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Test Monitoring Center

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ASTM D02.B1 Semiannual Report Passenger Car Reference Oil Testing

April 2020

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Passenger Car Engine Oil Testing Executive Summary

▶ Seq. IIIH

- Batch Code 7 rings successfully introduced.

▶ Seq. VH

- Attempts to introduce reblend of Oil 1009-1 were abandoned because of mild results. Panel obtained a replacement oil, 931, to be introduced in the future.

▶ Seq. IX

- Surveillance Panel approved use of Dealer piston where labs ran out of Grade BB pistons.

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Calibrated Labs and Stands*

Test	Labs	Stands
IIIH/A/B	5	16
IVA	2	2
IVB	3	9
VH	4	8
VIE	4	11
VIF	3	8
VIII	2	3
IX	3	6
X	3	7

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*As of 3/31/2020

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Sequence IIIH/A/B

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Sequence IIIH Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	21
Aborted Calibration Test	XC	1
Operationally Invalid Calibration Test (Lab Judgement)	LC	2
Operationally Invalid Calibration Test (Lab and TMC Judgement)	RC	1
Total		25

Sequence IIIH – Failed Tests

Test Status	#
No Failed Tests	0
Totals	0

Sequence IIIH – Lost Tests

Test Status	Cause	#
Aborted	Speed calibration error	1
Invalid	Oil Block Thermocouple calibration error	1
Invalid	Engine overheated, oil temperature control issues	1
Invalid	Speed Control issues, negative Qi	1
Totals		4

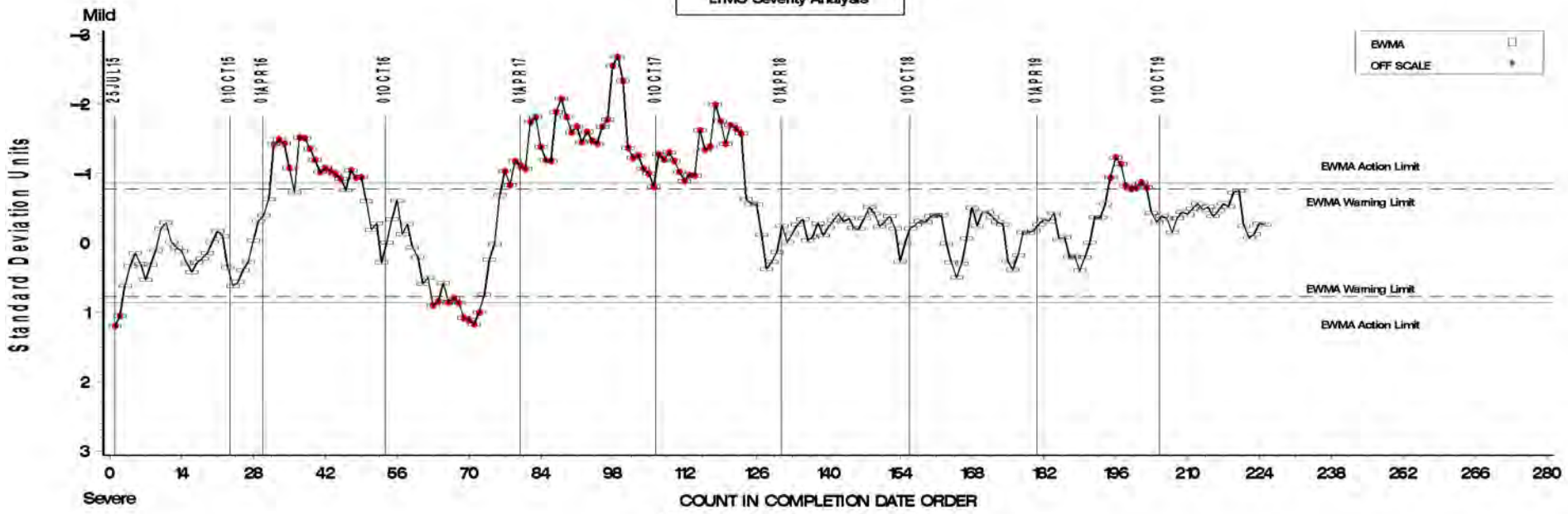
*Invalid and aborted tests

Sequence IIIH Test Severity

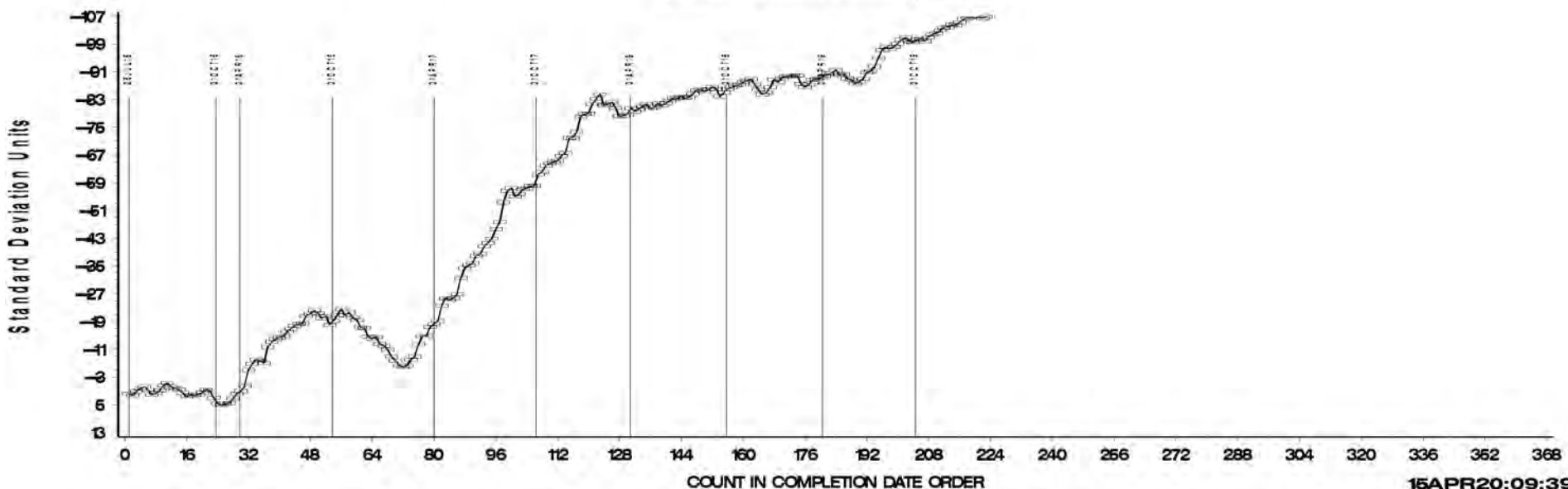
- All parameters are in control, except Average Piston Varnish, which is in action alarm (mild direction)

VISCOSITY INCREASE FINAL ORIG UNIT RES

LTMS Severity Analysis

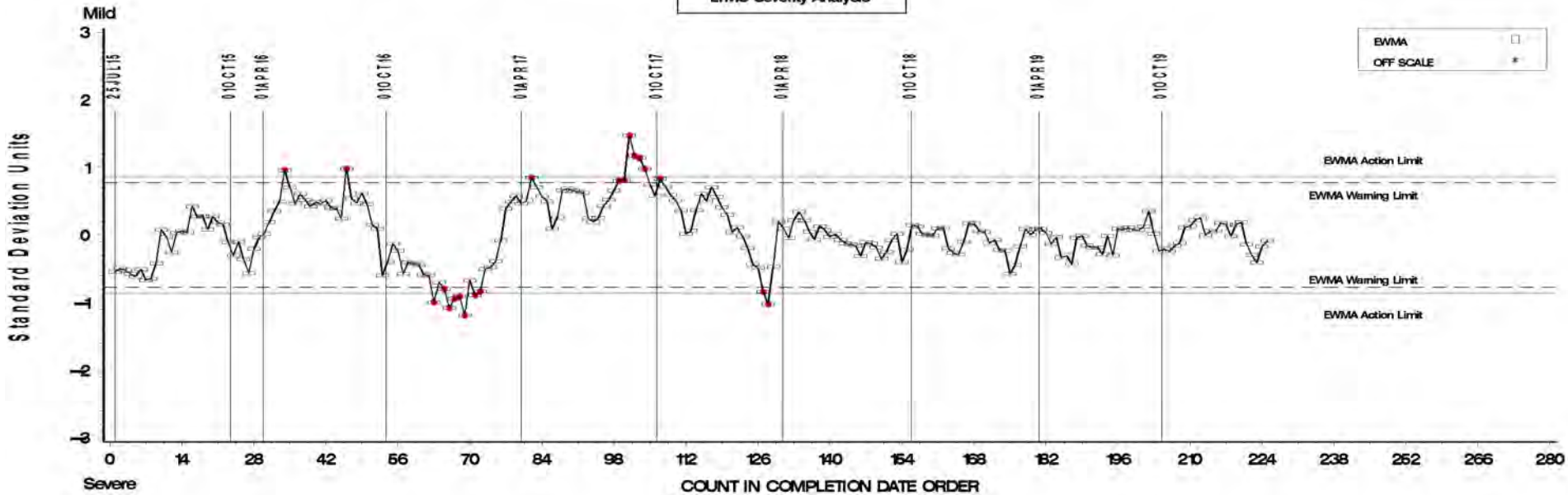


CUSUM Severity Analysis

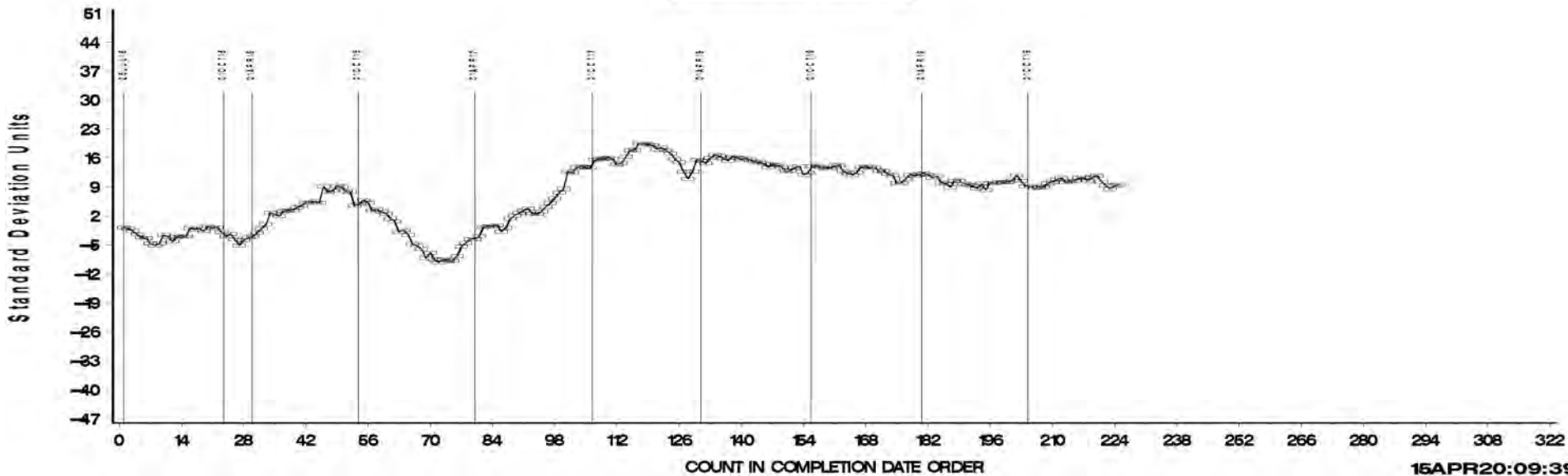


AVERAGE WEIGHTED PISTON DEPOSITS FNL ORIG U

LTMS Severity Analysis

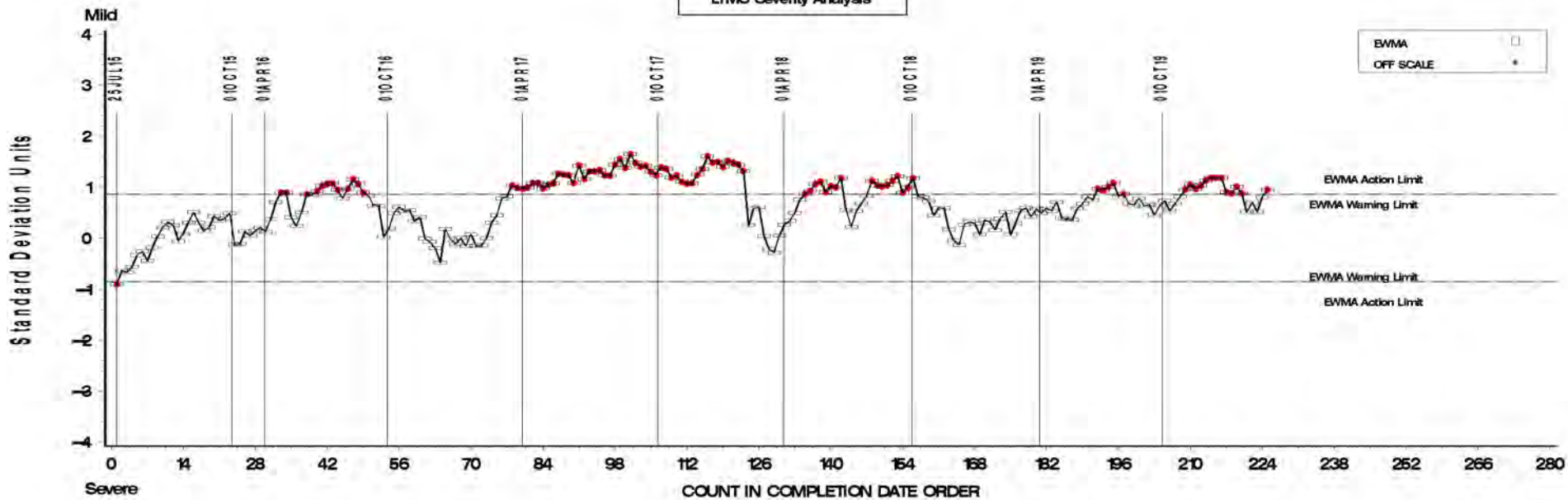


CUSUM Severity Analysis

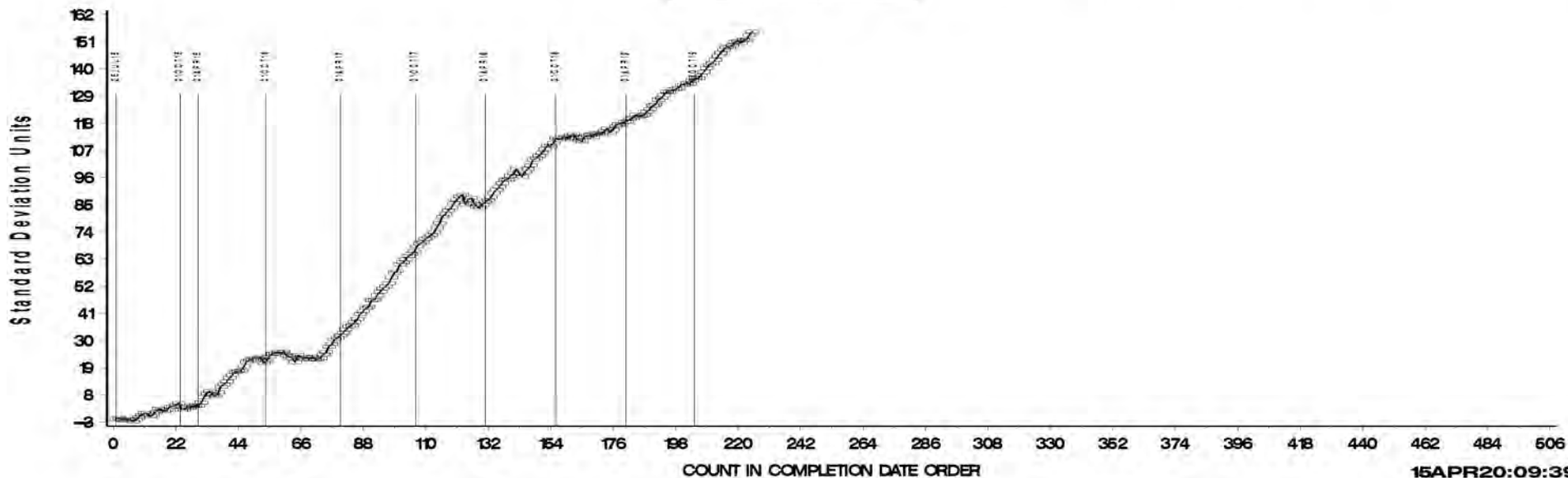


AVERAGE PISTON SKIRT VARNISH

LTMS Severity Analysis

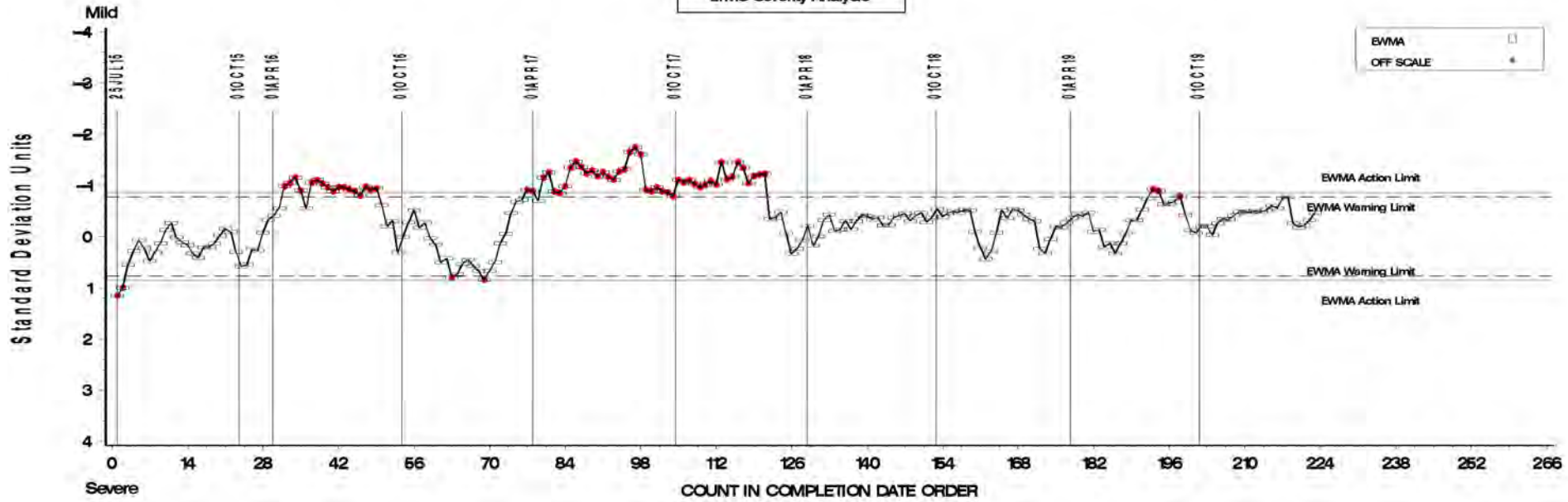


CUSUM Severity Analysis

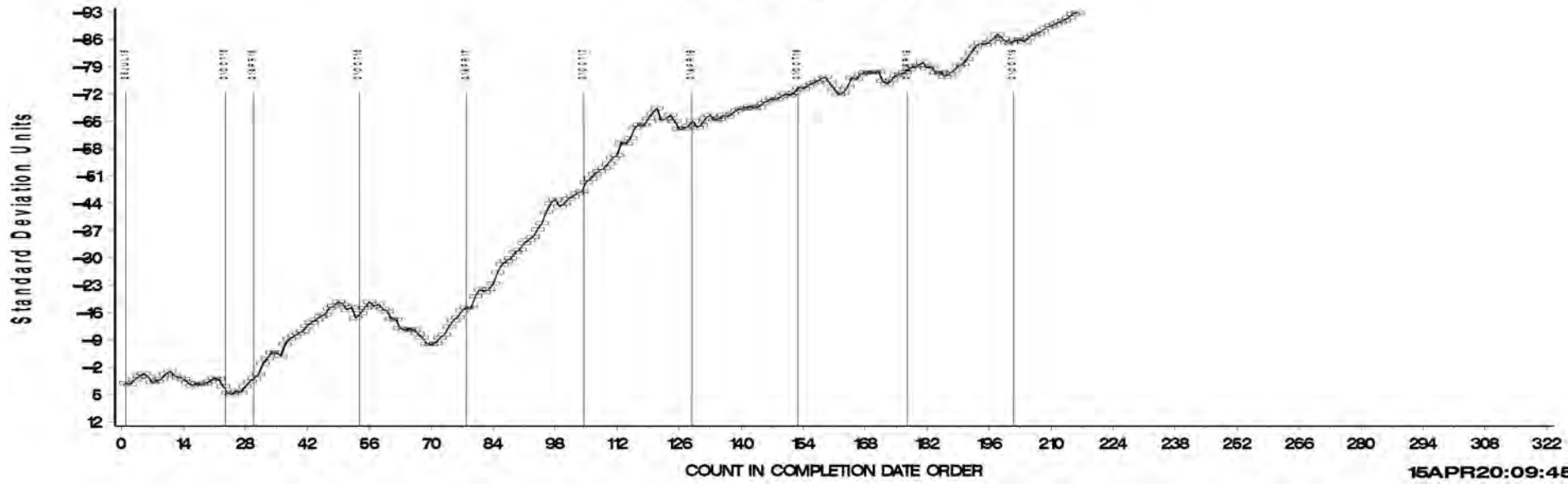


MRV FINAL ORIG UNIT RES [NM, FROZEN, SOLID]

LTMS Severity Analysis

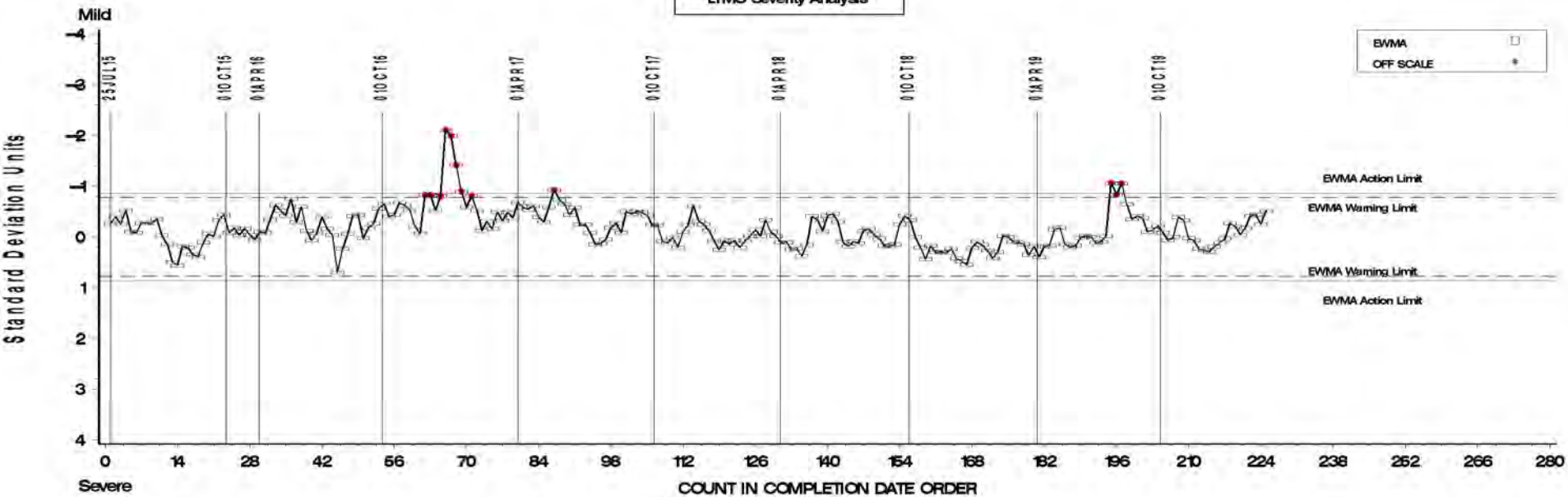


CUSUM Severity Analysis

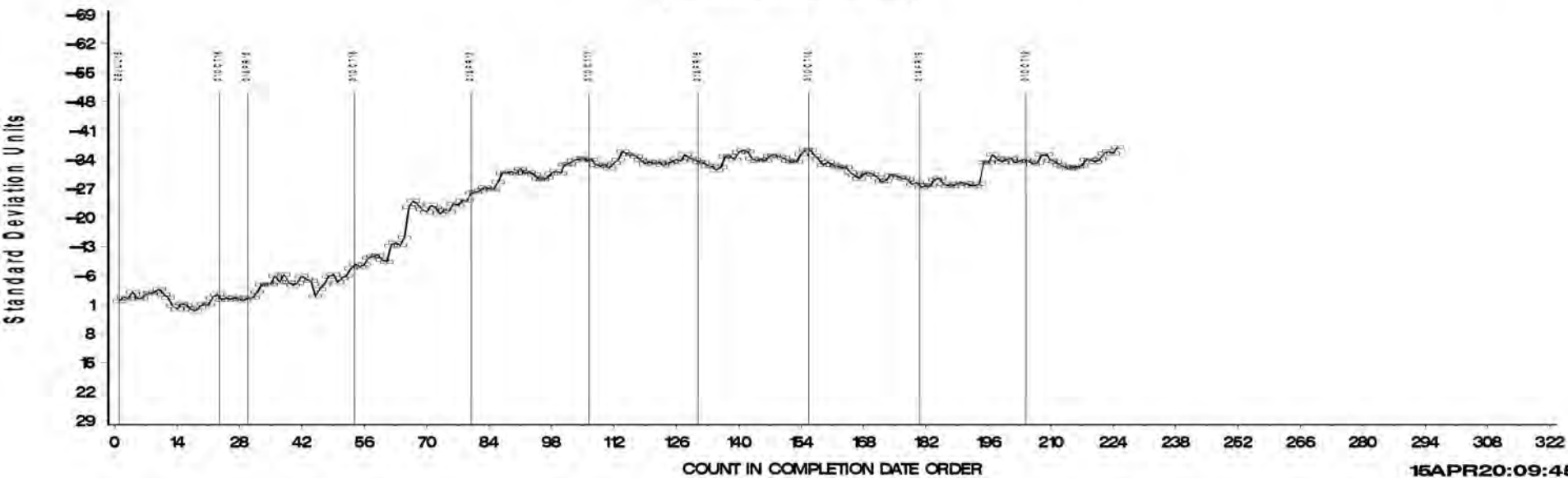


PHOSPHORUS RETENTION, FINAL RESULT

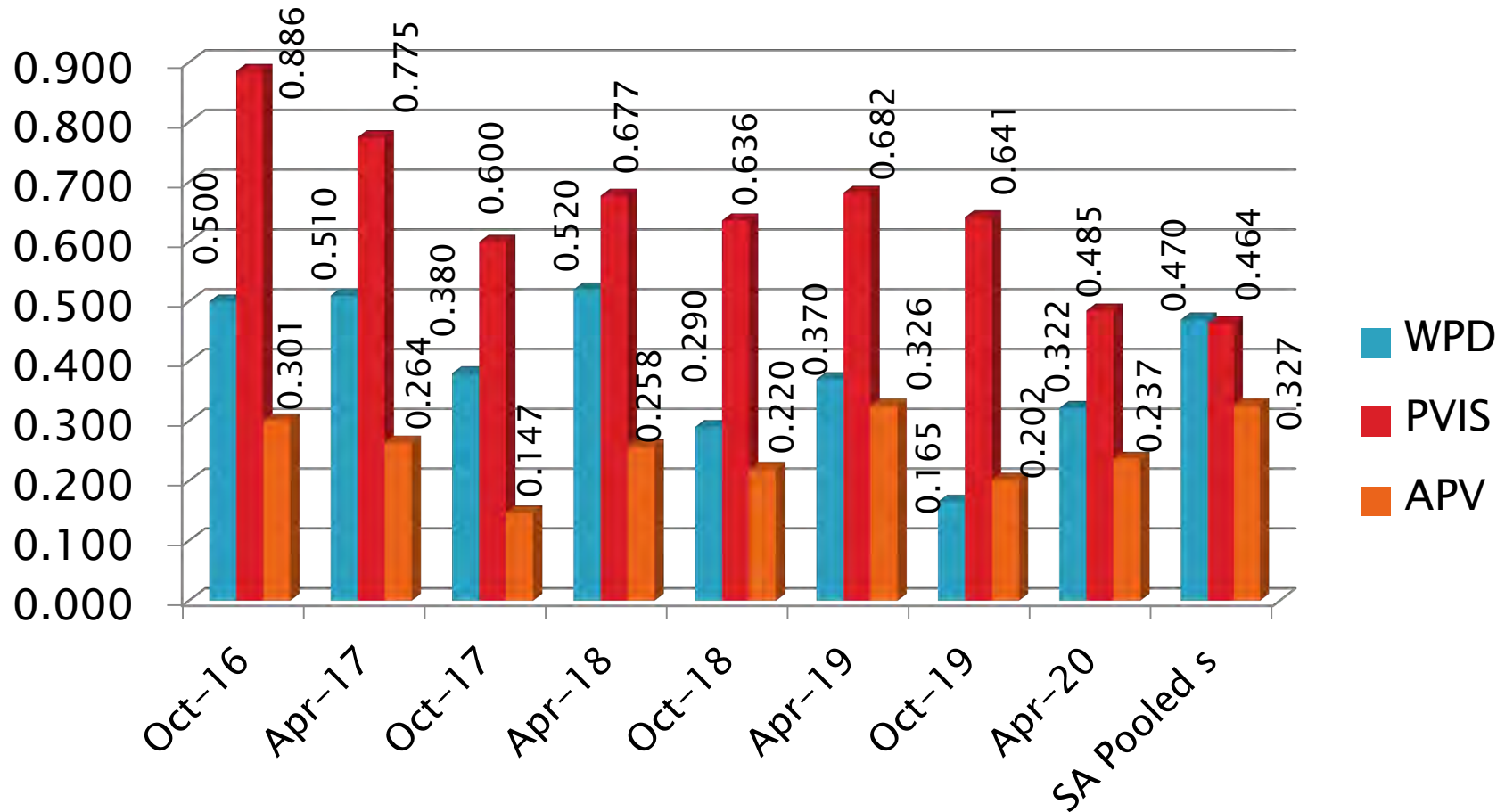
LTMS Severity Analysis



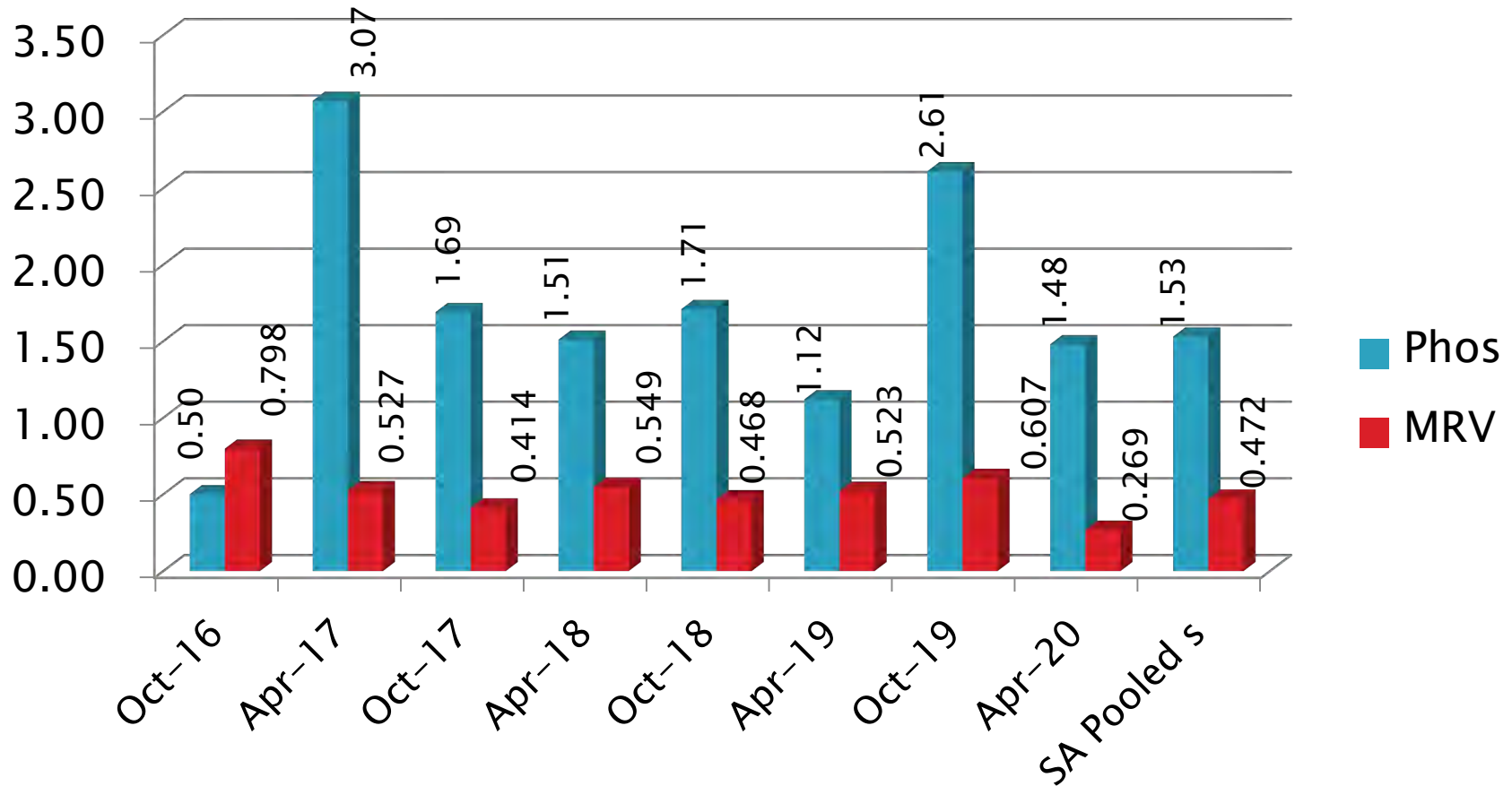
CUSUM Severity Analysis



IIH Precision Estimates



IIIHA/B Precision Estimates



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Sequence IVA

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Sequence IVA Activity

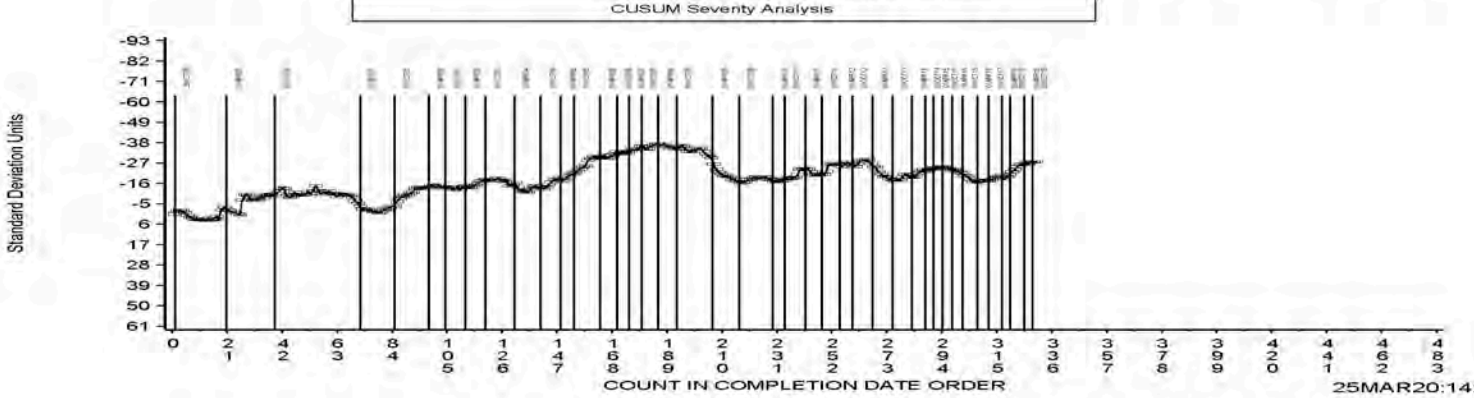
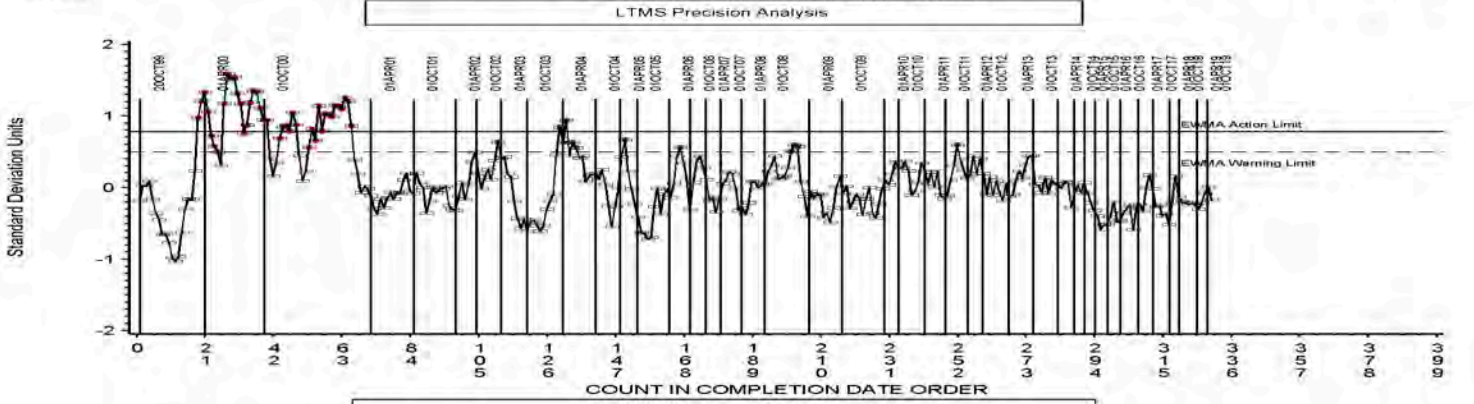
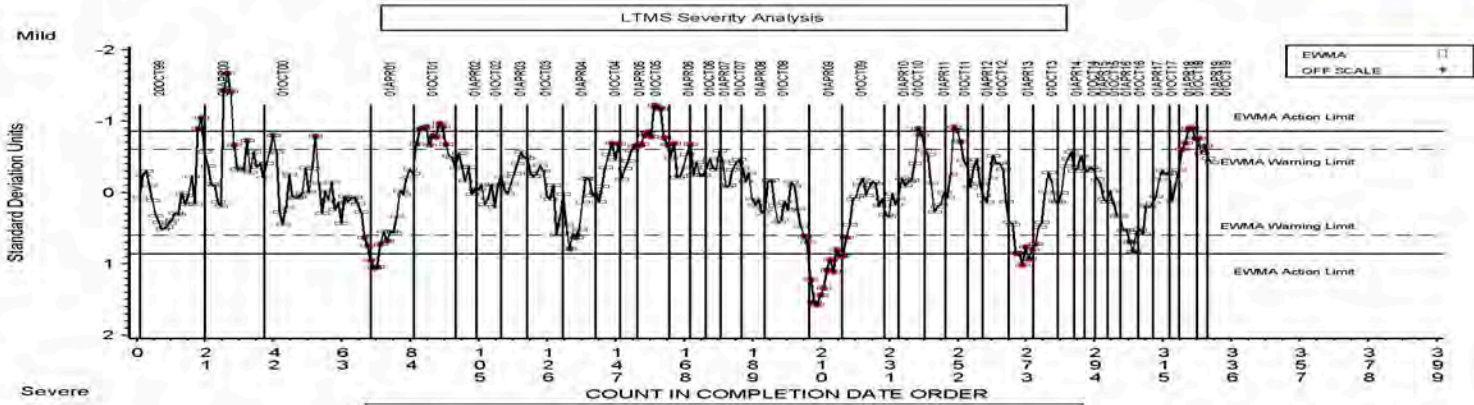
Test Status	Validity Code	#
Acceptable Calibration Test	AC	2
Total		2

Sequence IVA Test Severity

- ACW is in control

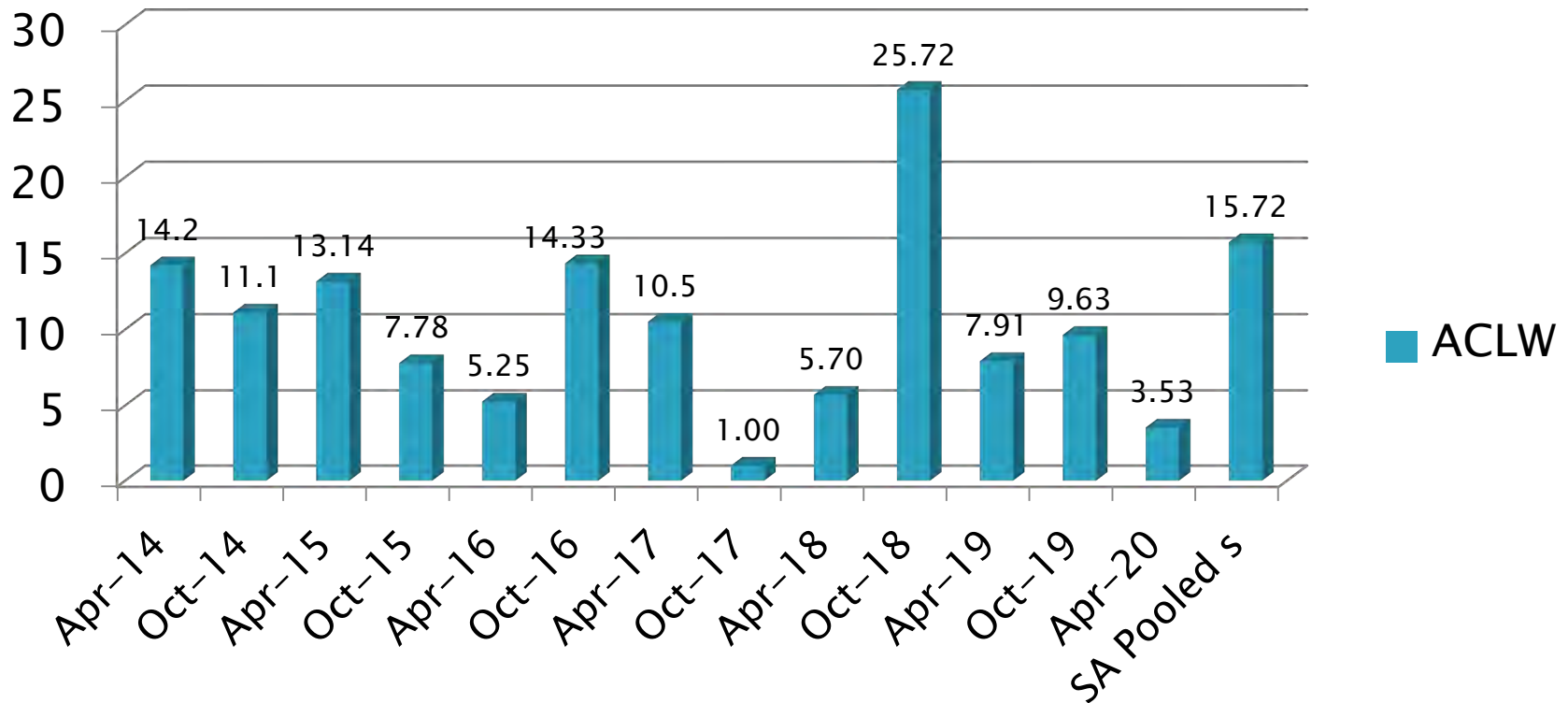
SEQUENCE IVA INDUSTRY OPERATIONALLY VALID DATA

AVERAGE CAM WEAR



Sequence IVA Precision Estimates

ACW



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Sequence IVB

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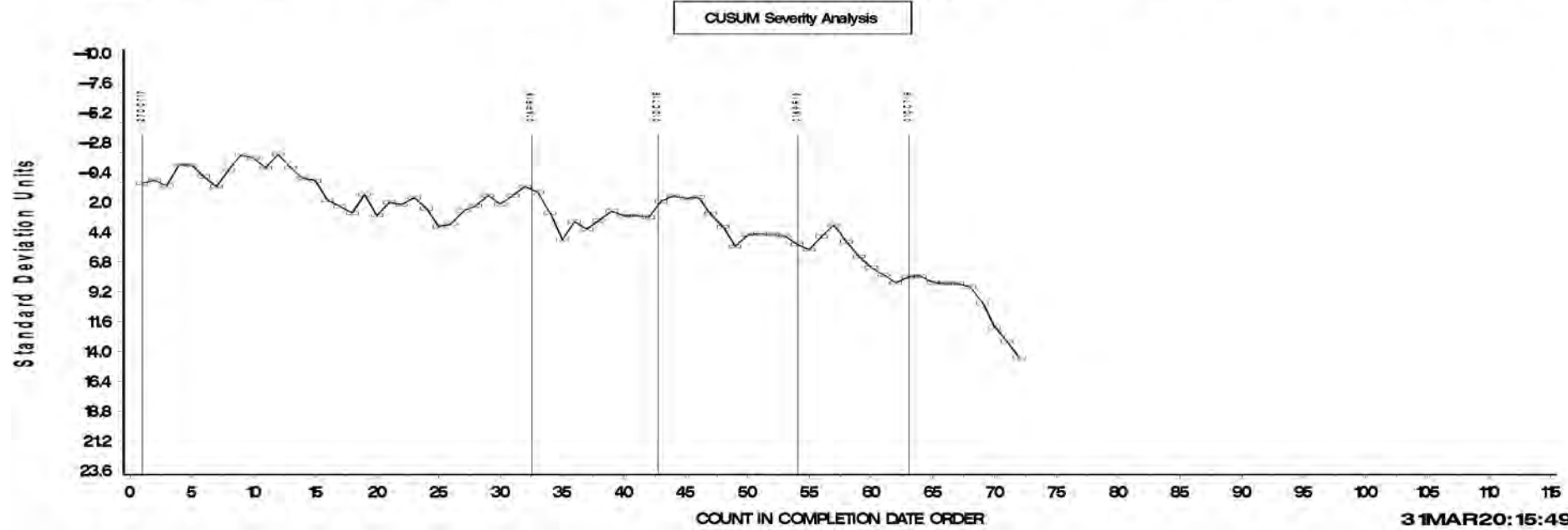
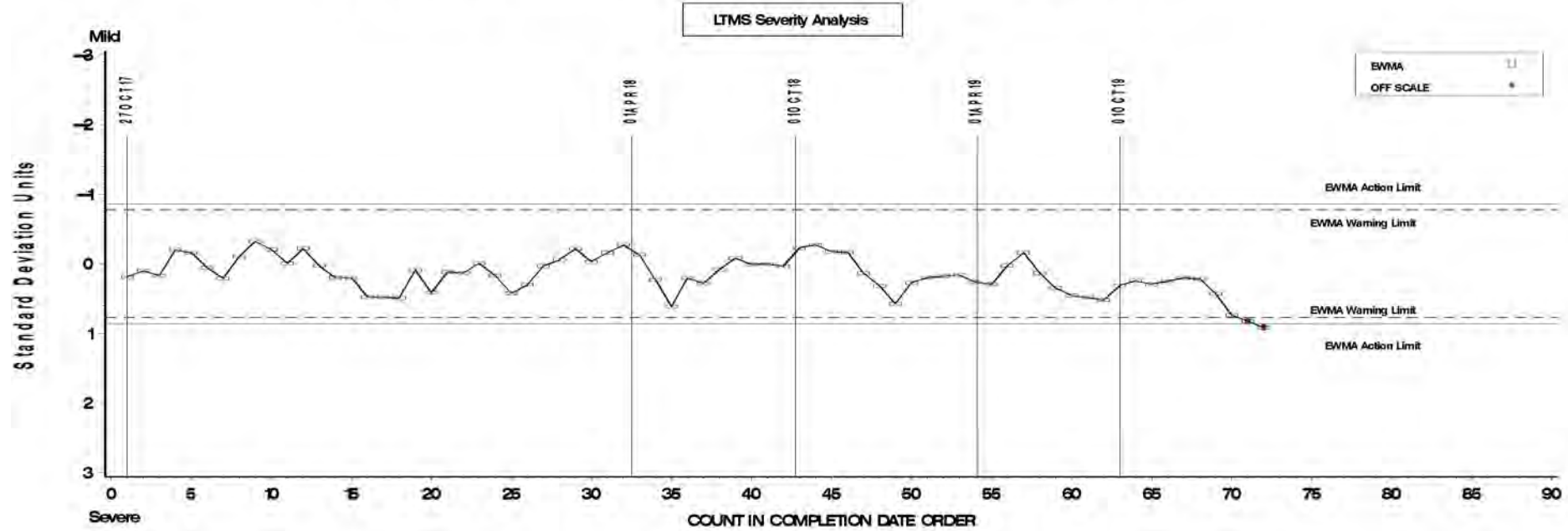
Sequence IVB Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	9
Total		9

Sequence IVB Test Severity

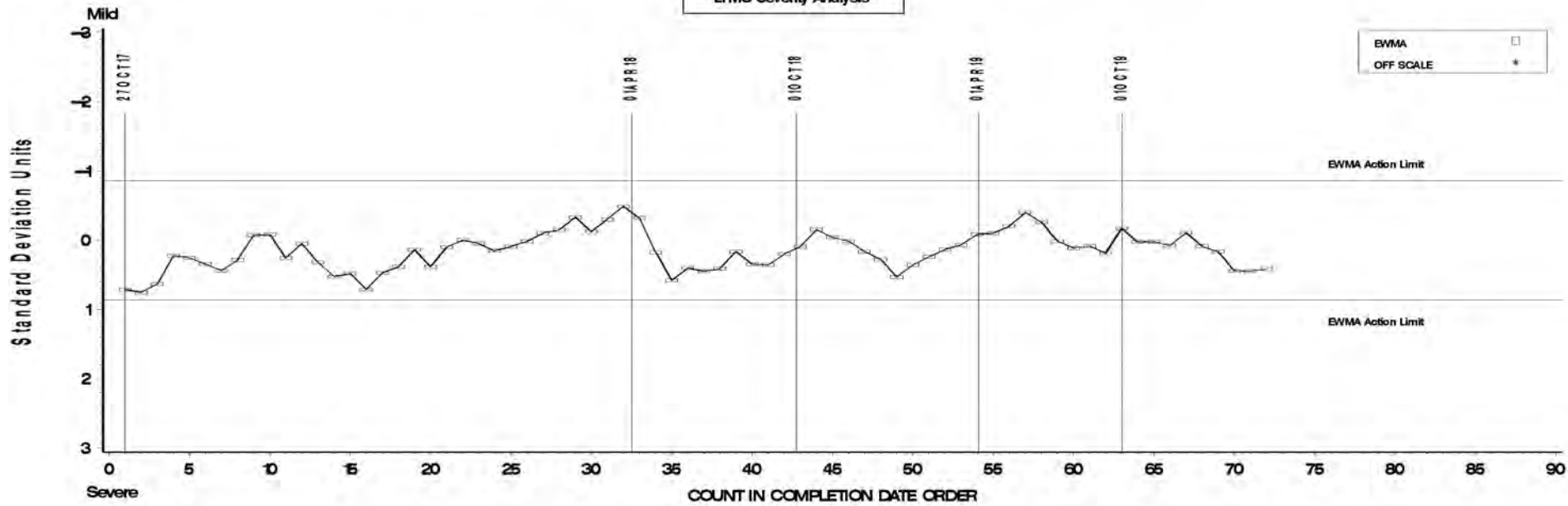
- AVLI in severity action alarm (severe direction)
- Fe in control.

AVERAGE VOLUME LOSS BY KEYENCE INTAKE Final

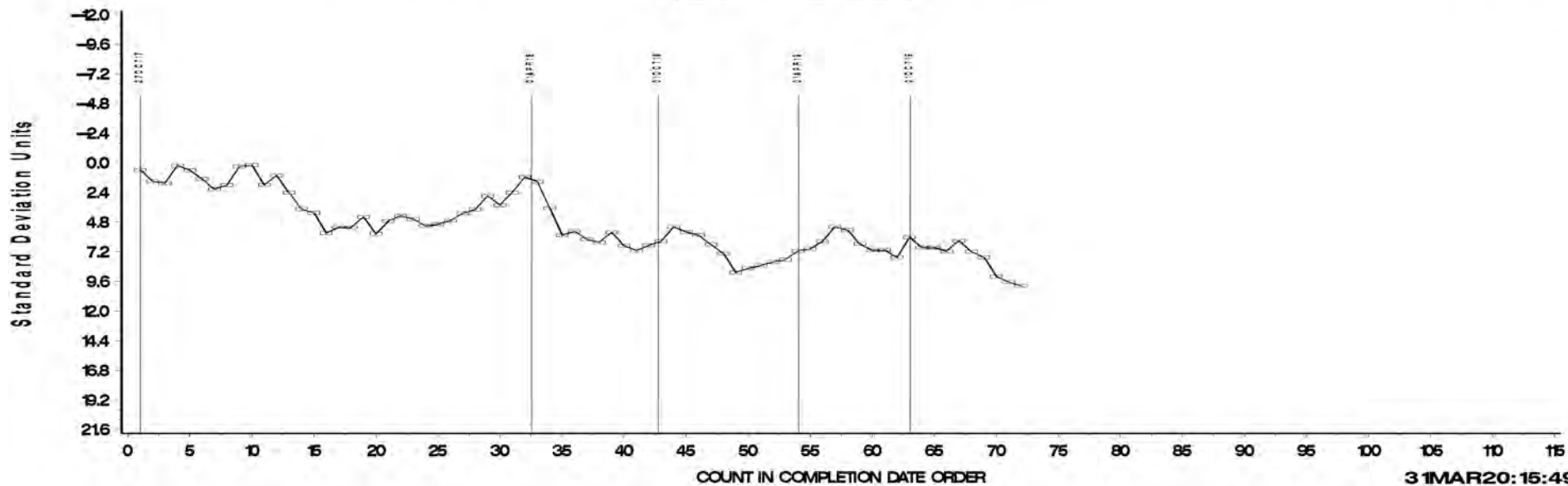


END OF TEST FE FINAL Severity Adjusted RESULT

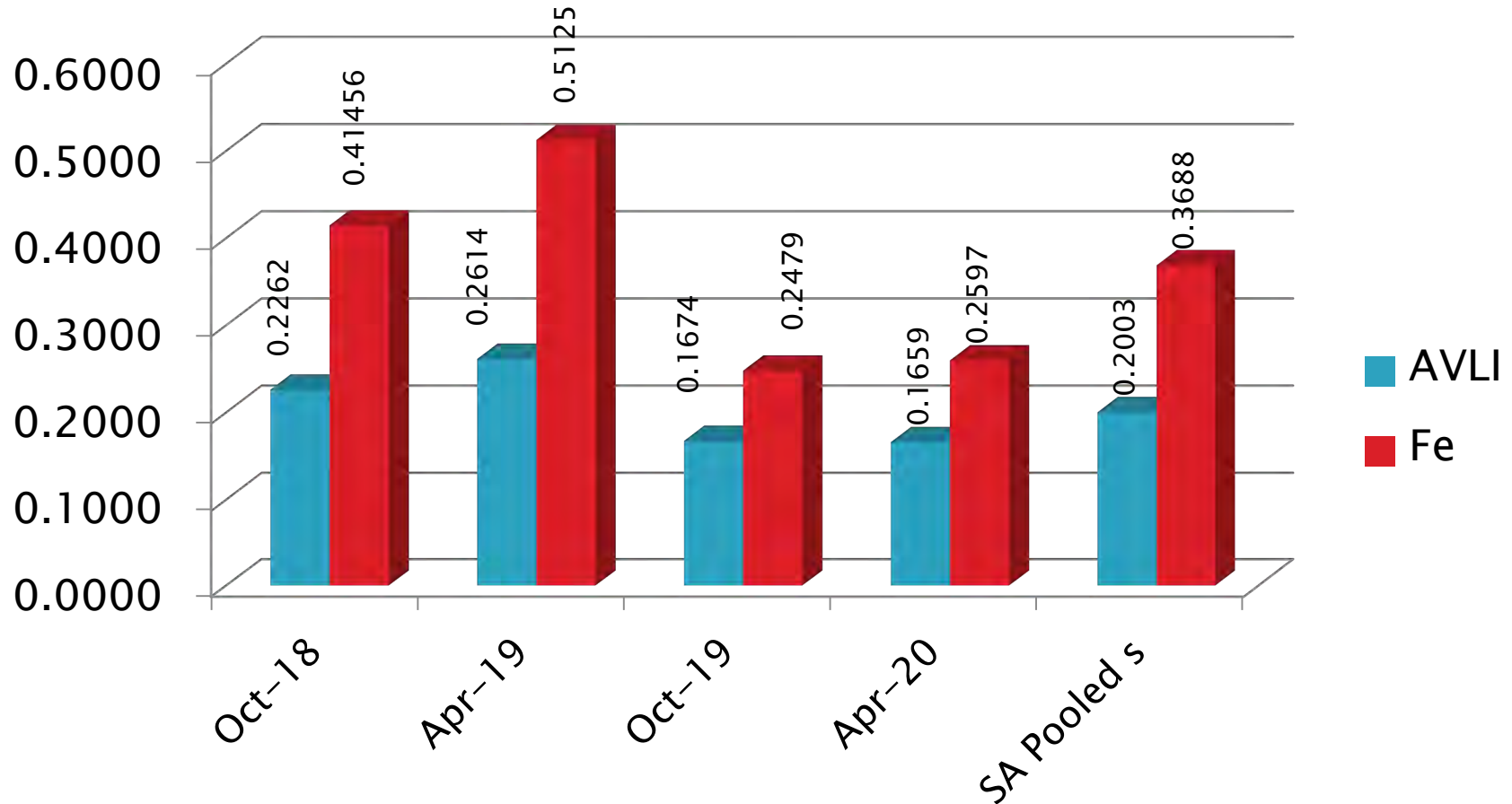
LTMS Severity Analysis



CUSUM Severity Analysis



Sequence IVB Precision Estimates



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Sequence VH

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Sequence VH Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	8
Statistically Unacceptable Calibration	OC	1
Acceptable Calibration Test, removed from charts (Reference oil 1009-1)	MC	1
Total		10

Sequence VH – Failing Tests

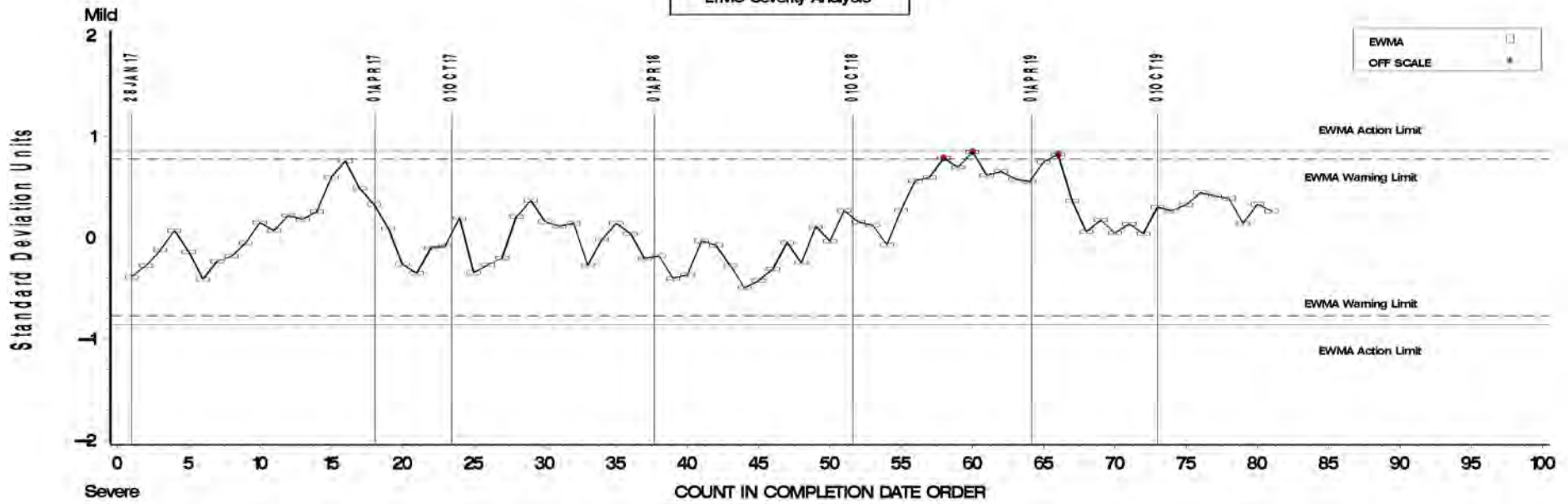
Test Status	#
Level 3 Ei Alarm AEV, APV	1
Totals	1

Sequence VH Test Severity

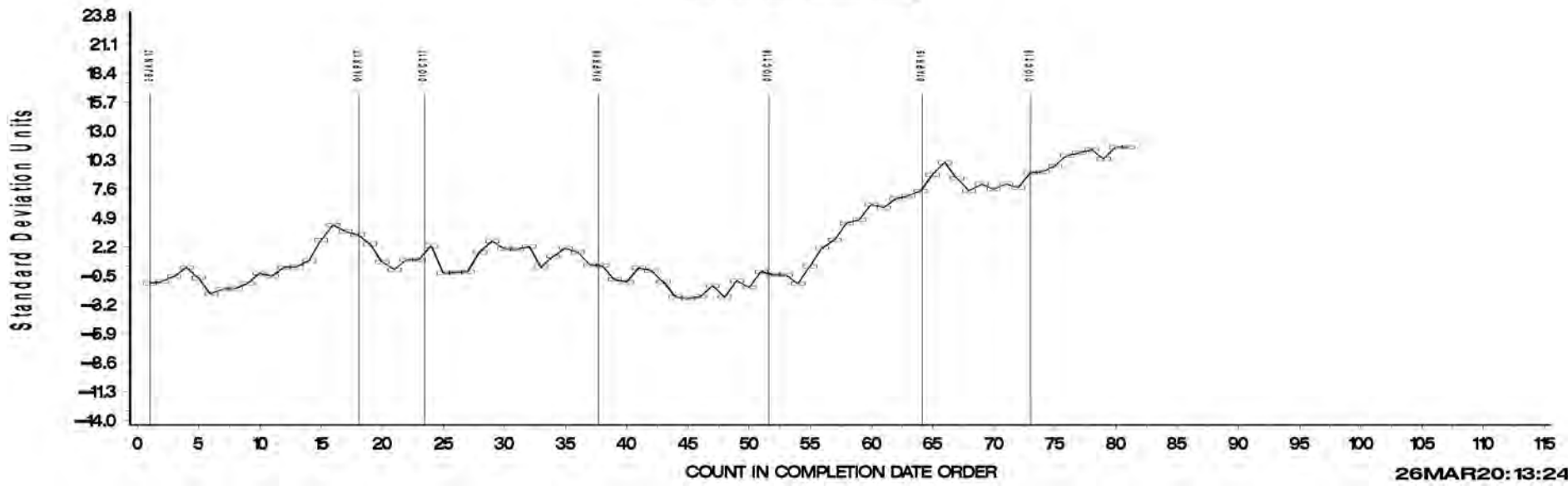
- All parameters in control

AVERAGE ENGINE SLUDGE

LTMS Severity Analysis

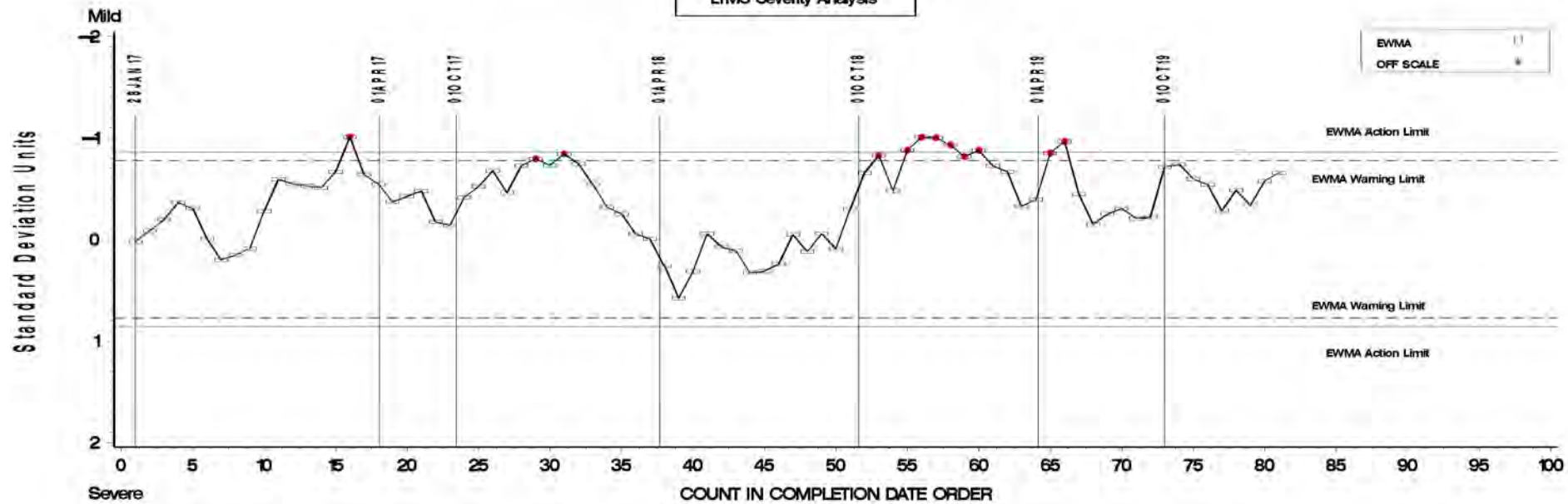


CUSUM Severity Analysis

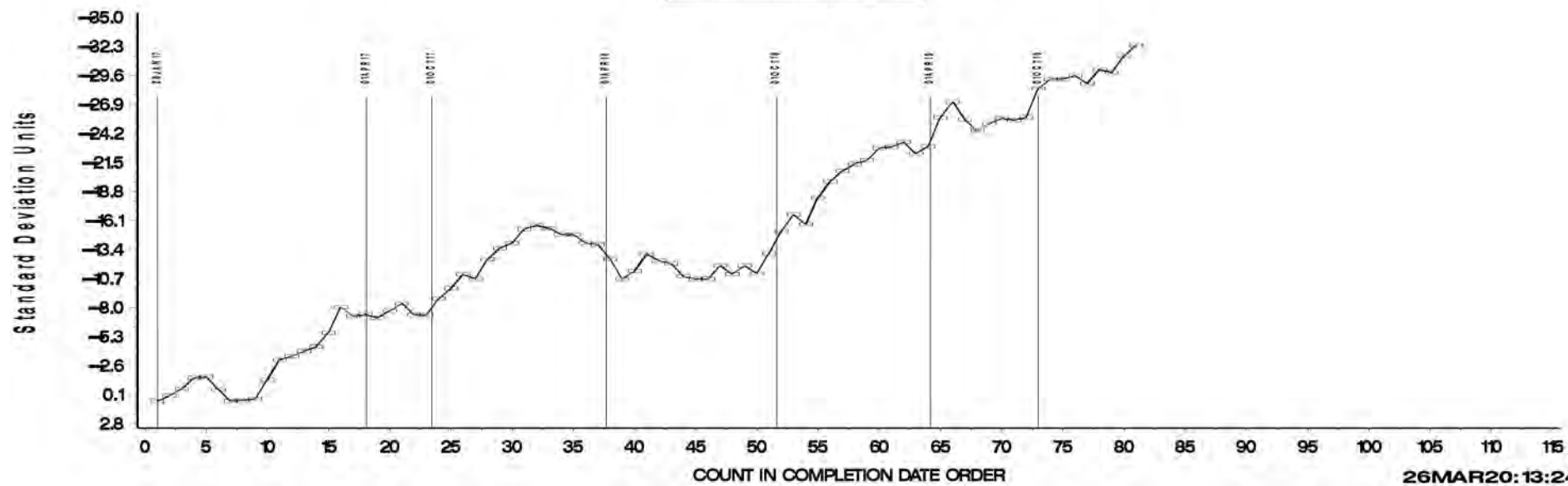


AVERAGE ROCKER COVER SLUDGE

LTMS Severity Analysis

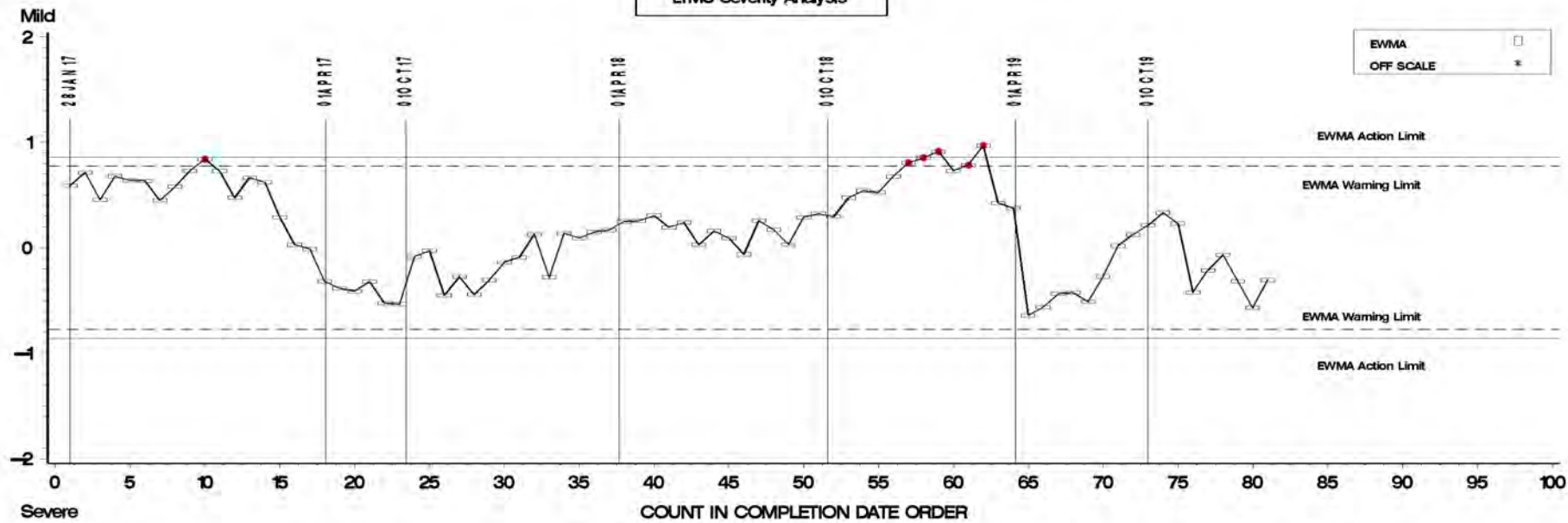


CUSUM Severity Analysis

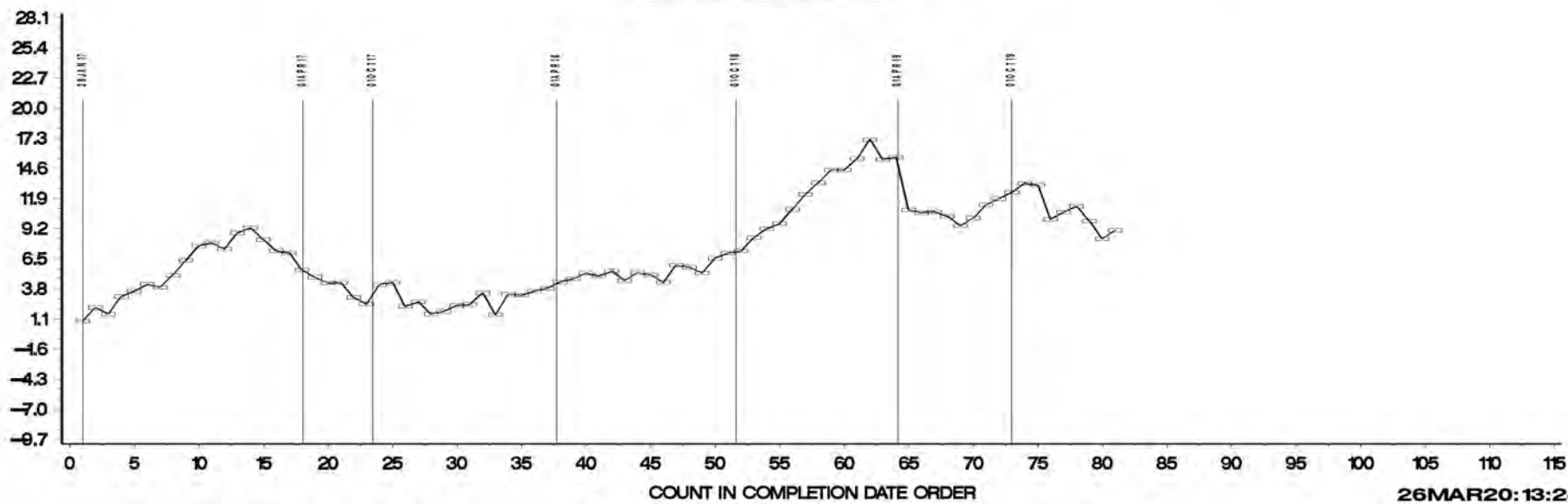


AVG. ENG. VARN. 50% RATING

LTMS Severity Analysis

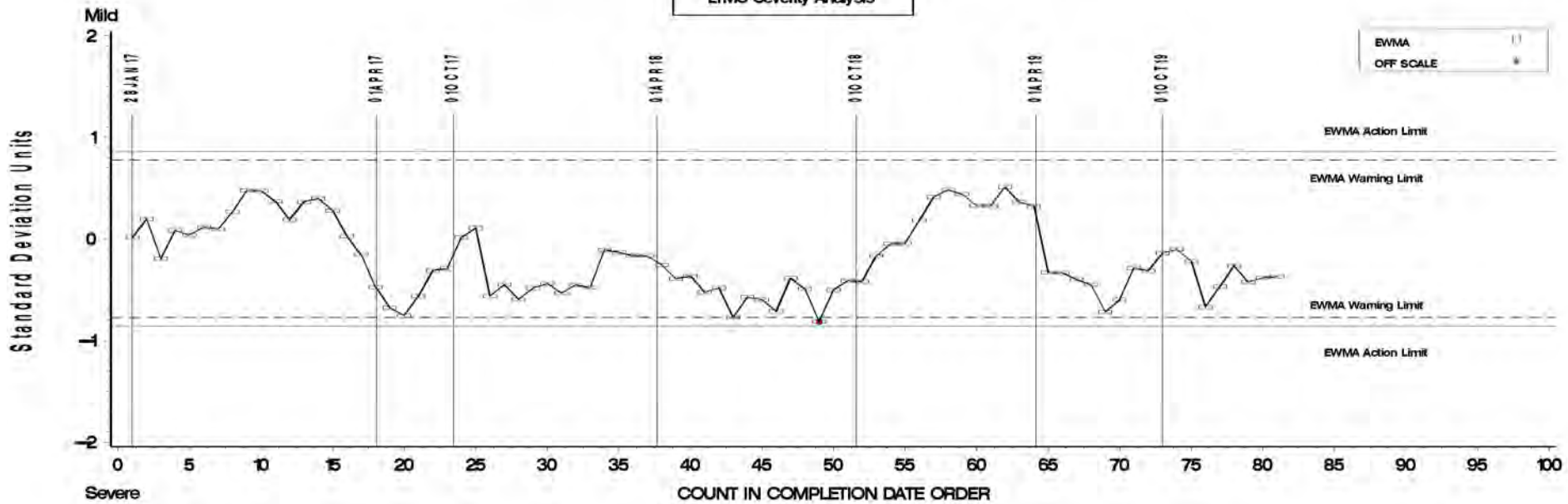


CUSUM Severity Analysis

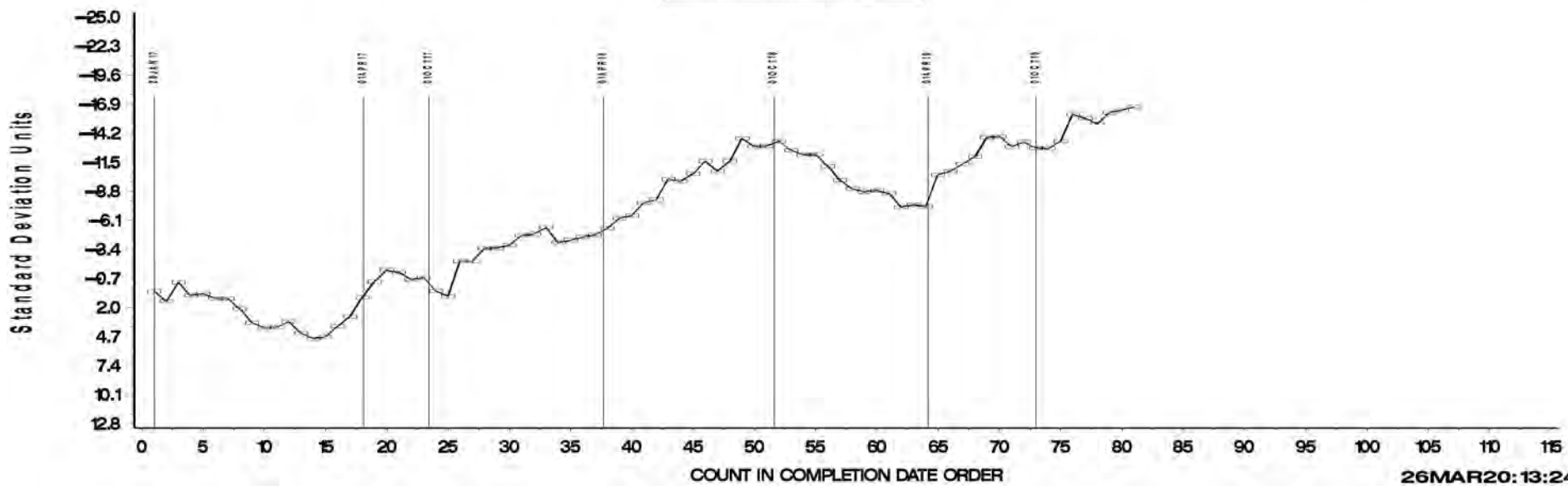


AVG PISTON SKIRT 50% RATING

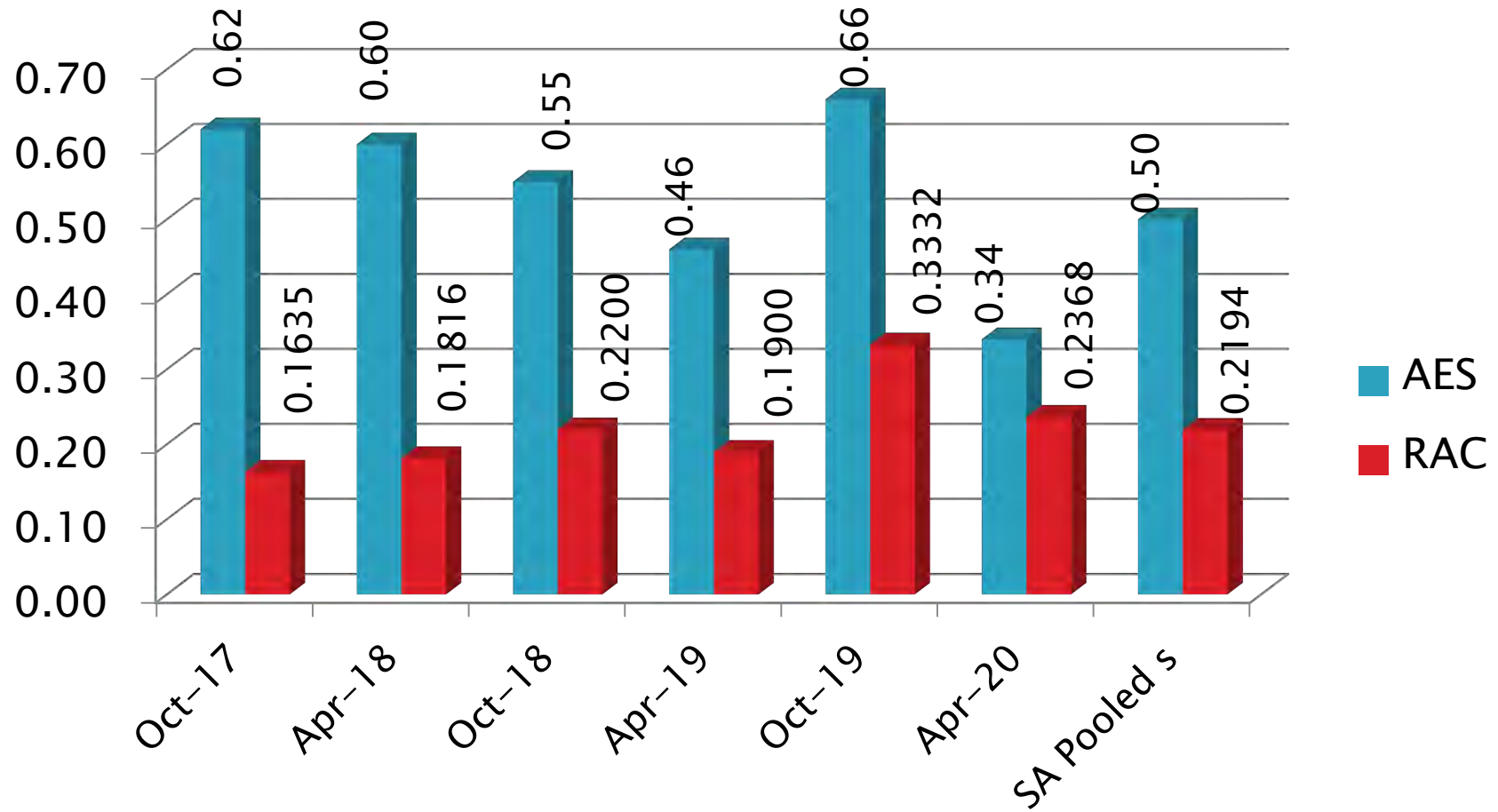
LTMS Severity Analysis



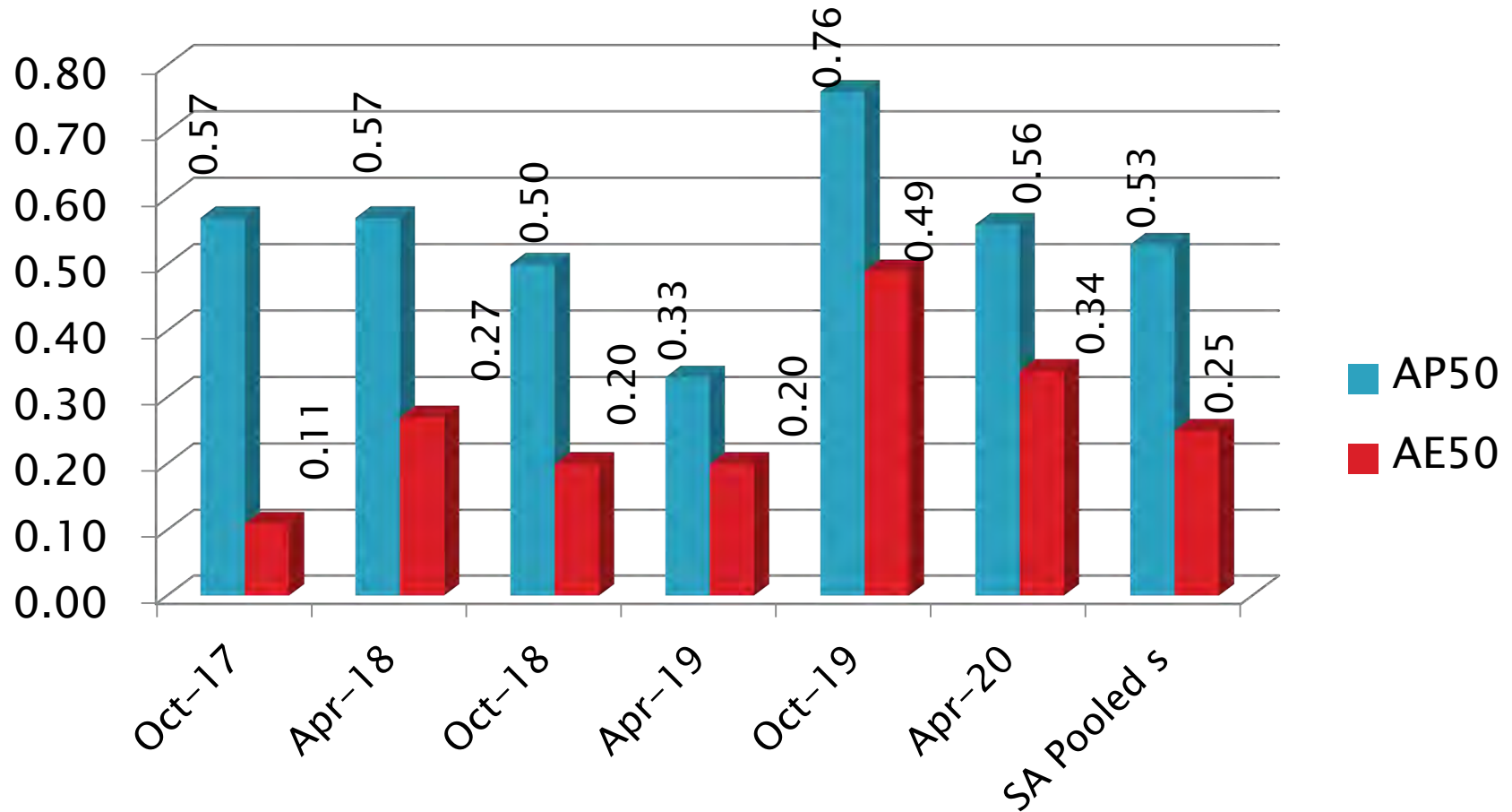
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Sequence VH Precision Estimates



Sequence VH Precision Estimates



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Sequence VIE

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Sequence VIE Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	29
Statistically Unacceptable Calibration Test	OC	1
Aborted Calibration Test	XC	1
Total		31

Sequence VIE- Failed Tests

Test Status	#
FEI1 Severe	1
Total	1

Sequence VIE – Lost Tests*

Test Status	Cause	#
Aborted	Dyno Bearing Failure	1
Totals		1

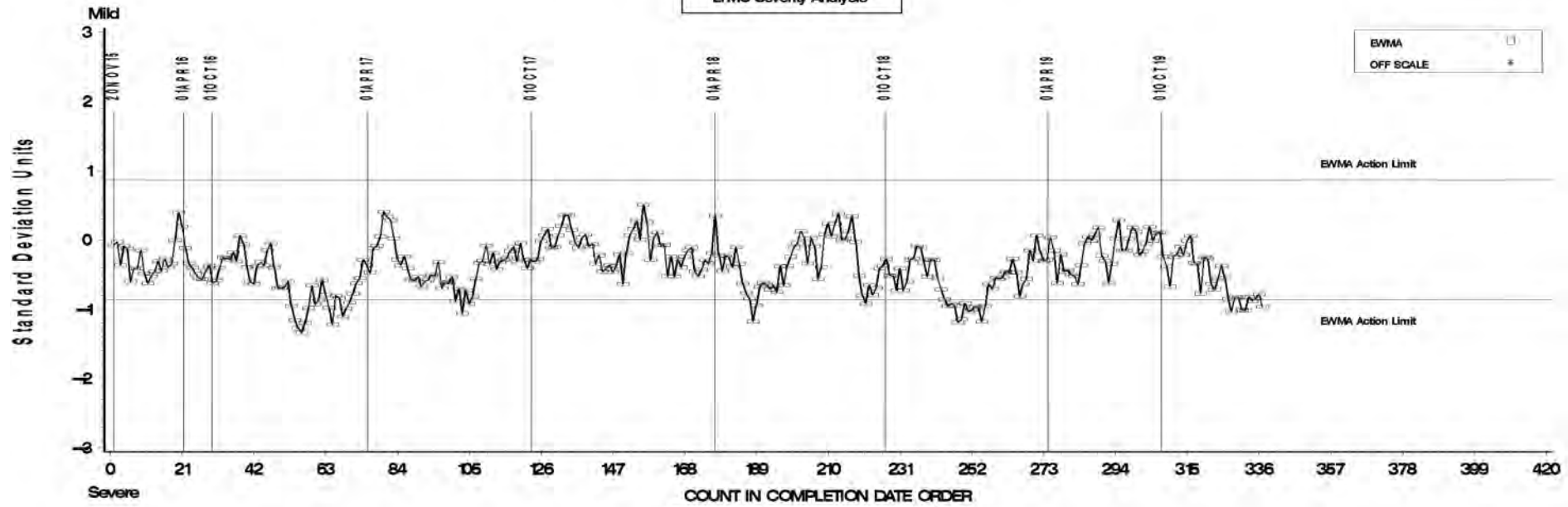
*Invalid and aborted tests

Sequence VIE Test Severity

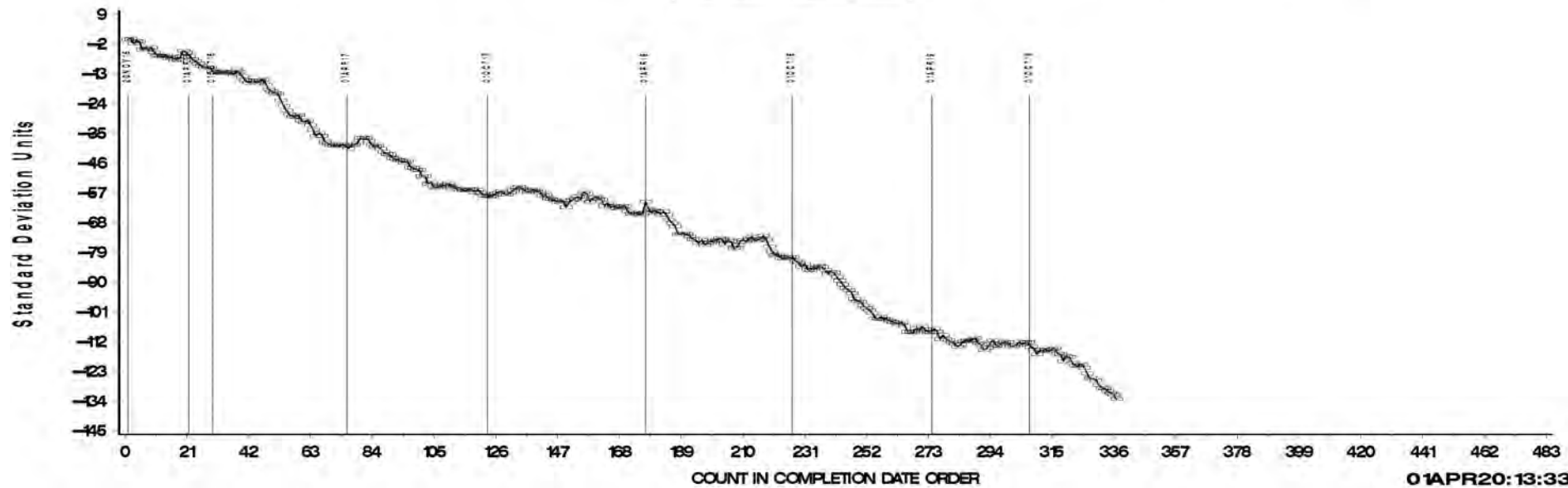
- FEI1 is in severity action alarm (severe direction)
- FEI2 is in control

FEI FINAL RESULT PHASE I

LTMS Severity Analysis

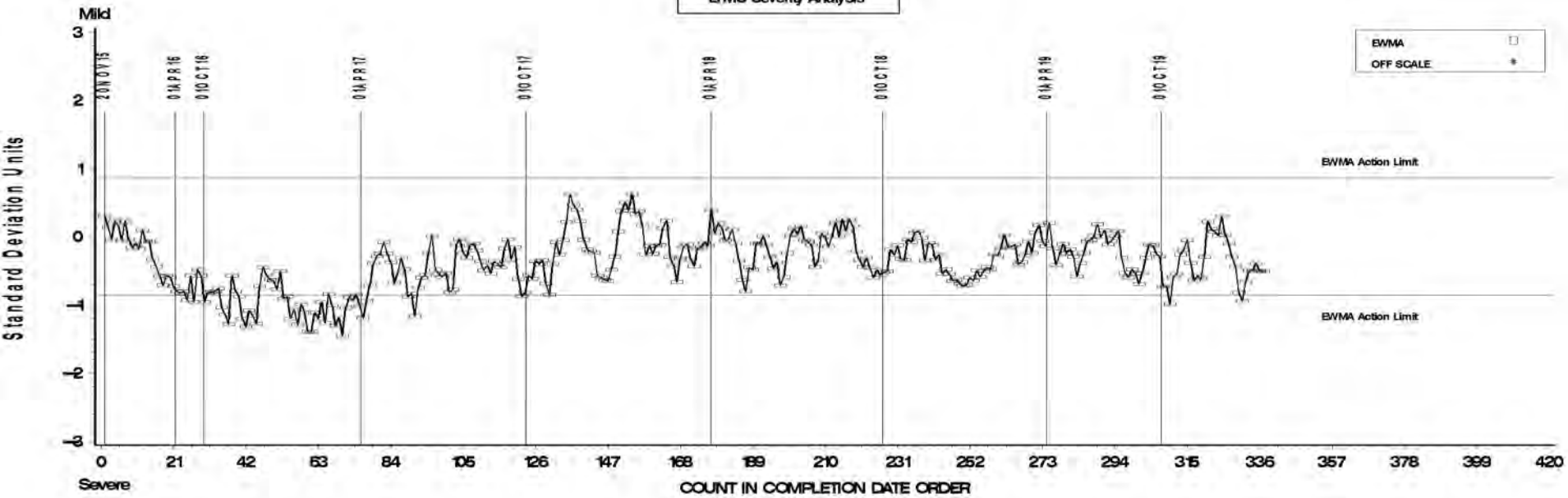


CUSUM Severity Analysis

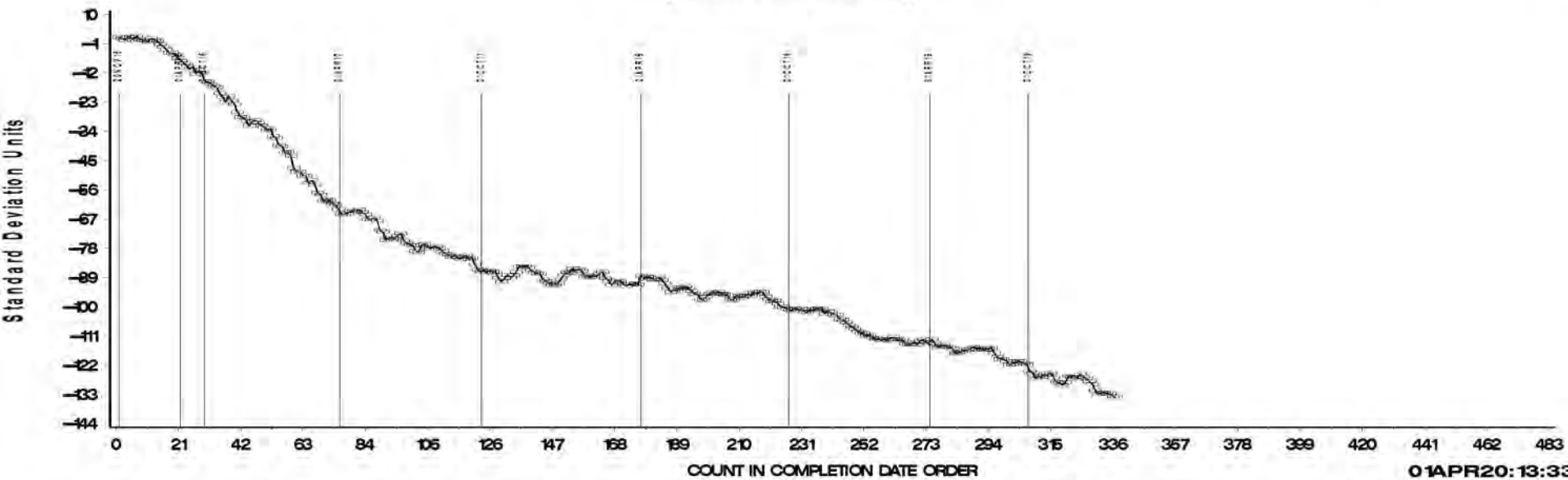


FEI FINAL RESULT PHASE II

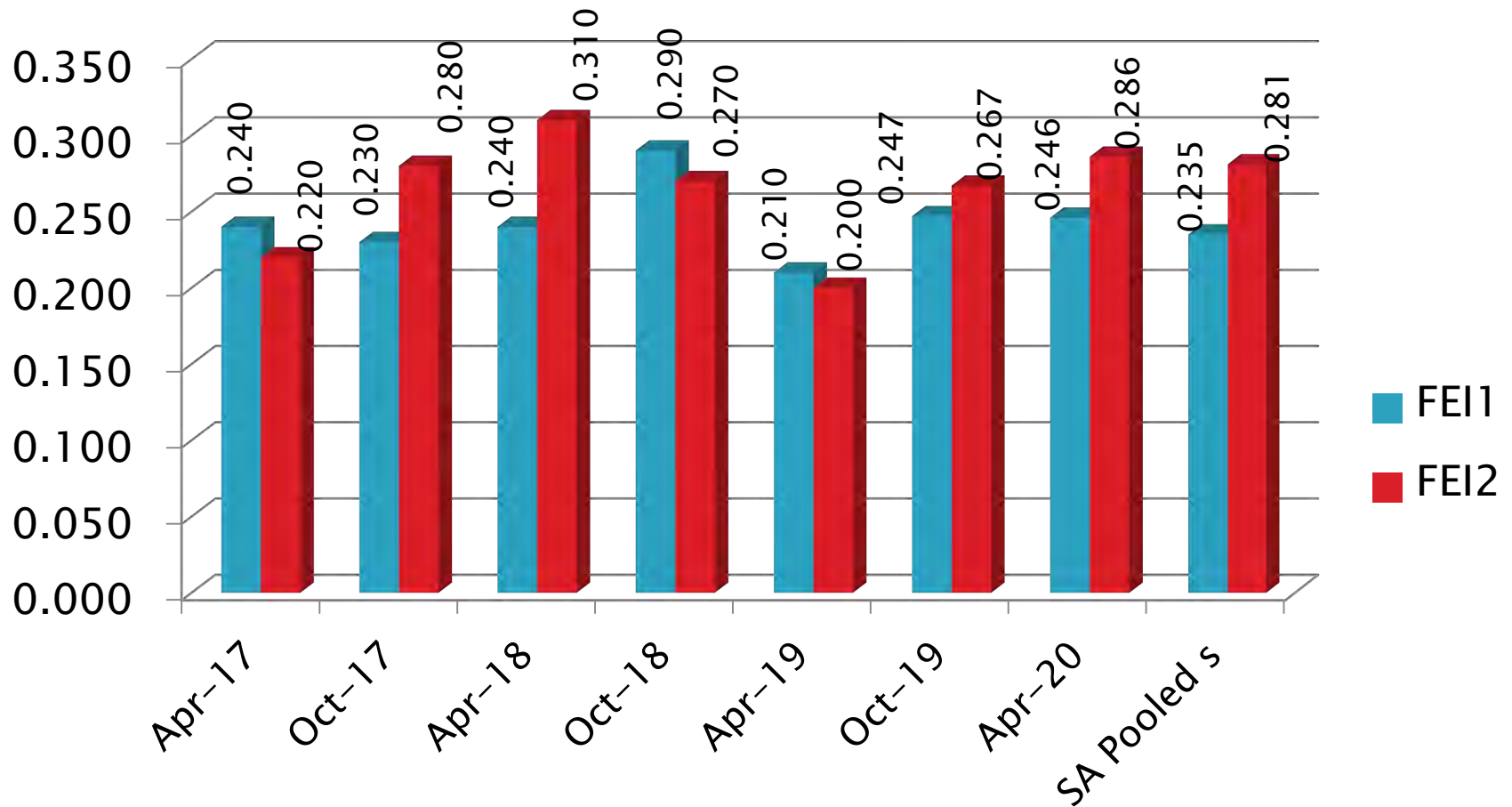
LTMS Severity Analysis



CUSUM Severity Analysis



Sequence VIE Precision Estimates



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Sequence VIF

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Sequence VIF Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	50
Failed Statistically	OC	6
Aborted	XC	3
Invalid by Lab	LC	2
Engine Abandoned	MC	2
Total		63

Sequence VIF – Failed Tests

Test Status	Number of Tests
Severe FEI1	2
Severe FEI2	3
Mild FEI1	1
Total	6

Sequence VIF – Lost Tests*

Test Status	Cause	#
Aborted	Engine failure	1
Aborted	Temperature calibration issue	1
Aborted	Fuel flow issues	1
Invalid	Data acquisition system errors resulting in missing data	1
Invalid	Baseline shift exceeded procedural limits (>0.40)	1
Totals		5

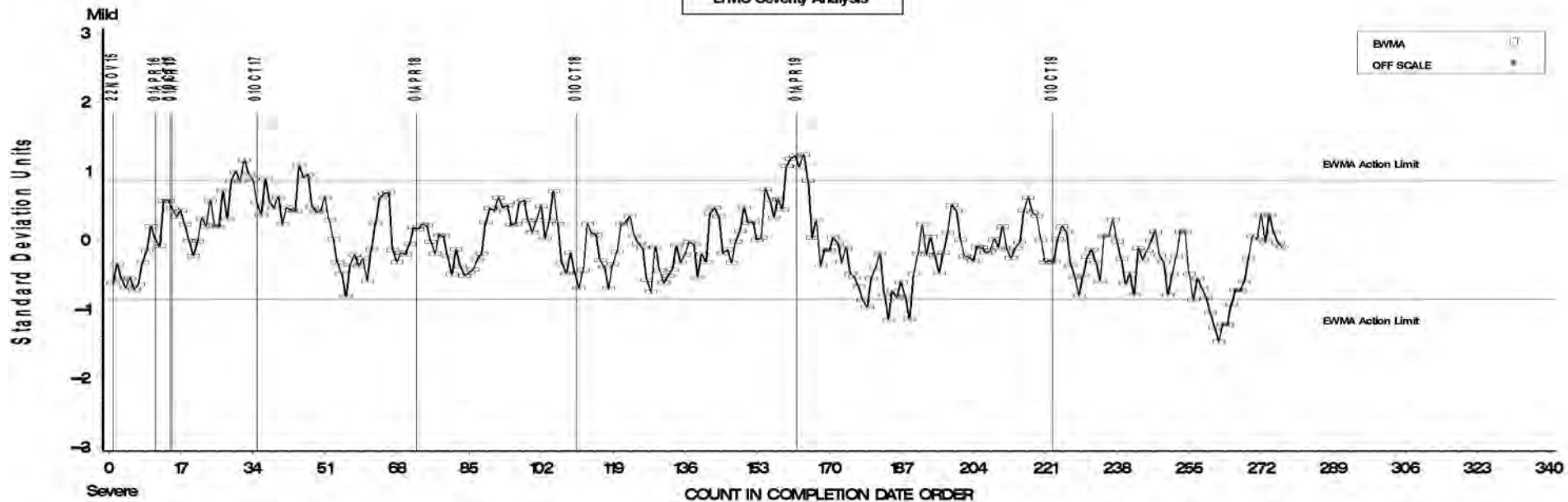
*Invalid and aborted tests

Sequence VIF Test Severity

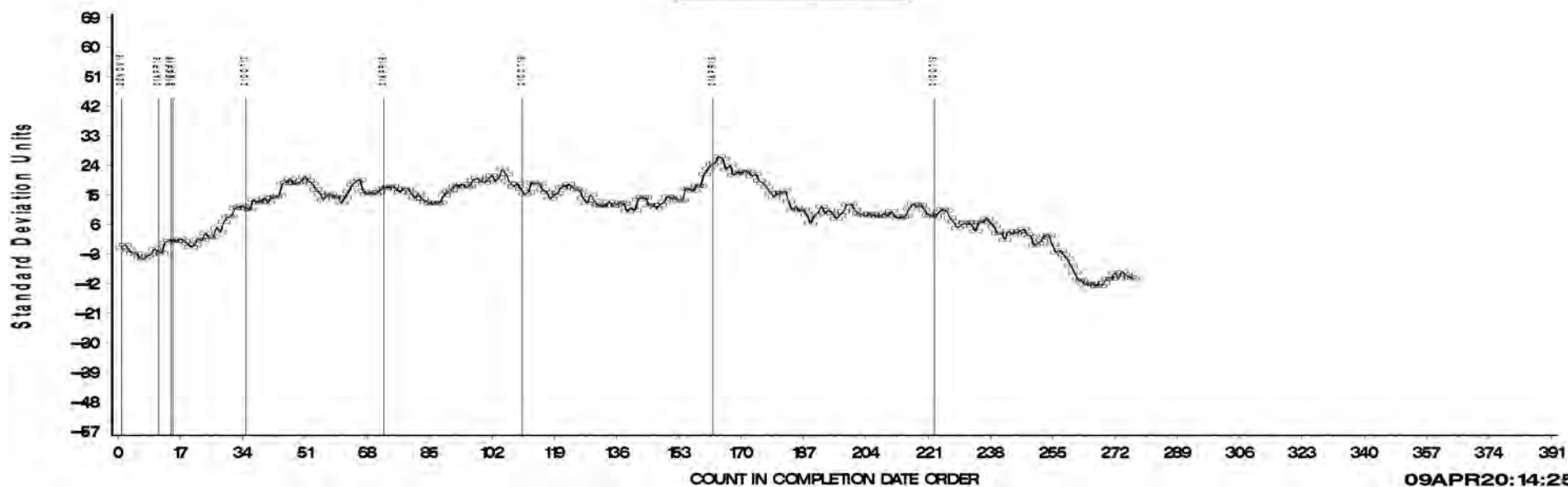
- FEI1 is in control
- FEI2 is in control

FEI FINAL RESULT PHASE I

LTMS Severity Analysis

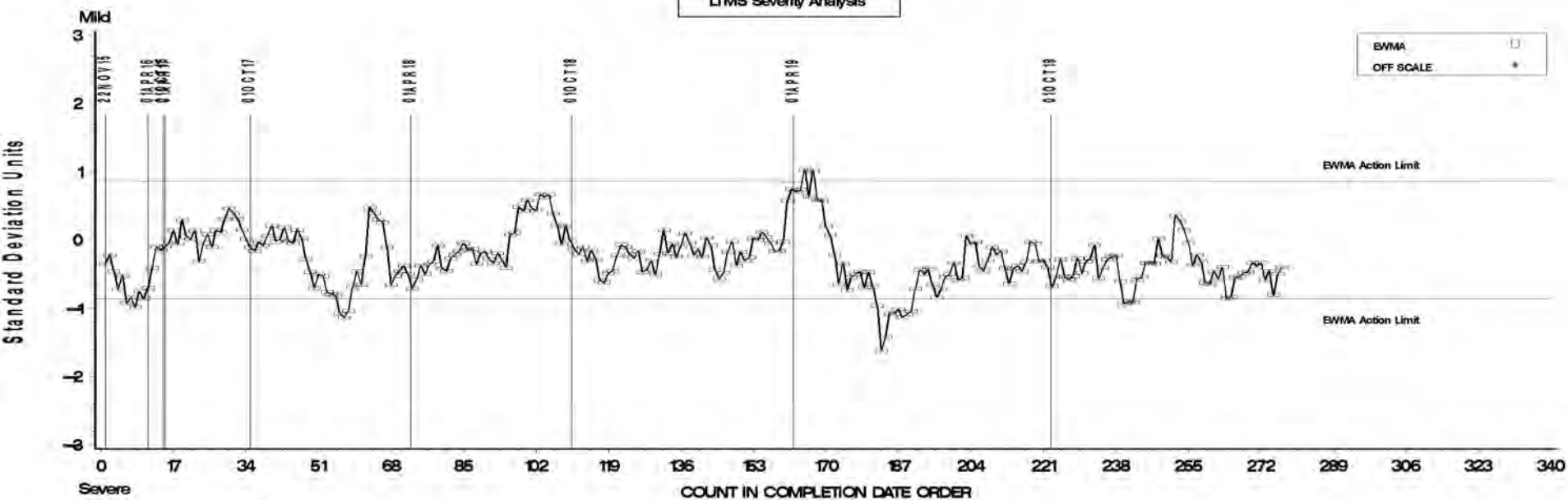


CUSUM Severity Analysis

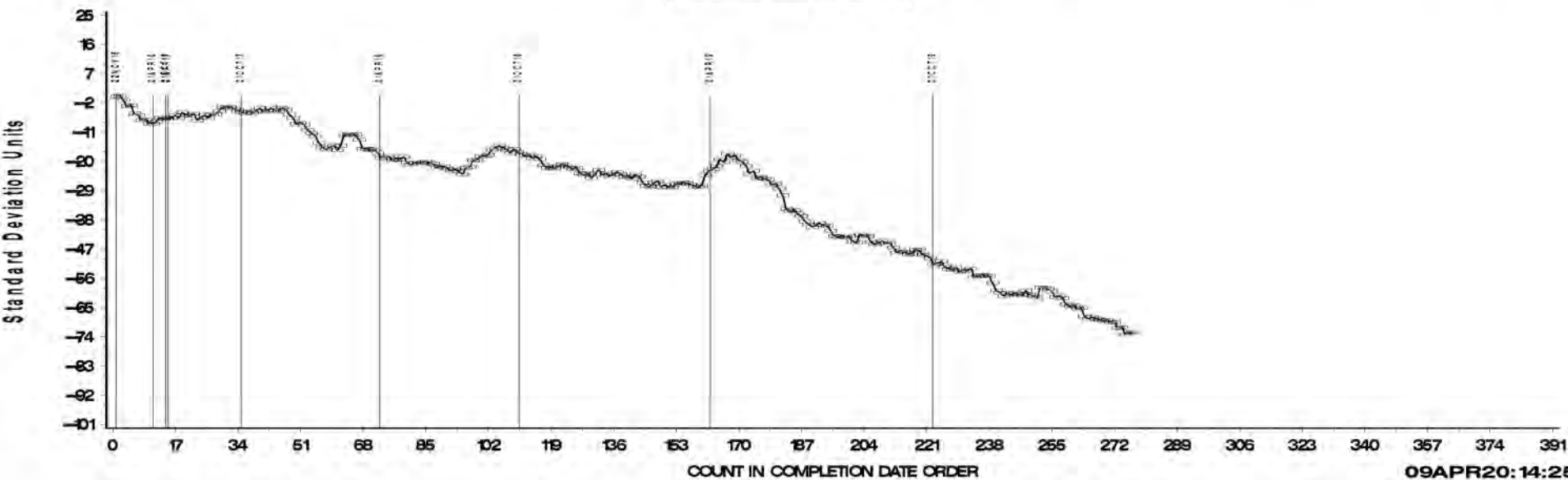


FEI FINAL RESULT PHASE II

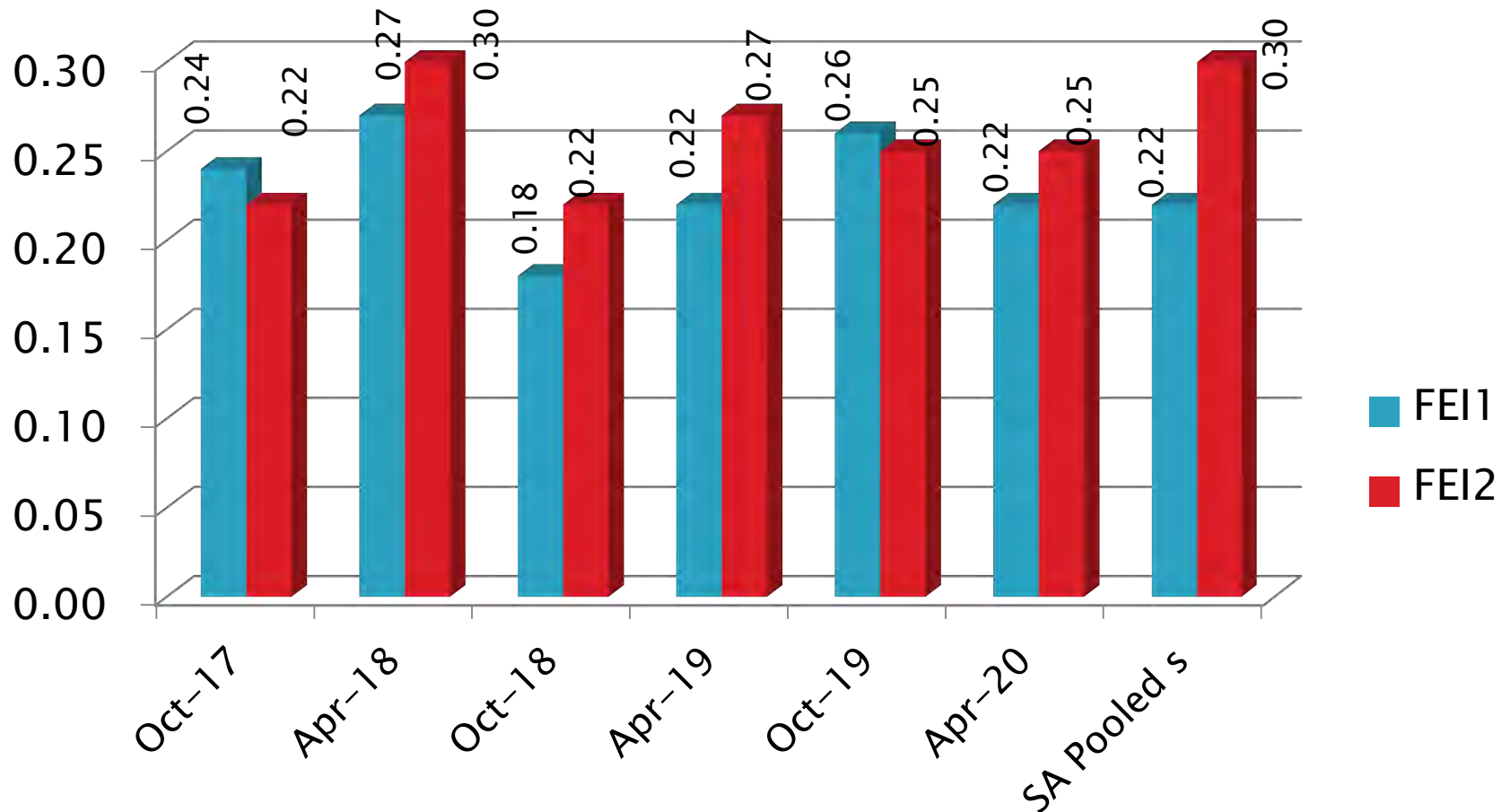
LTMS Severity Analysis



CUSUM Severity Analysis



Sequence VIF Precision Estimates



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Sequence VIII

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Sequence VIII Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	9
Statistically Unacceptable Calibration Test	OC	4
Operationally Invalid Calibration Test, Lab Judgement	LC	2
Total		15

Sequence VIII – Failed Tests

Test Status	Number of Tests
Severe Bearing Weight Loss	3
Stand EWMA Precision Alarm	1
Total	4

Sequence VIII – Lost Tests

Test Status	Cause	#
Invalid	Suspect Connecting Rod	1
Invalid	High Mechanical Wear	1
Totals		2

*Invalid and aborted tests

Sequence VIII Test Severity

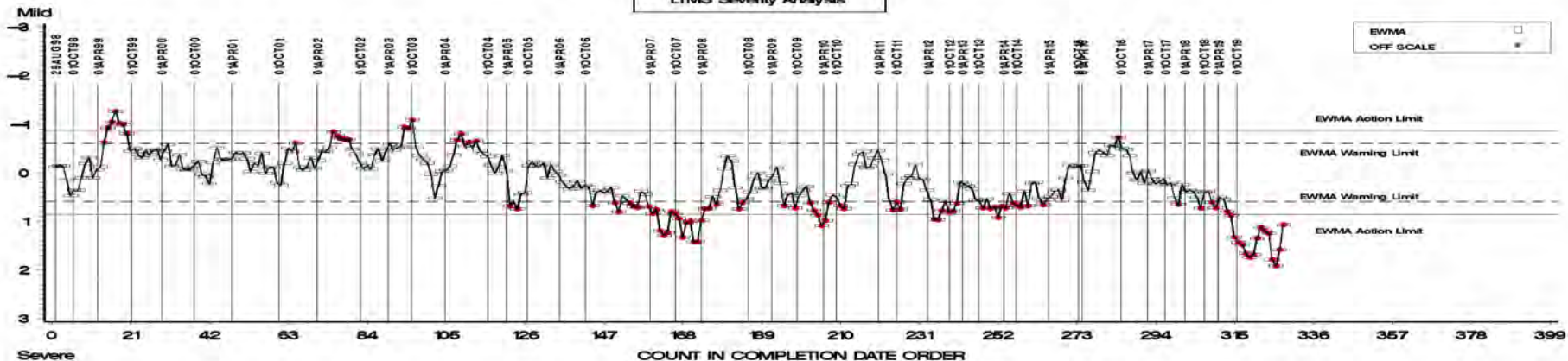
- Bearing Weight Loss is in severity action alarm (severe direction)
- Stripped Viscosity is in control

SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

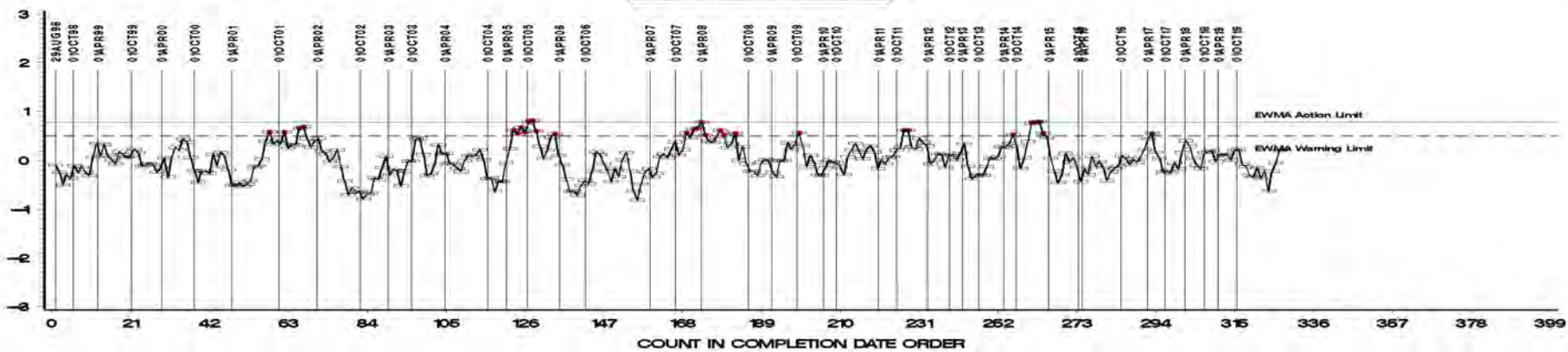


FINAL BEARING WEIGHT LOSS

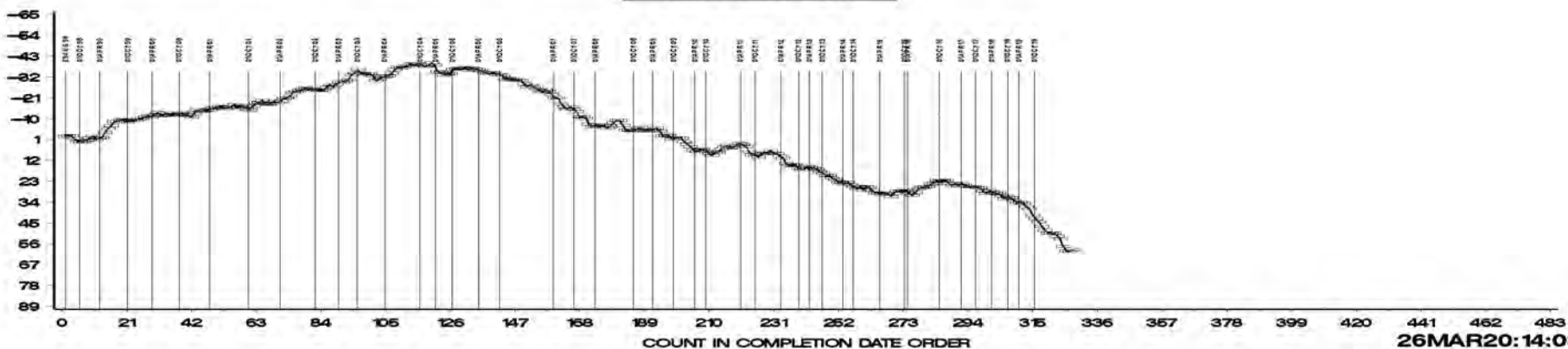
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

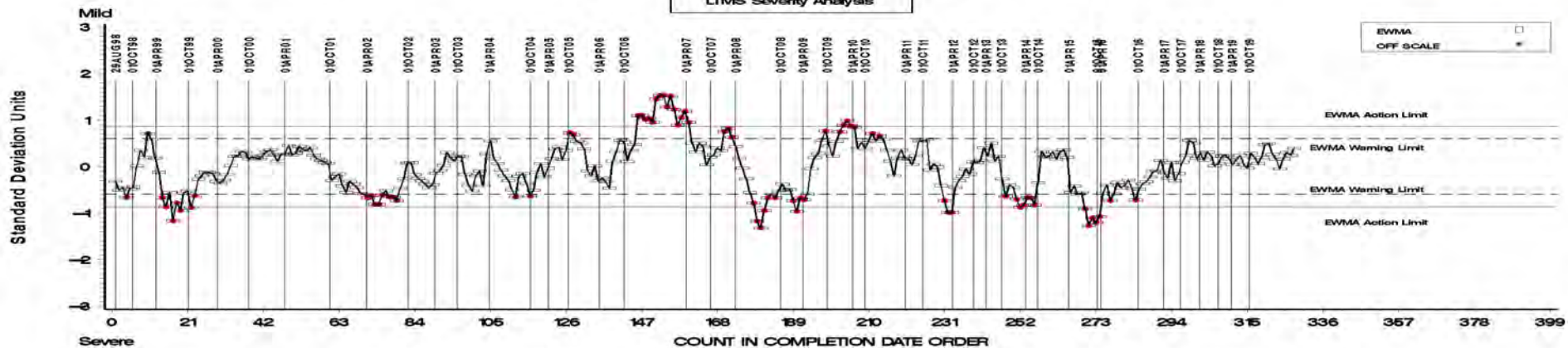


SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

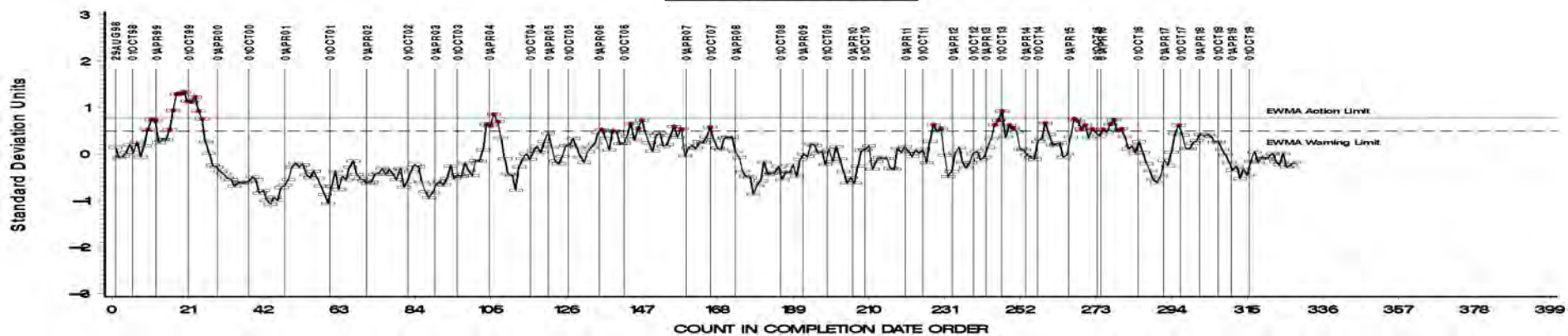


STRIPPED VIS. @ 100 DEG C

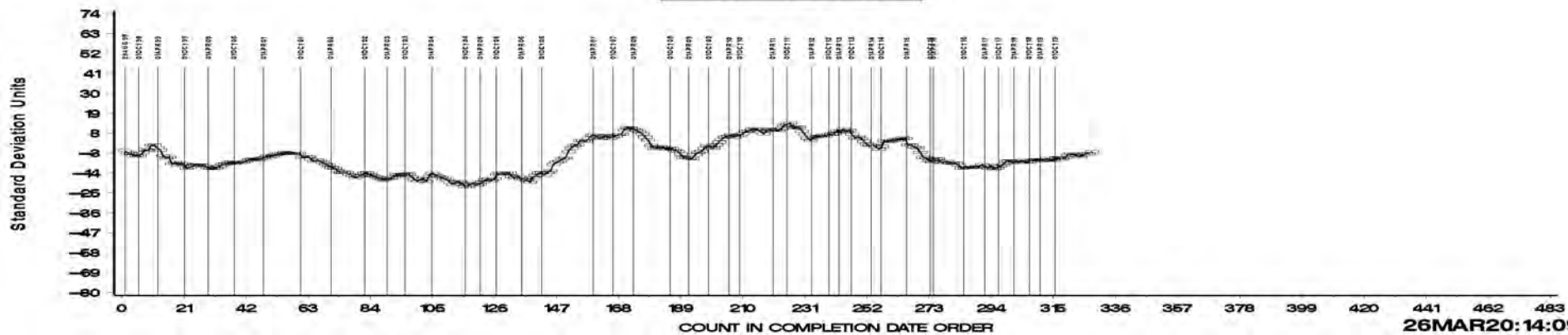
LTMS Severity Analysis



LTMS Precision Analysis

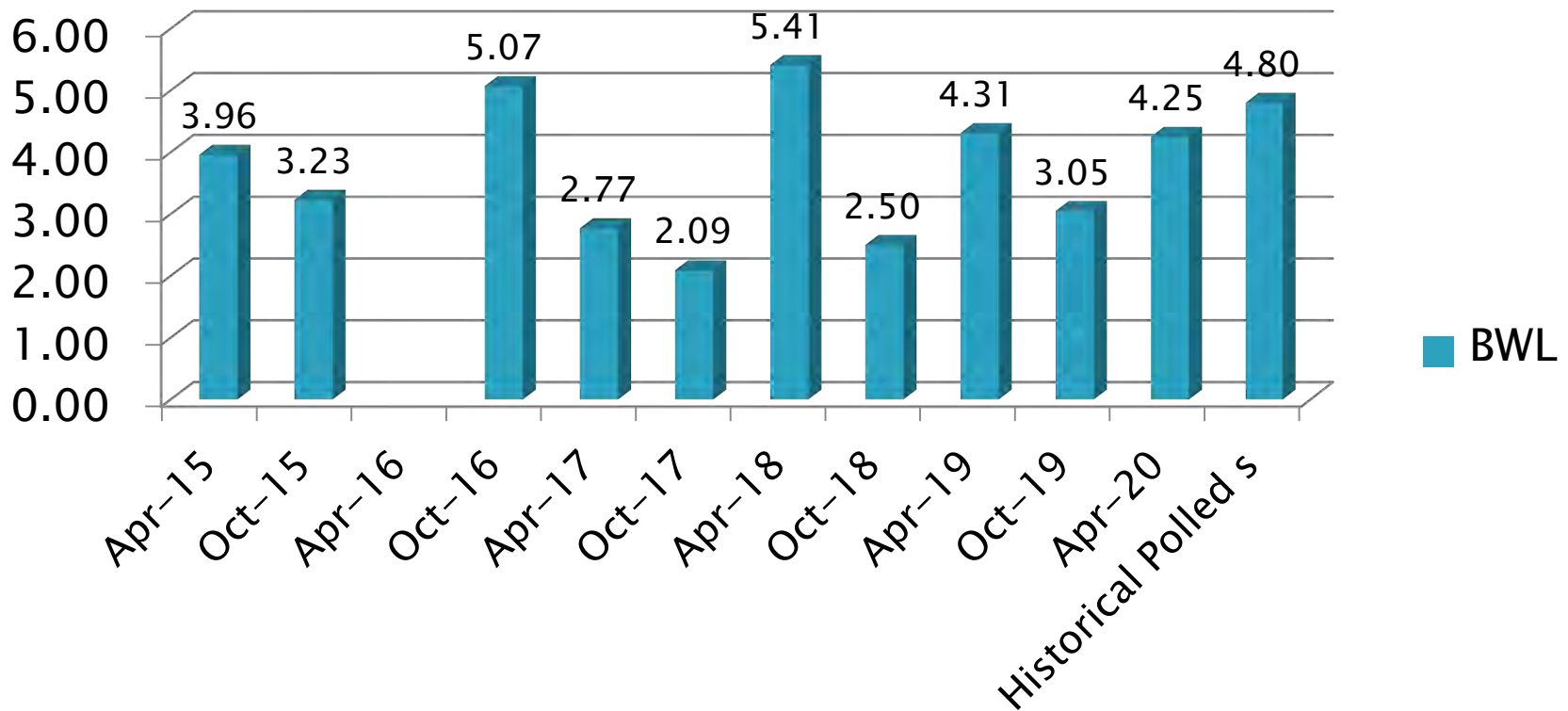


CUSUM Severity Analysis



Sequence VIII Precision Estimates

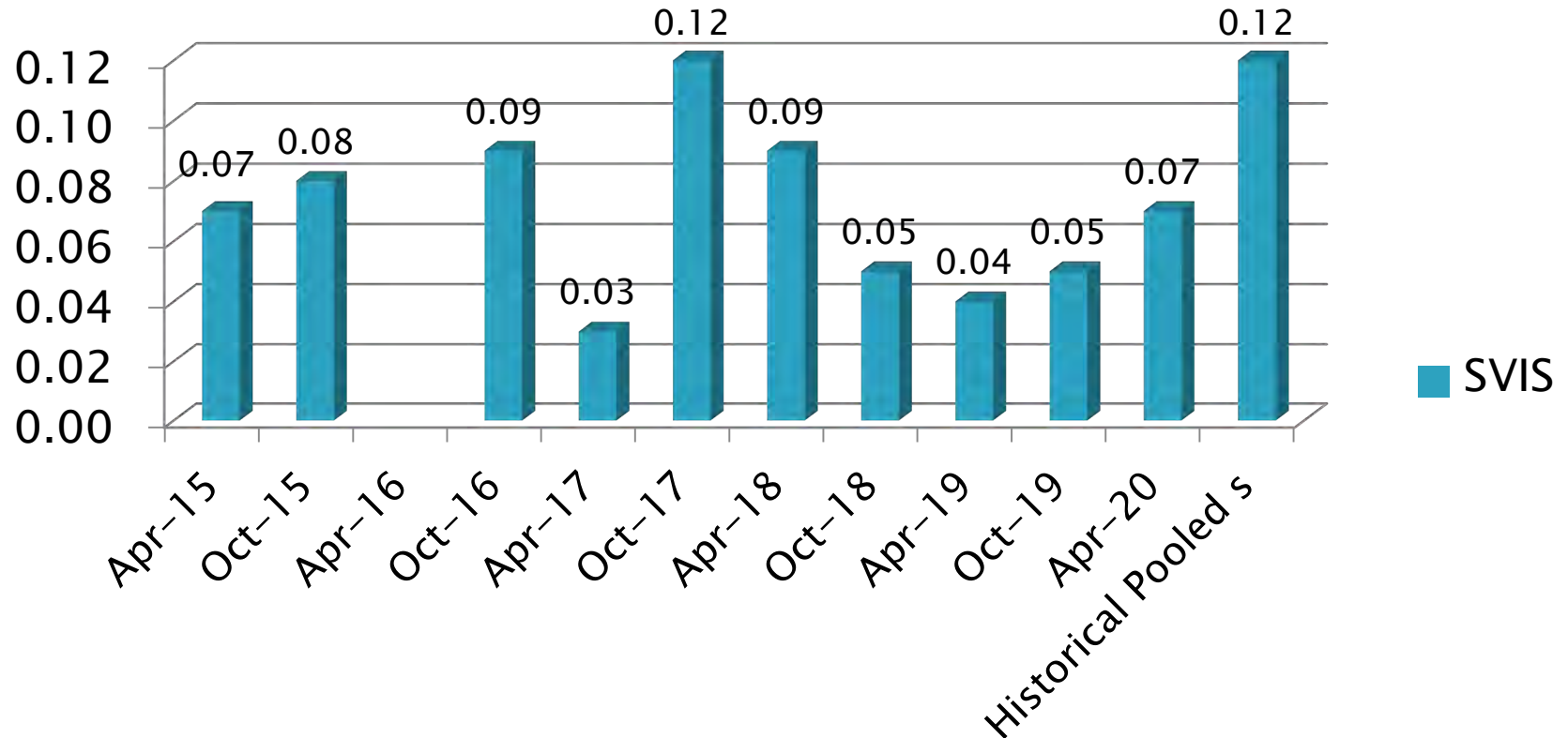
BWL



Sequence VIII Precision Estimates

SVIS

Historical Pooled s used for comparison purposes, parameter is not severity adjusted.



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Sequence IX

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Sequence IX Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	45
Statistically Unacceptable Calibration Test	OC	11
Operationally Invalid Calibration Test, lab determination	LC	3
Aborted Calibration Test	XC	1
Not for Industry Statistics Test, 2019 BB Piston	NN	2
Total		62

Sequence IX – Failed Tests

Test Status	Number of Tests
Ei Level 3 alarm	4
Ei Level 3, Zi level 2	1
Zi Level 2	6
Total	11

Sequence IX – Lost Tests*

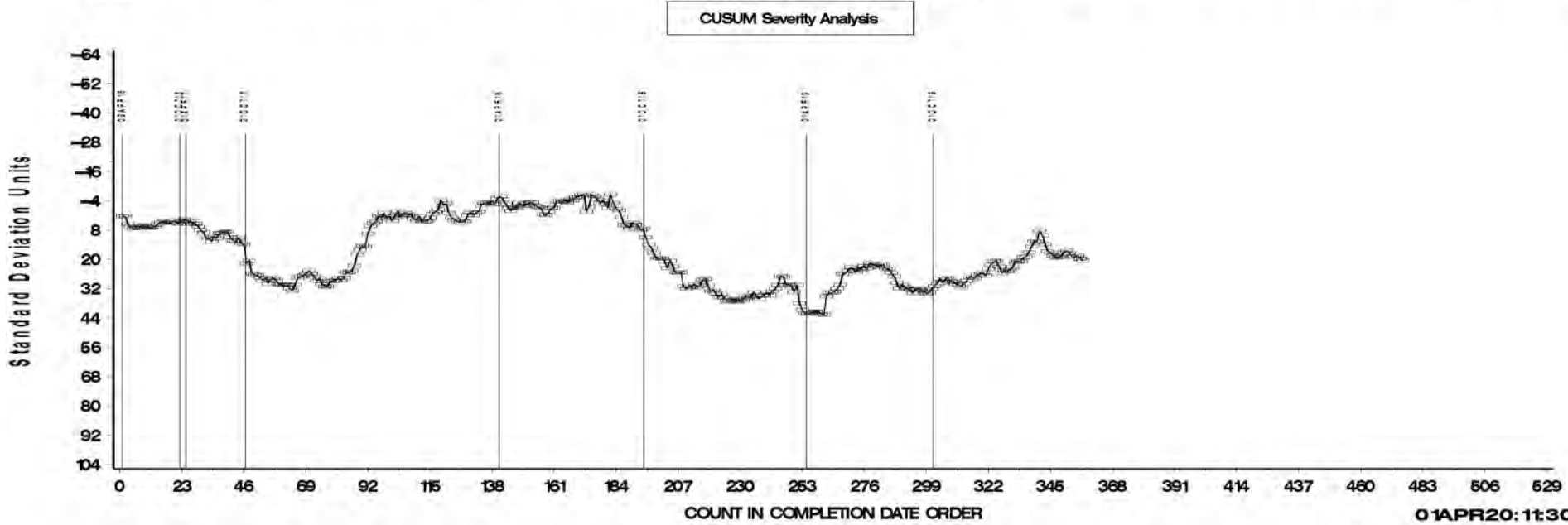
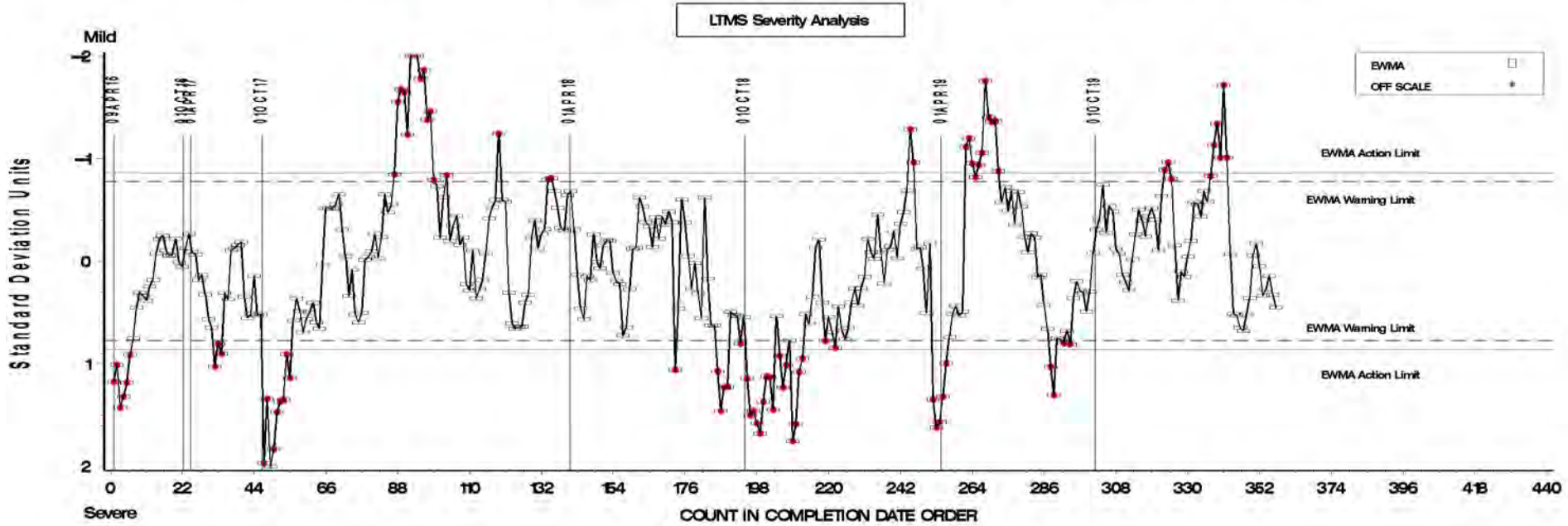
Test Status	Cause	#
Invalid	Lost Combustion Data	1
Invalid	Improper Oil Flush	1
Invalid	Incorrect Engine Timing	1
Aborted	Severe Preignition in Cylinder # 3	1
Totals		4

*Invalid and aborted tests

Sequence IX Test Severity

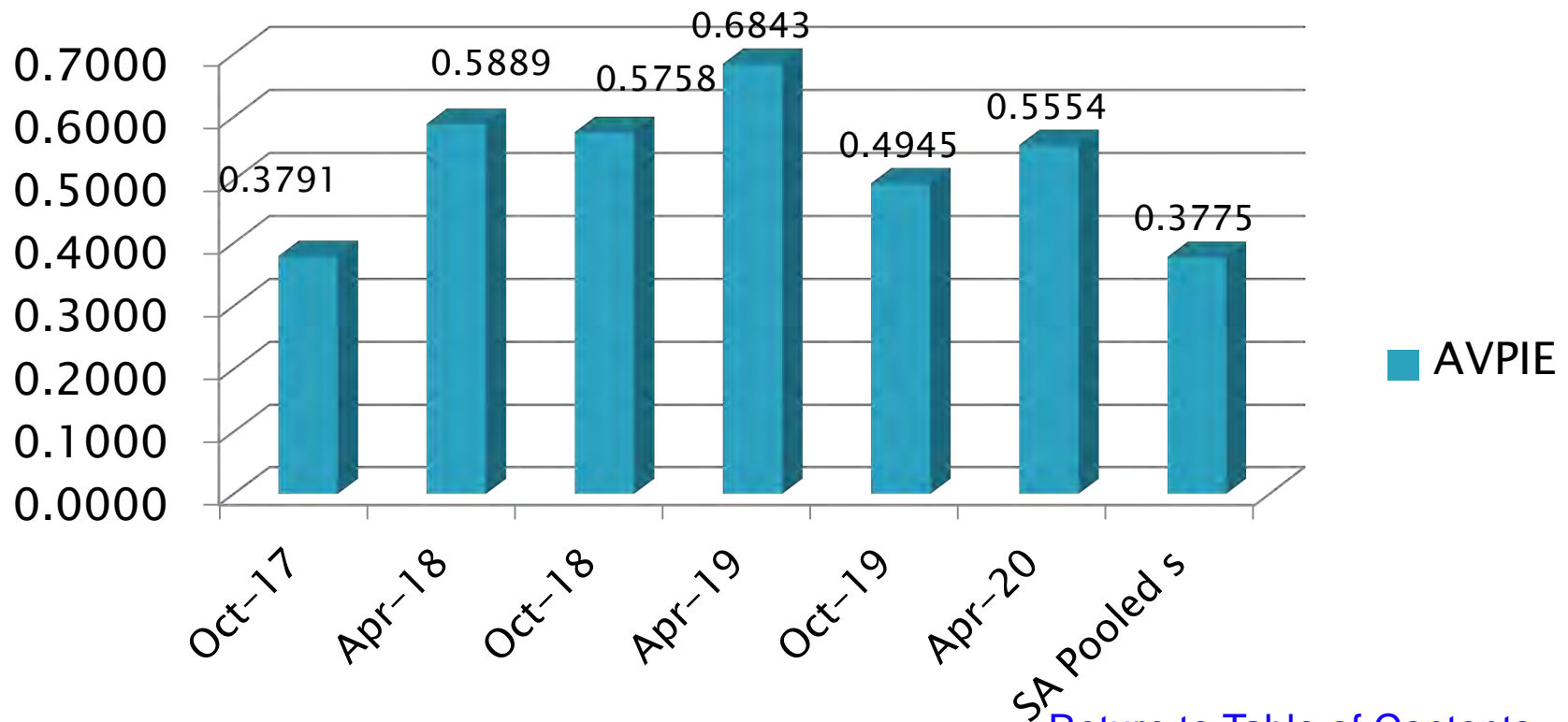
- Average number of Pre-ignitions in control.

AVERAGE NUMBER OF PREIGNITIONS FROM VALID ITERATIONS



Sequence IX Precision Estimates

AVPIE



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Sequence X

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Sequence X Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	8
Statistically Unacceptable Calibration Test	OC	1
Operationally Invalid Calibration Test (Lab determination)	LC	3
Total Number of Tests		12

Sequence X – Failed Tests

Test Status	Number of Tests
CHST Ei Level 3 alarm	1
Total	1

Sequence X – Lost Tests*

Test Status	Cause	#
Invalid	Air Charge Temperature control issues, negative Qi	1
Invalid	Fuel pump failure	1
Invalid	Broken clutch spring	1
Totals		3

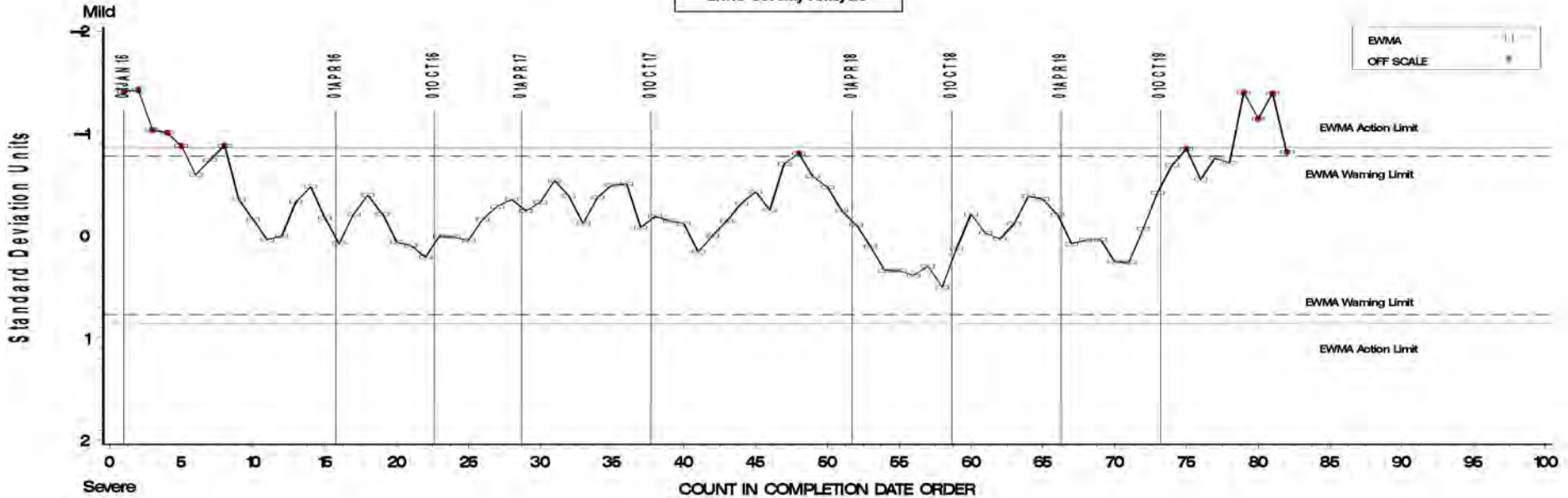
*Invalid and aborted tests

Sequence X Test Severity

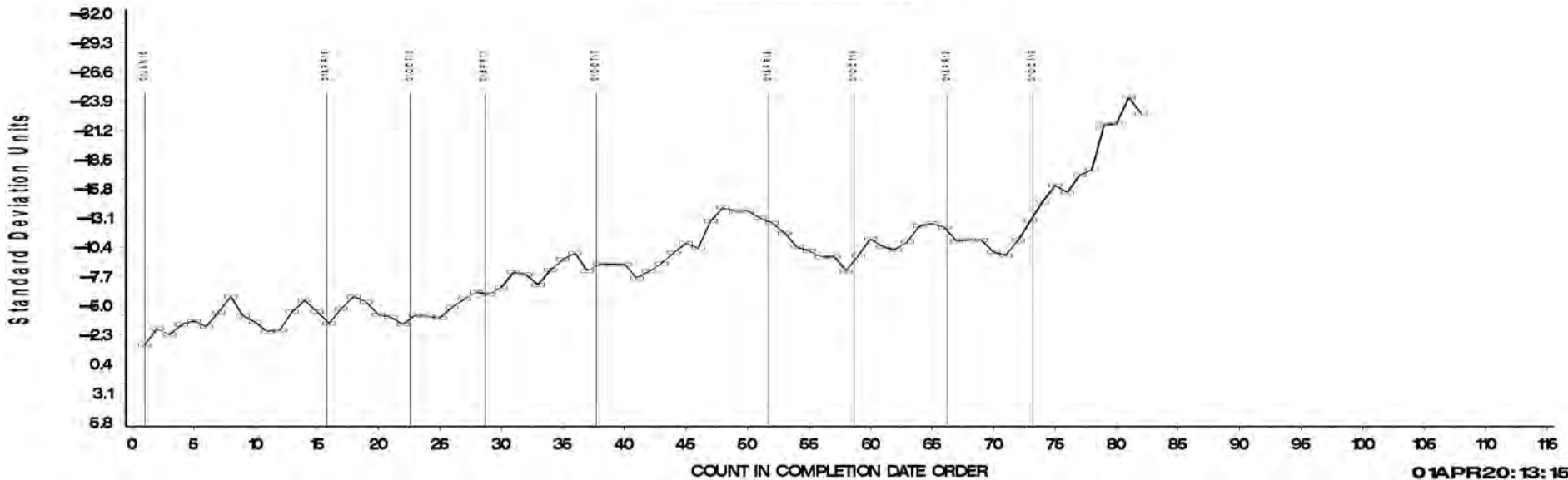
- Average Chain Stretch % in Severity Warning Alarm (mild direction).

END OF TEST CHAIN WEAR FINAL RESULT

LTMS Severity Analysis

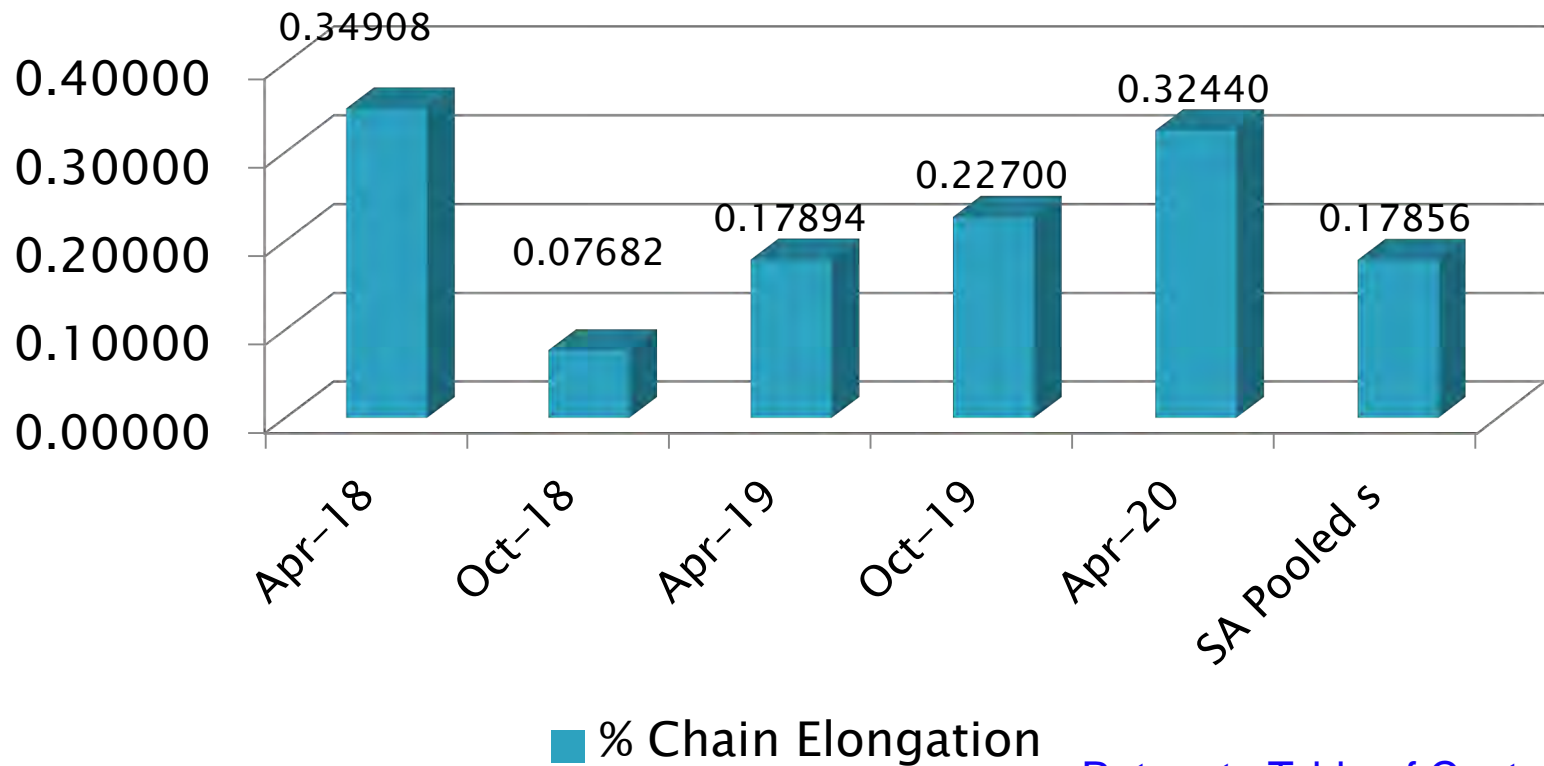


CUSUM Severity Analysis



Sequence X Precision Estimates

% Chain Elongation



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Information Letters

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Information Letters*

Test	Date	IL	Topic
IIIH	20200114	20-1	Clarified parameters to be used for calculating end of test phosphorus retention.
VH	20191203	19-1	Updated rater calibration requirements and corrected rating locations shown in Fig. A14.2
IX	20191202	19-1	Allowed use of dealer procured pistons and clarified/made corrections to iteration outlier criteria
IX	20200217	20-1	Added ASTM Test Method for oil analysis to reference documents. Clarified the test numbering scheme in section 10.5.1. Added termination of stand/engine calibration when engine is removed from stand and added additional alignment criteria when installing an engine in a test stand.
VIE	20200203	20-1	Added requirement to only add a new fuel batch to a laboratory tank when the volume of the current batch in the tank is 10% or less

*Available from TMC Website

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Information Letters* (cont.)

Test	Date	IL	Topic
VIF	20191104	19-3	Added D445 for Viscosity Measurements and FEISUM parameter and updated precision statement to include FEISUM.
VIF	20191203	19-4	Included requirement not to allow testing of 0W-16 Oils after testing 0W-12 or Lower Viscosity Oils
VIF	20200203	20-1	Added requirement to only add a new fuel batch to a laboratory tank when the volume of the current batch in the tank is 10% or less
X	20200115	20-1	Revised specified driveshaft length, corrected identification of engine oil inlet temperature, made corrections to Table 4 and clarified blowby measurement technique when using J-Tec meter. Made corrections to pre and post intercooler pressure measurement locations and addressed typographical errors in sections 8.2.6, 8.26.1.1 and figures A9.18, A9.28 and A10.2

*Available from TMC Website

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Reference Oil Inventory

»» Actions, Re-blends, Inventories
and Estimated Life

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Reference Oil Re-blends

➤ TMC 438-2

- This re-blend is being introduced. Seven tests completed this report period (Seq. IIIH)

➤ TMC 1006-2

- This oil is being held for IVA and IVB break-in. The panel may wish to use another oil for IVB Break-in as 1006-2 can not be re-blended.

Reference Oil Re-blends (cont)

➤ TMC 1009-1

- The Sequence V panel agreed to removed this oil due to performance issues. A replacement oil, 931 has been obtained.

➤ TMC 1011-1

- Reblend is now available (IVB/VH/VIF/X). Due to limited quantities, this oil may need to be introduced into most test areas next report period.

Reference Oil Inventory Estimated Life

Oil	Tests	Original Blend Amount (gallons)	Quantity Shipped in last 6 months	TMC Inventory (gallons)	Lab Inventory (gallons)	Estimated Life
220	IX	1100	70	250	70	2 years
221	IX	2120	100	764	90	2.5+ years
222*	IX	1040	60	0	35	<1 year
224	IX	1026	170	496	105	2+ years
270	X	1100	55	808	30	5 years
271	X	980	50	729	35	5 years
300-1	IVB	378	50	259	30	3 years
434-2	IIIH	495	0	0	12	<1 year

* Reference oil 222 can not be re-blended

Reference Oil Inventory Estimated Life

Oil	Tests	Original Blend Amount (gallons)	Quantity Shipped in last 6 months	TMC Inventory (gallons)	Lab Inventory (gallons)	Estimated Life
434-3	IIIH	980	35	771	20	5+ years
436	IIIH	1100	29	715.5	25	5+ years
438-1	IIIH	605	8.5	0	10	<1 year
438-2	IIIH	540	27.5	484	20	5 years
542-3	VIE/VIF	997	82	5	36	<1 Year
542-4	VIE/VIF	1100	281	500	138	2+ Years
543	VIF	1100	133	253	90	1 Year
544	VIE	897	30	245	60	4+ years

Reference Oil Inventory Estimated Life

Oil	Tests	Original Blend Amount (gallons)	Quantity Shipped in last 6 months	TMC Inventory (gallons)	Lab Inventory (gallons)	Estimated Life
704-1	VIII	897	21	50	10	1+ years
940	VH	560	21	96	24	2+ years
1006-2	IVA, VIII	5500	142	280	75	1 year
1009-1	VH, VIII	1100	21	922	3	5 years
1010-1	VIE	1760	76	293	90	1.5 years
1011	IVB/VH/VIF/X	1100	171	24	171	<1 year
1011-1	IVB/VH/VIF/X	1395	0	1395	0	5+ years
1012	IVB	2200	110	1610	100	5+ years

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LTMS Deviations

»» October 1, 2019 –
March 31, 2020

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LTMS Deviations

- No LTMS Deviations this period

LTMS Deviations

Historical Count of PCEO LTMS Deviations

Test	LTMS Deviations
IIIH	0
IVA	7
IVB	0
VH	0
VIE	0
VIF	0
VIII	3
IX	0
X	0

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Quality Index Deviations

»» October 1, 2019 –

March 31, 2020

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Quality Index Deviations

- One IIIH Quality Index Deviation requested this Report Period.
 - Deviation for Intake Air Temperature due to Air Handler inoperative during first 30 minutes of test.

Quality Index Deviations

Historical Count of PCEO Quality Index Deviations

Test	Quality Index Deviations
IIIH	6
IVA	30
IVB	1
VH	5
IX	1
X	2

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TMC Laboratory Visits

»» October 1, 2019 –
March 31, 2020

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TMC Lab Visits

Test	Number of Labs Visited
IIIH	4
IVB	1
IX	3
VH	2
VIE/VIF	3
VIII	2
X	1

Lab Visit Issues

- Seq. IIIH
 - Ten lengths of pipe not installed downstream of J-Tec.
 - No documentation to support humidity calibration.
- Seq. IX
 - AFR sensor and exhaust temperature probe not located properly.
 - Calibrations not performed every 90 days (2 labs)
 - Fuel Temperature not located with 155 mm of high pressure pump.
 - Pre-intercooler pressure probe not installed.
- Seq. VH
 - Coolant flow calibrated at only one set point.

Lab Visit Issues

- Seq. VI
 - Thermocouple exposed length >2 inches.
 - Fuel @ Flowmeter thermocouple not installed 100 to 500 mm before flowmeter inlet (2 labs).
 - Missed 90 day calibrations.
 - Oxygen sensors not installed in proper location
 - Flowmeter does not have minimum 5 diameters of smooth pipe downstream of flowmeter
- Seq. VIII
 - Intake Air temperature sensor not located per procedure.
- Seq. X
 - Driveshaft length not in accordance with procedure.
 - Pre-intercooler pressure sensor not located per procedure.

Labs have notified the TMC that these items were corrected or were corrected during the visit.

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Test Area Timelines

»» October 1, 2019 –
March 31, 2020

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Test Area Timeline Additions*

Test	Date	Topic	IL
IIIH	20191008	Introduced BC7 rings for Sequence IIIH testing	
IIIH	20200114	Clarified parameters to be used in Phos Retention calculation	20-1
IX	20191202	Allowed use of Dealer procured pistons for Sequence IX testing and updated outlier criteria when determining pre-ignition events	19-1
IX	20191206	First occurrence of Dealer pistons	
IX	20200227	Added ASTM Test Method for oil analysis to reference documents. Clarified the test numbering scheme in section 10.5.1. Added termination of stand/engine calibration when engine is removed from stand and added additional alignment criteria when installing an engine in a test stand.	20-1

*As of 03/31/2020

Test Area Timeline Additions*

Test	Date	Topic	IL
VH	20191024	1009-1 results removed from control charts and laboratory SA's recalculated.	
VH	20191203	Included sludge and reduced the number of varnish parts required for rater calibration and corrected Fig A14.2	19-1
VIE	20200203	Added requirement to only add a new fuel batch to a laboratory tank when the volume of the current batch in the tank is 10% or less	20-1
VIF	20191104	Added D 445 to reference documents and added FEISUM as a parameter in section 12 and added FEISUM precision estimates to Table 8.	19-3
VIF	20191203	Added requirement to not use engines which have had < 0W-16 vis grade oils for subsequent non-reference oil tests	19-4

*As of 03/31/2020

Test Area Timeline Additions*

Test	Date	Topic	IL
VIF	20200203	Added requirement to only add a new fuel batch to a laboratory tank when the volume of the current batch in the tank is 10% or less	20-1
X	20200115	Revised specified driveline length. Renamed engine oil inlet temperature as oil gallery temperature. Included coolant flow, pressure and lambda as controlled parameters and changed fuel temperature to a non controlled parameter. Addressed blowby measurement discrepancies when using J-Tec meter and intake air pressure probe location discrepancies and corrected typographical errors in Section 8.26.1.1 (b), figure A9.28 and Table A10.2	20-1

*As of 03/31/2020

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Rating Workshop Data

»» 2019 Light Duty Workshop

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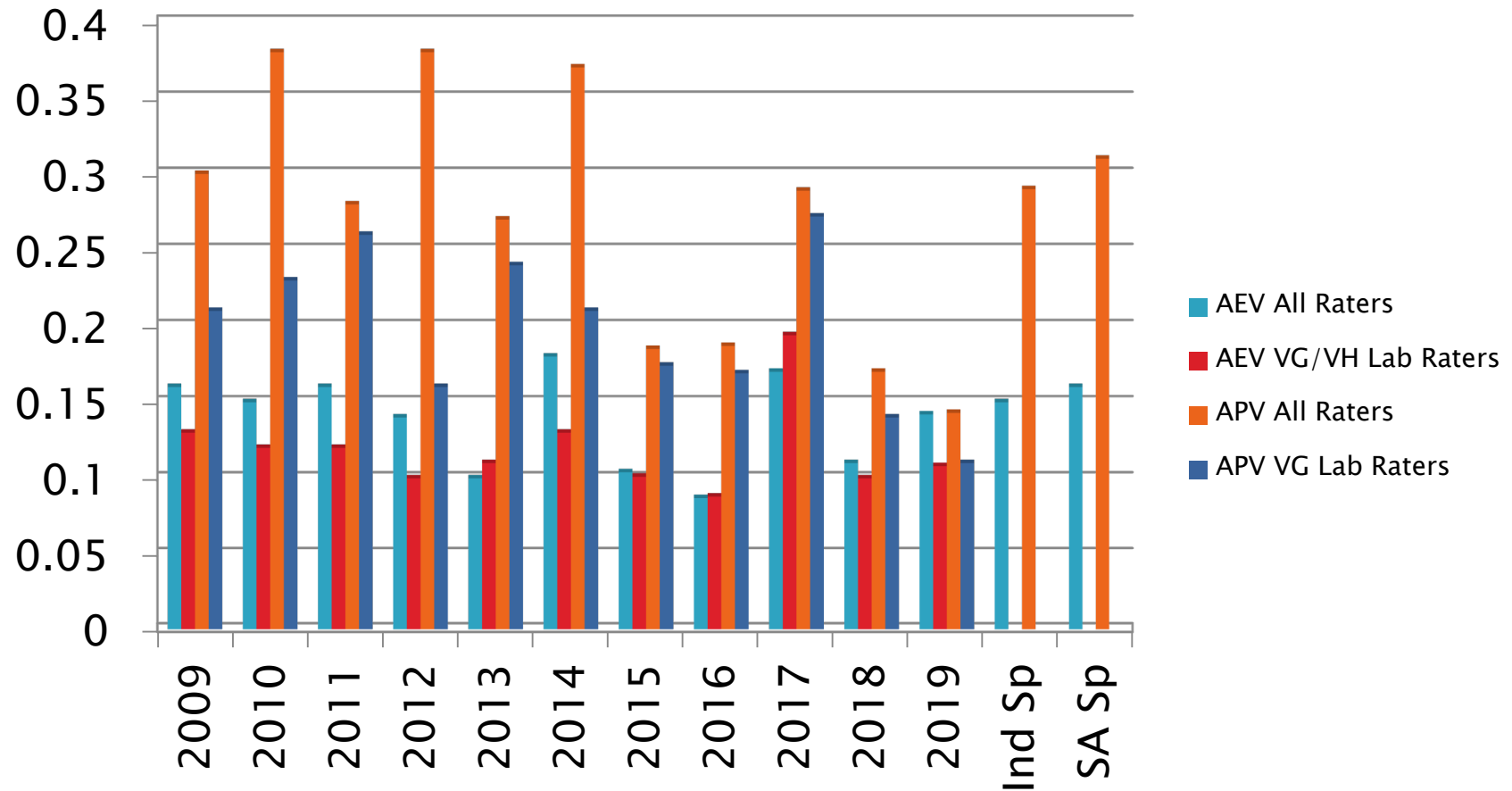
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Rating Workshop Data

- ▶ Summary of Precision Data From Light Duty Rating workshops:
 - VH Average Piston and Average Engine Varnish.
 - IIIH WPD

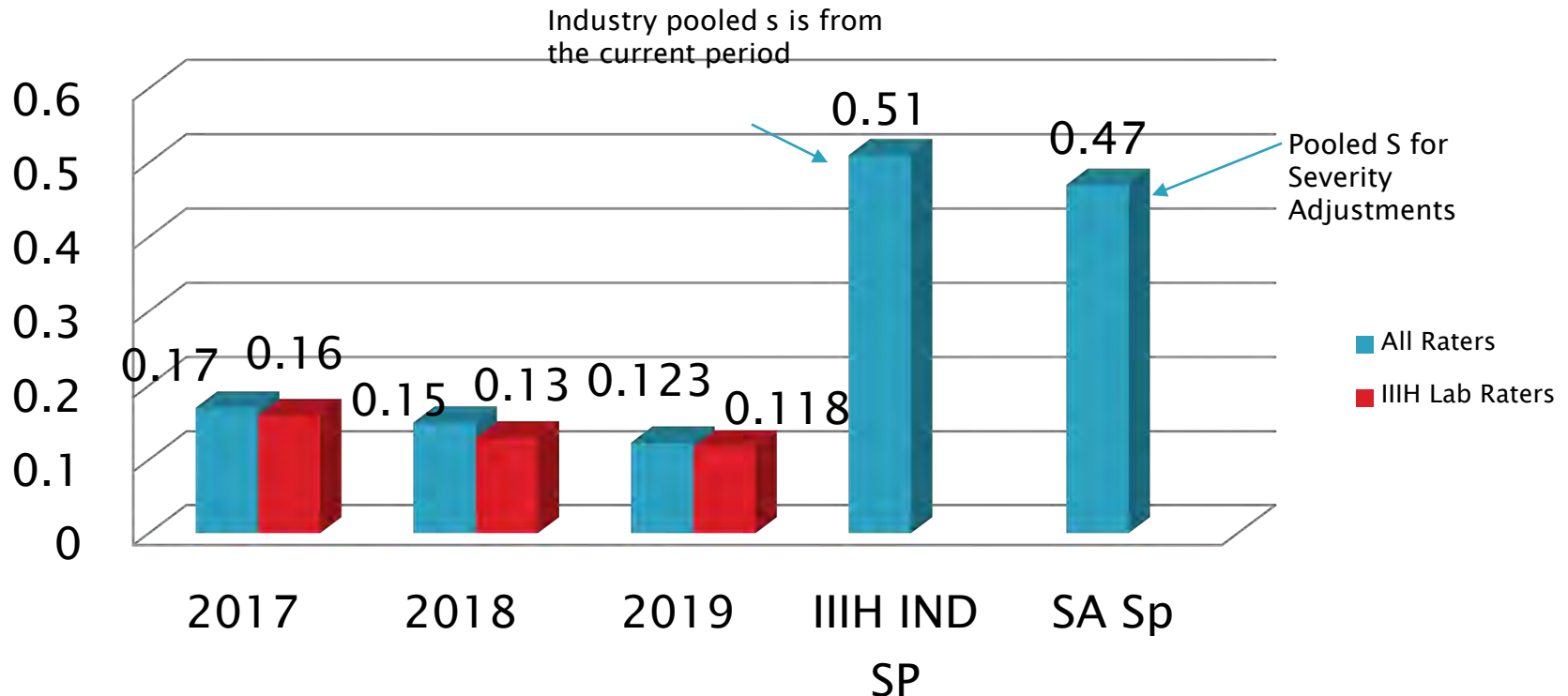
Sequence VG/VH Precision-Rating Workshop Data

Workshop Data for VG/VH Varnish



Sequence IIH Precision – Rating Workshop Data

Comparison of Workshop Pooled Standard Deviations with Industry Pooled Standard Deviations



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Miscellaneous Information

- ▶ Available on TMC Website:
 - Live Reference Test Data Bases
 - Surveillance Panel Meeting Minutes
 - Test Area Alarm Logs
 - Complete Test Area Timelines
 - LTMS Manual

- ▶ www.astmtmc.cmu.edu

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