ASTM D02.B1 Semiannual Report Passenger Car Reference Oil Testing

October 2016

Table of Contents

Table of Contents

Passenger Car Engine Oil Testing Executive Summary

- Seq. IIIH
  - Sequence IIIH calibrations began in April.
- Seq. VI
  - Industry estimates show a limited number of engines (3) remain for Sequence VID Testing
  - Monitoring of the VIE Test began in August
- Seq. VIII
  - 06-16 bearings were accepted, test is now available.

Return to Table of Contents

Calibrated Labs and Stands*

Test	Labs	Stands
IIIF	3	4
IIIG/A/B	3	5
IIIH/A/B	5	8
IVA	3	4
VG	3	6
VID	2	3
VIE	3	6
VIII	3	4

Return to Table of Contents

*As of 9/30/2016

Sequence IIIF

- October 2016

Sequence IIIF Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	7
Failed Calibration Test	OC	1
Operationally Invalid	LC	1
Total		9

Sequence IIIF – Failed Tests

Test Status	Number of Tests
Mild APV	1
Total	1

Sequence IIIF – Lost Tests

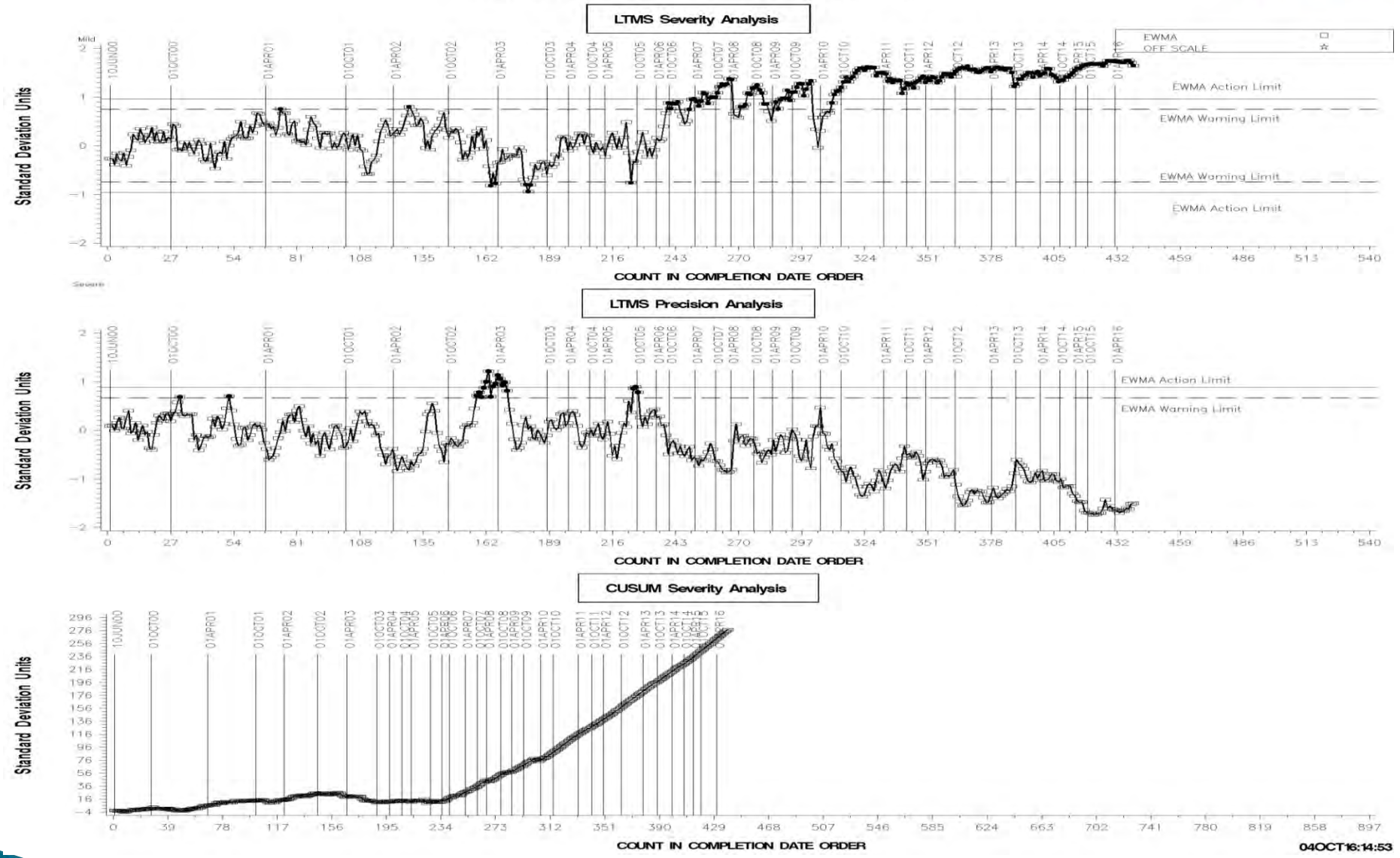
Test Status	Number of Tests
Cam Bearing Distress	1
Total	1

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 warning alarm (severe)

SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

AVERAGE PISTON SKIRT VARNISH FINAL ORIG UNIT RES



SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

HOURS FINAL ORIG RES (REFERENCE TESTS ONLY)

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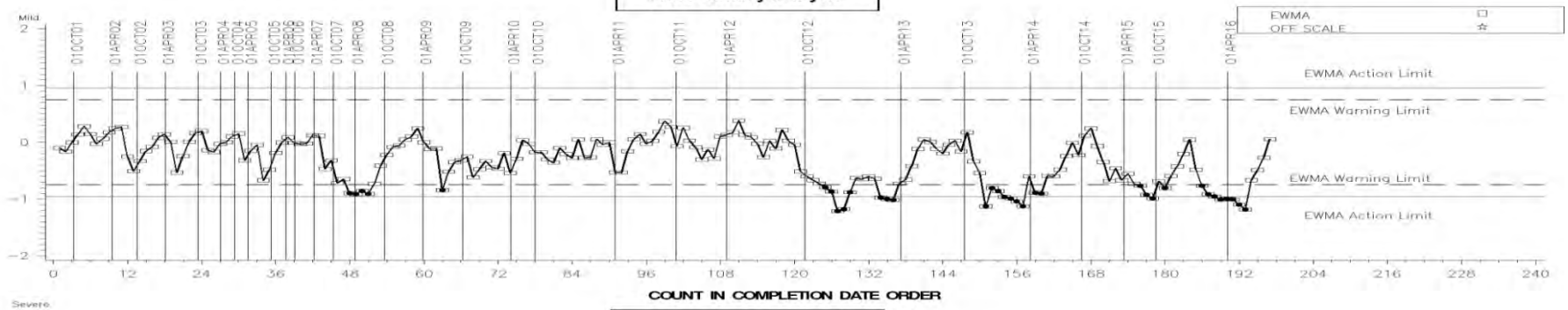
LTMS Severity Analysis



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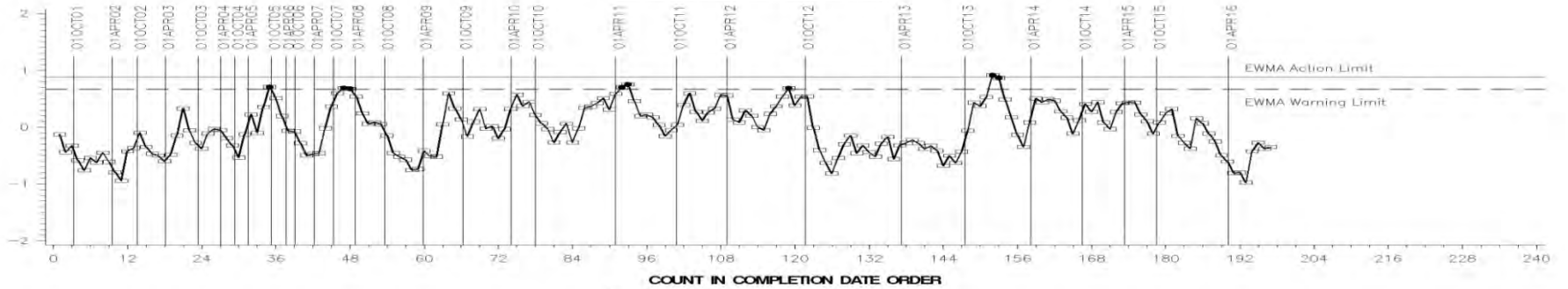
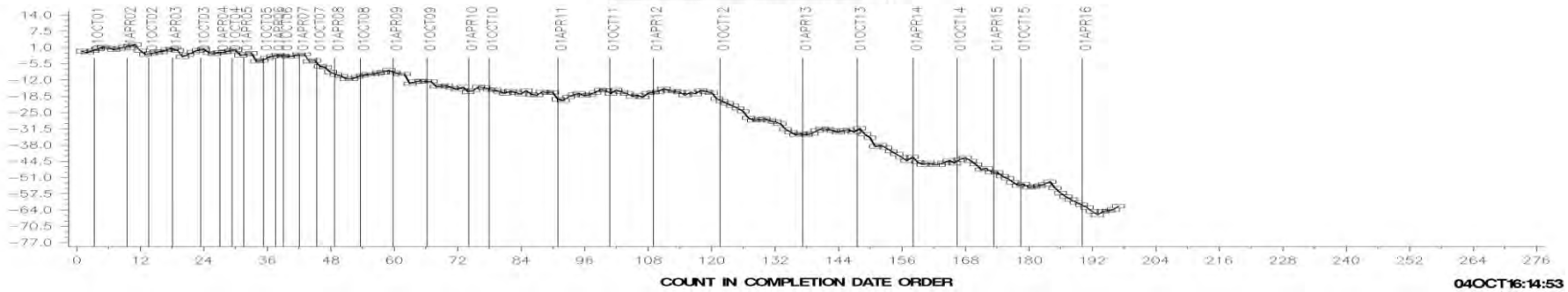


CUSUM Severity Analysis



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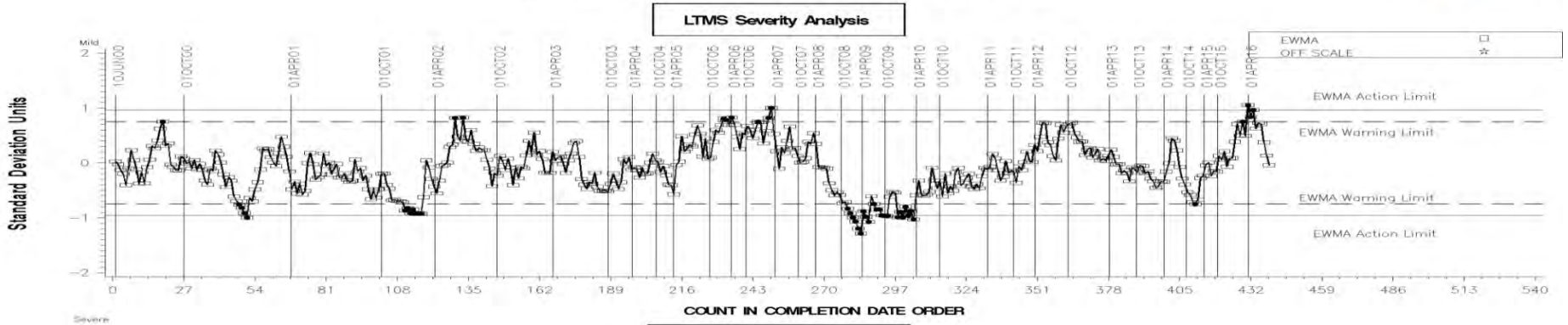
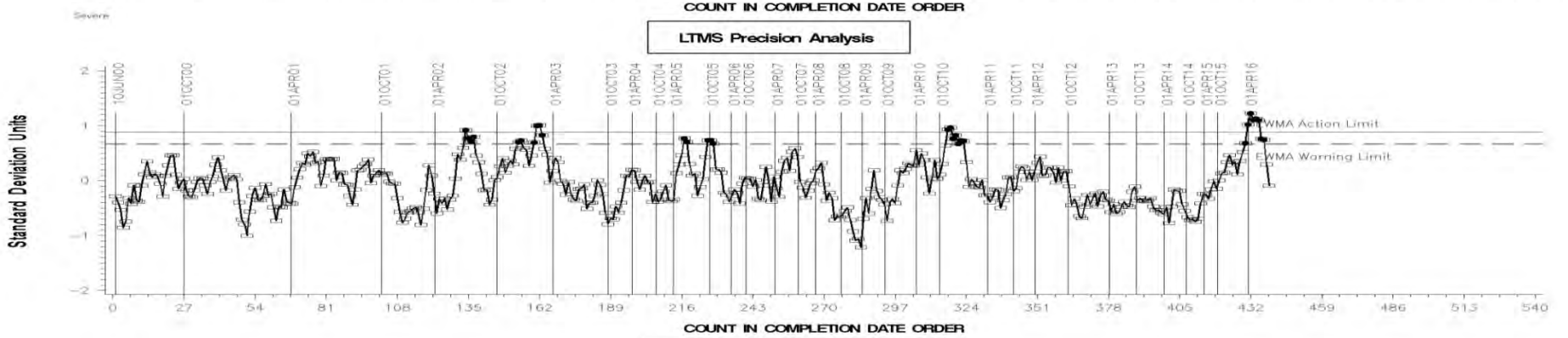
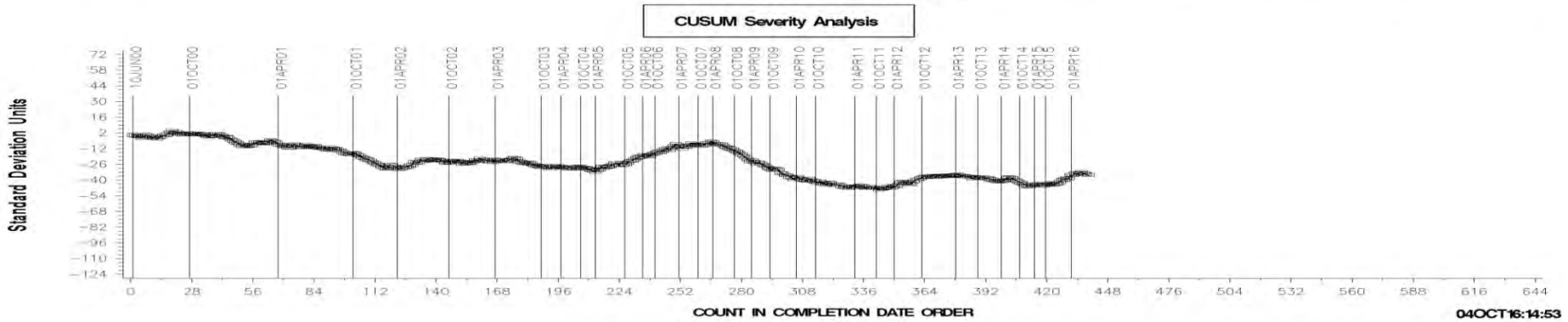
SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

AVERAGE WEIGHTED PISTON DEPOSITS FNL ORIG UNIT RES







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Test Monitoring Center
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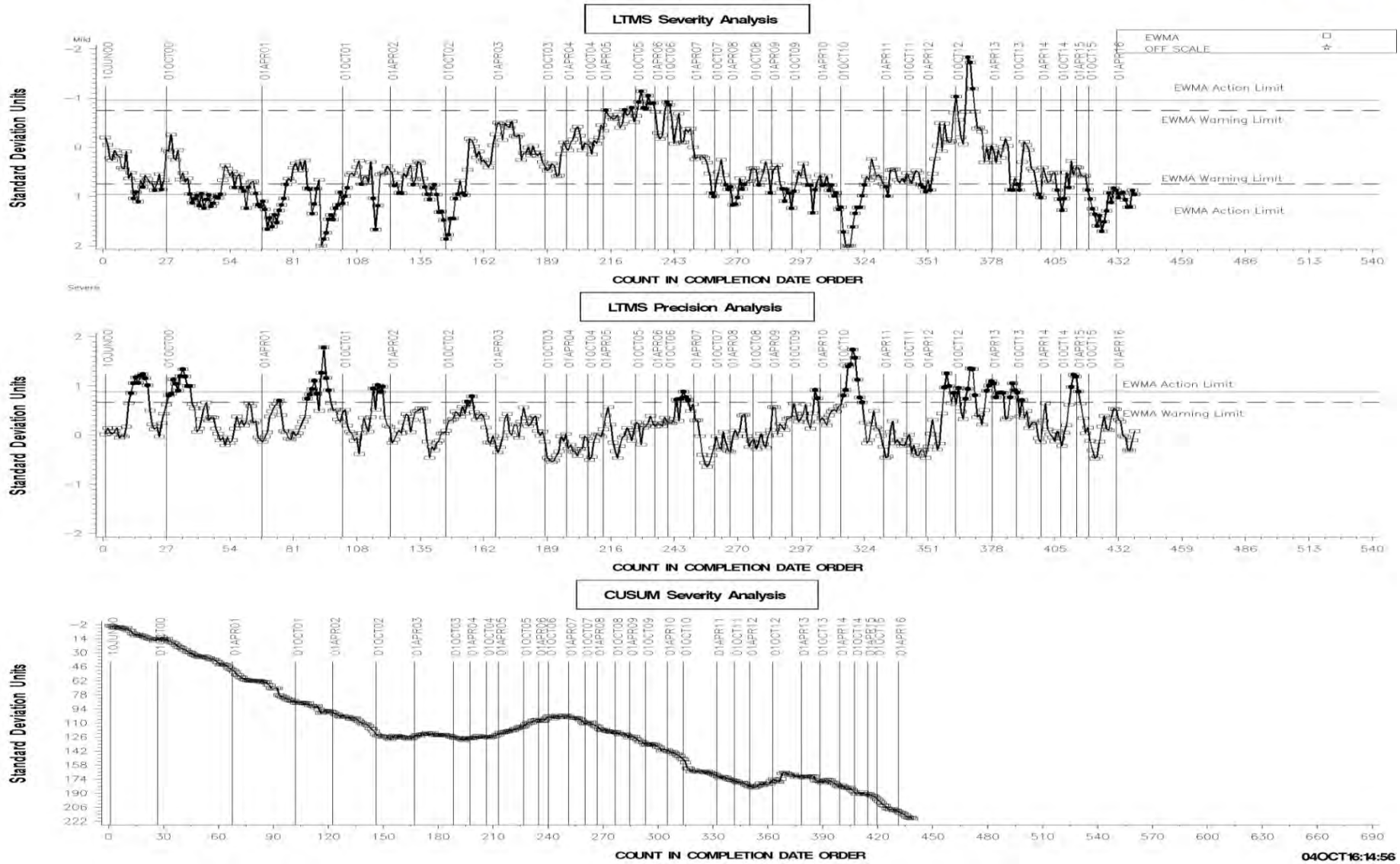
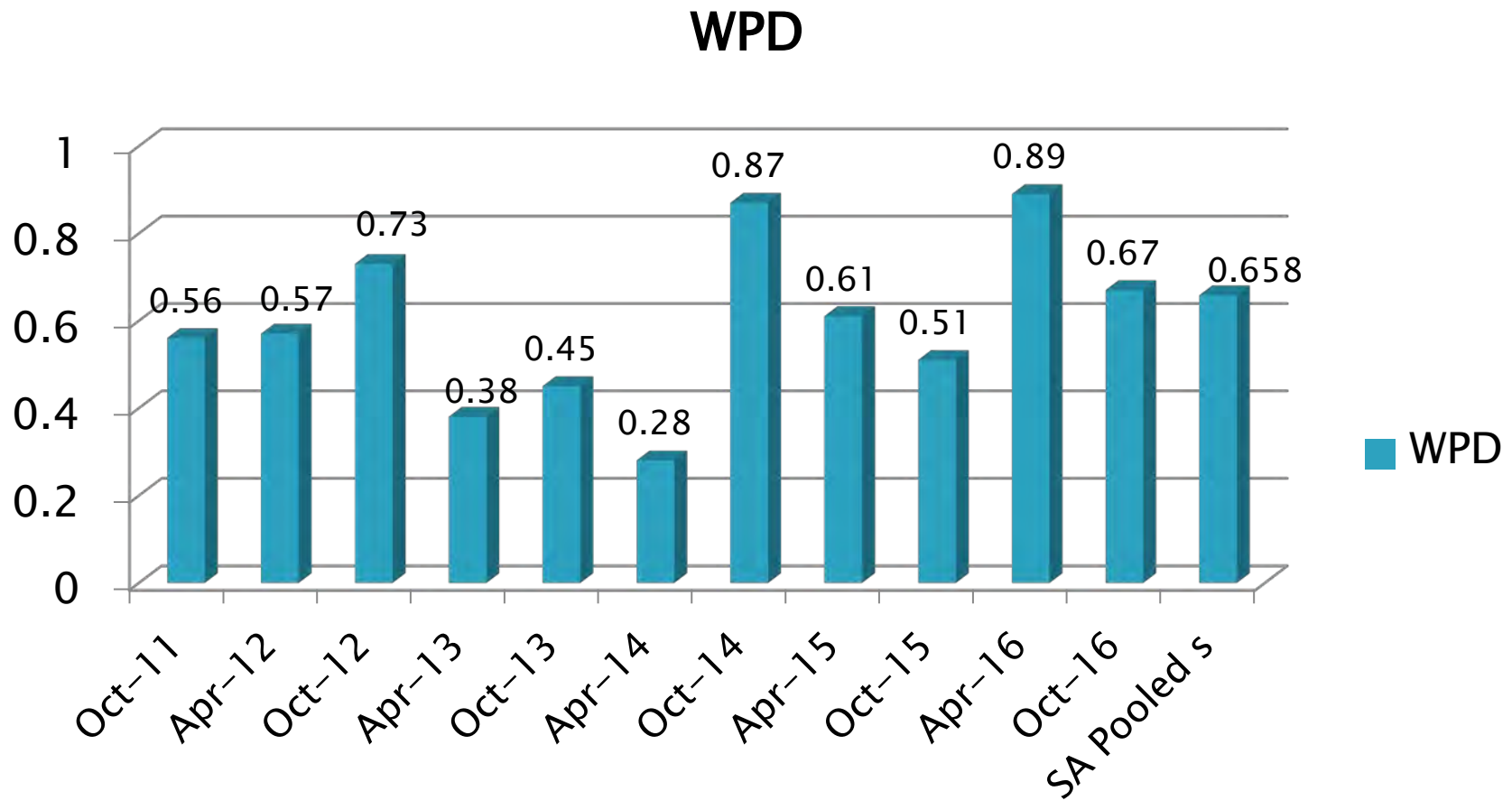
SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

% VISCOSITY INCREASE @ 060 HOURS



IIIF Precision Estimates



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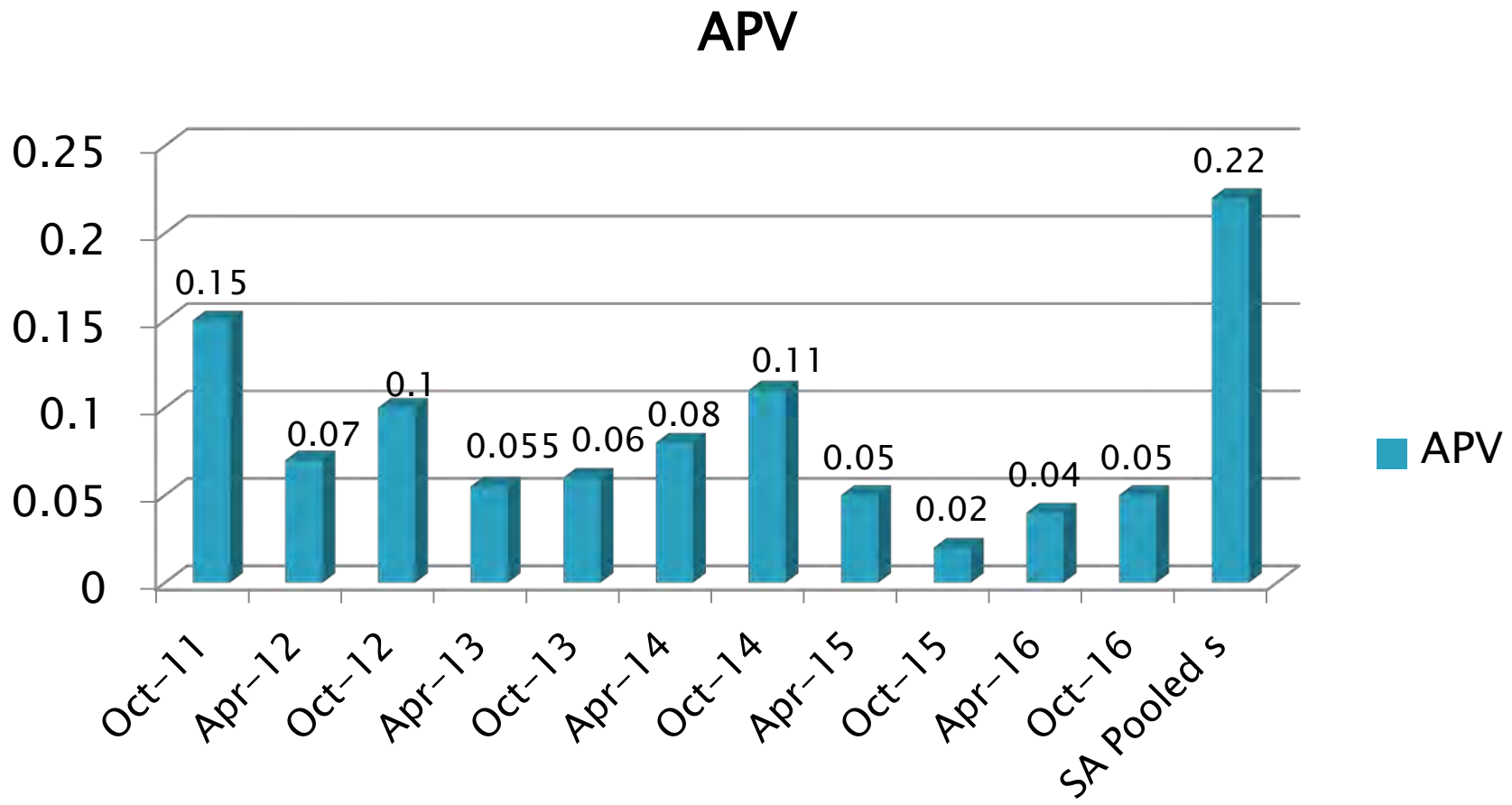

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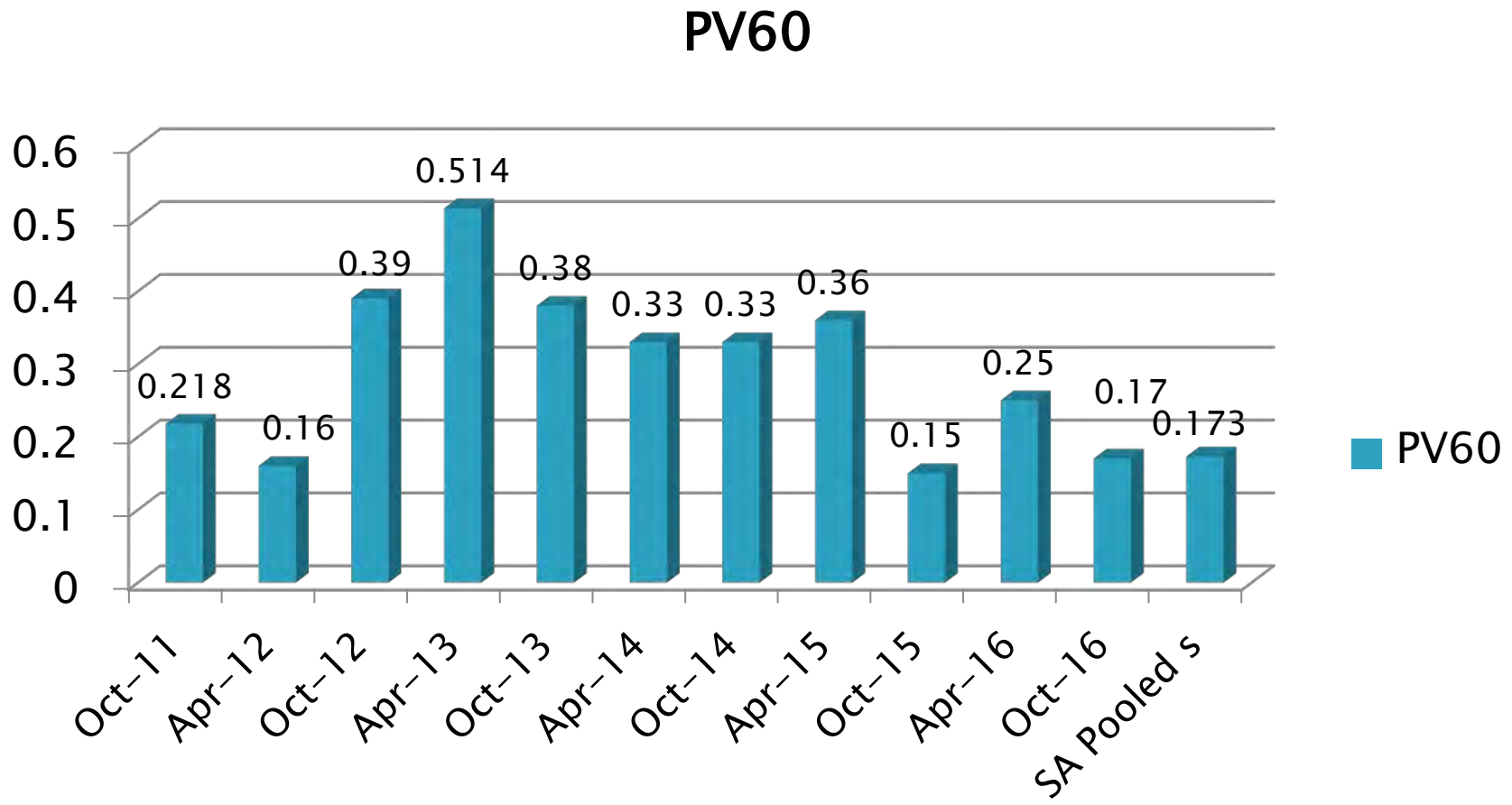
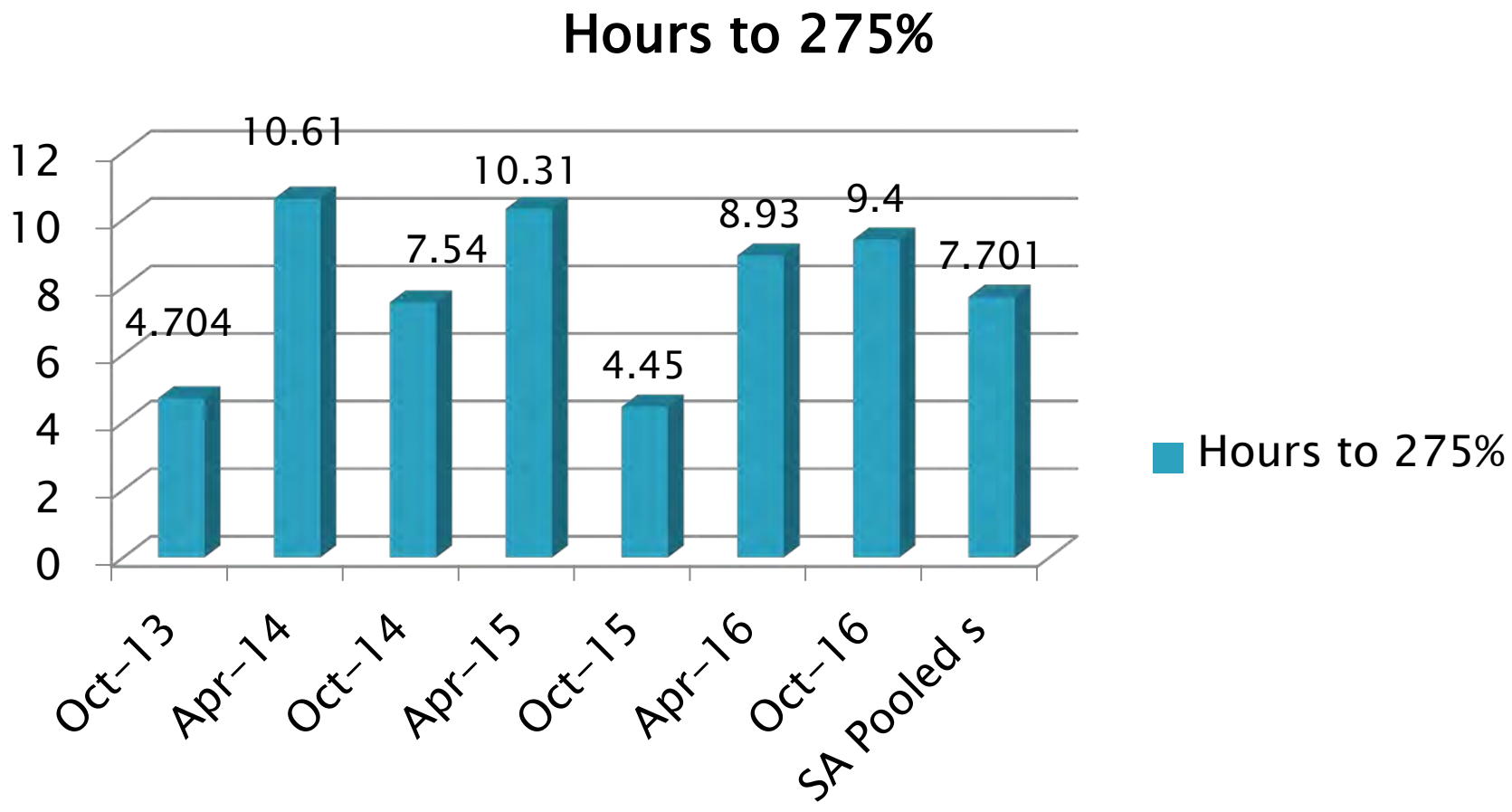


IIIF Precision Estimates



Return to Table of Contents

Sequence IIIG/A/B

- October 2016

Sequence IIIG Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	5
Aborted	XC	1
Total		**6**

Sequence IIIG – Lost Tests*

Test Status	Cause	#
Aborted	Computer malfunction resulted in loss of test data	1
Totals		**1**

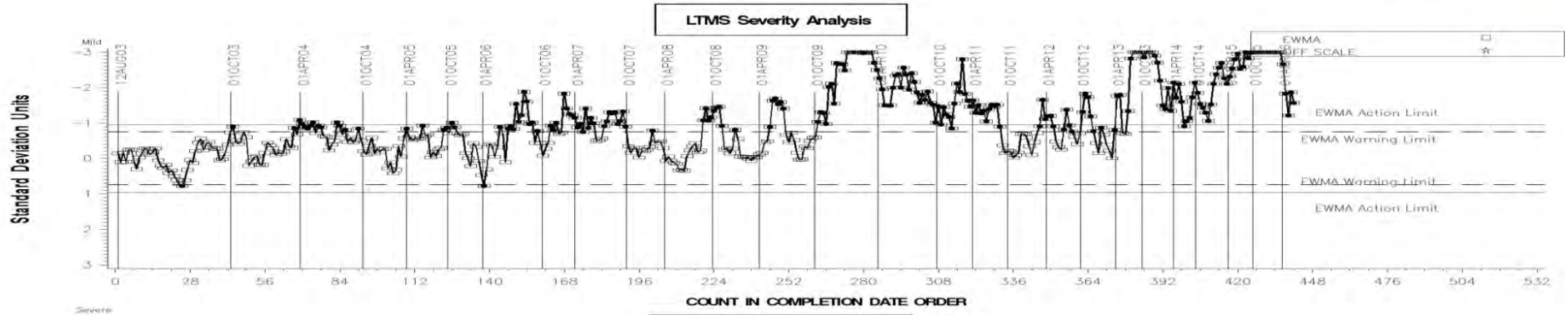
*Invalid and aborted tests

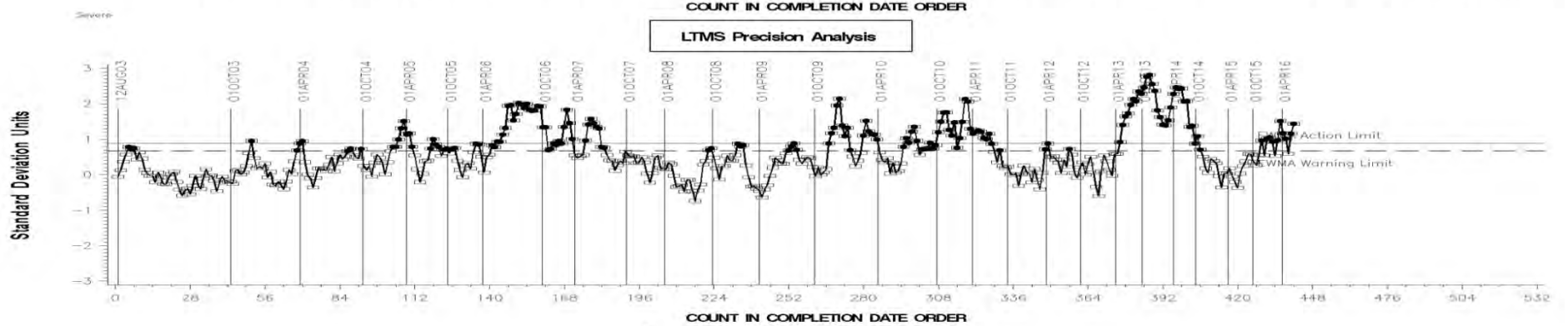
Sequence IIIG Test Severity

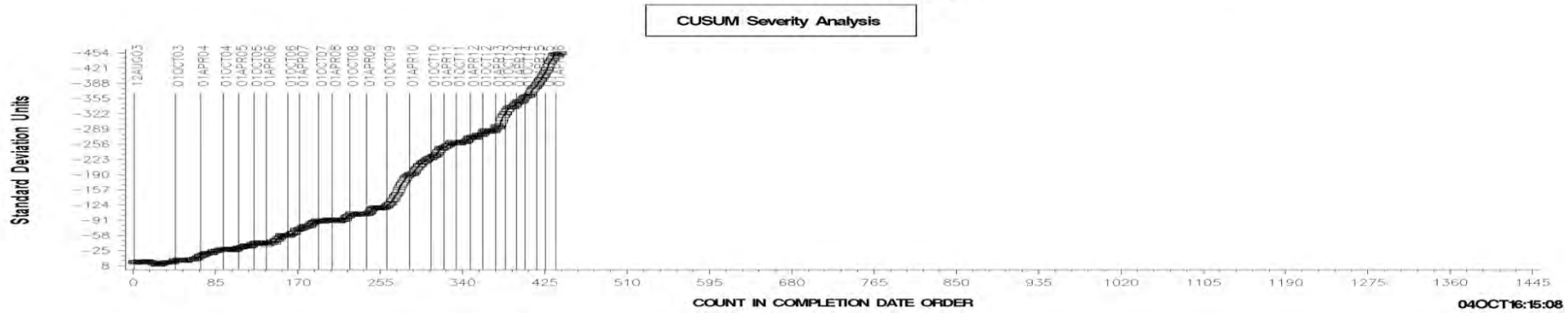
- ACLW in severity and precision action alarm
  - Long-term mild trend
- PVIS in severity action alarm (severe)
- WPD is in control
  - Long-term severe trend continuing
- MRV is in severity action alarm (severe)
- PHOS in severity and precision warning alarm (severe)

SEQUENCE IIIG INDUSTRY OPERATIONALLY VALID DATA

AVERAGE CAM + LIFTER WEAR







SEQUENCE IIIG INDUSTRY OPERATIONALLY VALID DATA

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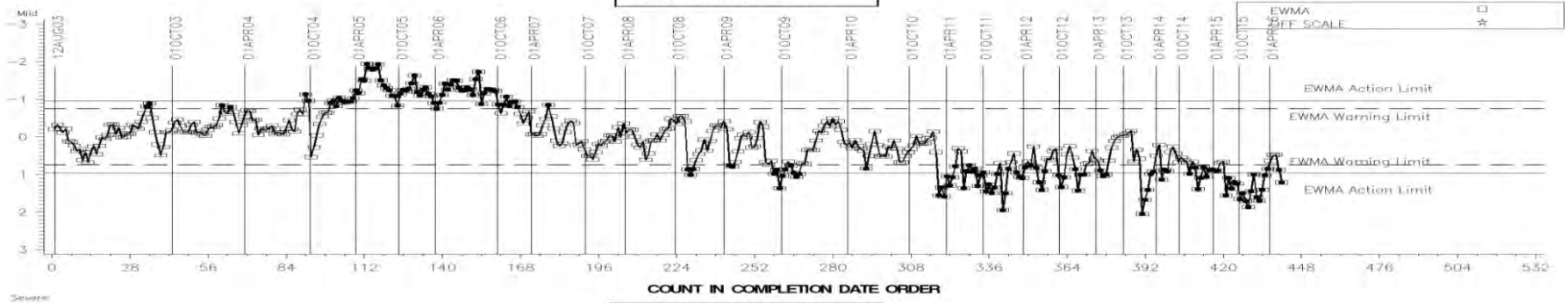
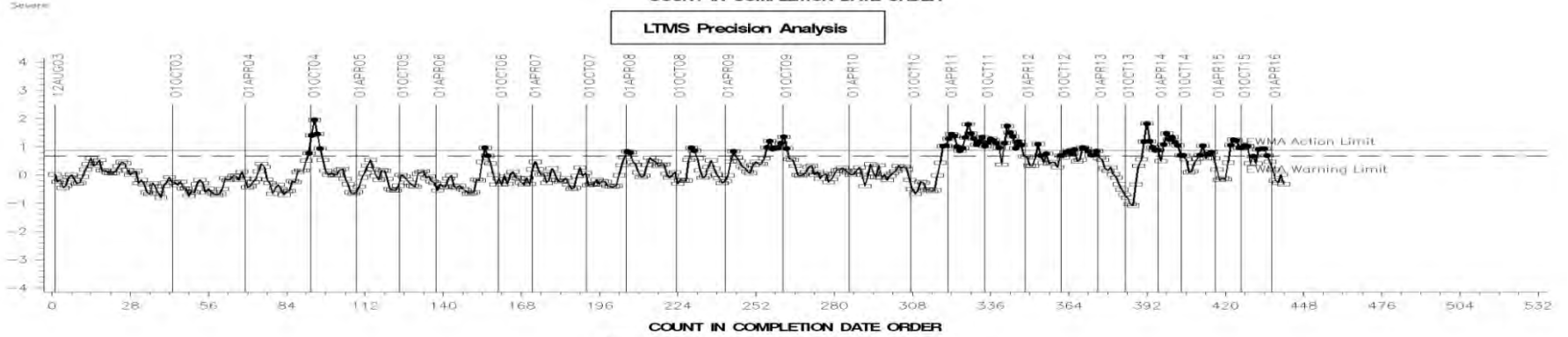
VISCOSITY INCREASE

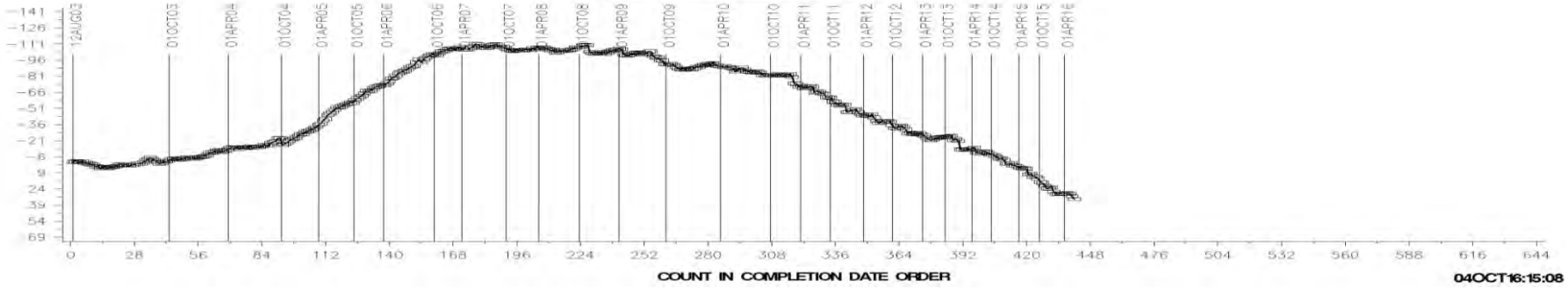
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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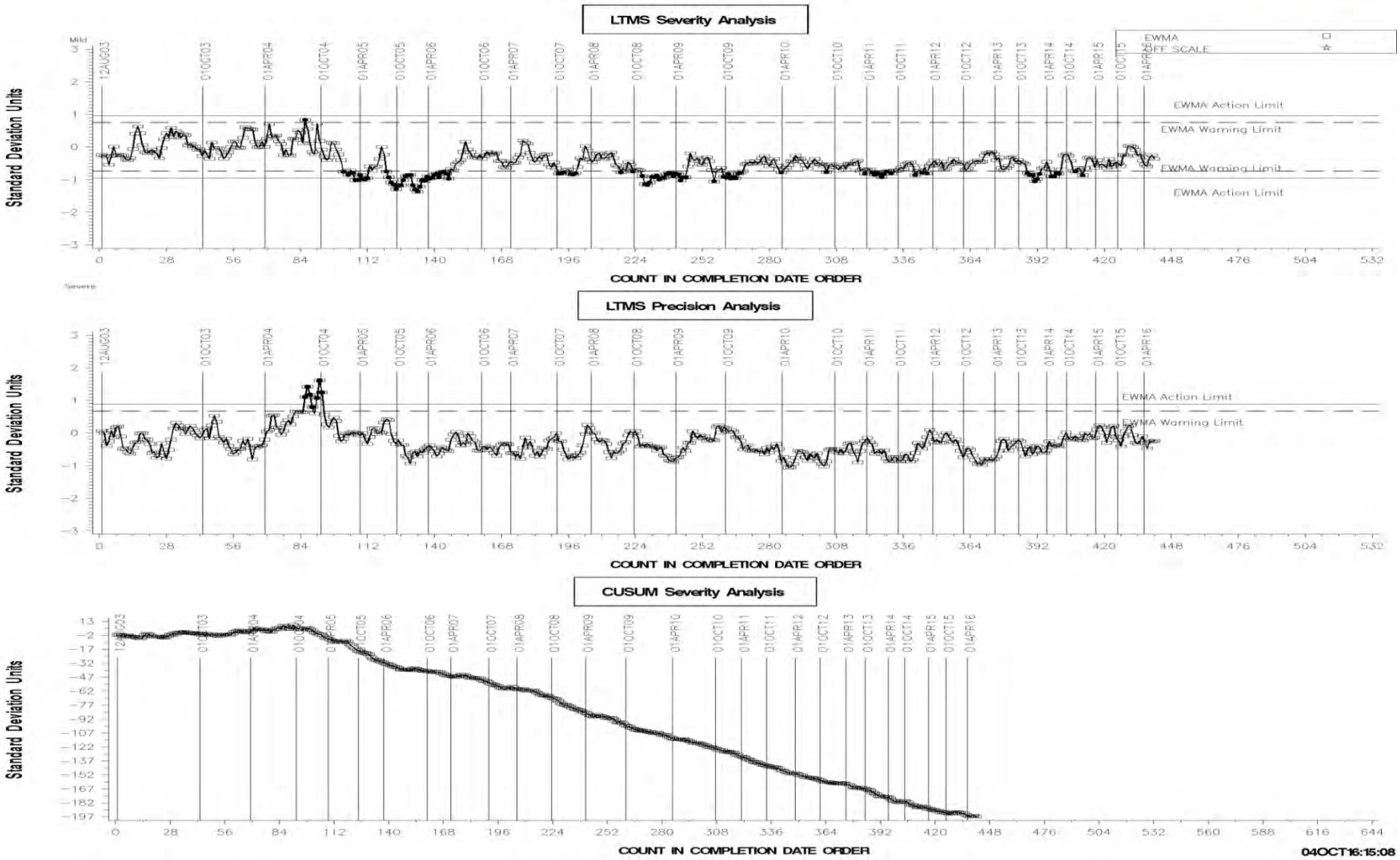
SEQUENCE IIIG INDUSTRY OPERATIONALLY VALID DATA

AVERAGE WEIGHTED PISTON DEPOSITS



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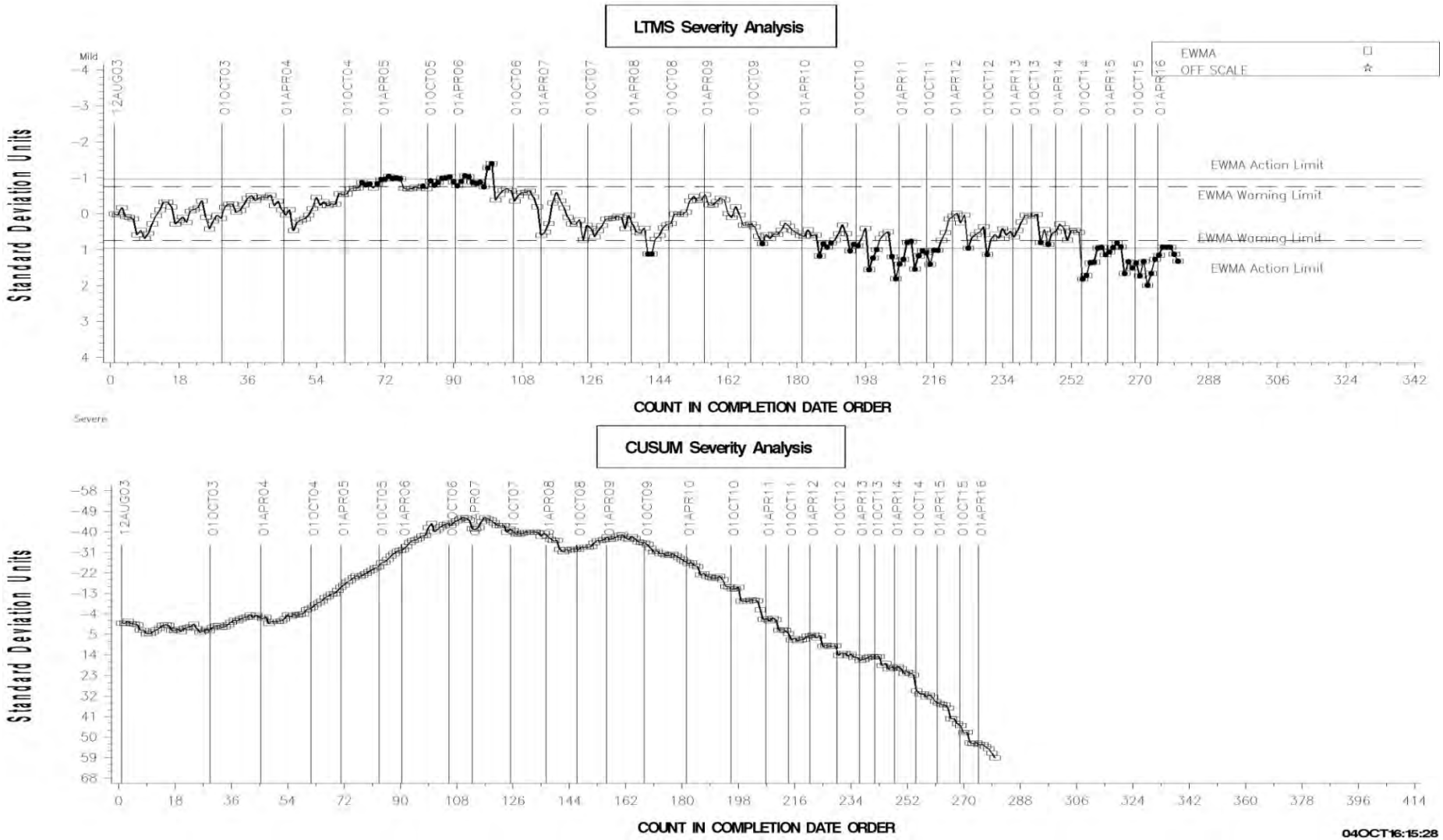
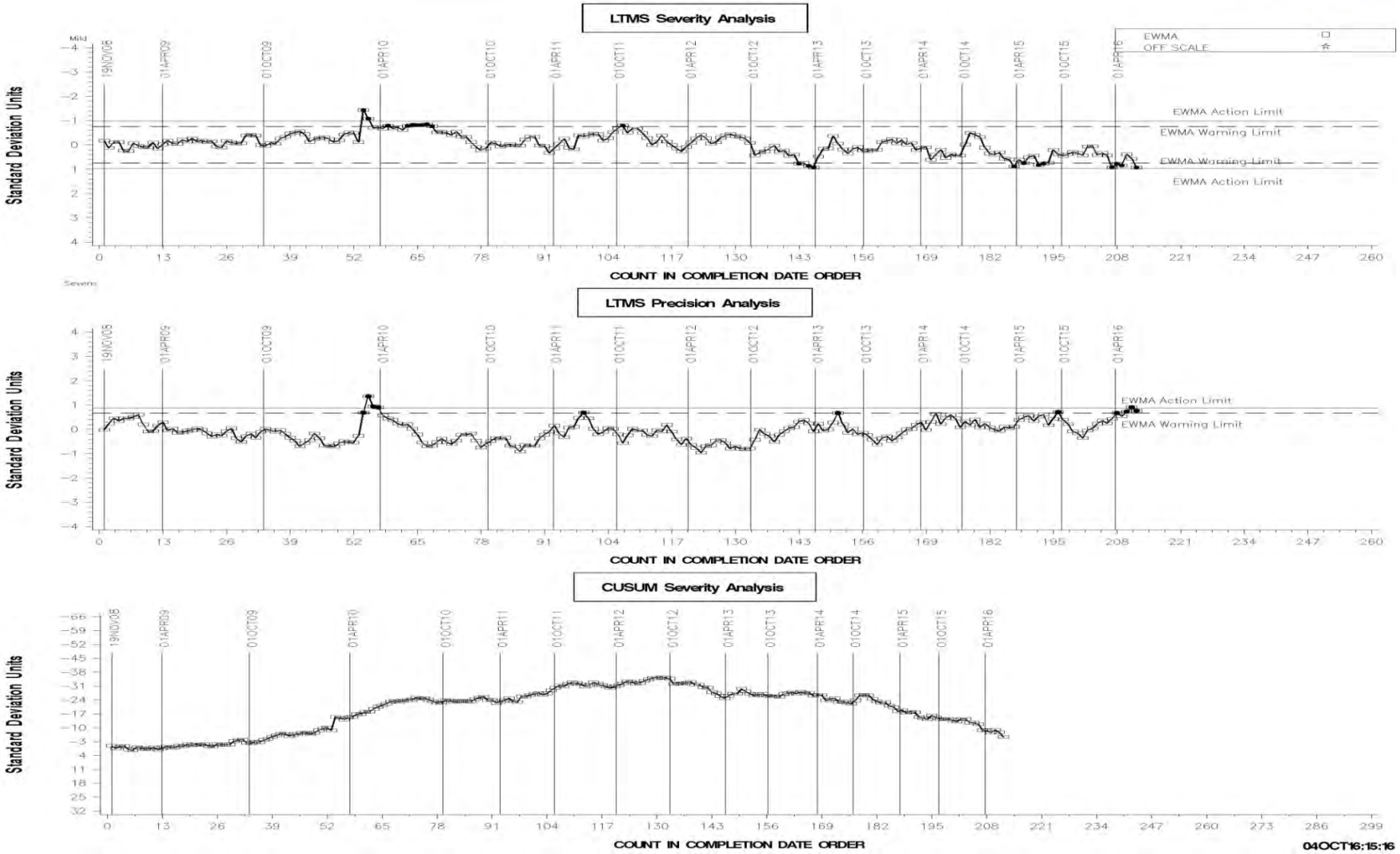
SEQUENCE IIIGA INDUSTRY OPERATIONALLY VALID DATA

MRV VISCOSITY RESULT

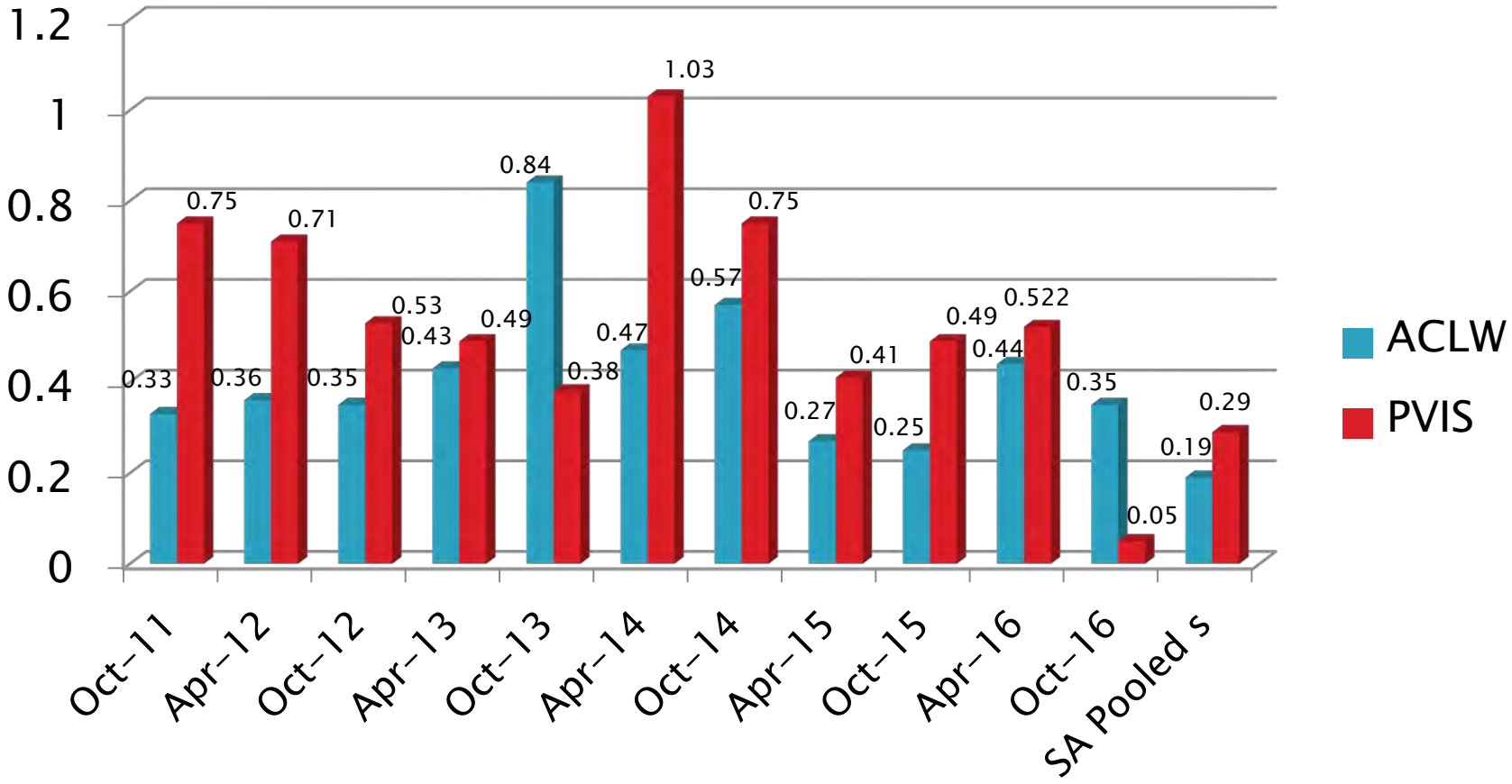


SEQUENCE IIIGB INDUSTRY OPERATIONALLY VALID DATA

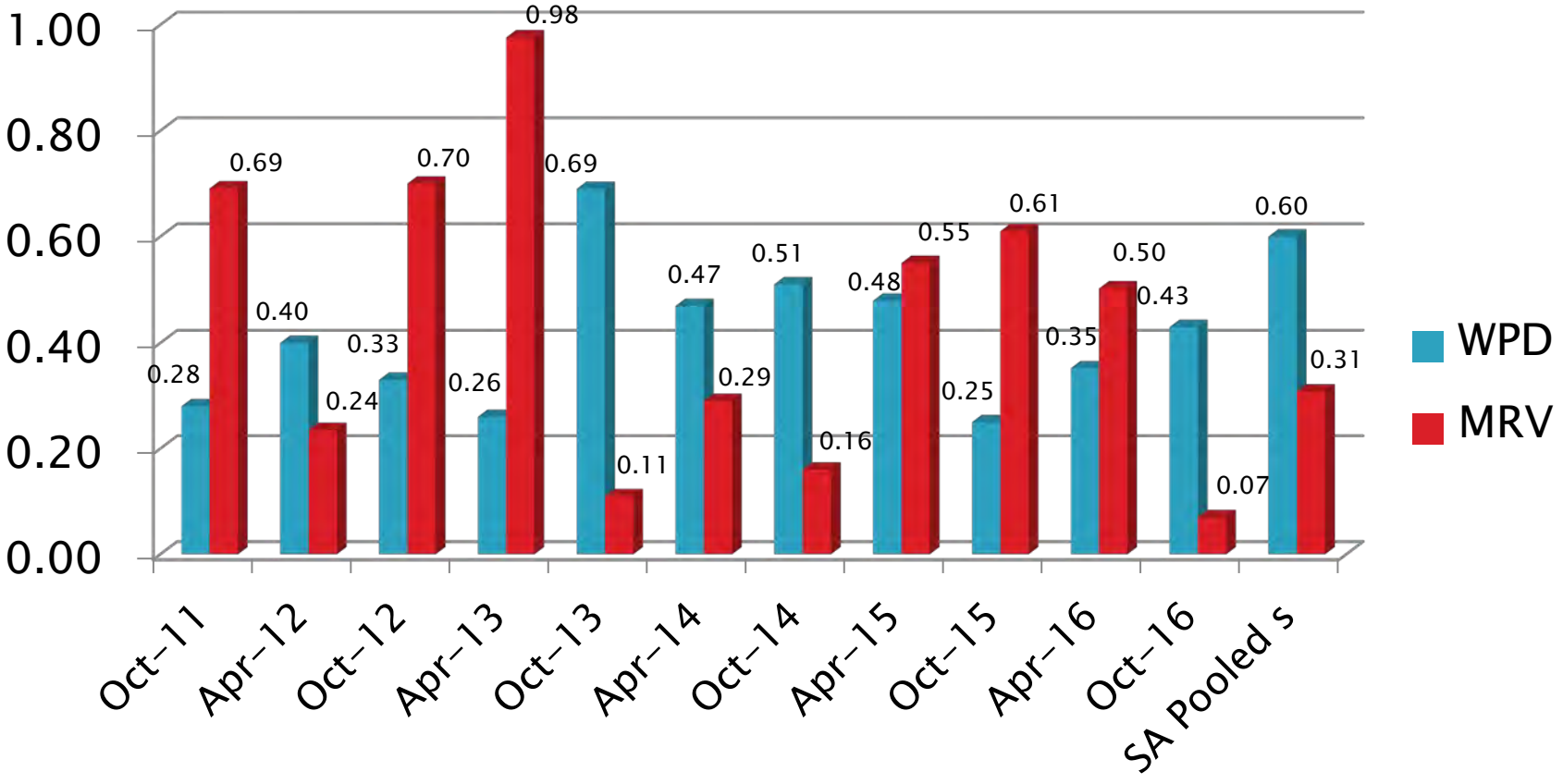
PHOS RETENTION



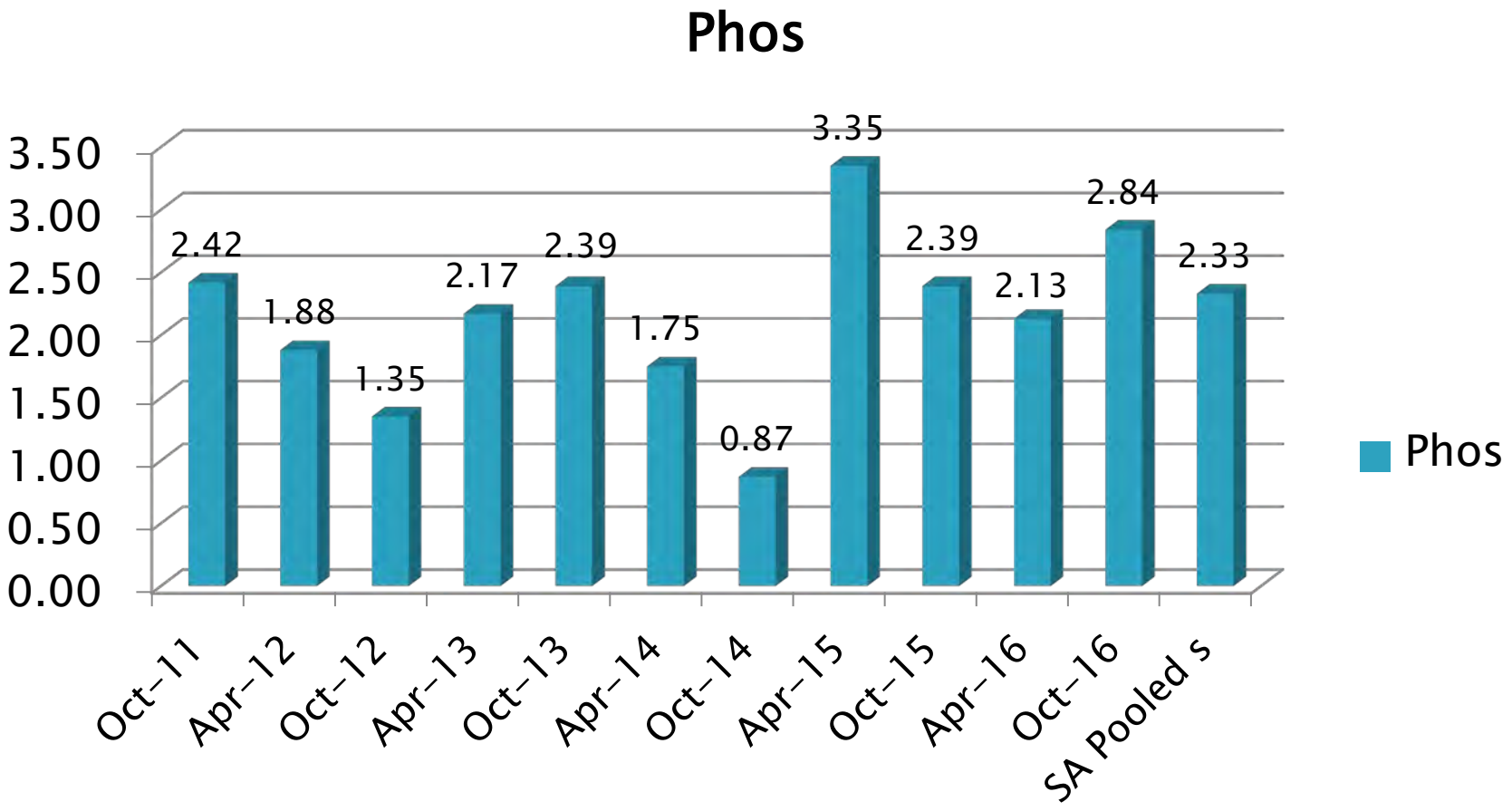
IIIG Precision Estimates



IIIG Precision Estimates



IIIG Precision Estimates



Return to Table of Contents

Sequence IIIH/A/B

- October 2016

Test Monitoring Center
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Sequence IIIH Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	15
Statistically Unacceptable Calibration Test	OC	8
Operationally Invalid Calibration Test	LC	1
Acceptable IIIF/IIIH Correlation Test	AI	1
Aborted IIIF/IIIH Correlation Test	XI	1
Total		**26**

Sequence IIIH – Failed Tests

Test Status	#
Level 3 Ei Alarm PVIS, WPD	2
Level 3 Ei Alarm MRV	1
Level 3 Ei Alarm WPD	3
Level 3 Ei Alarm PVIS	2
Totals	**8**

Sequence IIIH – Lost Tests*

Test Status	Cause	#
Aborted	Loss of Oil Temperature Control	1
Invalid	Excessive Downtime	1
Totals		**2**

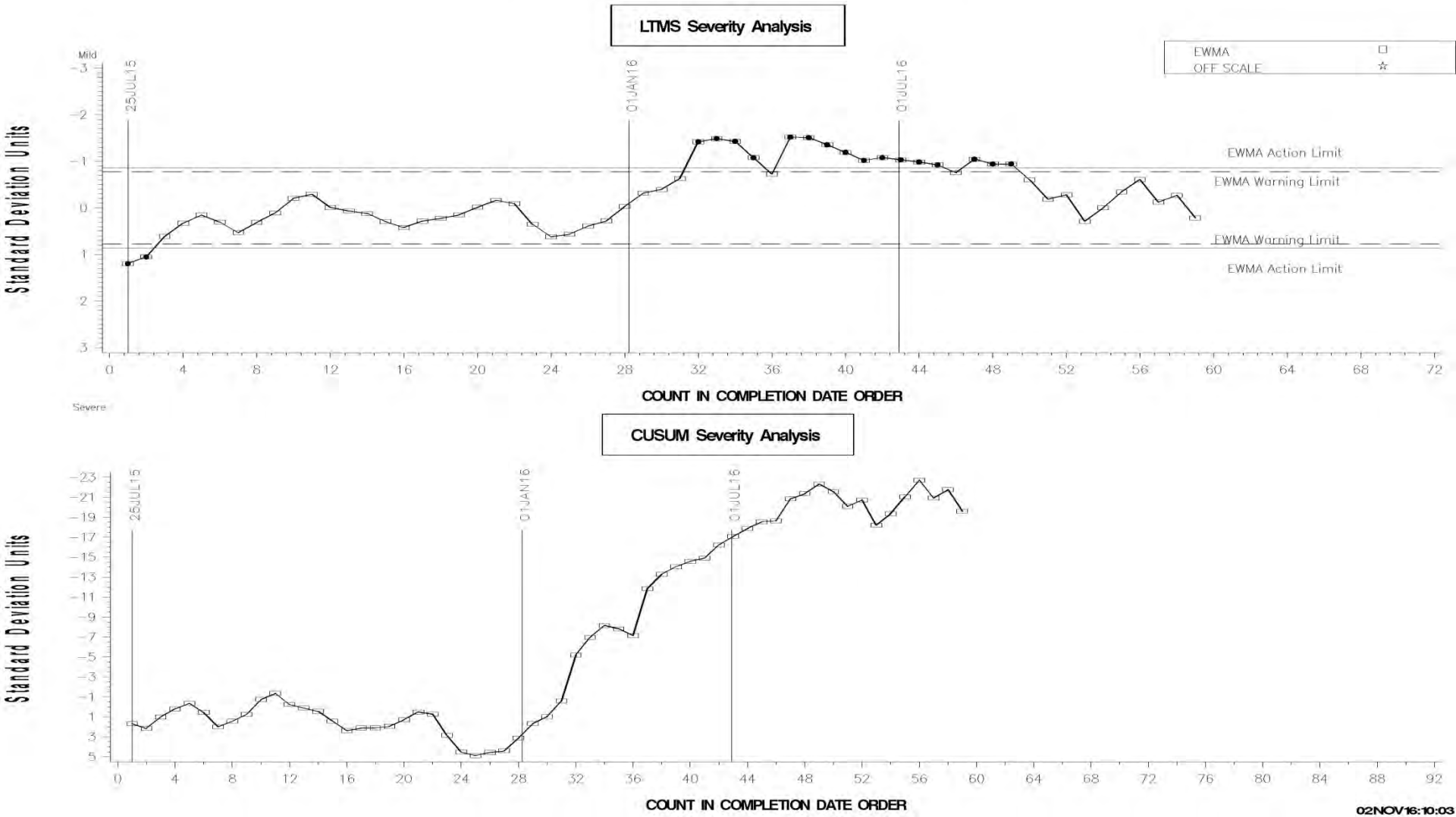
*Invalid and aborted tests

Sequence IIIH Test Severity

- PVIS is in control
- WPD is in control
- MRV is in control
- PHOS is in control

SEQUENCE IIIH INDUSTRY OPERATIONALLY VALID DATA

VISCOSITY INCREASE FINAL ORIG UNIT RES



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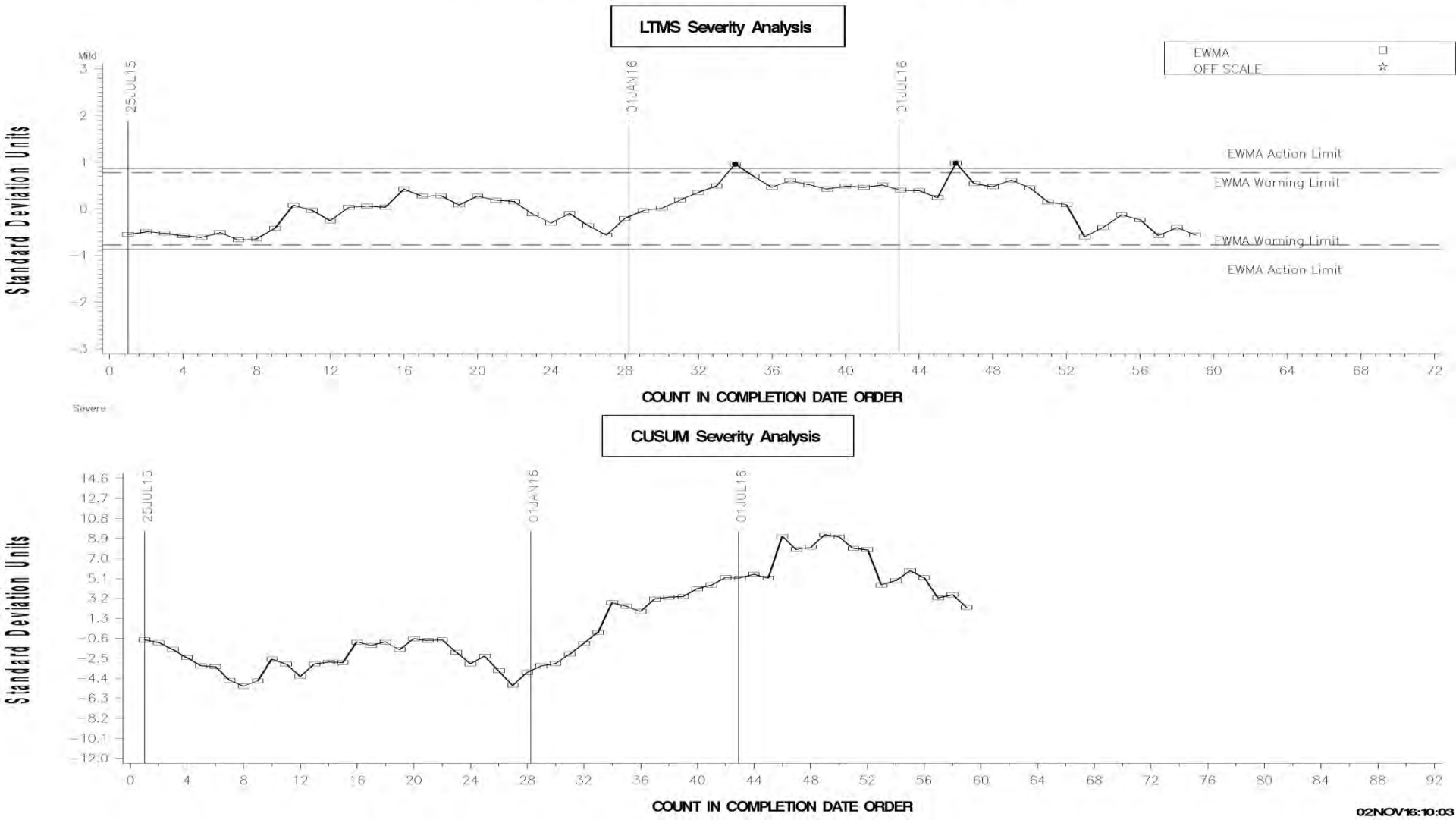
SEQUENCE IIIH INDUSTRY OPERATIONALLY VALID DATA

AVERAGE WEIGHTED PISTON DEPOSITS FNL ORIG U



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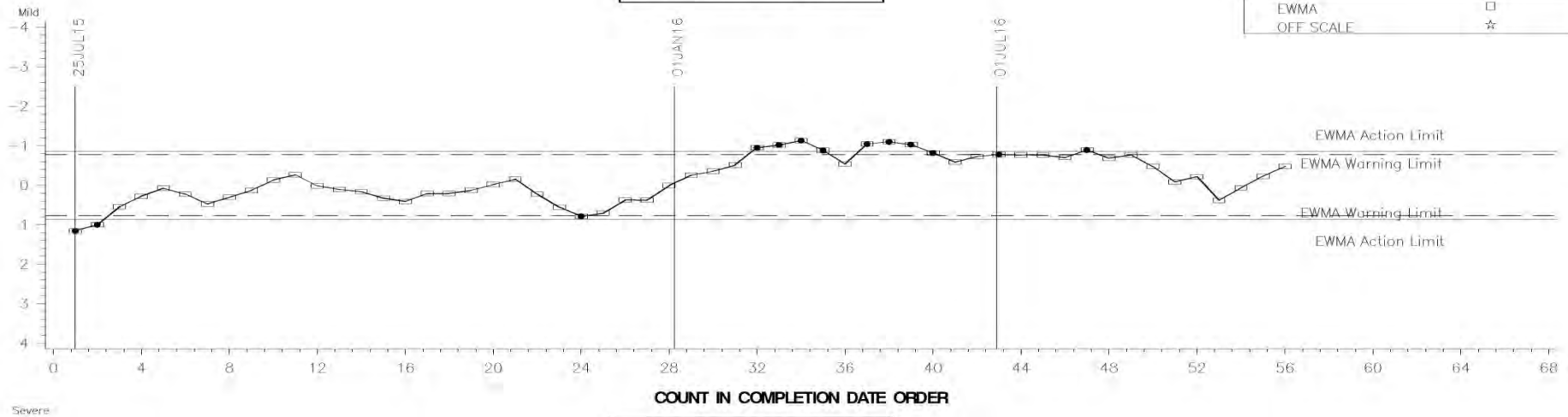
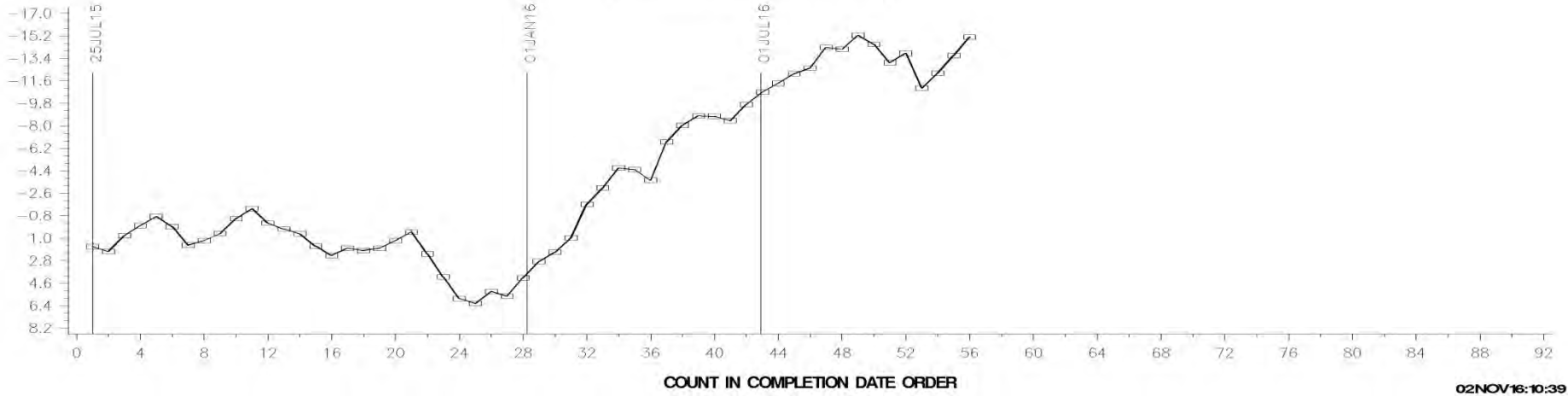
SEQUENCE IIIHA INDUSTRY OPERATIONALLY VALID DATA

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

LTMS Severity Analysis



CUSUM Severity Analysis



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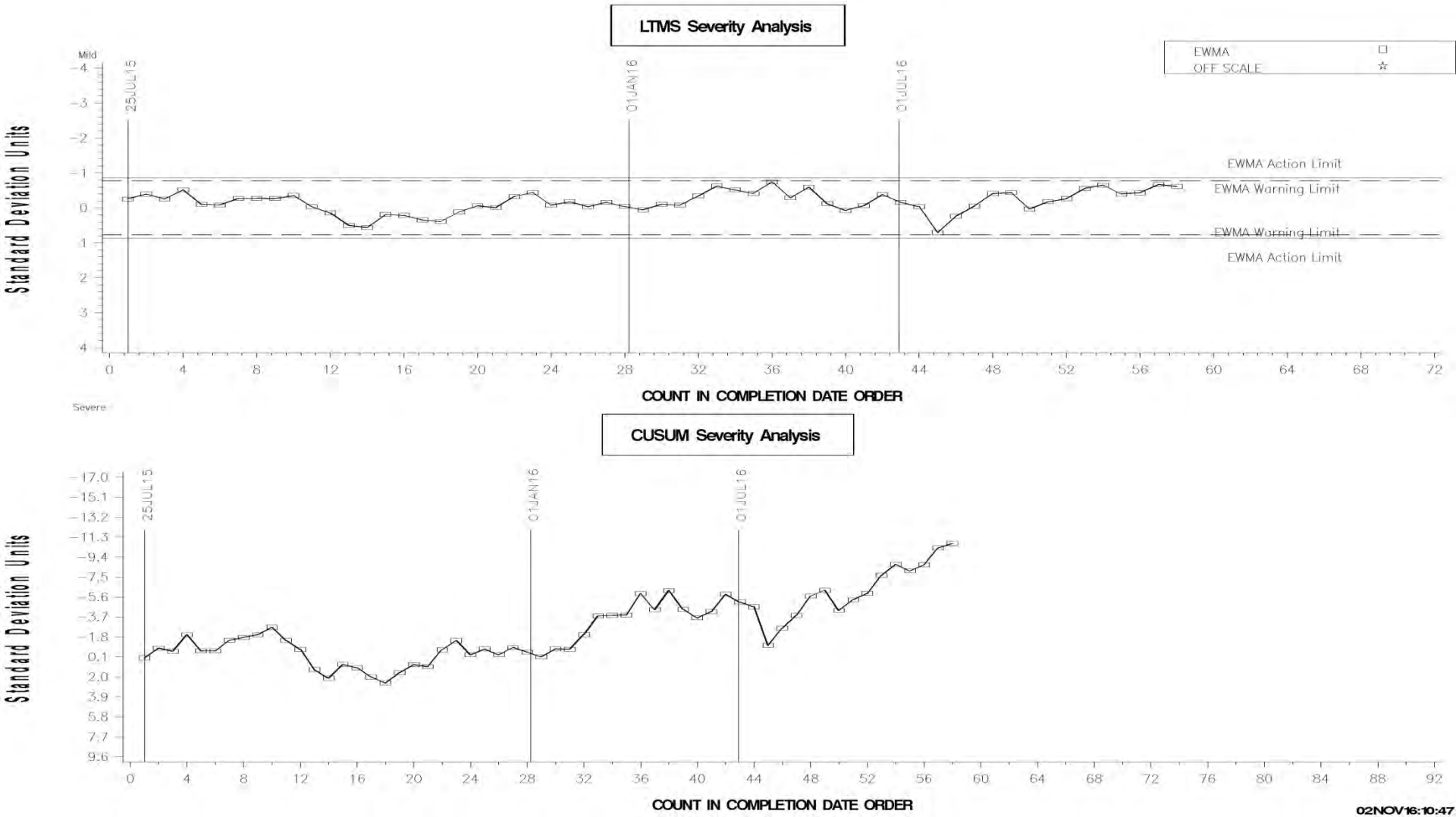
SEQUENCE IIIHB INDUSTRY OPERATIONALLY VALID DATA

PHOSPHORUS RETENTION, FINAL RESULT



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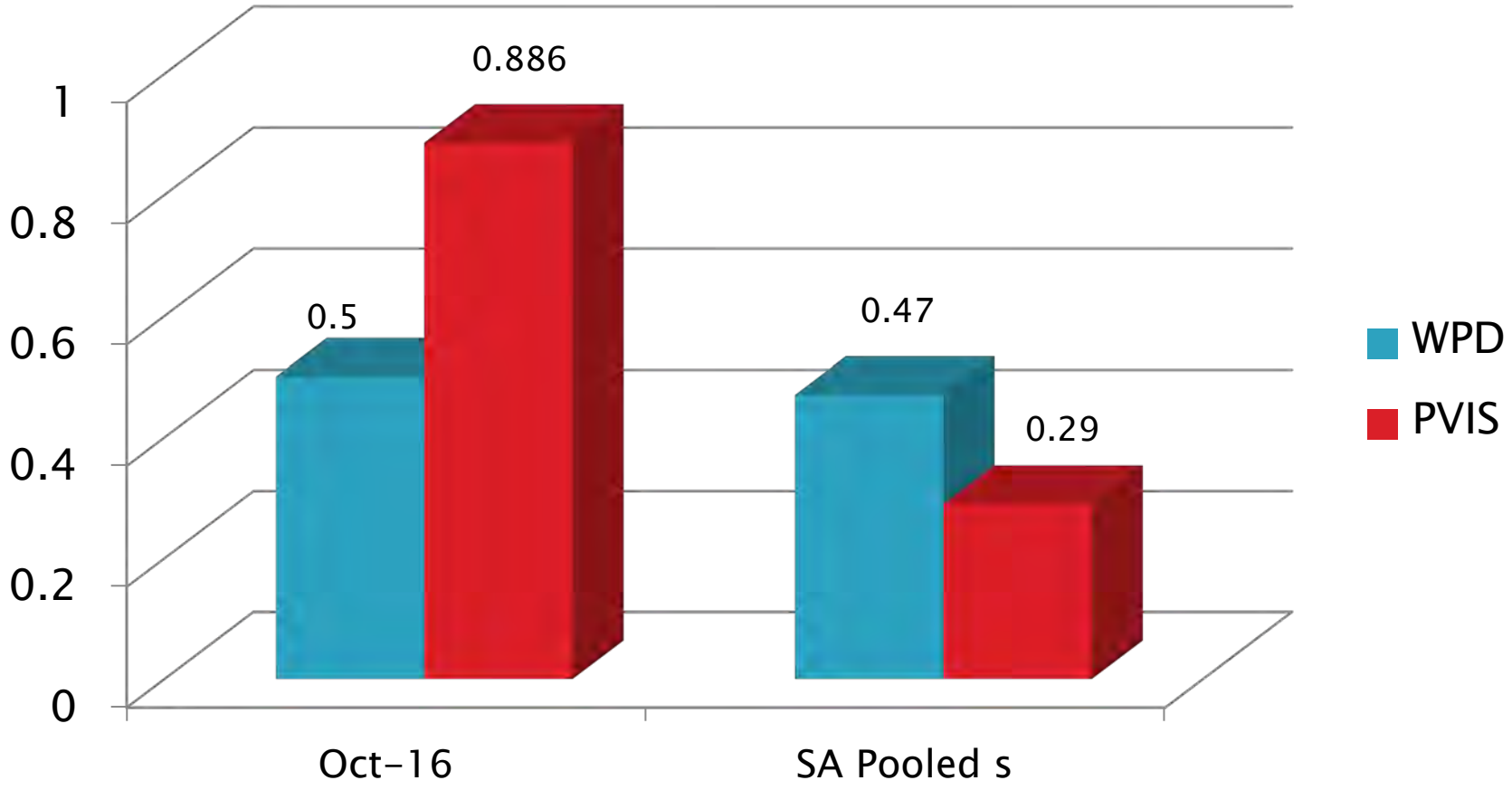
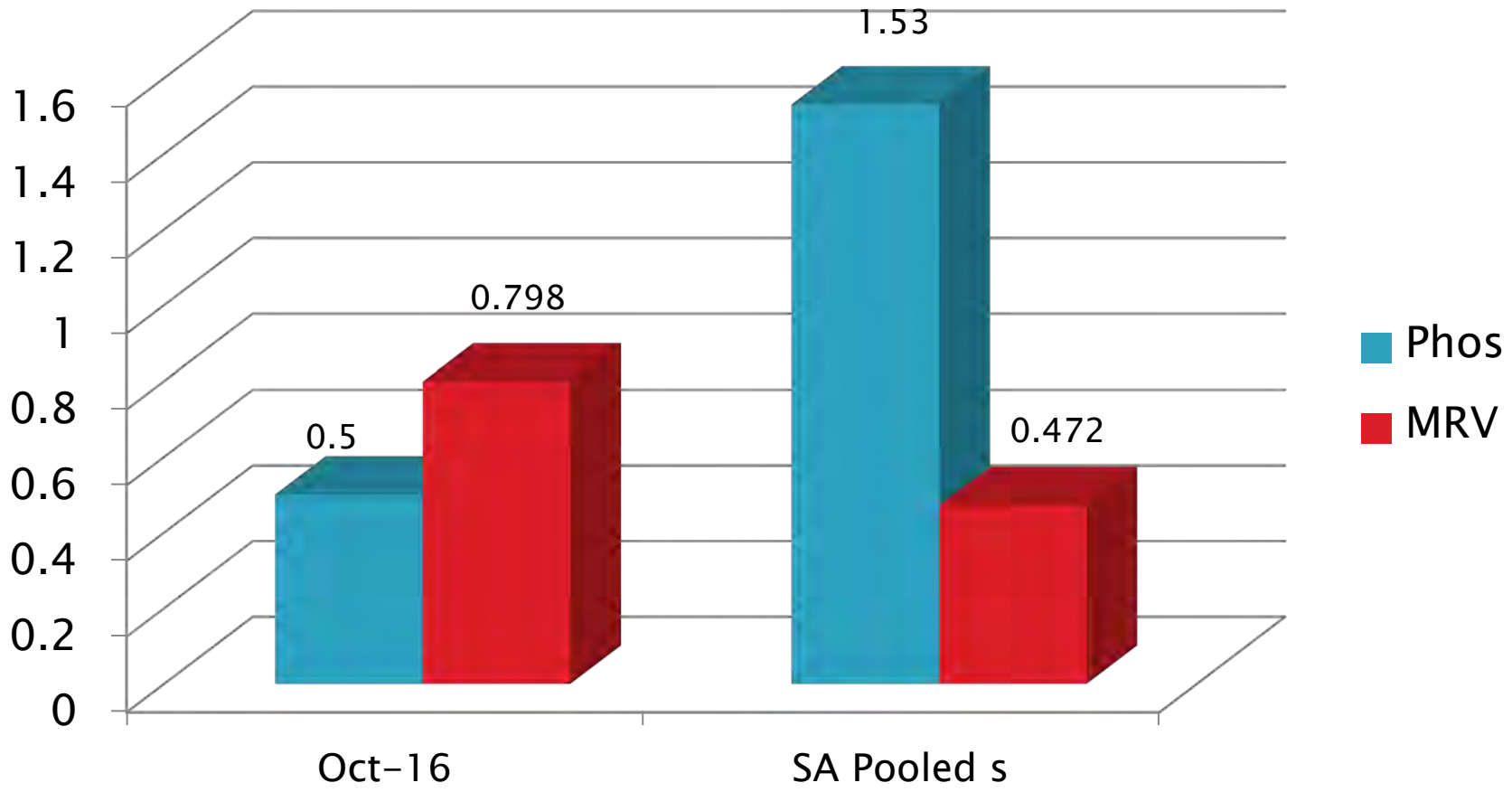
IIIH Precision Estimates



IIIHA/B Precision Estimates



Return to Table of Contents

Sequence IVA

- October 2016

Sequence IVA Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	4
Aborted Calibration Test	XC	1
Total		**5**

Sequence IVA – Lost Tests*

Test Status	Cause	#
Aborted	Loss of Exhaust Backpressure Control	1
Totals		**1**

*Invalid and aborted tests

Sequence IVA Test Severity

- ACW in control.

SEQUENCE IVA INDUSTRY OPERATIONALLY VALID DATA

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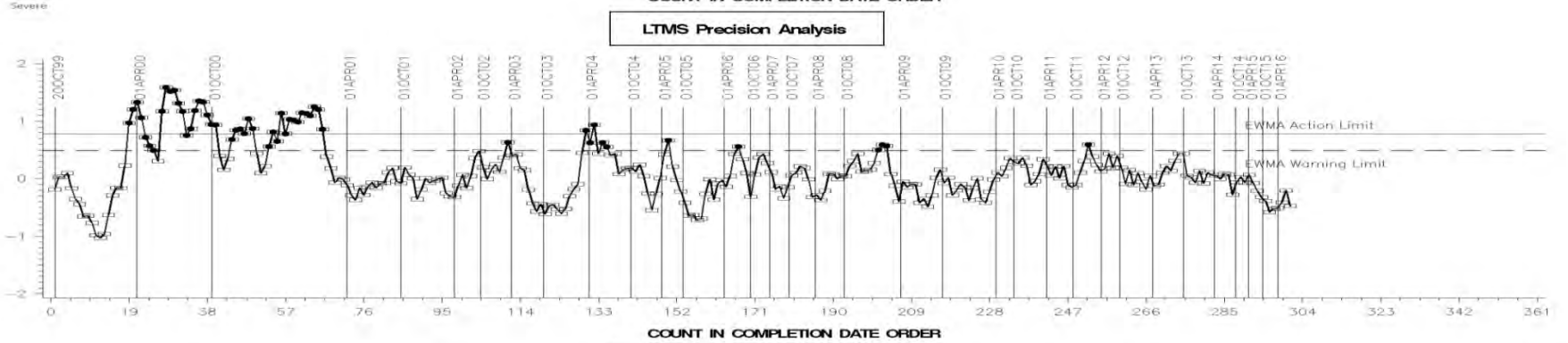
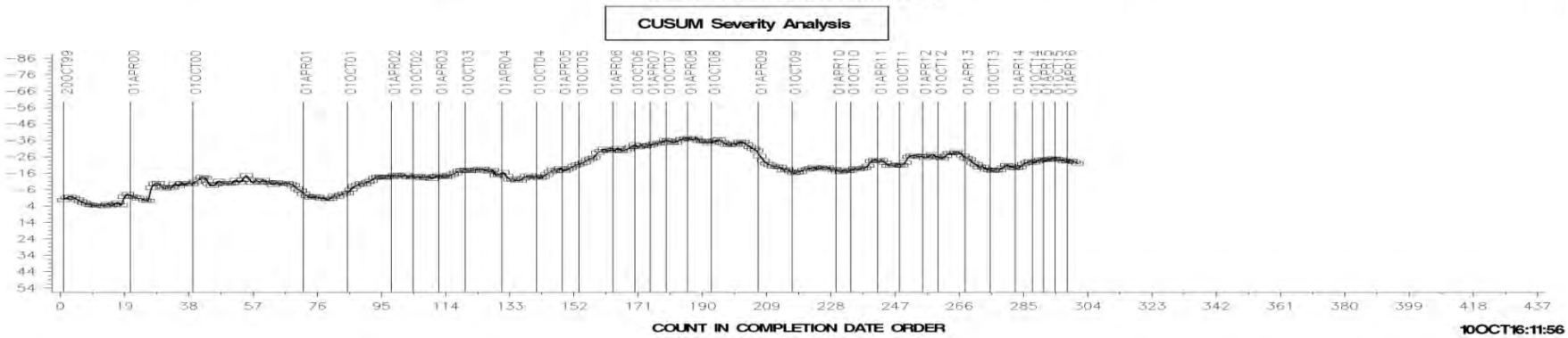
AVERAGE CAM WEAR

LTMS Severity Analysis

LTMS Precision Analysis



CUSUM Severity Analysis



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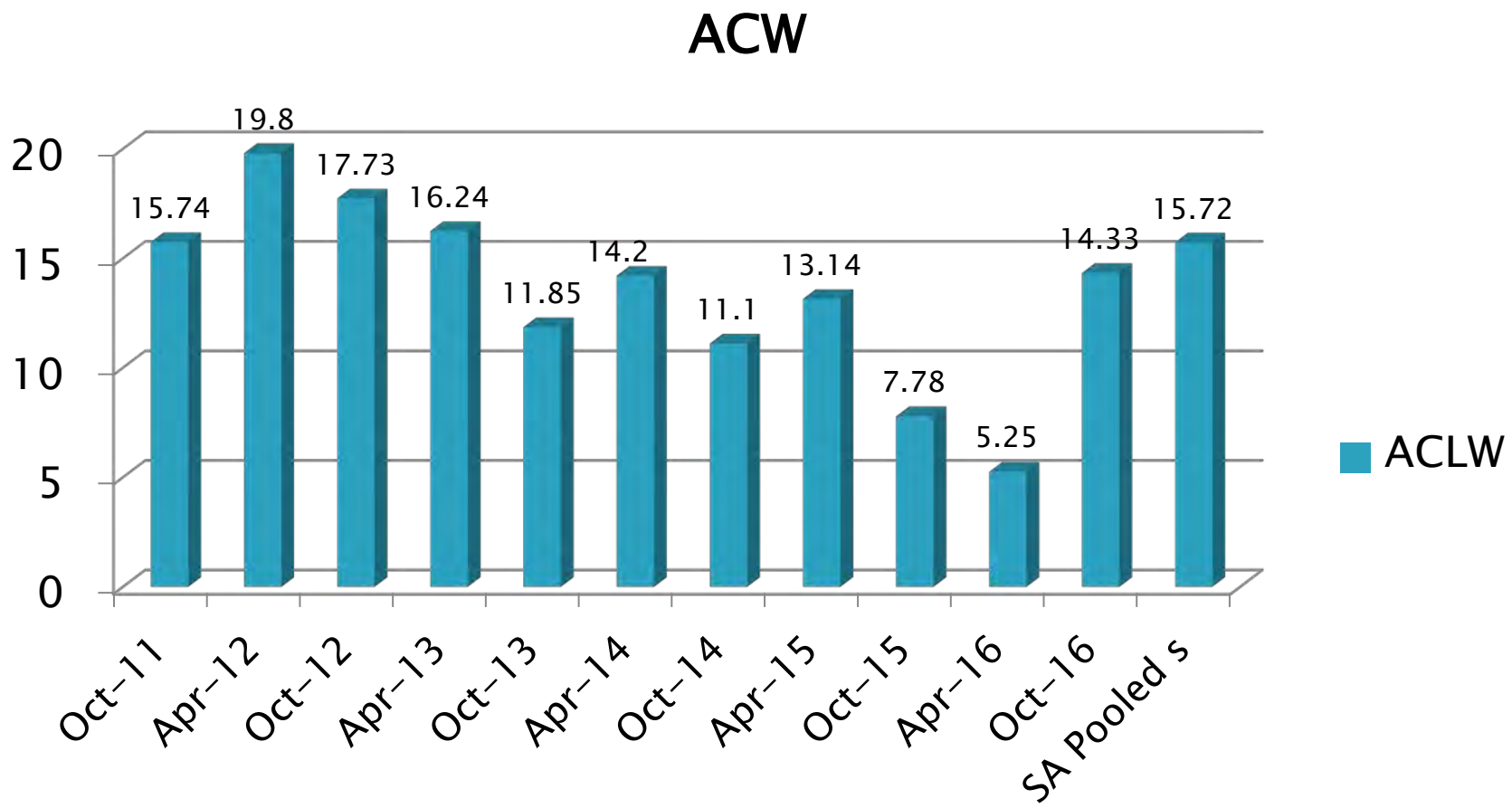
Sequence IVA Precision Estimates



Return to Table of Contents

Sequence VG

- October 2016

Sequence VG Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	6
Statistically Unacceptable Calibration Test	OC	1
VG-A Development Test	NN	3
Operationally Invalid	LC	1
Aborted	XC	1
Total		12

Sequence VG – Lost Tests*

Test Status	Cause	#
Aborted	Engine Coolant Flow Control	1
Invalid	Oil Additions exceeded 2000 grams	1
Totals		**2**

*Invalid and aborted tests

Sequence VG – Failed Tests

Reason	#
Severe OSCR	1
Totals	**1**

Sequence VG Test Severity

- AES in severity warning alarm (mild)
- AEV, APV, RAC and OSCR in control

SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

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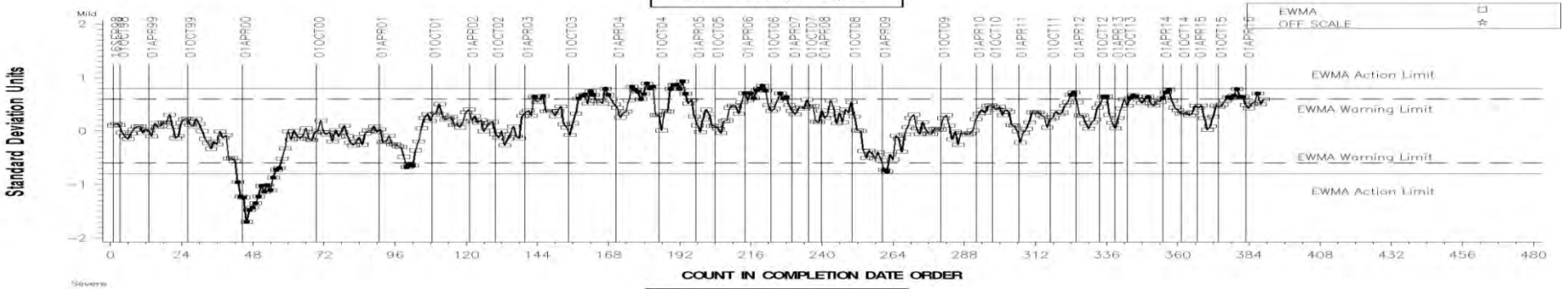
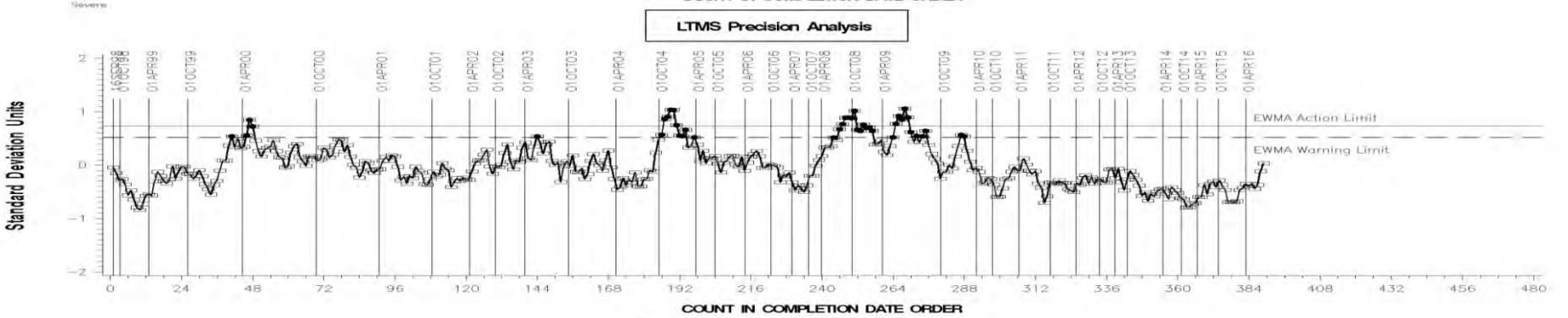
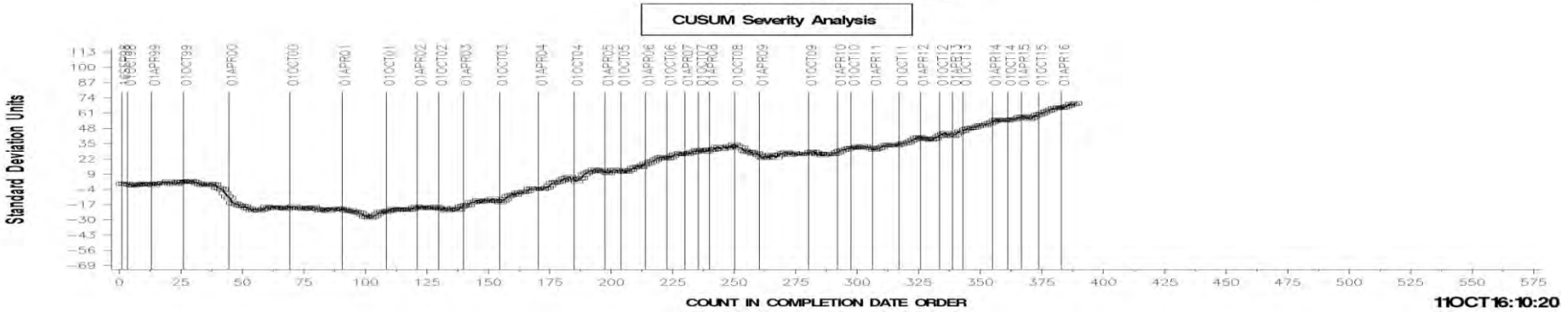
AVERAGE ENGINE SLUDGE







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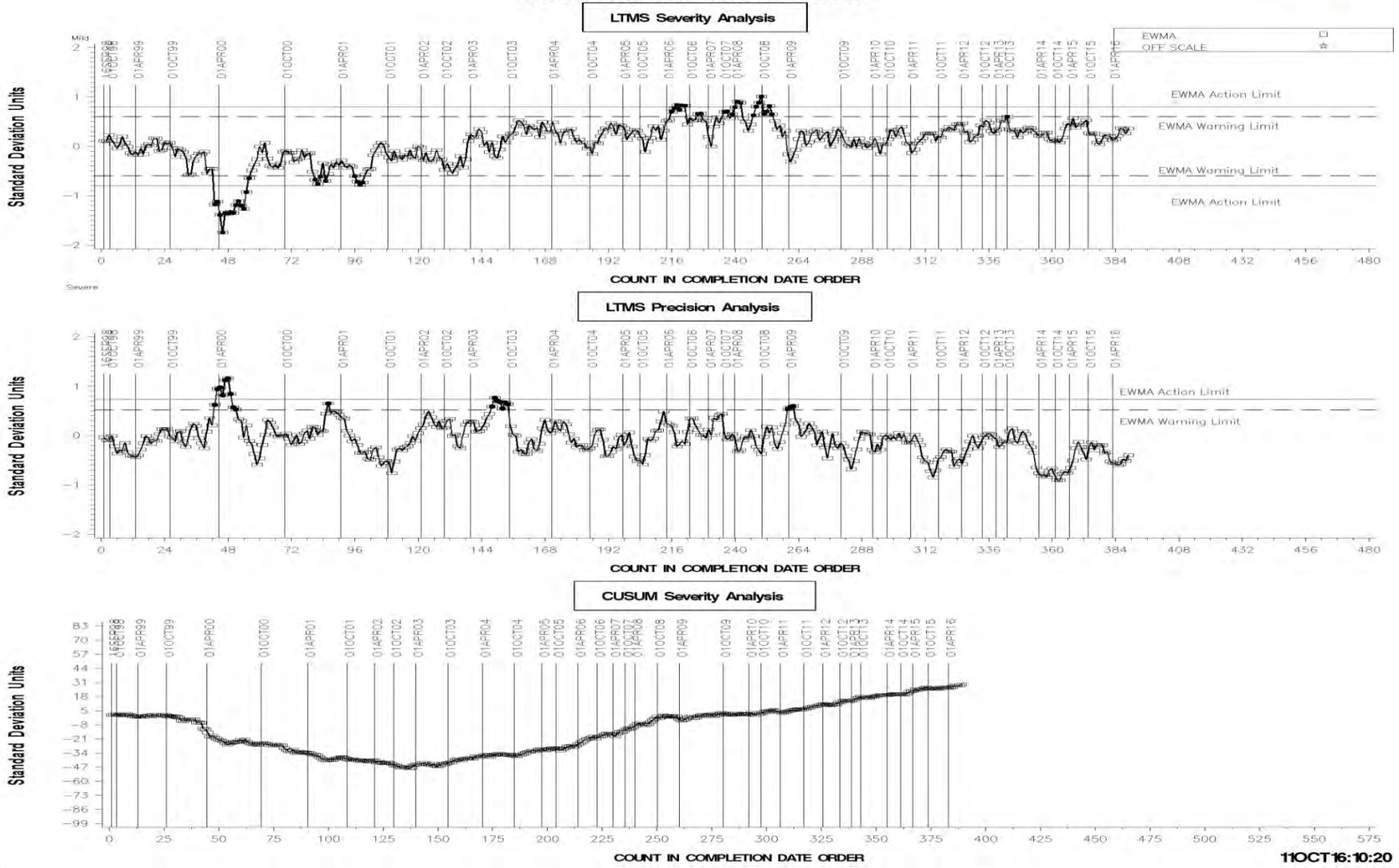
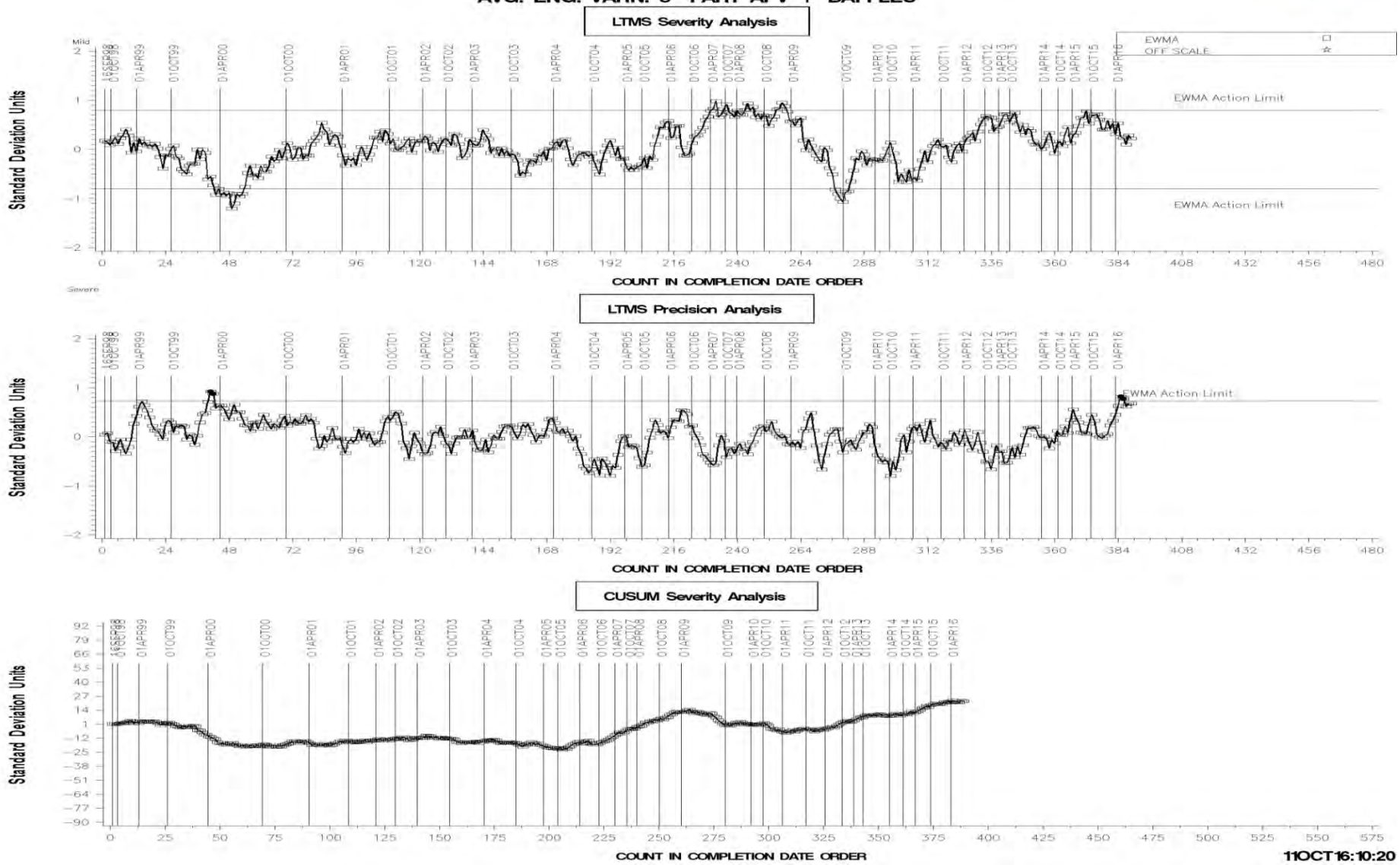
SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

AVERAGE ROCKER COVER SLUDGE



SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

AVG. ENG. VARN. 3—PART APV + BAFFLES

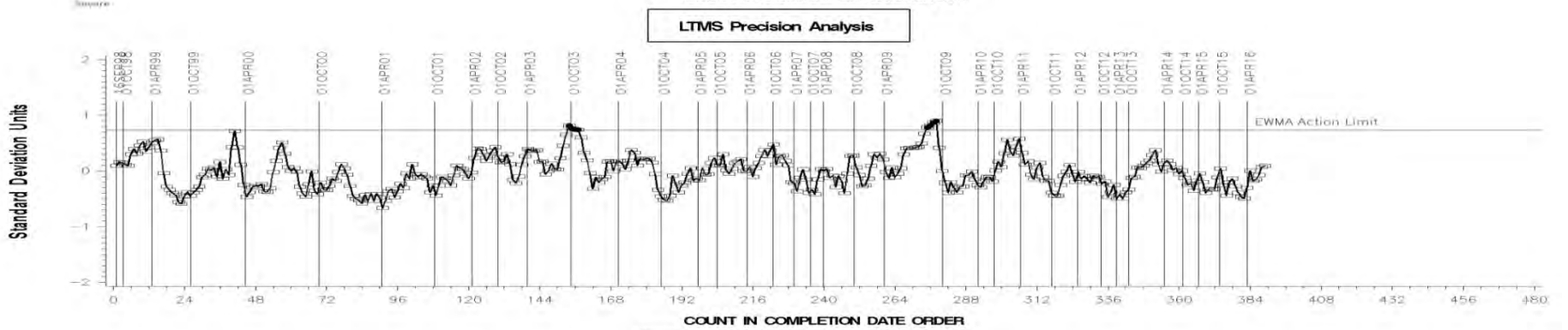


SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

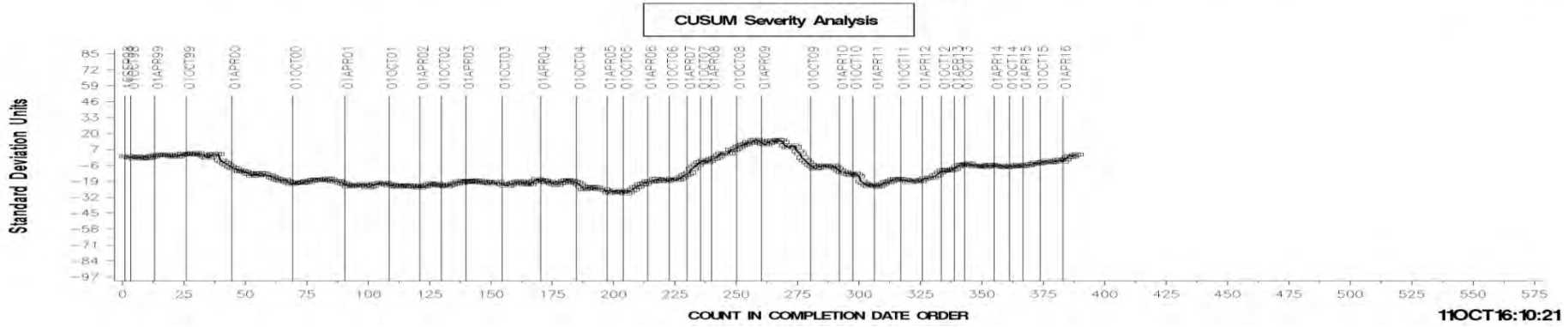
AVG PISTON SKIRT RATING

LTMS Severity Analysis

LTMS Precision Analysis



CUSUM Severity Analysis



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SEQUENCE VG INDUSTRY OPERATIONALLY VALID DATA

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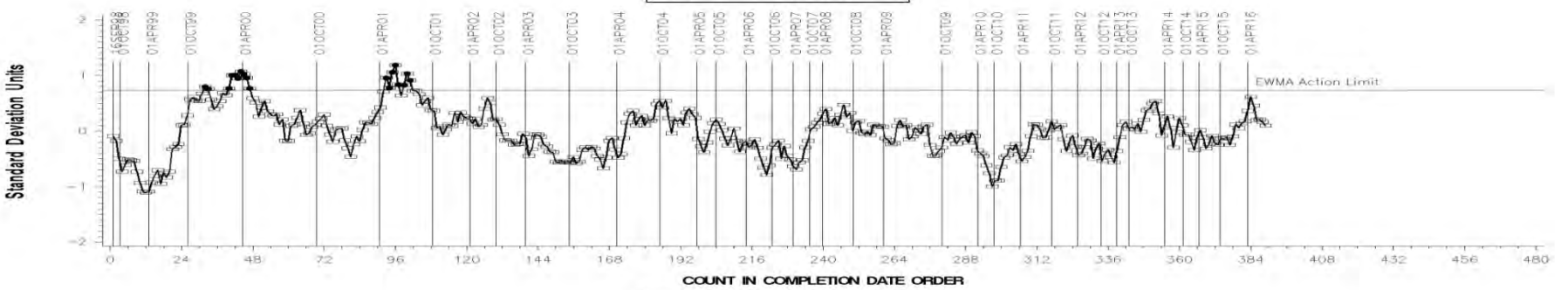
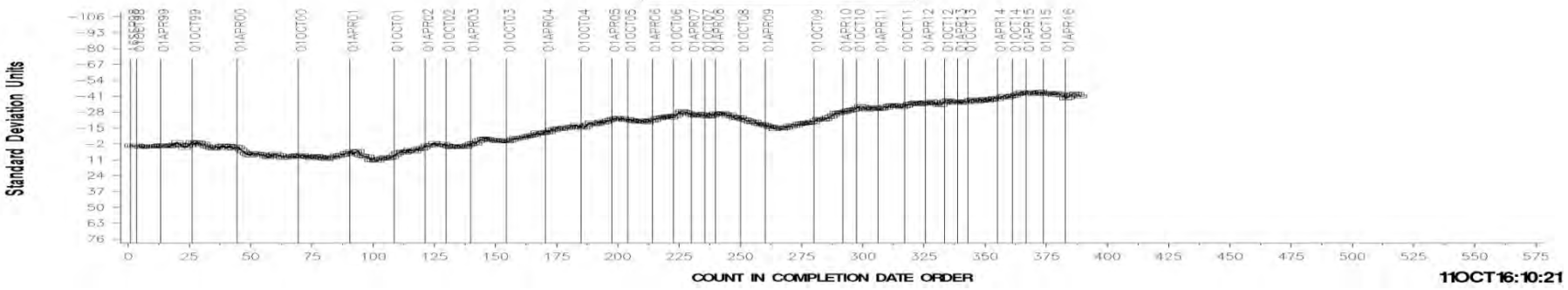
OIL SCREEN SLUDGE

LTMS Severity Analysis

LTMS Precision Analysis



CUSUM Severity Analysis



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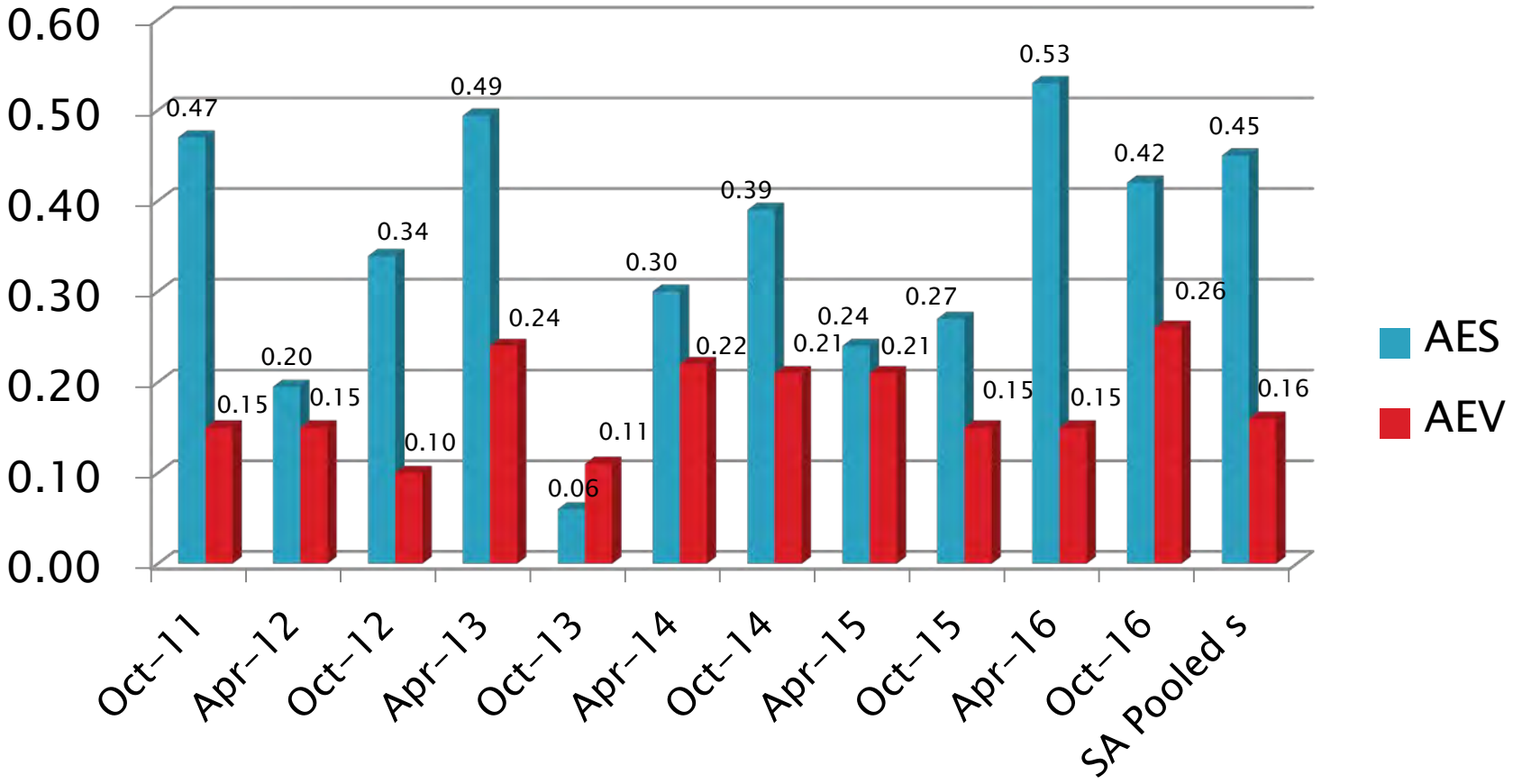
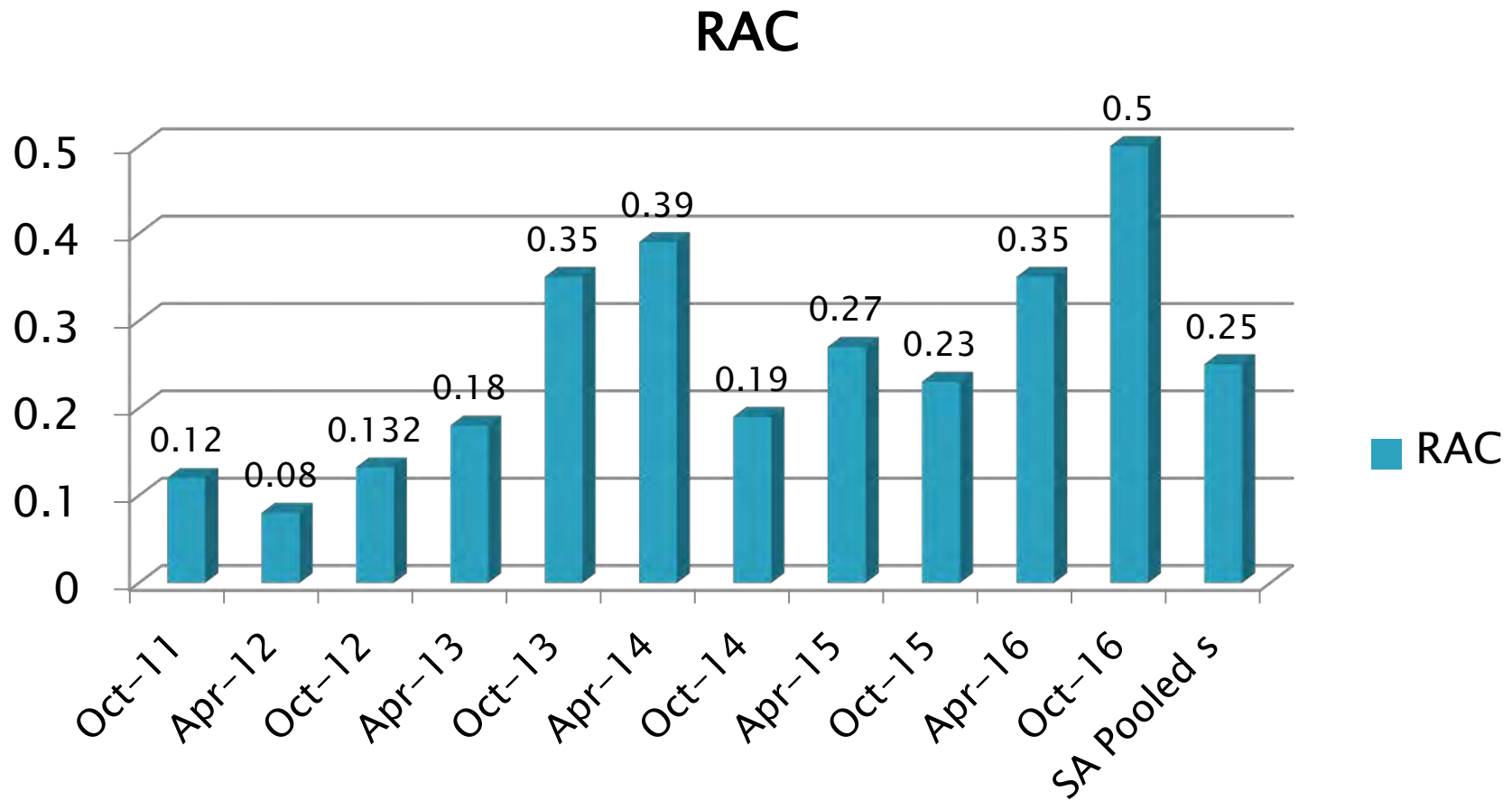
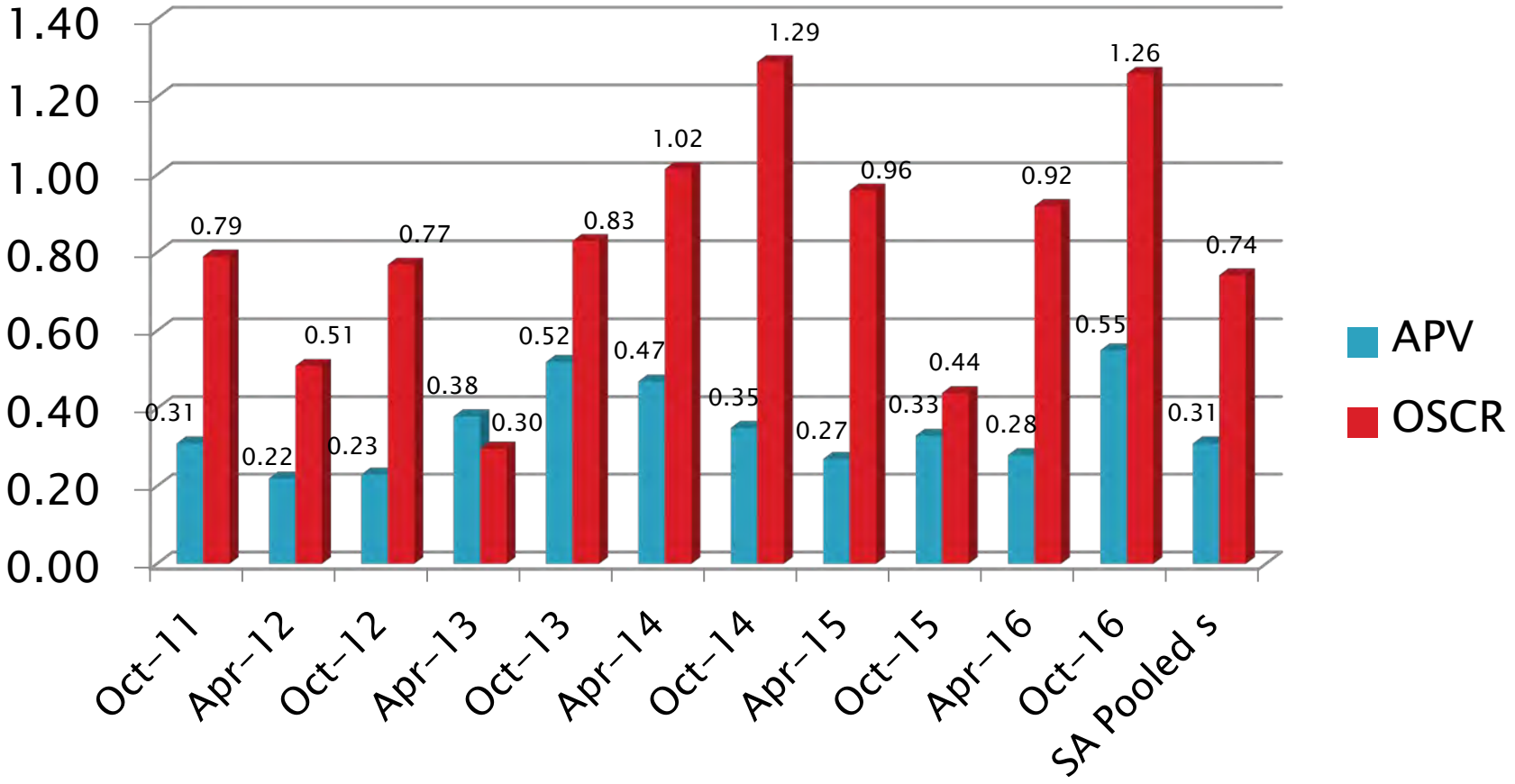
Sequence VG Precision Estimates



Sequence VG Precision Estimates



Sequence VG Precision Estimates



Return to Table of Contents

Sequence VID

- October 2016

Sequence VID Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	15
Failed Statistically	OC	4
Operationally Invalid	LC	1
Aborted	XC	1
Engine Abandoned, did not calibrate	MC	4
Operationally Invalid, Lab and TMC judgement	RC	2
Total		**27**

Sequence VID – Failed Tests

Test Status	Number of Tests
Severe FEI1	2
Mild FEI1	1
Severe FEI2	1
Total	**4**

Sequence VID – Lost Tests*

Test Status	Cause	#
Invalid	Load control	1
Invalid	Exhaust backpressure valve failed	1
Invalid	Intake air temperature, BL after, stage 4 out of spec	1
Aborted	Exceeded allowable number of shutdowns	1
Totals		**4**

*Invalid and aborted tests

Sequence VID Test Severity

- FEI1 is in Severity Action alarm (severe) and precision warning alarm
- FEI2 is in Precision and Severity (severe) Warning Alarm

SEQUENCE VID INDUSTRY OPERATIONALLY VALID DATA

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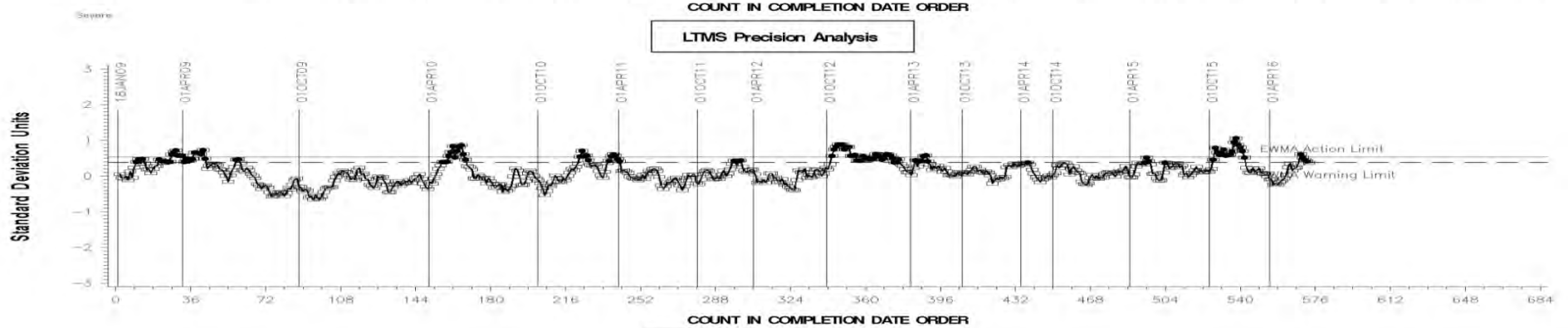
FEI FINAL RESULT PHASE I

LTMS Severity Analysis

Standard Deviation Units

COUNT IN COMPLETION DATE ORDER

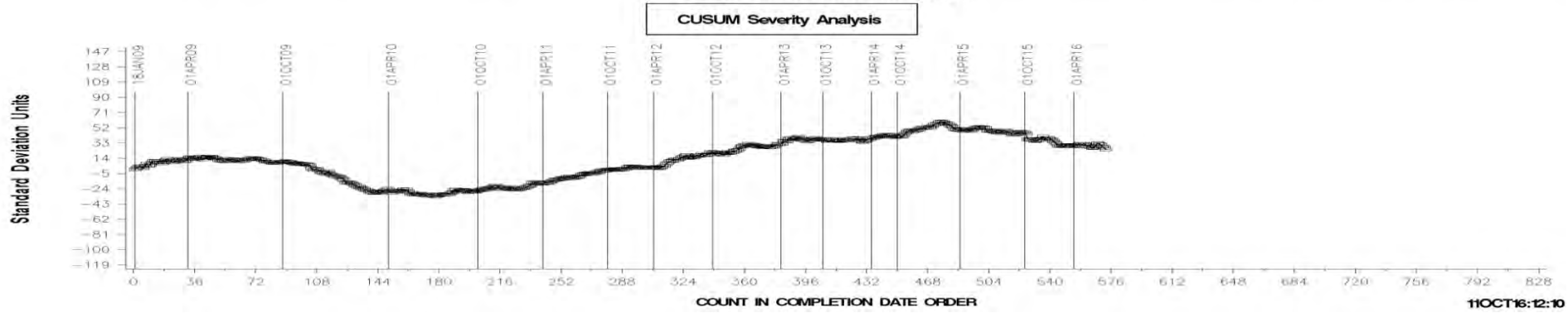
LTMS Precision Analysis



Standard Deviation Units

COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis



Standard Deviation Units

COUNT IN COMPLETION DATE ORDER

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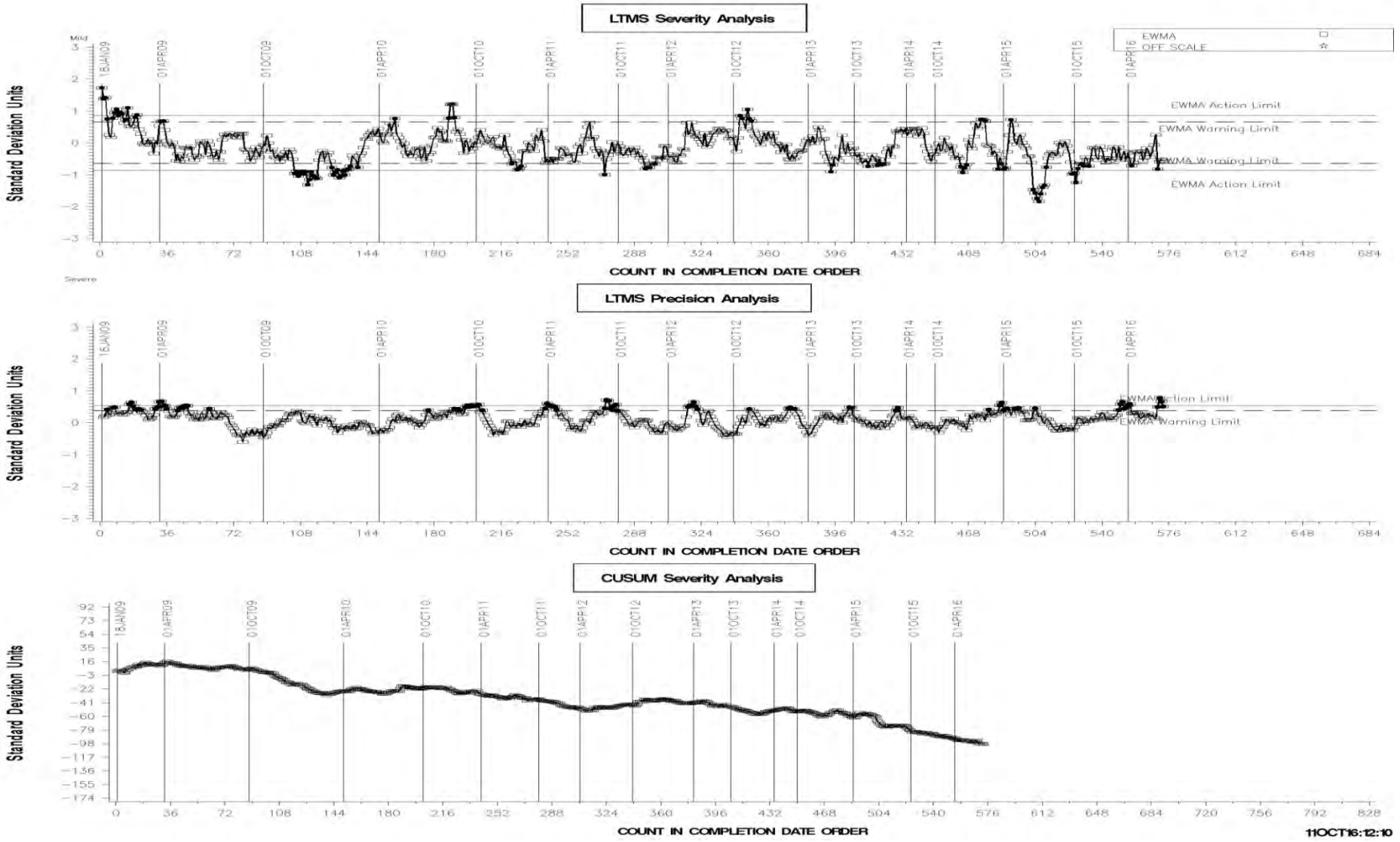
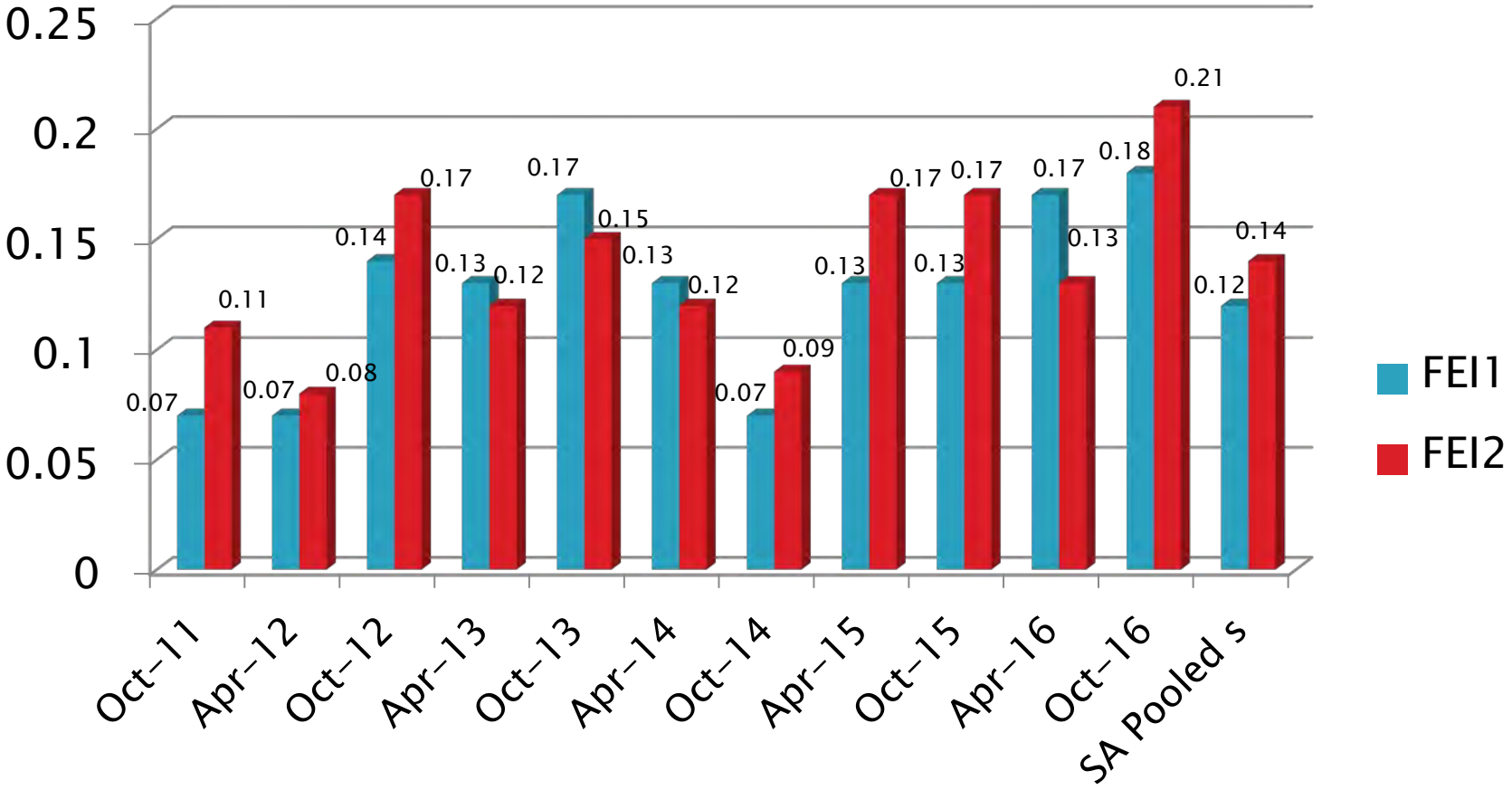
SEQUENCE VID INDUSTRY OPERATIONALLY VALID DATA

FEI FINAL RESULT PHASE II



Sequence VID Precision Estimates



Return to Table of Contents

Sequence VIE

- October 2016

Sequence VIE Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	6
Acceptable Matrix Test	AO	2
Failed Statistically	OC	2
Operationally Invalid Matrix Test	LO	2
Aborted Calibration Test	XC	1
Aborted Not for Industry Statistics Test	XN	1
Operationally Invalid Not for Industry Statistics Test	LN	1
Not for Industry Statistics Test	NN	19
Total		**34**

Sequence VIE – Failed Tests

Test Status	Number of Tests
Severe FEI2	2
Total	**2**

Sequence VIE – Lost Tests*

Test Status	Cause	#
Aborted	Program error	1
Invalid	Burned exhaust valve	2
Invalid	Oil consumption	1
Aborted	Internal damage	1
Totals		**5**

*Invalid and aborted tests

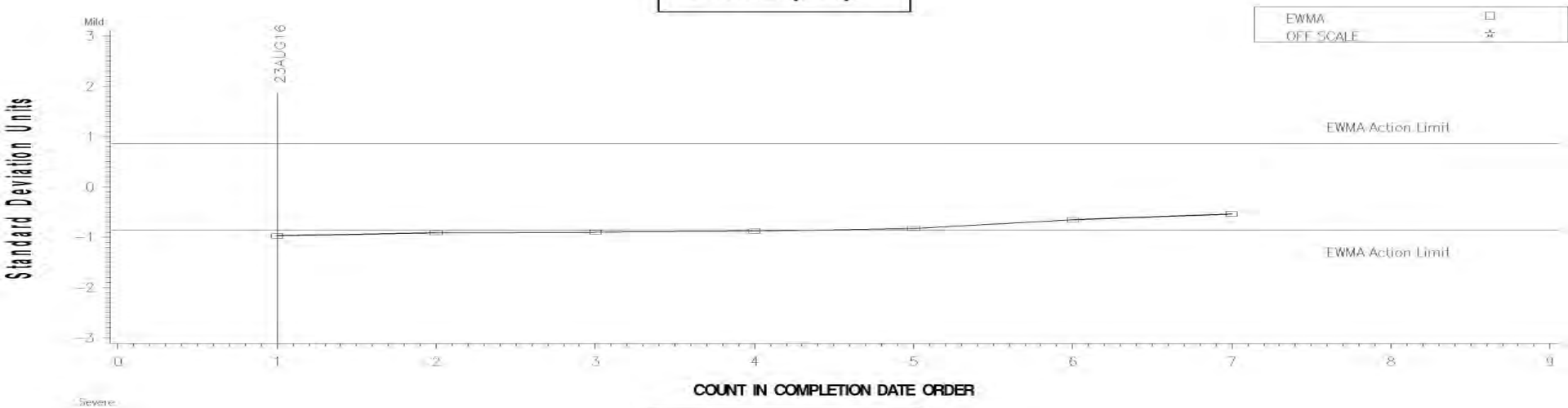
Sequence VIE Test Severity

- FEI1 and FEI2 are within control limits
- FEI2 trending severe
- FEI1 began severe but on target with last two tests reported

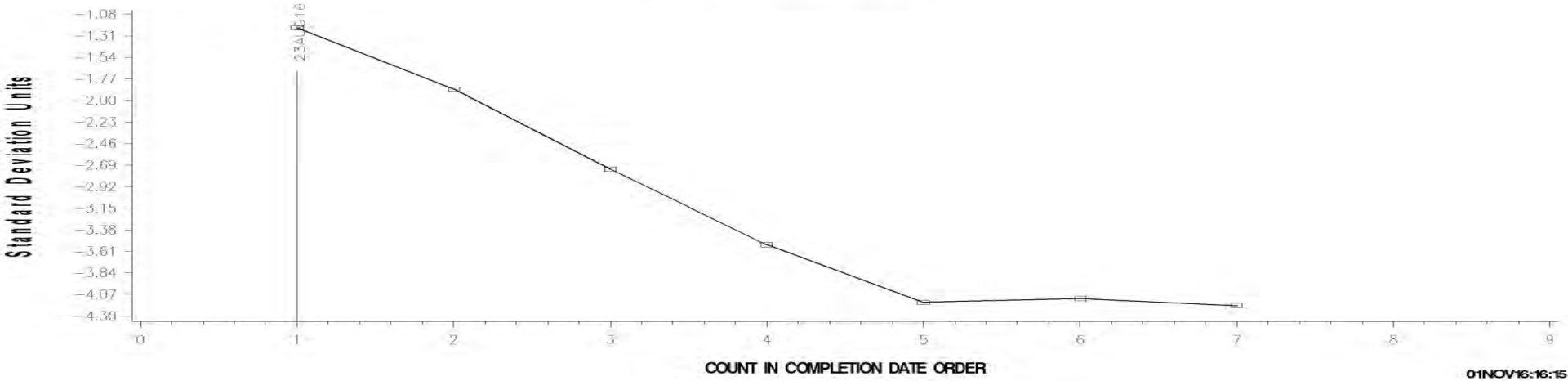
SEQUNCE VIE INDUSTRY OPERATIONALLY VALID DATA

FEI FINAL RESULT PHASE I

LTMS Severity Analysis



CUSUM Severity Analysis



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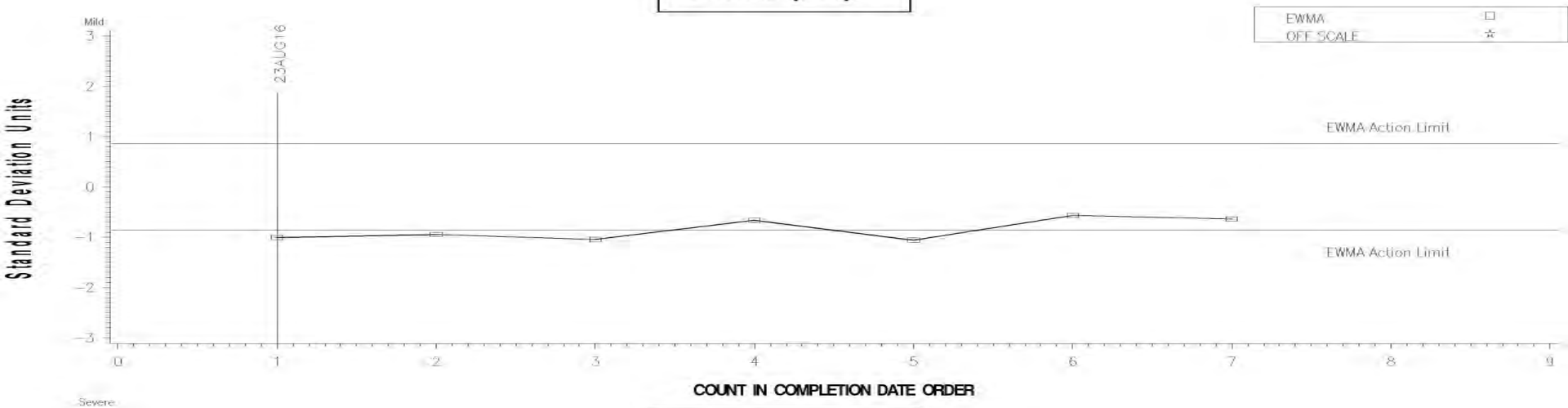
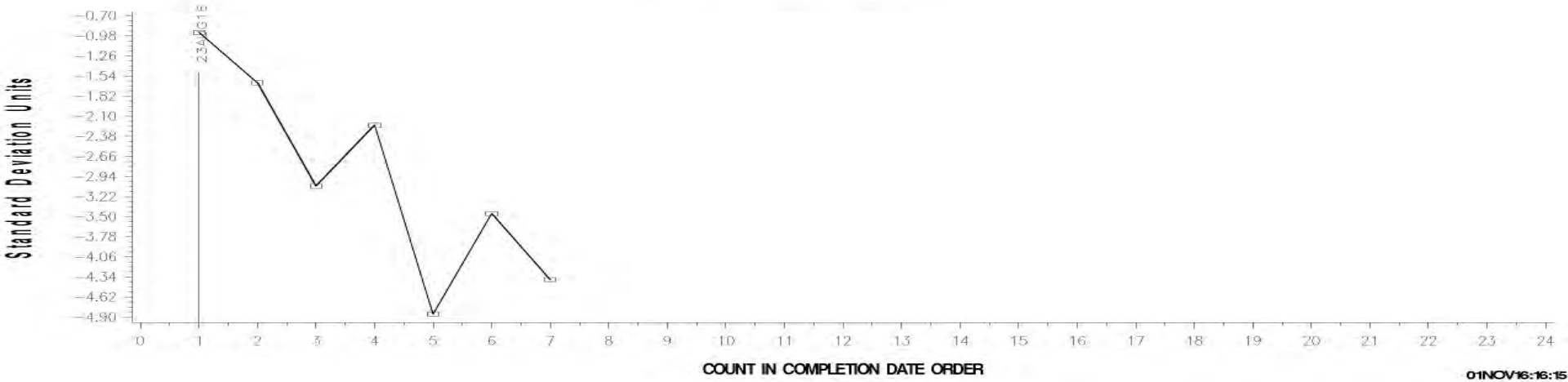
SEQUNCE VIE INDUSTRY OPERATIONALLY VALID DATA

FEI FINAL RESULT PHASE II

LTMS Severity Analysis



CUSUM Severity Analysis



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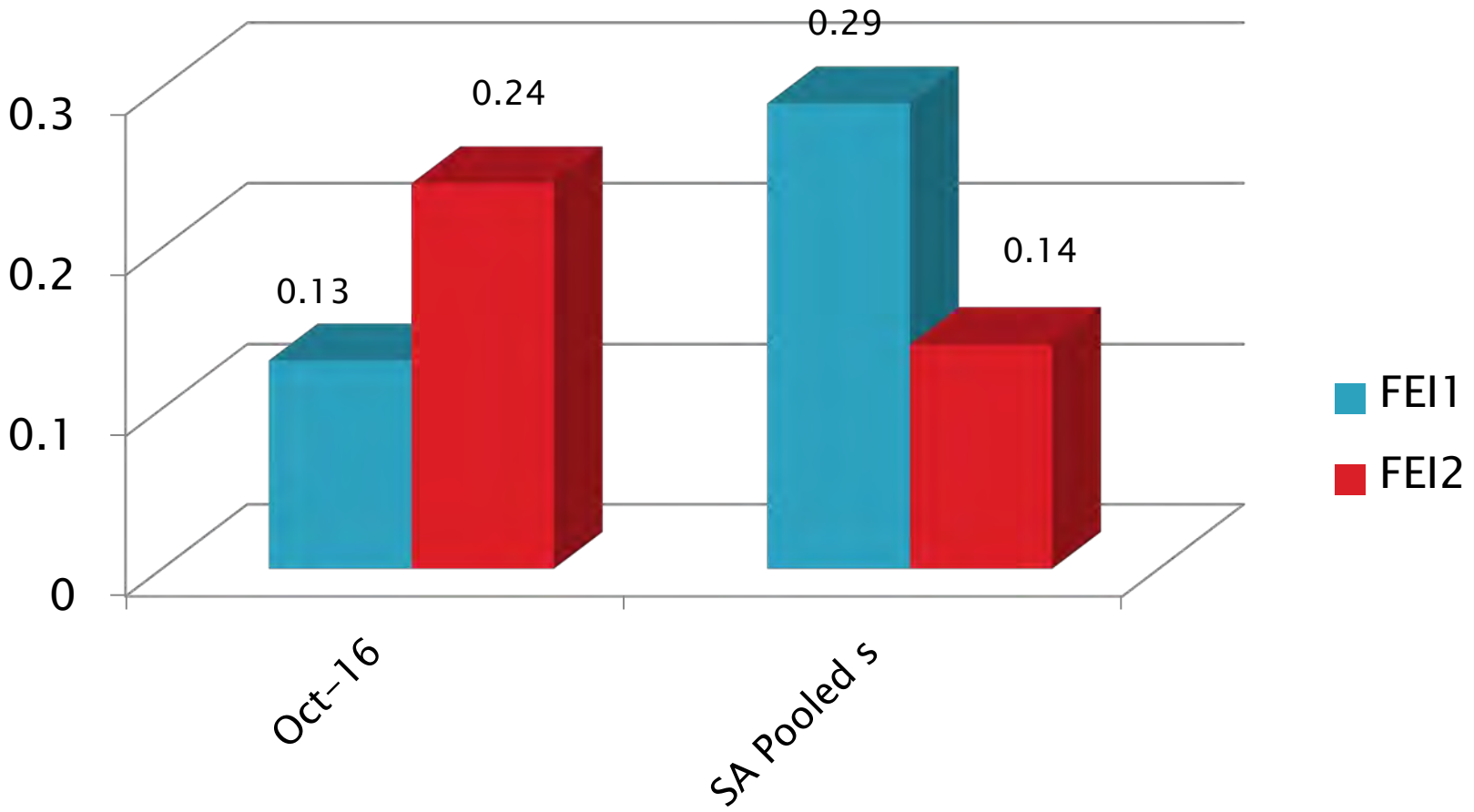
Sequence VIE Precision Estimates



Return to Table of Contents

Sequence VIII

- October 2016

Test Monitoring Center
http://astmtmc.cmu.edu
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Sequence VIII Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	9
Statistically Unacceptable Calibration Test	OC	2
Statistically Unacceptable Hardware Test	OH	1
Statistically Acceptable Hardware Test	AH	2
Operationally Invalid Hardware Test	LH	1
Operationally Invalid Calibration Test, Lab and TMC judgement	RC	2
Operationally Invalid Calibration Test, Lab judgement	LC	1
Statistically Acceptable Donated Test	AG	1
Aborted Calibration Test	XC	1
Total		19

Sequence VIII – Failed Tests

Test Status	Number of Tests
Strip Vis Precision Shewhart	1
Mild SVIS	1
Total	**2**

Sequence VIII – Lost Tests*

Test Status	Cause	#
Invalid	Damaged Crank	2
Aborted	Oil Leak	1
Invalid	Stand Vibration Issue, Failed Mounting	1
Invalid	Counterbalance Failure	1
Totals		**5**

*Invalid and aborted tests

Sequence VIII Test Severity

- Bearing Weight in severity warning alarm (mild).
- Stripped Viscosity is in severity warning alarm (severe)

SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

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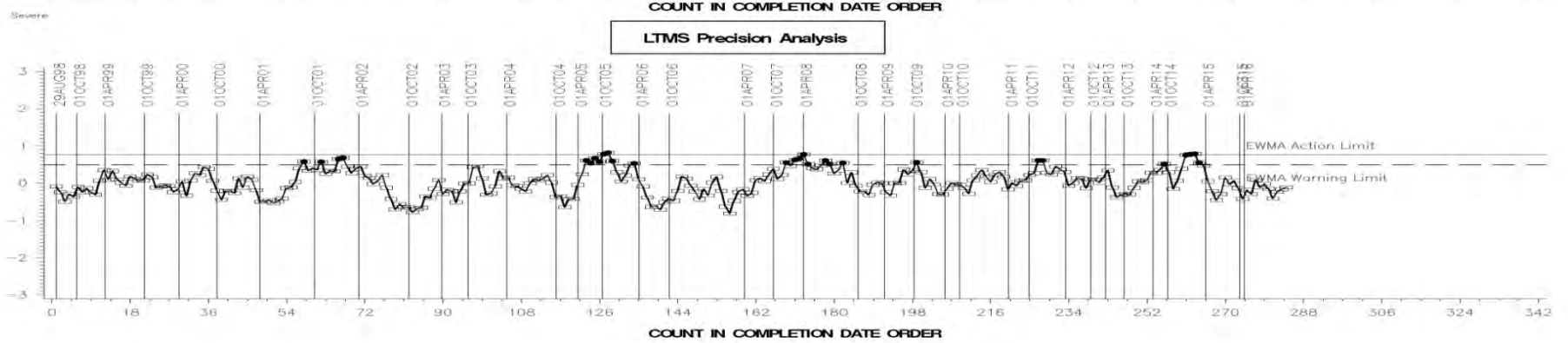
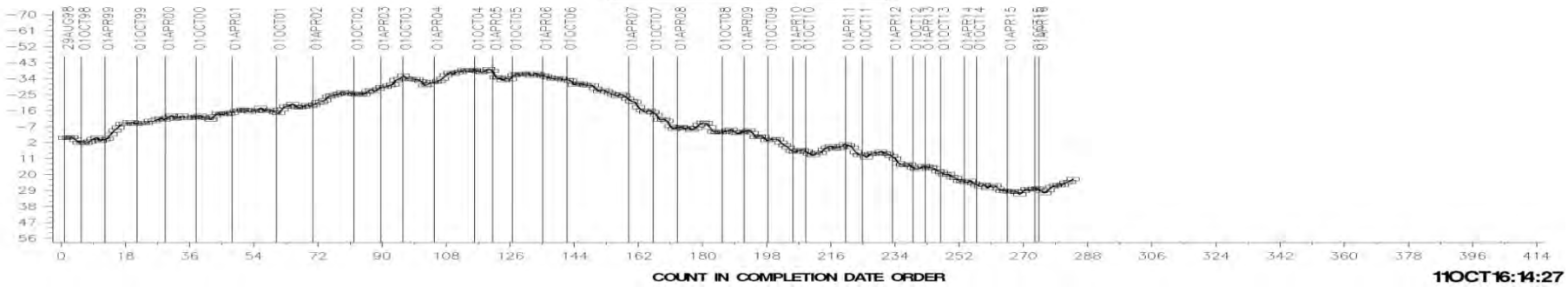
FINAL BEARING WEIGHT LOSS

LTMS Severity Analysis

LTMS Precision Analysis



CUSUM Severity Analysis



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SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

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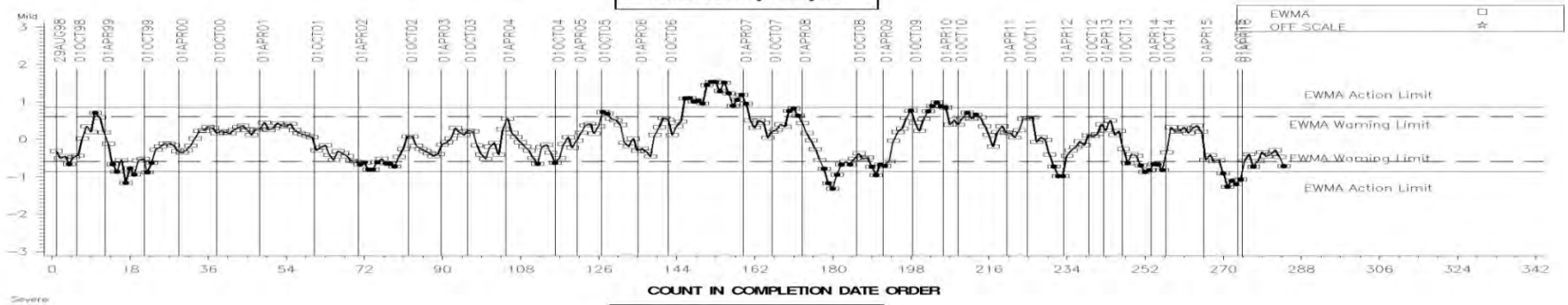
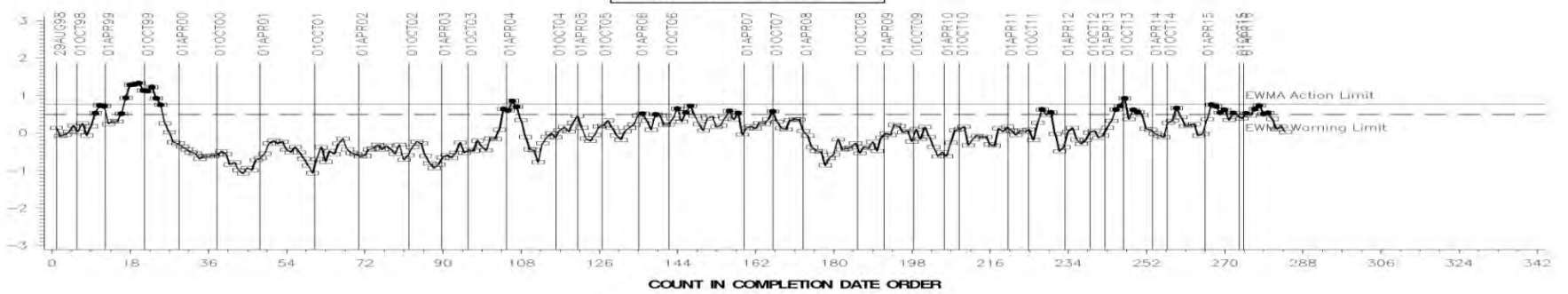
STRIPPED VIS. @ 100 DEG C

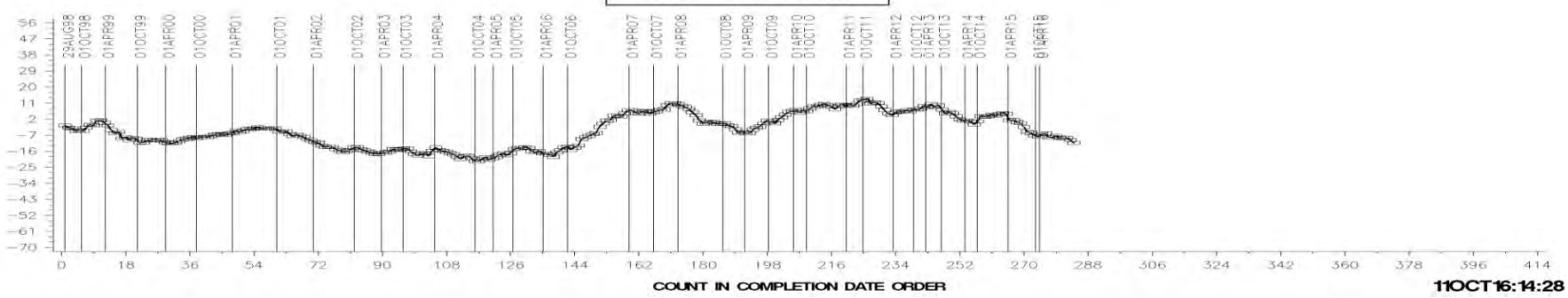
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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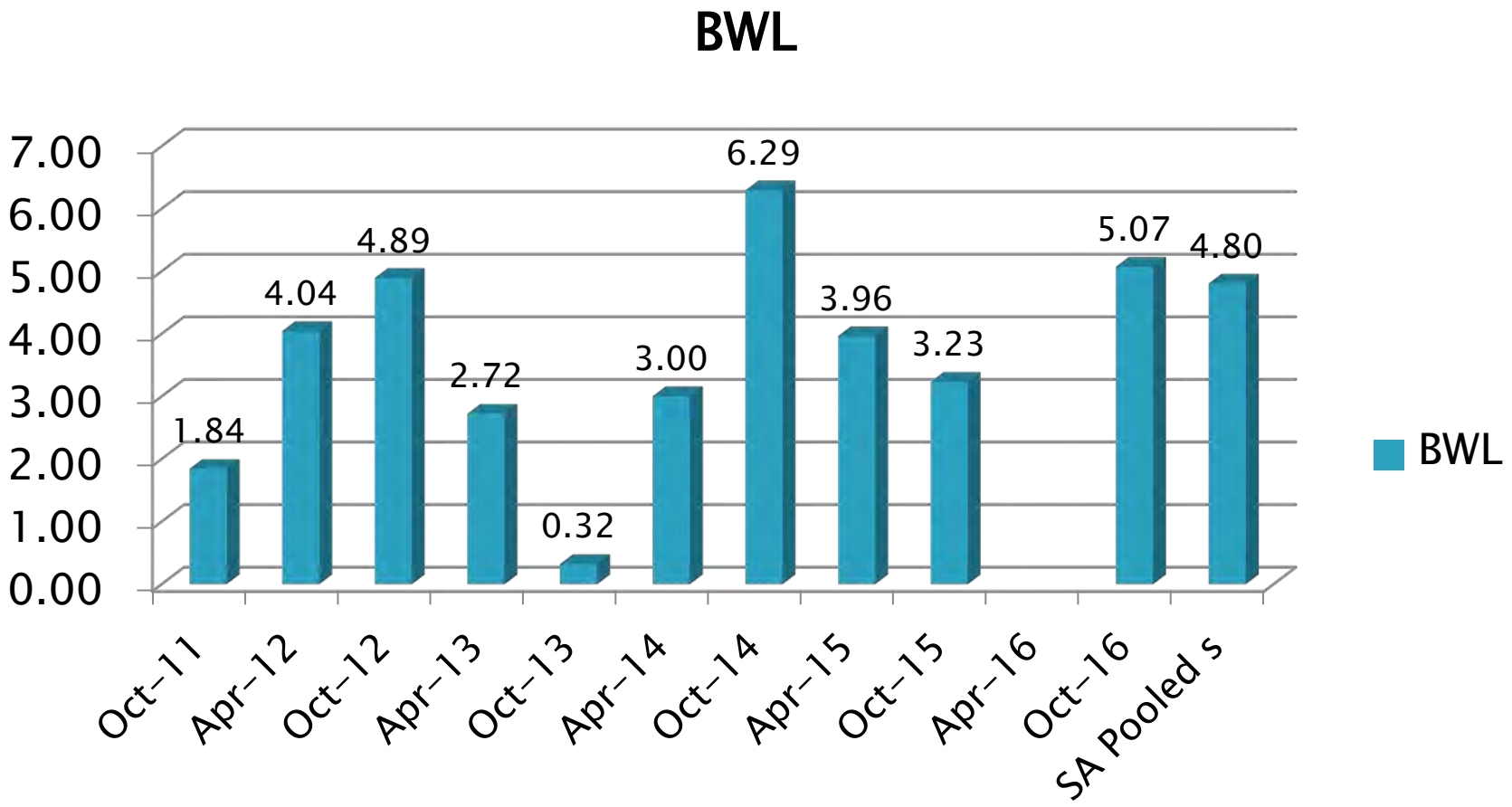
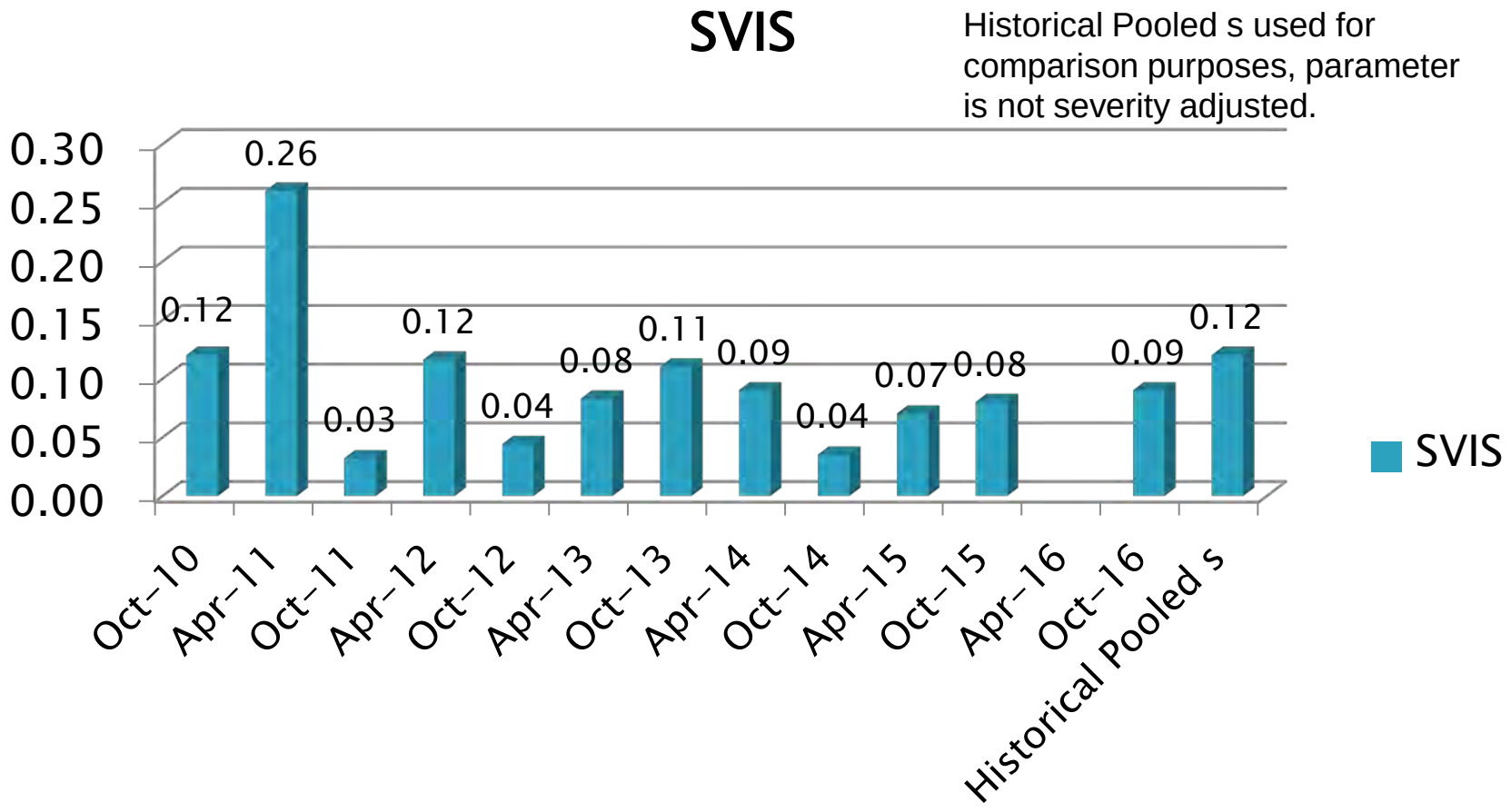
Sequence VIII Precision Estimates



Sequence VIII Precision Estimates



Return to Table of Contents

Information Letters

- April 1, 2016 – September 30, 2016

Information Letters*

Test	Date	IL	Topic
IIIF	20160616	16-3	Allowed re-use of piston pin OHT3F-014-1
IIIG	20160616	16-2	Allowed re-use of piston pin OHT3F-014-1
VG	20160608	16-1	Allowed use of alternate chilled exhaust manifold
VG	20160810	16-2	Allowed use of electronic coolant flow meter

*Available from TMC Website

Return to Table of Contents

Reference Oil Inventory

- Actions, Re-blends, Inventories and Estimated Life

Reference Oil Re-blends

- TMC 1009
  - Supplier has been contacted and is working on a reblend
- TMC 542-3
  - Re-blend of 542 is available
- TMC 434-3
  - Supplier has been contacted for re-blend

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
300	IVA	330	59	172	40	2+ years
433-1	IIIF	1045	0	0	8	<1 year
433-2	IIIF	500	32	261	63	2+ years
434	IIIG	550	0	<1	12	<1 year
434-1	IIIG	660	0	4	24	1.5 years
434-2	IIIG, IIIH	495	40	119	24	2+ years
435	IIIG	550	0	2	4	<1 year
435-2	IIIG	550	20	170	20	3+ 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
436	IIIH	1100	40	920	36	5+ years
438	IIIG	990	0	50	20	<2 years
438-1	IIIH	605	60	207	36	2 years
540	VID	1100	30	190	30	4+ years
542	VID	1100	0	0	5	<1 year
542-2	VID/E	1000	168	191	94	<1 years
542-3	VIE	997	0	997	0	4+Years
544	VIE	897	48	751	84	3+ years

Return to Table of Contents

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	19	109	12	3+ years
925-3	VG	975	0	10	6	<1 year
940	VG, VH	560	33	263	30	3+ years
1006-2	IVA, VG, VIII	5500	326	1870	67	2+ years
1007	IVA, VG	1968	0	0	30	<1 year
1009	VG, VIII	1100	25	18	63	1 year
1010	IIIG, VID	1100	0	3	5	<1 year
1010-1	VID/E	1760	126	1268	93	5 years

Return to Table of Contents

LTMS Deviations

- April 1, 2016 – September 30, 2016

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
VIII	3

Return to Table of Contents

Quality Index Deviations

- April 1, 2016 – September 30, 2016

Quality Index Deviations

- Four Quality Index Deviations this Report Period.
  - IIIF - Right EBP
  - IIIH - Intake Air Pressure and Load
  - IIIH – Speed and Load
  - VG - Oil Inlet Temperature

Quality Index Deviations

Historical Count of PCEO Quality Index Deviations

Test	Quality Index Deviations
IIIF	28
IIIG	16
IIIH	2
IVA	28
VG	45

Return to Table of Contents

TMC Laboratory Visits

- April 1, 2016 –
  September 30, 2016

TMC Lab Visits

Test	Number of Labs Visited
VH*	5
VIE	1
VIF	1
CWT	1

* Task Force Group Visit

Lab Visit Issues

- VH
  - Engine Coolant in thermocouple not located per procedure (3 Labs)
  - Oil Heat Exchanger not properly oriented
  - No sight glass in system
  - RAC cooling system no provision to balance flow
- VIE
  - More than 2” of exposed T/C sheathing, fuel rail temperature
  - Incorrect line size for oil filter connection
- CWT
  - MAPT and Intake Air pressure sensors not located as per procedure

Return to Table of Contents

Test Area Timelines

- April 1, 2016 – September 30, 2016

Test Area Timeline Additions*

Test	Date	Topic	IL
IIIF	20160616	Allowed re-use of piston pin OHT3F-014-1	16-3
IIIG	20160616	Allowed re-use of piston pin OHT3F-014-1	16-2
IIIH	20160415	Calibration Testing Begins	
VG	20160608	Allow use of alternate exhaust manifold	16-1
VG	20160810	Allow use of electronic flow meter	16-2
VIE	20160810	Calibration Testing Begins	
VIII	20160801	Approved use of 06-16 Bearings	

*As of 09/30/2016

Return to Table of Contents

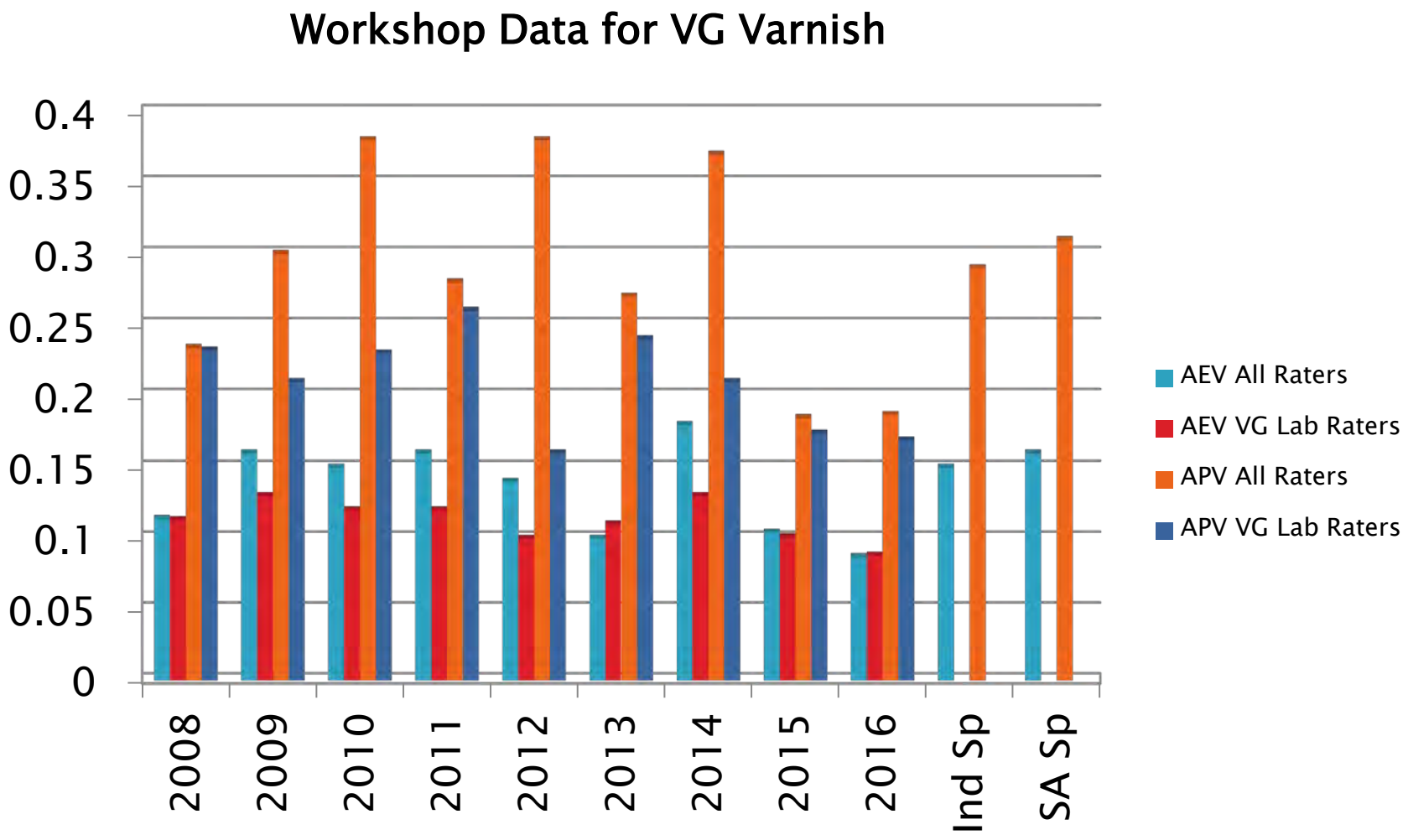
Rating Workshop Data

- 2016 Light Duty Workshop

Rating Workshop Data

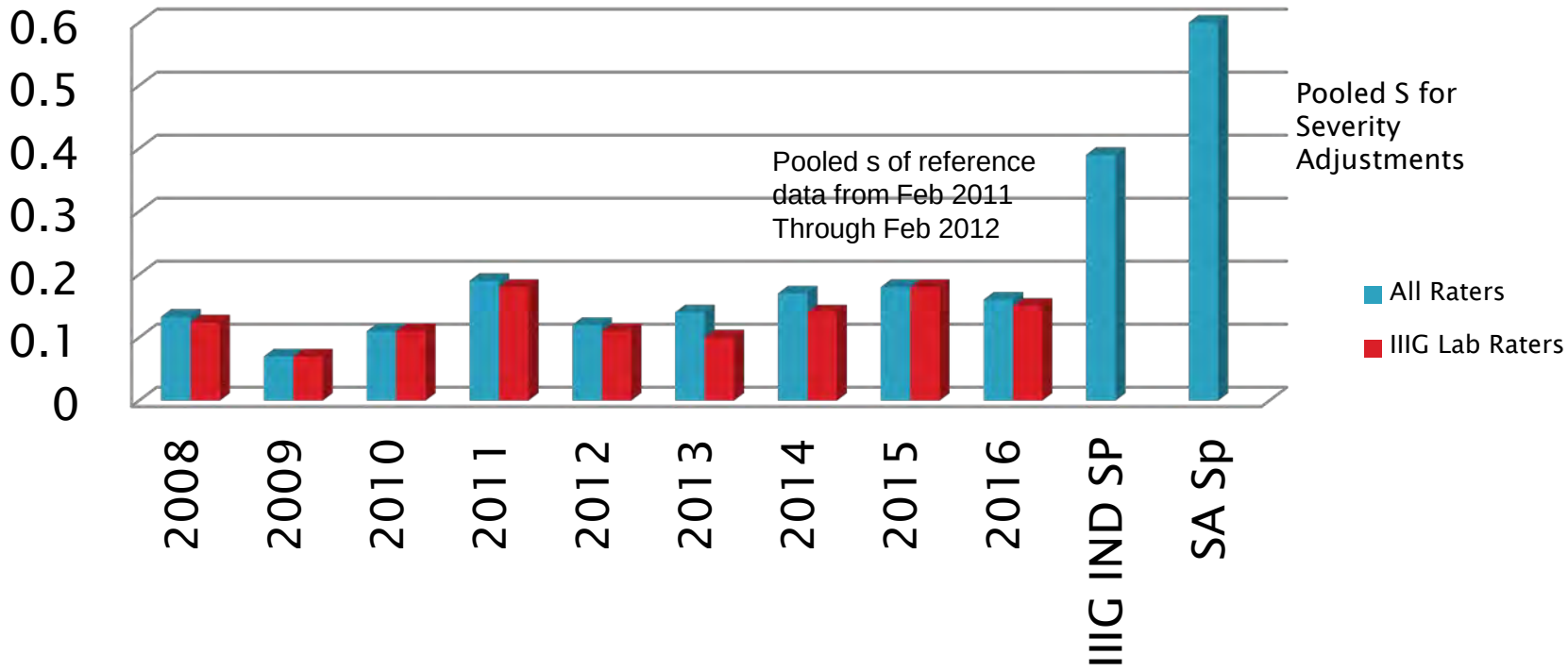
- Summary of Precision Data From Light Duty Rating workshops:
  - VG Average Piston and Average Engine Varnish.
  - IIIG WPD

Sequence VG Precision-Rating Workshop Data



Sequence IIIG Precision – Rating Workshop Data

Comparison of Workshop Pooled Standard Deviations with Industry Pooled Standard Deviations



Return to Table of Contents

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

Return to Table of Contents

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