

Sequence VID Limit Calculations

Sequence VID Precision Matrix Oil Data

First table is the average of all the viscosity grades and technologies. Some of these could be single test

Second table is the average data for the reference oils

	GF-5				GF-4				
	0W-20	5W-20	5W-30	10W-30	0W-20	5W-20	0W-30	5W-30	10W-30
FIE1	1.65	1.63	1.28	0.96	1.42	1.39	1.07	1.05	1.02
FEI2	0.97	0.80	0.62	0.38	1.10	1.10	0.84	0.85	0.82
FEI1-FEI2	0.68	0.83	0.66	0.58	0.32	0.29	0.33	0.20	0.20
HTHS100	5.51	5.91	6.69	7.68	5.68	6.22	6.5	7.06	7.16
HTHS150	2.78	2.79	3.17	3.28	2.69	2.72	3.06	3.13	3.22

	FEI1 Avg	FEI1 LSM	FEI2 Avg	FEI2 LSM	FEI1 – FEI2 Avg	FEI1-FEI2 LSM
Oil A (5W-20 GF-4)	1.38	1.32	1.11	1.04	0.27	0.28
Oil D (10W-30 GF-4)	1.02	0.87	0.84	0.71	0.18	0.16
Oil X (0W-20 GF-5)	1.66	1.49	0.97	0.8	0.69	0.69
Oil B (0W-30 GF-4)	1.01	0.97	0.72	0.63	0.29	0.52
Oil C (5W-30 GF-5)	1.35	1.25	0.71	0.59	0.64	0.66

Average FEI1 – FEI2

Difference for reference oils:

Average

GF-4 = 0.32

GF-5 = 0.68

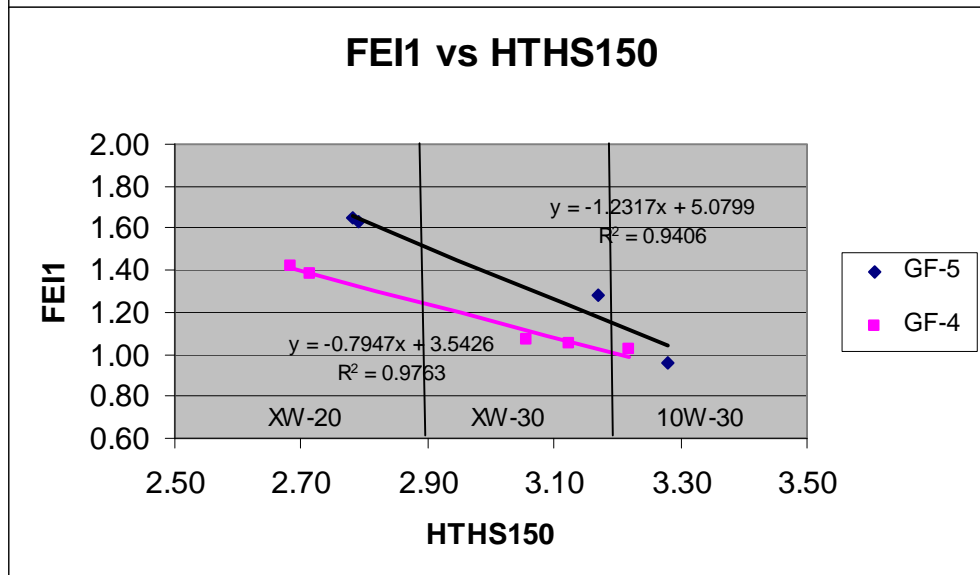
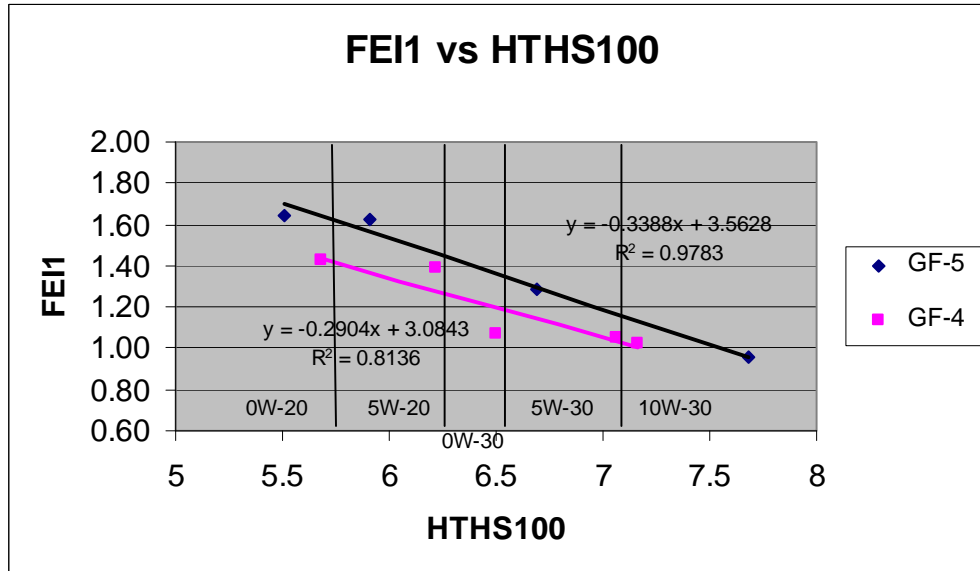
LSM

GF-4 = 0.32

GF-5 = 0.68

LSM = Least square mean

FEI1 vs HTHS100 separates data in four groups
 FEI1 vs HTHS150 separates data in three groups
 FEI1 shows separation between GF-4 and GF-5 oils



Fuel Economy Improvement with viscosity reduction

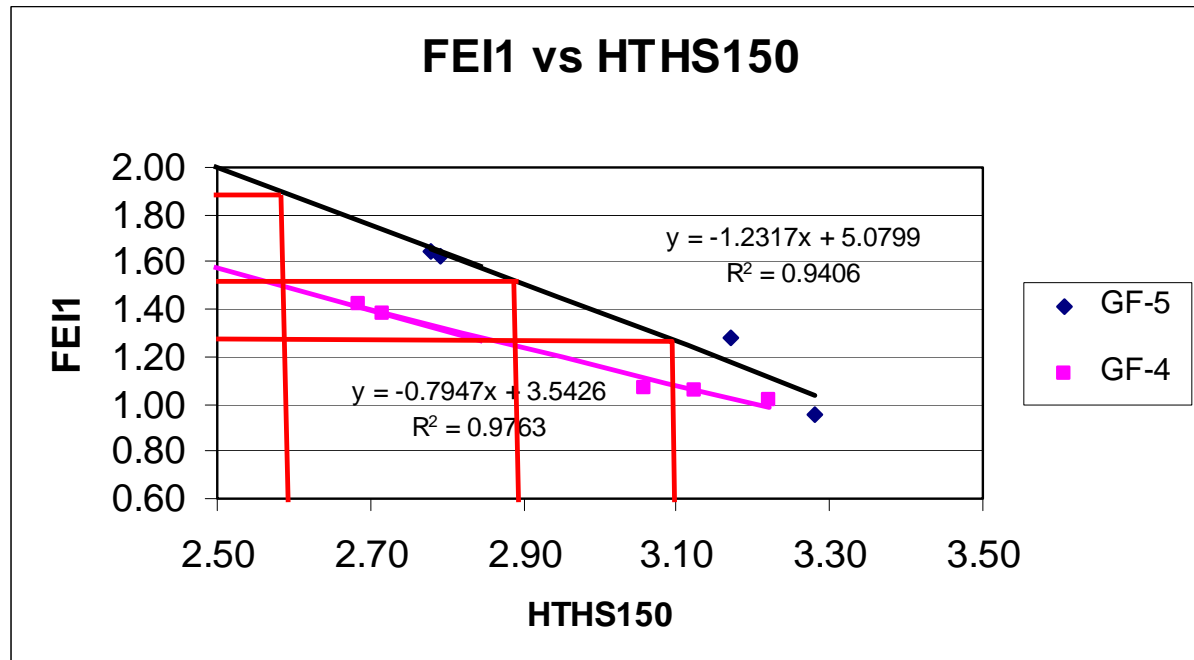
Fuel economy could be improved by reducing the HTHS150 viscosity to minimum for the respective viscosity grades, XW-20 = 2.6 mPa-s, XW-30 = 2.9 mPa-s, 10W-30 = 3.1 mPa-s. The plot below show estimates in FIE1 improvement from the reduced HTHS150.

Estimated FEI1 based on reducing HTHS150:

XW-20 = 2.6 mPa-s XW-20 GF-5 FEI1 \longrightarrow 1.88

XW-30 = 2.9 mPa-s XW-30 GF-5 FEI1 \longrightarrow 1.51

10W-30 = 3.1 mPa-s 10W-30 GF-5 FIE1 \longrightarrow 1.26



Approximate improvement from reducing viscosity:

XW-20 = 0.39% compared with precision matrix results for Oil X (1.49)

XW-30 = 0.26% compared with precision matrix results for Oil C (1.25)

GF-5 Fuel Economy Limits Calculating Using the Sequence VIB

GF-5 limits calculated using the Sequence VIB GF-4 limits plus the increase shown in the GF-5 Draft Specification. % improvement column shows the percent increase of GF-5 limit over GF-4 limits.) 0.5 increase in 10W-30, 5W-30 and 5W-20 grades. 1.0 and 0.8 increase in 0W-20 and 0W-30 grades.

GF-4 Limit			FEI increase from GF-5 Draft Spec per viscosity		GF-5 equivalent	% improvement
2.3	0W-20	FEI1	1.7	0.5	3.3	43
2		FEI2			3	50
2.3	5W-20	FEI1	1.2	0.2	2.8	22
2		FEI2			2.5	25
1.8	0W-30	FEI1	1.0	0.3	2.6	44
1.5		FEI2			2.3	53
1.8	5W-30	FEI1	0.7	0.7	2.3	28
1.5		FEI2			2	33
1.1	10W-30	FEI1	0.0		1.6	45
0.8		FEI2			1.3	63

Sequence VID limits calculated using the percent improvement from the Sequence VIB GF-5 limits table applied to Oil A, B and D and average 0W-20 and 5W-30 GF-4 oils and HTHS150 viscosity improvement

VID limits using GF-5 VIB % improvement				GF-5	% imp
0W-20	FEI1	1.42		2.03	43%
	FEI2	1.10		1.65	50%
5W-20	FEI1	1.39 1.32	Oil A	1.70 1.61	22%
	FEI2	1.10 1.04		1.38 1.30	25%
0W-30	FEI1	1.07 0.97	Oil B	1.64 1.40	44%
	FEI2	0.84 0.45		1.29 0.70	53%
5W-30	FEI1	1.05		1.34	28%
	FEI2	0.85		1.13	33%
10W-30	FEI1	1.02 0.87	Oil D	1.49 1.26	45%
	FEI2	0.82 0.71		1.34 1.15	63%

- Calculated FEI1 for 0W-20 (2.03) and 5W-20 (1.70) limit compares well with viscosity improved VID results for XW-20 FEI1=1.88
- Calculated FEI1 for 0W-30 and 5W-30 GF-5 limit compares well with viscosity improved VID results for XW-30 FEI2=1.51
- Calculated FEI1 for 10W-30 GF-5 limit is high but LMS compares well with viscosity improved VID results for 10W-30 FEI2=1.26
- Estimate 0.3% improvement in Sequence VID is equivalent to a 0.5% improvement in the Sequence VIB
- Calculated FIE2 compares well with the 0.3% reduction from FEI1 to FIE2 for the average loss of the GF-4 oils in the Sequence VID

Data in red calculated from the LSM

Conclusions

- 0.5% improvement in the Sequence VIB equates to approximately 0.3% improvement in the Sequence VID
- Using the percent improvement from the VIB limits calculated for GF-5, for calculating the VID GF-5 limits correlates with the FEI1 GF-5 prototype oil results with the improvement from the lower HTHS150 viscosity.
- Calculated FEI2 correlates with the average reduction in FEI2 for the GF-4 oils.

Limit Recommendations

- All viscosity grades approach
- 0W-20 FEI1/2 = 2.0/1.7
- 5W-20 FEI1/2 = 1.8/1.5
- 0W-30 FEI1/2 = 1.6/1.3
- 5W-30 FEI1/2 = 1.4/1.1
- 10W-30FEI1/2 = 1.2/0.9