# IVB Prove-Out Operational Data Review

Date: February 2, 2017

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With Additional Support from Other Stat Group Members

# Data Overview

- Operational data were collected from 101 to 102 hours of each test.
  - Each test hour contains 120 cycles (each cycle is 30 seconds)
  - Each cycle consists of 4 stages:
    - Stage 1 (7 seconds)
    - Stage 12: the transition from stage 1 to stage 2 (8 seconds)
    - Stage 2 (7 seconds)
    - Stage 21: the transition from stage 2 to stage 1 (8 seconds)

Tests included:

| Lab | Test |
|---|---|
| Intertek | IVB102-0-47 |
| | IVB102-0-48 |
| | IVB102-0-49 |
| | IVB165-0-15 |
| | IVB165-0-16 |
| Lubrizol | TRNGGD8BB |
| | TRNKVVM3B |
| | TRNT388PB |
| Southwest | 18-0-29 |
| | 18-0-30 |
| | 20-0-46 |

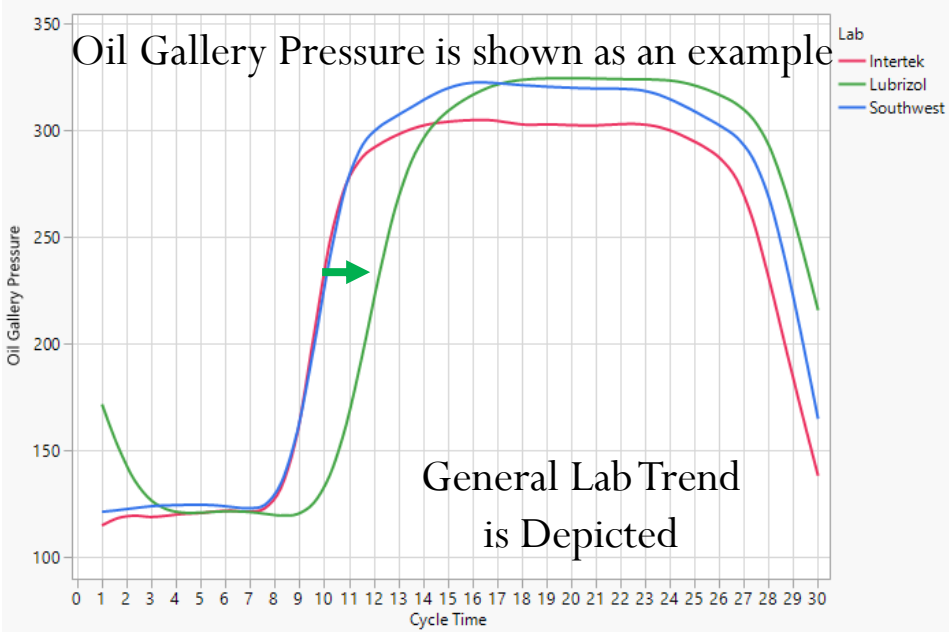
# Summary

- There are operational differences across the labs observed in some parameters:
  - The profile of the 30 second cycle at LZ is offset (lagged) from the other labs
  - There is a peak within the transition from stage 1 to stage 2 of IAR tests that is more pronounced than the other labs
  - The 30 second cycle profiles differ among the labs
  - Cycles occurring across the hour's worth of data differ between the labs
  - There is a slight difference in ramping during the transitions (mainly from stage 1 to 2)
  - In SwRI tests, it appears some parameters weren't quite stable at the being of the hour's worth of data reported
  - There is a magnitude difference between the labs
  - IAR stands differ
- The task force should consider the operational acceptability of the prove out tests prior to finalizing control limits for the precision matrix so QIs properly identify acceptable tests
  - Control limits should again be finalized after the precision matrix test are reviewed
- Should the methodology for how engine speed QIs are calculated be extended to other cyclic parameters like Exhaust Backpressure, Intake Air Pressure, Engine Oil Gallery Temperature, and Engine Torque?

# Summary - Lab Cycle Profile Offset

There are many parameters in which the cycle profiles are offset between the various labs (mainly LZ):

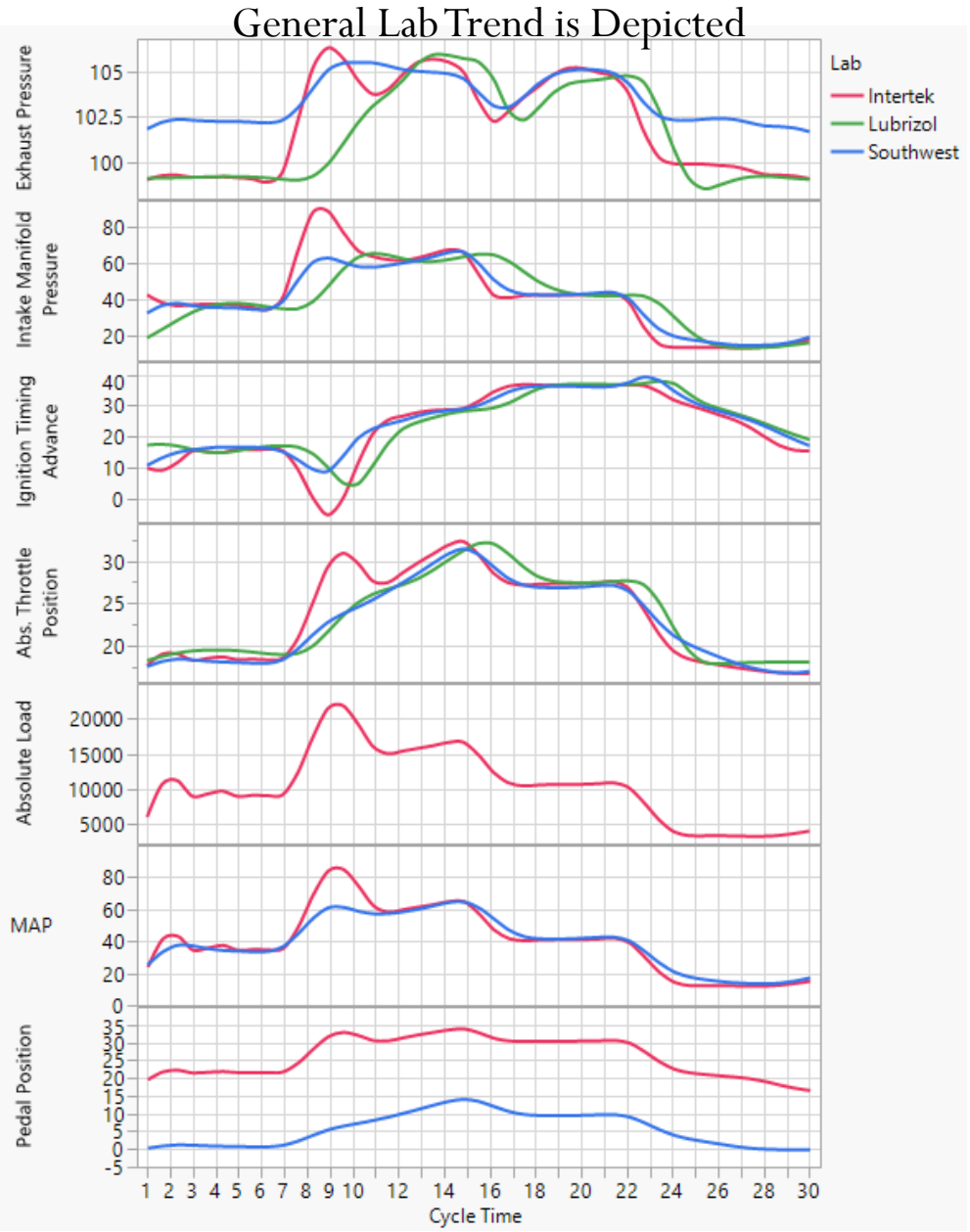
1. Parameters in which LZ's cycle profile is offset by a lag of ~1 second:
    1. Absolute Throttle Position
    2. Absolute Load
    3. Bank 1 STFT (~1 second offset from SwRI)
2. Parameters in which LZ's cycle profile is offset by a lag of ~1 to ~2 seconds:
    1. Engine Power
    2. Engine Speed (Dyno)
    3. Engine Speed (OBD)
    4. Ignition Timing Advance
3. Parameters in which LZ's cycle profile is offset by a lag of ~2 seconds:
    1. Blowby Flow Rate
    2. Crankcase Gas Pressure
    3. Coolant Delta
    4. Coolant Temperature Out of Engine
    5. Exhaust Pressure
    6. Exhaust Gas Temperature
    7. Intake Manifold Pressure
    8. Oil Gallery Pressure
    9. Engine Oil Gallery Temperature
4. LZ's Engine Oil Sump Temp cycle profile is offset by a lag of ~4 to ~5 seconds
5. The Fuel Flow Rate cycle at SwRI is offset from IAR by a lag of 1 second; LZ is offset from IAR by a lag of 1 second



# Summary – IAR Stage 1 to 2 Ramp Peak

There is a peak (or valley) in the transition from stage 1 to stage 2 that is more pronounced at IAR than the other labs. This is observed in the following parameters:

1. Exhaust Pressure
2. Intake Manifold Pressure
3. Ignition Timing Advance (OBD)
4. Absolute Throttle Position (OBD)
5. MAP (OBD)
6. Pedal Position (OBD)

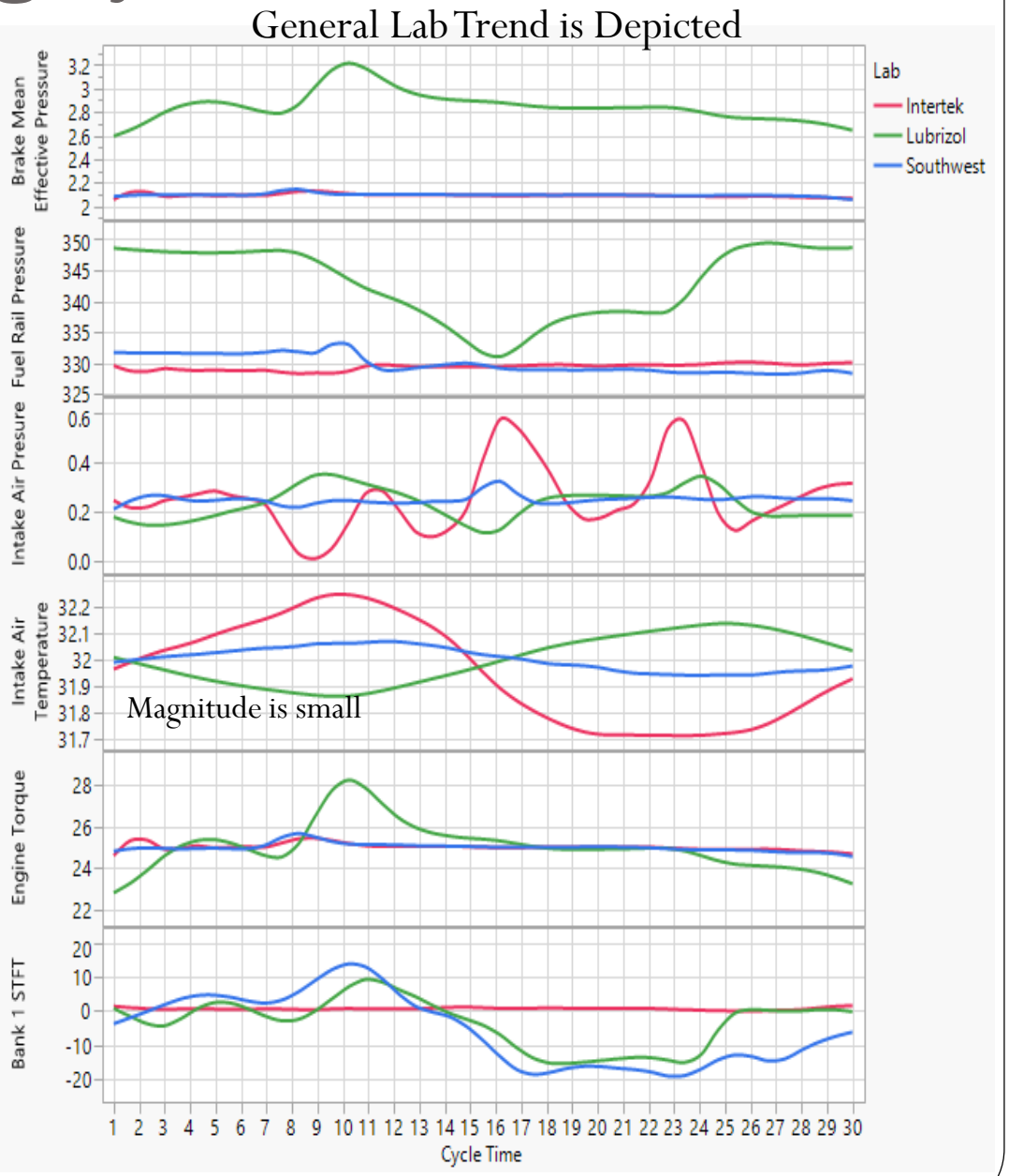


# Summary – Differing Cycle Profiles

The cycle profiles of some parameters are not consistent across the labs.

These include:

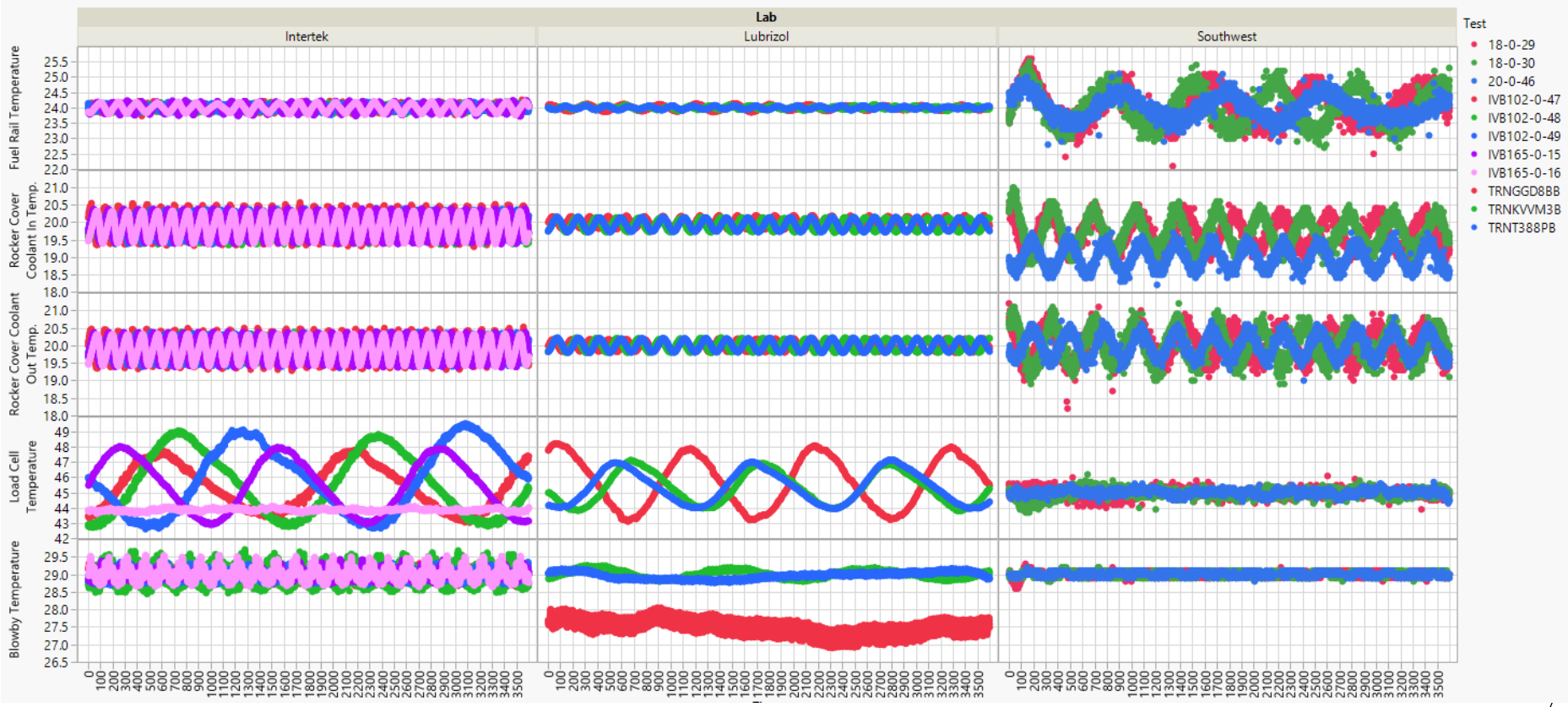
1. Brake Mean Effective Pressure
2. Fuel Rail Pressure
3. Intake Air Pressure
4. Intake Air Temperature
5. Engine Torque (OBD)
6. Bank 1 STFT (OBD)



# Summary–Cycling Differences Over Total Time

Some labs fluctuate over the hour of data differently in some parameters. These include:

1. Fuel Rail Temperature
2. Rocker Cover Coolant In & Out Temperatures
3. Load Cell Temperature
4. Blowby Temperature

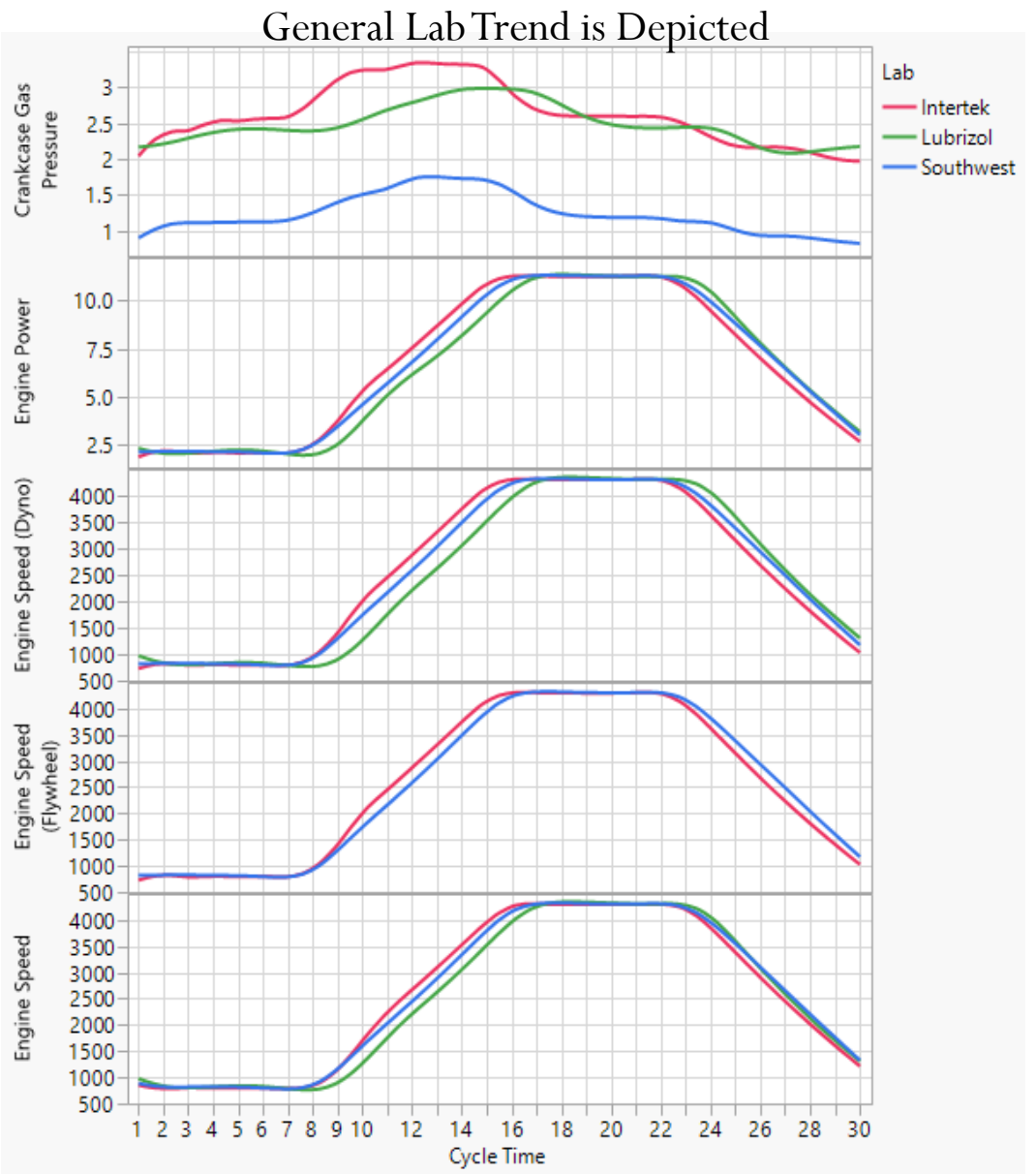


# Summary – Ramping Differences

The rate at which some parameters ramp is not consistent across the labs.
These include:

1. Crankcase Gas Pressure
2. Engine Power
3. Engine Speed
   (Dyno, Flywheel and OBD)

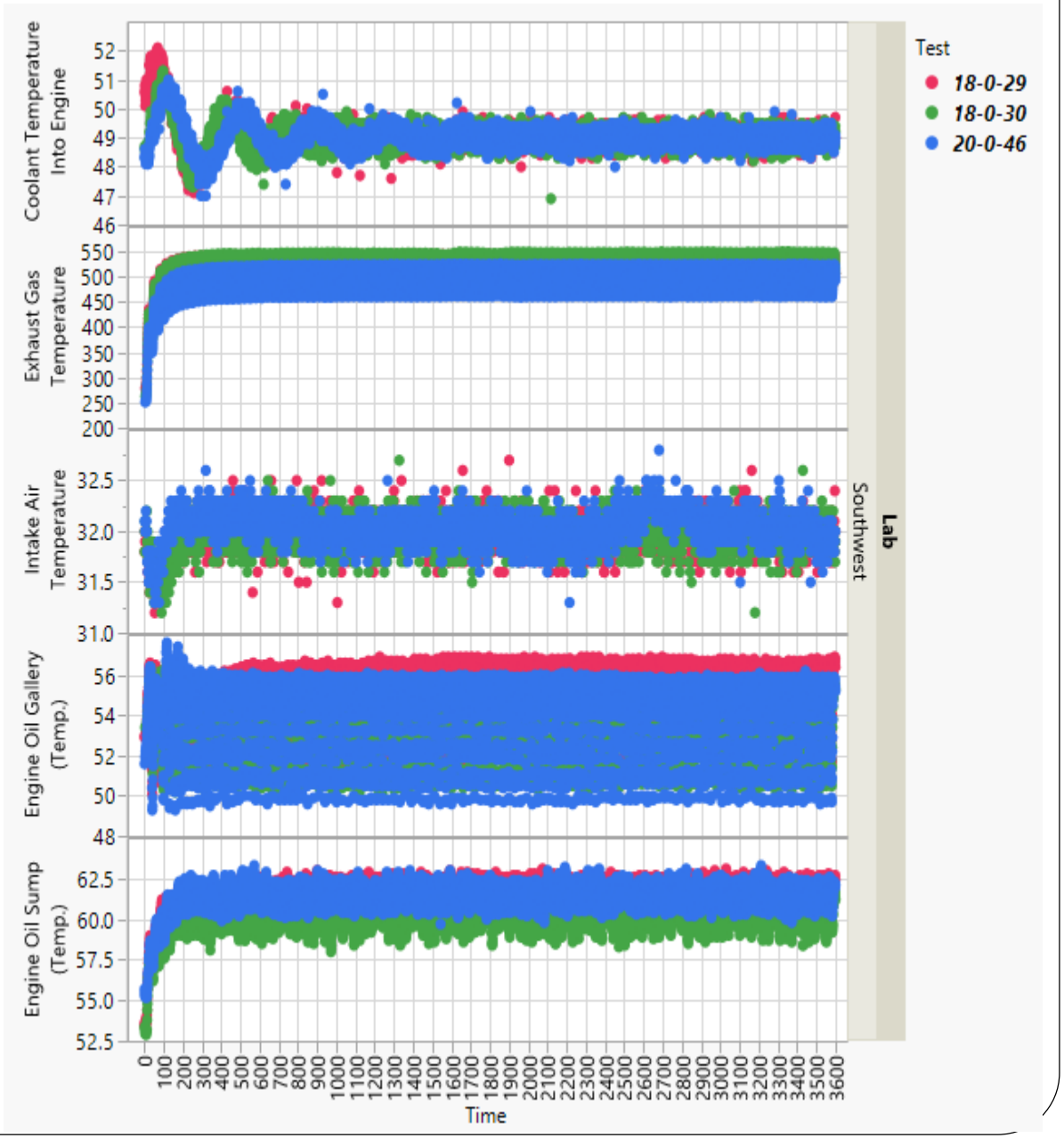
In particular, IAR is steepest during the first part of the transition from stage 1 to stage 2



# Summary – SwRI Stabilization

In SwRI tests, it appears some parameters weren't quite stable at the being of the data reported. These include:

1. Coolant Temperature into the Engine
2. Exhaust Gas Temperature
3. Intake Air Temperature
4. Engine Oil Gallery Temperature
5. Engine Oil Sump Temperature

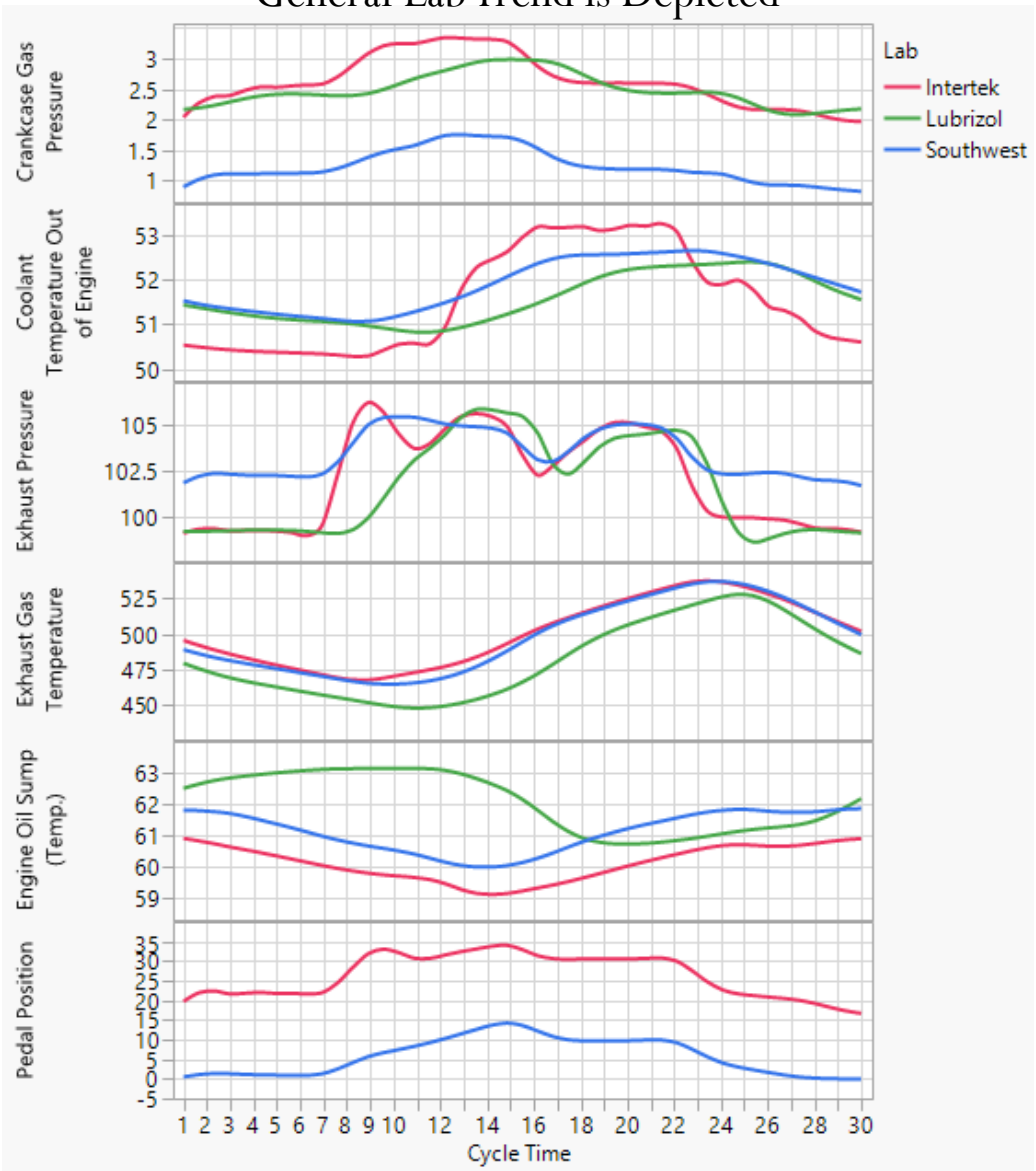


# Summary–Lab Offset

Labs differ in some parameters:

1. Crankcase Gas Pressure (SwRI lower)
2. Coolant Temperature Out of Engine (IAR has largest swing in temp)
3. Exhaust Pressure (SwRI least swing in pressure)
4. Exhaust Gas Temperature (LZ lower)
5. Engine Oil Sump Temperature (LZ > SwRI > IAR)
6. Pedal Position (IAR > SwRI)

General Lab Trend is Depicted

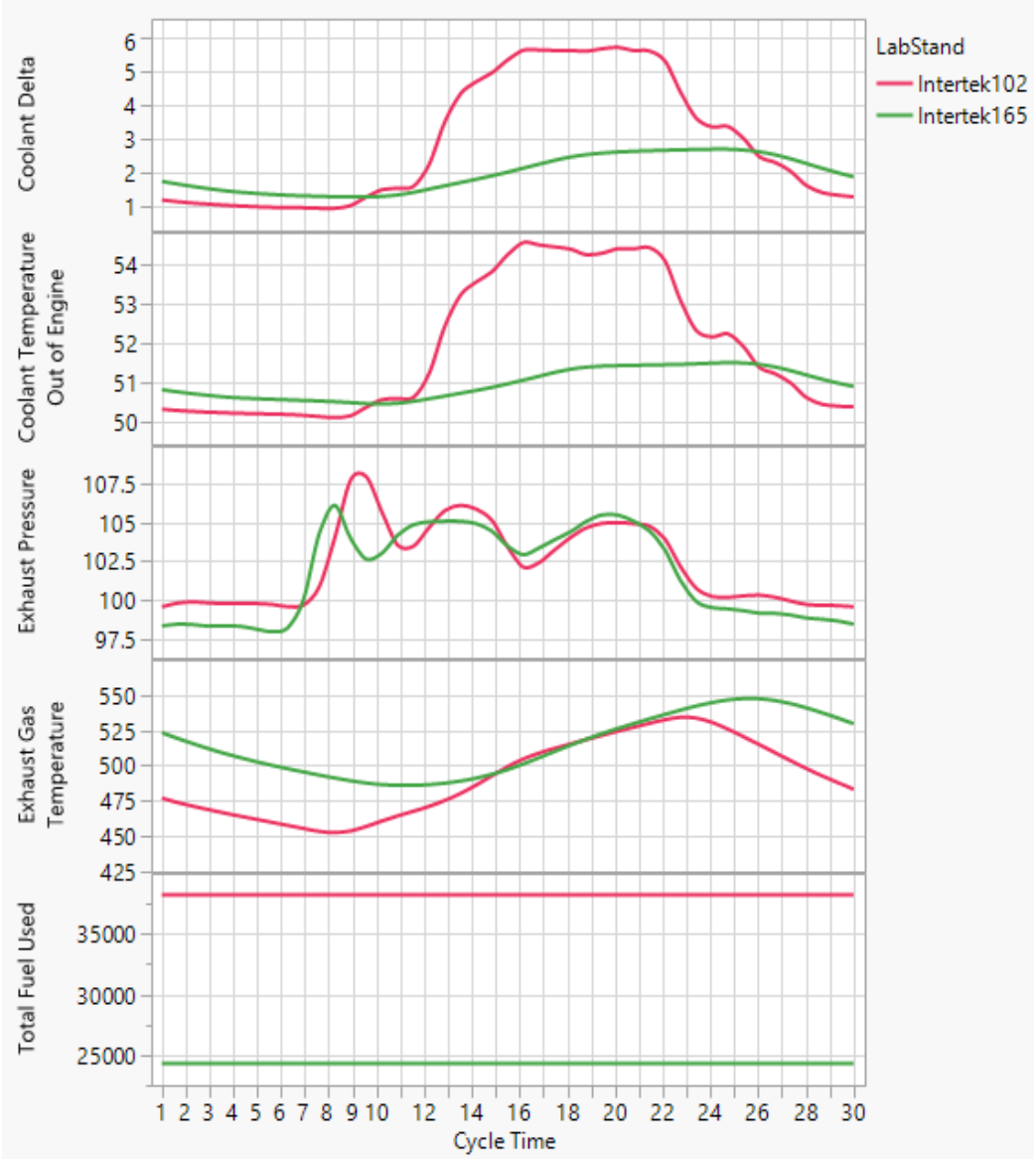


# Summary–IAR Stand Differences

IAR stands exhibit differences in the following parameters:

1. Coolant Delta & Coolant Temperature Out of Engine
    1. Stand 102 higher in stage 2 and transition from stage 1 to stage 2
2. Exhaust Pressure
    1. Stand 165 peak is sooner in transition from stage 1 to 2
3. Exhaust Gas Temperature (165 higher)
4. Total Fuel Used (102 higher)

General Stand Trend is Depicted

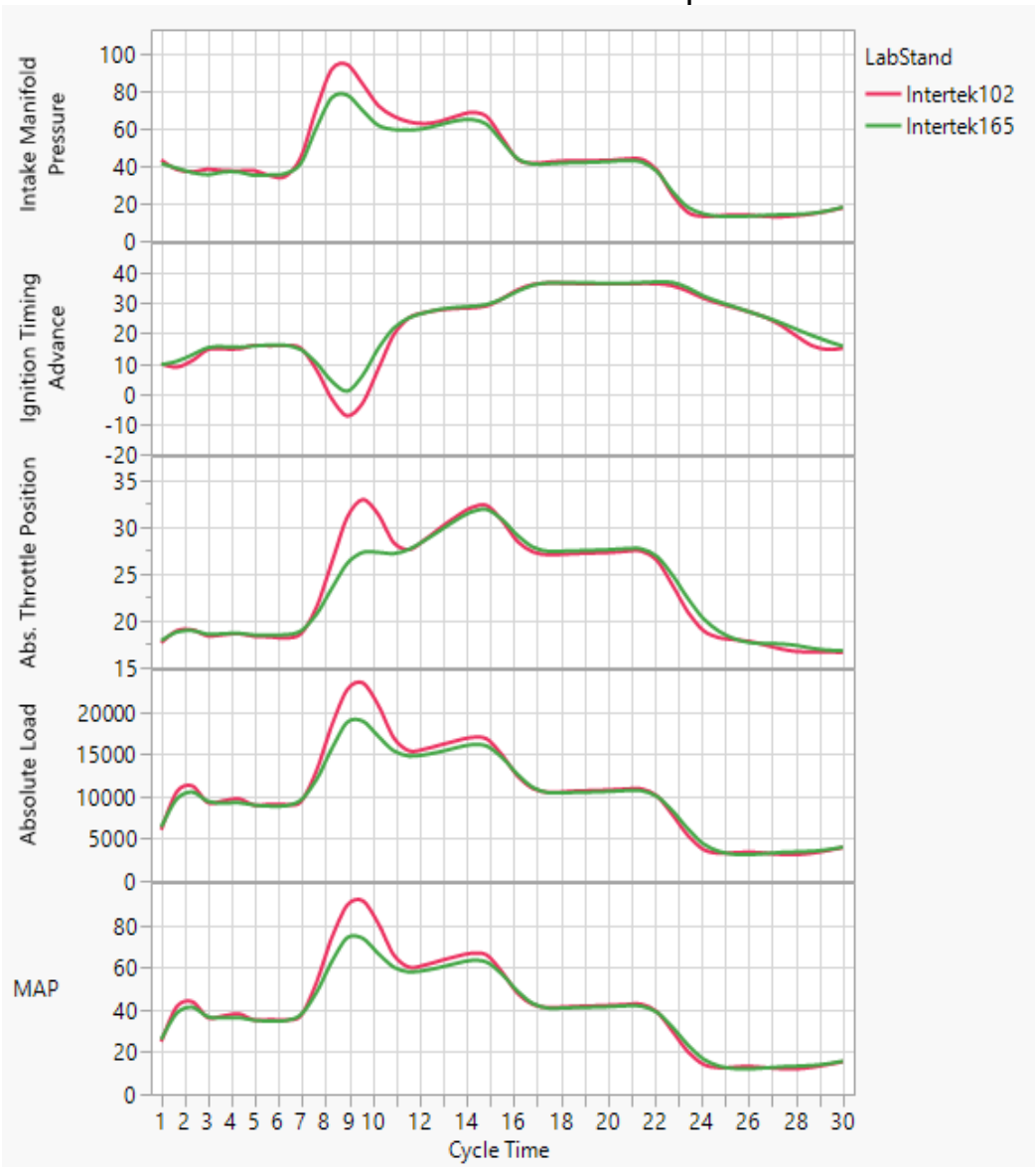


# Summary–IAR Stand Differences

The peak (or valley) in the transition from stage 1 to stage 2 is less pronounced in stand 165 than 102 in the following parameters:

1. Intake Manifold Pressure
2. Ignition Timing Advance
3. Absolute Throttle Position
4. Absolute Load
5. MAP

General Stand Trend is Depicted

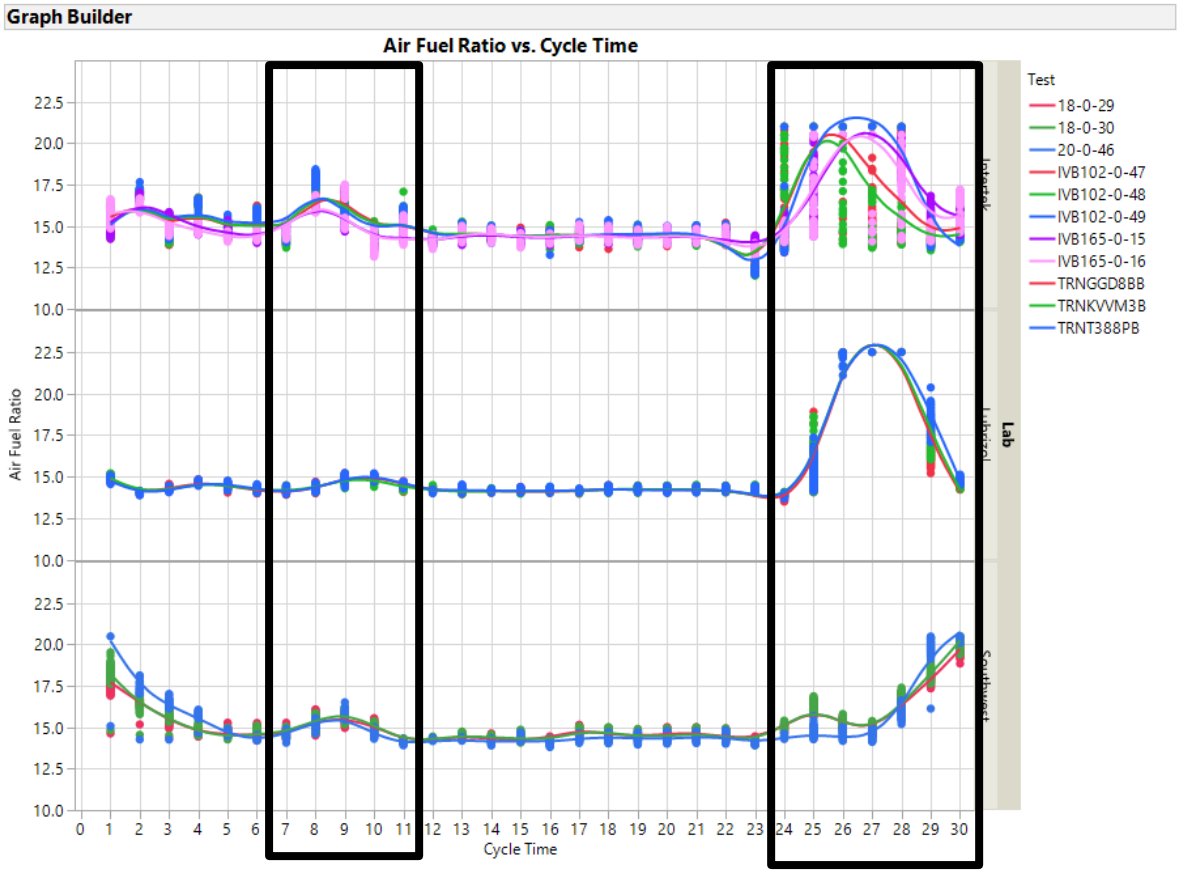


# Summary – Air Fuel Ratio Peaks

The spike in air fuel ratio at the beginning of the transition from stage 1 to stage 2 happens at slightly different times at the labs (IAR first, then SwRI followed by LZ). The magnitude of the peak is also different.

At LZ and IAR the air fuel ratio generally spikes up and then back down in the transition from stage 2 to stage 1 while at SwRI the air fuel ratio spikes up at the end of the transition and then spikes down at the beginning of stage 1.

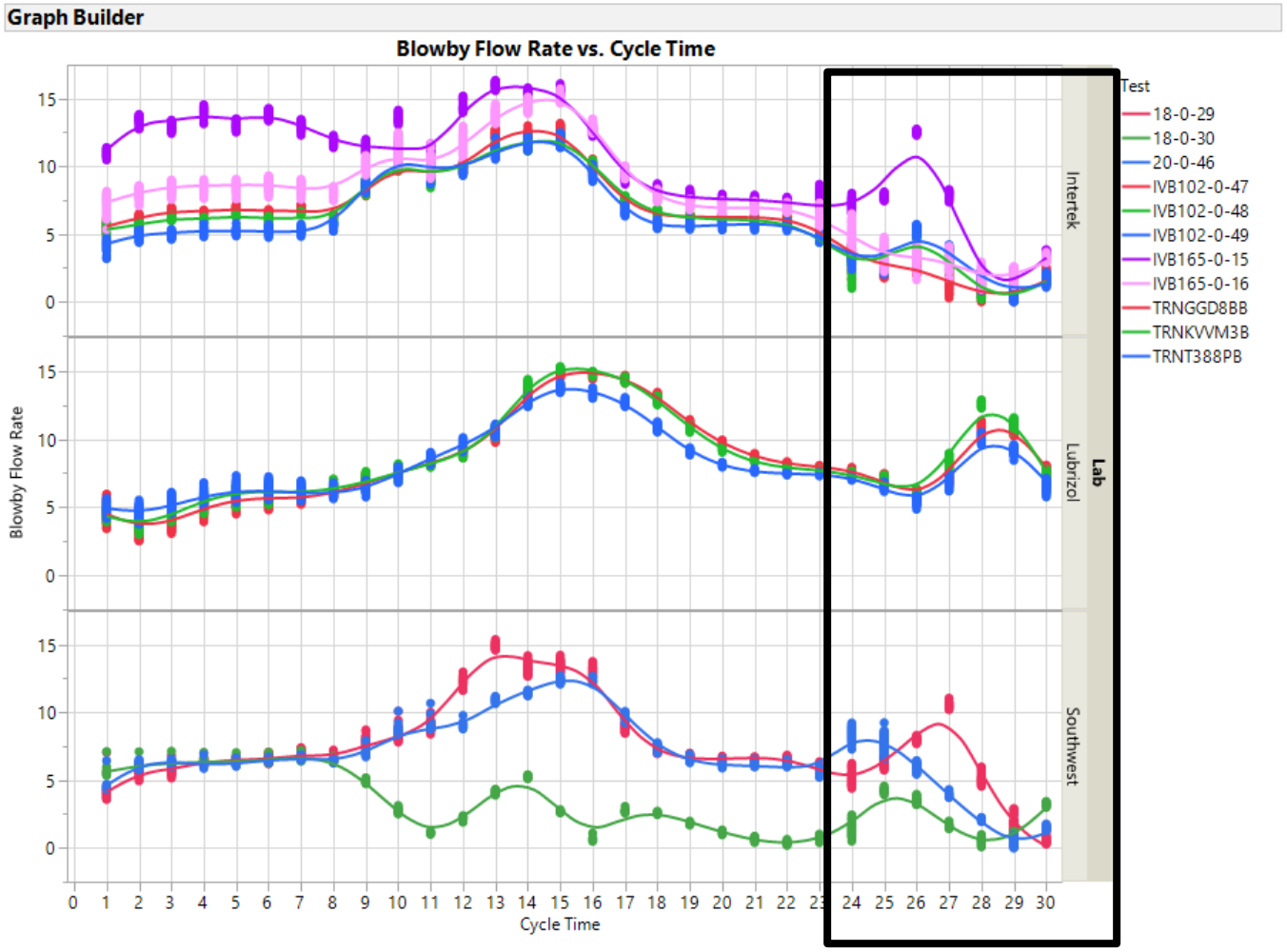
Also, the peak is higher at LZ than the other labs



# Summary – Stage 2 to 1 Blowby Ramp Peak

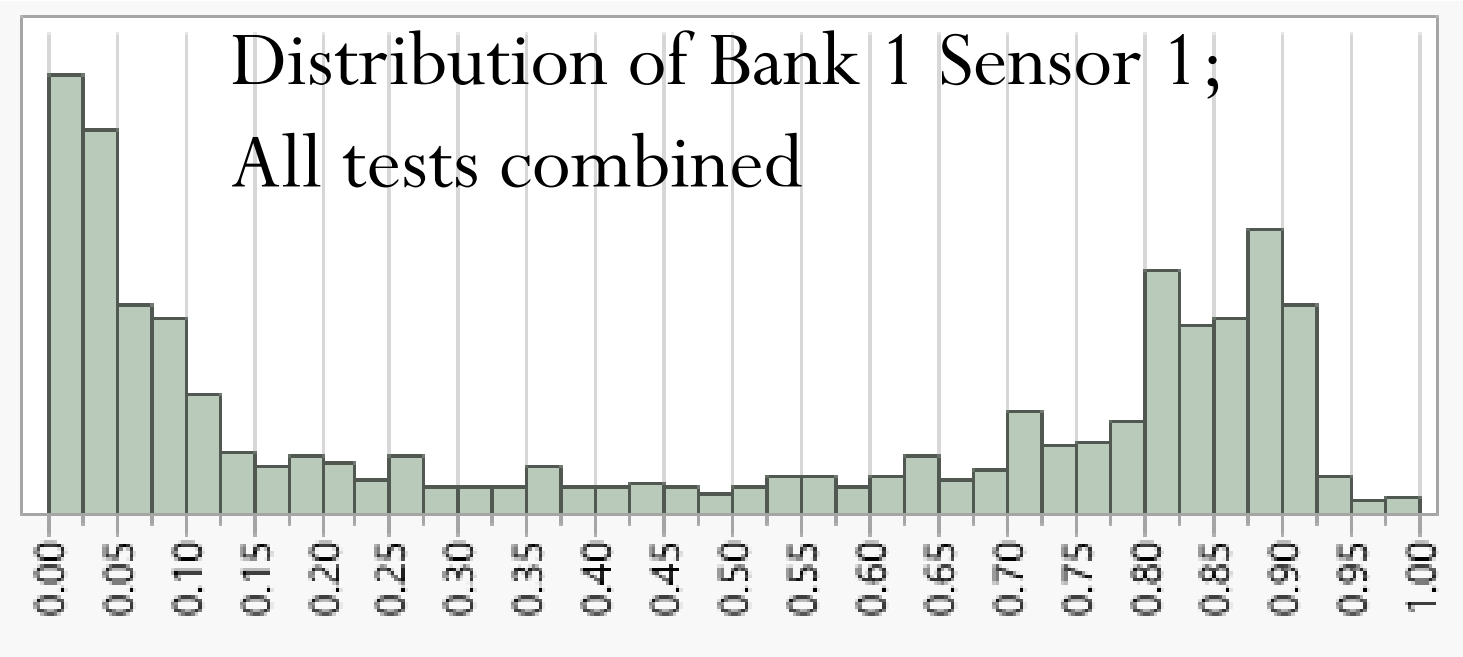
In the transition from stage 2 to stage 1:

1. IAR doesn't exhibit much of a peak
2. LZ's peak occurs later in the transition
3. SwRI isn't consistent from test to test



# Summary – Bank 1 Sensor 1

Bank 1 Sensor 1 values generally fall close to 0 and close to 1.



# QI Evaluation

From the DACA II:

- The upper and lower limits for the QI calculations are derived statistically from the operating conditions of the test development "Golden" stand. The limits should be adjusted and set during test development to result in a final QI of approximately .80 to .90 for each parameter on the Golden stand. These limits can be calculated from the operational data. This will result in a uniform criteria for assessing the quality of a test.

- Analyses were conducted to target QIs of approximately 0.8 and 0.9. Where available, limits from previous QI evaluations were utilized as a starting point.
  - Window 1 are limits to achieve approx. 0.9
  - Window 2 are limits to achieve approx. 0.8

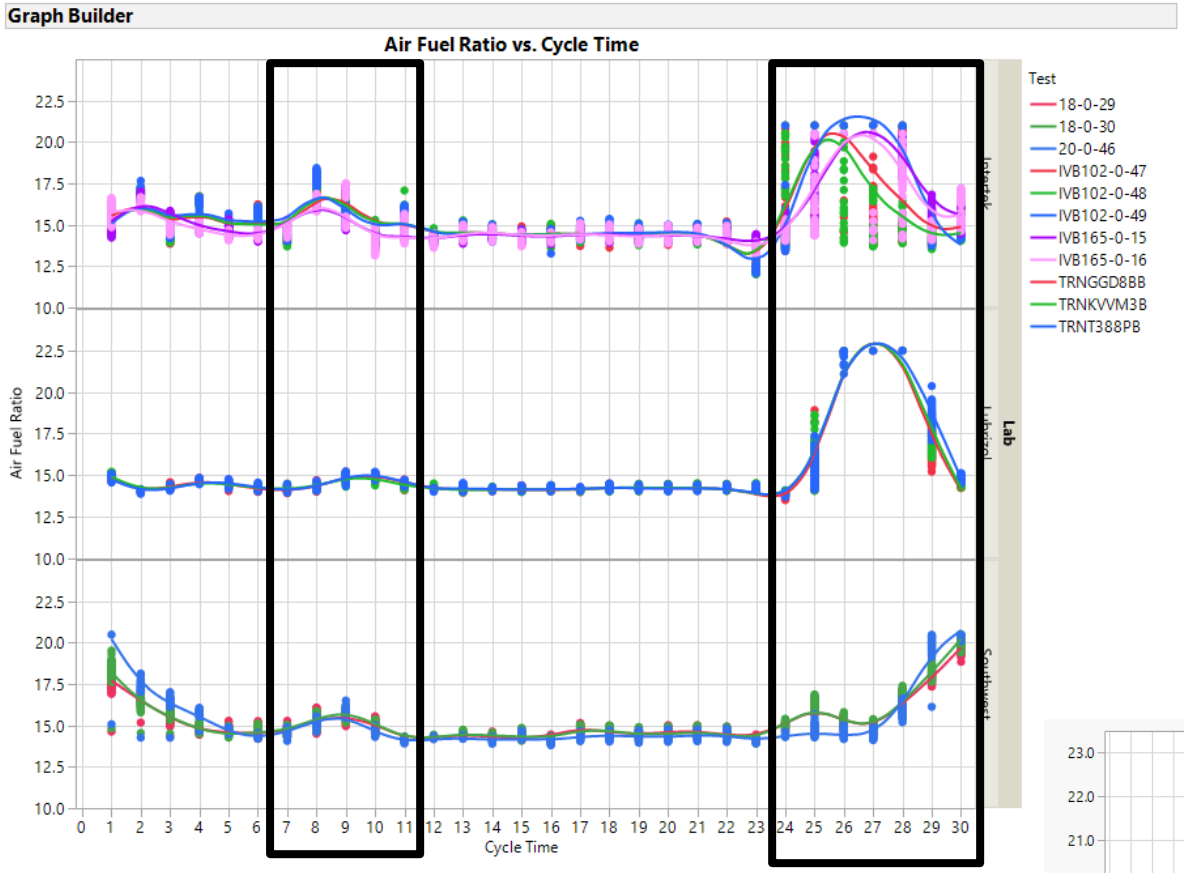
# QI Evaluation Summary

| Test no. | Window 1 Limits | Avg QI Window 1 | Window 2 Limits | Avg QI Window 2 | Comments |
|---|---|---|---|---|---|
| Intake Air Humidity | ± 0.75 g/kg | 0.92 | ± 0.5 g/kg | 0.83 | SwRI reported to only 1 decimal place |
| Engine Coolant In Temp | ± 1.0 C | 0.91 | ± 0.75 C | 0.84 | SwRI results unstable in first 10 minutes |
| Exhaust Backpressure | ± 4 kPa | 0.90 | ± 3 kPa | 0.83 | |
| Fuel Rail Temp | ± 1.0 C | 0.92 | ± 0.5 C | 0.97* | * - Average Based on IAR and LZ control only |
| Intake Air Pressure | ± 0.25 kPa | 0.80 | ± 0.20 kPa | 0.69 | |
| Intake Air Temp | ± 1.0 C | 0.92* | ± 0.75 C | 0.88* | Averages without 165-0-15, which had a negative QI for this parameter |
| Oil Gallery Temp | ± 5.0 C | 0.89 | ± 4.0 C | 0.82 | |
| RAC Temp Out | ± 1.0 C | 0.91 | ± 0.75 C | 0.84 | |
| Torque | ± 2.0 N m | 0.87 | ± 1.5 N m | 0.77* | 2 slightly negative QIs at LZ |
| Engine Coolant Flow Rate | ± 0.5 L/min | 0.92 | ± 0.4 L/min | 0.88 | |
| RAC Coolant Flow Rate | ± 1.0 L/min | 0.88 | ± 0.75 L/min | 0.79 | |
| Blowby Gas Temp | ± 1.0 C | 0.91 | | | TRNGGD8BB had QI of -8.54 |

# Appendix

# Air Fuel Ratio

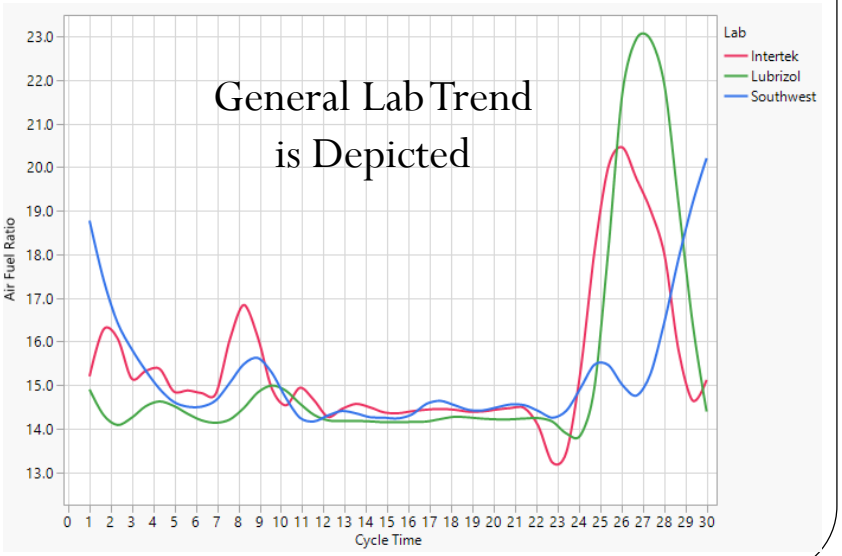
# Air Fuel Ratio




At LZ and IAR the air fuel ratio generally spikes up and then back down in the transition from stage 2 to stage 1 while at SwRI the air fuel ratio spikes up at the end of the transition and then spikes down at the beginning of stage 1.

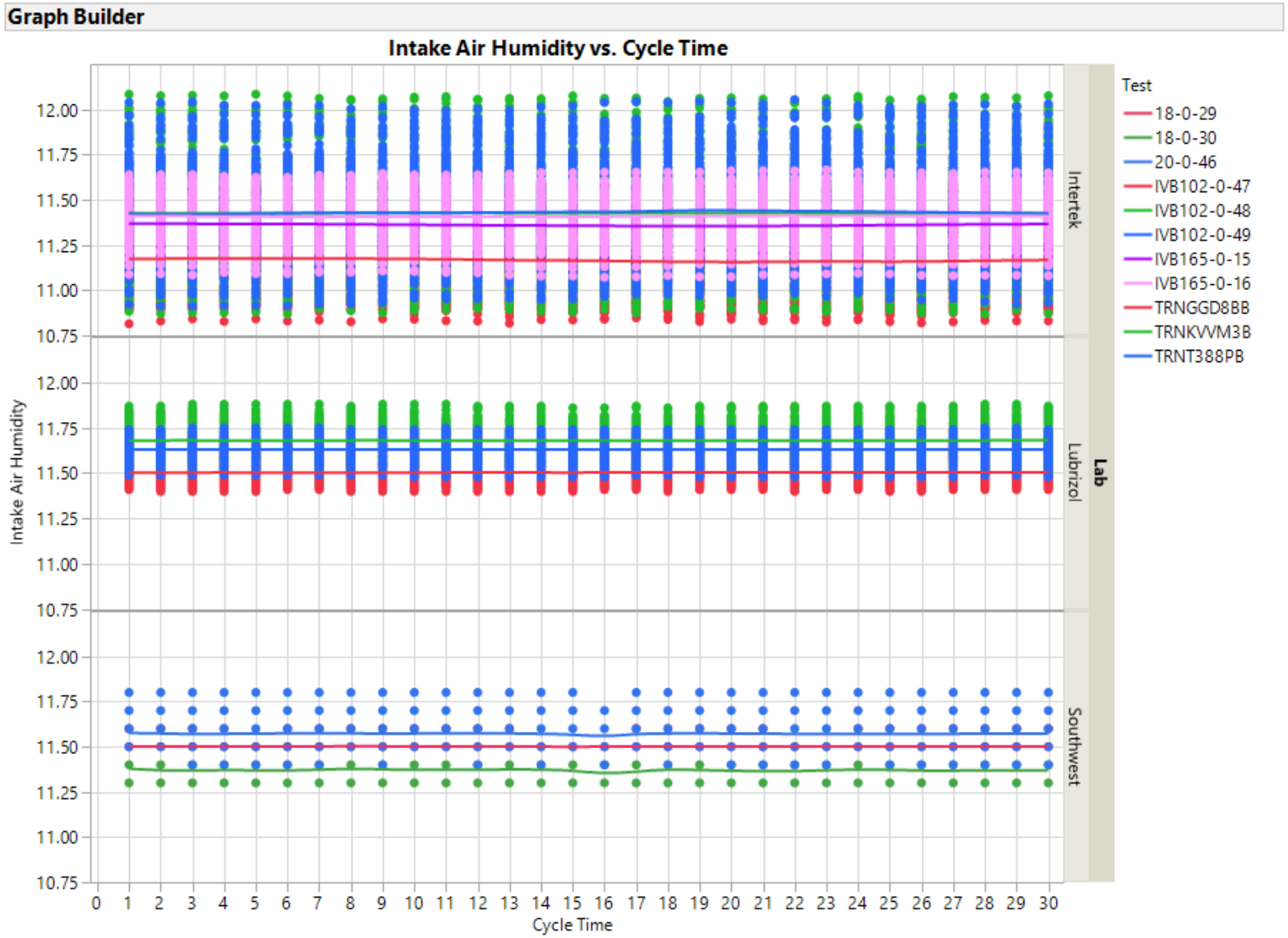
Also, the peak is higher at LZ than the other labs

The spike in air fuel ratio at the beginning of the transition from stage 1 to stage 2 happens at slightly different times at the labs (IAR first, then SwRI followed by LZ).



# Intake Air Humidity

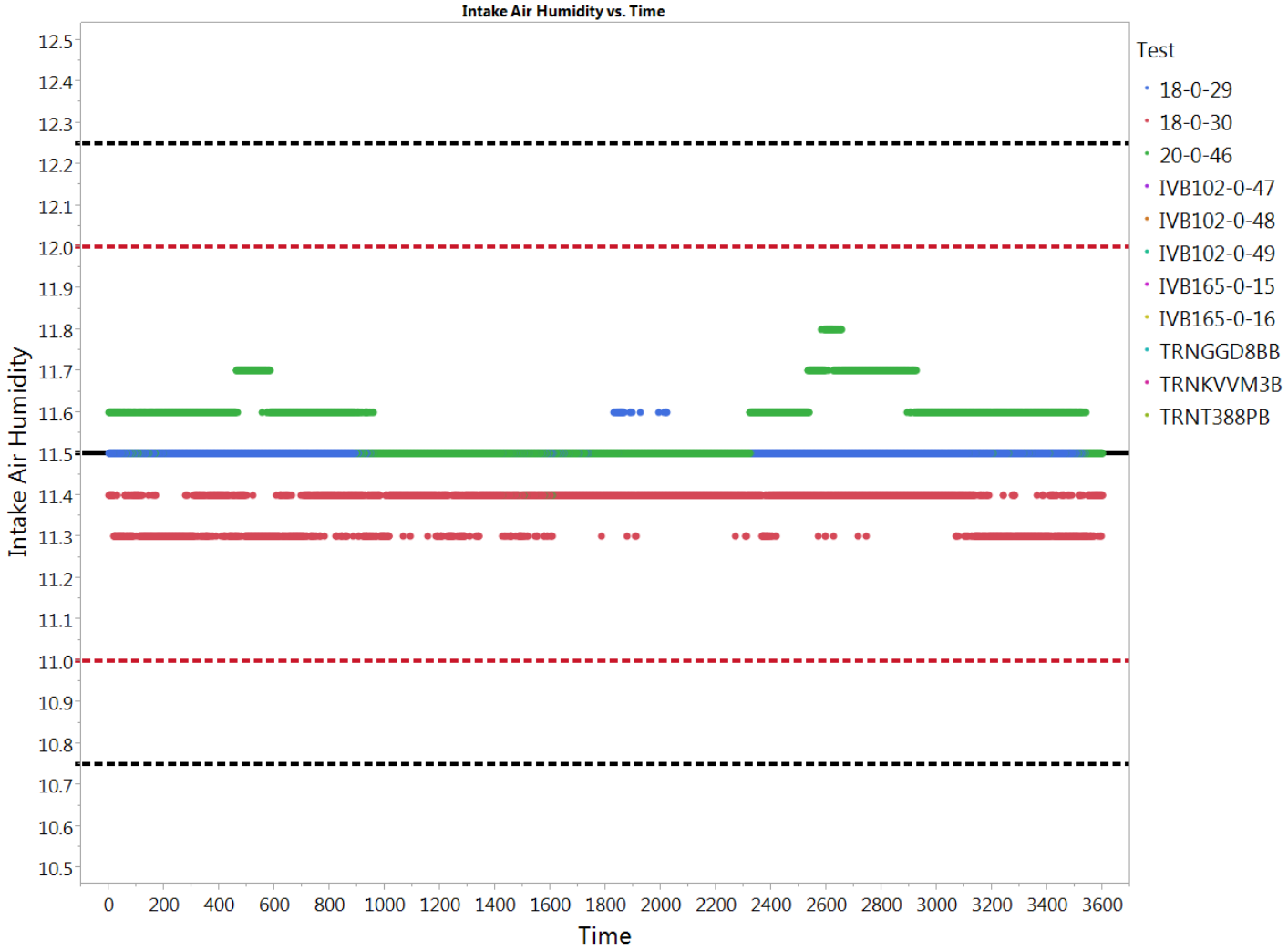
# Intake Air Humidity



# Intake Air Humidity QI
# Lab = SwRI

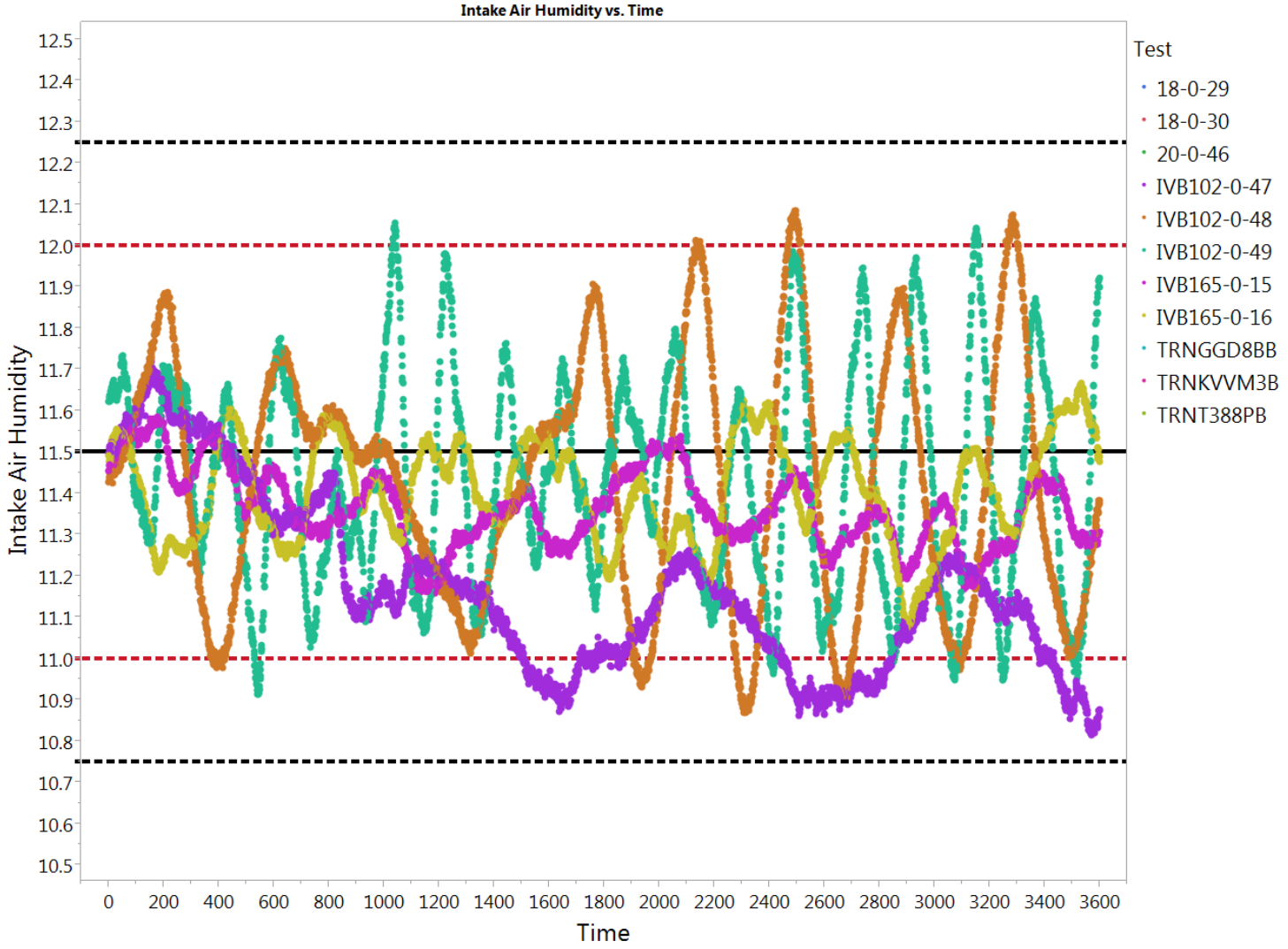
- Target : 11.5 g/kg
- Window size 1: +/- 0.75 g/kg
- Window size 2: +/- 0.50 g/kg

*Lab reported values to only one decimal point



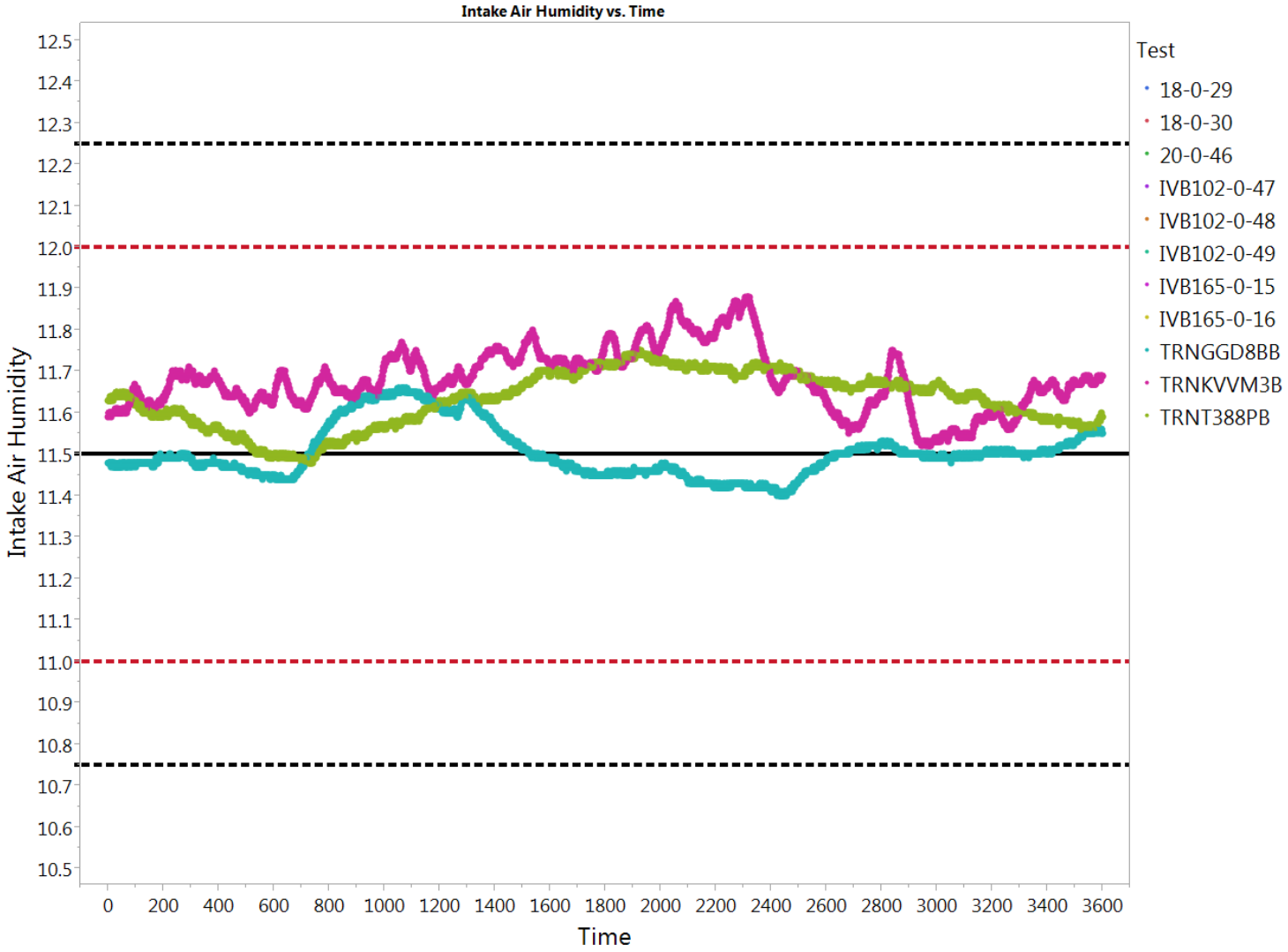
# Intake Air Humidity QI
# Lab = IAR

- Target : 11.5 g/kg
- Window size 1: +/- 0.75 g/kg
- Window size 2: +/- 0.50 g/kg



# Intake Air Humidity QI
# Lab = LZ

- Target : 11.5 g/kg
- Window size 1: +/- 0.75 g/kg
- Window size 2*: +/- 0.50 g/kg



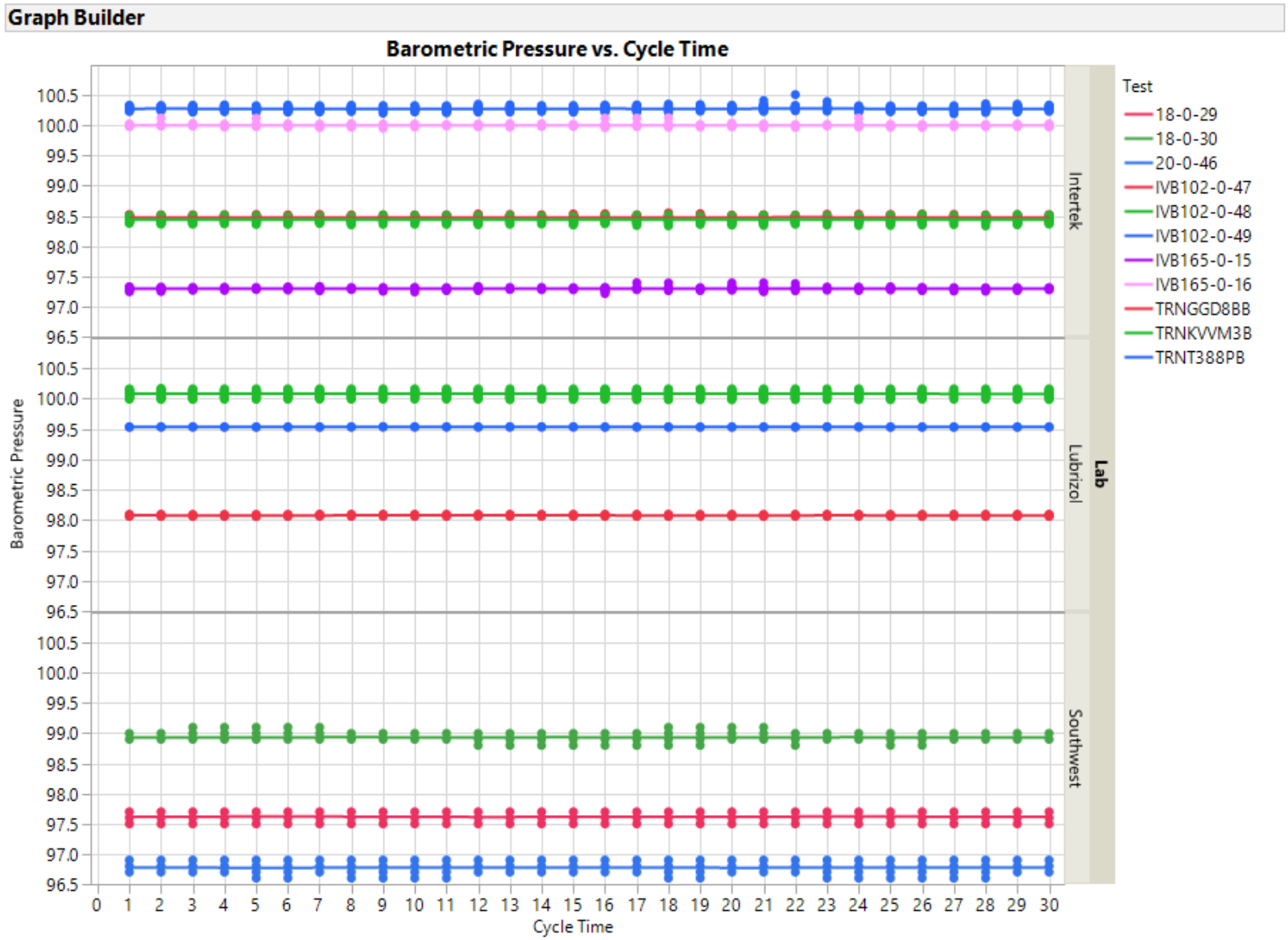
# Intake Air Humidity QI

- Target : 11.5 g/kg
- Window size 1: +/- 0.75 g/kg
- Window size 2: +/- 0.50 g/kg

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | 0.99 | 0.99 |
| 18-0-30 | 0.97 | 0.92 |
| 20-0-46 | 0.98 | 0.96 |
| 102-0-47 | 0.72 | 0.38 |
| 102-0-48 | 0.83 | 0.63 |
| 102-0-49 | 0.87 | 0.71 |
| 165-0-15 | 0.95 | 0.89 |
| 165-0-16 | 0.96 | 0.91 |
| TRNGGD8BB | 0.99 | 0.98 |
| TRNKVVM3B | 0.93 | 0.85 |
| TRNT388PB | 0.96 | 0.91 |
| **Average** | **0.92** | **0.83** |

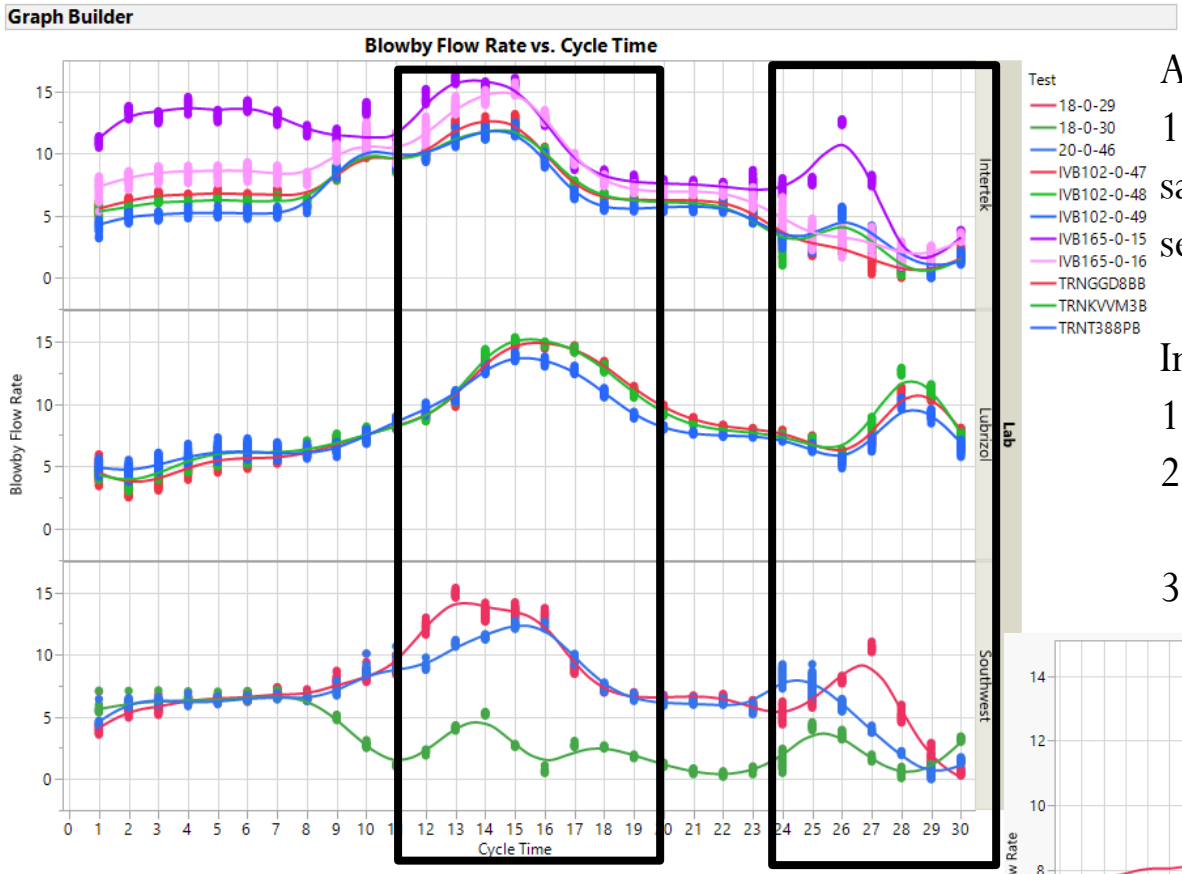
# Barometric Pressure

# Barometric Pressure



# Blowby Flow Rate

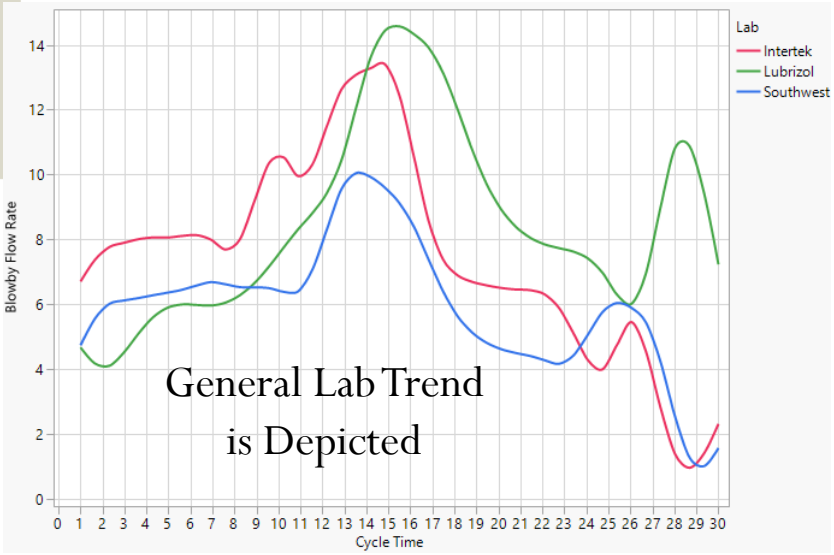
# Blowby Flow Rate




A peak occurs in the transition from stage 1 to stage 2 at IAR and SwRI, but the same peak in the cycle occurs a couple seconds later at LZ.

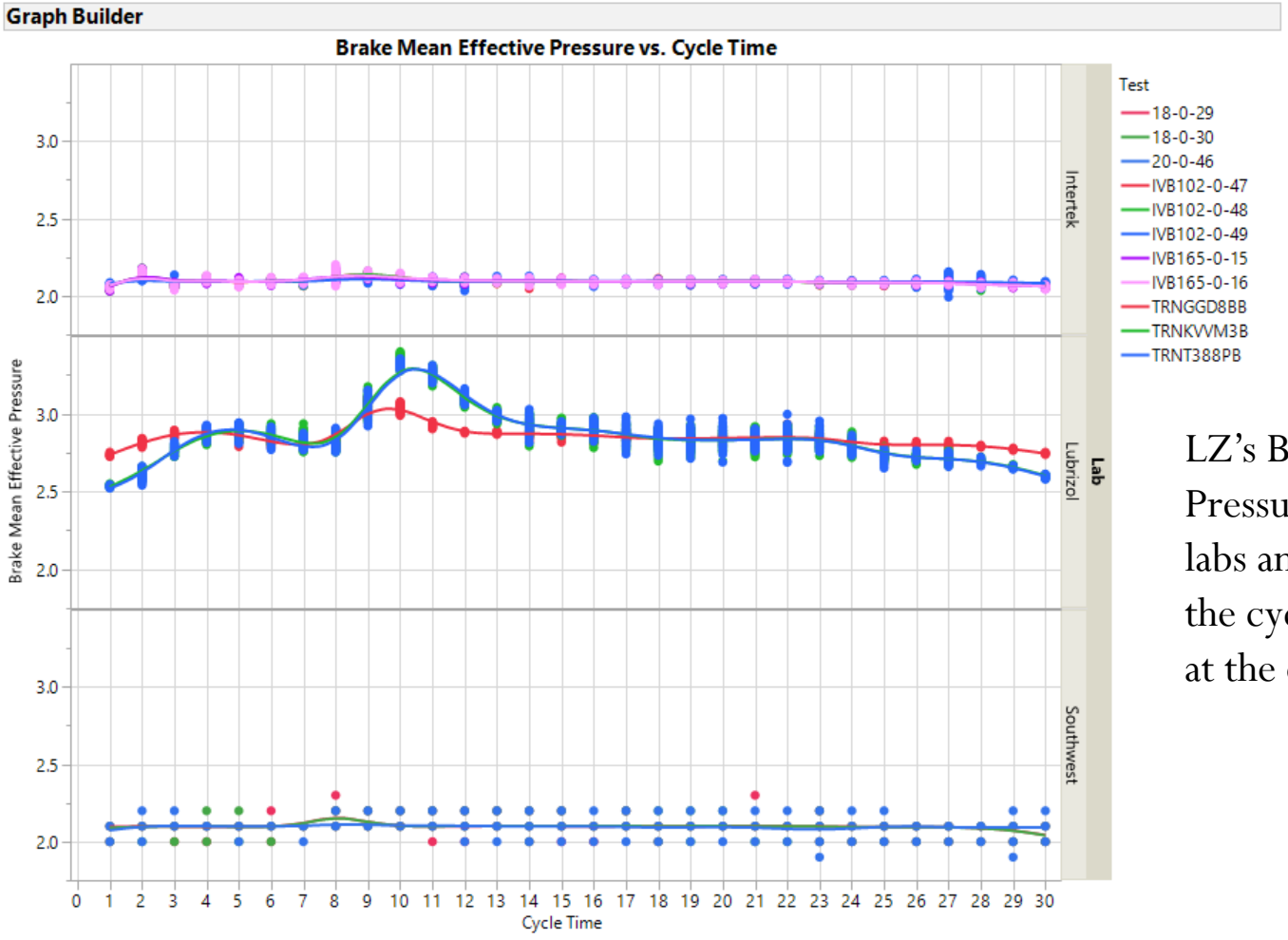
In the transition from stage 2 to stage 1:

1. IAR doesn't exhibit much of a peak
2. LZ's peak occurs later in the transition
3. SwRI isn't consistent from test to test



# Brake Mean Effective Pressure

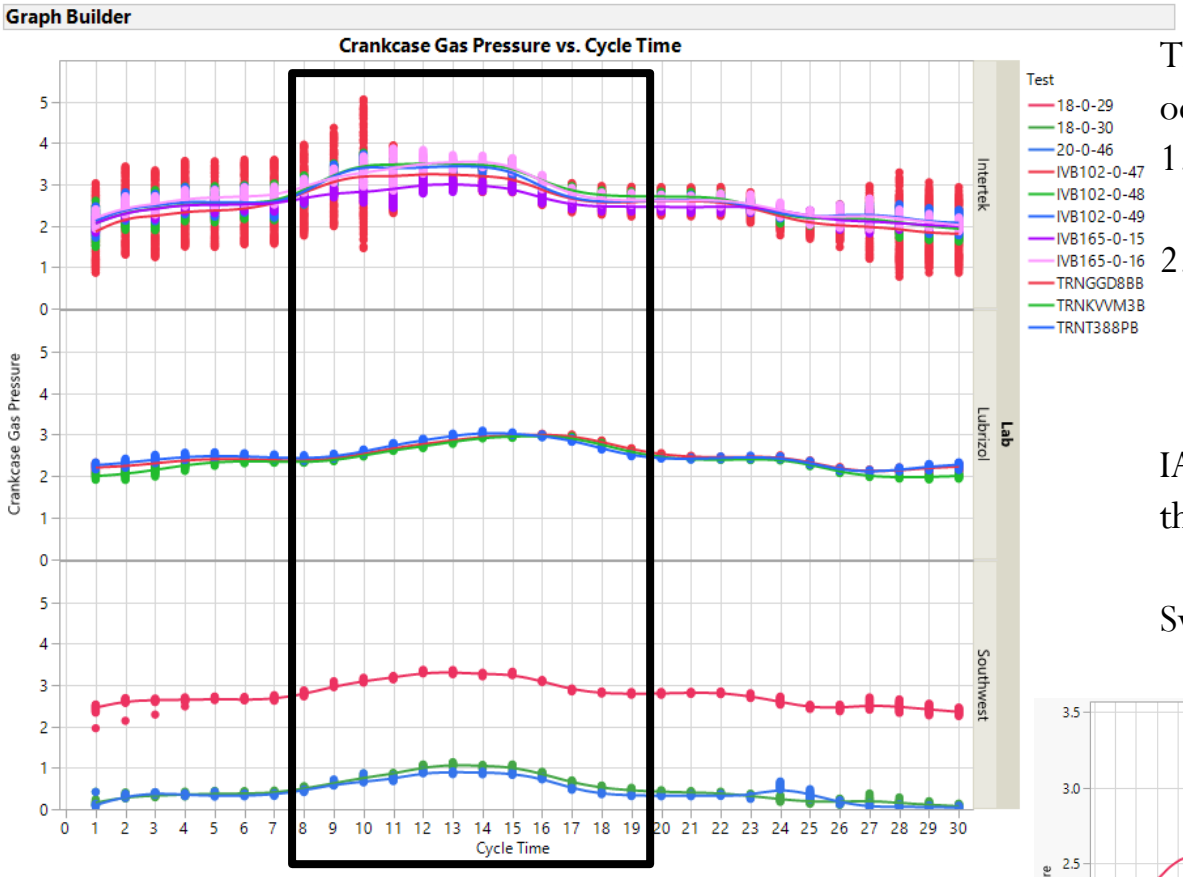
# Brake Mean Effective Pressure




LZ's Brake Mean Effective Pressure is higher than the other labs and exhibits fluctuations in the cycles that are not observed at the other labs.

# Crankcase Gas Pressure

# Crankcase Gas Pressure

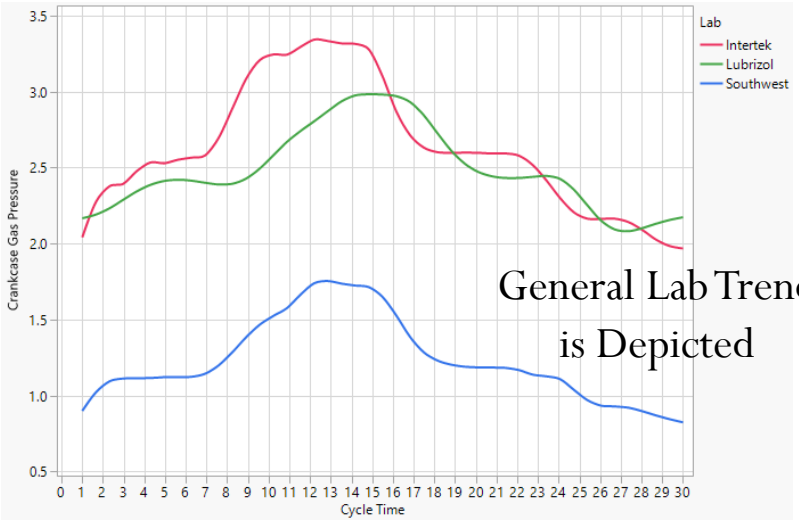



The increase in Crackcase Gas Pressure occurs at slightly different times at the labs:

1. The increase at SwRI and IAR occurs in the transition from stage 1 to stage 2
2. LZ's increase occurs mid way through the transition and continues part way through stage 2

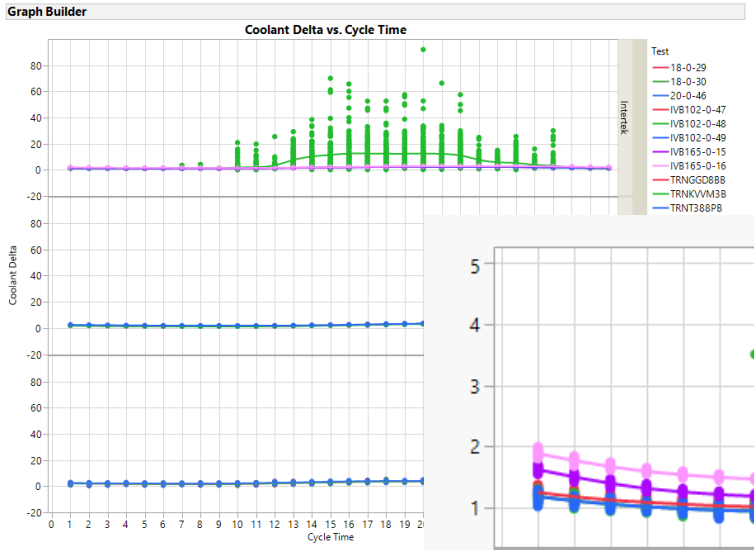
IAR's ramp from stage 1 to 2 differ is steeper than the other labs

SwRI tests are not consistent from test to test



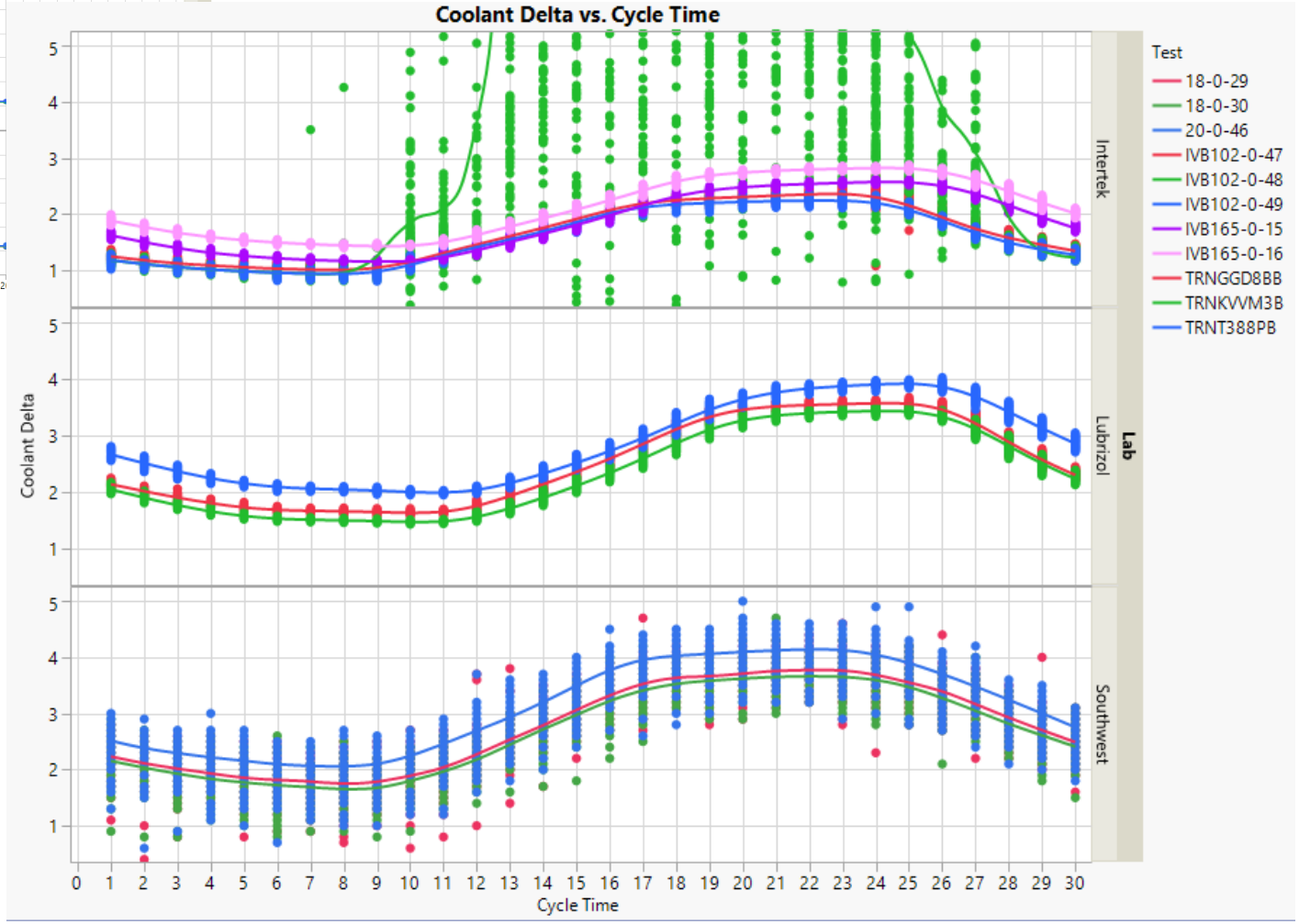
# Coolant Delta

# Coolant Delta



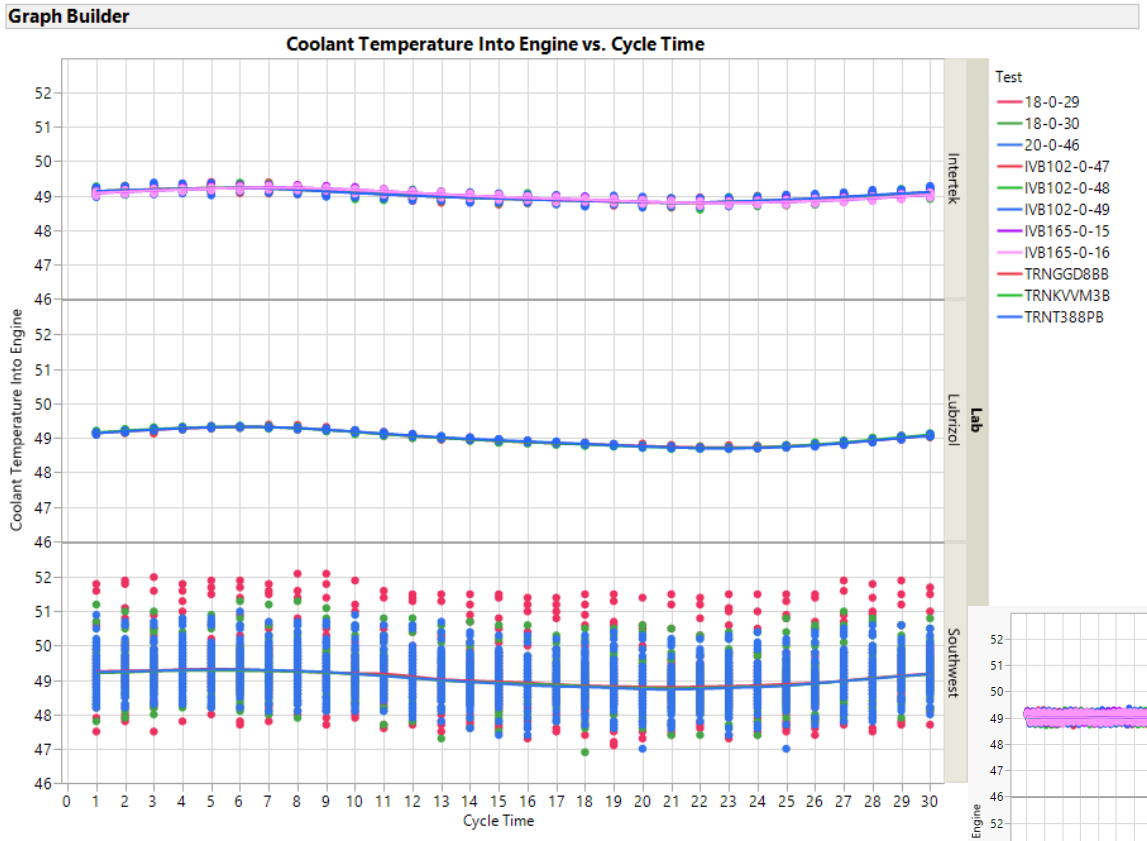

102-0-48 had a higher delta due to its coolant temperature out of engine

LZ's coolant delta cycle is ~2 second behind the other labs

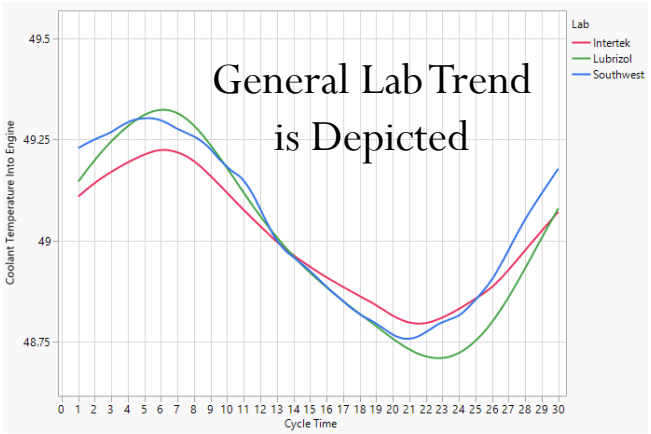


# Coolant Temperature Into Engine

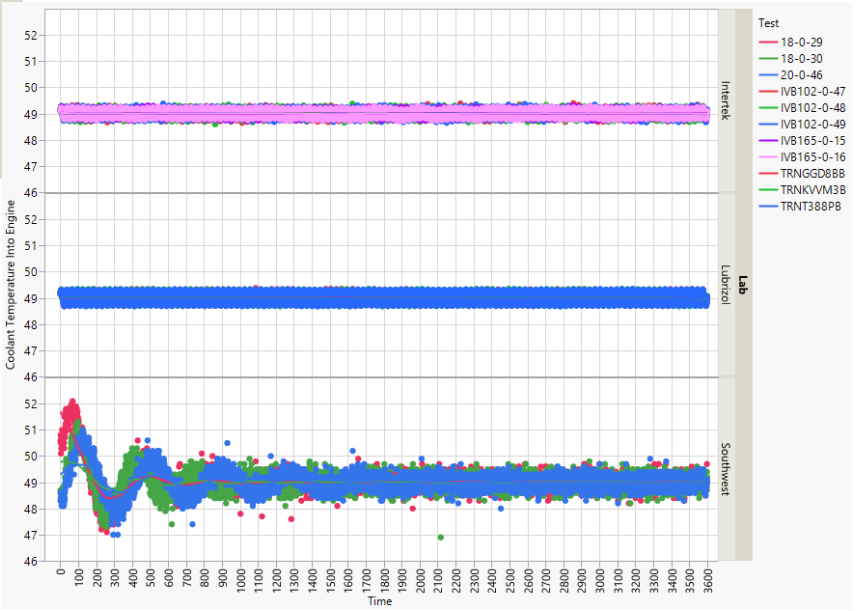
# Coolant Temperature Into Engine




Labs have similar profiles

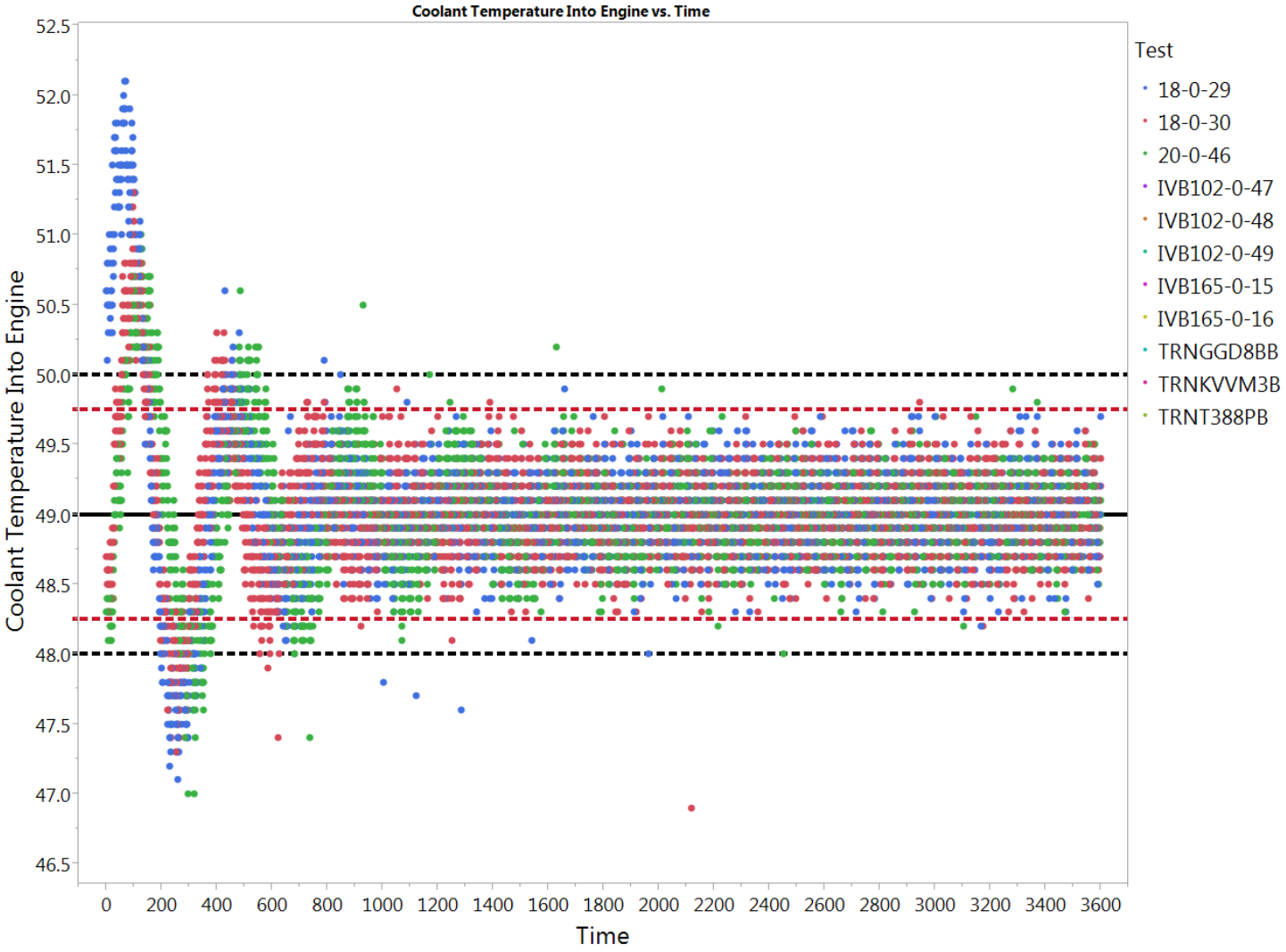



SwRI is more variable due to stabilization at the beginning of the data recorded



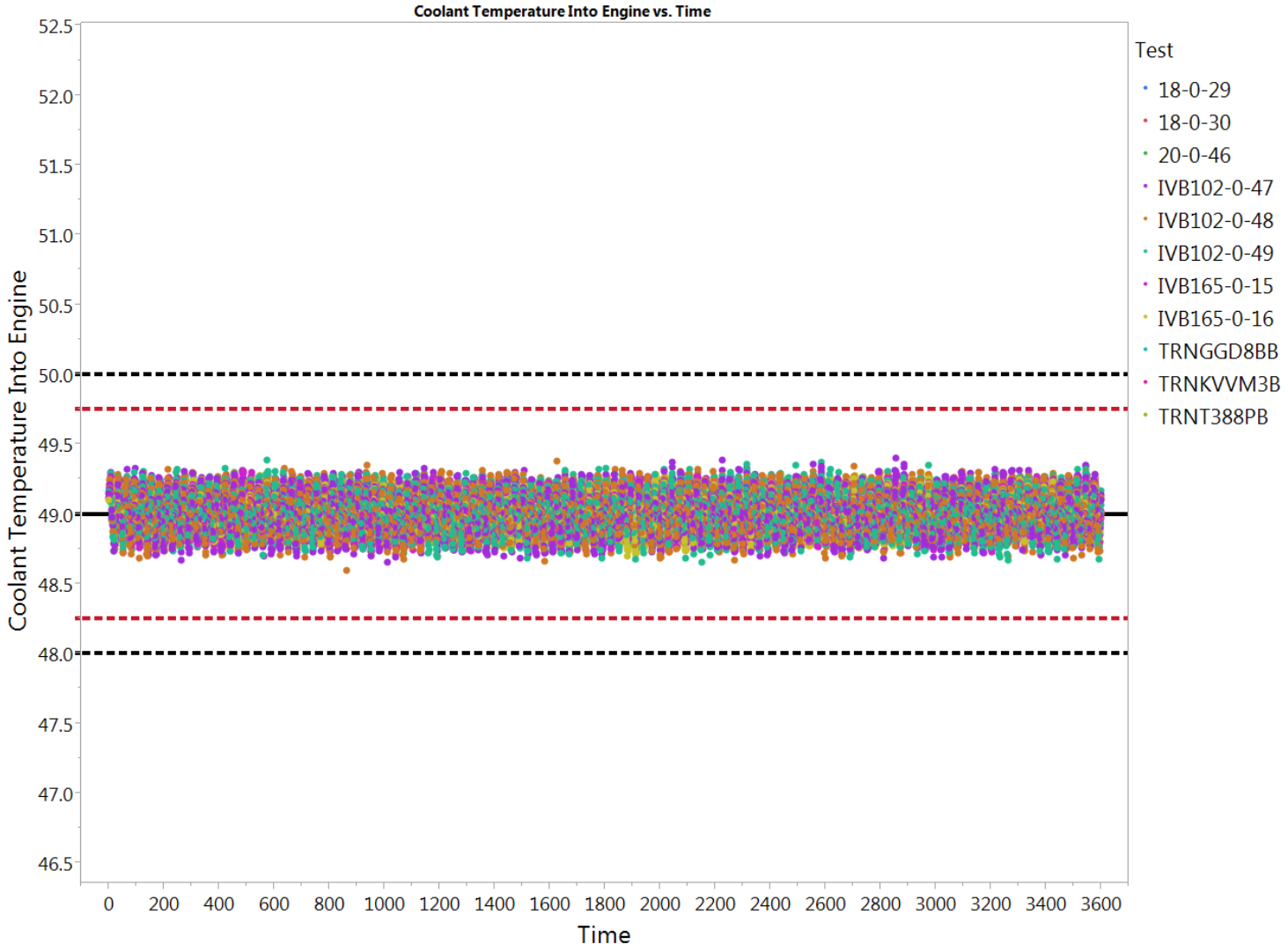
# Engine Coolant Temp In QI Lab = SwRI

- Target : 49 C
- Window size 1: +/- 1.0 C
- Window size 2: +/- 0.75 C



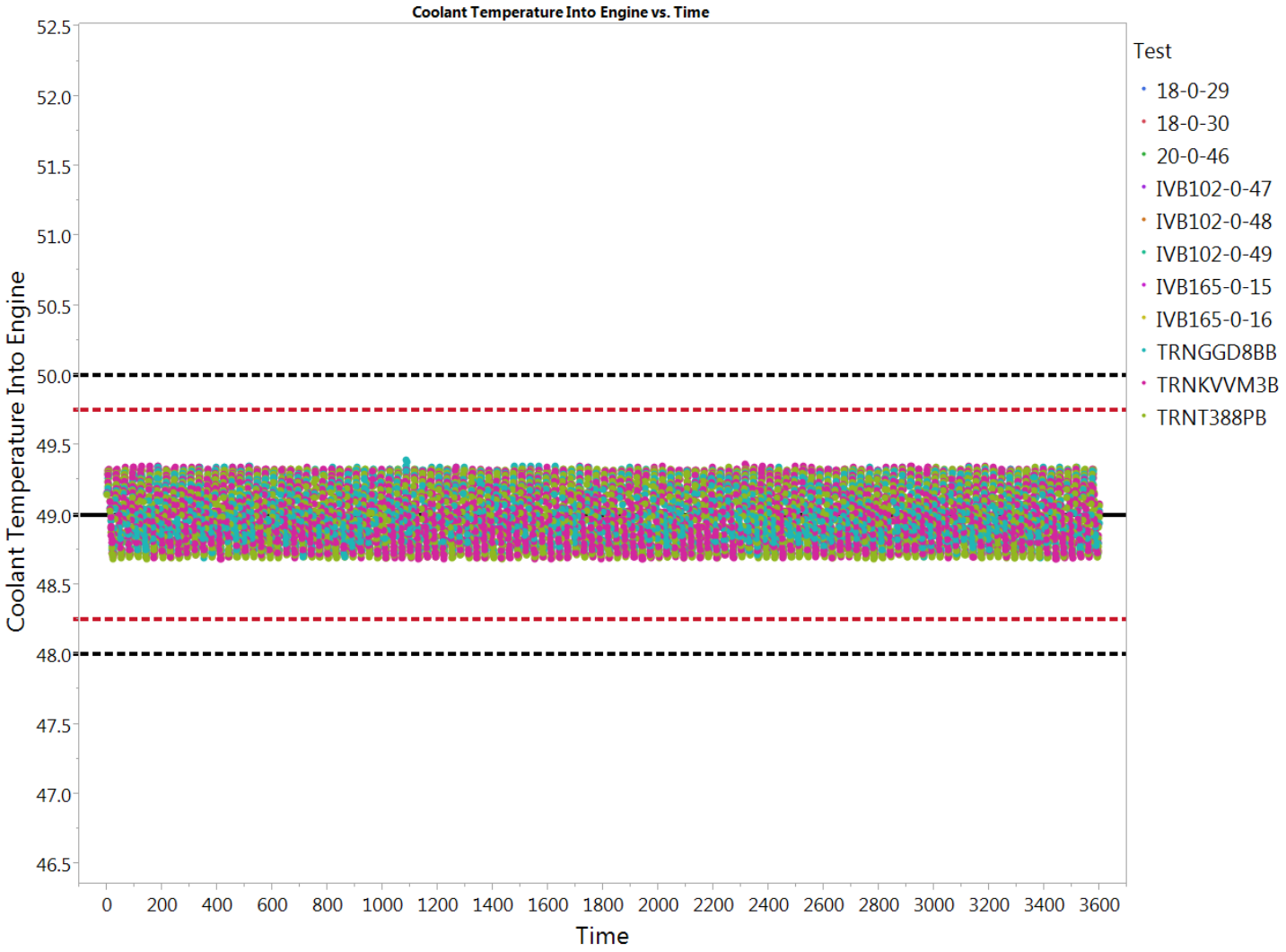
# Engine Coolant Temp In QI Lab = IAR

- Target : 49 C
- Window size 1: +/- 1.0 C
- Window size 2: +/- 0.75 C



# Engine Coolant Temp In QI Lab = LZ

- Target : 49 C
- Window size 1: +/- 1.0 C
- Window size 2: +/- 0.75 C



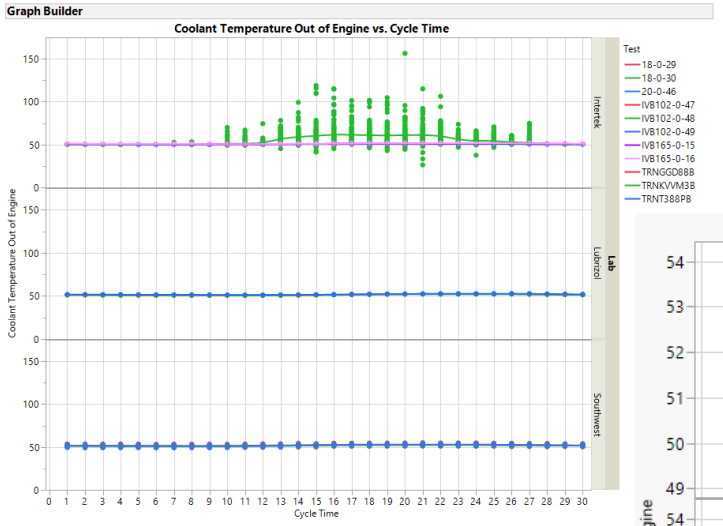
# Engine Coolant Temp In QI

- Target : 49 C
- Window size 1: +/- 1.0 C
- Window size 2: +/- 0.75 C

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | 0.68 | 0.42 |
| 18-0-30 | 0.81 | 0.66 |
| 20-0-46 | 0.80 | 0.64 |
| 102-0-47 | 0.98 | 0.96 |
| 102-0-48 | 0.98 | 0.96 |
| 102-0-49 | 0.98 | 0.96 |
| 165-0-15 | 0.98 | 0.96 |
| 165-0-16 | 0.98 | 0.96 |
| TRNGGD8BB | 0.96 | 0.92 |
| TRNKVVM3B | 0.95 | 0.92 |
| TRNT388PB | 0.96 | 0.92 |
| **Average** | **0.91** | **0.84** |

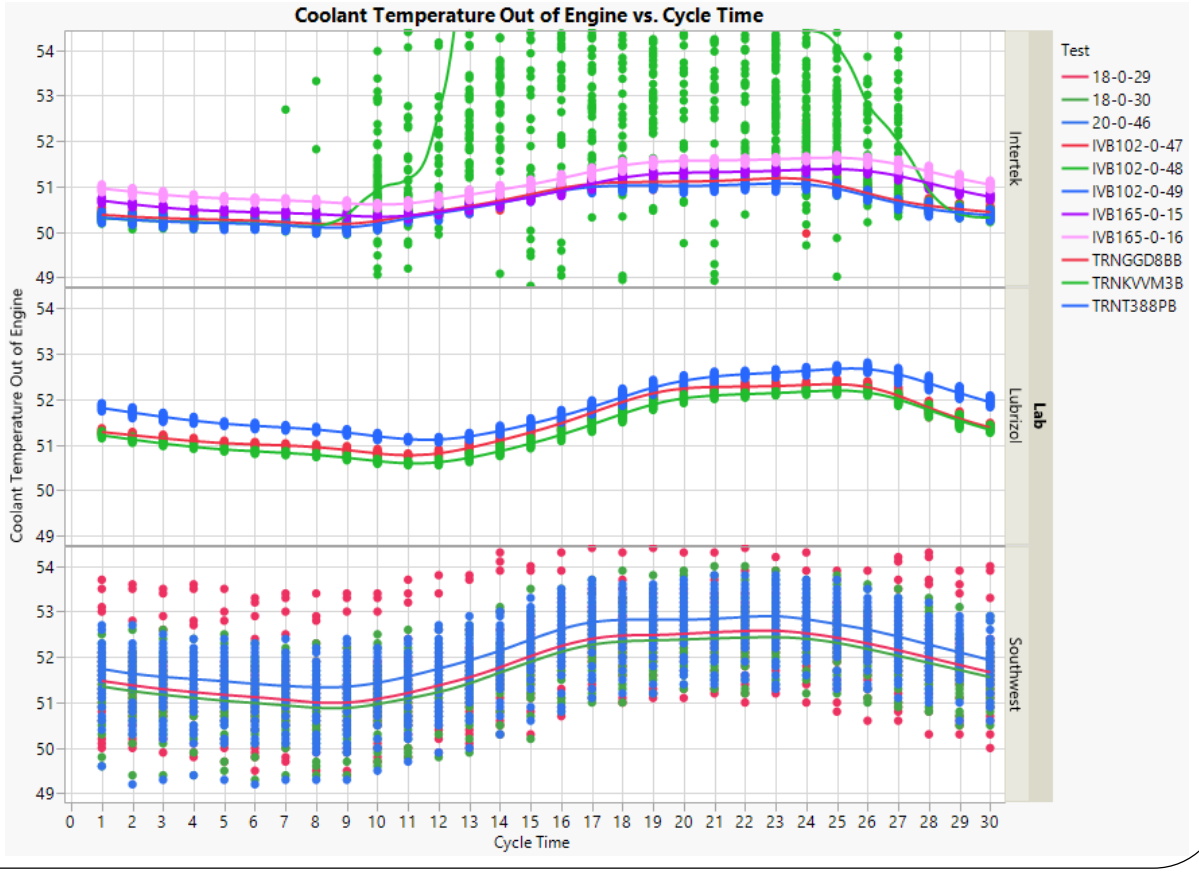
# Coolant Temperature Out of Engine

# Coolant Temperature Out of Engine



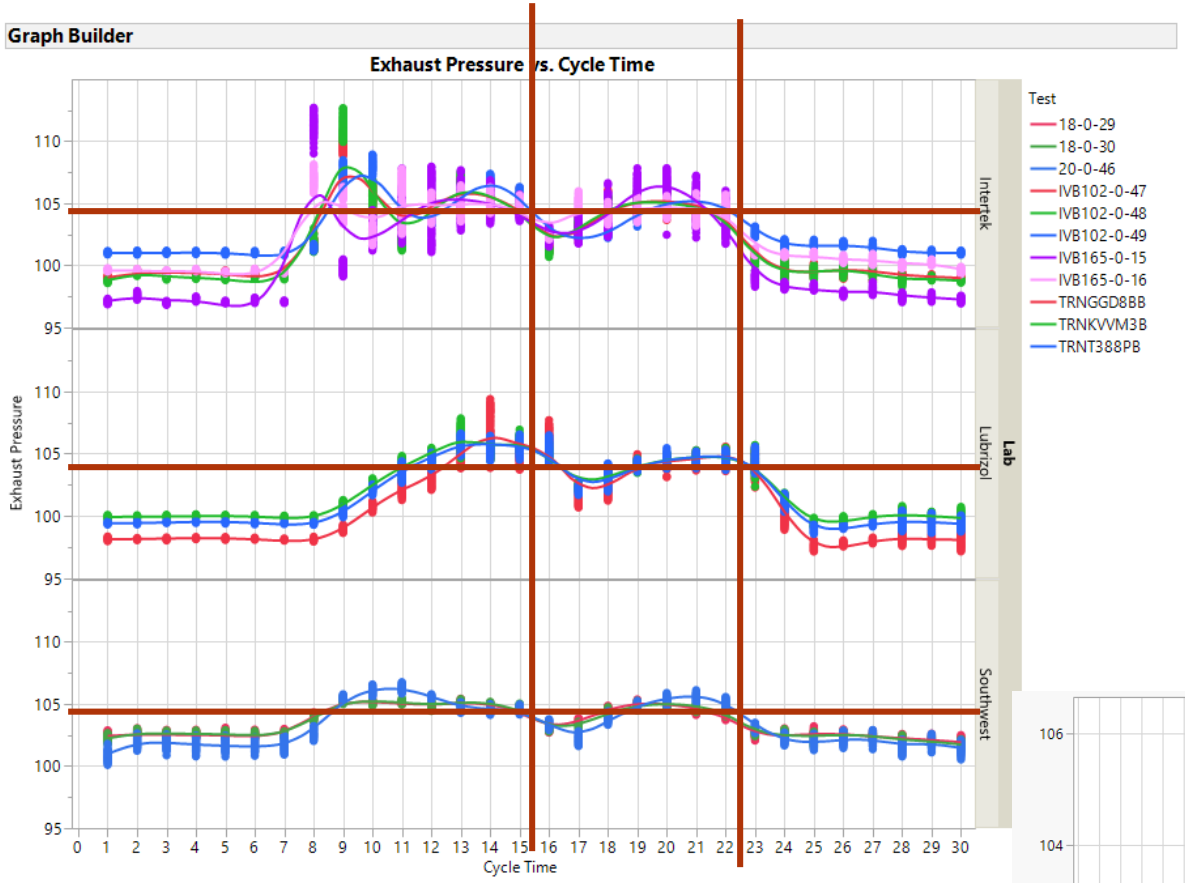

102-0-48 has higher temperature

LZ's coolant temperature profile is ~2 second behind the other labs



# Exhaust Pressure

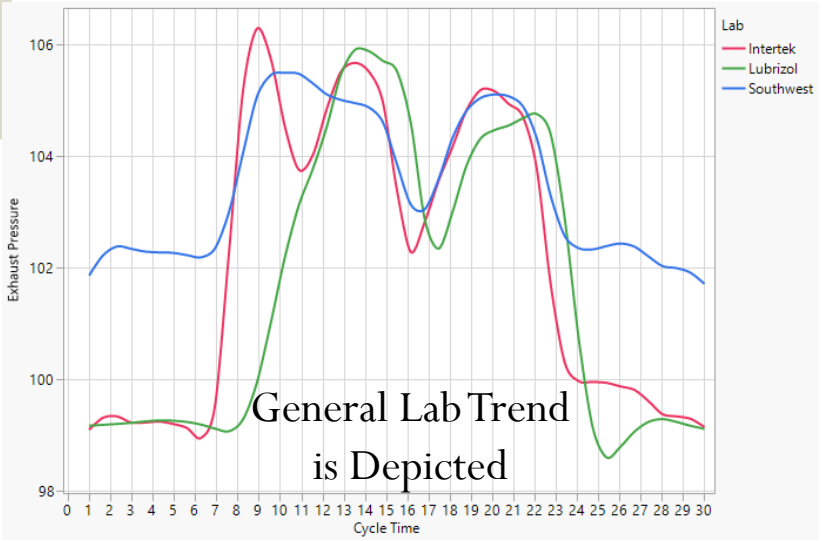
# Exhaust Pressure




The change in exhaust pressure during the transition from stage 1 to 2 at IAR has an additional peak compared to the other labs

LZ's profile is ~2 seconds behind the other labs

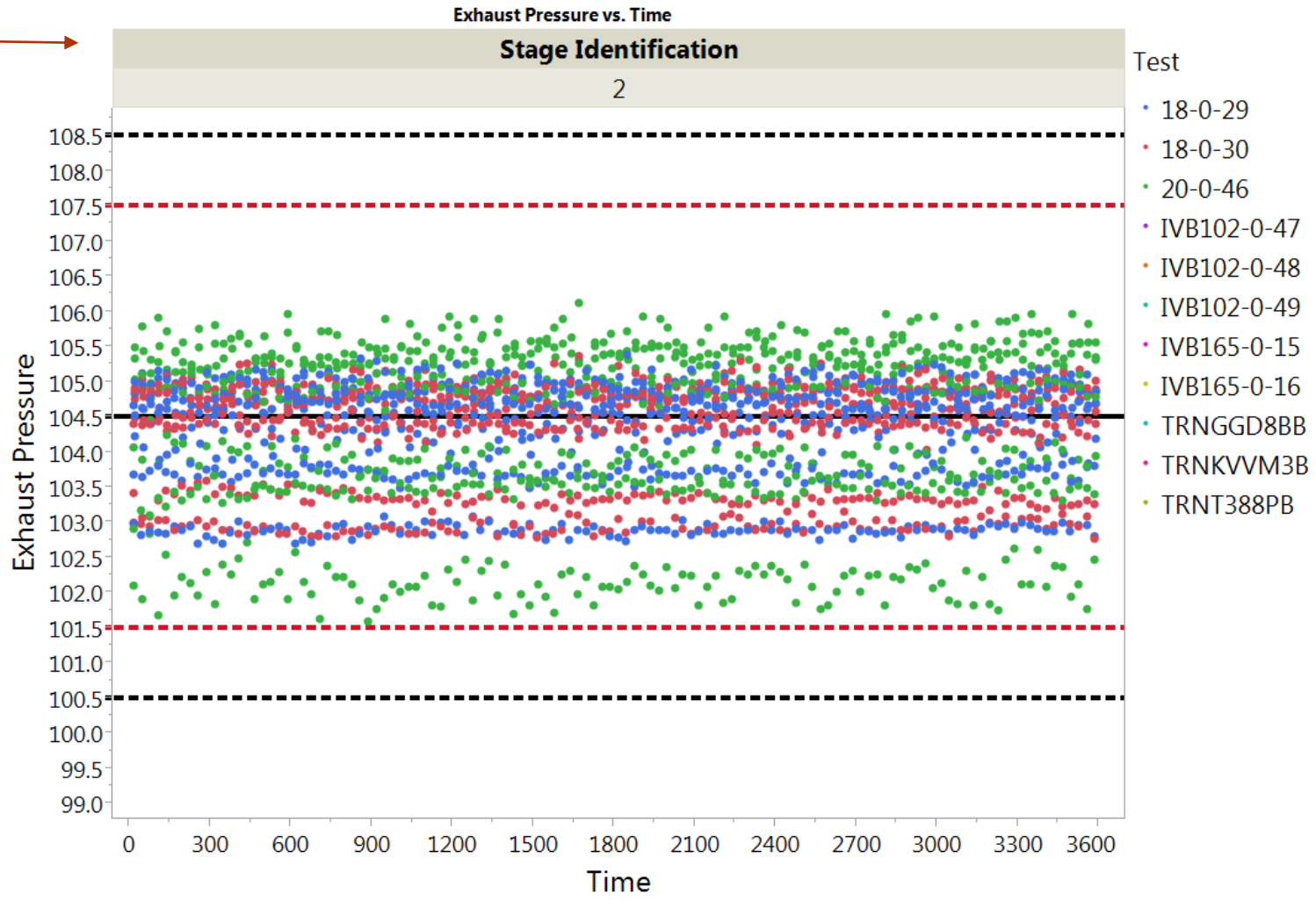
SwRI change in pressure is less than the other labs due to its pressure in stage 1 and the transition from stage 2 to 1



# Exhaust Backpressure QI
# Lab = SwRI

- Target : 104.5 kPa
- Window size 1: +/- 4 kPa
- Window size 2: +/- 3 kPa

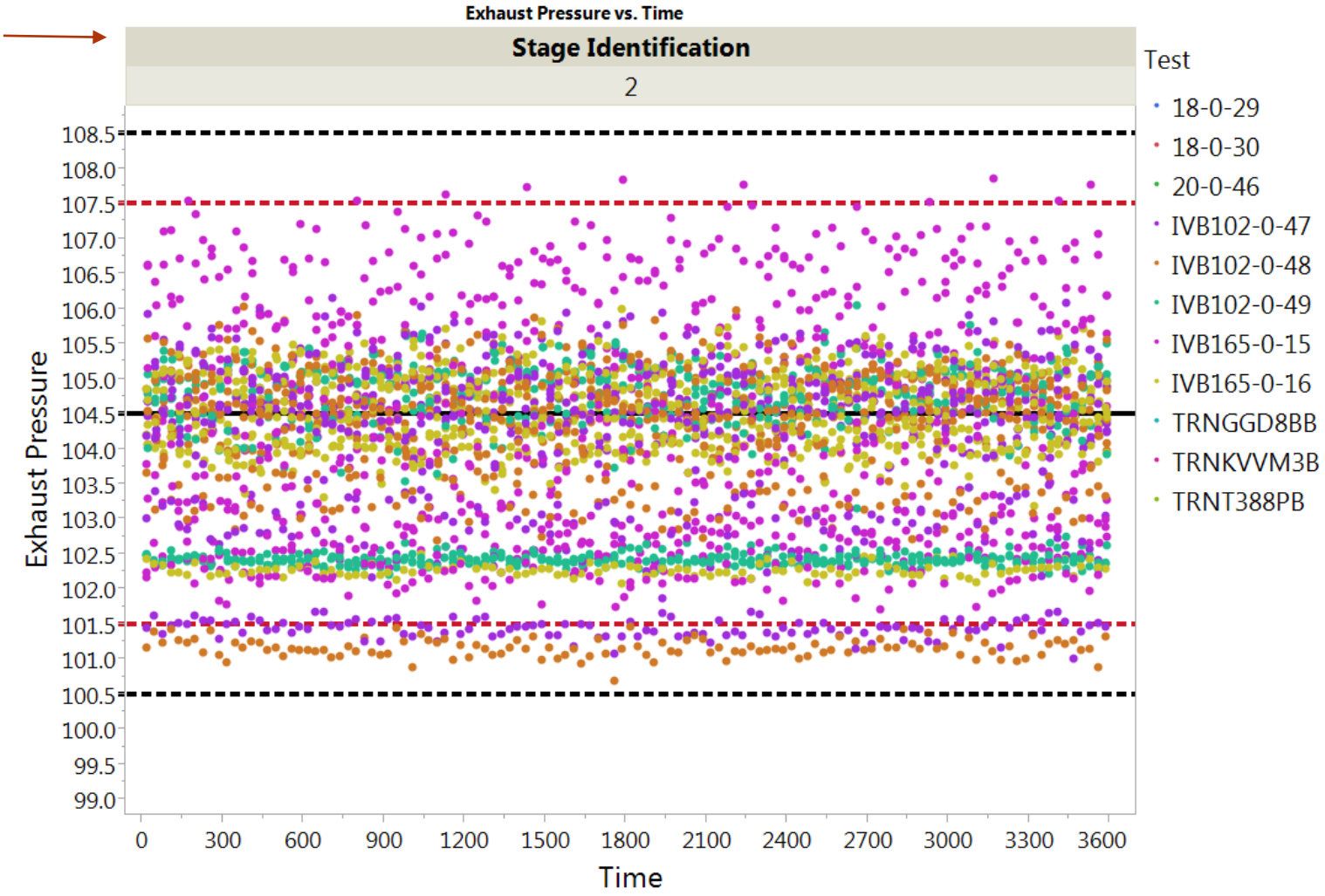
Stage 2 only



# Exhaust Backpressure QI
# Lab = IAR

- Target : 104.5 kPa
- Window size 1: +/- 4 kPa
- Window size 2: +/- 3 kPa

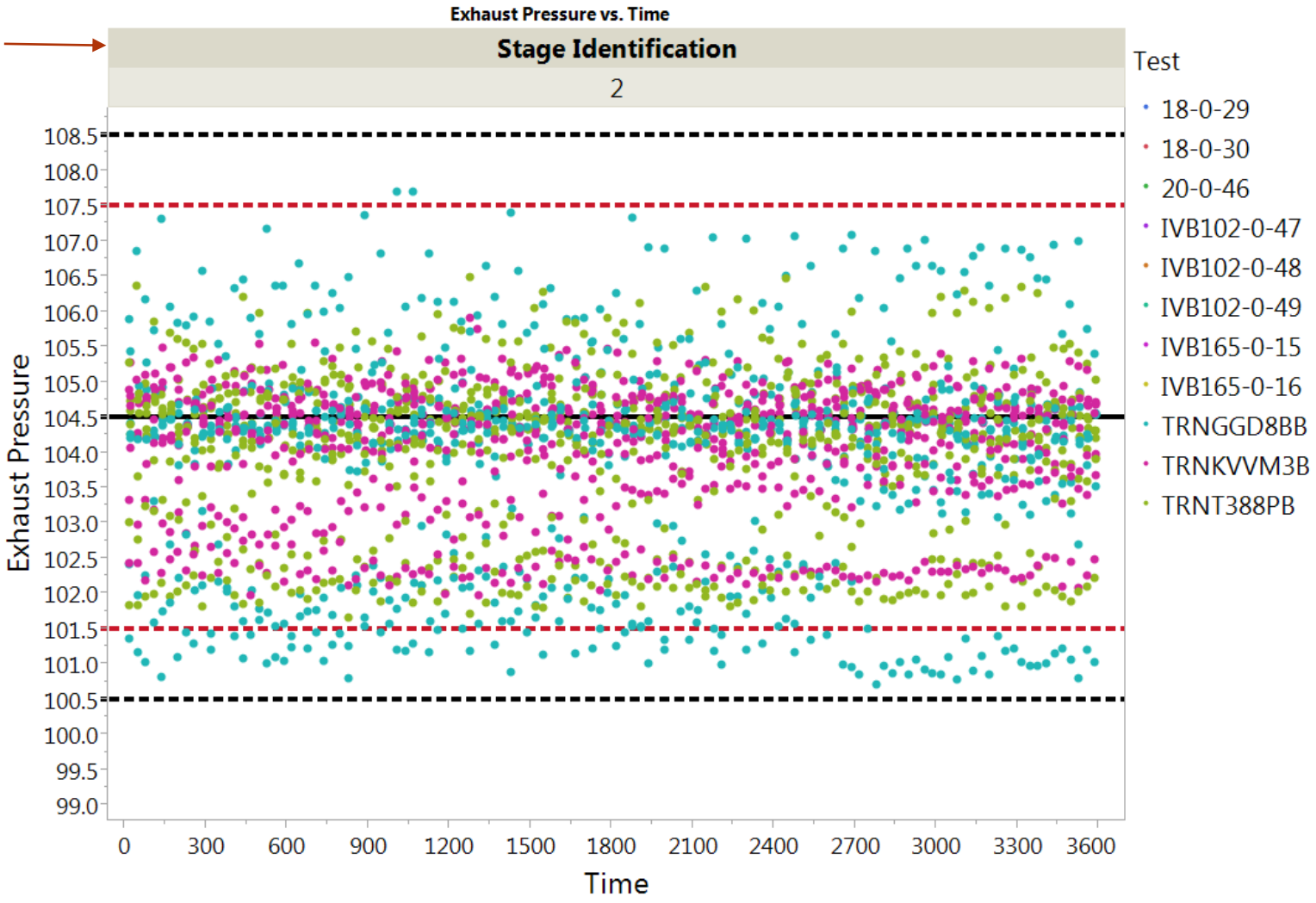
Stage 2 only



# Exhaust Backpressure QI
# Lab = LZ

- Target : 104.5 kPa
- Window size 1: +/- 4 kPa
- Window size 2: +/- 3 kPa

Stage 2 only



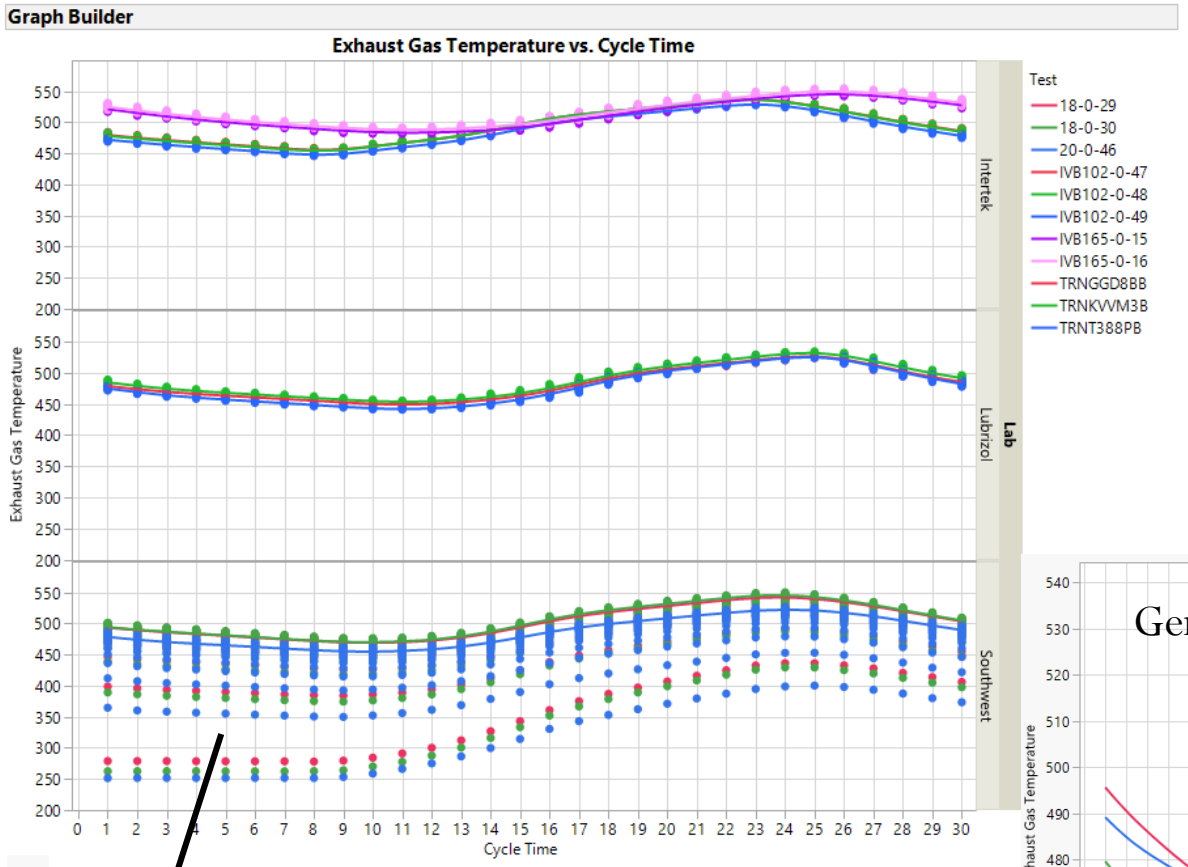
# Exhaust Backpressure QI

- Target : 104.5 kPa
- Window size 1: +/- 4 kPa
- Window size 2: +/- 3 kPa

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | 0.96 | 0.94 |
| 18-0-30 | 0.96 | 0.93 |
| 20-0-46 | 0.91 | 0.84 |
| 102-0-47 | 0.88 | 0.79 |
| 102-0-48 | 0.88 | 0.78 |
| 102-0-49 | 0.87 | 0.78 |
| 165-0-15 | 0.82 | 0.68 |
| 165-0-16 | 0.94 | 0.90 |
| TRNGGD8BB | 0.84 | 0.71 |
| TRNKVVM3B | 0.94 | 0.89 |
| TRNT388PB | 0.91 | 0.84 |
| **Average** | **0.90** | **0.83** |

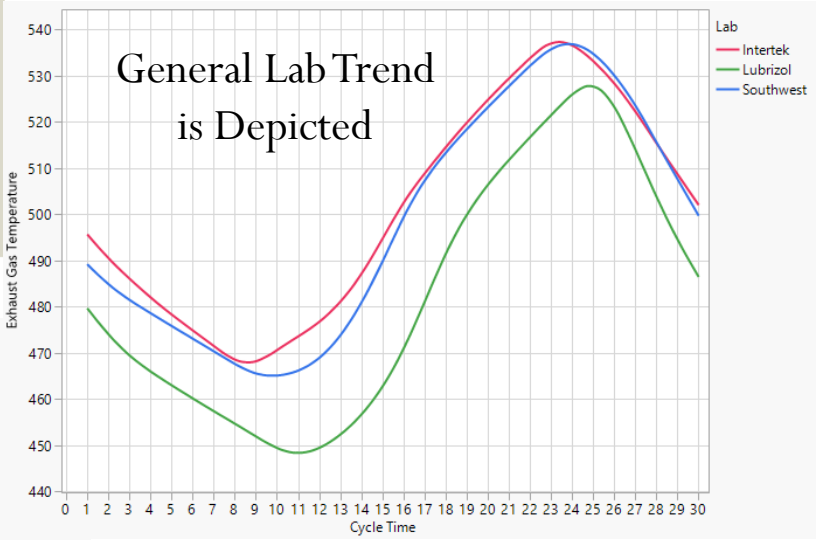
# Exhaust Gas Temperature

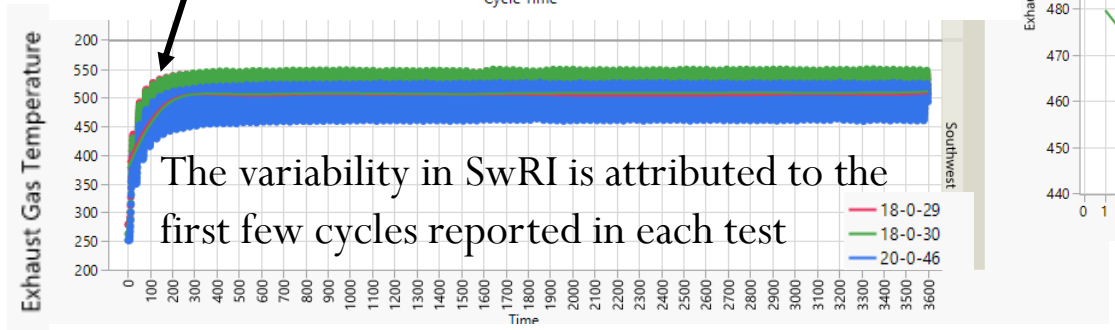
# Exhaust Gas Temperature




The profiles of the stands at IAR are offset from one another

LZ's profile ~2 seconds behind the other labs

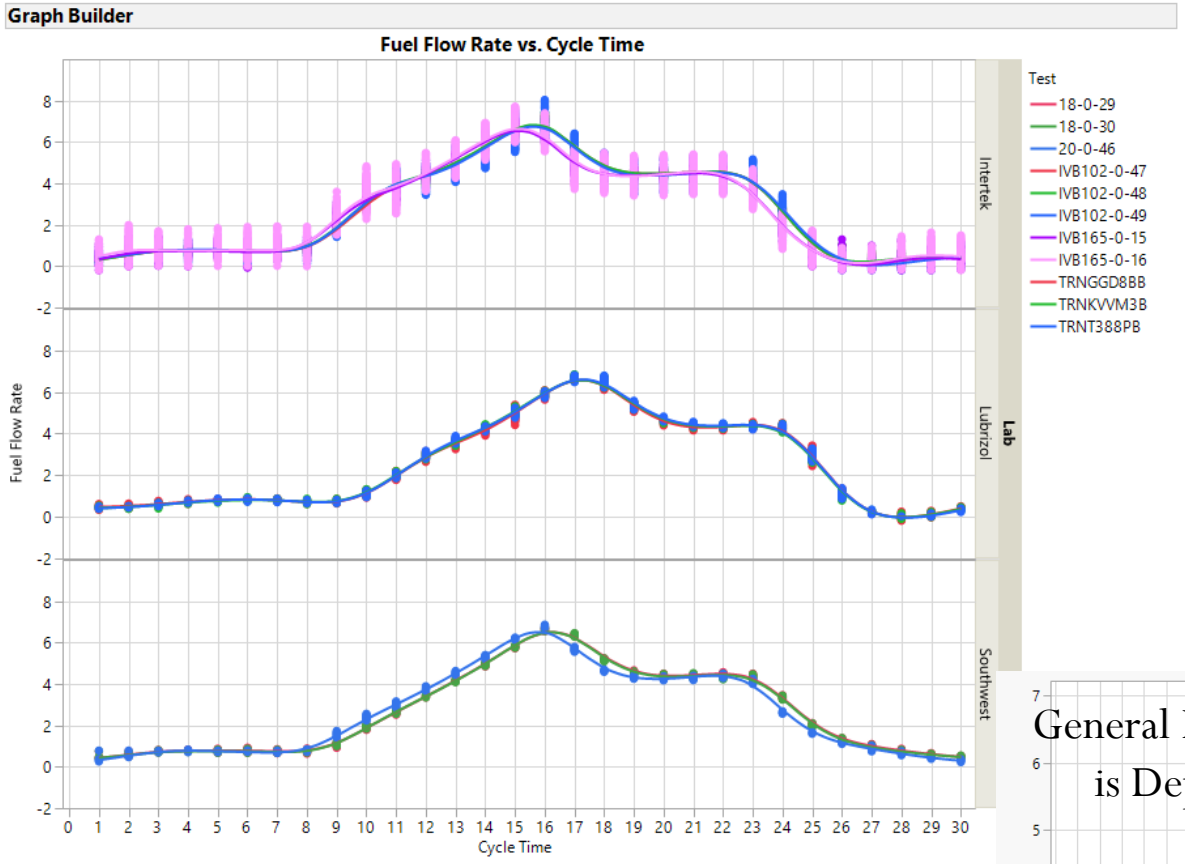


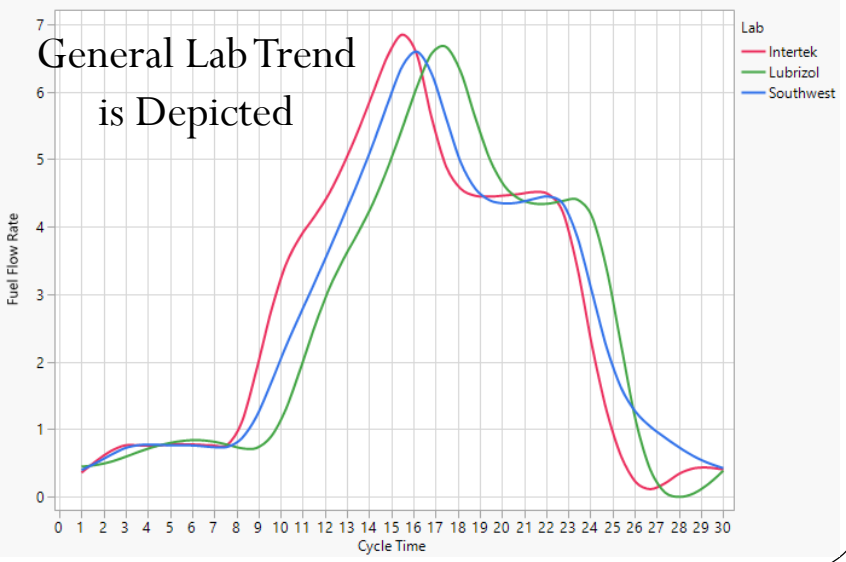

The variability in SwRI is attributed to the first few cycles reported in each test

# Fuel Flow Rate

# Fuel Flow Rate

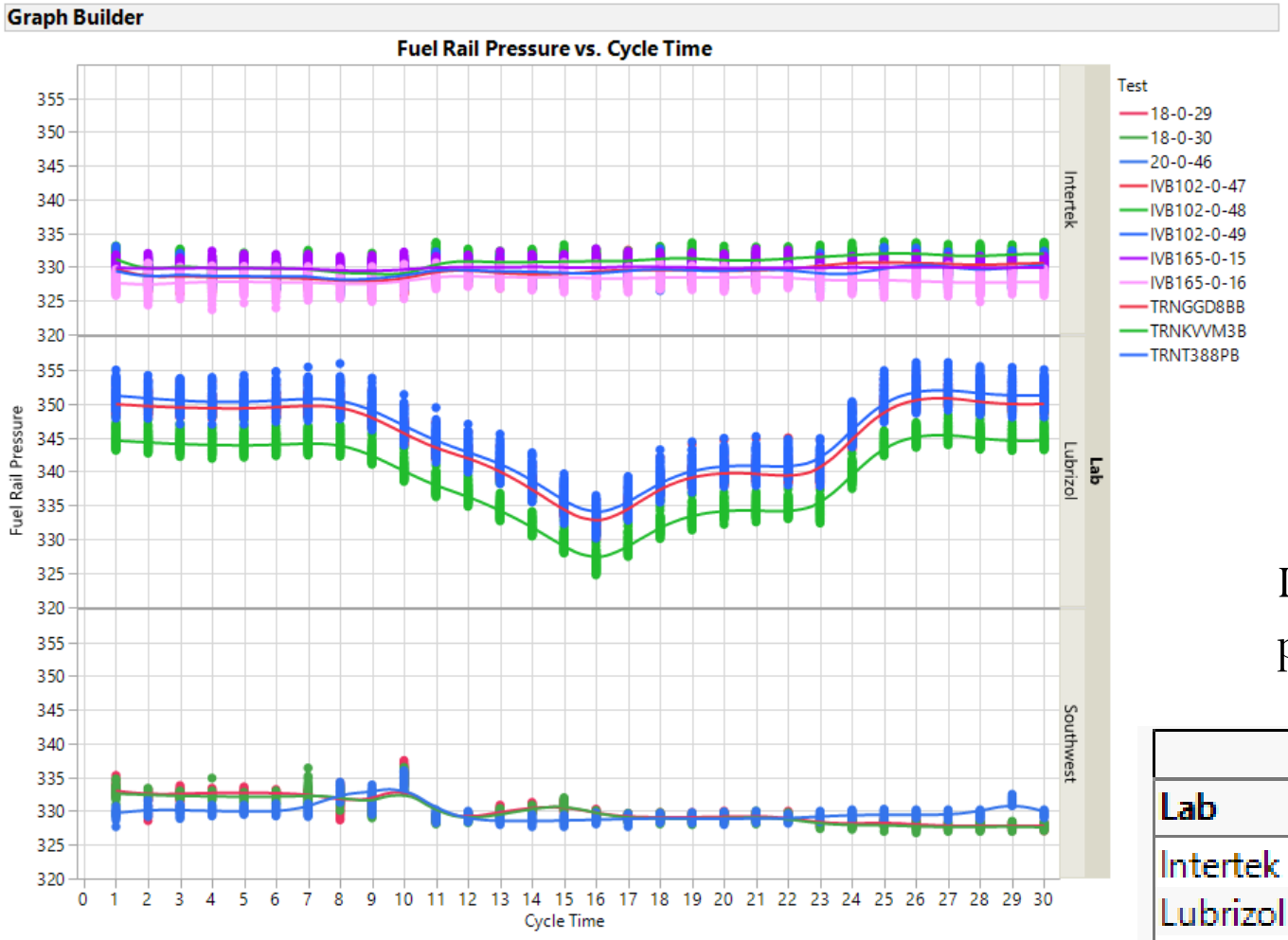



There is an offset in the cycles between the labs with SwRI being 1 second behind IAR, and LZ being 1 second behind SwRI.



# Fuel Rail Pressure

# Fuel Rail Pressure

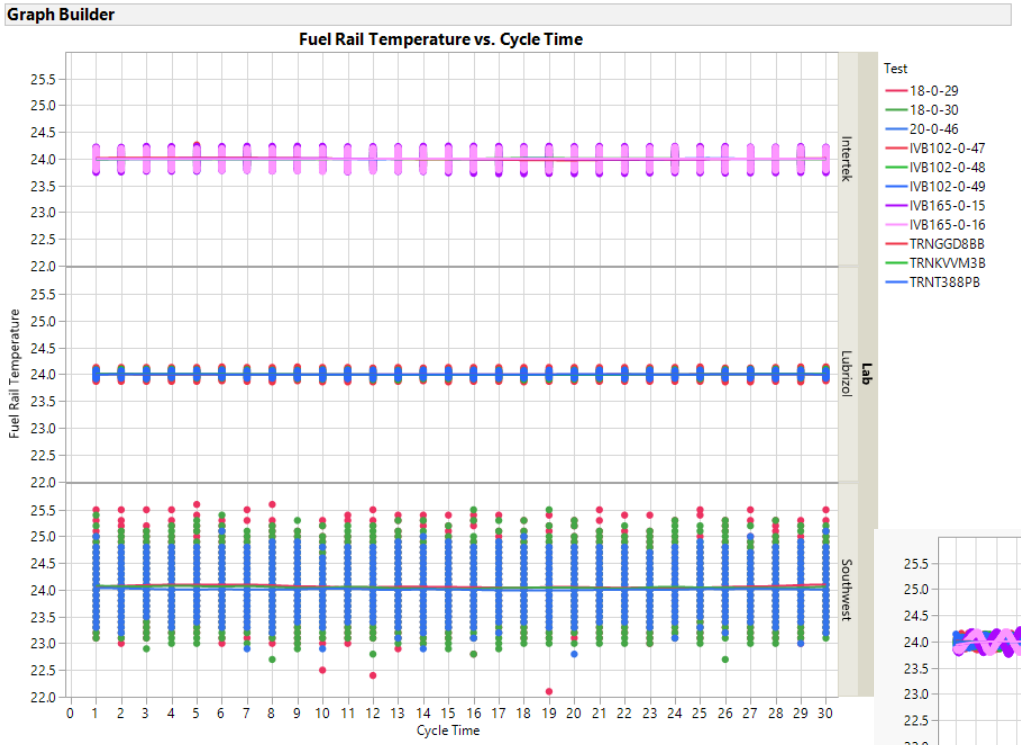



Labs have different pressure profiles

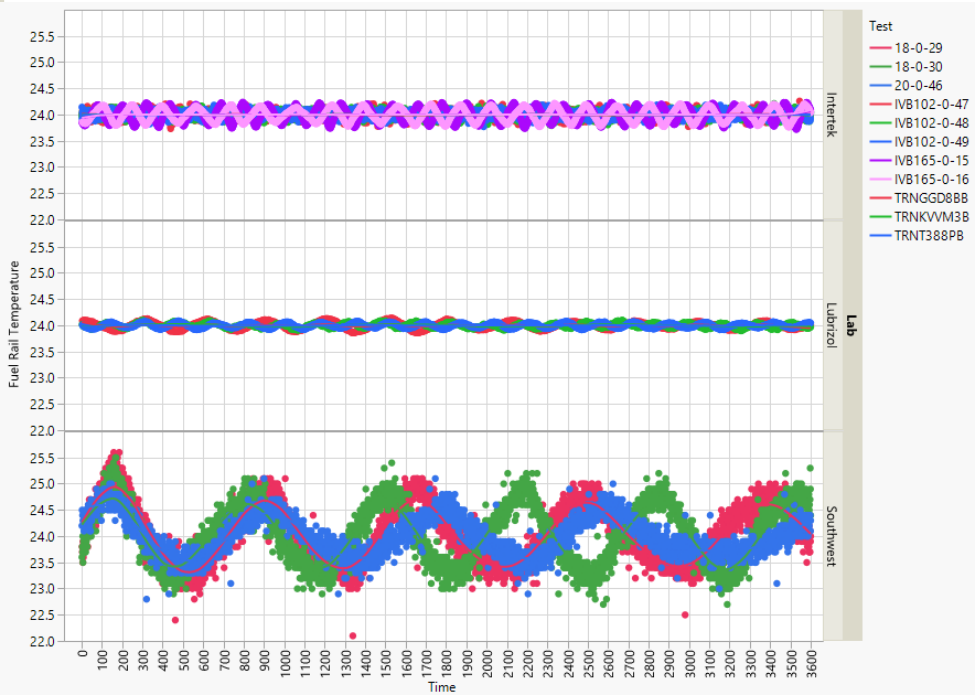
| | Fuel Rail Pressure |
|---|---|
| Lab | Mean |
| Intertek | 329.46337 |
| Lubrizol | 343.071966 |
| Southwest | 329.958435 |

# Fuel Rail Temperature

# Fuel Rail Temperature

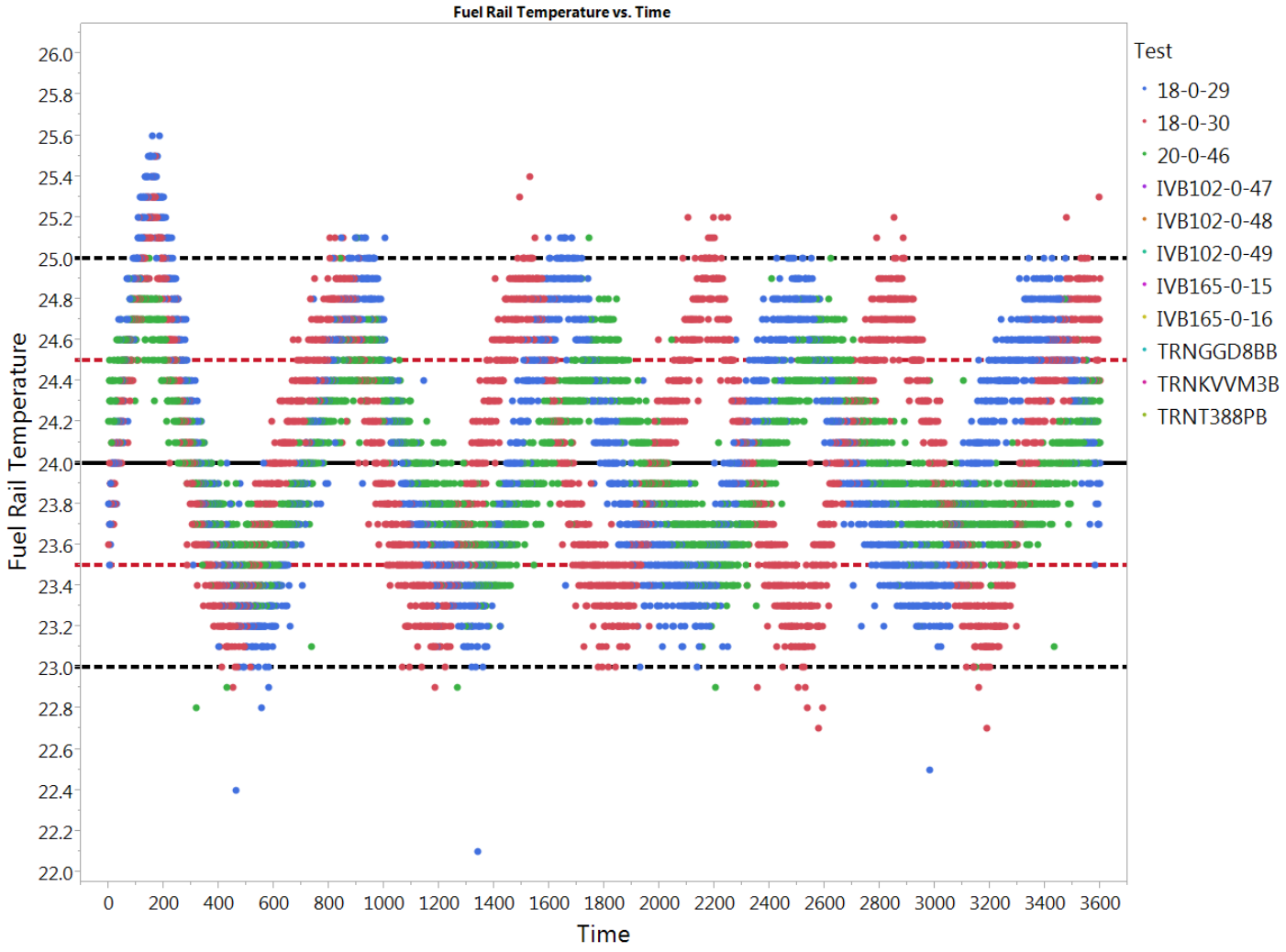



The increased variability at SwRI is due to the cycling of Fuel Rail Temperature over the hour of data



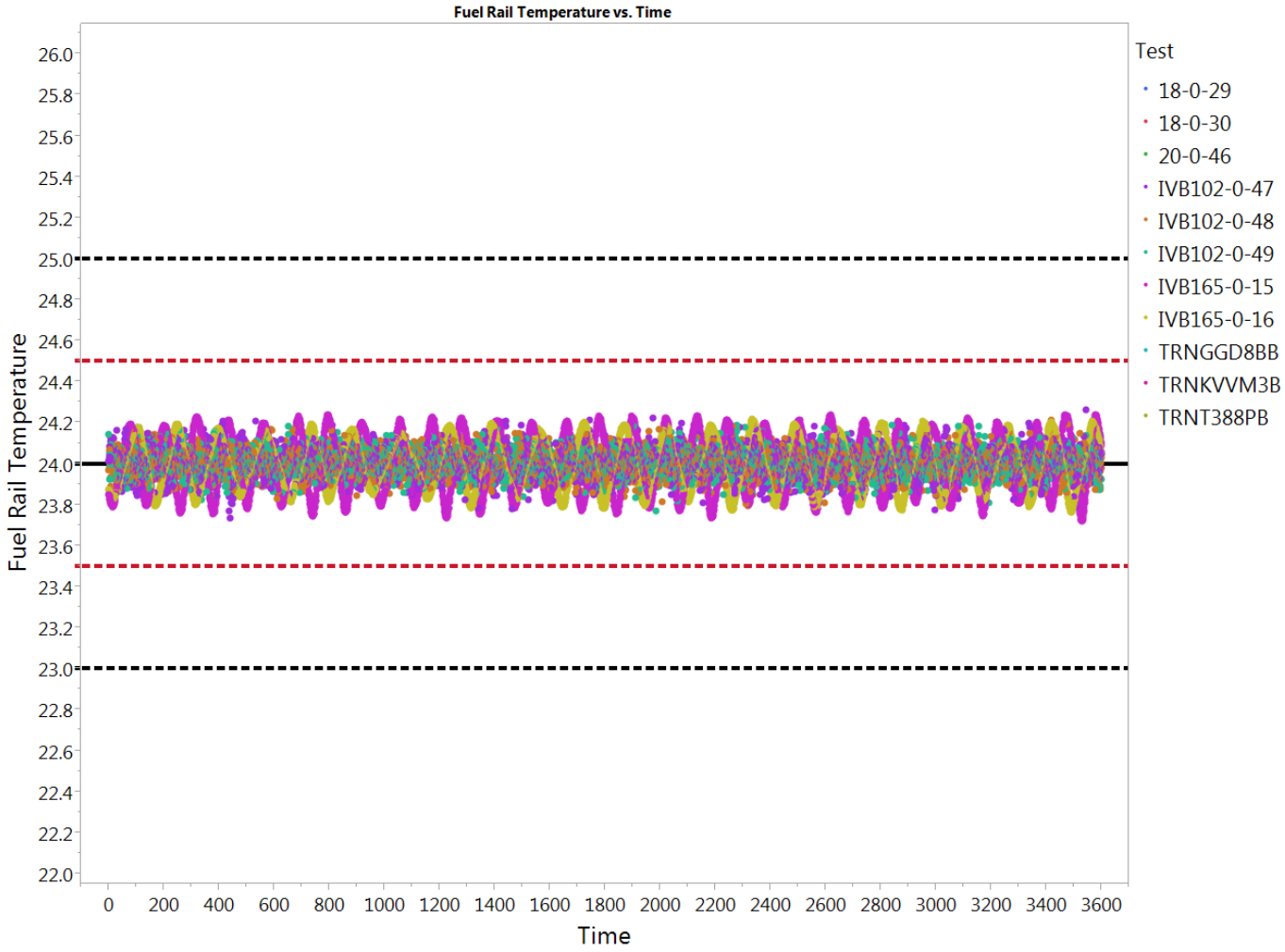
# Fuel Rail Temp QI
# Lab = SwRI

- Target : 24 C
- Window size 1: +/- 1 C
- Window size 2: +/- 0.5 C



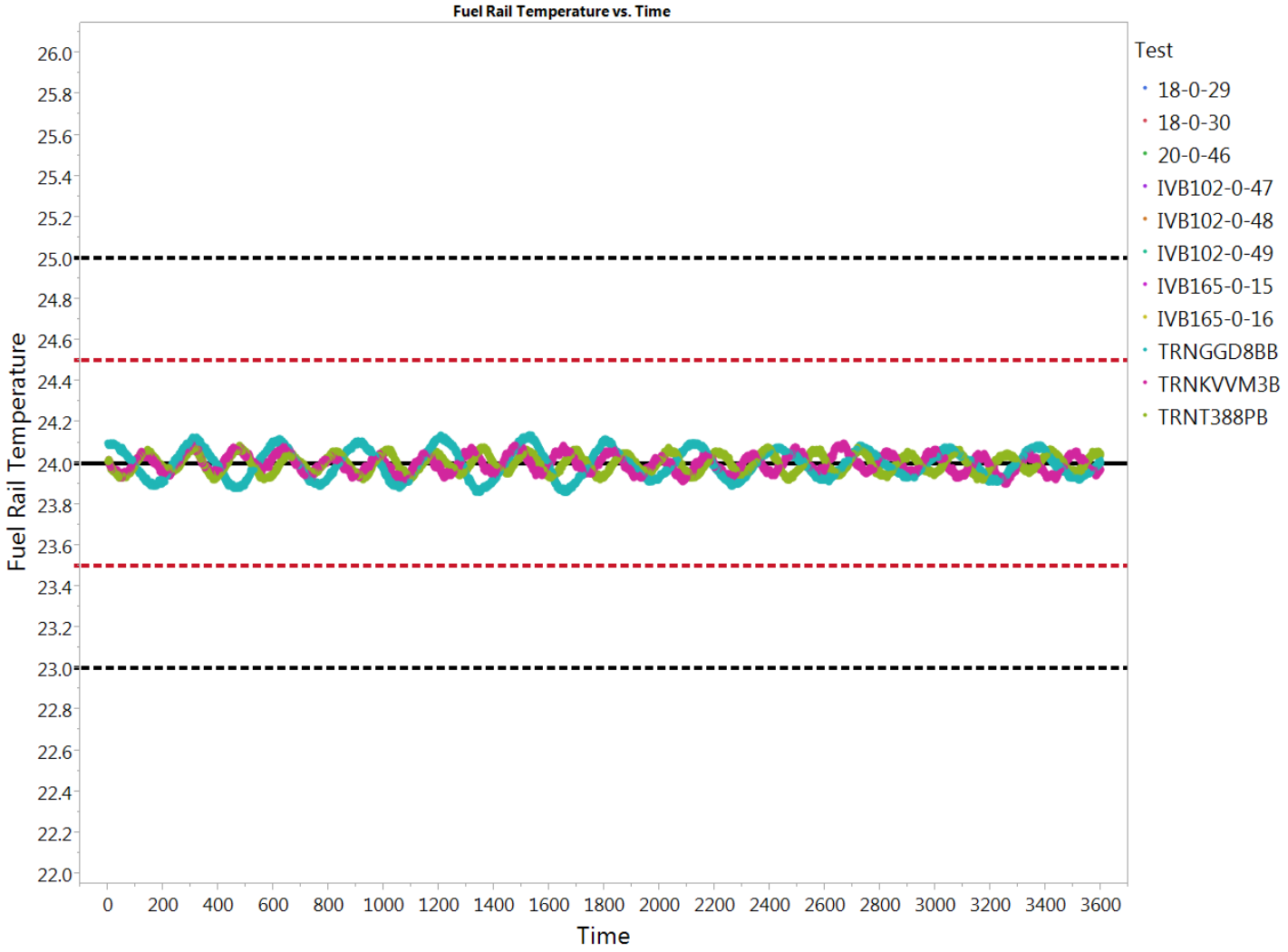
# Fuel Rail Temp QI
# Lab = IAR

- Target : 24 C
- Window size 1: +/- 1 C
- Window size 2: +/- 0.5 C



# Fuel Rail Temp QI
# Lab = LZ

- Target : 24 C
- Window size 1: +/- 1 C
- Window size 2: +/- 0.5 C



# Fuel Rail Temp QI

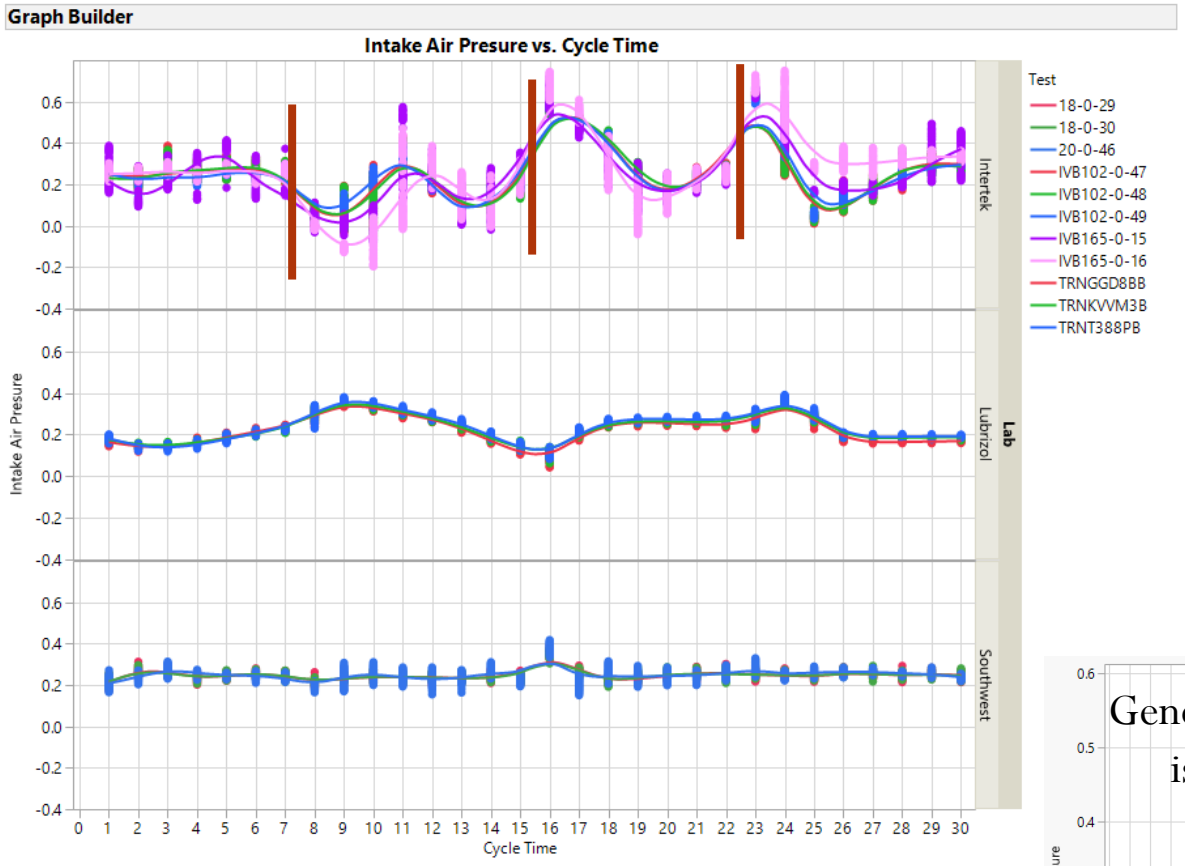
- Target : 24 C
- Window size 1: +/- 1 C
- Window size 2: +/- 0.5 C

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | **0.68** | -0.26 |
| 18-0-30 | **0.67** | -0.30 |
| 20-0-46 | **0.87** | 0.47 |
| 102-0-47 | 0.99 | 0.98 |
| 102-0-48 | 0.99 | 0.99 |
| 102-0-49 | 0.99 | 0.99 |
| 165-0-15 | **0.98** | 0.92 |
| 165-0-16 | **0.99** | 0.94 |
| TRNGGD8BB | 0.99 | 0.98 |
| TRNKVVM3B | 0.99 | 0.99 |
| TRNT388PB | 0.99 | 0.99 |
| **Average** | **0.92** | **0.97*** |

* - Average calculated without SwRI tests

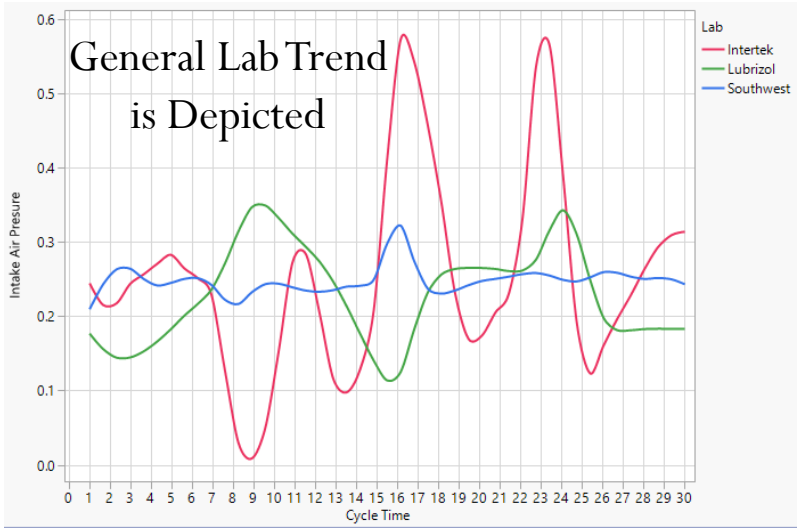
# Intake Air Pressure

# Intake Air Pressure



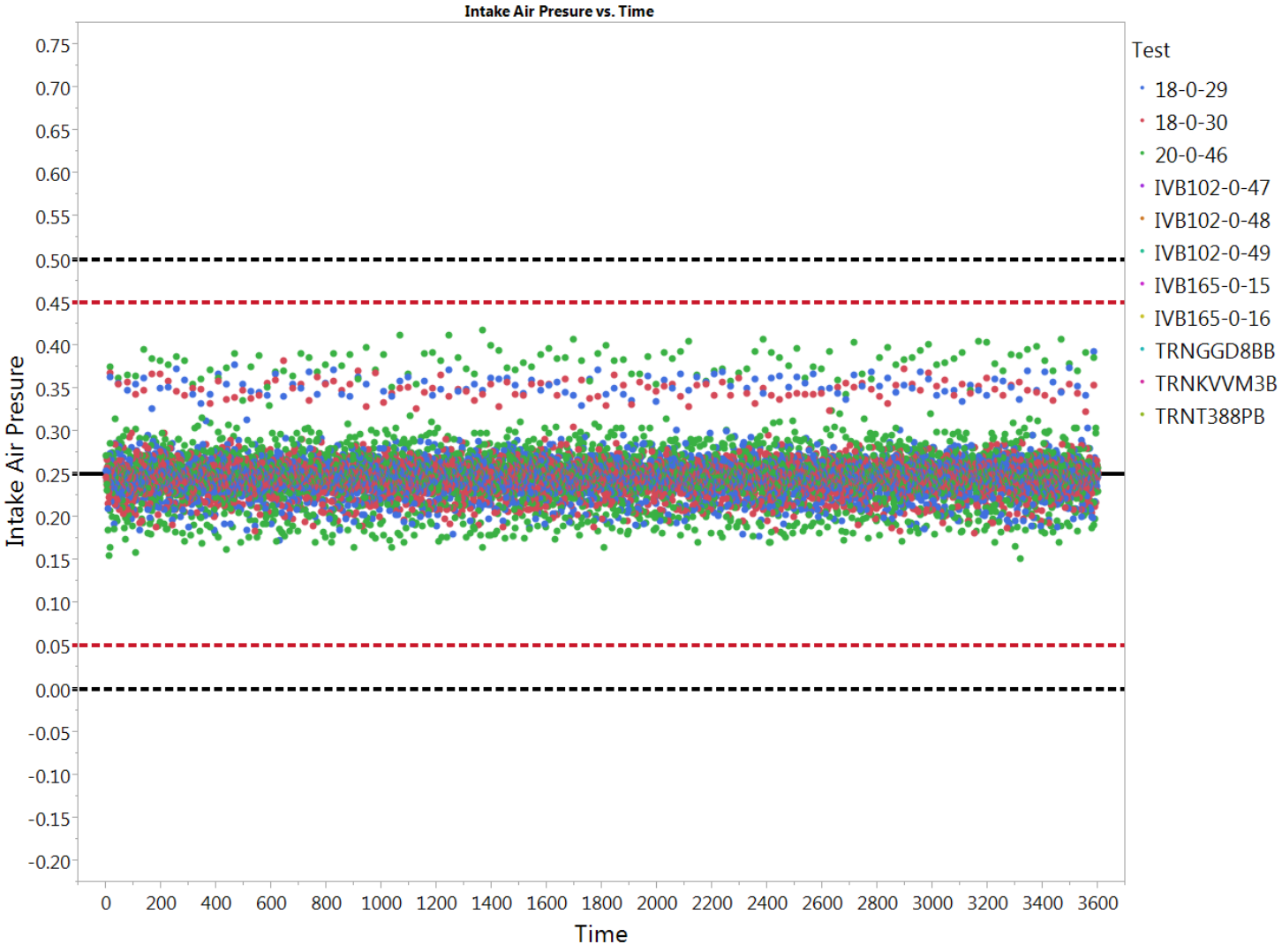

The profiles are different among the labs

IAR has the largest swing in pressure; SwRI as the least



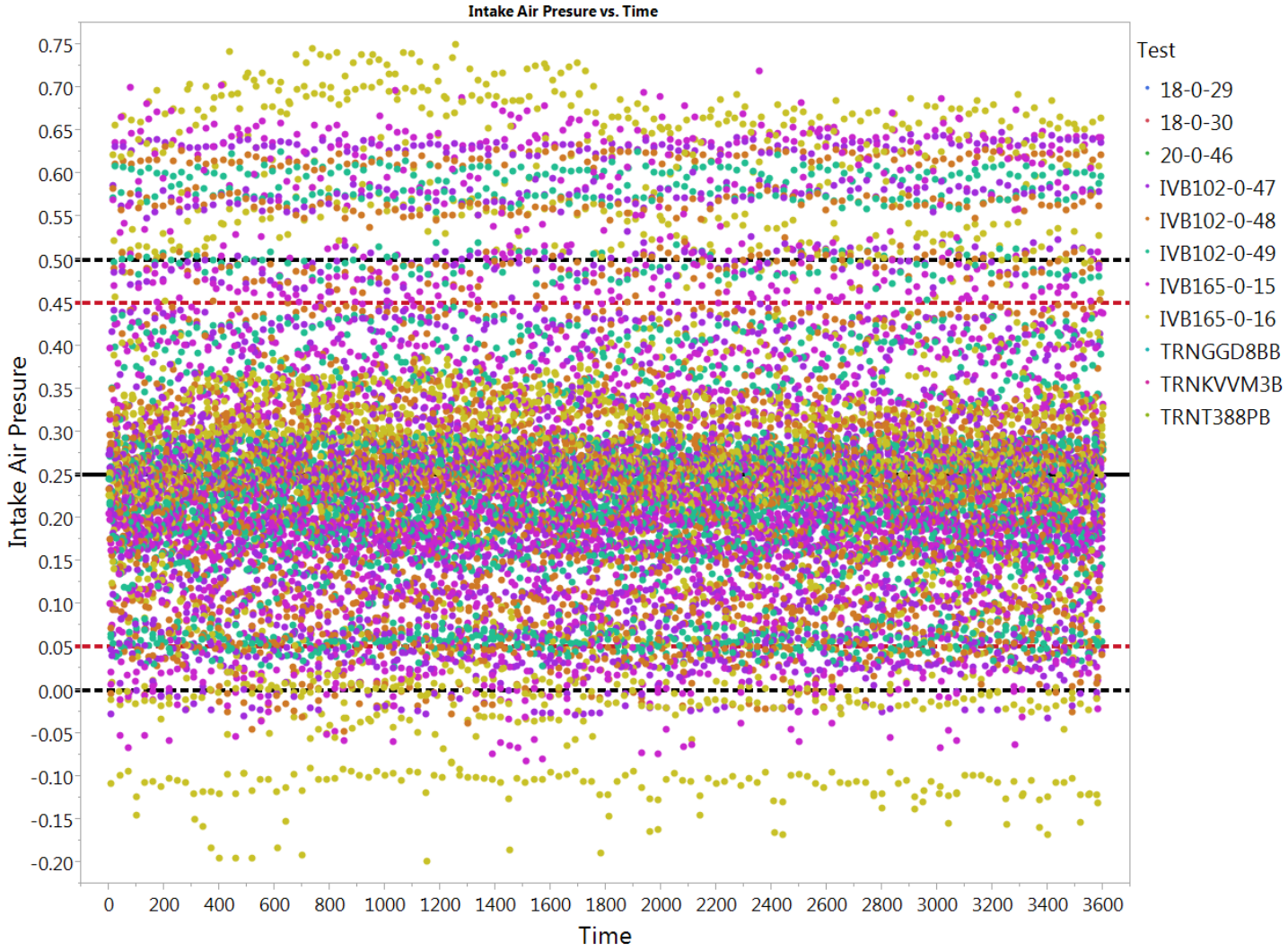
# Intake Air Pressure QI
# Lab = SwRI

- Target : 0.25 kPa
- Window size 1: +/- 0.25 kPa
- Window size 2: +/- 0.20 kPa



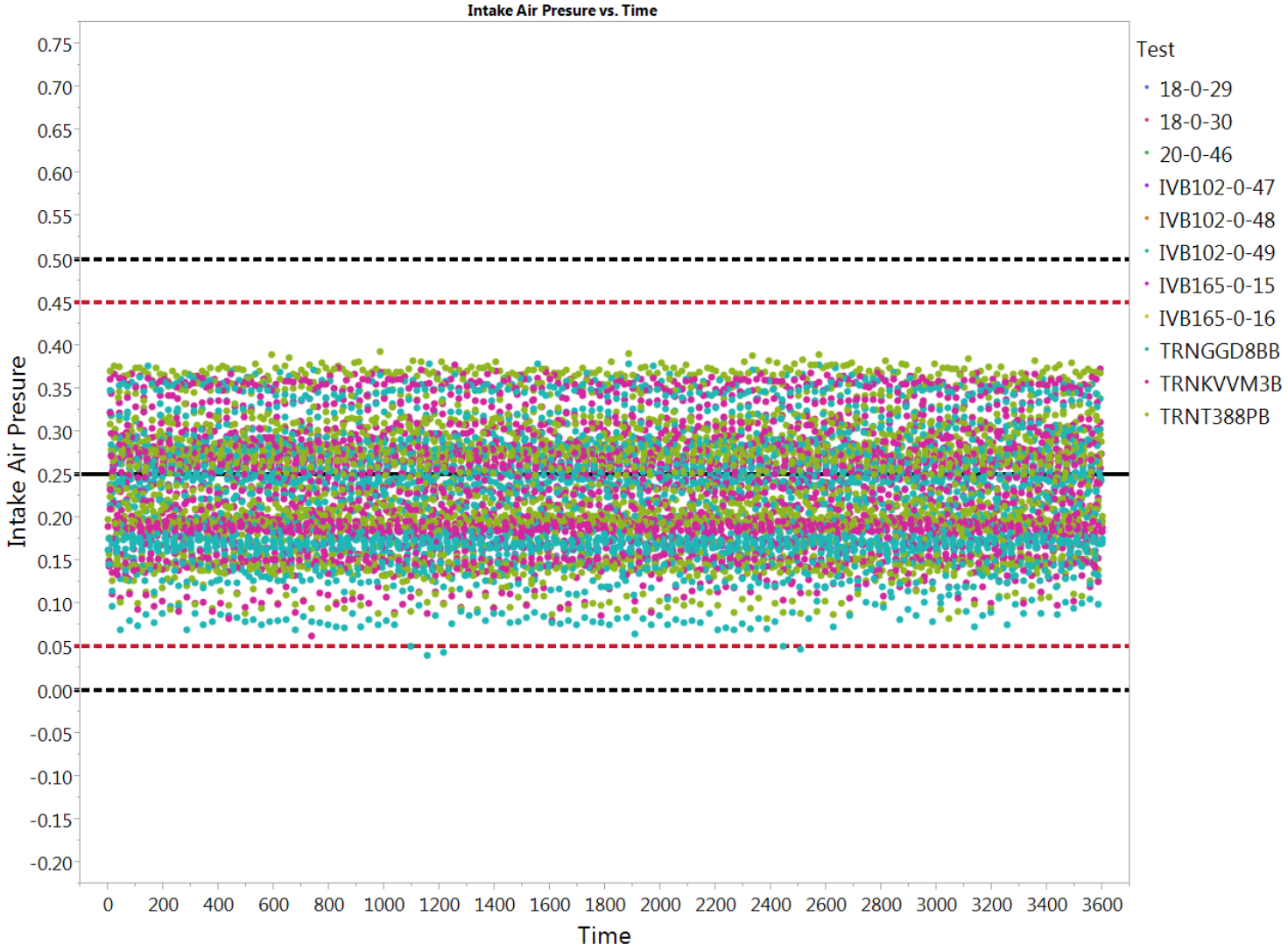
# Intake Air Pressure QI
# Lab = IAR

- Target : 0.25 kPa
- Window size 1: +/- 0.25 kPa
- Window size 2: +/- 0.20 kPa



# Intake Air Pressure QI
# Lab = LZ

- Target : 0.25 kPa
- Window size 1: +/- 0.25 kPa
- Window size 2: +/- 0.20 kPa



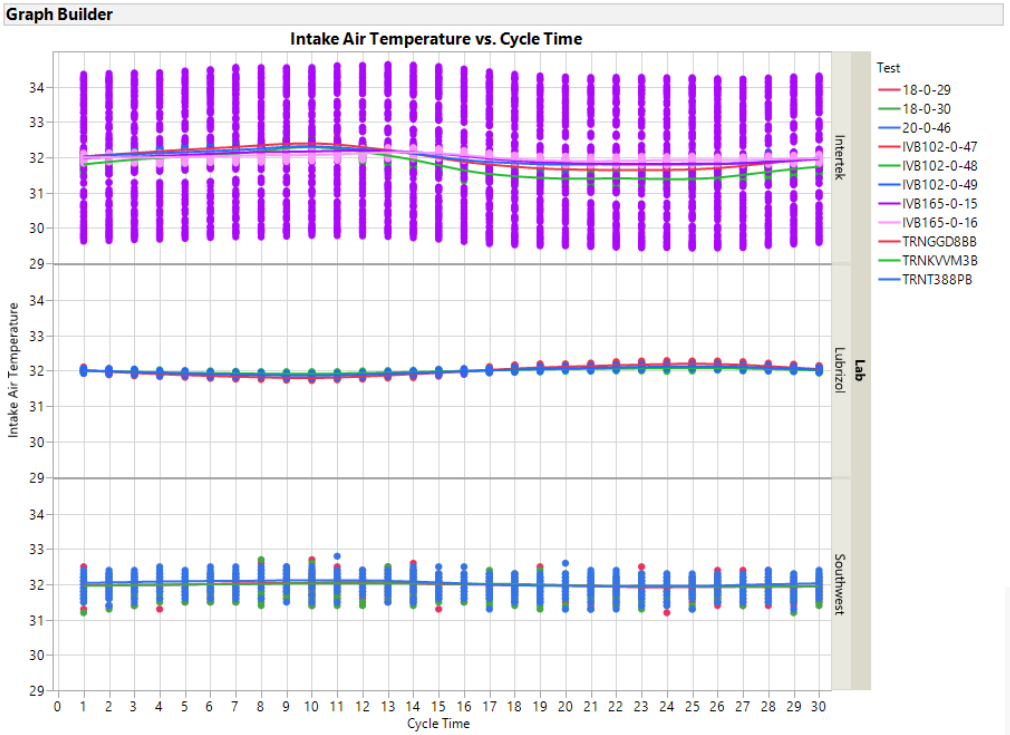
# Intake Air Pressure QI

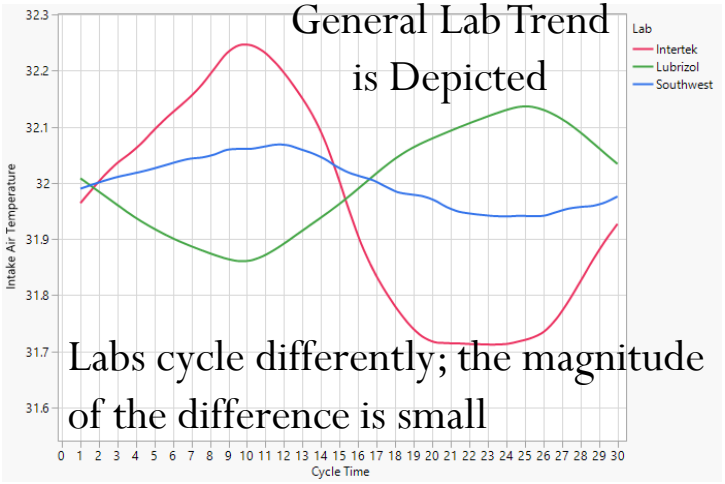
- Target : 0.25 kPa
- Window size 1: +/- 0.25 kPa
- Window size 2: +/- 0.20 kPa

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | 0.99 | 0.98 |
| 18-0-30 | 0.99 | 0.98 |
| 20-0-46 | 0.98 | 0.97 |
| 102-0-47 | 0.67 | 0.49 |
| 102-0-48 | 0.68 | 0.51 |
| 102-0-49 | 0.71 | 0.55 |
| 165-0-15 | 0.60 | 0.38 |
| 165-0-16 | 0.46 | 0.16 |
| TRNGGD8BB | 0.92 | 0.87 |
| TRNKVVM3B | 0.93 | 0.89 |
| TRNT388PB | 0.92 | 0.88 |
| **Average** | **0.80** | **0.69** |

# Intake Air Temperature

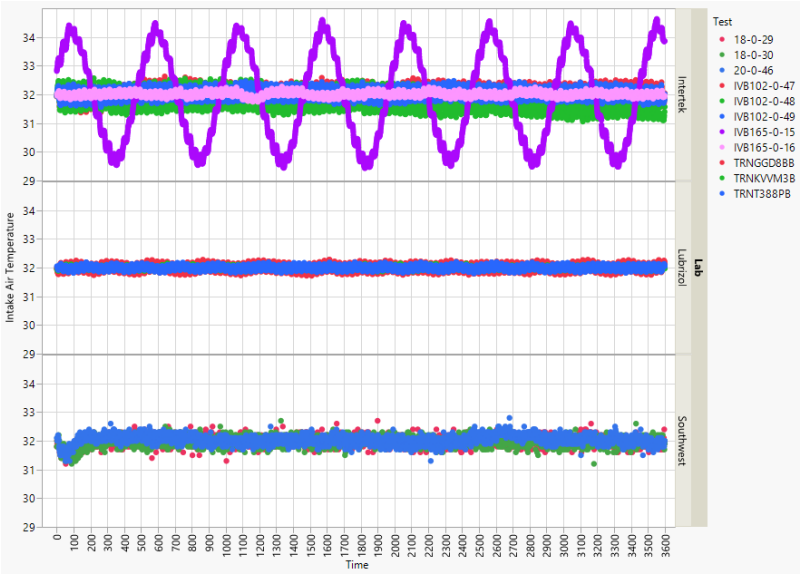
# Intake Air Temperature



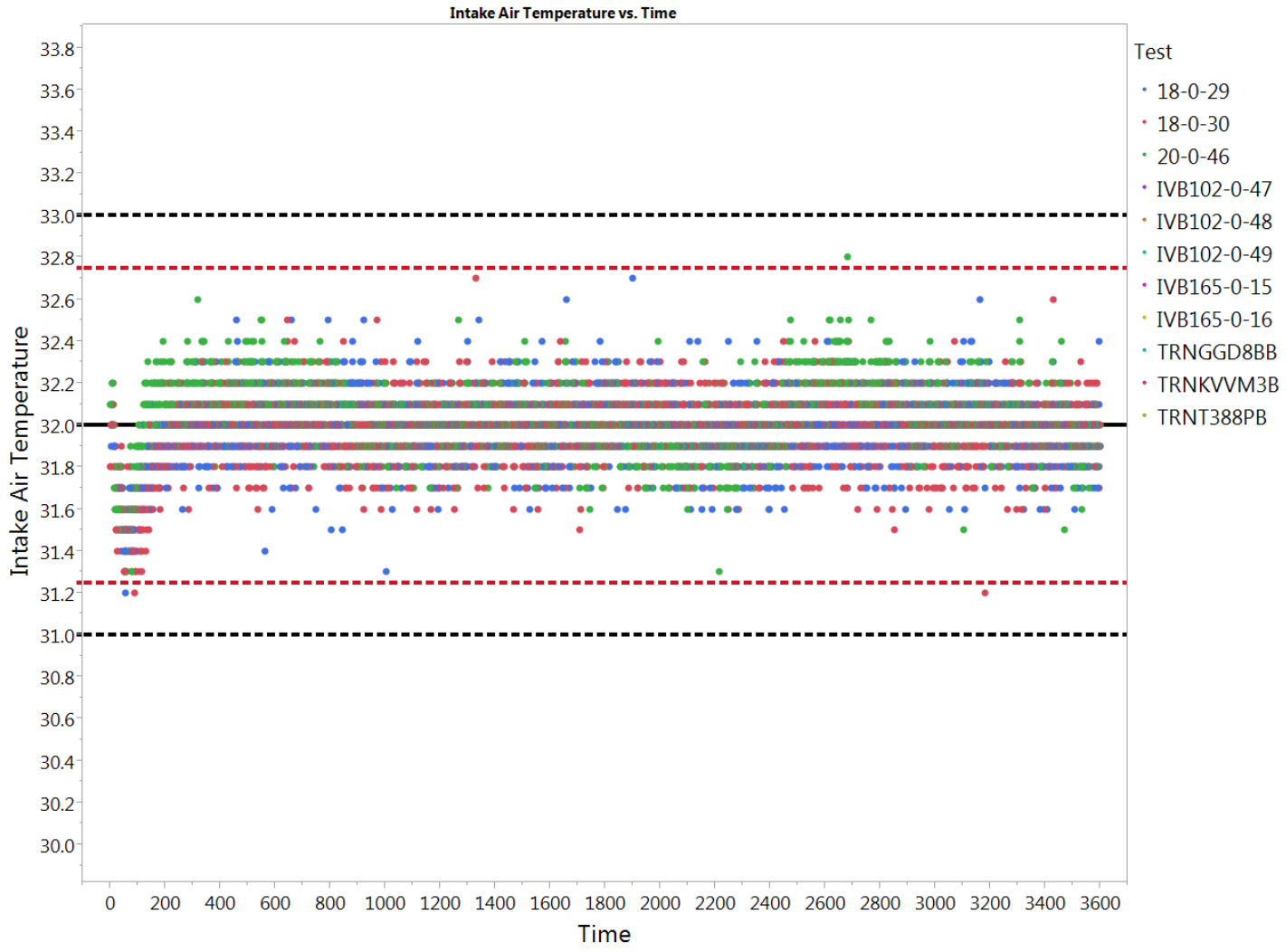

Compared to all other tests, IAR's test 165-0-15 has a different intake air temperature profile over the hour of data reported

SwRI has a dip in temperature at the start of the hour



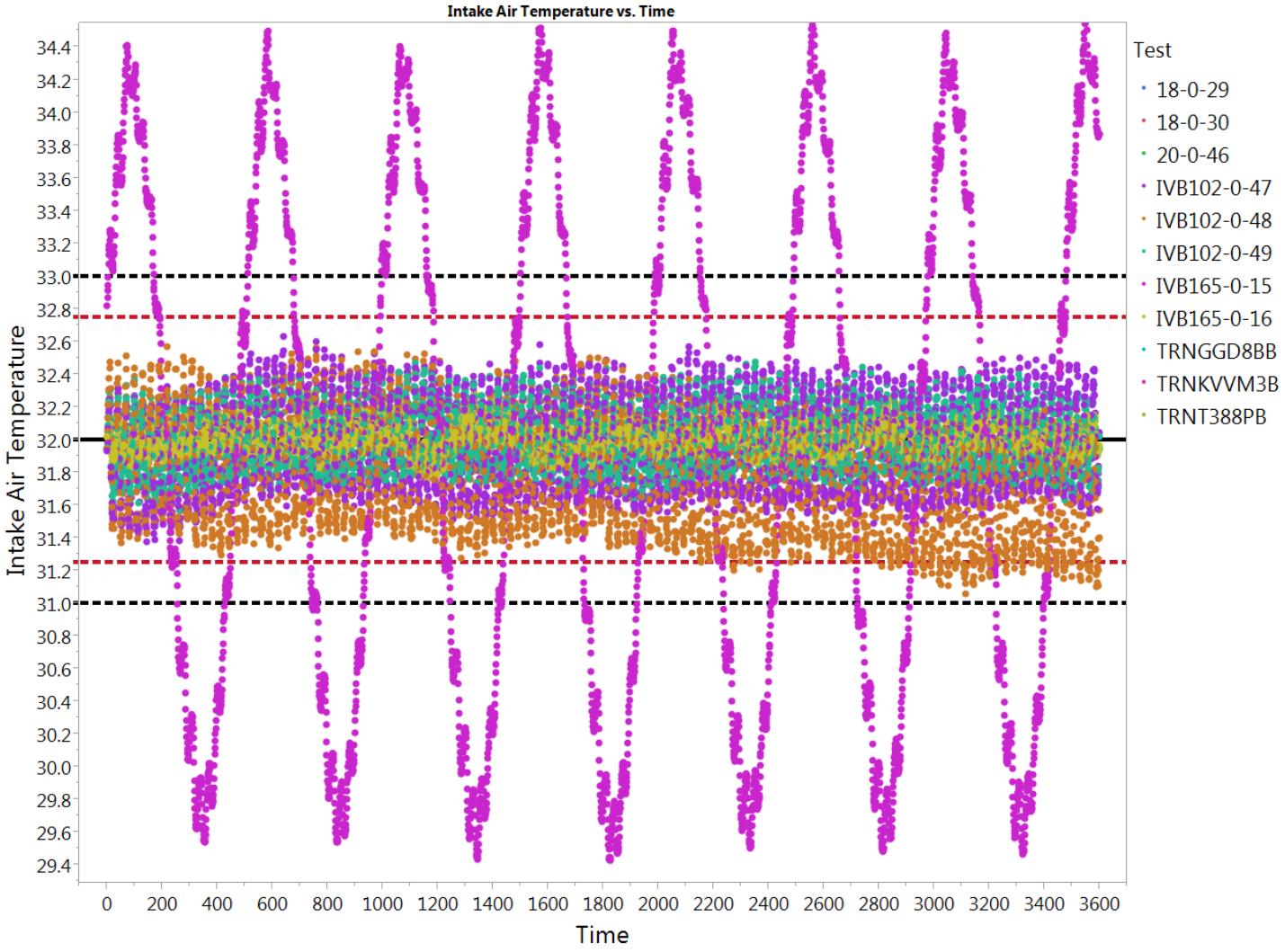
# Intake Air Temp QI
# Lab = SwRI

- Target : 32 C
- Window size 1: +/- 1 C
- Window size 2: +/- 0.75 C



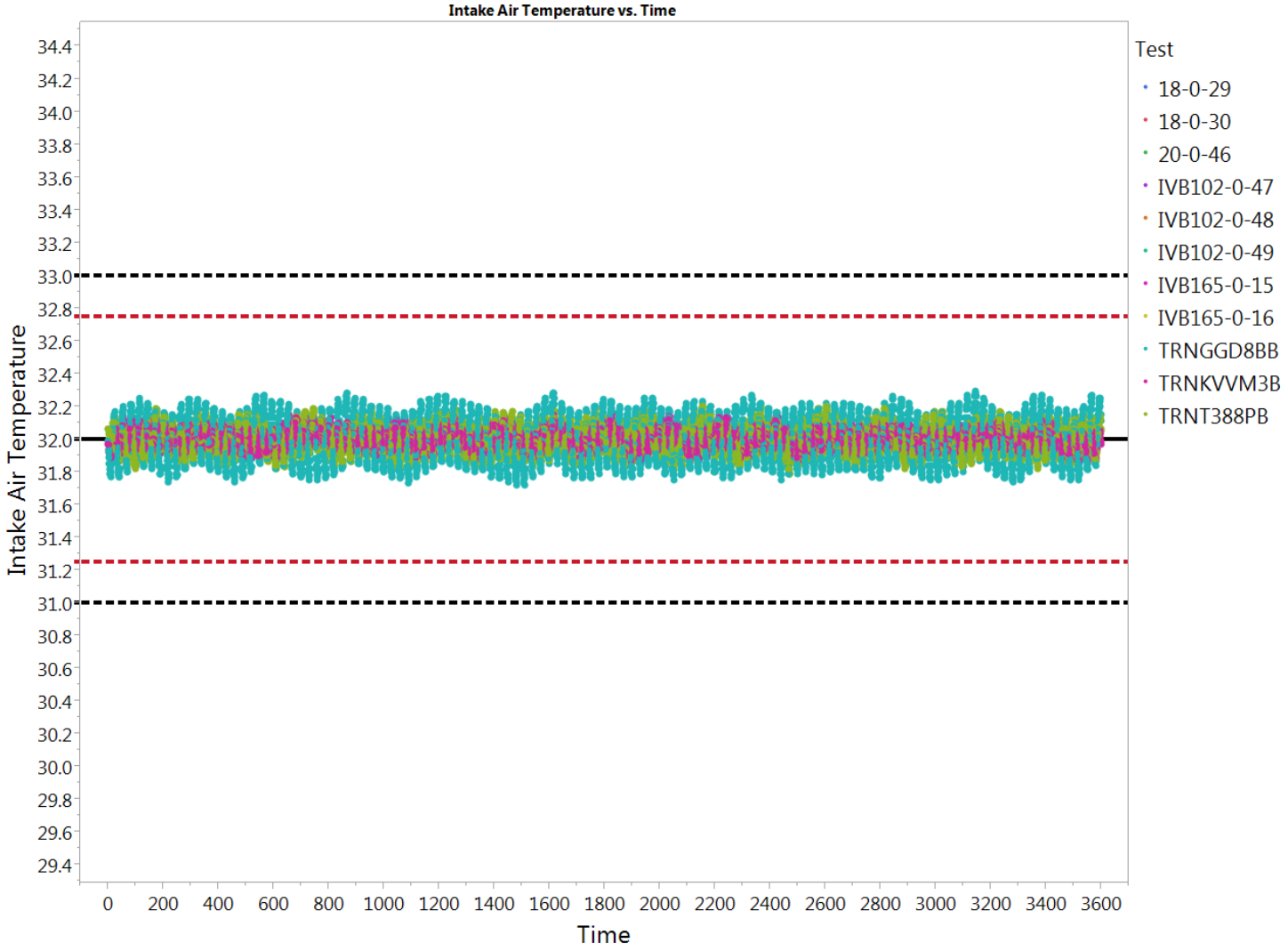
# Intake Air Temp QI
# Lab = IAR

- Target : 32 C
- Window size 1: +/- 1 C
- Window size 2: +/- 0.75 C



# Intake Air Temp QI
# Lab = LZ

- Target : 32 C
- Window size 1: +/- 1 C
- Window size 2: +/- 0.75 C



# Intake Air Temp QI

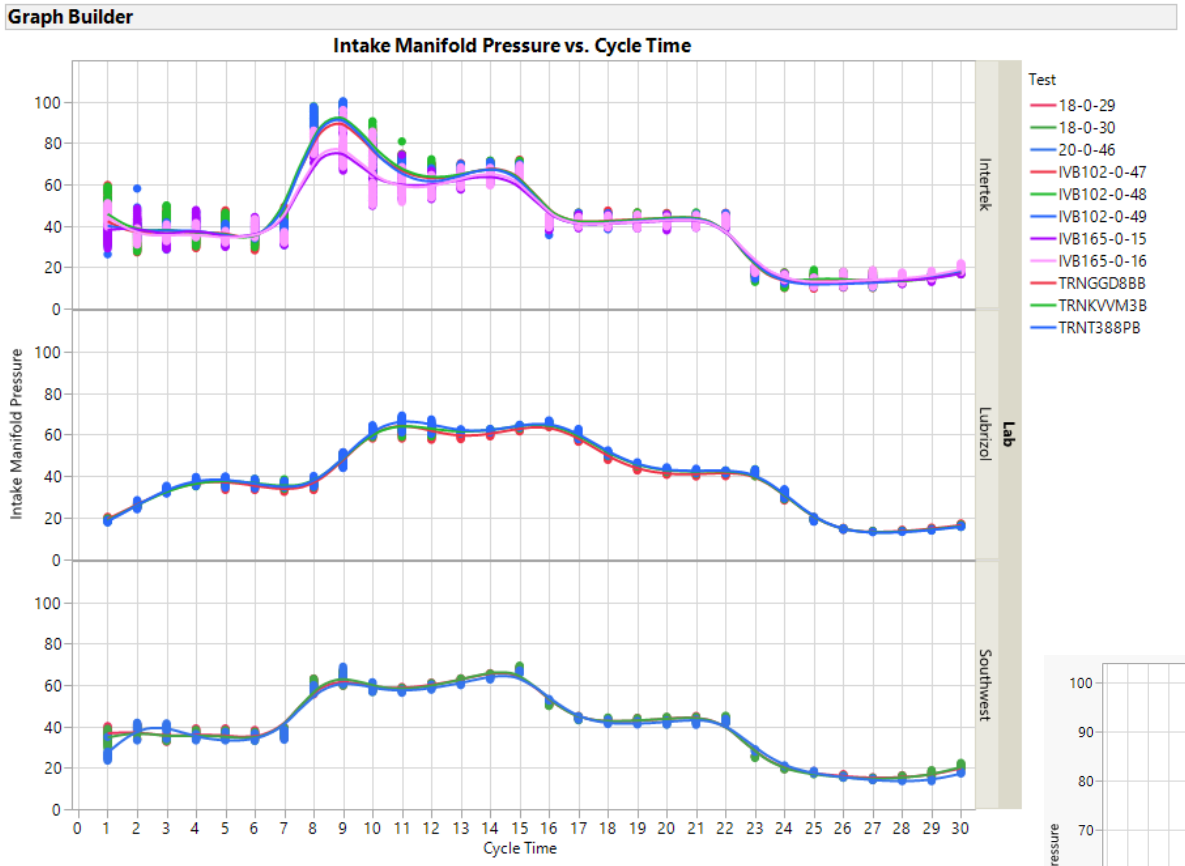
- Target : 32 C
- Window size 1: +/- 1 C
- Window size 2: +/- 0.75 C

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | .98 | .96 |
| 18-0-30 | .98 | .96 |
| 20-0-46 | .97 | .95 |
| 102-0-47 | .92 | .87 |
| 102-0-48 | .83 | .70 |
| 102-0-49 | .96 | .94 |
| 165-0-15 | -1.55 | -3.53 |
| 165-0-16 | .99 | .98 |
| TRNGGD8BB | .98 | .97 |
| TRNKVVM3B | .99 | .99 |
| TRNT388PB | .99 | .99 |
| **Average** | **0.96*** | **0.93*** |

* - Averages calculated without test number 165-0-15

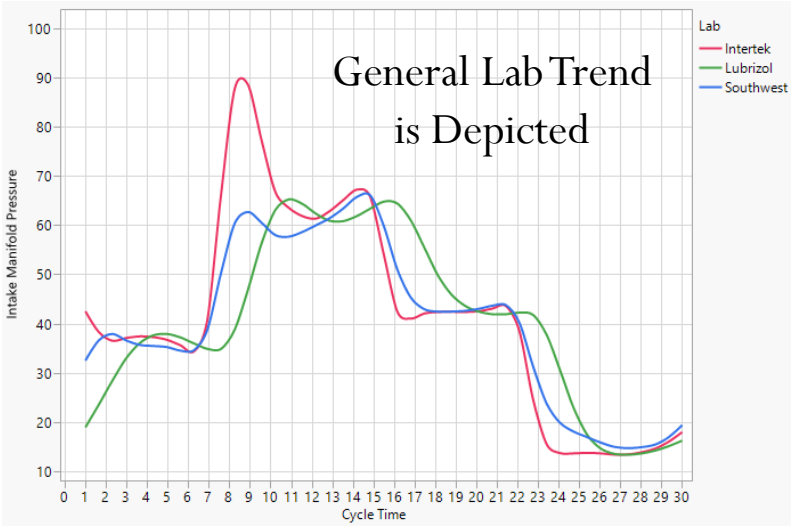
# Intake Manifold Pressure

# Intake Manifold Pressure



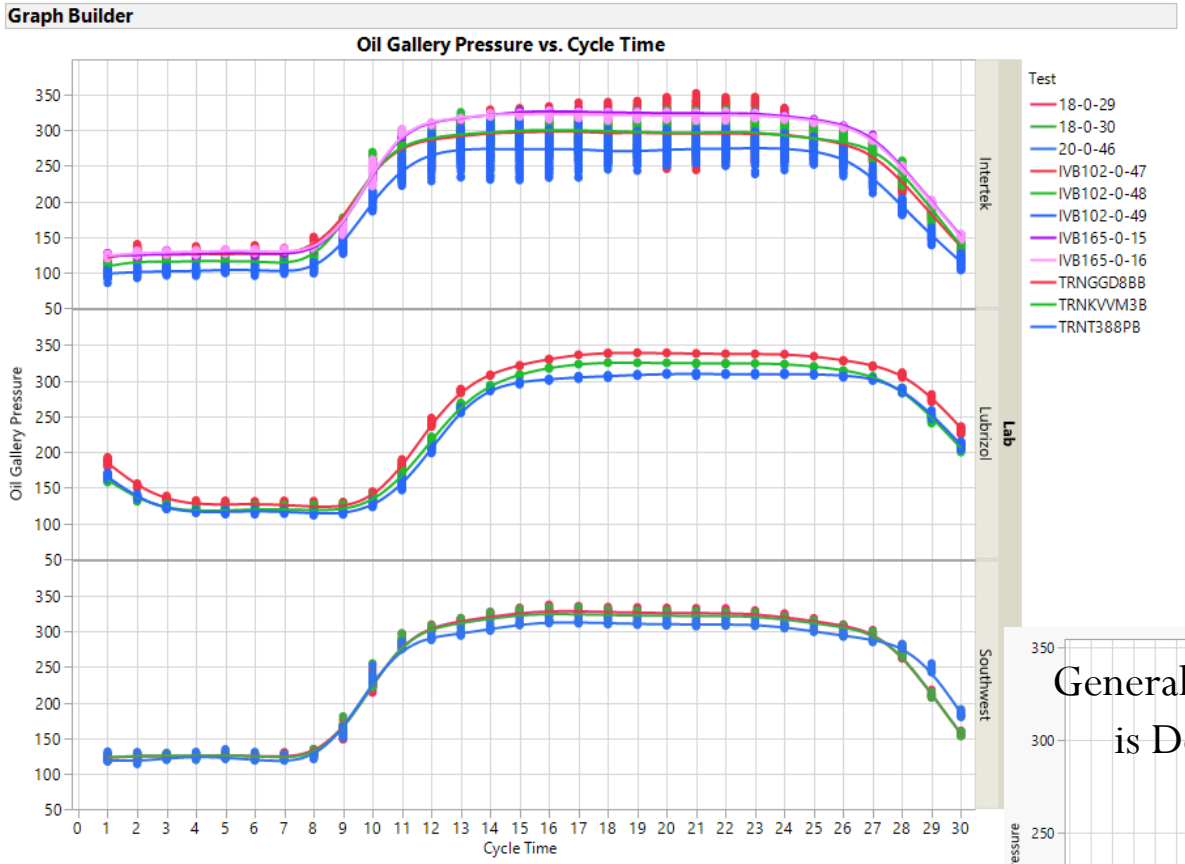

IAR's peak pressure is ~30 kPa higher than the other labs

LZ's cycle is offset ~2 seconds from the other labs

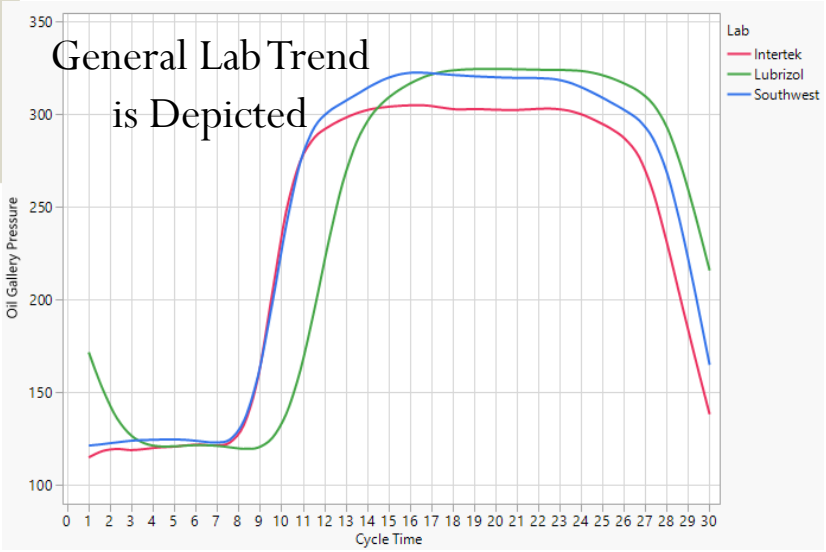


# Oil Gallery Pressure

# Oil Gallery Pressure

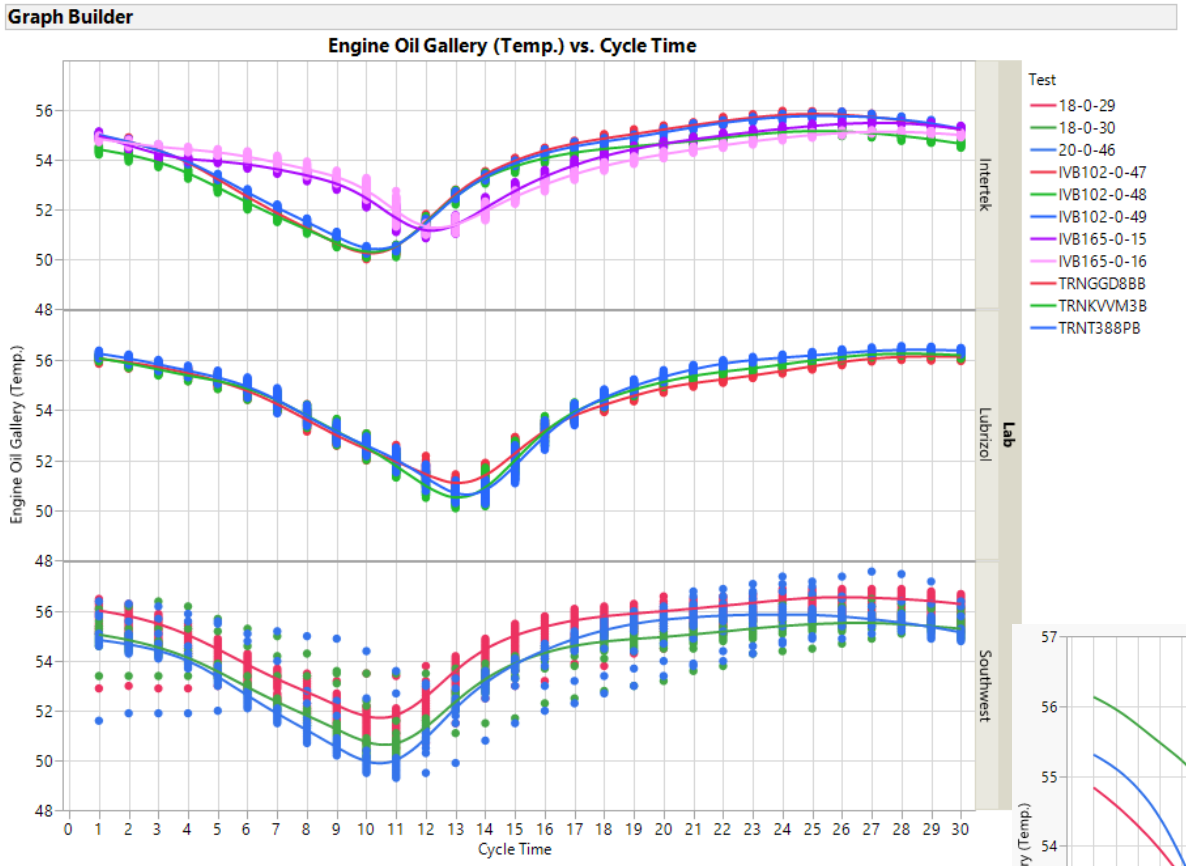



LZ's cycle is offset ~2 seconds from the other labs



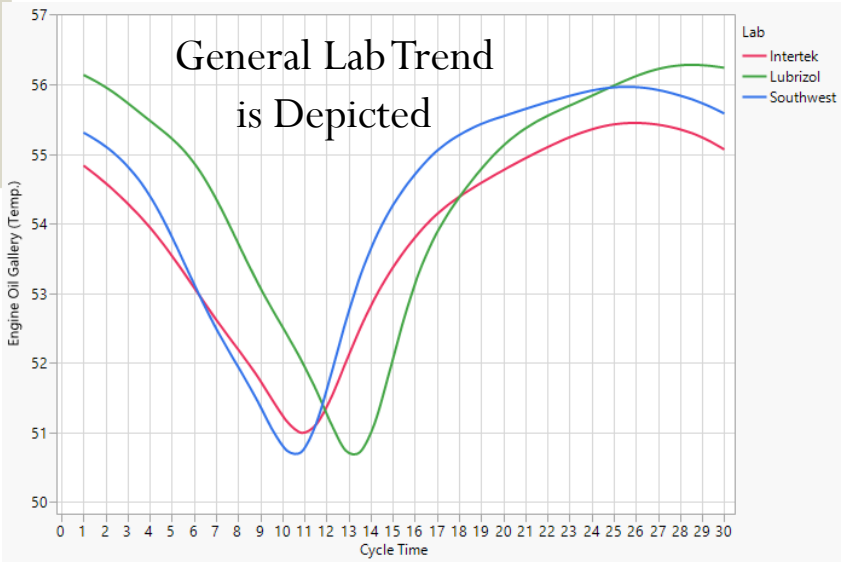
# Engine Oil Gallery Temperature

# Engine Oil Gallery Temperature




The profiles of IAR stands are offset from one another

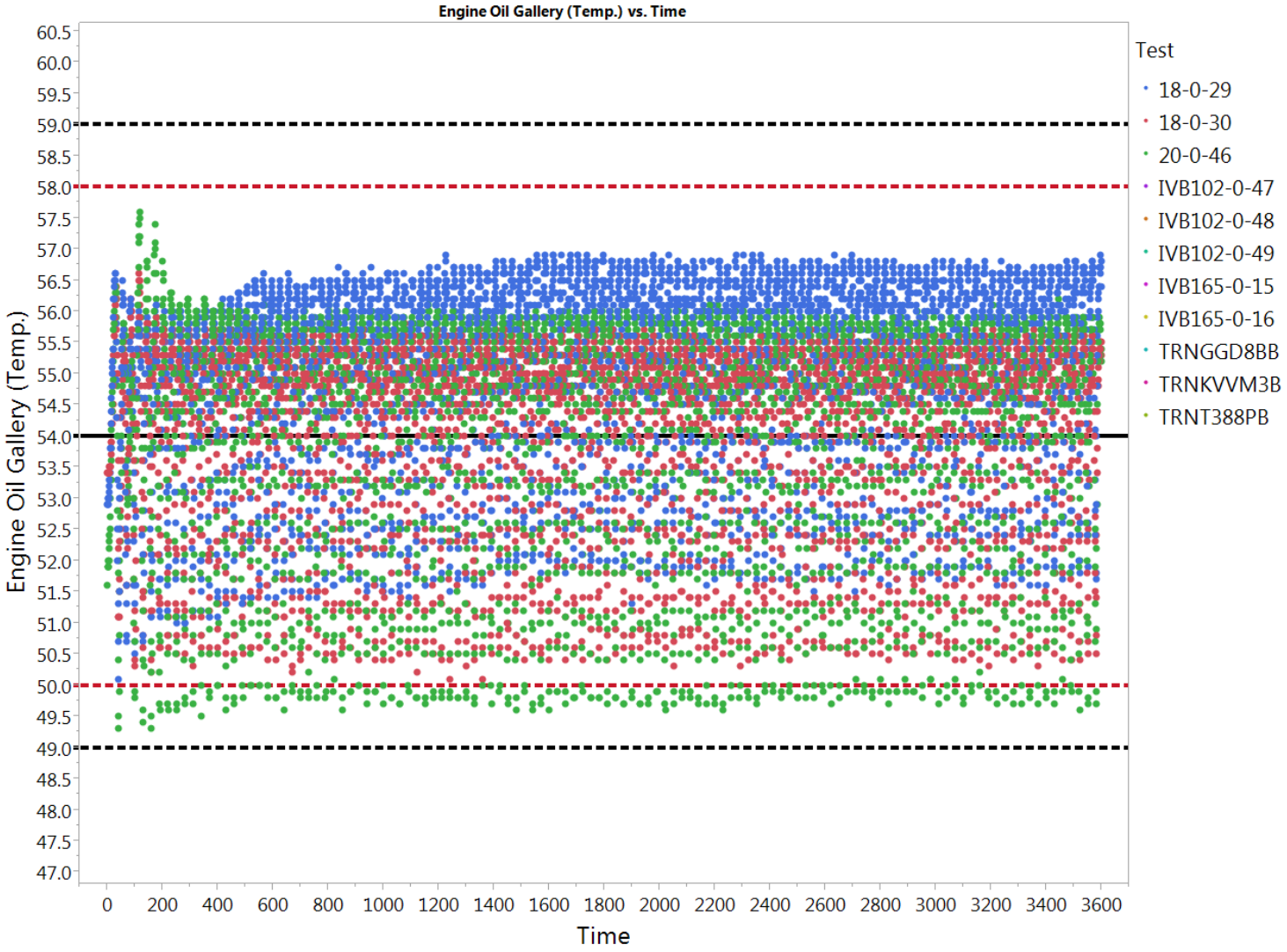
LZ's cycle is offset ~3 seconds from the other labs




Part of the variability in SwRI data is attributed to the temperature stabilizing in the first few cycles of data reported

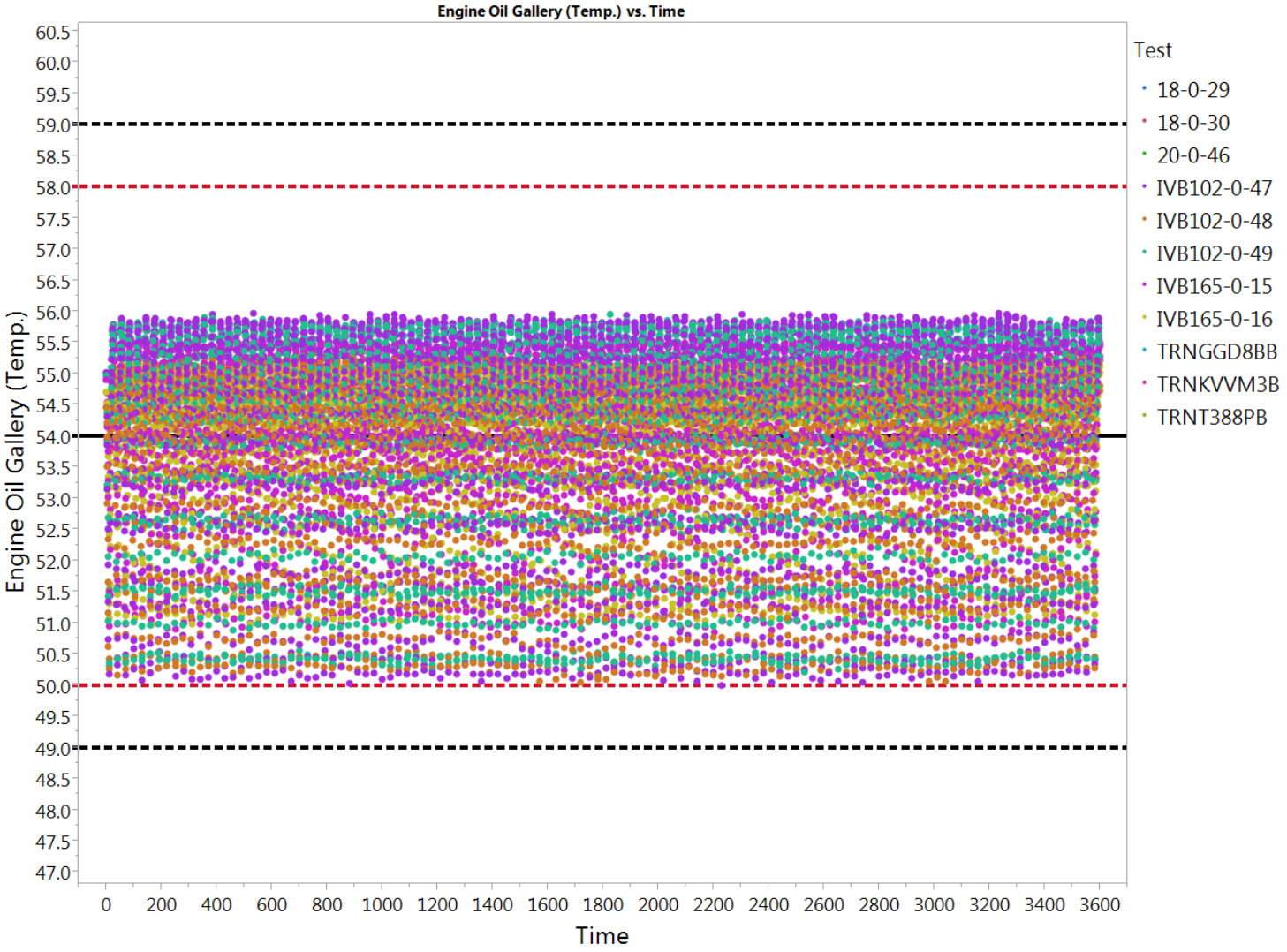
# Oil Gallery Temp QI
# Lab = SwRI

- Target : 54 C
- Window size 1: +/- 5 C
- Window size 2: +/- 4 C



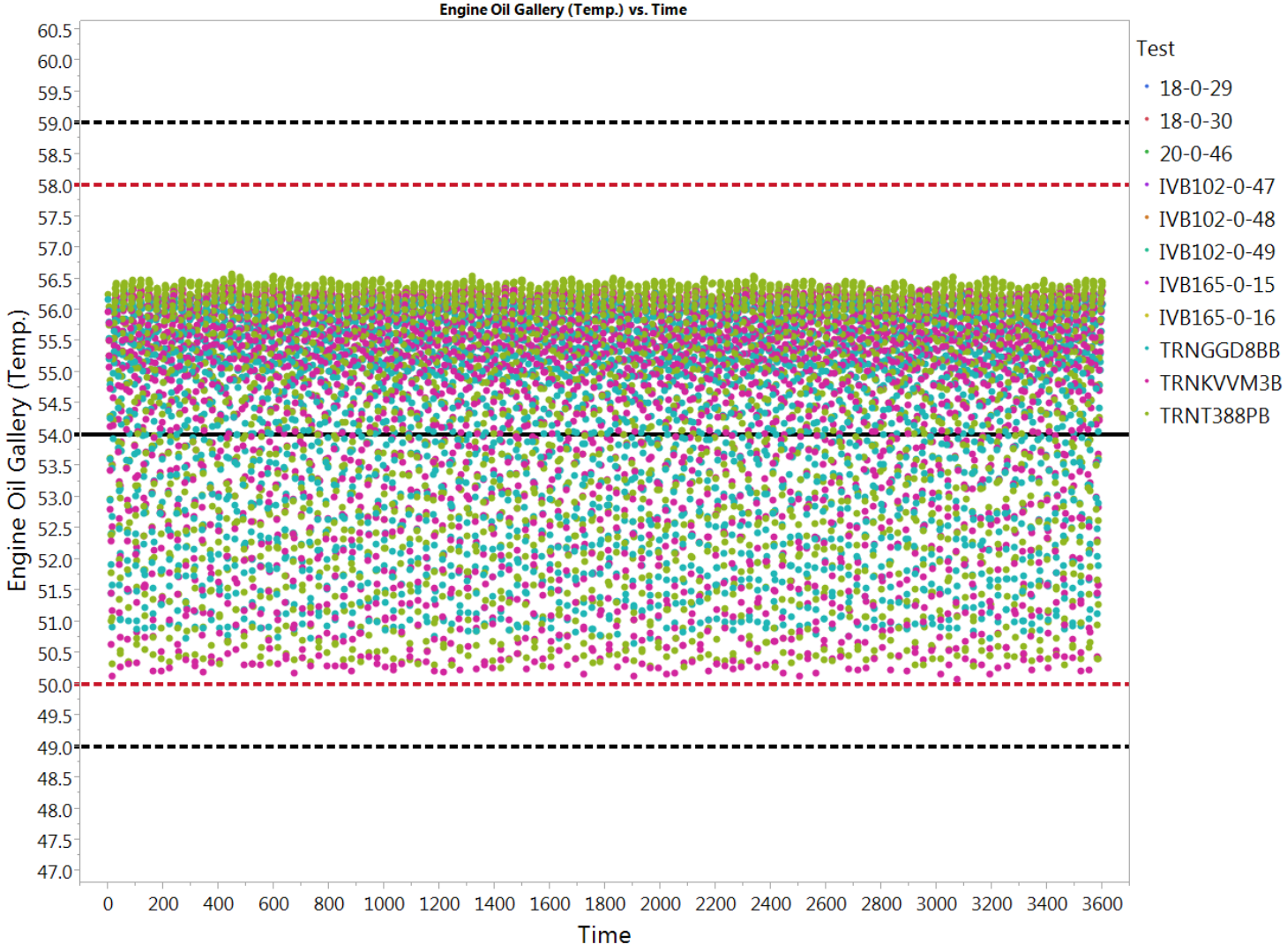
# Oil Gallery Temp QI
# Lab = IAR

- Target : 54 C
- Window size 1: +/- 5 C
- Window size 2: +/- 4 C



# Oil Gallery Temp QI
# Lab = LZ

- Target : 54 C
- Window size 1: +/- 5 C
- Window size 2: +/- 4 C



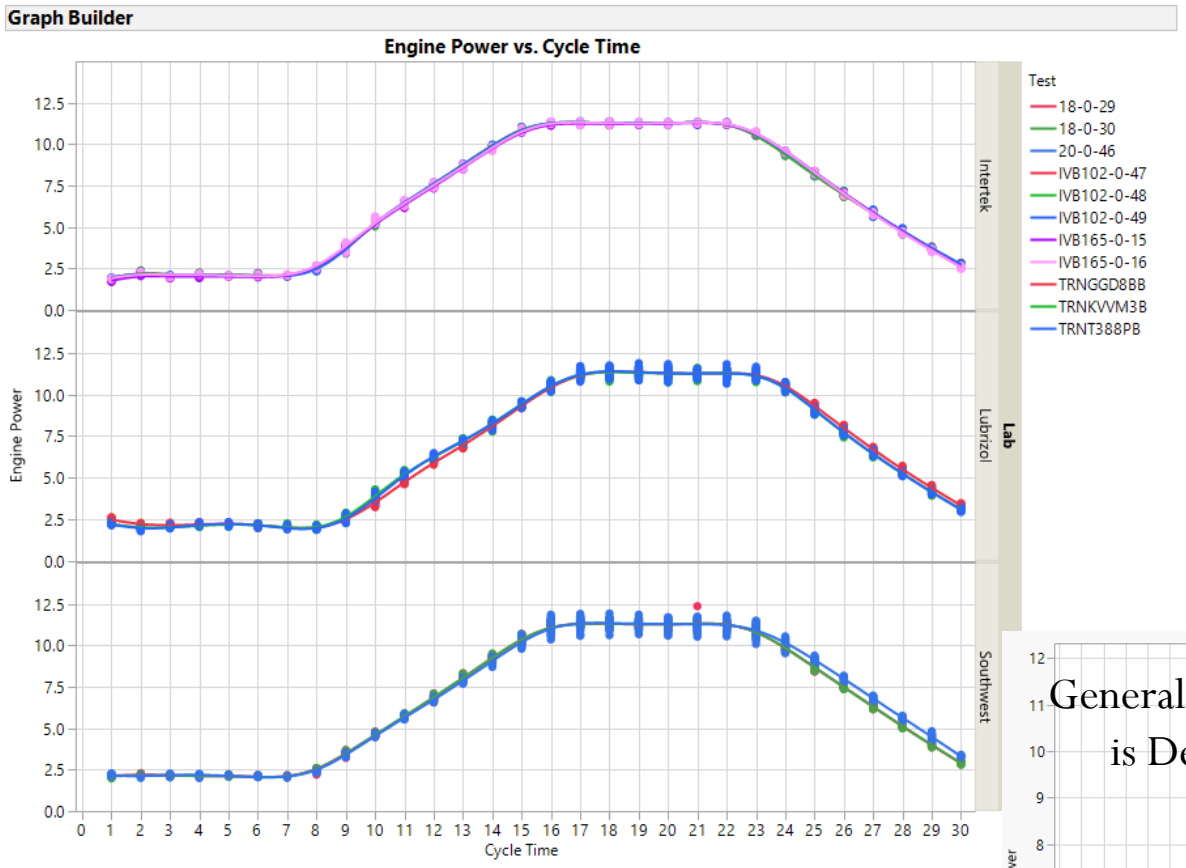
# Oil Gallery Temp QI

- Target : 54 C
- Window size 1: +/- 5 C
- Window size 2: +/- 4 C

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | 0.86 | 0.78 |
| 18-0-30 | 0.90 | 0.85 |
| 20-0-46 | 0.85 | 0.76 |
| 102-0-47 | 0.88 | 0.81 |
| 102-0-48 | 0.90 | 0.84 |
| 102-0-49 | 0.89 | 0.82 |
| 165-0-15 | 0.93 | 0.90 |
| 165-0-16 | 0.95 | 0.92 |
| TRNGGD8BB | 0.89 | 0.83 |
| TRNKVVM3B | 0.87 | 0.79 |
| TRNT388PB | 0.85 | 0.77 |
| **Average** | **0.89** | **0.82** |

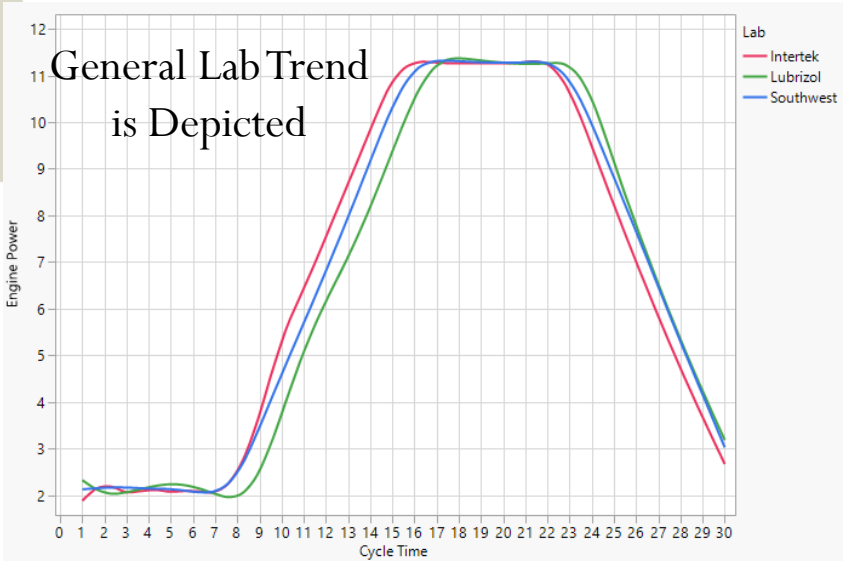
# Engine Power

# Engine Power



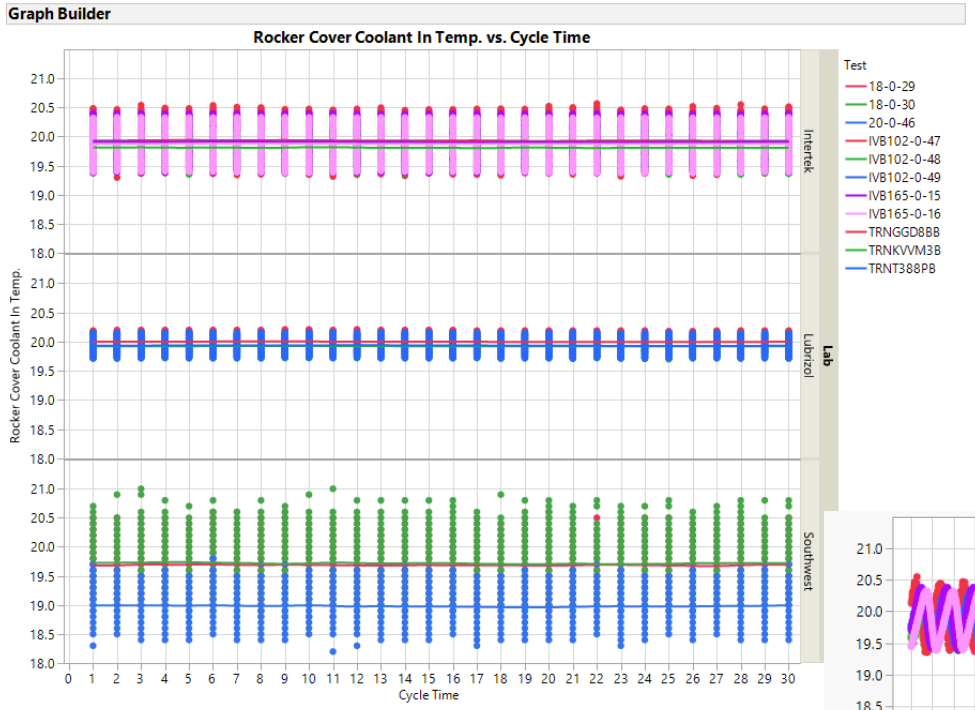

There are differences among the labs in how the engine power cycles:

1. LZ's cycle is ~1 to ~2 seconds offset from the other labs
2. IAR and SwRI ramp differently (slightly)

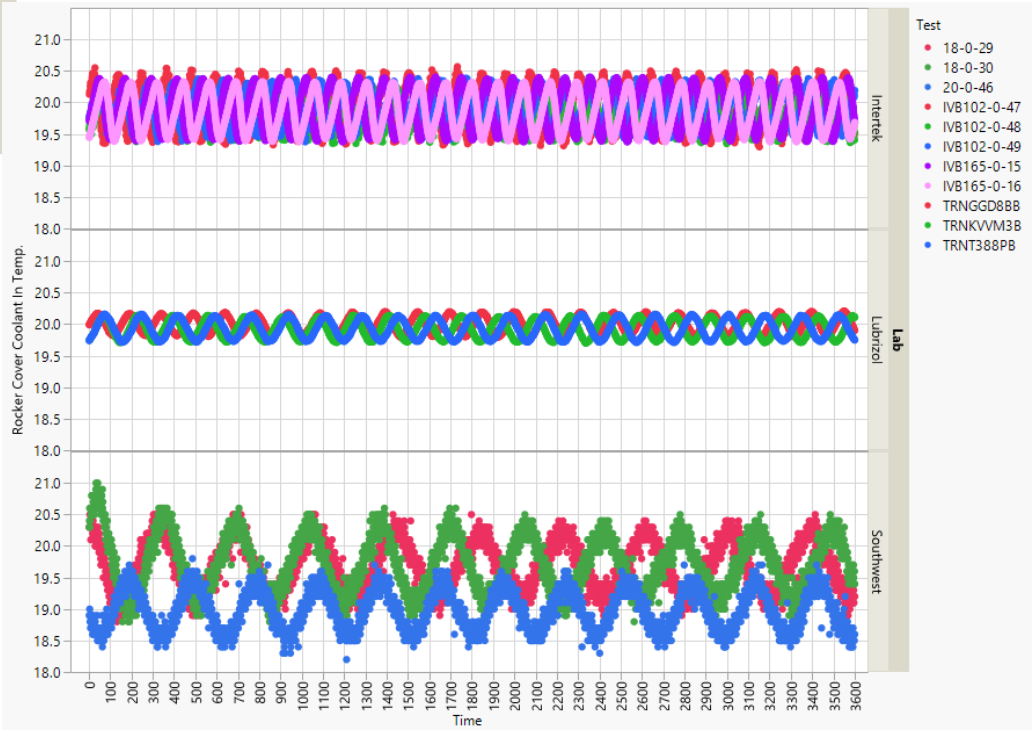


# Rocker Cover Coolant In Temperature

# Rocker Cover Coolant In Temperature

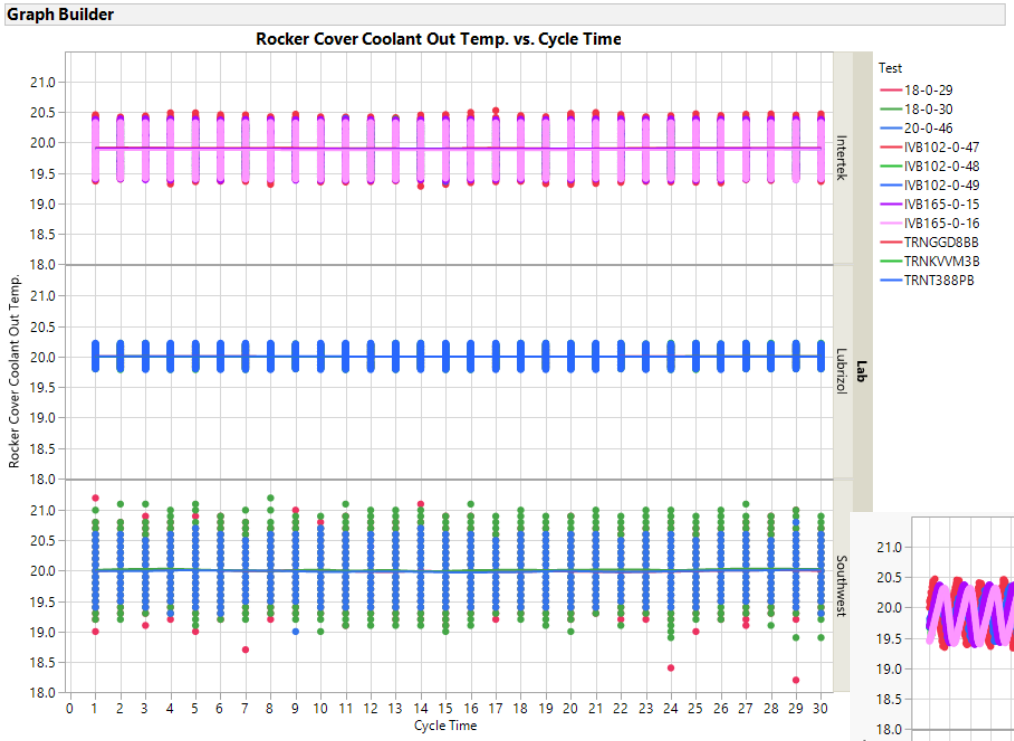



There appears to be a difference among the labs in how the rocker cover coolant in temperature cycles across the data collected.

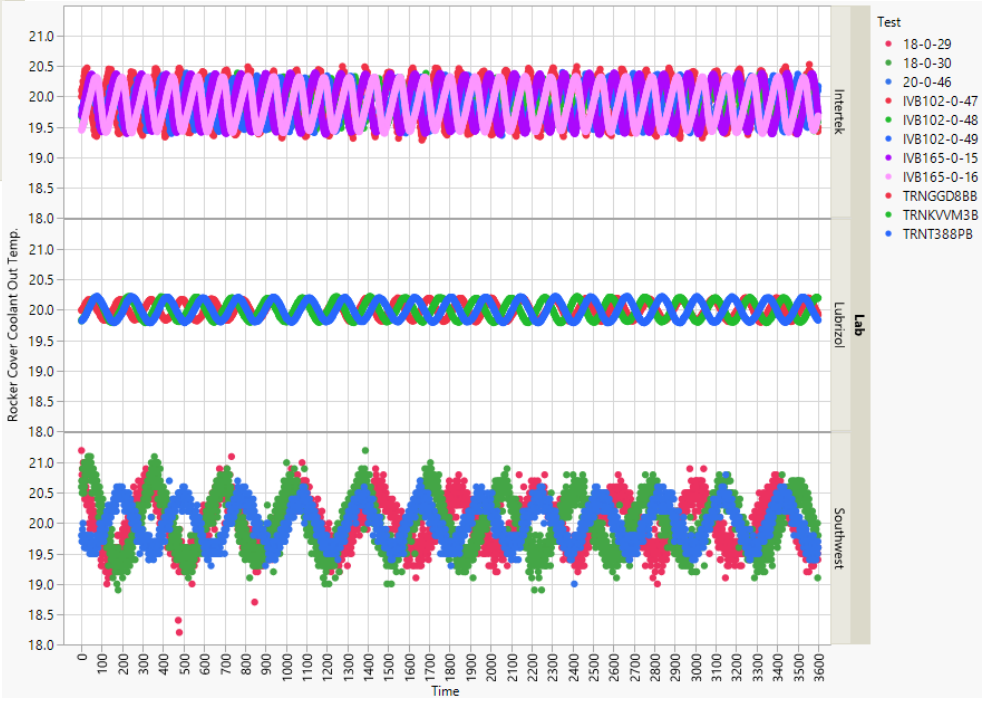


# Rocker Cover Coolant Out Temperature

# Rocker Cover Coolant Out Temperature



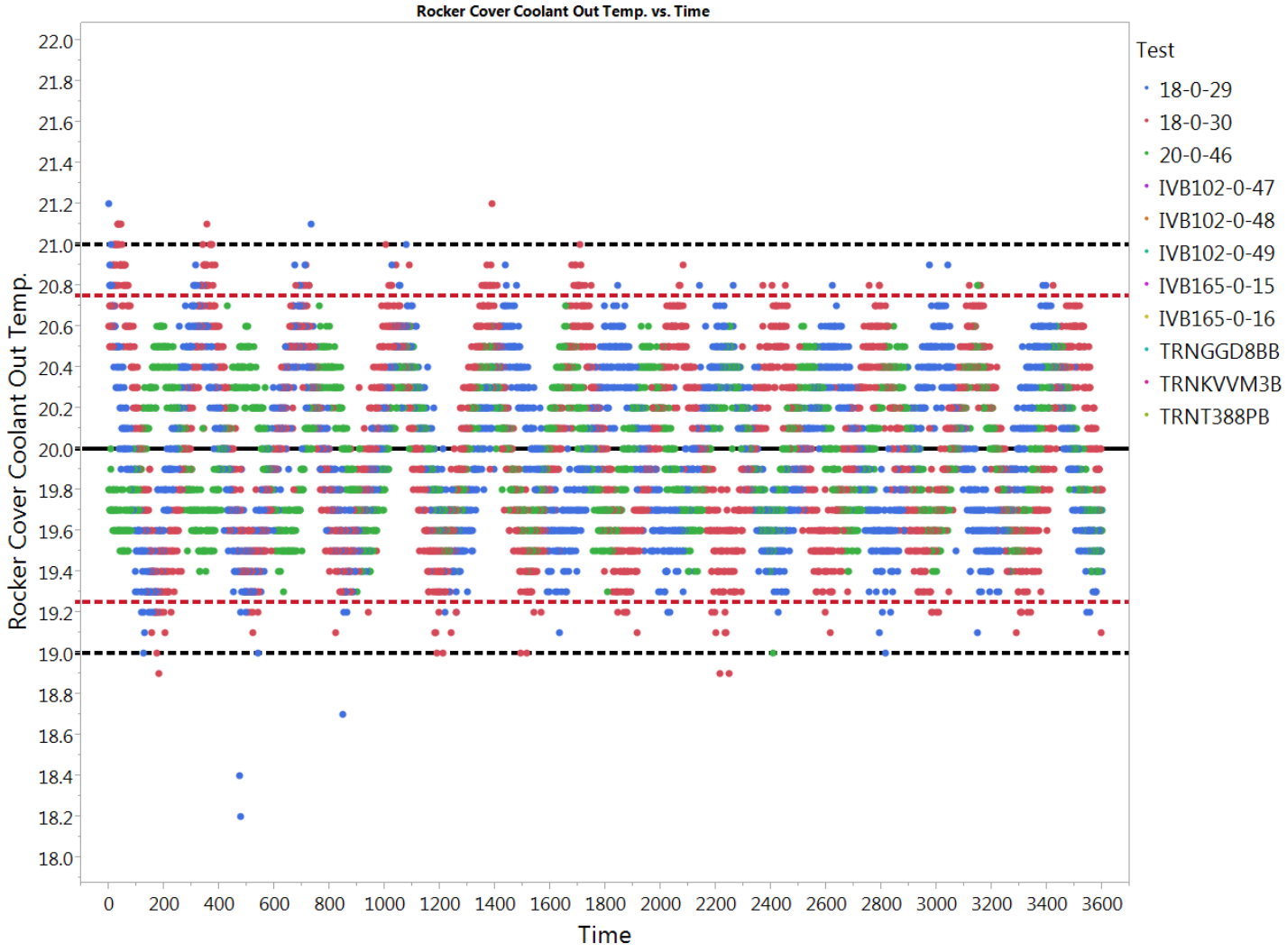

There appears to be a difference among the labs in how the rocker cover coolant out temperature cycles across the data collected.




Note: Test 20-0-46 has a coolant out temp of ~20 while its coolant in temp is ~19. All other test have coolant in and out temps of ~20.

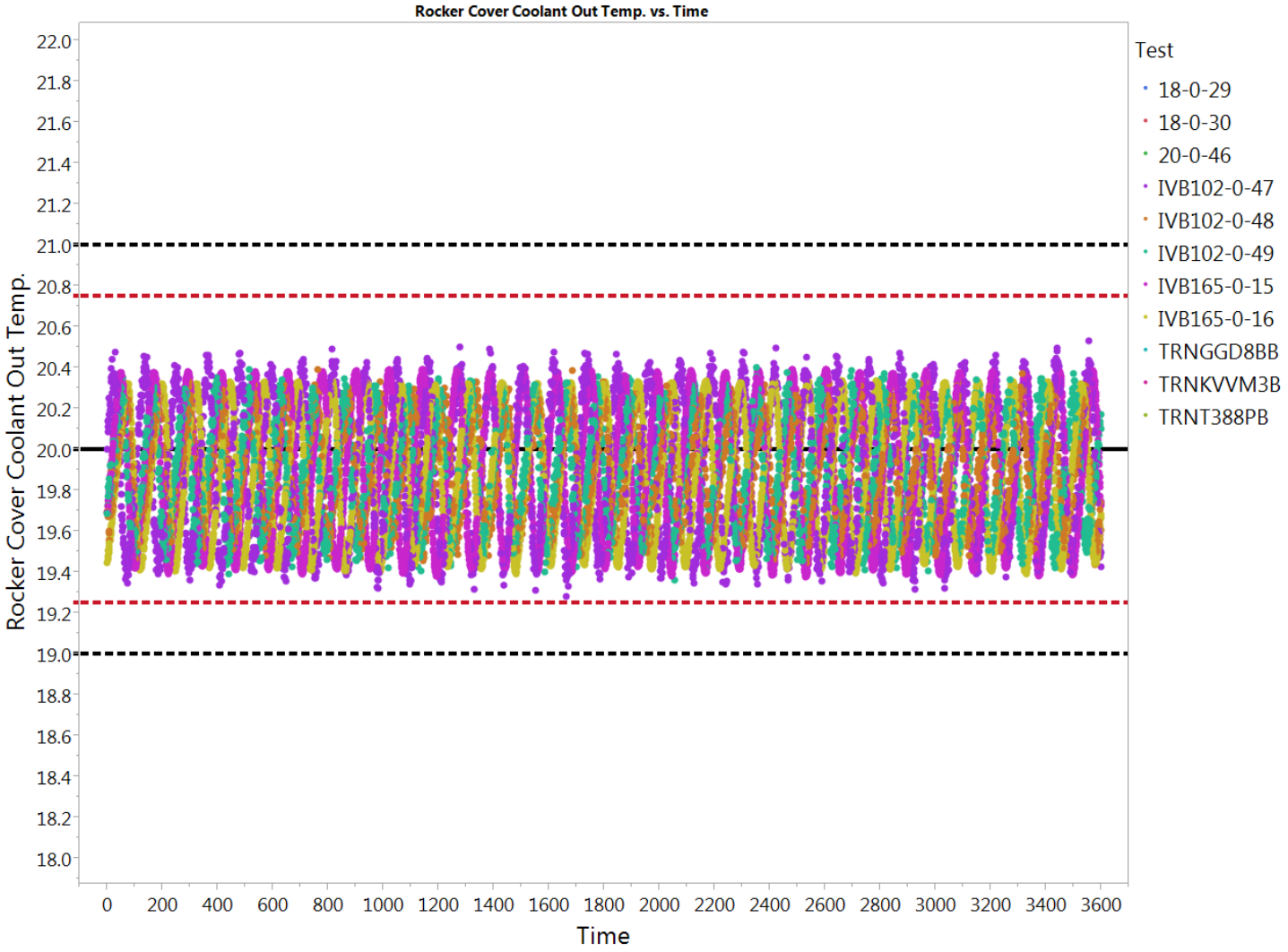
# RAC Coolant Temp Out QI
# Lab = SwRI

- Target : 20 C
- Window size 1: +/- 1.0 C
- Window size 2: +/- 0.75 C



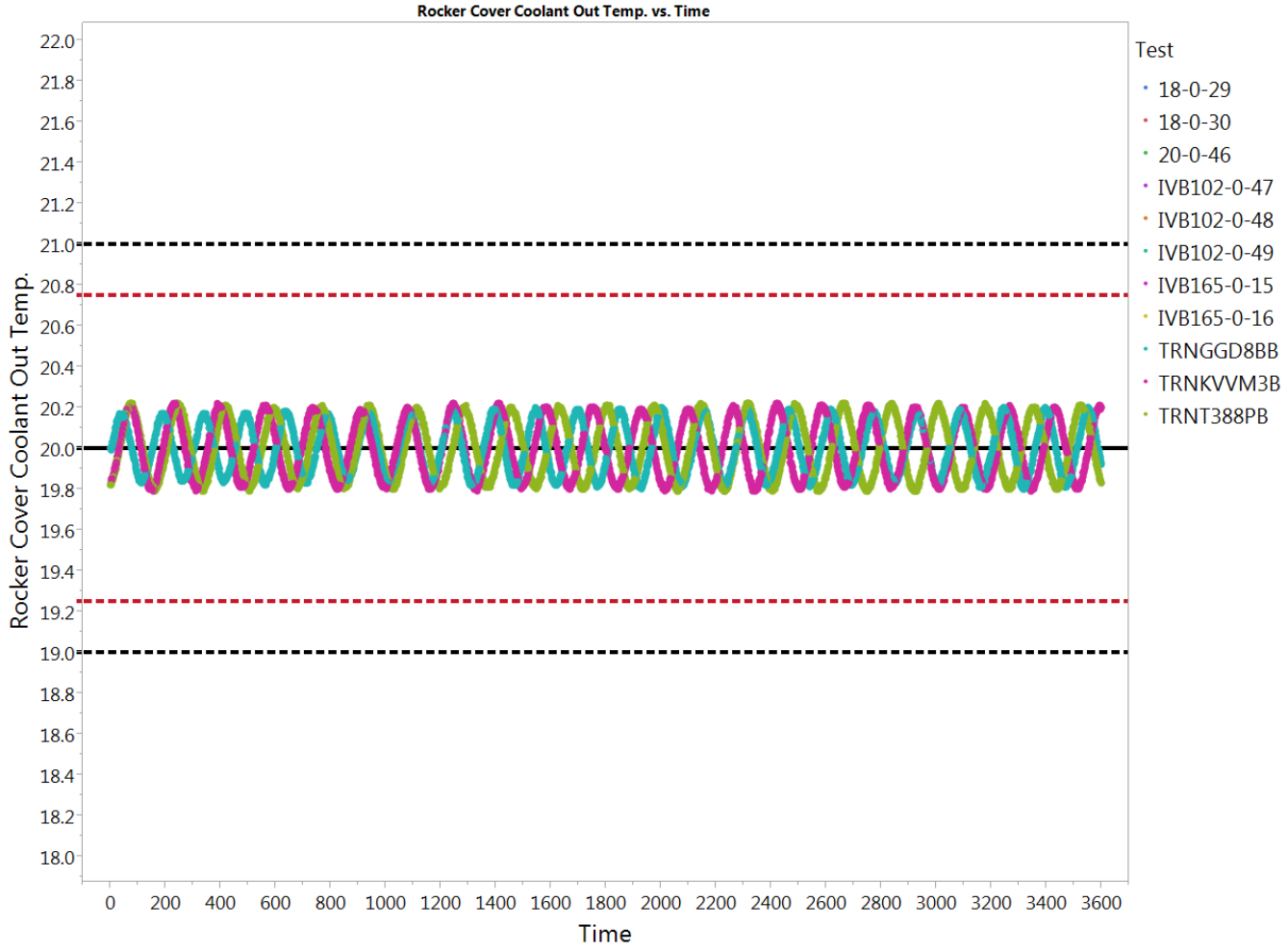
# RAC Coolant Temp Out QI
# Lab = IAR

- Target : 20 C
- Window size 1: +/- 1.0 C
- Window size 2: +/- 0.75 C



# RAC Coolant Temp Out QI
# Lab = LZ

- Target : 20 C
- Window size 1: +/- 1.0 C
- Window size 2: +/- 0.75 C



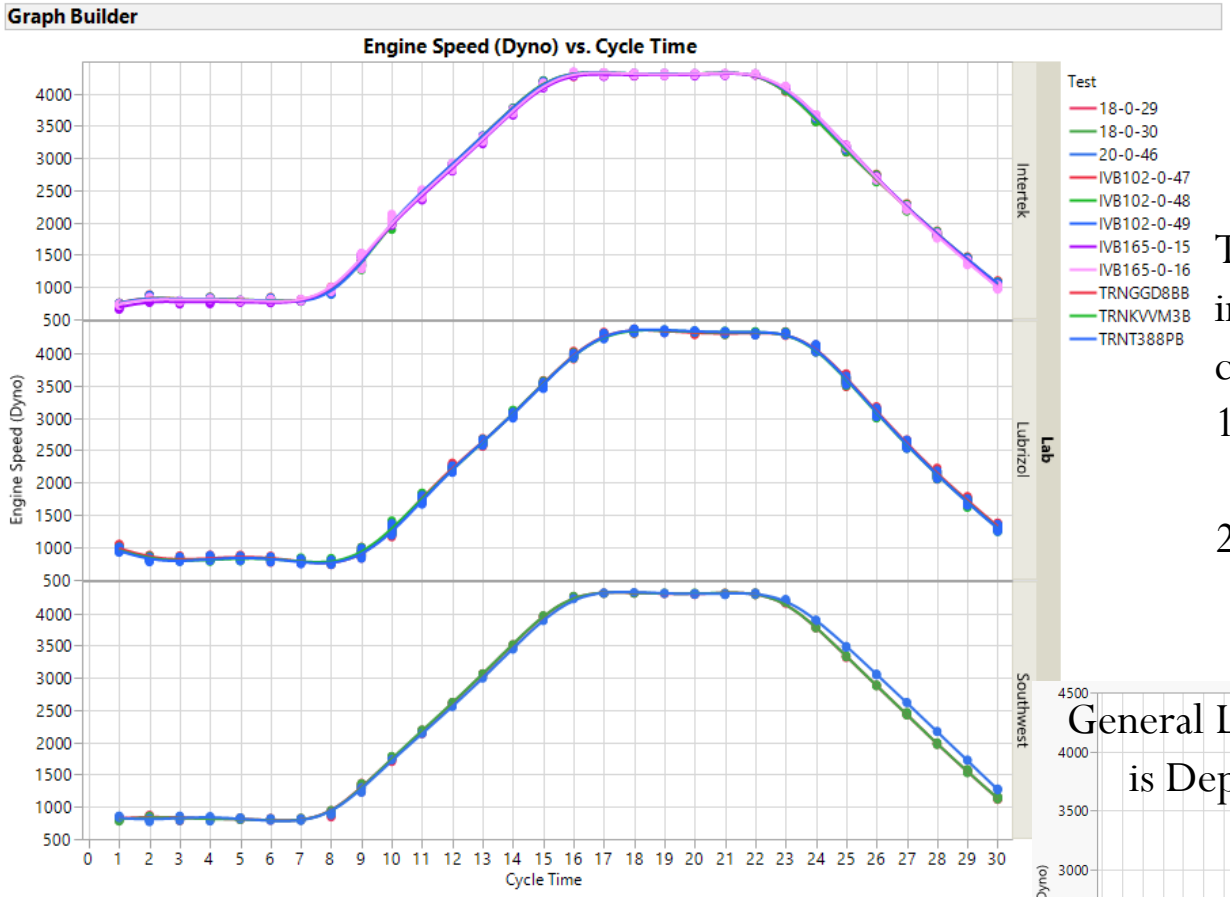
# RAC Coolant Temp Out QI

- Target : 20 C
- Window size 1: +/- 1.0 C
- Window size 2: +/- 0.75 C

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | 0.85 | 0.73 |
| 18-0-30 | 0.81 | 0.66 |
| 20-0-46 | 0.90 | 0.83 |
| 102-0-47 | 0.88 | 0.79 |
| 102-0-48 | 0.94 | 0.89 |
| 102-0-49 | 0.92 | 0.87 |
| 165-0-15 | 0.88 | 0.79 |
| 165-0-16 | 0.89 | 0.81 |
| TRNGGD8BB | 0.98 | 0.97 |
| TRNKVVM3B | 0.98 | 0.97 |
| TRNT388PB | 0.98 | 0.97 |
| **Average** | **0.91** | **0.84** |

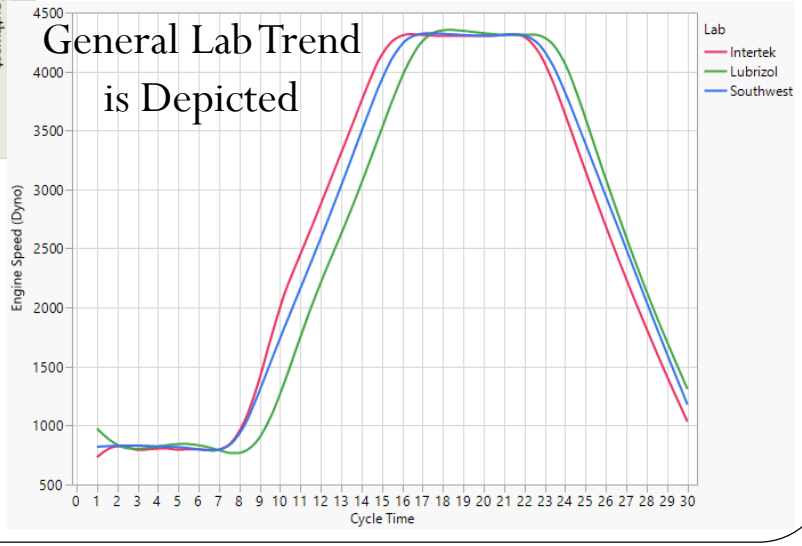
# Engine Speed (Dyno)

# Engine Speed (Dyno)



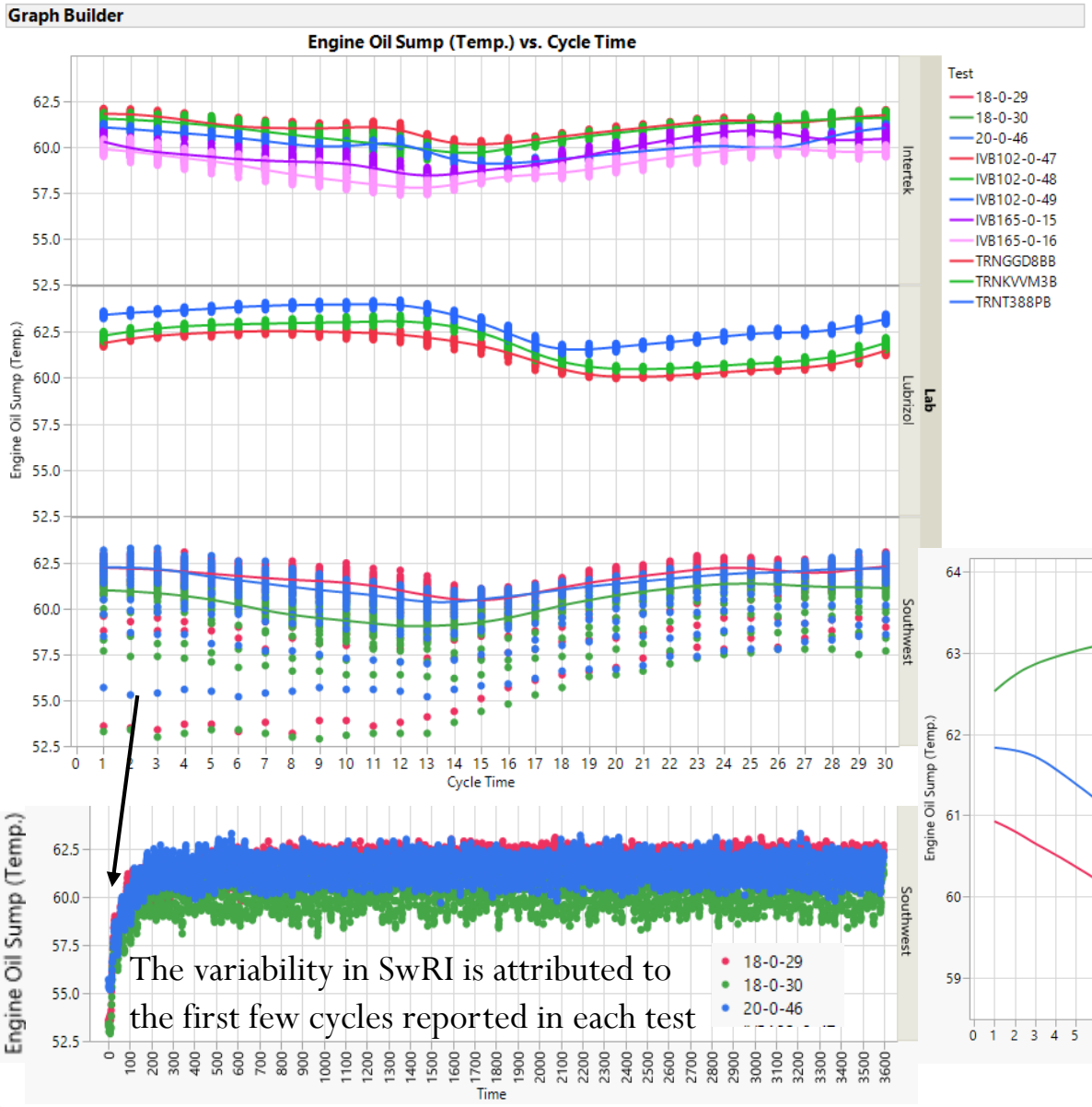

There are differences among the labs in how the engine speed (dyno) cycles:

1. LZ's cycle is ~1 to ~2 seconds offset from the other labs
2. IAR and SwRI ramp differently (slightly)



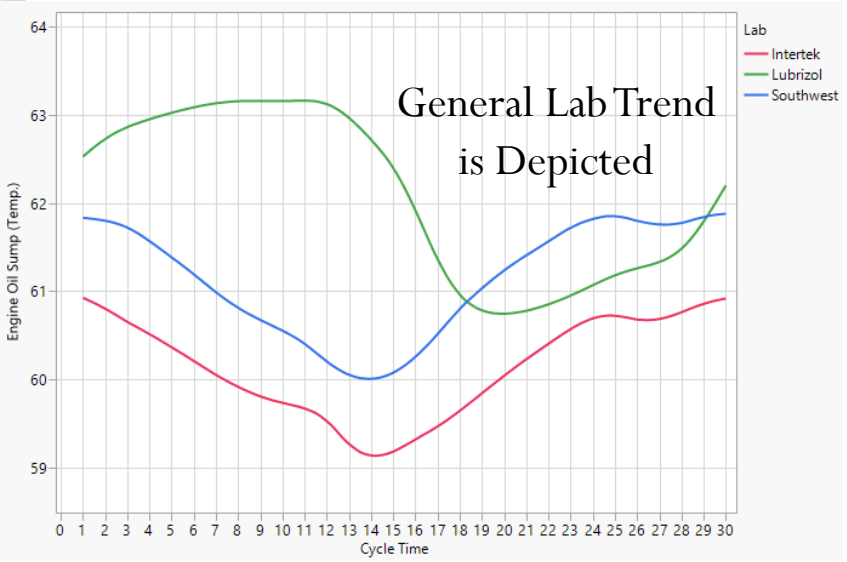
# Engine Oil Sump Temperature

# Engine Oil Sump Temperature



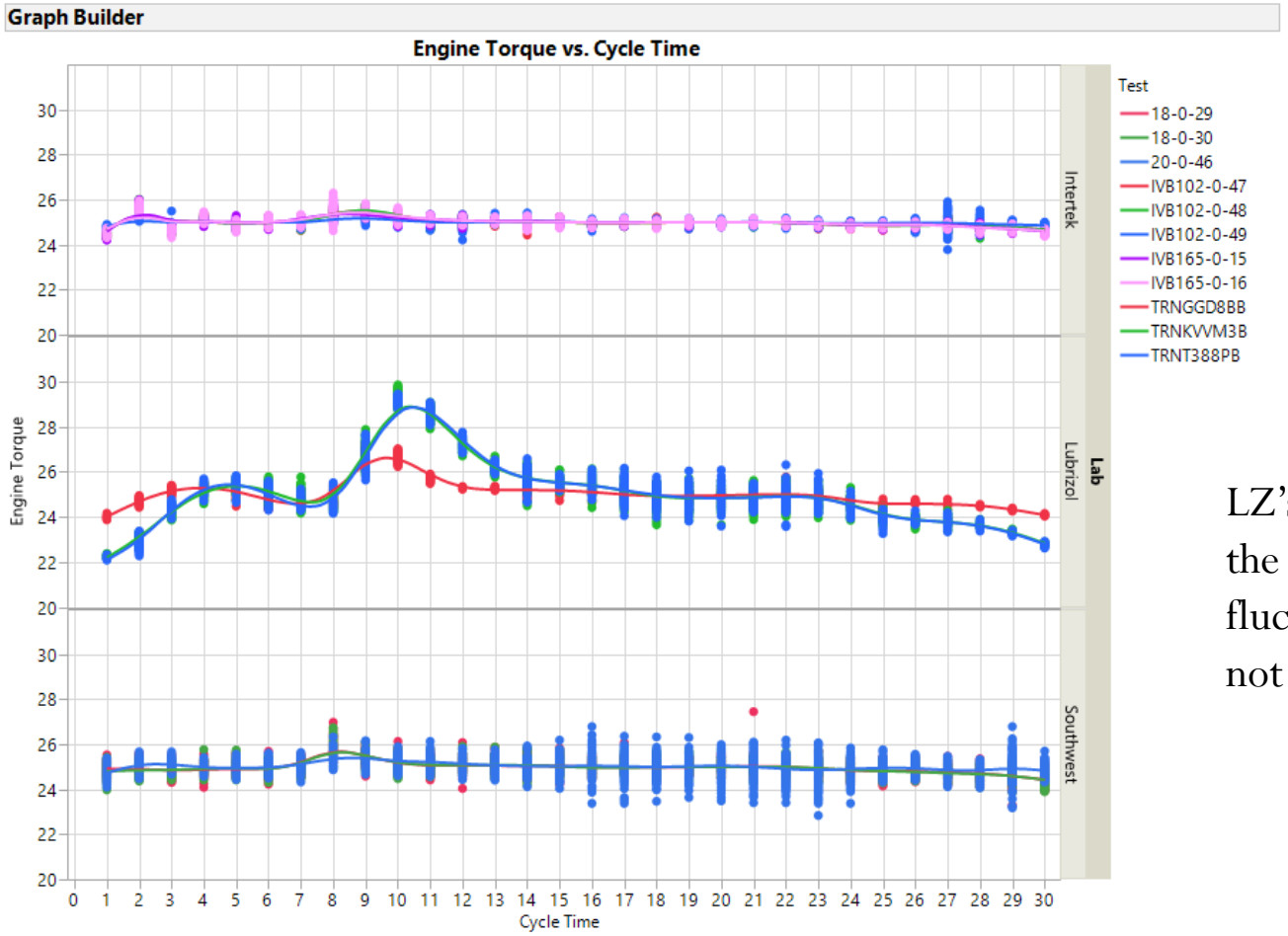

LZ's sump temperature cycles differently than the other labs

The labs' sump temperatures slightly differ with LZ being the highest and IAR being the lowest



# Engine Torque

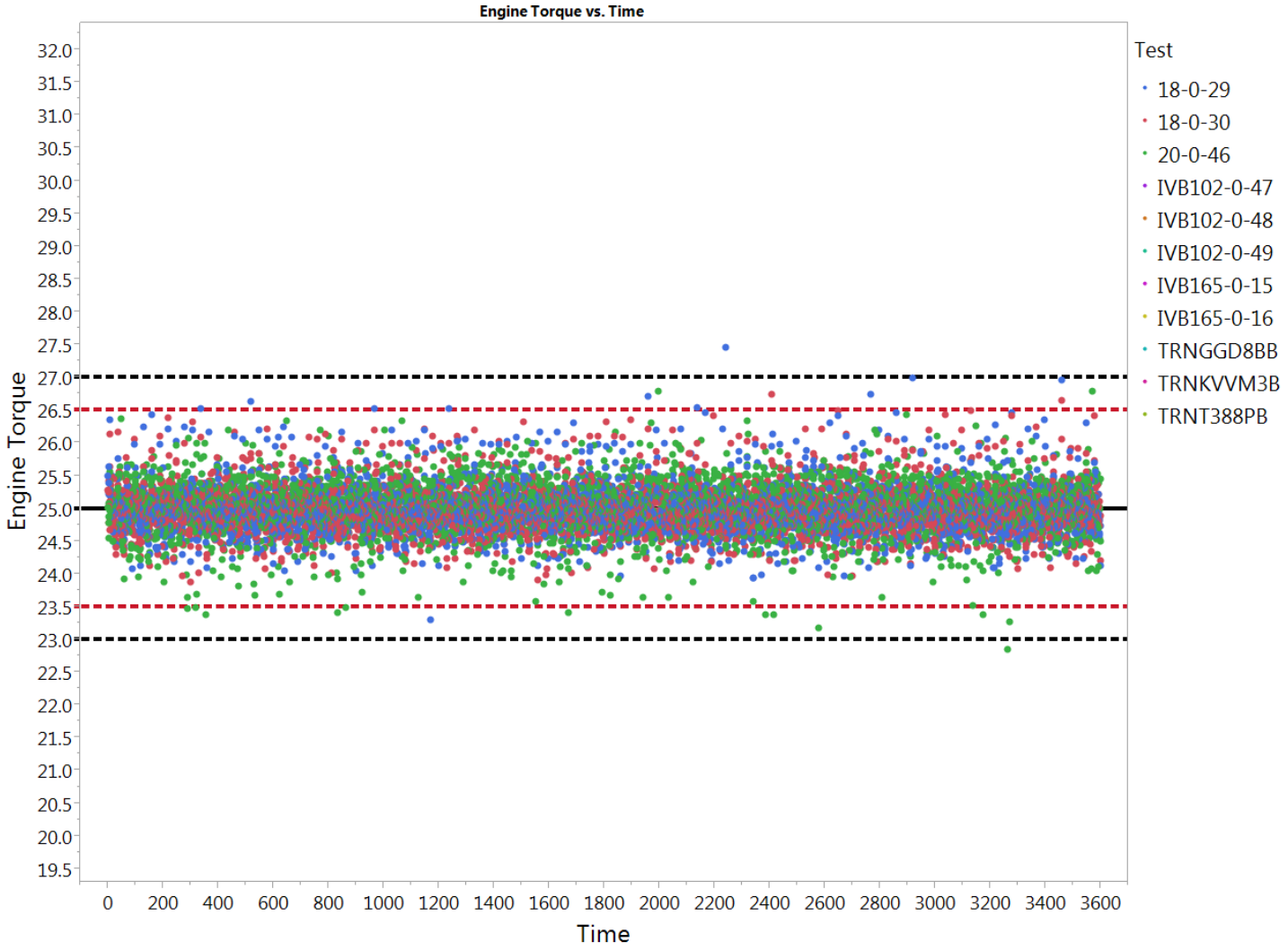
# Engine Torque




LZ's Engine Torque is higher than the other labs and exhibits fluctuations in the cycles that are not observed at the other labs.

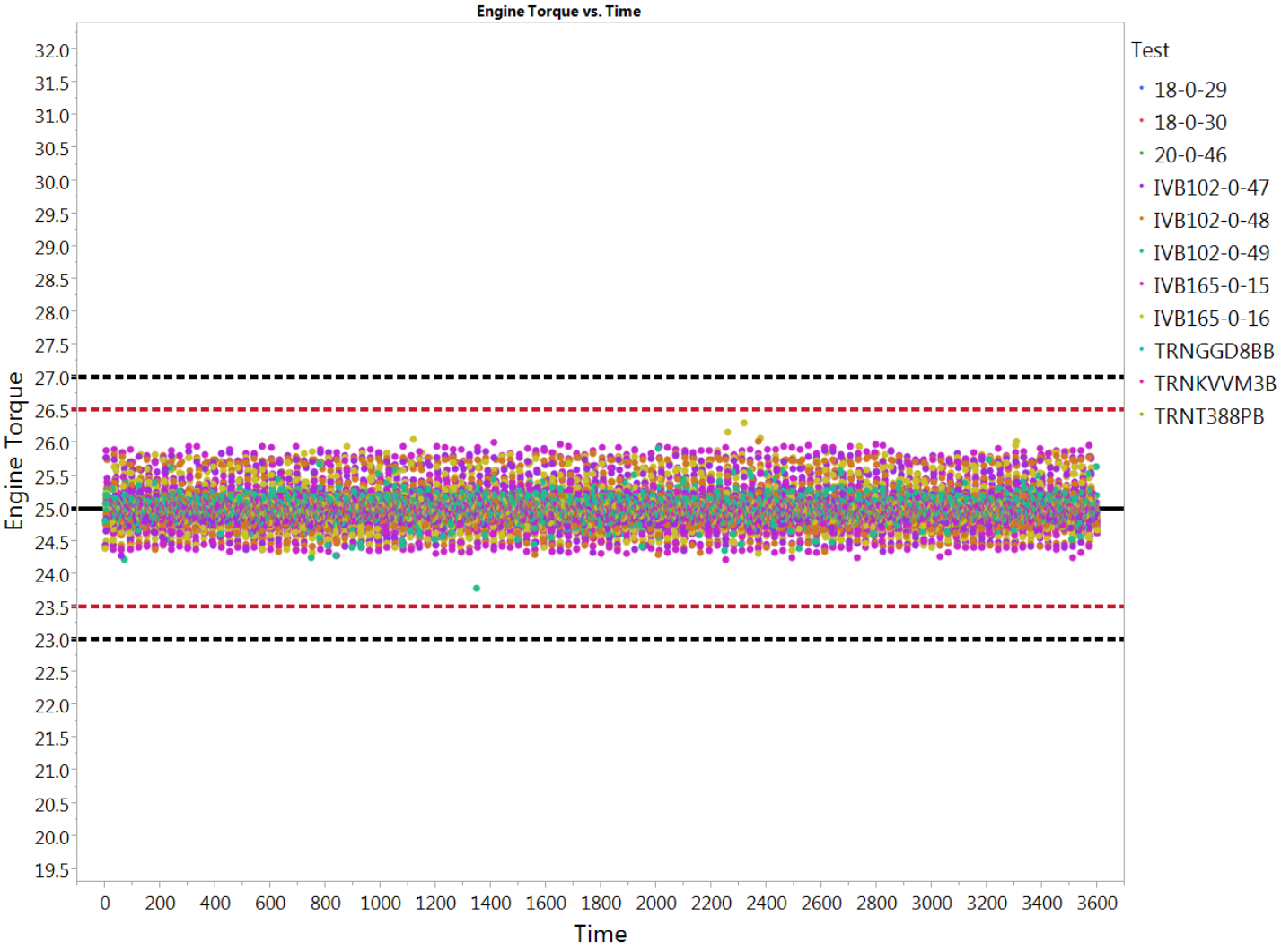
# Engine Torque QI
# Lab = SwRI

- Target: 25 N m
- Window size 1: +/- 2 N m
- Window size 2: +/- 1.5 N m



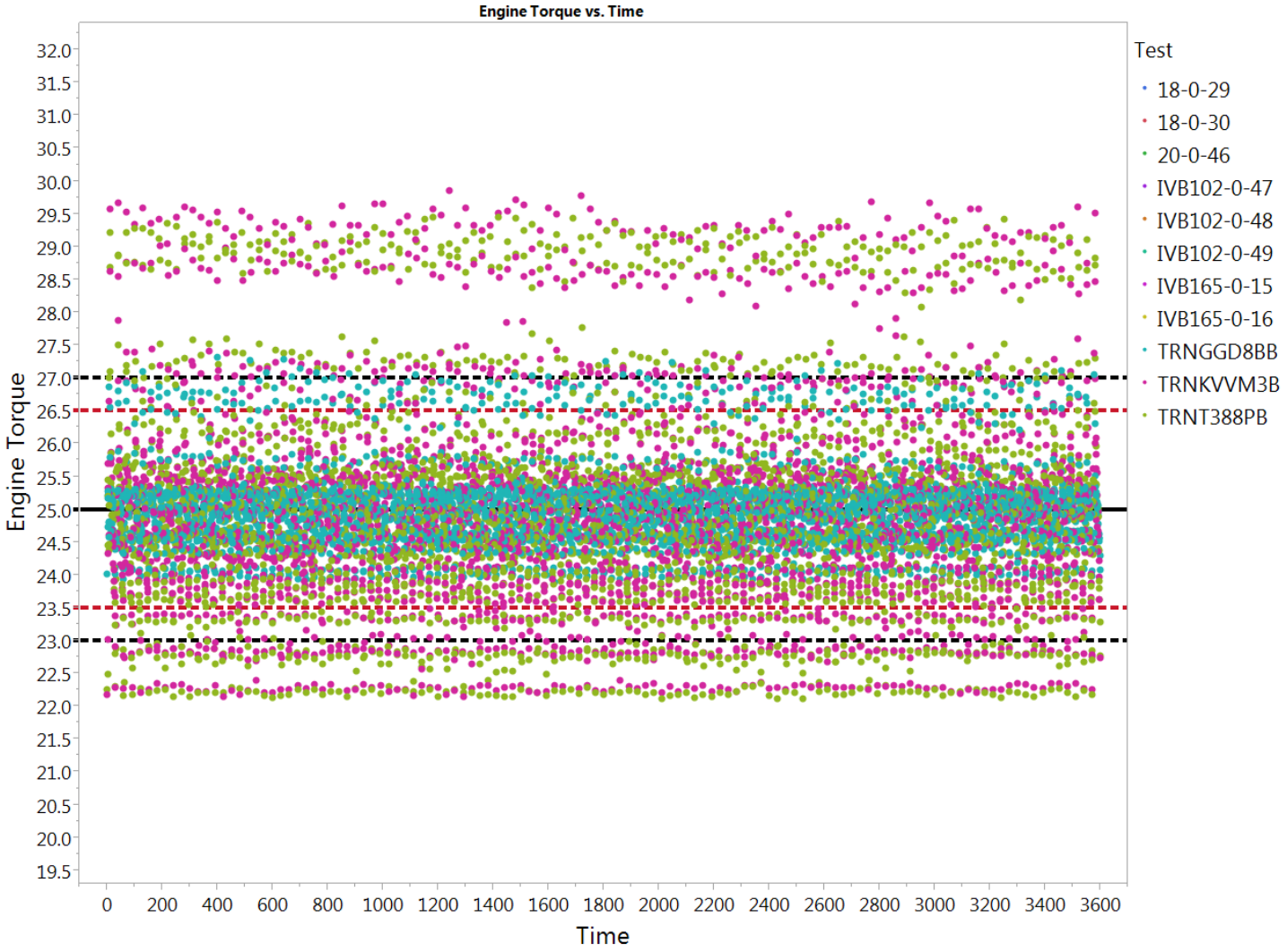
# Engine Torque QI
# Lab = IAR

- Target : 25 N m
- Window size 1: +/- 2 N m
- Window size 2: +/- 1.5 N m



# Engine Torque QI
# Lab = LZ

- Target : 25 N m
- Window size 1: +/- 2 N m
- Window size 2: +/- 1.5 N m



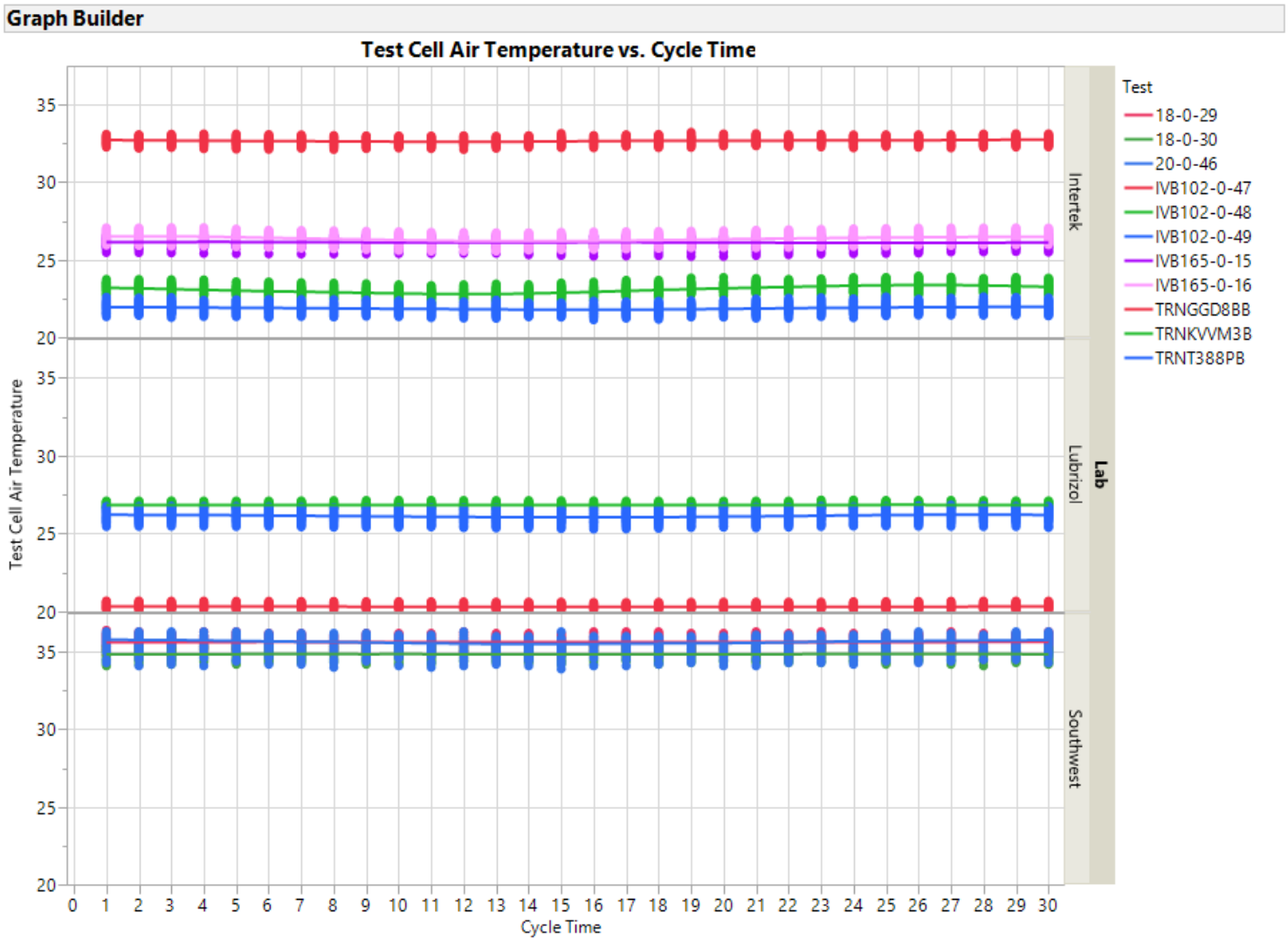
# Engine Torque QI

- Target : 25 N m
- Window size 1: +/- 2 N m
- Window size 2: +/- 1.5 N m

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | 0.97 | 0.95 |
| 18-0-30 | 0.97 | 0.95 |
| 20-0-46 | 0.96 | 0.93 |
| 102-0-47 | 0.98 | 0.97 |
| 102-0-48 | 0.98 | 0.97 |
| 102-0-49 | 0.99 | 0.99 |
| 165-0-15 | 0.98 | 0.97 |
| 165-0-16 | 0.98 | 0.97 |
| TRNGGD8BB | 0.91 | 0.84 |
| TRNKVVM3B | 0.43 | -0.01 |
| TRNT388PB | 0.42 | -0.04 |
| **Average** | **0.87** | **0.77** |

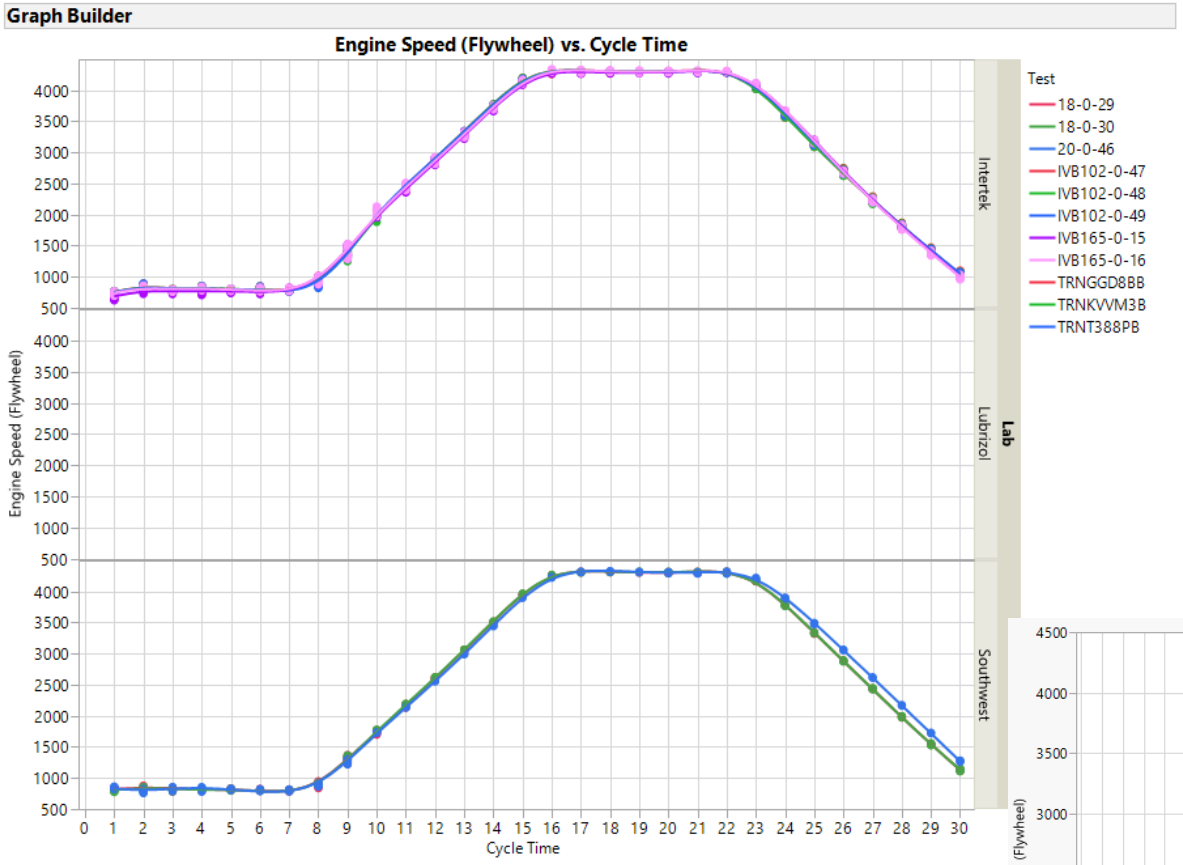
# Test Cell Air Temperature

# Test Cell Air Temperature

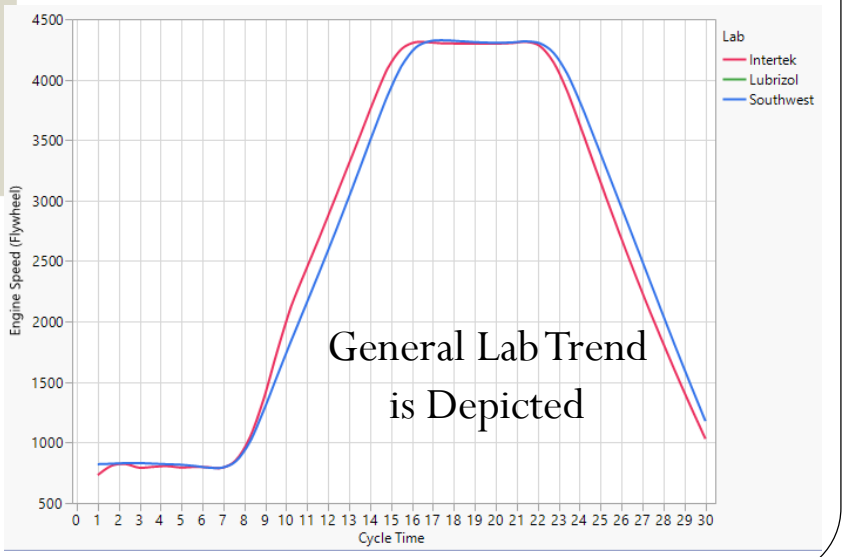


# Optional Non-ASTM Parameters

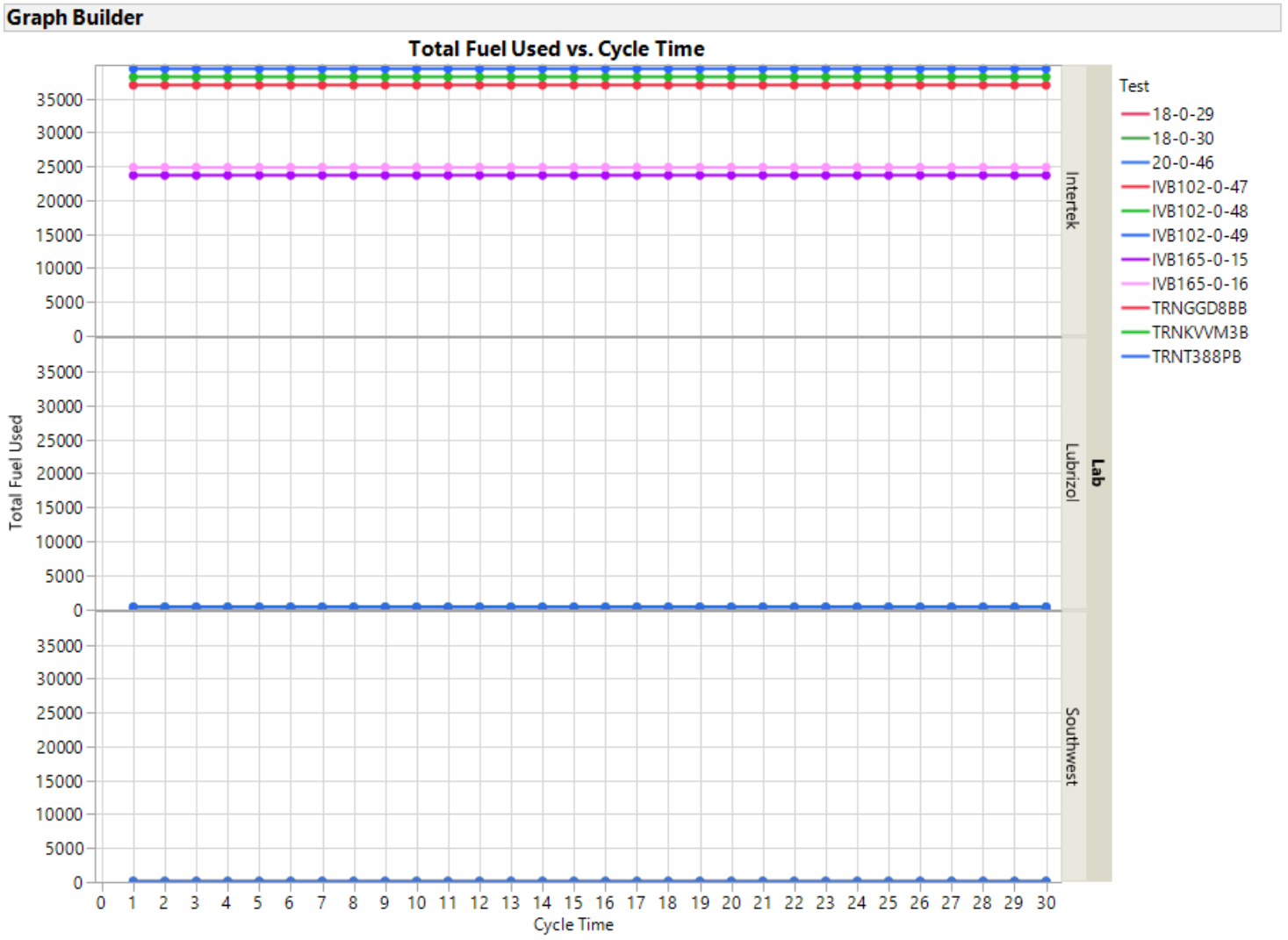
# Engine Speed (Flywheel)



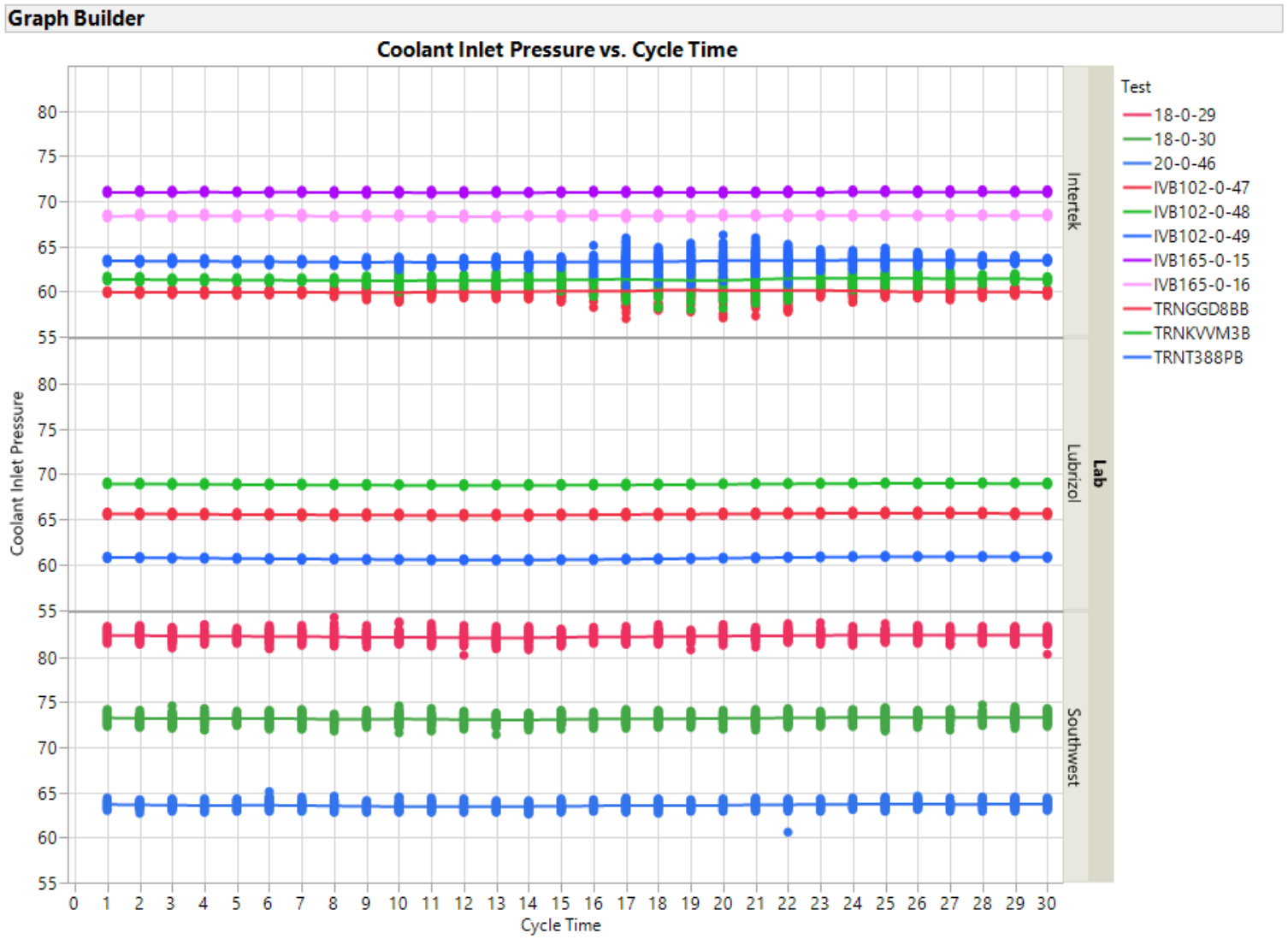

There is a slight difference in how IAR and SwRI ramp engine speed (flywheel)



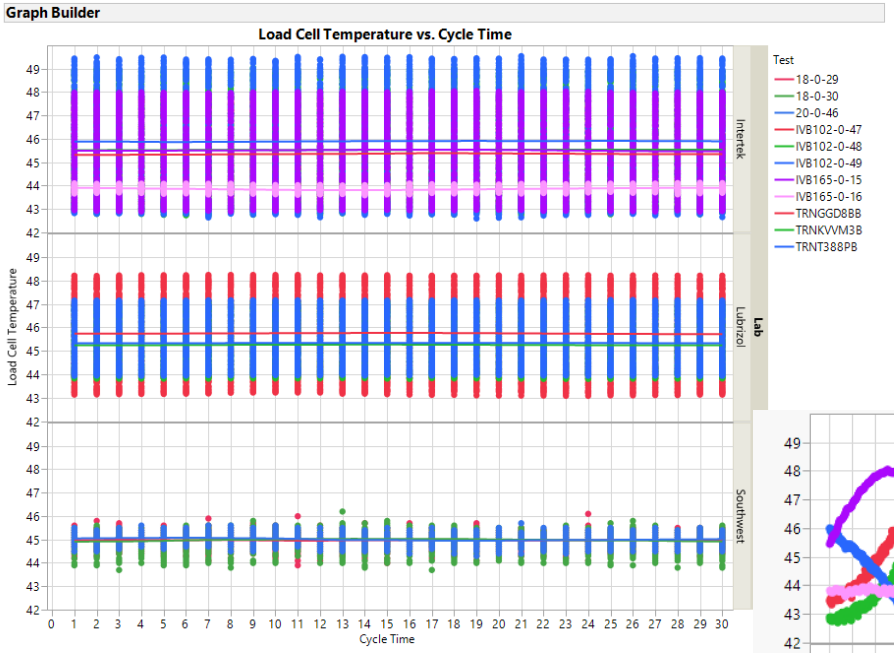
# Total Fuel Used



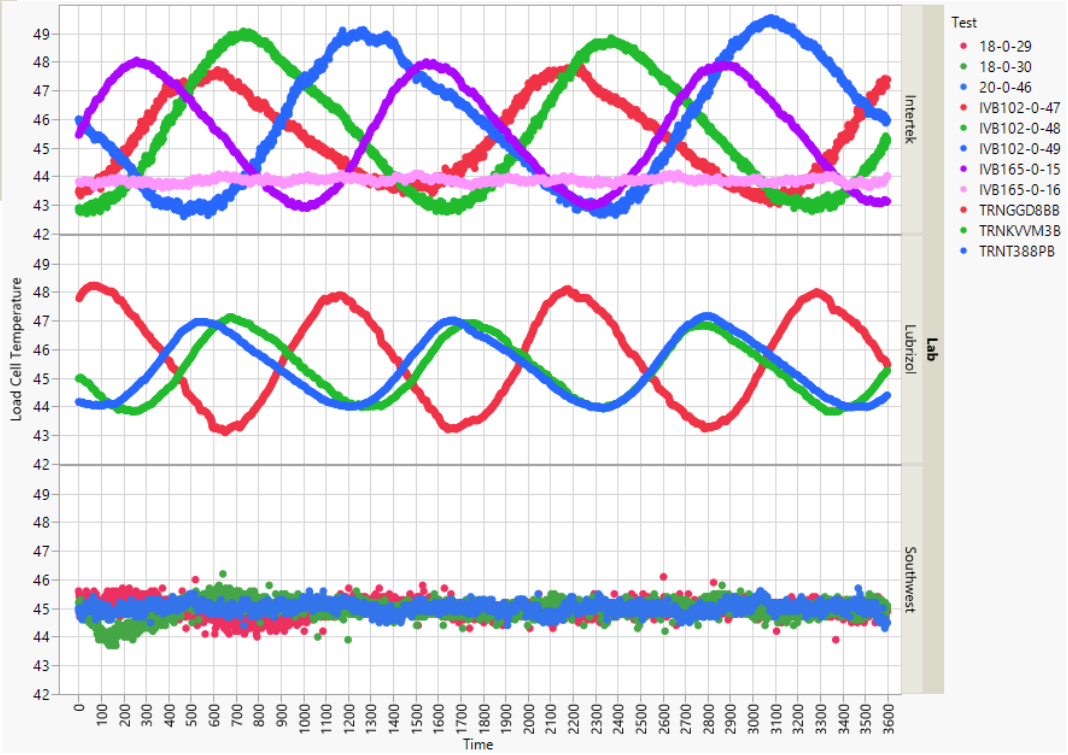
# Coolant Inlet Pressure



# Load Cell Temperature



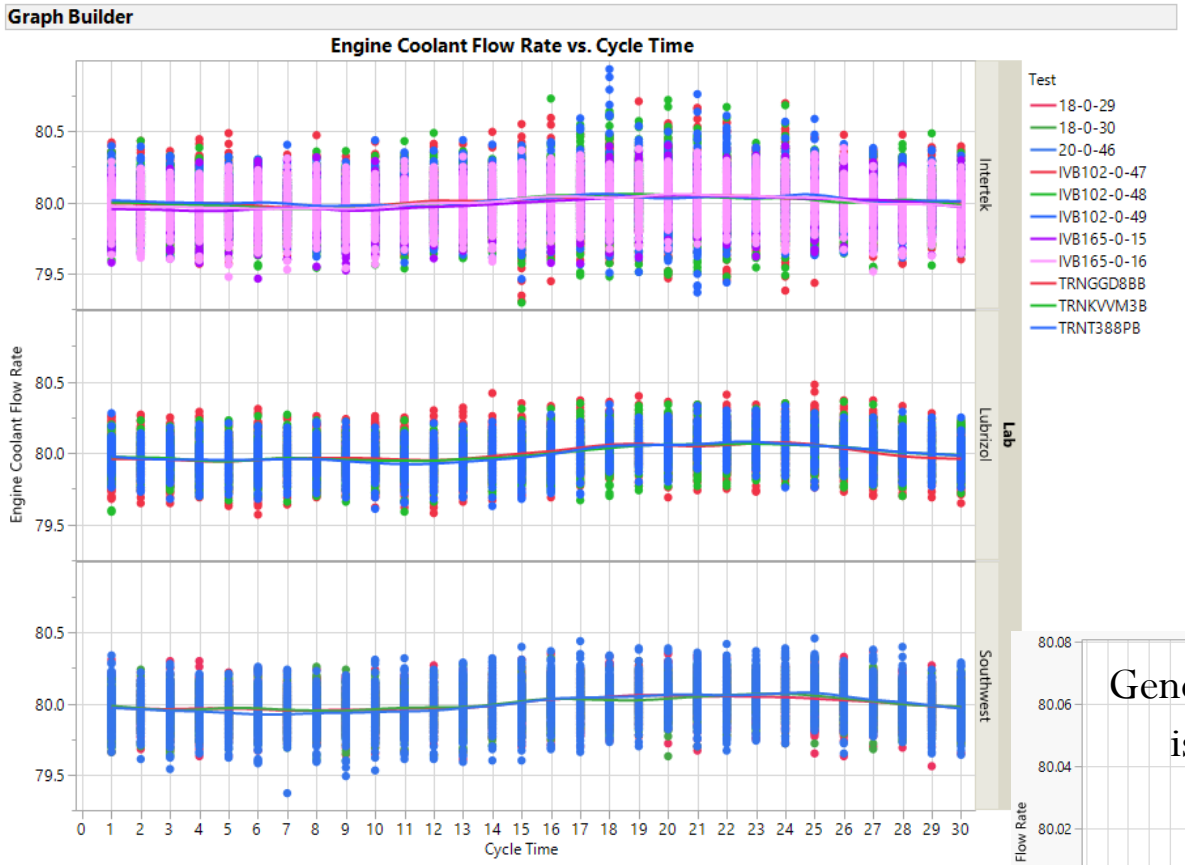

The load cell temperature fluctuates at IAR and LZ; it remains relatively constant at SwRI



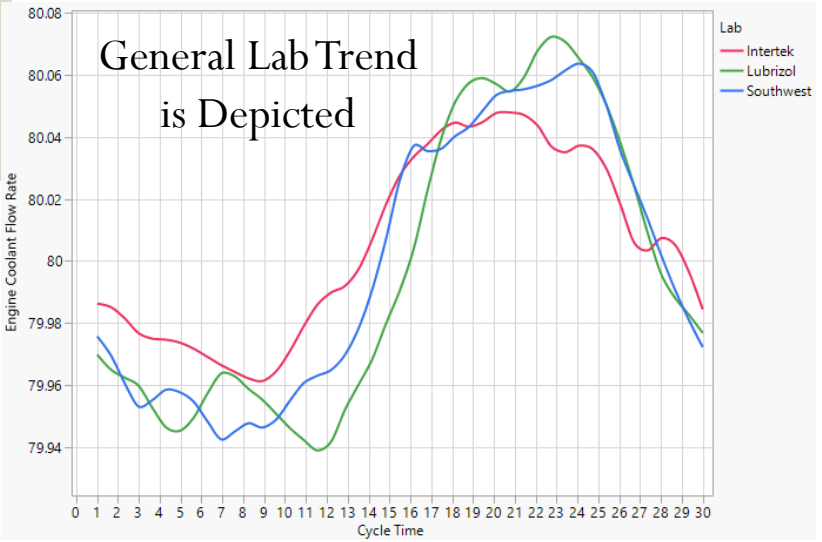
# New Parameters

# Engine Coolant Flow Rate

# Engine Coolant Flow Rate

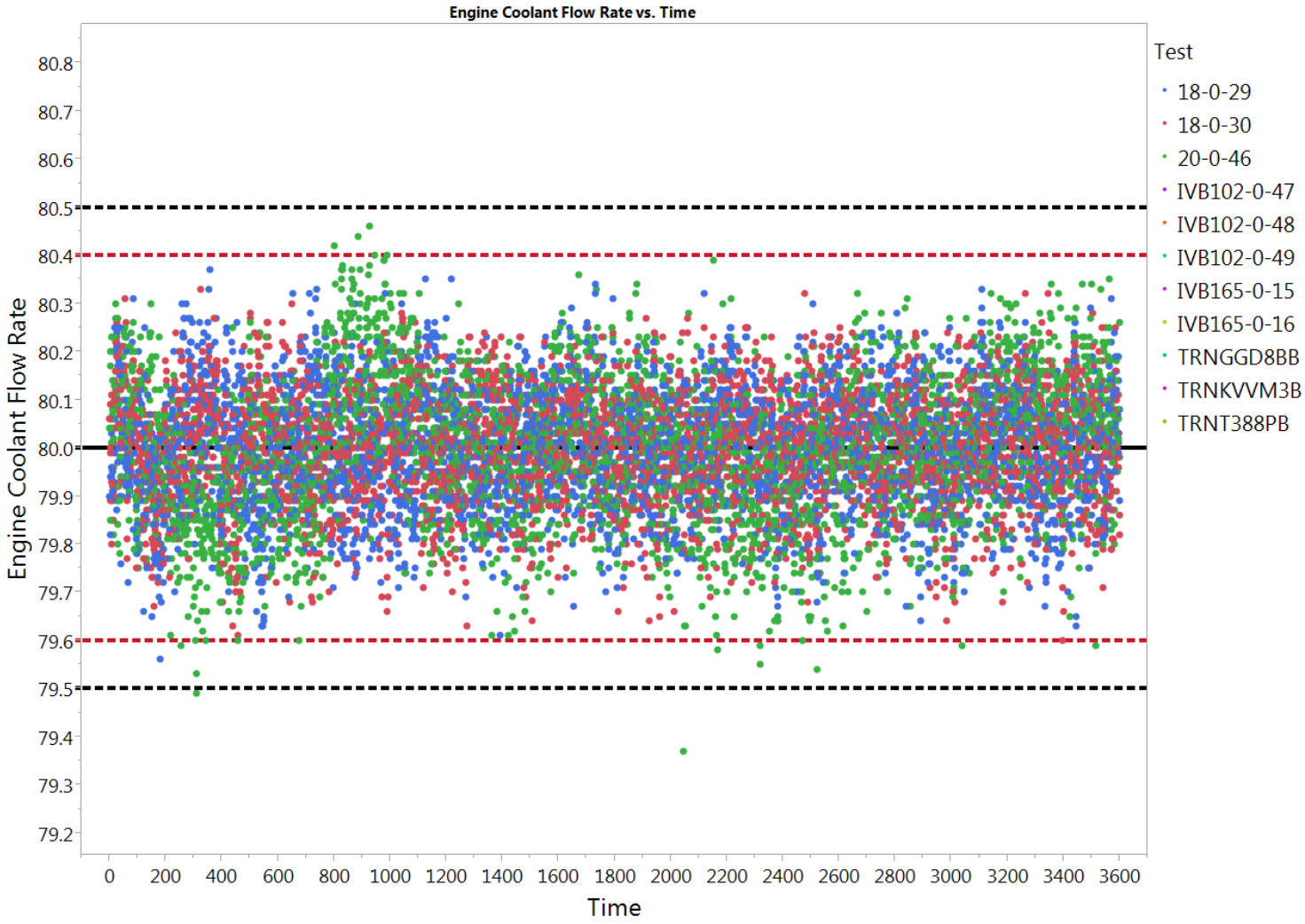



It's hard to say whether the engine coolant flow rate cycle profile differs across the various labs



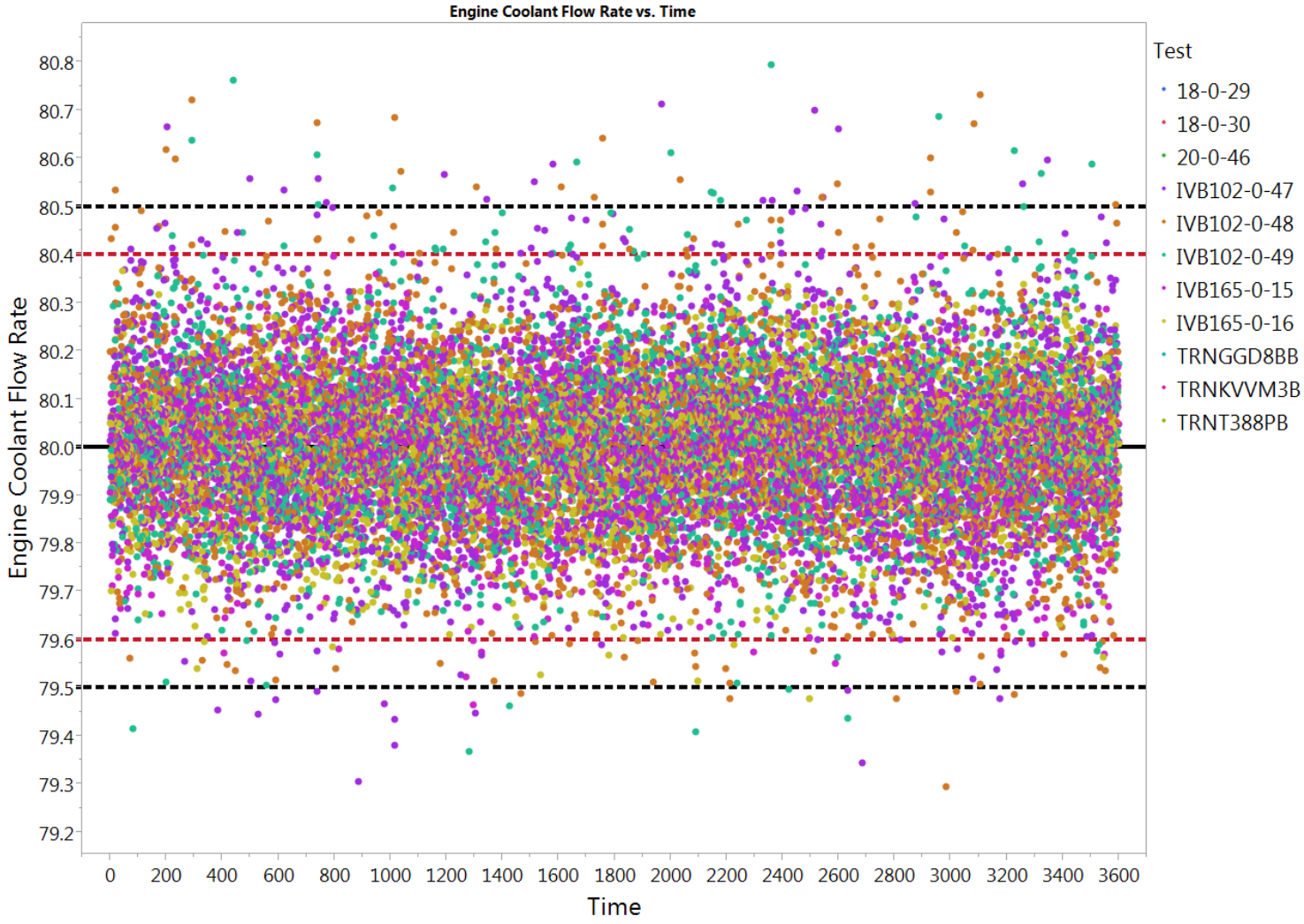
# Engine Coolant Flow Rate QI
# Lab = SwRI

- Target : 80 L/min
- Window size 1: +/- 0.5 L/min
- Window size 2: +/- 0.4 L/min



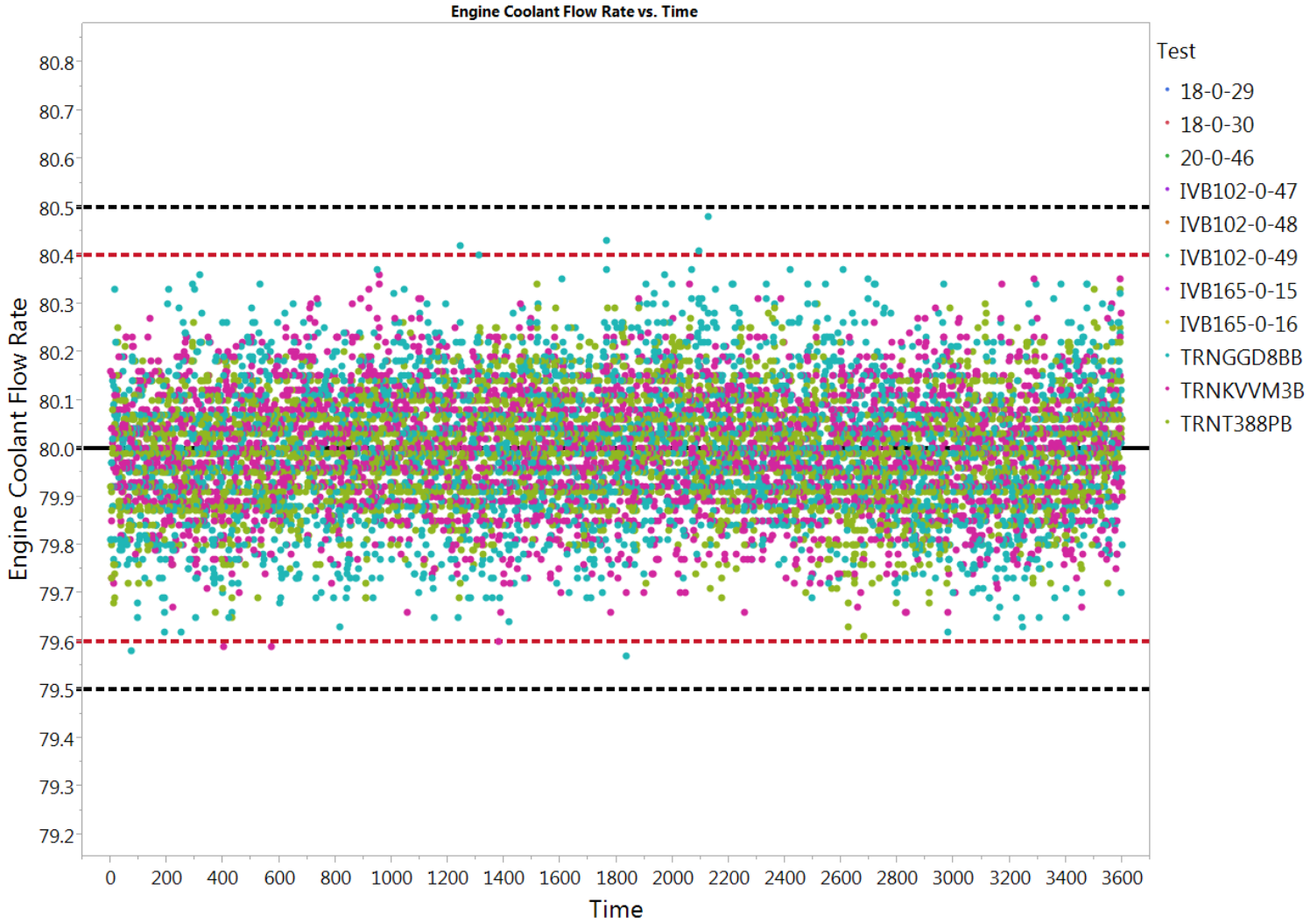
# Engine Coolant Flow Rate QI
# Lab = IAR

- Target : 80 L/min
- Window size 1: +/- 0.5 L/min
- Window size 2: +/- 0.4 L/min



# Engine Coolant Flow Rate QI Lab = LZ

- Target : 80 L/min
- Window size 1: +/- 0.5 L/min
- Window size 2: +/- 0.4 L/min



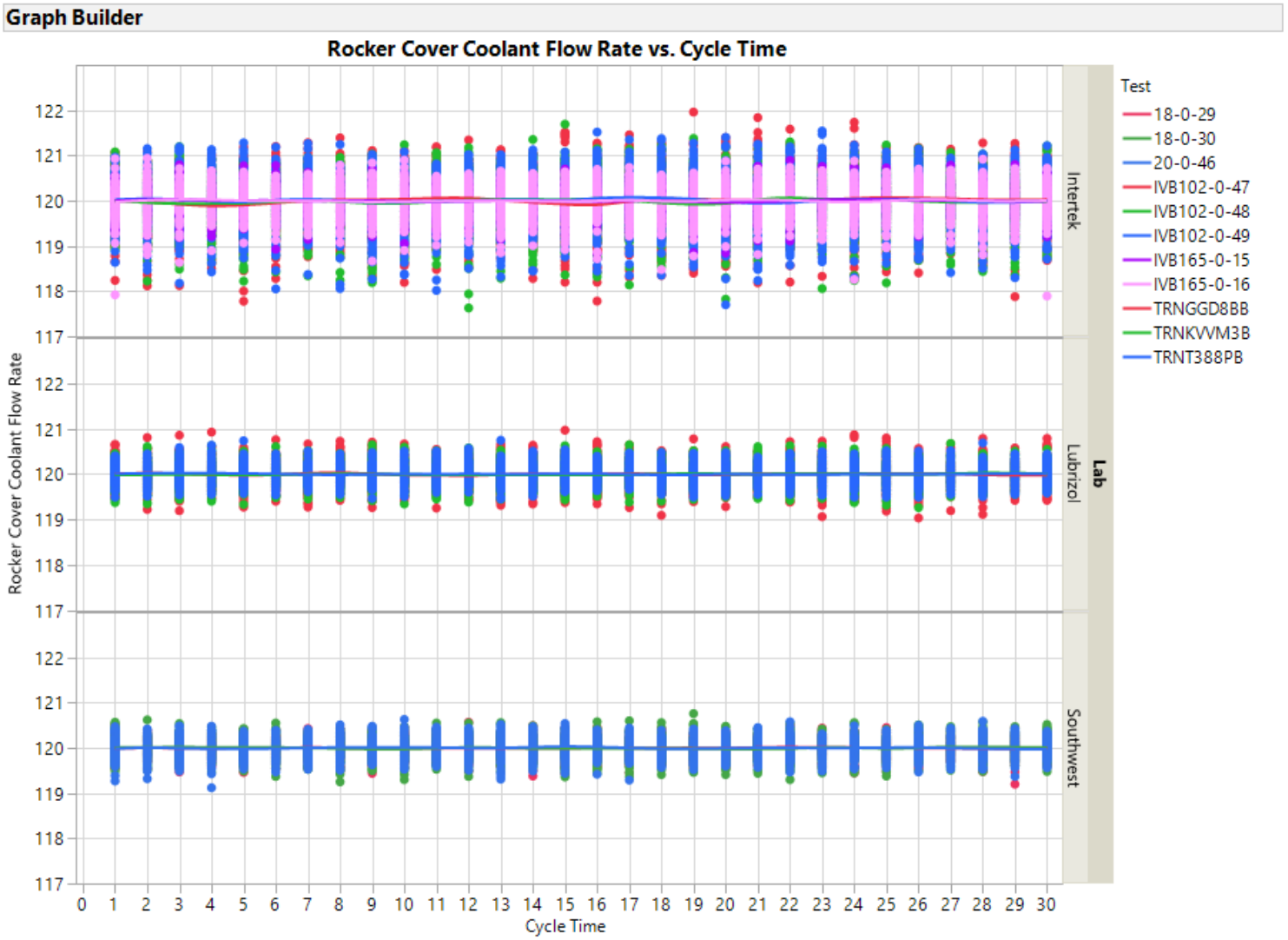
# Engine Coolant Flow Rate QI

- Target : 80 L/min
- Window size 1: +/- 0.5 L/min
- Window size 2: +/- 0.4 L/min

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | 0.94 | 0.91 |
| 18-0-30 | 0.95 | 0.92 |
| 20-0-46 | 0.92 | 0.87 |
| 102-0-47 | 0.88 | 0.81 |
| 102-0-48 | 0.88 | 0.82 |
| 102-0-49 | 0.90 | 0.84 |
| 165-0-15 | 0.93 | 0.89 |
| 165-0-16 | 0.93 | 0.89 |
| TRNGGD8BB | 0.92 | 0.88 |
| TRNKVVM3B | 0.94 | 0.91 |
| TRNT388PB | 0.95 | 0.93 |
| **Average** | **0.92** | **0.88** |

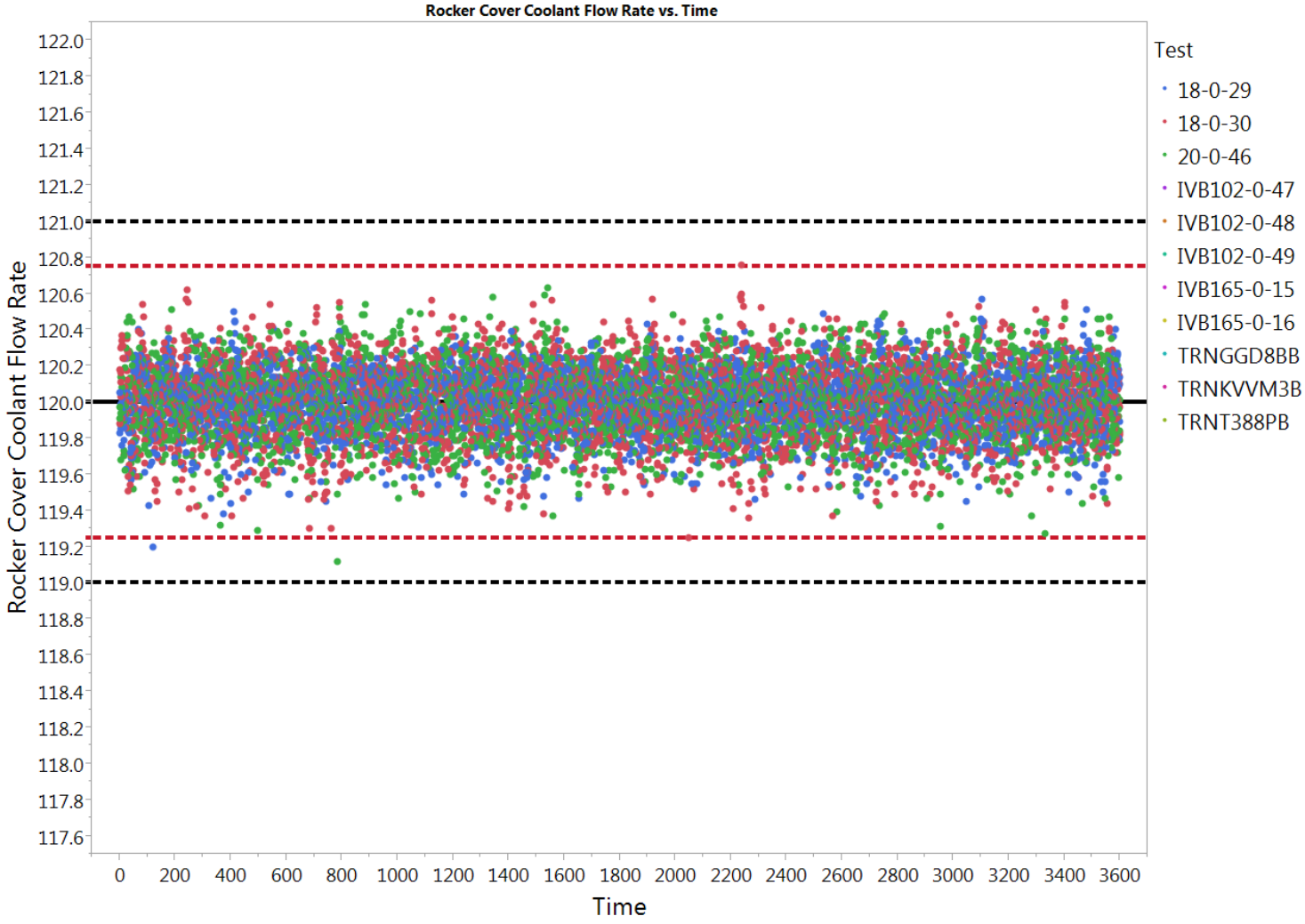
# Rocker Cover Coolant Flow Rate

# Rocker Cover Coolant Flow Rate



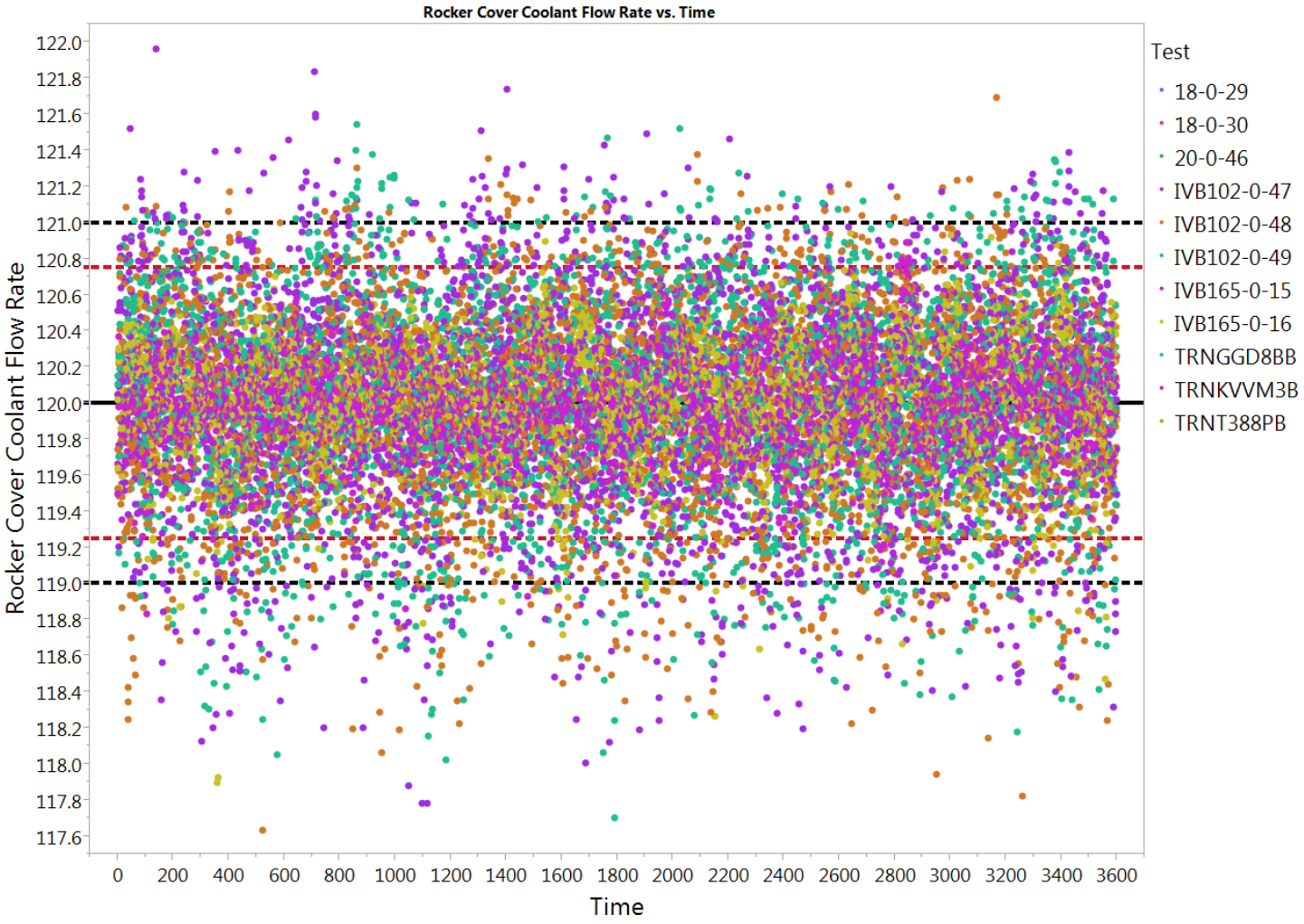
# RAC Coolant Flow Rate QI
# Lab = SwRI

- Target : 120 L/min
- Window size 1: +/- 1.0 L/min
- Window size 2: +/- 0.75 L/min



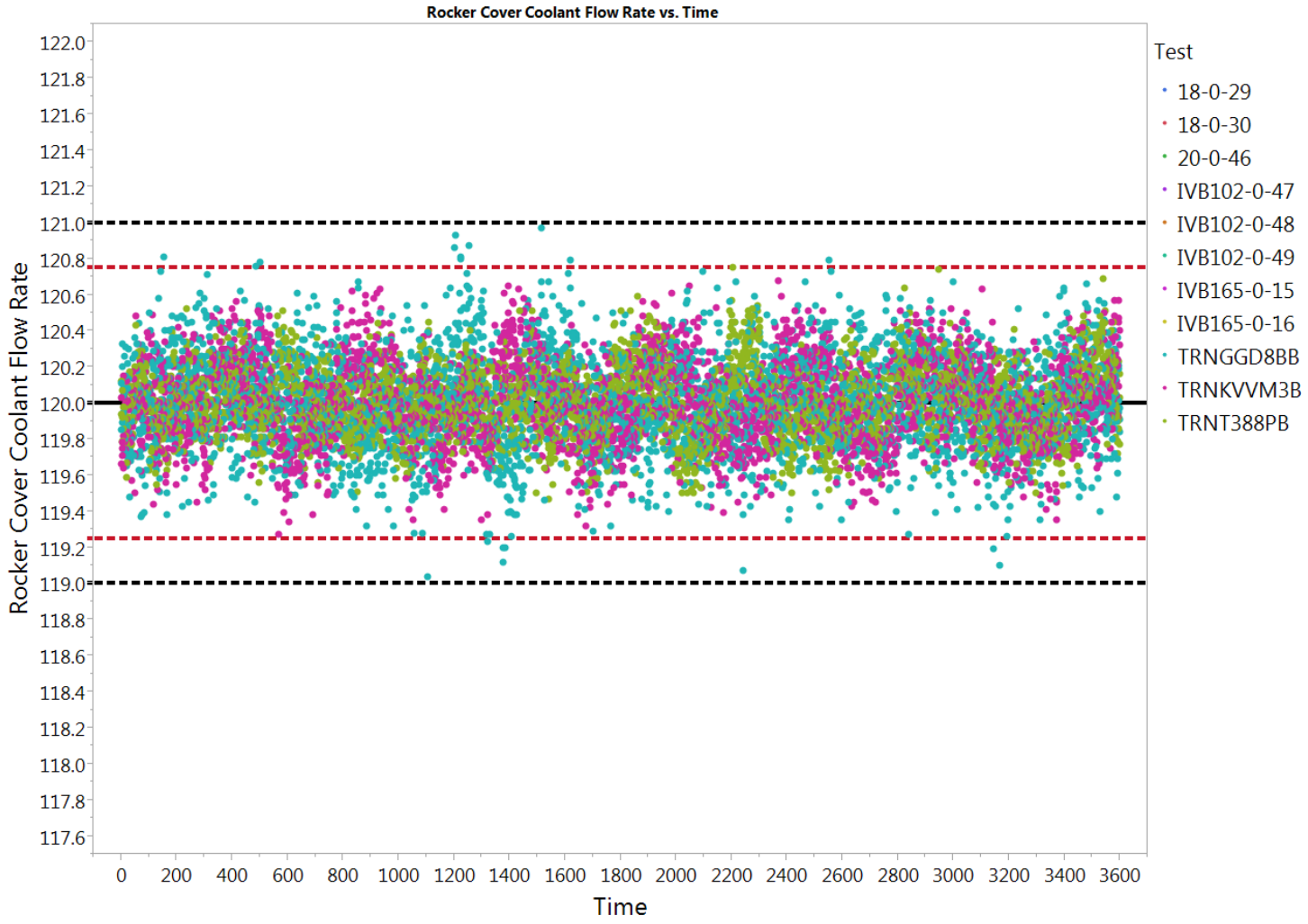
# RAC Coolant Flow Rate QI
# Lab = IAR

- Target : 120 L/min
- Window size 1: +/- 1.0 L/min
- Window size 2: +/- 0.75 L/min



# RAC Coolant Flow Rate QI
# Lab = LZ

- Target : 120 L/min
- Window size 1: +/- 1.0 L/min
- Window size 2: +/- 0.75 L/min



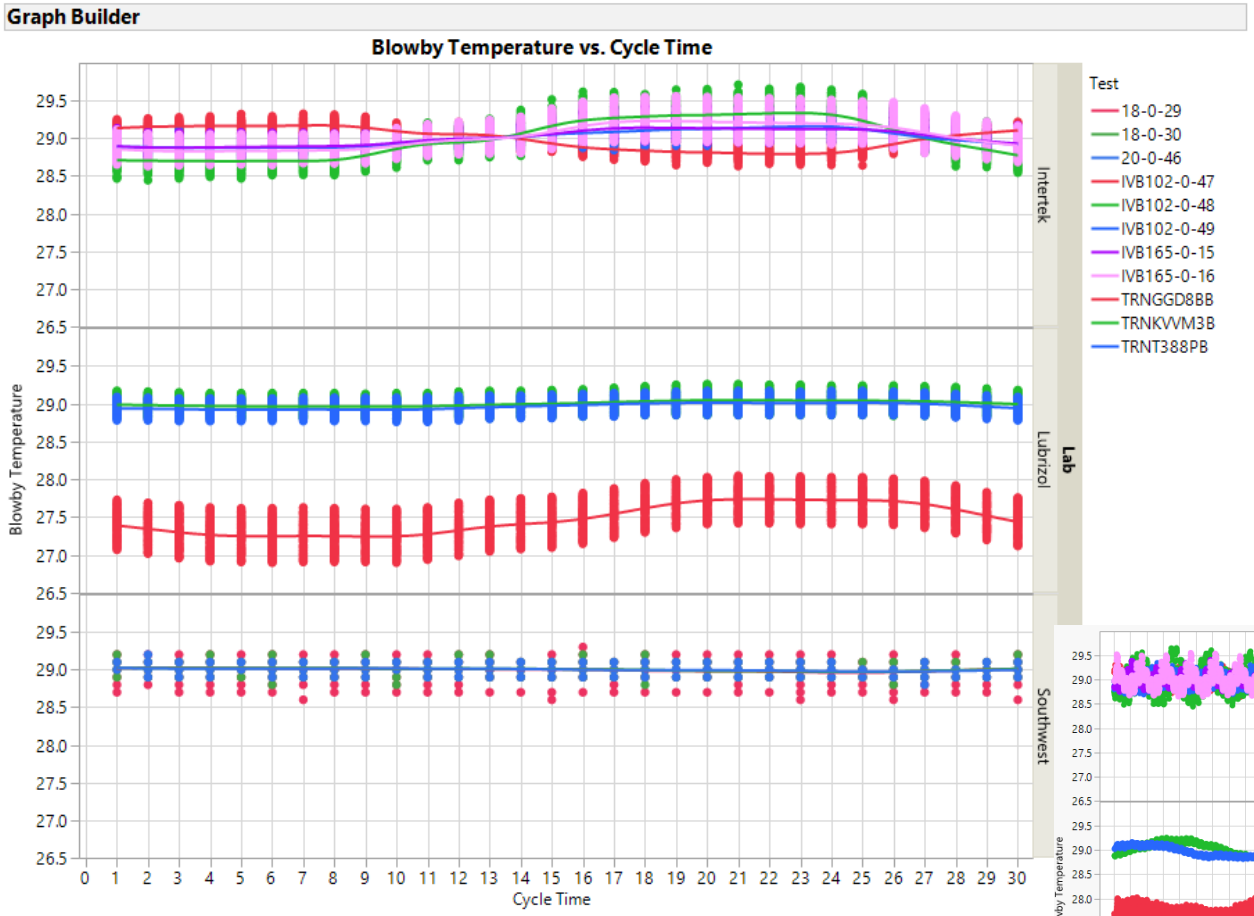
# RAC Coolant Flow Rate QI

- Target : 120 L/min
- Window size 1: +/- 1.0 L/min
- Window size 2: +/- 0.75 L/min

| Test no. | QI Window 1 | QI Window 2 |
|---|---|---|
| 18-0-29 | 0.97 | 0.95 |
| 18-0-30 | 0.96 | 0.93 |
| 20-0-46 | 0.96 | 0.94 |
| 102-0-47 | 0.67 | 0.41 |
| 102-0-48 | 0.72 | 0.49 |
| 102-0-49 | 0.71 | 0.48 |
| 165-0-15 | 0.94 | 0.89 |
| 165-0-16 | 0.90 | 0.81 |
| TRNGGD8BB | 0.93 | 0.88 |
| TRNKVVM3B | 0.95 | 0.91 |
| TRNT388PB | 0.97 | 0.94 |
| **Average** | **0.88** | **0.79** |

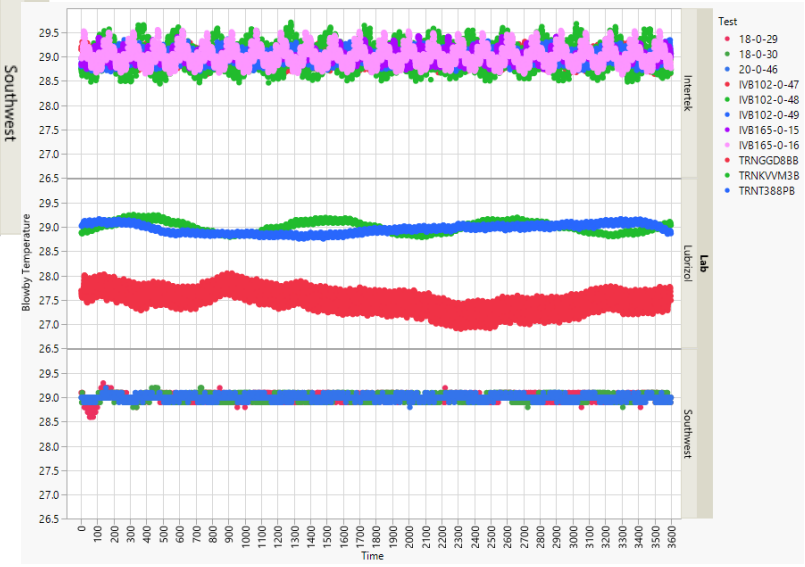
# Blowby Temperature

# Blowby Temperature




TRNGGD888 has a lower blowby temperature

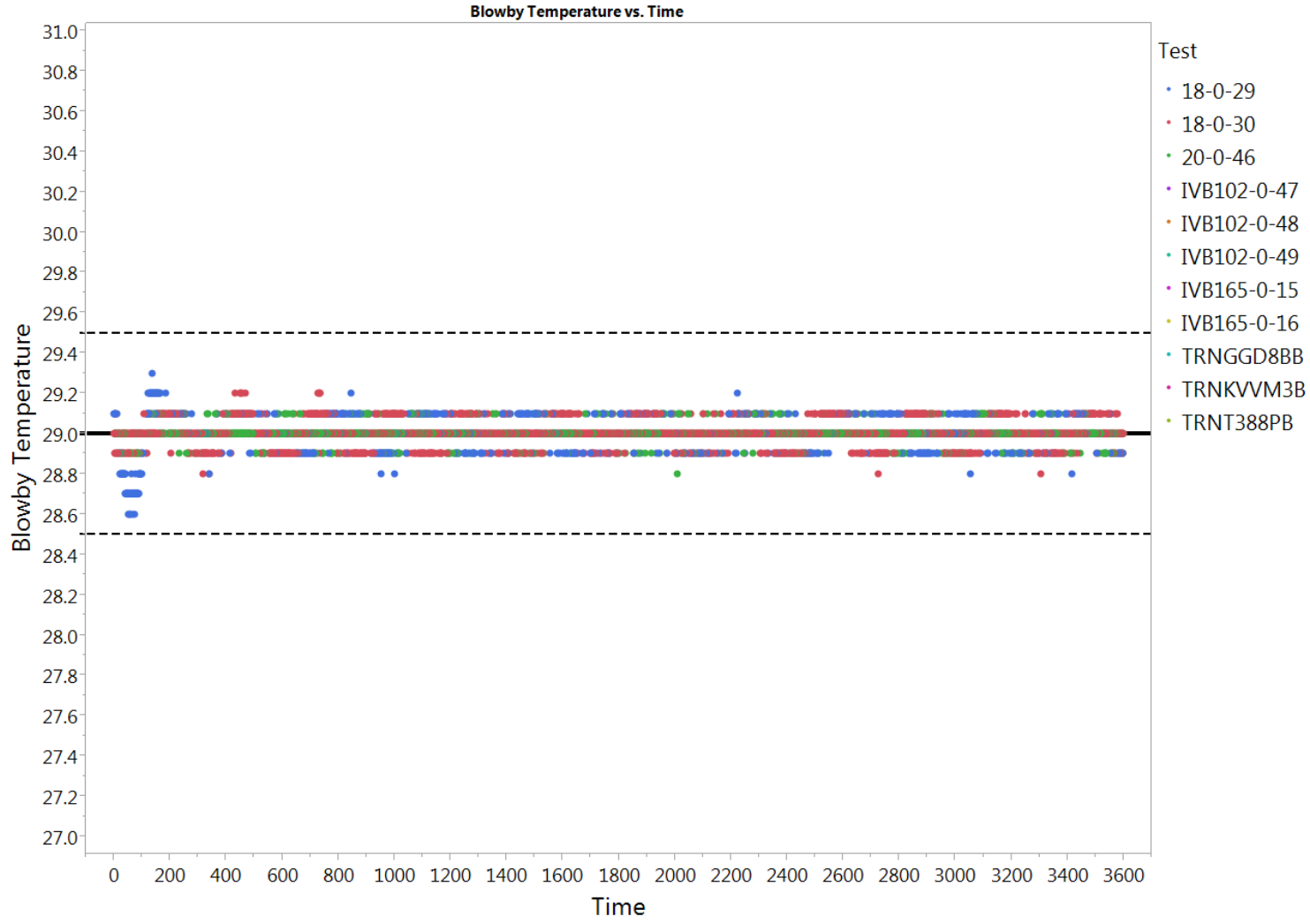
SwRI and LZ generally have cycle profiles that are more consistent than IAR



# Blowby Gas Temp QI
# Lab = SwRI

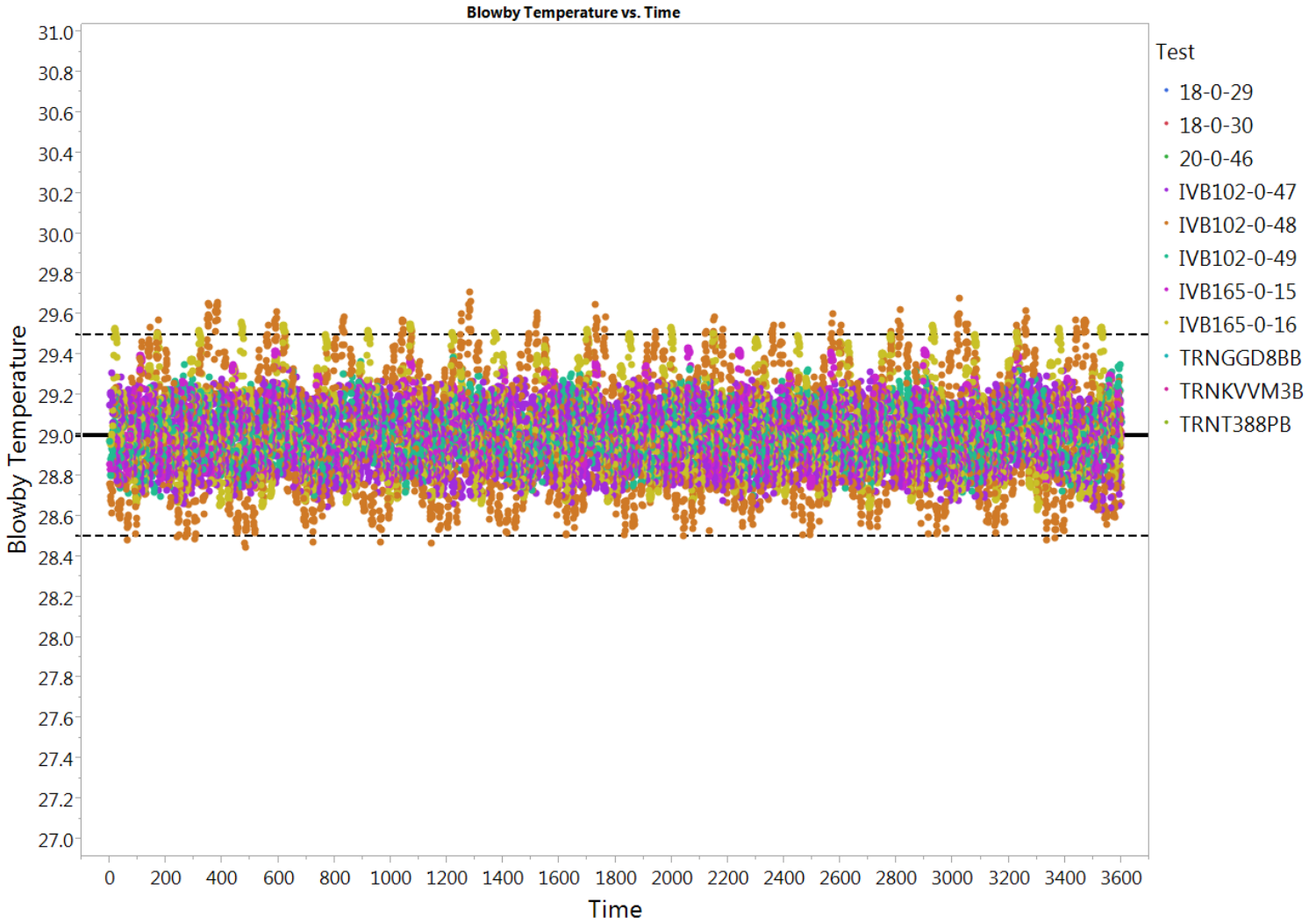
- Target : 29 C
- Window size 1: +/- 0.5 C

*Lab only reported one decimal place



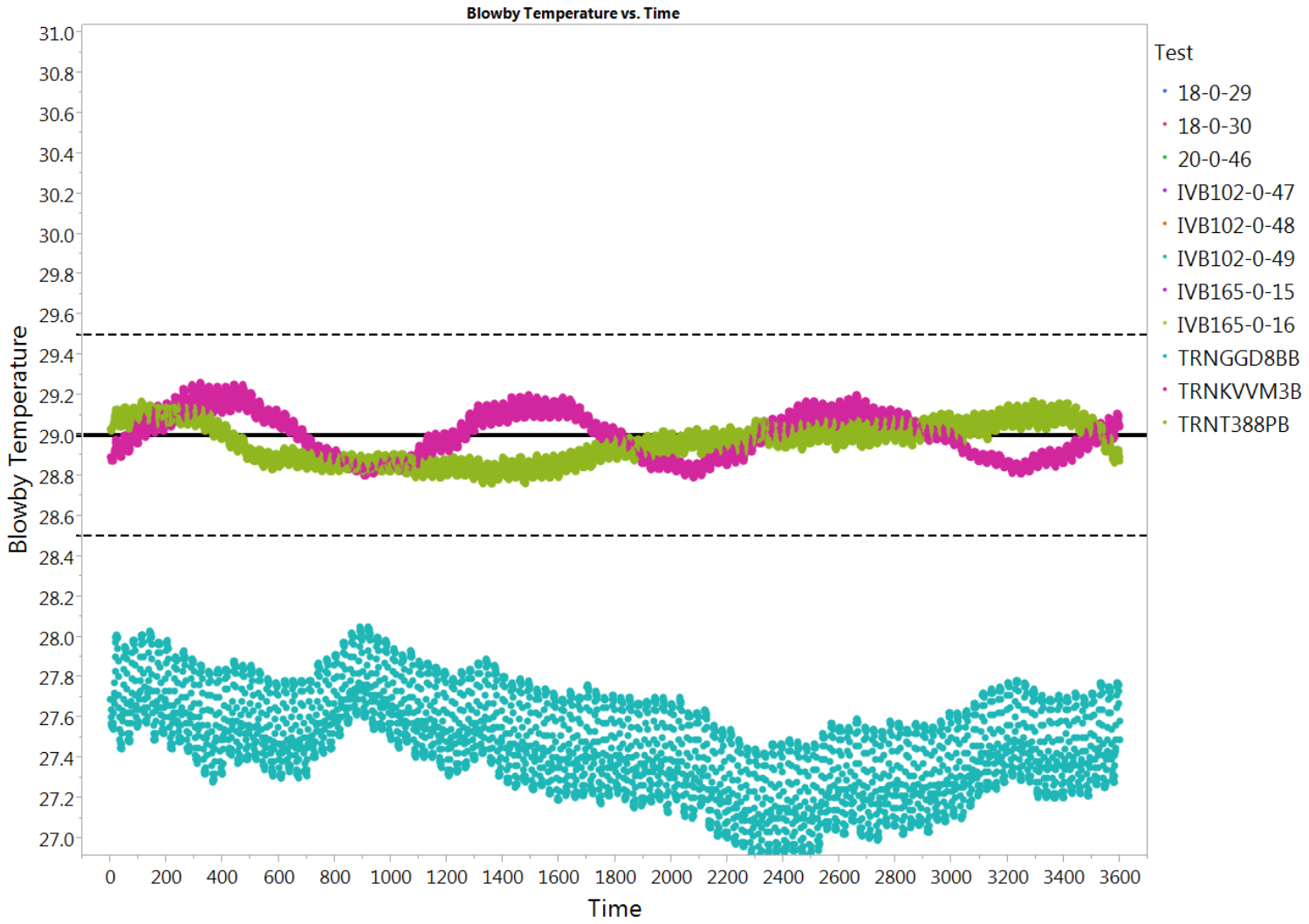
# Blowby Gas Temp QI
# Lab = IAR

- Target : 29 C
- Window size 1: +/- 0.5 C



# Blowby Gas Temp QI
# Lab = LZ

- Target : 29 C
- Window size 1: +/- 0.5 C



# Blowby Gas Temp QI

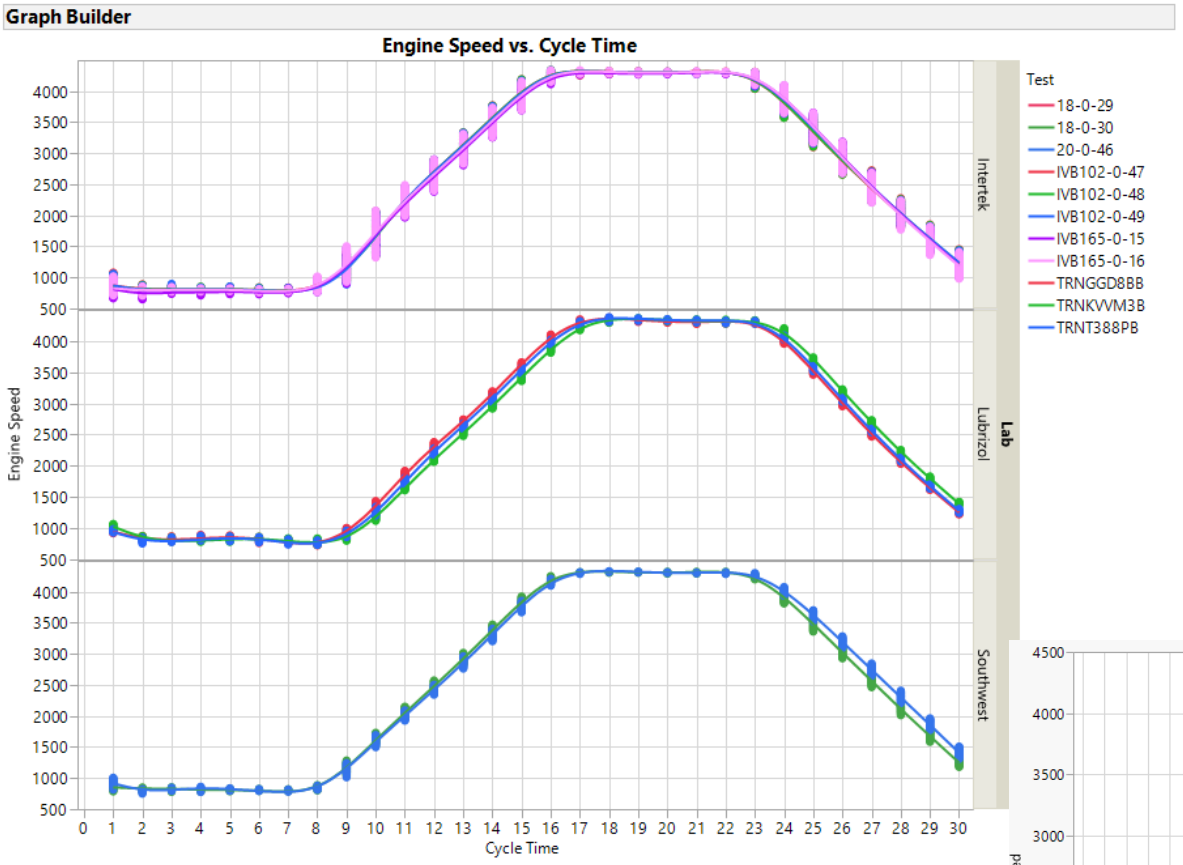
- Target : 29 C
- Window size 1: +/- 0.5 C

| Test no. | QI Window 1 |
|---|---|
| 18-0-29 | 0.98 |
| 18-0-30 | 0.98 |
| 20-0-46 | 0.99 |
| 102-0-47 | 0.91 |
| 102-0-48 | 0.70 |
| 102-0-49 | 0.94 |
| 165-0-15 | 0.91 |
| 165-0-16 | 0.81 |
| TRNGGD8BB | -8.54 |
| TRNKVVM3B | 0.95 |
| TRNT388PB | 0.96 |
| **Average** | **0.91*** |

* - Average calculated without TRNGGD8BB

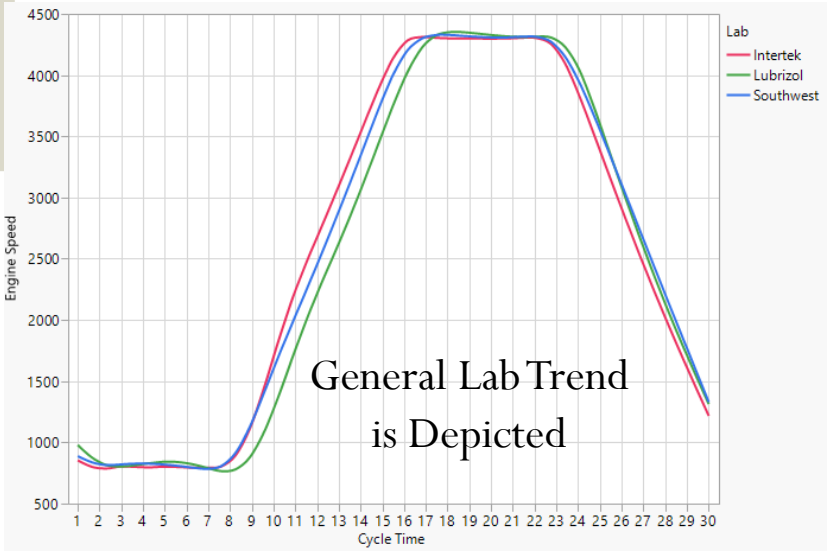
# OBD-II Parameters

# Engine Speed

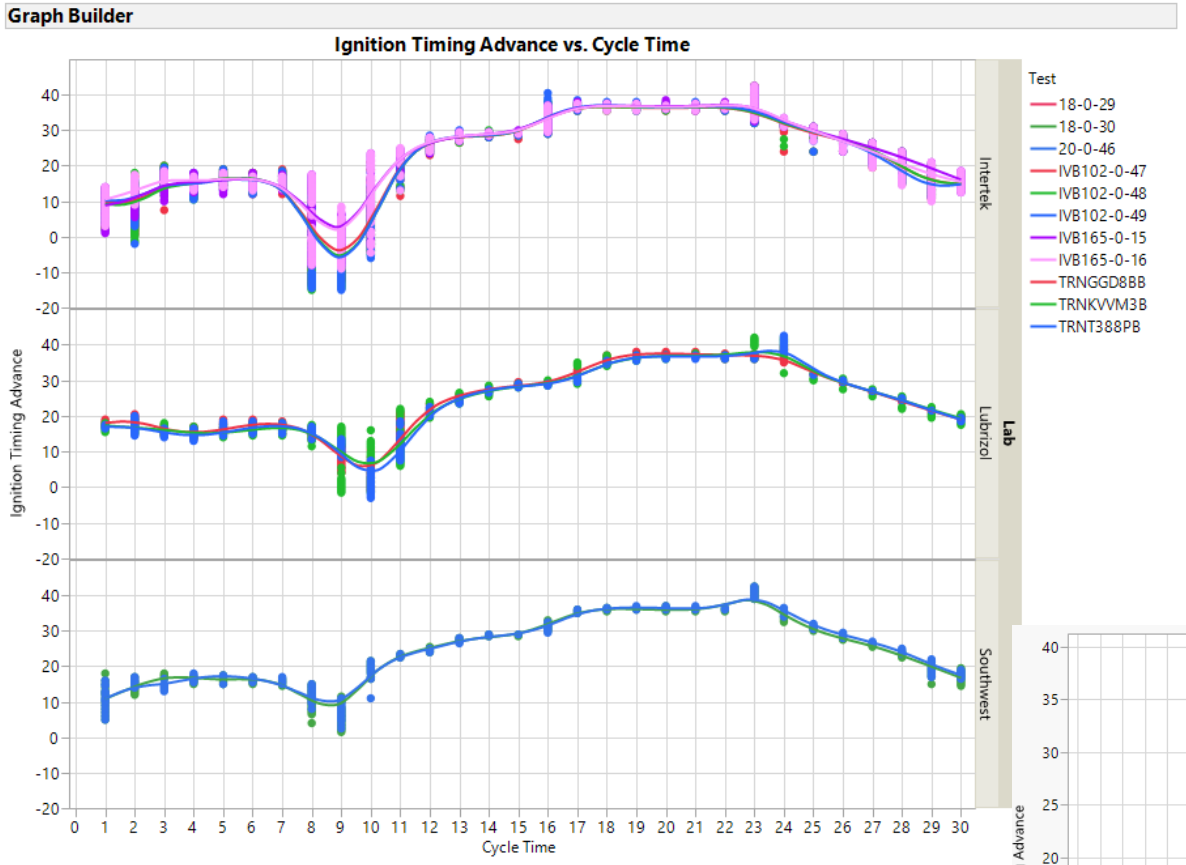



There are differences among the labs in how the engine speed cycles:

1. LZ's cycle is ~1 to ~2 seconds offset from the other labs
2. IAR and SwRI ramp differently (slightly)

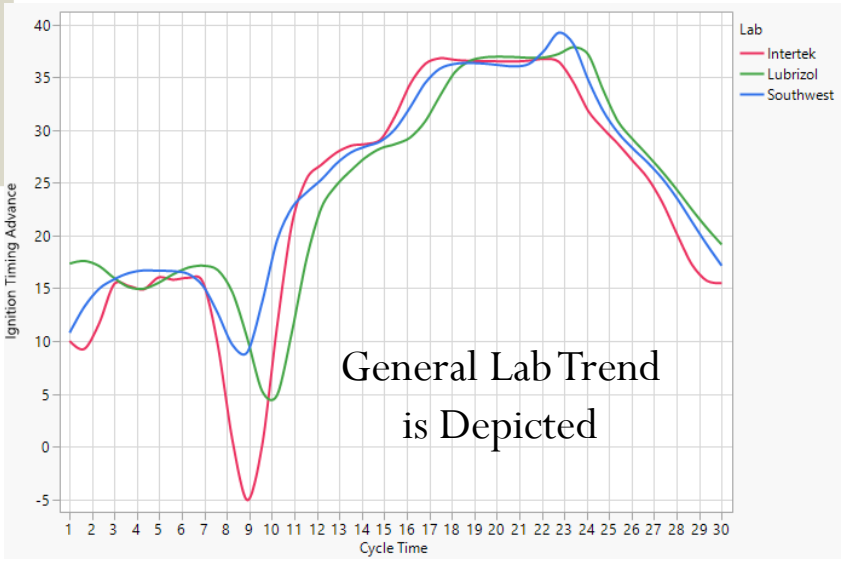


# Ignition Timing Advance

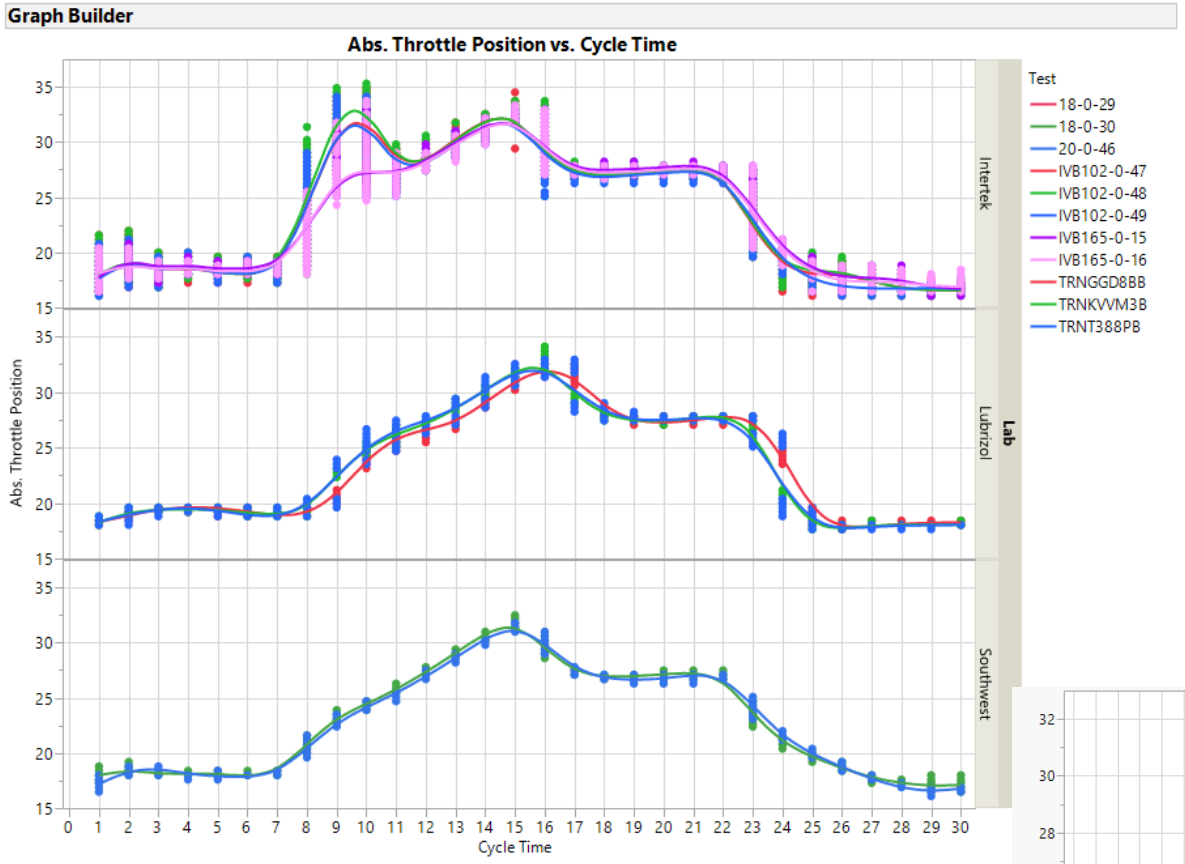



LZ's Ignition Timing Advance is offset ~1 to ~2 seconds from the other labs

IAR dips lower than the other labs at the beginning of the transition from stage 1 to stage 2

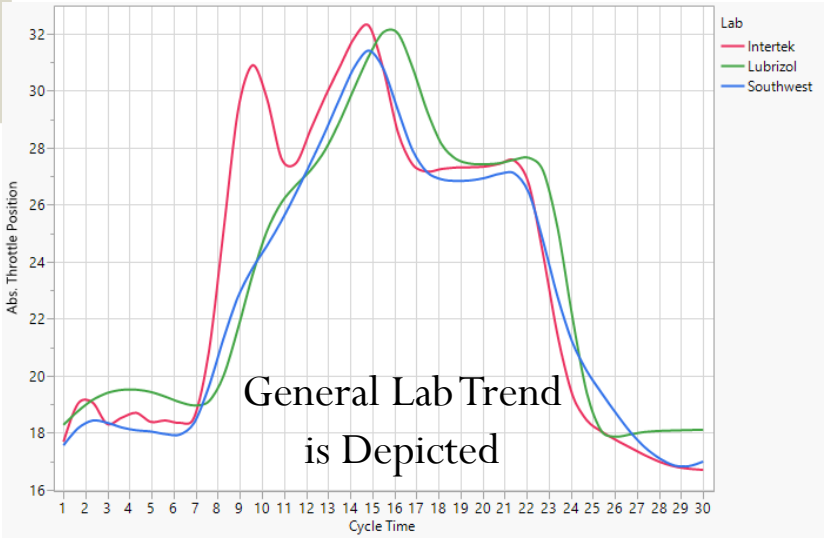


# Absolute Throttle Position

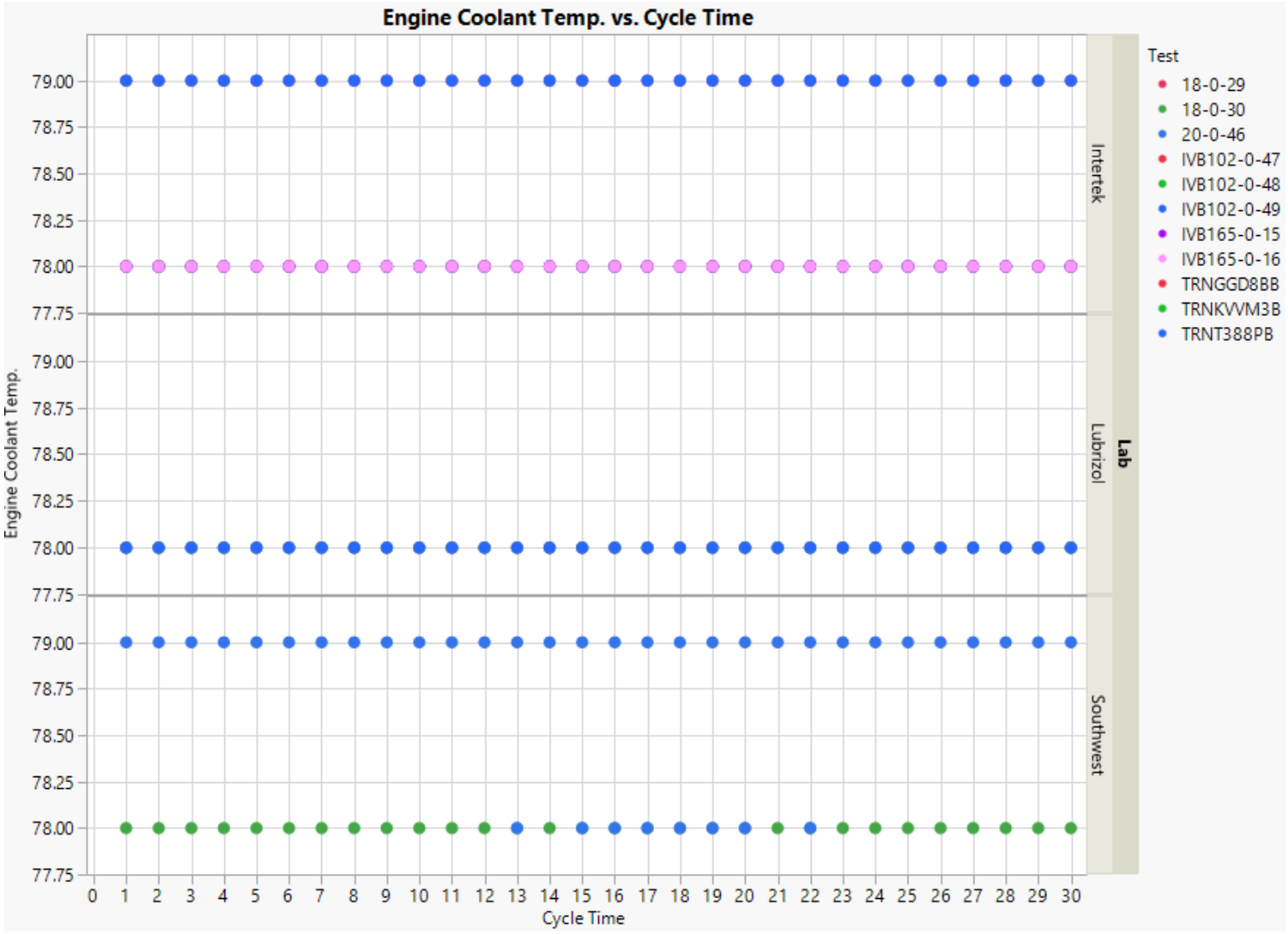



IAR's change is absolute throttle position during the transition from stage 1 to stage 2 is not an linear as the other labs.

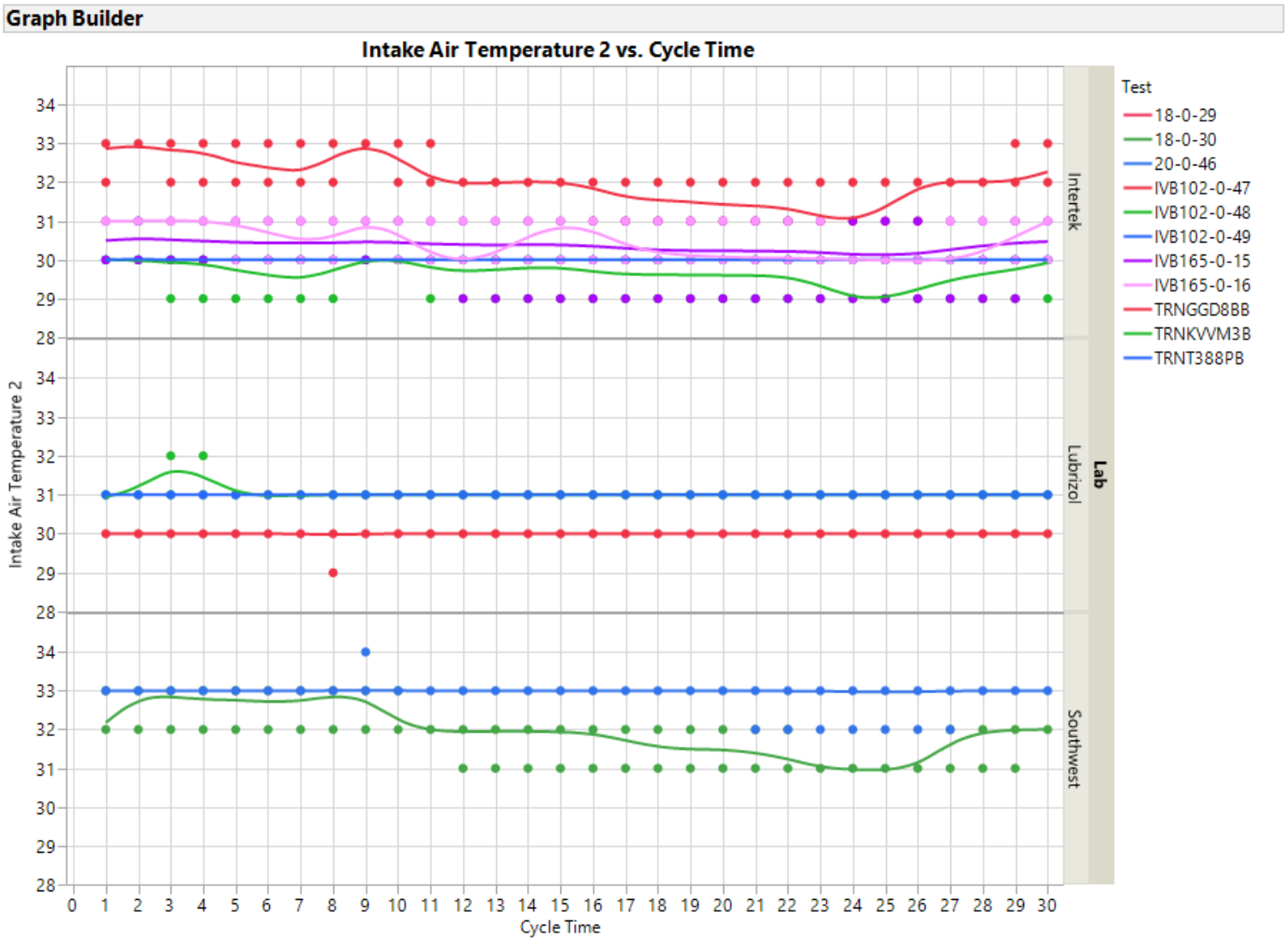
LZ's cycle profile is offset ~1 second from SwRI



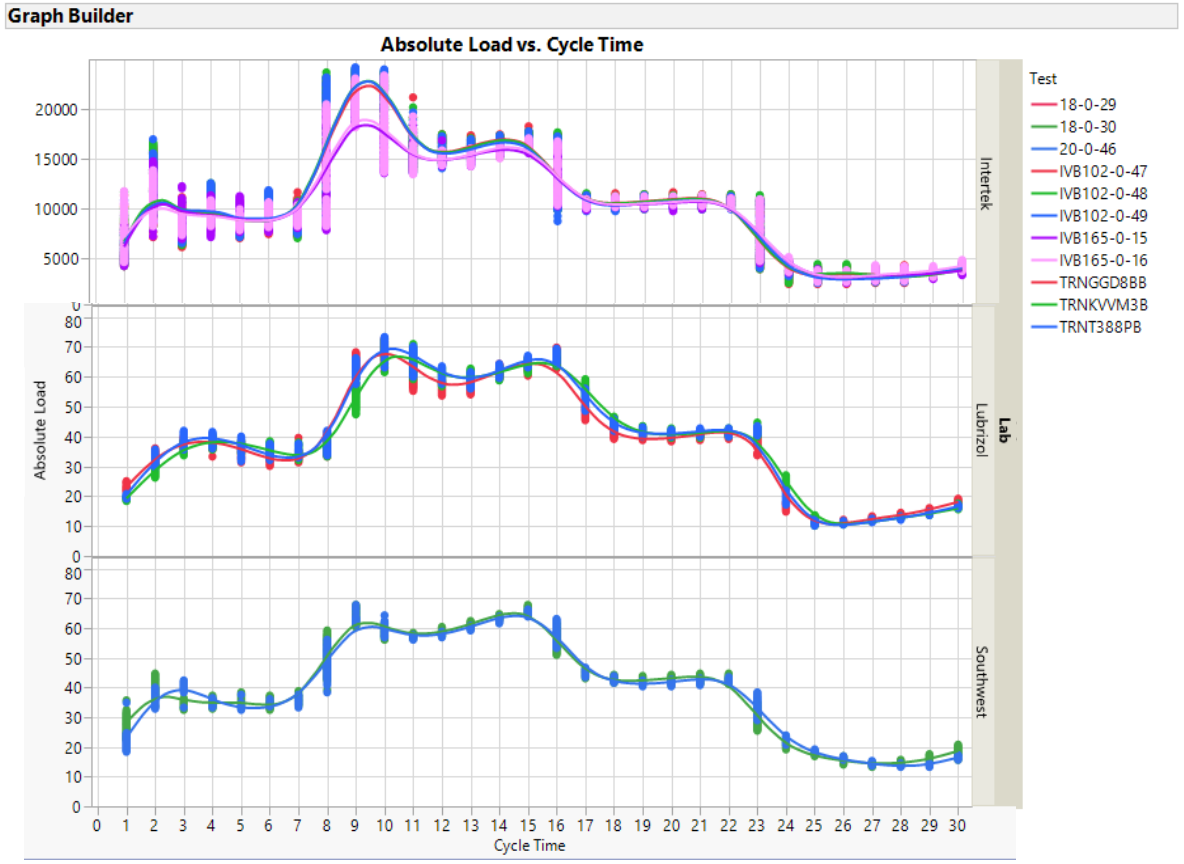
# Engine Coolant Temperature



# Intake Air Temperature



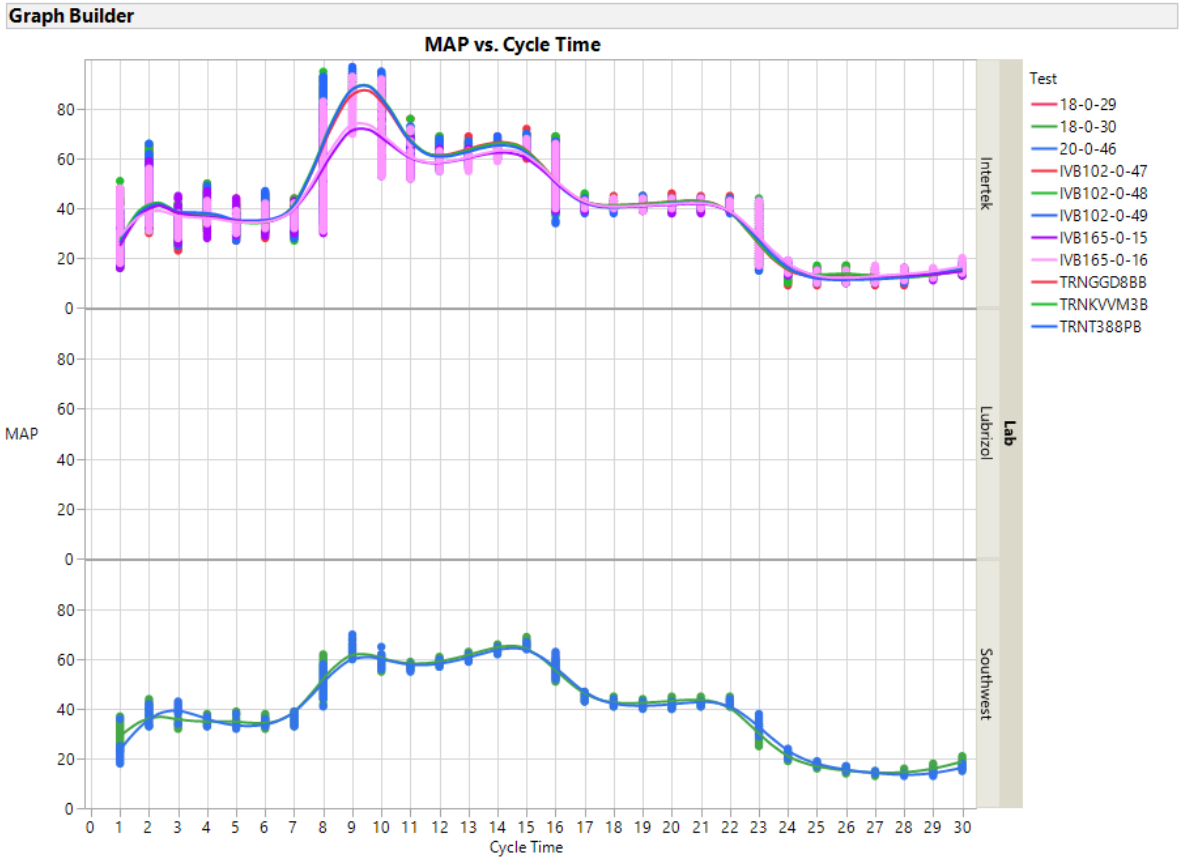
# Absolute Load




IAR's peak during the transition from stage 1 to 2 is higher than the other labs when the peak is compared to the rest of the cycle profile.

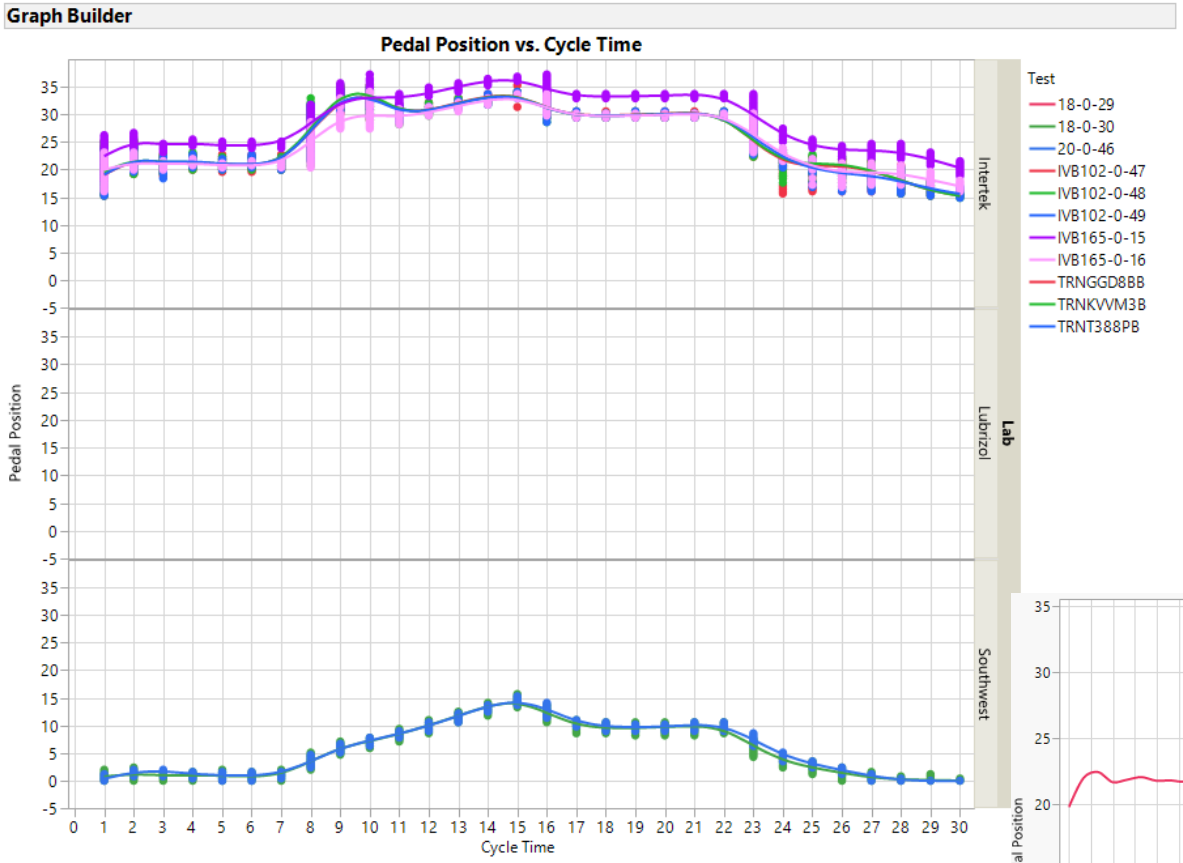
LZ's cycle profile is offset ~1 second from the other labs

# MAP

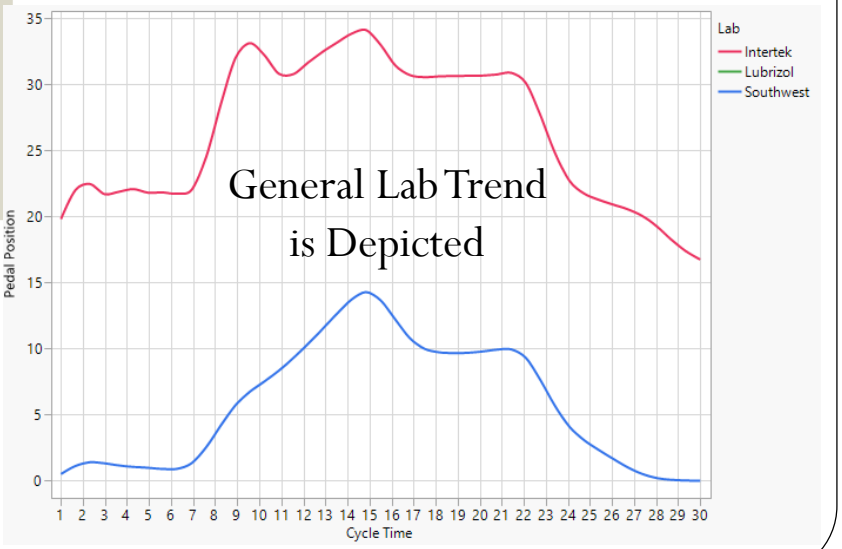



IAR's peak during the transition from stage 1 to 2 is higher than SwRI when the peak is compared to the rest of the cycle profile.

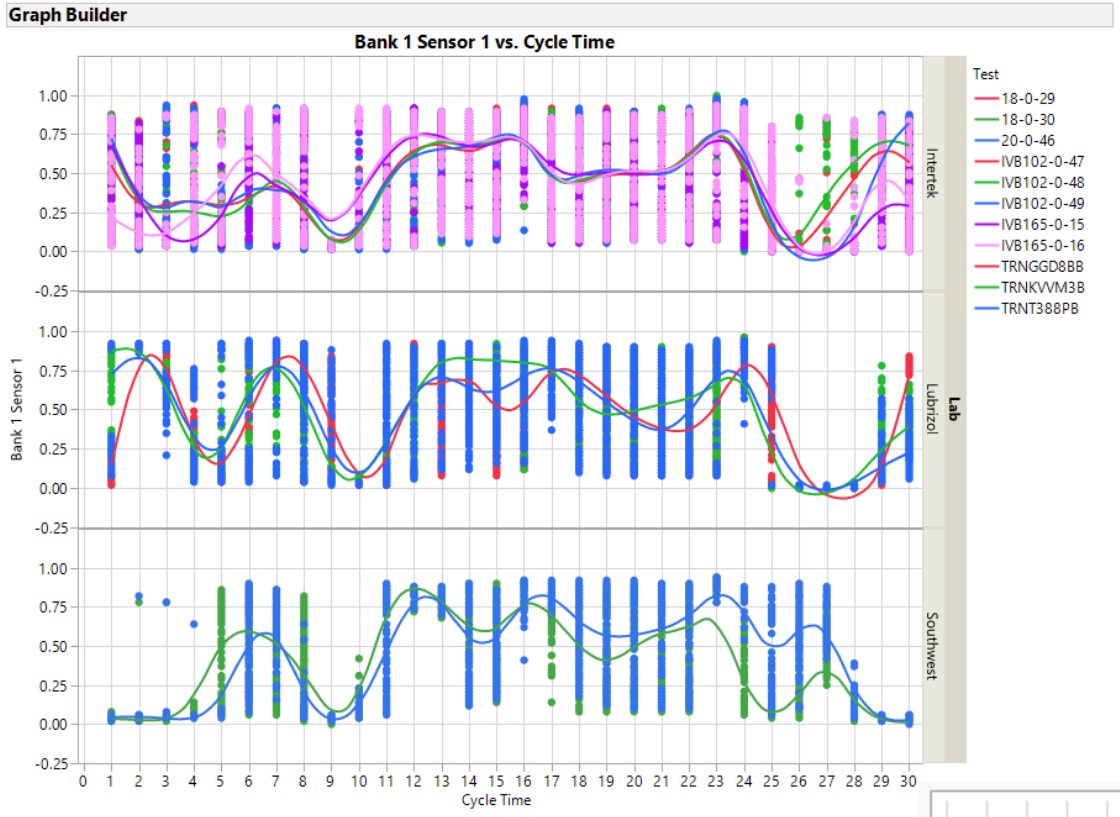
# Pedal Position



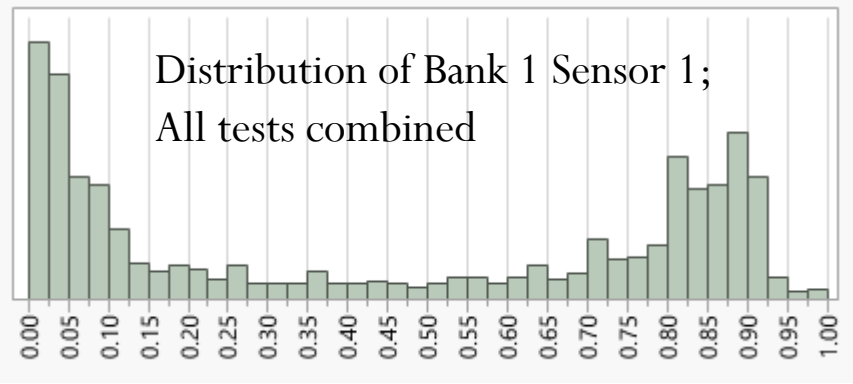

IAR's cycle profile has an additional peak than SwRI during the transition from stage 1 to stage 2



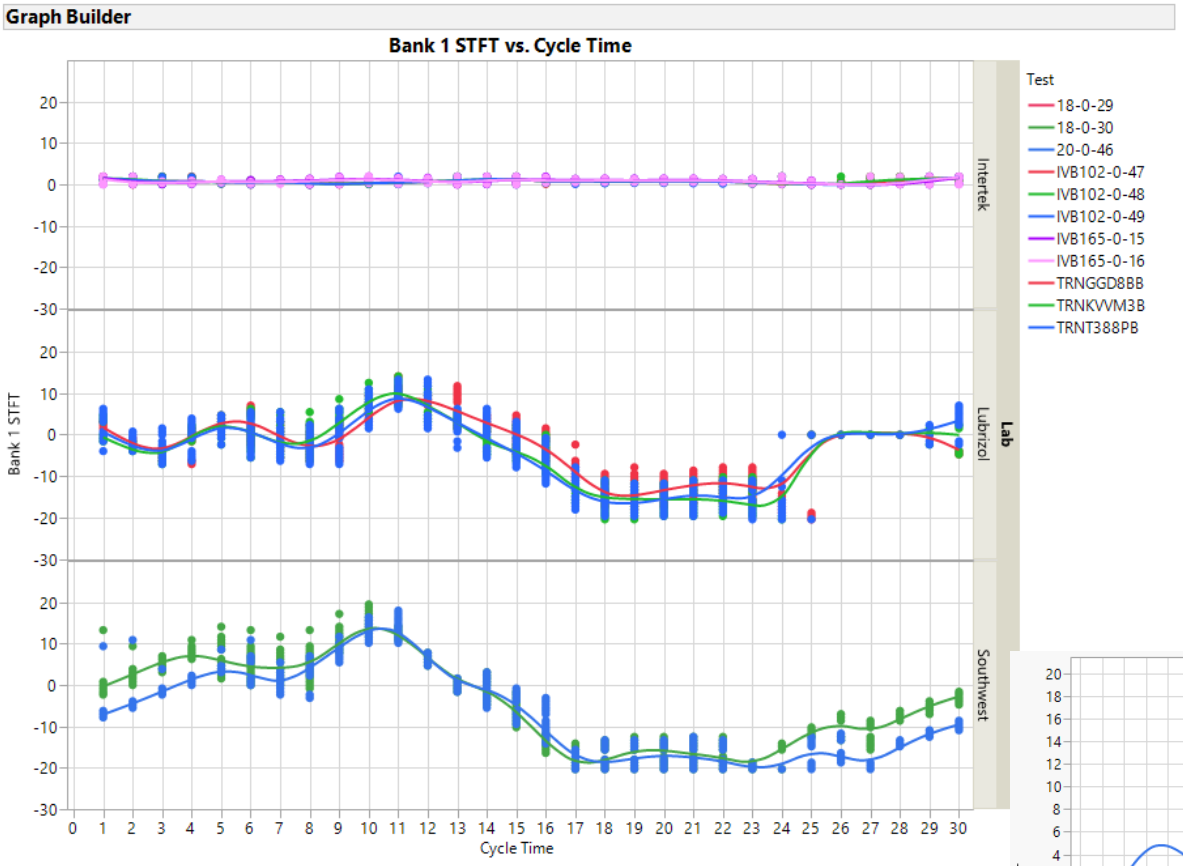
# Bank 1 Sensor 1




Bank 1 Sensor 1 values generally fall close to 0 and close to 1.

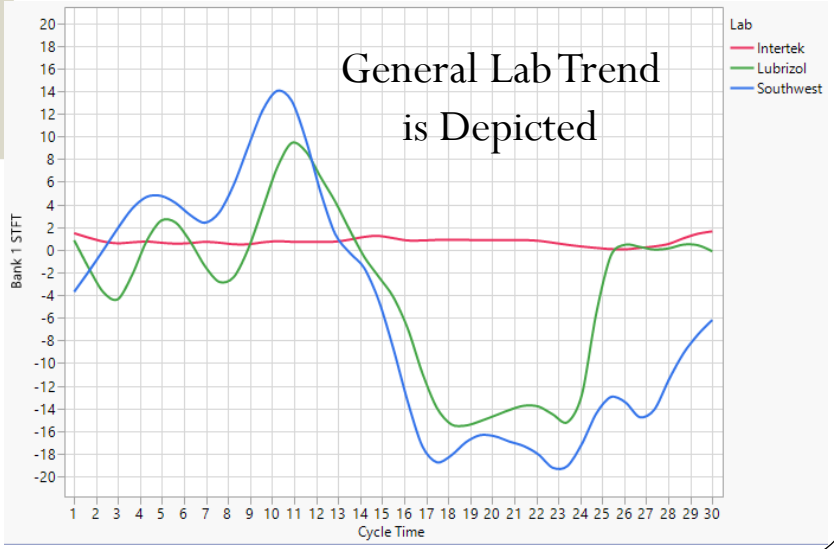


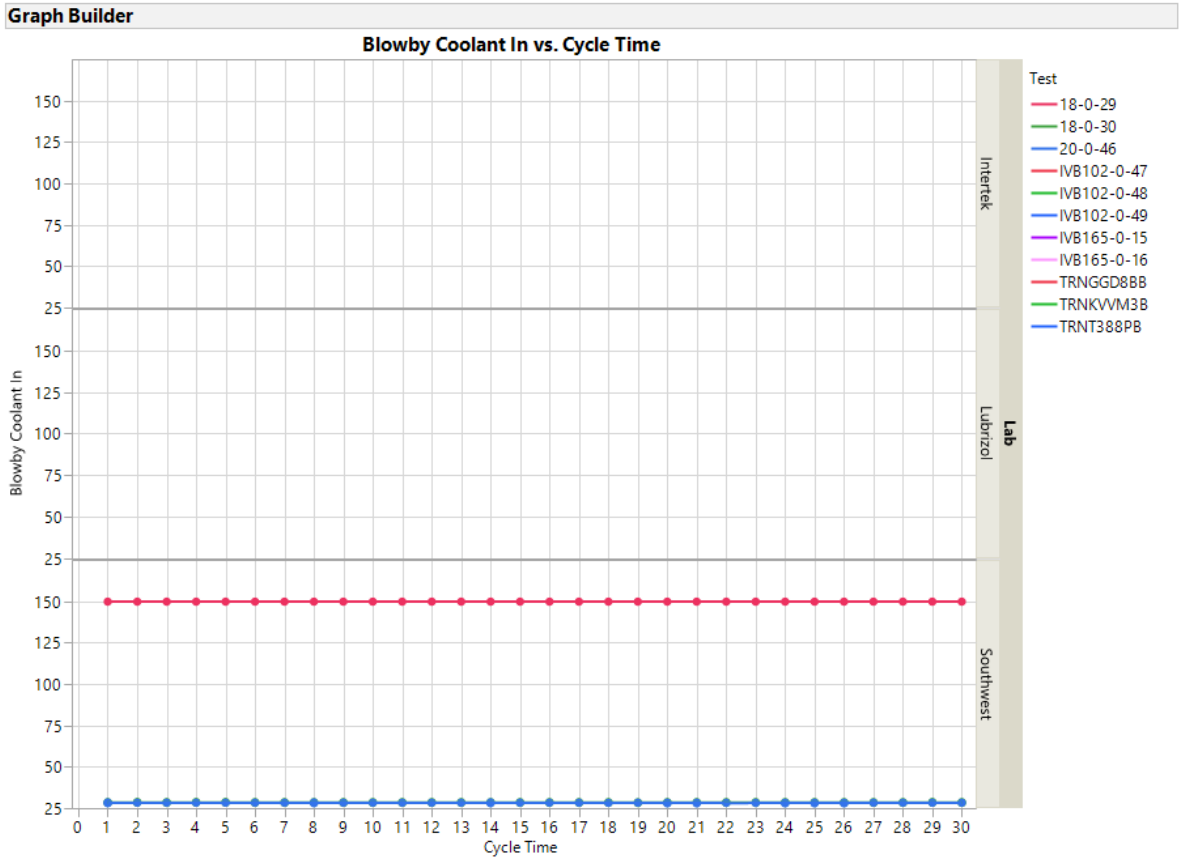
# Bank 1 STFT

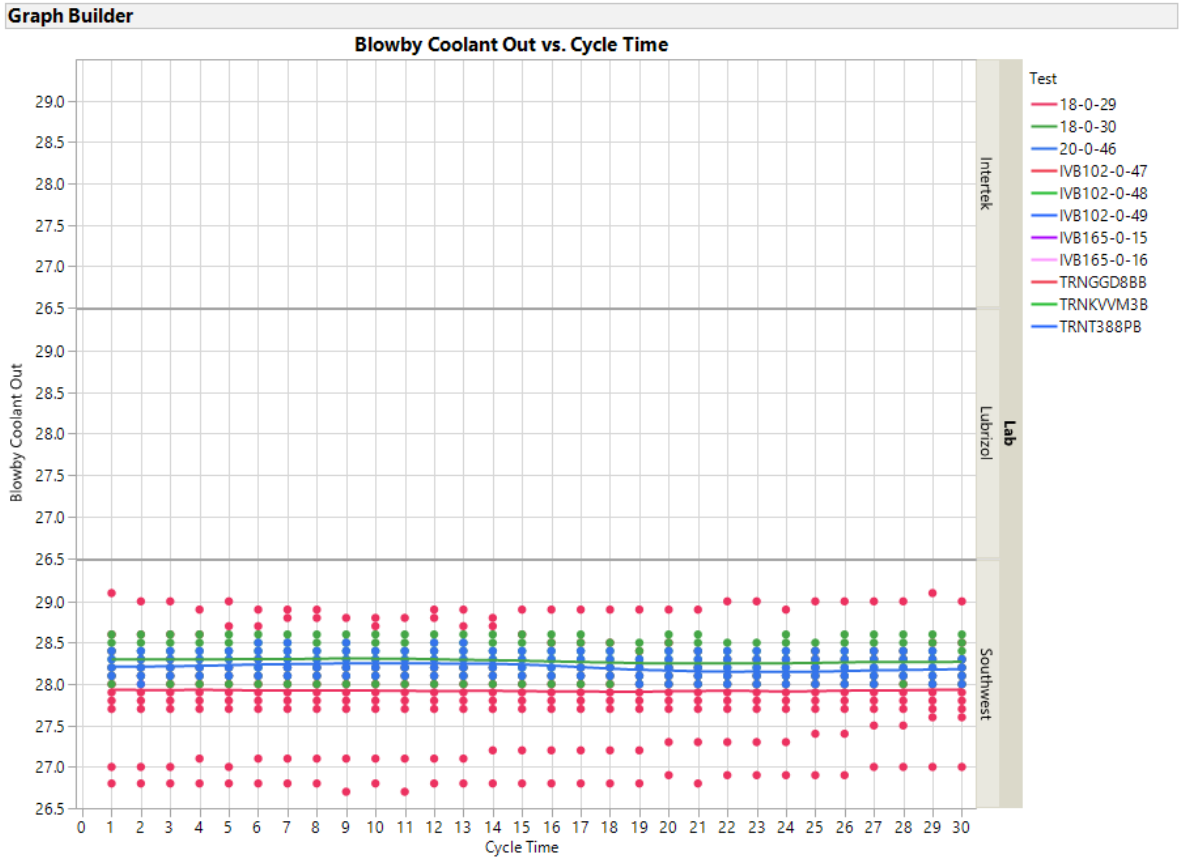



The cycle profiles of IAR tests look much different than LZ and SwRI

LZ's cycle profile is offset ~1 second from SwRI




Graph Builder
Blowby Coolant In vs. Cycle Time
Blowby Coolant In
Cycle Time
Lab
Intertek
Lubrizol
Southwest
Test
18-0-29
18-0-30
20-0-46
IVB102-0-47
IVB102-0-48
IVB102-0-49
IVB165-0-15
IVB165-0-16
TRNGGD8BB
TRNKVVM3B
TRNT388PB


Graph Builder
Blowby Coolant Out vs. Cycle Time
Blowby Coolant Out
Cycle Time
Lab
Intertek
Lubrizol
Southwest
Test
18-0-29
18-0-30
20-0-46
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IVB102-0-48
IVB102-0-49
IVB165-0-15
IVB165-0-16
TRNGGD8BB
TRNKVVM3B
TRNT388PB