What Does It All Mean: Technological and Economic Impact of Fast & Micro Gas Chromatography

Carl Rechsteiner
CRechsteiner Consulting, LLC, Petaluma, CA

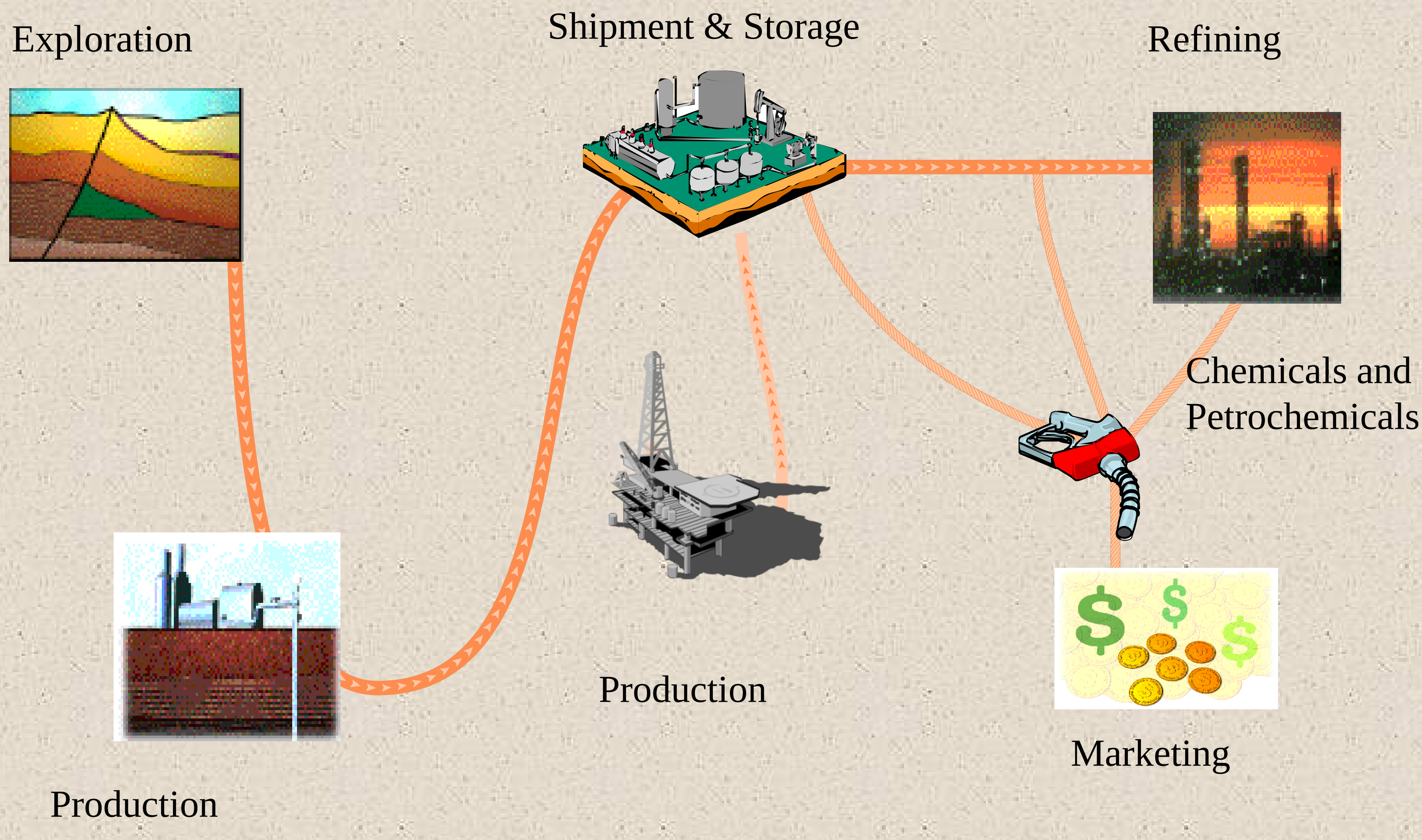
Abstract

Gas Chromatography (GC) is a premier measurement tool for volatile organic compounds. Its application spans a wide range of industries, from food and spirits, to fuels, chemicals, and their intermediates, to environmental monitoring. The expanding use of fast, micro GCs is leading to new opportunities for this valuable measurement approach in laboratories and process venues, driven by the compact, high performance, micro GC design, significant reductions in the measurement cycle times, and the ease and simplicity of interactions with the GC system. This presentation discusses the evolving technological and economic landscape for this technology.

Talk Outline

- Abstract
- Background
- Technology Impacts
    - Examples of Capabilities
- Economic Impacts
- Conclusion

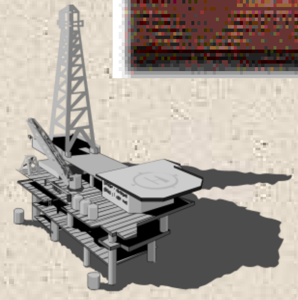
Integrated Oil Company Business Areas



GC Opportunities in Exploration & Production

GC complements other measurements by focusing on the oil composition:

Down-hole samples (Gases and Liquids)
Drilling Core Extracts
Drill Stem Tests
Crude Assay
Oil Maturation Studies
Reservoir Continuity
Biomarker Analysis, …



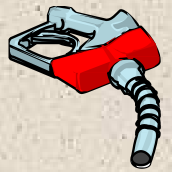
GC used for measurements for gasses, condensates, and oils:

Sales Gas Composition and BTU Content
Condensate Composition for Sales
Custody Transfer for natural gas, petroleum liquids
Crude Assay, …

GC Opportunities in Refining, Marketing & Chemicals Production

GC routinely used for Process Monitoring, Process Control, Process Troubleshooting, Product Release, and Environmental Issues:

- Refinery Gas Analyses
- Detailed Composition of Light Streams (DHA)
- Yield Curves
- Process Fingerprints
- Sulfur & Nitrogen Speciation and Fingerprints
- Trace contaminants in products



GC used in Product Integrity Disputes and Environmental Issues:

- Product Integrity Verification
- Gaseous Emissions
- Aromatics in Water or Soil
- Hydrocarbons in Water and Soil (incl. TPH)

Trends Driving Fast - Micro GCs

Cost of Infrastructure -

Lab/Building/Shelter, Power, Gas Supplies, HVAC, …

Cost of Operation –

Columns, Chemicals, Detectors, Injectors, Spare Parts, Gasses

Space Needs –

Lab Bench, Process Bay, On-shore or Off-shore

Reduced Manpower –

Reduced skilled manpower, “Do more with less!”

Faster Cycle Time

Assist reduced manpower, quicker decisions, move from process snapshot to real time control.

Measurements at the Point of Interest

Reduce cycle time, reduce infrastructure, reduce consumables

GC Evolution – Moving to Small & Fast

Agilent 7690

Falcon Calidus

Thermo
C2V - 200

Siemens Maxim II

ABB PGC1000

Falcon Calidus

Photos courtesy of vendor and their websites.

What is Needed to Realize Benefits

The opportunity is 1) to provide a substitute or add to conventional GCs, and 2) add GC measurements to remote locations that where only serviced by grab and run to the lab, or not at all.

To expand the use of GC in petroleum and petrochemical applications, we need to meet the trends:

reduce the analysis cycle time
(to a few minutes)

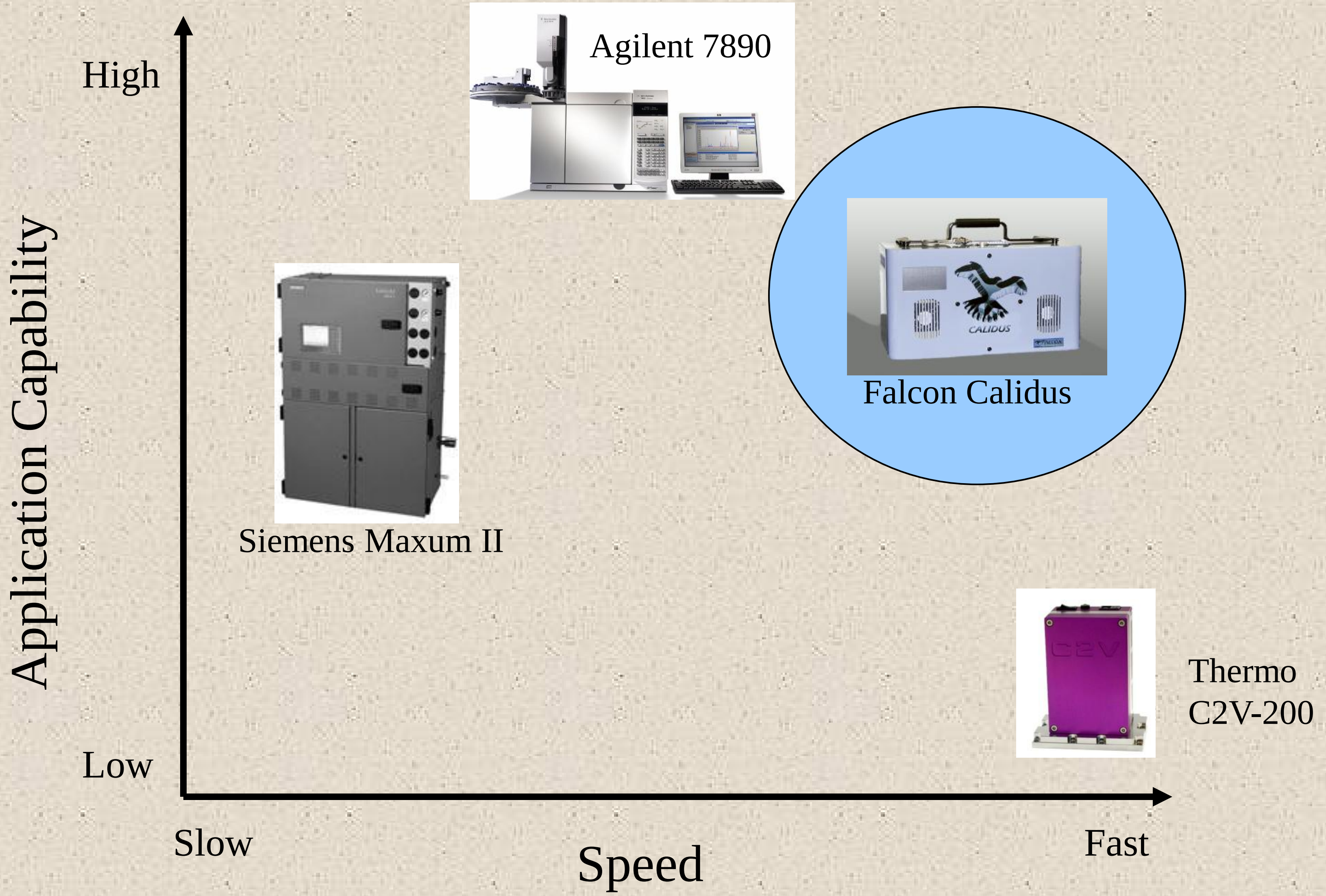
reduce the footprint and infrastructure requirements
(space, power, gases, etc.)

while maintaining the performance of research grade GCs.

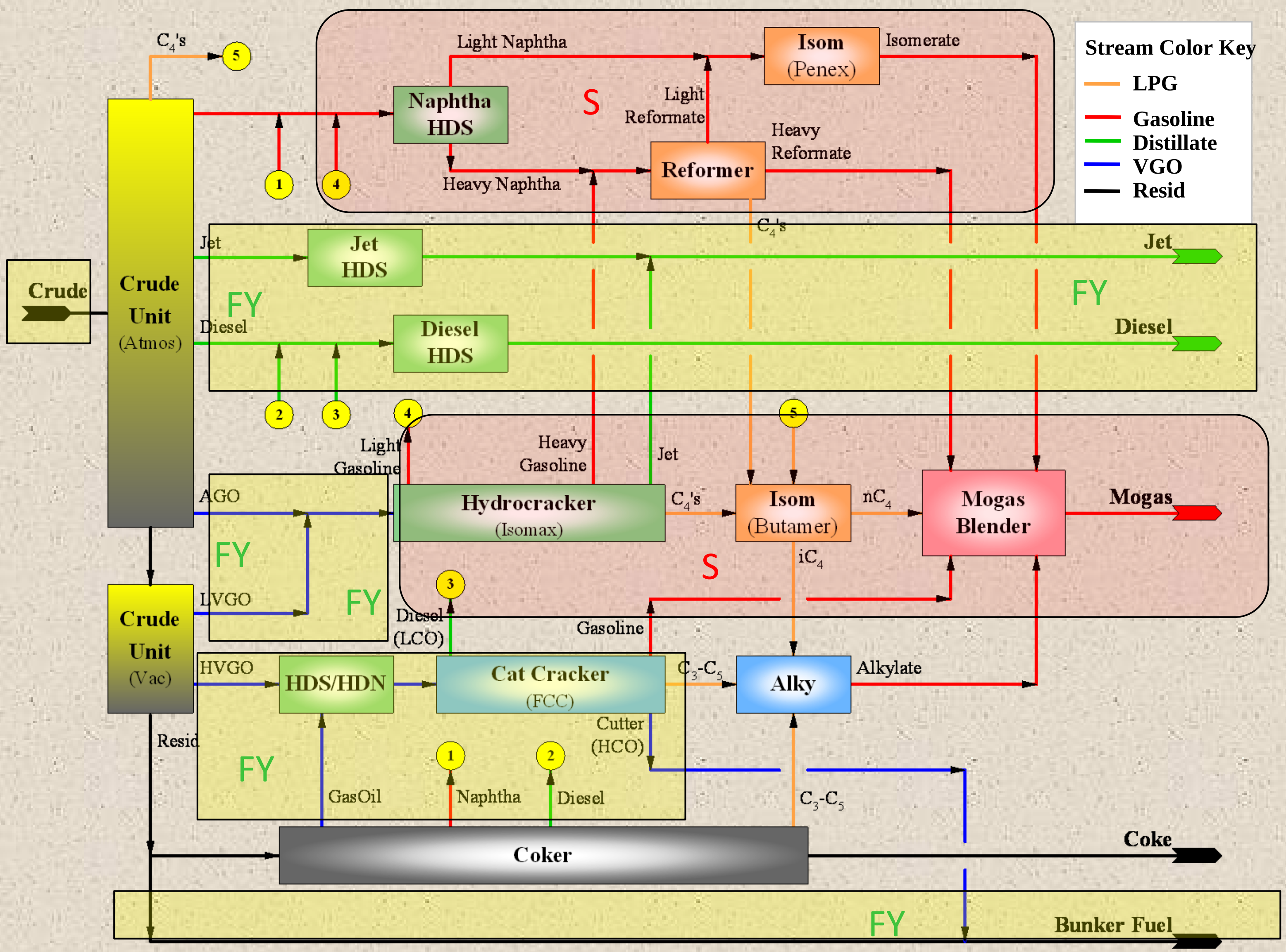
Achieving this goal is not simply a scaling issue. One needs to pay significant attention to the chromatographic system issues; for example, among the physical issues of dead volumes and small flows, GC control issues of reproducible and consistent column heating and temperature profiles, and software control and system electronics to precisely alter the GC conditions.

Sweet Spot in GC Technology

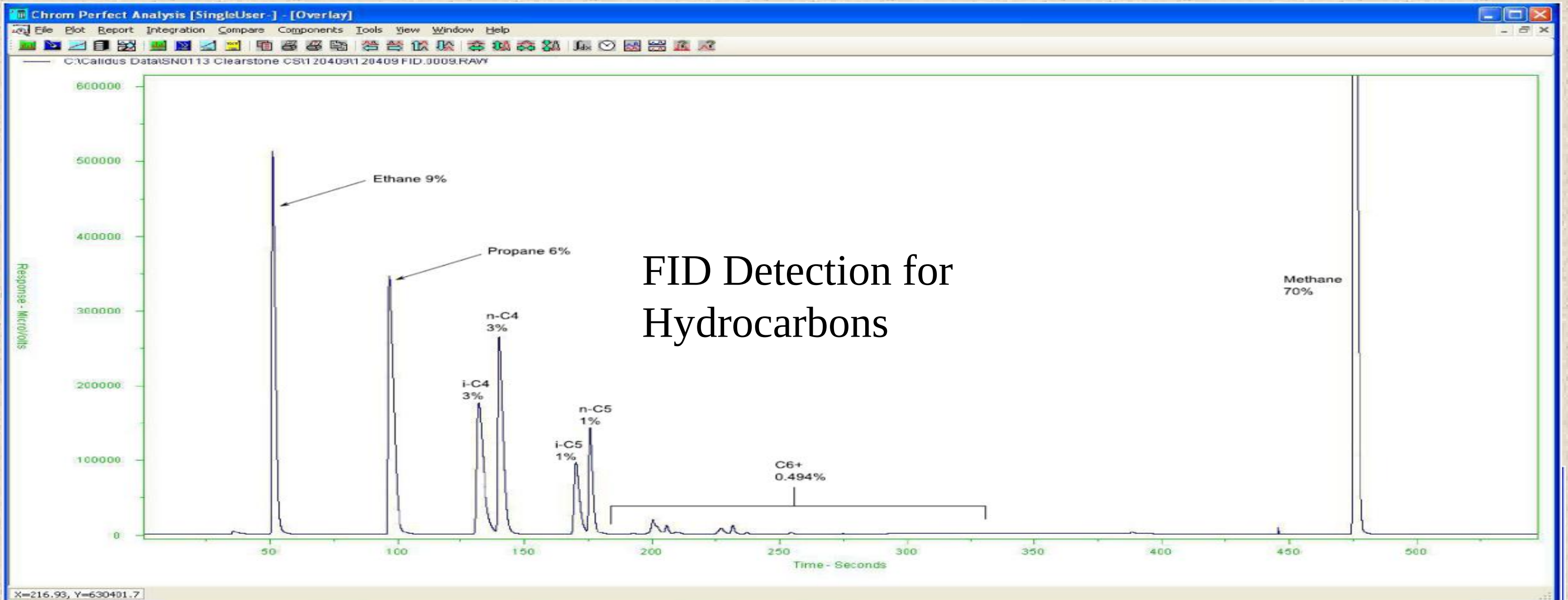
(Moving to smaller, faster yet capable systems)



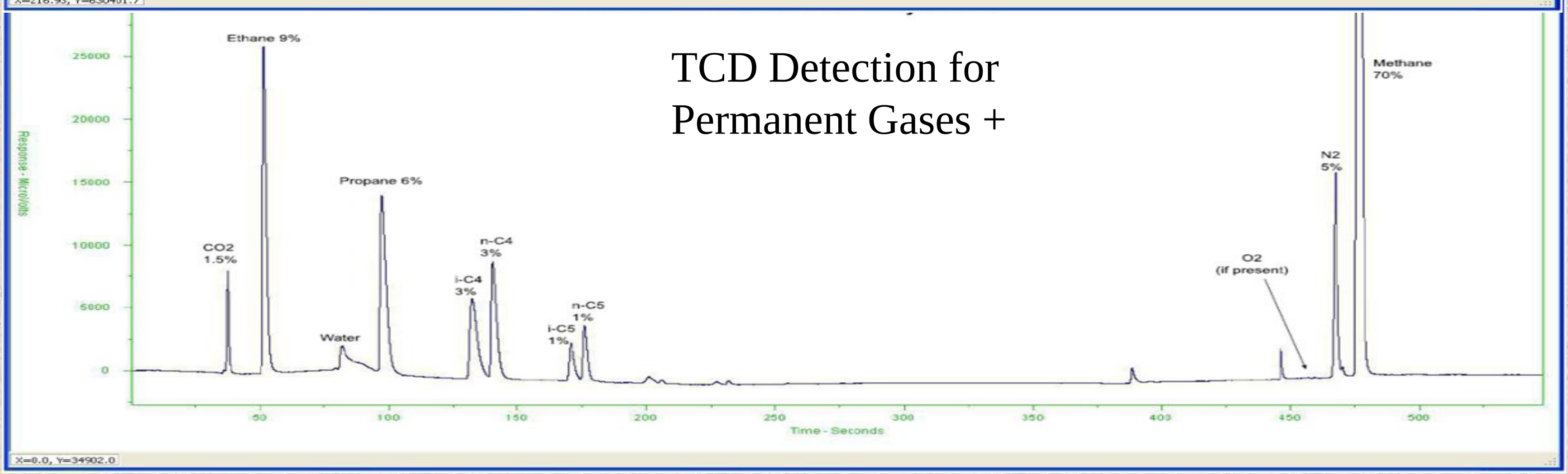
GC Applications Cover Most Refinery Streams



"Refinery" Gas Analysis



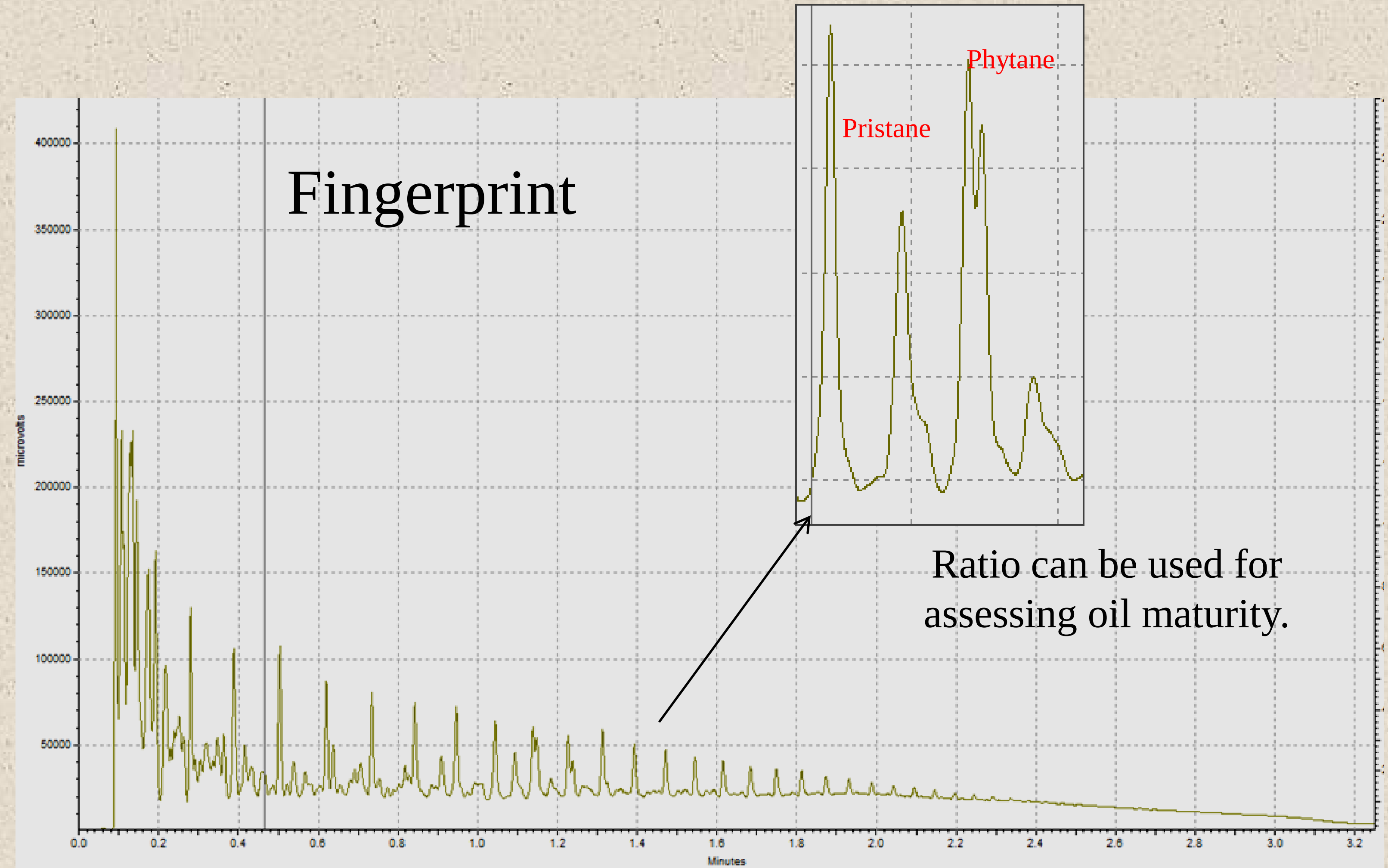
FID Detection for Hydrocarbons



TCD Detection for Permanent Gases +

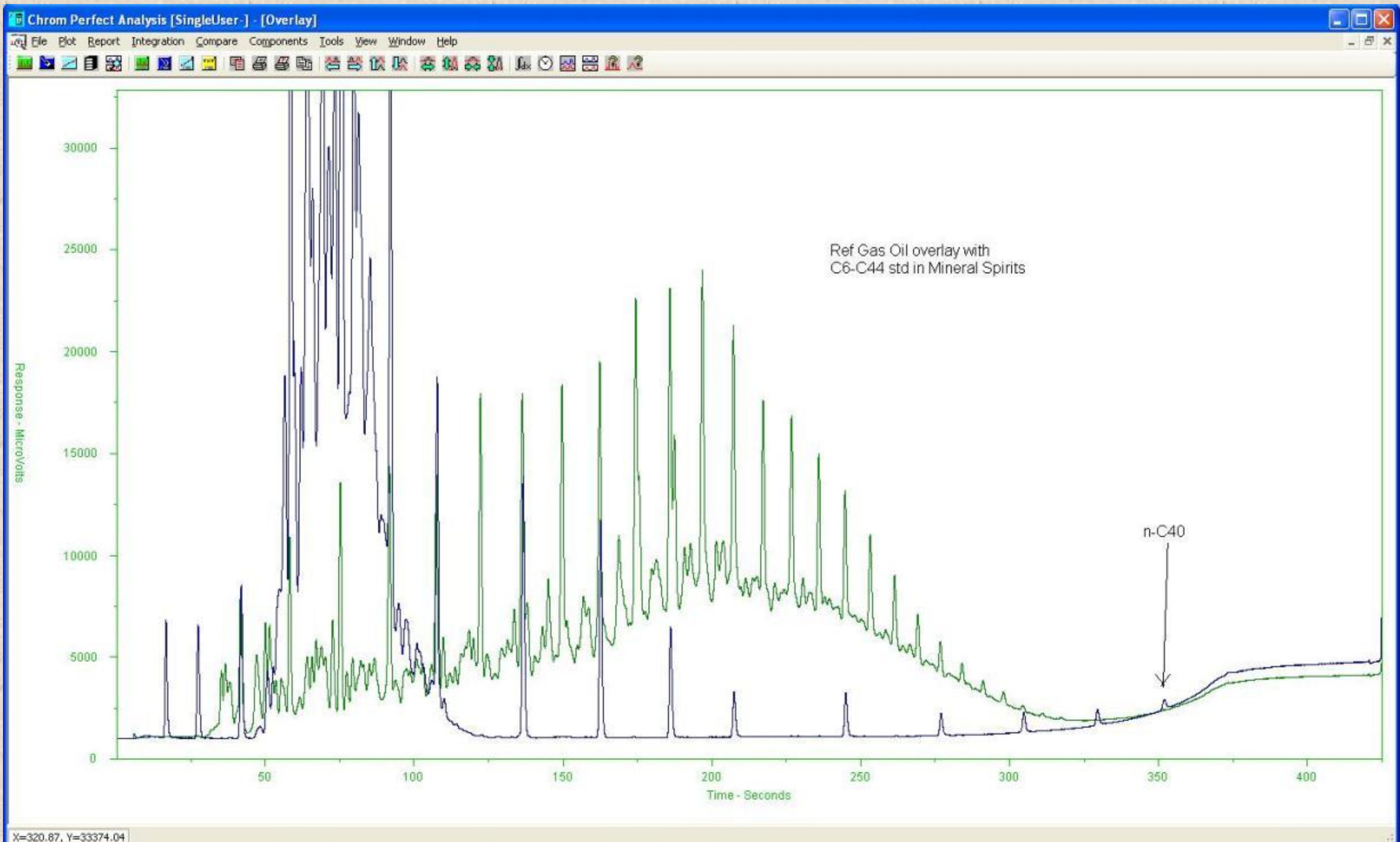
GC Application in Exploration

Biomarkers

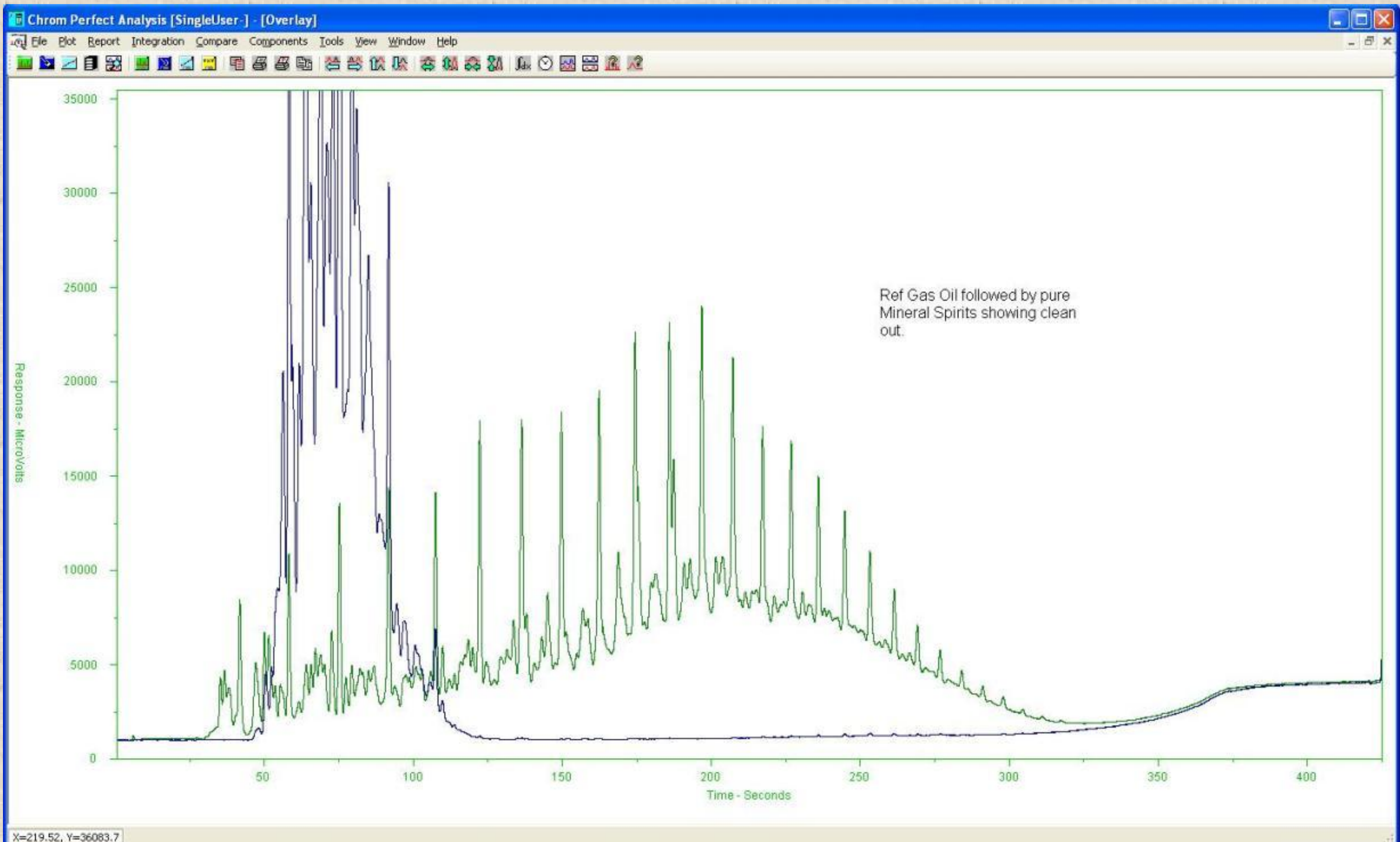


Comparison of Wide Boiling Range Materials

(Reference Gas Oil with n-Paraffin Standard)

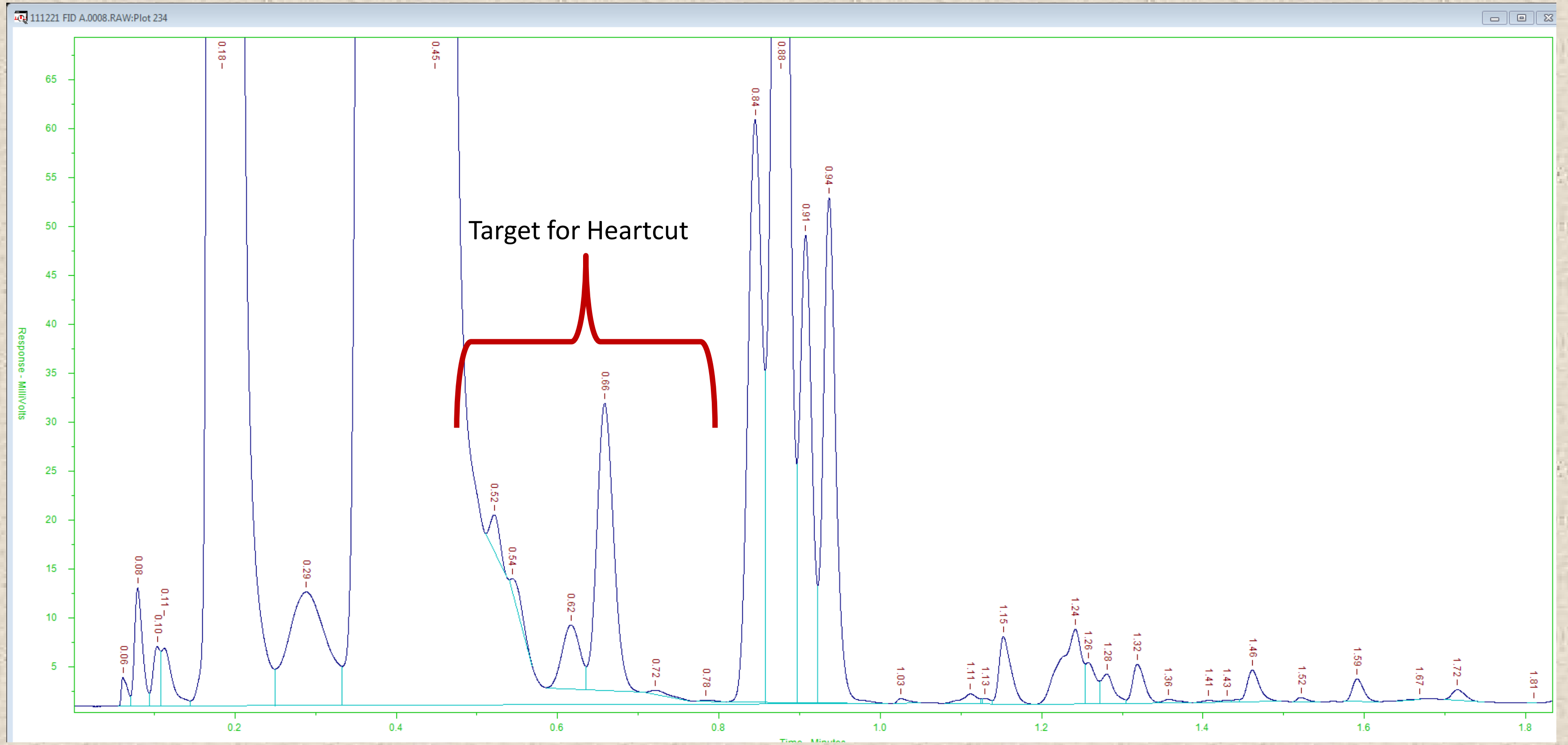


Demonstrating Minimal Carryover



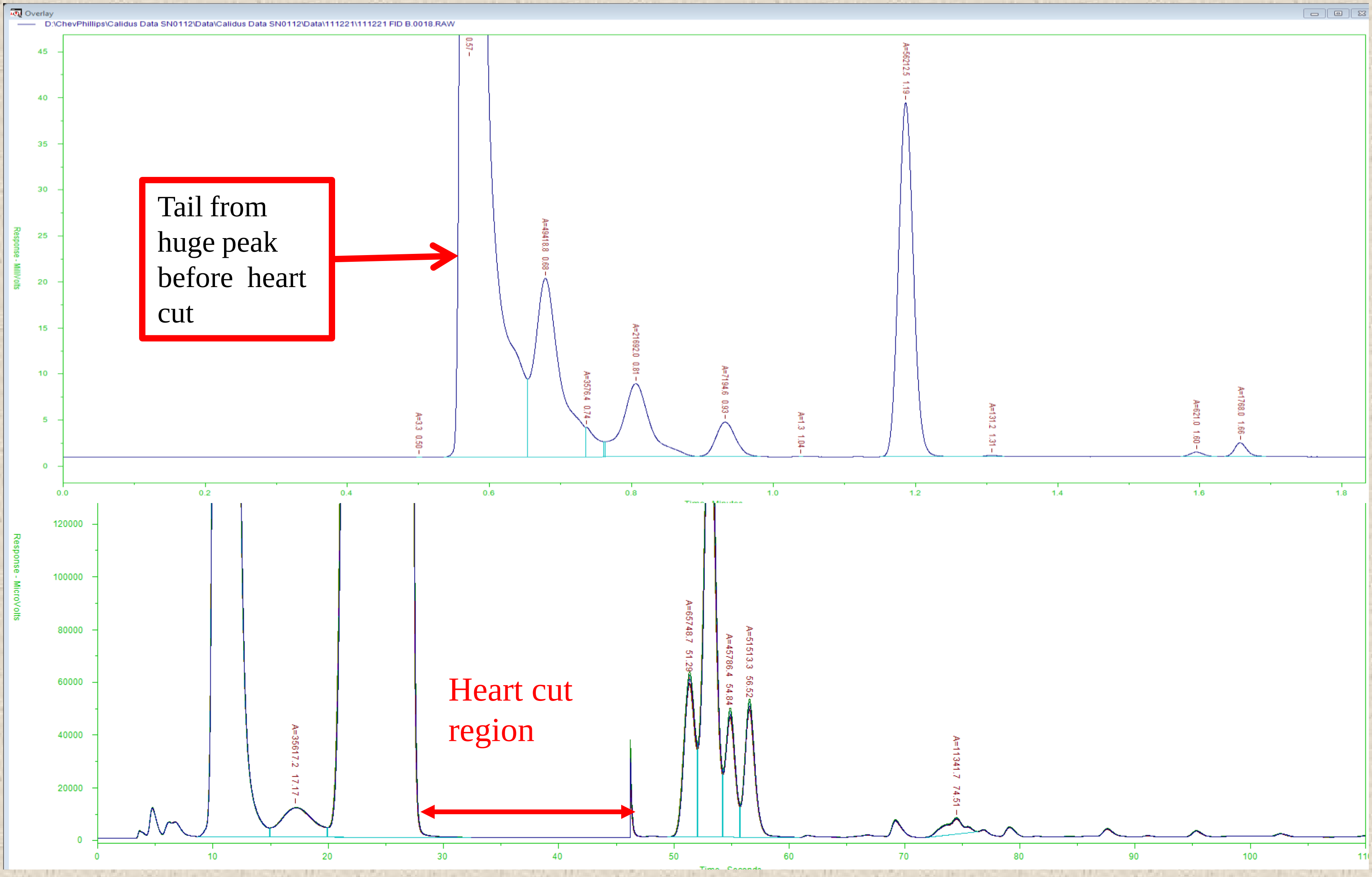
“Hexenes” fraction from NAO Process

(Normal Alpha Olefins)



Heartcut Analysis Results

(on MXT-Wax Column)



Refinery Field Lab Yield Determination

Rep #	0.5%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	99.5%
1	241.3	304.6	349.1	394.8	436.5	471.3	500.0	527.3	553.5	577.5	594.6	610.7	629.3	648.7	668.6	690.1	712.8	737.2	765.3	804.4	885.6
2	240.5	304.4	349.1	394.9	436.8	471.3	500.3	527.7	553.6	577.7	595.0	611.1	629.7	649.3	669.1	690.6	713.3	737.7	766.1	805.3	886.9
3	241.0	304.4	349.2	394.7	436.8	471.3	500.5	527.8	553.5	577.5	594.6	610.7	629.1	648.8	668.5	690.3	712.8	737.0	765.3	804.6	885.7
4	240.5	304.5	349.1	394.9	437.0	471.4	500.4	527.7	553.7	577.6	594.7	610.9	629.3	648.9	668.6	690.5	712.9	737.2	765.7	804.9	888.8
5	240.9	304.4	349.3	395.0	437.1	471.6	500.4	527.7	553.9	577.6	594.8	610.7	629.3	648.7	668.6	690.2	712.6	737.0	765.5	804.9	886.2
6	240.6	304.3	349.0	394.6	436.7	471.2	500.2	527.3	553.4	577.3	594.4	610.5	629.0	648.7	668.4	690.0	712.6	736.8	765.2	804.7	887.6
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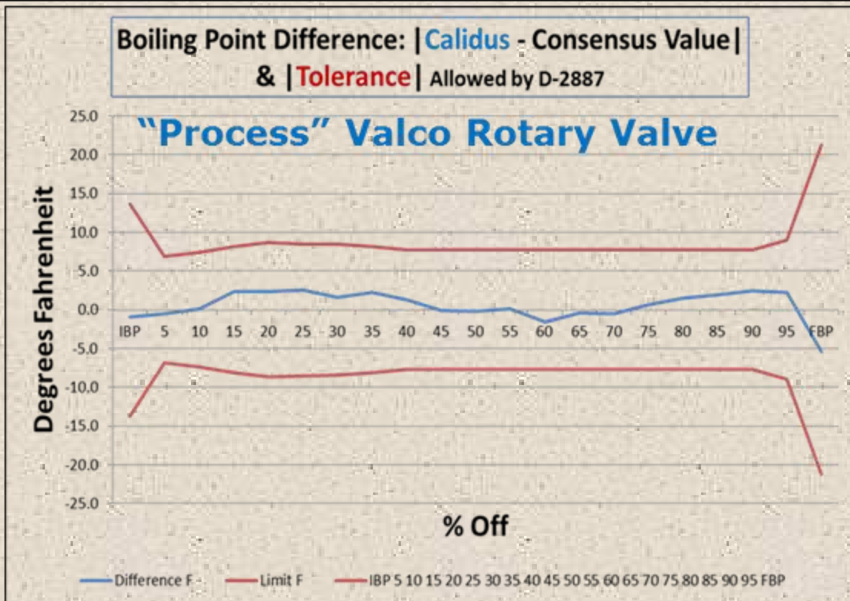
11	240.8	304.4	349.4	394.8	437.1	471.7	500.7	527.8	554.0	577.7	595.0	611.1	629.7	649.3	668.9	690.4	712.8	737.0	765.1	804.4	885.4
12	240.9	304.5	349.1	394.9	437.0	471.5	500.4	527.6	553.4	577.4	594.6	610.4	629.1	648.5	668.3	689.8	712.4	736.6	764.7	803.8	885.0
13	241.0	304.6	349.4	395.3	437.3	472.0	500.9	528.1	554.0	577.6	594.8	610.5	629.0	648.5	668.3	689.8	712.4	736.8	764.9	804.0	885.4
14	241.0	304.5	349.1	394.9	436.8	471.4	500.5	527.8	553.8	577.7	595.0	611.0	629.6	649.0	668.8	690.5	713.0	737.4	766.0	805.2	886.7
15	240.7	304.5	349.4	395.2	437.6	472.1	501.1	528.1	553.8	577.5	594.7	610.7	629.0	648.9	668.6	690.4	712.9	737.4	765.7	805.4	888.4
AVE	240.7	304.5	349.2	394.9	437.0	471.5	500.5	527.7	553.6	577.5	594.7	610.7	629.2	648.8	668.6	690.2	712.7	737.1	765.3	804.6	886.5
SDEV	0.39	0.12	0.13	0.19	0.28	0.27	0.29	0.24	0.22	0.14	0.20	0.25	0.25	0.27	0.24	0.27	0.30	0.31	0.39	0.47	1.13
RSD	0.16%	0.04%	0.04%	0.05%	0.07%	0.06%	0.06%	0.05%	0.04%	0.02%	0.03%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.05%	0.06%	0.13%
Consensus	239	304	349	393	435	469	499	526	552	576	594	610	629	649	669	690	712	736	764	803	887
Difference	1.71	0.45	0.21	1.94	1.99	2.53	1.47	1.69	1.64	1.52	0.73	0.72	0.24	-0.19	-0.41	0.22	0.75	1.06	1.35	1.59	-0.50

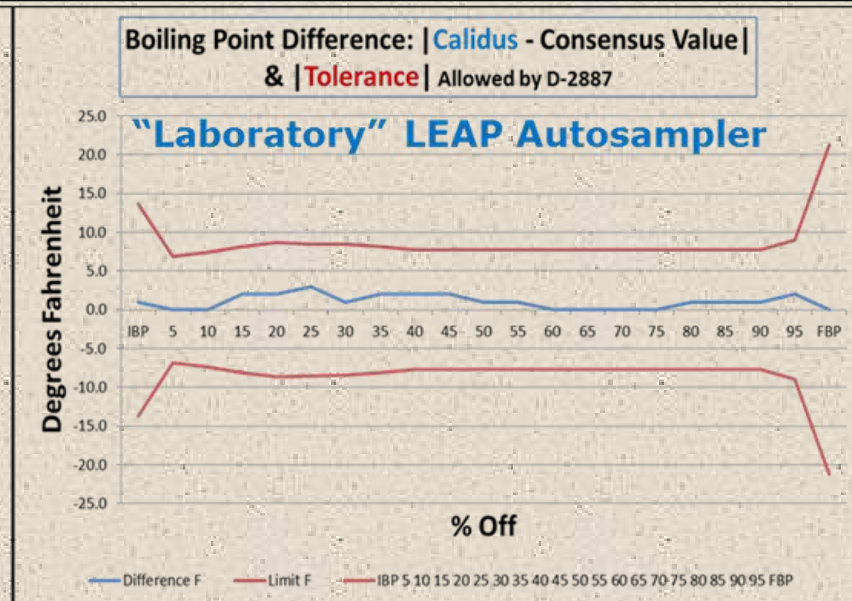
Initial BP = 241^{o}F   Final BP = 886^{o}F

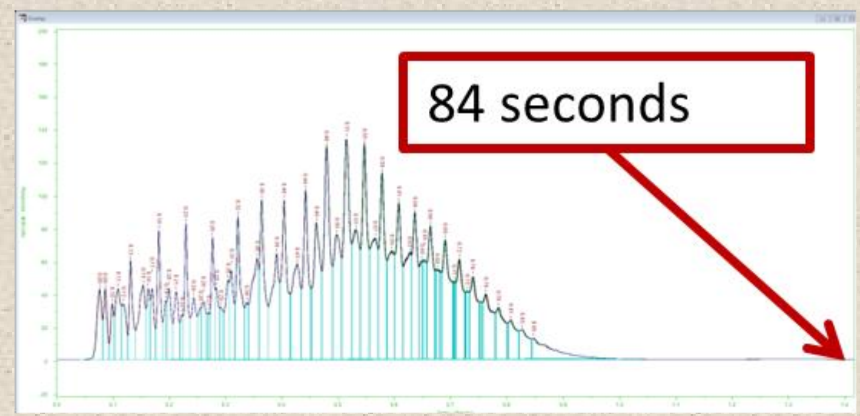
Ave. SDev = 0.3^{o}F   Ave. RSD = 0.05%

Ave. Difference from Consensus Value = 1.0^{o}F

On-Line Versus Lab Analysis

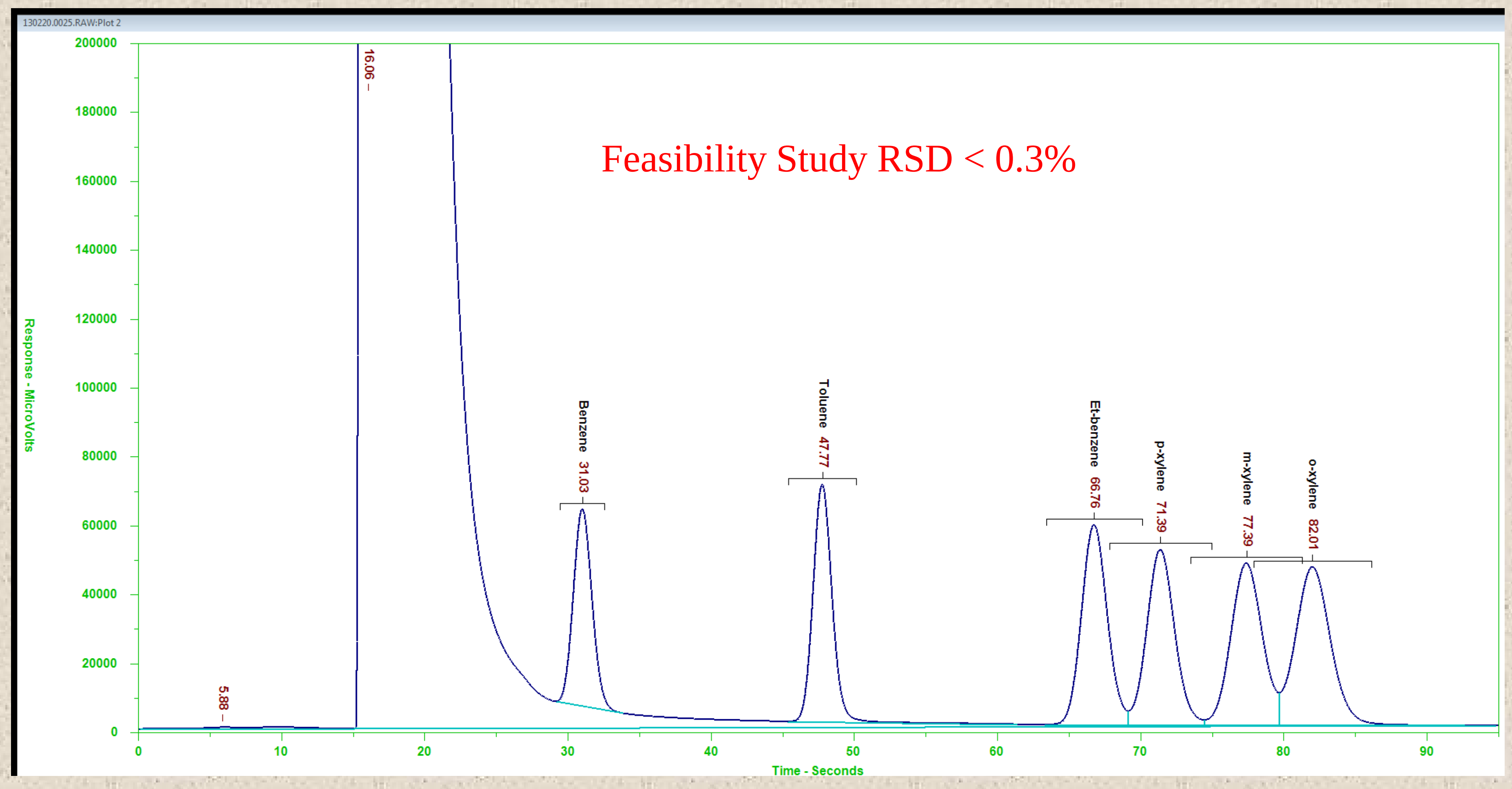






Environmental Standard

(Benzene, Toluene, Ethyl Benzene o-,m-,p-Xylene)



Economic Impacts

The Cost Side Examples

Lab Construction Cost

On-shore Lab	$80 - $100 per square foot
Off-shore Lab	$ 750 - $ 1100 per square foot

Thus a 1000 sq ft offshore lab space would cost on the order of $ 1,000,000.

This puts a premium on space. A single Calidus microGC, with a footprint <1/2 of a research grade GC, and the capacity to do the work of 4-5 research grade GCs, is an effective way to use such space.

Economic Impacts

The Cost Side Examples

Process Environment

Process GCs are usually in a building or shelter with heat traced sample lines. For a four GC, three sided shelter with sample conditioning systems, it might cost ca. $ 400,000. With the same characteristics, but only 1 fast, micro GC, the cost could be cut in half. If one could use a small, simple enclosure, the cost would be lower.

A significant cost is the heated lines that have to be run
to the GC and then back to the process. A typical heat traced line could cost between $10 and $40 per linear foot. Moving the GC closer to the point of interest, would minimize both the cost and the time delay associated with the GC measurements.

Economic Impacts

The Cost Side Examples Continued

Lab Operating Cost

	Conv.	Micro
Gas Supplies	He	H_2
Power Requirements	3000W	300W
HVAC Requirements*	12000W	300W
	heat removal	

*using previous example 1 microGC vs 4 conventional

Economic Impacts

The Profit Side Examples

A single new ethylene plant in Texas will produce 1.5 million tons of ethylene per year.

If use of fast, micro GCs allows better optimization and control of the process and reduces product quality concerns, each $0.01 per pound of margin improvement translates to an additional $ 30,000,000 net annual profit.

For a propylene plant in Texas which produces 900 tons per year a $ 0.01 per pound margin would net $ 18,000 annual profit.

For a hexene plant, again in Texas producing 200,000 pounds per year a $ 0.01 per pound margin would net $ 4,000,000 annual profit.

Economic Impacts

The Profit Side Examples continued

A common practice in many refineries is to divert high-valued product for some period of time (8, 12, 24 hours), when a new, different feedstock is processed, to assure that the conversion operation is stable.

With fast, microGCs showing when stability is reached, the transition between operating modes could be less than 1 hour.

If assume a 30,000 bbl/day plant with 8 hr waiting practice –

Reduce reprocessing, storage and handling cost

7 hrs * 52,500 gal/hr * cost/gal === $ 36,750 per incident per $ 0.10 cost

Lost profit due to new production

7 hrs * 52,500 gal/hr * margin/gal === $ 36,750 per incident per $ 0.10 margin

Summary

This presentation has illustrated the technology impacts of fast, microGCs in terms of displacing conventional research grade GCs and for opening new opportunities for applying GC technology for real-time process control as opossed to historical data archiving.

This presentation also illustrated the economic benefits and potential for reducing costs and enhancing revenue based on more timely decisions.