NIOSH Research of Occupational Exposures in the Upstream Oil and Gas Industry

Bradley King, PhD, MPH, CIH
National Institute for Occupational Safety and Health
Denver, CO

Health Effects Institute's Energy Research Program:
Research Planning to Understand Population-Level Exposures Related to Development of Oil and Natural Gas from Unconventional Resources

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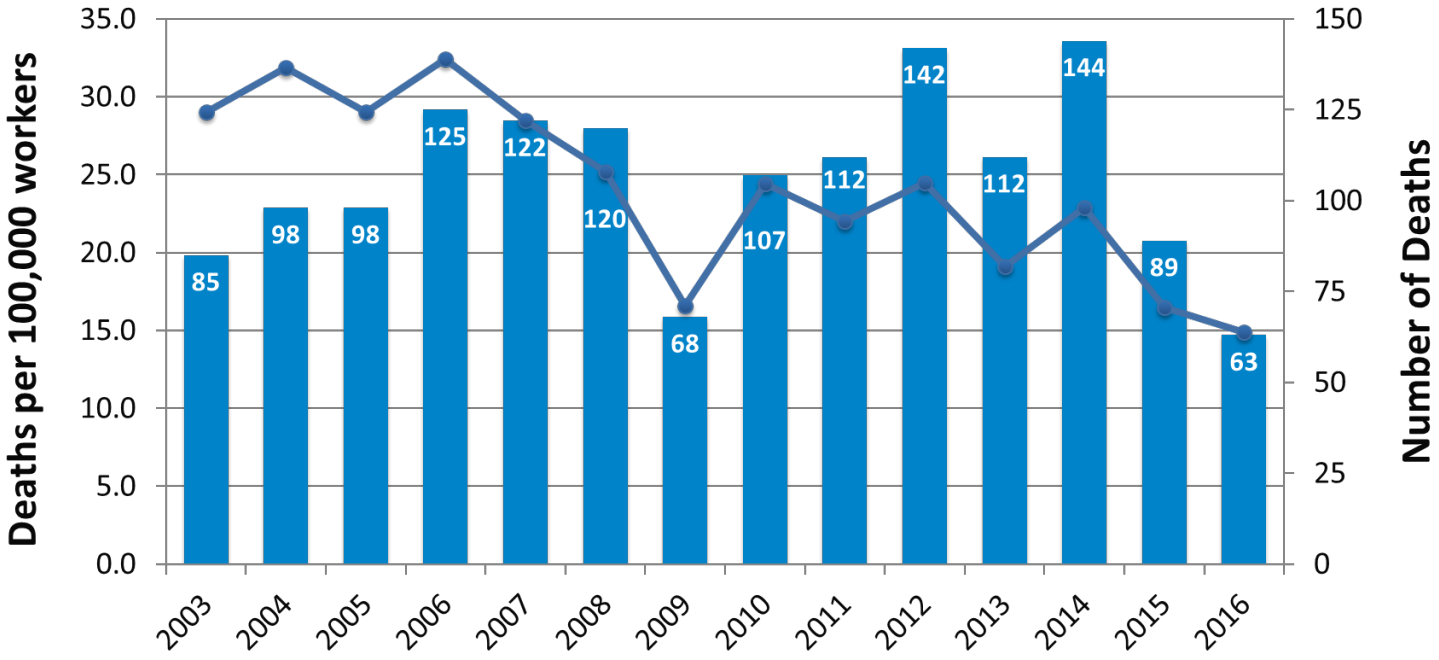
Upstream Oil and Gas Research: Epidemiology

Number and Rate of Fatal Work Injuries
U.S. Oil & Gas Extraction Industry, 2003–2016



N=1,485

Note: Fatality counts from BLS Census of Fatal Occupational Injuries. Worker Estimates from BLS Quarterly Census of Employment and Wages. Rate per 100,000 workers per year. Includes NAICS 211, 213111, 213112..

Fatalities in Oil and Gas (FOG) Database

NIOSH database that collects detailed information about oil and gas worker fatalities in the U.S.

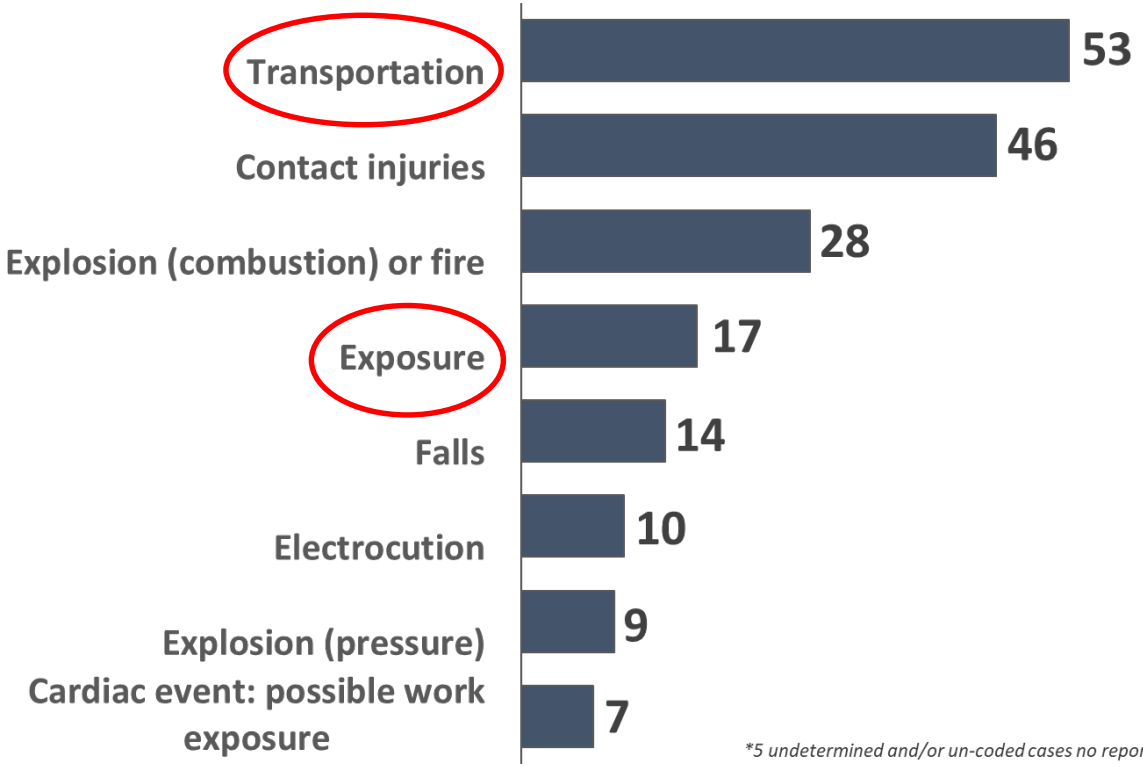
Includes	Fatal events to U.S. oil and gas extraction workers: • Onshore • Offshore • **All NAICS (O&G related)** • Motor vehicle incidents • **Non-traditional commuting** • Cardiac events
Excludes	Midstream, downstream, non-fatal injuries
Data Sources	OSHA case files, media, crash reports, autopsy reports, industry partners
Limitations	Roadway motor vehicle fatalities, chronic illness

Fatalities in FOG by Event Type, 2014–2016

Event type

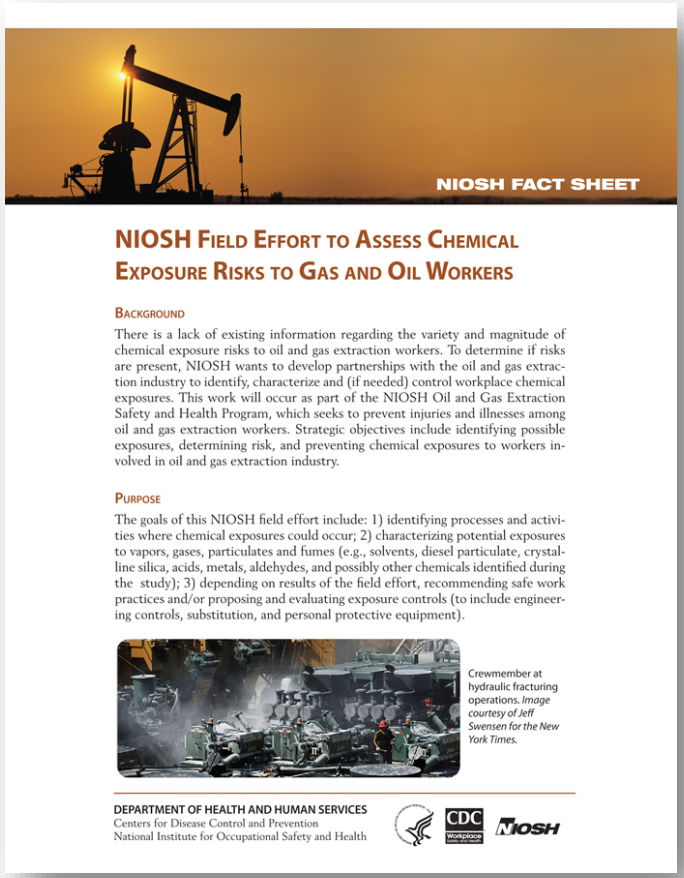
- How fatality occurred
- Event type similar to OIICS
- Initial event
- One per fatality

★ 15 cardiac events with no identified work exposure are not included in these data



*5 undetermined and/or un-coded cases no reported

Upstream Oil and Gas Research: Industrial Hygiene



NIOSH FACT SHEET

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 Gas and Oil Workers

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

Health Hazard: Respirable Crystalline Silica (RCS) during Hydraulic Fracturing

RCS Exposures

- Systematically evaluated occupational exposures at hydraulic fracturing sites [1]
  - 11 sites in 2010–2011
  - Sand mover operators/T-belt operators
    - Exposures can be 10–50 times greater than occupational exposure limits

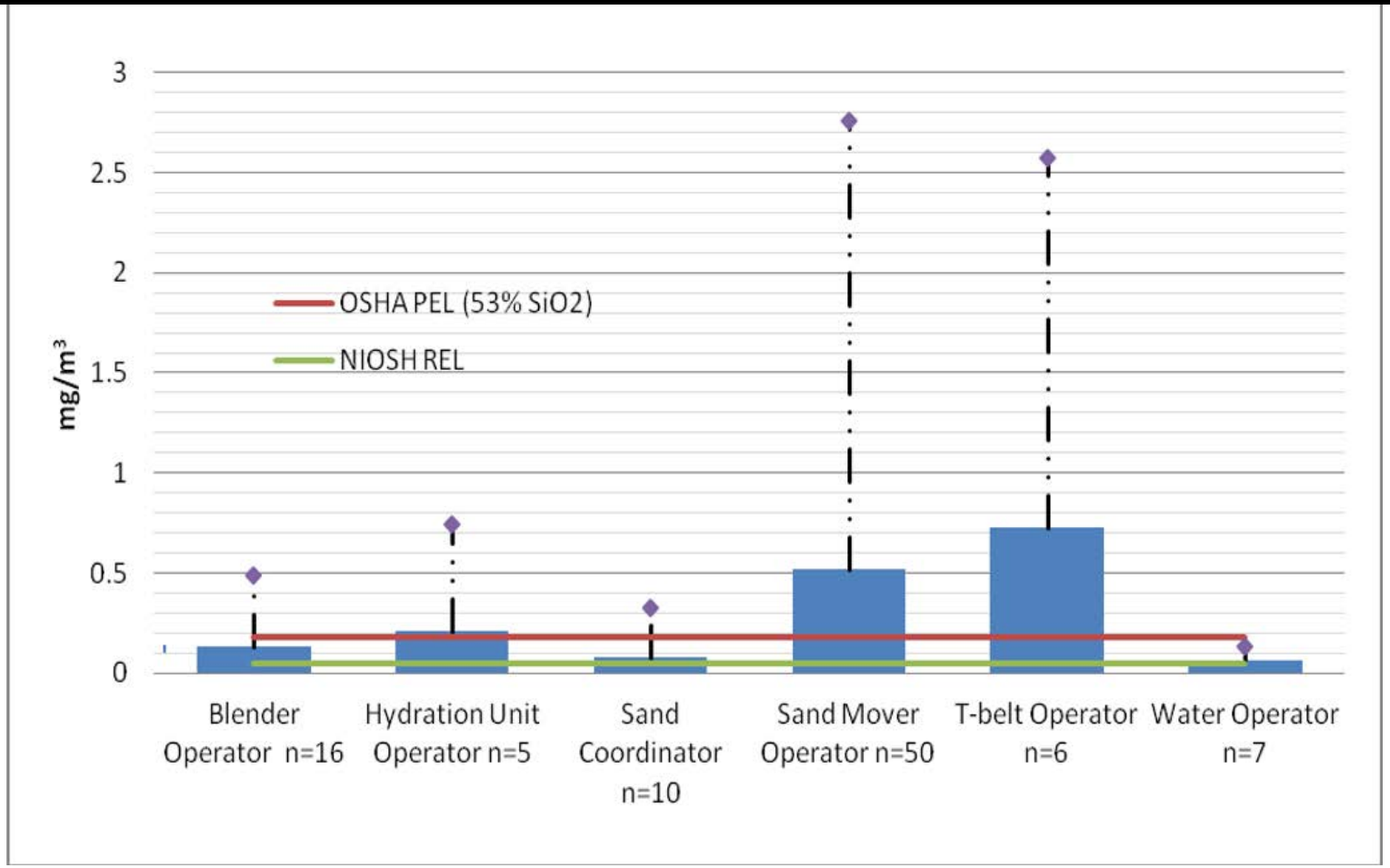
[1] Esswein, Breitenstein, Snawder, et.al,. *Occupational Exposures to Respirable Crystalline Silica in Hydraulic Fracturing* Jour. Occ. Env. Hyg. Vol. 10, Issue 7, May, 2013.

Study Results, by location

Site	> ACGIH TLV*	> NIOSH REL*	> OSHA PEL*	Total # samples
A	24 (92.3%)	19 (73.1%)	14 (53.9%)	26
B	16 (84.2%)	14 (73.7%)	12 (63.2%)	19
C	5 (62.5%)	5 (62.5%)	4 (50.0%)	8
D	19 (90.5%)	14 (66.7%)	9 (42.9%)	21
E	25 (92.6%)	23 (85.2%)	18 (66.7%)	27
F	4 (40%)	1 (10%)	0	10
G**	0	0	0	8
Total	93 (78%)	76 (64%)	57 (48%)	119

* Number of samples/% ** Composite of 2 locations

Exposure Comparisons, by Job Title

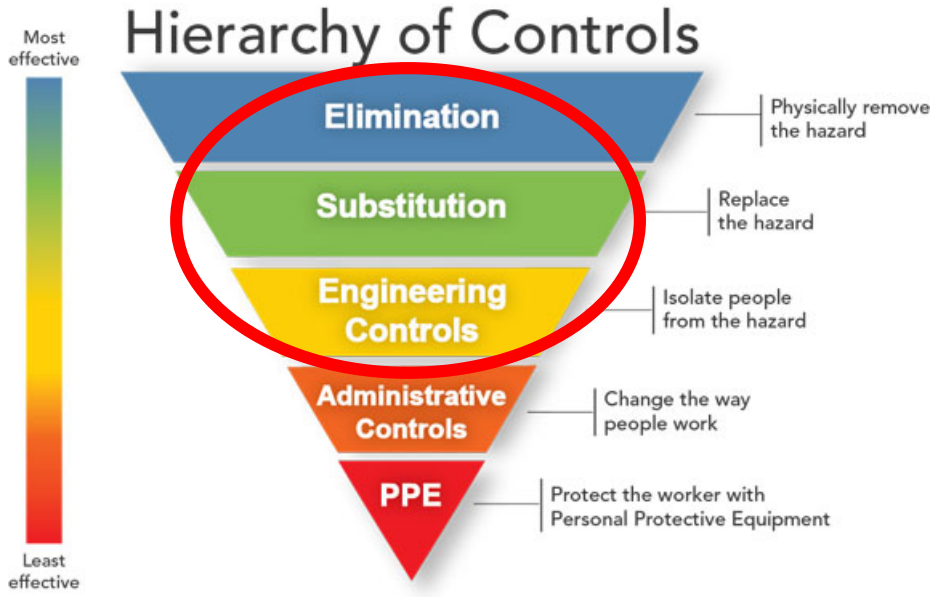


Elimination, Substitution, Engineering Controls

Examples of controls being developed by Industry

On-Site Dust Control

- Changes in proppant storage/handling/delivery
- Ceramic proppant
- Coated/treated sand proppant
- Portable baghouse
- Dust collectors with filters
- Personal decontamination booth



[National STEPS Network: Emerging Issues Focus Group]

Administrative Controls & Effective Training Programs

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).

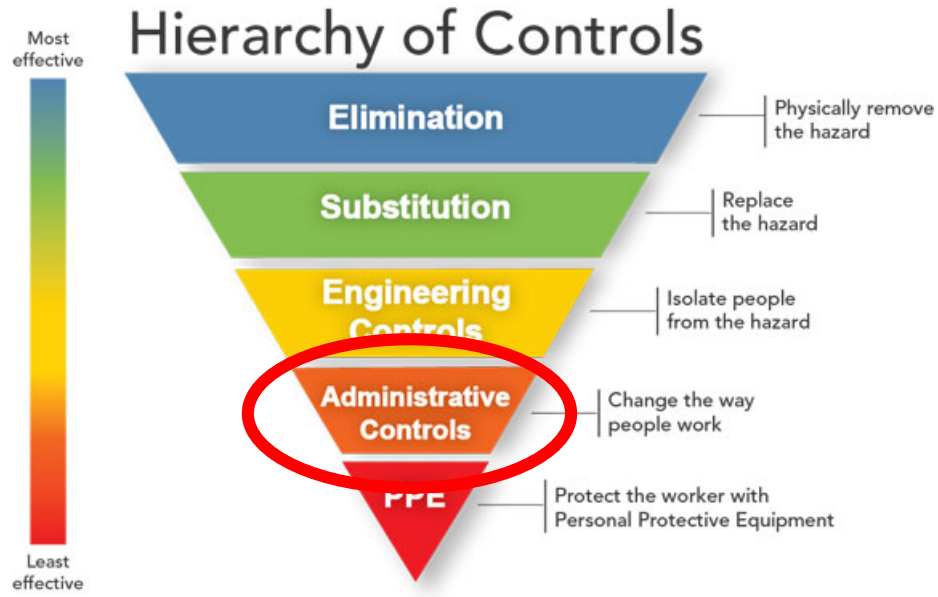
Photo credit: NIOSH

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.

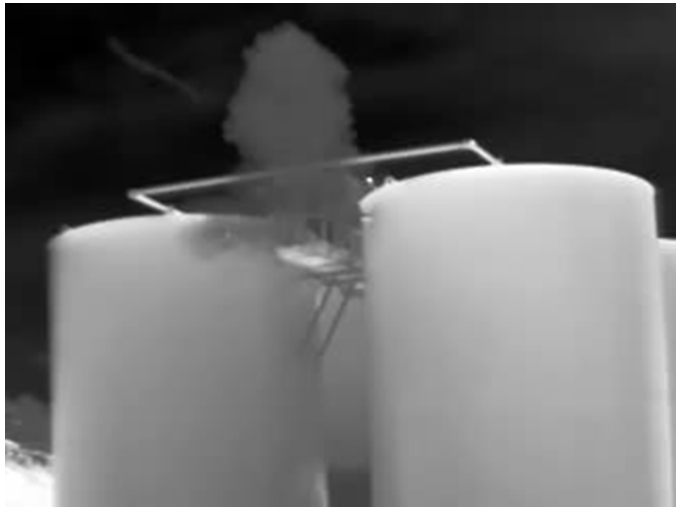
OSHA has jurisdiction over the safety and health of workers, including workers involved in upstream oil and gas operations. The General Duty Clause of the Occupational Safety and Health (OSH) Act and OSHA's General Industry Standards (29 CFR 1910) apply to the upstream industry. As part of the enforcement 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.



Health Hazard: Hydrocarbon Gases and Vapors during Manual Tank Gauging and Sampling

Opening Thief Hatch



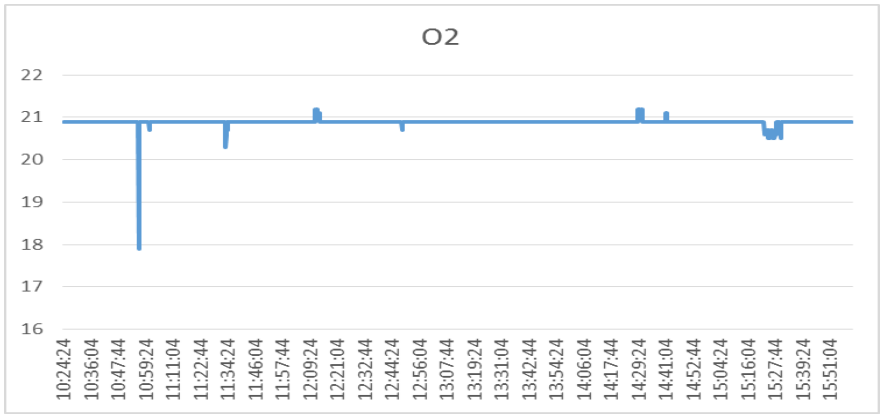
2010–2014 Hydrocarbon Related Worker Fatalities

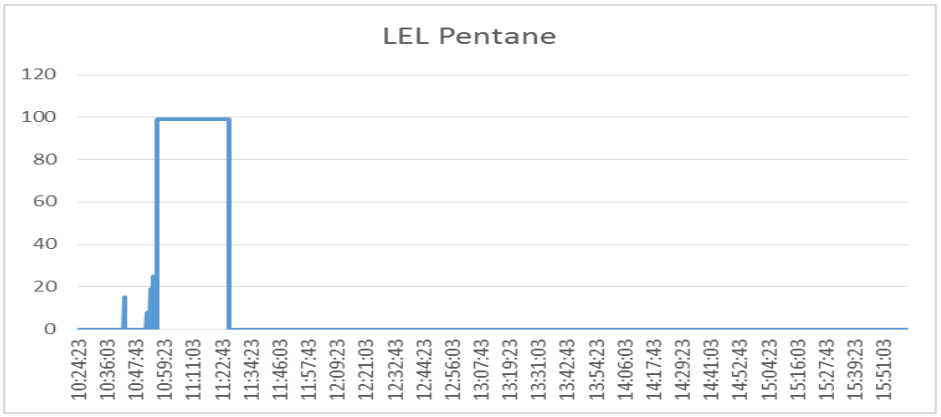
9 fatalities identified where inhalation of volatile hydrocarbons was a possible contributing factor[2]:

- 2010 (1); 2012 (1); 2013 (1); 2014 (6)
- North Dakota (3); Colorado (3); Texas (1), Oklahoma (1); Montana (1)
- All occurred at crude oil (production) tanks:
  - tank gauging (4)
  - sampling by pumpers/truckers (5)
  - working alone or not being observed (9)
- In at least one case:
  - victim sought medical evaluation for health effects (dizziness, disorientation, etc.) experienced during prior gauging activities

[2] NIOSH Science blog: https://blogs.cdc.gov/niosh-science-blog/2015/04/10/flowback-3/

Results of Personal Sampling (Hydrocarbons): Direct Reading





Results of PBZ Grab Samples When Hatch Opened

Gas or Vapor	Concentration Range (IDLH)
Methane	ND–5,979 ppm (5,000)
Ethane	ND–24,818 ppm (3,000)
Propane	ND–41,435 ppm (2,100)
i-Butane	ND–3,793 ppm (1,800)
n-Butane	ND–19,336 ppm (1,860)
i-Petane	ND–2,990 ppm (1,400)
n-Pentane	ND–3,385 ppm (1,500)

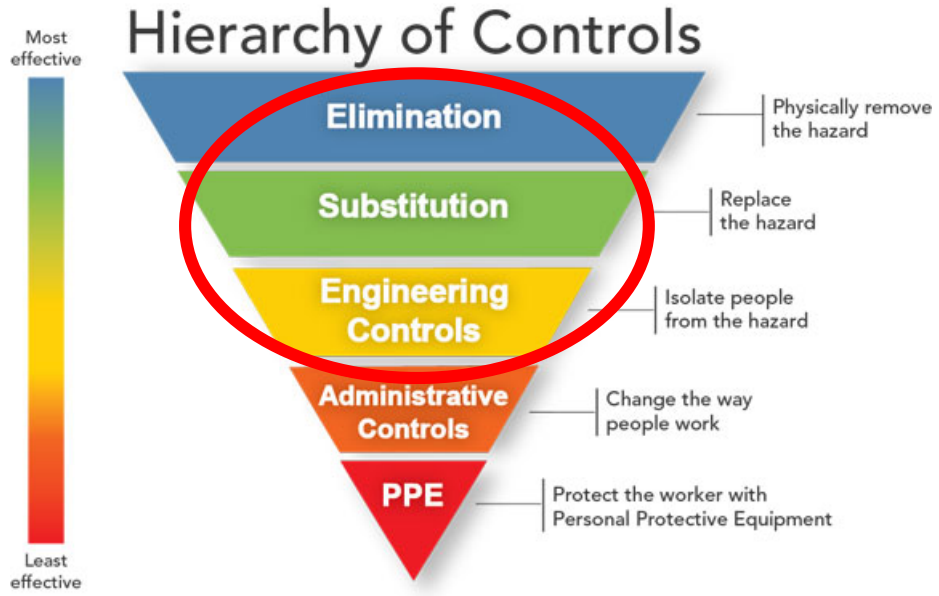
Vapor	Concentration Range (IDLH)
Benzene	ND–280 ppm (500)
Toluene	ND–129 ppm (800)
Ethylbenzene	ND–55 ppm (500)
Xylenes	ND–84 ppm (900)

IDLH = immediately dangerous to life or health

Elimination, Substitution, Engineering Controls

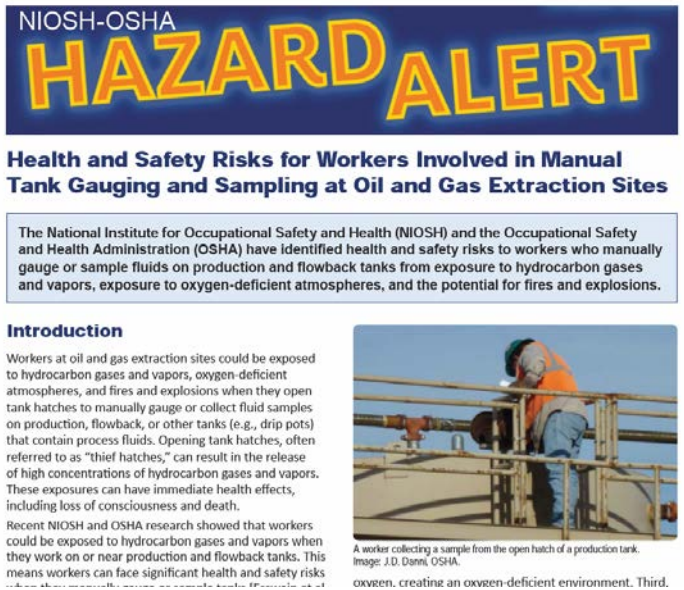
Develop alternative tank gauging procedures so workers do not have to routinely open hatches

- Remote tank gauging and sensing
- LACT units



Administrative Controls & Effective Training Programs

- Reduce times workers must manually gauge tanks
- Use multi-gas meters correctly
- Hazard communication



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.

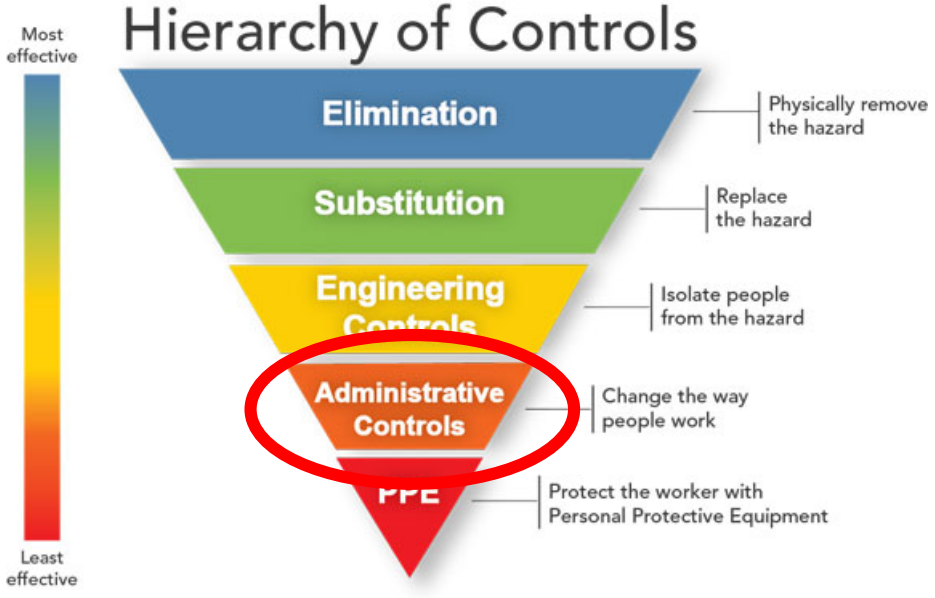
Introduction

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.

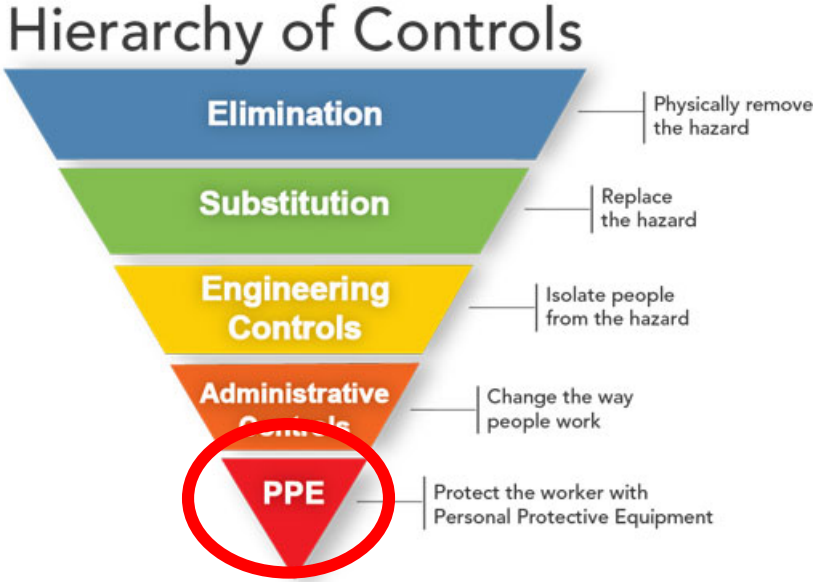
Recent NIOSH and OSHA research showed that workers could be exposed to hydrocarbon gases and vapors when they work on or near production and flowback tanks. This means workers can face significant health and safety risks

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

oxygen, creating an oxygen-deficient environment. Third,



Proper Respiratory Protection



- Utilize supplied air respirators for environments with oxygen deficiency and high low-molecular weight hydrocarbon concentrations

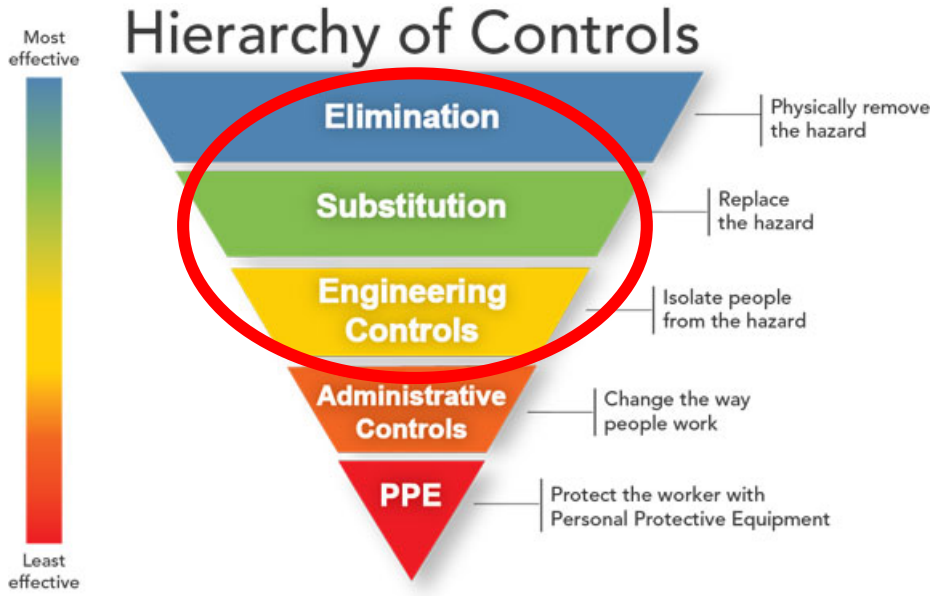
Health Hazard: Hydrocarbon Gases and Vapors during Fluid Transfer

Transferring to Truck

- 440–550 parts per million of hydrogen sulfide
- >100% lower explosive limit for methane
- < 19.5% oxygen concentration

Elimination, Substitution, Engineering Controls

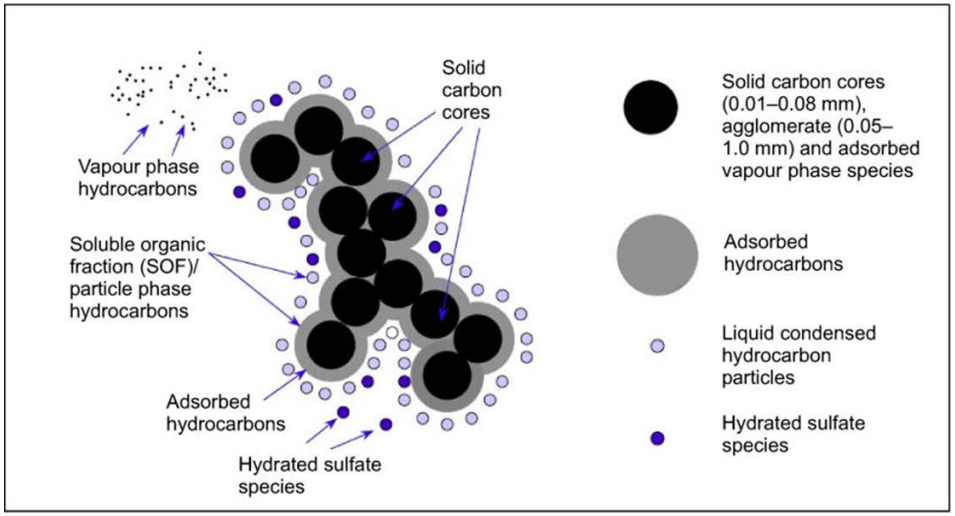
Utilize vent lines to direct hydrocarbon gases and vapor away from the work zone and potential ignition sources



Health Hazard: Diesel Particulate Matter

What is Diesel Particulate Matter?

- Complex aerosol: gases, respirable particulates, > 40 potentially toxic compounds
- Solid elemental carbon (EC) core with hydrocarbons, S, NOx adsorbed onto core
- Respiratory and cardiovascular health effects; carcinogen



Health Hazard: Diesel Particulate Matter

Combination of data from 2008–2012[3]

- 103 full shift air samples
  - 48 Personal Breathing Zone
  - 55 Area
- Site types
  - Completions Hydraulic Fracturing (56/103 or 54%)
  - Drilling (31/103 or 30%)
  - Servicing (16/103 16%)

[3] Eric J. Esswein, Marissa Alexander-Scott, John Snawder & Michael Breitenstein (2018). Measurement of area and personal breathing zone concentrations of diesel particulate matter (DPM) during oil and gas extraction operations, including hydraulic fracturing. Journal of Occupational and Environmental Hygiene, 15:1, 63-70, DOI: 10.1080/15459624.2017.1388512

Conclusions: Diesel Particulate Matter

- 10% (5/48) PBZ samples, > 20 µg /m^3 as EC
- 31% (17/55) area samples > 20 µg /m^3 as EC
- Proximity, #'s of sources, equipment configuration, weather conditions were determinants of exposures
- No statistically significant difference geometric means of PBZ vs. area results…some degree of homogenous risk for DPM exposure?

On-going Exposure Assessments: Well Drilling Processes

What We Sampled

- Vapors and emissions from diesel based mud
- Hydrocarbon gas and vapors from the well/production zone
- Combustible gas/vapors, CO, H_2S, Oxygen
- Total hydrocarbons
- Respirable particulates
  - Diesel particulate matter (DPM)
  - Silica, cement, dust
- Special treatment chemicals

Where We Sampled

Personal breathing zone samples on workers

- Shakerhands/Mudmen
- Motormen
- Roughnecks/Floorhands
- Derrickhands

Areas around the site

- Over mud tanks
- In the mixing room
- Over/around shakers
- In the trip room
- Processing solids

Questions? Bradley.King@cdc.hhs.gov

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

NIOSH Project Researchers

- Marissa Alexander-Scott
- Barbara Alexander
- David Caruso
- Mike Breitenstein
- Eric Esswein
- Ryan Hill
- Belinda Johnson
- Bradley King
- Alejandra Ramirez-Cardenas
- Kyla Retzer
- Sophi Ridl
- Emily Schmick
- John Snawder