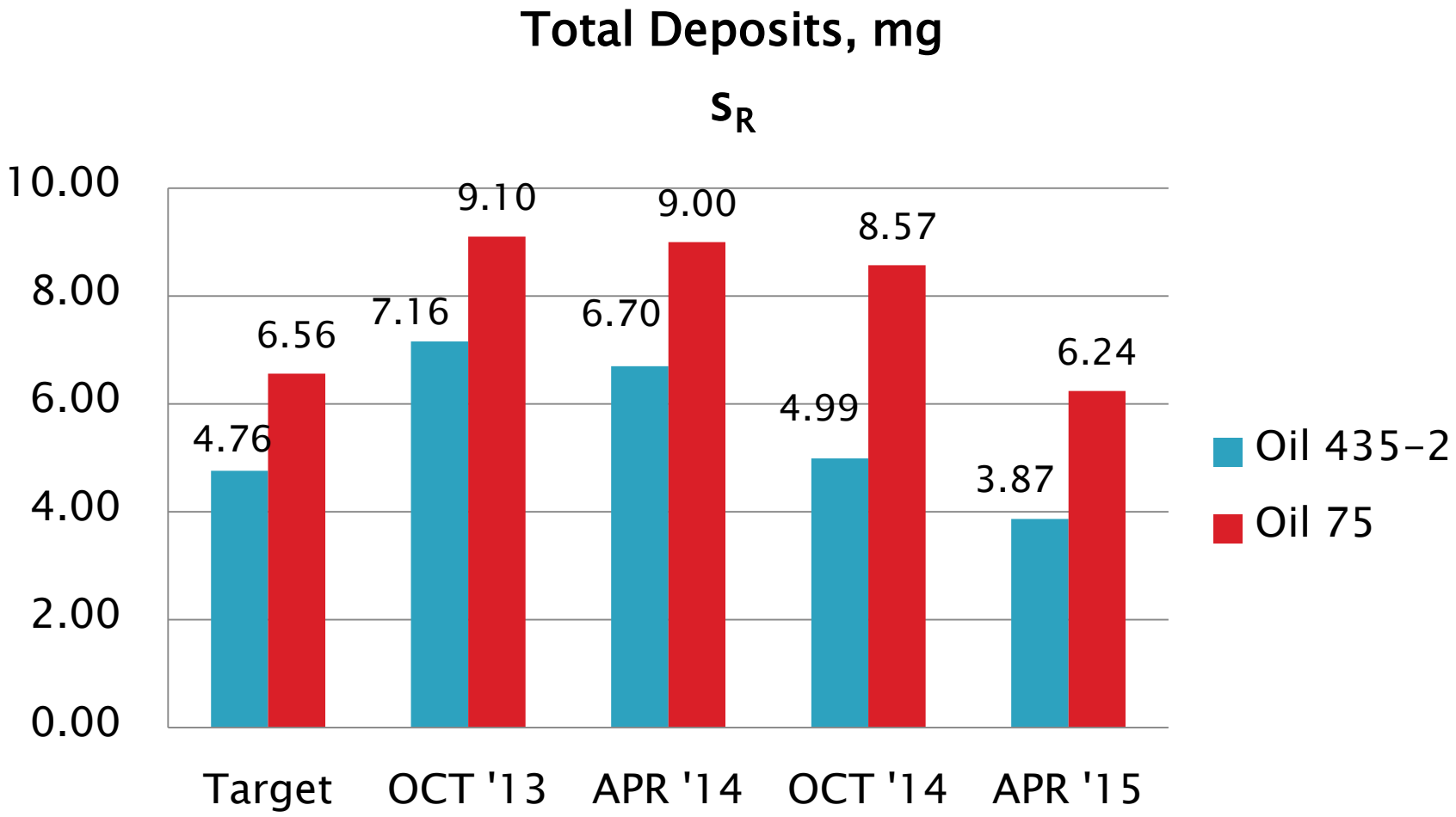
Total Deposits, mg
Performance by Oil

	Targets 20130415			10/1/13 – 3/31/14				4/1/14 – 9/30/14				10/1/14 – 3/31/15			
Oil Code	n	Mean	s_R	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s
435-2	30	26.71	4.76	9	27.9	6.70	-0.17	7	30.8	4.99	0.44	7	30.5	3.87	0.37
75	30	53.66	6.56	7	53.0	9.00	-0.10	8	53.0	8.57	-0.10	8	48.1	6.24	-0.85

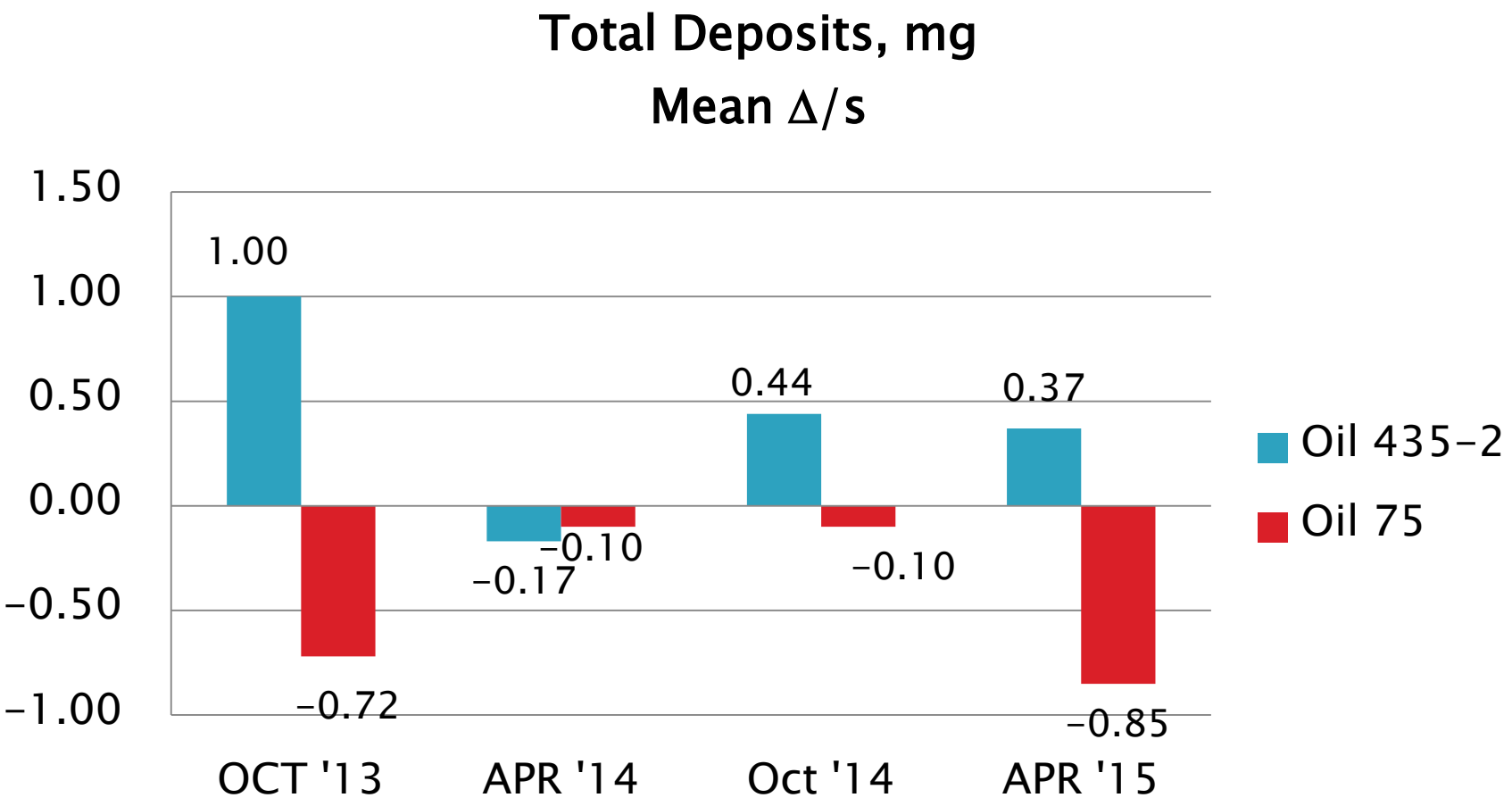
D6335 Performance by Oil



D6335 Performance by Oil



D6335 Performance by Oil



Return to Executive Summary

D7097: Deposits by MHT TEOST

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	83
Failed Calibration Test	OC	11
Operationally Invalidated by Lab	LC, XC	9
Operationally Invalidated After Initially Reported as Valid	RC	1
Donated Catalyst Screener Runs	AG	2
Non-blind Shakedown Run	NN	2
Excluded from Statistics (New Rig)	MC	1
Total		**109**

Number of Labs Reporting Data: 7

Fail Rate of Operationally Valid Tests: 12%

D7097: Deposits by MHT TEOST

Statistically Unacceptable Tests (OC)	No. Of Tests
Total Deposits Mild	4
Total Deposits Severe	7

- Ten operationally invalid calibration tests this period:
  - Sample leak, three tests (LC, XC)
  - Pump failure, one test (LC)
  - Catalyst mass offspec, two tests (RC, LC)
  - Broken glass in filter deposits, one test (XC)
  - Test ran overtime, one test (LC)
  - Power failure, two tests (XC)

- One test excluded from statistics (MC), new rig, reported as operationally valid but failed to calibrate.

D7097: Deposits by MHT TEOST

- Two shakedown runs (NN) to troubleshoot two different instruments at different labs.
- 2 donated runs to screen catalyst batch 14AA (AG, OG)
- Statistics biased by repeated fail on instrument GI, reporting (so far) seven consecutive failing runs (5 OC's severe - 4 this period, 2 XC aborts) and 1 NN shakedown. Lab is currently troubleshooting rig with additional shakedowns before attempting another calibration.
  - Period overall statistics shown including and excluding instrument G1.
  - Statistics by lab does include G1.
  - Statistics by oil exclude all instrument G1 runs.
- No TMC technical updates issued this period

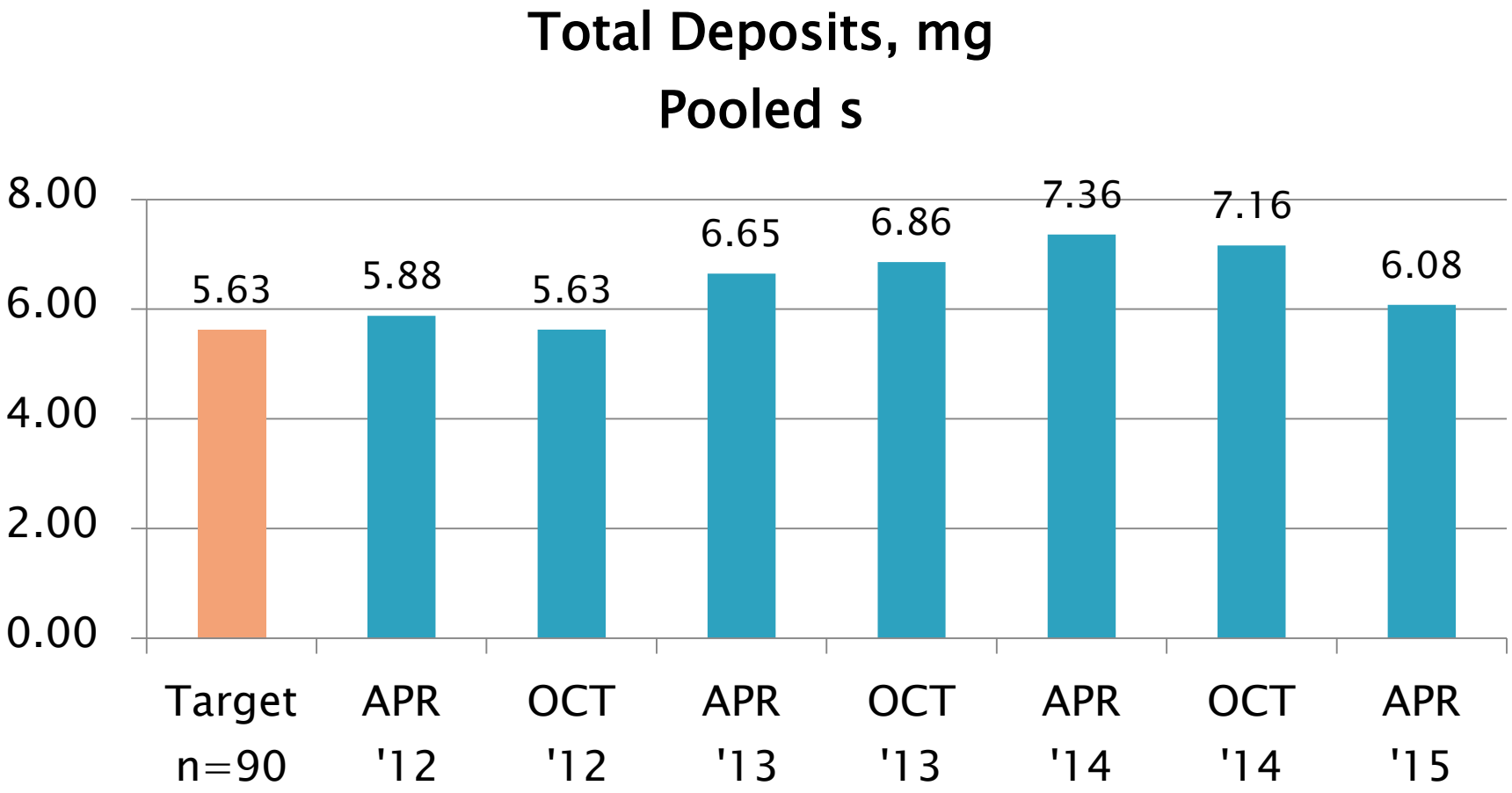
D7097: Deposits by MHT TEOST

Period Precision and Severity Estimates

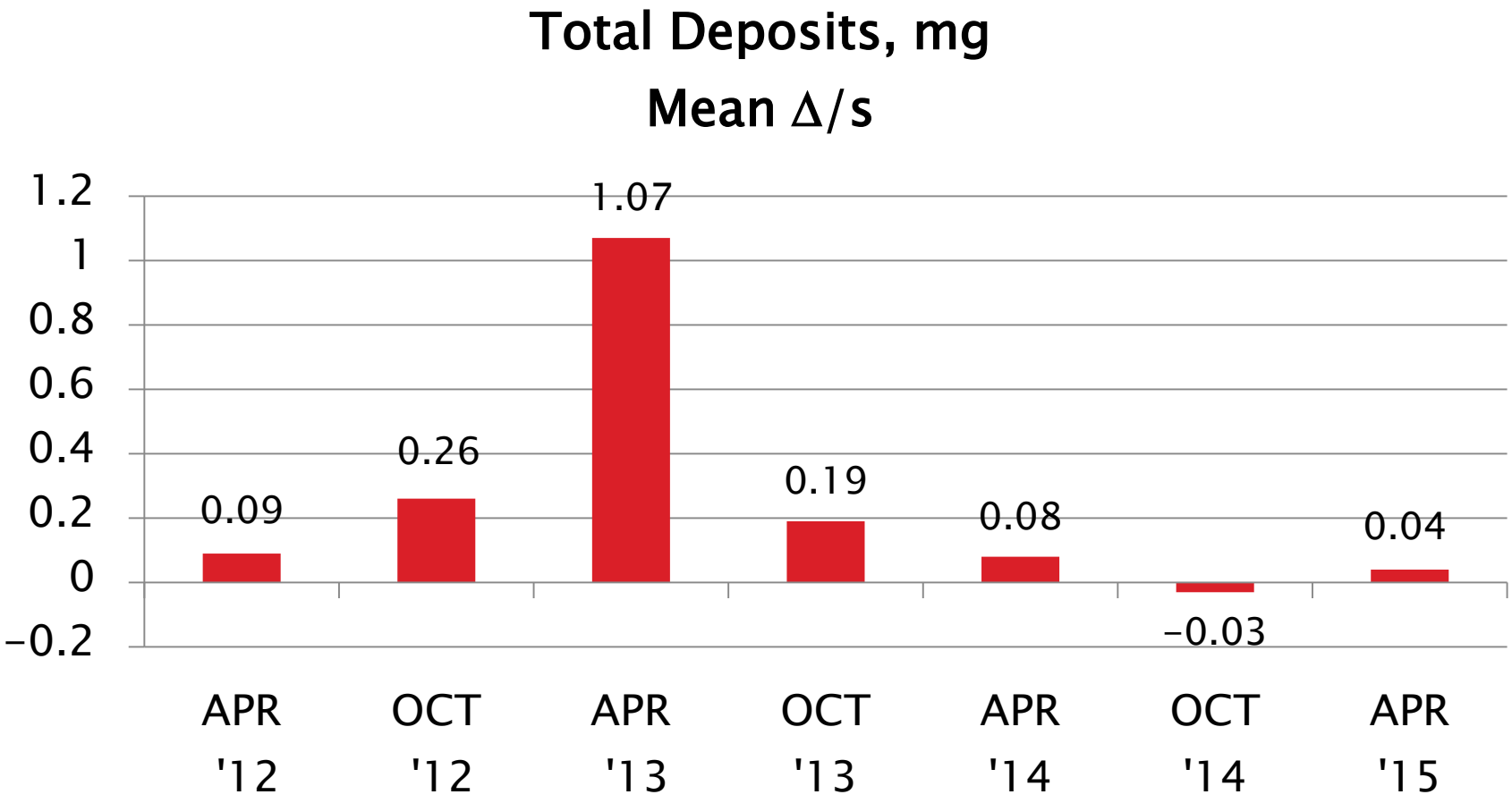
Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Current Targets 7/31/2006	90	87	5.63	-----
10/1/11 through 3/31/12	56	54	5.88	0.09
4/1/12 through 9/30/12	65	62	5.63	0.26
10/1/12 through 3/31/13	68	66	6.65	1.07
4/1/13 through 9/30/13	85	83	6.86	0.19
10/1/13 through 3/31/14	71	69	7.36	0.08
4/1/14 through 9/30/14	76	74	7.16	-0.03
10/1/14 through 3/31/15*	94	92	6.60	0.19
10/1/14 through 3/31/15*	90	88	6.08	0.04

*Four severe OC tests from instrument G1 included and excluded

D7097 Precision Estimates



D7097 Severity Estimates

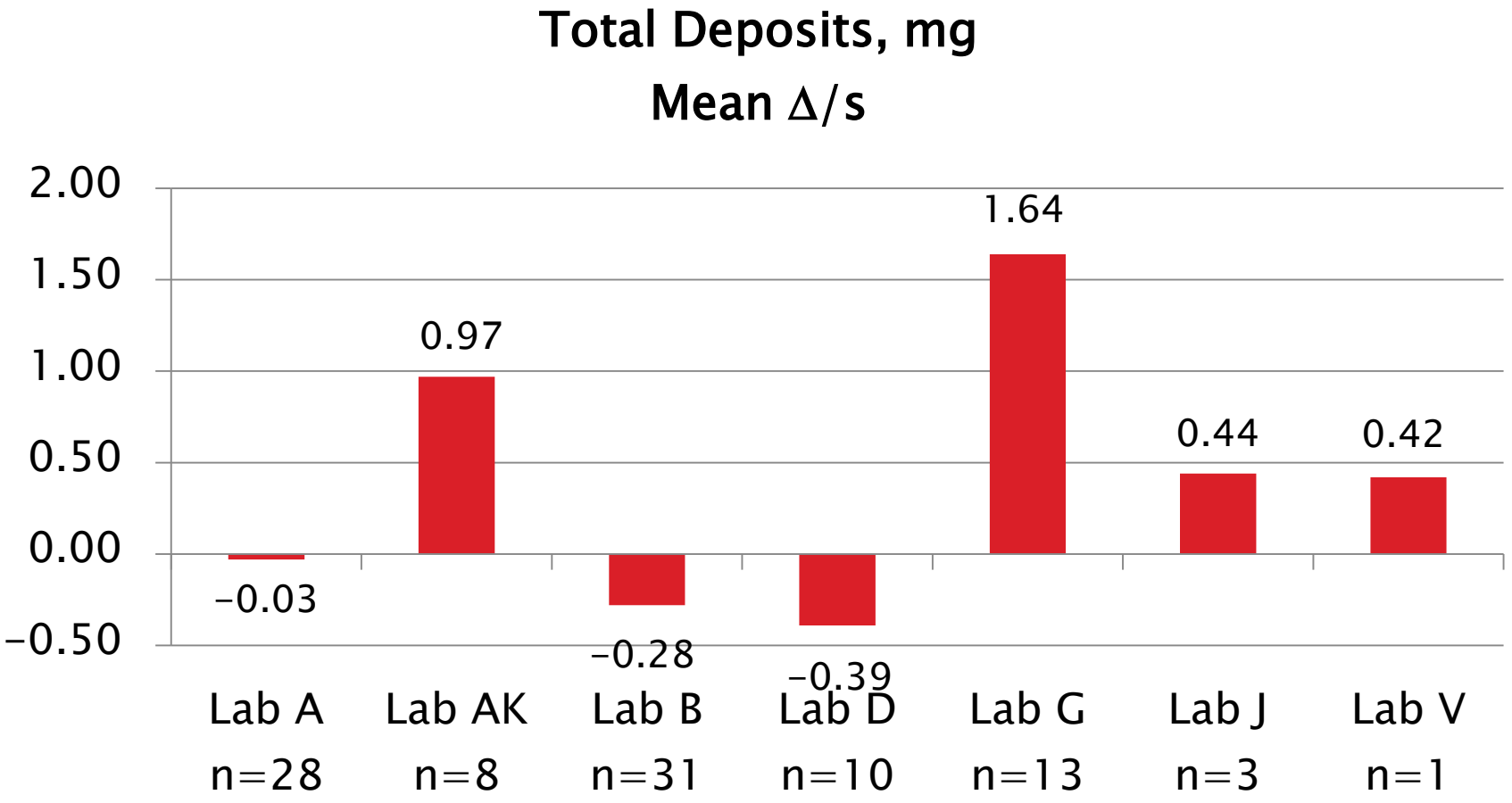


D7097: Deposits by MHT TEOST

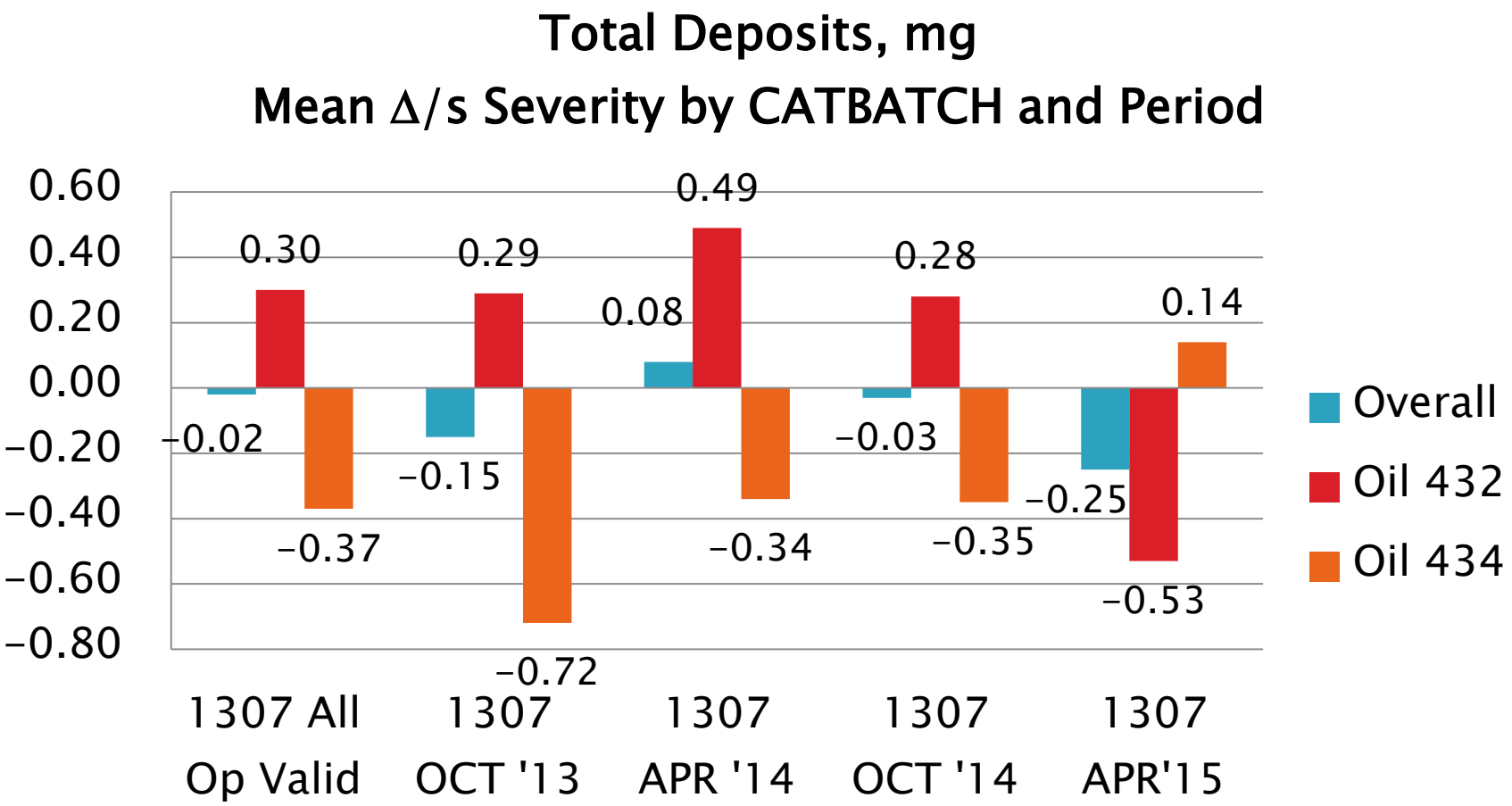
Current Period Severity Estimates by Lab
Total Deposits, mg

	n	Mean Δ/s
Lab A	28	-0.03
Lab AK	8	0.97
Lab B	31	-0.28
Lab D	10	-0.39
Lab G	13	1.64
Lab J	3	0.44
Lab V	1	0.42

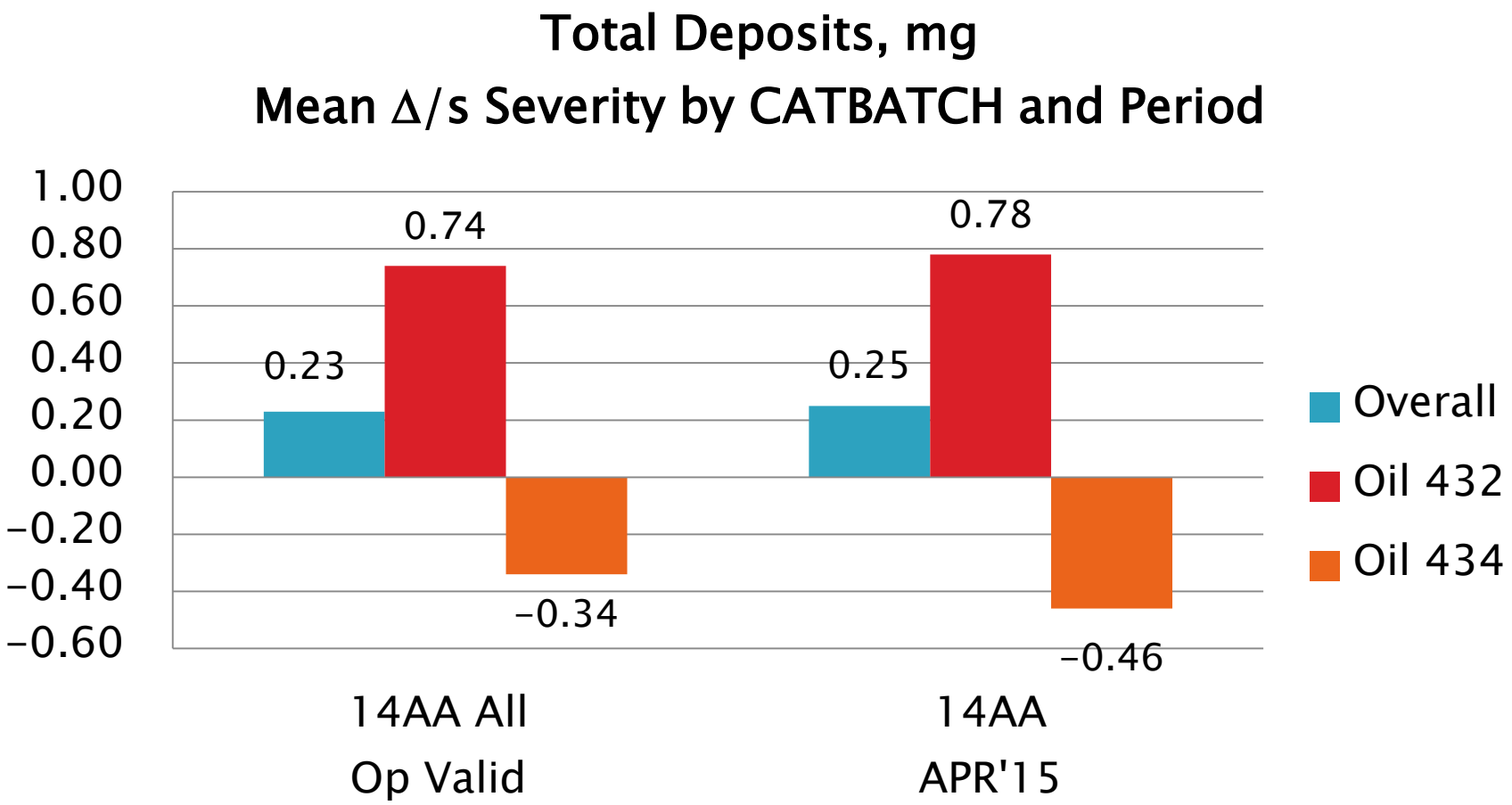
D7097 Lab Severity Estimates



D7097: Deposits by MHT TEOST



D7097: Deposits by MHT TEOST



D7097: Deposits by MHT TEOST

- Precision (Pooled s) is more precise than prior period
  - Less precise than target precision
- Performance (Mean Δ/s) is nearly on-target at 0.04 s (excluding instrument G1 results)
- All operationally valid tests this period report using Rod Batch L
- All operationally valid calibration tests this period report using Catalyst Batch 1307 (n=12, labs AK & D) or 14AA (n=82). Labs AK & D also report tests on batch 14AA.

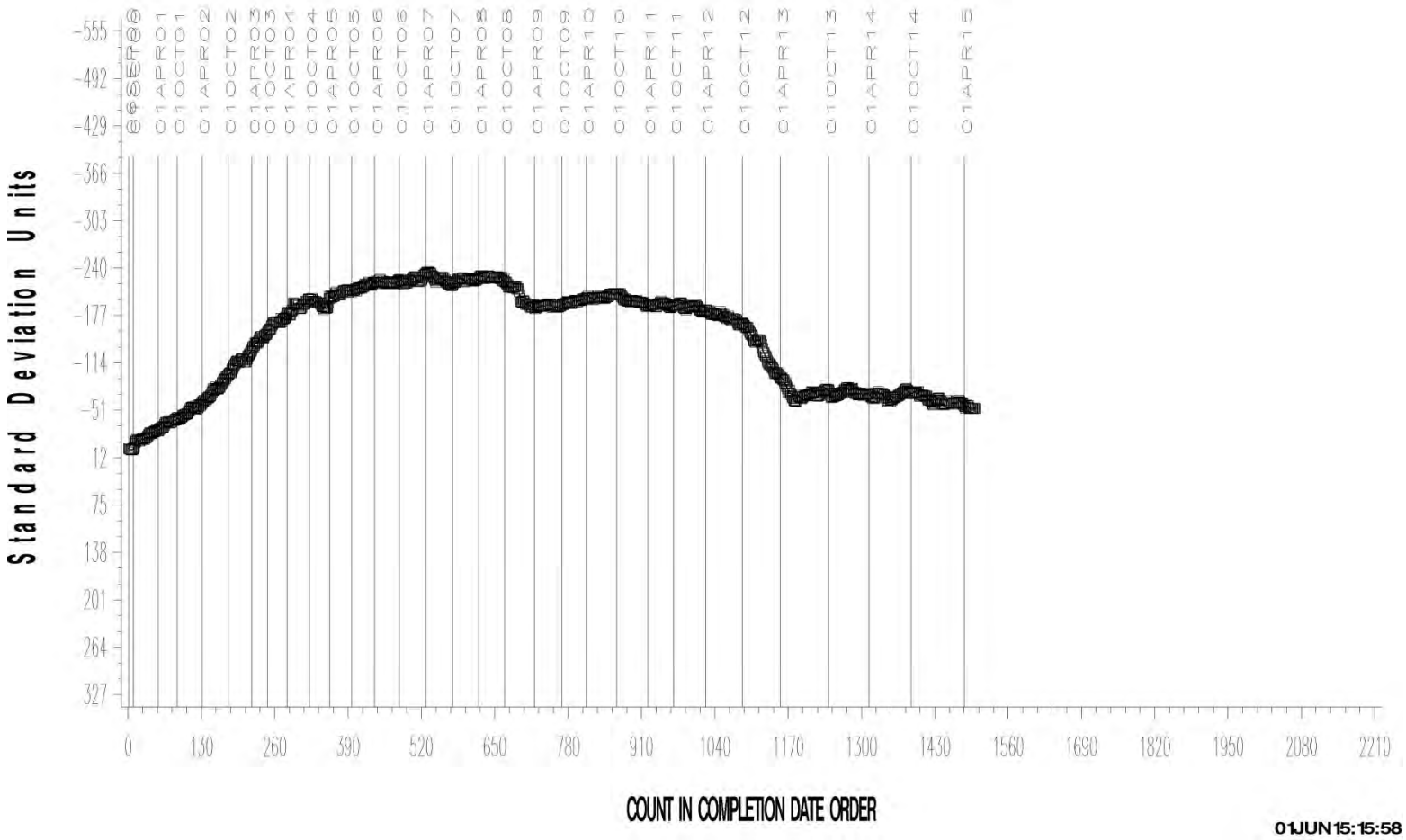
D7097: Deposits by MHT TEOST

- CUSUM severity plot shows OVERALL severity continues near target since introduction of catalyst batch 1307 and into the new catalyst batch 14AA
  - However, lab performance differences persist
  - Once again, the overall severe performance of oil 432 (0.38 s, n=50) is nearly offset by overall mild performance of oil 434 (-0.39 s, n = 40), with mostly new CATBATCH 14AA being run this period.
    - Similar to severity bias observed between the reference oils with CATBATCH 1307 in past periods.
  - Catalyst batches have been observed to bias performance differently for different oils, and may partially explain observed severity differences between the two reference oils oil, but does not explain ongoing lab severity differences.

MHT—4 TEOST INDUSTRY OPERATIONALLY VALID DATA

TOTAL DEPOSITS MG

CUSUM Severity Analysis



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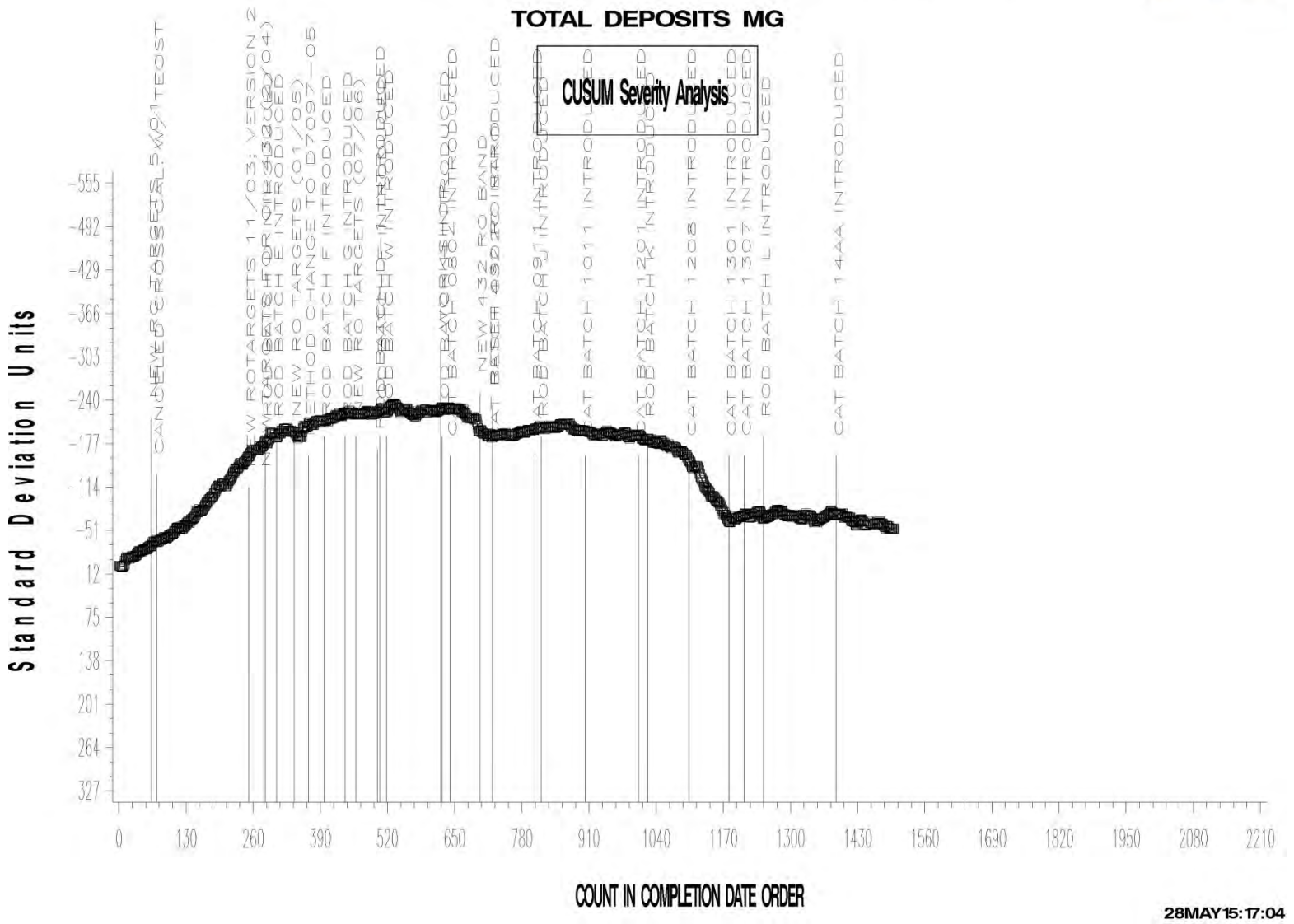
MHT—4 TEOST INDUSTRY OPERATIONALLY VALID DATA

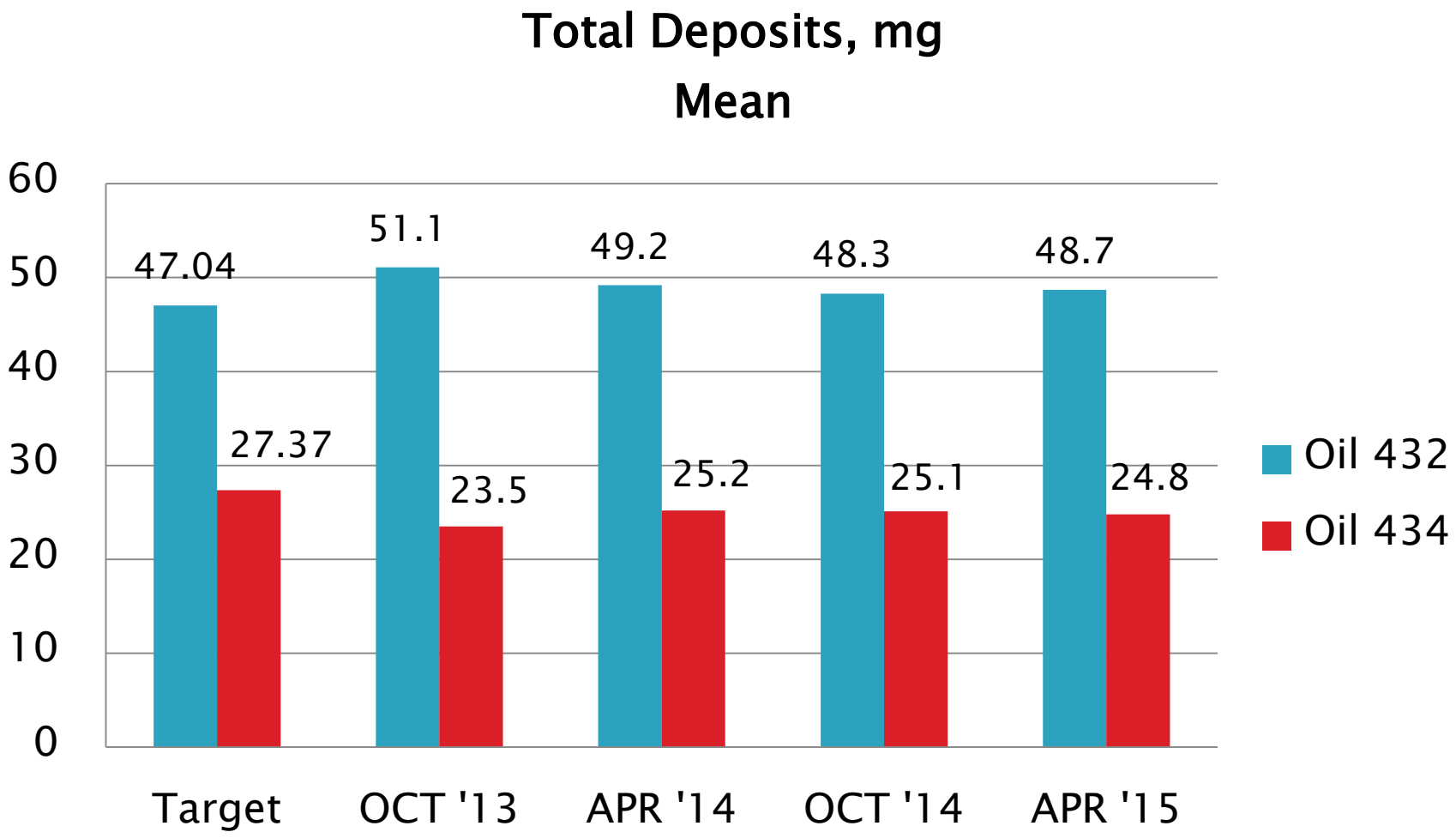


D7097 Performance by Oil

Total Deposits, mg
Performance by Oil

	Targets			10/1/13 – 3/31/14				4/1/14 – 9/30/14				10/1/14 – 3/31/15			
Oil Code	n	Mean	s_R	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s
432	30	47.04	4.50	36	49.2	6.69	0.49	39	48.3	6.87	0.28	50	48.7	5.55	0.38
434	30	27.37	6.57	35	25.2	8.00	-0.34	37	25.1	7.45	-0.35	40	24.8	6.68	-0.39

D7097 Performance by Oil



Test Monitoring Center
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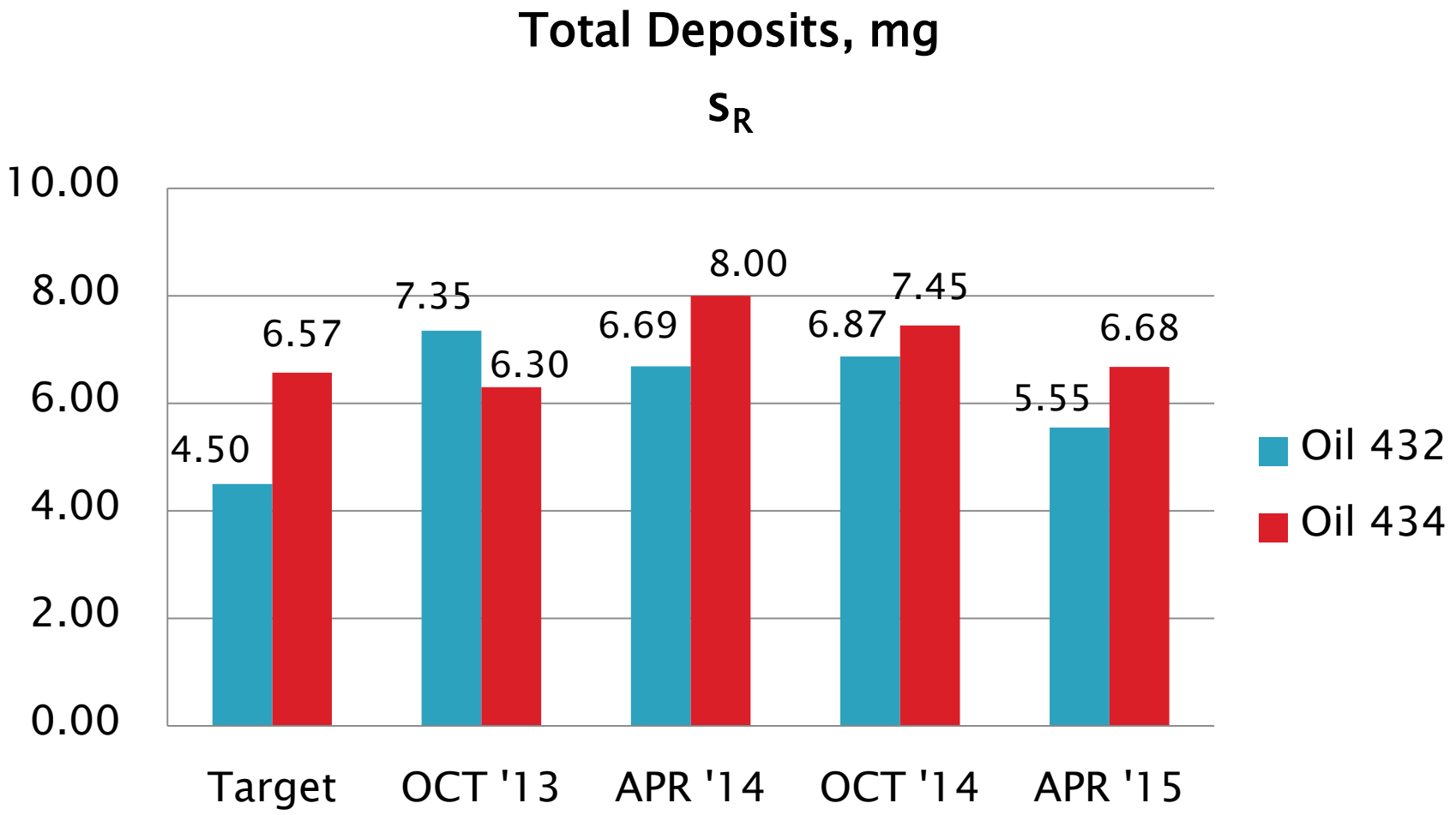
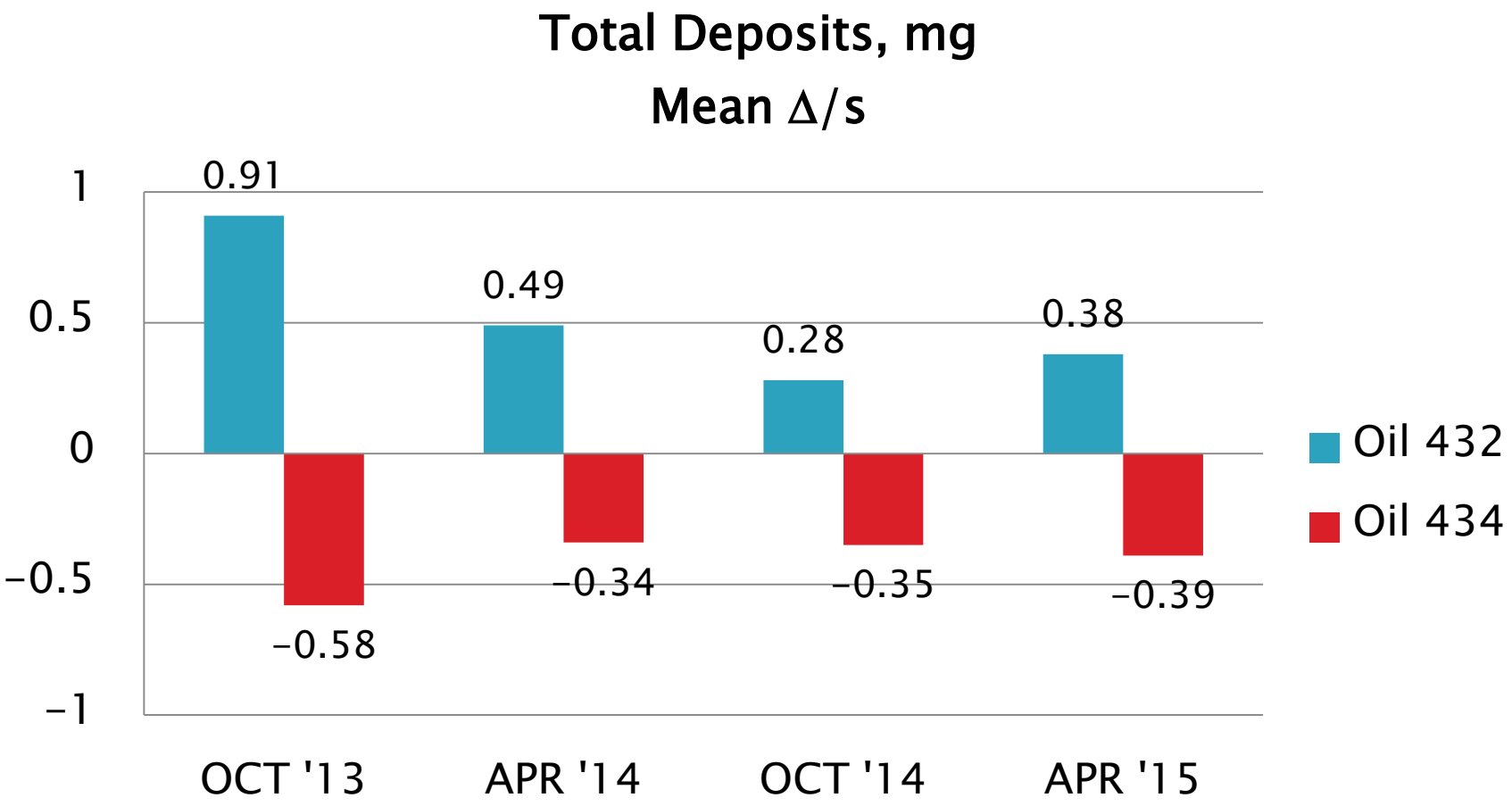
D7097: Deposits by MHT TEOST



D7097: Deposits by MHT TEOST



Return to Executive Summary

D6082: High Temperature Foam

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	10
Acceptable Discrimination Test	AS	4
Failed Calibration Test	OC	0
Operationally Invalidated by Lab	LC, XC	0
Operationally Invalidated After Initially Reported as Valid	RC	0
Total		**14**

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

D6082: High Temperature Foam

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

- No operationally or statistically invalid tests reported this period

- All operationally valid discrimination runs reported this period could discriminate oil 66 as a GF-5/SN failing oil for Foam Tendency.

- No TMC technical updates issued this period

D6082: High Temperature Foam

Period Precision and Severity Estimates Oil 1007

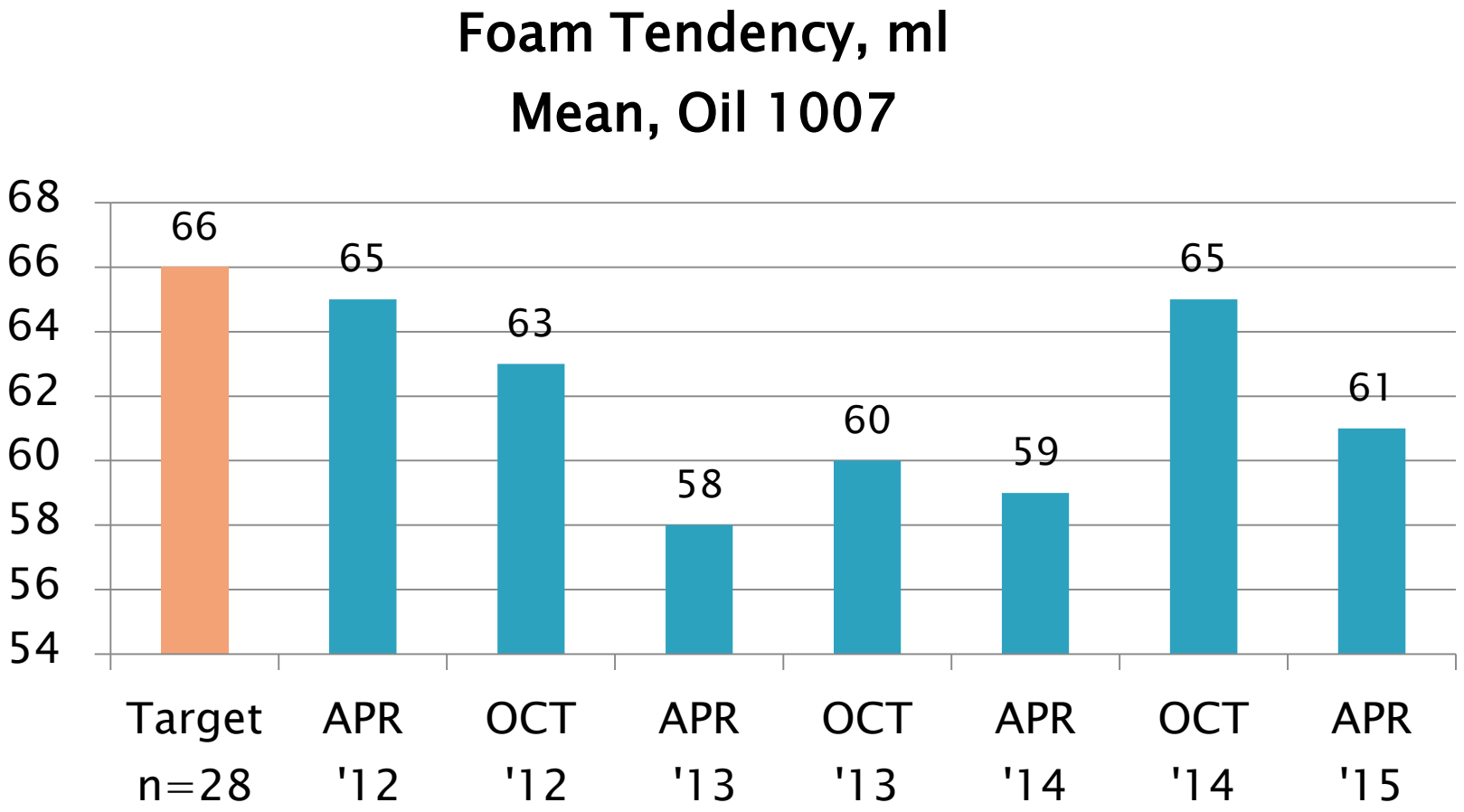
Foam Tendency, ml	n	Mean	Pooled s	Mean Δ/s
Current Targets	28	65.71	19.28	-----
10/1/11 through 3/31/12	8	65	13	-0.05
4/1/12 through 9/30/12	9	63	13	-0.14
10/1/12 through 3/31/13	8	58	10	-0.45
4/1/13 through 9/30/13	9	60	7	-0.32
10/1/13 through 3/31/14	11	59	8	-0.39
4/1/14 through 9/30/14	11	65	22	-0.05
10/1/14 through 3/31/15	10	61	12	-0.26

D6082: High Temperature Foam

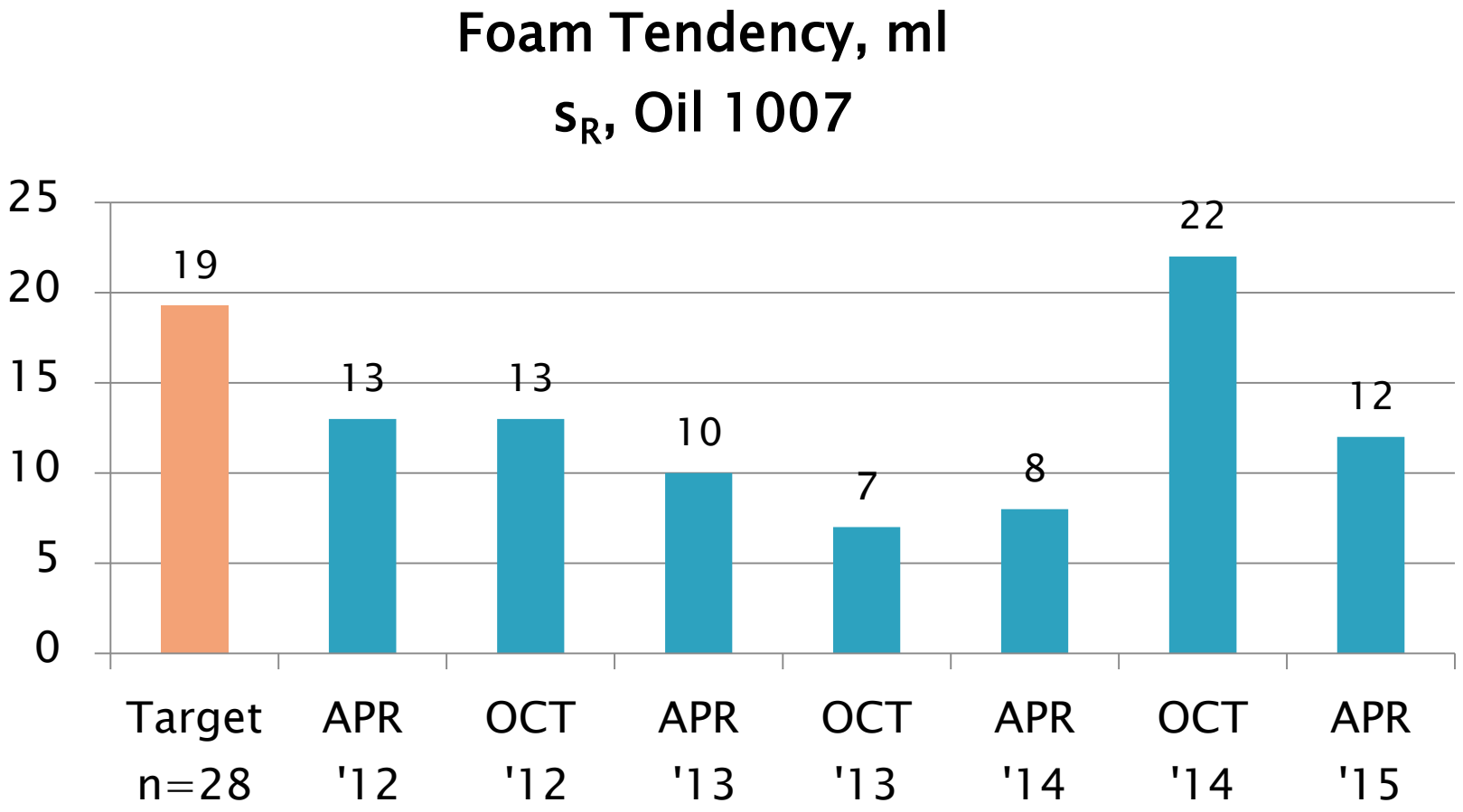
Period Precision and Severity Estimates Oil 1007

Foam Stability @ 1 min, ml	n	Mean	s
Current Targets	28	0.00	0.00
10/1/11 through 3/31/12	8	No non-zero occurrences	
4/1/12 through 9/30/12	9	No non-zero occurrences	
10/1/12 through 3/31/13	8	No non-zero occurrences	
4/1/13 through 9/30/13	9	No non-zero occurrences	
10/1/13 through 3/31/14	11	No non-zero occurrences	
4/1/14 through 9/30/14	11	No non-zero occurrences	
10/1/14 through 3/31/15	10	No non-zero occurrences	

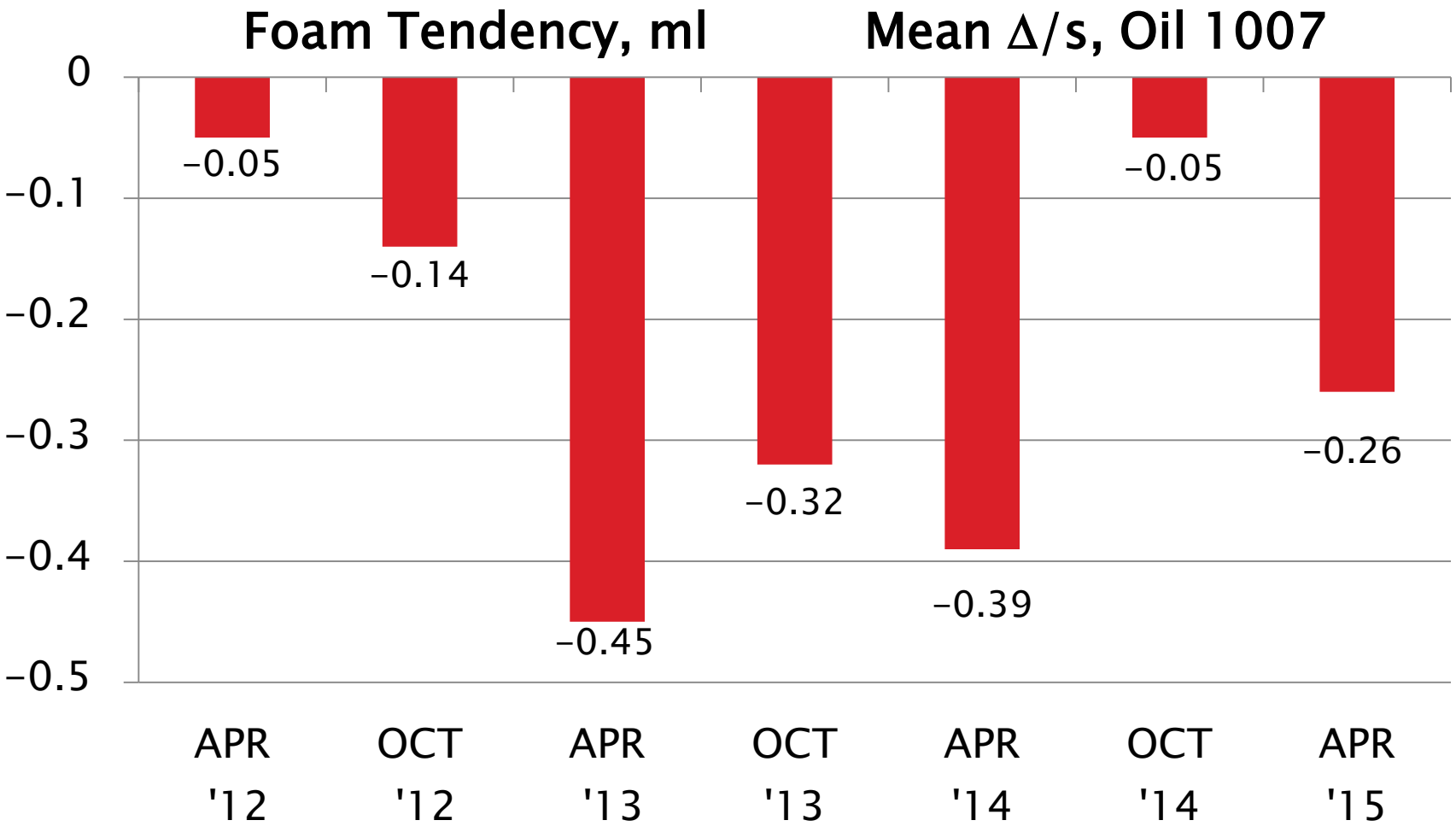
D6082: High Temperature Foam



D6082: High Temperature Foam



D6082: High Temperature Foam



Test Monitoring Center
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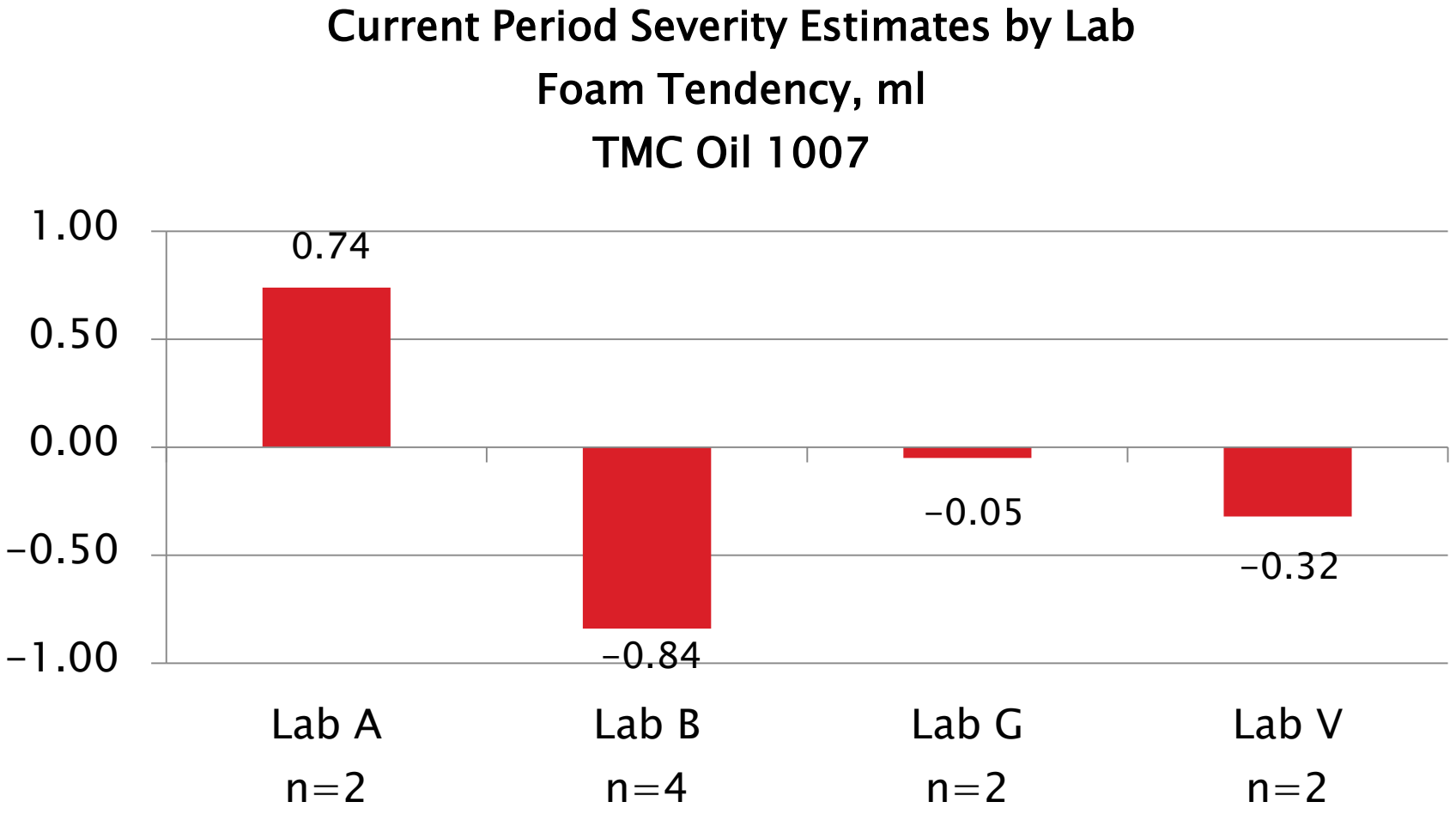
D6082: High Temperature Foam

Current Period Severity Estimates by Lab
Foam Tendency, ml
TMC Oil 1007

	n	Mean Δ/s
Lab A	2	0.74
Lab B	4	-0.84
Lab G	2	-0.05
Lab V	2	-0.32

D6082: High Temperature Foam



Test Monitoring Center
http://astmtmc.cmu.edu
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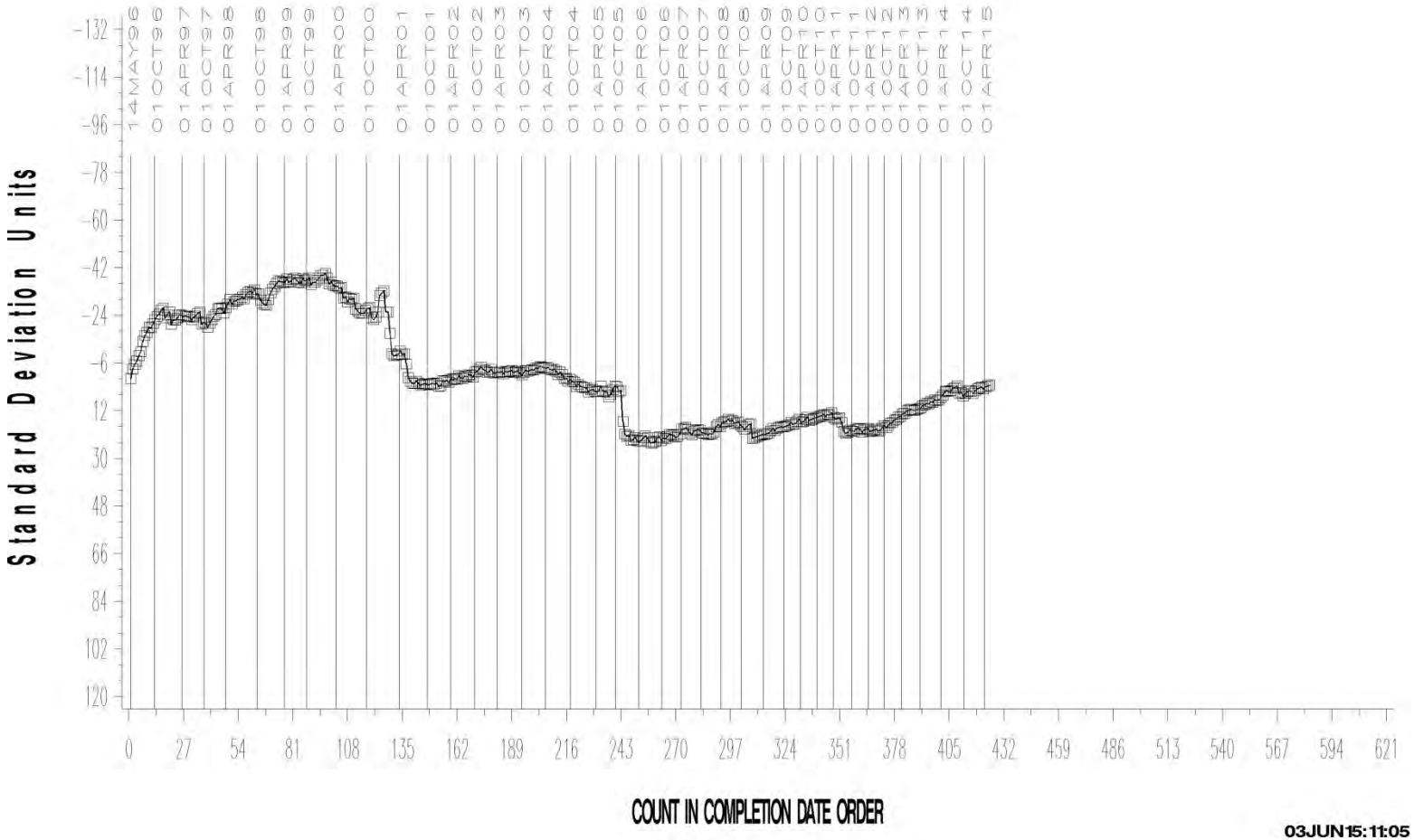
D6082: High Temperature Foam

- Foam Tendency Precision (Pooled s) is more precise than prior period
  - More precise than target precision
- Performance (Mean Δ/s) is -0.26 s mild
- No non-zero occurrences of Foam Stability
- All operationally valid discrimination runs demonstrated acceptable discrimination

D6082 HIGH TEMPERATURE FOAM INDUSTRY OPERATIONALLY VALID DATA

FOAM TENDENCY

CUSUM Severity Analysis



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Return to Executive Summary

D874: Sulfated Ash

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	6
Failed Calibration Test	OC	0
Operationally Invalidated by Lab	LC, XC	0
Operationally Invalidated After Initially Reported as Valid	RC	0
Total		**6**

Number of Labs Reporting Data: 3
Fail Rate of Operationally Valid Tests: 0%

D874: Sulfated Ash

Statistically Unacceptable Tests (OC)	No. Of Tests
Sulfated Ash Mild	0
Sulfated Ash Severe	0

- No operationally or statistically invalid tests reported this period
- No TMC technical updates issued this period

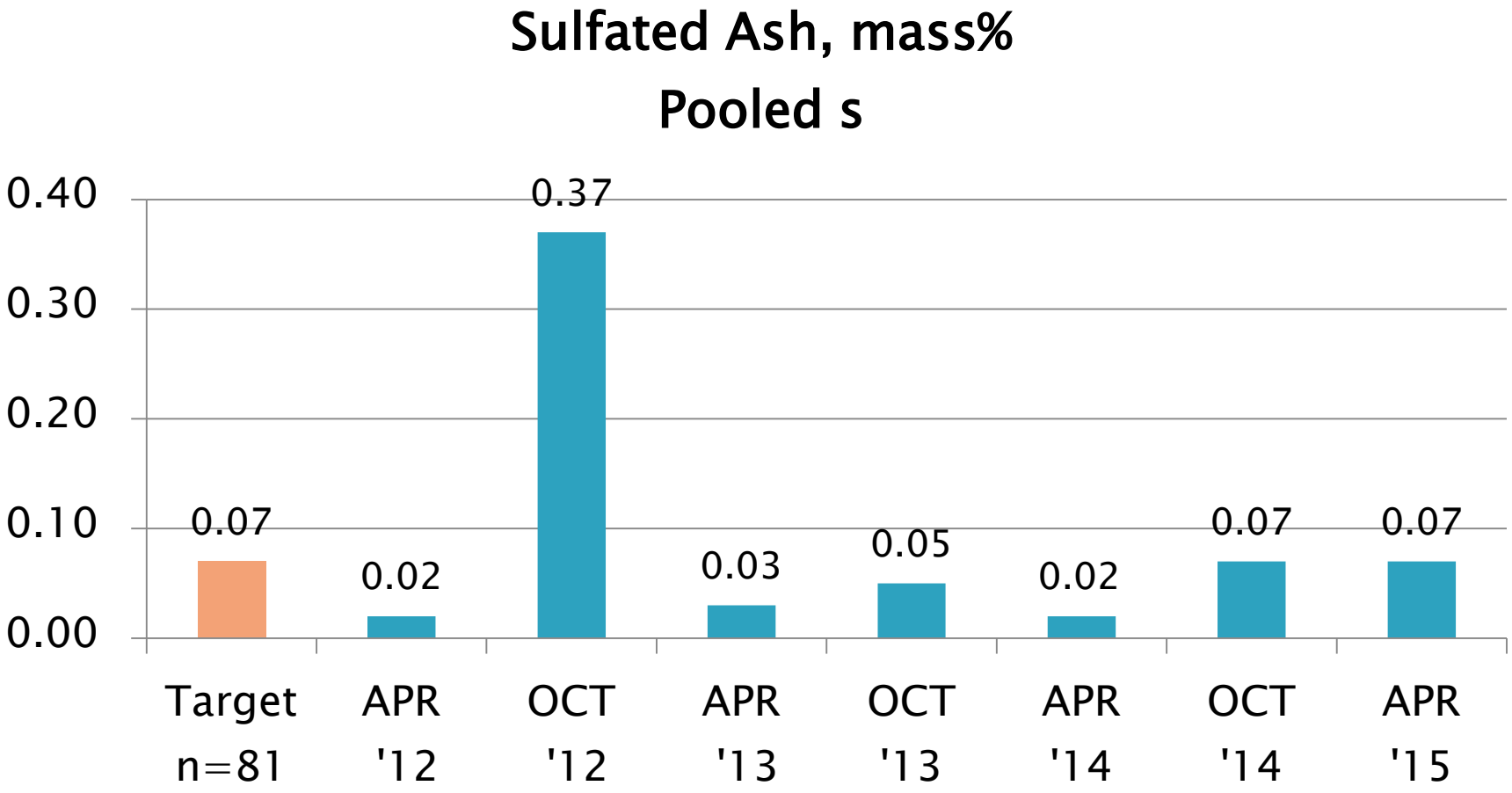
D874: Sulfated Ash

Period Precision and Severity Estimates

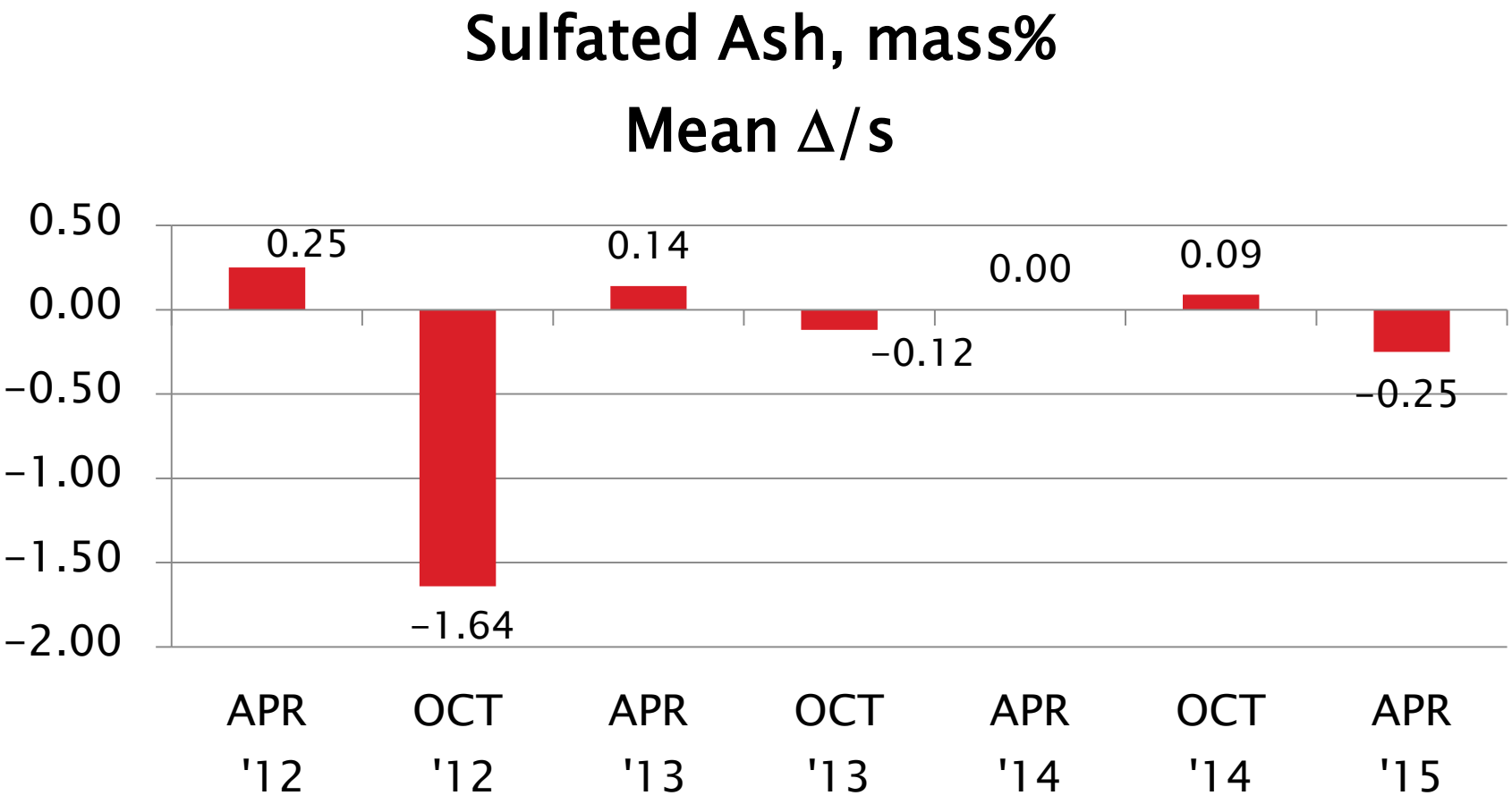
Total Deposits, mg	n	df	Pooled s	Mean D/s
Current Targets	81	78	0.07	-----
10/1/11 through 3/31/12	6	4	0.02	0.25
4/1/12 through 9/30/12*	7	4	0.37	-1.64
4/1/12 through 9/30/12*	6	3	0.04	0.01
10/1/12 through 3/31/13	7	4	0.03	0.14
4/1/13 through 9/30/13	6	3	0.05	-0.12
10/1/13 through 3/31/14	5	2	0.02	0.00
4/1/14 through 9/30/14	6	3	0.07	0.09
10/1/14 through 3/31/15	6	4	0.07	-0.25

*Period statistics with and without extreme result included

D874: Sulfated Ash



D874: Sulfated Ash

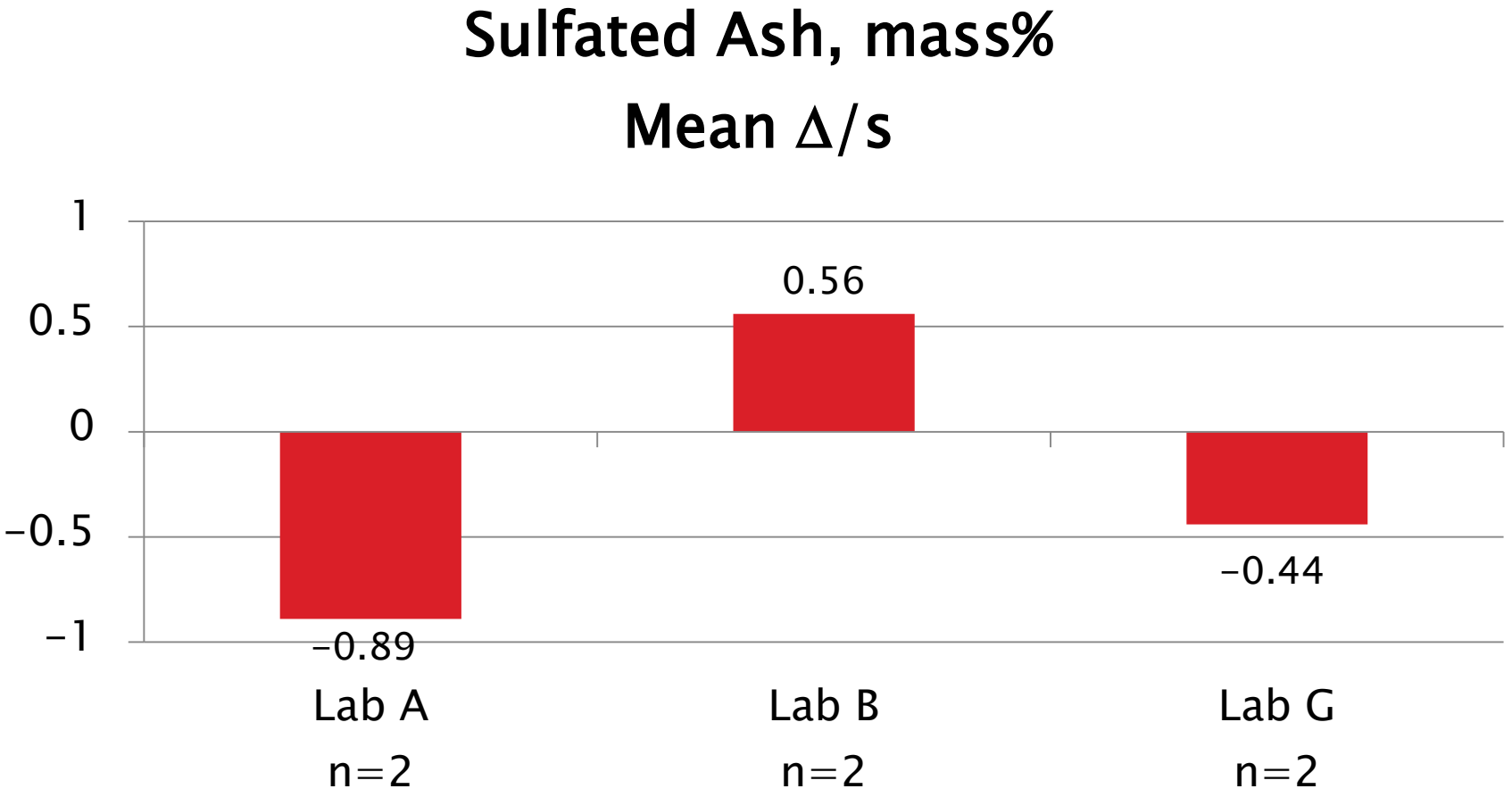


D874: Sulfated Ash

Current Period Severity Estimates by Lab
Sulfated Ash, mass%

	n	Mean Δ/s
Lab A	2	-0.89
Lab B	2	0.56
Lab G	2	-0.44

D874: Sulfated Ash



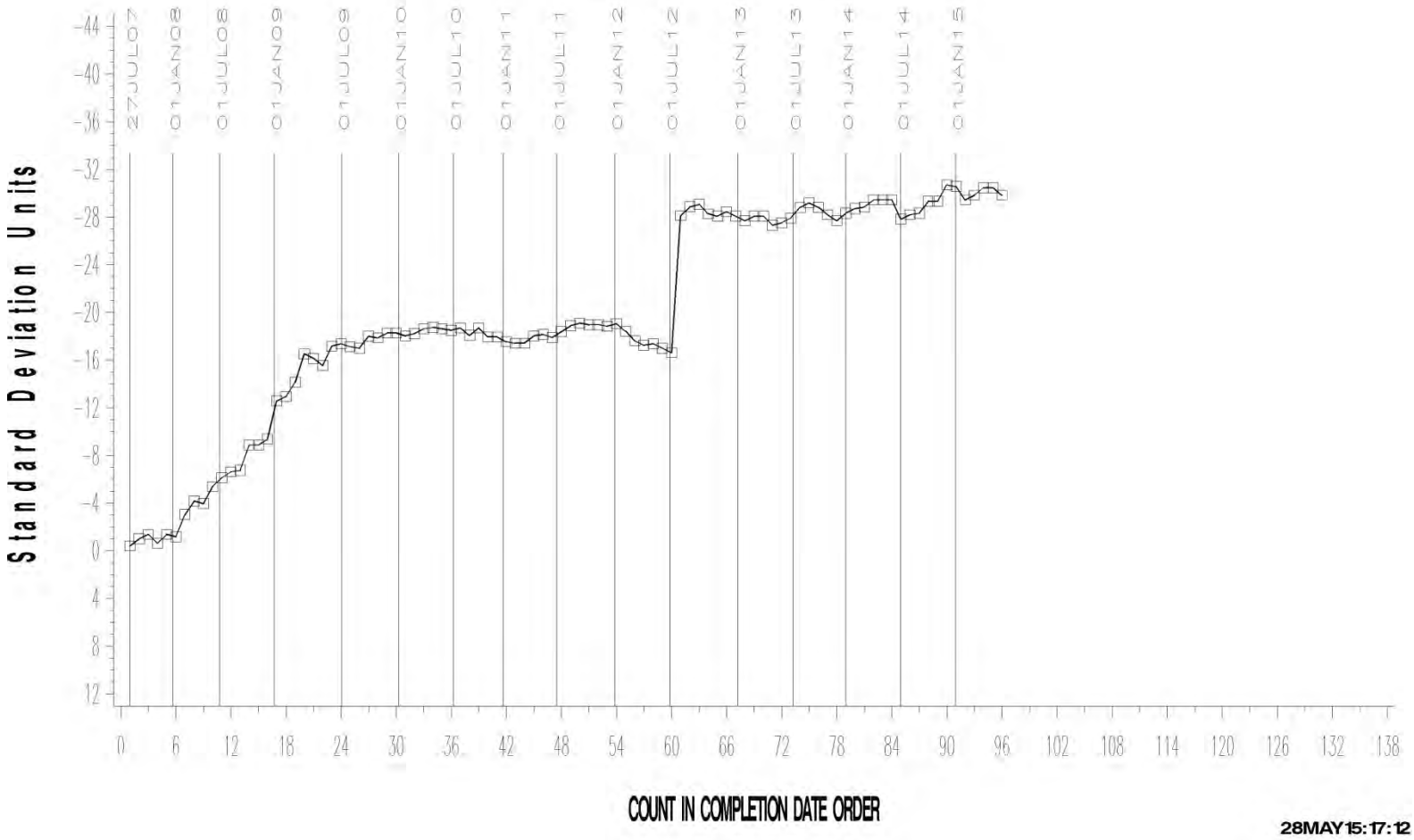
D874: Sulfated Ash

- Precision (Pooled s) is the same as the prior period
  - Equal to target precision
- Performance (Mean Δ/s) is -0.25 s mild
- TMC shipped an unusually high volume of reference oil 90 for QC check sample use, 5.1 gallons shipped over past 12 months, which is 19% of remaining inventory of 26.6 gallons.

D874 INDUSTRY OPERATIONALLY VALID DATA

TEST SAMPLE PERCENT SULFATED ASH

CUSUM Severity Analysis



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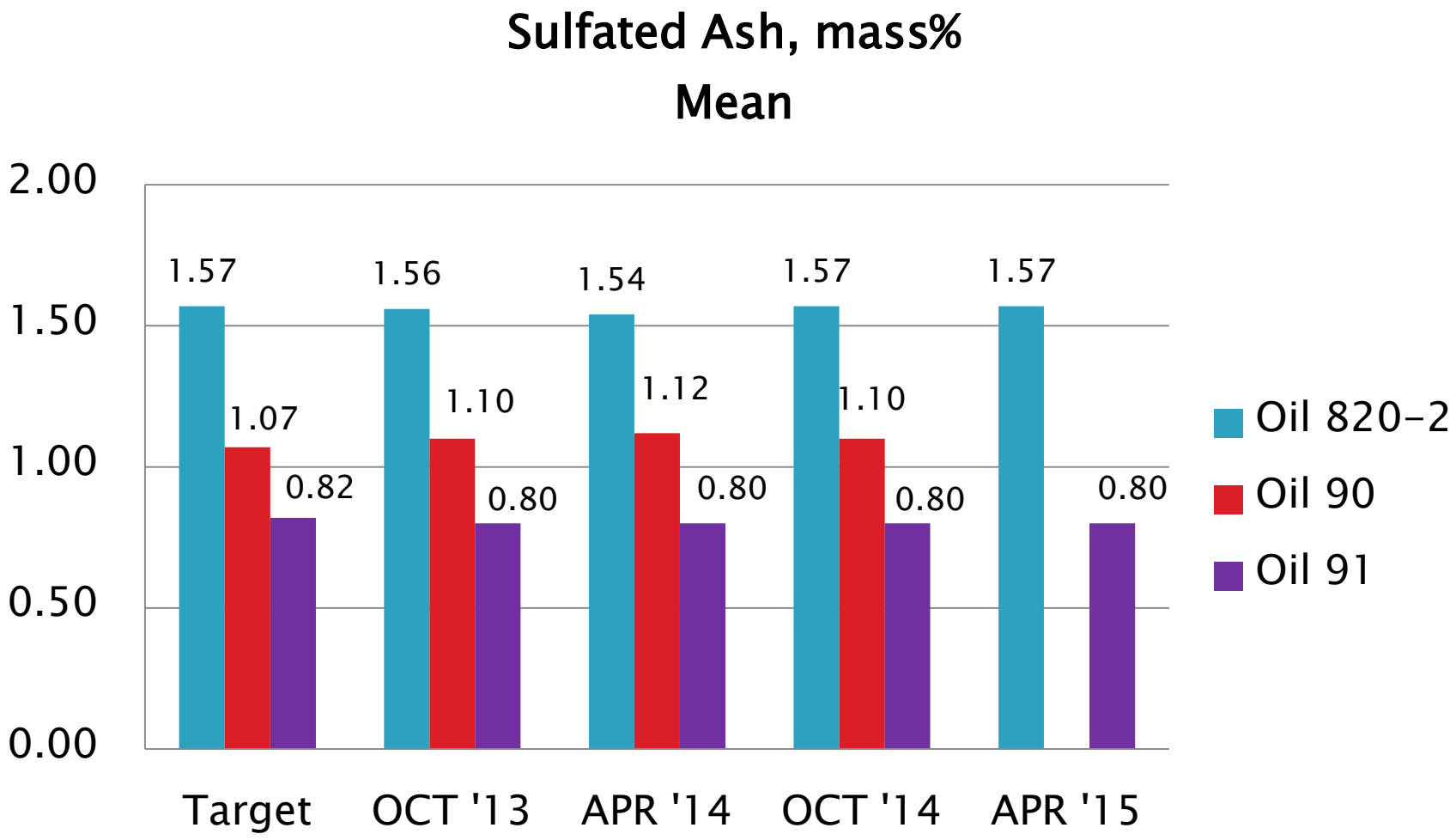
D874: Sulfated Ash

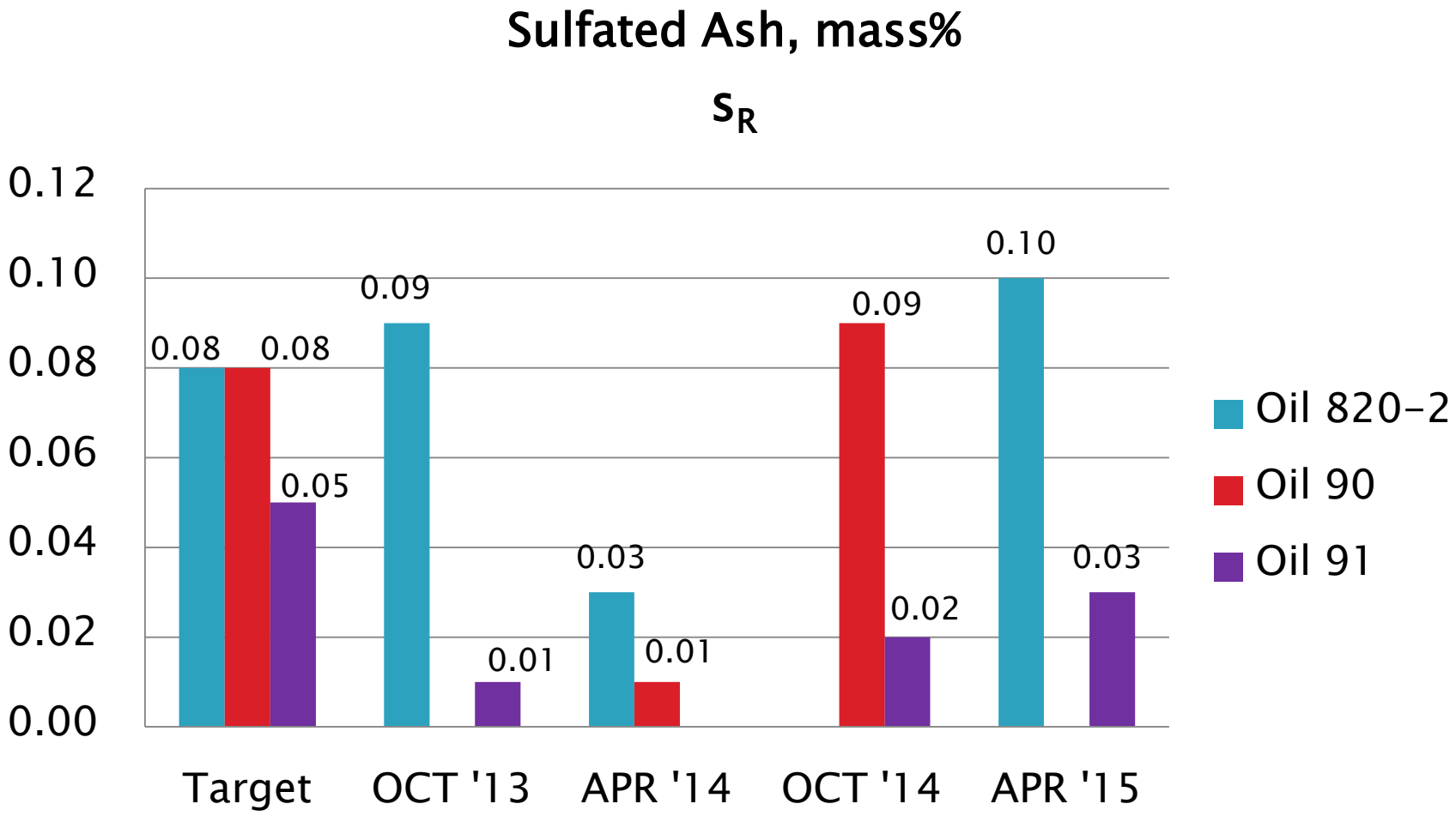
Performance by Oil
Sulfated Ash, mass%

	Targets			10/1/13 – 3/31/14				4/1/14 – 9/30/14				10/1/14 – 3/31/15			
Oil Code	n	Mean	s_R	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s
820-2	27	1.57	0.08	2	1.54	0.03	-0.38	1	1.57	---	0.00	3	1.57	0.10	-0.04
90	27	1.07	0.08	2	1.12	0.01	0.56	3	1.10	0.09	0.38	0	---	---	---
91	27	0.82	0.05	1	0.80	----	-0.40	2	0.80	0.02	-0.30	3	0.80	0.03	-0.47

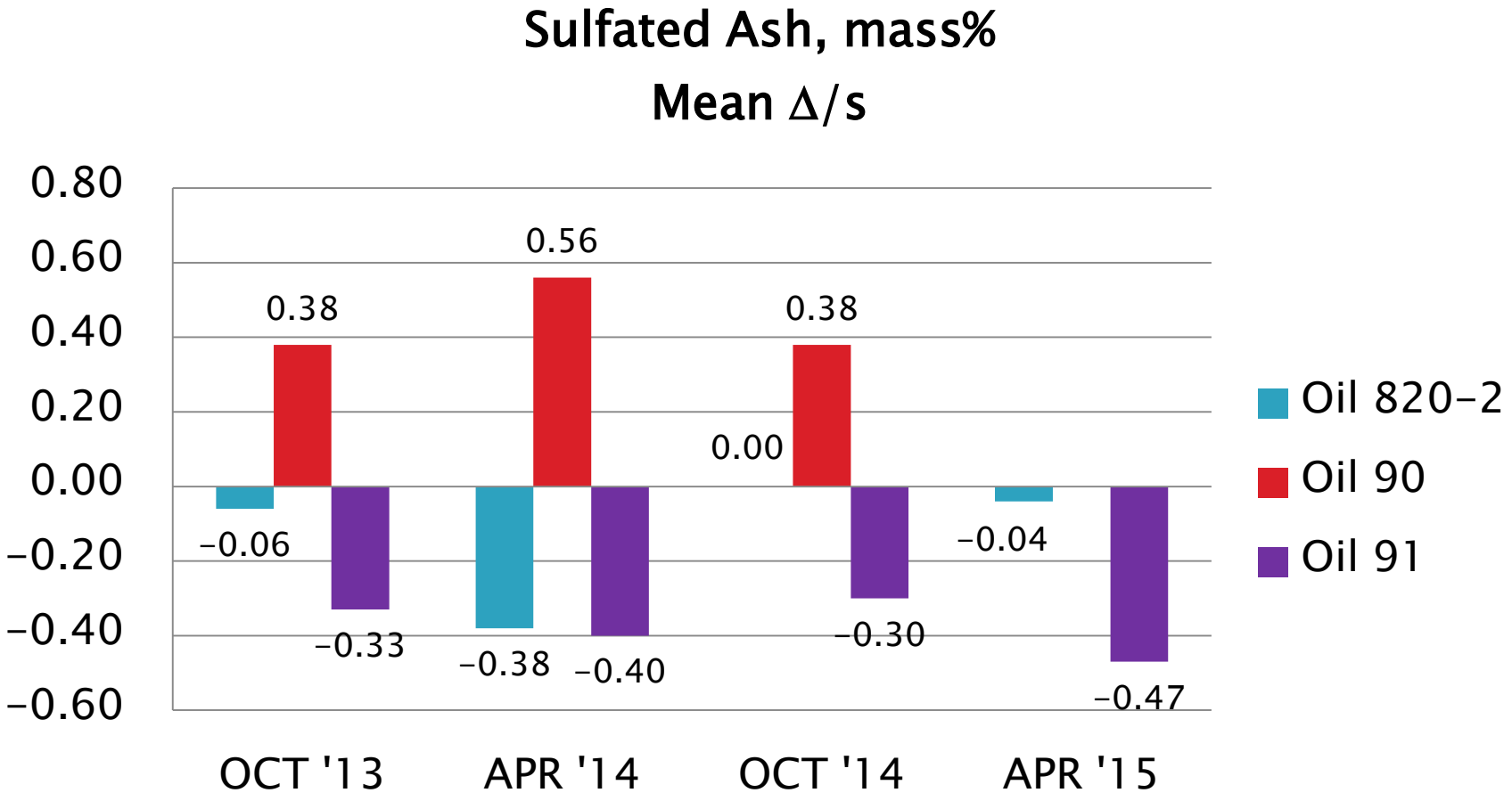
D874: Sulfated Ash



D874: Sulfated Ash



D874: Sulfated Ash



Return to Executive Summary

D7528: Oxidation by ROBO

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	79
Failed Calibration Test	OC	18
Operationally Invalidated by Lab	LC, XC	19
Operationally Invalidated After Initially Reported as Valid	RC	2
Non-reference shakedown, excluded from statistics	NN, MN, XN	8
Total		**126**

Number of Labs Reporting Data: 8
Fail Rate of Operationally Valid Tests: 19%

D7528: Oxidation by ROBO

Operationally Invalid Tests

- 9 tests vacuum system failure (LC, XC)
- 2 tests incorrect vacuum control valve setting (LC, XC)
- 3 tests heater or heater control failure (RC, LC, XC)
- 1 test power failure (XC)
- 3 tests NO_2 flow problems (LC, XC)
- 1 test stirrer failure (XC)
- 2 tests unexplained high EOT volatiles (RC, LC)

- Also had 8 shakedown runs (NN, MN, XN) for either new rigs or for rigs that had not calibrated with the TMC for more than 150 days. One run completed the three runs needed to pre-qualify new rig AQ2 for proceeding to calibration (successfully). 3 runs qualified an expired rig to proceed to calibration. One run was aborted on off-spec NO_2 flow, and three disqualified because of invalid VC valve adjustments made between pre-qualifying shakedown runs.

D7528: Oxidation by ROBO

Statistically Unacceptable Tests (OC)	No. Of Tests
Natural Log (MRV Viscosity) Mild	13
Natural Log (MRV Viscosity) Severe	5

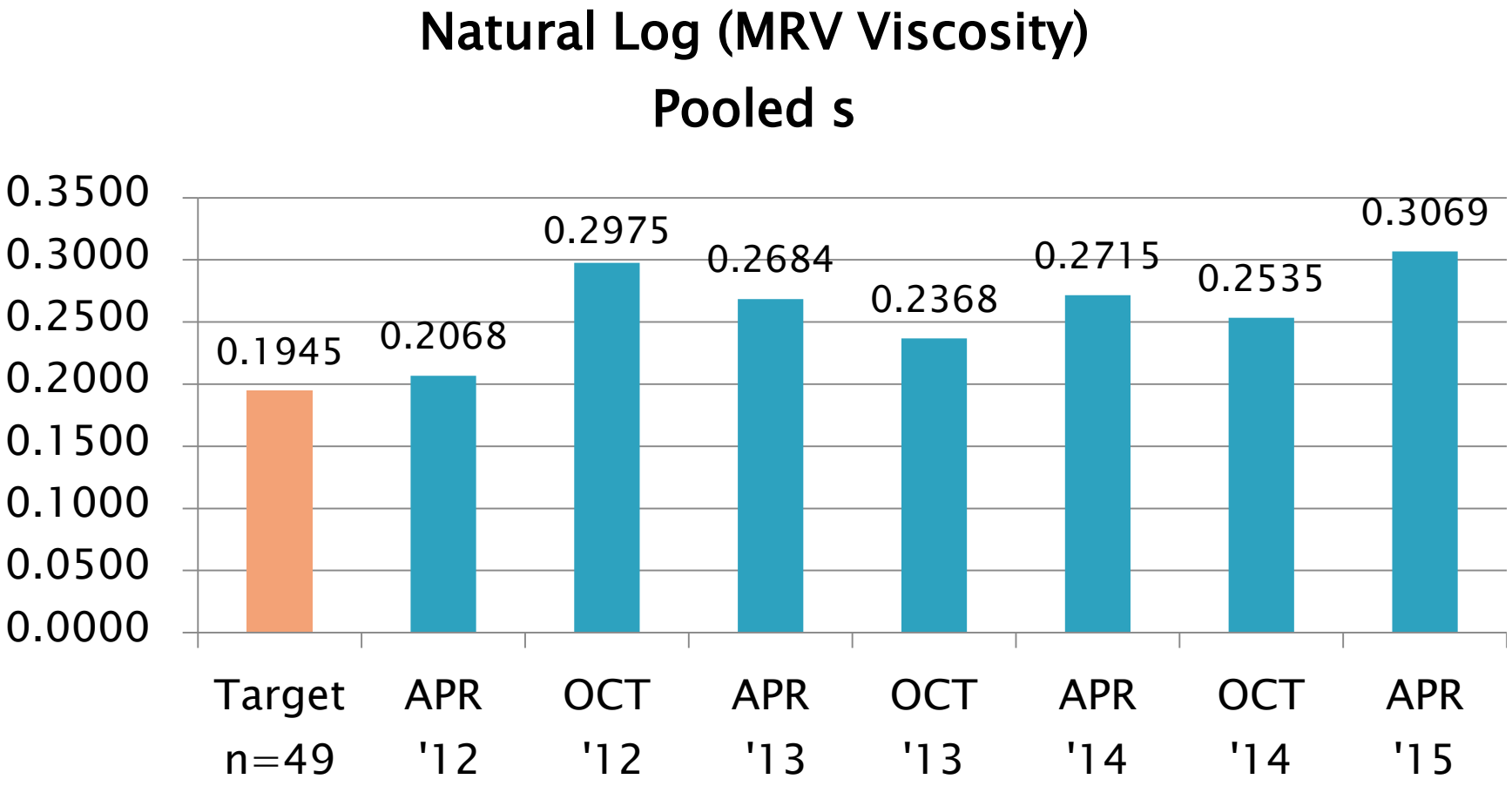
- No TMC technical updates issued this period.

D7528: Oxidation by ROBO

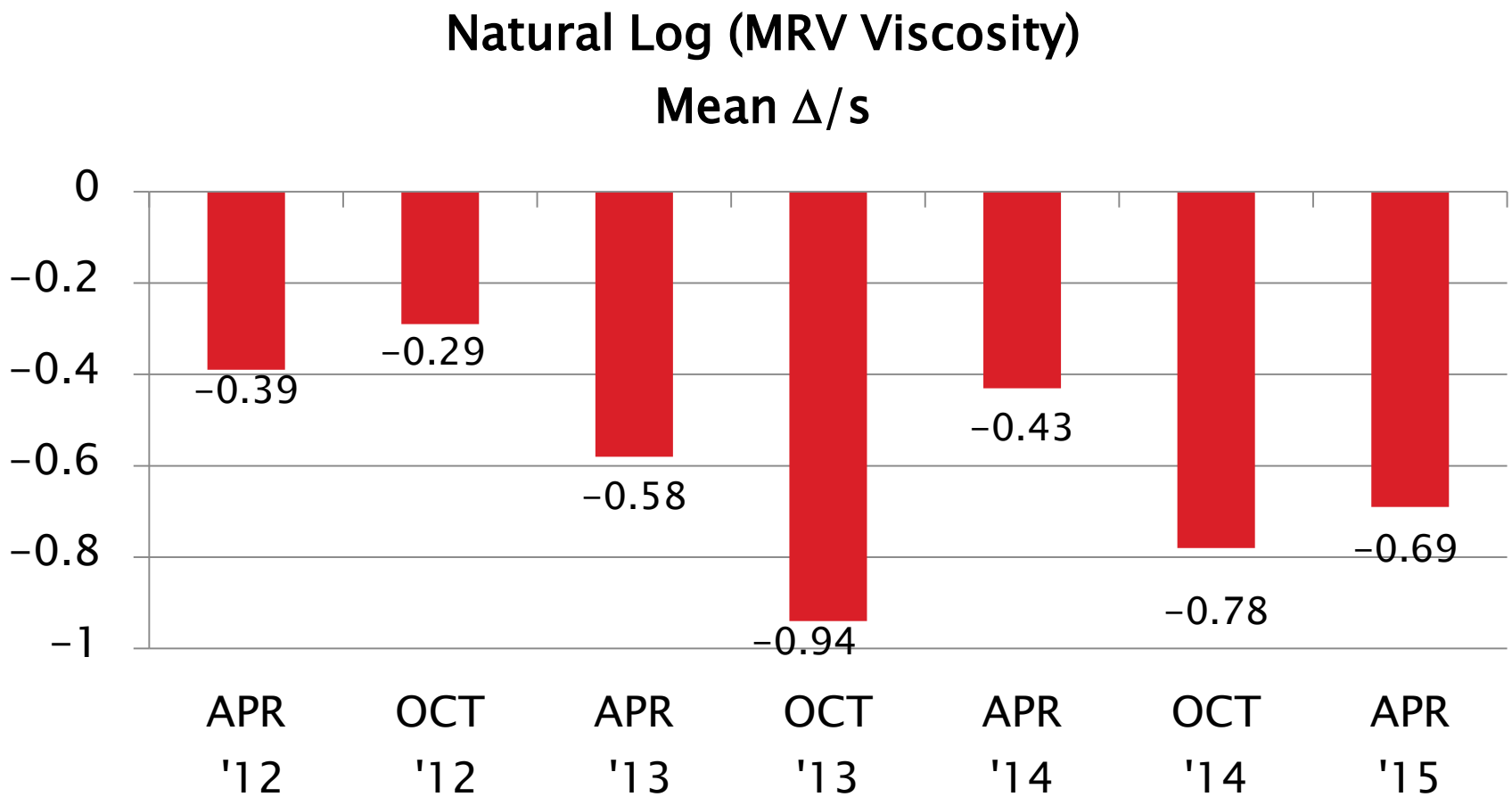
Period Precision and Severity Estimates

Natural Log (MRV Viscosity)	n	df	Pooled s	Mean D/s
Current Targets	49	46	0.1945	-----
4/1/11 through 9/30/11	96	92	0.2593	-0.69
10/1/11 through 3/31/12	93	90	0.2068	-0.39
4/1/12 through 9/30/12	86	83	0.2975	-0.29
10/1/12 through 3/31/13	109	106	0.2684	-0.58
4/1/13 through 9/30/13	90	87	0.2368	-0.94
10/1/13 through 3/31/14	85	82	0.2715	-0.43
4/1/14 through 9/30/14	83	80	0.2535	-0.78
10/1/14 through 3/31/15	97	94	0.3069	-0.69

D7528: Oxidation by ROBO



D7528: Oxidation by ROBO



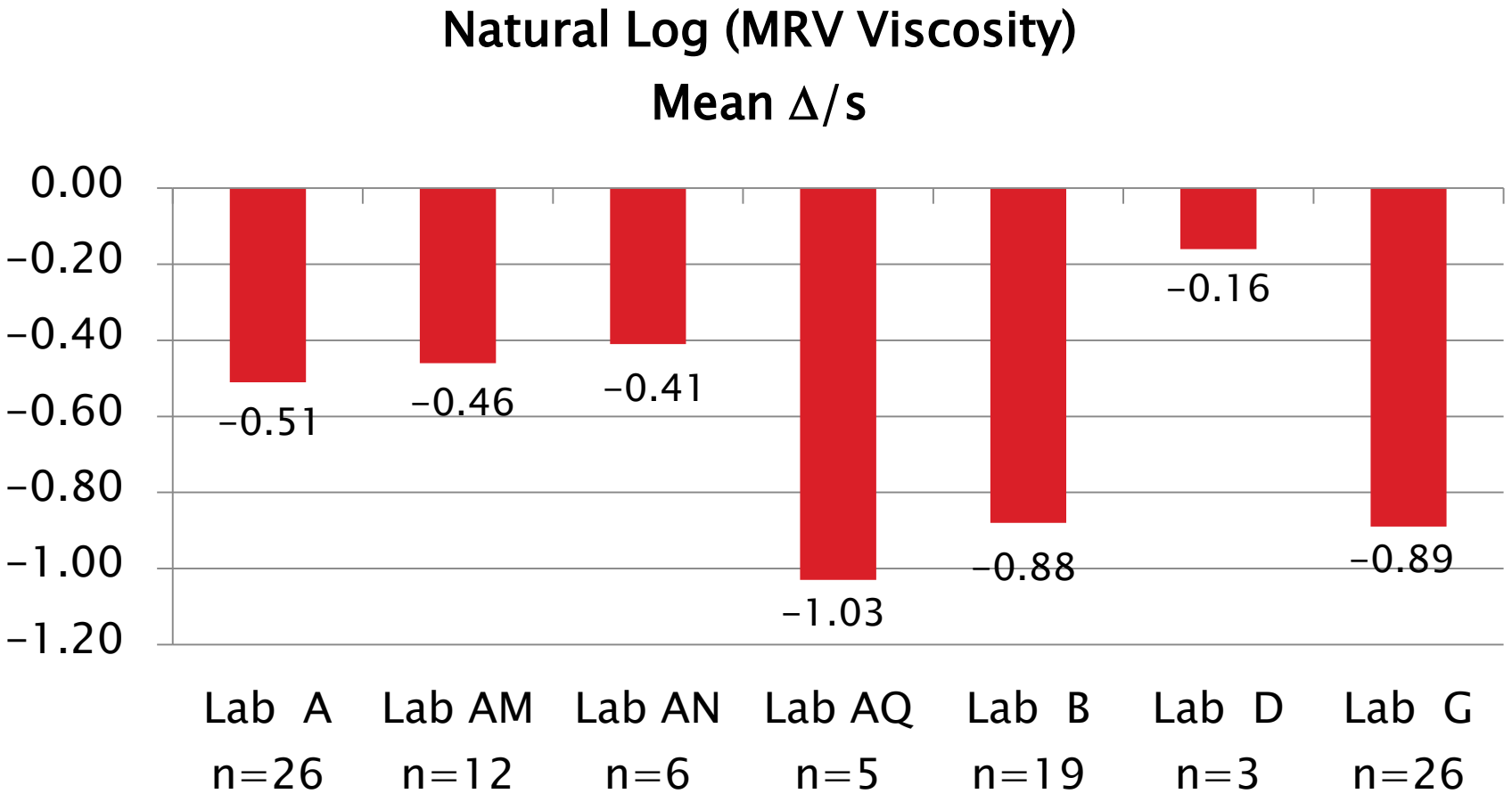
D7528: Oxidation by ROBO

Current Period Severity Estimates by Lab
Natural Log (MRV Viscosity)

	n	Mean Δ/s
Lab A	26	-0.51
Lab AM	12	-0.46
Lab AN	6	-0.41
Lab AQ	5	-1.03
Lab B	19	-0.88
Lab D	3	-0.16
Lab G	26	-0.89

Lab AS reported only shakedown runs this period, no calibrations.

D7528: Oxidation by ROBO



D7528: Oxidation by ROBO

- Precision (Pooled s) is less precise than prior six periods
  - Continues to be less precise than target precision

- Performance (Mean Δ/s) is -0.69 s mild
  - All calibrating labs are overall mild to some extent
  - One lab more than 1 s mild, overall (Lab AQ, n=5)
  - One test reported as operationally valid was more than 3 s from target (failed to calibrate but included in statistics):
    - Rig G3 3.4 s severe, Oil 438
    - Compared to last period where four tests exceeded 3 s, one as extreme as -5 s

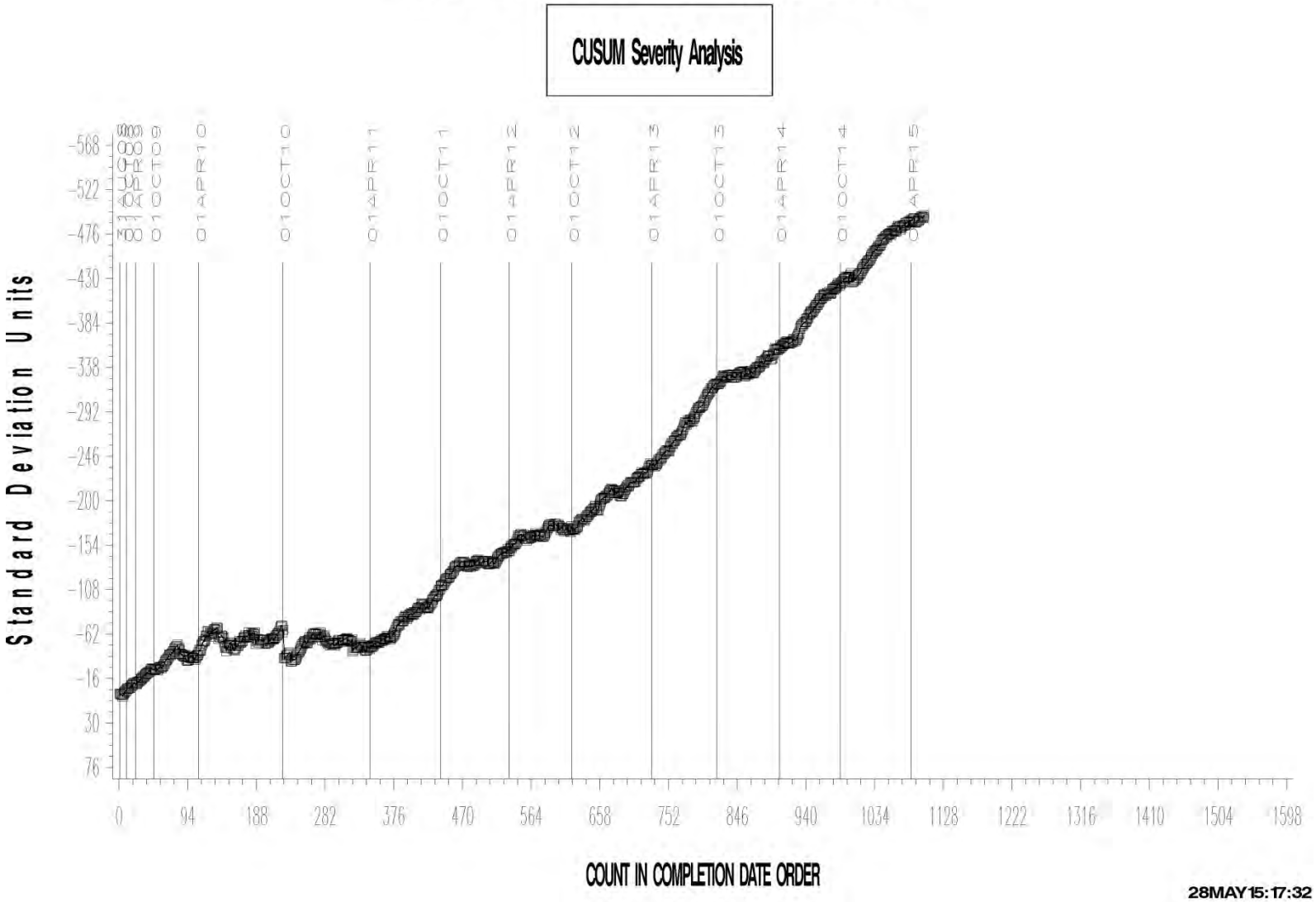
D7528: Oxidation by ROBO

- Oil 434 performing -1.06 s mild for period
- Oil 438 is exceptionally imprecise for period
  - Even more imprecise than a recent prior period, which showed very poor precision for oil 438

- CUSUM Severity Plot shows an ongoing overall mild trend since the 01APR11 timeline (following the ROBO workshop) with only brief periods of leveling (on-target) performance.

ROBO TEST INDUSTRY OPERATIONALLY VALID DATA

AGED OIL MRV APPARENT VISCOSITY



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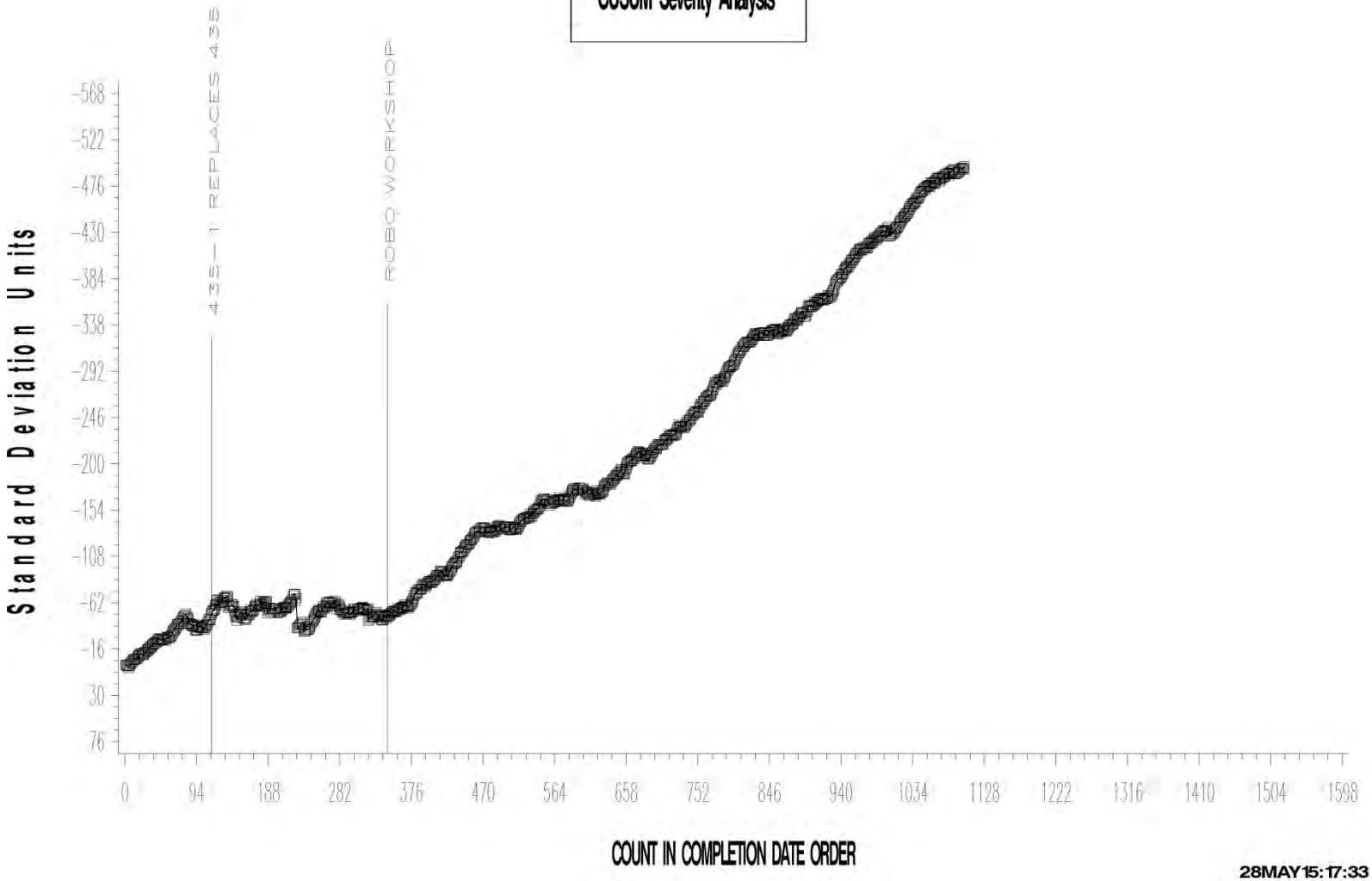
ROBO TEST INDUSTRY OPERATIONALLY VALID DATA

A Program of ASTM International

AGED OIL MRV APPARENT VISCOSITY

CUSUM Severity Analysis



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Test Monitoring Center

http://astmtmc.cmu.edu

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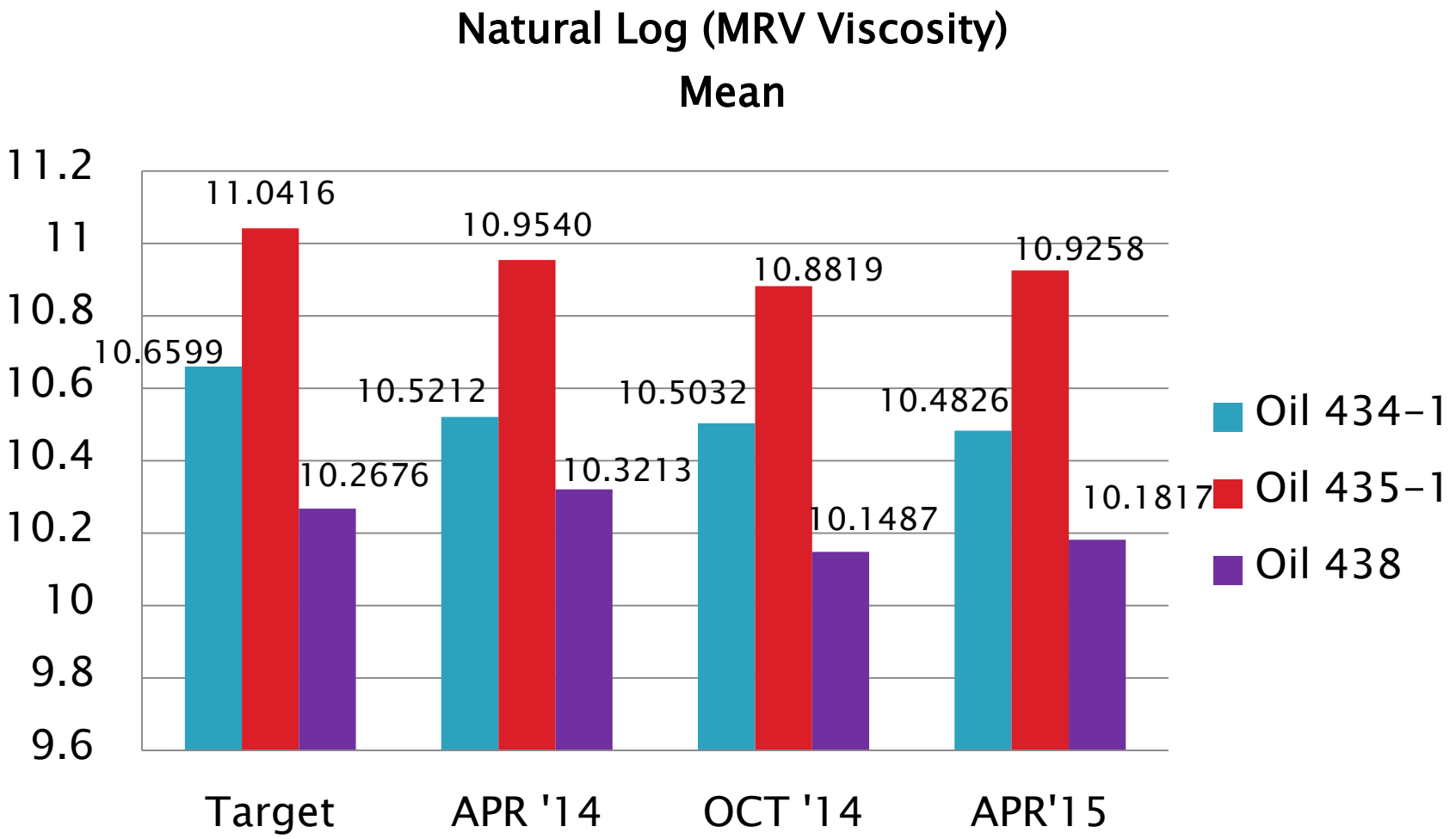
D7528: Oxidation by ROBO

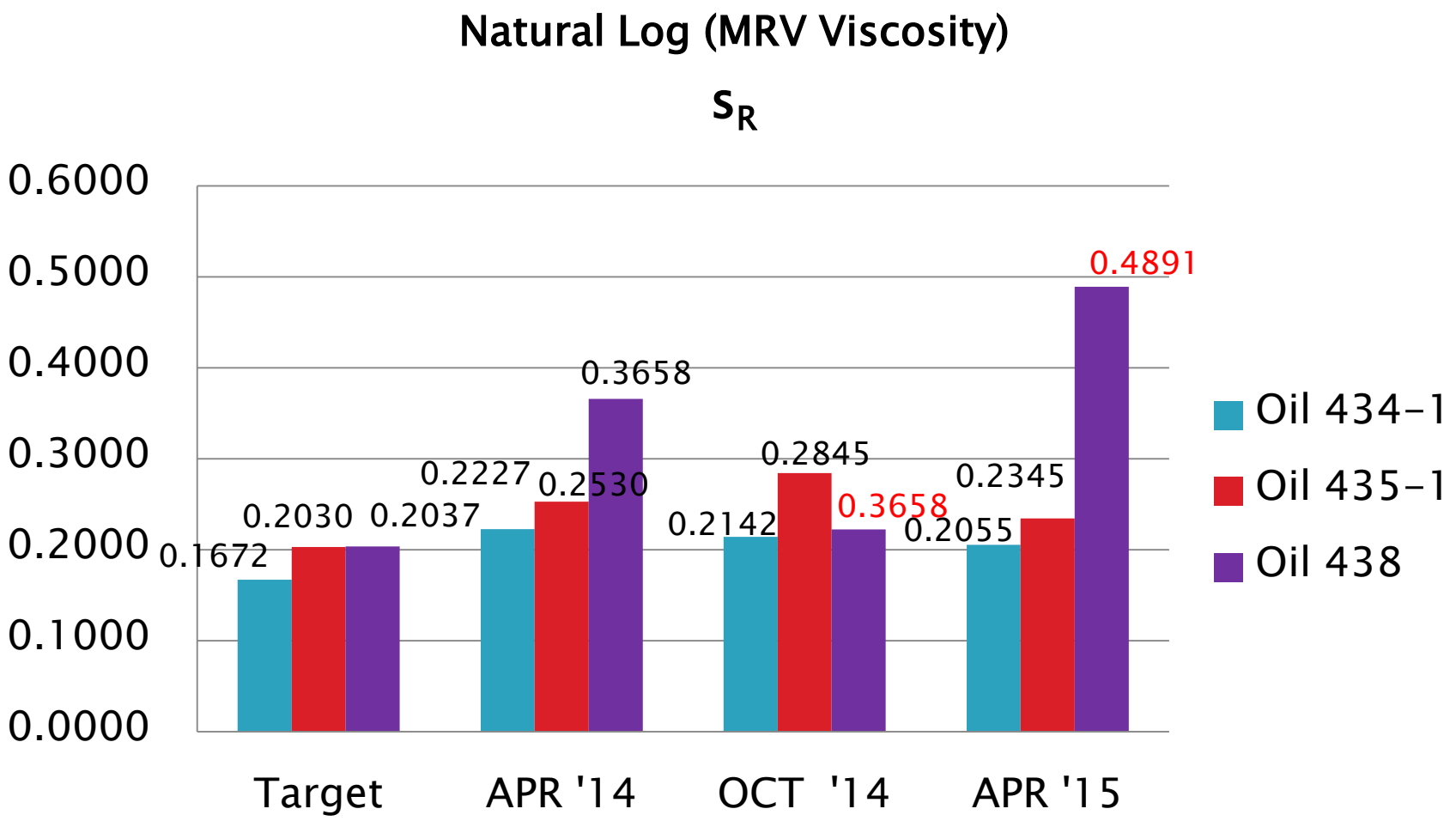
Performance by Oil
Natural Log (MRV Viscosity)

	Targets			10/1/13 - 3/31/14				4/1/14 - 9/30/14				10/1/14 - 3/31/15			
Oil Code	n	Mean	s_R	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s	n	Mean	s_R	Mean Δ/s
434-1	13	10.6599	0.1672	33	10.5212	0.2227	-0.83	22	10.5032	0.2142	-0.94	30	10.4826	0.2055	-1.06
435-1	22	11.0416	0.2030	33	10.9540	0.2530	-0.43	41	10.8819	0.2845	-0.79	44	10.9258	0.2345	-0.58
438	14	10.2676	0.2037	19	10.3213	0.3658	0.26	20	10.1487	0.2223	-0.58	23	10.1817	0.4891	-0.42

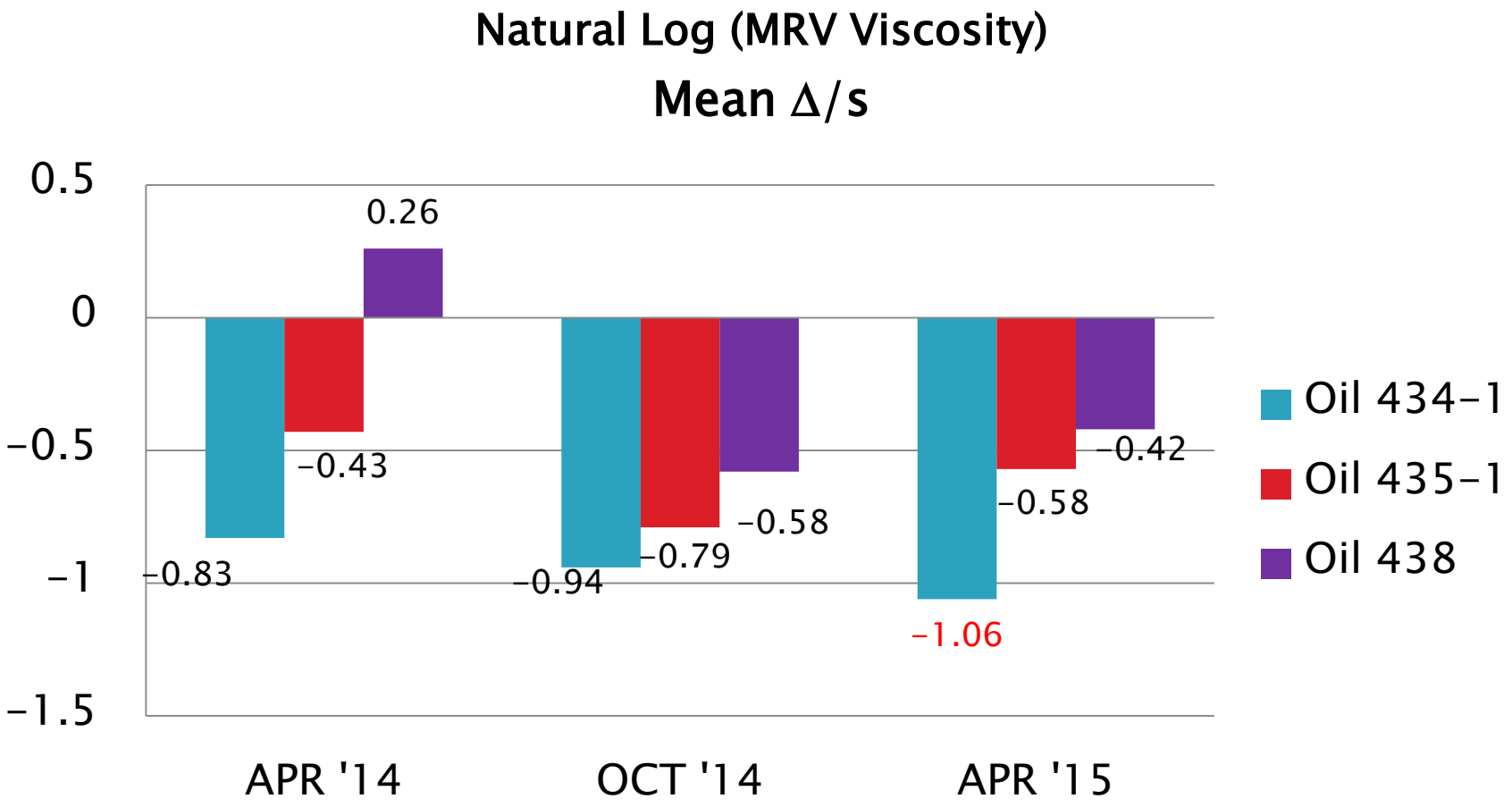
D7528: Oxidation by ROBO



D7528: Oxidation by ROBO



D7528: Oxidation by ROBO



Return to Executive Summary

Non-monitored Bench Tests

- **D6922 Homogeneity and Miscibility**
  - The TMC distributes six D6922 reference oils.
  - The TMC does not collect reference data or monitor test results for this test at this time.
  - **Oils rec'd by TMC 2002 – 2003**
    - **Formulations are at least 13 years old now**
    - **Should section or panel consider updating?**

- **D7563 Emulsification**
  - The TMC distributes two D7563 reference oils.
  - The TMC does not collect reference data or monitor test results for this test at this time.

Reference Oil Inventory

- As of 3/31/2015

Reference Oil Inventory

D5800, D6417, GI

Oil	Year Rec'd By TMC	Tests	TMC Inventory, gallons	Gallons Shipped last 12 months
VOLC12	2013	D5800	48.7	4.0
VOLD12	2013	D5800	50.3	2.5
VOLE12	2013	D5800	49.3	3.6
VOLD14	2014	D5800QC	403.5	36.5
52	1995	D6417	59.1	0.0
55	1995	D6417	66.2	0.0
58	1998	D6417, GI	110.1	0.3
62	1996	GI	1.2	0.2
1009*	2002	GI	46.8	----

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

Reference Oil Inventory

TEOST, MTEOS & ROBO

Oil	Year Rec'd By TMC	Tests	TMC Inventory, gallons	Gallons Shipped last 12 months
432	1998	MTEOS	11.6	1.4
434	2003	MTEOS	3.9	0.6
75	2010	TEOST	4.8	0.9
435-2*	2010	TEOST	45.5	----
434-1*	2008	ROBO	5.4	----
435-1*	2008	ROBO	27.4	----
438*	2003	ROBO	16.7	----

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

Reference Oil Inventory

D6082 & D874

Oil	Year Rec'd By TMC	Tests	TMC Inventory, gallons	Gallons Shipped last 12 months
1007	1998	D6082	15.7	4.2
66	2002	D6082	89.1	1.8
820-2	2001	D874	10.2	0.0
90	2005	D874	26.6	5.1
91	2006	D874	4.0	0.0

Reference Oil Inventory

D6922 Homogeneity & Miscibility Oils

Oil	Year Rec'd By TMC	Tests	TMC Inventory, gallons	Gallons Shipped last 12 months
HMA	2002	H&M	138.9	10.3
HMB	2002	H&M	142.4	10.6
HMC	2003	H&M	129.1	10.0
HMD	2002	H&M	136.6	10.3
HME	2002	H&M	122.9	10.0
HMF	2002	H&M	145.4	10.0

Reference Oil Inventory

D7563 Emulsion Retention Oils

Oil	Year Rec'd By TMC	Tests	TMC Inventory, gallons	Gallons Shipped last 12 months
EM2	2011	Emulsion	7.9	0.0
EM2-1	2011	Emulsion	25.0	0.0
EM5	2011	Emulsion	7.9	0.0
EM5-1	2011	Emulsion	25.0	0.0

Reference Oil Shipping Aliquots

Test	Quantity
D6417	1 ml
D6417QC	118 ml
D5800	100 ml
GI	25 ml
MTEOS	17 ml
TEOST	125 ml
D6082	525 ml
D874	32 ml
D874QC	1000 ml
ROBO	300 ml
ROBOQC	1000 ml
H&M	1000 ml
D7563	1000 ml

Additional Information

Additional Information

- Available on the TMC's Website:
  - CUSUM Severity Plots
  - Reference Data, Period Statistics and Timelines
  - Information Letters and Technical Memos
  - Report Forms & Data Dictionaries
  - Online Store, and more…

- www.astmtmc.cmu.edu

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