The Use of DRA in Crude Oil

COQA Meeting

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David Schwartz

Baker Hughes

Preview

- **Background**
- **Crude quality and DRA**
  - Key challenges
  - DRA chemistry and product composition
  - DRA fate testing
- **Summary and Conclusions**

(DRA is a “Drag Reducing Agent”)

Baker Hughes Incorporated

Provides best-in-class products and services to drill, evaluate, complete and produce oil and gas wells.

FY2009

Revenues: $9.6 billion

56% non-USA

34,000 employees

Facilities in 72 countries

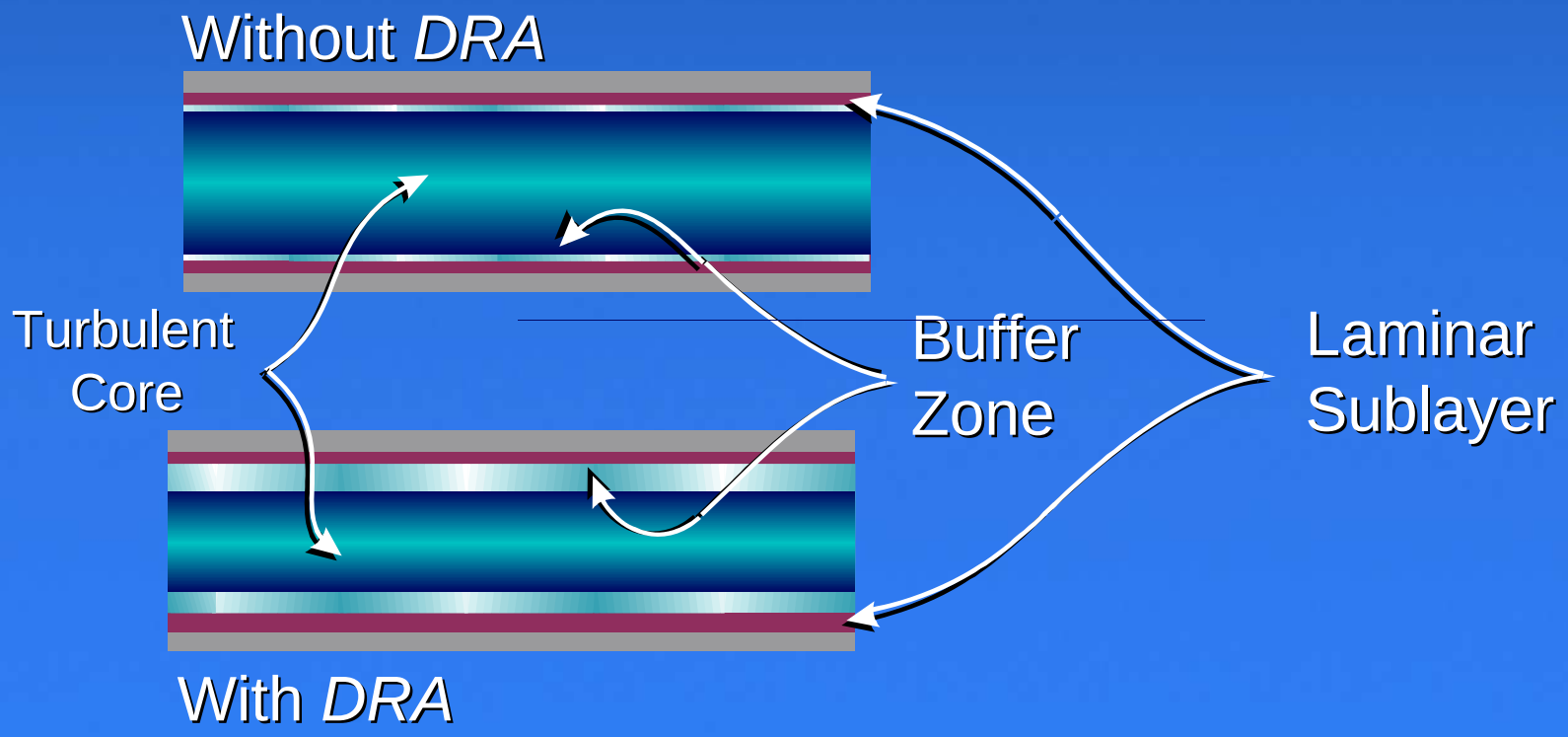
Operates in 90+ countries

Benefits of Drag Reducers

- **Increased throughput**
  - Without capital expenditure (new pumps, lines, etc.)
  - Allows pipelines to meet their scheduled nominations
- **Energy savings**
  - Cheaper than horsepower...can shut down pump stations
- **Scheduling flexibility**
  - Increases slow (or fast) component of line batches
- **Derated periods**
  - Maintain desired throughput at reduced MAOP
  - Maintain throughput during scheduled maintenance

Effect of DRA

- DRA dissolves in the pipeline liquid
- DRA decreases turbulent flow and increases laminar flow
- DRA does not coat the pipeline wall



Chemistry of Drag Reducers

- **DRA active ingredient**
  - Ultra-high molecular weight, linear poly-alpha-olefin
  - 100% hydrocarbon, ultra high MW, completely saturated

- **DRA product types**
  - Gel
    - Older technology, polymer “dissolved” in a hydrocarbon solvent
  - Slurry
    - Typically water-based
    - Freeze-protected versions also contain alcohol and/or glycol ether
    - Typically much higher performance than the gel products, and easier to handle

DRA Product Composition

Product type	Polymer (%)	Carrier(s) (%)	Other Ingredients
Gel	Polyolefin (10%)	Kerosene, pentane (90%)	None
Water-based slurry	Polyolefin (20-30%)	Water (60-75%)	Stabilizing agents (up to 5%)
Freeze-protected slurry	Polyolefin (20-30%)	Alcohol, glycol, glycol ether (10-75%)	Stabilizing agents (up to 5%)

Typical percentage composition ranges shown

Crude Oil Quality and DRA—Key Challenges

- **Refinery process differences**
  - Straight run cuts vs hydrotreated; product slate; etc.
- **Complexity of the DRA additive**
  - Some DRA's have 5 or more components
  - How low do you go? 1% of DRA, 0.1%, lower??
- **Refiners' perception of DRA risk vs reward**
- **Our direct customers are pipeline companies**
- **Any process impact could be small/slow**

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Crude Oil Quality and DRA--History

- **DRA additives first used in crude oil in 1979, on the trans-Alaskan pipeline system**
- **Around that time, we did the following work :**
  - Impact testing at two refineries
    - Process condition changes, product specs, trace metals levels
  - Lab testing examining desalter impact, foaming tendency and acid number
- **Since that time, DRA has been used to treat over 100 billion barrels of crude, all around the world**
- **No major problems tied to DRA**

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Who Uses DRA in Crude Oil

Shell
ExxonMobil
PEMEX
Enbridge
Alyeska
Marathon

BP
Maersk
Saudi Aramco
IOCL
YPF
Sinclair
Sunoco

PERN
SUMED
CEPE
KOC
KTO
CPC
BTC

DRA Fate Testing

- **Desalter**
  - Octanol/water partition coefficient (Log Pow)
  - EDDA
  - COD/BOD
- **Refined product quality**
  - TGA
  - Pyrolysis GC-MS
  - Spec testing on cut (spiked with DRA component(s) or distilled from DRA-containing crude)
- **Process impact**
  - All of the above
  - Elemental analysis
  - Chemical and process knowledge

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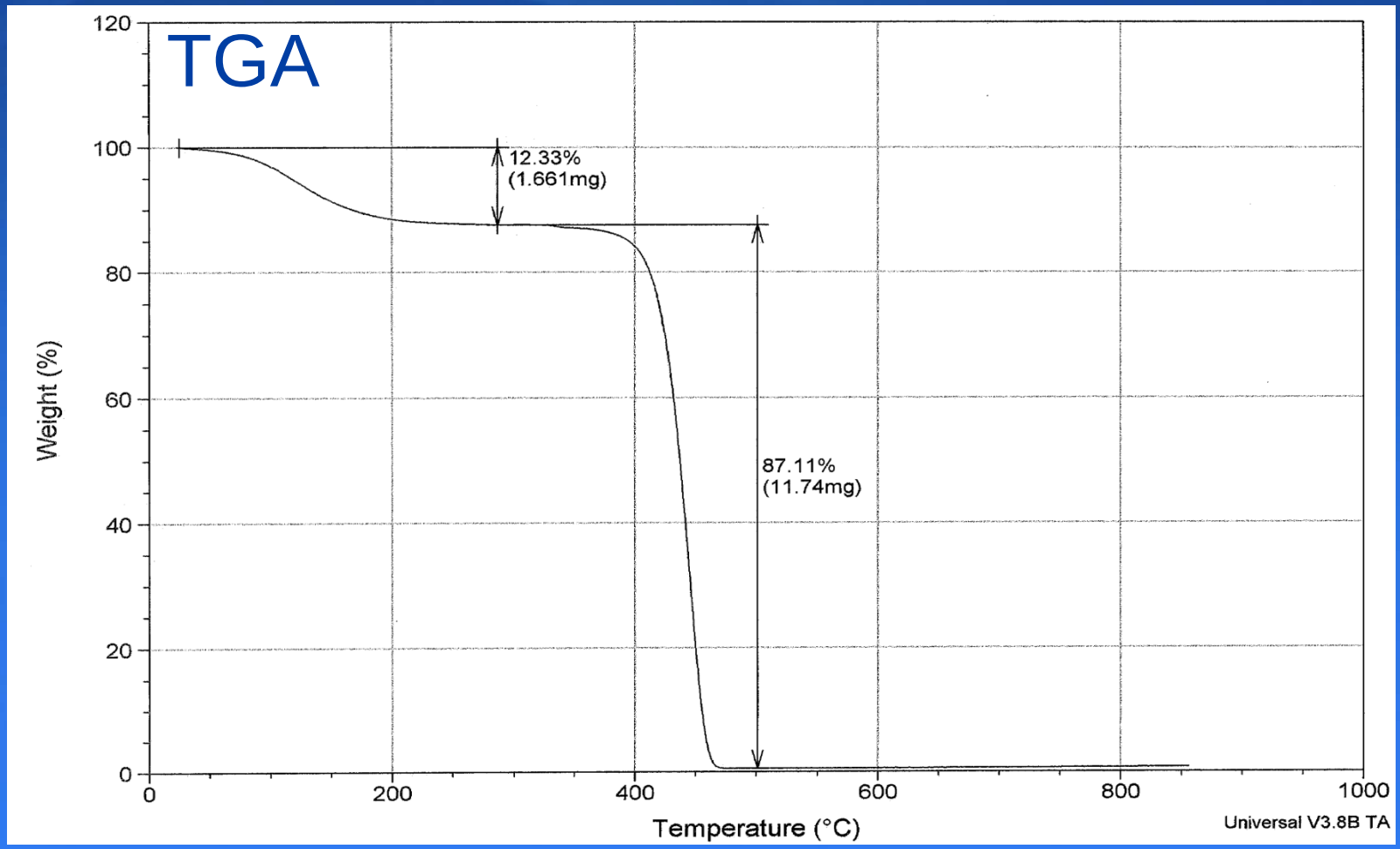
Testing for the Presence of DRA

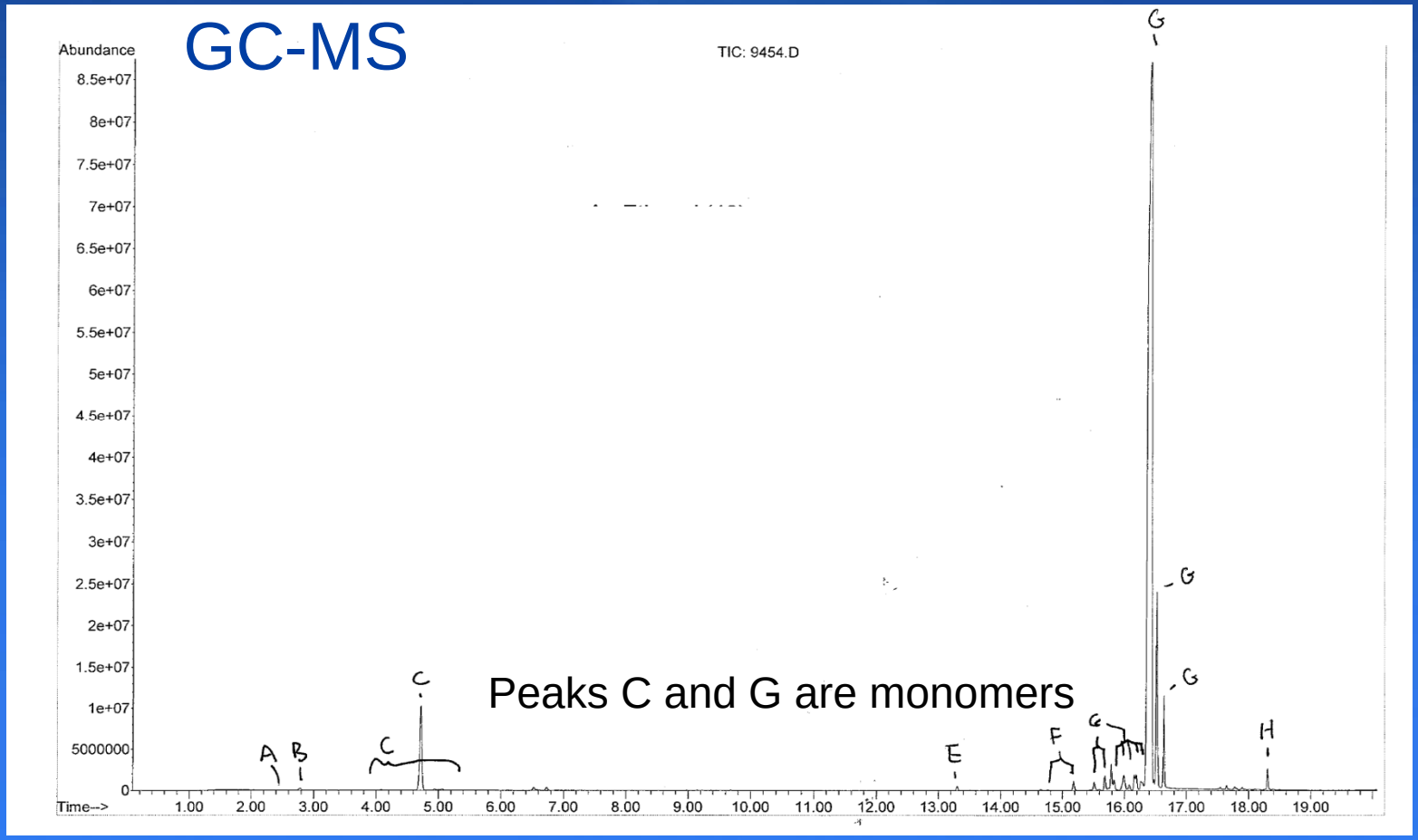
- **It's relatively easy to test a refined fuel sample for DRA**
  - Polymer—GPC, NMR, filterability
  - Carriers—GC/MS
  - Stabilizing agents—IR, GC/MS, etc.
- **Not so easy for a crude sample, due to the crude's complex composition**

DRA Polymer Fate



Polymer degrades at 400 C

DRA Polymer Fate Testing



Polymer degrades to its monomers (alpha-olefins), at 400 C

DRA Component Fate in a Refinery

Assume a crude contains100 ppm of a freeze-protected DRA additive (20% polymer, 45% water, 30% alcohol, 5% stabilizing agents):

Component	Level in crude	Expected fate
Polymer	20 ppm	VDU bottoms, then similar to other non-volatile, saturated hydrocarbons
Alcohol	30 ppm	Distills in ADU, based on boiling point
Stabilizing agent(s)	5 ppm	Varies

Typically, the polymer and carrier(s) will not be water soluble

Summary and Conclusions

- **DRA has been used in crude oil for over 30 years, over 100 billion barrels have been treated**
- **DRA additives provide significant benefits to crude producers, transporters, refiners and end users**
- **There are several real challenges in the area of DRA and crude quality**
- **We want to work with you to address any concerns you might have with respect to DRA**

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Thank you

Questions?

Supporting Information Follows

Slurry DRA Stabilizing Agents

- **A slurry stabilizing agent package must be “tri-functional”**
  - Partitioning (prevent agglomeration)
  - Wetting (prevent liquid/solid separation)
  - Rheology (slow down rate of separation)

- **Typical slurry stabilizing agents**
  - Metal stearates, sulfates, phosphates
  - Polyolefin waxes
  - Organic stearamides
  - Clays
  - Fatty acid waxes
  - Silica

EDDA Testing with FLO MXA

Sample	Dose Rate (ppm) BPR27140	Water Drop						WQ	Interface
		5'	10'	15'	20'	25'	30'	G	N/A
Light crude (no DRA additive)	**0**	**0.5**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**G**	**N/A**
	10	**0.2**	**0.4**	**0.5**	**0.6**	**0.8**	**0.8**	**G**	**N/A**
	30	**0.6**	**0.9**	**1.5**	**2**	**2.2**	**3**	**G-**	**G**
LC w/ additive	0	9	9	9	9	9	9	G	G
	10	9	9	9	9	9	9	G-	G
	30	9	9	9	9	9	9	G-	G
Heavy crude no additive	0	1.5	2.2	2.8	3	4	4	G	G-
	10	3.5	5	6	6	7	8	G	G-
	30	4.5	5.5	6.5	7	8	8	G	G-
HC w/additive	**0**	**3**	**3.5**	**3.5**	**4**	**5**	**5**	**G**	**G-**
	10	**3.5**	**5**	**5.**	**6**	**6**	**7**	**G**	**G-**
	30	**4**	**5.5**	**5.5**	**6**	**7**	**7**	**G**	**G-**

Initial BS&W

Sample 0	% Water	% BS	% Total	% Slug
LC –no additive	0	1.2	1.2	0.6 (plug) no water
LC w/ additive	**Tr**	**0.4**	**0.4**	**0.4**
HC no additive	0.1	0.6	0.6	0.2/0.4 (0.2% plug)
HC w/additive	0	0.4	0.4	0.2

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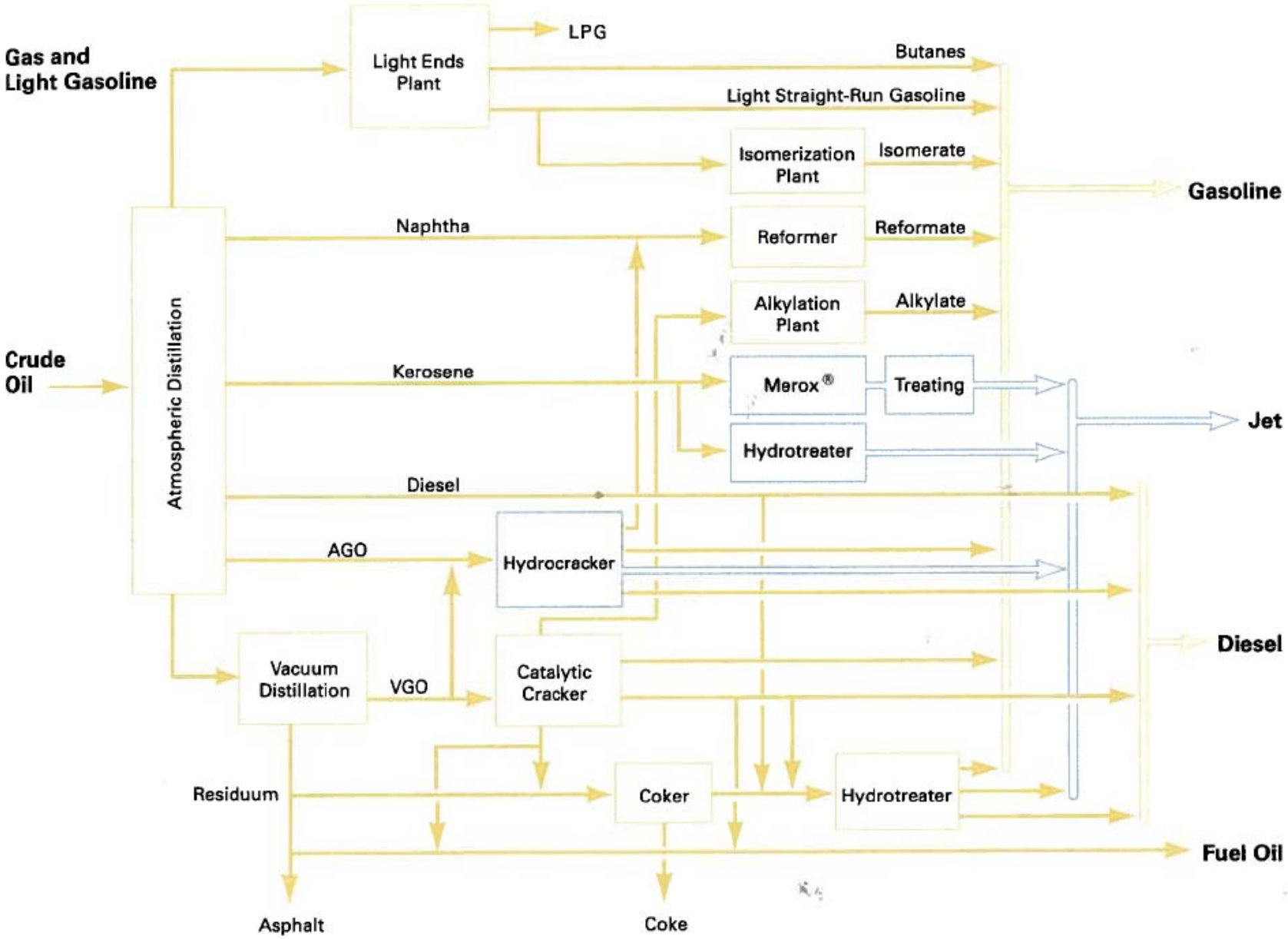
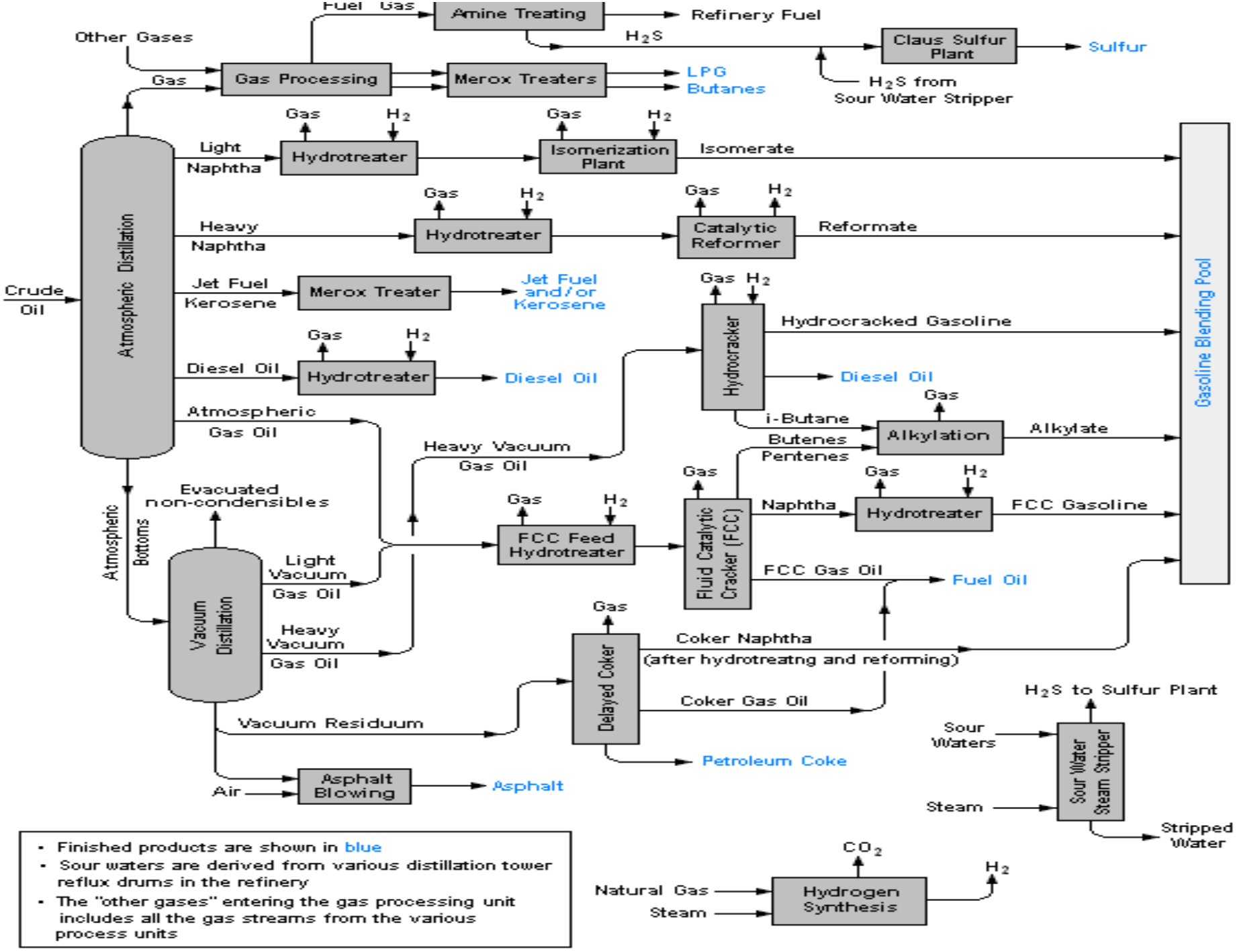

Gas and Light Gasoline
Light Ends Plant
LPG
Butanes
Light Straight-Run Gasoline
Isomerization Plant
Isomerate
Gasoline
Naphtha
Reformer
Reformate
Alkylation Plant
Alkylate
Crude Oil
Atmospheric Distillation
Kerosene
Merox®
Treating
Jet
Hydrotreater
Diesel
AGO
Hydrocracker
Diesel
Vacuum Distillation
VGO
Catalytic Cracker
Residuum
Coker
Hydrotreater
Fuel Oil
Asphalt
Coke


Fuel Gas
Amine Treating
Refinery Fuel
Other Gases
H2S
Claus Sulfur Plant
Sulfur
Gas
Gas Processing
Merox Treaters
LPG
Butanes
H2S from Sour Water Stripper
Gas
H2
Light Naphtha
Hydrotreater
Isomerization Plant
Isomerate
Heavy Naphtha
Catalytic Reformer
Reformate
Crude Oil
Atmospheric Distillation
Jet Fuel Kerosene
Merox Treater
Jet Fuel and/or Kerosene
Diesel Oil
Hydrocracker
Hydrocracked Gasoline
Atmospheric Gas Oil
i-Butane
Alkylation
Alkylate
Butenes
Pentenes
Heavy Vacuum Gas Oil
Evacuated non-condensibles
Atmospheric Bottoms
FCC Feed Hydrotreater
Fluid Catalytic Cracker (FCC)
Naphtha
FCC Gasoline
Light Vacuum Gas Oil
Vacuum Distillation
FCC Gas Oil
Fuel Oil
Heavy Vacuum Gas Oil
Coker Naphtha (after hydrotreatng and reforming)
Delayed Coker
Coker Gas Oil
H2S to Sulfur Plant
Vacuum Residuum
Sour Waters
Sour Water Steam Stripper
Petroleum Coke
Air
Asphalt Blowing
Asphalt
Steam
Stripped Water
Gasoline Blending Pool
CO2
Natural Gas
Steam
Hydrogen Synthesis
H2
• Finished products are shown in blue
• Sour waters are derived from various distillation tower reflux drums in the refinery
• The "other gases" entering the gas processing unit includes all the gas streams from the various process units

DRA and Refined Fuel Product Quality

- **EPA registration as a fuel additive**
- **Sulfur and metals levels**
- **Impact on fuel's spec. properties**
  - Corrosivity, filter plugging, cloud point, gums, etc.
- **Engine testing**
- **Behavior in biofuels**
  - Diesel/biodiesel blends
  - Ethanol/gasoline blends

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