Test Monitoring Center

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ASTM D02.B1 Semiannual Report Passenger Car Reference Oil Testing

April 2018

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Passenger Car Engine Oil Testing Executive Summary

- Seq. IIIH
  - Panel agreed to allow calibration to begin on Batch 5 pistons, 9 stands calibrated using batch 5 pistons.
- Seq. VIE
  - LTMS changes and Industry Correction factor adopted for reference tests completing on or after 3/14/18.

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Passenger Car Engine Oil Testing Executive Summary

- Seq. X (formerly Chain Wear)
  - Monitoring of the Test began in November with approval of 2016 BC grade pistons.
- BOI-VGRA
  - BOI-VGRA Testing is complete for Sequence IX and is underway for IIIH, VH, VIE, VIF and X

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Calibrated Labs and Stands*

Test	Labs	Stands
IIIF	2	3
IIIG/A/B	3	4
IIIH/A/B	5	14
IVA	2	3
VG	1	2

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*As of 3/31/2018

Calibrated Labs and Stands*

Test	Labs	Stands
VH	5	10
VIE	4	15
VIF	2	3
VIII	3	4
IX	3	5
X	4	9

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*As of 3/31/2018

Sequence IIIF

- April 2018

Sequence IIIF Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	4
Total		**4**

Sequence IIIF Test Severity

- APV
  - In severity action alarm, mild
  - Long-term mild trend continuing (Since October 2006)
- Hours to 275% Vis Increase
  - In control
- WPD
  - In control
- PV60
  - In severity action alarm (severe)

SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

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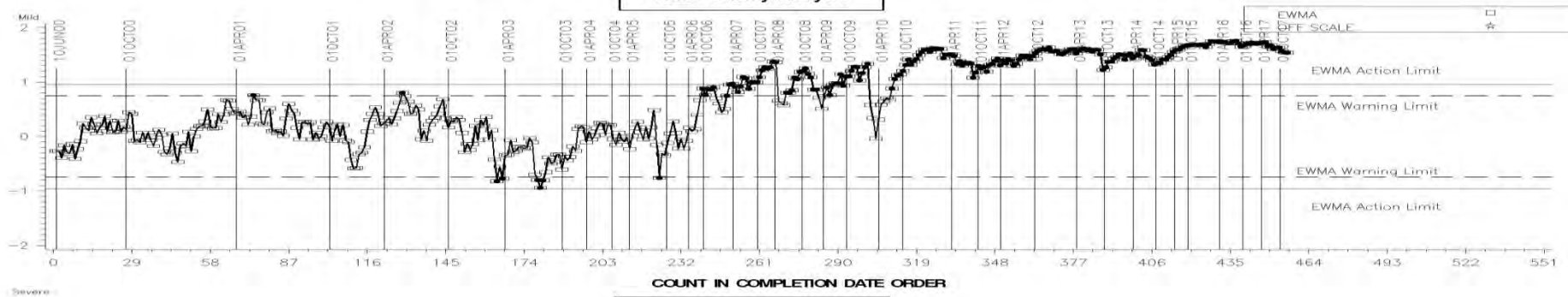
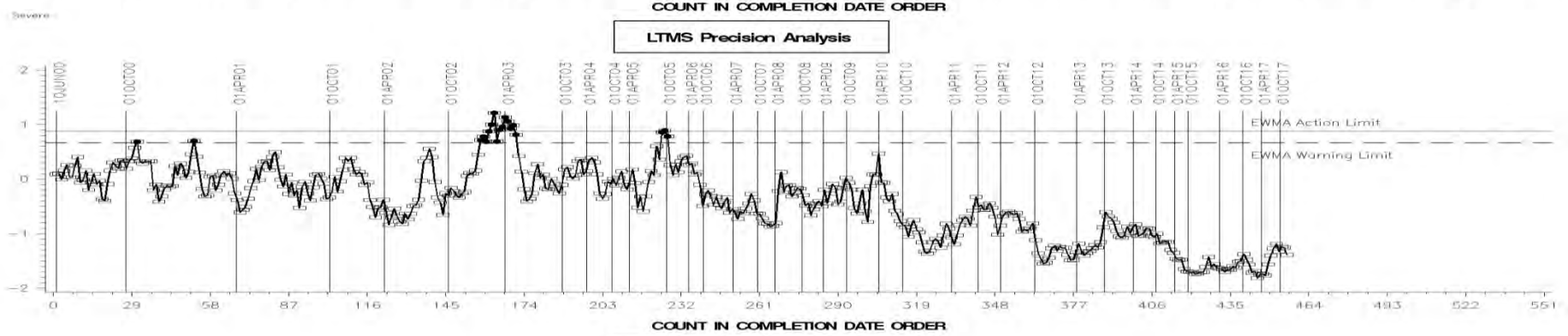
AVERAGE PISTON SKIRT VARNISH FINAL ORIG UNIT RES

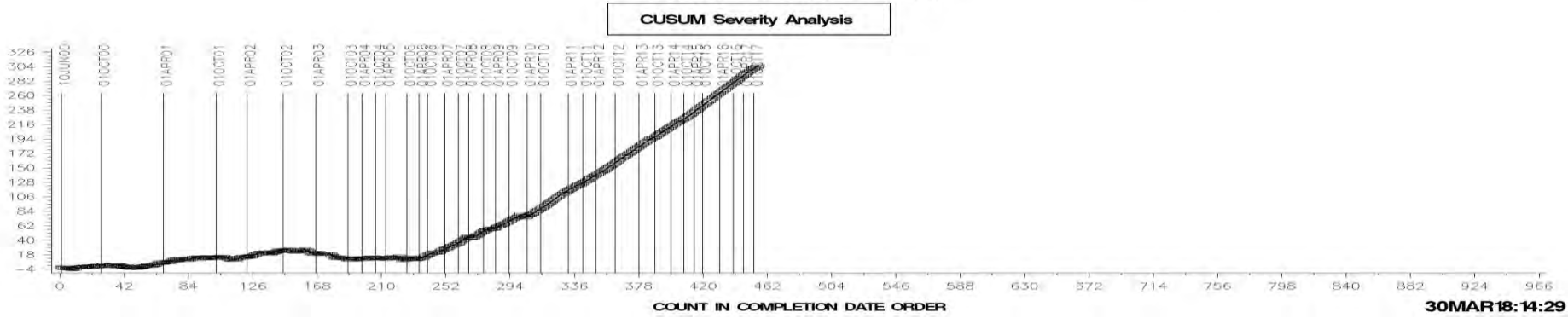
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

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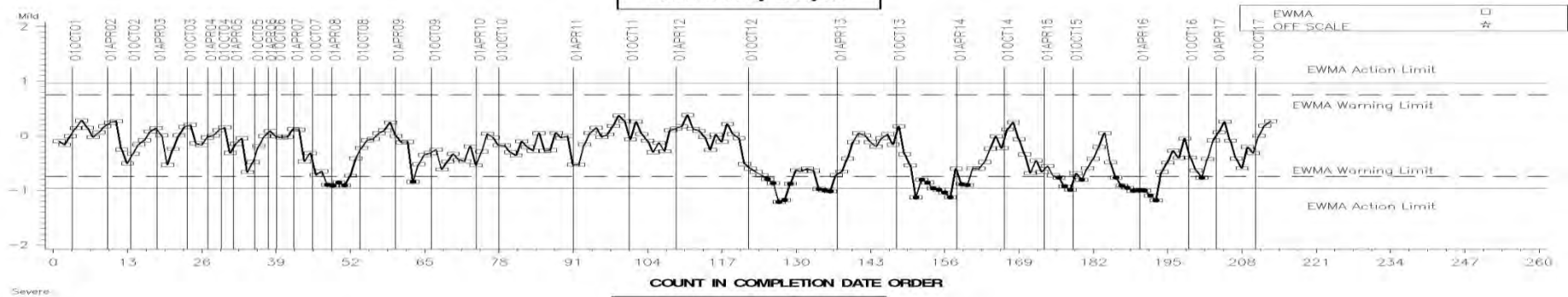
HOURS FINAL ORIG RES (REFERENCE TESTS ONLY)

LTMS Severity Analysis



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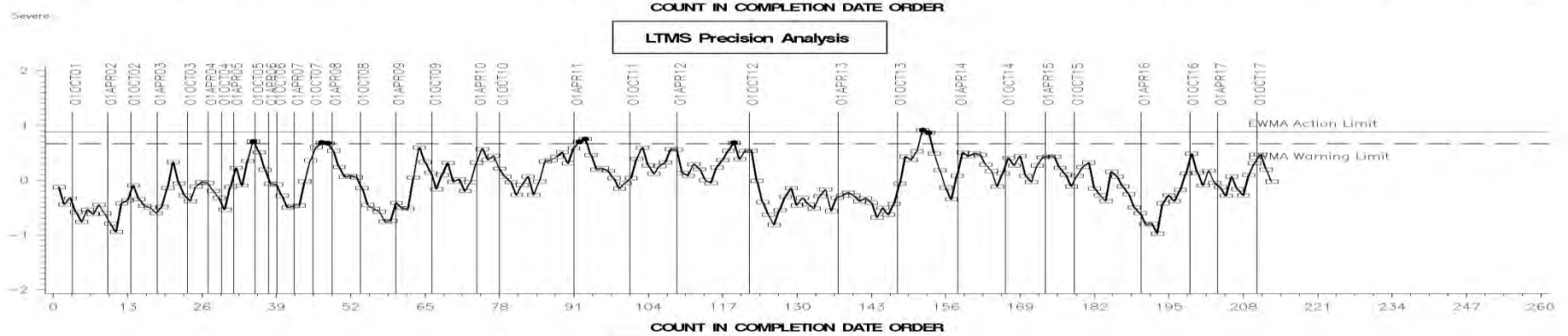
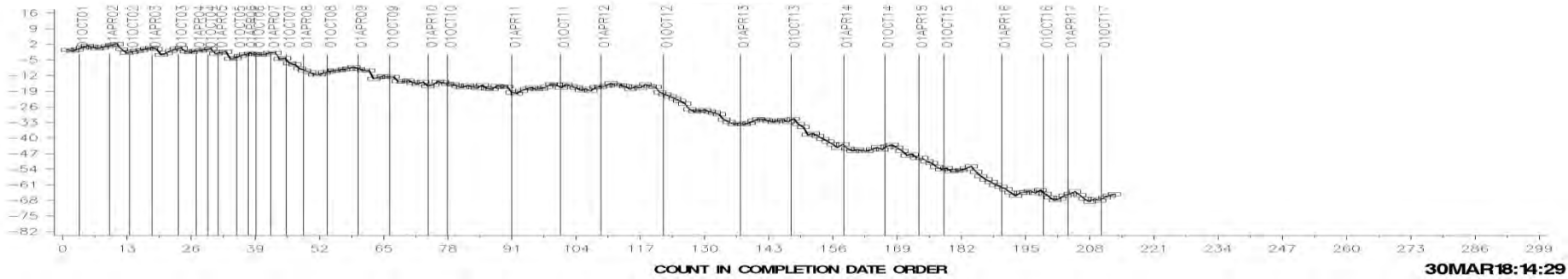


CUSUM Severity Analysis



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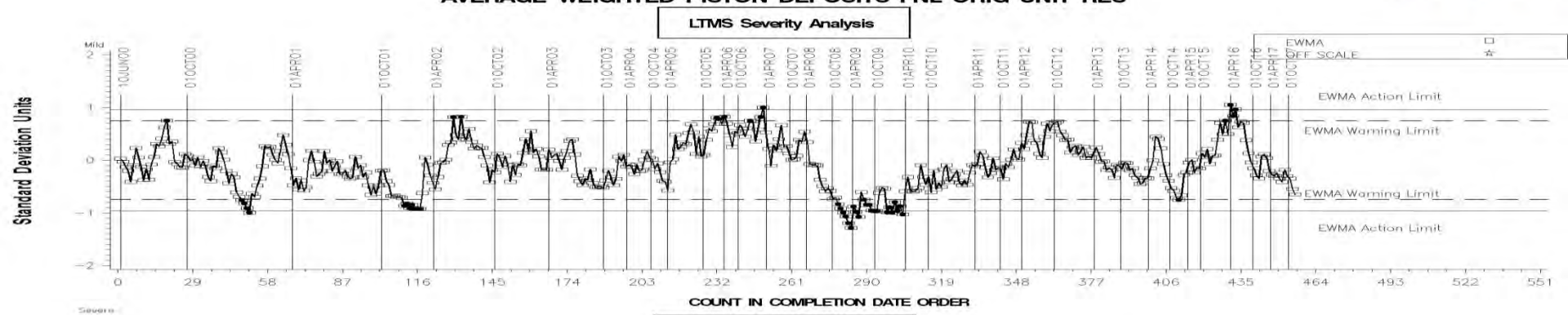
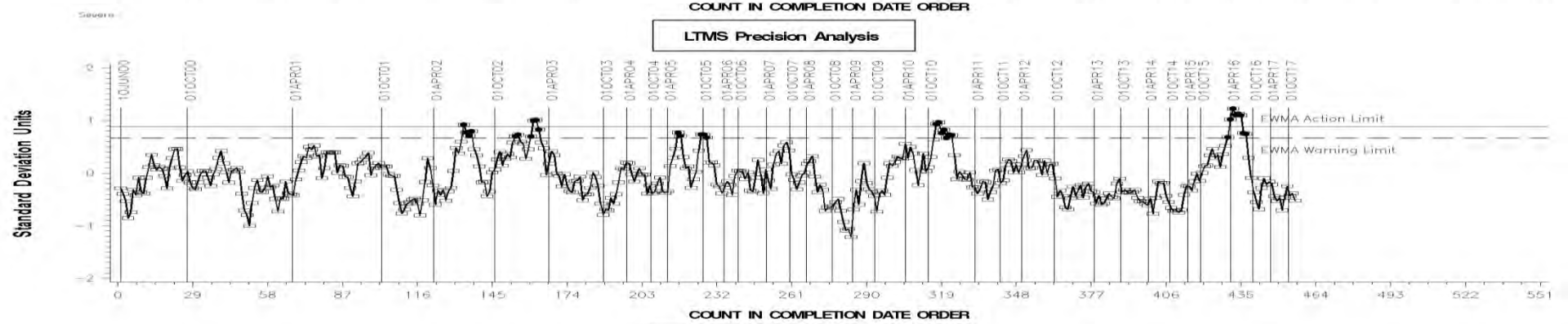
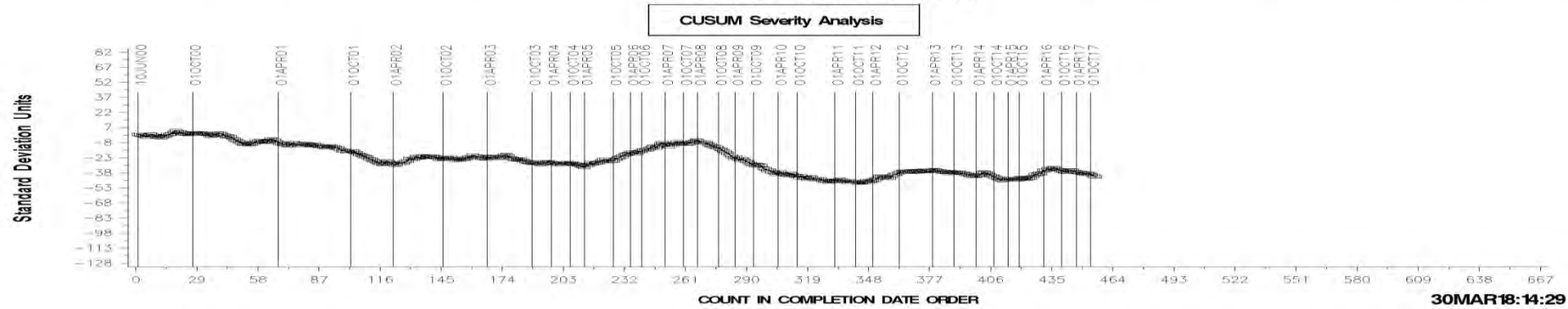
SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

AVERAGE WEIGHTED PISTON DEPOSITS FNL ORIG UNIT RES







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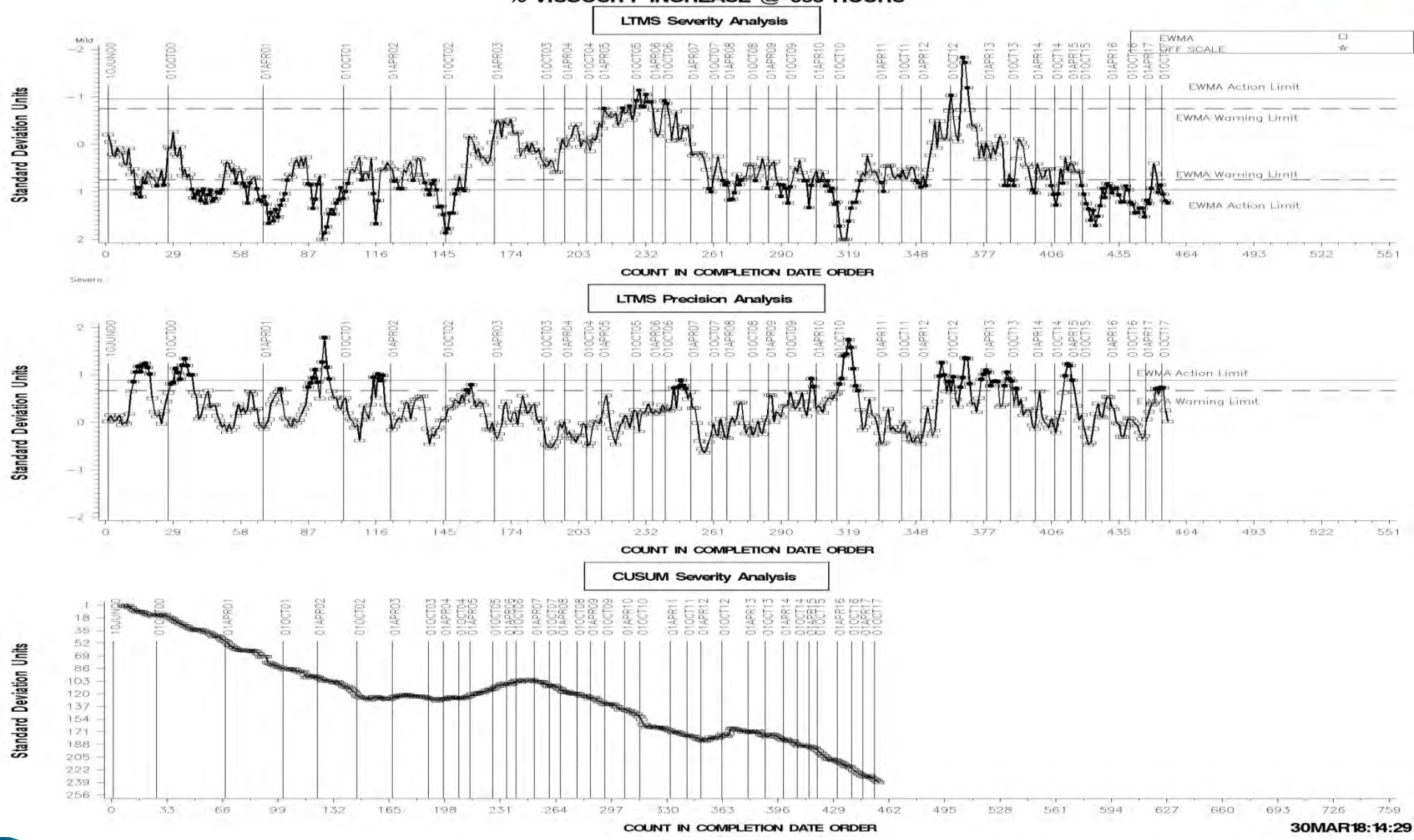
SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

% VISCOSITY INCREASE @ 060 HOURS



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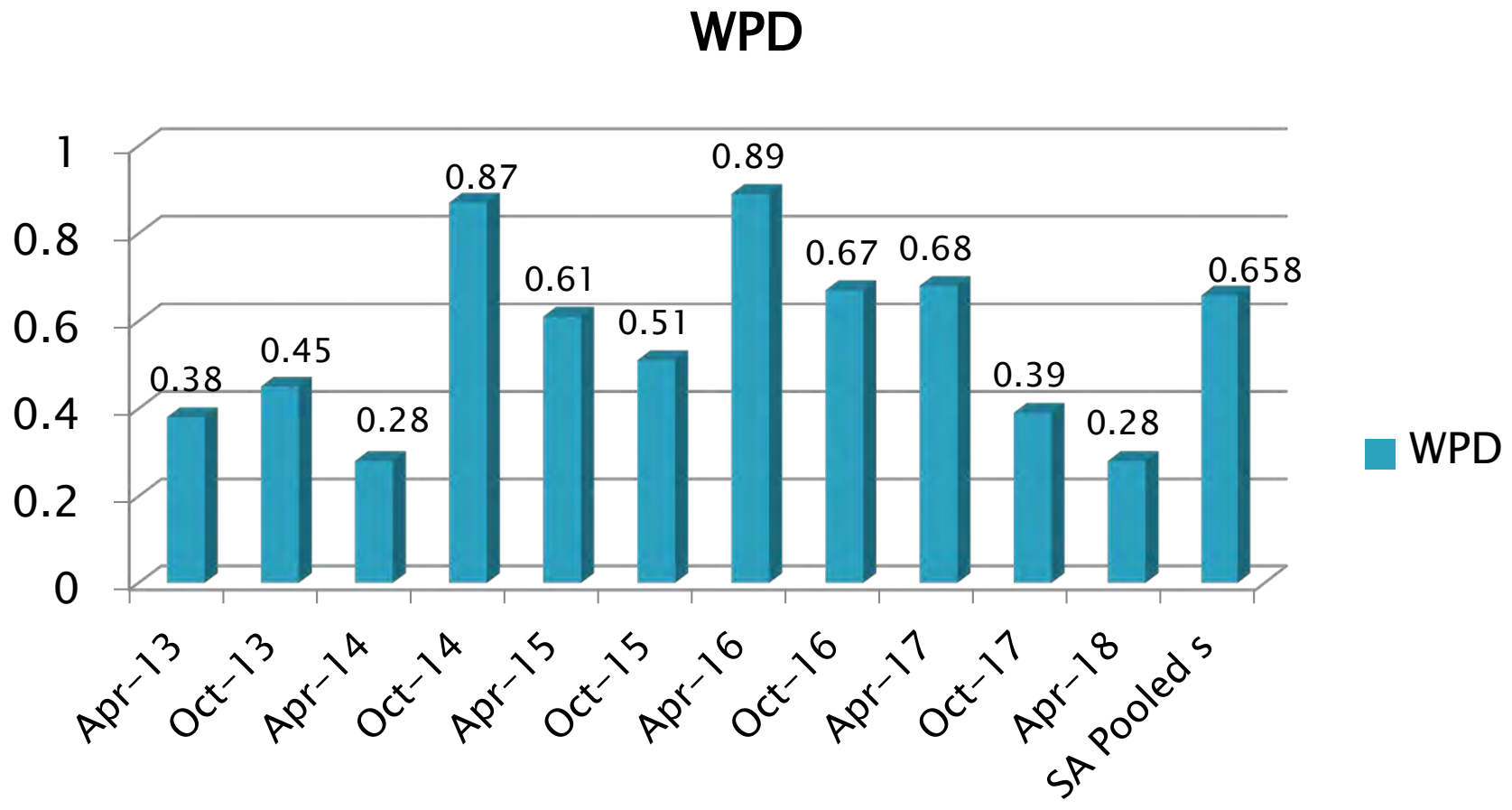
IIIF Precision Estimates



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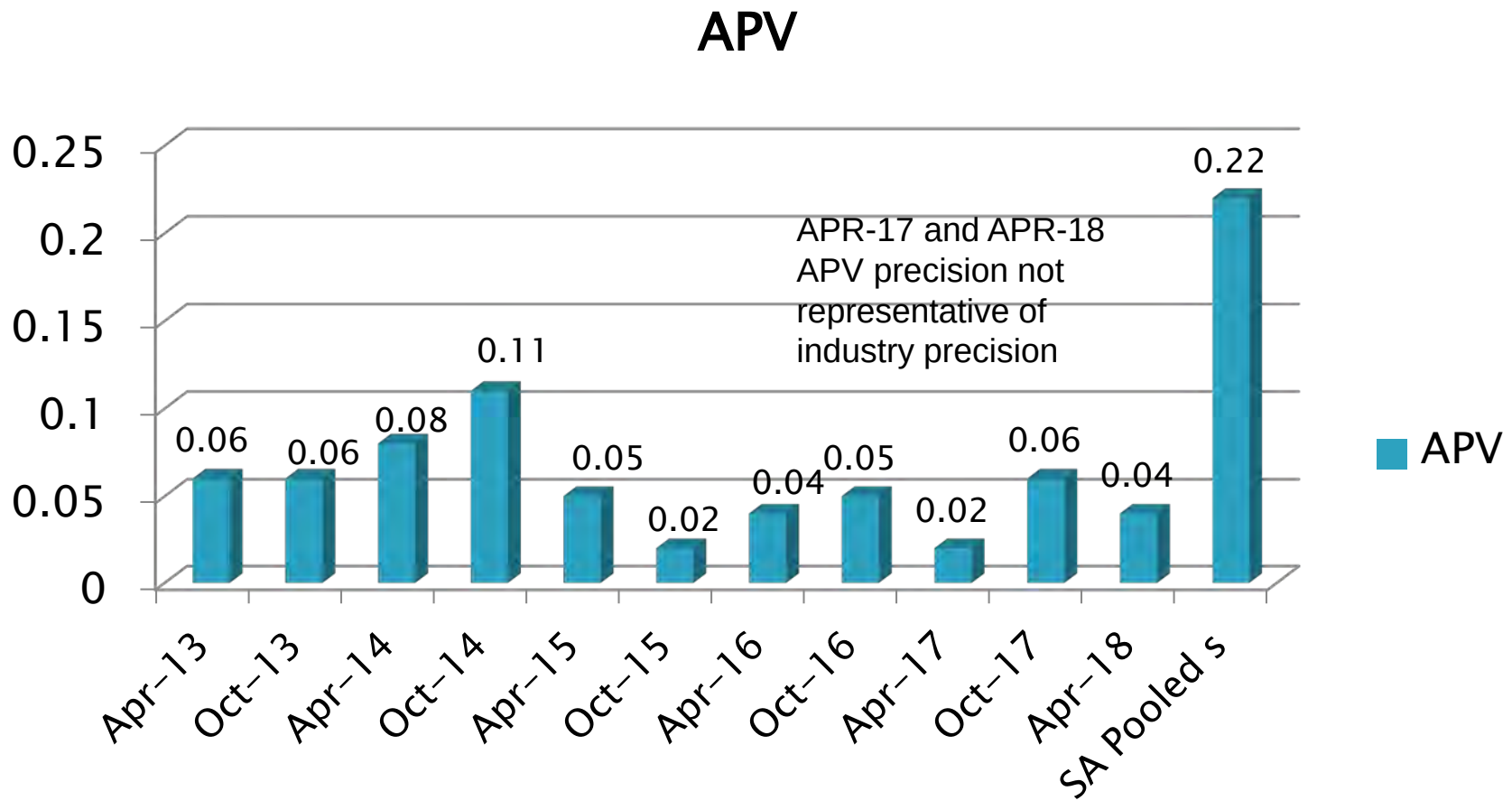

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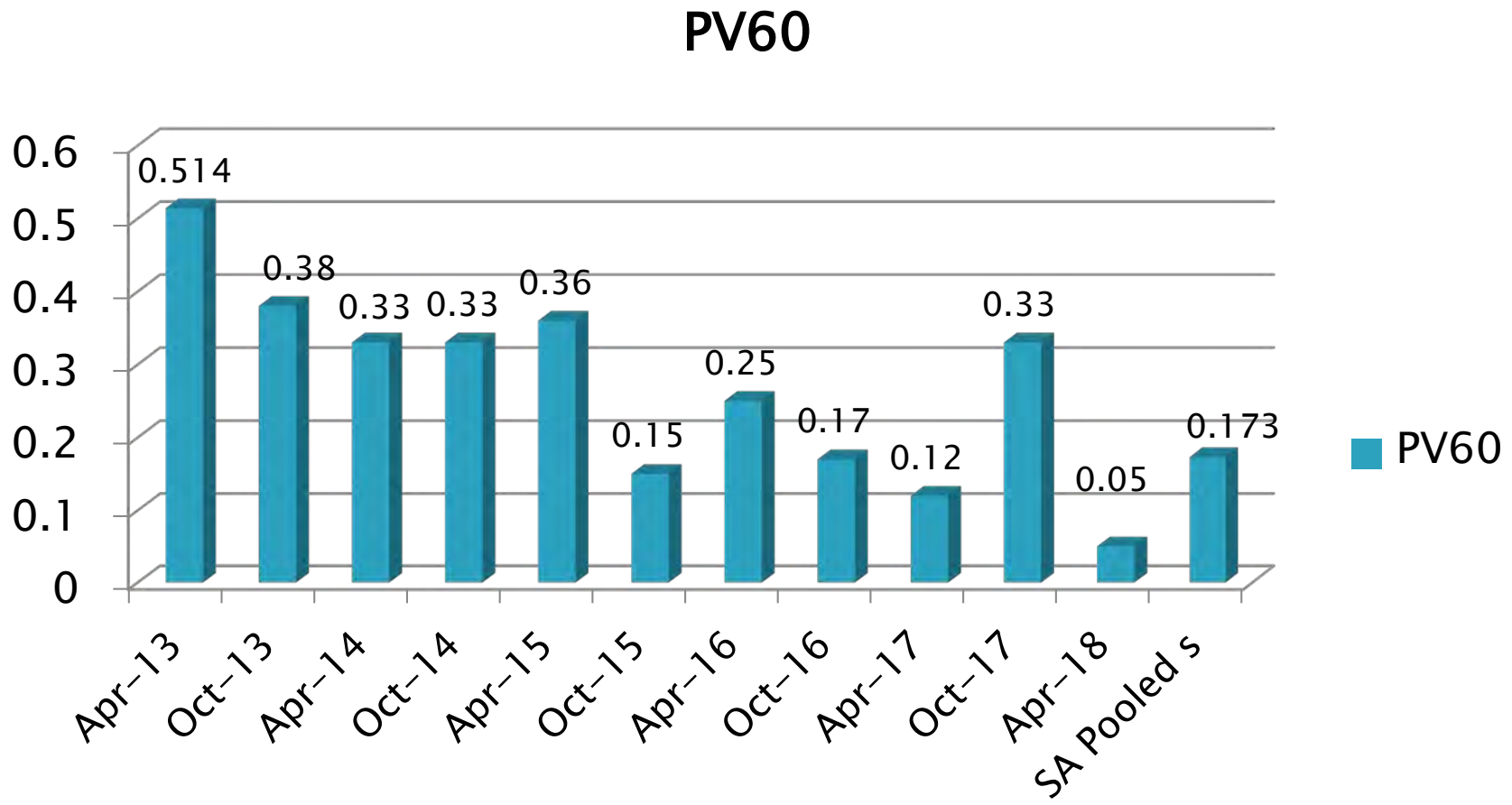

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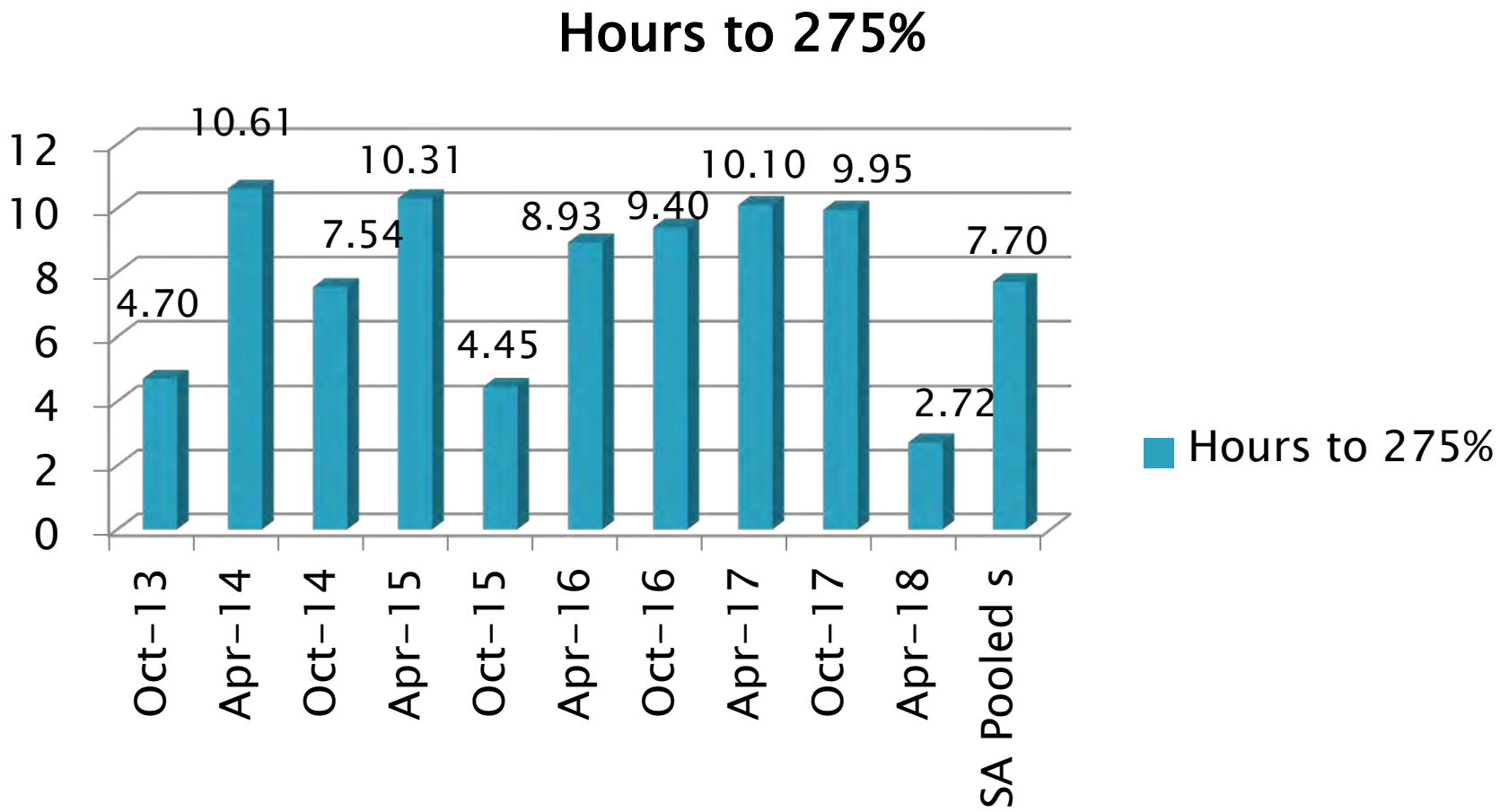

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Sequence IIIG/A/B

- April 2018

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Sequence IIIG Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	4
Statistically Unacceptable Calibration Test	OC	1
Total		**5**

Sequence IIIG – Failed Tests

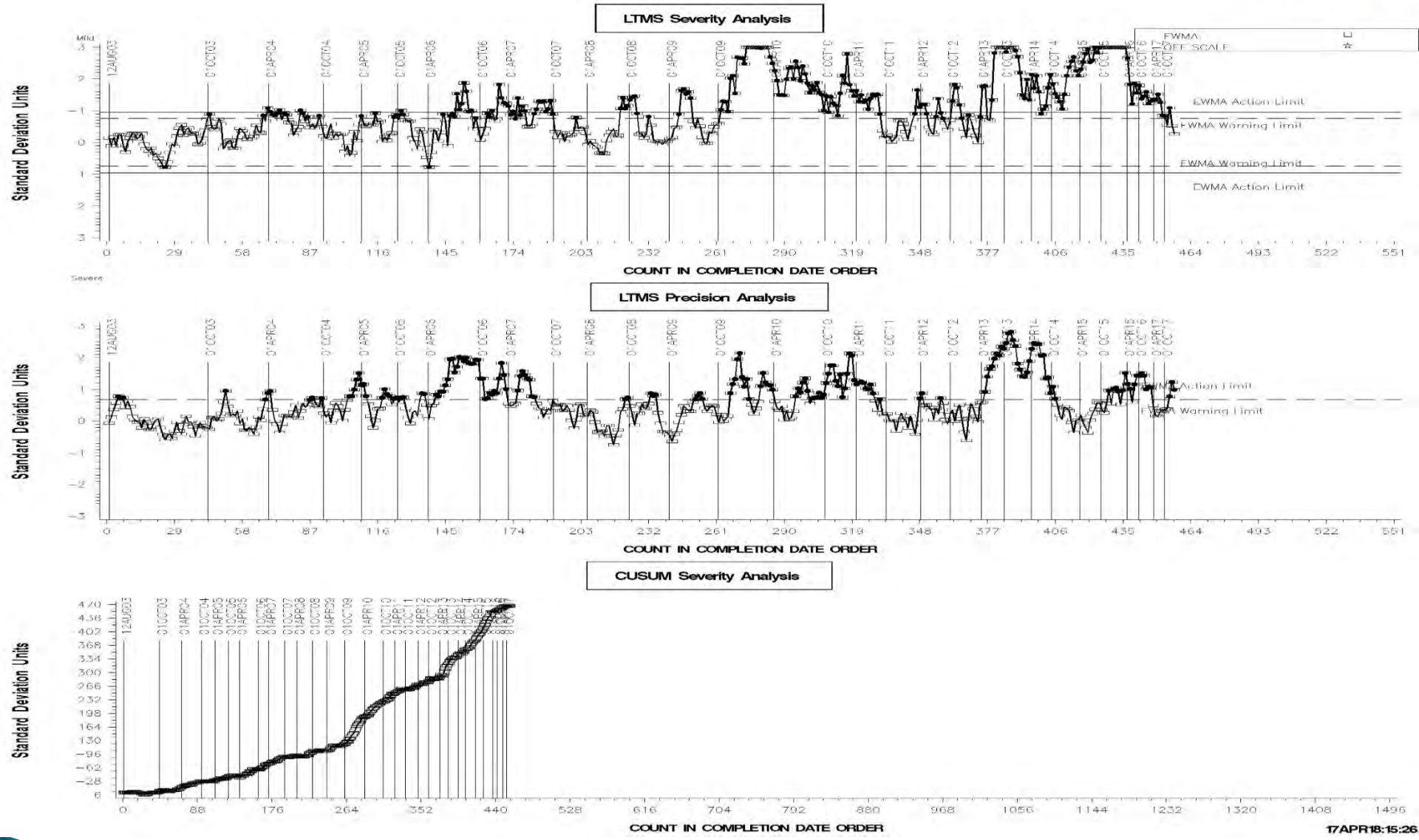
Test Status	#
Severe PVIS	1
Totals	**1**

Sequence IIIG Test Severity

- ACLW in precision warning alarm
  - Long-term mild trend
- PVIS
  - Precision action alarm
  - Severity action alarm (severe)
- WPD in severity warning alarm
  - Long-term severe trend continuing
- MRV is in severity action alarm (severe)
  - Long-term severe trend continuing
- PHOS in severe action alarm

SEQUENCE IIIG INDUSTRY OPERATIONALLY VALID DATA

AVERAGE CAM + LIFTER WEAR



SEQUENCE IIIG INDUSTRY OPERATIONALLY VALID DATA

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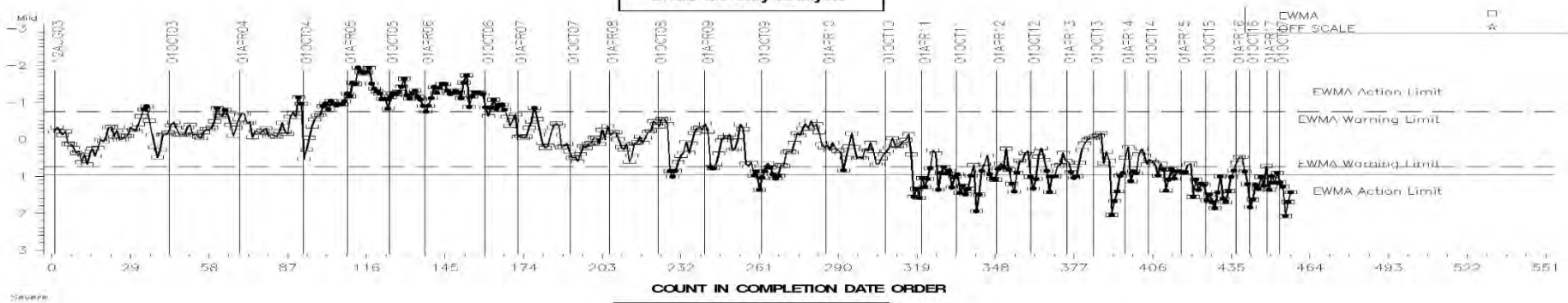
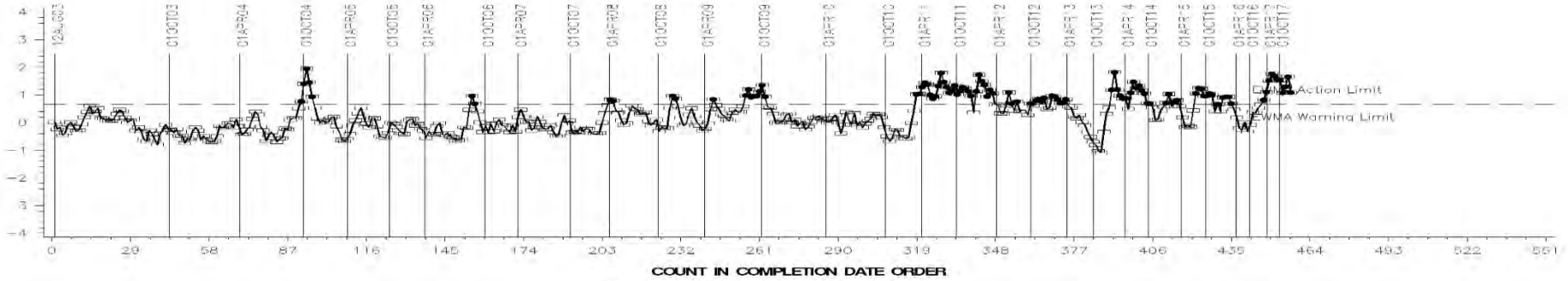
VISCOSITY INCREASE

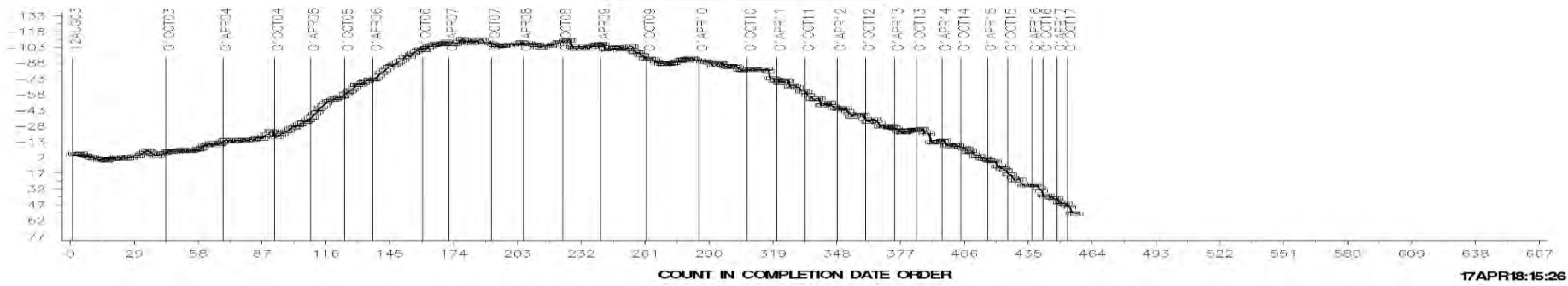
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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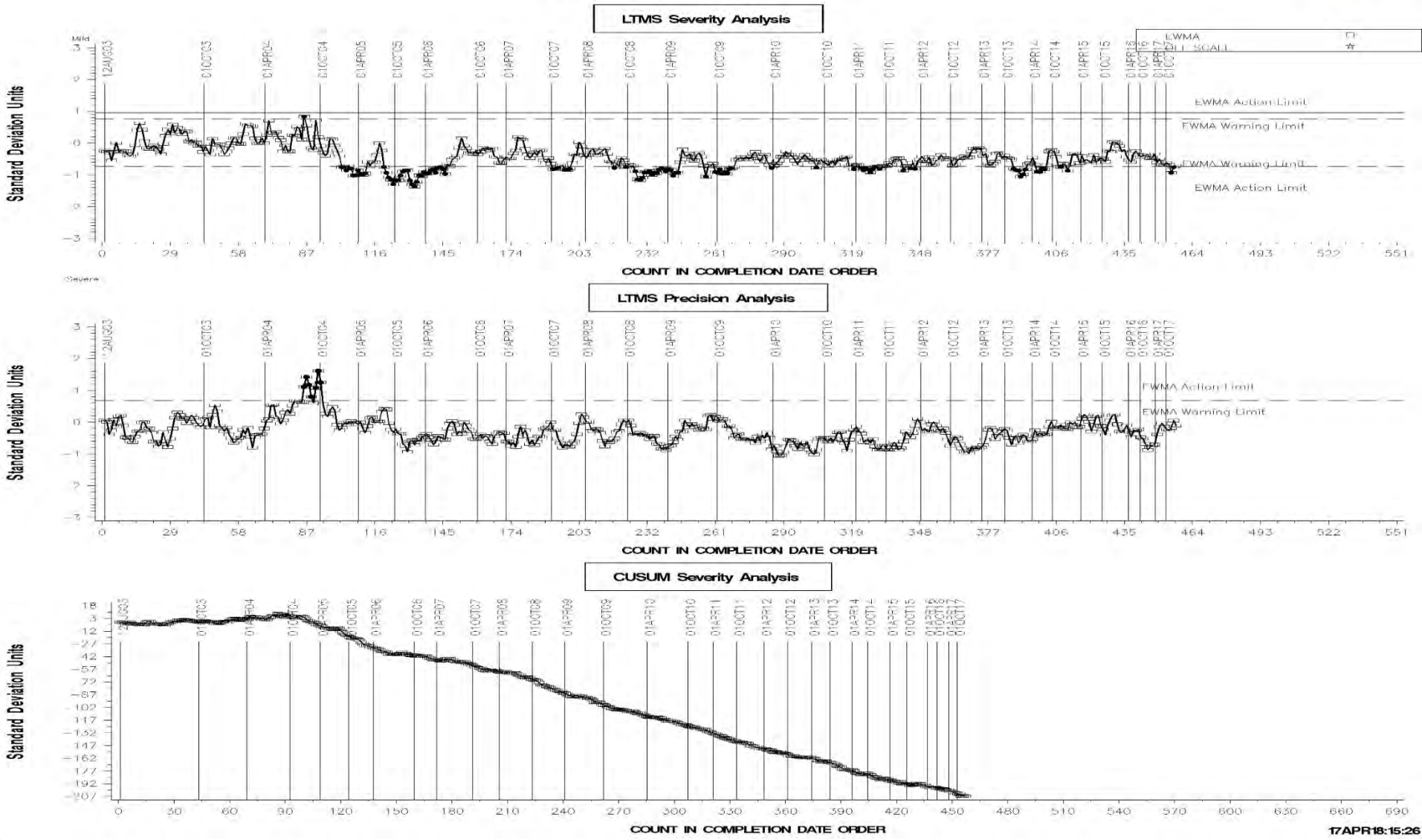
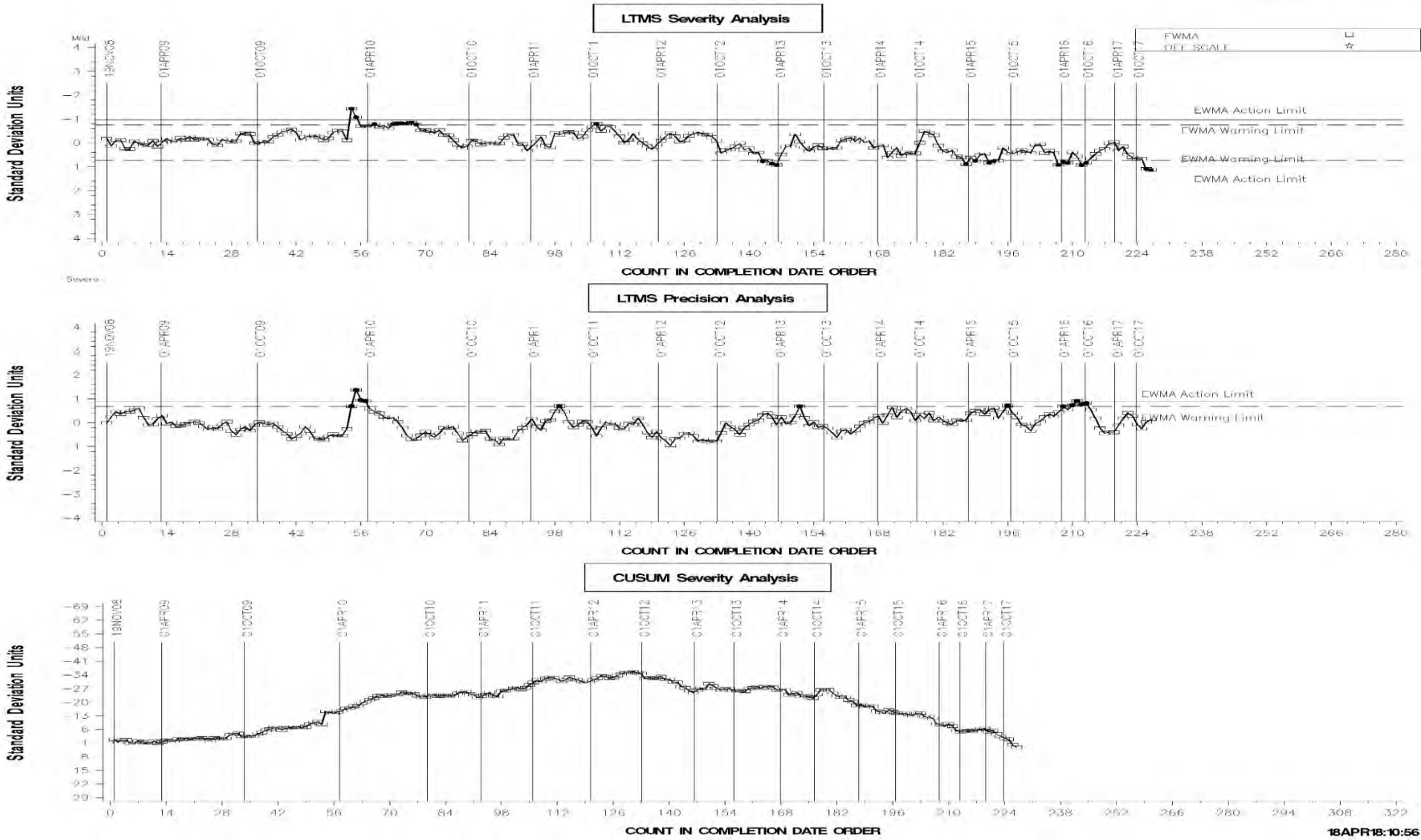
SEQUENCE IIIG INDUSTRY OPERATIONALLY VALID DATA

AVERAGE WEIGHTED PISTON DEPOSITS



SEQUENCE IIIGB INDUSTRY OPERATIONALLY VALID DATA

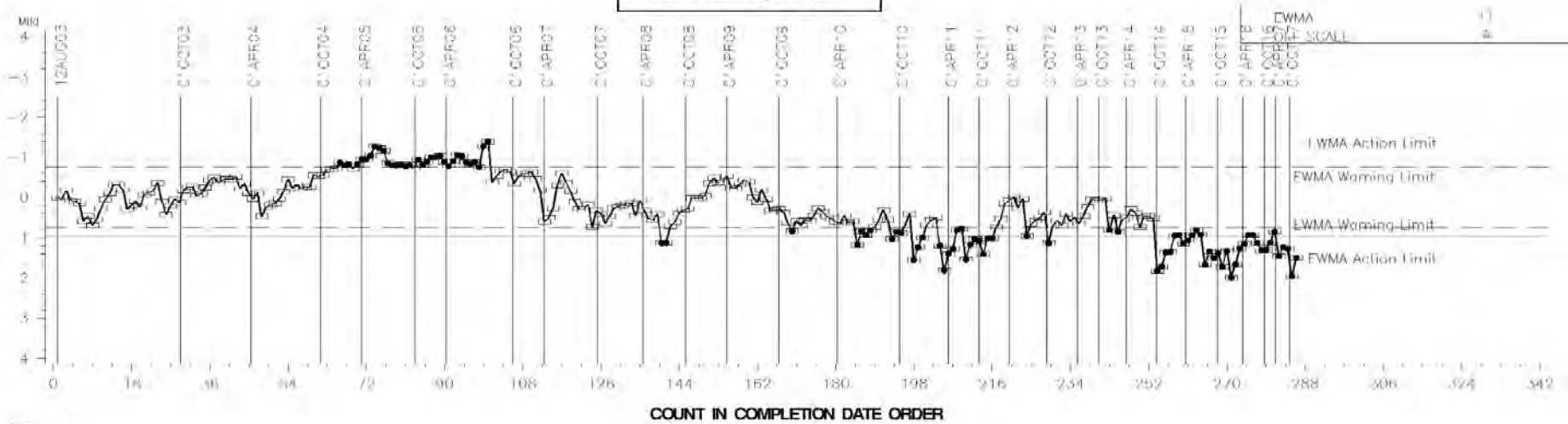
PHOS RETENTION



SEQUENCE IIIGA INDUSTRY OPERATIONALLY VALID DATA

MRV VISCOSITY RESULT

LTMS Severity Analysis



CUSUM Severity Analysis

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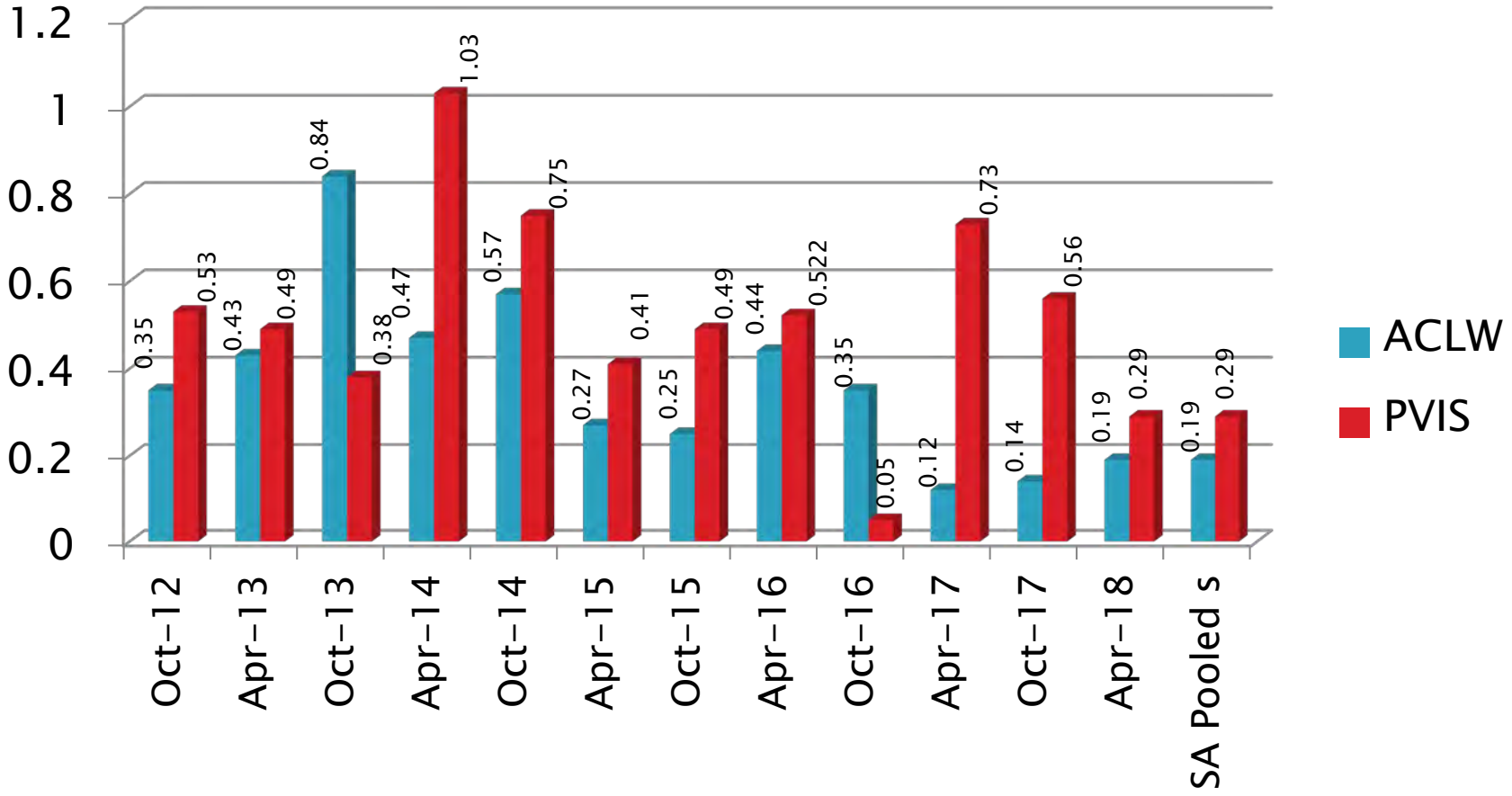
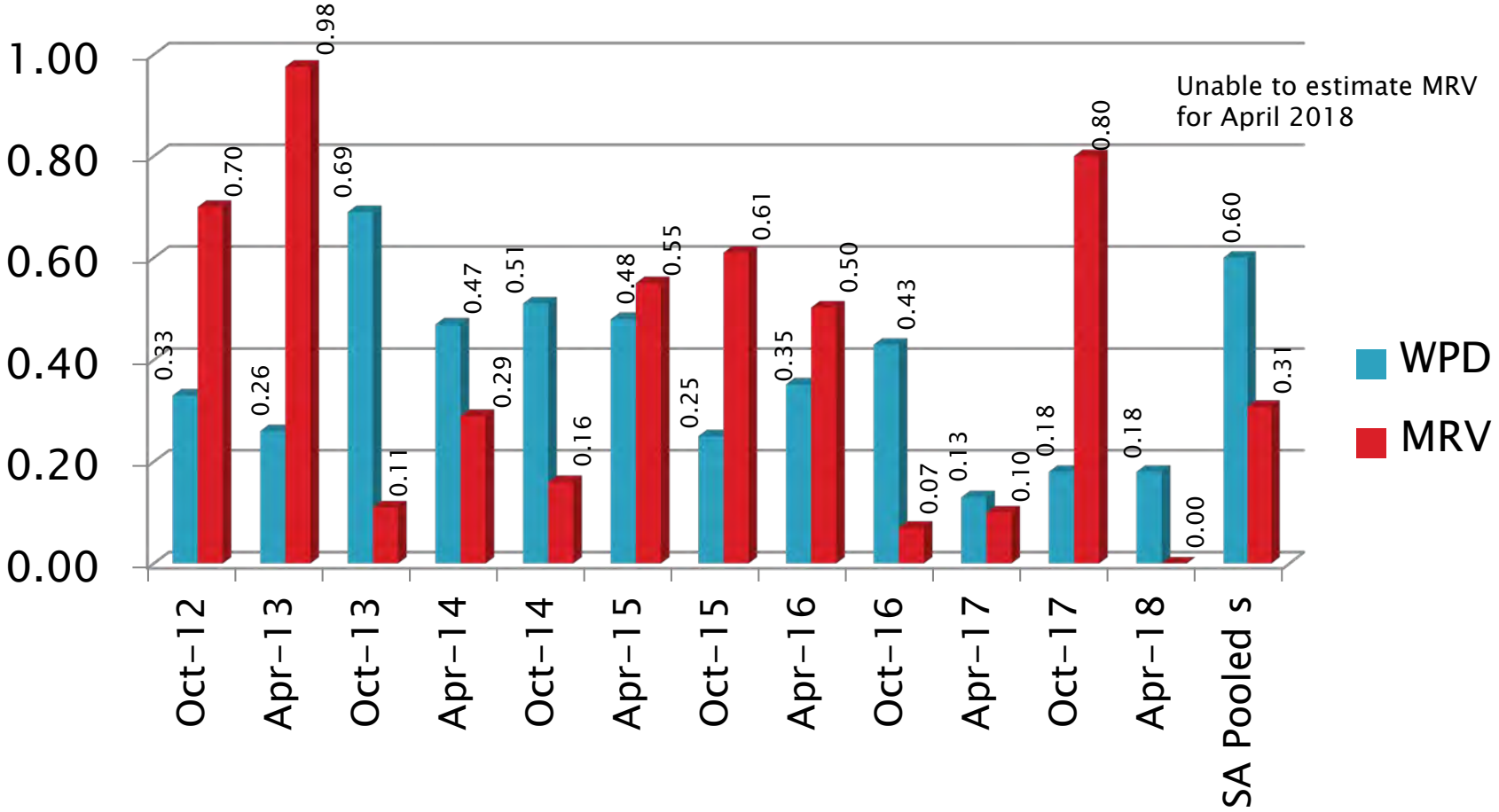
IIIG Precision Estimates



IIIG Precision Estimates



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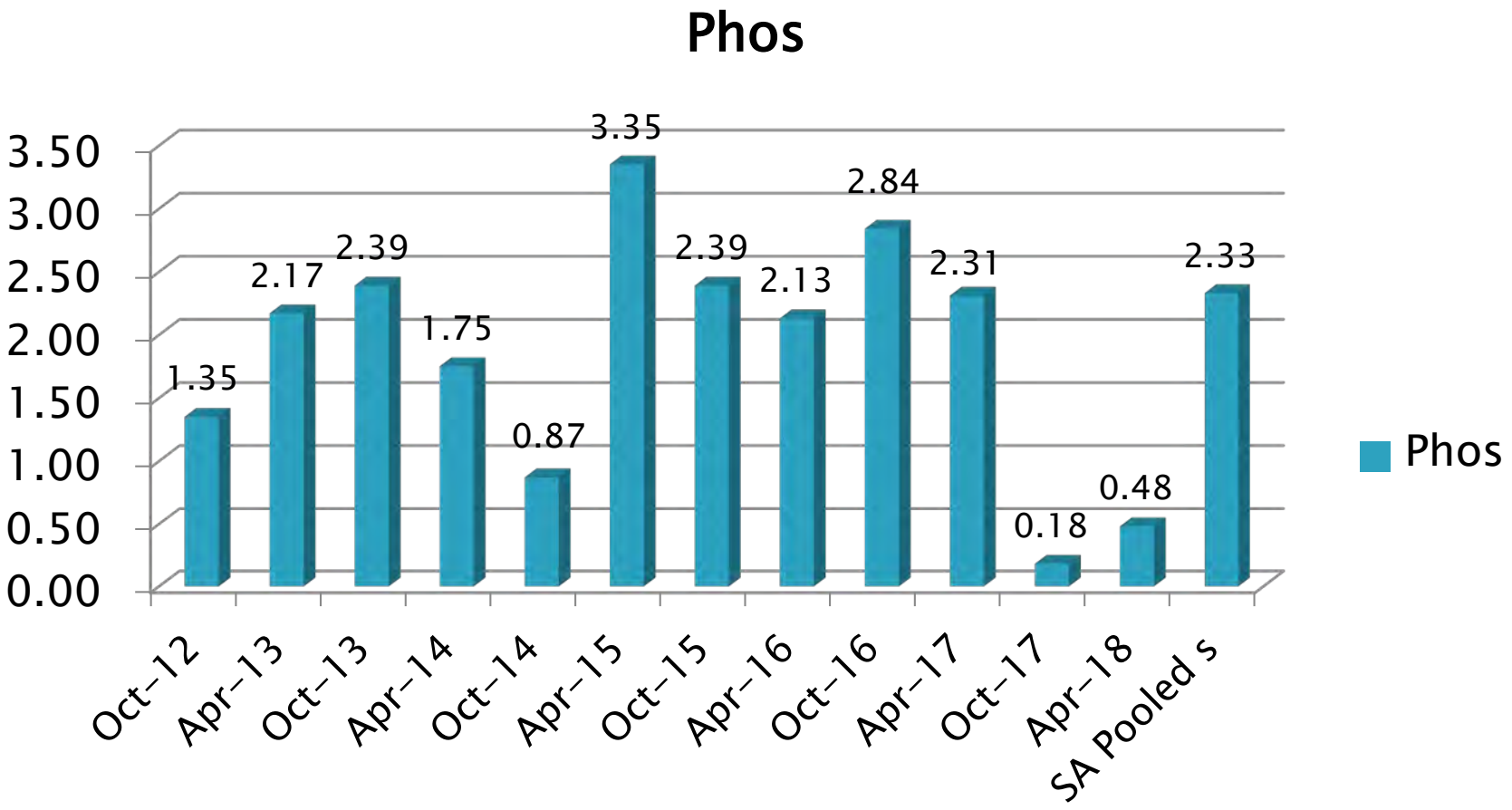

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Sequence IIIH/A/B

- April 2018

Sequence IIIH Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	16
Statistically Unacceptable Calibration Test	OC	8
Operationally Invalid Calibration Test, Lab Judgement	LC	1
Operationally Invalid Calibration Test, Lab & TMC Judgement	RC	1
Acceptable Industry Support Test (BC5 Piston)	AI	1
Donated Test (BC5 Piston)	AG	1
Aborted Calibration Test	XC	1
BOI-VGRA Matrix Tests	NI	9
Total		**38**

Sequence IIIH – Failed Tests

Test Status	#
Level 3 Ei Alarm PVIS, MRV, PHOS	1
Level 3 Ei Alarm PVIS, MRV	7
Totals	**8**

Sequence IIIH – Lost Tests*

Test Status	Cause	#
Invalid	Load Calibration Error	1
Invalid	Coolant Flow measurement device malfunctioning	1
Aborted	High oil consumption	1
Totals		3

*Invalid and aborted tests

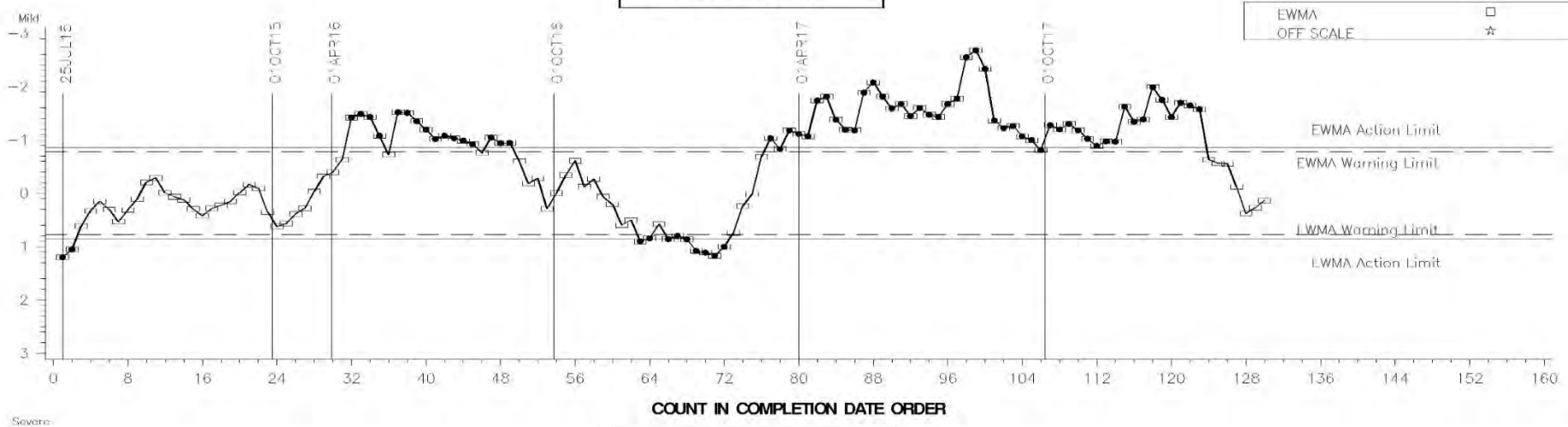
Sequence IIIH Test Severity

- All parameters are in control

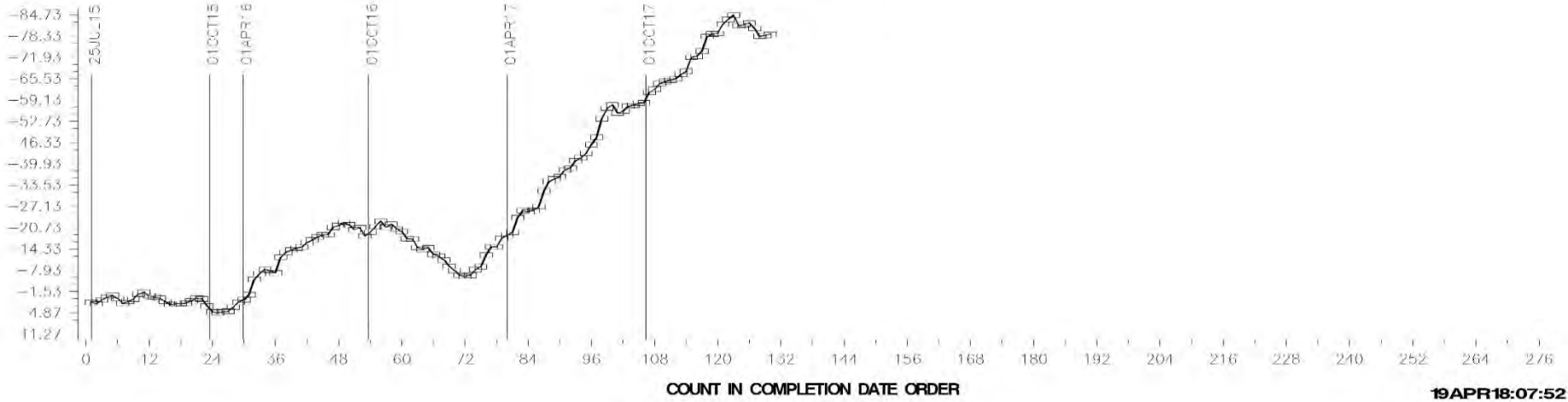
SEQUENCE IIIH INDUSTRY OPERATIONALLY VALID DATA

VISCOSITY INCREASE FINAL ORIG UNIT RES

LTMS Severity Analysis



CUSUM Severity Analysis



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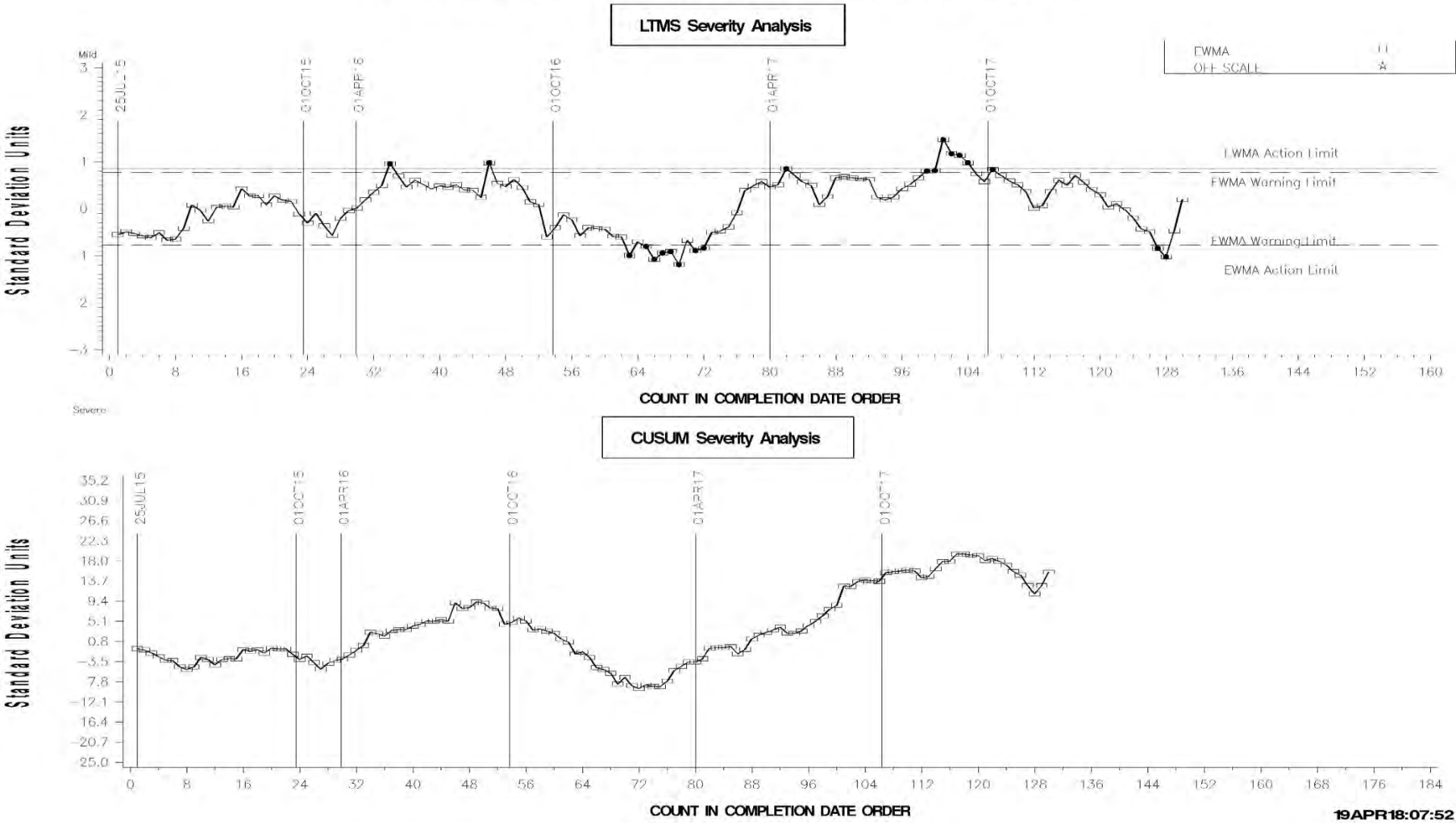
SEQUENCE IIIH INDUSTRY OPERATIONALLY VALID DATA

AVERAGE WEIGHTED PISTON DEPOSITS FNL ORIG U



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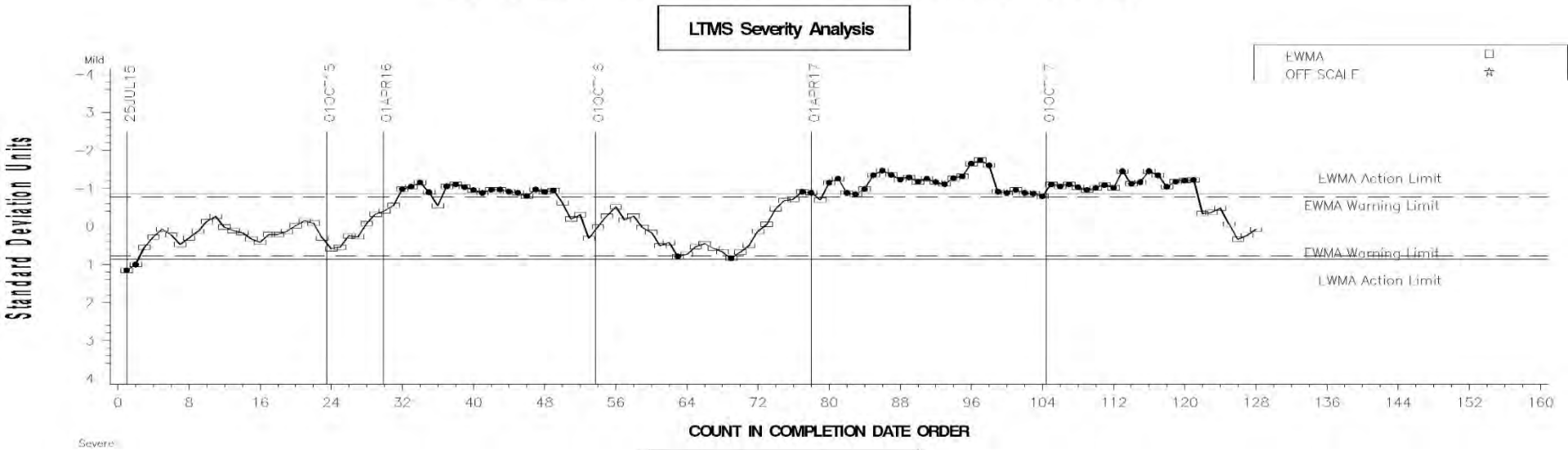
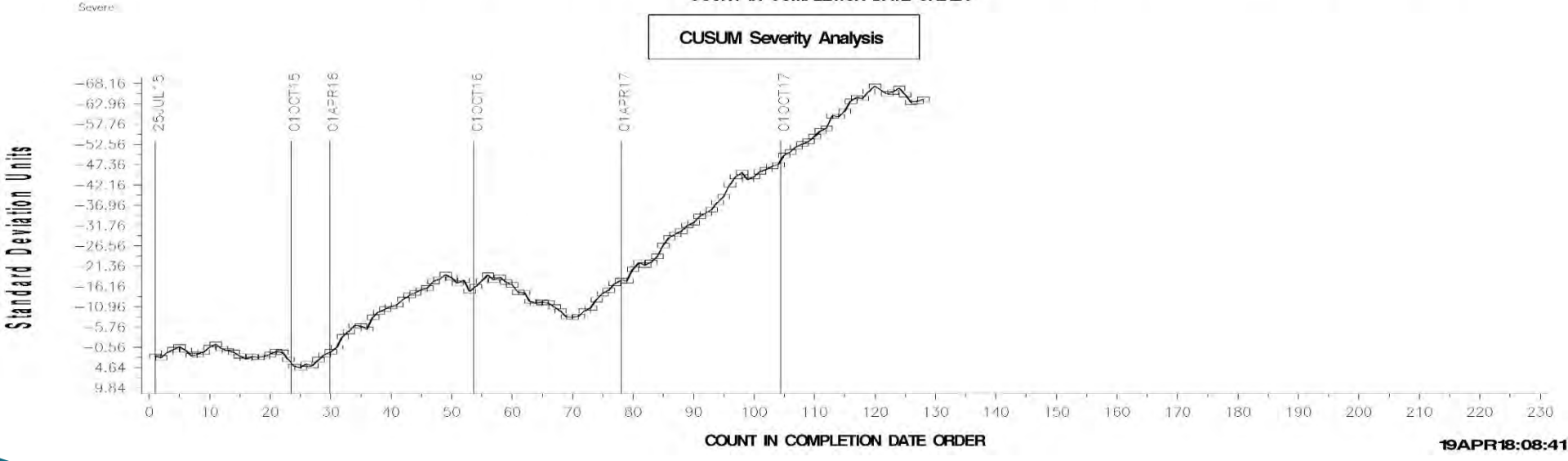
SEQUENCE IIIHA INDUSTRY OPERATIONALLY VALID DATA

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





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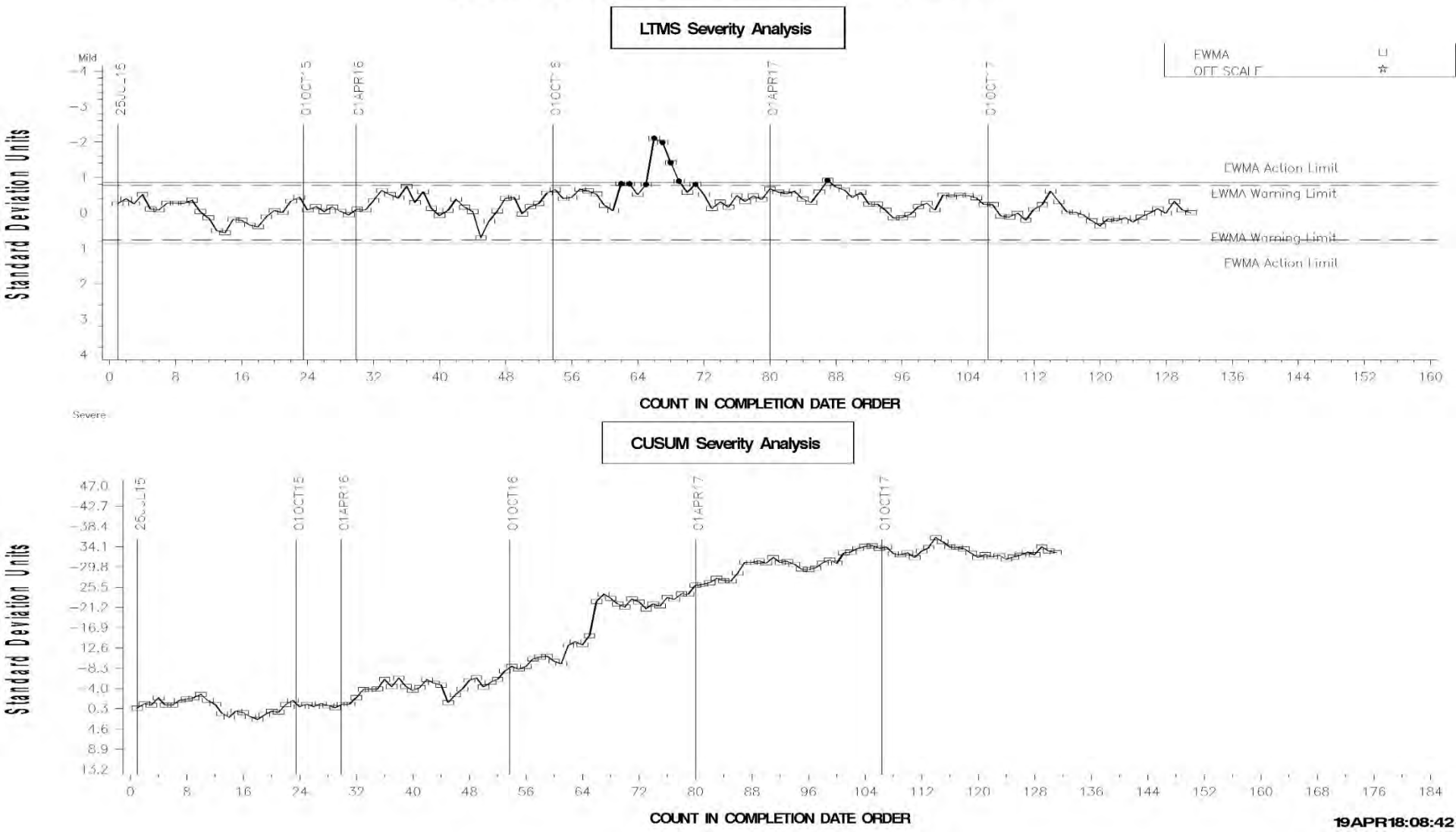
SEQUENCE IIIHB INDUSTRY OPERATIONALLY VALID DATA

PHOSPHORUS RETENTION, FINAL RESULT



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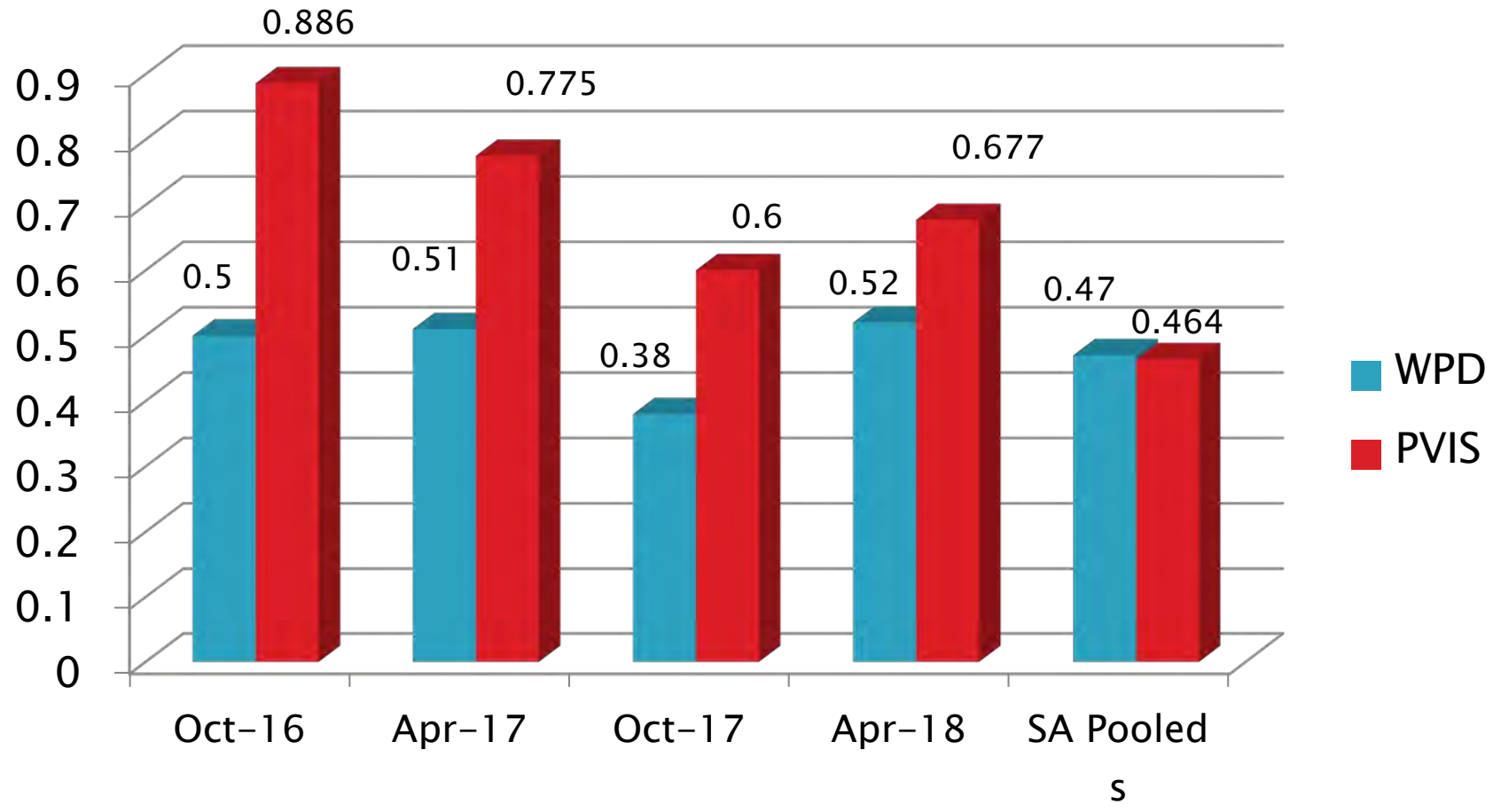
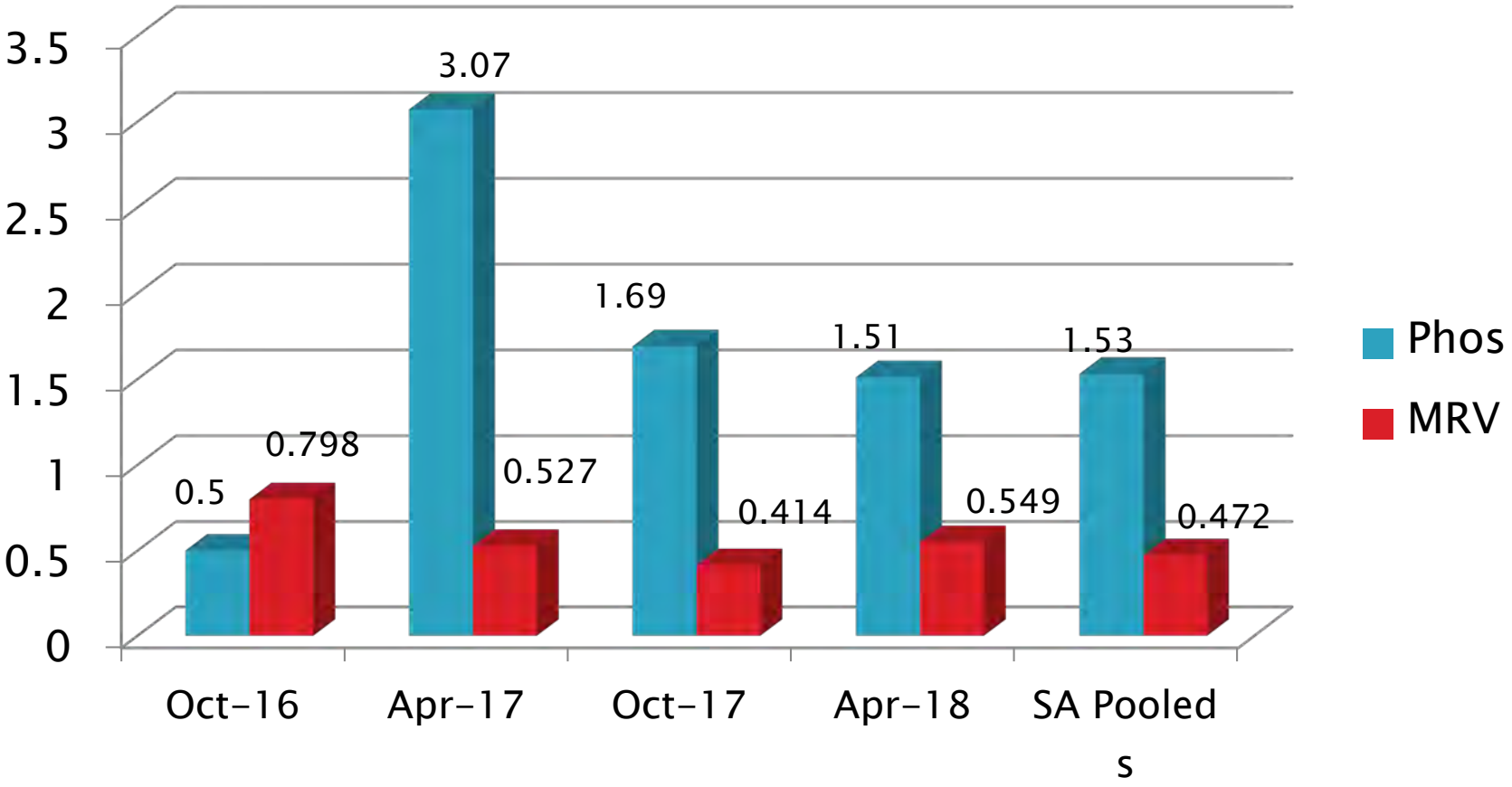
IIIH Precision Estimates



IIIHA/B Precision Estimates



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Sequence IVA

- April 2018

Sequence IVA Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	6
Operationally Invalid, Lab determination	LC	2
Total		**8**

Sequence IVA – Lost Tests*

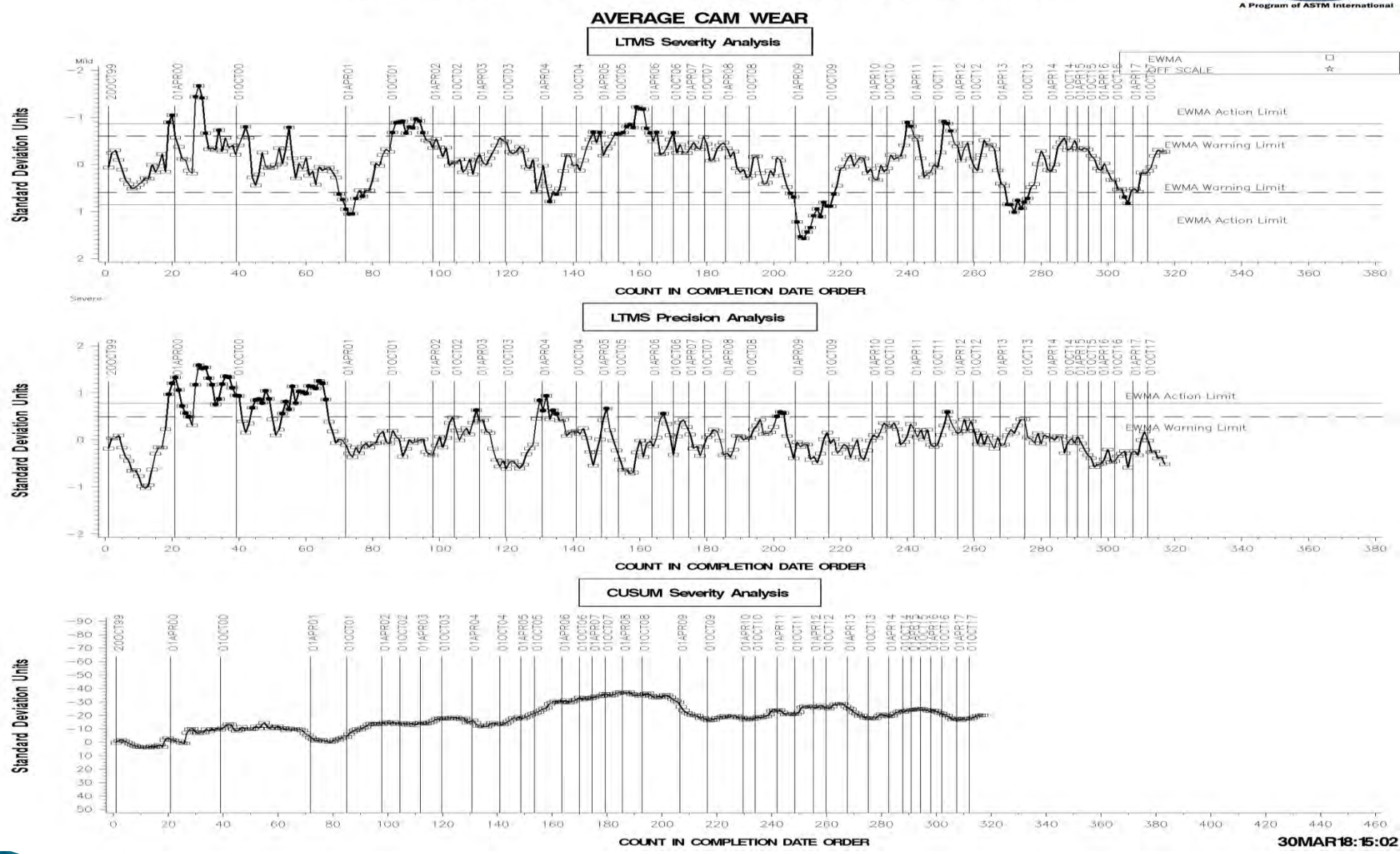
Test Status	Cause	#
Invalid	Improper Oil Flush	1
Aborted	Combustion Air Disconnected during Test	1
Totals		2

*Invalid and aborted tests

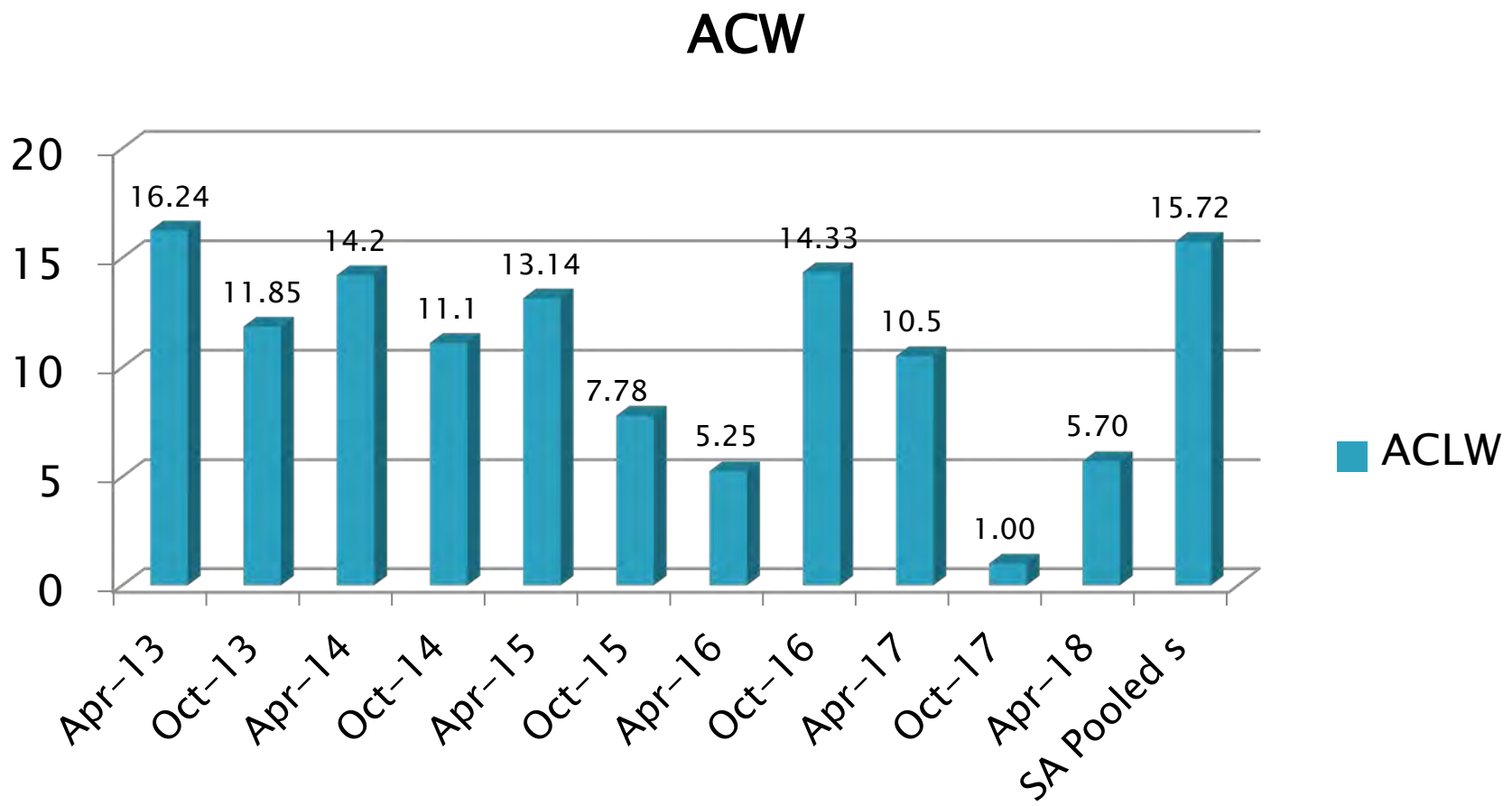
Sequence IVA Test Severity

- ACW in control.

SEQUENCE IVA INDUSTRY OPERATIONALLY VALID DATA



Sequence IVA Precision Estimates



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Sequence VG

- April 2018

Sequence VG Activity

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

Sequence VG Test Severity

- AES in precision warning alarm
- All other parameters in control

SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

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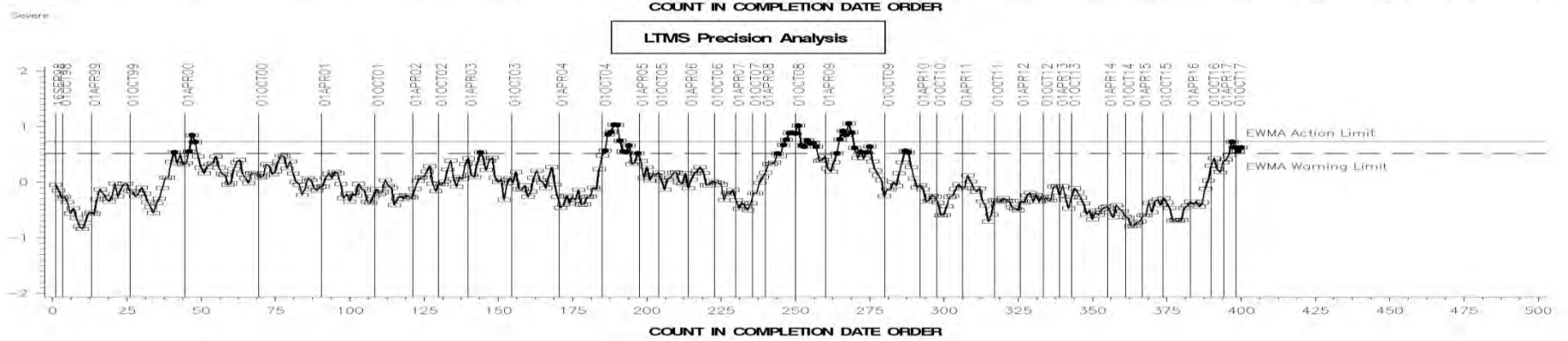
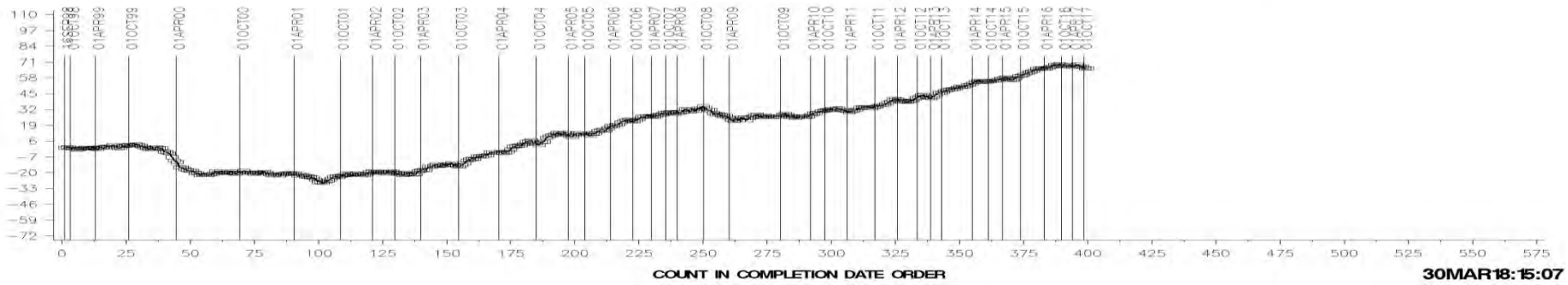
AVERAGE ENGINE SLUDGE

LTMS Severity Analysis

LTMS Precision Analysis



CUSUM Severity Analysis



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SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

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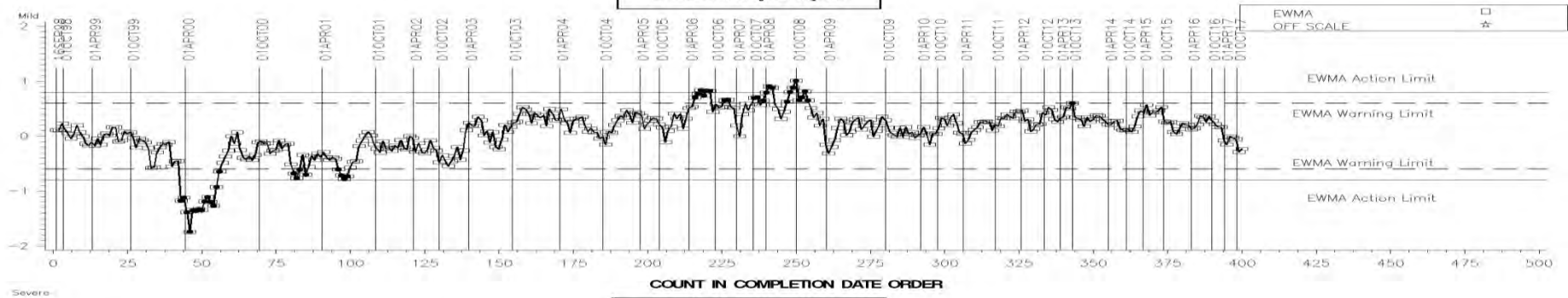
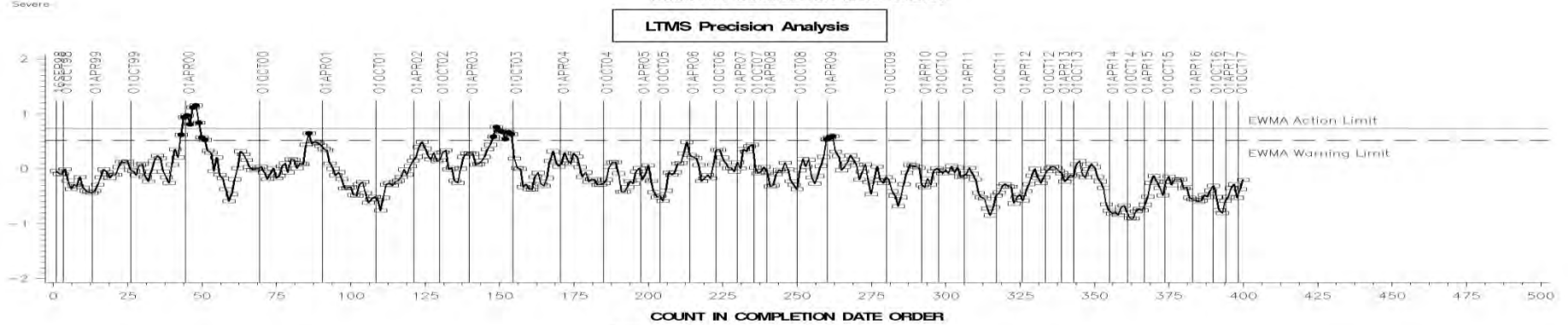
AVERAGE ROCKER COVER SLUDGE

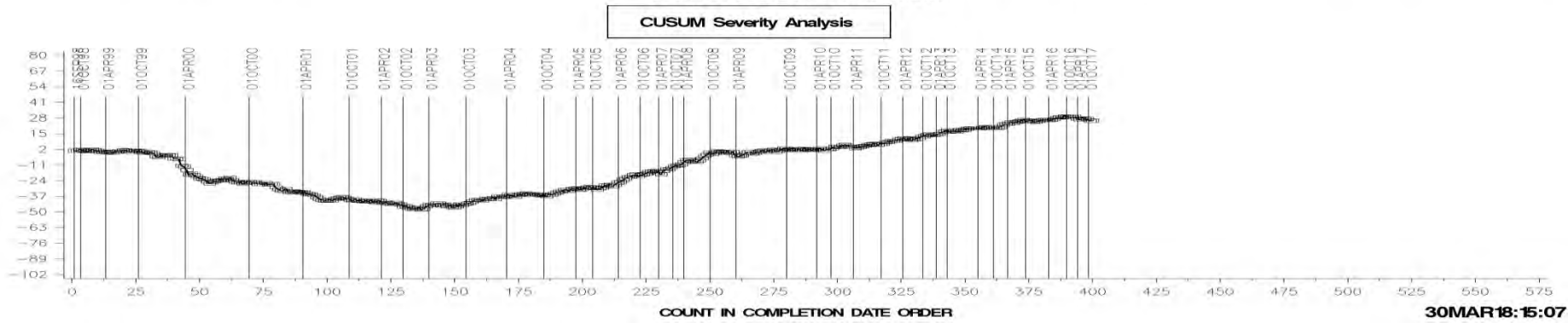
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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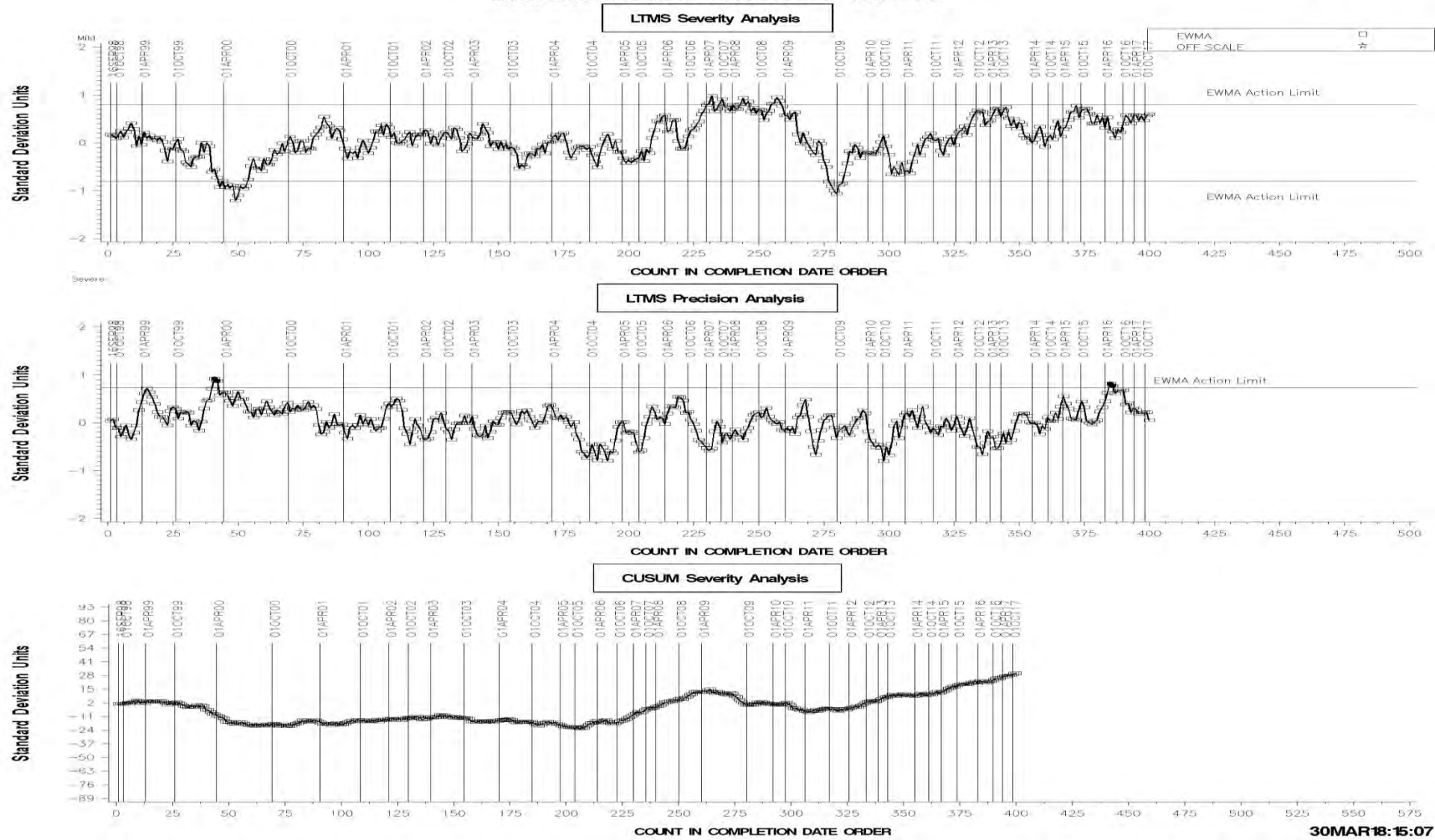
SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

AVG. ENG. VARN. 3—PART APV + BAFFLES



SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

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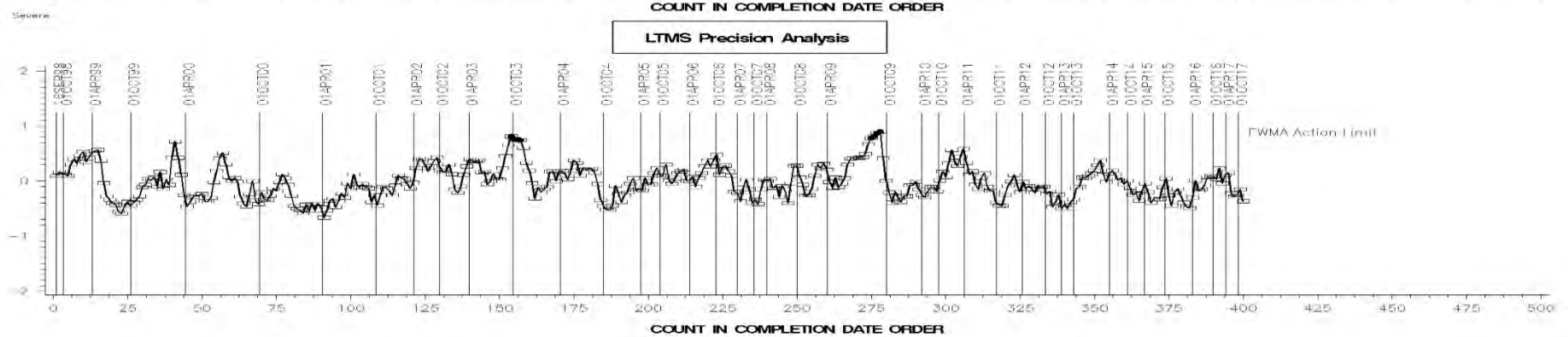
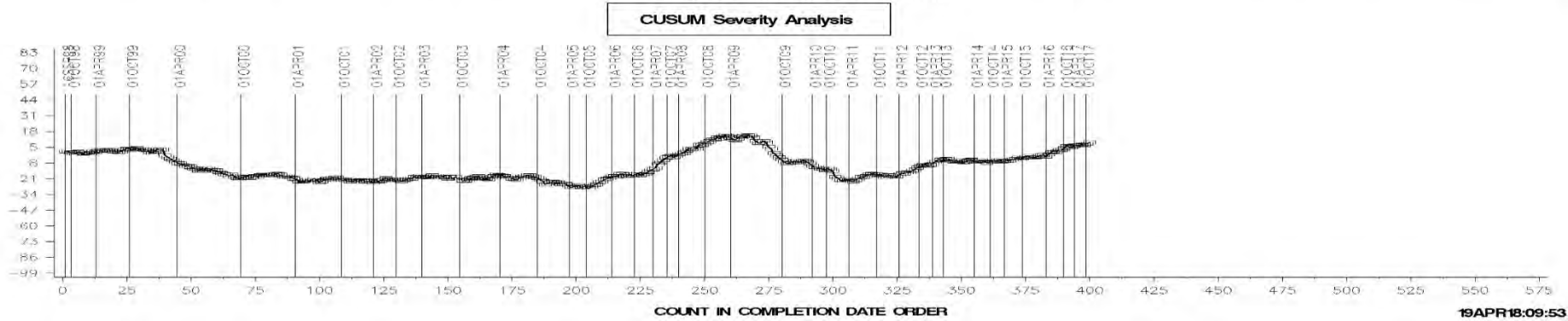
AVG PISTON SKIRT RATING

LTMS Severity Analysis

LTMS Precision Analysis



CUSUM Severity Analysis



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SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

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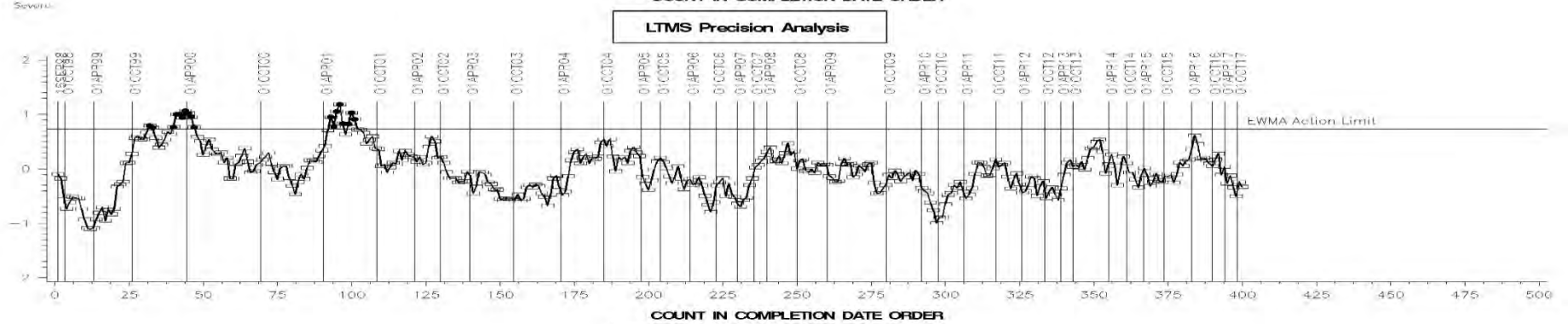
OIL SCREEN SLUDGE

LTMS Severity Analysis

LTMS Precision Analysis



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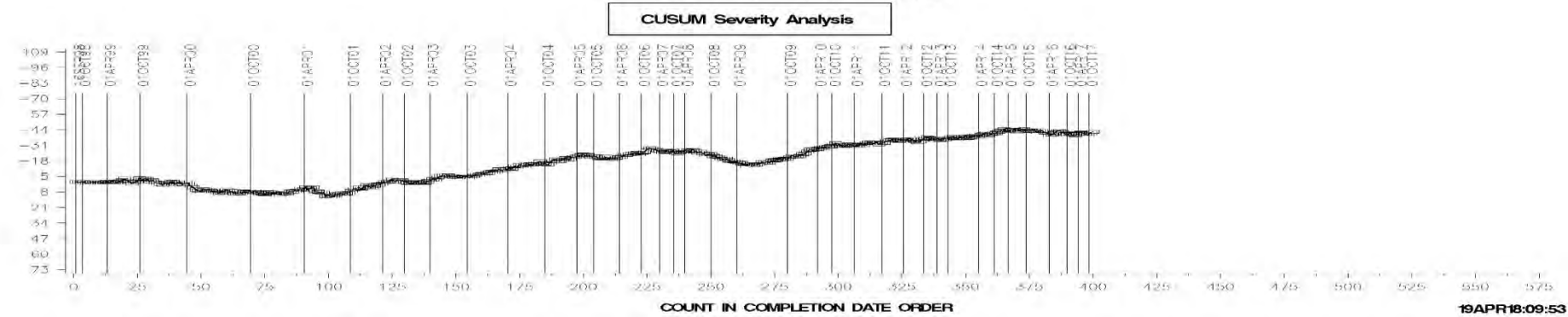

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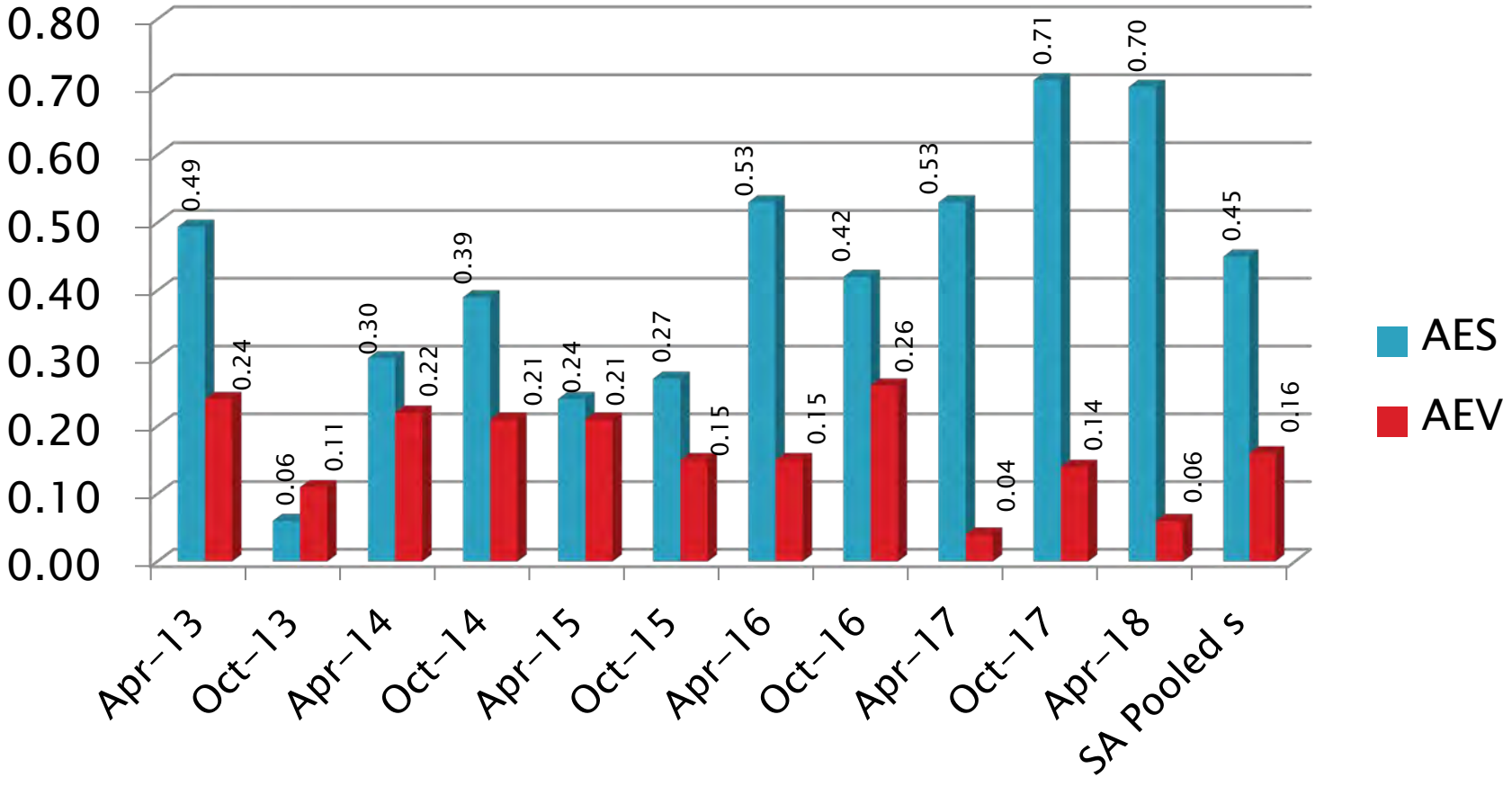
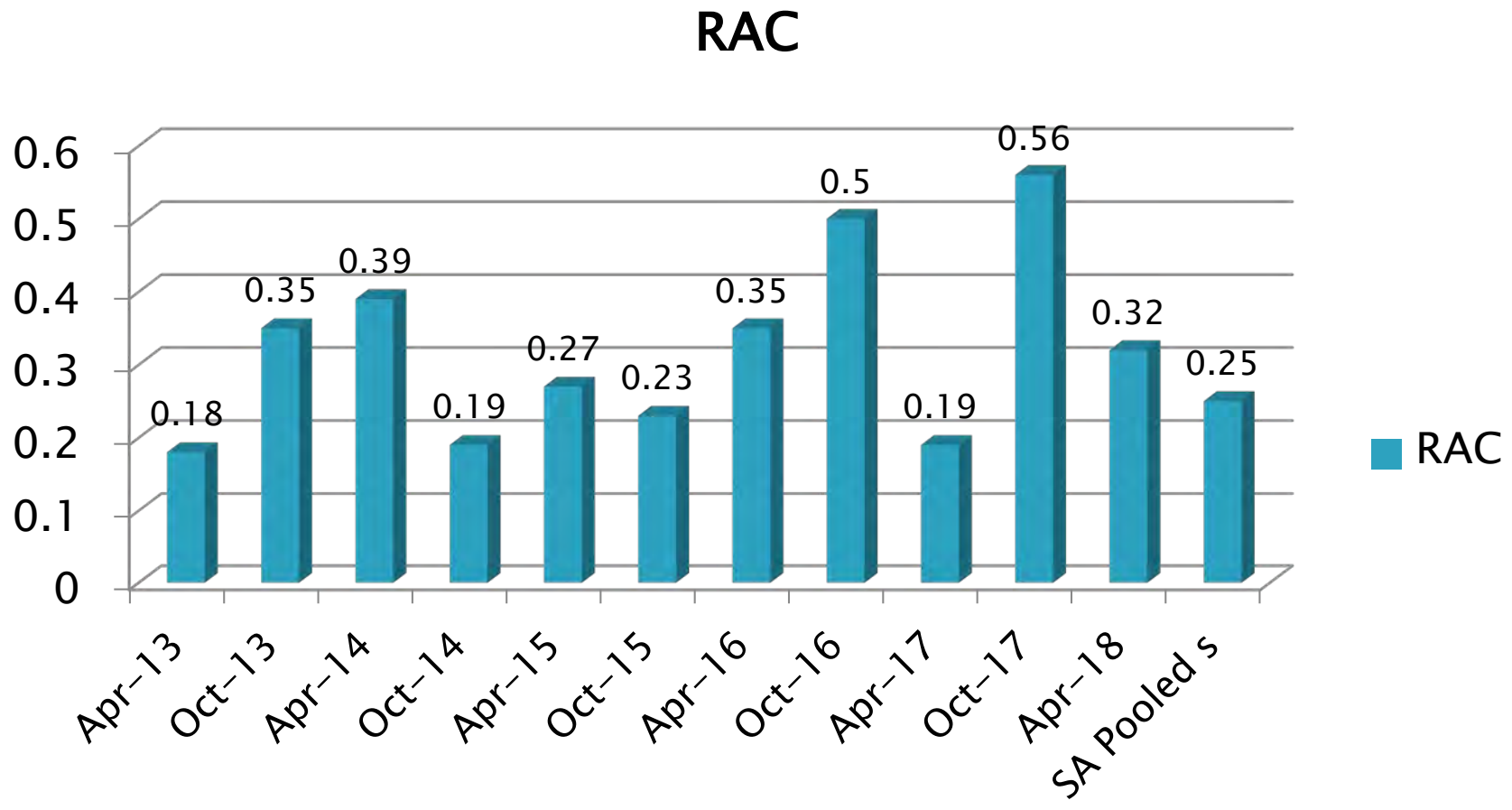
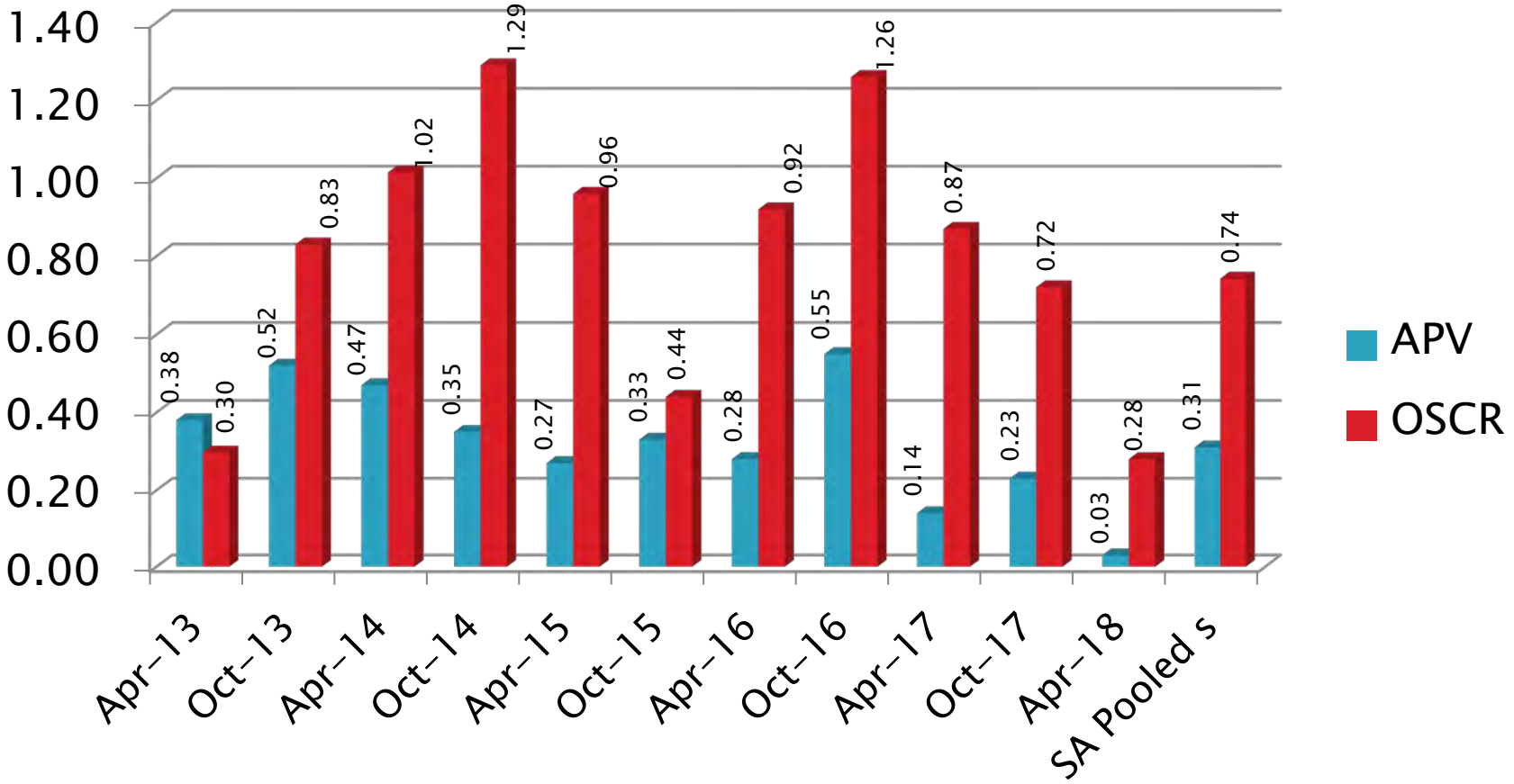
Sequence VG Precision Estimates



Sequence VG Precision Estimates



Sequence VG Precision Estimates



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Sequence VH

- April 2018

Test Monitoring Center
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Sequence VH Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	11
Statistically Unacceptable Calibration	OC	3
Operationally Invalid, Laboratory Judgement	LC	1
BOI-VGRA Matrix Test	NI	12
Total		**27**

Sequence VH – Lost Tests*

Test Status	Cause	#
Invalid	Oil In-Out Lines Switched	1
Totals		1

*Invalid and aborted tests

Sequence VH – Failing Tests

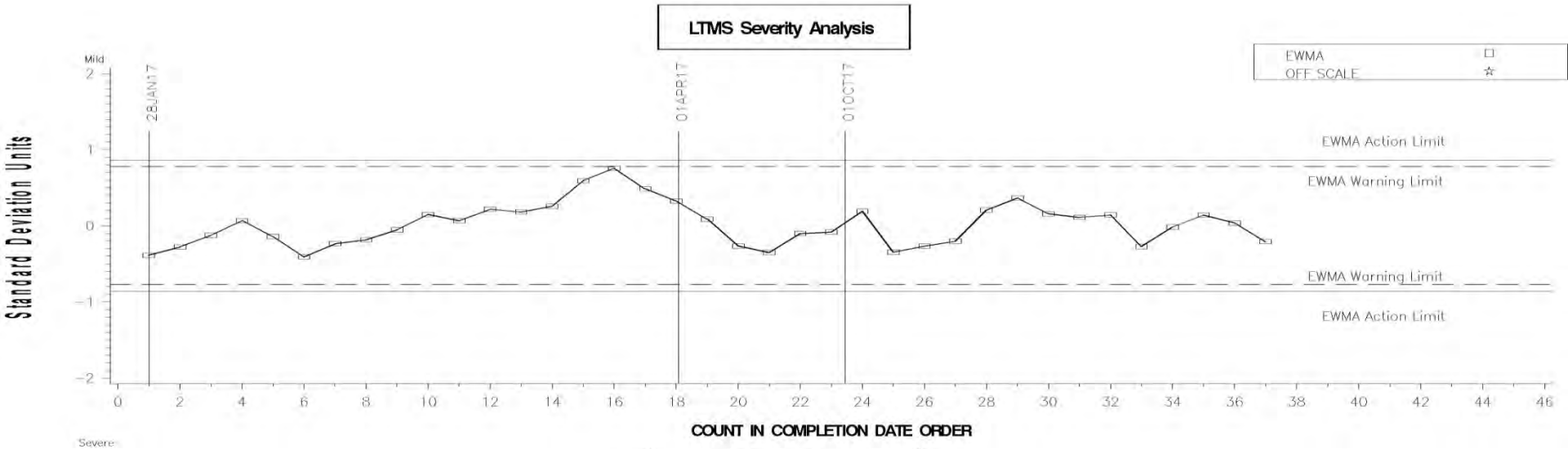
Test Status	#
Severe AEV50	1
Severe AEV50, APV50	1
Level 2 Zi Alarm AEV50	1
Totals	**3**

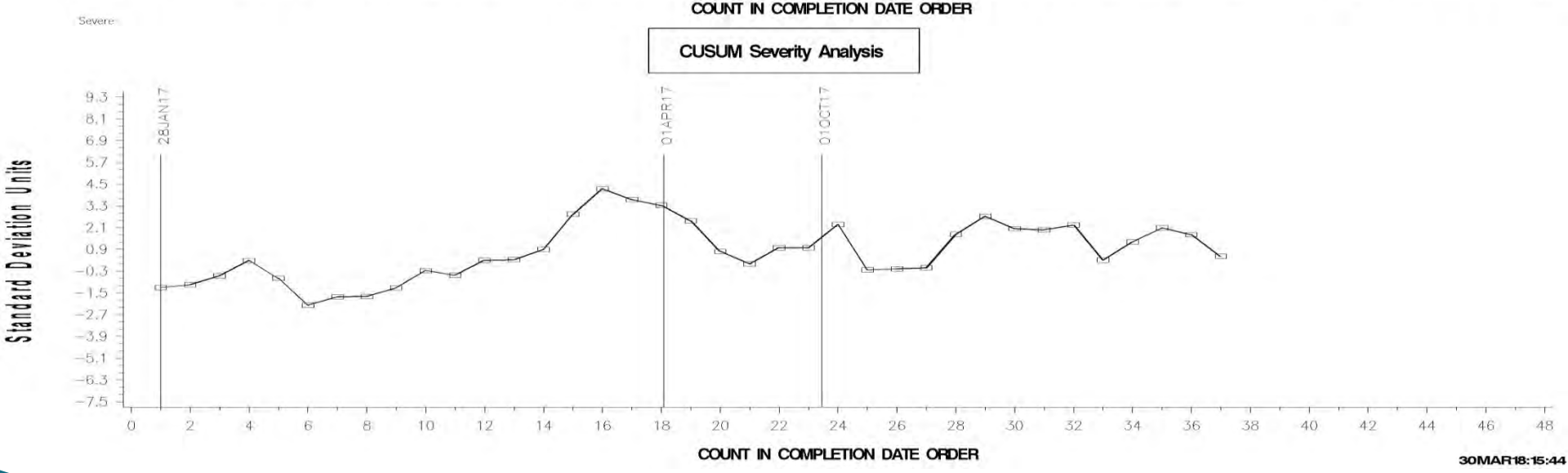
Sequence VH Test Severity

- All parameters in control

SEQUENCE VH INDUSTRY OPERATIONALLY VALID DATA

AVERAGE ENGINE SLUDGE

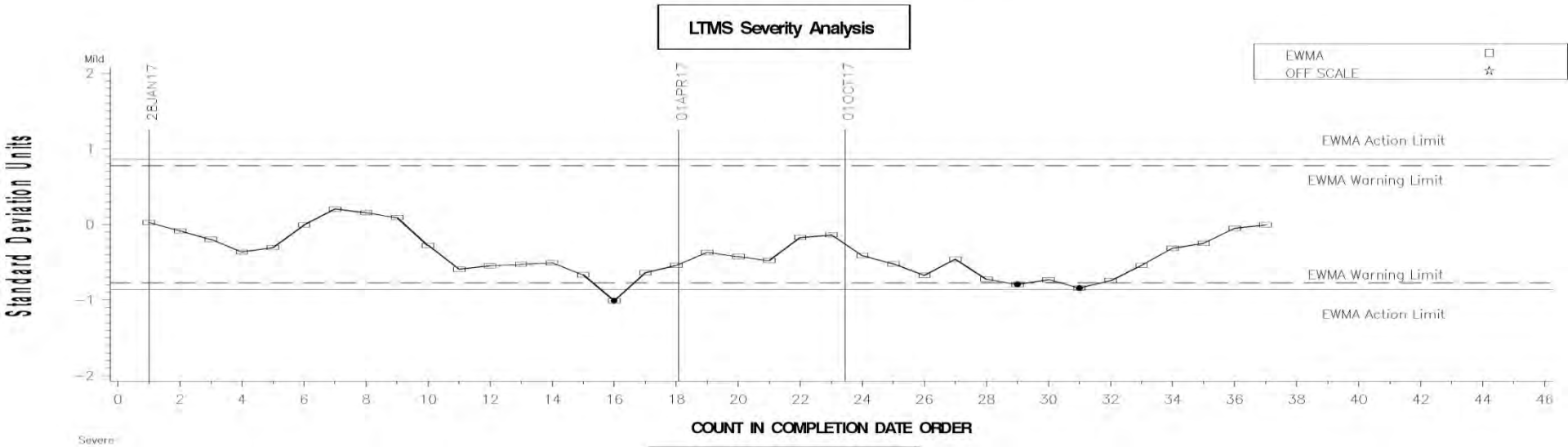


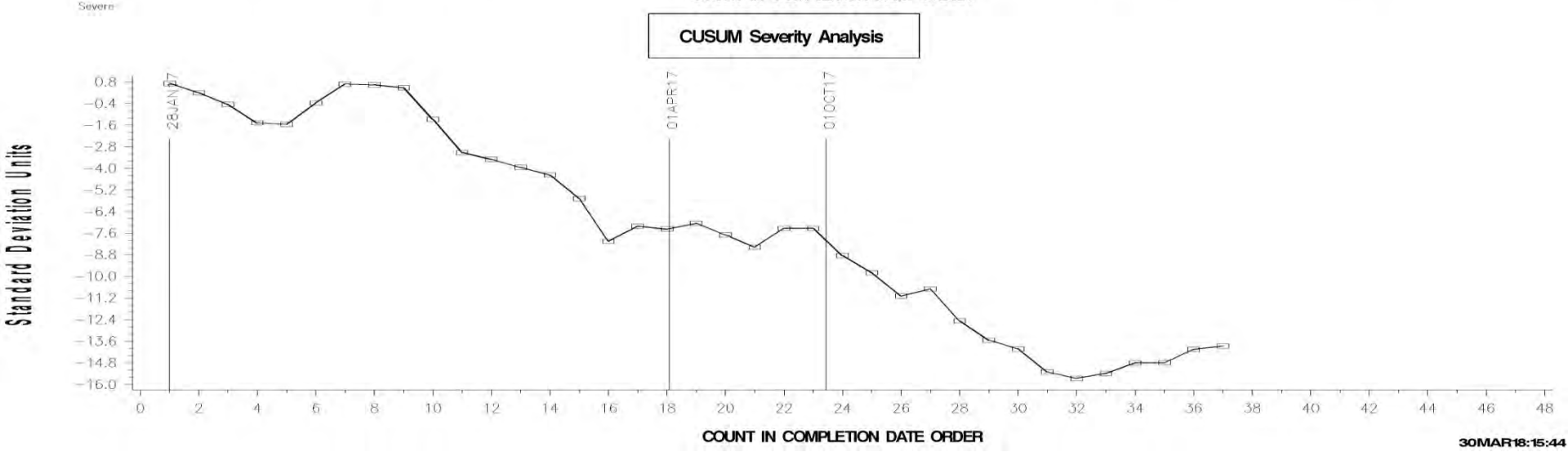


30MAR18:15:44

SEQUENCE VH INDUSTRY OPERATIONALLY VALID DATA

AVERAGE ROCKER COVER SLUDGE





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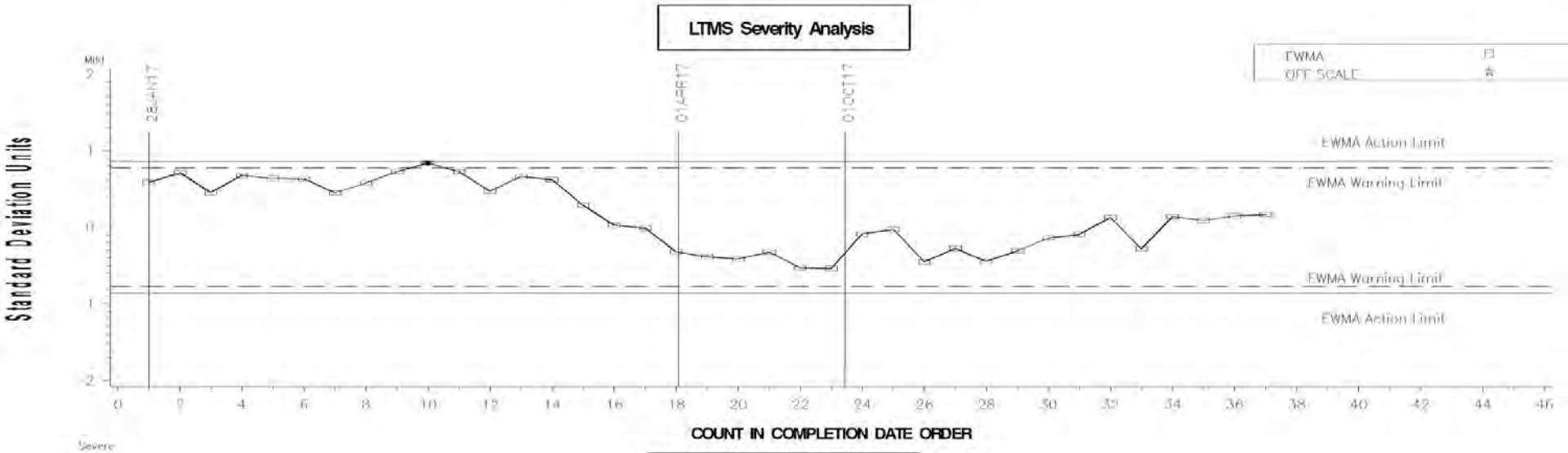
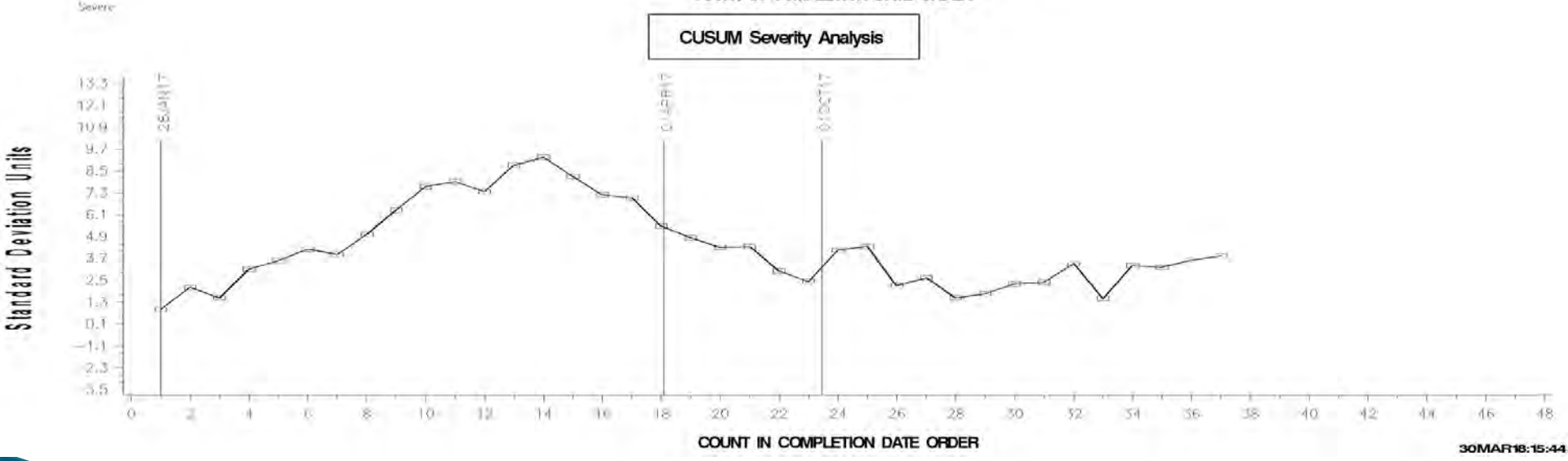
SEQUENCE VH INDUSTRY OPERATIONALLY VALID DATA

AVG. ENG. VARN. 50% RATING

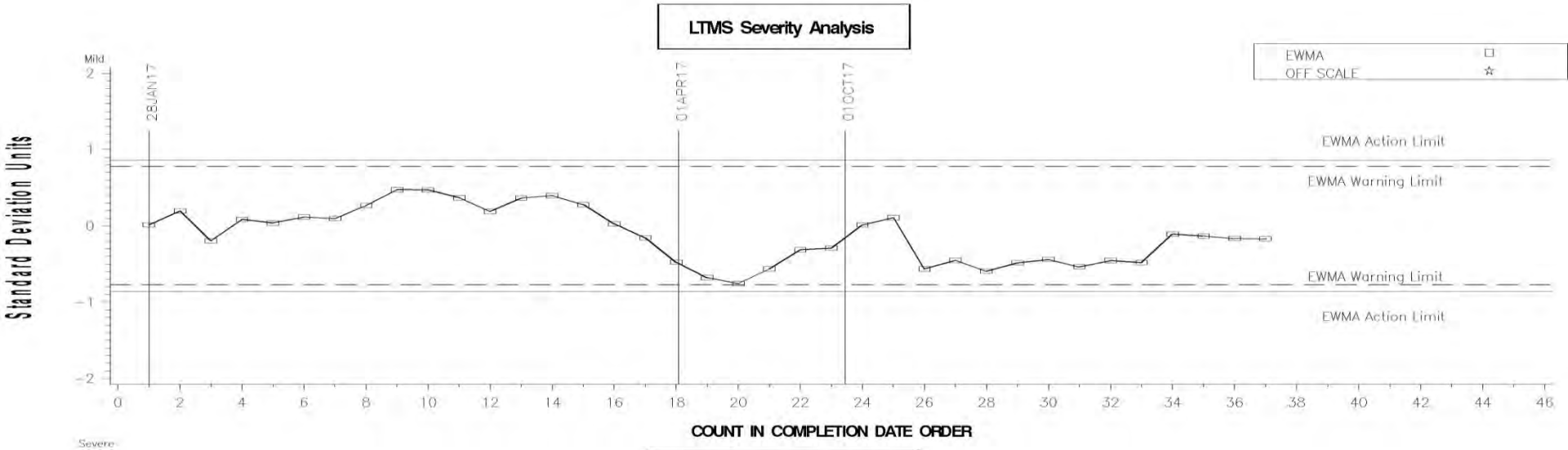


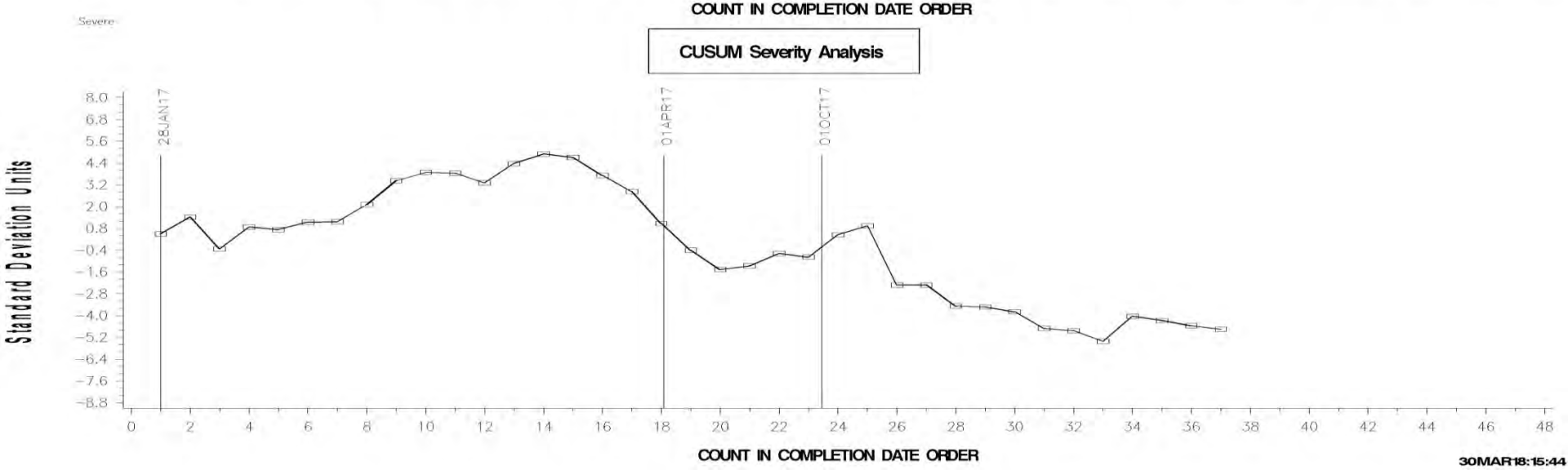


30MAR16:15:44

SEQUENCE VH INDUSTRY OPERATIONALLY VALID DATA

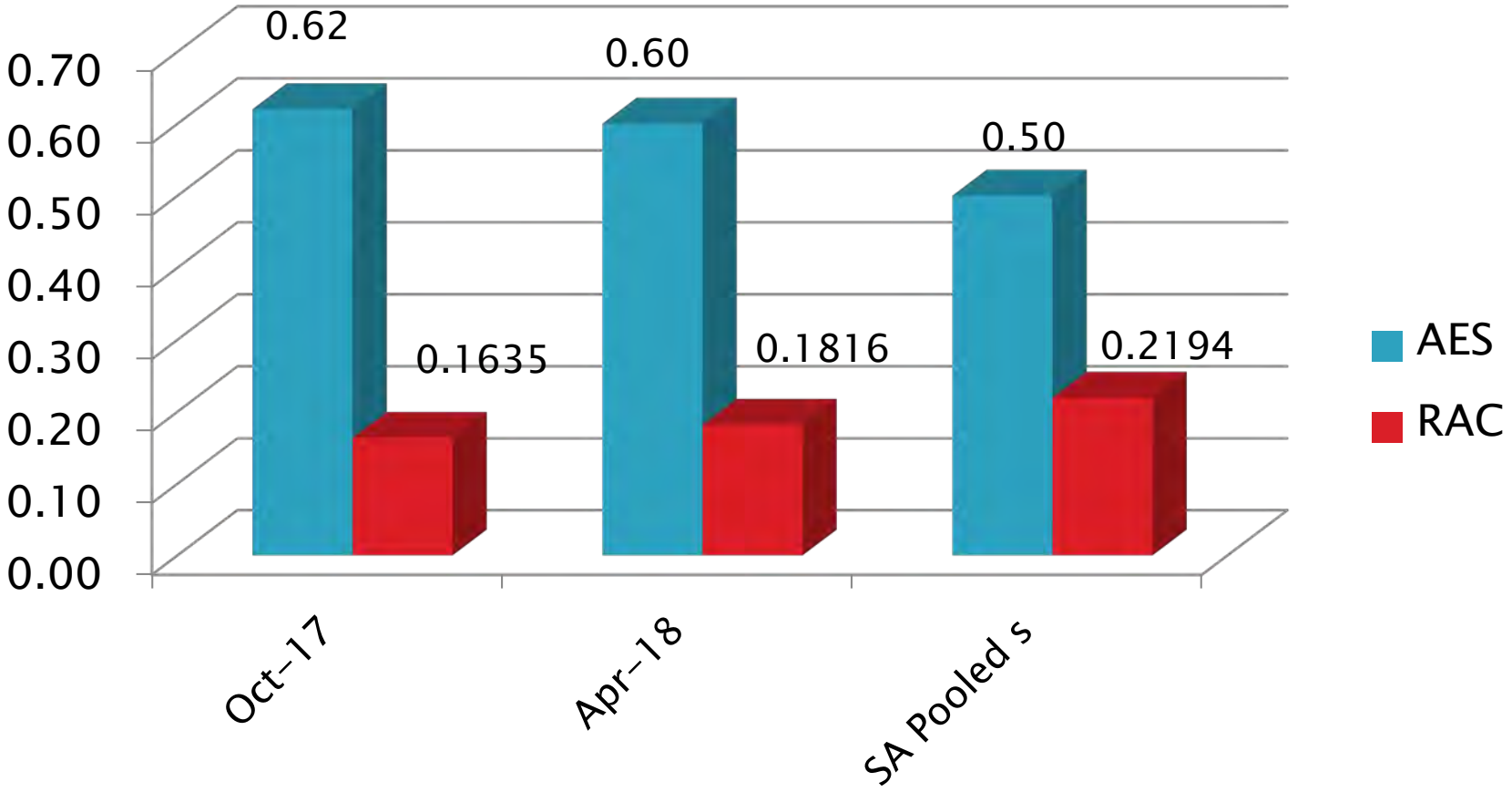
AVG PISTON SKIRT 50% RATING



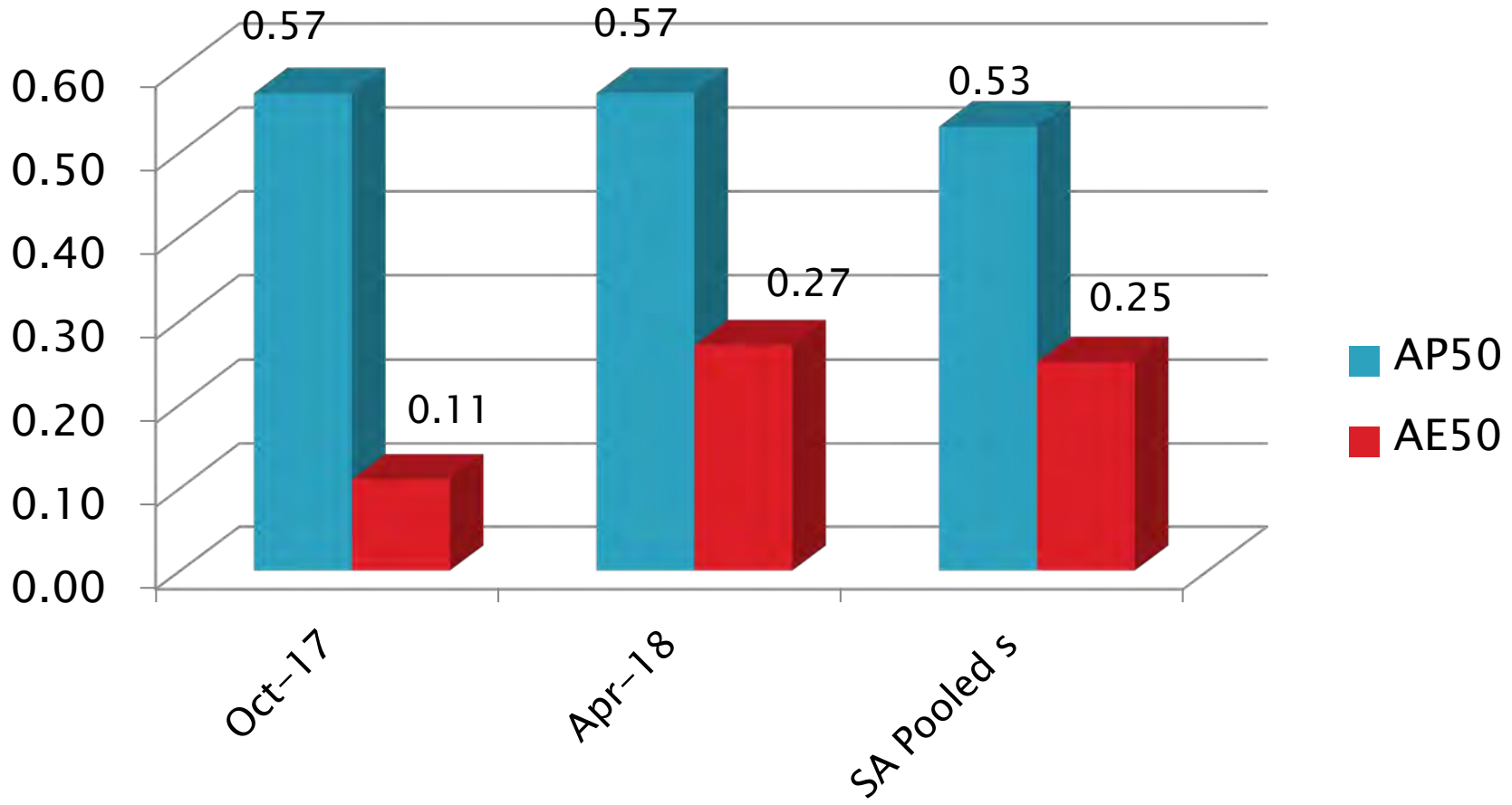


30MAR18:15:44

Sequence VH Precision Estimates



Sequence VH Precision Estimates



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Sequence VIE

- April 2018

Sequence VIE Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	40
Acceptable Industry Information Run (BOI-VGRA)	NI	14
Failed Statistically	OC	14
Operationally Invalid Calibration Test	LC	3
Aborted Calibration Tests	XC	4
Total		**75**

Sequence VIE – Failed Tests

Test Status	Number of Tests
Severe FEI2	7
Severe FEI1	4
FEI1 and FEI2 Mild	1
FEI2 Mild	1
FEI2 Severe, VI Alarm	1
Total	**14**

Sequence VIE – Lost Tests*

Test Status	Cause	#
Aborted	Engine Failure/Damage	2
Aborted	Electrical Problems at Stand	1
Aborted	Fuel Leak	1
Invalid	Load Cell Calibration Offset	2
Invalid	Coolant Flow Reversed	1
Totals		7

*Invalid and aborted tests

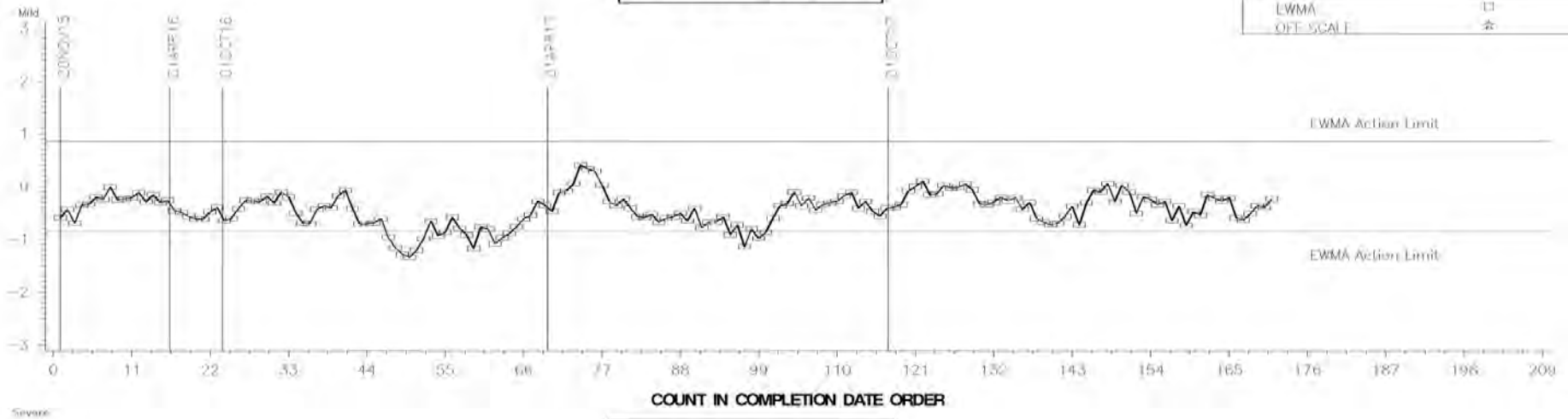
Sequence VIE Test Severity

- FEI1 and FEI2 are in control

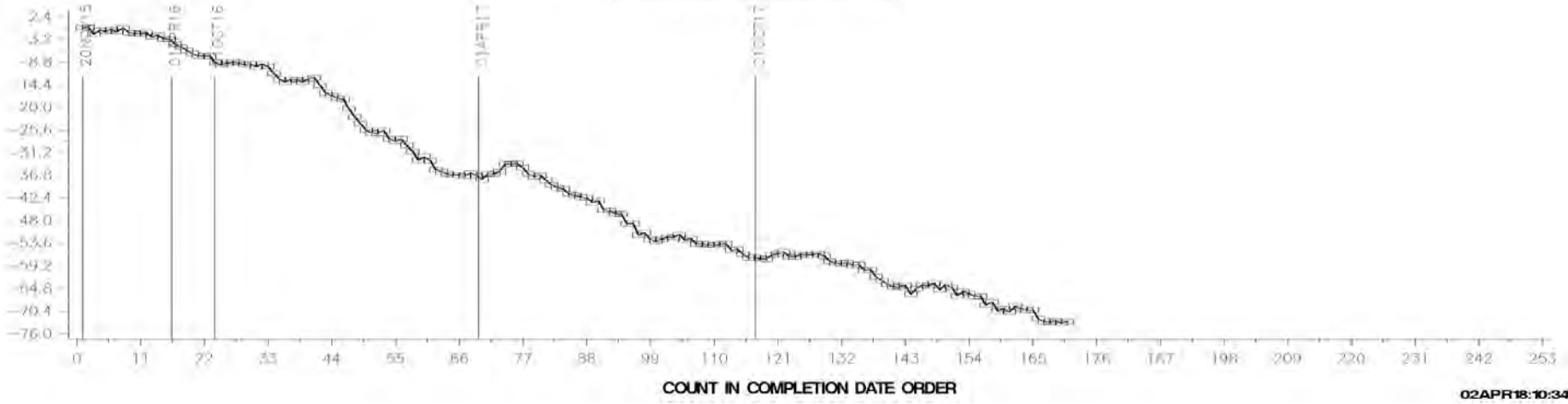
SEQUNCE VIE INDUSTRY OPERATIONALLY VALID DATA

FEI FINAL RESULT PHASE I

LTMS Severity Analysis



CUSUM Severity Analysis

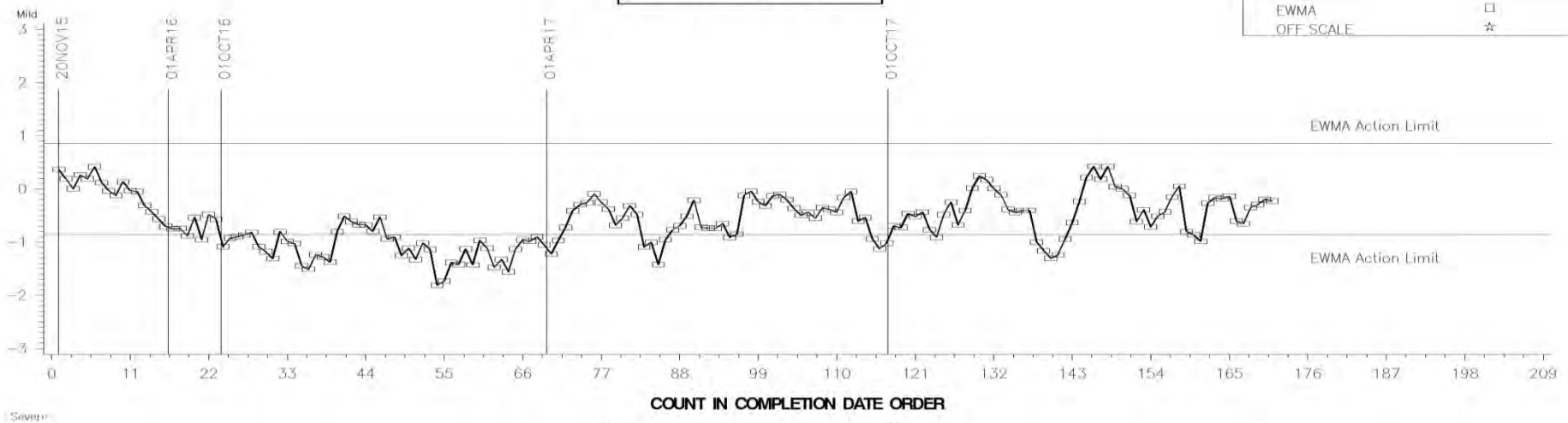


02APR18:10:34

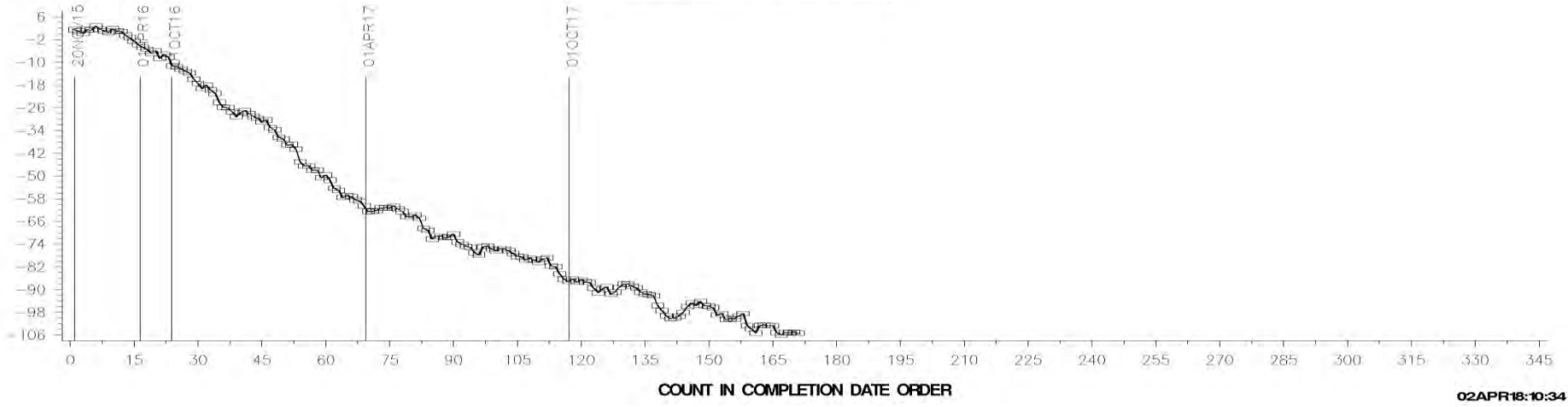
SEQUNCE VIE INDUSTRY OPERATIONALLY VALID DATA

FEI FINAL RESULT PHASE II

LTMS Severity Analysis



CUSUM Severity Analysis



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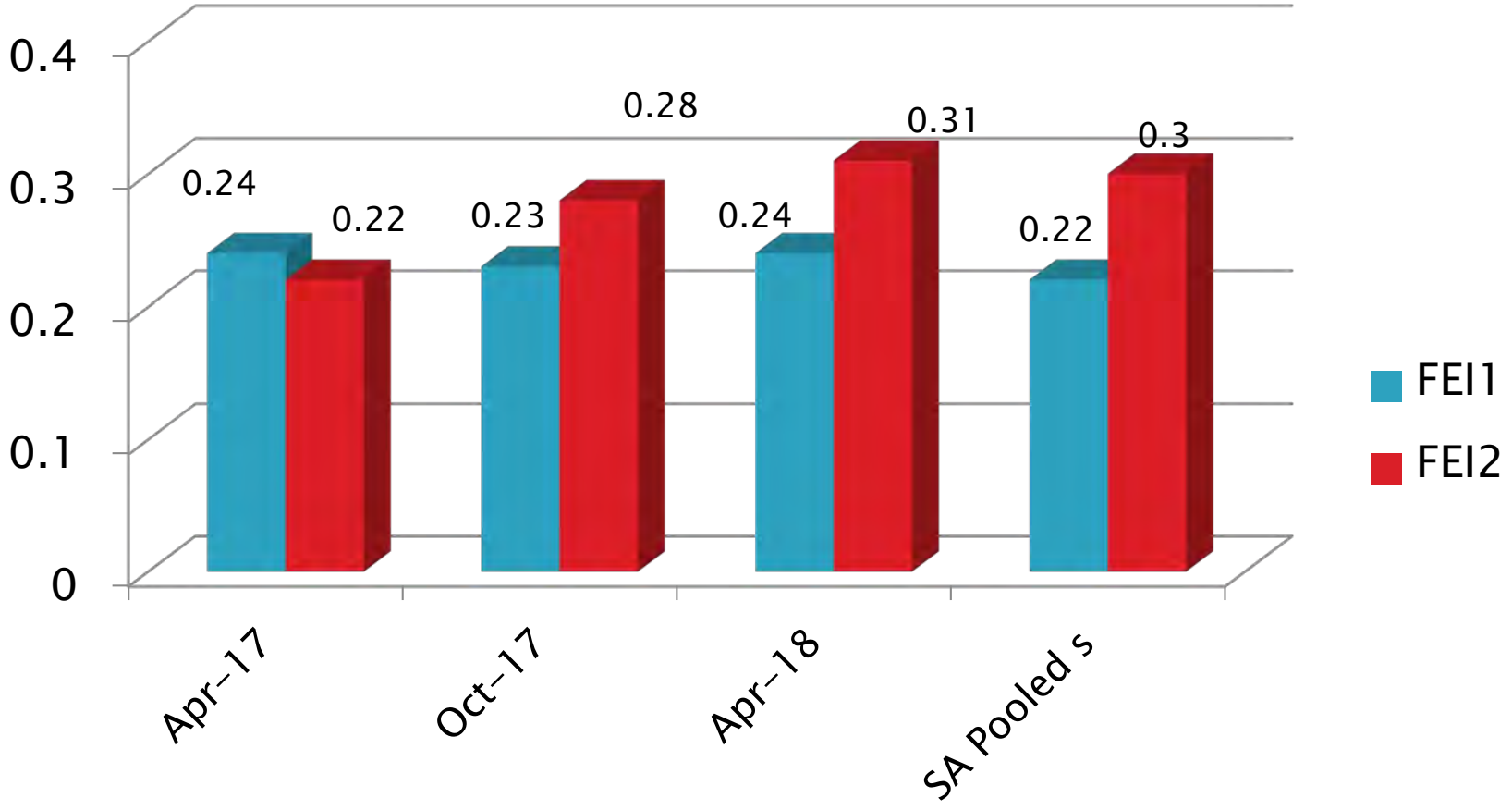
Sequence VIE Precision Estimates



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Sequence VIF

- April 2018

Sequence VIF Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	30
Failed Statistically	OC	8
Operationally Invalid Calibration Test	LC	1
Acceptable Industry Information Test (BOI)	NI	6
Total		**45**

Sequence VIF – Failed Tests

Test Status	Number of Tests
Mild FEI1	2
Severe FEI1	1
Severe FEI2	1
Vi Alarm FEI1	2
Vi Alarm FEI2	2
Total	**8**

Sequence VIF – Lost Tests*

Test Status	Cause	#
Invalid	Fuel Flow Meter Calibration Error	1
Totals		1

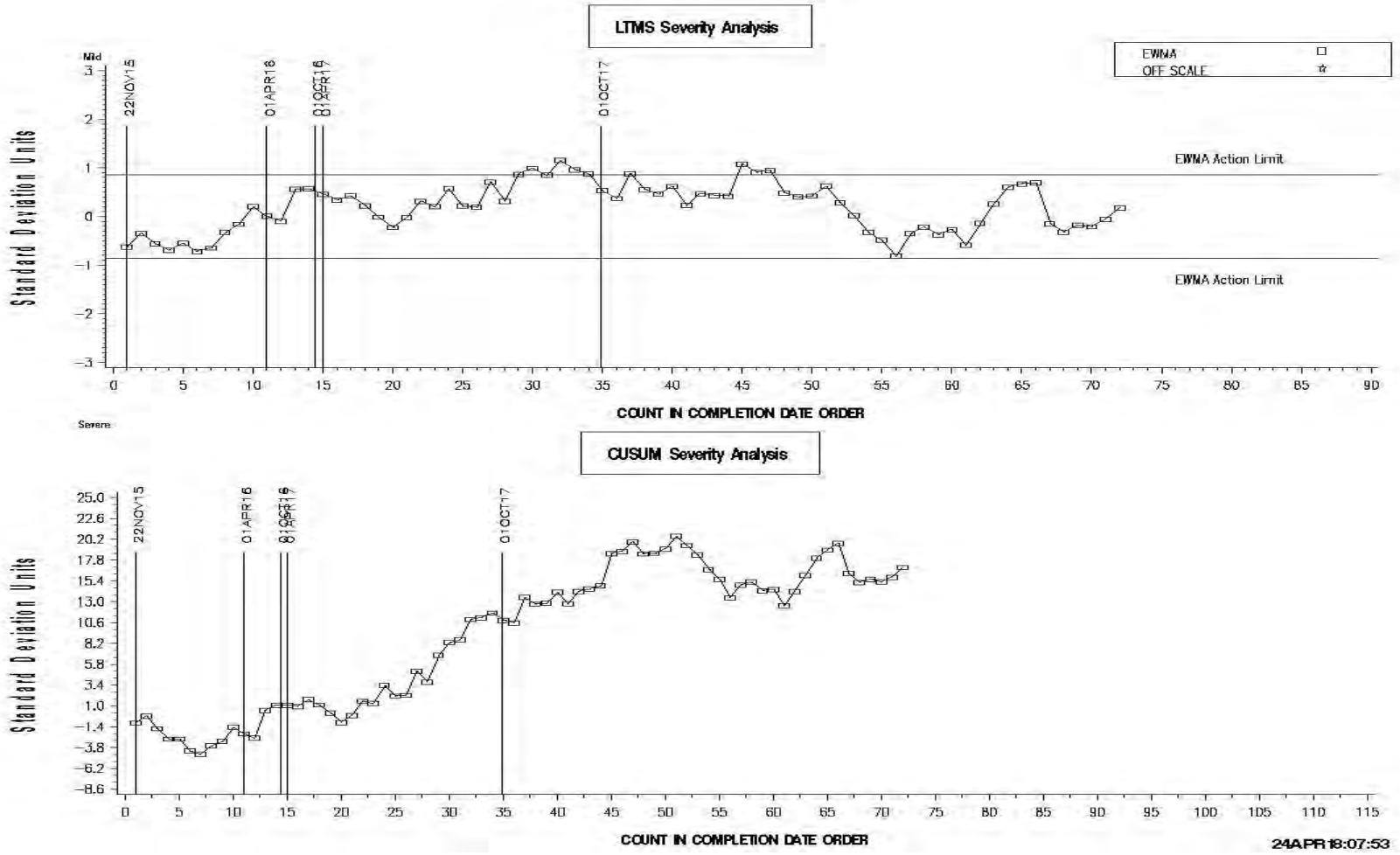
*Invalid and aborted tests

Sequence VIF Test Severity

- FEI1 and FEI2 are in control

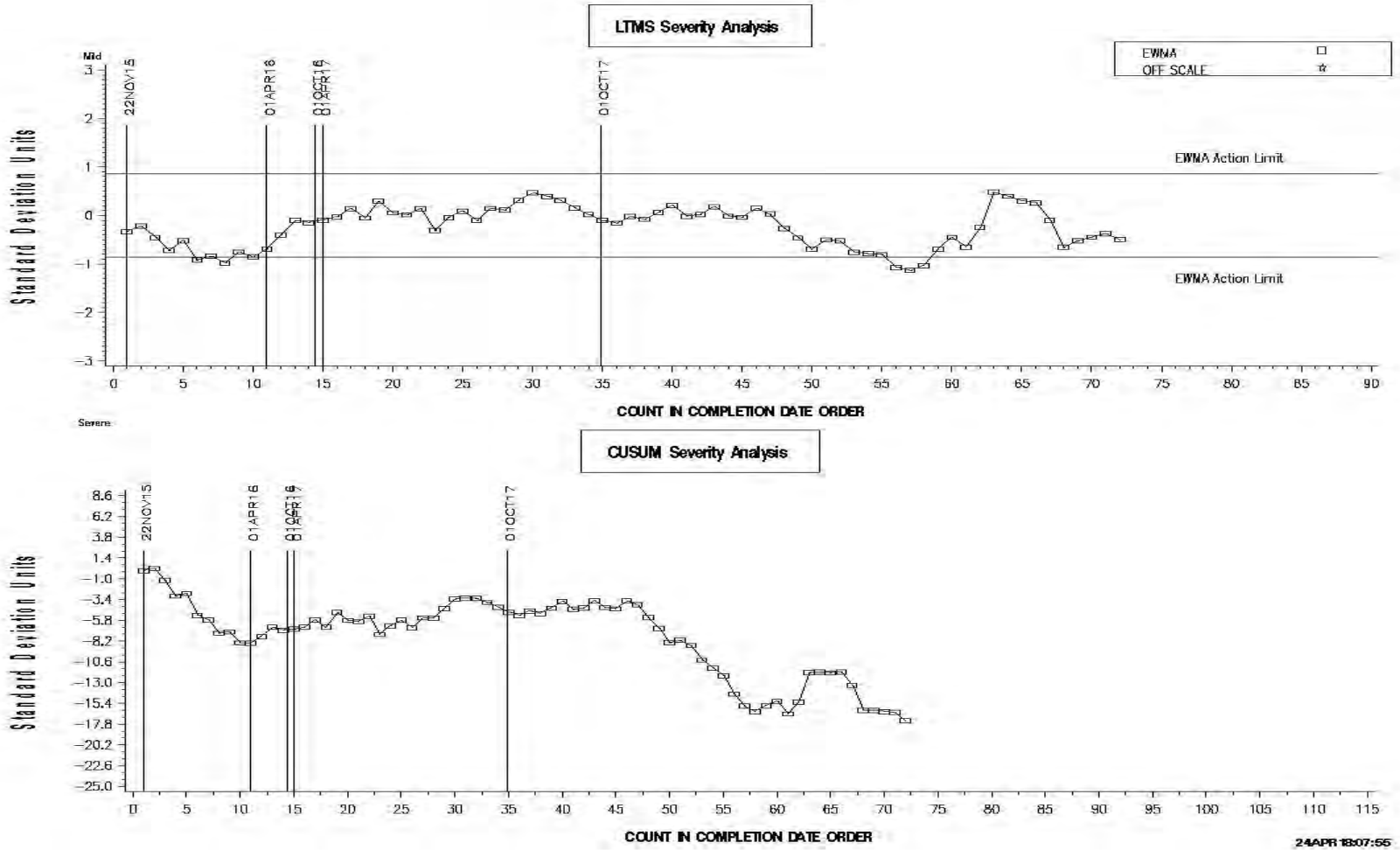
SEQUNCE VIF INDUSTRY OPERATIONALLY VALID DATA

FEI FINAL RESULT PHASE I

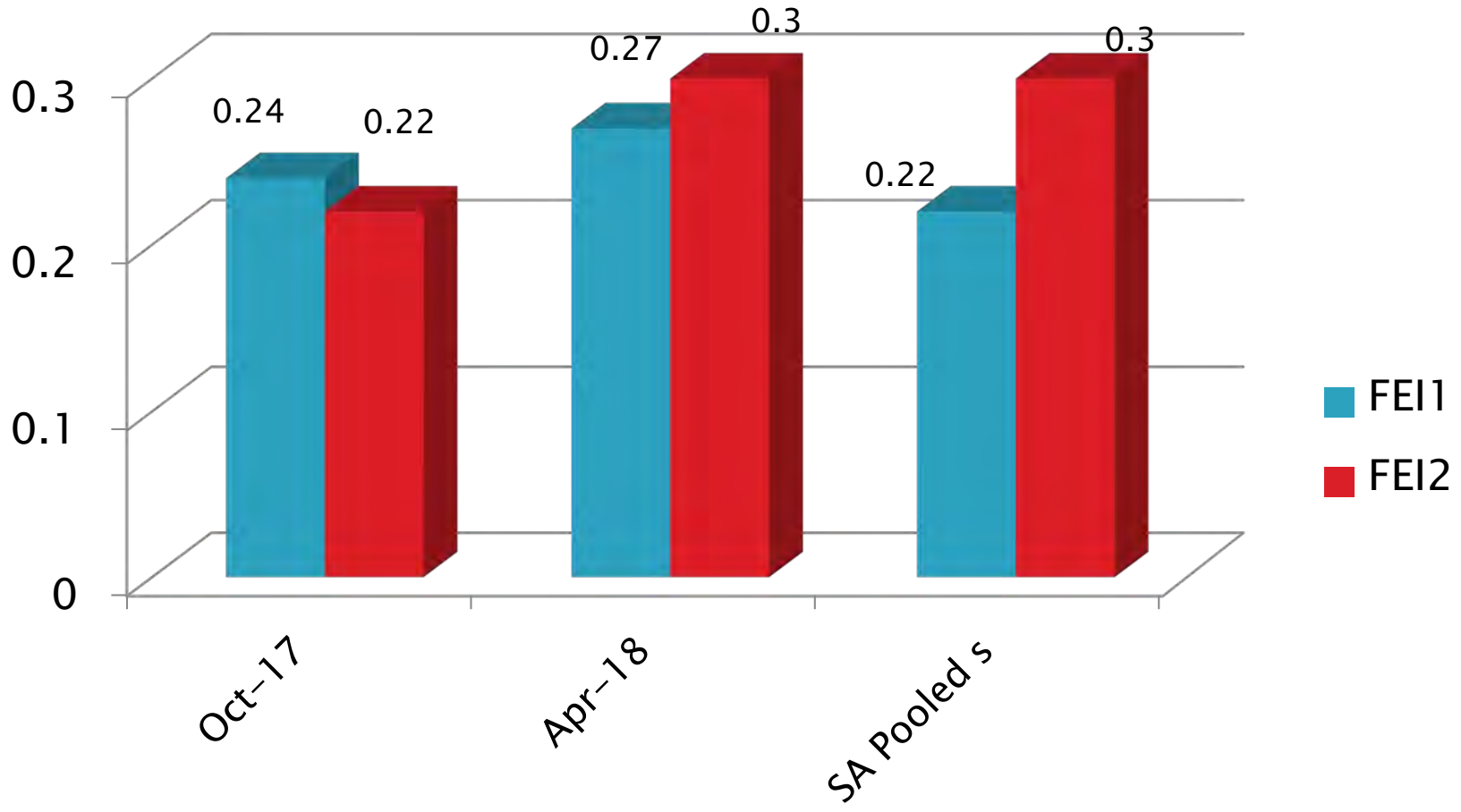


SEQUNCE VIF INDUSTRY OPERATIONALLY VALID DATA

FEI FINAL RESULT PHASE II



Sequence VIF Precision Estimates



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Sequence VIII

- April 2018

Sequence VIII Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	5
Operationally Invalid Calibration Test	LC	1
Total		6

Sequence VIII – Lost Tests*

Test Status	Cause	#
Invalid	Coolant temperature control problems	1
Totals		1

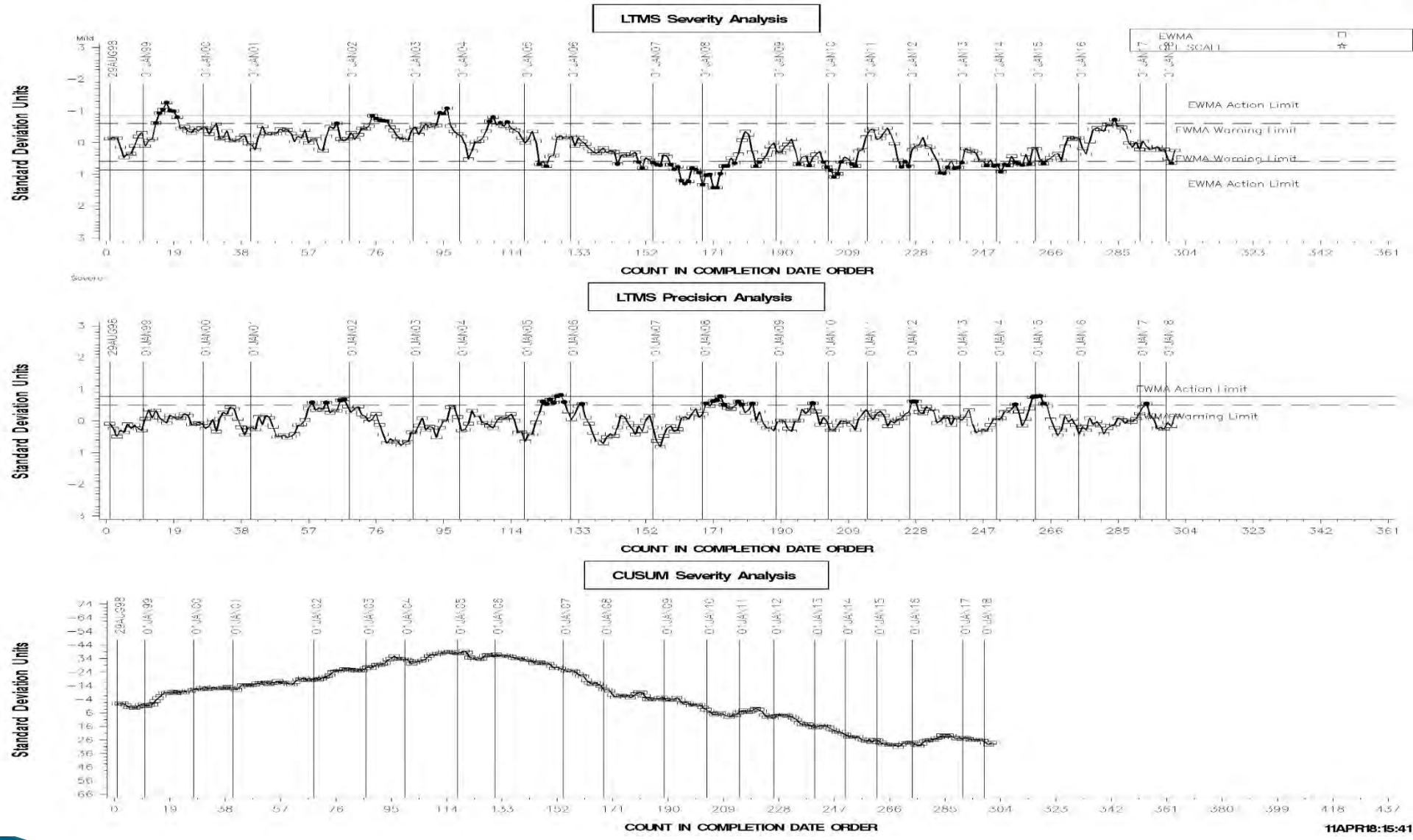
*Invalid and aborted tests

Sequence VIII Test Severity

- Bearing Weight Loss and Stripped Viscosity are in control

SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

FINAL BEARING WEIGHT LOSS



SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

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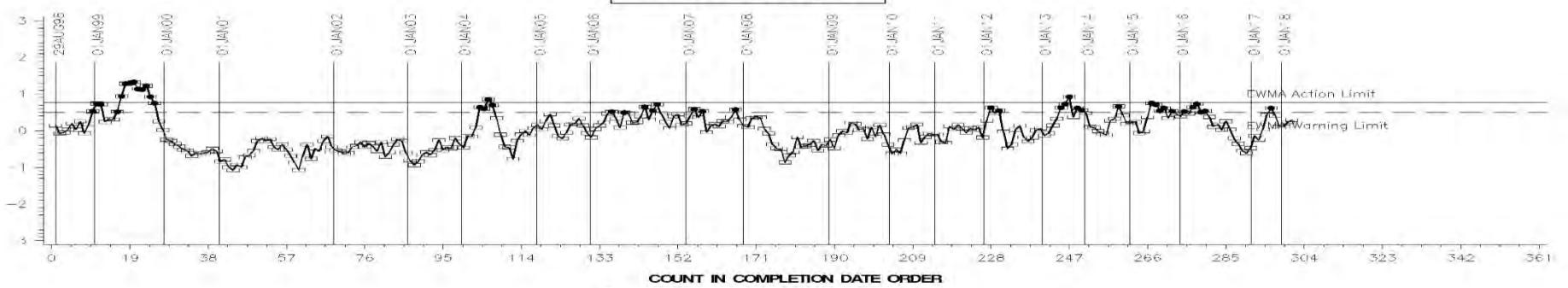
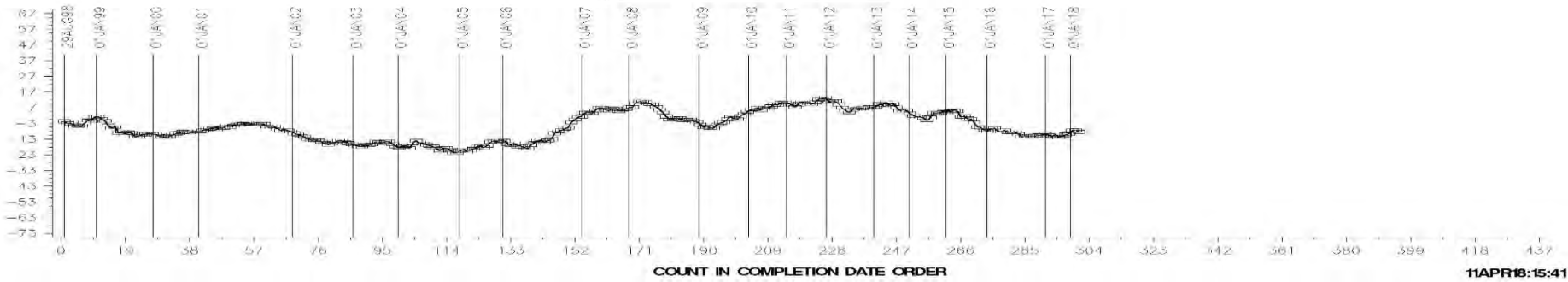
STRIPPED VIS. @ 100 DEG C

LTMS Severity Analysis

LTMS Precision Analysis

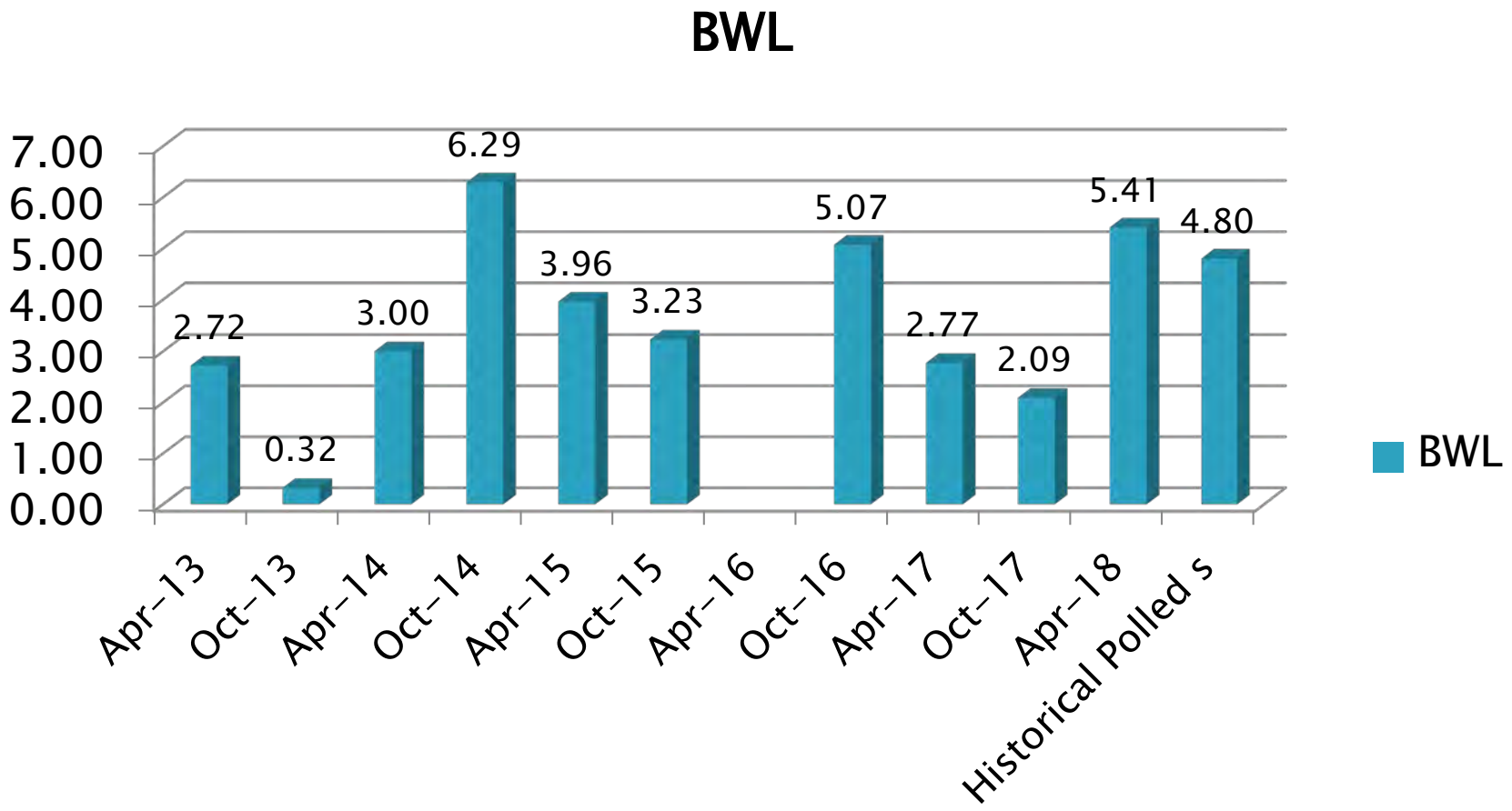


CUSUM Severity Analysis



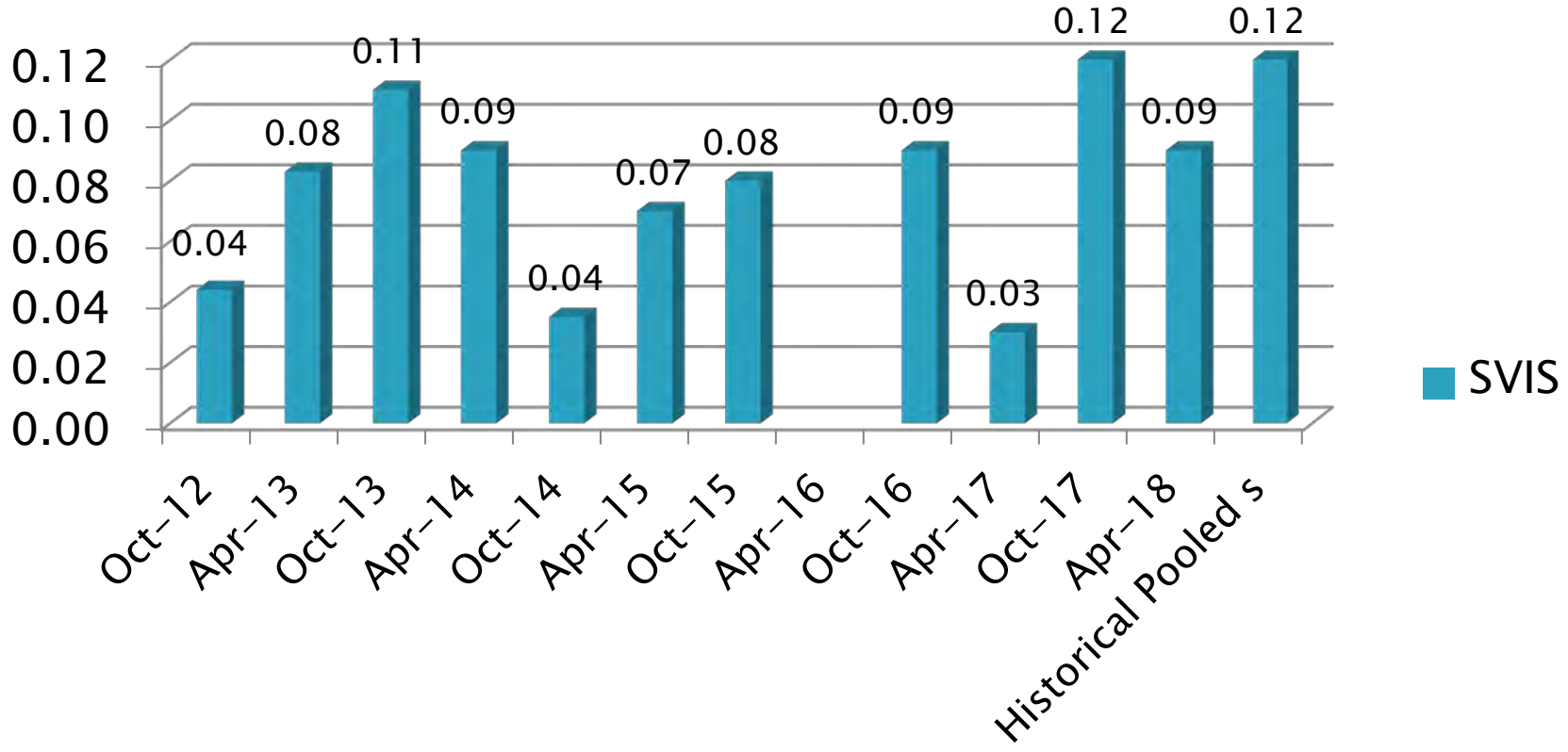
11APR18:15:41

Sequence VIII Precision Estimates



Sequence VIII Precision Estimates

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



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Sequence IX

- April 2018

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Sequence IX Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	67
Acceptable Donated Test	AG	1
Acceptable Discrimination Test	AS	3
Unacceptable Discrimination Test	OS	1
Statistically Unacceptable Calibration Test	OC	27

Sequence IX Activity – cont.

Test Status	Validity Code	#
Aborted Calibration Test	XC	2
Operationally Invalid Calibration Test, Lab Judgement	LC	4
Acceptable BOI-VGRA Test	NI	18
Total		123

Sequence IX – Failed Tests

Test Status	Number of Tests
Level 2 Zi Alarm	8
Level 3 Ei Alarm	14
Level 2 Zi and Level 3 Ei Alarm	5
Excessive Pre-ignitions (Discrimination oil)	1
Total	**28**

Sequence IX – Lost Tests*

Test Status	Cause	#
Aborted	Cylinder 1 damaged during previous test	1
Aborted	Operator error during flush	1
Invalid	Exceeded number of invalid iterations allowed	2
Invalid	Pistons not measured pre-test	2
Totals		6

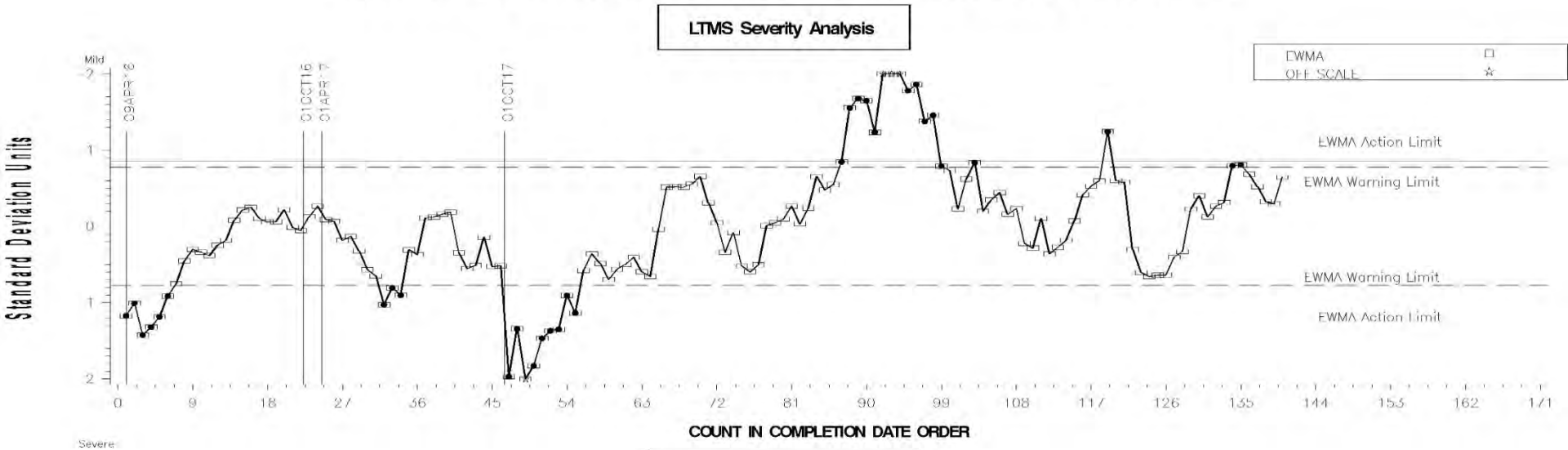
*Invalid and aborted tests

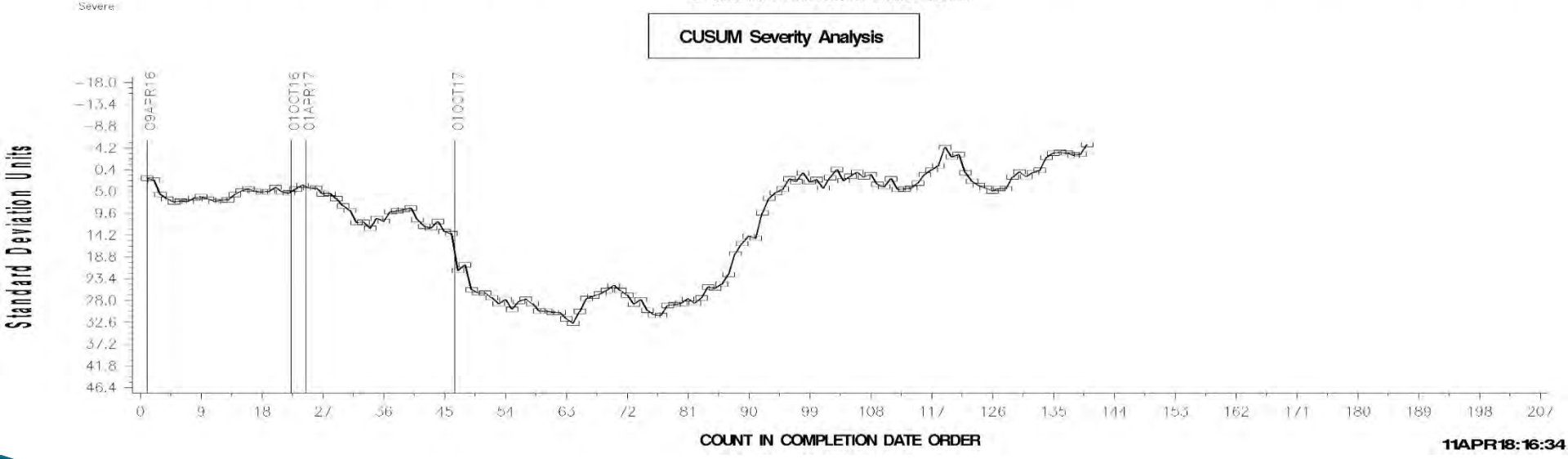
Sequence IX Test Severity

- Average number of Pre-ignitions in control.

SEQUENCE IX INDUSTRY OPERATIONALLY VALID DATA

AVERAGE NUMBER OF PREIGNITIONS FROM VALID ITERATIONS





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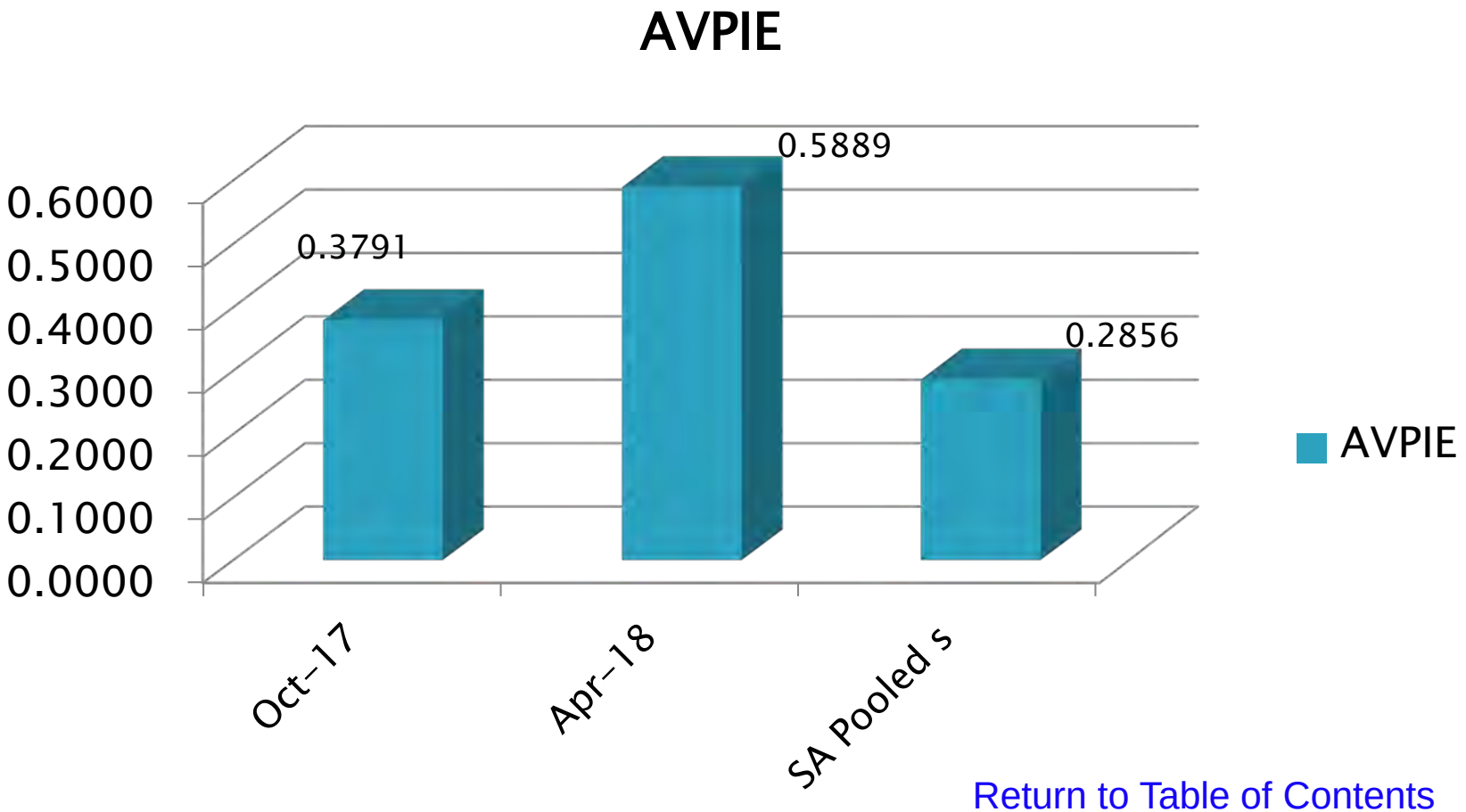
Sequence IX Precision Estimates



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Sequence X

- April 2018

Sequence X Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	14
Operationally Invalid Calibration Test, Lab Judgement	LC	1
Aborted BOI-VGRA Test	XI	1
Acceptable BOI-VGRA Test	NI	5
Total Number of Tests		21

Sequence X – Lost Tests*

Test Status	Cause	#
Invalid	Waste Gate Failed	1
Aborted	Operator error	1
Totals		**2**

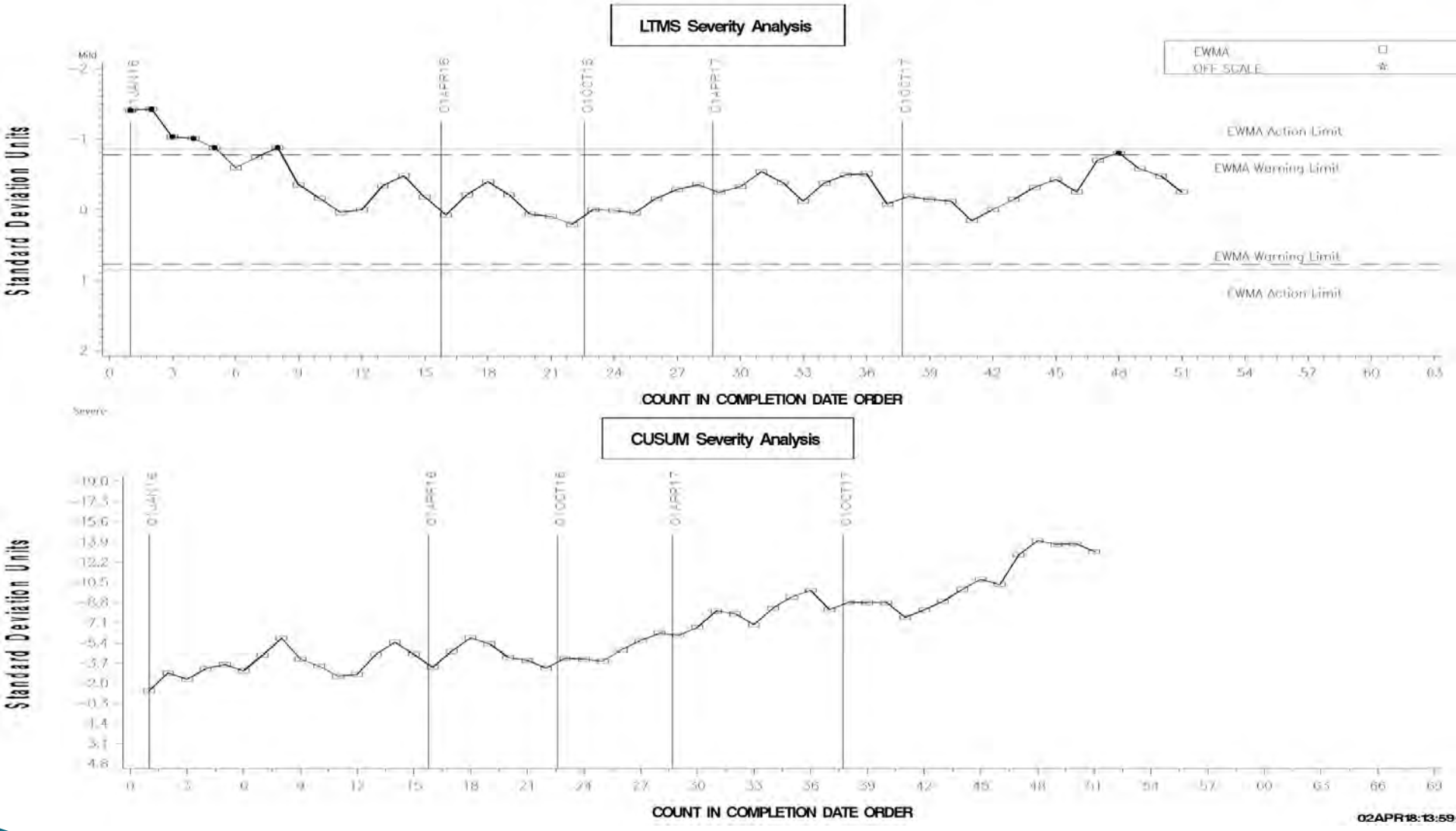
*Invalid and aborted tests

Sequence IX Test Severity

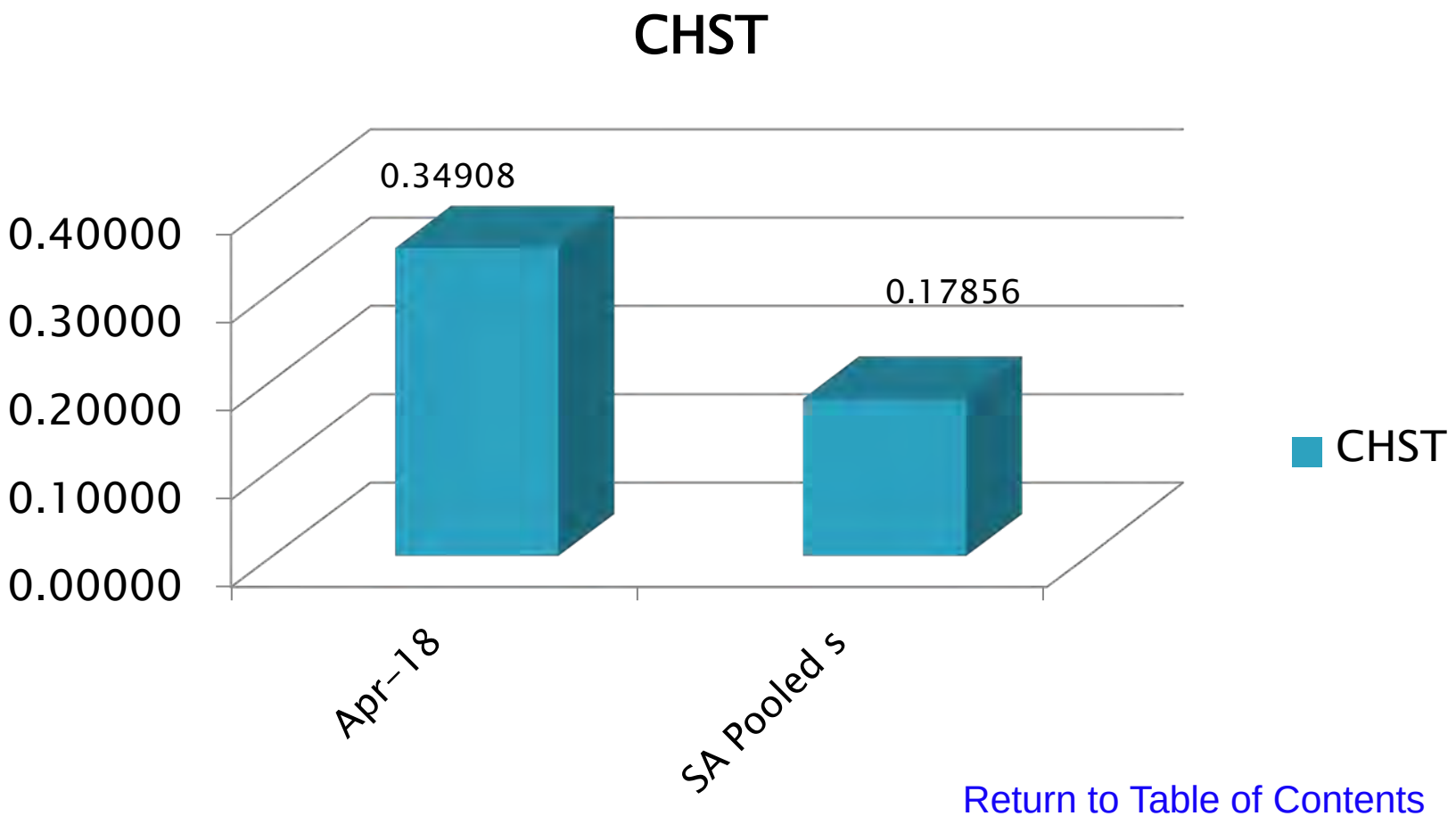
- Average Chain Stretch % in control.

SEQUENCE X INDUSTRY OPERATIONALLY VALID DATA

END OF TEST CHAIN WEAR FINAL RESULT



Sequence X Precision Estimates



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Information Letters

- April 2018

Test Monitoring Center
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Information Letters*

Test	Date	IL	Topic
IIIH	20170425	18-1	Revised MRV reporting method and updated supplier of PCM
VG	20180227	18-1	Revised fuel specification and updated analytical methods for fuel analysis
VIE	20171215	17-3	Updated Annex A17 to address additional engine build items, allowed reuse of cam phasers, addressed missing section 11.6.5.1, address valve mislabeling in A5.6 and corrected annex reference in section 9.4.4

*Available from TMC Website

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Reference Oil Inventory

- Actions, Re-blends, Inventories and Estimated Life

Reference Oil Re-blends

- TMC 222
  - < 1 year supply, supplier contacted, re-blend not available.
- TMC 300-1
  - This re-blend is available, not introduced yet.
- TMC 434-3
  - This re-blend is available, not introduced yet.
- TMC 438-2
  - This re-blend is available, not introduced yet.
- TMC 1009-1
  - This re-blend is available, not introduced yet.

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	60	548	50	3 years
221	IX	2120	300	1517	75	2.5+ years
222	IX	1040	225	205	100	<1 year
270	X	1100	85	878	30	<1 year
271	X	980	95	804	40	<1 year
300	IVB	330	36	7	28	<1 year
300-1	IVB	328	0	328	0	5 years
433-1	IIIF	1045	0	0	8	<1 year
433-2	IIIF	500	16	180	32	2+ years
434	IIIG	550	0	<1	12	<1 year

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
434-1	IIIG	660	0	4	20	1.5 years
434-2	IIIG, IIIH	495	18	7	28	<1 year
434-3	IIIG, IIIH	980	45	935	25	5+ years
435	IIIG	550	0	2	4	<1 year
435-2	IIIG	550	18	139	28	3+ years
436	IIIH	1100	105	797	52	5+ years
438	IIIG	990	16	21	20	1.5 years
438-1	IIIH	605	54	72	36	<1 year
438-2	IIIH	540	0	540	0	5 years
542-2	VIE	1000	25	0	24	<1 year
542-3	VIE	997	198	560	168	2+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
543	VIF	1100	54	762	30	3+ Years
544	VIE	897	107	321	84	2+ years
704-1	VIII	897	14	89	10	5+ years
940	VG, VH	560	27	199	30	3+ years
1006-2	IVA, VG, VIII	5500	275	1344	98	2+ years
1009	VG, VH, VIII	1100	5	34	18	<1 year
1009-1	VG, VH, VIII	1100	0	1094	6	5 years
1010-1	VIE	1760	243	801	90	3 years
1011	IVB/VH/VIF/X	1100	188	678	159	3 years
1012	IVB	2200	36	2065	16	5+ years

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LTMS Deviations

- October 1, 2017 – March 31, 2018

LTMS Deviations

- No LTMS Deviations this period

LTMS Deviations

Historical Count of PCEO LTMS Deviations

Test	LTMS Deviations
IIIF	6
IIIG	6
IIIH	0
IVA	7
VG	8
VID	3
VIE	0
VIF	0
VIII	3
IX	0
X	0

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Quality Index Deviations

- October 1, 2017 – March 31, 2018

Quality Index Deviations

- Five Quality Index Deviations this Report Period.
  - IVA – Rocker cover fresh air flow (Lab B)
  - VG – RAC coolant in temperature (Lab G)
  - IX – Intake air pressure (Lab B)
  - X – Speed (Lab A)
  - X – Air charge temperature (Lab A)

Quality Index Deviations

Historical Count of PCEO Quality Index Deviations

Test	Quality Index Deviations
IIIF	28
IIIG	16
IIIH	5
IVA	30
VG	46
IX	1
X	2

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TMC Laboratory Visits

- October 1, 2017 –
  March 31, 2018

TMC Lab Visits

Test	Number of Labs Visited
VIE	2
VH	2
IIIH	4

Lab Visit Issues

- VH
  - Exhaust backpressure probe not located properly.
  - Intake air temperature T/C not properly located
  - No sight glass in system
- VIE
  - Wrong line size to and from filter.
- IIIH
  - Part number missing from flow control valve, unable to verify correct part number.

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Test Area Timelines

- October 1, 2017 – March 31, 2018

Test Area Timeline Additions*

Test	Date	Topic	IL
IIIH	20180308	Updated PCM supplier and revised MRV reporting method	18-1
VG	20180227	Updated fuel specification and analytical methods for fuel analysis	18-1
VIE	20170925	Updated Annex A17 to address additional build items for using GM short block engines, corrected A5.6 and 9.4.4. Added missing section 11.6.5.1. Allow reuse of cam phasers.	17-3
X	20171128	Begin calibrated testing with 2016 Grade BC Pistons	

*As of 03/31/2018

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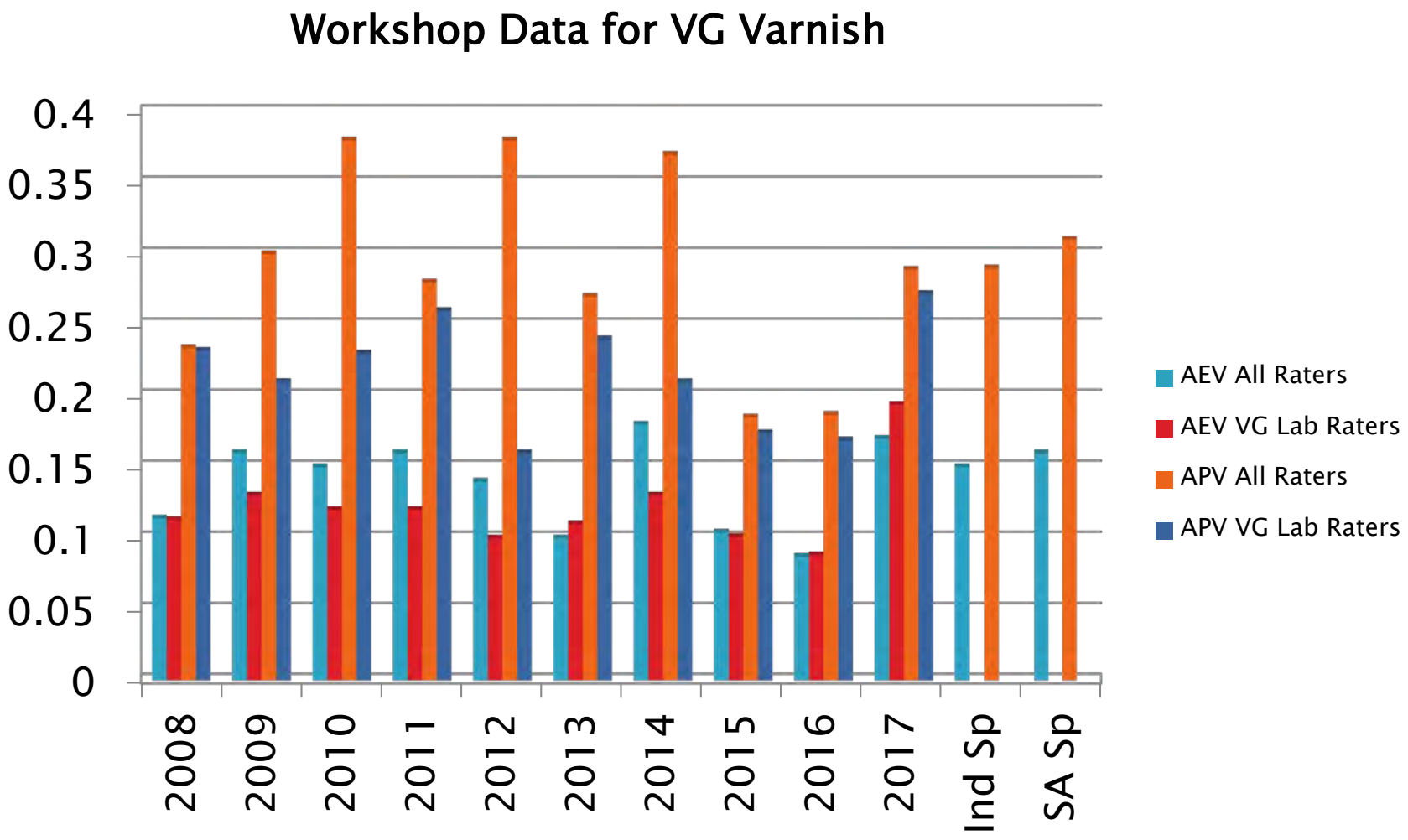
Rating Workshop Data

- 2017 Light Duty Workshop

Rating Workshop Data

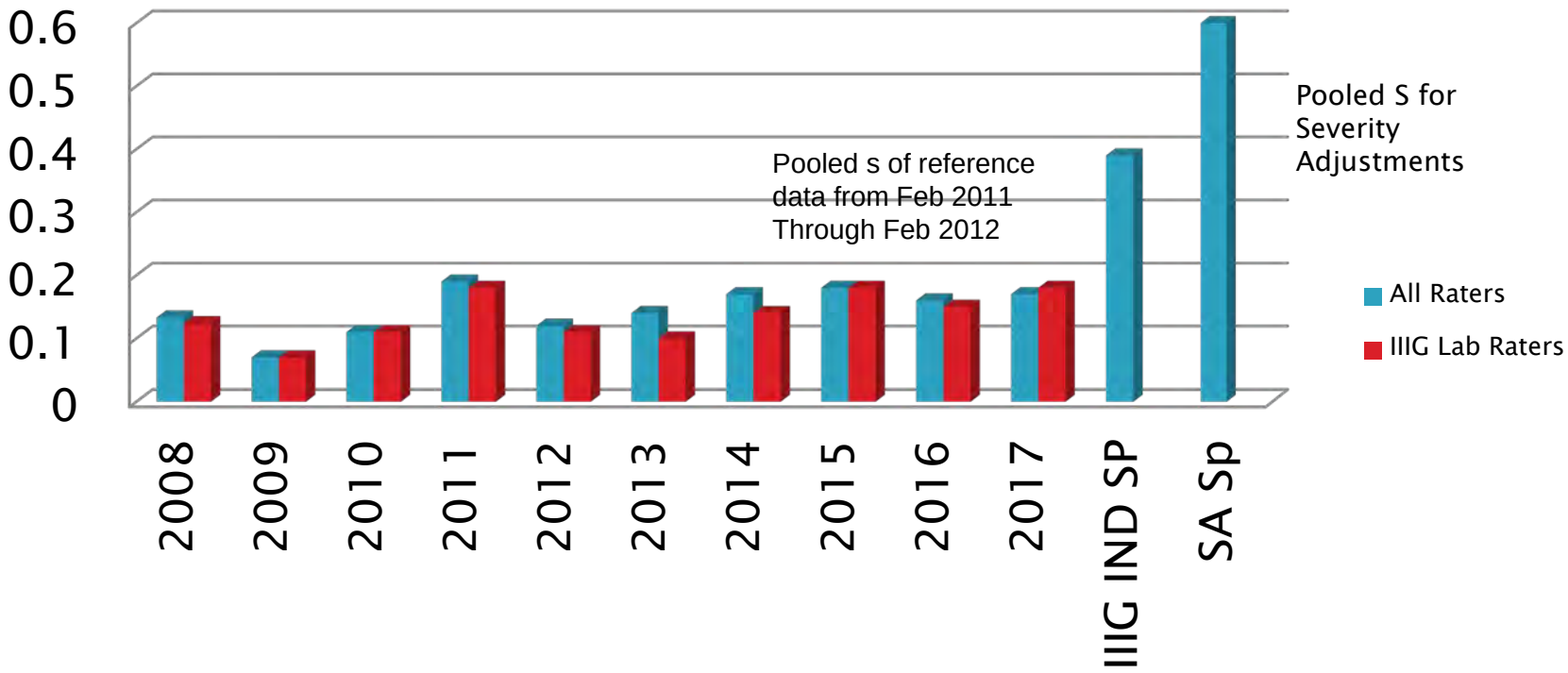
- Summary of Precision Data From Light Duty Rating workshops:
  - VG Average Piston and Average Engine Varnish.
  - IIIG WPD
  - IIIH WPD

Sequence VG Precision-Rating Workshop Data



Sequence IIIG Precision – Rating Workshop Data

Comparison of Workshop Pooled Standard Deviations with Industry Pooled Standard Deviations



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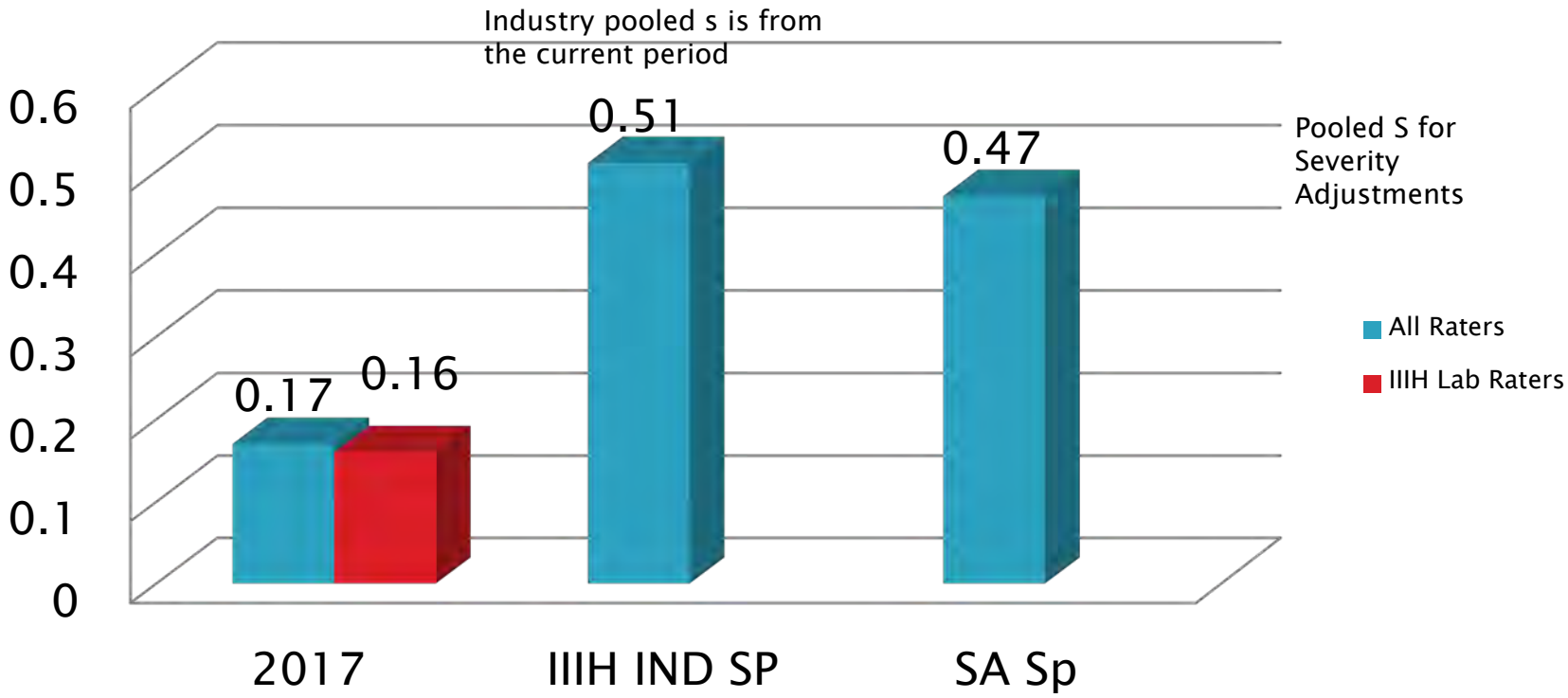
Sequence IIIH Precision – Rating Workshop Data

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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