

Group III Base Oils: Their Role & How to Take Advantage of Them

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By:

B. J. Hardy

K. K. Bjornen

S. F. Bell

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Topics

- What are Group III Base Oils?
- The link between chemical / molecular & lubricating characteristics
- Taking advantage of Group III Base Oils
- Conclusions

Caveat: this presentation reflects our North American market perspective



ConocoPhillips

Base Oil & Lubricants

- 4th largest US lubricant manufacturer
- Major producer of hydrocracked Group II base oil
- Extensive experience with hydrocracked Group III base oils since late 1990's

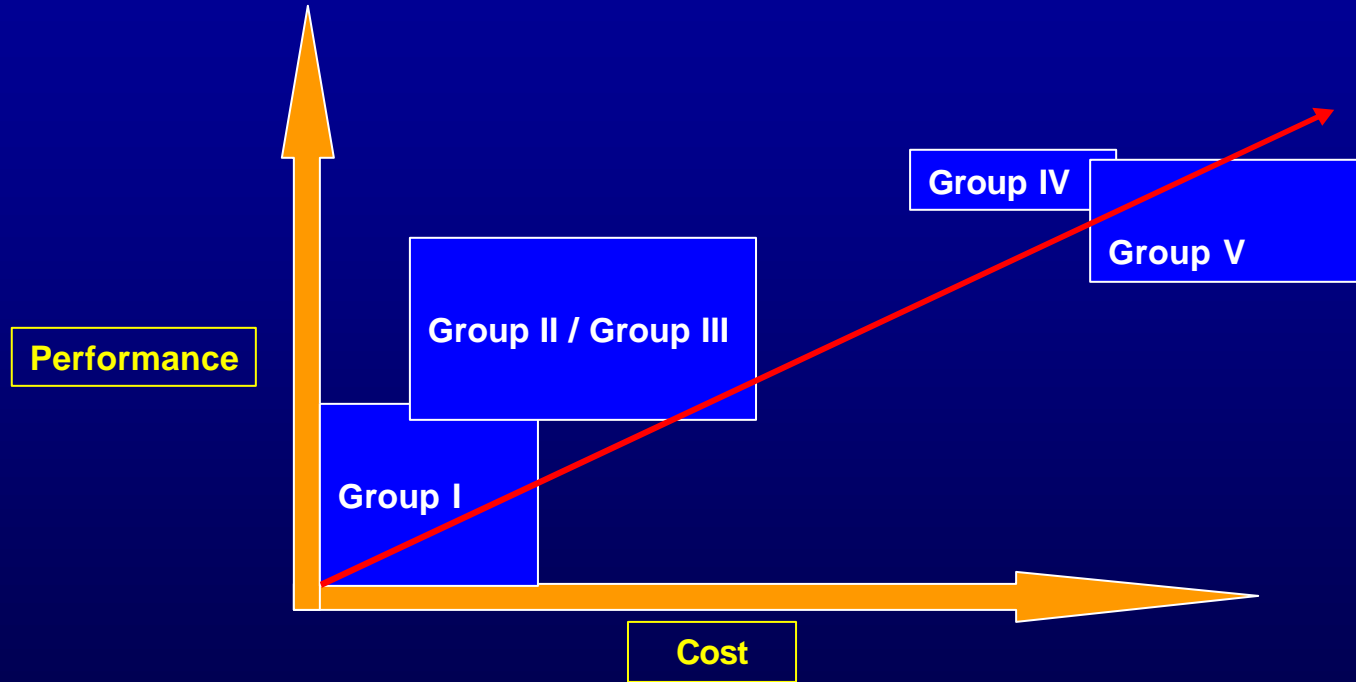
API Base Oil Categories

Group	Viscosity Index	Saturates %	Sulfur %
I	80 - 120	<90	>0.03
II	80 - 120	90 Min.	0.03 Max.
III	120+	90 Min.	0.03 Max.
IV (All PAO)	120 - 145 typical	100	0
V	All Others		

Note: Group IV characteristics shown are not part of the API Definitions

API base oil categories serve their purpose well, but there are pitfalls!

The Formulators Challenge: Optimize cost & performance



There are many base oils available - application requirements drive base oil selection

Group III Performance Benefits

Group III base oils offer benefits in three key performance areas:

- Viscosity Index
- Volatility
- Oxidation & Thermal Stability

A Bit of Chemistry

Aromatic



Naphthene



Cycloparaffin



Isoparaffin



More Paraffinic

Base oils with fewer ring molecules are more:
paraffinic, saturated, & stable

Paraffin Content vs. Refining Severity

	Hydro-cracked Group II	Hydro-cracked Group III	PAO
Paraffins	30	57	100
Mono-Cycloparaffins	45	36	-
Poly-Cycloparaffins	25	7	-
Aromatics	0.02	0.01	-



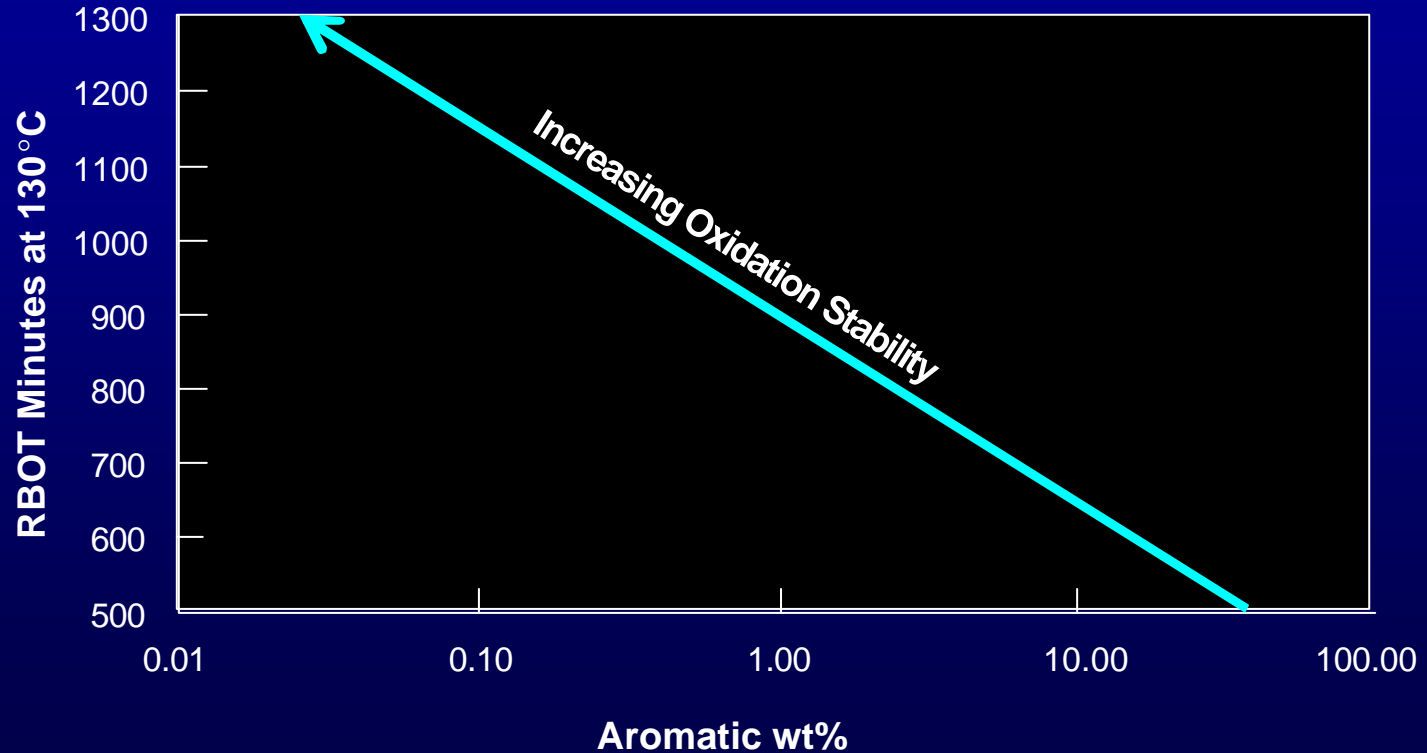
Cycloparaffin Content vs. Viscosity Index & Volatility

Base Oil API Category	I	II	III	IV
VI	101	102	128	124
Analysis (%)				
Avg # of rings	1.9	1.6	0.7	0
Noack Volatility	30	27	12	13

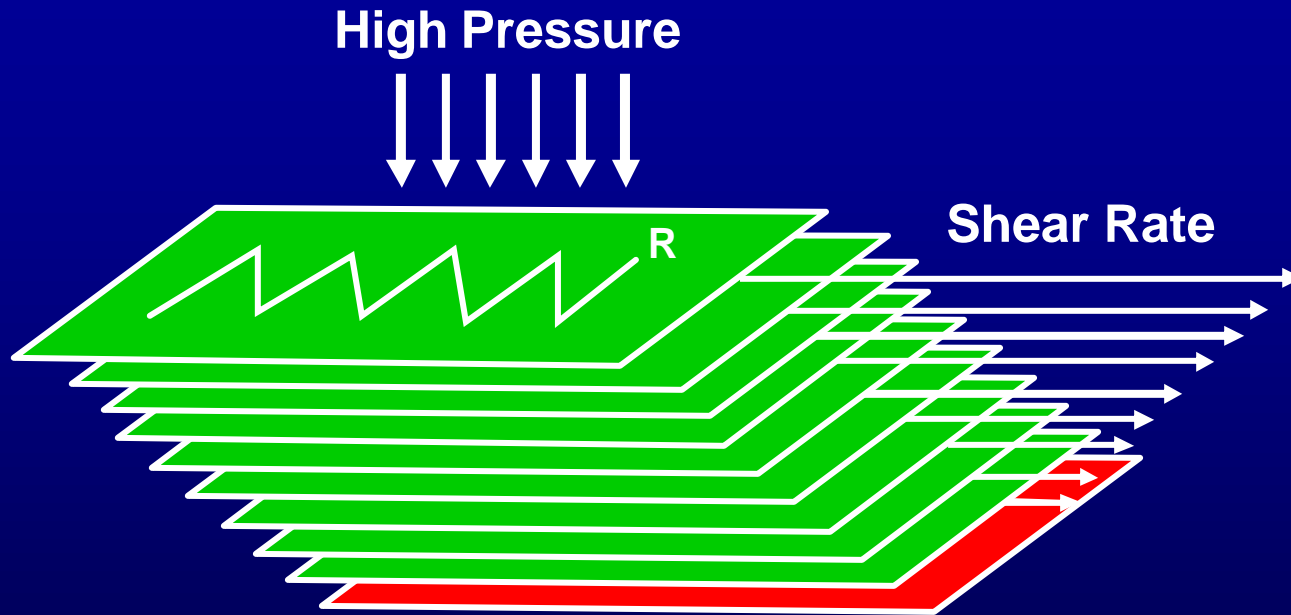
A lower # of rings (cycloparaffins) yield:

- Higher Viscosity Index
- Lower volatility

Oxidation as a Function of Aromatics



Lubricant Behavior in Contact

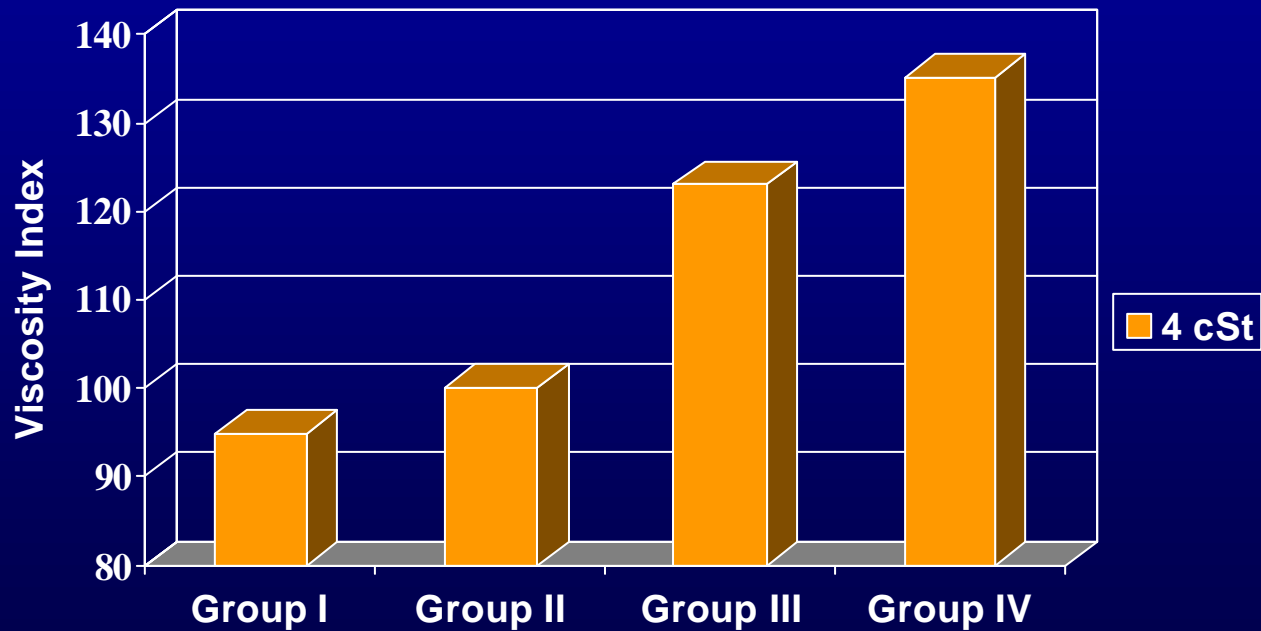


High Pressure

Energy Efficiency

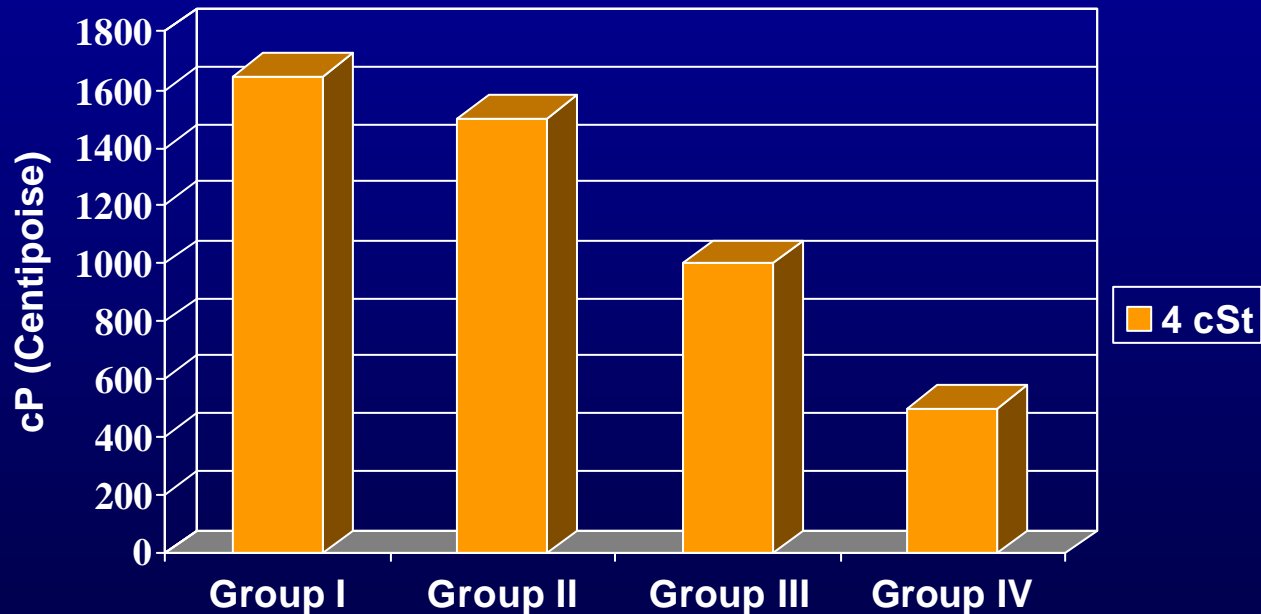
Characterized by low power loss between moving parts

Viscosity Index

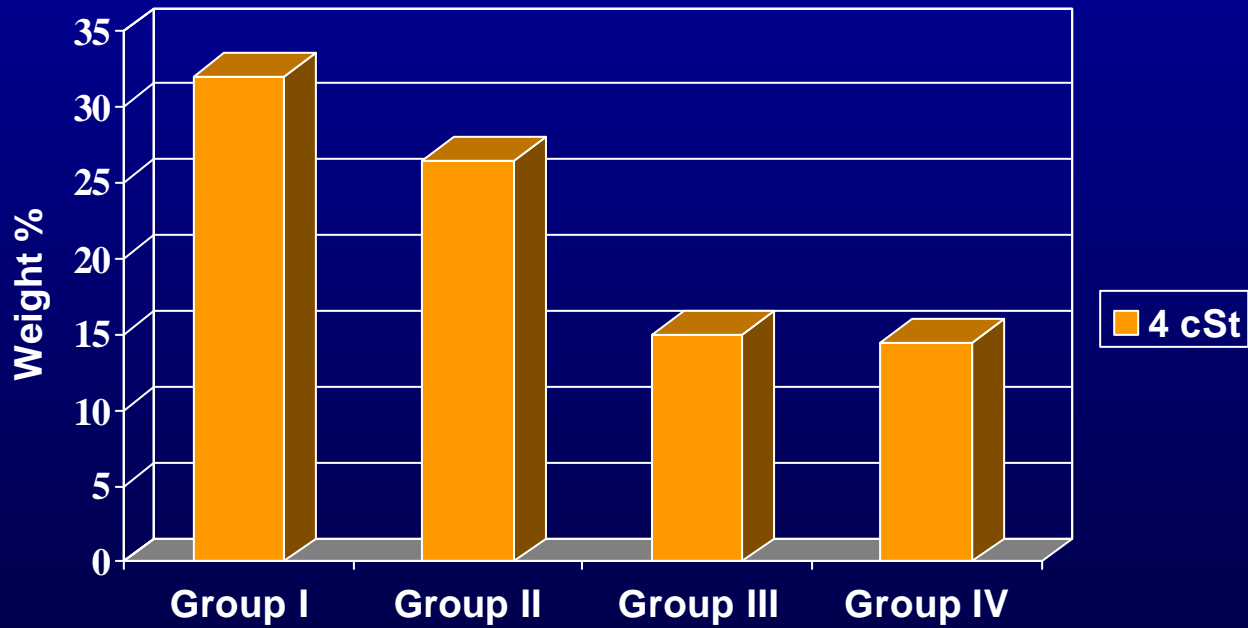


Cold Cranking Simulator

(@ -25 °C)



NOACK Volatility

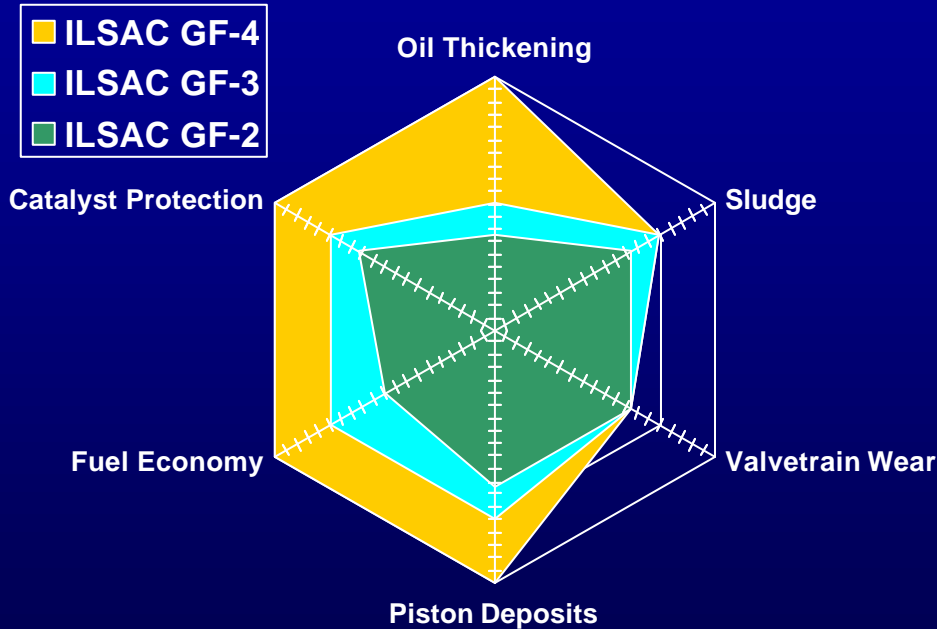


Taking Advantage of Group III Base Oils

Examples:

1. Passenger Car Engine Oils
2. Heavy Duty Engine Oils
3. Heat Transfer Fluids
4. Hydraulic Oils

Passenger Car Engine Oil GF-4 Specifications



OEM concerns:

- longer fluid life
- cleaner engines
- emissions system protection.

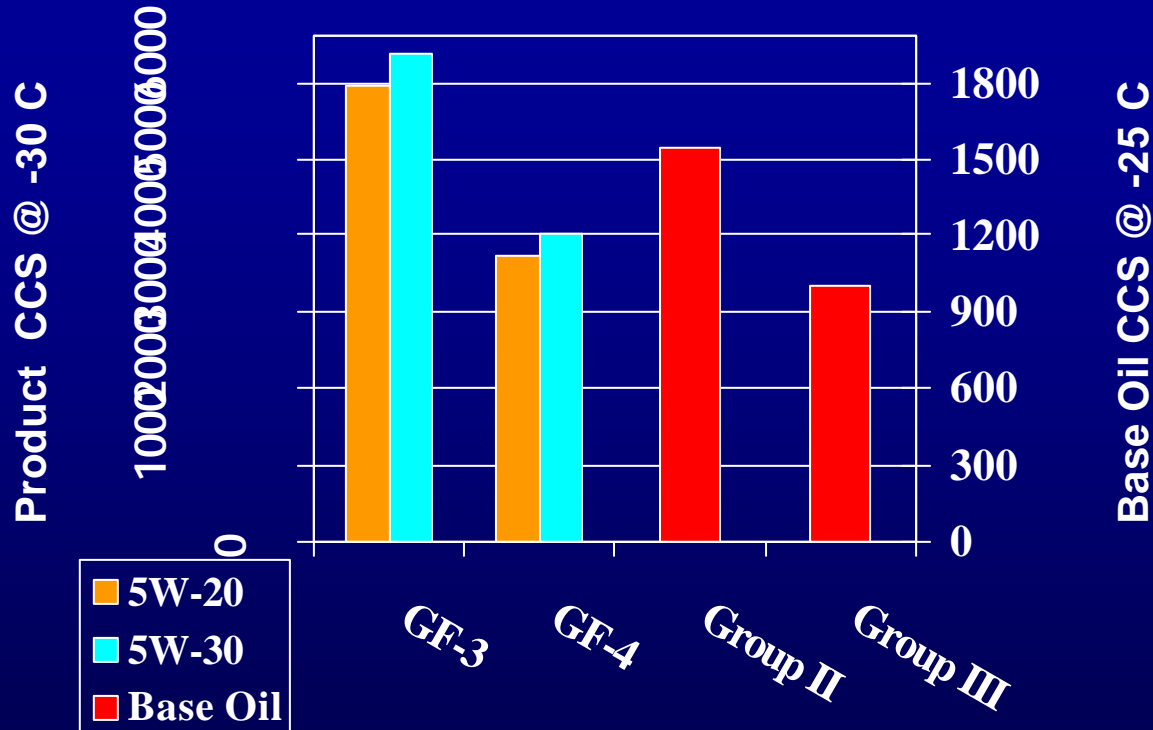
GF-4 tests are much more challenging for formulators

Group II and Group III 5W-30 Formulations

Base Stock API Category	II	II & III	III
Base Oil VI	102	120	130
Viscosity Modifier (%)	9.1	6.6	5.7
Noack Volatility (%)	21	14	12
Formulation CCS (cP @ -30 C)	6200	5500	5000
Formulation Kinematic Viscosity (cSt @ 100 C)	11.5	10.5	10.5

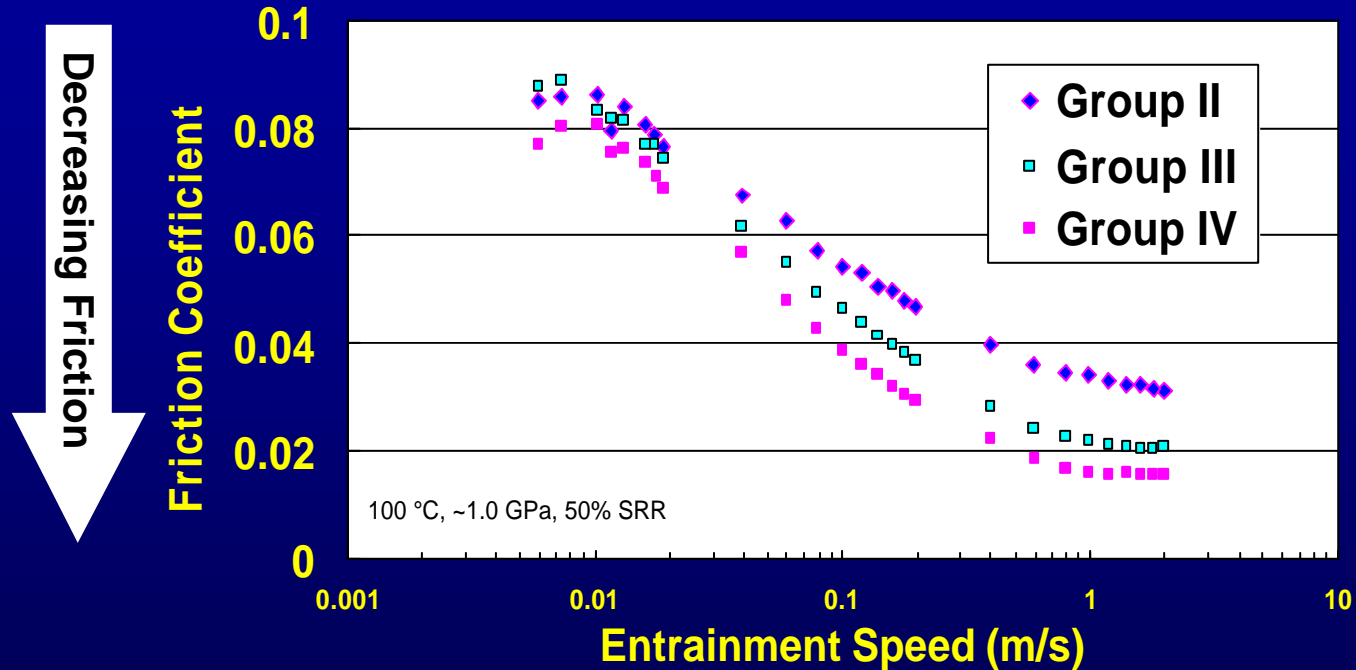
Higher VI base oils lower the volatility of finished blends & require less viscosity modifier

Comparison of CCS for Motor Oil Products



**Group III base oil has an inherent advantage
Over Group II when formulating for GF-4**

The Role of Base Oil in Fuel Economy



Friction: Group II > Group III > Group IV

Using higher quality base oil provides an edge for fuel economy

Lower friction = Better Fuel Economy

Heavy Duty Engine Oils: PC-10

PC-10 oils will be significantly different from today's technology

- Lower sulfur, Ash, phosphorus, & zinc
 - Sulfur – 0.4 wt.% max
 - Ash – 1.0 wt.% max
 - Phosphorus – 0.12 wt.% max
- Low sulfur (500 PPM) diesel fuel

And...Noack volatility limit will be lowered from 15% to 13%.

PC 10 Heavy Duty Engine Oils: Base Oils

Demand for high quality Group II and Group III base oils will increase

- Lower sulfur
- Higher oxidation stability
- Better soot dispersion capability
- Lower volatility

Sources of Sulfur in Heavy Duty Engine Oils

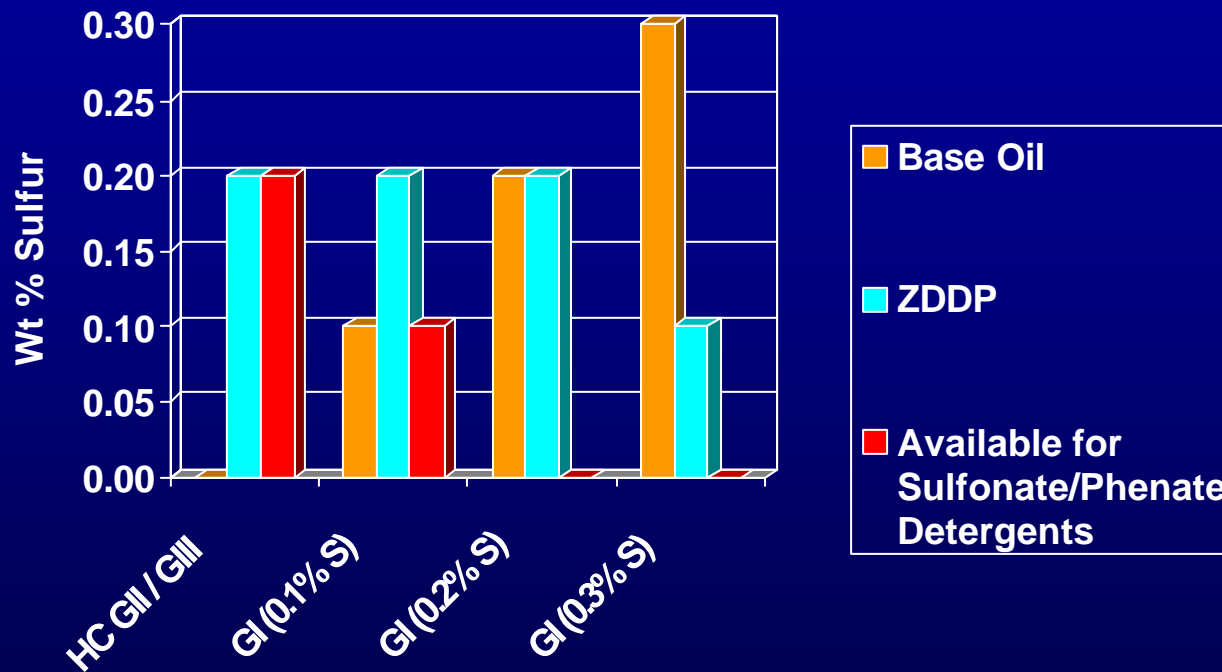
Additives

- Zinc Dithiophosphate (ZDDP)
- Sulfonate/Phenate (neutral and overbased)
Detergents
- Antioxidants

Base Oil

Sulfur management is key to finished HDEO formulations

PC-10: Base Oil Sulfur Becomes a Critical Characteristic



Any base oil with sulfur will limit PC-10 formulations

Heavy Duty Engine Oils

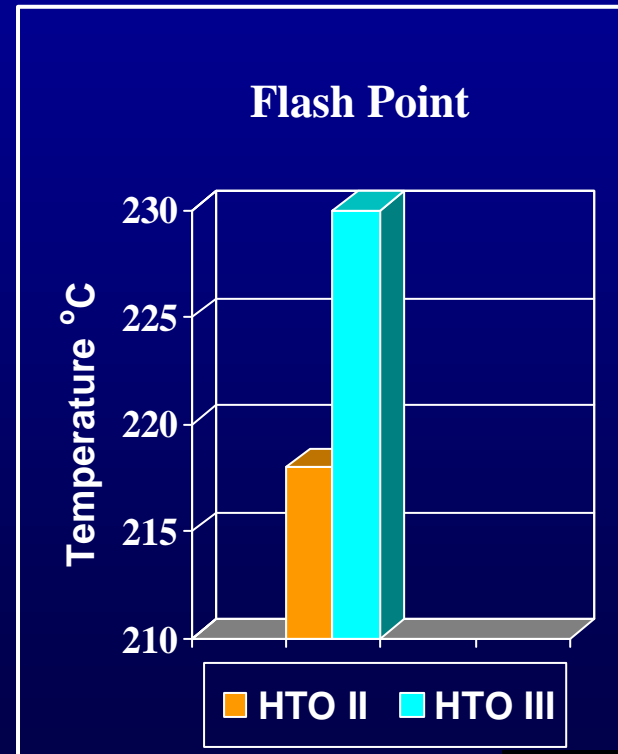
SAE 15W-40 Grades

	Group II <u>15W-40</u>	Group III <u>15W-40</u>
Kinematic Viscosity, cSt	14.6	14.5
CCS Viscosity, cP	6,200	5,800
MRV TP-1 Viscosity, cP	16,000	15,300
HTHS Viscosity, cP	4.13	4.14
Noack Volatility, %	13	4.7

**Group III base oils reduce volatility significantly
in heavy duty engine oils**

Heat Transfer Oils with Group III

- Lower Volatility
 - Higher Flash Points
 - Lower Vapor Pressure
 - Higher Autoignition Temperatures
- Better Operations at High Temperatures



ISO 32 Multigrade Hydraulic oil

Formulation Savings: Group III vs Group II Base Oil

Base Oil Type	II	II/III	III
Base Oil Ratio, %	100	70/30	100
Base Oil Viscosity cSt @ 40 °C	20.7	25.5	30.3
VI Improver, %	8.6	2.0	1.0
Cost Saving vs. Group II \$/gallon		0.60	0.80

The high viscosity index of Group III base oil reduces VI improver use for significant cost savings

Conclusions:

Group III Base Oils

1. Base oils are not all alike!!
2. Base oil performance is directly related to paraffin molecule composition
3. Group III base oils contain more isoparaffins & offer “step change” improvements in many lubricant applications
4. The role of Group III base oils: a cost-effective alternative between premium Group II base oils and PAO's

**Group III base oils are the logical next step
in evolving lubricant technology**