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UNITED STATES

NIOSH Field Studies: Exposure Assessment, Silica Controls and Gauging and Thiefing

Disclaimer: The findings and conclusions in this presentation have not been formally disseminated by NIOSH and should not be construed to represent any agency determination or policy.

Worker Exposure Assessment

Based on worksite operations and chemicals in the industry, workers have potential risks for exposures to multiple chemical hazards

Field Studies- identify and characterize workplace exposures and evaluate their significance.

- Become familiar with process operations
- Perform the preliminary, qualitative survey
- Perform workplace monitoring (quantitative evaluation)
- Interpret the sampling results and communicate with stakeholders
- Develop controls if needed
- Re-evaluate to determine effectiveness of controls

Exposure Hazards

Not an all-inclusive list

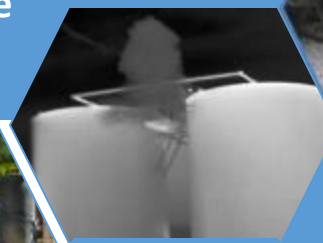
Silica

Volatile Organic Compounds (BTEX)

NORM and T-NORM

Biocides (aldehydes, quaternary, others)

Diesel particulate matter



Oil mists

Alcohols (Methanol)

Hydrogen sulfide (H_2S)

Metals

Acids & Bases

Polyaromatic Hydrocarbons

NIOSH FIELD STUDY STRATEGIES

- Focus on process or activity
  - Drilling, Completions, Production, Service
- Focus on exposure hazard
  - Chemical: Silica, Hydrocarbons, Diesel Exhaust etc
  - Physical: Noise, Heat/Cold, NORM
- Focus on emerging issue identified by surveillance
- Focus on worker exposures by production area
- Development and evaluations of controls

NIOSH Field Laboratories

2015 and 2016 Bravo Star Trailer (DART and WSD)

- 7 x 12 interior space
- Weatherized
- Heating/AC
- Can operate with generator power or supplied shoreline power

Finally, after 2 years!

Methods Used

- Standard Industrial Hygiene Methods
  - NMAM and OSHA Numbered Methods
  - Personal and Area Samples
- Direct Reading Methods
  - Real Time Instruments, Meters and Monitors
  - Video Exposure Monitoring
- Biological Monitoring
  - Measure Internal Exposures/Effects by Breath, Urine

Focus on Process-Completions

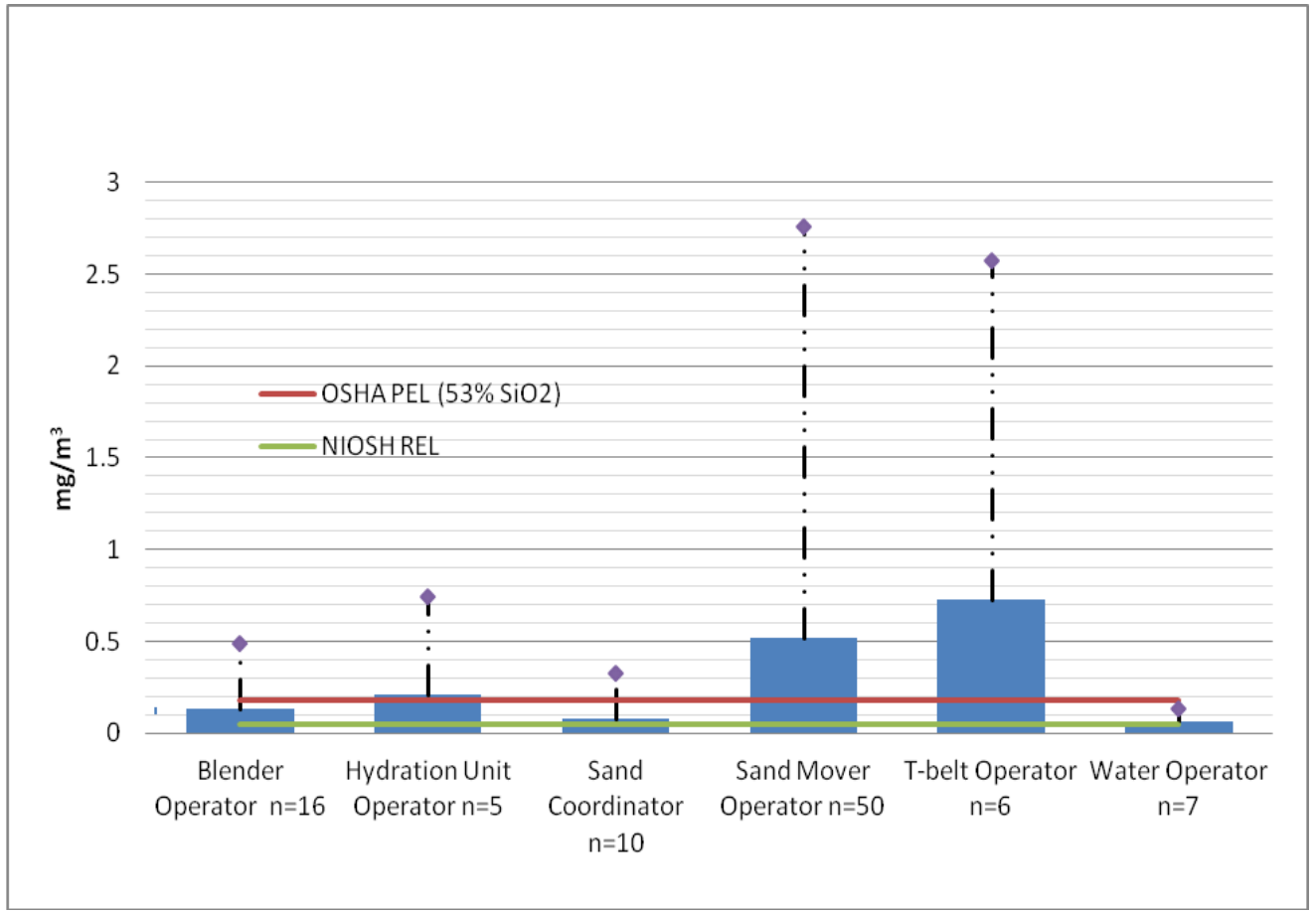
Health Hazard- Exposure to Respirable Silica during Hydraulic Fracturing

NIOSH researchers were the first to systematically evaluate occupational exposures to workers at hydraulic fracturing sites[1]

- Personal breathing zone air samples were collected for workers at 11 sites in 2010 and 2011
- Silica exposures for sand mover operators/T-belt operators can be 10-50 times greater than occupational exposure limits

[1] Esswein, Breitenstein, Snawder, et.al,. *Occupational Exposures to Respirable Crystalline Silica in Hydraulic Fracturing* Jour. Occ. Env. Hyg. Vol. 10, Issue 7, May, 2013

Exposure comparisons by job title

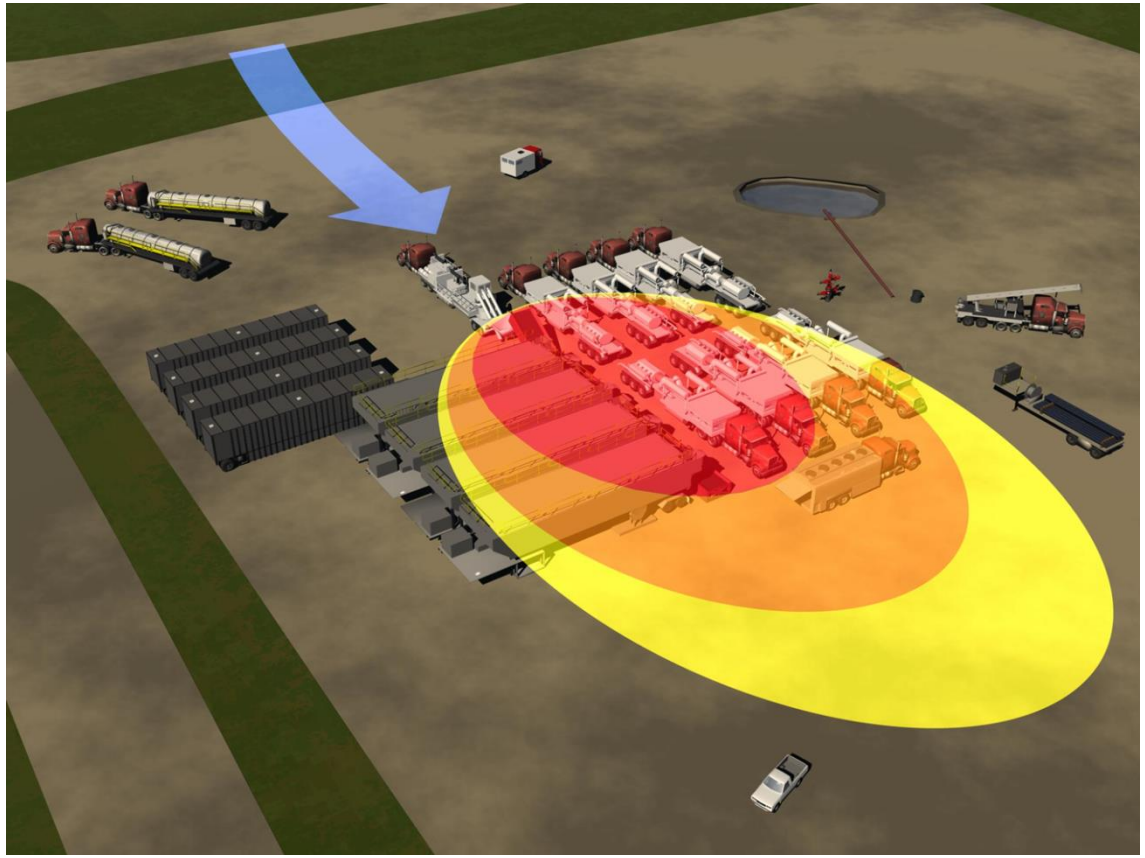


Point Sources of Respirable Crystalline Silica Release

Eight (8) primary points of dust release or generation from completions equipment or workplace operations

1) Dusts ejected from thief hatches on top of the sand movers during refilling operations
2) Dust ejected and pulsed through side fill ports on the sand movers during refilling operations
3) Dust generated by on-site truck vehicle traffic including sand trucks and crew trucks, the release of air brakes on sand trucks, and by winds
4) Dust released from the transfer belt under the sand movers
5) Dusts created as sand drops into, or is agitated in the blender hopper and on transfer belts
6) Dust released from operations of transfer belts between the sand mover and the blender
7) Dust released from the top of the dragon's tail on sand movers
8) Dust deposited on and released from workers coveralls

Respirable Silica Exposure Zones



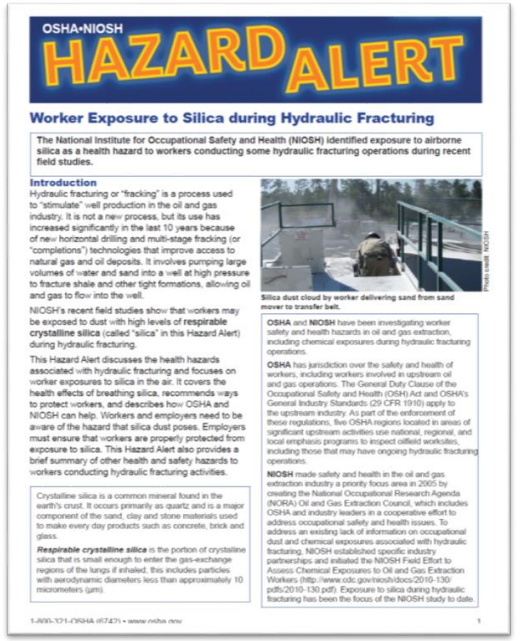
Maximum respiratory protection

Moderate respiratory protection

Avoid area during sand transfers and pumping

Impact of NIOSH RCS Study

- First study to identify RCS hazard during hydraulic fracturing
- OSHA-NIOSH Hazard Alert
- Industry formed RCS Workgroup
- JOEH article most downloaded of 2013
- Wide array of new, improved controls implemented


OSHA•NIOSH
HAZARD ALERT

Worker Exposure to Silica during Hydraulic Fracturing

The National Institute for Occupational Safety and Health (NIOSH) identified exposure to airborne silica as a health hazard to workers conducting some hydraulic fracturing operations during recent field studies.

Introduction

Hydraulic fracturing or "fracking" is a process used to "stimulate" well production in the oil and gas industry. It is not a new process, but its use has increased significantly in the last 10 years because of new horizontal drilling and multi-stage fracking (or "completions") technologies that improve access to natural gas and oil deposits. It involves pumping large volumes of water and sand into a well at high pressure to fracture shale and other tight formations, allowing oil and gas to flow into the well.

NIOSH's recent field studies show that workers may be exposed to dust with high levels of respirable crystalline silica (called "silica" in this Hazard Alert) during hydraulic fracturing.

This Hazard Alert discusses the health hazards associated with hydraulic fracturing and focuses on worker exposures to silica in the air. It covers the health effects of breathing silica, recommends ways to protect workers, and describes how OSHA and NIOSH can help. Workers and employers need to be aware of the hazard that silica dust poses. Employers must ensure that workers are properly protected from exposure to silica. This Hazard Alert also provides a brief summary of other health and safety hazards to workers conducting hydraulic fracturing activities.

Crystalline silica is a common mineral found in the earth's crust. It occurs primarily as quartz and is a major component of the sand, clay and stone materials used to make every day products such as concrete, brick and glass.

Respirable crystalline silica is the portion of crystalline silica that is small enough to enter the gas-exchange regions of the lungs if inhaled; this includes particles with aerodynamic diameters less than approximately 10 micrometers (μm).

Silica dust cloud by worker delivering sand from sand mover to transfer belt.

OSHA and NIOSH have been investigating worker safety and health hazards in oil and gas extraction, including chemical exposures during hydraulic fracturing operations.

OSHA has jurisdiction over the safety and health of workers, including workers involved in upstream oil and gas operations. The General Duty Clause of the Occupational Safety and Health (OSH) Act and OSHA's General Industry Standards (29 CFR 1910) apply to the upstream industry. As part of the enforcement of these regulations, five OSHA regions located in areas of significant upstream activities use national, regional, and local emphasis programs to inspect oilfield worksites, including those that may have ongoing hydraulic fracturing operations.

NIOSH made safety and health in the oil and gas extraction industry a priority focus area in 2005 by creating the National Occupational Research Agenda (NORA) Oil and Gas Extraction Council, which includes OSHA and industry leaders in a cooperative effort to address occupational safety and health issues. To address an existing lack of information on occupational dust and chemical exposures associated with hydraulic fracturing, NIOSH established specific industry partnerships and initiated the NIOSH Field Effort to Assess Chemical Exposures to Oil and Gas Extraction Workers (http://www.cdc.gov/niosh/docs/2010-130/pdfs/2010-130.pdf). Exposure to silica during hydraulic fracturing has been the focus of the NIOSH study to date.

Stimulate the Well (frac') Without Silica Proppant

- Complete elimination of proppant is not possible in all formations
- Manufactured proppants such as ceramic beads/ sintered bauxite limit generation of respirable silica

Engineering Controls

- Chemical treatment of silica sand reduces dust generation
- Elimination of pneumatic sand transfer from transport trucks
  - Silos, Containerized sand, Elevators
- Vacuum collection of dust from emission sources
- Equipment designed to prevent dust generation
- Retrofit existing equipment with controls





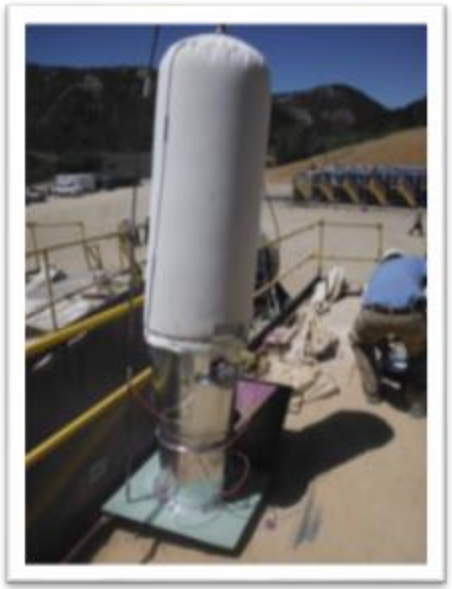
Incorporate Engineering Controls Where Possible

Focus on the Source!

- Thief hatches on sandmovers are a large contributor of dust emissions.
- An engineered control was needed to limit worker exposure

NIOSH Mini baghouse retrofit assembly

2012



2013

2015

Features

- ✓ Highly effective
- ✓ Inexpensive
- ✓ “bolt-on”
- ✓ Uses pneumatic energy
- ✓ In-field retrofit

Develop Effective Training Programs

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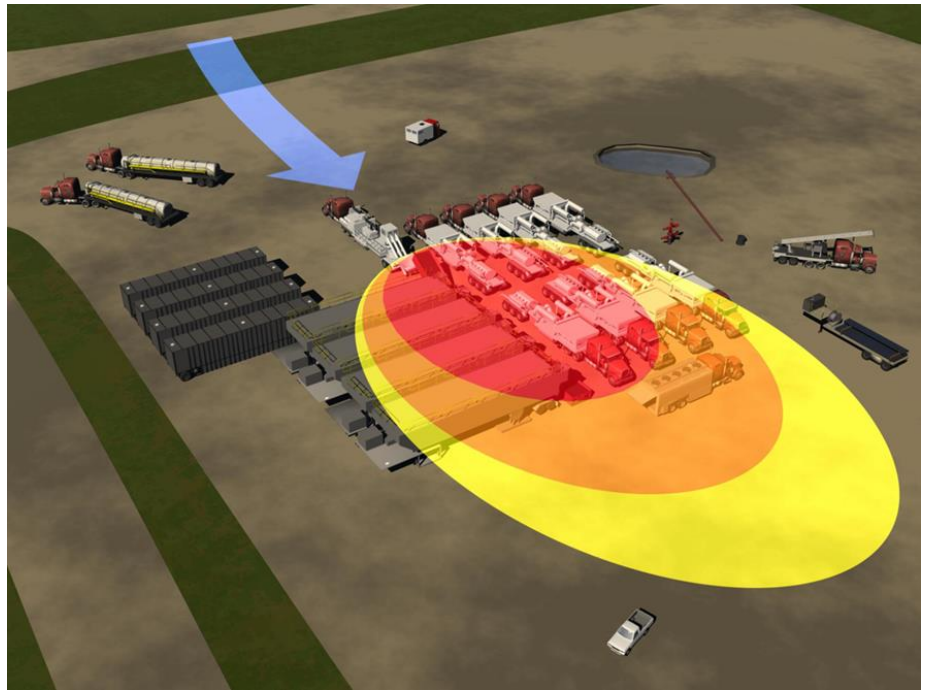
Hazard Communication



Maximum respiratory protection

Moderate respiratory protection

Avoid area during sand transfers and pumping

Fatalities Associated with Manual Gauging, Thieving, Fluid Handling

Nine (9) worker deaths where inhalation of petroleum hydrocarbons was likely factor.

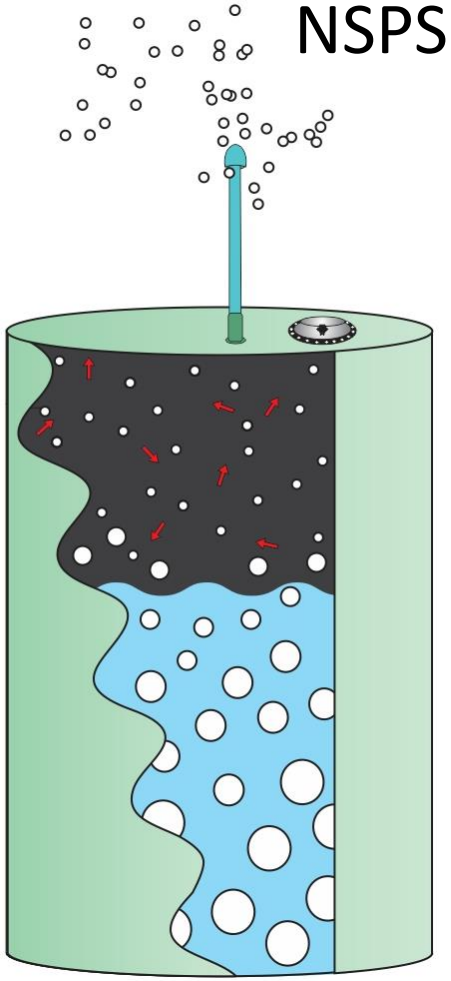
- All occurred at production tanks.
- 5 fatalities occurred during thieving (collecting a sample) by fluid haulers.
- One employee was wearing 4-gas monitor, reported 6.5% O2.
- One had sought medical evaluation for dizziness, etc. a few weeks prior.

For more information: www.cdc.gov/niosh/topics/ fog/data.html

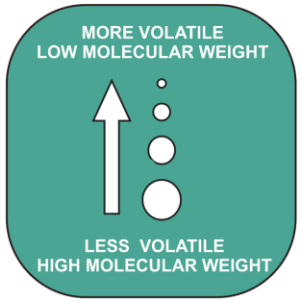
Evaluating Rapid Releases of Hydrocarbon

- Exposure assessments designed to measure gas and vapors released in plumes and during very short worker tasks
  - Non-traditional IH assessment methods
  - Grab Samples
  - PEAK, STEL, IDLH assessments
  - Real-time GC as well as GC/MS analysis

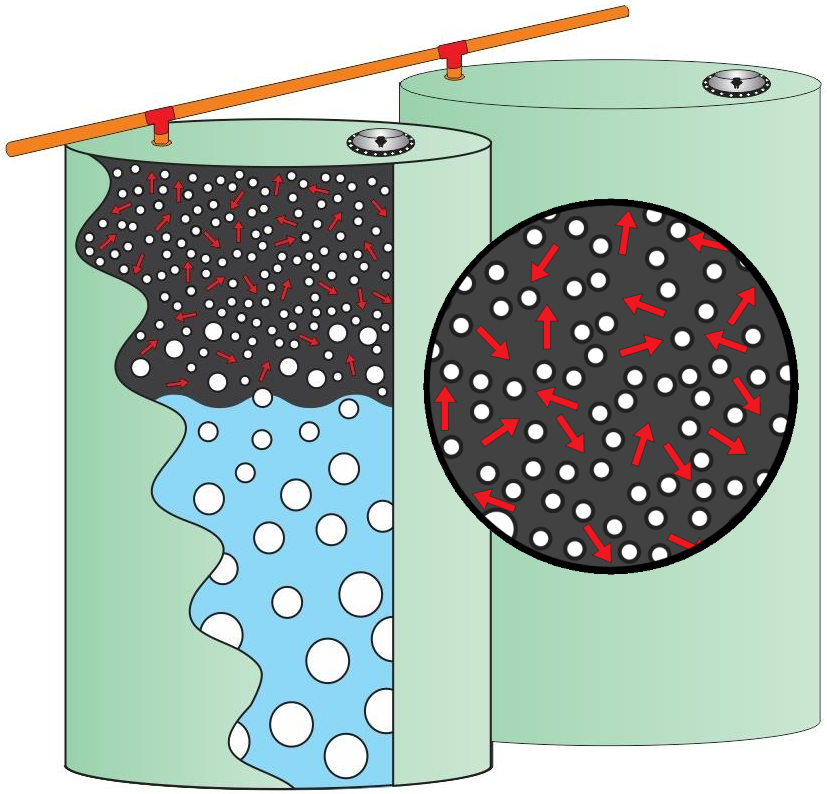
Behavior of Production Fluid Storage Vessels without NSPS 0000 Controls (pre-2012)



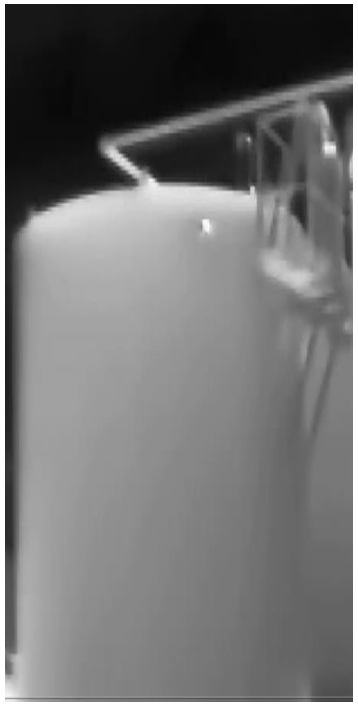
Tank is continuously vented to the atmosphere. Gases and vapors in tank are in equilibrium with outside air. No significant pressure on the tank.

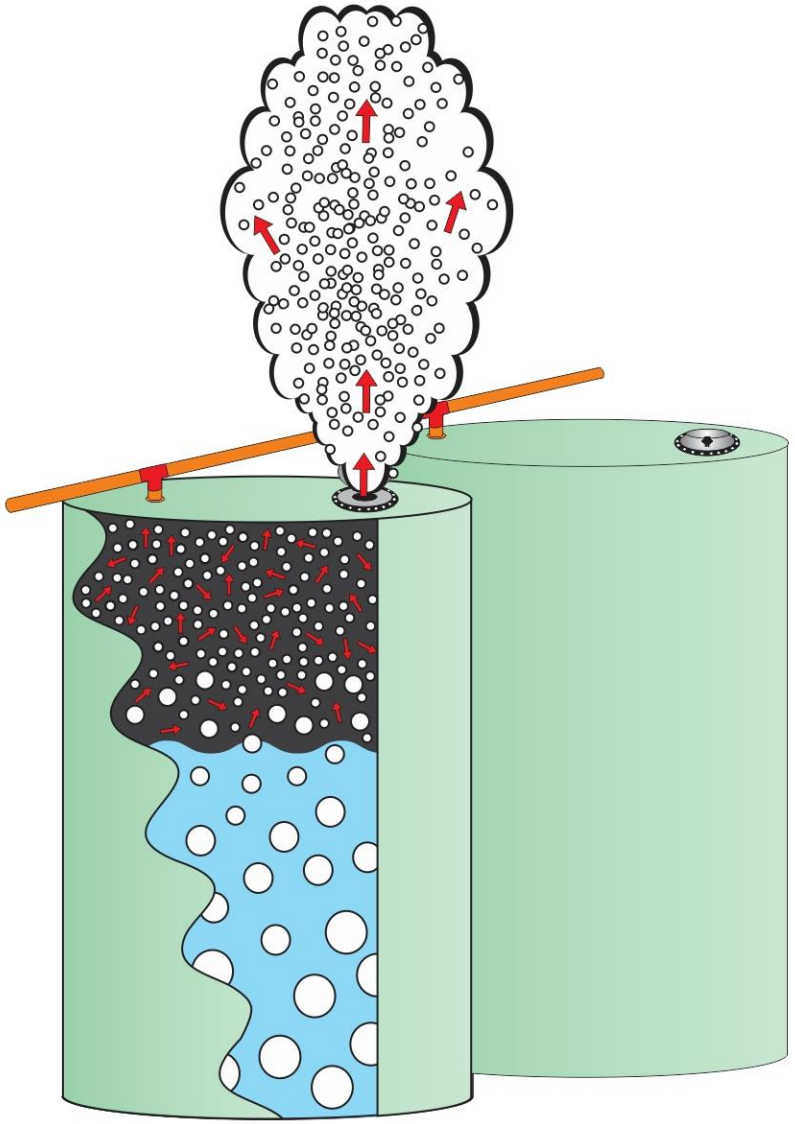


Behavior of Production Fluid Storage Vessels with NSPS 0000 Controls (post- 2012)

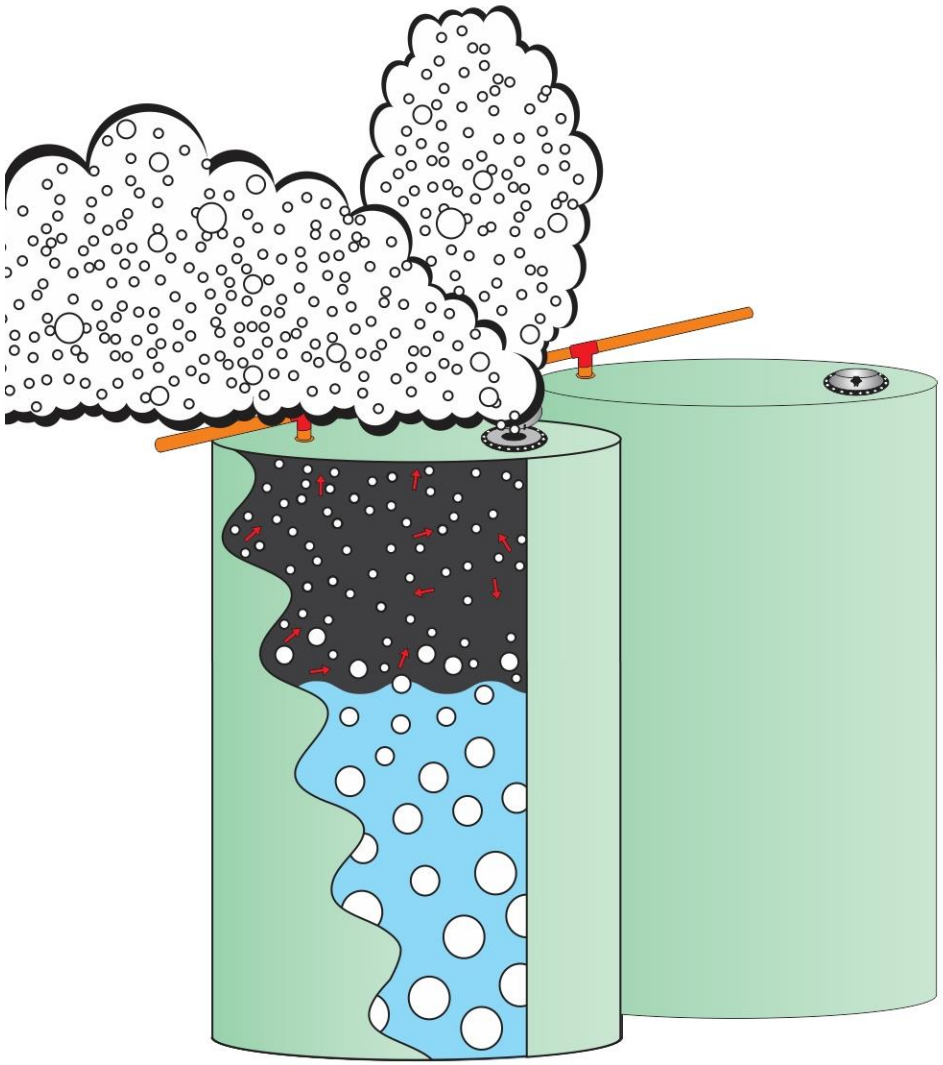


Hatch is closed. No visible emissions, greater than 95% VOCs produced are controlled. Gases and vapors in tank are in equilibrium with gas and vapors in the liquid hydrocarbon. The different gases and vapors are exerting pressure on the container.

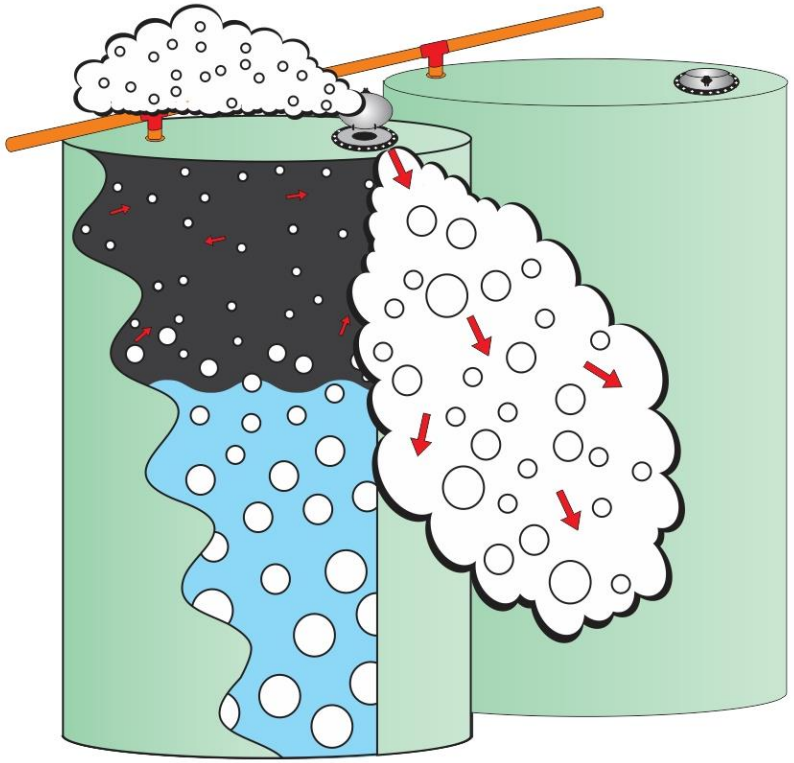




Hatch is opened. A large volume of gases (mostly propane and butane) rush out of the hatch very quickly. The “cloud” can displace oxygen in the immediate work area and presents an immediate asphyxiation hazard.



As hatch remains open, heavier hydrocarbons in the tank (pentane, hexane, heptane, BTEX) will evaporate and leave the tank and enter the workspace. Rate of flow is still high and these gases and vapors may be present at toxic and flammable concentrations.

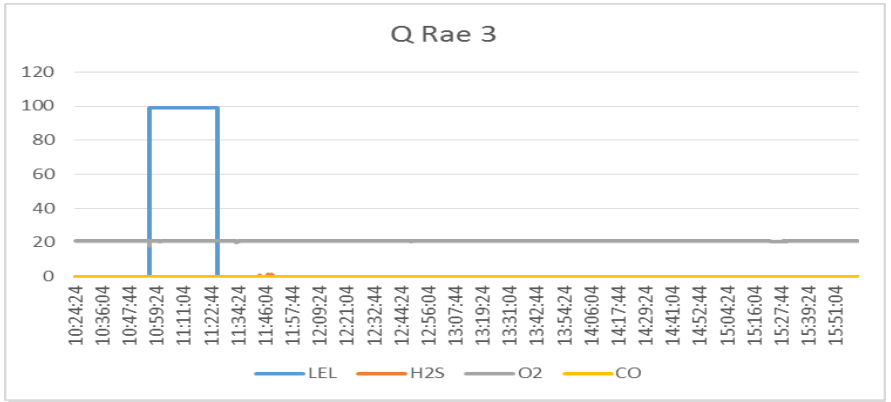


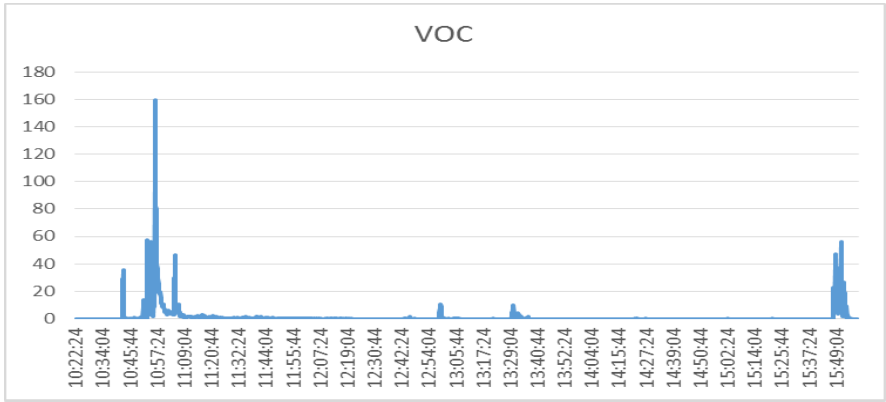
Hatch remains open. Gases and vapors in tank are approaching equilibrium with the environment and the rate of emission slows down significantly. Heavy gas and vapors drop toward the ground.

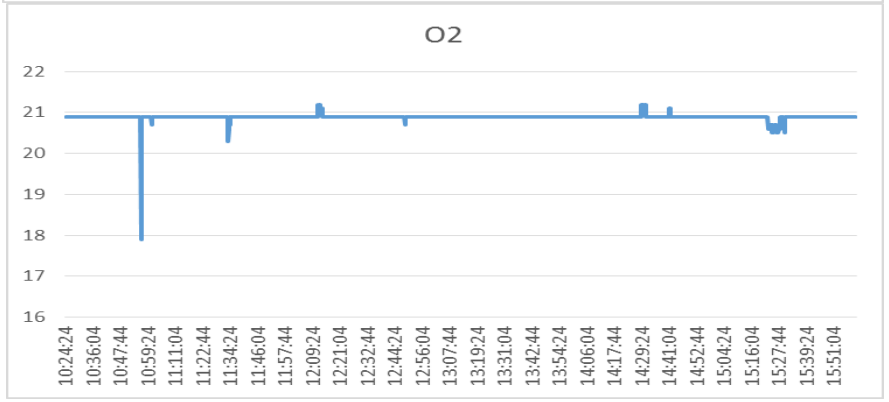
Determinants of Released Gas and Vapors

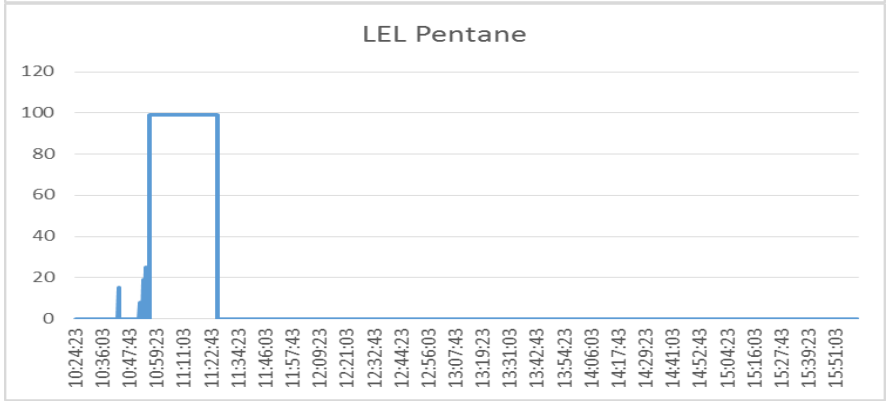
- Production rate of the well
- Composition of fluid and inherent vapor pressure – higher vapor pressure more gas and vapors in headspace
- Pressure setting on emission controls- gas and vapor equilibrium changes with pressure,
- Number of tanks in the battery-more tanks greater volume of release
- Proper operation of vapor controls

Direct Reading Instruments
Qualitative Characterization of Tank Release



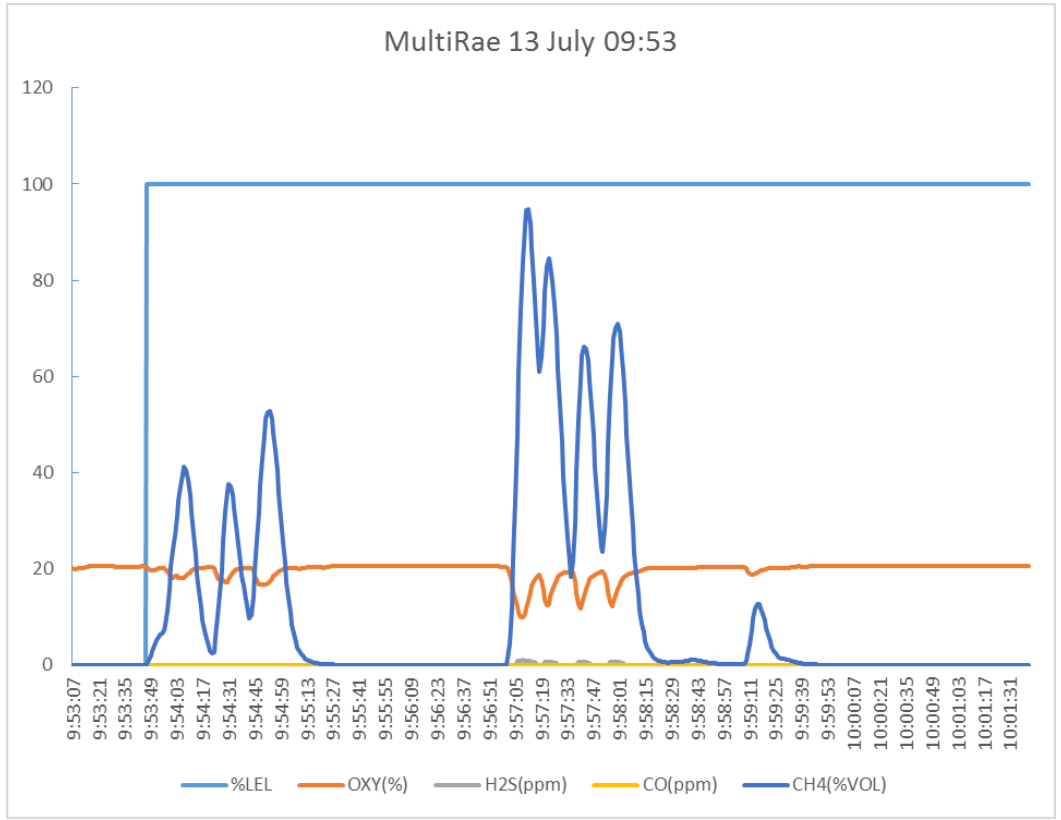






Train Workers to Limit Exposures

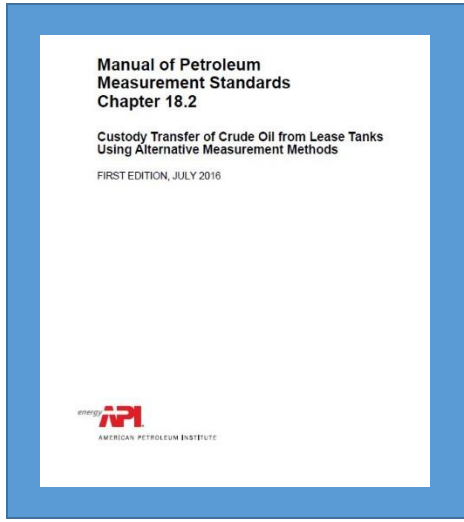
MOV 403 Fluttering Hatch Vent
Dickinson, ND
26August, 2015



Methane ppm	Ethane ppm	Propane ppm	i-Butane ppm	n-Butane ppm	i-Pentane ppm	n-Pentane ppm
267677	114194	103114	27200	50902	22793	11529

Apply Effective Controls

- Remote tank gauging and sensing
- Closed tank gauging systems
- LACT units
- Reduce quantity of times workers must manually gauge tanks



Develop Effective Training Programs

NIOSH-OSHA

HAZARD ALERT

Health and Safety Risks for Workers Involved in Manual Tank Gauging and Sampling at Oil and Gas Extraction Sites

The National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) have identified health and safety risks to workers who manually gauge or sample fluids on production and flowback tanks from exposure to hydrocarbon gases and vapors, exposure to oxygen-deficient atmospheres, and the potential for fires and explosions.

Introduction

Workers at oil and gas extraction sites could be exposed to hydrocarbon gases and vapors, oxygen-deficient atmospheres, and fires and explosions when they open tank hatches to manually gauge or collect fluid samples on production, flowback, or other tanks (e.g., drip pots) that contain process fluids. Opening tank hatches, often referred to as "thief hatches," can result in the release of high concentrations of hydrocarbon gases and vapors. These exposures can have immediate health effects, including loss of consciousness and death.

Recent NIOSH and OSHA research showed that workers could be exposed to hydrocarbon gases and vapors when they work on or near production and flowback tanks. This means workers can face significant health and safety risks when they manually gauge or sample tanks [Esswein et al. 2014; Jordan 2015]. These risks are in addition to the risk of exposure to hydrogen sulfide (H_2S), a well-recognized chemical exposure hazard for those who work in the oil and gas extraction and production industry [OSHA].

NIOSH and OSHA also identified nine worker fatalities that occurred while workers manually gauged or sampled production tanks from 2010–2014 [NIOSH 2015]. Exposures to hydrocarbon gases and vapors and/or oxygen-deficient atmospheres are believed to be primary or contributory factors to the workers' deaths [Harrison et al. 2016].

Working on or near oil and gas production tanks is of particular concern because these tanks may contain concentrated hydrocarbon gases and vapors that are under pressure. When the thief hatch is opened, the release of these pressurized gases and vapors can expose workers. Second, the gases and vapors can displace

A worker collecting a sample from the open hatch of a production tank. Image: J.D. Dixon, OSHA.

oxygen, creating an oxygen-deficient environment. Third, the hydrocarbon gas and vapor concentrations can exceed 10% of the lower explosive limit (LEL), creating a chance for fires and explosions. Exposure to hazardous atmospheres and fire/explosion risks will vary depending on tank contents and operating conditions, the presence of ignition sources, and other factors (Box 1, page 3).

What's in this Alert?

This Hazard Alert describes the safety and health hazards when workers manually gauge or sample fluids from production, flowback, or other tanks. It recommends ways to protect workers by eliminating or reducing exposures to hazardous atmospheres, and actions employers should take to ensure that workers are properly aware of the hazards and protected from exposure to hydrocarbon gases and vapors. This alert is a supplement to the OSHA Alliance Tank Hazard Alert released in 2015 [National STEPS Network 2015].

1-800-321-OSHA (6742) • www.osha.gov

1-800-CDC-INFO (1-800-232-4636) • www.cdc.gov/niosh

Hazard Communication

Multi-gas meters

API Recommended Practices

energy API®

OSHA/NIOSH/NSTEPS Alliance Hazard Alert

http://www.nationalstepsnetwork.org/docs_tank_gauging/TankHazardInfographicFinal04_22_15.pdf

Future Directions for NIOSH Exposure Assessment Research in the Oil and Gas Extraction Industry

- Acute Exposure Hazards (VOC exposures, flammability hazards) During Handling of Crude, Produced Water, etc.
- Flowback (VOCs, aldehydes, alcohols, BTEX)
- Long term evaluation: NIOSH Mini Baghouse Retrofit Assembly Long term goal: licensing, adoption
- Drilling (VOCs, diesel particulate [DPM], silica)
- Servicing Operations (NORM, VOCs, DPM)

Focus on Worker Exposures by Production Area

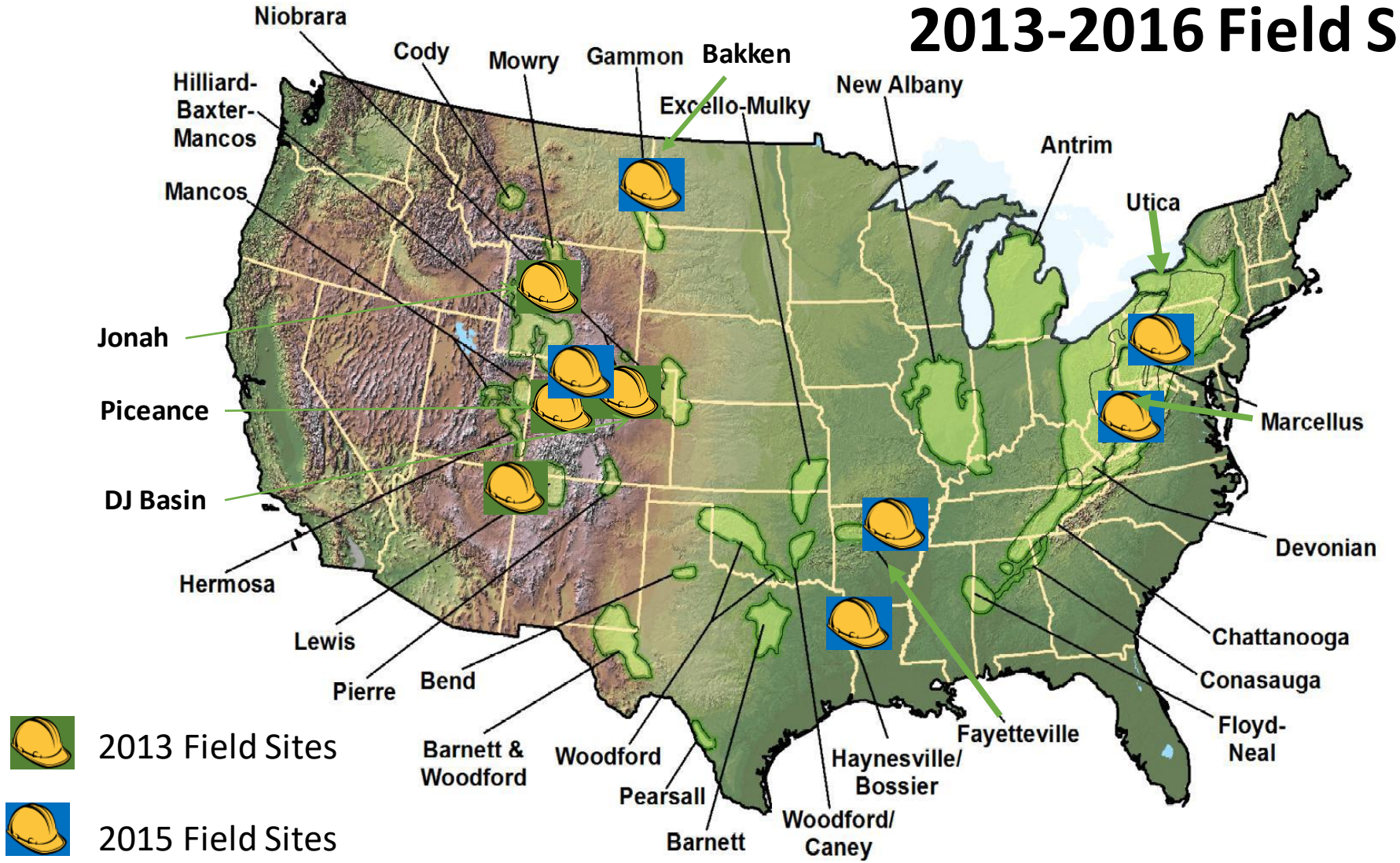
What Operations Did We Study?

- Flow Back Operation- Oil wells, Wet and Dry Gas Wells
- Lease Operators
  - Legacy wells
  - Newer Wells
- Drill Out
- Production Operators
- Pigging Operations

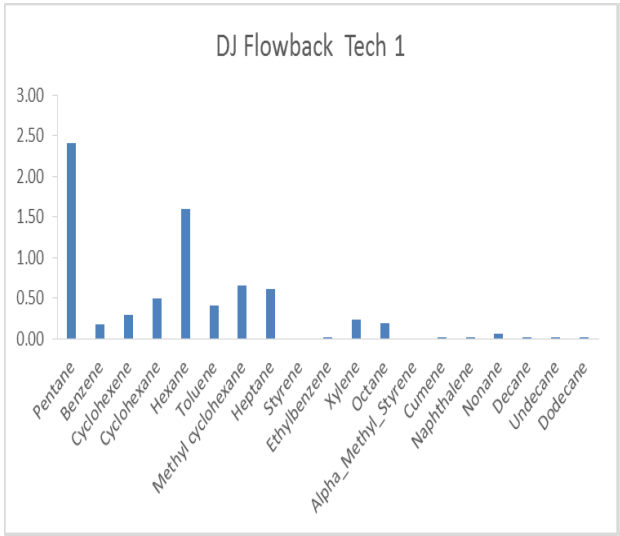
What Areas or Basins

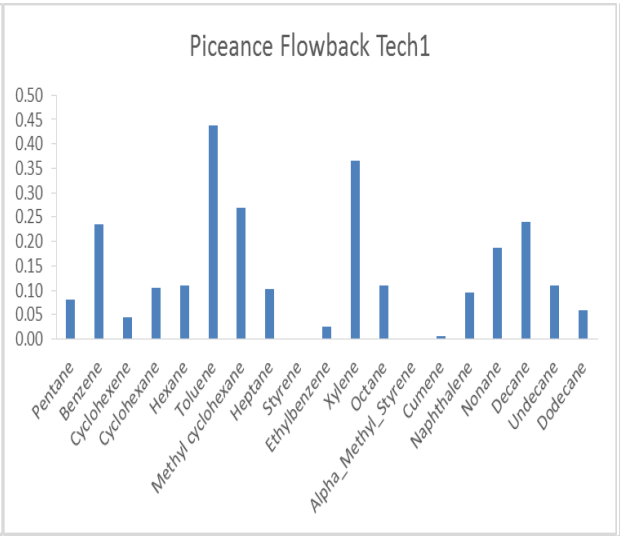
- Fayetteville Shale- Dry Gas
- Marcellus- Wet and Dry Gas
- Utica Shale-Wet Gas
- DJ- Oil and Gas
- Piceance-Oil and Gas
- San Juan-Oil and Gas
- Jonah-Oil and Gas
- Bakken-Oil

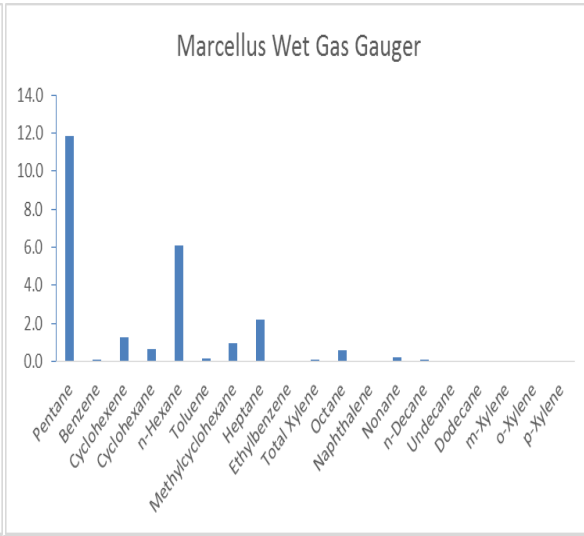
2013-2016 Field Sites

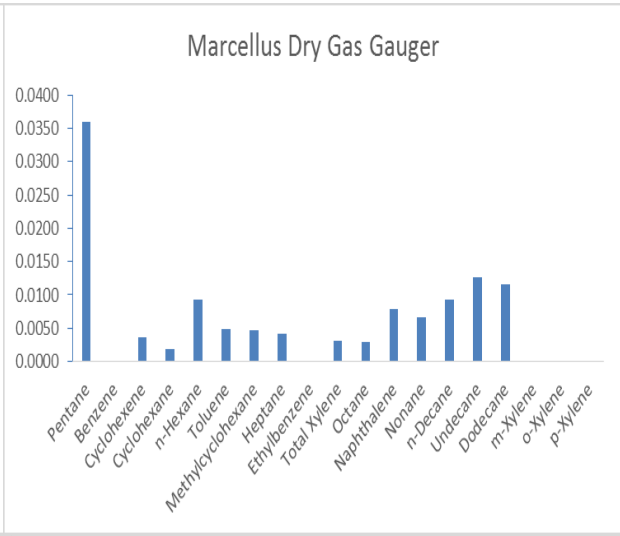


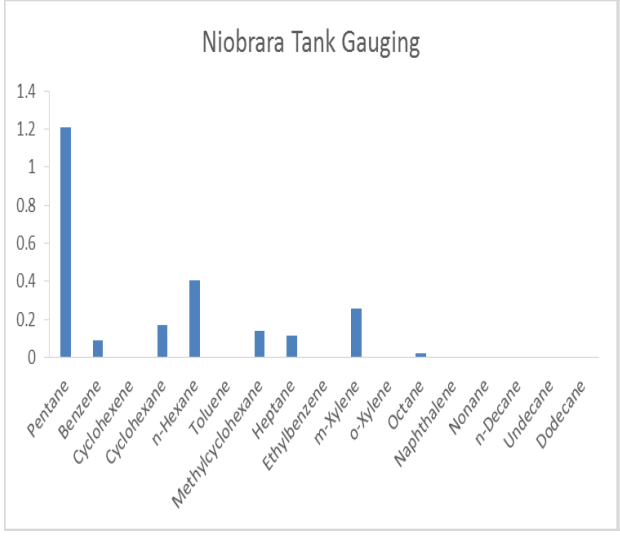
Comparison of PBZ Gas and Vapor Profile by Basin

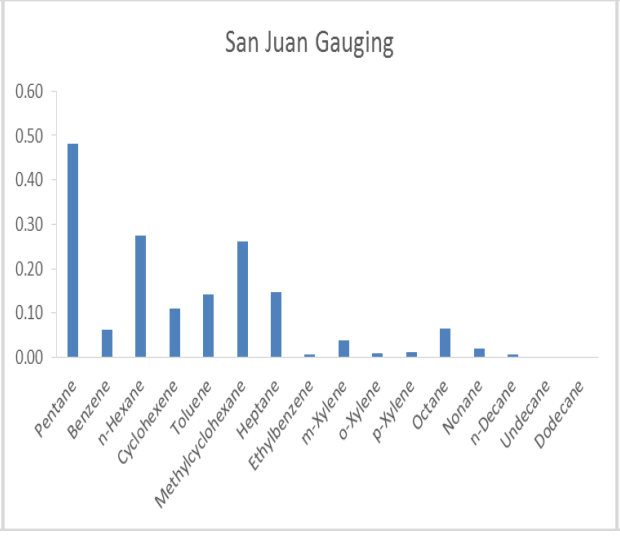


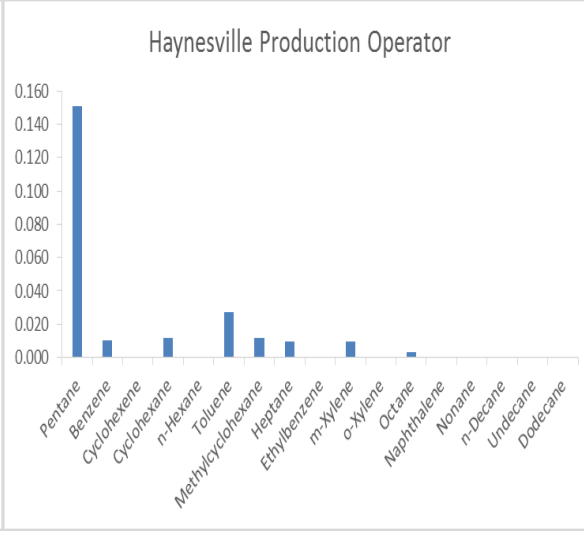


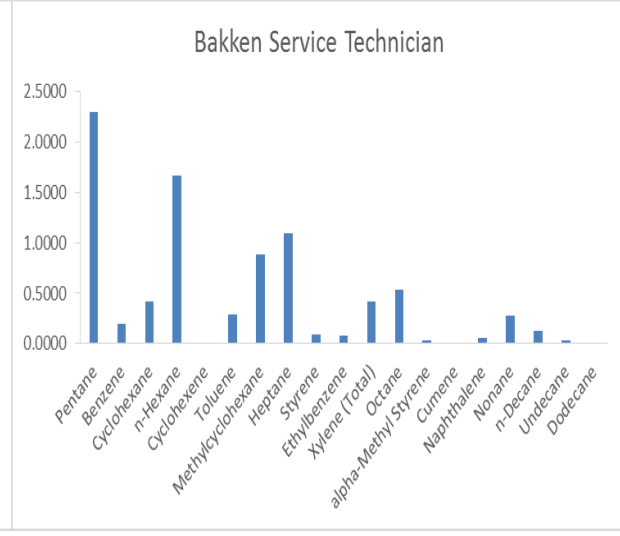




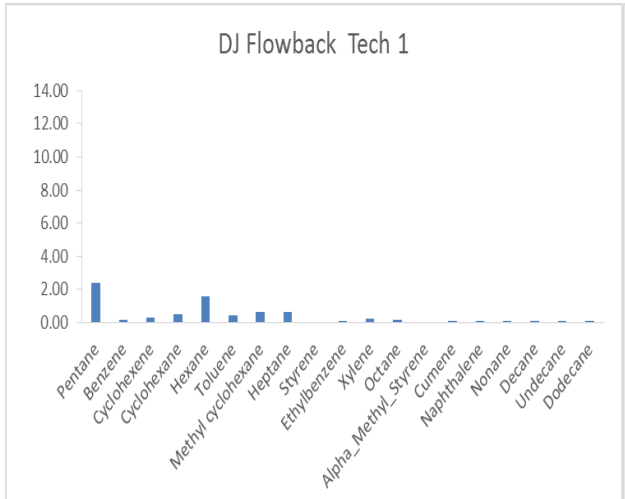


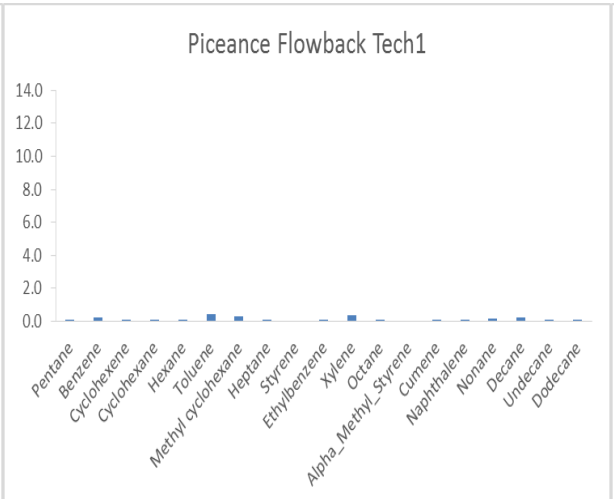


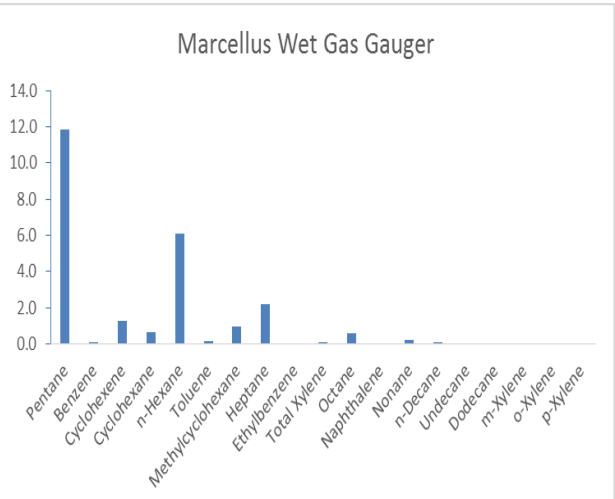


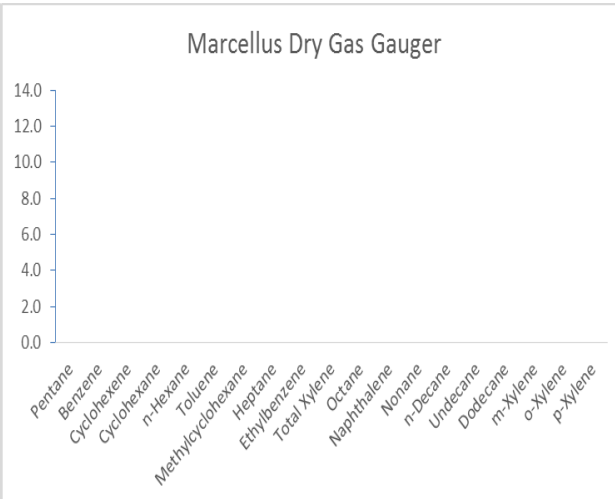


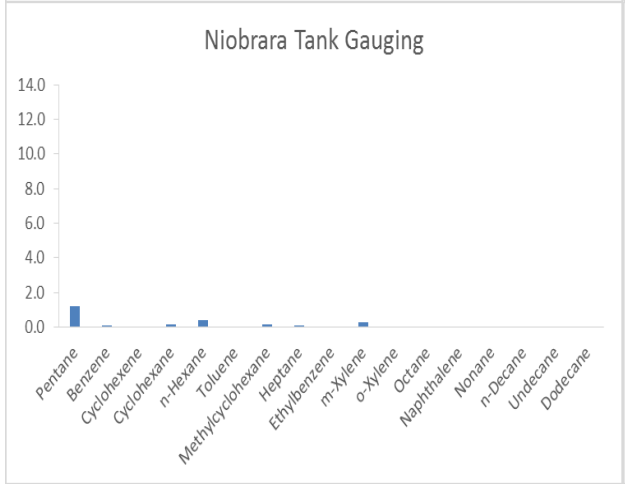
Previous Graphs on the Same Scale

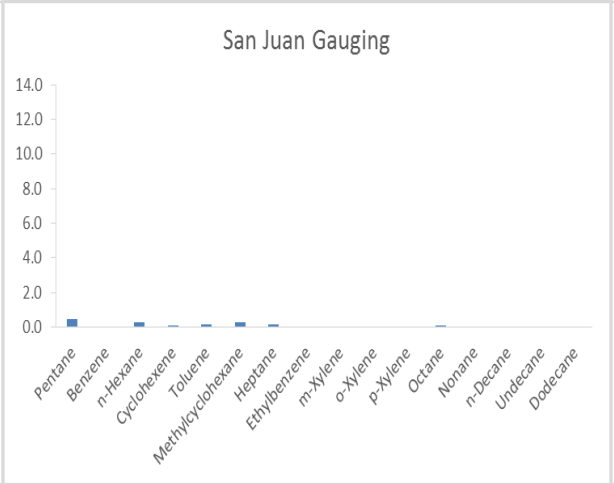


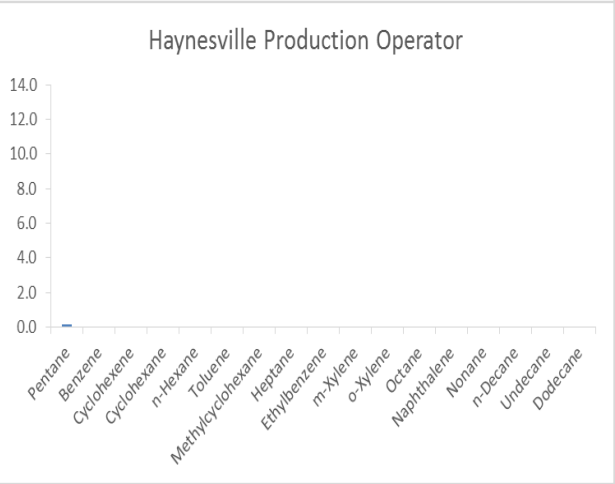


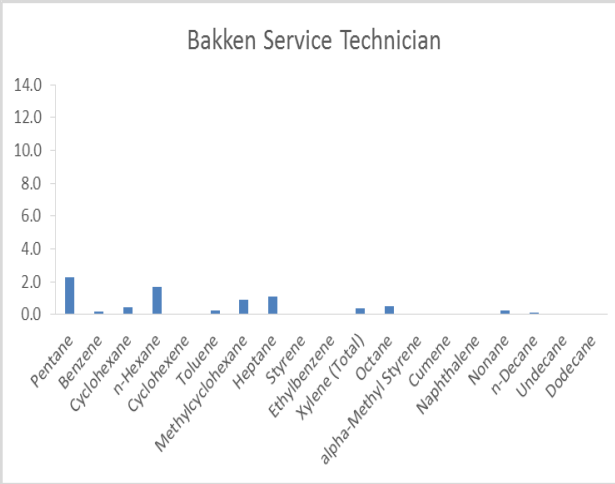




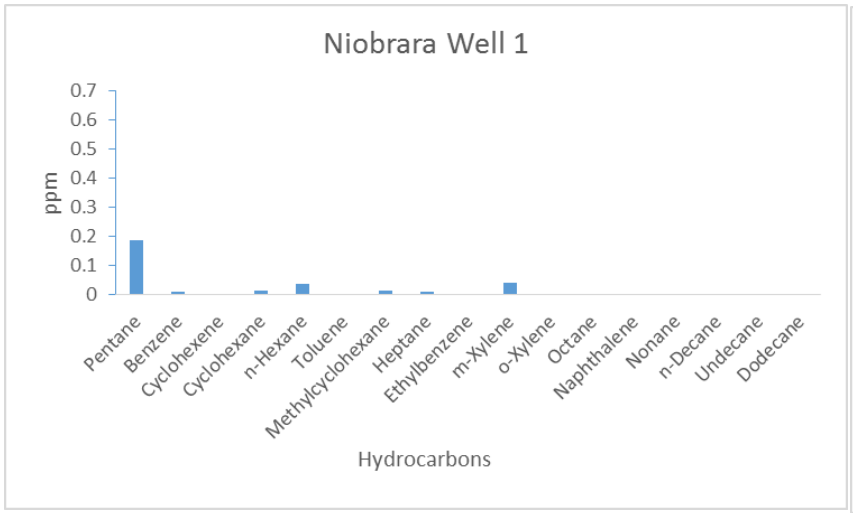


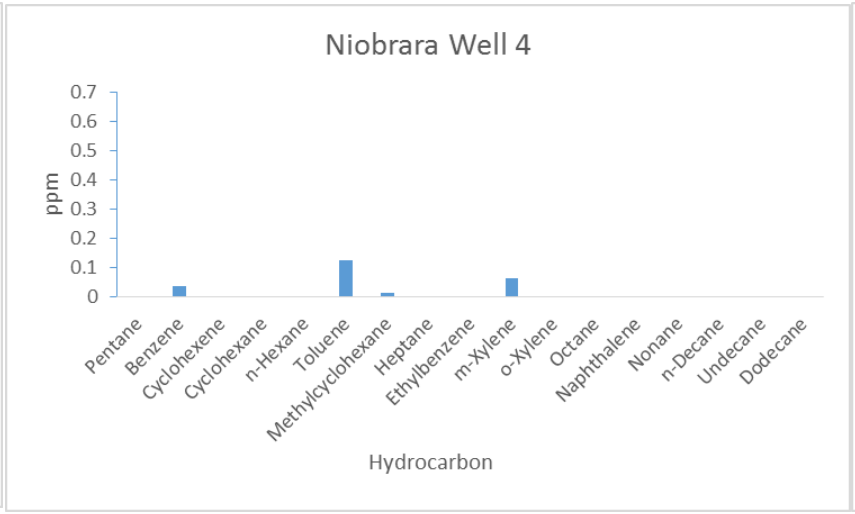


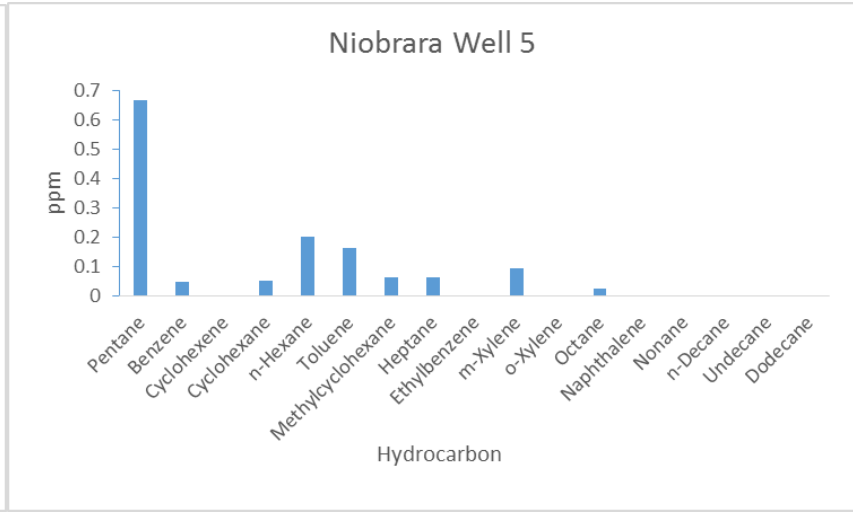




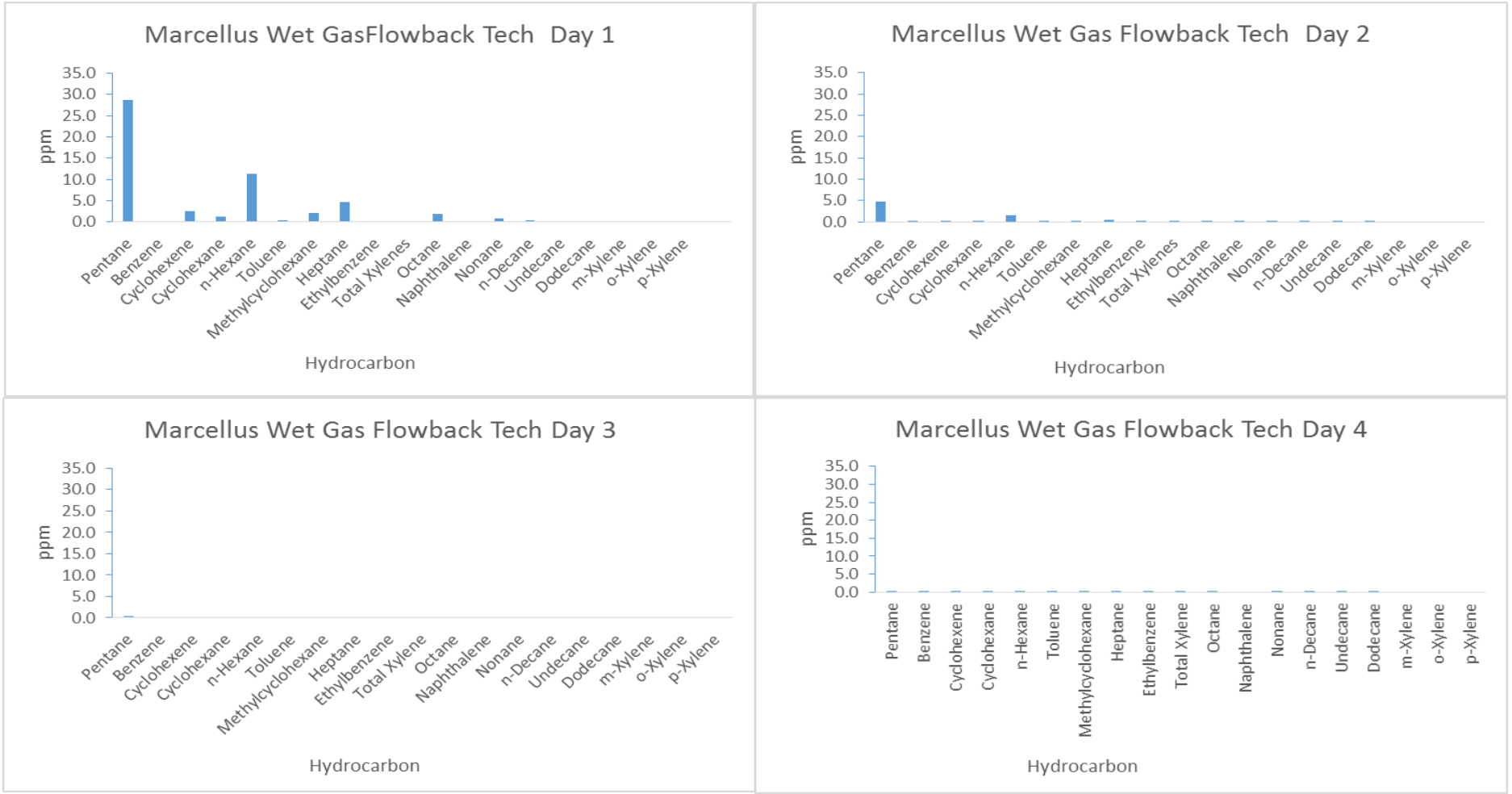
Variation in composition and concentration in PBZ samples collected in the Niobrara (CO) Basin Different Wells.







Variation composition and concentration in PBZ samples collected on a flowback worker over 4 days at the same well in the Marcellus (PA) basin.

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