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Caterpillar C13

Summary Matrix Data Analysis
24 tests

November 29th, 2005

Summary (1)

- Data source:
  - 24 test results for six PC-10 oils (three Base Oils and two Technologies)
- Critical parameters:
  - Delta OC; Top Land Carbon; Top Groove Carbon; Carbon at the Top Side of the Second Ring
- Lab differences:
  - Lab F is different from all the other labs for **Delta OC**
  - Lab B is different from all the other labs for **TLC**
  - Lab A is different from Lab G for **TGC**

Summary (2)

- Impact of Base Oil on **Delta OC** seems to vary with Technology
  - Delta OC increases with Base Oil (1,2,3) for Technology B
  - And there are no significant differences among Base Oils for Technology A

- In general, for TGC & TLC, Base Oil 3 results are higher when compared to Base Oil 2 and Base Oil 1

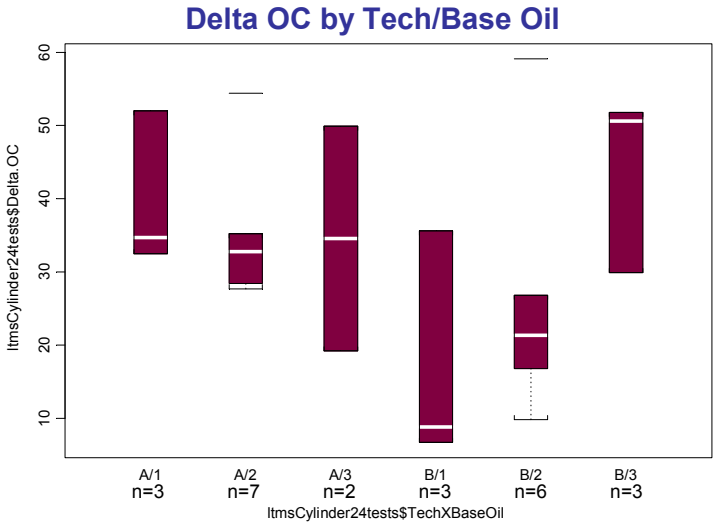
- For Carbon at the Top Side of the Second Ring (R2TCA)
  - Base Oil 3 results are higher when compared to Base Oil 2 and Base Oil 1
  - Base Oil 2 results are higher when compared to Base Oil 1

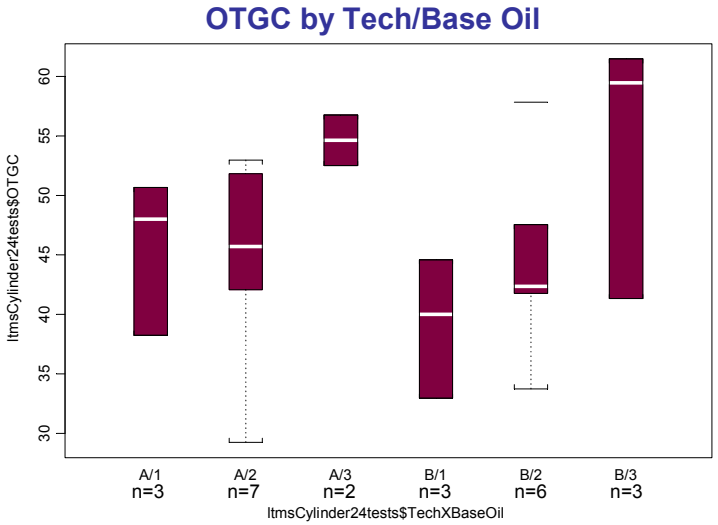
Summary (3)

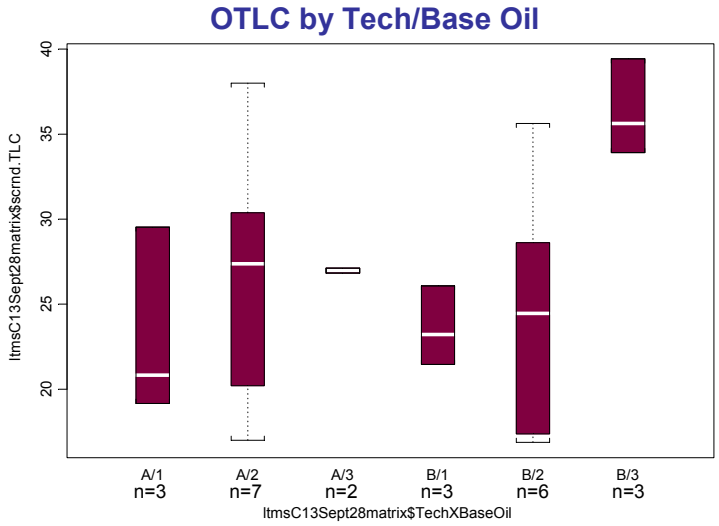
- Correlation of Delta OC with Deposits is very weak: ~ 0.4 or lower, some of them not significantly different from zero

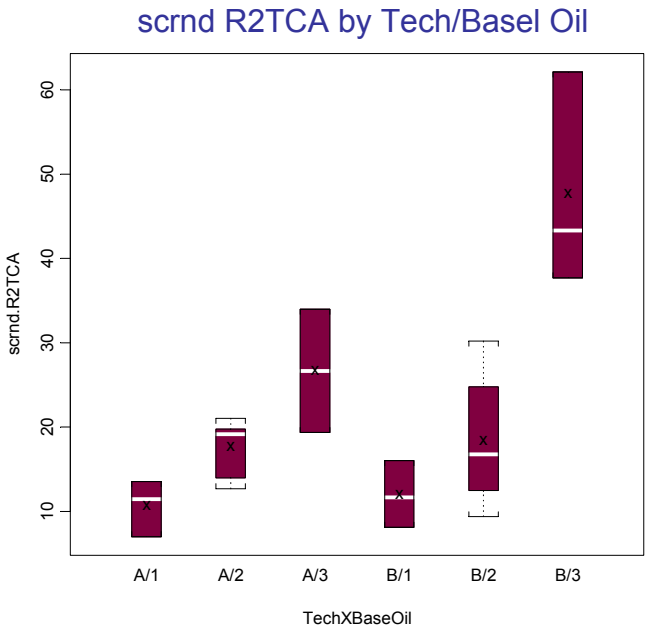
- Precision:
  - E_p is greater than 1 for TLC
  - ~ 0.90 for TGC
  - ~ 0.69 for Delta OC
  - No MAD survey for R2TCA

Parameter versus Tech/Base Oil Combination









Pairwise Correlations: 24 tests

Taking into account the final model for each parameter

Variable	by Variable	Correlation	Count	Signif Prob
Residual scrnd TLC	**Residual Delta OC**	**0.3578**	24	**0.086**
Residual OTGC24	**Residual Delta OC**	**0.398**	24	**0.0541**
Residual OTGC24	Residual scrnd TLC	-0.2718	24	0.1989
Residual LN scrnd R2TCA	**Residual Delta OC**	**0.0784**	24	0.7156
Residual LN scrnd R2TCA	Residual scrnd TLC	0.0594	24	0.7829
Residual LN scrnd R2TCA	Residual OTGC24	0.3057	24	0.1463

24 tests / raw data

Variable	by Variable	Correlation	Count	Signif Prob
scrnd TLC	**Delta OC**	**0.3756**	24	0.0705
OTGC24	**Delta OC**	**0.4481**	24	0.0281
OTGC24	scrnd TLC	0.3053	24	0.1468
scrnd R2TCA	**Delta OC**	**0.1545**	24	0.471
scrnd R2TCA	scrnd TLC	0.4925	24	0.0145
scrnd R2TCA	OTGC24	0.4571	24	0.0247

Precision

- Desirable values for E p are greater than 1
  - E p is greater than 1 for TLC and close to 1 for OTGC

	Precision based on the model		Median of MAD survey	E p1	E p2
Parameter	24 tests	32 tests			
Delta OC	6.52	6.82	4.5	**0.6902**	**0.6598**
OTGC	5.54	5.43	5	**0.9025**	**0.9208**
scrnd TLC	4.02	4.25	4.5	**1.1194**	**1.0588**
LN scrnd R2TCA	0.297 (transf)	0.3 (transf)			
LN scrnd R2TCA	5.22 (around median)				

MAD survey indicates the maximum acceptable difference between two test results on the same formulation

Appendix:

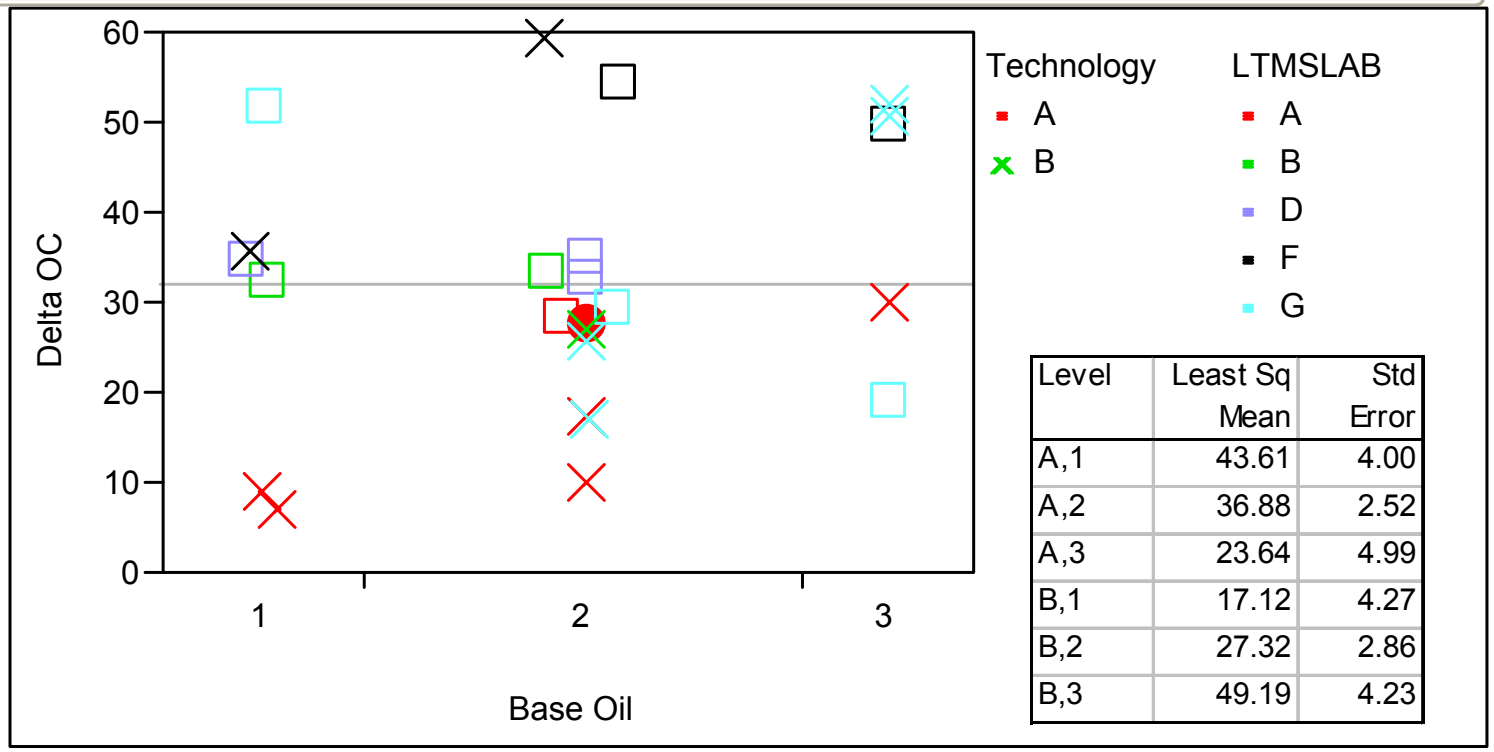
Plots

1. Delta OC versus Base Oil
2. OTGC versus Base Oil
3. scrnd TLC versus Base Oil
4. scrnd R2TCA versus Base Oil

Modeling Summary by parameter

Delta OC versus Base Oil

Delta OC By Base Oil

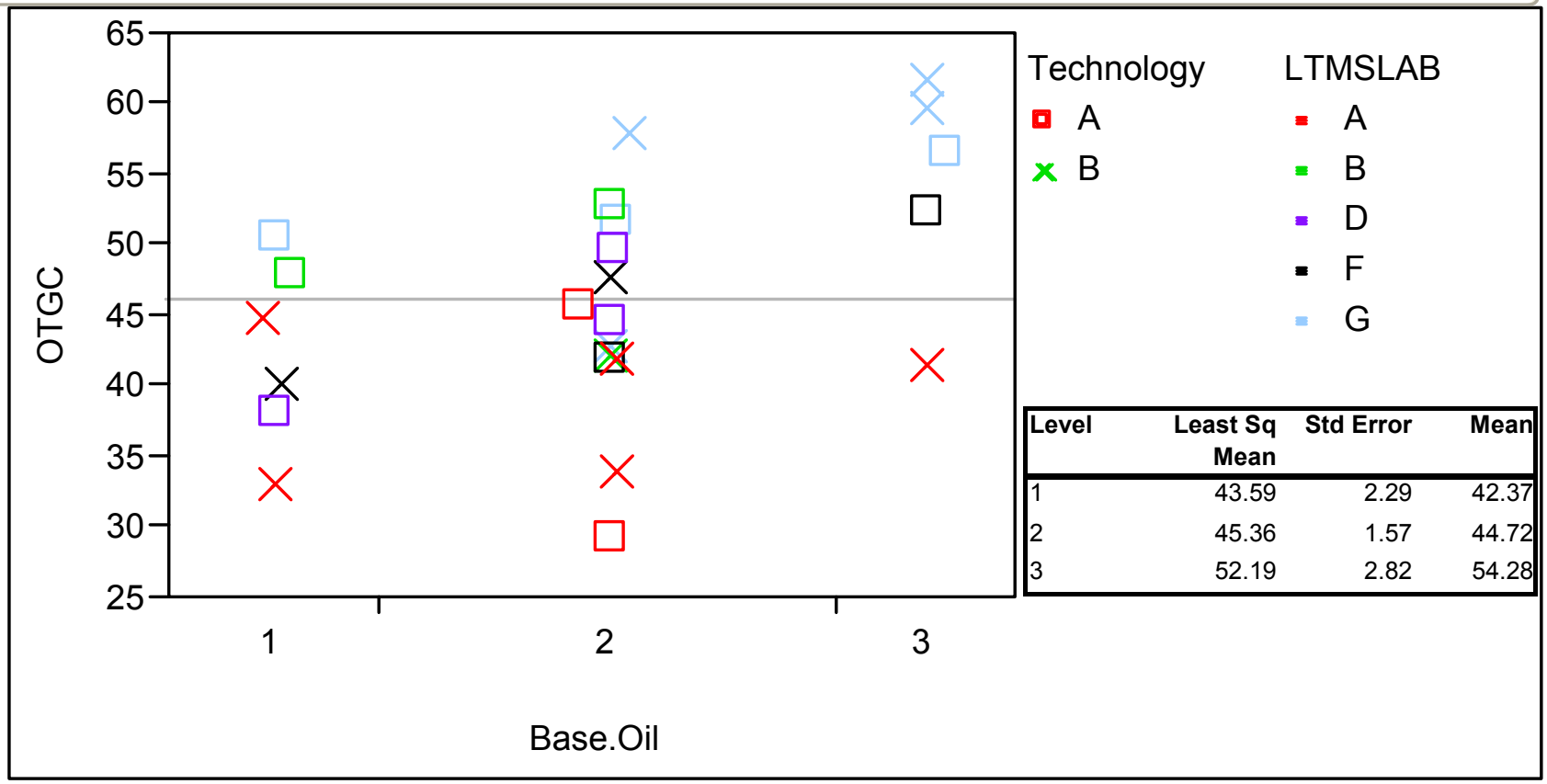


Level	Least Sq Mean	Std Error
A,1	43.61	4.00
A,2	36.88	2.52
A,3	23.64	4.99
B,1	17.12	4.27
B,2	27.32	2.86
B,3	49.19	4.23

Excluded Rows 8

OTGC versus Base Oil

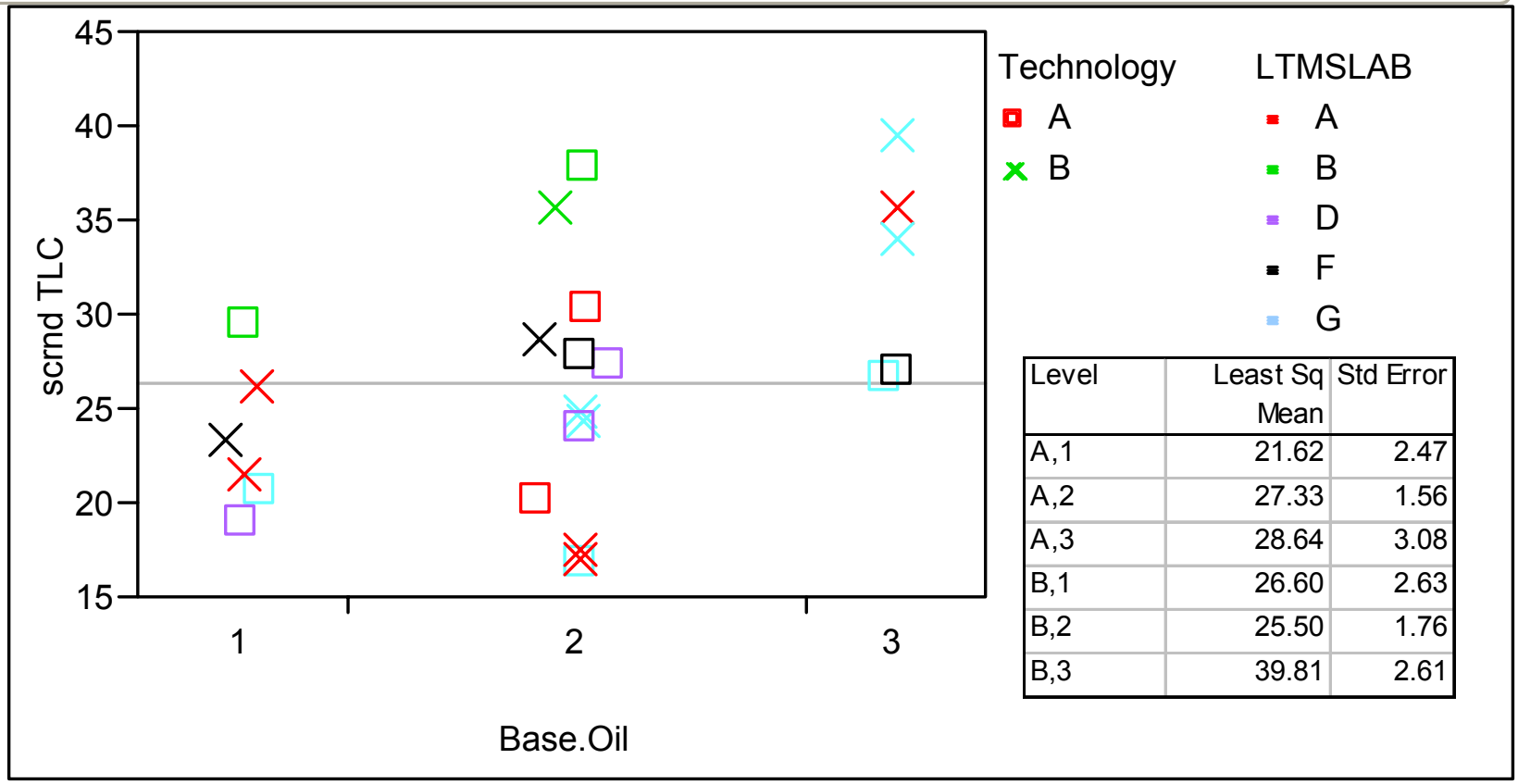
OTGC By Base.Oil



Level	Least Sq Mean	Std Error	Mean
1	43.59	2.29	42.37
2	45.36	1.57	44.72
3	52.19	2.82	54.28

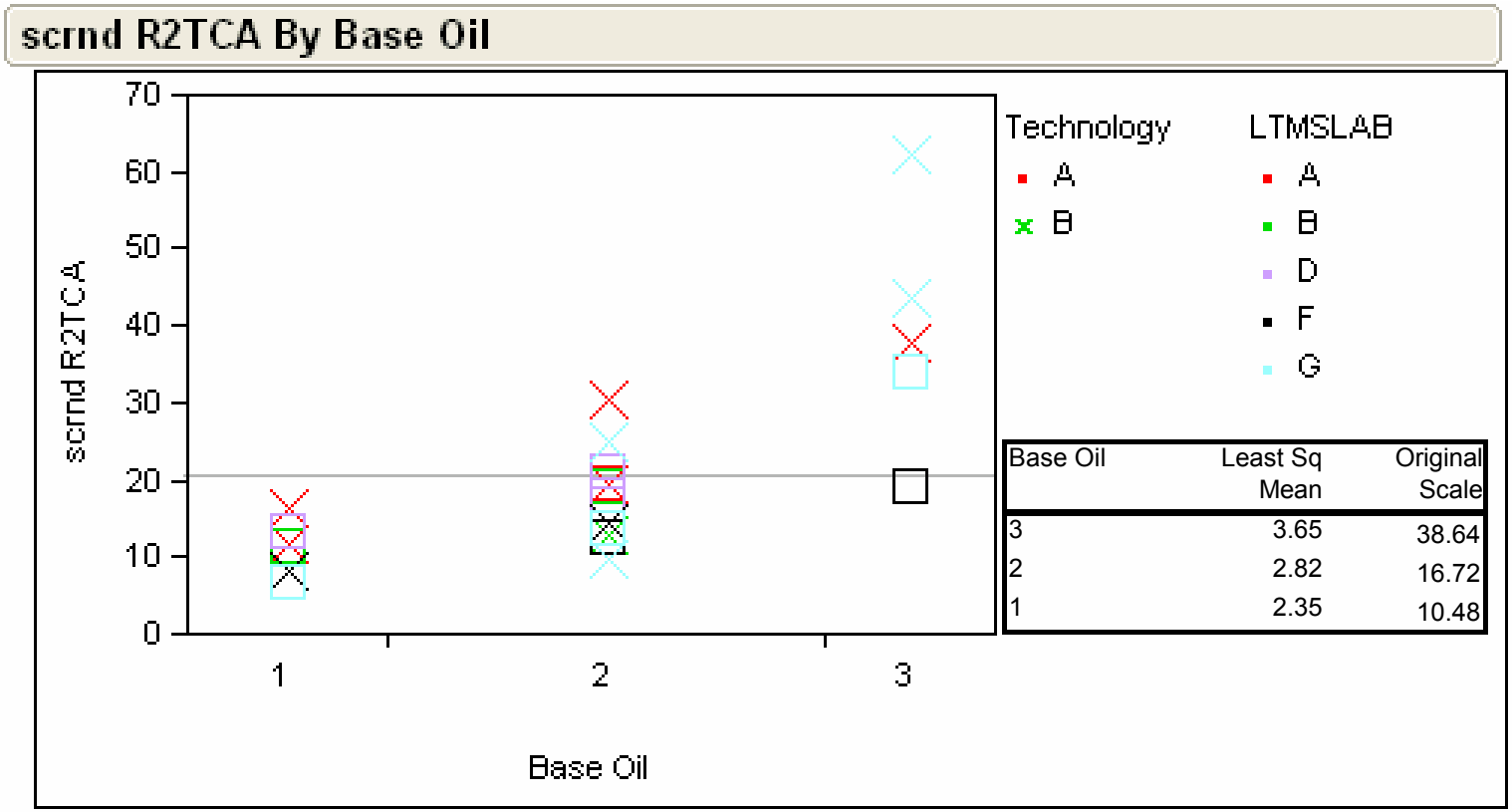
scrnd TLC versus Base Oil

scrnd TLC By Base.Oil



Level	Least Sq Mean	Std Error
A,1	21.62	2.47
A,2	27.33	1.56
A,3	28.64	3.08
B,1	26.60	2.63
B,2	25.50	1.76
B,3	39.81	2.61

scrnd R2TCA versus Base Oil



Modeling Summary by parameter

24 tests analysis based on Technology Type and Base Oil Type					
Parameter	**Transformation**	**Final Model**	**Rsquare adj**	**Precision**	**Lab differences**
Delta OC	None	Lab, Technology, Base Oil and interaction of Technology & Base Oil	81%	6.52	Lab F is different from other labs
OTGC	None	Lab and Base Oil	56%	5.54	Lab A different from Lab G
scrnd TLC	None	Lab, Technology, Base Oil and interaction of Technology & Base Oil	63%	4.02	Lab B is different from other labs
R2TCA *	Natural log	Lab and Base Oil	69%	0.3	Lab A and Lab F (borderline)

* Using the data available; the data issues discussed during the last SP meeting are being addressed