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ASTM D02.B2 Semi-Annual Report Heavy Duty Reference Oil Testing

October 2011

Heavy Duty Testing

Executive Summary

- ▶ 1P
 - Working to obtain a new batch of liners
 - Stand calibrations were extended to conserve hardware
- ▶ ISB
 - Correction factors applied to both parameters to address long-term severe trend on Batch B tappets with Batch E, F, and G cams.
- ▶ ISM
 - CWL correction factor updated from +1.3 mg to +2.5 mg.

Heavy Duty Testing

Executive Summary

- ▶ T-8/E
 - Correction factors implemented for all parameters to return test severity to historical levels.
- ▶ T-12
 - Correction factors implemented in April for the STWN hardware combination
 - Correction factors were updated in May

Calibrated Labs and Stands*

Test	Labs	Stands
1K	3	3
1N	4	5
1M-PC	2	2
1P	1	1
1R	1	1
C13	2	4
ISB	3	3
ISM	5	6
EOAT	1	1
RFWT	1	1
T-8/E	2	3
T-10A	1	1
T-11	2	5
T-12	4	10
T-12A	4	10

*As of 9/30/2011

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Test Activity Levels

»» April 1, 2011 –

September 30, 2011

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CAT – SCOTE Tests

Test Status	Validity Code	1K	1N	1M-PC	1P	1R
Acceptable Calibration Test	AC	2	3	2	0	0
Failed Calibration Test	OC	0	0	0	0	0
Operationally Invalid	LC	0	0	0	1	0
Aborted	XC	0	0	0	2	0
Total		2	3	2	3	0

CAT - C13 Test

Test Status	Validity Code	C13
Acceptable Calibration Test	AC	3
Failed Calibration Test	OC	0
Operationally Invalid	LC	0
Aborted	XC	0
Total		3

Cummins Tests

Test Status	Validity Code	ISB	ISM
Acceptable Calibration Test	AC	1	2
Failed Calibration Test	OC	0	0
Operationally Invalid	LC	0	0
Aborted	XC	0	0
Total		1	2

Light Duty Diesel Tests

Test Status	Validity Code	EOAT	RFWT
Acceptable Calibration Test	AC	1	1
Failed Calibration Test	OC	0	0
Operationally Invalid	LC	1	0
Aborted	XC	0	0
Total		2	1

Mack Tests

Test Status	Validity Code	T-8/E	T-10A	T-11	T-12	T-12A
Acceptable Calibration Test	AC	3	1	5	7	7
Failed Calibration Test	OC	1	0	1	0	0
Operationally Invalid	LC	0	0	1	0	0
Aborted	XC	1	0	1	1	1
Total		5	1	8	8	8

Failed Tests

Test Status	Test	Number of Tests
Mild VI38 and RV48	T-8/E	1
Mild SOOT	T-11	1
Total		2

Lost Tests*

*Invalid and aborted tests

Test Status	Cause	1P	EOAT	T-8/E	T-11	T-12
Aborted	High Oil Consumption	2	0	0	1	0
Invalid	High Oil Consumption	1	0	0	0	0
Invalid	Speed Calibration Error	0	1	0	0	0
Aborted	Missed Soot Window	0	0	1	0	1
Invalid	Engine Damage, coolant leak into cylinders	0	0	0	1	0
Total		3^A	1	1	2	1^B

^A All lost tests were on a single new stand.

^B Test was also an aborted T-12A.

Test Severity

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September 30, 2011

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CAT Test Severity

▶ 1K

- WDK, TGC, ETOC are in control.
- TGF and BSOC
 - Within Chart Limits
 - Long-term mild trend continuing

- Charts shown in [Appendix 1.a.](#)

▶ 1N

- All parameters trending mild
- TGF and TLHC in alarm

- Charts shown in [Appendix 1.b.](#)

CAT Test Severity

▶ 1 M-PC

- Both parameters (TGF & WTD) are in control.

- Charts shown in [Appendix 1.c.](#)

▶ 1 P

- TGC, WD, TLC are in control.
- OC and ETOC in alarm, severe direction.
 - Continuation of long-term trend.

- Charts shown in [Appendix 1.d.](#)

CAT Test Severity

▶ 1R

- TGC, WD, BTOC, and ETOC are in control.
- TLC in alarm, mild direction

- Charts shown in [Appendix 1.e.](#)

▶ C13

- All parameters are in control.
- TLC showing mild trend.

- Charts shown in [Appendix 1.f.](#)

Cummins Test Severity

▶ ISB

- ACSW in control.
- ATWL in control, showing evidence of mild trend.

- Charts shown in [Appendix 1.g.](#)

▶ ISM

- ASR and IAS in control.
- CWL within limits, but trending mild.
- FPD in alarm mild.
 - FPD trend started prior to new filter introduction.

- Charts shown in [Appendix 1.h.](#)

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Light Duty Diesel Test Severity

▶ EOAT

- AEOA in control.

- Charts shown in [Appendix 1.i.](#)

▶ RFWT

- AFW in control.

- Charts shown in [Appendix 1.j.](#)

Mack Test Severity

▶ T-8/E

- All parameters trending mild.
- RV48 and RV2 in alarm.
 - Panel has addressed with correction factors.

- Charts shown in [Appendix 1.k.](#)

▶ T-10A

- MRV within limits, but trending mild

- Charts shown in [Appendix 1.l.](#)

Mack Test Severity

▶ T-11

- SOOT4 in control.
- SOOT, SOOT5, and MRV trending mild.
 - SOOT5 in alarm.

- Charts shown in [Appendix 1.m.](#)

▶ T-12

- All parameters within chart limits.
- PB and PB2 showing evidence of severe trend.

- Charts shown in [Appendix 1.n.](#)

Mack Test Severity

- ▶ T-12A
 - MRV is in alarm, trending mild.
- Charts shown in [Appendix 1.o.](#)

Test Precision

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September 30, 2011

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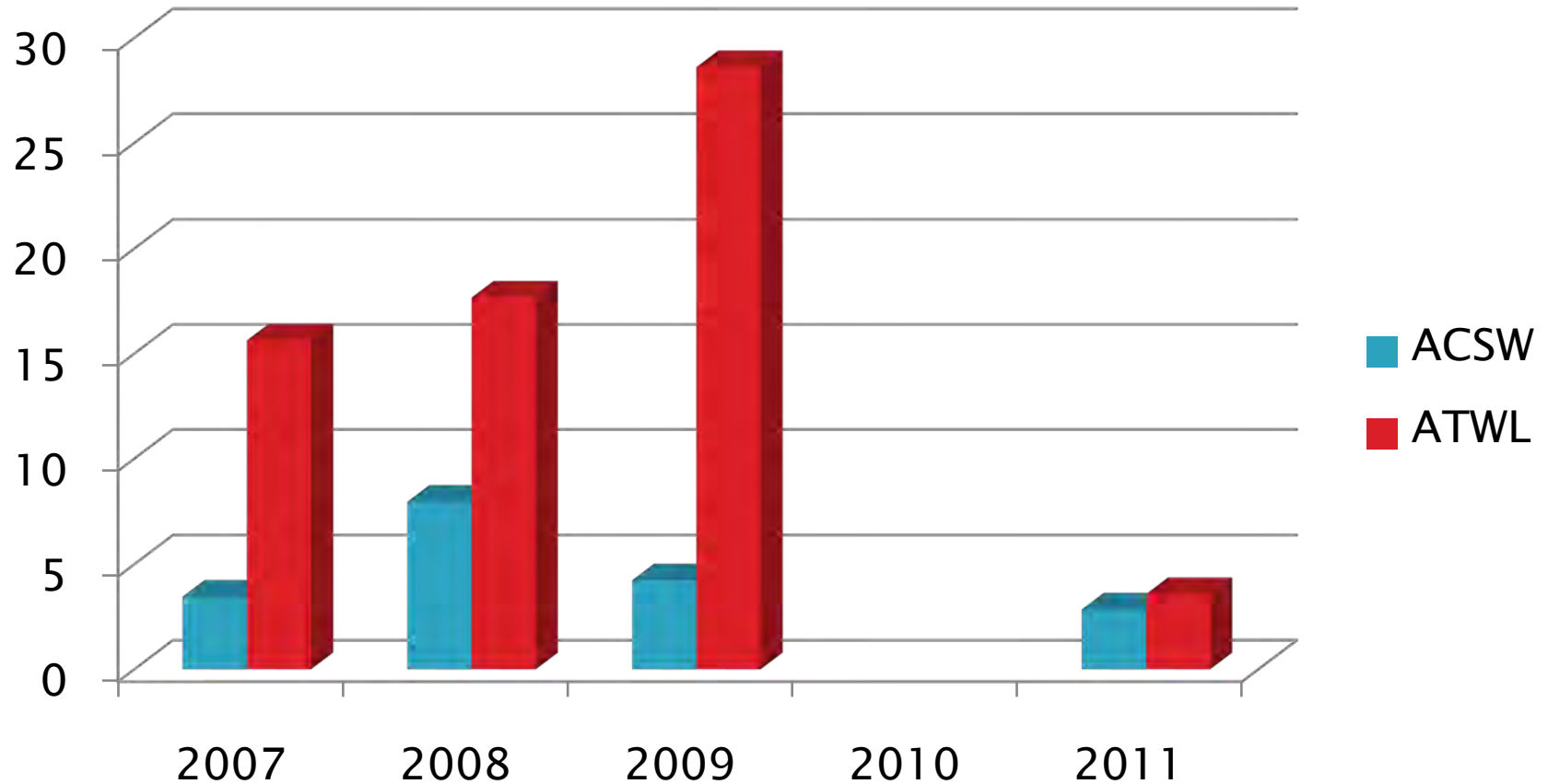


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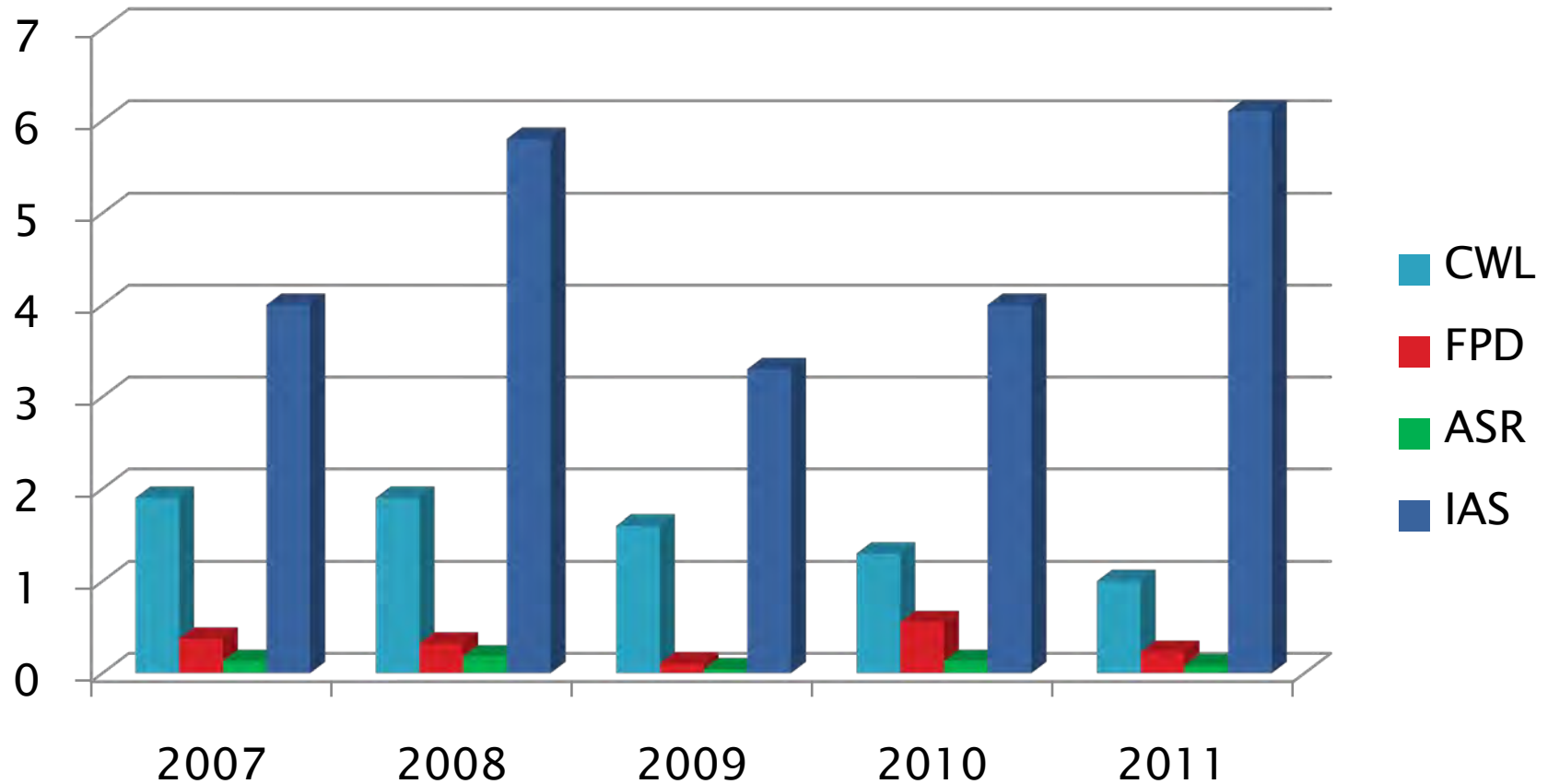
Test Precision Estimates

- ▶ Presented on an annual basis for years where sufficient data exist
- ▶ For several test types, including all CAT tests, precision estimates are not available due to low activity levels
- ▶ Current year estimates are year-to-date

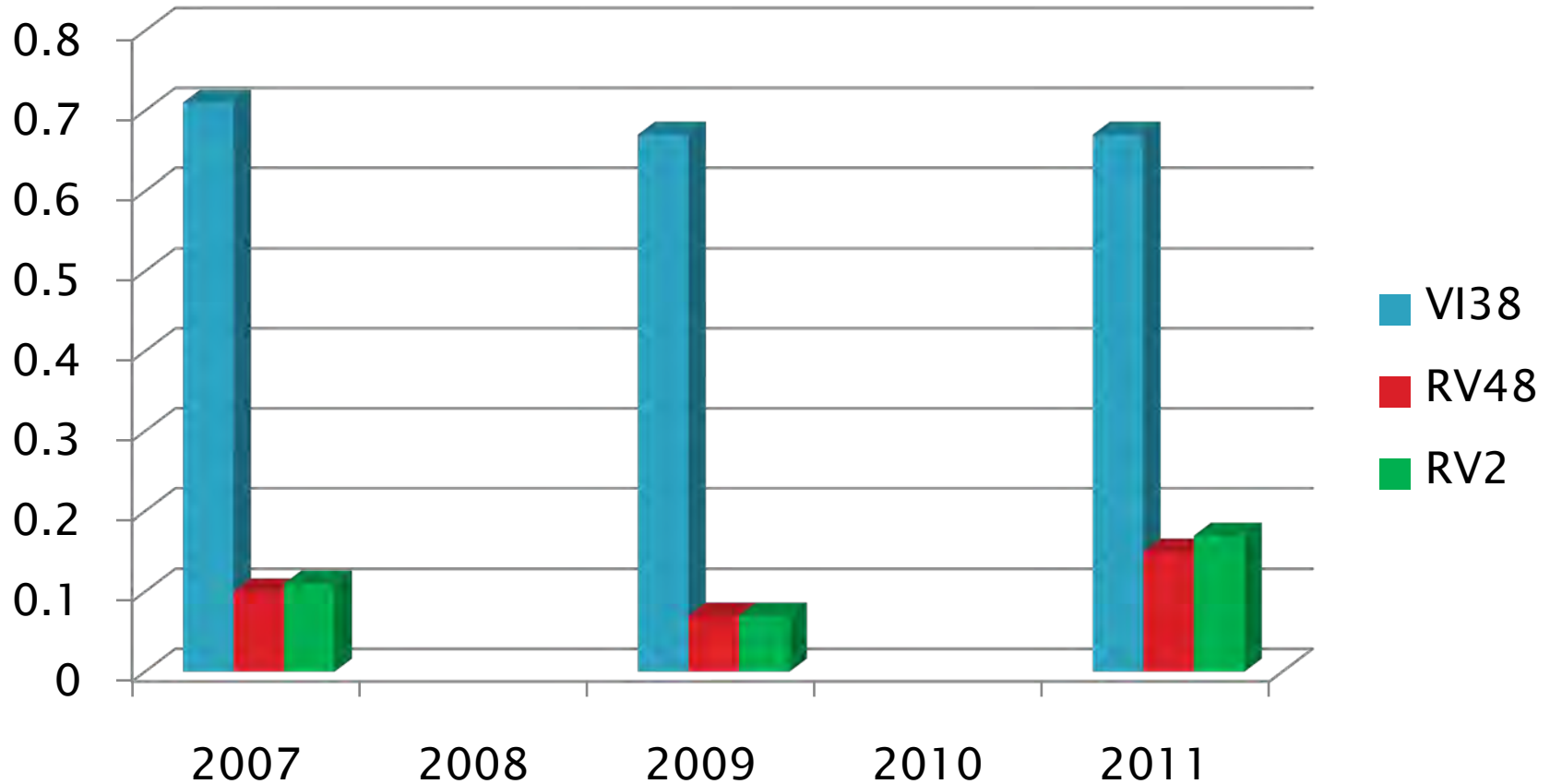
ISB Precision Estimates



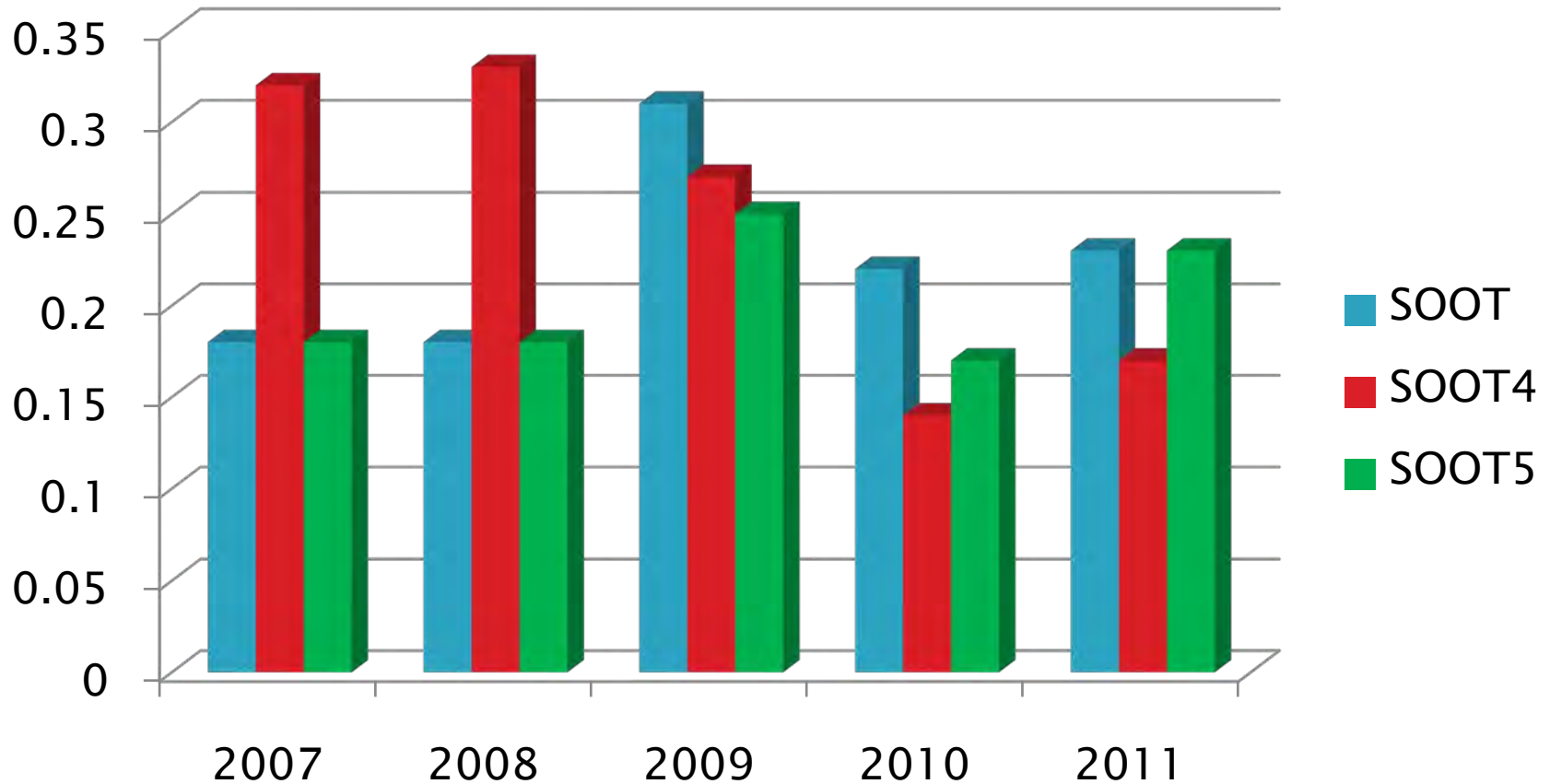
ISM Precision Estimates



T-8/E Precision Estimates

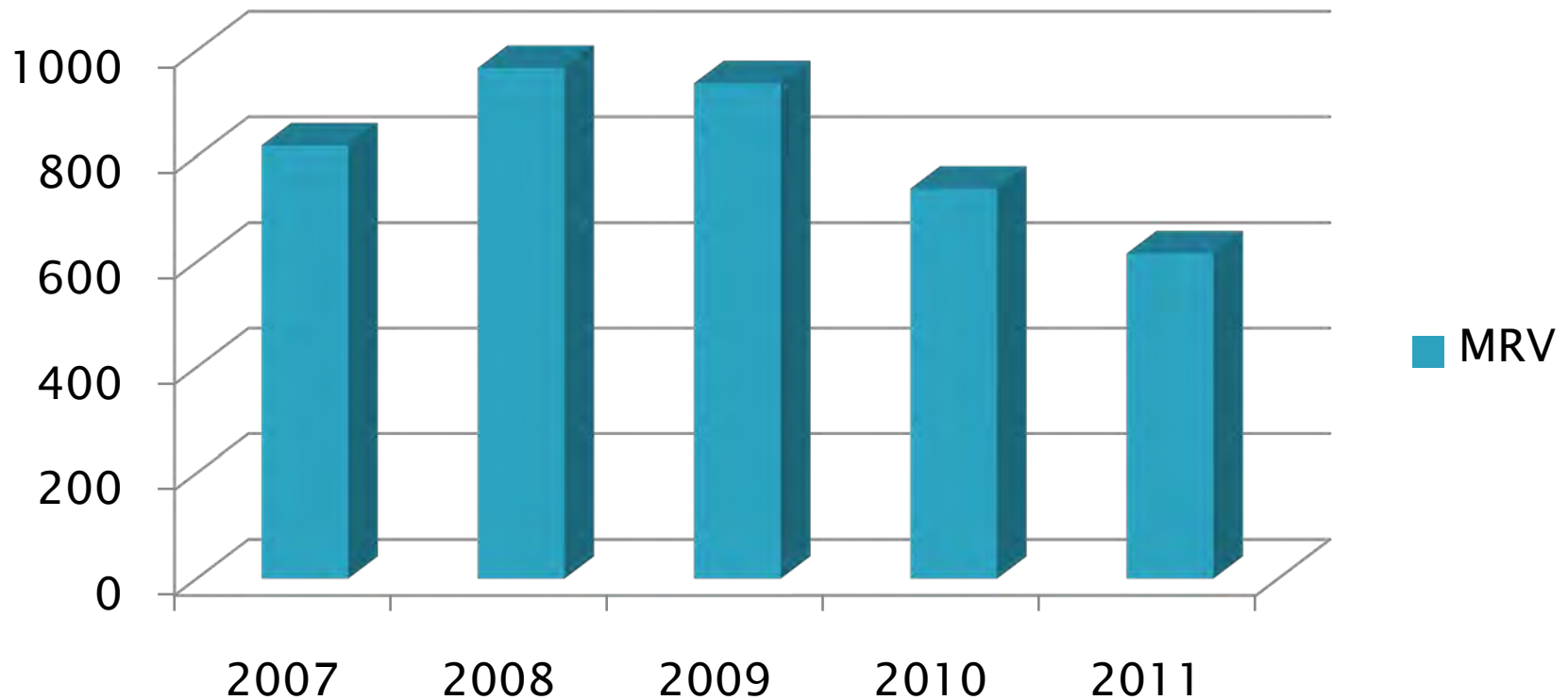


T-11 Precision Estimates

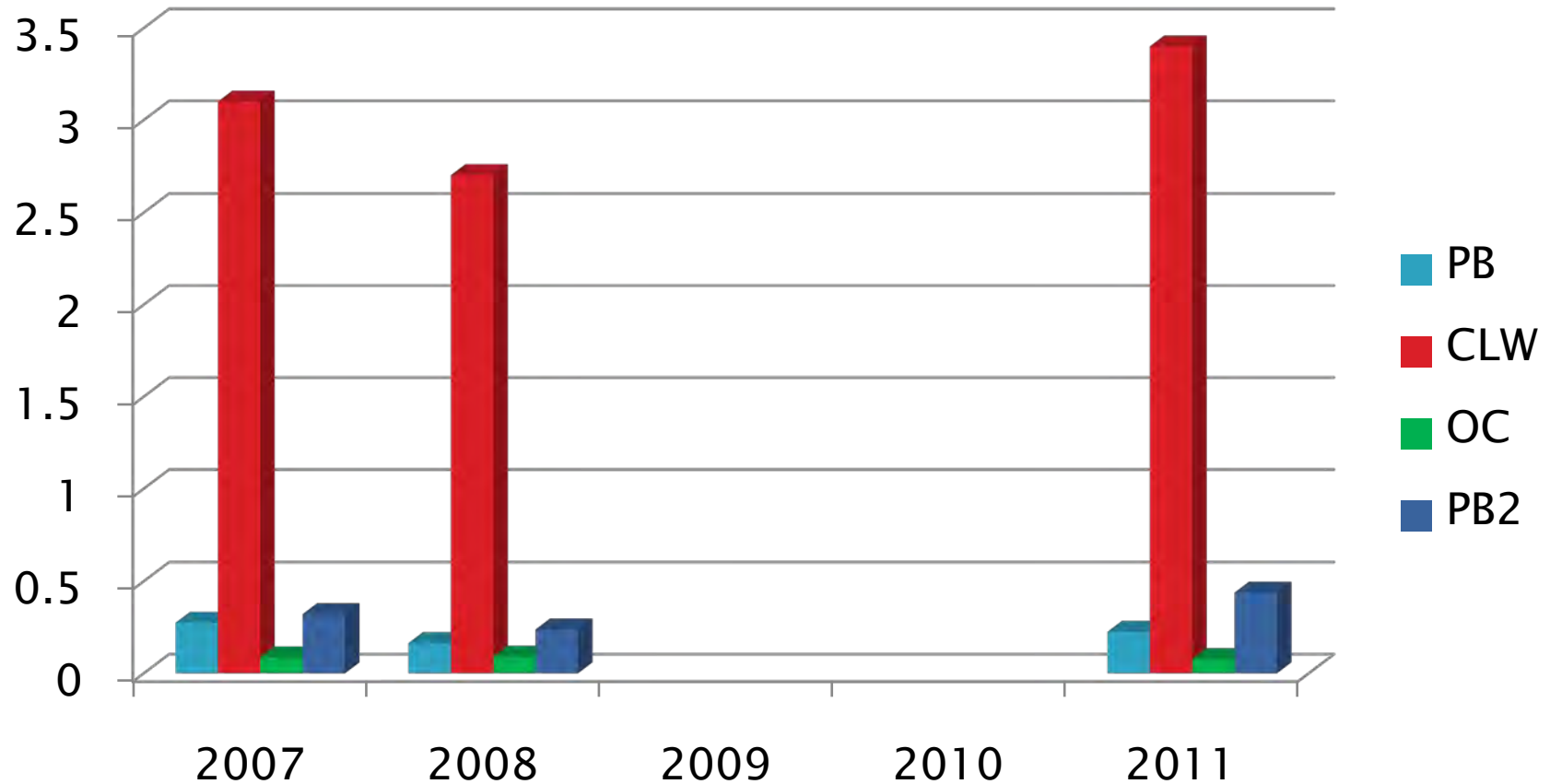


T-11 Precision Estimates

MRV

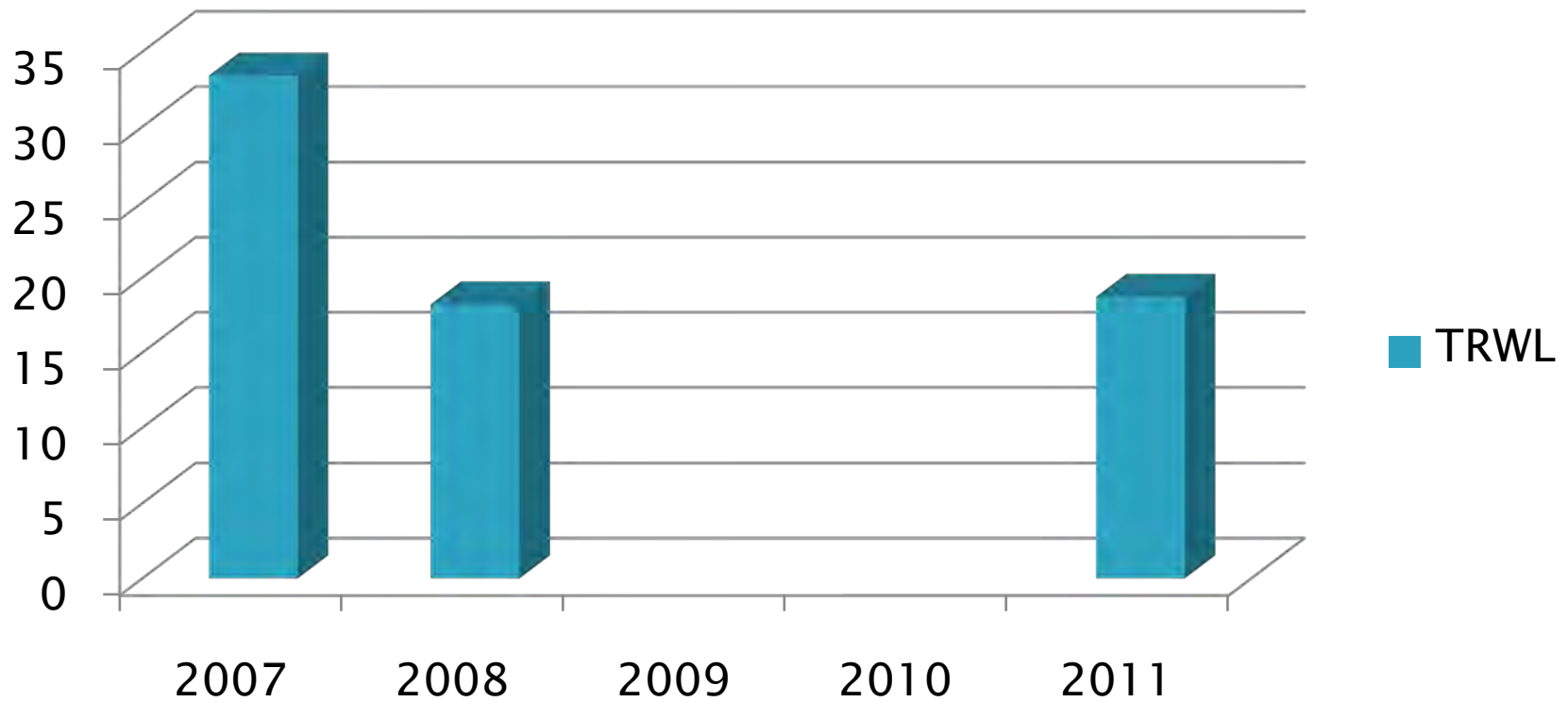


T-12 Precision Estimates



T-12 Precision Estimates

TRWL



Information Letters

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September 30, 2011

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Information Letters*

Test	Date	IL	Topic
ISB	May 11, 2011	11-1, Seq. 4	ACSW and ATWL Correction Factors
ISM	May 11, 2011	11-1, Seq. 6	Updated CWL Correction Factor
T-12	April 15, 2011	11-1, Seq. 8	STWN Hardware Approval and Correction Factors
T-12	May 9, 2011	11-2, Seq. 9	Updated STWN Hardware Correction Factors
T-12	August 23, 2011	11-3 Seq. 10	Updated Oil Consumption Calculation

*Available from TMC Website

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Reference Oil Inventory

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

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Reference Oil Actions

➤ *Action Required:* TMC 1005-3

- Cannot be re-blended
- Estimated supply ~ 1.5 years
- Panels will need to identify replacement
- Tests Affected: 1P, 1R, EOAT, RFWT, T-8/E

Reference Oil Re-blends

- Oils with ~ 2 years or less supply
 - Re-blends still available
 - TMC will pursue re-blend in due course
 - Oils Affected
 - 820-3, 821-2, 831-1

Reference Oil Inventory Estimated Life

Oil	Tests	Original Blend Amount	Quantity Shipped in last 6 months	TMC Inventory	Lab Inventory	Estimated Life
809-1	1K, 1N	9134	10	2604	40	5+ years
811-2	1K, 1N	1732	10	1375	60	5+ years
820-3	1R, T-10A, T-11	2750	159	472	168	1.5 years
821-2	T-12	450	50	300	100	2 years
830-2	ISM	3786	0	1201	225	5+ years
831-1	C13, ISB	1300	0	459	130	~1.5 years
873-2	1M-PC	1650	0	248	40	5+ years
1005-3	1P, 1R, EOAT, RFWT, T-8/E	2000	145	958	328	2 years

LTMS Deviations

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September 30, 2011

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LTMS Deviations

- One T-12 LTMS Deviation in Current Period
 - First industry test on SRUM2 hardware combination
 - Mack SP discarded the hardware combination
 - Test removed from lab's control chart

Historical Count of HD LTMS Deviations

Test	LTMS Deviations
1M-PC	2
1N	2
T-8/E	2
T-10A	1
T-12	1

Quality Index Deviations

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Quality Index Deviations

- No HD Quality Index Deviations this period

Historical Count of HD Quality Index Deviations

Test	LTMS Deviations
1P	11
1R	1
ISM	2
T-10A	1
T-11	3
T-12	3

TMC Laboratory Visits

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September 30, 2011

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TMC Lab Visits

- No HD lab visits this period

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Test Area Timelines

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Test Area Timeline Additions

Test	Date	Topic	IL
ISB	20110421	CORRECTION FACTORS IMPLEMENTED FOR TESTS USING BATCH B TAPPETS AND BATCHES E, F, OR G CAMSHAFTS.	11-1
ISM	20110430	UPDATE CROSSHEAD WEIGHT LOSS INDUSTRY CORRECTION FACTOR FROM +1.3 MG TO +2.5 MG.	11-1
T12	20110519	CFS UPDATED FOR ALL PARAMETERS FOR STWN HARDWARE COMBINATION.	11-2
T12	20110405	CFS IMPLEMENTED FOR ALL PARAMETERS FOR STWN HARDWARE COMBINATION.	11-1
T8	20110917	CORRECTION FACTORS IMPLEMENTED FOR ALL PARAMETERS.	11-1
T8	20110917	OIL 1005-3 TARGETS UPDATED.	

*As of 9/30/2011

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Additional Information

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September 30, 2011

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Additional 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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Appendix 1 Heavy Duty Reference Oil Testing Control Charts October 2011

Appendix 1.a

1 K Control Charts

» Severity, Precision, and CuSum

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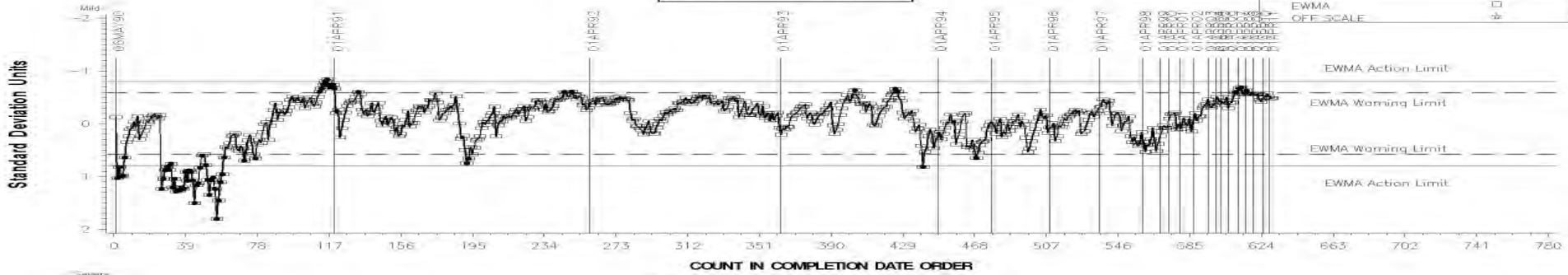
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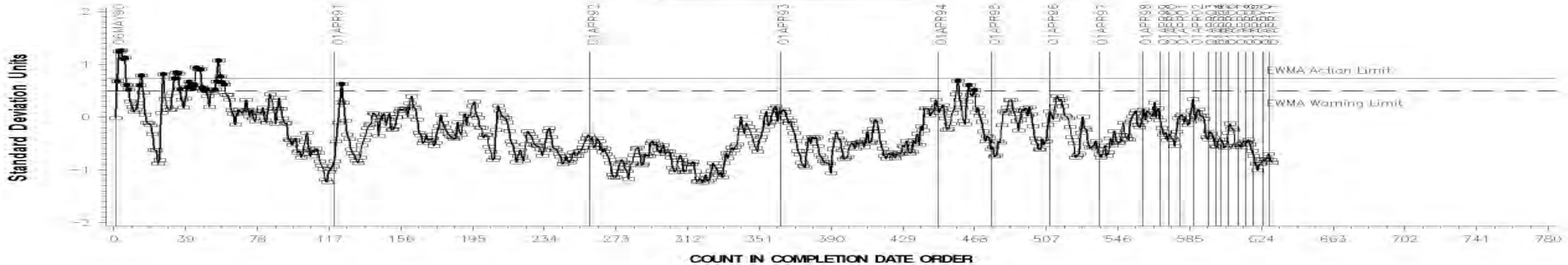
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Top Groove Fill

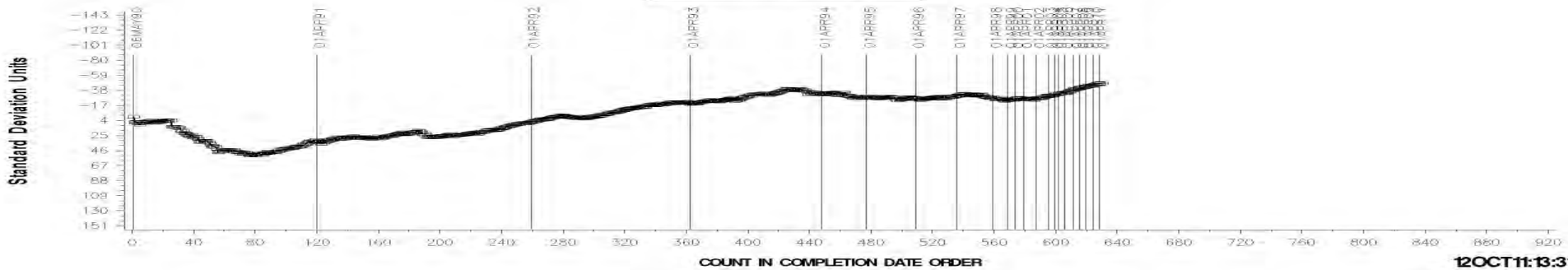
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



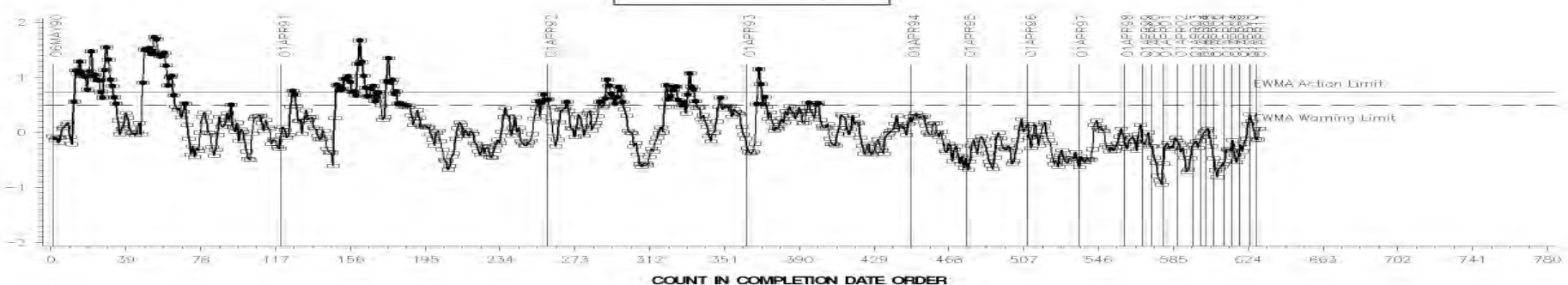
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Weighted Total Demerits

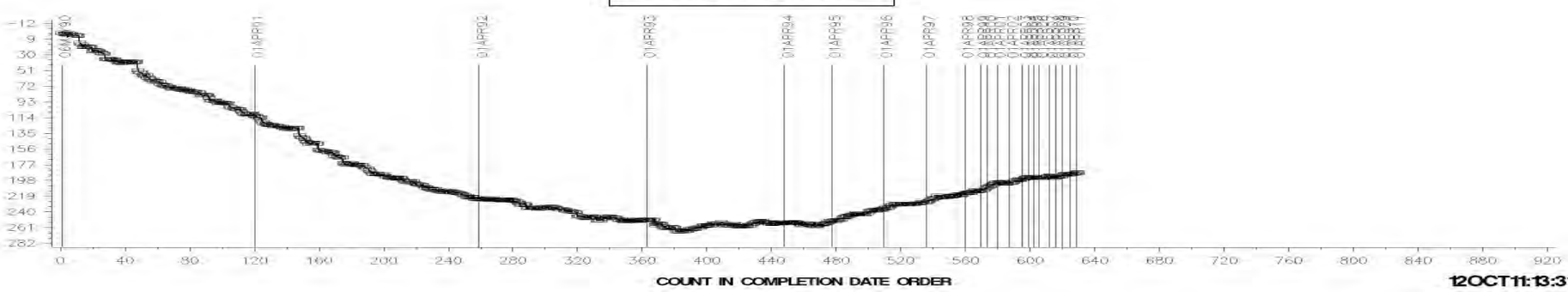
LTMS Severity Analysis



LTMS Precision Analysis



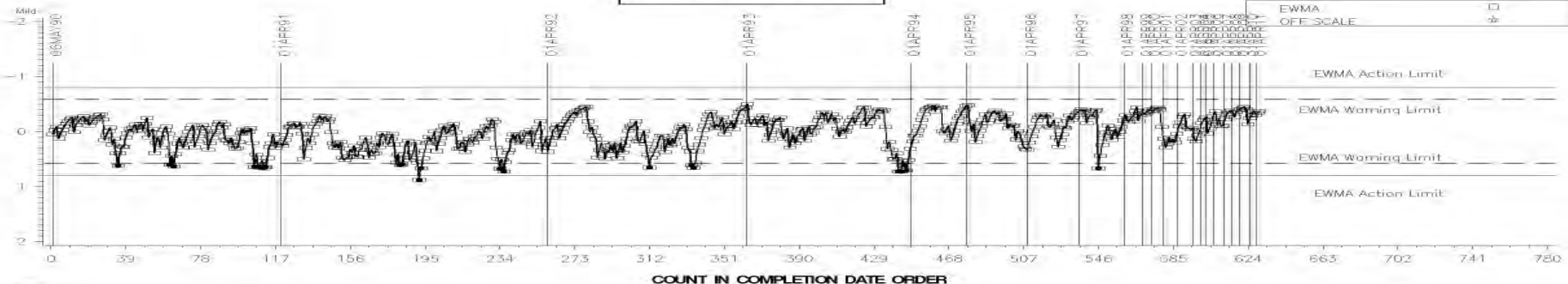
CUSUM Severity Analysis



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FINAL TRANSFORMED TOP LAND HEAVY CARBON

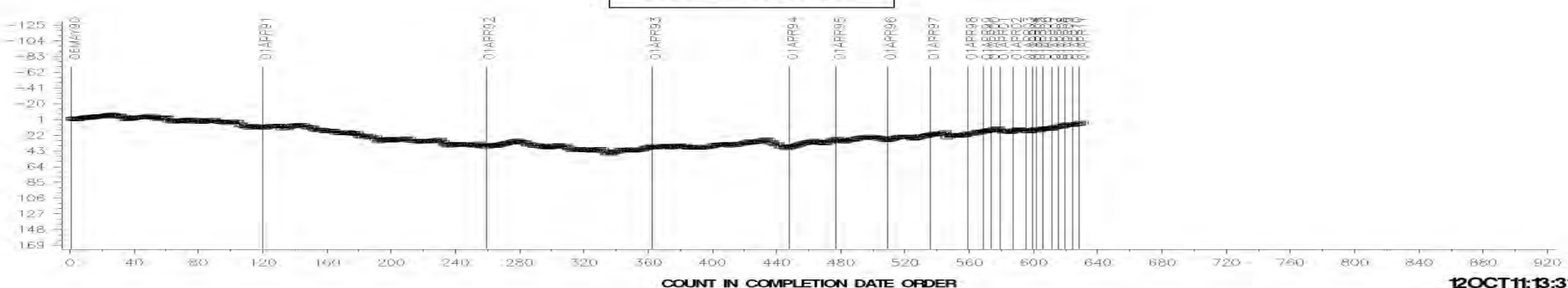
LTMS Severity Analysis



LTMS Precision Analysis



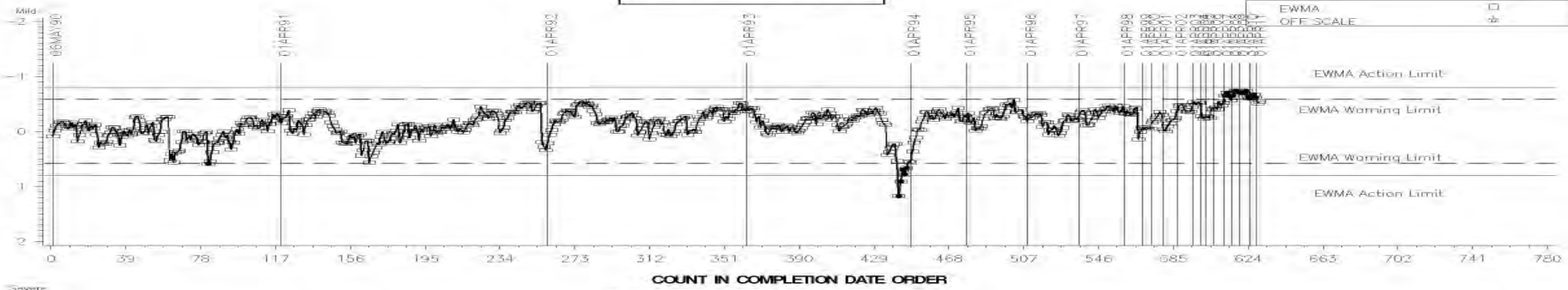
CUSUM Severity Analysis



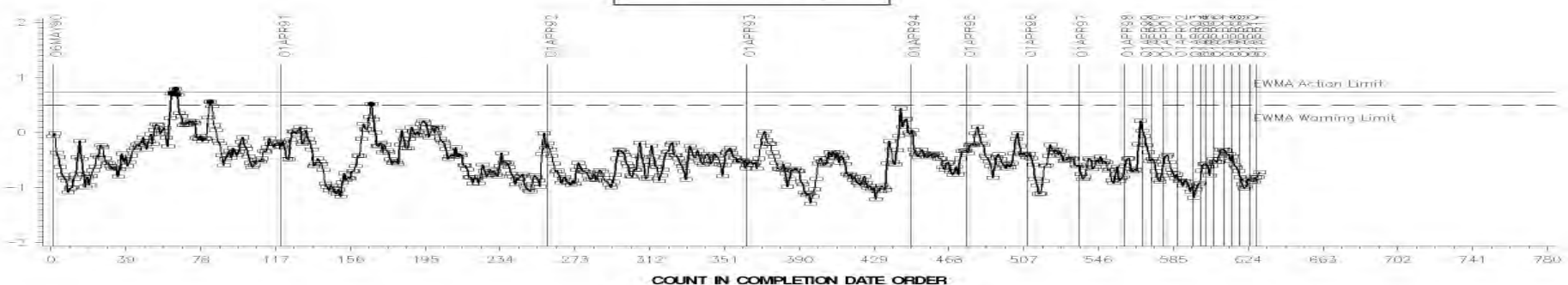
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BSOC

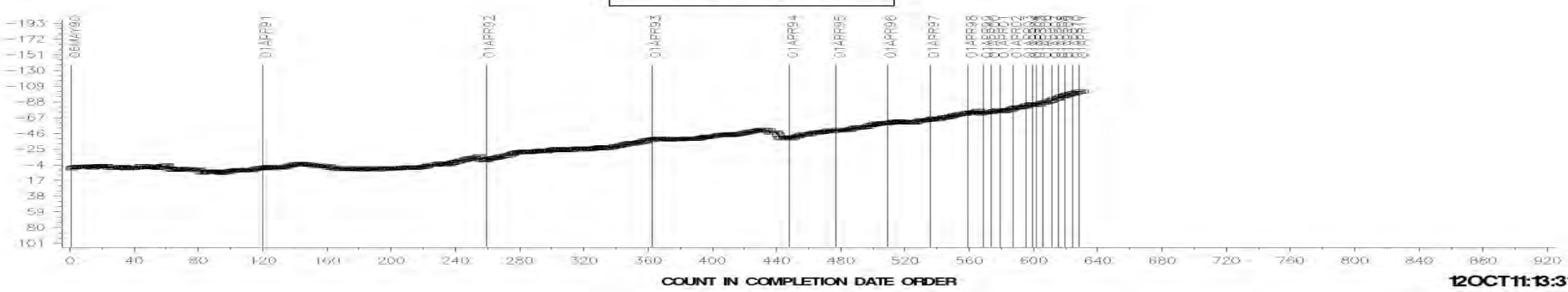
LTMS Severity Analysis



LTMS Precision Analysis



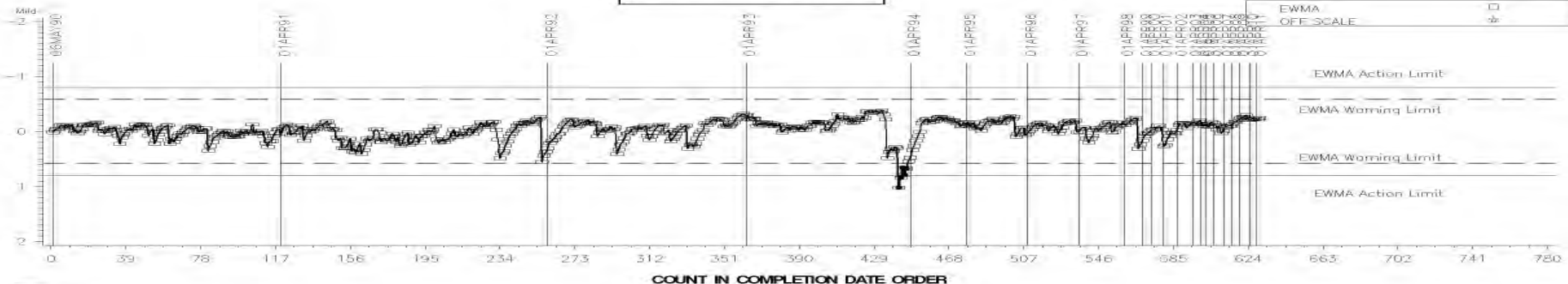
CUSUM Severity Analysis



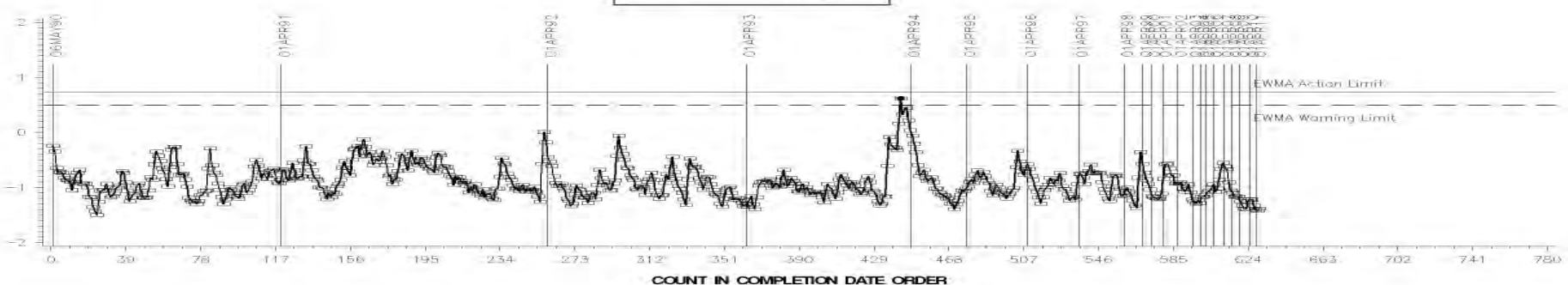
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EOTOC

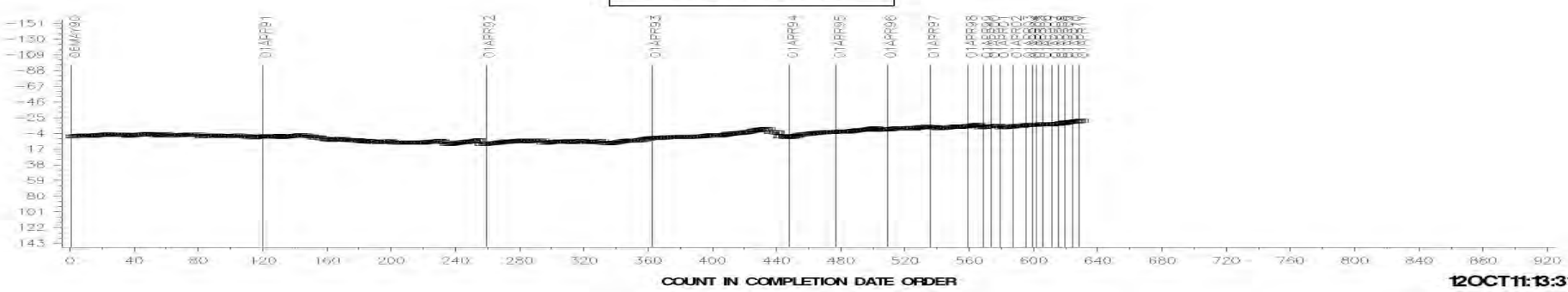
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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[Return](#)

Appendix 1.b

1 N Control Charts

» Severity, Precision, and CuSum

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Top Groove Fill

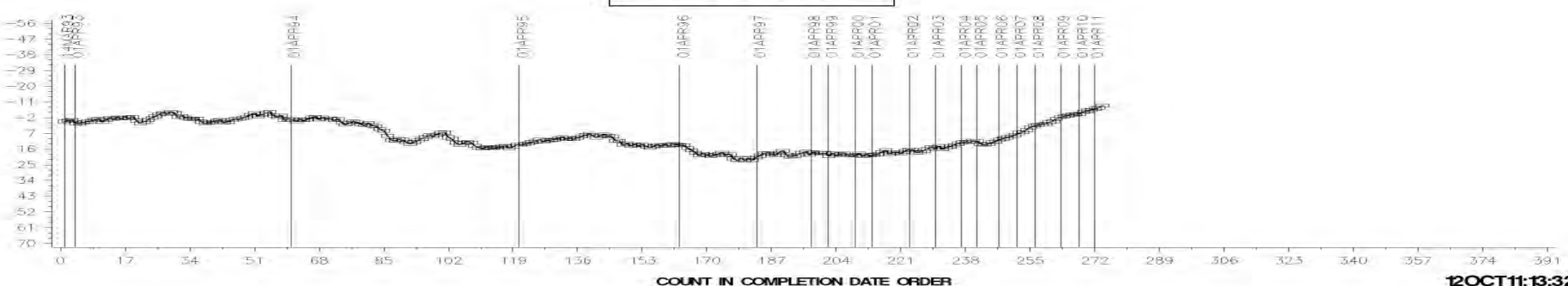
LTMS Severity Analysis



LTMS Precision Analysis



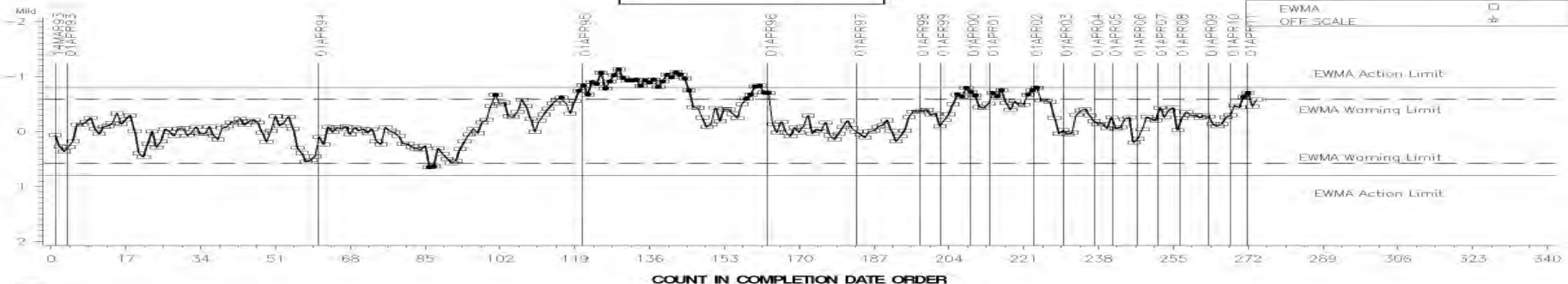
CUSUM Severity Analysis



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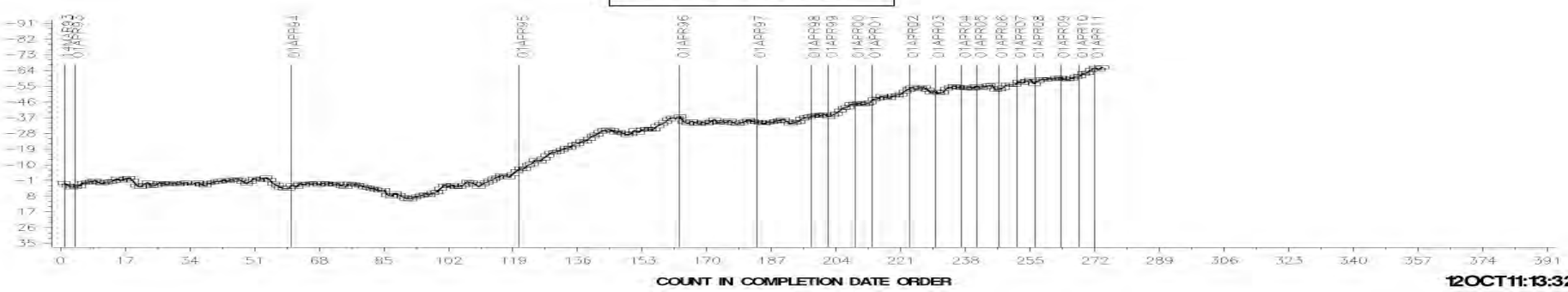
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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FINAL TRANS. TOP LAND HEAVY CARBON

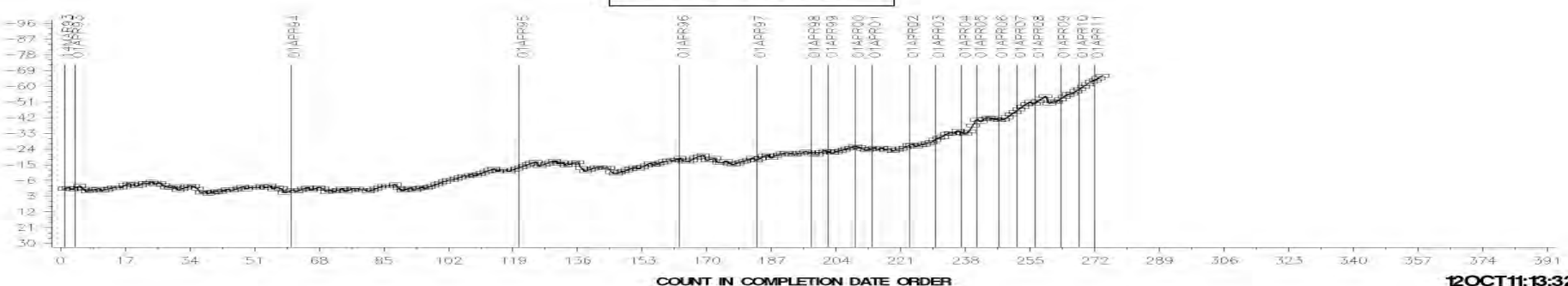
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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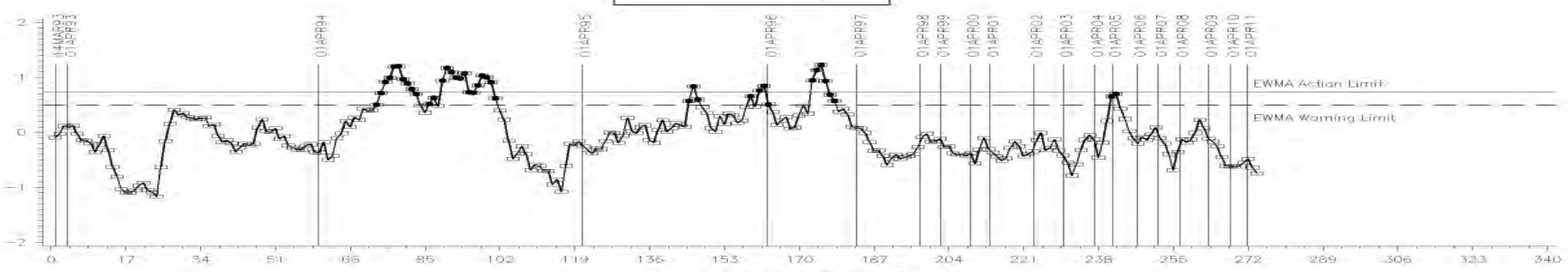


BSOC

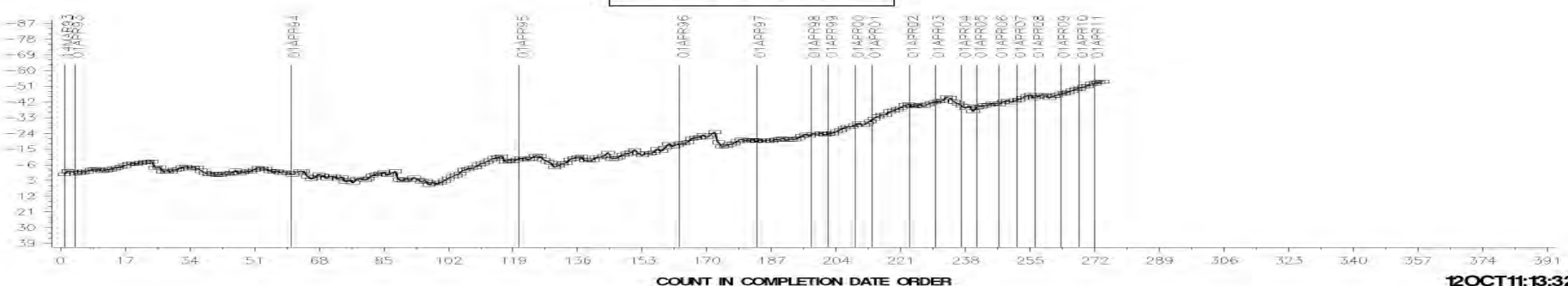
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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Appendix 1.c

1 M-PC Control Charts

» Severity, Precision, and CuSum

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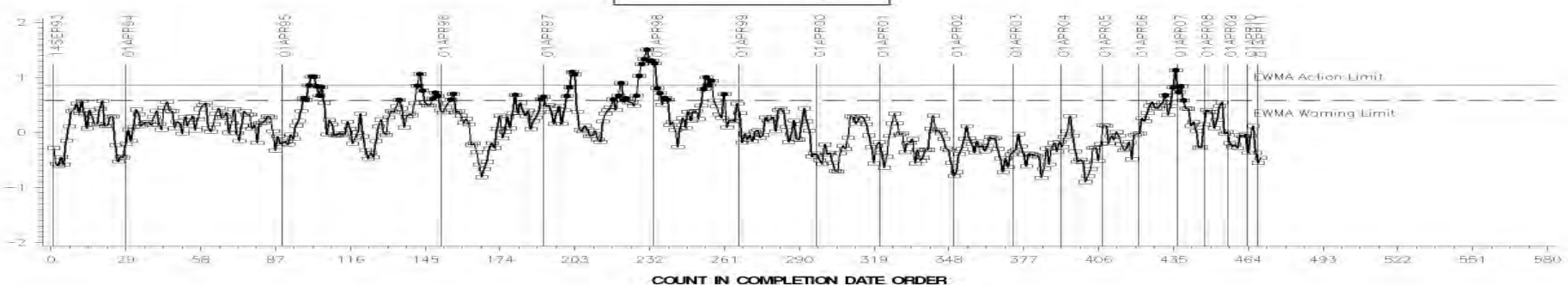
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FINAL TOP GROOVE FILLING

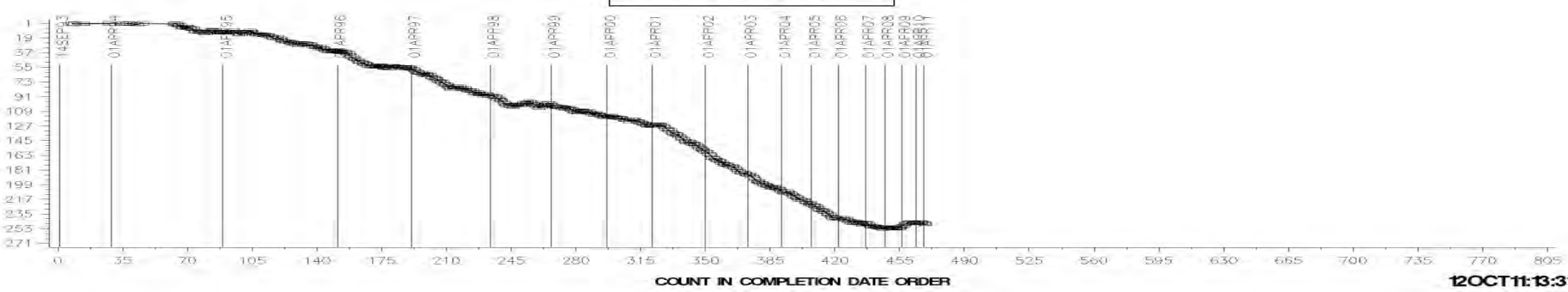
LTMS Severity Analysis



LTMS Precision Analysis



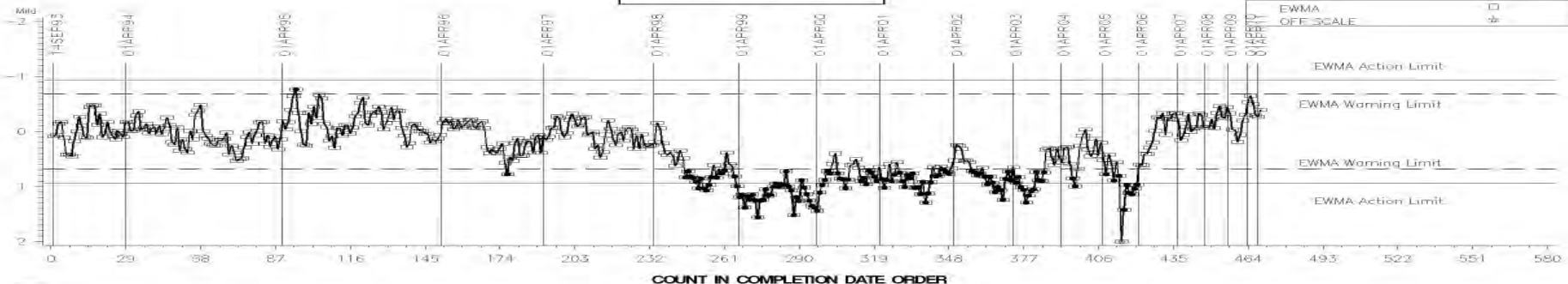
CUSUM Severity Analysis



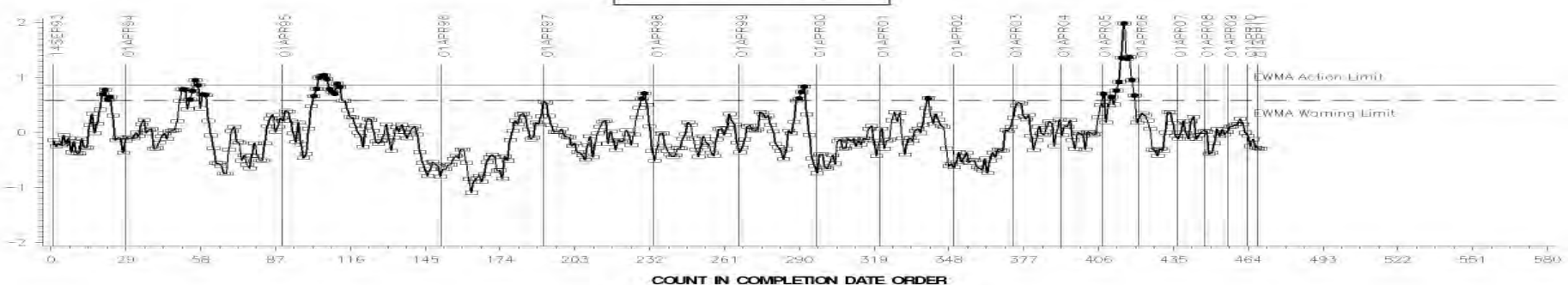
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Weighted Total Demerits

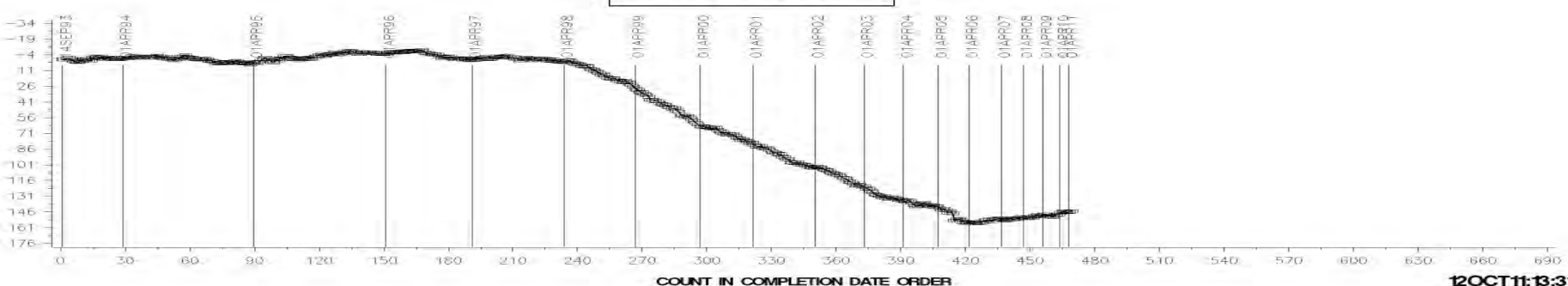
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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Appendix 1.d

1 P Control Charts

» Severity, Precision, and CuSum

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CATERPILLAR 1P INDUSTRY OPERATIONALLY VALID DATA

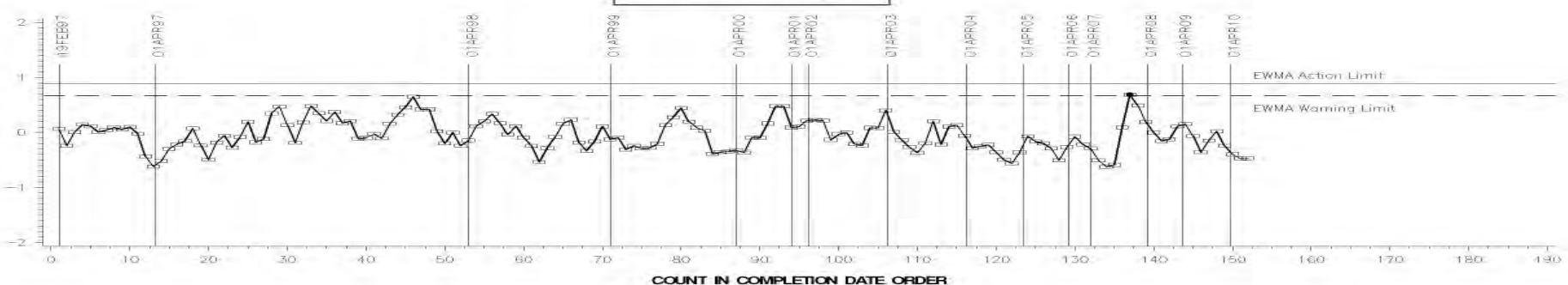


TOP GROOVE CARBON

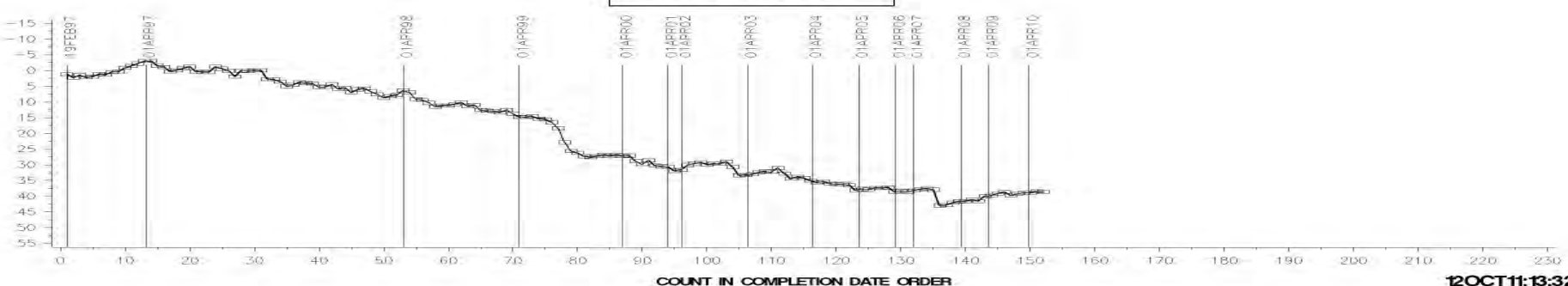
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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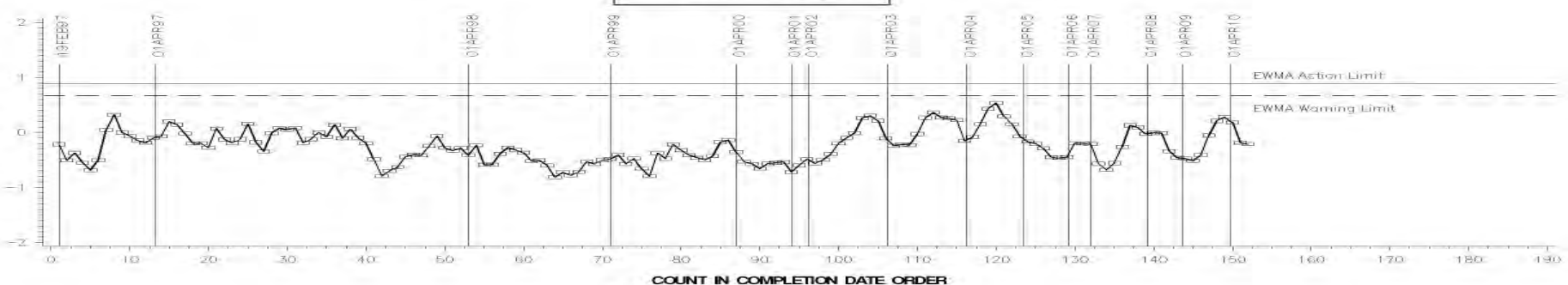


TOP LAND CARBON

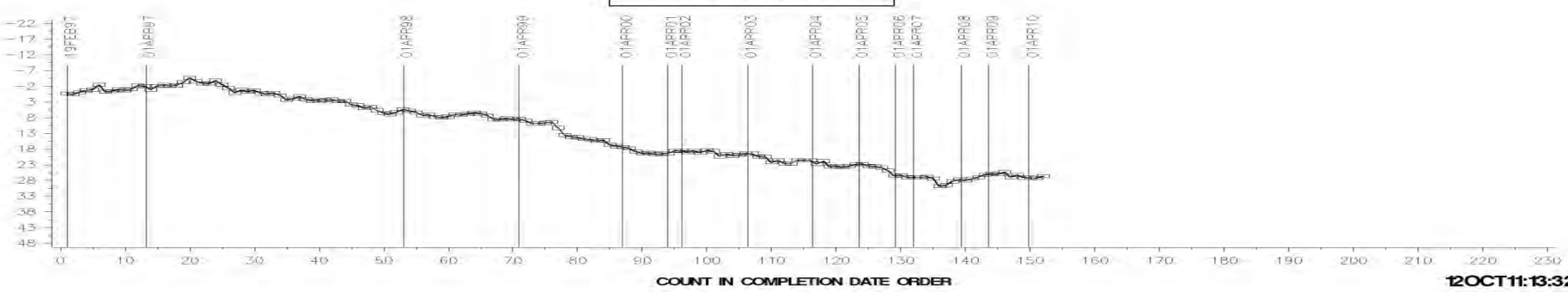
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

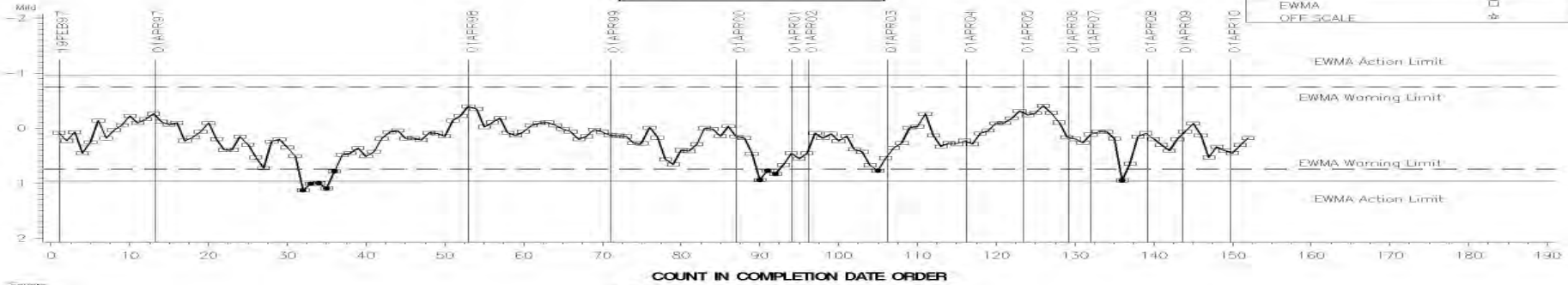


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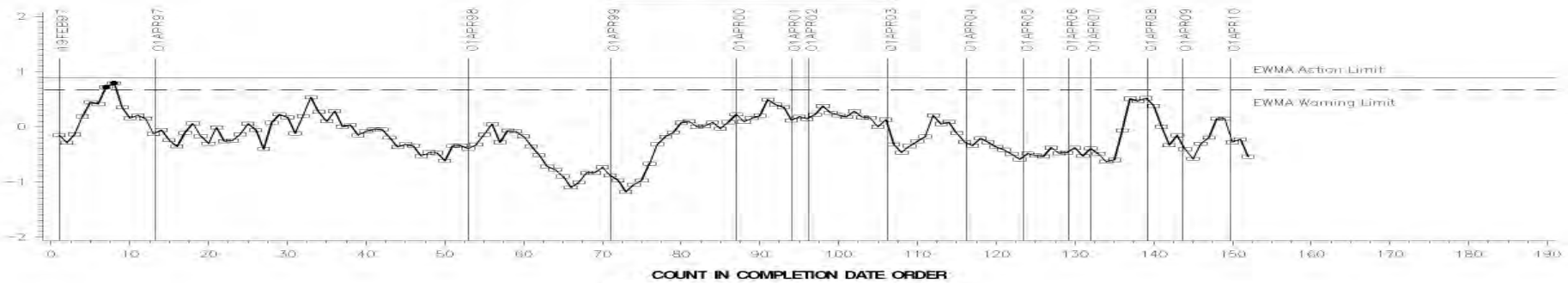


WEIGHTED TOTAL DEMERITS

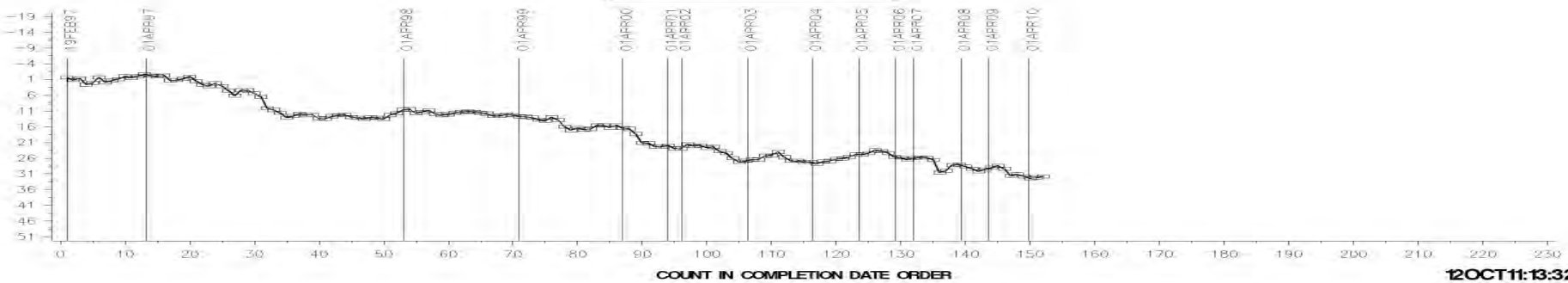
LTMS Severity Analysis



LTMS Precision Analysis



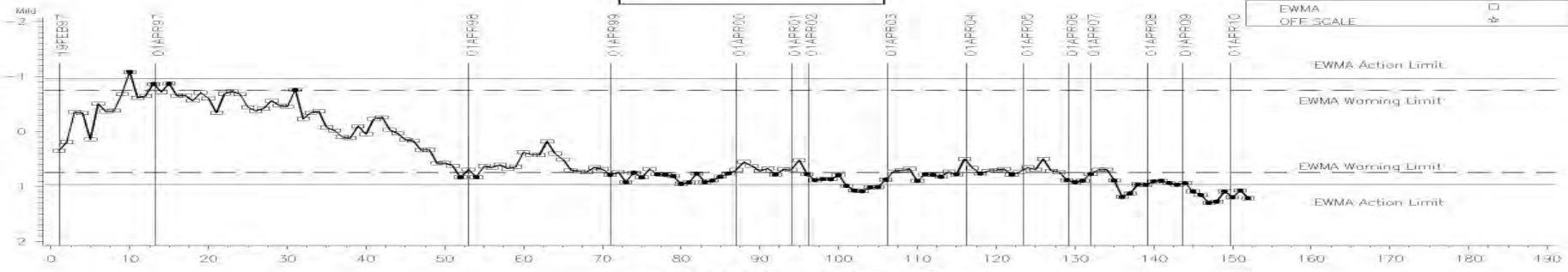
CUSUM Severity Analysis



12OCT11:13:32

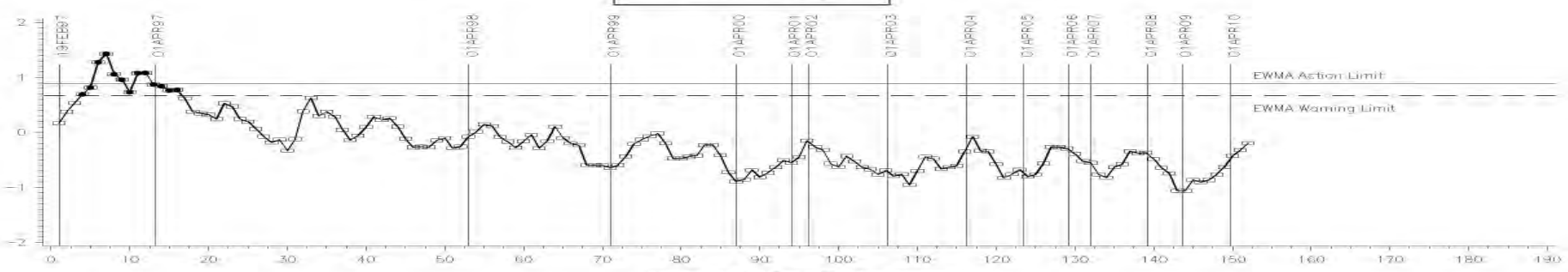
OIL CONSUMPTION

LTMS Severity Analysis



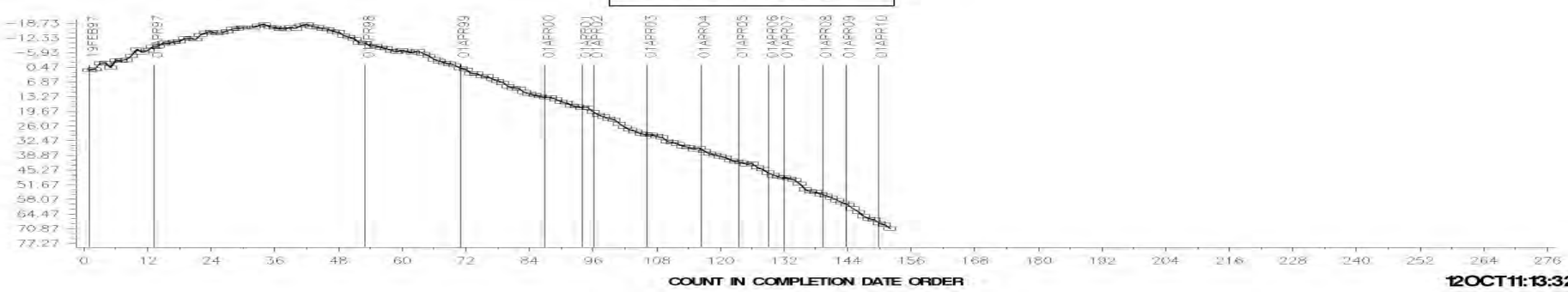
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis



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CATERPILLAR 1P INDUSTRY OPERATIONALLY VALID DATA



EOTOC

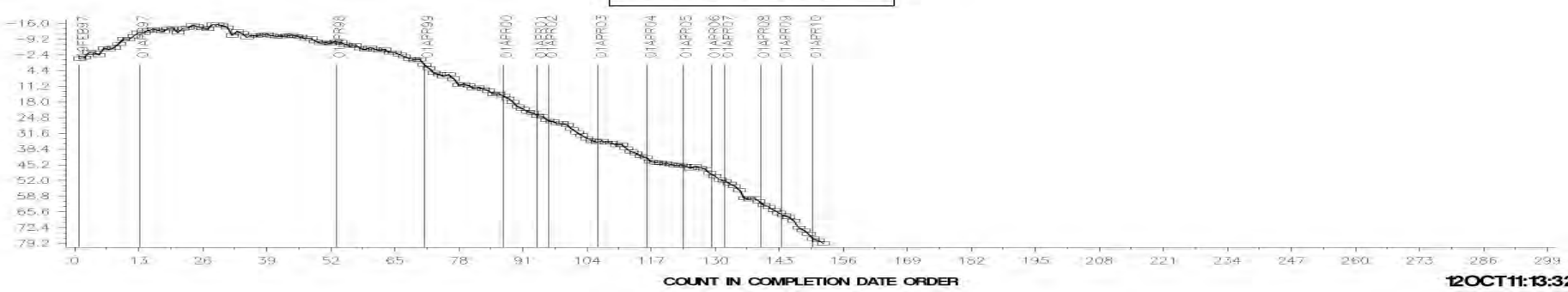
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



12OCT11:13:32

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Appendix 1.e

1 R Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

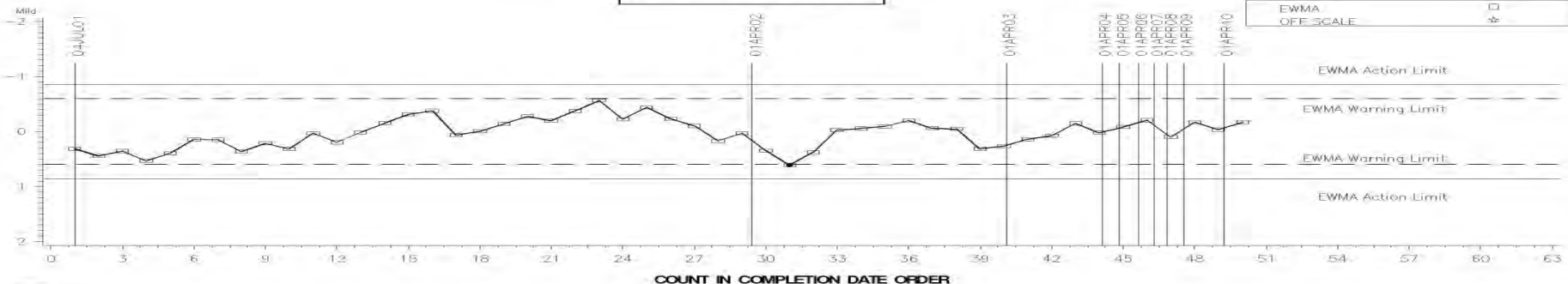
<http://astmtmc.cmu.edu>



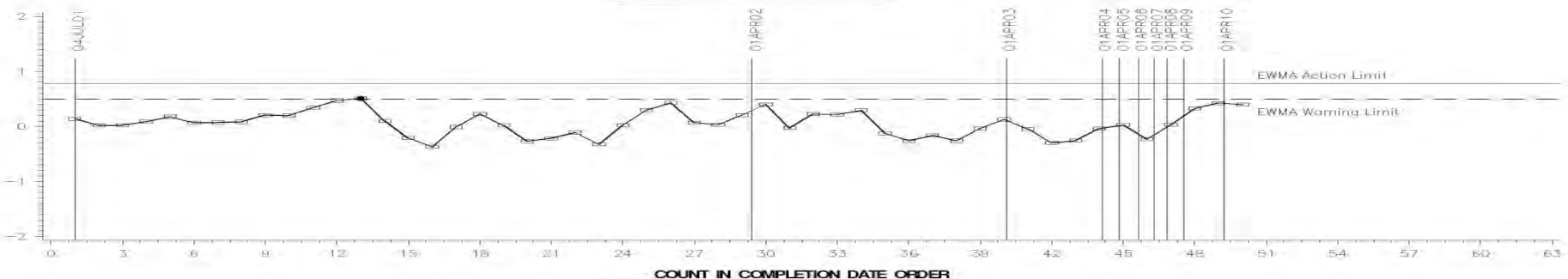
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FINAL WEIGHTED TOTAL DEMERITS (DEMERITS)

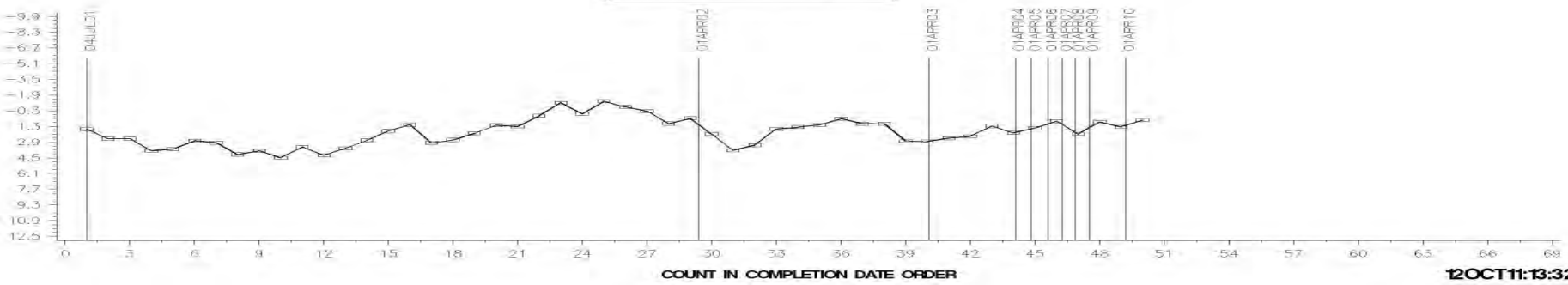
LTMS Severity Analysis



LTMS Precision Analysis



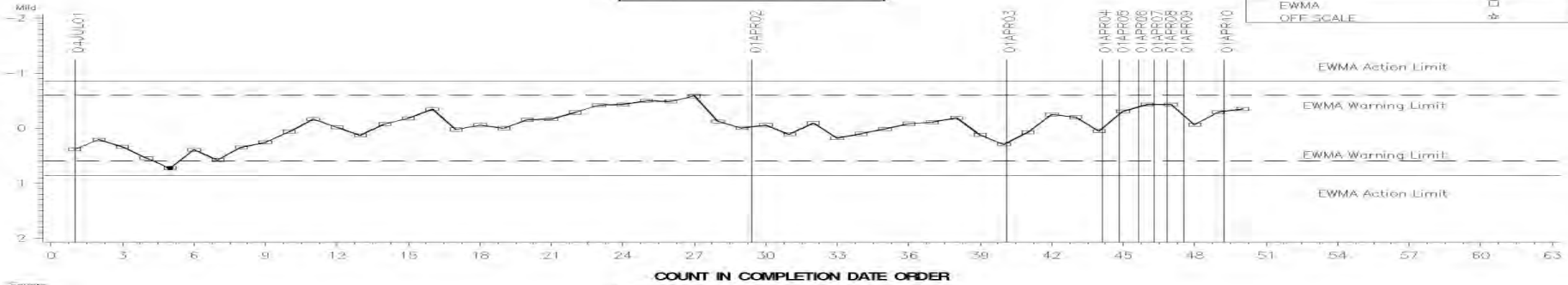
CUSUM Severity Analysis



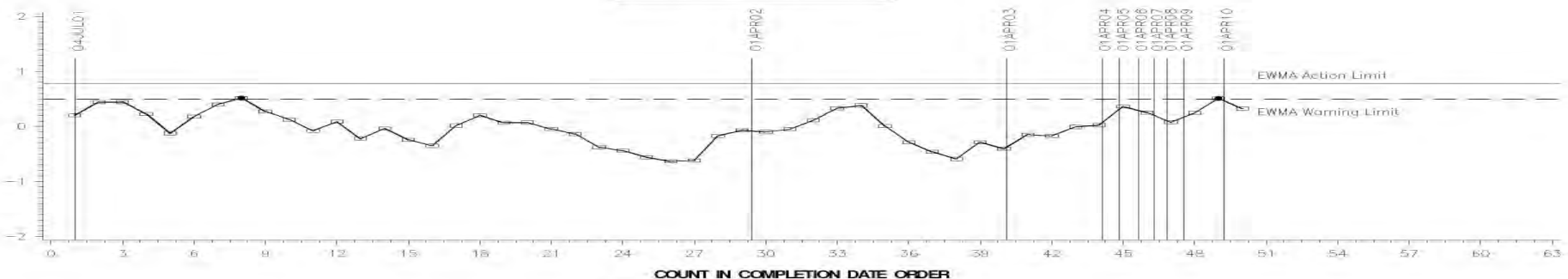
12OCT11:13:32

FINAL TOP GROOVE CARBON (DEMERITS)

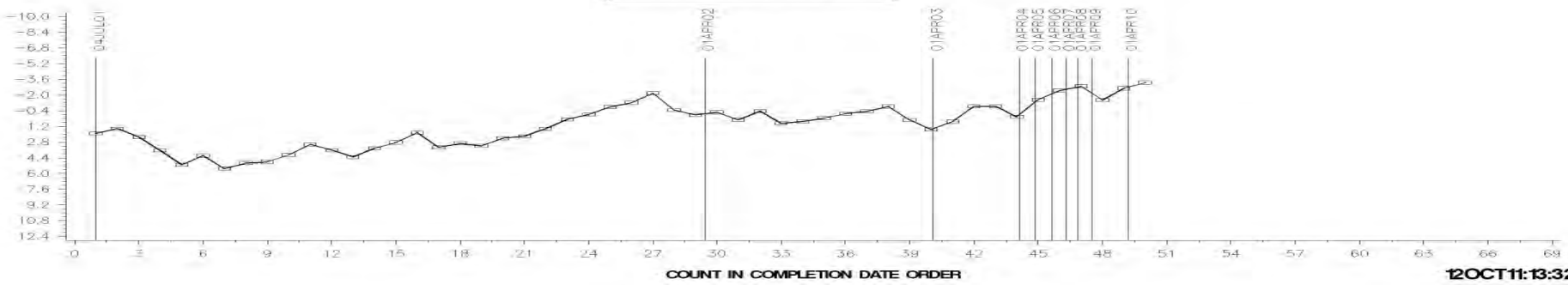
LTMS Severity Analysis



LTMS Precision Analysis



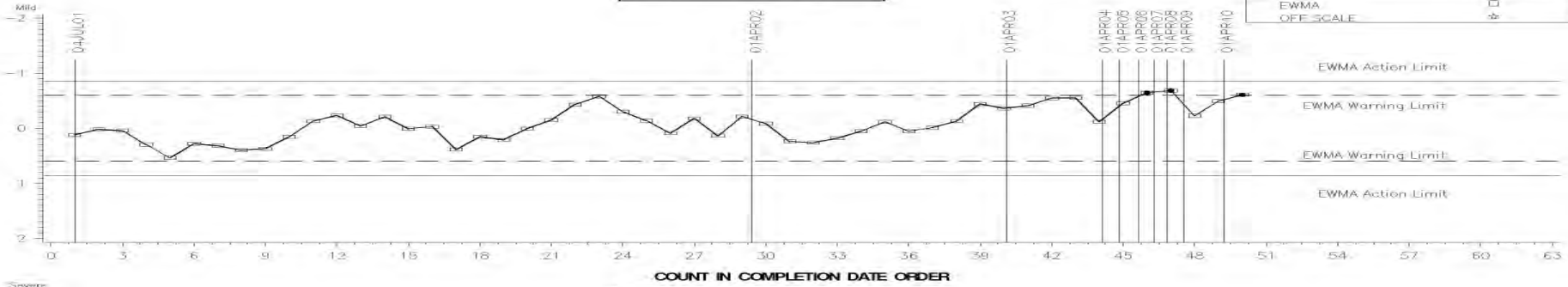
CUSUM Severity Analysis



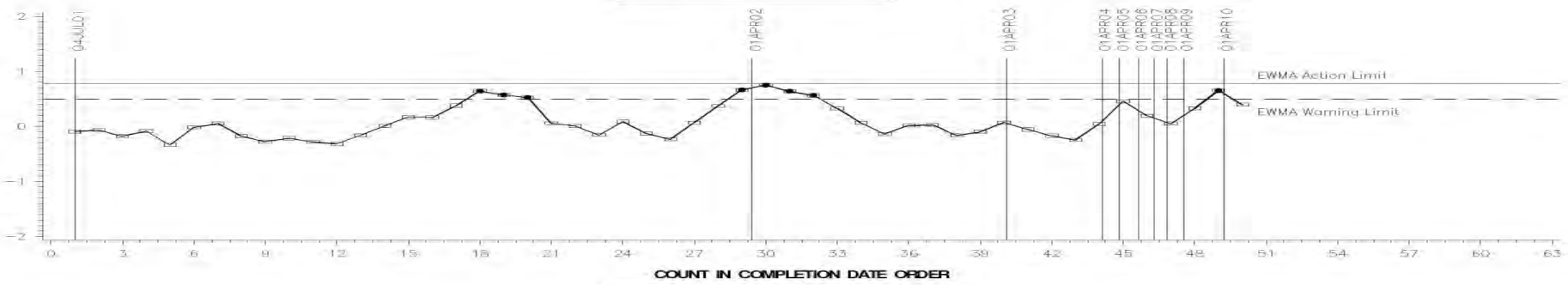
12OCT11:13:32

FINAL TOP LAND CARBON (DEMERITS)

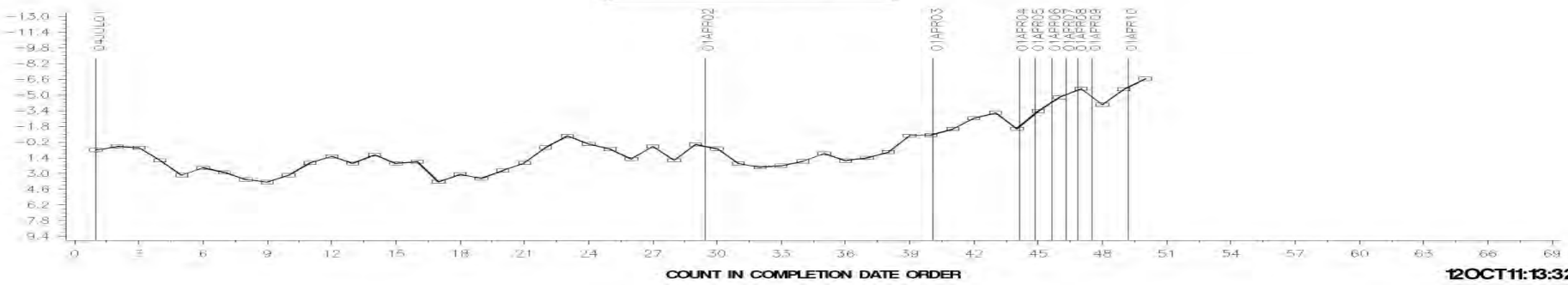
LTMS Severity Analysis



LTMS Precision Analysis



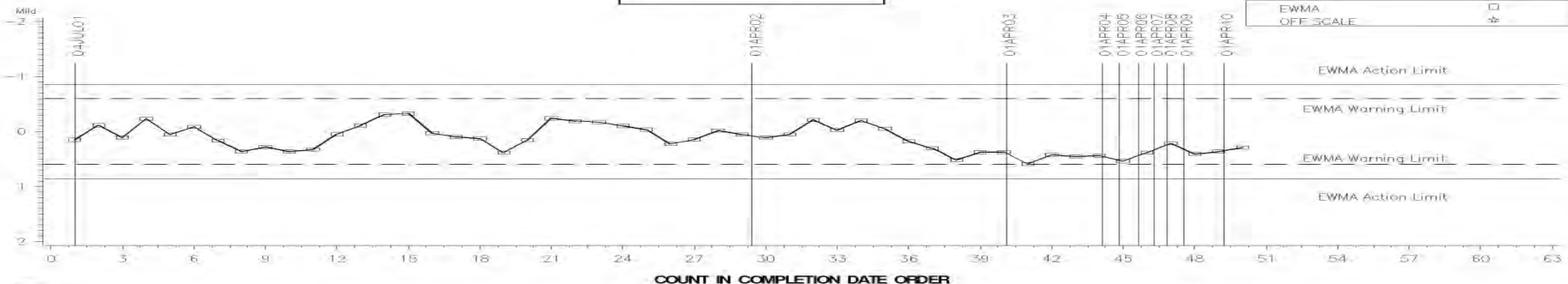
CUSUM Severity Analysis



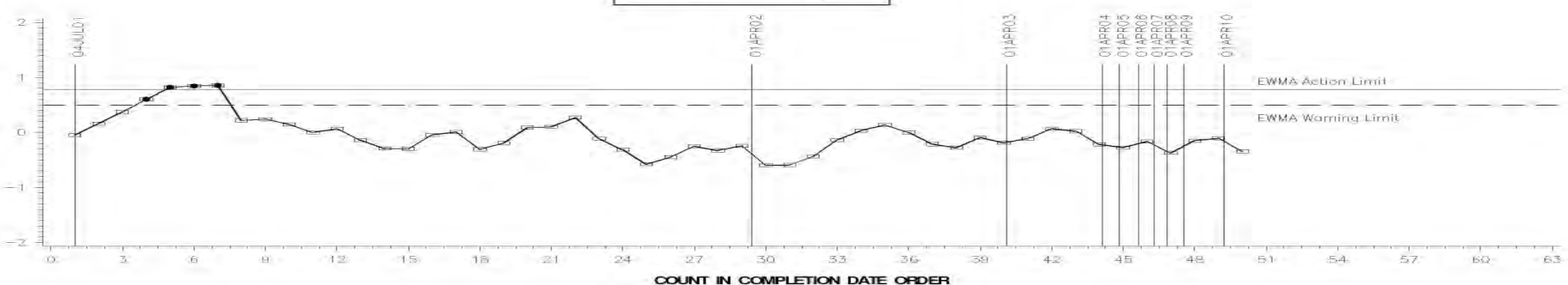
12OCT11:13:32

FINAL BOTOC

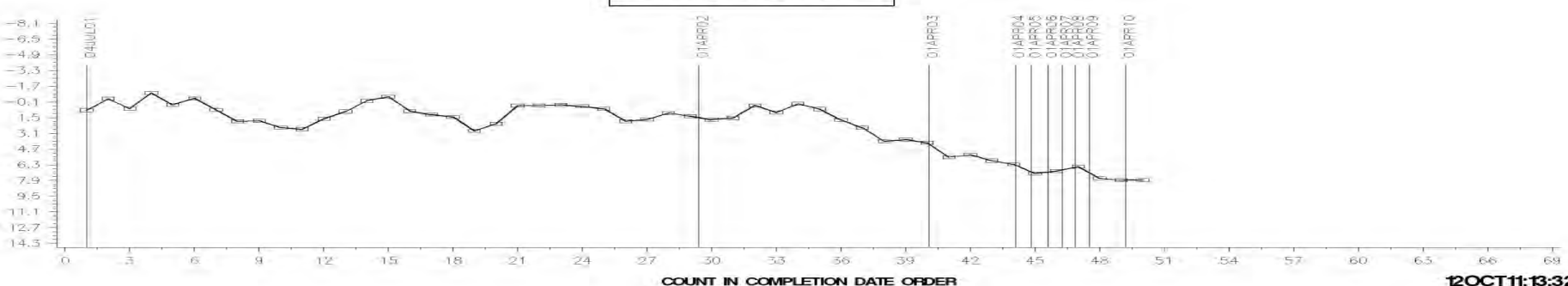
LTMS Severity Analysis



LTMS Precision Analysis



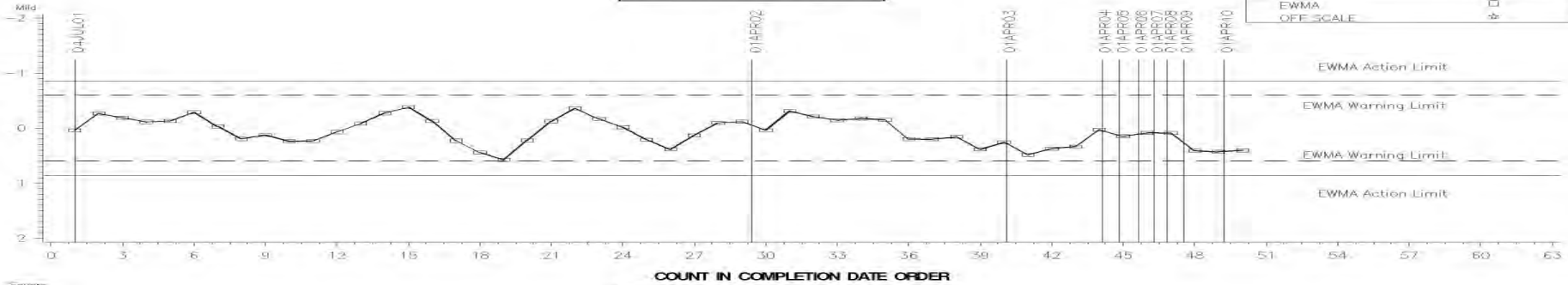
CUSUM Severity Analysis



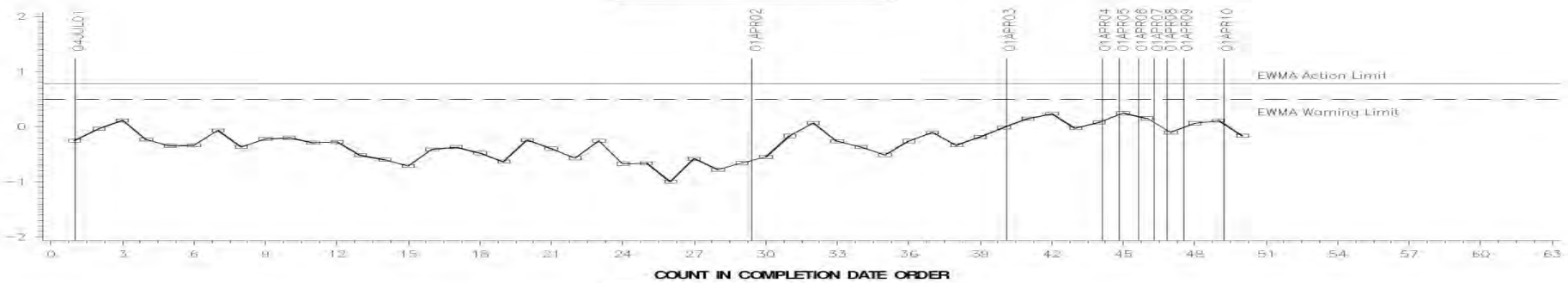
12OCT11:13:32

FINAL EOTOC (g/h)

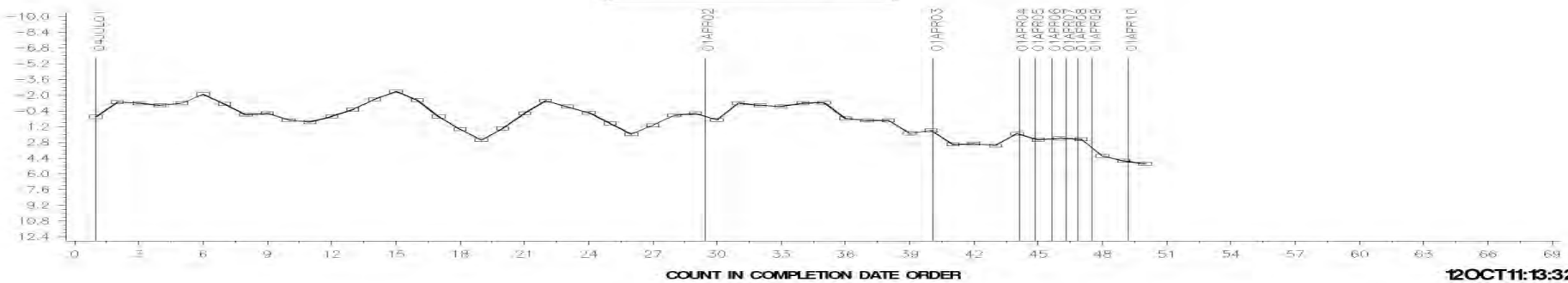
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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Appendix 1.f

C13 Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

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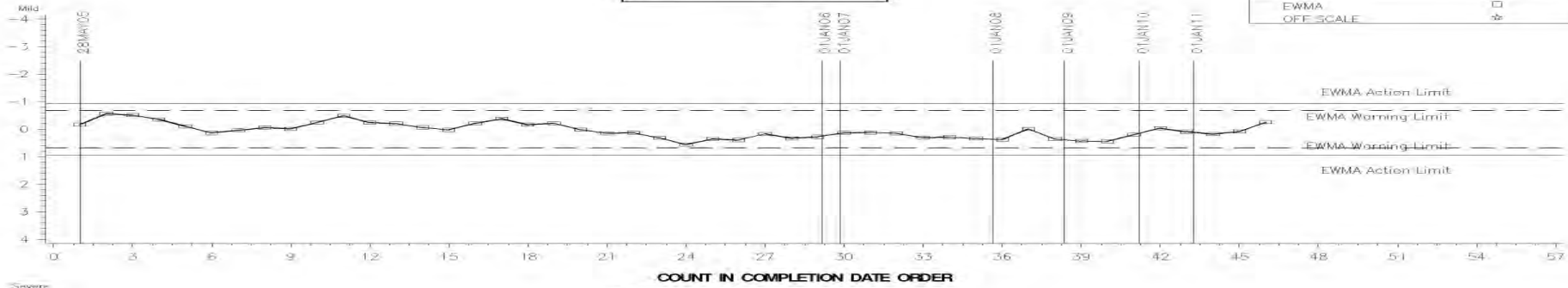


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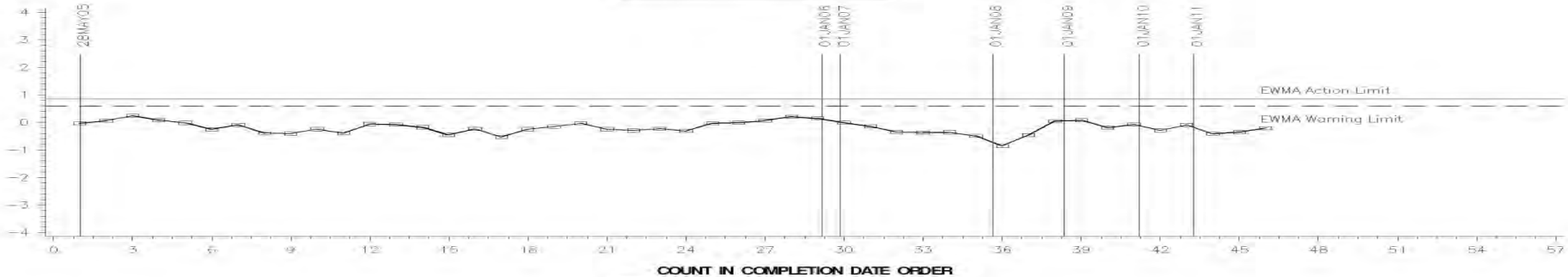
C13 INDUSTRY OPERATIONALLY VALID DATA

TOP GROOVE CARBON AVG — FINAL RESULT

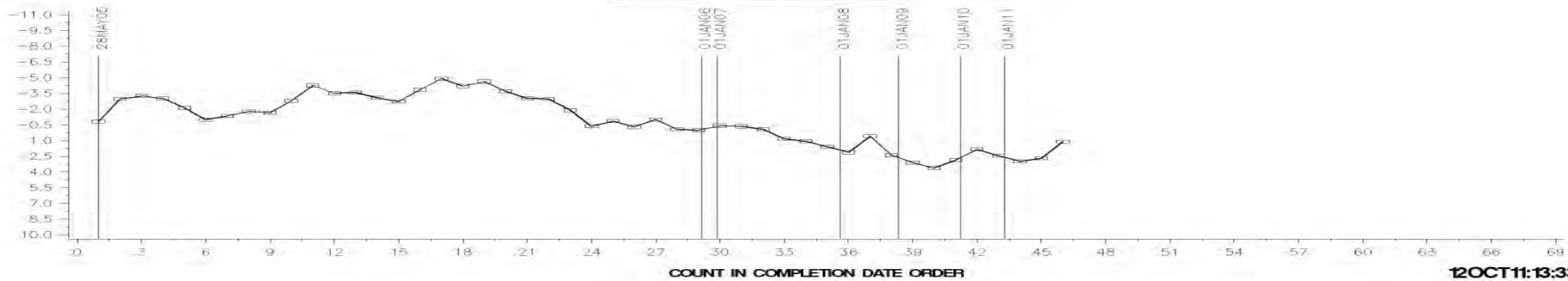
LTMS Severity Analysis



LTMS Precision Analysis



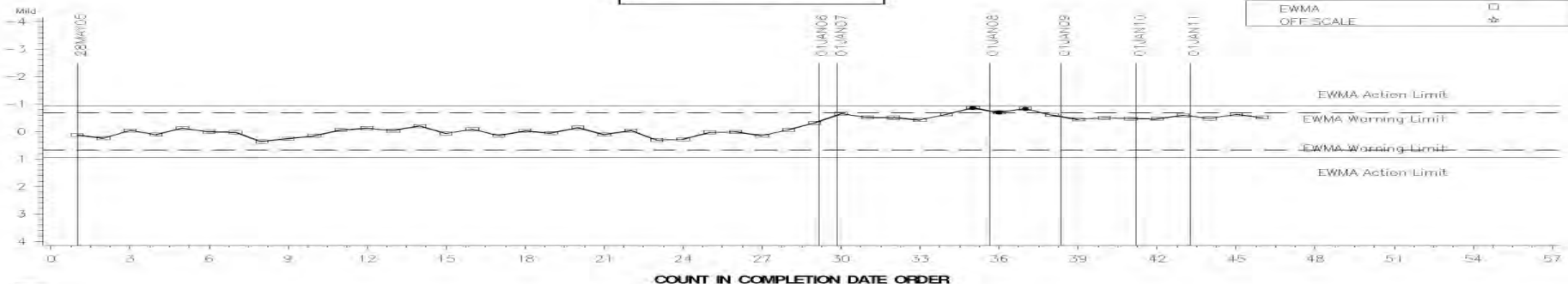
CUSUM Severity Analysis



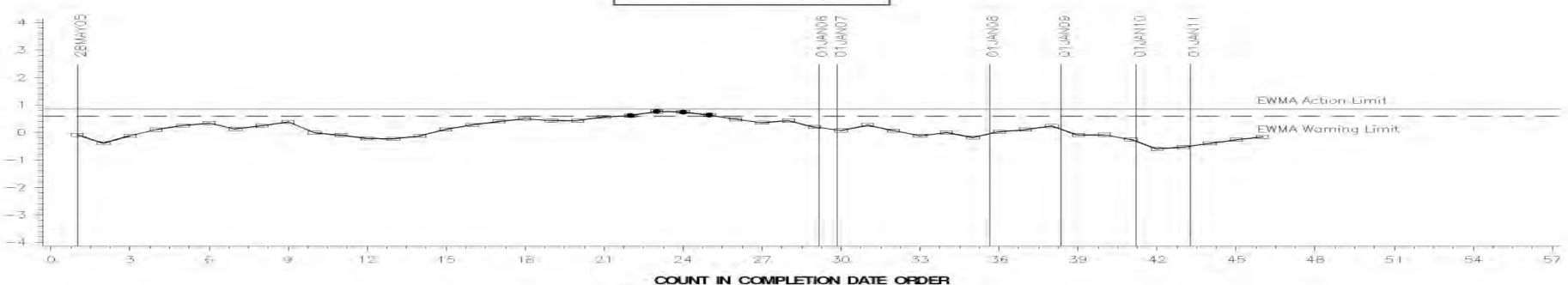
12OCT11:13:33

TOP LAND CARBON AVG. — FINAL RESULT

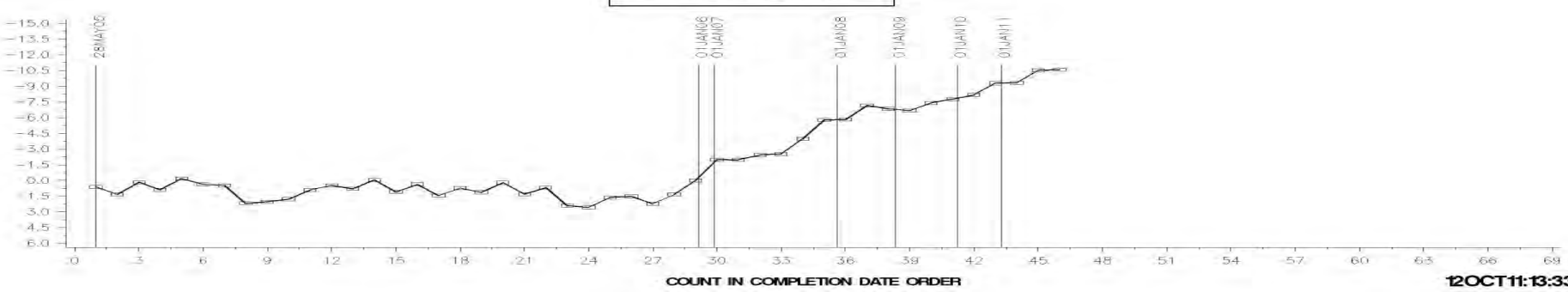
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



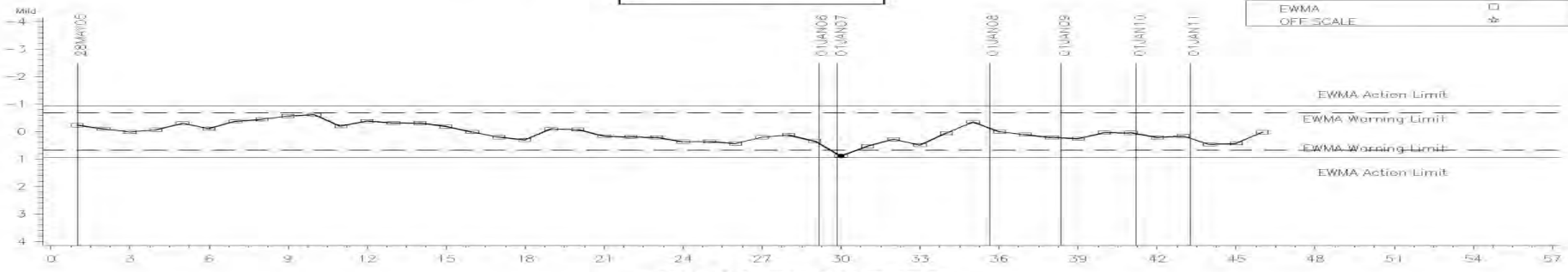
12OCT11:13:33

C13 INDUSTRY OPERATIONALLY VALID DATA

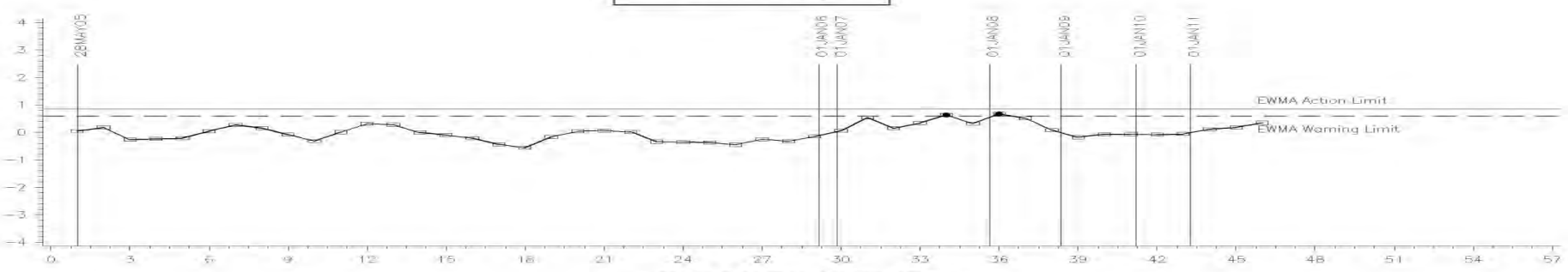


2ND RING TOP CARBON AVG. — FINAL RESULT

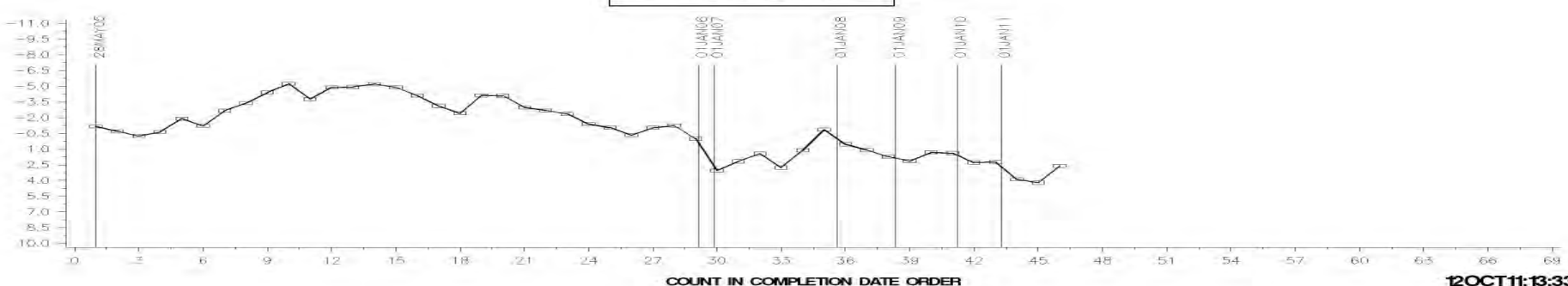
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

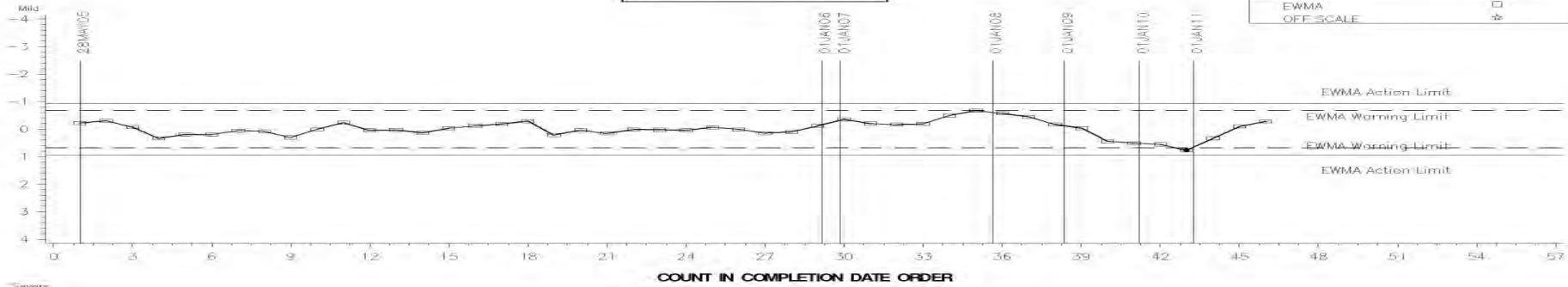


12OCT11:13:33

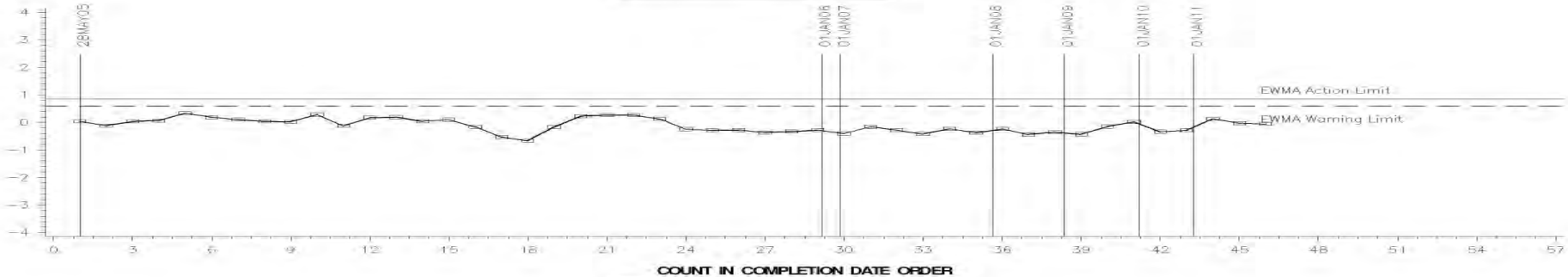


OIL CONS. DELTA — FINAL RESULT

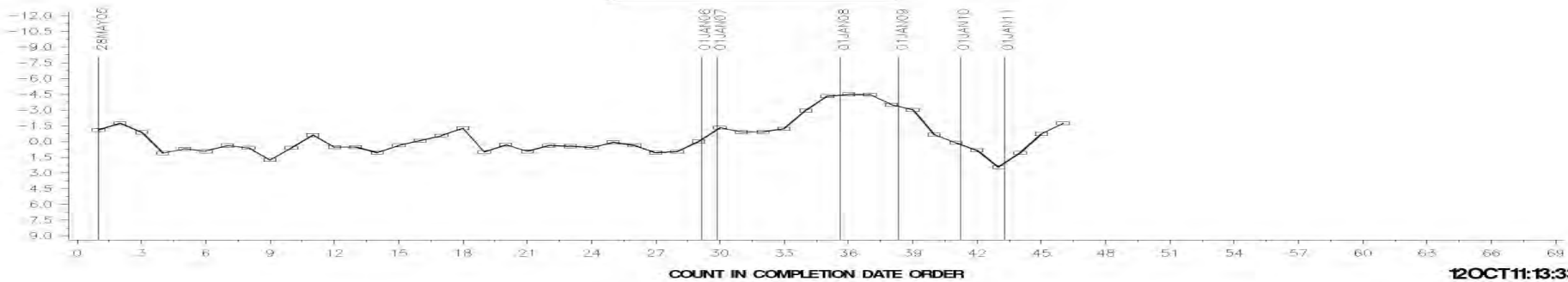
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



12OCT11:13:33

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Appendix 1.g

ISB Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

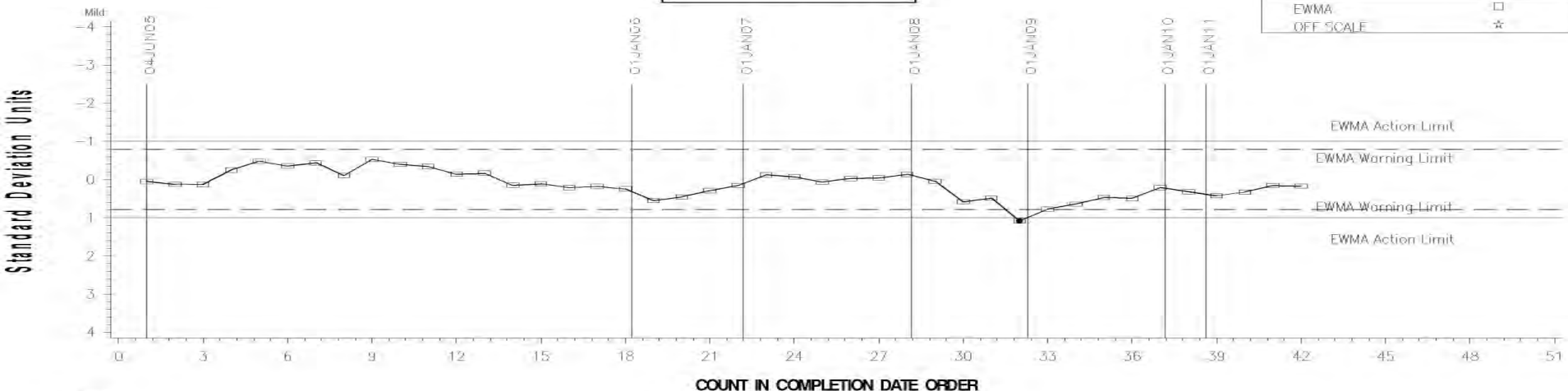
<http://astmtmc.cmu.edu>



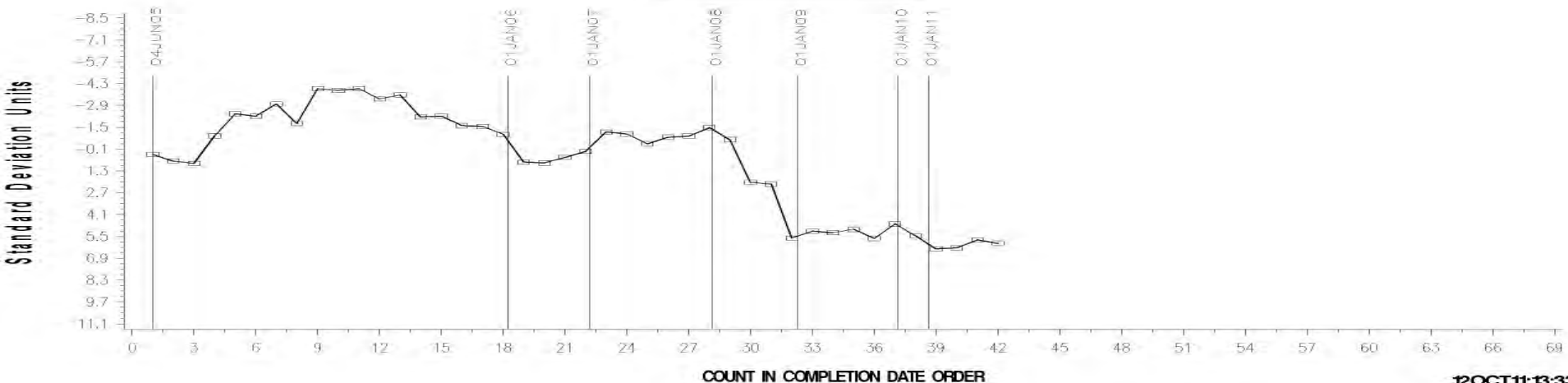
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AVERAGE CAMSHAFT WEAR

LTMS Severity Analysis



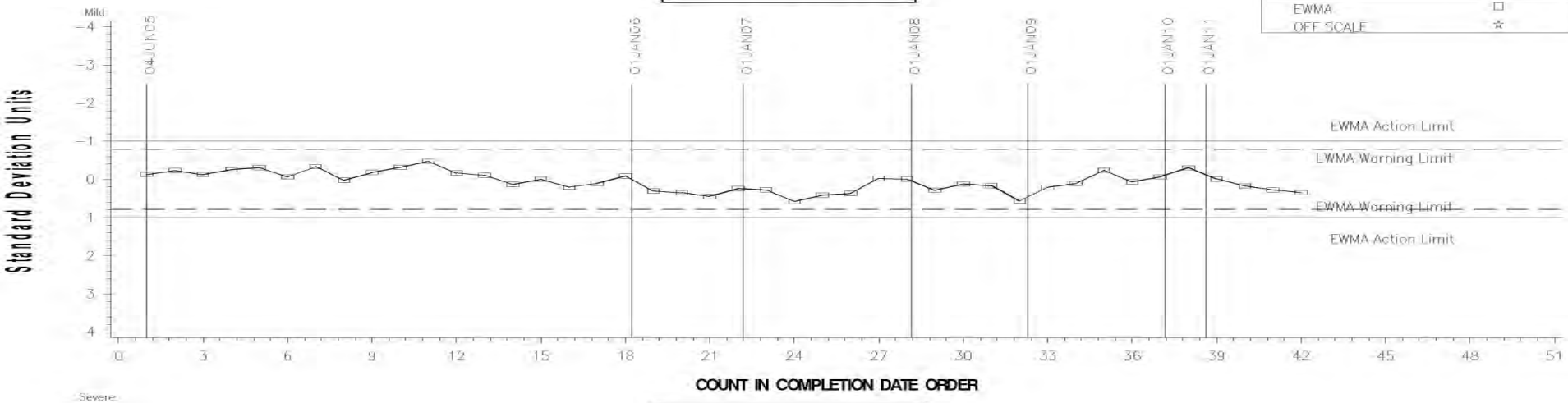
CUSUM Severity Analysis



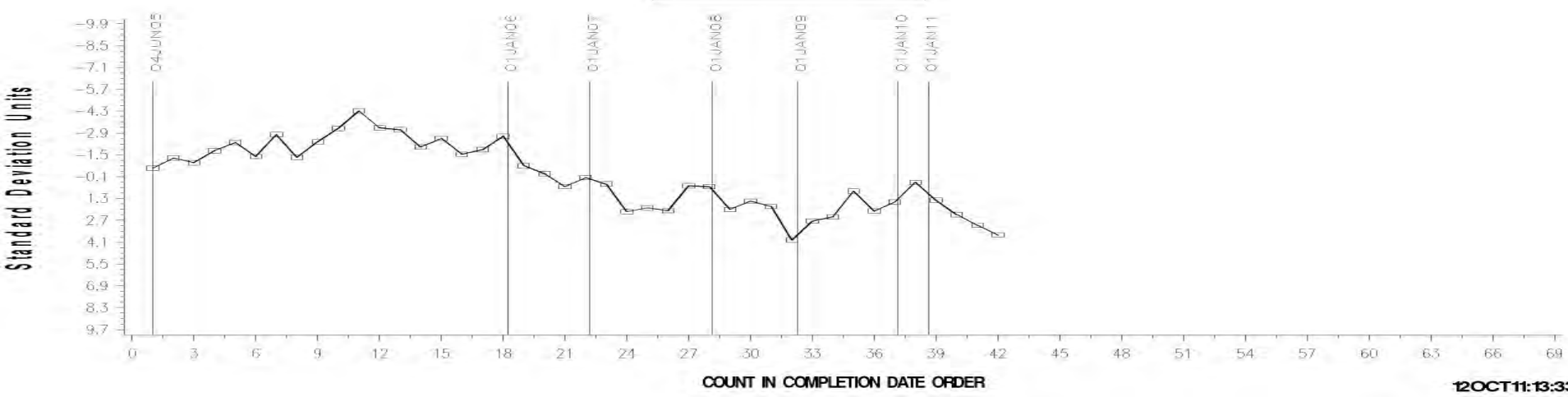
12OCT11:13:33

AVERAGE TAPPET WEIGHT LOSS

LTMS Severity Analysis



CUSUM Severity Analysis



12OCT11:13:33

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Appendix 1.h

ISM Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

<http://astmtmc.cmu.edu>



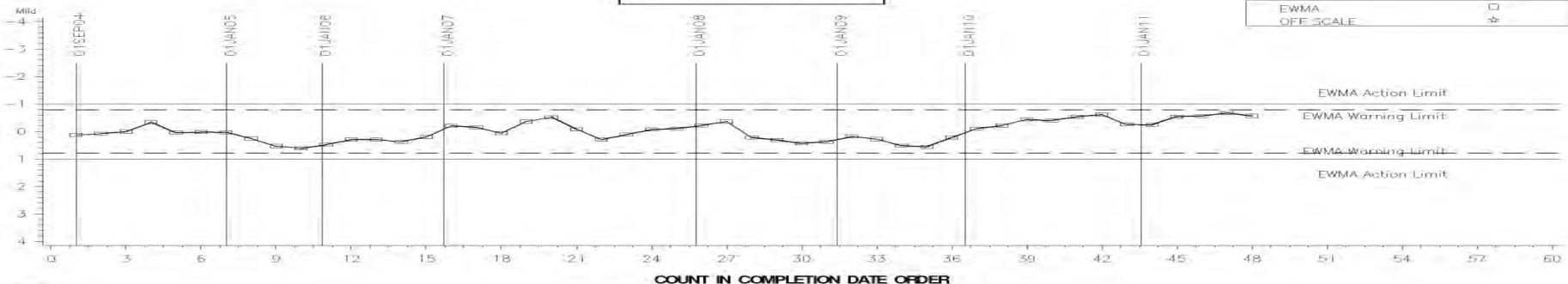
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ISM INDUSTRY OPERATIONAL VALID DATA

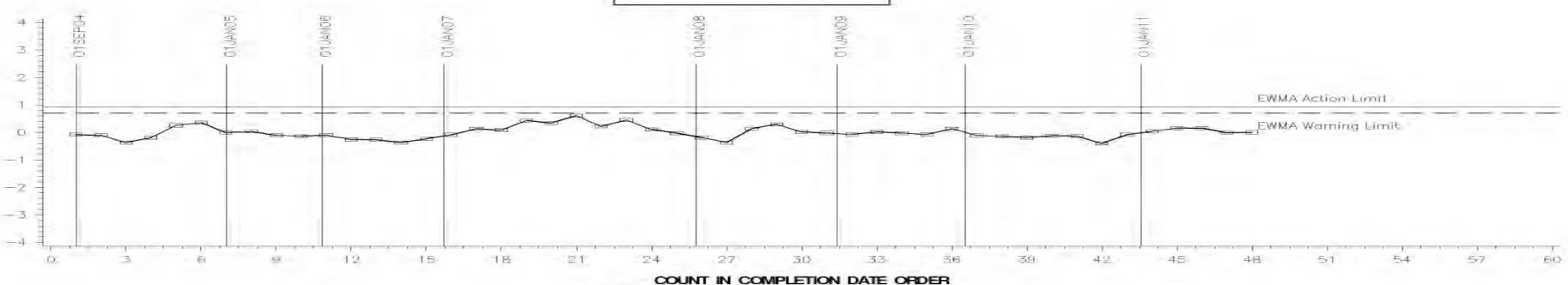


CROSSHEAD WEIGHT LOSS ADJUSTED TO 3.9 % SOOT

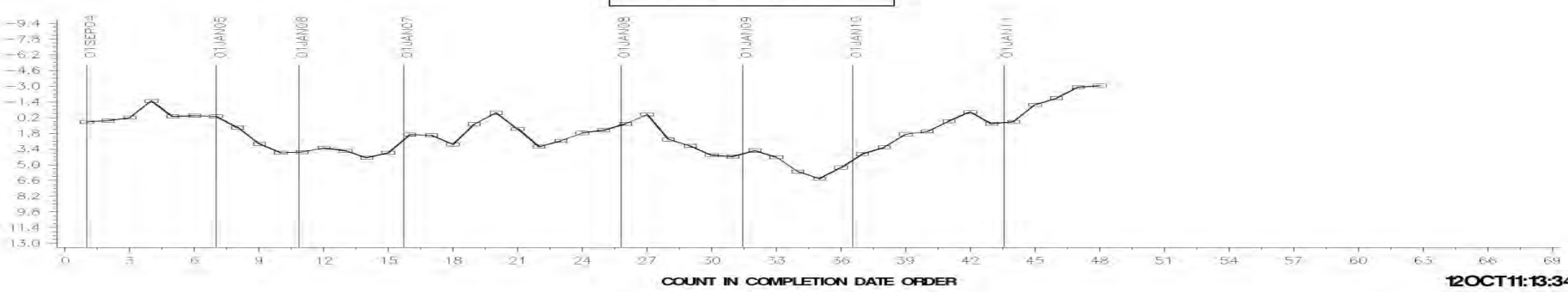
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

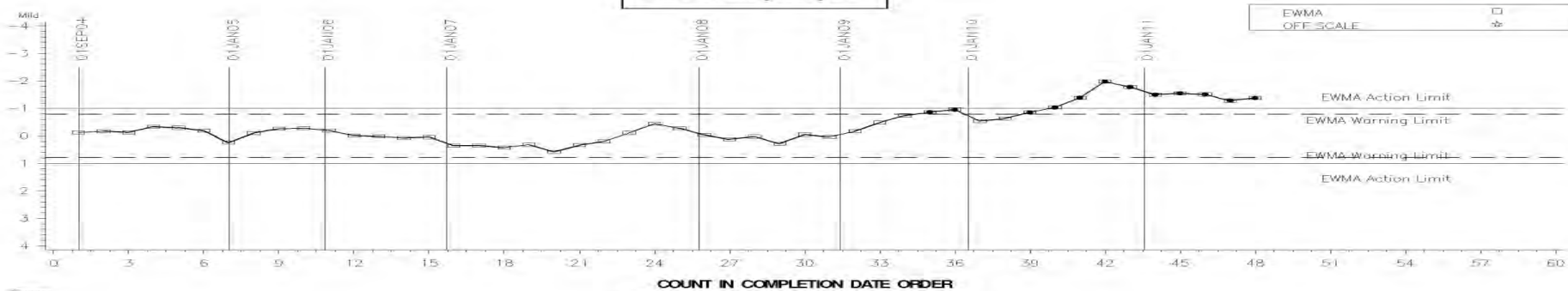


12OCT11:13:34



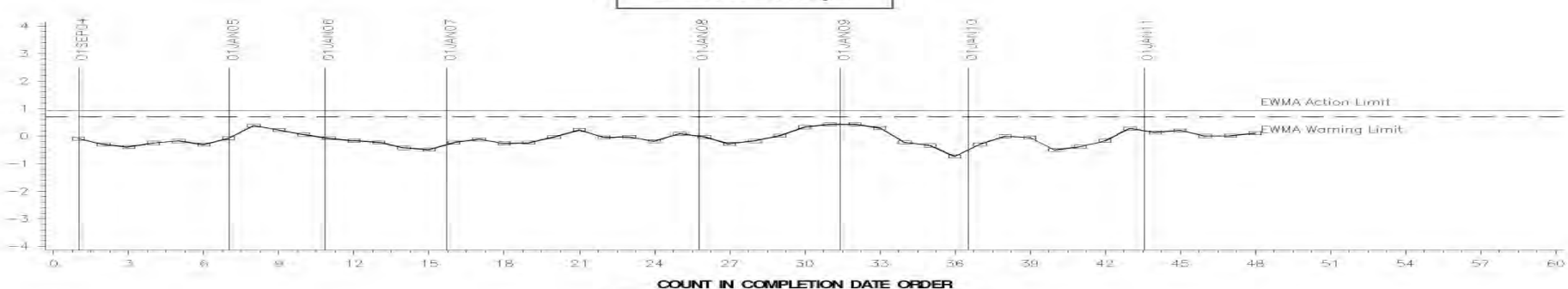
FILTER PLUGGING DELTA P

LTMS Severity Analysis



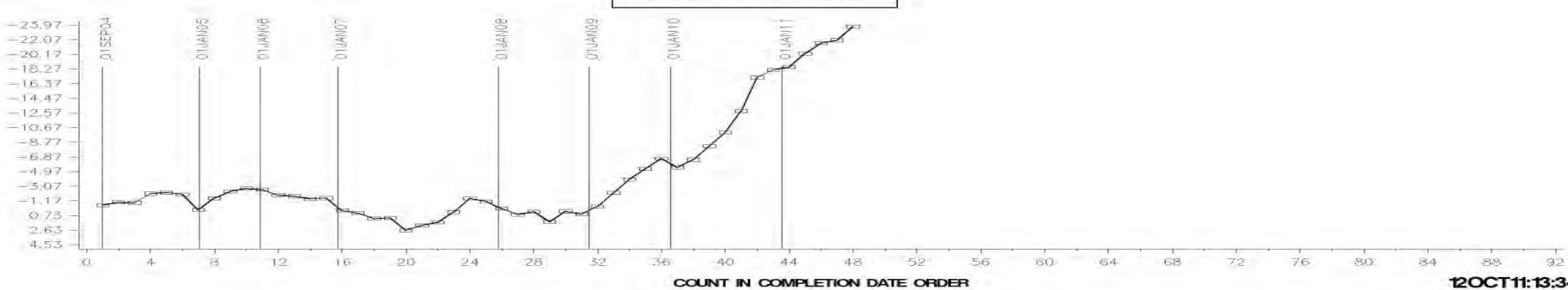
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis

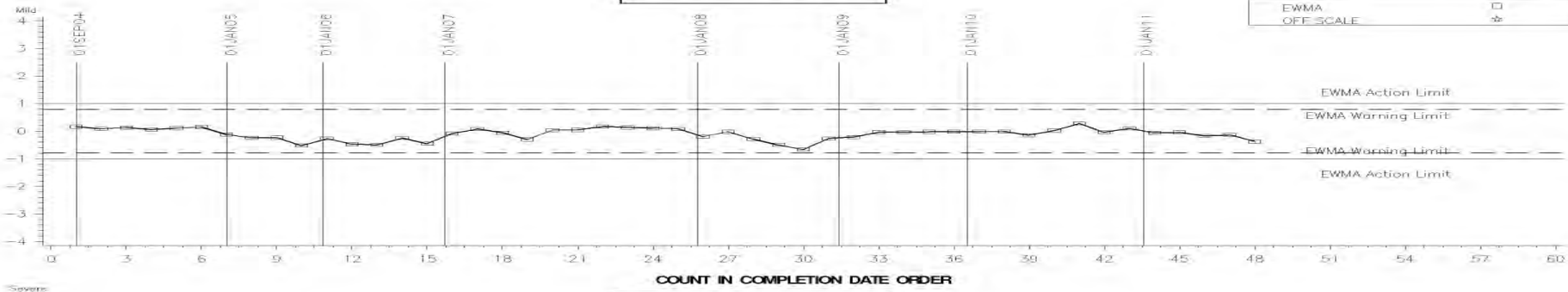


COUNT IN COMPLETION DATE ORDER

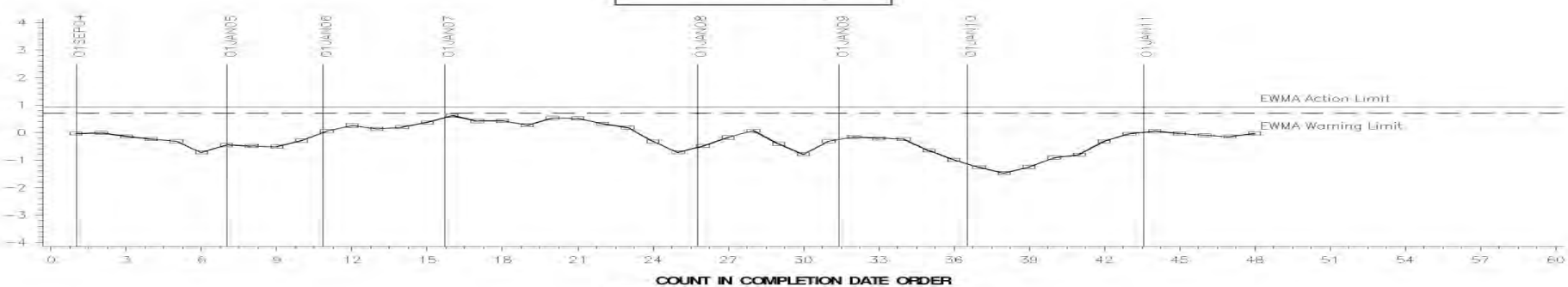
12OCT11:13:34

AVERAGE SLUDGE RATING

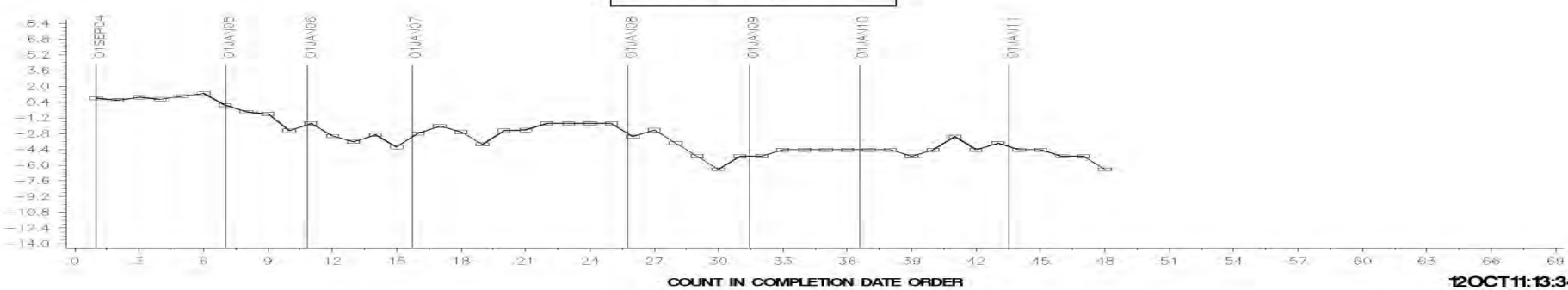
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

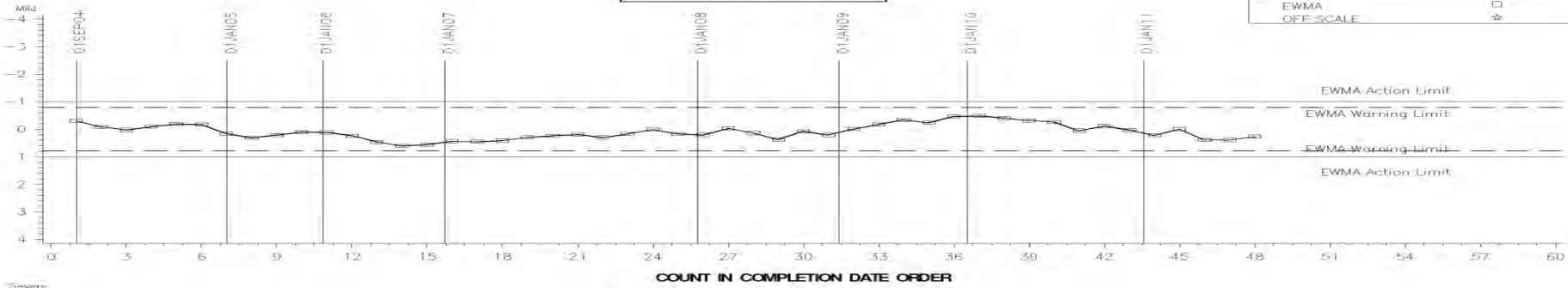


12OCT11:13:34

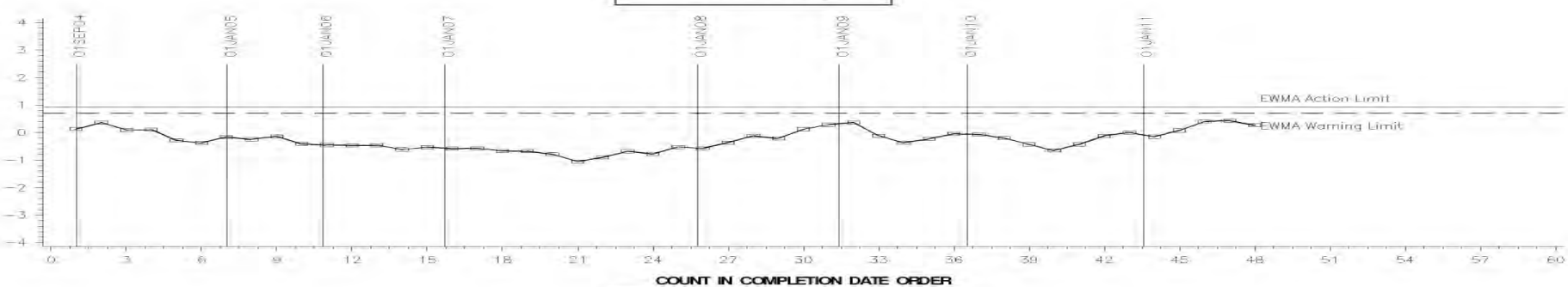
ISM INDUSTRY OPERATIONALLY VALID DATA

INJECTOR SCREW WEIGHT LOSS ADJUSTED TO 3.9% SOOT

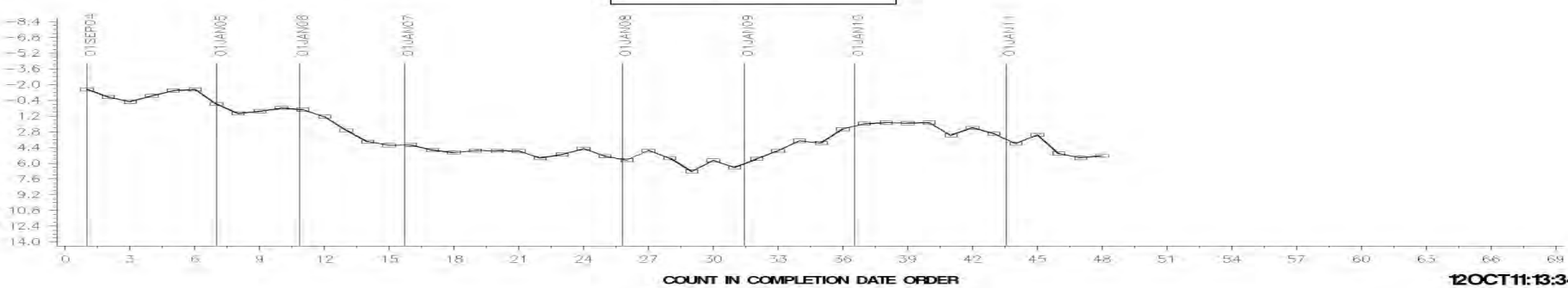
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



12OCT11:13:34

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Appendix 1.i

EOAT Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

<http://astmtmc.cmu.edu>

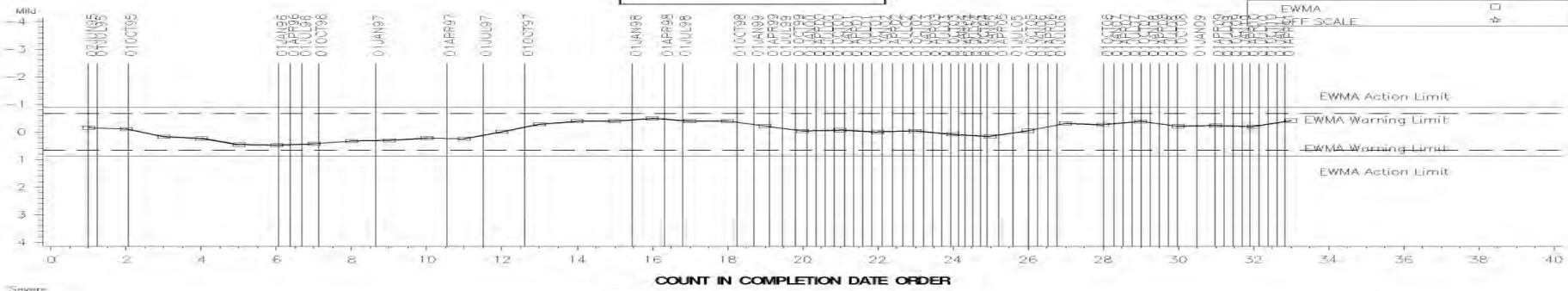


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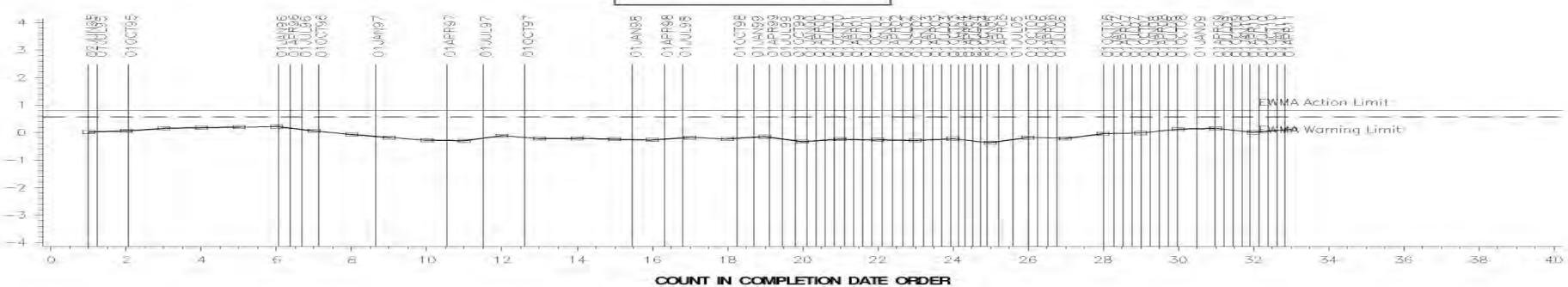
EOAT INDUSTRY OPERATIONALLY VALID DATA

ENGINE OIL AERATION

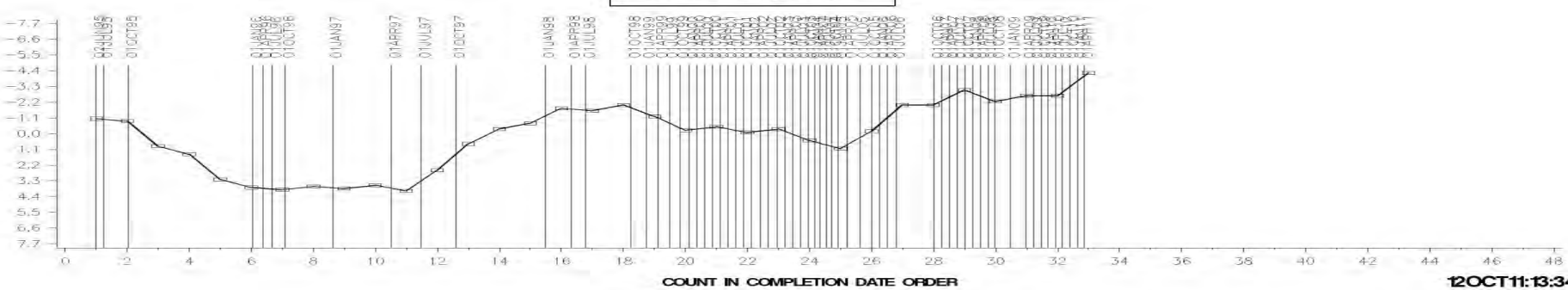
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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Appendix 1.j

RFWT Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

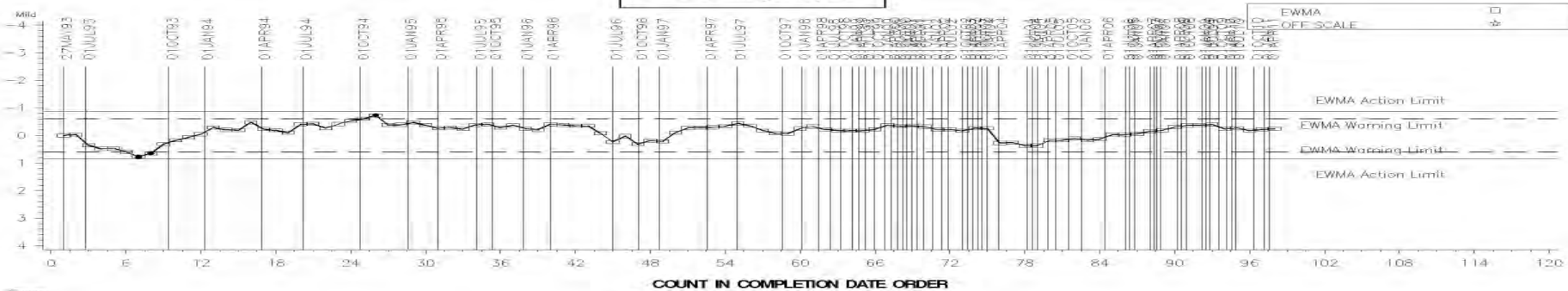
<http://astmtmc.cmu.edu>



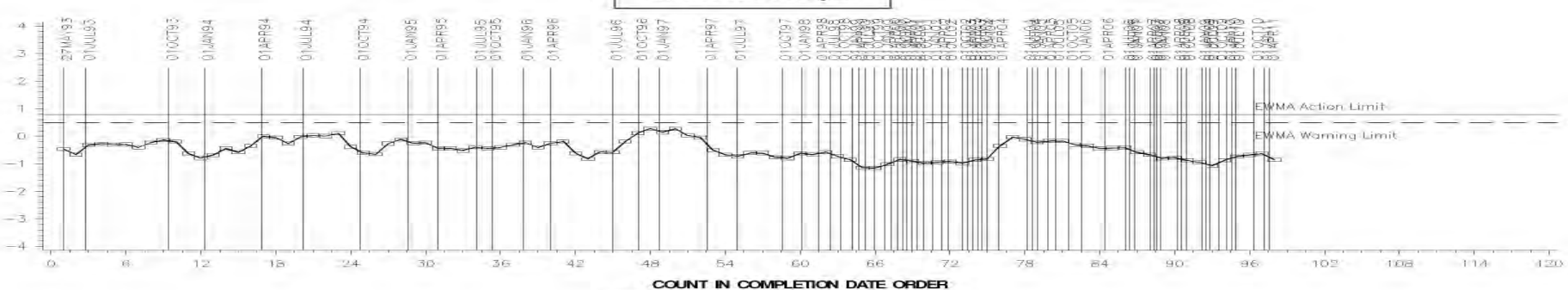
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Average Follower Wear

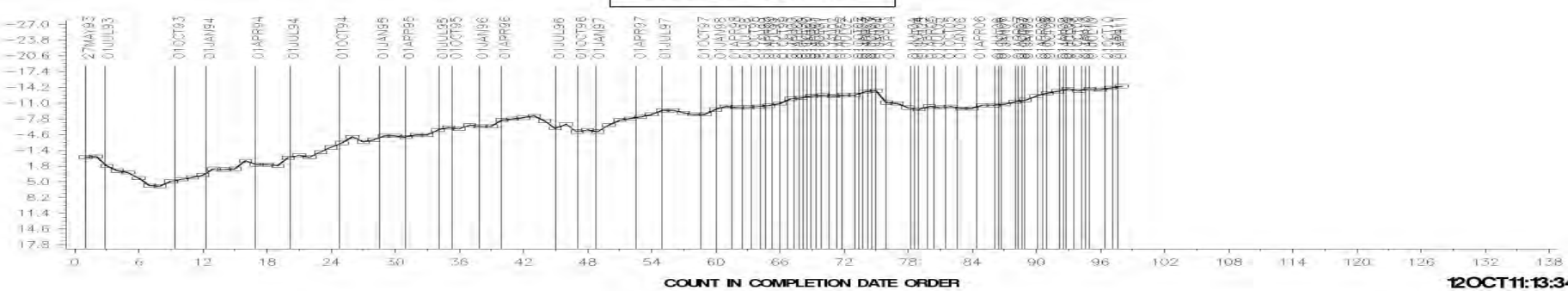
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



12OCT11:13:34

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Appendix 1.k

T-8/T-8E Control Charts

» Severity, Precision, and CuSum

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VISCOSITY INCREASE AT 3.8% SOOT

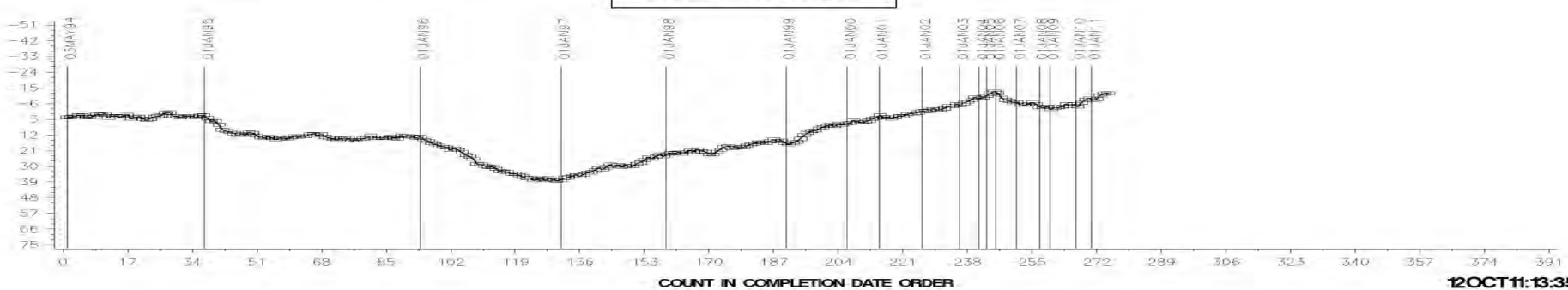
LTMS Severity Analysis



LTMS Precision Analysis



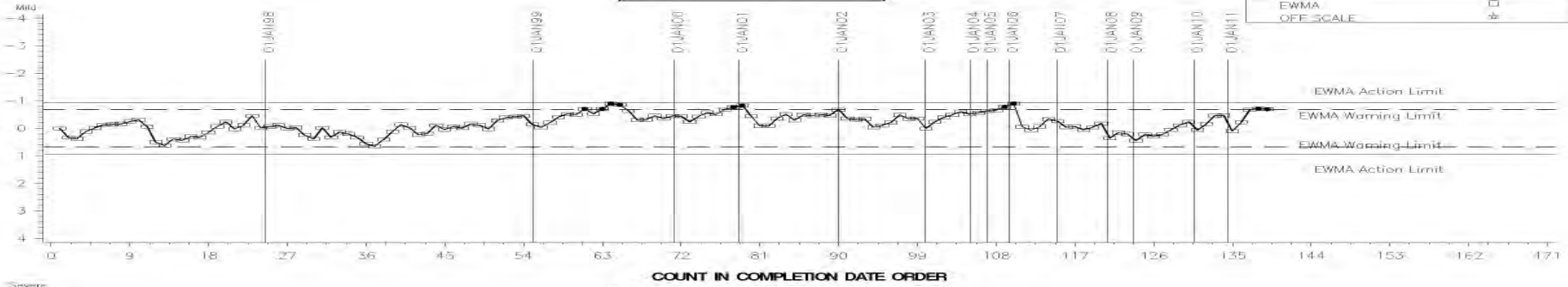
CUSUM Severity Analysis



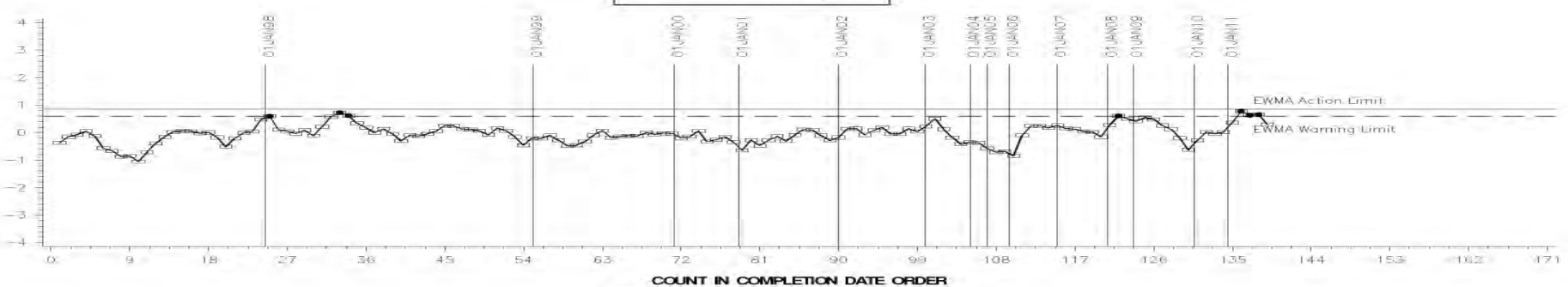
12OCT11:13:35

RELATIVE VISCOSITY AT 4.8% (50% LOSS)

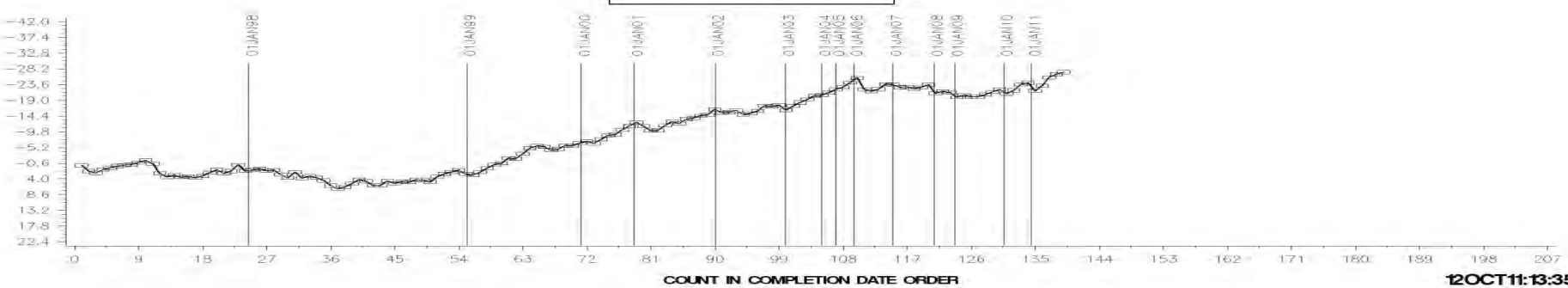
LTMS Severity Analysis



LTMS Precision Analysis



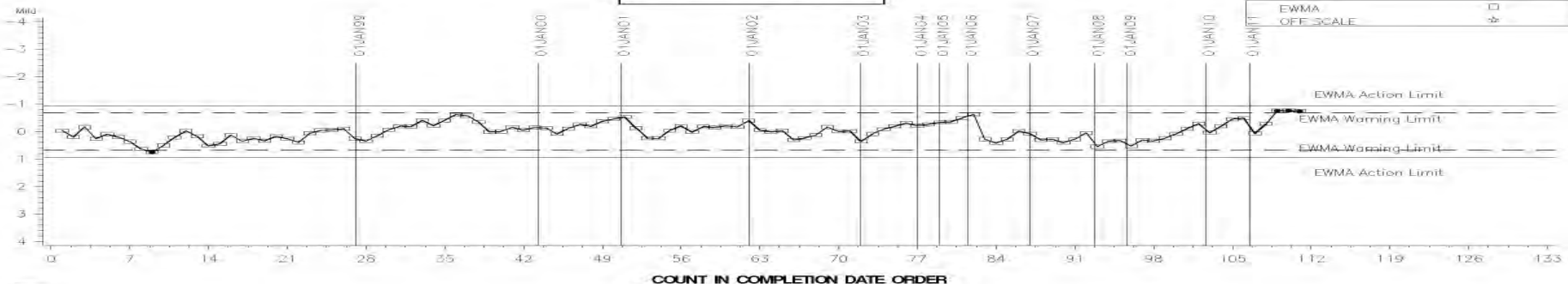
CUSUM Severity Analysis



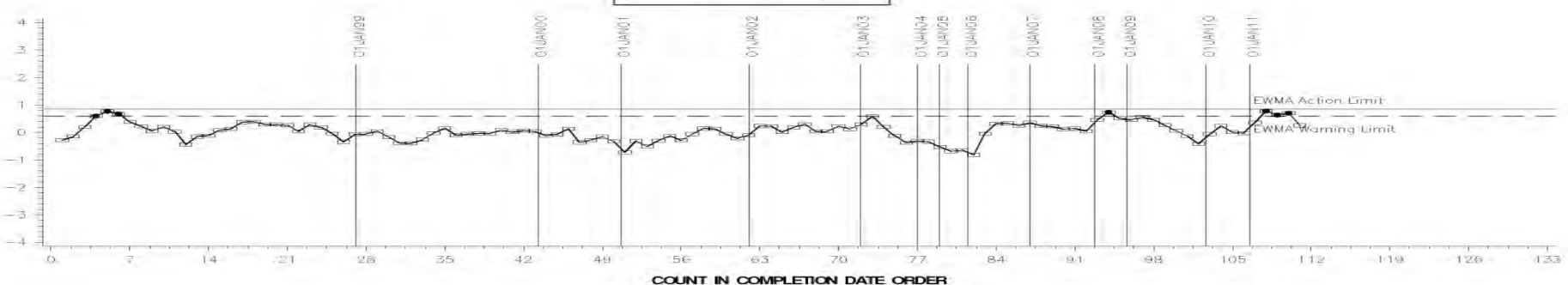
12OCT11:13:35

RELATIVE VISCOSITY AT 4.8% (100% LOSS)

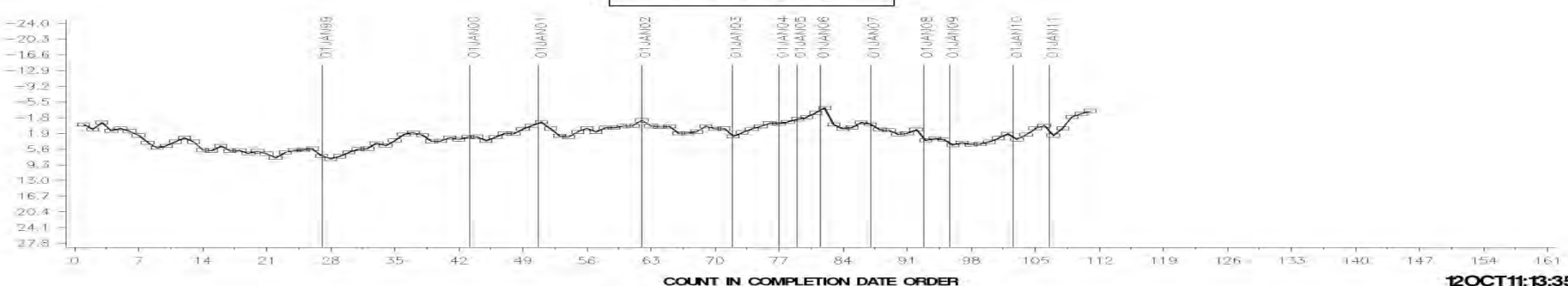
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



12OCT11:13:35

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Appendix 1.1

T-10A Control Charts

» Severity, Precision, and CuSum

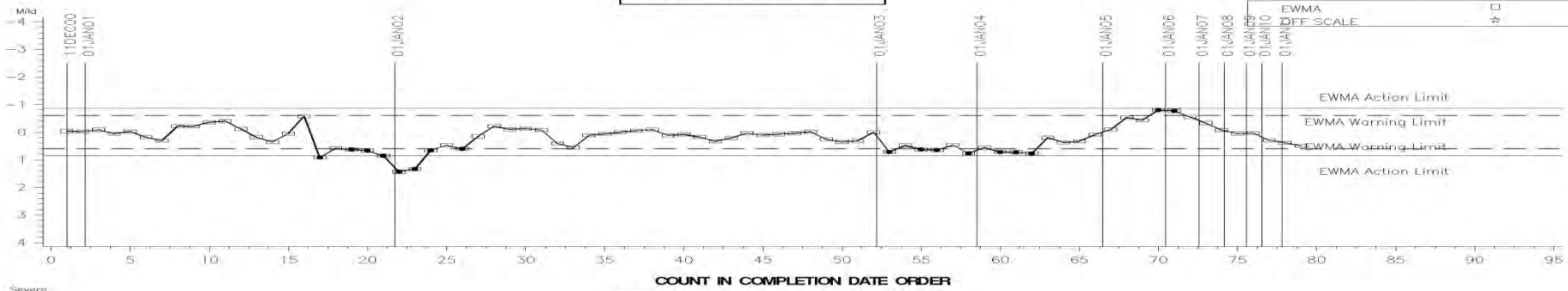
Test Monitoring Center

<http://astmtmc.cmu.edu>

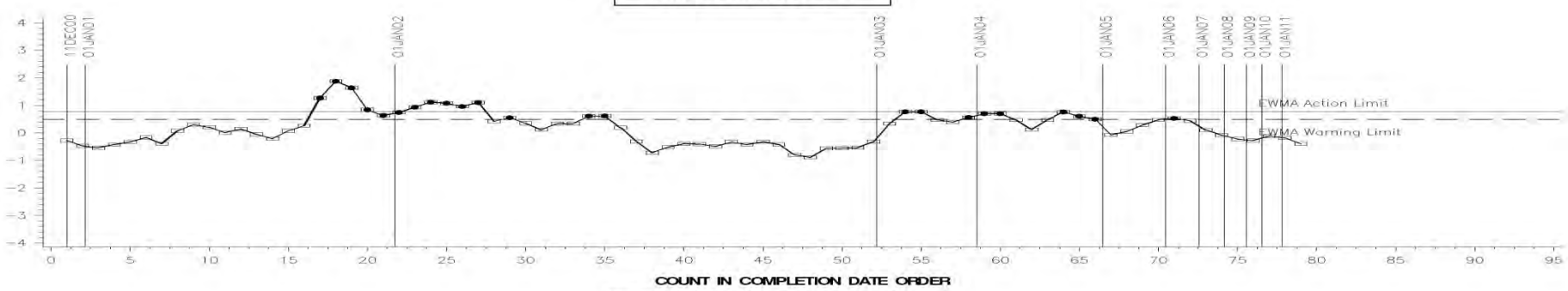


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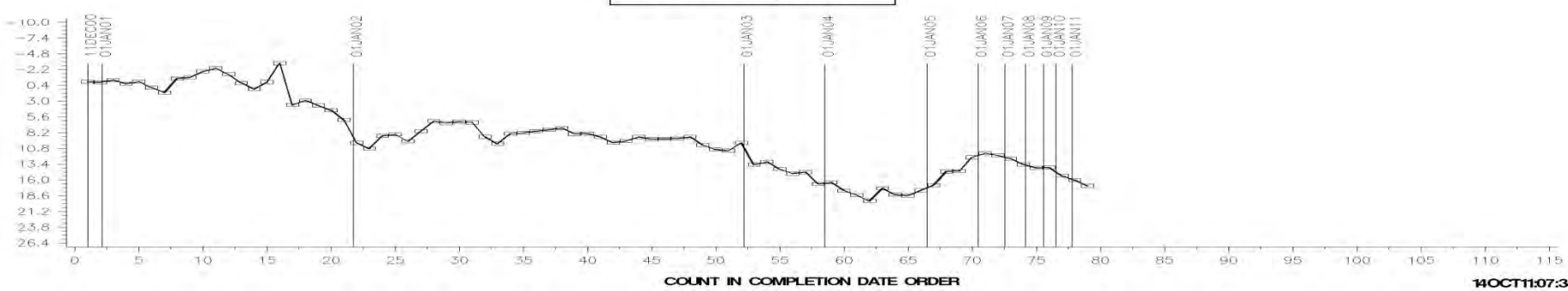
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



14OCT11:07:38

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Appendix 1.m

T-11 Control Charts

» Severity, Precision, and CuSum

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<http://astmtmc.cmu.edu>



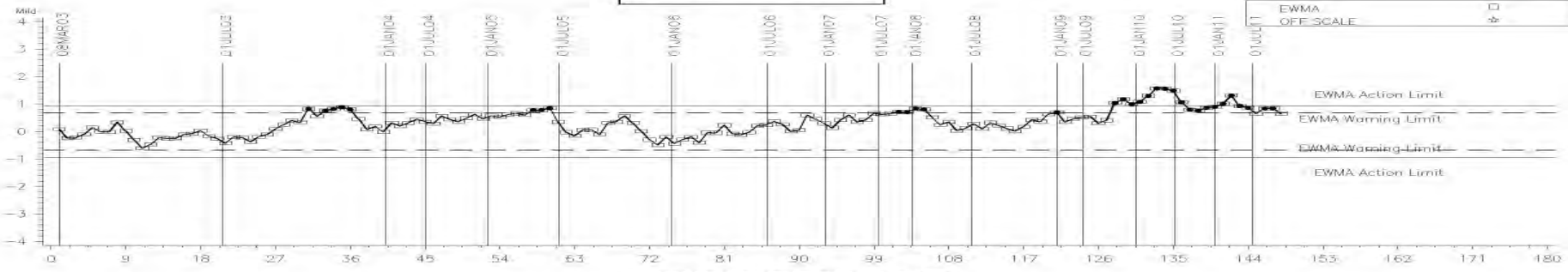
A Program of ASTM International

T-11 INDUSTRY OPERATIONAL VALID DATA



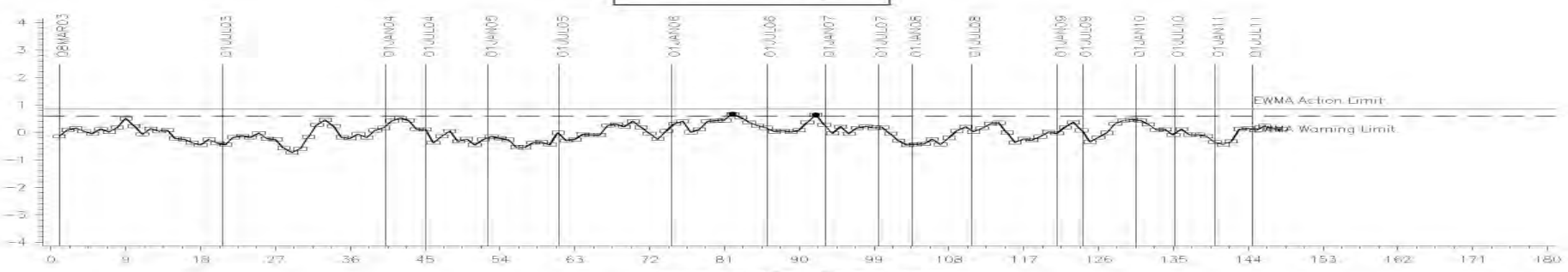
SOOT AT 12 cSt

LTMS Severity Analysis



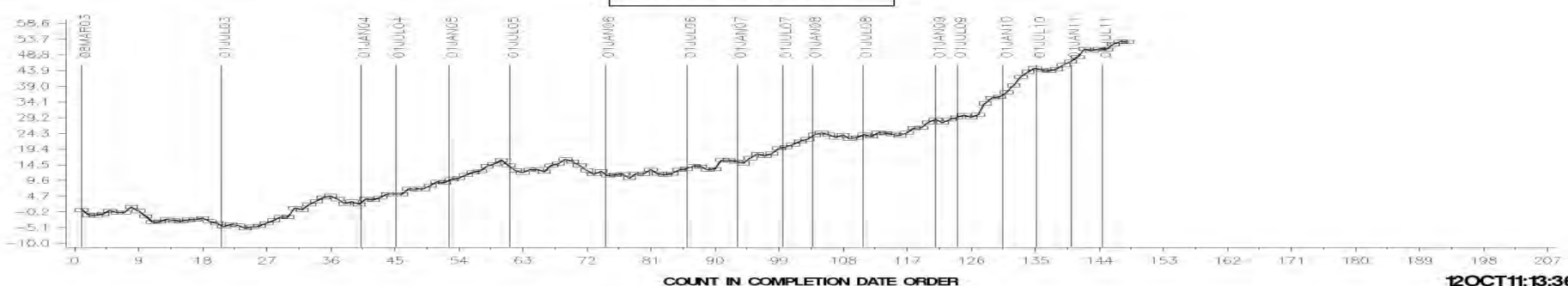
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis



12OCT11:13:36

Test Monitoring Center

<http://astmtmc.cmu.edu>

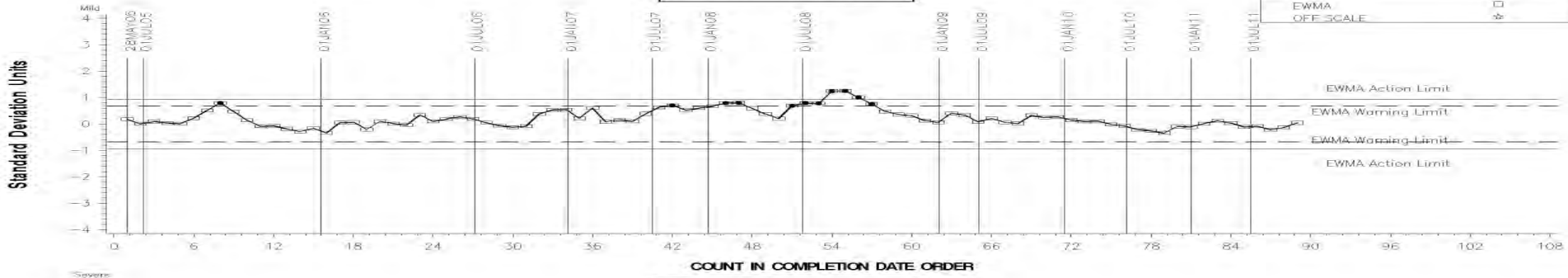


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T-11 INDUSTRY OPERATIONAL VALID DATA

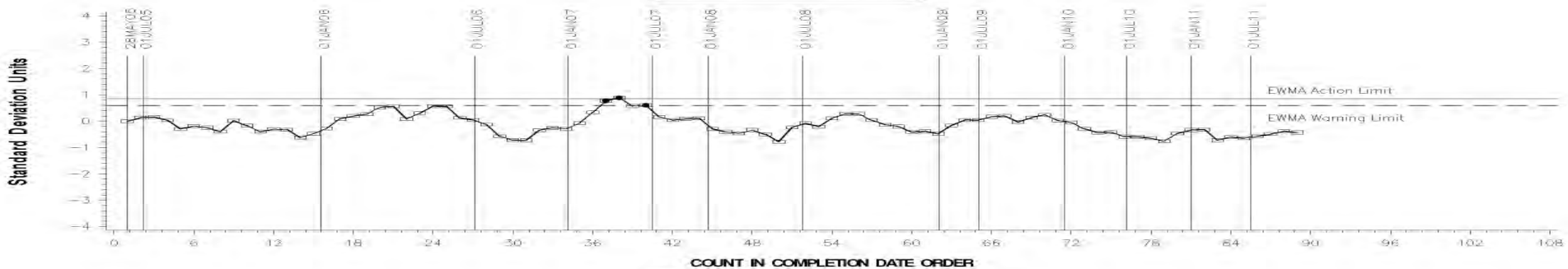
SOOT @ 4 cSt - FINAL RESULT

LTMS Severity Analysis



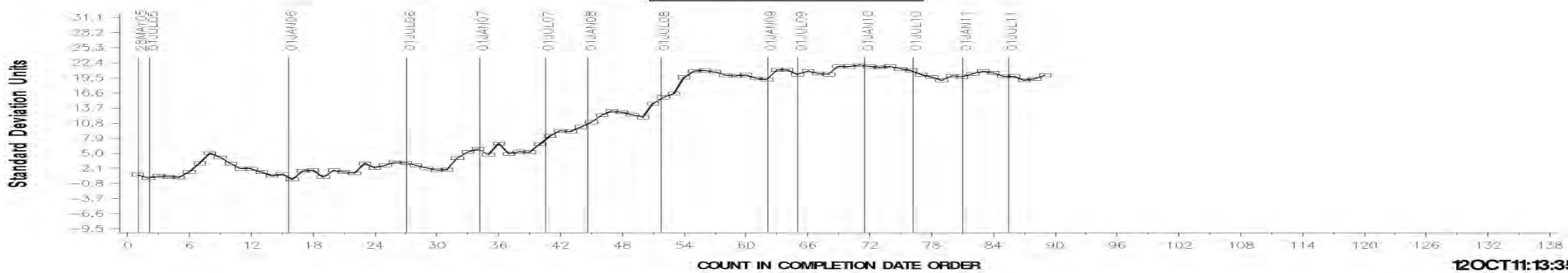
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis

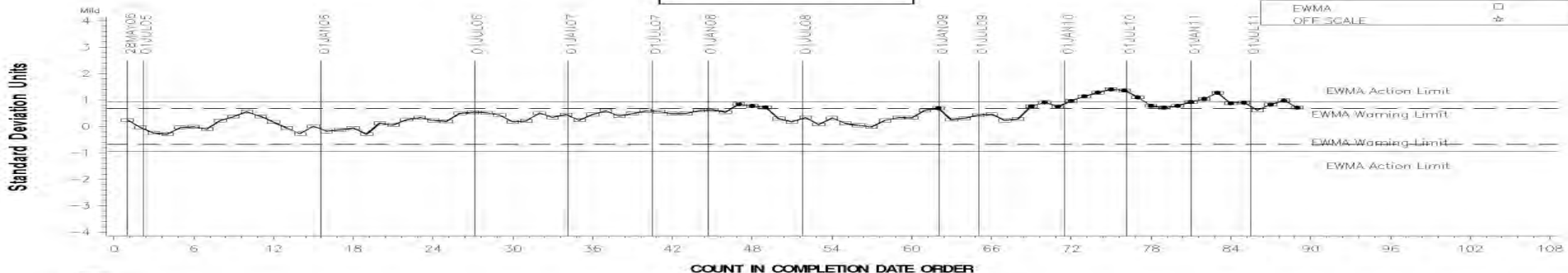


COUNT IN COMPLETION DATE ORDER

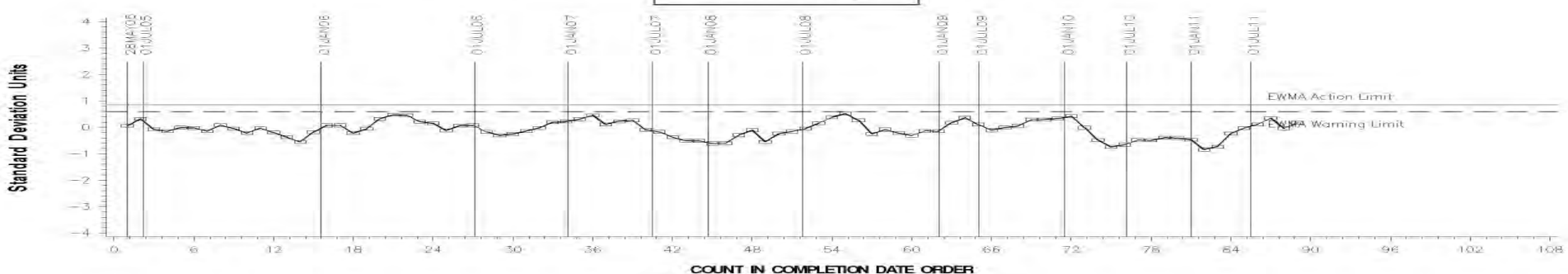
12OCT11:13:35

SOOT @ 15 cSt - FINAL RESULT

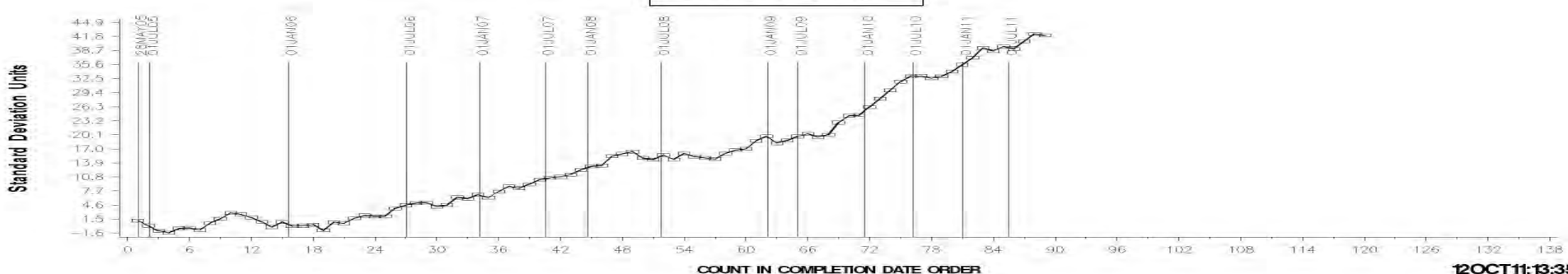
LTMS Severity Analysis



LTMS Precision Analysis



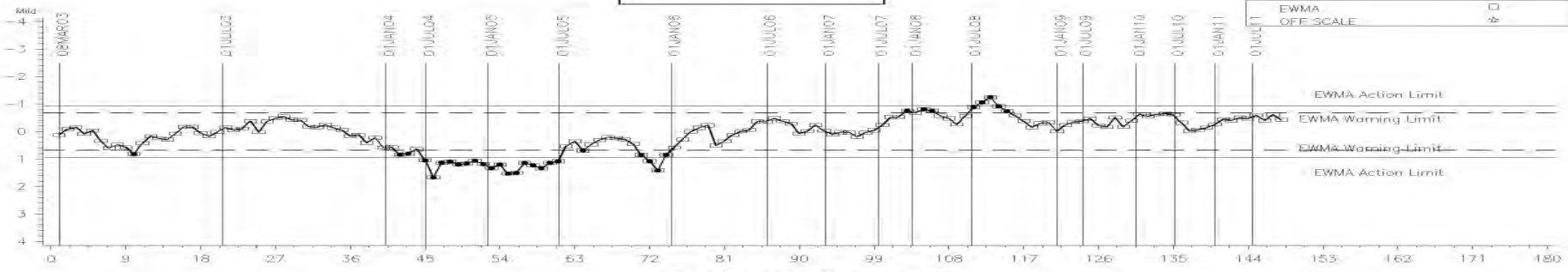
CUSUM Severity Analysis



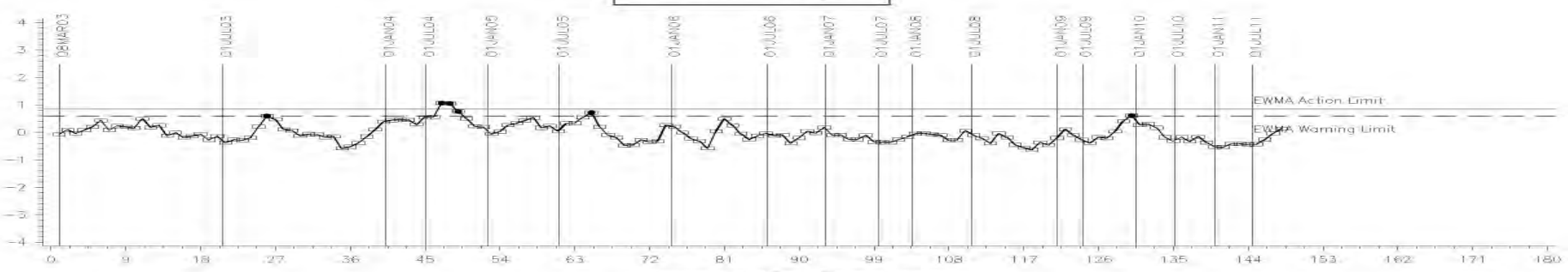
12OCT11:13:35

MRV VISCOSITY

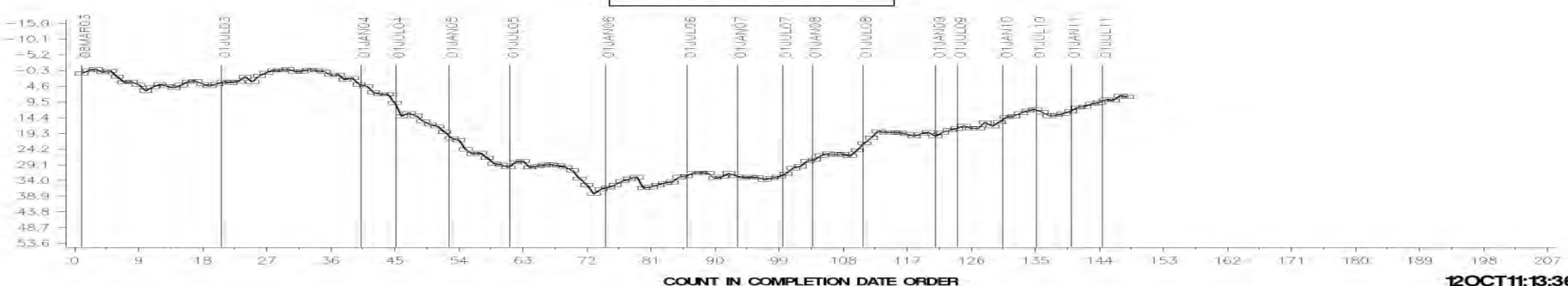
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



12OCT11:13:36

[Return](#)

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<http://astmtmc.cmu.edu>

Appendix 1.n

T-12 Control Charts

» Severity, Precision, and CuSum

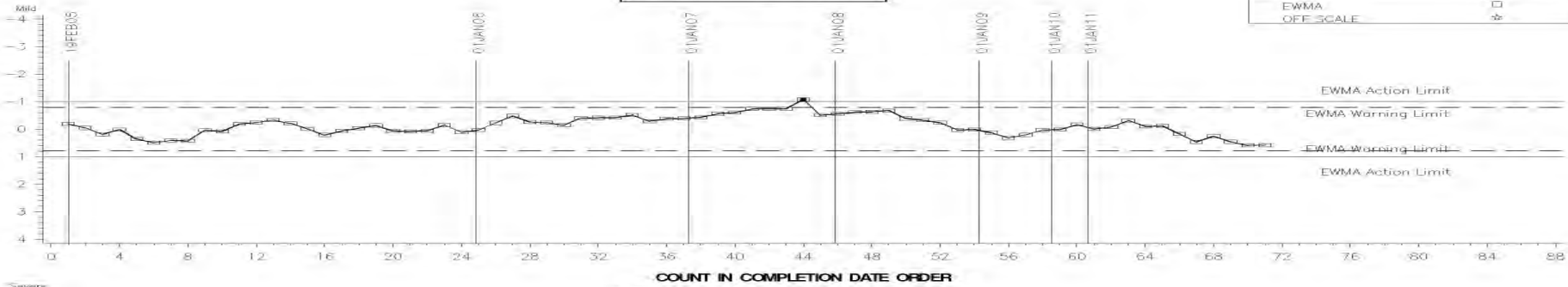
Test Monitoring Center

<http://astmtmc.cmu.edu>

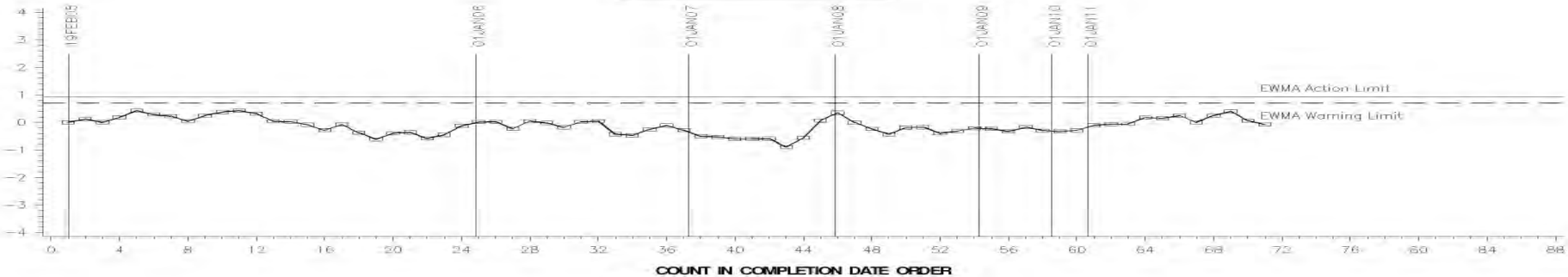


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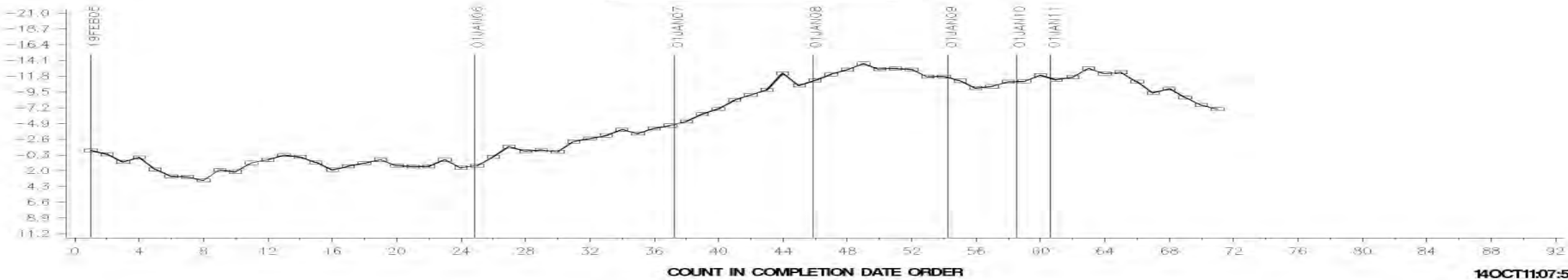
LTMS Severity Analysis



LTMS Precision Analysis

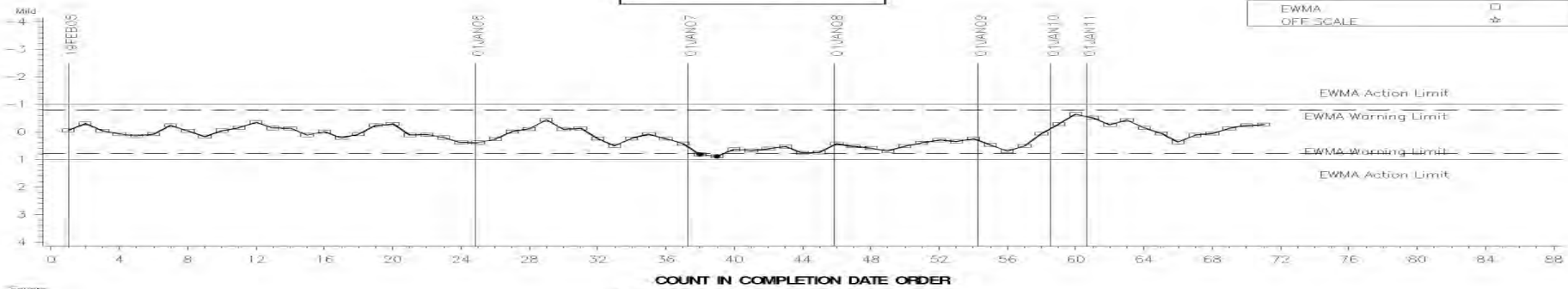


CUSUM Severity Analysis

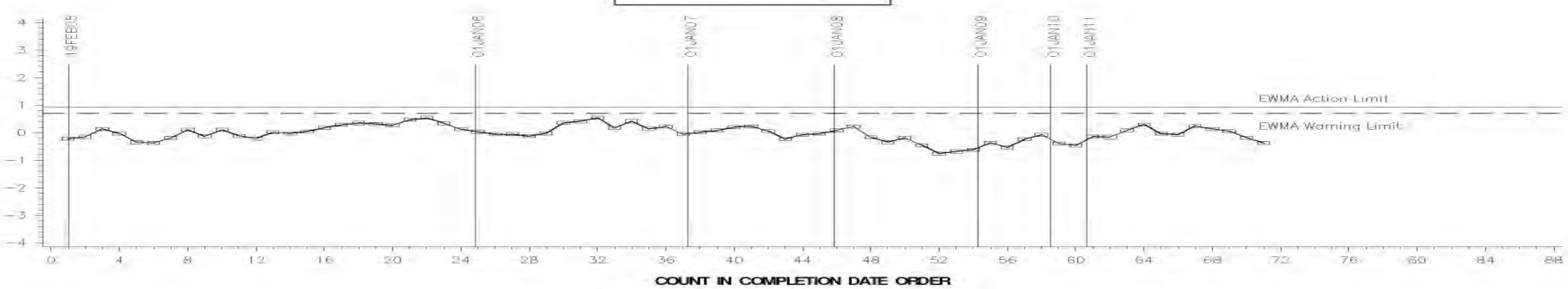


14OCT11:07:56

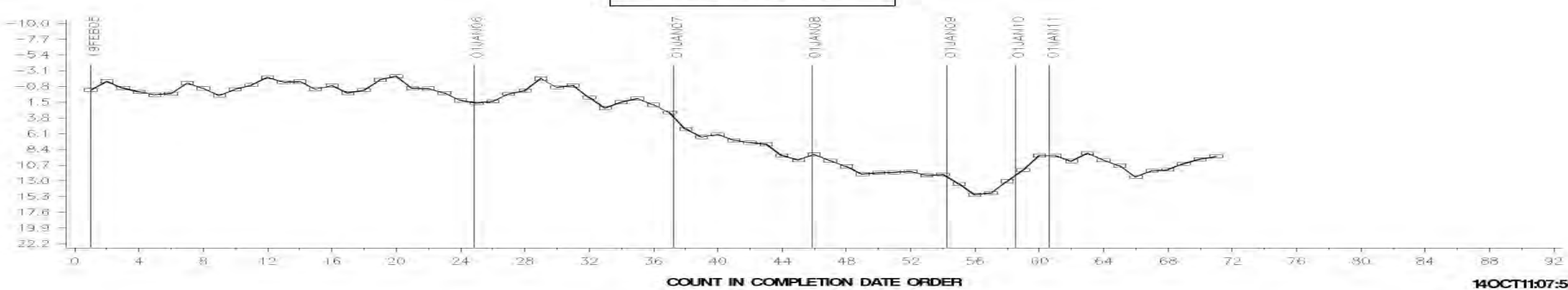
LTMS Severity Analysis



LTMS Precision Analysis



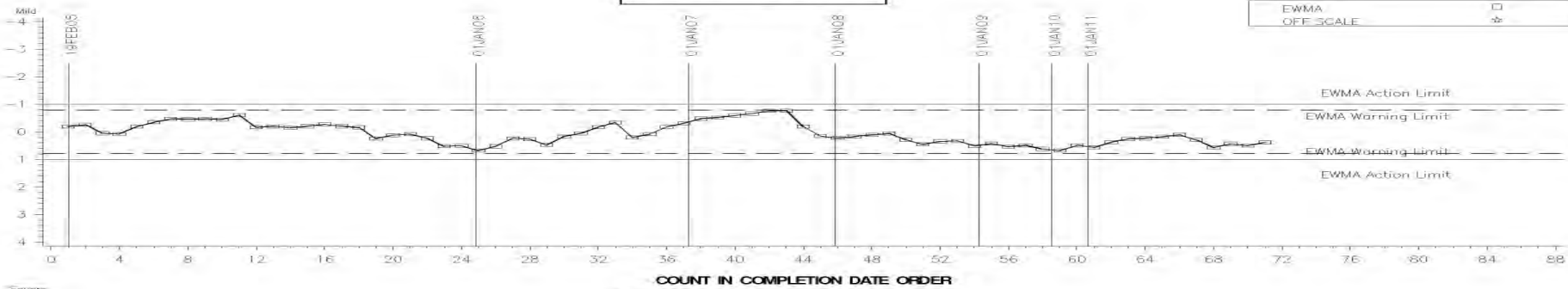
CUSUM Severity Analysis



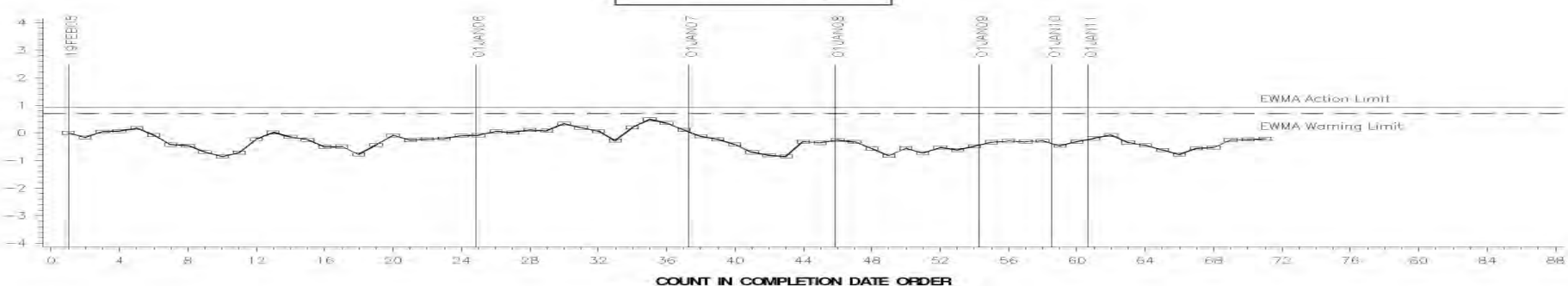
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MACK T-12 INDUSTRY OPERATIONALLY VALID DATA
 AVG. TOP RING WEIGHT LOSS (TRWL)

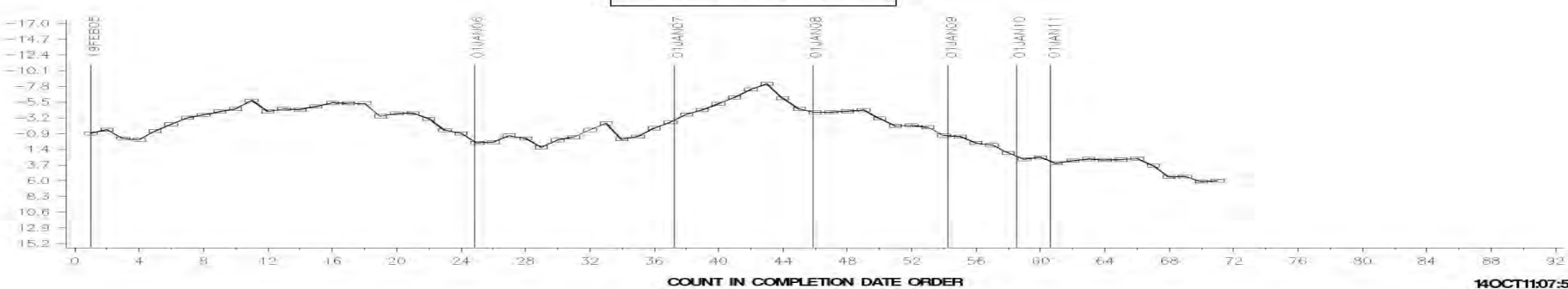
LTMS Severity Analysis



LTMS Precision Analysis



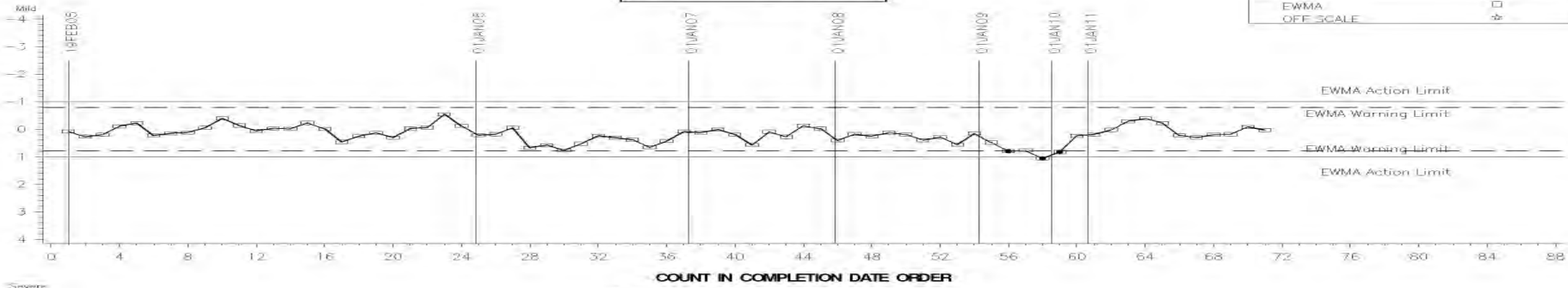
CUSUM Severity Analysis



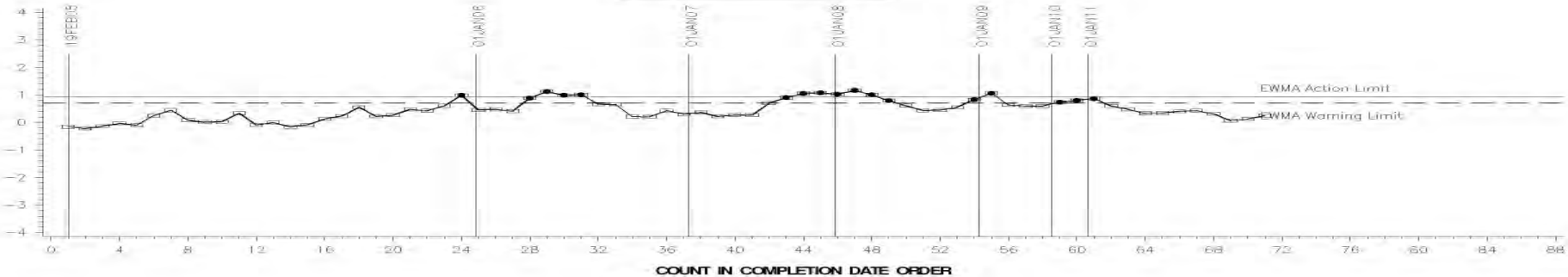
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MACK T-12 INDUSTRY OPERATIONALLY VALID DATA
FINAL TRANS. RES. OIL CONSUMPTION

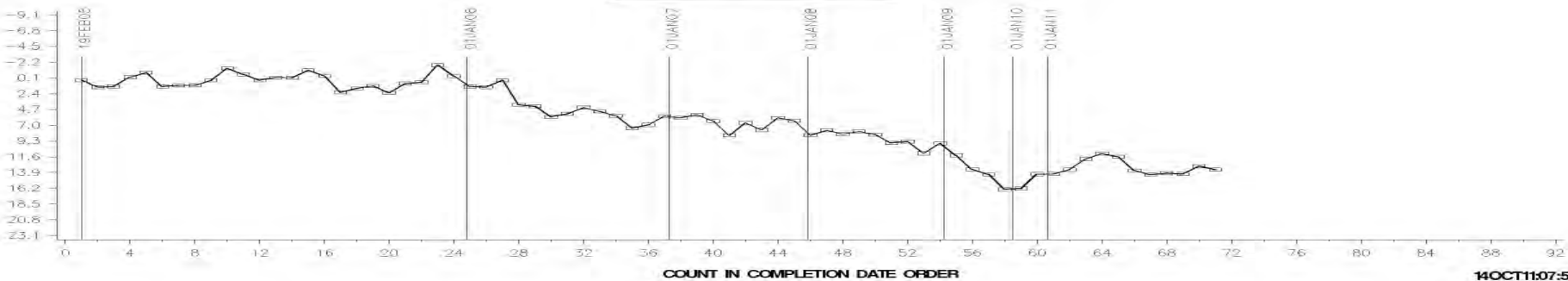
LTMS Severity Analysis



LTMS Precision Analysis

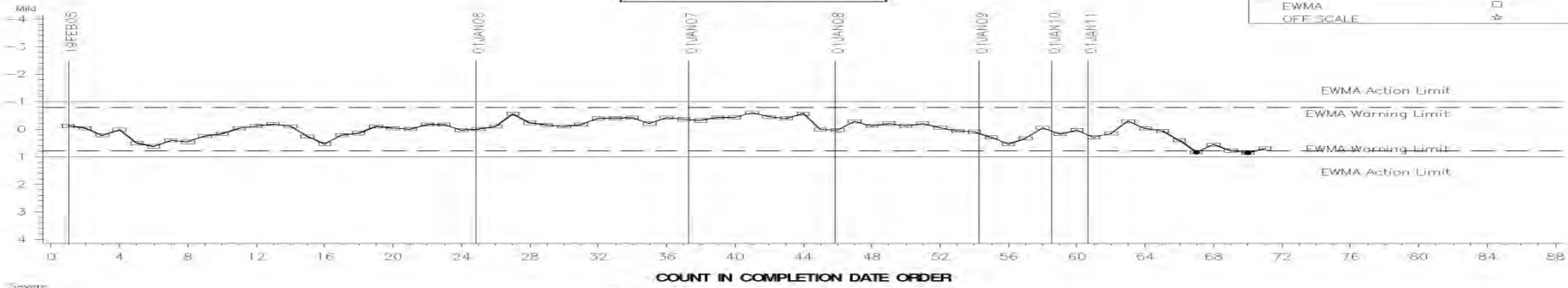


CUSUM Severity Analysis

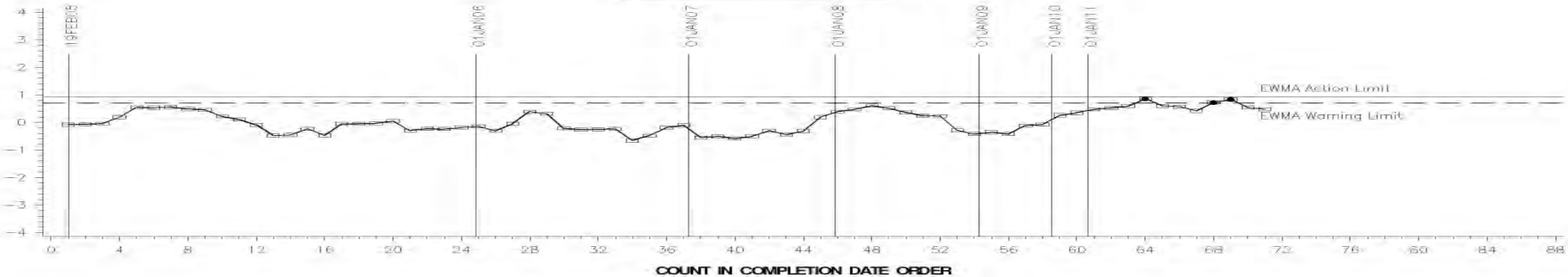


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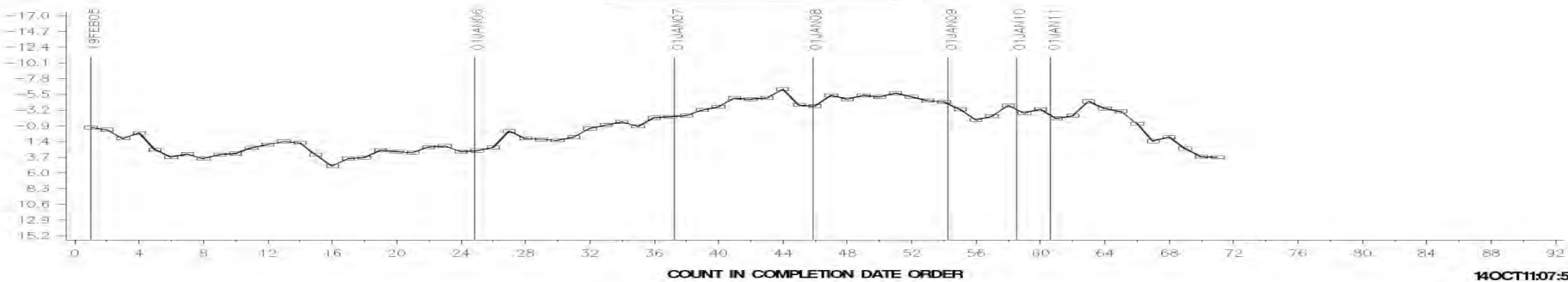
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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Return

Appendix 1.0

T-12A Control Charts

» Severity, Precision, and CuSum

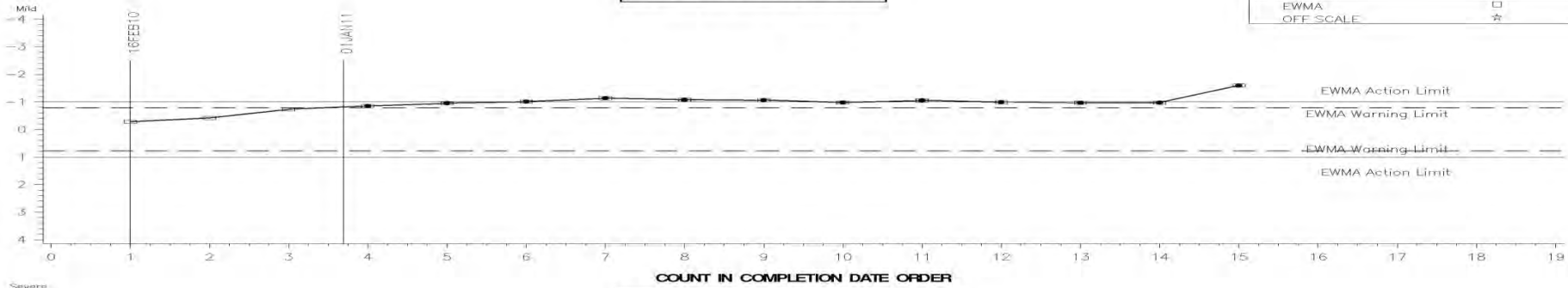
Test Monitoring Center

<http://astmtmc.cmu.edu>

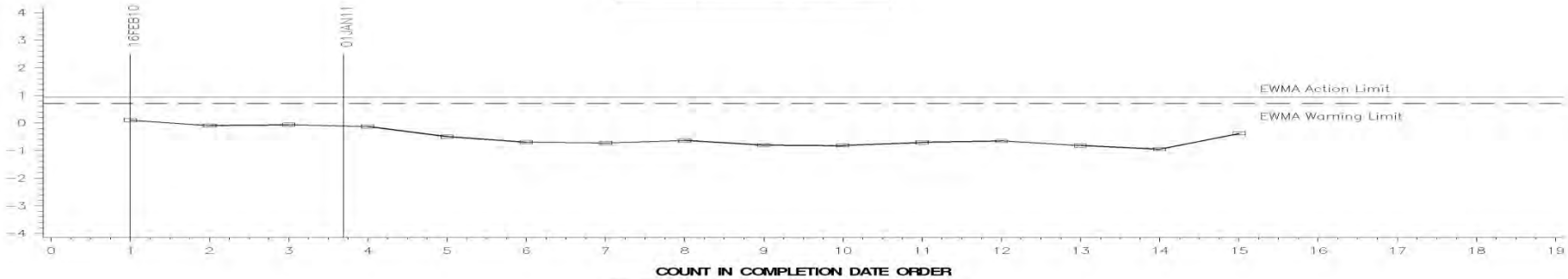


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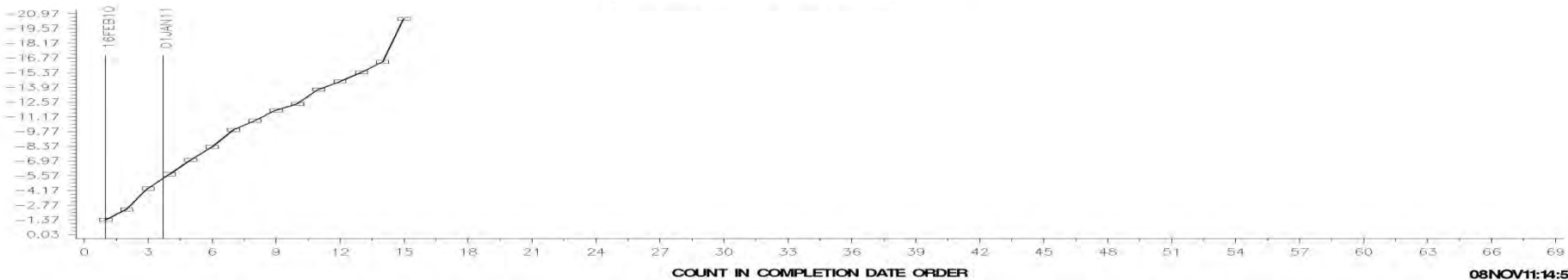
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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