NIOSH Safety and Health Research in Oil and Gas Extraction

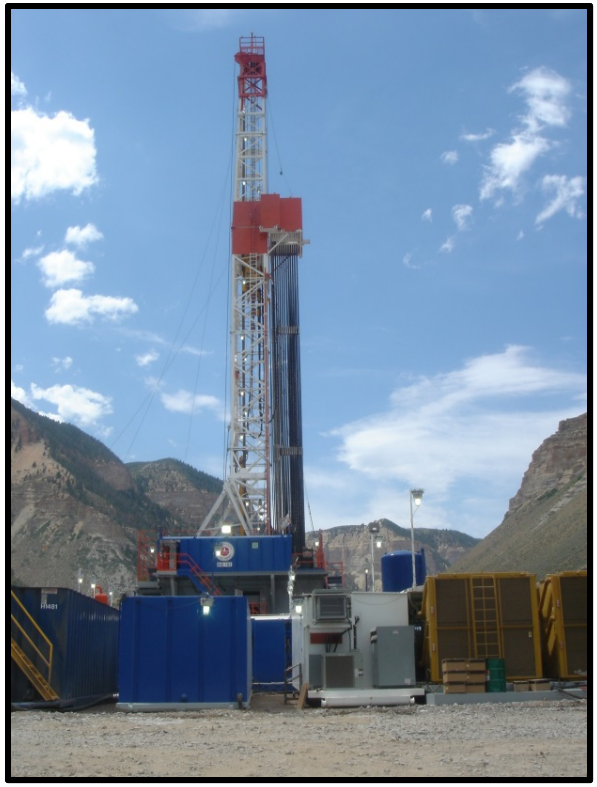
Board of Scientific Counselors Meeting
September 18, 2013

Max Kiefer, NIOSH Western States Office

Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Overview

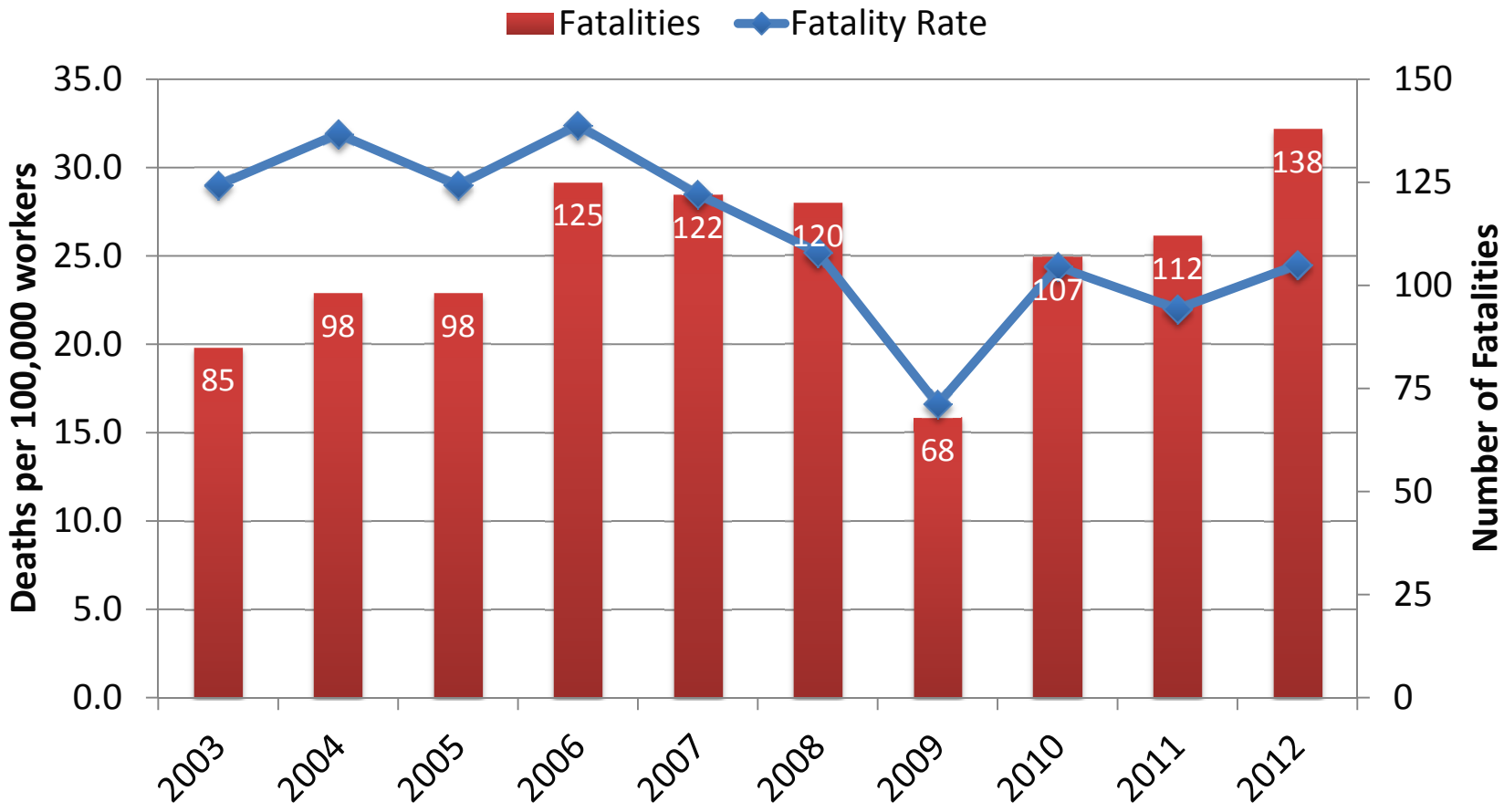
- NIOSH Oil & Gas Sector Program overview
- Field effort to assess chemical exposure risks to Oil and Gas workers
- Future research activities
- Questions



Oil and Gas Exploration and Production

Exploration and production (E&P) operations include a wide variety of activities including seismic and geophysical activities, site preparation, drilling, completions

Occupational Fatality Rate and Industry Activity, Oil and Gas Extraction, 1993-2012



NIOSH OIL & GAS EXTRACTION SAFETY & HEALTH PROGRAM
Research Projects and Publications Timeline

NORA

Seed Money to Support Learning

Chemical Exposures to Oil & Gas Workers (EE, JS, MB)

Contact Injury Prevention Project (PS)

Motor Vehicle Best Practices in Oil & Gas (KR)

PPE Use in O&G: Seat Belts & Fall Protection (NM)

Preventing Fires & Explosions in Oil & Gas (JB)

Chemical Exposures to O&G Workers (MB)

Rig Move Safety for Oil & Gas Workers (EC)

Injuries in the Offshore Oil & Gas Industry (RH)

Preventing Falls in Oil & Gas (PS)

Projects

- NORA Projects
- PHP Projects

2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

Outputs

- Publications
- DVDs

2007
SPE Article: Working Hard to Work Safely

2008
SPE Article: Fatalities by Company Type and Size

2008
MMWR: Fatalities Among O&G Workers

2008
Take Pride in Your Job: Seat Belts & Fall Protection

2009
Fact Sheet: Chemical Exposures to O&G Workers

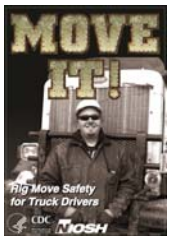
2010
Move It! Rig Move Safety for Roughnecks

2011
SPE Article: Mortality Statistics for the US Upstream Industry

2011
Well Servicing: Fatal Injuries in the Upstream O&G Industry

2011
ASSE Professional Safety: Effective Training, A Case Study from the O&G Industry

2012
Move It! Rig Move Safety for Truckers



2013
SPE Article: Review of the Literature: MV Safety Practices

2013
Occupational Exposures to Respirable Crystalline Silica during Hydraulic Fracturing

NIOSH Interdisciplinary Team – Unconventional Oil & Gas Operations

- Subject matter experts
- Received orientation-level industry training
- Participate in field studies as appropriate
- Review draft outputs
- Assist with dissemination of research findings

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

Who Can Participate

Workers, managers, supervisors, and health and safety professionals involved in oil and gas drilling and servicing operations are encouraged to participate in the field effort.

Floorcrew on drilling platform. *Image courtesy of Eric Esswein, NIOSH.*

Benefits of Participation

Companies can leverage the industrial hygiene expertise of a NIOSH field research team to help identify if chemical exposure risks are present or absent, and based on results of field studies, prioritize and control potential workplace chemical exposures at their worksites. Data and results collected by NIOSH in the field effort will be communicated to the company in letter format. Become involved with NIOSH and be seen as a leader in occupational safety and health in the gas and oil industry.

Note: This Field Research Effort will be fully funded by NIOSH; there is no cost to participate. NIOSH is a part of the Centers for Disease Control and Prevention (CDC). NIOSH is federal agency responsible for conducting research and providing guidance related to occupational health and safety. NIOSH is not a regulatory agency. Federal regulations provide for trade secret protection for participating companies.

How to Become Involved

To learn more about the Field Effort to Characterize Chemical Exposures in Oil and Gas Extraction Workers, contact Eric Esswein, CIH, at (303) 236–5946, or submit inquiries electronically or by mail to: eje1@cdc.gov or Eric Esswein, NIOSH, Denver Federal Center, P.O. Box 25226 Denver, CO. 80225

Sand truck operator at hydraulic fracturing operations. *Image courtesy of Eric Esswein, NIOSH.*

Worker Exposures

Worksite operations, processes, and chemicals used in the industry suggest workers have potential risks for exposures to multiple chemical hazards.

Chemical Exposures Risks

- Silica
- Diesel emissions
- Components of fracturing fluids
- Hydrocarbons and other volatile organic compounds (BTEX)
- Hydrogen sulfide (H_2S)
- Acids/bases
- Biocides (aldehydes, others)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Metals (Pb)

Not an inclusive list

Completions: Hydraulic Fracturing

Silica (Quartz)

- Respirable crystalline silica
- OSHA NPRM
- Silicosis, lung cancer, other diseases
- Occupational hazard of antiquity
- Preventable disease
- Used as a proppant during HF
  - Hundreds of thousands of pounds per stage
- Virtually 100% silica

How much respirable crystalline silica is the NIOSH REL?

500 micrograms (µg's)

Photo: Geoff Plumlee, USGS

NIOSH REL = 0.05 mg/m^3 TWA

0.05 mg/m^3 = 50 micrograms (µg) mg/m^3

1 m^3 of air = 1,000 liters

Normal breathing rate (moderate work, 1 work day) = 10 m^3 (10,000 liters of air)

50 micrograms x 10 m^3 = 500 µg's

Initial Field Effort: Respirable Crystalline Silica

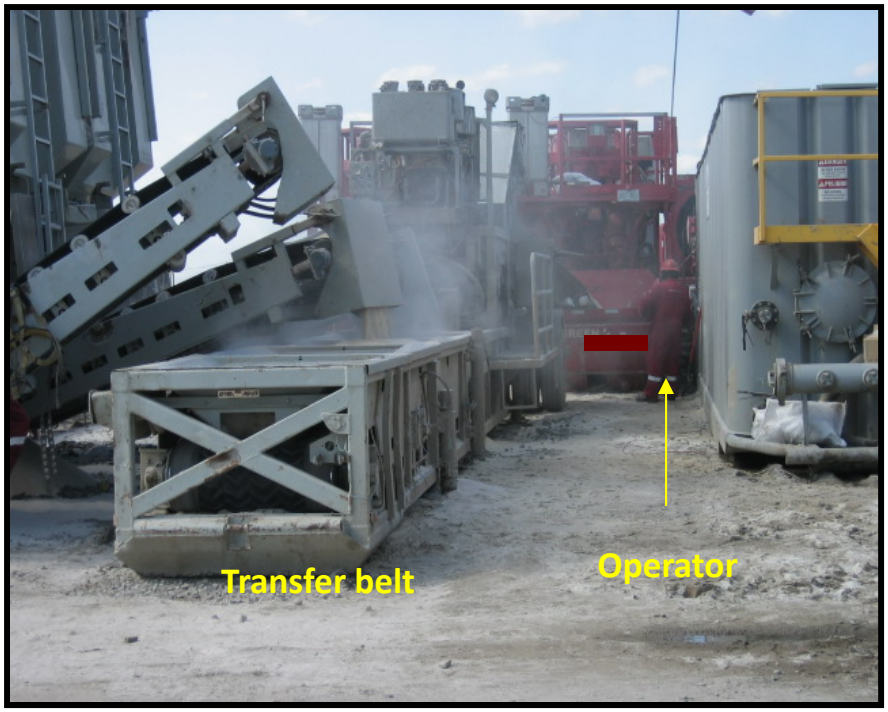
Field Work (2010-2011):

- 11 sites, 5 states
- CO (7 sites), AR, PA, TX, ND
- Winter, spring, summer
- Elevation: 300 – 5000 ft.
- Single stage refracs, multi stage, zipper fracs
- Slickwater & gel fracs
- Silica sand, resin coated and ceramic

Hot Loading – Hydraulic Fracturing

Sand transfer operations

Sand transfer operations



Respirable Silica Results by Location[1]

Site	> ACGIH TLV 0.025 mg/m³	> NIOSH REL 0.05 mg/m³	> OSHA PEL 0.1 mg/m³ (100% silica)	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
Total	93 (83.8%)	76 (68.5%)	57 (51.4%)	111

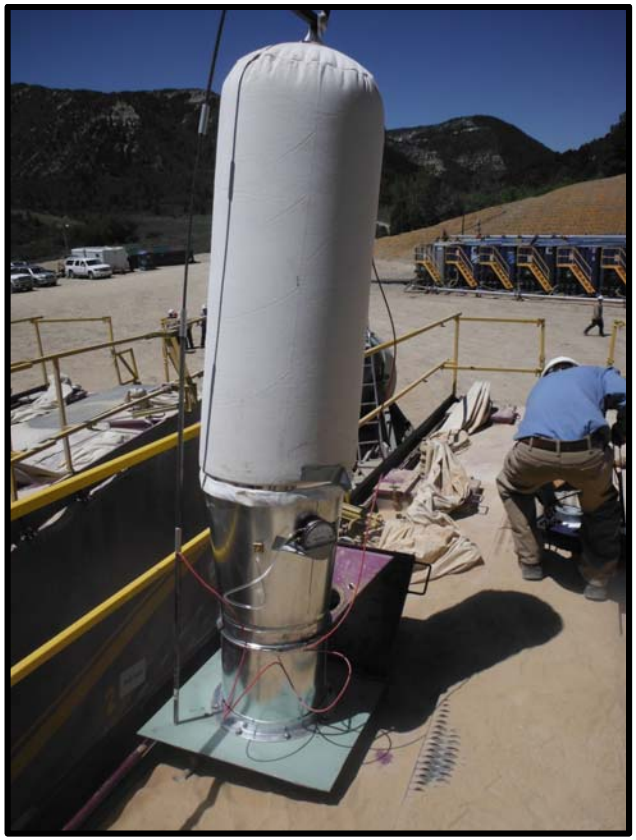
[1] Esswein, Breitenstein, Snawder, et.al,. *Occupational Exposures to Respirable Crystalline Silica in Hydraulic Fracturing* Jour. Occ. Env. Hyg. Vol. 10, Issue 7, May, 2013

8 Primary Points of Dust Generation

1. Release from top hatches, sand movers
2. Transfer belt under sand movers
3. Site traffic
4. Sand dropping in blender hopper
5. Release from T-belt operations
6. Release from dragon tail
7. Dust ejected from fill ports on sand movers
8. Release from work uniforms

Initial Field Effort: Outcomes

- Numerous conference presentations 2012-2013
- OSHA/NIOSH Hazard Alert
- NIOSH Science Blog
- JOEH article
- NIOSH mini baghouse retrofit assembly
- Increased awareness and adoption of controls



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Occupational Exposures to Respirable Crystalline Silica During Hydraulic Fracturing

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This report describes a previously uncharacterized occupational health hazard: work crew exposures to respirable crystalline silica during hydraulic fracturing. Hydraulic fracturing involves high pressure injection of large volumes of water and sand, and smaller quantities of well treatment chemicals, into a gas or oil well to fracture shale or other rock formations, allowing more efficient recovery of hydrocarbons from a petroleum-bearing reservoir. Crystalline silica ("frac sand") is commonly used as a proppant to hold open cracks and fissures created by hydraulic pressure. Each stage of the process requires hundreds of thousands of pounds of quartz-containing sand; millions of pounds may be needed for all zones of a well. Mechanical handling of frac sand creates respirable crystalline silica dust, a potential exposure hazard for workers. Researchers at the National Institute for Occupational Safety and Health collected 111 personal breathing zone samples at 11 sites in five states to evaluate worker exposures to respirable crystalline silica during hydraulic fracturing. At each of the 11 sites, full-shift samples exceeded occupational health criteria (e.g., the Occupational Safety and Health Administration calculated permissible exposure limit, the NIOSH recommended exposure limit, or the ACGIH threshold limit value), in some cases, by 10 or more times the occupational health criteria. Based on these evaluations, an occupational health hazard was determined to exist for workplace exposures to crystalline silica. Seven points of dust generation were identified, including sand handling machinery and dust generated from the work site itself. Recommendations to control exposures include product substitution (when feasible), engineering controls or modifications to sand handling machinery, administrative controls, and use of personal protective equipment. To our knowledge, this represents the first systematic study of work crew exposures to crystalline silica during hydraulic fracturing. Companies that conduct hydraulic fracturing using silica sand should evaluate their operations to determine the potential for worker exposure to respirable crystalline silica and implement controls as necessary to protect workers.

[Supplementary materials are available for this article. Go to the publisher's online edition of Journal of Occupational and Environmental Hygiene *for the following free supplemental resource: a file containing controls and recommendations to limit worker exposures to respirable crystalline silica at hydraulic fracturing work sites.]*

Keywords completions operations, crystalline silica, hydraulic fracturing, oil and gas extraction, sand

Correspondence to: Eric J. Esswein, National Institute for Occupational Safety and Health, Western States Office, Denver Federal Center, P.O. Box 25226, Denver, CO 80225; e-mail: ejc1@cdc.gov.

INTRODUCTION

Occupational exposure to respirable crystalline silica is a well-established hazard in mining, sandblasting, foundry work, agriculture, and construction, but not for oil and gas extraction work, which includes hydraulic fracturing.[1–9] Hydraulic fracturing involves high pressure injection of large volumes of water (≈95% of total volume) "proppant" (≈4.5%, typically as silica sand) and lesser quantities (≤1.0%) of treatment chemicals (commonly a combination of surfactants, acids, scale inhibitor, clay stabilizers, corrosion/precipitation inhibitors, pH adjusting agents, gels, gel breakers, and biocides) into hydrocarbon-bearing strata to enhance recovery of oil and gas, particularly from deep shale formations. Hydraulic fracturing creates and enhances cracks and fissures in the geology; proppant holds the fractures open, allowing more efficient and sustained flow back of gas or oil.

Also called "well stimulation," "pressure pumping," or "completions operations," hydraulic fracturing has been used since the 1940s and has increased substantially over the last 10 years with the advent of "unconventional" drilling techniques (e.g., directional and horizontal) to access oil and gas not previously feasible with vertical drilling techniques alone.

Journal Publication

Available online:
www.tandfonline.com

Initial Field Effort: Impact

- Respirable crystalline silica focus group
- Nationwide awareness of an emerged hazard
- Development/dissemination of control options
- Patent-pending baghouse control
- Private industry development and production of controls
- ND OSHA O&G “sweep” includes health component and industry participation
- Industry support for NIOSH investigations to evaluate other chemical risks

Current Field Effort: 2013-2016

- Internally funded NIOSH project
- Volatile organic compounds
  - BTEX, alcohols, PAHs, biocides
  - Real time and integrated monitoring
- Biological monitoring and dermal assessments
- Diesel emissions
- NORM
- Numerous sites, geographical locations, seasons
- Includes drilling and servicing

Diesel Emissions

Photo: courtesy of Jeff Swensen, NY Times

Chemicals

Biocides

Chemical additives added to frac fluids: friction reducers, biocides, acids,

Completions: Flowback Operation

Flowback Tank: Gauging

0530 hrs. steam, hydrocarbon vapors visible

1200 hrs.

Flowback Tank – Remote IR

Production Tanks

VOC Monitoring: Production Tank

Monitoring: Flowback Separators
(multiple contaminants)

NIOSH Toxicology Research – Hydraulic Fracturing 2014-2017

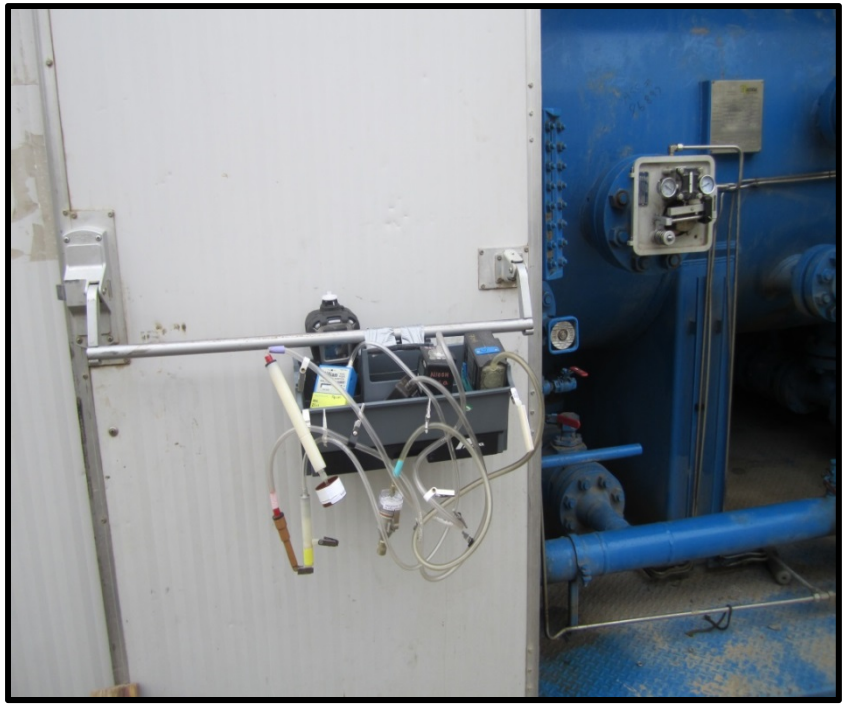
- NIOSH Health Effects Laboratory Division (HELD)
- Mixed exposure
  - Diesel exhaust and respirable crystalline silica
- Potential synergistic effect
- Rat animal model
  - 3 exposure doses, 3 post-exposure periods
- Lung and extra-pulmonary organ system endpoints
  - Cardiovascular
  - Immune
  - Brain
  - Blood

Current/Planned Activities

- Silica control evaluation
- Worker exposure to VOC's, dermal and biological monitoring, other health stressors
- Toxicological research
  - Silica and DPM
- Possible mid-stream initiative
- Collaboration and joint projects with DOE NETL
- Participation on Inter Agency UOG Work Group
- Expand partnerships
- Comprehensive technical document
- Off-shore initiative

Off-Site

On-Site



NIOSH – BSC Discussion

- Suggestions for communicating new findings of hazards in this rapidly growing industry (given our obligation of company/worker notification first and need to raise awareness in a timely fashion)?
- Suggestions for presenting findings where we have conclusive scientific evidence but have not yet published a peer-reviewed article?

Thank you for your Attention