

# Sudden Deaths Among Oil and Gas Extraction Workers Resulting from Oxygen Deficiency and Inhalation of Hydrocarbon Gases and Vapors — United States, January 2010–March 2015

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In 2013, an occupational medicine physician from the University of California, San Francisco, contacted CDC's National Institute for Occupational Safety and Health (NIOSH), and the Occupational Safety and Health Administration (OSHA) about two oil and gas extraction worker deaths in the western United States. The suspected cause of these deaths was exposure to hydrocarbon gases and vapors (HGVs) and oxygen (O<sub>2</sub>)-deficient atmospheres after opening the hatches of hydrocarbon storage tanks. The physician and experts from NIOSH and OSHA reviewed available fatality reports from January 2010 to March 2015, and identified seven additional deaths with similar characteristics (nine total deaths). Recommendations were made to industry and regulators regarding the hazards associated with opening hatches of tanks, and controls to reduce or eliminate the potential for HGV exposure were proposed. Health care professionals who treat or evaluate oil and gas workers need to be aware that workers might report symptoms of exposure to high concentrations of HGVs and possible O<sub>2</sub> deficiency; employers and workers need to be aware of this hazard and know how to limit exposure. Medical examiners investigating the death of oil and gas workers who open tank hatches should consider the contribution of O<sub>2</sub> deficiency and HGV exposure.

Workers at oil and gas well sites often manually gauge the level of fluid or collect a sample from storage tanks containing process fluids. These workers climb to the top of the tanks, open a "thief" hatch (a closable aperture on atmospheric tanks, used to sample the tank contents) (Figure), and either place a device into the hatch to measure the fluid level or lower a "thief" sampler (a hollow tube) into the tank to collect liquid samples. In 2013, an occupational medicine physician from the University of California, San Francisco, received a report of a 2012 oil and gas worker fatality in North Dakota; that state's medical examiner attributed death to the inhalation of petroleum hydrocarbons. The male worker, aged 21 years, was gauging crude oil production tanks on the well site, at night and alone. A coworker found the victim unconscious near the open hatch. Colleagues initiated cardiopulmonary resuscitation, and the worker was transported to the hospital where he was pronounced dead approximately 2 hours later. An autopsy found no obvious signs of traumatic injury. Toxicology testing identified detectable quantities of low-molecular weight

hydrocarbons (propane and butane), and evidence of heavier molecular weight hydrocarbons. No indication of exposure to hydrogen sulfide (H<sub>2</sub>S) was identified. Initially, the death was attributed to cardiovascular disease and later to hydrocarbons. The occupational medicine physician subsequently identified a second worker who died from a sudden cardiac event in 2010 while performing tank gauging; H<sub>2</sub>S was excluded as a factor. The physician contacted NIOSH and OSHA about these two deaths.

To identify other oil and gas extraction worker fatalities associated with exposure to HGVs, the physician and experts from NIOSH and OSHA reviewed media reports, OSHA case files, and the NIOSH Fatalities in Oil and Gas database. Cases were defined as nontraumatic oil and gas extraction worker deaths occurring during January 2010–March 2015, in which the workers were 1) performing tank gauging, sampling, or fluid transfer activities at oil and gas well sites; 2) working in proximity to a known and concentrated source of HGVs (e.g., an open hatch); 3) not working in a confined space; and 4) not exposed to H<sub>2</sub>S, fires, or explosions. All available information on identified fatalities was reviewed, including OSHA investigations, coroner and toxicology reports, gas monitor data, and exposure assessment data.

Nine deaths, occurring from January 2010 to March 2015, were identified (Table); six of the deaths occurred during 2014. Three deaths occurred in Colorado, three in North Dakota, and one each in Montana, Oklahoma, and Texas. The median age of workers was 51 years (range = 20–63 years), and all were male. All of the victims were working alone at the time of the incidents and were found collapsed on a tank or catwalk, or at the base of the catwalk stairs. In at least five cases, the hatch was open when the worker was found. Five of the fatalities occurred during the collection of a fluid sample, and four occurred during tank gauging. Toxicologic data on HGVs were not consistently collected during autopsy, but petroleum hydrocarbon vapors were noted as a cause of death for three workers.

Only one of the nine workers was known to have been provided a respirator, but fit-testing had not occurred, and the air-purifying respirator was not suitable for high concentrations of HGVs or O<sub>2</sub> deficiency. The exposure assessment conducted by OSHA following the 2010 case found O<sub>2</sub> concentrations as low as 11% at 1 foot above the open thief hatch (O<sub>2</sub> concentrations

**FIGURE. An oil field worker manually gauges the level of process fluid in a fixed production oil tank\* — United States**



Photo/Todd Jordan, Occupational Safety and Health Administration.

\* 1) The worker peers down an open hatch of the oil tank. 2) In some regions, workers gauge oil tanks by opening tank hatches, visually observing liquid levels, and then manually measuring liquid oil levels. 3) As commonly designed, fixed oil tanks often are interconnected for both liquid and vapor, allowing contents to equalize over multiple tanks. Equalization of tanks can result in a high volume of off-gassed vapors when a tank hatch is opened. 4) The windsock is a visual indicator for the worker to stay positioned upwind while gauging.

in ambient air = 21%). In addition, HGV concentrations were in excess of the lower-explosive limit (minimum concentration of a gas necessary to support its combustion in air), suggesting exposures high enough (>10,000 parts per million [ppm]) to cause acute central nervous system symptoms. In case number seven, the worker wore a data-logging, continuous multi gas monitor as a regular work practice. Three weeks before the fatal event, he was examined in an emergency department after experiencing altered consciousness while gauging a tank. Gas monitor data during this event revealed a 5-minute interval, concurrent with his symptoms, when O<sub>2</sub> concentrations were in the range of 10% to 15% and flammable HGVs exceeded the lower-explosive limit. On the day of his death, the gas monitor again indicated that the lower-explosive limit had been exceeded, with O<sub>2</sub> concentrations as low as 7%.

### Discussion

During January 2010–March 2015, at least nine deaths of oil and gas workers occurred in the United States, with exposure to HGVs a confirmed or suspected factor. Oil and gas extraction

is a high-risk industry, with overall occupational fatality rates seven times the national average (1). Although safety hazards in the industry are well-known, few published reports address chemical exposures and acute occupational illness associated with oil and gas extraction. Recent exposure assessments have identified that opening thief hatches and manual gauging or sampling from hydrocarbon-containing tanks, outdoors in nonconfined spaces, is widely practiced and poses substantial and potentially lethal hazards to workers (2–4). These hazards include sudden exposure to high concentrations (>100,000 ppm) of low-molecular weight HGVs, accompanied by displacement of air, resulting in O<sub>2</sub> deficiency. Inhaled O<sub>2</sub> concentrations of <15% can significantly impair central nervous system function, and concentrations of <10% can result in loss of consciousness and possible death within seconds to minutes (5). Low O<sub>2</sub> blood levels (hypoxemia) can exacerbate cardiac ischemia and increase the release of epinephrine (adrenalin). High concentrations (i.e., 50,000 ppm to ≥100,000 ppm) of low-molecular

weight hydrocarbons, particularly butane, have been shown in animal studies and human reports to sensitize the heart to epinephrine-induced ventricular fibrillation, a lethal cardiac arrhythmia (6–8). The simultaneous exposure to high levels of low-molecular weight HGVs and a low O<sub>2</sub> atmosphere above an open tank hatch poses a risk for sudden cardiac death. Preexisting coronary artery disease can exacerbate that risk. In addition, high levels of low-molecular weight HGVs can exert anesthetic effects that contribute to central nervous system depression (9). The exposure-assessment samples also showed concentrations of propane, butane, pentane, and 2-methylbutane exceeding 100% of the lower-explosive limit (3). Concentrations of explosive gases in excess of 10% of the lower-explosive limit are considered immediately dangerous to life or health. Because of the nine identified fatalities, the exposure-assessment findings, and the potential mechanism for sudden cardiac death, OSHA, NIOSH and multiple industry stakeholders collaboratively issued a hazard alert on tank gauging at oil and gas well sites (10). In addition, the Bureau of Land Management has proposed changes to current federal

**TABLE. Sudden deaths caused by inhalation of hydrocarbon gases and vapors and oxygen deficiency among oil and gas extraction workers — United States, January 2010–March 2015**

Worker	Year of death	Age (yrs)	State	Job title	Job task	Location/position of decedent when found	Time of day found	Coroner's stated cause of death
1	2010	30	Montana	Crew worker	Gauging	Slumped over on catwalk	3:00 a.m.	Hypertensive and atherosclerotic cardiovascular disease
2	2012	21	North Dakota	Flow tester	Gauging	On catwalk next to open hatch	12:30 a.m.	Hydrocarbon poisoning due to inhalation of petroleum vapors
3	2013	39	North Dakota	Truck driver	Collecting sample	On knees, slumped over catwalk railing in front of open hatch	10:20 a.m.	Sudden cardiac arrhythmia (primary), morbid obesity and arteriosclerotic heart disease (contributory)
4	2014	57	Oklahoma	Truck driver	Collecting sample	Slumped over on catwalk next to tank	10:12 a.m. (time of death)	Undetermined (no autopsy performed)
5	2014	51	Colorado	Truck driver	Collecting sample	Hanging from guardrail, hooked by clothing	10:39 a.m. (time of death)	Sudden cardiac death due to ischemic heart disease
6	2014	57	Colorado	Truck driver	Collecting sample	Collapsed over open hatch	10:30 a.m.	Atherosclerotic cardiovascular disease
7	2014	59	Colorado	Truck driver	Collecting sample	Collapsed over open hatch	1:40 p.m.	Toxic gas inhalation and oxygen displacement by volatile hydrocarbons (primary), atherosclerotic cardiovascular disease
8	2014	63	Texas	Tank gauger	Gauging	At bottom of catwalk stairs	4:14 a.m.	Arteriosclerotic and hypertensive cardiovascular disease
9	2014	20	North Dakota	Flow tester	Gauging	Face down over open hatch	5:00 a.m.	Cardiac arrhythmia, with cardiac hypertrophy, coronary artery hypogenesis, obesity and petroleum hydrocarbon vapors

regulations\* that replace outdated technology and practices with remote tank gauging technologies, reducing or eliminating the need for manual tank gauging.

Health professionals need to recognize the signs and symptoms of exposure to high concentrations of HGVs and possible O<sub>2</sub>-deficient atmospheres in oil and gas workers. Health and safety professionals need to recognize and act on nonfatal warning signs and symptoms, such as dizziness, confusion, immobility, and collapse in oil and gas workers who might have been exposed to high concentrations of HGVs and to O<sub>2</sub>-deficient atmospheres. As required by OSHA regulations, employers should reduce or eliminate the hazard; this can include practices that allow for alternative fluid sample collection points, remote monitoring of fluid levels, proper use of gas monitors, respiratory protection meeting OSHA requirements, and worker training. Employers also need to ensure that workers do not work alone where they might have risks for exposures to high concentrations of hydrocarbons and low-O<sub>2</sub> environments.

\* <https://www.federalregister.gov/articles/2015/09/30/2015-24008/onshore-oil-and-gas-operations-federal-and-indian-oil-and-gas-leases-measurement-of-oil>.

Having automated external defibrillators available at worksites is also important. Medical examiners and coroners investigating workplace fatalities need to be aware of the possibility that exposure to high concentrations of HGVs and O<sub>2</sub>-deficient atmospheres can result in sudden cardiac death in oil and gas extraction workers. Analysis of antemortem or postmortem blood for documentation of HGV exposure is available from clinical toxicology laboratories.

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## References

## Summary

## What is already known on this topic?

Oil and gas extraction workers experience high rates of traumatic work-related fatalities. Tank gauging and sampling activities can expose workers to high concentrations of hydrocarbon gases and vapors (HGVs), in some cases at levels immediately dangerous to life or health.

## What is added by this report?

Exposure to high concentrations of HGVs and oxygen-deficient atmospheres during manual tank gauging and sampling can pose a risk for sudden cardiac death. Although the first two deaths described in this series were not immediately recognized as work-related, the occurrence of seven additional deaths under similar circumstances suggests that HGV exposure during manual tank gauging and sampling can be life-threatening.

## What are the implications for public health practice?

Health care professionals need to be aware of the risks to oil and gas extraction workers related to exposure to high concentrations of HGVs and to oxygen deficiency. Medical examiners and coroners investigating worksite fatalities need to be aware that these exposures can result in sudden cardiac death and include appropriate toxicology analyses in their investigation. A thorough worksite assessment is warranted if any workers exhibit signs or symptoms of HGV exposure or oxygen deficiency. Implementation of measures to reduce or eliminate HGV exposures is important, including practices that allow for alternative fluid sample collection points, remote monitoring of fluid levels, proper use of gas monitors, respiratory protection meeting the requirements of the Occupational Safety and Health Administration, and worker training.

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