Unconventional Oil and Gas Extraction: What You Need to Know About Occupational Health Risks for Workers in the Modern Oil and Gas Boom

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Acknowledgments

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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.
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• Centers for Disease Control and Prevention (CDC)
• Research + Prevention
• Non-regulatory

http://www.cdc.gov/niosh/
What do we really know about upstream health and safety risks?
Radioactive Tracers?
Methanol?
Sensitizers?
Polyaromatic hydrocarbons?
Biocides?
N-BTEX?
TENORM?
Mixed exposures?
Dermal exposures?
Diesel Particulate?
Fatigue?
Nano materials?
Freshly fractured quartz?
Phenol formaldehyde resin-coated proppant?
Hydrochloric acid?
Propargyl alcohol?
Falls from Heights
Vehicle crashes
Leaf (Pb)
Struck by incidents
Noise
H₂S
Dropped objects
Heat & cold stress
Caught in
Well blow outs?
Respirable quartz
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).

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

Web search: NIOSH Field Effort, Oil and Gas

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.

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 the 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

Web search: NIOSH Field Effort, Oil and Gas

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

Sand truck operator at hydraulic fracturing operations. Image courtesy of Eric Esswein, NIOSH.
NIOSH Oil & Gas Extraction Industrial Hygiene Field Research Project

- Lack of information: diversity, magnitude of potential chemical exposures to workers

- Unknowns: work practices, products, formulations, equipment, where chemical exposures most likely to occur

- Emphasis Upstream E&P, S & h

- Better understand the h aspects of O&G
Why S?

- Standards: OSHA 1910, 1926, EPA,
  - ANSI/ASSE, API-RPs, etc.
- Severity: injury/accident outcomes
- Surveillance: fatality, recordable, injury rates tracked & compiled (BLS, OSHA, ISN, PEC)
- Significance: ratings, contracts
Why little h?

S
• Fatality
• Recordable injury
• Immediate
• Acute
• Severe
• Knowable
• Visible
• Familiar
• Soon and certain

h
• Illness
• Latent effects exposures
• Delayed
• Chronic
• Mild
• Unknown
• Occult
• Obscure
• Long and latent
Gen’l Overview Oil and Gas E & P:

1. Site preparations
2. Drilling and casing well
3. Completions
4. Flowback
5. Production
Oil and Gas E & P

Completions (hydraulic fracturing)

Slurry sand (or other proppant), water and treatment chemicals injected down the well bore.

High pressure (8-9000 psi) slurry forced through well casing holes (perforations).

Pressurized slurry creates fractures in the hydrocarbon bearing strata, proppant maintains the space in the fractures allowing gas and oil to enter well bore.
Hydraulic Fracturing

Hydraulic fracturing, or “fracking,” involves the injection of more than a million gallons of water, sand and chemicals at high pressure down and across into horizontally drilled wells as far as 10,000 feet below the surface. The pressurized mixture causes the rock layer, in this case the Marcellus Shale, to crack. These fissures are held open by the sand particles so that natural gas from the shale can flow up the well.
# E&P Chemical Exposure Risks

<table>
<thead>
<tr>
<th>Chemical Exposure</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respirable Crystalline Silica</td>
<td>Hydraulic Fracturing</td>
</tr>
<tr>
<td>Hydrocarbons, (e.g., BTEX)</td>
<td>Completions Operations (C.O.’s)</td>
</tr>
<tr>
<td>Metals (Pb)</td>
<td>Drilling Operations</td>
</tr>
<tr>
<td>Biocides (glutaraldehyde)</td>
<td>C.O.’s</td>
</tr>
<tr>
<td>Diesel Emissions</td>
<td>Drilling, C.O.’s</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>Drilling and C.O.’s</td>
</tr>
<tr>
<td>Polycyclic Aromatic Hydrocarbons</td>
<td>Drilling, C.O.’s</td>
</tr>
<tr>
<td>Acids/bases</td>
<td>Drilling, C.O.’s</td>
</tr>
<tr>
<td>Gases: ozone, oxides of nitrogen</td>
<td>Drilling, C.O.’s</td>
</tr>
<tr>
<td>Naturally Occurring Radioactive Materials (NORM)</td>
<td>Drilling, C.O.’s</td>
</tr>
<tr>
<td>Oil Mists</td>
<td>Drilling</td>
</tr>
</tbody>
</table>

*Not an inclusive list*
Respirable crystalline silica: exposure risks from multiple sources during hydraulic fracturing
2010-2011
6 states
11 sites

Bakken
Eagle Ford
Silica exposures can exceed OEL’s \(^1, *\)

<table>
<thead>
<tr>
<th>Site</th>
<th>&gt; ACGIH TLV</th>
<th>&gt; NIOSH REL</th>
<th>&gt; OSHA PEL</th>
<th>Total # samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>24 (92.3%)</td>
<td>19 (73.1%)</td>
<td>14 (53.9%)</td>
<td>26</td>
</tr>
<tr>
<td>B</td>
<td>16 (84.2%)</td>
<td>14 (73.7%)</td>
<td>12 (63.2%)</td>
<td>19</td>
</tr>
<tr>
<td>C</td>
<td>5 (62.5%)</td>
<td>5 (62.5%)</td>
<td>4 (50.0%)</td>
<td>8</td>
</tr>
<tr>
<td>D</td>
<td>19 (90.5%)</td>
<td>14 (66.7%)</td>
<td>9 (42.9%)</td>
<td>21</td>
</tr>
<tr>
<td>E</td>
<td>25 (92.6%)</td>
<td>23 (85.2%)</td>
<td>18 (66.7%)</td>
<td>27</td>
</tr>
<tr>
<td>F</td>
<td>4 (40%)</td>
<td>1 (10%)</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>93 (83.8%)</td>
<td>76 (68.5%)</td>
<td>57 (51.4%)</td>
<td>111</td>
</tr>
</tbody>
</table>


*OELs (Occupational Exposure Limits)
Relative comparisons, (mg/m$^3$) by job title

- T-belt Operator
- Sand Mover Operator
- Blender Operator
- Hydration Unit Operator
- Sand Coordinator
- Water Tank Operator

OSHA PEL
NIOSH REL
Comparisons, respirable silica (mg/m³), 95% confidence intervals for job titles with 5 or more samples

- Blender Operator n=16: 0.091 ± 0.327
- Hydration Unit Operator n=5: 0.072 ± 0.259
- Sand Coordinator n=10: 0.054 ± 0.048
- Sand Mover Operator n=50
- T-belt Operator n=6
- Water Operator n=7
How much respirable crystalline silica is the NIOSH REL?

NIOSH REL = 0.05 mg/m$^3$ TWA

0.05 mg/m$^3$ = 50 micrograms (µg)

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
<table>
<thead>
<tr>
<th>Job Title</th>
<th>Total # of samples</th>
<th>Arithmetic Mean</th>
<th>Arithmetic Std. Deviation</th>
<th>Min</th>
<th>Max</th>
<th>Median</th>
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<tbody>
<tr>
<td>Blender Operator</td>
<td>16</td>
<td>2.58</td>
<td>0.59</td>
<td>0.14</td>
<td>9.70</td>
<td>2.03</td>
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<tr>
<td>Chemical Truck Operator</td>
<td>3</td>
<td>3.32</td>
<td>1.63</td>
<td>0.80</td>
<td>6.38</td>
<td>2.78</td>
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<tr>
<td>Fueler</td>
<td>2</td>
<td>0.85</td>
<td>0.17</td>
<td>0.68</td>
<td>1.02</td>
<td>0.85</td>
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<tr>
<td>Hydration Unit Operator</td>
<td>5</td>
<td>4.28</td>
<td>2.79</td>
<td>0.18</td>
<td>14.92</td>
<td>0.88</td>
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<tr>
<td>Mechanic</td>
<td>3</td>
<td>1.20</td>
<td>0.39</td>
<td>0.46</td>
<td>1.76</td>
<td>1.38</td>
</tr>
<tr>
<td>Operator, Data Van</td>
<td>1</td>
<td>0.86</td>
<td>---</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
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<tr>
<td>Pump Truck Operator</td>
<td>1</td>
<td>0.42</td>
<td>---</td>
<td>0.42</td>
<td>0.42</td>
<td>0.42</td>
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<tr>
<td>Q.C. Tech</td>
<td>1</td>
<td>0.26</td>
<td>---</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>Roving Operator</td>
<td>4</td>
<td>0.52</td>
<td>0.24</td>
<td>0.12</td>
<td>1.18</td>
<td>0.39</td>
</tr>
<tr>
<td>Sand Coordinator</td>
<td>10</td>
<td>1.60</td>
<td>0.57</td>
<td>0.34</td>
<td>6.52</td>
<td>1.22</td>
</tr>
<tr>
<td>Sand Truck Driver</td>
<td>1</td>
<td>0.82</td>
<td>---</td>
<td>0.82</td>
<td>0.82</td>
<td>0.82</td>
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<tr>
<td>Sandmover Operator</td>
<td>50</td>
<td>10.44</td>
<td>1.59</td>
<td>0.14</td>
<td>55.10</td>
<td>7.62</td>
</tr>
<tr>
<td>T-belt Operator</td>
<td>6</td>
<td>14.55</td>
<td>7.57</td>
<td>0.30</td>
<td>51.40</td>
<td>9.06</td>
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<tr>
<td>Water Tank Operator</td>
<td>7</td>
<td>1.23</td>
<td>0.34</td>
<td>0.38</td>
<td>2.72</td>
<td>1.12</td>
</tr>
<tr>
<td>Wireline Operator</td>
<td>1</td>
<td>0.14</td>
<td>---</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Total</td>
<td>111</td>
<td>6.45</td>
<td>0.93</td>
<td>0.12</td>
<td>55.10</td>
<td>2.18</td>
</tr>
</tbody>
</table>
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
Silica aerosols created during sand transfer

40/70 mesh before sand transfer

Collected by NIOSH mini baghouse
Method 1: Resuspension of bulk dust, analysis for aerodynamic mass and size distribution

Chamber concentration: 5 mg/m³

Greatest mass of silica particles average 1.75 microns (µm)

Mass Geometric Mean = 1.75 µm
Mass Geometric SD = 2.4
Method 2: Analysis of bulk dust sample by scanning electron microscope (SEM) equipped with Gresham light element detector and IXRF digital imaging system (EDS).

- 72.4% of particles > 0.5 < 5 µm
- Particle size distribution, silica dust

<table>
<thead>
<tr>
<th>Size Range</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.5 µm</td>
<td>6.3%</td>
</tr>
<tr>
<td>0.5-&lt;1 µm</td>
<td>25.0%</td>
</tr>
<tr>
<td>1-&lt;2 µm</td>
<td>30.6%</td>
</tr>
<tr>
<td>2-&lt;3 µm</td>
<td>13.0%</td>
</tr>
<tr>
<td>3-&lt;5 µm</td>
<td>8.8%</td>
</tr>
<tr>
<td>5-&lt;10 µm</td>
<td>9.2%</td>
</tr>
<tr>
<td>10-20 µm</td>
<td>3.5%</td>
</tr>
<tr>
<td>&gt;20 µm</td>
<td>3.5%</td>
</tr>
</tbody>
</table>

Greatest mass of silica particles between 1 and < 2 µm
Sample contained a wide range of particle sizes from 0.1 µm to 7 µm
Near nano-sized crystalline silica particles

Examples of a small silica particles with approx. 100 nm diameters.
Hydrocarbon exposure risks, flowback operations

2013
3 basins,
6 sites