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Understanding Oil and Gas Extraction Worker Fatalities through the Fatalities in Oil and Gas Extraction Database

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Abstract

The U.S. oil and gas extraction (OGE) industry fatality rate (25.0 deaths per 100,000 workers) remains well above the rate for all U.S. workers (3.7 per 100,000 workers), and in 2014, the U.S. Bureau of Labor Statistics (BLS) recorded an all-time high of 144 OGE worker deaths (BLS, 2015; Mason et al. 2015). OGE is a complicated, diverse, dynamic, and specialized industry that presents unique challenges to understanding trends in fatal events. In 2014, the National Institute for Occupational Safety and Health (NIOSH) Oil and Gas Extraction Sector Program developed a database, Fatalities in Oil and Gas Extraction (FOG), to address these challenges by collecting detailed industry specific information about OGE worker fatalities.

FOG includes all identified U.S. worker fatalities related to OGE, irrespective of the North American Industry Classification System (NAICS) code of the employer. Incidents occurring during non-traditional commutes and cardiac events that begin at work are also included. FOG relies on several data sources for incident identification and information, including government agencies, media, and professional contacts.

Nine publications using FOG data were reviewed to assess the capabilities of this new database in providing information about OGE worker fatalities. The evaluation found that FOG enhances the understanding of fatal events through its broad inclusion criteria and specificity in the type of information it collects. With these features, FOG unravels the complexities OGE worker fatalities, and has been used to identify emerging issues, provide new information on worker groups not typically included in OGE fatality data, and to help better understand the risk factors leading to OGE fatalities. Its success shows FOG is powerful tool that can be used for targeted, data driven interventions.

Introduction

Despite a significant decrease in the fatality rate to workers in the U.S. oil and gas extraction (OGE) industry in recent years, workers in the industry are seven times more likely to die on the job than other U.S workers (Mason et al. 2015). The historically elevated fatality rate in the OGE industry prompted research into the risk factors associated with fatal events. Analyses have largely depended on data from the U.S. Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI), and have yielded important findings (Mode et al. 2008; Gunter et al. 2013; Retzer et al. 2013; Mason et al. 2015).

The most recent research into the 1,189 U.S. OGE worker fatalities that occurred from 2003–2013 found most victims were male (99%), non-Hispanic white (71%), and 25–34 years old (28%). The largest number of fatalities were to workers from companies that provide support operations to prepare wells for production and completion (North American Industry Classification System [NAICS] code 213112), but workers from companies that drill wells (NAICS code 213111) had the highest fatality rate. The leading types of fatalities were transportation incidents (40%) and contact injuries (26%) (Mason et al. 2015). A separate analysis of fatal motor vehicle incidents from 2003–2009 identified pickup trucks as the most common vehicle involved in crashes, and workers at greatest risk were from establishments with less than 99 employees and those not wearing a safety belt (Retzer et al. 2013).

Still, many stakeholders have identified the need for increased surveillance efforts to better understand the risk factors associated with fatal events (NORA Oil and Gas Extraction Sector Council, 2011; Witter et al. 2014; Mason et al. 2015). This type of research requires information on the unique characteristics of the OGE industry that may influence fatal events, such as long working hours, multi-employer worksites, remote locations, and specialized equipment and processes. Unfortunately, these variables are outside of the scope of traditional occupational surveillance systems. To fill this data gap, the National Institute for Occupational Safety and Health (NIOSH) Oil and Gas Extraction Sector Program launched the Fatalities in Oil and Gas Extraction (FOG) database in 2014. FOG collects detailed information about fatalities to OGE workers to better understand the risk factors associated with these events. This paper details how the unique capabilities of FOG are being leveraged to provide more information about fatalities in the OGE industry.

Methods

Development of FOG began in 2013, and included NIOSH researchers and members of the National Occupational Research Agenda Oil and Gas Extraction Sector Council (NORA Council). Facilitated by NIOSH, the NORA Council is a diverse group of stakeholders that represent academia, government, and the OGE industry (NIOSH, 2015a). NIOSH worked with this group to determine the types of information that should be included in FOG to ensure it provides useful information to adequately describe fatal events, so interventions can be appropriately targeted. The collaboration resulted in FOG having several unique features, as detailed below.

FOG includes all identified land-based and offshore U.S. worker fatalities related to OGE. This includes workers involved in the exploration, drilling, completing, and equipping of oil and gas wells, as covered under the OGE NAICS codes (211, 213111, and 213112). Also included are workers from other industries who were doing work for the OGE industry at the time of the incident, such as site preparation and related construction activities for oil and gas wells (included in NAICS code 238910); hauling materials for OGE activities (included in NAICS code 484220 and 484230); and performing geophysical surveying and mapping services for OGE (included in NAICS code 541360). In addition, workers involved in hauling crude oil or natural gas from the producing property to a processing or storage facility are included in FOG. Finally, to address some of the unique characteristics of the industry, such as remote worksites and uncharacterized exposures, cardiac events that begin at work and non-traditional commuting fatalities related to OGE, as defined above, are included. FOG defines a non-traditional commute as meeting one of the following criteria; worker travel in excess of 90 minutes or 50 miles one-way; workers transported by an employer-paid transportation service; or workers traveling as a crew in a privately or company owned vehicle. FOG excludes non-fatal injuries and workers involved in any midstream or downstream activities (included in NAICS codes 22121, 23712, 486, 32411, 42471, 42472, 447, and 4869).

FOG has the capability to collect more than 50 types of information (i.e. variables) on each fatal incident and the worker/s involved. Much of this information is unique to OGE and addresses key issues that were identified by the NORA Council. Some variables in FOG are assigned to the incident and some are assigned to each fatally injured worker. Variables at the incident level are those that would be common to all fatalities

associated with the incident, such as the date the event occurred, location, and operation and activities the crew was engaged in. Other variables are specific to each fatally injured worker, such as the worker's age, years of experience, and cause of the fatality (event type). Also, some variables in FOG are only applicable to certain situations. For example, an incident that occurred offshore would include data on the wave height and distance from shore. As fatalities are identified, they are reviewed by at least two NIOSH researchers to ensure they meet the inclusion criteria for FOG and all applicable variables have been coded correctly.

FOG relies on a number of sources for incident identification and information. These include the Occupational Safety and Health Administration (OSHA), the Bureau of Safety and Environmental Enforcement (BSEE), the United States Coast Guard (USCG), state and local government agencies, media alerts, public records, and professional contacts. A data source for identifying fatal work-related motor vehicle crashes and fatalities associated with work-related chronic illness has not been identified. Therefore, these fatalities are underreported in FOG.

Active data collection for FOG began in 2014, however data from previous years is available to address specific issues. These data includes fatalities under OSHA jurisdiction that occurred from 2005–2013 to workers in the OGE NAICS codes (211, 213111, and 213112). These data have not been coded by all the variables in FOG, but fatalities related to a specific issue can be identified through key word searches of the narrative and analysis by event type (coded using the Occupational Injury and Illness Classification System).

A review of the impact of FOG to date is provided in this paper, including a summary of the outputs produced using FOG data and how this information has led to an increased understanding of fatal events and substantive changes in health and safety policies and practices within the industry.

Data and Results

FOG data has been used in at least nine publications and products since its launch. Products range from highly technical multi-page reports to single page infographics. As detailed in Table 1, products and publications are either 1) special topic products that addressed fatalities related to a specific issue or 2) periodic reports that analyzed all fatalities identified by FOG over a specified period of time. Several special topic publications were produced that describe fatalities to workers involved in tank gauging and sampling activities at oil and gas sites. One special topic product focuses on fatalities associated with hot work on oilfield tanks, tankers, and other related equipment. And three periodic reports detail fatalities that occurred during 2014.

Table 1—Publications using FOG data, Jan 2014-Apr 2016

	Title of publication	Author/s	Publication type (year published)
Special topic publications	Suspected Inhalation Fatalities Involving Workers during Manual Tank Gauging, Sampling, and Fluid Transfer Operations on Oil and Gas Well Sites, 2010-2014	NIOSH	NIOSH FOG web report (2014)
	UPDATE: Reports of Worker Fatalities during Manual Tank Gauging and Sampling in the Oil and Gas Extraction Industry	King B, Esswein E, Retzer K, et al.	NIOSH Science Blog (2015)
	Tank hazard alert	OSHA–nSTEPS Network–NIOSH Alliance	Infographic (2015)
	NIOSH-OSHA Hazard alert: health and safety risks for workers involved in manual tank gauging and sampling at oil and gas extraction sites	NIOSH, OSHA	NIOSH publication, OSHA publication (2016)
	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	Harrison R, Retzer K, Kosnett M, et al.	CDC MMWR (2016)
	Hazard alert: fatalities associated with hot work on oilfield tanks, tankers and other related equipment	OSHA–nSTEPS Network–NIOSH Alliance	Infographic (2016)
Periodic publications	Fatalities in the U.S. Oil and Gas Extraction Industry: Recent Trends and New Details	Retzer K, Hill R, Mason K, et al.	Conference paper (2015)
	Oil and gas extraction worker fatalities, 2014 mid-year report: January 1, 2014–June 30, 2014	Retzer K, Ridl S, Hill R	NIOSH publication (2015)
	Oil and gas extraction worker fatalities 2014	Ridl S, Retzer K, Hill R	NIOSH publication (expected 2017)

Special topic reports

In 2013, an occupational medicine physician alerted NIOSH to two worker death that occurred during gauging activities on crude oil storage tanks. The occupational medicine physician suspected inhalation of hydrocarbon gases and vapors may have contributed to the workers' deaths. In response, FOG data from 2010–2014 was reviewed to identify other fatalities under similar circumstances. The analysis revealed a total of nine workers deaths that occurred during gauging or sampling activities at oil and gas wellsites, in which inhalation of hydrocarbon gases and vapors may have contributed to the workers' deaths (Harrison et al. 2016). The identification of these fatalities prompted the posting of a FOG web report. This report provides a description of each fatality and characteristics of the incidents, noting that all of the fatalities occurred on crude oil production tanks and all of the workers were working alone (NIOSH, 2015b).

Subsequent to this report, several other products were developed. The first, a NIOSH science blog provided timely information on the nine fatalties, potential exposures, and recommendations (King, 2015). A few weeks after this posting, a one-page infographic hazard alert was put out by the OSHA–National Service Transmission, Exploration and Production Safety (nSTEPS) Network–NIOSH Alliance. This product focuses on the hazards of opening thief hatches on storage tanks and provides bullet point recommendations to employers and workers on how to prevent or limit exposure (OSHA–nSTEPS Network–NIOSH Alliance, 2015). Next, a NIOSH-OSHA hazard alert was released. This is the most thorough document to date on this issue and it gives an in-depth discussion on the nine identified fatalities, exposure assessments conducted while workers opened tank hatches, the mechanism of exposure, factors

that may increase or decrease worker exposure, and recommendations to prevent or limit exposures (NIOSH et al. 2016). A final publication, reported in the Centers for Disease Control and Prevention's (CDC) Morbidity and Mortality Weekly Report (MMWR), specifically targets healthcare professionals and medical examiners and coroners to ensure they are aware of the issue, so appropriate steps can be taken when a worker seeks healthcare or has died while tank gauging or sampling fluid storage tanks (Harrison et al. 2016).

FOG data was also reviewed to gain a better understanding about fire and combustion explosion events. From 2005–2015 FOG identified 85 deaths due to fires and combustion explosions. Of these, 28 involved hot work (e.g. welding). This analysis prompted the development of a one-page infographic hazard alert from the OSHA–nSTEPS Network–NIOSH Alliance. Similar in style to the previous hazard alert released by this group, this product describes the hazards while conducting hot work around oilfield equipment and provides a bullet point list of recommendations to workers and employers (OSHA–nSTEPS Network–NIOSH Alliance 2016).

Periodic reports

Three publications describe fatalities identified by FOG that occurred in 2014; a conference proceeding paper, and mid-year and full year reports (Retzer et al. 2015a; Retzer et al. 2015b; Ridl et al. 2017).

The most comprehensive publication, the full year report, details the 88 fatal incidents that accounted for 101 fatalities in the OGE industry in 2014 that were identified by FOG. Ten of these incidents involved more than one worker death. Fatalities were analyzed by NAICS code and three FOG specific variables: event type, operation, and activity (Ridl et al. 2017). Definitions and select findings from these analysis can be found in Table 2.

Also included in the report is a description of all identified incidents. The level of detail provided for each incident varies due to available information. Many common factors were identified within the narratives when examined by event type. Most notably, fluid storage tanks, tankers, or separators were implicated in nine fire and combustion explosion fatalities, as well as, eight exposure related fatalities. Addtionally, Five out of seven electrocutions occurred due to contact with overhead powerlines. Finally, for roadway motor vehicle incidents, only half of the fatally injured workers were wearing seatbelts, and seven workers and one non-oil and gas worker died in five fatigue related crashes (Ridl et al. 2017).

Table 2—Select findings from the Oil and Gas Extraction Worker Fatalities 2014 report

Total incidents: 88 (101 fatalities)
Multiple fatality incidents: 10 (23 fatalities)

Industry group

Industry group is based on NAICS, which codes business establishments according to similarity in the processes used to produce goods or services. A company's NAICS code is determined by its primary business. Each fatality is assigned to one industry group.

Fatalities in FOG by industry group, 2014

Industry group (NAICS)	# of fatalities (%)
Service company (213112)	45 (45)
Drilling company (213111)	27 (27)
Operating company (211)	10 (10)
Unknown	11 (11)
Other industries (multiple)[3]	8 (8)
Total	101 (100)

Event type

FOG event types describe how the fatal injury or illness occurred. Each fatality is assigned one event type. In instances where two or more events occur, precedence is given to the initial event type.

Fatalities in FOG by event type category, 2014

Event type category	# of fatalities (%)
Vehicle incident	28 (27)
Contact injuries	24 (24)
Explosion (combustion) or fire	14 (14)
Exposure	11 (11)
Explosion (pressure)	9 (9)
Falls	8 (8)
Electrocutions	7 (7)
Total	101 (100)

Operation

Operations are distinct stages or processes in oil and gas extraction. Each incident is assigned one operation.

Fatalities in FOG by operation, 2014

Operation	# of fatalities (%)
Site preparation	2 (2)
Drilling	26 (26)
Casing installation	5 (5)
Completions	20 (20)
Production	13 (13)
Well servicing or workover	9 (9)
Other operations[4]	11 (11)
Unspecified operation	15 (15)
Total	101 (100)

Activities

Activities are components or steps within operations that may occur many times during several different operations. Several activities may be occurring simultaneously. Therefore, each incident will be assigned as many activities as appropriate to adequately characterize the event.

Activities associated with the greatest # of fatalities in FOG, 2014

Activity	# of fatalities
Motor vehicle travel	18
Material handling: crane, forklift, winch truck	12
Rig or equipment repair or maintenance	11
Commuting: non-traditional	10
Make up or break out tubulars	8
Production rig activities	8
Rigging up or down	8

[1] As of January 10, 2017, the 2014 full year report had not been published. Therfore, data described from this report is preliminary. For the most current information, see the FOG website (https://www.cdc.gov/niosh/topics/fog/).

[2] Percentage does not total due to rounding

[3] Other industries include: All other specialty trade contractors (NAICS 2389900); Specialized freight (NAICS 4842); Hazardous waste treatment and disposal (NAICS 562211); Constructing, mining, and forestry machinery and equipment rental and leasing (NAICS 532412)

[4] Other operations include: Offshore; Tank refurbishment and custom fabrication; Vehicle repair or maintenance; Waste fluids treatment and disposal

Discussion

Although only launched two years ago, due to its unique characteristics, FOG provides new and useful information about fatalities in the OGE industry. First, FOG has a broad inclusion criteria that seeks to understand all fatalities related to OGE. In 2014, FOG identified eight fatalities to workers from other industries that were doing work in the OGE industry at the time of the incident (Ridl et al. 2017). These eight worker deaths would not typically be attributed to OGE, since fatality data is usually grouped based on the primary business of the employer rather than the industry the worker was working in at the time of the incident. The information FOG provides on these workers will help determine if there are any specific risks to this group of workers, and ensure safety messages reach the appropriate audience.

Additionally, FOG includes all non-traumatic events that begin at work, including cardiac events. In 2014, FOG identified 15 worker fatalities where the cause of death was not listed as work-related (Ridl et al. 2017). Usually, these types of events would be excluded from occupational fatality databases, but are included in FOG since certain characteristics of the OGE industry, such as remote worksites, physically demanding work, and uncharacterized chemical exposures, may influence the outcome or occurrence of these events. By tracking these incidences, FOG provides the opportunity to better understand the impact of these occupational factors on OGE workers.

Already, FOG's broad inclusion criteria has proven beneficial and helped identify nine fatalities related to tank gauging and fluid sampling. In only three of these fatalities hydrocarbon exposure was listed as a cause of death, meaning the other six fatalities would likely have not met the inclusion criteria for other occupational fatality databases (Harrison et al. 2016). Therefore, without analysis of FOG data, it is doubtful that all of these fatalities would have been identified, resulting in limited evidence that hydrocarbon concentrations emitted from thief hatches were significant enough to cause death.

Most importantly, the robust characterization of this issue resulted in lasting change. The nSTEPS Network, the largest industry-led safety and health organization, created a focus group dedicated to issues associated with tank gauging. As part of these meetings and in other forums, several companies shared their approaches to eliminating or reducing worker exposures to hydrocarbon gases and vapors during the activities of concern (nSTEPS Network, 2015; BHP Billiton, 2016). Also, the American Petroleum Institute (API) developed a new safety standard, *API MPMS Chapter 18.2*, in response to this issue. This standard describes methods for tank gauging and sampling that do not require workers to open thief hatches, the primary recommendation for preventing exposure (NIOSH, 2016; Porter, 2016). Subsequent to its publication, the standard was adopted by the U.S. Bureau of Land Management (BLM) in updates to Onshore Orders 3, 4, and 5 (BLM, 2016). This means that OGE companies can more easily implement the methods described in the API safety standard on oil and gas leases managed by BLM (i.e. those on federal and Indian lands) (NIOSH, 2016). FOG data was a critical component in understanding hazards during tank gauging and sampling, and as the OGE industry changes, FOG will continue to be a useful tool for identifying other potential emerging safety and health issues.

Beyond its broad inclusion criteria, the type of information FOG collects is important. Several variables in FOG such as, the operation and activities occurring at the time of the incident, or the types of equipment used provides new information on oil and gas extraction worker fatalities, which is already being used for targeted interventions. For example, the FOG analysis of fire and combustion explosion deaths found that approximately one third of these fatalities were related to hot work around oilfield tanks, tankers, and related equipment (OSHA–nSTEPS Network–NIOSH Alliance, 2016). The ability to narrow down a large portion of fire and combustion explosion fatalities to just one activity and type of equipment did not exist before FOG, which enabled a focused effort that resulted in a targeted hazard alert rather than a generic product.

Additionally, the analysis of fatalities that occurred in 2014 yielded several insights and opportunities for targeted interventions. Examples include, findings that five of the seven electrocutions (71%) were due to equipment coming into contact with overhead powerlines during material handling activities using a crane,

forklift, or winch truck. Also, FOG found that approximately three quarters of contact injury fatalities were associated with at least one of the following four activities; material handling using crane, forklift, winch truck; laydown and pickup of tubulars; make up and break out of tubulars; and rigging up or down of drilling or production rigs (Ridl et al. 2017). In each of these instances, FOG helps delineate where interventions would be most beneficial.

Another important component of several FOG publications is a description of what happened during each fatal incident. Inclusion of the descriptions allows for the identification of commonalities within the narratives that may have not been evident in analysis of FOG variables. This approach was particularly useful in the incident description review conducted in the 2014 full year fatality report that revealed 18 common factors among incident descriptions (Ridl et al. 2017).

In addition to identifying reoccurring situations, descriptions can be used as a teaching tool for occupational safety and health professionals to convey meaningful safety messages. Studies have shown that storytelling can have a positive effect of safety behaviors and attitudes (Ricketts et al. 2010). However, detailed accounts of fatal incidents in the OGE industry often do not enter the public sphere. The 2014 full year fatality report provides 88 narratives that occupational safety and health professionals can use to add relevance to safety messages (Ridl et al. 2017).

FOG does have some important limitations. First, FOG does not capture all fatalities in the industry. In 2014, CFOI counted 144 fatalities from the OGE NAICS codes. This compares to 101 fatalities identified by FOG, even though it has a broader inclusion criteria than CFOI. Motor vehicle fatalities make up the majority of this discrepancy. In 2014, CFOI attributed 67 fatalities to roadway motor vehicle incidents, whereas FOG only identified 18 (BLS, 2015; Ridl et al. 2017). As noted, a reliable data source to identify work-related motor vehicle fatalities for FOG has not been secured, but NIOSH researchers are strengthening partnerships with state agencies to better capture this type of event. In the meantime, insights may be found in the recent matching of CFOI roadway motor vehicle fatalities to detailed crash data from the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) (Byler et al. 2016). However, these data will lack the industry specific variables included in FOG.

Also, the quality of FOG data varies from robust to sparse. FOG relies on in-depth information and its utility is greatly hindered when few details from data sources are provided. Currently, NIOSH researchers are working to improve access to and increase the quality of information about fatal incidents from investigating agencies.

Finally, FOG is in its infancy. Only one year of active data collection has been published, making it difficult to draw conclusions. Future years of data collection are planned, as well as, an expansion of FOG to add non-fatal severe injuries to the database and allow for data to be queried on the NIOSH FOG website. The additions will likely help identify longer term trends and opportunities for prevention.

Despite its current limitations, FOG is being used successfully to increase knowledge about oil and gas worker fatalities. This success is a direct result of the ongoing collaboration and commitment by NIOSH partners; most importantly, the members of the NORA Council who helped create FOG and who continue to provide feedback to guarantee its future success. Another key partnership, the OSHA–nSTEPS Network–NIOSH Alliance, has created the platform for a stronger working relationship between these groups and ensured the data from FOG is used in a meaningful and proactive way, as evidenced by the two infographic style hazard alerts produced by this group. More work remains to be done to protect the health and safety of workers in the OGE industry and the information from FOG will ensure an appropriate focus for health and safety initiatives in the future.

Awknowledgments

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