



T-12
Cylinder Liner Wear
&
Top Ring Weight Loss
Data Request

April 14, 2009



Data Request Overview

The following information is presented in response to the ASTM Mack Surveillance Panel's inquiry requesting T-12 wear profiles from the ACC candidate test database. ACC PAPTG requested services of the ACC Monitoring Agency in preparing this information in a manner that would maintain sponsor confidentiality. The ACC Monitoring Agency prepared the data request according to the guidelines established by ACC PAPTG and agreed upon by the ASTM Mack Surveillance Panel:

- A) Calculate the ratio of each cylinder's measured wear parameter results (liner wear and TRWL) to the respective measured average wear result for each test.
- B) Calculate the statistics of these ratios, and report any effects which are statistically significant, e.g. labs, sponsors, absolute average wear amount, EOT date, ring batch, viscosity grade, etc. (Note, based on a pre-analysis discussion with the ACC Monitoring Agency, Surveillance Panel Chairman and an industry statistician it was determined the significance test was not necessary.)
- C) The ACC Monitoring Agency can then provide the average profile ratio values, and graphic depictions of averaged data plotted against any effects of interest (without divulging individual data points).
- D) Explore additive vs. multiplicative profiles by repeating the above analyses with parameters of each cylinder's results' difference from (rather than ratio to) the average result.

For graphical presentation purposes the ACC Monitoring Agency has only shown the 4 largest sponsors and laboratories. The 4 largest sponsors represent 90% of the entire operationally valid ACC T-12 data base. The 4 largest laboratories represent 91% of the entire operationally valid ACC T-12 data base. All data were as measured without any severity adjustments or industry corrections applied.



Cylinder Liner Wear Ratio for each cylinder was calculated as follows:

For Cylinder 1: $CLWRATIO = C1ALW / AMACLW$

For Cylinder 2: $CLWRATIO = C2ALW / AMACLW$

For Cylinder 3: $CLWRATIO = C3ALW / AMACLW$

ETC.

Cylinder Liner Wear Difference for each cylinder was calculated as follows:

For Cylinder 1: $CLWDIFF = C1ALW - AMACLW$

For Cylinder 2: $CLWDIFF = C2ALW - AMACLW$

For Cylinder 3: $CLWDIFF = C3ALW - AMACLW$

Where*:
C X ALW is the Average Cylinder Liner Wear for Cylinder X .
AMAC LW is the as measured test Average Cylinder Liner Wear

- Consult T-12 Data Dictionary & Test Report Forms for mnemonics.

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Top Ring Weight Loss Ratio for each cylinder was calculated as follows:

For Cylinder 1: $TRWLRATIO = TRWL1 / AMATRWL$

For Cylinder 2: $TRWLRATIO = TRWL2 / AMATRWL$

For Cylinder 3: $TRWLRATIO = TRWL3 / AMATRWL$

ETC.

Top Ring Weight Loss Difference for each cylinder was calculated as follows:

For Cylinder 1: $TRWLDIFF = TRWL1 - AMATRWL$

For Cylinder 2: $TRWLDIFF = TRWL2 - AMATRWL$

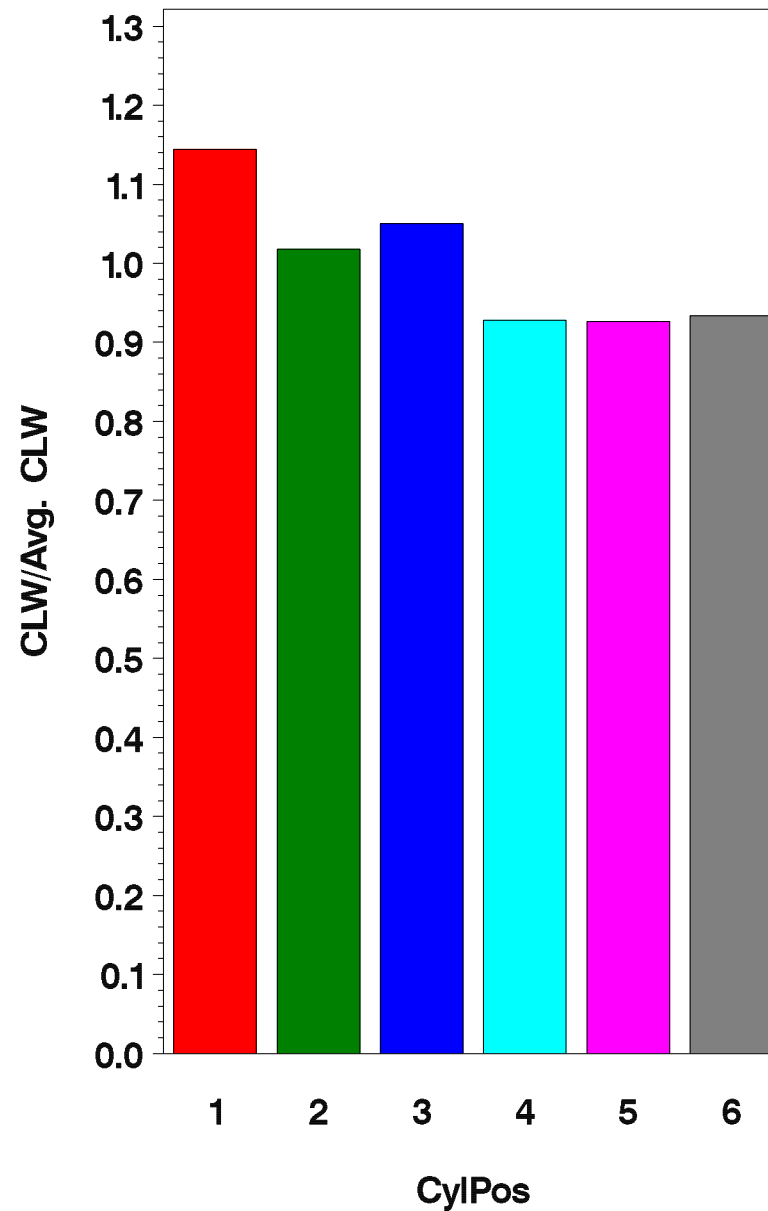
For Cylinder 3: $TRWLDIFF = TRWL3 - AMATRWL$

Where*:
TRWLX is the Top Ring Weight Loss for Cylinder X.
AMATRWL is the as measured test Average Top Ring Weight Loss.

* Consult T-12 Data Dictionary & Test Report Forms for mnemonics.

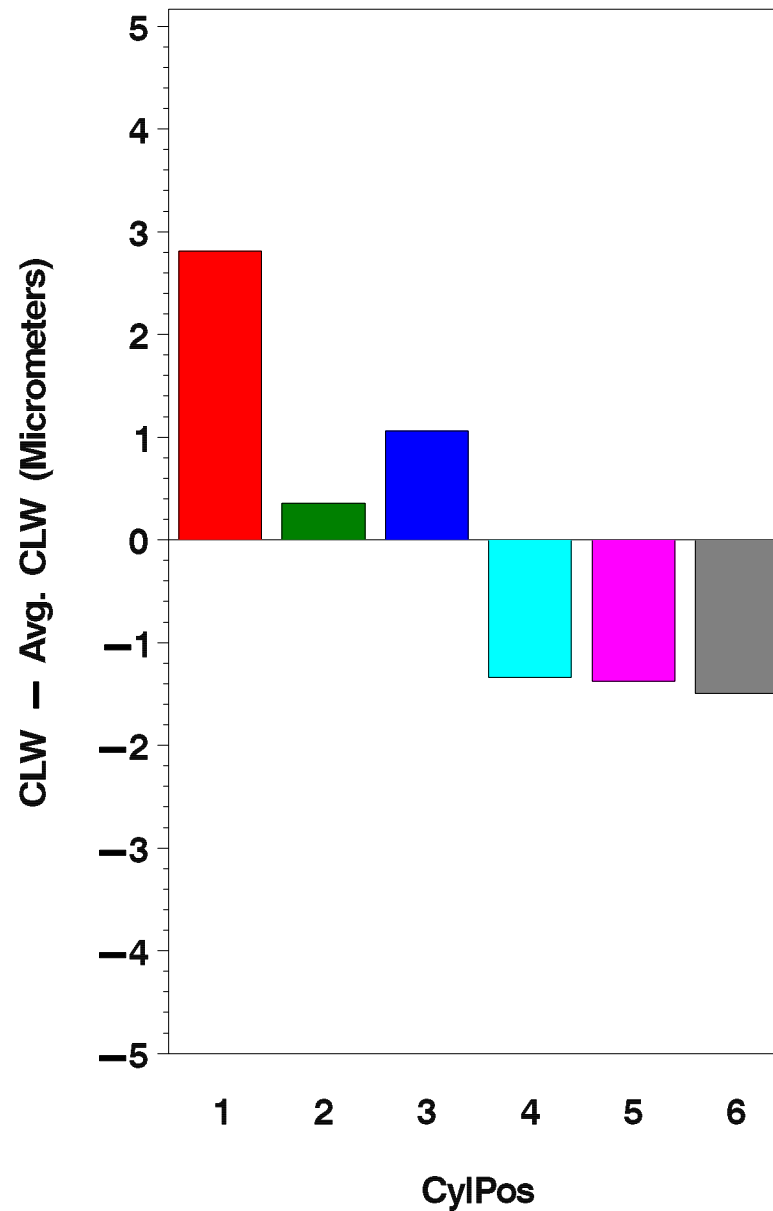


T-12 Cylinder Liner Wear By Cylinder Position





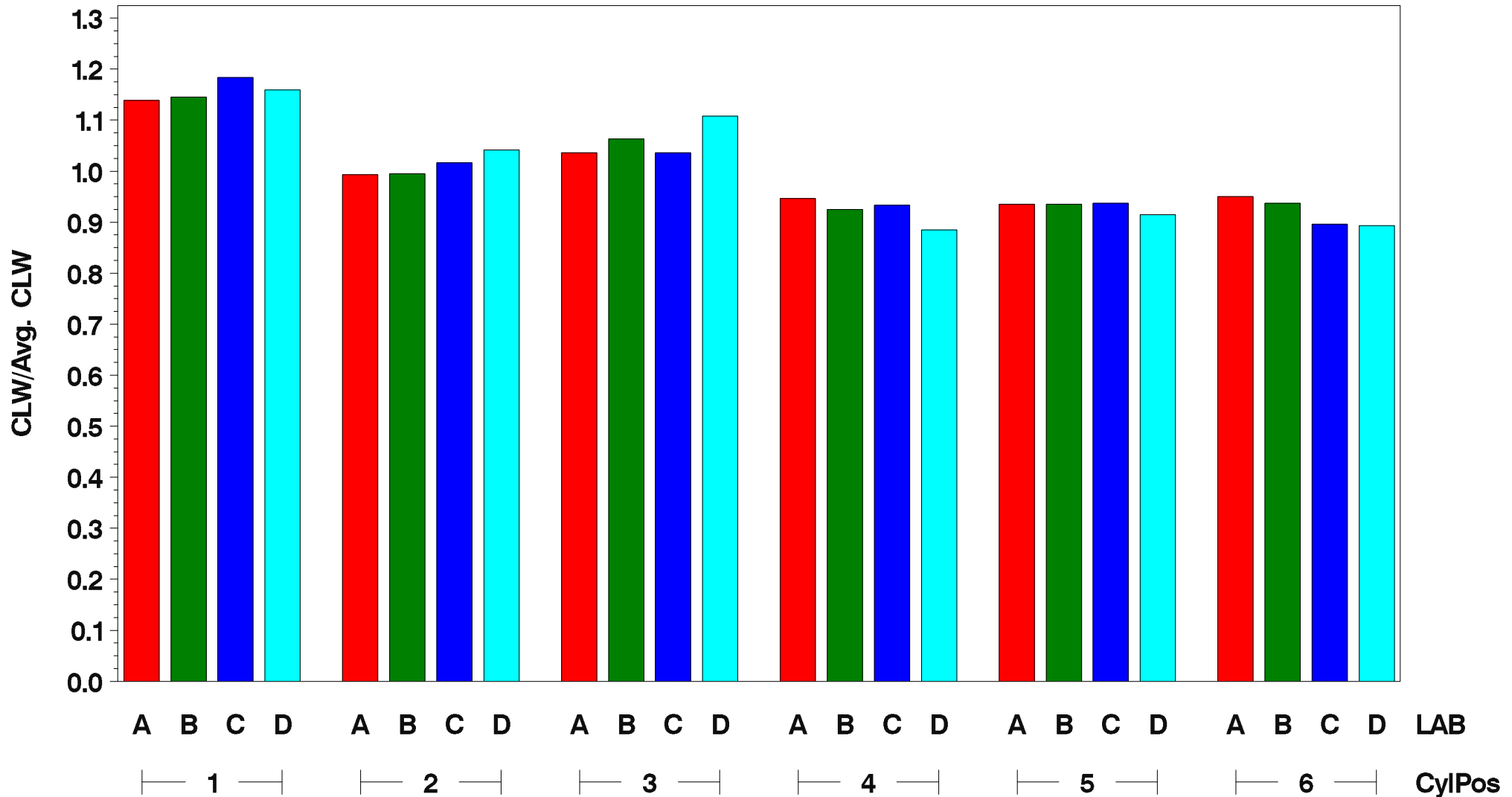
T-12 Cylinder Liner Wear By Cylinder Position





T-12 Average Cylinder Liner Wear By Cylinder Position & Labs

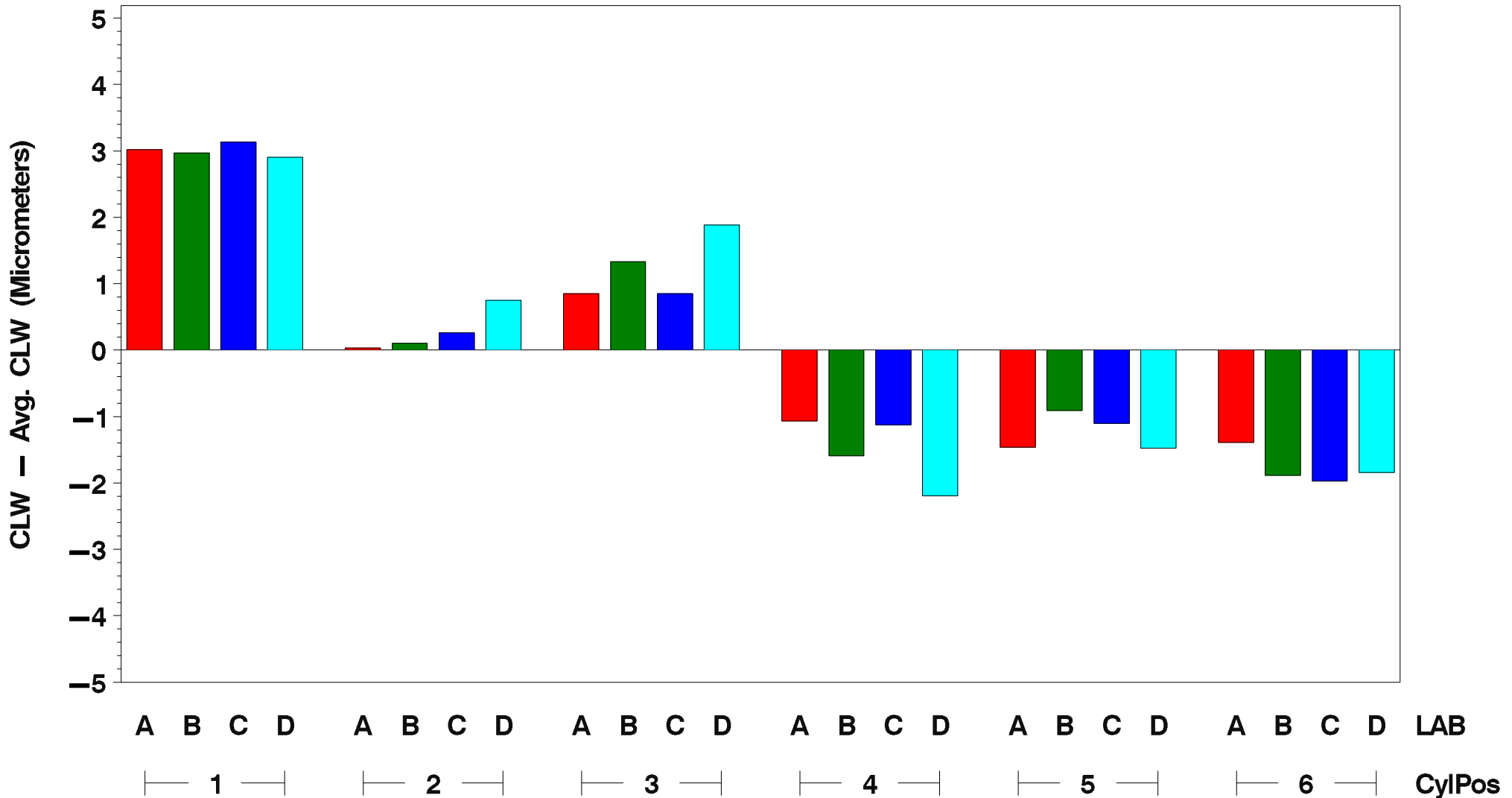
4 Largest Labs





T-12 Average Cylinder Liner Wear By Cylinder Position & Labs

4 Largest Labs



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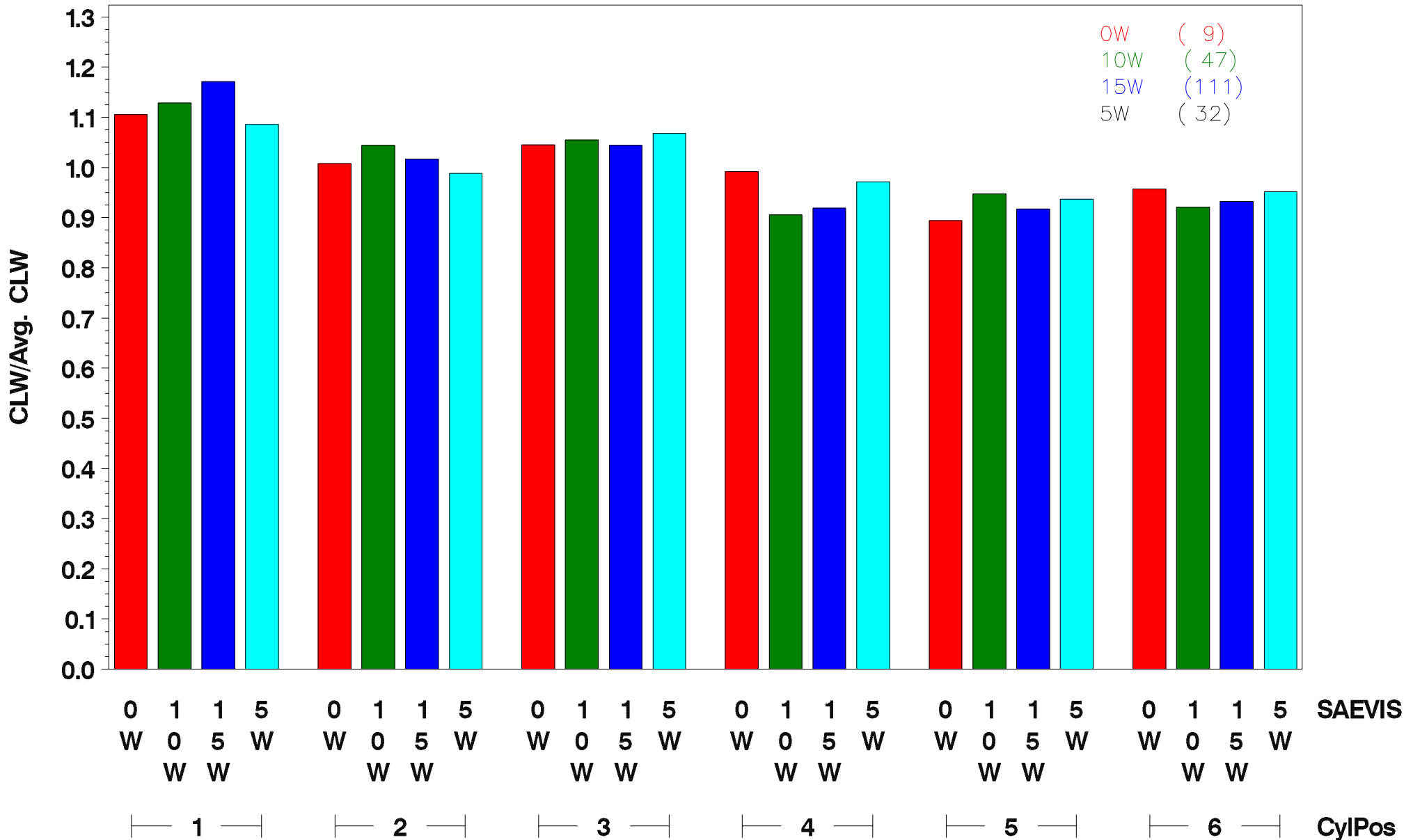
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T-12 Cylinder Liner Wear By Cylinder Position & SAE 'W' Grade



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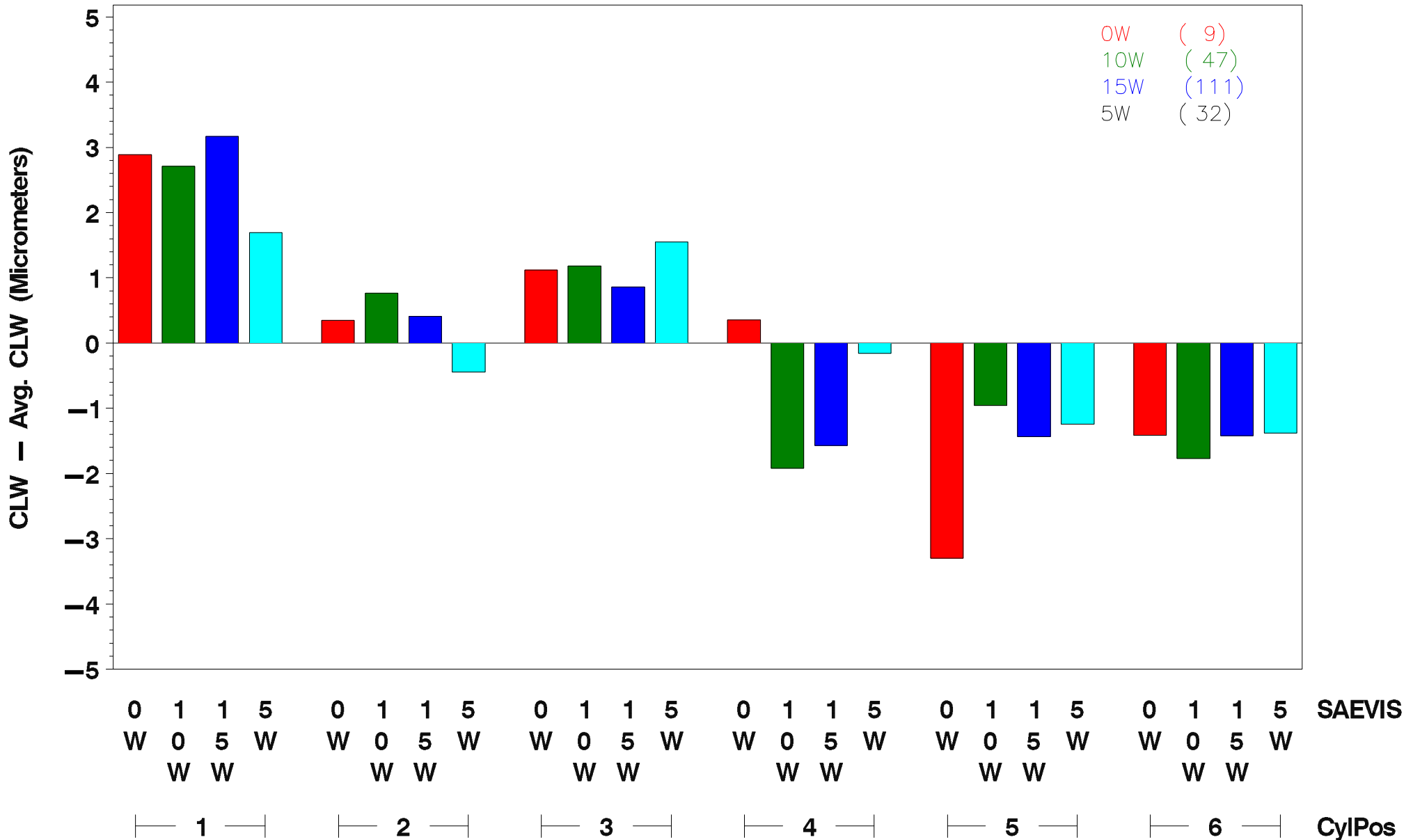
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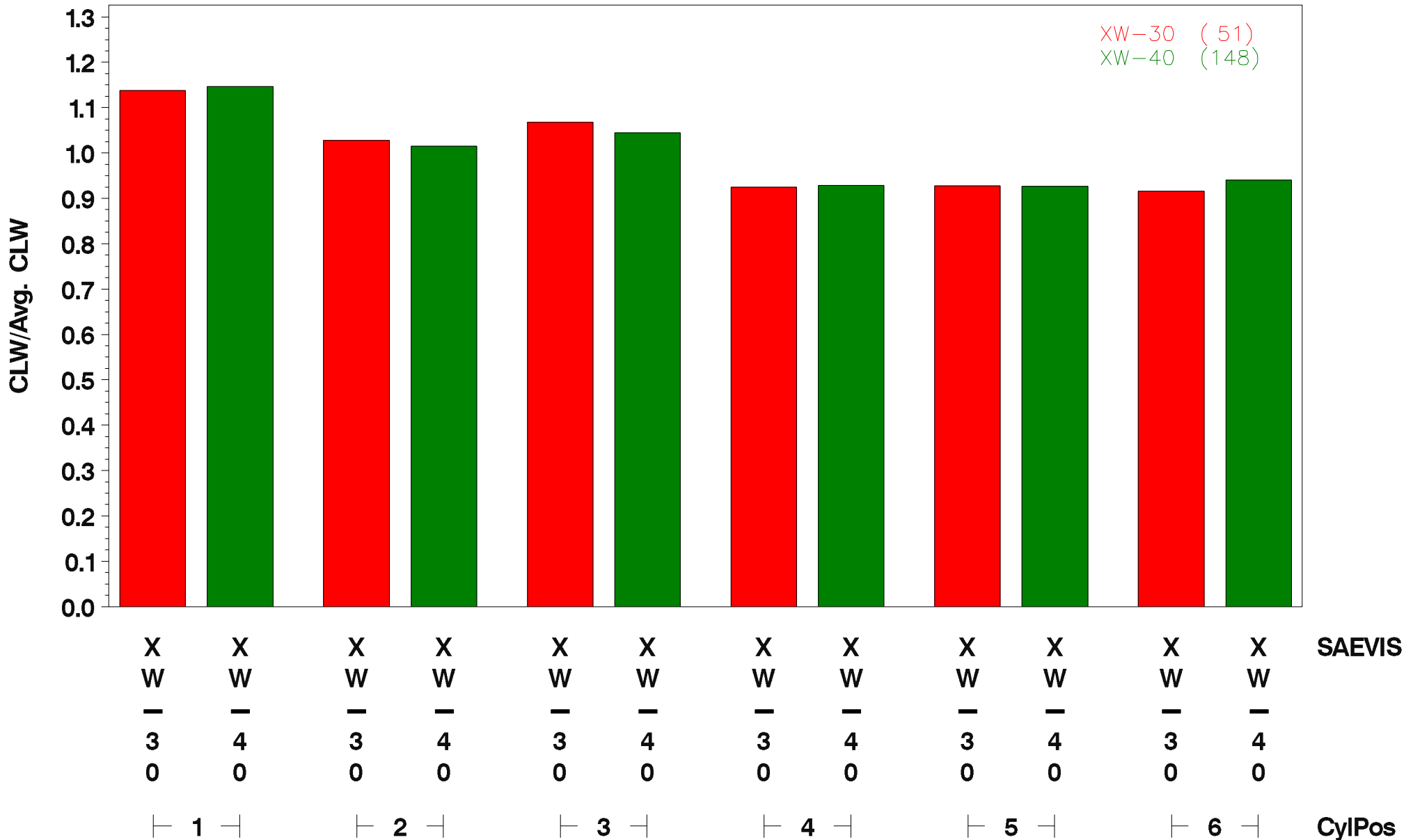
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T-12 Cylinder Liner Wear By Cylinder Position & SAE Viscosity



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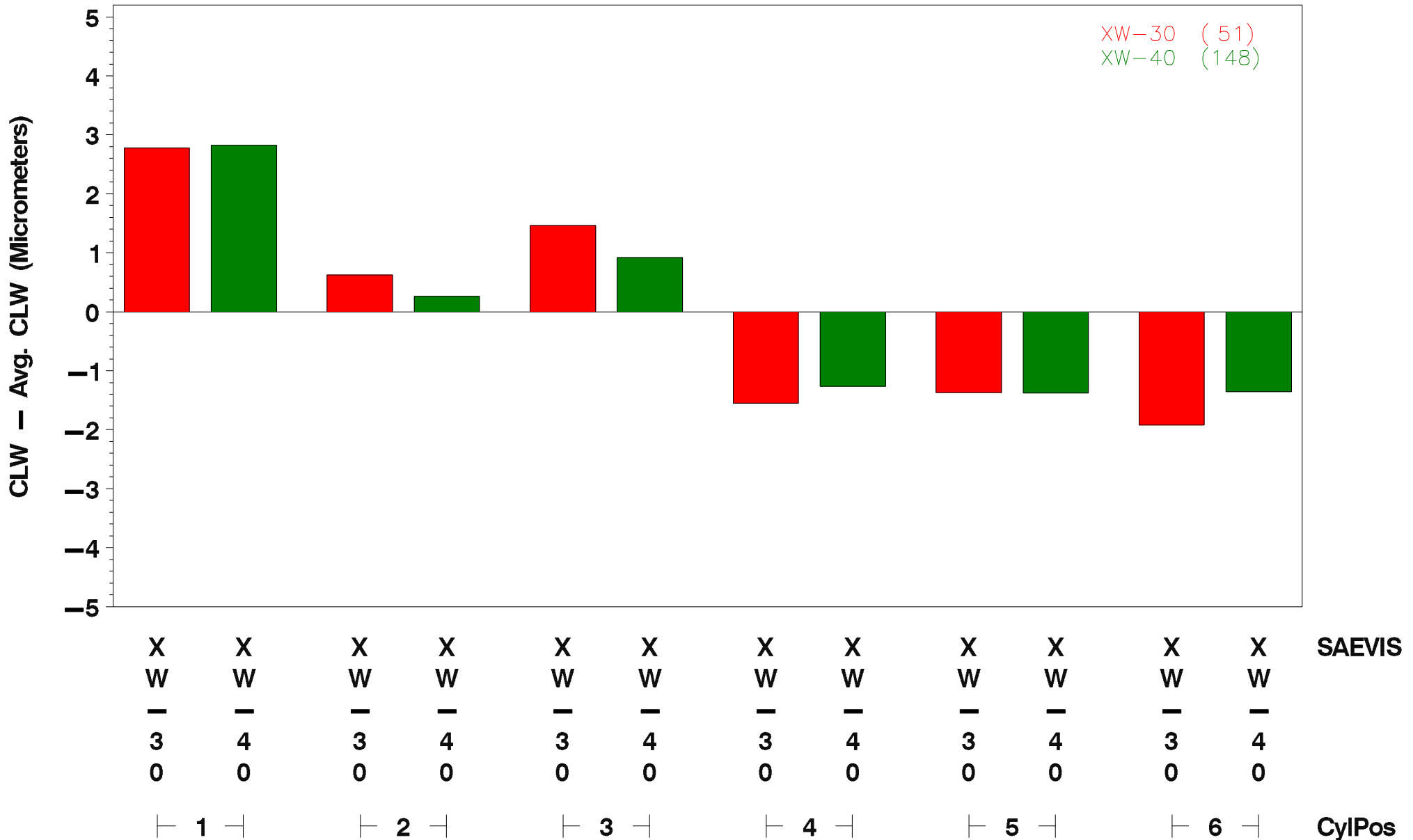
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T-12 Cylinder Liner Wear By Cylinder Position & SAE Viscosity



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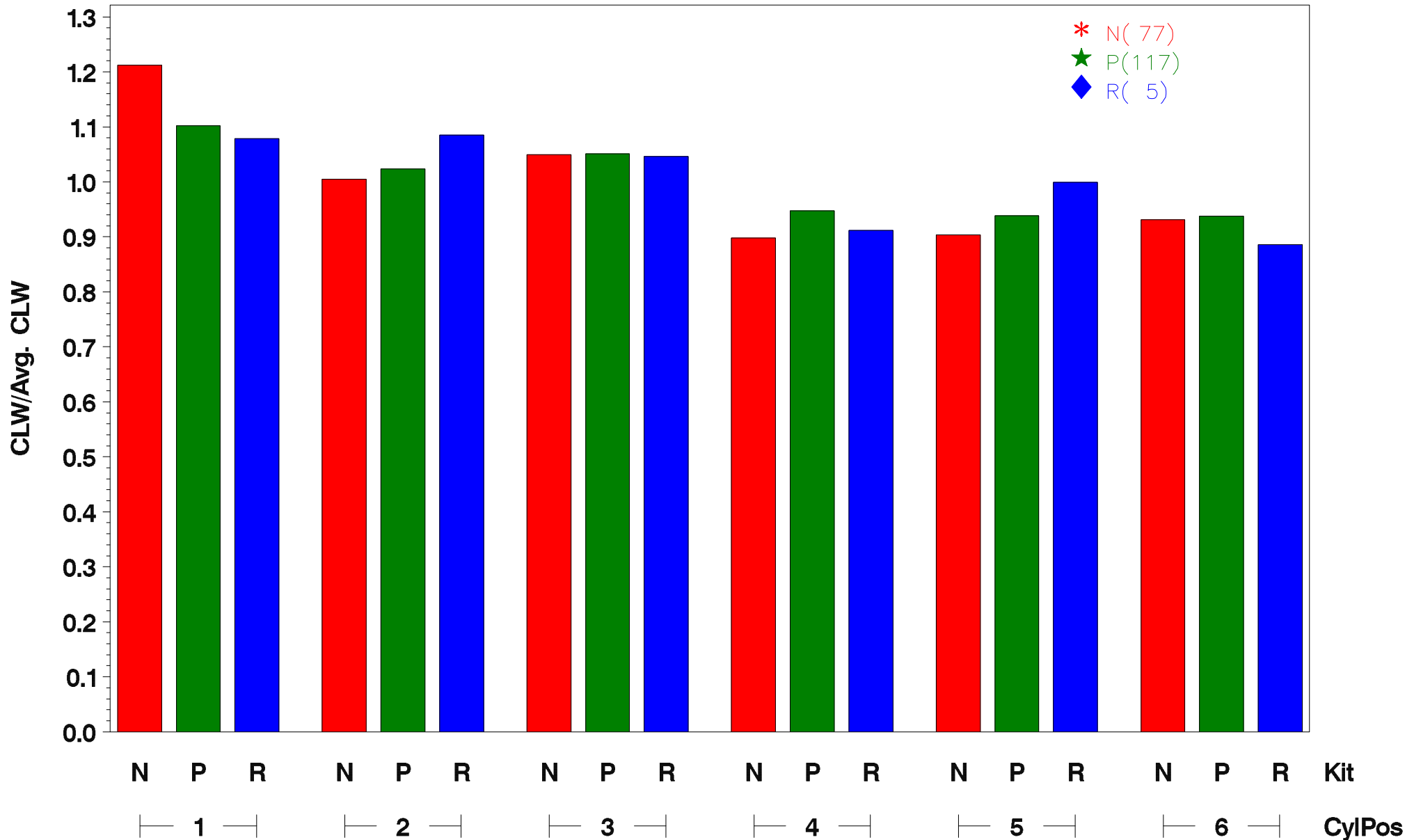
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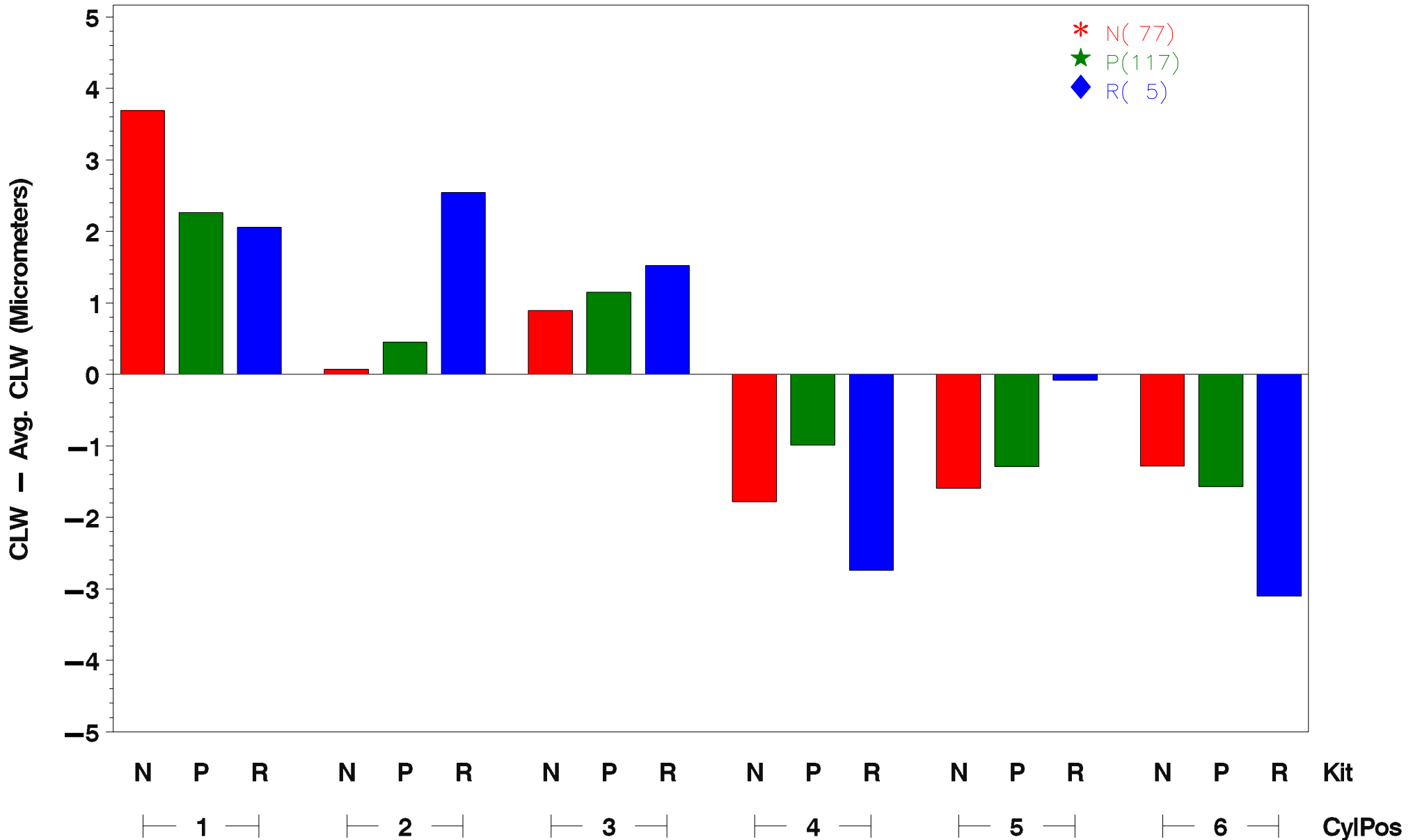
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T-12 Cylinder Liner Wear By Cylinder Position & Kit





T-12 Cylinder Liner Wear By Cylinder Position & Kit



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T-12 Avg. Cylinder Liner Wear Statistics

Group	Subset	Cylinder Position	N-Size	Ratio		Difference	
				Mean	STD	Mean	STD
All	All	1	199	1.14	0.20	2.81	4.09
	All	2	199	1.02	0.14	0.35	3.05
	All	3	199	1.05	0.15	1.06	3.25
	All	4	199	0.93	0.17	-1.34	3.95
	All	5	199	0.93	0.15	-1.38	3.07
	All	6	199	0.93	0.16	-1.50	3.36

Group	Subset	Cylinder Position	N-Size	Ratio		Difference	
				Mean	STD	Mean	STD
Lab	A	1	N/A	1.14	0.19	3.02	4.16
	A	2	N/A	0.99	0.14	0.03	3.57
	A	3	N/A	1.04	0.13	0.85	3.46
	A	4	N/A	0.95	0.20	-1.07	4.88
	A	5	N/A	0.94	0.13	-1.46	3.08
	A	6	N/A	0.95	0.14	-1.39	3.39
	B	1	N/A	1.14	0.24	2.97	5.07
	B	2	N/A	0.99	0.12	0.11	2.74
	B	3	N/A	1.06	0.16	1.33	3.24
	B	4	N/A	0.93	0.14	-1.59	3.35
	B	5	N/A	0.94	0.18	-0.91	3.82
	B	6	N/A	0.94	0.18	-1.88	4.13
	C	1	N/A	1.18	0.18	3.13	3.49
	C	2	N/A	1.02	0.13	0.26	2.50
	C	3	N/A	1.04	0.14	0.85	2.59
	C	4	N/A	0.93	0.14	-1.13	3.24
	C	5	N/A	0.94	0.17	-1.10	3.04
	C	6	N/A	0.90	0.16	-1.97	3.26
	D	1	N/A	1.16	0.21	2.91	4.28
	D	2	N/A	1.04	0.12	0.75	2.10
	D	3	N/A	1.11	0.15	1.88	2.95
	D	4	N/A	0.88	0.13	-2.20	2.56
	D	5	N/A	0.92	0.16	-1.48	3.04
	D	6	N/A	0.89	0.17	-1.84	3.21

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T-12 Avg. Cylinder Liner Wear Statistics

Group	Subset	Cylinder Position	N-Size	Ratio		Difference	
				Mean	STD	Mean	STD
SAEVIS	0W	1	9	1.11	0.08	2.89	2.71
	0W	2	9	1.01	0.19	0.34	5.66
	0W	3	9	1.05	0.18	1.12	3.89
	0W	4	9	0.99	0.18	0.36	6.25
	0W	5	9	0.89	0.17	-3.30	4.75
	0W	6	9	0.96	0.12	-1.41	3.27
	10W	1	47	1.13	0.18	2.71	4.36
	10W	2	47	1.04	0.14	0.77	2.74
	10W	3	47	1.05	0.15	1.18	3.76
	10W	4	47	0.91	0.15	-1.92	3.64
	10W	5	47	0.95	0.15	-0.96	2.98
	10W	6	47	0.92	0.17	-1.77	3.41
	15W	1	111	1.17	0.22	3.17	4.28
	15W	2	111	1.02	0.13	0.41	2.74
	15W	3	111	1.04	0.13	0.86	2.77
	15W	4	111	0.92	0.17	-1.57	3.61
	15W	5	111	0.92	0.15	-1.44	2.86
	15W	6	111	0.93	0.16	-1.42	3.37
	5W	1	32	1.09	0.16	1.69	3.17
	5W	2	32	0.99	0.17	-0.45	3.55
5W	3	32	1.07	0.18	1.55	3.89	
5W	4	32	0.97	0.19	-0.16	4.57	
5W	5	32	0.94	0.16	-1.24	3.28	
5W	6	32	0.95	0.15	-1.38	3.41	

Group	Subset	Cylinder Position	N-Size	Ratio		Difference	
				Mean	STD	Mean	STD
SAEVIS	XW-30	1	51	1.14	0.16	2.78	3.69
	XW-30	2	51	1.03	0.13	0.62	2.88
	XW-30	3	51	1.07	0.15	1.46	3.53
	XW-30	4	51	0.92	0.16	-1.55	3.83
	XW-30	5	51	0.93	0.15	-1.37	2.86
	XW-30	6	51	0.92	0.15	-1.92	3.05
	XW-40	1	148	1.15	0.21	2.82	4.23
	XW-40	2	148	1.01	0.14	0.26	3.11
	XW-40	3	148	1.04	0.15	0.92	3.15
	XW-40	4	148	0.93	0.17	-1.27	4.00
	XW-40	5	148	0.93	0.15	-1.38	3.14
	XW-40	6	148	0.94	0.16	-1.35	3.46

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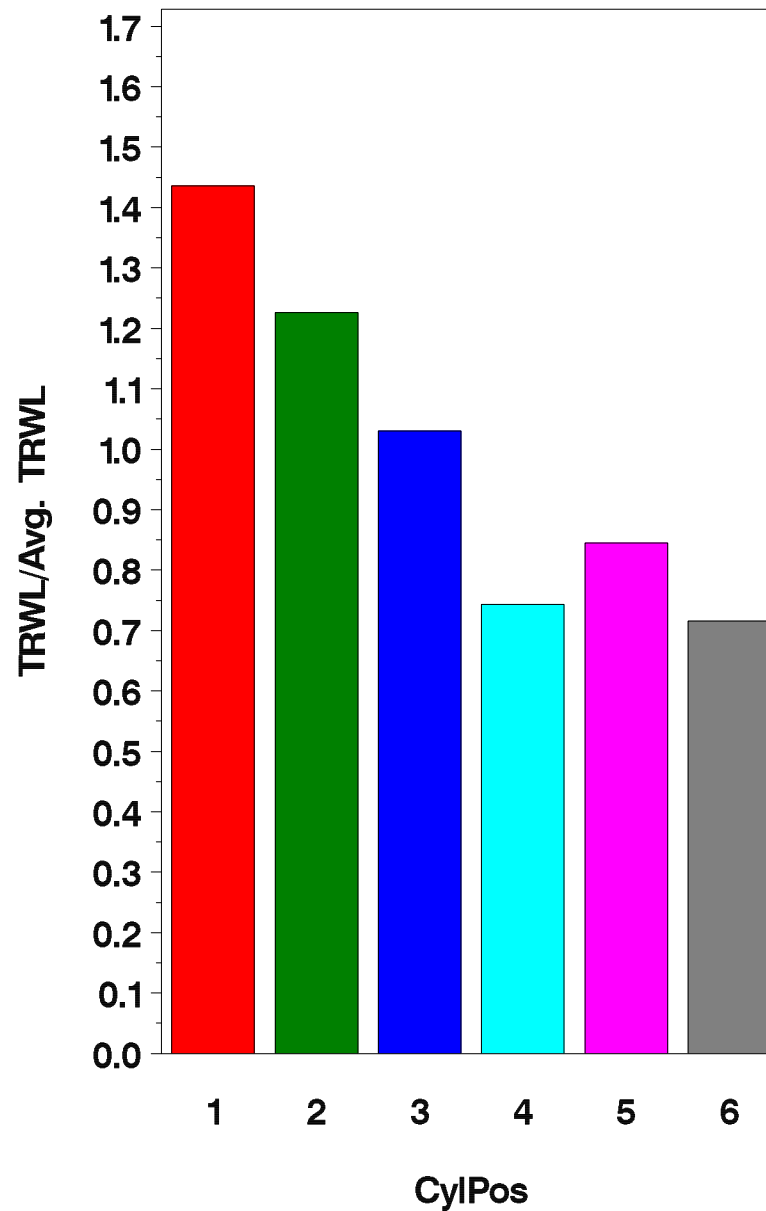
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T-12 Avg. Cylinder Liner Wear

Group	Subset	Cylinder Position	N-Size	Statistics Ratio		Difference	
				Mean	STD	Mean	STD
Kit	N	1	77	1.21	0.20	3.69	3.73
	N	2	77	1.01	0.12	0.07	2.15
	N	3	77	1.05	0.15	0.89	2.50
	N	4	77	0.90	0.16	-1.78	3.09
	N	5	77	0.90	0.17	-1.59	2.97
	N	6	77	0.93	0.16	-1.28	2.79
	P	1	117	1.10	0.19	2.26	4.04
	P	2	117	1.02	0.15	0.45	3.52
	P	3	117	1.05	0.15	1.15	3.65
	P	4	117	0.95	0.18	-0.99	4.44
	P	5	117	0.94	0.14	-1.29	3.15
	P	6	117	0.94	0.15	-1.57	3.61
	R	1	5	1.08	0.27	2.06	8.19
	R	2	5	1.09	0.09	2.54	2.67
	R	3	5	1.05	0.13	1.52	4.17
	R	4	5	0.91	0.11	-2.74	3.19
	R	5	5	1.00	0.09	-0.08	2.67
	R	6	5	0.89	0.18	-3.10	5.39

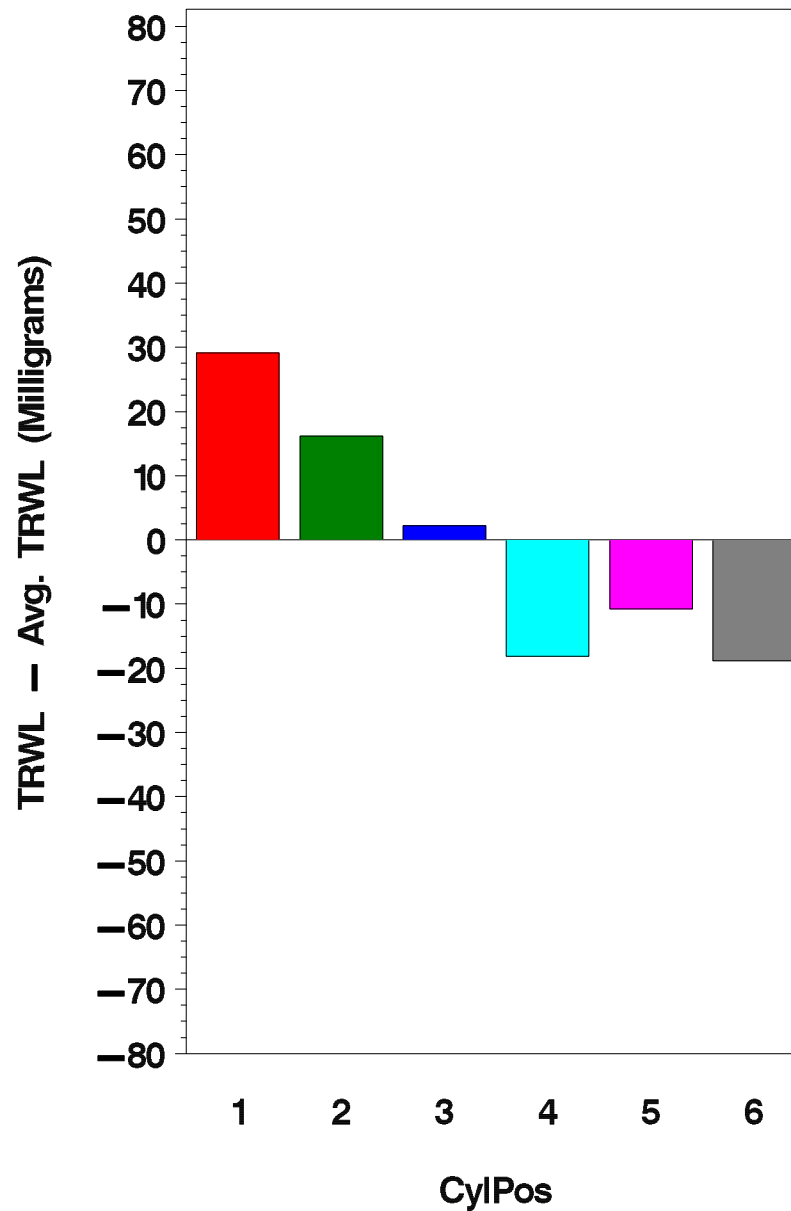


T-12 Top Ring Weight Loss By Cylinder Position



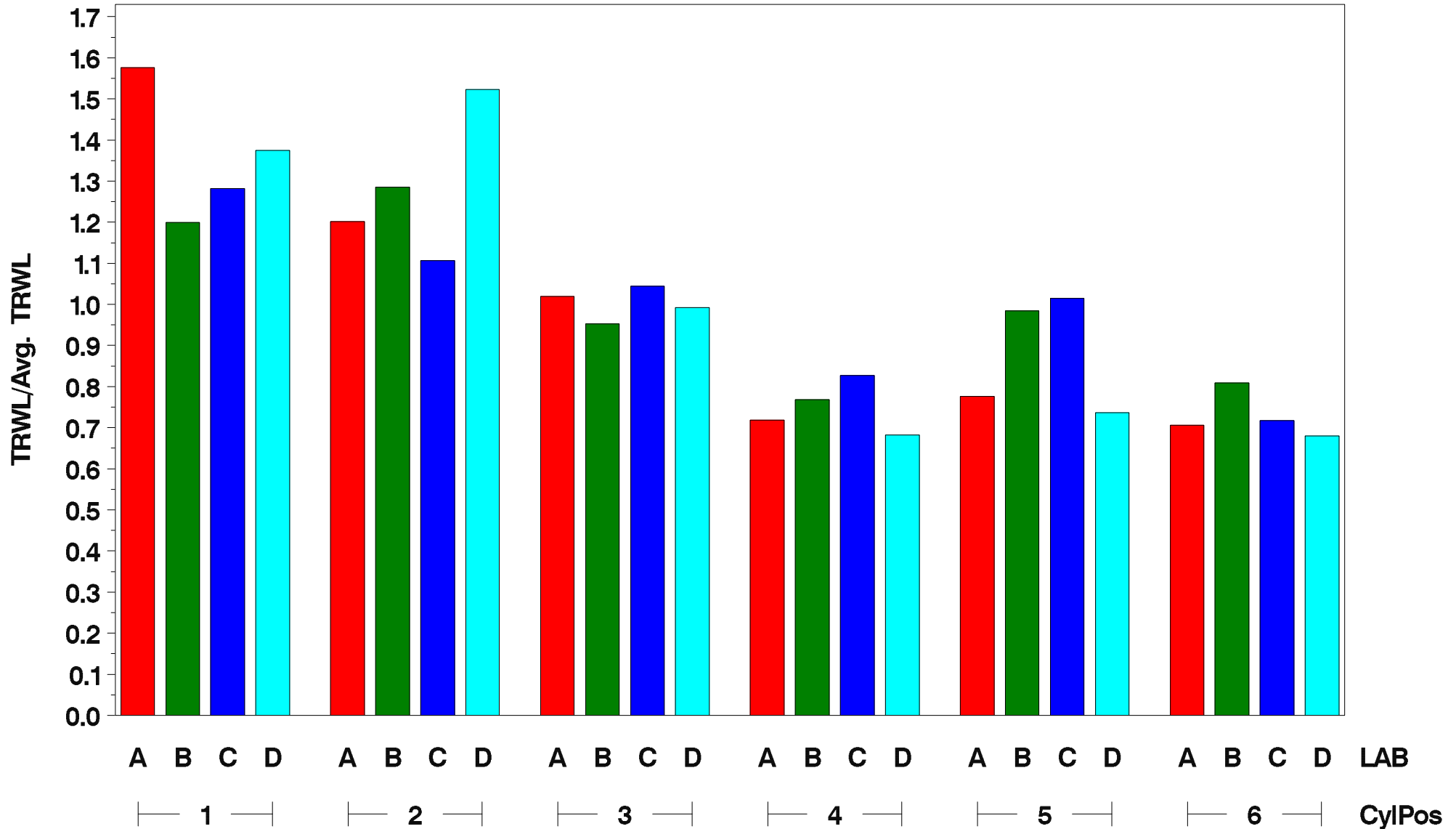


T-12 Top Ring Weight Loss By Cylinder Position



T-12 Top Ring Weight Loss By Cylinder Position & Labs

4 Largest Labs



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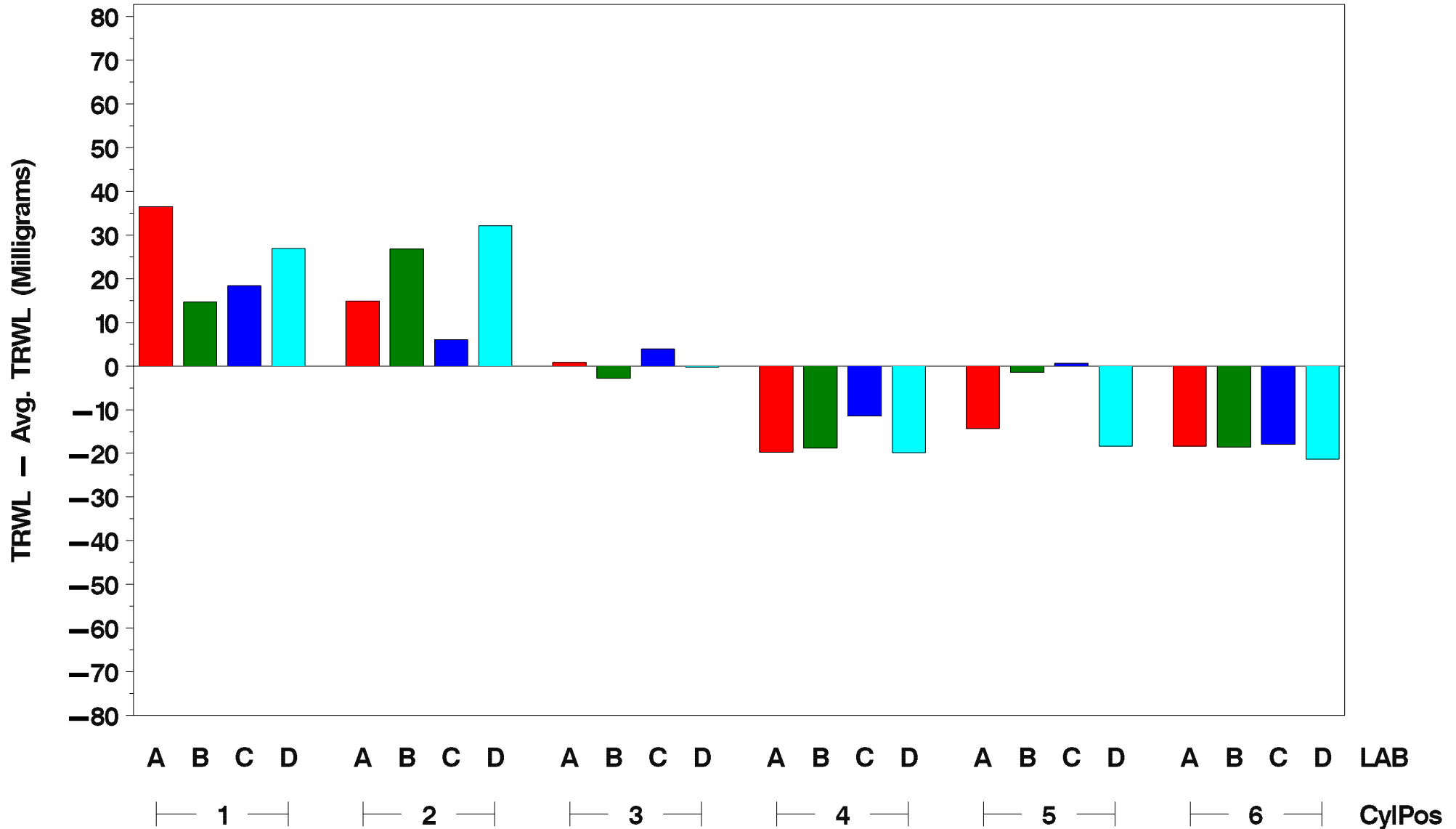
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T-12 Top Ring Weight Loss By Cylinder Position & Labs

4 Largest Labs



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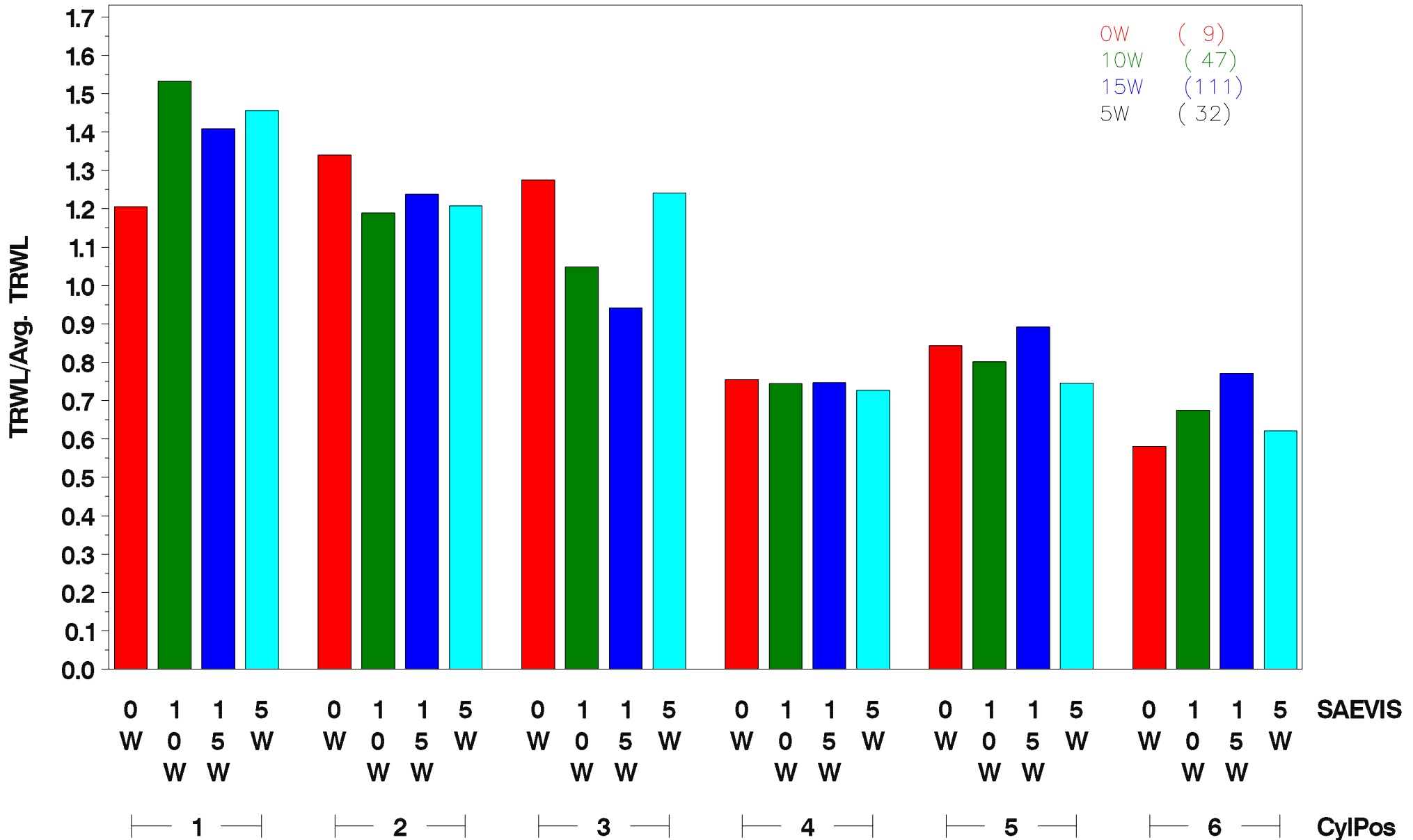
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T-12 Top Ring Weight Loss By Cylinder Position & SAE 'W'



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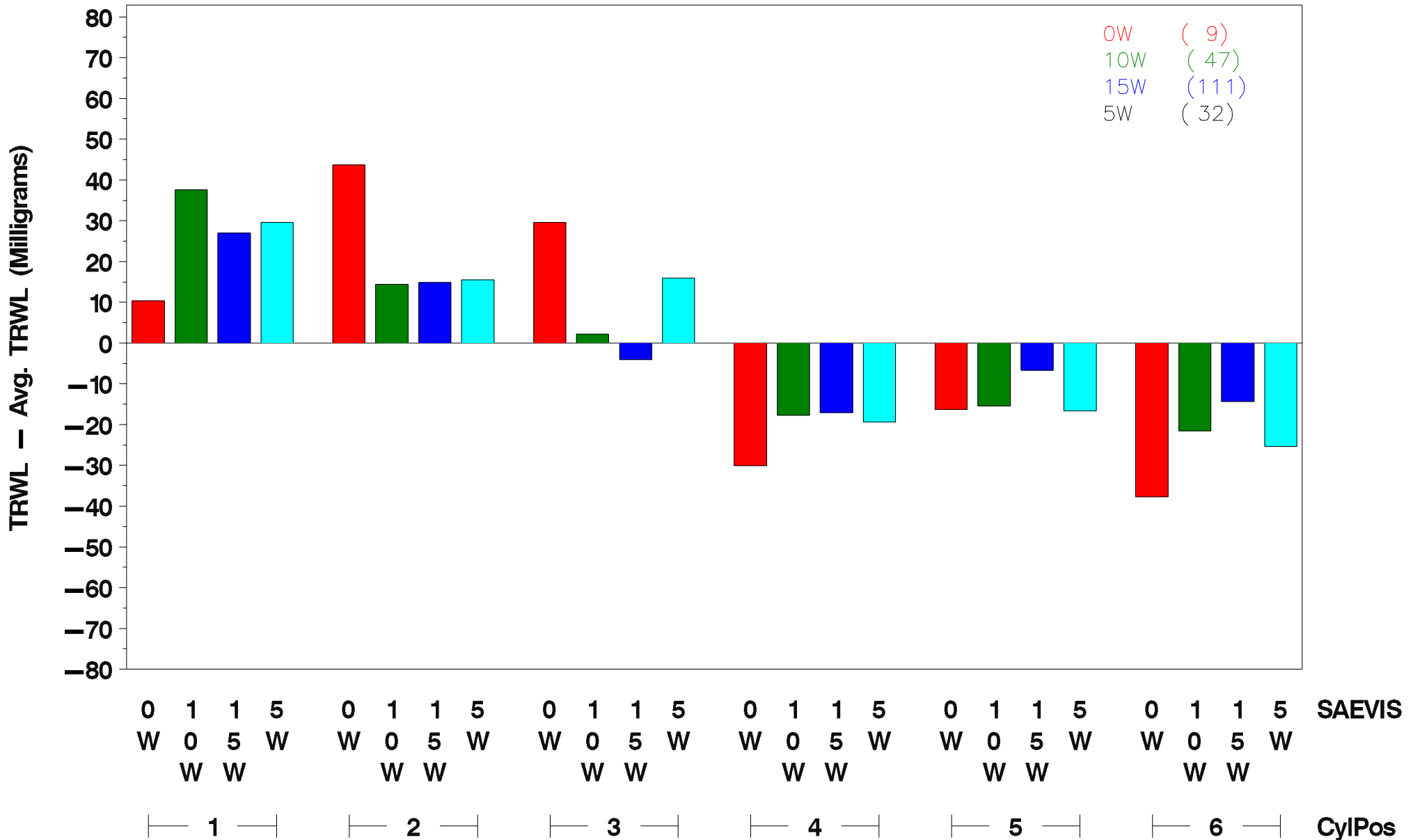
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T-12 Top Ring Weight Loss By Cylinder Position & SAE 'W'



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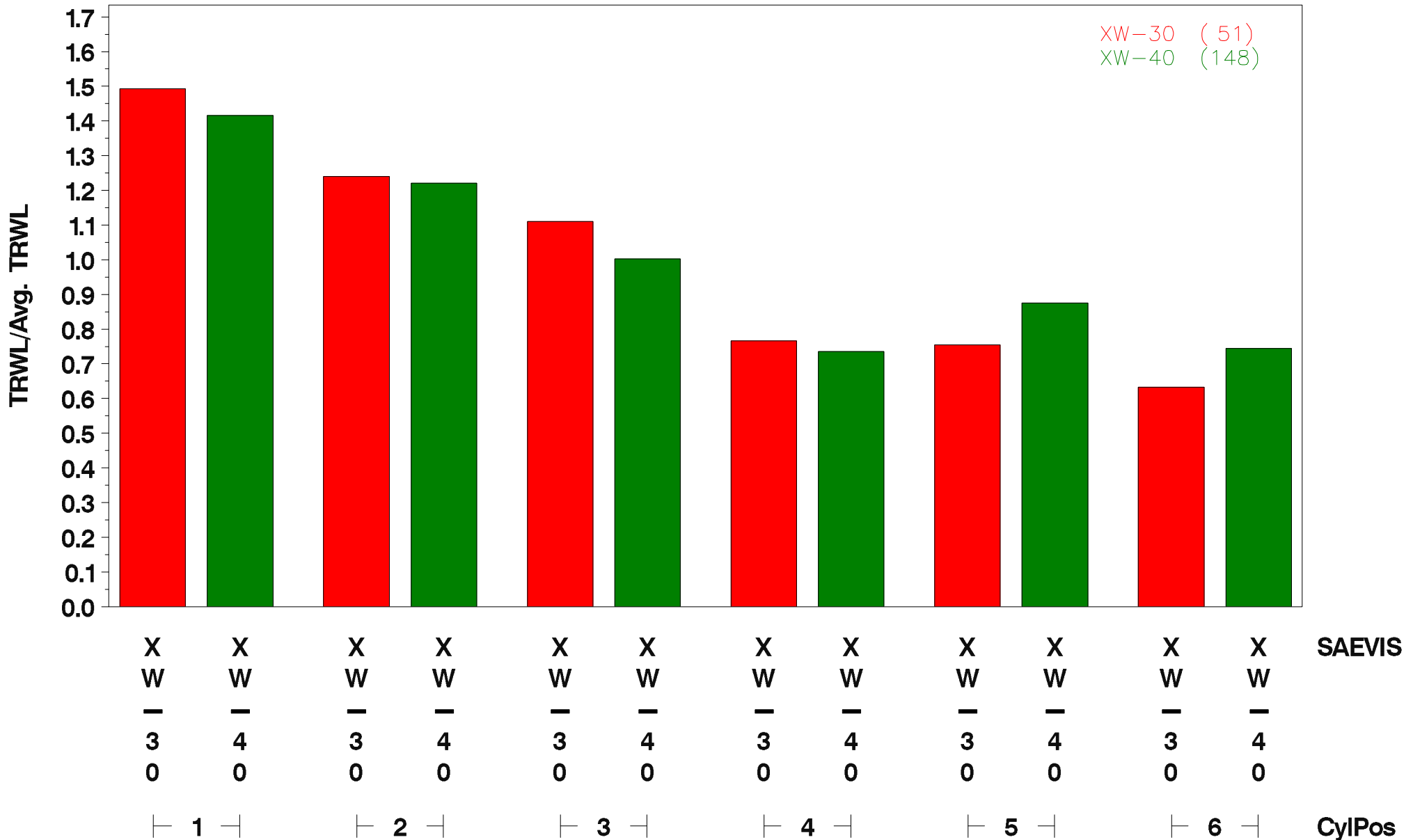
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T-12 Top Ring Weight Loss By Cylinder Position & SAE Viscosity



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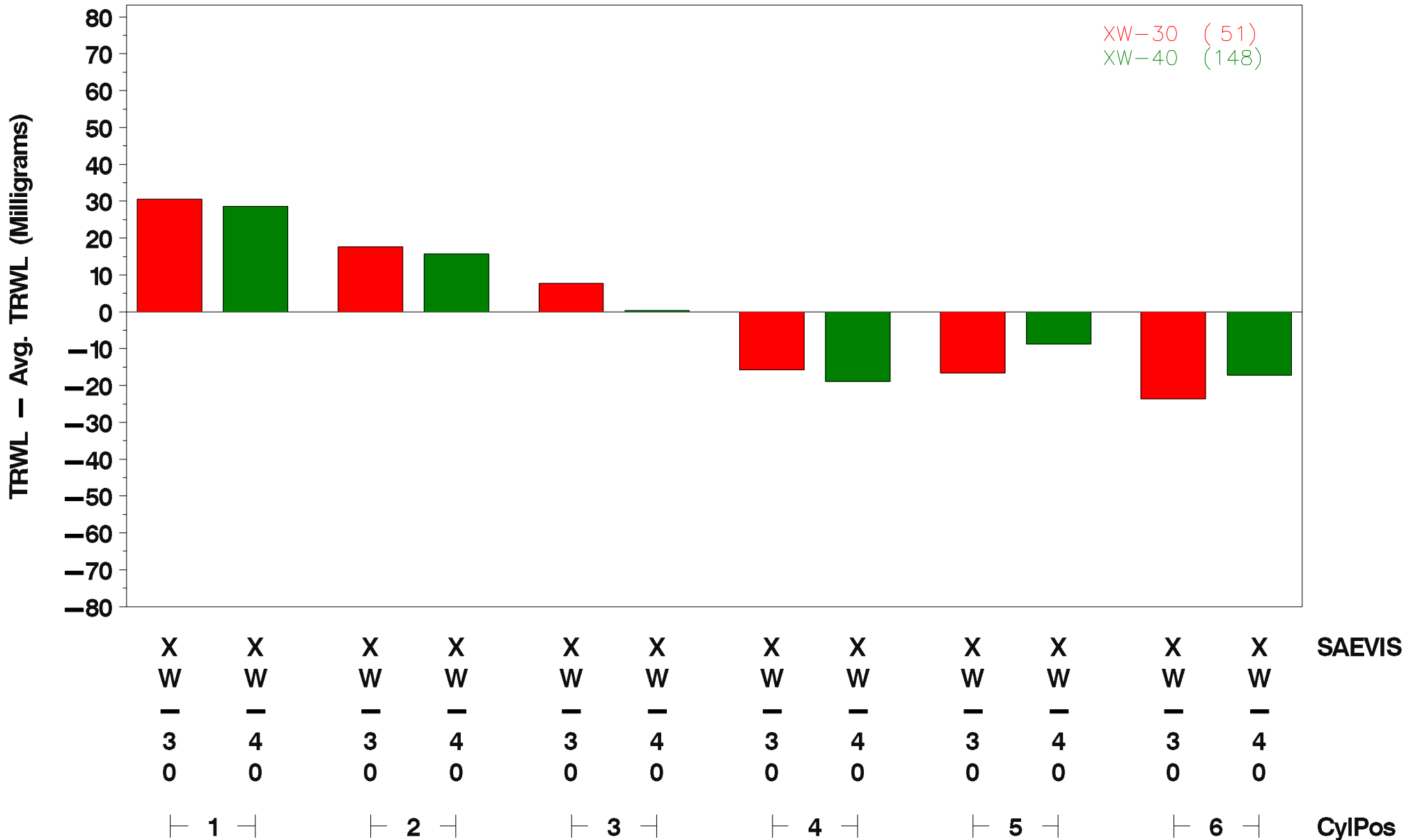
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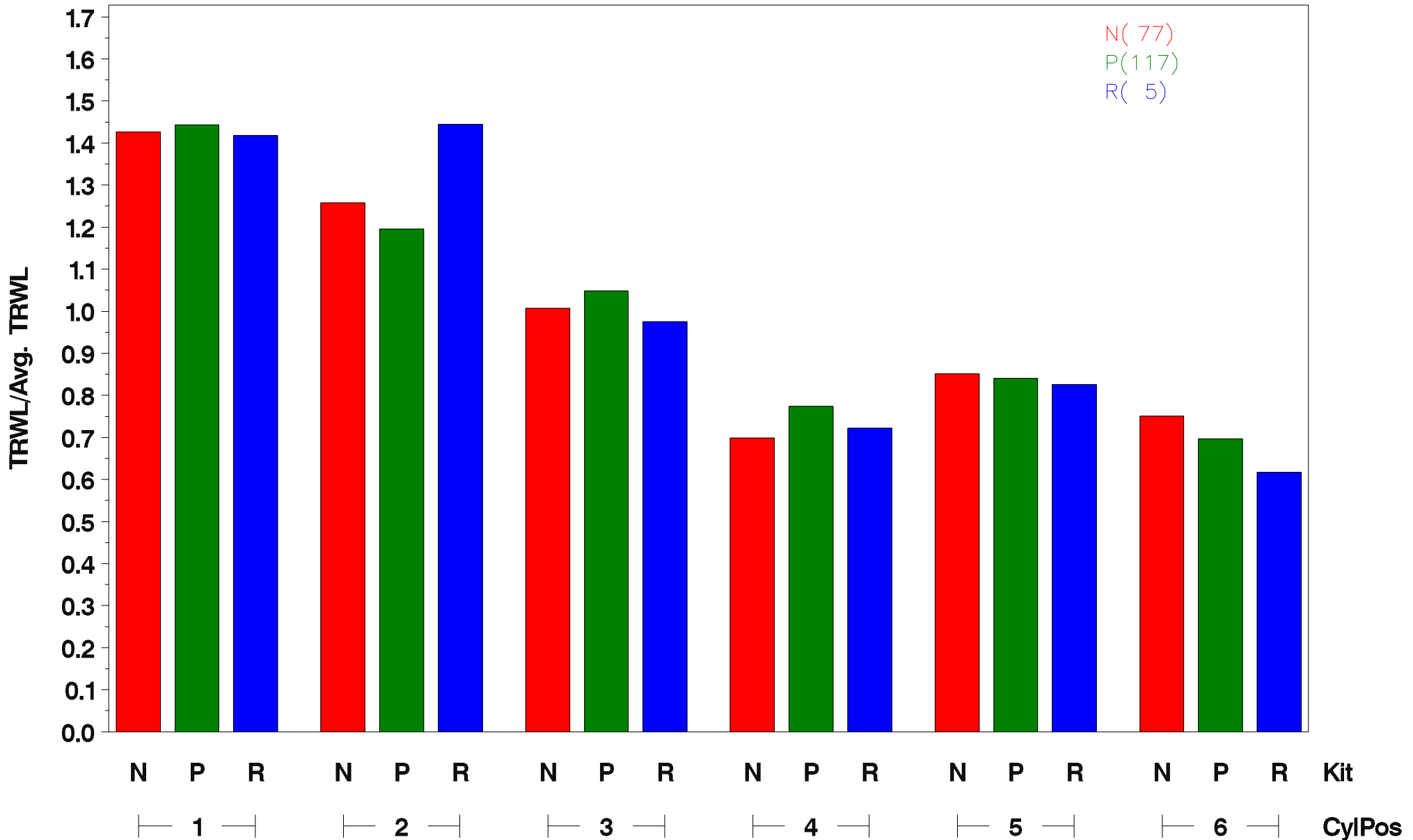
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T-12 Top Ring Weight Loss By Cylinder Position & SAE Viscosity



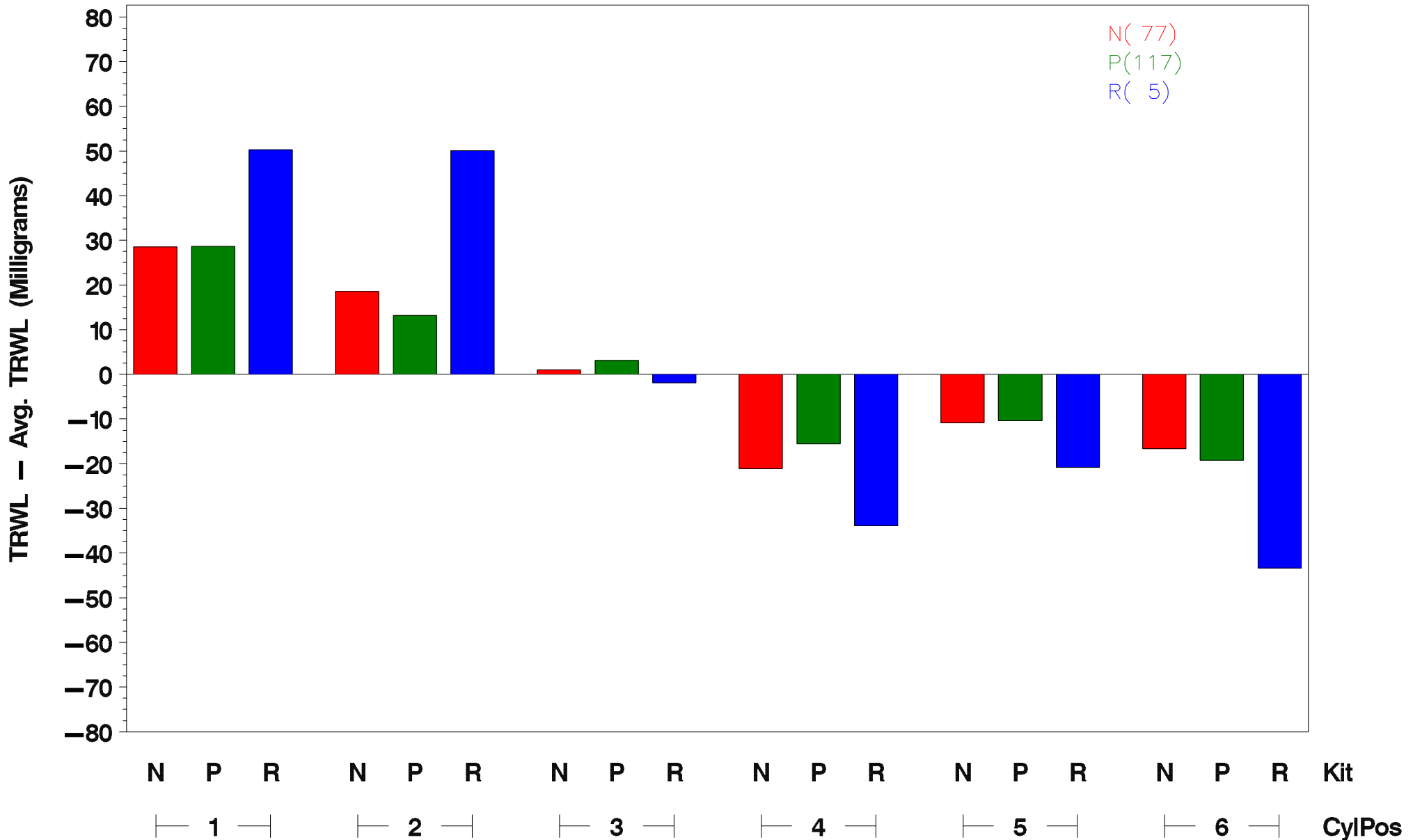


T-12 Top Ring Weight Loss By Cylinder Position & Kit





T-12 Top Ring Weight Loss By Cylinder Position & Kit



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T-12 Top Ring Weight Loss Statistics

Group	Subset	Cylinder Position	N-Size	Ratio		Difference	
				Mean	STD	Mean	STD
All	All	1	199	1.44	0.45	29.14	34.57
	All	2	199	1.23	0.41	16.15	30.99
	All	3	199	1.03	0.37	2.18	27.47
	All	4	199	0.74	0.28	-18.14	22.29
	All	5	199	0.84	0.34	-10.77	24.79
	All	6	199	0.72	0.29	-18.83	22.82

Group	Subset	Cylinder Position	N-Size	Ratio		Difference	
				Mean	STD	Mean	STD
Lab	A	1	N/A	1.58	0.44	36.44	32.07
	A	2	N/A	1.20	0.42	14.86	35.29
	A	3	N/A	1.02	0.35	0.80	24.42
	A	4	N/A	0.72	0.28	-19.70	22.65
	A	5	N/A	0.78	0.29	-14.26	22.86
	A	6	N/A	0.71	0.29	-18.31	21.96
	B	1	N/A	1.20	0.45	14.67	42.60
	B	2	N/A	1.29	0.33	26.76	31.56
	B	3	N/A	0.95	0.51	-2.76	47.95
	B	4	N/A	0.77	0.27	-18.80	25.87
	B	5	N/A	0.98	0.40	-1.37	30.47
	B	6	N/A	0.81	0.39	-18.58	38.13
	C	1	N/A	1.28	0.45	18.42	32.05
	C	2	N/A	1.11	0.40	6.00	23.79
	C	3	N/A	1.04	0.32	3.88	21.17
	C	4	N/A	0.83	0.34	-11.44	22.41
	C	5	N/A	1.01	0.37	0.60	24.50
	C	6	N/A	0.72	0.33	-17.95	21.48
	D	1	N/A	1.37	0.36	26.90	32.37
	D	2	N/A	1.52	0.38	32.10	25.21
	D	3	N/A	0.99	0.32	-0.20	19.32
	D	4	N/A	0.68	0.18	-19.84	13.70
	D	5	N/A	0.74	0.27	-18.33	19.51
	D	6	N/A	0.68	0.18	-21.35	16.21

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T-12 Top Ring Weight Loss Statistics

Group	Subset	Cylinder Position	N-Size	Ratio		Difference	
				Mean	STD	Mean	STD
SAEVIS	0W	1	9	1.20	0.50	10.37	58.10
	0W	2	9	1.34	0.69	43.67	76.30
	0W	3	9	1.28	0.52	29.60	58.88
	0W	4	9	0.75	0.29	-30.06	36.70
	0W	5	9	0.84	0.37	-16.27	39.00
	0W	6	9	0.58	0.23	-37.66	30.61
	10W	1	47	1.53	0.48	37.52	37.58
	10W	2	47	1.19	0.37	14.42	28.54
	10W	3	47	1.05	0.38	2.17	26.94
	10W	4	47	0.74	0.33	-17.69	24.13
	10W	5	47	0.80	0.29	-15.40	24.14
	10W	6	47	0.67	0.24	-21.49	19.16
	15W	1	111	1.41	0.44	26.97	31.57
	15W	2	111	1.24	0.39	14.83	25.38
	15W	3	111	0.94	0.27	-4.02	18.13
	15W	4	111	0.75	0.27	-17.02	20.37
	15W	5	111	0.89	0.36	-6.70	24.38
	15W	6	111	0.77	0.31	-14.29	22.63
	5W	1	32	1.46	0.44	29.62	30.06
	5W	2	32	1.21	0.42	15.53	30.10
	5W	3	32	1.24	0.50	15.98	33.58
	5W	4	32	0.73	0.24	-19.32	21.06
	5W	5	32	0.74	0.28	-16.58	20.61
	5W	6	32	0.62	0.27	-25.35	22.12

Group	Subset	Cylinder Position	N-Size	Ratio		Difference	
				Mean	STD	Mean	STD
SAEVIS	XW-30	1	51	1.49	0.45	30.54	30.75
	XW-30	2	51	1.24	0.44	17.54	34.09
	XW-30	3	51	1.11	0.37	7.64	24.40
	XW-30	4	51	0.77	0.39	-15.81	26.44
	XW-30	5	51	0.75	0.27	-16.54	20.04
	XW-30	6	51	0.63	0.24	-23.55	18.92
	XW-40	1	148	1.42	0.46	28.65	35.88
	XW-40	2	148	1.22	0.39	15.67	29.96
	XW-40	3	148	1.00	0.37	0.30	28.28
	XW-40	4	148	0.74	0.23	-18.94	20.72
	XW-40	5	148	0.88	0.35	-8.79	26.00
	XW-40	6	148	0.74	0.30	-17.20	23.85



T-12 Top Ring Weight Loss Statistics

Group	Subset	Cylinder Position	N-Size	Ratio		Difference		
				Mean	STD	Mean	STD	
Kit	N	1	77	1.43	0.47	28.51	36.96	
	N	2	77	1.26	0.40	18.53	29.20	
	N	3	77	1.01	0.38	1.01	29.40	
	N	4	77	0.70	0.27	-21.12	22.48	
	N	5	77	0.85	0.33	-10.81	23.22	
	N	6	77	0.75	0.33	-16.59	25.60	
	P	1	117	1.44	0.45	28.64	32.09	
	P	2	117	1.20	0.41	13.13	30.93	
	P	3	117	1.05	0.37	3.12	26.00	
	P	4	117	0.77	0.29	-15.50	21.61	
	P	5	117	0.84	0.35	-10.32	25.67	
	P	6	117	0.70	0.27	-19.25	20.40	
	R	1	5	5	1.42	0.45	50.28	52.63
	R	2	5	5	1.44	0.38	50.10	42.00
	R	3	5	5	0.97	0.29	-1.90	35.28
	R	4	5	5	0.72	0.21	-33.92	27.68
	R	5	5	5	0.83	0.27	-20.78	30.61
	R	6	5	5	0.62	0.20	-43.40	19.76