IIIH Task Force Conference Call December 5, 2014

Attendees:
Chrysler Haiying Tang, Saad Abouzahr, Jeff Betz
Infineum Andy Ritchie, Mike McMillan, Gordon Farnsworth, Doyle
Intertek Adison Schweitzer
Lubrizol George Szappanos
Afton Ed Altman Bob Campbell
Ashland Amol Savant
TMC Rich Grundza
Halterman Tracy King
Shell Scott Lindholm Jeff Shu
SwRI Karin Haumann, Sid Clark
OHT Jason Bowden

Karin started the discussions with a review of the operational data Karin sent out about twenty minutes prior to the call explaining the changes to tables and additional content with color shading for each lab. See attachment 1.

Dotted lines are REO 434 and solid lines are REO2

Karin explained the change of rate of increase in Oxidation and Nitration numbers are what she looks for in the data.

Karin asked if Afton was using a different method for FTIR analysis. Ed Alton indicated he felt he was using the same method for calculating and Ed felt the problem may have been related to the units he used for the data entry.

Karin will send the SwRI method used to all the labs.

George agreed the LZ 434-1 run seemed to break around 70 hours, and felt they were severe indicated by about 20 hours. Karin and Ed agreed however Afton and SwRI are not that much more severe when looking at the Nitration and Oxidation numbers.

George discussed the blowby readings recorded at LZ and believes the operators may have used different orifice size for the calculations. George will check with the operators to see if this could be part of the problems as he had no secondary indication there should have been that change in blowby.

Moving on, the REO2 runs at Lubrizol repeated very nicely. Karin commented she has seen blowby trends like the Lubrizol 434 test during development.

Rich Grundza did not have time to run a regression analysis on the data.

The next slides are metals analysis and the group discussed the slides. Addison asked if we plotted Silicon and Rich suggested he would include the data as it comes into the TMC.

Amol asked about plotting WPD vs PVIS and possible trends looking at the slopes for the data.

Moving to Operational Data. See attachment 2.

Controlled Parameters:
George asked if everyone could save their data with two decimal points.
The group agreed there seems to be about a 0.2 delta between banks. Rich confirmed the difference and the group indicated it may be a real measurement and Karin commented the controller treats the banks differently to heat up the catalyst and may be carried over throughout the test. Rich commented all the data seemed to be biased to one bank but would like to go back to confirm his data as he may have Afton's data reversed.

The group discussed control methods between the IIIG and the IIIH.

Coolant flow:
The group discussed variable control at Lubrizol and George discussed possible air entrainment in the system due to the configuration of the coolant surge tank. George is working on better methods of getting the air out of the system.

George also explained they had a process water failure around 17 – 17 hours that complicated the problem during the 434 test.

Karin explained she had seen troubles with temperature overshoot on warm-up after oil levels and needs to work on overshoot stabilization.

The group discussed whether labs are running the coolant pumps during oil levels. Lubrizol indicated they have been shutting down the coolant pump during oil levels as something that slipped through the setup during programming the control states. George manually ran the coolant pump on a level and realized a longer warm up time for start after an oil level. LZ will change their pump to on during the entire test.

Fuel Rail Pressure:
Labs agreed they needed to standardize fuel rail configurations.

Rich commented the labs and stands all show differing levels of control.

Karin agreed to include fuel system standardization on the list.

Exhaust Backpressure:
The group discussed control at 3kPa and the labs discussed problems holding that low a pressure. The group seemed to agree to look at control capabilities up to 4.5kPa and where their control set points will be on the PID Controllers.

Karin commented about making this change on the Prove-out testing. Bob Campbell cautioned about making such a change when taking data to the AOAP level making such a change. The group continued discussion about exhaust backpressures and whether they should be changed.

Karin suggested we are looking at repeatability on stands for Prove-out testing, and conversation continued with concerns about making backpressure changes before going into Matrix Testing without running the final procedure.

Ed Altman suggested moving forward and we make decisions based on what we feel needs changing before going forward. Jeff Betz expressed if we have to be at 4.0 to 4.5 kPa then we need to make that change. Addison agreed labs should set up a slave engine to see what everyone can control at. This will be listed in the Action Items for further work.

Karin explained she ran a sweep of engine exhaust backpressures in 0.5 increments from 3.0 to 6.0kPa. Karin will resend that data to the group for review.

Addison will run at 4.5kPa on his slave engine and report and Karin has an engine she can change the control to see what happens to control points. George indicated he can make 4.5kPa work. Afton plans to start a test next week and would like to discuss where to run based on slave engine work and discussion with the group before that start.

Intake Air Pressure;
Everyone will run without the production air box

Coolant Pressure;
The group discussed pressures in the recovery tank and the reasons why we decided to measure coolant pressure at the coolant out fitting from the engine. Reservoir pressure will be somewhat dependent on total head pressure related to where the recovery tank is located in the system.

The group also discussed:
Fuel Rail Temp
Intake Air Temp
Coolant out temperature stabilizations during re-start.

The group agreed they need to set times on the control states to account for temperature overshoots to stable control before going on test condition.

Uncontrolled Parameters:
Intertek Nox on stand 182 is being worked on with ECM supplier for the sensor to see if that may be an issue.

All labs seem to show an offset in NOx between banks.

Lubrizol believes they had a unit reporting difference and will perform a fuel flow calibration on their system and report back to the group to see if that explains their higher fuel flow rates.

Crankcase pressures seem to be OK

Ed Altman suggested we switch from vacuum to manifold absolute pressure for future data recording.

The group discussed differences on oil pump pressures and the differences between starts. George expressed concerns and the group will continue looking into the data.

George will send oil pressure plots to the group for future discussions.

The group discussed variability on exhaust temperatures possibly being related to thermocouple insertion depths. Karin indicated SwRI also had to replace a thermocouple wire during one of the SwRI tests and also believes coolant temperature variations could also be related to thermocouple variations.

The group discussed oil sump temperature readings and where the thermocouple locations on in-house fabricated oil pans. George indicated he took various depth readings but with the new OHT oil pan that should not be a concern.

The group also agreed they need to calibrate the OHT oil pan levels to standardize on oil level calculations. Ed expressed concern about where the crankcase pressure tap comes of the oil pan and suggested a 90° tap off the connector to prevent oil getting trapped in the line.

Ed Altman commented we have yet to look at cylinder surface finish and blowby parameters. Rich has yet to plot those parameters related to cylinder surface finish and other cylinder parameters. Rich will run a regression analysis on blowby vs surface finish parameters.

Karin suggested she looked at hours 6 through 81 for all the blowby data she looked at. Ed still suggested looking at the first data points. Rich indicated he will look at the data.

Haiying Tang indicated the desire on Chrysler's behalf to recommend the test is ready for Matrix Testing. The group continued discussion with comments from many individuals about cylinder honing and piston rung gapping and analyzing the data to further look into repeatability and reproducibility. Karin commented that Chrysler would like to recommend to the AOAP that the data shows the test is repeatable and shows discrimination of the prove-out oils. Karin went on to say there will be continued improvements on this test for years just like all the sequence tests experience.

The group continued discussion with comment from Andy Ritchie about TMC responsibility to make these decisions as they have done as much as they possibly can and the group needs to make the decisions and recommendations. Rich commented the precision, repeatability, and reproducibility all comes from the Precision Matrix. Karin commented the task for this group is to demonstrate all the labs can run this test and generate the same data the development lab generated during the development program.

The group continued discussion about performance of the test at Afton and Lubrizol with Ed Altman expressing concern about his blowby profile and concerns about cylinder surface finish and the starting blowby.

Karin commented the variability we currently have in the test is included in all the prove-out data and there is nothing we are going to do that will increase that variability. Ed Altman and Amol continued to discuss blowby related to surface finish and startup ramp times to test conditions. George commented that he feels there is still room for improvement and felt we are

about 90% of the way there and feels confident we can zero in on the test precision between the labs.

Haiying again asked if Ed felt he could be ready to discuss Afton's data on Monday and if the group could discuss the reproducibility and repeatability of the test. Karin again indicated we have data indicating the aforementioned question and there was some comment about that data being generated between production hardware and final supplier provided hardware i.e., piston rings after which Karin reminded the group there has been some statistical valuations performed that show there was not a statistical difference between the production and final hardware on some of the development and prove-out data.

The group continued discussion with comment from Ed, Amol, George, Karin, and others with the final discussion focused on the feeling that everyone agreed we are about 90% of the way there and possibly could recommend approval of readiness for Matrix Testing in January.

Scott Lindholm commented that the AOAP is looking for recommendation from this group as the technical group to decide when the test might be ready for Matrix Testing understanding this is the first test going through the system at this time. Scott suggested this panel work diligently at making this decision and be cognizant of what the criterion is and what's been done in the past for the IIIG and other tests. Andy Ritchie also commented he encourages the group to continue moving forward and suggested possibly making a motion that would contain a subject too clause explaining all of the concerns that need to be addressed. The group discussed possible wording of a motion that covered many areas of concern, however, the group could not agree on a consensus on wording.

Conversation turned to whether the labs could run the test and have their statisticians be able to recommend the data / results are good, by comparison to all the prove-out data being the same at all the labs.

Karin asked the group to truly define the same results in a fired engine test saying this is why we have acceptance bands and referred to the variability between the prove-out testing and the variability of the performance of reference oil 434 in the IIIG indicating all the prove-out data falls within the band for the IIIG. The group discussed data for the IIIG based on 434 and 434-1 and whether the data set for the IIIH could be better and whether the high viscosity results are outliers. Rich was not certain the targets have been updated between 434 and 434-1.

The group discussed acceptance bands and being careful about the oils we are looking at where the good oils, i.e., REO2 and REO3 are performing and we chose 434 to look at discrimination. George commented that his data shows there could be as much as 10 hours difference between his stand and other labs running the test and feels 10 hours is significant.

Scott Lindholm reminded the group that the AOAP is only looking for recommendation from this group whether the test can be run repeatable between the labs, the decisions made on discrimination, volatility, backward compatibility, will be made at the AOAP level.

Karin agreed we were not going to make a decision today and wanted to make a list of what needs to be done and looked at prior to having a call Monday afternoon to continue discussion after Afton sees their post-test results.

List of Items needed to move forward to Matrix Readiness:

1) Group needs to review Afton 434-1 results.
2) Afton would like to compare cylinder surface finish data between labs.
3) Group needs to review and discuss oil pressure variables between tests.
4) Karin needs to provide updated copy of the Test Procedure.
5) Sid needs to provide updated copy of the Engine Assembly Manual.
6) Sid needs to update the Controls States document to include changes required as a result of discussions during the Lubrizol lab inspection.

The group agreed to the aforementioned list and having a conference call on Monday afternoon to discuss these issues and whether the group could agree on a recommendation for the AOAP meeting during ASTM.

Action Items:

1) Karin will forward the SwRI method of quantifying Oxidation and Nitration so everyone is using the same method.
2) Rich Grundza will include Si in the data plot as the data comes into the TMC.
3) Lubrizol will change coolant pump control to "on" during the entire test, i.e., not shutting the pump "off" during oil leveling shut downs.
4) The group will look closer into fuel pressure control i.e., mechanical pressure regulators and measurement points within the test cells.
5) The group will investigate running engine exhaust back pressures at 3.5 to 4.5 kPa. Karin will run the engine she is currently running at 4.5 kPa and report controller position to the group. Karin will also forward earlier exhaust back pressure study information to the group.
6) Need to update the IIIH Control States document to include changes to warm-up and temperature stabilization times for on-test conditions.
7) Lubrizol will perform a fuel cell calibration and George will report back to the group on calibration results.
8) Labs will change to Manifold Air Pressure vs. manifold vacuum.
9) George Szappanos will forward his oil pressure plots by oil to the group for further discussion.
10) Addison Schweitzer will calibrate the OHT Oil Pan and share his information with the group. Lubrizol and Afton will also calibrate their OHT Oil Pans.
11) IAR will forward oil consumption data to Rich after calibrating the new OHT Oil Pan.

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

IIIH Prove-out Run Data

December 5, 2014

Final Procedure Data

Oil	Lab	Stand	Run	Hardware	EOT Date	Pvis (%)		WPD (merits)	
						90 Hours	100 Hours	90 Hours	100 Hours
REO2*	SR	64		Production	4/15/14	125.9	274.5	--	3.46
REO2	SR	64		Production	4/22/14	129.5	355.8	--	3.49
REO2	SR	77		Production	5/3/14	40.4	--	5.89	--
REO2	SR	64		Production	5/24/14	60.7	147.2	--	3.95
REO2	SR	64	58	Final	8/4/14	78.5	--	4.76	--
REO2	SR	64	64	Final	9/6/14	54.8	--	4.72	--
REO2	IAR	91		Production	8/12/14	77.1	--	4.02	--
REO2	IAR	91	1-2	Final	10/14/14	121.6	--	3.63	--
REO2	IAR	182	0-1	Final	11/4/14	46.4	--	5.15	--
REO2	LZ	341	0-1	Final	11/16/14	71.1	--	4.52	--
REO2	LZ	341	3-3	Final	11/30/14	44.6	--	4.82	--
REO2	EV	CB106	0-1	Final	11/28/14	45.9	--	4.38	--
TMC 434-1*	SR	77		Production	4/16/14	177.8	517.4	--	3.39
TMC 434-1	SR	77		Production	4/22/14	195.6	723.8	--	3.36
TMC 434-1	SR	77		Production	5/27/14	211.2	--	5.59	--
TMC 434-1	SR	77	79	Final	10/18/14	143.7	--	4.27	--
TMC 434-1	IAR	182	1-2	Final	10/11/14	90.5	--	4.76	--
TMC 434-1	LZ	341	2-2	Final	11/23/14	754.7	--	3.8	--
REO3	SR	77		Production	7/2/14	17.9	27.5	--	7.13
REO3	SR	64		Final	11/30/14	21.2	--	6.8	--

*4 ounce oil adds

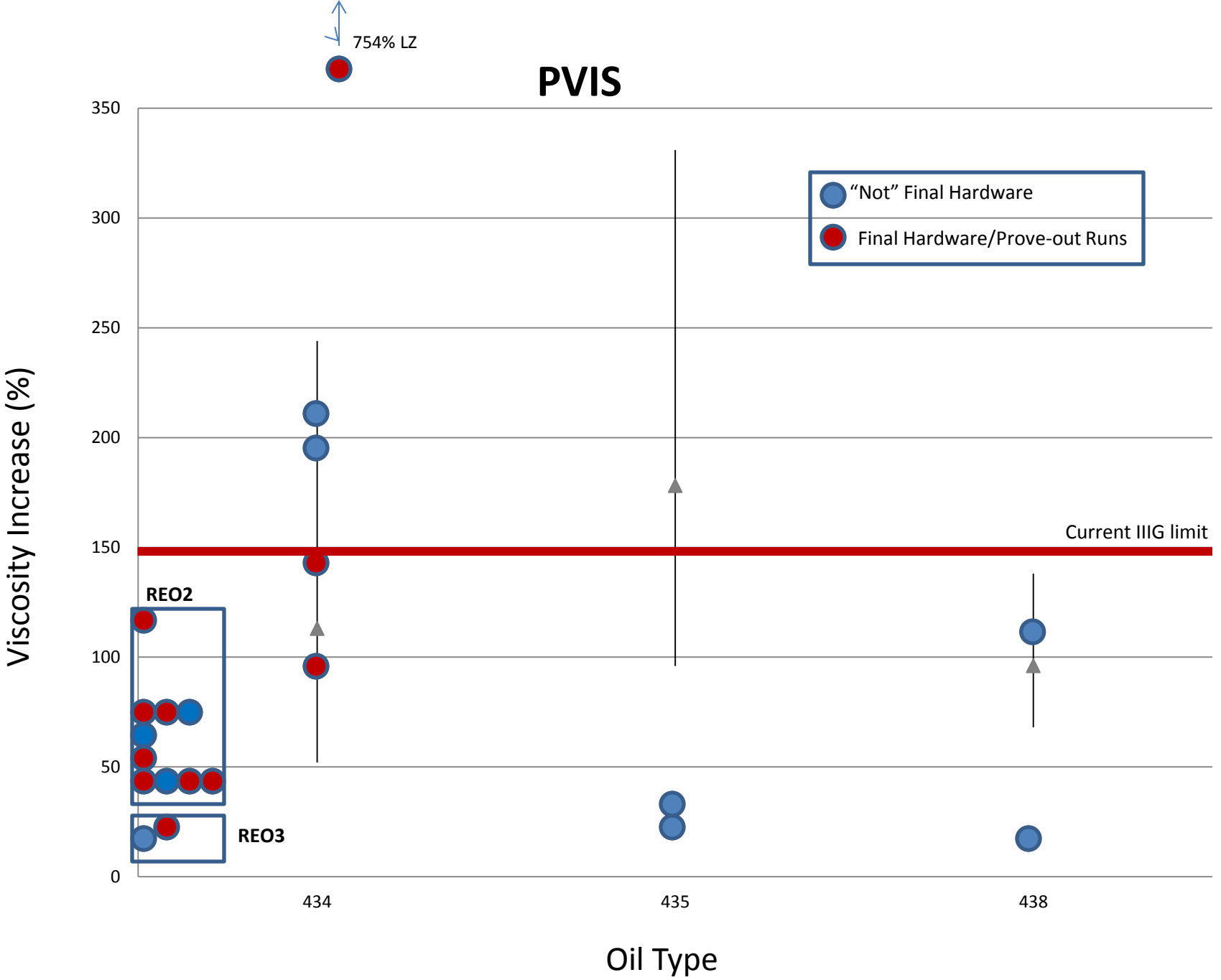
IIIG REO Targets

PVIS

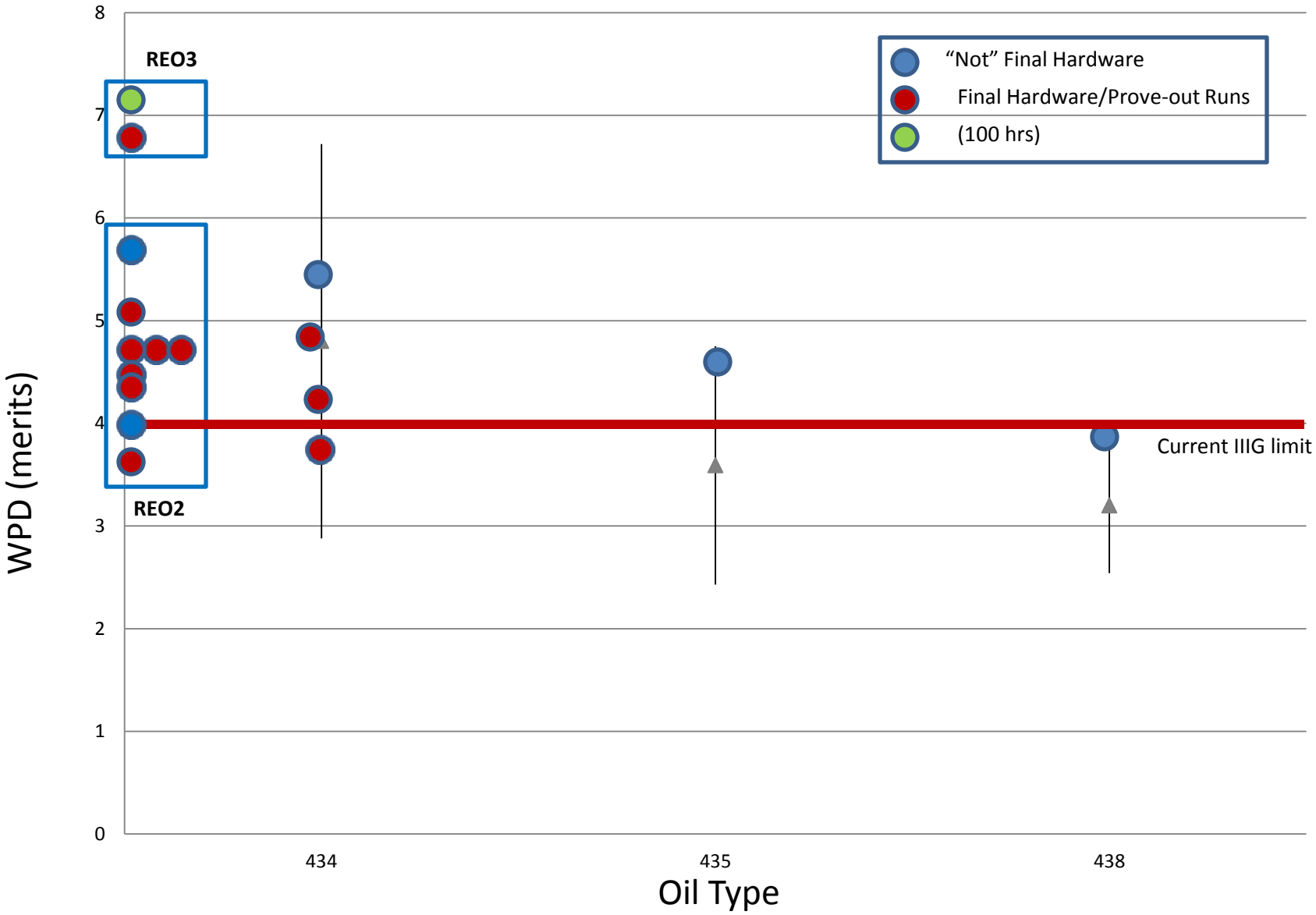
434-1	113 ± 61
435-1	178 ± 82
438	97 ± 29

WPD

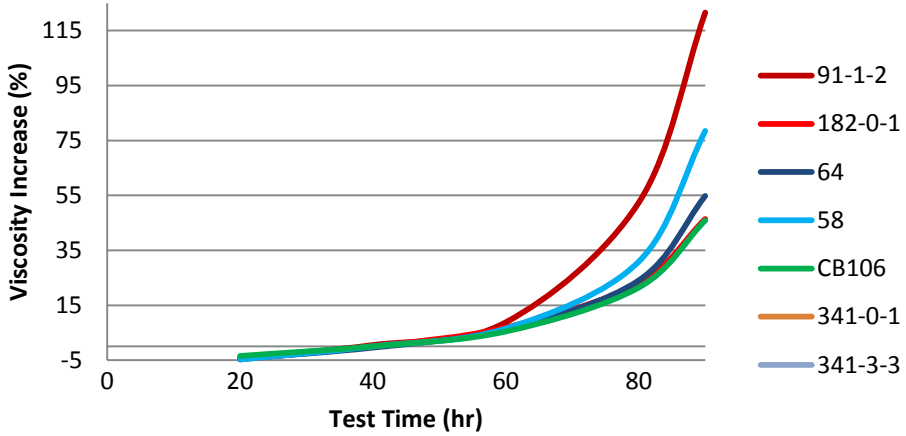
434-1	4.80 ± 1.92
435-1	3.59 ± 1.16
438	3.20 ± 0.66


754% LZ
PVIS
350
300
250
200
150
100
50
0
Viscosity Increase (%)
"Not" Final Hardware
Final Hardware/Prove-out Runs
Current IIIG limit
REO2
REO3
434
435
438
Oil Type

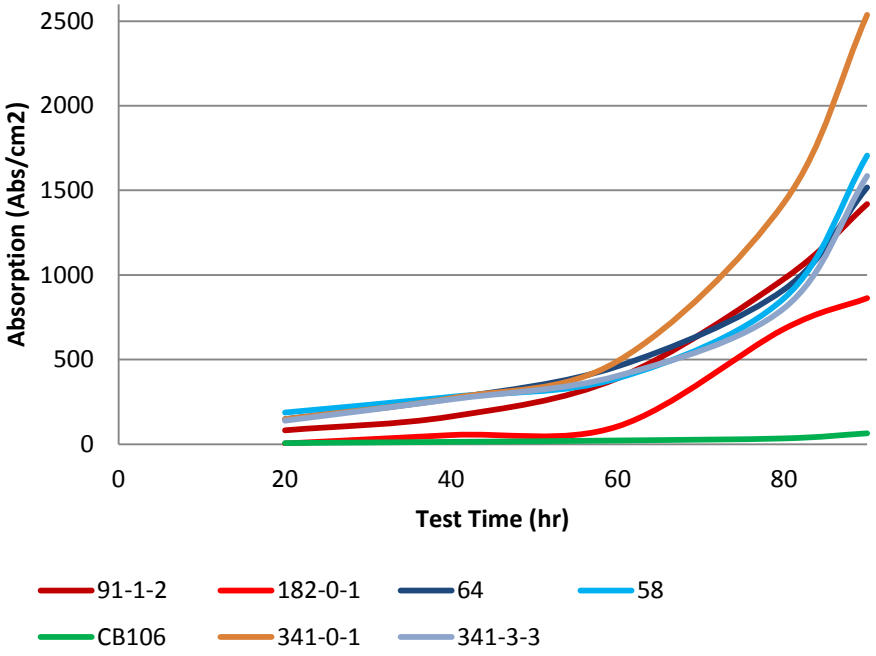
WPD


8
7
6
5
4
3
2
1
0
REO3
REO2
"Not" Final Hardware
Final Hardware/Prove-out Runs
(100 hrs)
Current IIIG limit
WPD (merits)
434
435
438
Oil Type

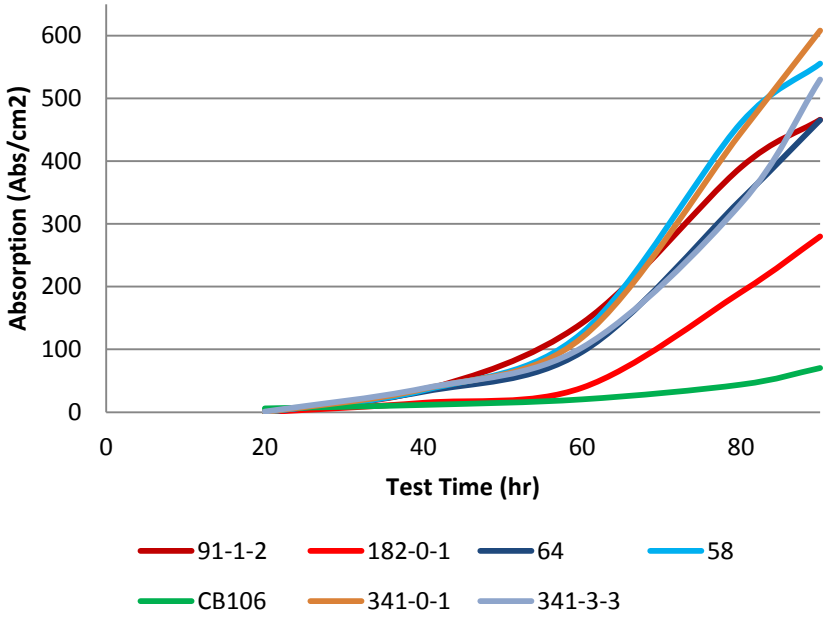
PVis - REO2



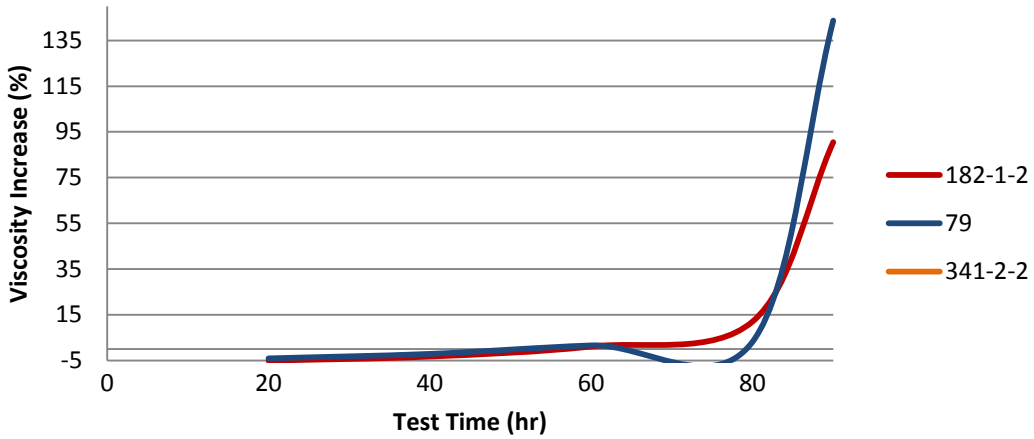
Oxidation - REO2



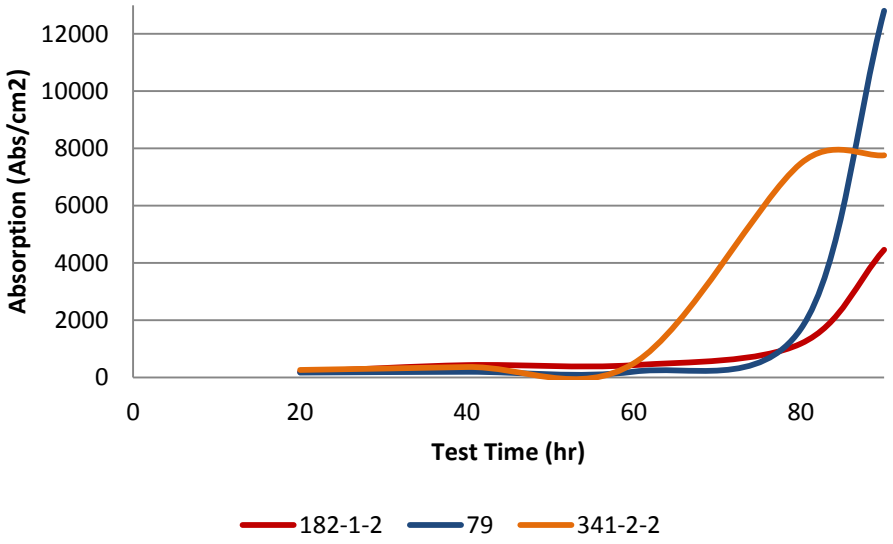
Nitration - REO2



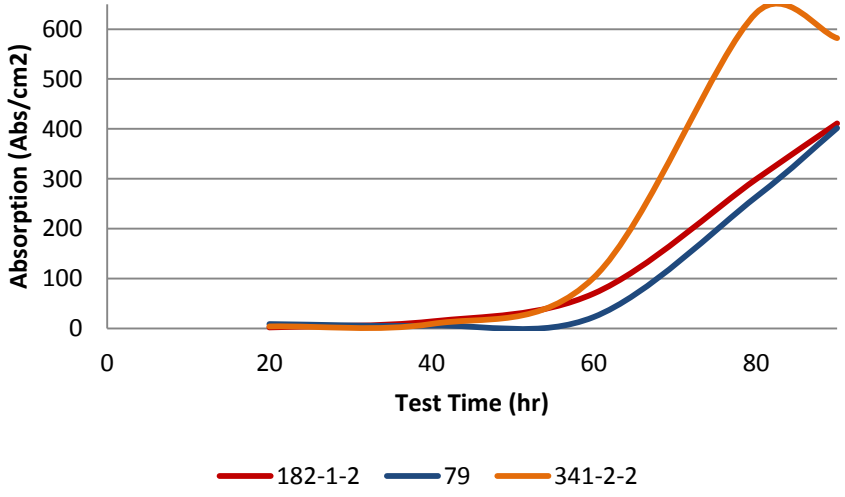
PVis - 434

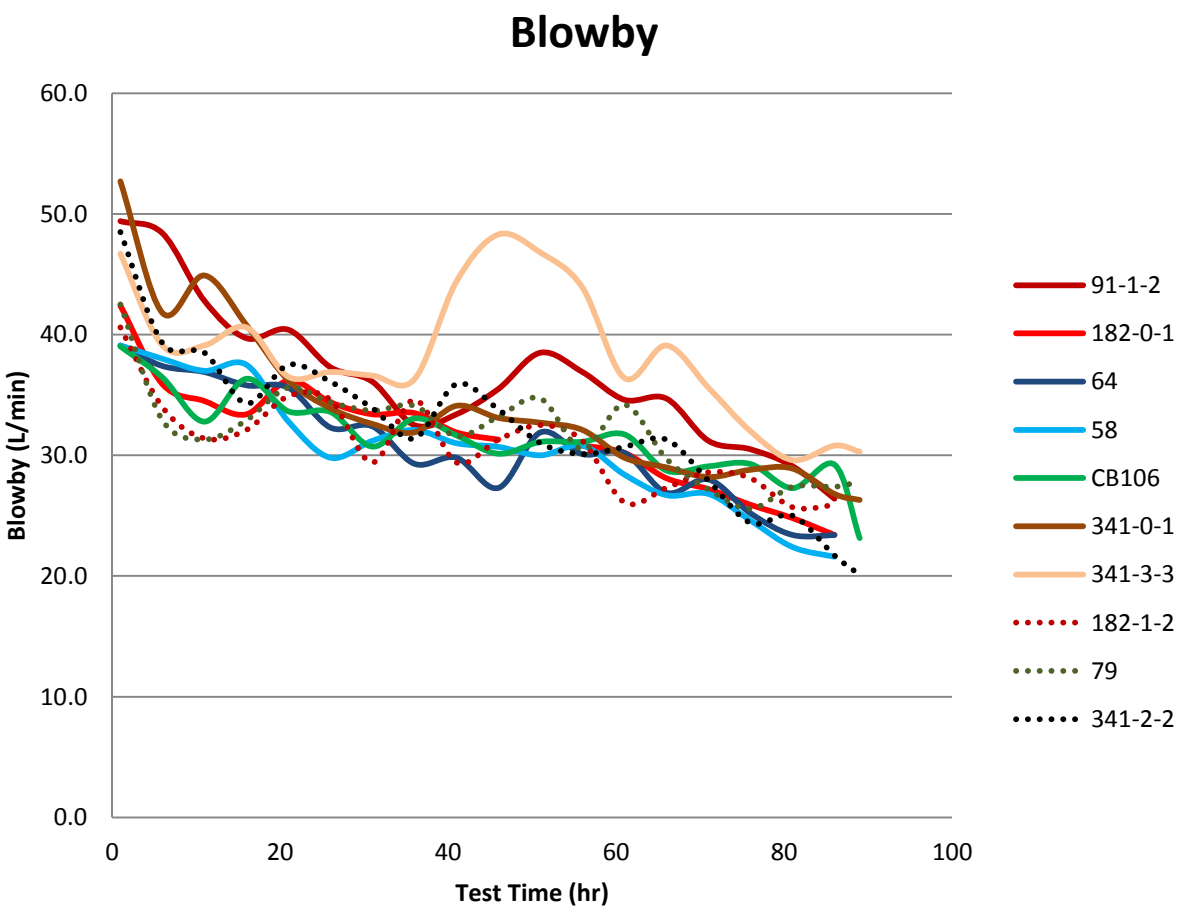


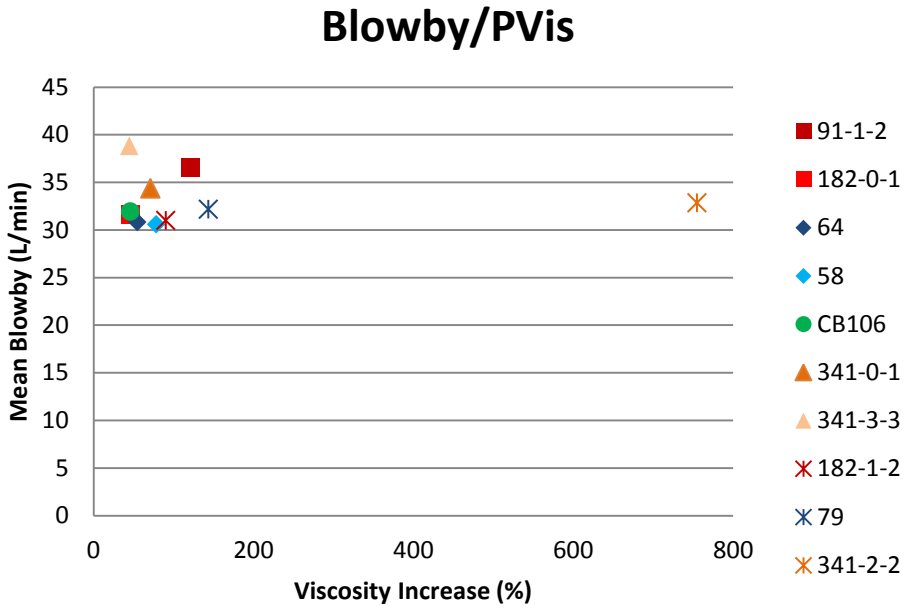
Oxidation - 434-1

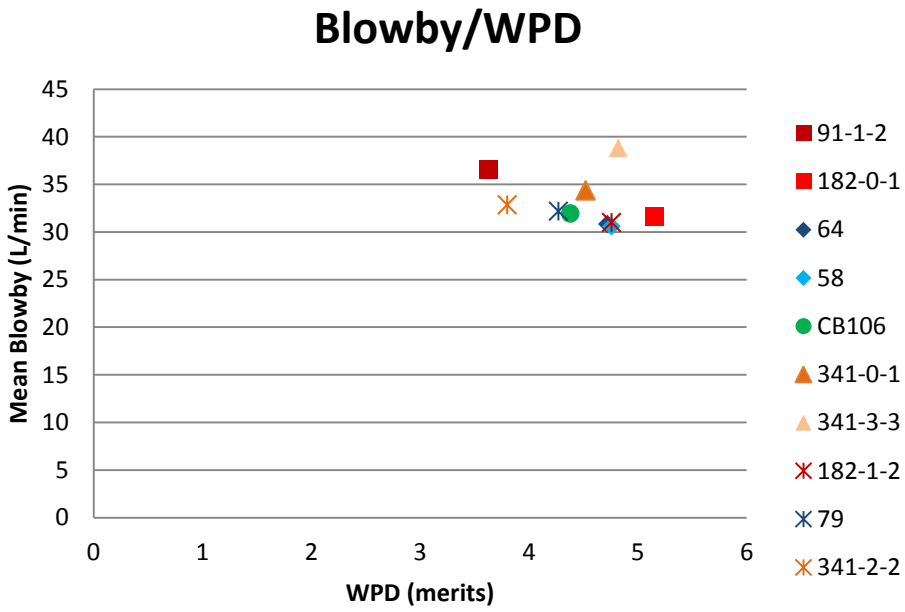


Nitration - 434-1

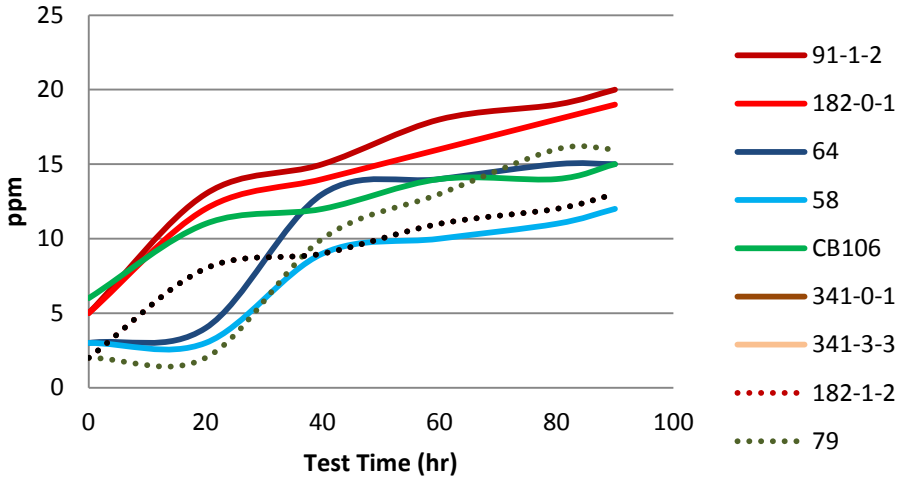



Blowby
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Blowby (L/min)
0
20
40
60
80
100
Test Time (hr)
91-1-2
182-0-1
64
58
CB106
341-0-1
341-3-3
182-1-2
79
341-2-2

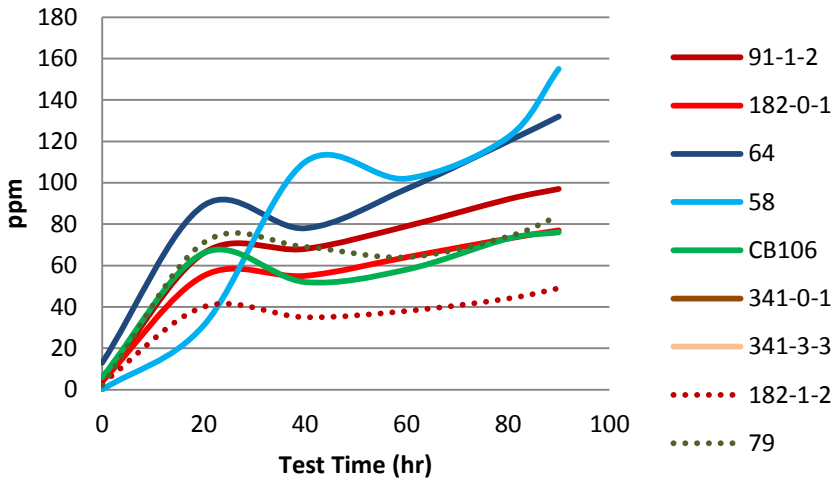

Blowby/PVis
Mean Blowby (L/min)
45
40
35
30
25
20
15
10
5
0
0
200
400
600
800
Viscosity Increase (%)
91-1-2
182-0-1
64
58
CB106
341-0-1
341-3-3
182-1-2
79
341-2-2


Blowby/WPD
Mean Blowby (L/min)
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
WPD (merits)
91-1-2
182-0-1
64
58
CB106
341-0-1
341-3-3
182-1-2
79
341-2-2

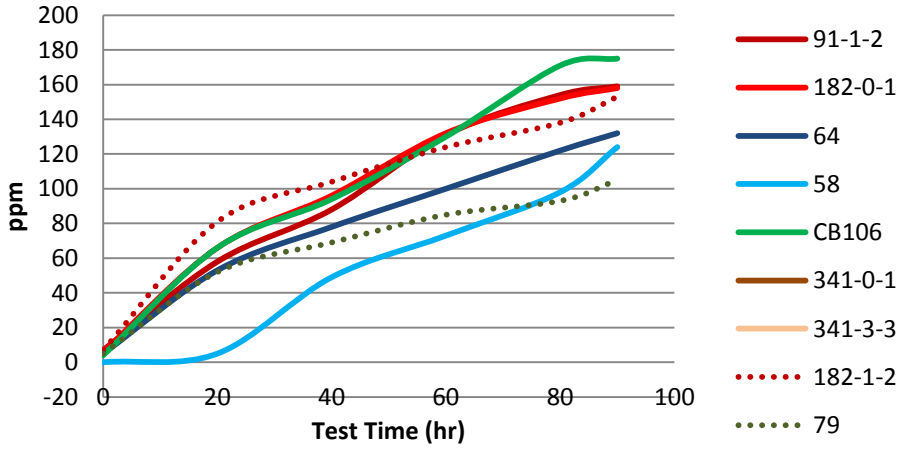
Aluminum



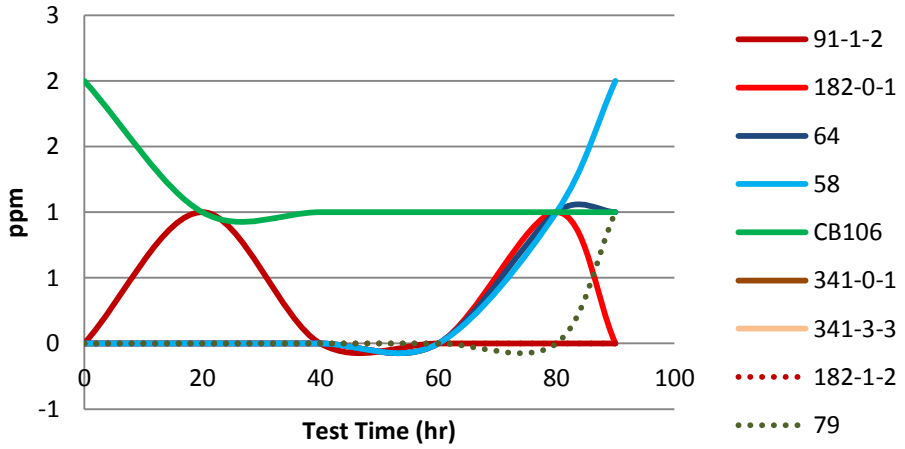
Copper



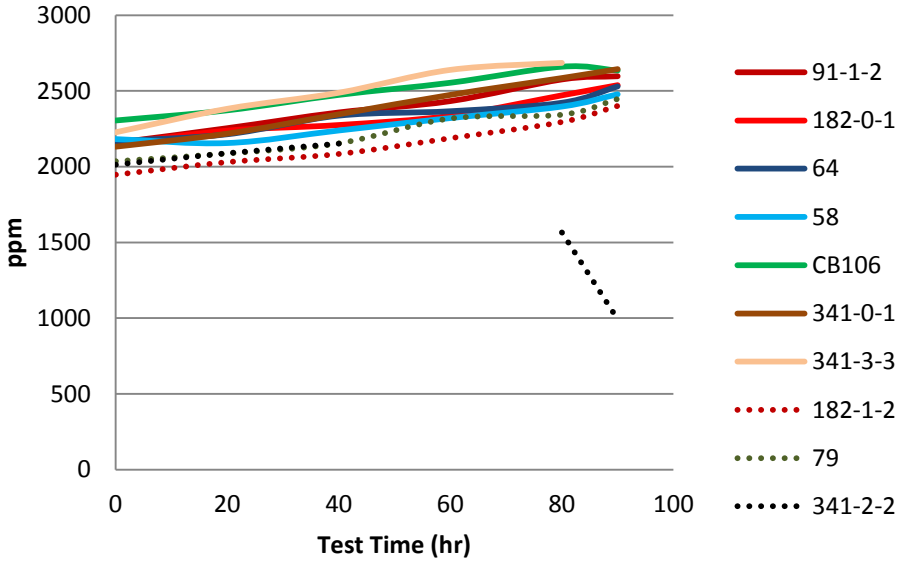
Iron



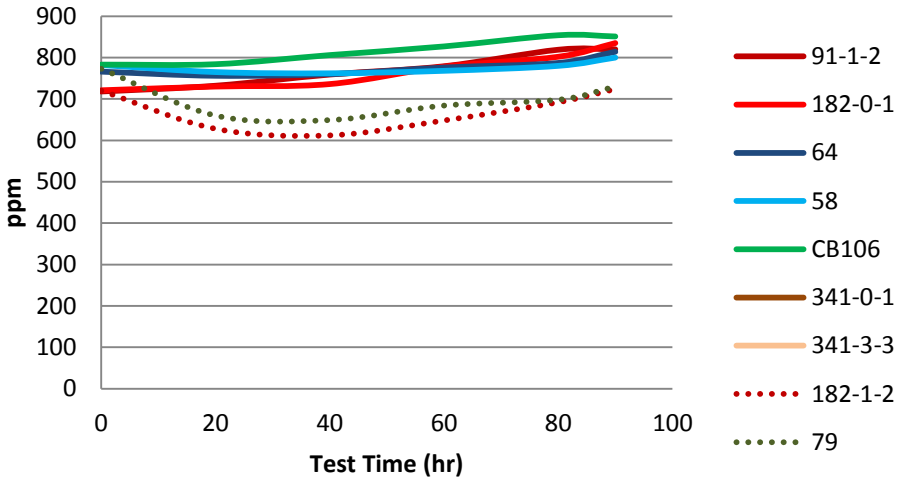
Lead



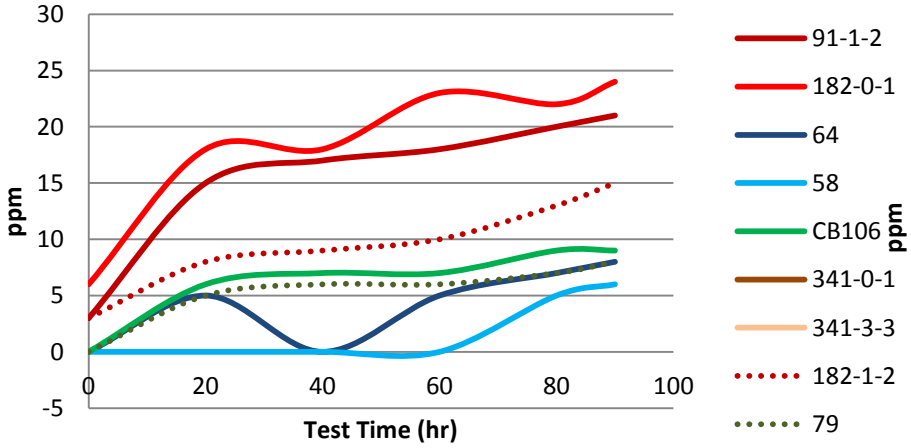
Calcium



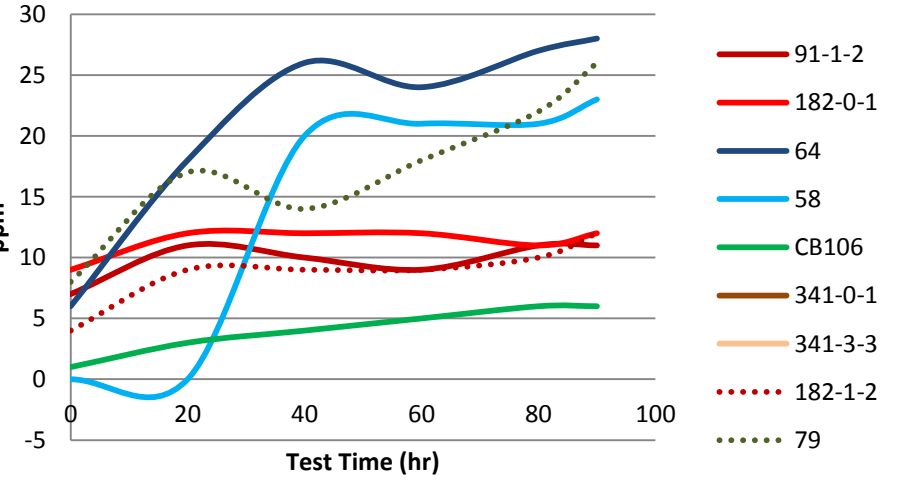
Phosphorus

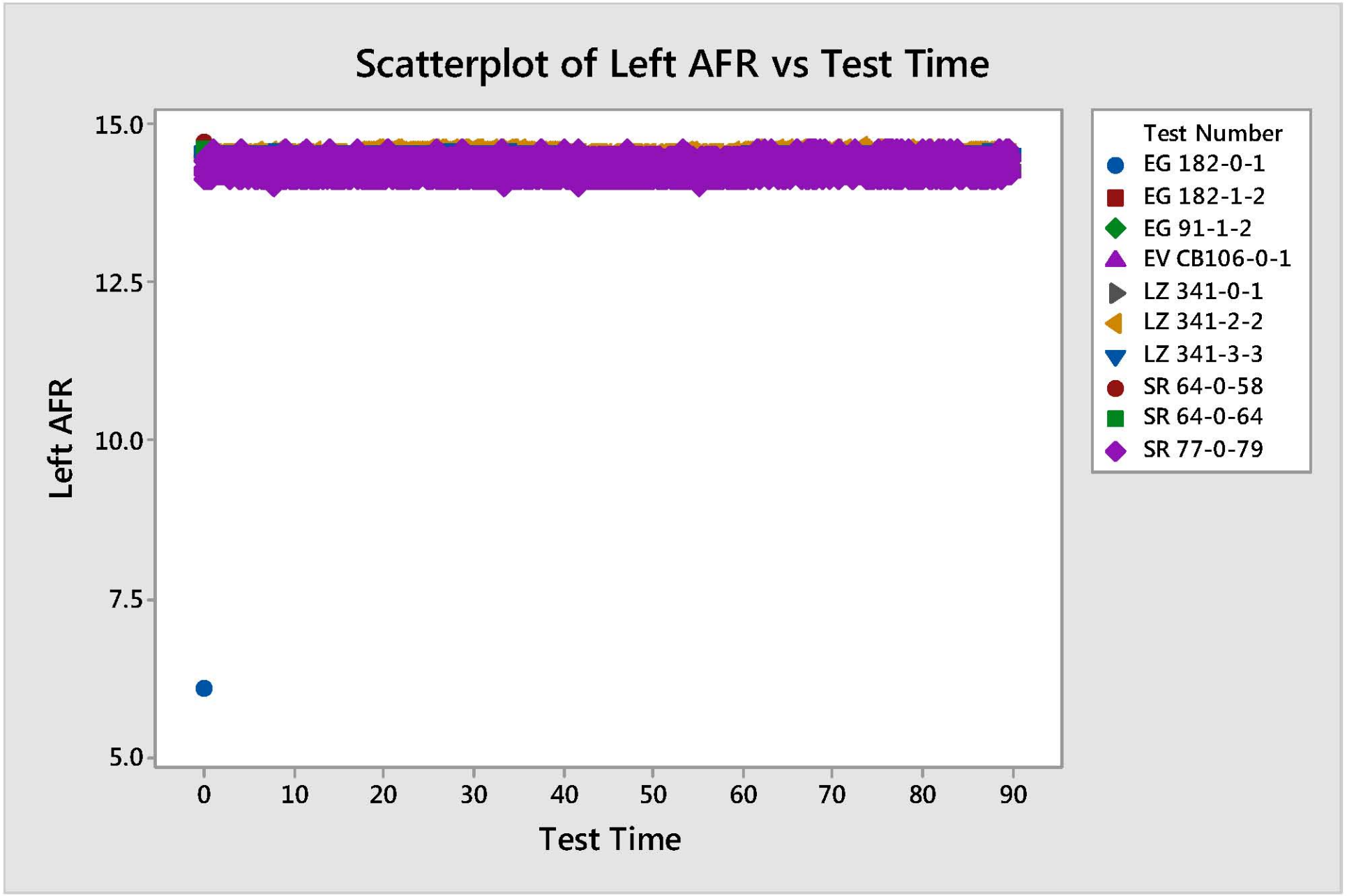


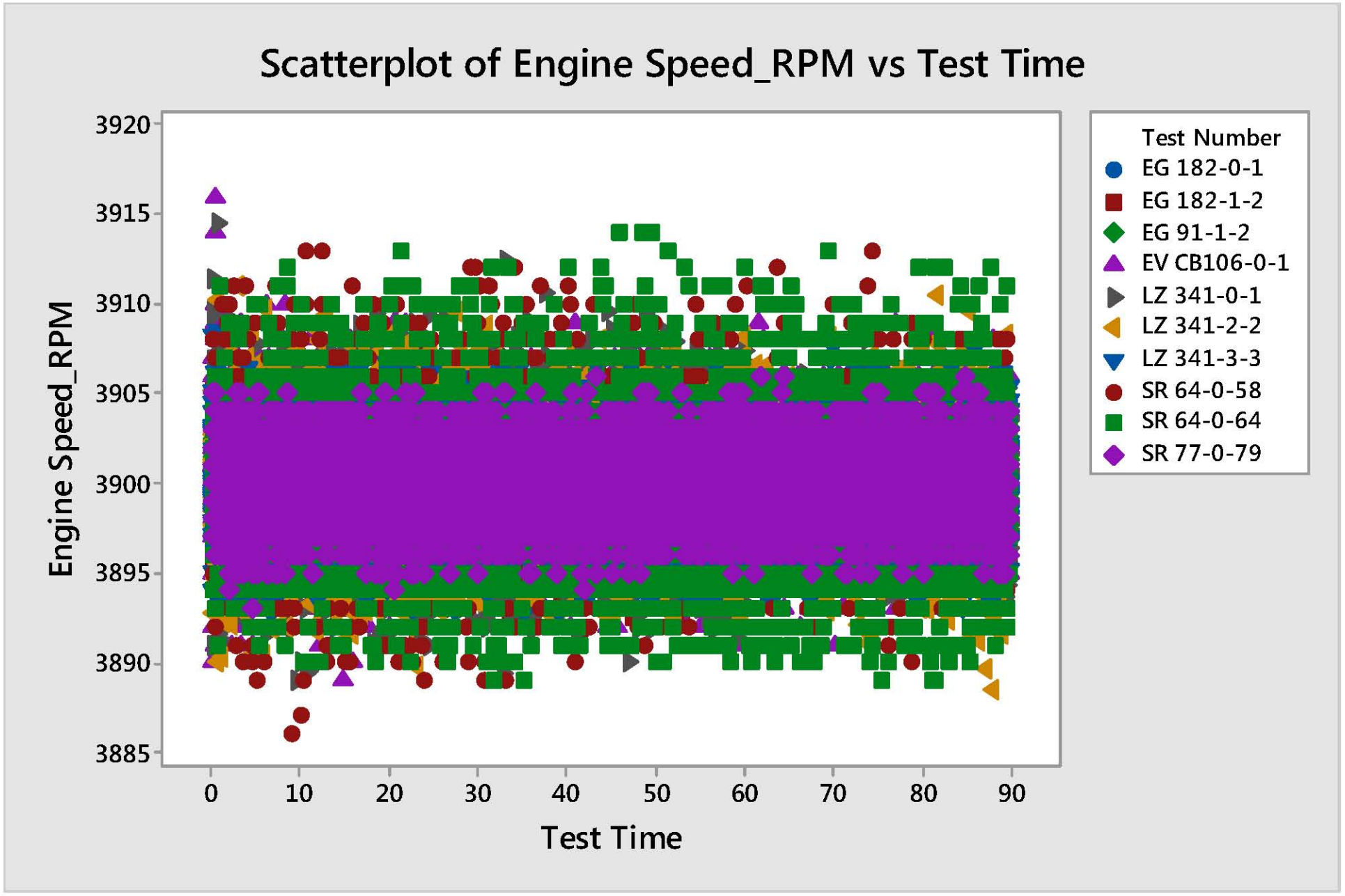
Potassium

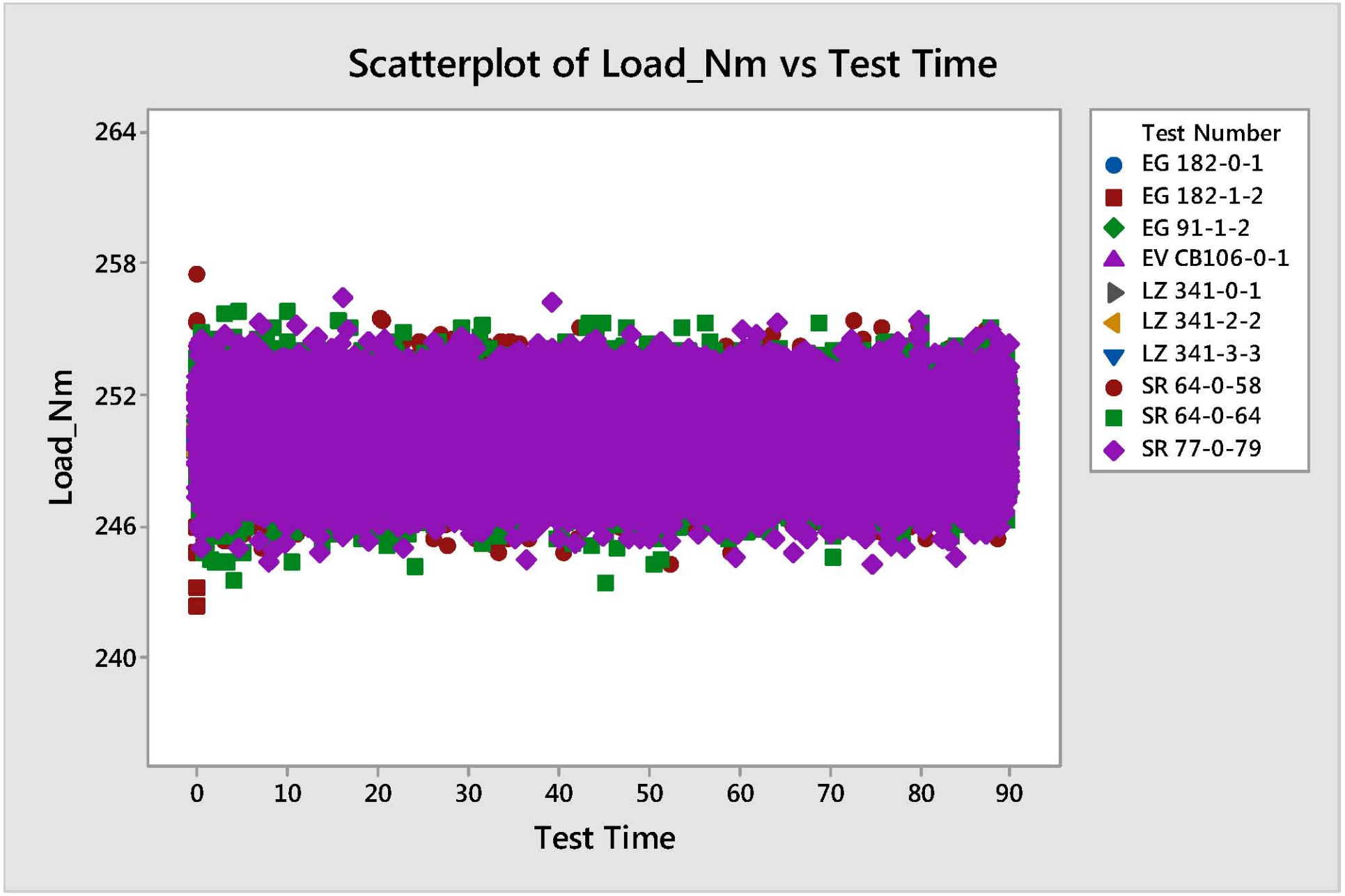


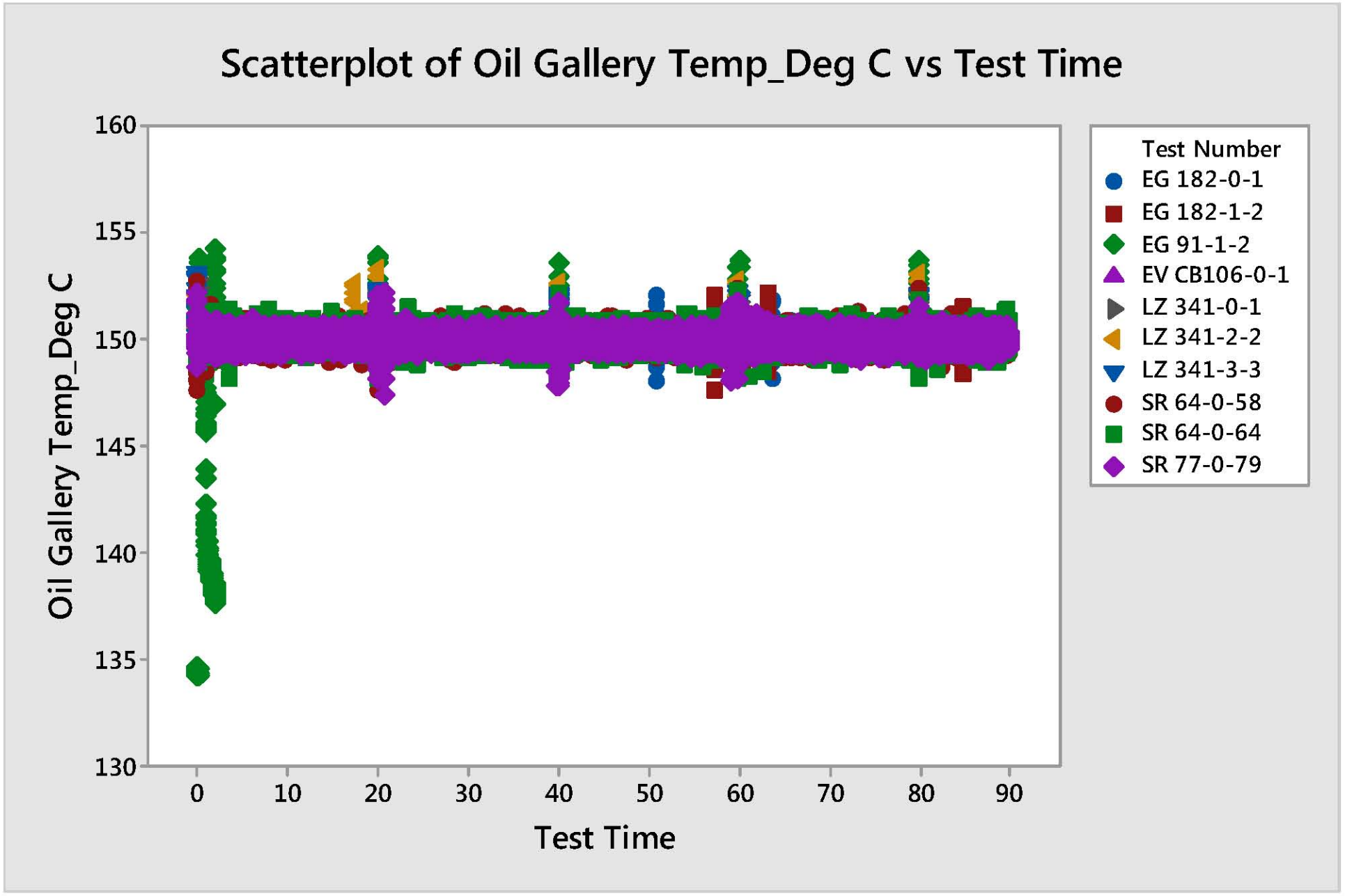
Sodium

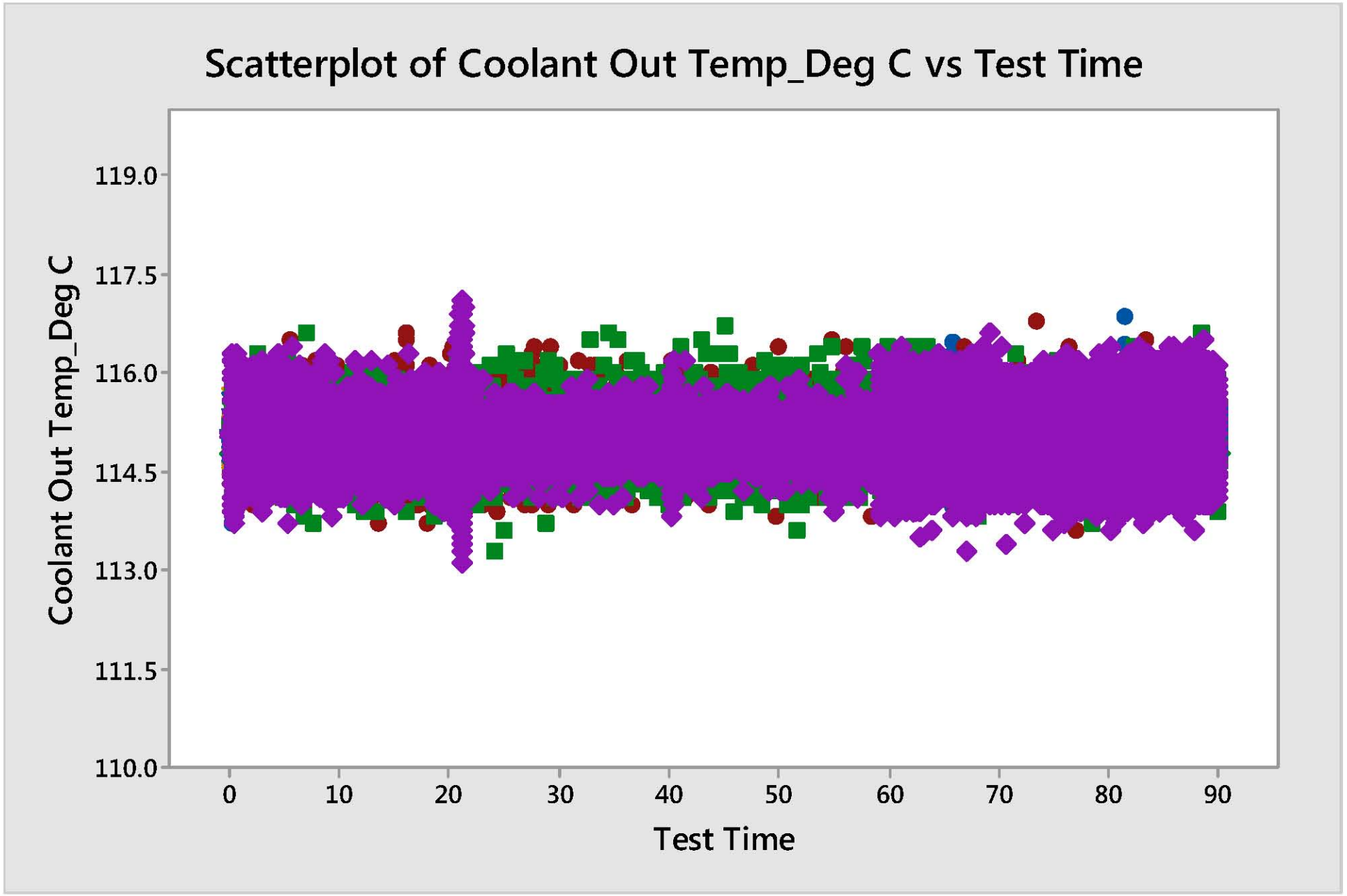


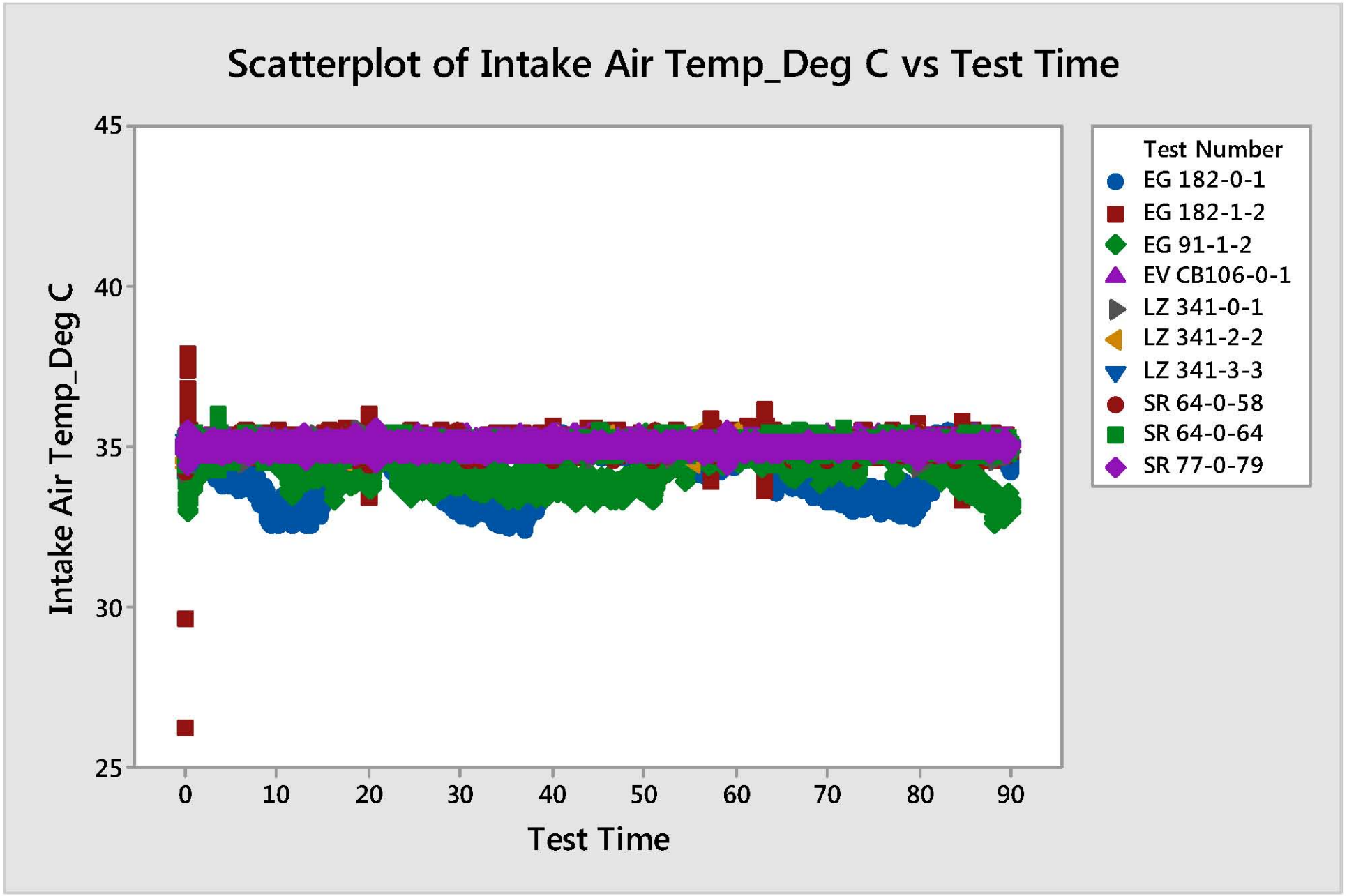

Scatterplot of Left AFR vs Test Time
Left AFR
15.0
12.5
10.0
7.5
5.0
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

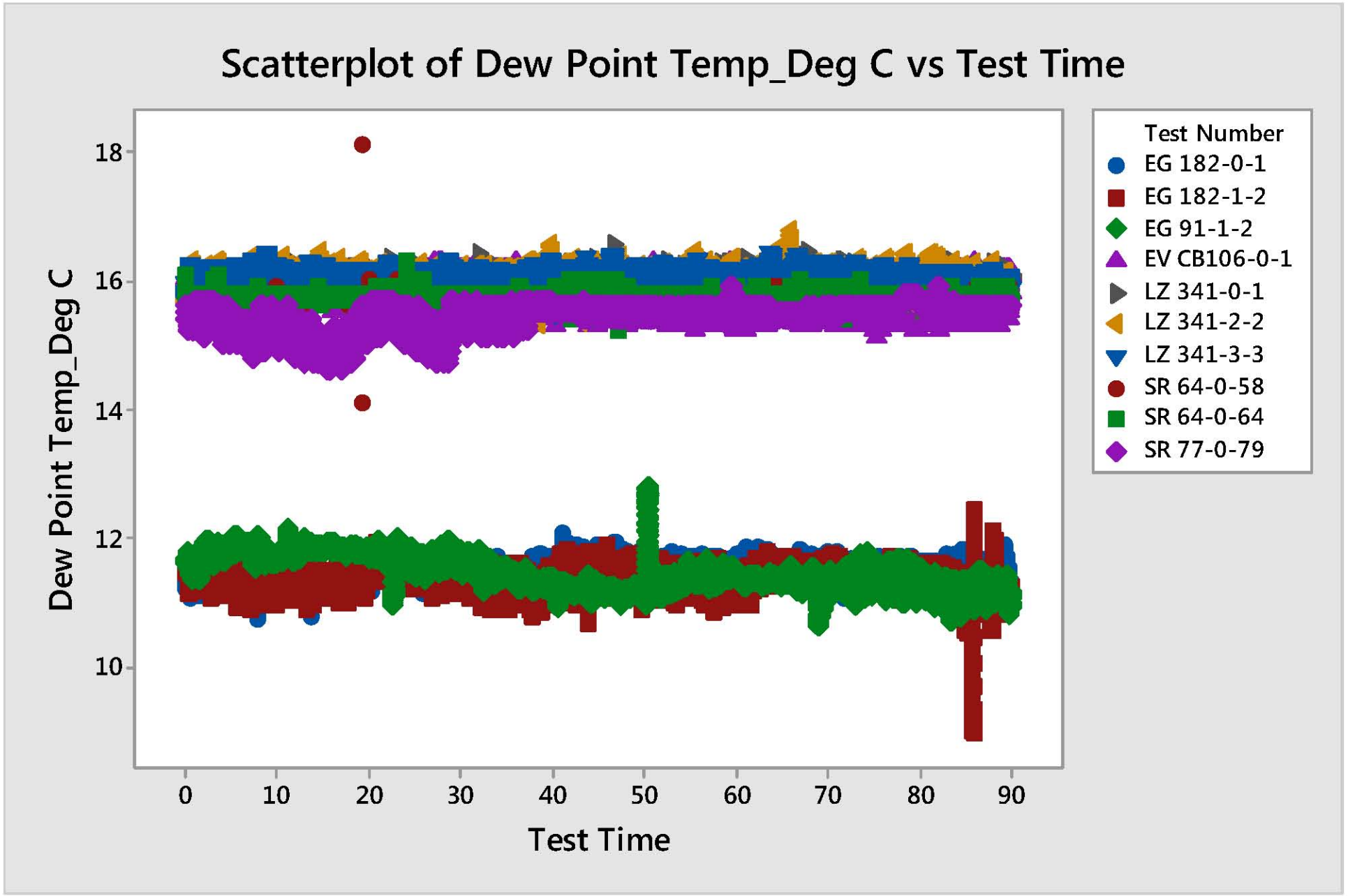

Scatterplot of Engine Speed_RPM vs Test Time
Engine Speed_RPM
3920
3915
3910
3905
3900
3895
3890
3885
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

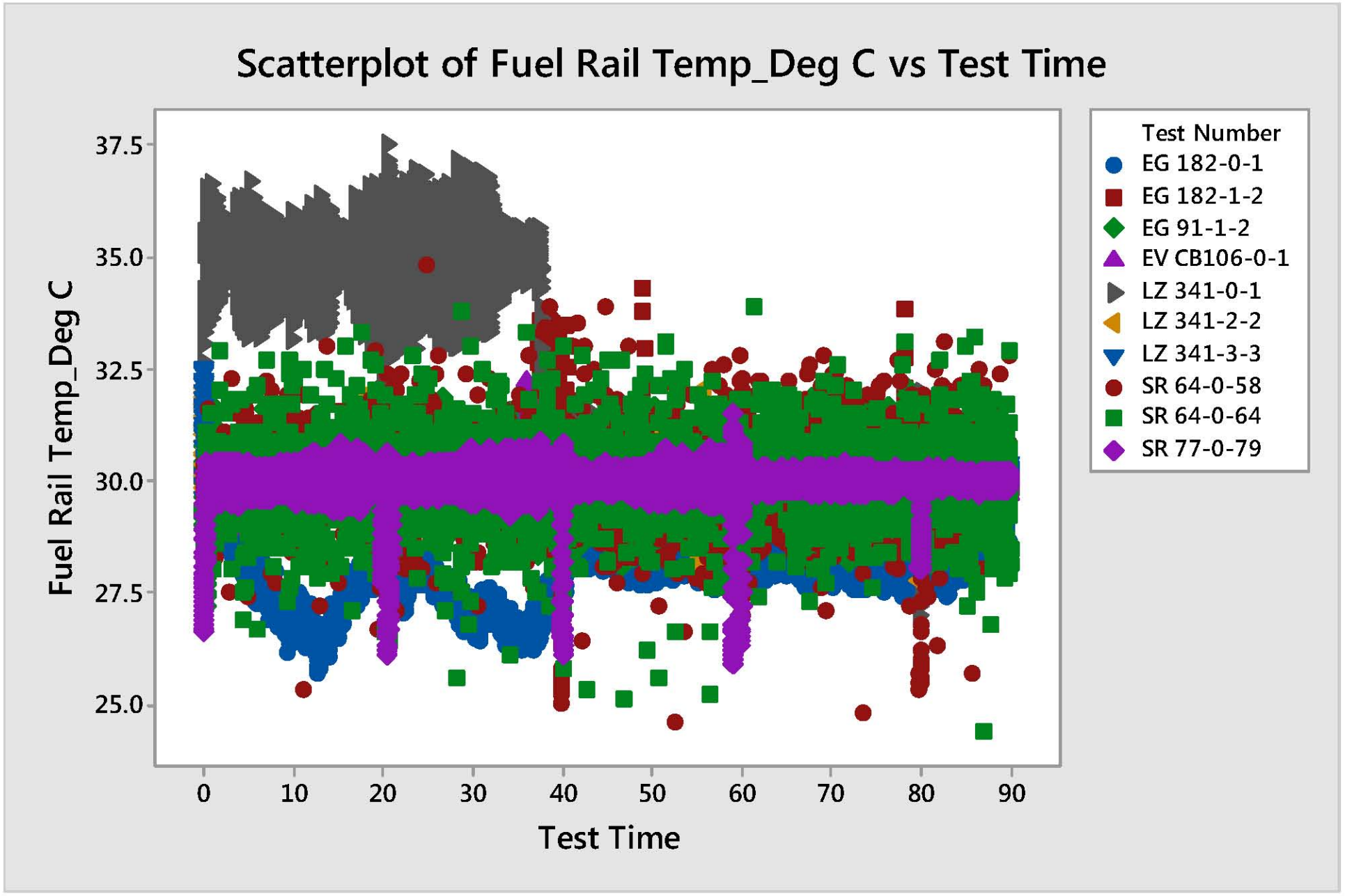

Scatterplot of Load_Nm vs Test Time
Load_Nm
264
258
252
246
240
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

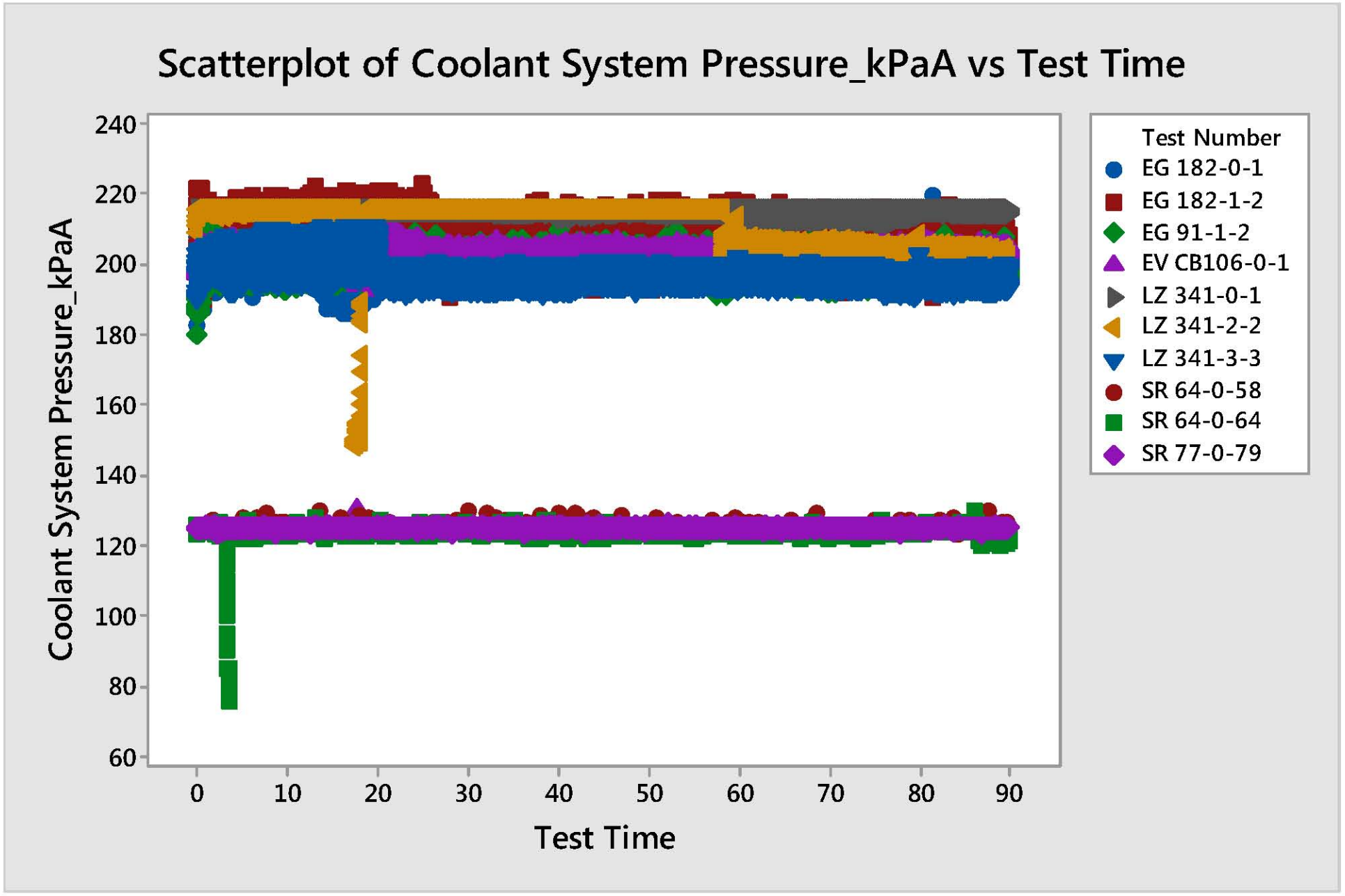

Scatterplot of Oil Gallery Temp_Deg C vs Test Time
Oil Gallery Temp_Deg C
160
155
150
145
140
135
130
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

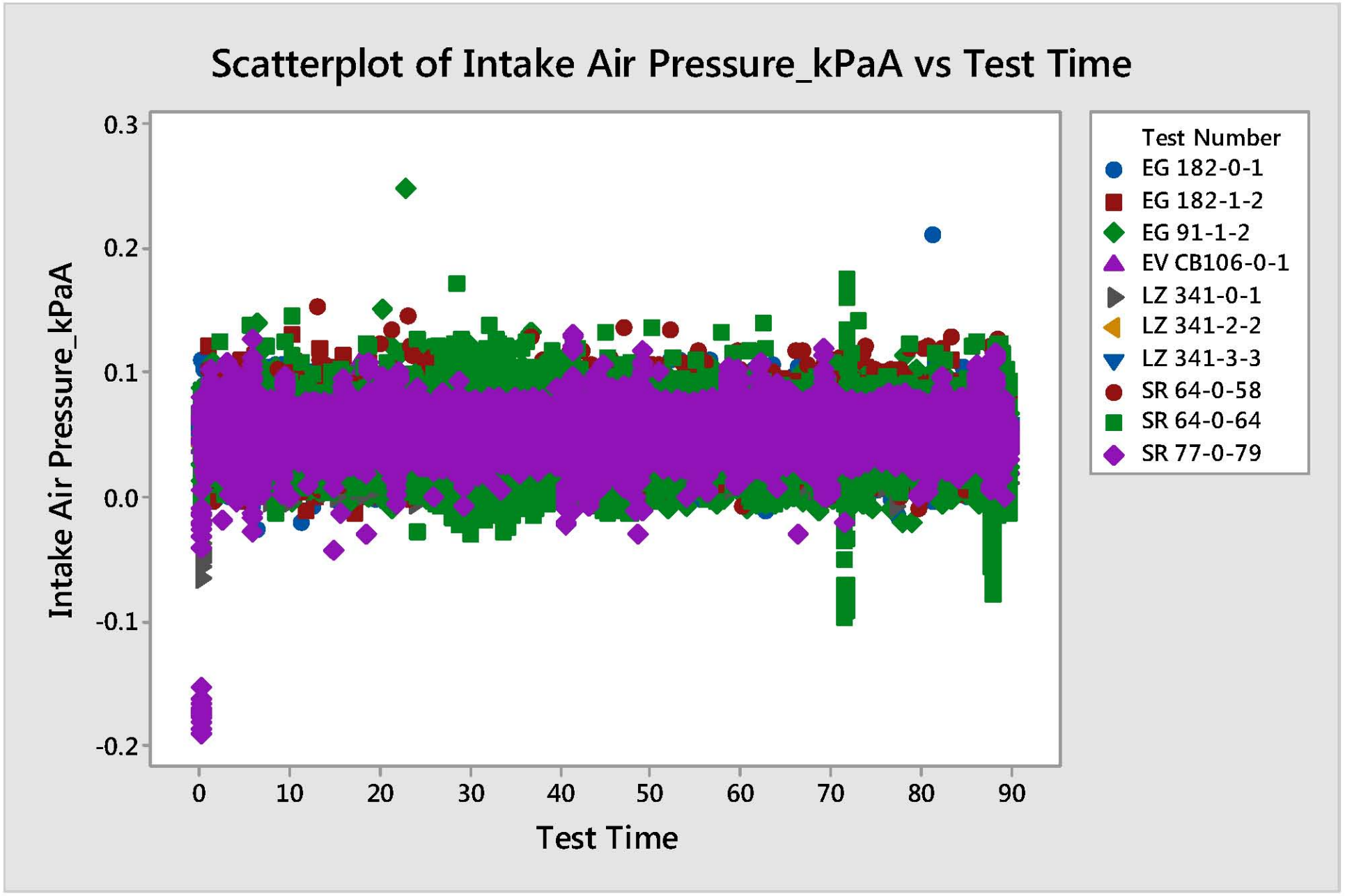

Scatterplot of Coolant Out Temp_Deg C vs Test Time
Coolant Out Temp_Deg C
119.0
117.5
116.0
114.5
113.0
111.5
110.0
0
10
20
30
40
50
60
70
80
90
Test Time

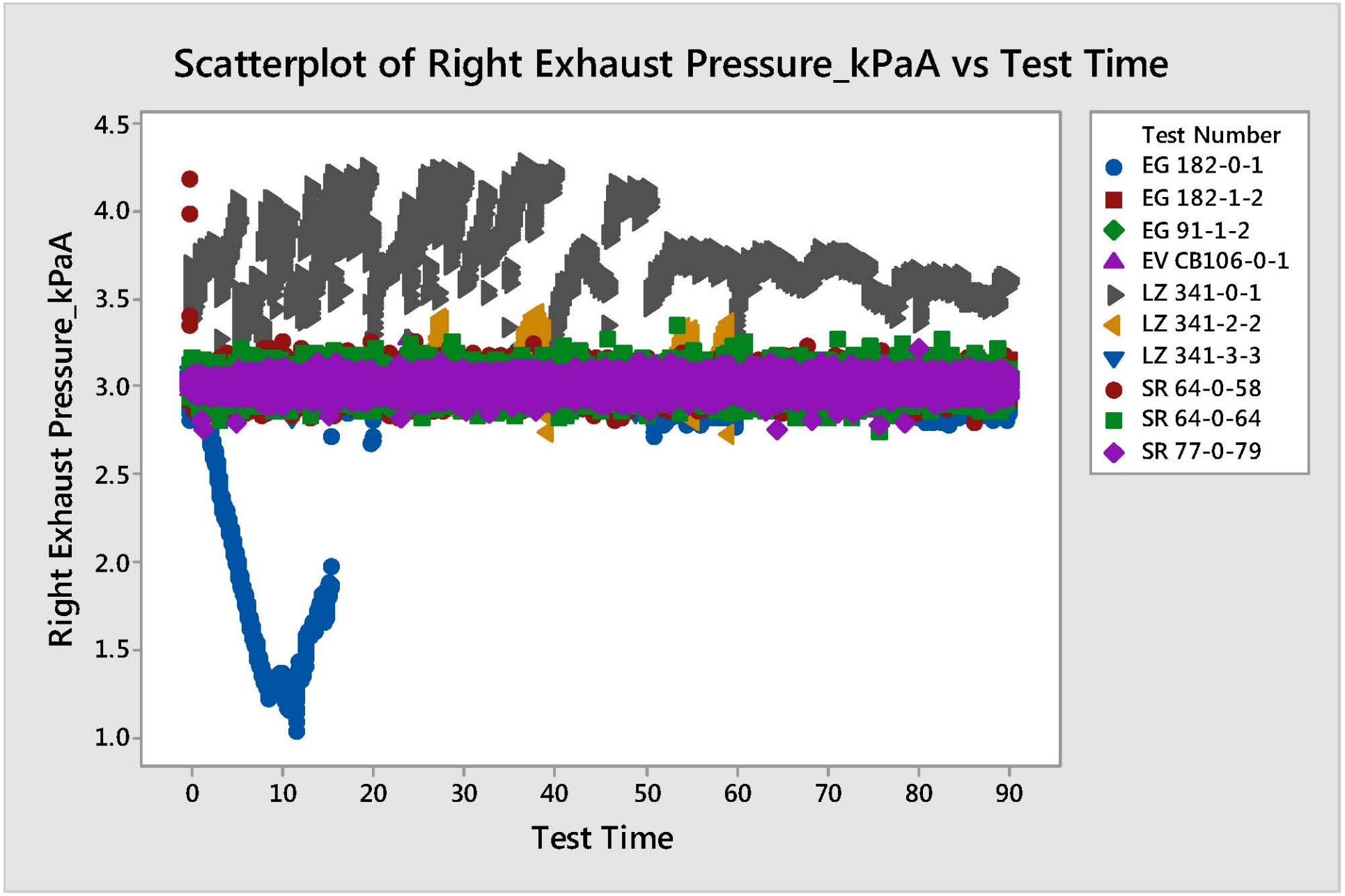

Scatterplot of Intake Air Temp_Deg C vs Test Time
Intake Air Temp_Deg C
45
40
35
30
25
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

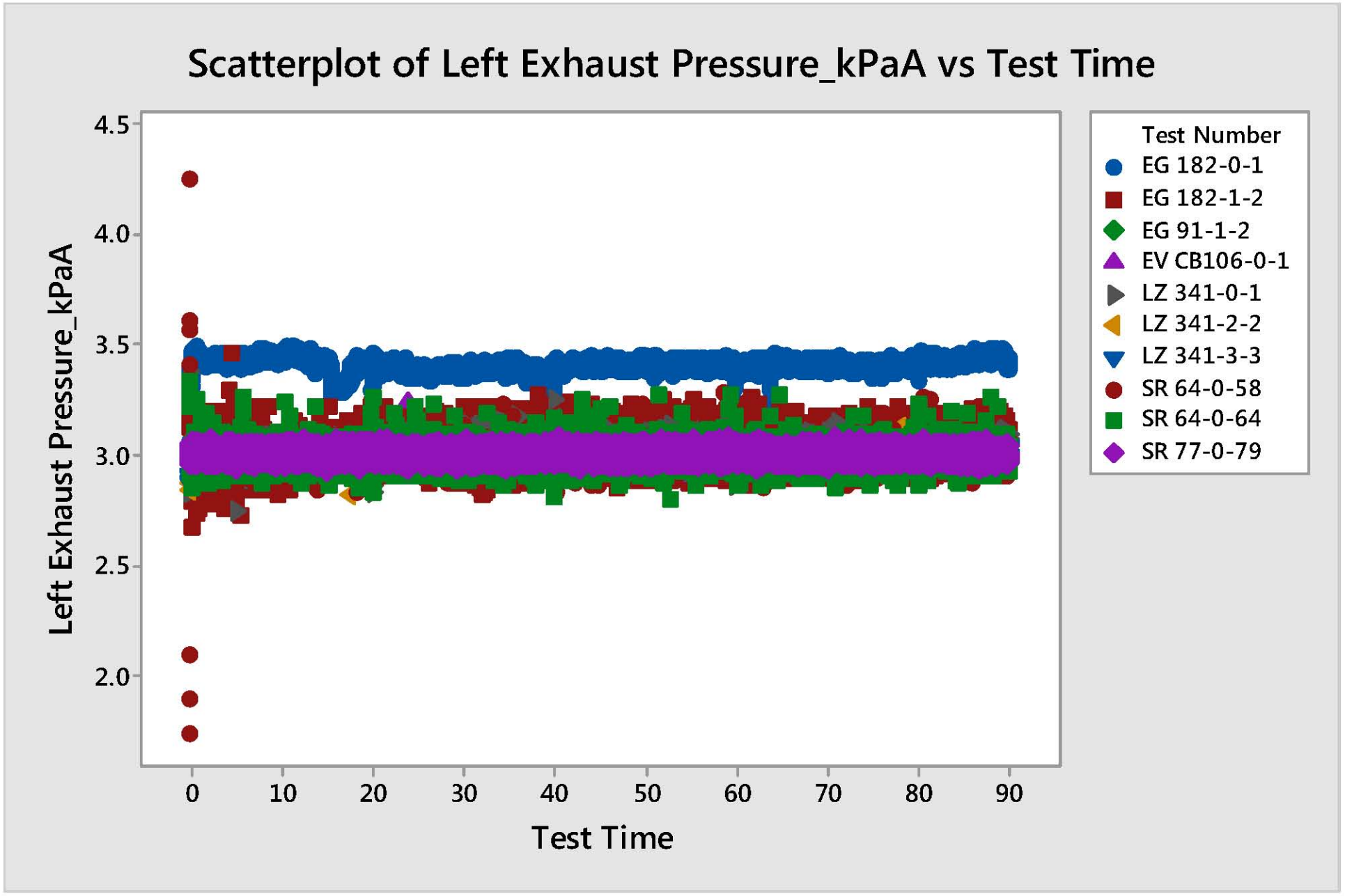

Scatterplot of Dew Point Temp_Deg C vs Test Time
Dew Point Temp_Deg C
18
16
14
12
10
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

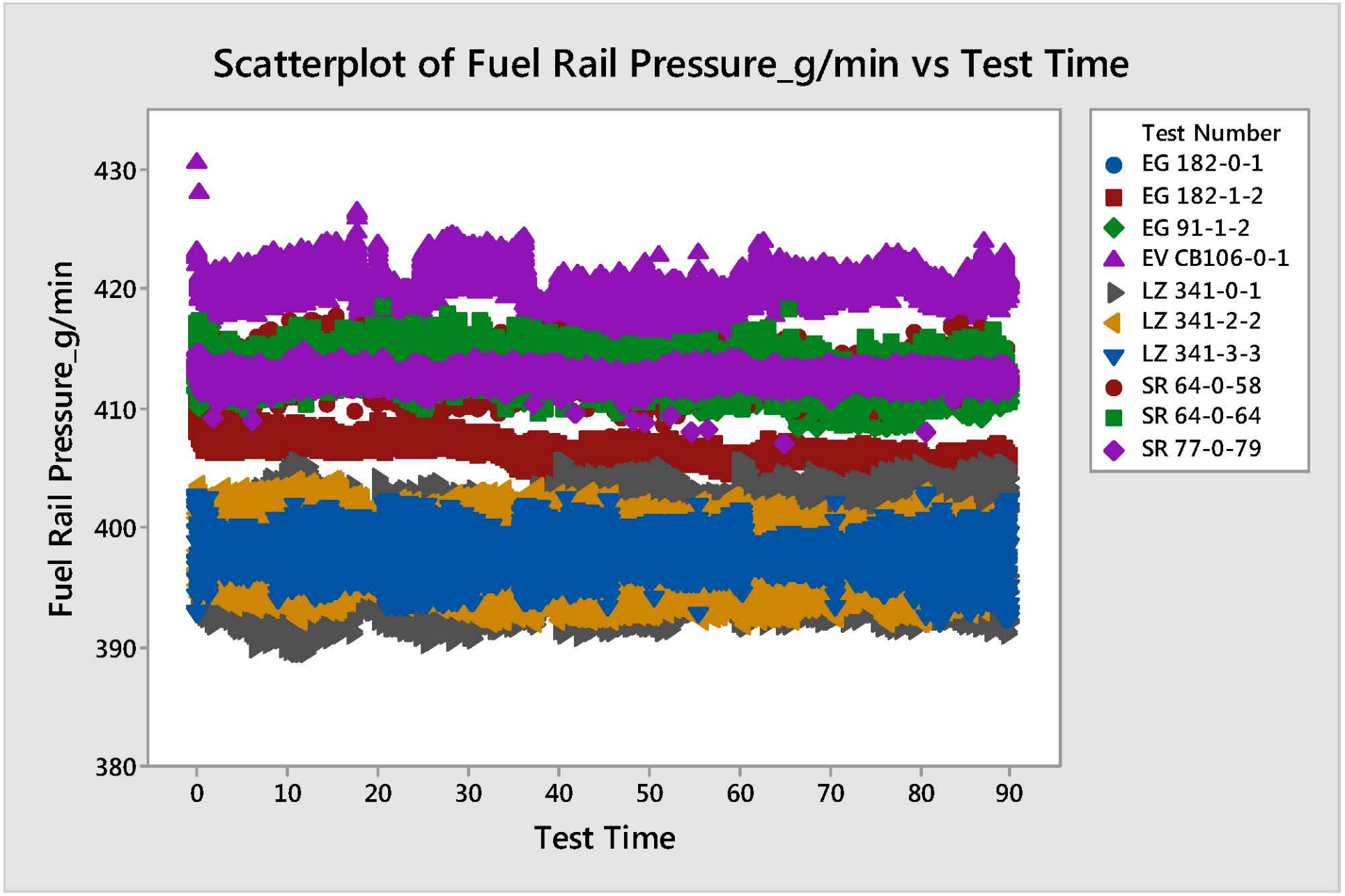

Scatterplot of Fuel Rail Temp_Deg C vs Test Time
Fuel Rail Temp_Deg C
37.5
35.0
32.5
30.0
27.5
25.0
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

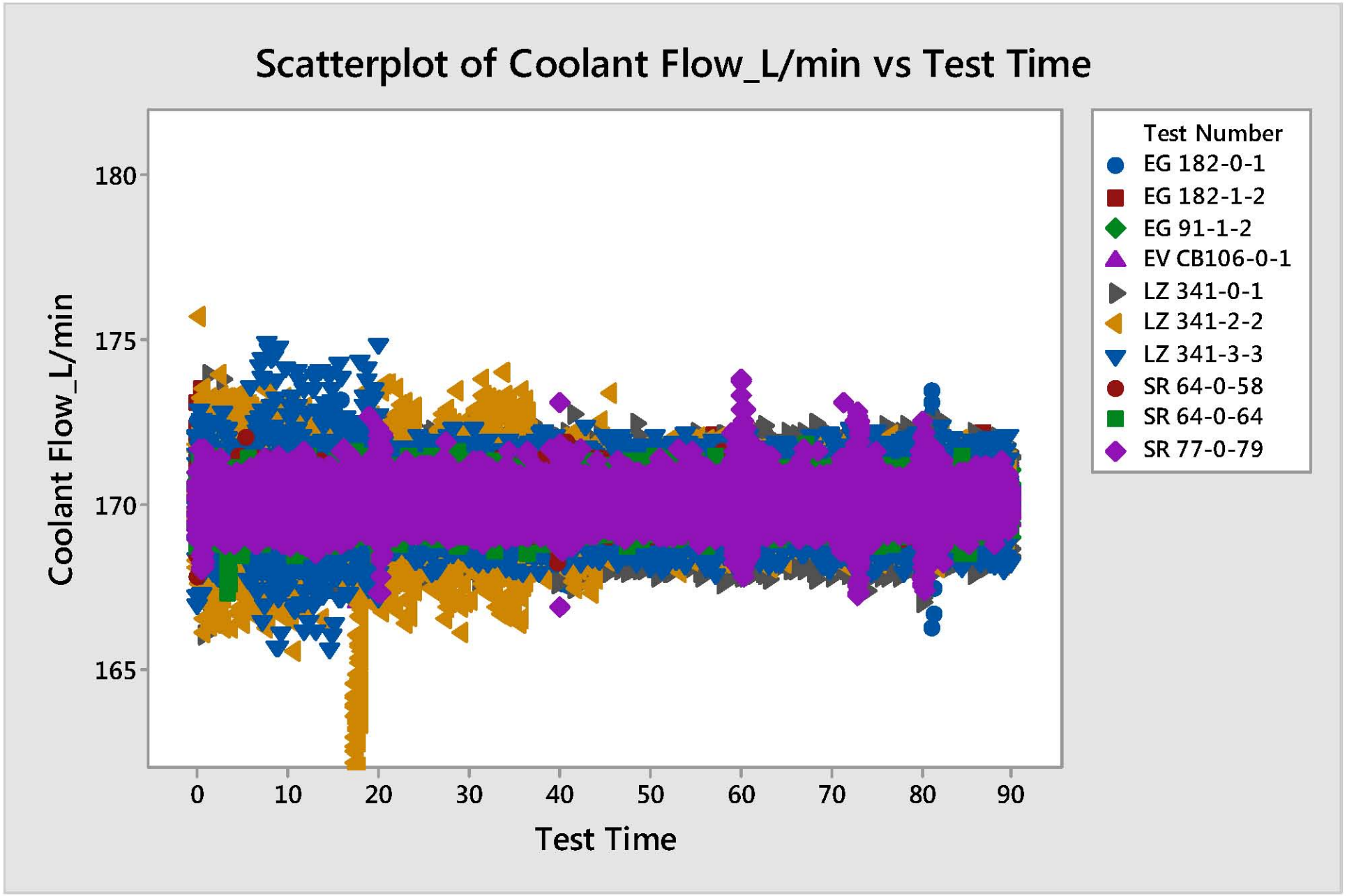

Scatterplot of Coolant System Pressure_kPaA vs Test Time
Coolant System Pressure_kPaA
240
220
200
180
160
140
120
100
80
60
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

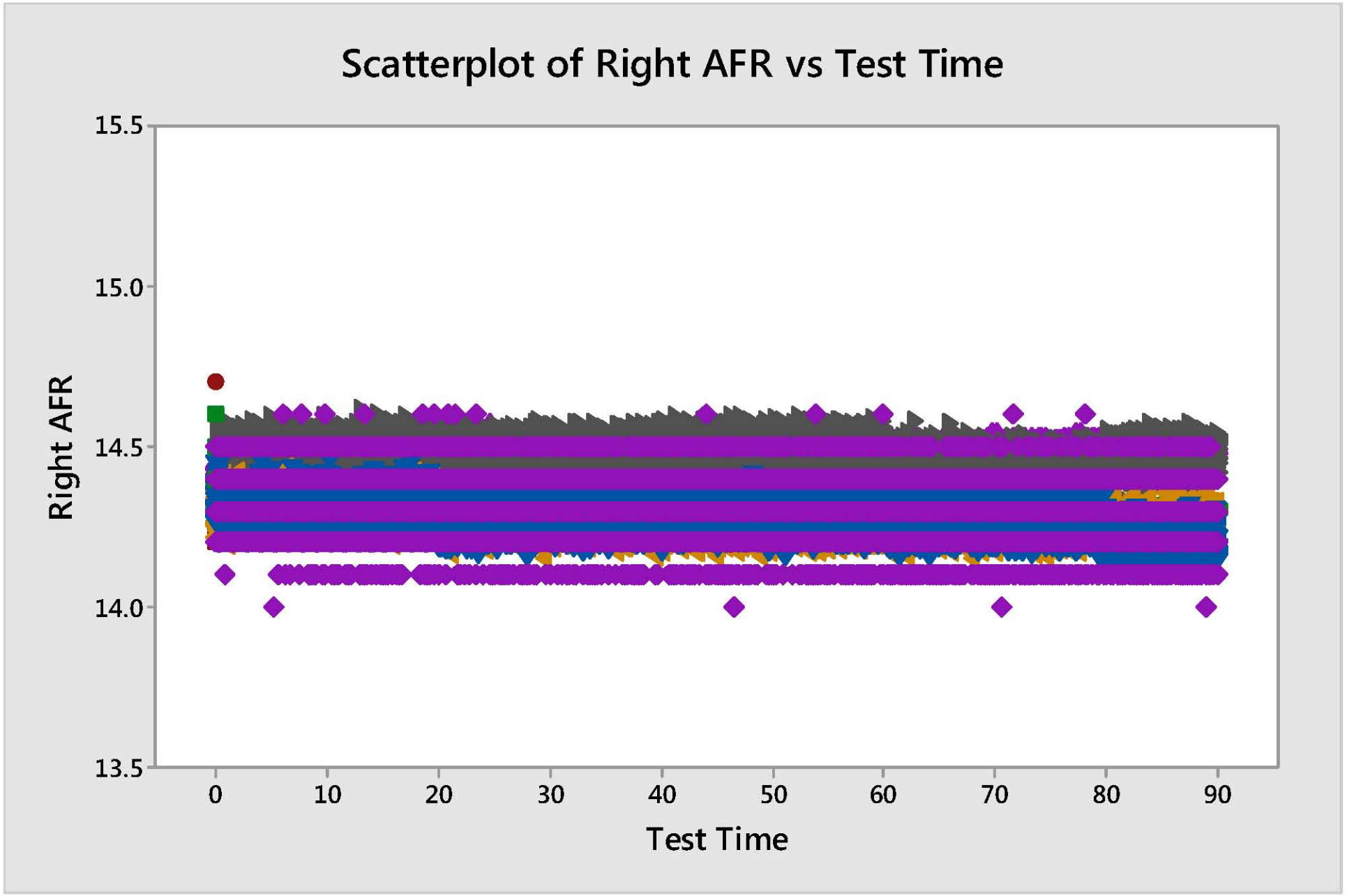

Scatterplot of Intake Air Pressure_kPaA vs Test Time
Intake Air Pressure_kPaA
0.3
0.2
0.1
0.0
-0.1
-0.2
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

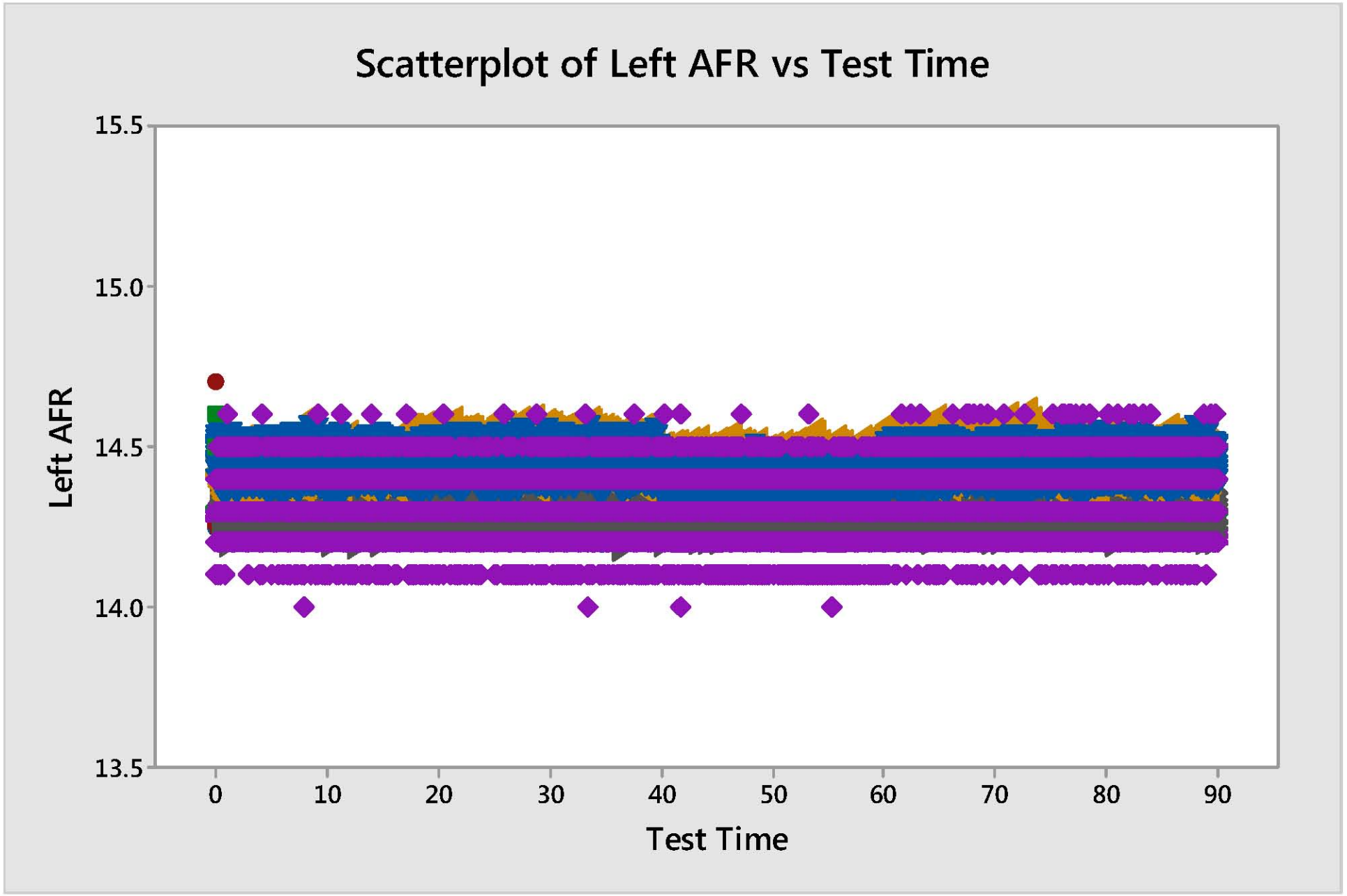

Scatterplot of Right Exhaust Pressure_kPaA vs Test Time
Right Exhaust Pressure_kPaA
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

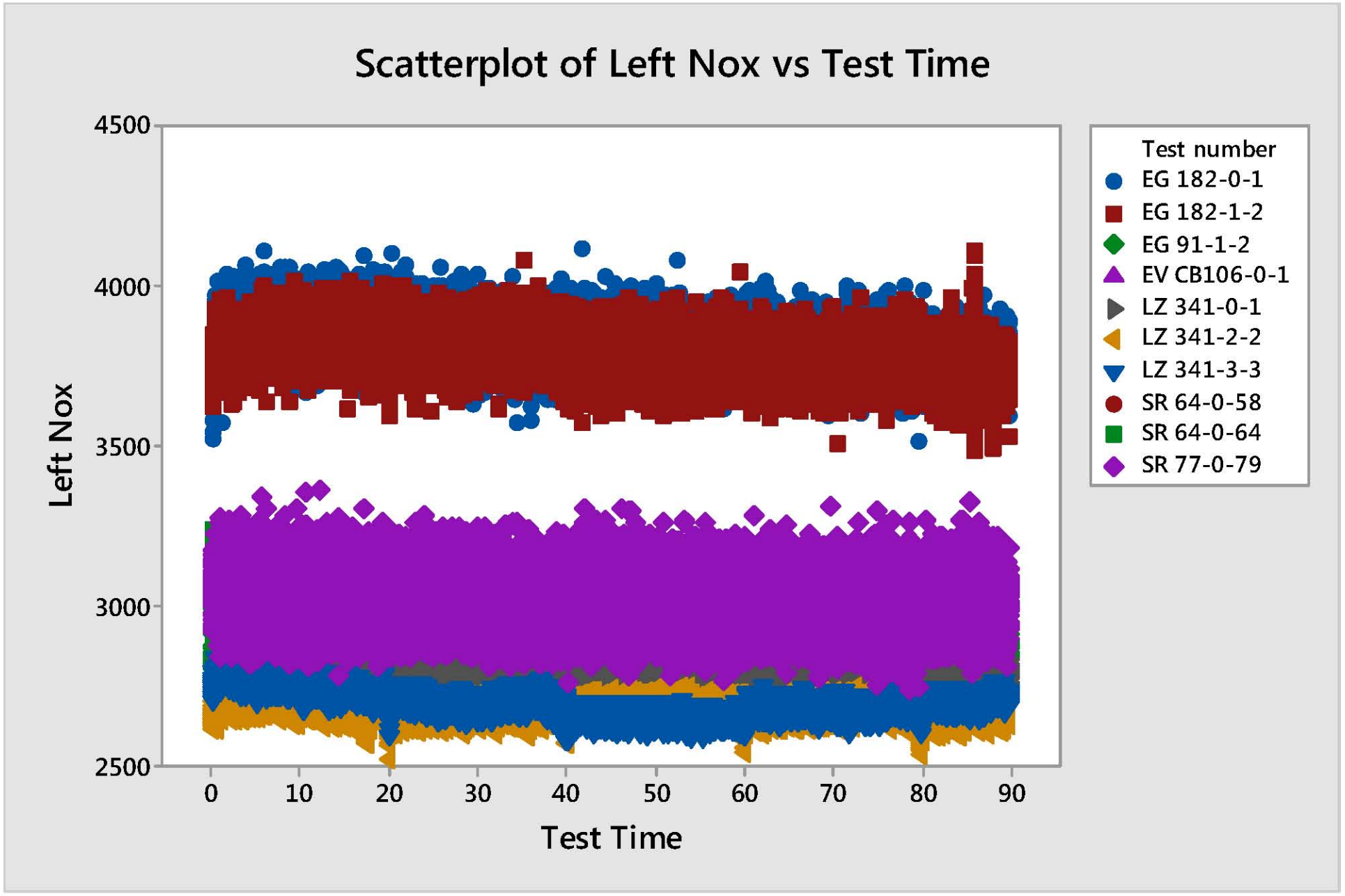

Scatterplot of Left Exhaust Pressure_kPaA vs Test Time
Left Exhaust Pressure_kPaA
4.5
4.0
3.5
3.0
2.5
2.0
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

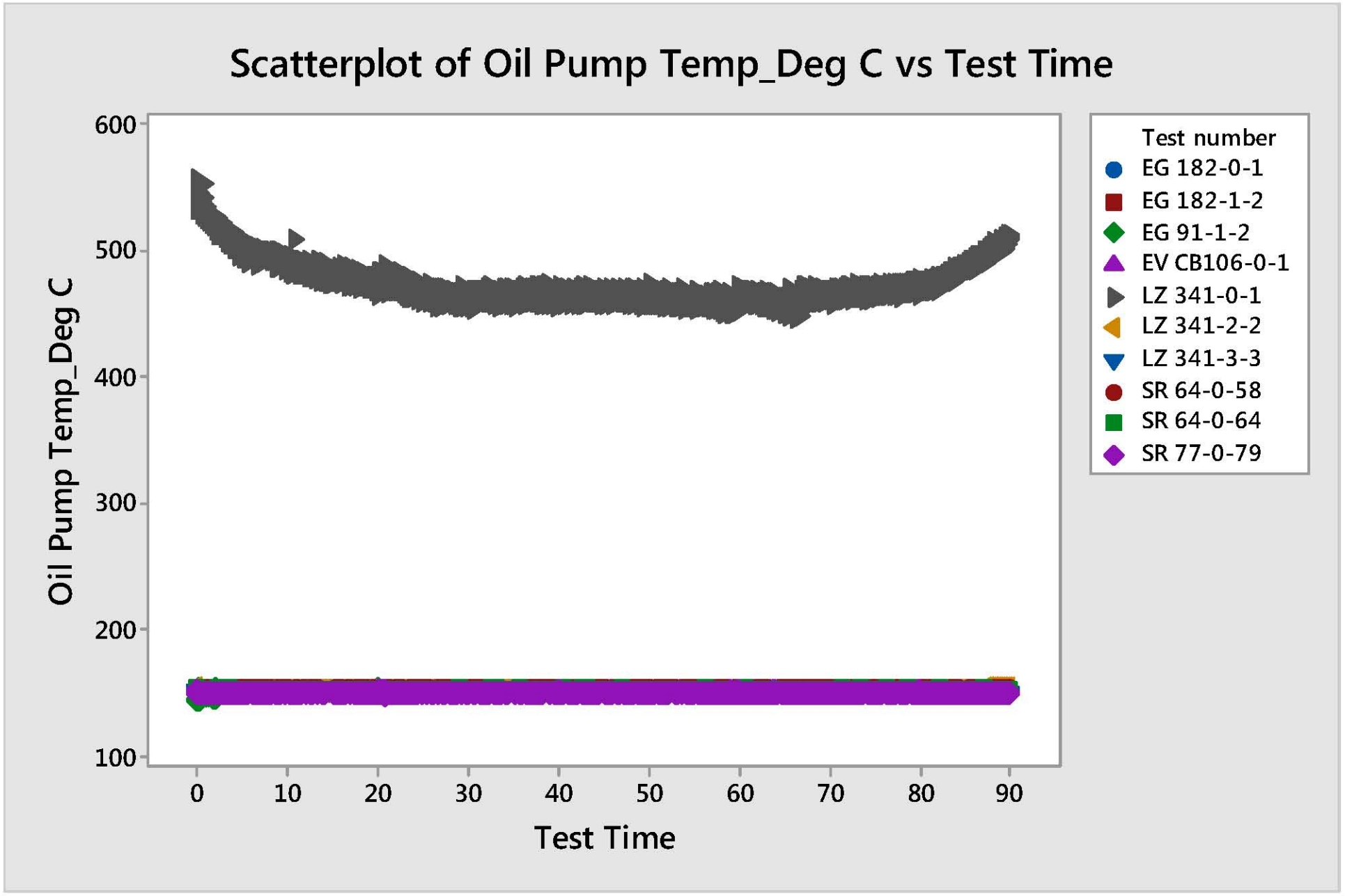

Scatterplot of Fuel Rail Pressure_g/min vs Test Time
Fuel Rail Pressure_g/min
430
420
410
400
390
380
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

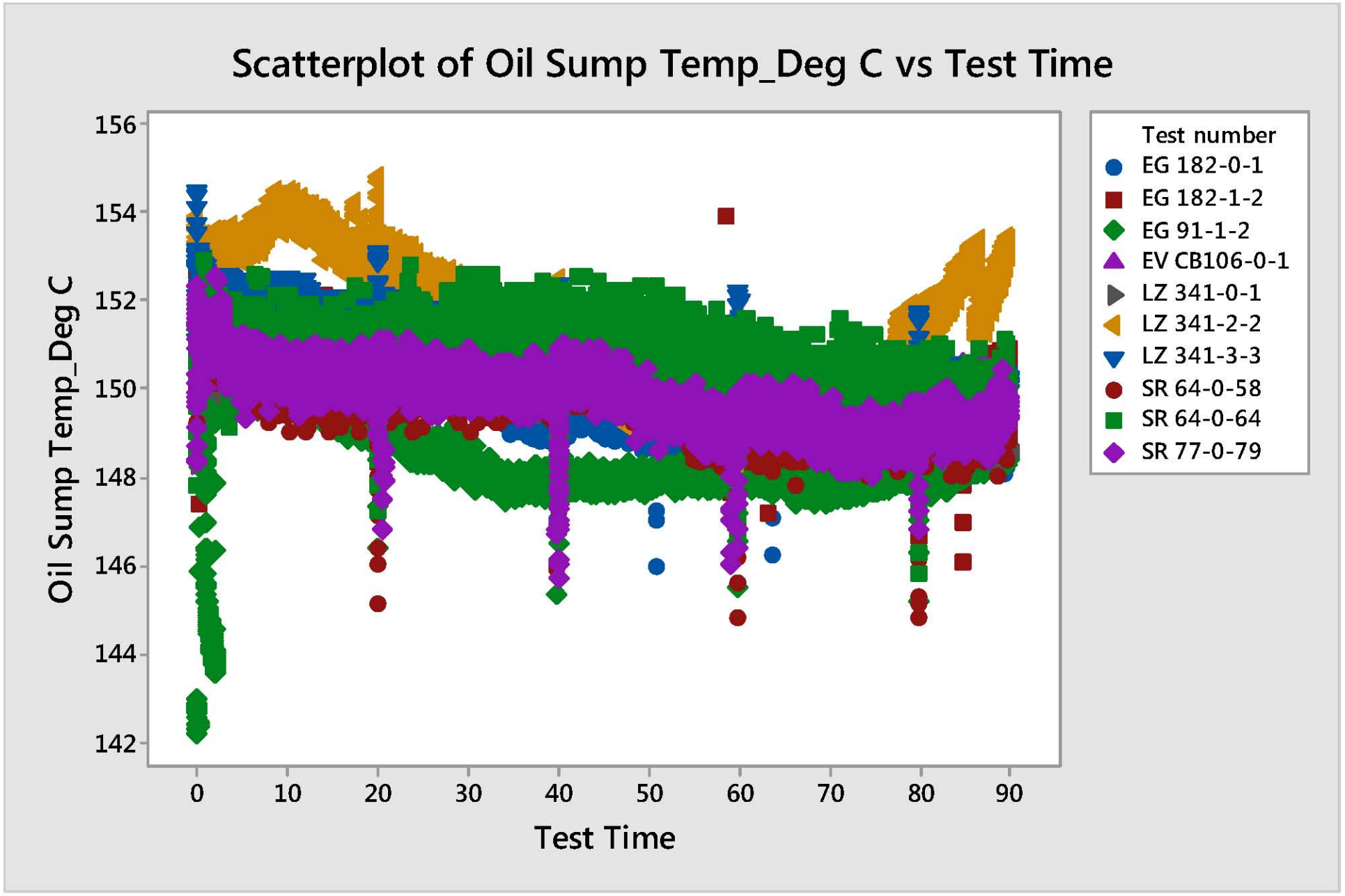

Scatterplot of Coolant Flow_L/min vs Test Time
Coolant Flow_L/min
180
175
170
165
0
10
20
30
40
50
60
70
80
90
Test Time
Test Number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

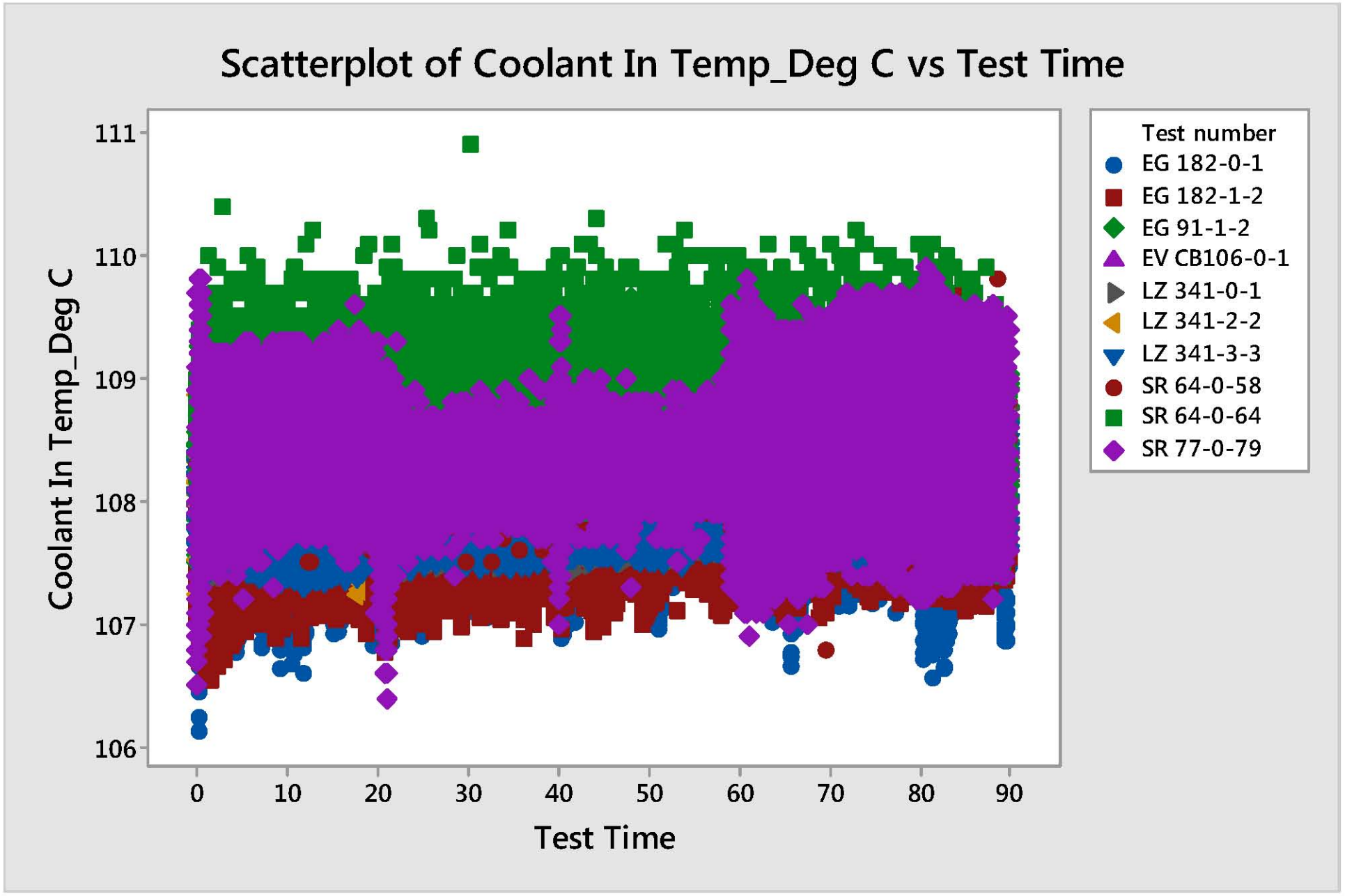

Scatterplot of Right AFR vs Test Time
Right AFR
15.5
15.0
14.5
14.0
13.5
0
10
20
30
40
50
60
70
80
90
Test Time

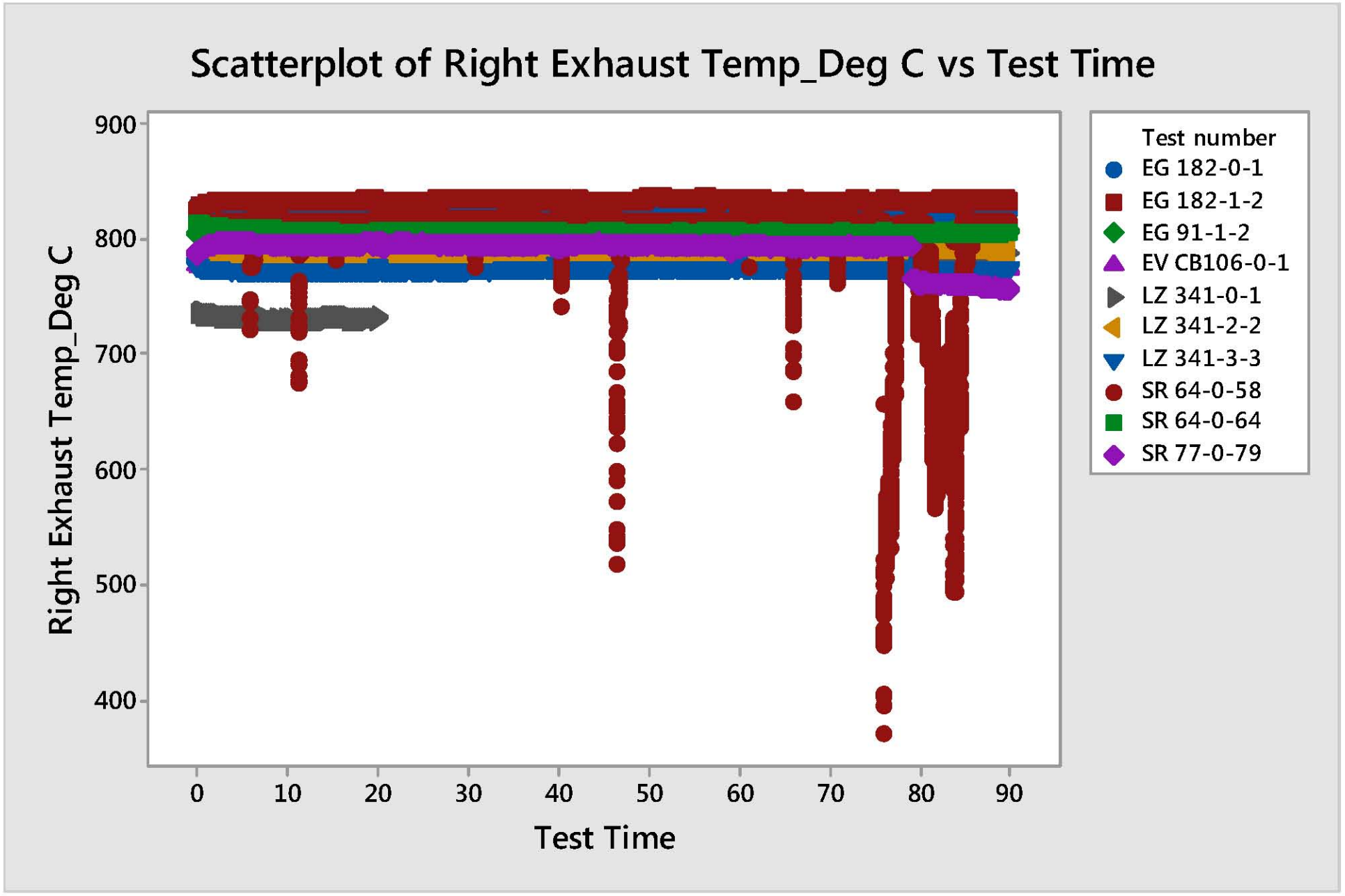

Scatterplot of Left AFR vs Test Time
Left AFR
15.5
15.0
14.5
14.0
13.5
0
10
20
30
40
50
60
70
80
90
Test Time

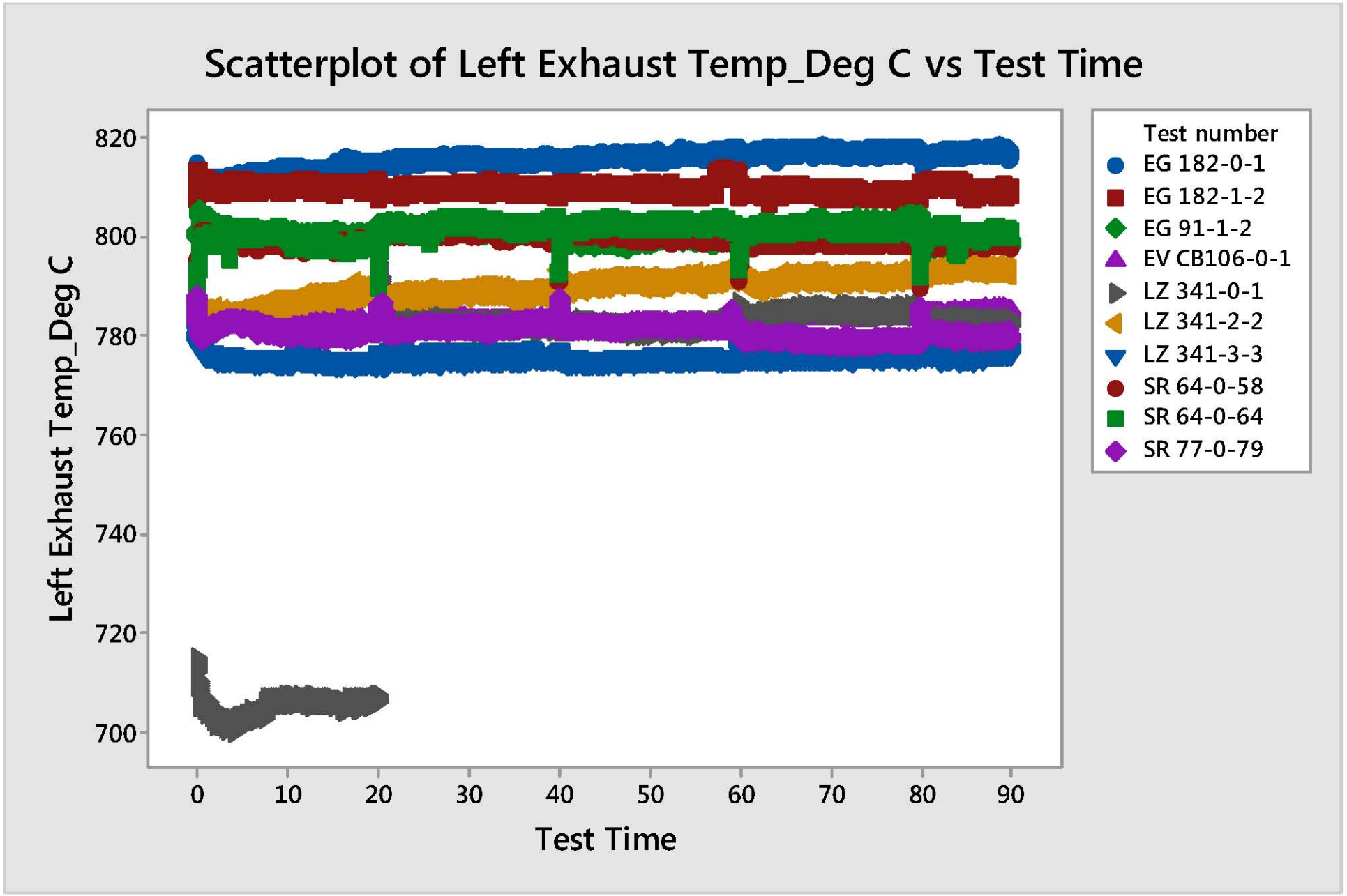

Scatterplot of Left Nox vs Test Time
Left Nox
4500
4000
3500
3000
2500
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

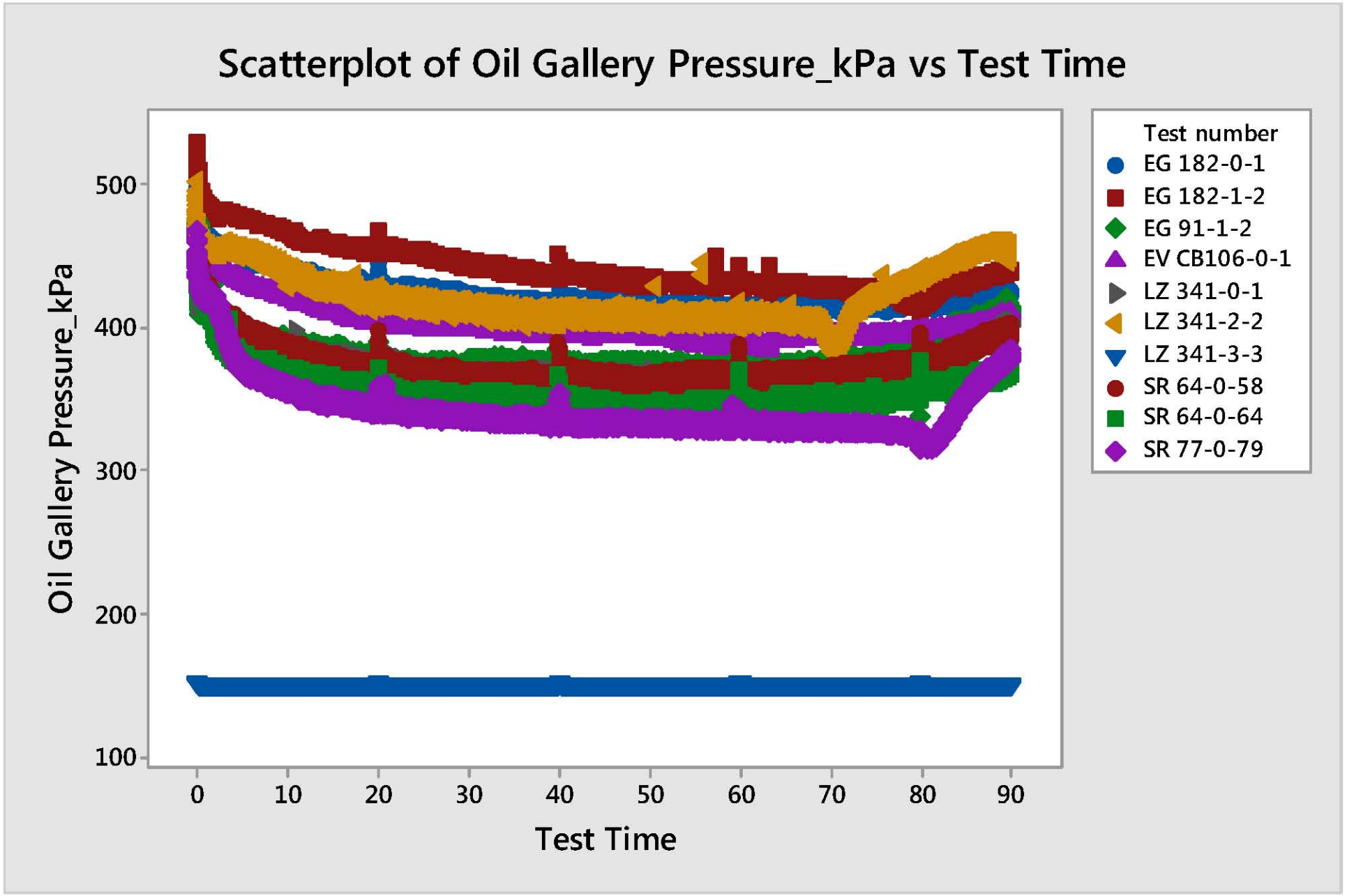

Scatterplot of Oil Pump Temp_Deg C vs Test Time
Oil Pump Temp_Deg C
600
500
400
300
200
100
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

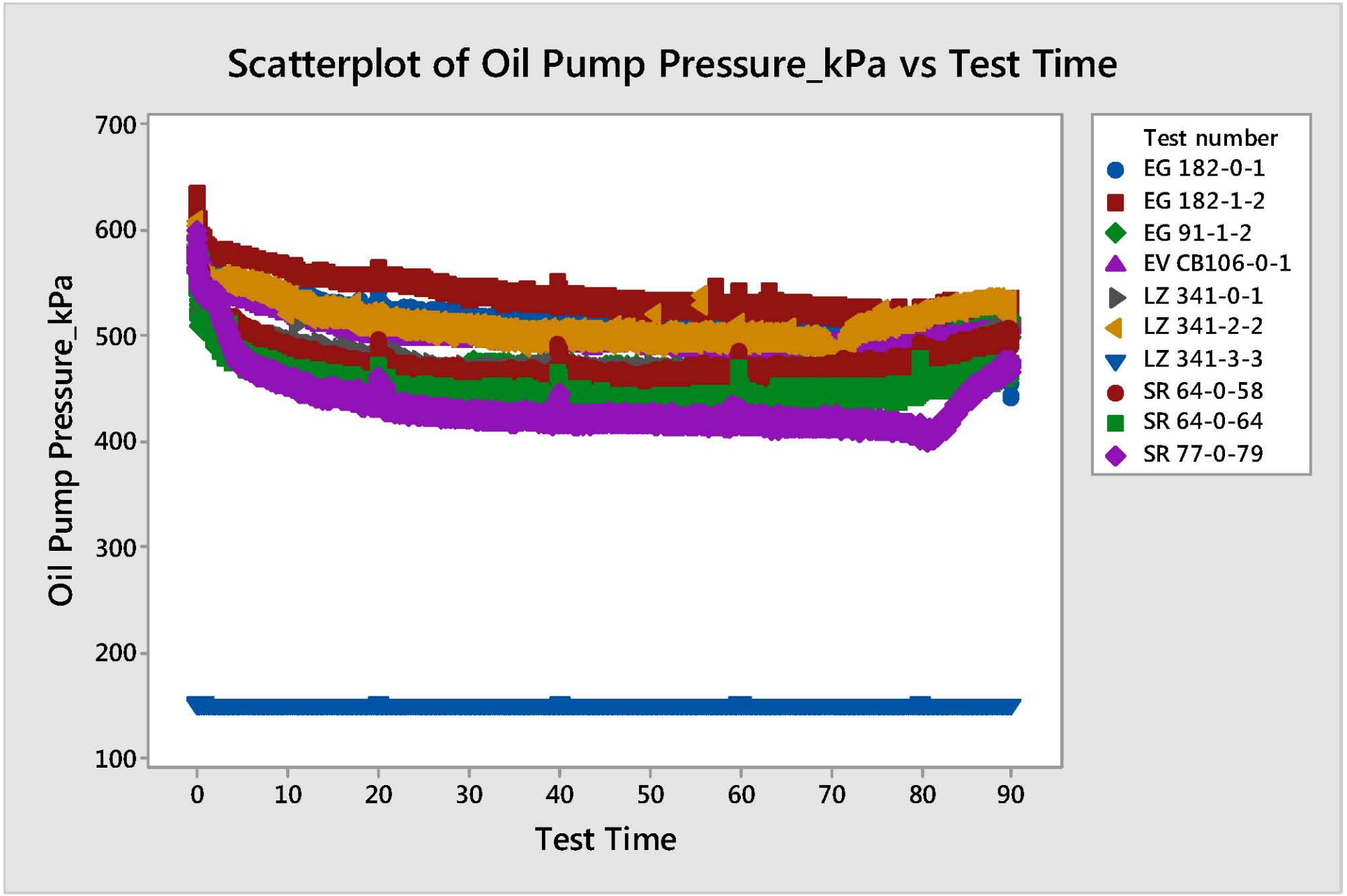

Scatterplot of Oil Sump Temp_Deg C vs Test Time
Oil Sump Temp_Deg C
156
154
152
150
148
146
144
142
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

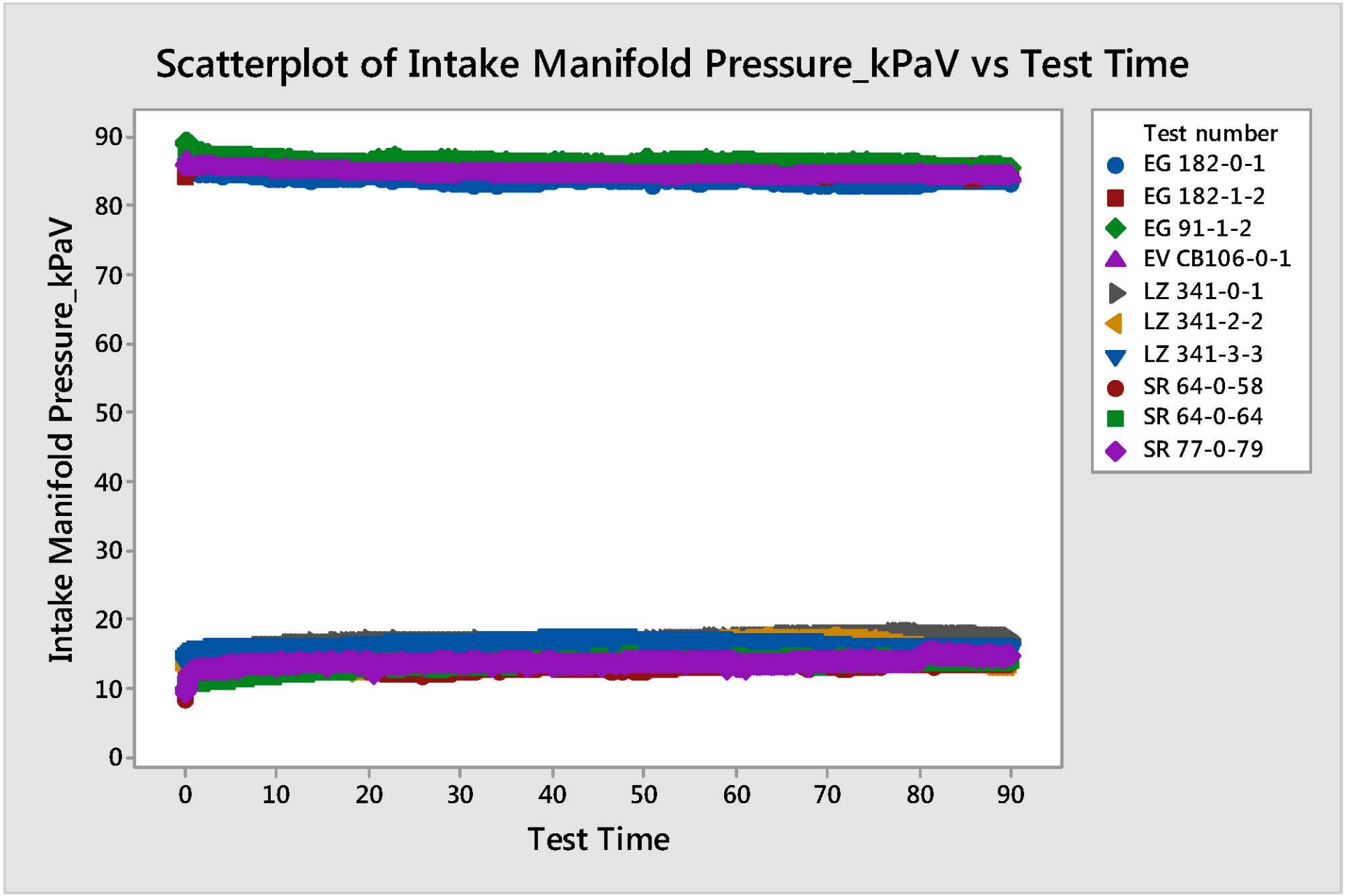

Scatterplot of Coolant In Temp_Deg C vs Test Time
Coolant In Temp_Deg C
111
110
109
108
107
106
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

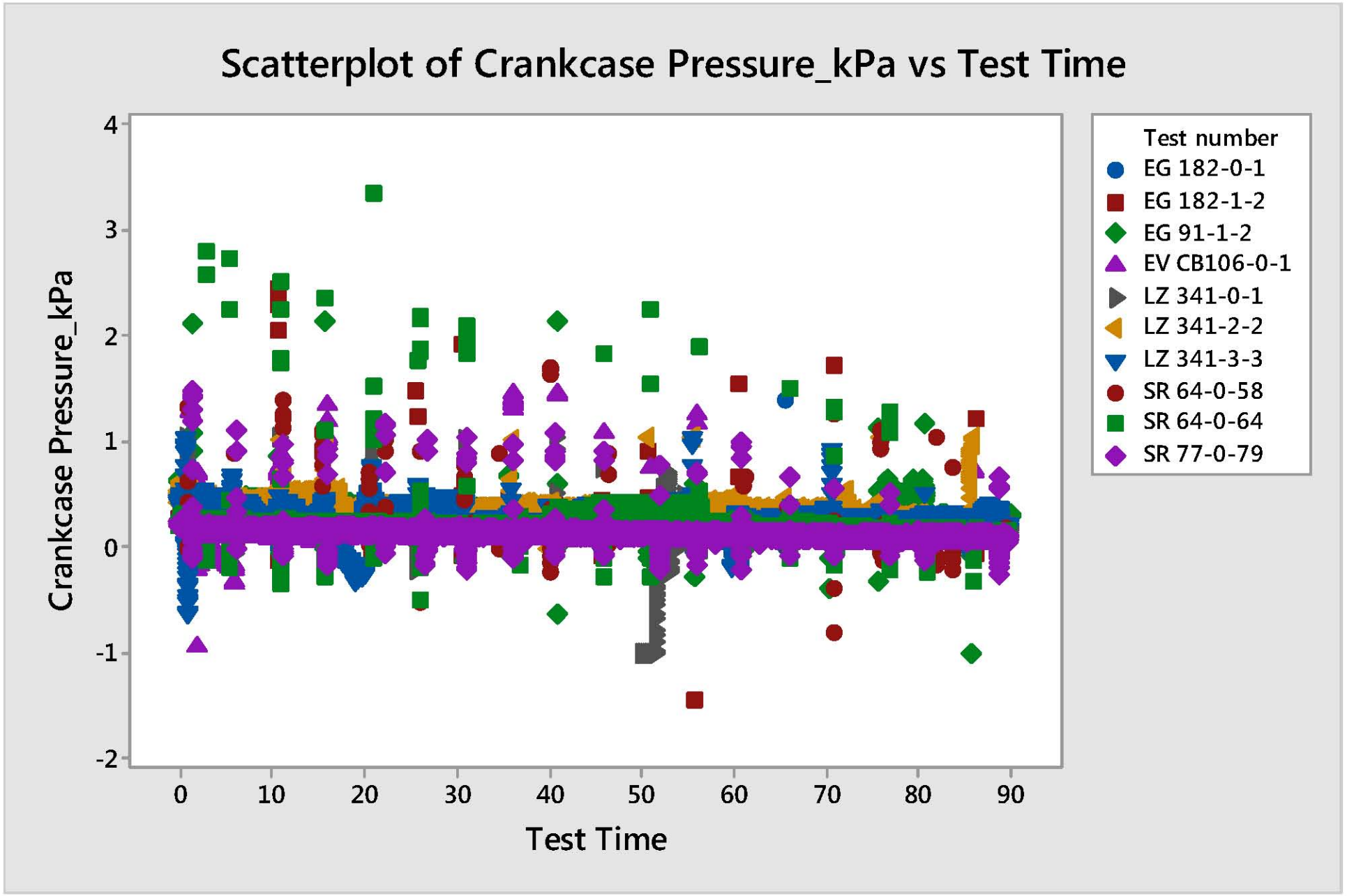

Scatterplot of Right Exhaust Temp_Deg C vs Test Time
Right Exhaust Temp_Deg C
900
800
700
600
500
400
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

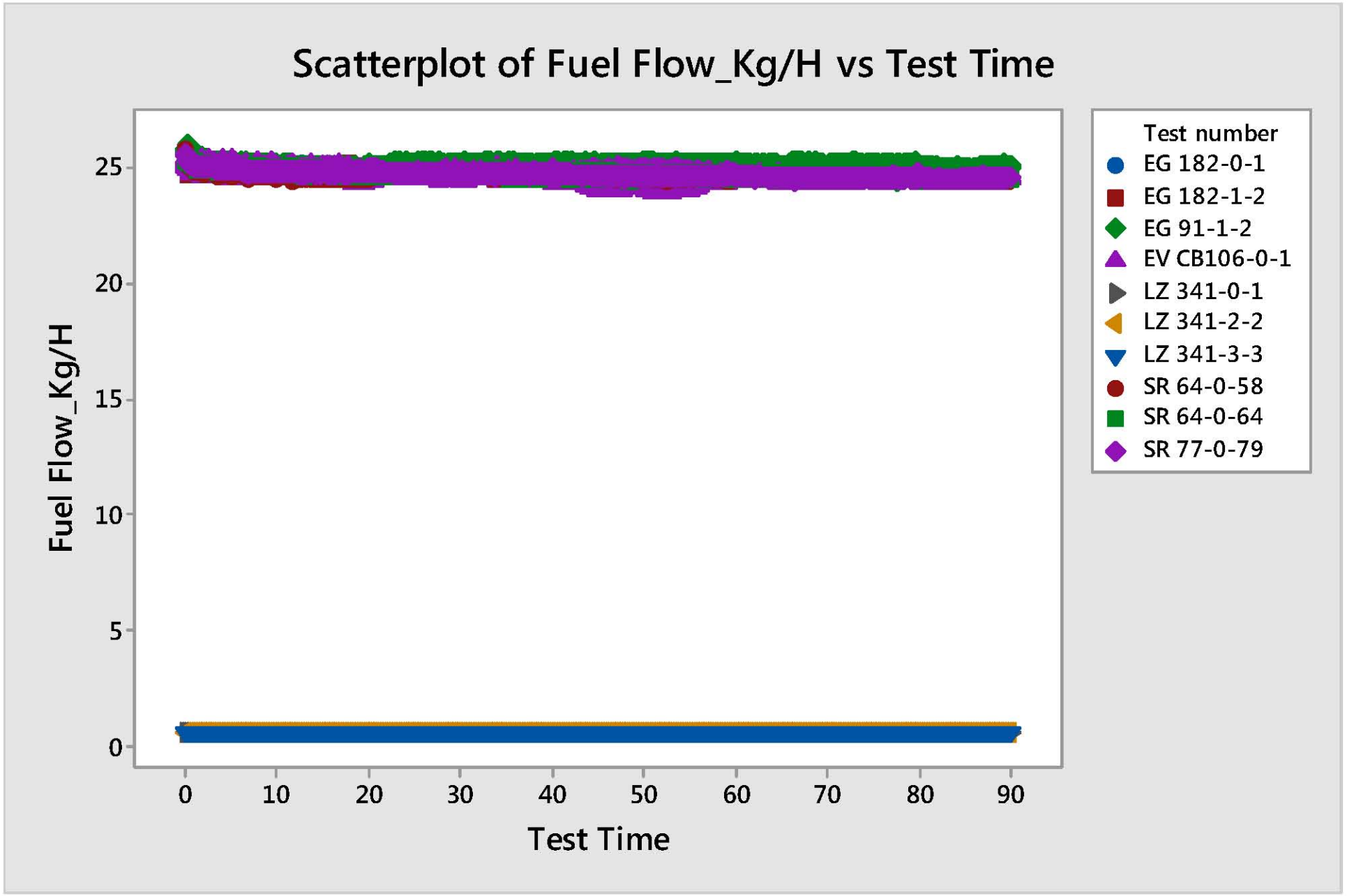

Scatterplot of Left Exhaust Temp_Deg C vs Test Time
Left Exhaust Temp_Deg C
820
800
780
760
740
720
700
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

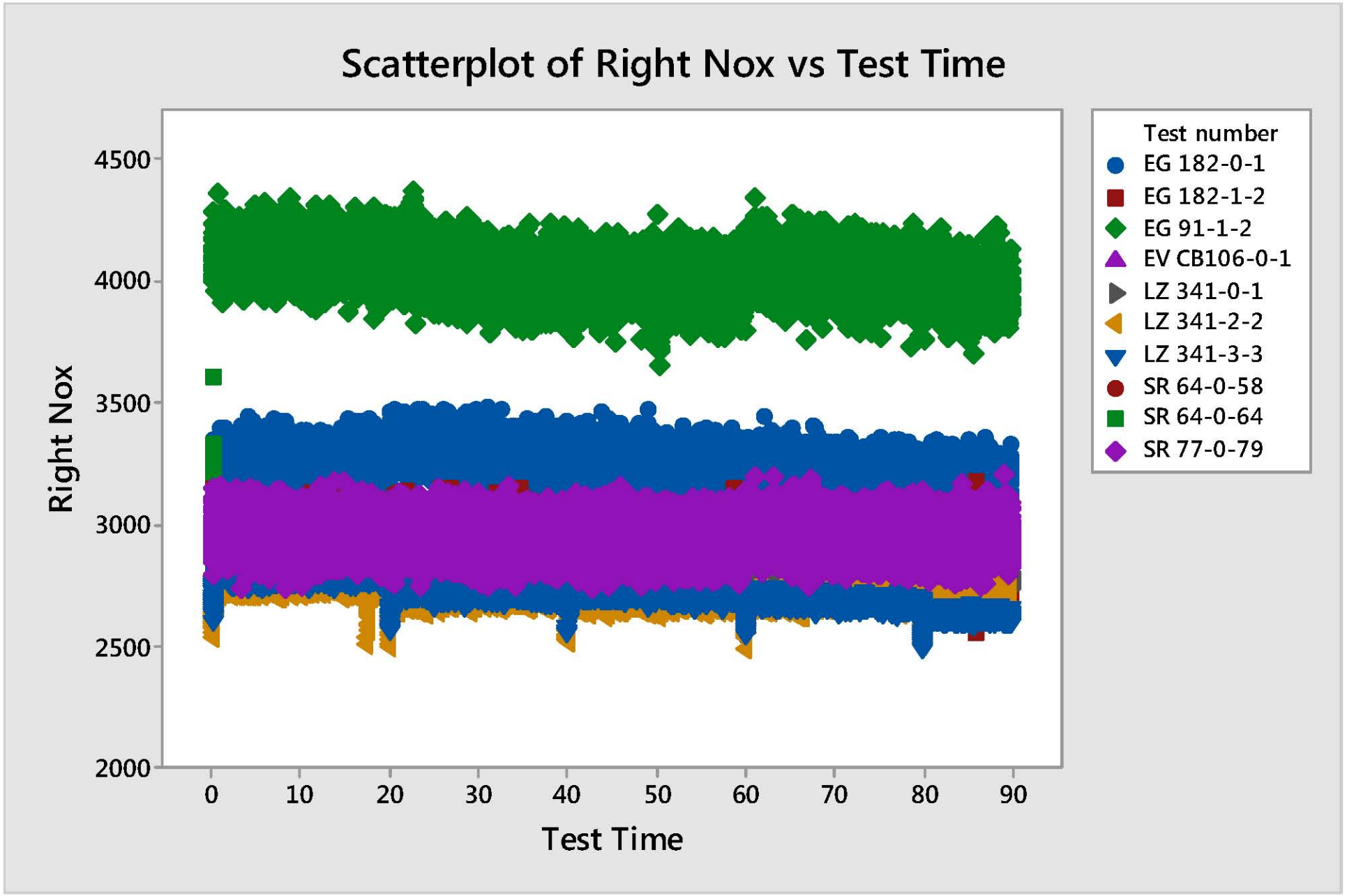

Scatterplot of Oil Gallery Pressure_kPa vs Test Time
Oil Gallery Pressure_kPa
500
400
300
200
100
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79

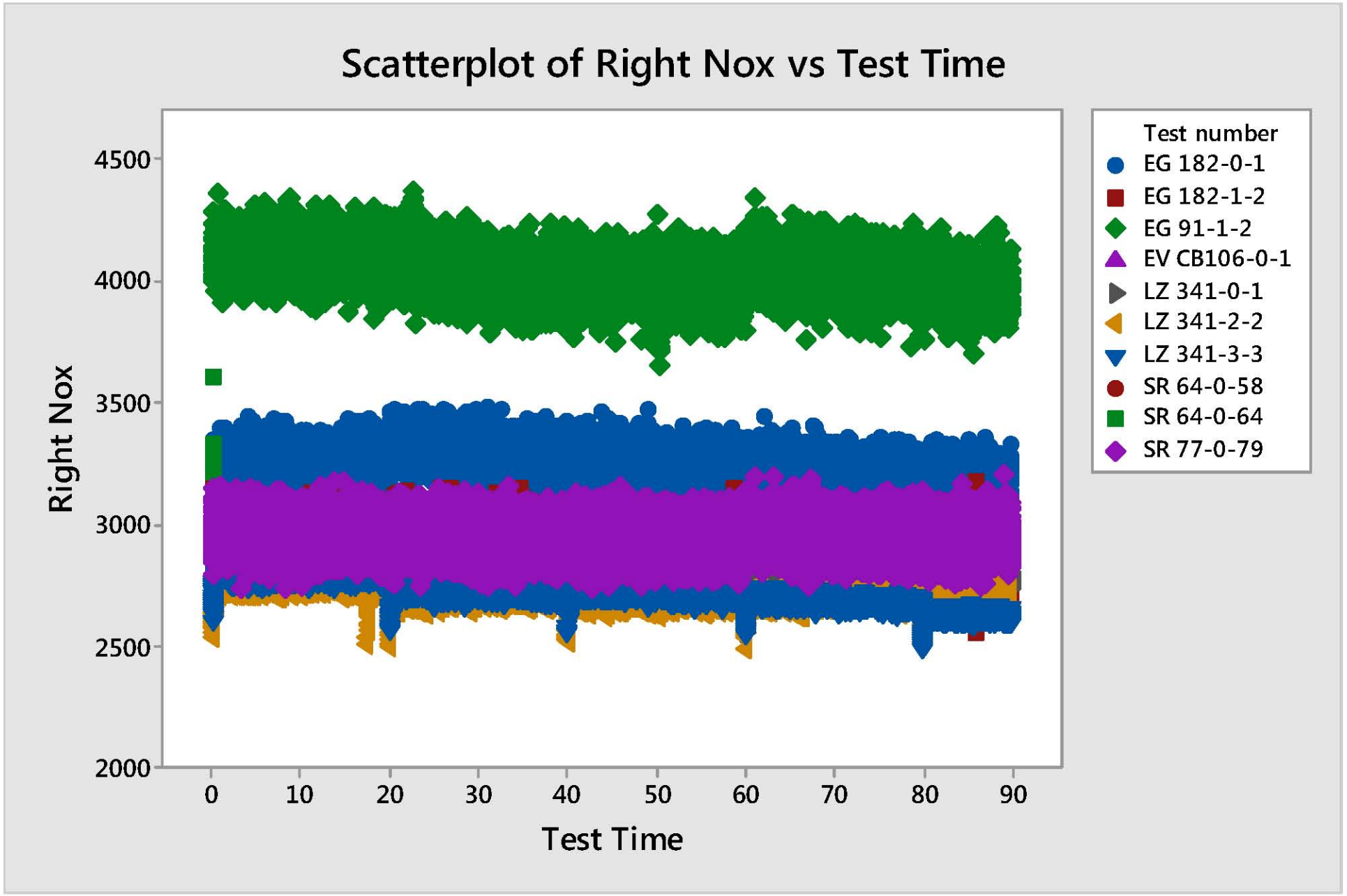

Scatterplot of Oil Pump Pressure_kPa vs Test Time
Oil Pump Pressure_kPa
700
600
500
400
300
200
100
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79


Scatterplot of Intake Manifold Pressure_kPaV vs Test Time
Intake Manifold Pressure_kPaV
0
10
20
30
40
50
60
70
80
90
Test Time
0
10
20
30
40
50
60
70
80
90
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79


Scatterplot of Crankcase Pressure_kPa vs Test Time
Crankcase Pressure_kPa
4
3
2
1
0
-1
-2
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79


Scatterplot of Fuel Flow_Kg/H vs Test Time
Fuel Flow_Kg/H
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79


Scatterplot of Right Nox vs Test Time
Right Nox
4500
4000
3500
3000
2500
2000
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79


Scatterplot of Right Nox vs Test Time
Right Nox
4500
4000
3500
3000
2500
2000
0
10
20
30
40
50
60
70
80
90
Test Time
Test number
EG 182-0-1
EG 182-1-2
EG 91-1-2
EV CB106-0-1
LZ 341-0-1
LZ 341-2-2
LZ 341-3-3
SR 64-0-58
SR 64-0-64
SR 77-0-79