



Oronite

Mack T13 Reference Data Analysis 20150922 Update Including Seventeen Fuel Flow Controlled and Five 823 Tests

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09/24/2015



Overview

- **OC calculations are nearly resolved**
- **We now have five test results on the new batch of reference oil**
- **We might now guess at separating reblend from control effects**
- **Is improved precision from fuel flow control, less severe results on a scale that should be transformed, or the labs getting better at running the test?**
- **Looks like they might have been almost right**
 - **there is no evidence to dispute improved precision**
 - **but there is evidence of severity shift**



What's next

- **Can we decide what is going on?**
- **Do we need ICFs and / or transformation?**
- **Alter LTMS (standard deviations and / or transformation)?**
- **Propose modification to exit ballot limits?**



Data

- **LTMS dataset 9/22/2015**
 - **48 usable test results – chart Y plus operationally valid torque controlled tests**
- **Three of five labs have run at least two chartable fuel flow controlled tests**
- **Five tests with reblend reference oil have been submitted**
- **We have addressed OC calculations**



OC Calculations

- OC has been corrected for most tests.
- One test to be resubmitted
- Three tests with possible round off differences within 0.1

OC	OC Calc
30.0	30.0
28.7	28.7
26.2	26.2
26.7	26.7
21.8	21.8
28.3	28.3
25.3	25.3
23.9	23.9
17.5	17.5
22.7	22.7
19.3	19.3
35.3	35.3
40.8	40.8
21.5	21.5
21.9	21.9
22.9	22.9
25.9	27.8
22.7	22.7
29.6	29.6
29.0	29.0
23.2	23.2
24.8	24.8
24.1	24.1
22.3	22.3
26.3	26.3
25.7	25.7
38.9	38.9
19.8	19.8
24.8	24.8
18.9	18.9
20.9	20.9
20.7	20.7
23.1	23.1
11.3	11.3
17.7	17.7
27.4	27.4
25.1	25.1
22.8	22.8
28.8	28.9
27.5	27.6
28.6	28.6
23.6	23.6
21.8	21.9
21.8	21.8
35.3	35.3
34.8	34.8
10.6	10.6
20.8	20.8



Transformations

- Box-Cox analysis says IRPH and OCCalc don't appear to need transformation
- KV40 would really like a square root transformation

IRPH				KV40				OCCalc			
Obs	rmse	LAMBDA	confint	Obs	rmse	LAMBDA	confint	Obs	rmse	LAMBDA	confint
1	45.215	-2		1	364.04	-2		1	8.54012	-2	
2	42.399	-1.9		2	301.546	-1.9		2	8.19129	-1.9	
3	39.775	-1.8		3	250.498	-1.8		3	7.86765	-1.8	
4	37.331	-1.7		4	208.735	-1.7		4	7.56781	-1.7	
5	35.054	-1.6		5	174.509	-1.6		5	7.29051	-1.6	
6	32.933	-1.5		6	146.409	-1.5		6	7.03453	-1.5	
7	30.958	-1.4		7	123.294	-1.4		7	6.79876	-1.4	
8	29.117	-1.3		8	104.239	-1.3		8	6.58212	-1.3	
9	27.404	-1.2		9	88.496	-1.2		9	6.38363	-1.2	
10	25.809	-1.1		10	75.459	-1.1		10	6.20236	-1.1	
11	24.325	-1		11	64.638	-1		11	6.03742	-1	
12	22.945	-0.9		12	55.635	-0.9		12	5.88799	-0.9	
13	21.664	-0.8		13	48.127	-0.8		13	5.75327	-0.8	
14	20.474	-0.7		14	41.855	-0.7		14	5.63254	-0.7	
15	19.373	-0.6		15	36.607	-0.6		15	5.52508	-0.6	
16	18.354	-0.5		16	32.215	-0.5		16	5.43024	-0.5	
17	17.414	-0.4		17	28.543	-0.4		17	5.34739	-0.4	
18	16.549	-0.3		18	25.481	-0.3		18	5.27595	-0.3	*
19	15.755	-0.2		19	22.945	-0.2		19	5.21535	-0.2	*
20	15.031	-0.1		20	20.865	-0.1		20	5.16508	-0.1	*
21	14.373	0		21	19.191	0		21	5.12465	0	*
22	13.779	0.1		22	17.88	0.1		22	5.09359	0.1	*
23	13.246	0.2		23	16.9	0.2		23	5.07149	0.2	*
24	12.774	0.3		24	16.225	0.3	*	24	5.05794	0.3	*
25	12.361	0.4		25	15.833	0.4	*	25	5.05259	0.4	Best
26	12.003	0.5		26	15.703	0.5	Best	26	5.0551	0.5	*
27	11.701	0.6		27	15.819	0.6	*	27	5.06517	0.6	*
28	11.453	0.7	*	28	16.162	0.7	*	28	5.08251	0.7	*
29	11.256	0.8	*	29	16.72	0.8		29	5.1069	0.8	*
30	11.109	0.9	*	30	17.482	0.9		30	5.13809	0.9	*
31	11.011	1	*	31	18.441	1		31	5.17592	1	*
32	10.959	1.1	*	32	19.593	1.1		32	5.2202	1.1	*
33	10.952	1.2	Best	33	20.94	1.2		33	5.2708	1.2	*
34	10.987	1.3	*	34	22.486	1.3		34	5.32761	1.3	*
35	11.062	1.4	*	35	24.241	1.4		35	5.39054	1.4	
36	11.177	1.5	*	36	26.218	1.5		36	5.45951	1.5	
37	11.328	1.6	*	37	28.434	1.6		37	5.53448	1.6	
38	11.514	1.7	*	38	30.909	1.7		38	5.61542	1.7	
39	11.734	1.8		39	33.668	1.8		39	5.70234	1.8	
40	11.985	1.9		40	36.739	1.9		40	5.79525	1.9	
41	12.267	2		41	40.157	2		41	5.89418	2	



IR Oxidation Peak Height at 360 hours

- Estimate of standard deviation improved over original precision estimate (11.0 versus 12.4)
- Evidence (p=0.04) that severity shifted with change to fuel flow control. {or did something else change?}

IRPH						IND	LSMEAN	823	PC11A	PC11B	PC11C	PC11D	PC11E	PC11F
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F									
Model	11	61594.98759	5599.54433	46.18	<.0001	823	125.1		0.7143	<.0001	0.9571	0.9984	<.0001	0.9803
Error	36	4364.73053	121.24251			PC11A	137.9	0.7143		<.0001	0.0616	0.6637	<.0001	0.0792
Corrected Total	47	65959.71812				PC11B	53.5	<.0001	<.0001		<.0001	<.0001	1	<.0001
						PC11C	116.4	0.9571	0.0616	<.0001		0.5529	<.0001	1
R-Square	Coeff Var	Root MSE	IRPH Mean			PC11D	128.6	0.9984	0.6637	<.0001	0.5529		<.0001	0.6676
0.933827	10.75754	11.0	102.3563			PC11E	54.4	<.0001	<.0001	1	<.0001	<.0001		<.0001
						PC11F	117.6	0.9803	0.0792	<.0001	1	0.6676	<.0001	
Source	DF	Type III SS	Mean Square	F Value	Pr > F									
IND	6	49885.67938	8314.2799	68.58	<.0001									
LTMSLAB	4	1992.38087	498.09522	4.11	0.0076									
Control	1	569.47322	569.47322	4.7	0.0369									
Parameter	Estimate		Standard Error	t Value	Pr > t 									
Control fuelflow	-10.2922579	B	4.7489924	-2.17	0.037									



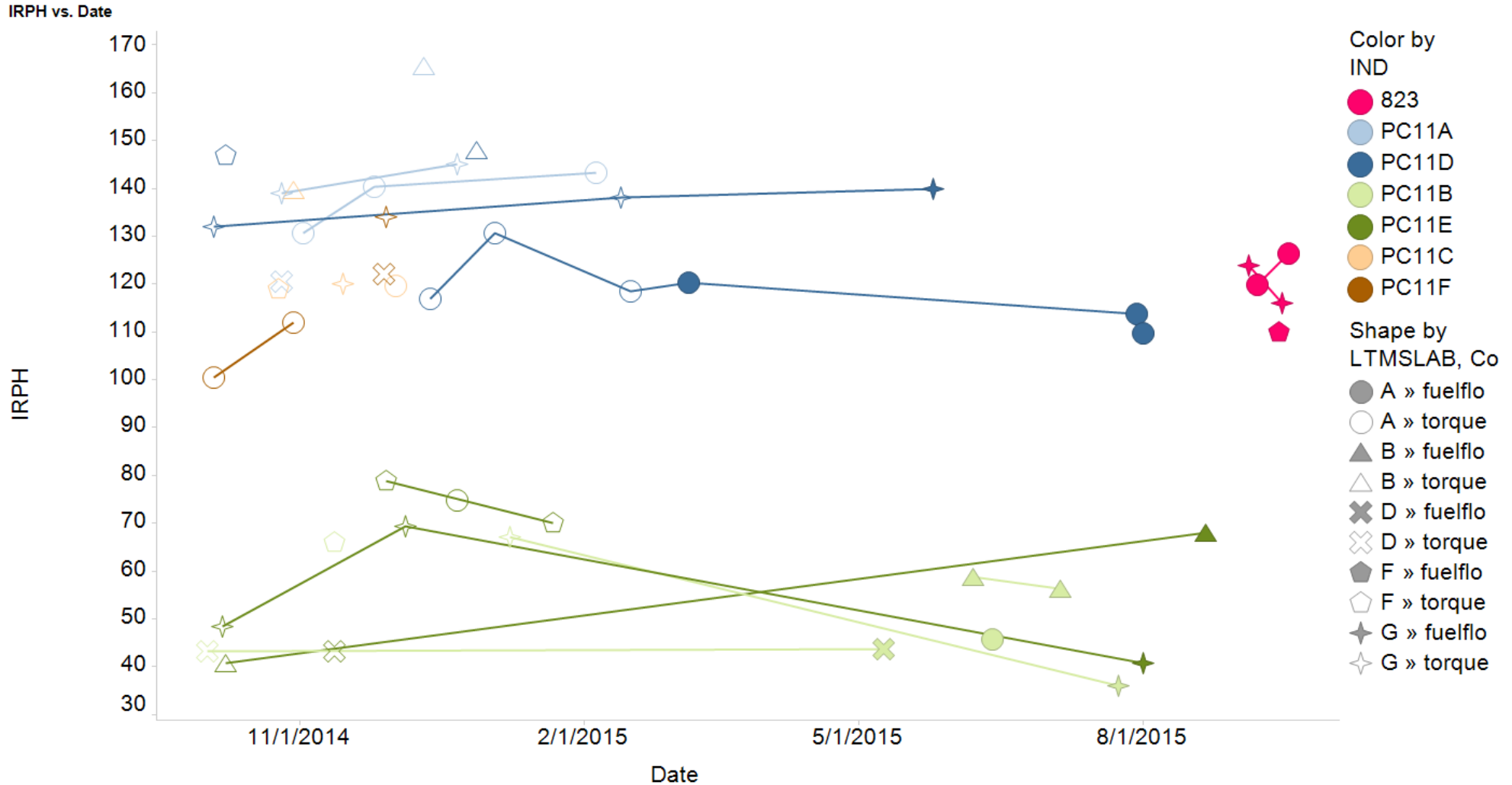
IR Oxidation Peak Height at 360 hours

- Using ICF +10.3 for fuel flow tests
- Estimate of standard deviation improved over original precision estimate (11.0 versus 12.4)
- 823 still a bit lower than A and D but not significantly
- LSMeans very close to original analysis

IRPHfin														
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	IND	LSMEAN	823	PC11A	PC11B	PC11C	PC11D	PC11E	PC11F
Model	11	58431.51426	5311.95584	43.81	<.0001	823	130.2		0.7143	<.0001	0.9571	0.9984	<.0001	0.9803
Error	36	4364.73053	121.24251			PC11A	143.1	0.7143		<.0001	0.0616	0.6637	<.0001	0.0792
Corrected Total	47	62796.24479				PC11B	58.6	<.0001	<.0001		<.0001	<.0001	1	<.0001
						PC11C	121.6	0.9571	0.0616	<.0001		0.5529	<.0001	1
R-Square	Coeff Var	Root MSE	IRPHfin Mean			PC11D	133.8	0.9984	0.6637	<.0001	0.5529		<.0001	0.6676
0.930494	10.40841	11.0	105.7896			PC11E	59.6	<.0001	<.0001	1	<.0001	<.0001		<.0001
						PC11F	122.7	0.9803	0.0792	<.0001	1	0.6676	<.0001	
Source	DF	Type III SS	Mean Square	F Value	Pr > F									
IND	6	49885.67938	8314.2799	68.58	<.0001									
LTMSLAB	4	1992.38087	498.09522	4.11	0.0076									
Control	1	0.00032	0.00032	0	0.9987									
Parameter	Estimate	Standard Error	t Value	Pr > t										
Control fuelflow	0.0077421 B	4.7489924	0	0.999										



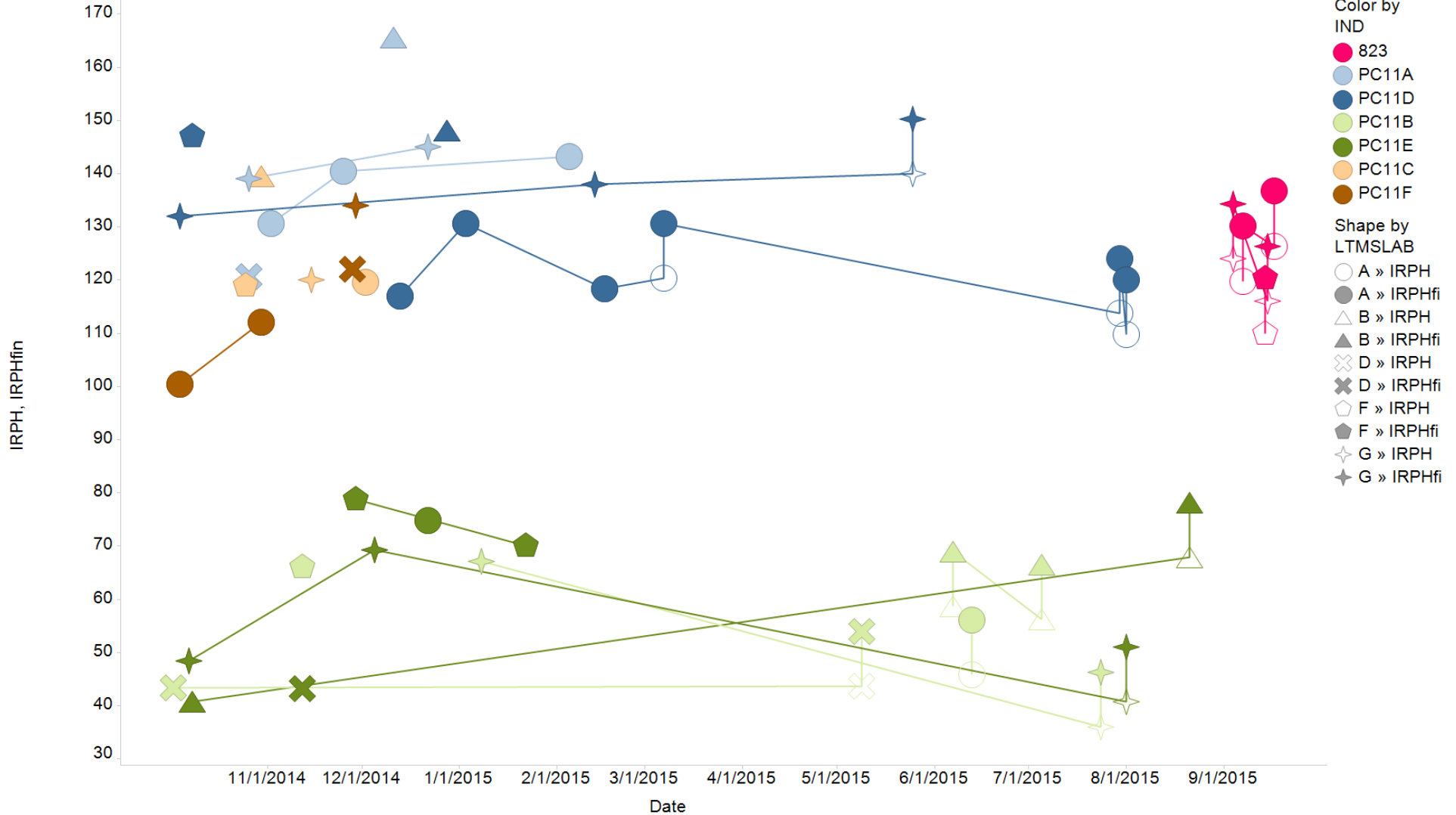
IR Oxidation Peak Height at 360 hours





IR Oxidation Peak Height at 360 hours

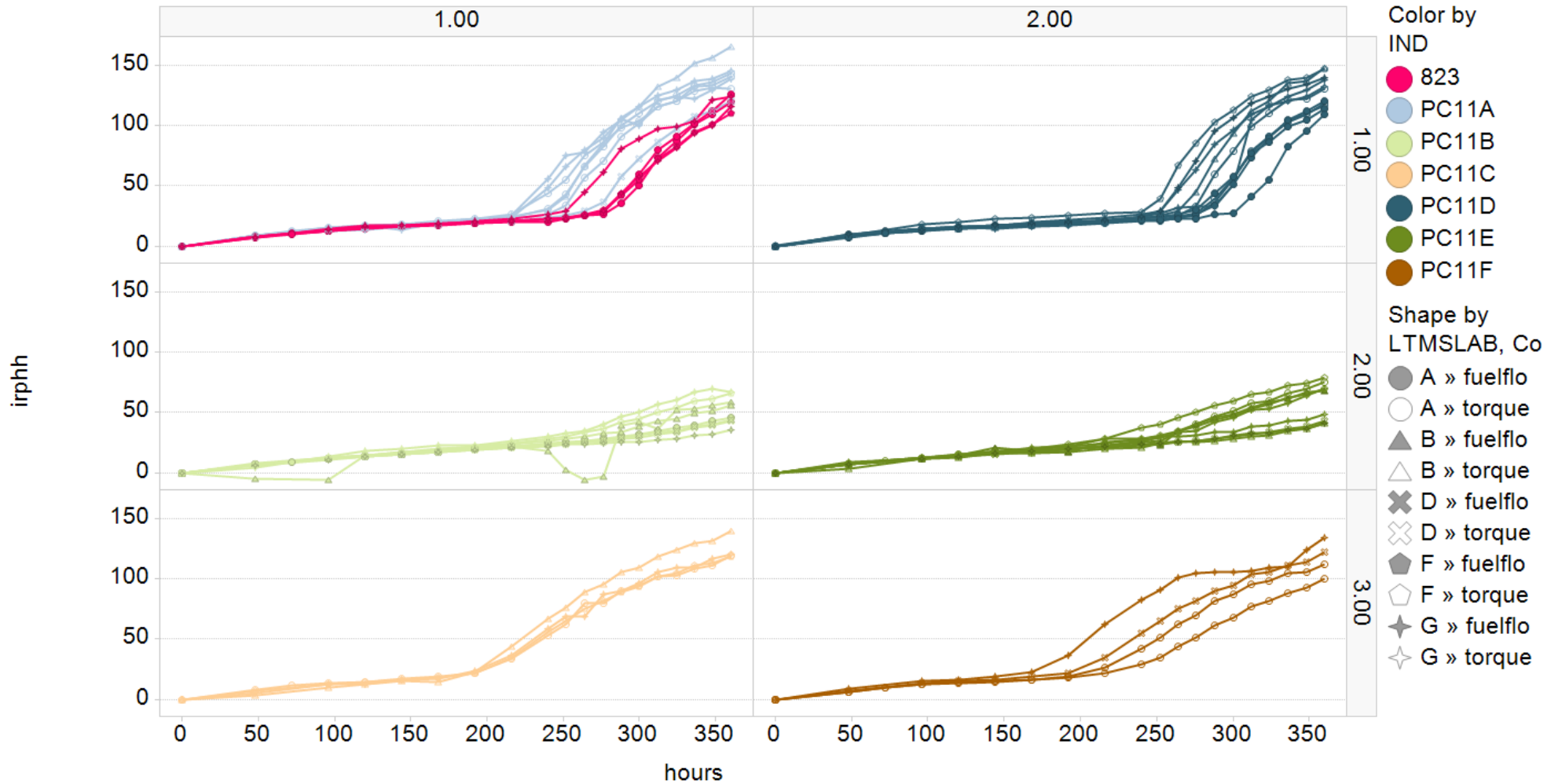
IRPH, IRPHfin vs. Date





IR Oxidation Peak Height at 360 hours

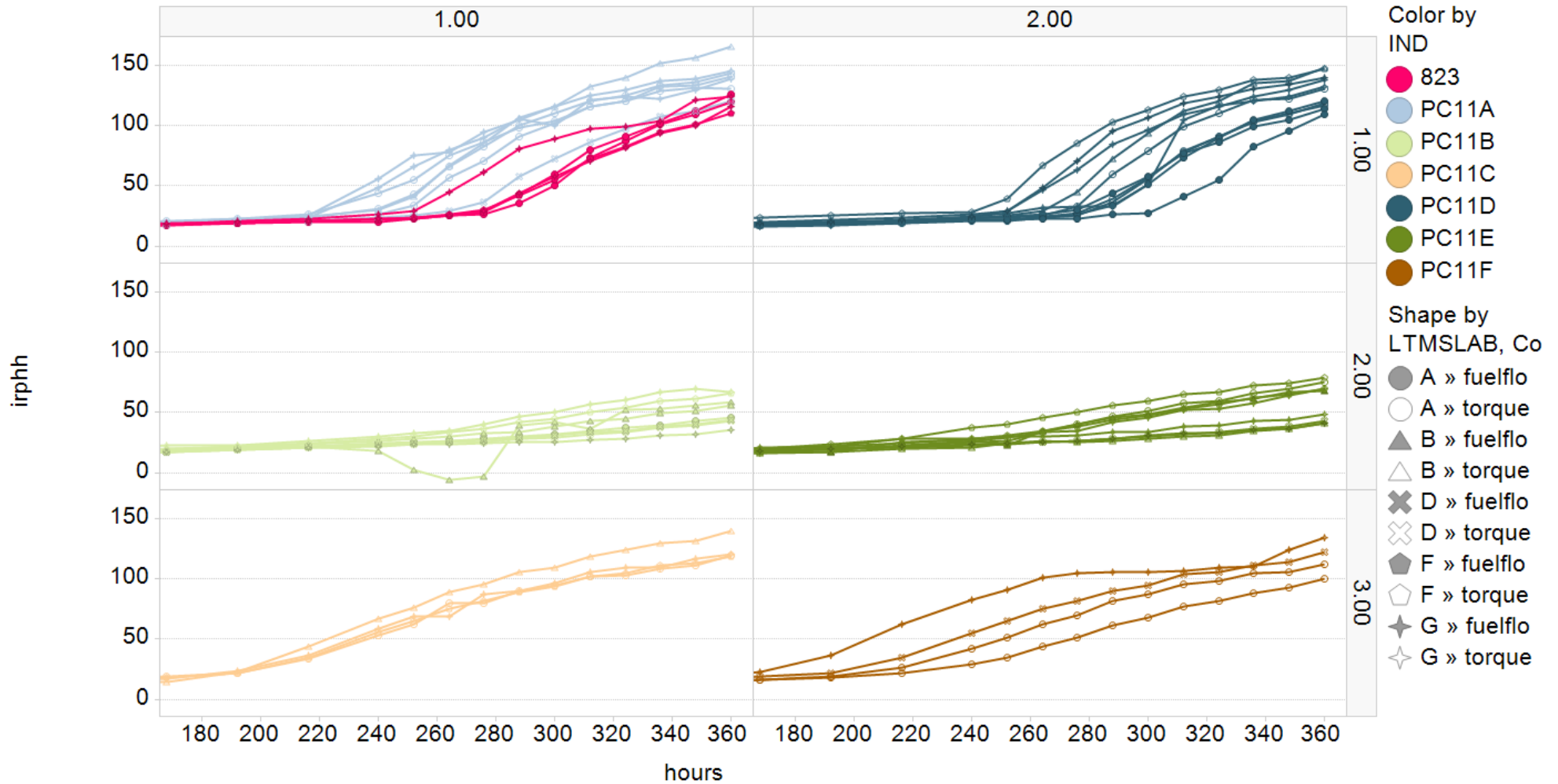
irphh vs. hours





IR Oxidation Peak Height at 360 hours

irphh vs. hours



Viscosity at 40°C percent increase from 300 to 360 hours



- Estimate of standard deviation improved versus original precision estimate (18.4 versus 23.2)
- Marginal evidence (p=0.07) that severity shifted with change to fuel flow control. {or did something else change?}

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	IND	LSMEAN	823	PC11A	PC11B	PC11C	PC11D	PC11E	PC11F
Model	11	39743.64352	3613.0585	10.62	<.0001	823	69.0		0.9934	0.001	0.999	1	0.002	0.9967
Error	36	12242.52314	340.07009			PC11A	78.3	0.993		<.0001	0.826	0.975	<.0001	1
Corrected Total	47	51986.16667				PC11B	17.3	0.001	<.0001		0.016	<.0001	1	0.001
						PC11C	62.3	0.999	0.826	0.016		0.993	0.004	0.908
R-Square	Coeff Var	Root MSE	KV40 Mean			PC11D	70.0	1.000	0.975	<.0001	0.993		<.0001	0.992
0.764504	33.14737	18.4	55.63333			PC11E	16.2	0.002	<.0001	1	0.004	<.0001		0.000
						PC11F	77.9	0.997	1	0.001	0.908	0.992	0.000	
Source	DF	Type III SS	Mean Square	F Value	Pr > F									
IND	6	27863.28745	4643.88124	13.66	<.0001									
LTMSLAB	4	3333.71313	833.42828	2.45	0.0636									
Control	1	1204.82452	1204.82452	3.54	0.0679									
Parameter	Estimate	Standard Error	t Value	Pr > t										
Control fuelflow	-14.97048619	7.95349886	-1.88	0.068										

Square Root Viscosity at 40°C percent increase from 300 to 360 hours



- Estimate of standard deviation improved versus original precision estimate (18.4 versus 23.2)
- Marginal evidence (p=0.07) that severity shifted with change to fuel flow control. {or did something else change?}

sqrtKV40															
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	IND	sqrtKV40	KV40	823	PC11A	PC11B	PC11C	PC11D	PC11E	PC11F
Model	11	240.0238177	21.8203471	14.86	<.0001	823	8.33	69.4		0.9998	<.0001	0.990	1	0.000	1
Error	36	52.8729165	1.4686921			PC11A	8.67	75.1	1.000		<.0001	0.826	0.992	<.0001	0.9999
Corrected Total	47	292.8967342				PC11B	3.93	15.5	<.0001	<.0001		0.001	<.0001	1	<.0001
						PC11C	7.62	58.1	0.990	0.826	0.001		0.981	0.001	0.966
R-Square	Coeff Var	Root MSE	sqrtKV40 Mean			PC11D	8.23	67.8	1.000	0.992	<.0001	0.981		<.0001	1.000
0.819483	17.21969	1.21	7.037849			PC11E	4.08	16.6	0.000	<.0001	1	0.001	<.0001		<.0001
						PC11F	8.44	71.3	1.000	0.9999	<.0001	0.966	1.000	<.0001	
Source	DF	Type III SS	Mean Square	F Value	Pr > F										
IND	6	168.2679161	28.0446527	19.09	<.0001										
LTMSLAB	4	15.5538937	3.8884734	2.65	0.0491										
Control	1	7.2855247	7.2855247	4.96	0.0323										
Parameter	Estimate	Standard Error	t Value	Pr > t											
Control fuelflow	-1.164137886 B	0.52268422	-2.23	0.032											

Square Root Viscosity at 40°C percent increase from 300 to 360 hours



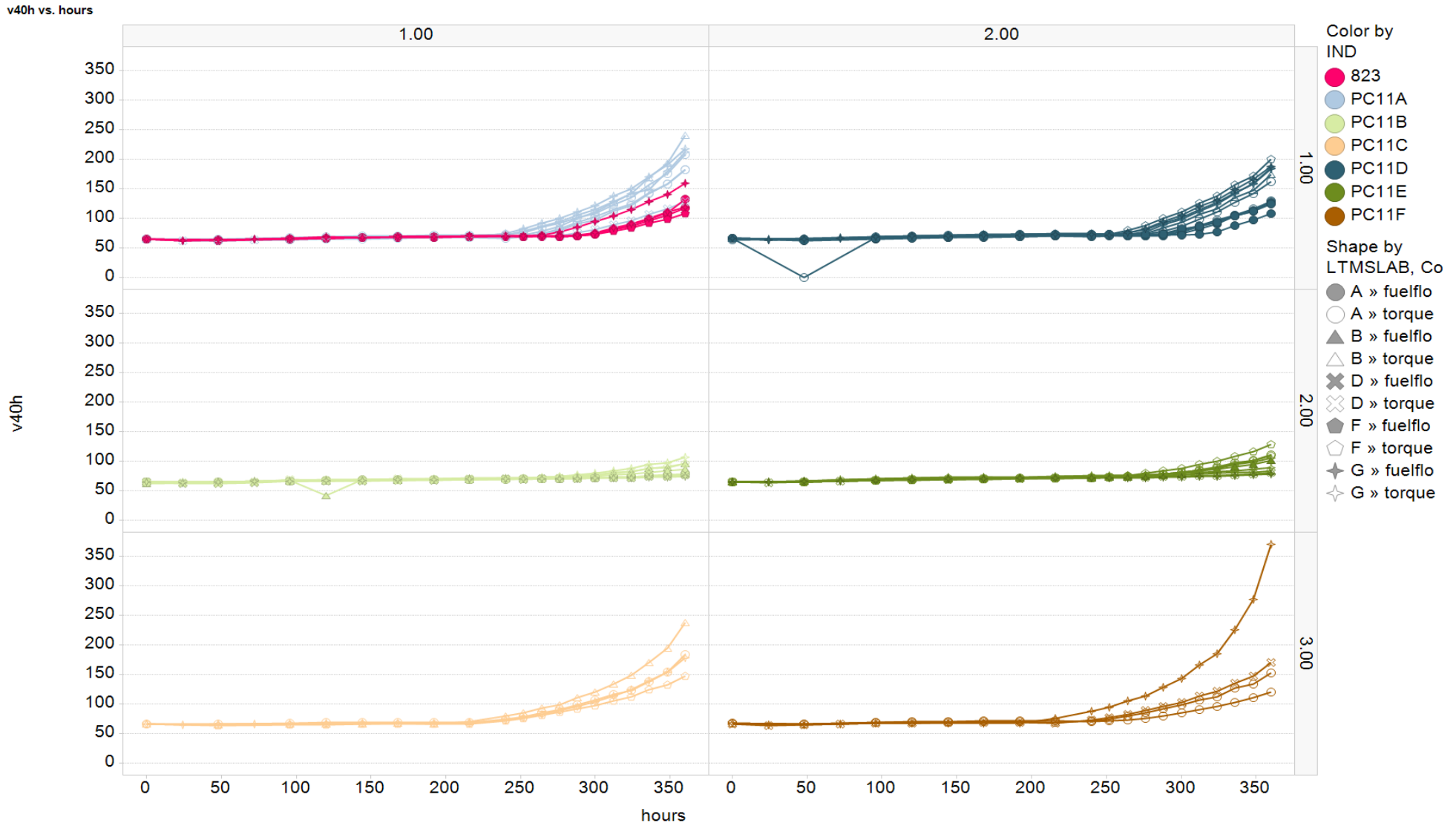
- Using ICF +1.16 in square root scale for fuel flow tests
- Estimate of standard deviation 1.21 in square root scale
- 823 still a bit lower than A and D but not significantly
- LSMeans close to original analysis

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	IND	lsmean	KV40	823	PC11A	PC11B	PC11C	PC11D	PC11E	PC11F
Model	11	214.2169297	19.4742663	13.26	<.0001	823	8.91	79.4	0.9998	<.0001	0.990	1	0.000	1	
Error	36	52.8729165	1.4686921			PC11A	9.25	85.5	1.000	<.0001	0.826	0.992	<.0001	0.9999	
Corrected Total	47	267.0898462				PC11B	4.51	20.4	<.0001	<.0001	0.001	<.0001	1	<.0001	
						PC11C	8.20	67.2	0.990	0.826	0.001		0.981	0.001	0.966
R-Square	Coeff Var	Root MSE	ocCOR Mean			PC11D	8.81	77.7	1.000	0.992	<.0001	0.981		<.0001	1.000
0.802041	16.3229	1.21	7.424516			PC11E	4.66	21.7	0.000	<.0001	1	0.001	<.0001	<.0001	
						PC11F	9.02	81.4	1.000	0.9999	<.0001	0.966	1.000	<.0001	
Source	DF	Type III SS	Mean Square	F Value	Pr > F										
IND	6	168.2679161	28.0446527	19.09	<.0001										
LTMSLAB	4	15.5538937	3.8884734	2.65	0.0491										
Control	1	0.000092	0.000092	0	0.9937										
Parameter	Estimate	Standard Error	t Value	Pr > t											
Control fuelflow	-0.004137886 B	0.52268422	-0.01	0.994											

Viscosity at 40°C percent increase from 300 to 360 hours



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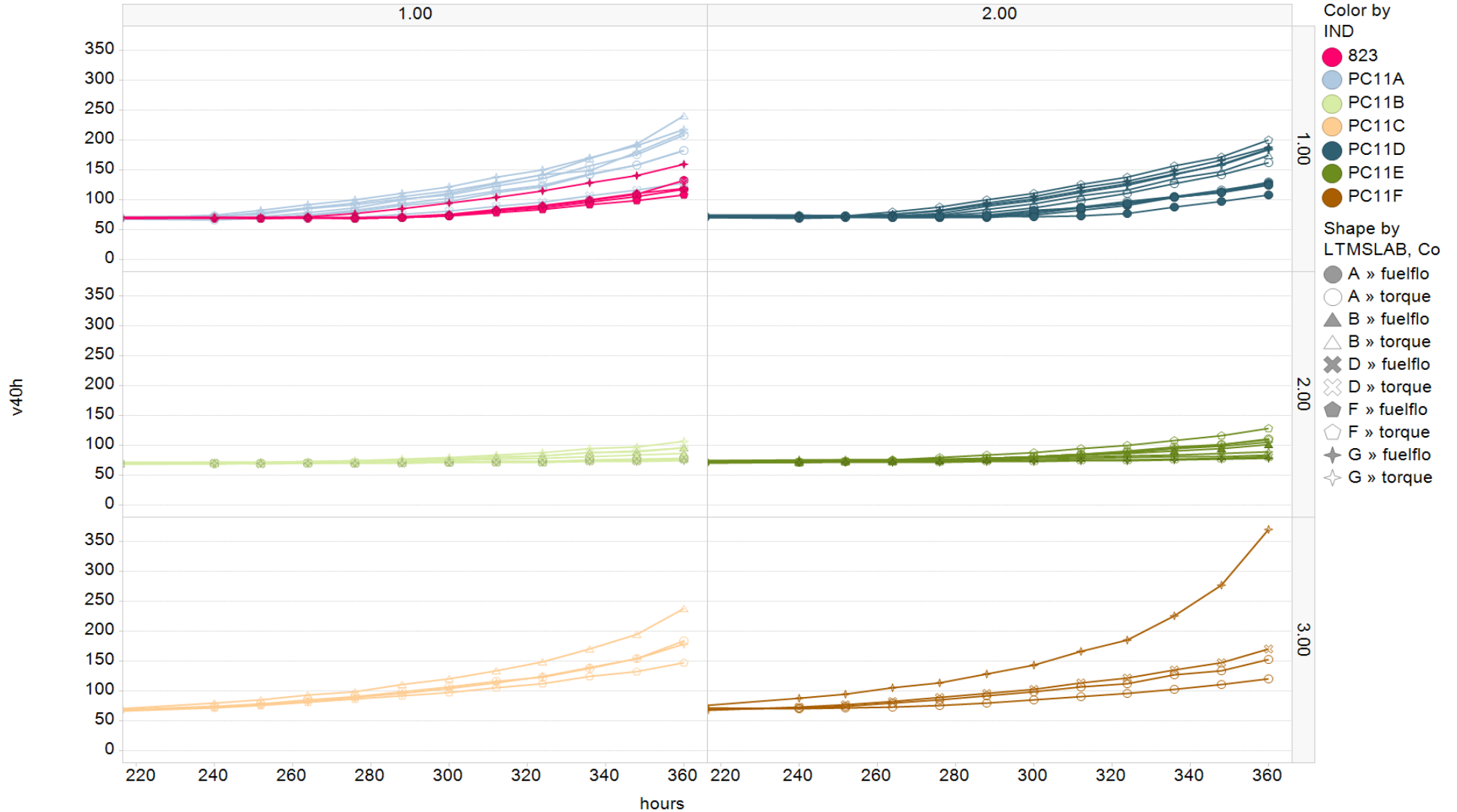


Viscosity at 40°C percent increase from 300 to 360 hours



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v40h vs. hours

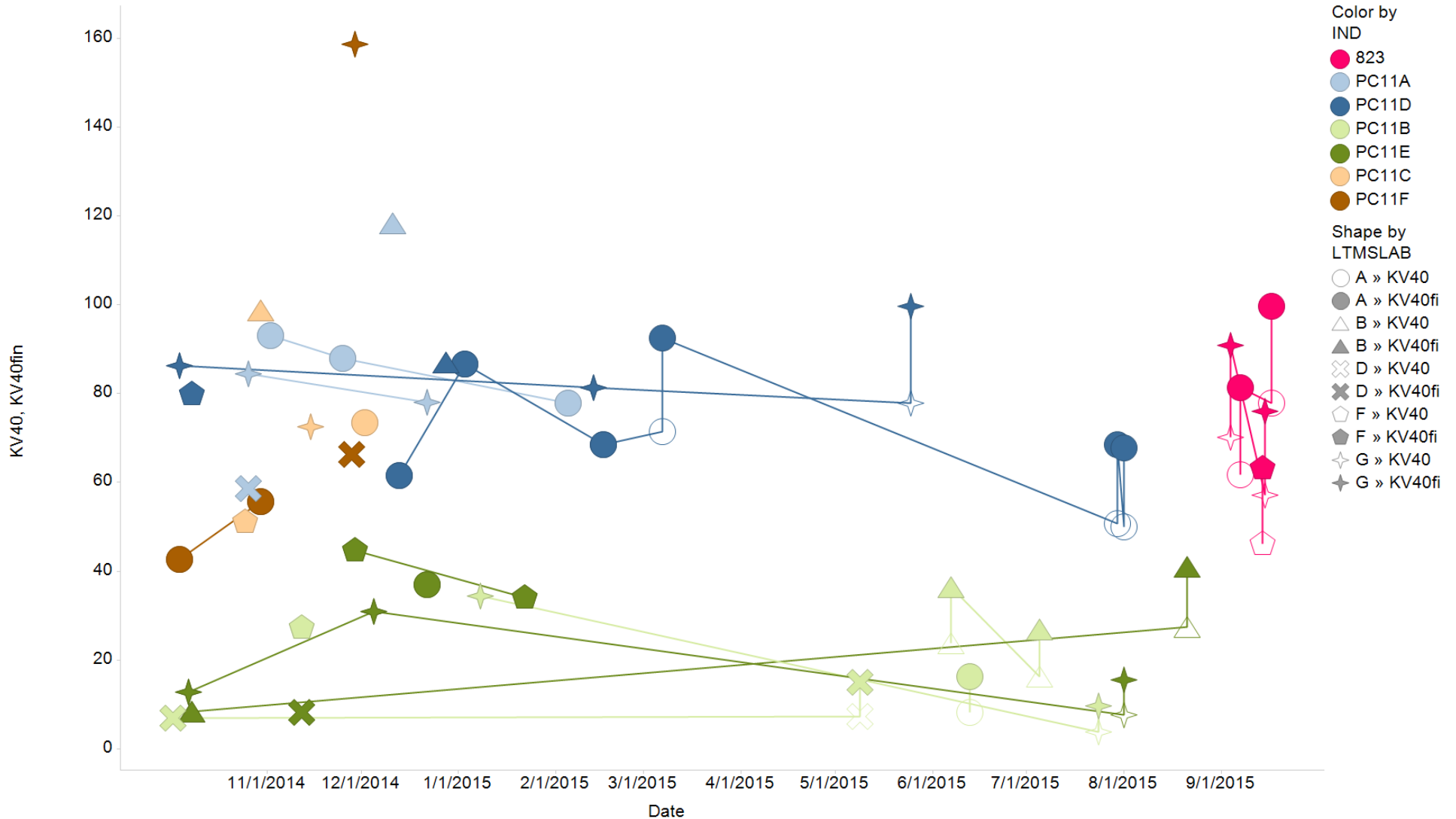


Viscosity at 40°C percent increase from 300 to 360 hours



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KV40, KV40fin vs. Date





OC Average 48 to 192 hours

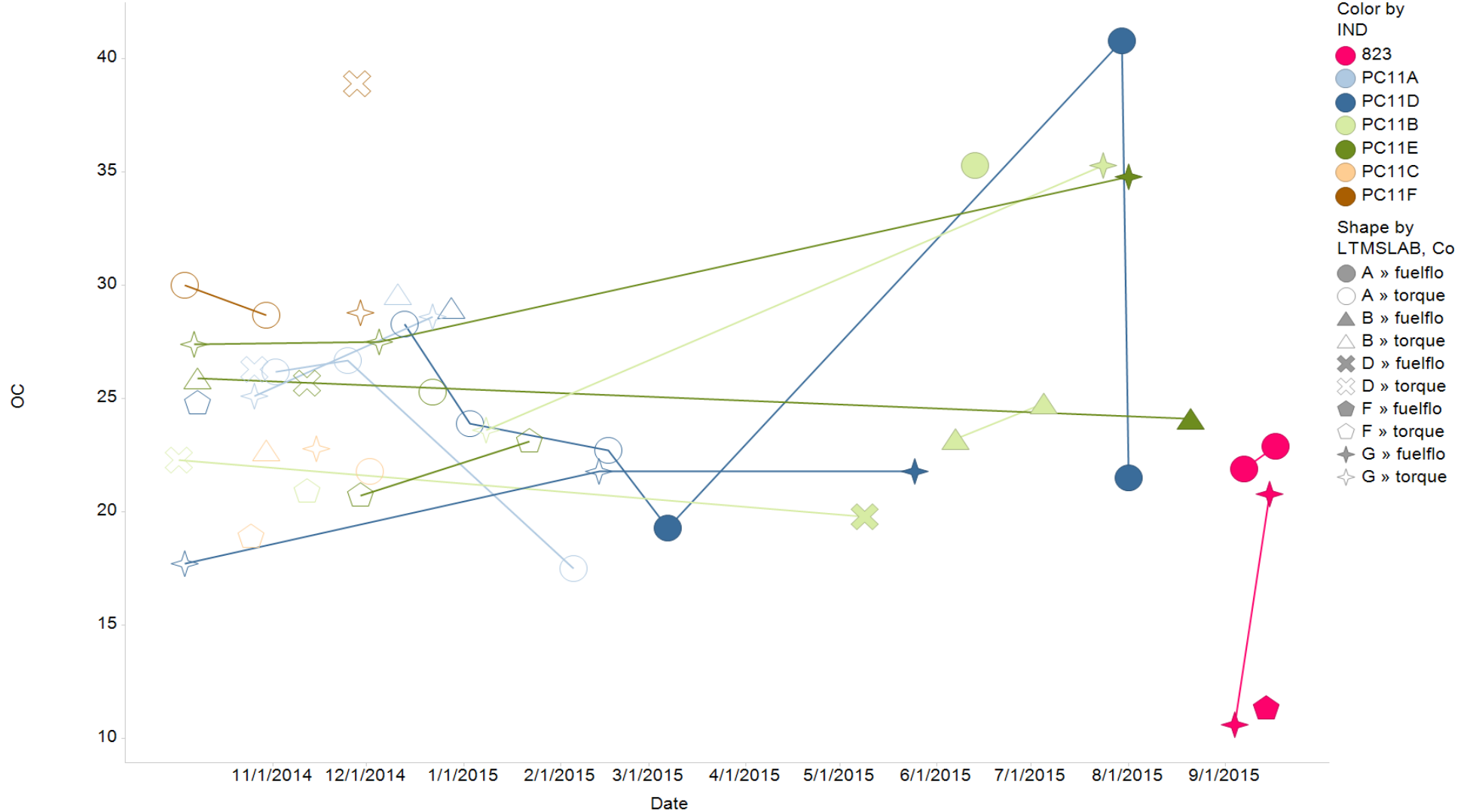
- Estimate of standard deviation: 5.2
- No evidence (p=0.27) that severity shifted with change to fuel flow control but what about 823?

OCCalc														
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	IND	LSMEAN	823	PC11A	PC11B	PC11C	PC11D	PC11E	PC11F
Model	11	668.95533	60.814121	2.27	0.032	823	16.1		0.167	0.099	0.663	0.164	0.040	0.010
Error	36	964.44397	26.79011			PC11A	26.1	0.167		1.000	0.961	0.995	1.000	0.557
Corrected Total	47	1633.399301				PC11B	25.1	0.099	1.000		0.995	1.000	0.990	0.490
						PC11C	22.9	0.663	0.961	0.995		0.999	0.838	0.236
R-Square	Coeff Var	Root MSE	OCCalc Mean			PC11D	24.3	0.164	0.995	1.000	0.999		0.919	0.233
0.409548	20.81634	5.2	24.86468			PC11E	27.1	0.040	1.000	0.990	0.838	0.919		0.759
						PC11F	31.9	0.010	0.557	0.490	0.236	0.233	0.759	
Source	DF	Type III SS	Mean Square	F Value	Pr > F									
IND	6	467.5381407	77.9230235	2.91	0.02									
LTMSLAB	4	70.9842937	17.7460734	0.66	0.622									
Control	1	33.9538384	33.9538384	1.27	0.268									
Parameter	Estimate		Standard Error	t Value	Pr > t									
Control fuelflow	2.5131502 B		2.23234471	1.13	0.2677									



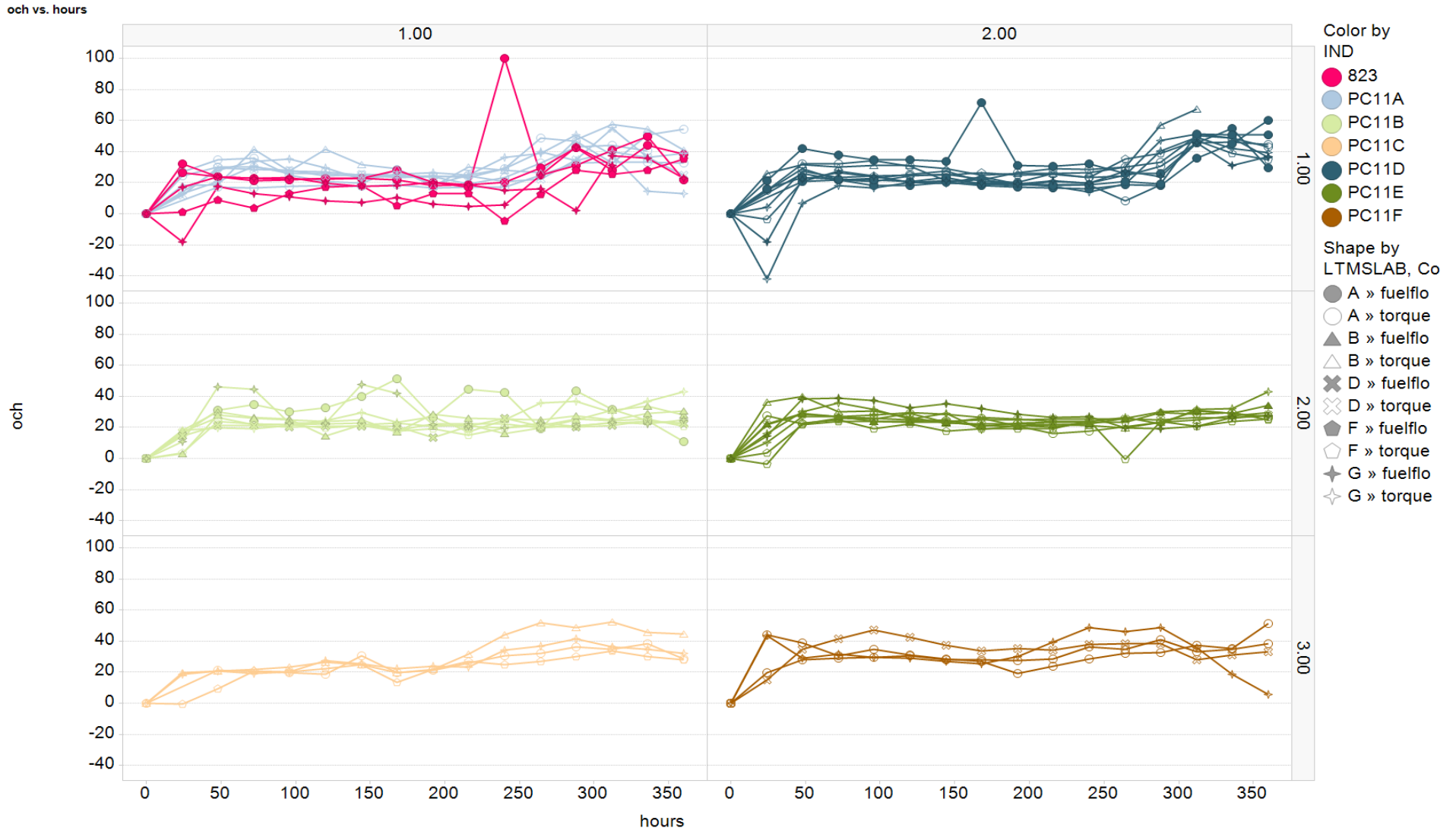
OC Average 48 to 192 hours

OC vs. Date





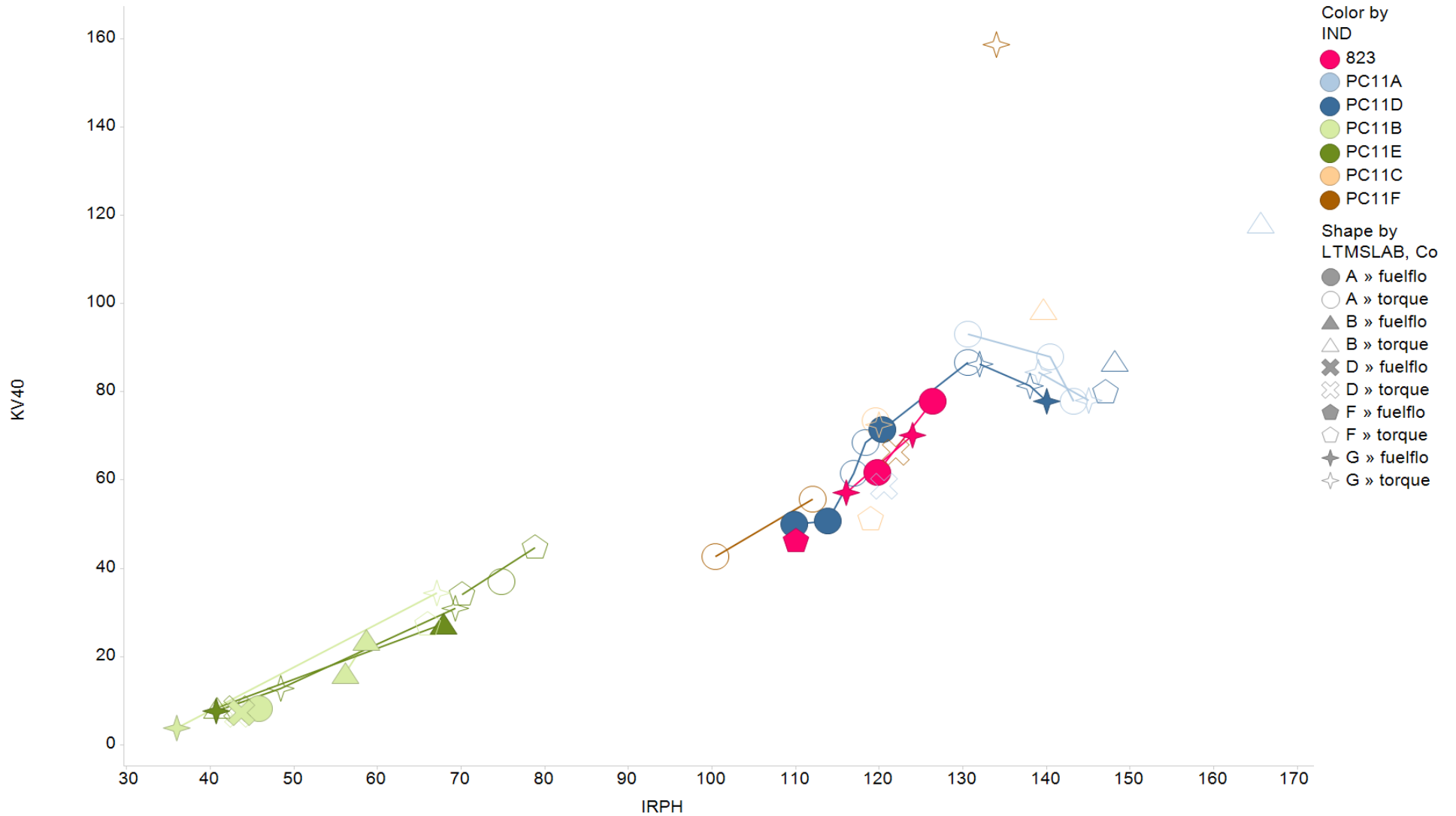
OC Average 48 to 192 hours





KV40 versus IRPH

KV40 vs. IRPH





Tiered Limits

LTMS 09/10/2015 Estimated Standard Deviations						
	Proposed Limit	Standard Deviation		1 Test	2 Test	3 Test
Mack T13 PC11						
IR Oxidation Peak Height at 360 hours	125	10.7		125	130	132
Percent Increase in Viscosity at 40°C from 300 to 360 hour	75	18.5		75	84	88
Average Oil Consumption 48 to 192 hours, g/hr	45	5.3		45	48	49
LTMS 09/22/2015 Estimated Standard Deviations						
	Proposed Limit	Standard Deviation		1 Test	2 Test	3 Test
Mack T13 PC11						
IR Oxidation Peak Height at 360 hours	125	11.0		125	130	133
Percent Increase in Viscosity at 40°C from 300 to 360 hour*	75	1.21		75	85	90
Average Oil Consumption 48 to 192 hours, g/hr	45	5.2		45	48	49
*Standard deviation and calculations in square root scale						