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MARITIME SECURITY

Public Safety Consequences of a Liquefied Natural Gas Spill Need Clarification

Statement of Jim Wells, Director
Natural Resources and Environment

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GAO-07-633T

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Public Safety Consequences of a Liquefied Natural Gas Spill Need Clarification

GAO Highlights

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Highlights of GAO-07-633T, testimony before the Committee on Homeland Security, House of Representatives

Why GAO Did This Study

Liquefied natural gas (LNG) is a supercooled liquid form of natural gas. U.S. LNG imports are projected to increase to about 17 percent of natural gas supplies by 2030, from about 3 percent today. To meet this increase, energy companies have submitted 32 applications for new terminals. If a terrorist attack on an LNG tanker caused a spill, potential hazards, such as fire, asphyxiation, and explosions, could result. The Department of Energy (DOE) recently funded a study to conduct small- and large-scale experiments to refine and validate models that calculate how heat from large LNG fires would affect the public.

This testimony is based on GAO's recently released report, *Maritime Security: Public Safety Consequences of a Terrorist Attack on a Tanker Carrying Liquefied Natural Gas Need Clarification* (GAO-07-316). To prepare this report, GAO examined the results of six recent unclassified studies on the effects of an LNG spill and convened a panel of 19 experts to identify areas of agreement on the consequences of a terrorist attack on an LNG tanker.

What GAO Recommends

GAO recommended that DOE incorporate the key issues GAO's expert panel identified, particularly the potential for cascading failure, into its current LNG study. DOE concurred with this recommendation.

www.gao.gov/cgi-bin/getrpt?GAO-07-633T.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells at (202) 512-3841 or wellsj@gao.gov.

What GAO Found

The six studies GAO reviewed examining the potential effect of a fire resulting from an LNG spill produced varying results; some studies also examined other potential hazards of a large LNG spill and reached consistent conclusions on explosions. Specifically, the studies' conclusions about the distance at which 30 seconds of exposure to the heat (heat hazard) could burn people ranged from less than 1/3 of a mile to about 1-1/4 miles. Sandia National Laboratories (Sandia) conducted one of the studies and concluded, based on its analysis of multiple attack scenarios, that a good estimate of the heat hazard distance would be about 1 mile. Federal agencies use this conclusion to assess proposals for new LNG import terminals. The variations among the studies occurred because, with no data on large spills from actual events, researchers had to make numerous modeling assumptions to scale up the existing experimental data for large LNG spills. Three of the studies also examined other potential hazards of an LNG spill, including LNG vapor explosions and sequential failure of multiple tanks on the LNG vessel (cascading failure). All three studies considered LNG vapor explosions unlikely unless the vapors were in a confined space. Finally, the Sandia study examined the potential for cascading tank failure and concluded that only three of the five tanks in a typical tanker would potentially be affected, and that such failure would increase the duration of the LNG fire.

GAO's panel of experts generally agreed on the public safety impact of an LNG spill caused by a terrorist attack, disagreed on specific conclusions of the Sandia study, and suggested future research priorities. Experts agreed that the most likely public safety impact of an LNG spill is the heat impact of a fire and that explosions are not likely to occur unless LNG vapors are in confined spaces. However, the experts did not all agree with the heat hazard and cascading failure conclusions reached by the Sandia study. Finally, they suggested priorities to guide future research aimed at clarifying uncertainties about heat impact distances and cascading failure. DOE's recently funded study involving large-scale LNG fire experiments addresses only some of the research priorities the expert panel identified.

LNG Tanker Passing Downtown Boston on Its Way to Port

Source: GAO.

United States Government Accountability Office
Washington, DC 20548

Mr. Chairman and Members of the Committee:

I am pleased to be here to discuss the results of our recently released report on the public safety consequences of a terrorist attack on a tanker carrying liquefied natural gas (LNG).[1] As you know, LNG is a supercooled liquid form of natural gas, which, if spilled, poses potential hazards, such as fire, asphyxiation, and explosions. U.S. imports of LNG, now about 3 percent of total U.S. natural gas supplies, are projected to be about 17 percent of U.S. supplies by 2030. To meet this increased demand, energy companies have submitted 32 applications to federal regulators to build new terminals for importing LNG in 10 states and 5 offshore areas. Access to accurate information about the consequences of LNG spills is crucial for developing risk assessments for LNG siting decisions. Despite several recent modeling studies of the consequences of potential LNG spills, uncertainties remain about the risks such spills would pose to the public. One of these studies, conducted by Sandia National Laboratories (Sandia) in 2004, is used by the Coast Guard to assess the suitability of waterways for LNG tankers traveling to proposed LNG facilities. In this context, DOE has recently funded a new study that will conduct small- and large-scale LNG fire experiments to refine and validate existing models that calculate how heat from large LNG fires would affect the public.

My testimony today summarizes the results of our report. Specifically, I will (1) describe the results of recent unclassified studies on the consequences of an LNG spill and (2) identify the areas of agreement and disagreement among experts concerning the consequences of a terrorist attack on an LNG tanker. To address these issues, we examined six unclassified studies of the consequences of LNG spills. We also convened a Web-based panel of 19 experts to identify areas of agreement and disagreement on LNG spill consequence issues. Because some additional studies are classified, we will be issuing a separate classified report with related findings at a later date.

[1]GAO, *Maritime Security: Public Safety Consequences of a Terrorist Attack on a Tanker Carrying Liquefied Natural Gas Need Clarification*, GAO-07-316 (Washington, D.C.: Feb. 22, 2007). This report was prepared at the request of this Committee, the House Committee on Energy and Commerce, and Representative Edward J. Markey.

Summary

The six unclassified studies we reviewed all examined the heat impact of an LNG fire but produced varying results; some studies also examined other potential hazards of a large LNG spill and reached consistent conclusions on explosions. Specifically, the studies' conclusions about the distance at which 30 seconds of exposure to the heat could burn people—also termed the heat impact distance—ranged from less than 1/3 of a mile to about 1-1/4 miles. These variations occurred because, with no data on large spills from actual events, researchers had to make numerous modeling assumptions to scale up the existing experimental data for large LNG spills. These assumptions involved the size of the hole in the tanker, the number of tanks that fail, the volume of LNG spilled, key LNG fire properties, and environmental conditions, such as wind and waves. Three of the studies also examined other potential hazards of an LNG spill, including LNG vapor explosions, asphyxiation, and the sequential failure of multiple tanks on the LNG vessel (cascading failure). All three studies considered LNG vapor explosions unlikely unless the vapors were in a confined space. Only the Sandia study examined asphyxiation and concluded that asphyxiation did not pose a hazard to the general public. Finally, only the Sandia study examined the potential for cascading failure of LNG tanks and concluded that only three of the five tanks on a typical LNG vessel would be involved in such an event and that this number of tanks would increase the duration of the LNG fire.

Our panel of 19 experts generally agreed on the public safety impact of an LNG spill, disagreed on specific conclusions of the Sandia study, and suggested future research priorities. Experts agreed on three main points: (1) the most likely public safety impact of an LNG spill is the heat impact of a fire; (2) explosions are not likely to occur in the wake of an LNG spill unless the LNG vapors are in confined spaces; and (3) some hazards, such as freeze burns and asphyxiation, do not pose a hazard to the public. However, the experts disagreed with a few conclusions reached by the Sandia study that the Coast Guard uses to assess the suitability of waterways for LNG tankers going to proposed LNG terminals. Specifically, all experts did not agree with the study's 1-mile estimate of heat impact distance resulting from an LNG fire: 7 of 15 thought Sandia's distance was "about right," 8 were evenly split on whether the distance was "too conservative" or "not conservative enough," and 4 did not answer this question. Experts also did not agree with the Sandia National Laboratories' conclusion that only three of the five LNG tanks on a tanker would be involved in a cascading failure. Finally, experts suggested priorities to guide future research aimed at clarifying uncertainties about heat impact distances and cascading failure, including large-scale fire experiments, large-scale LNG spill experiments on water, the potential for cascading

failure of multiple LNG tanks, and improved modeling techniques. DOE's recently funded study involving large-scale LNG fire experiments addresses some, but not all, of the research priorities the expert panel identified.

Background

As scientists and the public have noted, an LNG spill could pose potential hazards. When LNG is spilled from a tanker, it forms a pool of liquid on the water. As the liquid warms and changes into natural gas, it forms a visible, foglike vapor cloud close to the water. The cloud mixes with ambient air as it continues to warm up, and eventually the natural gas disperses into the atmosphere. Under certain atmospheric conditions, however, this cloud could drift into populated areas before completely dispersing. Because an LNG vapor cloud displaces the oxygen in the air, it could potentially asphyxiate people who come into contact with it. Furthermore, like all natural gas, LNG vapors can be flammable, depending on conditions. If the LNG vapor cloud ignites, the resulting fire will burn back through the vapor cloud toward the initial spill. It will continue to burn above the LNG that has pooled on the surface—this is known as a pool fire. Small-scale experiments to date have shown that LNG fires burn hotter than oil fires of the same size. Both the cold temperatures of spilled LNG and the high temperatures of an LNG fire have the potential to significantly damage the tanker, causing a cascading failure. Such a failure could increase the severity of the incident. Finally, concerns have been raised about whether an explosion could result from an LNG spill.

The Federal Energy Regulatory Commission is responsible for approving applications for onshore LNG terminal sitings, and the U.S. Coast Guard is responsible for approving applications for offshore sitings. In addition, the Coast Guard reviews an applicant's Waterway Suitability Assessment, reaches a preliminary conclusion on whether the waterway is suitable for LNG imports, and identifies appropriate strategies that reduce the risk posed by the movement of an LNG tanker.

Studies Identified Different Distances for the Heat Effects of an LNG Fire, but Agreed on Other LNG Hazards

The six studies we examined identified various distances at which the heat effects of an LNG fire could be hazardous to people. The studies' results about the distance at which 30 seconds of exposure to the heat could burn people ranged from less than 1/3 of a mile (about 500 meters) to about 1-1/4 miles (more than 2,000 meters). The studies' variations in heat effects occurred because (1) different assumptions were made in the studies' models about key parameters of LNG spills and (2) the studies were designed and conducted for different purposes. Since no large-scale data are available for LNG spills, researchers made numerous modeling assumptions to scale up the existing experimental data for large spills. Key assumptions made included hole size and cascading failure, waves and wind, the volume of LNG spilled, and the amount of heat radiated from the fire. For example, studies made assumptions for the size of the hole in the LNG tanker that varied from less than 1 square meter up to 20 square meters. Additionally, the studies were conducted for different purposes. Two studies were academic analyses of the differences between LNG and oil spills; three specifically addressed spills caused by terrorist attacks, which was a concern in the wake of the September 11 attacks; and the final study developed appropriate methods for regulators to use to estimate heat hazards from LNG fires. Results of these studies can be found in our report being released today.

Some studies also examined other potential hazards, such as explosions, asphyxiation, and cascading failure, and identified their potential impacts on public safety. Three studies examined the potential for LNG vapor explosions, and all agreed that it is unlikely that LNG vapors could explode if the vapors are in an unconfined space. Only one study examined the potential for asphyxiation following an LNG spill if the vapors displace the oxygen in the air. It concluded that fire hazards would be the greatest problem in most locations, but that asphyxiation could threaten the ship's crew, pilot boat crews, and emergency response personnel. Finally, only the Sandia study examined the potential for cascading failure of LNG tanks and concluded that only three of the five tanks would be involved in such an event and that this number of tanks would increase the duration of the LNG fire.

Experts Generally Agreed That the Most Likely Public Safety Impact of an LNG Spill Is the Heat Effect of a Fire, but That Further Study Is Needed to Clarify the Extent of This Effect

The 19 experts on our panel generally agreed on the public safety impact of an LNG spill, disagreed with specific conclusions of the Sandia study, and suggested future research priorities.[2] Specifically:

- Experts agreed that the main hazard to the public from a pool fire is the heat from the fire, but emphasized that the exact hazard distance depends on site-specific weather conditions; composition of the LNG (relative percentages of methane, propane, and butane); and the size of the fire.

[2] We considered experts to be "in agreement" if more than 75 percent of them indicated that they completely agreed or generally agreed with a given statement. Not all experts commented on every issue discussed.

- Eighteen of 19 experts agreed that the ignition of a vapor cloud over a populated area could burn people and property in the immediate vicinity of the fire. Three experts emphasized in their comments that the vapor cloud is unlikely to penetrate very far into a populated area before igniting.

- With regard to explosions, experts distinguished between explosions in confined spaces and in unconfined spaces. For confined spaces, such as under a dock or between the hulls of a ship, they agreed that it is possible, under controlled experimental conditions, to induce explosions of LNG vapors; however, a detonation—the more serious type of vapor cloud explosion—of confined LNG vapors is unlikely following an LNG spill caused by a terrorist attack. For unconfined spaces, experts were split on whether it is possible to induce such explosions under controlled experimental conditions; however, even experts who thought such explosions were possible agreed that vapor cloud explosions in unconfined spaces are unlikely to occur following an LNG spill caused by a terrorist attack.

Our panel of 19 experts disagreed with a few of the Sandia study's conclusions and agreed with the study authors' perspective on risk-based approaches to dealing with the hazards of potential LNG spills. For example:

- Seven of 15 experts thought Sandia's heat hazard distance was "about right," and the remaining 8 experts were evenly split as to whether the distance was "too conservative" (i.e., larger than needed to protect the public) or "not conservative enough" (i.e., too small to protect the public). Officials at Sandia National Laboratories and our panel of experts cautioned that the hazard distances presented cannot be applied to all sites because of the importance of site-specific factors. Additionally, two experts explained that there is no "bright line" for hazards—that is, 1,599 meters is not necessarily "dangerous," and 1,601 meters is not necessarily "safe."

- Nine of 15 experts agreed with Sandia's conclusion that only three of the five LNG tanks on a tanker would be involved in cascading failure. Five experts noted that the Sandia study did not explain how it concluded that only three tanks would be involved in cascading failure.

- Finally, experts agreed with Sandia's conclusion that consequence studies should be used to support comprehensive, risk-based management and planning approaches for identifying, preventing, and mitigating hazards from potential LNG spills.

The experts also suggested priorities for future research—some of which are not fully addressed in DOE's ongoing LNG research—to clarify uncertainties about heat impact distances and cascading failure. These priorities include large-scale fire experiments, large-scale LNG spill experiments on water, the potential for cascading failure of multiple LNG tanks, and improved modeling techniques. As part of DOE's ongoing research, Sandia plans to conduct large-scale LNG pool fire tests, beginning with a pool size of 35 meters—the same size as the largest test conducted to date. Sandia will validate the existing 35-meter data and then conduct similar tests for pool sizes up to 100 meters. Of the top 10 LNG research priorities the experts identified, only 3 have been funded in the DOE study, and the second highest ranked priority, cascading failure, was not funded. One expert noted that although the consequences of cascading failure could be serious, because the extreme cold of spilled LNG and the high heat of an LNG fire could damage the tanker, there are virtually no data looking at how a tanker would be affected by these temperatures.

Conclusions

It is likely that the United States will increasingly depend on LNG to meet its demand for natural gas. Consequently, understanding and resolving the uncertainties surrounding LNG spills is critical, especially in deciding where to locate LNG facilities. While there is general agreement on the types of effects of an LNG spill, the study results have created what appears to be conflicting assessments of the specific heat consequences of such a spill. These assessments create uncertainty for regulators and the public. Additional research to resolve some key areas of uncertainty could benefit federal agencies responsible for making informed decisions when approving LNG terminals and protecting existing terminals and tankers, as well as providing reliable information to citizens concerned about public safety.

To provide the most comprehensive and accurate information for assessing the public safety risks posed by tankers transiting to proposed LNG facilities, we recommended that the Secretary of Energy ensure that DOE incorporates the key issues the expert panel identified, particularly the potential for cascading failure, into its current LNG study.

DOE concurred with our recommendation.

Mr. Chairman, this concludes my prepared statement. I would be happy to respond to any questions that you or Members of the Committee may have.

Contacts and Acknowledgments

For further information about this testimony, please contact me at (202) 512-3841 or wellsj@gao.gov. James W. Turkett, Janice M. Poling, and Carol Herrnstadt Shulman also made key contributions to this statement.

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