Exposure Hazards in Oil and Gas Extraction Workers: Flowback and Production Testing (Completions Operations)

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Disclaimer

The findings and conclusions in this presentation are those of the author(s) and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

NIOSH Field Effort to Assess Chemical Exposure Risks to Gas and Oil Workers

Background

There is a lack of existing information regarding the variety and magnitude of chemical exposure risks to oil and gas extraction workers. To determine if risks are present, NIOSH wants to develop partnerships with the oil and gas extraction industry to identify, characterize and (if needed) control workplace chemical exposures. This work will occur as part of the NIOSH Oil and Gas Extraction Safety and Health Program, which seeks to prevent injuries and illnesses among oil and gas extraction workers. Strategic objectives include identifying possible exposures, determining risk, and preventing chemical exposures to workers involved in oil and gas extraction industry.

Purpose

The goals of this NIOSH field effort include: 1) identifying processes and activities where chemical exposures could occur; 2) characterizing potential exposures to vapors, gases, particulates and fumes (e.g., solvents, diesel particulate, crystalline silica, acids, metals, aldehydes, and possibly other chemicals identified during the study); 3) depending on results of the field effort, recommending safe work practices and/or proposing and evaluating exposure controls (to include engineering controls, substitution, and personal protective equipment).

Crewmember at hydraulic fracturing operations. *Image courtesy of Jeff Swensen for the New York Times.*

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH Field Effort to Assess Chemical Exposure Risks to Oil and Gas Workers

www.cdc.gov/niosh/docs/2010-130/

What is Flowback?

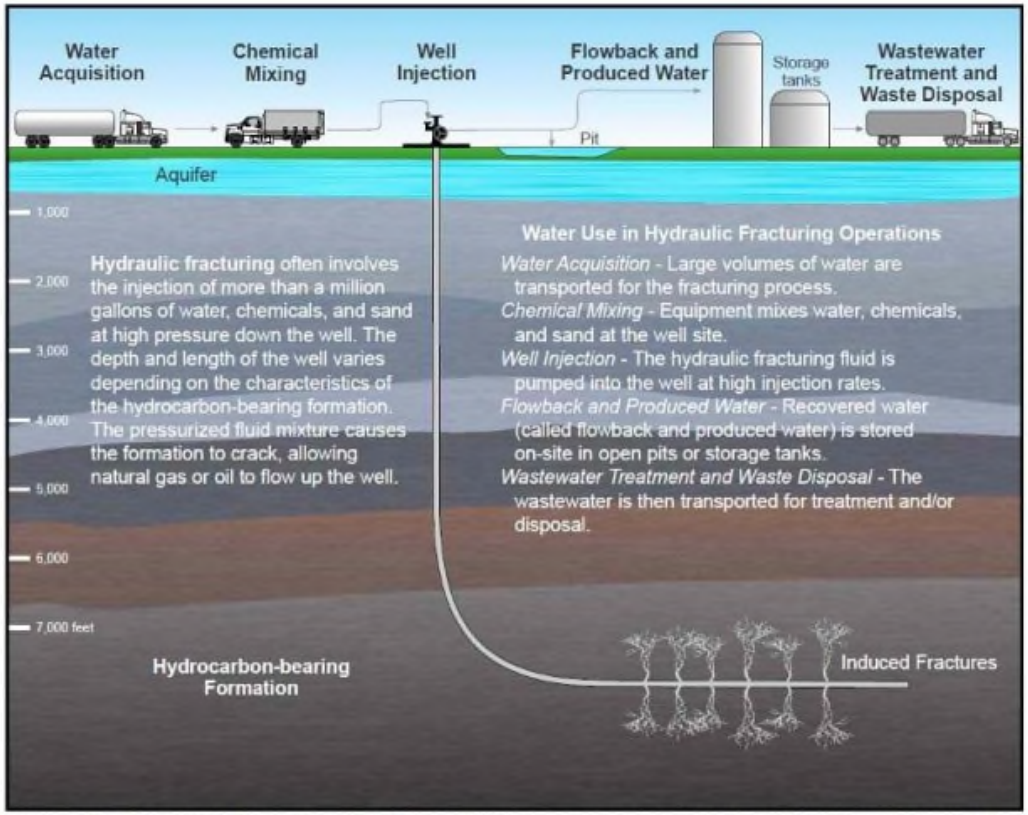

FIGURE 6. ILLUSTRATION OF A HORIZONTAL WELL SHOWING THE WATER LIFECYCLE IN HYDRAULIC FRACTURING

Process fluids from wellbore return to the surface and are collected after hydraulic fracturing is completed.

Returned fluids can contain volatile hydrocarbons from the formation and treatment chemicals used during hydraulic fracturing.

Risks for exposures: measuring flow, gauging tanks, working around tanks and process fluids

Field Visits: Spring/Summer 2013

- Six sites in Colorado and Wyoming
  - Fields: Piceance, Jonah, DJ Basin
  - Worker activities: Flowback, Production watch, Water transport, Lease operations

1. Identify processes/activities that may pose exposure risks
2. Identify sources of exposures
3. Assess exposures

Workers Evaluated

- Flowback Tech
  - gauging/strapping flowback tanks

Workers Evaluated

- Flowback Leadman
  - monitoring/operating separator

Workers Evaluated

- Production Watch
  - gauging production tanks

Industrial Hygiene Methods

1. Full-shift and short-term samples for VOCs (e.g., benzene), PAHs, alcohols, glutaraldehyde, and silica/respirable dust
    - Sorbent media and filters
    - Personal breathing zone (PBZ) and area air samples

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2. Spot measurements for VOCs and benzene
    1. Real-time, direct reading instruments
    2. PBZ and area air samples

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3. Lower explosive limits (LEL) monitoring

Occupational Exposure Limits*: Benzene

Exposure Limit	Limit Values
Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) - General Industry	1 part per million (ppm) time-weighted average (TWA) 5 ppm short-term exposure limit (STEL)
OSHA PEL – Sectors Excluded from General Industry	10 ppm TWA 25 ppm Ceiling 50 ppm Maximum peak above ceiling (10 minutes)
National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL)	0.1 ppm TWA 1 ppm STEL 500 ppm immediately dangerous to life or health (IDLH) Ca (potential occupational carcinogen); Skin
American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) (2013)	0.5 ppm TWA 2.5 ppm STEL A1 (confirmed human carcinogen); Skin; BEI (Biological Exposure Index)

*based on an 8-hour TWA, 40 hour work week

Spot Measurement, Headspace of Tanks

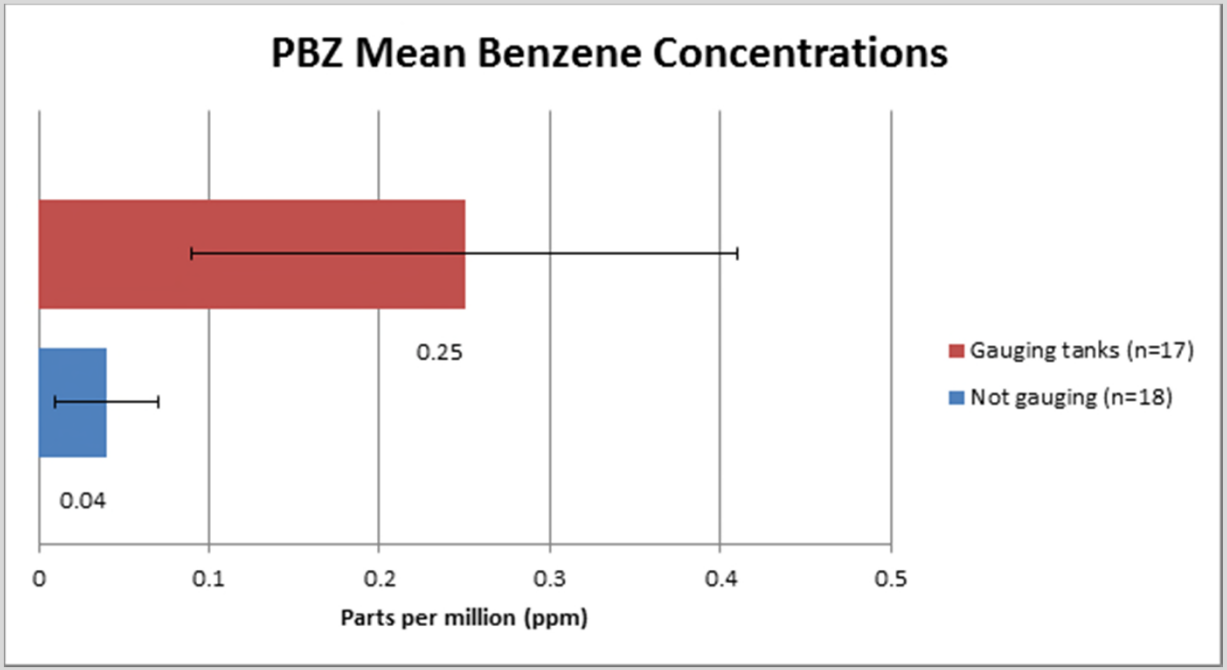
- Flowback tank (no controls)
  - VOCs: 10–2000 ppm
  - Benzene : 0–>250 ppm
- Flowback tanks (with controls)
  - Reduced Emissions Completions (REC)
  - VOCs: 10–400 ppm
  - Benzene: 0–30 ppm

Spot Measurements, Headspace of Tanks

- Production tanks
  - VOCs: 10–>2000 ppm
  - Benzene: 0–>300 ppm
- Water tanks
  - VOCs: 10–200 ppm
  - Benzene: 0–>40 ppm

Full-shift Personal Breathing Zone Benzene Measurements

TWA Range: Not Detected–0.65 ppm



- $p < 0.05$ (Student's t test), for gaugers vs. non-gaugers

Worker Benzene Biomonitoring

- s-PMA Range: 0–20.9 µg creatinine

- Summary stats:
  - Average for workers gauging tanks:

    6.1 ± 5.3 µg creatinine (n=17)
  - Average for workers not gauging tanks:

    2.5 ± 3.9 µg creatinine (n=18)

Example 1: Patterns of Exposure during Gauging (temporal and spatial)

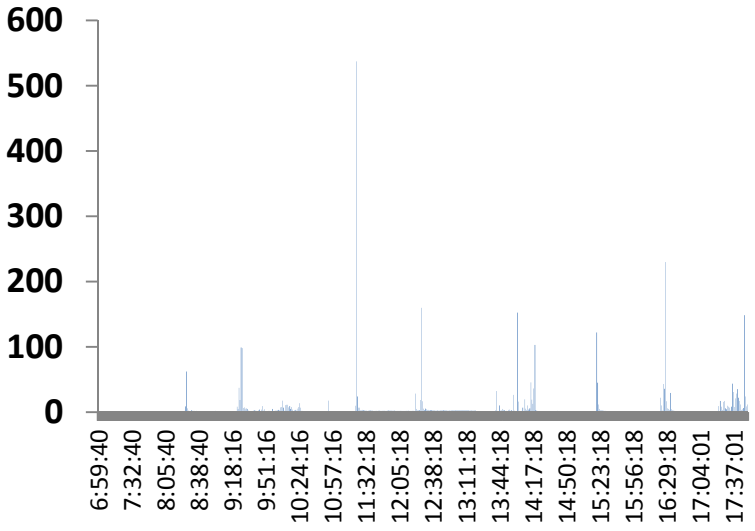
Worker gauging once per hour vs. Worker not gauging

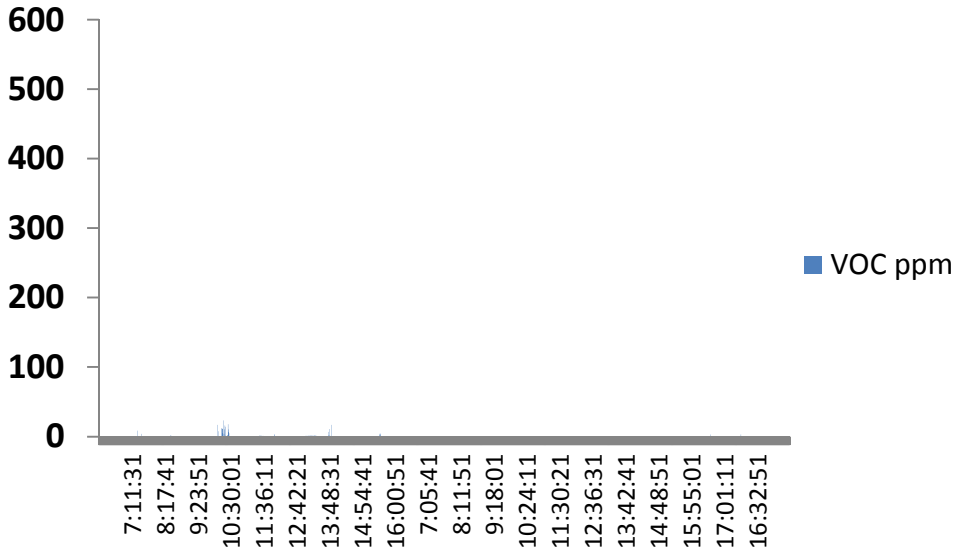
- Peak VOC = 537 ppm
- TWA VOC = 5.89 ppm
- TWA Benzene = 0.23 ppm

Peak VOC = 23.5 ppm

TWA VOC = 0.203 ppm

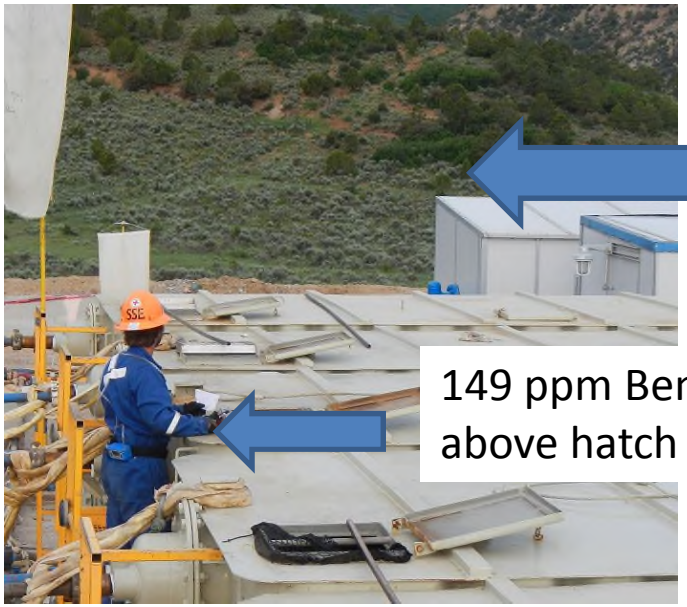
TWA Benzene = 0.01 ppm





Q. Why were the gauging worker's peak exposures so high?

A. This worker did not consistently gauge standing on top of the tank. Gauging from ladder reduces distance to source resulting in higher exposures.



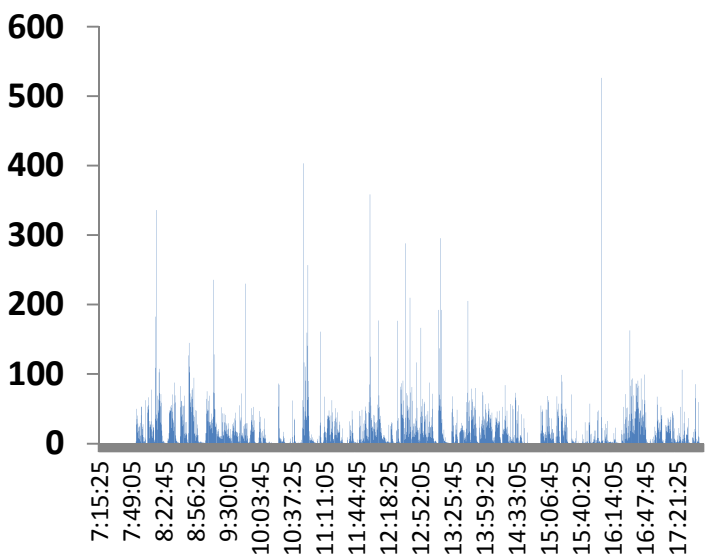
1.2 ppm Benzene at 54 inches above hatch

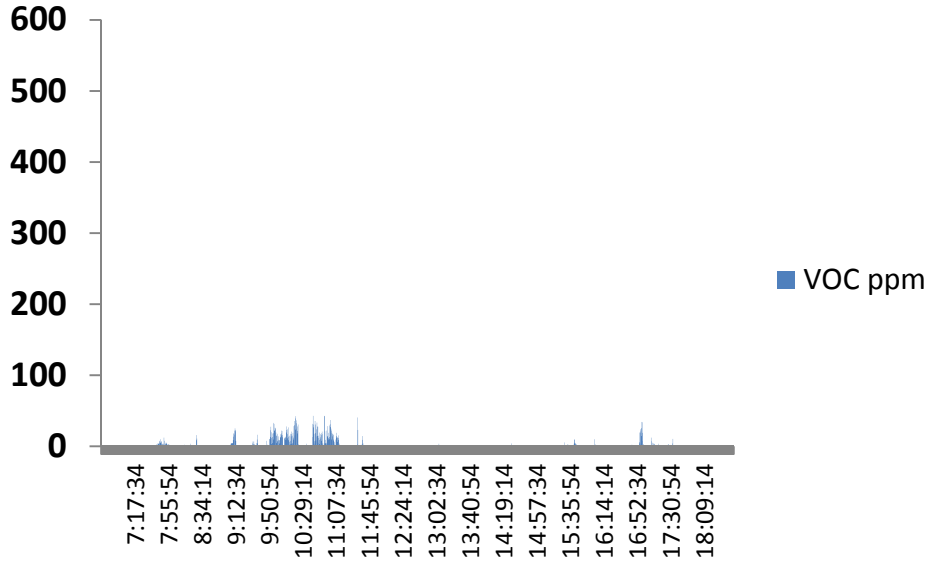
149 ppm Benzene at 18 inches above hatch

Example 2: Patterns of Exposure during Gauging (temporal and spatial)

Worker gauging 2x each hour vs. Worker not gauging

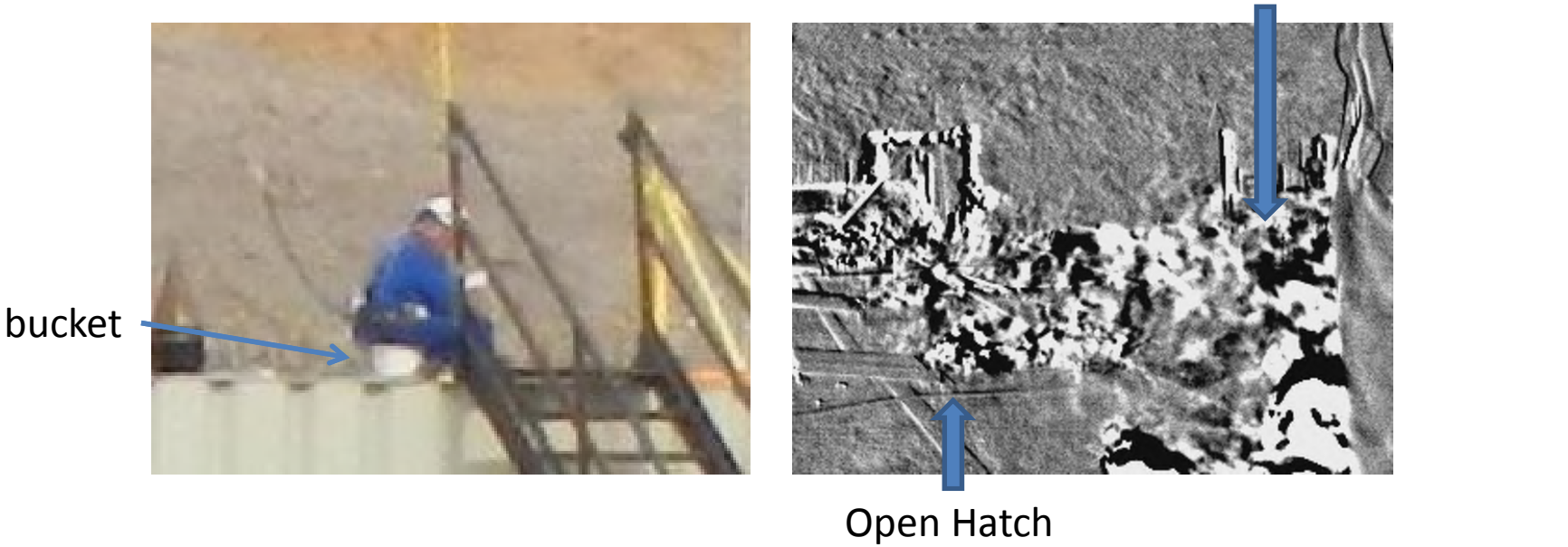
- Peak VOC = 523 ppm — Peak VOC = 42.9 ppm
- TWA VOC = 20.2 ppm — TWA VOC = 1.87 ppm
- TWA Benzene = 0.45 ppm — TWA Benzene = 0.05 ppm





Q. Why were the gauging worker's exposures so high?

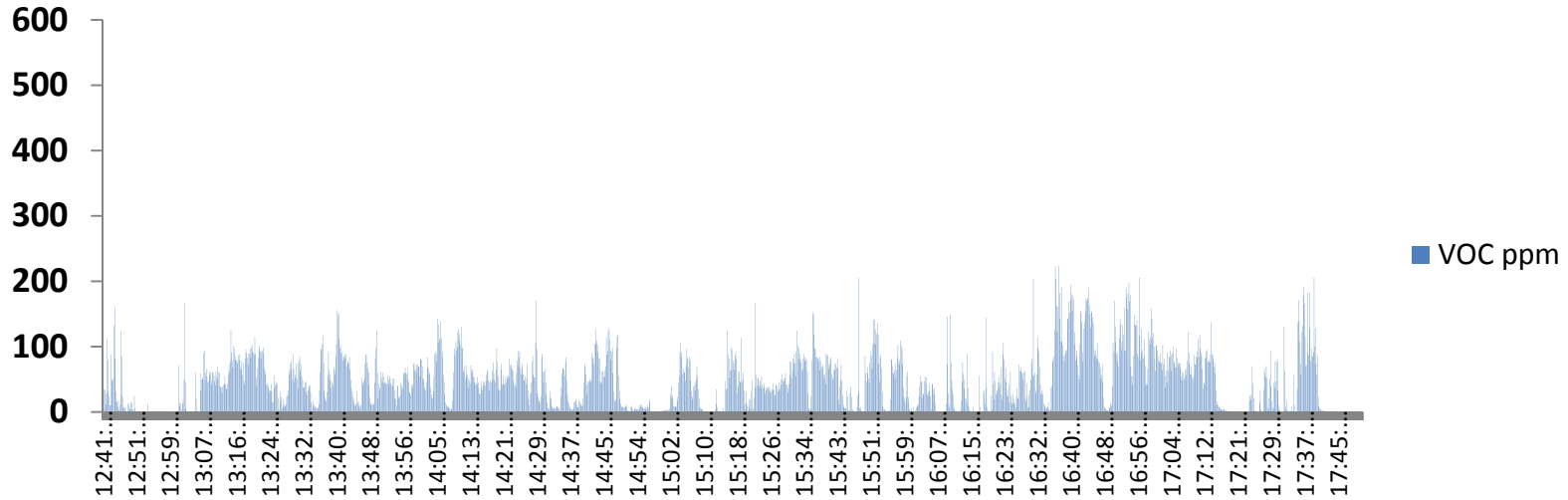
A. Worker was very careful to sample at his full height above hatches. However, he spent the entire shift on top of the tank in hydrocarbon plume.



Example 4: Patterns of Exposure Downwind of Tanks (temporal and spatial)

Immediately downwind of flowback tank (10 meters)

- Very early stage of flowback
- PBZ Peak VOC = 220 ppm
- PBZ TWA VOC = 46.8 ppm



Q. Why were these exposures elevated?

A. Sampling location was less than 10 meters from tank, while plugs were being drilled. Potential for very high release of hydrocarbons.

- Area Peak VOC = 200 ppm
- Area TWA VOC = 17.1 ppm
- Area TWA Benzene = 1.1 ppm

Other Compounds Monitored

- Glutaraldehyde:
  - All PBZ and area samples below limit of detection (LOD), except for one
  - one PBZ sample returned a trace concentration
- Propargyl Alcohol:
  - All area samples below LOD, except for one
  - one area sample returned result of 0.0043 ppm
- Methanol:
  - All area samples below LOD

Other Compounds Monitored

- PAHs:
  - Napthalene detected in multiple samples at parts per billion (ppb) range
- Silica and respirable dust:
  - All PBZ samples below NIOSH, OSHA, ACGIH OELs, except for one
    - This one sample was invalid due to accidental contamination

Flammable/Explosive Hazards

- Direct reading instruments showed many instances of short term excursions measuring as high as 40% of the Lower Explosive Limit (LEL)
  - especially while drilling plugs and during snubbing
  - measured near areas of flowback tanks, separators, and tank batteries

Conclusions

- Risks for VOC, benzene exposures:
  - spatial and temporal variables
  - intermittent, task-based
- Gauging tanks:
  - highest risk for exposures, contributes to highest TWAs
  - only few minutes, repeated throughout day

Conclusions (cont'd.)

- Potential for exposures:
  - dependent on proximity to sources
    - pad perimeter monitoring, very low levels of total VOCs
- Potential for exposure varies:
  - formation, basin
  - "Age" of well, notable factor for exposures

Conclusions (cont'd.)

- Controls are available
  - Reduced Emissions Completions (i.e., 'green completions'): appears to reduce potential for exposures through containment

Portable REC equipment Source: https://www.globalmethane.org/expo-docs/india10/postexpo/oil_robinson.pdf

Conclusions (cont'd.)

- Potential for exposures to other analytes measured during flowback appeared to be low
- Flammable/explosive hazards can exist due to the presence of combustible gas peaks detected

Request for Assistance

- Additional field research required
- Requesting additional industry partners to assist in further evaluating sites, locations, and activities
- These results are preliminary
- Communication of initial research results: NIOSH Science Blog, journal article, conference presentations

Questions?

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Alice Hamilton, M.D.
Mother of U.S. Occupational Medicine
1869–1970