CATERPILLAR 1K TEST: PRELIMINARY ANALYSIS OF POTENTIAL SHIFT OVER TIME

August 25th, 2015

September 21st, 2015 (Slides 23 to 32 were added)

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Performance you can rely on.

Outline

- Data
- Plots by parameter
- Data Analysis by parameter
- Main remarks

Data overview:

- Chart = Yes/ No

	CHART	N Rows
1	N	457
2	Y	647

Plots presented next: Target 809-1 and 811-1: 08 1993 (marked as “T”)

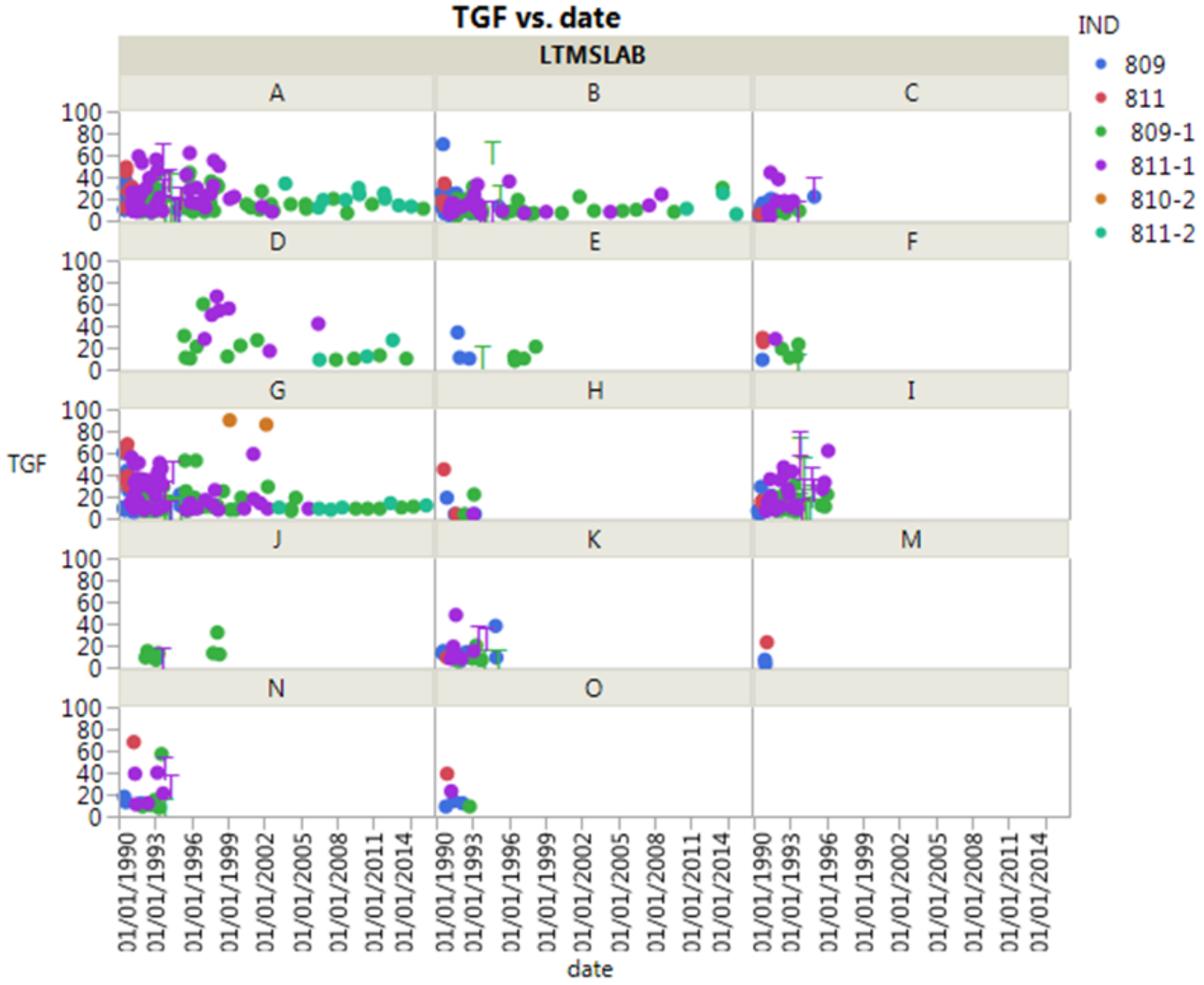
Labs running more recently: A, B, D, G

Labs without target tests: D, H, M, O

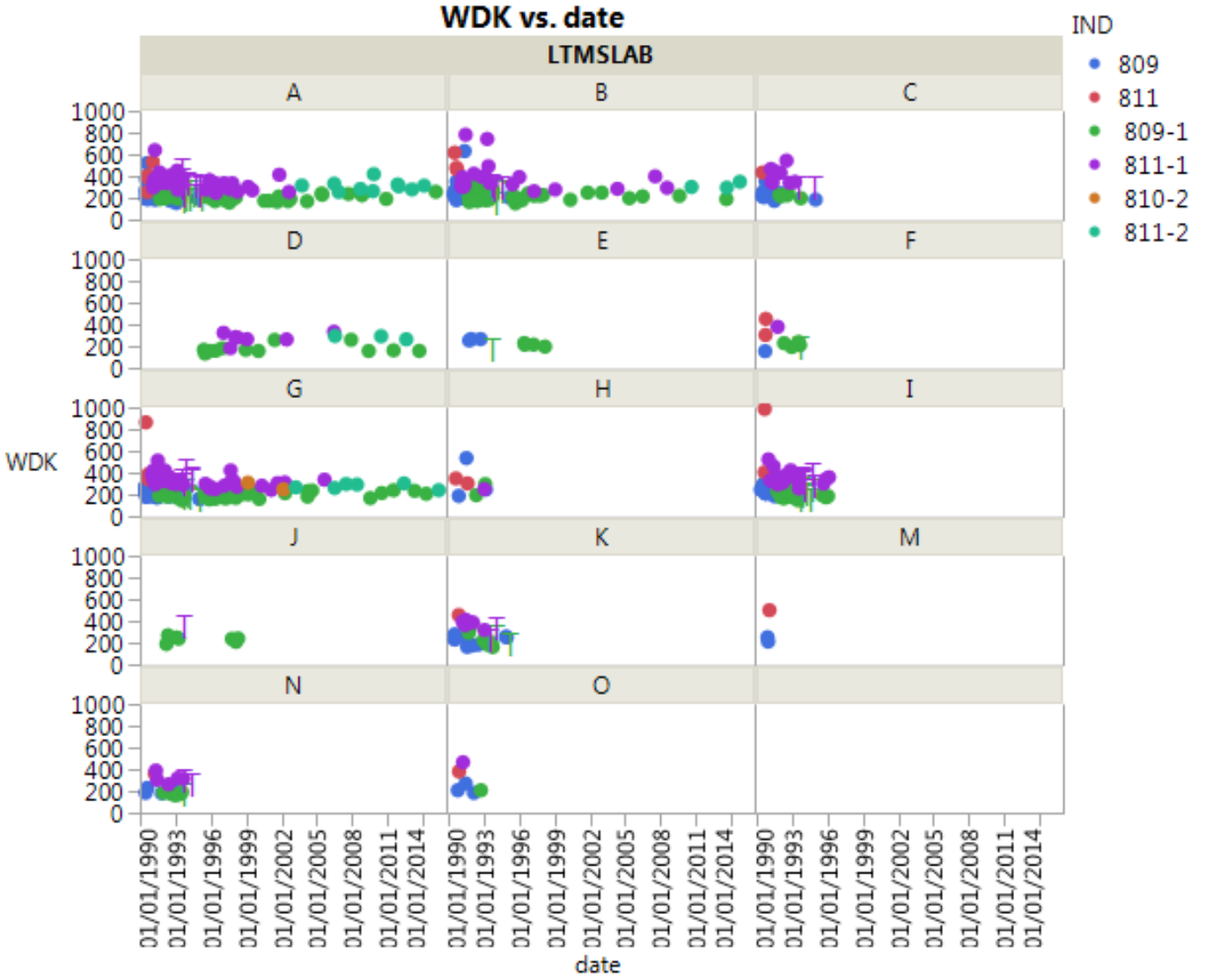
2	1Y3555	1
3	1Y3555G	1
4	1Y-35	1
5	1Y355	79
6	1Y3555	63
7	1Y35555	1
8	1Y3555G	27
9	1Y3555-G	1
10	1Y3556	1
11	1Y355G	2

All liners coded by one of the names on the list were assumed to be1Y3555

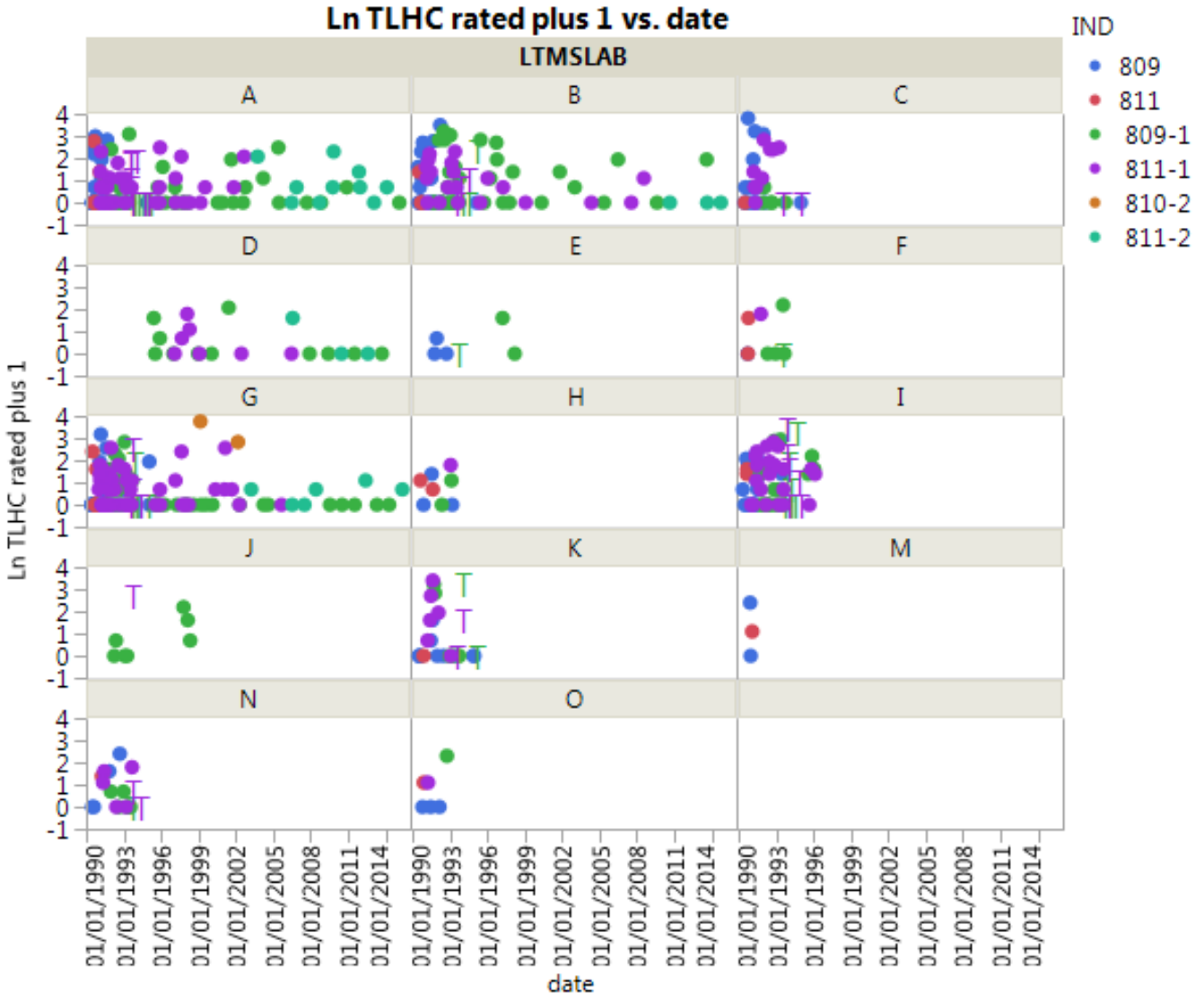
TGF: Chart = Yes; including 809/811 and re-blends



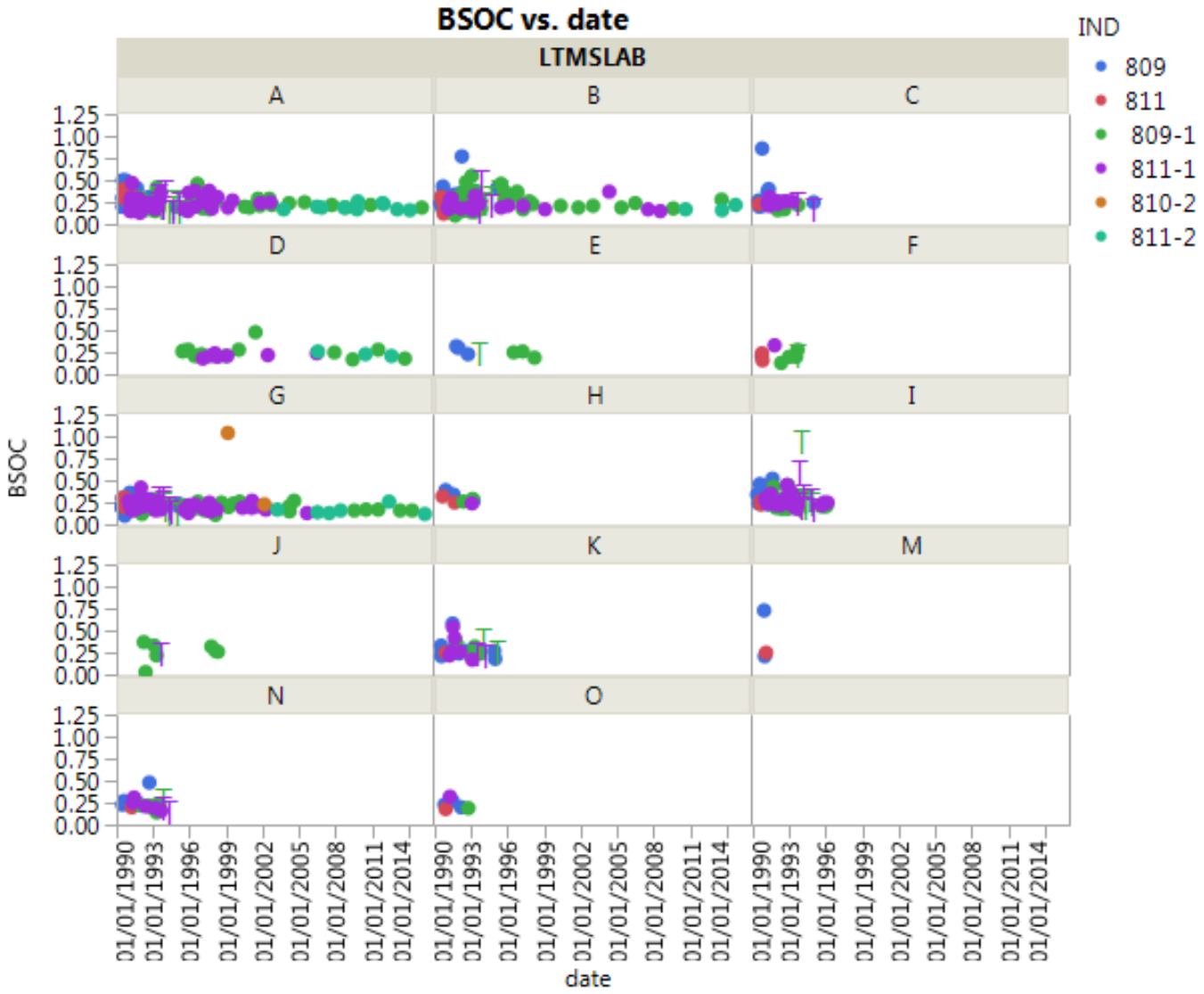
Data (cont.)
WDK: Chart = Yes; including 809/811 and re-blends



Data (cont.): Top Land Heavy Carbon transformed
Chart = Yes; including 809/811 and re-blends



Data (cont.)
Oil Consumption: Chart = Yes; including 809/811 and re-blends



Defining the working data set for modeling

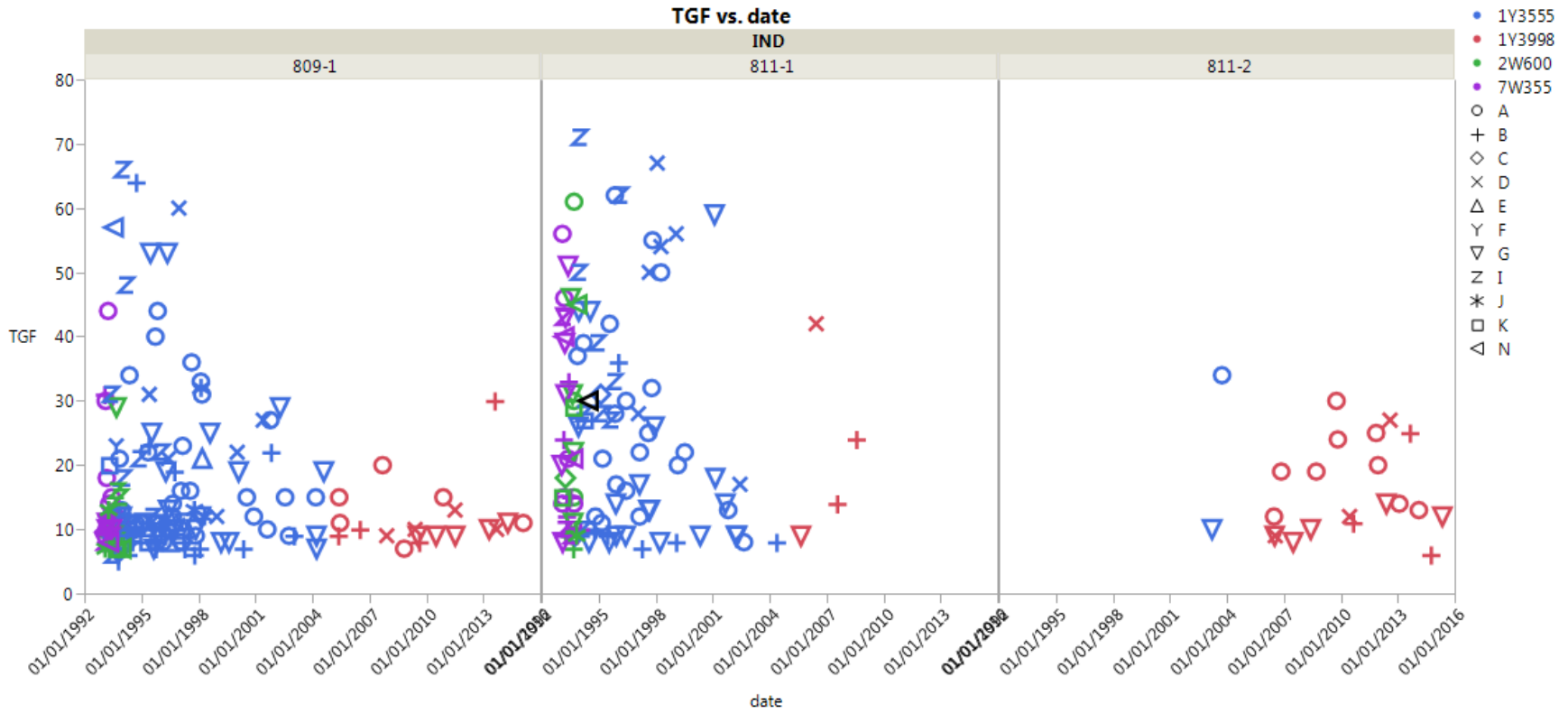
- 1K started in 1990; initially lot of tests were being assigned chart = N
- Liners:
  - 1Y702 (at start of the test)
  - 7W355 (introduced in 1991)
  - 2W600 (introduced in 1992)
  - 1Y3555 (introduced in 1993)
  - 1Y3998 (introduced in 2005)
- 809-1 and 811-1 Targets, collected between 08/31/1993 to 05/20/1995, have been defined with multiple liners: 30 tests for each oil. One liner is missing.

		LINER	Liner target	N Rows
T	1	7W355	Target	3
T	2	2W600	Target	10
T	3	1Y3555	Target	46
T	4		Target	1

- Working data:
  - Started with 301 tests from 1993 forward and chart = Yes. This subset included tests with liners 7W355 and 2W600 and I prefer to focus on the latest liners: 1Y3555 and 1Y3998. By the way, the conclusions are the same using 301 or 223 tests.
  - Went down to 223, after deciding to use Target tests with whatever liners they had plus all tests after last target test ran (which corresponds to all tests after 06/02/1995).
  - I created a new column called Liner/Target with levels: Target, 1Y3555 and 1Y3998

TGF vs. date by Oil and Lab

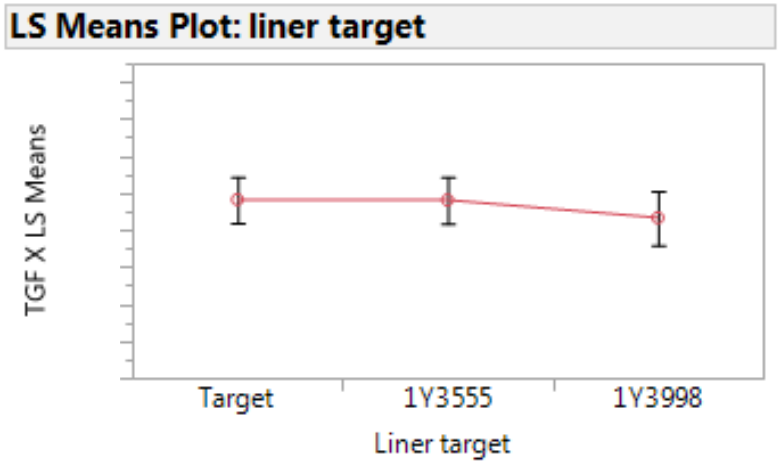
n=301*



*includes liners 7W355, 2W600 and beginning of 1Y3555 before 809-1 and 811-1 targets were set

TGF transformed to achieve constant variance n=223

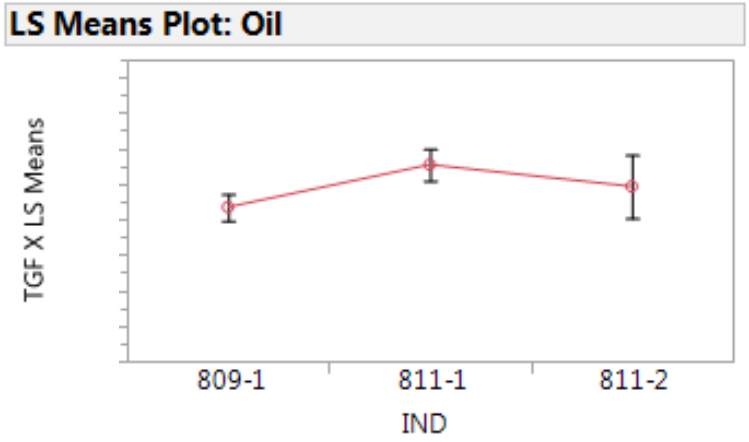
Model 1



Model 1: Lab, Oil, Liner target*

No evidence that Target, 1Y3555 and 1Y3998 differ

Model 1: similar estimates for model 2



Model 2: Lab, Oil, Date (normalized) n=223

The coefficient for Date is negative, (-0.880067), not statistically significant (t ratio=-1.27)

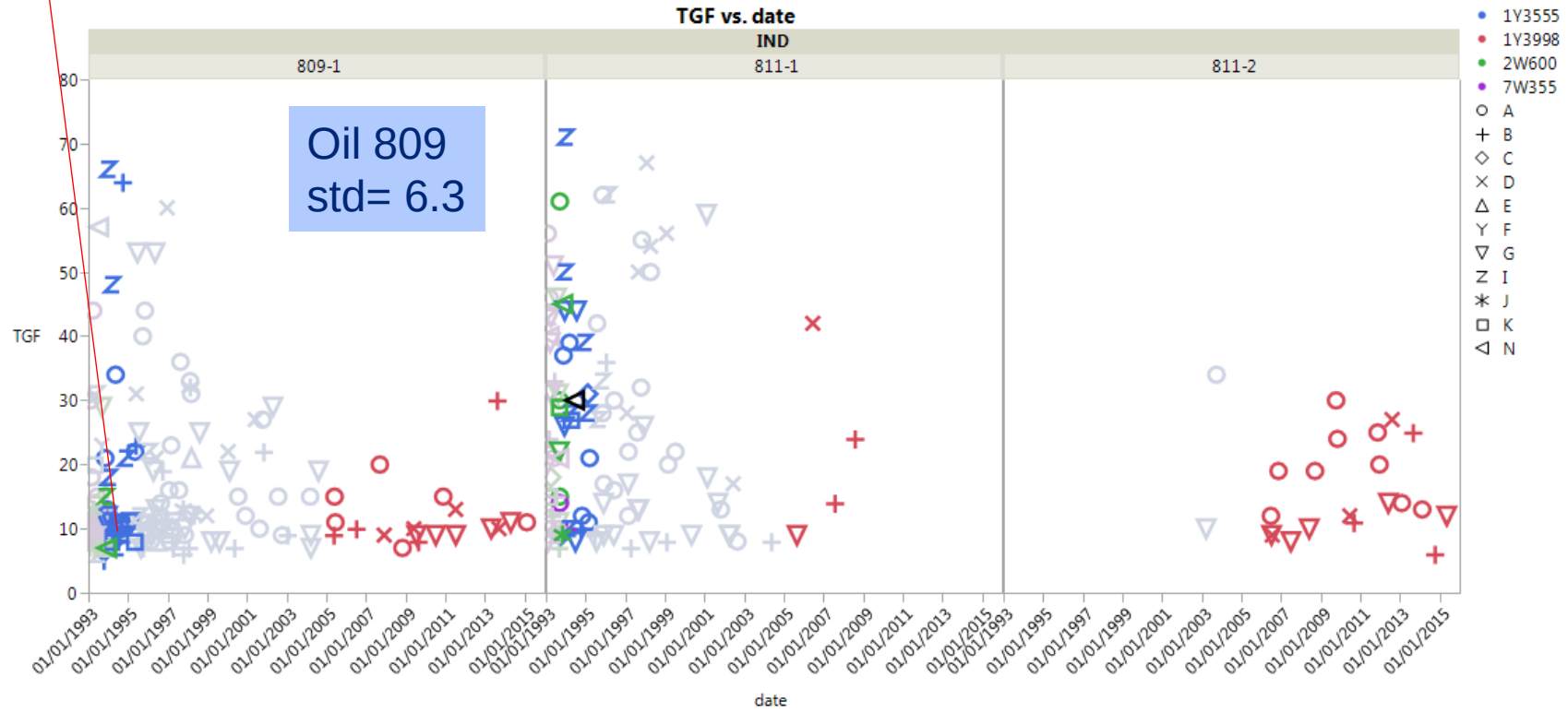
TGF: looking at variability

Pooled standard deviation for tests with most recent liner 1Y3998

At Target, 50% of the data is below 11

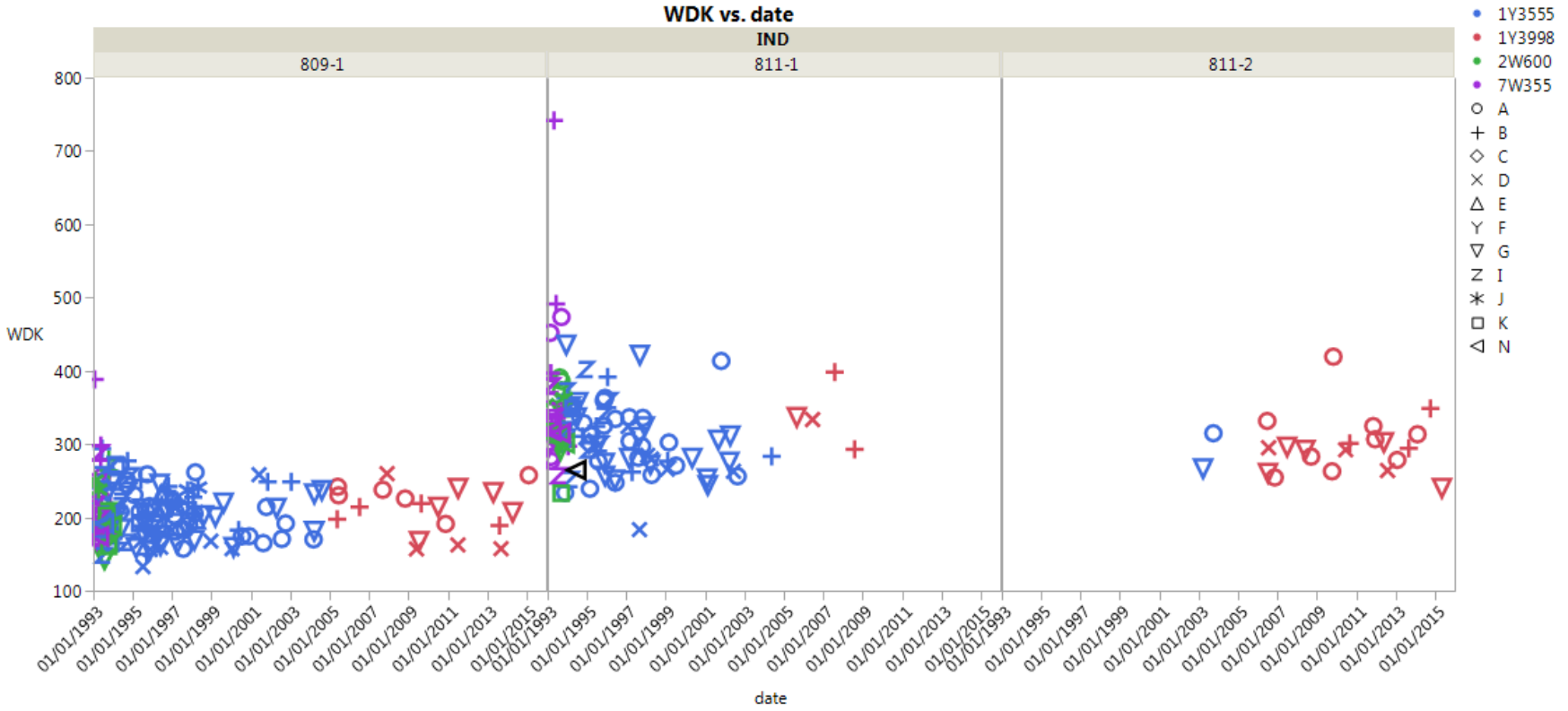
TGF						incl. 811-1
Oil	Liner	N	Mean	Std	pooled std	pooled std
809-1	1Y3998	19	11.89474	5.332237	6.317585	7.268923
809-1	Target	30	17.46667	15.6728		
811-1	1Y3998	4	22.25	14.5688		
811-1	Target	30	27.33333	16.57654		
811-2	1Y3998	20	15.95	7.126489		

Std changed over time



WDK vs. date by Oil and Lab

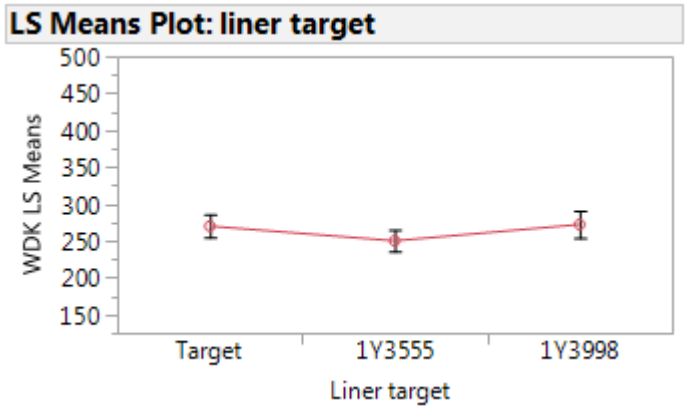
n=301*



*includes liners 7W355, 2W600 and beginning of 1Y3555 before 809-1 and 811-1 targets were set

LN WDK: transformed to achieve constant variance n=223

Model 1

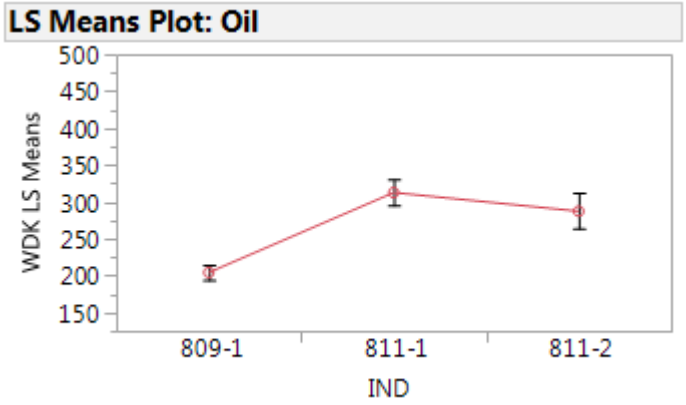


Liner Target			Least Sq Mean
1Y3998	A		272.2
Target	A		270
1Y3555		B	250.1

Model 1: Lab, Oil, Liner target*
Note that 17328, high test from Lab B - liner 7W355 is not part of the target and not included in this subset.

No evidence that Target and 1Y3998 differ

Model 1: similar estimates for model 2



Oil			Least Sq Mean
811-1	A		312.7
811-2	A		287.5
809-1		B	204.4

Model 2: Lab, Oil, Date (normalized)

The coefficient for Date is positive (+0.0097401), not statistically significant (t ratio=+0.73)

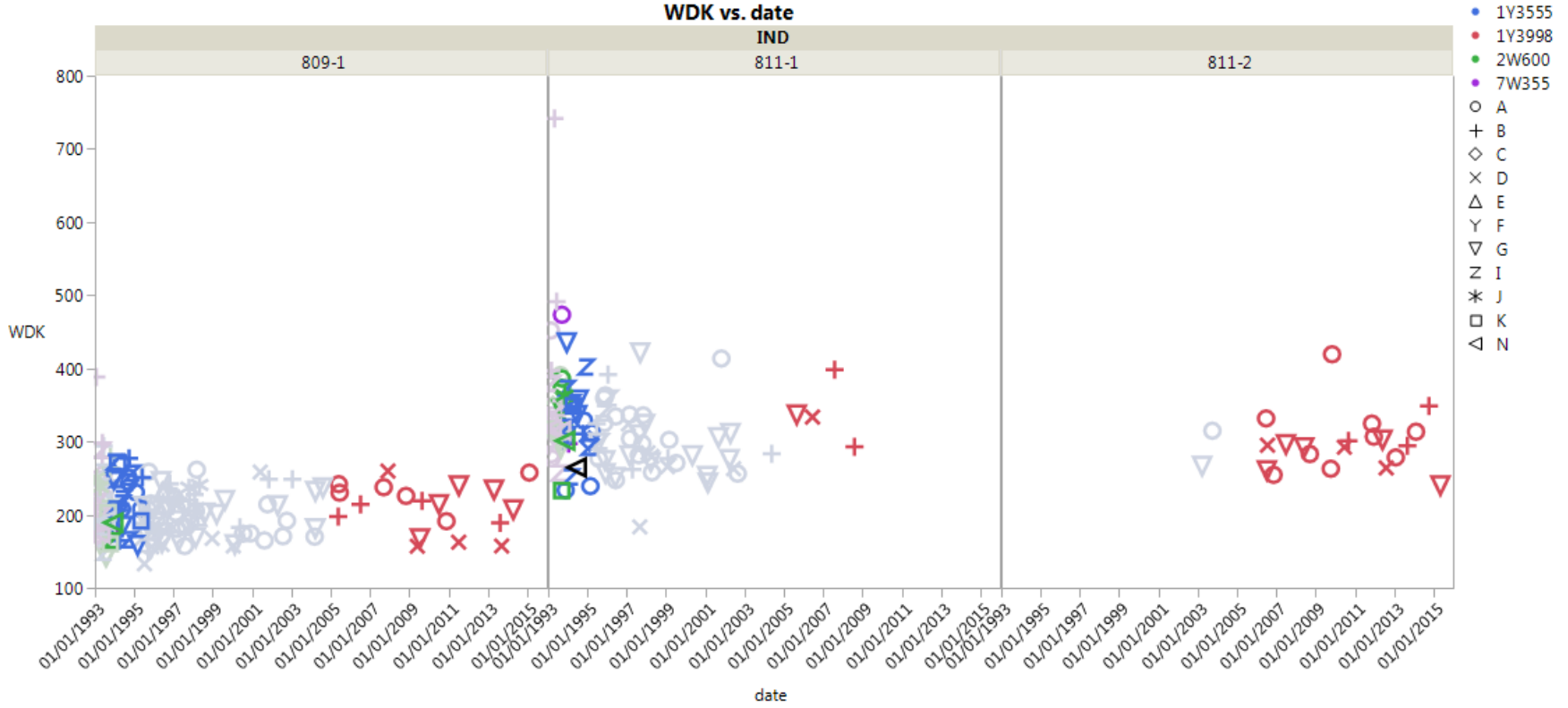
* Defined in slide 8

WDK: looking at variability

Pooled standard deviation for tests with most recent liner 1Y3998

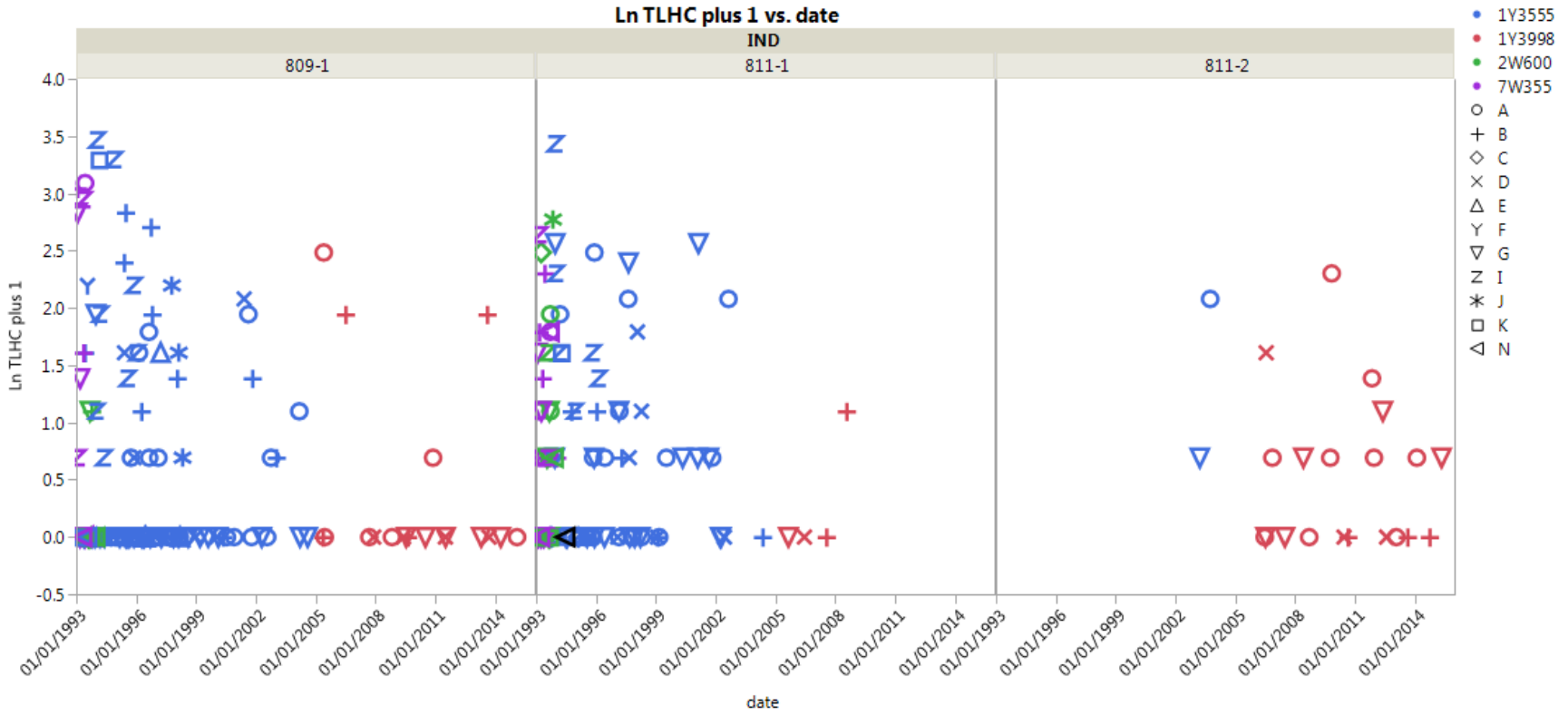
WDK						incl. 811-1
IND	Liner target	N	Mean	Std	pooled std	pooled std
809-1	Target	30	216.4	35.64721	36.25158	36.84602
809-1	1Y3998	19	211.0421	32.78203		
811-1	Target	30	327.7433	55.91403		
811-1	1Y3998	4	340.825	43.51478		
811-2	1Y3998	20	298.36	39.25668		

Not suggesting change in std, but thought you would ask questions about pooled std



LN (TLHC +1) vs. date by Oil and Lab
Non critical

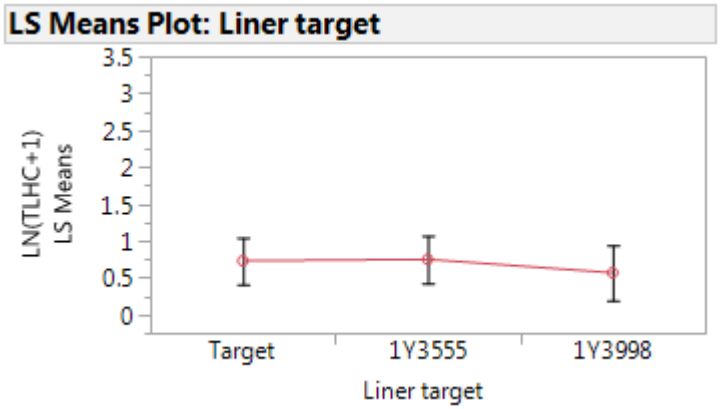
n=301*



*includes liners 7W355, 2W600 and beginning of 1Y3555 before 809-1 and 811-1 targets were set

LN (TLHC+1): n=223

Model 1

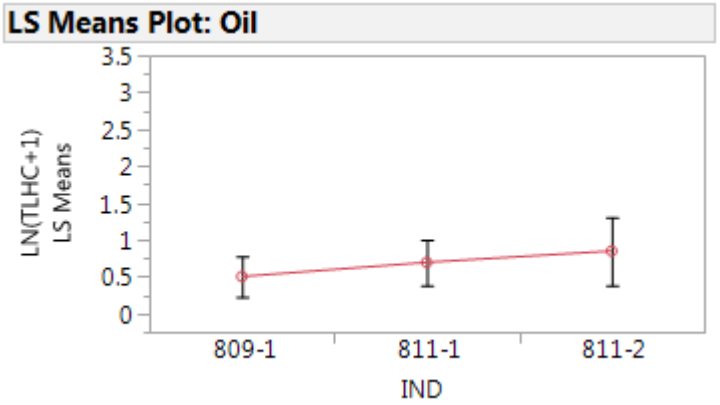


Level		Least Sq Mean
1Y3555	A	0.74969936
Target	A	0.72933900
1Y3998	A	0.56808021

Model 1: Lab, Oil, Liner/Target*

No evidence that Target, 1Y3555 and 1Y3998 differ

Model 1: similar estimates for model 2



Level		Least Sq Mean
811-2	A	0.84911024
811-1	A	0.69452440
809-1	A	0.50348394

Model 2: Lab, Oil, Date
(normalized)

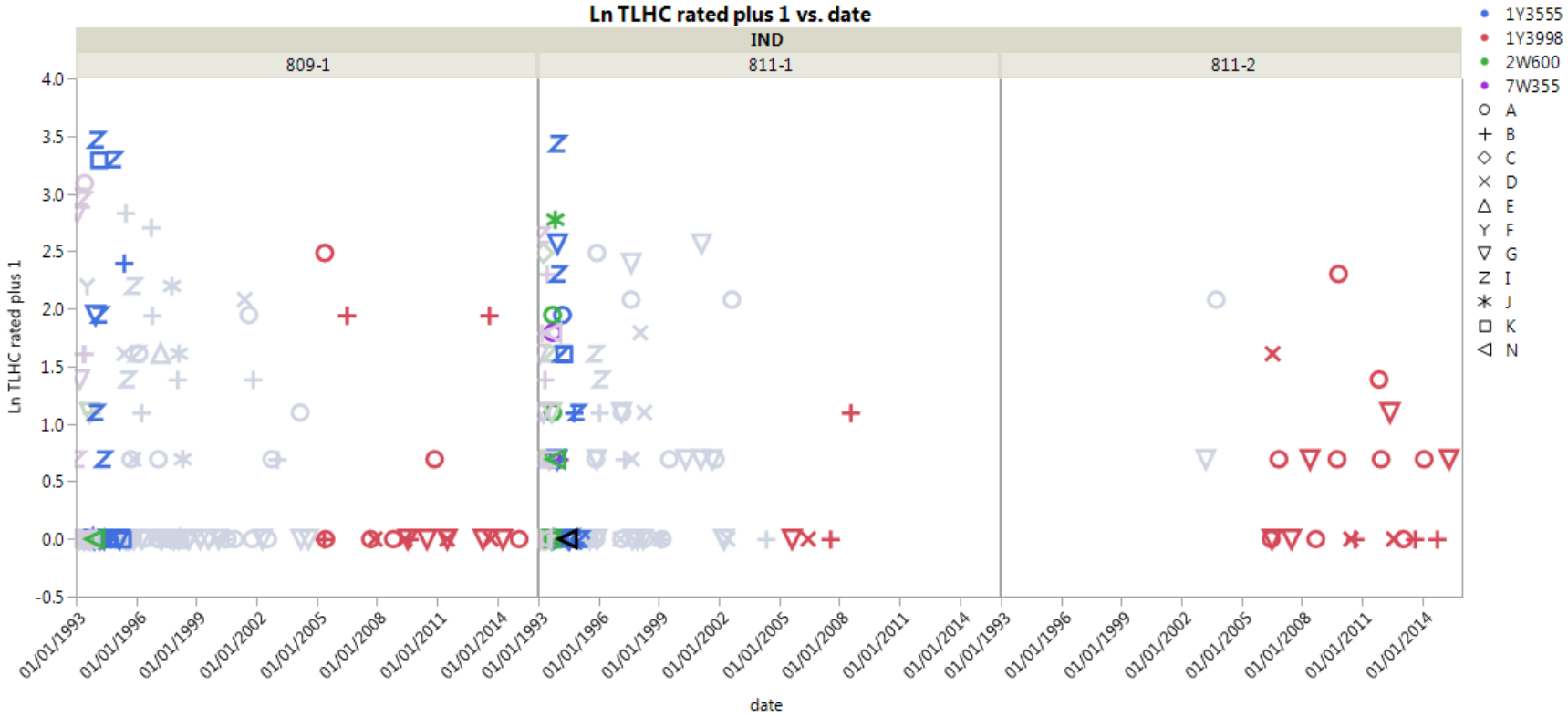
The coefficient for Date is negative, (-0.059892), not statistically significant (t ratio= -0.85)

* Defined in slide 8

LN (TLHC+1): looking at variability

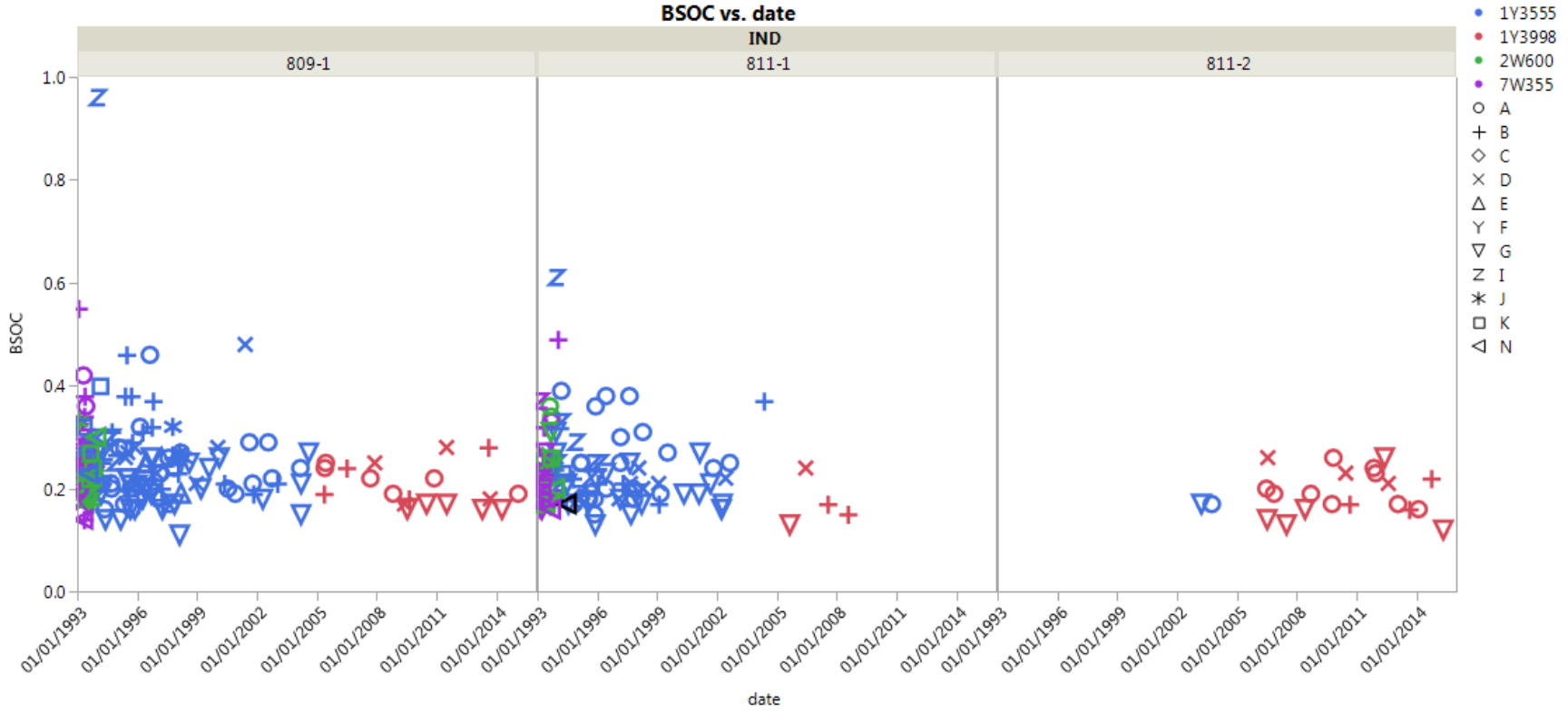
Pooled standard deviation for tests with most recent liner 1Y3998

						incl. 811-1
Oil	Liner target	N	Mean	Std	pooled std	pooled std
809-1	Target	30	0.604629	1.141378	0.733928	0.721721
809-1	1Y3998	19	0.372099	0.802692		
811-1	Target	30	0.868166	1.021422		
811-1	1Y3998	4	0.274653	0.549306		
811-2	1Y3998	20	0.527791	0.662229		



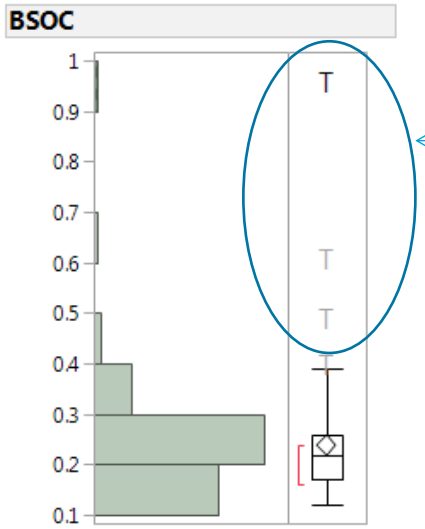
Oil Consumption: vs. date by Oil and Lab
Non critical

n=301



The analysis indicated that there may be a trend going down, likely associated with liner 1Y3998. Further analysis will be done and a correction will be proposed

Oil consumption: more details

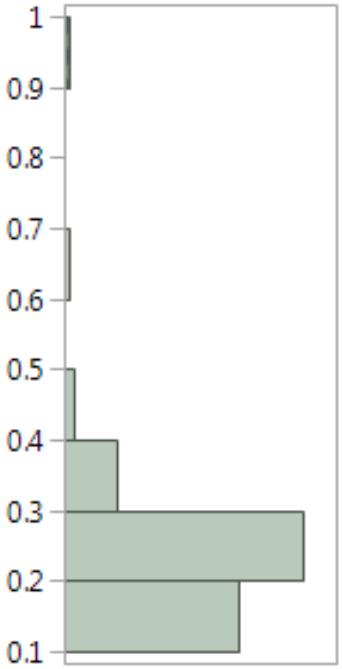


Quantiles		
100.0%	maximum	0.96
99.5%		0.96
97.5%		0.538
90.0%		0.31
75.0%	quartile	0.26
50.0%	median	0.22
25.0%	quartile	0.17
10.0%		0.16
2.5%		0.13
0.5%		0.12
0.0%	minimum	0.12

Summary Statistics	
Mean	0.2383495
Std Dev	0.103138
Std Err Mean	0.0101625
Upper 95% Mean	0.2585068
Lower 95% Mean	0.2181923
N	103

Part of the Target, above the 0.5 g/kWh

Zoom of the plot



LTMS excerpt for 1K

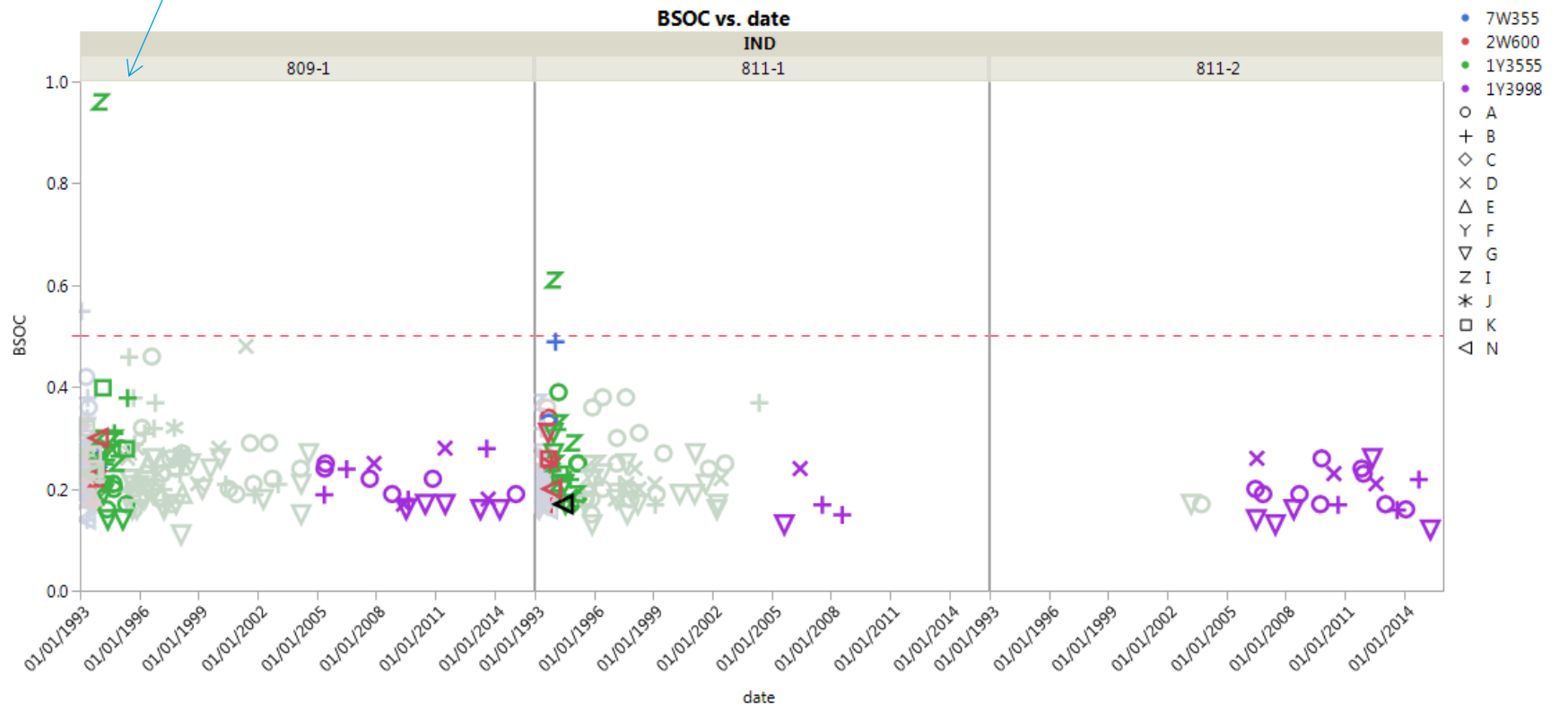
- Exceed Shewhart test stand chart limit for severity (all parameters except Average Oil Consumption)
  - Conduct an additional calibration test.
- Exceed 0.5 g/kWh Average Oil Consumption
  - Conduct an additional calibration test.

Oil Consumption: Mean and standard deviation by oil/liner combination

excludes 18515 from lab I

BSOC						incl. 811-1
IND	Liner target	N= 222	Mean	Std	pooled std	pooled std
809-1	Target	29	0.245862	0.063948	0.04234	0.04278
809-1	1Y3998	19	0.205263	0.040739		
811-1	Target	30	0.266667	0.09693		
811-1	1Y3998	4	0.1725	0.047871		
811-2	1Y3998	20	0.1935	0.043803		

BSOC					
Oil	Liner target	N= 223	Mean	Std	pooled
809-1	Target	30	0.269667	0.144735	0.042
809-1	1Y3998	19	0.205263	0.040739	
811-1	Target	30	0.266667	0.09693	
811-1	1Y3998	4	0.1725	0.047871	
811-2	1Y3998	20	0.1935	0.043803	



BSOC target clarification

- It seems that for Target test 15233, the BSOC value used for calculating the target is 0.22 when the ltms published value is 0.26

Lab	Testkey	VALID	OIL	REPORT	TGF	WDK	TLHC	BSOC	BSOC ltms	diff BSOC
E	15233	AC	809-1	931115	12	190.2	0	0.22	0.26	0.04

- The table below reflects this difference:
  - Target mean is 0.268 and std = 0.145
  - My calculations generate a mean = 0.270 and std = 0.145

BSOC						incl. 811-1
Oil	Liner target	N= 223	Mean	Std	pooled std	pooled std
809-1	Target	30	0.269667	0.144735	0.04234	0.04278
809-1	1Y3998	19	0.205263	0.040739		
811-1	Target	30	0.266667	0.09693		
811-1	1Y3998	4	0.1725	0.047871		
811-2	1Y3998	20	0.1935	0.043803		

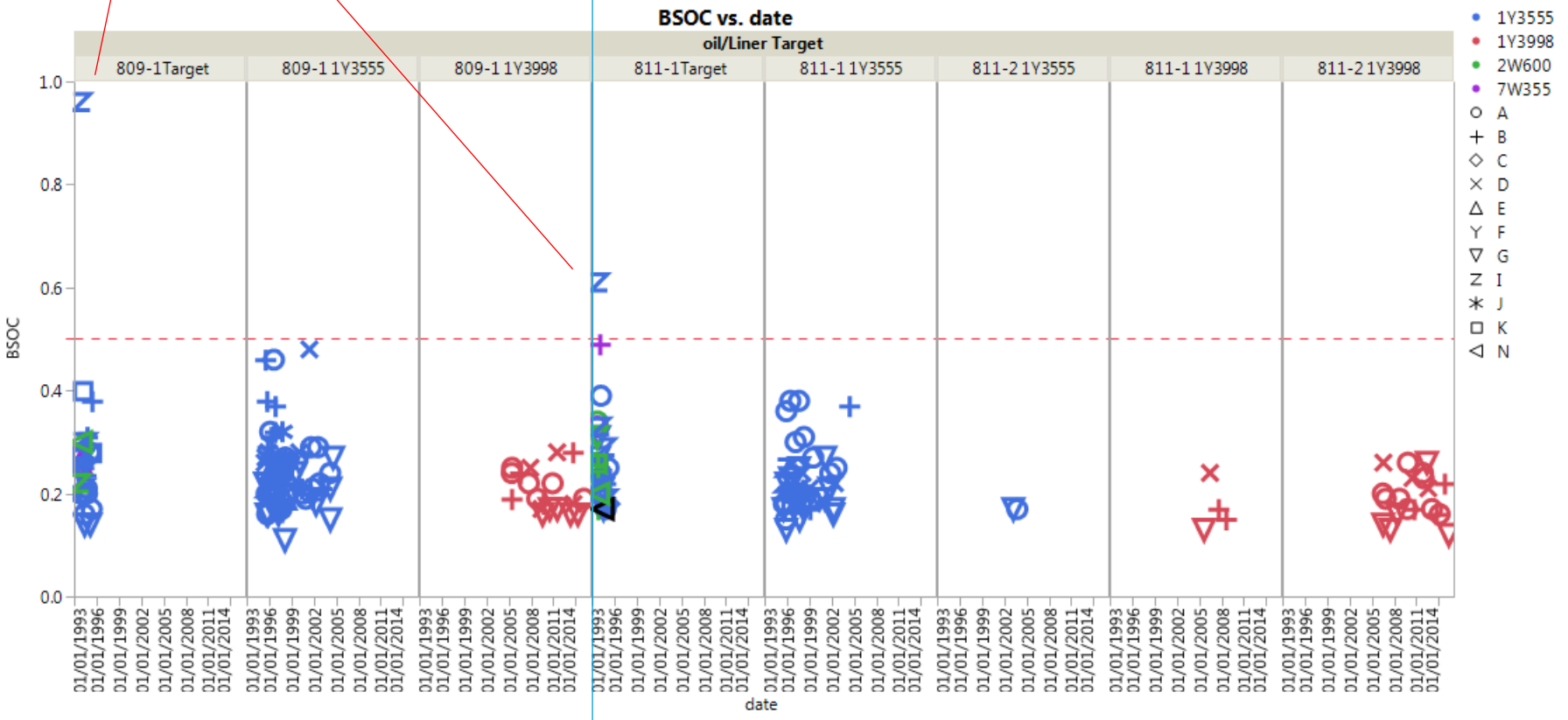
Main remarks

- SP may want to review the standard deviation for TGF. Standard deviations seem to have gone back to levels seen before for 809. The standard deviations for WDK and Log (TLHC+1) did not change as much as TGF's.
- I will be happy to propose a correction factor for Oil consumption – non critical, if necessary
- Please, contact me if you have any questions or want to see more details about the analysis. I did not include all the details to keep the number of slides down.

BSOC: n=223

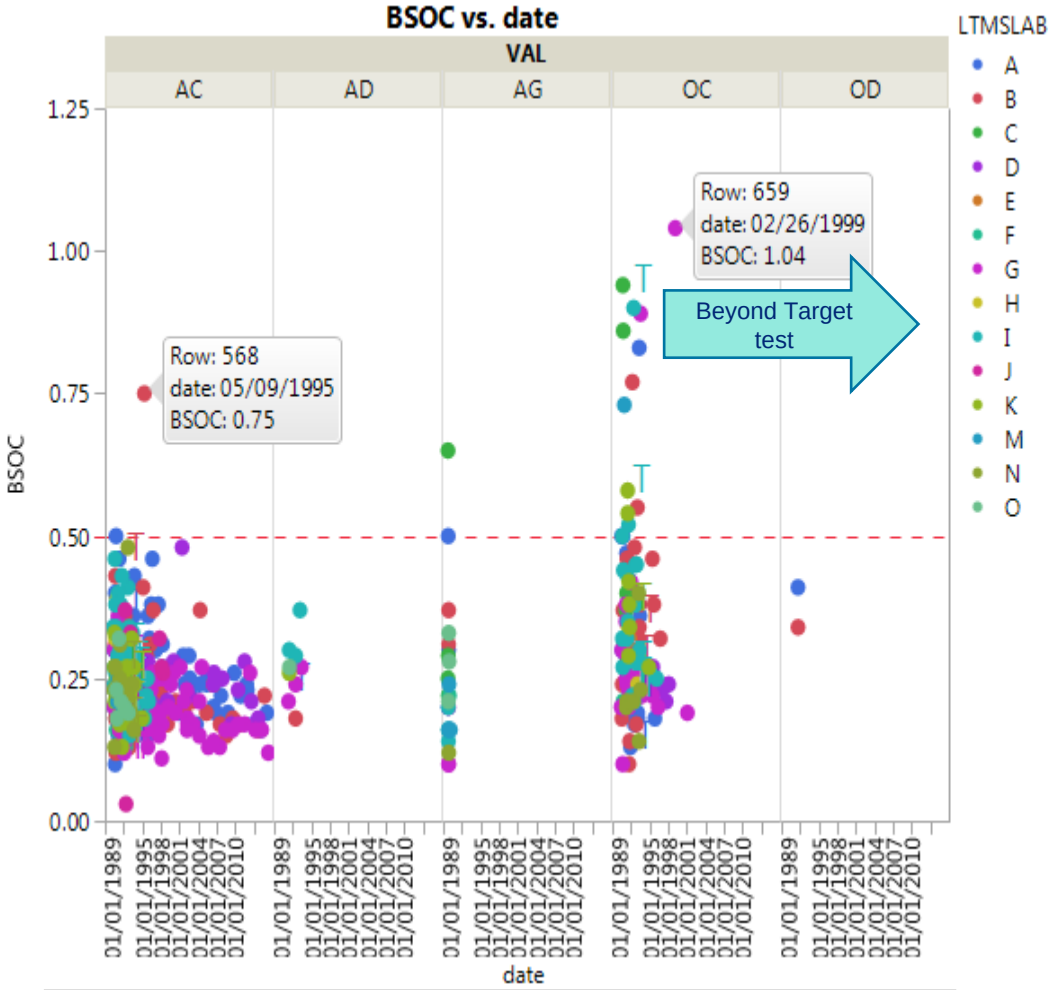
Both tests from Lab I:
01/1994; 12/1993

811



809

Since target time, test has not generated these high fliers



Validity Designation	Definition	Test Designation	Definition
A	acceptable for intended purpose	C	calibration test
O	operationally valid, does not meet statistical criteria	D	double blind, for calibration
R	operationally invalid, reported as valid by lab, not in stats	E	fuel run also for calibration
X	aborted, not in stats	F	fuel run for fuel approval only
L	operationally invalid as determined by lab, not in stats	G	industry donated test, not for calibration
N	acceptable for intended purpose, and not in stats	H	hardware run also for calibration
M	not acceptable for intended purpose, and not in stats	I	hardware run for hardware approval only
P	pending (not resolved), not in stats	N	non-blind, information
T	Temporary	O	calibration approval by sources other than TMC
		S	discrimination test, not for calibration

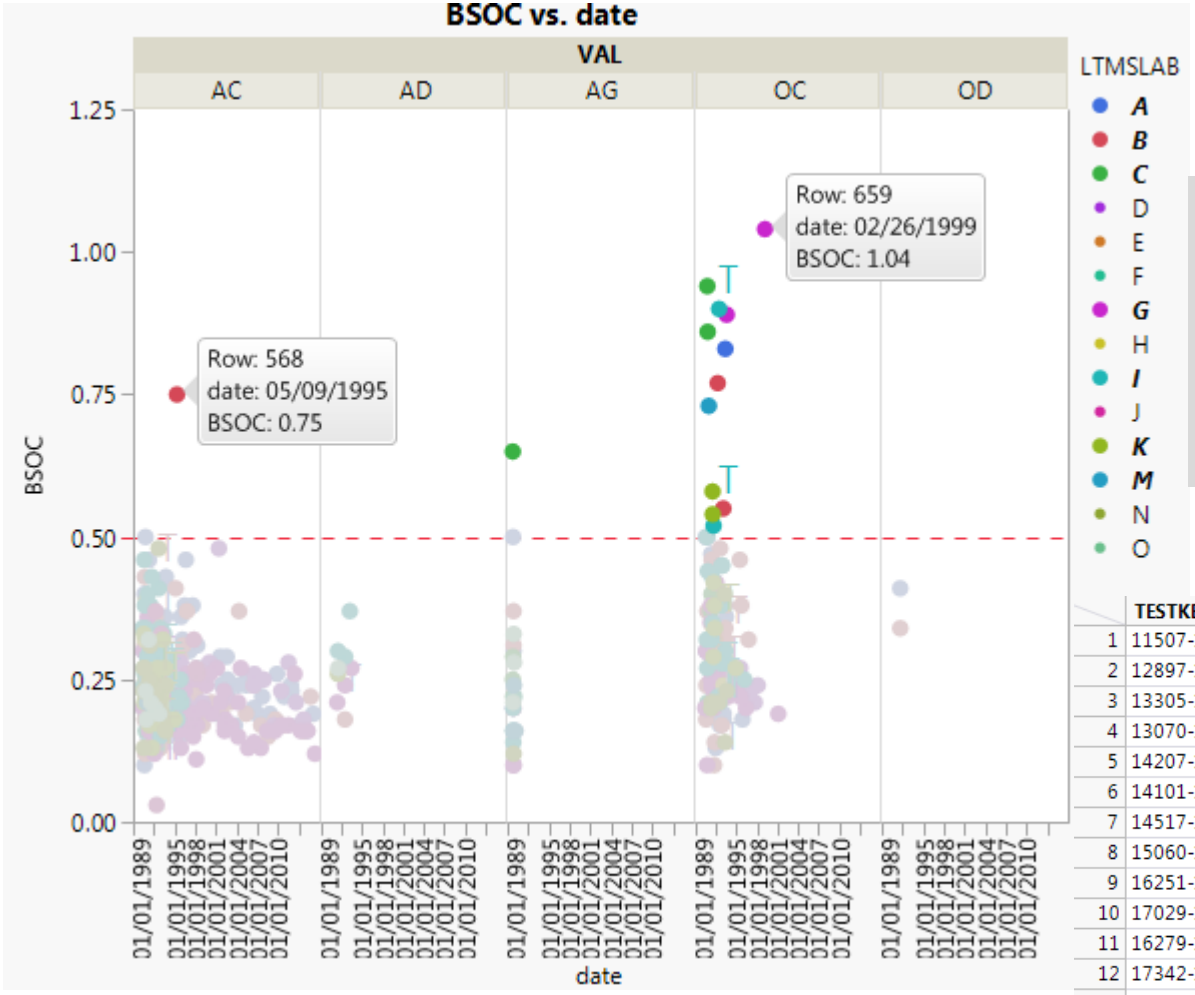
- Even considering all “A” and “O” tests (not just chart=yes), since the target test in 01/94, there were only two tests (refer to labeled tests in the plot) that were higher than 0.48 g/kWh.
- One test ran in 1995 and the other 1999, both tests with oil 810-2.
- There are only two 810-2 chart =yes in the file and 810-2 has not been tested since 2002.

Note that,

1Y3555: introduced in 1993
1Y3998: introduced in 2005

- Even before the new liner was introduced, fliers had not been observed for a long time.

If you ask me to identify these tests



Only two (in blue) are part of the target set. The other two are early liners. The other tests are older oils.

	TESTKEY	LTMSLAB	LTMSAPP	VAL	CHART	IND	LTMSDATE
1	11507-1K	C	2	AG	N	810	19891003
2	12897-1K	C	2	OC	N	810	19900912
3	13305-1K	C	2	OC	Y	809	19901004
4	13070-1K	M	1	OC	Y	809	19901204
5	14207-1K	K	2	OC	Y	809	19910620
6	14101-1K	K	1	OC	Y	811-1	19910627
7	14517-1K	I	7	OC	Y	809	19910813
8	15060-1K	B	10	OC	Y	809	19920323
9	16251-1K	I	9	OC	N	810-1	19920606
10	17029-1K	B	11	OC	Y	809-1	19930115
11	16279-1K	A	6	OC	N	810-1	19930504
12	17342-1K	G	2	OC	N	810-1	19930720
13	18401-1K	I	7	OC	Y	811-1	19931219
14	18515-1K	I	5	OC	Y	809-1	19940115
15	19670-1K	B	11	AC	N	810-2	19950509
16	19632-1K	G	6	OC	Y	810-2	19990226

BSOC: Corrections and new standard deviations

All this to give you a reason to also consider Table 2 on the right.

Table 1 refers to all the data we have been considering after the target has been set.

Table 2 excludes one test from 809-1 target set and one test from 811-1, both from lab I.

In case you ask me about the validity codes for the data in Table 1:

	VAL	N Rows
1	AC	197
2	AD	1
3	LC	1
4	OC	24

Table 1 n=223

oil/Liner Target	# of tests	Mean(BSOC)	Std Dev(BSOC)
809-1Target	30	0.27	0.1447
809-1 1Y3555	73	0.24	0.0689
809-1 1Y3998	19	0.205	0.0407
811-1Target	30	0.267	0.0969
811-1 1Y3555	45	0.223	0.061
811-2 1Y3555	2	0.17	0
811-1 1Y3998	4	0.173	0.0479
811-2 1Y3998	20	0.194	0.0438
	809-1 diff	0.065	0.104
	811-1 diff	0.073	0.0531

Table 2 n=221

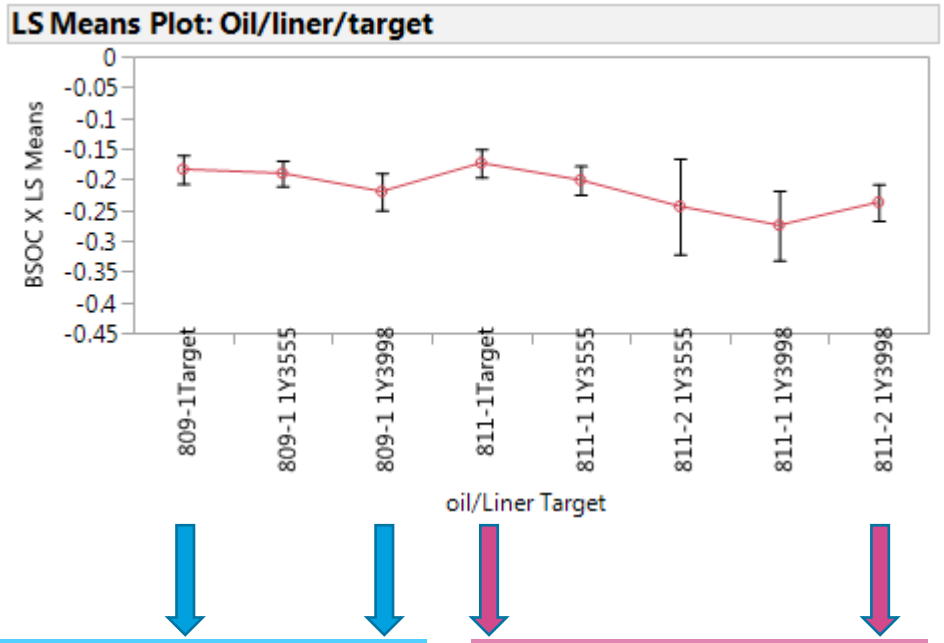
oil/Liner Target	# of tests	Mean(BSOC)	Std Dev(BSOC)
809-1Target	29	0.246	0.0639
809-1 1Y3555	73	0.24	0.0689
809-1 1Y3998	19	0.205	0.0407
811-1Target	29	0.255	0.0733
811-1 1Y3555	45	0.223	0.061
811-2 1Y3555	2	0.17	0
811-1 1Y3998	4	0.173	0.0479
811-2 1Y3998	20	0.194	0.0438
	809-1 diff	0.041	0.0232
	811-1 diff	0.061	0.0295

Potential corrections: there are many possibilities… I listed a few below

- Option 1: simple mean & standard deviation
  - Using Table 1: take differences between average 809-1/811-1 Target and current liner
  - Update standard deviation (adopt std from new liner?)
- Option 2: simple mean & standard deviation
  - Using Table 2: take differences between average 809-1/811-1 Target and current liner
  - Update standard deviation (adopt std from new liner?)
- Option 3: simple mean & standard deviation
  - Take difference 809-1 Target and current liner using Table 2 and take difference 811-1 Target and current liner from Table 1
  - Update standard deviation (adopt std from new liner?)
- Option 4: Use a model; choose a transformation;
  - n=223 (no exclusions)
  - n=222 (exclude one target test oil 809-1 from lab I)
  - Use model/transformation to determine correction factor and common standard deviation for both oils; use transformed variable from now on to monitor chart
  - Use model/transformation to determine correction factor. Update standard deviation using data from the tables 1 and 2 and continue monitoring chart using original units

The best transformation & all data Model: Lab, oil/liner/target (n=223)

$$\frac{\left(BSOC^{-0.8} - 1\right)}{-11.784245274768}$$



Level		Least Sq Mean
811-1Target	A	-0.17
809-1Target	A B	-0.18
809-1 1Y3555	A B	-0.19
811-1 1Y3555	A B C	-0.20
809-1 1Y3998	A B C	-0.22
811-2 1Y3998	C	-0.24
811-2 1Y3555	A B C	-0.24
811-1 1Y3998	B C	-0.27

Difference between estimated means of 809-1 Target and current liner is **not** statistically significant

Difference between estimated means of 811-1 Target and current liner is statistically significant

1N: only 811-1 data were used to generate the final correction factor.

- The correction generated for 811-1 is 0.06.
- The correction generated for 809-1, although difference between target and new liner not statistically significant, is 0.04.
- In any case, both will be wrong when applied to all candidate oils.
- CF= 0.04 may be a conservative option, if one believes smaller CFs are more conservative

The best transformation & all data
Model: Lab, oil/liner/target (n=223) *More details*

Response BSOC X

Whole Model

Summary of Fit

RSquare	0.291379
RSquare Adj	0.232615
Root Mean Square Error	0.054178
Mean of Response	-0.20271
Observations (or Sum Wgts)	223

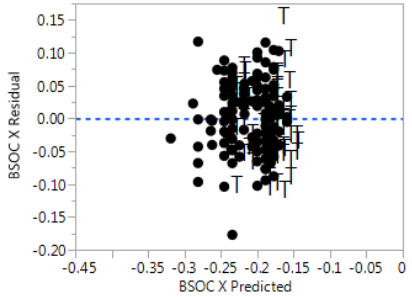
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	17	0.24742762	0.014555	4.9585
Error	205	0.60173397	0.002935	Prob > F
C. Total	222	0.84916160		<.0001*

Effect Tests

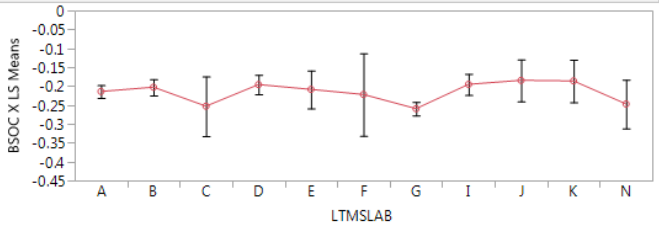
Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
LTMSLAB	10	10	0.13921348	4.7428	<.0001*
oil/Liner Target	7	7	0.08414444	4.0952	0.0003*

Residual by Predicted Plot



LTMSLAB

LS Means Plot



LSMeans Differences Tukey HSD

α= 0.050 Q= 3.25547

Level			Least Sq Mean
J	A	B	-0.1846049
K	A	B	-0.1860950
I	A		-0.1952058
D	A		-0.1958165
B	A		-0.2027838
E	A	B	-0.2085530
A	A		-0.2140825
F	A	B	-0.2220574
N	A	B	-0.2471742
C	A	B	-0.2530966
G		B	-0.2596137

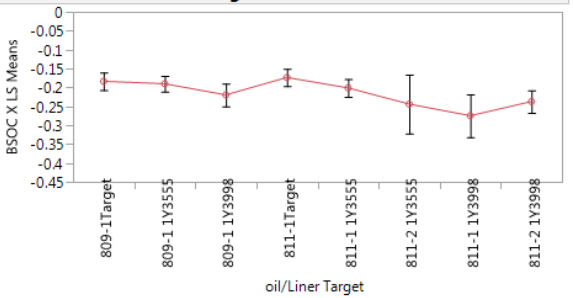
Levels not connected by same letter are significantly different.

oil/Liner Target

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
809-1Target	-0.1834442	0.01184616	-0.18290
809-1 1Y3555	-0.1899599	0.01036291	-0.19484
809-1 1Y3998	-0.2196036	0.01538241	-0.22407
811-1Target	-0.1733202	0.01170197	-0.17667
811-1 1Y3555	-0.2011214	0.01193412	-0.21006
811-2 1Y3555	-0.2438826	0.03946311	-0.26536
811-1 1Y3998	-0.2745523	0.02883572	-0.27443
811-2 1Y3998	-0.2370855	0.01510387	-0.24274

LS Means Plot: Oil/liner/target



LSMeans Differences Tukey HSD

α= 0.050 Q= 3.06251

Level				Least Sq Mean
811-1Target	A			-0.17
809-1Target	A	B		-0.18
809-1 1Y3555	A	B		-0.19
811-1 1Y3555	A	B	C	-0.20
809-1 1Y3998	A	B	C	-0.22
811-2 1Y3998			C	-0.24
811-2 1Y3555	A	B	C	-0.24
811-1 1Y3998		B	C	-0.27

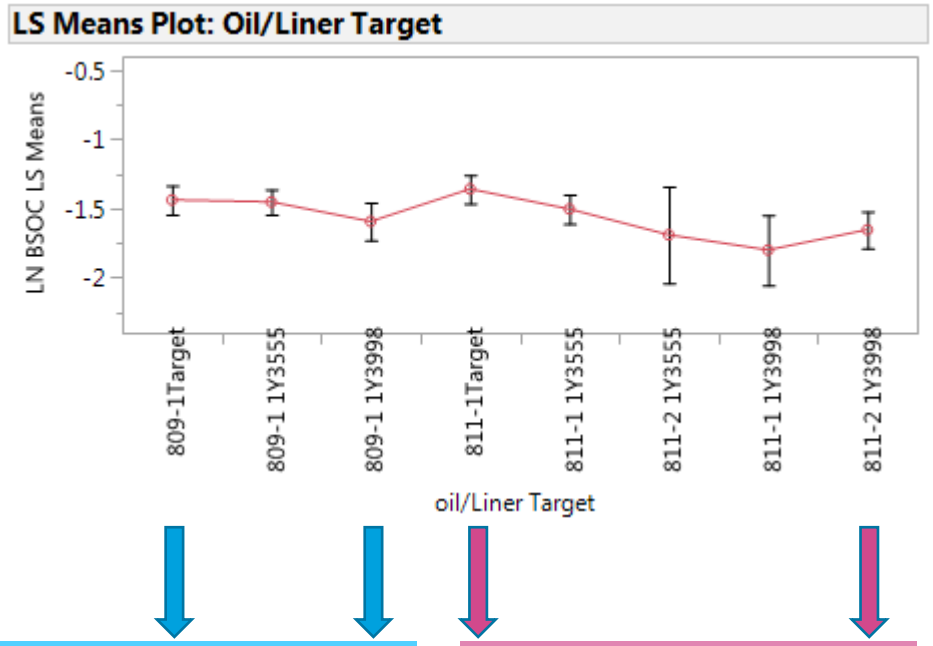
Levels not connected by same letter are significantly different.

CF: Take the difference between Target and liner 1Y3998

811-1
Target -0.17 => 0.25
1Y3998 -0.24=> 0.19

809-1
Target -0.18=>0.24
1Y3998 -0.22=>0.20

Ln(BSOC) for n=222 *I will be happy to work on other options but had to limit the number now*



Level	Least Sq Mean
811-1Target A	-1.358801
809-1Target A B C	-1.437981
809-1 1Y3555 A B	-1.452479
811-1 1Y3555 A B C	-1.503524
809-1 1Y3998 B C	-1.593397
811-2 1Y3998 C	-1.653635
811-2 1Y3555 A B C	-1.690304
811-1 1Y3998 B C	-1.800354

Difference between estimated means of 809-1 Target and current liner is **not** statistically significant

Difference between estimated means of 811-1 Target and current liner is statistically significant

The correction generated for 811-1 is 0.07.
The correction generated for 809-1, although difference between target and new liner not statistically significant, is 0.03.

Note that for the 1N: the SP only 811-1 data to generate the final correction factor.

Ln(BSOC) for n=222: not the best transformation, but perhaps good enough

Response LN BSOC

Whole Model

Summary of Fit

RSquare	0.26667
RSquare Adj	0.205559
Root Mean Square Error	0.242924
Mean of Response	-1.50094
Observations (or Sum Wgts)	222

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	17	4.377710	0.257512	4.3637
Error	204	12.038495	0.059012	Prob > F
C. Total	221	16.416204		<.0001*

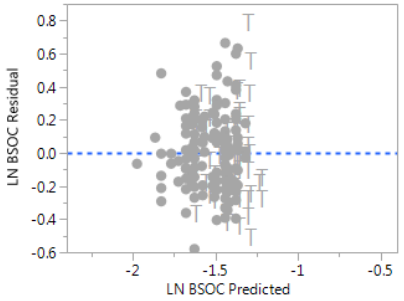
Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	23	1.462714	0.063596	1.0884
Pure Error	181	10.575781	0.058430	Prob > F
Total Error	204	12.038495		0.3618
				Max RSq
				0.3558

Effect Tests

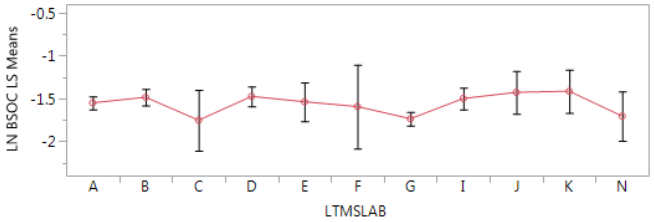
Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
LTMSLAB	10	10	2.4027393	4.0716	<.0001*
oil/Liner Target	7	7	1.6476058	3.9885	0.0004*

Residual by Predicted Plot



LTMSLAB

LS Means Plot



LSMeans Differences Tukey HSD

α= 0.050 Q= 3.25566

Level		Least Sq Mean
K	A B	-1.414420
J	A B	-1.427784
D	A	-1.474435
B	A	-1.484877
I	A	-1.499108
E	A B	-1.537224
A	A	-1.549878
F	A B	-1.593005
N	A B	-1.704571
G	B	-1.736046
C	A B	-1.753055

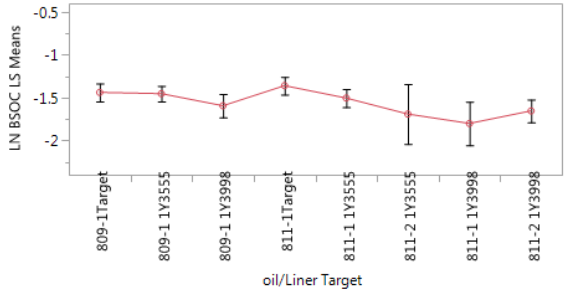
Levels not connected by same letter are significantly different.

oil/Liner Target

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
809-1Target	-1.437981	0.05349114	-1.4367
809-1 1Y3555	-1.452479	0.04646517	-1.4644
809-1 1Y3998	-1.593397	0.06897310	-1.6014
811-1Target	-1.358801	0.05249677	-1.3725
811-1 1Y3555	-1.503524	0.05351071	-1.5335
811-2 1Y3555	-1.690304	0.17694532	-1.7720
811-1 1Y3998	-1.800354	0.12929409	-1.7841
811-2 1Y3998	-1.653635	0.06772453	-1.6677

LS Means Plot: Oil/Liner Target



LSMeans Differences Tukey HSD

α= 0.050 Q= 3.06267

Level		Least Sq Mean
811-1Target	A	-1.358801
809-1Target	A B C	-1.437981
809-1 1Y3555	A B	-1.452479
811-1 1Y3555	A B C	-1.503524
809-1 1Y3998	B C	-1.593397
811-2 1Y3998	C	-1.653635
811-2 1Y3555	A B C	-1.690304
811-1 1Y3998	B C	-1.800354

Levels not connected by same letter are significantly different.

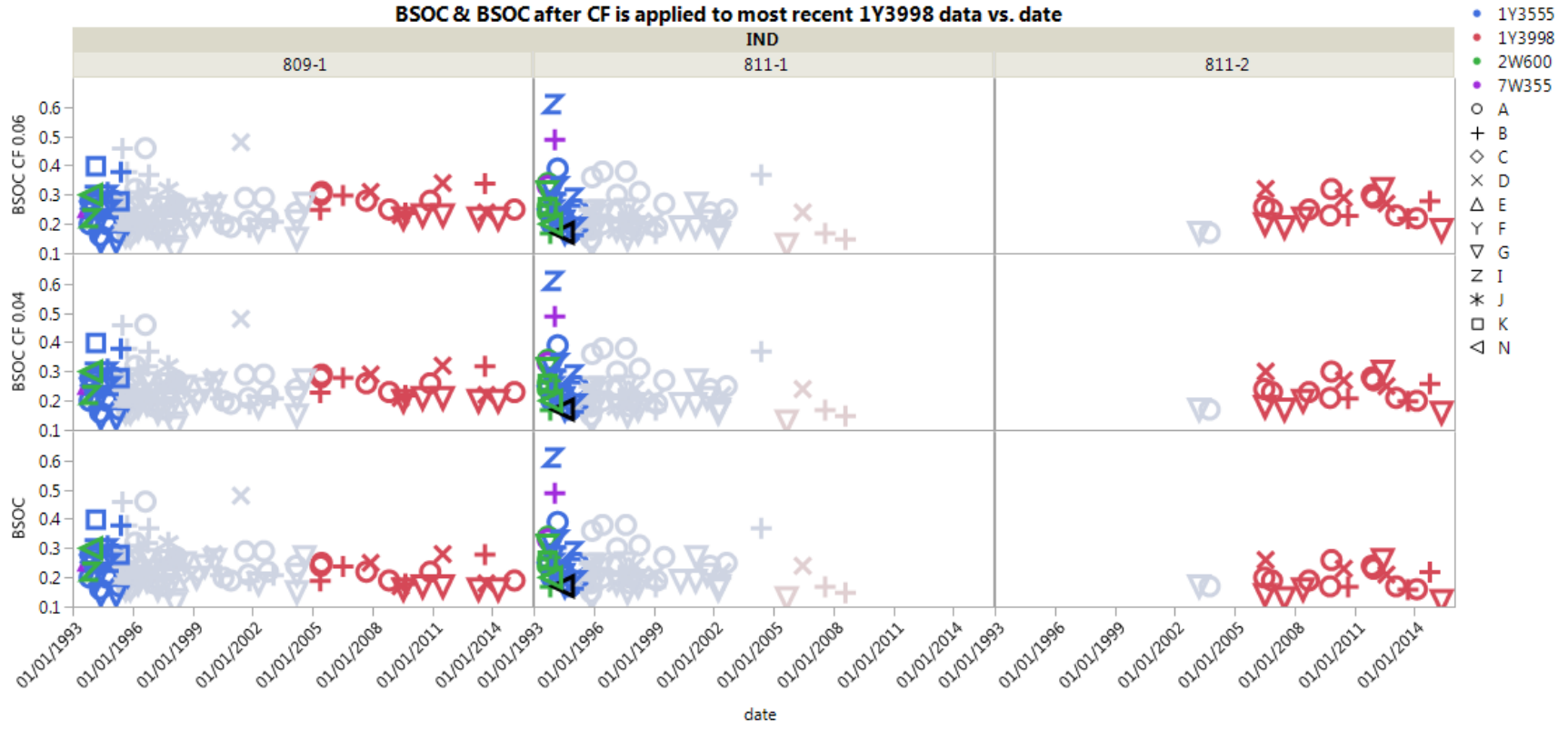
CF: Take the difference between Target and liner 1Y3998

811-1 estimated mean
-1.36=> 0.257
-1.65=> 0.191
→ 0.066

809-1 estimated mean
-1.44=> 0.237
-1.59=> 0.203
→ 0.034

To give you an idea of what a CF=0.04 or 0.06 would do to data in general

809-1: Difference between estimated means of 809-1 Target and current liner is **not** statistically significant
811-1: Difference between estimated means of 811-1 Target and current liner is statistically significant



Final comments

- Questions?
- I will be happy to investigate additional options
- Please, let me know which specific analysis you would like to see

APPENDIX

LINER	testkey	Target	Li
2W600	17826		
2W600	15768	Target	
7W355	17676		
1Y3555	18525		
2W600	18881	Target	
2W600	18512		
2W600	18511		
2W600	17669	Target	
7W355	17671	Target	
2W600	18400		
2W600	18742	Target	
2W600	17673	Target	
2W600	16966		
2W600	18271		
2W600	18528		
2W600	18273		
2W600	18274		
1Y3555	18513		
1Y3555	17534	Target	
1Y3555	18883		
2W600	18272	Target	
1Y3555	18921	Target	
2W600	15038	Target	
7W355	15233	Target	
1Y3555	18504	Target	
2W600	18402	Target	
2W600	17677	Target	
1Y3555	17674	Target	
1Y3555	18505	Target	
1Y3555	19207	Target	
1Y3555	18884	Target	
2W600	18535	Target	
1Y3555	19072	Target	
1Y3555	18401	Target	
1Y3555	18506	Target	
1Y3555	19210	Target	
1Y3555	18875	Target	

Refer to LTMS

1K Reference Oil Targets

1K Reference Oil Targets											
Oil	n	Effective Dates		WDK		TGF		TLHC[3]		BSOC	
		From[1]	To[2]	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
809	30	5-6-90	***	219.2	41.9	12.3	6.3	0.398	0.9	0.272	0.117
809-1	30	8-16-91	***	216.4	35.6	17.5	15.7	0.605	1.1	0.268	0.145
810-2[5]	--	2-1-98	12-31-99	247.4	38.4	53.8	22.1	2.065	1.4	0.309	0.212
	8	1-1-00	***	261.3	38.8	55.3	20.2	1.935	1.7	0.375	0.331
811[4]	--	7-1-90	8-20-91	327.7	55.9	27.3	16.6	0.868	1.0	0.267	0.097
811-1	30	1-1-91	***	327.7	55.9	27.3	16.6	0.868	1.0	0.267	0.097

1 Effective for all tests completed on or after this date.
2 *** = currently in effect.
3 Transformation for TLHC is ln(TLHC+1)
4 Targets based on 811-1.
5 Targets based on 810-1.

1K: No correction factors

APPENDIX B (continued)
HISTORY OF INDUSTRY CORRECTION FACTORS

Test Area	Effective		Condition	Description
	From	To		
1M-PC	None		All Tests	None
1K	None		All Tests	None

LTMS

WEIGHTED DEMERITS
Unit of Measure: Demerits
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809	219.2	41.9
809-1	216.4	35.6
811-1	327.7	55.9

TOP GROOVE FILL
Unit of Measure: Percent
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809	12.3	6.3
809-1	17.5	15.7
811-1	27.3	16.6

TOP LAND HEAVY CARBON
Unit of Measure: LN(TLHC+1)
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809	0.398	0.9
809-1	0.605	1.1
811-1	0.868	1.0

AVERAGE OIL CONSUMPTION
Unit of Measure: g/kW-h
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809	0.272	0.117
809-1	0.268	0.145
811-1	0.267	0.097

- Exceed EWMA laboratory chart action limit for severity (all parameters noted below)
  - Calculate laboratory Severity Adjustment (SA) for each parameter that exceeds action limit, using the current laboratory EWMA (Z_i) as follows:

Weighted Demerits: $SA = (-Z_i) \times (35.6)^*$
Top Groove Fill: $SA = (-Z_i) \times (15.7)^*$
Top Land Heavy Carbon: $SA = (-Z_i) \times (1.1)^*$

* s based on reference oil 809-1

Data n= 301: excluding 809/811 data

New targets have been established for 809-1 and 811-1

LINER	Target	N Rows
	Target	1
1Y3555		131
1Y3555	Target	46
1Y3998		43
1Y702		0
2W600		22
2W600	Target	10
7W355		45
7W355	Target	3
	Sum	301

	Liner target	N Rows
1	Target	60
2	1Y3555	120
3	1Y3998	43
4		78

N=223

Other liners