ADVANCEMENTS IN MICRO GAS CHROMATOGRAPHY (GC)

Fast Analysis of C1 to C8 hydrocarbons for mud logging applications within 2 minutes using a temperature programmable Micro GC Fusion®

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Introduction

- Mud Logging Introduction
- Gas Sampling at the Well Site
- Gas Chromatography (GC) for Hydrocarbon Analysis
- Instrumentation
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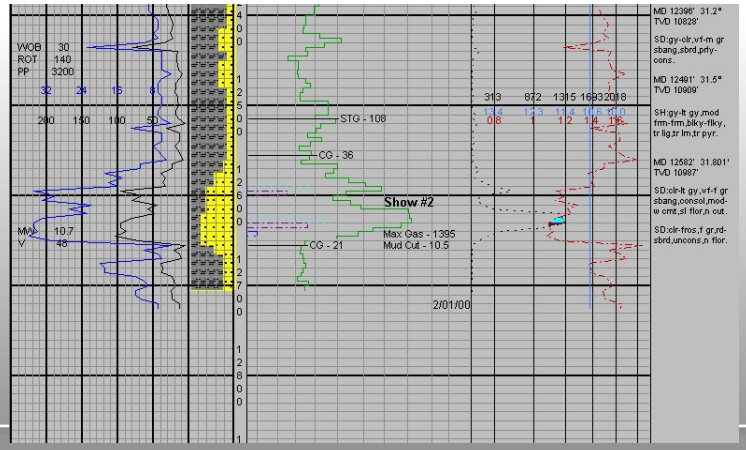
- Methods and Data
  - C1-C5 in 34 seconds
  - C1-C8 in 2 minutes
- On-Site Tips for Successful Analysis
- Future Development

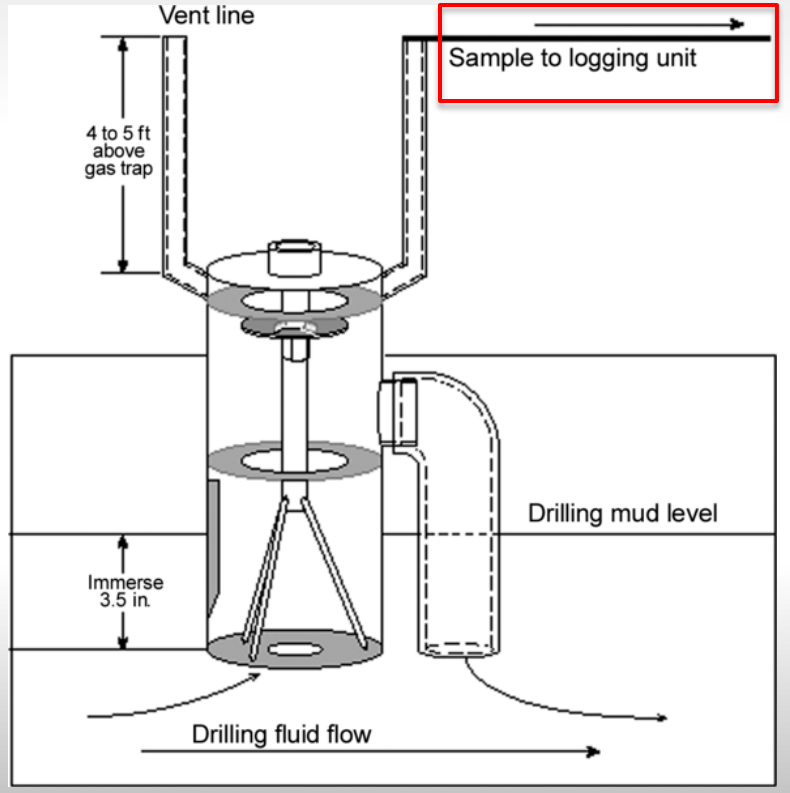
Mud Logging Introduction

- Mud logging is the creation of detailed reports of a borehole on a well site during active drilling
- Liquid, or “mud”, is used as the drilling fluid to bring gas, formation fluids, and rock cuttings to the surface for analysis
- A mud log provides key geographical information, including lithology, rate of penetration, and hydrocarbon content
- The concentration of C1-C8 compounds is critical and must be performed on a continuous, 24-7 basis



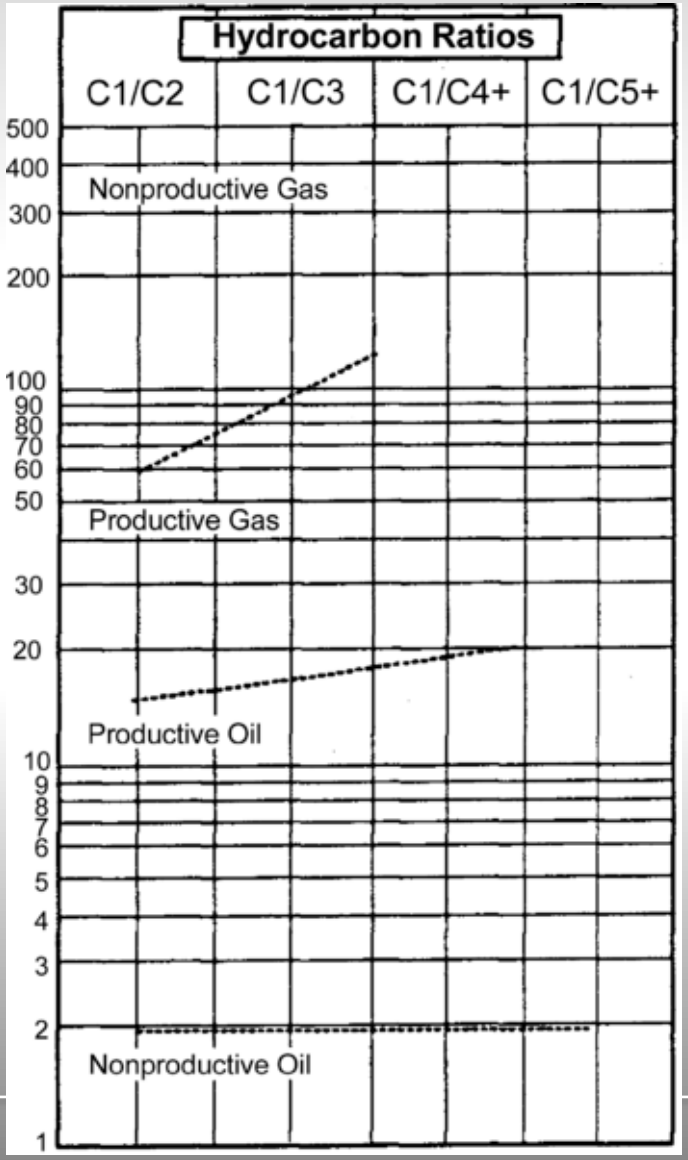
Gas Sampling at the Well Site

- A gas trap allows the mud to separate between the gas and liquid components
- The head space gas then goes to the gas analyzer
- Gas chromatography (GC) is often used to analyze the gas sample



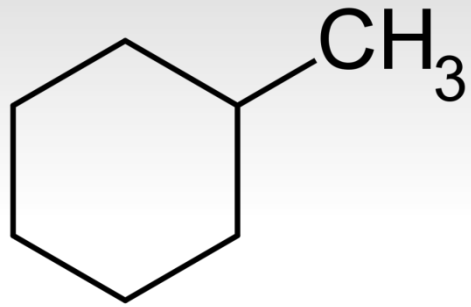
Gas Chromatography for Hydrocarbon Analysis

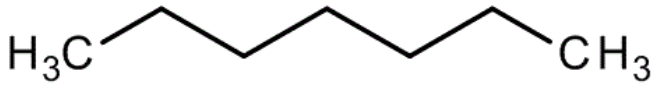
- GC has been used for mud logging for decades to characterize reservoir fluid composition
- Each reservoir is composed of different amounts of hydrocarbon species
- The amount and ratios of compounds help identify zones of producible oil or gas
- Other calculations are used for wetness (W_h), balance (B_h), and character (C_h)

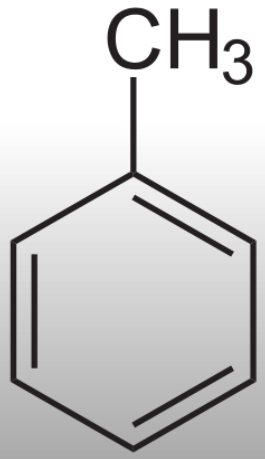


Gas Chromatography for Hydrocarbon Analysis

- C1-C5 compounds are of main importance; however, analysis of heavier hydrocarbons is often desired
- Heavier hydrocarbons, such as methylcyclohexane and C7 help indicate the presence of liquid phases







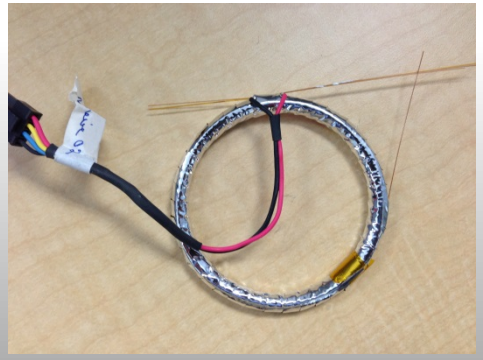
Instrumentation

- Small, transportable GC with microelectromechanical systems (MEMS) technology
- Successor to the 3000 Micro GC
- Gas only analysis
- Thermal conductivity detector (TCD)

Micro GC Fusion

Instrument Features

- Temperature programmable columns
  - Minimizes carryover
  - Allows for more components to elute on a single column
  - Increases sample throughput
- Modular configuration
  - Each module contains an injector, column, and TCD
  - Easy module exchange in the field
- Web-based user interface
  - Can run on any operating system/platform
  - Can be operated from the front panel display
- Integrated sample conditioner (optional)
  - Reduces of sample pressures from up to 1000 psi down to approximately 5 psi
  - Filters out particulates
  - Heats the sample to 100 ºC



Isothermal Method – C1-C5

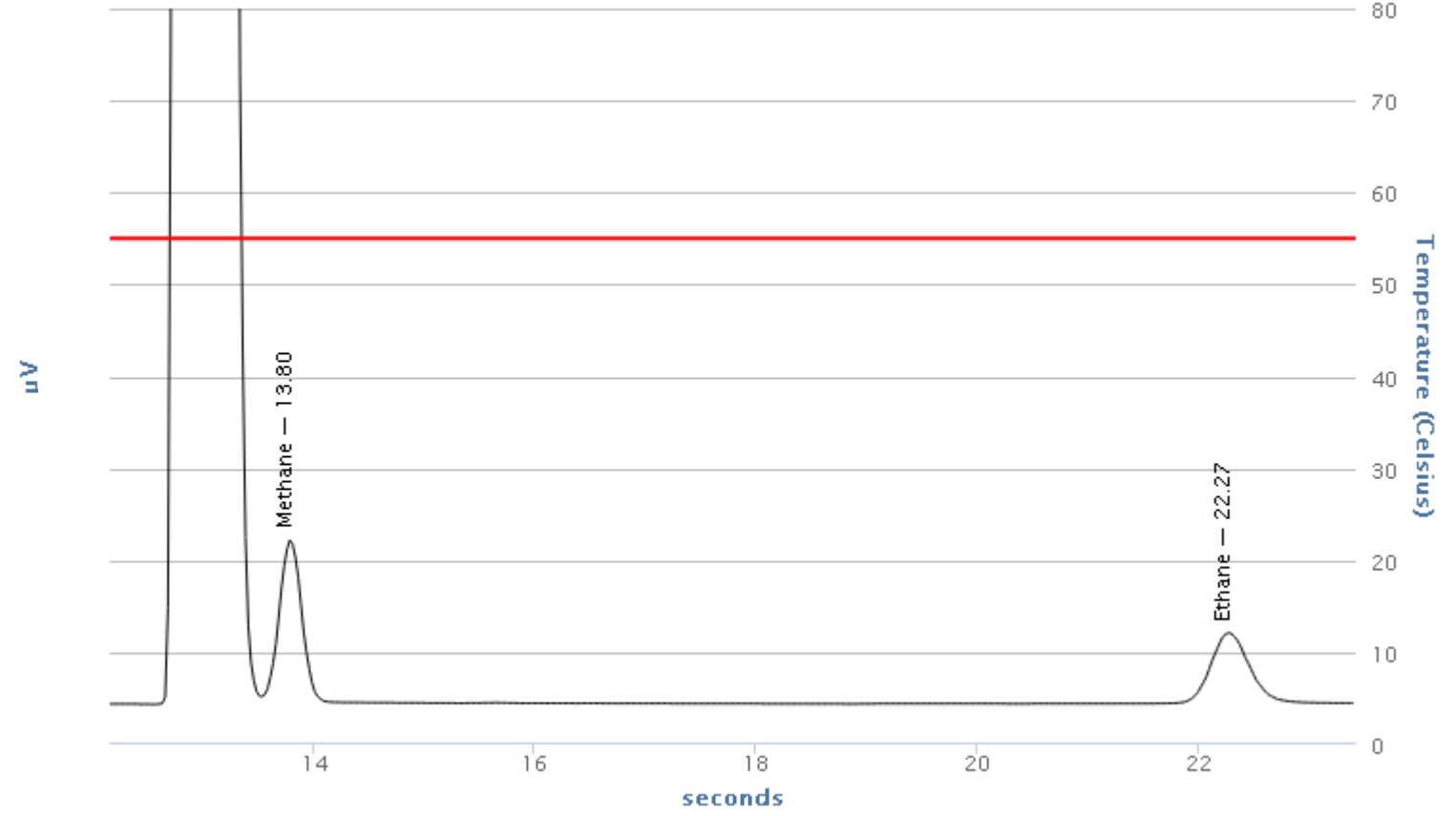
- 2 module system
  - Module A – 8m RT-Q-Bond, variable volume injector
  - Module B – 10m Rxi-1ms, variable volume injector
- A method was designed to run continuously, using isothermal operation
- Total cycle time was 34 seconds

Calibration Standard

Component	Amount (%)
Nitrogen	99.191
Methane	0.200
Ethane	0.101
Propane	0.100
iC4	0.102
nC4	0.103
iC5	0.102
nC5	0.101

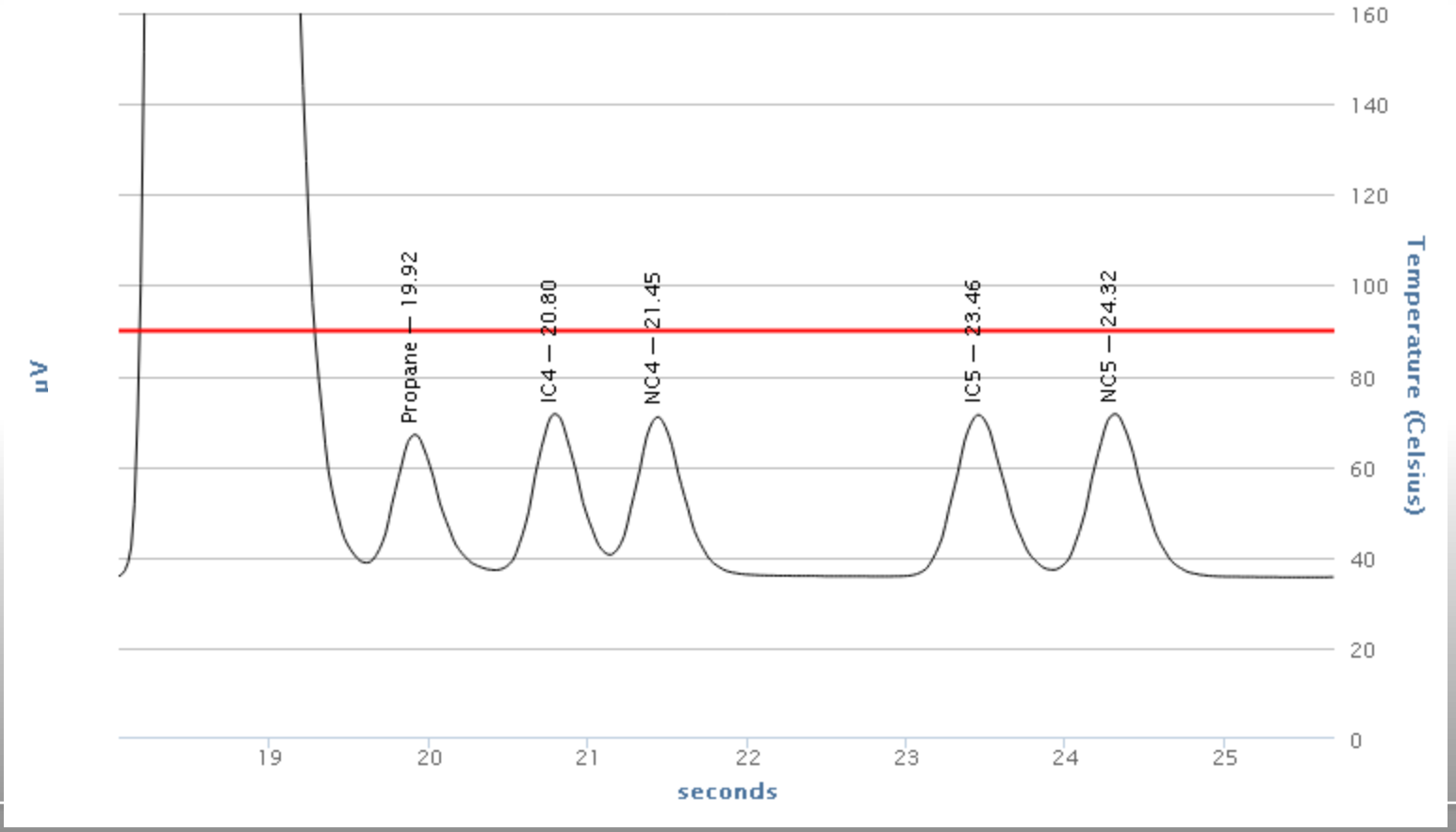
Chromatograms

- Module A: RT-Q-Bond
- Initial parameters used:
  - 55°C, 37 psi, 15 ms injection time, 5 second pump, Helium carrier gas



Chromatograms

- Module B: Rxi-1ms
- Initial parameters used:
  - 90°C, 33 psi, 15 ms injection time, 5 second pump, Helium carrier gas

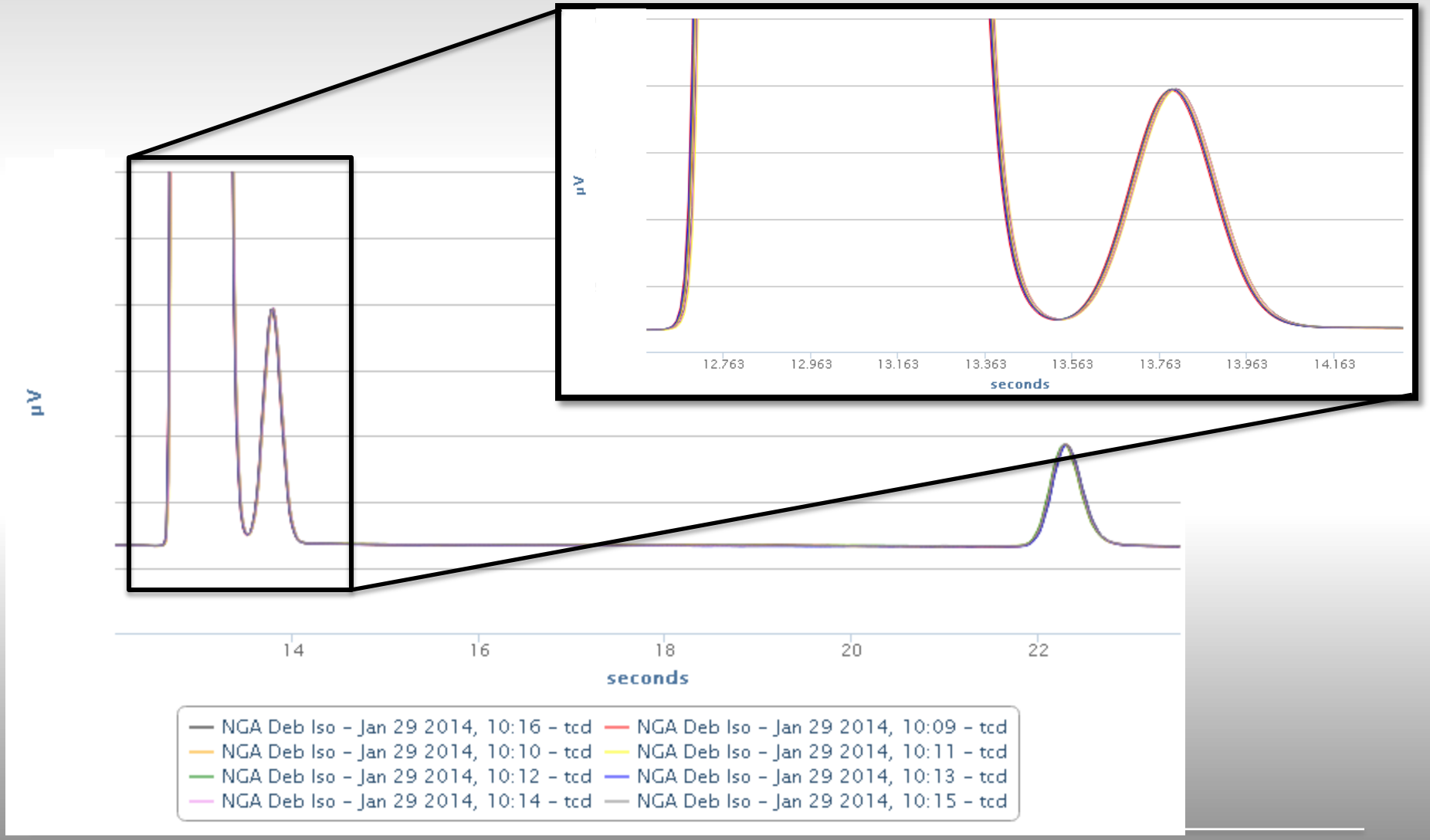


Repeatability

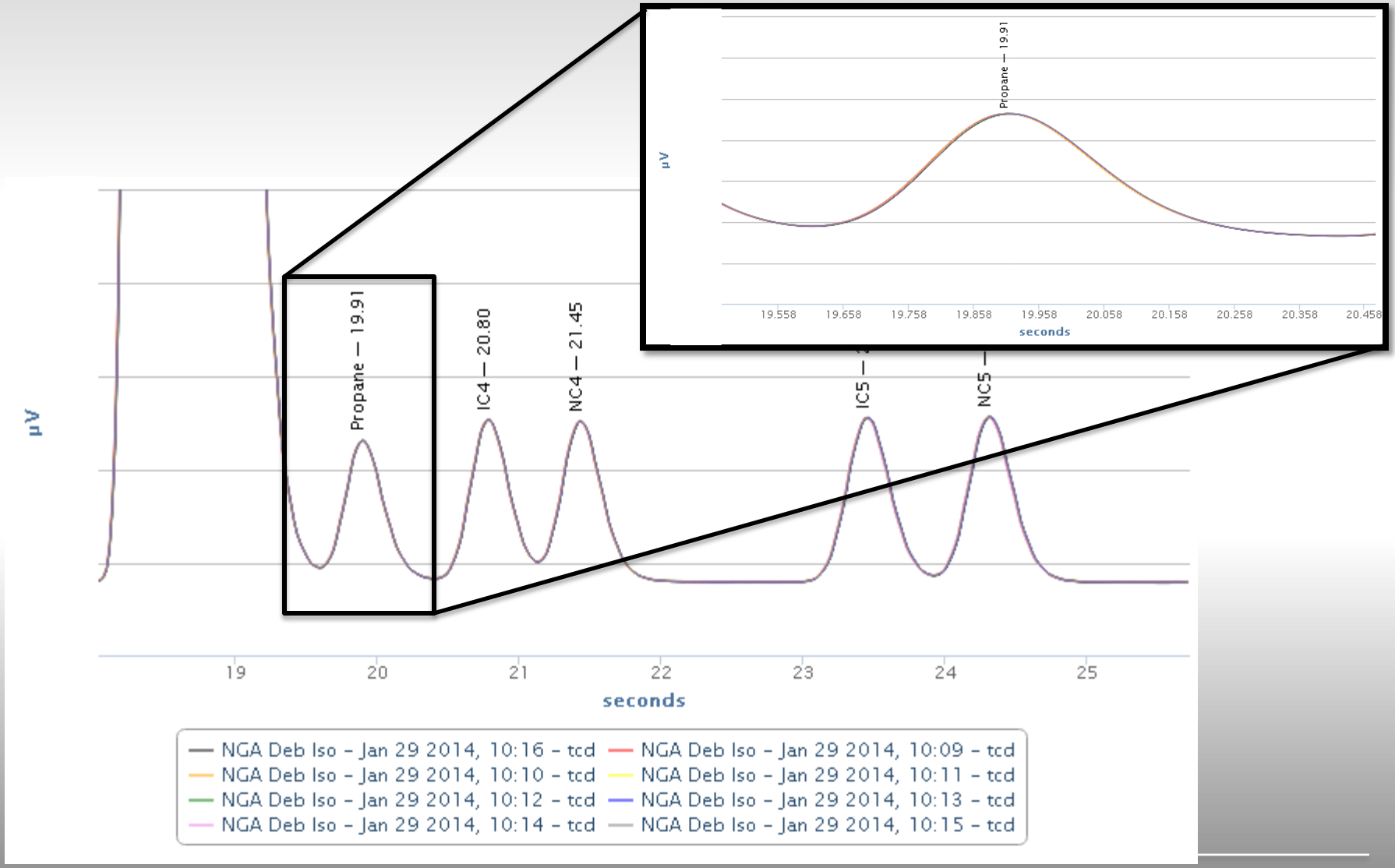
- Exceptional repeatability
  - Less than 0.1 %RSD for retention time
  - Less than 0.6 %RSD for area

1/29/2014	Last 10 runs (10:09 a.m. to 10:16 a.m.)	
	Area %RSD	RT %RSD
Nitrogen	0.09	0.037
Methane	0.57	0.041
Ethane	0.51	0.049
Propane	0.05	0.000
iC4	0.33	0.025
nC4	0.46	0.024
iC5	0.39	0.000
nC5	0.33	0.021

10 Runs Overlaid – RT-Q-Bond

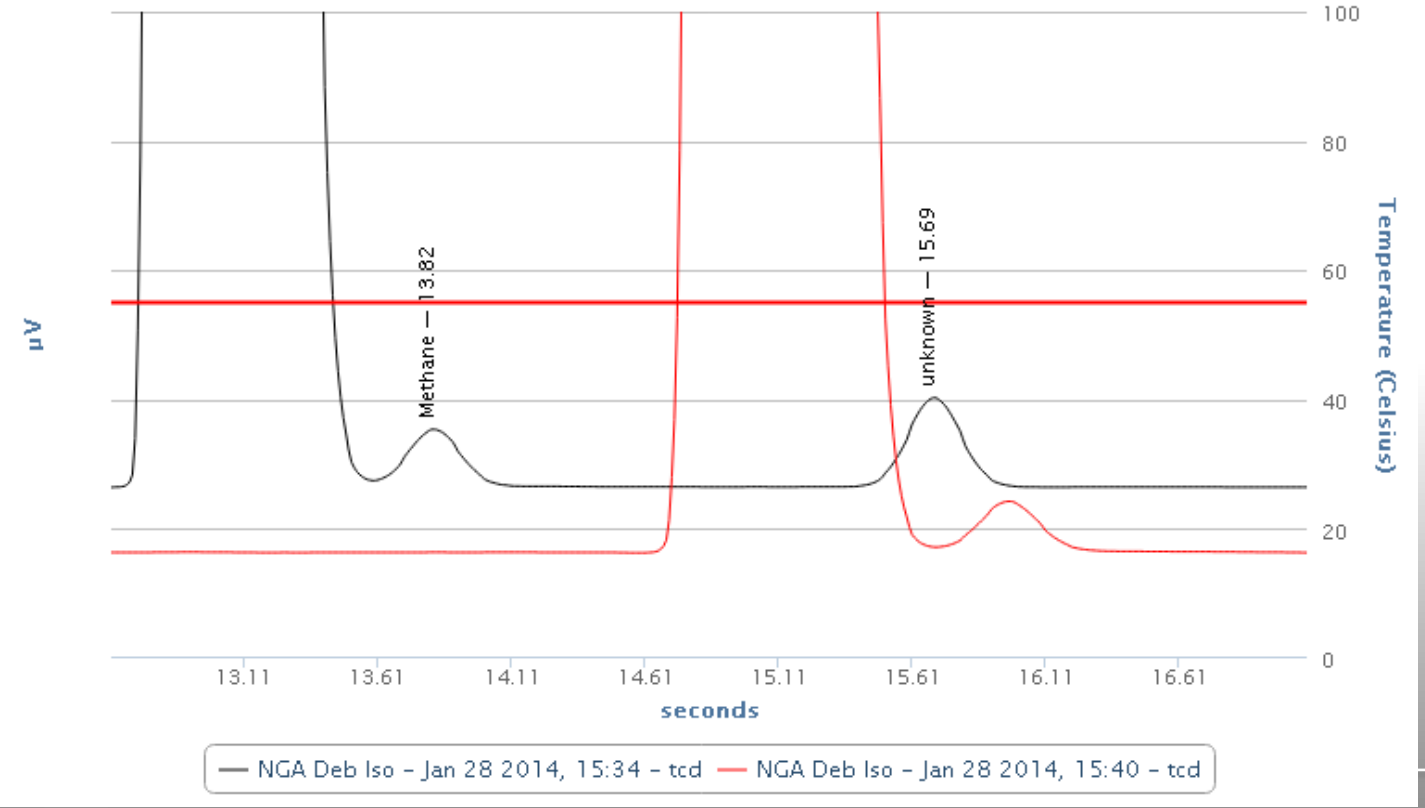


10 Runs Overlaid – Rxi-1ms



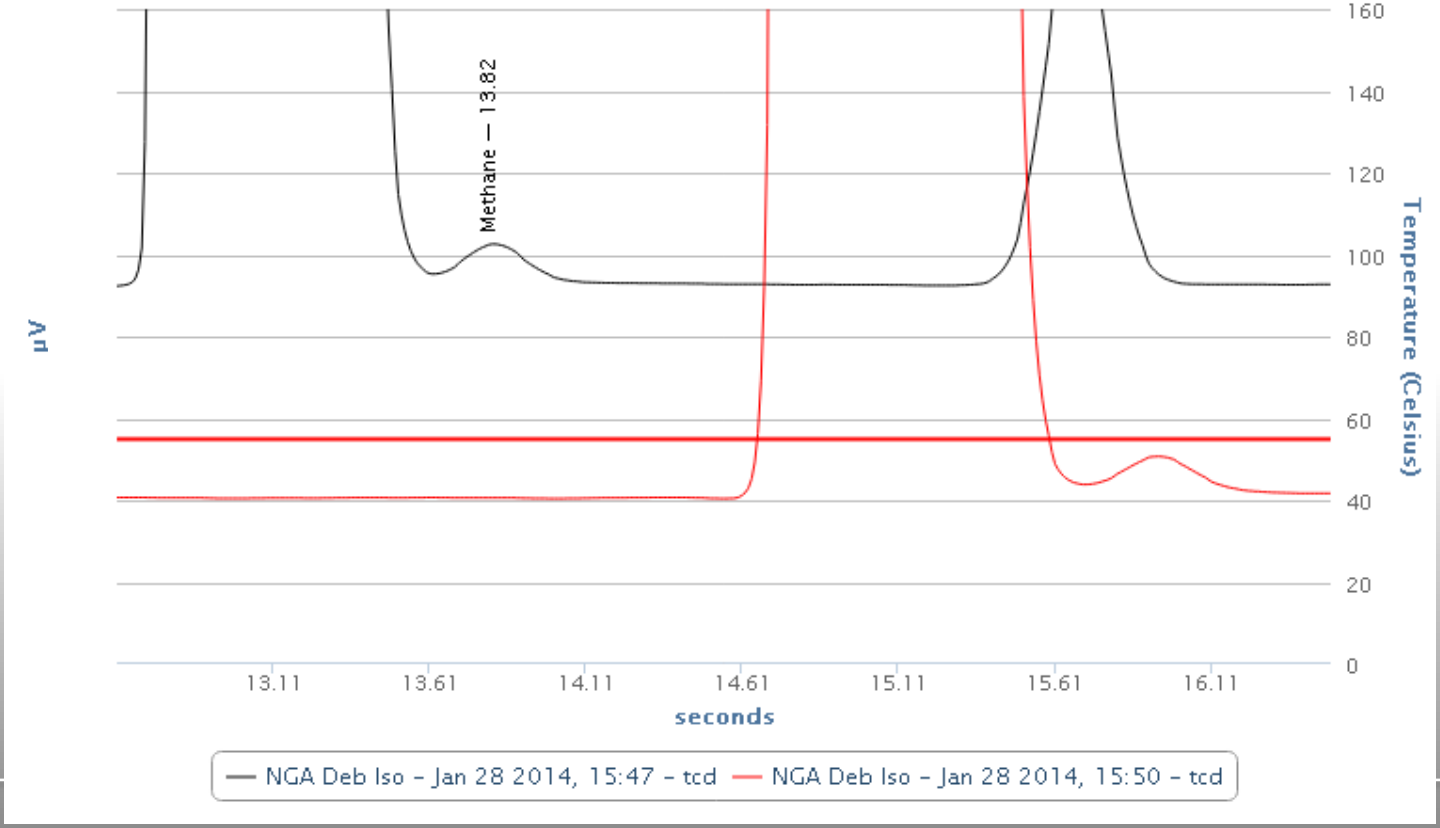
500 ppm Methane

- Module A: RT-Q-Bond - 37 psi and 32 psi
- Syringe dilution
- Reported concentration 0.051%



100 ppm Methane

- Module A: RT-Q-Bond - 37 psi and 32 psi
- Syringe dilution
- Reported concentration 0.014%



Temperature Ramped Method – C1-C8

- 2 module system
  - Module A – 8m RT-Q-Bond, variable volume injector
  - Module B – 10m Rxi-1ms, variable volume injector
- A method was designed to run continuously, using temperature programming
- Total cycle time was approximately 2 minutes

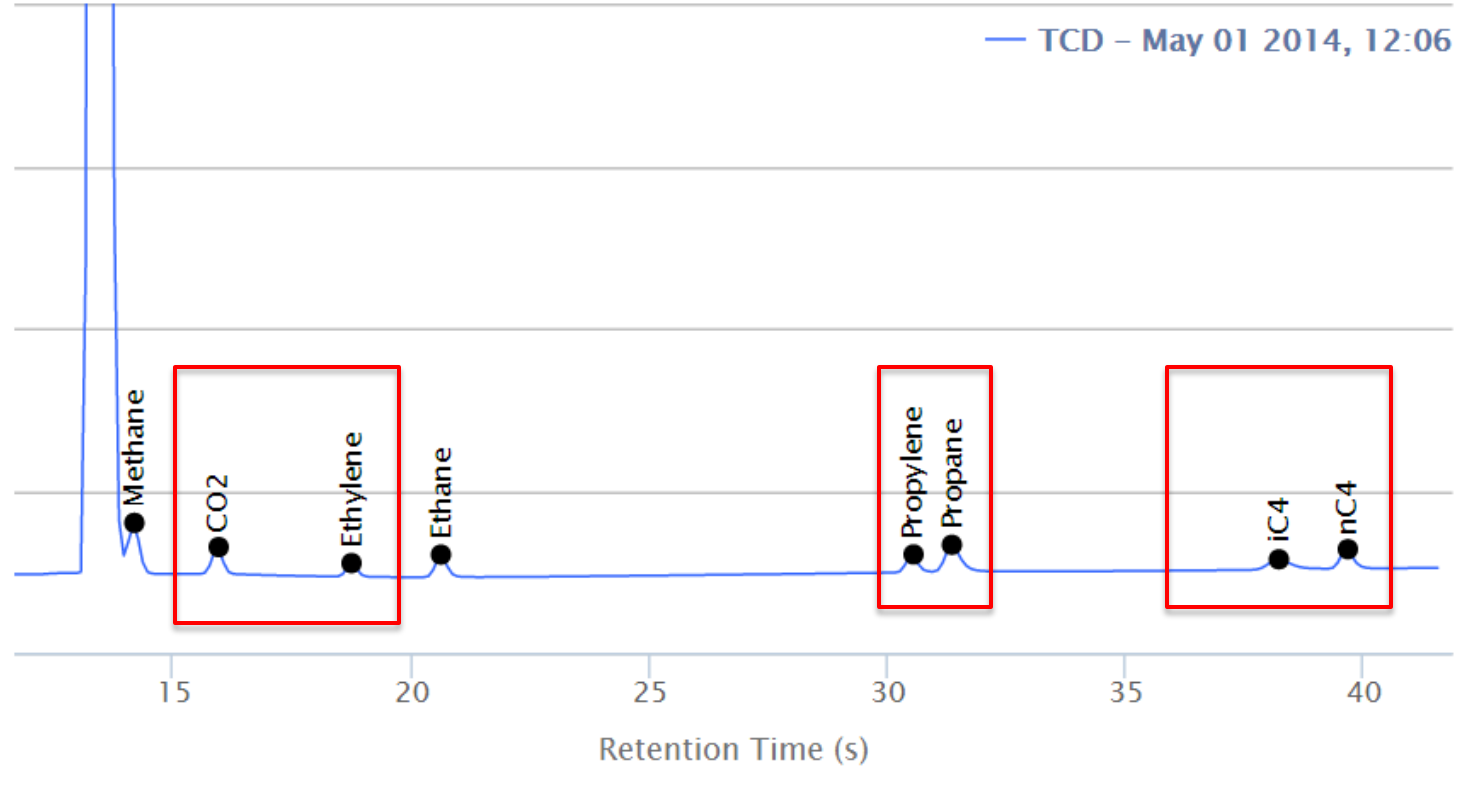
Extended Calibration Standard

Component	Amount (%)
Nitrogen	98.054
Methane	0.5
CO2	0.197
Ethylene	0.095
Ethane	0.2
Propylene	0.103
Propane	0.197
iC4	0.098
nC4	0.098
iC5	0.102
nC5	0.102

Component	Amount (%)
nC6	0.12
Benzene	0.021
Cyclohexane	0.032
nC7	0.01
Methylcyclohexane	0.01
Toluene	0.011
nC8	0.02

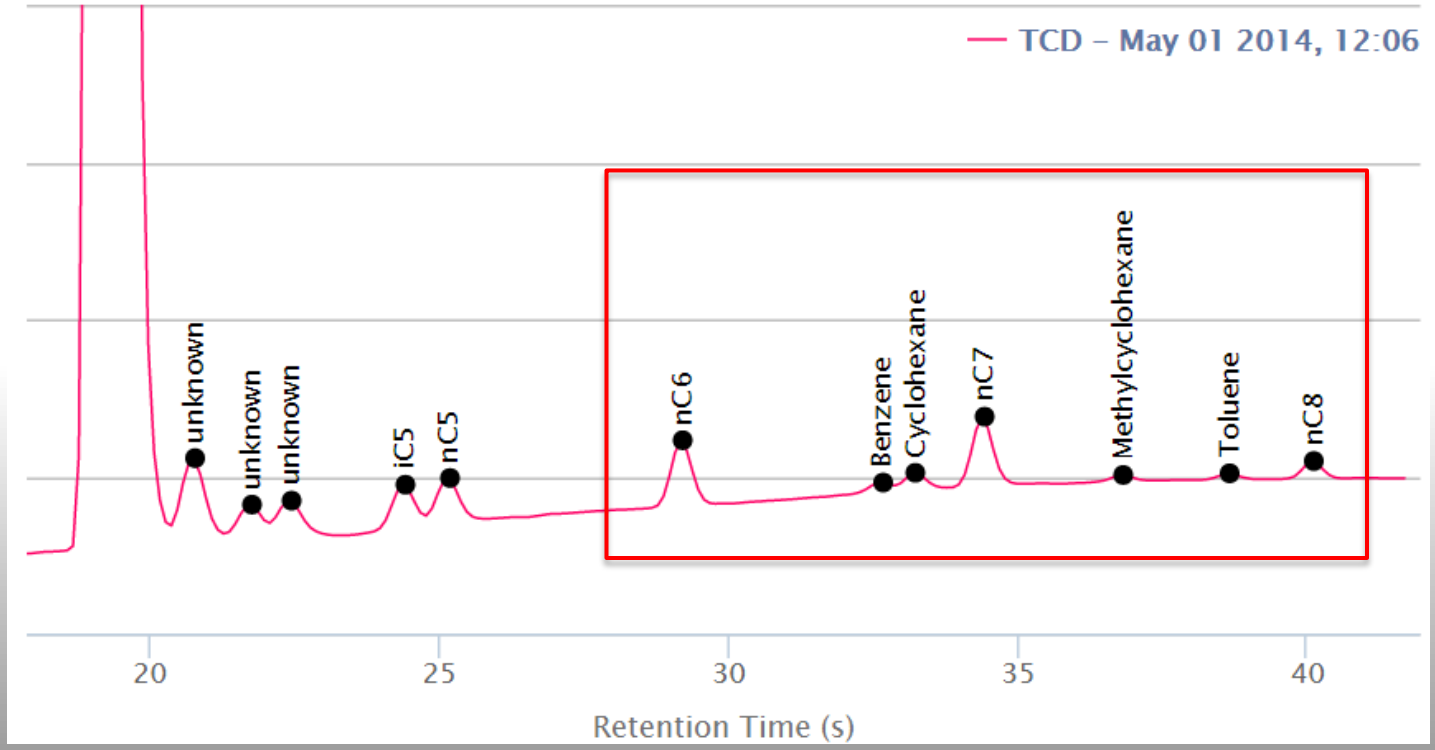
Chromatograms

- Module A: RT-Q-Bond
  - 55°C(15s hold)→220°C(10s hold)
  - 7°C/s, 35 psi, 30 ms injection time, Helium carrier gas



Chromatograms

- Module B: Rxi-1ms
  - 75°C(9s hold) → 220°C(12s hold)
  - 7°C/s, 33 psi, 80ms injection time, Helium carrier gas

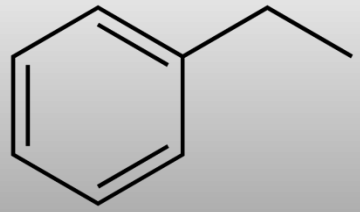


On-Site Tips for Successful Analysis

- Power
  - Access to stable power
  - Surge protector, UPS
- Heated transfer lines
  - To keep heavier hydrocarbons from condensing
- Gas trap stability
- Water traps, filters

Future Developments

- Method was optimized for speed
  - Aggressive nature of the ramp may not be optimized for instrument stability
- Future developments will include:
  - Backflush injectors to prevent carryover
  - Different combination of columns types/lengths
  - Analysis of ethylbenzene, nC9 with the same cycle time

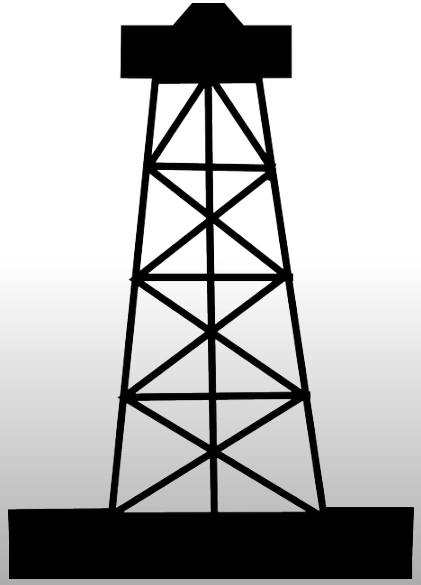


Conclusion

- Using isothermal operation, C1-C5 compounds can be analyzed within 34 seconds using Micro GC Fusion with excellent repeatability
- Using new rapid temperature ramping, C1-C8 compounds can be analyzed within 2 minute cycle time
  - Additional compounds, such as CO2, ethylene, and propylene were also analyzed
- Future developments will focus on optimizing the configuration of Micro GC Fusion and the corresponding methods for the mud logging industry

References

- http://petrowiki.org/Formation_evaluation_during_mud_logging
- http://petrowiki.org/Mud_logging
- http://www.ppdm.org/wiki/index.php/Well_Operations_Reference_guide



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Questions?