Base Oil Price Setting Mechanisms

Amy Claxton, P.E.
My Energy

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Anti-Trust / Good Faith / Limitations

My Energy will:

• Provide historical base oil pricing data & discuss price setting mechanisms
• Share crude price forecasts from the US Energy Information Agency (EIA) & Paris-based International Energy Agency (IEA)

My Energy will not:

• Speculate on future prices that may be charged by a seller or group of sellers for crude oil, natural gas, or their byproducts
• Provide a price forecast to a public audience
US Base Oil Price Setting Mechanisms
In a Global Base Oil World

• Historical Base Oil Price Setting Mechanisms

• Then versus now, or Why Today's Base Oil Prices Correlate Less Well With Crude Prices

• API Base Oils Group I, II, III, IV and V - different price mechanisms or the same?
Pricing Mechanisms:

**Supply Versus Demand Over Time**
is the fundamental price setting mechanism for bagels,
Bic pens, and base oils
Price ceilings and price floors: supply vs demand

- **CEILING** - who is willing to pay for what
  - High demand (undersupply) creates rising prices

- **FLOOR** – lowest possible price setting mechanism
  - Oversupply depresses prices
  - Over time, highest cost producers exit the business
Crude-derived products: crude oil is a “floor”

- Benchmark crude pricing sets a price “floor” for crude-derived products in each region

- Why? Raw material costs are 80% or more of refined product total cost for fuel products as well as base oils
Crude pricing is subject to fluctuation

WTI price since 1970, $US

- Crude price forecasting is a humbling experience
But we can count on product pricing to follow crude pricing over time.

**WTI and gasoline price, $ / gal**

- Hurricane Katrina shuts down refineries & pipelines
- Post-hurricane refinery repairs
- Unplanned refinery down-time

Sources: EIA Short Term Energy Outlook, Thomson Reuters
In a “Group I world”, base oil prices tracked crude prices fairly well: crude + base oil opex

Base Oil & WTI Historical Pricing, $/B

- Supply vs demand = base oil margin above crude
- Oversupply brings falling margins

• It was easy to look smart during the 1980s and 1990s predicting base oil margins

Source: EIA, ICIS
Heavy base oil viscosity grades cost more to produce and have a slightly higher floor

- Group I viscosity grades have different opex to produce
  - The heavier the viscosity, the higher the cost to manufacture
  - Yield on crude, energy intensity, throughput limitations

- Cost to produce: SEBS > 600N > 150N > 100N so prices have always been higher for heavier viscosities
Historical ceilings – set by the market

• Base oil is not one market - multiple viscosities, many markets

• Ceilings (prices) go up in tight supply
  - Viscosity blend ratios change where possible
  - Imports, naphthenic / paraffinic blending
  - Blending with PAO, PAG pushes base oil price ceiling higher
And then we started making different qualities and types of base oils

<table>
<thead>
<tr>
<th>API Group</th>
<th>% saturates</th>
<th>% sulfur</th>
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<td>I</td>
<td>&lt; 90 % sats <em>and/or</em></td>
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- Supply versus demand is still the bottom line
- But supply versus demand of exactly what?
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• Historical Base Oil Price Setting Mechanism

• Then versus now, or Why Today's Base Oil Prices Correlate Less Well With Crude Prices

• API Base Oils Group I, II, III, IV and V - different price mechanisms or the same?
Today’s base oil market has multiple **quality** tiers as well as multiple **viscosity** tiers

- Pricing is not tied to API group – tied to supply vs demand

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- Supply vs demand balances within each viscosity grade, quality level, and quality level within a specific grade
Base oil pricing mechanisms: new world order?

- No – Same World Order – Supply Versus Demand
- But more products, more complexity, more quality levels within single markets
Today’ model – still have ceilings and floors

- Same ceiling set by finished lube market / process oil demand
  - More base oil quality choices – variations in VI, saturates, sulfur

- Same floor - high cost producers cover total cost or shut down
Today’s price ceilings – set by what?

• Quality of Group III > Group II > Group I?

Price ceiling

API Group III
API Group II
API Group I

• Easy decision to build new Group II / III capacity, since Group II or III will sell for higher price than Group I, right?
Today’s ceiling – not what we expected

• The market had other ideas – supply versus demand ....

- Buyers / formulators choose base oils to meet specific quality requirements regardless of the API Group “Label”
  - API groups are blended together to meet lowest total cost
Ceilings set by the market as before

- Formulators choose base oils regardless of API Group “Label”
  - API groups are blended together to meet lowest total cost
  - Will pay for specific properties where needed
  - Will not pay for unnecessary quality, but use if convenient

- Confusing since prices are not aligned with API Groups –
  aligned with supply vs demand of base oils with the
  viscosity, volatility, saturates, and / or VI required for
  certain applications
Today’s simplified ceilings
(Amy’s Aggie Math Ceilings)

- ~ 120 VI for 4 cSt base oil to meet low SAE J300 Noack, CCS
- Other markets pay requisite prices for base oils with specific viscosity, saturates, VI, needed to meet their specs

Base oils for low viscosity SAE J300 oils
Base oils for top PCEO, HDEO; industrial, process
Base oils for everything else
It’s not just about quality – it’s also about viscosity

• Shortfalls in heavy viscosity base oils created its own dynamic
  - Supply vs demand for Bright Stock sets a new ceiling
  - Supply vs demand for heavy viscosity base oils pushes ceilings up on any finished lubricant requiring heavy viscosity oils

• Group I Bright Stock supply / demand fundamentals lead to price ceilings as high or higher than Group III base oils
Global supply vs demand drives prices – for each quality level and each viscosity grade

- Light neutral oversupply; prices depressed in all global trading hubs
- Group I Bright Stock sells for more than Group III 4 cSt
Group II pricing – why isn’t it much higher than Group I?

- Group II premium over Group I with HDEO category soot control regulations – higher saturates allowed additive backout

- Otherwise, Group I and Group II compete for the same applications; market does not reward what it does not need
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- Then versus now, or Why Today's Base Oil Prices Correlate Less Well With Crude Prices
- API Base Oils Group I, II, III, IV and V - different price mechanisms or the same?
Base oil price floors – different by API group?

- No change versus historical – long term base oil price floors must cover total cost of highest cost producers

- Group I manufacturers are highest cost
  - In an oversupplied market high cost producers shut down
Oversupply – high cost producers shut down … So why all the Group I capacity?

- Supply theory says high cost producers competing in an oversupplied market making the same products will eventually shut down

- But supply theory never said “High cost producers must compete with low cost producers selling unrelated products”

Source: My Energy
Same supply vs demand mechanisms but now we have multiple supply models - with different product streams generating revenue - to cover their costs

- Group I producers have the highest operating cost - *and the highest by-product revenue streams*

**Group I Solvent Processing**

- Highest operating cost
- Standard VI
- Standard saturates
- Wide viscosity range
- Wax by-product
Multiple base oil supply models

- Group II producers have lower operating cost vs Group I solvent processing, and different revenue streams to cover their costs versus Group I

**Group II Hydroprocessing**

- Lower operating cost
- Standard VI
- High saturates
- Narrower viscosity range
- No Bright Stock
- Excellent low sulfur diesel byproduct
Multiple base oil supply models

- Group III producers via fuels hydrocracker bottoms upgrading have the lowest operating cost, highest product quality, and different revenue streams to cover their costs vs Group I and II.

**Group III Hydroprocessing – Fuels HCU Bottoms**

- Lowest operating cost
- Highest VI
- High saturates
- Narrow viscosity range
- No Bright Stock
- Excellent low sulfur diesel byproduct
“Structural Break” in Base Oil Industry Supply Model

• Despite overlapping products, base oil producers have different revenue streams to cover their costs, depending on manufacturing model

• Competition between producers with similar revenue streams – lowest raw material cost, best yields, lowest op cost
Wrap up: Pricing Mechanisms

Supply Versus Demand Over Time is the fundamental price setting mechanism for bagels, Bic pens, and base oils
New technology led to expectation: Group III > Group II > Group I prices

Grp I 100N, 150N, 600N, SEBS
Grp II 3, 4, 5, 8 cSt
Grp III 3, 4, 6 cSt

• But the market had different ideas based on supply vs demand
Co-existence of API Groups due to different revenue streams covering costs

- Economic theory says high cost producers in an over-supplied market will ultimately shut down

<table>
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<th>Group</th>
<th>2016 Global Base Oil Capacity</th>
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<tbody>
<tr>
<td>Group I</td>
<td>44%</td>
</tr>
<tr>
<td>Group II</td>
<td>34%</td>
</tr>
<tr>
<td>Group III</td>
<td>13%</td>
</tr>
<tr>
<td>Naphthenic</td>
<td>9%</td>
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- Only true when producers have similar product slates / revenue streams, i.e. if there is a homogeneous market
Base oil pricing mechanisms: new world order is actually the same old world order

Supply versus demand of any given product determines its price

- Demand is driven by formulators choosing base oils to meet quality requirements at the lowest total formulated cost - regardless of the API Group “Label”

Same for bagels, Bic pens, and base oils
My Energy
Amy A. Claxton, P.E.
aaclaxt@yahoo.com

Global Supply/Demand, Trade Analysis
Price Mechanisms, Mfg Economics
Base Oils Waxes GTL
Industry Trend-spotting & Forecasting
Technology Evaluation & Due Diligence