14th Annual Bunker and Residual Fuel Conference

Compliance with IMO Regulations - New Strategies for Refiners in the U.S. and Internationally

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• IMO Regulation and Compliance Options

• Strategies for Refiners Heading Toward 2020 and the 0.5% Sulfur Cap

• Comparative Advantage of Refiners in the U.S. Versus Other Regions

• Summary
• IMO 2020 SOx regulation for bunker fuel offers competing compliance options.

• Demand side responses:
  – Emissions abatement, i.e., exhaust gas scrubbers
  – Reduce demand (slower steaming, etc.)
  – Waivers (Non compliance!)

• Supply side responses:
  – Increase MGO, MDO, ECA fuel type volumes
  – Manufacture LSFO (0.5 wt.% max. sulfur fuel oil)
  – LNG and other low sulfur fuel alternatives
• Which compliance option will dominate over the long run?
• What might a refiner be thinking now? Perhaps:
• Which compliance option will dominate over the long run?

• What might a refiner be thinking now? Perhaps:

“This isn’t our first low sulfur rodeo, and it probably won’t be the last. But, this one doesn’t look like the others.”

• Let’s look at this visually for more insight on that perspective.
Sulfur has been removed on the supply side in diesel and gasoline markets.
IMO 2020 compliance allows an option for sulfur to be removed on the demand side.
IMO Regulation and Compliance Options

Complex Market Dynamics

IMO 2020 compliance allows an option for sulfur to be removed on the supply side as well.
Natural gas competes in multiple ways as a solution.
Complex Market Dynamics

SUPPLY SIDE

Crude

Refining

Steam Methane Reforming

CAPEX, OPEX, Infrastructure Considerations

Low Sulfur Fuel Oil

High Sulfur Fuel Oil

LNG

Sulfur

H₂

H₂

DEMAND SIDE

Gasoline (ultra low sulfur)

Jet/Kerosene

Diesel (ultra low sulfur)

Low SOx

High SOx

Marine Use

Inland Power/Heat

Scrubbers

Scrubbers

Substitution?

Substitution?

Coal, others...

IMO Regulation and Compliance Options
Questions to Consider
Depending on Perspective

• How will your industry adjust?

• For Refiners:
  
  – If bunker fuel oil is NOT currently part of a your product slate, will LSFO (0.5% S) prices and demand be attractive enough to adjust the slate?
  
  – If HSFO is currently part of the product slate, how low will HSFO prices go?
Any Indication From the Financial Markets?

Source: CME Group (Platts) “3.5% Fuel Oil Barges FOB Rotterdam Crack Spread Futures Quotes Globex” http://www.cmegroup.com/trading/energy/#refinedProducts
CAPEX related (proactive)

- Increase resid upgrading capacity (Cokers, Hydrocrackers)
- Increase distillate hydrodesulfurization capacity
- Increase sour gas treatment and sulfur recovery capacity
- Various combinations and/or newer technologies...
- What about the future of jet fuel (last sulfur “sink”)?

OPEX related (reactive)

- Crude diet adjustments
- Adjust refinery flow rates (shift heavy, low-sulfur barrels)
- Increase (any) available unit capacity utilization
Strategies for Refiners
Heading Toward 2020 and the 0.5% Sulfur Cap

Basic FCC Cracking Refinery – Simplified Model

Gas Plant -Treating
Sulfur Recovery
Reforming
Alkylation & Isomerization
Naphtha Hydrotreating

Crude

Atmospheric Tower

Vacuum Tower

Sulfur
Fuel Gas
LPG
Gasoline

Jet/Kero

Diesel/AGO

Light Ends
Naphtha

H₂

H₂S

H₂

650°F

450°F

650°F+

950°F

1050°F

1050°F+

950°F

LVGO

HVGO

FCC

LCO

MCB/Slurry

Vacuum Resid

Source: PRISM™ Assay Viewer
Basic FCC Cracking Refinery – Simplified Model

BASE CASE - BRET CRUDE

Middle Distillates Yield and Quality

<table>
<thead>
<tr>
<th>Yield (vol. %)</th>
<th>Diesel/AGO</th>
<th>Jet/Kero</th>
<th>Diesel Sulfur (RHS→)</th>
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<tbody>
<tr>
<td>0.0%</td>
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<tr>
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Diesel Sulfur (wt. %)

Brent
37.5 API
0.40 % S

Before HDT

Fuel Oil Yield and Quality

<table>
<thead>
<tr>
<th>Yield (vol. %)</th>
<th>VR</th>
<th>MCB</th>
<th>LCO</th>
<th>FO Sulfur (RHS→)</th>
</tr>
</thead>
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<td>0.0%</td>
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Fuel Oil Sulfur (wt. %)

Brent
37.5 API
0.40 % S
Basic FCC Cracking Refinery – Simplified Model

1. Gas Plant - Treating
   Sulfur Recovery
   Reforming
   Alklation & Isomerization
   Naphtha Hydrotreating

Crude → Atmospheric Tower (450°F → 650°F)
   Light Ends → Naphtha → Light Ends
   H₂, H₂S → Jet/Kero

HDT → Diesel/AGO

Vacuum Tower (650°F+ → 950°F → 1050°F)
   LVGO, H₂S, H₂ → FCC
   MCB/Slurry → Vacuum Resid

Fuel Oil Yield and Quality

Middle Distillates Yield and Quality

Fuel Oil Sulfur (wt. %)

Yield (vol. %)

Bonny Light
35.1 API
0.15 % S

Brent
37.5 API
0.40 % S

Arab Light
32.5 API
1.93 % S

Diesel/AGO
Jet/Kero
Diesel Sulfur (RHS→)

Before HDT

Fuel Oil Yield and Quality

Fuel Oil Sulfur (wt. %)

Yield (vol. %)

Bonny Light
35.1 API
0.15 % S

Brent
37.5 API
0.40 % S

Arab Light
32.5 API
1.93 % S

VR
MCB
LCO

Source: PRISM™ Assay Viewer
Basic FCC Cracking Refinery – Simplified Model

CRUDE DIET CHANGE

Fuel Oil Yield and Quality

Yield (vol. %)

Fuel Oil Sulfur (wt. %)

Source: PRISM™ Assay Viewer
Basic FCC Cracking Refinery – Simplified Model

CRUDE DIET CHANGE II

1. Gas Plant - Treating
   Sulfur Recovery
   Reforming
   Alkylation & Isomerization
   Naphtha Hydrotreating

Atmospheric Tower

- Sulfur
- Fuel Gas
- LPG
- Gasoline

Crude

- Light Ends
- Naphtha

450°F

650°F

H₂S

H₂

Jet/Kero

Diesel/AGO

Vacuum Tower

- LVGO
- HVGO

LCO

MCB/Slurry

Vacuum Resid

- FO Sulfur (wt. %)

Yield (vol. %)

Source: PRISM™ Assay Viewer

Fuel Oil Yield and Quality

- VR
- MCB
- LCO
- LVGO
- FO Sulfur (RHS→)

Strategies for Refiners
Heading Toward 2020 and the 0.5% Sulfur Cap
Basic FCC Cracking Refinery – Simplified Model

CRUDE DIET CHANGE WITH VGO DOWNGRADE

Fuel Oil Yield and Quality

1. Gas Plant - Treating
   Sulfur Recovery
   Reforming
   Alkylation & Isomerization
   Naphtha Hydrotreating

2. Crude
   Atmospheric Tower
   Vacuum Tower
   FCC
   LVGO
   MCB/Slurry
   Vacuum Resid

3. Sulfur
   Fuel Gas
   LPG
   Gasoline

4. Light Ends
   Naphtha

5. H₂
   H₂S

6. H²S

7. H²

8. Jet/Kero
   Diesel/AGO

9. Fuel Oil Sulfur (wt. %)

Source: PRISM™ Assay Viewer
Highly complex refinery configurations.

Under utilization might allow some flexibility in adjusting yield slate; some “room to fill”.

Relatively lower energy costs supported by inexpensive, abundant natural gas.

Access to competitively priced “over-the-fence” hydrogen.

Relatively minimal (forced) exposure to HSFO markets.
• U.S. natural gas forecast for 2017 is 73.3 Bcf/d.
• 2018 is forecast at 3.3 Bcf/d (+4.5%) above 2017.
• Henry Hub price expected to remain low.

Source: EIA (Short-Term Energy Outlook, June 2017); EIA (Today In Energy) "United States Remains the World’s Top Producer of Petroleum and Natural Gas Hydrocarbons", June 7, 2017
Access to “On-Demand” Hydrogen

- Multiple hydrogen pipeline networks available; e.g.,
- Gulf Coast Connection Project (2012)
  - Houston to New Orleans
  - 600 miles of bidirectional pipeline
  - 22 hydrogen plants
  - Over 1 Billion Scf/D of hydrogen capacity

US Refining Yield Trends: Less Heavy, More Light Oil Products

Yields (Volume % of Crude Oil)

Bottom-of-the-Barrel Yields

Distillate + Gasoline Yields

2016 Average Resid Fuel Oil wt.% Sulfur

Source: PRISM™, EIA
Underutilized Resid Upgrading Capacity

Coker and Hydrocrackers have (some) “room to fill”?

Hydrocracking Utilization Rates

Coking Utilization Rates

Source: EIA
• PADD 3 offers most availability.
• Total 2016 U.S. coastal PADD available upgrading capacity was approximately 850,000 B/D (high end estimate).

Comparative Advantage of Refiners in the U.S. Versus Other Regions

Source: EIA
Delayed Coker Yields for Different Feed Blends

Source: AFPM Paper AM-15-75 “Heavy Oil Import for Delayed Coking Feed” (Table 2 – Delayed Coker Yields for Different Feed Blends) Sloley et. al., March 22-24, 2015.
Reproduced with authorization from CH2M HILL.
• Lots of uncertainty! Which creates:
  – Barriers to investment.
  – Stand-offs between shippers & refiners.

• Reducing fuel oil sulfur can be challenging and options limited without making investments.

• U.S. refiners are generally poised to take advantage.
  – Low energy costs (abundant, low-cost natural gas).
  – Access to hydrogen.
  – Asset underutilization?

• Although there are reports of significant under-utilization of upgrading assets, it is not enough to “solve the global problem”.

Summary