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# **Test Monitoring Center**

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

October 2016

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# Heavy Duty Testing

## Executive Summary

- ▶ Reference Oils
  - 830-2, 831-3
    - ISM and C13/ISB reference oil re-blends being pursued
- ▶ New Test
  - Daimler DD13 Scuffing Test is now being monitored
- ▶ Test Issues
  - CAT 1N Test Severity Investigation ongoing by Surveillance Panel
  - T12 top ring procurement delayed due to coating error

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# Calibrated Labs and Stands\*

| Test       | Labs | Stands |
|------------|------|--------|
| 1K         | 1    | 1      |
| 1N         | 4    | 5      |
| 1M-PC      | 1    | 1      |
| 1P         | 3    | 3      |
| 1R         | 1    | 1      |
| C13        | 3    | 3      |
| ISB        | 3    | 5      |
| ISM        | 4    | 4      |
| EOAT       | 0    | 0      |
| RFWT       | 2    | 2      |
| T-8/E      | 2    | 3      |
| T-11       | 4    | 5      |
| T-12/T-12A | 4/4  | 7/7    |
| T-13       | 5    | 10     |
| COAT       | 3    | 3      |
| DD13       | 3    | 5      |

\*As of  
09/30/20163

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# SCOTE 1K

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# 1 K Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 1        |
| Failed Calibration Test     | OC            | 0        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 0        |
| <b>Total</b>                |               | <b>1</b> |



# 1 K Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No failed tests  | 0               |
| Total            | 0               |

# 1 K Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No invalid tests | 0        |
| Aborted      | No aborted tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

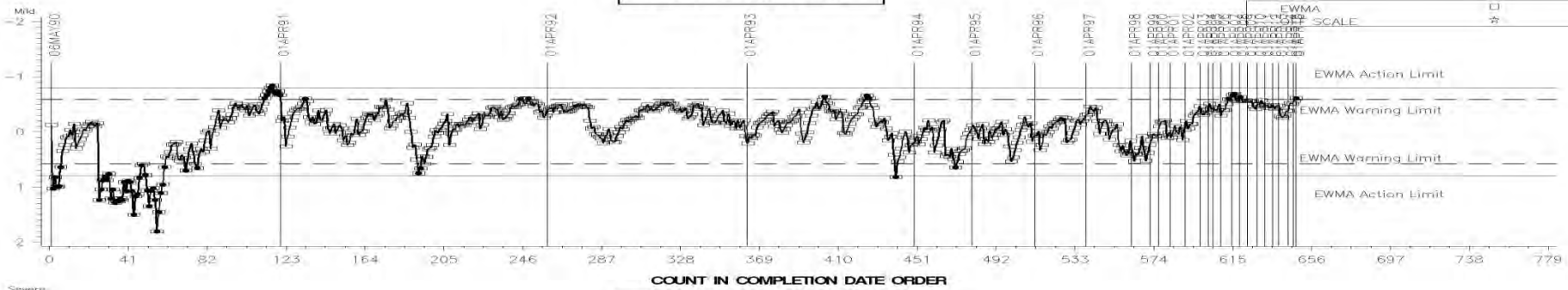
\*Invalid and aborted tests

# 1 K Test Severity

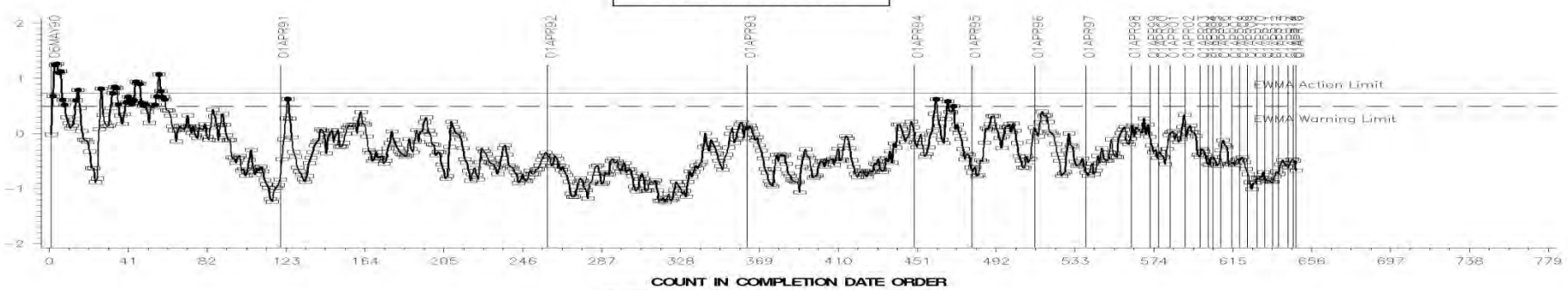
- ▶ WDK, TLHC, ETOC are in control
- ▶ TGF in Warning Alarm in the mild direction
- ▶ BSOC in Action Alarm in the mild direction

FINAL TGF

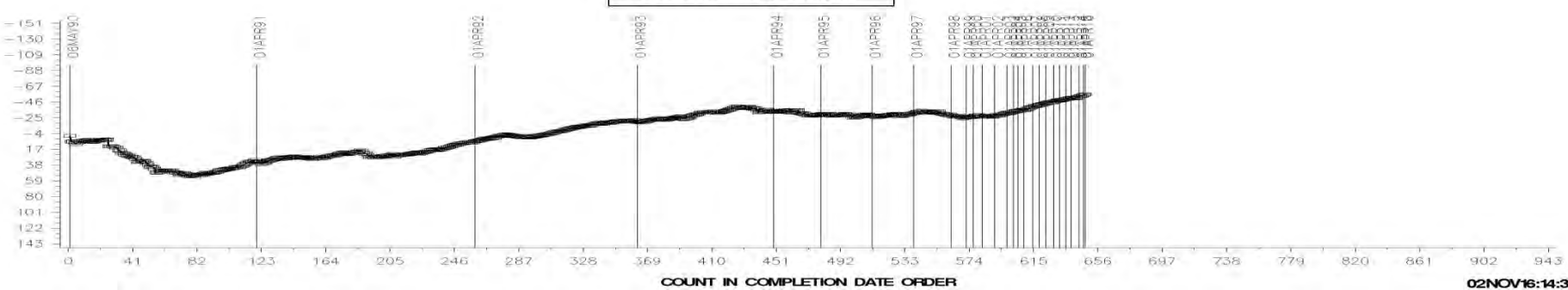
LTMS Severity Analysis



LTMS Precision Analysis



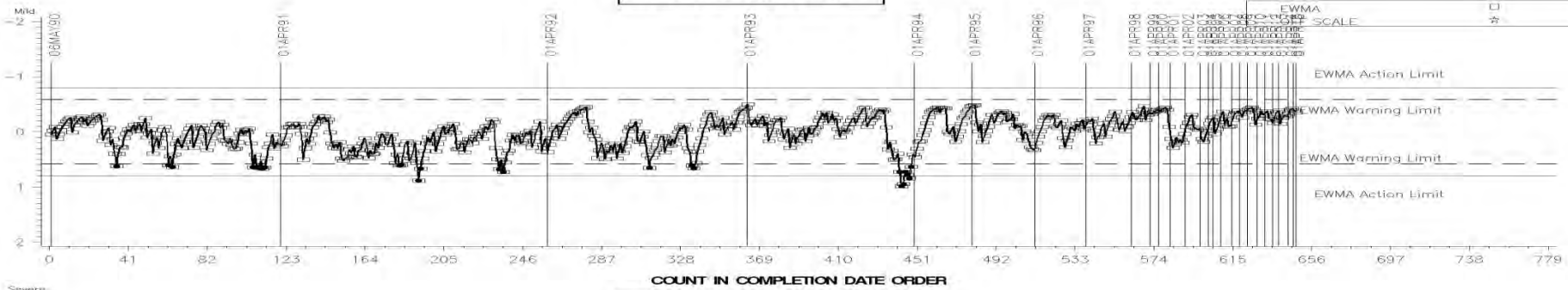
CUSUM Severity Analysis



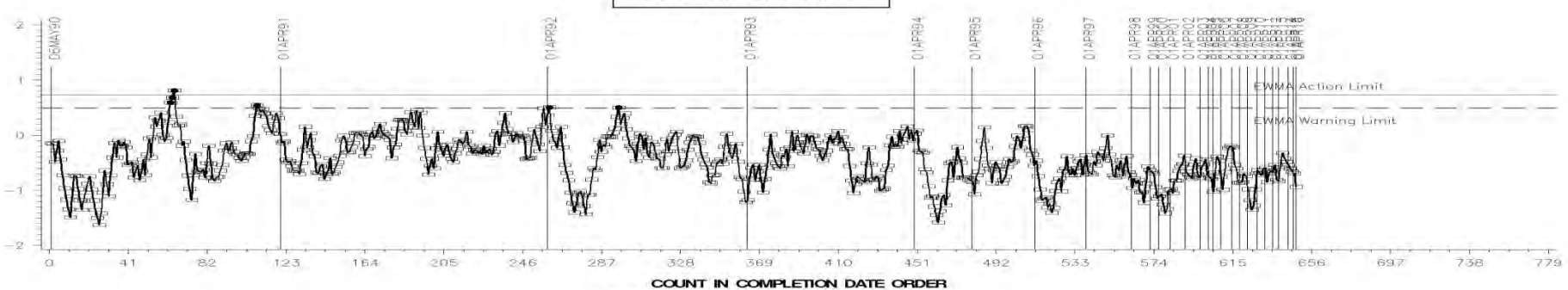
02NOV16:14:31

FINAL TLHC

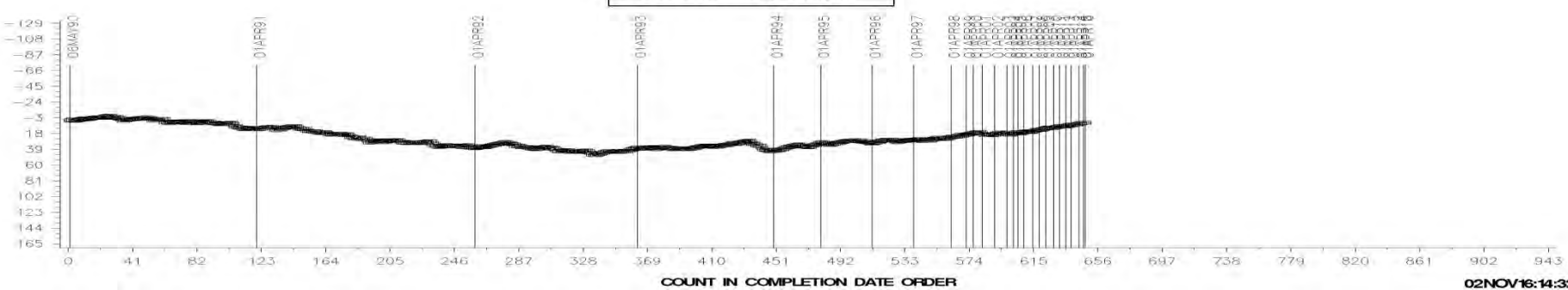
LTMS Severity Analysis



LTMS Precision Analysis



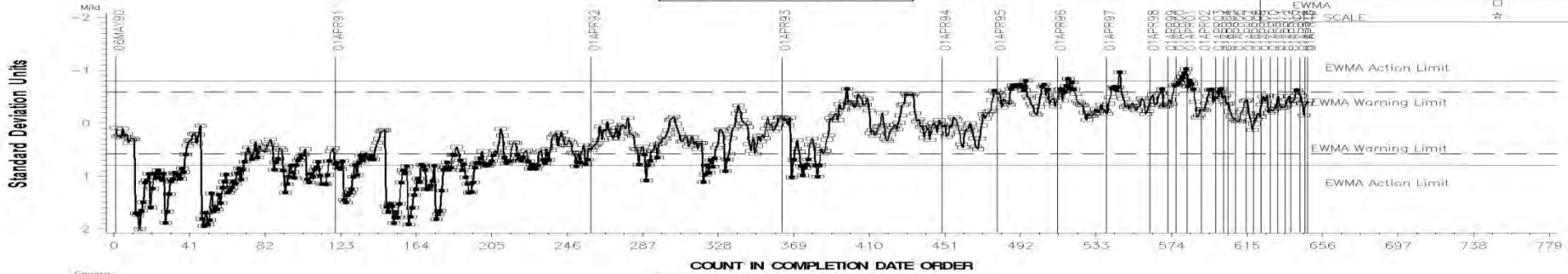
CUSUM Severity Analysis



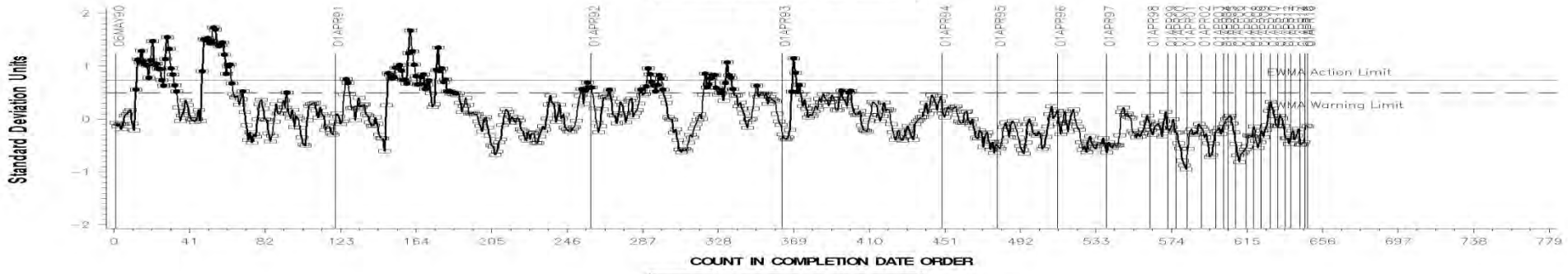
02NOV16:14:32

FINAL Weighted Total Demerits

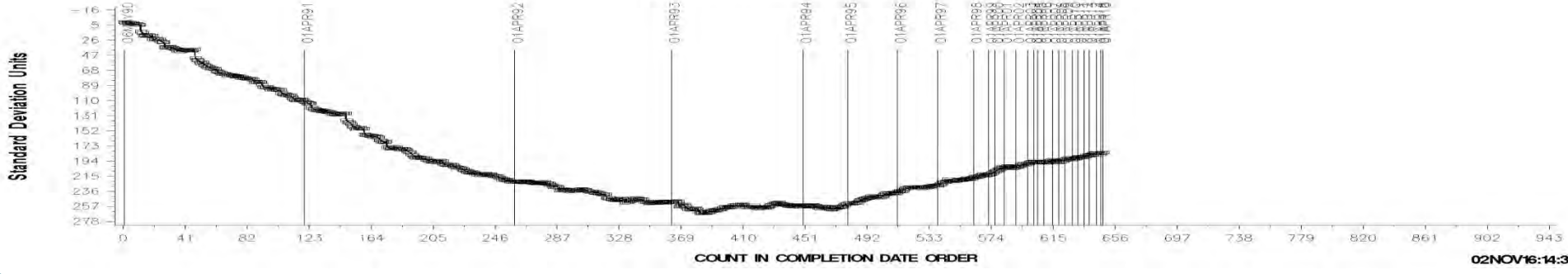
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



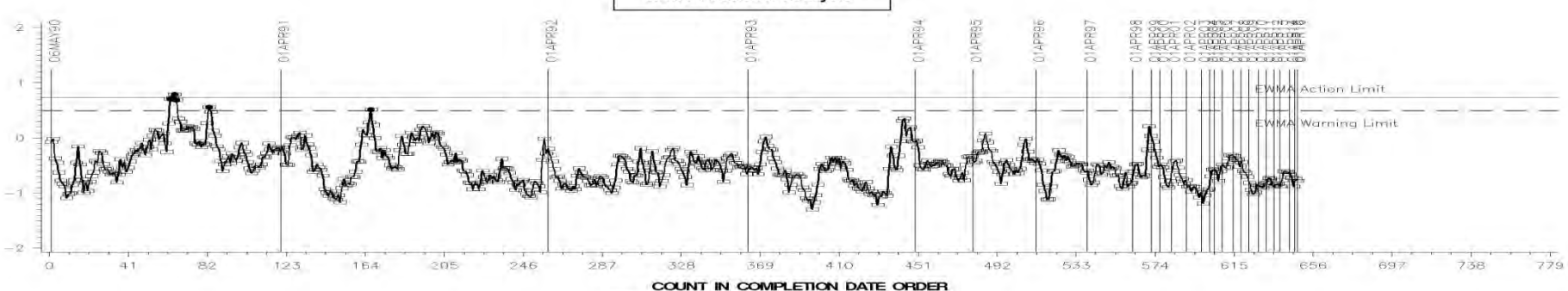
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FINAL BSOC

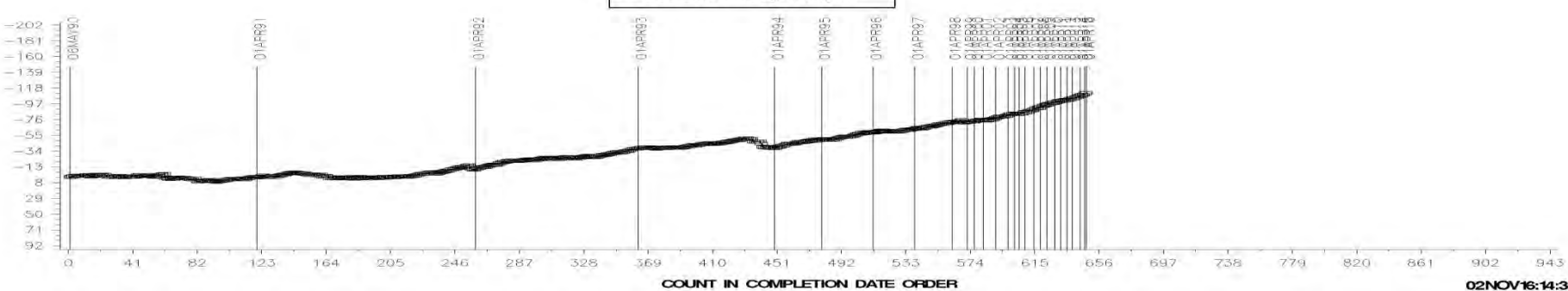
LTMS Severity Analysis



LTMS Precision Analysis

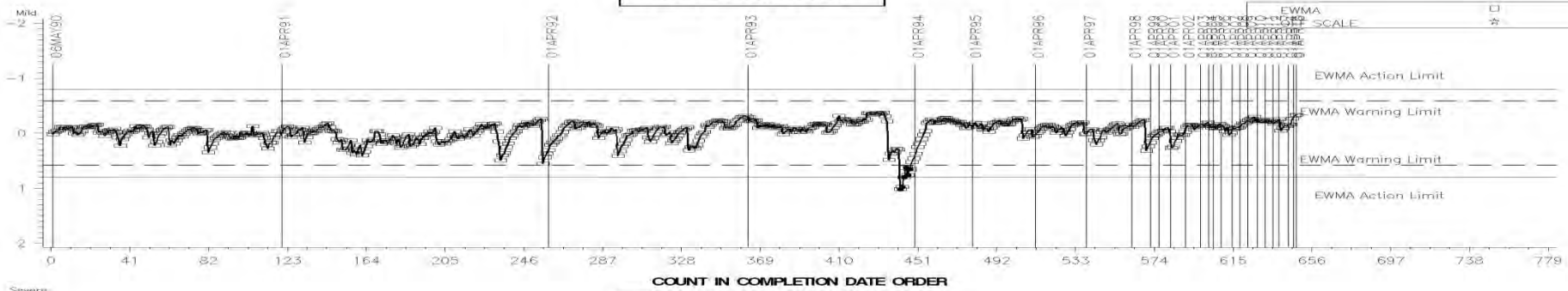


CUSUM Severity Analysis



FINAL EOTC

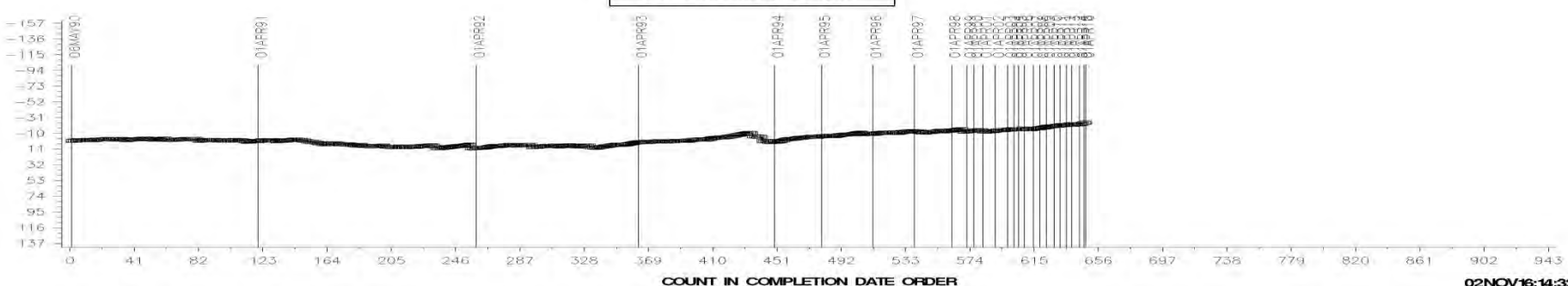
LTMS Severity Analysis



LTMS Precision Analysis



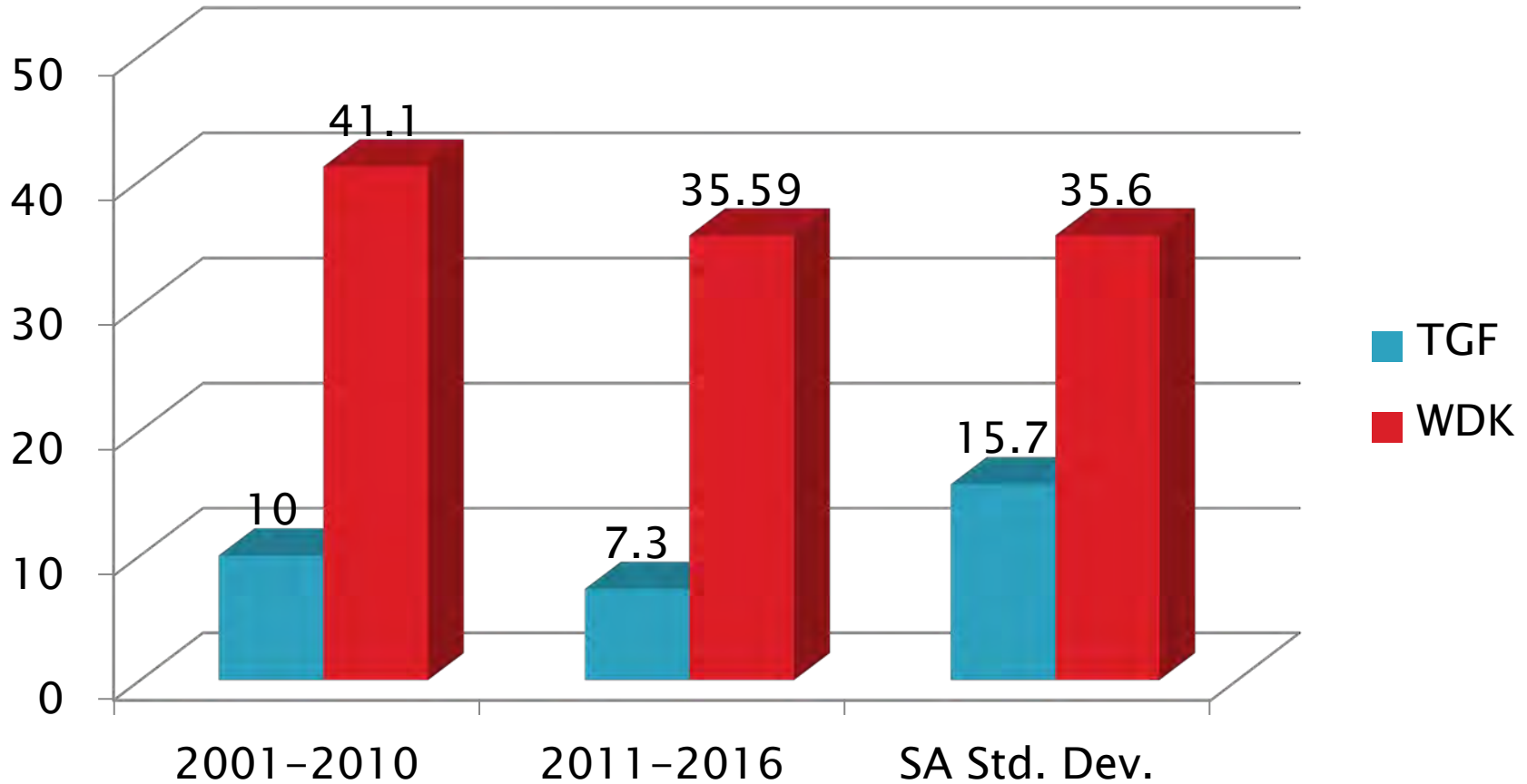
CUSUM Severity Analysis



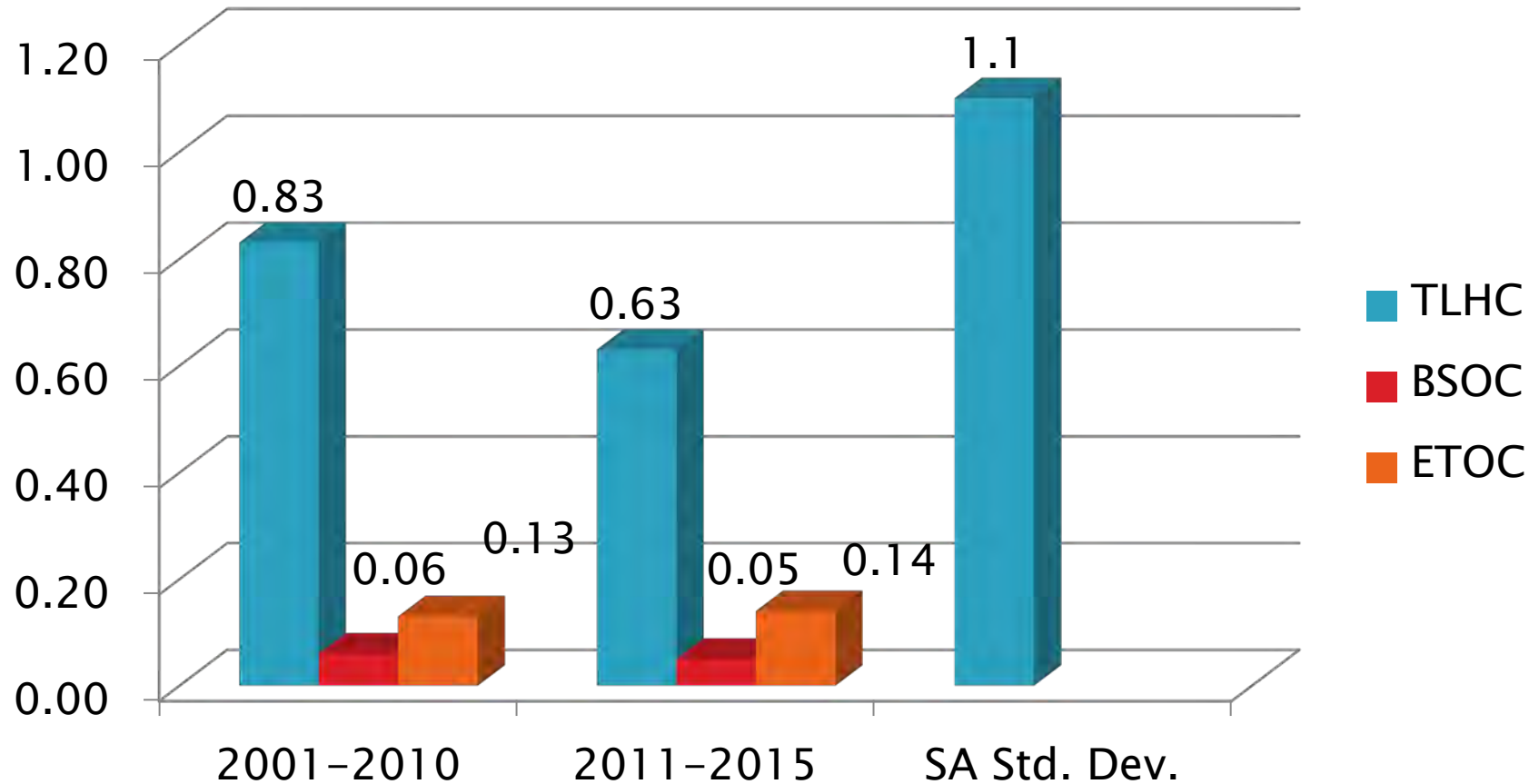
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# 1 K Precision Estimates



# 1K Precision Estimates



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# SCOTE 1N

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# 1 N Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 1        |
| Failed Calibration Test     | OC            | 3        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 0        |
| <b>Total</b>                |               | <b>4</b> |

# 1 N Failed Tests

| Failed Parameter         | Number of Tests |
|--------------------------|-----------------|
| Severe Top Groove Fill   | 2               |
| Stand Zi Top Groove Fill | 1               |
| <b>Total</b>             | <b>3</b>        |

# 1 N Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No invalid tests | 0        |
| Aborted      | No aborted tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

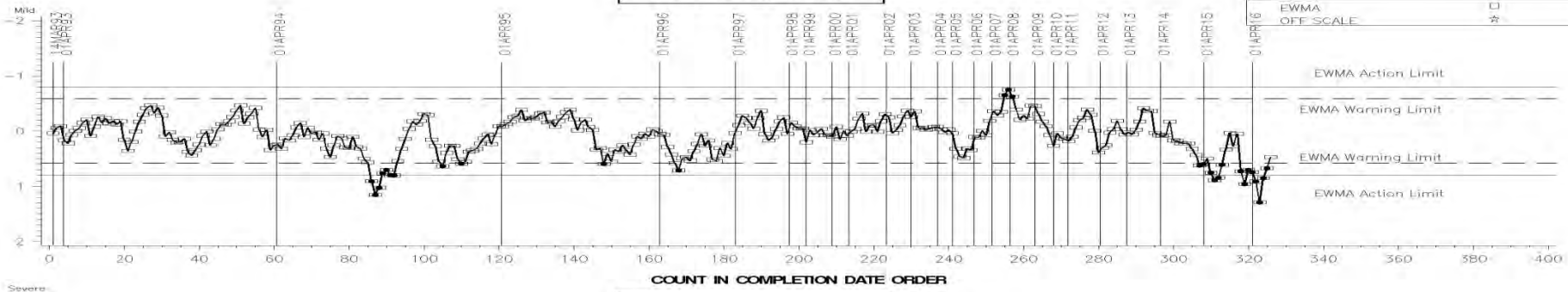
\*Invalid and aborted tests

# 1 N Test Severity

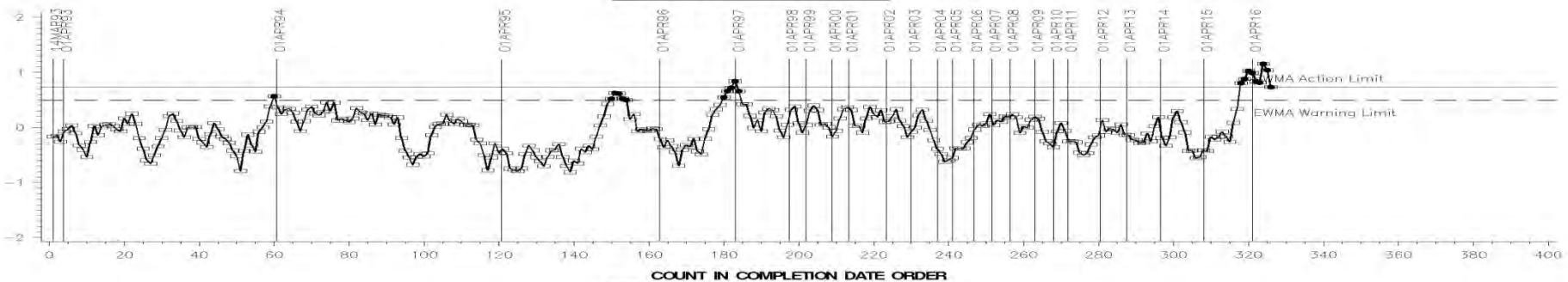
- ▶ WDN in severity action alarm mild direction.
- ▶ TGF in precision warning alarm.
- ▶ TLHC and BSOC in control
- ▶ Severity trends are being evaluated by surveillance panel

FINAL CORRECTED TGF

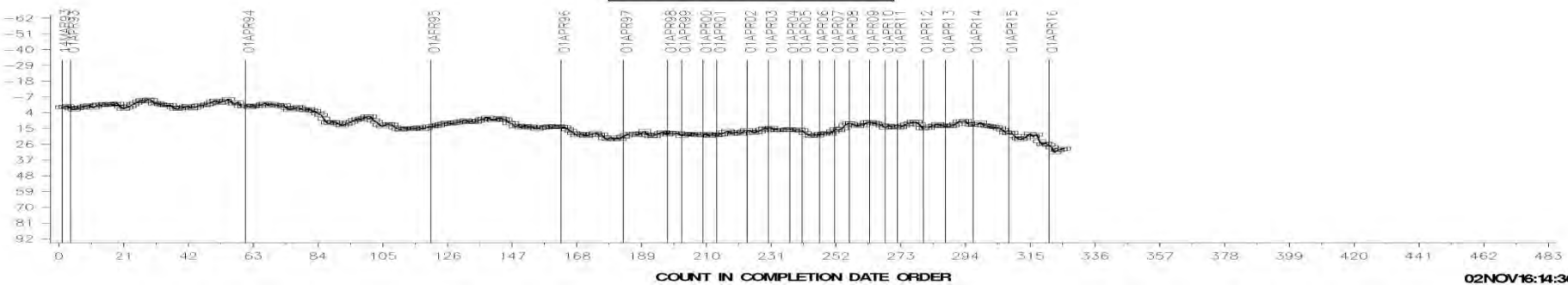
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

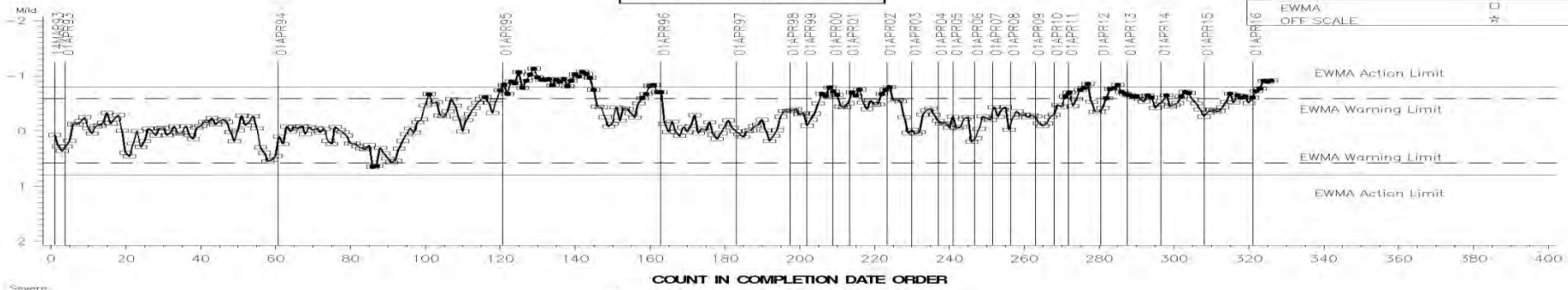


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Weighted Total Demerits

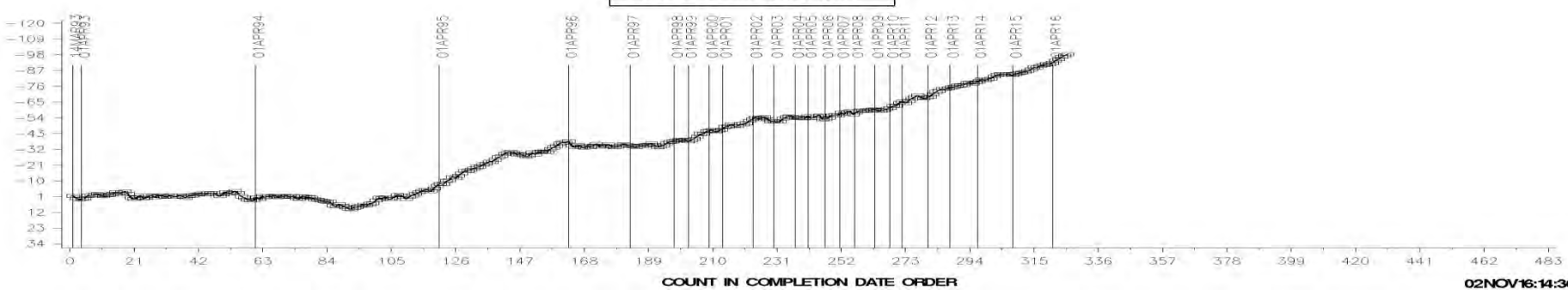
LTMS Severity Analysis



LTMS Precision Analysis



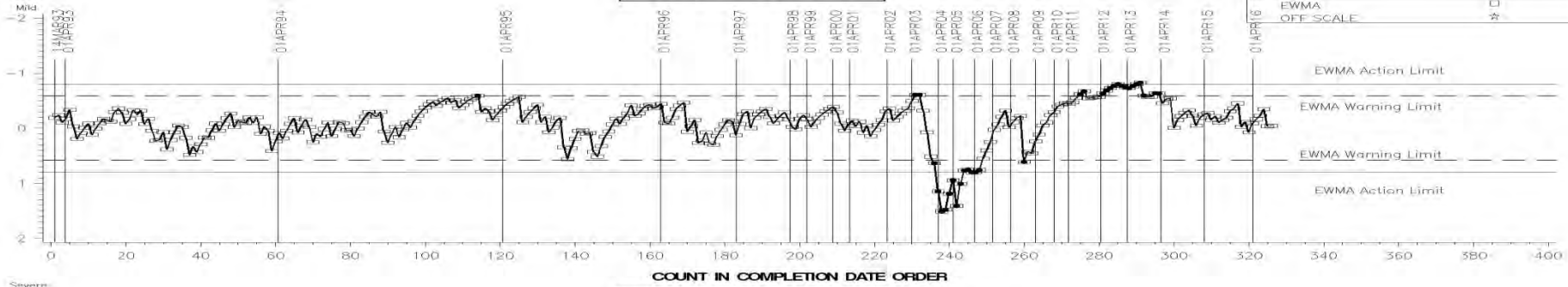
CUSUM Severity Analysis



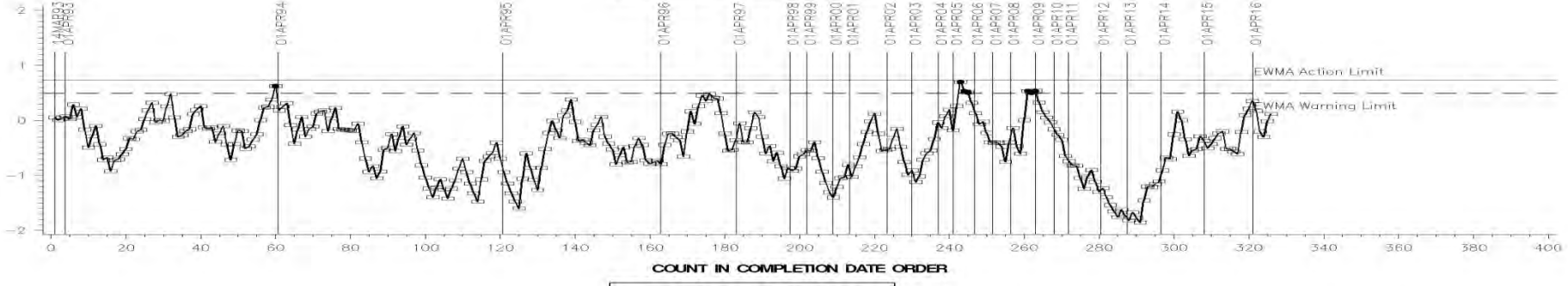
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Top Land Heavy Carbon

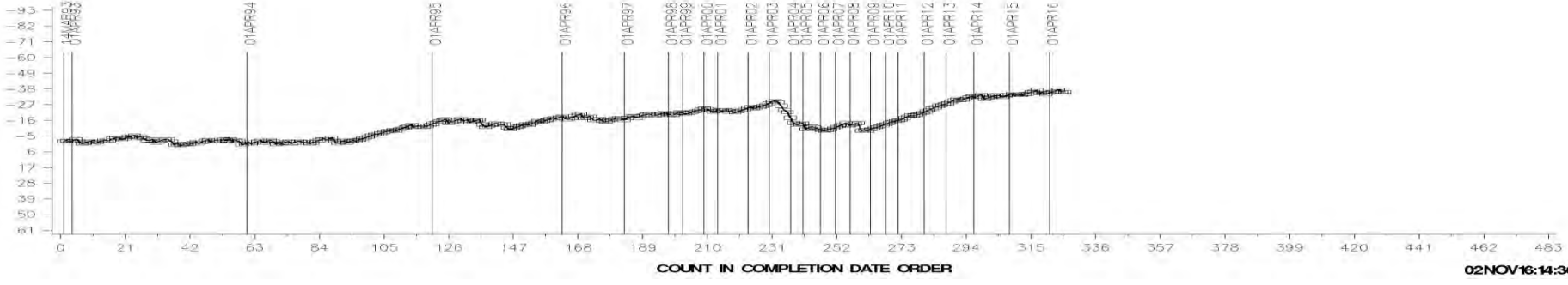
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis



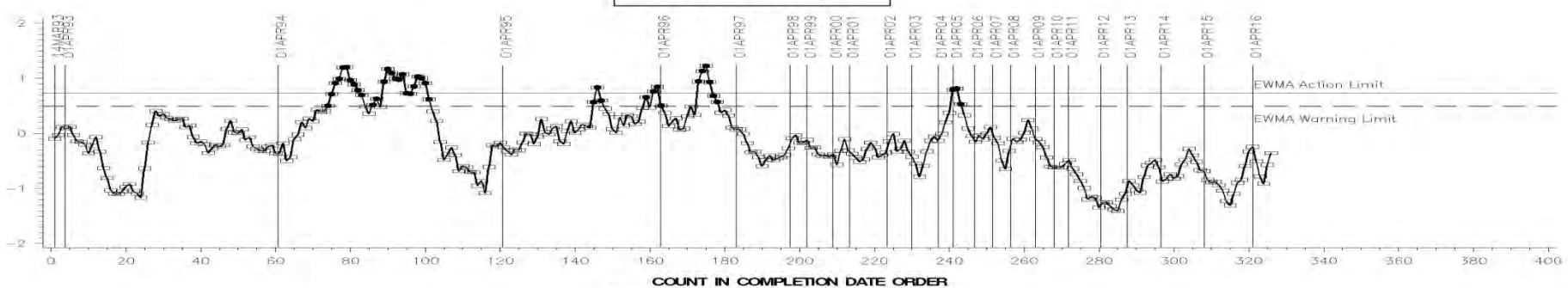
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BSOC

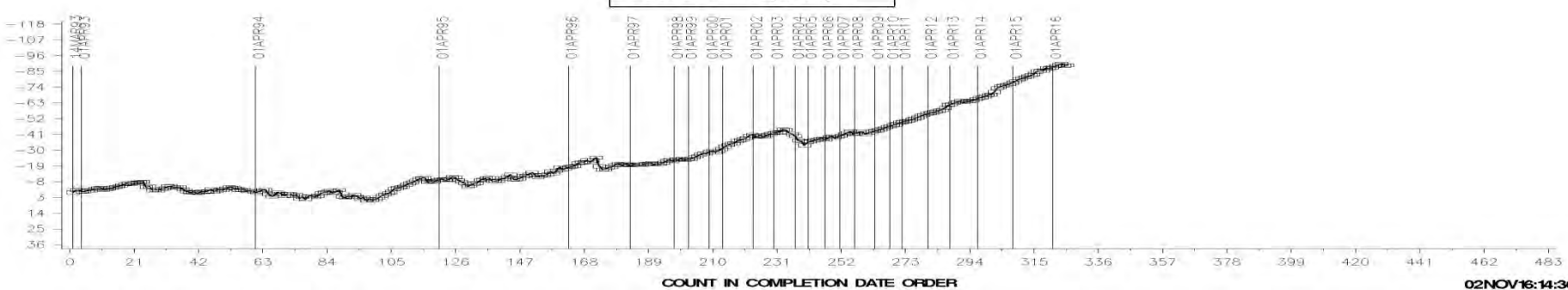
LTMS Severity Analysis



LTMS Precision Analysis



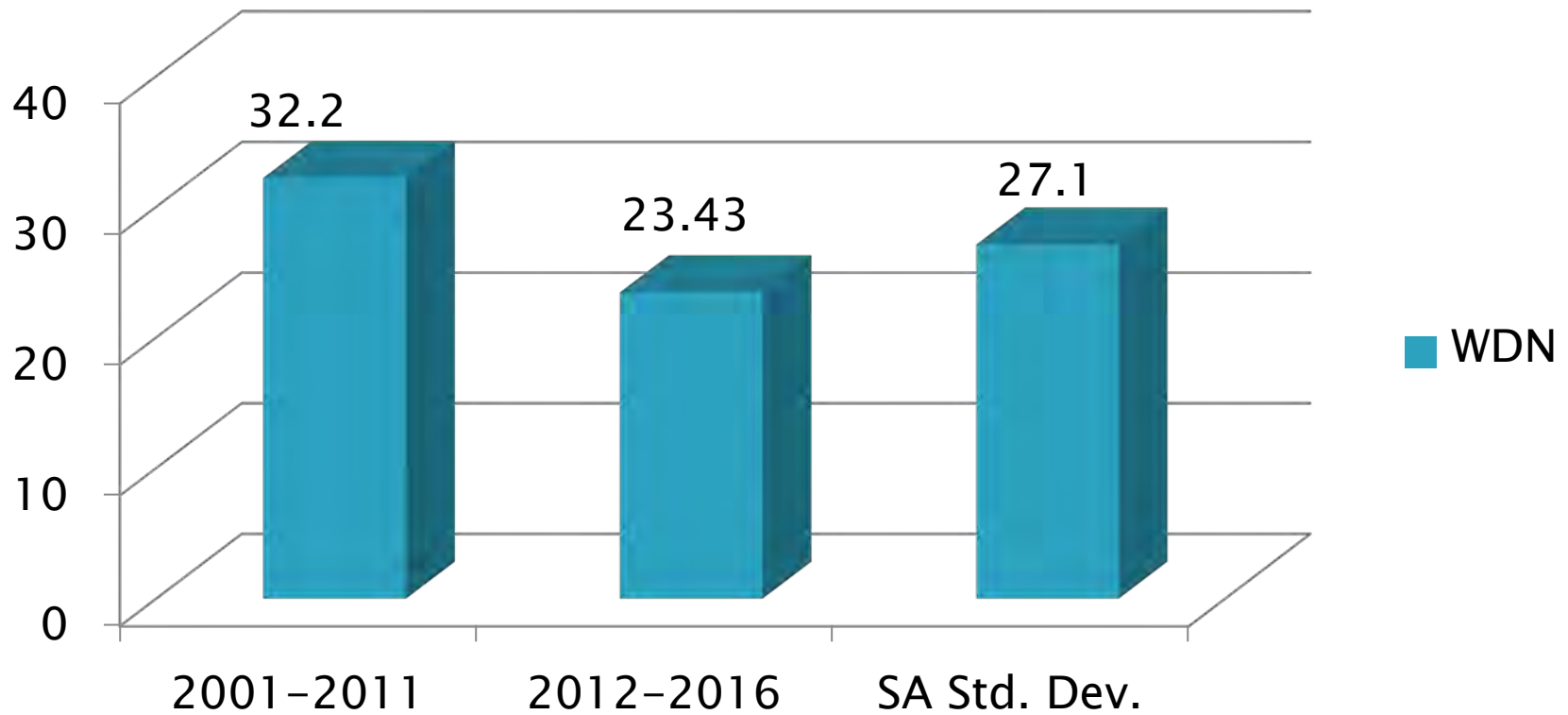
CUSUM Severity Analysis



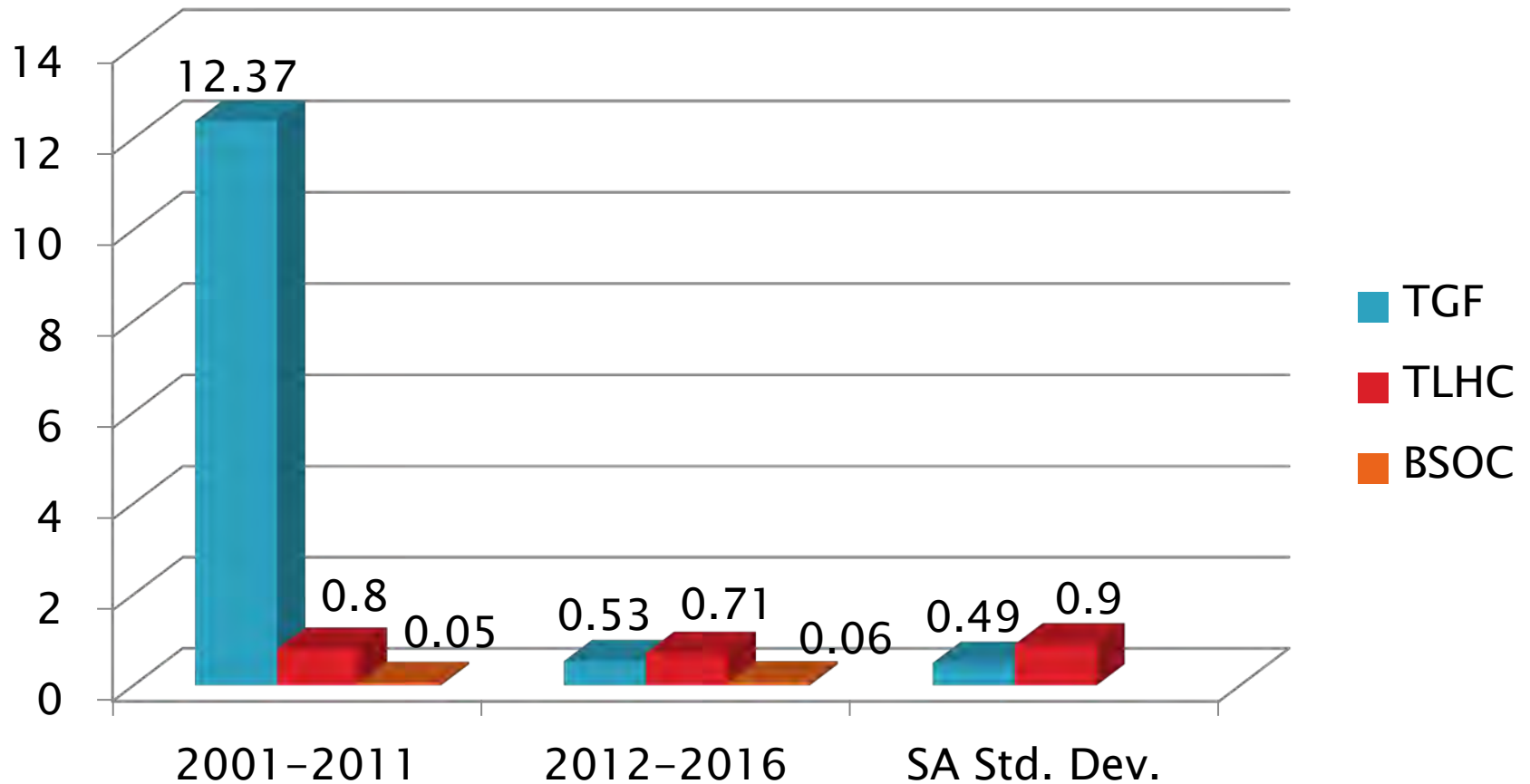
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# 1 N Precision Estimates

## WDN



# 1N Precision Estimates



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# 1 M-PC Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 1        |
| Failed Calibration Test     | OC            | 0        |
| Operationally Invalid       | LC            | 0        |
| <b>Total</b>                |               | <b>1</b> |

# 1 M-PC Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No Failed Test   | 0               |
| <b>Total</b>     | <b>0</b>        |



# 1 M-PC Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No invalid tests | 0        |
| Aborted      | No aborted tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

\*Invalid and aborted tests

# 1 M-PC Test Severity

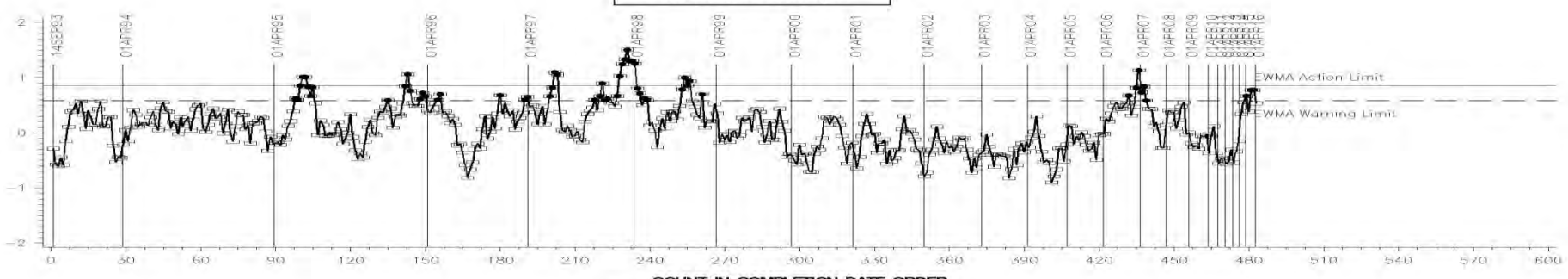
- ▶ WTD and TGF are in control.

FINAL TOP GROOVE FILLING

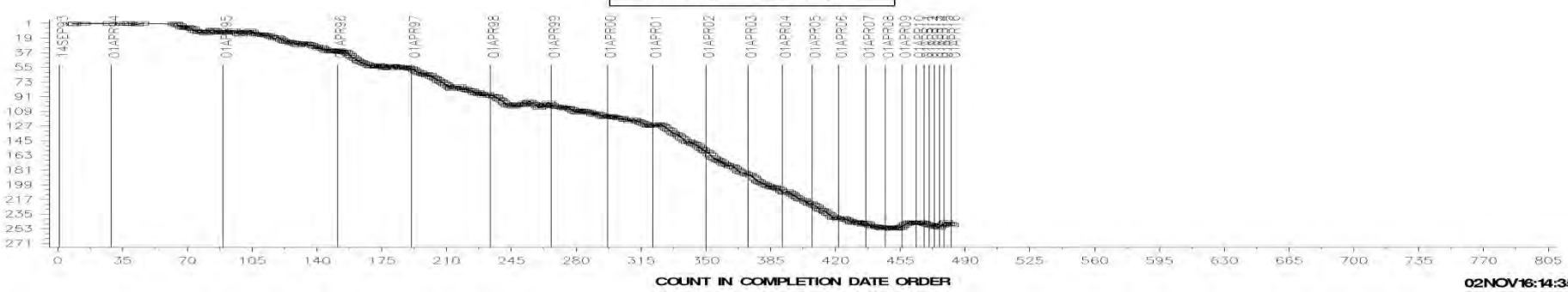
LTMS Severity Analysis



LTMS Precision Analysis



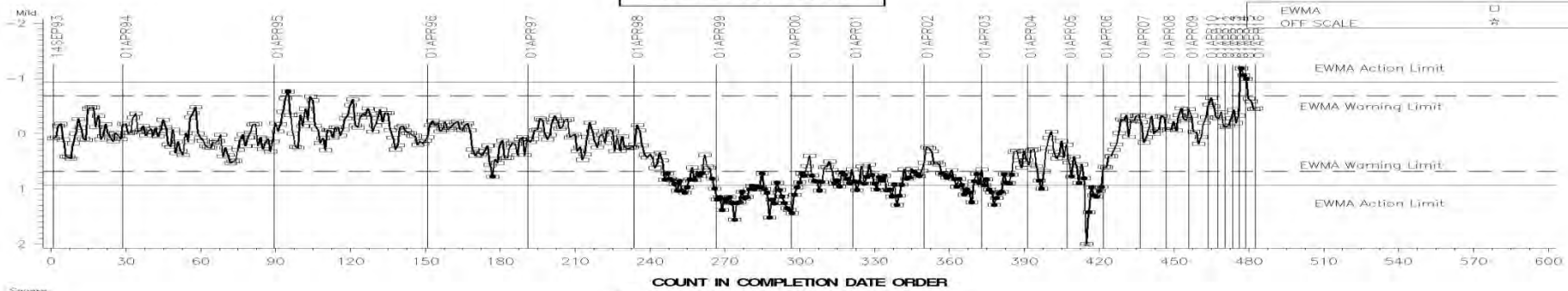
CUSUM Severity Analysis



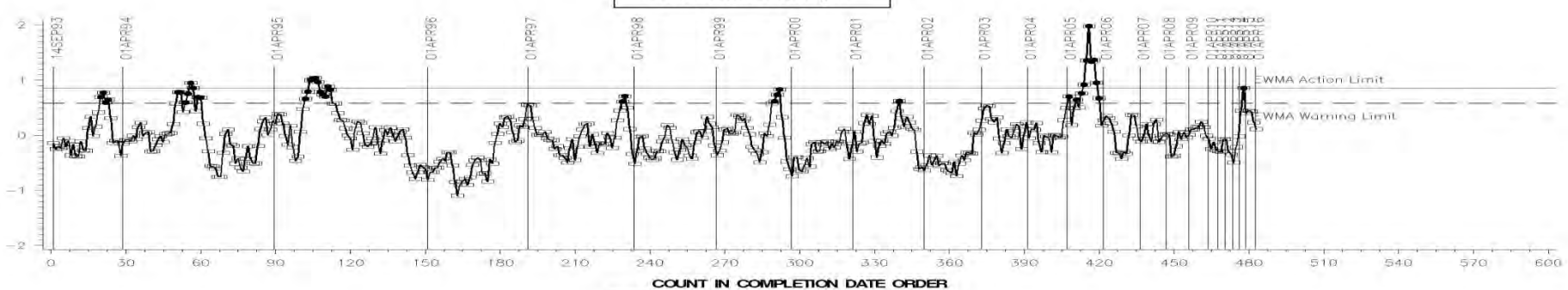
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Weighted Total Demerits

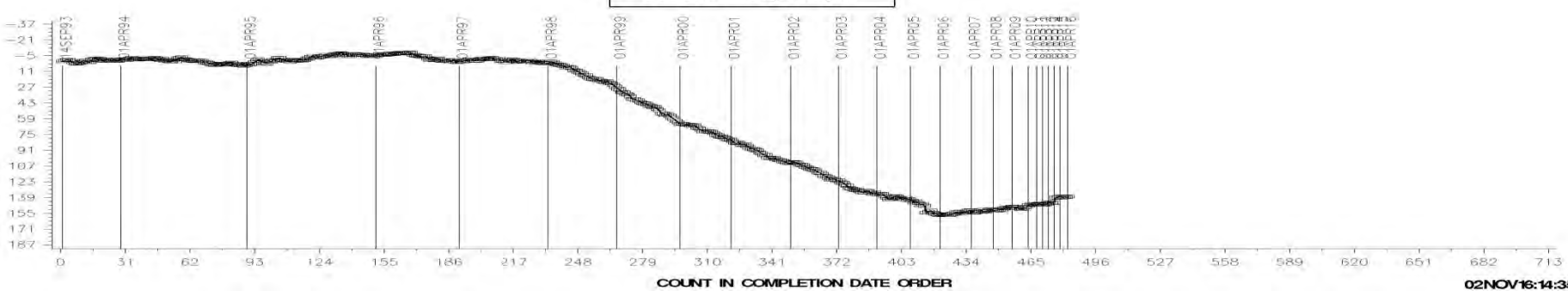
LTMS Severity Analysis



LTMS Precision Analysis

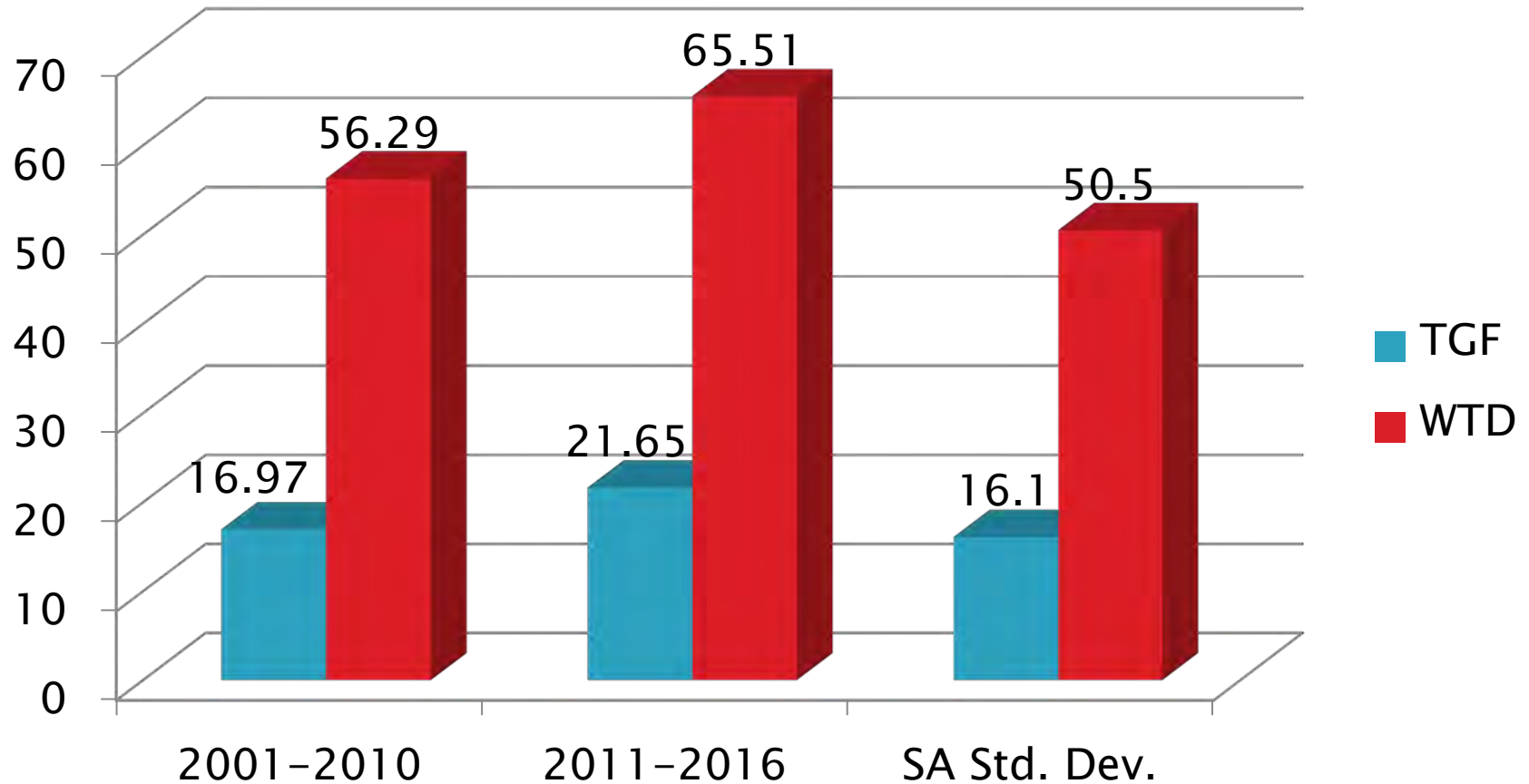


CUSUM Severity Analysis



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# 1 MPC Precision Estimates



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# 1P Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 3        |
| Failed Calibration Test     | OC            | 0        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 0        |
| Donated                     | AG            | 0        |
| <b>Total</b>                |               | <b>3</b> |

# 1 P Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No failed tests  | 0               |
| <b>Total</b>     | <b>0</b>        |



# 1P Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No invalid tests | 0        |
| Aborted      | No aborted tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

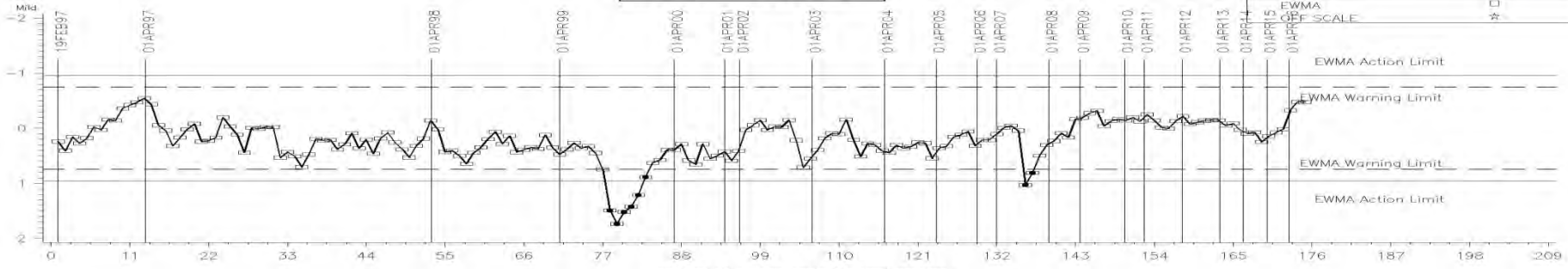
\*Invalid and aborted tests

# 1 P Test Severity

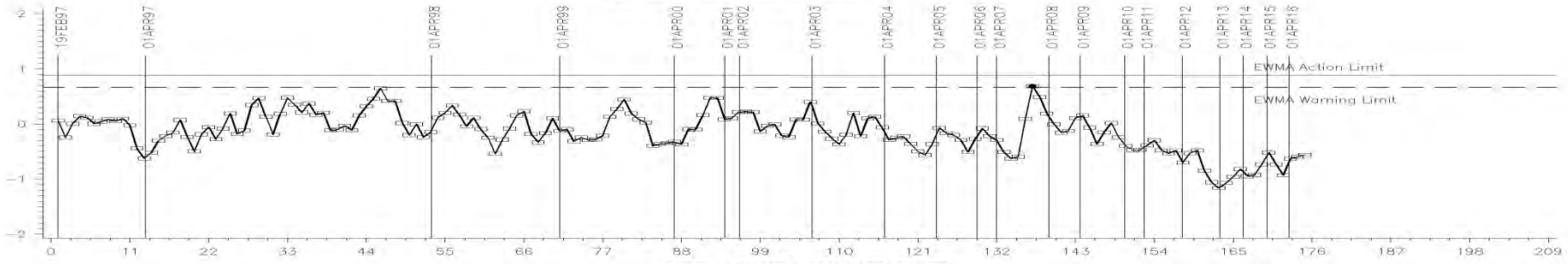
- ▶ EOTOC is in action alarm severe direction.
- ▶ TLC in warning alarm mild direction.
- ▶ TGC, OC and WD are in control.

TOP GROOVE CARBON

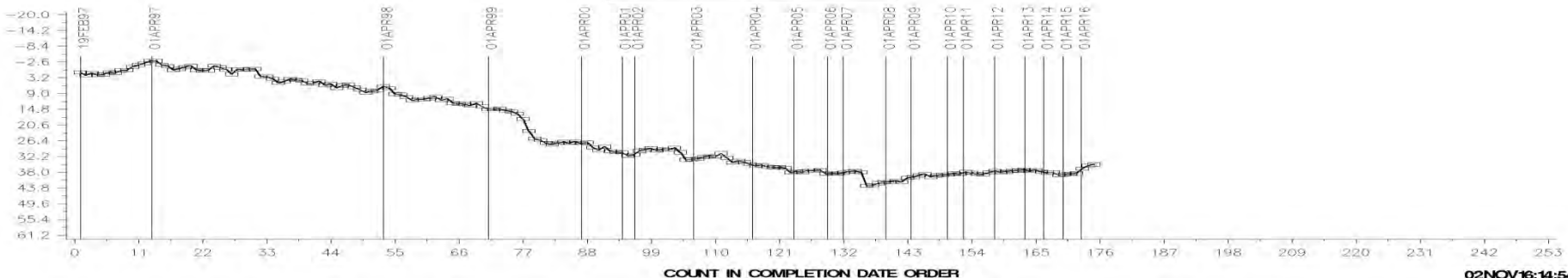
LTMS Severity Analysis



LTMS Precision Analysis



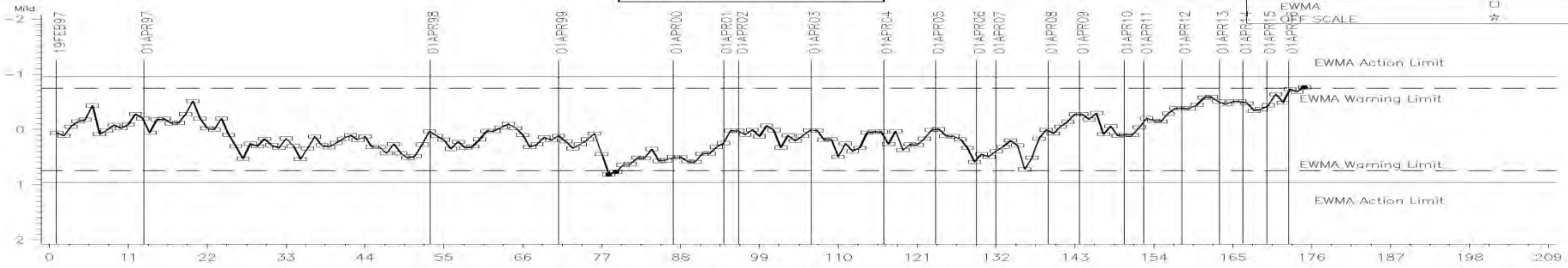
CUSUM Severity Analysis



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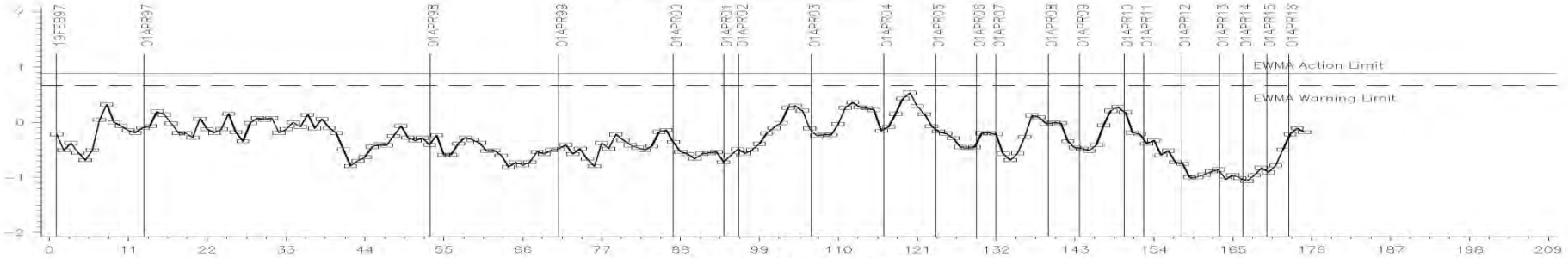
TOP LAND CARBON

LTMS Severity Analysis



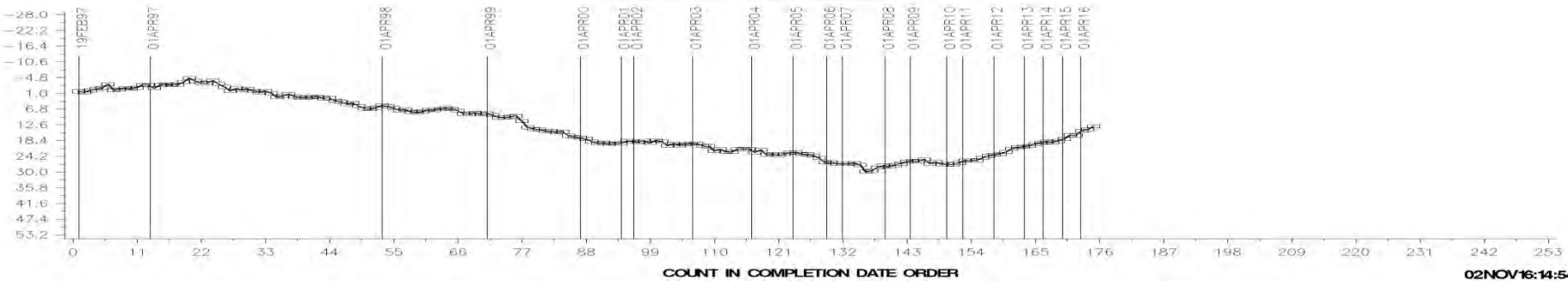
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis

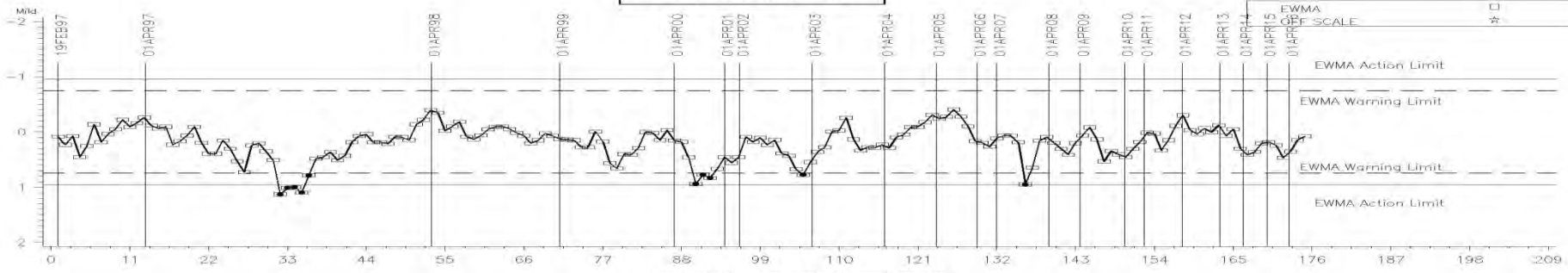


COUNT IN COMPLETION DATE ORDER

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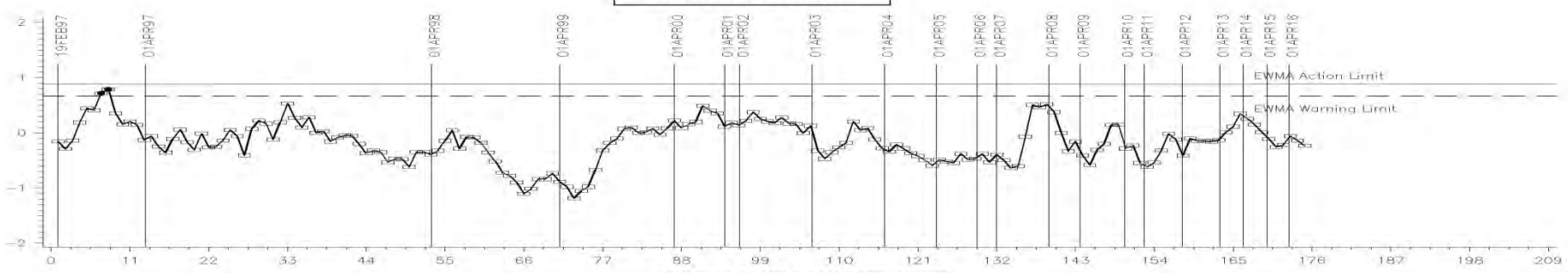
WEIGHTED TOTAL DEMERITS

LTMS Severity Analysis



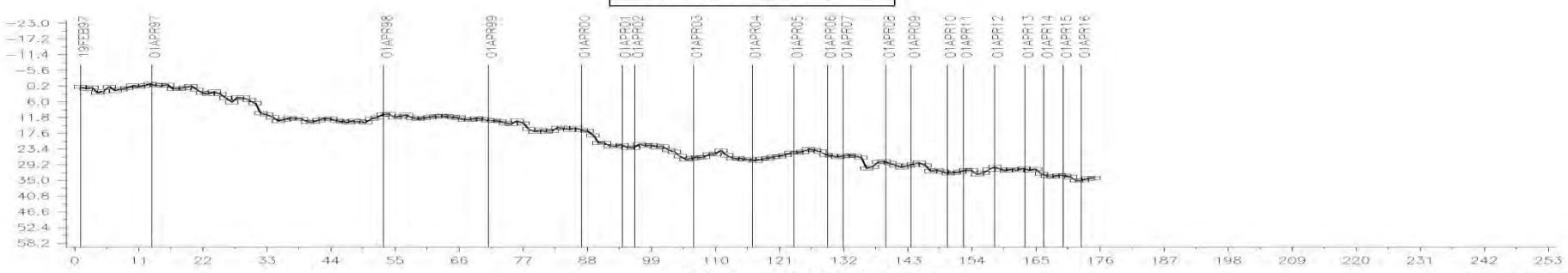
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis

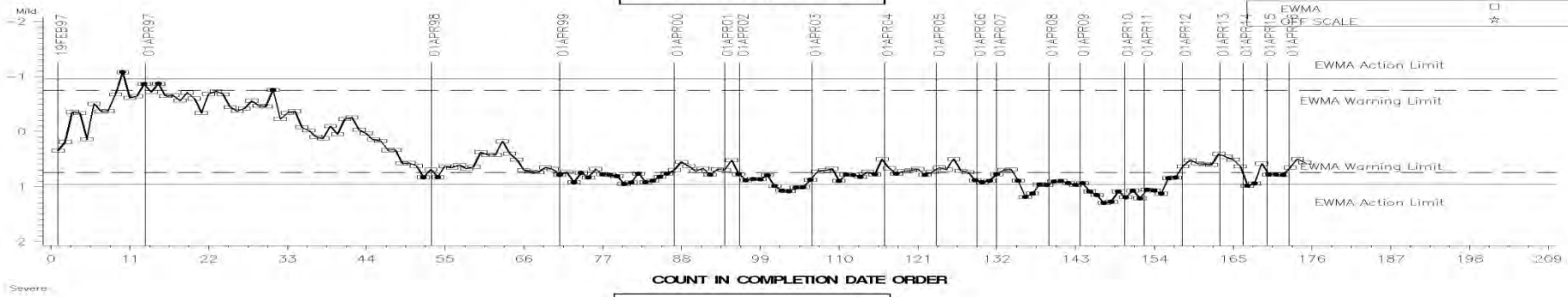


COUNT IN COMPLETION DATE ORDER

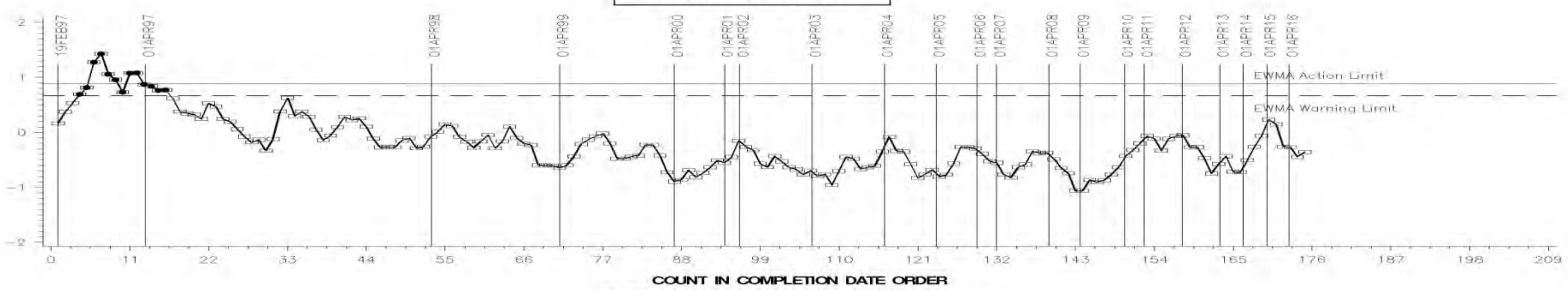
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OIL CONSUMPTION

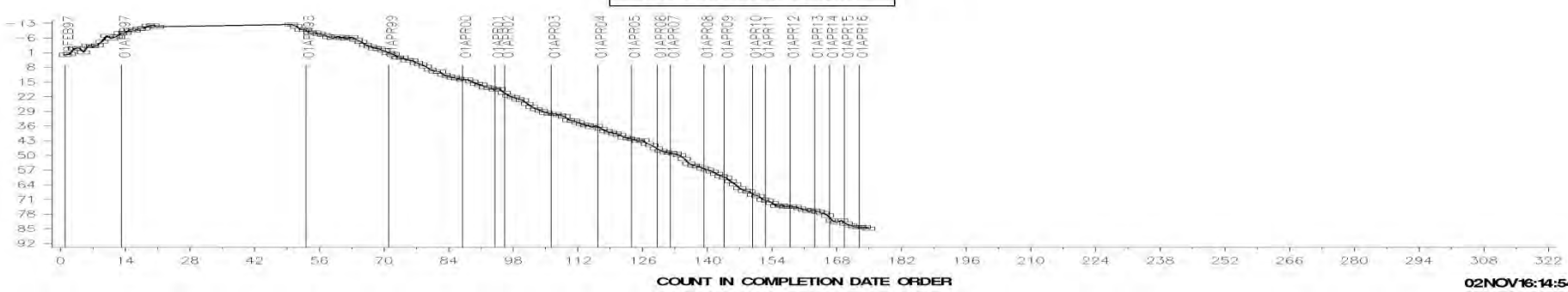
LTMS Severity Analysis



LTMS Precision Analysis



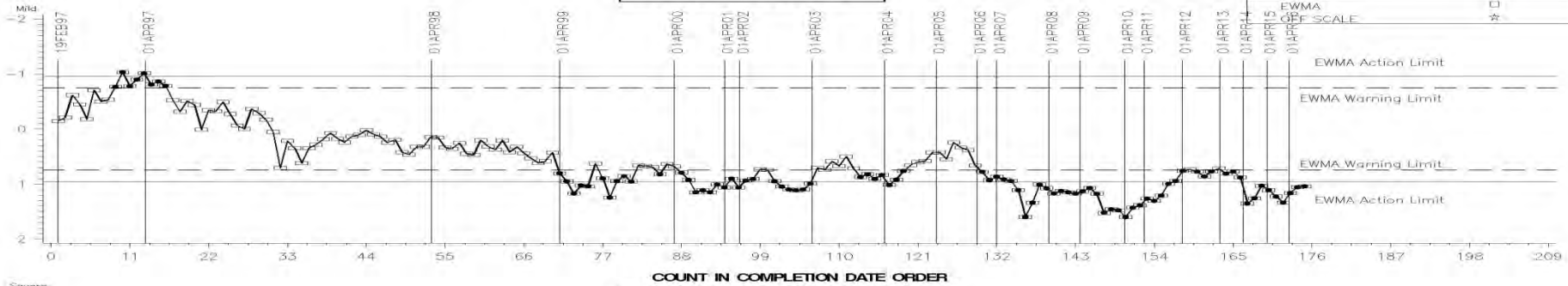
CUSUM Severity Analysis



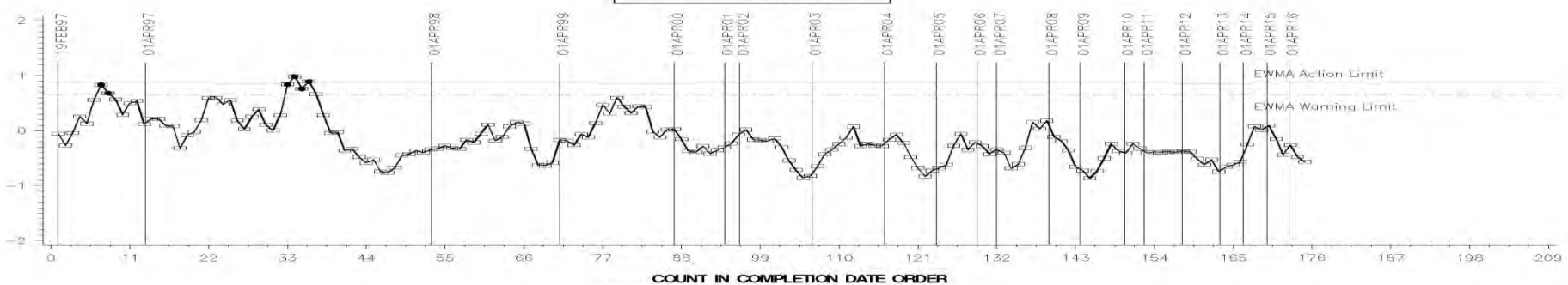
02NOV16:14:54

EOTOC

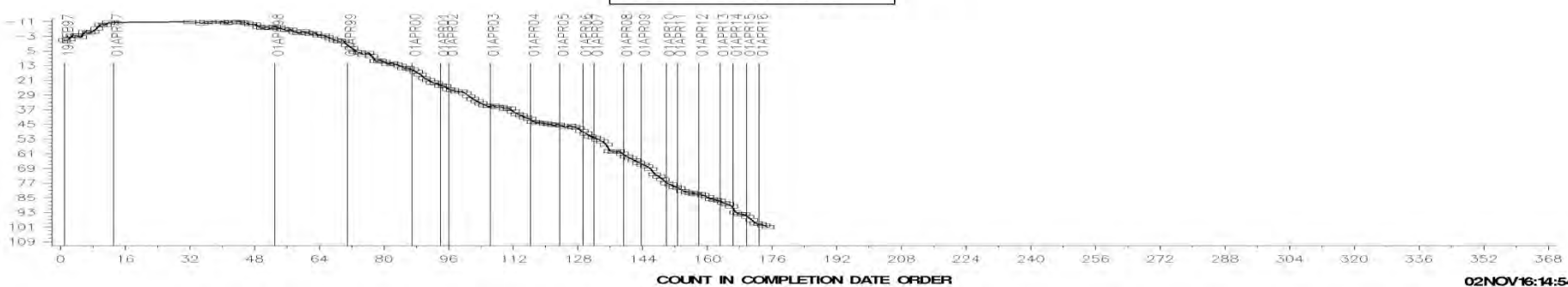
LTMS Severity Analysis



LTMS Precision Analysis

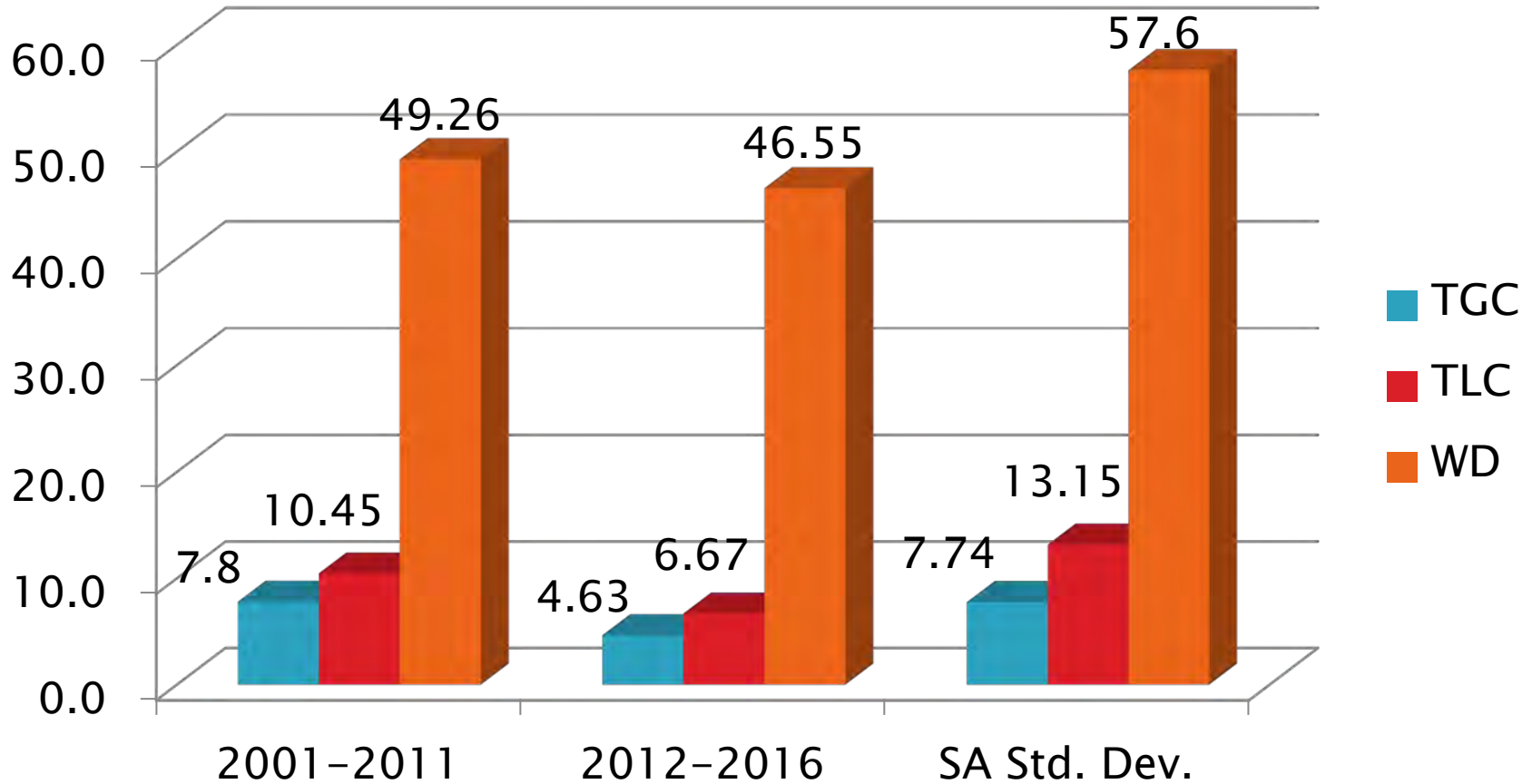


CUSUM Severity Analysis



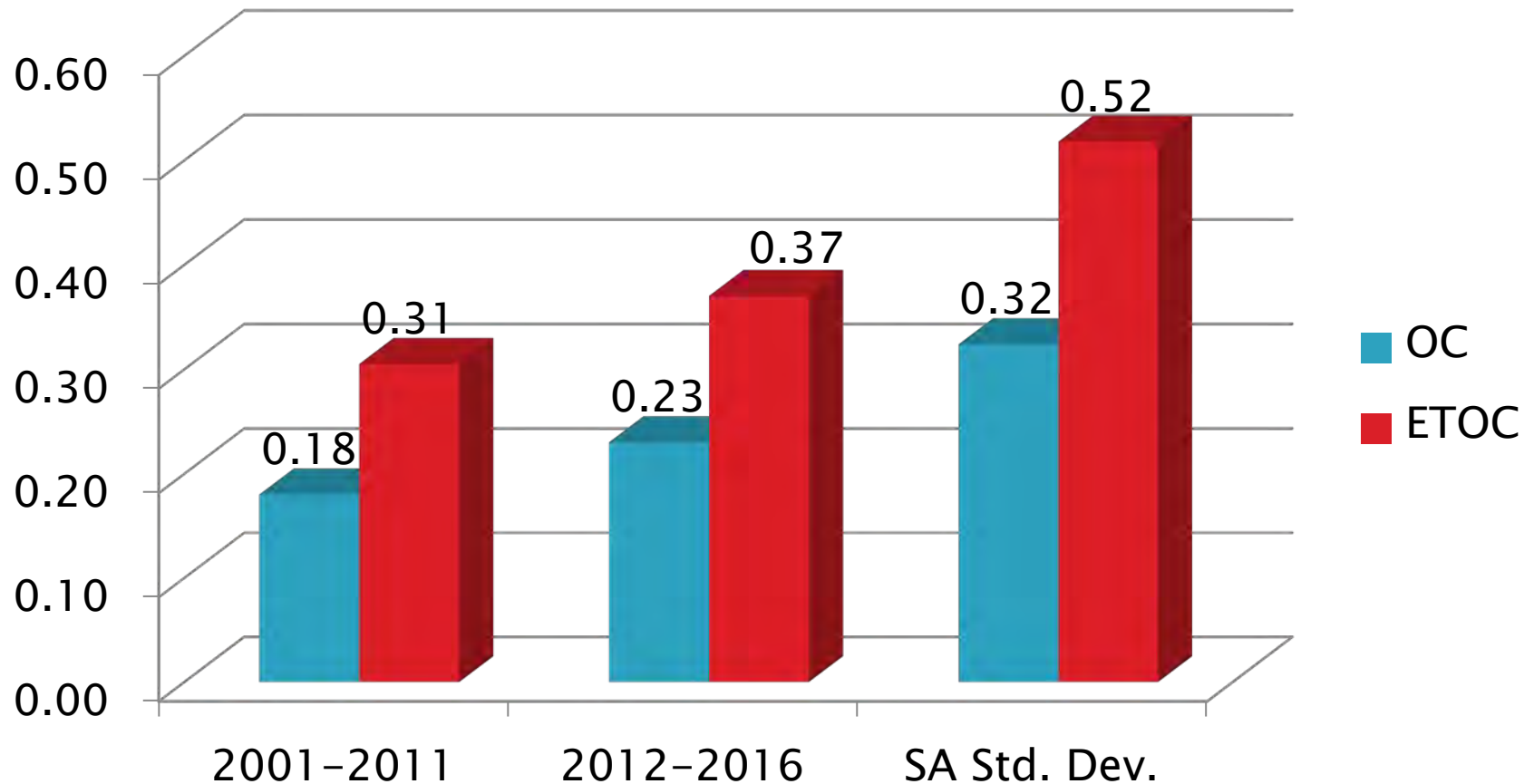
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# 1P Precision Estimates





# 1P Precision Estimates



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# SCOTE 1 R

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# 1 R Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 0        |
| Failed Calibration Test     | OC            | 0        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 0        |
| <b>Total</b>                |               | <b>0</b> |

# 1 R Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No Failed Tests  | 0               |
| Total            | 0               |

# 1 R Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No invalid tests | 0        |
| Aborted      | No aborted tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

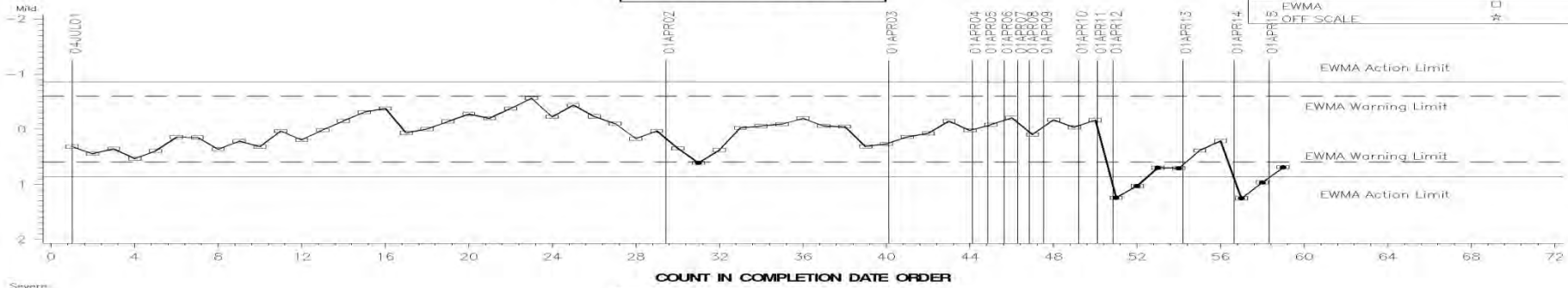
\*Invalid and aborted tests

# 1 R Test Severity

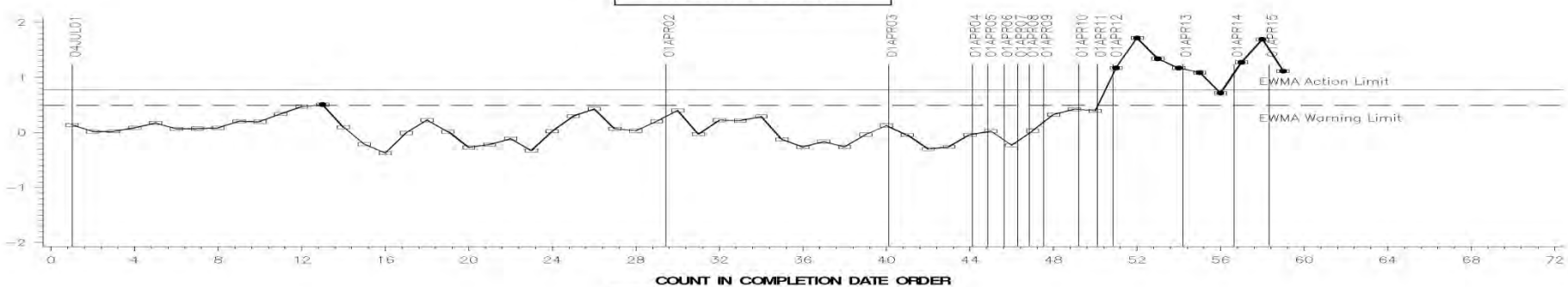
- ▶ WD in severity warning alarm severe direction
- ▶ BTOC is in control.
- ▶ WD, TGC, TLC and ETOC in precision alarm

FINAL WEIGHTED TOTAL DEMERITS (DEMERITS)

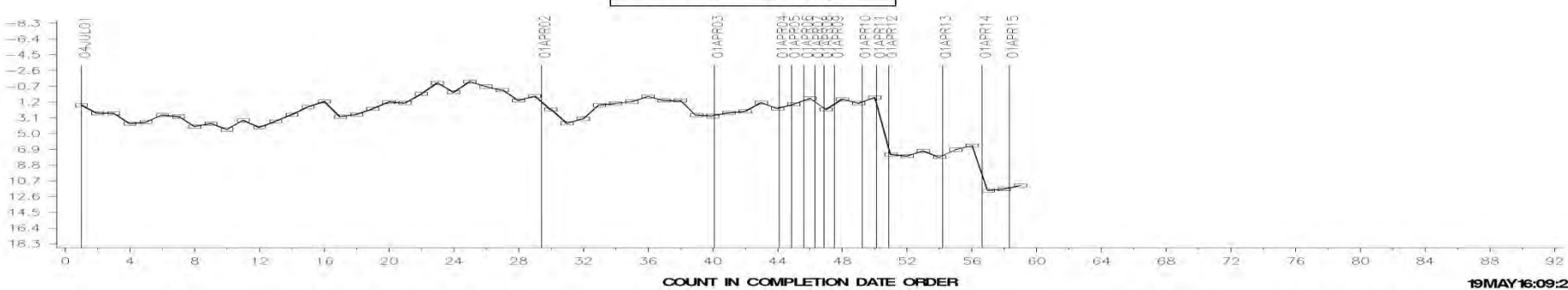
LTMS Severity Analysis



LTMS Precision Analysis



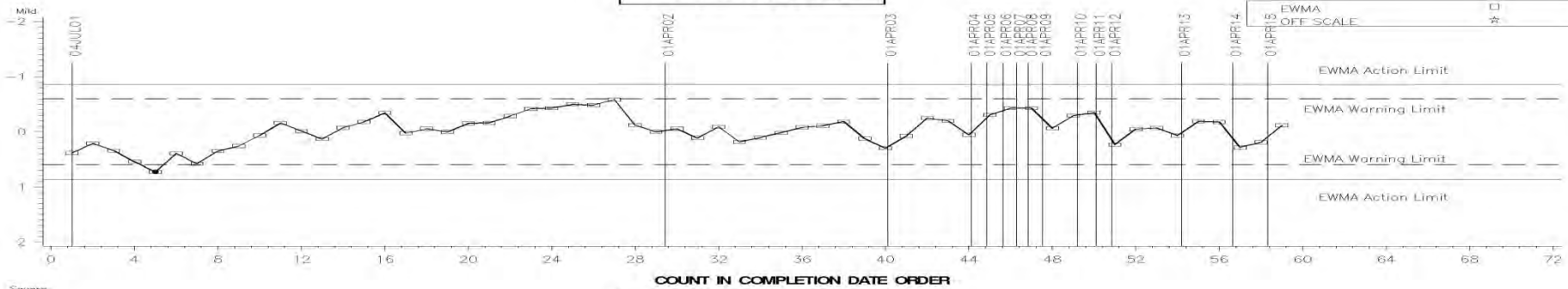
CUSUM Severity Analysis



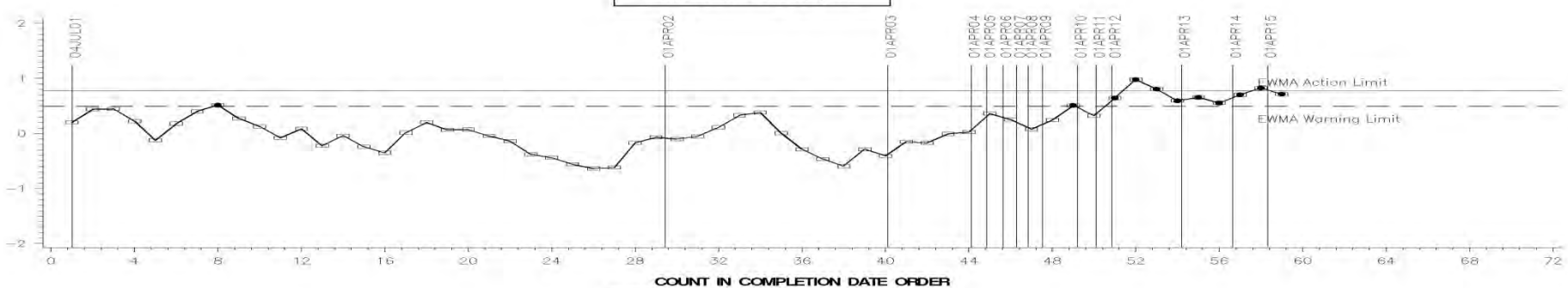
19MAY16:09:22

FINAL TOP GROOVE CARBON (DEMERITS)

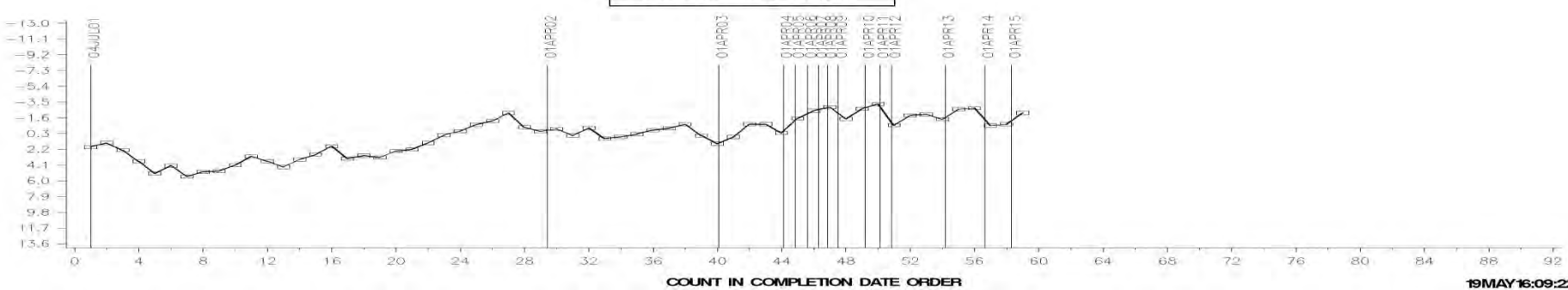
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

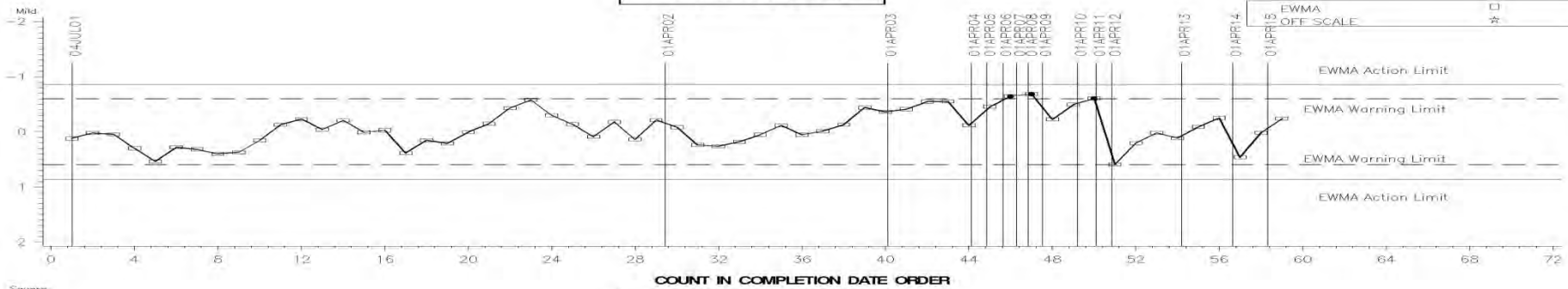


19MAY16:09:22

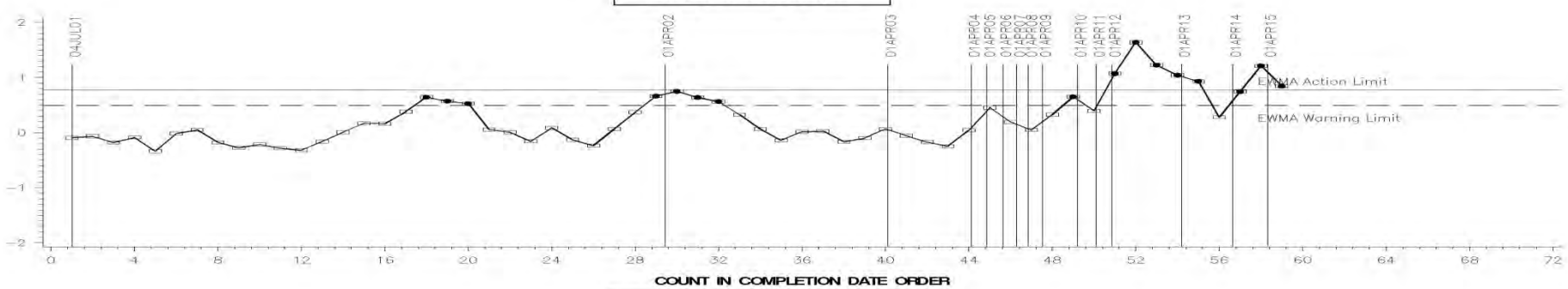


FINAL TOP LAND CARBON (DEMERITS)

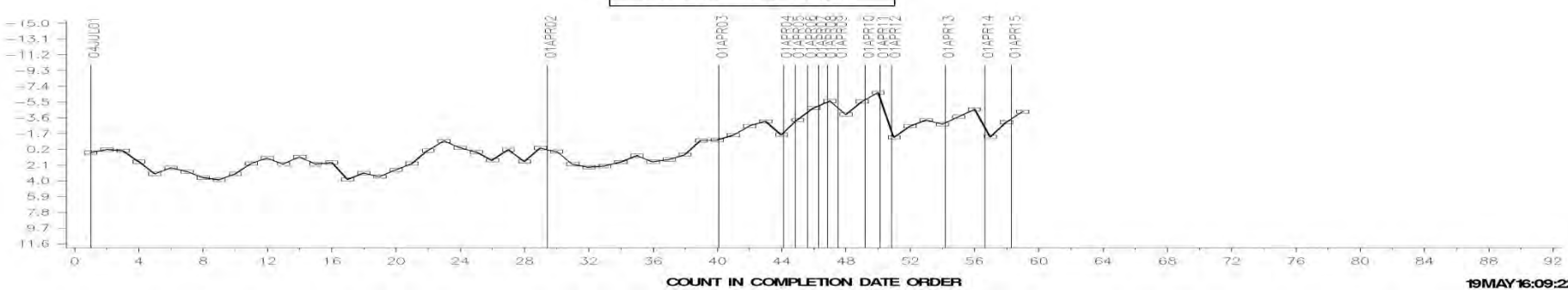
LTMS Severity Analysis



LTMS Precision Analysis



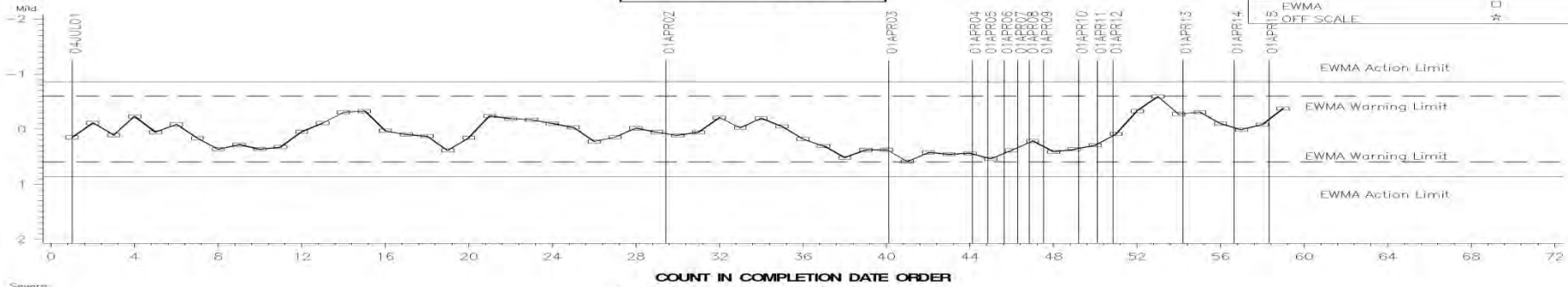
CUSUM Severity Analysis



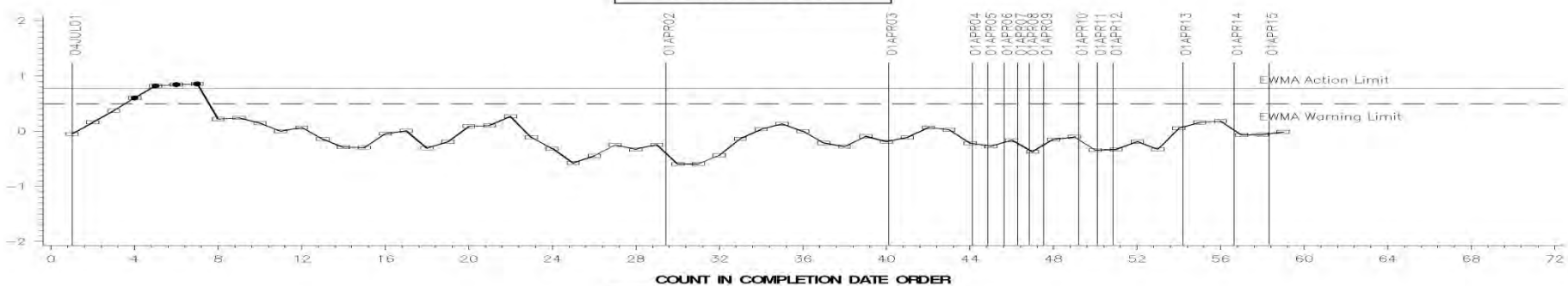
19MAY16:09:22

FINAL BOTOC

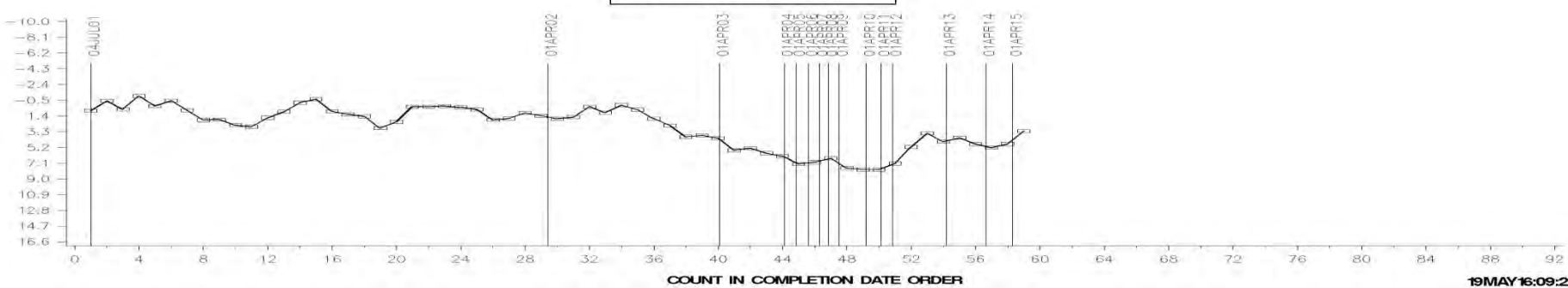
LTMS Severity Analysis



LTMS Precision Analysis



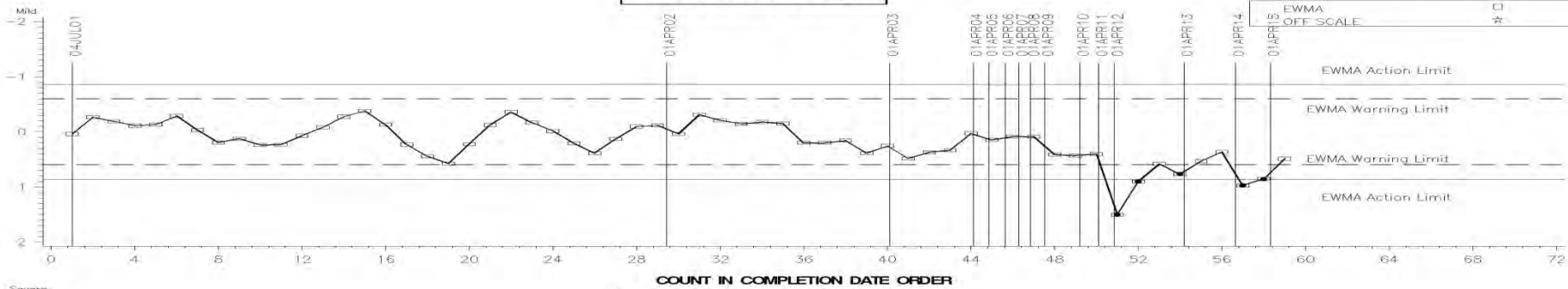
CUSUM Severity Analysis



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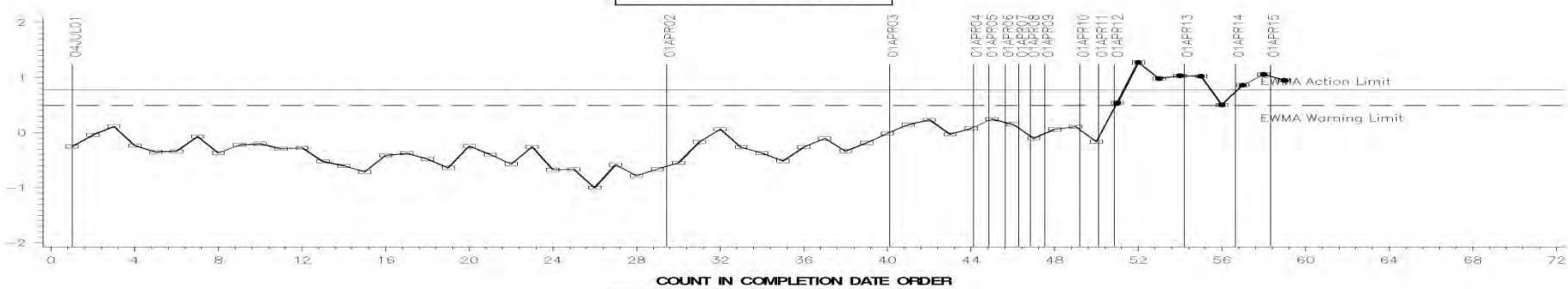
FINAL EOTC (g/h)

LTMS Severity Analysis



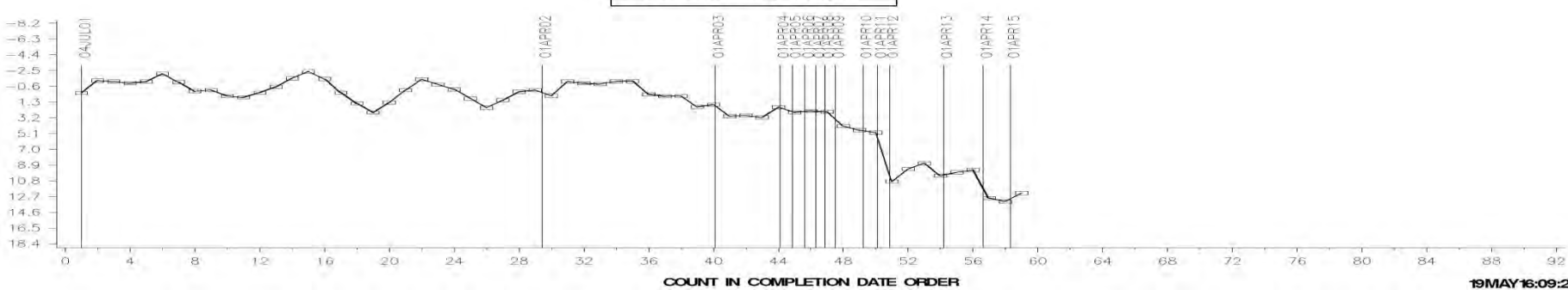
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

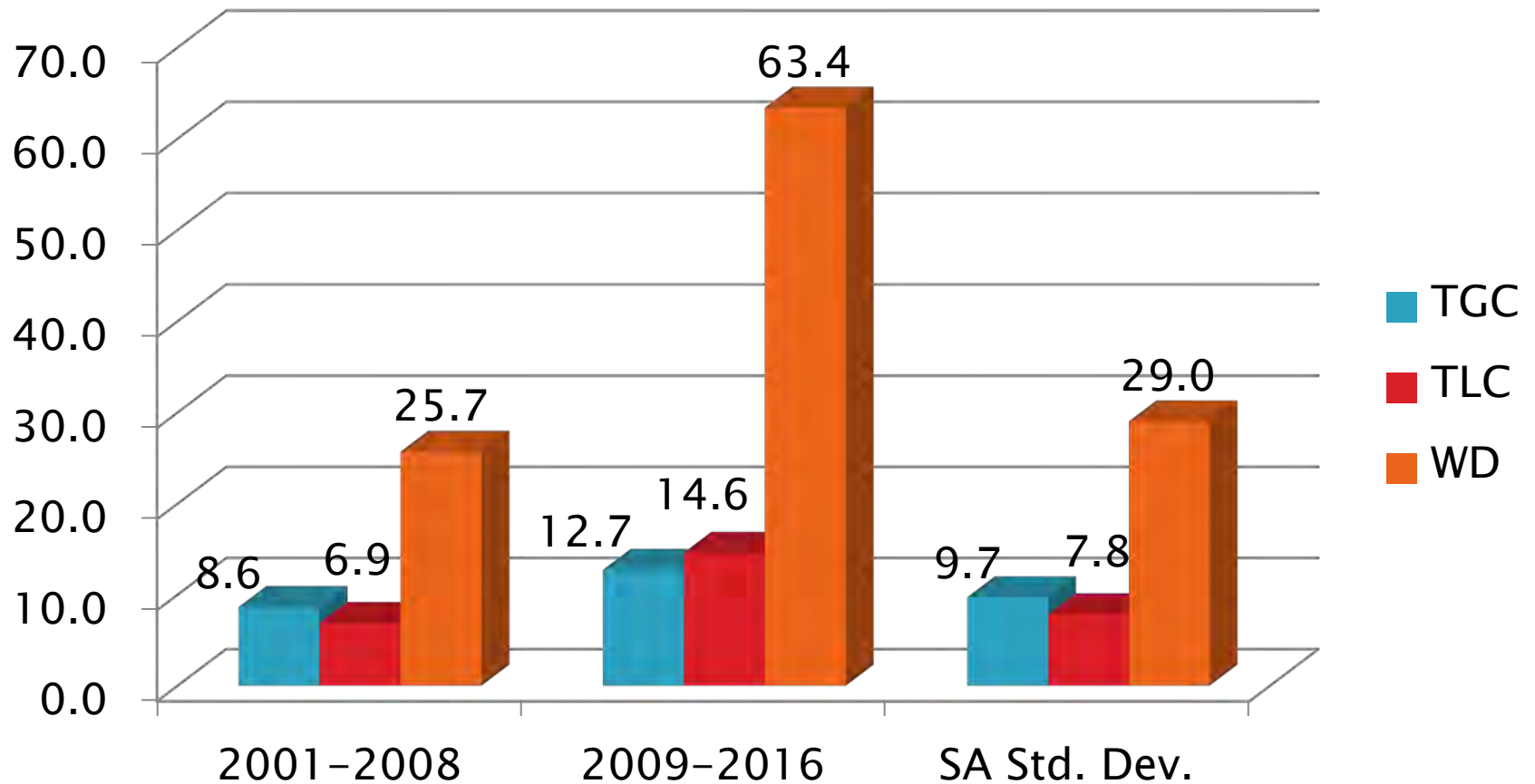
CUSUM Severity Analysis



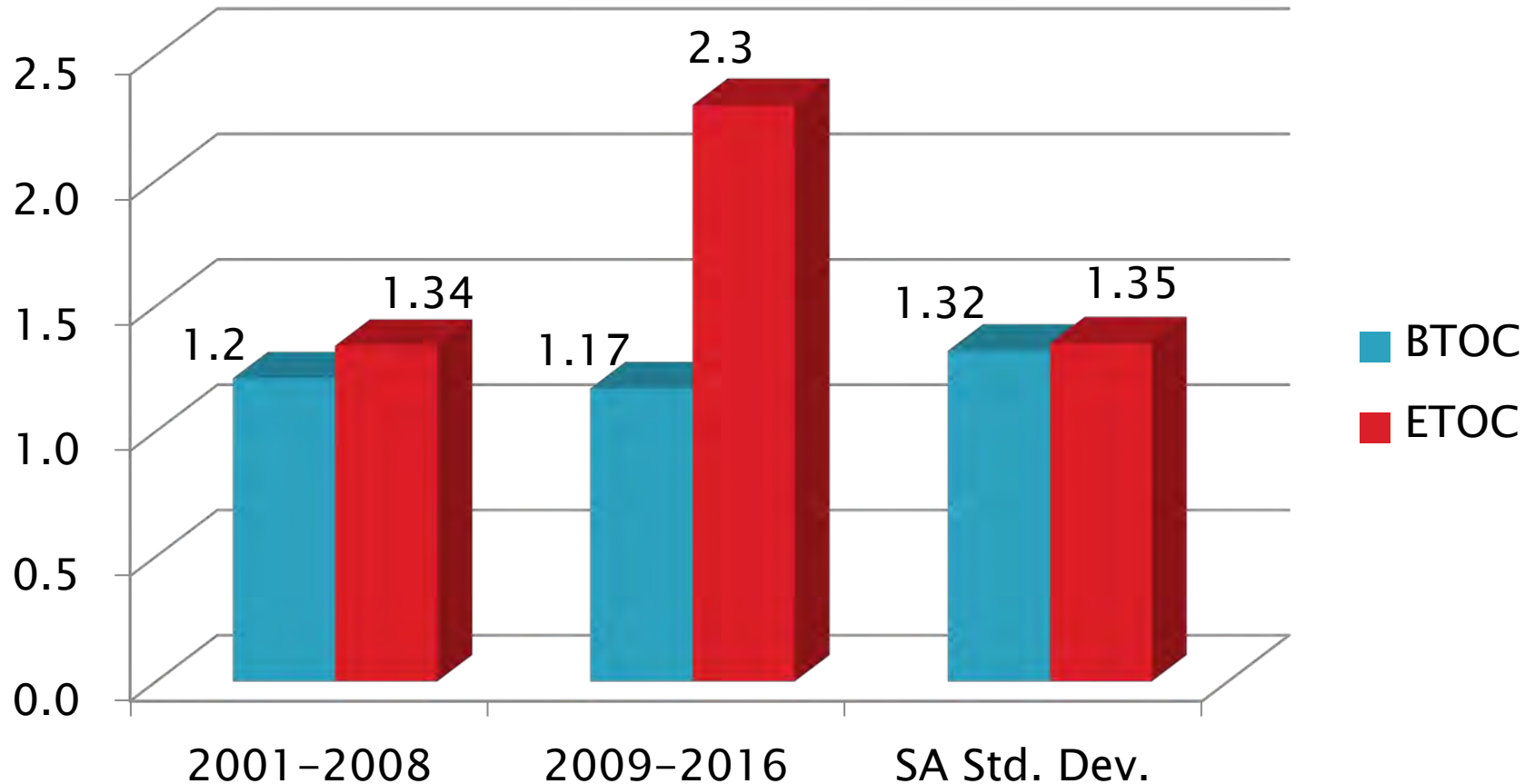
COUNT IN COMPLETION DATE ORDER

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# 1R Precision Estimates



# 1 R Precision Estimates



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# CAT C13

»» October 2016

# C13 Test Activity

| Test Status                 | Validity Code | C13      |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 1        |
| Failed Calibration Test     | OC            | 1        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 0        |
| <b>Total</b>                |               | <b>2</b> |

# C13 Failed Tests

| Failed Parameter       | Number of Tests |
|------------------------|-----------------|
| Severe Oil Consumption | 1               |
| Total                  | 1               |



# C13 Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No invalid tests | 0        |
| Aborted      | No aborted tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

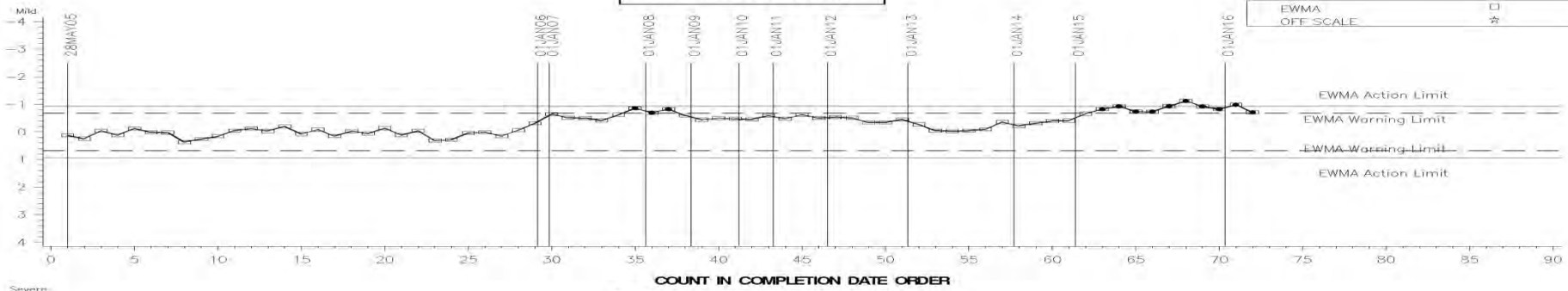
\*Invalid and aborted tests

# C13 Test Severity

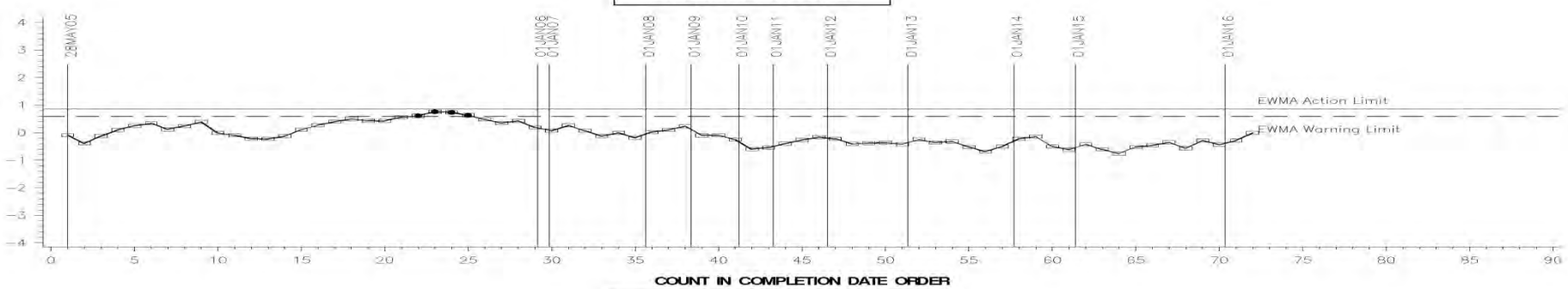
- ▶ TGC is in control. TGC near severity warning alarm.
- ▶ OC and R2TC in precision warning alarm.
- ▶ TLC in severity warning alarm mild direction.

TOP LAND CARBON AVG. - FINAL RESULT

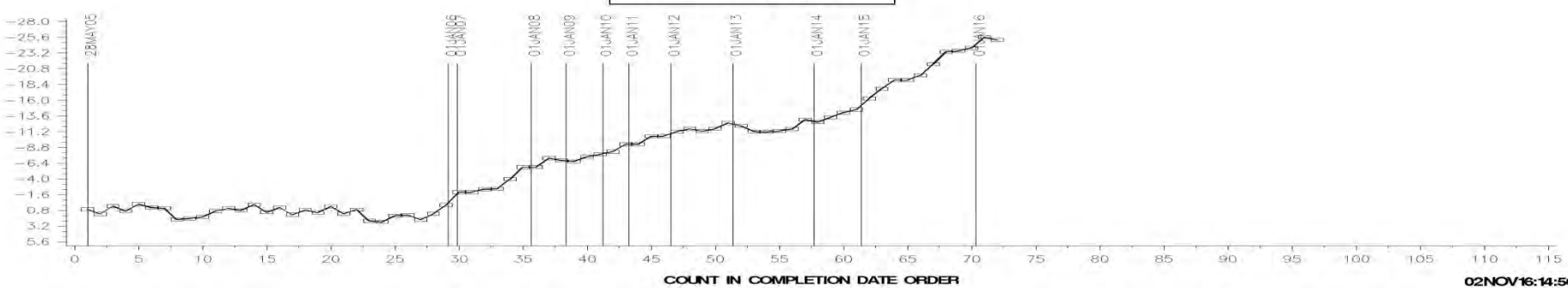
LTMS Severity Analysis



LTMS Precision Analysis



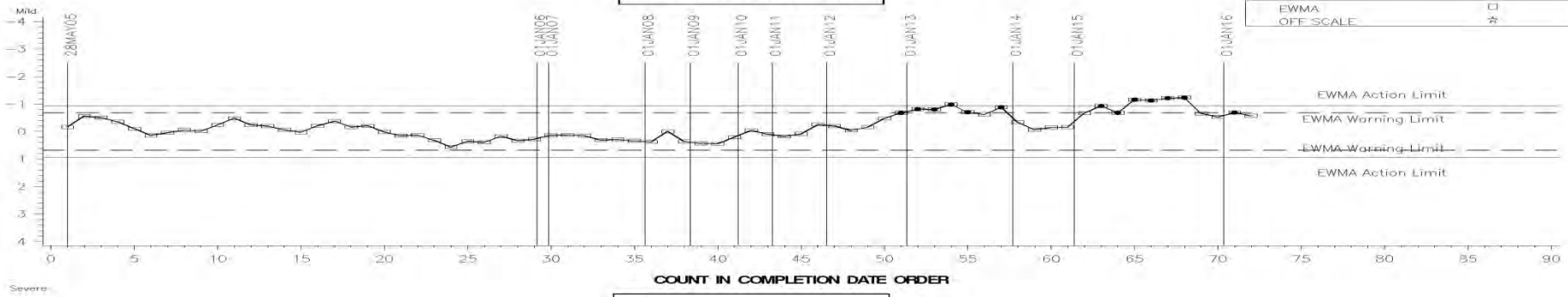
CUSUM Severity Analysis



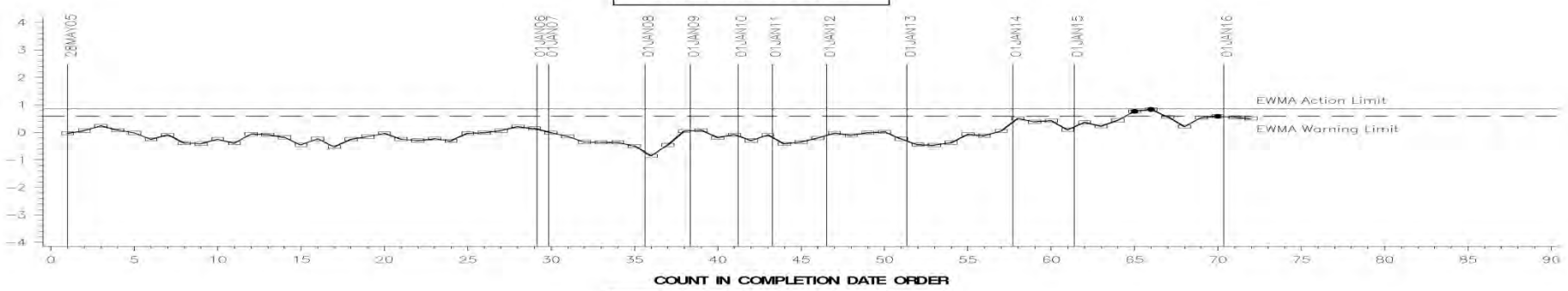
02NOV16:14:56

TOP GROOVE CARBON AVG - FINAL RESULT

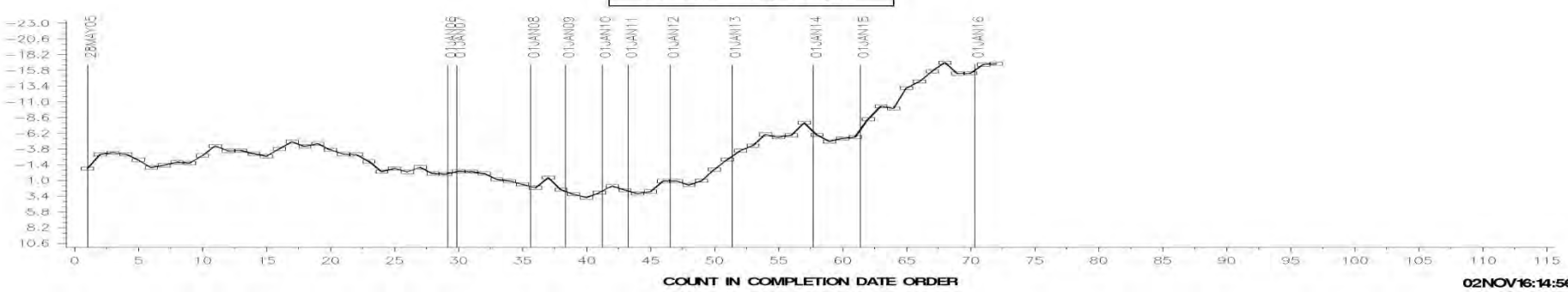
LTMS Severity Analysis



LTMS Precision Analysis



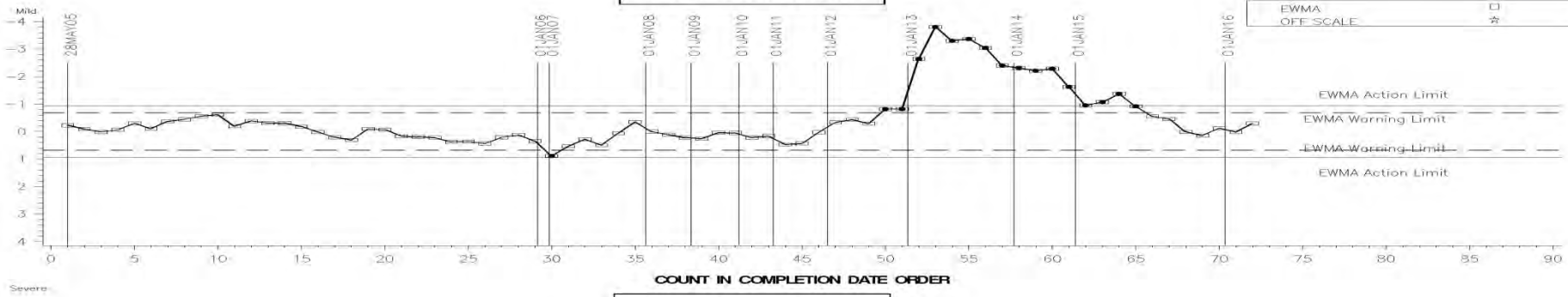
CUSUM Severity Analysis



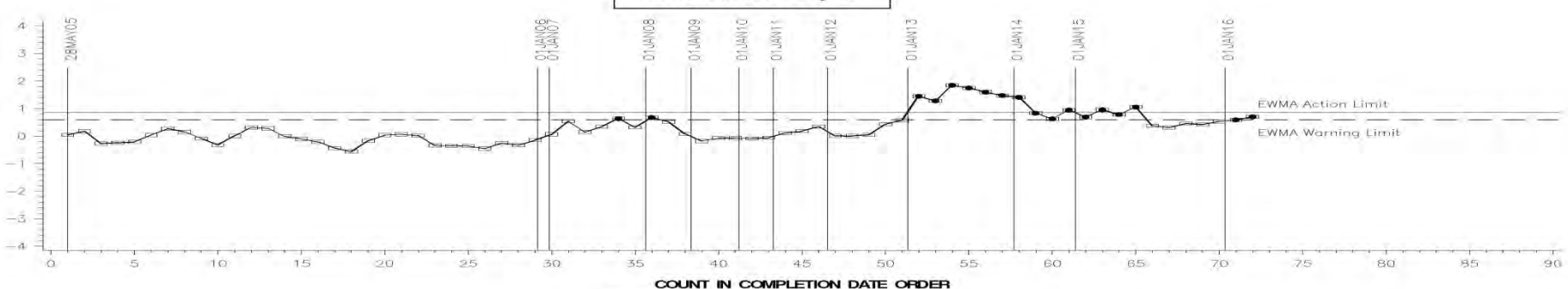
02NOV16:14:56

2ND RING TOP CARBON AVG. — FINAL RESULT

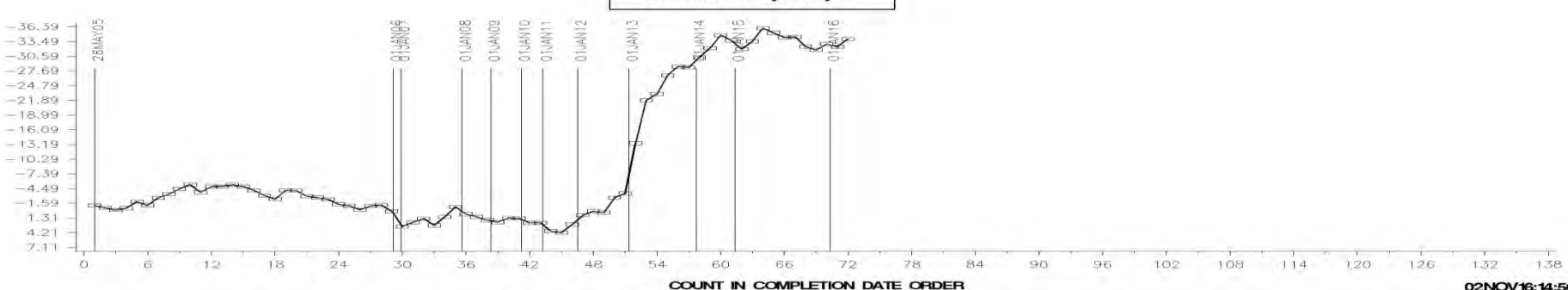
LTMS Severity Analysis



LTMS Precision Analysis



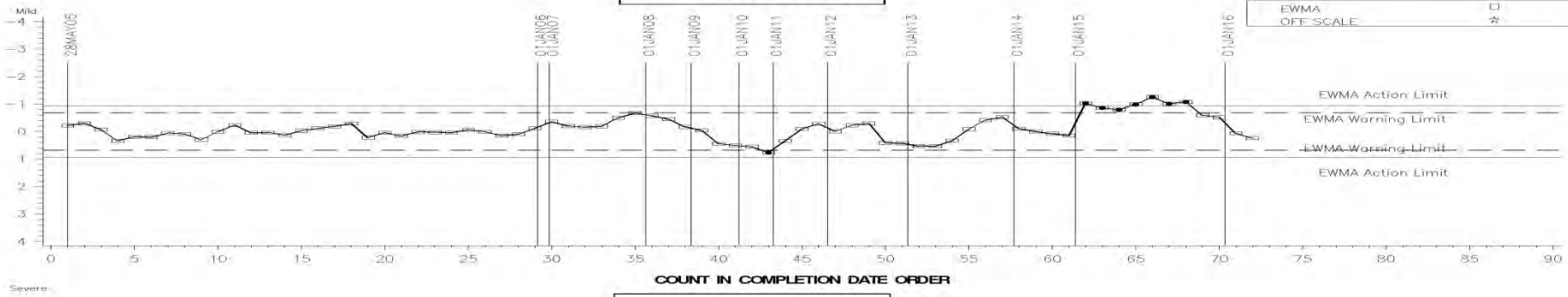
CUSUM Severity Analysis



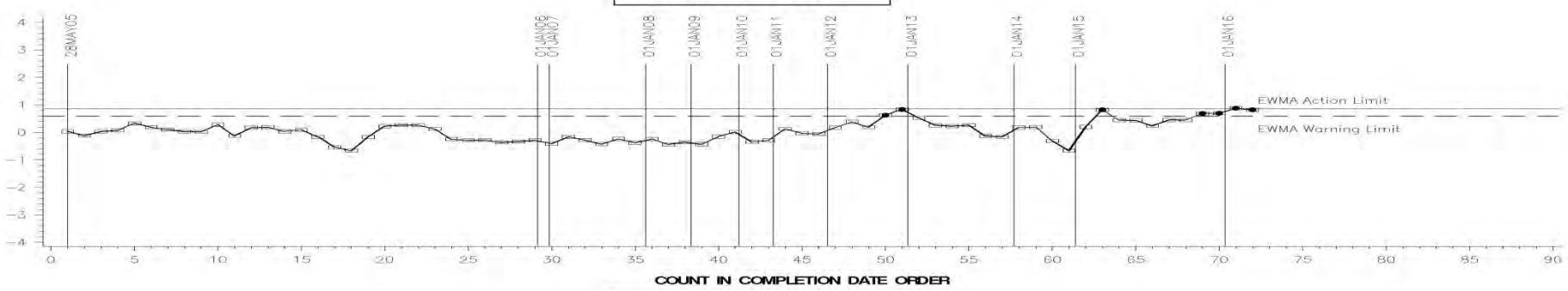
02NOV16:14:56

OIL CONS. DELTA - FINAL RESULT

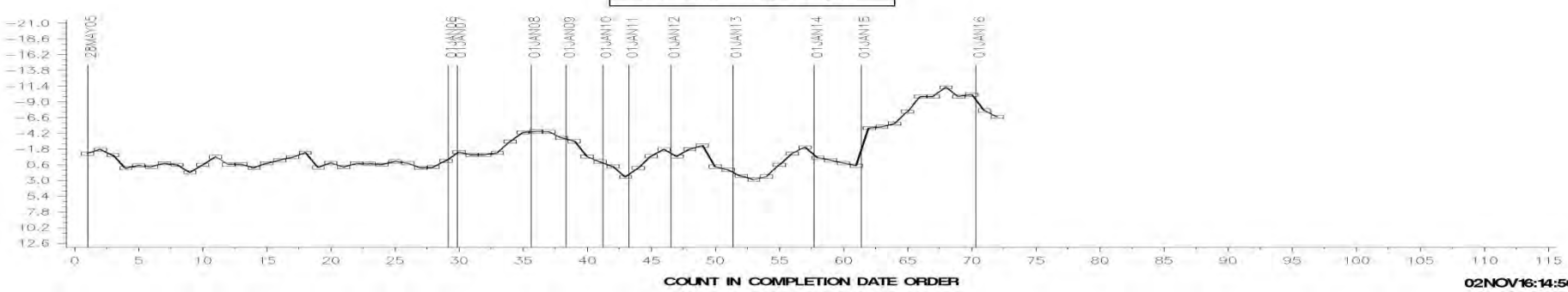
LTMS Severity Analysis



LTMS Precision Analysis

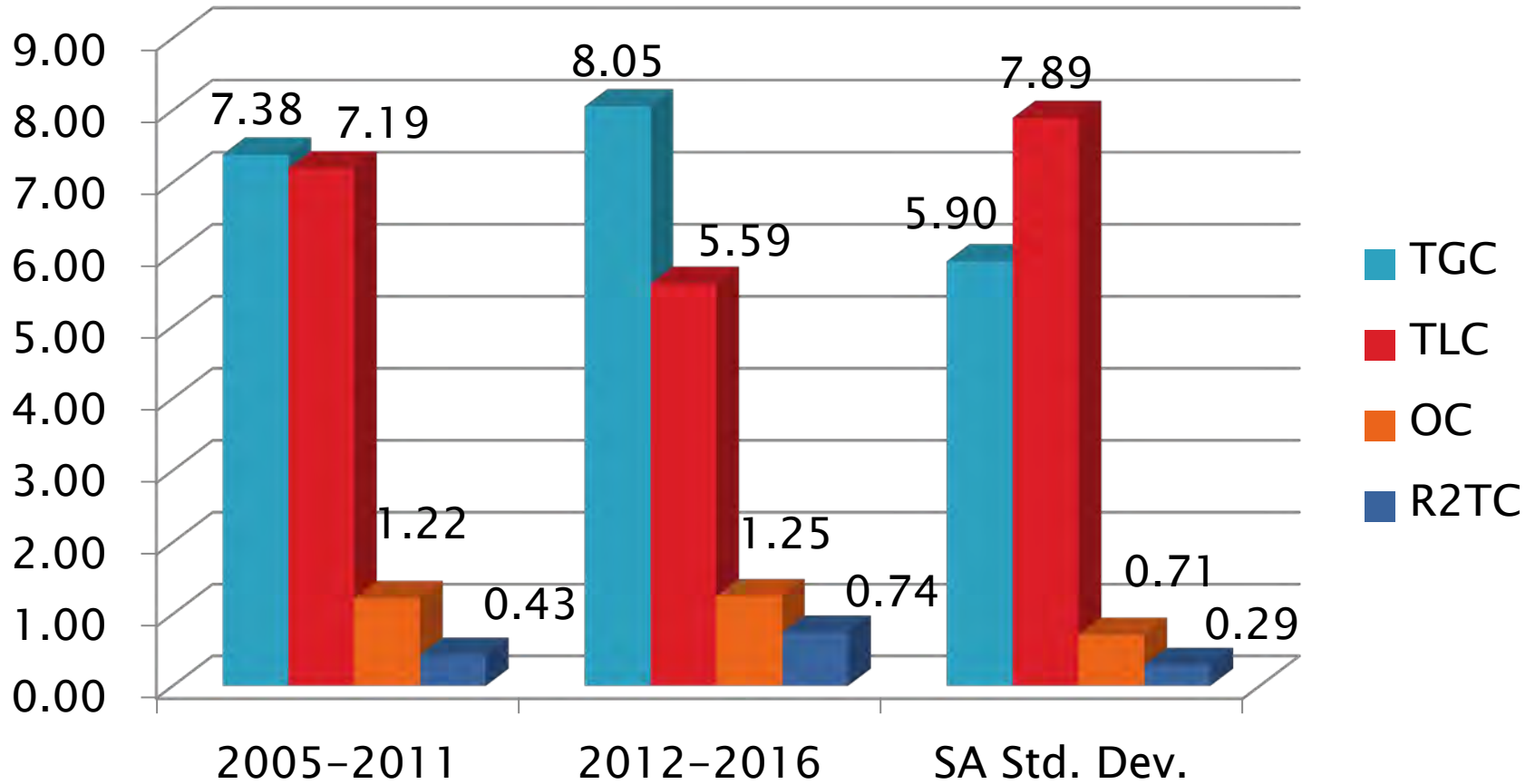


CUSUM Severity Analysis



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# C13 Precision Estimates



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# C13 Oil Aeration (COAT)

»» October 2016

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# COAT Test Activity

| Test Status                 | Validity Code | COAT     |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 4        |
| Failed Calibration Test     | OC            | 2        |
| Operationally Invalid       | LC            | 1        |
| Aborted                     | XC            | 0        |
| <b>Total</b>                |               | <b>7</b> |

# COAT Failed Tests

| Failed Parameter      | Number of Tests |
|-----------------------|-----------------|
| Average Aeration Mild | 2               |
| Total                 | 2               |

# COAT Lost Tests\*

| Status       | Cause  | #        |
|--------------|--|----------|
| Invalid      | Sample Oil Pressure Transducer Calibration out of spec | 1        |
| Aborted      | No aborted tests                                       | 0        |
| <b>Total</b> |  | <b>1</b> |

\*Invalid and aborted tests

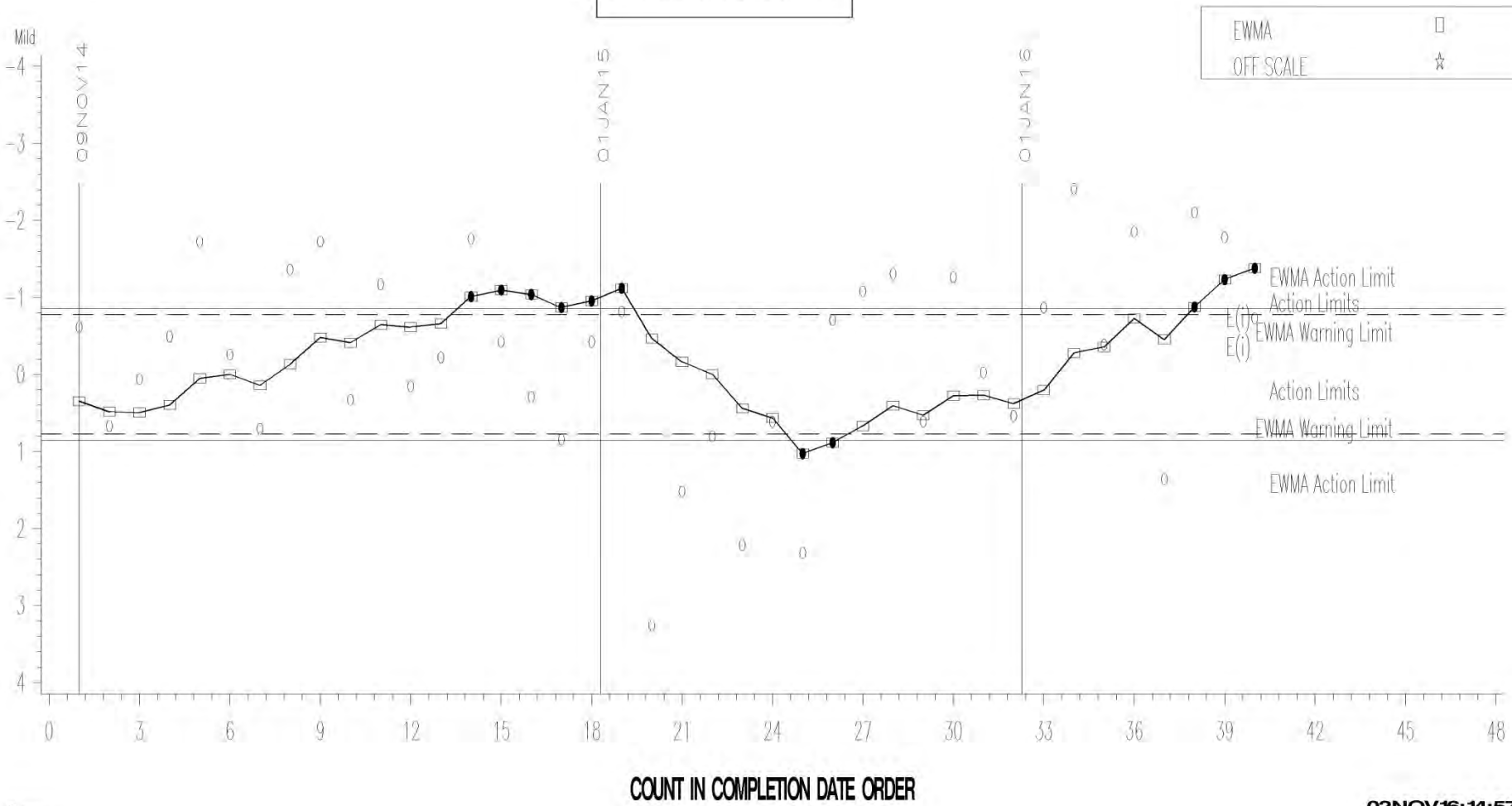
# COAT Test Severity

- ▶ AAVE is in action alarm (Level 2 Zi Alarm) in the mild direction.

AVERAGE AERATION HOURS 40 — 50

LTMS Severity Analysis

Standard Deviation Units

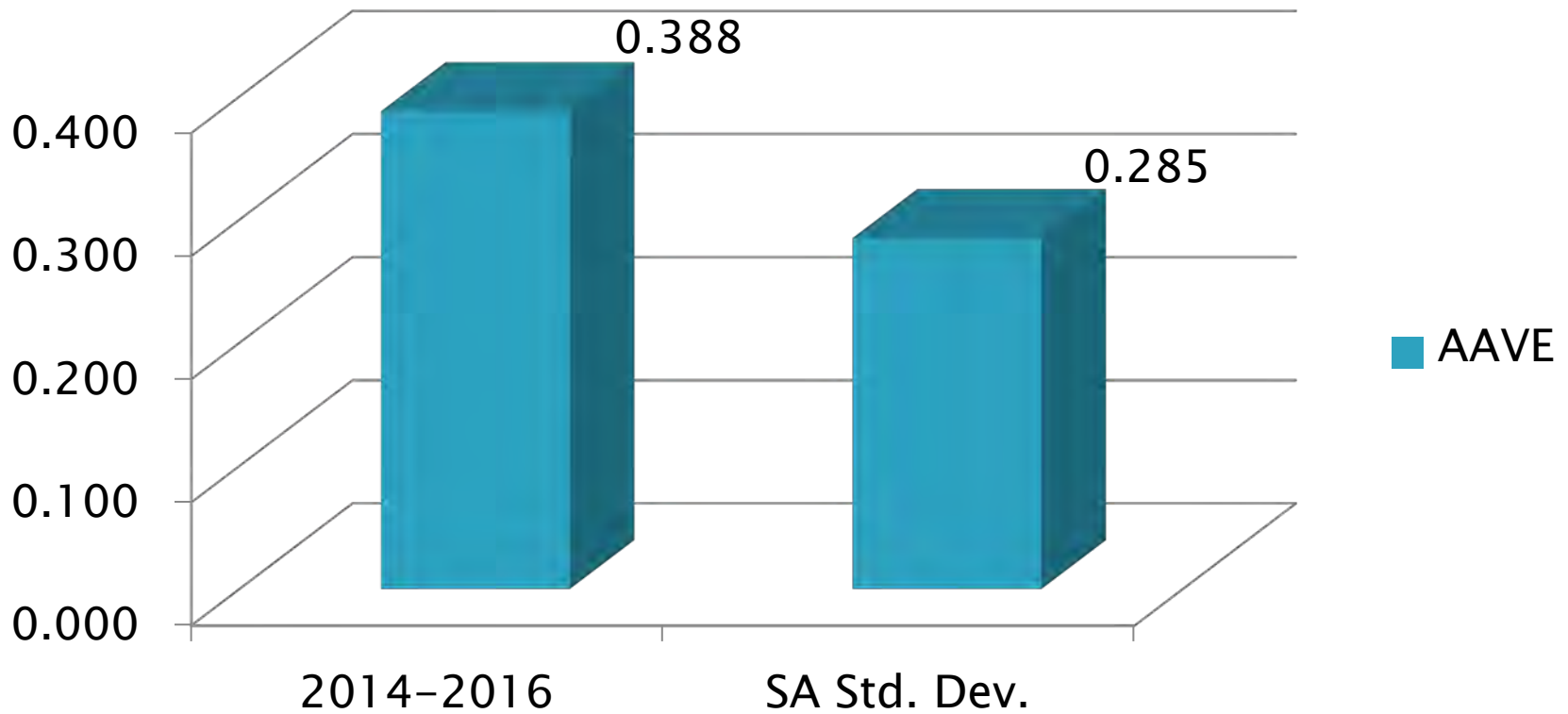


Severity

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# COAT Precision Estimates

## AAVE



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# Daimler DD13 Scuffing Test

»» October 2016

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# DD13 Test Activity\*

| Test Status                 | Validity Code | COAT      |
|-----------------------------|---------------|-----------|
| Acceptable Calibration Test | AC            | 12        |
| Failed Calibration Test     | OC            | 3         |
| Operationally Invalid       | LC            | 0         |
| Aborted                     | XC            | 0         |
| <b>Total</b>                |               | <b>15</b> |

\*Includes all test activity from 2015 and 2016



# DD13 Failed Tests

| Failed Parameter    | Number of Tests |
|---------------------|-----------------|
| Hours to Scuff Mild | 3               |
| <b>Total</b>        | <b>3</b>        |

# DD13 Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No invalid tests | 0        |
| Aborted      | No aborted tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

\*Invalid and aborted tests

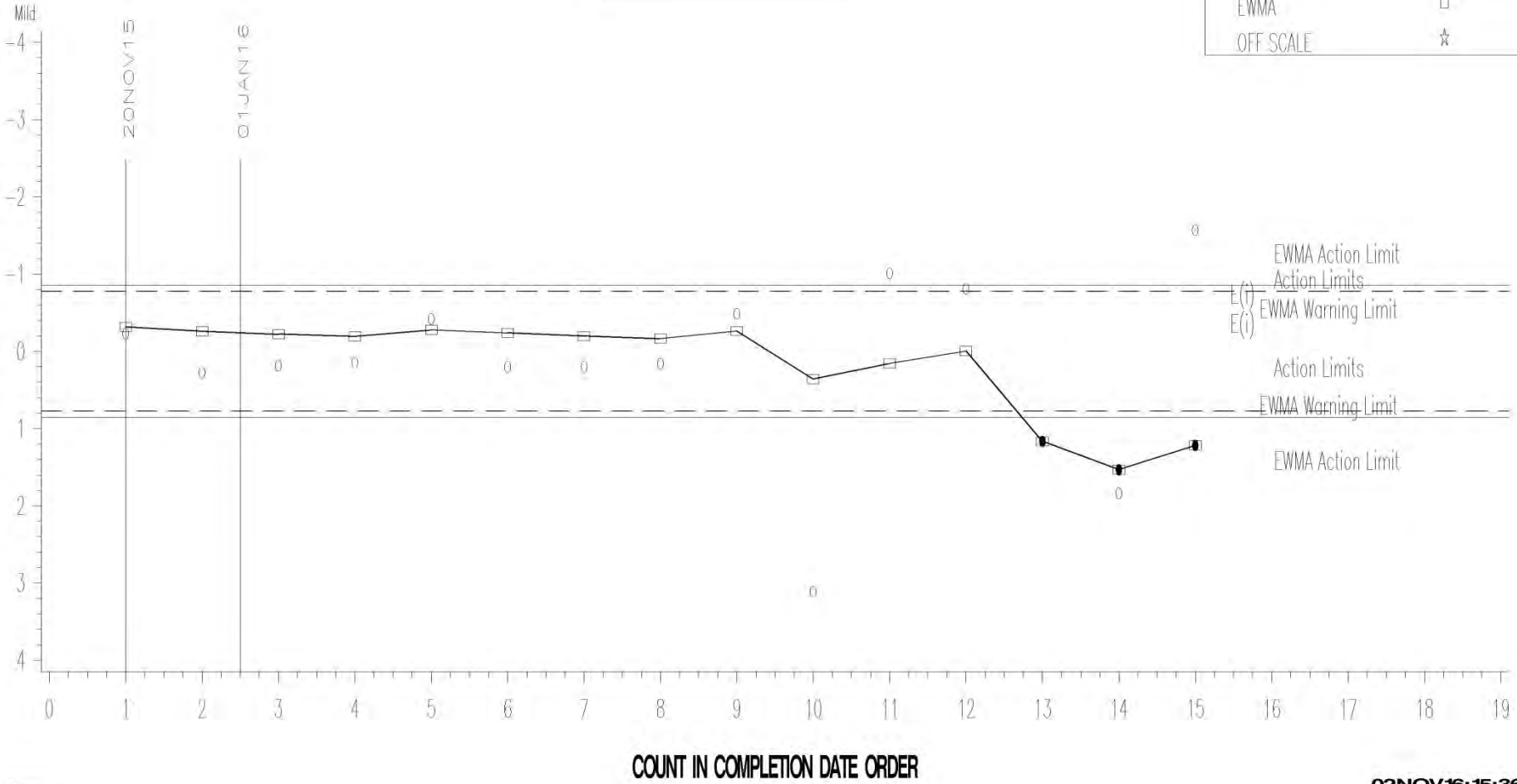
# DD13 Test Severity

- ▶ HRS2SCF is in action alarm (Level 2 Zi Alarm) in the mild direction.

FNL. ORIG. UNIT HOURS TO SCUFF

LTMS Severity Analysis

Standard Deviation Units

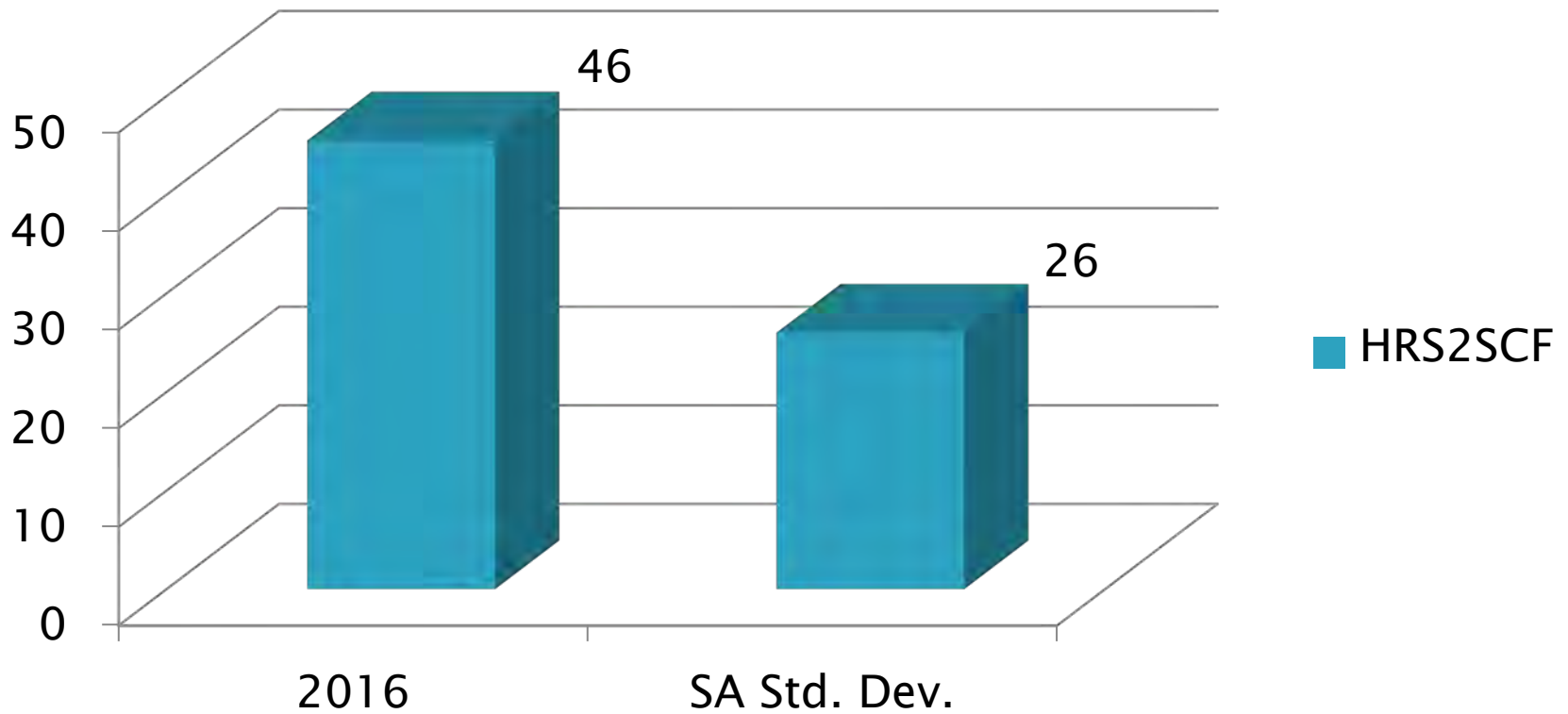


Severe

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# DD13 Precision Estimates

## HRS2SCF



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# Cummins ISB

»» October 2015

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# ISB Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 3        |
| Failed Calibration Test     | OC            | 1        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 0        |
| <b>Total</b>                |               | <b>4</b> |

# ISB Failed Tests

| Failed Parameter                       | Number of Tests |
|--|-----------------|
| Mild Average Tappet Weight Loss (ATWL) | 1               |
| <b>Total</b>                           | <b>1</b>        |



# ISB Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No Invalid Tests | 0        |
| Aborted      | No Aborted Tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

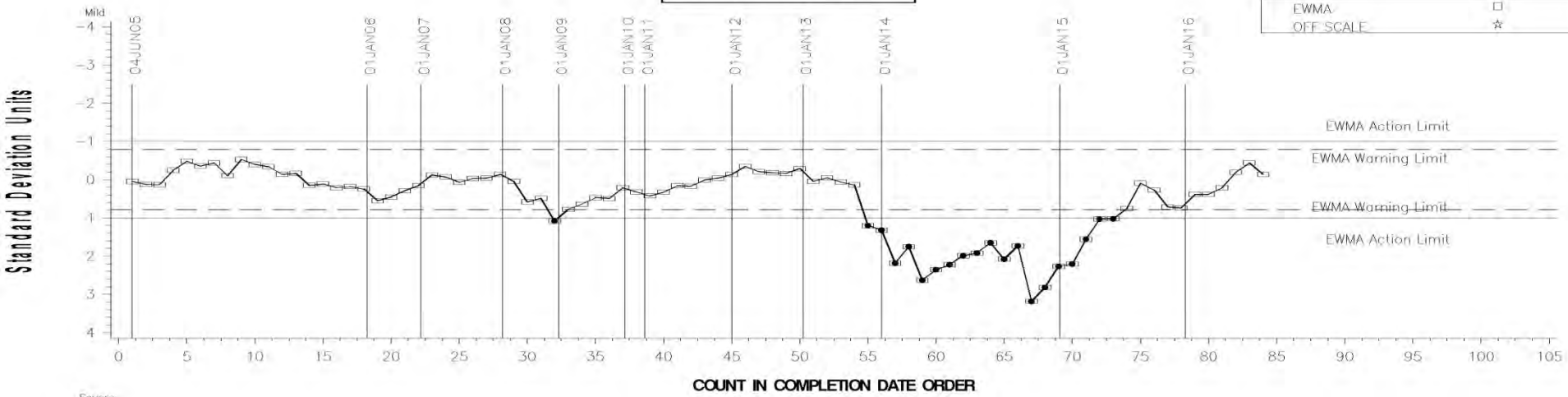
\*Invalid and aborted tests

# ISB Test Severity

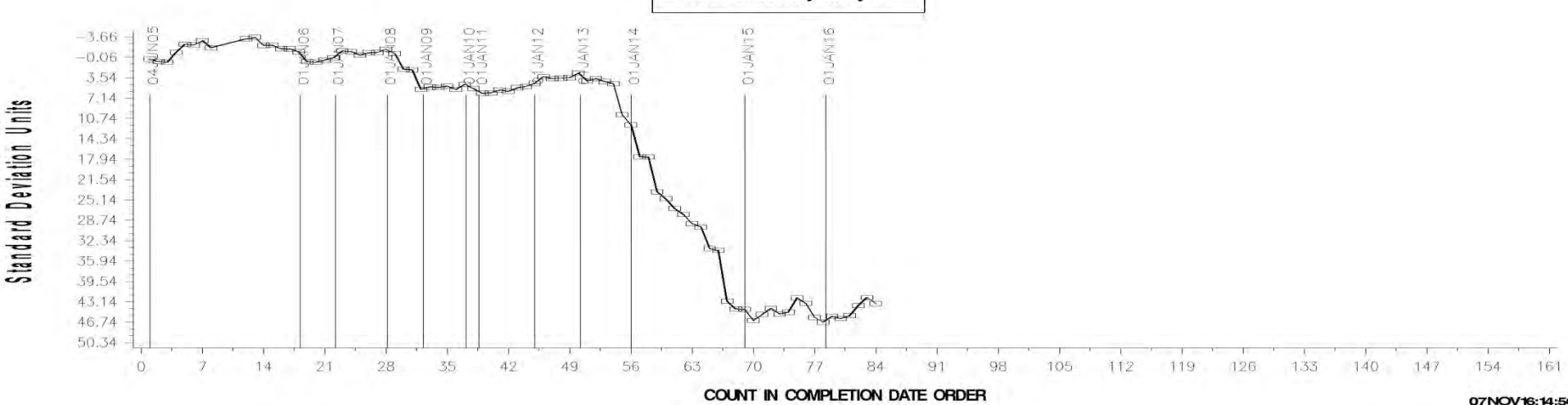
- ▶ ACSW and ATWL are in control.

AVERAGE CAMSHAFT WEAR

LTMS Severity Analysis



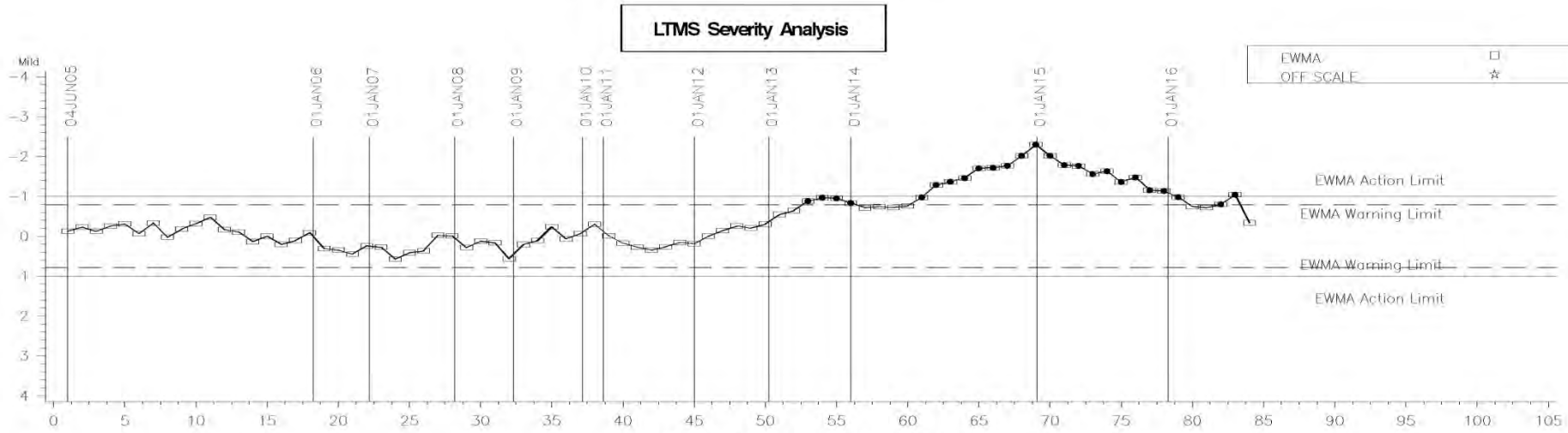
CUSUM Severity Analysis



07NOV16:14:56

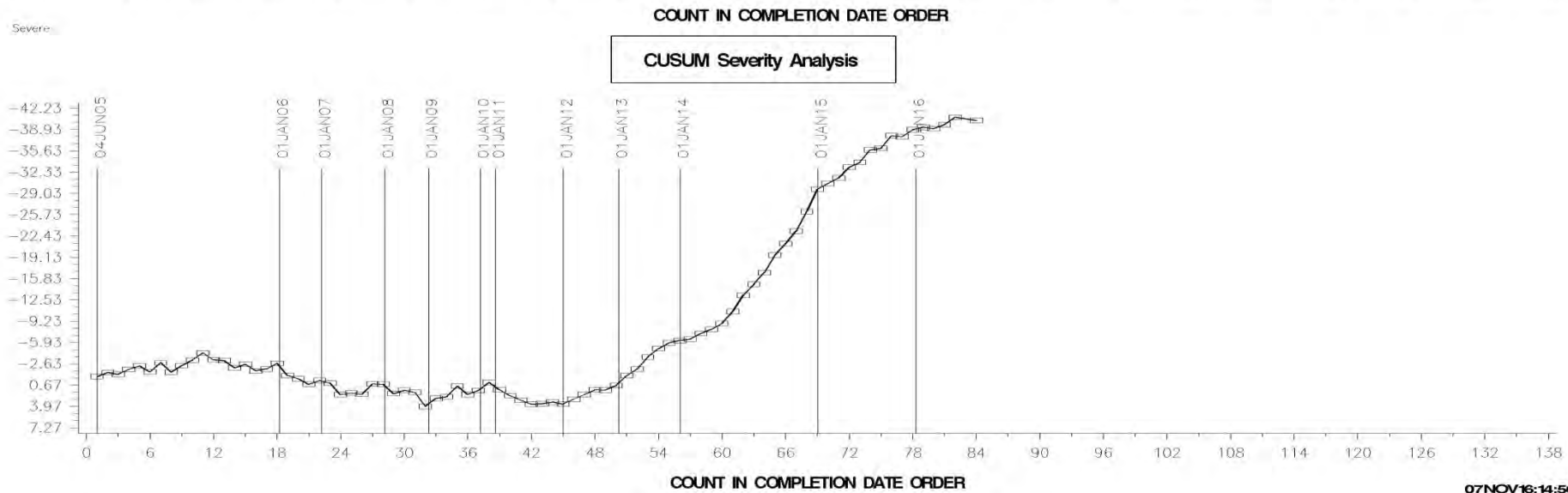
AVERAGE TAPPET WEIGHT LOSS

Standard Deviation Units



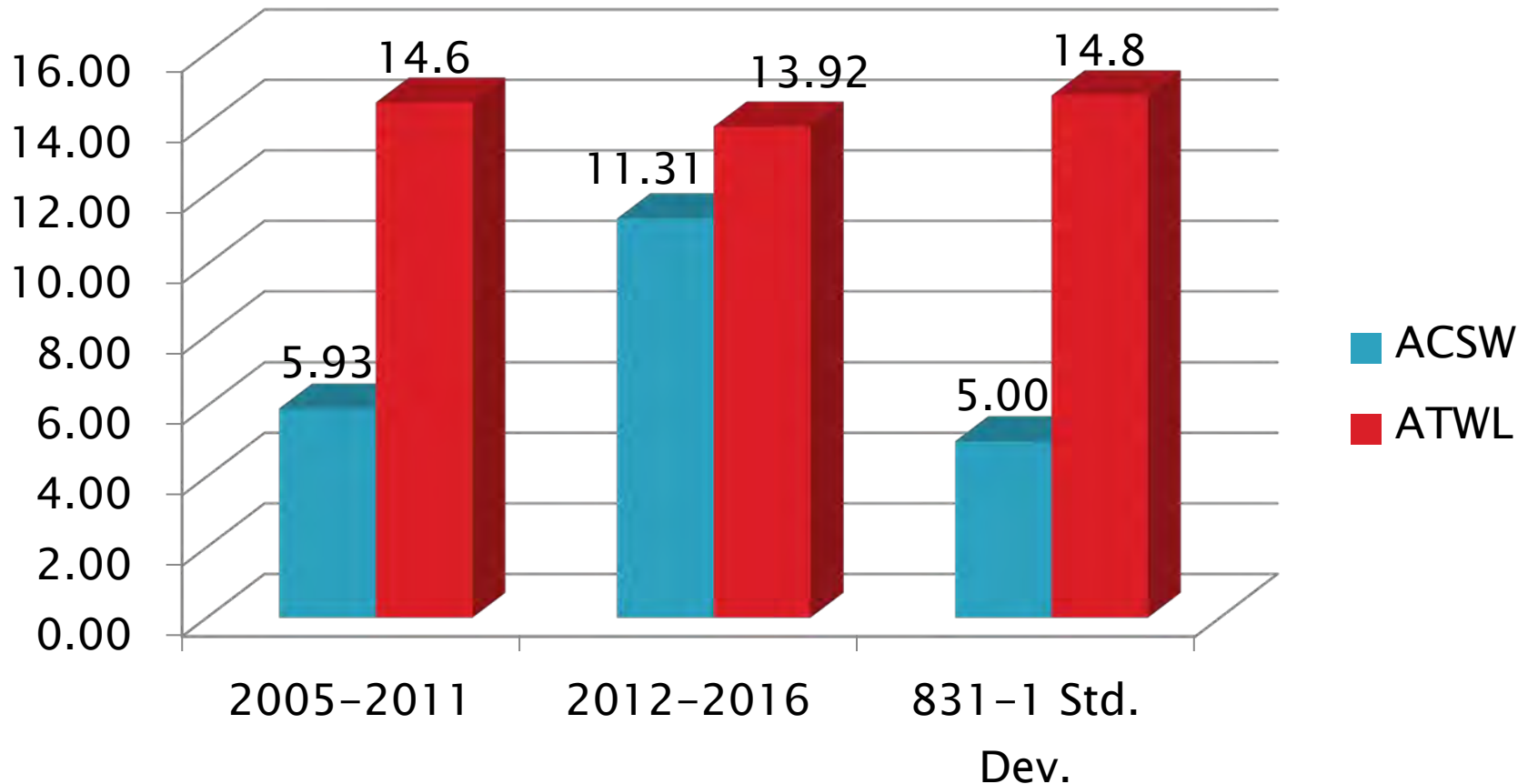
Severe:

Standard Deviation Units



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# ISB Precision Estimates



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# Cummins ISM

»» October 2016

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# ISM Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 3        |
| Failed Calibration Test     | OC            | 0        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 0        |
| Pending                     | PC            | 2        |
| <b>Total</b>                |               | <b>5</b> |

# ISM Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No failed tests  | 0               |
| <b>Total</b>     | <b>0</b>        |



# ISM Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No Invalid Tests | 0        |
| Aborted      | No Aborted Tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

\*Invalid and aborted tests

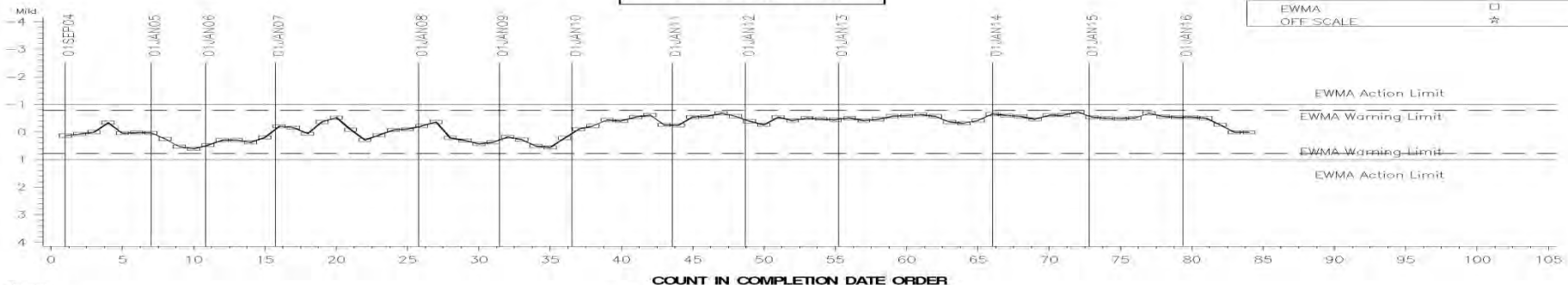
# ISM Test Severity

- ▶ ASR, CWL, FPD and IAS in control.
  - FPD trending mild and near warning alarm.

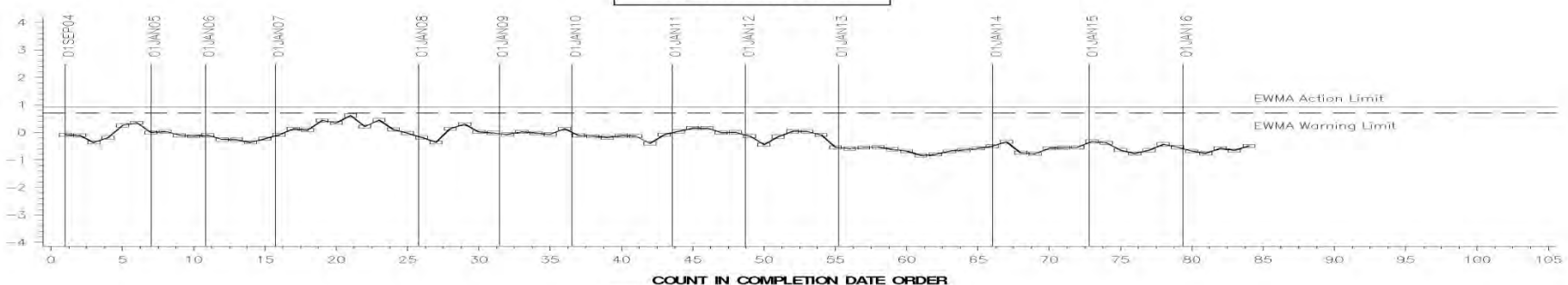
# ISM INDUSTRY OPERATIONALLY VALID DATA

## CROSSHEAD WEIGHT LOSS ADJUSTED TO 3.9 % SOOT

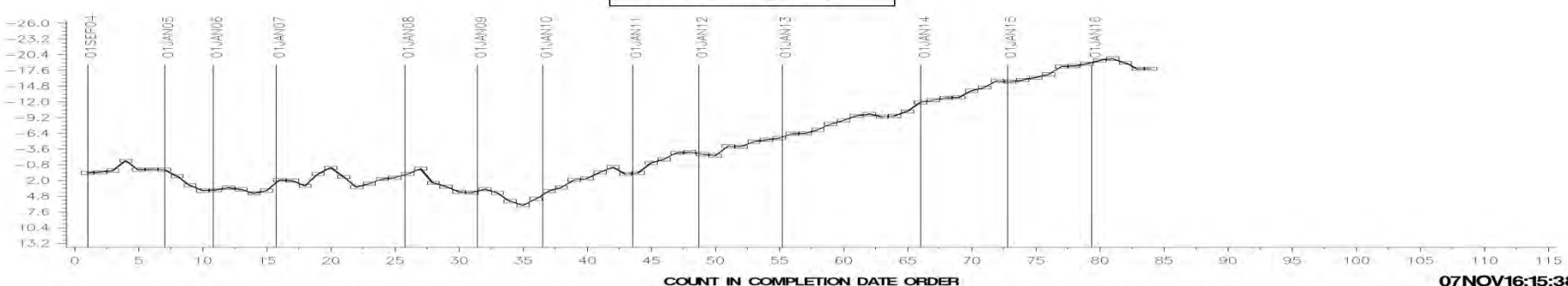
LTMS Severity Analysis



LTMS Precision Analysis



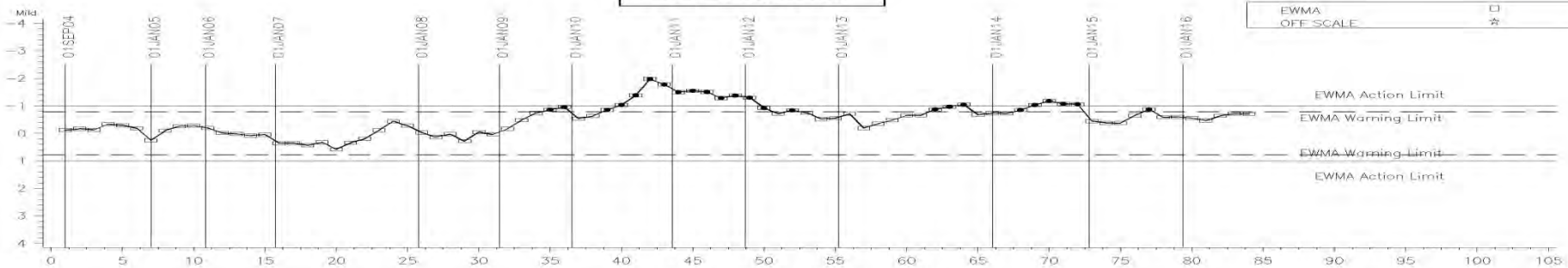
CUSUM Severity Analysis



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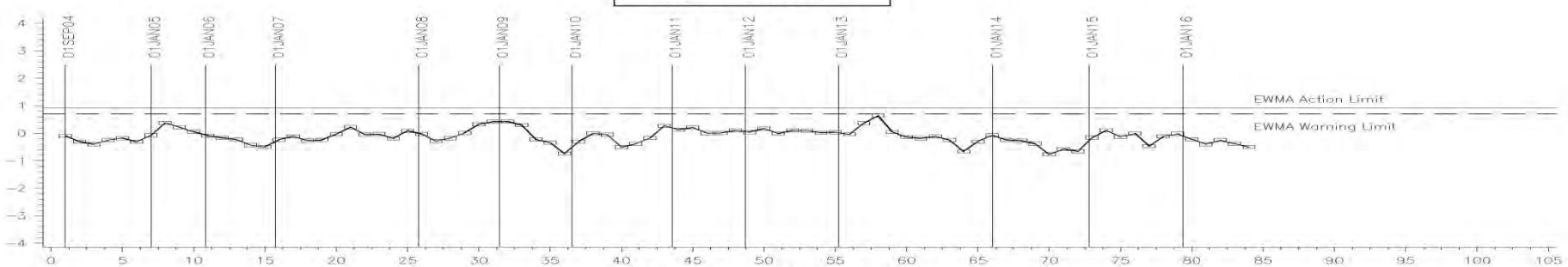
## FILTER PLUGGING DELTA P

### LTMS Severity Analysis



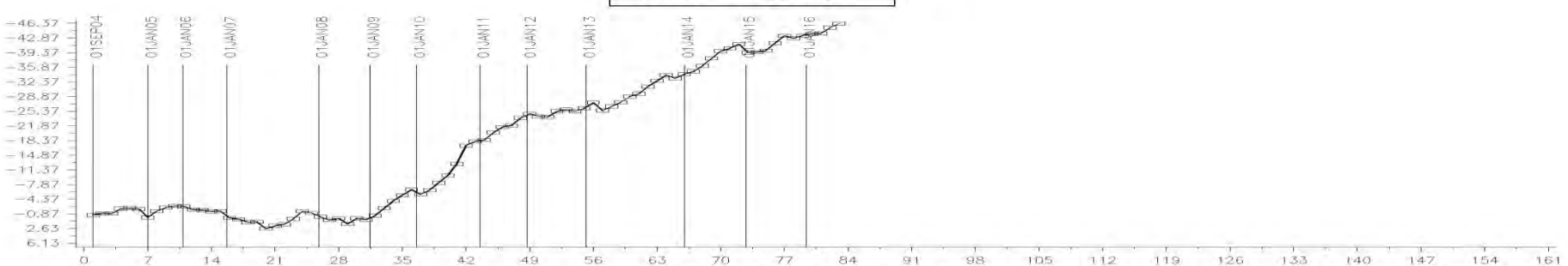
COUNT IN COMPLETION DATE ORDER

### LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

### CUSUM Severity Analysis

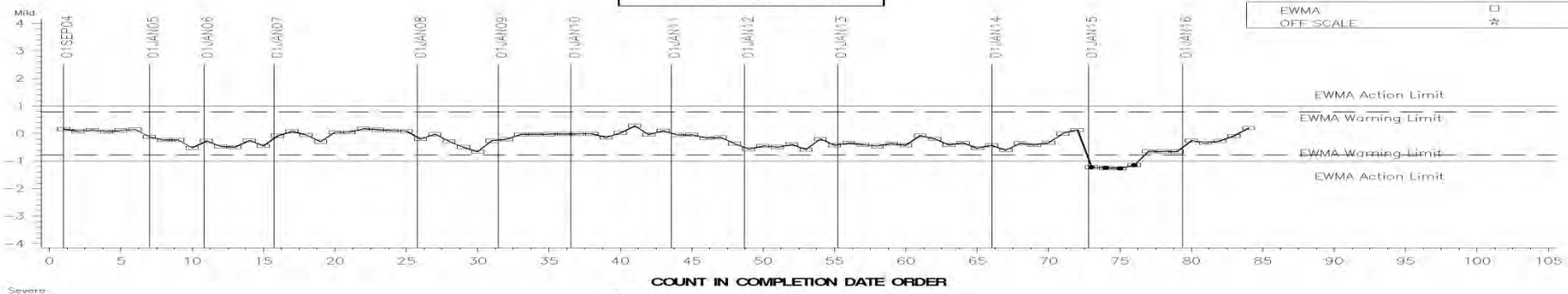


07NOV16:15:38

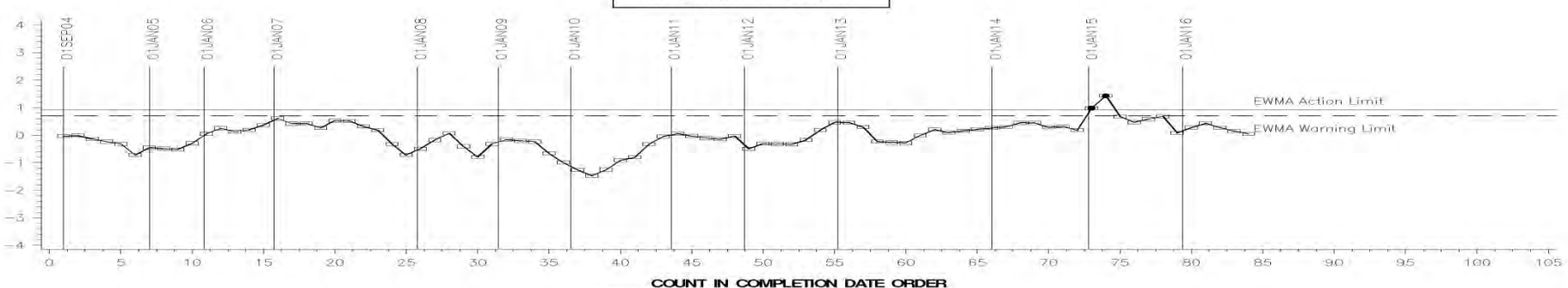
# ISM INDUSTRY OPERATIONALLY VALID DATA

## AVERAGE SLUDGE RATING

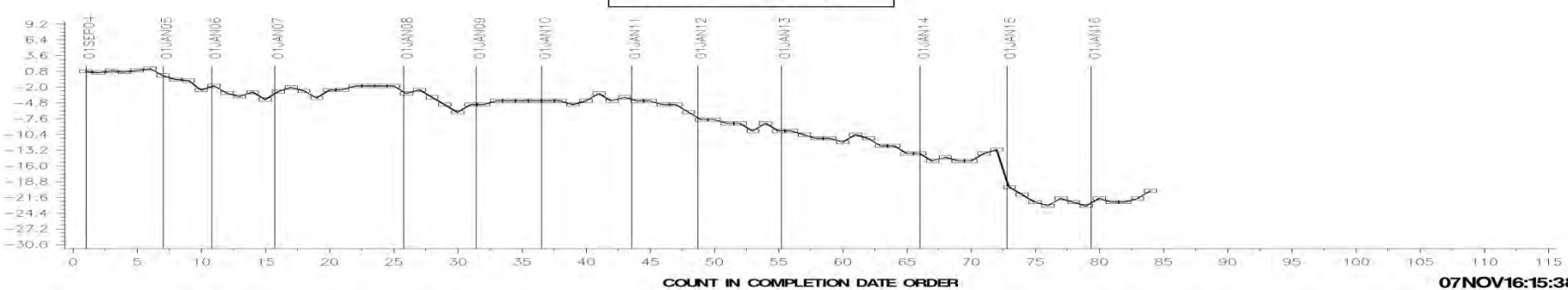
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

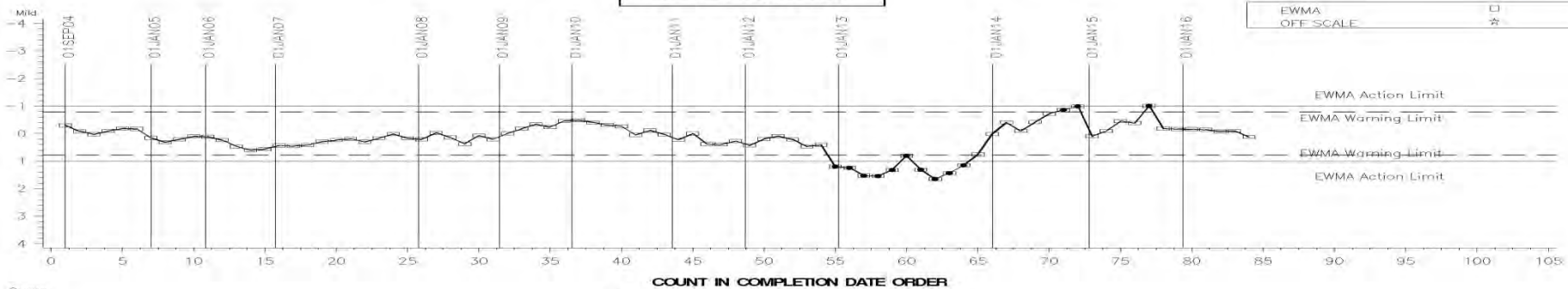


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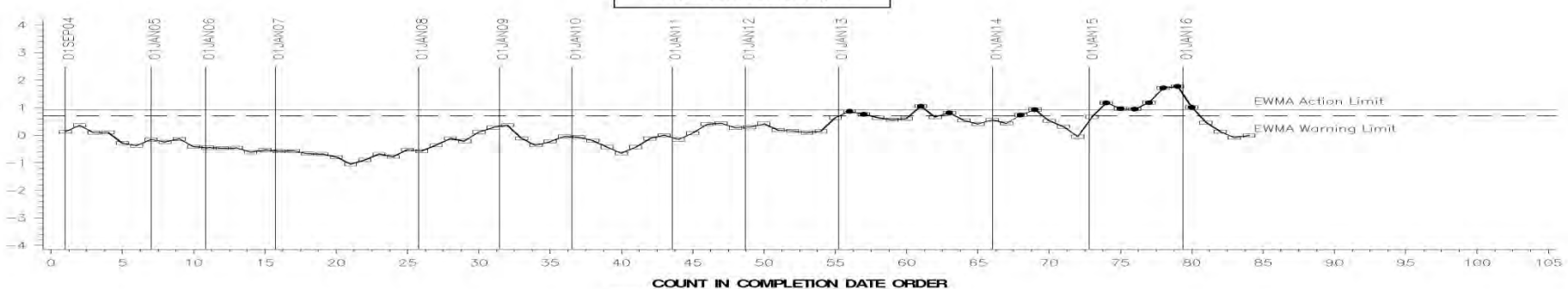
# ISM INDUSTRY OPERATIONALLY VALID DATA

## INJECTOR SCREW WEIGHT LOSS ADJUSTED TO 3.9% SOOT

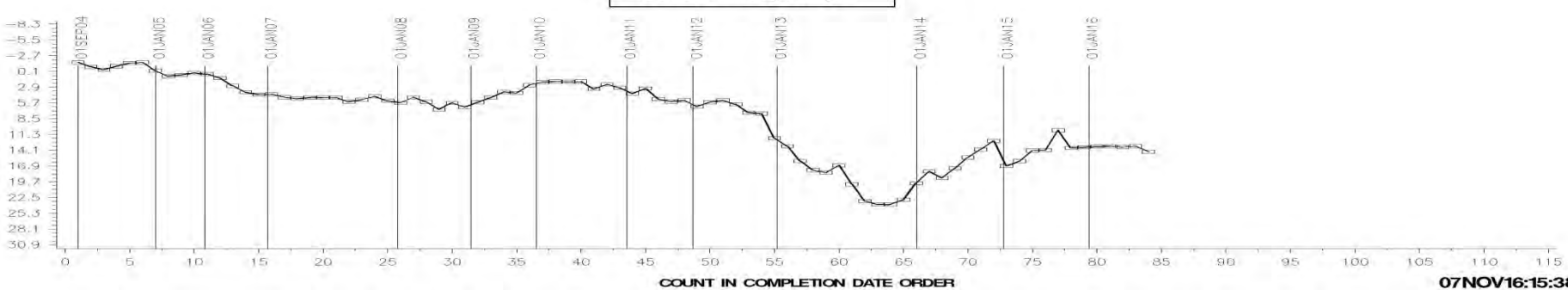
LTMS Severity Analysis



LTMS Precision Analysis

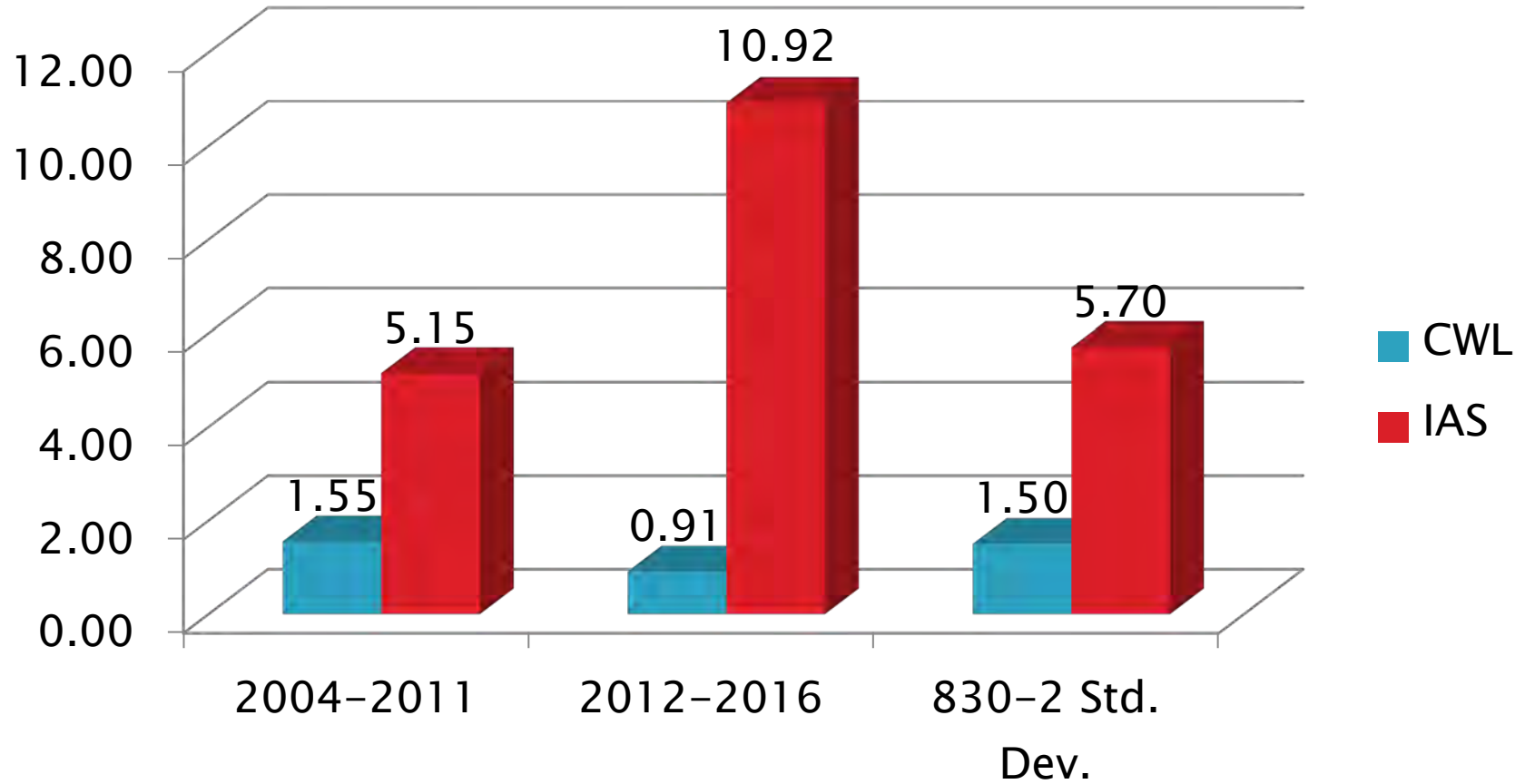


CUSUM Severity Analysis

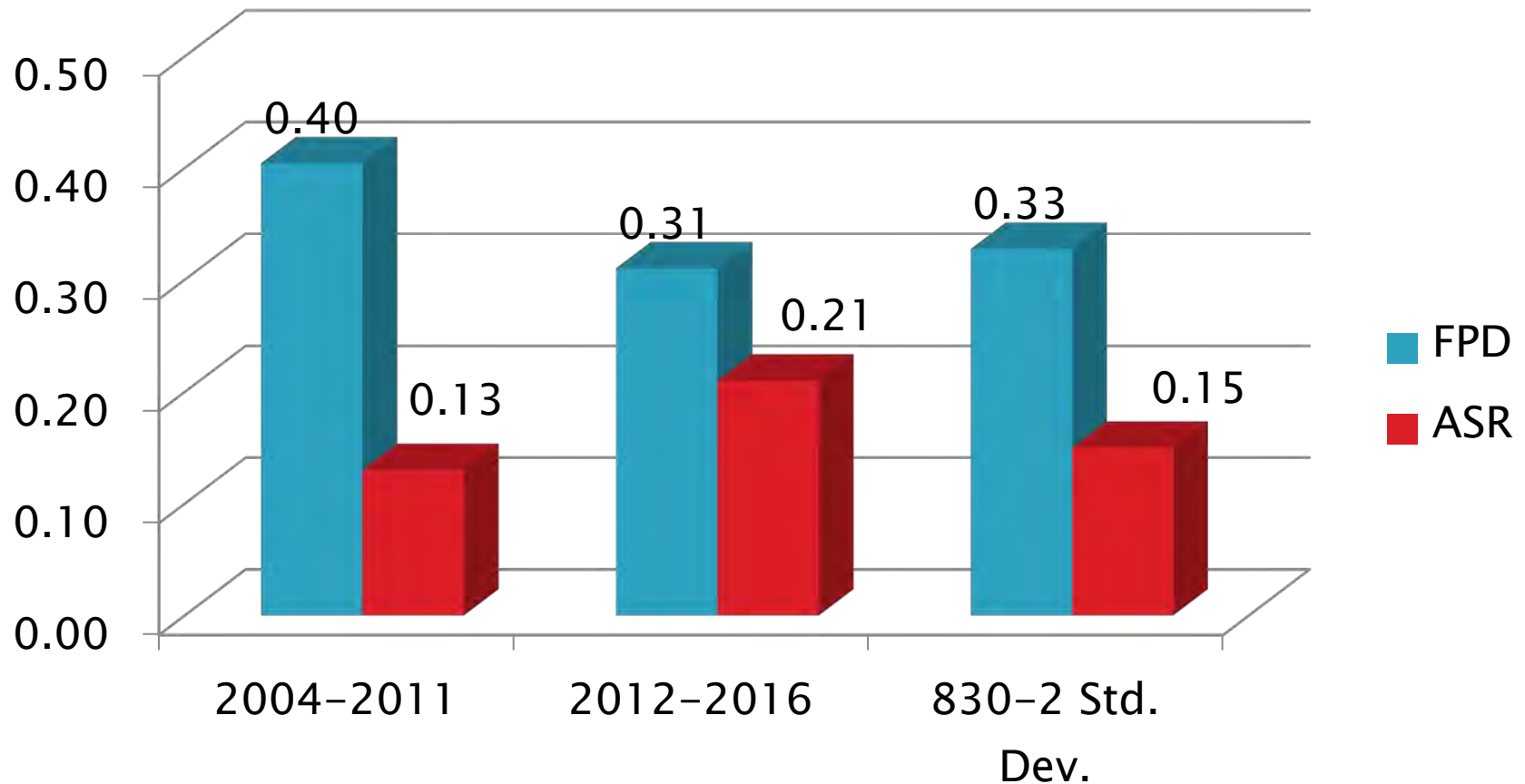


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# ISM Precision Estimates



# ISM Precision Estimates



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# EOAT

»» October 2016

# EOAT Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 0        |
| Failed Calibration Test     | OC            | 0        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 0        |
| <b>Total</b>                |               | <b>0</b> |

# EOAT Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No failed tests  | 0               |
| Total            | 0               |

# EOAT Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No invalid tests | 0        |
| Aborted      | No aborted tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

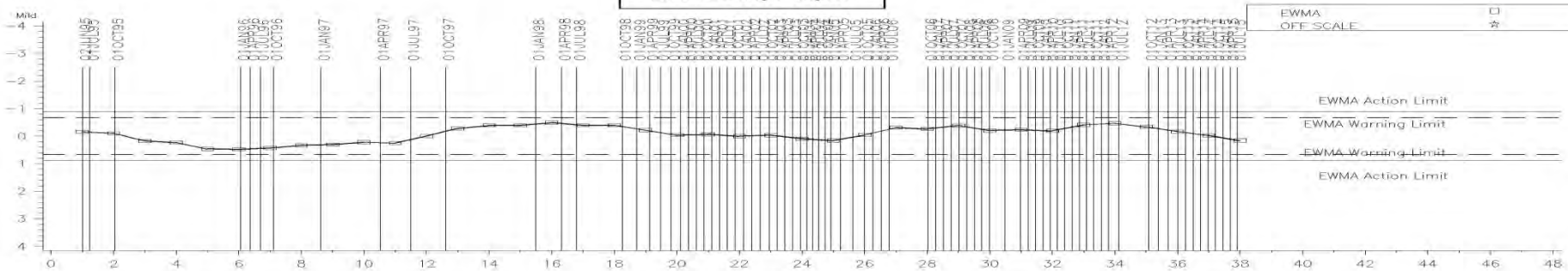
\*Invalid and aborted tests

# EOAT Test Severity

- ▶ As no EOAT tests were reported this period no statement about test severity or precision can be made.

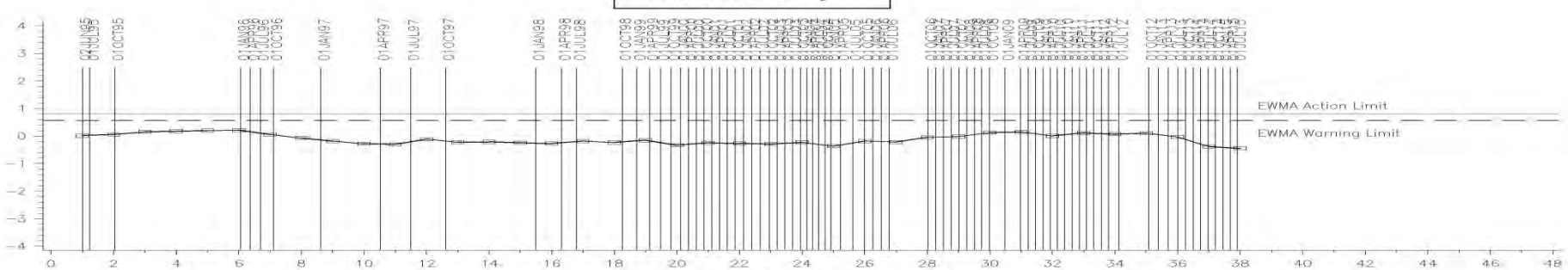
ENGINE OIL AERATION

LTMS Severity Analysis



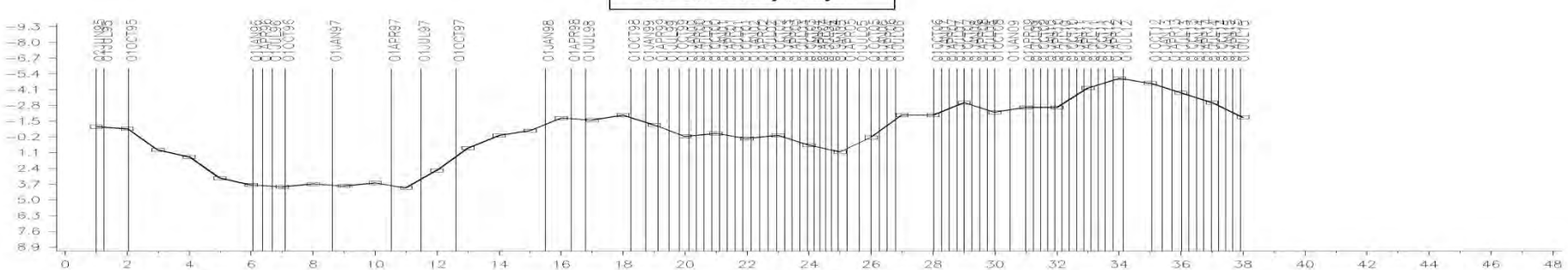
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis

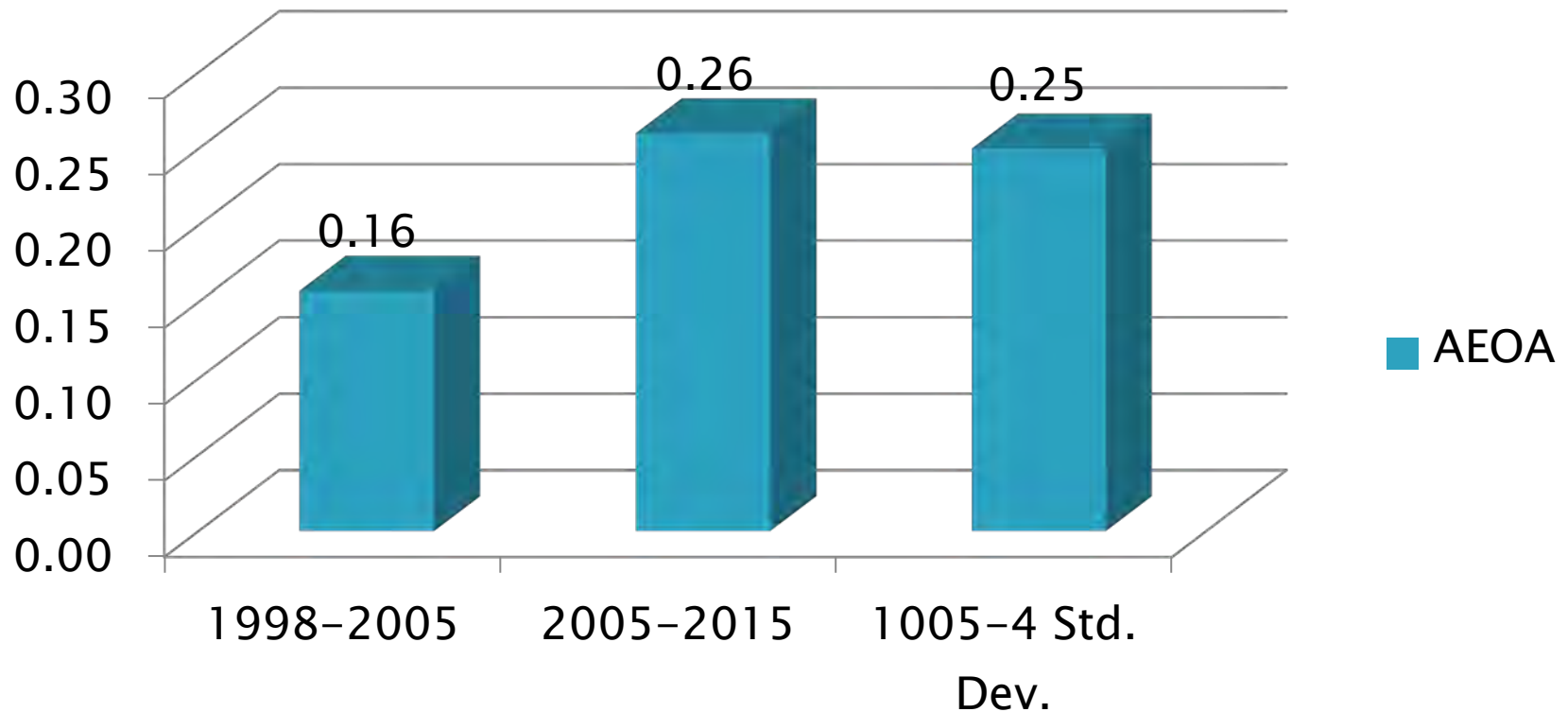


COUNT IN COMPLETION DATE ORDER

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# EOAT Precision Estimates

## AEOA



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# RFWT

»» October 2016



# RFWT Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 1        |
| Failed Calibration Test     | OC            | 0        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 0        |
| <b>Total</b>                |               | <b>1</b> |

# RFWT Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No failed tests  | 0               |
| Total            | 0               |

# RFWT Lost Tests\*

| Status       | Cause            | #        |
|--------------|------------------|----------|
| Invalid      | No invalid tests | 0        |
| Aborted      | No aborted tests | 0        |
| <b>Total</b> |                  | <b>0</b> |

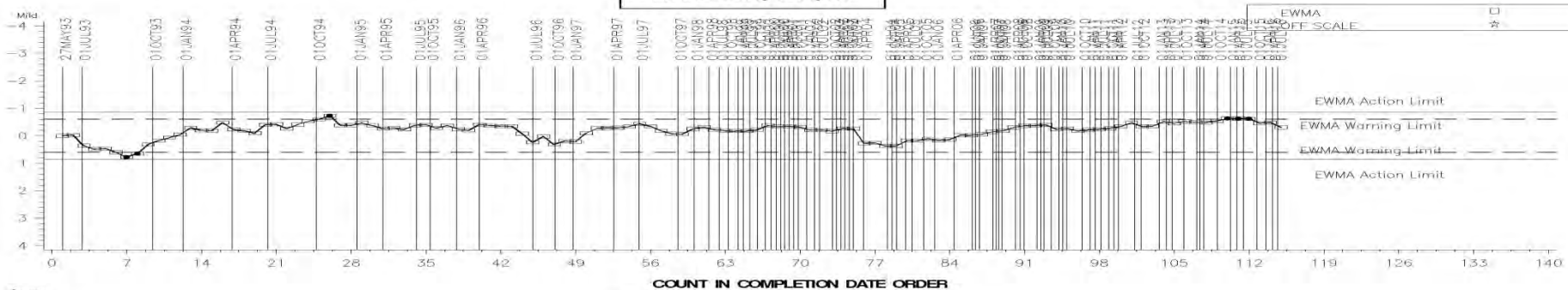
\*Invalid and aborted tests

# RFWT Test Severity

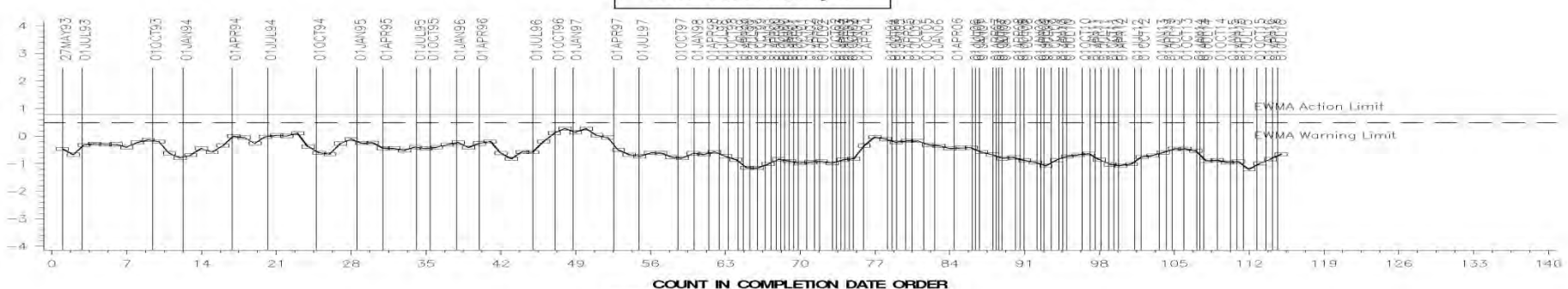
- ▶ AFW is in control.

## Average Follower Wear

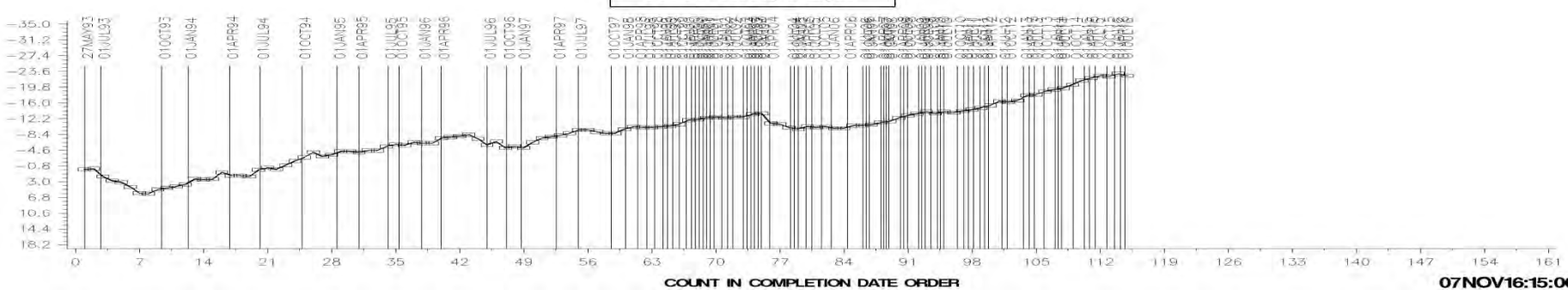
### LTMS Severity Analysis



### LTMS Precision Analysis



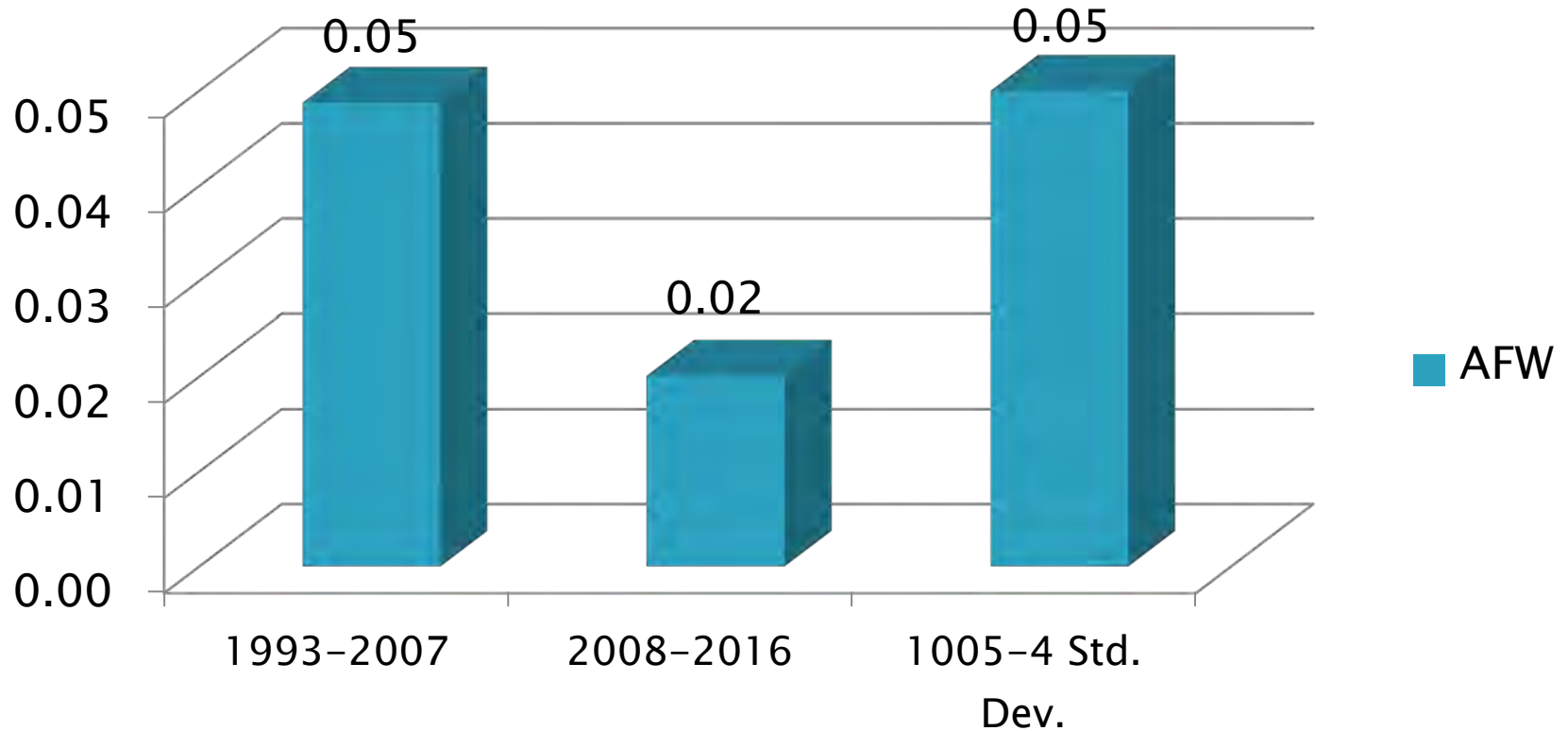
### CUSUM Severity Analysis



07NOV16:15:06

# RFWT Precision Estimates

AFW



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# Mack T-8/T-8E

»» October 2016

Test Monitoring Center

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# T-8/T-8E Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 3        |
| Failed Calibration Test     | OC            | 2        |
| Operationally Invalid       | LC            | 0        |
| Aborted                     | XC            | 2        |
| <b>Total</b>                |               | <b>7</b> |



# T-8/T8-E Failed Tests

| Failed Parameter        | Number of Tests |
|-------------------------|-----------------|
| Mild VI38 and RV48      | 1               |
| Mild VI38, RV2 and RV48 | 1               |
| <b>Total</b>            | <b>2</b>        |

# T-8/T8-E Lost Tests\*

| Status       | Cause              | #        |
|--------------|--------------------|----------|
| Invalid      | No Invalid Tests   | 0        |
| Aborted      | Missed soot window | 1        |
| Aborted      | Mechanical failure | 1        |
| <b>Total</b> |                    | <b>2</b> |

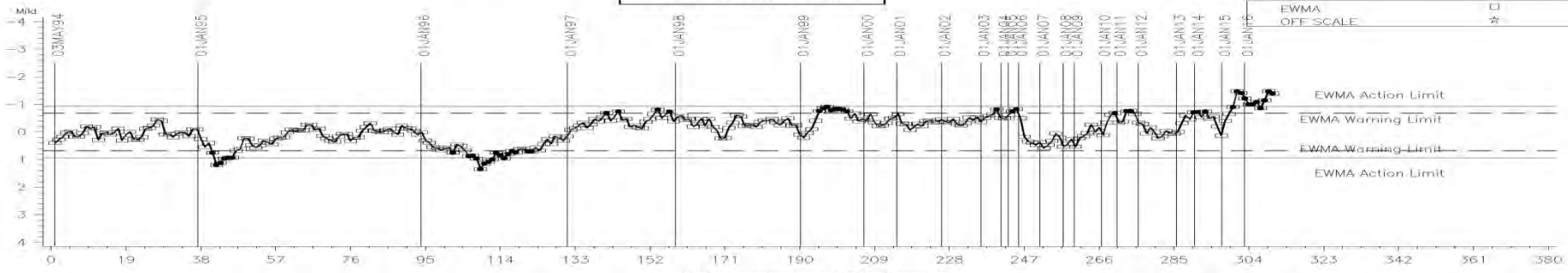
\*Invalid and aborted tests

# T-8/T-8E Test Severity

- ▶ VI38 is in severity action alarm in mild direction.
- ▶ RV2 in severity warning alarm in mild direction.
- ▶ RV48 and RV2 in precision action alarm.

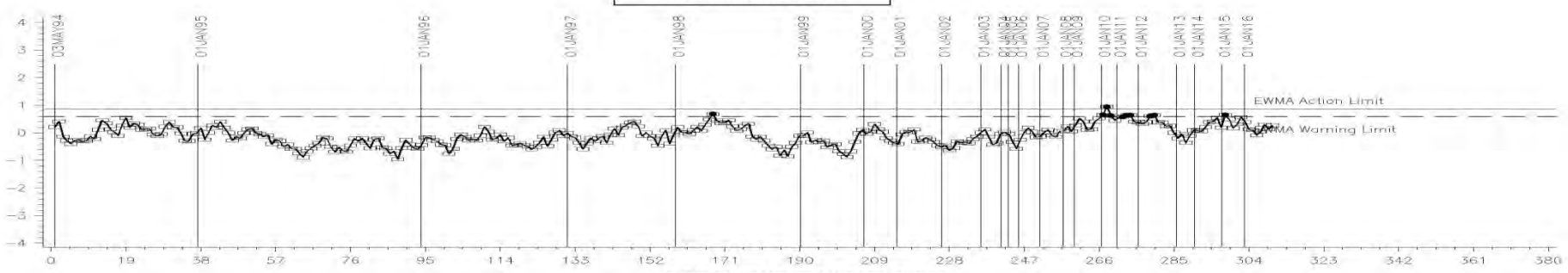
FINAL REFERENCE VISCOSITY AT 3.8% TGA SOOT LEVEL

LTMS Severity Analysis



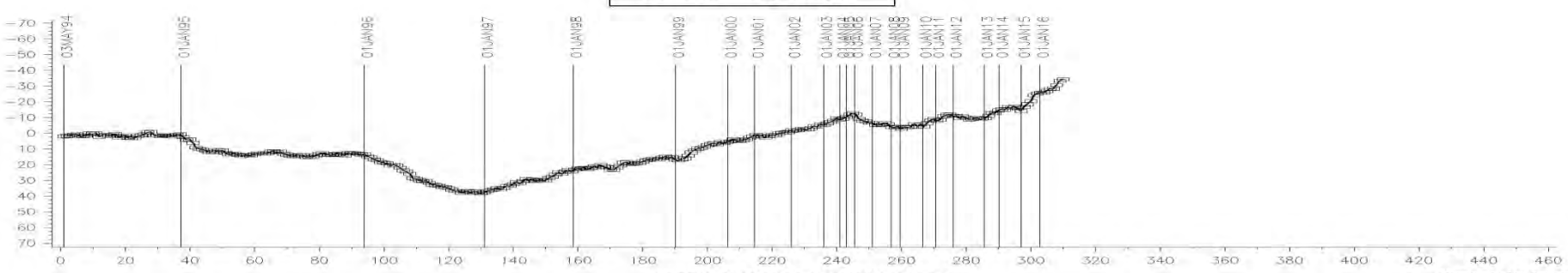
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis

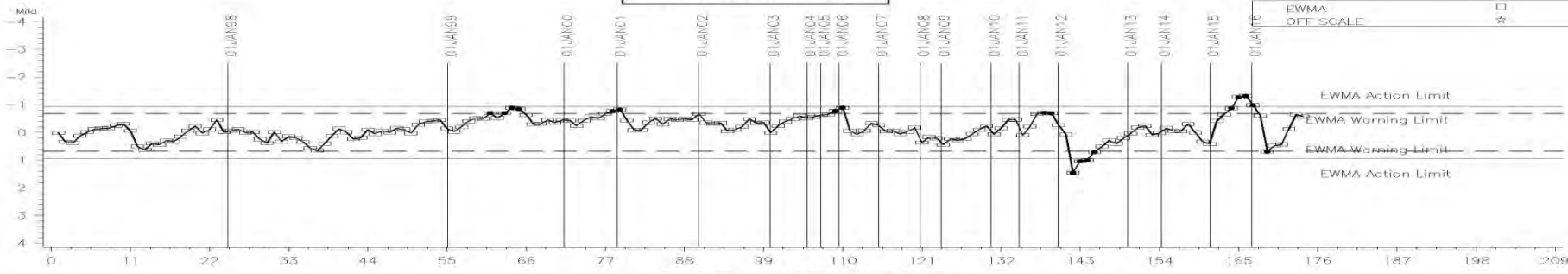


COUNT IN COMPLETION DATE ORDER

07NOV16:15:23

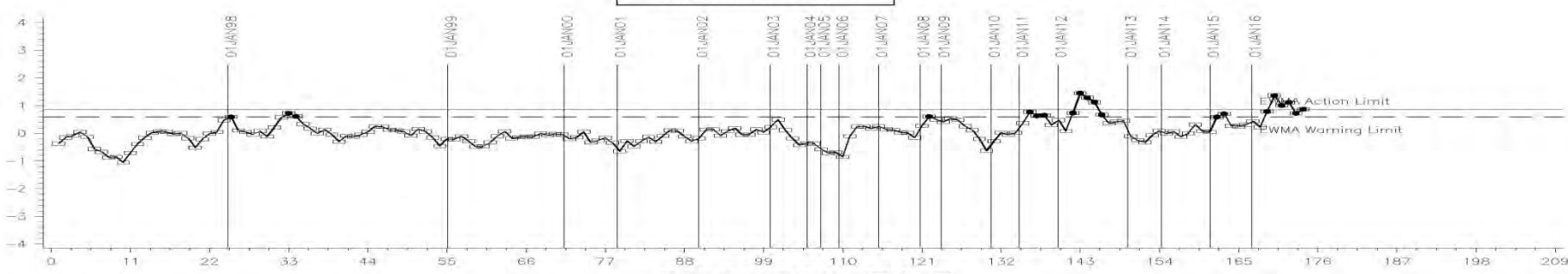
FINAL RELATIVE VISCOSITY (50% LOSS)

LTMS Severity Analysis



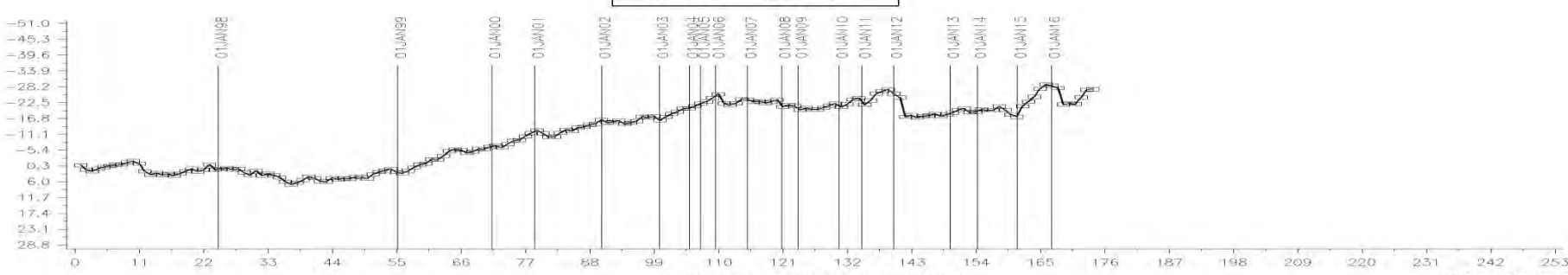
COUNT IN COMPLETION DATE ORDER

LTMS Precision Analysis



COUNT IN COMPLETION DATE ORDER

CUSUM Severity Analysis

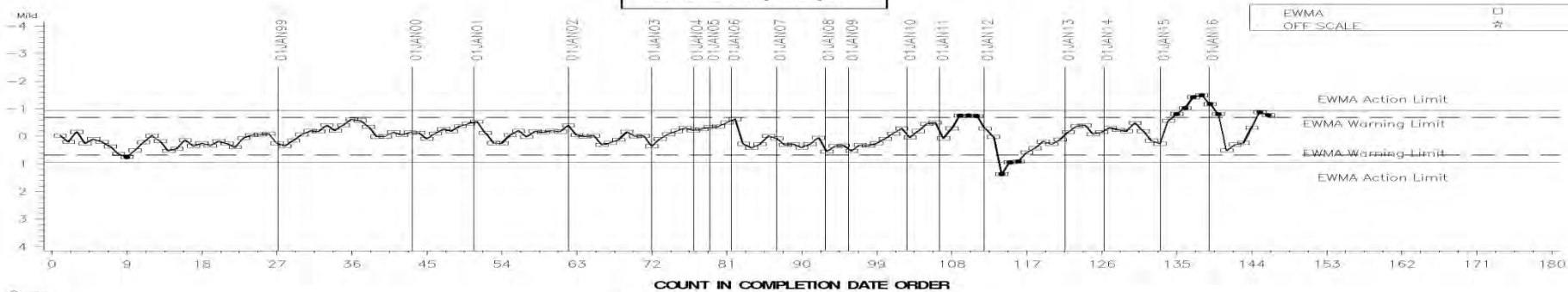


COUNT IN COMPLETION DATE ORDER

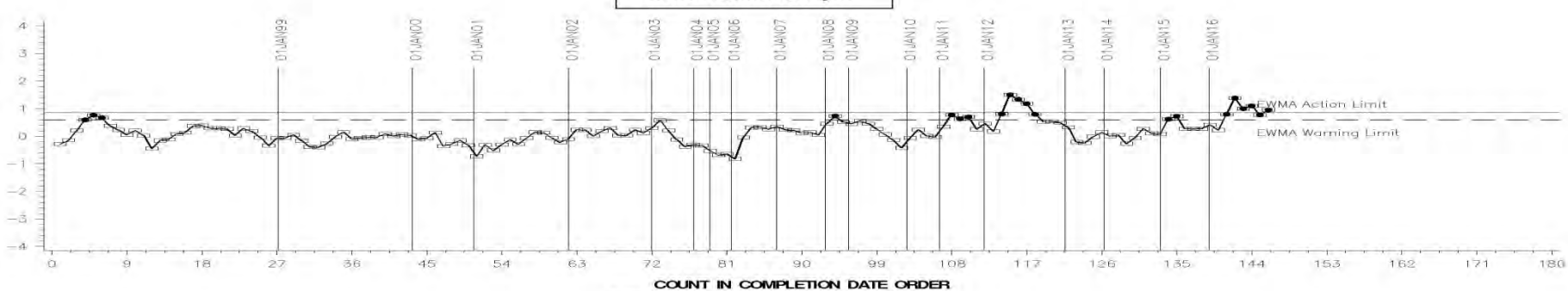
07NOV16:15:23

FINAL RELATIVE VISCOSITY (100% LOSS)

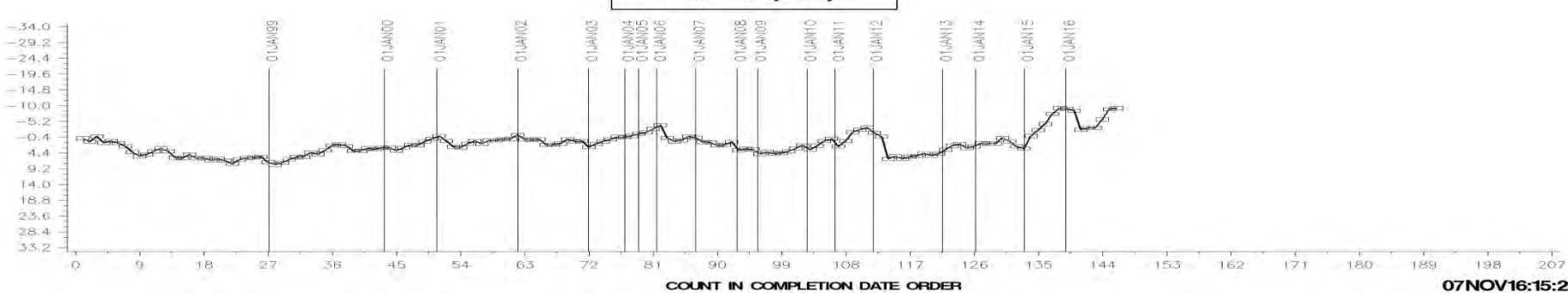
LTMS Severity Analysis



LTMS Precision Analysis

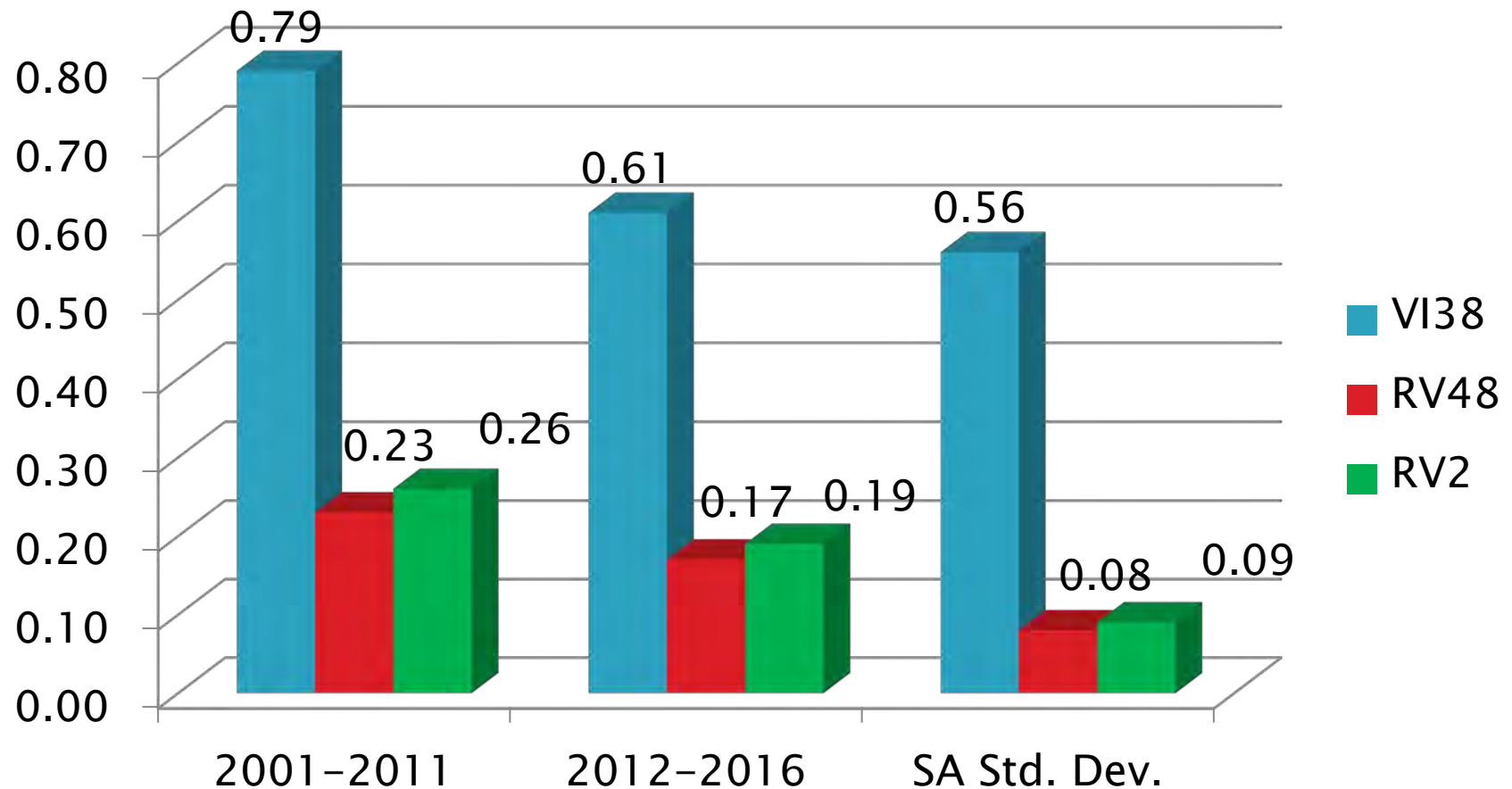


CUSUM Severity Analysis



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# T-8/E Precision Estimates



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# Mack T-11

»» October 2016

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# T-11 Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 4        |
| Failed Calibration Test     | OC            | 0        |
| Operationally Invalid       | LC/RC         | 1        |
| Aborted                     | XC            | 0        |
| <b>Total</b>                |               | <b>5</b> |

# T-11 Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No failed tests  | 0               |
| Total            | 0               |

# T-11 Lost Tests\*

| Status       | Cause                          | #        |
|--------------|--------------------------------|----------|
| Invalid      | Bad coolant inlet thermocouple | 1        |
| Aborted      | No Aborted Tests               | 0        |
| <b>Total</b> |                                | <b>1</b> |

\*Invalid and aborted tests

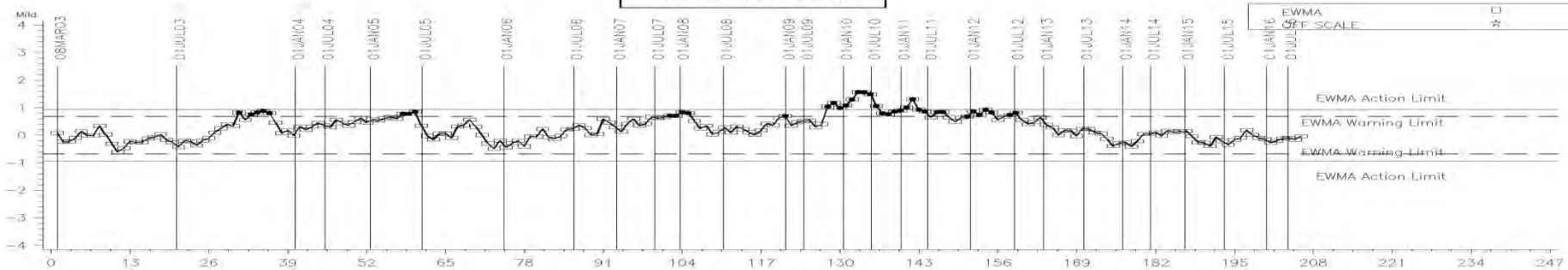
# T-11 Test Severity

- ▶ SOOT and SOOT5 are in control.
- ▶ SOOT4 is in severity action alarm in the mild direction.
- ▶ SOOT4 and MRV in precision warning alarm.

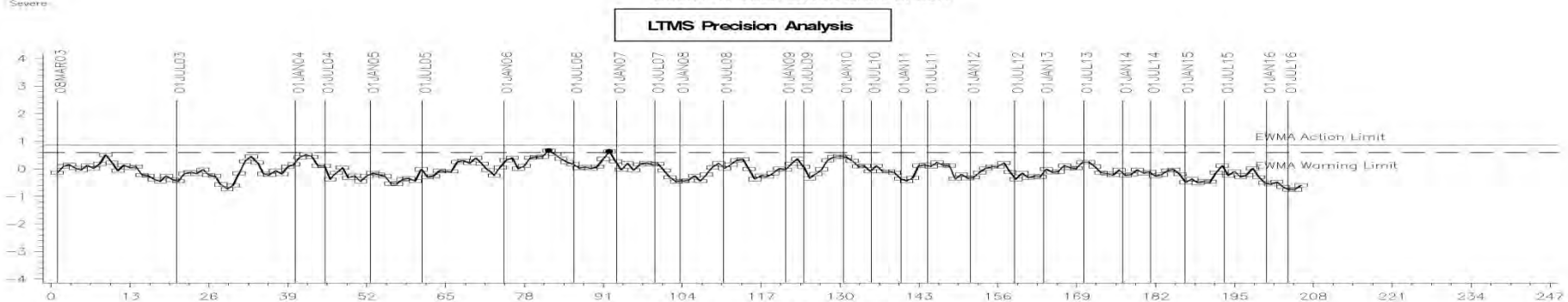
# T-11 INDUSTRY OPERATIONAL VALID DATA

## SOOT AT 12 cSt

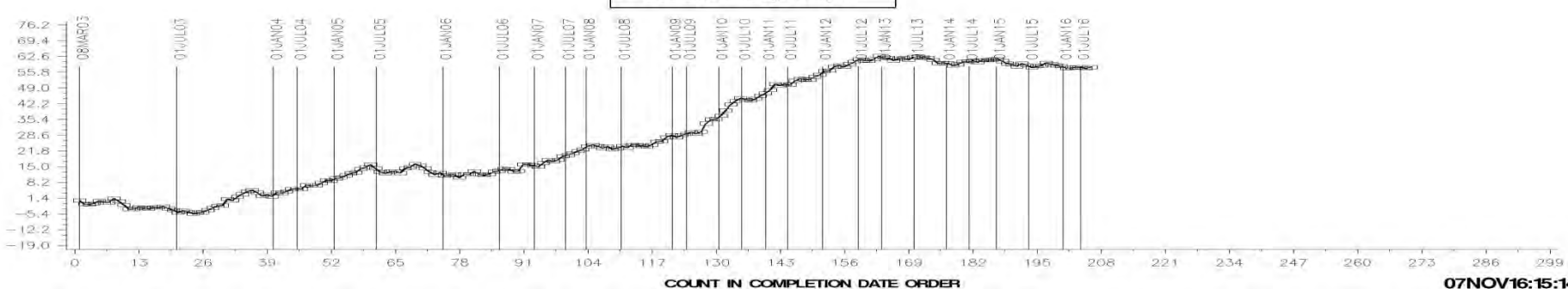
### LTMS Severity Analysis



### LTMS Precision Analysis



### CUSUM Severity Analysis

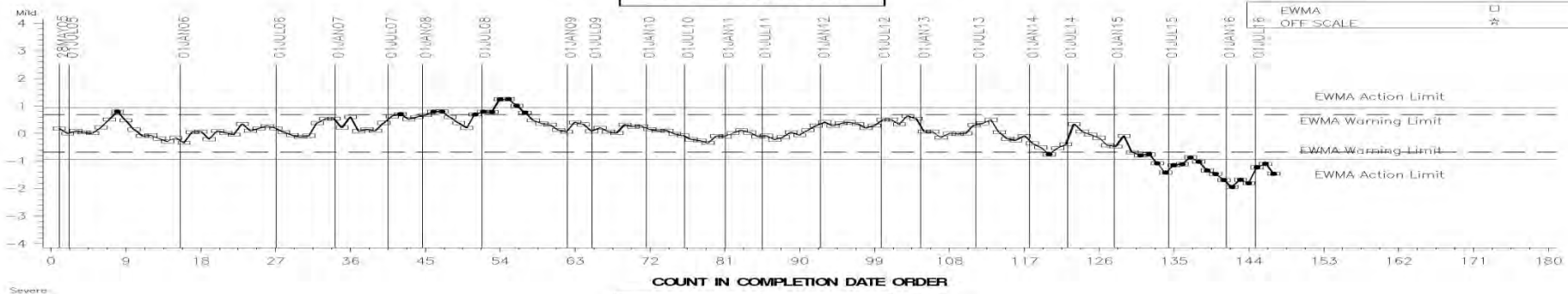


07NOV16:15:14

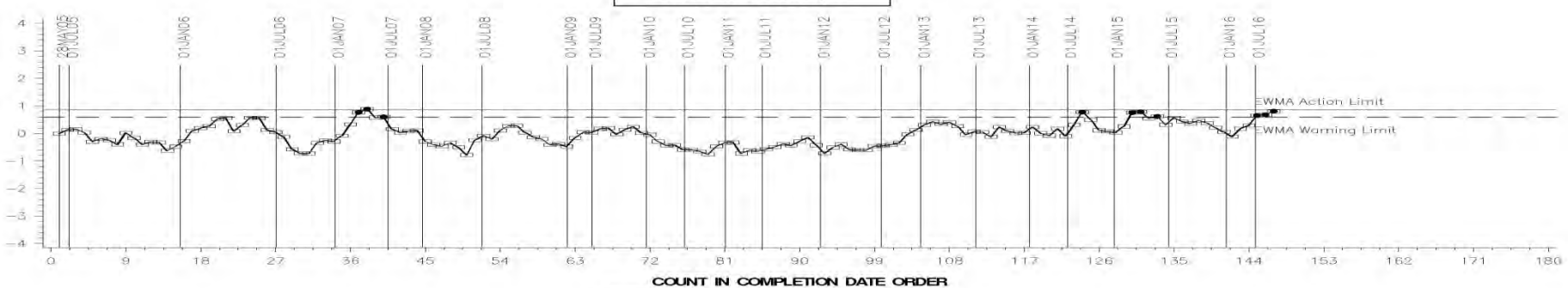
# T-11 INDUSTRY OPERATIONALLY VALID DATA

## SOOT @ 4 cSt - FINAL RESULT

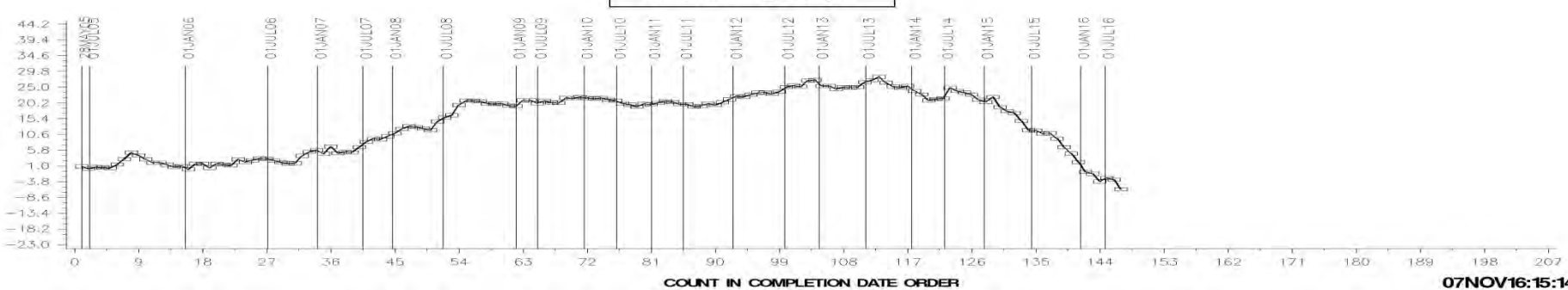
LTMS Severity Analysis



LTMS Precision Analysis



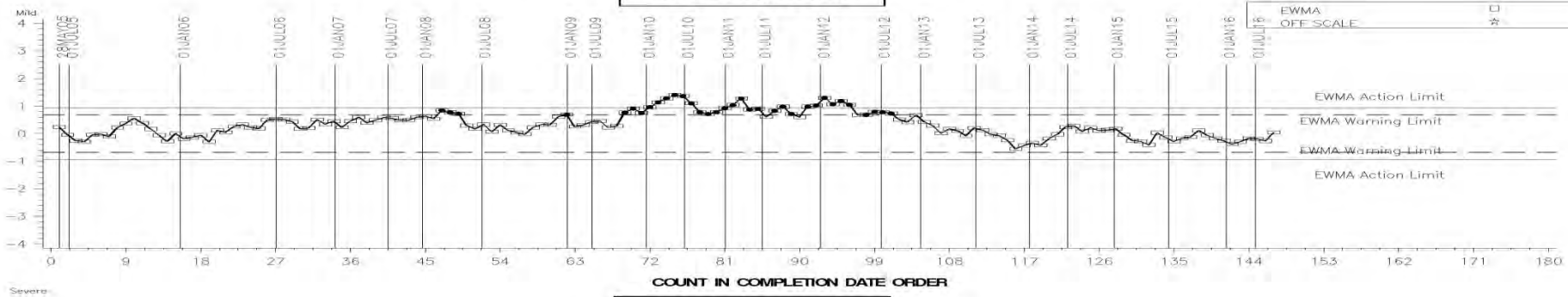
CUSUM Severity Analysis



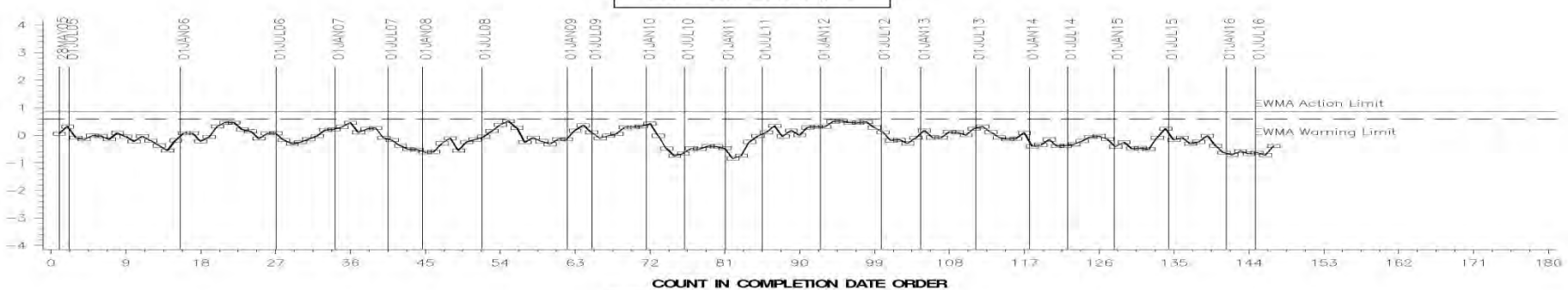
07NOV16:15:14

## SOOT @ 15 cSt - FINAL RESULT

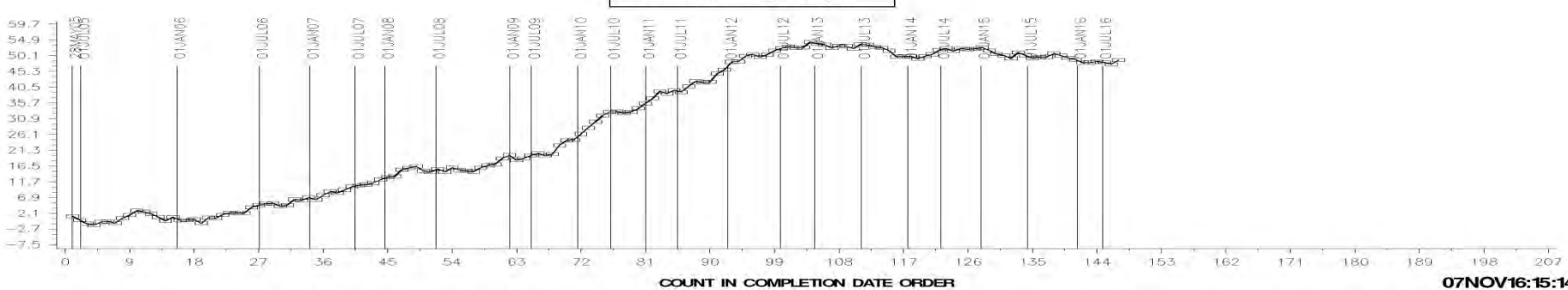
LTMS Severity Analysis



LTMS Precision Analysis



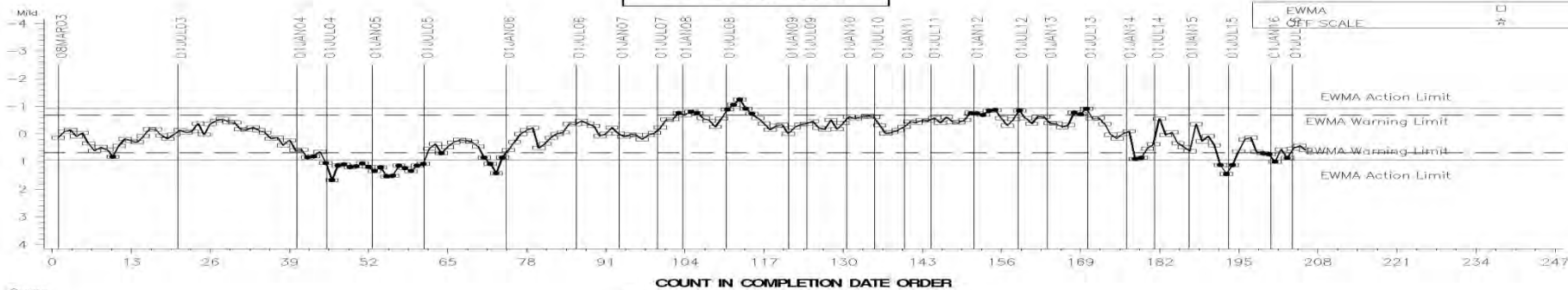
CUSUM Severity Analysis



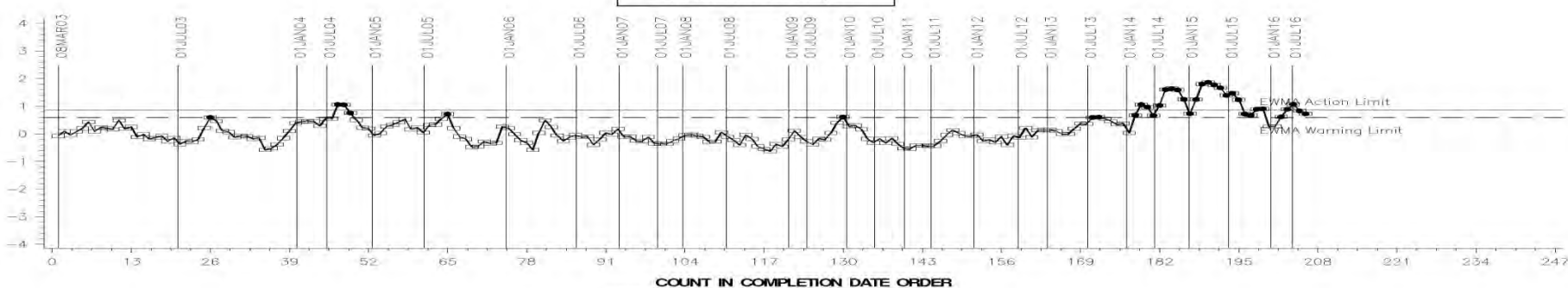
07NOV16:15:14

MRV VISCOSITY

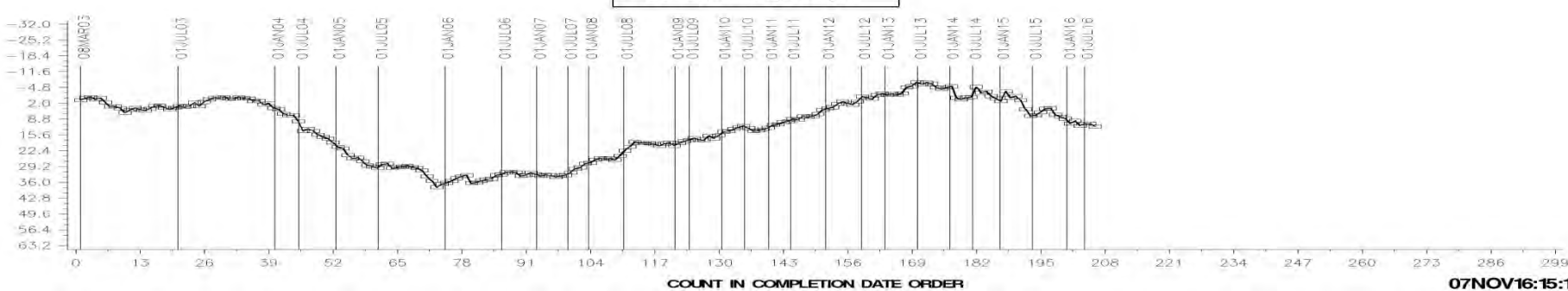
LTMS Severity Analysis



LTMS Precision Analysis



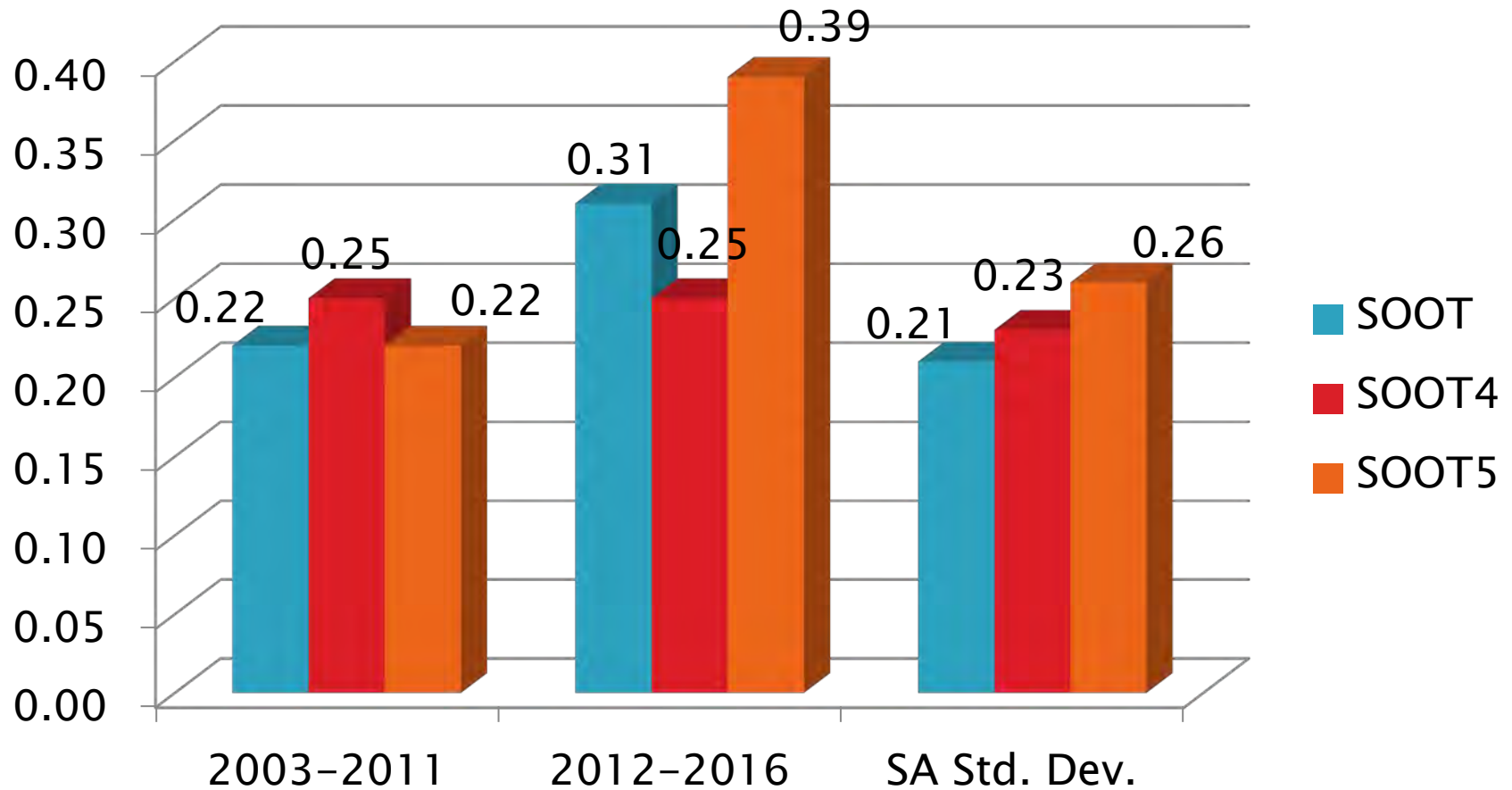
CUSUM Severity Analysis



07NOV16:15:14

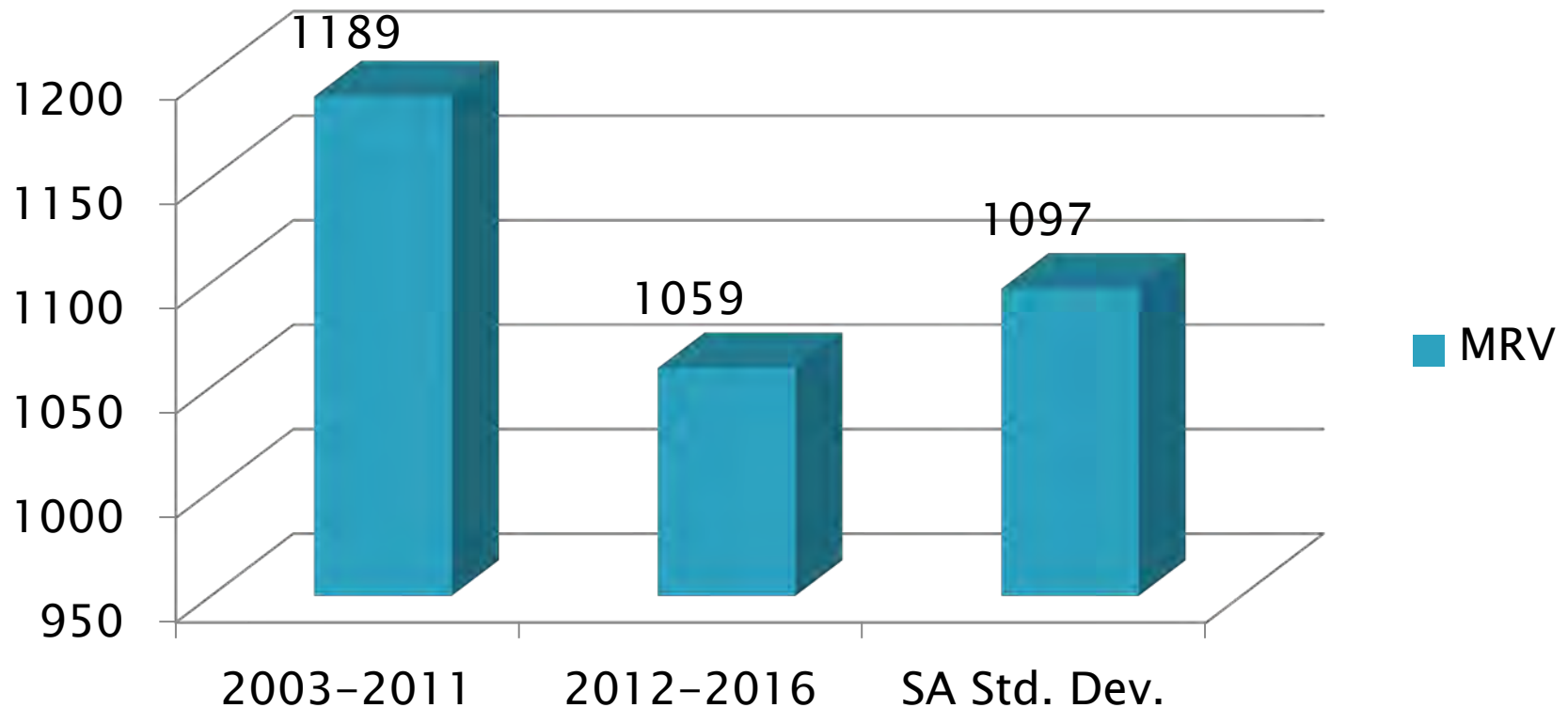


# T-11 Precision Estimates



# T-11 Precision Estimates

## MRV



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# Mack T-12

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# T-12 Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 2        |
| Failed Calibration Test     | OC/MC         | 0        |
| Operationally Invalid       | LC/LI         | 1        |
| Aborted                     | XC/XI         | 1        |
| <b>Total</b>                |               | <b>4</b> |

# T-12 Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No failed tests  | 0               |
| <b>Total</b>     | <b>0</b>        |

# T-12 Lost Tests\*

| Status       | Cause                  | #        |
|--------------|------------------------|----------|
| Invalid      | Wrong top ring coating | 1        |
| Aborted      | Wrong top ring coating | 1        |
| <b>Total</b> |                        | <b>2</b> |

\*Invalid and aborted tests

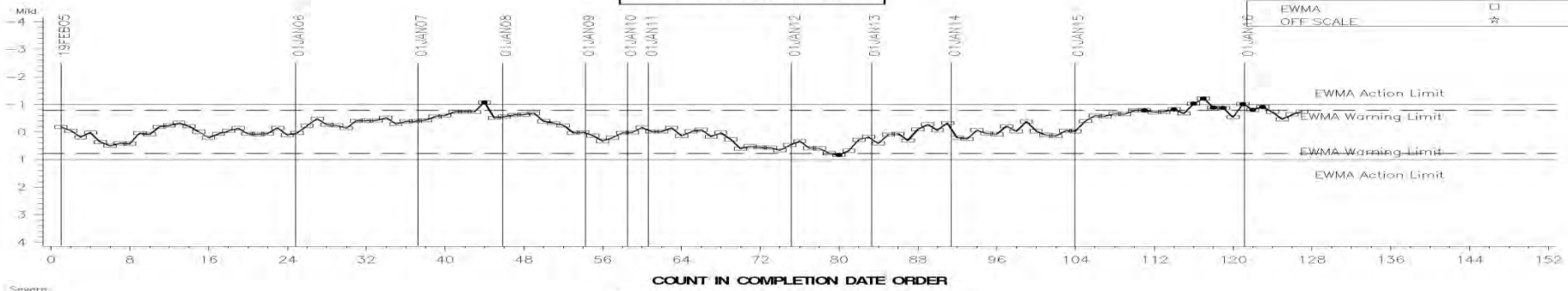
# T-12 Test Severity

- ▶ PB, CLW, TRWL and OC parameters are in control.
- ▶ PB2 in severity warning alarm in mild direction. Also in precision action alarm.

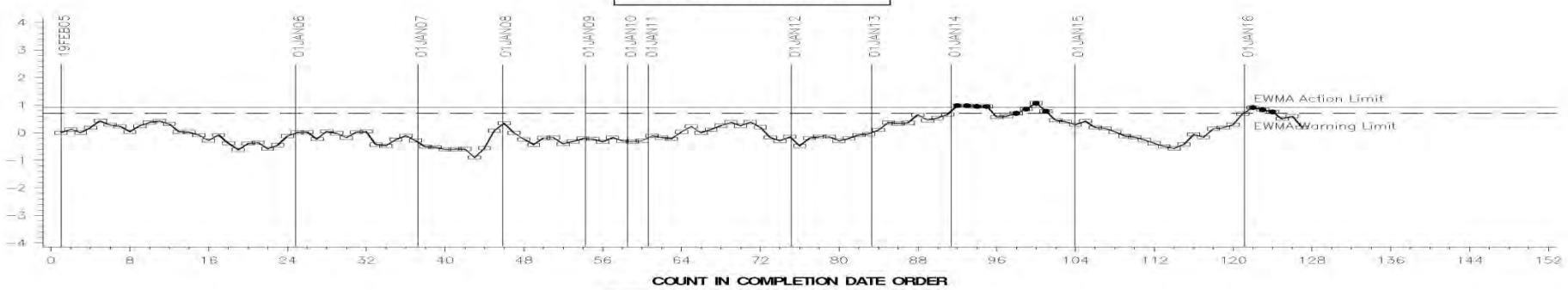
# MACK T-12 INDUSTRY OPERATIONAL VALID DATA

## FINAL TRANS. RES. DELTA PB @ EOT

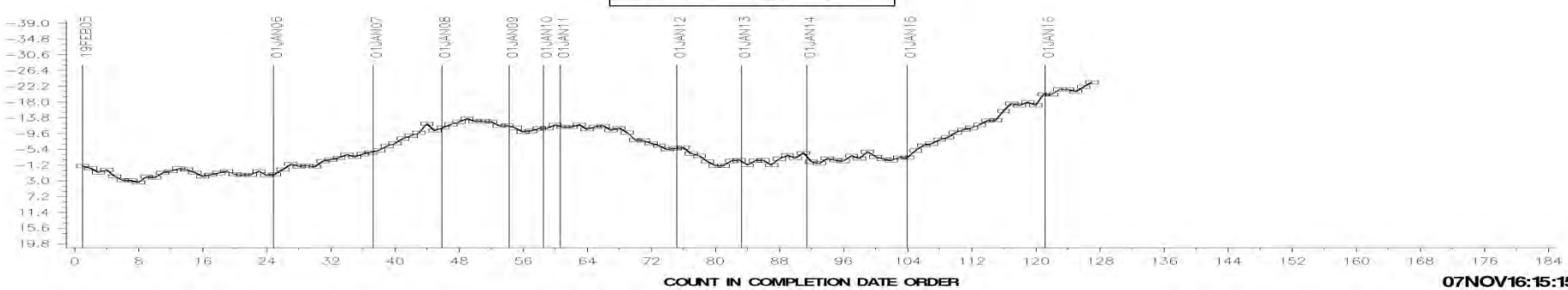
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

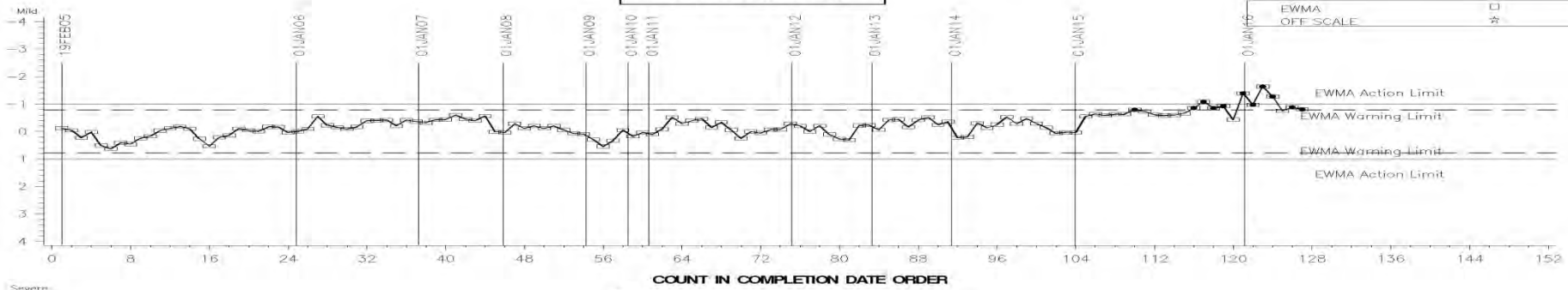


07NOV16:15:15

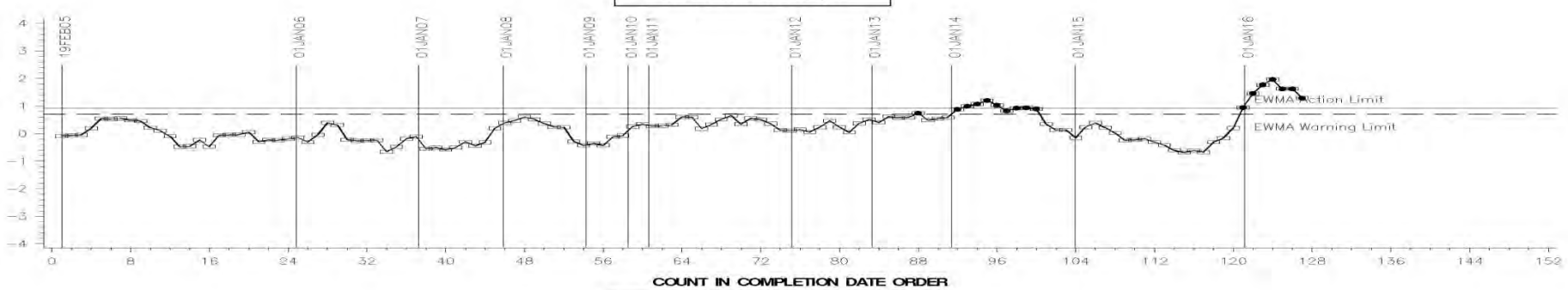


## FINAL TRANS. RES. DELTA PB 250-300H

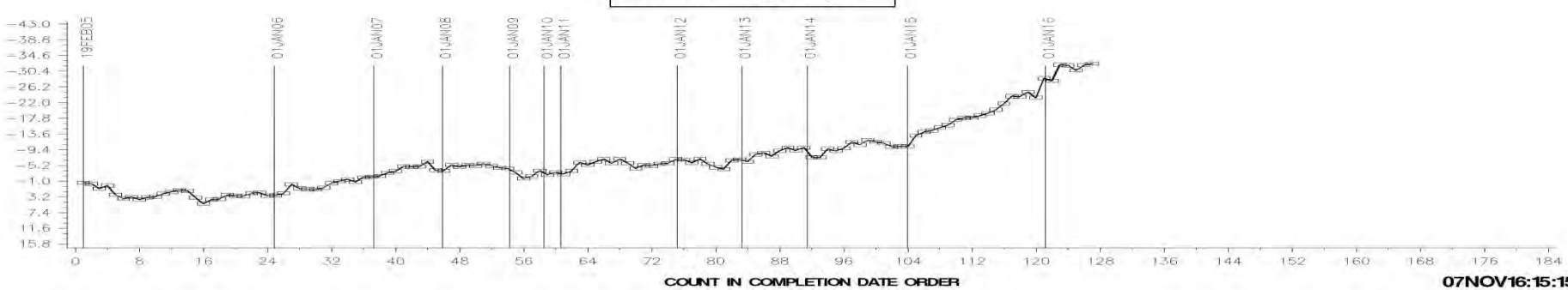
LTMS Severity Analysis



LTMS Precision Analysis



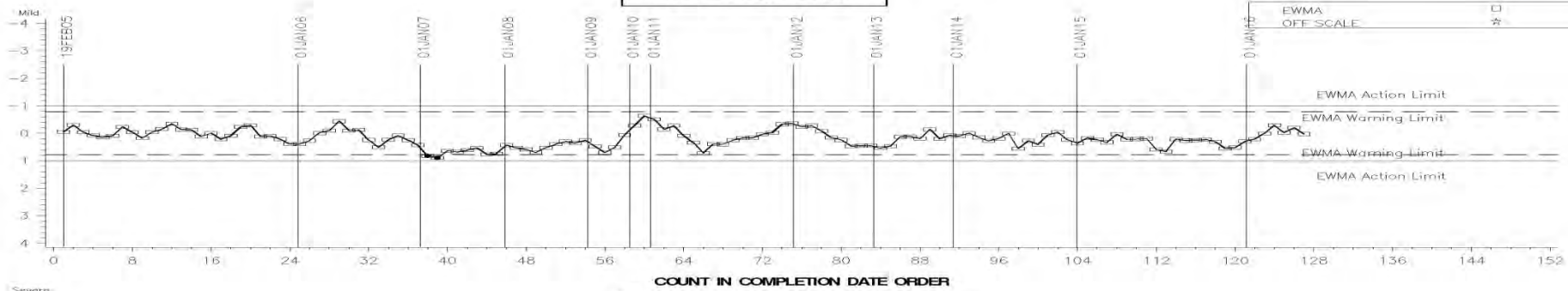
CUSUM Severity Analysis



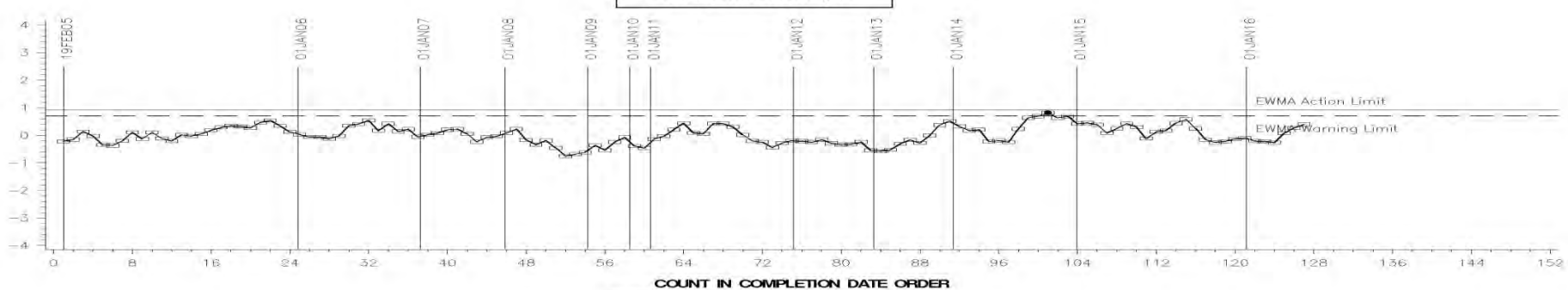
07NOV16:15:15

## AVG. CYLINDER LINER WEAR (CLW)

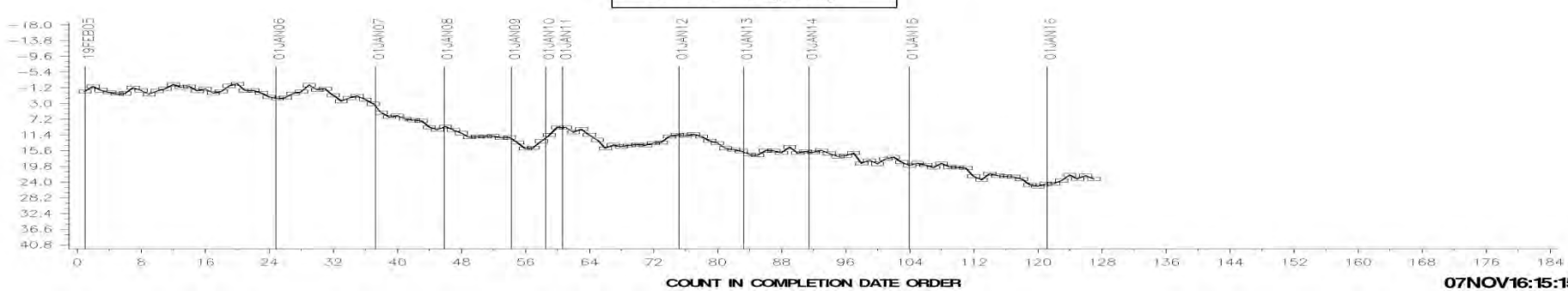
LTMS Severity Analysis



LTMS Precision Analysis



CUSUM Severity Analysis

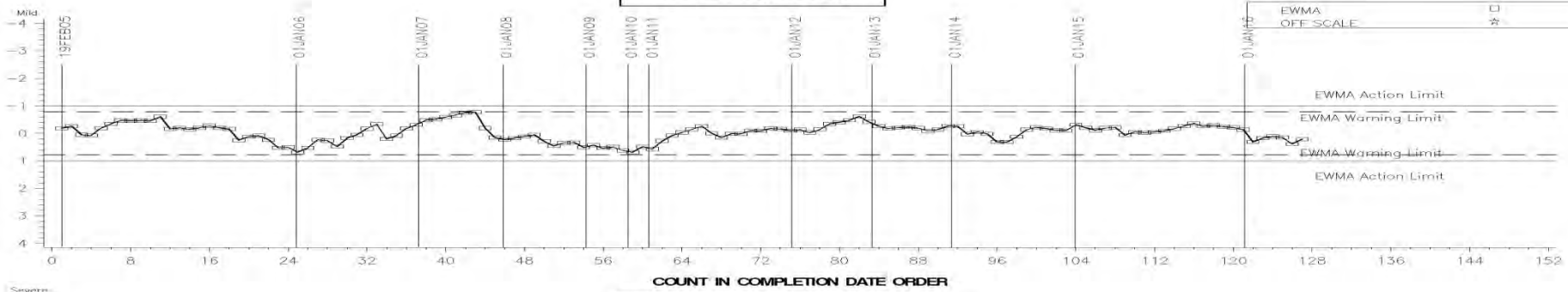


07NOV16:15:15

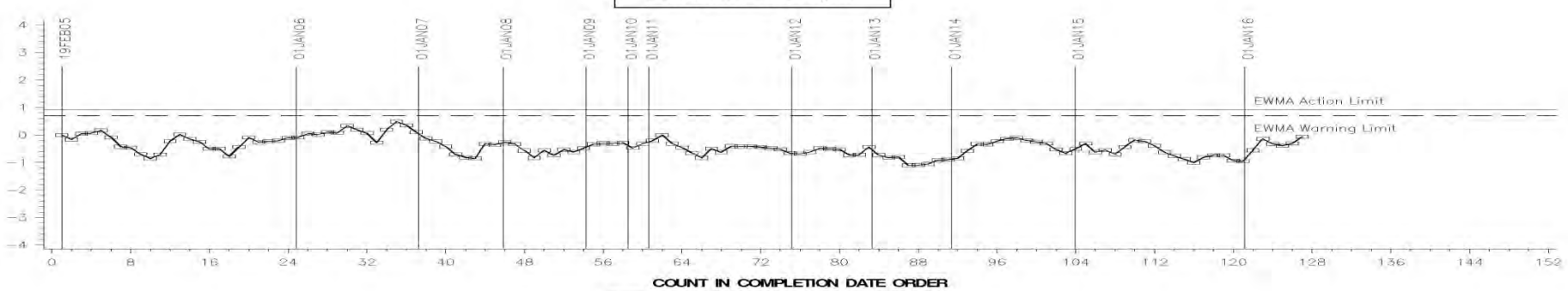
# MACK T-12 INDUSTRY OPERATIONAL VALID DATA

## AVG. TOP RING WEIGHT LOSS (TRWL)

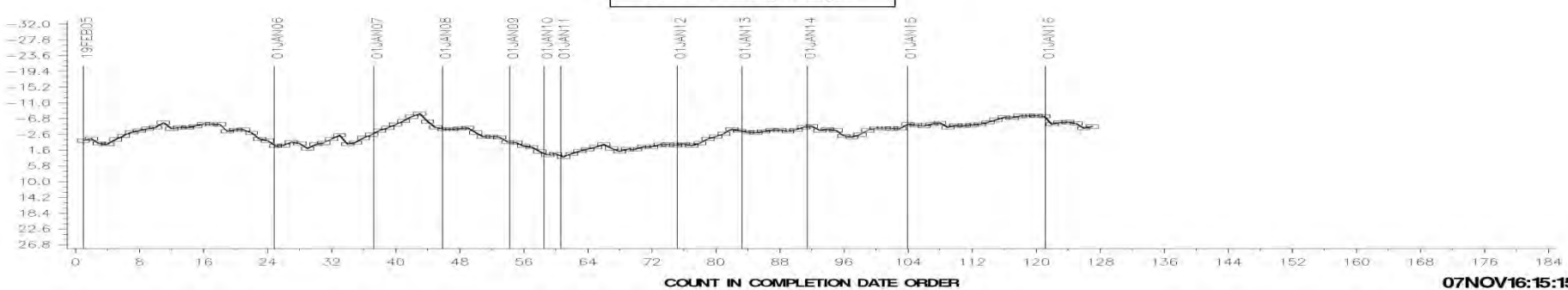
LTMS Severity Analysis



LTMS Precision Analysis



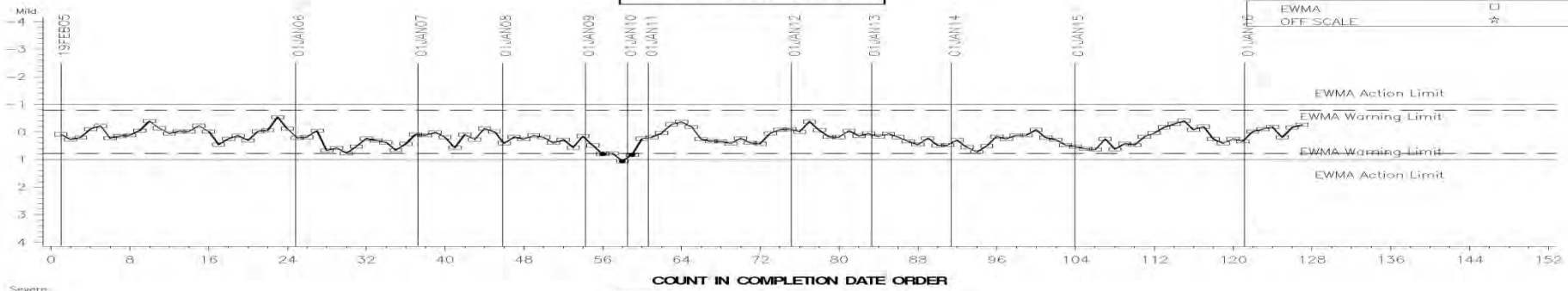
CUSUM Severity Analysis



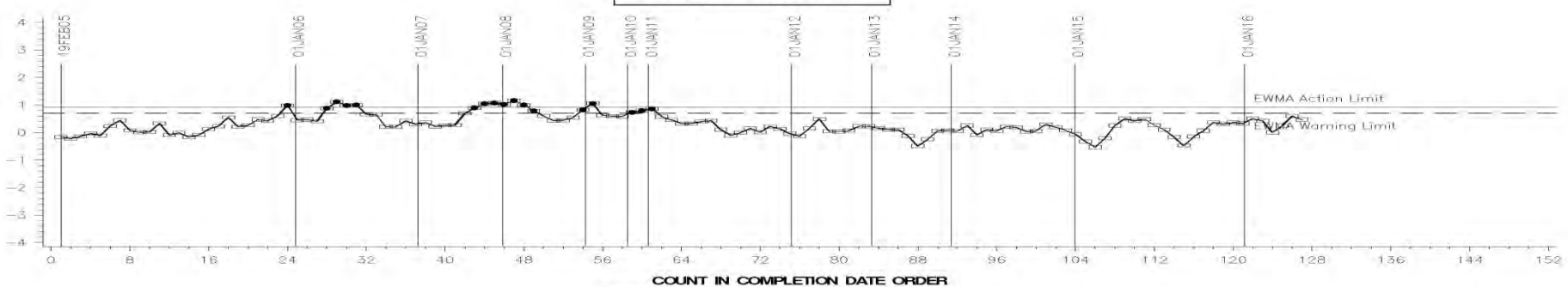
07NOV16:15:15

FINAL TRANS. RES. OIL CONSUMPTION

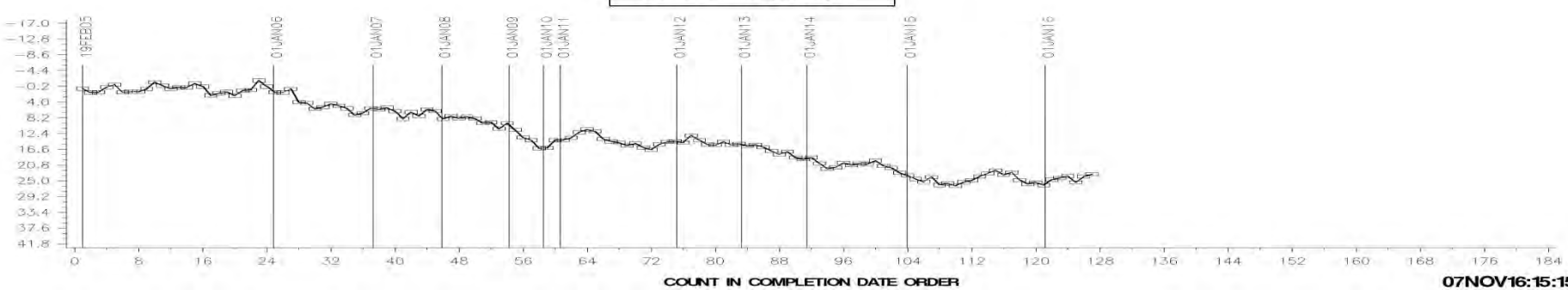
LTMS Severity Analysis



LTMS Precision Analysis

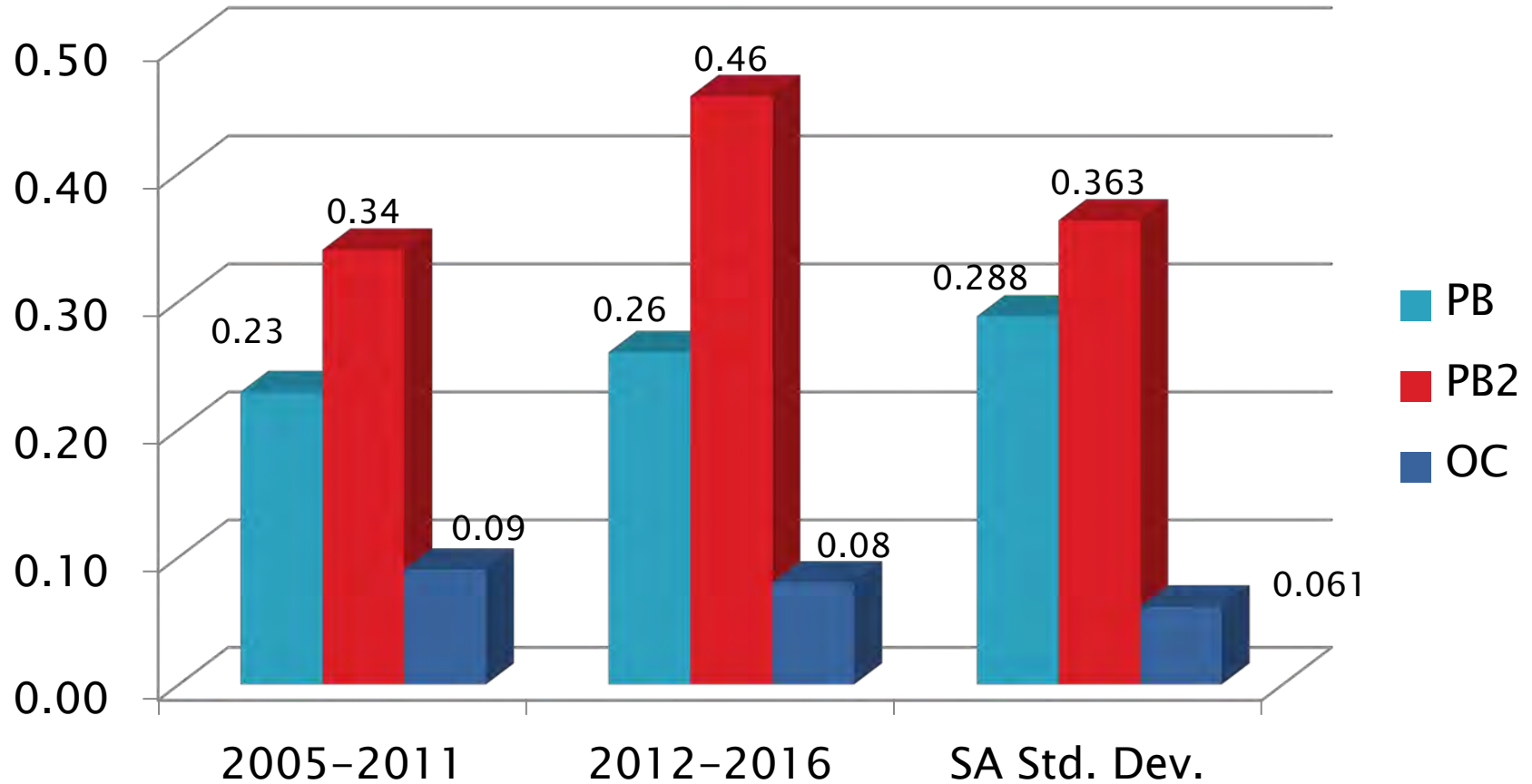


CUSUM Severity Analysis

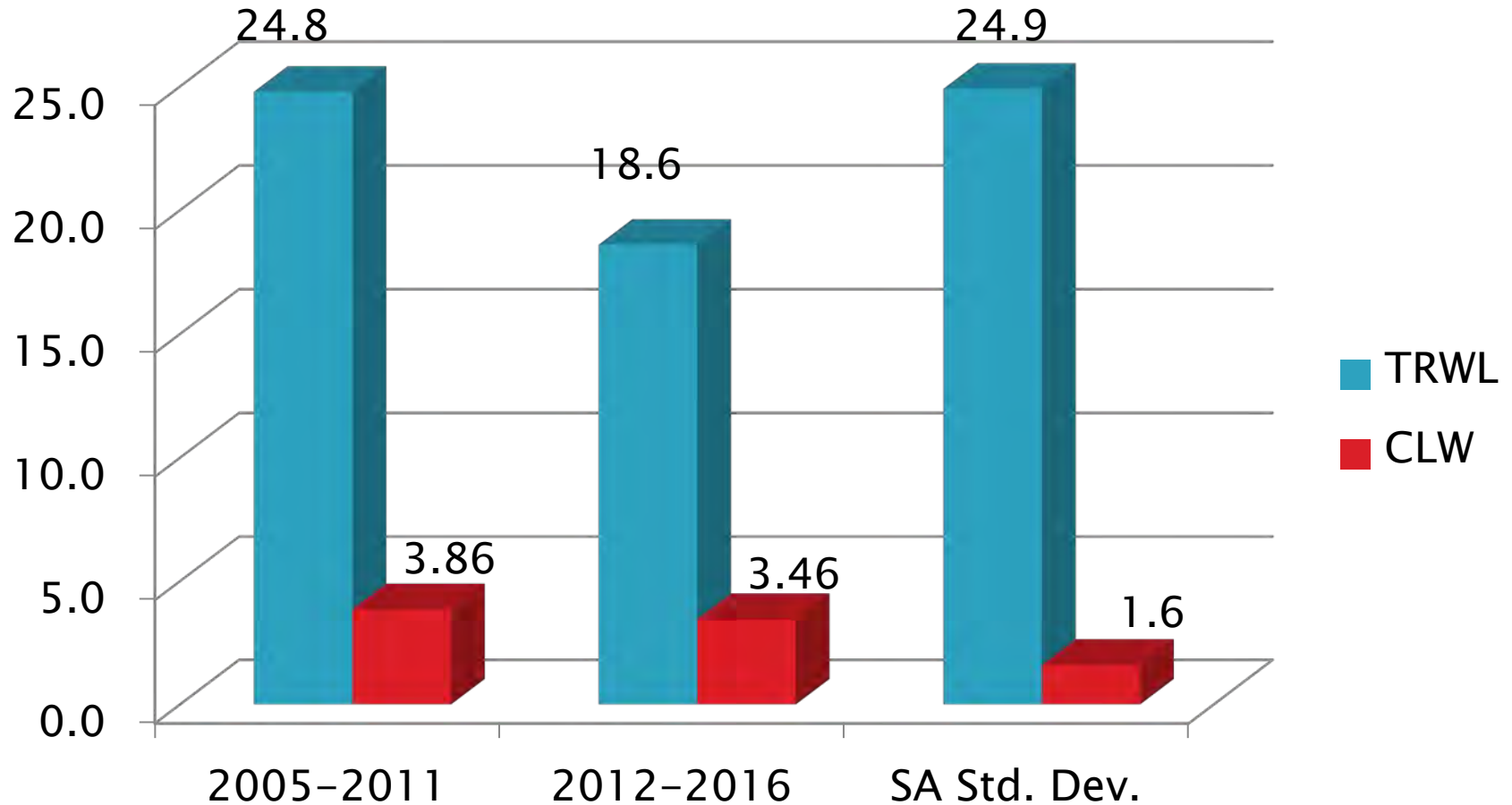


07NOV16:15:15

# T-12 Precision Estimates



# T-12 Precision Estimates



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# Mack T-12A

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# T-12A Test Activity

| Test Status                 | Validity Code | #        |
|-----------------------------|---------------|----------|
| Acceptable Calibration Test | AC            | 2        |
| Failed Calibration Test     | OC/MC         | 0        |
| Operationally Invalid       | LC/LI         | 1        |
| Aborted                     | XC/XI         | 1        |
| <b>Total</b>                |               | <b>4</b> |



# T-12A Failed Tests

| Failed Parameter | Number of Tests |
|------------------|-----------------|
| No failed tests  | 0               |
| <b>Total</b>     | <b>0</b>        |

# T-12A Lost Tests\*

| Status       | Cause                  | #        |
|--------------|------------------------|----------|
| Invalid      | Wrong top ring coating | 1        |
| Aborted      | Wrong top ring coating | 1        |
| <b>Total</b> |                        | <b>2</b> |

\*Invalid and aborted tests

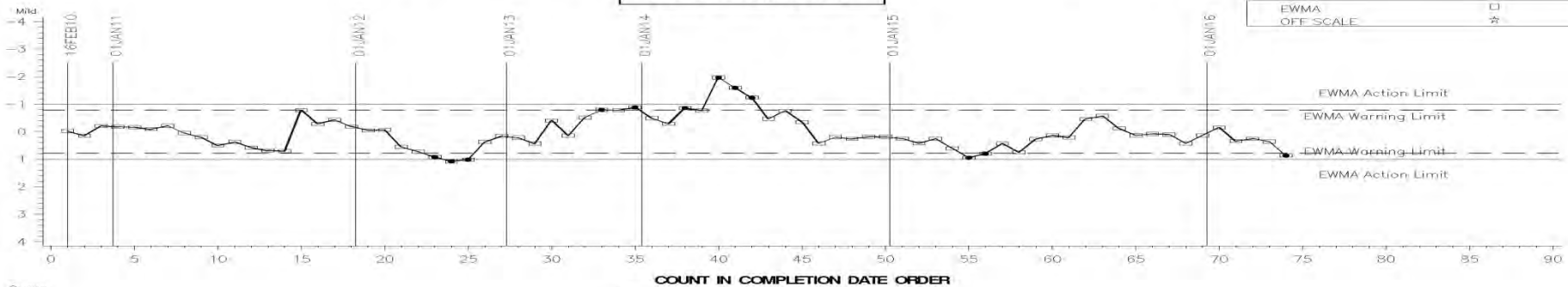
# T-12A Test Severity

- ▶ MRV is severity warning alarm in the severe direction as well as precision warning alarm.

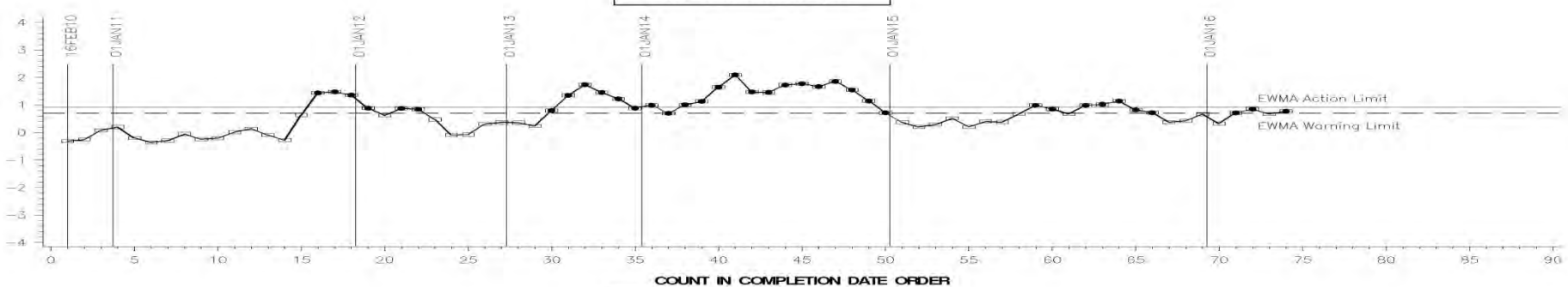
# MACK T-12A INDUSTRY OPERATIONAL VALID DATA

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

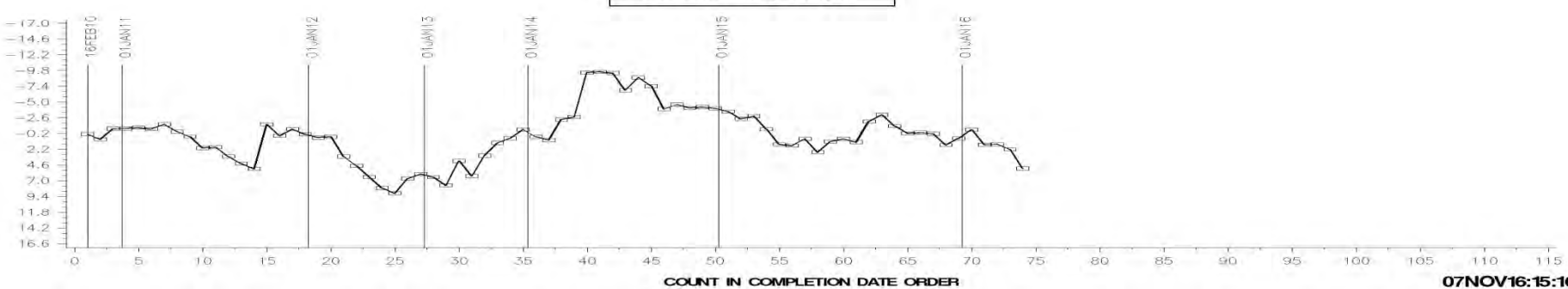
LTMS Severity Analysis



LTMS Precision Analysis



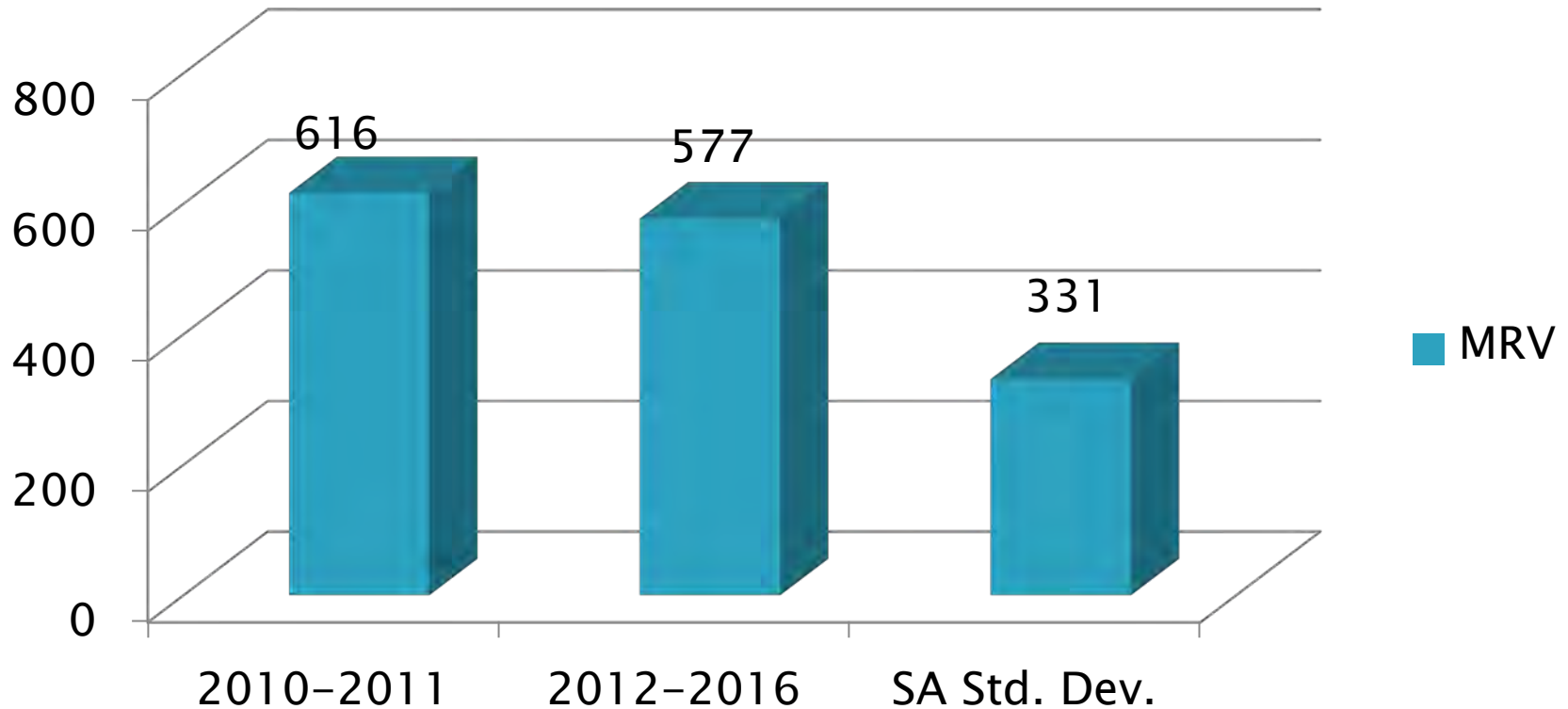
CUSUM Severity Analysis



07NOV16:15:16

# T-12A Precision Estimates

## MRV



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# Mack T-13

»» October 2016

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# T-13 Test Activity

| Test Status                 | Validity Code | #         |
|-----------------------------|---------------|-----------|
| Acceptable Calibration Test | AC            | 9         |
| Failed Calibration Test     | OC            | 1         |
| Operationally Invalid       | LC            | 1         |
| Aborted                     | XC            | 1         |
| <b>Total</b>                |               | <b>12</b> |

# T-13 Failed Tests

| Failed Parameter                 | Number of Tests |
|----------------------------------|-----------------|
| T-13 IRPH and KV40 Increase Mild | 1               |
| <b>Total</b>                     | <b>1</b>        |



# T-13 Lost Tests\*

| Status       | Cause                          | #        |
|--------------|--------------------------------|----------|
| Invalid      | Low oil jet pressure           | 1        |
| Aborted      | Engine failure during break-in | 1        |
| <b>Total</b> |                                | <b>2</b> |

\*Invalid and aborted tests

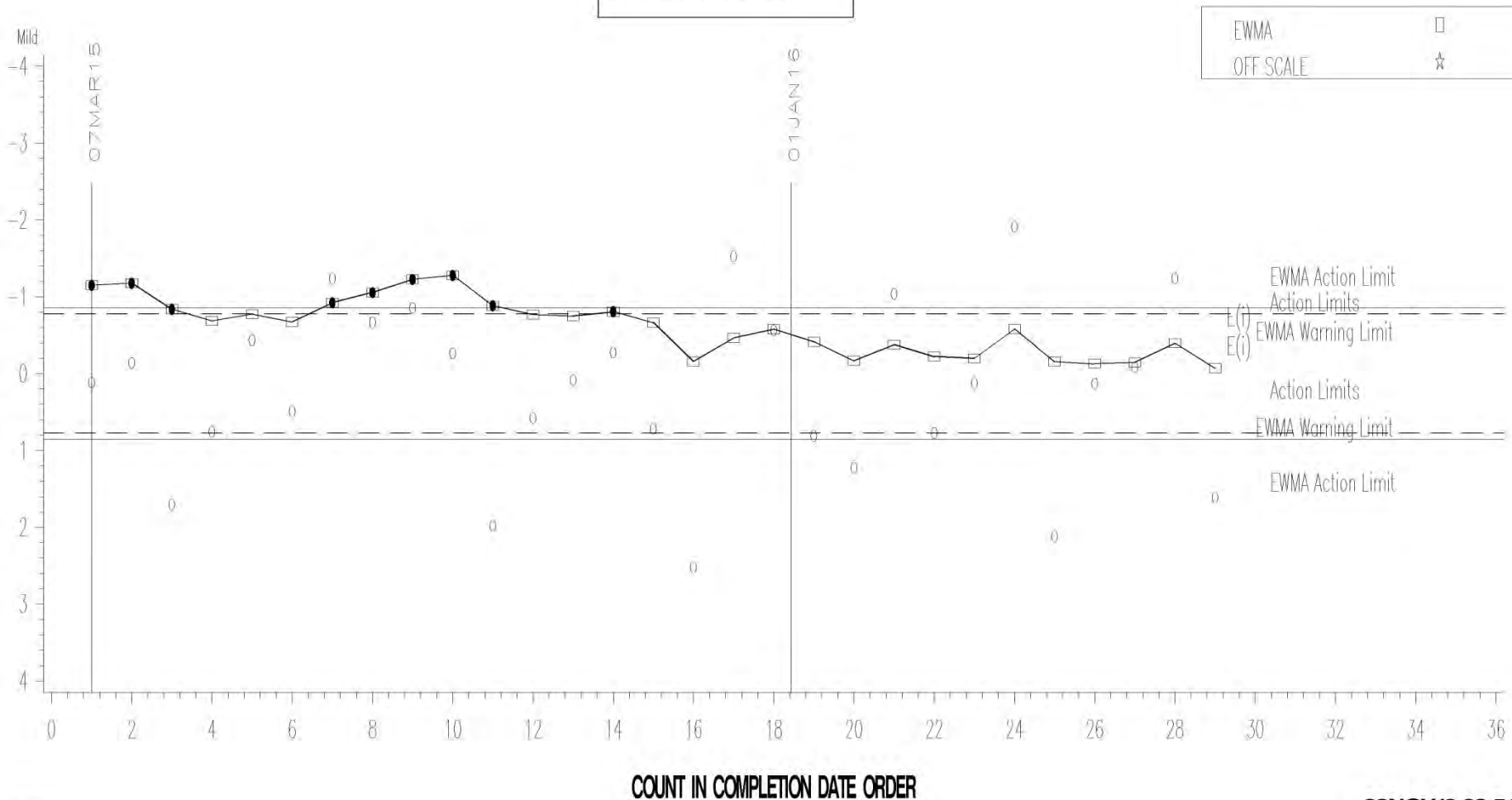
# T-13 Test Severity

- ▶ IRPH and KV40PC are in control.
  - KV40PC near the severity warning limit in the mild direction.

FINAL ORIGINAL PEAK HEIGHT IR AT EOT

LTMS Severity Analysis

Standard Deviation Units



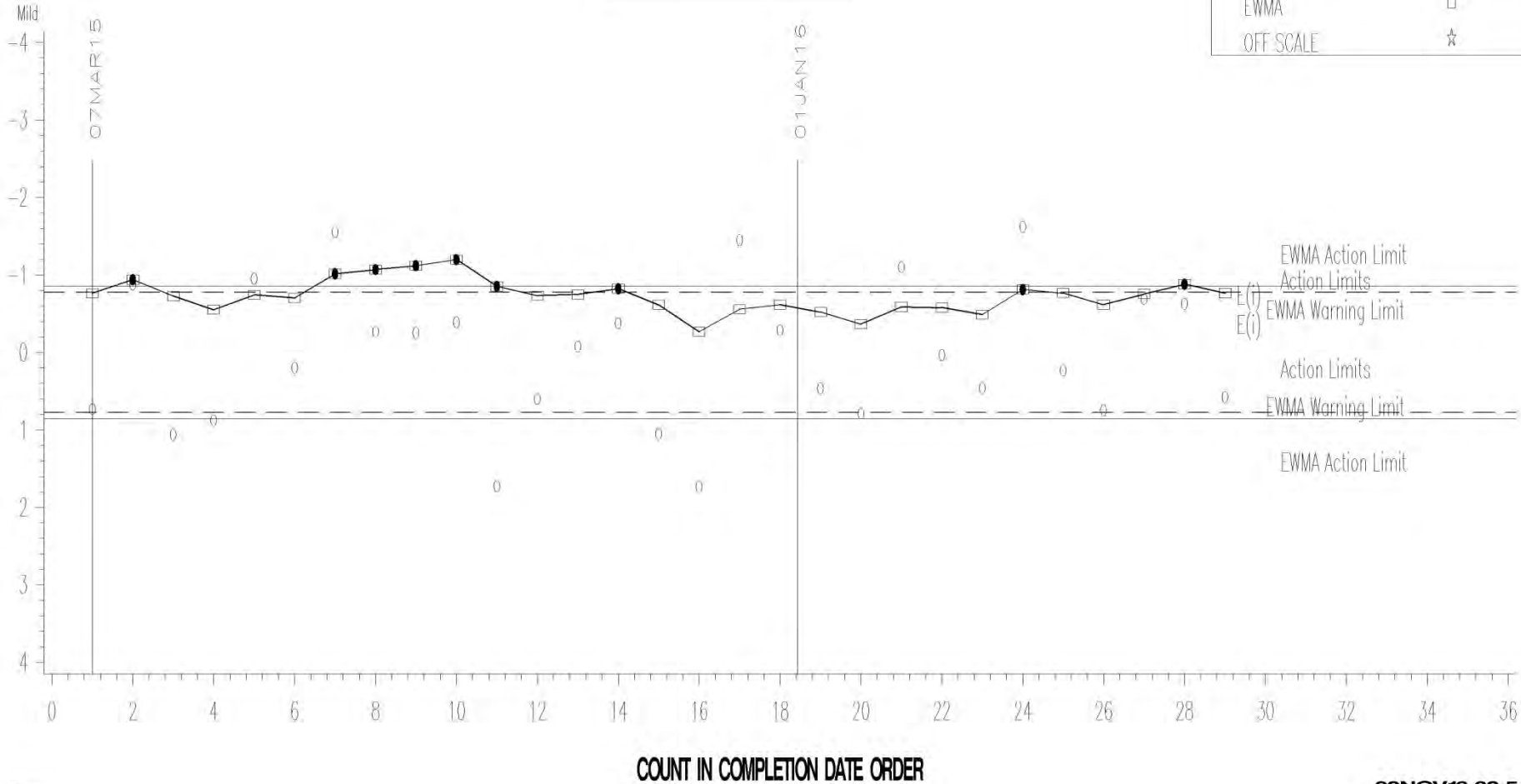
Severe

08 NOV 16: 08:54

FNL. ORIG. UNIT KINEMATIC VISCOSITY AT 40 DEG C % CHANGE 300-360 HRS

LTMS Severity Analysis

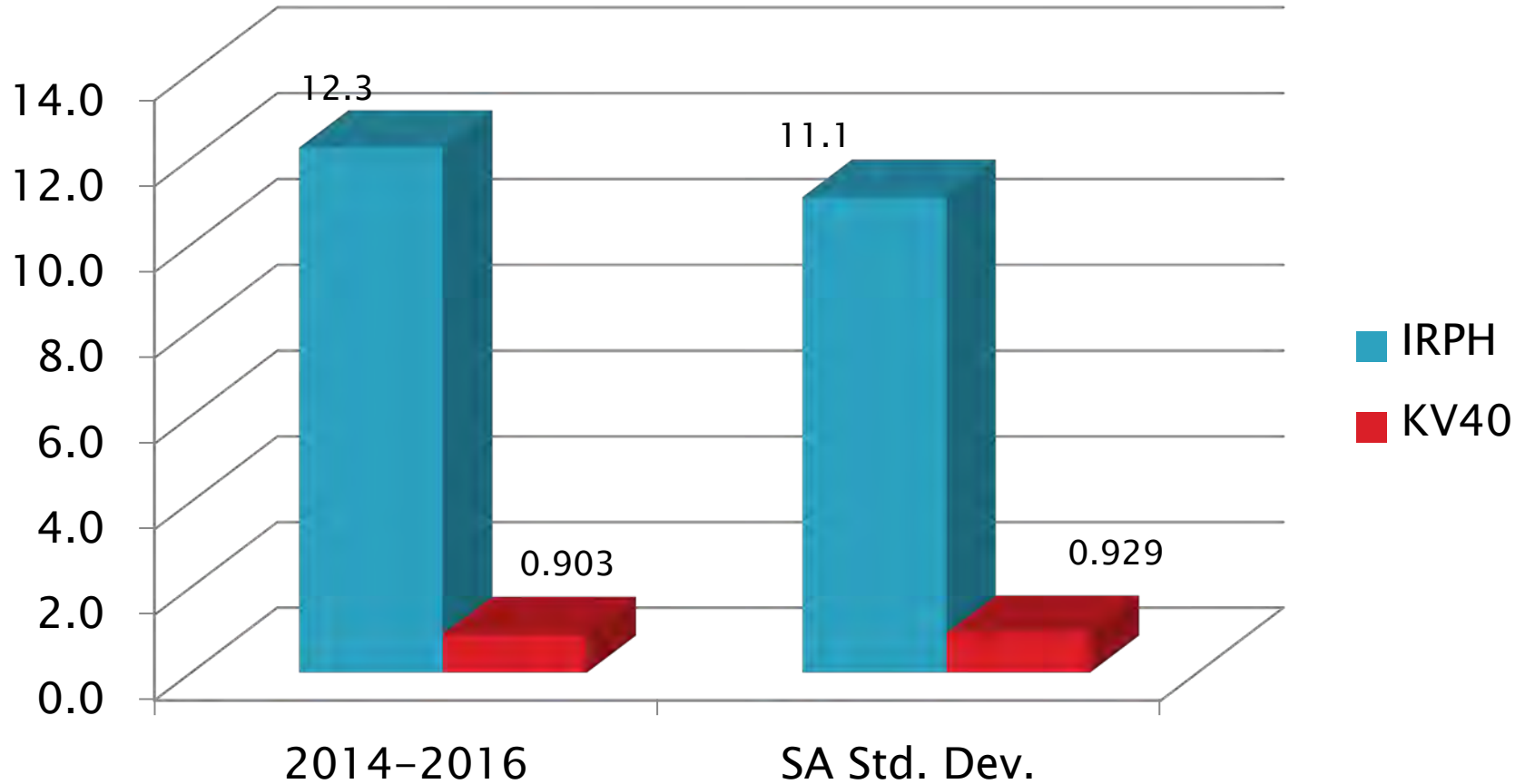
Standard Deviation Units



Severity

08 NOV 16: 08:54

# T-13 Precision Estimates



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# Information Letters

»» April 1, 2016 –  
September 30, 2016

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# Information Letters\*

| Test  | Date      | IL   | Topic  |
|-------|-----------|------|--|
| ISB   | 4/7/2016  | 16-1 | Changes to ISB Wear Parameter Reporting  |
| ISM   | 4/7/2016  | 16-1 | Changes to ISM Wear Parameter Reporting  |
| T13   | 4/22/2016 | 16-1 | Viscosity Increase @ 40 °C Final Minimum Value   |
| 1K/1N | 5/26/2016 | 16-1 | Changes to 1K/1N Humidity Measurement Device Calibration   |
| C13   | 5/26/2016 | 16-1 | Oil Consumption Calculation Clarification  |
| T11   | 6/8/2016  | 16-1 | T-11 Test Fuel Sole Supply   |
| T8    | 6/9/2016  | 16-1 | T-8 Sole Source Fuel Supply  |
| T12   | 6/9/2016  | 16-2 | T-12 Test Fuel Sole Supply   |
| T13   | 6/9/2016  | 16-2 | T-13 Test Fuel Sole Supply   |
| 1K1N  | 6/22/2016 | 16-2 | Changes to 1K/1N Cooling System Specifications   |
| 1P    | 6/22/2016 | 16-1 | Changes to 1P Humidity Measurement Device Calibration  |
| 1R    | 6/22/2016 | 16-1 | 1. Changes to 1R Humidity Measurement Device Calibration<br>2. Test Fuel Sole Source Designation |

\*Available from TMC Website

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# Information Letters \*-Continued

| Test | Date      | IL   | Topic   |
|------|-----------|------|---|
| COAT | 6/22/2016 | 16-1 | COAT Test Fuel Sole Supply and Non-Editorial Ballot Items |
| T13  | 9/13/2016 | 16-3 | T-13 FTIR Peak Height Oxidation Name Change               |

\*Available from TMC Website

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# Reference Oil Inventory

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

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# Reference Oil Reblends

- ▶ Reblend of 830-2 being pursued for ISM.
- ▶ Reblend of 831-3 being pursued for C13 and ISB.

# 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                  | 0                                 | 2189          | 126           | 5+ years       |
| 811-2 | 1K, 1N          | 1732                  | 1                                 | 1000          | 40            | 5+ years       |
| 822-2 | 1R, T-10A, T-11 | 4386                  | 84                                | 3235          | 224           | 5+ years       |
| 821-4 | T-12            | 4495                  | 50                                | 3084          | 175           | 5+ years       |
| 823   | T-13            | 1796                  | 101                               | 1194          | 140           | 3 years        |
| 830-2 | ISM             | 3786                  | 125                               | 99            | 225           | 1.5 years      |
| 831-3 | C13, ISB        | 972                   | 90                                | 182           | 325           | 1 year         |

# Reference Oil Inventory Estimated Life

| Oil    | Tests                     | Original Blend Amount | Quantity Shipped in last 6 months | TMC Inventory | Lab Inventory | Estimated Life |
|--------|---------------------------|-----------------------|-----------------------------------|---------------|---------------|----------------|
| 873-2  | 1M-PC                     | 1650                  | 0                                 | 67            | 40            | 5+ years       |
| 1005-4 | 1P, 1R, EOAT, RFWT, T-8/E | 2000                  | 0                                 | 74            | 30            | < 0.5 years    |
| 1005-5 | 1P, 1R, EOAT, RFWT, T-8/E | 3826                  | 275                               | 3177          | 285           | 5+ years       |
| 832    | COAT                      | 1166                  | 56                                | 695           | 140           | 5+ years       |
| 833    | COAT                      | 1152                  | 140                               | 512           | 168           | 2.5 years      |
| 864    | DD13                      | 121                   | 100                               | 21            | 0             | 0.1 years      |
| 864-1  | DD13                      | 1576                  | 50                                | 1324          | 200           | 5+ years       |
| 866    | DD13                      | 341                   | 50                                | 266           | 25            | 3 years        |

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# LTMS Deviations

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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               |

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# Quality Index Deviations

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# Quality Index Deviations

- ▶ 1 P Qi Deviation
  - Coolant out temperature negative Qi due to replacement of heat exchanger and controller retuning.
- ▶ T13 Qi Deviation
  - Intake air temperature negative Qi due to facility heating steam system shutdown.



# Quality Index Deviations

## Historical Count of HD Quality Index Deviations

| Test  | Qi Deviations |
|-------|---------------|
| 1P    | 14            |
| 1R    | 1             |
| ISM   | 3             |
| C13   | 2             |
| T-10A | 1             |
| T-11  | 3             |
| T-12  | 6             |
| T-13  | 1             |
| COAT  | 3             |

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# TMC Laboratory Visits

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# TMC Lab Visits

| Test | Number of Labs Visited |
|------|------------------------|
| T13  | 1                      |

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# Lab Visit Issues

- ▶ T13
  - No discrepancies were found.

# Test Area Timelines

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# Test Area Timeline Additions\*

| Test  | Date      | Topic  | IL/Memo |
|-------|-----------|--|---------|
| ISB   | 4/7/2016  | Changes to ISB Wear Parameter Reporting  | 16-1    |
| ISM   | 4/7/2016  | Changes to ISM Wear Parameter Reporting  | 16-1    |
| T13   | 4/22/2016 | Viscosity Increase @ 40 °C Final Minimum Value   | 16-1    |
| 1K/1N | 5/26/2016 | Changes to 1K/1N Humidity Measurement Device Calibration   | 16-1    |
| C13   | 5/26/2016 | Oil Consumption Calculation Clarification  | 16-1    |
| T11   | 6/8/2016  | T-11 Test Fuel Sole Supply   | 16-1    |
| T8    | 6/9/2016  | T-8 Sole Source Fuel Supply  | 16-1    |
| T12   | 6/9/2016  | T-12 Test Fuel Sole Supply   | 16-2    |
| T13   | 6/9/2016  | T-13 Test Fuel Sole Supply   | 16-2    |
| 1K1N  | 6/22/2016 | Changes to 1K/1N Cooling System Specifications   | 16-2    |
| 1P    | 6/22/2016 | Changes to 1P Humidity Measurement Device Calibration  | 16-1    |
| 1R    | 6/22/2016 | 1. Changes to 1R Humidity Measurement Device Calibration<br>2. Test Fuel Sole Source Designation | 16-1    |

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\*As of 9/30/2016

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# Test Area Timeline Additions\*

| Test | Date      | Topic   | IL/Memo |
|------|-----------|---|---------|
| COAT | 6/22/2016 | COAT Test Fuel Sole Supply and Non-Editorial Ballot Items | 16-1    |
| T13  | 9/13/2016 | T-13 FTIR Peak Height Oxidation Name Change               | 16-3    |

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# Rating Workshop Data

»» 2016 Heavy Duty Workshop

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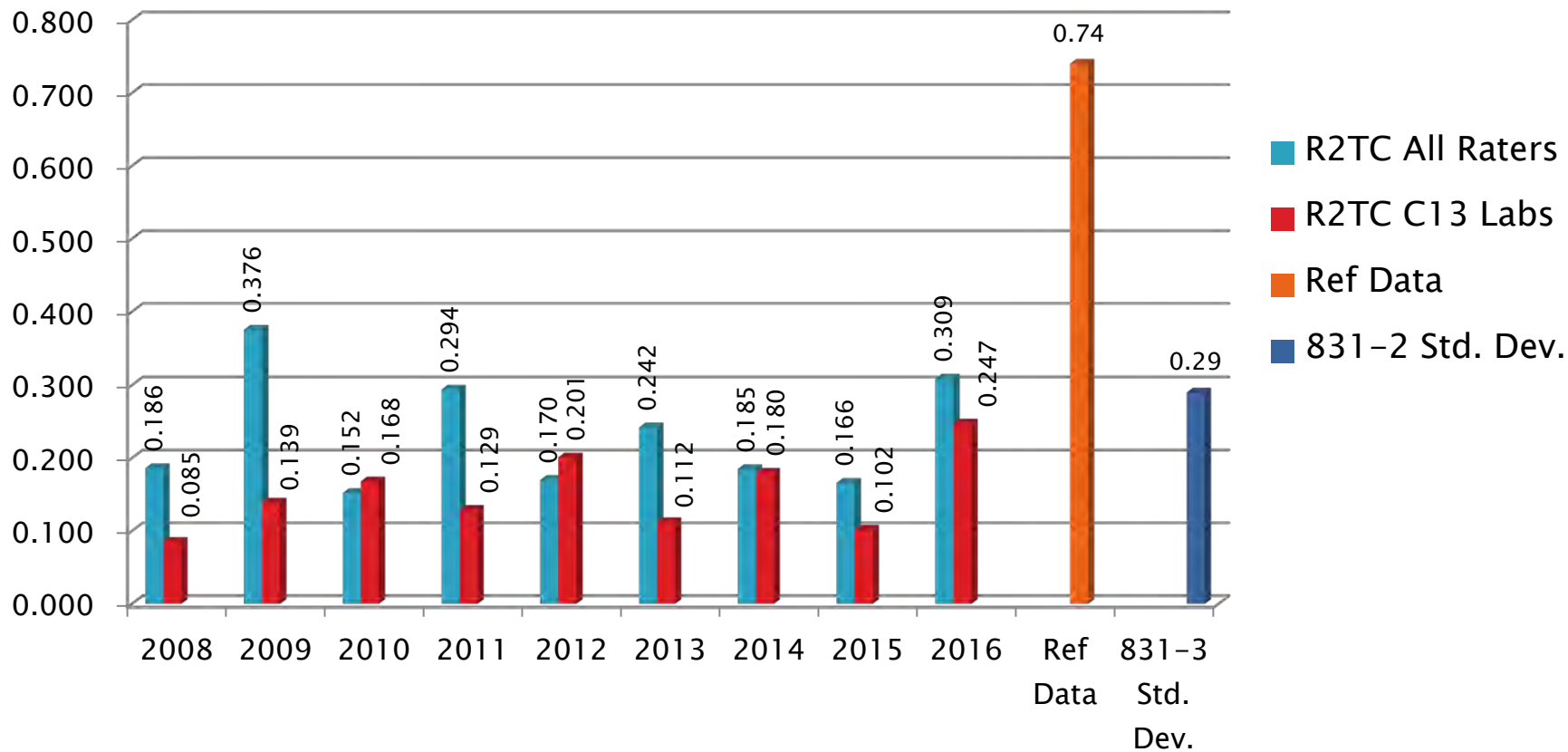


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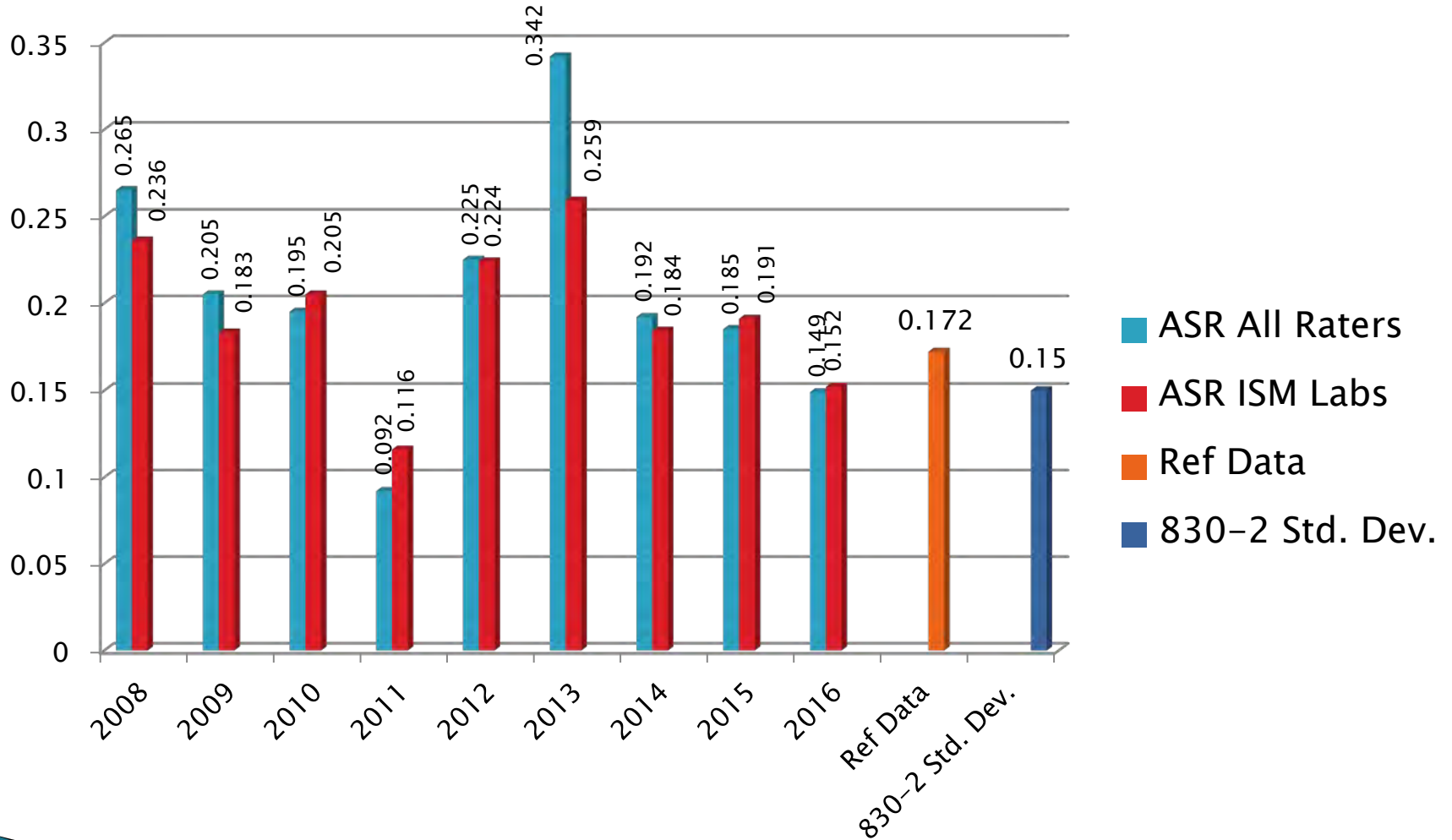


# C13 2<sup>nd</sup> Ring Carbon Precision – Rating Workshop Data

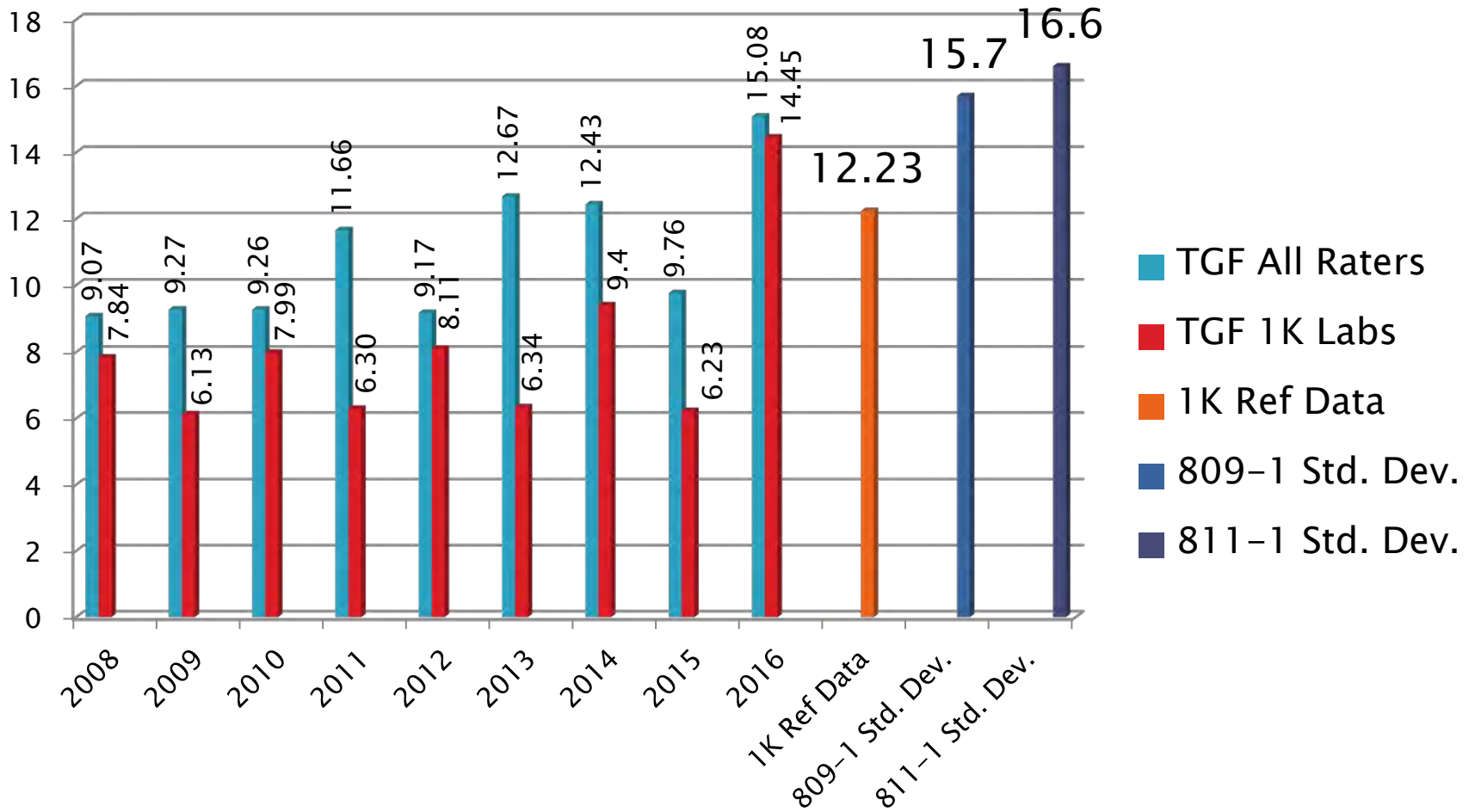
## R2TC



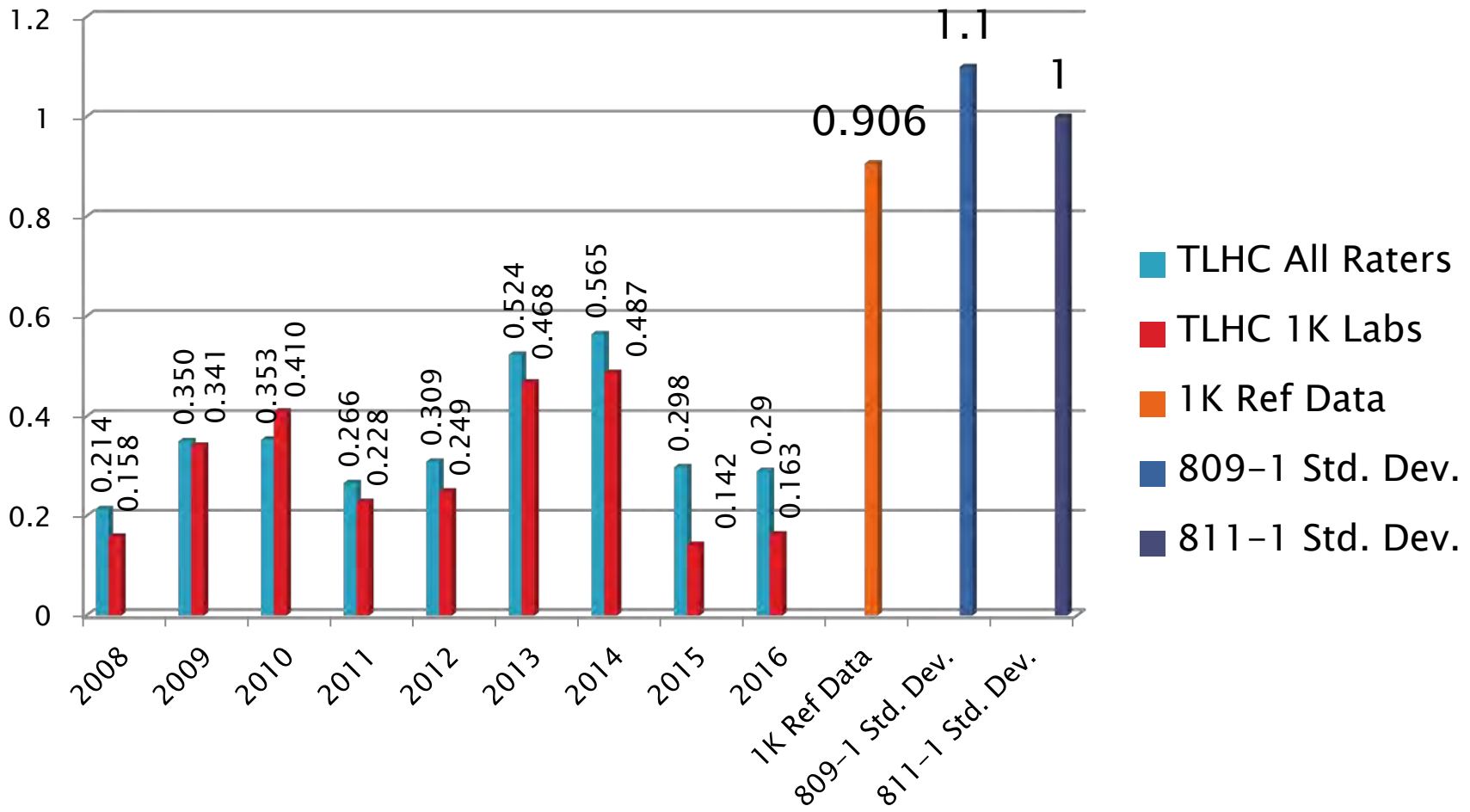
# ISM Sludge Rating Precision - Rating Workshop Data



# Deposit Rating Precision - Rating Workshop Data



# Deposit Rating Precision - Rating Workshop Data



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# Miscellaneous 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](http://www.astmtmc.cmu.edu)

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