IIIH Task Force Conference Call
October 1, 2015 1:00PM Central
Call-in 713-222-0377
Pass Code 5214824464

Attendees:

Chrysler: Haiying Tang
Shell: Karin Haumann
Oronite: Jo Martinez, Robert Stockwell, Kaustav, Sinha
Afton: Ed Altman
Ashland: Amol Savant
Infineum: Andy Ritchie, Gordon Farnsworth, Mike McMillan
Lubrizol: George Szappanos, Michael Conrad, Kevin OMalley
Intertek: Adison Schweitzer
SwRI: Pat Lang, Ankit Chaudhry, Travis Kostan, Sid Clark
TMC: Rich Grundza
OHT: Jason Bowden, Matt Bowden
IMTS: Dave Passmore
Ford: Ron Romano
Idemitsu: Scott Rajala
GM: Bruce Matthews

Karin opened the meeting announcing we had a hard stop at 3:00 Eastern / 2:00 Central

The Agenda is attached as (Attachment #1)

The first order of business was review of the E-Ballot concerning changes to the IIIH Engine Assembly Manual and Forms changes posted to the TMC Website. As there were no discerning comments, the E-Ballot is considered Approved and the information will be posted to the TMC Website.

The second order of business, Karin informed the group that since they last spoke, the core lab group had conducted a IIIH Data Review, of which she included as a smaller sub set for review during the call showing some of the parameters of interest from the larger data set in her presentation materials for this call identified as (Attachment #2 “IIIH Data Review”). Karin also informed the group they can review the complete, Full Data Set of this review on the TMC Website.

Karin reviewed the IIIH Data Review and appropriate lab personnel commented for each section of the review. Karin indicated that slides 7 & 8 should be disregarded as these variations were approved during the test review.

The labs agreed they were all working on Fuel Temperature Control and discussed the reasons for setting the temperature at 30°C. Discussion focused on fuel temperature settings during development and prove-out testing with the focus on not wanting to change the specifications from the prove-out data. The group discussed each parameter in detail with Rich Grundza agreeing the Test Monitoring

Center will review all limits looking at Prove-Out and Precision Matrix Data and base limits around the data after everything has been reviewed.
After discussion the following Motion was made:
Ed Altman / Addison Schweitzer
Accept the as valid the tests reviewed in the current operational data review. The Test Keys accepted as valid are:

106768, 106755, 106786, 106793, 106795, 106792, 107872, 110227

Karin then called the question;
Zero Objections
Zero Waves
Motion Passed Unanimously

Karin next reviewed the IIIH Reference Oils (Attachment #3 "IIIH Reference Oils")
The group reviewed the Reference Oil Data understanding some of the data had yet to be reported to the TMC but was included in the presentation with exception the final run from Lab E.

The next order of business, Jo Martinez presented a statistical analysis review of the current available data (Attachment #4 IIIH Precision Matrix Data Analysis 092915).

After Jo Martinez's review of the data, Karin reminded everyone that the data discussed was based on four tests/stand from each lab with exception Lab "E" which was re-running their first test and setting up to run their final tests after making changes to correct problems found during the initial core group parameter review.

Karin asked Lab E to forward their presentation to the group for review (Attachment #5 "ASH 1st 2 PM Tests validity discussion) and the group reviewed his presentation. Karin reminded the group that Ashland's 1st test was in-validated and the 2nd test was pending the core group's upcoming review.

Karin then tabled this conversation pending the outcome of that review.

Karin then indicated the complete data set will be forwarded to the full statistical review group once the data set was complete. Additionally, Karin reminded the group earlier in the call that the Precision Matrix was designed allowing Lab E to be excluded from the initial review thereby allowing acceptance and inclusion of their data to be included in the first 20 Reference Test Updated Limits.

The meeting adjourned at 3:00pm Eastern / 2:00pm Central.

This is a compilation from notes recorded during the call, with comments from member participants during the Draft Review. Certain subjects may not necessarily be in exact order; however, they are believed to represent an accurate account of the call. If anyone feels changes or additional content may be necessary, please contact Sid Clark @ 586-873-1255 or Sidney.Clark@swri.org

Thanks, Sid

Attachment #1

# Sequence IIIH Task Force
# October 1, 2015 1:00 pm CDT
# Call-in Number: 713-222-0377
# Conference Number: 5214824464

**Old Business:**

E-ballot to approve proposed Engine Assembly Manual Changes and TMC Form Changes

**Matrix Test Validity**

IIIH Data Review 3 – Karin Haumann

**Matrix Data Collected**

Reference Oils – Karin Haumann

IIIH Precision Matrix Data Analysis - Jo Martinez

**Matrix Status**

Status of outstanding tests – Amol Savant

**Next Meeting**

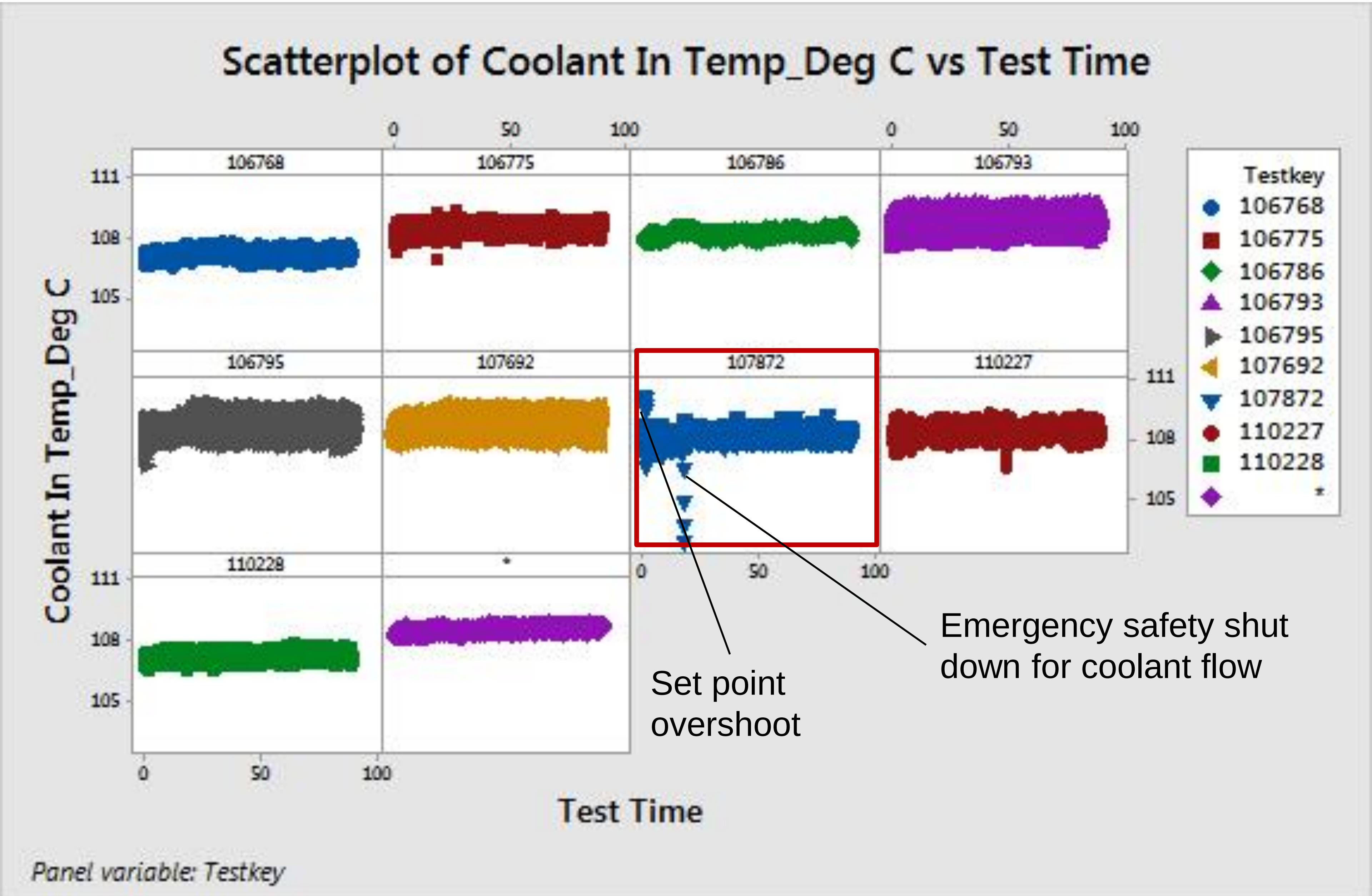
TBD

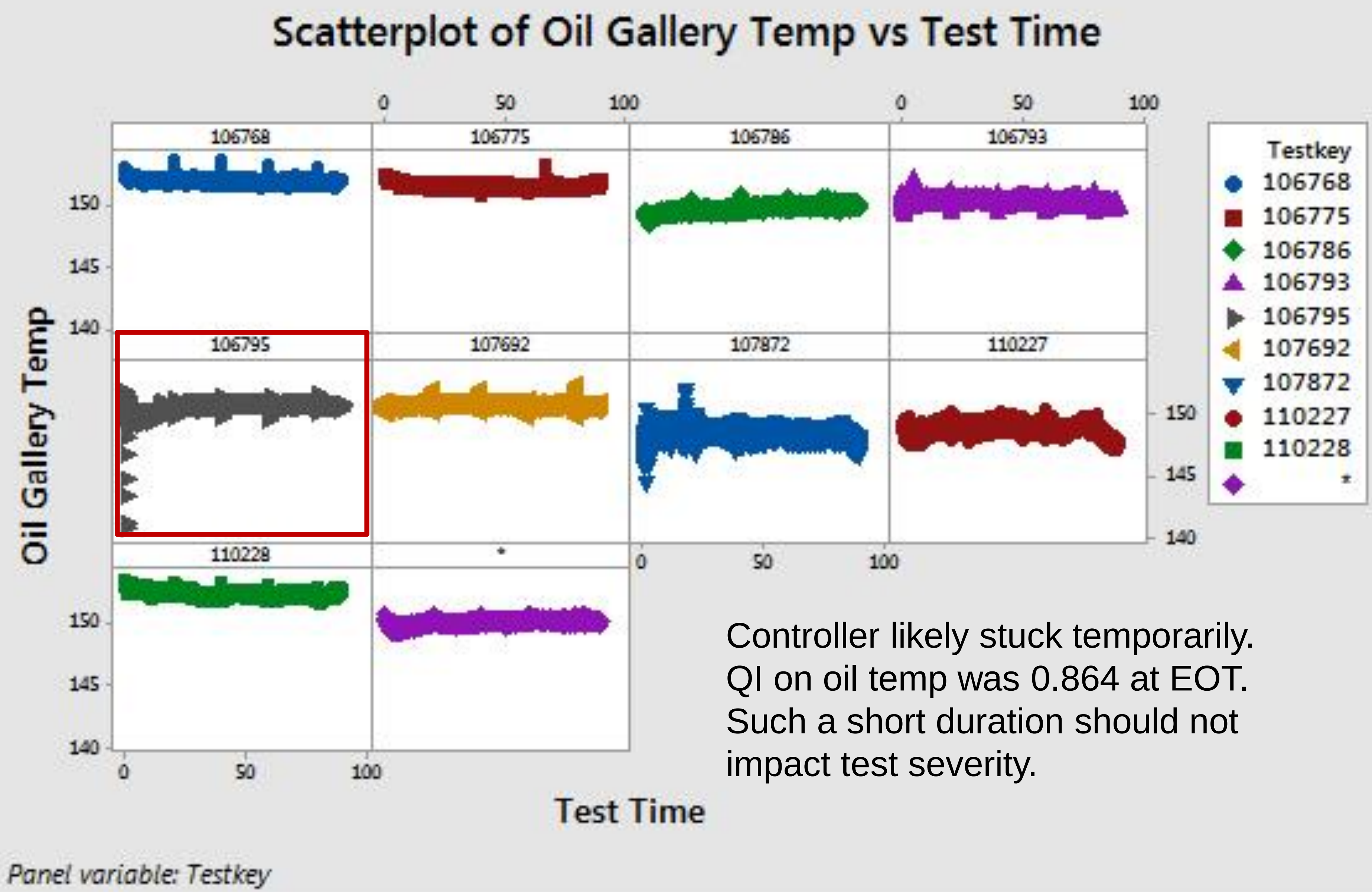
Attachment #2

# IIIH Precision Matrix
# Third Operational Data Review

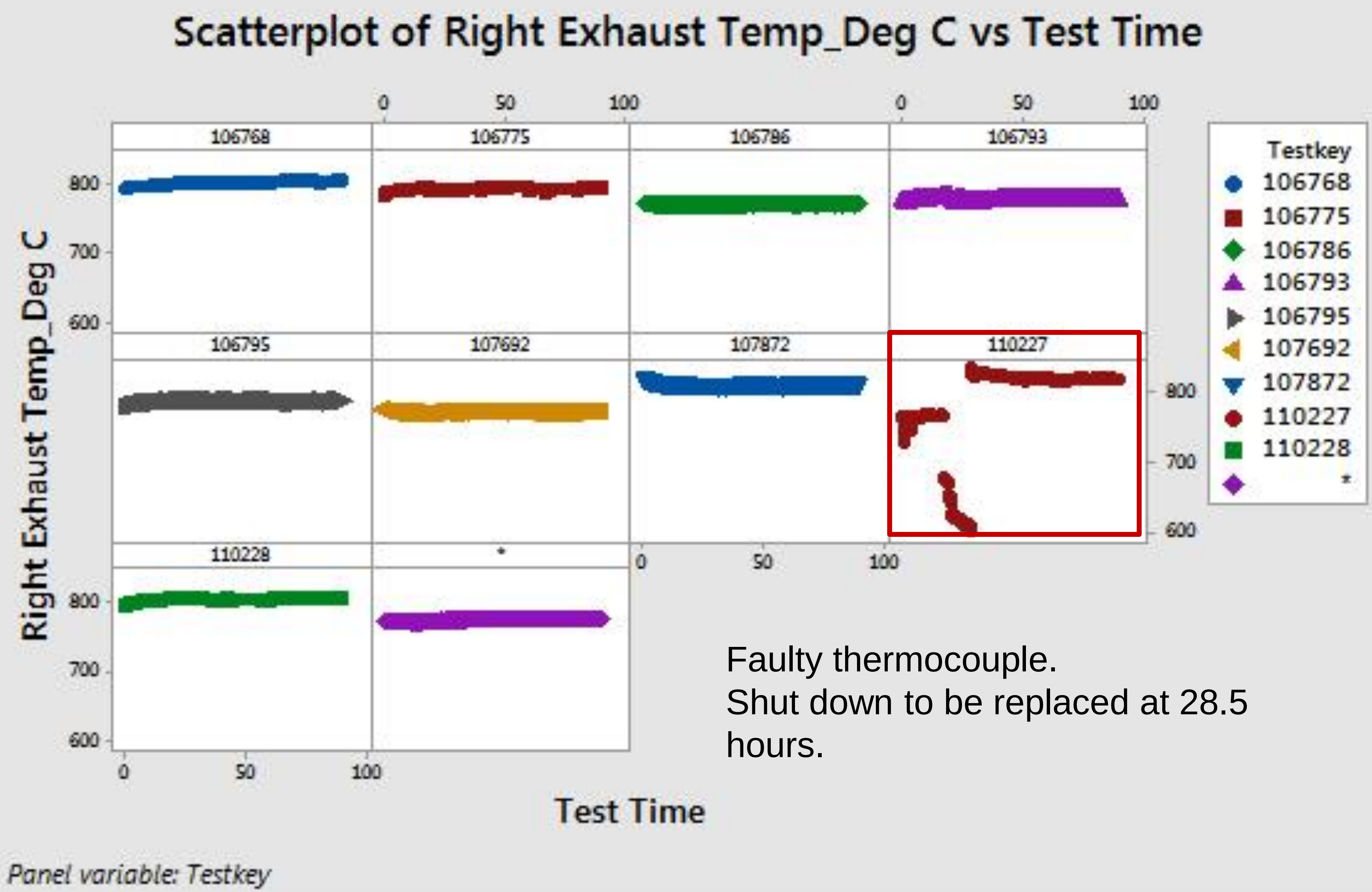
Findings of anomalies in the data

October 1, 2015

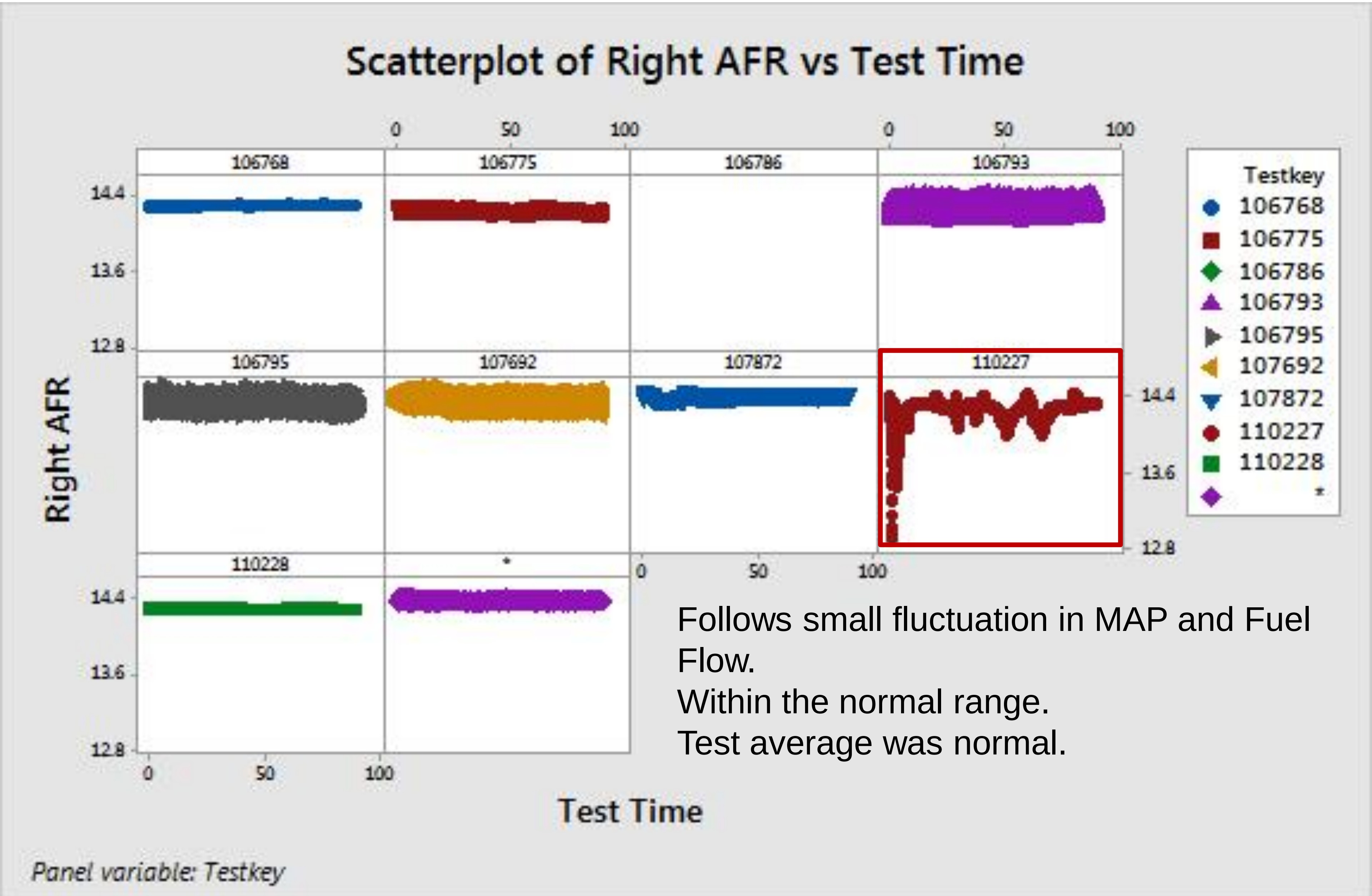

Scatterplot of Coolant In Temp_Deg C vs Test Time
Coolant In Temp_Deg C
Test Time
Panel variable: Testkey
Testkey
106768
106775
106786
106793
106795
107692
107872
110227
110228
*
Set point overshoot
Emergency safety shut down for coolant flow



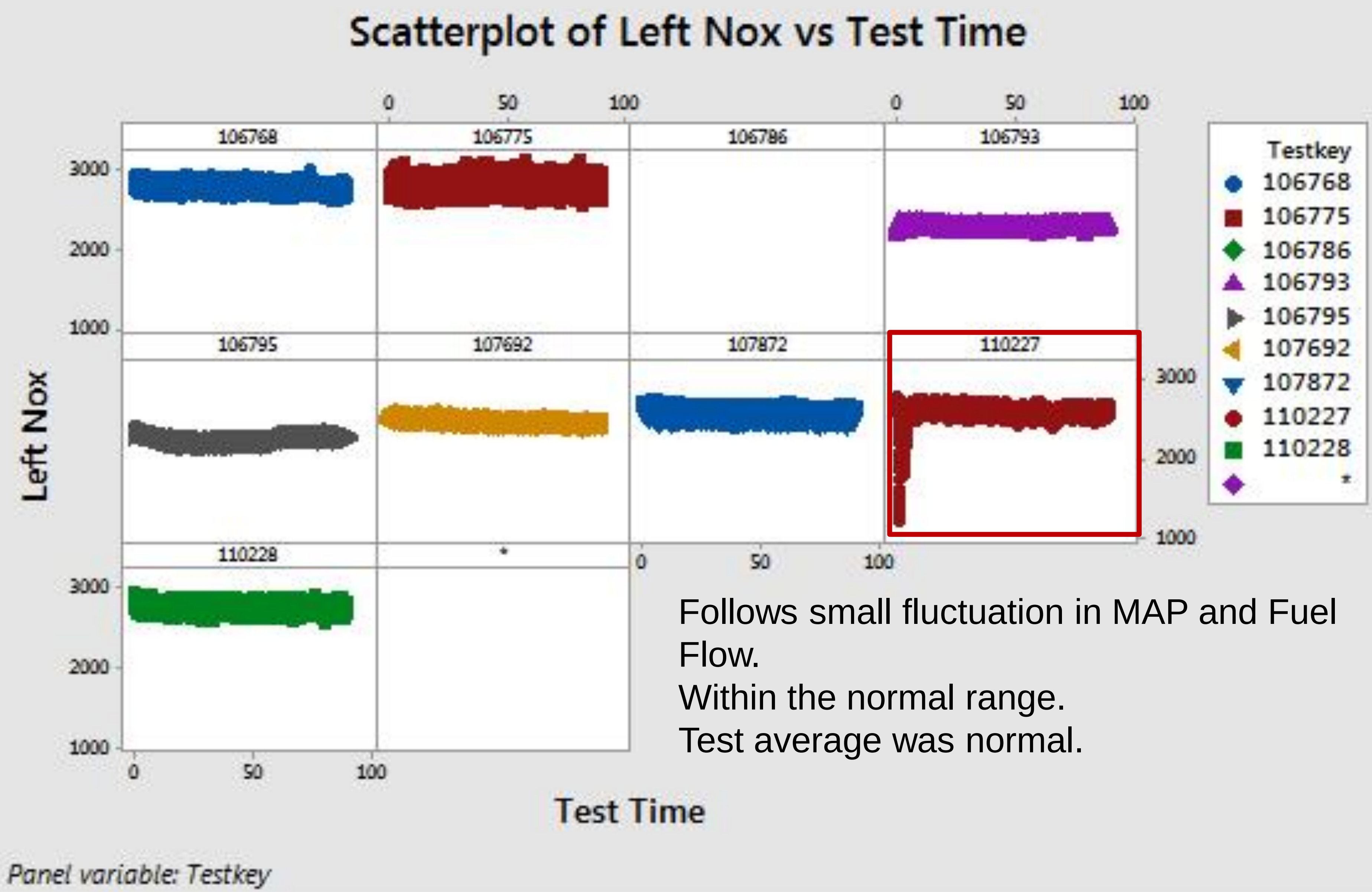

Controller likely stuck temporarily. QI on oil temp was 0.864 at EOT. Such a short duration should not impact test severity.



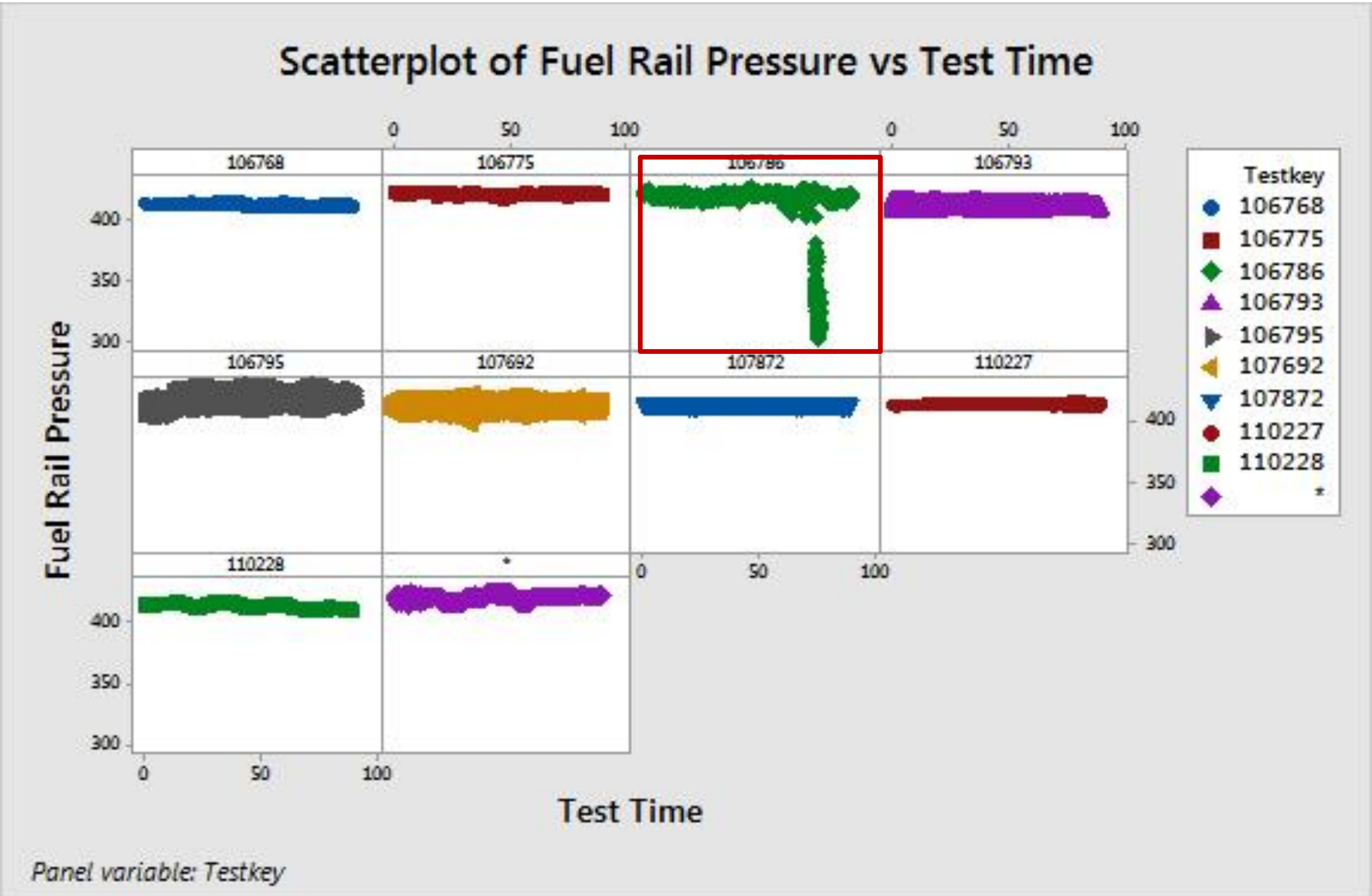

Faulty thermocouple.
Shut down to be replaced at 28.5 hours.



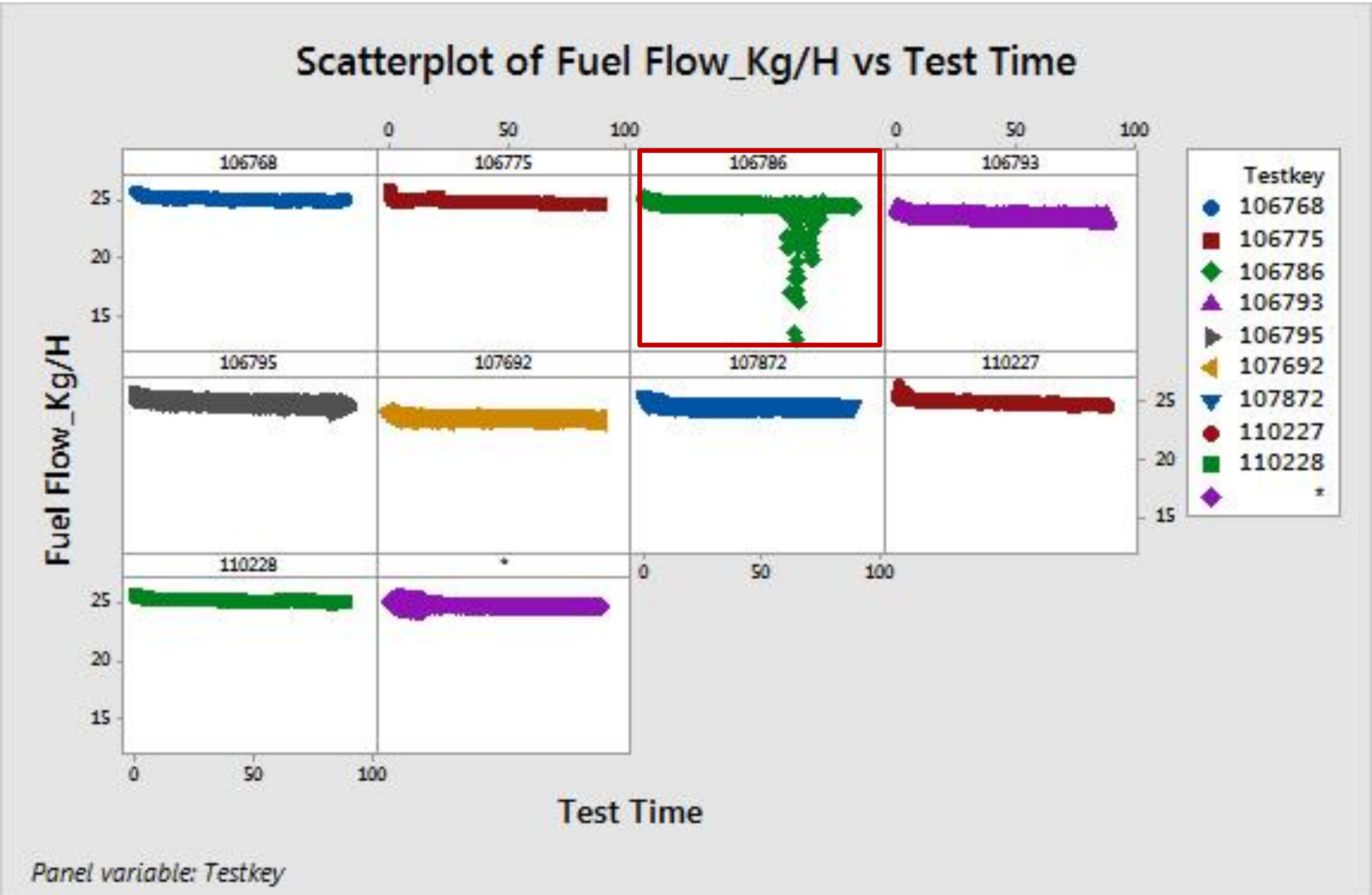

Follows small fluctuation in MAP and Fuel Flow.
Within the normal range.
Test average was normal.




Follows small fluctuation in MAP and Fuel Flow.
Within the normal range.
Test average was normal.



Scatterplot of Fuel Rail Pressure vs Test Time
106768
106775
106786
106793
106795
107692
107872
110227
110228
*
Fuel Rail Pressure
Test Time
400
350
300
0
50
100
Testkey
106768
106775
106786
106793
106795
107692
107872
110227
110228
*
Panel variable: Testkey

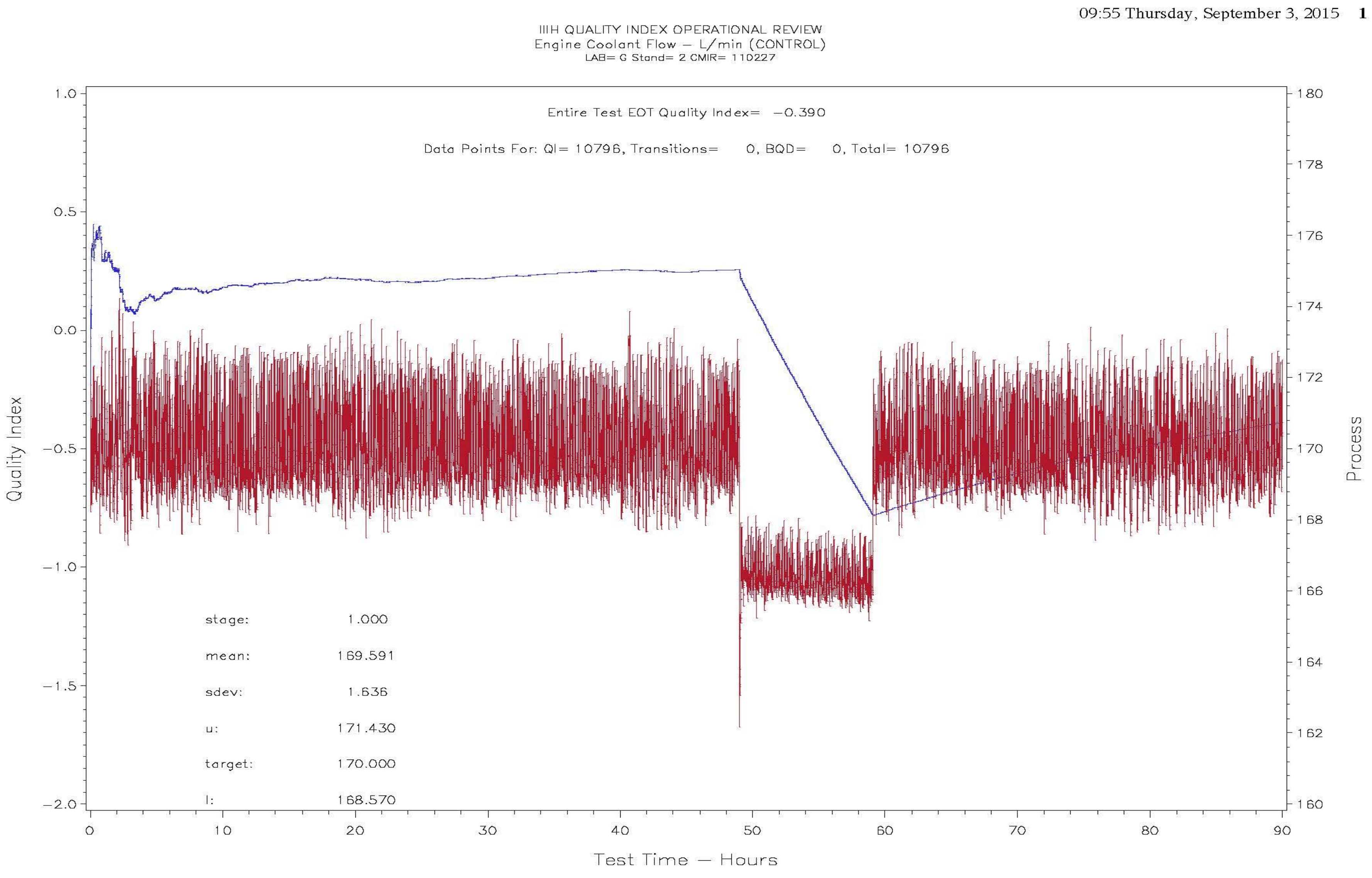

Scatterplot of Fuel Flow_Kg/H vs Test Time
106768
106775
106786
106793
106795
107692
107872
110227
110228
*
Testkey
106768
106775
106786
106793
106795
107692
107872
110227
110228
*
Fuel Flow_Kg/H
Test Time
0
50
100
15
20
25
Panel variable: Testkey

# QI Plots from 3rd Matrix Tests

# Summary of Controlled Parameters

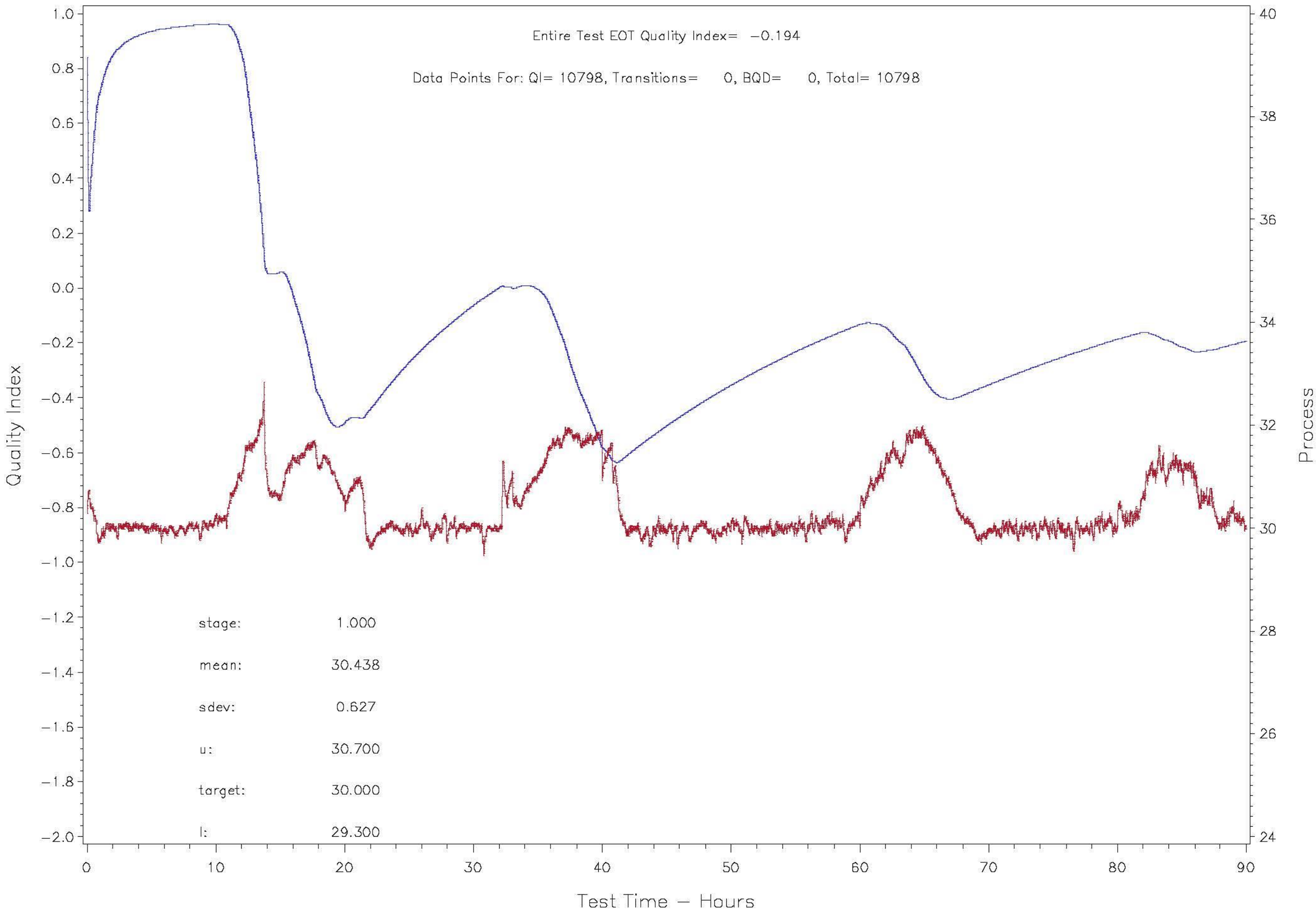
- Most issues from previous tests have been resolved.
- Intake air pressure and fuel temperature continue to be slightly challenging.

# Coolant Flow

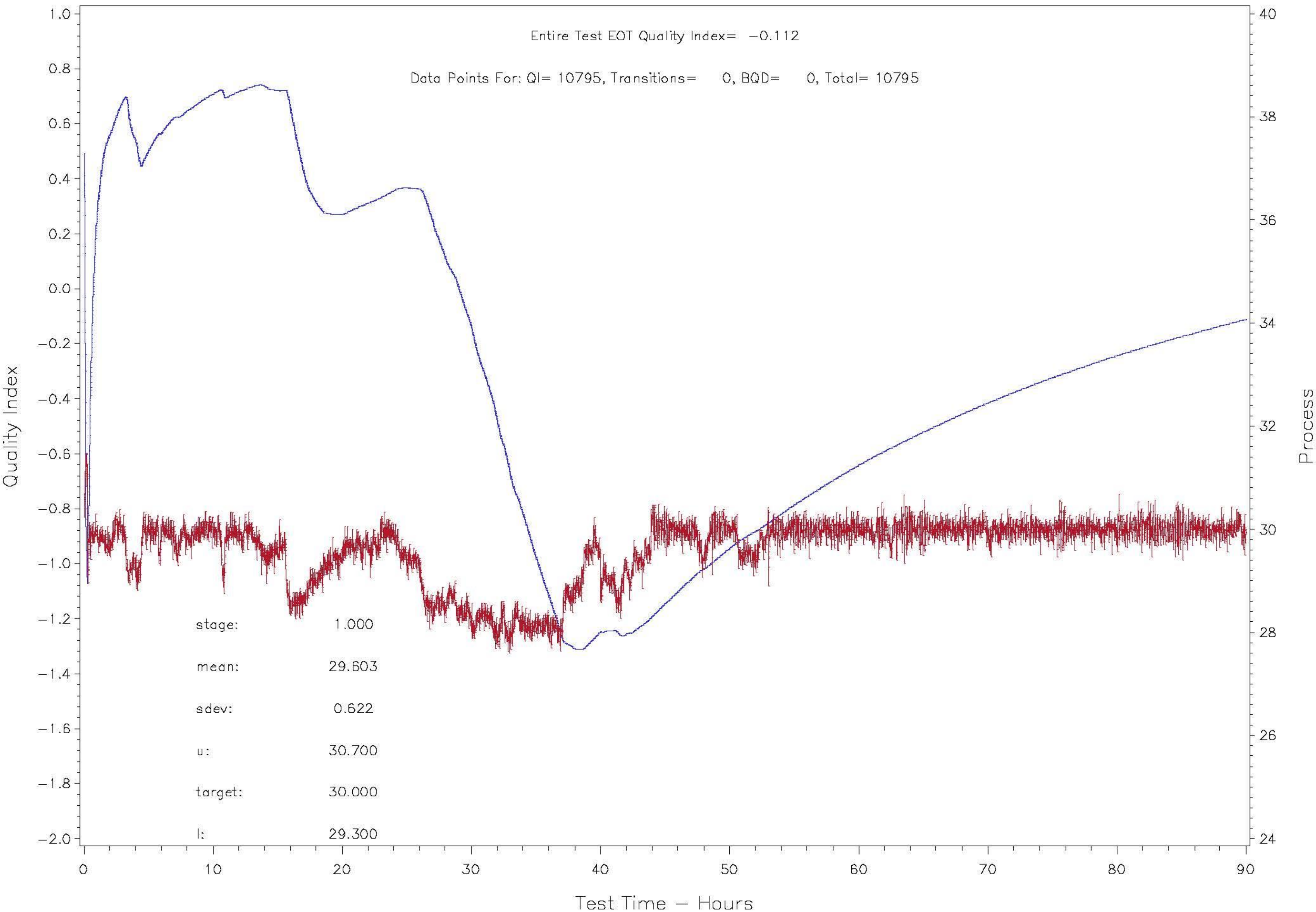


# Fuel Temperature

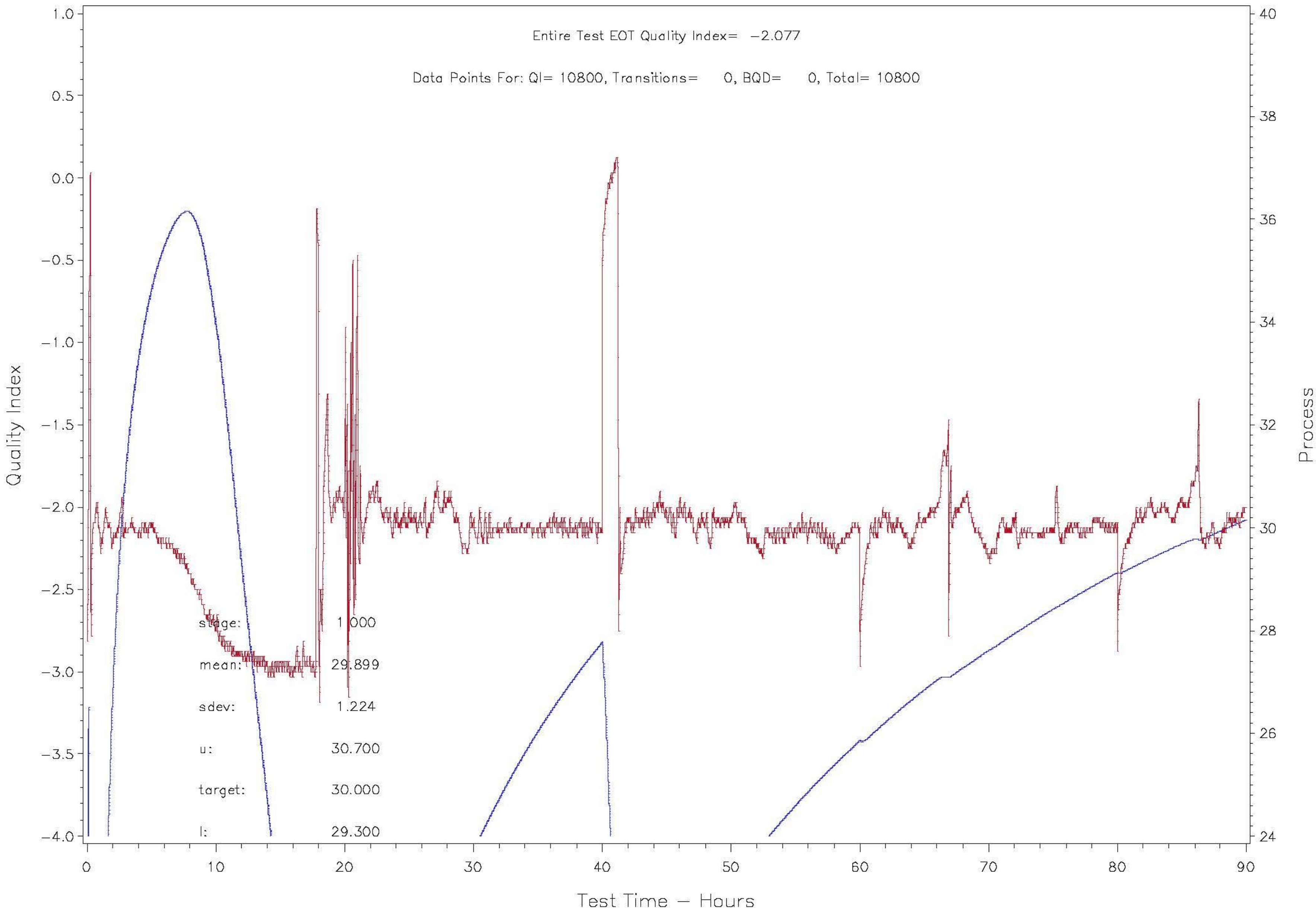
IIIH QUALITY INDEX OPERATIONAL REVIEW
Fuel Inlet Temperature – Degrees C (CONTROL)
LAB= B Stand= 341 CMIR= 106795



IIIH QUALITY INDEX OPERATIONAL REVIEW
Fuel Inlet Temperature – Degrees C (CONTROL)
LAB= G Stand= 1 CMIR= 110228

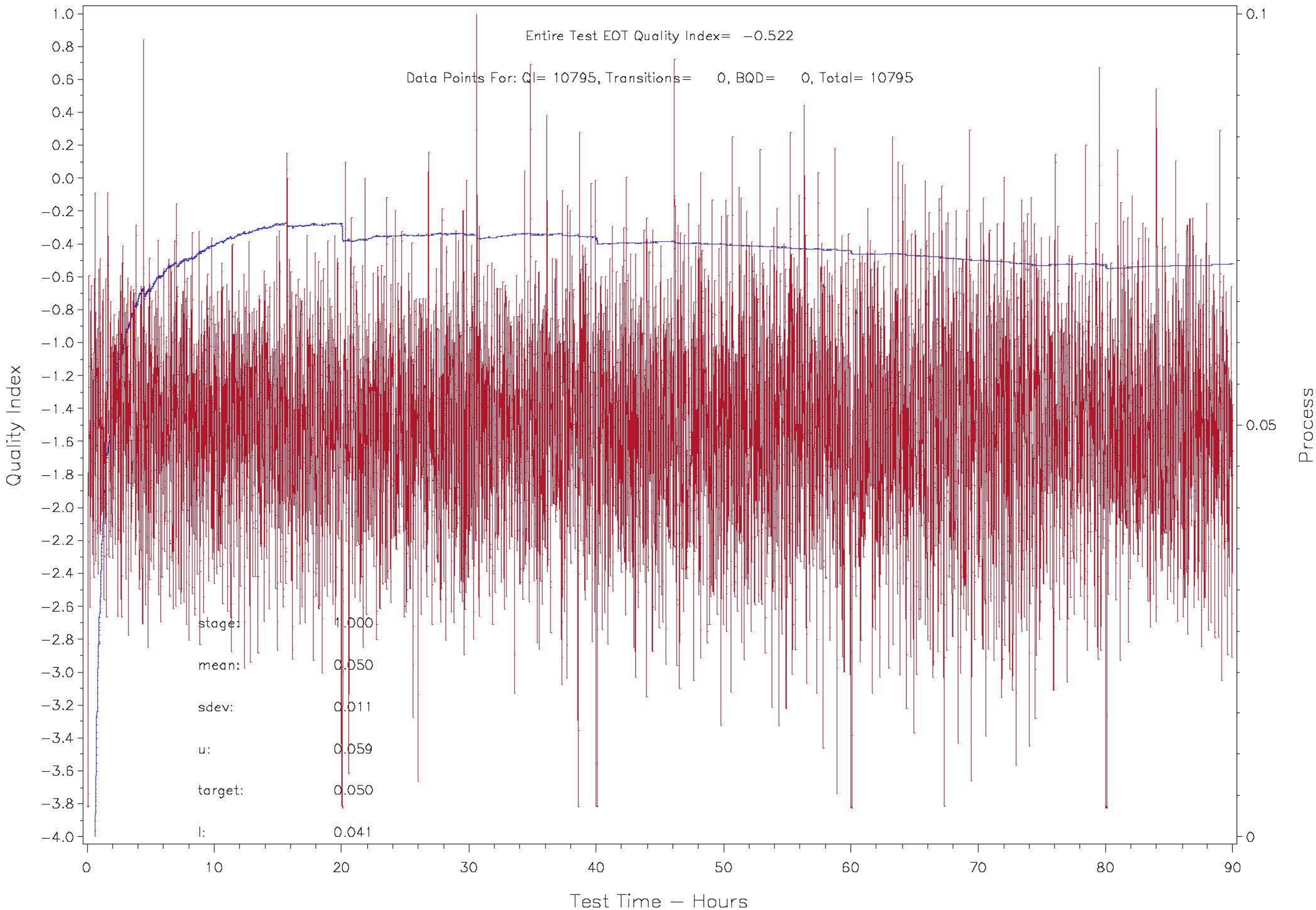


IIIH QUALITY INDEX OPERATIONAL REVIEW
Fuel Inlet Temperature – Degrees C (CONTROL)
LAB= A Stand= 2 CMIR= 106775

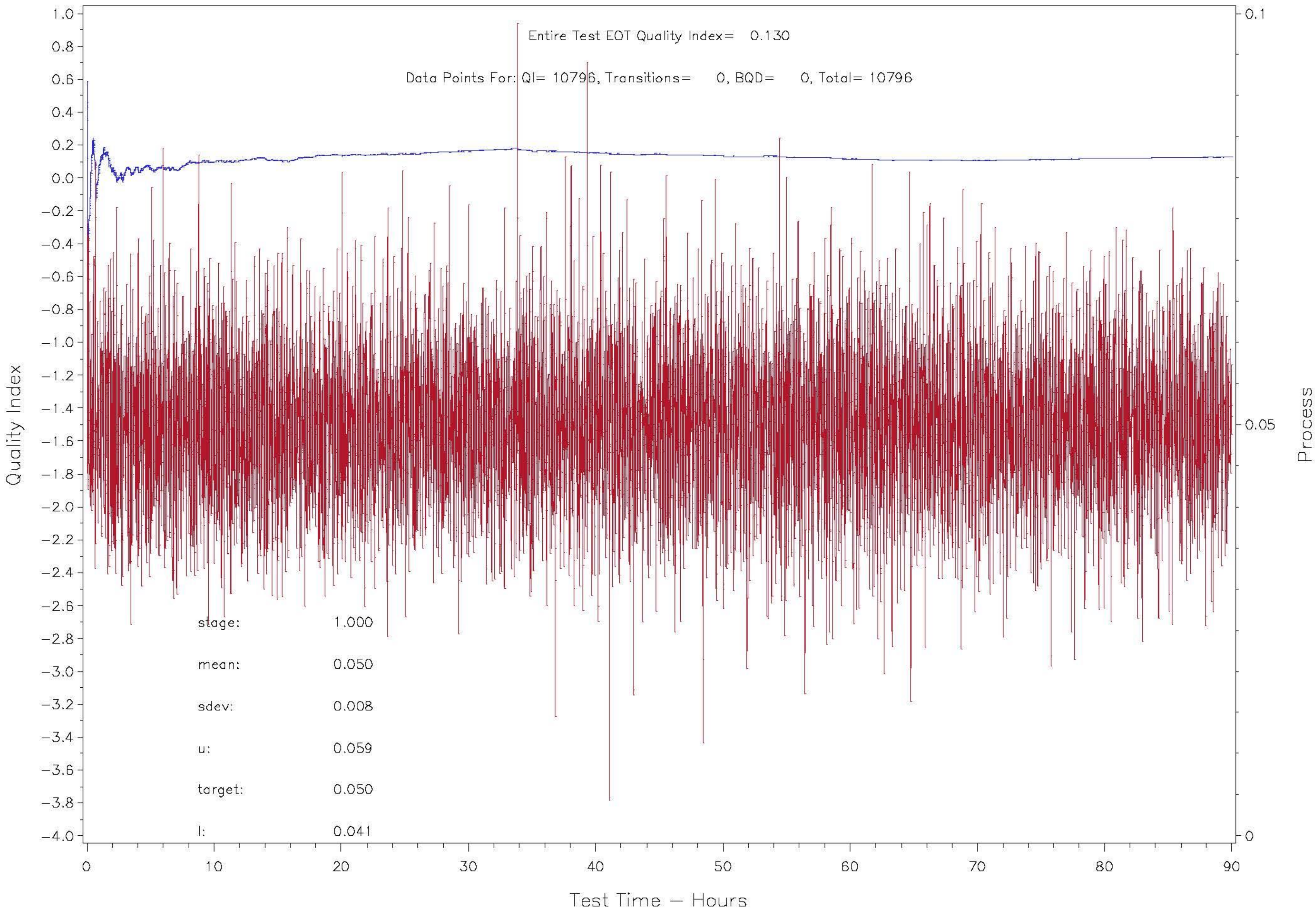


# Intake Air Pressure

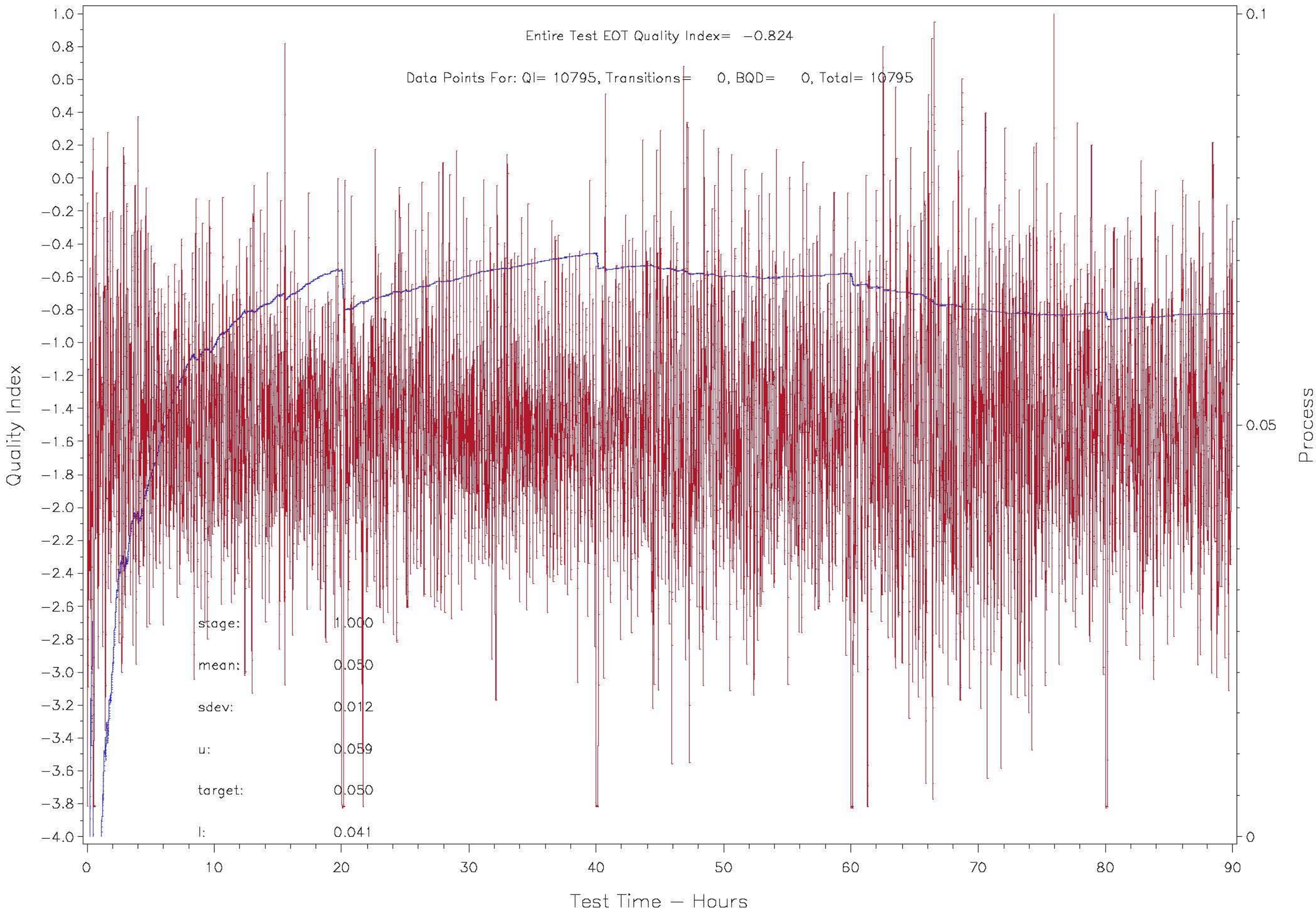
IIIH QUALITY INDEX OPERATIONAL REVIEW
Intake Air Pressure – kPa (CONTROL)
LAB= G Stand= 1 CMIR= 106768



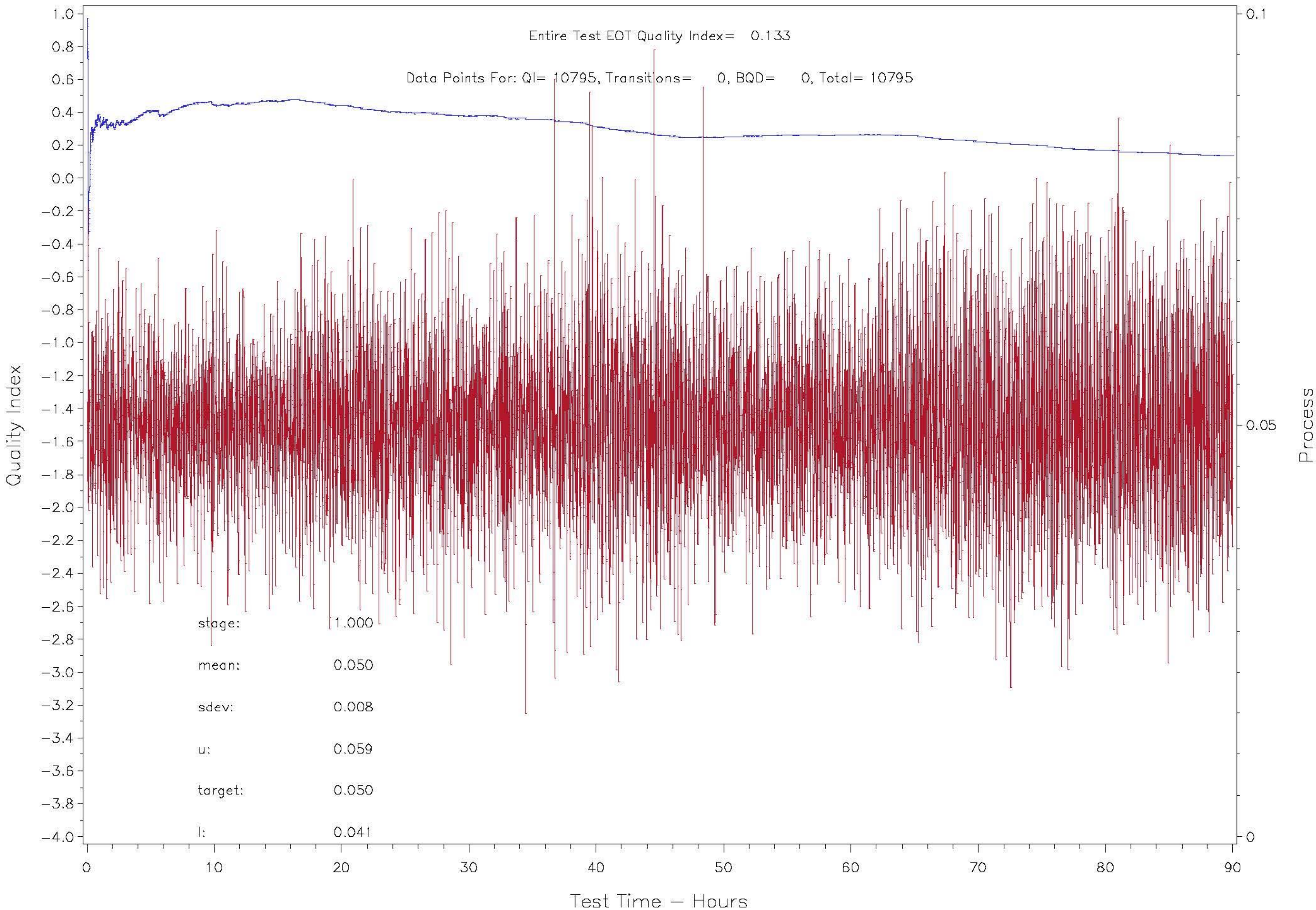
IIIH QUALITY INDEX OPERATIONAL REVIEW
Intake Air Pressure – kPa (CONTROL)
LAB= G Stand= 2 CMIR= 110227



IIIH QUALITY INDEX OPERATIONAL REVIEW
Intake Air Pressure – kPa (CONTROL)
LAB= G Stand= 1 CMIR= 110228



IIIH QUALITY INDEX OPERATIONAL REVIEW
Intake Air Pressure – kPa (CONTROL)
LAB= G Stand= 2 CMIR= 107872



# Conclusion

- Some minor anomalies were observed
  - The root causes have been identified
  - It is believed that the effect on the overall tests and the test results is negligible
- The data review group recommends that the Task Force accept these tests as operationally valid.

Attachment #3

# IIIH Reference Oils

# Objectives for Reference Oils

- ✓ Include:
  - ✓ Borderline oils to identify shifts in test severity over time
  - ✓ An oil that performs poorly on WPD to maintain test discrimination (438-1)
  - ✓ An oil that performs poorly on pVis to maintain test discrimination (434-2)
  - ✓ An oil that performs well on both WPD and pVis (436)

# Expectations of Reference Oils

- ✓ 434-2 would discriminate on pVis as a failing oil
- ✓ 436 would perform well on both pVis and WPD
- ✓ 438-1 would discriminate on WPD as a failing oil

Trade-Offs:

- Potentially high variability on pVis for 438-1
- Potentially high variability on WPD for 434-2

# Prove-Out IIIG and Data

| | IIIG WPD | IIIG kV40 Increase, % | Field Test kV100 | Field Test Hot Stuck Rings | IIIG/field Performance |
|---|---|---|---|---|---|
| GF-5 limits | 4.0 | 150 | NA | NA | |
| TMC 435 | 2.43~4.75 | 96~331 | - | - | Borderline pVis and failing WPD |
| **TMC 434*** | **2.9~6.7** | **52~244** | **-** | **-** | **Borderline pVis and WPD** |
| **TMC 438*** | **2.54~3.86** | **68~138** | **-** | **-** | **Failing WPD** |
| **REO2 (TMC 436)*** | **>4.5** | **~100** | **Stay in grade** | **None** | **Passing** |
| REO3 | >5 | <100 | Stay in grade | None | High passing |

*IIIH Reference Oils

Attachment #4

# Sequence IIIH Precision Matrix Data Analysis

Jo Martinez

Sep. 29, 2015





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# Summary

- LnPVIS
  - Precision: RMSE,s=0.58 (prove-out s=0.61)
  - Oil Discrimination: 434-2 > 436
  - Lab/Stand Difference: A1 > D1
  - Influential observation: TK106788 D1 434-2 PVIS=13.6

- WPD
  - Precision: RMSE,s=0.47 (prove-out s=0.40)
  - Oil Discrimination: 436, 434-2 > 438-1
  - No significant lab difference
  - Influential observation: TK107872 G2 438-1 WPD=4.5

# 25 out of 28 Tests Included in the Analysis

**IIIH Matrix Test Status**

| Run Order | Lab-Stand | D-1 | E-1 | B-1 | G-1 | G-2 | A-1 | A-2 |
|---|---|---|---|---|---|---|---|---|
| | 1 | 434-2 106788-IIIH | 438-1 106784-IIIH Low MAP and Fuel Flow | 438-1 106796-IIIH Oil Leak; 438-1 106797-IIIH | 436 106763-IIIH | 436 106764-IIIH | 438-1 106774-IIIH | 434-2 106778-IIIH |
| | 2 | 434-2 106789-IIIH Loss of Oil Pressure; 434-2 106789A-IIIH | 436 106782-IIIH | 436 106792-IIIH | 438-1 106767-IIIH | 434-2 107873-IIIH | 438-1 107869-IIIH | 438-1 107870-IIIH |
| | 3 | 436 106786-IIIH | 434-2 106781-IIIH | 436 106793-IIIH | 438-1 106768-IIIH | 434-2 110227-IIIH | 434-2 106779-IIIH | 436 106775-IIIH |
| | 4 | 438-1 106791-IIIH | 434-2 | 434-2 106795-IIIH | 434-2 110228-IIIH | 438-1 107872-IIIH | 436 106777-IIIH | 436 106776-IIIH |

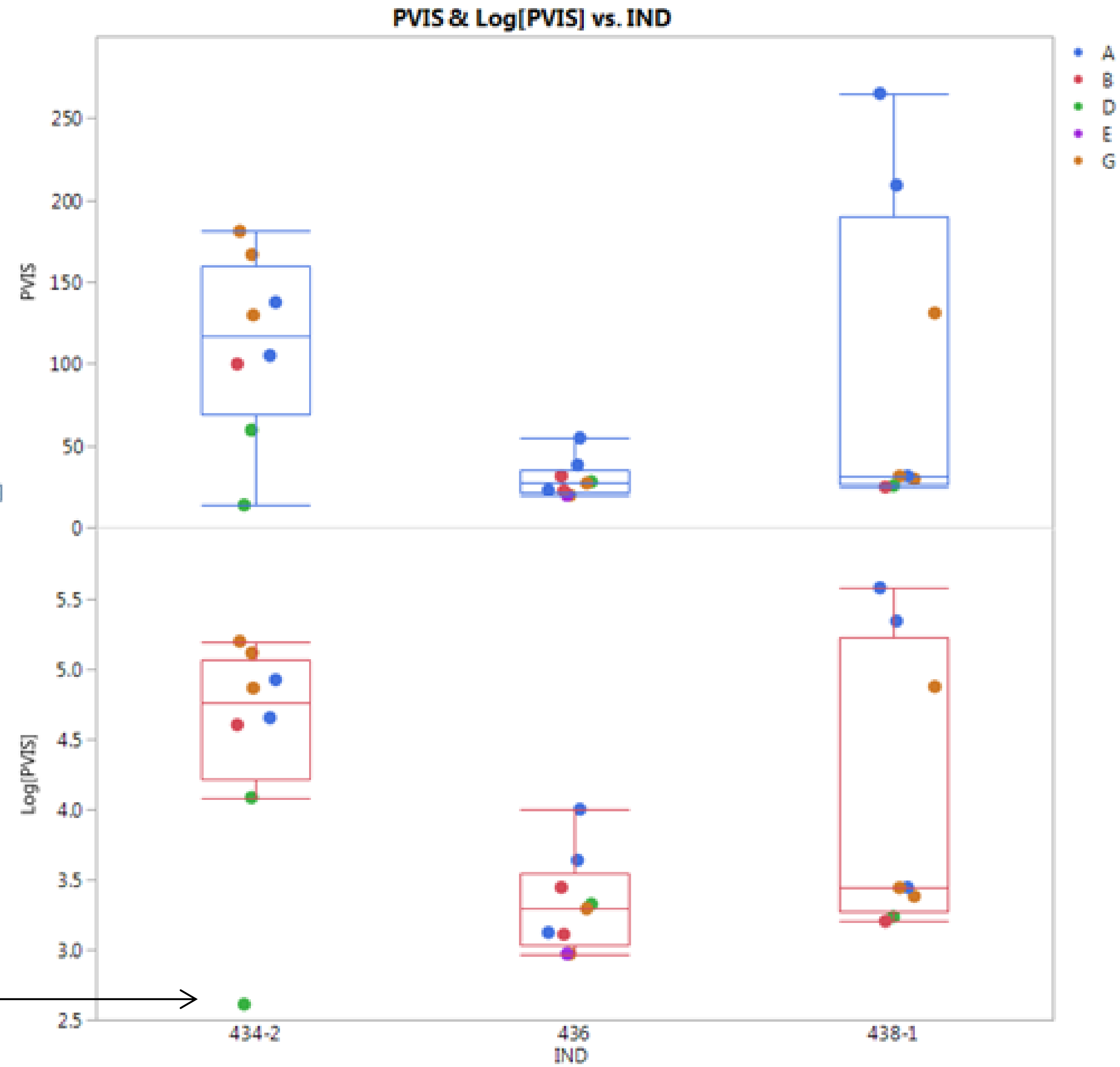
Test Reported

Invalid

# PM Data

| IND | PVIS | TESTKEY | WPD | PHOS | LTMSDATE | LTMSTIME | LTMSLAB | LTMSAPP |
|---|---|---|---|---|---|---|---|---|
| 438-1 | 265.1 | 106774-IIIH | 3.34 | 79.22 | 20150725 | 08:34 | A | 1 |
| 434-2 | 137.5 | 106778-IIIH | 3.98 | 78.47 | 20150727 | 07:45 | A | 2 |
| 436 | 26.9 | 106764-IIIH | 3.99 | 95.62 | 20150731 | 14:43 | G | 2 |
| 436 | 19.5 | 106763-IIIH | 4.45 | 94.73 | 20150731 | 16:10 | G | 1 |
| 434-2 | 13.6 | 106788-IIIH | 4.73 | 79.83 | 20150801 | 03:27 | D | 1 |
| 438-1 | 24.6 | 106797-IIIH | 3.32 | 73.6 | 20150815 | 14:45 | B | 1 |
| 438-1 | 31.2 | 106767-IIIH | 3.33 | 81.3 | 20150816 | 08:58 | G | 1 |
| 434-2 | 166.6 | 107873-IIIH | 4.10 | 79.94 | 20150816 | 11:29 | G | 2 |
| 438-1 | 209.0 | 107869-IIIH | 3.10 | . | 20150816 | 13:50 | A | 1 |
| 438-1 | 31.3 | 107870-IIIH | 3.42 | . | 20150817 | 12:30 | A | 2 |
| 436 | 19.5 | 106782-IIIH | 4.25 | . | 20150818 | 05:23 | E | 1 |
| 436 | 22.4 | 106792-IIIH | 4.77 | 93.64 | 20150825 | 16:14 | B | 1 |
| 434-2 | 59.4 | 106789A-IIIH | 5.60 | 78.85 | 20150829 | 05:05 | D | 1 |
| 438-1 | 29.4 | 106768-IIIH | 3.46 | 80.85 | 20150829 | 13:06 | G | 1 |
| 434-2 | 180.9 | 110227-IIIH | 3.35 | 81.28 | 20150829 | 17:48 | G | 2 |
| 436 | 31.3 | 106793-IIIH | 4.96 | . | 20150830 | 18:02 | B | 1 |
| 434-2 | 129.6 | 110228-IIIH | 4.28 | 81.22 | 20150904 | 14:44 | G | 1 |
| 436 | 38.0 | 106775-IIIH | 4.62 | 91.51 | 20150905 | 16:40 | A | 2 |
| 438-1 | 130.9 | 107872-IIIH | 4.50 | 79.4 | 20150905 | 19:04 | G | 2 |
| 434-2 | 99.8 | 106795-IIIH | 3.93 | 81.34 | 20150905 | 20:30 | B | 1 |
| 436 | 27.8 | 106786-IIIH | 4.72 | 95.3 | 20150906 | 09:54 | D | 1 |
| 434-2 | 104.9 | 106779-IIIH | 3.66 | 78.39 | 20150912 | 15:15 | A | 1 |
| 438-1 | 25.4 | 106791-IIIH | 3.59 | 79.22 | 20150915 | 05:06 | D | 1 |
| 436 | 54.6 | 106777-IIIH | 4.3 | | | | A | 1 |
| 436 | 22.7 | 106776-IIIH | 4.92 | | | | A | 2 |

# PVIS Data




Influential Observation



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# LnPVIS ANOVA Results

**Summary of Fit**

| | |
|---|---|
| RSquare | 0.716471 |
| RSquare Adj | 0.574707 |
| Root Mean Square Error | 0.584535 |
| Mean of Response | 3.936889 |
| Observations (or Sum Wgts) | 25 |

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 8 | 13.814745 | 1.72684 | 5.0540 |
| Error | 16 | 5.466896 | 0.34168 | Prob > F |
| C. Total | 24 | 19.281641 | | 0.0029* |

**Lack Of Fit**

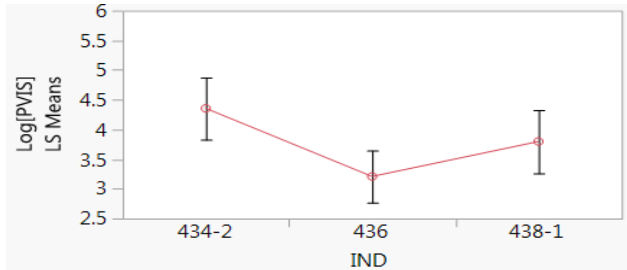
**Parameter Estimates**

**Effect Tests**

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| IND | 2 | 2 | 4.9202105 | 7.2000 | 0.0059* |
| LTMSLAB | 4 | 4 | 4.4657561 | 3.2675 | 0.0387* |
| LTMSAPP[LTMSLAB] | 2 | 2 | 3.1433534 | 4.5998 | 0.0264* |

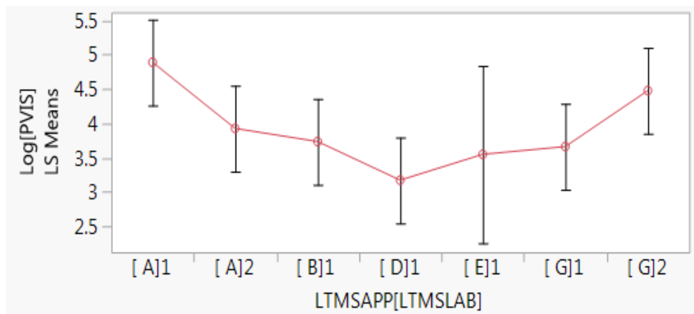
Conclusions:

- 434-2 > 436
- A1 > D1
- RMSE, s = 0.58 (Prove-out s=0.61)




| Level | | Least Sq Mean |
|---|---|---|
| 434-2 | A | 4.3539549 |
| 438-1 | A B | 3.7970038 |
| 436 | B | 3.2086482 |

| Level | - Level | Difference | Std Err Dif | Lower CL | Upper CL | p-Value |
|---|---|---|---|---|---|---|
| 434-2 | 436 | 1.145307 | 0.3018525 | 0.366427 | 1.924186 | 0.0043* |
| 438-1 | 436 | 0.588356 | 0.3018525 | -0.190524 | 1.367235 | 0.1574 |
| 434-2 | 438-1 | 0.556951 | 0.3018525 | -0.221928 | 1.335830 | 0.1870 |




| Level | | Least Sq Mean |
|---|---|---|
| [ A]1 | A | 4.8912537 |
| [ G]2 | A B | 4.4781702 |
| [ A]2 | A B | 3.9262701 |
| [ B]1 | A B | 3.7341203 |
| [ G]1 | A B | 3.6614530 |
| [ E]1 | A B | 3.5483019 |
| [ D]1 | B | 3.1716825 |

Levels not connected by same letter are significantly different.

# LnPVIS ANOVA Results - without TK106788

## Summary of Fit

| | |
|---|---|
| RSquare | 0.791041 |
| RSquare Adj | 0.679597 |
| Root Mean Square Error | 0.49301 |
| Mean of Response | 3.992173 |
| Observations (or Sum Wgts) | 24 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 8 | 13.801964 | 1.72525 | 7.0981 |
| Error | 15 | 3.645877 | 0.24306 | Prob > F |
| C. Total | 23 | 17.447841 | | 0.0006* |

## Lack Of Fit

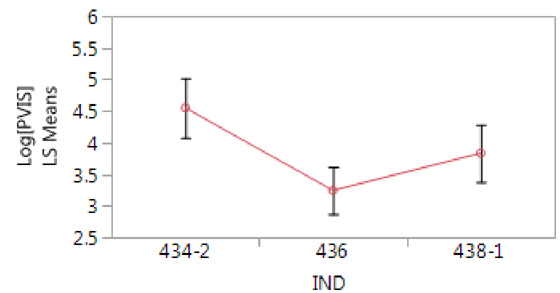
## Parameter Estimates

## Effect Tests

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| IND | 2 | 2 | 6.0814073 | 12.5102 | 0.0006* |
| LTMSLAB | 4 | 4 | 2.3964033 | 2.4648 | 0.0899 |
| LTMSAPP[LTMSLAB] | 2 | 2 | 3.0144634 | 6.2011 | 0.0109* |

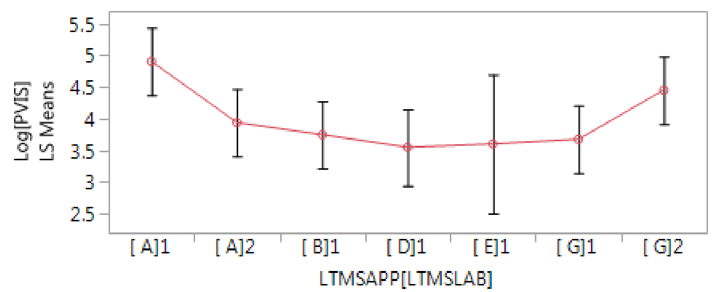
Conclusions:

- 434-2 > 436, 438-1
- A1 > D1, G1
- RMSE, s = 0.49 (Prove-out s=0.61)




| Level | | Least Sq Mean |
|---|---|---|
| 434-2 | A | 4.5515355 |
| 438-1 | B | 3.8332941 |
| 436 | B | 3.2449385 |

| Level | - Level | Difference | Std Err Dif | Lower CL | Upper CL | p-Value |
|---|---|---|---|---|---|---|
| 434-2 | 436 | 1.306597 | 0.2613194 | 0.627827 | 1.985366 | 0.0004* |
| 434-2 | 438-1 | 0.718241 | 0.2613194 | 0.039472 | 1.397011 | 0.0375* |
| 438-1 | 436 | 0.588356 | 0.2545891 | -0.072932 | 1.249643 | 0.0850 |




| Level | | | Least Sq Mean |
|---|---|---|---|
| [ A]1 | A | | 4.9046945 |
| [ G]2 | A | B | 4.4512885 |
| [ A]2 | A | B | 3.9397110 |
| [ B]1 | A | B | 3.7475611 |
| [ G]1 | | B | 3.6748938 |
| [ E]1 | A | B | 3.6020653 |
| [ D]1 | | B | 3.5480265 |

Levels not connected by same letter are significantly different.





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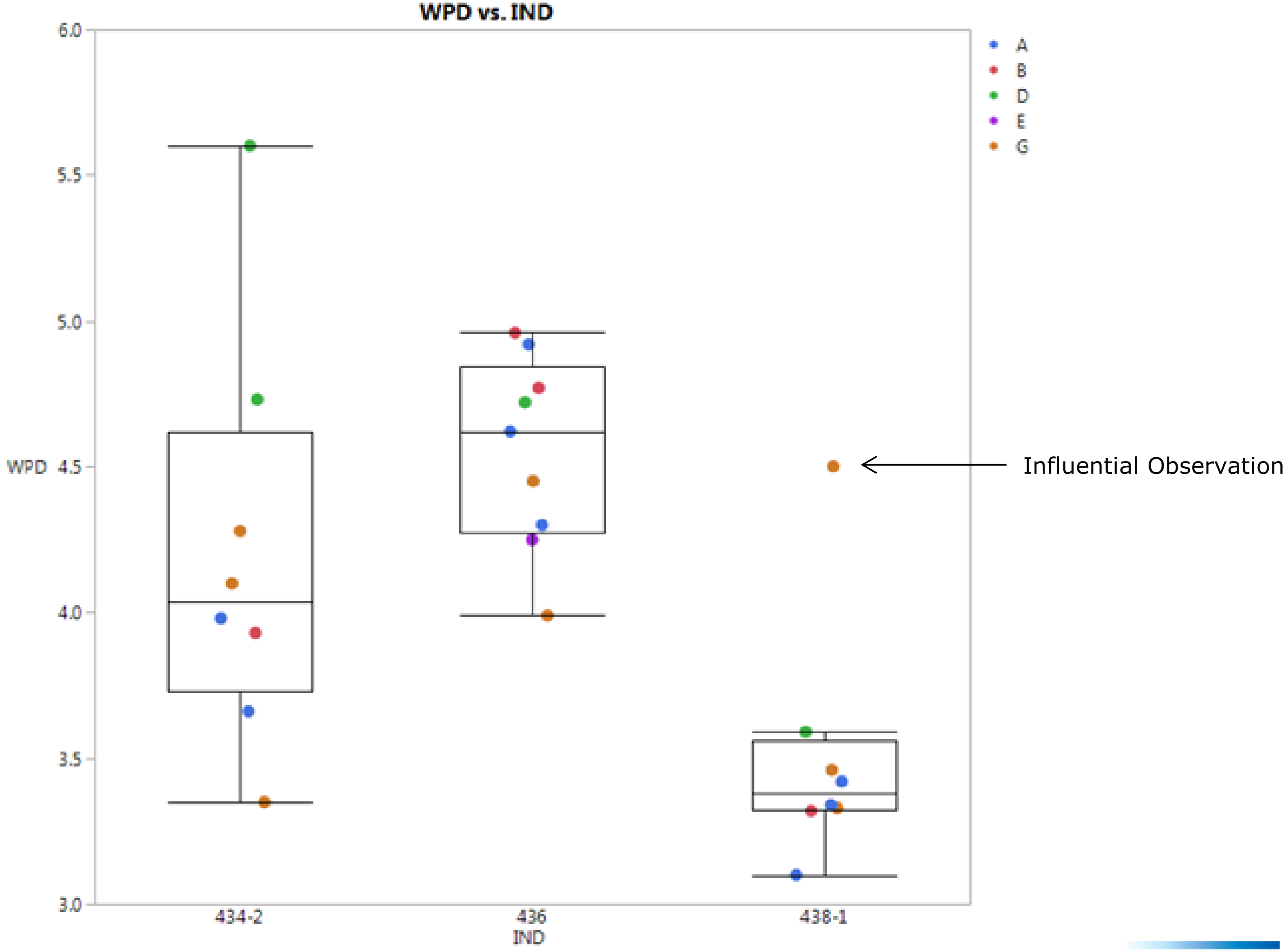
# WPD Data



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# WPD ANOVA Results

### Summary of Fit

| | |
|---|---|
| RSquare | 0.618544 |
| RSquare Adj | 0.491392 |
| Root Mean Square Error | 0.466324 |
| Mean of Response | 4.1068 |
| Observations (or Sum Wgts) | 25 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 6 | 6.347095 | 1.05785 | 4.8646 |
| Error | 18 | 3.914249 | 0.21746 | Prob > F |
| C. Total | 24 | 10.261344 | | 0.0041* |

### Lack Of Fit

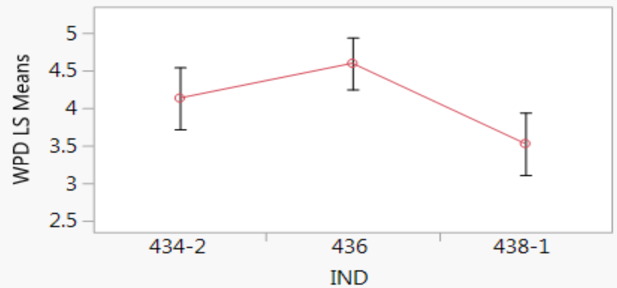
### Parameter Estimates

### Effect Tests

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| IND | 2 | 2 | 4.4963511 | 10.3384 | 0.0010* |
| LTMSLAB | 4 | 4 | 1.6040886 | 1.8441 | 0.1644 |

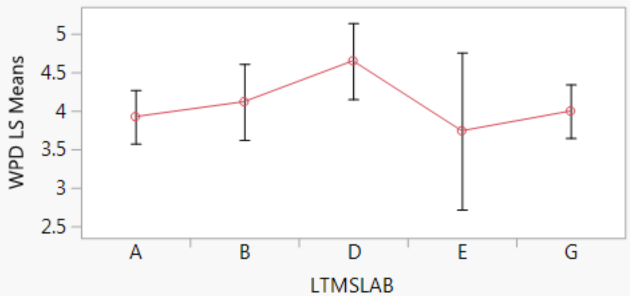
Conclusions:

- 436, 434-2 > 438-1
- No significant lab differences
- RMSE, s=0.47 (Prove-out, s = 0.40)




| Level | | Least Sq Mean |
|---|---|---|
| 436 | A | 4.5954660 |
| 434-2 | A | 4.1325152 |
| 438-1 | B | 3.5268478 |

| Level | - Level | Difference | Std Err Dif | Lower CL | Upper CL | p-Value |
|---|---|---|---|---|---|---|
| 436 | 438-1 | 1.068618 | 0.2359665 | 0.466393 | 1.670843 | 0.0007* |
| 434-2 | 438-1 | 0.605667 | 0.2359665 | 0.003442 | 1.207892 | 0.0486* |
| 436 | 434-2 | 0.462951 | 0.2388268 | -0.146574 | 1.072476 | 0.1568 |




| Level | | Least Sq Mean |
|---|---|---|
| D | A | 4.6481069 |
| B | A | 4.1173692 |
| G | A | 3.9963154 |
| A | A | 3.9234465 |
| E | A | 3.7394770 |

Levels not connected by same letter are significantly different.





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# WPD ANOVA Results – without TK107872

Chevron Oronite

## Summary of Fit

| | |
|---|---|
| RSquare | 0.817564 |
| RSquare Adj | 0.720265 |
| Root Mean Square Error | 0.35049 |
| Mean of Response | 4.090417 |
| Observations (or Sum Wgts) | 24 |

## Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 8 | 8.257643 | 1.03221 | 8.4026 |
| Error | 15 | 1.842653 | 0.12284 | Prob > F |
| C. Total | 23 | 10.100296 | | 0.0002* |

## Lack Of Fit

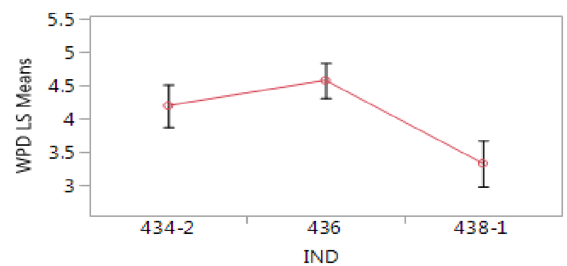
## Parameter Estimates

## Effect Tests

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| IND | 2 | 2 | 5.3858135 | 21.9214 | <.0001* |
| LTMSLAB | 4 | 4 | 1.9550917 | 3.9788 | 0.0214* |
| LTMSAPP[LTMSLAB] | 2 | 2 | 0.6616185 | 2.6929 | 0.1002 |

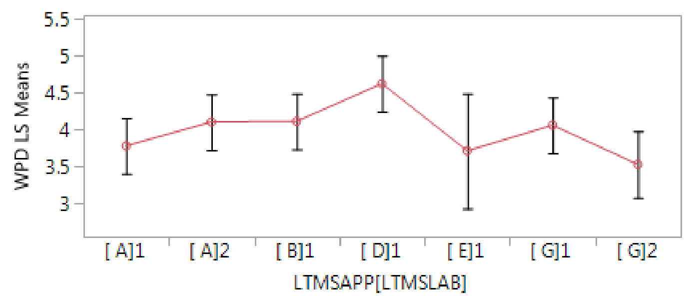
Conclusions:

- 436, 434-2 > 438-1
- D1 > G2
- RMSE, s=0.35 (Prove-out, s = 0.40)




| Level | | Least Sq Mean |
|---|---|---|
| 436 | A | 4.5749829 |
| 434-2 | A | 4.1956671 |
| 438-1 | B | 3.3282461 |

| Level | - Level | Difference | Std Err Dif | Lower CL | Upper CL | p-Value |
|---|---|---|---|---|---|---|
| 436 | 438-1 | 1.246737 | 0.1902801 | 0.752490 | 1.740984 | <.0001* |
| 434-2 | 438-1 | 0.867421 | 0.1953104 | 0.360108 | 1.374734 | 0.0013* |
| 436 | 434-2 | 0.379316 | 0.1815869 | -0.092351 | 0.850982 | 0.1258 |




| Level | | | Least Sq Mean |
|---|---|---|---|
| [ D]1 | A | | 4.6193246 |
| [ B]1 | A | B | 4.1094956 |
| [ A]2 | A | B | 4.0994956 |
| [ G]1 | A | B | 4.0561798 |
| [ A]1 | A | B | 3.7761798 |
| [ E]1 | A | B | 3.7079825 |
| [ G]2 | | B | 3.5241930 |

Levels not connected by same letter are significantly different.

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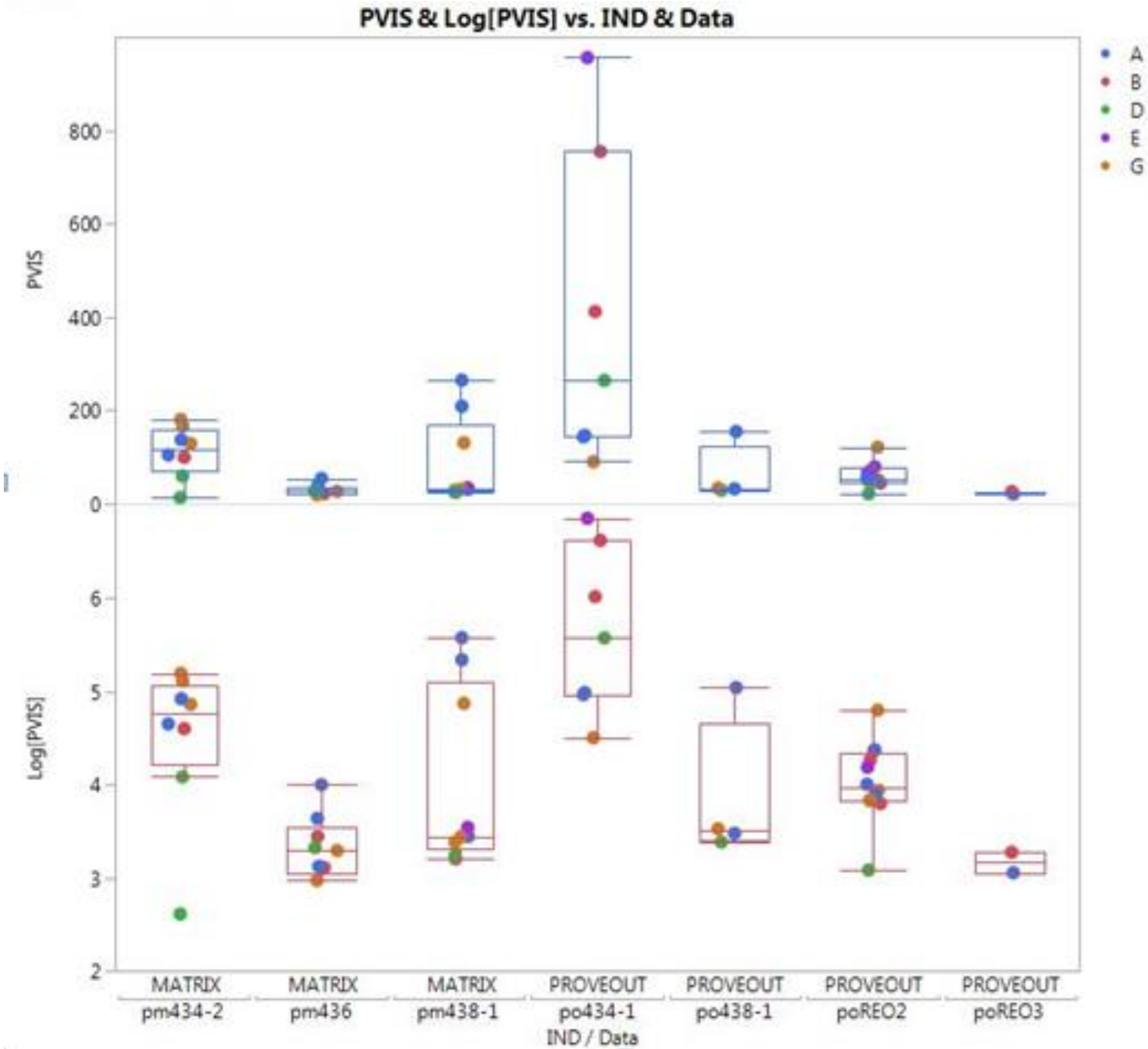
# PVIS Prove-out and PM Data





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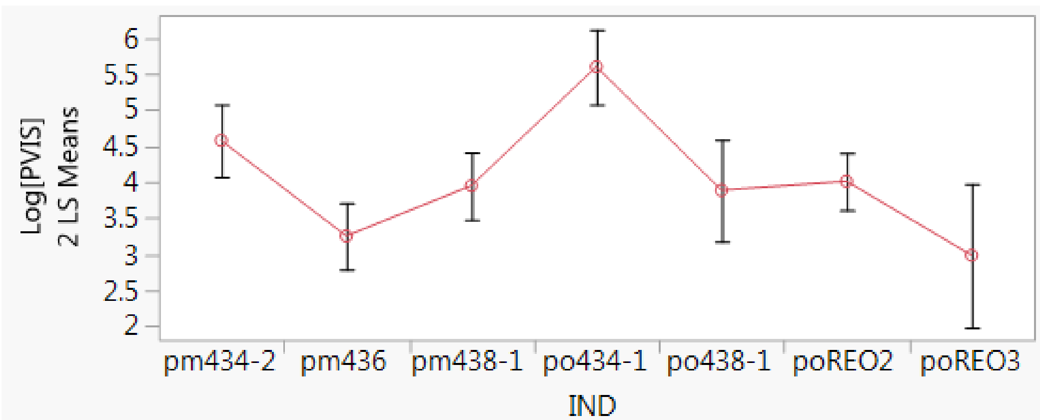
# PVIS Severity

Prove-out (po): REO2, REO3, 438-1 < 434-1
Precision Matrix (pm): 436 < 434-2

No significant REO2/436 nor 438-1 severity shift between prove-out and PM but marginal severity shift between 434-1 and 434-2

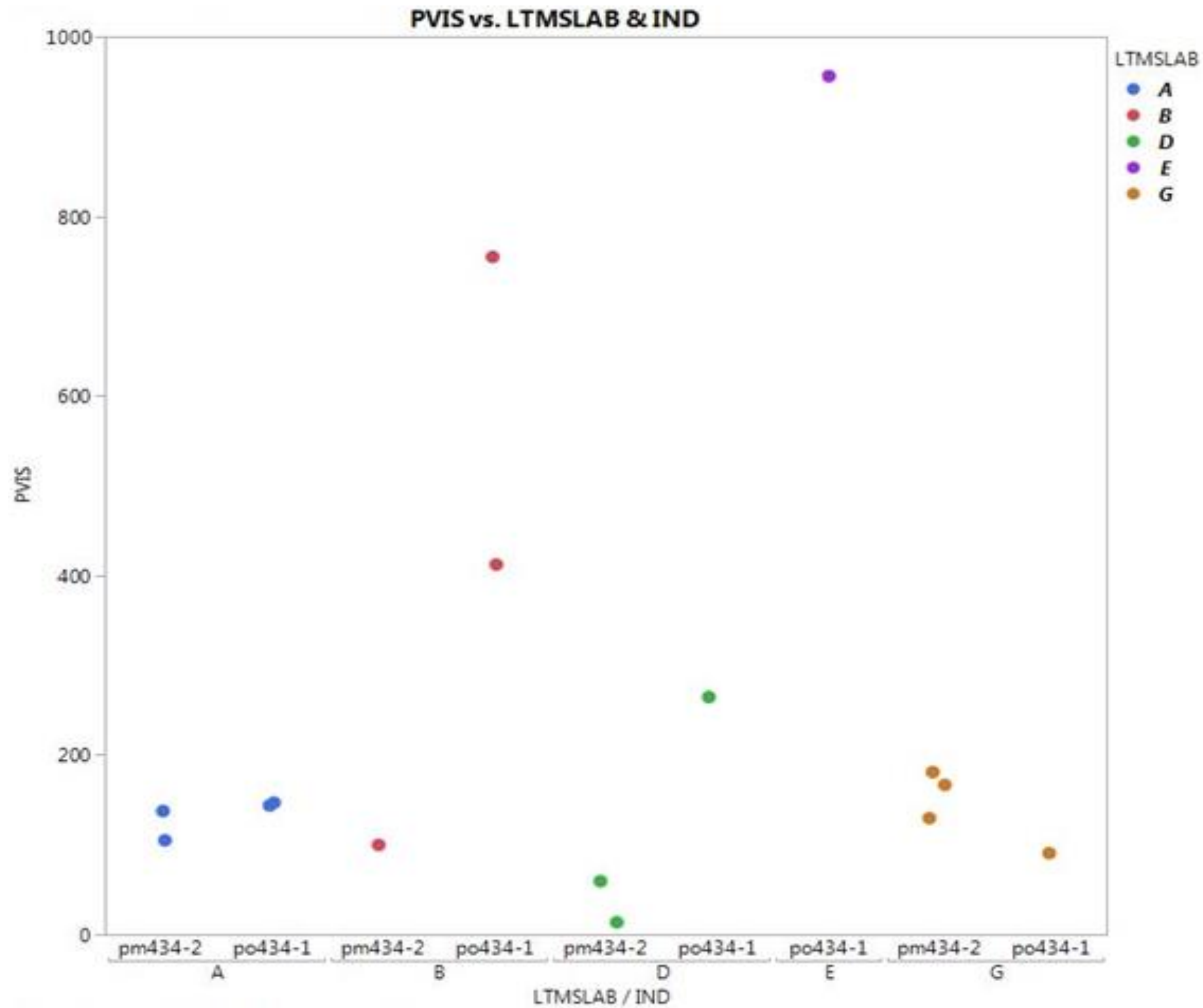



| Level | | Least Sq Mean |
|---|---|---|
| po434-1 | A | 5.5988583 |
| pm434-2 | A B | 4.5761904 |
| poREO2 | B C | 4.0103060 |
| pm438-1 | B C | 3.9498256 |
| po438-1 | B C | 3.8860871 |
| pm436 | C | 3.2518872 |
| poREO3 | B C | 2.9848301 |

Levels not connected by same letter are significantly different.

| Level | - Level | Difference | Std Err Dif | Lower CL | Upper CL | p-Value |
|---|---|---|---|---|---|---|
| po434-1 | poREO3 | 2.614028 | 0.5471598 | 0.91613 | 4.311930 | 0.0004* |
| po434-1 | pm436 | 2.346971 | 0.3403868 | 1.29071 | 3.403232 | <.0001* |
| po434-1 | po438-1 | 1.712771 | 0.4327015 | 0.37005 | 3.055495 | 0.0052* |
| po434-1 | pm438-1 | 1.649033 | 0.3441448 | 0.58111 | 2.716955 | 0.0004* |
| pm434-2 | poREO3 | 1.591360 | 0.5499462 | -0.11519 | 3.297909 | 0.0816 |
| po434-1 | poREO2 | 1.588552 | 0.3223861 | 0.58815 | 2.588955 | 0.0003* |
| pm434-2 | pm436 | 1.324303 | 0.3333462 | 0.28989 | 2.358716 | 0.0050* |
| poREO2 | poREO3 | 1.025476 | 0.5284110 | -0.61425 | 2.665198 | 0.4668 |
| po434-1 | pm434-2 | 1.022668 | 0.3574431 | -0.08652 | 2.131856 | 0.0878 |
| pm438-1 | poREO3 | 0.964995 | 0.5407983 | -0.71317 | 2.643157 | 0.5658 |
| po438-1 | poREO3 | 0.901257 | 0.6002278 | -0.96132 | 2.763835 | 0.7422 |
| poREO2 | pm436 | 0.758419 | 0.2984470 | -0.16770 | 1.684535 | 0.1723 |
| pm438-1 | pm436 | 0.697938 | 0.3192720 | -0.29280 | 1.688677 | 0.3255 |
| pm434-2 | po438-1 | 0.690103 | 0.4162461 | -0.60156 | 1.981764 | 0.6468 |
| po438-1 | pm436 | 0.634200 | 0.4120133 | -0.64433 | 1.912726 | 0.7200 |
| pm434-2 | pm438-1 | 0.626365 | 0.3311919 | -0.40136 | 1.654093 | 0.4976 |
| pm434-2 | poREO2 | 0.565884 | 0.3135160 | -0.40699 | 1.538762 | 0.5526 |
| pm436 | poREO3 | 0.267057 | 0.5348261 | -1.39257 | 1.926686 | 0.9987 |
| poREO2 | po438-1 | 0.124219 | 0.3970883 | -1.10799 | 1.356431 | 0.9999 |
| pm438-1 | po438-1 | 0.063738 | 0.4097027 | -1.20762 | 1.335095 | 1.0000 |
| poREO2 | pm438-1 | 0.060480 | 0.2988093 | -0.86676 | 0.987721 | 1.0000 |

# PVIS 434-1 and 434-2 Data




Severity shift only seen in labs B and D?



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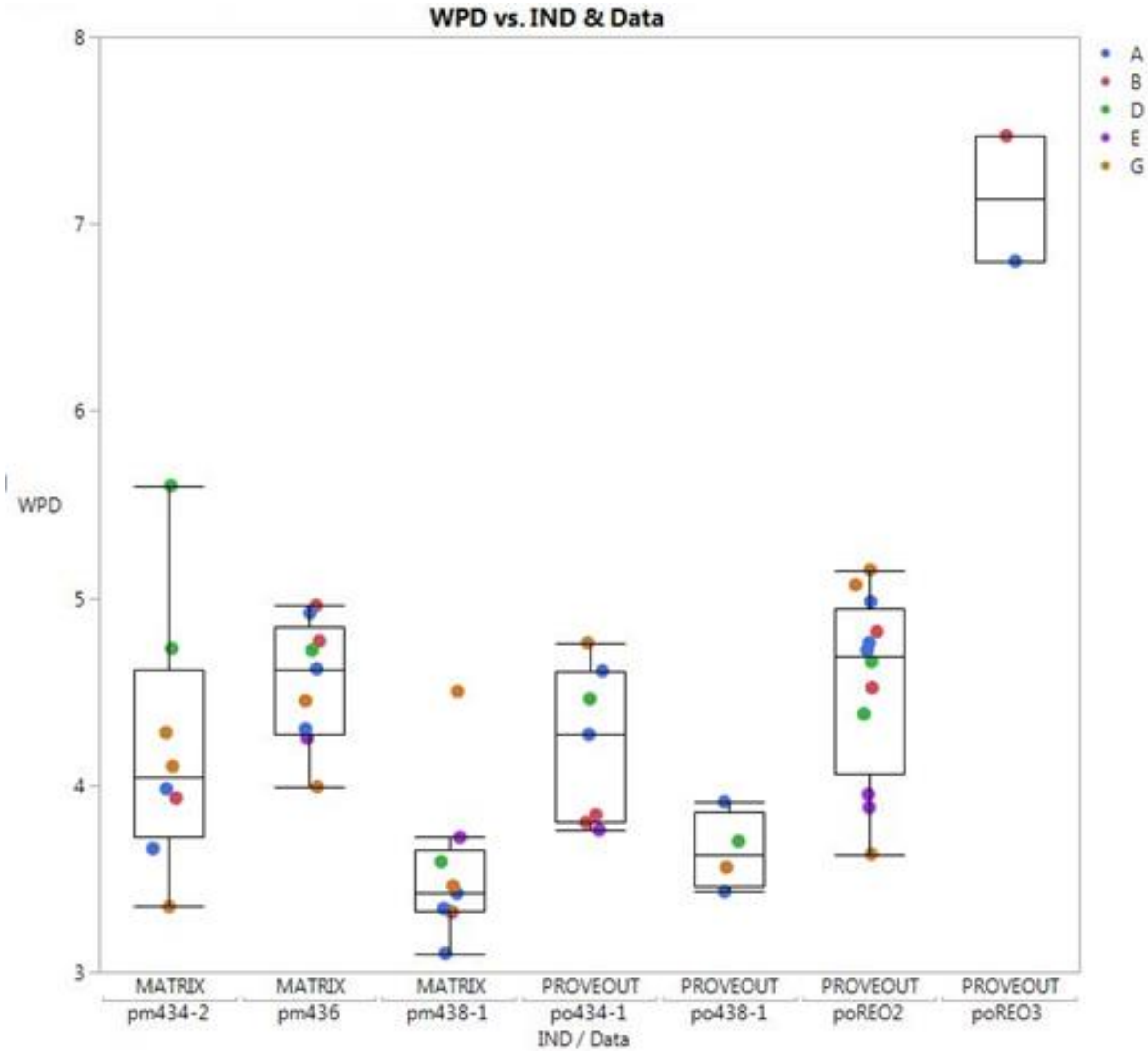
# WPD Prove-Out and PM Data



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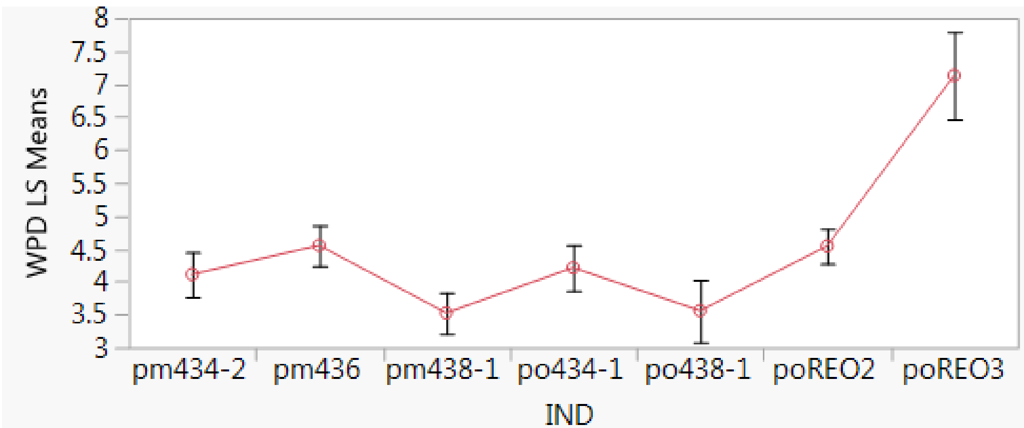
# WPD Severity

Prove-out (po): REO2, 434-1, 438-1 < REO3; 438-1 < REO2
Precision Matrix (pm): 438-1 < 436, 434-2

No significant oil severity shift between prove-out and PM

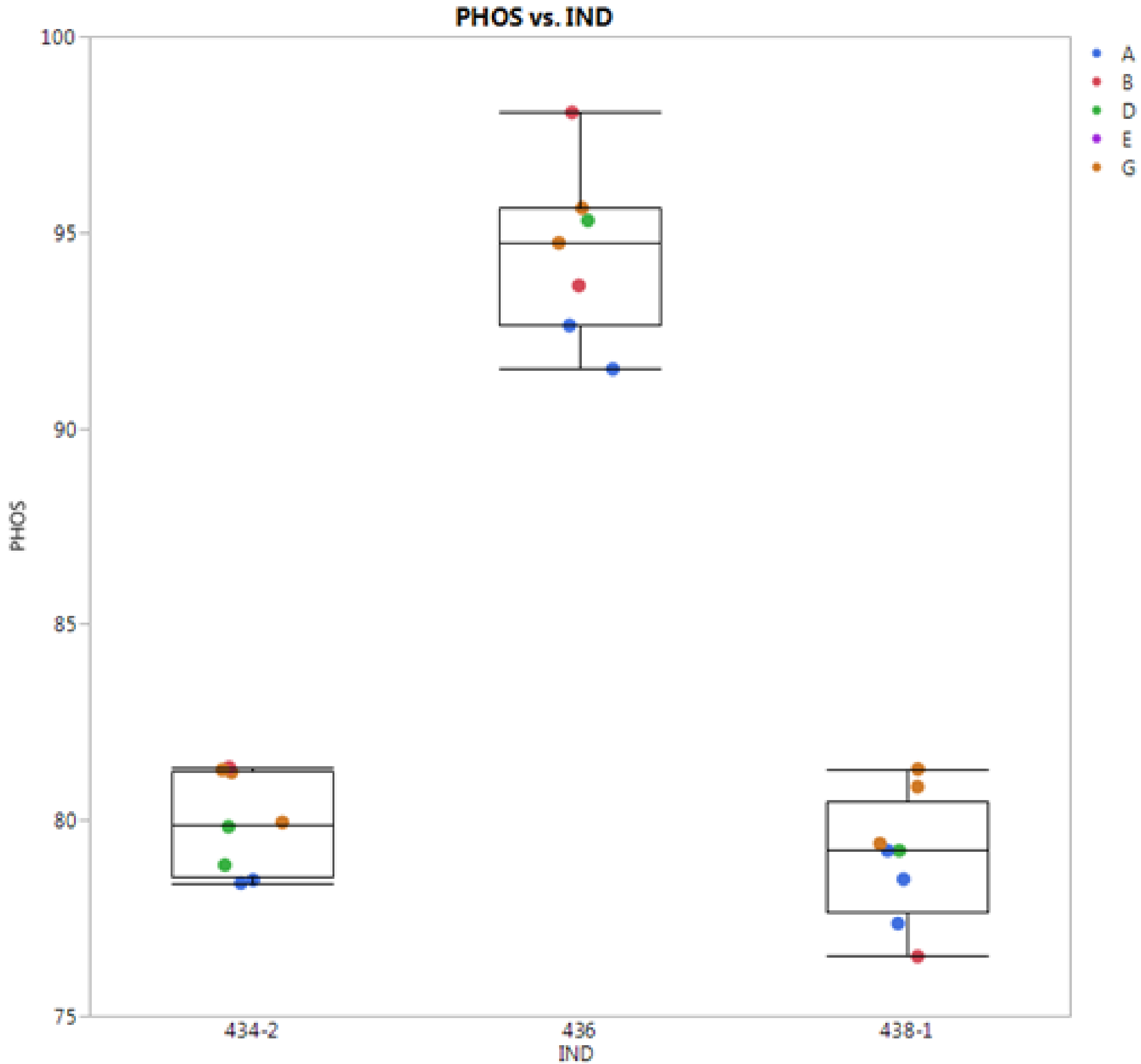



| Level | | Least Sq Mean |
|---|---|---|
| poREO3 | A | 7.1299306 |
| pm436 | B | 4.5498729 |
| poREO2 | B | 4.5415829 |
| po434-1 | B C | 4.2128373 |
| pm434-2 | B C | 4.1117757 |
| po438-1 | C | 3.5598085 |
| pm438-1 | C | 3.5264432 |

Levels not connected by same letter are significantly different.

| Level | - Level | Difference | Std Err Dif | Lower CL | Upper CL | p-Value |
|---|---|---|---|---|---|---|
| poREO3 | pm438-1 | 3.603487 | 0.3622891 | 2.47926 | 4.727713 | <.0001* |
| poREO3 | po438-1 | 3.570122 | 0.4021017 | 2.32235 | 4.817892 | <.0001* |
| poREO3 | pm434-2 | 3.018155 | 0.3684174 | 1.87491 | 4.161398 | <.0001* |
| poREO3 | po434-1 | 2.917093 | 0.3665507 | 1.77964 | 4.054544 | <.0001* |
| poREO3 | poREO2 | 2.588348 | 0.3539906 | 1.48987 | 3.686823 | <.0001* |
| poREO3 | pm436 | 2.580058 | 0.3582882 | 1.46825 | 3.691868 | <.0001* |
| pm436 | pm438-1 | 1.023430 | 0.2138852 | 0.35972 | 1.687141 | 0.0004* |
| poREO2 | pm438-1 | 1.015140 | 0.2001769 | 0.39397 | 1.636312 | 0.0002* |
| pm436 | po438-1 | 0.990064 | 0.2760140 | 0.13356 | 1.846569 | 0.0145* |
| poREO2 | po438-1 | 0.981774 | 0.2660155 | 0.15630 | 1.807252 | 0.0109* |
| po434-1 | pm438-1 | 0.686394 | 0.2305479 | -0.02902 | 1.401811 | 0.0674 |
| po434-1 | po438-1 | 0.653029 | 0.2898734 | -0.24648 | 1.552540 | 0.2917 |
| pm434-2 | pm438-1 | 0.585332 | 0.2218705 | -0.10316 | 1.273823 | 0.1418 |
| pm434-2 | po438-1 | 0.551967 | 0.2788496 | -0.31334 | 1.417271 | 0.4430 |
| pm436 | pm434-2 | 0.438097 | 0.2233137 | -0.25487 | 1.131066 | 0.4537 |
| poREO2 | pm434-2 | 0.429807 | 0.2100292 | -0.22194 | 1.081553 | 0.4030 |
| pm436 | po434-1 | 0.337036 | 0.2280303 | -0.37057 | 1.044641 | 0.7558 |
| poREO2 | po434-1 | 0.328746 | 0.2159714 | -0.34144 | 0.998930 | 0.7301 |
| po434-1 | pm434-2 | 0.101062 | 0.2394566 | -0.64200 | 0.844124 | 0.9995 |
| po438-1 | pm438-1 | 0.033365 | 0.2744661 | -0.81834 | 0.885066 | 1.0000 |
| pm436 | poREO2 | 0.008290 | 0.1999342 | -0.61213 | 0.628710 | 1.0000 |

# Phos Data



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# PHOS ANOVA Results

### Summary of Fit

| | |
|---|---|
| RSquare | 0.971241 |
| RSquare Adj | 0.962782 |
| Root Mean Square Error | 1.399788 |
| Mean of Response | 84.05043 |
| Observations (or Sum Wgts) | 23 |

### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 5 | 1124.9164 | 224.983 | 114.8221 |
| Error | 17 | 33.3099 | 1.959 | Prob > F |
| C. Total | 22 | 1158.2263 | | <.0001* |

### Lack Of Fit

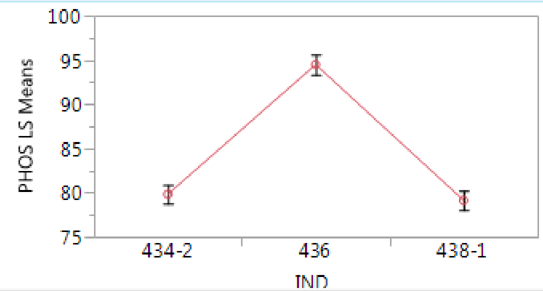
### Parameter Estimates

### Effect Tests

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| IND | 2 | 2 | 1055.9958 | 269.4682 | <.0001* |
| LTMSLAB | 3 | 3 | 23.7308 | 4.0371 | 0.0245* |

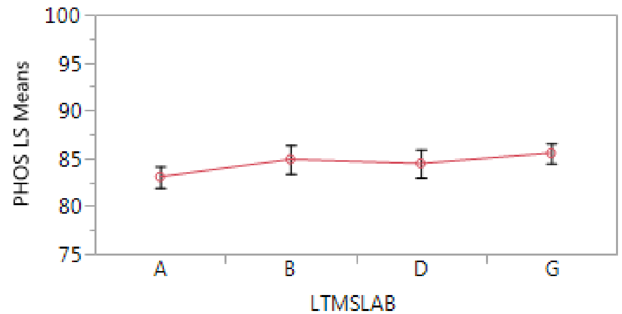
Conclusions:

- 436 > 438-1, 434-2
- Lab G > Lab A
- RMSE, s=1.40 (IIIGB LTMS, s = 2.33)




| Level | | Least Sq Mean |
|---|---|---|
| 436 | A | 94.493612 |
| 434-2 | B | 79.833201 |
| 438-1 | B | 79.138865 |

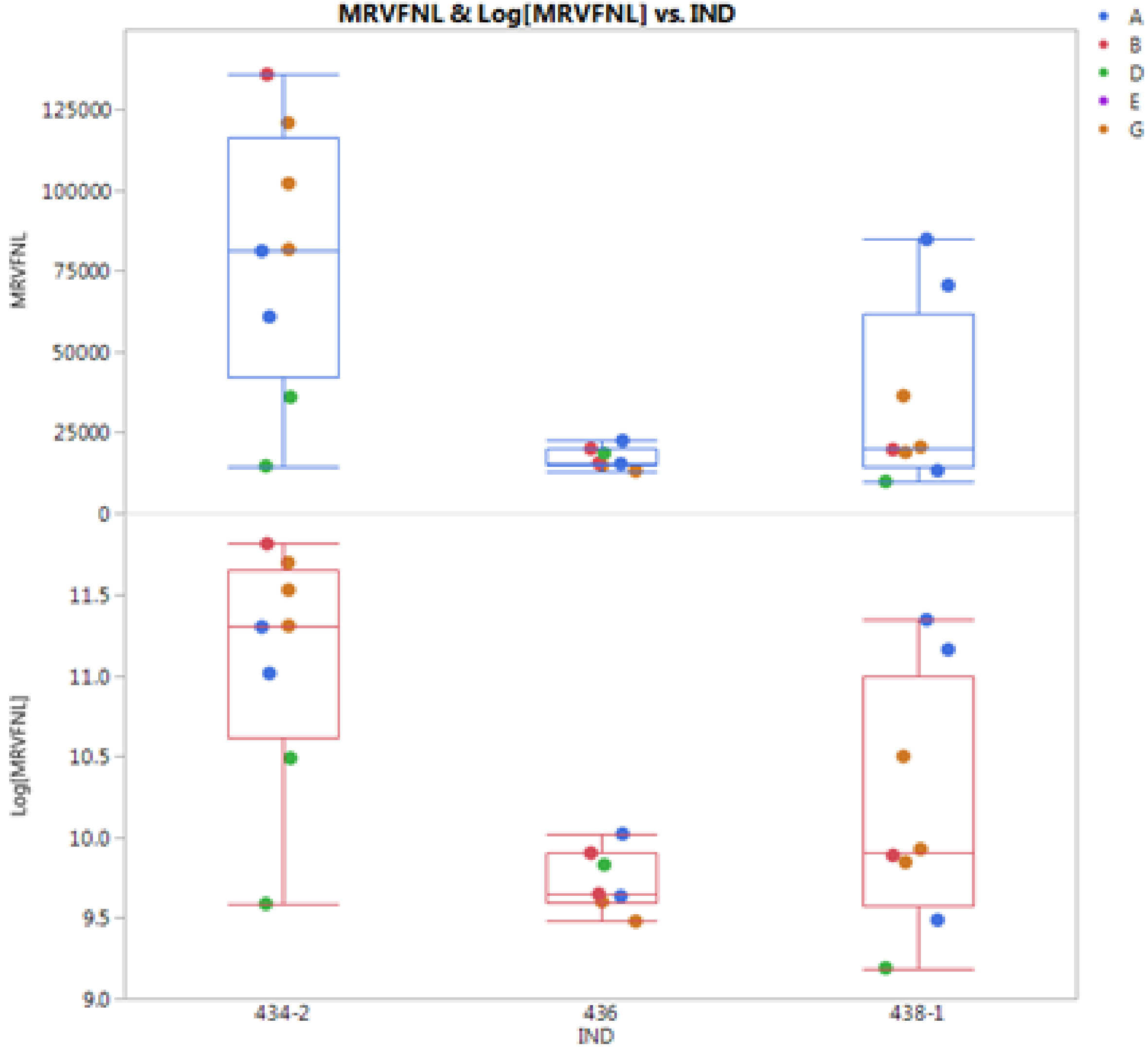
| Level | - Level | Difference | Std Err Dif | Lower CL | Upper CL | p-Value |
|---|---|---|---|---|---|---|
| 436 | 438-1 | 15.35475 | 0.7365072 | 13.4653 | 17.24415 | <.0001* |
| 436 | 434-2 | 14.66041 | 0.7391051 | 12.7643 | 16.55648 | <.0001* |
| 434-2 | 438-1 | 0.69434 | 0.7086543 | -1.1236 | 2.51229 | 0.5991 |




| Level | | | Least Sq Mean |
|---|---|---|---|
| G | A | | 85.543132 |
| B | A | B | 84.888737 |
| D | A | B | 84.463840 |
| A | | B | 83.058528 |

Levels not connected by same letter are significantly different.

# MRV Data



MRVFNL & Log[MRVFNL] vs. IND
MRVFNL
125000
100000
75000
50000
25000
0
Log[MRVFNL]
11.5
11.0
10.5
10.0
9.5
9.0
434-2
436
438-1
IND
A
B
D
E
G

# LnMRV ANOVA Results

Chevron Oronite

**Summary of Fit**

| | |
|---|---|
| RSquare | 0.755873 |
| RSquare Adj | 0.641948 |
| Root Mean Square Error | 0.503745 |
| Mean of Response | 10.35888 |
| Observations (or Sum Wgts) | 23 |

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 7 | 11.785459 | 1.68364 | 6.6348 |
| Error | 15 | 3.806384 | 0.25376 | Prob > F |
| C. Total | 22 | 15.591843 | | 0.0011* |

**Lack Of Fit**

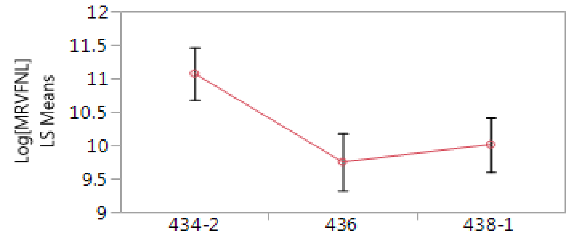
**Parameter Estimates**

**Effect Tests**

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| IND | 2 | 2 | 7.0671246 | 13.9249 | 0.0004* |
| LTMSLAB | 3 | 3 | 3.0786314 | 4.0440 | 0.0272* |
| LTMSAPP[LTMSLAB] | 2 | 2 | 1.4835337 | 2.9231 | 0.0847 |

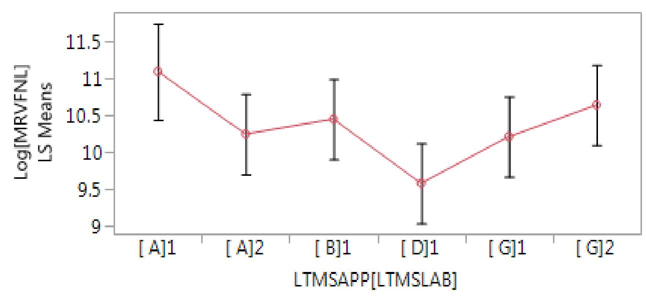
Conclusions:

- 434-2 > 436, 438-1
- A1 > D1
- RMSE, s=0.50 (IIIGA LTMS, s = 0.32)




| Level | | Least Sq Mean |
|---|---|---|
| 434-2 | A | 11.072899 |
| 438-1 | B | 10.010153 |
| 436 | B | 9.752532 |

| Level | - Level | Difference | Std Err Dif | Lower CL | Upper CL | p-Value |
|---|---|---|---|---|---|---|
| 434-2 | 436 | 1.320367 | 0.2734815 | 0.610007 | 2.030727 | 0.0006* |
| 434-2 | 438-1 | 1.062746 | 0.2609870 | 0.384840 | 1.740652 | 0.0027* |
| 438-1 | 436 | 0.257621 | 0.2807113 | -0.471518 | 0.986760 | 0.6378 |




| Level | | | Least Sq Mean |
|---|---|---|---|
| [ A]1 | A | | 11.091127 |
| [ G]2 | A | B | 10.637142 |
| [ B]1 | A | B | 10.446716 |
| [ A]2 | A | B | 10.244187 |
| [ G]1 | A | B | 10.208968 |
| [ D]1 | | B | 9.576684 |

Levels not connected by same letter are significantly different.





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Attachment #5

# Anomalies in uncontrolled (non-Qi) parameters noted by TF Op-data review group

## - Explanation, action / resolution

## - Test Validity assessment

-by Amol Savant

- Ashland Inc. / Valvoline

# Issues noted in TF Op-data review

## Regarding 2 Non-controlled parameters : MAP and Fuel Flow

Test 1 – (CMIR106784) Found to have significantly lower MAP and significantly lower values and arbitrary shift in Fuel Flow in comparison with other tests

Test 2 – (CMIR106782) Found to have lower MAP compared to other tests

Three different characteristics were observed in the nature of the MAP plot

1) Overall average being lower

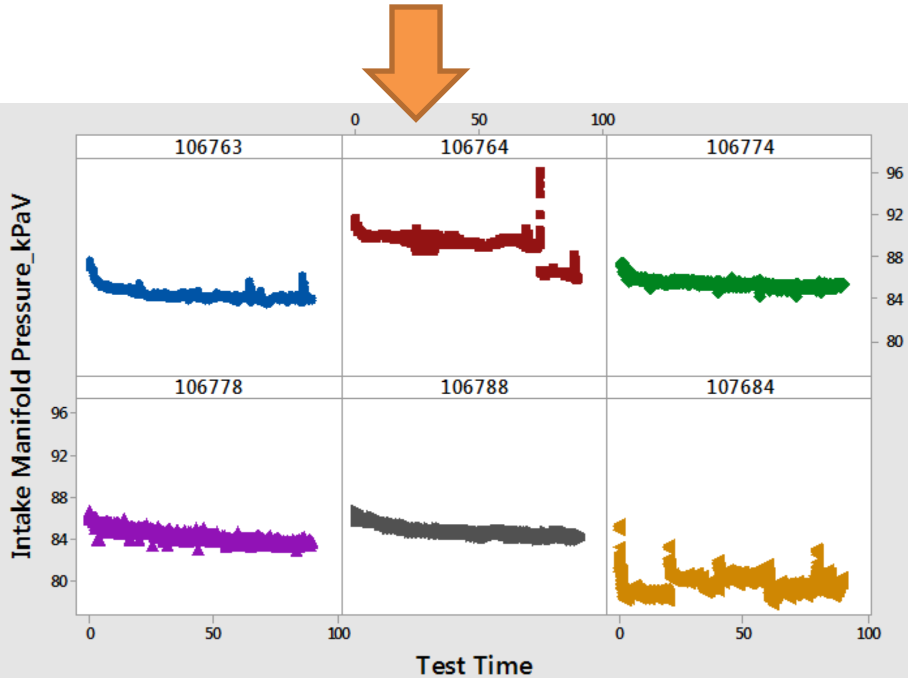
2) MAP seemed to start at higher number and drop to lower within 1st 20mins for each restart of the engine

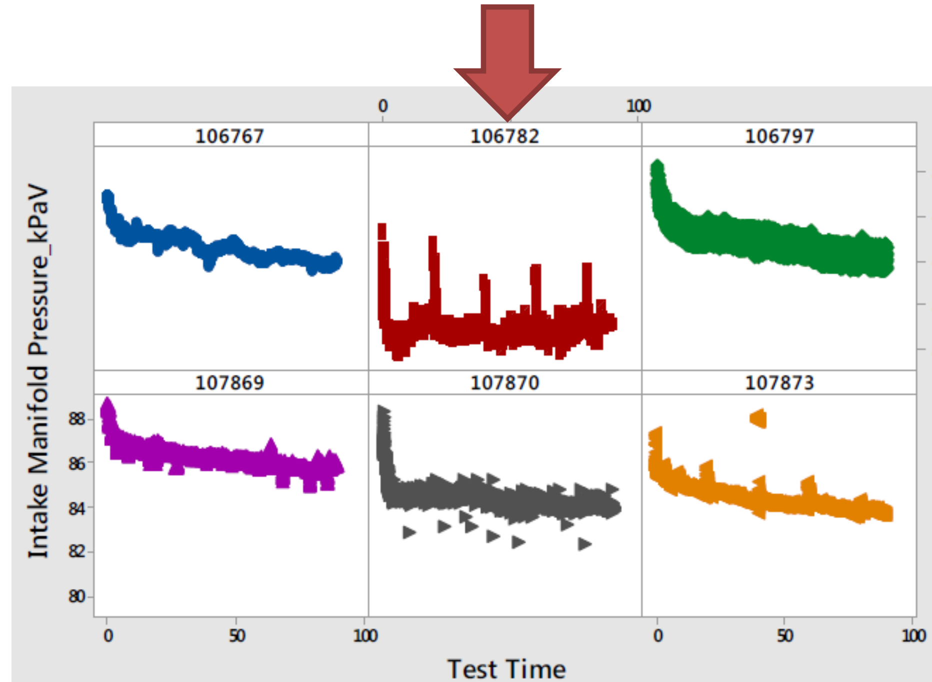
3) Additionally, for 1st test MAP seemed to start at slightly different values at each restart.

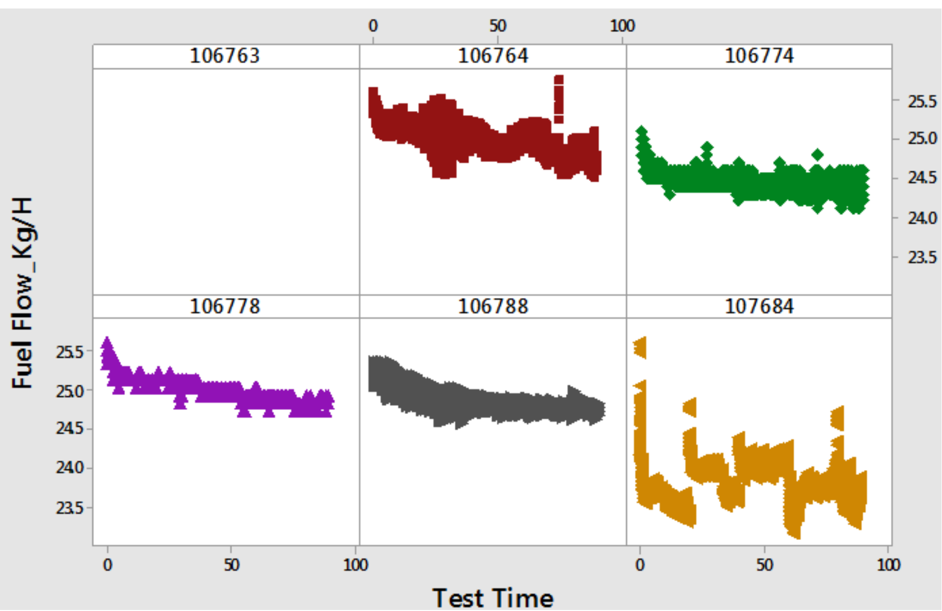
This MAP behavior seemed to directly influence characteristics seen in fuel flow plot for these tests.

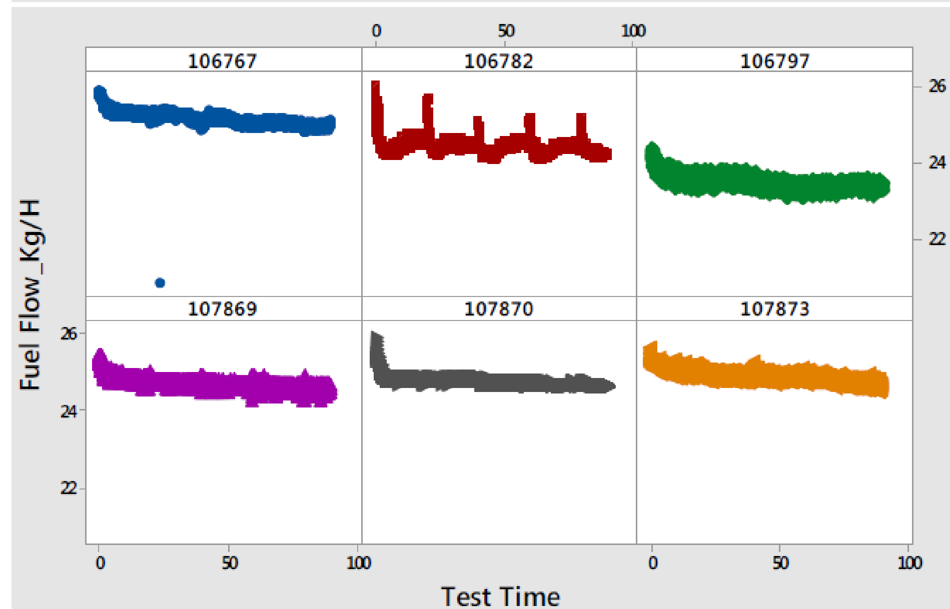
PM Test 1 (CMIR106784)

PM Test 2 (CMIR106782)



# Investigation findings

After the non-conformities noted by TF on the 1st test, investigation was done on the stand –

- It was found that dyno. torque calibration was off (by ~ 4.5 Nm) due to offset in calib. arm length (0.25”). This was corrected before start of the 2nd test. Also, as per George’s suggestion the dyno. calib. was done after stand warmup. (We believe, it was due to this change, it can be observed from the 2nd test plot that the Fuel Flow was in line with the other tests, higher compared to our 1st test.)
- Additionally, during running the test 2nd test, –ve 1.5 kPa offset was noted in DAQ- MAP channel in comparison to CAN - MAP channel. The MAP data from 2nd test was later corrected to reflect this offset. (MAP plot of 2nd test on previous slide does not show these corrected values, shown ahead).
- After correcting MAP values, the overall average of MAP for the 2nd test came out to be 82.7kPa closer to where other tests ran.

Above 2 changes helped to resolve 1st non-conformity characteristic noted in MAP waveform (overall avg.) while the other 2 were resolved later as discussed ahead.

# Investigation findings

| | | | Average values for entire test | | |
|---|---|---|---|---|---|
| Test No. | Testkey | Oil | MAP Orig. Reported | MAP after Offset Corr. | Fuel Flow (as Orig.) |
| PM 1 | 106784 | 438-1 | 79.5 (kPa) | 81.0 (kPa) | 23.7 (kg/h) |
| PM 2 | 106782 | 436 | 81.2 (kPa) | 82.7 (kPa) | 24.6 (kg/h) |

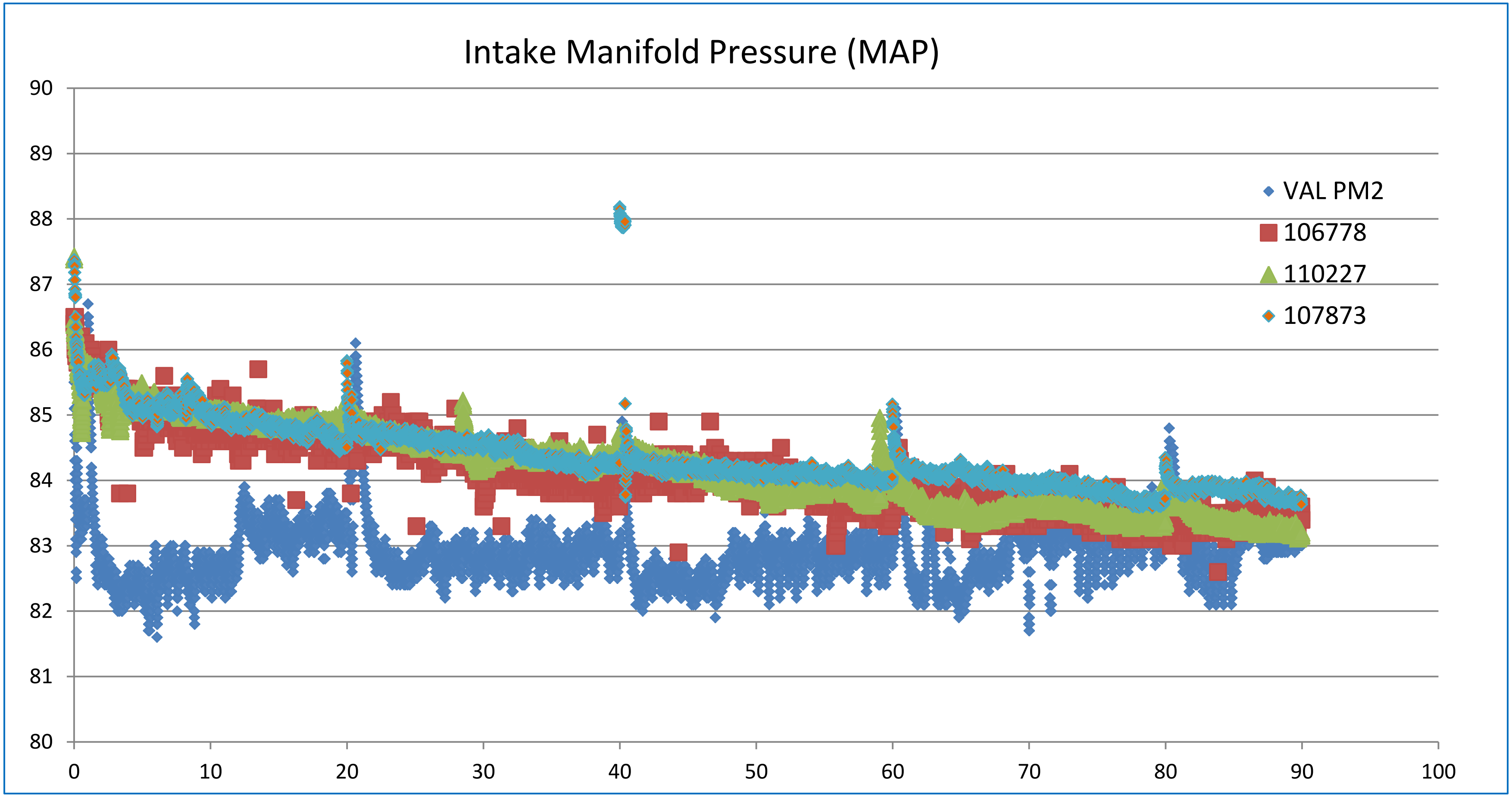
- Findings and subsequent corrections described in previous slide means the 1st test ran significantly lower on MAP as well as on Fuel Flow compared to other tests, and we concur with TF Op data review group's assessment of invalidating the 1st test (CMIR106784)
- However, in case of the 2nd test –

  Fuel flow numbers were in line / comparable to the other tests

  and with the corrected MAP numbers, the MAP was closer to other tests

  (corrected values plotted ahead)

# Plot of corrected MAP values in comparison with some other PM tests

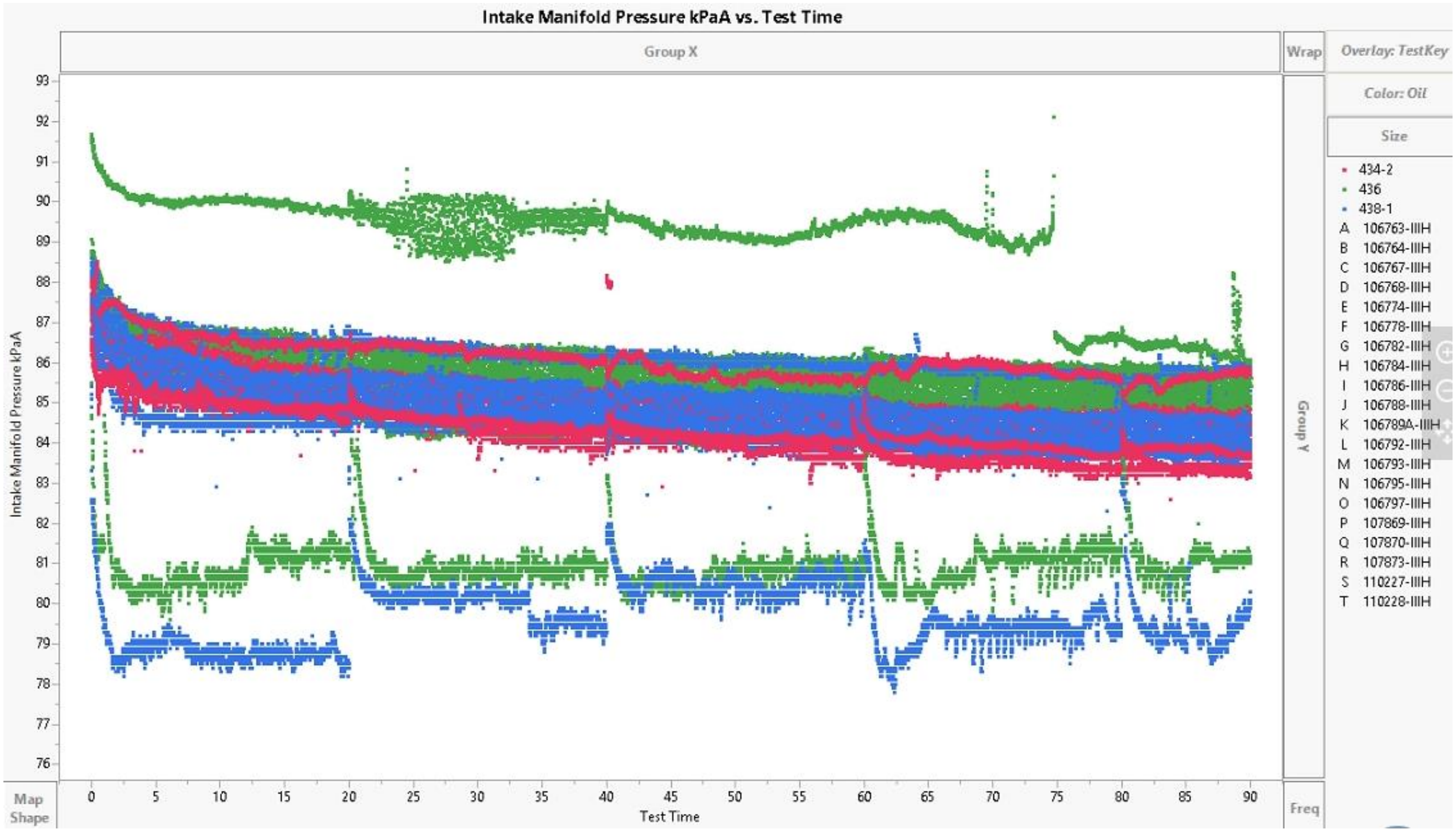



Even though, these corrected MAP values were slightly lower than other tests,

We do not believe that had any significant impact on the test results, especially as fuel flow ran correctly.

Also, atleast one other test showed such deviation in MAP compared to the bulk grouped values and was deemed operationally valid. (exhibit shown ahead)

# Exhibit:




Plot by courtesy – Kevin O'Malley, Lubrizol

# Resolution of initial drift, arbitrary offset in MAP

(2nd & 3rd non-conformity characteristics noted in MAP waveform)

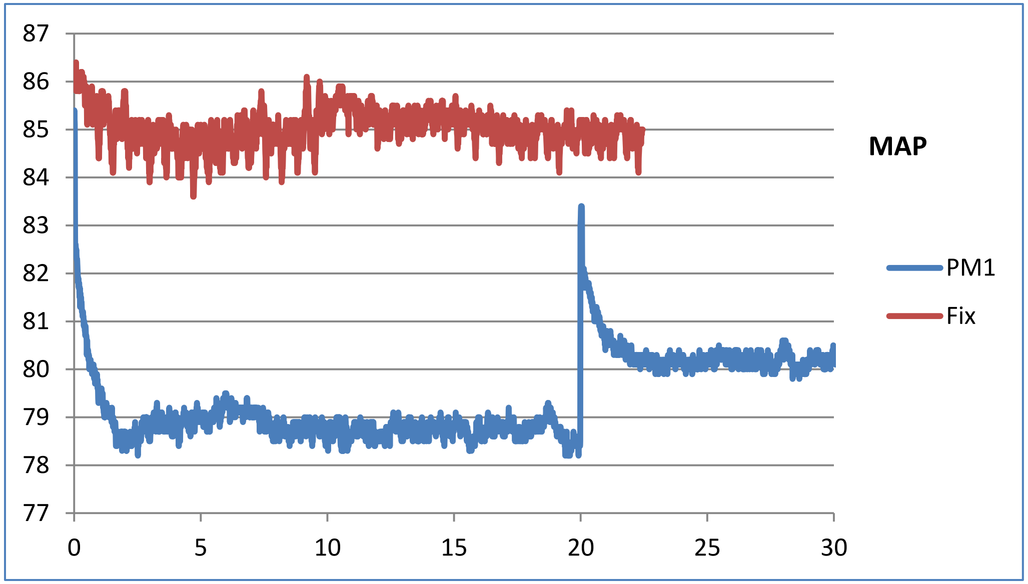
- It was found by subsequent investigations of our stand that due to the combination of type of loadcell that was being used and proximity of it to un-cooled exhaust downpipes, the loadcell was receiving a lot of heat conducted through loadarm creating temp. distribution across the strain gage and therefore was exhibiting thermal drift in o/p voltage changing the torque value resulting in lowering of MAP during initial hour after engine start.

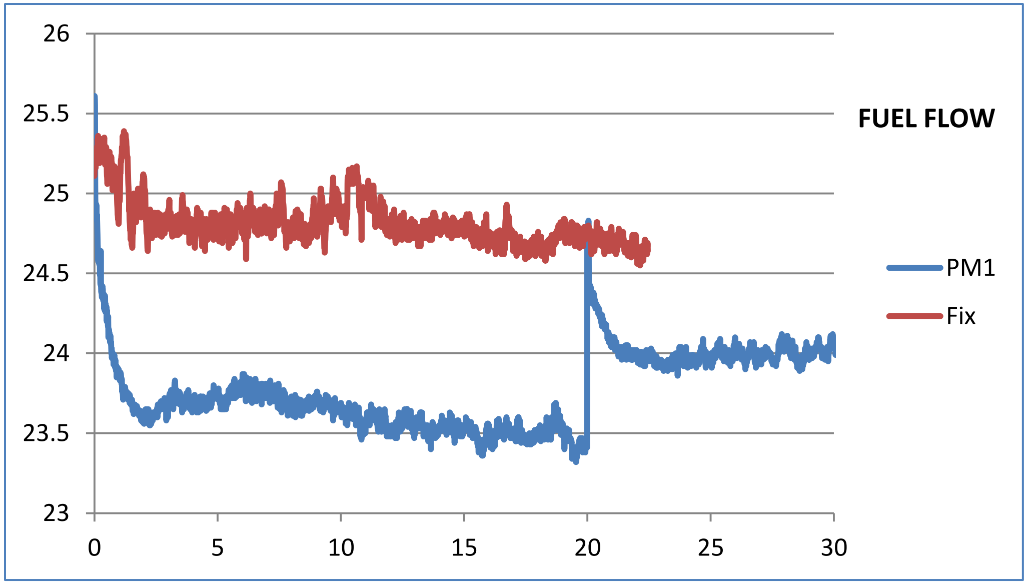
- This was resolved by increasing loadcell control temp to 55`C to provide thermal equilibrium and changing to pancake-type loadcell

# Resolution of initial drift, arbitrary offset in MAP

20+hr run data after loadcell changes was provided to TF and was validated to successfully resolve the load/MAP start-up drift and arbitrary shift issue

(it is now, not needed to calib. dyno after warm-up as loadcell is always in thermal equilibrium)



# Conclusion

- In light of information / evidences presented here –

- ➢ We concur with TF assessment of the 1st PM test that it ran at significantly lower load / MAP
and can be / has been invalidated.

- ➢ However, in case of the 2nd PM test, the fuel flow was in line with other tests and MAP was also closer to other tests.

  Therefore, we believe that the 2nd test (CMIR106782) ran similar to others and should be deemed as ‘valid’.