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Test Monitoring Center

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

April 2012

Heavy Duty Testing

Executive Summary

▶ Reference Oils

- **820-3 cannot be reblended**
 - Supplier is working on 820-3 replacement oil
- **1005-3 cannot be reblended**
 - Issue not yet addressed by Surveillance Panels
 - Less than 1 year supply remaining

Heavy Duty Testing

Executive Summary

- ▶ 1P
 - New Batch of 1Y3997 liners were successfully introduced in December 2011
- ▶ ISB
 - Correction factors applied to both parameters to address for new hardware: Batch C tappets with Batch H cams.
- ▶ T-8/E
 - Correction factors implemented for all parameters to return test severity to historical levels.

Calibrated Labs and Stands*

Test	Labs	Stands
1K	3	4
1N	4	7
1M-PC	1	1
1P	4	4
1R	0	0
C13	2	3
ISB	3	3
ISM	4	5
EOAT	1	1
RFWT	1	1
T-8/E	2	3
T-10A	1	1
T-11	4	4
T-12	4	8
T-12A	4	8

*As of 3/31/2012

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Test Activity Levels

»» October 1, 2011 –

March 30, 2012

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CAT – SCOTE Tests

Test Status	Validity Code	1K	1N	1M-PC	1P	1R
Acceptable Calibration Test	AC	2	6	1	5	0
Failed Calibration Test	OC	0	0	0	0	0
Operationally Invalid	LC	0	0	0	1	0
Aborted	XC	0	1	0	0	0
Total		2	7	1	6	0

CAT - C13 Test

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

Cummins Tests

Test Status	Validity Code	ISB	ISM
Acceptable Calibration Test	AC	3	3
Failed Calibration Test	OC	0	0
Operationally Invalid	LC	1	0
Aborted	XC	0	0
Total		4	3

Light Duty Diesel Tests

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

Mack Tests

Test Status	Validity Code	T-8/E	T-10A	T-11	T-12	T-12A
Acceptable Calibration Test	AC	4/3 ^A	1	9	6	6
Failed Calibration Test	OC	0/1 ^A	0	0	0	0
Operationally Invalid	LC	0	0	2	0	0
Aborted	XC	0	0	0	1	2
Total		4	1	11	7	8

^ATest passed T-8 criteria; failed T-8E criteria

Failed Tests

Test Status	Test	Number of Tests
Severe RV48	T-8E	1
Total		1

Lost Tests*

*Invalid and aborted tests

Test Status	Cause	1N	1P	ISB	T-11	T-12/A
Aborted	Loss of oil charge due to broken drain line	1	0	0	0	0
Invalid	Excessive test length and mid-test engine work	0	1	0	0	0
Invalid	Insufficient number of Stage B cycles (<32000)	0	0	1	0	0
Invalid	Wrong injector nozzles	0	0	0	1	0
Invalid	EGR cooler failure; oil contaminated with coolant	0	0	0	1	0
Aborted	Spun rod bearing	0	0	0	0	2 ^A
Total		1	1	1	2	2

^A One test was both a T-12 and T-12A; one test a T-12A only

Test Severity

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March 31, 2012

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CAT Test Severity

▶ 1K

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

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

▶ 1N

- TGF, TLHC, and BSOC trending mild
- TLHC and BSOC in alarm

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

CAT Test Severity

▶ 1M-PC

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

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

▶ 1P

- 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 long-term mild trend.

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

Cummins Test Severity

▶ ISB

- Both ACSW and ATWL are in control.
- Charts shown in [Appendix 1.g.](#)

▶ ISM

- All parameters in control.
 - CWL trending mild.
 - FPD mild trend may be ending.
 - ASR possibly trending severe.
- Charts shown in [Appendix 1.h.](#)

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
 - VI38 in control.
 - RV48 & RV2 in alarm: severity (severe) and precision.
 - A single, very-severe test influencing charts.
- Charts shown in [Appendix 1.k.](#)
- ▶ T-10A
 - MRV within limits, but trending severe
- Charts shown in [Appendix 1.l.](#)

Mack Test Severity

▶ T-11

- All parameters within chart limits.
 - SOOT, SOOT5, and MRV trending mild.

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

▶ T-12

- All parameters within chart limits.
 - CLW and OC showing mild trend.
 - TRWL showing long-term severe trend.

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

Mack Test Severity

- ▶ T-12A
 - MRV is in control.
- Charts shown in [Appendix 1.o.](#)

Test Precision

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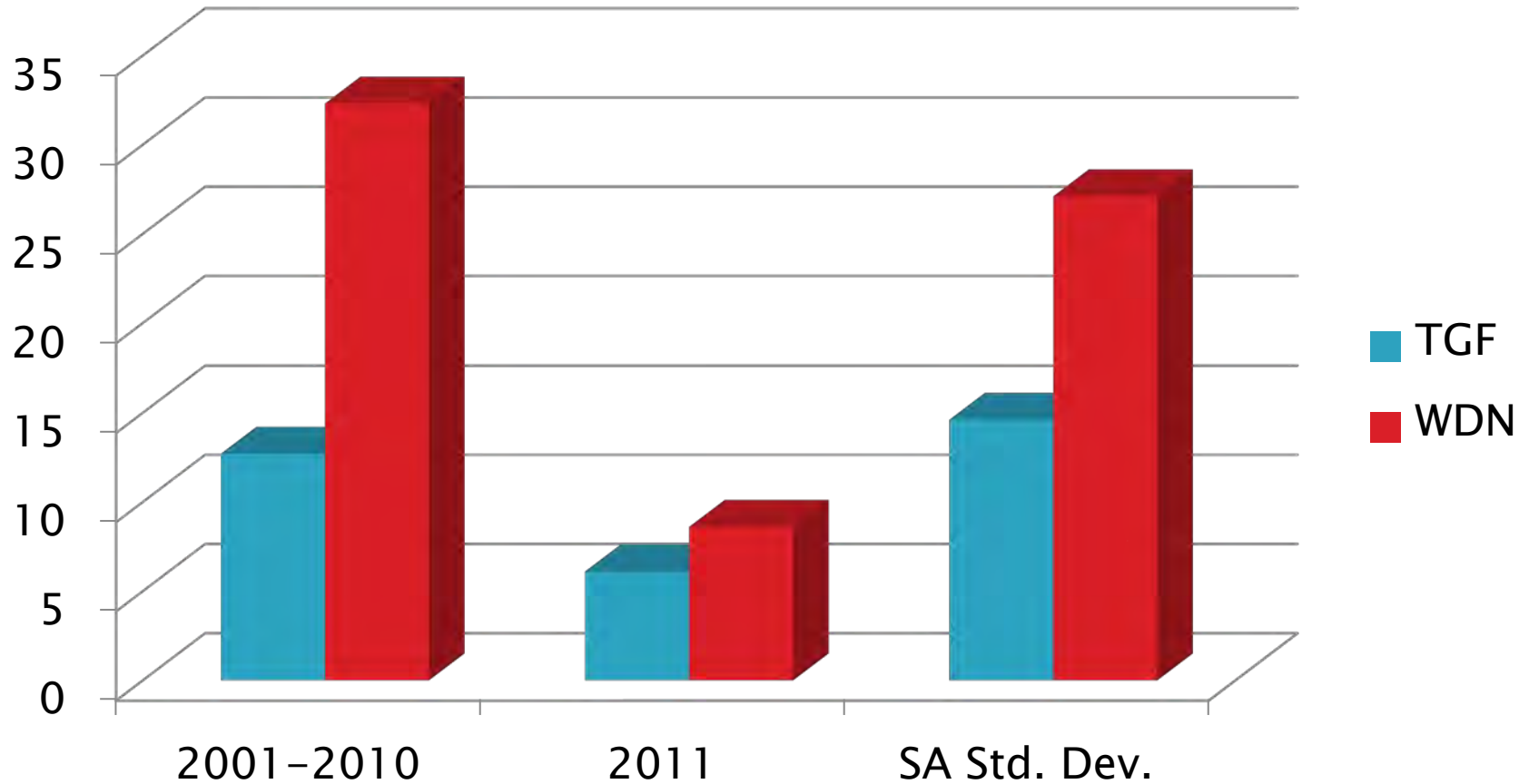


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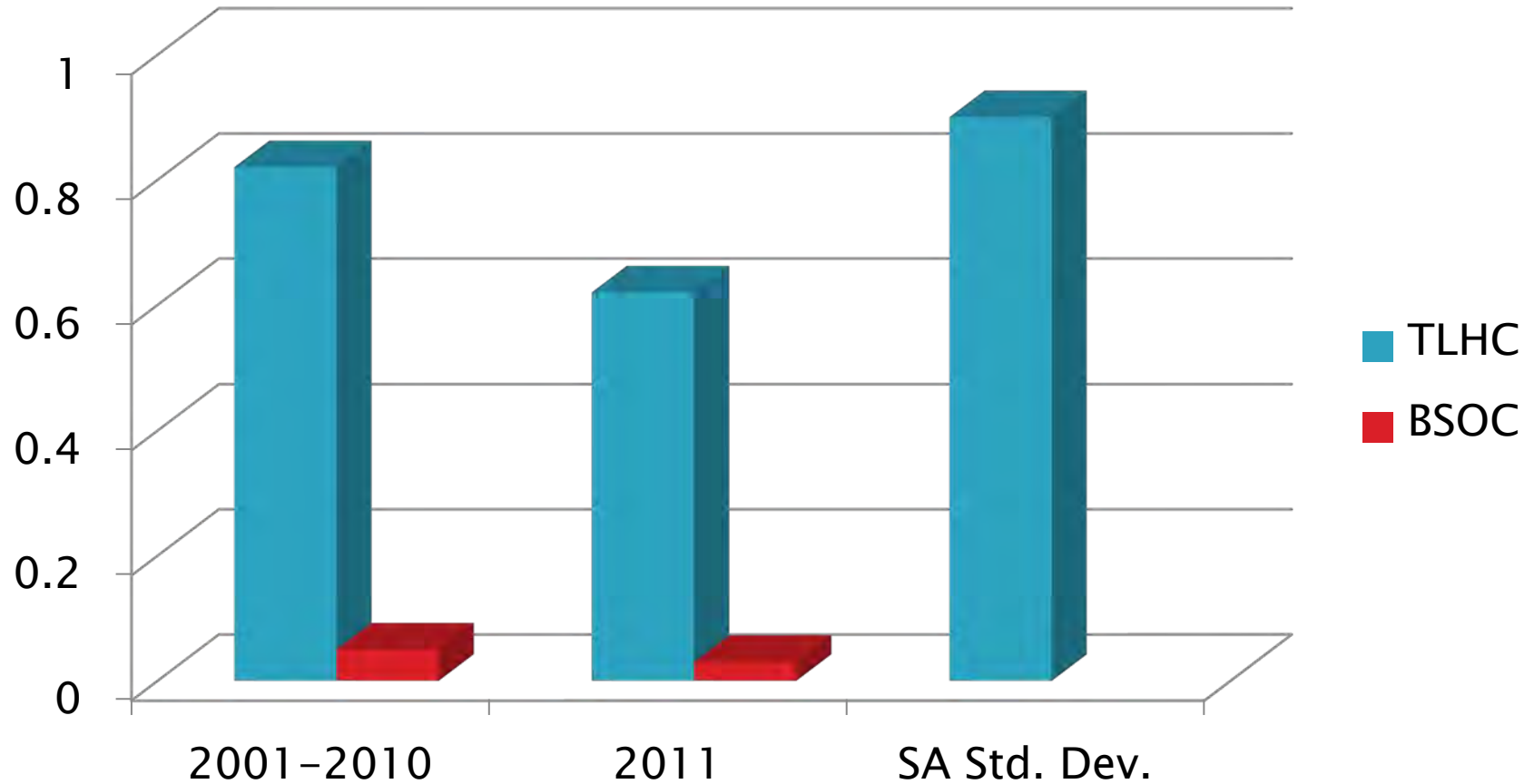
Test Precision Estimates

- ▶ Presented for years where sufficient data exist
- ▶ Precision estimates are shown with reference oil std. deviations, or where applicable, with Severity Adjustment std. deviations
- ▶ For several test types, precision estimates are not available due to low activity levels

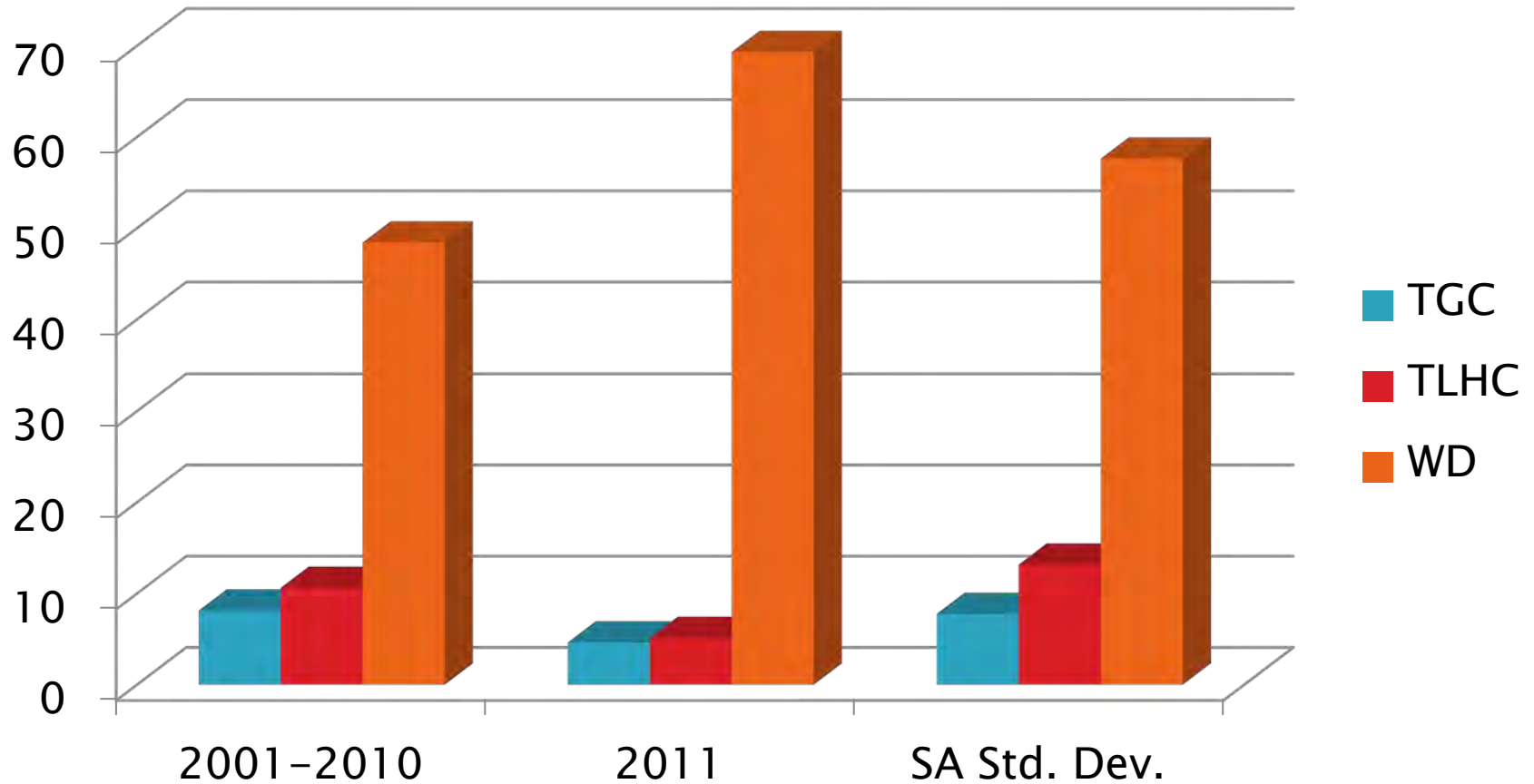
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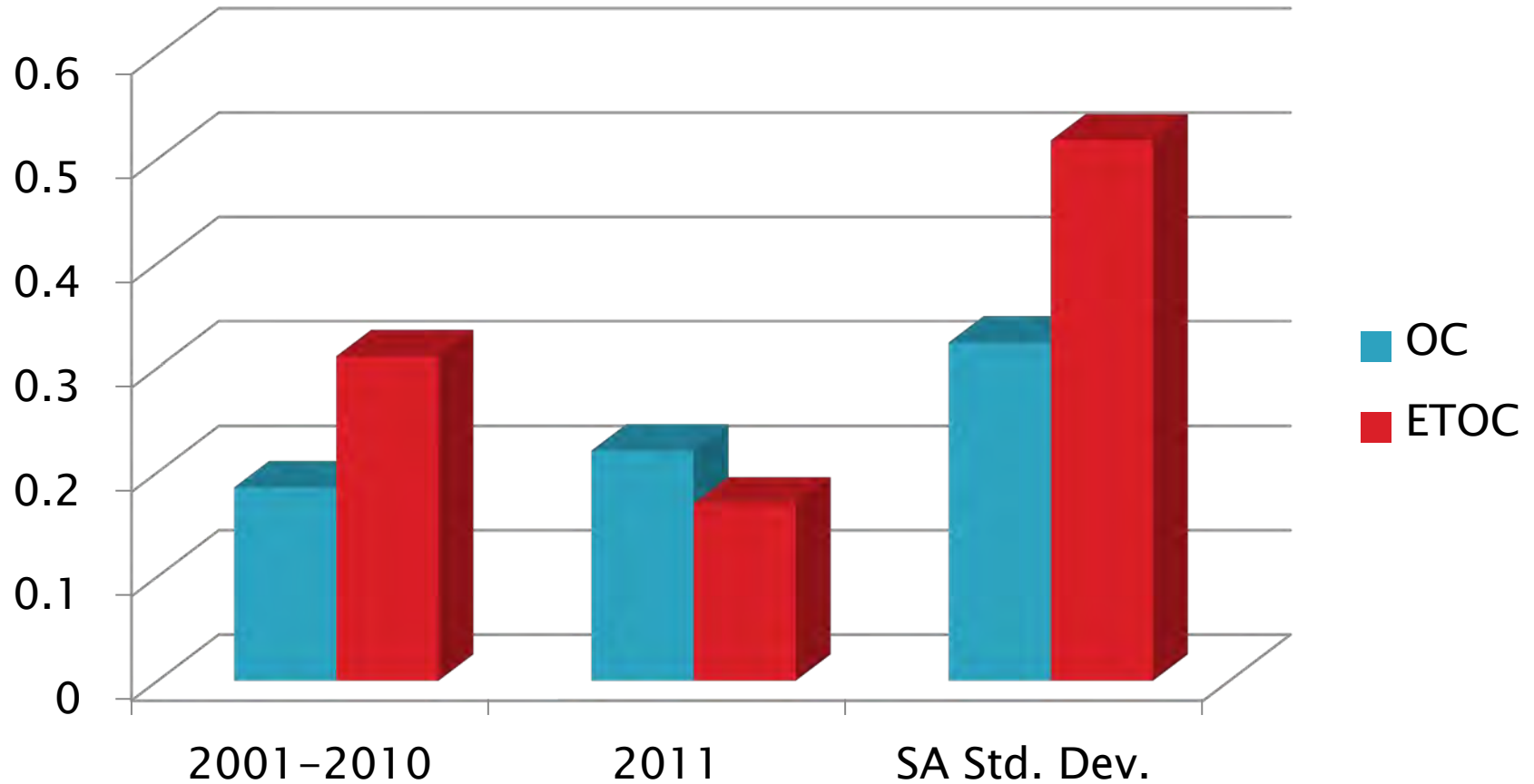
1 N Precision Estimates



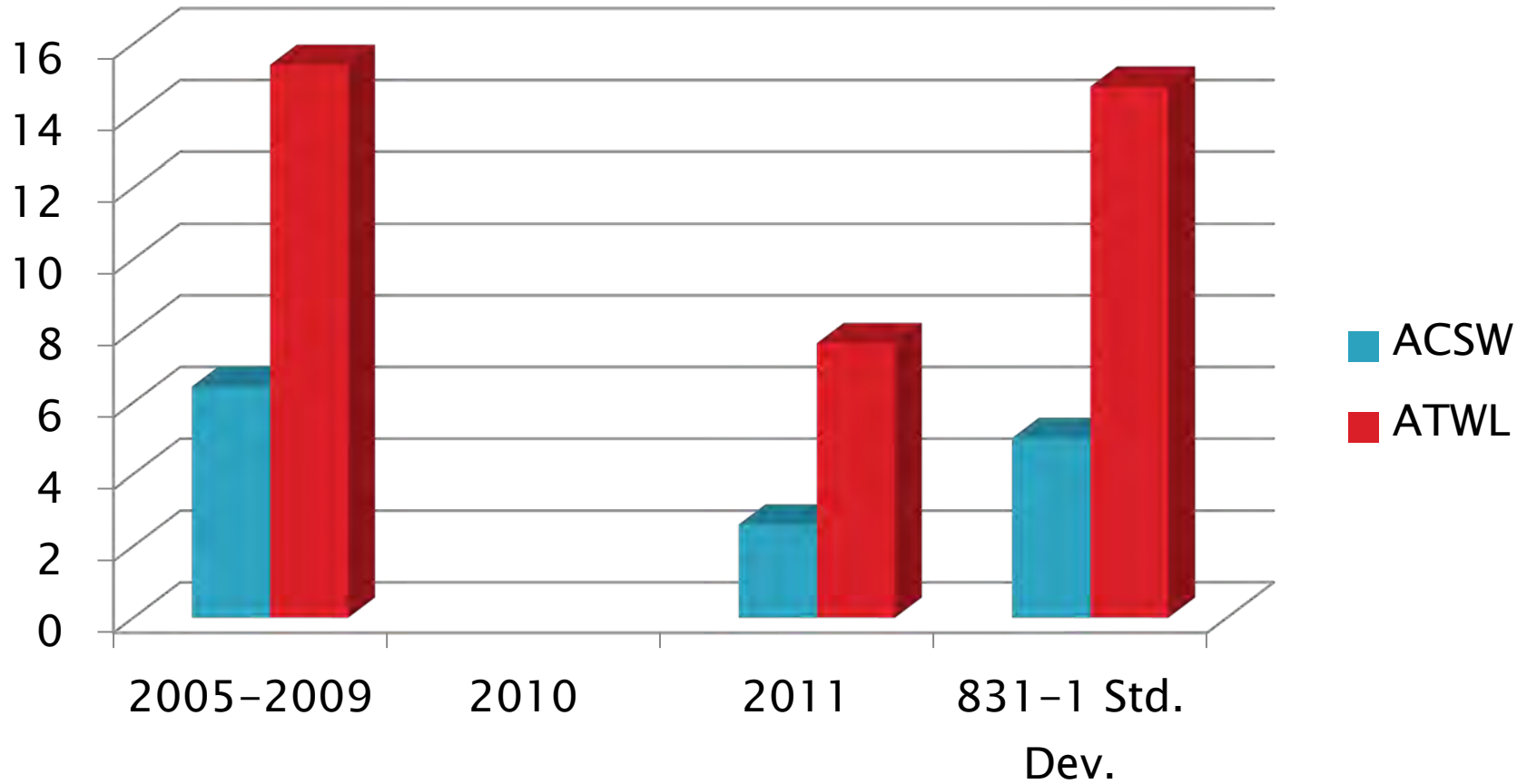
1 P Precision Estimates



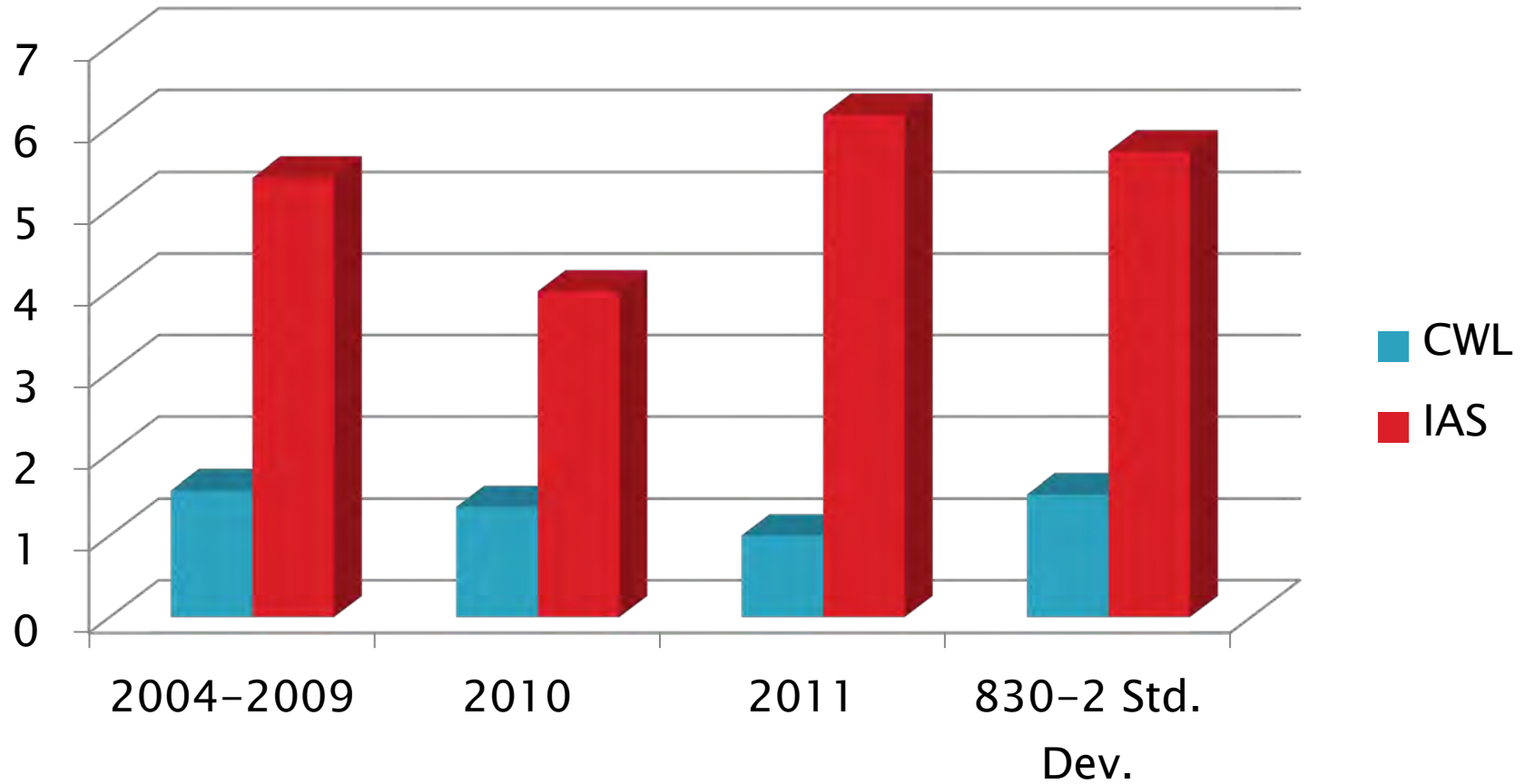
1 P Precision Estimates



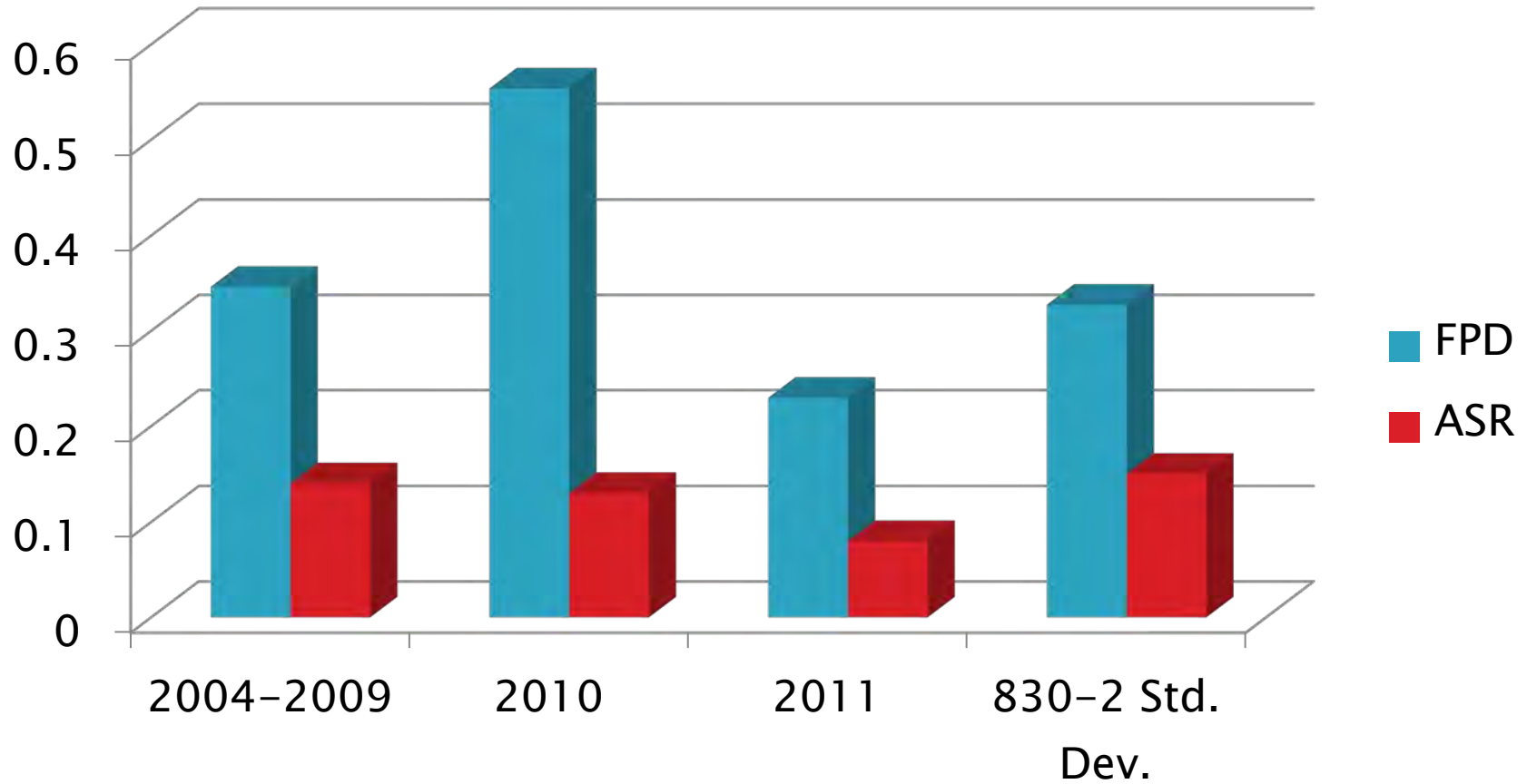
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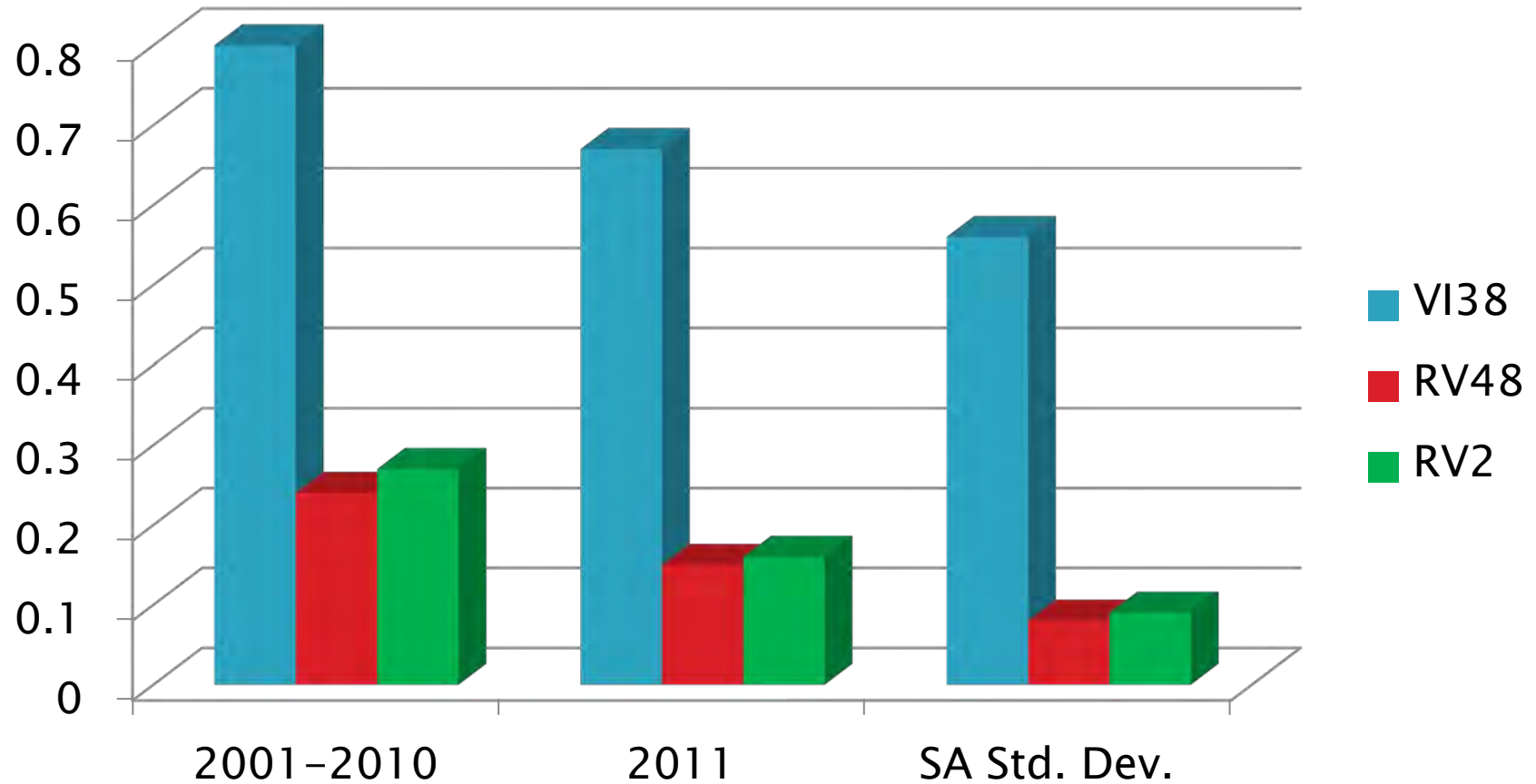
ISM Precision Estimates



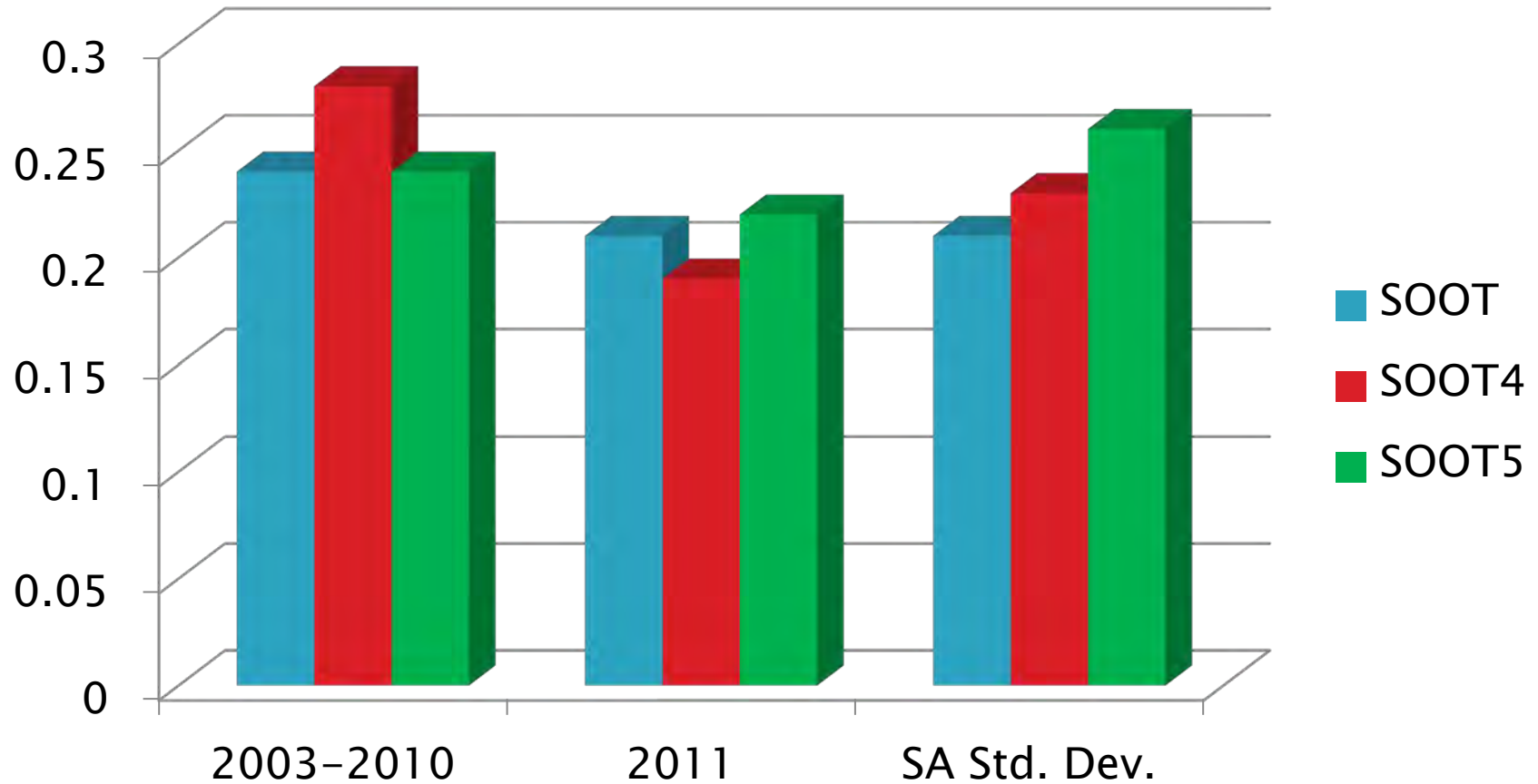
ISM Precision Estimates



T-8/E Precision Estimates

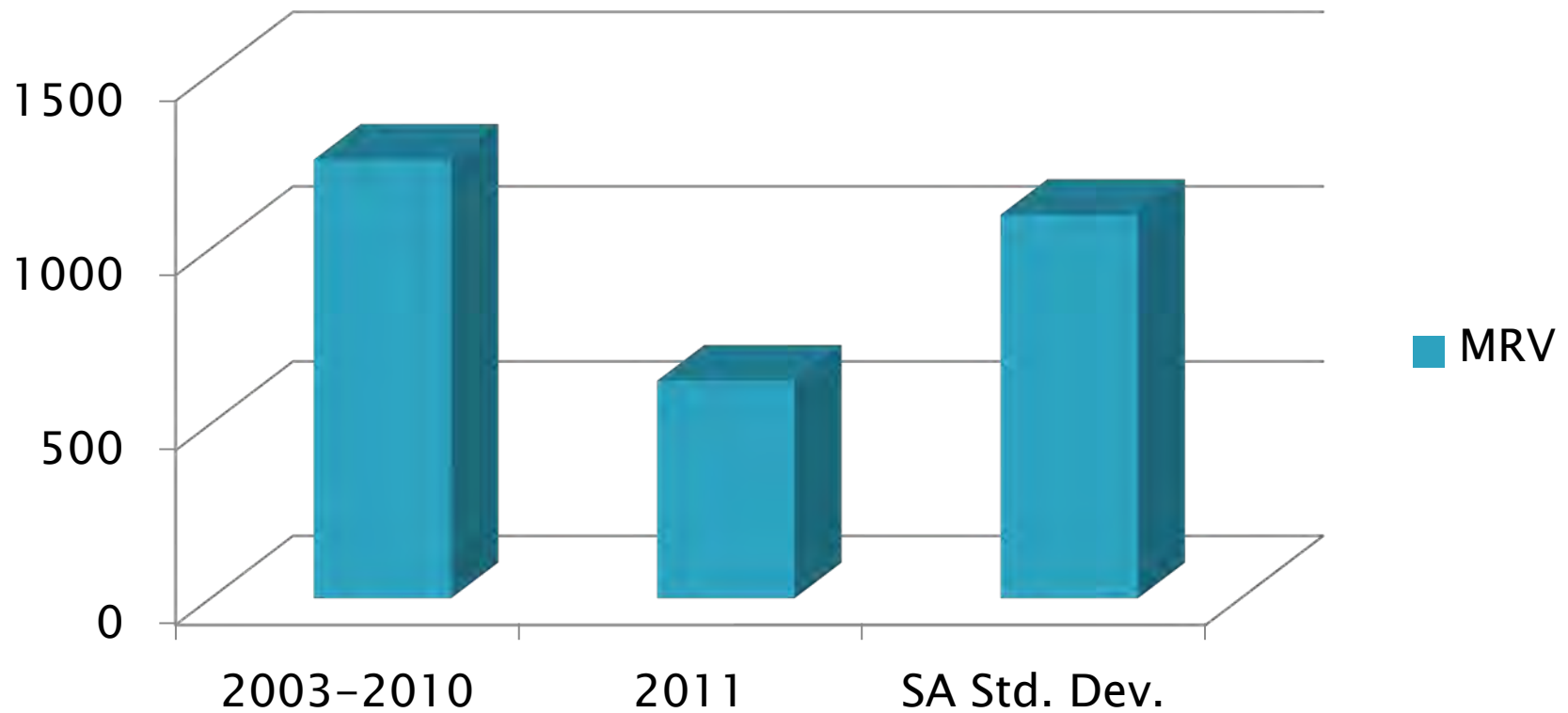


T-11 Precision Estimates

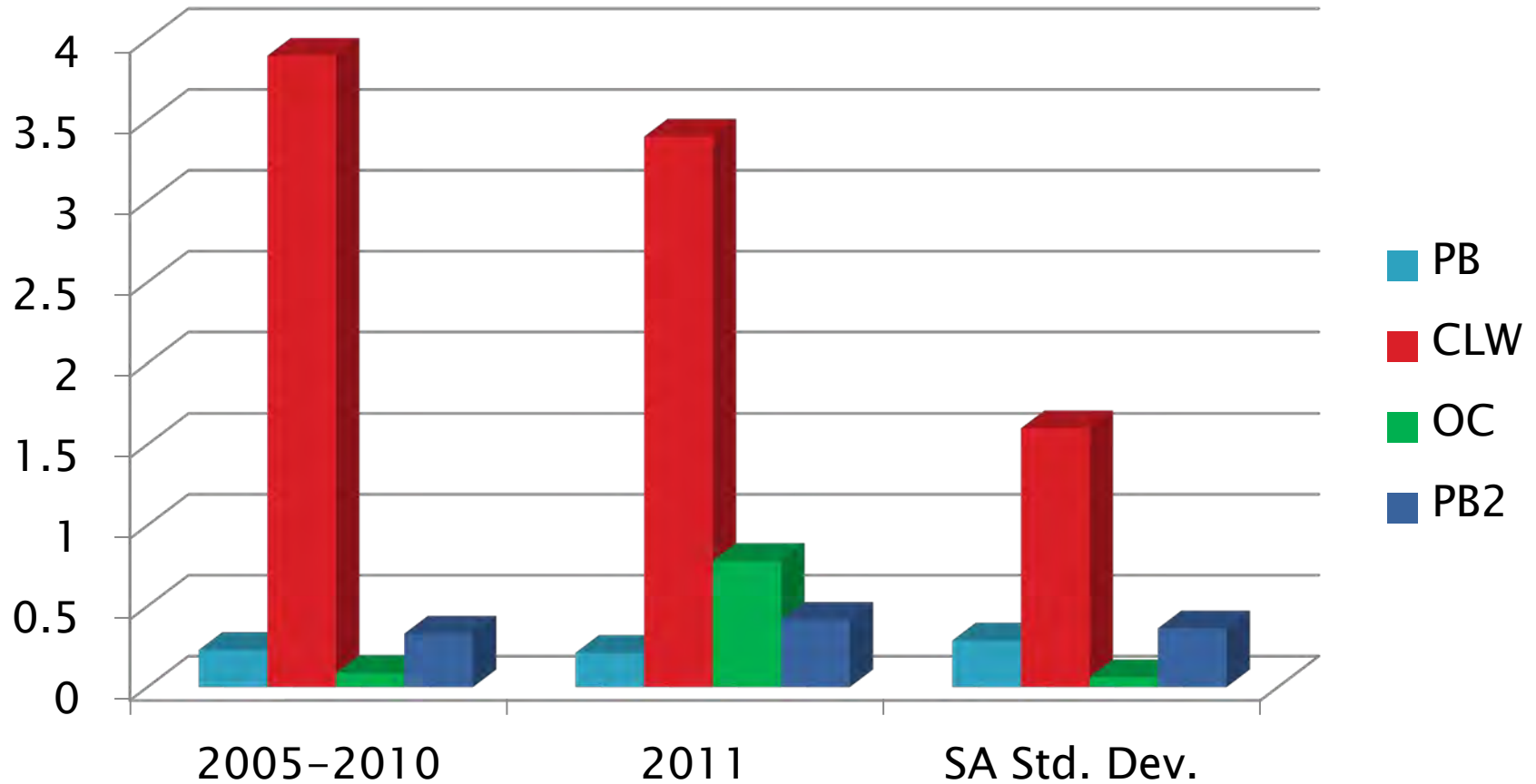


T-11 Precision Estimates

MRV

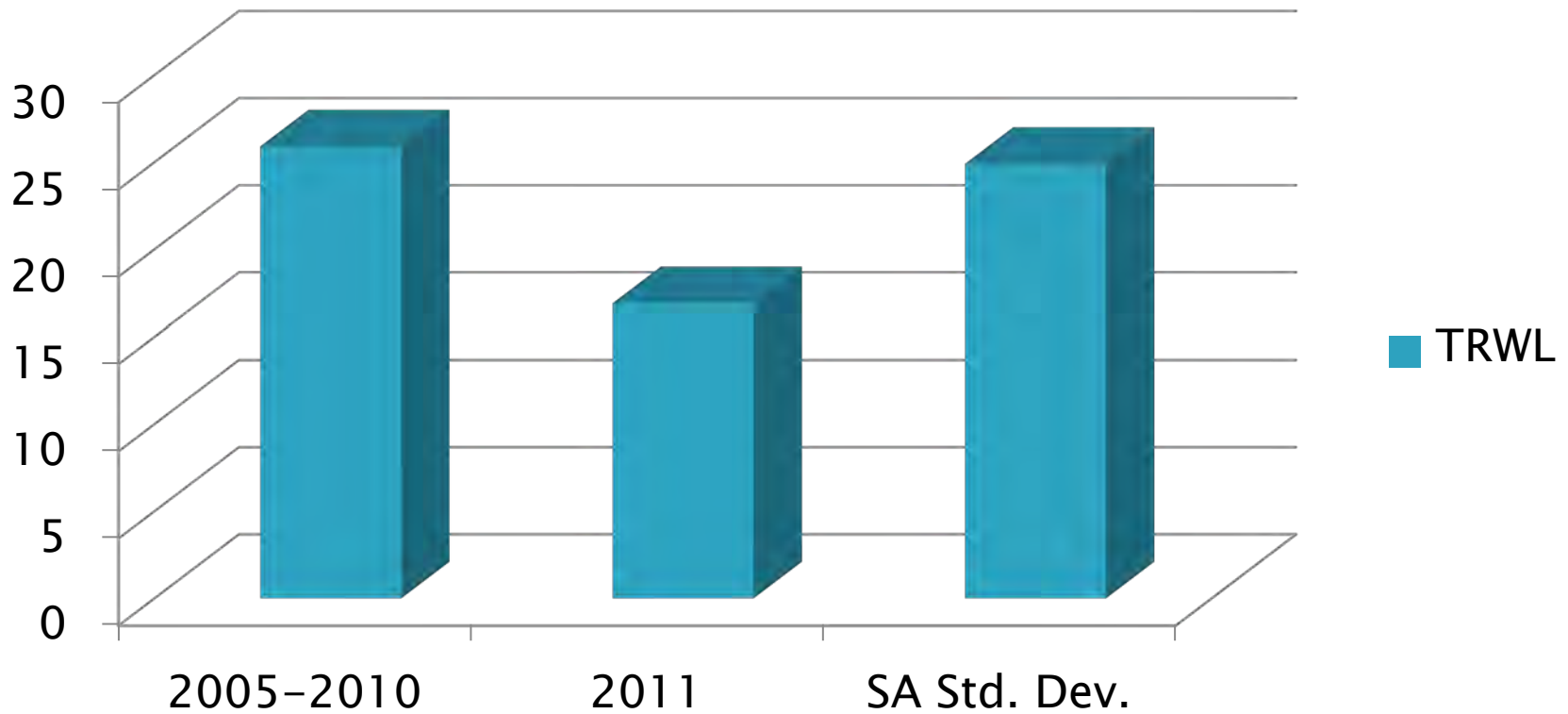


T-12 Precision Estimates



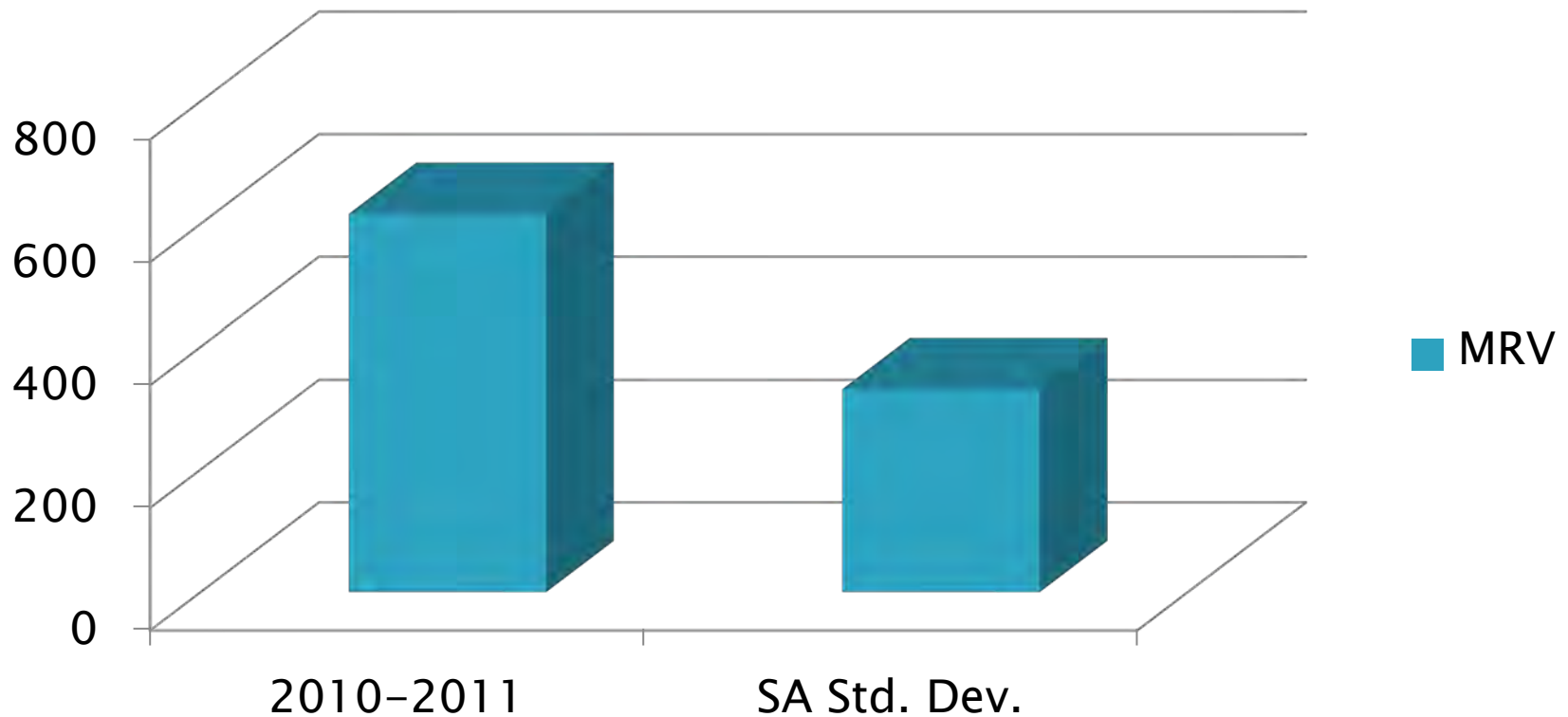
T-12 Precision Estimates

TRWL



T-12A Precision Estimates

MRV



Information Letters

»» October 1, 2011 –
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Information Letters*

Test	Date	IL	Topic
ISB	January 17, 2012	12-1, Seq. 5	ACSW and ATWL Correction Factors for Batch C Tappets / Batch H Camshafts
T-8/E	November 10, 2011	11-1, Seq. 19	VI38, RV48, and RV2 Correction Factors

*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 year
- Panels will need to identify replacement
- Tests Affected: **1P, 1R, EOAT, RFWT, T-8/E**

Reference Oil Actions

➤ *Action Required:* TMC 820-3

- Cannot be re-blended
- Estimated supply ~ 1 year
- Supplier working to identify replacement
 - Panels will need to approve
- Tests Affected: **1R, T-10A, T-11**

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
 - 821-2
 - 831-1: reblend has been obtained

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	34	2570	50	5+ years
811-2	1K, 1N	1732	50	1325	50	5+ years
820-3	1R, T-10A, T-11	2750	417	55	224	~ 1 year
821-2	T-12	450	206	94	200	~ 1 year
830-2	ISM	3786	120	1081	200	5+ years
831-1	C13, ISB	1300	190	269	220	~ 1.5 years
831-2	C13, ISB	880	0	880	0	5+ years
873-2	1M-PC	1650	0	248	30	5+ years
1005-3	1P, 1R, EOAT, RFWT, T-8/E	2000	400	558	251	~ 1 year

LTMS Deviations

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March 31, 2012

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LTMS Deviations

- No LTMS Deviations in Current Period

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

- One T-12 Quality Index Deviation this period
 - Intake Manifold Temperature
 - Caused by improperly sized control valve
 - Adequate control restored once valve was replaced

Historical Count of HD Quality Index Deviations

Test	LTMS Deviations
1P	11
1R	1
ISM	2
T-10A	1
T-11	3
T-12	4

TMC Laboratory Visits

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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	20111211	CORRECTION FACTORS IMPLEMENTED FOR TESTS USING BATCH C TAPPETS AND BATCH H CAMSHAFTS.	12-1
1P	20121216	NEW BATCH OF 1Y3997 LINERS APPROVED.	

*As of 3/31/2012

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Additional Information



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Additional Information

- ▶ Available on TMC Website:
 - Oil Assignment Request and Test File Upload
 - 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

April 2012

Appendix 1.a

1 K Control Charts

» Severity, Precision, and CuSum

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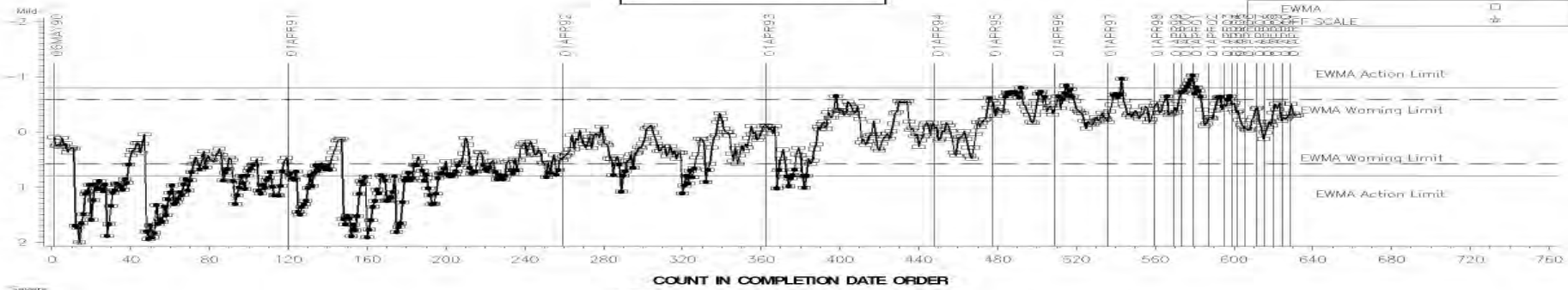


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Weighted Total Demerits

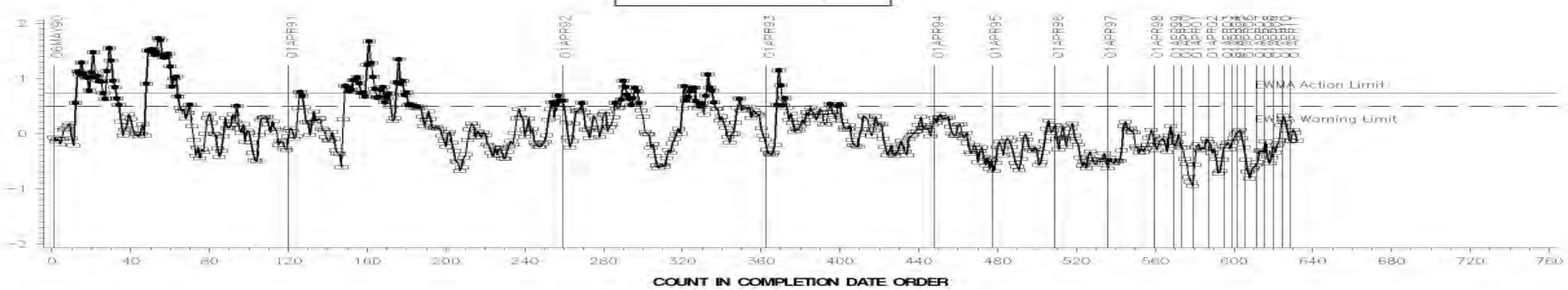
LTMS Severity Analysis

Standard Deviation Units



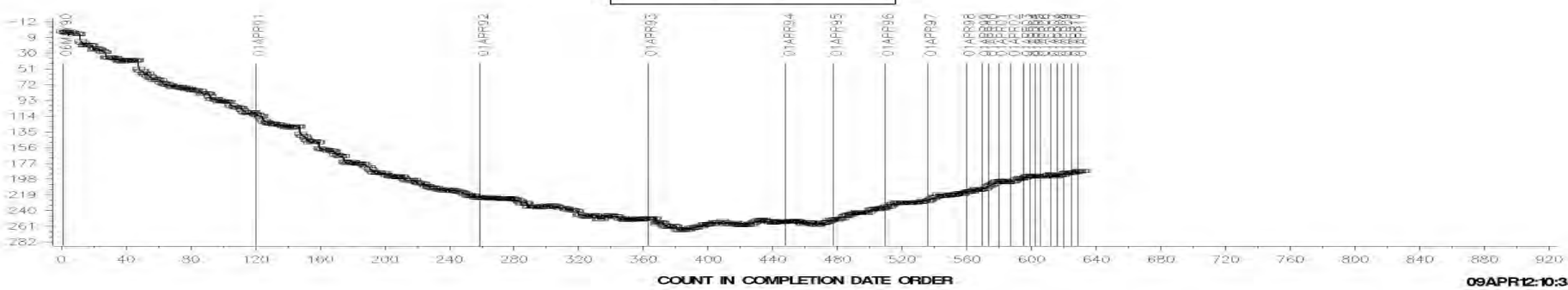
LTMS Precision Analysis

Standard Deviation Units



CUSUM Severity Analysis

Standard Deviation Units



09APR12:10:35

LTMS Severity Analysis

Standard Deviation Units



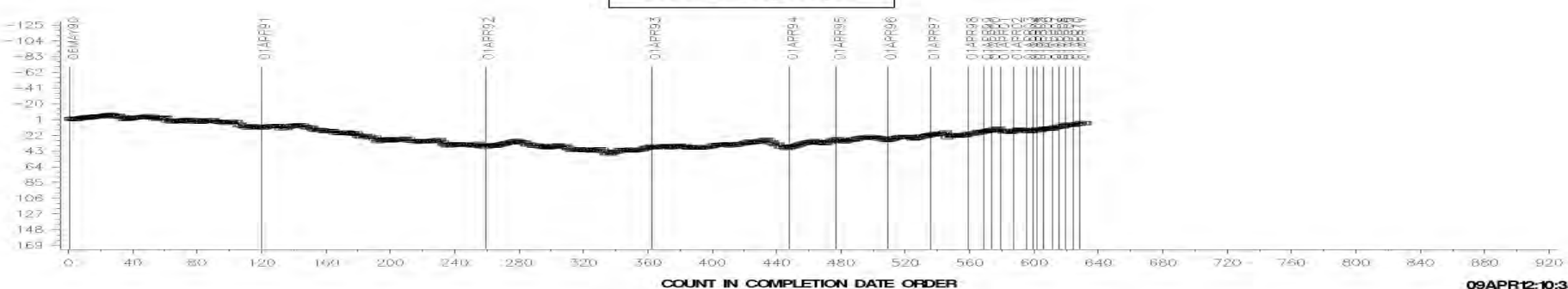
LTMS Precision Analysis

Standard Deviation Units



CUSUM Severity Analysis

Standard Deviation Units

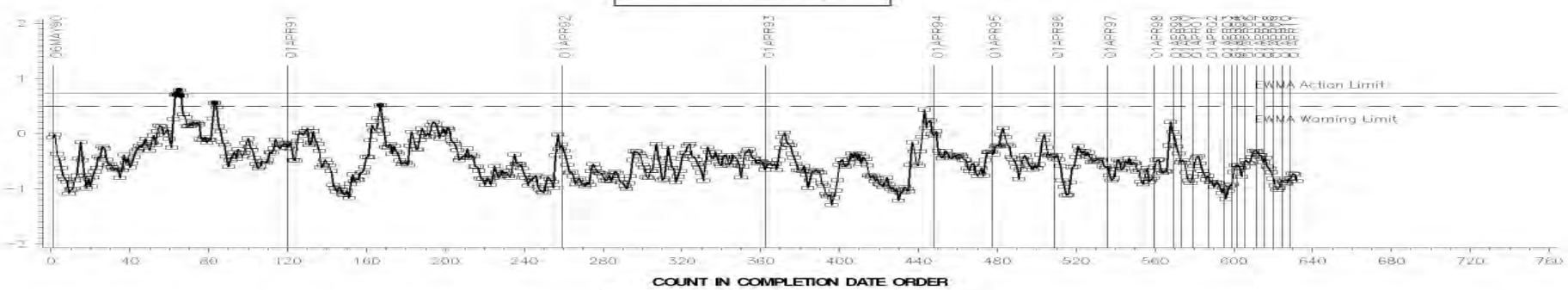


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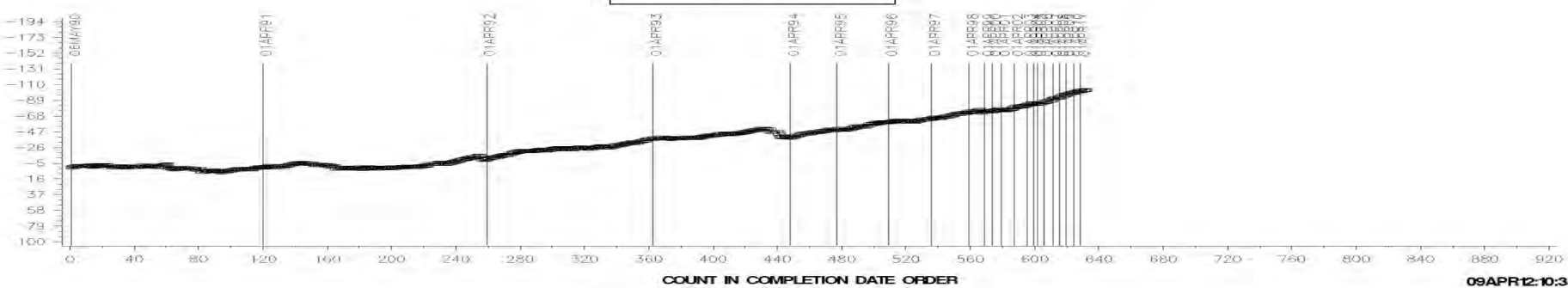
LTMS Severity Analysis



LTMS Precision Analysis



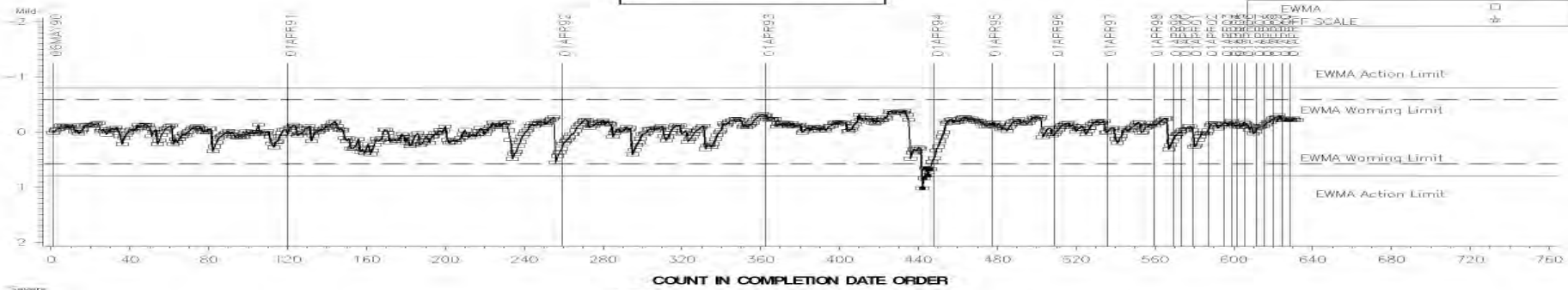
CUSUM Severity Analysis



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LTMS Severity Analysis

Standard Deviation Units



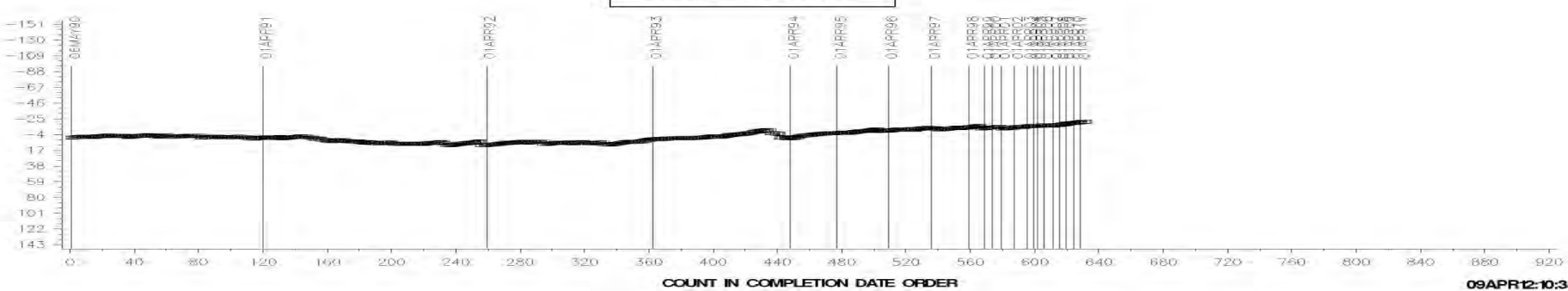
LTMS Precision Analysis

Standard Deviation Units



CUSUM Severity Analysis

Standard Deviation Units



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Appendix 1.b

1 N Control Charts

» Severity, Precision, and CuSum

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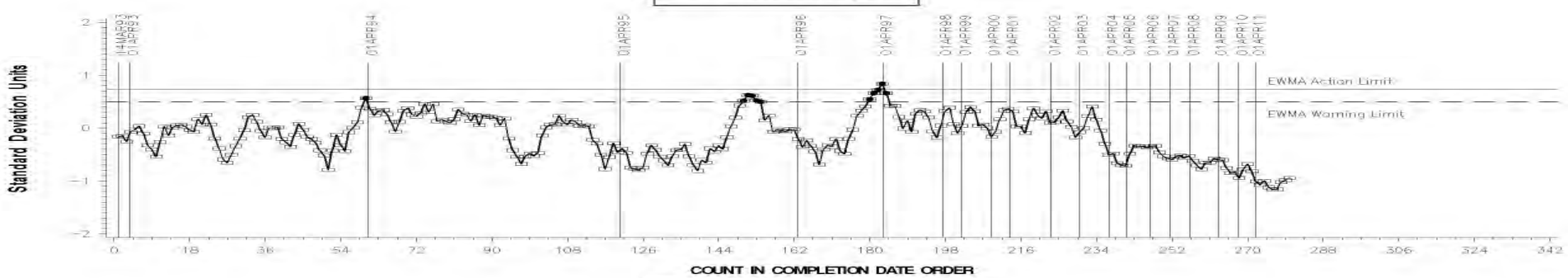
Top Groove Fill

LTMS Severity Analysis



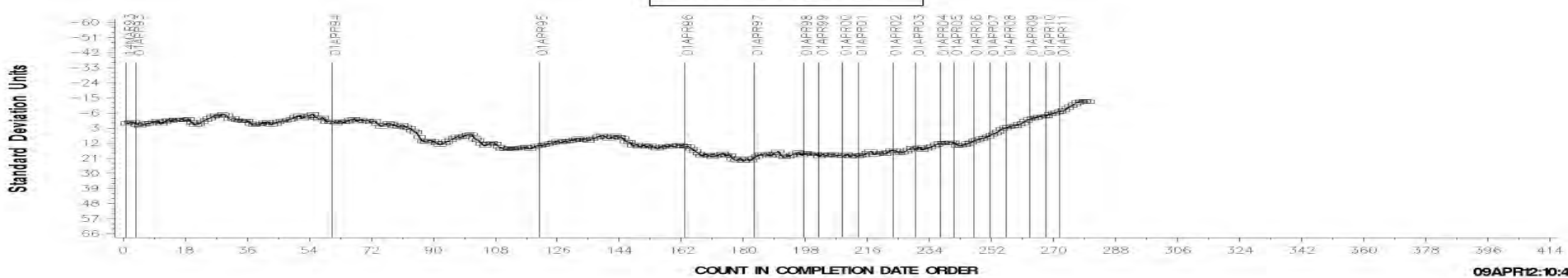
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis



COUNT IN COMPLETION DATE ORDER

09APR12:10:41

Weighted Total Demerits

LTMS Severity Analysis



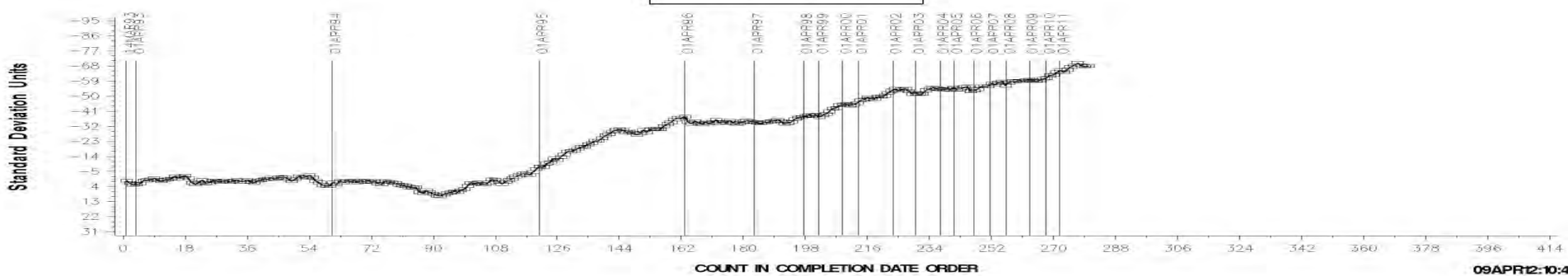
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis



COUNT IN COMPLETION DATE ORDER

09APR12:10:41

FINAL TRANS. TOP LAND HEAVY CARBON

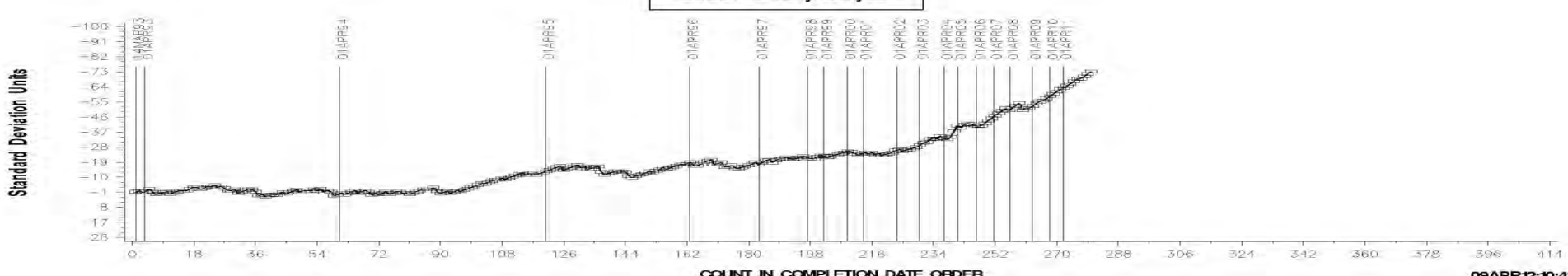
LTMS Severity Analysis



LTMS Precision Analysis

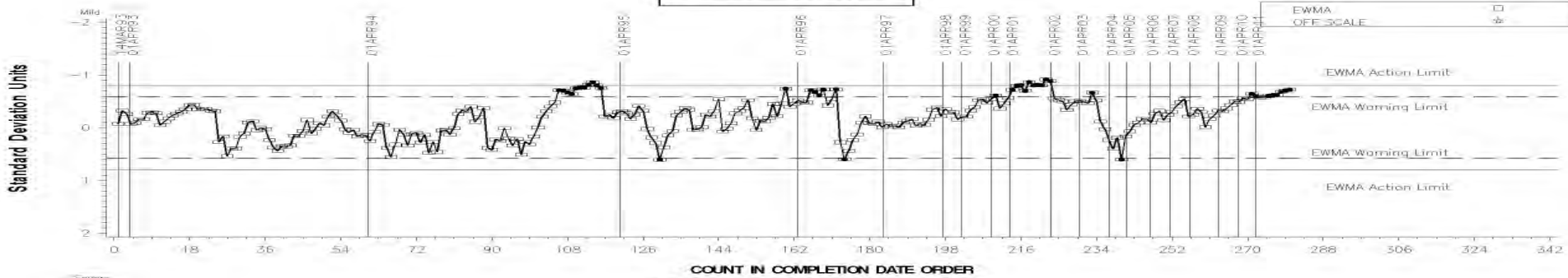


CUSUM Severity Analysis



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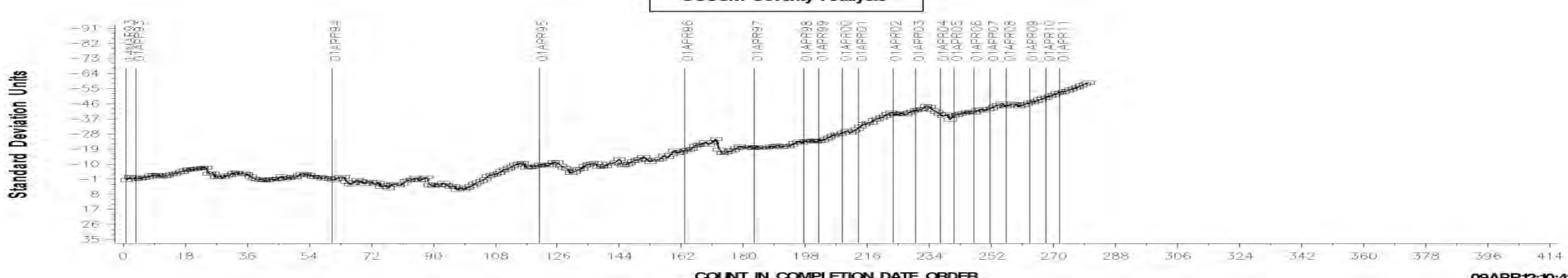
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



09APR12:10:42

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Appendix 1.c

1 M-PC Control Charts

» Severity, Precision, and CuSum

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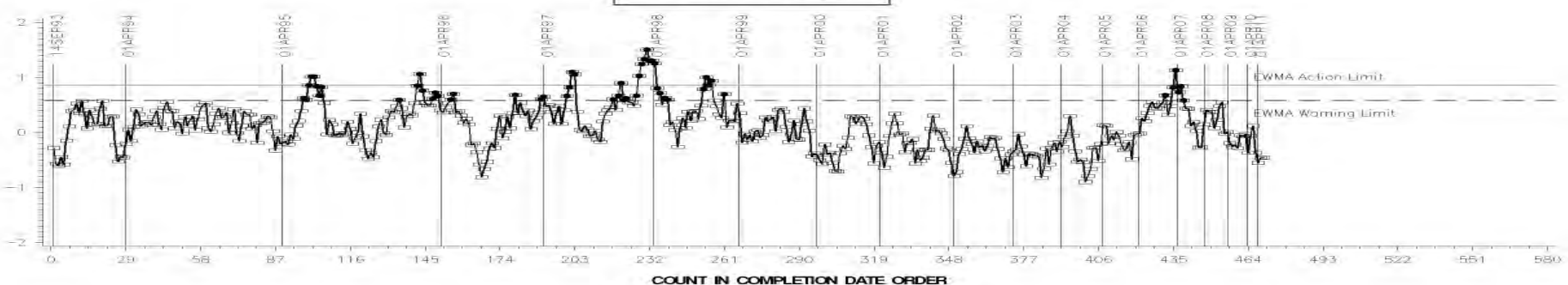
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FINAL TOP GROOVE FILLING

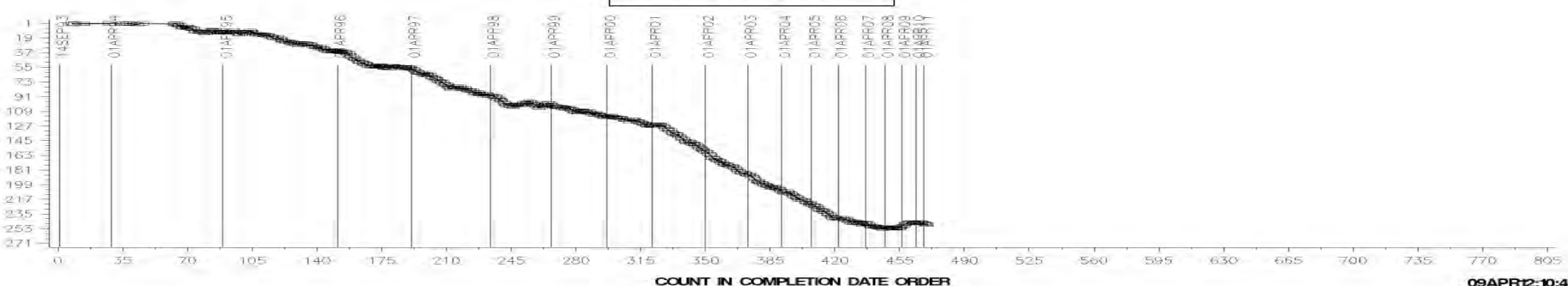
LTMS Severity Analysis



LTMS Precision Analysis



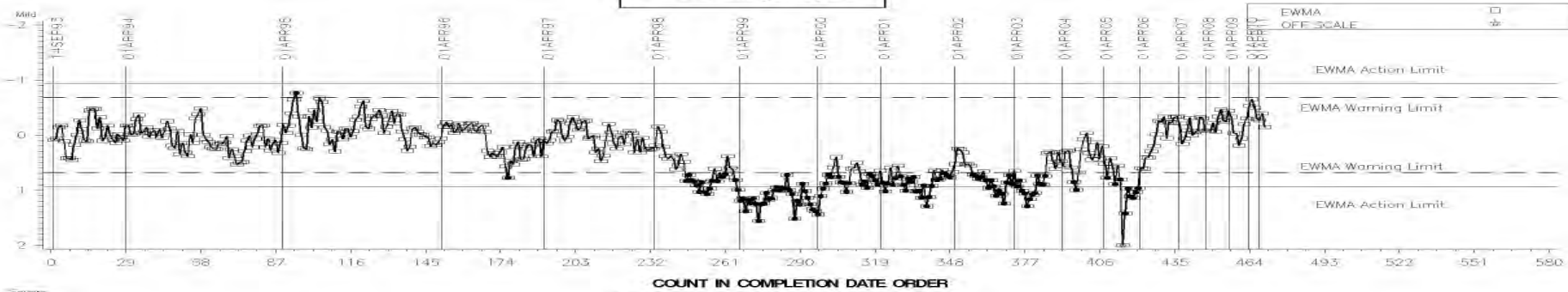
CUSUM Severity Analysis



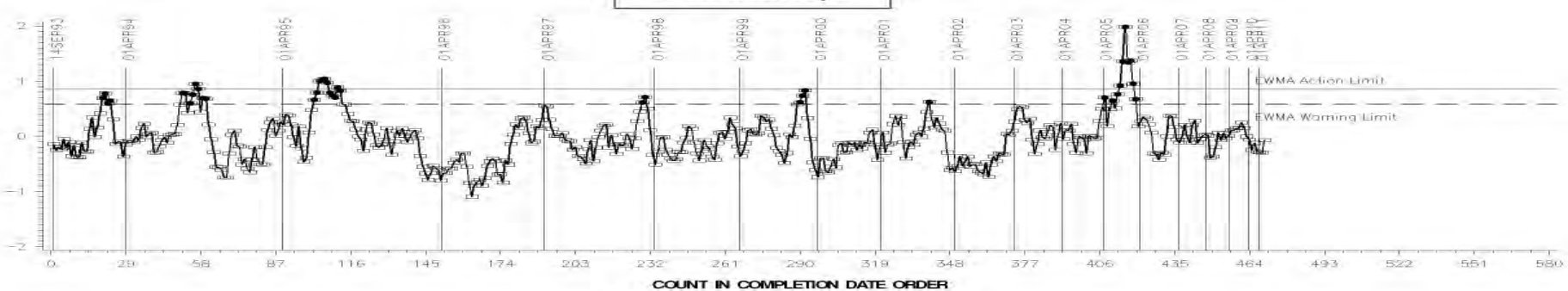
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Weighted Total Demerits

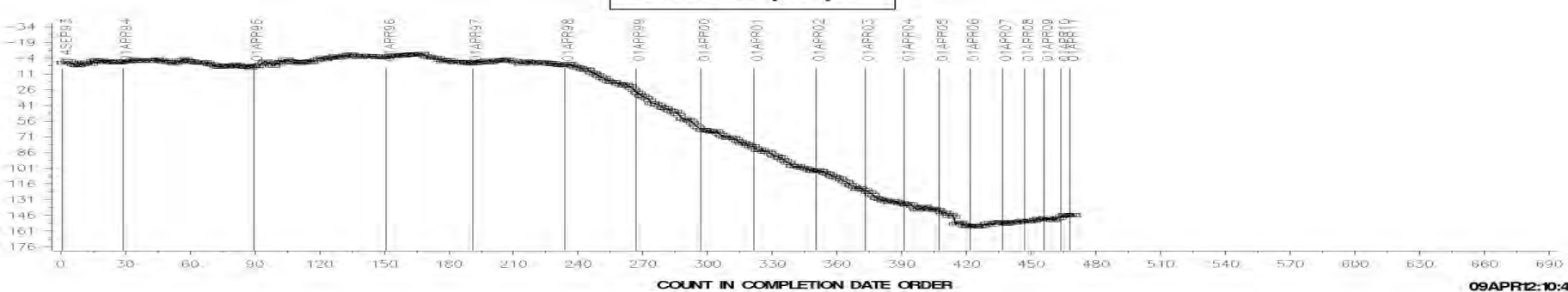
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



09APR12:10:41

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Appendix 1.d

1 P Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

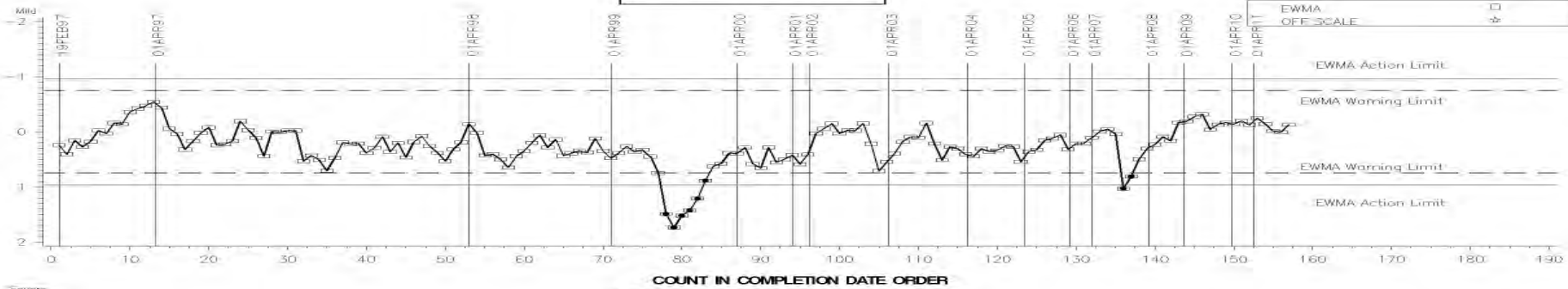
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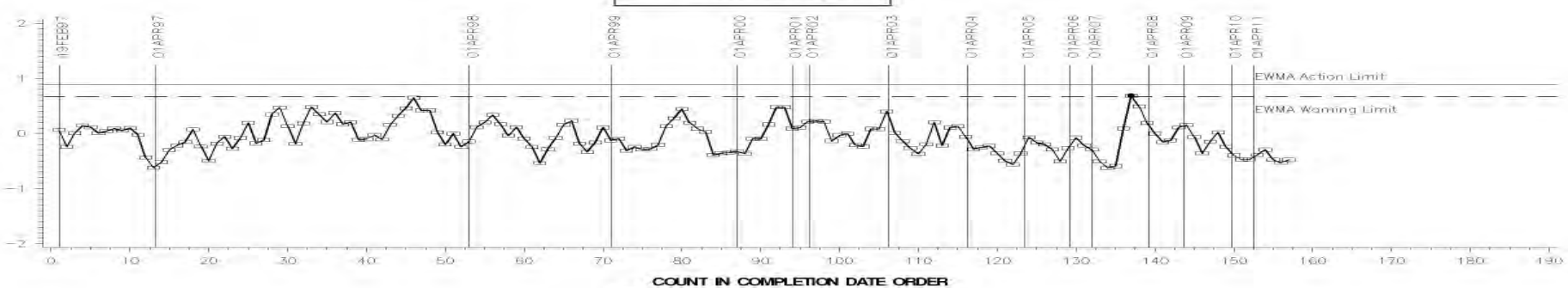
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TOP GROOVE CARBON

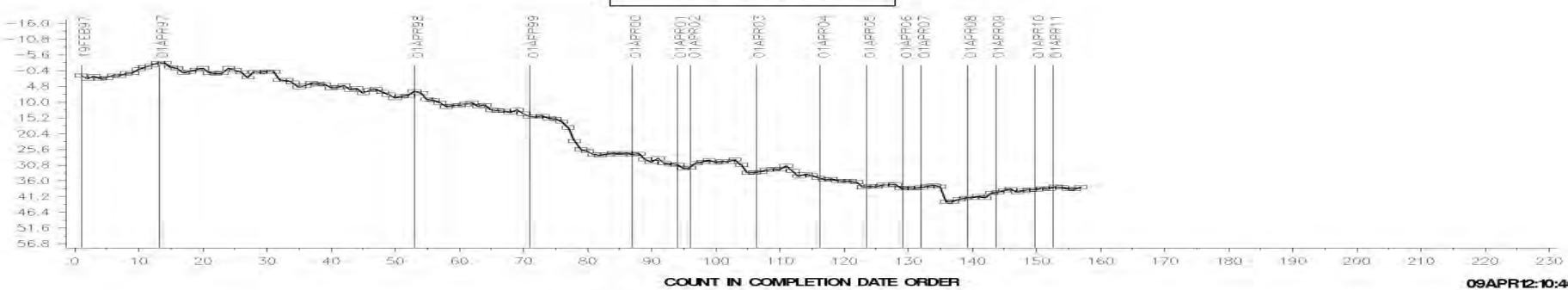
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



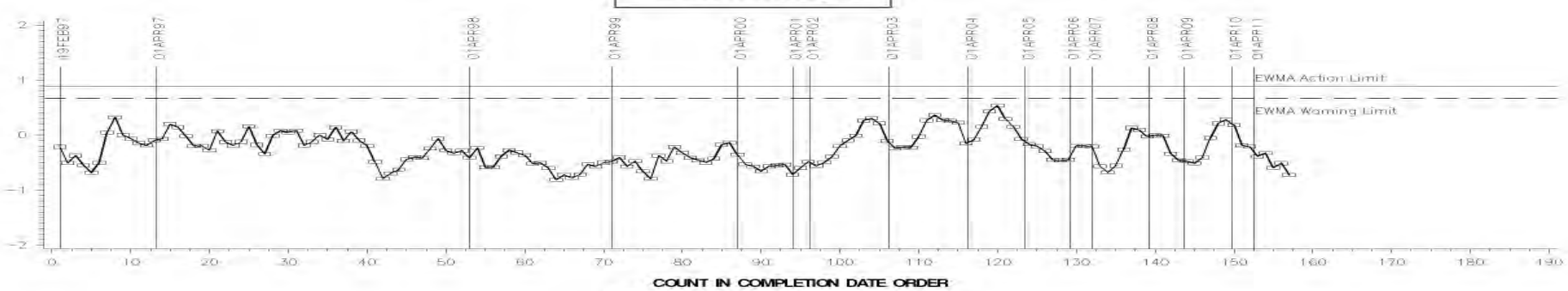
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TOP LAND CARBON

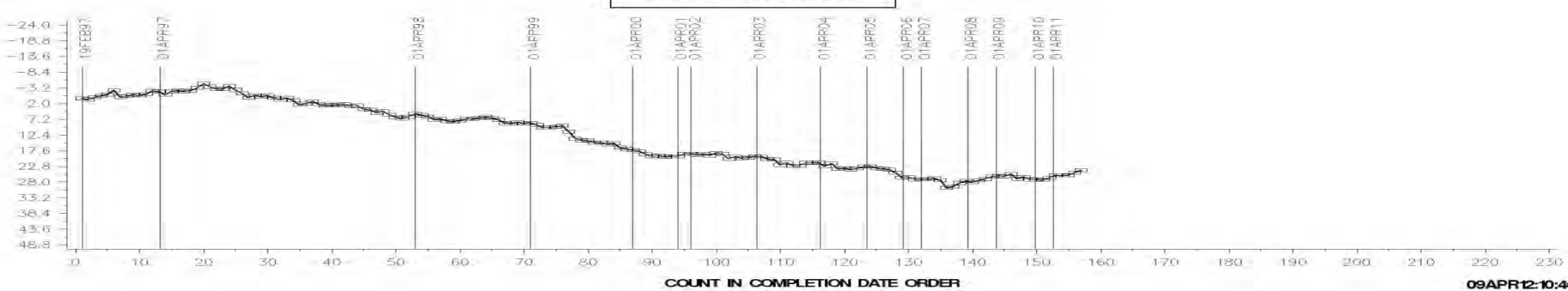
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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WEIGHTED TOTAL DEMERITS

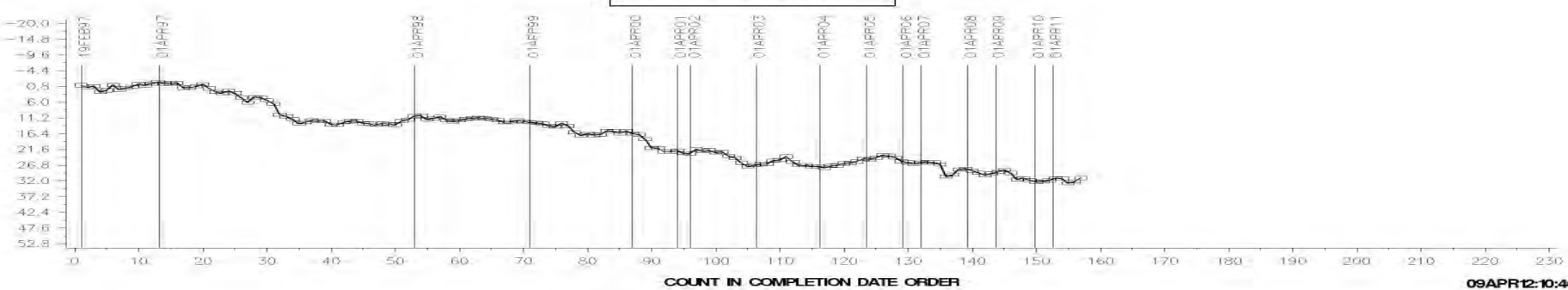
LTMS Severity Analysis



LTMS Precision Analysis



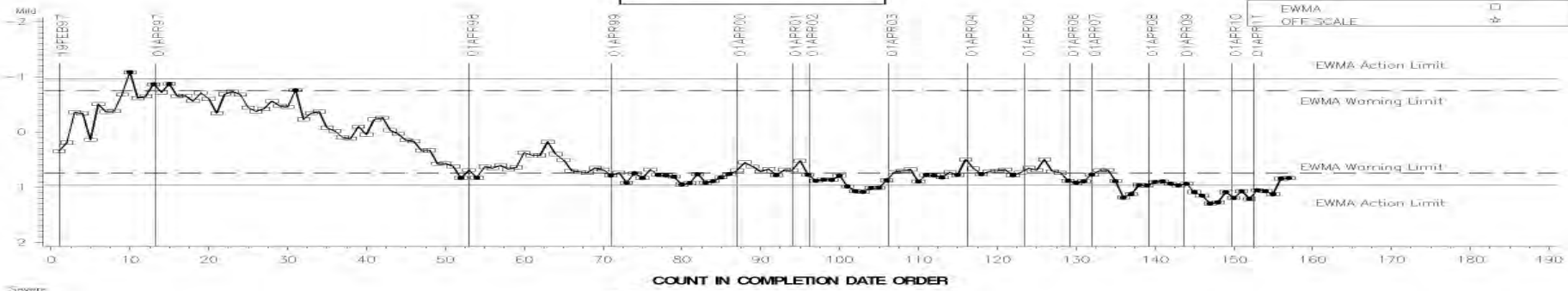
CUSUM Severity Analysis



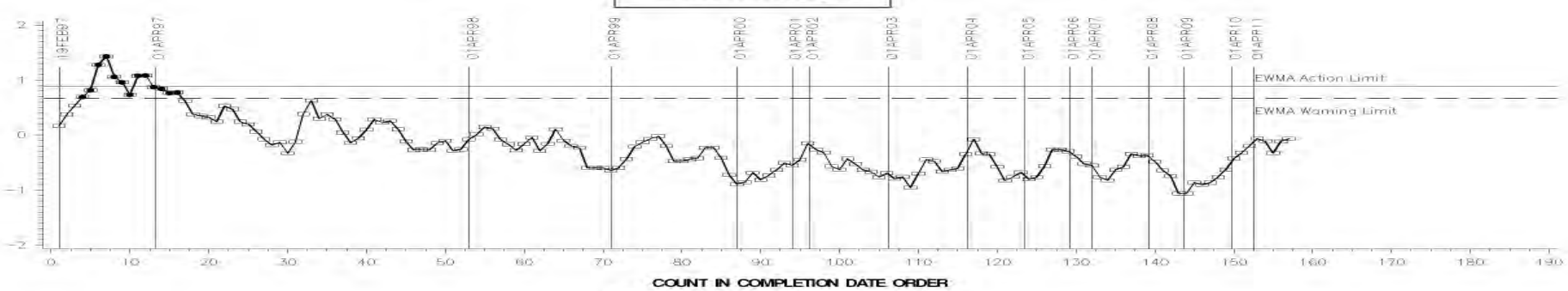
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OIL CONSUMPTION

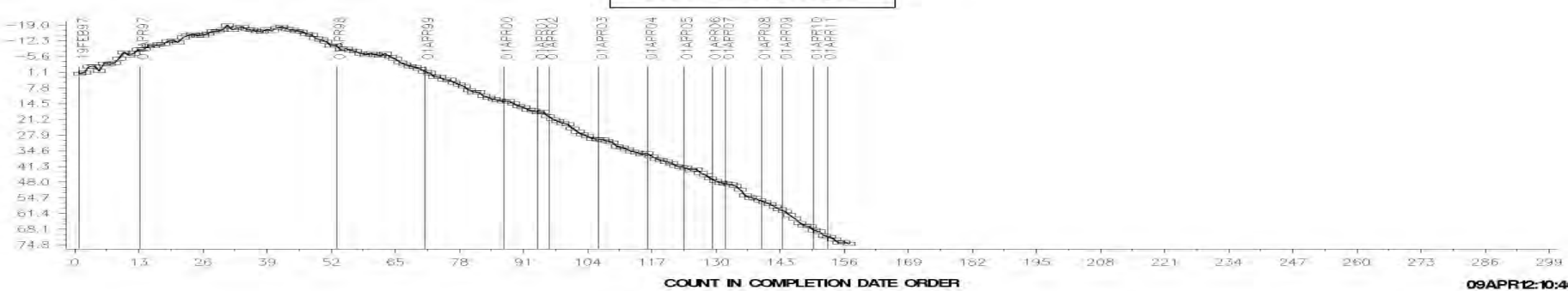
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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EOTOC

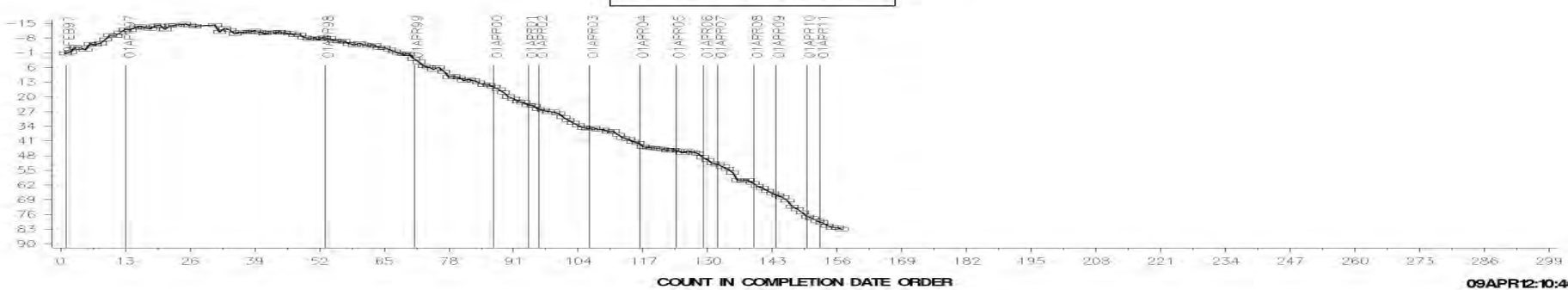
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



09APR12:10:46

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Appendix 1.e

1 R Control Charts

» Severity, Precision, and CuSum

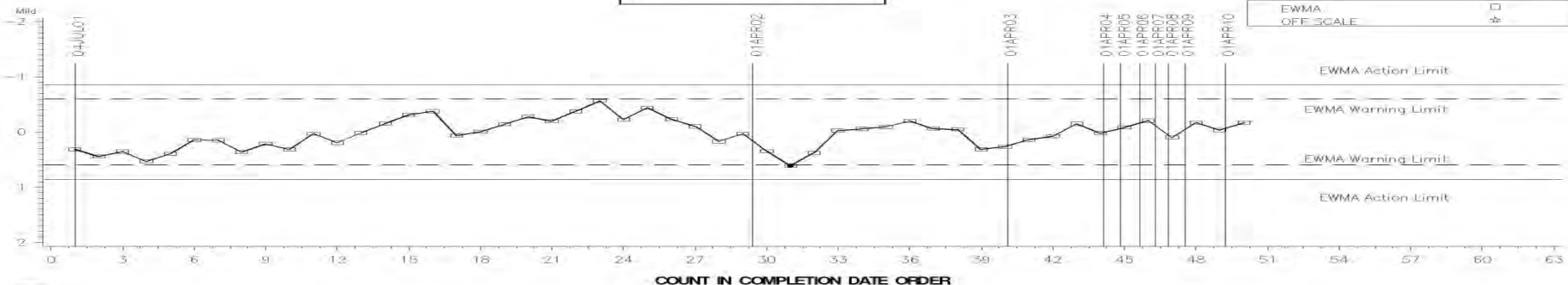
Test Monitoring Center

<http://astmtmc.cmu.edu>

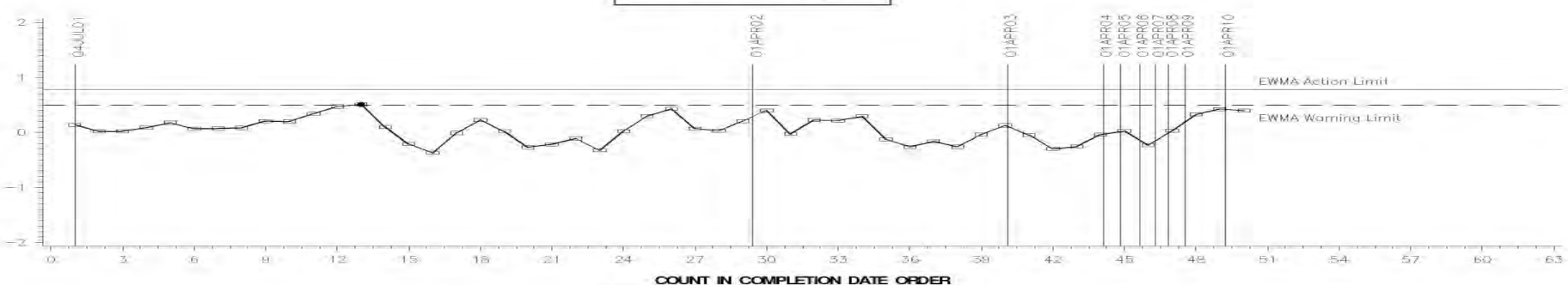


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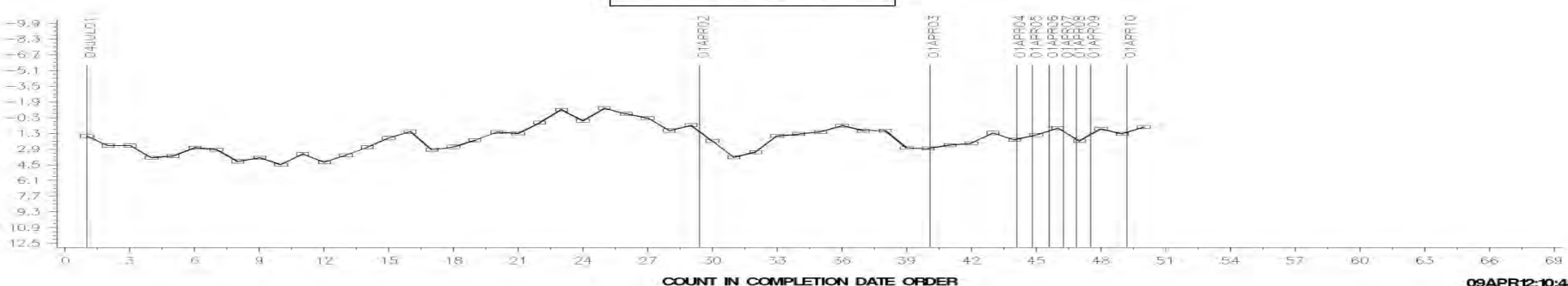
LTMS Severity Analysis



LTMS Precision Analysis

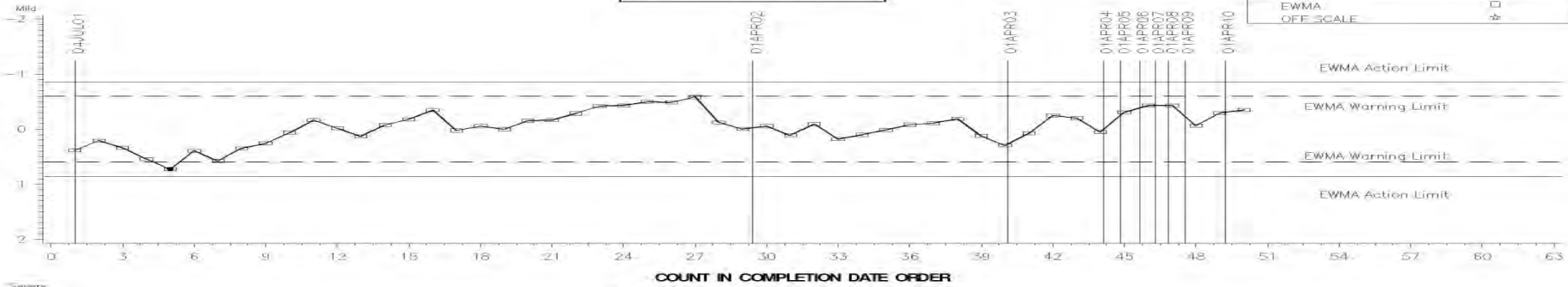


CUSUM Severity Analysis

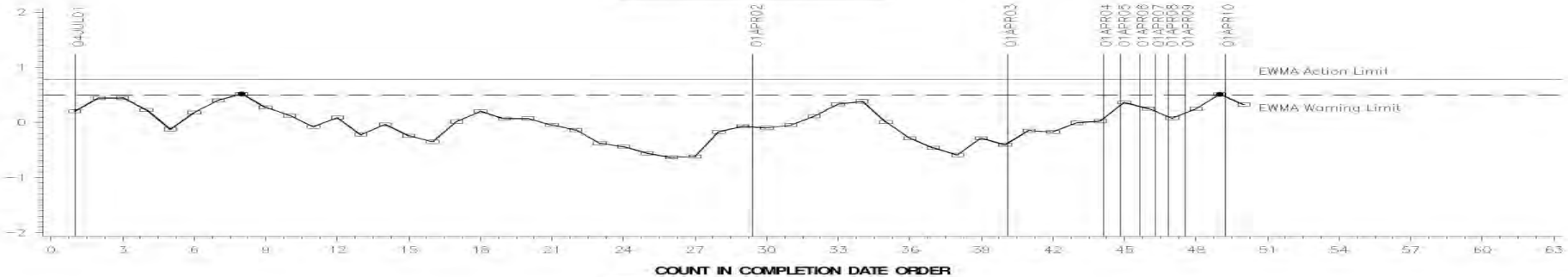


09APR12:10:48

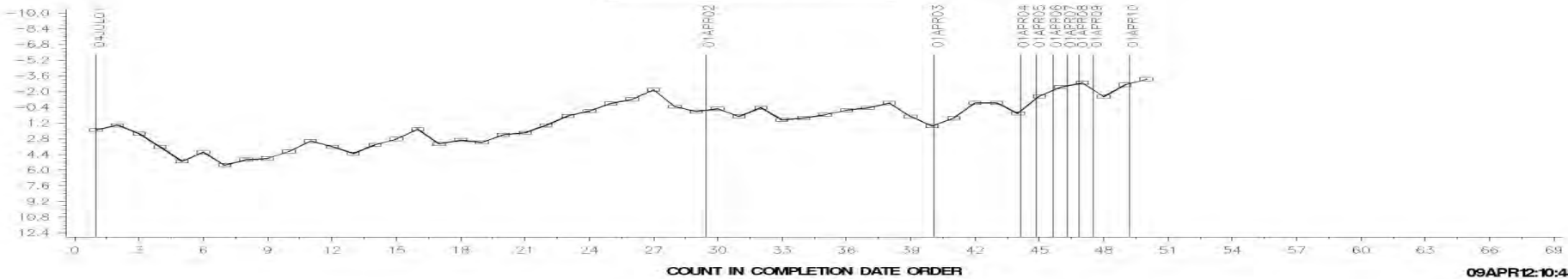
LTMS Severity Analysis



LTMS Precision Analysis

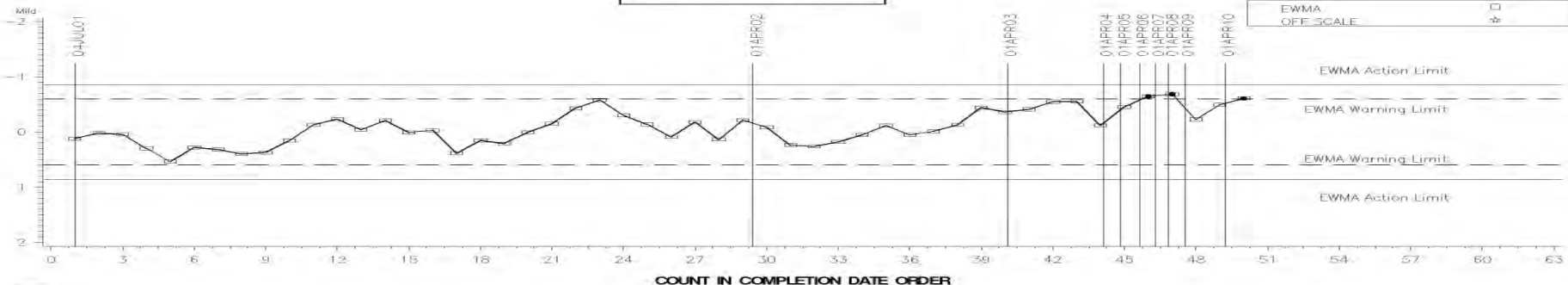


CUSUM Severity Analysis

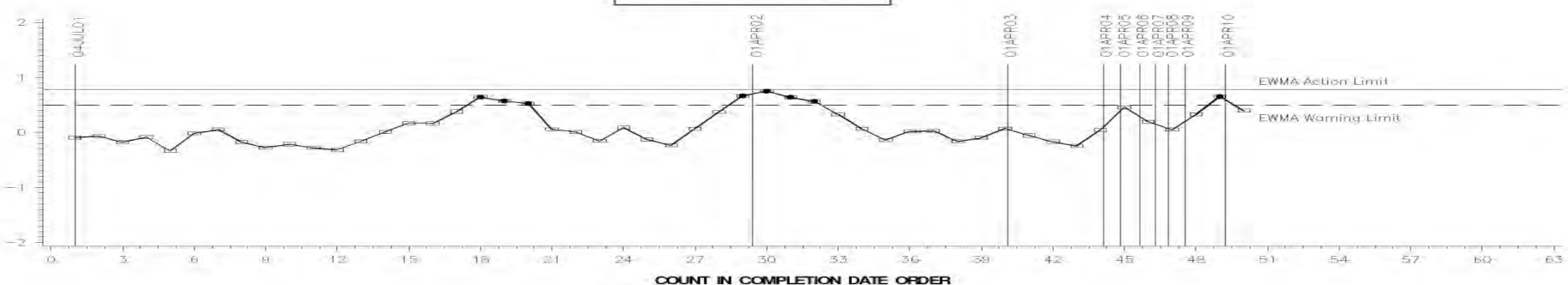


09APR12:10:48

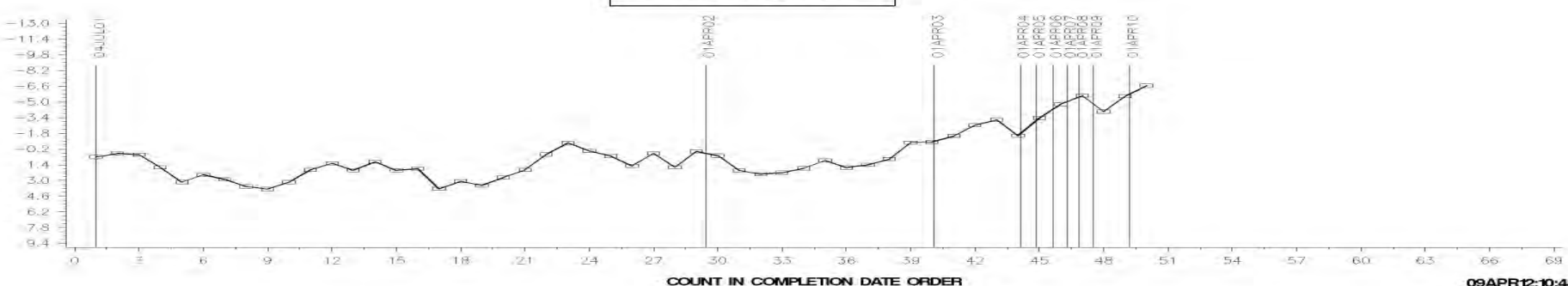
LTMS Severity Analysis



LTMS Precision Analysis



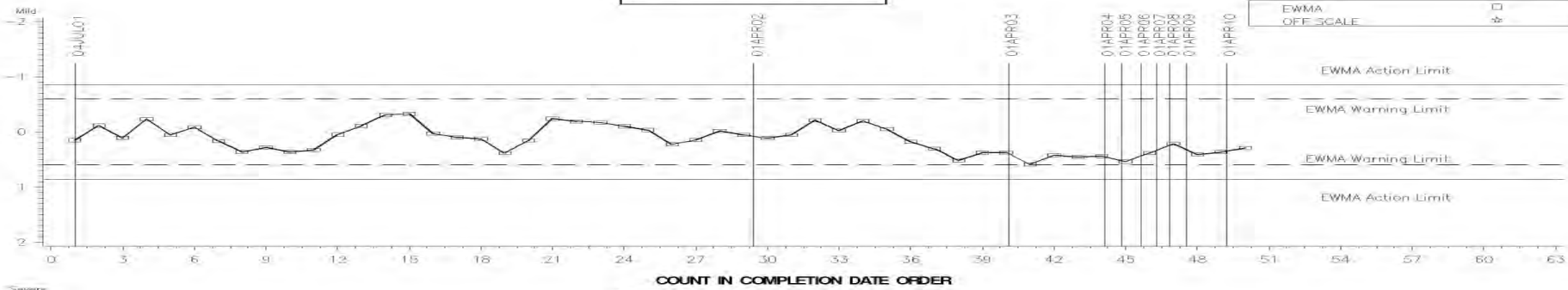
CUSUM Severity Analysis



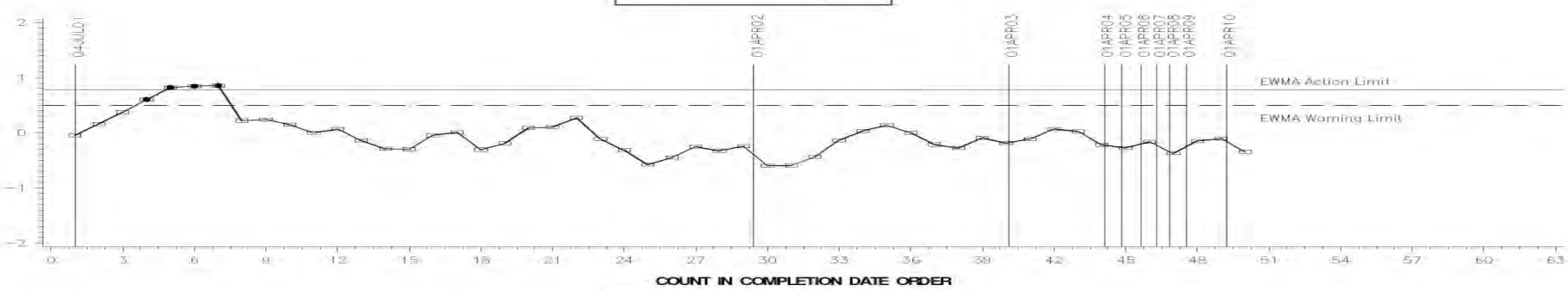
09APR12:10:48

FINAL BOTOC

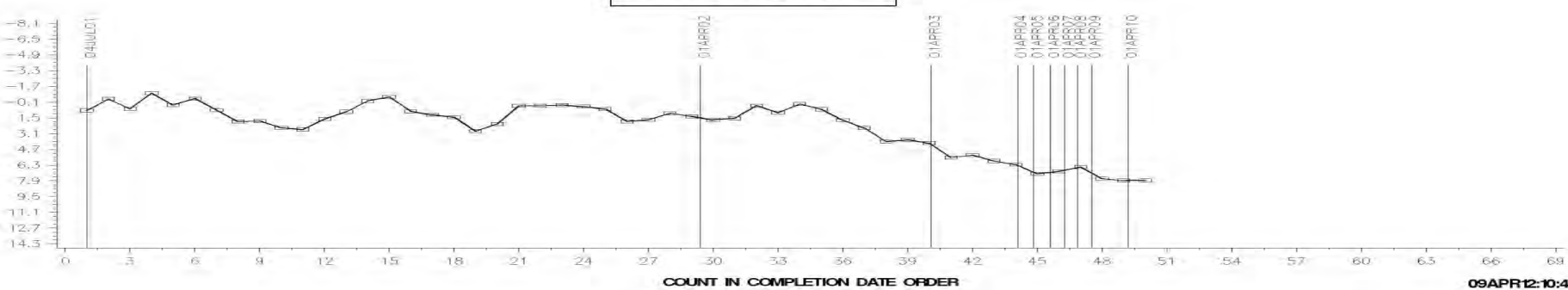
LTMS Severity Analysis



LTMS Precision Analysis



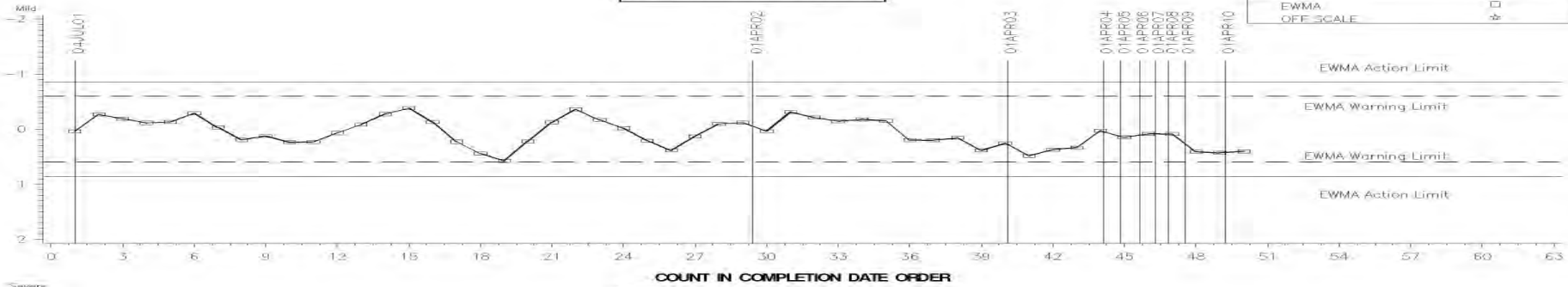
CUSUM Severity Analysis



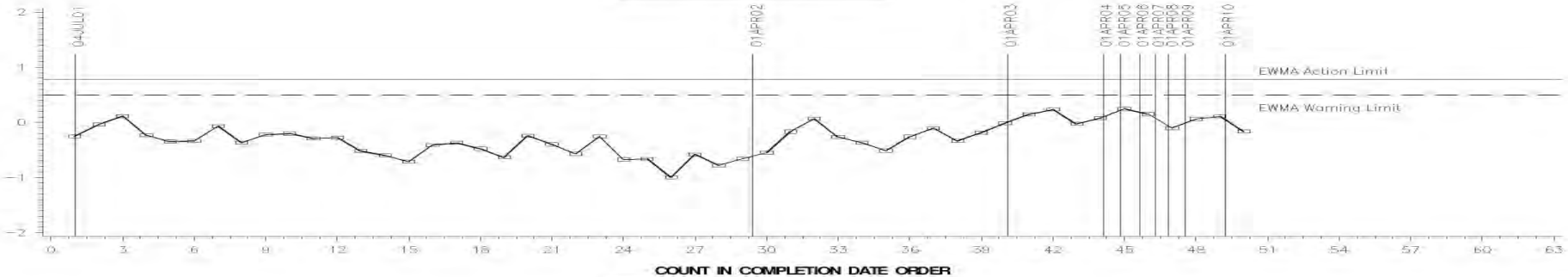
09APR12:10:48

FINAL EOTC (g/h)

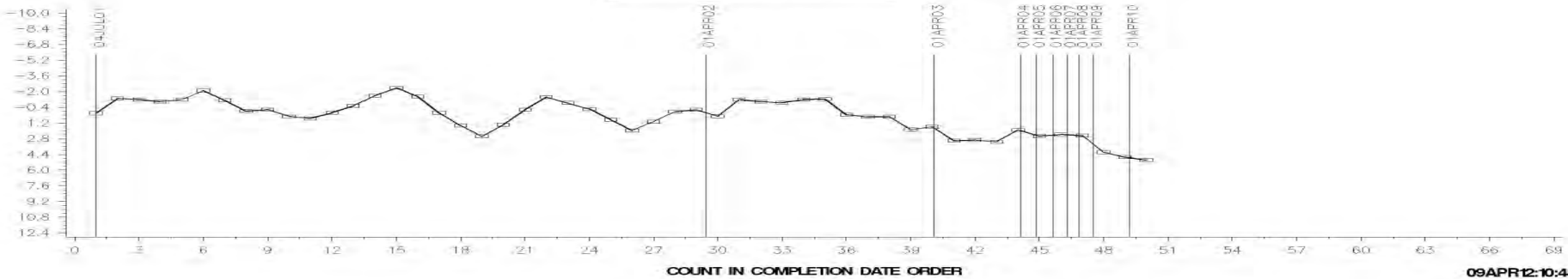
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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Appendix 1.f

C13 Control Charts

» Severity and CuSum

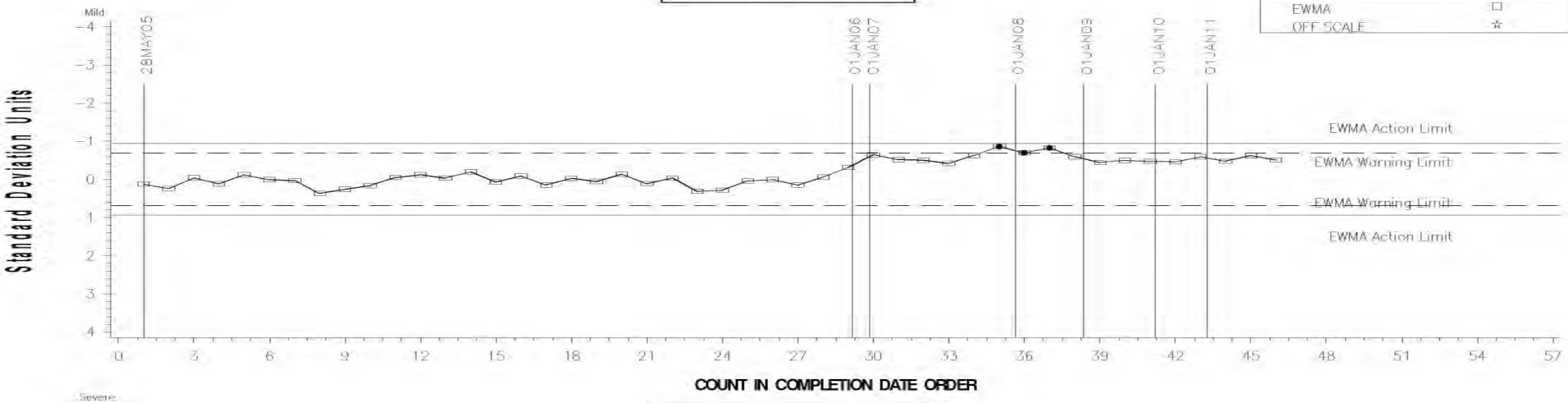
Test Monitoring Center

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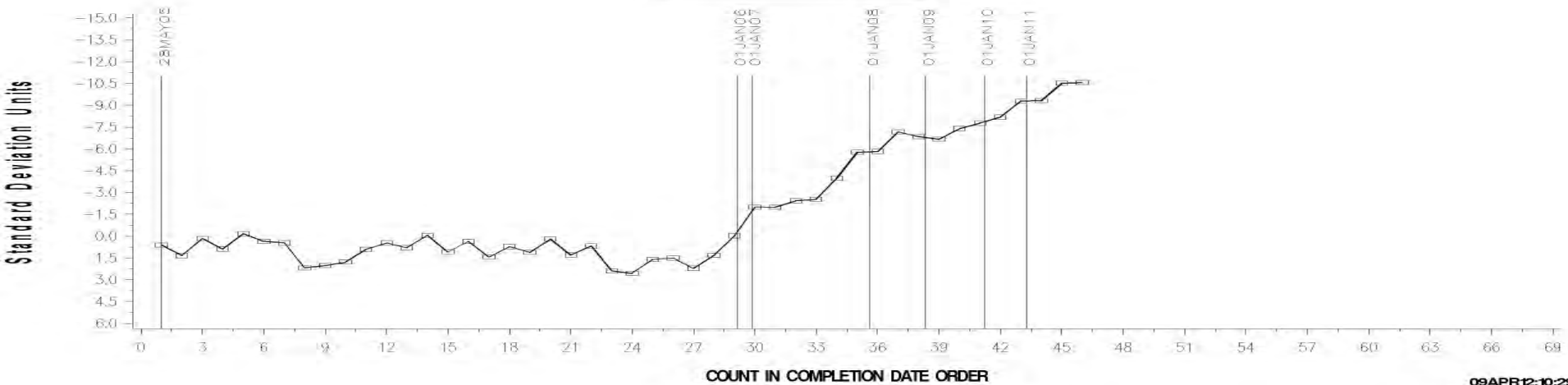


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LTMS Severity Analysis



CUSUM Severity Analysis

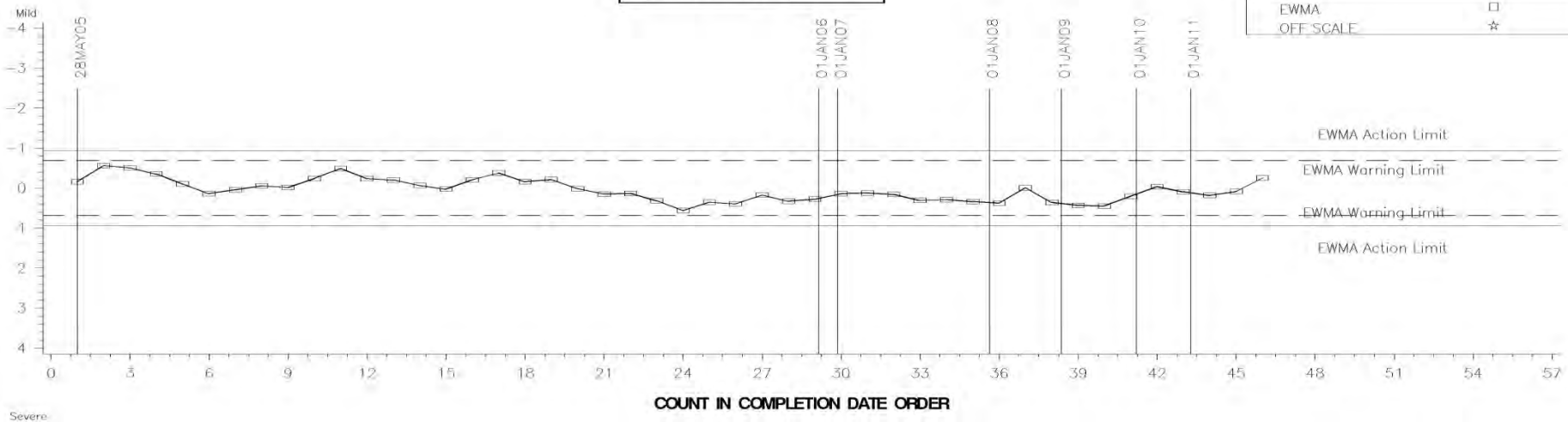


09APR12:10:29

C-13 INDUSTRY OPERATIONALLY VALID DATA
 TOP GROOVE CARBON AVG — FINAL RESULT

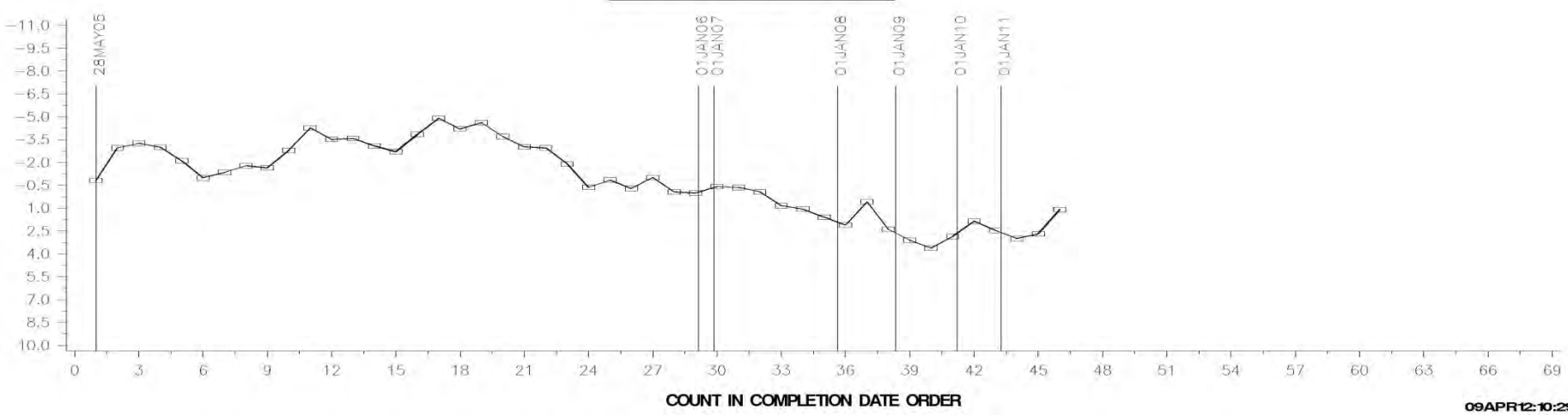
Standard Deviation Units

LTMS Severity Analysis



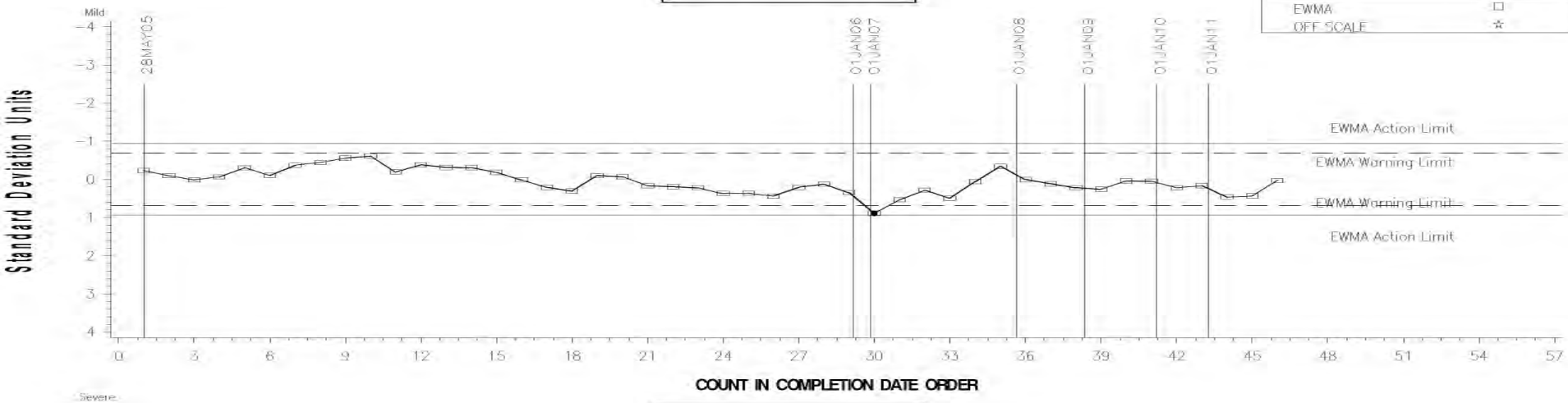
Standard Deviation Units

CUSUM Severity Analysis

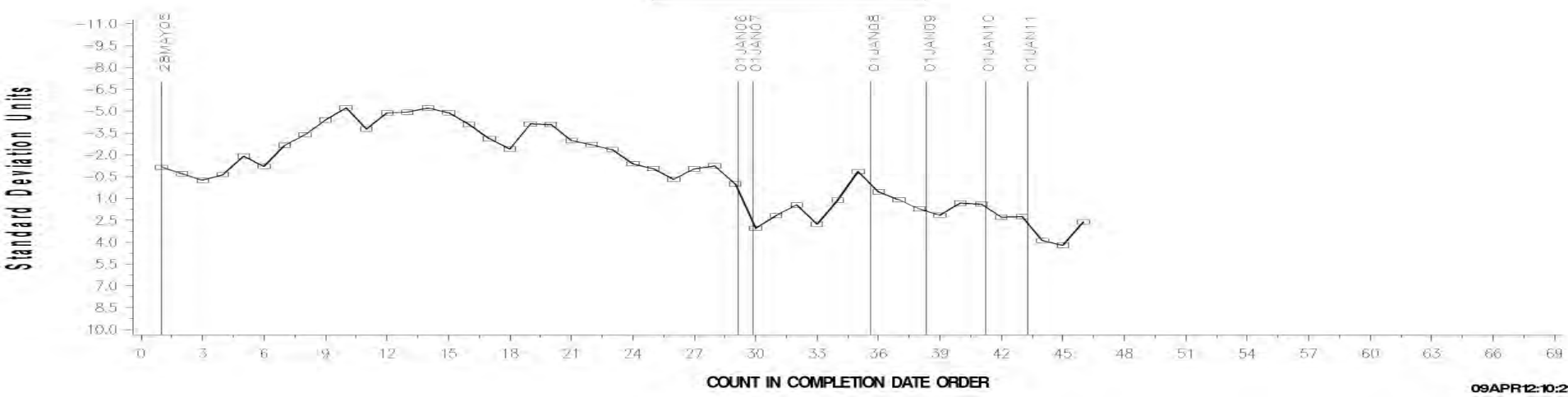


09APR12:10:29

LTMS Severity Analysis



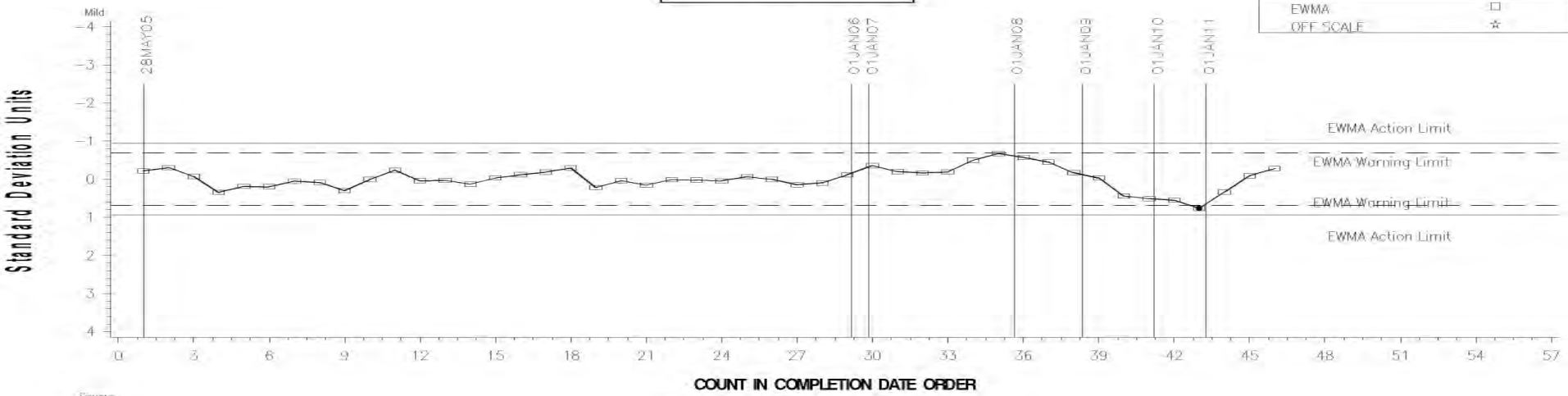
CUSUM Severity Analysis



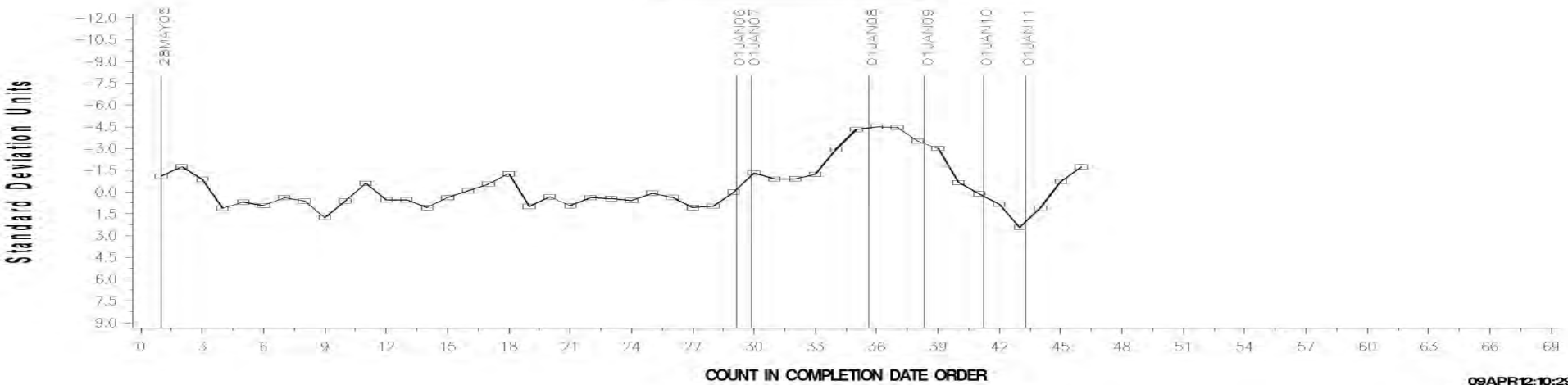
09APR12:10:29

OIL CONS. DELTA — FINAL RESULT

LTMS Severity Analysis



CUSUM Severity Analysis



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Appendix 1.g

ISB Control Charts

» Severity and CuSum

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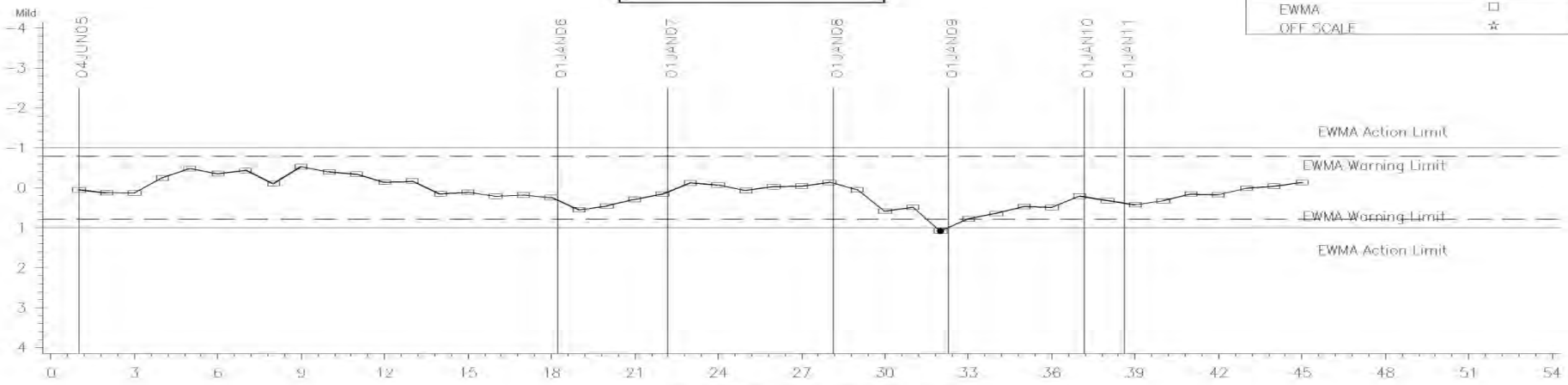


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AVERAGE CAMSHAFT WEAR

Standard Deviation Units

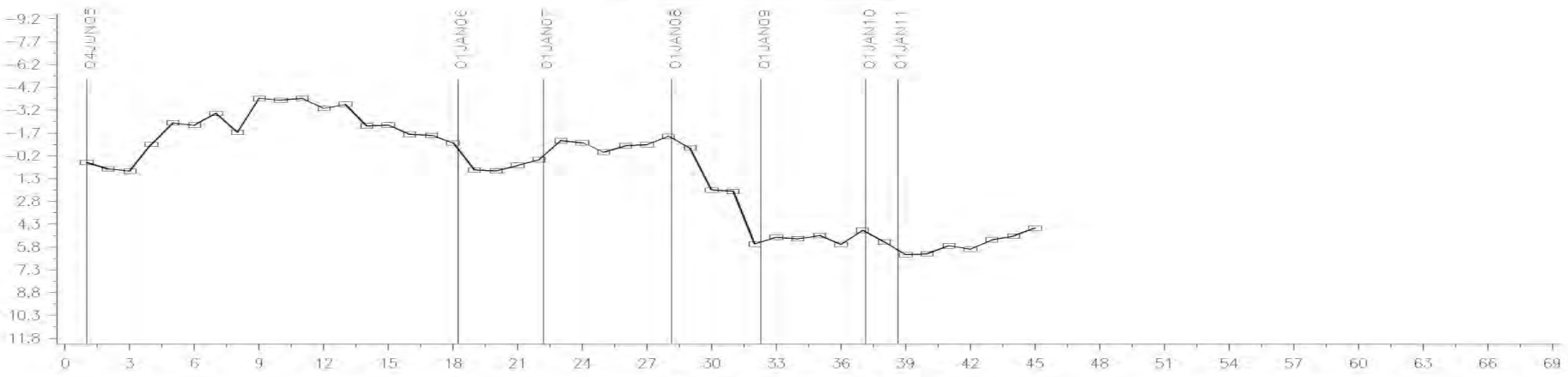
LTMS Severity Analysis



COUNT IN COMPLETION DATE ORDER

Standard Deviation Units

CUSUM Severity Analysis

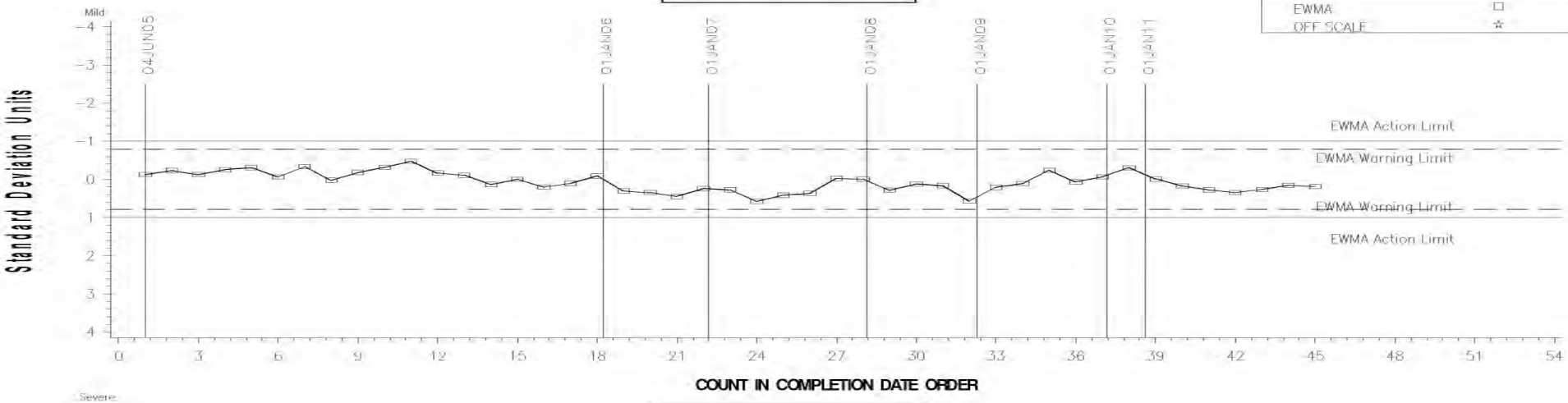


COUNT IN COMPLETION DATE ORDER

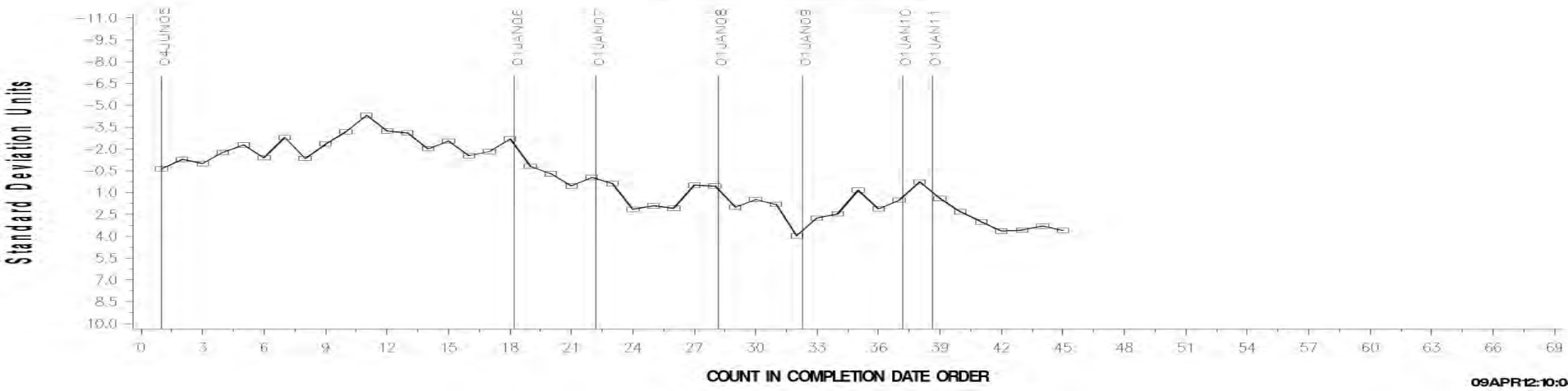
09APR12:10:04

AVERAGE TAPPET WEIGHT LOSS

LTMS Severity Analysis



CUSUM Severity Analysis



09APR12:10:04

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Appendix 1.h

ISM Control Charts

» Severity and CuSum

Test Monitoring Center

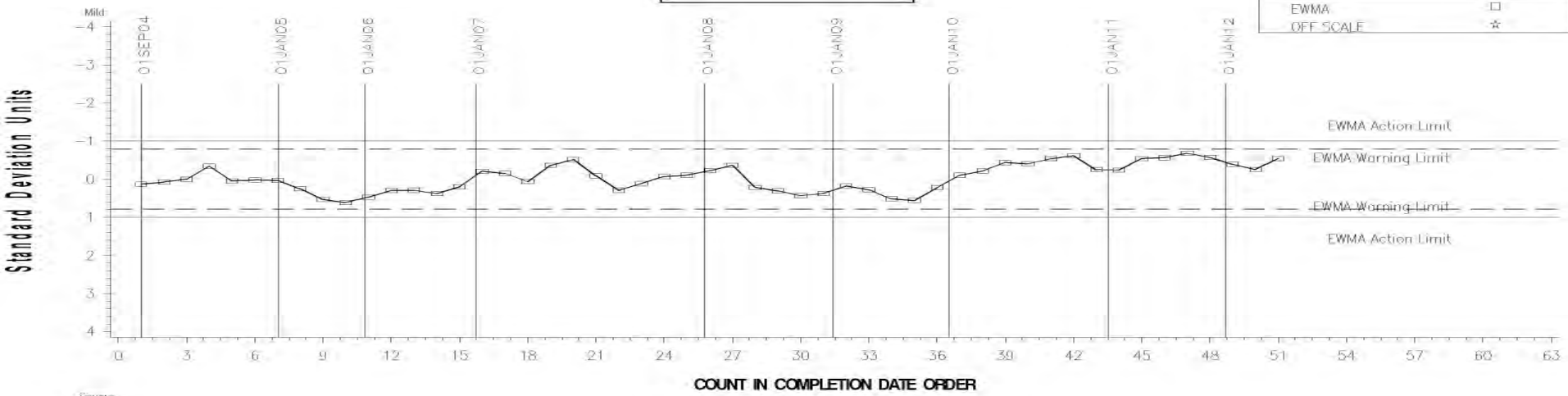
<http://astmtmc.cmu.edu>



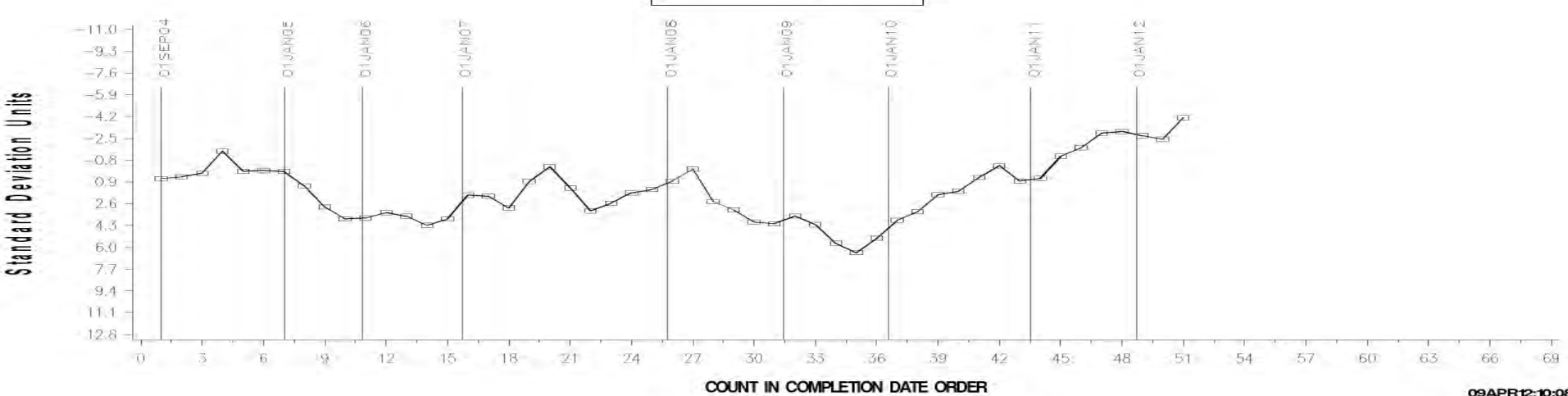
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CROSSHEAD WEIGHT LOSS ADJUSTED TO 3.9 % SOOT

LTMS Severity Analysis



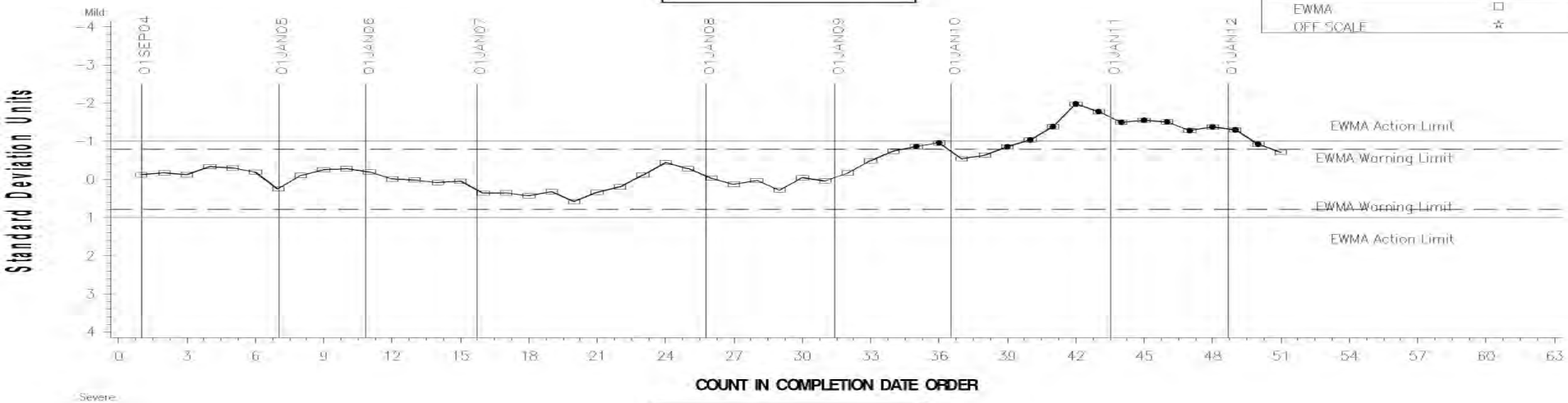
CUSUM Severity Analysis



09APR12:10:08

FILTER PLUGGING DELTA P

LTMS Severity Analysis



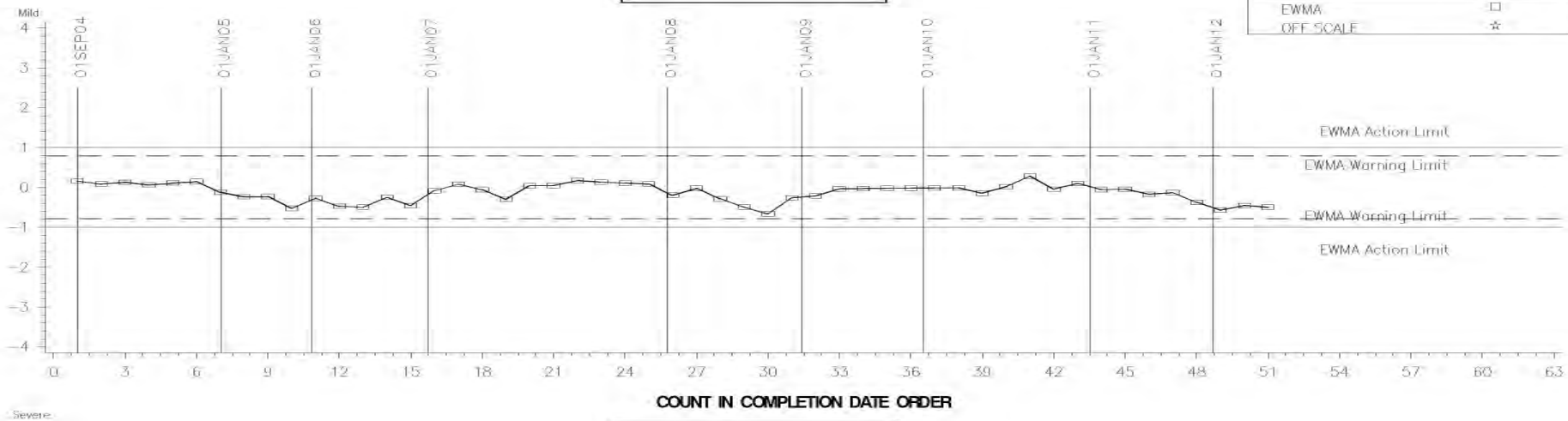
CUSUM Severity Analysis



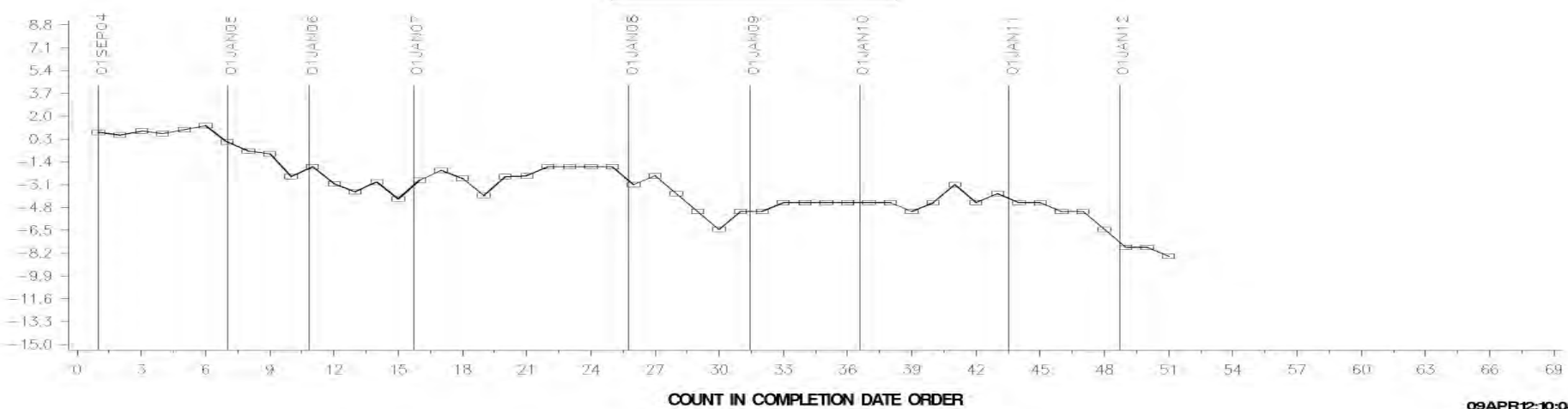
09APR12:10:08

AVERAGE SLUDGE RATING

LTMS Severity Analysis



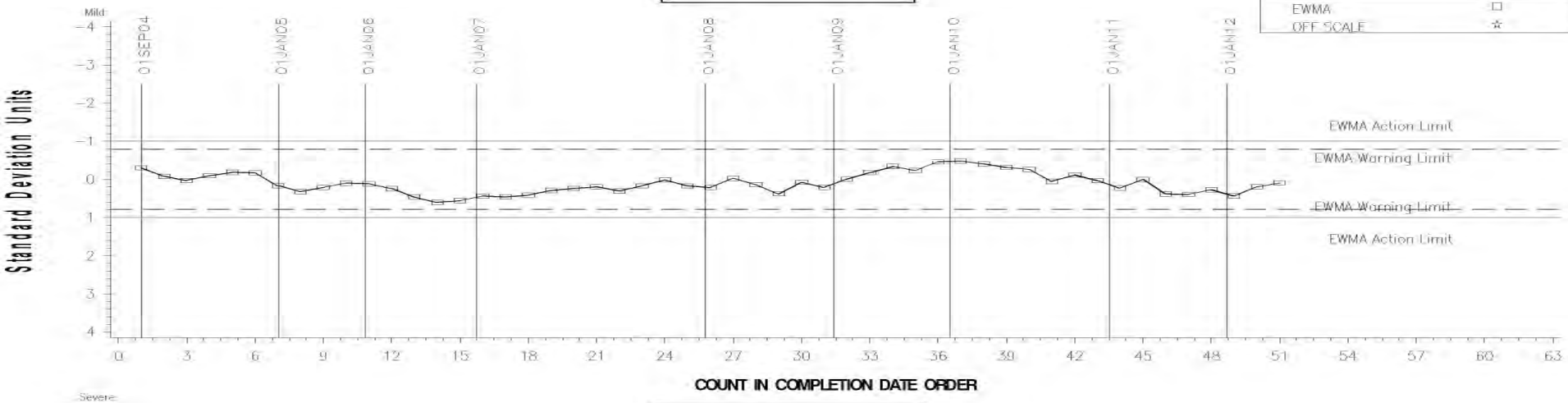
CUSUM Severity Analysis



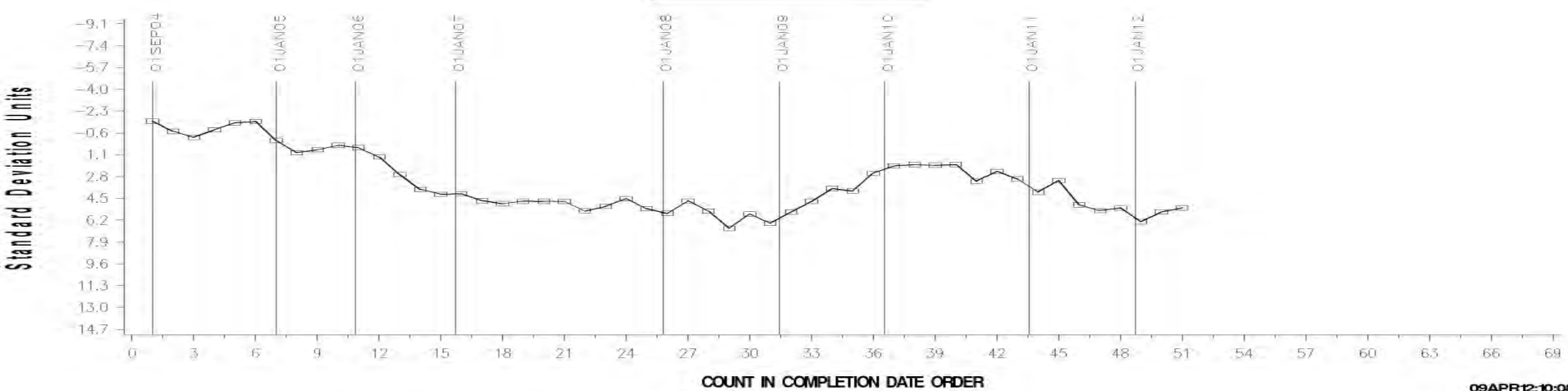
09APR12:10:08

INJECTOR SCREW WEIGHT LOSS ADJUSTED TO 3.9% SOOT

LTMS Severity Analysis



CUSUM Severity Analysis



09APR12:10:08

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Appendix 1.i

EOAT Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

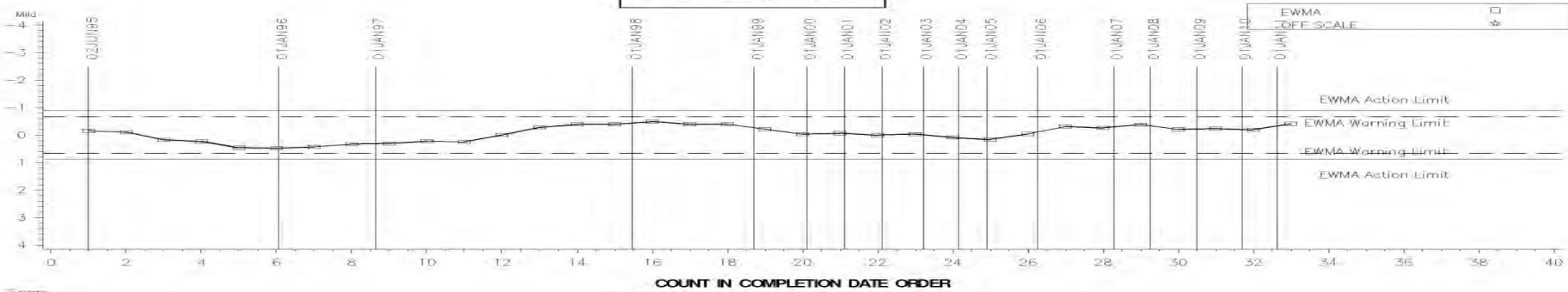
<http://astmtmc.cmu.edu>



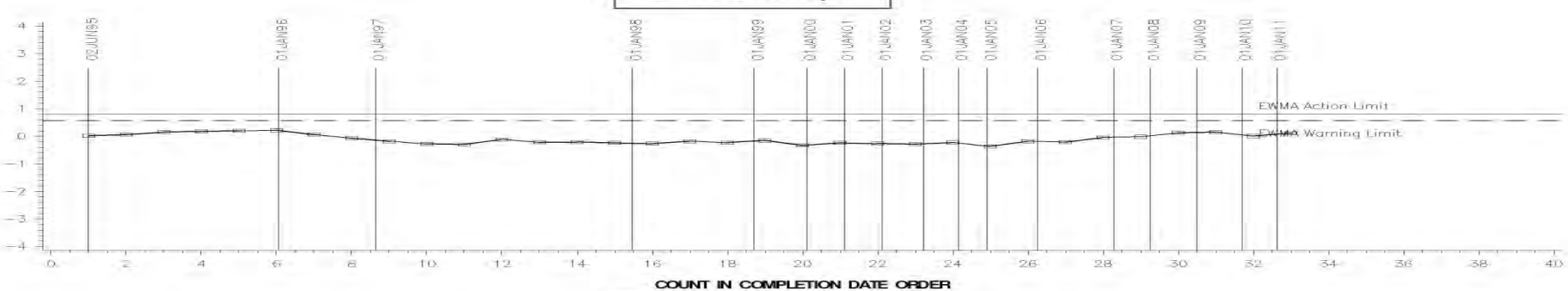
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ENGINE OIL AERATION

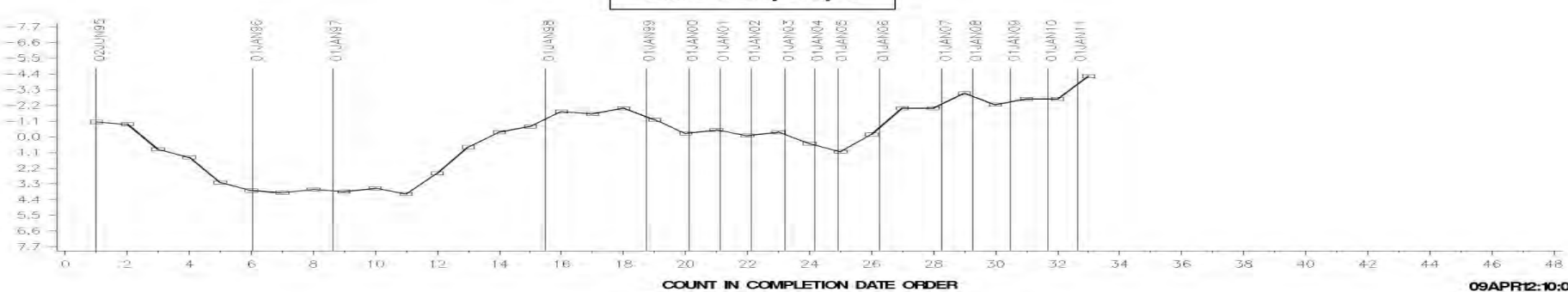
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



09APR12:10:01

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Appendix 1.j

RFWT Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

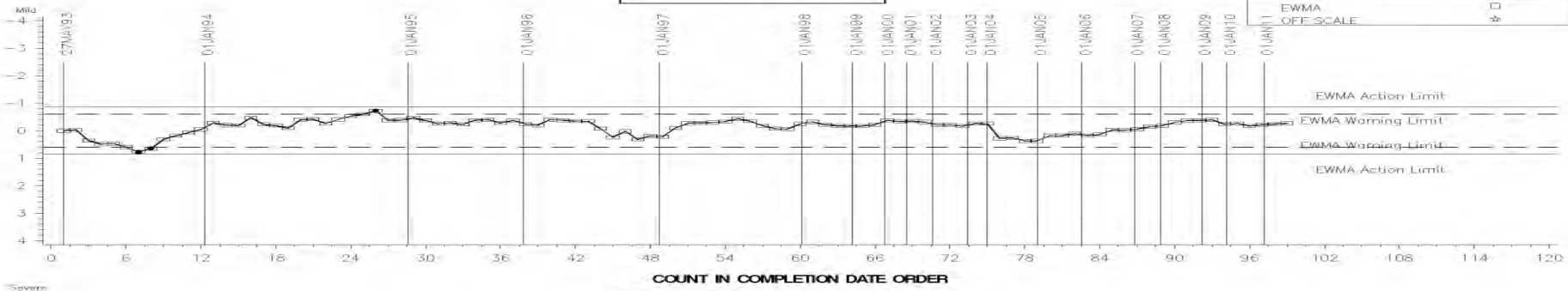
<http://astmtmc.cmu.edu>



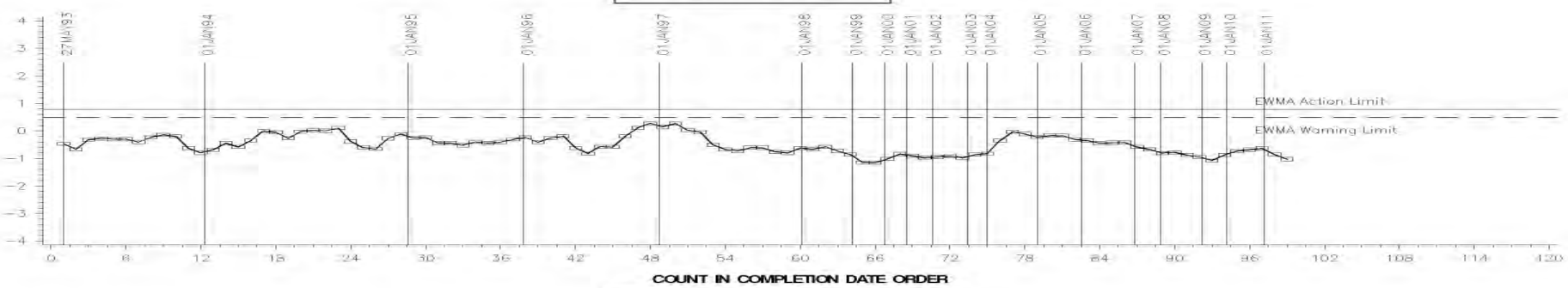
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Average Follower Wear

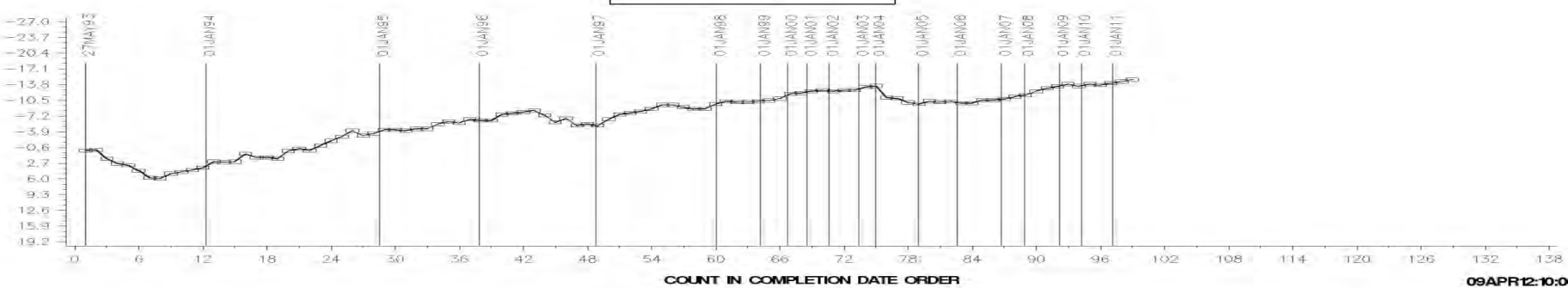
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



09APR12:10:00

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Appendix 1.k

T-8/T-8E Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

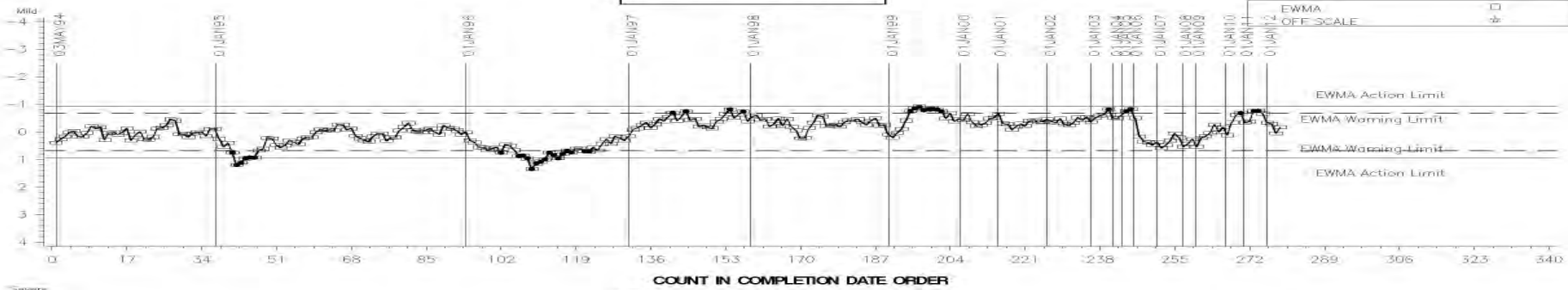
<http://astmtmc.cmu.edu>



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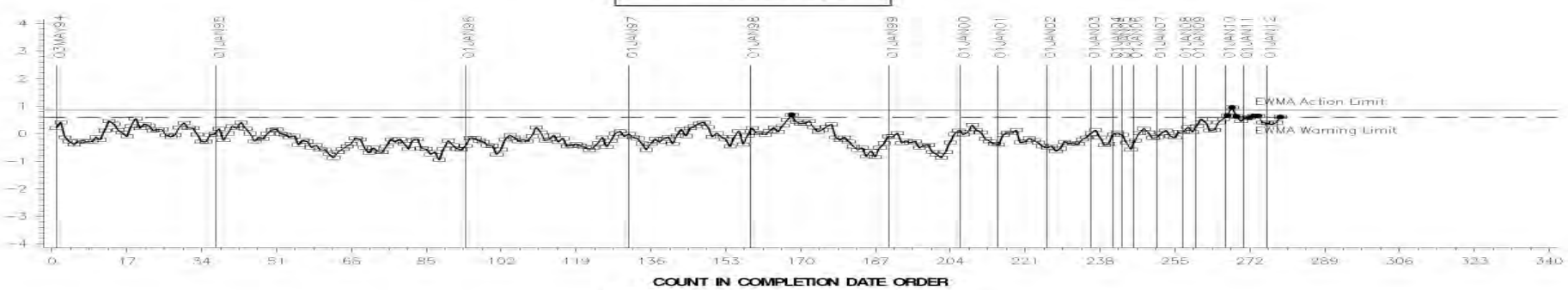
LTMS Severity Analysis

Standard Deviation Units



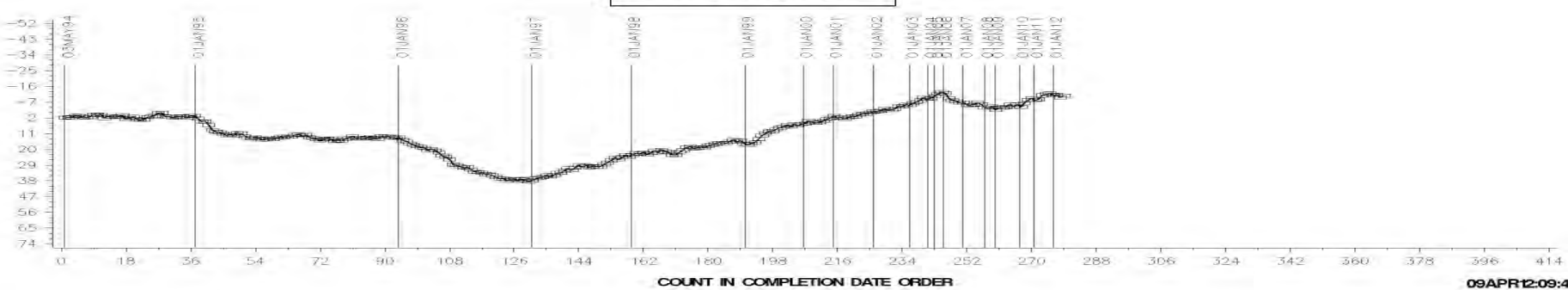
LTMS Precision Analysis

Standard Deviation Units



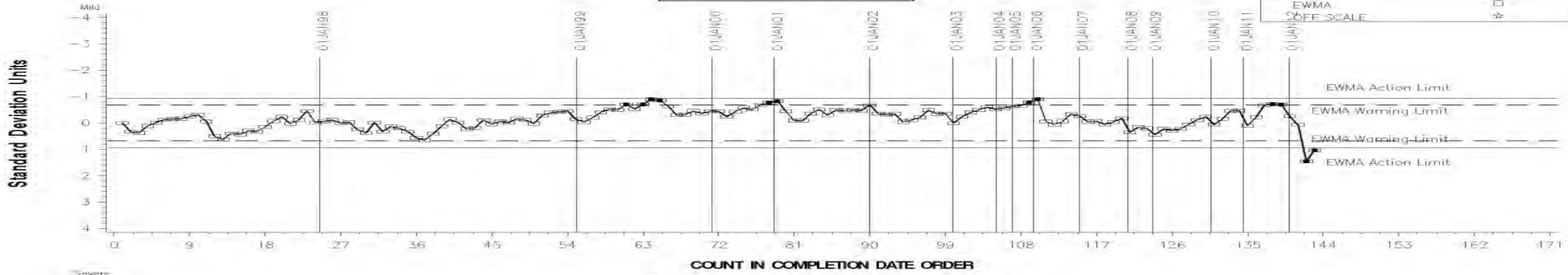
CUSUM Severity Analysis

Standard Deviation Units

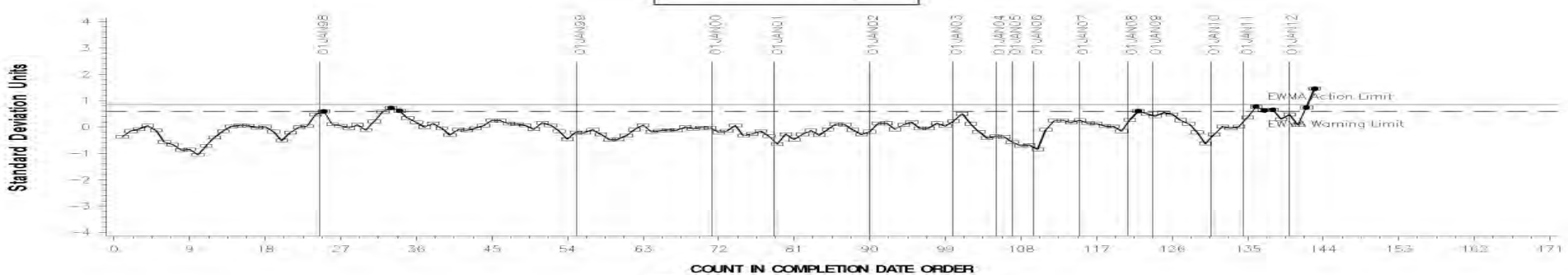


09APR12:09:41

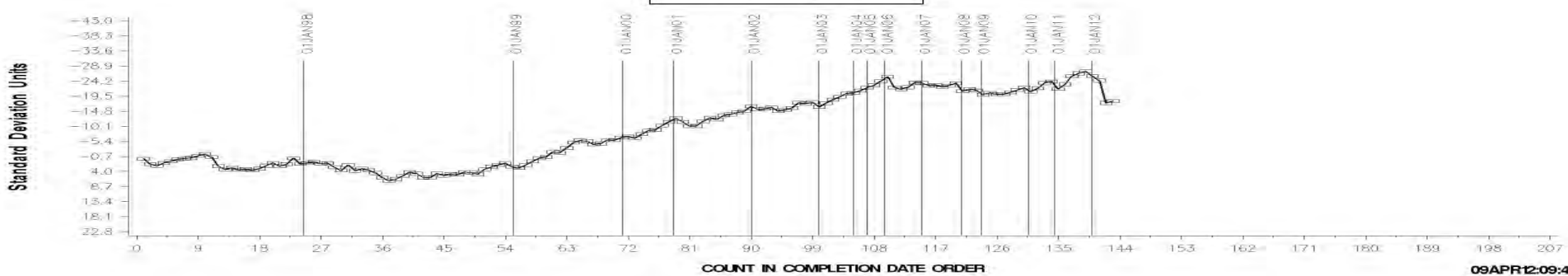
LTMS Severity Analysis



LTMS Precision Analysis

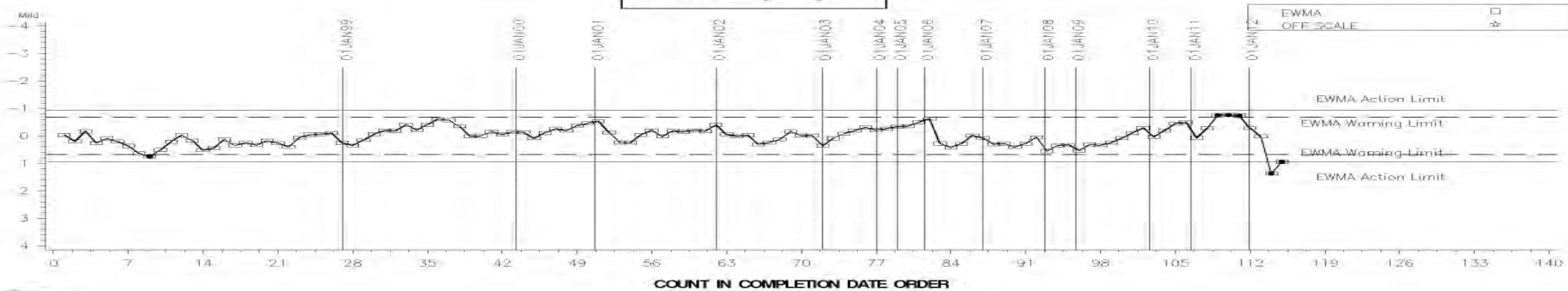


CUSUM Severity Analysis

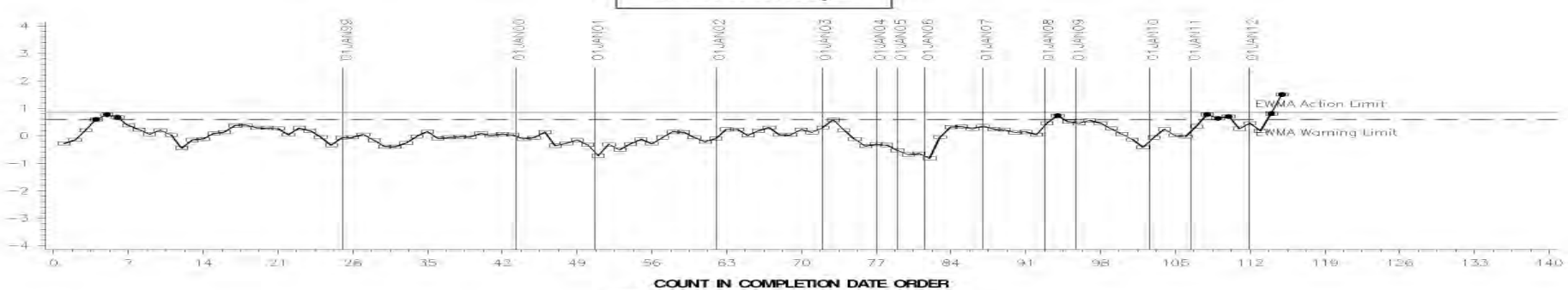


09APR12:09:41

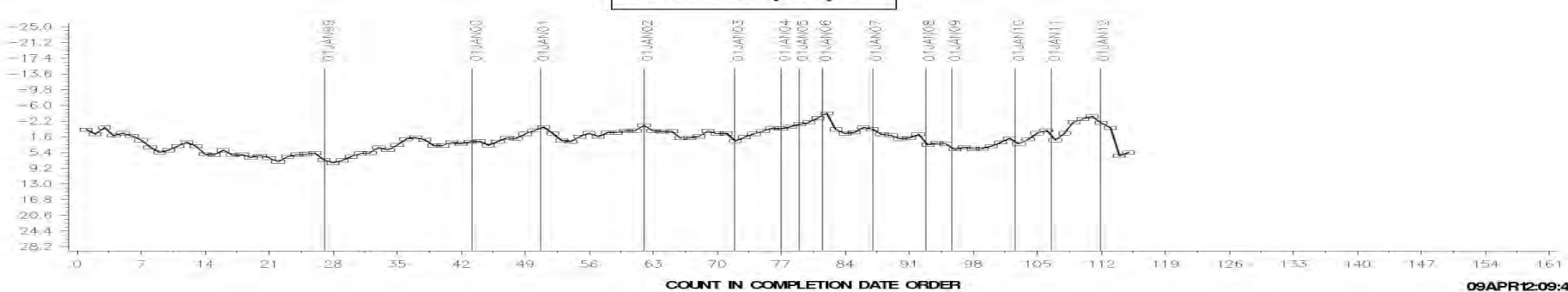
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



09APR12:09:41

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Appendix 1.1

T-10A Control Charts

» Severity, Precision, and CuSum

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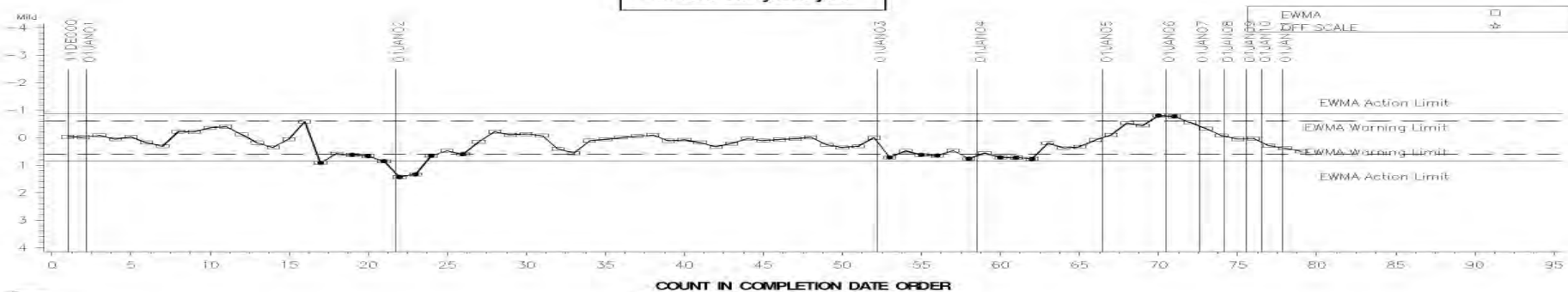
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T10A INDUSTRY OPERATIONAL VALID DATA

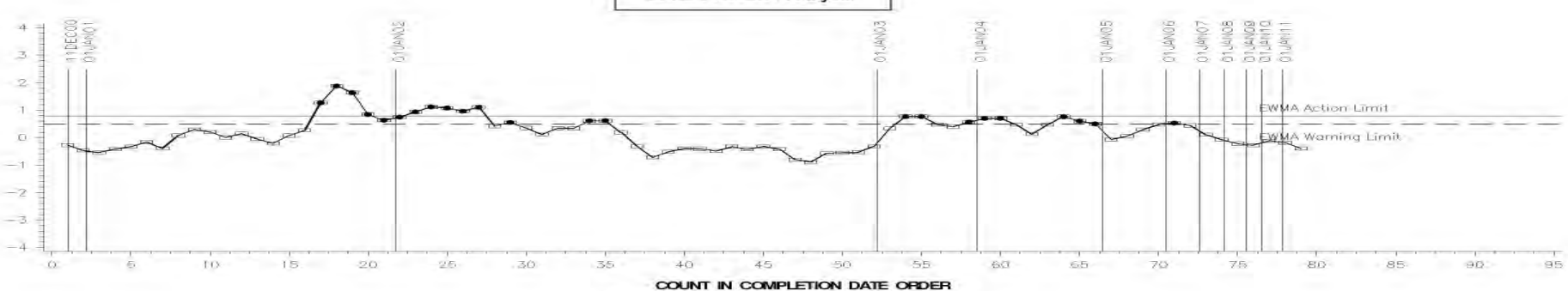
MRV VISCOSITY @ 75H



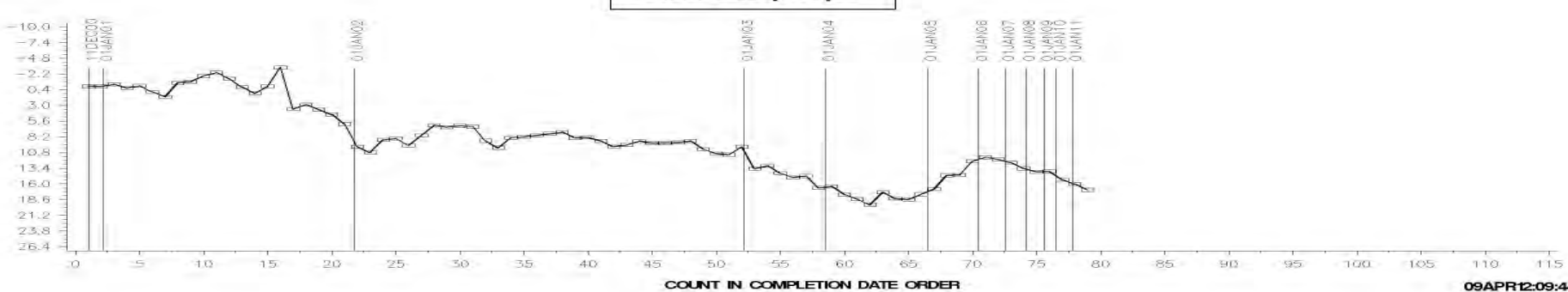
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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Appendix 1.m

T-11 Control Charts

» Severity, Precision, and CuSum

Test Monitoring Center

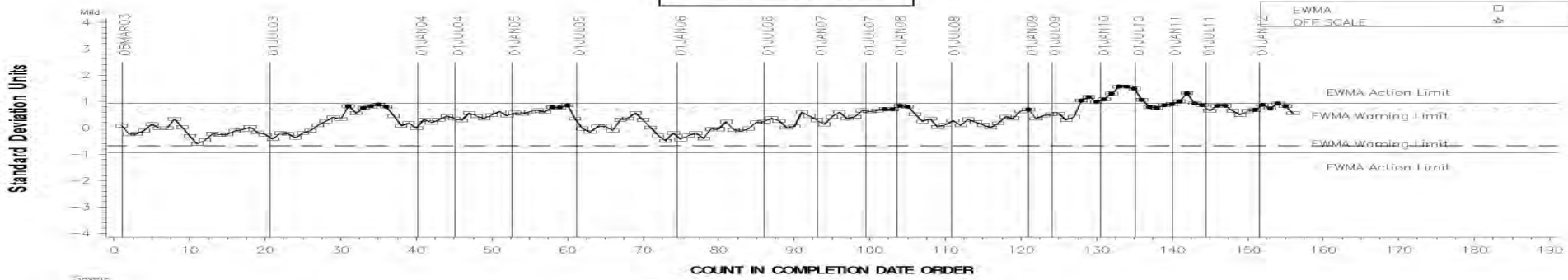
<http://astmtmc.cmu.edu>



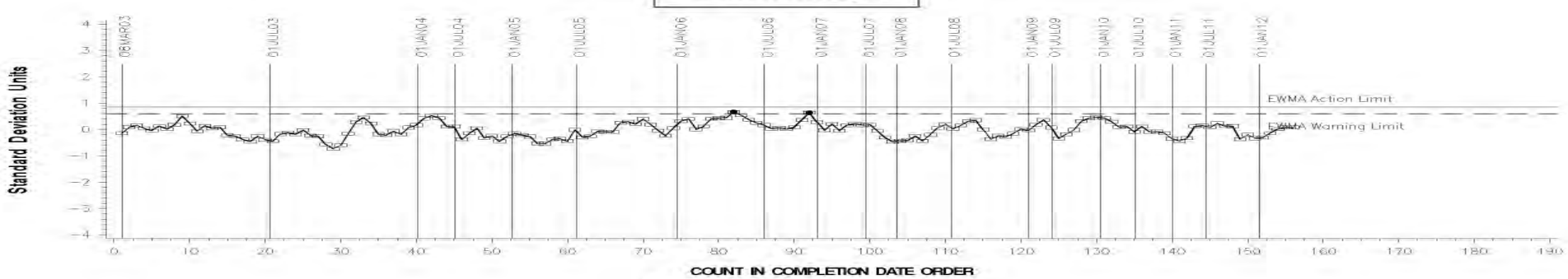
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SOOT AT 12 cSt

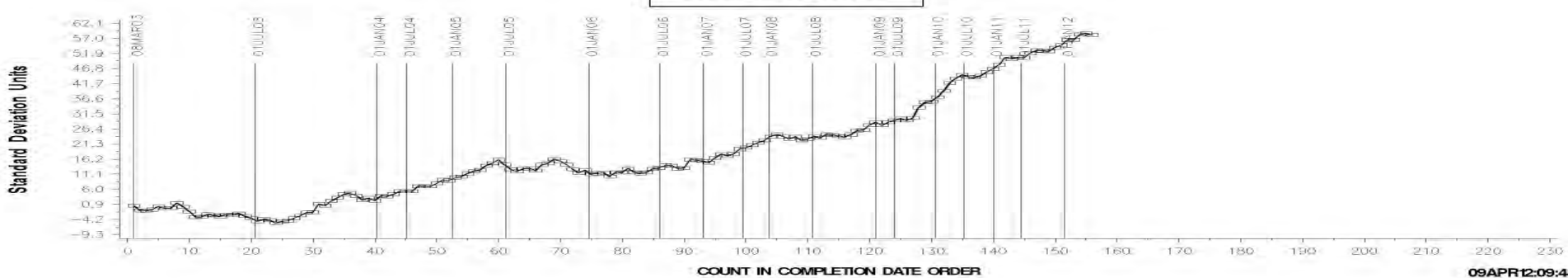
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



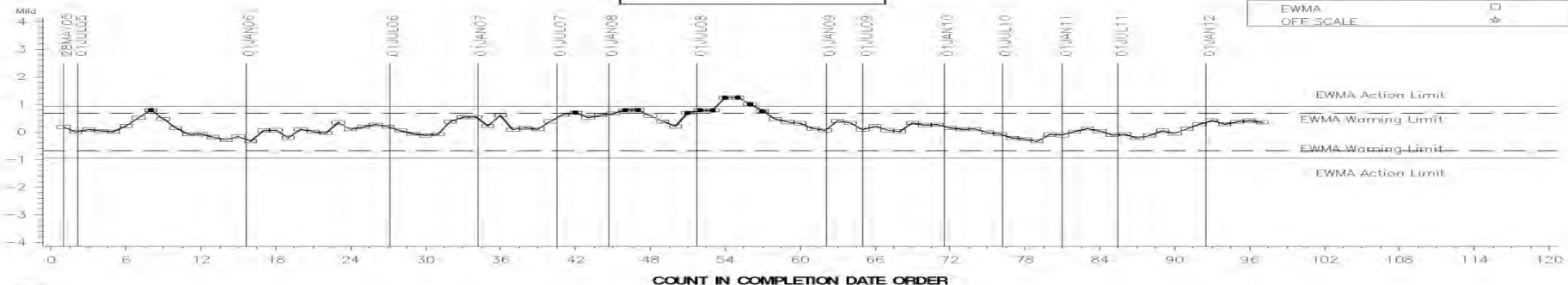
09APR12:09:48

T-11 INDUSTRY OPERATIONAL VALID DATA

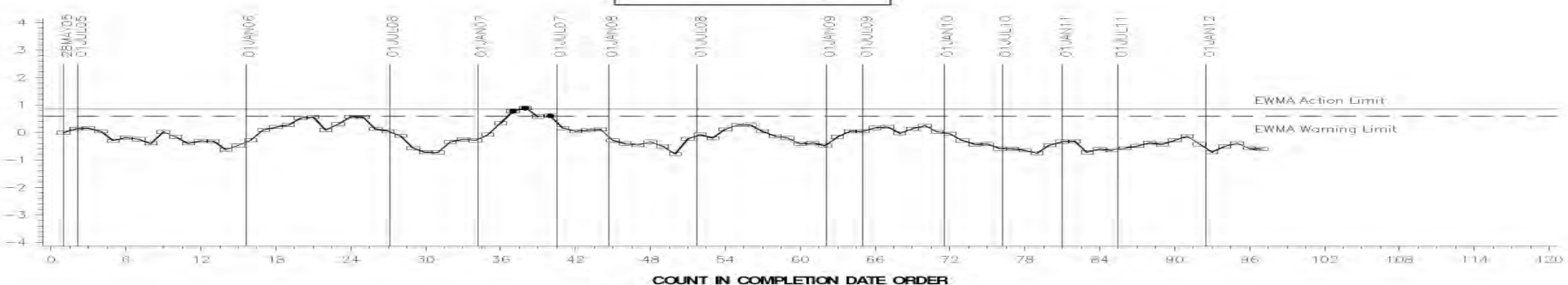
SOOT @ 4 cSt - FINAL RESULT



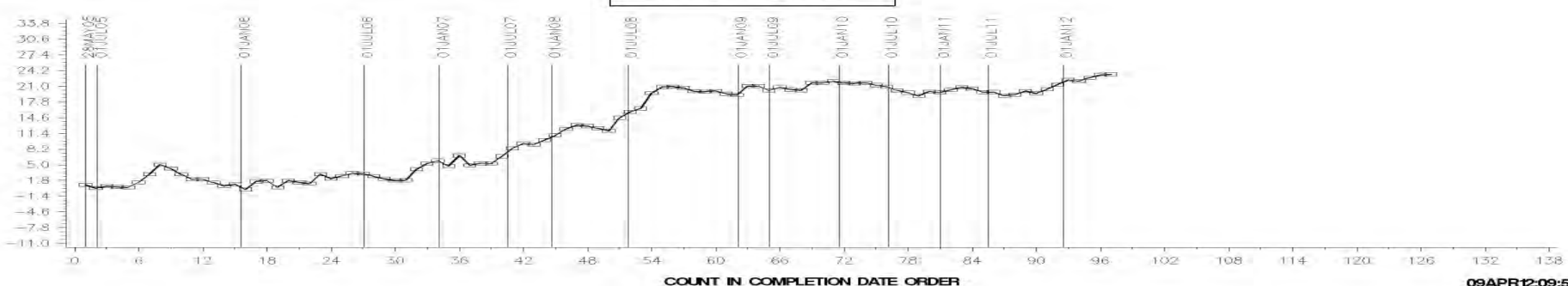
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



09APR12:09:51

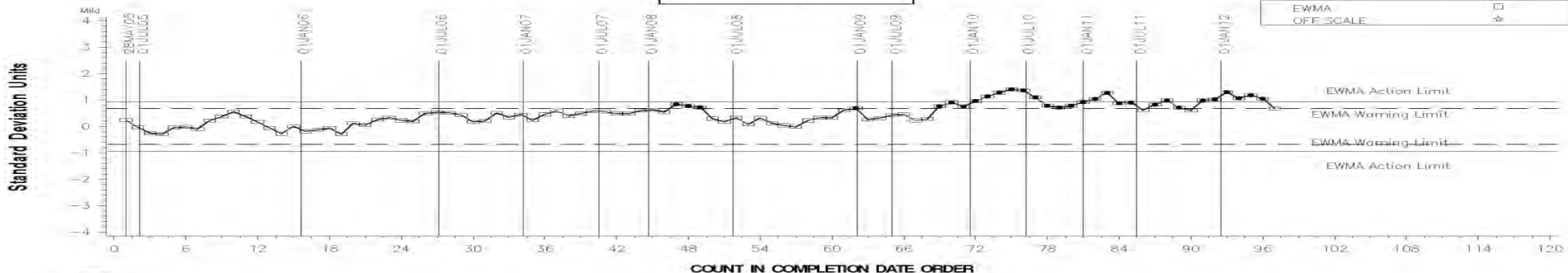


T-11 INDUSTRY OPERATIONAL VALID DATA

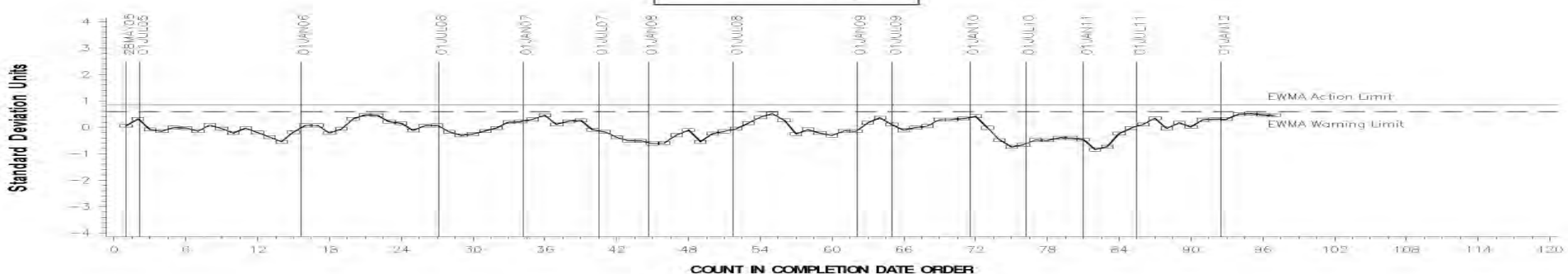
SOOT @ 15 cSt - FINAL RESULT



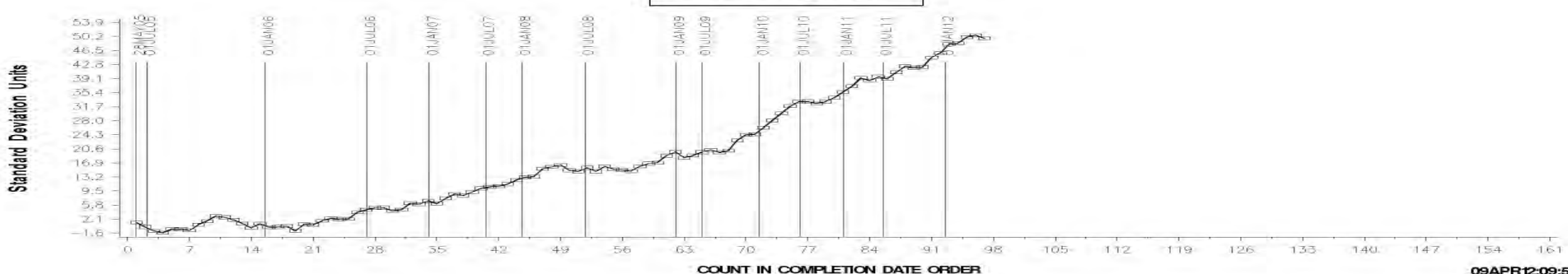
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

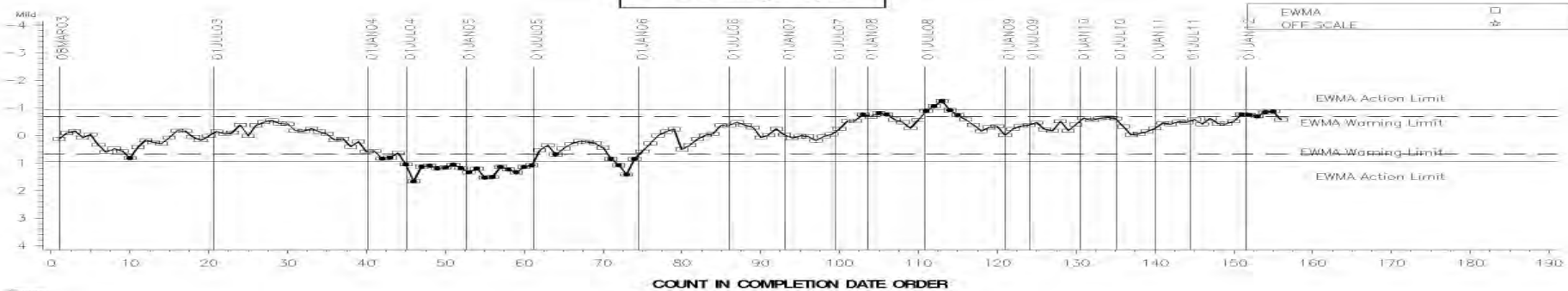


09APR12:09:51

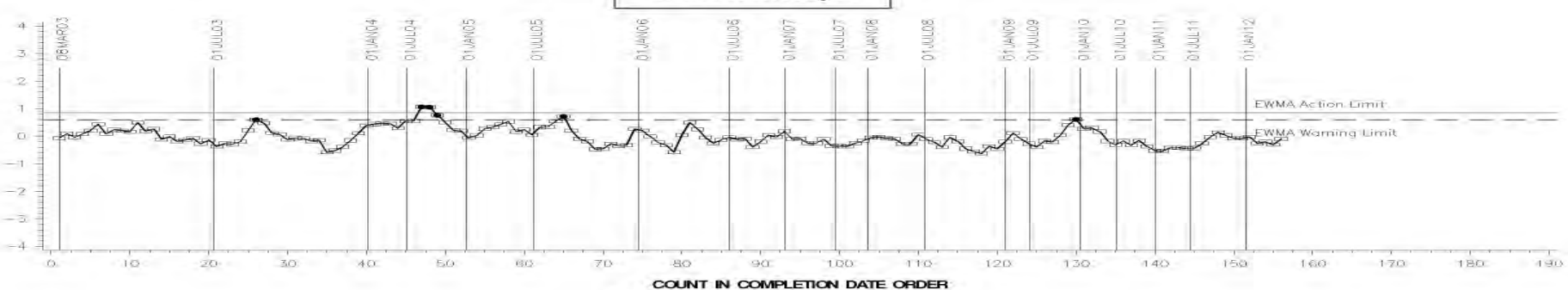


MRV VISCOSITY

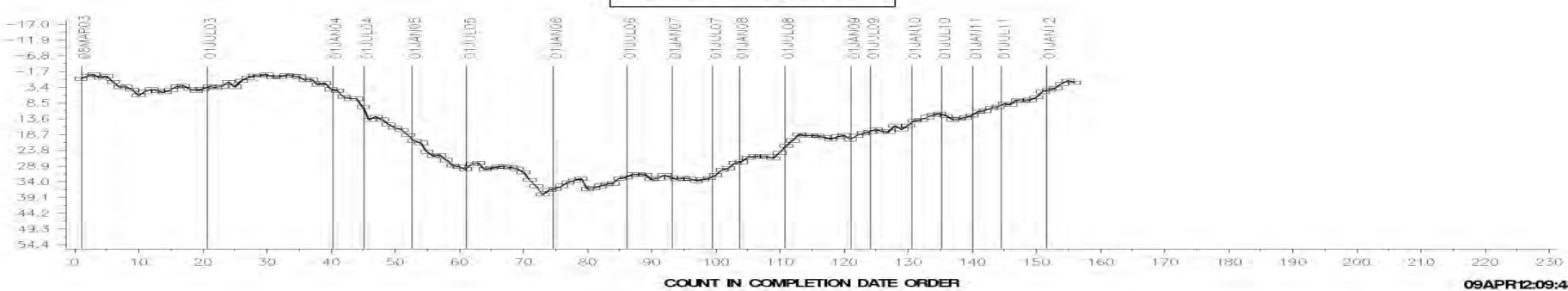
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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Appendix 1.n

T-12 Control Charts

» Severity, Precision, and CuSum

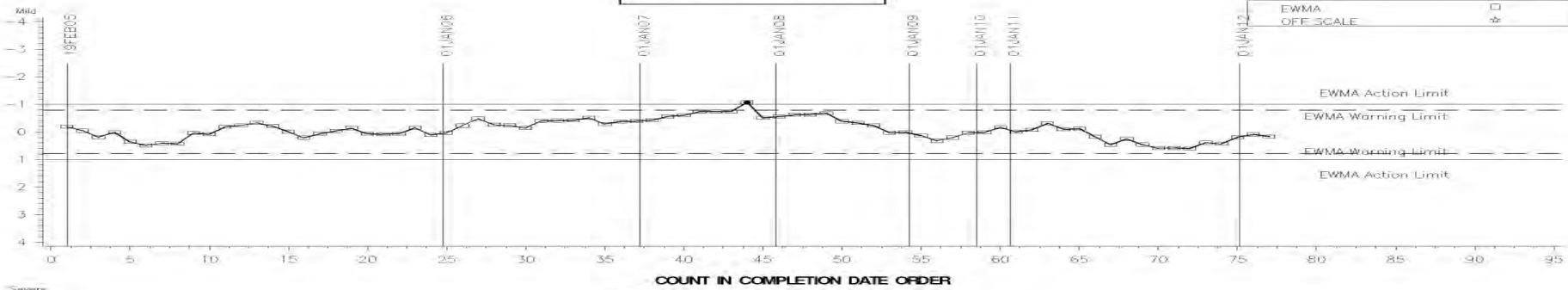
Test Monitoring Center

<http://astmtmc.cmu.edu>

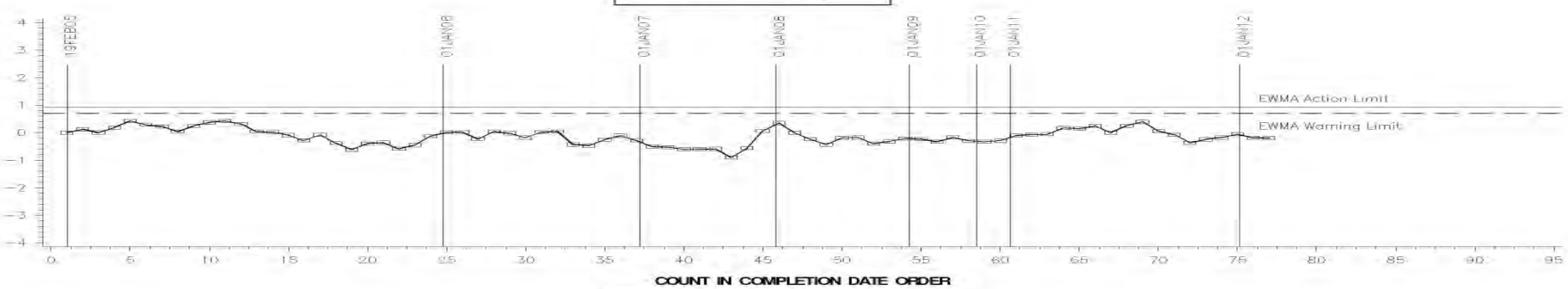


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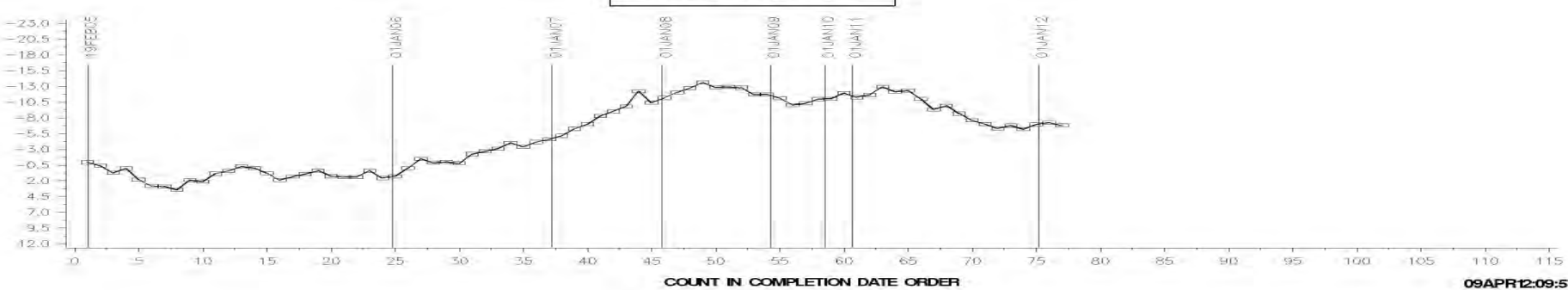
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



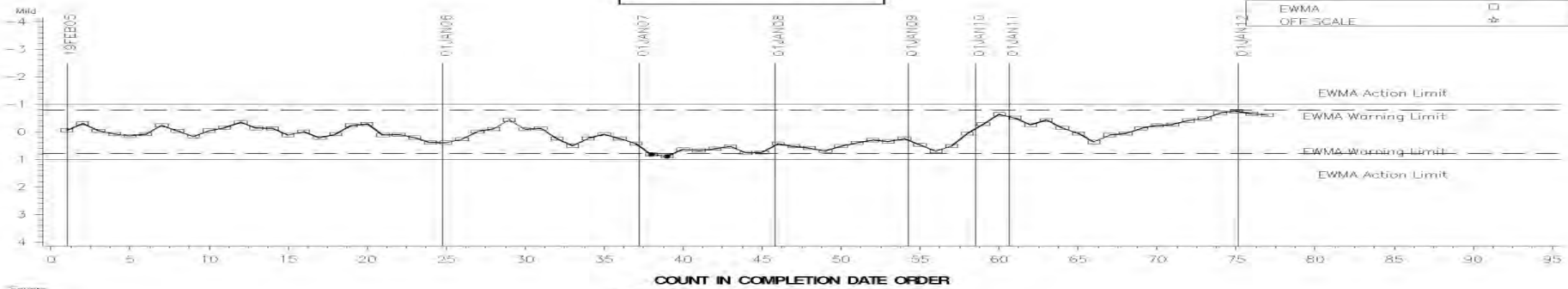
09APR12:09:57

MACK T-12 INDUSTRY OPERATIONALLY VALID DATA

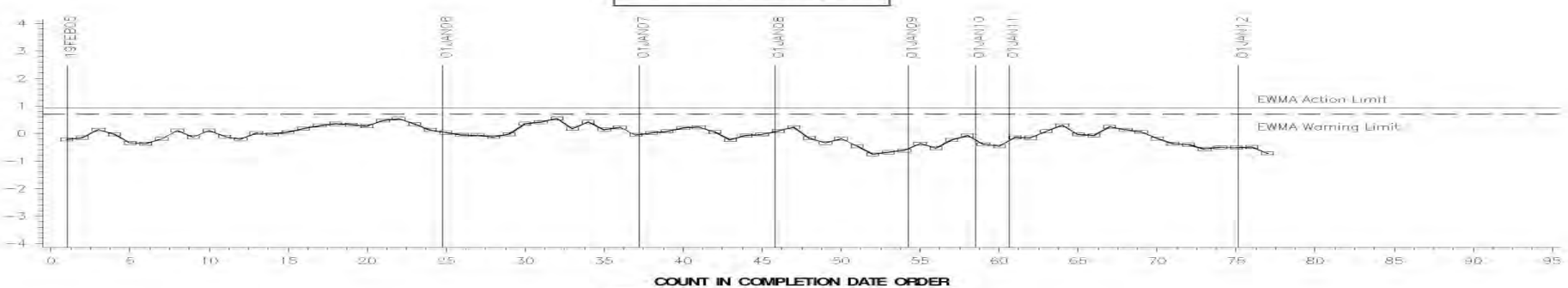
AVG. CYLINDER LINER WEAR (CLW)



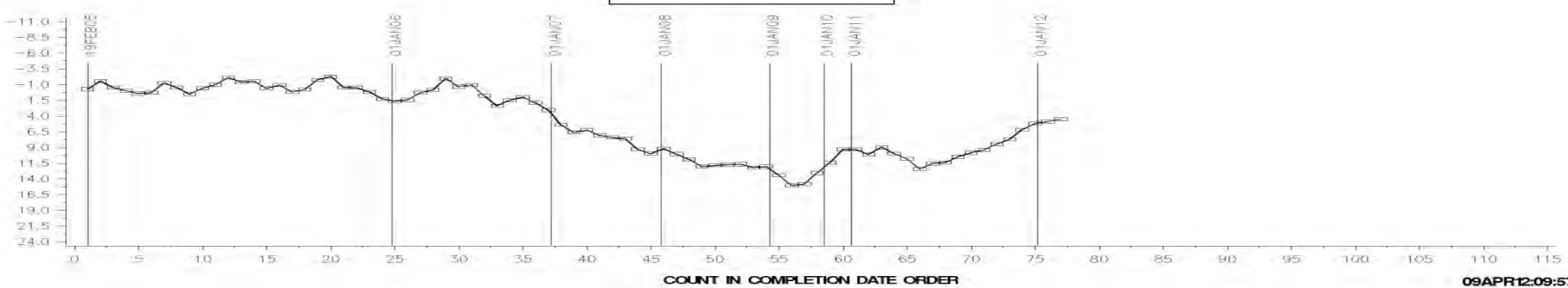
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



09APR12:09:57

Test Monitoring Center

<http://astmtmc.cmu.edu>



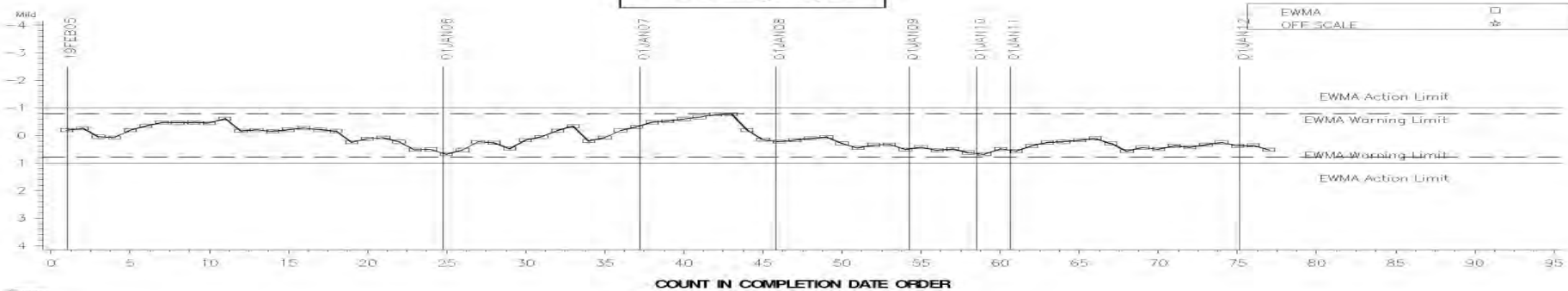
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MACK T-12 INDUSTRY OPERATIONAL VALID DATA

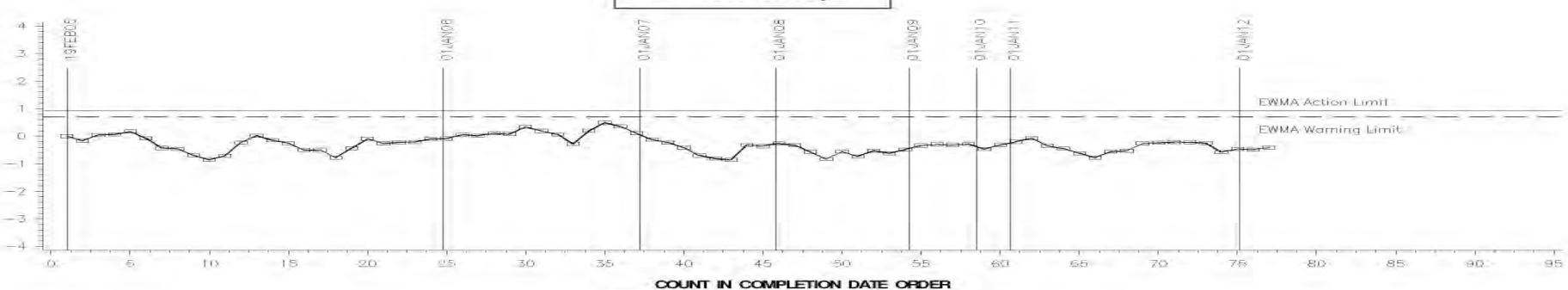
AVG. TOP RING WEIGHT LOSS (TRWL)



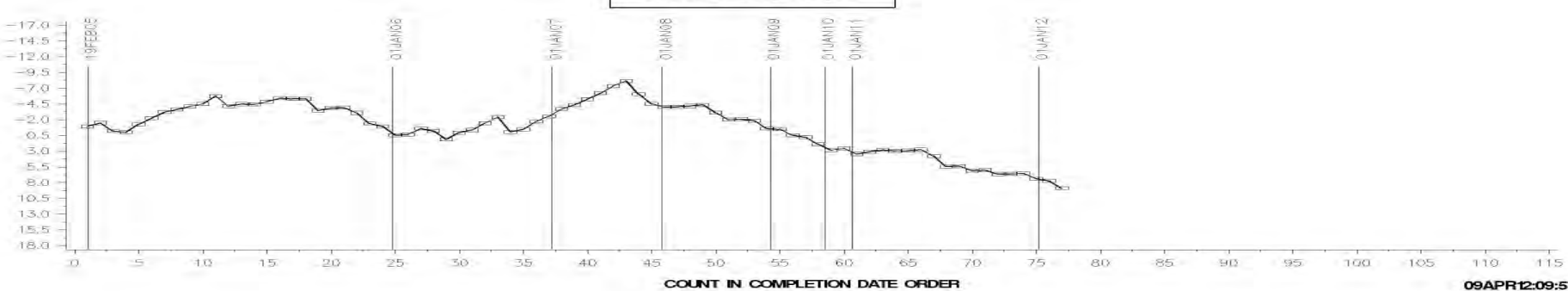
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



09APR12:09:57

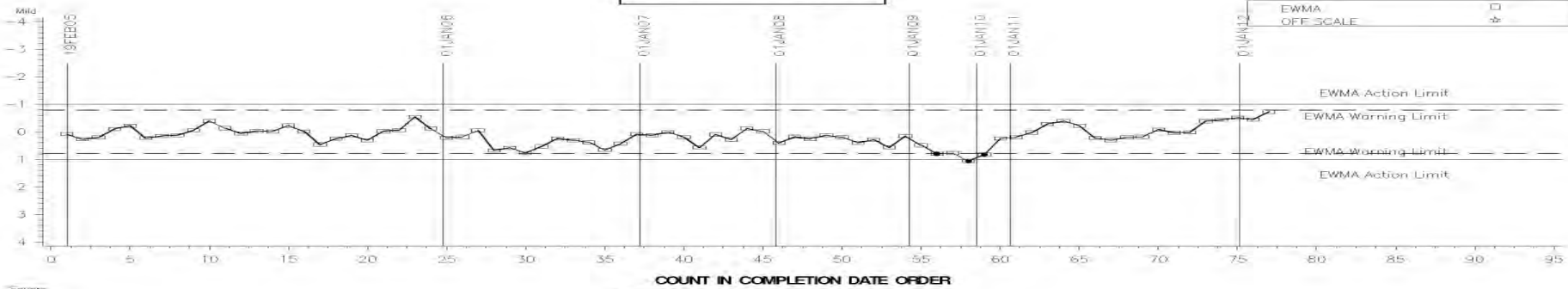
Test Monitoring Center

<http://astmtmc.cmu.edu>

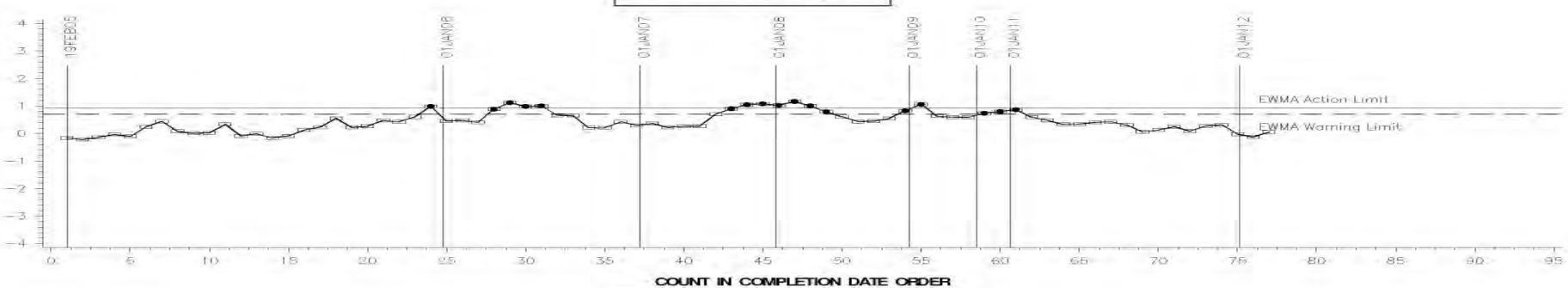


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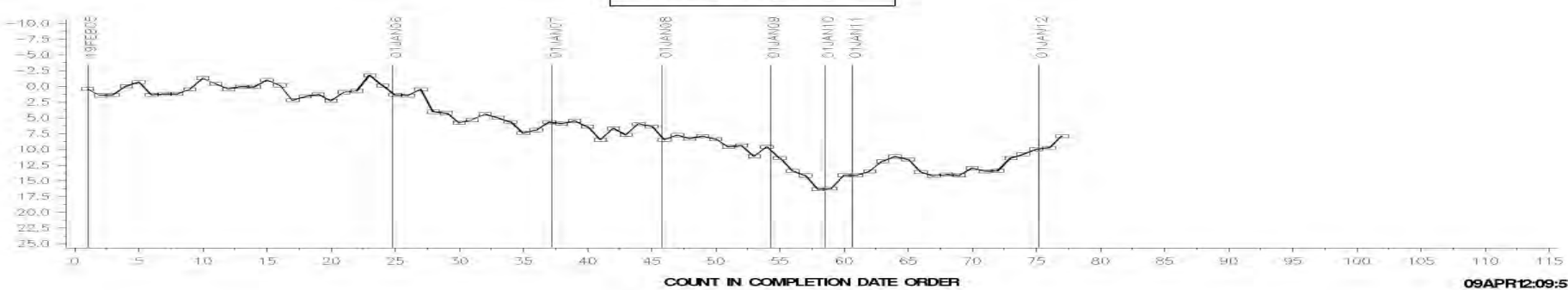
LTMS Severity Analysis



LTMS Precision Analysis

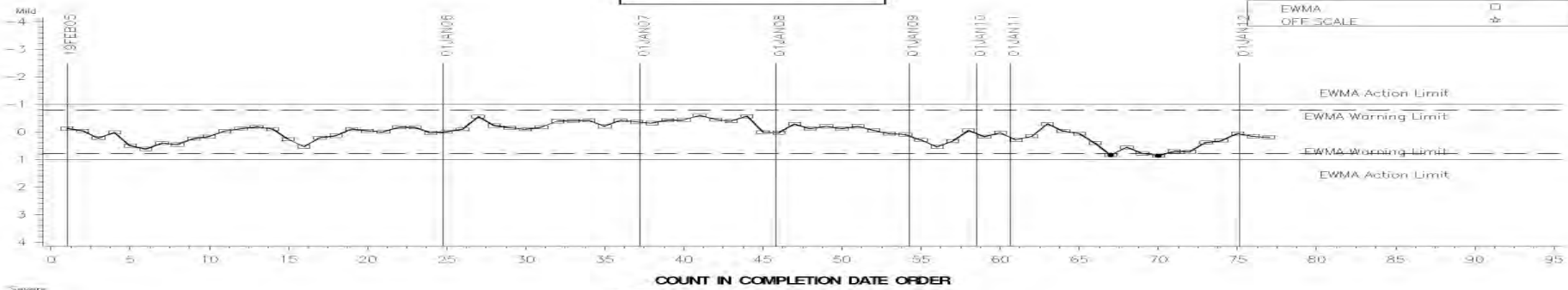


CUSUM Severity Analysis

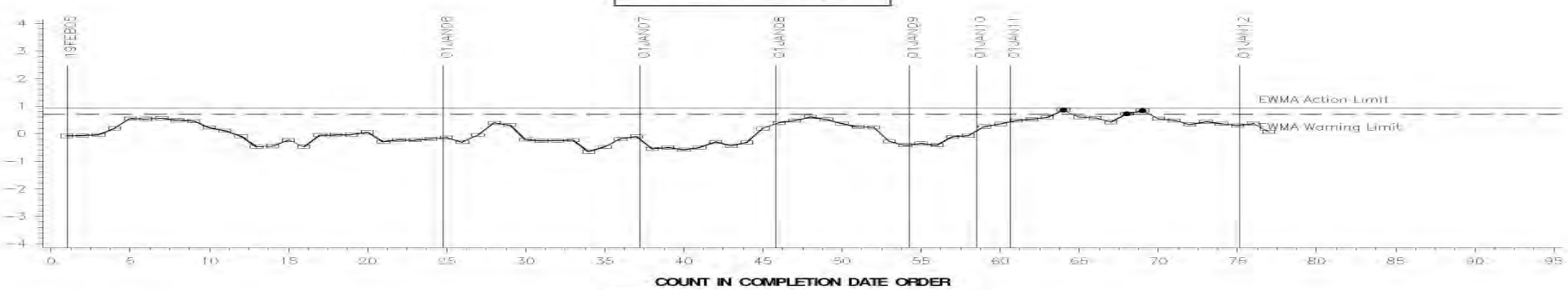


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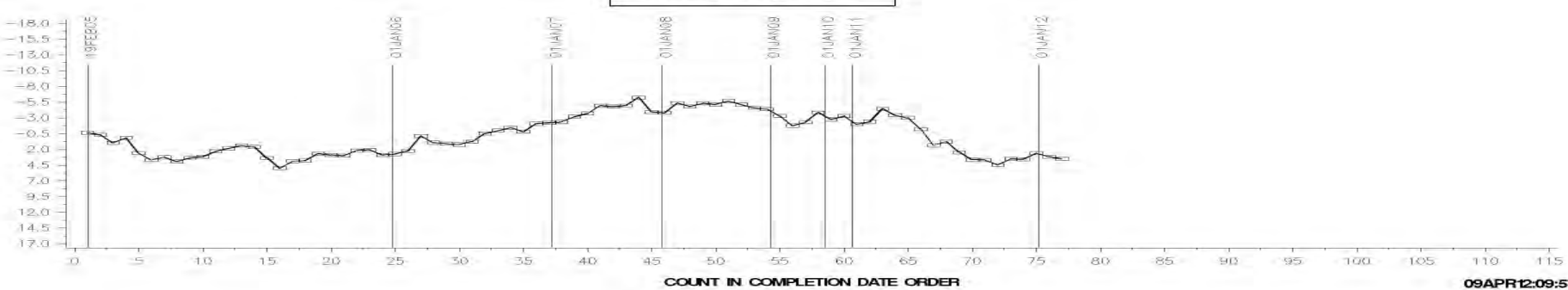
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



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Appendix 1.0

T-12A Control Charts

» Severity, Precision, and CuSum

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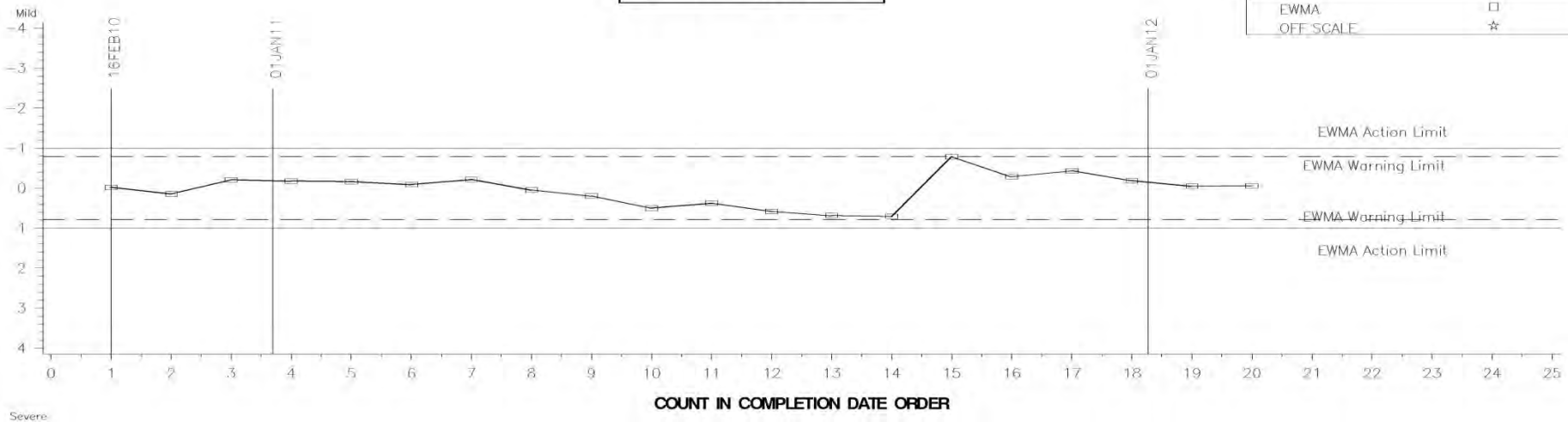
<http://astmtmc.cmu.edu>



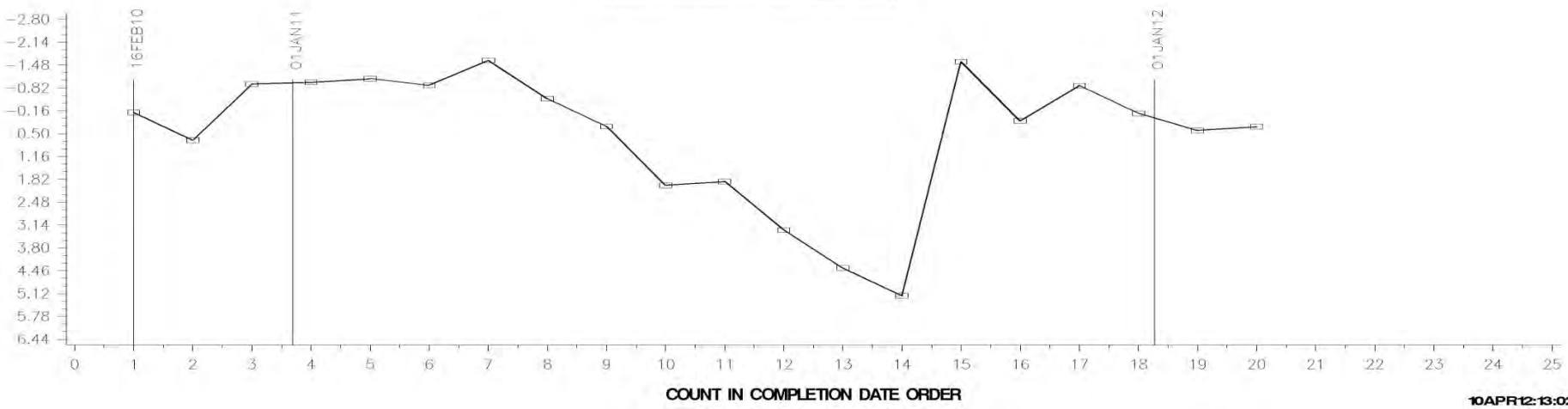
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FINAL ORIGINAL UNIT MRV VISCOSITY [NM, SOLID, FROZEN, <, >]

LTMS Severity Analysis



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