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Report to Congressional Committees

April 2018

GAS PIPELINE SAFETY

Stakeholders' and Officials' Views on Federal Odorizing Requirements

GAO-18-409

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GAO Highlights

Highlights of GAO-18-409, a report to congressional committees

Why GAO Did This Study

The nation's gas pipeline network moves about 74 billion cubic feet of combustible gas to homes and businesses daily. To alert the public of a gas leak before an explosion occurs, PHMSA has different requirements for odorizing gas. All gas transported by distribution pipelines throughout communities must be odorized. Gas transported across many miles by transmission pipelines is required to be odorized only in certain populated areas. There are no requirements to odorize gas in gathering pipelines. Congress included a provision in statute for GAO to review odor requirements for all pipelines.

This report presents the views of federal and state pipeline safety officials and industry and safety stakeholders on: (1) the advantages and disadvantages of odorizing combustible gases in pipelines; and (2) whether and how federal requirements for odorizing pipelines should be modified. GAO reviewed relevant regulations and reports; surveyed officials in 48 states and the District of Columbia; and interviewed PHMSA and NTSB officials. GAO also interviewed 34 stakeholders, including 14 experts identified by the National Academies, and 20 other industry and safety stakeholders.

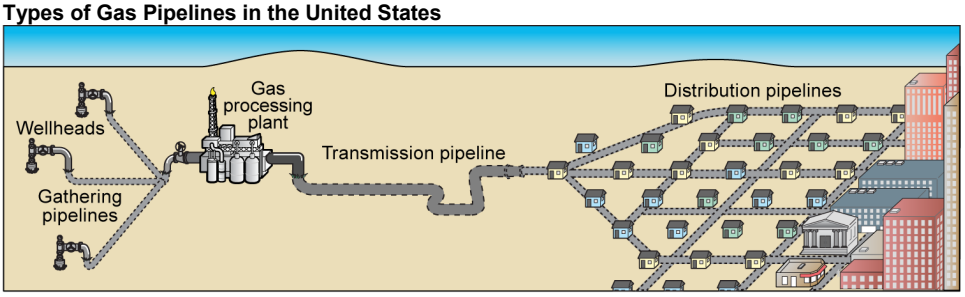
View GAO-18-409. For more information, contact Susan Fleming at (202) 512-2834 or flemings@gao.gov.

What GAO Found

Pipeline and Hazardous Materials Safety Administration (PHMSA) and National Transportation Safety Board (NTSB) officials, state officials, and stakeholders GAO contacted cited safety as the main advantage to odorizing combustible gases in pipelines, primarily for distribution pipelines in densely populated areas (see figure). Specifically, adding a chemical with a distinctive odor to gas allows the public to generally detect leaks before an explosion can occur. The most frequently cited disadvantage was that commonly used sulfur-based odorants must be removed—primarily from gas in transmission pipelines—before the gas can be used in certain processes, such as producing fertilizer.

While federal odorization requirements follow a risk-based approach by focusing on pipelines in populated areas, the officials and stakeholders GAO contacted disagreed on the need to modify these requirements for some pipelines. Specifically, because distribution pipelines run through populated areas, everyone GAO contacted generally agreed that these pipelines should be odorized for safety, as currently required. For gathering pipelines, the majority of officials and stakeholders did not see a need to modify regulations because these pipelines would be technically challenging to odorize and are primarily located in rural areas. However, about two-thirds of state officials and about half of stakeholders said that additional transmission pipelines should be odorized for public safety.

Types of Gas Pipelines in the United States



Sources: Pipeline and Hazardous Materials Safety Administration; and GAO. | GAO-18-409

Conversely, officials from PHMSA and NTSB and about half of the stakeholders contacted noted that, because transmission pipelines operate at high pressure and generally rupture rather than leak, it is unlikely that odorant could mitigate risk. Instead, other required safety practices—such as internal pipeline inspections—can provide more preventative, risk-based safety management, according to PHMSA officials. In this regard, PHMSA officials said that they plan to strengthen risk-based safety requirements for transmission and gathering pipelines as part of on-going rulemakings. PHMSA anticipates issuing these rules in 2019.

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Abbreviations

DOT	Department of Transportation
EIA	Energy Information Administration
Manual	2017 American Gas Association Odorization Manual
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIPES	Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016
Psi	pounds per square inch

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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April 18, 2018

The Honorable John Thune
Chairman
The Honorable Bill Nelson
Ranking Member
Committee on Commerce, Science and Transportation
United States Senate

The Honorable Greg Walden
Chairman
The Honorable Frank Pallone
Ranking Member
Committee on Energy and Commerce
House of Representatives

The Honorable Bill Shuster
Chairman
The Honorable Peter A. DeFazio
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

In 2017, the nation's gas pipeline network moved about 73.6 billion cubic feet per day of dry natural gas to homes, schools, and businesses.[1] Pipelines are relatively safe when compared with other modes of transporting hazardous goods. However, a pipeline leak could allow these colorless, odorless gases to seep undetected into areas where people live or work, with potentially devastating results. To alert the public of a dangerous buildup of gas before an explosion can occur, federal pipeline safety regulations—established by the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA)—require that combustible gases transported by certain pipelines be odorized by adding a chemical with a distinctive odor that can be easily

[1] Energy Information Administration's (EIA) estimate for 2017. EIA forecasts that natural gas production will reach 80.3 billion cubic feet per day in 2018. Dry gas is natural gas that remains after the liquefiable hydrocarbon portion has been removed from the gas stream; and any volumes of nonhydrocarbon gases have been removed. Dry natural gas is also known as consumer-grade natural gas.

recognizable by a person with a normal sense of smell.[2] Specifically, all gases in distribution pipelines, which run throughout cities and communities, must be odorized.[3] Gases transported by large, high-pressure transmission pipelines, which run across the country, are required to be odorized only in certain populated areas.[4] Gases collected by gathering pipelines from wells in gas drilling areas are not required to be odorized.

The Protecting our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act of 2016 included a provision for us to review the potential impact of requiring that combustible gases transported by all pipelines be odorized.[5] This report presents the views of federal and state officials and industry and safety stakeholders on:

1. the advantages and disadvantages of odorizing combustible gases transported by pipeline; and
2. whether and how federal pipeline odorization requirements should be modified.

To address both objectives, we reviewed relevant statutes, regulations, and our prior work related to federal and state gas pipeline odorization requirements. We also collected data from PHMSA on pipeline miles by pipeline type, the gases odorized, and the odorant types for fiscal year 2016 through 2018. We assessed the reliability of these data by interviewing PHMSA officials on how it was collected and verified and determined that the data were sufficiently reliable for our purposes. We interviewed PHMSA and National Transportation Safety Board (NTSB) officials on the current federal odorization requirements, as well as whether and how they should be modified.

[2] 49 C.F.R. § 192.625(a).

[3] 49 C.F.R. § 192.625(a).

[4] 49 C.F.R. § 192.625(b).

[5] The provision requested an assessment of the costs and benefits of odorizing all combustible gas in pipeline transportation; however, nationwide data for such an assessment are not available.

We also surveyed pipeline safety officials in the contiguous 48 states and the District of Columbia to collect information on both objectives.[6] We received a 100 percent response rate. To develop the survey questions, we conducted initial interviews with state pipeline safety officials and stakeholders to identify issues regarding pipeline odorization requirements. We also reviewed key literature to ascertain the advantages and disadvantages of odorizing gas transported by pipelines. The survey was reviewed by an internal, independent survey expert and pretested with three potential respondents from state pipeline safety agencies. We did this to ensure that:

1. the questions were clear and unambiguous,
2. the terms we used were precise,
3. the survey did not place an undue burden on the agency officials completing it, and
4. the survey was independent and unbiased.

We took steps in survey design, data collection, and analysis to minimize non-sampling errors. Our results are not subject to sampling error because we administered our survey to all 48 lower contiguous state pipeline safety agencies and the District of Columbia.[7] The survey data were collected from September through November 2017.

In addition, we interviewed 34 stakeholders. We worked with the National Academies of Science to identify 14 experts that we interviewed to discuss their views on both objectives.[8] These experts were selected based on their expertise in the following areas: chemistry, gas industry, odorant industry, chemical manufacturing industry, and public health and safety, with all areas of expertise balanced to obtain a wide variety of viewpoints. Finally, we interviewed 20 other industry and safety

[6] We did not include Alaska and Hawaii in our survey because they do not participate in pipeline safety oversight with PHMSA. Further, Puerto Rico was not included because the survey was conducted during the aftermath of Hurricanes Irma and Maria.

[7] The survey was conducted using self-administered electronic questionnaires posted on the World Wide Web. We sent e-mail notifications to 49 agencies responding to our survey. We also e-mailed each potential respondent a unique password and username to ensure that only members of the target population could participate in the survey. To encourage respondents to complete the survey, we sent an e-mail reminder to each non-respondent about 2 weeks after our initial e-mail message.

[8] We use the term “interviewed” to include everyone who expressed opinions, whether that was in an interview or through a written response.

stakeholders including: representatives from chemical manufacturing associations, gas pipeline operators, odorant manufacturers, and pipeline safety groups to discuss both objectives.[9] These interviews with experts and stakeholders are not generalizable to the entire population of possible experts and stakeholders. For reporting purposes, we developed the following series of indefinite quantifiers to describe the 34 total stakeholder responses from the 14 experts and 20 other industry and safety stakeholders we interviewed:

- 6 or less of the 34 total is described as "a few";
- 7 to 13 is described as "some";
- 14 to 19 is described as "about half";
- 20 to 26 is described as "many"; and
- 27 or more is described as "most".

See appendix II for a list of experts and other stakeholders interviewed.

We conducted this performance audit from June 2017 to April 2018 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

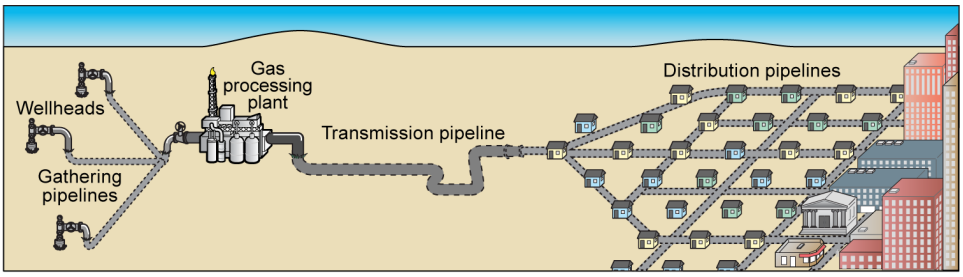
Roughly two-thirds of domestic energy supplies are transported through over 2.6 million miles of pipelines throughout the United States. These pipelines carry hazardous liquids and natural gas from producing wells to end users (residences and businesses). Natural gas, which is combustible, accounts for 99.8 percent of all gas distributed in the United States. Other combustible gases transported by pipeline include hydrogen, landfill gas, synthetic gas, and propane. Within this nationwide system, three main types of pipelines serve different purposes and users (see fig. 1):[10]

[9] Gas pipeline operators were selected for interviews based on their pipeline system size in miles and region of operation.

[10] All pipeline mileage data are as of February, 2018.

- Gathering pipelines. The estimated 11,500 miles of onshore gas gathering pipelines subject to PHMSA regulation collect natural gas from wells in production areas. These pipelines then typically transport the gas to processing facilities, which in turn refine it and send the gas to transmission pipelines. Gathering pipelines range in diameter from about 2 to 12 inches and operate at pressures that range from about 5 to 1,400 pounds per square inch (psi). These pipelines tend to be located in rural areas but can also be located in urban areas. PHMSA estimates that another 230,000 miles of gas gathering pipelines are not subject to federal regulation based on their generally rural location and low operating pressures.
- Transmission pipelines. The estimated 298,000 miles of onshore transmission pipelines carry natural gas, sometimes over hundreds of miles, to communities and large-volume users (e.g., factories). Transmission pipelines tend to have the largest diameters and pressures of any type of pipeline, generally ranging from 12 inches to 42 inches in diameter and operating at higher pressures ranging from 400 to 1,440 psi.
- Distribution pipelines. The estimated 2,170,000 miles of natural gas distribution and service pipelines transport natural gas from transmission pipelines to residential, commercial, and industrial customers. These pipelines tend to be smaller, sometimes less than 1 inch in diameter, and operate at lower pressures, from 0.25 to 100 psi.

Figure 1: Types of Gas Pipelines in the United States



Sources: Pipeline and Hazardous Materials Safety Administration; and GAO. | GAO-18-409

A specific pipeline only carries one type of gas. These gases may be colorless and odorless, which is why odorizing them may be necessary to safely alert people of a leak.

All odorants used in the United States contain sulfur. According to PHMSA officials, there are nine primary sulfur-based odorants used domestically for transporting combustible gas, all but one contain mercaptan—a type of chemical with a distinctive sulfur smell—which is

blended with other chemicals for stability.[11] Pipeline operators select the odorant blend that works best for their pipeline network. Distribution pipeline operators add the odorant to their gas, usually at the "city gate", or the place where transmission pipelines connect to a distribution pipeline network. The odorant is transported and stored in a concentrated liquid form that has a strong smell, is flammable, and is toxic. The odorant is injected into the gas stream at the "city gate" odorization station and vaporizes into the gas. In its diluted form, the odorants are nontoxic.

PHMSA, within the Department of Transportation (DOT), administers DOT's national regulatory program to ensure the safe transportation of natural gas by pipeline. PHMSA oversees and enforces pipeline operators' compliance with federal odorization requirements for interstate pipelines, which are primarily transmission pipelines. Most states have agreements with PHMSA to oversee and enforce pipeline operators' compliance with federal requirements—including odorization requirements—for intrastate pipelines, which are primarily distribution pipelines.[12] These states may also impose safety requirements that are more stringent than federal requirements.[13] Under the current regulatory system, most gathering pipelines are not subject to federal safety requirements, based on their location.[14] Only gathering pipelines close to populated areas or waterways are currently subject to federal requirements.

In March 2012, we reported that land use changes have resulted in development encroaching on existing gathering pipelines and the increased extraction of oil and natural gas from shale deposits has resulted in the development of new gathering pipelines, some of which are larger in diameter and operate at higher pressure than older pipelines. Therefore, we recommended that PHMSA collect data on gathering pipelines to help determine whether to expand regulation of these

[11] Sulfides are another type of sulfur-based chemical used in the blends. Tetrahydrothiophene (THT or thiophane) is a sulfide used in blends with mercaptan or as a single component odorant that does not contain mercaptan. Sulfides are chemically more stable than mercaptans, but mercaptans possess the highest odor intensity.

[12] Alaska and Hawaii do not have agreements with PHMSA to oversee intrastate pipelines.

[13] 49 U.S.C. § 60104(c).

[14] 49 U.S.C. § 60101(b).

pipelines.[15] In April, 2016, PHMSA issued the Gas Transmission and Gathering Notice of Proposed Rulemaking that would: 1) require all gas gathering pipeline operators to submit operating and accident data to PHMSA, 2) more clearly define "gathering pipeline" to better identify pipelines subject to PHMSA's requirements, and 3) increase the number of gathering pipeline miles under PHMSA's jurisdiction.[16] PHMSA estimates that the new rule would increase the number of gathering pipeline miles with reporting requirements by 344,000 and the number of gathering pipeline miles subject to additional safety measures by almost 70,000.

The overall framework for federal gas pipeline regulations—including odorization requirements—is designed to mitigate risk. All pipelines regulated by PHMSA are required to meet uniform, minimum safety standards. Regarding odorization, these minimum standards prescribe that a combustible gas must be odorized so that at a concentration in air of one-fifth of the lower explosive limit, the gas is readily detectable by a person with a normal sense of smell.[17] The proximity of pipelines to populated areas, where leaks present the greatest risk, determines whether or not the gas needs to be odorized. Since 1970, PHMSA has categorized pipelines into four classes based on their proximity to populated areas to determine the odorization requirements for gas transported by distribution and transmission pipeline. Class 1 locations are in rural areas and Class 4 locations are in densely populated areas (see table 1.). All combustible gases transported by distribution pipelines are required to be odorized because these pipelines are primarily in

[15] GAO, *Pipeline Safety: Collecting Data and Sharing Information on Federally Unregulated Gathering Pipelines Could Help Enhance Safety*, GAO-12-388 (Washington D.C.: March 22, 2012).

[16] 81 Fed. Reg. 20722 (Apr. 8, 2016). In 2018, PHMSA revised this rulemaking to three separate gathering and transmission pipeline rules: Pipeline Safety: Safety of Gas Transmission Pipelines, MAOP Reconfirmation, Expansion of Assessment Requirements and Other Related Amendments; Pipeline Safety - Safety of Gas Transmission Pipelines, Repair Criteria, Integrity Management Improvements, Cathodic Protection, Management of Change, and Other Related Amendments; and Pipeline Safety -Safety of Gas Gathering Pipelines rulemaking. The first two are relevant for transmission and the third is relevant for gathering pipelines. All three rulemakings are due for publication in 2019.

[17] 49 C.F.R. §192.625 (a). The lower explosive limit is the lowest concentration (percentage) of a gas in air capable of producing a flash of fire in presence of an ignition source.

populated areas. Some transmission pipelines in highly populated—Class 3 and 4—areas are also required to be odorized.[18]

Table 1: Pipeline and Hazardous Material Safety Administration Class Designations for Gas Pipelines

PHMSA Class Level	Location features
Class 1	An offshore area or any location with 10 or fewer buildings intended for human occupancy within 220 yards of the centerline of the pipeline.
Class 2	Any location with more than 10 but fewer than 46 buildings intended for human occupancy within 220 yards of the centerline of the pipeline.
Class 3	Any location with more than 46 buildings intended for human occupancy within 220 yards of a pipeline, or an area where the pipeline lies within 100 yards of either a building or a small, well-defined outside area that is occupied by 20 or more persons at least 5 days a week for 10 weeks in any 12-month period.
Class 4	Any location where unit buildings with four or more stories above ground are prevalent.

Source: 49 C.F.R. § 192.5. I GAO-18-409

In addition, PHMSA has a supplemental risk-based regulatory program termed “integrity management” for pipelines in “high-consequence areas” where an incident would have greater consequences for public safety or the environment. Integrity management has been a part of PHMSA’s risk-based regulatory approach for natural gas transmission pipelines since 2004, and for natural gas distribution pipelines since 2011. The risk-based integrity management programs for natural gas transmission pipelines require operators to systematically identify and mitigate risks to pipeline segments located in high-consequence areas. For example, in these areas operators must monitor their pipelines for signs of corrosion and repair corroded lines within a specified period of time. High-consequence areas for natural gas pipelines include highly populated or frequently used areas, such as parks. These areas may overlap with Class 3 or Class 4 locations. The integrity management program for distribution pipelines applies to all distribution pipelines due to their proximity to populated areas.

[18] 49 C.F.R. §192.625 (b).

Officials and Stakeholders Said That Odorizing Gas in Pipelines Improves Public Safety, but Can Impede Some Industrial Processes

Pipeline Gas Odorization Facilitates Early Detection, Particularly in Populated Areas

Almost all officials and stakeholders we interviewed and the state pipeline safety officials we surveyed told us that the advantage of using sulfur-based odorants to odorize combustible gas transported by pipeline is public safety.[19] Sulfur-based odorants have a low-odor threshold, so are easily detected at low concentrations. With a smell similar to that of rotten eggs, this odor is particularly advantageous when used in distribution pipelines that are located in areas where people congregate (e.g., homes, businesses and hospitals). If individuals smell an odorant, they can call emergency services and alert those nearby of a potential gas leak, possibly helping to prevent an explosion that could result in the loss of life and property.

According to federal regulations, all local distribution companies must conduct outreach to educate the public and others on what to do when they smell a gas leak.[20] To this end, the 2017 American Gas Association Odorization Manual (manual) states that some local distribution companies have gone beyond placing the traditional scratch-and-sniff insert in customers' billing statements—to inform them about gas leaks

[19] For information on the advantages and disadvantages of non-sulfur based odorants, see appendix I.

[20] All pipeline operators (except master meter or petroleum gas system operators) are required to develop and implement a written continuing public education program. 49 C.F.R. § 192.616 Operators' programs must specifically include provisions to educate the public, appropriate government organizations and persons participating in excavation activities about hazards of and safety steps to take in the event of a gas leak. 49 C.F.R. § 192.616(d) In addition, operators' programs and media used must be as comprehensive as necessary to reach all areas in which the operator transports gas. 49 C.F.R. § 192.616(f)

and odor—to implementing “Smell Gas Act Fast!” campaigns. According to the manual, these campaigns are designed to better educate the public on the smell and nature of natural gas, along with the need to quickly take action if the odor is detected. Responding immediately to the smell of natural gas can help to prevent possible accidents. For example, when authorities were reportedly called to a Rockville, Maryland home in November 2017 to investigate an odor from a natural gas leak, authorities evacuated several nearby homes as a safety precaution in the event of an explosion, until the source of the leak could be identified and addressed.

While nearly all stakeholders we interviewed said that public safety was the key advantage associated with odorizing combustible gases (in particular, combustible gases transported by distribution pipeline), some experts expressed differing opinions on the use of handheld electronic combustible gas detection devices as an alternative to detect gas leaks. According to one expert, these devices are better suited to detect gas at levels much lower than an individual’s sense of smell would allow. This expert also noted that odor does not wake a sleeping individual so a gas leak could go undetected for hours. However, a second expert noted that during his experience with pipeline accident investigations over the past 40 years, he was aware of about 10 cases in which deceased individuals were found after a gas leak accident holding a portable combustible gas detector because (1) the device may not have indicated the presence of gas in one location while a nearby location may have been explosive due to a gas leak; or (2) the user may not have been properly trained on the instrument’s limitations to identify a safe area. Accordingly, that expert stated that odorization is the most effective safety method for alerting the public of a possible gas leak. Additionally, a third expert noted that (1) electronic detectors can be difficult to place in certain areas and (2) odorants allow the public to quickly detect gas leaks without acquiring or maintaining external equipment.

The Primary Disadvantages Officials and Stakeholders Cited Are Odor Removal for Some Industries and False Alarms

The most common disadvantage of sulfur-based odorants cited by officials and stakeholders we contacted is the need to remove the odorant for some industrial processes. Officials from both federal safety regulatory agencies we interviewed (PHMSA and NTSB); approximately half of state pipeline safety officials surveyed; and about half of the stakeholders interviewed reported that sulfur-based odorants used in transmission pipelines can cause an adverse chemical reaction during processing for some industries. For example, sulfur in natural gas can be detrimental in the production of electricity, fertilizer, and glass because it interferes with

the catalyst used during production.[21] PHMSA and NTSB officials and about half of the stakeholders said that before these items are produced, operators must remove any added (or naturally occurring) sulfur from their combustible gas, adding another step to production. One expert and three stakeholders told us that removing the odorant also resulted in added cost for some operators. However, because most transmission pipelines are in less populated areas and not odorized, many manufacturers currently receive unodorized gas from transmission pipelines and do not need to remove odorant, according to the industry associations we interviewed.

In addition, some stakeholders warned that accidental spills of concentrated odorant, using more odorant than needed, or releasing excessive amounts of odorant during operators' maintenance activities can lead to false alarm calls. One pipeline operator told us that an employee spilled odorant on a glove and the public made several false alarm calls due to the odorant's potent smell as the employee drove through town with the glove on the back of a truck. Officials from PHMSA, an official from a pipeline safety organization and representatives from two pipeline industry associations told us that the public could get accustomed to these types of odorant leaks and begin to ignore them or have a false sense of security when a real gas leak does occur. For example, the official from the pipeline safety organization told us that he has heard of at least one location where odorant leaks frequently occurred, and the public began to ignore the smell.

Additionally, under certain conditions, sulfur-based odorants can be hazardous to human health and the environment. A few stakeholders told us that odorants released in excessive amounts may cause health concerns. For example, during a presentation before the Pipeline Safety Trust, a Los Angeles County public health official stated that it appears a sulfur-based odorant was related to public health complaints made in 2015 after a 4-month long natural gas leak from a natural gas storage facility in California's Aliso Canyon. Many of the reported symptoms matched those made after a 2008 natural gas storage tank leak in Alabama, which included respiratory problems; eye, nose, and throat irritation; headache; nausea; and dizziness. While at least one study has been conducted and another is planned on the long-term effects of sulfur-

[21] A catalyst is a substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change

based odorants on human health, no direct cause and effect relationships have been established.

Finally, a few stakeholders noted potential environmental hazards regarding the use of odorants. For example, one stakeholder told us that odorants can become a hazardous waste depending on the quantity used and the amount of time the chemical remains in one location prior to use; one expert and another stakeholder noted that sulfur-based odorants when spilled may contaminate waterways; and four experts and two stakeholders warned that when combusted, sulfur-based odorants can produce acid rain. Also, according to PHMSA officials, these odorants are both toxic and flammable in their concentrated state. However, none of the stakeholders provided specific examples of when an odorant caused environmental damage.

Officials and Stakeholders Had Mixed Views on Need to Modify Odorization Requirements

Many Officials and Stakeholders Agreed That Federal Distribution Pipeline Odorization Regulations Do Not Need to be Modified

General consensus exists among those we spoke with (including federal regulatory and safety officials, experts identified by the National Academies, and industry stakeholders) that federal requirements to odorize all gases in distribution pipelines are sufficient as written and do not need to be modified.[22] PHMSA and NTSB officials we interviewed and many commenting stakeholders articulated this view. In addition, state pipeline officials we surveyed generally did not indicate a need to change federal regulations for odorizing distribution pipelines. Due to the proximity of distribution pipelines to areas where people live and work,

[22] We asked federal officials, state safety officials, experts identified by the National Academies, and stakeholders from the gas industry about the sufficiency of federal gas odorization requirements more generally, as well as whether or not odorization requirements should be expanded to all gathering and transmission pipelines. However, we did not explicitly ask state pipeline officials in our survey about federal distribution pipeline odorization requirements, so their views were not collected on whether these regulations should be modified.

officials, experts, and stakeholders we interviewed emphasized the importance of odorizing gas in distribution pipelines to reduce the safety risk to the public.

As we have previously reported, the operating characteristics of distribution pipelines make odorant a key factor in reducing safety risk. In 2012 we reported that distribution pipelines operate at lower pressures, so pipeline failures are more likely to involve slow leaks rather than explosive ruptures.[23] Leaking gas can accumulate in confined spaces, or migrate away from the pipeline until it finds an ignition source and potentially causes injury, death, and/or property damage. These slow leaks are difficult to see or hear, so odorants provide a critical warning to call emergency services and inform those nearby of a potential gas leak before it ignites.

Many Officials and Stakeholders Agreed That Odorizing Gathering Pipelines Could Be Technically Challenging with Little Added Safety Benefit

Of those we interviewed or surveyed, about half of stakeholders and a third of state pipeline safety officials did not indicate a need to modify existing regulations for odorizing gas in gathering pipelines.[24] Further, a few commenting experts said odorizing those pipelines would be technically challenging. According to the experts, technological challenges stem from the fact that gas contains natural sulfur at many of the wells where gathering pipelines collect the raw gas. The natural sulfur in the raw gas could counteract the added chemical sulfur odorant, masking the smell of each and lowering the effectiveness of the odorant. Further, one stakeholder said that odorizing gathering pipelines would be logistically difficult and expensive given the number of wells that would each need an odorization station. For example, according to this stakeholder, there are roughly 500,000 gas wells nationwide and each odorizer would cost $2,000 as a capital investment.[25] In addition, this stakeholder said that any safety benefit of adding odorant would be limited because most gas wellheads and gathering pipelines are located in sparsely populated rural areas.

[23] GAO, *Safety Effects of Less Prescriptive Requirements for Low-Stress Natural Gas Transmission Pipelines Are Uncertain*, GAO-12-389R, (Washington D.C.: February 16, 2012).

[24] NTSB is currently reviewing an incident in Firestone, Colorado involving gathering pipelines, and therefore could not comment on federal requirements for gathering pipelines at the time of our interview.

[25] We were unable to assess the reliability of this estimate.

While the majority of stakeholders and state survey respondents did not see a need to odorize gas in gathering pipelines, a third of the state safety officials and three other stakeholders said all gathering pipelines should be odorized for additional safety regardless of any technical challenge.[26] However, requiring all gathering pipelines to be odorized at the federal level would have to be consistent with federal pipeline safety regulations. According to the safety regulations, a risk assessment, including an assessment of the benefits and costs of proposed regulatory standards, is required to be considered in any decision on whether to impose a new safety standard.[27] According to PHMSA officials, they do not have the data to report on any incidents on gathering pipelines where odorant may have made a difference. Moreover, PHMSA officials stated that they do not have the data to formulate an educated opinion or viewpoint as to the need to odorize gathering pipelines. To address this lack of data, the Pipeline Safety -Safety of Gas Gathering Pipelines rulemaking, if approved, will provide PHMSA with more data on gas gathering pipeline infrastructure and incident data. According to PHMSA officials, the data collected will inform PHMSA on the best path forward regarding further regulation of gas gathering pipelines, including the need for odorization. Officials anticipate publishing the final rule in summer 2019.

Officials' and Stakeholders' Views Differed on Need to Odorize Transmission Pipeline Gas

Officials, stakeholders and survey respondents generally disagreed about the need to odorize all transmission pipelines. Officials from NTSB as well as about half of the stakeholders we contacted said the current regulations for odorizing gas in certain transmission pipelines in populated areas were sufficient. Additionally, NTSB officials said they were not aware of incidents where odorants in a transmission pipeline would have alerted the public in time to prevent the incident. These officials and stakeholders generally said that odorizing gas in transmission pipelines is not an effective means of reducing the risk of an incident. For example, one stakeholder said that at the typically high pressure at which most transmission pipelines operate, even a relatively small hole in the pipeline would cause a rupture that would excavate the earth around it so people would hear and see the evidence of the leak. Some experts also said that odorizing gas in all transmission pipelines

[26] The remaining third of state safety officials either did not have an opinion or did not have any gathering pipeline in their state.

[27] 49 U.S. C. § 60102 (b) (2) (E)

could have increased costs and other challenges for pipeline operators or gas end users. For example, one expert said that odorizing all gas transported in the transmission pipeline system would require tens of thousands of odorization facilities. This expert also said that if gas is odorized in transmission pipelines, some industries currently receiving unodorized gas will be affected negatively because they either must incur the additional processing and cost of removing the odorant or find new ways to receive gas that is not odorized.

Further, PHMSA officials and representatives from the Interstate Natural Gas Association of America said that the integrity management program for transmission pipelines provides more preventative, risk-based safety management than odorants, which rely on reducing risk through early detection of a leak that has already occurred. The integrity management program requires operators to assess the integrity of their pipelines within high consequence areas—which, by definition, encompass Class 3 and 4 locations—on a regular basis using any of three approved methods: (1) running an in-line inspection tool, or "smart pig", through the pipeline to detect anomalies, such as corrosion, that can cause leaks (2) conducting a direct assessment using data and direct examination of the pipeline from aboveground to identify problem areas, or (3) hydrostatically testing a portion of the pipeline by removing the gas product, replacing it with water, and increasing the pressure of the water above the maximum allowable operating pressure of the pipeline to test its integrity. These inspection methods are designed to detect issues that could cause a gas leak before the leak occurs. Following the assessments, pipeline operators are required to prioritize and repair anomalies found during assessments.

While odorants could be added in addition to integrity management requirements, PHMSA officials said that integrity management more effectively helps assure an acceptable level of safety for transmission pipelines than an odorant could because the risk assessments focus on the potential causes of leaks and ruptures for these types of pipelines and, therefore, are more preventative than odorizing. In a September 2006 report, we found that PHMSA's gas pipeline integrity management program benefits public safety by incorporating risk-based management principles into pipeline safety oversight,[28] and in June 2013, we reported

[28] GAO, *Natural Gas Pipeline Safety: Integrity Management Benefits Public Safety, but Consistency of Performance Measures Should Be Improved*, GAO-06-946, (Washington, D.C.: September 8, 2006).

that transmission pipeline operators were conducting periodic assessments and making repairs to pipelines in high consequence areas.[29]

Transmission pipeline operators are also required through the integrity management program to proactively take measures to reduce the risk or potential impact of an accident. Based on inspections of interstate transmission operators' integrity management programs, PHMSA officials noted that—while transmission pipeline operators could opt to odorize gas in a transmission pipeline—they are not aware of any operator to date that has concluded that odorizing transmission pipelines was necessary to reduce risk. Instead, operators use tools such as electronic leak detection and remotely-controlled valves to detect potential leaks and shut down the pipeline if needed.

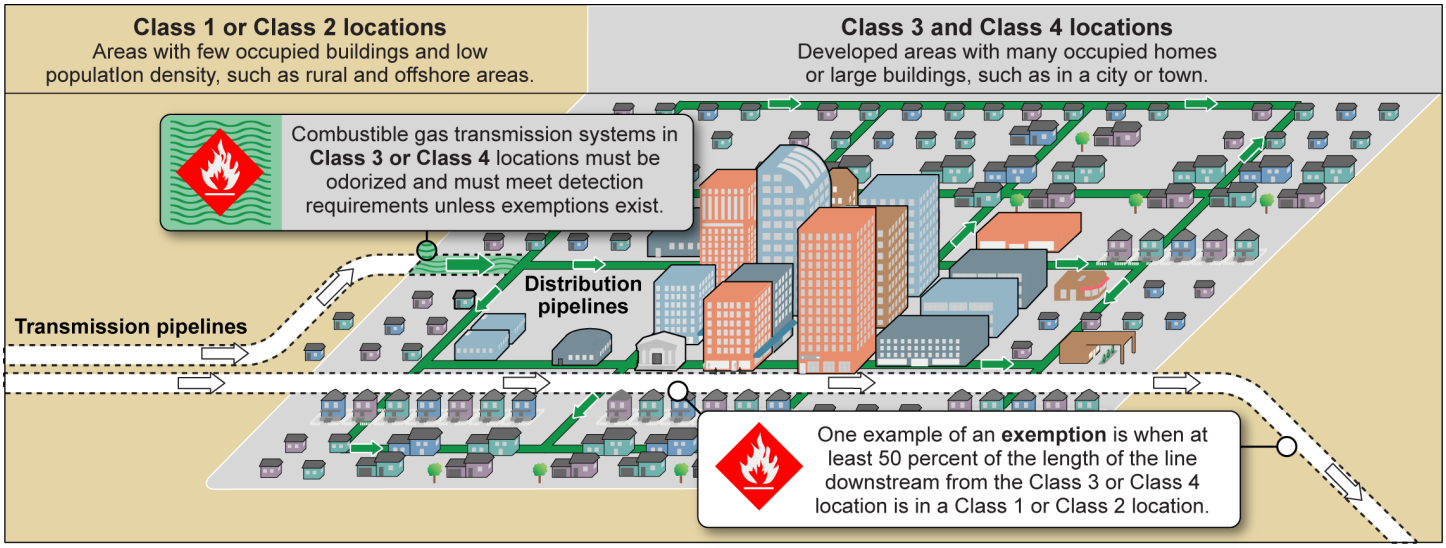
While the preventative safety practices required under the gas transmission pipeline integrity management program are designed to mitigate risk without requiring the use of odorant, officials from two states and one stakeholder questioned the sufficiency of integrity management practices. However, as part of the ongoing two rulemakings: the Pipeline Safety: Safety of Gas Transmission Pipelines, MAOP Reconfirmation, Expansion of Assessment Requirements and Other Related Amendments and the Pipeline Safety - Safety of Gas Transmission Pipelines, Repair Criteria, Integrity Management Improvements, Cathodic Protection, Management of Change, and Other Related Amendments Rulemaking, PHMSA also plans to strengthen and expand requirements for the gas integrity management program for transmission pipelines. For example, PHMSA plans to expand the requirements for periodic assessments and subsequent repairs to additional pipeline mileage beyond that located in high consequence areas. PHMSA plans to publish these rulemaking in March and June, 2019, respectively. The 2016 PIPES Act includes a mandate for GAO to review PHMSA's gas integrity management program as soon as PHMSA publishes the final rule.

In contrast to the opinions expressed above that transmission pipeline odorization requirements are sufficient, 31 of 49 state pipeline safety officials surveyed responded that these requirements are not stringent enough for safety. Of these respondents, several said that exemptions

[29] GAO, *Natural Gas Pipeline Safety: Guidance and More Information Needed before Using Risk-Based Reassessment Intervals*GAO-13-577, (Washington, D.C.: June 27, 2013).

that currently apply to some operators with transmission pipelines in Class 3 and Class 4 locations should not be allowed.[30] There are several exemptions, determined by the overall class location of the pipeline or end use of the gas. For example, one class location exemption is that when at least 50 percent of the length of the pipeline downstream from the more populated Class 3 or Class 4 location is in a less populated Class 1 or Class 2 location, the gas does not need to be odorized (see fig. 2).[31]

Figure 2: Class Location Odorization Requirements and Exemptions



Source: GAO. | GAO-18-409

Eliminating the current regulatory exemptions for certain transmission pipelines and requiring operators to odorize all gas transported by transmission pipeline through Class 3 or Class 4 locations may not be cost-beneficial under federal regulatory risk assessment principles, which direct the agency to assess the benefits and costs of changes in regulatory standards. For example, while four states cited increased public safety as the reason to remove the existing exemption, PHMSA and NTSB officials could not identify any incidents where odorants in a transmission pipeline would have prevented damage. In addition, as described above, some experts told us that removing the exemptions

[30] 49 C.F.R. § 192.625(b)(1)-(4).

[31] 49 C.F.R. §192.625(b)(1).

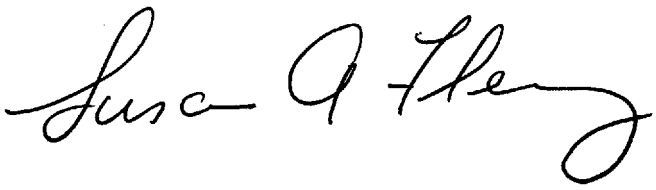
could have increased costs and other challenges for pipeline operators or gas end users. PHMSA officials also said that the definition of a high-consequence area under the gas integrity management program encompasses all Class 3 and Class 4 locations, so the risk-based preventative measures required under that program apply to the areas exempt from odorization requirements.

Agency Comments

We provided a draft of this product to DOT for review and comment. DOT provided technical comments that were incorporated, as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretary of the Department of Transportation, and other interested parties. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or FlemingS@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.



Susan Fleming
Director, Physical Infrastructure

Appendix I: Advantages and Disadvantages of Non-sulfur Based Odorants

While our report focuses on sulfur-based odorants, which are used in the United States, we also asked experts and stakeholders about the advantages and disadvantages of non-sulfur based odorants. According to a German-based manufacturer of non-sulfur odorants, these odorants are used in some European countries, including Germany and Austria. This manufacturer also told us that the German energy industry has embraced using non-sulfur based odorants, in part, to meet German emissions regulations, as these odorants do not produce sulfur dioxide and contribute to acid rain when burned.

Most of the experts and stakeholders that we interviewed were generally unfamiliar with non-sulfur based odorants. Those with some familiarity offered the following advantages and disadvantages.

Advantages:

Three experts and stakeholders reported that non-sulfur based odorants:

- have less adverse impact on the environment; for example, no acid rain effects;
- may cost less for some operators because less product may be needed than sulfur-based odorants; and
- do not adversely impact some operators' processes.

Disadvantages:

Four experts noted that non-sulfur based odorants:

- have a smell that the American public does not associate with a gas leak.

Two experts commented that non-sulfur based odorants:

- may be chemically unstable; and
- can react with other compounds.

Two experts noted that non-sulfur based odorants:

- may have a higher level of toxicity.

Appendix II: Experts and Other Industry and Safety Stakeholders Interviewed by GAO

Table 2: Experts:

Expert Name	Organization
David Bull	ViaData LP
Frankie Wood-Black	Sophic Pursuits
John Bromly	W. Aus. Dept. of Mines
John Jacobus	Jacobus & Associates
John Roberts	Rimkus Consulting
John Zurcher	Blacksmith Group
Karen Crippen	Gas Technology Institute
M. Sam Mannan	Texas A&M University
Matt Stennett	Middle Tennessee Natural Gas Utility District
Melissa Spinelli	National Grid
Richard Kuprewicz	Accufacts Inc.,
Richard Sanders	RES Services, LLC
Rosemarie Halchuck	Xcel Energy
Zac Lowe	Southern Company Gas

Source: GAO. | GAO-18-409

Table 3: Stakeholders:

Gas Associations
American Gas Association
Interstate Natural Gas Association of America
National Association of Pipeline Safety Representatives
American Public Gas Association
GPA Midstream Association
American Petroleum Institute
Safety Organization
Pipeline Safety Trust
Los Angeles County Department of Public Health
Operators
Maine Natural Gas
Columbia Gas of Ohio
Iroquois Pipeline Operating Co
California Gas Transmission
Dominion Energy Transmission
Targa Pipeline Partners
Air Products
Odorant Manufacturers
Arkema
Chevron Philips
Symrise
Chemical Manufacturing Associations
The Fertilizer Institute
American Fuel and Petrochemical Manufacturers

Source: GAO. | GAO-18-409

Appendix III: Contact and Staff Acknowledgements

Contact

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Staff Acknowledgements

In addition to the individual named above, other key contributors to this report were Sara Vermillion, Assistant Director; Sarah Jones, Analyst in Charge; Jennifer W. Clayborne; Timothy J. Guinane; David K. Hooper; Delwen A. Jones; Josh Ormond; Rebecca R. Parkhurst; and Kelly L. Rubin.