ASTM D02.B1 Semiannual Report Passenger Car Reference Oil Testing

October 2023

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Passenger Car Engine Oil Testing Executive Summary

- Reblends of oils 224, 543, 542, 940 and 1010-1.
  - The Sequence VI panel is currently introducing Oils 543-1, 542-5 and 1010-2.
  - Sequence IX panel is introducing 224-1.
  - The Sequence V panel is not introducing 940-1 at this time and is re-evaluating further use of 940 in the reference system.
  - The VIII Panel has dropped reference oil 1006-2 based on input from the supplier showing concerns about its age and usefulness. The IV panel needs to address continued use of this oil.

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Passenger Car Engine Oil Testing
Executive Summary (cont.)

- IIIH PVIS/MRV Trend
  - Both PVIS and MRV have been trending mild and have been encountering sporadic warning and action alarms. The panel updated standard deviations for all current reference oils this report period.
- Sequence VIE Severity
  - Both FEI1 And FEI2 have exhibited long term severe trends as evidenced by Cusum and EWMA charts. During this period, however, the charts now reflect on or near target performance for both parameters. The panel also approved VIEBL6 for use.

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Passenger Car Engine Oil Testing
Executive Summary (cont.)

- Aged Oil LSPI
  - The Sequence IX panel recently approved a modification to Test Method D8291 to allow for an aging process to be included in the LSPI test. Two stands have calibrated, and two others are attempting to calibrate. Reblends of both reference oils API01 and API02 are being pursued and should be available shortly.

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Passenger Car Engine Oil Testing
Executive Summary (cont.)

- Sequence VIII became available October 5, 2023
  - The Sequence VIII test had been unavailable last period. The panel has successfully conducted matrix tests to introduce 03-22 bearings, generate targets for reference oil 1009-1, and also develop industry correction factors for both BWL and SVIS. These changes all took effect 10/5/23. These updated charts and precision estimates are included in this report period since these tests were actually completed during this report period. The panel also is using 1009-1 as the reference oil moving forward

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Calibrated Labs and Stands*

Test	Labs	Stands
IIIH/A/B	6	12
IVA	1	1
IVB	4	5
VH	4	9
VIE	4	16
VIF	1	2
VIII	0	0
IX	4	6
IXAGED	3	2
X	4	5

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*As of 9/30/2023

Sequence IIIH/A/B

- October 2023

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Sequence IIIH/A/B Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	12
Statistically Unacceptable Calibration Test	OC	1
Total		**13**

Sequence IIIH – Failing Tests

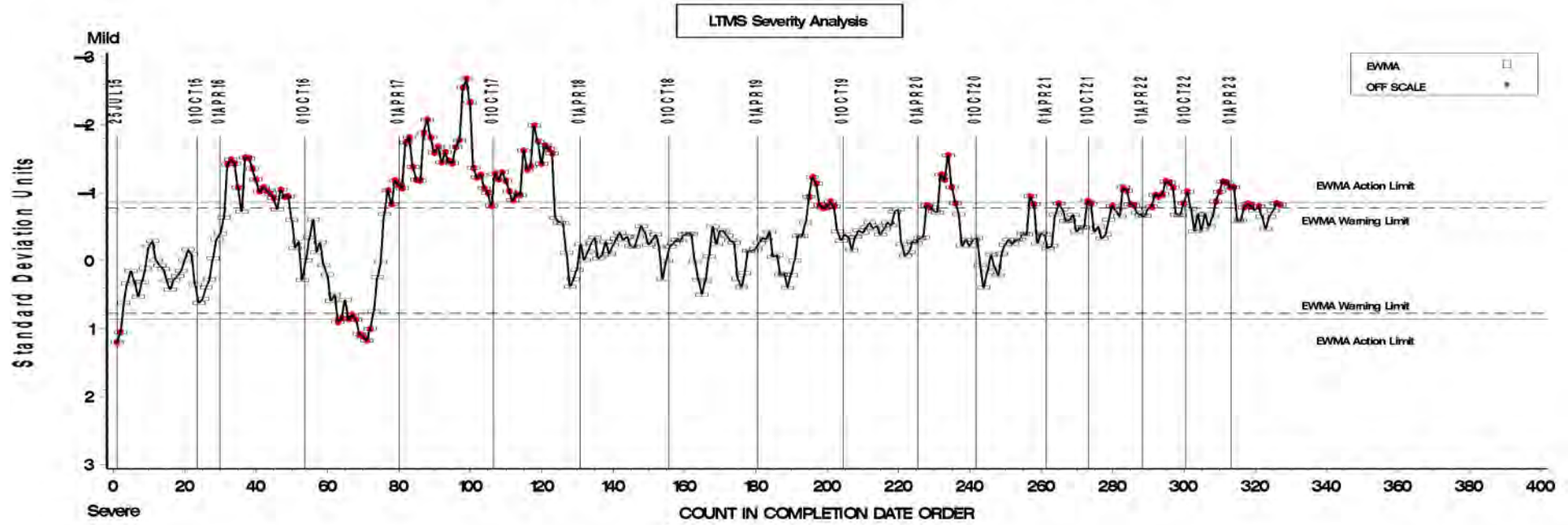
Test Status	#
PVIS Severe	1
Total	**1**

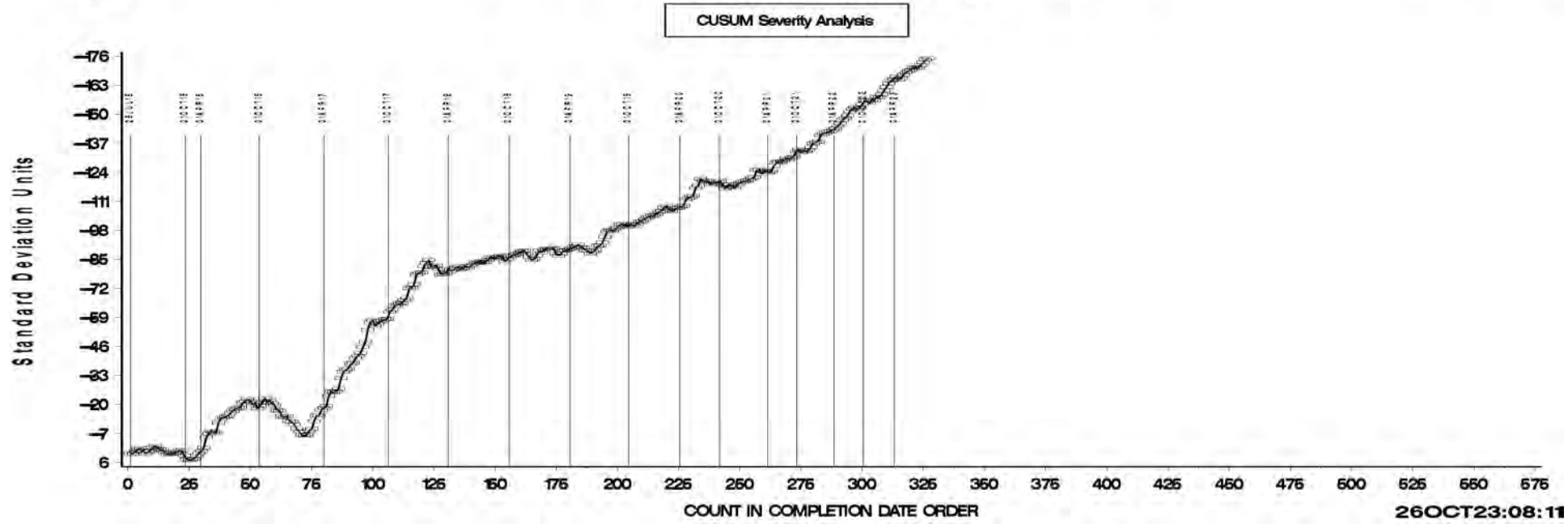
Sequence IIIH Test Severity

- APV is in action alarm (mild direction)
- PVIS is in warning alarm (mild direction)
- All other parameters are in control.

SEQUENCE IIIH INDUSTRY OPERATIONALLY VALID DATA

VISCOSITY INCREASE FINAL ORIG UNIT RES





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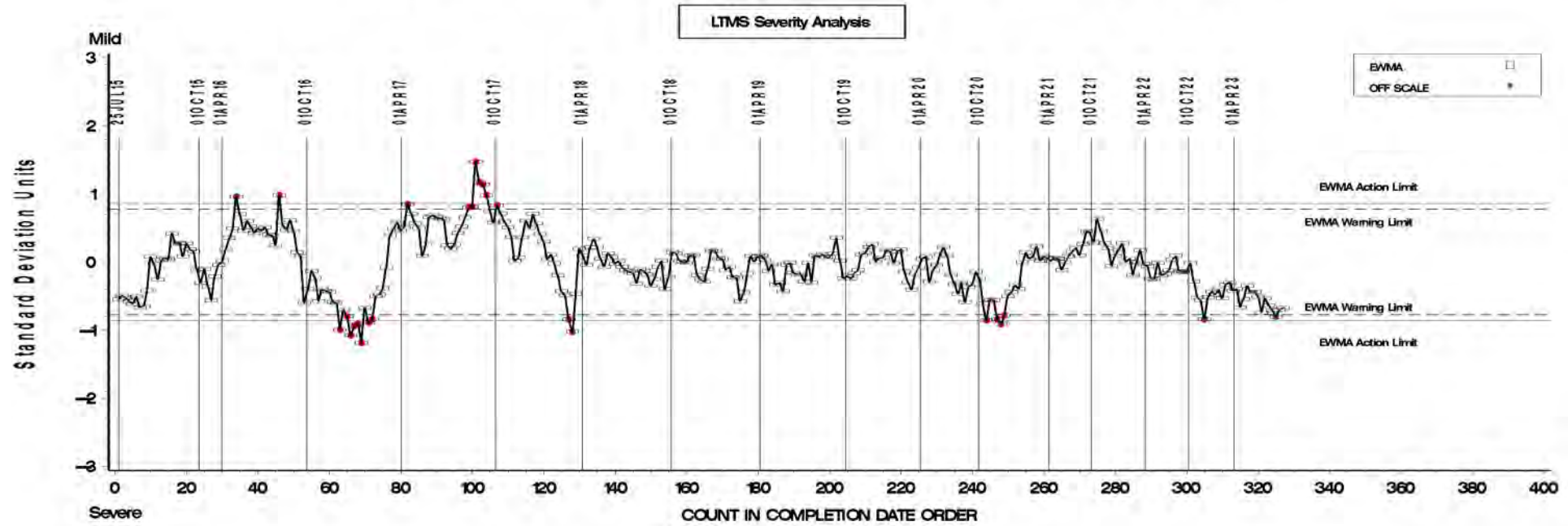
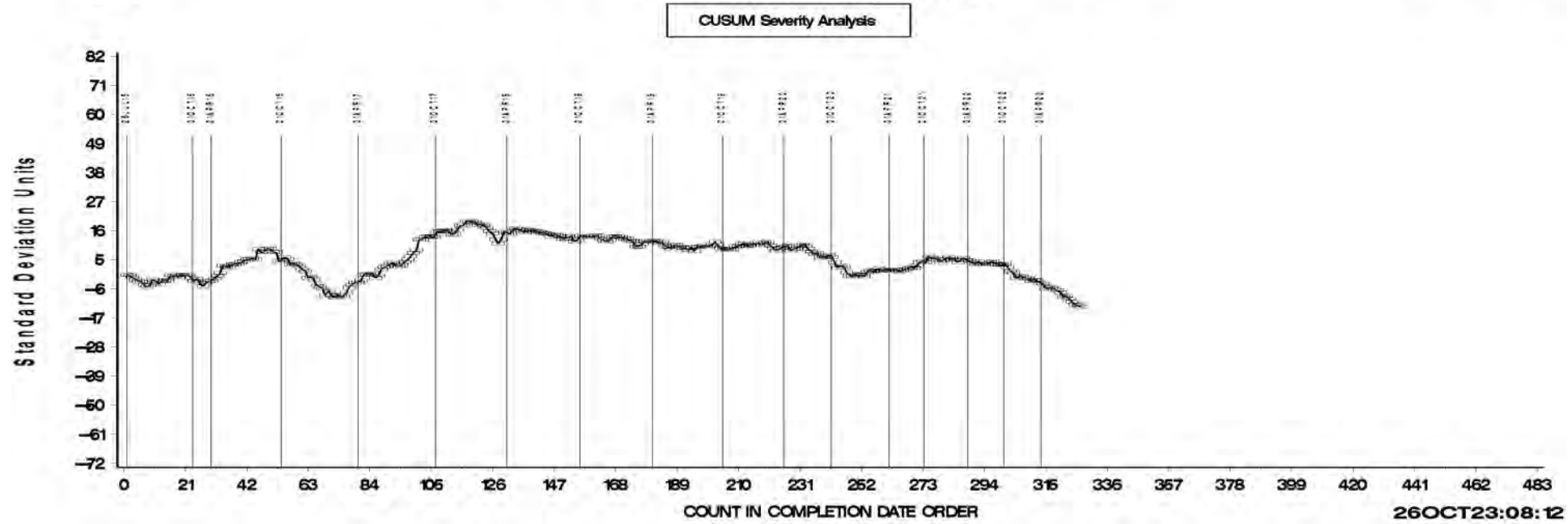
SEQUENCE IIIH INDUSTRY OPERATIONALLY VALID DATA

AVERAGE WEIGHTED PISTON DEPOSITS FNL ORIG U





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SEQUENCE IIIH INDUSTRY OPERATIONALLY VALID DATA

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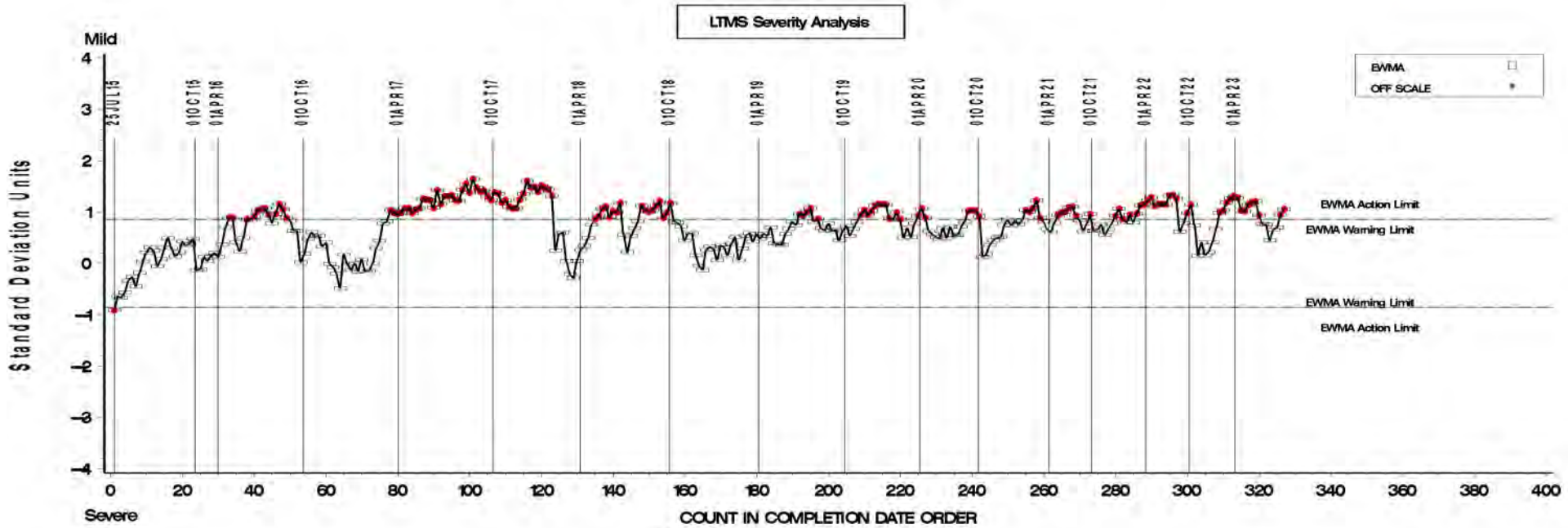
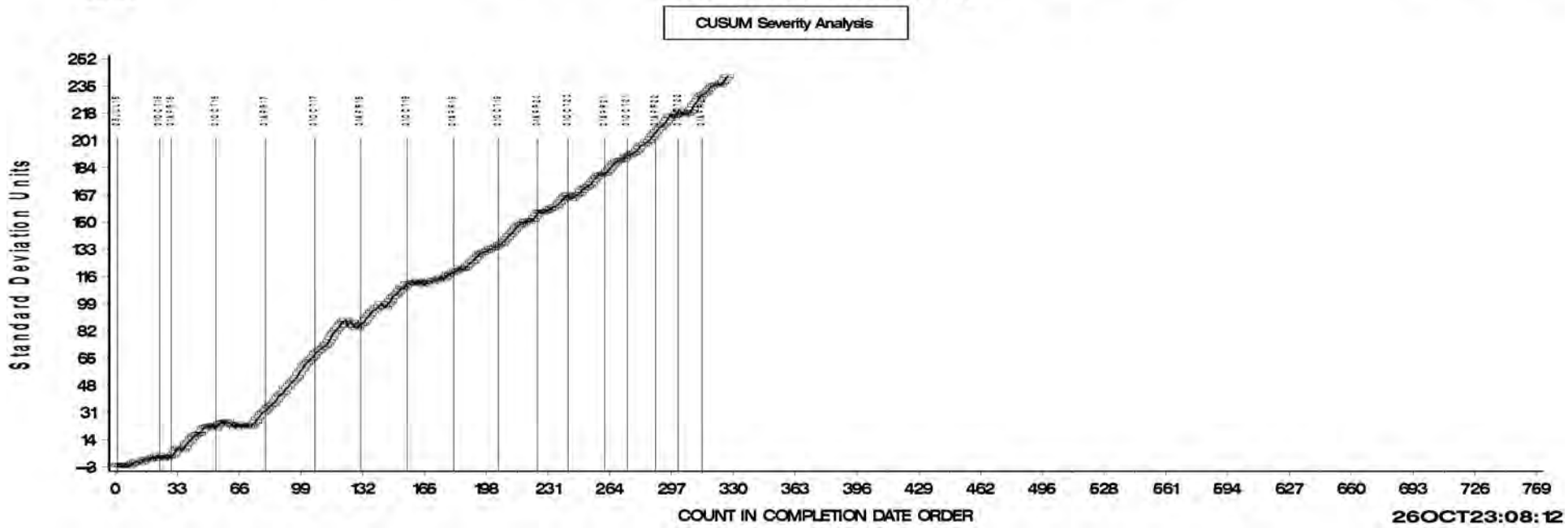
AVERAGE PISTON SKIRT VARNISH





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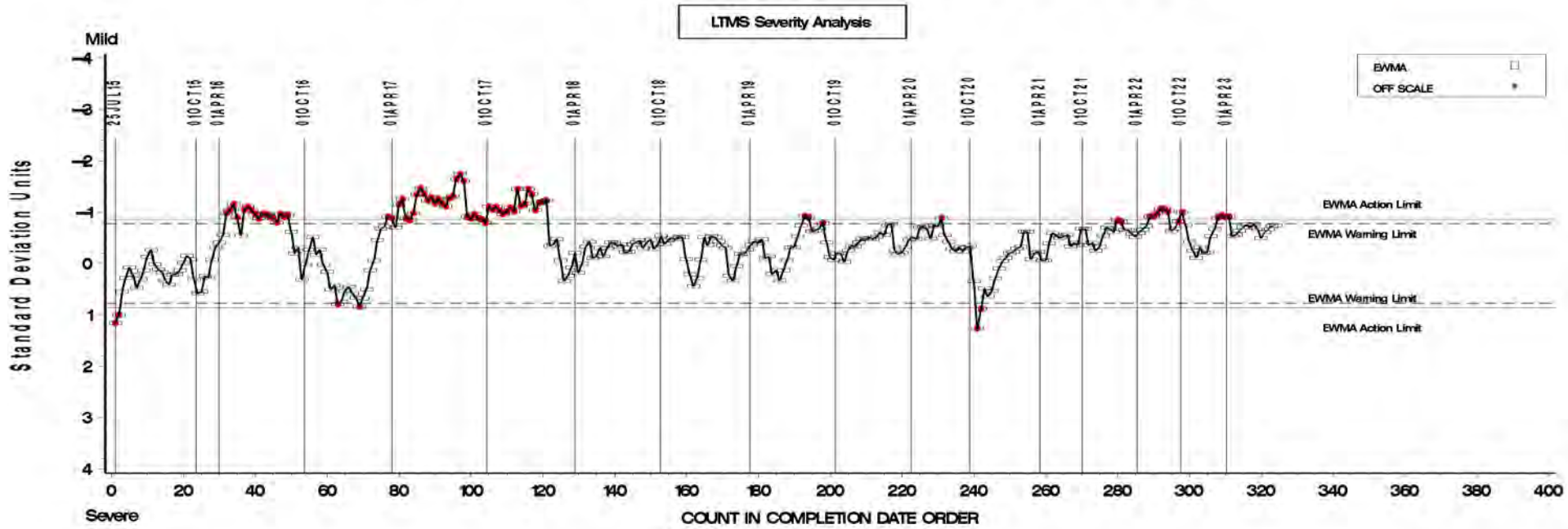
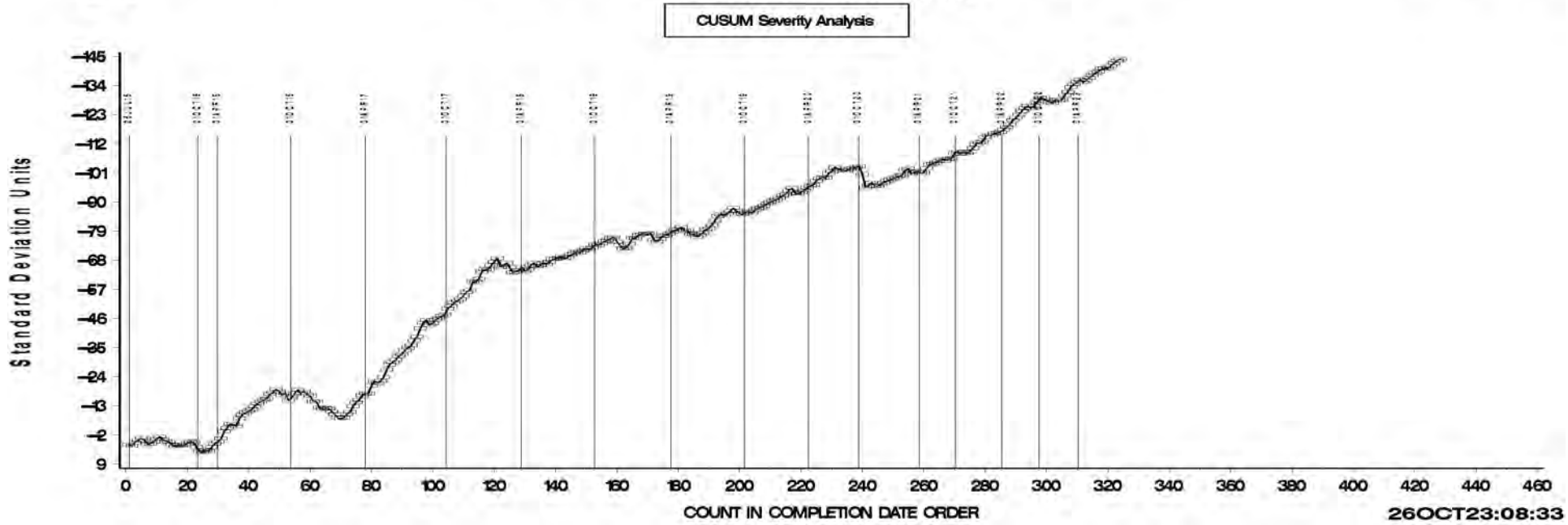
SEQUENCE IIIHA INDUSTRY OPERATIONALLY VALID DATA

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





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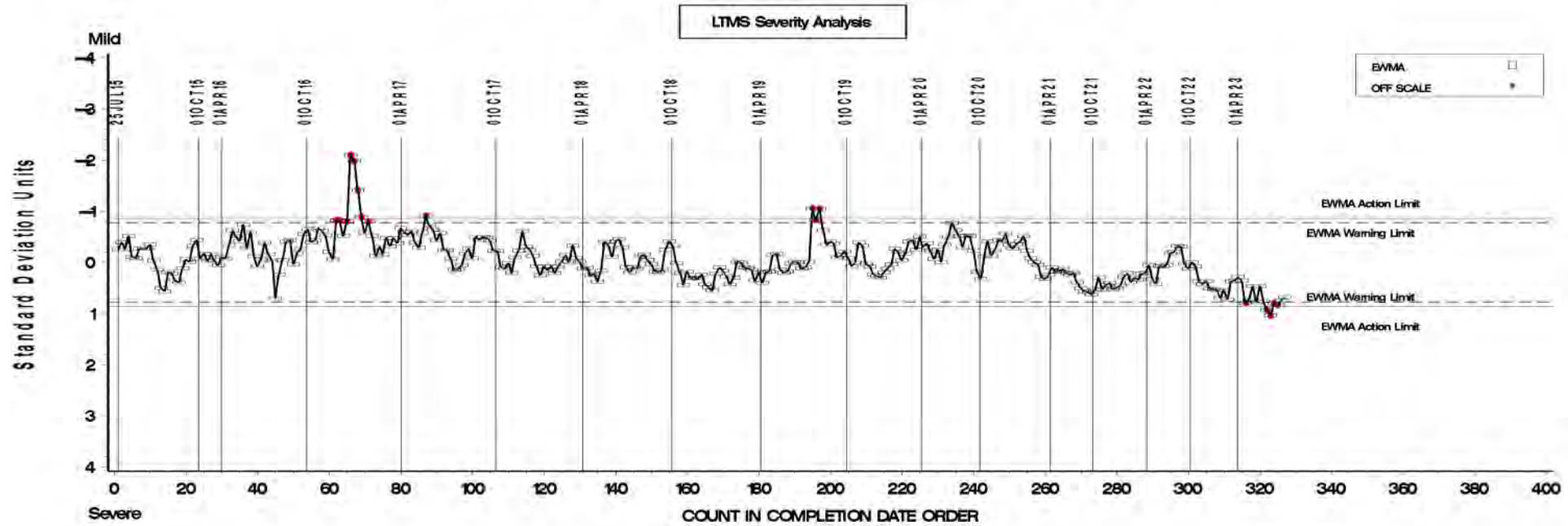
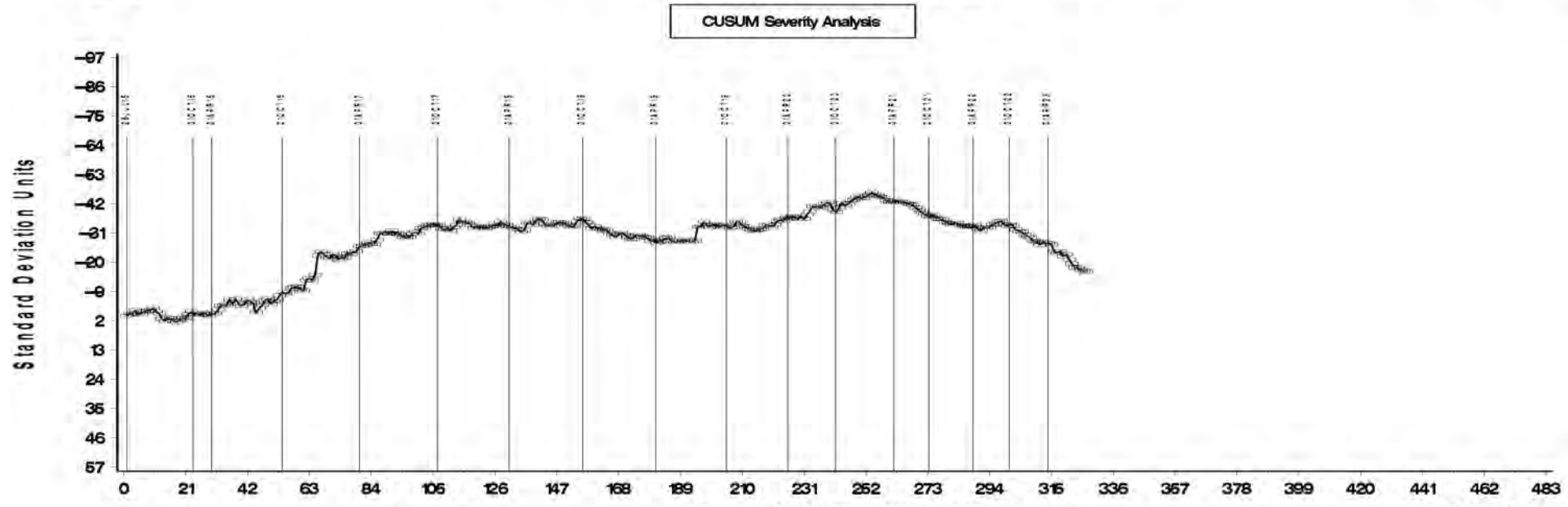
SEQUENCE IIIHB INDUSTRY OPERATIONALLY VALID DATA

PHOSPHORUS RETENTION, FINAL RESULT





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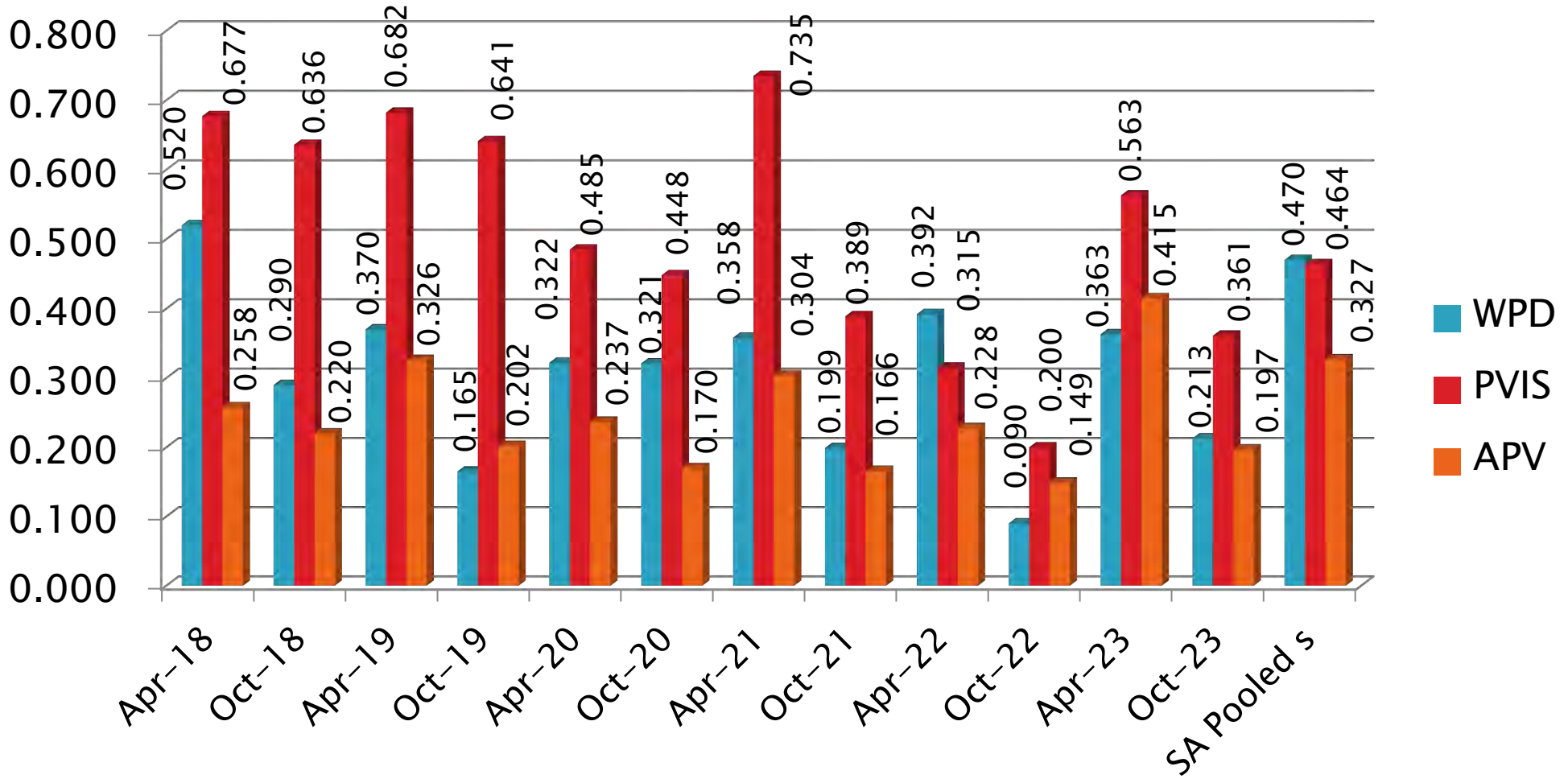
IIIH Precision Estimates



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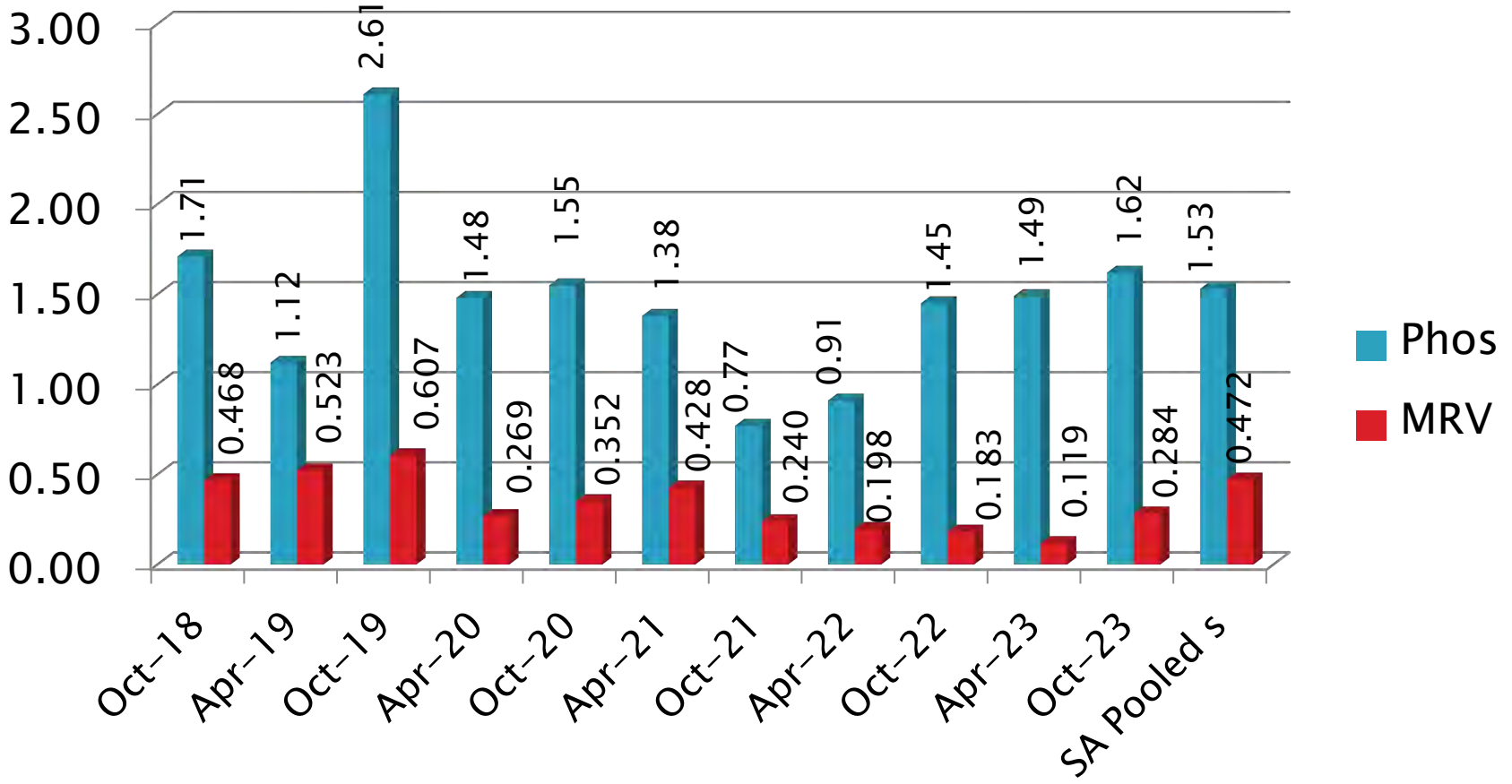
IIIHA/B Precision Estimates



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Sequence IVA

- October 2023

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Sequence IVA Activity

Test Status	Validity Code	#
No Test Reported This Period		0
Total		**0**

Sequence IVA Test Severity

- Since calibration periods have been extended to one year, there was no reference test activity this report period. All charts are from the previous report period.

SEQUENCE IVA INDUSTRY OPERATIONALLY VALID DATA

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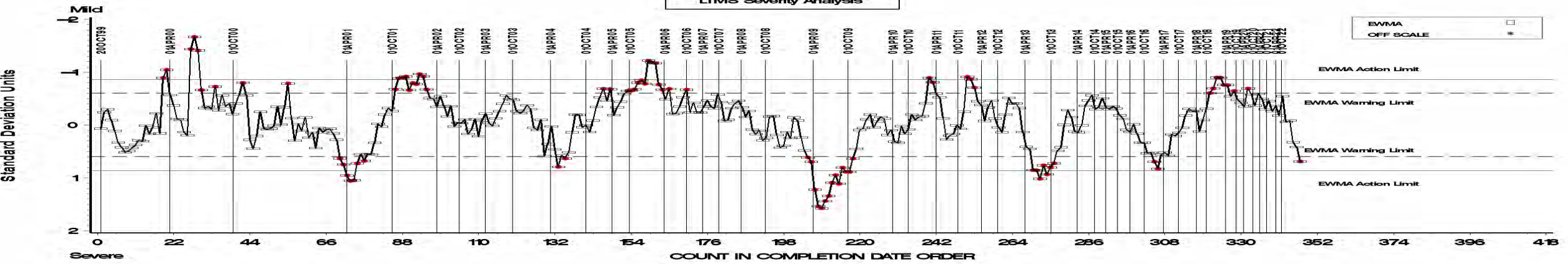
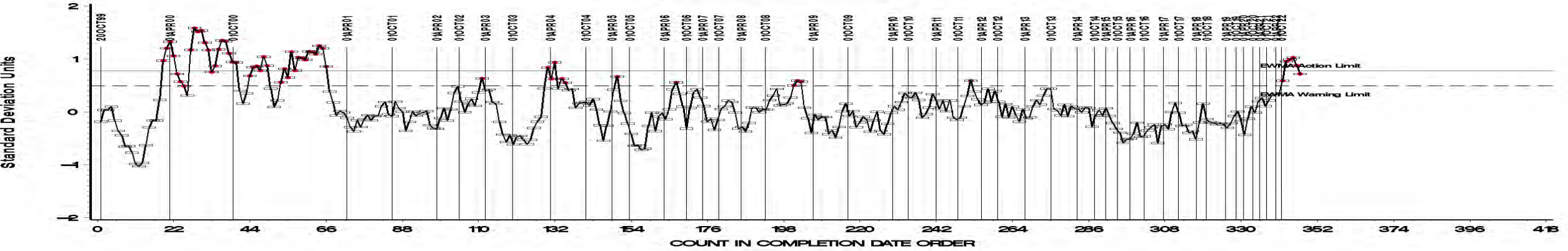
AVERAGE CAM WEAR

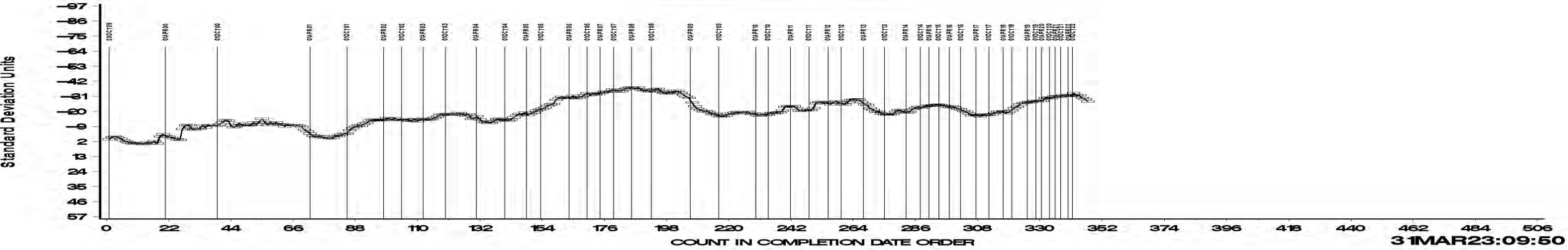
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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SEQUENCE IVA INDUSTRY OPERATIONALLY VALID DATA

Last 20 results

AVERAGE CAM WEAR

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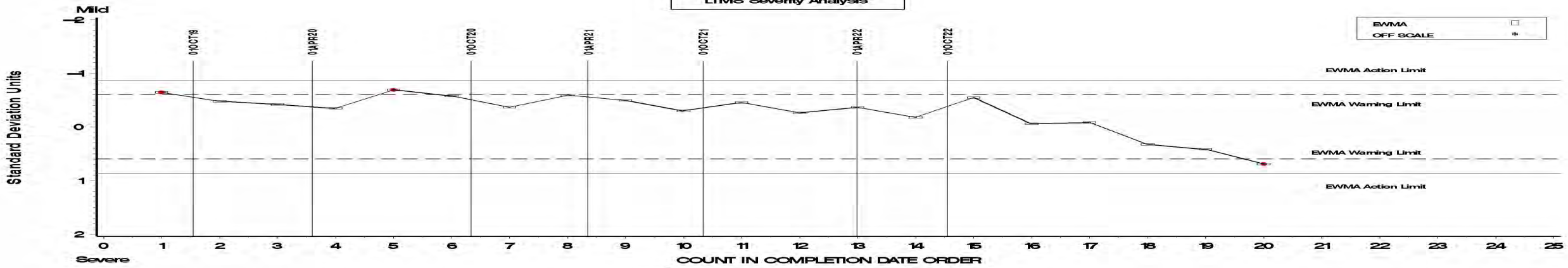
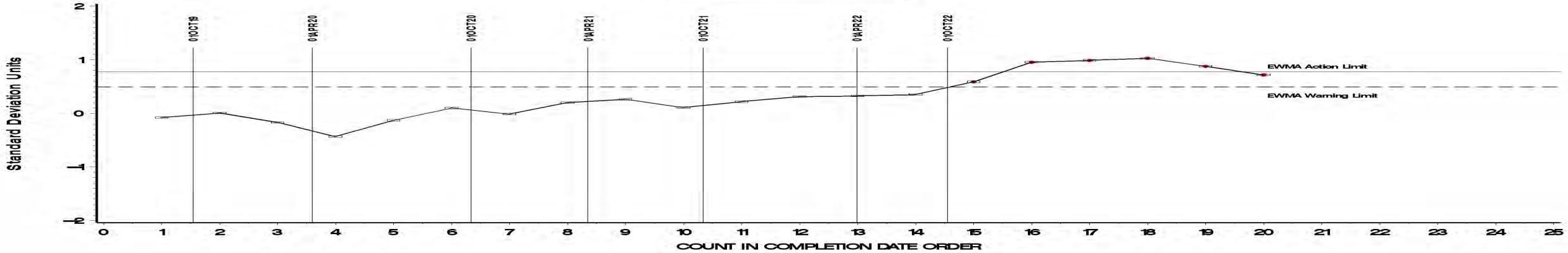
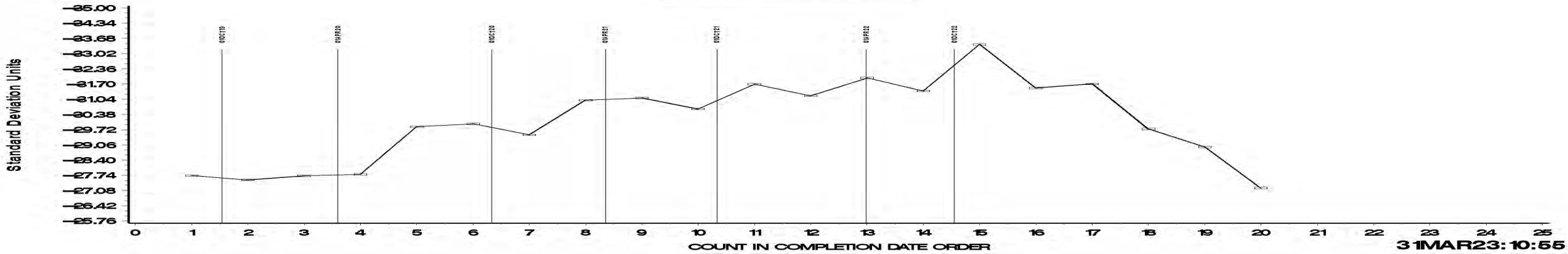
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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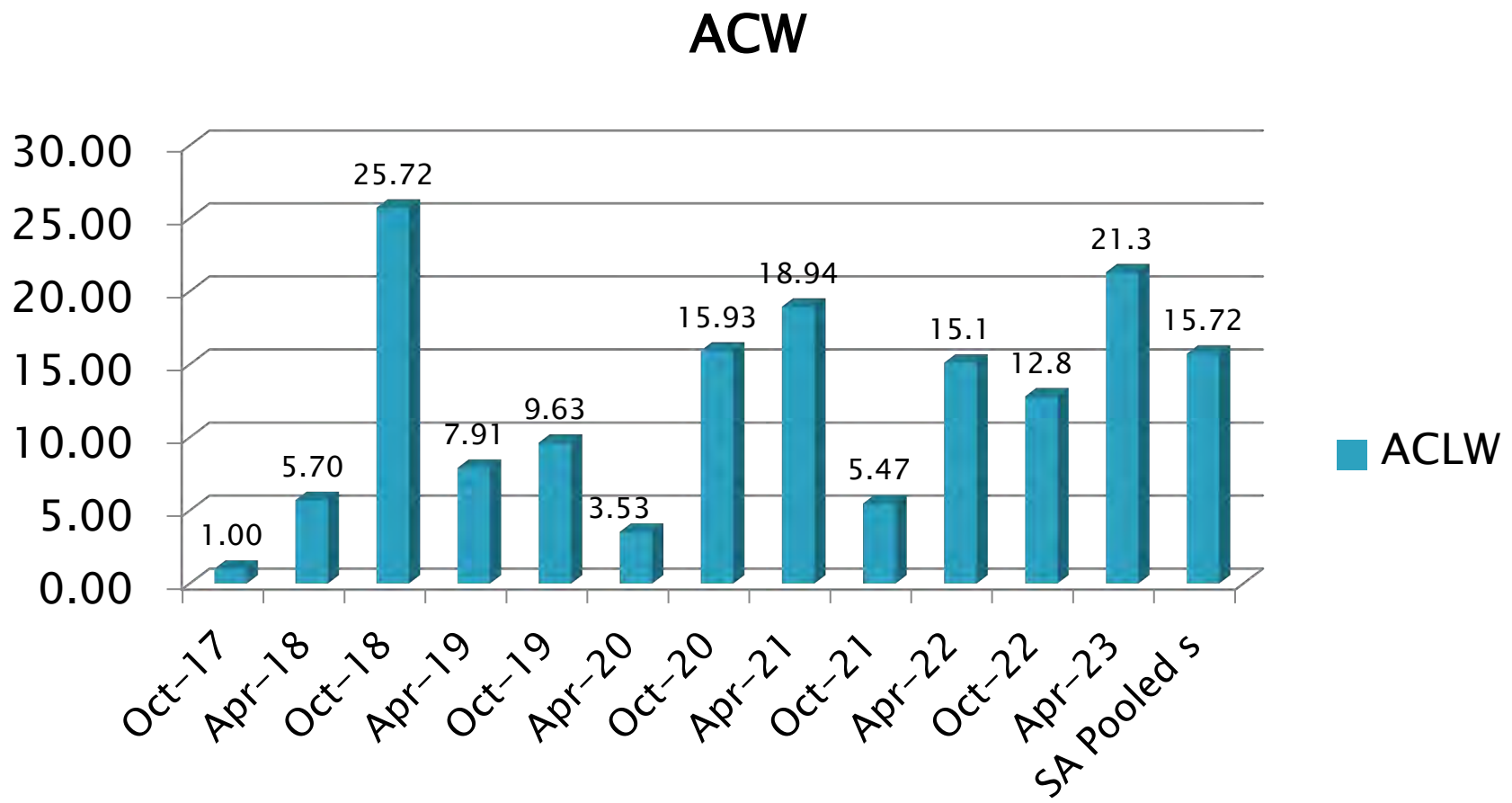
Sequence IVA Precision Estimates



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Sequence IVB

- October 2023

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Sequence IVB Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	7
Statistically Unacceptable Calibration Test	OC	1
Total		**8**

Sequence IVB – Failing Tests

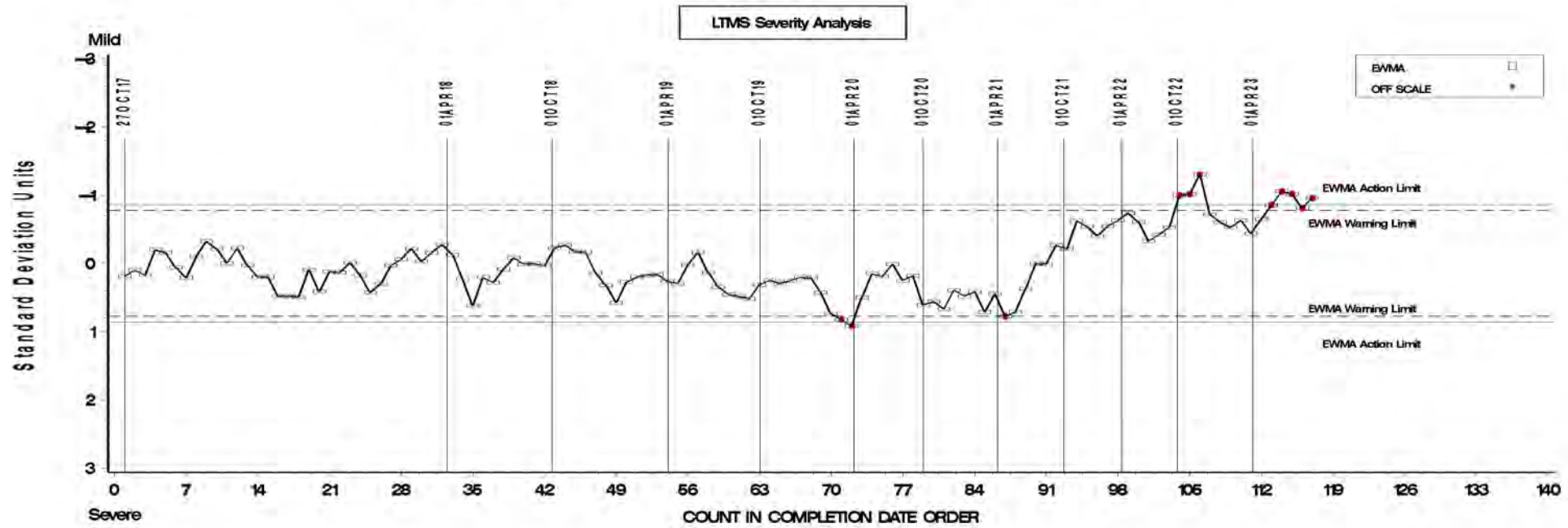
Test Status	#
Level 3 Ei alarm (mild Direction)	1
Total	**1**

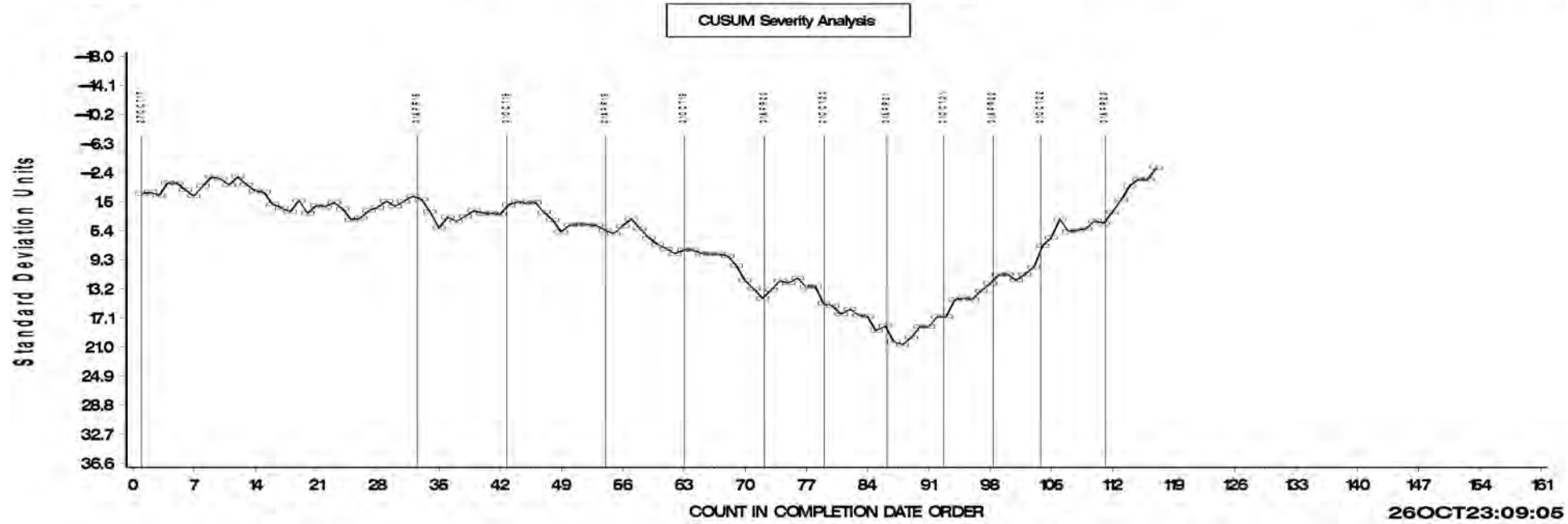
Sequence IVB Test Severity

- AVLI and Fe are in action alarm (mild direction).

SEQUENCE IVB INDUSTRY OPERATIONALLY VALID DATA

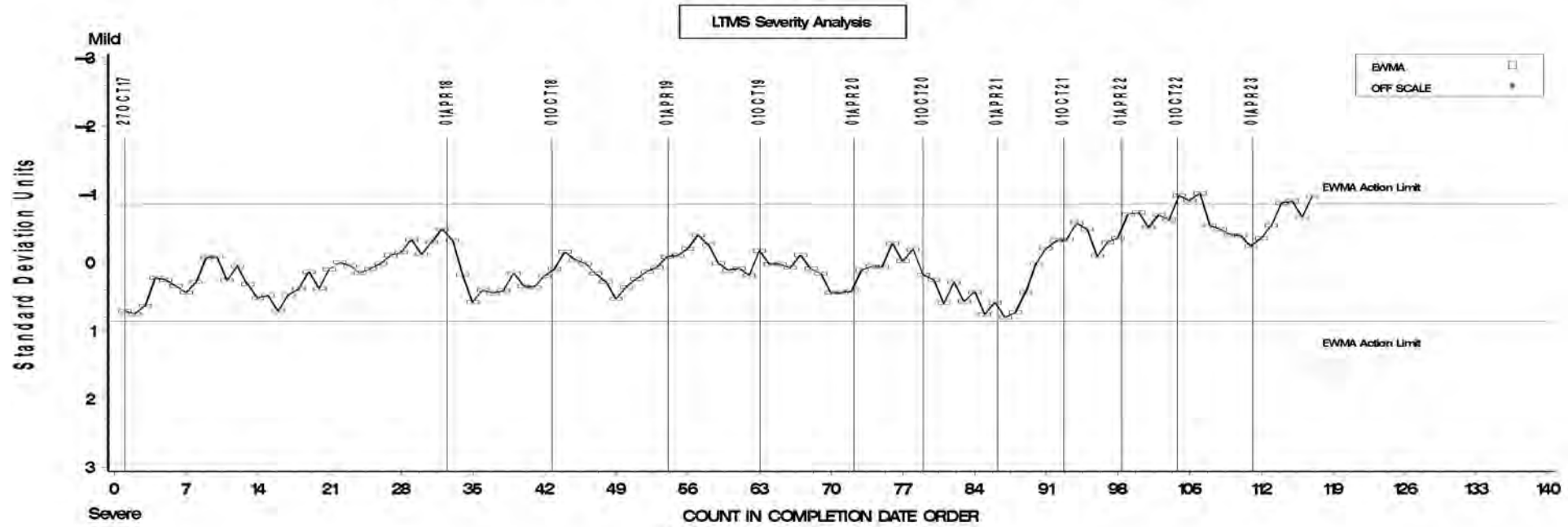
AVERAGE VOLUME LOSS BY KEYENCE INTAKE Final

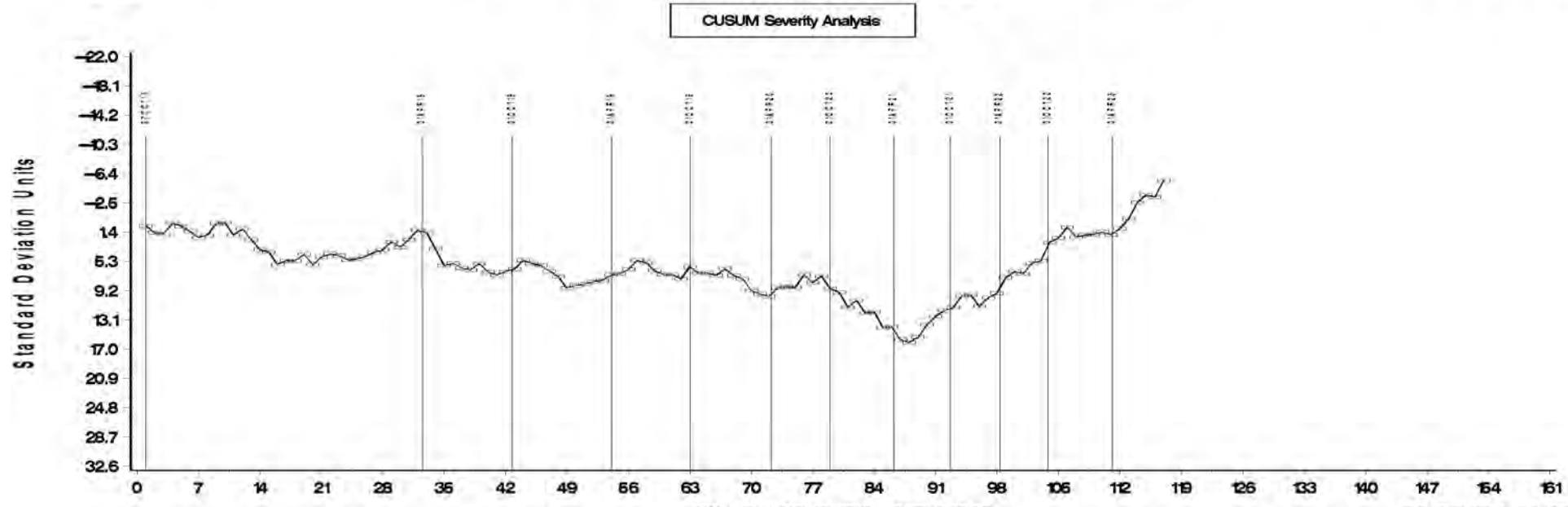




SEQUENCE IVB INDUSTRY OPERATIONALLY VALID DATA

END OF TEST FE FINAL Severity Adjusted RESULT





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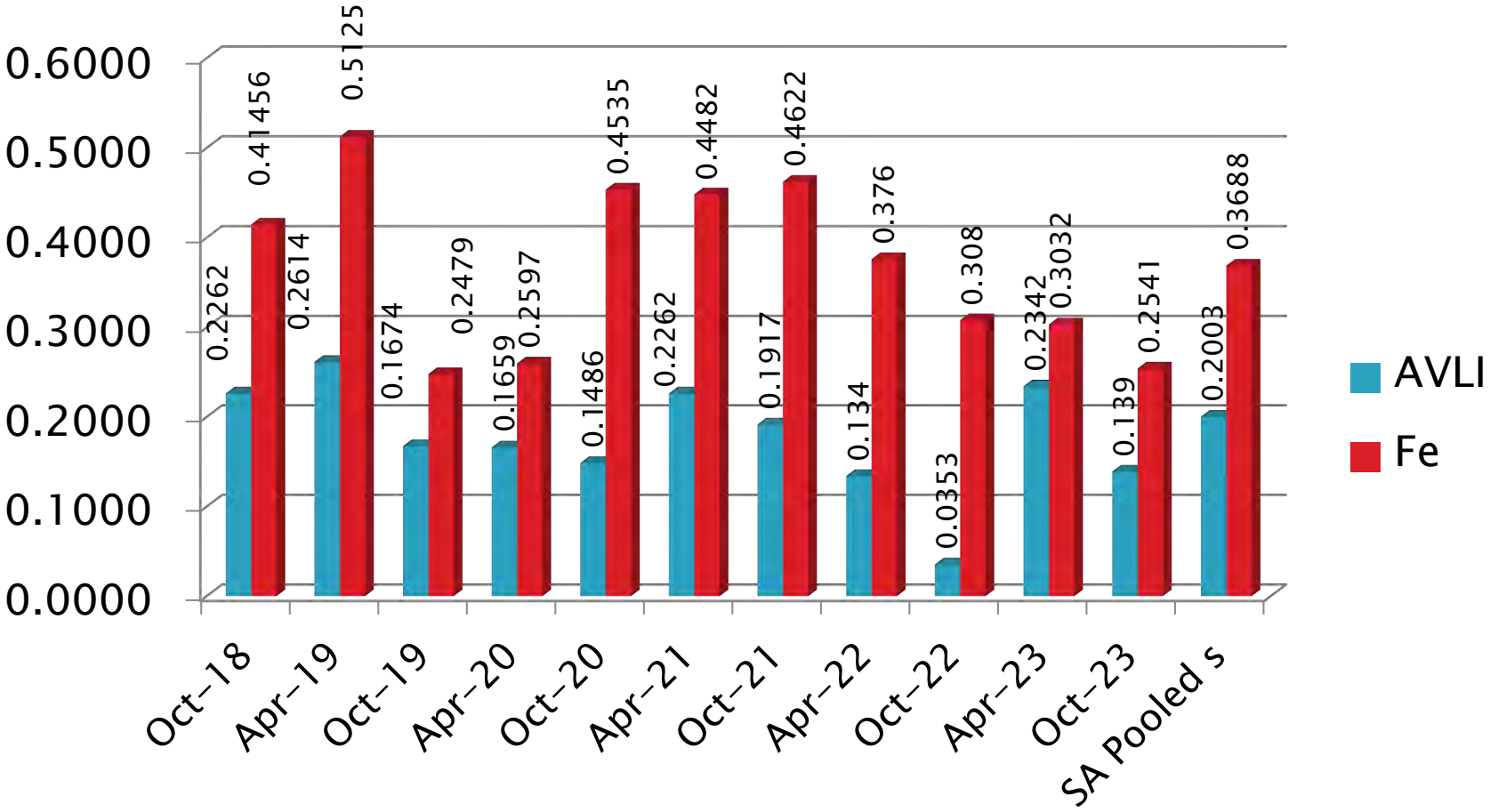
Sequence IVB Precision Estimates



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Sequence VH

- October 2023

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Sequence VH Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	10
Statistically Unacceptable Calibration Test	OC	1
Total		**11**

Sequence VH – Failing Tests

Test Status	#
AES, RAC and APV Ei Level 3 alarms (Severe Direction)	1
Total	**1**

Sequence VH Test Severity

- AES, RAC and APV parameters within control limits
- AE50 is in severity action alarm (severe direction)

SEQUENCE VH INDUSTRY OPERATIONALLY VALID DATA

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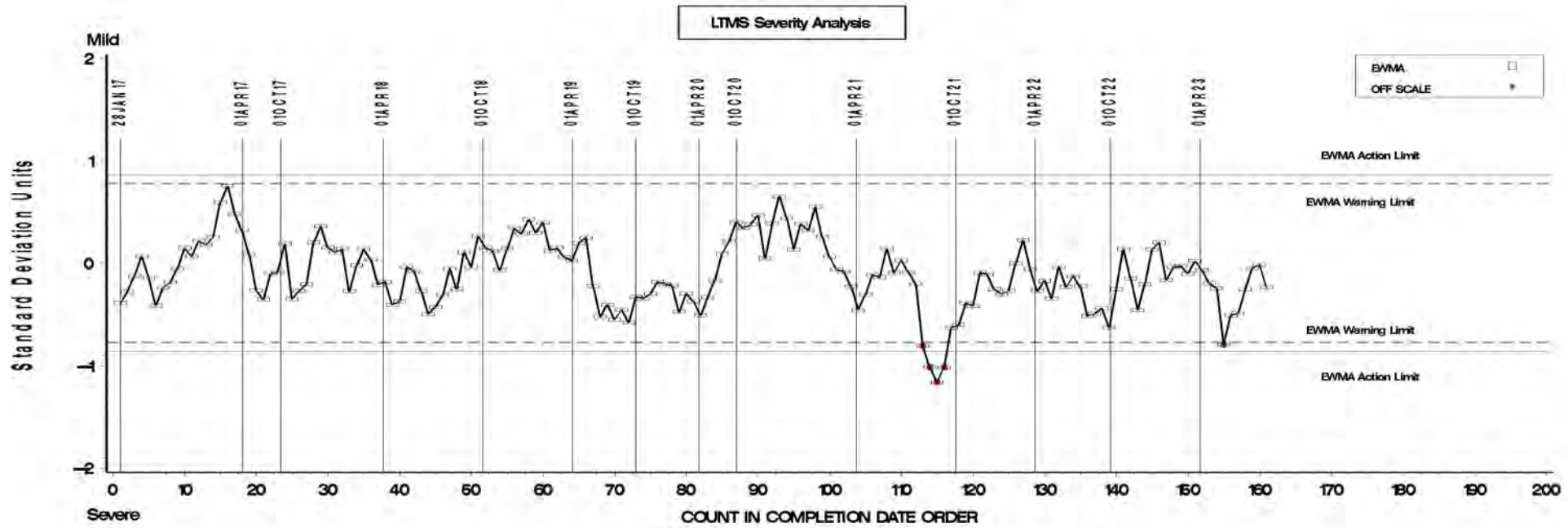
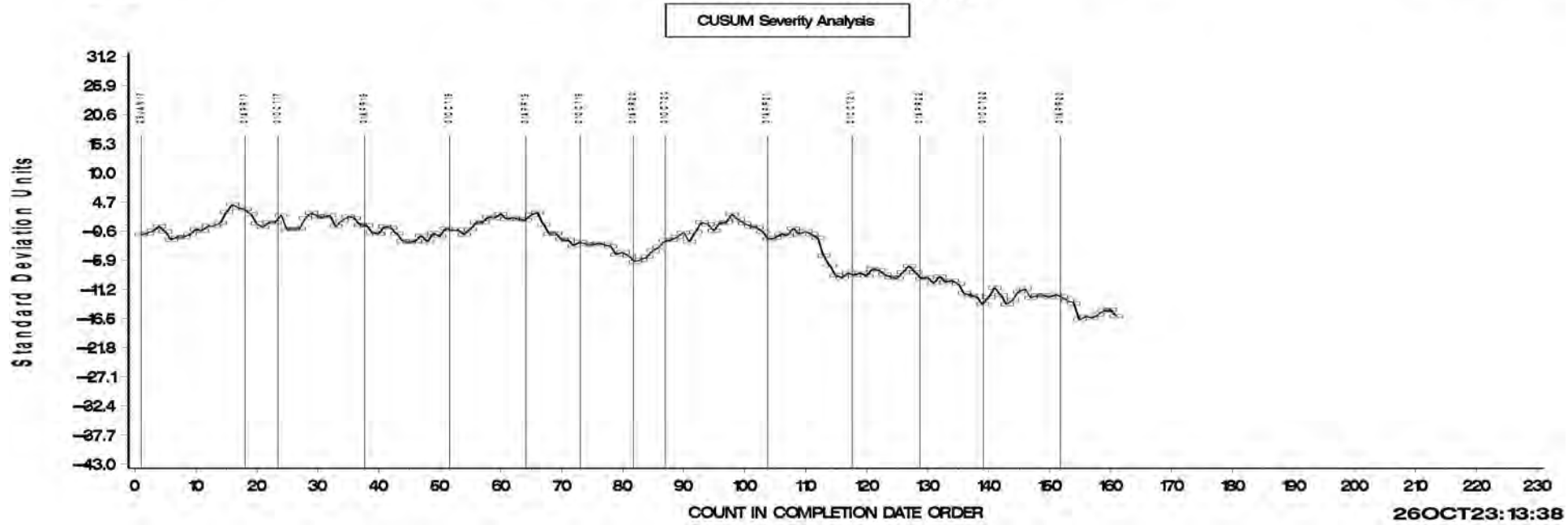
AVERAGE ENGINE SLUDGE





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SEQUENCE VH INDUSTRY OPERATIONALLY VALID DATA

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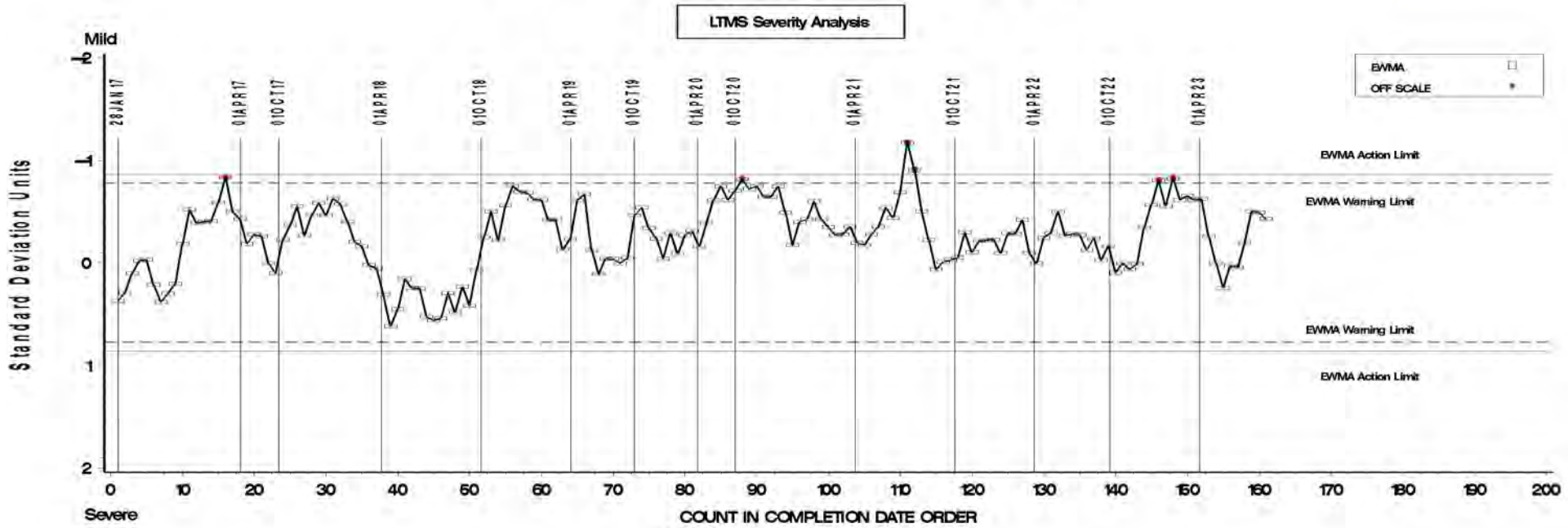
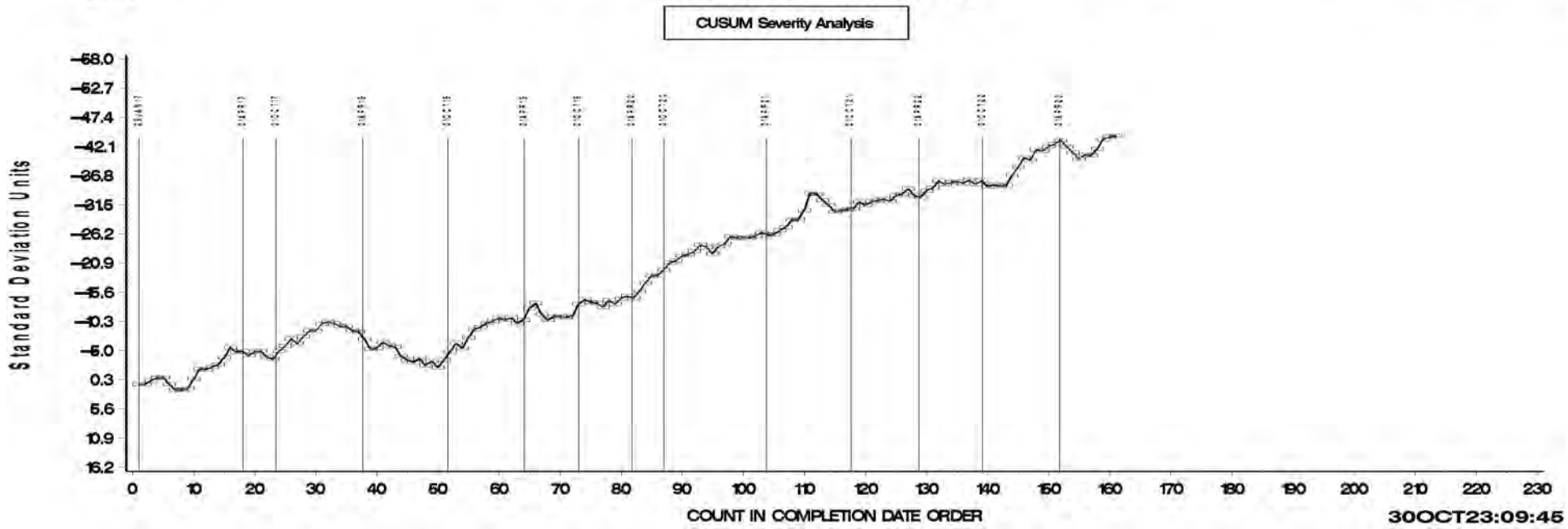
AVERAGE ROCKER COVER SLUDGE





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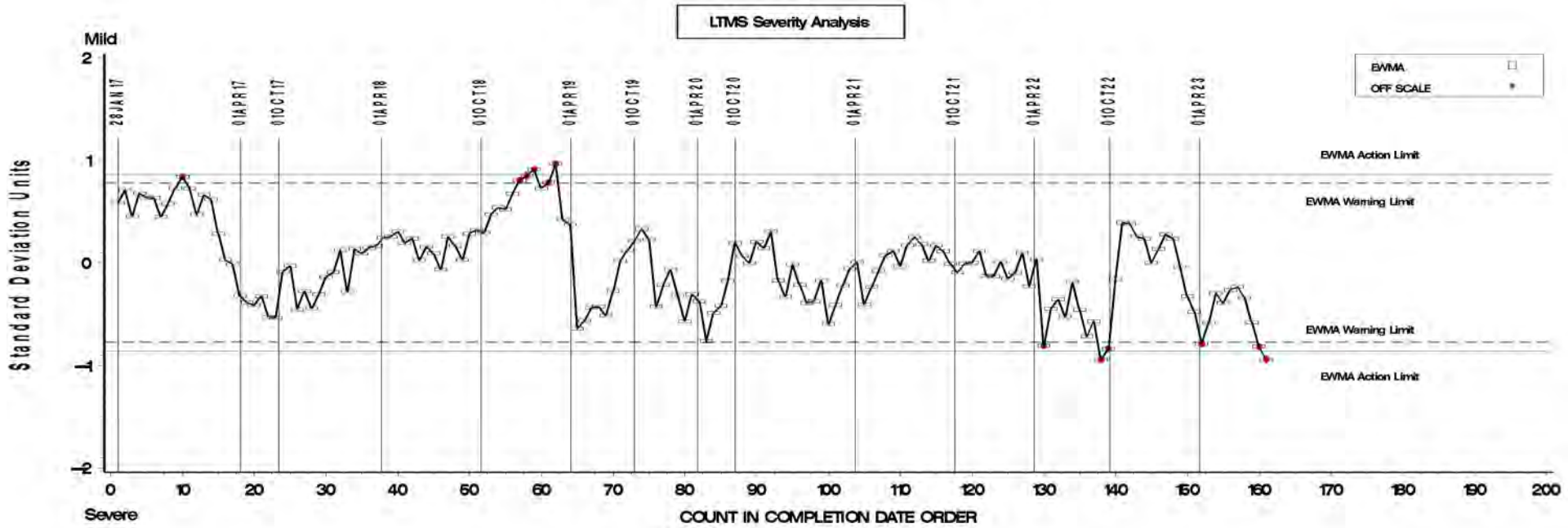
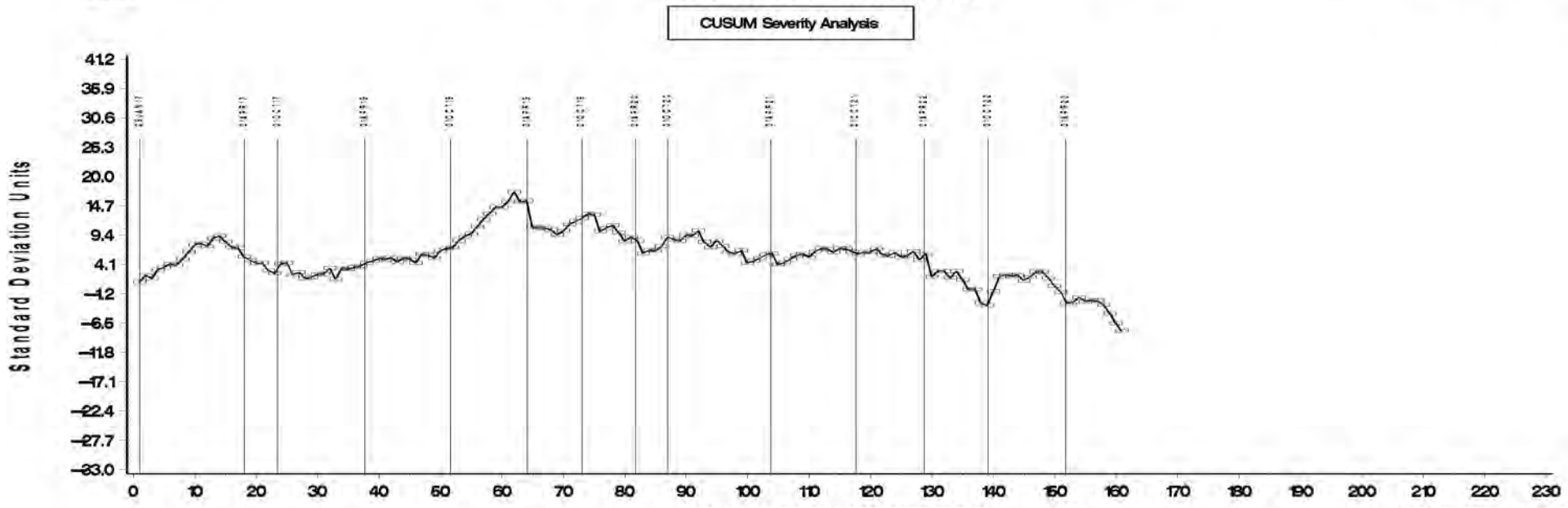
SEQUENCE VH INDUSTRY OPERATIONALLY VALID DATA

AVG. ENG. VARN. 50% RATING





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SEQUENCE VH INDUSTRY OPERATIONALLY VALID DATA

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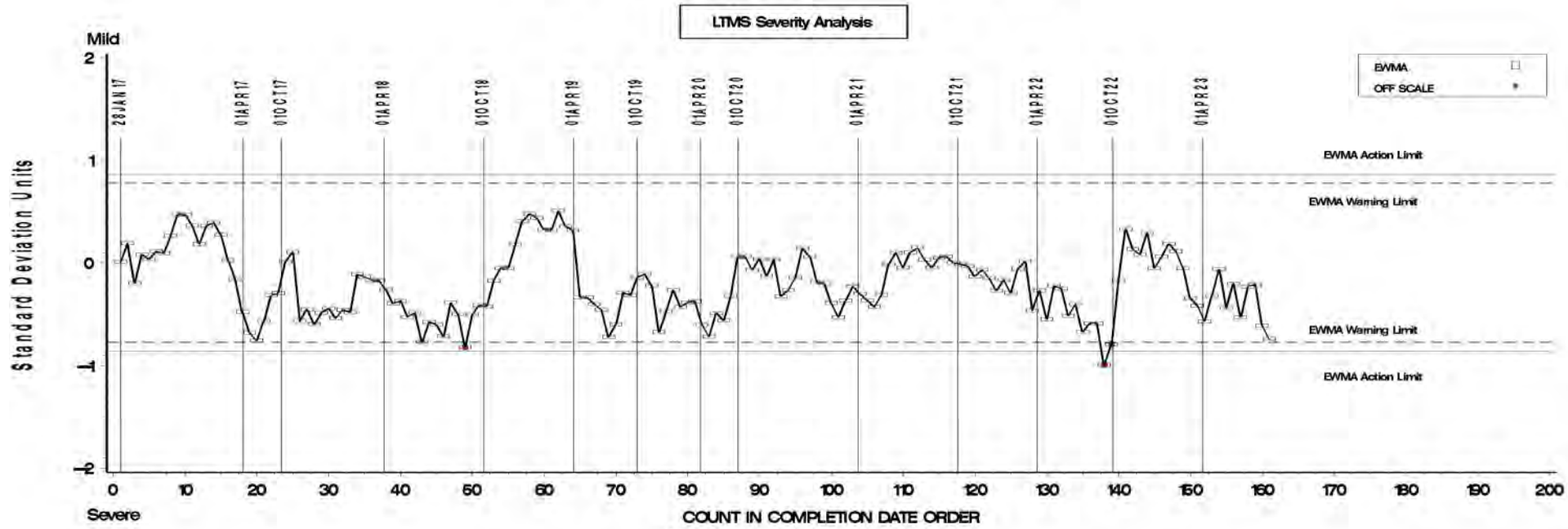
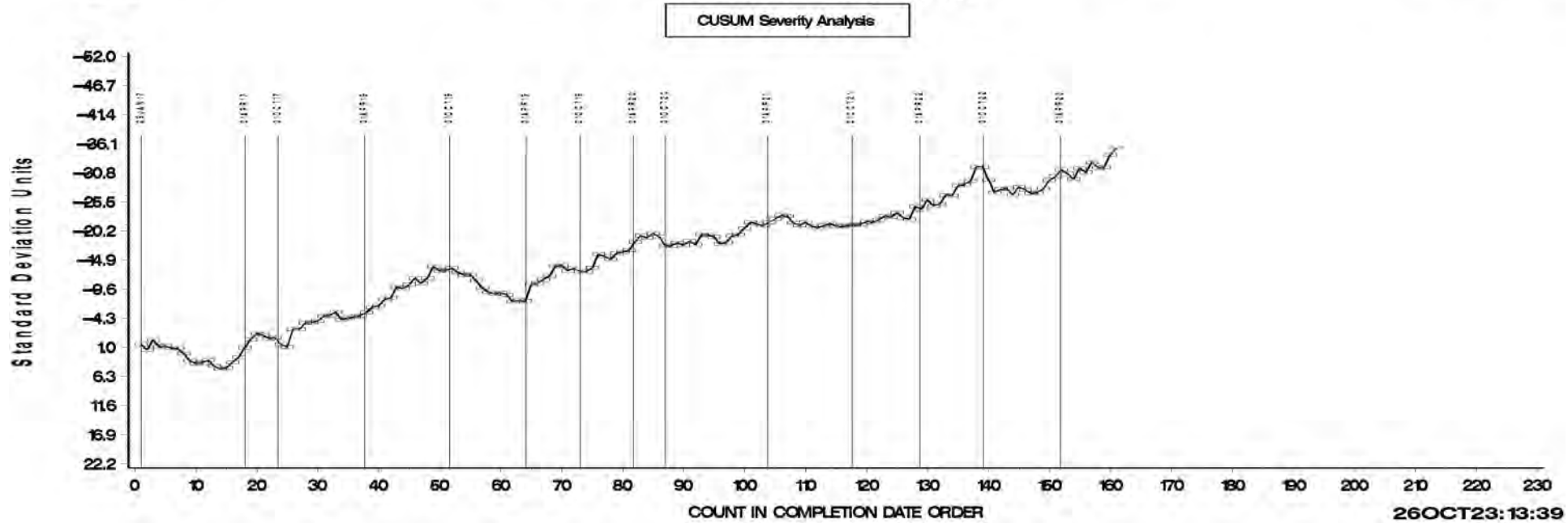
AVG PISTON SKIRT 50% RATING





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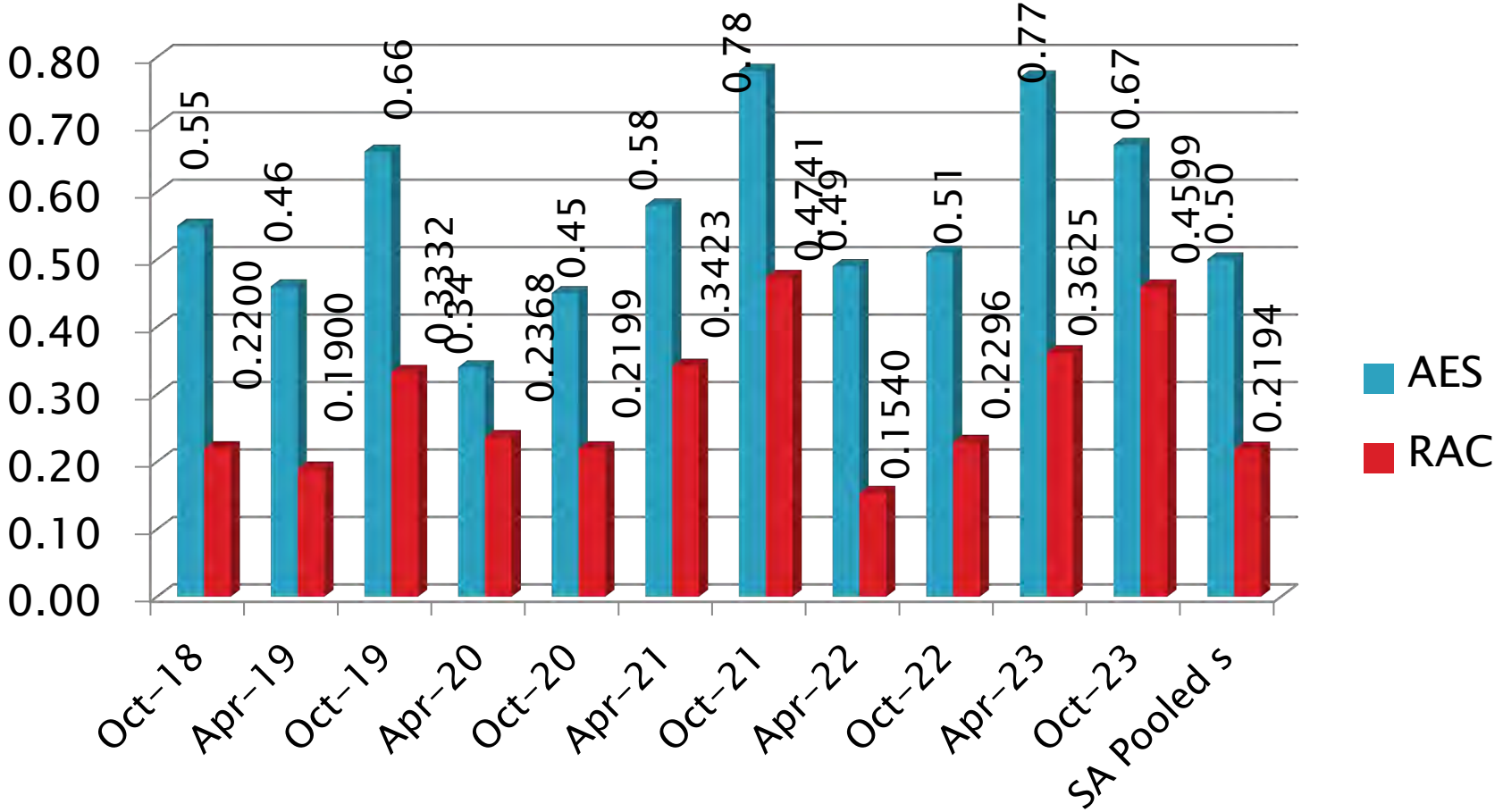
Sequence VH Precision Estimates



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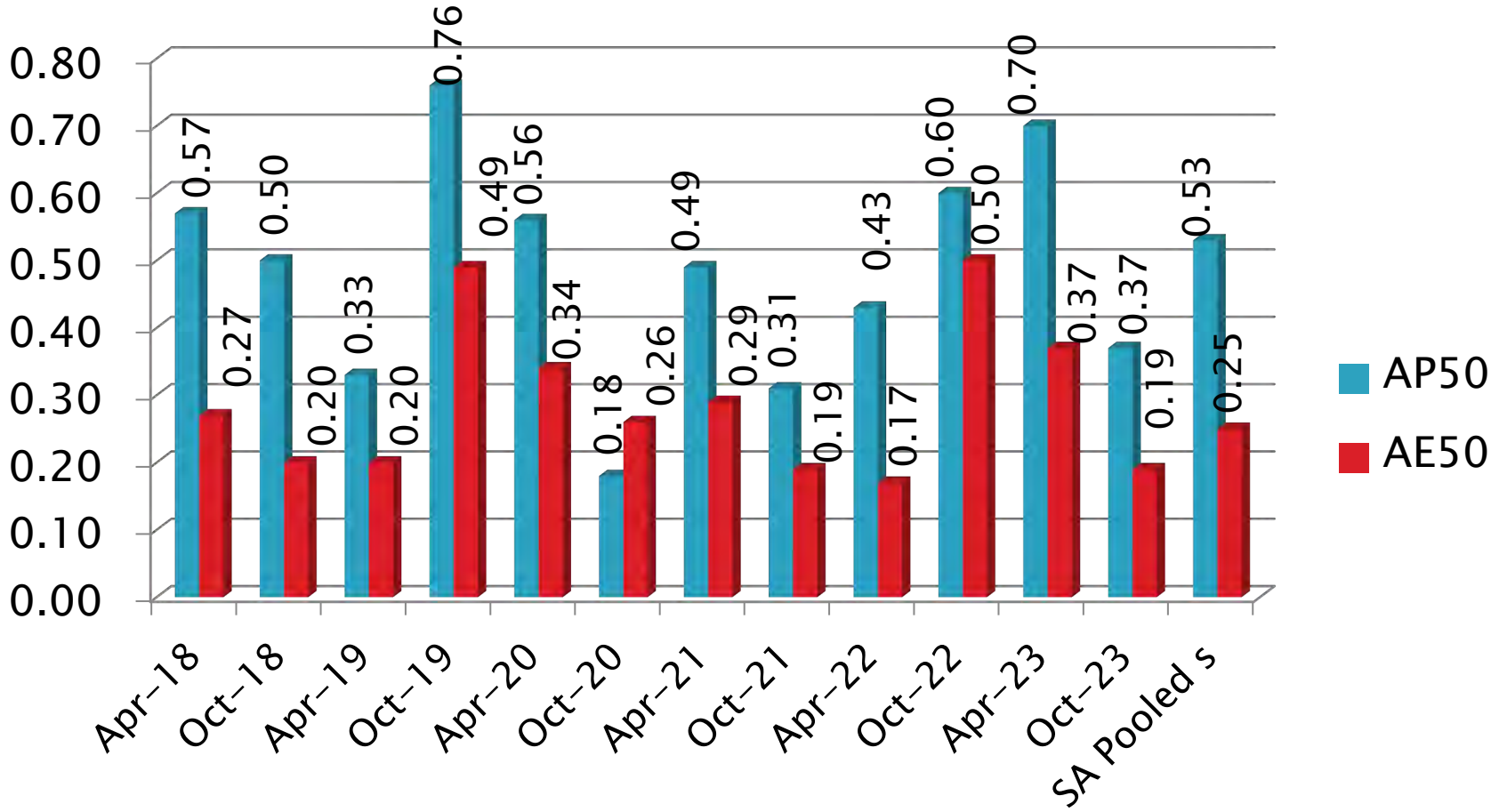
Sequence VH Precision Estimates



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Sequence VIE

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Sequence VIE Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	27
Engine Abandoned	MC	2
Operationally Invalid Calibration Test	LC	1
Aborted Calibration Test	XC	2
Total		**32**

Sequence VIE – Lost Tests*

Test Status	Cause	#
Invalid	Speed Out of Spec during 16 hour aging (Phase I)	1
Aborted	Dyno failure	1
Aborted	Flushing error	1
Totals		**3**

*Invalid and aborted tests

Sequence VIE Test Severity

- FEI1 and FEI2 are in control but have shown long term severe trends in the Cusum and EWMA charts.

SEQUNCE VIE INDUSTRY OPERATIONALLY VALID DATA

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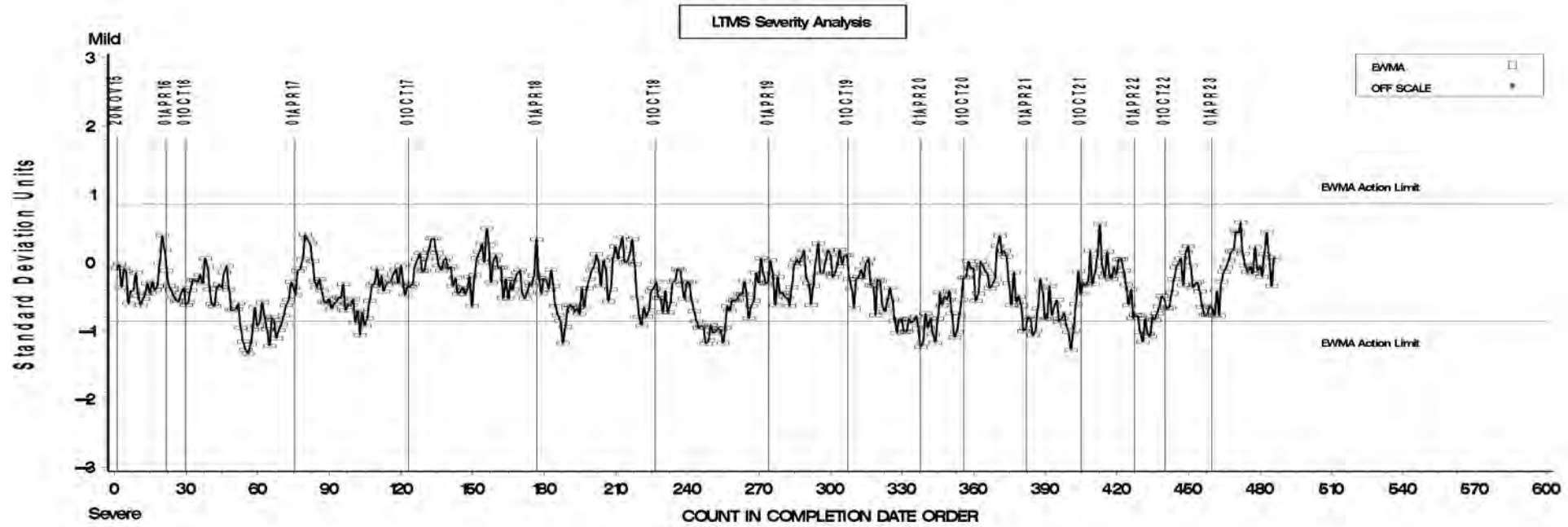
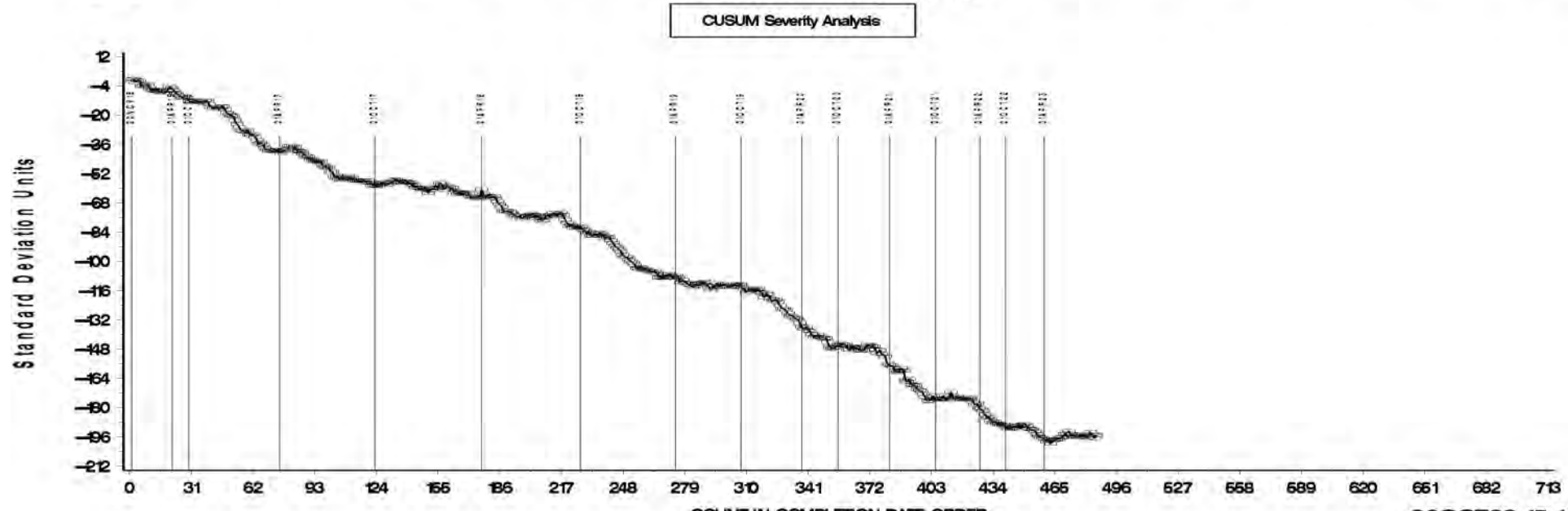
FEI FINAL RESULT PHASE I





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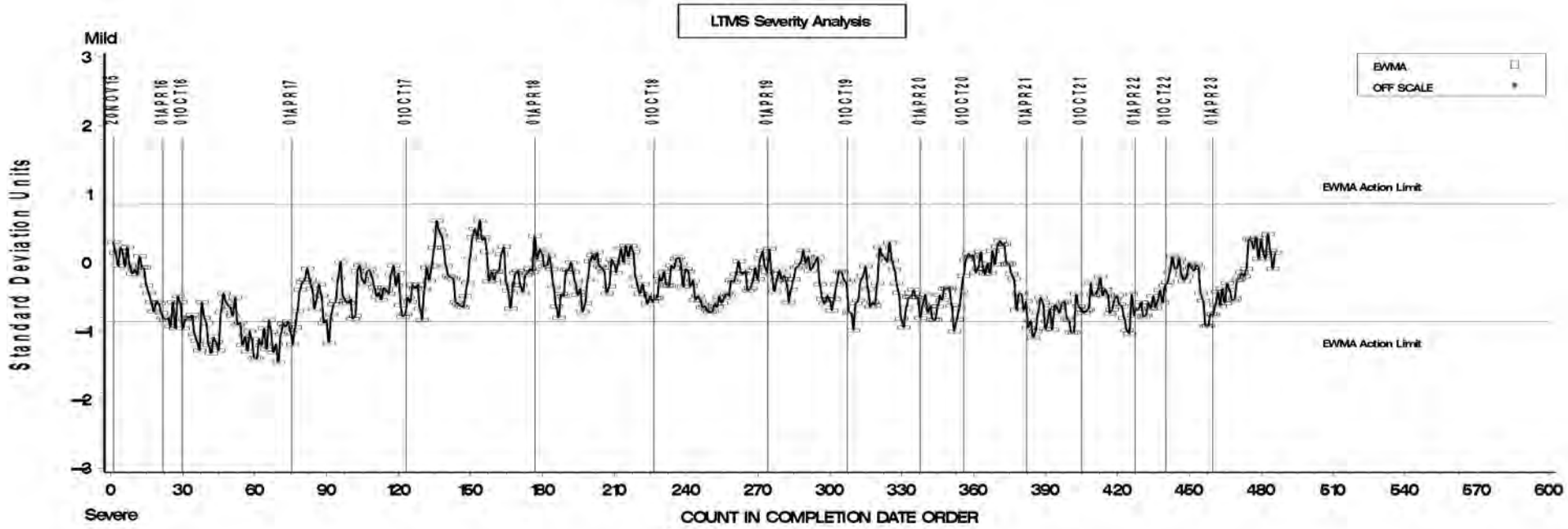
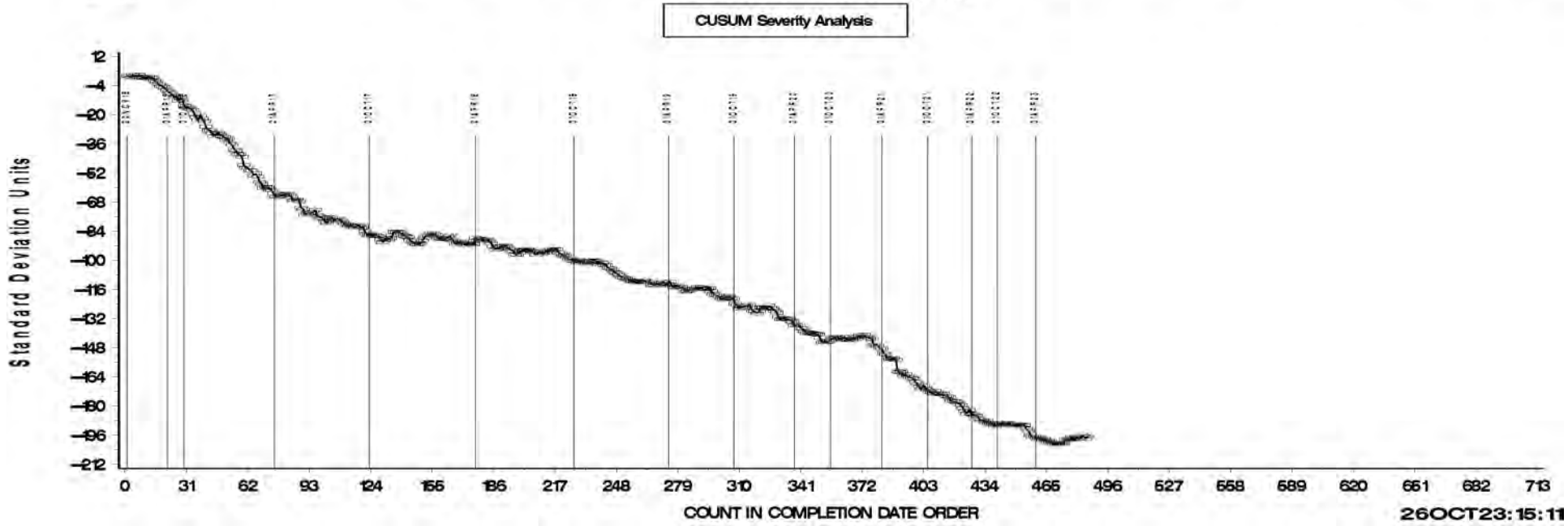
SEQUNCE VIE INDUSTRY OPERATIONALLY VALID DATA

FEI FINAL RESULT PHASE II





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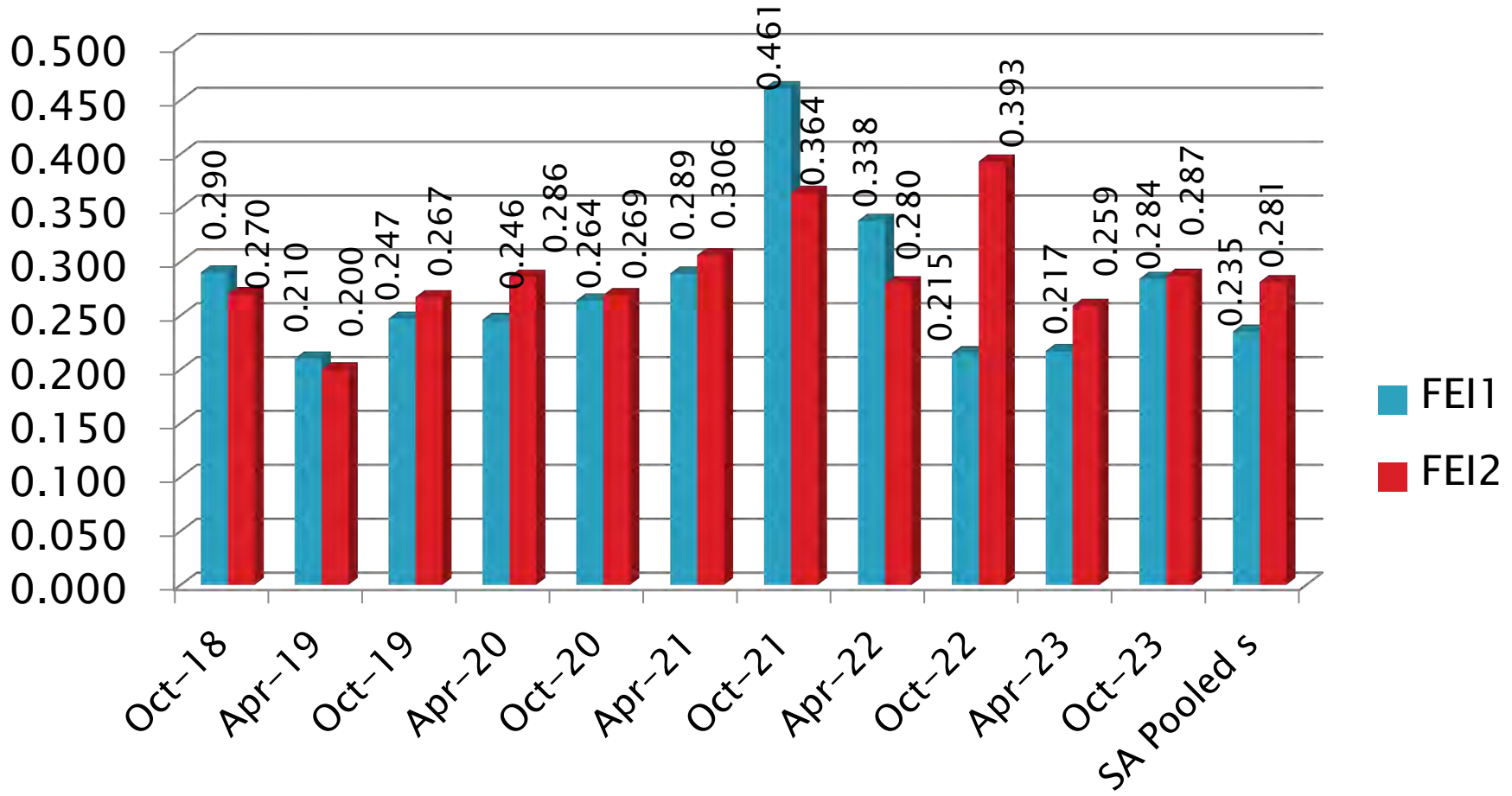
Sequence VIE Precision Estimates



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Sequence VIF

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Sequence VIF Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	11
Aborted Calibration Test	XC	1
Engine Abandoned	MC	1
Statistically Unacceptable Calibration Test	OC	2
Total		**15**

Sequence VIF – Failing Tests

Test Status	#
FEI2 Wi Alarm, Severe direction	1
FEI2 Vi Alarm	1
Total	**2**

Sequence VIF – Lost Tests*

Test Status	Cause	#
Aborted	Exceeded Allowable number of shutdowns	1
Totals		**1**

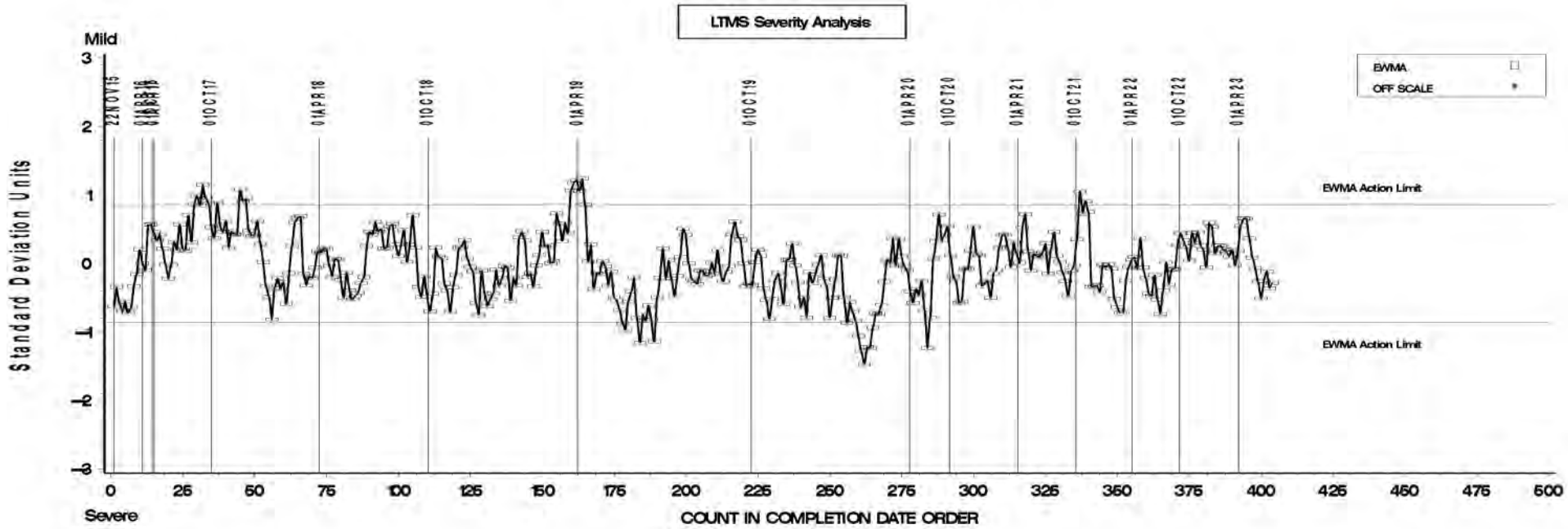
*Invalid and aborted tests

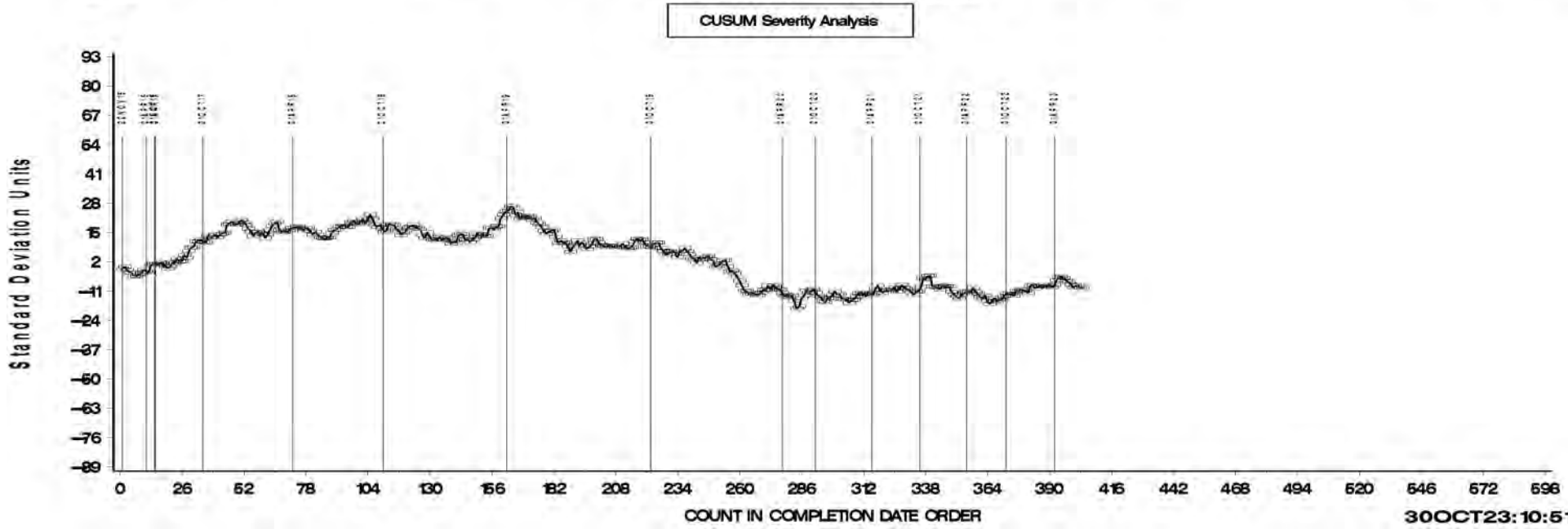
Sequence VIF Test Severity

- FEI1 is in control
- FEI2 is in control

SEQUNCE VIF INDUSTRY OPERATIONALLY VALID DATA

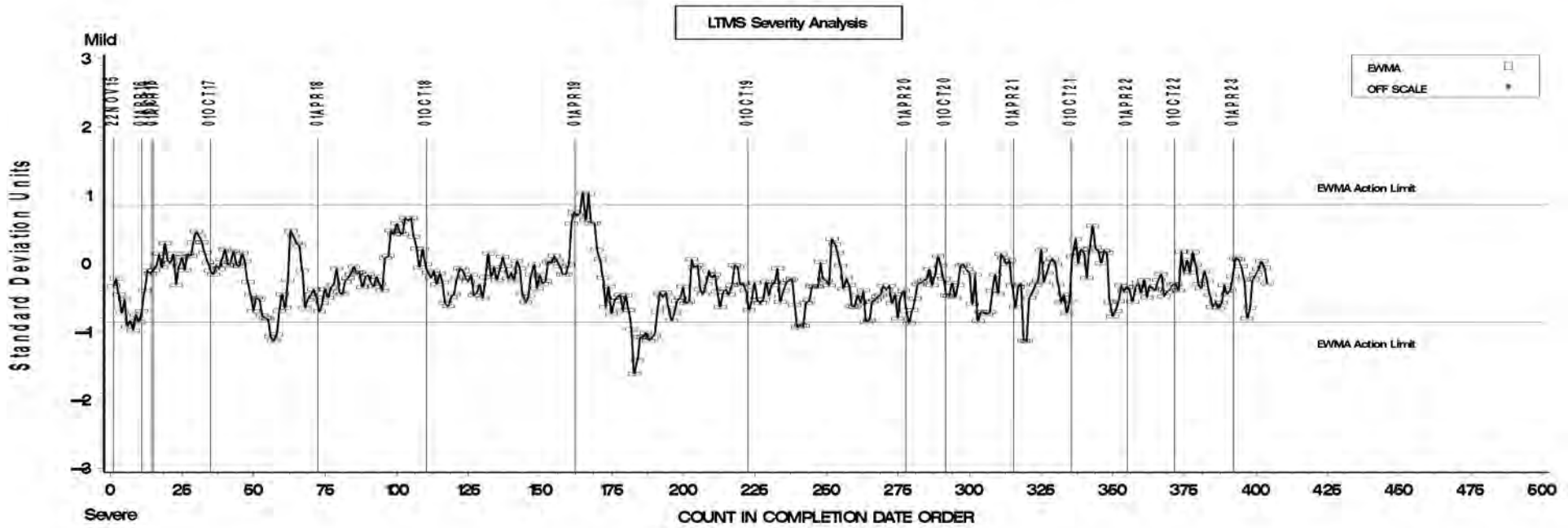
FEI FINAL RESULT PHASE I

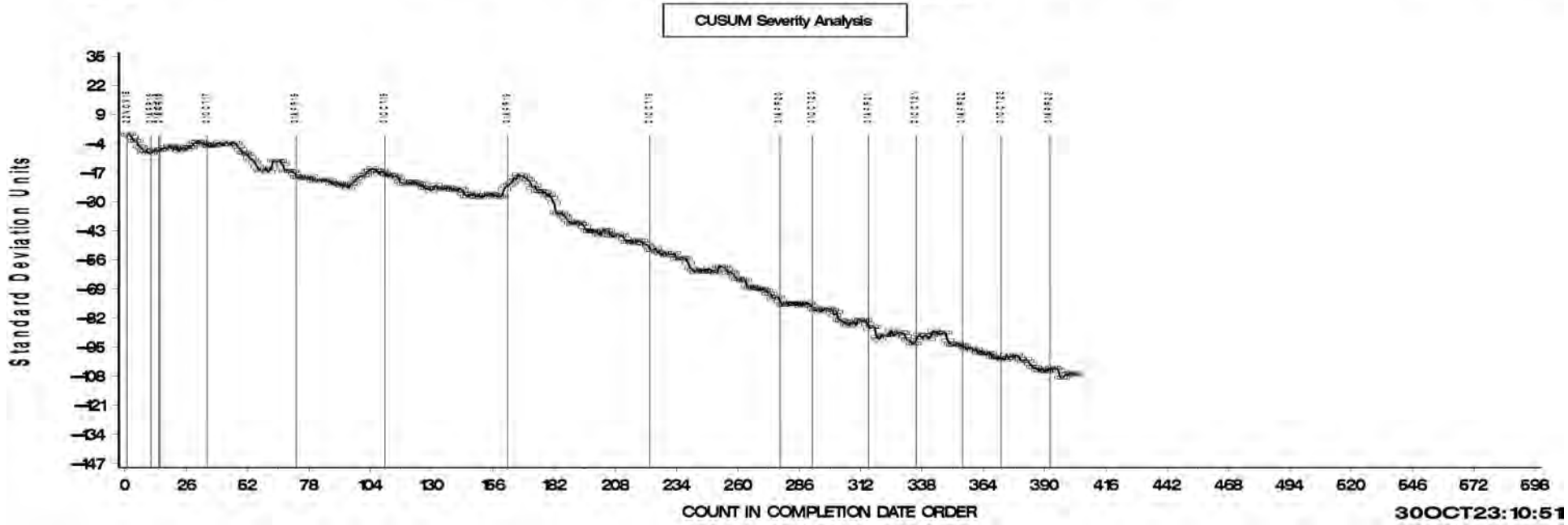




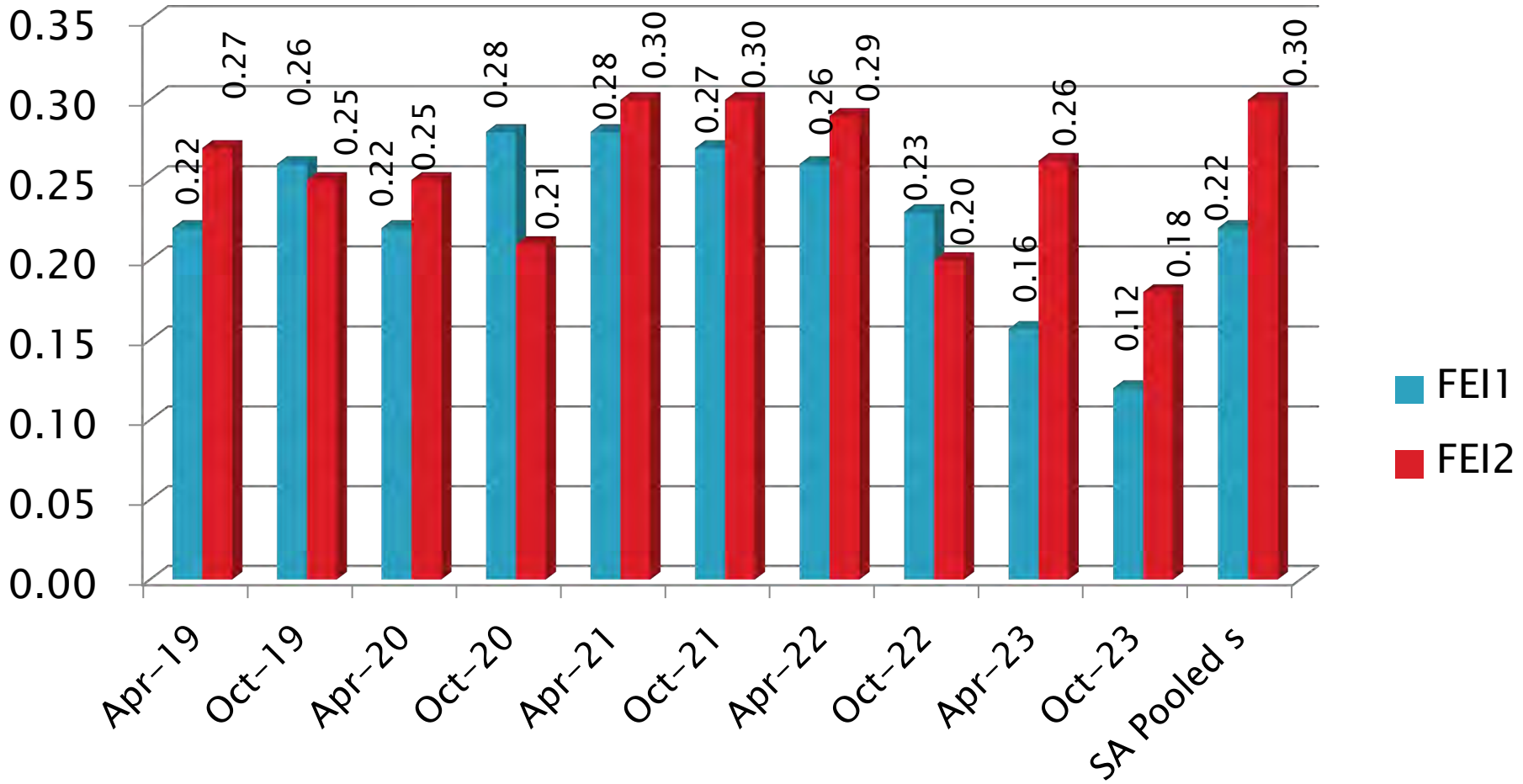
SEQUNCE VIF INDUSTRY OPERATIONALLY VALID DATA

FEI FINAL RESULT PHASE II





Sequence VIF Precision Estimates



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Sequence VIII

- October 2023

Test Monitoring Center
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Sequence VIII Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	3
Failed Calibration Test	OC	1
Operationally Invalid Not For Industry Statistics (High Mechanical Wear)	LI	5
Not for Industry Statistics (Severity Evaluation)	NI	12
Total		21

Sequence VIII – Lost Tests*

Test Status	Cause	#
Invalid	High Mechanical Wear	5
Totals		**5**

*Invalid and aborted tests

Sequence VIII– Failed Tests

Test Status	#
Stand Precision Shewhart Alarm	1
Total	1

Sequence VIII Test Severity

- BWLS is in control
- SVIS is in Severity Action Alarm (Severe direction)

Note: Tests were completed before the end of the report period, but charted on October 5, 2023.

SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

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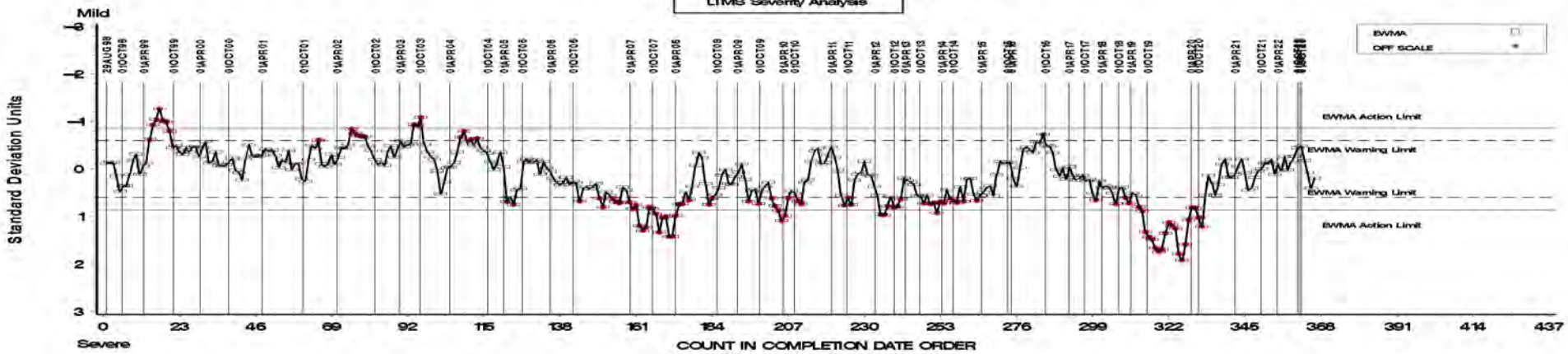
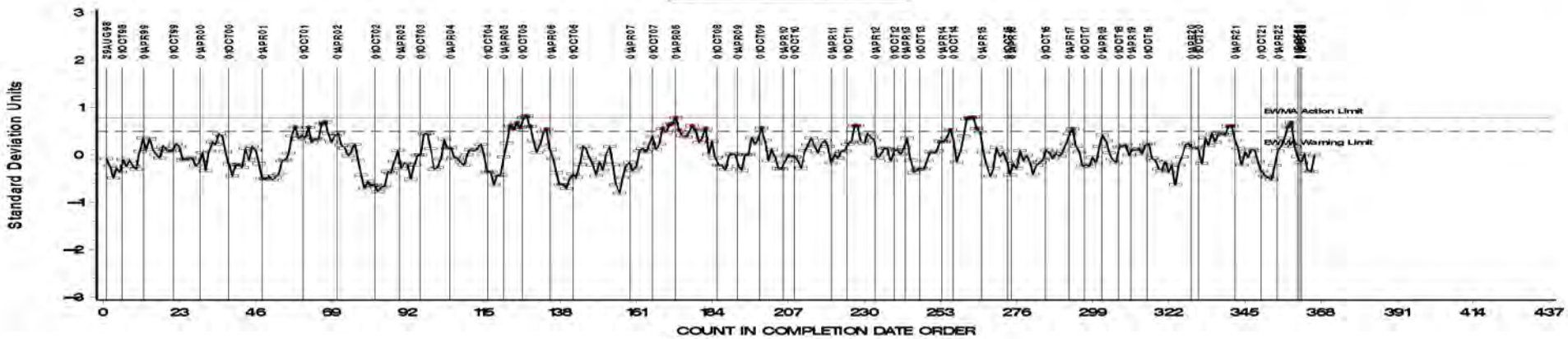
FINAL BEARING WEIGHT LOSS

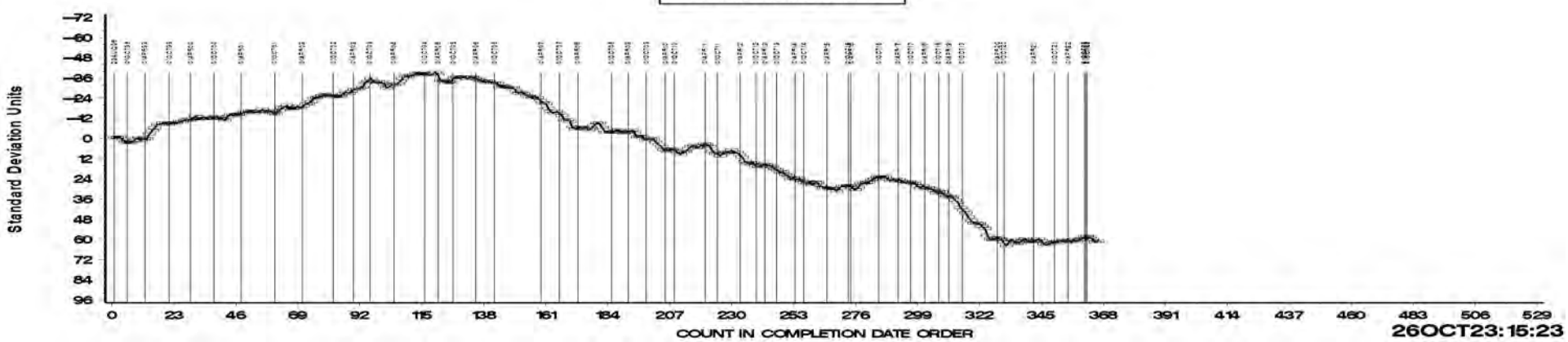
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

STRIPPED VIS. @ 100 DEG C

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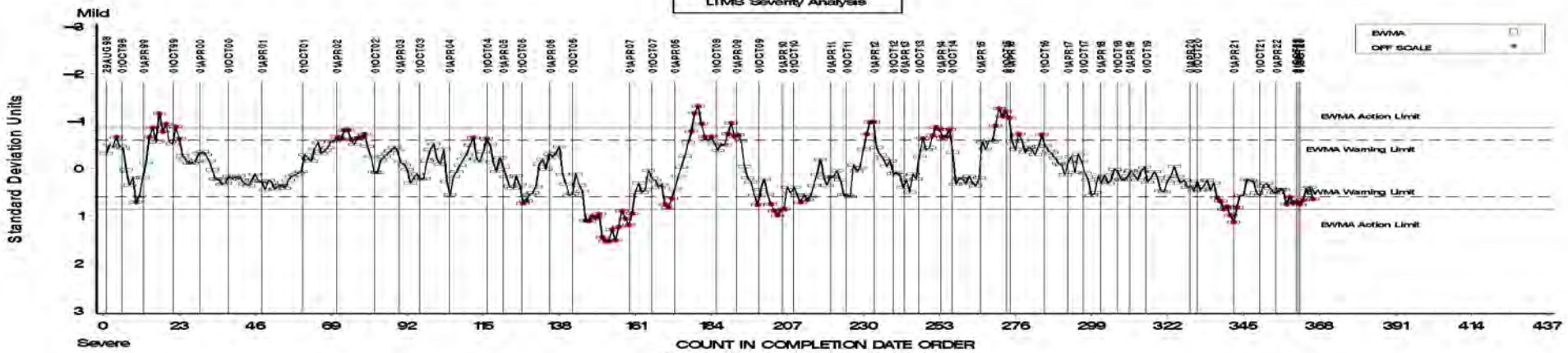
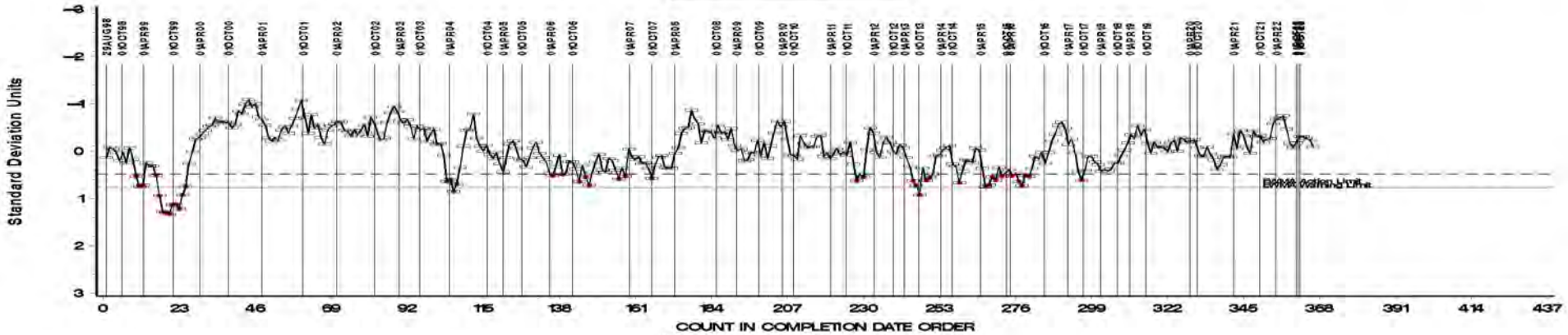
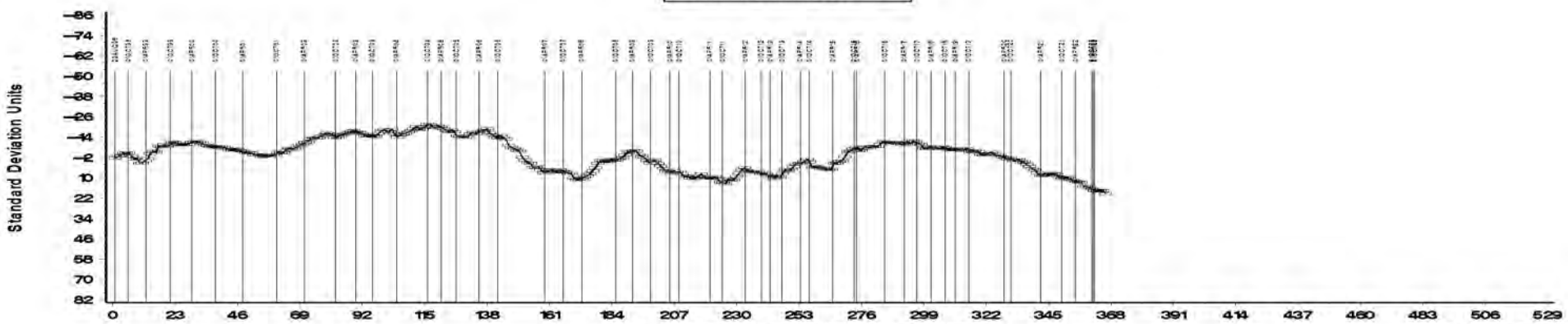
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

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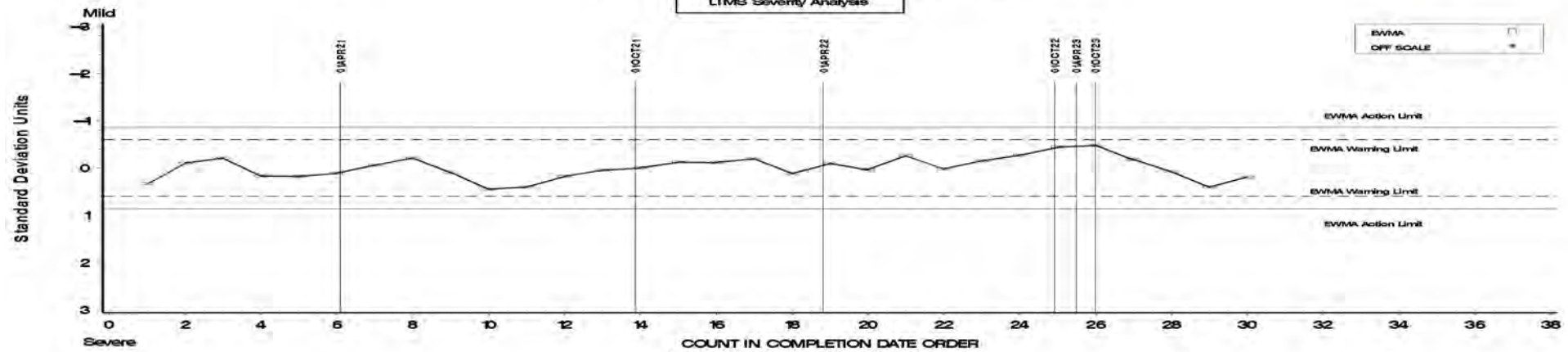
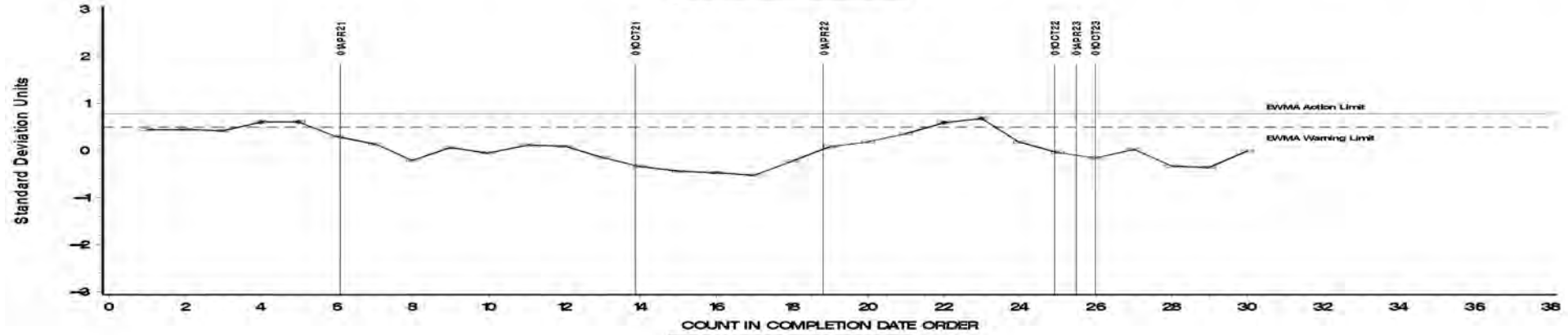
FINAL BEARING WEIGHT LOSS

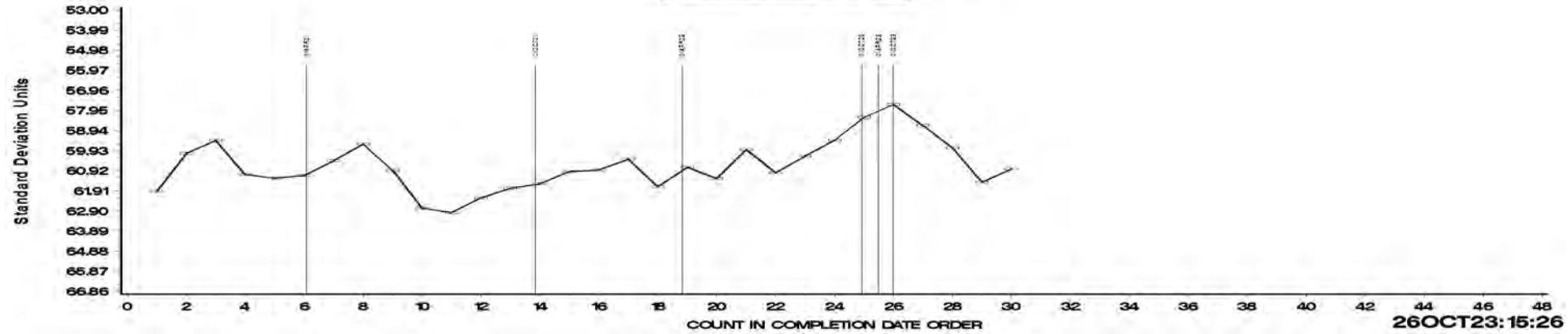
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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SEQUENCE VIII INDUSTRY OPERATIONALLY VALID DATA

Last 20 results

STRIPPED VIS. @ 100 DEG C

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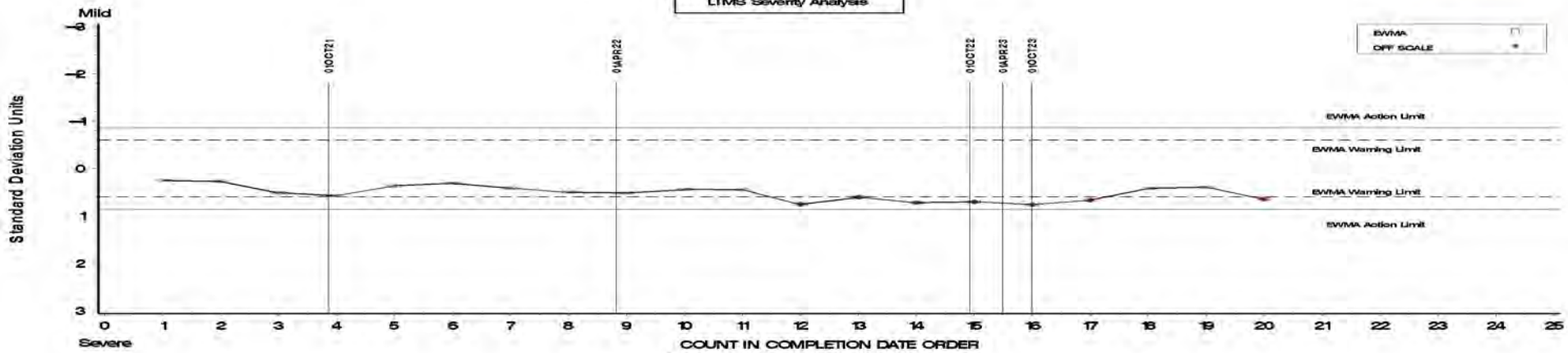
LTMS Severity Analysis



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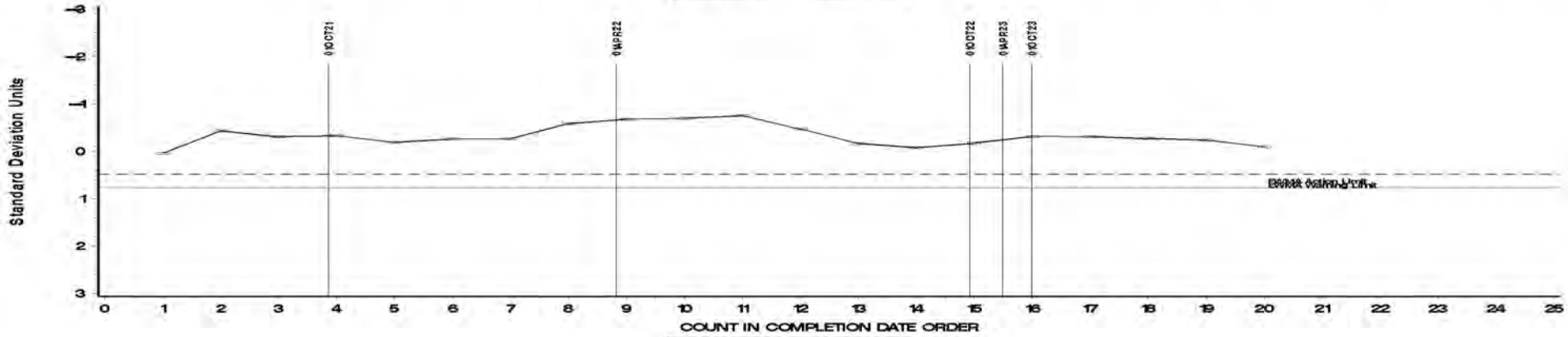
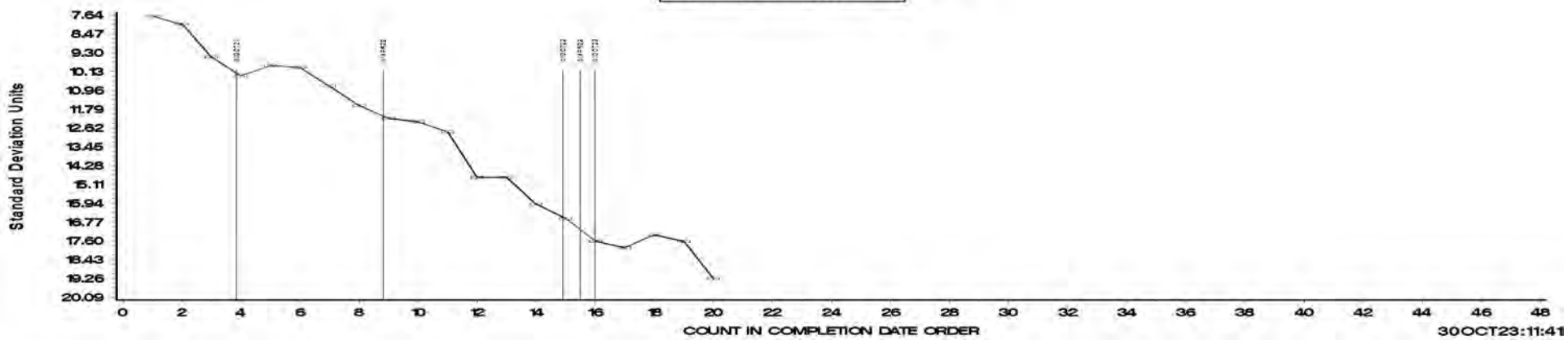


CUSUM Severity Analysis



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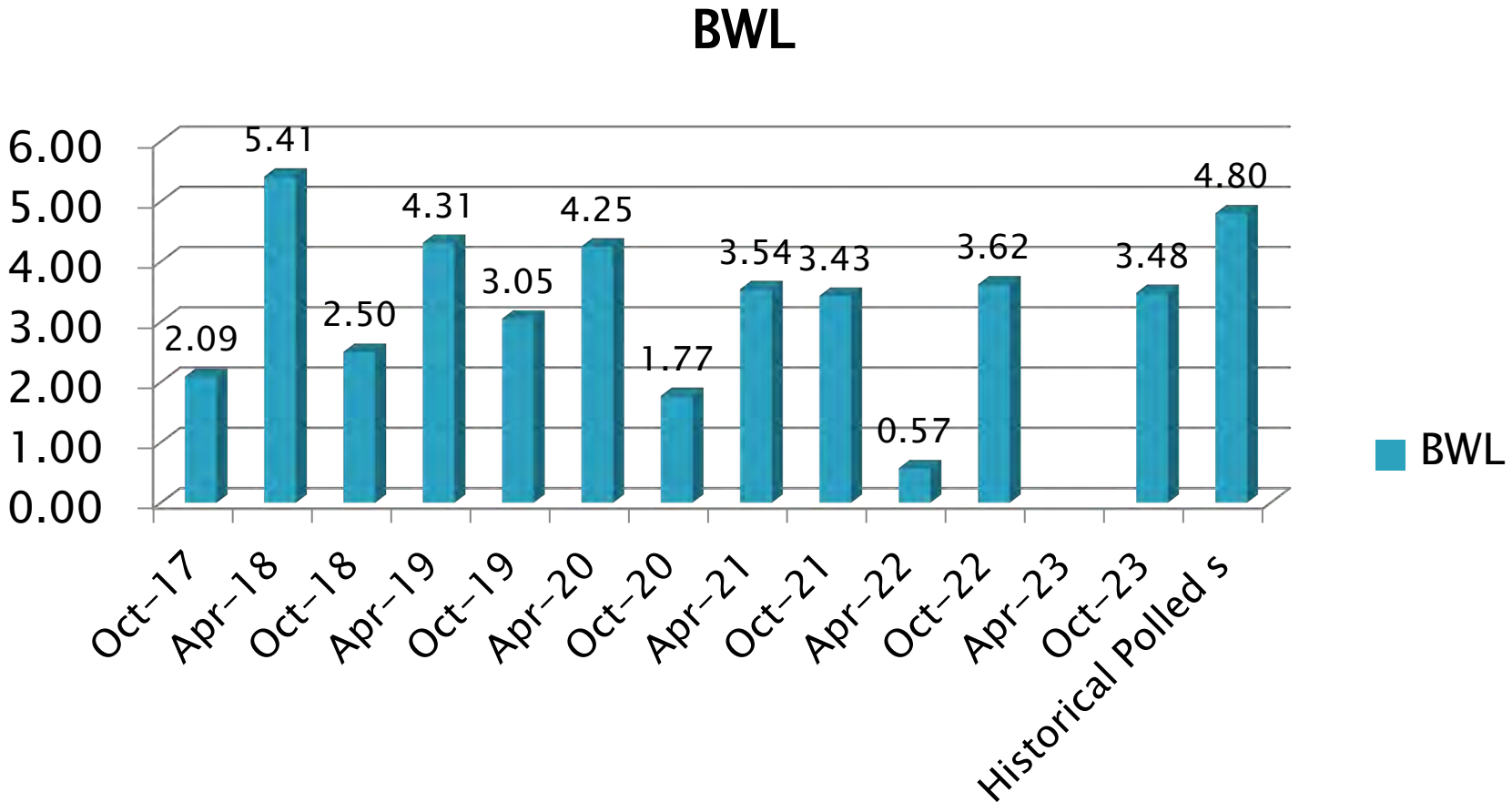
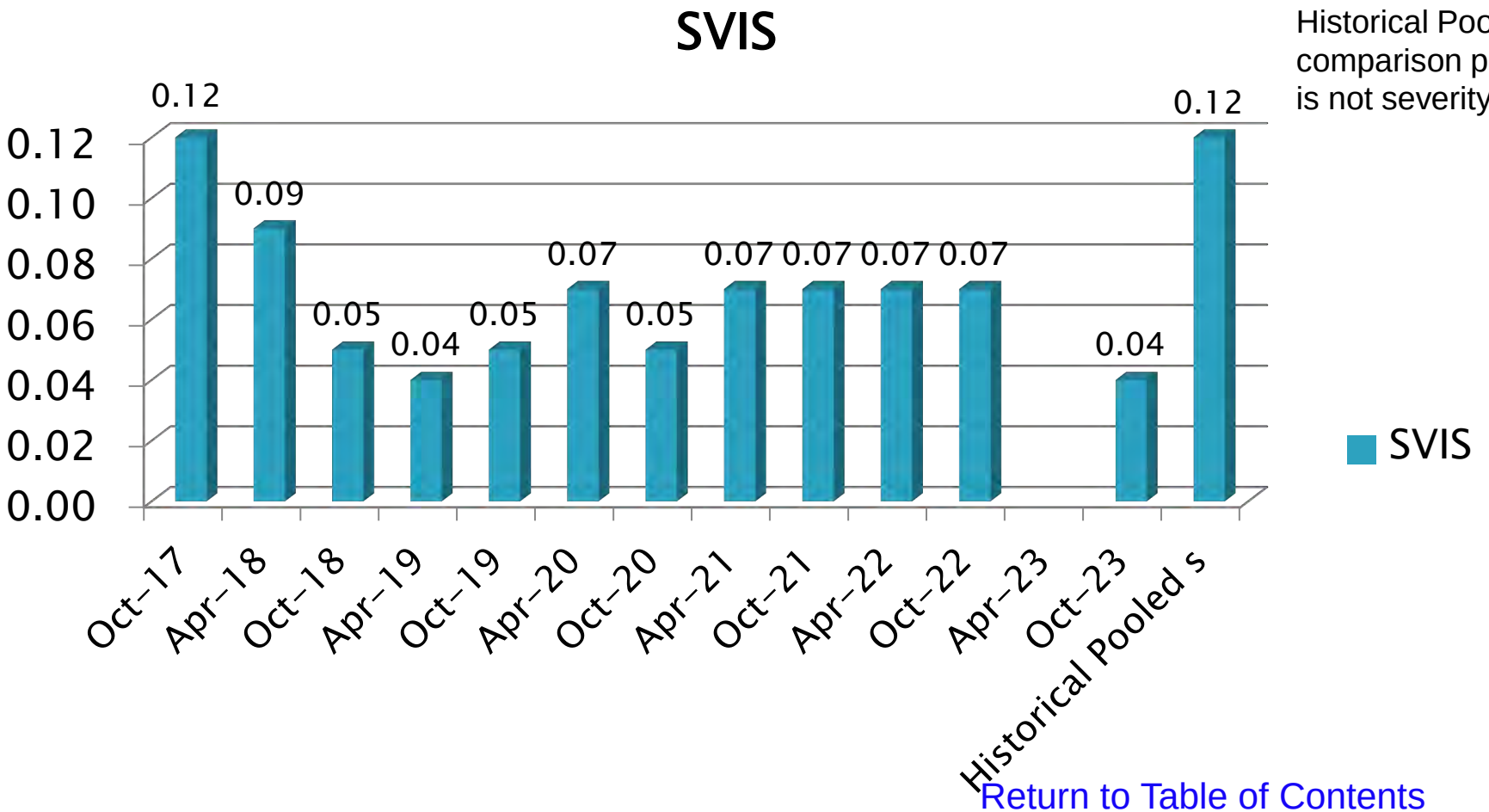
Sequence VIII Precision Estimates



Sequence VIII Precision Estimates



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

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Sequence IX

- October 2023

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Sequence IX Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	15
Statistically Unacceptable Calibration Test	OC	4
Operationally Invalid Calibration Test (lab judgement)	LC	2
Engine Abandoned	MC	1
Total		**22**

Sequence IX – Failed Tests

Test Status	Number of Tests
Ei Level 3 alarm (mild direction)	2
Ei Level 3 alarm (severe direction)	1
Zi Level 2 alarm (severe direction)	1
Total	**4**

Sequence IX – Lost Tests*

Test Status	Cause	#
Invalid	Exceeded downtime limit	1
Invalid	Lost data during iteration D	1
Totals		**2**

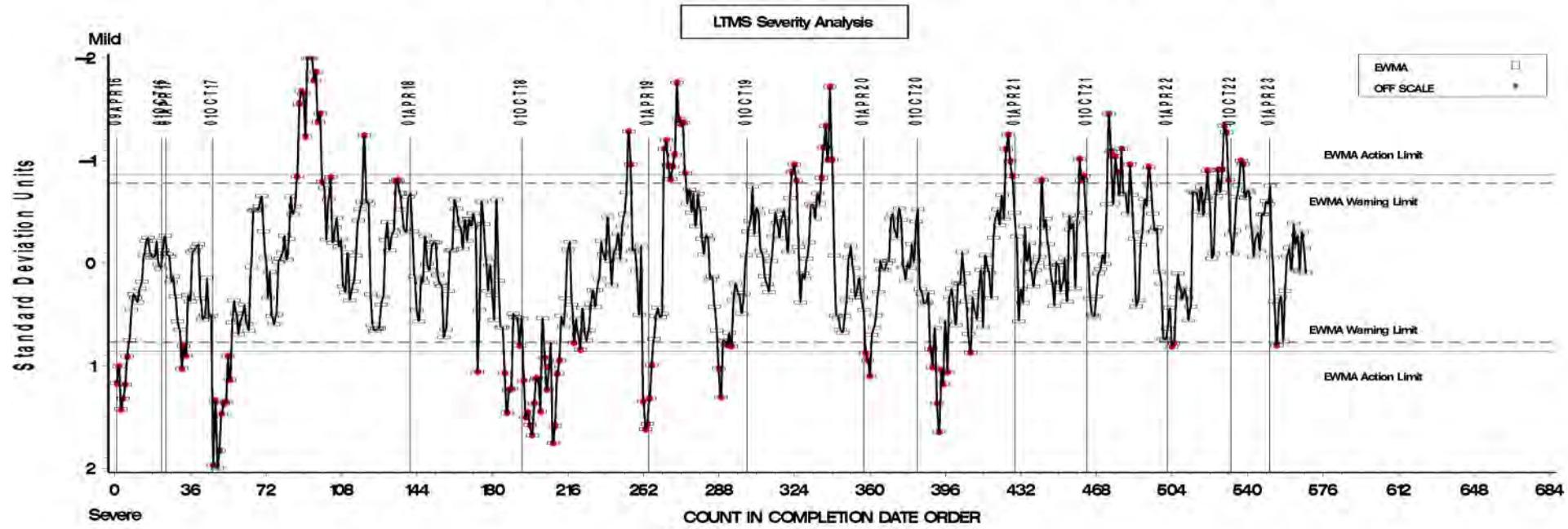
*Invalid and aborted tests

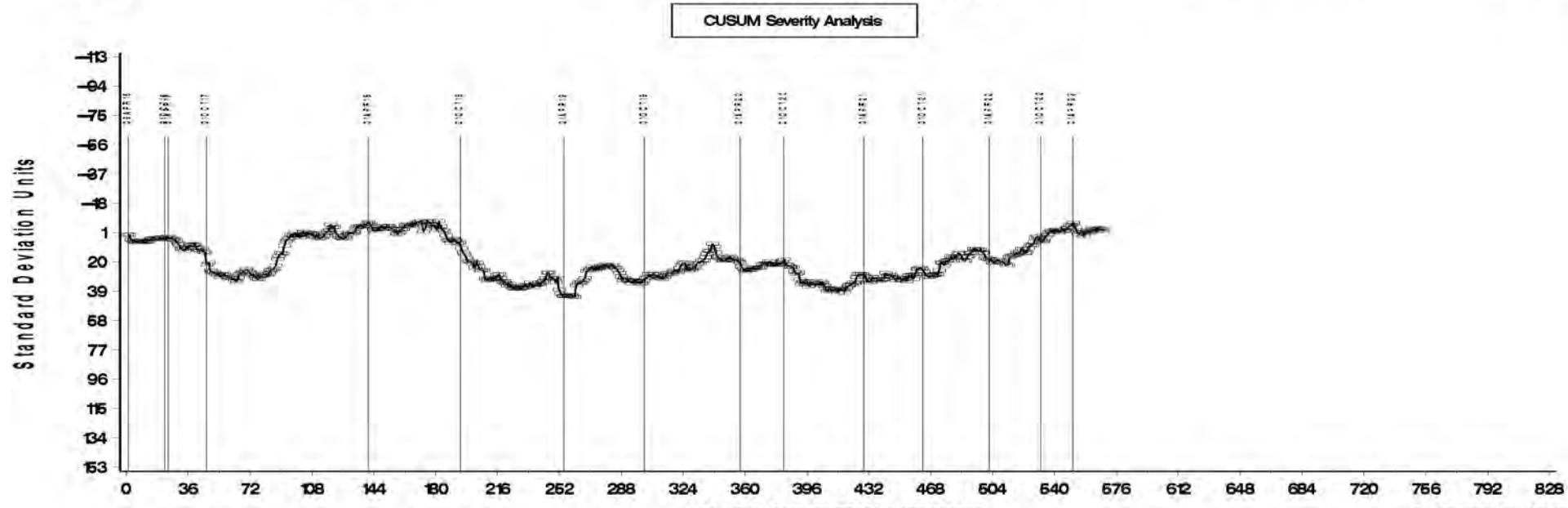
Sequence IX Test Severity

- Average number of Pre-ignitions in control.

SEQUENCE IX INDUSTRY OPERATIONALLY VALID DATA

AVERAGE NUMBER OF PREIGNITIONS FROM VALID ITERATIONS





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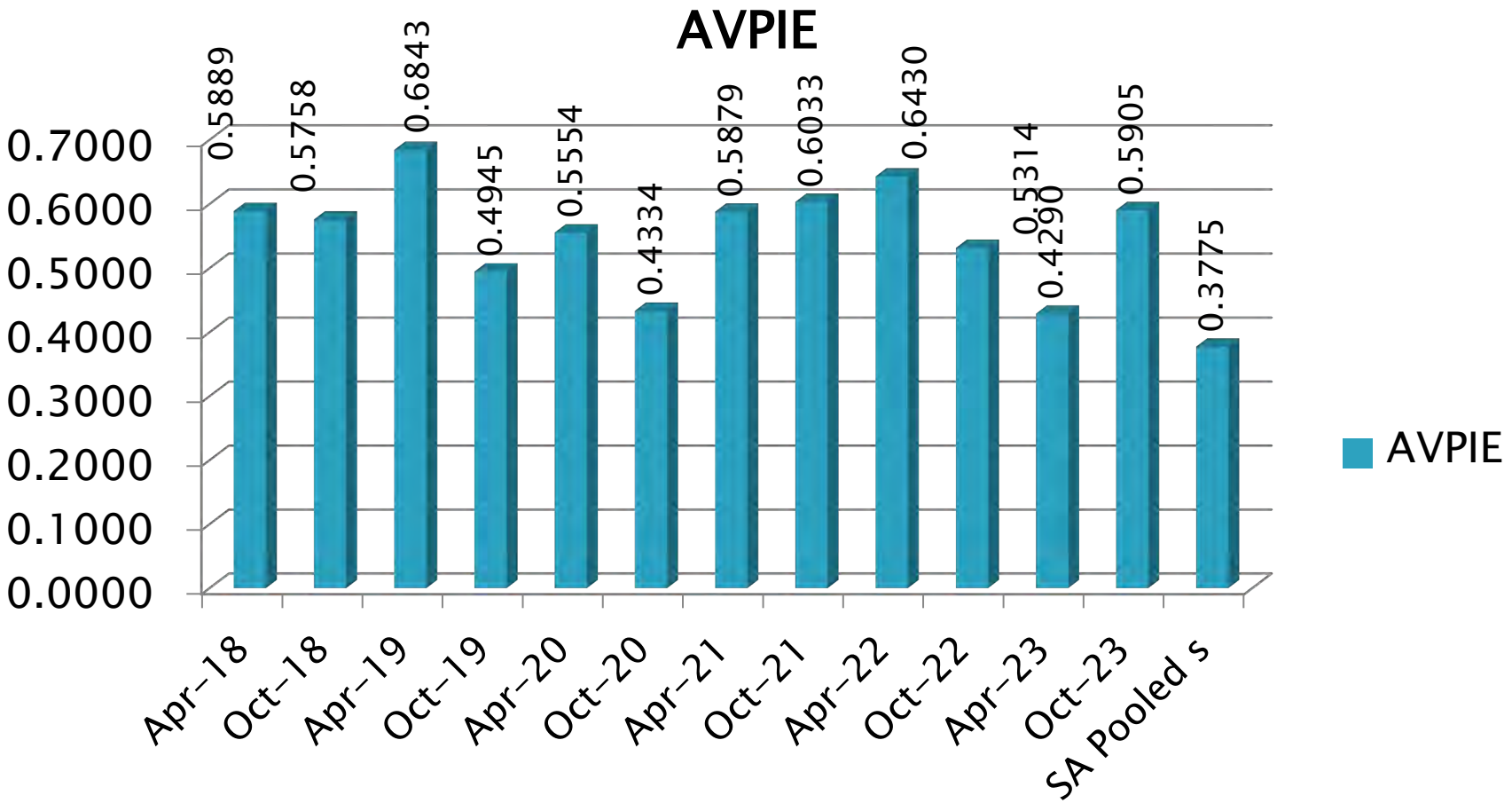
Sequence IX Precision Estimates



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Sequence IXAGED

- October 2023

Test Monitoring Center
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Sequence IXAGED Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	2
Statistically Unacceptable Calibration Test	OC	2
Total		**4**

Sequence IXAGED – Failed Tests

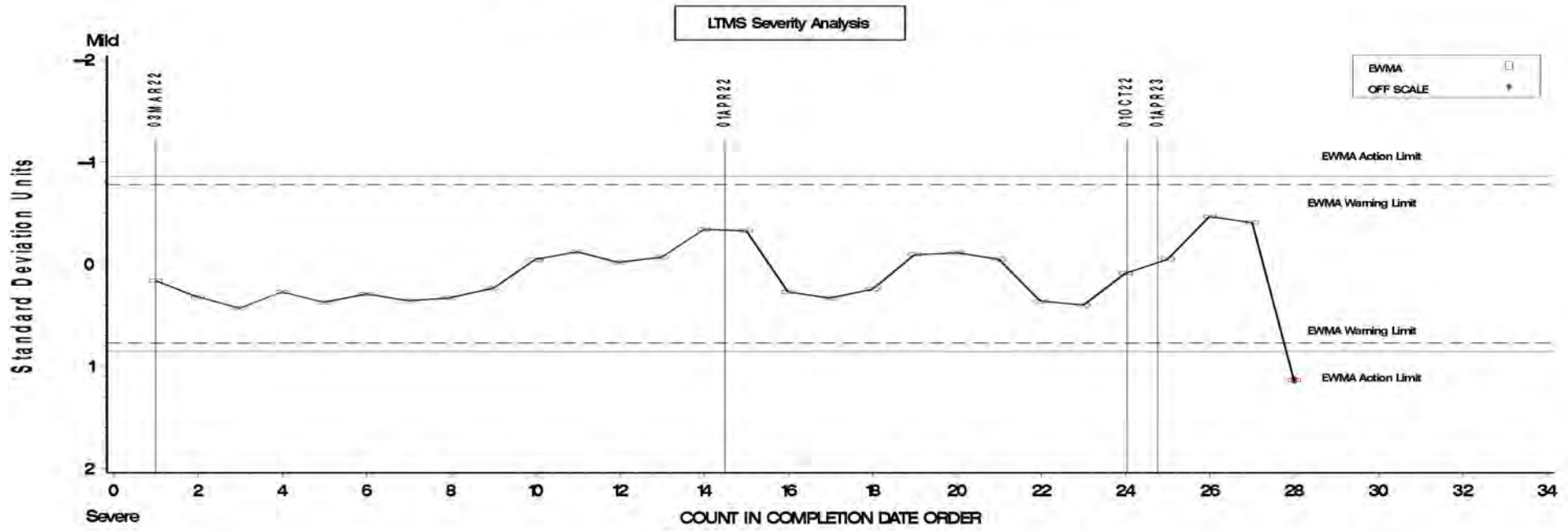
Test Status	Number of Tests
Ei Level 3 alarm (mild direction)	1
Ei Level 3 alarm (severe direction)	1
Total	**2**

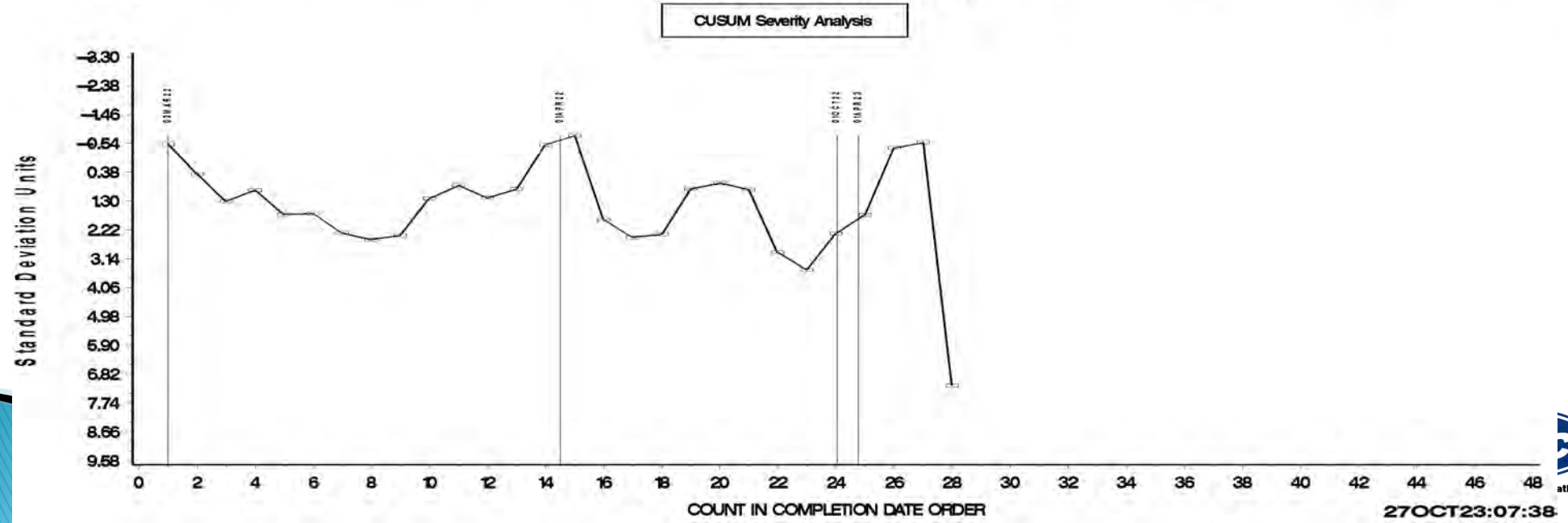
Sequence IX Test Severity

- Average number of Pre-ignitions in severity action alarm. Alarm appears to be the result of one test which was 3.782 s severe.
- The large degradation in precision appears to be caused by the two failing results, both on oil API02. The first test was 5.28 AVPIE while the second test was 26.92 AVPIE

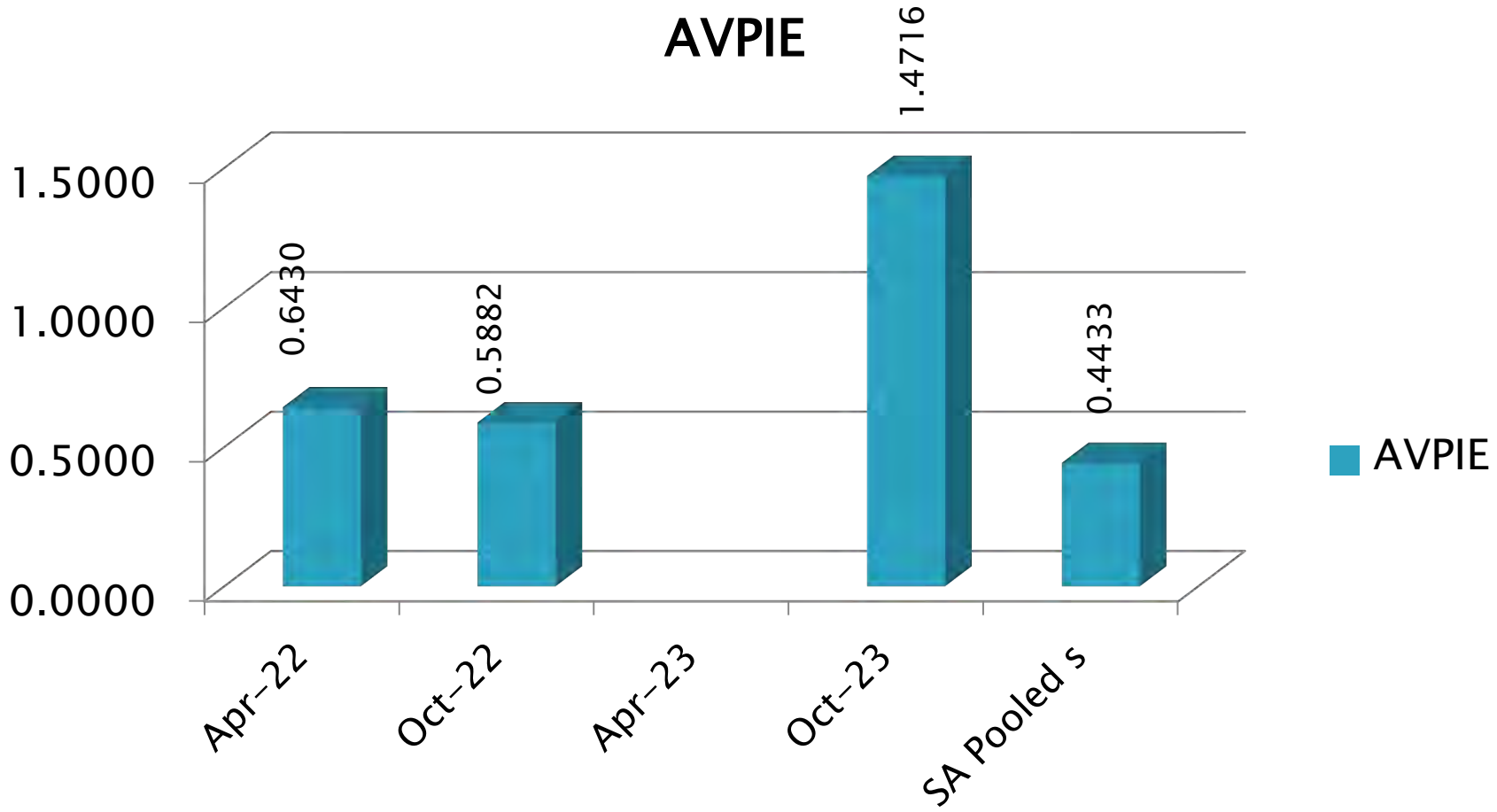
SEQUENCE IX AGED INDUSTRY OPERATIONALLY VALID DATA

AVG # of Preignitions, original units





Sequence IX Precision Estimates



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Sequence X

October 2023

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Sequence X Activity

Test Status	Validity Code	#
Acceptable Calibration Test	AC	6
Acceptable Discrimination Test	AS	6
Aborted Discrimination Test	XS	1
Operationally Invalid Calibration Test (Laboratory Judgement)	LC	1
Total Number of Tests		**14**

Sequence X – Lost Tests*

Test Status	Cause	#
Aborted	Blowby Out of Spec at hour 120 (low)	1
Invalid	Blowby Temperature Out of Spec	1
Totals		**2**

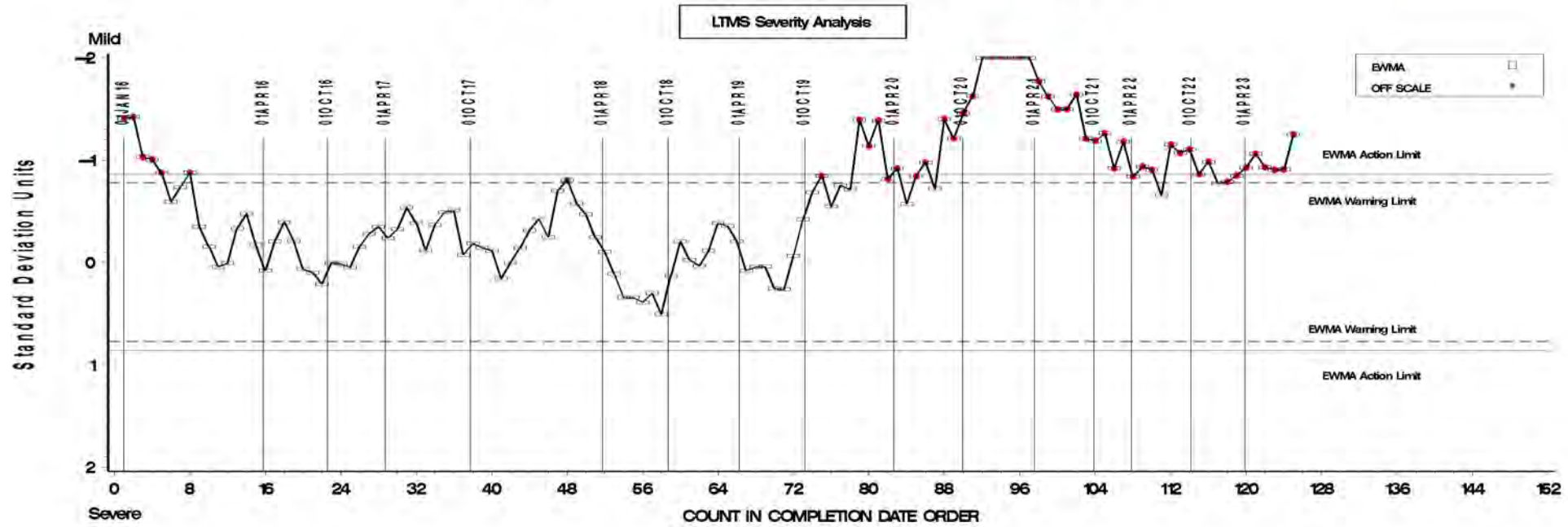
*Invalid and aborted tests

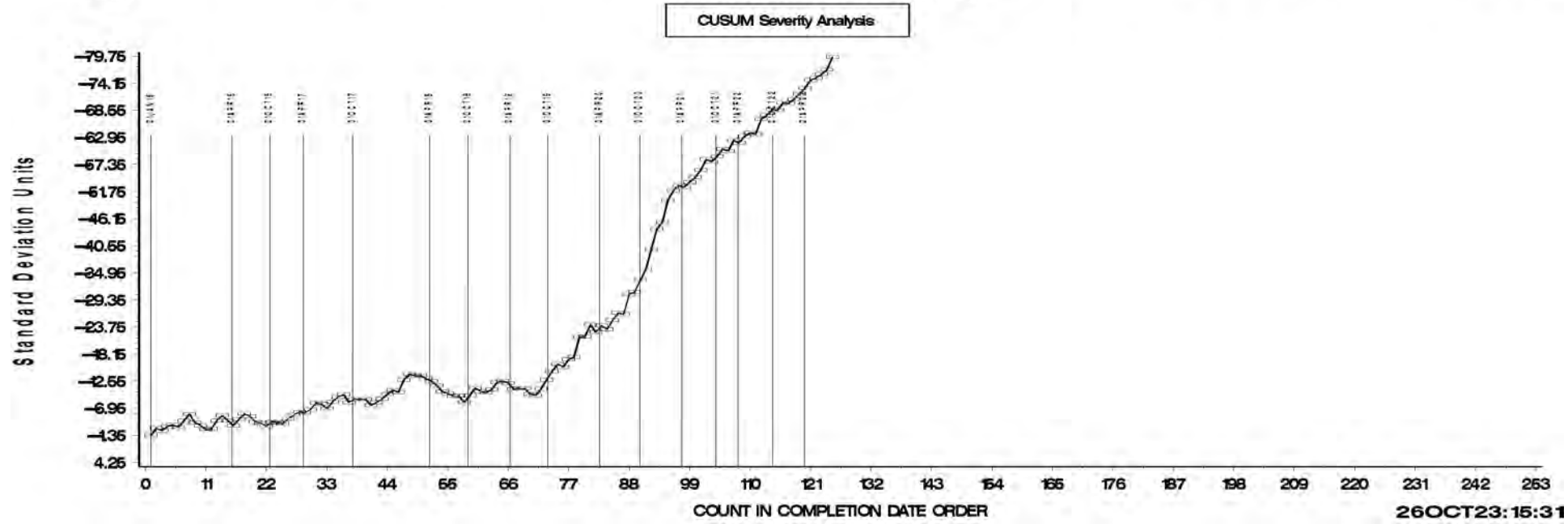
Sequence X Test Severity

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

SEQUENCE X INDUSTRY OPERATIONALLY VALID DATA

END OF TEST CHAIN WEAR FINAL RESULT





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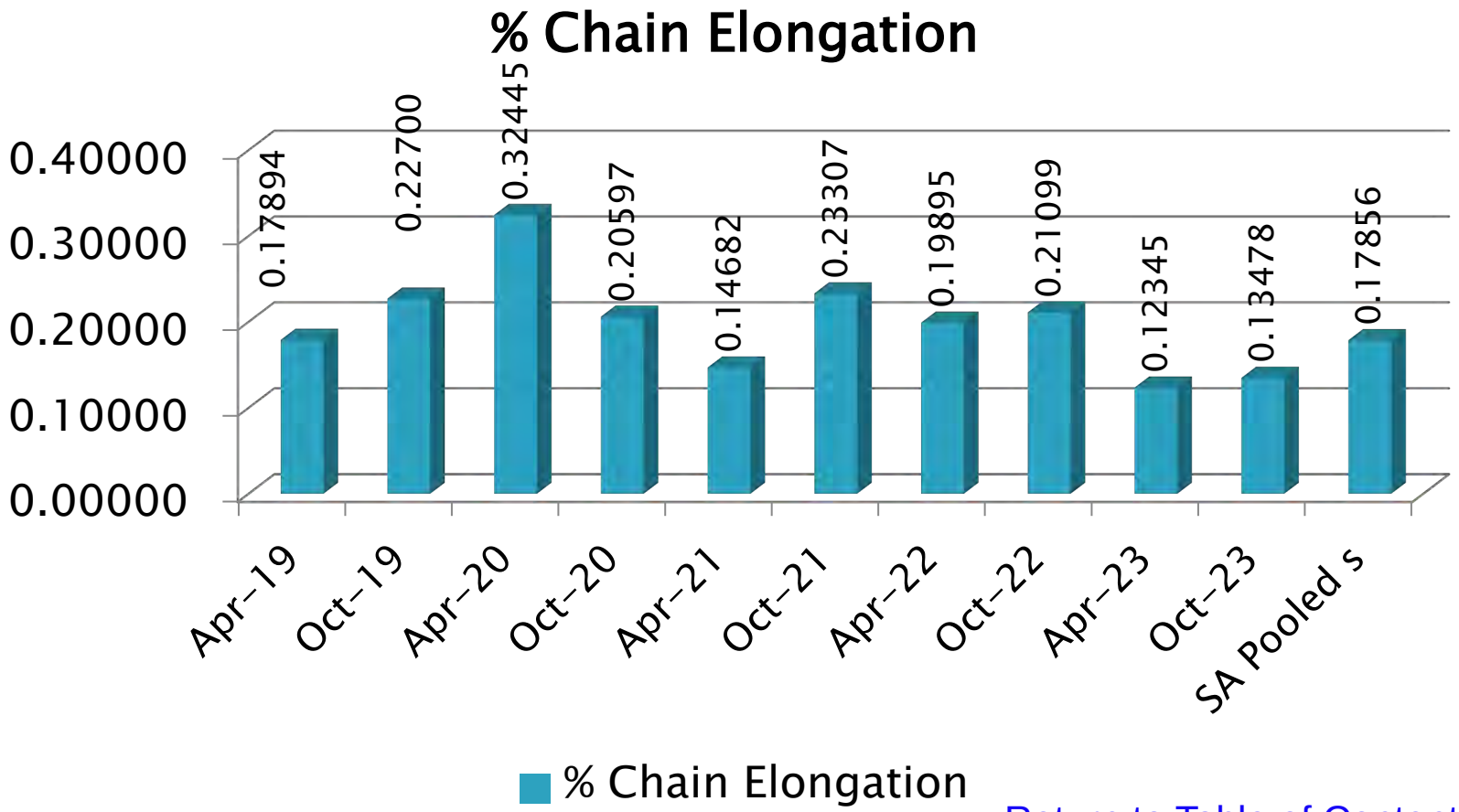
Sequence X Precision Estimates



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Information Letters

October 2023

Test Monitoring Center
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Information Letters*

Test	Date	IL	Topic
IVB	20230710	23-1	Addition of isolation and drain valves to fuel system
IX	20230831	23-2	Added Appendix X2, Aging Procedure to Test Method D8291 and allowed use of machined pistons
VH	20230614	23-2	Removed requirement rate cam baffle and rocker cover prior to cleaning these parts
VIE	20230724	23-2	Corrected error in Table 5 of Test Method D8114
X	20230503	23-1	Required use of 271 as discrimination oil for calibration purposes and extended calibration period to 1 year
X	20230609	23-2	Corrected several items in blowby system drawing

*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 220 and 224

- A reblend for reference oil 220 has been received and is available for introduction. Reference oil 224-1 began introduction this period, with seven results reported from four labs.

TMC 704-1

- The supplier has been contacted and this oil can not be reblended. The panel will need to search for a replacement. This oil is no longer available from the TMC. Three tests oil remain in active labs. The VIII panel is dropping this oil.

VIEBL and FO6

- A new batch of VIEBL and FO6 has been blended and shipped to the labs. Additional testing was completed and VIEBL6 has been approved for use. Two reference tests from two labs were reported using this oil.

Reference Oil Re-blends

TMC 542-4 and 1010-1

- Both reference oils 542-4 and 1010-1 have been depleted at the TMC. Reblends for reference oils are currently being introduced in the VIE test. Nine results on 542-4 and eight results on 1010-2 were reported this period

TMC 543

- A limited quantity remains of reference oil 543. A reblend of this oil, 543-1 has been obtained by the TMC. Two results were reported on this oil this period.

TMC 940

- A limited quantity remains of reference oil 940. A reblend of this oil, 940-1 has been obtained by the TMC. The panel agreed to suspend the use of this oil until additional results on the other two oils with the new fuel batch could be evaluated.

Reference Oil Re-blends

- TMC API01 and API02
  - Both reference oils for IXAGED are in limited quantity at TMC and laboratory. Reblends are in process and should be available soon.
- TMC 1006-2
  - Less than 200 gallons remain at TMC. The Sequence VIII has dropped this oil because of age concerns and replaced it with 1009-1. The Sequence IVA has not taken any action with regard to this oil and will need to address this oil moving forward.

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
API01	IXAGED	152	0	8	32	<1 year
APIO2	IXAGED	194	0	10	24	<1 year
220	IX	1100	40	0	60	1-2 years
220-1	IX	1060	0	1060	0	5+ Years
221	IX	2120	100	212	70	2.5 years
224	IX	1026	0	0	20	<1 year
224-1	IX	220	85	98	45	2 years
270	X	1100	60	490	45	5 years
271	X	980	60	608	30	5 years
300-1	IVB	378	15	206	30	3 years
434-3	IIIH	980	38	586	25	5+ 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	12.5	590	20	5+ years
438-1	IIIH	605	0	0	2.5	<1 year
438-2	IIIH	540	7.5	366	35	5 years
542-3	VIE/VIF	997	0	0	18	<1 Year
542-4	VIE/VIF	1100	0	0	42	<1 Year
542-5	VIE/VIF	1060	141	795	84	4 years
543	VIF	1100	42	0	54	<1 Year
543-1	VIF	1000	20	956	24	5+ Years
544	VIE	897	56	124	36	2 years
704-1*	VIII	897	0	0	7.5	1.5 years

*Reference oil 704-1 can not be reblended. Panel moving to 1009-1.

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
931	VH	908	21	767	21	5+years
940	VH	560	24	0	33	1 year
940-1	VH	485	0	0	0	5+ years
1006-2*	IVA, VIII	5500	15	10	32.5	3 years
1009-1	VIII	950	46	854	16	5+ years
1010-1	VIE	1760	0	5	6	~1 year
1010-2	VIE	550	84	412	42	5 year
1011	IVB/VH/VIF/X	1100	0	0	34	Depleted
1011-1	IVB/VH/VIF/X	1395	187	868	140	4+ years
1012	IVB	2200	60	1134	75	5+ years

*Sequence VIII Panel dropped this oil due to age considerations

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LTMS Deviations

April 1, 2023 – September 30, 2023

Test Monitoring Center
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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

April 1, 2023 – September 30, 2023

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Quality Index Deviations

- Two deviations were issued this period.
  - A VH Deviation for oil Inlet temperature due to a mistake in tuning changes being made to the stand control system while the test was running.
  - A second deviation was issued for Sequence IX intake air humidity issues caused by problems with the building air handling system.

Quality Index Deviations

Historical Count of PCEO Quality Index Deviations

Test	Quality Index Deviations
IIIH	8
IVA	32
IVB	2
VH	11
IX	2
X	3

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TMC Laboratory Visits

- April 1, 2023 – September 30, 2023

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TMC Lab Visits

Test	Number of Labs Visited
IIIH	1
IVB	0
IX	1
VH	1
VIE/VIF	3
VIII	0
X	3

Lab Visit Issues

- Sequence IIIH–Unapproved thermocouple type installed in exhaust.
- Sequence IIIH–O_2 Sensor installed not the same part number as listed in procedure.

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Test Area Timelines

- April 1, 2023 – September 30, 2023

Test Monitoring Center
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Test Area Timeline Additions*

Test	Date	Topic	IL
IIIH	20230912	Updated standard deviations for RO's 434-3, 436 and 438-2 for PVIS, WPD, APV and MRV parameters. Updated WPD Mean for RO 438-2	
IVB	20230710	Added provision for including drain and isolation valve in fuel system	23-1
IX	20221216	Allow use of alternate cooling pump and type K thermocouples	22-4
VH	20230614	Removed requirement rate cam baffle and rocker cover prior to cleaning these parts	23-2
VIE	20230720	First Occurrence of VIEBL6	
VIE	20230724	Corrected Table 5 in D8114	IL23-2

*As of 09/30/2023

Test Area Timeline Additions*

Test	Date	Topic	IL
VIF	20230527	First Occurrence Reference oil 543-1	
VIF	20230903	First Occurrence VIEBL6	
VIII	20231005	Surveillance Panel approved changes to LTMS to drop oils 1006-2 and 704-1 and use oil 1009-1 for test monitoring.	
IX	20230831	Allowed use of machined pistons	23-2
X	20230503	Modified calibrations to include RO 271 as a discrimination oil and increased calibration period to 1 year or 15 tests	23-1
X	20230609	Corrected several items in blowby system drawing	23-2

*As of 09/30/2023

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Rating Workshop Data

- Summary of Precision Data From Rating workshops:
  - VH Average Piston, Average Engine Varnish.
  - VH Sludge added for this workshop as calibration requirement
  - IIIH WPD
  - Data is from 2023 workshop; 2020 and 2021 workshops were cancelled due to pandemic. The 2022 and 2023 workshops only includes raters from calibrated labs.
  - Next update will be in the April 2024 report.

Rating Workshop Data

- 2023 ASTM Deposit Rating Workshop

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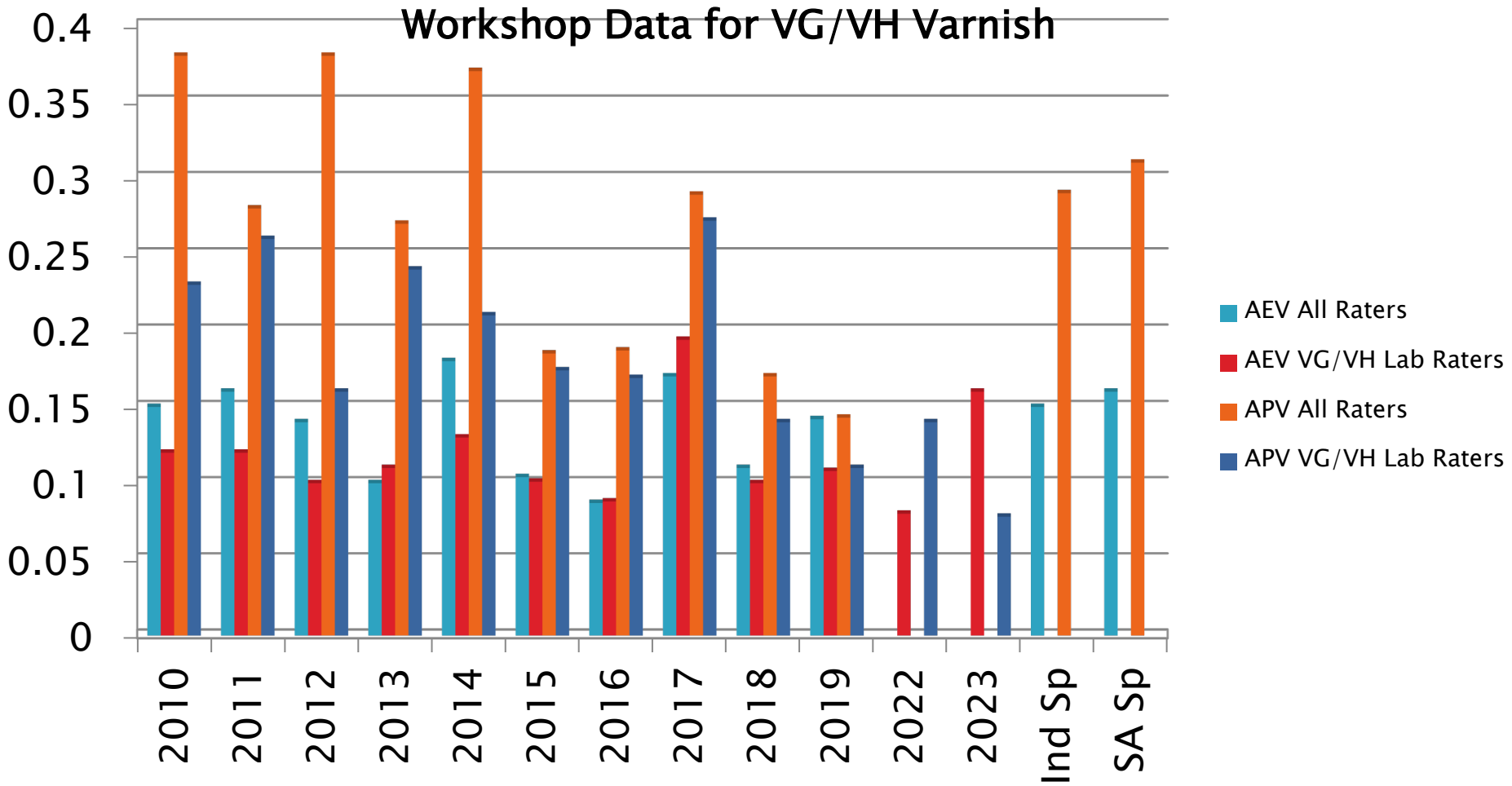
Sequence VG/VH Precision-Rating Workshop Data



Test Monitoring Center
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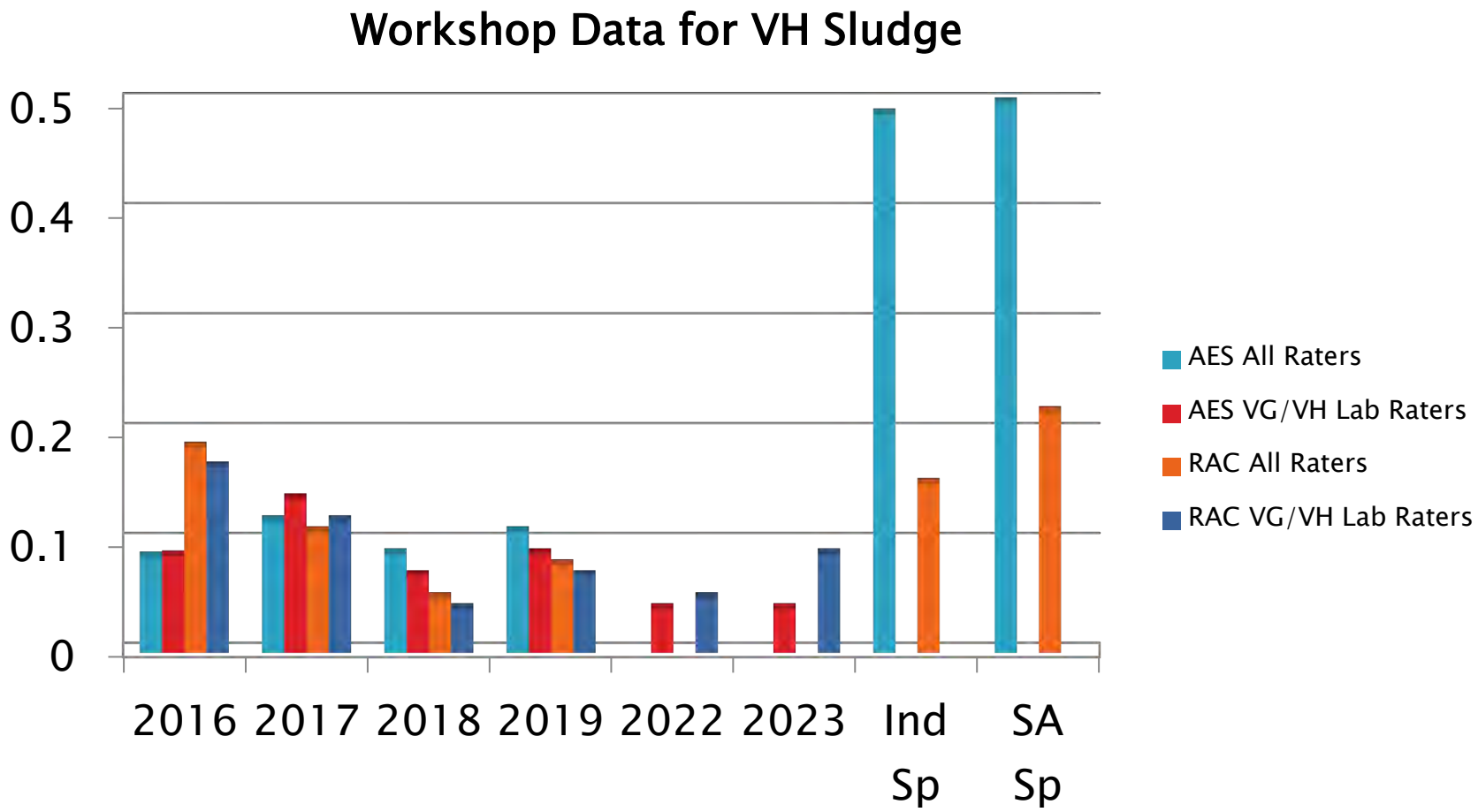
Sequence VH Precision-Rating Workshop Data



Sludge parameters were added for rater calibration in 2019
2022 and 2023 Workshop were for Lab Raters only!

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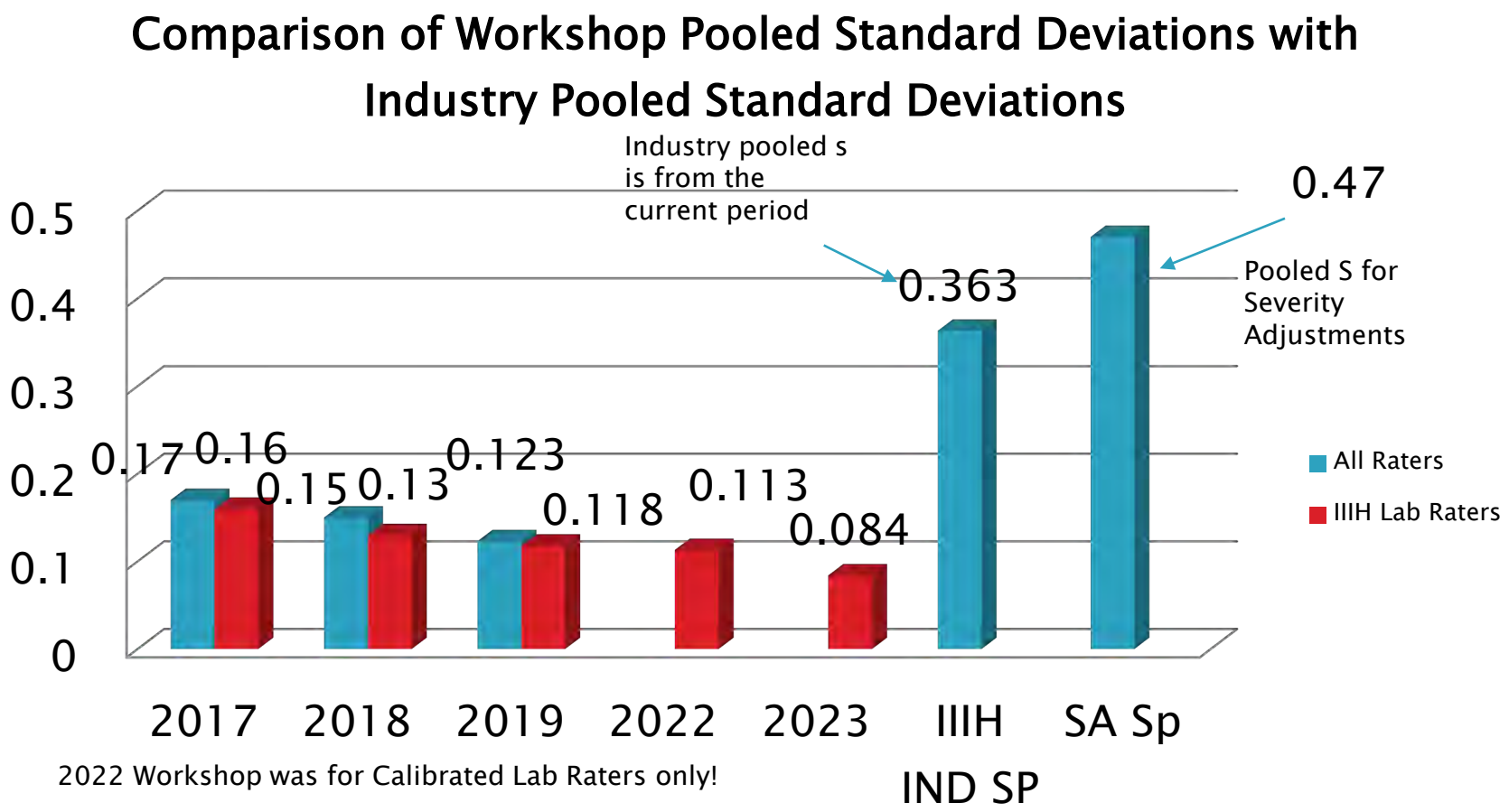
Sequence IIIH Precision – Rating Workshop Data



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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

- https://www.astmtmc.org

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