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Liquefied Natural Gas

Ensuring its safe and secure marine transportation

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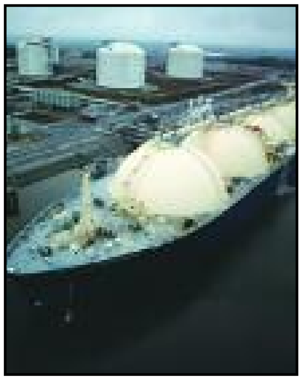

On the Cover

A liquefied natural gas (LNG) tanker docked at Trunkline LNG Company import terminal in Lake Charles, La. Courtesy Southern Union Company.

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Assistant Commandant's Perspective

by Rear Adm. T. H. Gilmour
Assistant Commandant for Marine Safety, Security & Environmental Protection

Liquefied natural gas, or LNG, has been up until recently an exotic commodity, delivered to only a few U.S. ports. But of late, LNG has emerged as a vital component of the United States' suite of energy resources. This will result in an increase in the number of ports and facilities that can and will handle LNG.

As the United States' energy needs continue to rise, its domestic natural gas production is nearing its peak. Canada's natural gas pipelines, our proximate and primary source of imported gas, are not expected to be able to meet the growing residential, industrial, and electricity-generating demands for natural gas. At the same time, the steady march of technology has significantly reduced the cost of natural gas liquefaction and transport, leading to a jump in the number of gas-producing countries that are eager to supply our natural gas demands. These "supply and demand" principles have united to fuel rapid growth in the international LNG market.

Currently, the United States consumes about 25 percent of the world's annual natural gas production, although over 95 percent of the entire world's proven natural gas reserves are outside of North America. Over the next 20 years, U.S. natural gas consumption is projected to increase by 40 percent, and it is doubtful that our domestic gas production will rise at the same rate. Therefore, the difference between our consumption and production will have to be made up by importing natural gas, and the most viable method of this is the seaborne importation of LNG.

In response to this critical need for imported LNG, Congress, in 2002, amended the Deepwater Port Act to include natural gas. The amended Act allows for the licensing of deepwater ports (DWPs) in the Exclusive Economic Zone along all of the maritime coasts of the United States. In cooperation with other federal and state agencies, the Coast Guard is responsible for processing applications for deepwater ports. The Department of Transportation's Maritime Administration is the actual licensing issuing authority for the deepwater ports. To date, the Coast Guard has processed three deepwater port applications, and eight others are in various stages of review.

For the siting of onshore LNG facilities, the Coast Guard works closely with the Federal Energy Regulatory Commission (FERC), which has primary responsibility for permitting onshore LNG operations. In concert with other agencies, the applicant, and interested stakeholders, the Coast Guard conducts a Waterway Suitability Assessment of the affected waterway for the additional LNG vessel traffic. This assessment addresses the navigational safety, waterways management, and port security issues introduced by the proposed LNG marine operations. The local Captain of the Port will make a recommendation as to whether all identified safety and security risks can be adequately mitigated or eliminated. This recommendation and the associated information are then used by FERC during its decision-making and permitting process.

Without a doubt, clean-burning natural gas is a critical element of our nation's energy mix. The forecasted growth of world LNG trade and imports will continue to drive the need for deepwater and onshore LNG terminals. The Coast Guard will ensure this vital product is **safely** and **securely** moved throughout our nation's waterways and delivered to these terminals.

T. H. Gilmour

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Champion's Point of View

by CAPT. LORNE THOMAS
Office Chief, U.S. Coast Guard Operating and Environmental Standards

Over the last few years, there has been a substantial increase in the worldwide production and transportation of liquefied natural gas (LNG). To increase the United States' ability to import LNG to meet this rising demand, the energy industry identified several potential sites for additional LNG import terminals along our coasts. Right on the heels of this shoreside facility expansion, the engineering and technology for deepwater LNG ports matured, and a 2002 amendment to the Deepwater Port Act opened the door for LNG deepwater port applications. Very quickly, the Coast Guard, in addition to several other federal agencies, became deeply immersed in the application and approval process for numerous shoreside and offshore deepwater LNG terminals.

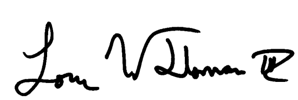
Meeting this challenge head-on, the Coast Guard has demonstrated its ability to rapidly adapt and adjust its resources to meet a compelling national need. In the field, the Captains of the Port, in consultation with their respective Harbor Safety and Area Maritime Security Committees, are busy assessing the waterways that the LNG ships will be navigating.

The overall safety record of the LNG industry is exceptional and continues to be well managed and effectively regulated. However, the security risks inherent with the movement of such large ships, full of a potentially volatile cargo, in today's indeterminate environment have added another level of complexity and, in some locations, controversy to the marine transport and transfer of the supercooled gas. However, the Captains of the Port are identifying and effectively implementing measures to mitigate the safety and security risks to the populace and critical infrastructure along those waterways.

The Office of Operating and Environmental Standards (G-MSO) is at the forefront of the Coast Guard Headquarters' effort to increase LNG throughput capacity. The Vessel and Facility Operating Standards Division (MSO-2) has developed policy relating to the siting of shoreside LNG terminals in concert with the Federal Energy Regulatory Commission, our federal partner in this initiative and the agency with the lead responsibility for permitting such terminals.

The Office's Deepwater Ports Standards Division (MSO-5) was created specifically to process the LNG deepwater port license applications in coordination with the Department of Transportation's Maritime Administration. The Coast Guard is charged with the responsibility of completing the Environmental Impact Statements for the deepwater ports. This division leads the environmental review effort within the federal government and also oversees the post-licensing work, including development of design, plan review, construction, inspection, and compliance standards.

This *Proceedings* issue is a compilation of articles on LNG from a diverse mixture of Coast Guard, government, industry, and academic members as well as other LNG stakeholders. We include a variety of topics and viewpoints, while welcoming different perspectives on the same issue or process. I appreciate the skill and professionalism of the *Proceedings* staff, and I would like to sincerely thank the authors for their time and talent putting together contributions for this edition. In closing, I would also like to acknowledge the continuing efforts and cooperation of the many agencies and industry representatives in achieving our mutual goal of ensuring the safe and secure marine transportation of LNG.



LNG: Liquefied Natural Gas

What is it? Is it safe?
What is the Coast Guard doing about it?

By Dr. A. Schneider
Chemical Engineer, Hazardous Materials Standards Division
U.S. Coast Guard Office of Operating and Environmental Standards (G-MSO)

What is LNG?
LNG is liquefied natural gas, which is the very cold liquid form of natural gas—the fuel that's burned in gas stoves, home heaters, and electric power plants. When it warms back up, LNG becomes natural gas again. You can't liquefy natural gas without cooling it. Many countries export and many others import LNG by ship; the United States does both.

What is LNG Chemically?
LNG, as mentioned, is very cold natural gas that is in a liquid form rather than gas. Chemically, it's mostly methane, with small amounts of ethane, propane, and butane. LPG (liquefied petroleum gas), sometimes referred to as bottled gas, is a heavier gas that can be liquefied under pressure or by refrigeration. It is mostly propane and butane. Gasoline is heavier still and is a liquid at room temperature. Heating oil is even heavier and doesn't boil unless heated. And asphalt is so heavy that it's a solid. But in a way they are all pretty similar, because they all burn.

Where Does LNG Come From?
LNG comes from natural gas that's been cooled to below -256 degrees F, with some impurities removed. Natural gas comes from underground gas fields by itself or in oil fields, along with crude oil. There's very little difference between natural gas and vaporized LNG; mostly LNG is a little purer; before liquefying the natural gas engineers remove the pollutants, like sulfur.

Where Do We Get LNG?
The U.S. gets liquefied natural gas from countries including Algeria, Brunei, Malaysia, Nigeria, Trinidad and Tobago, Oman, and Qatar. In the future we can expect the U.S. to get LNG from even more countries. Right now, there are 17 terminals worldwide where LNG is liquefied and pumped aboard LNG ships, and approximately 40 terminals where LNG is pumped off LNG ships and stored in large tanks on land and vaporized as needed by consumers. In the United States, natural gas is liquefied and exported from the Gulf of Alaska; LNG is imported and vaporized into natural gas at Boston, Mass.; Cove Point, Md.; Savannah, Ga.; and Lake Charles, La. Recently, a new offshore terminal in the Gulf of Mexico opened and took its first shipload of LNG. The Coast Guard and other agencies are reviewing as many as 40 more proposals for onshore and offshore LNG importation terminals; while we can expect that not all of these proposed terminals will be built, many will no doubt be.

Why Do We Have to Transport LNG on Tank Ships?
Normally, you ship natural gas by pipeline, but you can't build a pipeline from the Middle East or Africa to the United States, so engineers created ships capable of carrying the liquid form of natural gas. Natural gas needs to be liquefied (cooled to below -256 degrees F), because you'd need the volume capacity of 600 ships of natural gas at ambient temperature/pressure to equal one shipload of LNG. Since you can't afford to build and operate that many ships to carry that amount of natural gas, shipping LNG is the only practical way to import the necessary quantities that this country needs.

All LNG ships have two hulls, in effect a "double ship" that protects the cargo in a collision or grounding.

Is LNG Safe?

No fuel or petroleum product is completely safe: not coal, oil, or liquefied natural gas, all of which are carried on ships. LNG is a fuel, and, when it becomes a gas and mixes with air, it will burn. You can never consider anything that burns completely safe, even fairly innocuous materials like wood and cooking oil. But some are worse than others, and liquefied natural gas is far from the worst. When LNG vapor reaches an open flame, it easily catches fire and will burn everything within the vapor-air mixture; the same as when natural gas burns. Due to the extra care in designing, maintaining, and operating LNG ships, they all have excellent safety records. There have been some fires at shore facilities, but those are rare events. However, if a ship catches fire, it could be very serious. That's why the LNG industry and the Coast Guard are very careful about the movement of liquefied natural gas.

Is an LNG Ship a Floating Bomb?

No. LNG contains a great deal of energy, but so does a pile of coal. LNG is a liquid that won't burn until it becomes a vapor, and the vapor won't burn until it mixes with air and becomes diluted to between 5 percent and 15 percent LNG vapor in air. Above 15 percent, there's not enough air for it to burn, and below 5 percent, there's not enough LNG vapor to burn. LNG vapor clouds burn when they are in the 5-15-percent dilution range, but they don't explode. U.S. Coast Guard tests have demonstrated that unconfined LNG vapor clouds do not detonate, they only burn.

How Do The Hazards of LNG Compare?

Some cargoes are more hazardous, and some are less. Some cargoes are so bad that the Coast Guard doesn't allow them on tank ships. Liquefied chlorine is an example of one of these that the Coast Guard will not allow on tank ships, because it is too dangerous. On the other hand, the Coast Guard allows gasoline in tanks that are built to much less stringent design requirements than liquefied natural gas tanks. Because LNG's hazards are in between gasoline's hazards and liquefied chlorine's hazards, the Coast Guard allows it on tank ships (unlike chlorine) but with strict safety measures (more than those for gasoline).

What Do LNG Tank Ships Look Like?

LNG tank ships look different from regular tank ships carrying oil and chemicals. Each LNG tank ship has two hulls, so that, if a collision or grounding punctures the outer hull, the ship will still float and the LNG will not spill out. LNG tanks are either spherical (and the upper half of the sphere sticks out above the deck), or box-shaped. The ships tend to ride high in the water, even when loaded. A typical LNG ship is 950 feet long and 150 feet wide, and many new ships being built are even bigger.

Due to the extra care in designing, maintaining, operating, and inspecting LNG ships, they have an excellent safety record, with no major problems in more than 33,000 sea voyages.

How Are LNG Ships Designed?

LNG tank ships are designed with safety and security in mind. They must meet tough international and U.S. Coast Guard standards. These are high-tech ships, using special materials and designs to safely handle the very cold LNG. All ships have two hulls, in effect a double ship that protects the cargo in the event of a collision, grounding, or a terrorist act. Even before the ship construction has begun, government safety experts review the plans. The ships are inspected during construction and are periodically inspected after completion. International and U.S. Coast Guard rules cover just about every safety feature of these ships, as well as crew training standards.

What is LNG's Safety Record on Ships?

Everyone involved in liquefied natural gas transportation takes safety very seriously. There are many lives and a great deal of money at stake. Government and industry work together to make sure these ships are designed, maintained, and manned with safety in mind; industry maintains them with oversight by periodic government inspection, and government sets the standards for crew training. This has resulted in an outstanding safety record. Over the last 30 years, there have been about 33,000 LNG voyages worldwide, and on none of these has there been a significant LNG spill. Currently, there are approximately 180 LNG ships with about 110 more being built. They are so well designed that, even when a submarine surfaced directly under an LNG ship, there was no damage to the LNG tanks, even though there was damage to the tank ship's bottom.

The Future?

We can expect more LNG importation into the United States, which will require more Coast Guard involvement to enhance the safety and security of LNG marine operations within our ports. On several different dimensions, the Coast Guard will continue to mitigate the safety and security risks presented by importing LNG.

***About the author**: Dr. A. Schneider is a chemical engineer in the U.S. Coast Guard and began his career working with LNG safety issues in 1974. He has written many technical papers, most involving LNG.*

The Developing Market for LNG in the United States

Demand for natural gas is expected to exceed supply.

by Mr. Jeff C. Wright
Chief, Energy Infrastructure Policy Group, Office of Energy Projects, Federal Energy Regulatory Commission

The annual demand for natural gas in the United States is expected to increase to 30.7 trillion cubic feet (Tcf) by 2025.[1] Domestic production of natural gas will lag behind demand, increasing to only 22.4 Tcf by 2025, (Figure 1). Our customary natural gas trading partner, Canada, can no longer supply enough natural gas to bridge the gap between supply and demand. Therefore, to meet current and future demand for gas, the United States will need to increase its imports of natural gas from the only other possible source—liquefied natural gas, or LNG.

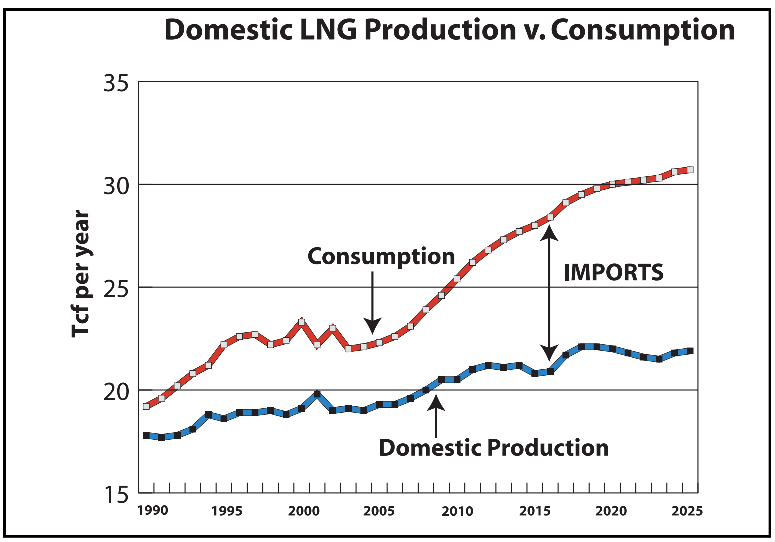


Figure 1: Domestic production of natural gas will not keep pace with demand.

Sources of Natural Gas

Traditionally, the vast majority of the U.S. natural gas supply is produced primarily from underground natural gas fields within our borders, both onshore and offshore. This domestic production peaked at 19.7 Tcf in 2001 and has actually declined to a production level of 18.9 Tcf in 2004. Until 1992, domestic production accounted for over 90 percent of the nation's gas supply.[2] To make up the shortfall between the nation's gas demand and its production, it has been necessary to import natural gas.

Since the late 1950s imported natural gas has made a contribution to the nation's gas supply, and its significance has only increased over time. In 2001 net imports (imports into the U.S., less exports to other countries) represented 16.2 percent of total U.S. consumption, an all-time high.[3] The vast majority of these imports come from Canada via pipeline (Figure 2). Until recently, Canadian natural gas accounted for over 90 percent of the natural gas imported into the U.S.[4] The remainder of the imported gas was liquefied natural gas. While LNG currently is a relatively small component of U.S. gas supply, its importance is increasing. In 2000, LNG represented 1 percent of U.S. gas consumption but increased to almost 3 percent by 2004.

Uses for Natural Gas

Natural gas demand in the United States is categorized by sectors. The residential sector makes use of gas primarily for space heating, cooking, and heating water. Commercial sector use is defined as the gas used by non-manufacturing entities such as hotels, restaurants, stores, and other service entities and government agencies. The industrial sector uses natural gas to heat plants and factories; to power machinery; as an ingredient in petrochemicals; in mining operations; and for various uses in agriculture, forestry, fisheries, and construction. Use for electric power consumption (the generation of electricity) is estimated to grow the most by 2025—a growth rate of over 3.1 percent per year—and is expected to be the largest single consuming sector.[5] A minor, but necessary, use of natural gas is as a fuel to assist in the gathering, processing, and transporting of gas to the end users. Table 1 shows the composition of U.S. gas consumption in 2004 and expected consumption in 2025.

Another use of gas, while not actually consumption, is the export of natural gas to Mexico. The United States has been a consistent net exporter of gas to Mexico since the mid-1980s, and the exports, while not a great portion of total gas consumption, have greatly increased in a relative sense since 1999. In 1999 net exports to Mexico totaled almost 93 billion cubic feet (Bcf)—approximately 0.1 Tcf—and increased to 397 Bcf in 2004 (about 0.4 Tcf), representing an increase of over 325 percent in five years. This is significant in that any net outflows of gas from the U.S. will have to be replaced by more imported gas.

Gas Supply Problems

U.S. gas demand is expected to increase by 40 percent by 2025; however, domestic supply, which has not equaled demand for many years, will only increase by 14.5 percent. Supply will not keep pace with this demand growth for several reasons. First, production from conventional underground gas deposits is projected to decline between now and 2025.[6] This decline is somewhat offset by increased gas production from non-conventional domestic gas sources (most notably coal-bed methane), increased production from deepwater sources (greater than 200 meters) in the Gulf of Mexico, and the commencement of deliveries of Alaskan gas to the lower 48 states. The Alaskan volumes are problematic, since there has been no application to construct the necessary infrastructure to transport the gas, and the timeline from application to first delivery is approximately 10 years.

A second problem is the flattening of gas production in Canada, the primary source of U.S. natural gas imports. The National Energy Board of Canada states,

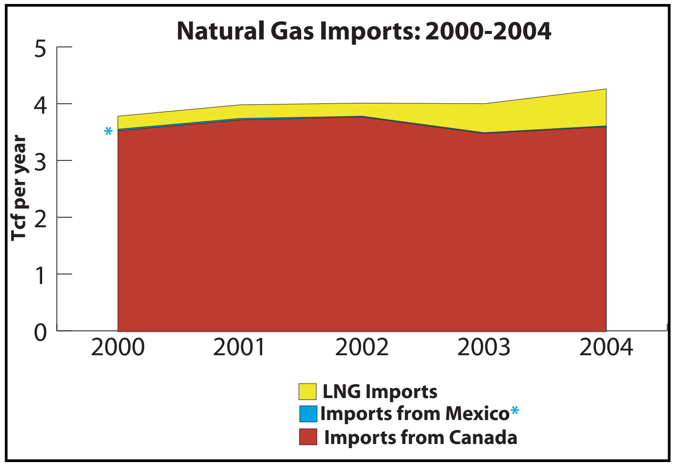


Figure 2: Canadian gas accounts for a large proportion of U.S. imports of natural gas, but LNG imports are beginning to play a larger role.

"The Western Canadian Sedimentary Basin accounts for more than 90 percent of the gas production in Canada and for about 23 percent of North American natural gas production annually. In the last few years, gas production from the WCSB appears to have flattened after many years of growth, leading to increased uncertainty about the ability of industry to increase or even maintain current production levels from the basin over the longer term."[7]

Sector	2004 Gas Consumption, in Tcf (Percent of Total Consumption)	Estimated 2025 Gas Consumption, in Tcf (Percent of Total Consumption)
Residential	4.9 (21.7%)	6.0 (19.5%)
Commercial	3.0 (13.3%)	4.1 (13.1%)
Industrial	7.4 (33.1%)	9.0 (29.3%)
Electric Power	5.4 (23.9%)	9.4 (30.7%)
Pipeline Uses	1.8 (7.9%)	2.1 (6.8%)

Note: Transportation uses of natural gas make up less than 1 percent of total consumption.
Source: Annual Energy Outlook 2005, Energy Information Administration, U.S. Department of Energy February 2005, Table 13.

Table 1: Composition of U.S. gas consumption in 2004 and expected consumption in 2025.

Canada's maturing gas production, along with a growing economy, will combine to constrain future imports to the U.S. Other problems are the onshore and offshore restrictions and moratoria on developing domestic gas reserves in the eastern Gulf of Mexico, along the Atlantic and Pacific Coasts, and in the Rocky Mountains. It is estimated that the complete moratoria on developing gas reserves on both coasts has denied access to 54 Tcf of natural gas.[8] Access to about 25 Tcf of reserves in the eastern Gulf of Mexico is prohibited.[9] Further, federal policies restrict access to 125 Tcf in the Rocky Mountain area, the location of one of the largest onshore reserves of natural gas in the U.S.[10]

Finally, as mentioned earlier, exports of gas to Mexico have increased greatly in the last few years. Although these exports do not constitute a large outflow of gas at present, if the Mexican economy continues to grow, its demand for gas will increase and require the U.S. to import an increasing amount of gas to meet, not only domestic needs, but also the needs of Mexico. Hopefully, Mexico will develop its own domestic reserves and commence the importation of LNG.

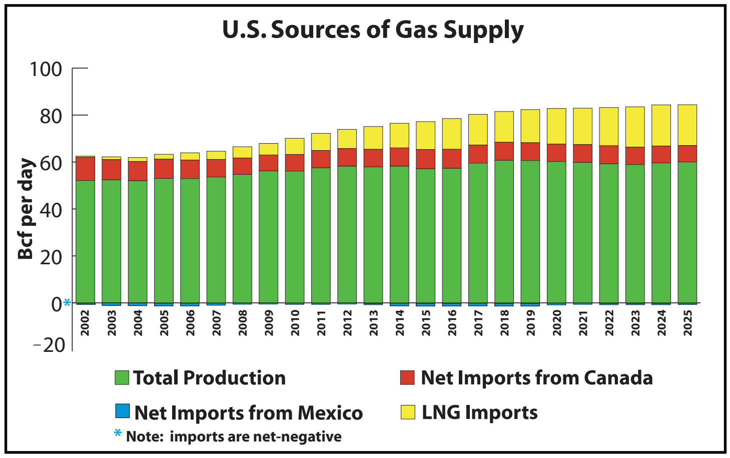


Figure 3: The U.S. will become increasingly dependent upon LNG imports as a component of its gas supply.

A "New" Source of Natural Gas?

The above discussion shows a need for a new source of natural gas for the U.S. to meet its increasing demands. Since this "new" source of gas will have to originate outside of the North American continent, there is only one option—LNG.[11] Although the U.S. has imported gas in the form of liquefied natural gas since 1971, the amount is relatively small, compared to the total gas consumption. Until 2000, LNG had been less than 1 percent of the U.S. gas supply. In that year, LNG imports reached 226 Bcf, about 1 percent of the U.S. gas supply. Still, this level of imported LNG would not meet the growing gap between supply and demand. A change in policy was necessary.

In October 2002 the Federal Energy Regulatory Commission (FERC) conducted a public conference on natural gas issues, which found that FERC's open access requirements were deterring investment in new LNG facilities in the U.S.[12] Conference participants argued that investors in LNG facilities "needed the assured access to terminal capacity that could not occur under open-season bidding...and that many foreign governments would not approve liquefied natural gas export projects without clear and certain access to markets."[13]

Subsequent to this conference, in December 2002, FERC issued a preliminary determination on a proposed LNG terminal in Hackberry, La., now known as the Hackberry Decision. The Hackberry Decision did not require open access service for the terminalling services that the new LNG terminal would offer. It noted that sales from the LNG terminal would be in competition with sales from other deregulated gas supply sources in the Gulf Coast region. Essentially, the Hackberry Decision removes LNG import facilities from a transportation function and equates them with traditional unregulated gas supply fields.

The Hackberry Decision states, "This approach may provide incentives to develop additional energy infrastructure to increase much-needed supply into the United States."[14] The Hackberry Decision also noted that the amendment to the Deepwater Port Act, the Maritime Transportation Security Act of 2002, which gave the Maritime Administration and the Coast Guard jurisdiction over the construction of LNG terminals in federal waters, provides that the license holder may have exclusive use of the capacity of the LNG terminal for its own use and need not offer its capacity on an open access basis.[15] As additional support for the Hackberry Decision, FERC reasoned that "onshore LNG facilities should be at competitive parity with offshore facilities."[16]

The resulting reaction to the policy changes has been greater than expected. Currently, the U.S. has about 4.2 Bcf per day of deliverability from five LNG terminals that bring gas into the lower 48 states. This includes the new Gulf Gateway offshore terminal that commenced service in March 2005. FERC has approved another 12 Bcf per day of deliverability at eight new terminals and expansions totaling 1.6 Bcf per day at two existing terminals. The Coast Guard and Maritime Administration have approved, in addition to the Gulf Gateway terminal, two other offshore terminals, with a combined deliverability of 2.6 Bcf per day. All told, 16.2 Bcf per day of deliverability has been approved for new and existing LNG terminals. In addition, FERC has also approved two projects totaling 1.7 Bcf per day of pipeline capacity that would transport regasified Bahamian LNG to Florida.

There are pending requests before FERC and the Coast Guard and Maritime Administration for 25.2 Bcf per day of deliverability at new and existing LNG terminals and 0.5 Bcf per day of capacity from another pipeline that would transport regasified Bahamian LNG to Florida. There are also other potential onshore and offshore sites totaling about 6 Bcf per day of deliverability. If that weren't enough, two sites in eastern Canada with a combined deliverability of 2 Bcf per day have received environmental approval and could potentially deliver natural gas to the U.S. Northeast. Also, Mexico has also approved two sites totaling 2.4 Bcf per day that not only could help supply its needs (and reduce U.S. exports to Mexico), but could also deliver volumes to the Western U.S. (Mexico has also approved a third terminal that would primarily supply an electric generation facility within the country. This gas would not be available for export to the U.S.).

The projected U.S. annual demand for natural gas by 2025 is 30.7 Tcf. This translates to an average daily demand of about 84 Bcf per day (Figure 3). The total daily deliverability of the LNG terminals that are in operation, have been approved, are currently pending, and could potentially be proposed is 53.8 Bcf, approximately 64 percent of the expected U.S. demand in 2025. Obviously, due to competitive reasons, for example, plants proposed in the same geographic area; stakeholder concerns; and the high capital cost of these plants, not all that have received or will receive approval will be built. More realistically, the National Petroleum Council, in its September 2003 report to the Secretary of Energy, estimated that nine new terminals and nine expansions to existing terminals would be built in North America and that LNG import capacity would be approximately 15 Bcf per day by 2025. This would amount to approximately 18 percent of U.S. gas supply in 2025.

Conclusion

The U.S. has recognized that it will not meet its gas demands in the future unless it expands the possible sources of gas supply beyond the North American continent. Current estimates of the world's proved reserves of natural gas total 6,040 Tcf, many times the amount of gas that the United States expects to consume by 2025.[19] As the world's demand for natural gas increases, not only will liquefaction capacity have to increase, but regasification capacity in the U.S. will have to expand to compete with other nations in the world LNG market. It should be noted that Japan and South Korea imported 60 percent of the 6.1 Tcf of LNG traded in 2004.[20] Timely policy changes by U.S. regulatory bodies have resulted in a plethora of requests for authorization to construct LNG terminals. To maintain our standard of living and grow our economy, LNG import capacity must expand in time to attract sellers and to meet the expected increase in gas demand.

About the author: *Mr. Jeff Wright is Chief, Energy Infrastructure Policy Group, Office of Energy Projects, Federal Energy Regulatory Commission. He earned a B.A. in economics from the College of William and Mary; and an M.B.A. from the University of Maryland. He serves on the faculty of the NARUC Annual Regulatory Studies Program. He has served as project manager on construction projects involving installation and expansion of natural gas pipelines.*

Endnotes

1 Annual Energy Outlook 2005, Energy Information Administration, U.S. Department of Energy, February 2005, Table 13.
2 Historical Natural Gas Annual, 1930 Through 2000, Energy Information Administration, U.S. Department of Energy, December 2001, Table 2.
3 Natural Gas Monthly, Energy Information Administration, U.S. Department of Energy, June 2005, Table 2.
4 Natural Gas Monthly, Energy Information Administration, U.S. Department of Energy, June 2005, Table 6.
5 Annual Energy Outlook 2005, Energy Information Administration, U.S. Department of Energy, Table 13.
6 Annual Energy Outlook 2005, Energy Information Administration, U.S. Department of Energy. Table 14.
7 Canada's Conventional Natural Gas Resources: A Status Report, National Energy Board, April 2004, pp. 9-10.
8 Balancing Natural Gas Policy – Fueling the Demands of a Growing Economy, National Petroleum Council, September 2003, Volume 1, p. 35.
9 Id., p. 35.
10 Id., p. 35.
11 This "new" source has been in use in the United States for close to 25 years. In 1971, deliveries of imported LNG commenced at the Distrigas LNG facility in Everett, Mass. There are now five terminals (including Everett) that regasify LNG and deliver it into the pipeline grid of the lower 48 states.
12 "Open Access" means that there is non-discriminatory, equal access to terminalling (i.e., vaporization) services at LNG facilities.
13 Hackberry LNG Terminal, L.L.C. (now Cameron LNG, LLC), 101 FERC ¶61,294 (2002), mimeo at p. 6.
14 Id., mimeo at p. 6.
15 Maritime Transportation Security Act of 2002, Pub. L. No. 107-295.
16 101 FERC ¶61,294 (2002), mimeo at p. 6.
17 The term "deliverability" refers to the amount of LNG that can be regasified and delivered into the pipeline grid.
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Regional LNG Update

Energy demand fuels liquefied natural gas import site development in the Gulf of Mexico.

by Mr. D. Blakemore
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Liquefied natural gas (LNG) import terminals in the Gulf of Mexico are not new. The Trunkline LNG import terminal located in Lake Charles, La., has operated since 1981. Fairly recent developments include the 18 proposals to build and operate LNG facilities both onshore and offshore in the Gulf of Mexico.

Focus on the Gulf

Within Eighth Coast Guard District boundaries, the Federal Energy Regulatory Commission (FERC) is processing (as this article is being written) 12 onshore permit requests (Figure 1). There are a total of 21 permit requests nationally, and the Coast Guard and the Maritime Administration (MARAD) are evaluating six deepwater projects, from a national total of 10 projects.

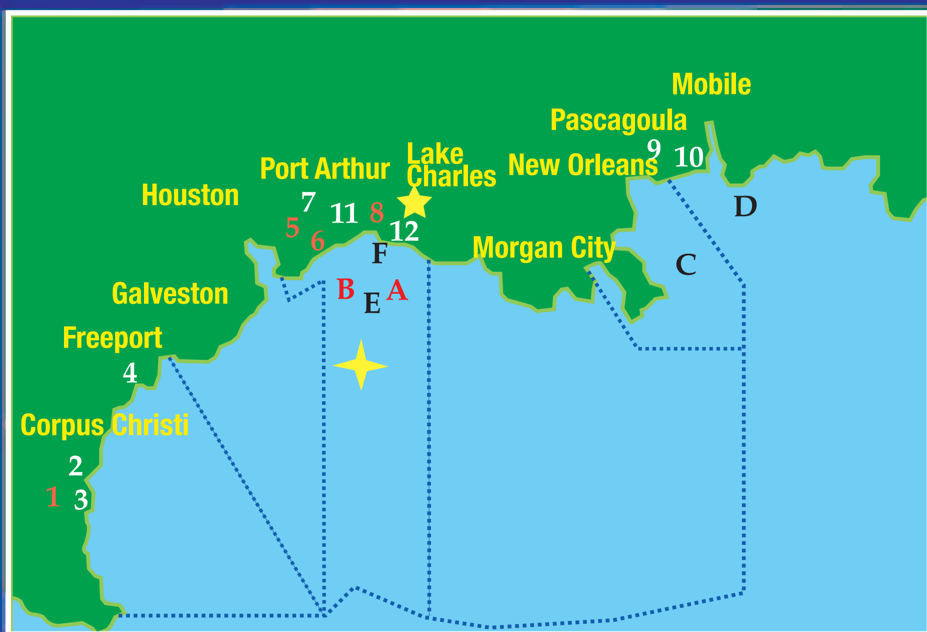
Additionally, Excelerate Energy LLC, a Texas-based LNG shipper, has received a deepwater port license from MARAD, constructed a port 116 miles south of the Louisiana coast, and has already delivered one load of LNG to the port. The Gulf Gateway Energy Bridge Deepwater Port was constructed in less than 15 months and, in March 2005, delivered almost 3 billion cubic feet of natural gas to United States downstream markets. Gulf Gateway Deepwater Port consists of an Energy Bridge regasification vessel and a submerged turret offloading (STL) buoy (Figure 2). The regasification vessel retrieves the STL buoy (which is connected to a gas pipeline), draws it into a specifically designed compartment within the ship, regasifies the LNG onboard the ship, then transfers the gas to markets onshore via pipelines. Figure 3 illustrates this system. Gulf Gateway is capable of delivering 690 million cubic feet of natural gas per day.

LNG Potential of the Gulf of Mexico

Not all proposed projects will come to fruition. The Department of Energy estimates that the United States will need nine additional large LNG import facilities to meet future natural gas consumption requirements. The Gulf of Mexico is attractive to LNG development for several reasons. For deepwater port projects, there is an extensive natural gas pipeline infrastructure already in place in the southern United States and the Gulf of Mexico that is capable of handling large quantities of natural gas. Tying into this existing gas pipeline system decreases expensive construction costs and minimizes environmental impacts caused by construction and dredging of lengthy new pipeline facilities.

There is an accessible and proven offshore supply and service industry located throughout Louisiana and Texas that can immediately support construction and operation of new deepwater ports. There are a

LNG Projects w/in D8 Boundaries



ID	PROJECT	COMPANY	STATUS
1	Cheniere Corpus	Cheniere	Approved
2	Vista Del Sol Corpus	Exxon Mobil	Processing
3	Ingleside Energy	Occidental	Processing
4	Freeport	Cheniere	Processing
5	Sabine Pass	Cheniere	Approved
6	Port Arthur LNG	Sempra	Approved
7	Golden Pass	Exxon Mobil	Processing
8	Cameron	Sempra	Approved
9	Casotte Landing	Chevron	Processing
10	Gulf	Gulf LNG	Processing
11	Creole Trail	Cheniere	Processing
12	Point Comfort	Calhoun LNG	Processing

ID	PROJECT	COMPANY	STATUS
A	Port Pelican	Cheniere	Approved
B	Gulf Landing	Exxon Mobil	Approved
C	Main Pass Energy Hub	Freeport MacMoran	Processing
D	Compass Port	Conoco Philips	Processing
E	Pearl Crossing	Exxon Mobil	Processing
F	Beacon Port	Conoco Philips	Processing

Deepwater Operating – Excelerate Energy

Onshore Operating – Trunkline LNG

Figure 1: LNG projects within Coast Guard District Eight boundaries.

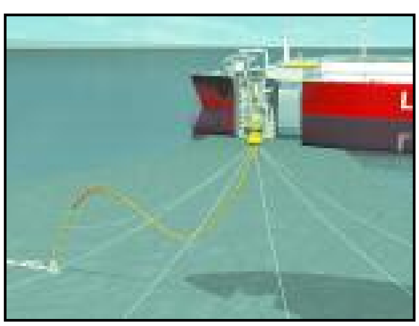
number of designated shipping fairways and harbor approaches that provide safe transit, free of surface and subsurface obstructions for large LNG carriers. There are several potential fabrication sites for concrete gravity-based structures that can be used as offshore LNG storage tanks located along the Gulf Coast. And, finally, water depths and water and air temperatures in the Gulf of Mexico are amenable to LNG deepwater ports.

A minimum water depth of approximately 50 to 60 feet is needed to berth LNG carriers. The continental shelf in the Gulf of Mexico extends out to 120 miles and has water depths from 60 to 600 feet. And, although extremely controversial, open rack vaporizer (ORV) regasification systems operate best in the tropical climate and warm Gulf waters as compared to colder waters found on the East and West Coasts. Onshore facilities located along the Gulf Coast also have attributes that are favorable for LNG site selections. Like deepwater ports, there is a vast gas pipeline infrastructure from Florida to Texas that provides easy access to Texas, Louisiana, and Mississippi gas markets. Connecting into these pipelines lessens the impact to the environment caused by new pipeline construction. There is ample land zoned for industrial use that is large enough to accommodate LNG storage tanks, regasification plants, and docking facilities. Much of this land is considered to be brownfield, or areas that have been previously disturbed and cleared of vegetation. This obviously minimizes the need to disturb pristine wildlife areas or wetlands. These tracts of land are also removed from populated areas. This eases security concerns and minimizes land-use conflicts with special interest groups. And, finally, there are numerous deepwater channels in the Gulf of Mexico that provide easy access for LNG vessels.

LNG tankers moored at the CMS Trunkline facility in Lake Charles, La.

Figure 2: Gulf Gateway submerged turret offloading buoy.

Figure 3. Basic STL buoy vessel configuration.



Gulf Controversy?

Potential growth of the LNG industry in the Gulf of Mexico has its opponents. Onshore facilities have drawn the skepticism of home and landowners who are wary of the safety and security of both LNG tankers and facilities. Deepwater ports have drawn strong interest from most federal and state environmental agencies, as well as local environmental, conservation, and commercial and recreational fisheries interest groups. At the heart of the deepwater port issue is industries' desired use of open rack vaporizers to regasify liquefied natural gas. Environmentalists claim that ORVs will significantly harm fisheries, while LNG project companies assert that ORVs will have minimal impact on oceanic environment. Unfortunately for both opponents and proponents, there is very little reliable data available to analyze or to project potential environmental impacts on Gulf fisheries.

Despite the concerns about LNG, the Coast Guard will be busy in the future with LNG development in the Gulf of Mexico.

The LNG Market and its Effects on Shipbuilding

Increasing demand for LNG fuels increased shipbuilding.

by Lt. Matt Barker
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Each year the demand for energy throughout the world increases drastically. This is especially true in the United States, where energy demand accounts for the majority of worldwide oil consumption. It is well known that the growing energy use is rapidly depleting the world's oil reserves, and, as a result, the oil production in many of the most prosperous oil fields is on the decline. With the demand for energy increasing and the supply of oil decreasing, other energy options need to be considered. One alternative energy source is liquefied natural gas (LNG). Liquefied natural gas has a small role in today's energy market, accounting for less than 10 percent of the market. However, with the discovery of new natural gas reserves and the evolution of LNG shipping capabilities, it is likely that the LNG market will continue to grow in the future.

Because it is neither economically feasible nor logistically possible to transport the world's supply of natural gas via pipelines, the use of cryogenic ships is necessary for intercontinental transport.

Global Natural Gas

The global reserves of natural gas are known to be in the range of 5,500 trillion cubic feet (Tcf), while estimates say that the total global reserve may be as large as 14,000 trillion Tcf.[1] Unfortunately these reserves are located in remote areas that are thousands of miles away from civilization. Due to the remote location of this resource, it is very difficult and expensive to transport natural gas to consumers. To span these large distances, pipelines are used to transport the gas over land and cryogenic ships are used to transport the gas in its liquid phase over the water. Because it is neither economically feasible nor logistically possible to transport the world's supply of natural gas via pipelines, the use of cryogenic ships is necessary for intercontinental transport.

Natural gas was once considered to be of little value and was largely ignored in exporting countries because there was no local demand for that resource. However, as new markets for LNG emerged across the globe, those countries possessing natural gas learned how to use the evolving LNG technologies to supply natural gas to markets around the world.[2] The major exporters of LNG are the countries of Algeria, Australia, Brunei, Indonesia, Libya, Malaysia, Nigeria, Oman, and the United Arab Emirates. With new LNG liquefaction facilities being built or planned, the countries of Egypt, Equatorial Guinea, Iran, Norway, Peru, Russia, Venezuela, and Yemen will soon join that list.

LNG Shipment

In the current natural gas market, liquefied natural gas is shipped in large volumes on ships that service dedicated routes. The price of these ships is continuing to drop, from a reported peak price of $280 million in 1995. The cost of a conventional LNG carrier is approximately $150 to $160 million, for a ship with a carrying capacity up to 145,000 m^3. LNG carriers are constructed with expensive cryogenic containment systems that are necessary to transport the natural gas in its liquid state at a temperature of -261 degrees F. However, the evolution in LNG technology is helping to reduce the construction costs.

These expensive ships are constructed for use on dedicated shipping routes, with contracts that last for as long as 20 years. This differs from the oil market, where conventional oil tankers are built on speculation.[3] These dedicated LNG shipping routes run strictly between the LNG production facility and a marine receiving terminal. Most liquefied natural gas carriers are owned by companies that own either the LNG liquefaction facility or the LNG receiving facility. Operating these LNG carriers on routes dedicated to guaranteed contracts helps to minimize the financial risks involved and provides a stable market for both the facility and ship owners.[4]

Plans for new LNG infrastructure, marine terminals, and gas carriers are growing, along with the increasing demand for natural gas throughout the world. In the near future it is predicted that the size of LNG ships will increase, while the cost of construction will continue to decrease. It appears that, as the future LNG markets expand throughout the world, the liquefied natural gas trade routes will evolve and become more flexible. It is likely that the newer LNG carriers will no longer be bound to long contracts that service only dedicated routes. The future LNG trade may involve carriers that are hired as needed to service emerging LNG production facilities and LNG marine terminals throughout the world. At the end of 2003, approximately 10 percent of the LNG carriers in operation or scheduled for construction were not under contract to service a dedicated route between production and receiving facilities.

Some liquefied natural gas market experts believe that by 2006 independent ship owners, or owners who are not tied to dedicated LNG routes, will control 36 percent of the liquefied natural gas market.[5] This prediction represents the common belief that the future LNG market will be much more dynamic and flexible. Actions taken by many of the large companies that either import or export LNG further support these predictions of the future LNG market. Recently, companies such as BP, Shell, and Tokyo Gas have placed orders for LNG ships that are not dedicated to a specific project.[6]

LNG Carriers

There are approximately 181 LNG carriers in operation today, with a total capacity of 21,143,964 m^3. All of these LNG carriers were built in Japan, Korea, Europe, or the United States. Of these, 16 ships have a capacity of less than 50,000 m^3; 15 ships have a capacity between 50,001 to 100,000 m^3; and 150 ships have a capacity between 100,001 m^3 and 150,000 m^3.

Plans for new LNG infrastructure, marine terminals, and gas carriers are growing, along with the increasing demand for natural gas throughout the world.

Most of the smaller LNG carriers have been in service for several decades, and it is likely that they will be replaced by much larger ships. In the first five months of 2005, there were five new LNG carriers added to the fleet with a combined carrying capacity

In the current natural gas market, liquefied natural gas is shipped in large volumes on ships that service dedicated routes.

of 699,000 m^3. The addition of these five LNG carriers represents a 3 percent net increase in the liquefied natural gas shipping capacity worldwide and is indicative of the expanding LNG market.[7]

The anticipated growth of the LNG market is well represented by the number of LNG carriers that are scheduled for construction. Throughout the world, shipbuilders currently have plans to build 115 new LNG carriers, with a combined total carrying capacity of more than 17,000,000 m^3. There are only nine shipyards in the world building LNG tankers: Three are in Japan, three are in Korea, two are in Europe, and one is in China. Among carriers now scheduled, two ships will have capacity of less than 50,000 m^3, three ships will have capacity between 50,000 to 100,000 m^3, 76 ships will have capacity between 100,001 to 150,000 m^3, 24 ships will have capacity between 150,001 to 200,000 m^3, and 10 ships will have capacity over 200,000 m^3.[8] This reveals that the trend in LNG shipbuilding is toward larger ships to accommodate the increasing LNG demand. The size of LNG carriers is expected to grow, but will be limited by the size of the ports at the marine terminals they service.

The future of LNG will be driven by the necessity to supplement declining oil reserves and the push for cleaner power generation throughout the world. The level to which the worldwide LNG market will grow still remains unclear. There are many complex economic, environmental, and safety factors that will dictate the future growth of LNG. The recent growth in the liquefied natural gas market, including new proposals for both production and receiving facilities, as well as increased LNG shipbuilding, indicate that liquefied natural gas will most certainly play an important role in the future global energy market. As demand for natural gas increases, the shipbuilding industry will adjust accordingly to ensure that the LNG fleet is able meet the needs of emerging liquefied natural gas markets.

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Liquefied Natural Gas Shipment

Public-private partnerships facilitate safety, security, and reliability.

by Mr. Joseph E. McKechnie
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Cmdr. Tom Miller
Chief, Prevention Department, U.S. Coast Guard Sector Boston

Mr. Mark Skordinski
Manager, Safety, Security, and Training; Distrigas of Massachusetts LLC

The liquefied natural gas (LNG) industry in the United States and other countries was developed to link huge gas reserves in geographically remote parts of the world with regions in need of more natural gas. For example, Japan and Korea import LNG to meet almost all their natural gas needs, and half of Spain's natural gas demand is met through the importing of LNG.

For over three decades, LNG operations have been safely conducted in Boston Harbor. Originally, barges fitted with tank trucks transported LNG from anchored LNG carriers (LNGCs) to Boston Gas Company's shoreside LNG facility in Dorchester, Mass. Starting in 1971, LNG began arriving at the Distrigas of Massachusetts LLC's marine import facility in Everett, Mass. As of June 2005, over 650 cargoes with volumes ranging from 60,000 to 140,000 cubic meters, accounting for roughly half of the LNG imported into the United States, have been delivered into the Port of Boston without serious incident.

LNG facilities throughout the world generally have had an excellent safety record. In November 2002, Congress enacted the Maritime Transportation Security Act of 2002, which expanded the Coast Guard's role in providing port security concerning a variety of maritime activities, including the marine transportation of oil, compressed natural gas, and LNG.

LNGC *Catalunya Spirit*. Courtesy SUEZ LNG NA and Distrigas of Massachusetts.

While hydrocarbon fuels such as oil and gasoline are routinely transported through metropolitan areas, Boston is the only U.S. city that receives LNG deliveries by ship in this manner. This proximity requires the management of those risks inherent to the marine transportation of petroleum products to be flawless. The Port of Boston Partnership for LNG Safety, a partnership between the U.S. Coast Guard Sector Boston and SUEZ LNG NA, is an example of cooperative partnering between private industry and governmental agencies.

Cooperation

Ensuring safe, secure, timely, and reliable shipping is directly related to how well a company interacts with its regulator(s). The LNG carrier *Berge Boston*, which is under a long-term charter to SUEZ LNG NA, was the first vessel in the world to meet the new International Code for the Security of Ships and of Port Facilities (ISPS) certification. In addition, the work with the Coast Guard to bring LNG ships into the Port of Boston became the model for the Coast Guard's Operation Safe Commerce Project, a nationwide effort to enhance transportation safety and security while facilitating commerce.

LNGC *Matthew* loading at Atlantic LNG in Point Fortin, Trinidad. Courtesy Atlantic LNG in Point Fortin, Trinidad.

The fundamental premise for the Port of Boston Partnership for LNG Safety was to identify all stakeholder port conditions challenging the transportation of LNG, provide prescribed responses where deemed appropriate, and develop guidelines for making critical decisions in response to conditions or incidents that may occur during the transit within Boston Harbor. Since the LNG industry has enjoyed a respectable safety record over the past 35 years, the work group relied upon the expert opinion of the stakeholders involved in the importation of LNG into Boston. Stakeholders included vessel agents; docking and harbor pilots; operational Coast Guard units; port authorities; citizen action groups; federal agencies such as the Federal Aviation Administration, Immigration and Customs Enforcement, and the Federal Bureau of Investigation (FBI); as well as state and local emergency response organizations.

LNGC *Berge Boston* backing under the Tobin Bridge in Boston Harbor. Courtesy Boston Towing and Transportation.

Through constructive engagement with these stakeholders, a comprehensive plan was jointly created to identify procedures and practices to assist in the decision-making process. By working in concert with the affected industry, Sector Boston carefully considered real-world input from many sources as partners in safety, rather than simply dictating conclusions in the more traditional regulator–regulated industry relationship. Requests for the plan have been received from such diverse locations as Belgium, Australia, Algeria, the United Kingdom, Qatar, Trinidad and Tobago, and Japan.

Closed-Loop Operations

Yet another key component of LNG security is what has become known as the closed loop. This idea grew from the post-September 11, 2001, question regarding terrorism threats and the perceived concern of LNG carrier hijacking on the high seas. To adequately secure the supply chain, loading ports have been vetted by Coast Guard personnel against ISPS standards, vessels have been confirmed to be in compliance with

LNGC *Berge Boston* was the first ISPS-certificated vessel. Courtesy SUEZ LNG NA and Distrigas of Massachusetts.

ISPS, and all U.S. LNG terminals have been found to be in full compliance with the applicable standards. Additionally, the vessels are equipped with satellite tracking systems that are monitored around the clock by both company personnel and the Coast Guard to ensure no anomalies in transit. As long as the vetted vessels continue to trade between the vetted loading and discharge ports without deviation, the integrity of the security system has been maintained. Should an operation breach the integrity of this closed loop, measures such as internal void space searches, crew validation, and/or underwater dive surveys are taken to bring it back under this umbrella.

LNGC Matthew **inbound to Boston Harbor. Courtesy of SUEZ LNG NA and Distrigas of Massachusetts.**

Ship Arrival and Transit Coordination

Arrival and transit coordination are critical to the continued on-time delivery of LNG cargoes to the Port of Boston. Due to the nature of the transit, the security posture employed necessitates skillful leveraging of the maritime law enforcement agencies. The management of operational missions in support of an LNGC transit demands lock step coordination among the Massachusetts State Police Marine Division, Massachusetts Environmental Police, Boston Police Department Marine Division, and the Coast Guard. To facilitate this planning effort, a series of pre-arrival notices are developed and provided to the partners for use in executing this safety and security mission:

1. Annually, SUEZ LNG NA coordinates with the Coast Guard and the partnering law enforcement agencies to determine blackout transit dates. This long-range planning avoids known conflicts in maritime operations and has served the port partners well.

2. A 30/5-day notice is provided for scheduled arrival dates. This medium-range plan sets the deliberate planning phase in motion.

3. A 96-hour advance notice of arrival is provided to the ship arrival and notification system. This solidifies a specific port call and sets in motion pre-arrival screening and boarding determinations.

4. Finally, 72/24/12-hour notices are provided to lock in resource assignment, inspection and boarding teams, and agency scheduling.

Transit coordination is truly a port-wide effort; it expands beyond the immediate law enforcement partners and includes steps to closely link the other maritime elements into the arrival and departure processes. At this time in history, the execution of LNGC transits has been very well practiced, and all the port players are well aware of the transit restrictions and are quick to make the necessary plans not to impact the LNGC transit. However, the Coast Guard conducts daily review of the vessel arrival sheet, marine event calendar, and other waterway activities to ensure that any transit conflicts are identified early and steps are taken to address them with the respective vessel agent, maritime agency, and/or pilots. Likewise SUEZ LNG NA has remained flexible by adjusting to last-minute requests for schedule changes, which strengthens the port-wide commitment to keeping commerce flowing.

A unified command system is also implemented, made up of law enforcement partners, and utilized to manage the LNGC inbound and outbound transits. The introduction of emerging technologies such as HAWKEYE, an integrated maritime surveillance system, into the unified command capabilities has added visual tracking resources, greatly enhancing the overall ability to monitor the execution of the operation from the remote location of the Sector Command Center. This has further expanded and leveraged the on-water capabilities to respond and react to on-water, air, or landside threats (actual or perceived).

Planning

Together, we have employed a systematic approach to determine security risks, implement detection and deterrent practices, and refine response and recovery practices. This approach uses the concept of risk management and, in particular, consequence reduction to address and manage safety and security issues.

After 9/11, SUEZ LNG NA recognized the operational impacts of a safety or security incident on any segment of the maritime transportation industry within the Port of Boston. A risk-based approach that assesses consequence determination, potential threats as communicated by the FBI and their outcomes, and a selection of appropriate risk controls was implemented to address any credible threat scenario. Specific risk controls designed to enhance safety and security have included:

- strengthened emergency, contingency, and business continuity plans;
- increased law enforcement liaison efforts;
- increased employee awareness;
- increased visitor and vehicle monitoring;
- installation of physical obstructions;
- investment in two high-powered tugboats with state-of-the-art fire control equipment;
- development of detailed security plans with deployment based on Homeland Security and Coast Guard threat levels; and
- participation on the Coast Guard's LNG Unified Command team.

LNGC Berge Boston **inbound to Boston Harbor. Courtesy SUEZ LNG NA and Distrigas of Massachusetts.**

The tug *Freedom*, a tractor tug, provides port-wide service. Courtesy SUEZ LNG NA and Distrigas of Massachusetts.

Of particular note is the shiprider program, where Coast Guard members are invited to board the vessel at either the loading port or the discharge port and ride the vessel to its next destination. This program provides an opportunity for Coast Guard members to interact with the officers and crew of the LNGCs in an informal setting and provides ample time to complete all required vessel inspections and tests. SUEZ LNG NA has also provided training to local first responders by hosting practical tabletop exercises, onboard orientation sessions, as well as simulator training for harbor pilots and docking masters.

All of these steps and initiatives have strengthened the capabilities of the Port of Boston Partnership for LNG Safety, but, equally important, the capabilities of the Port of Boston as a whole to detect, deter, and prevent a safety or security incident have been dramatically strengthened as well.

Conclusion

Both the initial and long-term success of any safety and security effort begins and ends with tangible processes: defining the mission; conducting planning that includes technology options; fostering a commitment from management; and developing an institutional culture conducive to doing things right the first time, every time. By committing to work together, the vital energy resource of LNG will continue to be delivered to the residents of New England in the safest and most secure manner possible.

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Cmdr. Tom Miller is the Chief, Prevention Department, at U.S. Coast Guard Sector Boston, Mass. He earned a B.S. in marine engineering from the U.S. Coast Guard Academy in 1989. In 1996 he earned two M.S. degrees from the Massachusetts Institute of Technology: one in naval architecture and marine engineering and the second in mechanical engineering. Cmdr. Miller has over 14 years of marine safety experience, including tours at Marine Safety Office Boston, Office of Design and Engineering Standards Naval Architecture Division, and Marine Safety Office Puget Sound.

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Accidents, Incidents, Mistakes, and the Lessons Learned From Them

The sometimes volatile history of liquefied natural gas.

by MR. JOSEPH J. NICKLOUS
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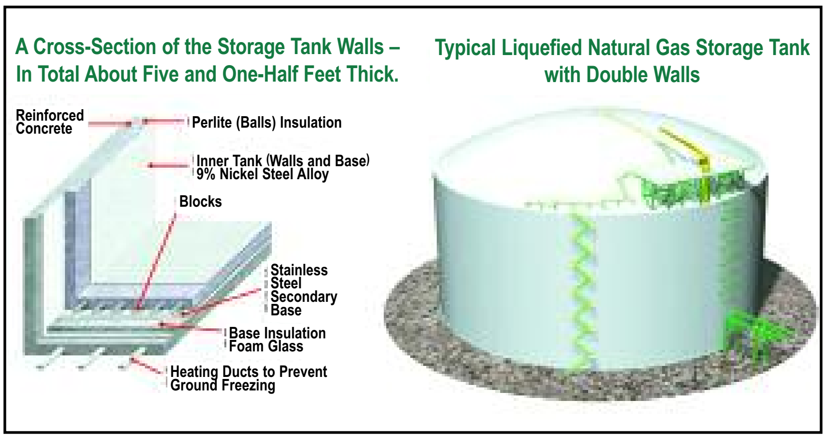

Figure 1: Modern LNG tanks are double walled, to contain any leakage.

The cooling of a gas to a liquid (liquefaction) dates back to the 19th century, when British chemist and physicist Michael Faraday experimented with liquefying gases, including natural gas.[1] In 1873 the first practical compressor refrigeration machine was built in Munich by German engineer Karl Von Linde.

Liquefied natural gas (LNG) compresses to a small fraction of its original volume (approximately 1/600) under liquefaction. With the amount of flammable material that LNG contains, it has the potential to be an extremely dangerous chemical, if handled improperly. The liquefaction of natural gas raised the possibility of its transportation to many destinations. In January 1959 *Methane Pioneer*, a converted World War II freighter containing five aluminum prismatic tanks, carried a liquefied natural gas cargo from Lake Charles, La., to Canvey Island, United Kingdom. This demonstrated that the transportation of large quantities of LNG safely across the ocean was possible.

The Cleveland Incident

In 1941 the first commercial LNG plant was built in Cleveland, Ohio. This plant ran without incident until 1944. That year, the plant expanded and added an additional LNG tank. This tank was added during World War II, when stainless steel alloys were scarce. Therefore, low-nickel alloy (3.5-percent nickel) was substituted in the construction of the tank. Low-nickel steel does not have the same properties as stainless steel, and, shortly after going into service, the tank failed.

At the time of failure, the tank had been filled to capacity, and the failure caused the contents of the entire tank to be emptied into the streets and sewers of the surrounding city. When the vapors from this spill ignited, the ensuing fire engulfed the nearby tanks and surrounding areas. Within 20 minutes of the initial release of LNG, a second spherical tank failed, due to the weakening from the fire. During the entire incident, 128 people were killed, 225 were injured, and 475 surrounding acres were directly impacted.

The primary reason for this failure was the initial substitution of low-nickel steel for stainless steel. The steel that was used in the construction of the tank is now known to be susceptible to brittle fracture at the temperature at which LNG is stored (-260 degrees F). The location of the facility was also to blame for the accident. The vibrations produced from a nearby bombshell stamping plant and heavily traveled railroad station probably accelerated the crack propagation. The outer wall of the tank was made of carbon steel, which cannot withstand direct contact with liquefied natural gas, and this most likely fractured immediately upon contact with the LNG. Additionally, the diking around the tanks was insufficient for the volume of LNG that was contained within the tank. This allowed the liquefied natural gas to escape the immediate area, spread over a wider area, and worsen the impact once the vapor cloud ignited.

Other Land-Based LNG Incidents

Since the Cleveland event, there are only four other land-based LNG incidents that resulted in any fatalities. The incidents occurred in Arzew, Algeria, 1977; Cove Point, Md., 1979; Bontang, Indonesia, 1983; and Skikda, Algeria, 2004. These fatalities were strictly limited to plant and facility personnel. The incidents caused no damage or harm to people of the surrounding community.

The remaining reported land-based incidents involving LNG facilities can be grouped into several categories, including:

- leaks or spills that resulted in minor damage to the facility,
- construction accidents in which no liquefied natural gas was present,
- vapor releases that either ignited or did not ignite.

Of these remaining reported incidents, some involved injuries of some sort solely involving employees of the plant or facility. Opponents of LNG cite these incidents in or around LNG plants or facilities that resulted in fatalities. But while many of these incidents may have occurred in close proximity to LNG, none of these were directly attributable to LNG.

LNG Facility Safety Equipment and Technology

The incident at the LNG peak-shaving facility in Cleveland enabled the LNG community to become a safer industry, due to a wide variety of changes in LNG regulations dealing with issues ranging from liquefied natural gas storage to its transportation. The causes of the Cleveland mishap, such as the substitution of a weaker alloy steel and the inadequate diking around the storage tank, magnified this incident to become the example that is most often cited when talking about the risks associated with LNG. However, it should be understood that the Cleveland facility would not meet today's LNG safety standards.

The Federal Energy Regulatory Commission (FERC) requires safety zones around LNG facilities. These distances must be great enough so that flammable vapor cannot reach the property lines. Also, tanks must be spaced far enough apart from each other to prevent a fire in one tank from causing failure to an adjacent tank.

Modern tanks feature double walls, with the outside tank being able to completely contain the contents of the inner tank should there ever be a leak (Figure 1). Older, single-walled tanks must be surrounded with embankments large enough to contain the entire contents of the LNG tank. These are both requirements of the National Fire Protection Association (NFPA). NFPA requirements also address the protection of facilities from earthquakes. No LNG storage tank failures have occurred due to seismic activity since the implementation of these regulations.

Improvements in technology in cryogenics pointed out the flaw of using low-nickel steel for cryogenic applications; therefore, tanks are now made with 9-percent nickel-steel, which does not become brittle at low temperatures. In their 35-year history, these tanks have never had a crack failure.

LNG Vessel Safety

The safety record for LNG transportation by vessel has a history that is enviable by almost all other heavily transported dangerous commodities. Since 1959, when the commercial transportation of liquefied natural gas began, there has never been a shipboard death involving liquefied natural gas. The LNG tank ship fleet currently consists of 180 carriers and has so far safely delivered over 33,000 shiploads, while covering more than 60 million miles.

The LNG fleet delivers more than 110 million metric tons annually to ports around the world. According to the U.S. Department of Energy, over the life of the industry, eight marine incidents worldwide have resulted, involving the accidental spillage of liquefied natural gas. In these cases, only minor hull damage occurred, and there were no cargo fires. Seven additional marine-related incidents have occurred, with no significant cargo loss. This safety record is attributable to continuously improving tanker technology, tanker safety equipment, comprehensive safety procedures, training, equipment maintenance, and effective government oversight.

Government Oversight

The U.S. Coast Guard (USCG) is responsible for assuring the safety of marine operations at LNG terminals and of tankers in U.S. coastal waters. It regulates the design, construction, manning, and operation of LNG vessels and the duties of LNG ship officers and crews. USCG rules often incorporate International Maritime Organization codes for construction and operation of ships.

USCG:

- inspects LNG ships, including foreign flag vessels, to ensure they comply with safety regulations;
- works with terminal and ship operators and host port authorities to ensure policies and procedures conform to required standards;
- works with operators to conduct emergency response drills and joint exercises to test response plans;
- ensures that operators have adequate safety and environmental protection equipment and procedures in place to respond to an incident;
- determines the suitability of a waterway to transport liquefied natural gas safely;
- creates safety rules for specific ports. For example, in cooperation with port captains, it sets port safety zones and may require tug escorts. A buffer zone is required for each tanker.

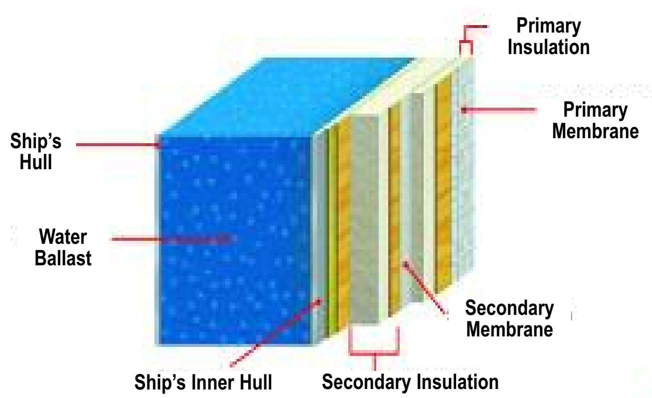

Figure 2: LNG carriers feature double hulls.

LNG Vessel Safety Equipment and Technology

Liquefied natural gas is transported in double-hulled ships designed to prevent leakage or rupture in an accident. For most LNG carriers, the cargo is stored in either membrane containment systems made of special materials or in spherical tanks located within the ship's inner hull. For membrane containment systems, a complete secondary containment system surrounds the primary container. The insulation space between the two has sensing equipment able to detect even the smallest presence of methane (the main component of natural gas), possibly indicating a leak of LNG (Figure 2).

LNG is stored unpressurized at an extremely cold temperature (-260 degrees F). Should a tank ever fail and a leak result, fire is possible, but only if there is the right concentration of liquefied natural gas vapor in the air and a source of ignition. Since such a combination rarely exists, explosions are highly unlikely. According to FERC, "LNG is not explosive. Although a large amount of energy is stored in LNG, it cannot be released rapidly enough to cause the overpressures associated with an explosion." FERC adds, "LNG vapors (methane) mixed with air are not explosive in an unconfined environment." [2]

LNG ships have emergency shutdown systems that can identify potential safety problems and shut down operations. This significantly limits the amount of liquefied natural gas that could be released. Fire and gas detection and fire fighting systems help address the risk of fire. Special operating procedures, training, and maintenance further contribute to safety.

LNG vessels also have equipment to make ship handling safer. This equipment includes sophisticated radar and positioning systems that enable the crew to monitor the ship's position, traffic, and identified external hazards. A global maritime distress system automatically transmits signals if an onboard emergency occurs that requires external assistance. In addition, some LNG ships use velocity meters to ensure safe speeds when berthing. When moored, automatic line monitoring helps keep ships secure. When connected to the onshore system, the instrument systems and the shore-ship LNG transfer system act as one, allowing emergency shutdowns of the entire system both from ship and from shore.

Future Outlooks

The popular perception of liquefied natural gas is that it is inherently dangerous. While it possesses a set of hazards that need to be managed, when looking at the actual incidents involving liquefied natural gas, there are very few that put the surrounding area and public in danger. The rigorous attention to detail, coupled with the constantly emerging technology, should continue to give LNG one of the better safety records for a hazardous material.

[1]Source material for this article was obtained from the following:
The Center for Liquefied Natural Gas, "LNG Vessel Safety," http://lngfacts.org/marine_information/vessel_safety.html.
The Center for Liquefied Natural Gas, "LNG Facility Safety," http://www.lngfacts.org/facilities/fac_safety.html.
CH•IV International, "Safety History of International LNG Operations," January 2005.
[2]FERC website, http://www.ferc.gov/industries/gas/indus-act/lng-safety.asp.

Liquefied Natural Gas Risk Management

Risk and safety issues resulting from large LNG spills over water.

by Mr. Michael Hightower and Mr. Louis Gritzo
Sandia National Laboratories

The increasing demand for natural gas in the United States could significantly increase the number and frequency of marine liquefied natural gas (LNG) imports. While many studies have been conducted to assess the consequences and risks of potential LNG spills, the increasing importance of marine LNG imports suggests that consistent methods and approaches be identified and implemented to help improve public safety.[1,2,3,4]

While standard procedures and techniques exist for the analysis of the potential hazards from an LNG spill on land, no equivalent set of standards currently exists for LNG spills over water. This is due in part to the lack of large-scale data of LNG spills onto water, as well as the much more complicated physical and dispersion phenomena that occur when a very cold liquid, such as liquefied natural gas, is spilled onto water.

LNG Spill Risk Analysis

For these reasons, the U.S. Department of Energy (DOE) requested that Sandia National Laboratories develop guidance on a risk-based analysis approach to assess and quantify potential hazards and consequences of a large liquefied natural gas spill during marine transportation. Sandia was also tasked with reviewing strategies that could be implemented to help reduce the possibility of a spill during maritime transportation, as well as to mitigate the hazards and risks associated with such a spill.

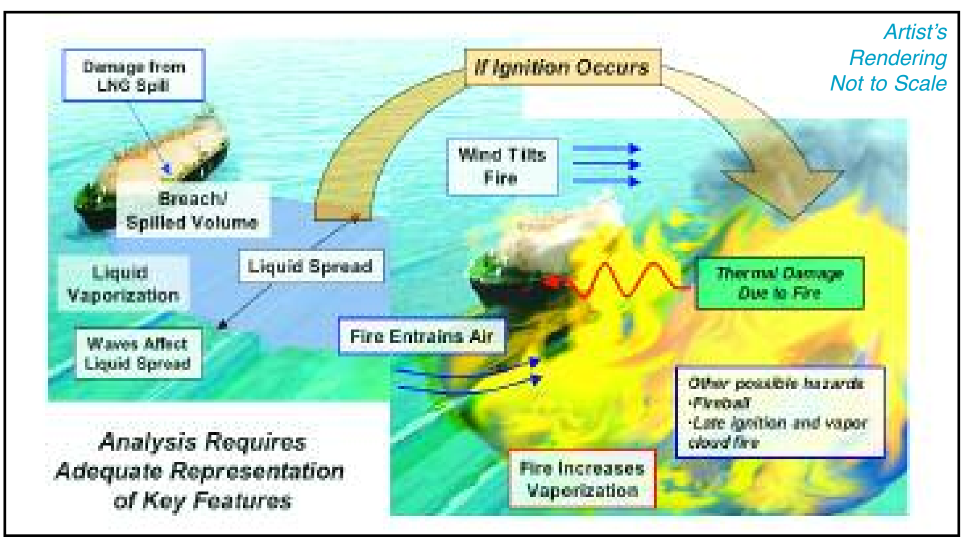

Figure 1: Key features impacting possible LNG carrier spills.

To support this effort, Sandia worked with DOE, the U.S. Coast Guard, LNG industry and ship management agencies, LNG shipping consultants, and government intelligence agencies to collect background information on LNG ship and cargo tank designs, accident and threat scenarios, and standard LNG ship safety and risk-management operations.

The results of the Sandia study were peer reviewed by both federal agency and external technical panels and are available in a Sandia report, "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water."[5]

The purpose of the report is to provide guidance to communities and agencies dealing with potential marine LNG imports on the general safety, security, and hazard issues associated with a potential spill, and where to focus risk-prevention and mitigation efforts to improve public safety. Because site-specific conditions, such as nearby terrain and obstacles, wind conditions, waves, and currents, impact the dispersion and consequences of an LNG spill, the report provides the expected range of hazards rather than specific hazard distances.

Factors Impacting an LNG Cargo Tank Breach and Spill

Figure 1 provides a conceptual idea of the processes that can occur during a liquefied natural gas spill. First, an LNG cargo tank must be breached, either from an event such as a collision or grounding, or possibly from an event such as an intentional attack. Quantifying the likelihood and result of such events impacts the probable volume and duration of the LNG spill as well as the associated hazards. Many variables influence the amount of LNG spilled during an event, including the type of event and the location of the breach, the cargo tank geometry and construction materials, and the LNG vessel size and design.

Depending on the size and location of an LNG cargo tank breach, liquefied natural gas could spill onto or into the LNG ship, flow from the breach onto the water surface, or both. Depending on whether there is early or late ignition, LNG dispersion will occur through volatilization of the LNG from contact with the much warmer water and be transported as a vapor cloud in the air or as a liquid on the water surface. Several variables must be considered in assessing the impacts of an LNG spill, including potential ignition sources, ignition times, and site-specific environmental factors.

These will determine whether the liquefied natural gas will disperse without igniting, burn as a pool fire, or burn as a vapor fire. Any assumptions made can have a significant impact on the estimates of the hazard levels and distances for a liquefied natural gas spill and should be carefully evaluated.

Potential Hazards of Large LNG Spills over Water

To assess the potential hazards of a large LNG spill over water, existing experimental data were evaluated and analysis and modeling were used to assess several potential hazards, including asphyxiation, cryogenic burns, and cryogenic damage to the ship from the very cold LNG, dispersion, fires, and explosions. Available accidental and intentional threat information was used to identify possible breaching scenarios. Based on this review, the most likely hazards to people and property would be thermal hazards from an LNG fire. Cryogenic and fire damage to an LNG ship were also identified as concerns that could cause additional damage to LNG cargo tanks following an initial cargo tank breach, though the additional impact on public safety would be limited.

The hazard analysis results are presented in Tables

HOLE SIZE (m^2)	TANKS BREACHED	DISCHARGE COEFFICIENT	BURN RATE (m/s)	SURFACE EMISSIVE POWER (kW/m^2)	POOL DIAMETER (m)	BURN TIME (min)	DISTANCE TO 37.5 kW/m^2 (m)	DISTANCE TO 5 kW/m^2 (m)
ACCIDENTAL EVENTS								
1	1	.6	$3x10^{-4}$	220	148	40	177	554
2	1	.6	$3x10^{-4}$	220	209	20	250	784
INTENTIONAL EVENTS								
5	3	.6	$3x10^{-4}$	220	572	8.1	630	2118
5*	1	.6	$3x10^{-4}$	220	330	8.1	391	1305
5	1	.9	$3x10^{-4}$	220	405	5.4	478	1579
5	1	.6	$8x10^{-4}$	220	202	8.1	253	810
12	1	.6	$3x10^{-4}$	220	512	3.4	602	1920

*nominal case

Table 1: Potential thermal hazard distances for several possible breaching events.

1 and 2 for fire and dispersion, respectively, for several possible breach scenarios. The results assume spill volumes of one-half the contents of a standard LNG cargo tank, approximately 12,500 m^3, for each LNG cargo tank breached. As shown, accidental events cause smaller breach sizes and subsequently smaller hazard distances than intentional events. The expected breach sizes from intentional threats can range from 2-12 m^2. A nominal breach size for an intentional event was found from this analysis to be in the range of 5 m^2 and is the nominal value shown in Table 2.

HOLE SIZE (m2)	TANKS BREACHED	POOL DIAMETER (m)	SPILL DURATION (min)	DISTANCE to LFL (m)
ACCIDENTAL EVENTS				
1	1	181	40	1536
2	1	256	20	1710
INTENTIONAL EVENTS				
5	1	405	8.1	2450
5	3	701	8.1	3614

Table 2: Potential lower flammability limit (LFL) distances for possible vapor dispersions.

Most intentional events are expected to provide an ignition source, such that a pool fire occurs and the likelihood of a large unignited release of LNG is unlikely. The 37.5 kW/m^2 and 5 kW/m^2 values shown in Table 1 are thermal flux values commonly recognized for defining hazard distances for LNG.[6] The 37.5 kW/m^2 is a level suggesting severe structural damage and major injuries if expected for over 10 minutes. The 5 kW/m^2 is a level suggesting second-degree skin burns on exposed skin if expected for periods of over about 20 seconds, and is the value suggested as the protection standard for people in open spaces. The distances shown in Table 2 are to the lower flammability limit (LFL) or the lowest level at which liquefied natural gas will burn. This value is commonly used as the maximum hazard distance for a vapor dispersion fire.

The results suggest that thermal hazards will occur predominantly within 1600 meters of an LNG spill, with the highest hazards generally in the near field (approximately 250–500 meters of a spill). While thermal hazards can exist beyond 1600 meters, they are generally lower in most cases.

Risk Management Approaches for Marine LNG Transport

Risks and hazards from a potential marine LNG spill can be reduced through a combination of approaches, including reducing the potential for a spill, reducing the consequences of a spill, or improving LNG transportation safety equipment, security, or operations to prevent or mitigate a spill.

For example, a number of international and U.S. safety and design standards have been developed for LNG ships to prevent or mitigate an accidental LNG spill over water. These standards are designed to prevent groundings, collisions, and steering or propulsion failures. They include traffic control, safety zones around the vessel while in transit within a port, escort by Coast Guard vessels, and coordination with local law enforcement and public safety agencies. These efforts have been exemplary, and, in more than 40 years of LNG marine transport operations, there have been no major accidents or safety problems either in port or on the high seas.[7] In addition, since September 11, 2001, additional security measures have been implemented to reduce the potential for intentional LNG spills over water. They include earlier notice of a ship's arrival (from 24 hours to 96 hours), investigation of crew backgrounds, at-sea boardings of LNG ships, special security sweeps, and positive control of a liquefied natural gas ship during port transit.

Other proactive risk management approaches can help reduce both the potential for and hazards of such events. These include:

- improvements in ship and terminal safety/security systems—including im-proved surveillance, tank and insulation upgrades, tanker standoff protection systems;
- modifications and improvements in LNG tanker escorts, extension of vessel movement control zones, and safety operations near ports and terminals;
- improved surveillance and searches of tugs, ship crews, and vessels;
- redundant or offshore mooring and offloading systems; and
- improved emergency response systems to reduce fire and dispersion hazards and improved emergency response coordination and communication.

Risk prevention and mitigation techniques are especially useful in zones where the potential impact on public safety and property can be high. Therefore, risk identification and risk management processes should be conducted in cooperation with appropriate stakeholders, including public safety officials and elected public officials and include site-specific issues and conditions, available intelligence, threat assessments, safety and security operations, and available resources.

Guidance on Risk Management for Marine LNG Transport

Based on the analyses conducted, the following general risk management "zones" have been recommended:

Zone 1: These are areas in which LNG shipments transit narrow harbors or channels, pass under major bridges or over tunnels, or come within approximately 250 meters to 500 meters of people and major infrastructure elements, such as military facilities, population and commercial centers, or national icons. Within this zone, the risk and consequences of an LNG spill could be significant and have severe negative impacts. Thermal radiation poses a severe public safety and property hazard, and can damage or significantly disrupt critical infrastructure located in this area.

Risk management strategies for LNG operations in this zone should address both vapor dispersion and fire hazards. Therefore, the most rigorous deterrent measures, such as vessel security zones, waterway traffic management, and establishment of positive control over vessels are options to be considered as elements of the risk management process. Coordination among all port security stakeholders is essential. Incident management and emergency response measures should be carefully evaluated to ensure adequate resources such as firefighting and salvage are available for consequence and risk mitigation.

Zone 2: These are areas in which LNG shipments and deliveries occur in broader channels or large outer harbors, or within approximately 250 – 750 meters for accidental spills or 500 - 1500 meters for intentional spills, of major critical infrastructure elements like population or commercial centers. Within Zone 2, the consequences of an LNG spill are reduced and risk reduction and mitigation approaches and strategies can be less extensive.

In this zone, risk management strategies for LNG operations should focus on approaches dealing with both vapor dispersion and fire hazards. The strategies should include incident management and emergency response measures such as ensuring areas of refuge like enclosed areas and buildings are available, development of community warning signals, and community education programs to ensure persons know what precautions to take.

Zone 3: This zone covers LNG shipments and deliveries that occur more than approximately 750 meters for accidental spills or 1600 meters for intentional spills, from major infrastructures, population/commercial centers, or in large bays or open water, where the risks and consequences to people and property of an LNG spill over water are minimal. Thermal radiation poses minimal risks to public safety and property.

Within Zone 3, risk reduction and mitigation strategies can be significantly less complicated or extensive. Risk management strategies should concentrate on incident management and emergency response measures that are focused on dealing with vapor cloud dispersion. Measures should ensure areas of refuge are available, and community education programs should be implemented to ensure that persons know what to do in the unlikely event of a vapor cloud.

Endnotes

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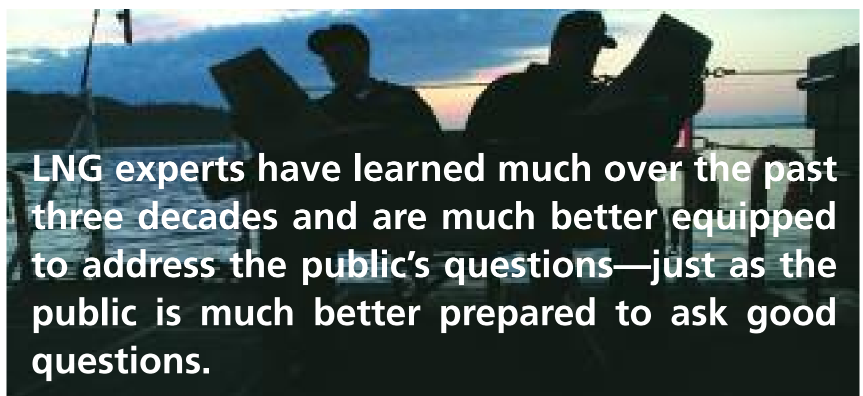
Mr. Michael Hightower is a distinguished member of the technical staff in the Energy Systems Analysis Department at Sandia. He is involved in activities in support of critical infrastructure safety, security, and reliability. He currently leads research and development programs in water and energy resource sustainability and water and energy infrastructure security and protection.

Mr. Louis Gritzo is the manager of the Fire Science and Technology Department at Sandia. His organization is responsible for laboratory and large-scale fire science research and testing, as well as development of modern analytic tools for fire, dispersion, and thermal analysis. Mr. Gritzo is the author or co-author of numerous papers and reports on fire modeling, testing, and analysis.

LNG and Public Safety Issues

Summarizing current knowledge about potential worst-case consequences of LNG spills onto water.

by Jerry Havens
Professor, Chemical Engineering, University of Arkansas



LNG experts have learned much over the past three decades and are much better equipped to address the public's questions—just as the public is much better prepared to ask good questions.

In 1976 Coast Guard Admirals were being called to Capitol Hill to answer the question: If 25,000 m^3 of liquefied natural gas (LNG) were spilled on water without ignition, how far might a flammable cloud travel before it would not pose a hazard? As technical advisor to the Office of Merchant Marine Safety in the Coast Guard's Bulk Hazardous Cargo Division, I was assigned to provide an answer on the LNG vapor cloud issue within a couple of weeks. Although no longer with the Coast Guard, I am still working on the problem 30 years later.

Past Lessons

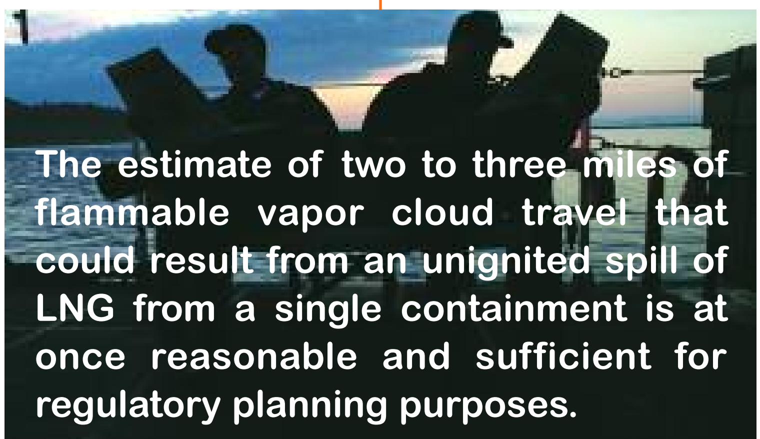
The tragic events of September 11, 2001, changed everything. Watching the World Trade Towers fall sharply focused my research of LNG spills on water. It is understood now that the towers fell because the insulation was knocked off the steel, which could then not withstand the extreme fire exposure. The lesson from this is to understand the consequences of such events, not only in planning for decisions that are within our control, but in planning for events over which we may have little or no control.

LNG experts have learned much over the past three decades and are much better equipped to address the public's questions—just as the public is much better prepared to ask good questions. For space constraints this discussion sidesteps many important issues in the LNG debate; however, it summarizes what is currently known about potential worst-case consequences for public safety of LNG spills onto water.

The description of current LNG knowledge is aided by reference to reports prepared in 2004 by the ABS Shipping Group for the Federal Energy Regulatory Commission[1] and by the Sandia National Laboratory for the Department of Energy.[2] These two reports, which appear to be largely accepted by all of the regulatory agencies involved, emphasize for their analyses one scenario of the consequences of LNG marine spills—spillage onto water of 12,500 m^3 of LNG, which is representative of approximately one half of a single tank on a typical LNG ship. While the Sandia report does provide some consideration of multiple-tank spills, it suggests that such occurrences would not involve more than three tanks at one time. The choice of spillage of only half a tank appears to be the result of the report's consideration of the extreme implausibility of the rapid spillage of the entire tank as an initial result of a terrorist attack. However, limiting discussion to the initial results of a terrorist attack is not necessarily sufficient.

LNG Vapor Cloud Dispersion

My year-long look at the LNG vapor dispersion issue for the Coast Guard produced a report[3] in 1978 that reviewed several predictions by leading authorities of the vapor cloud extent, following spillage of 25,000 m^3 LNG onto water. Those estimates ranged from 0.75 mile to a little over 50 miles. The range was narrowed by showing the errors in reasoning underlying the lowest and highest estimates, but the uncertainty range could not be tightened closer than three to 10 miles.



The estimates, which range between approximately two and three miles, presented in the Sandia and ABS Group reports are endorsable. Note, though, that these estimates are for the spillage of 12,500 m^3 of LNG, half the amount considered in the Coast Guard report produced in 1978. Nonetheless, the estimate of two to three miles of flammable vapor cloud travel that could result from an unignited spill of LNG from a single containment is at once reasonable and sufficient for regulatory planning purposes. Indeed, given the uncertainties involved, the point of diminishing returns has been reached on this scenario for vapor dispersion from a 12,500 m^3 LNG spill on water.

Thermal Radiation from LNG Pool Fires

For thermal radiation from pool fires, the findings of the ABS Group and Sandia reports are also endorsable. Both reports appear to provide estimates of approximately one mile as the distance from a pool fire on a 12,500 m^3 spill on water to which unprotected persons could receive second-degree burns in 30 seconds (based on a thermal flux criterion of 5 KW/m^2). Although this estimate is reasonably representative of the best available estimates of the distance to which the public could be exposed (to this damage criterion), the endorsement is qualified as follows.

First, the use of a thermal flux criterion that would result in second-degree burns in 30 seconds is not necessarily appropriate to ensure public safety, as such exposure essentially ensures that serious burns will occur at that distance to persons who cannot gain shelter within 30 seconds. Aside from questions about the ability of even the most able to gain shelter in such a short time, questions are also raised about the safety of those less able. Lower thermal flux criteria (~1.5 KW/m^2) are prescribed in other national and international regulations designed to provide safe separation distances for the public from fires. Since such lower thermal flux level criteria could increase the distances prescribed in the ABS Group and Sandia reports by as much as one and a half to two times, this end point criteria for ensuring public safety from LNG fires should be reconsidered, especially if the goal is to provide for public safety.

Second, the mathematical modeling methods in the reports that predict the various levels of thermal radiation intensity from a massive LNG pool fire are not on as firm scientific ground as are the methods for predicting vapor cloud dispersion. The vapor cloud question has been more extensively studied to provide data for the models' verification. The physical basis for extrapolation from small-scale experimental data is better understood for vapor dispersion than are the methods in present predictions of thermal radiation extent from pool fires. Sandia and others are considering the need for further large-scale LNG fire testing. Such tests should be conducted with appropriate scientific planning and for the purpose of obtaining experimental data that could be used to verify mathematical modeling methods; this additional testing is advised to provide a better understanding of large LNG fires on water.

However, the Sandia report states that cascading events, resulting either from brittle fracture of structural steel on the ship or failure of the insulation that results in LNG vaporization at rates exceeding the capability of the relief valves, cannot be ruled out. Foamed plastic insulation, widely used on LNG carriers, would be highly susceptible to failure by melting or decomposition. It is a cardinal safety rule that the pressure limits on tanks carrying flammable or reactive materials should not be exceeded, as such excess portends catastrophic rupture of the containment. While the Sandia report concludes that such cascading events would be very unlikely to involve more than three of the five tanks on a typical LNG carrier, the report's optimism in this regard is unexplained. Once cascading failures begin, what would stop the process from resulting in the total loss of all LNG aboard the carrier? More research is indicated, but such efforts should not delay immediate attention to ascertain or disprove this potential vulnerability.

Other Hazards

Other hazards associated with spilling LNG onto water include oxygen deprivation, cold-burns, rapid phase transitions, and explosions in confined spaces, as well as the potential for unconfined vapor cloud explosions (UVCEs) if the LNG contains significant heavies. As the hazards of oxygen deprivation and cryogenic burns are not expected to affect the public, they will not be considered further here.

Explosions in confined spaces, either combustion events or events of rapid phase transition, may have the potential for causing secondary damage that could lead to further spillage of LNG. Unconfined vapor cloud explosions cannot be dismissed if the cargo contains significant amounts—perhaps greater than 12 to 18 percent, based on Coast Guard-sponsored tests at China Lake in the 1980s—of gas components heavier than methane. Enrichment in higher boiling point components of LNG remaining on the water can lead to vapor cloud concentrations that pose a UVCE hazard, even if the concentration of liquid initially spilled does not. LNG contact with ship structural steel, rapid phase transitions, and gas explosions in confined spaces on the ship are not expected to pose hazards to the public, except as they may relate to the ship's vulnerability to further damage following the cryogenic cargo spillage onto ship structures, with or without ignition.

Vulnerability Issues

Coast Guard Navigation and Vessel Inspection Circular No. 05-05, "Guidance on Assessing the Suitability of a Waterway for Liquefied Natural Gas (LNG) Marine Traffic," incorporates requirements for a vulnerability assessment that identifies the exposures that might be exploited to ensure the success of an attempted terrorist attack.[4] Two types of vulnerabilities are considered: system and asset. System vulnerabilities consider the ability of the terrorist to successfully launch an attack; asset vulnerabilities consider the physical properties of the target that may influence the likelihood of success of a terrorist attack.

Worst Case?

The hazards of brittle fracture, rapid phase transitions, and explosions in confined ship spaces, as well as cascading events that may result from the extreme fire exposure a ship would experience if a nominal 12,500 m^3 spill on water around the ship was ignited, will require careful consideration. The definition of the worst case event that could be realized as a result of a terrorist attack is likely to hinge on the assessment of the asset vulnerabilities that is required to be considered in NVIC 05-05. This is largely where our unfinished work remains.

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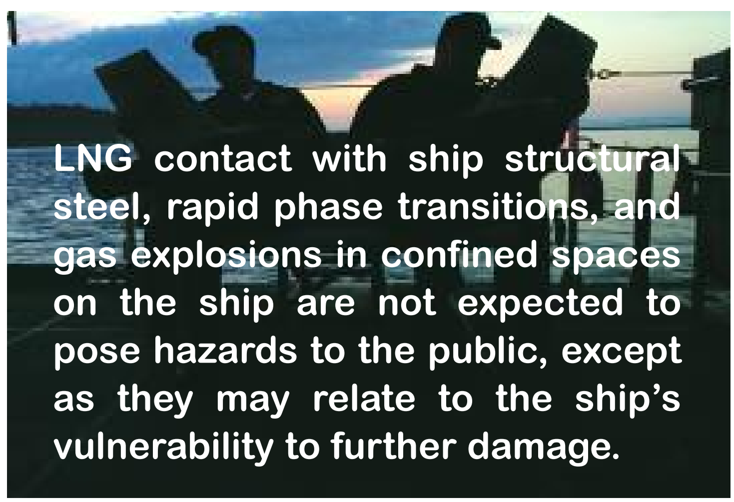

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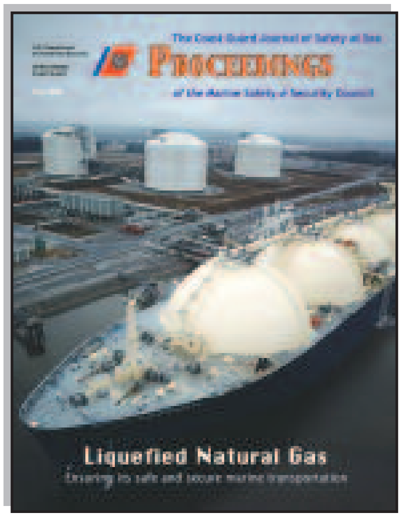

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PROCEEDINGS Magazine, Fall 2005

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Reader's Survey

Liquefied Natural Gas Transportation

Risks and common misconceptions.

by Filippo Gavelli, Ph.D.
Senior Engineer, Exponent, Inc.

and Harri Kytomaa, Ph.D.
Principal Engineer and Director of Thermal Science and Engineering, Exponent, Inc.

Maritime commercial transportation of liquefied natural gas (LNG) to the United States began in 1971, with the opening of the Everett, Mass., LNG receiving terminal. More than 30 years later, the safety record of worldwide LNG transportation remains remarkable, with only a very limited number of safety incidents of any kind, two of which resulted in small fires, and no major accidents with loss of cargo in more than 33,000 loaded trips.

The LNG tanker fleet has been rapidly growing, with more than 170 tankers currently in service, approximately 100 presently in shipyards, and an estimated 100 more to be ordered over the next decade.[1] The rapid growth of liquefied natural gas commerce makes understanding the risks associated with LNG tankers and receiving terminals critical to maintaining the excellent safety record achieved to date.

Risks Associated with LNG Transport

The most severe accident that may realistically occur to a loaded LNG tanker is the breach of one or more storage tanks, with consequent discharge of liquefied natural gas outboard. No accidents leading to loss of cargo have occurred over the history of maritime liquefied natural gas transportation. This safety record is at least partially due to the double-hulled construction of LNG tankers and the separation between the LNG cargo tank and the inner hull, which effectively makes the cargo tank's wall a third safety barrier to outside penetrations.

In the worst grounding accident of a loaded LNG tanker, the *El Paso Kayser* ran onto rocks and grounded at 19 knots in the Straits of Gibraltar in June 1979, loaded with 99,500 m^3 of LNG. The *Kayser* suffered heavy bottom damage over the whole length of the cargo spaces, as well as flooding to the starboard double bottom and wing ballast tanks. However, the membrane cargo containment was not breached, and no liquefied natural gas was spilled. [2]

In 1984, during the Iran-Iraq war, three maverick missiles were launched from an aircraft at the *Gaz Fountain*, a prismatic tanker that was carrying butane and propane. Although the attack caused a fire, the tanker survived this intentional attack.

The absence of major accidents in the past history of liquefied natural gas maritime transportation represents a safety record that is unparalleled when it is compared with the marine transportation of other flammable or combustible liquids. But that does not preclude the possibility that accidents may occur in the future. A thorough analysis of the hazards associated with LNG transportation is necessary to recognize specific hazards, minimize their likelihood of occurring, and/or mitigate or control the severity of their outcome.

Risk Analysis

The sparse experience associated with accidents in marine LNG operations has presented difficulties in identifying plausible hazards and in quantifying how often these may happen. This dilemma pushed the federal government to fund Sandia National Laboratory to conduct a risk study that resorts to engineering analysis to supplement the limited past

No accidents leading to loss of cargo have occurred over the history of maritime liquefied natural gas transportation.

accident experience (see article, "Liquefied Natural Gas Risk Management," in this edition). The 2004 Sandia report presents a valuable roadmap for a risk-based approach to liquefied natural gas transportation hazards with a comprehensive overview of the factors and circumstances that can result in liquefied natural gas spills. This report considers both intentional and accidental spills and breaks down spill scenarios into the following series of events:

- the initial event that breaches a liquefied natural gas tank,
- flow of liquefied natural gas out of containment,
- spread of liquefied natural gas on water,
- evaporation of liquefied natural gas,
- early and late ignition of a liquefied natural gas pool,
- analysis of the resulting pool fire and the radiant heat on surrounding structures and people. This last step is used to define hazard zones.

As discussed in the Sandia report, one of the fundamental steps in the risk assessment of liquefied natural gas transportation safety is the accurate modeling of all of the above phases of an LNG spill scenario. Current models, including those presented by Sandia, take a conservative approach to several steps of a spill scenario due to the lack of experience and realistic data. As a result, the size of the hazard zones tends to be overestimated. Four elements that have a significant influence on the size of hazard zones are:

- the flow rate of liquefied natural gas from a breached tank,
- the initial rate of evaporation of liquefied natural gas when it first mixes with water,
- the influence of waves on the spreading pool,
- the shape and size of the resulting pool fire.

The flow rate of liquefied natural gas from a breached tank has not been addressed rigorously. Current spill models estimate the process of liquefied natural gas discharge using the orifice flow model, where the flow is driven by the hydrostatic pressure head of LNG above the hole. This flow, however, can only occur if the LNG tank is open to the atmosphere at the top of the tank. This requires that the vacuum breakers are open and that they offer no resistance to the outflow of liquefied natural gas through the breach. If these conditions are not satisfied, the liquefied natural gas will flow in a surge-like manner out of the tank, in a manner similar to the "glug-glug" of an emptying bottle. The "glug-glug" flow rate out of a breached tank can be up to six times slower than the flow out of an open tank, and any reduction in the flow rate from the assumed "open-tank" values will result in a decrease in the estimated size of the resulting fire. As liquefied natural gas first pours onto water, it will experience aggressive mixing, resulting in rapid local evaporation. This reduces the amount of LNG that remains to spread as a pool and, therefore, also reduces the ultimate pool size.

Empirical data on the influence of waves on the spreading of the LNG pool is limited. The Quest report[3], "Modeling LNG Spills in Boston Harbor," addressed the effect of waves in a simplified manner, assuming them to be stationary, but nonetheless demonstrated that waves reduce the spread of the liquefied natural gas pool, particularly in the late stages of the spill. As the liquefied natural gas pool thins, the gravity-driven spreading of the pool will slow across the waves when the liquefied natural gas becomes trapped in troughs between waves. In the wave troughs, the interface between LNG and the water will behave in a largely frictionless manner; the LNG will pool at the bottom of the trough, reducing the surface area for heat transfer and, therefore, reducing the evaporation rate.

No experimental data are available on pool fires of dimensions comparable to the postulated accident scenarios. Although the radiation of large pool fires can be modeled based on the shape of the flame, the shape of very large pool fires is not well known. The Moorhouse correlation for flame height predicts flame height-to-diameter (L/D) ratios between 1.0 and 2.0.[3] The literature indicates that larger pool fires tend to break up into flamelets or a collection of smaller pool fires, resulting in a more realistic L/D ratio of 1.0 or less.[4,5,6] This flame breakup will be enhanced by the presence of waves and the deformation of the pool into elongated shapes. The net result is a reduced amount of thermal radiation on surrounding structures and infrastructure. This effect is currently poorly characterized, but it is a critical component in the determination of accurate hazard zones.

In summary, hazard zones that are sized in accordance to the methodology presented by the Sandia report have a built-in margin of safety, due to the overestimation of the LNG pool and associated fire size for any one scenario.

Common Misconceptions

The ongoing debate over the safety and risks to infrastructure, the environment, and neighboring communities has given rise to myths and misconceptions regarding the hazards associated with maritime LNG transport. Some of the most common of these myths are identified and discussed below.

> **MYTH: The January 19, 2004, explosion at the Skikda, Algeria, liquefaction facility indicates that LNG operations are dangerous.** This accident impacted approximately 2 percent of the world's liquefaction capacity and caused 27 fatalities. The Skikda accident was caused by a hydrocarbon leak of unknown origin, which was ingested into the boiler of the liquefaction line. The boiler explosion is believed to have initiated a larger explosion.

LNG receiving terminals in the United States do not use high pressure steam boilers such as the one involved in the Skikda accident. Precautions are taken in the United States to position the air intake of combustion equipment to prevent the intake of flammable or combustible gases. In addition, liquefaction processes differ from regasification facilities. Regasification facilities do not use refrigerants, which can have greater explosive destructive capacity than methane (pound for pound) if mixed with air and ignited. These refrigerants typically contain methane, ethane, propane, butane, and iso-pentane in differing concentrations.

> **MYTH: LNG tankers contain more energy than 50 atom bombs and are attractive terrorist targets.** This statement is based on the incorrect and misleading premise that the magnitude of an explosion can be estimated based on the available chemical energy. Following the same logic, a tanker full of wood could also be said to contain the chemical energy of multiple atom bombs.

What determines the destructive capacity of a fuel or an explosive is the rate of energy released upon ignition. Methane, the main component of LNG, is known to burn slowly and cannot be made to detonate or form destructive shock waves when ignited in an open environment. Higher molecular weight hydrocarbons such as propane, butane, or pentane have a greater destructive power than methane.

Recent regulations impose strict security procedures to limit the possibility of terrorist attacks. These include crew background checks and the pre-boarding and inspection of tankers, as well as multiple security measures at receiving terminals.

> **MYTH: If one LNG tank is breached in an attack, the entire tanker will be destroyed.** Even if a tank were breached, the initial consequence would be a pool fire in the immediate area of the ship. Subsequent tanks may fail, but it is practically impossible for them to all fail at the same time.

Although unlikely, if a second or subsequent tanks were to fail, they would be expected to do so sequentially. In a sequential failure of more than one tank, the impact will remain limited to the immediate area of the tanker and would most probably result in a prolonged fire, not in an explosion.

> **MYTH: A pool fire near an LNG tanker will cause nearby tanks to explode.** Boiling liquid expanding vapor explosion (BLEVE) is a phenomenon associated with uninsulated pressurized tanks, such as propane tanks. When the uninsulated tank is subjected to an external fire, pressure in the tank will rapidly rise and ultimately cause its rupture.

The insulation around LNG tanks is used to minimize the evaporation of LNG during ocean transit. This insulation will also insulate the liquefied natural gas cargo in the presence of an external fire and will limit the rate of rise of the internal tank pressure. In the event that some of the insulation is compromised, LNG tanks are equipped with pressure-relief valves. Venting through these is designed to keep the pressure within an acceptable range to prevent the tank from exploding.

> **MYTH: The experience with the *USS Cole* (October 2000) and the *Limburg* (October 2002) in Yemen show that double hulls can be breached with explosive-laden small vessels.** These two terrorist attacks were carried out with explosive-laden dinghies. Both attacks caused similar openings in the outer hull of a size similar to that of a garage door. The *Limburg* incident demonstrated the protective nature of a double hull with a comparatively small breach through the second hull (approximately 1 m^2).

The cargo in an LNG tanker is not only protected by the double hull, but also by the separation distance and the presence of the LNG containment layers. Therefore, an LNG tank would probably not incur as great a breach as the *Limburg*, if any at all.

> **MYTH: LNG spills over water are explosive, due to rapid phase transitions.** Rapid phase transitions are physical explosions caused by rapid vaporization of liquefied natural gas that do not involve combustion or burning. When liquefied natural gas flows on water, it forms a thin vapor film that separates it from the water. In locations of vigorous mixing, this film can be breached and LNG can come into direct contact with water. Under those conditions the LNG can undergo rapid evaporation, causing a rapid phase transition.

In past spill experiments, rapid phase transitions have been observed at the first point of mixing with water and at the leading edge of a spill. Mixing is known to be the most vigorous at these two locations. Rapid phase transitions are much less energetic than combustion explosions. Unconfined rapid phase transitions are generally not considered hazardous; however, these can cause structural damage if they were to occur in a confined space.

The debate over the safety and risks to infrastructure, the environment, and neighboring communities has given rise to myths and misconceptions regarding the hazards associated with maritime LNG transport.

Conclusions

The LNG infrastructure, including liquefaction, transportation and receiving facilities, is in a state of rapid development globally. In the United States, multiple proposals for terminals (both off and onshore) continue to face challenges, due to some opposition from authorities and neighboring communities. These new facilities bring forth new processes and technologies. With these new processes and facilities new challenges and concerns continue to arise.

Much has been learned since the days of the Cleveland peak shaving facility accident (see the article, "Accidents, Incidents, Mistakes, and the Lessons Learned From Them," in this issue). After the attacks on the World Trade Center, safety concerns have helped usher in an increasing number of off-shore terminal proposals, with the recent opening of the Gulf Gateway Energy Bridge as the first receiving terminal of its kind. Concerns related to the impact of major spills and fires have resulted in the careful definition of scientifically defendable hazard zones to protect infrastructure and communities near off-shore facilities.

The advent of off-shore receiving terminals has also spawned a new set of challenges. Most recently, open rack vaporizers (ORV), which are used to vaporize liquefied natural gas using an open loop process that pumps up to hundreds of thousands of gallons of sea water per day over LNG tubes, have gained much attention. There has been some concern about the impact of this process on fish eggs, larvae, and other microorganisms. In light of multiple proposals that would use ORVs, there is also a concern of the cumulative impact on fisheries. Not only will it be important to perform scientifically defensible studies on the impact on fish eggs and larvae in this case, and to develop unambiguous monitoring and management programs, it will be equally important to communicate the findings of these studies in a manner that renders the science and its meaning tangible to local communities, legal professionals, and politicians.

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LNG Tank Designs

Special cargo requires specific design.

by Mr. Thomas Felleisen
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Gas carrier tanks, according to International Maritime Organization (IMO) rules, must be one of three types. Those are ones built according to standard oil tank design (Type A), others that are of pressure vessel design (Type C), and, finally, tanks that are neither of the first two types (Type B). All LNG tanks are Type B from the Coast Guard perspective, because Type B tanks must be designed without any general assumptions that go into designing the other tank types.

Type B Tanks: Designed From "First Principles"

All tank designs have the common principle that the material will not fail catastrophically; any imperfection that could develop into a crack will grow slowly. This "leak before failure" principle has always been a critical design requirement for liquefied natural gas tanks.

Another example of a first principle is the answer to the question: Is the tank capable of supporting itself? There are three general Type B tank designs for LNG. The first type of design, the membrane tank, is supported by the hold it occupies. The other two designs, spherical and prismatic, are self-supporting.

The first gas carrier tanks that were used in a continuous regular trade in the United States were of the membrane tank design. In 1965 Phillips Petroleum contacted the Coast Guard concerning a proposal that the energy company had made to Tokyo Gas for shipping LNG from Alaska. The shipments were to be made in tanks that were designed by Worms and Co., Paris, France. This design later became known as the Gaz Transport design. At first, the LNG carriers were envisioned as being 34,000 cubic meters, but eventually the design called for the 71,500 cubic meter vessels that became the *Artic Tokyo* and *Polar Alaska.*

Membrane Tanks

Membrane tanks are composed of a layer of metal (primary barrier), a layer of insulation, another liquid-proof layer, and another layer of insulation. Those several layers are then attached to the walls of the externally framed hold.

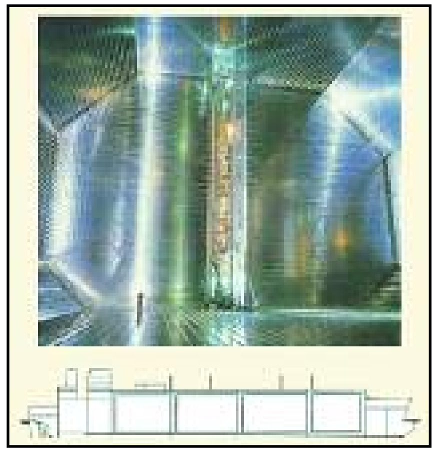
Figure 1: Inside view of an Invar membrane LNG cargo tank.

In the case of the first design, the primary and secondary barriers are sheets of Invar, an alloy of 36-percent nickel steel. Unlike regular steel, Invar hardly contracts upon cooling. The insulation layers are plywood boxes holding perlite, a glassy material. The Coast Guard, while reviewing the design, requested testing that would show the integrity of both the primary and secondary barriers. Secondary barrier testing and acceptance criteria were very hard to develop but are necessary to ensure containment integrity.

It should be noted that the insulation for the Gaz Transport membranes has been discussed generally. All membranes are built up from the surface of a hold using discrete units of insulation (called panels) that are anchored to it. Special insulation is inserted around the anchors (called studs). Also, there are special methods for sealing joints between panels. A membrane design, therefore, is fairly complex, and a complete discussion of any one design's intricacies would be too lengthy to completely detail.

A competing type of membrane system is the Technigaz membrane. It was in use on ships carrying ethylene hailing the United States in 1968.[1] However,

All tank designs have the common principle that the material will not fail catastrophically; any imperfection that could develop into a crack will grow slowly. This "leak before failure" principle has always been a critical design requirement for liquefied natural gas tanks.

the Technigaz system was formally accepted for LNG service in 1970. That was the "Mark I" system. It and subsequent versions have a 9-percent nickel primary barrier, which has a waffle design appearance. The Mark I had two balsa wood insulation layers on either side of the secondary barrier, which was made of three-ply sugar maple plywood. Each of the balsa wood layers were actually several layers of blocks in alternating grain direction—one layer's grain would run horizontal to the tank wall and the next would run vertical. Technigaz had two subsequent versions of the Mark I; these are known as the MK II and MK III. The MK II did not receive acceptance from the Coast Guard. The MK III uses polyurethane foam in lieu of balsa wood and, instead of sugar maple plywood, uses "Triplex." Triplex is a sandwich of aluminum foil between two layers of woven glass cloth.

Gaz Transport and Technigaz have since merged into one company, GTT. Likewise, the designs of the two membrane companies have merged into a combined membrane system, the CS1. The first installation of the membrane did not go as planned, and no ship in service is equipped with the membrane. GTT designs are increasingly being specified for new ships because the design can be readily tailored to a variety of sizes.

Self-Supporting Tanks

The alternative to a membrane tank is a self-supporting tank. The most well known is the Moss-designed spherical tank that many people equate with the appearance of an LNG carrier (Figure 2). The large spherical tanks, almost half of which appear to protrude above a ship's deck, is often what people visualize when someone says "LNG carrier." The early sphere designs were shells of 9-percent nickel steel. Subsequently, aluminum was used. The sphere is installed in its own hold of a double-hulled ship, so that it is supported around its equator by a steel cylinder (called a skirt). The covered insulation surrounding the sphere can channel any leakage to a drip tray located under the sphere's "south pole."

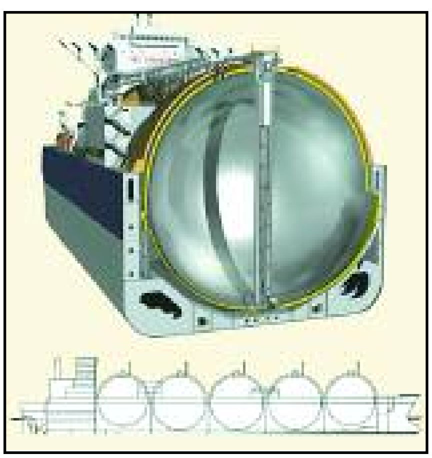

Figure 2: The spherical tank design that many people equate with the appearance of an LNG carrier.

Some older 9-percent nickel steel tanks have shown significant amounts of swallow cracking after years of service. The cracks develop next to the welds due to the effect of the heat of the welding on the original material (known as the "heat-affected zone"). The cracks can be repaired by gouging them out and welding in new material. Aluminum tanks can have a different cracking problem. Attaching the aluminum tank to a steel cylinder is a difficult process, due to the metals involved, and cracks are liable to develop where those materials are joined.

The second type of self–supporting tank is the Self-supporting, Prismatic, Type B (SPB) tanks by Ishikawajima Heavy Industries (IHI). These tanks are reminiscent of the tanks on old single-skin oil tankers; the framing is internal to the tank. The material for tank construction can be aluminum, 9-percent nickel steel, or 304 stainless steel, but only ships with aluminum tanks have been trading to U.S. ports. The tanks are installed in the hold of a double hull ship and are insulated with covered polyurethane foam that also is able to serve as channeling for any possible tank leakage to drip trays.

Other Designs

Beside the preceding types of tank designs, there are several types that were proposed some years back but were never built. Both the IHI "flat top" and the Hitachi Zosen (for LPG) prismatic designs were not considered acceptable because carbon-manganese steel is not suitable for prismatic designs. As mentioned earlier, Gaz Transport and Technigaz make prismatic membrane tanks, but in the early 1970s, both companies were interested in making spherical membrane tanks. The Gaz Transport design was a joint effort with Pittsburgh-Des Moines Steel Company. Mitsubishi Heavy Industries proposed a cylindrical design that was conceptually similar to the Moss sphere design. That proposal was a hemispherical base (supported equatorially by a skirt) with a short cylindrical section above the hemisphere, and all topped with a shape that was oval in cross section.

In the future, there will certainly be new developments in tank designs, and the Coast Guard will be active in reviewing them to ensure the design's integrity.

[1] U.S. Coast Guard, Proceedings of the Merchant Marine Safety Council, August 1968, p. 149.

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Compressed Natural Gas

An alternative to liquefied natural gas?

by Ms. Lucy Rodriguez
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The idea of transporting compressed natural gas (CNG) by vessel is nothing new. The first prototype vessel was tested off the coast of New Jersey in the 1960s. While proving transport of CNG was feasible, the design standards of the time dictated that containment tanks have very thick, heavy walls, resulting in shipping costs that were too expensive.[1]

Since that time, technological improvements with high-strength materials have enabled industry to solve the steel weight problem that hindered CNG transport in the past. In some instances, industry has proposed combining these improvements with experience with submarine pipelines and their rules, and the knowledge of the shipping industry, to develop new alternatives for transporting compressed natural gas in bulk.[2]

Figure 1: In this ENERSEA design, the ship contains arrays of vertically positioned steel cylinders within insulated holds.

Driving Forces

According to the Energy Information Administration, global natural gas consumption is projected to increase 70 percent between 2001 and 2025. The natural gas portion of the total energy consumption is forecasted to increase from 23 to 25 percent over that time.[3] However, a significant amount of the world's natural gas reserves is located far away from its market.

When untapped natural gas reserves are located far enough from the market that pipelines cannot be justified, the gas is referred to as "stranded gas." In these instances, the equipment necessary for LNG processing (liquefaction, storage, transportation, regasification, and terminal facilities) is too costly.

"Associated gas" is a gas reserve found in an oil reservoir. More restrictions are being placed against the flaring of this gas, which then requires reinjection of the gas into the reservoir. However, reinjection poses a problem, because it can inhibit oil production. As with stranded gas, it is often not economically viable to invest in pipelines or LNG facilities to bring this to market.

That is where CNG alternatives come into play. Industry studies have compared the cost of shipping gas using CNG and LNG shipping. For one-way distances of 2,500 to 4,000 miles or less, compressed natural gas is increasingly attractive. Although CNG ships are more costly to build than LNG carriers, CNG does not require gas liquefaction, storage, or regasification and terminal facilities.[4] With CNG, gas can be discharged directly from an offshore terminal to a land-based gas grid.

CNG Technology

Compressed natural gas involves dehydration, condensate removal, cooling, and compression of natural gas into specially designed systems of pressure vessels or piping. [5] A compressed natural gas ship is a bulk carrier in which the holds are filled with pressure vessels. Depending on the technology, the compressed natural gas is carried at temperatures ranging from -20 degrees F to ambient and pressures ranging from 1,000 to 3,600 psi. This makes it possible to load large quantities of gas into a vessel.

Higher pressures enable larger quantities of gas to be transported; however, that would also require containment systems of greater weight. The technical challenge industry faces is in designing a robust containment system that will balance many factors, such as the mass and capacities of the containment system and the speed of the vessel to make it economically attractive, while satisfying the safety requirements of class societies, regulatory agencies, and the International Maritime Organization.

Industry is attempting to follow the International Gas Carrier Code (IGC), which is used in the design of LNG ships. However, compressed natural gas projects are dealing with gases that are being transported at elevated pressures with respect to LNG; furthermore, CNG is employing multiple pressurized containers per cargo tank in contrast to LNG, which generally utilizes one pressure container per tank. In designing these new cargo systems, developers are using limit state design codes to attain the same level of safety that exists with LNG systems.

Coast Guard and CNG

From a regulatory perspective, the Coast Guard needs to understand the risks new concepts pose to vessel safety, the environment, and the security of United States' ports. New compressed natural gas cargo containment system designs should exhibit safety equivalent to that of LNG, yet the International Gas Code is not completely applicable for the construction and equipment of CNG technology. Emerging CNG technologies differ from that of any current vessels, due to factors such as the pressures imposed on CNG cargo containment systems during normal operating conditions and the cyclical pressure ranges the systems will experience during loading and offloading. The difficulty of conducting traditional internal and external inspections of the pressure vessels is another factor contributing to safety concerns. For those reasons as well as their novelty in comparison to existing gas carriers, these containment systems need additional scrutiny.

Fortunately, others in the marine community are also recognizing the challenges and opportunities associated with compressed natural gas transport. Classification societies, such as Det Norske Veritas (DNV) and the American Bureau of Shipping (ABS), have issued "DNV Rules for Compressed Natural Gas Carriers" and a "Guide for Vessels Intended to Carry Compressed Natural Gas in Bulk," respectively.

Additionally, industry is working with the class societies throughout the design process to ensure the safety of their new ventures. In 2003 the Centre for Marine CNG, a not-for-profit entity located at the St. John's campus of Memorial University of Newfoundland, Canada, was founded; the organization is dedicated to large-scale marine transport of compressed natural gas.

Several novel concepts for the carriage of CNG in bulk are under development.

Proposed CNG Technologies

ENERSEA

In this design, the ship contains arrays of vertically positioned steel cylinders within insulated holds, along with specially designed gas conditioning and handling systems (Figure 1). The gas cargo cylinder bodies are made from steel pipes that have high strength and toughness at low temperatures to contain the compressed natural gas at pressures ranging from 1400-1800 psi and temperatures from -40 degrees F to 0 degrees F (typically, -20 degrees F). EnerSea refers to this combination of pressure and temperature as VOTRANS (Volume Optimized Transport & Storage), which allows for reductions in loading compression horsepower. VOTRANS uses a liquid (glycol/water mix) displacement system to push the gas out when discharging the cargo, which works to control pressures and temperatures during both loading and unloading. Vessel loading and unloading operations utilize buoy systems with associated subsea pipelines, connected to shore-based or offshore infrastructure. EnerSea's VOTRANS ship concept has been granted "Approval in Principle" by ABS, which is the first step in the regulatory and vessel certification process.

TRANSCANADA

The TransCanada Gas Transport Module (GTM) is a composite reinforced pressure vessel built to the American Society of Mechanical Engineers' (ASME) pressure vessel code (Figure 2). In this concept, hori-

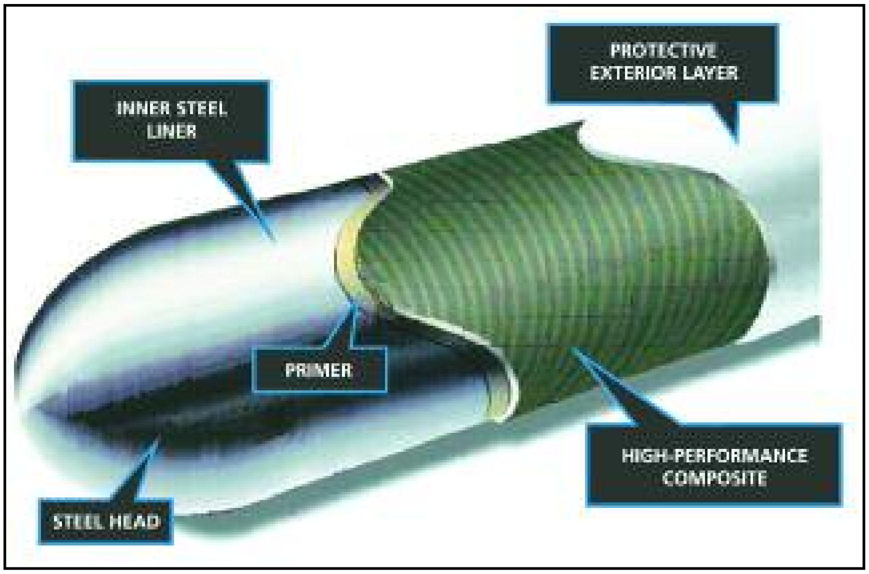


Figure 2: The TransCanada GTM compressed natural gas system will operate when full at approximately 3,000 to 3,600 psi and between 100 to 300 psi when unloaded.

zontally positioned cargo cylinders are connected together in holds and maintained at ambient temperature. All piping systems attach to the GTM cargo cylinder at the fixed end and vertically rise above the steel main deck to valving and associated equipment in the open on top of the deck. The GTM compressed natural gas system will operate when full at approximately 3,000 to 3,600 psi and between 100 to 300 psi when unloaded. This is the same operating range as CNG vehicle fuel systems generally in use today. The GTM CNG system uses barges, shuttled with tugs, or self -propelled carriers. Compression and dehydration facilities are included at the loading site, and offloading facilities at the unloading site usually consist of a small compressor, pressure let-down valve, heating and measuring equipment. These facilities are on the shore, with an underwater pipeline connecting to an offshore buoy. TransCanada has been commercializing the GTM for barge applications and received design approval in 2001 from the American Bureau of Shipping for a specific CNG barge for inland water use. GTM use in carriers received "Approval in Principal" from Lloyd's Register in 2003.

KNUTSEN

PNG (Pressurised Natural Gas) is a Knutsen OAS Shipping Registered Trade Mark for CNG transport. Knutsen proposes a compressed natural gas ship, with 42-inch diameter steel pipes, oriented vertically. The cargo cylinders operate at ambient temperature and at approximately 3,600 psi. The containment system received "Approval" from DNV. The ship design received "Approval in Principle" from DNV and is based on a combination of an oil tanker and a container ship, with arrangements to ensure safety and functionality for the new application (Figure 3). The ships are sized based on different gas transport volumes and distances. The PNG® technology does not allow for any free water in the natural gas, so the water is removed either onshore or offshore, prior to the compression that is required to load the PNG® ship. During the initial part of the loading and unloading sequences, the gas is heated onboard to keep the cargo containment system at ambient conditions. The PNG® ship is emptied by pressure/flow control, without any compression, until the system pressure reaches the receiving system pressure, which can typically be around 1000 psi.

SEA NG MANAGEMENT

The pressure vessels in this design are called "coselles." Cran & Stenning developed this technology in the mid-1990s, which increased the more recent interest in CNG. The coselle pressure vessel is a patented technology that is comprised of a large coil of 6-inch diameter ERW steel pipe in a carousel container (Figures 4 & 5), as opposed to the conventional straight pipe pressure bottle with domed ends. The name "coselle" is derived from the description "a coil in a carousel." The standard coselle is about 51 feet in diameter, 11 feet high, and weighs about 460 tons. Depending on the capacity of the ship, coselles, which are not removable, can be stacked on top of each other at least eight high. The ship is designed to

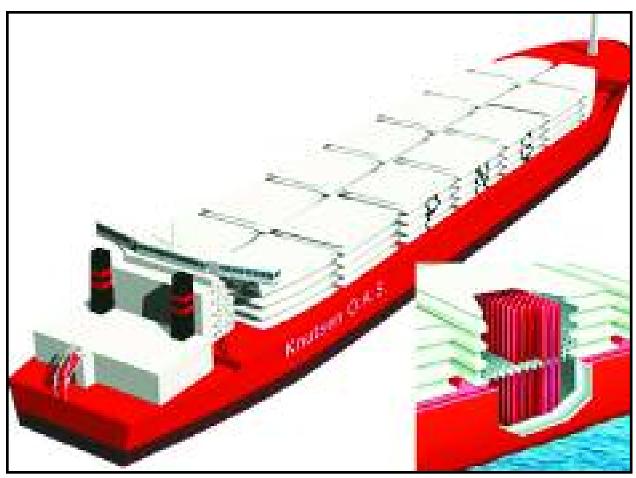
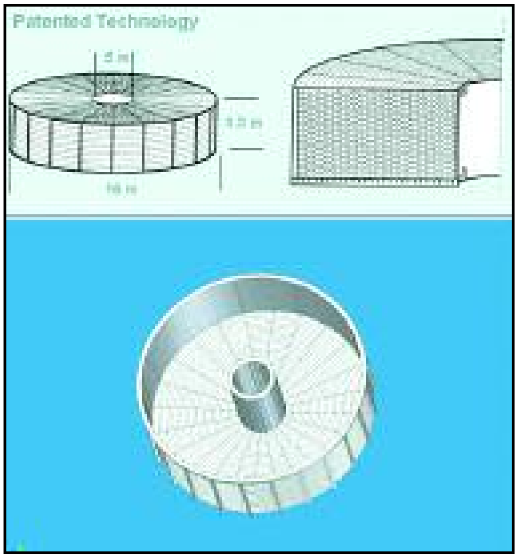
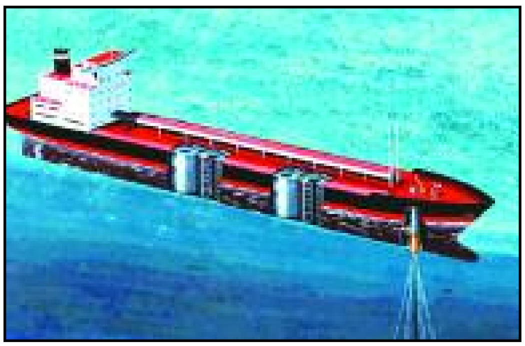


Figure 3: Knutsen proposes a compressed natural gas ship, with 42-inch diameter steel pipes, oriented vertically.



Figures 4 and 5: The pressure vessels in the Sea NG Management design are called "coselles." The name "coselle" is derived from the description "a coil in a carousel."



operate at ambient temperature and pressures, ranging from 3,400 to 3,600 psi. As with other designs in this pressure range, loading requires infrastructure to dehydrate and compress the gas. The unloading, which is accomplished by blow-down through an offshore buoy, requires a small compressor. The coselle concept has received "Approval in Principle" from both ABS and DNV.

SEAONE MARITIME

Natural gas is transported in oceangoing gas carriers in a liquefied form, termed Compressed Gas Liquid™ (CGL™), which is different from both LNG and CNG (Figure 6). The production gas is conditioned aboard the CGL™ tanker, and the natural gas components (methane, ethane, butane, and propane) are transported on the same tanker in a liquefied form. The resulting CGL™ volume is equivalent to approximately two-thirds of the volumetric ratio of LNG. Thus, the company also refers to their CGL™ transportation model as LNG Lite™. The liquefied gas is transported at 1400 psig at -40 degrees F in a pipeline system mounted in the cargo area of the tankers. This CGL™ technology has U.S. and international patents pending and the CGL™ tanker designs have received Lloyd's Register "Approval in Principle." According to the company, shore-based processing, conditioning, liquefaction, and regas plants are not required. The production or associated gas can be loaded via offshore buoys directly onto tankers, on which is located gas conditioning and processing equipment. The conditioned gas is unloaded to offshore buoys and then into a land-based gas grid.

Summary

As the demand for natural gas increases on a worldwide basis, the compressed natural gas market niche will become more attractive. It is only a matter of time before CNG reaches the point of commercialization. The Coast Guard will be there, working to support the development of compressed natural gas technologies that are safe and environmentally responsible.

Endnotes

[1] TransCanada (2004). What is CNG?. Retreived June 24, 2005, from www.transcanada.com/company/What_is_CNG.html.

[2] (2004). Pipeline technology makes transporting CNG viable. Hydrocarbon Asia. 14 (6), 14-15.

[3] Energy Information Administration (2001). International Energy Annual 2001, DOE/EI and System for the Analysis of Global Energy Markets, 2004.

[4] ABS (2004, March). Transporting Compressed Natural Gas. ABS Technical Bulletins.

[5] National Petroleum Council (2003). Balancing Natural Gas Policy – Fueling the Demands of a Growing Economy (2003), Volume 5 Transmission & Distribution Task Group Report and LNG Subgroup Report, Appendix D.

With special thanks to the following for their contributions: James Cran of Cran & Stenning Technology Inc.; Charles White of EnerSea Transport LLC; Gregory Cano of TransCanada PipeLines; Per Lothe and Nils Kristian Strom of Knutsen OAS Shipping; Dr. Bruce Hall of SeaOne Maritime Corp.

Figure 6: The Seaone Maritime also refers to their CGL™ transportation model as LNG Lite.™

LNG Carrier Construction in Asia

Rising demand fuels rising construction

by Chief Warrant Officer Scott Chroninger
Senior Marine Inspector, U.S. Coast Guard Activities Far East

The rising demand for natural gas throughout the world is fueling the rise in demand for liquefied natural gas (LNG) carriers. The technology and skill required to construct LNG carriers takes years to develop and is limited to a handful of shipyards throughout Asia and Europe, with the majority of the construction being completed in Korea and Japan. Not surprisingly, these shipyards have increased their production of these carriers.

The Players

Mitsubishi Heavy Industries in Nagasaki, Japan; as well as Daewoo Shipbuilding and Marine Engineering and Samsung Shipbuilding, both in Korea, have focused on the construction of membrane tank liquefied natural gas vessels. Meanwhile, Hyundai Heavy Industries has developed a spherical tank design, along with its mobile offshore drilling unit construction program. Other builders in Asia with a proven LNG carrier construction program include Kawasaki Heavy Industries and Mitsui Shipbuilding.

In 2004, of 125 vessels constructed by the 10 most prominent builders, 85 (68 percent) were constructed in Asian shipyards. This majority representation is set to increase, as orders for additional LNG carriers during the next few years have filled all available construction slots.

Designs

Current orders would indicate a continued preference for membrane tanks of the Gaz Transport (GT) No. 96, 36-percent nickel steel, and the Technigaz Mark III, 9-percent nickel steel, systems.

New design concepts such as the regasification vessels, built at Koje Island, South Korea, and employed off the Texas coast, illustrate the ability of

Second from left, Mr. Mark McGrath, Vice President ABS Pacific; Rear Adm. Thomas Gilmour, Assistant Commandant for Marine Safety, Security, and Environmental Protection; and Capt. (Ret.) Terry Rice observe LNG cargo containment construction at Samsung Heavy Industries. Capt. Michael L. Blair, USCG.

Rear Adm. Gilmour, center, and Mr. Mark McGrath, right, Vice President ABS Pacific, overlook the construction facilities at Samsung Heavy Industries. Capt. Michael L. Blair, USCG.

Asian shipbuilders to successfully design and complete new concept construction projects to meet customer requirements.

Larger vessels with new propulsion and cargo containment systems are now under construction and will be followed by even larger ships in the near future. Plans in Qatar, with its reserve of 14 trillion cubic meters of natural gas, include construction of as many as 46 additional LNG carriers.

Economics

Owner representation is generally less expensive to maintain in South Korea. This has led to larger owner representative site teams in South Korea than that of their counterparts in Japan. Shipbuilders in Korea have built an infrastructure (including schools and medical facilities) solely for the support of the owner representatives at all major shipbuilding facilities in the area.

In Ulsan, South Korea, a complete lodging facility identified as "The Foreigner Compound" is available to customers of Hyundai Heavy Industries,and provides a community atmosphere, including a clubhouse for the members of the on-site teams. Individuals from different projects and their families live in this neighborhood, sharing their cultures and reducing any difficulties encountered with living in a foreign country. International schools are available to all students and generally accept students from all language backgrounds.

U. S. Coast Guard Activities Far East looks forward to the increase in LNG carrier activity in the near future. In the past it has been able to respond to the request for examinations for the issuance of a Certificate of Compliance for Gas Carrier through the overseas tankship inspection program. Their experience with liquefied natural gas and the access to the vessels under construction provide the Coast Guard Senior Marine Inspectors at Activities Far East with unique opportunities we can leverage to provide service for our partners within the industry and provide training for Coast Guard personnel assigned to ports with newly constructed LNG receiving terminals.

About the author: *Chief Warrant Officer Scott Chroninger joined the Coast Guard in 1981 and entered the Marine Inspector training program in 1994. He is currently assigned to U.S. Coast Guard Activities Far East, Tokyo, Japan, with an area of responsibility encompassing all areas from Vladivostok Russia to New Zealand to Pakistan. Since 1998 he has conducted marine safety examinations and inspections on commercial vessels in the Asian region.*

Coast Guard Marine Safety Center

Streamlines SOE Process.

By Lt. Brandi Baldwin
Staff Engineer/Cargo Specialist, U.S. Coast Guard Marine Safety Center

As U.S. demand for liquefied natural gas (LNG) continues to rise, the fleet of LNG carriers expands as well. Each gas carrier entering U.S. waters is reviewed and inspected by the Coast Guard for compliance with U.S. and international requirements, and receives a certificate of compliance (COC) with a Subchapter O Endorsement (SOE). The SOE, generated by the Coast Guard Marine Safety Center (MSC), details specific instructions for gas carriers operating in U.S. waters. Without a valid SOE, the vessel may be restricted from conducting cargo operations or denied entry to port.

Procedural Changes
In May 2005, MSC modified the procedures for SOE renewals to reduce the administrative burden and eliminate unnecessary vessel delays caused by expired SOEs. The new process does not impact the scope or frequency of the COC inspection, nor does it affect MSC's review of vessel plans and certificates for an initial SOE. The purely administrative change benefits the Coast Guard and industry without impacting vessel safety.

The primary source of information for the SOE is the International Certificate of Fitness (COF), a document issued by the flag state or class society to indicate compliance with international regulations. Previously, the SOE referenced a specific COF by certificate number, issue date and expiration date, and expired with either the International Certificate of Fitness or COC, whichever expired first.

When the vessel received a new COF, the SOE had to be updated and reissued. When a new SOE is generated, a Coast Guard Marine Inspector must attend the vessel to issue it, regardless of whether or not the vessel is due for a COC exam. Since the validity period of the certificate of fitness can range from several months to five years, the SOE was often out of synch with the biennial COC cycle.
The revised SOE format eliminates the dependence on a particular COF. Unless the vessel changes its list of cargoes or modifies the cargo containment system, the SOE remains valid as long as the vessel holds a current COF, and expires with the COC.

Redundant Updates Eliminated
The new format also eliminates another common cause for an administrative SOE update: the change of a vessel's name and registry. The reference to a vessel's flag state has been removed, and the vessel name is now an editable field that can be modified by the Marine Inspector prior to issuance. The only permanent identification information on the new SOE is the official number, which is unlikely to change throughout the life of the vessel.

With the implementation of this program, the SOE will only need to be updated when the vessel modifies its cargo containment system. For example, the installation of deck tanks, an increase in the cargo tank maximum allowable relief valve settings, or a change in the vessel's cargo list all would require an updated SOE. Since these activities also would trigger an inspection, the issuance of the new SOE imposes no additional burden on the vessel or the inspector.

The new SOE format also reduces the administrative burden on MSC. More than 75 percent of the SOEs processed by the MSC last year were updates for purely administrative reasons. Eliminating those submissions allows engineers to focus on technical review of plans and documents for initial SOE applications.

Visit MSC's website www.uscg.mil/hq/msc/T2.htm for more information. Send comments to msc-coc@msc.uscg.mil.

The launch of the Energy Bridge™ Regasification Vessel *Excellence*. Courtesy of Excelerate Energy, LLC.

Manning the Ship

The rapid expansion of the LNG fleet and the implications for seafaring human resources.

by Dr. Hisashi Yamamoto
Secretary, International Association of Maritime Universities

The competence of seafarers serving on liquefied natural gas (LNG) ships is the most critical element for the safe ocean transportation of LNG; however, the ongoing dramatic expansion of the world's LNG fleet (Tables 1 and 2) has coincided with a time when the number of experienced and qualified seafarers in general will be rapidly declining. Will there be enough competent seafarers to man these ships?

The heart of the matter can be summarized in a word: shortage.

- Shortage of qualified seafarers for LNG carriers, both those in existence and those to be delivered over the next five years and beyond.
- Shortage of time to educate and train qualified LNG officers in time for delivery of new LNG carriers now on order or under construction.
- Shortage of the capacity for educating and training LNG qualified mariners worldwide, in terms of facilities, training capabilities, and, above all, having enough qualified instructors with sufficient experience of actual service onboard LNG carriers to train LNG seafarers of the next generation.
- Shortage of opportunities to exchange accumulated knowledge for the enhancement of seafaring human resources in the LNG supply chain, due to the competitive forces of the current LNG market.

The Facts and Figures

Understanding the following facts and figures is essential for a strategic consideration of the current LNG industry and, particularly, the shipping component.

World's LNG Fleet (As of the end of May 2005)
Source: Clarkson Research Services Ltd.[1]

	Number of ships
Serving as of May 2005	Total 182 ships
Expected total new contracts in 2005	50–65 (21 are firm orders)
Expected number on order at the end of 2005	143–158 *
Expected total LNG fleet by the end of 2009	339–354 +

Table 1
* The figures include those contracted before 2005.
\+ The figures include those to be delivered during June and December 2005

Delivery Schedule of LNG Ships (As of the end of May 2005)

Year	Number of ships
2004 (Sept.-Dec.)	2 (delivered)
2005	20
2006	27
2007	30
2008 - 2009	86–101
Total	165–180

Table 2
Source: Clarkson Research Services Ltd.

Estimated Demand for officers for the LNG Ships on Order

Year	Deliveries	Newly required seafarers	
		Total	Officers *
2004 (4th Qtr)	2 (delivered)	120	40 [24]
2005	20	1,200	400 [240]
2006	27	1,620	540 [324]
2007	30	1,800	600 [360]
2008 -2010	86–101	5,160–6,060	1,722–2,020 [1,032–1,212]
Total	165–180	9,900–10,800	3,300–3,600 [1,980–2,160]

Table 3

* Figures in [ ] show the number of Senior Officers (Management Level)
The number of seafarers and officers are calculated by the author based on the assumptions following Table 3, and on the expected number of deliveries in Table 2 by Clarkson Research Services. Source: Clarkson Research Services Ltd.

Assumptions

- Thirty seafarers on board an LNG ship.[2]
- Ten out of the 30 seafarers on board are officers.
- Six officers out of 10 are Senior Officers (Master, Chief Officer, Officer in charge of cargo, Chief Engineer, 1st Assistant Engineer in charge of cargo, and 2nd Engineer).[3]
- The rest of the 20 seafarers are all ratings.
- Two sets of crew per ship (The employment contract term is usually "four on, four off," meaning serving on board for four months, followed by a holiday for four months.) Therefore, each LNG ship should have two complements (Table 3).

Demand for Turbine Engineers Estimated to Increase

LNG ships use steam turbine engines as the main propulsion system for the purpose of efficiently using the boil-off gas from their cargo tanks. They are among the only type of commercial cargo ships that employ steam turbine engineers today. Over the past 30 years, since the first oil crisis in the early 1970s, the world maritime community has significantly reduced its capacity to educate and train steam turbine engineers. The most critical shortage, therefore, has been experienced in this area today (Table 4).

Turbine Engineers – Estimated Demand* (As of the end of May 2005)

Year	Deliveries	Newly required turbine engineers	
		Officers	Senior Officers
2004 (4th Qtr)	2 (delivered)	20	12
2005	20	200	120
2006	27	270	162
2007	30	300	180
2008–2010	86–101	860–1,010	516–606
Total	165–180	1,650–1,800	990–1,080

Table 4

* The projected turbine engineer needs here are a subset of the total additional needs projected in Table 3.
The number of seafarers and officers are calculated by the author based on the assumptions following Table 3, and on the expected number of deliveries in Table 2 by Clarkson Research Services.

The Challenge

Is the world maritime community capable of supplying the required number of qualified LNG seafarers in time, without compromising the level of competence of each and every seafarer?

Shortage of Qualified Mariners for LNG Carriers

The LNG shipping segment has been a unique microcosm, consisting of highly specialized companies (Table 5). It has been stable, with each member having its own systems to satisfy its respective demand for seafarers. A fine balance of supply and demand has been realized through this mechanism. The whole supply capacity of LNG seafarers has been the aggregate of each of the constituents of this microcosm. The expansion that we are observing now is revolutionary. It has never happened so quickly before, or in a segment of the industry that is technically so different from other segments of the shipping industry.[4] To make matters worse, two more points exacerbate the situation, exactly at the time the new deliveries reach their peak in 2007 to 2009.

(1) The rapidly declining number of existing LNG officers, mainly as the result of aging and retirement. It is expected to be a massive worldwide problem by 2010.[5]

(2) Decreasing supply of cadets. The younger generation in traditional sea-going positions has been showing less and less interest in going to sea, and junior officers typically leave the seagoing segment of the industry prior to taking on senior level seago-

ing positions. This makes it difficult to ensure a sustained supply of officers for the next generation. There is yet no effective means to counter this tendency.

World's LNG Ship Operators (As of September 2004)

A total of 35 companies	
The biggest company; STASCO (Shell)	22 ships (13%)*
Top 5 companies	77 ships (44%)
Top 10 companies	111 ships (64%)
Top 15 companies	141 ships (81%)

Table 5

* Figures in ( ) indicates share % in terms of number of ships.
Source: Diamond Gas Operation (a subsidiary of Mitsubishi Corporation)

Shortage of Time

Is there ample time to supply a sufficient number of LNG-qualified seafarers to meet the growing demand of the industry in a way that has never happened so quickly before?

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) 1978, as amended in 1995, requires a minimum of four years of approved seagoing service to obtain certification as a master, but this can be reduced to three years, if at least one year of the approved seagoing service has been served as chief mate. This includes one year of approved seagoing service, as part of an approved training program to become certified as an officer in charge of a navigational watch (OICNW) at the operational level.

Regulation V/1 of STCW mandates additional requirements for the training and qualification of masters, officers, and ratings on tankers.

Masters, chief engineer officers, chief mates, second engineer officers, and any person with immediate responsibility for loading, discharging, and care in transit or handling of cargo are required to have (1) experience appropriate to their duties (sub-paragraph 2.1) and (2) completed an approved specialized training program (sub-paragraph 2.2).

The established scales of experience in the LNG industry as the basis of expertise are:
(1) For senior officers with no tanker experience:
At least two familiarization voyages on tankers. Such voyages should include at least one training voyage in a supernumerary capacity. The training voyage requirement may be 28 days, or it may require at least one loading and one discharge. Thereafter, a specialized liquefied gas course is required.

(2) For senior officers already experienced in the tanker trades, but not the gas trades:
Only the training voyage as above should be necessary (as well as the specialized liquefied gas course, if the senior officer has not already completed it).[6]

There is a significant difference between the minimum seagoing service time required by STCW and best industry practice for a new entrant officer to become a master. While STCW only requires four years approved seagoing service (including OICNW) to obtain certification as a master (reduced to three years if at least one year of the approved seagoing service has been served as chief mate), it is a tacit understanding in the industry that it takes 10 to 12 years for a new entrant officer to become a master.

The challenge is to supply 2,500 to 3,000 senior officers for the LNG shipping industry, who satisfy the above minimum requirements, within less than five years, followed by years of required education and training of these mariners. Add to this the simultaneous demand for replacement of a similar number of retiring senior LNG officers. An educated estimate of the aggregate demand for the period is 5,000 or more. All stakeholders must realize that we must begin immediately to educate and train the next generation of officers.

Shortage of the Capacity for Educating and Training LNG-Qualified Mariners

Until now, the microcosm of traditional world LNG shipping industry has managed its supply capacity of qualified LNG officers through in-house training facilities and third-party education and training institutions.

These are harmoniously managed to meet the forecasted demand of LNG officers, the growth of which has been modest and predictable.

The significant factor in today's LNG industry is the number of new entrants who do not have any prior LNG shipping experience. They have no in-house training facilities, and they have no LNG ships to provide relevant hands-on training. They have been flocking to the existing third-party education and training institutions through ship managers. Existing training facilities worldwide are full to capacity and struggling to keep up with demand. In the near future, the industry will require an infusion of 2,500 to 3,000 trained officers to keep pace with demand. It is essential that we address the training of these officers immediately.

Shortage of instructors is also a concern, although it is perhaps not as obvious as other shortages. ISM Code 6.5 states that cargo handling simulators are most valuable for the continuation of high operational standards. Any training utilizing a simulator depends on the competence of the instructors. The simulator itself, however costly it may be, can be a tool or toy, depending on the quality of instructors and the educational system using it.

Traditional and new entrant operators, and delivery years of their new LNG ships (As of September 2004)

Operators	2004	2005	2006	2007	2008	TOTAL
Traditional Operators	7	14	18	17	7	**63**
New Entrant Operators	2	1	9	13	6	**31**
TOTAL	**9**	**15**	**27**	**30**	**13**	**94**

Table 6

Source: Diamond Gas Operation (a subsidiary of Mitsubishi Corporation), and Clarkson Research Services Ltd.

Whether or not there is a sufficient number of qualified instructors readily available not only for simulator training, but also for the training of all the other required competence of LNG officers, will decide the capacity of education and training LNG officers. The International Association of Maritime Universities (IAMU) has concluded that instructors for LNG officers should have at least six months' experience of service as management level officers onboard commercially trading LNG ships. As the wage levels of LNG qualified senior officers have been skyrocketing to levels as high as $15,000 per month or more for a master for the month onboard, they are showing signs of further increase, as the supply and demand balance of the LNG officer labor market worsens. The hard reality seems to be dampening the hopes of all the parties concerned. There should be no undue optimism here, either.

Shortage of Opportunities to Exchange Accumulated Knowledge

Currently, the small world of LNG shipping is comprised of a few experienced owners, operators, and ship managers. The LNG shipping market has been largely controlled by a few sellers of LNG shipping services. The experience and expertise have been accumulated on an individual company basis.

The transformation now underway is characterized by the unprecedented numbers and speed with which new participants are entering the market (Table 6). Competition now exists on a global scale. Those companies with experience and expertise in LNG shipping are able to provide a level of service quality far superior to those competitors newly entering the marketplace. The new entrants to the field are in need of knowledge, yet they find themselves distanced from the resources that are vital for the safe operation of LNG ships. In other words, there has been very much limited technological transfer. There is not yet a harmonious collaboration among the related industries and parties such as classification societies, underwriters, and academia. The issue is delicate. It is difficult to find the point where the two contradicting vectors, namely, public interests vs. private interests, will be balanced.

It is also true that sharing knowledge is beneficial to all the parties concerned, above all to the general public, by enhancing the levels of operational safety. Should the prestigious safety record of the industry be interrupted, the negative implications would be daunting, not only to the general public, but also to the LNG industry itself—importers, exporters, and administrations.

Transformation of the World's Higher Education Institutions for Mariners

The LNG trade is based on a long-term project period of 20 to 25 years. Ocean transportation, a vital part of the project, is also planned with a long-term perspective. The supply of qualified seafarers, therefore, should be planned and implemented with this view.

The higher education institutions for mariners are most qualified for the role of supplying qualified LNG officers to the industry. They are also the institutions upon whom the world LNG industry is depending. It is, therefore, worth our while to pay attention to the very critical transformation now underway at almost all the maritime higher educational institutions of the world.

Demise of the Rationale for a National Government Maritime Academy System

The rapidly expanding globalization of world shipping in the past couple of decades has taken away the reason for the government of each country to finance merchant marine universities/academies at tax payers' expense, with the realization that its national flag merchant marine fleet is rapidly decreasing, mainly through flagging out in search for less expensive foreign seafarers.

The Reform of the University System

The global trend of reform of university systems puts the particular emphasis on enhancing competence in academic and research activities. The hands-on fields of a highly vocational nature, such as seafarer education and training, have consistently received less attention and strive constantly to justify their existence. The uniqueness of merchant marine universities and academies in providing both an academic degree and a seafaring certificate of competence is now raising serious questions as to which of the two should be given the higher priority. The common decision for these institutions is to choose academic and research fields as their future course of survival.[7]

The exceptions to this trend can be seen in those countries who have a clear policy to keep the maritime higher education institutions intact from the national security viewpoint (such as the United States), or to meet the rapidly increasing ocean transportation needs of their own countries, and reflecting the development of the international trades of their national economies (such as China, India, and Vietnam).

The majority of the maritime higher education institutions located in Europe, Japan, and other developing countries that have the history and tradition, as well as a rich accumulation of academic and educational resources, are accelerating their pace toward academics and research competitiveness. This trend seems irreversible.

A Call for Innovative and Immediate Action

The ongoing dynamic expansion of the world LNG shipping market has brought the critical issue of qualified seafarers into the spotlight.

This attention is largely due to:

- LNG imports directly concern the national security of each importing country;
- the speed of this expansion is unprecedented;
- the biggest expansion of the import, which is at the background of this historical LNG fleet expansion, will be seen in the United States, followed by the United Kingdom / European Union, China, and India;
- An LNG ship is the most sophisticated type of ship;
- the size of these ships becomes dramatically larger from the present maximum size of 145,000 cubic meters to 200,000 to 250,000 cubic meters (a 38 to 73 percent increase in capacity);
- there are a number of rapid technical advancements, including the cargo containment system of a LNG ship now on order, and, therefore;
- they require top-notch seafarers, of which there is a critical shortage.

This leads to the fundamental argument surrounding the globalization of international shipping today—the absence of an ultimately responsible party in charge of administering the training of every seafarer serving on board LNG ships. This absence derives from the principle of respecting the flag states.

The implication is clear. The vacuum of responsibility concerning the assurance of supply capacity and competence control of mariners serving on LNG carriers should immediately be filled with an appropriate international mechanism that can be sustained on a long-term basis.

Flag States of LNG Ships of the World (As of September 2004)

(A) National Flag [12 Countries]	**(Total: 89 ships)**
Algeria	(6 ships)
Australia.	(4 ships)
Brunei	(8 ships)
EU 7 (Belgium, France, Italy, Luxemburg, Malta, Spain, and UK)	(28 ships)
Japan	(25 ships)
Malaysia	(18 ships)
(B) International Shipping Registry [3 Countries]	**(Total: 14 ships)**
Norway International Shipping Registry (NIS)	(9 ships)
Denmark International Shipping Registry (DIS)	(1 ship)
Isle of Man (IOM)	(4 ships)
(C) Other Flag States [7 Countries]	**(Total: 71 ships)**
Bahamas	(6 ships)
Bermuda	(12 ships)
Liberia	(16 ships)
Marshall Island	(8 ships)
Panama	(20 ships)
Singapore	(7 ships)
St. Vincent	(2 ships)
TOTAL : 22 Countries	**(Total: 174 ships)**

Table 7
Source: Diamond Gas Operation (a subsidiary of Mitsubishi Corporation)

Limited Number of Countries Actually Involved in LNG Trade

There is a positive side, in that there is a limited number of countries actually involved in LNG trade, either as exporters (now 13), or as importers (now

13),[8] or flag states (22) (Table 7). In 2003, the top three countries (Japan, Korea, and the United States) and a region (EU) imported 91 percent of the world's total ocean-borne LNG. The combined share of the three countries and EU by 2009 will certainly be far more than that of 2003, as the imports by the United States and EU will sharply increase by that time.

IAMU organized the world's very first international LNG roundtable, focusing on the seafarer issue in the LNG supply chain. The two-day roundtable was held in Busan, Korea, beginning on February, 28 2005. The roundtable attendees included representatives of the Society of International Gas Tanker and Terminal Operators (SIGTTO); the United States Department of Transportation, Maritime Administration (MARAD); the Department for Transport of the United Kingdom; and the Australian Maritime Safety Authority; IAMU representatives attended as the delegate of maritime academia.

At this roundtable, IAMU and SIGTTO signed a joint statement that was endorsed by the representatives of the administrations and other roundtable participants.[9] The joint statement successfully sets the foundation for the voluntary collaborative international platform suggested in this article. The parties agreed that they would:

(1) using information gathered from companies, industry bodies, classification societies, and others, as appropriate, finalize an inventory of enhanced competency standards for safe LNG operations and prepare training packages and assessment criteria to deliver these competencies effectively;

(2) formally present to the International Maritime Organization (IMO) the need to consider LNG competency standards, training packages, and assessment criteria, and request that the needs of the LNG sector receive the urgent attention of the Maritime Safety Committee;

(3) provide assistance to the Maritime Safety Committee in this effort and;

(4) devise an appropriate framework for implementing the above actions.

Korea Maritime University (KMU) has been taking the leading role in these efforts of IAMU, because it is located at the heart of the world's LNG transportation today. An overview of Korea shows that it is home to:

- an LNG shipbuilding industry that has 73 percent of the world's total LNG new building orders;
- four experienced LNG shipping companies and;
- the world's biggest single importer of LNG, namely Korea Gas Corporation (KOGAS).

Such factors offer the most favorable environment for LNG human resource reproduction through accessibility to the latest technologies and technical expertise.

SIGTTO has been independently developing competency standards for all officer ranks on LNG vessels. SIGTTO hopes to submit these standards to IMO (as an information paper) in 2005. SIGTTO intends that these standards will be accepted as the industry minimum best practice.[10]

Conclusion

Additional commitment is required to build upon the solid foundation set by adoption of the joint statement at the IAMU roundtable earlier this year. We should establish a broader based voluntary collaborative platform that includes all relevant administrations, wider industry and academia participation, and all relevant international organizations of maritime professionals, such as the International Association of Classification Societies (IACS) and the Nautical Institute, to maintain the enviable safety record of LNG ocean transportation. Close coordination with IMO should be maintained throughout the process. The discussions among all the parties on how to build an effective framework that can deal with the challenge of the shortage of qualified LNG officers should be at the top of the agenda.

The core concept of this framework is a concentration of all the available resources in the global scale under a collaborative management, sharing the principles of transparency, efficiency, and reasonable cost sharing.

We must foster a truly innovative, proactive, and sustainable global mechanism that assures that each seafarer assigned to an LNG ship is competent and qualified.

The international shipping market must be able to assure the safe and uninterrupted flow of LNG, one of the most environmentally friendly primary energy sources, for the best benefit of the general public of both exporting and importing countries.

Endnotes

1. Clarkson Research Service Ltd. provides statistical research services to worldwide shipping, banking, and investment interests. Its research team

compiles and interprets data on the world's cargo and offshore fleets of over 25,000 vessels on a daily basis, including technical features, freight rates, ship prices and cargo/economic statistics. It is accessible on the Internet at: http://www.clarksons.net.

2. This assumption is based on actual crew size data from current LNG ships, as projected to slightly increase due to various factors associated with the higher demand market for LNG and the new LNG ships that are being built to meet this increased demand for far more diversified trading routes.

3. Because of the unique physical nature of LNG, cargo handling is the vital part of the operation of an LNG ship. The mandatory rules and regulations require assignment of a senior officer(s) in charge of cargo on board. The U.S. Coast Guard rules require the Chief Officer to be assigned as the officer in charge of cargo. In view of the critical importance of the roles of the engineering officers in cargo operations, LNG ships usually have two senior officers in charge of cargo on board, one each from the deck and engine department, the closest collaboration of both of whom will ensure the safe and efficient cargo operation. This is a part of the best practice of the industry.

4. Andrew Clifton, "LNG on the boil…", *Seaways*, February, 2005.

5. The age structure of the Japanese seafarers vividly illustrates this. Japan is currently the biggest LNG importing country in the world with about 47% of the total ocean borne LNG of the world. Japan is the biggest flag state of LNG ships with 25 as of September 2004. Japanese senior officers are the core of the safe operation of Japanese LNG fleet. The total number of Japanese officers was 2,746 as of October 1, 2002, out of whom 56.8% were older than 45 then, and 66.5% were over 40 years of age. The retirement age for officers at the major Japanese shipping companies is 53, and it is expected that almost all the senior officers in the age group will retire before 2010. For the colored diagram, please access to: The Japanese Shipowners' Association, "The Current State of Japanese Shipping" March, 2004, PDF file at http://www.jsanet.or.jp/e/shipping-e/index.html, p.29.

6. SIGTTO, *Crew Safety Standards and Training for Large LNG Carriers-Essential Best Practices for the Industry*, First Edition, Witherbys Publishing, London, 2003, p.9 (2.2.4 Experience).

7. Maritime universities in EU are good examples. EU has been vigorously pursuing the objectives of standardizing the higher education system in the member countries in line with the Bologna Agreement. Maritime universities are also subject to this campaign. Transformations of Maritime Academy to Maritime Universities in Poland in the past couple of years are typical example of shifting the institutional focus from the practical seafarer education and training to research and academic activities. It should be remembered that the shift inevitably means that more funds are allocated to research activities, and less to seafarer education and training, and that thus the status of Maritime Department weakens within that institution. Japan lost independence of the two Yokozuna higher seafarer educational institutions, namely Tokyo University of Mercantile Marine, and Kobe University of Mercantile Marine, in 2003, as a part of the national policy of rationalization and revitalization of Japanese higher education system. The core principle of this national policy is to introduce the principle of competition into the nation's universities, with an express objective to enhance their research capacity. The two Yokozunas were transformed to faculty status at two different universities, where their capacities of research are assessed by the third party regularly. The amount of the funding from the government is subject to this third party assessment. The ground for seafarer education and training has significantly been weakened.

8. Not only are there currently just 12 countries that export LNG, there are only 12 countries that import it as well. Of the importers there are 6 in Europe (France, Greece, Italy, Portugal, Spain, and Turkey), 3 in Asia (Japan, Korea, and Taiwan) and the United States and Puerto Rico. Clarkson Research Studies and LNG shipping solutions, *LNG Trade and Transport 2003*, September, 2003, p.14 . Egypt started to export, and India started to import after the publication of the report.

9. The full text of the Joint Statement is available at the homepage of IAMU at: http://iamu-edu.org/workinggroups/lng.php.

10. Lloyd's List; *Standards on Way for Gas Carrier Officer Training*, Monday, August 08 2005 News, p.3.

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The Safe Transfer of Liquefied Natural Gas

Person-in-charge qualification requirements for bulk liquefied gas transfers.

by LT. CMDR. DEREK A. D'ORAZIO
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Each transfer of bulk liquefied gases as cargo and each cool-down, warm-up, gas-free, or air-out of a liquefied gas cargo tank must be supervised by a qualified person in charge (PIC) as per 46 CFR 154.1831 (Subchapter O) and 33 CFR Part 155.710.[1] Regulation V/1 of the Standards of Training, Certification & Watchkeeping (STCW) for Seafarers Convention, 1978, as amended, sets the international mandatory minimum requirements for qualification of personnel on seagoing tankers. 46 CFR Part 13 implements STCW for U.S. tankermen licensed/documented by the Coast Guard, while foreign mariners are subject to STCW as implemented by their respective national merchant mariner licensing/documentation systems.

Foreign Flag PIC

The persons in charge of bulk liquefied gas transfers from foreign flag tankers in U.S. waters must hold appropriate licenses/documents and dangerous cargo endorsements/certificates issued by the flag state of the vessel, attesting that the PIC meets the requirements of STCW Regulation V/1. Among other additional requirements, foreign flag person in charge of bulk liquefied gas transfers in U.S. waters must also be capable of communicating in English.[2]

Tankerman-PIC LG Endorsement

The Coast Guard offers various types of tankermen endorsements under 46 CFR Part 13, depending on the cargo (dangerous liquids or liquefied gases); vessel type (barge or other); and responsibilities of the mariner (PIC, assistant, or engineer). Likewise, STCW has different requirements depending on the level of responsibility of the mariner. The scope of this article is limited to Tankerman-PIC LG endorsement and the STCW equivalent, which authorizes the mariner to serve as the person in charge of a bulk liquefied gas transfer.[3]

All 46 CFR Part 13 tankermen endorsements require two training courses: basic shipboard firefighting and a cargo course applicable to the type of cargo being endorsed, such as dangerous liquids or liquefied gases. The firefighting course for Tankerman-PIC LG endorsement must meet the basic firefighting section of International Maritime Organization (IMO) Resolution A.437 (XI), "Training of Crews in Fire Fighting." All current Coast Guard-approved basic firefighting courses are 16 hours in duration. The cargo course for Tankerman-PIC LG endorsement must cover all of the topics listed in 46 CFR Table 13.121(f), column 3. Current Coast Guard-approved tank ship LG cargo courses are approximately 60 hours in duration.

In addition to the firefighting and cargo course requirements, each type of tankerman endorsement requires prior service/experience on tank vessels, with some degree of recency of that prior service/experience. The Tankerman-PIC endorsement also requires that the mariner have participated in a minimum number of cargo transfers, under the supervision of a qualified Tankerman-PIC, while onboard the tank vessel.[4]

STCW Requirements

Under STCW, masters, chief engineers, chief mates, second engineers, and any person with immediate responsibility for a bulk liquefied gas transfer must:

- complete an approved shore-based firefighting course,

- have one to three months of approved seagoing service on tankers or complete an approved tanker familiarization course,
- have appropriate experience on liquefied gas tankers and,
- complete a specialized liquefied gas tanker training program.

Section A-V/1 of the STCW Code provides syllabi for the tanker familiarization course and the specialized training program for liquefied gas tankers.

Developments

STCW generally provides training requirements in the form of competence tables and requires that mariners practically demonstrate proficiency in these competencies prior to certification. IMO model courses are then developed in accordance with the STCW tables of competence. This is not the case for tanker qualifications. STCW only requires training—not practical demonstrations of competence—covering the topics listed in Section A-V/1 of the STCW Code. The IMO model courses for tanker personnel were developed based on the listed topics, not on any tables of competence, because there currently are none.

The Coast Guard offers various types of tankermen endorsements under 46 CFR Part 13, depending on the cargo, vessel type, and responsibilities of the mariner.

A proposal was submitted in January 2005 at the 80th session of the IMO Maritime Safety Committee to develop tables of competence for tanker qualifications for possible future incorporation into STCW.

In light of the recent international discussion, the Coast Guard enlisted the assistance of the Merchant Marine Personnel Advisory Committee (MERPAC) to help develop competence tables for personnel serving on tankers. For more information, please access the MERPAC website as follows: www.homeport.uscg.mil/mycg/portal/ep/home.do (click on "Ports & Waterways" in the left-hand column of the opening screen, then select MERPAC under "Safety Advisory Committees" in the middle column, reference Task Statement #51).

For More Information

Specific questions regarding tankermen qualifications and certification for U.S. mariners should be referred to the National Maritime Center and/or the nearest Regional Examination Center: www.uscg.mil/STCW/home.htm

Specific questions about enforcement of STCW requirements for crewmembers on foreign flag vessels in U.S. waters should be referred to the Office of Compliance (G-MOC) and/or the local Coast Guard office responsible for the waterway in question: www.uscg.mil/hq/g-m/nmc/compl/.

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Endnotes

[1] This includes both liquefied natural gas (LNG) and liquefied petroleum gas (LPG) transfers.
[2] See 33 CFR 155.710(c).
[3] See 46 CFR 13.107; STCW Regulation V/1, paragraph 2 & Section A-V/1, paragraphs 22–34.
[4] See 46 CFR 13.203.

LNG and the Deepwater Port Act

Responding to increasing domestic demand for natural gas.

by Mr. Mark Prescott
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The Deepwater Port Act was signed into law in early 1975 to provide a means for bringing more oil into the United States. Its purpose was to regulate location, ownership, construction, and operation of deepwater ports; protect marine and coastal environments; protect the rights of states; and promote the construction and operation of deepwater ports as a safe and effective means of importing oil. While only one port was ever built, the Louisiana Offshore Oil Port (LOOP), it has been very successful in oil imports, currently accounting for the movement of over 10 percent of oil imported into the United States.

Recognizing the success of LOOP, Congress passed the Deepwater Port Modernization Act in 1996. Its purpose was to update and improve the Deepwater Port Act; assure that regulation of deepwater ports was not more burdensome than necessary compared to other modes of importing or transporting oil; recognize that deepwater ports are generally subject to effective competition and eliminate unnecessary oversight in the ports' business decisions; and promote innovation, flexibility, and efficiency in the management and operation of deepwater ports by removing or reducing unnecessary, or overly burdensome, federal regulations or license provisions.

The Deepwater Port Act stipulates that the Secretary of Transportation is responsible for issuing, amending, or rescinding a license for a deepwater port. Shortly after the Modernization Act was passed, the Secretary delegated authority to process deepwater port applications to the Coast Guard and the U.S. Maritime Administration (MARAD) and delegated the regulation, inspection, and oversight of pipelines associated with deepwater ports to the Department of Transportation's Office of Pipeline Safety (now known as the Pipeline and Hazardous Material Safety Administration). The delegation of authority to MARAD can be found in 49 Code of Federal Regulations Part 1.66(aa)(1) and contains little discussion of how responsibilities are to be divided between the Coast Guard and MARAD. In June 2003 the Secretary of Transportation further delegated authority to license deepwater ports to the Maritime Administrator.

Even though the Coast Guard has been moved from the Department of Transportation to the Department of Homeland Security since the Secretary of Transportation's original delegation to the Coast Guard, the Coast Guard still maintains responsibility for processing applications in coordination with MARAD. What has developed for processing LNG deepwater port applications is a division of labor along the core competencies of each agency, with the Coast Guard being the lead federal agency in the development of the environmental impact statement (EIS). In addition, the Coast Guard is responsible for review and approval of operations manuals, engineering standards and design oversight, security, waterways management, and inspections.

Natural Gas Added to DWP Act

Prior to September 11, 2001, one major energy company began inquiring about applying for a deepwater port license for importing natural gas. A Coast Guard legal review confirmed that the DWP Act was applicable only for importing oil, and, thus, jurisdiction for such a project was unclear. The assumption was that either the Coast Guard or the Federal Energy Regulatory Commission (FERC) would ultimately have regulatory authority over such a facility. With industry's interest increasing, the Coast Guard had planned to pursue a legislative change proposal seeking to add provisions for importing natural gas to the Deepwater Port Act.

After the 9/11 terrorist attacks occurred, concern over liquefied natural gas (LNG) carriers rose as these were feared to be prime targets for terrorists. In fact, as an immediate precaution the LNG terminal near Boston, owned by Tractebel, was temporarily shut down pending an evaluation of security measures and the risks associated with bringing LNG tankers into Boston Harbor. Eventually, additional security measures were implemented and the facility was reopened, but security concerns raised by local communities have become a major issue for many of the proposed shore-side LNG terminals.

Recognizing the growing need for natural gas, the high-level interest from the energy industry to import more LNG, and the concerns surrounding the siting of shore-side facilities and the desire to site them in more remote locations, Congress added natural gas to the Deepwater Port Act as part of the Maritime Transportation Security Act (MTSA) of 2002. Since that time, 11 applications for LNG deepwater ports have been submitted to the Coast Guard. In February 2005 the Maritime Administration issued a record of decision approving the Shell Gulf Landing deepwater port application, bringing the total LNG deepwater port approvals to three, which includes the previous approvals of Excelerate's Gulf Gateway and ChevronTexaco's Port Pelican.

LNG Industry Drivers

Something of a perfect storm is currently occurring with regard to the natural gas market in the United States. Domestic demand continues to rise, with the vast majority of new power generation set up to burn natural gas. Domestic production, on the other hand, has not increased nearly enough. In fact, with U.S. demand projected to increase by 50 percent over the next 20 years, domestic production is seen as relatively flat.

With approximately 15 percent of U.S. natural gas needs supplied by pipeline from Canada, U.S. production had previously been able to meet the demand with the price below $3 per million British thermal units (BTUs). At that price, the cost of liquefaction, transportation, and regasification made importing natural gas essentially noncompetitive. The exception was New England, where, because of location at the end of the pipelines, supply was more restrictive and pipeline tariffs on natural gas being supplied from the Gulf of Mexico drove the cost high enough that importing LNG had been a cost-effective option.

What changed is that the price of natural gas began moving upward (expected above $10 per million BTUs this winter) and at the same time improving technology and increasing efficiency reduced the liquefaction and transportation costs. These factors,

Through the Deepwater Port Modernization Act, Congress encouraged flexibility to allow for innovation in both the design and operation of a deepwater port.

coupled with an abundance of natural gas in other parts of the world, have led to the rush to develop LNG terminals in the United States. The continental United States currently has only four natural gas import terminals, which are located at Everett, Mass.; Cove Point, Md.; Elba Island, Ga.; and Lake Charles, La. Though all these were built in the 1970s, only within the last six years have Cove Point and Elba Island begun to receive natural gas again, and, with the exception of the LNG terminal at Everett, all the existing terminals are attempting to expand their capacity. The contribution of LNG is expected to rise from less than 2 percent of the U.S. natural gas supply to over 15 percent by 2025.

Immediate Applications

Literally within hours of President George W. Bush signing the MTSA that authorized importing LNG via deepwater port, the Coast Guard received the very first LNG deepwater port application from ChevronTexaco. A month later, El Paso submitted the second of what has risen to be a total of 11 deepwater port applications.

Under the Deepwater Port Act, a record of decision is expected to be issued within 356 days of submission or 330 days after the application is determined to be complete. Since the Coast Guard did not have an existing staff to process deepwater port applications, the Commandant authorized the formation of a dedicated division within the Office of Operating and Environmental Standards.

With the assistance of an environmental consultant hired for each application received, the Coast Guard's Deepwater Ports Standards Division (G-MSO-5) must develop an environmental impact statement for each application. The completion of the EIS is a very substantial element in processing a deepwater port application, and the Coast Guard must work with other agencies involved to ensure all concerns are addressed in a single EIS that will serve for all federal permitting requirements. Executive Order 13212 requires federal agencies to streamline and accelerate the permitting of energy-related projects and established a White House Task Force to work with and monitor federal agencies' efforts in this regard. With help from the leadership of the task force, a broad interagency agreement was developed that lays out responsibilities of all involved federal agencies (see www.uscg.mil/hq/g-m/mso/mso5.htm).

Deepwater Port Designs Greatly Varied

Through the Deepwater Port Modernization Act, Congress encouraged flexibility to allow for innovation in both the design and operation of a deepwater port. To accommodate this principle, the Coast Guard regulations for design and operation in 46 Code of Federal Regulations Part 149 and 150, respectively, allow the applicant to propose the standards to be used for design and propose how a facility will operate to ensure safety, security, and protection of environment. The value of this flexibility can be seen in the great variety of designs that have been submitted thus far. Concerns have been raised by some that the technology or concepts are unproven and will create too great of a risk. The Coast Guard disagrees with that position because, while some aspects of a design are unique, they generally represent combinations of established and proven technology being deployed in a new way.

The first operational LNG deepwater port, Excelerate's Gulf Gateway, is an excellent example of just that concept. Gulf Gateway uses a submerged turret loading (STL) system that has a very extensive and successful history of use in the North Sea. In the North Sea, STL buoys are used to load shuttle tankers for movement of oil to onshore terminals. In this case, LNG carriers are using the STL to discharge gas through the STL buoy into a pipeline to shore. Other examples of innovation with proposed deepwater designs include the use of gravity-based structures, existing offshore platforms, and floating storage and regasification units. Navigation and Vessel Inspection Circular 03-05, "Guidance for Oversight of Post-Licensing Activities Associated With Development of Deepwater Ports," which was promulgated on May 16, 2005, lays out the design, oversight, and approval process (see www.uscg.mil/hq/g-m/mso/mso5.htm).

As companies pursue a variety of offshore and onshore options and attempt to line up supply contracts for the natural gas critical to the U.S. energy portfolio, the number of deepwater port projects that will ultimately be built is unclear. Over 50 projects have been proposed for North America, but most experts believe that 12 new facilities at the most will actually be built. However, until the expected new gas supplies are locked in and approach the anticipated gap caused by rising consumption, we can expect numerous proposals trying to establish portals to U.S. gas markets.

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Examining the *Excelsior*

Completing the initial COC examination of the first-ever LNG carrier with onboard regasification.

by Captain Mark. K. Lane
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by Cmdr. Chris Oelschlegel
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by Lt. Cmdr. Callan Brown
Chief of Compliance, U.S. Coast Guard Marine Safety Office Port Arthur

An initial certificate of compliance (COC) examination was recently completed in two parts on the first liquefied natural gas carrier (LNGC) in the world with onboard regasification. COC examinations are conducted to ensure that foreign-flagged vessels carrying Subchapter O hazardous liquefied gasses in bulk comply with applicable U.S. and international regulations and conventions. Inspectors from U.S. Coast Guard Marine Safety Office Port Arthur, Texas, were sent to Korea, along with a representative from the Coast Guard's team of traveling inspectors, to commence the COC examination aboard the Belgian-flagged liquefied natural gas regasification vessel *(LNGRV) Excelsior* (Figure 1).

Performing the examination overseas served several purposes, including observing onboard gas trials while underway; attending meetings and complete safety convention compliance tours of the vessel with the resident classification society surveyor; meeting key personnel associated with the vessel including officers, owners' representatives, systems engineers and persons in charge (PICs); and learning the overall scope of the operation as planned upon arrival in the Gulf of Mexico. Gaining first-hand vessel knowledge in Korea was an essential component of this initial and unique safety compliance examination, and it facilitated the timely completion of those outstanding items to be completed for certification to operate in U.S. waters. The outstanding cooperation and coordination received from vessel owners, owners' representatives, and Excelerate Energy was vital to both the successful initiation and completion of this initial COC examination.

Figure 1: *LNGRV Excelsior* departing Pusan, South Korea. Courtesy Captain Mark K. Lane, Excelerate Energy, LLC.

Background

In 2000 the El Paso Corporation began to explore the novel concept of shipboard LNG regasification. The theory was that an offshore offloading system could be designed and built at far less cost than a shore-based facility and that, by delivering the product offshore in its gaseous state, expensive shore-based facilities could be eliminated from the transport equation. El Paso chose the Gulf of Mexico for its initial installation, selecting a site 116 miles off the Louisiana-Texas border as the location of a deepwater port named the Gulf Gateway Energy Bridge. In 2003 El Paso's work was purchased by Excelerate Energy, who then proceeded to build the port, con-

Figure 2: Forerunner deployment during sea/regas trials by builder DSME off the coast of Korea. The STL compartment has not yet received the final coat of paint prior to delivery. Courtesy Captain Mark K. Lane, Excelerate Energy, LLC.

tract for three LNGRV vessels, and commence the operation.

The marriage of two existing technologies, applied here and not seen aboard conventional LNG tankers, enables the *LNGRV Excelsior* to regasify and discharge its own cargo at sea. The first of these technologies is the cargo handling system known as the submerged turret loading (STL) buoy. The STL buoy is designed to mate vertically within a compartment built into the forward hull known as the STL compartment (Figure 2). The STL buoy is connected to a sub-sea pipeline via an extremely durable, high-pressure, flexible pipe known as the riser. While not in use, the buoy floats at a state of neutral buoyancy approximately 100 feet below the surface and is held in position by eight anchor cables and four suction pilings. The LNGRV locates the buoy by using differential global positioning system technology and an acoustic beacon system. A traction winch on *Excelsior* hauls the buoy upward into the STL compartment, where it is secured by large hydraulic clamps that hold the STL buoy firmly in position. The STL compartment is dewatered, a high-pressure gas swivel is seated to the top of the STL buoy, and the connection is tested. From this point the gas produced by the ship can be discharged into the sub-sea transmission network for distribution to the mainland. One detail of the Gulf Gateway that makes it unique when compared to future LNG/STL installations is the use of an unmanned meter platform.

Figure 3: Port side regasification plant high-pressure LNG pumps. Courtesy Captain Mark K. Lane, Excelerate Energy, LLC.

The Gulf Gateway can introduce gas into two pipelines at once; therefore, flow stream metering equipment is required and controlled by the PICs aboard the Excelsior during cargo operations.

Figure 4: Starboard outboard regasification plant vaporizer as seen from the LNG inlet side. This is one of six vaporizers installed. Courtesy Captain Mark K. Lane, Excelerate Energy, LLC.

The second technology is a shipboard regasification plant. The regasification plant consists primarily of a suction drum, six high-pressure pumps (Figure 3), and six shell-and-tube heat exchangers. LNG is stored in the cargo tanks at a pressure slightly above atmospheric and is pumped by feed pumps into a suction drum. The high-pressure pumps take suction and increase the pressure of the LNG from the suction drum and send it to the vaporizers (Figure 4) up to a pressure of 100 bars (approximately 1400 psig). Gasification is achieved by passing the LNG through the water-heated shell and tube vaporizers; the gas is then metered and passed via a back pressure control valve through an emergency shutdown valve. In turn, it is directed to either the STL buoy in the STL compartment to export the gas ashore or, alternatively, to the dedicated high-pressure manifold for a more traditional discharge method.

COC Examination

Even with these two technologies employed, the *Excelsior* remains a conventional membrane LNG tanker given its cargo containment system and steam propulsion plant, the latter of which is designed to burn cargo boil-off for propulsion. It is important to note that the cargo block can be completely isolated from the regasification plant and the STL compartment. As such, a significant portion of the COC inspection included examination and testing of routine items found on LNG carriers. Examples of such routine examination and testing included, but was not limited to:

- **Certificates and documents:** Classification documents, manning certification, and

International Safety Management Certificate were examined.

- **General exam items:** Navigation safety and lifesaving equipment (bridge gear checked, steering tested, fire pumps run, water wash down system run, pollution prevention equipment examined, and machinery spaces examined, which included testing of the gas detection system by shutdown of the master gas valve and automatic switch over from gas to fuel oil boiler firing).
- **Cargo operational safety:** Cargo gauging, vapor overpressure, and cargo tank overflow control were all examined and alarms tested; the inert gas system, including inter barrier sample points, vent mast sample points, and compressor room sample points, was tested. The nitrogen generator, a vital component to the safe operation of the conventional cargo containment system as well as the regasification plant and STL compartment, was examined. Related cargo safety systems, including cargo venting systems, cargo tank, and inter barrier space relief valves, were examined.
- **Drills:** Abandon ship and fire fighting drills were held and critiqued.

COC examination items considered nonconventional and unique to *Excelsior* focused on the two technologies discussed earlier: the STL compartment and the regasification plant.

COC examination items particular to the STL compartment included:

- **Gas detection:** Due to its location far forward on the LNGRV, the STL compartment and regas plant is equipped with its own gas sampling points that feed into the forward gas detection panel. High-pressure gas transits through the riser and STL buoy and makes operation and testing of this system critical to safety; therefore, placement of the gas sampling points was examined. The panel and all sampling points were tested.
- **Emergency riser disconnect sequence:** An emergency disconnect sequence disconnects the flexible riser from the STL buoy and then releases the buoy from the LNGRV in the event of a major gas leak or similar significant casualty. This can be tested or initiated from multiple locations. For examination purposes, the sequence should be demonstrated before the LNGRV has begun discharging through the STL buoy or after the discharge is complete. The inspection should under no circumstances culminate in the release of the STL buoy itself through the final step of this sequence, the emergency buoy disconnect. As a precaution, the STL buoy remains secured to the ship using the messenger line, although slack, while the sequence is demonstrated. For COC purposes, a successful test was conducted from the bridge and verified using the installed closed circuit television system (Figure 5).

Figure 5: Mock-up or "dummy" buoy testing during sea/regas trials by builder DSME off the coast of Korea. The purpose of this test is for confirmation of buoy handling equipment and procedures. Courtesy Captain Mark K. Lane, Excelerate Energy, LLC.

- **STL compartment oily water monitor:** The STL compartment was flooded and then dewatered to the sea to accomplish STL buoy retrieval and release. Because of the hydraulic equipment the compartment contains, an oily water monitor was installed. Although not a requirement, the crew does rely on it to detect hydraulic fluid to avoid an overboard discharge. Therefore the detector should be checked using hydraulic fluid similar to that powering STL compartment hydraulics.
- **Blast doors:** The STL compartment is fitted with blast doors at the top to relieve overpressure in the compartment in the unlikely event of a flange or riser failure. These were examined for COC purposes.
- **Airlock:** The access door to below deck spaces adjacent to the STL compartment is fitted with an airlock. Its overall function and alarms were verified.

COC examination items specific to the regasification plant included:

- **Flange guards:** The regasification equipment consists of high-pressure pumps and high-pressure piping not fitted on conventional LNG carriers. Flange failure of any of the piping components during regasification operations could result in a gas release. All high-pressure LNG flanges were verified that they were fitted with spray shields and examined during regasification operations.
- **Vent mast:** The regasification system has a dedicated vent mast with relief piping routed to it. The vent mast should be examined, and the seals on the regasification system relief valves should be checked against the ship's testing records.
- **Gas detection:** In addition to the LNG cargo system fixed gas detection, the regasification equipment has a dedicated fixed gas detection system located in the forward electronic switchgear room. This system monitors critical high-pressure areas of the regasification plant. The forward panel and all associated sampling points were tested, along with the repeater panel in the main cargo control room.
- **Water deluge and spray systems:** The deluge system runs constantly during cargo operations and was observed operating satisfactorily on several occasions during regasification operations, flooding the stainless steel deck beneath the regasification plant. The deluge system will be in operation during any regasification period and is likely charged when the LNGRV arrives in port because parts of the regasification system are cooled down prior to arrival. The water spray system can be manually activated and is similar to that fitted on a conventional LNG carrier. However, activating the water spray system while certain exposed cargo equipment is at cryogenic temperatures for testing purposes is not recommended. It is suggested that this system be tested prior to regasification operations or verify with the cargo engineer and vessel records that the system was satisfactorily tested.
- **Automatic shutdown sequence:** The regasification equipment has an automatic shutdown sequence initiated by green line failure from the STL control system, resulting in the automatic closure of ESD valves and shutdown of all associated high-pressure pumps, strip pumps, and cargo pumps. This was safely demonstrated prior to cargo operations.
- **Nitrogen generator:** The LNGRV is equipped with a nitrogen generator that is used, not only to inert the cargo tank inter barrier spaces, but is key to inerting and purging the regasification plant and STL riser system, both prior to and post-regasification operations. Its operation was verified.

Conclusion

Completing the initial COC in two parts facilitated a more thorough examination of this first-ever LNGRV (Figure 6). This included joint development of a COC examination checklist, with owner/operator recommended emergency shutdown testing procedures for the STL compartment and regasification plant. It also ensured that no major obstacles existed prior to *LNGRV Excelsior*'s first call to U.S. waters. Observation of the two technologies in operation, up to and including the commissioning of the Gulf Gateway and commercial discharge of the first regasified cargo, was an added bonus. The examination also afforded time for valuable interface with key personnel associated with the vessel and the port, including classification society surveyors, vessel cargo, deck and engineering officers, PICs, and vessel owners' representatives.

Figure 6: *LNGRV Excelsior* and sister ship *Excellence* at the DSME Shipyard, Okpo, South Korea. Courtesy Captain Mark K. Lane, Excelerate Energy, LLC.

About the authors:

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Lt. Cmdr. Callan Brown, USCG, is a 1987 graduate of Coast Guard Officer Candidate School. He has served in the marine safety program as a marine inspector for the past 14 years. Prior assignments include MSO New Orleans and MSO Houston-Galveston. Currently, Lt. Cmdr. Brown is chief of compliance at MSO Port Arthur.

Third-Party Technical Review

NVIC 03-05 opens the door for certifying entities to review LNG deepwater ports.

by Mr. Ken Smith
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As the Maritime Transportation Security Act of 2002 (MTSA) was developed, Congress provided for an amendment to the Deepwater Port Act of 1974 to include the importation of natural gas. Moments after the MTSA became law in November 2002, the Coast Guard received its first liquefied natural gas (LNG) deepwater port (DWP) license application. Given the extreme energy demands projected for the United States, a total of 11 energy companies have now applied for a license to build and operate a new LNG deepwater port. Though all of these applications will not likely be built, the Coast Guard quickly realized that the resources needed to complete detailed technical plan reviews for LNG deepwater ports far exceeded that currently available. Navigation and Vessel Inspection Circular 03-05, “Guidance for Oversight of Post-Licensing Activities Associated with Development of Deepwater Ports (DWP’S),” will hopefully expedite the Coast Guard review and approval process by providing voluntary guidelines for third-party technical review.

The MTSA required the Secretary of Transportation to promulgate regulations in support of the design, construction, and operation of LNG deepwater ports. To this end, the Coast Guard examined an extensive number of potential standards, regulations, and guides applicable to deepwater ports. However, the deepwater port concepts being considered by industry ranged from traditional fixed-platform structures, gravity-based structures (concrete), and various floating structures. A search of existing codes and standards by Coast Guard and industry engineers identified hundreds of design and construction criteria applicable to the vastly different LNG deepwater port concepts. To further complicate the issue, the Deepwater Port Modernization Act of 1996 (DWPMA) directed the Coast Guard to ensure that the regulation of deepwater ports was no more burdensome than other transportation modes. This would be accomplished by promoting innovation, flexibility, and efficiency in the management and operation of deepwater ports, with the removal of duplicative, unnecessary, or overly burdensome federal regulations or license provisions.

Given the range of design variations, the Coast Guard and other federal agencies with expertise in LNG determined that it was not practicable to identify a specific regulatory regime that would incorporate all the applicable individual standards (U.S. and international). The Coast Guard concluded that the rules and guides published by recognized classification societies and other international organizations not only identify specific standards that we would otherwise identify individually, but also provide a sufficient framework and adequate guidance for design, fabrication, installation, and maintenance to ensure deepwater ports are safely operated. This cooperative research was embodied in the Temporary Interim Rule (TIR) (69 FR 724 January 6, 2004) published by the Coast Guard to revise Title 33 U.S. Code of Federal Regulations (CFR) Subchapter NN.

The preamble to the TIR emphasized the opportunity for industry to leverage existing and state-of-the-art technology while designing to a mutually acceptable compendium of recognized codes and standards addressing all facets of the port's structure and equipment. Unfortunately, this flexibility in the selection of design codes and standards negates the traditional learning curve and the many other experience-based advantages achieved by enforcing one familiar set of standards. Given the resources and special areas of technical expertise needed to address the dynamic range of designs for deepwater ports, the Coast Guard considered a new approach for handling the review, approval, and inspection of these projects.

> **Prospective deepwater port operators also have much to gain by voluntarily exercising the use of an approved CE.**

Third-Party Review

Earlier this year, the Deepwater Ports Standards Division (G-MSO-5) at Coast Guard Headquarters released a voluntary policy for handling post-licensing activities associated with deepwater ports. This policy, promulgated in NVIC 03-05, provided guidance in several important areas not clearly addressed by the TIR. Throughout development of the NVIC, staff members of G-MSO-5 worked closely with staff of the Marine Safety Center (MSC), the Office of Design and Engineering Standards (G-MSE), and other federal agencies having a cooperative role and experience in regulating certain aspects of deepwater ports. Some of the other federal agencies included the Federal Energy Regulatory Commission (FERC), the Minerals Management Service (MMS), and the Office of Pipeline Safety in the Department of Transportation.

The Coast Guard, along with many other federal agencies, recognized the value in utilizing third parties. Recognized classification societies have made notable contributions to the Coast Guard's marine safety missions by conducting technical plan review and inspections on the Coast Guard's behalf under provisions created by a number of different memorandums of understanding (MOUs) and NVICs. The Coast Guard's development of NVIC 03-05 drew from this experience and encouraged the use of independent third parties to assist owners, operators, and the Coast Guard by acting as certifying entities (CEs). Similar to a program established by the MMS for handling offshore platforms, NVIC 03-05 breaks DWP projects into a design, fabrication, installation, and maintenance phase and defines the roles of the operator, the CE, and the Coast Guard.

Operators desiring third-party review may propose to the Coast Guard their choice of qualifying technical firms or organizations that can demonstrate their ability to conduct a thorough and sound technical assessment of the deepwater port. Each organization must sufficiently demonstrate to G-MSO-5 and MSC engineers their capabilities, resources, administration, and experience that will adequately support an independent technical review. If accepted by the Coast Guard, the firm or organization will be designated as the CE for one or more phases of the project.

The first critical step for the CE is to review the operator's design basis documents. These documents will present a general overview of the deepwater port, including the port's structure, marine systems, cryogenic/natural gas processing systems, firefighting systems, lifesaving systems, and habitability. The design basis must then reference the codes and standards to which these systems will be designed, inspected, and maintained. Upon completion of their review, the CE will provide a recommendation to MSC and G-MSO-5 to approve or reject the design basis for the port. If approved, the CE must submit an action plan for approval by the Coast Guard. The action plan establishes the specific expectations and obligations of each party for a particular phase of the deepwater port's development. The action plan must detail the submissions expected of the operator along with a communication and interaction plan to be followed by all parties. Once the design basis documents and the action plan are approved, the CE may then approve plans and calculations and perform inspections on behalf of the Coast Guard. Each phase culminates in a final report, submitted to the cognizant Officer in Charge of Marine Inspection (OCMI), G-MSO-5, and the MSC, whereby the CE certifies all major components and systems of the deepwater port are safe for their intended purpose and comply with the previously approved set of codes and standards.

NVIC 03-05 breaks DWP projects into a design, fabrication, installation, and maintenance phase and defines the roles of the operator, the CE, and the Coast Guard.

With this framework for third-party review, significant benefits to the Coast Guard may be realized. Considering the sheer size and scope of the current deepwater port conceptual designs, using a CE allows the Coast Guard to facilitate aggressive design and construction schedules with minimal resources. Rather than conducting complete plan review on each port, staff engineers at the MSC will conduct focused oversight on critical design elements or systems. The combination of third-party certification and oversight will enable the Coast Guard to meet its obligations under the DWPMA and support the U.S. energy policy by aiding the importation of natural gas in a safe and conscientious manner.

Prospective deepwater port operators also have much to gain by voluntarily exercising the use of an approved CE. Operators have the opportunity to leverage the considerable technical expertise of classification societies and commercial engineering firms in the fields of ocean, mechanical, chemical, civil, and environmental engineering. Classification societies and commercial firms usually have the human resources and experience to handle the gamut of advanced technologies and innovative designs expected in deepwater ports, or they have the ability to adjust their resources to meet the scheduling needs in an expeditious manner. With the flexibility provided by third-party review, operators and CEs can develop plan review and inspection programs that are specifically tailored to meet the needs of their individual projects, while at the same time providing Coast Guard stakeholders (G-MSO-5, MSC, and local OCMI) the ability to maintain regulatory control and oversight.

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Notice of availability for NVIC 03-05 was published in the Federal Register on June 8, 2005 (FR Vol. 70, No. 109, 33351). An electronic copy may be obtained at: http://www.uscg.mil/hq/g-m/nvic/index00.htm.

Approval of Shoreside LNG Terminals

The Coast Guard's role and its relationship with FERC for siting onshore or near-shore LNG terminals.

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The permitting and approval process for a shore-side liquefied natural gas (LNG) terminal can be both complicated and controversial and is a completely different process from that for an LNG deepwater port. For a shore-side LNG terminal, the Federal Energy Regulatory Commission (FERC) is the lead federal agency with approval authority over the siting, design, and operation of the terminal. This applies to LNG terminals built along the waterfront as well as those built beyond the shoreline but inside state waters. State waters typically extend three miles from shore, except in Texas and Florida where they extend three marine leagues (or about 10 miles) from shore.

Coast Guard and Georgia Department of Natural Resource boats patrol the east side of Elba Island on the Savannah River in front of the Southern LNG facility June 2004. The boats were enforcing a security zone on the river established for the G8 Summit. All recreational boating traffic was restricted; however, commercial traffic was allowed to move in and out of the port with some Coast Guard escorts. USCG photo by PA2 Dana Warr.

This article will focus on the Coast Guard's role and its relationship with FERC for the siting of onshore LNG terminals or near-shore LNG terminals that are located within state waters. An LNG terminal that is built offshore beyond state waters is subject to the Deepwater Port Act, and in this case the Department of Transportation (DOT) is the lead federal agency with approval authority over the license for a deepwater port. The authority to process deepwater port applications has been delegated by DOT to the Coast Guard and the Maritime Administration (MARAD), with the Coast Guard being responsible for evaluation of environmental impacts and approval of the siting, design, and operation of the deepwater port, among other things. Noting this distinction is important because there has been confusion in the LNG industry and the general public about the roles and responsibilities for these different types of LNG terminals.

The siting of an LNG terminal is a multifaceted regulatory process that involves both FERC and Coast Guard regulations. For its part, the Coast Guard plays an important role in the review and approval process by providing input for the environmental impact statement (EIS) prepared by FERC and advising FERC on maritime safety and security aspects of the proposed LNG shipping and transfer operations. Additionally, the Coast Guard Captain of the Port (COTP) is required by regulation, specifically Title 33 Code of Federal Regulations (CFR) Part 127.009, to assess the suitability of the waterway for LNG marine traffic and issue a letter of recommendation (LOR). One benefit of Coast Guard participation in FERC's EIS process is that the environmental review triggered by the Coast Guard action of issuing an LOR, in accordance with the National Environment Policy Act (NEPA), can be met by the Coast Guard's participation as a cooperating agency for FERC's EIS. Therefore, the Coast Guard can adopt FERC's EIS and does not have to prepare an environmental review document of its own.

Another benefit of the Coast Guard's cooperation with FERC is that it ensures maritime security as well as navigational safety considerations are taken into account in FERC's siting decision for an LNG facility. Post-September 11, 2001, any waterway suitability assessment for LNG marine traffic must consider the security implications to the port as well as the navigational safety risk factors. However, the Coast Guard regulations on "Waterfront facilities handling liquefied natural gas and liquefied hazardous gas," 33 CFR Part 127, were written pre-9/11 and currently only list navigational safety considerations when assessing the suitability of a waterway for LNG marine traffic.

To address this shortcoming, in February 2004 the Coast Guard entered into an interagency agreement, with FERC and the DOT agreeing to work in a coordinated manner to address maritime safety and security issues for a proposed LNG terminal and the impact of its LNG marine operations on the port environment. Additionally, on June 14, 2005, the Coast Guard promulgated Navigation and Vessel Inspection Circular (NVIC) 05-05, "Guidance on Assessing the Suitability of a Waterway for LNG Marine Traffic," which provides detailed guidance on how both safety and security risks should be identified, analyzed, and mitigated when assessing the suitability of a waterway for LNG marine traffic.

FERC's EIS Process

As the lead federal agency, FERC coordinates input from various cooperating agencies with relevant subject matter expertise, such as the Coast Guard, in preparing an EIS for a proposed LNG terminal (Table 1). FERC evaluates issues ranging from air quality and biological impacts, to cultural and

The Coast Guard provides a security zone for the first shipment of liquefied natural gas to Cove Point, Md., in 23 years. USCG photo by PA3 Donnie Brzuska.

socioeconomic impacts, to safety and security impacts. As part of the EIS process, FERC typically holds one or more scoping meetings, which are open to the public and usually held in the local area of the proposed LNG terminal, to engage with the local stakeholders and determine the scope of the issues and concerns that need to be addressed in the EIS.

The preparation of an EIS is a two-step process. First, FERC prepares and publishes a draft EIS, with an announcement in the Federal Register requesting public comment. Once the public comment period has closed, FERC then addresses all comments and

FERC's Timeline		Month	USCG's Timeline	
Applicant:	FERC:		Applicant:	COTP/FMSC:
Pre-Filing (7-9 months before Filing)	**Start EIS process**	-9 -8 -7	**Submit LOI & Preliminary WSA** (at same time as Pre-Filing)	**Start LOR program & review of Preliminary WSA**
		-6		
		-5		
		-4		
		-3		
		-2		
		-1		
Filing		0	**Submit Follow-on WSA**	**Review/Validation of Follow-on WSA**
		1		
		2		
		3		**Issue Waterway Suitability Report to FERC**
	Issue Draft - EIS	4		
		5		
		6		
		7		
	Issue Final - EIS	8		
		9		
	Issue Final Order (10-12 months after Filing)	10 11 12		**Issue LOR** (anytime after Final-EIS issued)

Table 1 **TIMELINE FOR PROCESS**[1]

[1] *The recently enacted Energy Policy Act of 2005 requires project sponsors who propose the siting and construction of onshore LNG facilities and related interstate pipelines to use the commission's pre-filing process.*

prepares and publishes a final EIS. The final EIS is the primary document that FERC's commissioners reference when they decide whether or not to authorize the siting, construction, and operation of a proposed LNG terminal.

The EIS process allows for consideration of activities that are connected to the principal matter under environmental review—the siting of the proposed terminal. With shore-side LNG terminals, relevant connected activities include matters related to LNG tanker transits to and from the LNG terminal. Therefore, FERC's EIS process takes into account the impact of the LNG tanker traffic on the port, including such factors as a cargo release from an LNG tanker and the potential consequences to public safety and health and the impact on adjacent infrastructure. As a cooperating agency, the Coast Guard assists FERC by providing input to the EIS regarding the maritime transportation aspects of the proposed LNG operation, including risk management strategies to responsibly manage safety and security risks along the waterway.

Coast Guard's LOR Process

As mentioned above, the Coast Guard also has its own regulatory process that must be fulfilled. Per 33 CFR 127.007, the applicant is required to submit a letter of intent (LOI) to the Coast Guard COTP. The LOI identifies the location, provides a description of the proposed facility, and provides characteristics of the LNG tankers and the frequency of the shipments. It also includes charts showing waterway channels and identifying commercial, industrial, environmentally sensitive, and residential areas in and adjacent to the waterway used by the LNG tankers.

Once the LOI has been received by the COTP, the COTP will then prepare and issue an LOR to the owner or operator of the facility and to the state and local government agencies having jurisdiction, as to the suitability of the waterway for LNG marine traffic. This regulation states the COTP must base the LOR on factors including density and character of marine traffic in the waterway; locks, bridges, or other man-made obstructions in the waterway; and other factors adjacent to the facility, including depth of water, tidal range, protection from high seas; natural hazards including reefs, rocks, and sandbars; underwater pipelines and cables; and distance of the berthed LNG tankers from the channel and the width of the channel.

Safety and Security

To clarify how maritime security and navigational safety risk factors associated with the proposed LNG operations should be evaluated and mitigated, the Coast Guard and FERC jointly developed NVIC 05-05. This NVIC clearly describes the relationship between the Coast Guard and FERC and outlines a review and approval process that meets the requirements of each agency. It also introduces the concept of a waterway suitability assessment (WSA), which takes a holistic approach in evaluating the safety and security implications of LNG maritime operations on a port, including identification of appropriate risk mitigation measures. The NVIC provides voluntary guidance to an applicant for a shore-side LNG terminal on how to prepare a WSA. It also provides guidance to the COTP on how to review and validate the

WSA, in cooperation with the key stakeholders at the port such as the Area Maritime Security Committee.

The NVIC advocates a risk-based approach to LNG safety and security, based on the findings in the Sandia National Laboratories report entitled "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water" (Sandia Report #SAND2004-6258), which was released in December 2004. Enclosure (3) of the NVIC identifies risk mitigation strategies to consider based on the various risk factors within the port. This enclosure is designated as sensitive security information (SSI), since, if disclosed, it could be used to subvert or exploit security measures and can only be released by the COTP on a need-to-know basis in accordance with the guidelines for handling SSI material.

The enclosure is a quick-reference tool that includes measures to consider for addressing conventional waterways management and navigational safety issues such as groundings, allisions and collisions, as well as measures to consider for deterring terrorist attacks. The intent of this quick-reference tool is to ensure that the accidental and intentional release scenarios identified in the Sandia Labs Report are considered when preparing and reviewing a WSA. However, this tool is not intended to force the use of risk management strategies that may not be effective for a given port or prevent the use of other risk management strategies that may be more effective. Some of these risk management strategies are aimed at reducing the vulnerability of LNG tankers to damage, while others are aimed at reducing the consequences if damage does occur. This tool is not intended to take the place of a comprehensive risk assessment but should help to set the direction and establish the scope of such an assessment.

Once the applicant has completed the WSA and submitted it to the COTP, it is reviewed by the COTP and other stakeholders, such as the Area Maritime Security Committee and Harbor Safety Committee, to validate the assumptions in the WSA. Upon completion of the review, the COTP will issue a report to FERC on the suitability of the waterway for LNG marine traffic, which will be incorporated into the EIS and used by FERC's commissioners in their deliberations on siting of the proposed facility. An important outcome of the WSA process is the determination of what resources are presently available within the port and what additional resources will be needed to reasonably safeguard the delivery of LNG. The Coast Guard will provide this determination to FERC so they have sufficient information on the capability of the port community to implement the risk management measures that the COTP deems necessary to responsibly manage the risks of the LNG marine traffic in the port. This information is necessary so that FERC's commissioners can make an informed decision as to whether the project is in the public interest.

Another benefit of the Coast Guard's cooperation with FERC is that it ensures maritime security as well as navigational safety considerations are taken into account in FERC's siting decision for an LNG facility.

The guidance contained in NVIC 05-05 is applicable to all new LNG terminal proposals. For proposed shore-side LNG terminals that were under review or had been approved but not yet constructed prior to promulgation of the NVIC on June 14, 2005, the provisions of the NVIC and the need to complete a WSA will be applied on a case-by-case basis. For existing shore-side LNG terminals, the existing safety and security measures should be considered appropriate, although they are subject to case-by-case review if conditions warrant; for example, if a modification or expansion of the existing facility is proposed.

Ongoing Efforts

The guidance put forth by NVIC 05-05 was developed to meet an urgent need for a national policy and may be updated as more information comes to light regarding risks and risk management measures for the marine transportation of LNG. Also, a regulatory development project is being contemplated by the Coast Guard that could establish specific security requirements that would apply when assessing the suitability of a waterway for LNG marine traffic. The Coast Guard and FERC have had an excellent working relationship and will continue to work together on both a national and local level to address the safety and security of LNG terminals in a cooperative and coordinated manner.

About the authors:

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Lt. Cmdr. Darnell Baldinelli was co-author of NVIC 05-05. He has worked with the liquefied natural gas (LNG) industry 11 of his 15 years in the Coast Guard with assignments at Marine Safety Office Port Arthur, Texas; Activities Far East Tokyo, Japan; Marine Safety Office Savannah, Ga.; and Coast Guard Headquarters Office of Port, Vessel and Facility Security.

Environmental Impacts of Coast Guard LNG Actions

NEPA analysis will be required for almost any action Coast Guard might take to license an LNG terminal.

by Mr. Francis H. Esposito
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It's too late to plan. The Coast Guard Captain of the Port's (COTP) letter of recommendation (LOR) is due, and the Federal Energy Regulatory Commission (FERC) has already issued its approval for the liquefied natural gas (LNG) facility. Why can't we just make the laws go away? Better yet, why can't we turn back the clock and do the environmental planning when there is time for it? Federal agencies discover all too frequently that they have triggered the environmental planning requirements of the National Environmental Policy Act (NEPA) and other laws when it is too late to plan and just in time to be sued. When the LOR is related to an LNG facility, the intensity level is raised several notches as these facilities attract even more attention from the press and public.

Let us turn back the clock to the beginning of the project, when there is time to plan. We will examine the environmental planning laws generally, and then we will consider activities the Coast Guard engages in both for shoreside LNG facilities and for deepwater ports. Finally, we will see how NEPA and other planning laws should work in both cases.

What is NEPA?

In 1969 Congress passed a policy act to deal with the latest in a series of student activist-led issues such as the Vietnam War and the Civil Rights Movement. It's no real surprise that NEPA has been interpreted to be a public participation law that forces decision makers to take a hard look at environmental consequences of their acts. The courts subsequently determined that the language of Section 102, "major federal actions significantly affecting the quality of the human environment," applied to almost any federal action.

The primary objective of NEPA is to improve environmental decisions. It is important to note that a very small portion of all federal actions result in an environmental impact statement (EIS). The traditional EIS process often begins with an environmental assessment (EA) to determine whether an EIS or a finding of no significant impact is appropriate. There are categorical exclusions for minor action that clearly will not present a significant impact. A list of these exclusions is included in several official Coast Guard and departmental publications. These are exclusions, which means that the action is covered by NEPA but excluded from further analysis. The group of actions that are exempted is very narrow indeed. There are a number of express statutory exemptions from NEPA compliance; a number of courts have recognized an exemption from strict compliance with the NEPA process, where procedures followed by an agency are functionally equivalent to the procedures required by NEPA and its implementing regulations. To assist, NEPA created the Council on Environmental Quality (CEQ) in the Executive Office of the President to regulate the implementation of NEPA and specific requirements for the preparation of an EIS.

Why Should I Care?

The first rule of thumb is that NEPA always applies. There are no statutory exemptions within NEPA itself, nor has CEQ promulgated any regulation exempting certain actions from compliance with NEPA. A side benefit to proper NEPA review is that it usually leads one to address other potential issues in the form of Coastal Zone Management Act, Endangered Species Act, or National Historic Preservation Act compliance. LNG facility applications usually require a full EIS. For shoreside applications, the Coast Guard actions can be described by the agency responsible for completing the EIS—the FERC. The Coast Guard is responsible for processing the environmental impact statements for LNG deepwater port applications.

What's the Worst That Could Happen?

If we ignore NEPA requirements, a neighbor or competitor might bring an Administrative Procedure Act action based on our failure to comply with NEPA. The court must decide: 1) whether the agency has observed the procedure required by law; 2) the scope of the agency's authority; and 3) whether, on the facts presented, the agency's decision lies within that range. If all of the requirements are met, the court must find that the choice made by the agency was not "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." Specifically, the plaintiff will allege our entire program lacked any sort of NEPA analysis and, therefore, ought to be enjoined. While we may have some defenses to offer, such as those mentioned above, the worst case situation would include an injunction requiring us to re-examine each and every plan submitted for proper NEPA compliance. Such an order would definitely be issued in the glare of intense publicity.

CG Activities at LNG Facilities

The Coast Guard plays several roles in LNG facility license review. For shoreside facilities, the Coast Guard supports the decision maker, FERC, by exercising regulatory authority over LNG facilities that affect the safety and security of port areas and navigable waterways. For deepwater ports, licensed by the Maritime Administration (MARAD) under the Deepwater Port Act (DWPA), the Coast Guard performs its usual navigation and safety roles and, most importantly, the writing of the EIS for each license application.

Shore-Based LNG Facilities

There is no specific, statutory mandate for a letter of intent (LOI) or letter of recommendation (LOR). The Coast Guard has chosen the LOR process to fulfill its various responsibilities under the Ports and Waterways Safety Act, for matters related to navigation safety and waterways management and all matters pertaining to the safety of facilities or equipment located in or adjacent to navigable waters. The Coast Guard is required by regulation to issue a LOR.

The process involves two steps: First, an owner who intends to build a new LNG facility or reactivate or modify an existing one must submit an LOI to the local COTP in whose jurisdiction the proposed facility will be located. The LOI must include a variety of information about the project and must be presented to the local COTP at least 60 days prior to construction of the LNG facility; most COTPs receive the LOI much earlier than 60 days in advance. The second step of the process is the COTP's issuance of the LOR to the operator of the proposed facility, and to state and local authorities having jurisdiction, regarding the suitability of the waterway for LNG marine traffic

The first rule of thumb is that NEPA always applies. There are no statutory exemptions within NEPA itself, nor has CEQ promulgated any regulation exempting certain actions from compliance with NEPA.

The Coast Guard also has authority for LNG facility security plan review, approval, and compliance verification as provided in Title 33 CFR Part 105.410(b). In addition, the Coast Guard will review and approve the facility's operations manual and emergency response plan (33 CFR 127.019).

Deepwater Ports

The Deepwater Port Act of 1974 (33 U.S.C. 1501 et seq.) requires that the Secretary of Transportation, since delegated to the Maritime Administrator, issue or deny a license for a deepwater port within 330 days after an application is deemed to be complete as determined by the date of publication of a notice of application in the Federal Register. The act also specifies that MARAD must comply with NEPA. Coast Guard efforts to support MARAD in meeting this mandate have been largely successful but certainly not without challenge and controversy.

The DWPA assumes that all agencies will cooperate in the EIS process. Unfortunately, time constraints make it very difficult for some agencies to review very large, complex documents on very short schedules required to comply with the DWPA. Some agencies have obvious and very clear areas of expertise, knowledge, and jurisdiction, such as the Environmental Protection Agency (EPA) with the Clean Water Act or the Clean Air Act. On the other hand, some agencies have less obvious or clear jurisdictional roles; Minerals Management Service regulates Clean Air Act issues from oil drilling platforms, and the National Oceanic and Atmospheric Administration (NOAA) has water quality concerns related to the aquatic environment. The list of multiple voices based on numerous agendas is considerable. As a result, the administrator is often left with conflicting and unclear data. His or her job, as is the case with any decision maker, is to sort through the various issues and address them according to the criteria of the statute. NEPA assists them by mandating a study, usually an EIS. The Coast Guard, by law, is charged with preparing the EIS for deepwater port applicants.

An applicant for a license under the Deepwater Port Act is required to assist in gathering information crucial to the processing of its application. Failure to do so allows Coast Guard (pursuant to 33 CFR.148.107) to suspend processing of the license application until the required information is received, analyzed, and incorporated into the EIS. The period of suspension shall not be counted in determining the date prescribed by the time limit set forth in the law. The so-called stop clock action is accomplished by a joint letter from Coast Guard Headquarters (G-MSO-5) and the Maritime Administration to the applicant.

The Way Ahead

Shore-Based LNG Terminals: The Coast Guard's issuance of an LOR is a federal action that triggers the requirements of NEPA, just as the FERC's issuance of its permit triggers its compliance with NEPA. The Coast Guard may adopt FERC's EIS to satisfy its own NEPA responsibilities. However, all required Coast Guard NEPA analysis and documentation must be complete prior to the issuance of the final LOR. NVIC 05-05, "Guidance on Assessing the Suitability of a Waterway for Liquefied Natural Gas (LNG) Marine Traffic," urges timely and early coordination with the environmental staff at the appropriate Coast Guard Civil Engineering Unit (CEU). This ensures that all Coast Guard actions pertaining to issuance of the LOR are adequately covered and analyzed in the FERC draft EIS and final EIS. Pursuant to the President's CEQ guidance, Coast Guard analysis of the FERC EIS will be limited to assuring that Coast Guard comments have been addressed and that the EIS covers the Coast Guard's specific action(s). CEU environmental staff must sign the adopted EIS as official environmental reviewer of the document for the Coast Guard.

For each of the 11 applications processed to date, the Coast Guard has had to evaluate, broker, and resolve hundreds of comments and concerns from a multitude of sources.

LNG Deepwater Ports: The deepwater port challenge is somewhat different. Close and sometimes contentious discussions among regulatory agencies and the applicant have become the norm as the Coast Guard tries to press the process along and complete an EIS in time. For each of the 11 applications processed to date, the Coast Guard has had to evaluate, broker, and resolve hundreds of comments and concerns from a multitude of sources. The concerns have ranged from the small (rewording the draft for clarity) to the significant (flow speed and mesh sizes in the warming water intake).

Conclusion

NEPA analysis, in some form, will be required for almost any action the Coast Guard might take to license an LNG terminal. With proper use of NVIC 05-05, the FERC EIS will cover most actions associated with shoreside terminals. For deepwater ports, the Coast Guard will continue in its diligent effort to make certain that NEPA is complied with. Above all, Coast Guard personnel should be certain to consult NEPA professionals during the development and review of any environmental documents.

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FERC's Environmental Review Process

How the U.S. Coast Guard participates.

by Mr. Richard Hoffmann
Director, Division of Gas–Environment & Engineering, Office of Energy Projects, Federal Energy Regulatory Commission

by Ms. Lauren O'Donnell
Deputy Director, Division of Gas–Environment & Engineering, Office of Energy Projects, Federal Energy Regulatory Commission

by Ms. Alisa Lykens
Gas Outreach Manager, Office of Energy Projects, Federal Energy Regulatory Commission

Liquefied natural gas (LNG) is a significant energy source. It is important that the agencies responsible for assessing the public interest, authorizing the siting, and ensuring public safety and security work in tandem to examine the issues that are raised in newly proposed and authorized LNG facilities.

For onshore and near-shore LNG import facilities, the Federal Energy Regulatory Commission (FERC), the U.S. Department of Transportation (DOT), and the U.S. Coast Guard have mutual responsibilities. As a result, FERC, the Coast Guard and DOT took the first steps toward addressing this shared jurisdiction by signing the "Interagency Agreement for the Safety and Security Review of Waterfront Import/Export Liquefied Natural Gas Facilities" in February 2004. The agreement identified the roles and responsibilities of the three agencies and set in motion the mechanisms for ensuring the seamless review of safety and security issues of onshore LNG facilities. In a post-September 11, 2001, world, the need to conduct a coordinated review process is more important than ever.

Siting is the primary role of FERC, while safety and security issues at the shoreside facilities are shared concerns among the three agencies. The marine facilities and tanker operations are squarely in the Coast Guard's realm. Among the regulatory roles, both FERC and the Coast Guard have responsibilities under the National Environmental Policy Act (NEPA) by virtue of the approvals that the agencies need to give before construction or operation of an LNG terminal.

Agency Actions and NEPA

When a project sponsor proposes to build new onshore facilities or reactivate or modify an existing one, an application must be filed with FERC for authorization. This need for a decision by the commission triggers a NEPA review. Similarly, the required decision by the Coast Guard in a letter of recommendation on the suitability of the waterway for LNG traffic also triggers a NEPA review. FERC is required to conduct an environmental review of the siting, construction, and safety issues. The Coast Guard has a clear responsibility to assess the navigational suitability of the waterway, vessel transit and the waterfront facility operations.

DOT's role is to establish and enforce safety regulations and standards related to siting, design, installation, construction, operation, inspection, and fire prevention for the shoreside portion of the LNG import terminal. DOT's overall role in safety is crucial. It does not have to issue a permit.

So, how does it all come together? The agreement established that the vehicle for analyzing and documenting the agency actions related to safety and security would be the environmental document required by NEPA. Further, the agreement stated that FERC would be the lead federal agency for the NEPA review and that the Coast Guard would participate as a cooperating agency. Using the commission's environmental document, normally an environmental impact statement (EIS), ensures numerous opportunities for public review and comment within a controlled timeframe.

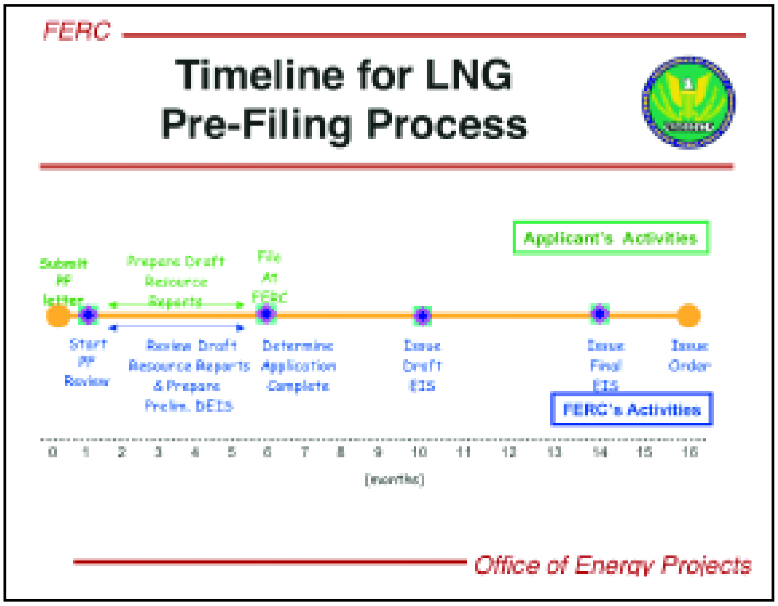

Figure 1: Timeline for LNG pre-filing process.

While the agreement acknowledged the need to work together and clarified the agencies' roles, the nuts and bolts of merging the agencies' processes and missions still needed to be completed. Consequently, the Coast Guard, with the participation of FERC staff, issued its Navigation and Vessel Inspection Circular (NVIC) No. 05-05, "Guidance on Assessing the Suitability of a Waterway for Liquefied Natural Gas Marine Traffic," in June 2005. The NVIC clearly lays out the process to be followed by the project sponsors and gives the Coast Guard the assurance of a consistent relationship with FERC regardless of project location.

FERC's NEPA Process and the Coast Guard

The recently enacted Energy Policy Act of 2005 requires project sponsors who propose the siting and construction of onshore LNG facilities and related interstate pipelines to use the commission's pre-filing process. In response to the Energy Policy Act, FERC issued a Notice of Proposed Rulemaking in August 2005 and issued a Final Rule in October. The rule promulgates regulations for project sponsors to comply with the commission's pre-filing review process for LNG import terminal projects, mandating at least six months be spent in pre-filing review prior to filing an application at the FERC.

Using the pre-filing process, project sponsors work with FERC staff to start the NEPA review process before filing an application with the commission, involving the public and agencies to identify issues from the scoping process and resolve the issues. As a result, the project sponsor files a more complete application allowing an EIS to be issued in about eight months after the filing of a complete application (Figures 1 and 2).

Established about five years ago, FERC's pre-filing process is evolving as we review each project on a case-by-case basis. It has proven to be very popular with the natural gas industry. It offers a significant time savings, but is not a short-cut, and allows full public participation.

The Coast Guard's role, as a cooperating agency, is to get involved early, providing the necessary support for the NEPA analysis as a subject matter expert for maritime safety and security of port areas and navigable waterways and addressing the full range of risk management strategies to manage safety and security aspects of LNG maritime transportation. The Coast Guard's contributions are reiterated in the goals and components of the agreement and the NVIC. The FERC staff assists the Coast Guard by doing the day-to-day work associated with the preparation and management of the EIS and by directing project sponsors to work in accordance with the NVIC and address the relevant issues.

The EIS is just one part of the record developed by the commission as a tool in determining whether or not to approve a project. A final approval will only be granted if, after consideration of both environmental and non-environmental issues, FERC finds that a proposed project is in the public interest. The EIS will also be used by the Coast Guard in considering its decision of whether to issue a letter of recommendation to the project sponsor. The Coast Guard is one of several federal agencies who cooperate in the federal review of the EIS. For example, the U.S. Army Corps of Engineers also cooperates in FERC's EIS review with the intent of adopting the same EIS for considering the permits necessary (pursuant to the Clean Water Act) to construct and operate the project.

Coast Guard Participation in FERC Proceedings

The FERC staff needs the assistance of Coast Guard staff to identify and address issues raised during the public scoping process regarding safety, security, and tanker operations. Input from both the marine safety office (MSO) and the civil engineering unit (CEU) staffs of the Coast Guard are required to fully identify and understand the issues.

During the pre-filing process, the FERC staff works to ensure that the EIS satisfies the requirements of the Coast Guard and other cooperating agencies. The commission project manager will work with the relevant CEU staff through the Coast Guard Captains of the Port (COTPs) and the MSO, for assisting or presenting at public scoping meetings, answering questions on roles and responsibilities, and attending interagency meetings with participating agencies. At this point, the CEU, through the MSO, cooperates with FERC in determining the scope of the EIS and in identifying and evaluating environmental issues raised during the scoping period. This may include evaluating alternative LNG terminal sites, assessing safety zones, docking areas, and port locations.

Consultation between the project sponsor and the Coast Guard should start with the preparation of the preliminary waterway suitability assessment (WSA) so that, by the time the preliminary WSA and letter of intent are submitted to the Coast Guard, the project is already on the radar screen. The commission requires a project sponsor's letter of intent and preliminary WSA be provided with its pre-filing request.

After the project sponsor files its application at FERC, and provides a follow-on WSA to the Coast Guard, the draft EIS is prepared for issuance. Prior to issuing the draft EIS, the commission's engineering staff leads a technical conference to review design and safety issues of the import terminal facilities, and the Coast Guard evaluates the WSA. Recommendations from the conference and the waterway suitability report are included in the draft EIS.

The CEU/MSO staffs get an opportunity to review/revise the administrative draft EIS, prior to it being issued to the public. The EIS will include mitigation measures, assessed by both the Coast Guard and FERC staff, which the commission staff recommends as conditions of approval of the project.

Once the draft EIS is issued, public comment meetings on the draft EIS are held, providing another opportunity for the Coast Guard to assist FERC staff, especially at the comment meetings. A final EIS is prepared, which takes into account and responds to the comments received during a 45-day public comment period. The final EIS is issued, and the agencies will use the information to make a final decision on whether to approve the project.

If a project is approved, the project sponsor will be required to file an implementation plan that defines how it will comply with the conditions attached to the approval before construction will be allowed to start. FERC, Coast Guard, and DOT work together to oversee compliance with the Federal Safety Standards, conditions of FERC and Coast Guard approvals, and conduct field/site inspections and technical conferences, as necessary, to ensure all conditions are met. Routine construction compliance and site inspections are conducted, and final approval to begin service must be issued before the facility is fully operational.

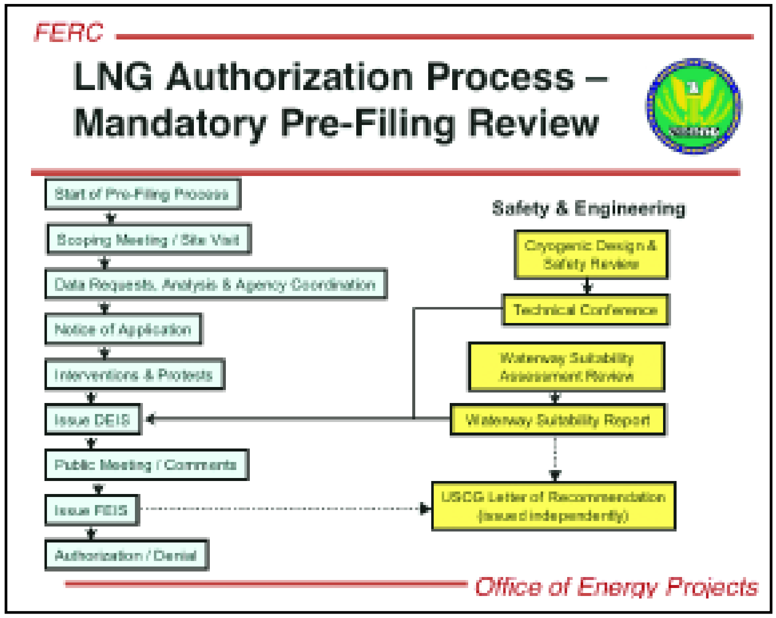

Figure 2: LNG authorization process—mandatory pre-filing review.

FERC staff will also conduct annual inspections of the LNG facility for the life of the project.

Goals and Benefits of Coordinated Efforts

FERC, agencies, stakeholders, and the industry are seeing the benefits of pre-filing. The efforts of the commission, the Coast Guard, other cooperating agencies, and DOT together make the pre-filing process a valuable tool for coordinating the joint processing of applications for LNG facilities.

For additional information about FERC's pre-filing process, to determine the EIS project manager for a particular project, or for general inquiries regarding LNG proposals at the commission, please contact Alisa Lykens, Gas Outreach Manager, at (202) 502-8766.

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Engineering Safety Review of Shoreside LNG Facilities

FERC's engineering safety review of LNG terminals is important to a safe and reliable operation.

by Mr. Kareem M. Monib
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A liquefied natural gas (LNG) terminal is, in a certain sense, an amphibious facility with one foot in the water and one foot on land. While most of the articles in this issue address topics related to the marine part of the LNG lifecycle, an examination of shoreside safety in an LNG terminal is important because the operation of one part of the plant will necessarily impact the rest of the plant. This article will discuss what the Federal Energy Regulatory Commission (FERC) does when it reviews the onshore part of proposed designs.

Overview

The onshore safety review seeks to ensure a safe and reliable design for proposed LNG import terminals located on land. Since the late 1970s, FERC has performed numerous such reviews using both commission engineering staff and outside expertise. These have resulted in FERC requiring companies to alter or reassess various design features of their proposed LNG terminals, the effect of which is a safer and more reliable facility.

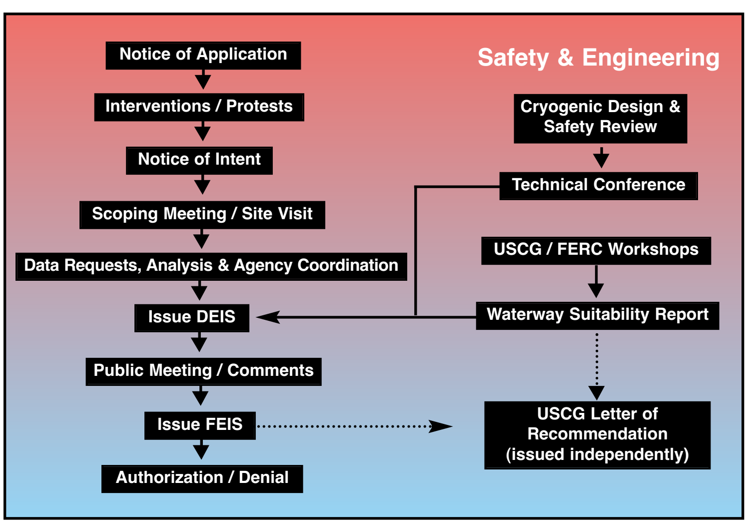

Figure 1: The LNG review process.

The safety review comprises two main elements: The first is a cryogenic design and technical review. As part of this review, which also includes an evaluation of safety systems, FERC conducts a technical conference with the applicant to resolve areas of concern. Secondly, the commission performs a siting analysis that determines hazard zones to limit the effect of a spill or fire. In addition, issues related to the security of the facility are addressed, following the U.S. Coast Guard's NVIC 05-05, "Guidance on Assessing the Suitability of a Waterway for Liquefied Natural Gas (LNG) Marine Traffic." The conclusions of the safety review are published in the draft environmental impact statement (EIS) issued for review and comment by the public. The flow chart in Figure 1 shows the overall LNG review process.

Cryogenic Design and Technical Review

The cryogenic design and technical review seeks to ensure a safe and reliable design for an LNG terminal. A reliable design is one that eliminates or reduces hazards from operations. In addition to reliability, the review will assess a facility's safety system design, which involves the application of engineering and procedural controls to manage hazards.

The cryogenic design and technical review examines the design for systems that unload, store, and vaporize LNG as well as auxiliary systems, such as boiloff handling. It is not meant to substitute for the preliminary hazard assessment that is normally carried out by the engineering firm that designs the facility; rather, it provides a focused assessment of the design, specifically concentrating on areas of concern that may have been overlooked. A complete list of these areas would be too long to mention here, but a few examples may help to illustrate what is involved.

The review examines, for example, the calculations for the size and design of tank relief valves, whose role is to prevent the tank from over-pressurizing in the event that a large amount of boiloff gas is produced. The term *boiloff gas* refers to the vapor produced from the evaporation of LNG, which is always maintained at the temperature of its boiling point (-260 degrees F), while it flows through piping or is stored in a tank. The presence of boiloff gas tends to complicate an otherwise straightforward process and necessitates an intelligent design that can handle unexpected situations where large amounts of boiloff gas may be produced. For this reason, a robust boiloff handling system is an important concern of the cryogenic design review. Relief valves are also placed throughout the process piping to ensure that any trapped LNG does not heat up, vaporize, and rupture a pipe. The placement of such valves, in a safe and effective manner, is a priority of the design review.

Another area assessed by the design review is the materials of construction. Materials that are suitable for cryogenic temperatures must be used wherever the possibility of cryogenic temperatures can be achieved. At very cold temperatures carbon steel can become brittle and can crack if exposed to LNG. Since the worst LNG accident in U.S. history occurred in Cleveland, Ohio, in 1944, when a tank collapsed as a result of a material failure, numerous design and safety measures have been implemented. For process piping that will be exposed to LNG, only certain grades of stainless steel containing higher percentages of nickel and chromium are used because they retain enough ductility and strength for use at cold temperatures. Similarly, inner tanks are constructed from 9 percent nickel steel or aluminum. The review examines designs where a non-cryogenic material may have been selected for a section of piping because it would not normally be exposed to LNG, although in emergency situations LNG or cold vapor could be present. Such abnormal conditions are some of what the cryogenic review aims to uncover to ensure the safety of the facility.

Facility Safety Systems

In addition to reliability of the process itself, the design review evaluates the proposed facility's safety systems. This includes the important area of spill containment. A well-designed plant considers the possibility of a spill anywhere that LNG is stored or transferred. Troughs must run beneath piping and be designed to direct potential spills away from critical areas into sumps and impoundments. Troughs may also utilize insulated concrete to reduce the amount of vapor generated in the event of an LNG spill. The design review will examine the layout of troughs, impoundments, and sumps to make sure that their placement minimizes the impact of a potential fire on surrounding equipment.

Figure 2. FERC review will assess the coverage of firewater, dry chemical, and deluge systems. Courtesy FERC.

Hazard detection is another vital component of the safety system. There are many types of hazard detection, but those most commonly used in an LNG facility are combustible gas, fire, low temperature, and smoke detectors. Combustible gas detectors detect the presence of natural gas, and ultraviolet or infrared detectors detect the presence of a flame. Low temperature detectors are used to detect the presence of a cryogenic liquid. The design review makes certain that hazard detection provides complete coverage for all the various plant systems. In some instances the review may find that a detector could be placed in a location that would provide earlier detection or more coverage of an area.

The design review also incorporates FERC's knowledge of incidents that occur in other countries. For example, on January 19, 2004, a blast occurred at Sonatrach's Skikda, Algeria, LNG liquefaction facility. An investigation concluded that a gas leak had entered the air intake of a boiler, causing a fire and subsequent explosion. As a result, FERC reviews the hazard detection devices on air intakes for combustion or ventilation equipment. Hazard detection is used to initiate alarm and shutdown processes as well as hazard control systems, all of which are examined in the design review.

The emergency shutdown system (ESD) is another important safety feature for any terminal. The logic of an ESD is commonly depicted in a cause-and-effect matrix that looks at process values and determines whether certain equipment or valves should be shut down, either by hazard detection or by manual pushbuttons throughout the plant. The design review includes an assessment of the cause-and-effect matrix to ensure that the design company has performed a thorough hazard identification study and designed its shutdown logic accordingly.

Along with a review of the ESD, the hazard control system will also be reviewed (Figure 2). This system is responsible for managing a fire or spill and often includes a variety of methods used to effectively contain, suppress, or extinguish a hazard. Foam agents and dry chemical extinguishers are especially suited to flammable liquid-type fire protection. These may be portable or fixed installations that are pumped from a central station. Firewater systems are useful, not for extinguishing an LNG fire, but for cooling nearby structural elements to contain the fire until it can be extinguished by other means. Fireproofing of critical structures is also important. As with hazard detection, hazard control is examined to make sure that the entire facility has adequate coverage.

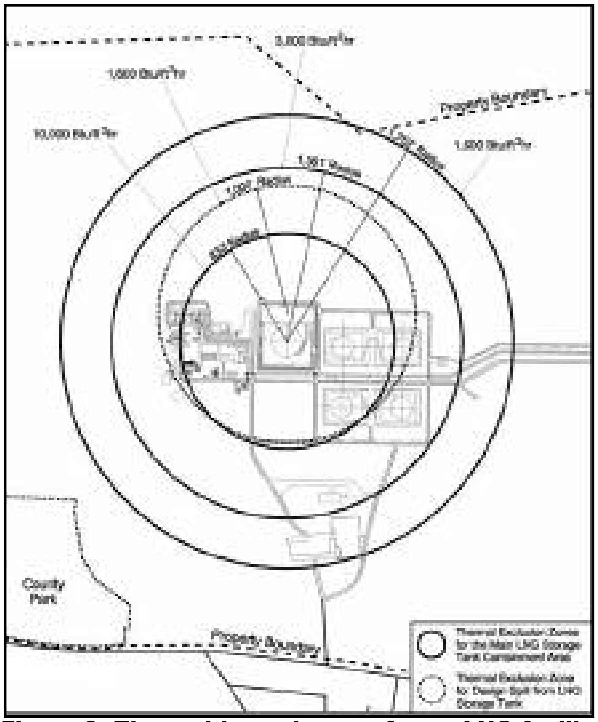

Figure 3: Thermal hazard zones for an LNG facility. Courtesy FERC.

Evaluation of hazard zones
Another major component of the review is the determination of hazard hazard zones for the various spill scenarios from onshore facilities. These zones are calculated in compliance with the Code of Federal Regulations (49 CFR 193) and include exclusions based on two different types of hazards: thermal radiation hazard zones based on the occurrence of an LNG fire and vapor dispersion zones based on the occurrence of an LNG spill that has vaporized and become a flammable cloud. Proposed import terminals must have either ownership or control over all land that lies within any exclusion zone. This requirement is meant to limit the number of people affected by a potential hazard. Both thermal radiation and vapor dispersion hazard zones are calculated, using models approved by regulations and using atmospheric conditions that give the largest results. The spill scenarios for these calculations are based on impoundment dimensions for the LNG storage tanks and on pipe ruptures that last for 10 minutes for process and transfer areas.

Thermal radiation hazard zones are specified at various radiation levels (Figure 3). The 1,600 British thermal unit (Btu)/ft^2-hr zone cannot impact outdoor assembly areas occupied by 50 or more people. This level of radiation can cause second degree burns in 30 seconds to an exposed and unprotected person. The 3,000 Btu/ft^2-hr zone cannot extend to offsite structures used for occupancies or residences. This level is specified to make sure that wooden structures, which can ignite at 4,000 Btu/ft^2-hr, are safe. The 10,000 Btu/ft^2-hr zone cannot cross a property line that can be built upon. At this level of radiation, damage to structures can occur. Vapor dispersion zones extend to one half of the lower flammability limit of methane. Methane is flammable in only a relatively narrow range of 5 to 15 percent gas-in-air, 5 percent being the lower flammability limit.

FERC's engineering safety review of LNG terminals is an important element in the effort to ensure a safe and reliable operation. Although the focus of this article has been on shoreside facilities, many of the concerns encountered here are to be found in the process piping and equipment located on the marine platform. A good understanding of the issues related to both marine and shoreside facilities will contribute to a safer LNG terminal for everyone.

About the author: *Mr. Kareem M. Monib is employed in the LNG Engineering Branch of the Federal Energy Regulatory Commission, where he performs cryogenic design and safety reviews of proposed facilities as well as inspections of operating LNG import terminals and peak-shaving plants. He earned a master's degree in chemical engineering from Pennsylvania State University.*

Implementing the WSA

Developing robust safety and security plans for onshore LNG facilities.

by Mr. David N. Keane
Chairman, Communications Committee, The Center for LNG

by Mr. Dennis M. Maguire
Member, Shipping Committee, The Center for LNG

by Mr. Ray A. Mentzer
Chairman, Technical Committee, The Center for LNG

According to the U.S. Department of Energy (DOE), demand for natural gas is expected to grow by more than a third over the next 20 years, and imports of liquefied natural gas (LNG) will be an increasingly important source of supply for the United States. Over the past three years, more than 40 new LNG terminal projects have been proposed in North America to receive imports of LNG. New LNG terminal projects go through a comprehensive permitting process, led by the Federal Energy Regulatory Commission (FERC) for onshore terminals and by the U.S. Coast Guard for offshore projects. The process involves rigorous assessments of technical design, environmental impacts, safety, and security. As part of the permitting process, the Coast Guard plays a major role in ensuring the safety and security of LNG marine transits to new LNG terminals.

The procedures and guidance developed by the Coast Guard in conjunction with industry, federal, state, and local authorities have created a robust process to provide for the safe transit of LNG in U.S. ports and waterways. This article focuses on: a) the reasons for the growing interest in LNG and b) the Waterway Suitability Assessment (WSA) put forth in the Coast Guard's Navigation and Vessel Inspection Circular (NVIC), "Guidance On Assessing the Suitability Of A Waterway for Liquefied Natural Gas (LNG) Marine Traffic" (NVIC 05-05). The latter was developed in conjunction with federal and state agencies, as part of the approval process for securing a letter of recommendation (LOR) from the Coast Guard to transport LNG via ship through state and federal waters to an onshore LNG terminal. Specifically, this article addresses the establishment of protocols for waterway safety and vessel security, as part of a collaborative process with the appropriate stakeholders, including industry, federal, state, and local authorities.

The Need for LNG

The United States has a large and growing demand for energy, particularly natural gas. At the same time, the country is struggling to maintain current levels of production. According to the Energy Information Administration, the United States could face a supply imbalance of natural gas of about eight trillion cubic feet by 2025, resulting from an increase in consumption of more than one-third over today's usage.

Some ask why we do not simply drill more wells in the traditional U.S. producing areas to meet increasing demand for natural gas. Unfortunately, productivity in domestic natural gas supplies in the country's existing gas producing areas, such as the Permian Basin in West Texas, the Anadarko Basin in Oklahoma, and the Gulf of Mexico, is declining. As drilling continues in these traditional producing regions, new wells on average produce less, reflecting the maturity of these areas. Therefore, these traditional producing areas cannot be relied on to provide the increase in natural gas supply needed to meet the country's growing demand.

Natural gas supply forecasts include continued imports from Canada and future deliveries from Alaska. Unfortunately, while most of today's natural gas imports are from Canada, production is declining similar to the United States, and, even with the future construction of a pipeline to deliver Alaskan gas to the lower 48, a significant shortfall of natural gas supplies is forecast. Thus, even with Canadian and Alaskan production of natural gas, additional supplies will still be needed to close the supply-demand gap.

LNG is forecast to be an essential component in meeting U.S. natural gas requirements. There is an abundance of natural gas in the world, and many exporting countries are expanding their LNG infrastructure to compete in the developing world market. These countries include Trinidad and Tobago, Norway, Qatar, Egypt, Nigeria, Indonesia, and Australia.

To meet the growing demand for natural gas and, hence, LNG, the United States requires the construction of more LNG import terminals. While the United States currently has four onshore LNG terminals, a National Petroleum Council study for the U.S. Department of Energy forecast the need for seven to nine new terminals by 2025.

LNG Shipping: Proven Safety Record

Before turning to the role of the Coast Guard in the permitting process, it is important to recognize the proven safety record of the LNG shipping industry. In the nearly 40-year history of LNG operations worldwide and more than 45,000 cargo deliveries, no releases of LNG related to a breach or failure of a cargo tank have occurred. This record includes regular ship transits to ports in urban areas such as Boston and Tokyo. The safety record is due to the multiple levels of protection built into LNG carriers, including double hulls, the industry's high engineering and operational standards, and the high degree of regulatory oversight.

Role of the Coast Guard

The Coast Guard plays a pivotal role in the safe transit and delivery of LNG. Planning for LNG vessels calling at a marine facility in the United States involves three key considerations: safety, security, and emergency response.

The FERC, the lead agency for the permitting of onshore LNG terminals, requires that new terminal projects undertake emergency response planning in collaboration with local emergency response authorities. The waterway safety and security planning processes come under the jurisdiction of the Coast Guard.

An applicant proposing a new LNG terminal or modification of an existing LNG terminal must submit a letter of intent (LOI) to the U.S. Coast Guard Captain of the Port (COTP). The COTP then prepares a letter of recommendation (LOR) as to the suitability of the waterway in question for LNG traffic. A proposed LNG terminal project cannot proceed without an LOR deeming the waterway suitable for LNG ship traffic.

With the promulgation of NVIC 05-05, a WSA is now required prior to the issuance of the LOR. The WSA process is solely under the direction of the Coast Guard’s Captain of the Port. According to the NVIC, the purpose of a WSA is "...to ensure that full consideration is given to safety and security of the port, the facility, and the vessels transporting LNG." The WSA identifies credible safety hazards and security threats to LNG shipping in that port and waterway and identifies appropriate risk mitigation measures.

Safety Portion of the WSA

The safety portion of the WSA, in most cases, will be straightforward and well-understood by the marine participants in major ports, due to existing knowledge of the physical characteristics and existing traffic patterns on the waterway and the robust LNG ship design and operating procedures.

The development of the safety portion of the WSA includes examination of navigational safety issues to protect against groundings, collisions, and allisons. The WSA includes information on the commercial traffic within the waterway, recreational vessel usage of the waterway, and the time of day when the waterway is at its peak usage. It also includes physical considerations such as bridges, natural or man-made hazards, underwater pipelines, as well as important or significant icons, such as parks and monuments, along the transit route and nearby the berth at the LNG terminal.

The process requires industry input on a number of issues, such as vessel size, number of voyages per year, availability of tugs, and proposed role of local pilots, all of which the Coast Guard evaluates before issuing a LOR.

Security Portion of the WSA

The September 11, 2001, terrorist attacks heightened concern about the potential for future terrorist-related incidents and have led to a robust review of secu-

Figure 1: The *Methane Kari Elin* is BG's newest LNG carrier. The vessel has a cargo capacity of 138,200 cubic meters, with an overall length of 279 meters, a beam of 43 meters, and gross tonnage of 93,410 tons.

rity systems for all types of public and industrial infrastructure, including LNG facilities, as well as the identification and implementation of steps to mitigate security risks. For LNG terminal projects and related shipping, NVIC 05-05 calls for the involvement of a cross section of the law enforcement community affected by the transit of LNG vessels bound for a U.S. port. This includes law enforcement in coastal communities that lie along the vessel's transit route. The COTP may also involve standing committees, such as the Area Maritime Security Committee (AMSC), which is made up of law enforcement and other industrial users of the port, and/or ad hoc committees to participate in the process.

As part of the WSA, an analysis is prepared by the project applicant, drawing on internal and/or external security expertise, to determine potential security threats and risks to the vessel, the public, and property along the transit route and at the terminal berth. The analysis includes measures that should be employed to mitigate those risks. The stakeholder team, such as AMSC, reviews the analysis for completeness and accuracy. Subsequently, the COTP, with input from stakeholders, prepares a waterway management plan for use when an LNG vessel calls on that port. The plan should be developed with an eye toward flexibility as it must be able to change to meet the specific operational requirements of each transit as well as changes in MARSEC threat levels.

All stakeholders have the same goal in mind when developing the safety and security components for the WSA, and that is the protection of the public. However, participants may have differing points of view regarding the appropriate security posture, including threat levels, safety zones, and role of escort vessels. Striking a balance is necessary in this complex process. Some may propose an approach of mitigating all possible threats regardless of likelihood. Others, including the Center for LNG and FERC, recommend a risk-based approach considering the likelihood of the threat and the mitigation steps in place to manage such a threat.

A primary objective of the WSA is to identify the federal, state, local, and private sector resources needed to carry out the mitigation measures identified in the WSA. The WSA also requires the identification of the resources currently available and the mechanism by which funding will be provided for additional public resources needed for the safety and security of the LNG shipping in that port.

In summary, the WSA process, including the safety and security assessments and identification of appropriate mitigation steps, is used to develop the waterway management plan. The latter is approved by the Captain of the Port.

Port and Project-Specific Assessments

NVIC 05-05 outlines a standard process for all onshore LNG project applicants to use to assess transit safety and security and determine appropriate mitigation measures. However, it is important to understand that assessments of risk and the identification of mitigation steps must be done on a site-specific basis. Risks and mitigation measures can be expected to vary across proposed LNG projects depending on the physical nature of the waterway, existing traffic on the waterway, the proposed terminal site and configuration, and proximity to critical infrastructure and population centers. The waterway management plan for a specific LNG terminal project on one waterway may not be appropriate for another project on another waterway or even another LNG terminal project in the same port.

Stakeholder Participation in Waterway Assessments

Prior to the issuance of NVIC 05-05, the Coast Guard completed a series of workshops relating to LNG terminal proposals in Narragansett Bay, R.I., that demonstrated the viability of a broad cross section of security, law enforcement, and industry officials working together to produce a workable security plan. The workshop participants identified measures necessary to manage the risks associated with LNG traffic in the specific waterways. These measures complement the port's Area Maritime Security Plan already in place as required by the Maritime Transportation Security Act of 2002 (MTSA).

As part of the assessment process for these projects, the Coast Guard also identified several protocols to mitigate specific risks and created an initial waterway management plan for each project. The latter will become the basis for appropriate security measures for each maritime security threat level for those specific projects. Prior to an LNG vessel being granted permission to enter U.S. or state waters, both the vessel and the facility will need to be in full compliance with the appropriate requirements of the MTSA and the International Ship and Port Facility Security (ISPS) Code and the security protocols established by the COTP in the waterway management plan for the specific waterway. Additionally, the resources required to implement the security protocols must be in place before the Coast Guard allows any LNG vessel access to a U.S. port.

Conclusion

The United States will need to increase LNG imports, as well as to continue to develop North American natural gas supplies, to provide the clean burning natural gas needed to heat our homes, fuel our industry, and generate electricity. The LNG industry is committed to working with the Coast Guard to implement the WSA process so that the marine transport of LNG to terminals in the United States will continue to be done in a safe and secure manner.

About the authors:

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About The Center for LNG:

The Center for LNG is a broad coalition of producers, shippers, terminal operators and developers, energy trade associations, and natural gas consumers. Its goal is to enhance public education and understanding about LNG. Access the center at http://www.lngfacts.org/.

LNG Safety and Security

A local Federal Maritime Security Coordinator's perspective.

by Capt. Mary E. Landry
Chief, Marine Safety Division, First U.S. Coast Guard District

Since September 11, 2001, liquefied natural gas (LNG) issues have typically been a weekly occurrence in the media. New applications for a facility, word of a new vessel under construction, the need for an increase in imports, or public concern over safety and security have all been frequent topics for discussion.

Soon after the attacks, the Captain of the Port (COTP) at the U.S. Coast Guard Marine Safety Office (MSO) Boston quickly assessed the status of shipping in the port of Boston and closed it to marine traffic. Ports were being closed across the United States.

For Boston, closing the port included ensuring that the LNG vessel at the Everett Distrigas Terminal in Everett, Mass., was departing as planned. The vessel had finished offloading and was planning on being outbound that morning. The company quickly ensured that the outbound transit commenced.

In the days following the attacks, MSO Boston settled into a command post mode and began working on how to resume commercial shipping while ensuring an adequate level of port security. With most ports across the nation reopening to commercial traffic a few days after 9/11, and with Boston having the luxury of a port security unit (PSU) arriving to complement its force, the command felt it had adequately reprioritized missions overnight and focused on port security. The one exception came when the State of Massachusetts, the City of Boston, and the City of Everett grew concerned with the next LNG arrival that was due into the Everett Terminal.

As the LNG carrier (LNGC) *Matthew* began its transit from Trinidad to Boston, the port security regime put in place in Boston was not enough to allay concerns. The Everett LNG import facility was located in a densely populated area, and vessels transiting to that facility passed through a restricted waterway that converged with waterfront businesses, residential communities, and Logan International Airport. The local fire chiefs of Everett, Chelsea, and Boston had unsuccessfully fought the siting decision for the facility in the 1970s when the plant went into operation. The safety concerns they had at that time were translated to security concerns and revisited with a new eye toward "malicious intent." The 30-year safety track record of LNG companies did not satisfy these concerns.

The Captain of the Port Order required the *LNGC Matthew* to supply: 1) a threat and vulnerability assessment, 2) a security plan, and 3) a consequence management plan. Complying with this order would take time, and the company diverted the vessel's cargo elsewhere while it worked on meeting the requirements of the COTP Order. This solution was only temporary, as it became clear that the region would need the gas supplied by this facility in the very near future. With winter approaching, options were limited to keep the supply of gas uninterrupted in the Northeast and Distrigas was a key supplier.

At this point, the date was late September 2001, and the *Matthew* was most likely the only ship in the U.S. being held out. Most ports were reopened, and the backlog of ships in the queue in places like New York and Long Beach, Calif., was abating. Security protocols for boarding ships offshore were underway, and port facilities across the nation were being visited by the Coast Guard and encouraged to upgrade security. The Everett Distrigas Terminal and the parent company were destined to have the first formal vessel and facility security plan almost a full three years in advance of the Maritime Transportation Security Act (MTSA) regulations and the International Ship and Port Facility Security (ISPS) Code requirements.

The Coast Guard, in cooperation with local, state, and federal governments and industry, accomplished a tremendous amount of work to ensure that the first LNG vessel could safely and securely arrive in Boston. The facility provided various studies and plans to support this work. Distrigas commissioned Lloyds of London to conduct an LNG study and a security company to do a threat analysis/vulnerability assessment. The Department of Energy (DOE), the Federal Energy Regulatory Commission (FERC), and other agencies provided input based on a request to Secretary Ridge from then acting Massachusetts Governor Jane Swift. DOE requested a government-sponsored analysis, as many state and local agencies were skeptical of relying solely on an industry-sponsored study. A workgroup consisting of federal, state, local, and private-sector members validated the studies and plans provided by Distrigas and devised an agreed-upon threat assessment, security plan, and consequence management plan for the LNG deliveries. Soon after, the LNG ship was allowed to enter the port of Boston in early October 2001.

People, however, were still skeptical of the risks posed by LNG deliveries. In November 2001 the U.S. Coast Guard First District Commander formally requested that Coast Guard Headquarters commission a working group to examine the risk and public safety factors posed by LNG facilities. Several companies were submitting application for additional LNG facilities in the First District. The First District stated that the Coast Guard's work as a cooperating agency in FERC's permitting process hinged on having an

Figure 1: A 25-foot Homeland Security boat from Coast Guard Station Boston, foreground, provides a security escort for the liquefied natural gas (LNG) tanker *Matthew* in Boston Harbor. Escorts of LNG tankers are a multi-agency priority, consisting of Coast Guard, local, and state police, and Massachusetts Environmental Patrol. PA3 Kelly Newlin, USCG.

appropriate analysis and a reasonable scope of the issues to adequately address safety, security, and consequence management issues. The First District also recommended that this work be performed in cooperation with DOE, FERC, the Coast Guard, and the National Oceanic and Atmospheric Administration (NOAA) (if deemed necessary) so that the federal government could speak with one voice with regard to the issue. Even though the Coast Guard knew that industry was ready to provide this analysis, with competition for project approval and with public skepticism about industry sponsoring the work, a federally sponsored analysis needed to be done.

The concerns with LNG vessel and facility security emerged as a significant issue during the application process for two other shoreside facilities in New England. One was for a facility in Fall River, Mass., at the site of a former Shell fuel terminal. The other application was for marine deliveries to start up at the Keyspan facility in Providence, R.I., where a tank already existed that was filled by 2,000 trucks per year from the Distrigas facility in Everett. The experience from Boston and from Activities Baltimore's work in reactivating the Cove Point LNG facility provided a framework and the outline of a process for MSO Providence to conduct the necessary evaluations for input to FERC. Existing regulations under 33 CFR 127 outlined the Letter of Intent and Letter of Recommendation requirements, and the Coast Guard had identified the need for vessel and security standards. Requirements and security measures were already in place, using the Coast Guard's broad authority under the Ports and Waterways Safety Act. Additionally, Coast Guard Headquarters staff members were working with the FERC and the Department of Transportation's (DOT) Research and Special Projects Administration to come up with an interagency agreement to avoid duplication of effort and ensure that safety and security issues would be addressed.

The marine safety field units were monitoring the status of this work and consulting with CG Headquarters and each other as the applications for new facilities increased in number across the United States. Working with the applicants and members of the federal, state, and local port community, MSO Providence began a year-and-a-half-long journey into piloting a process, which is now formally outlined in the Coast Guard's Navigation and Vessel Inspection Circular (NVIC) 05-05, "Guidance on Assessing the Suitability of a Waterway for Liquefied Natural Gas (LNG) Marine Traffic." Examining both safety and security issues well in advance of any decision being rendered by FERC was important. Additionally, the initial assemblages of port security committees and other maritime stakeholders had come together with a common purpose to ensure no overlaps or gaps in port security work existed. These relationships proved invaluable as this process began.

Several challenges occurred along the way. First, when the work began in Providence, neither the more comprehensive American Bureau of Shipping (ABS) nor the DOE Sandia Lab's studies had been published. The parameters of the Lloyds and the initial government-sponsored study by Quest study were being used, but both studies were being debated, depending on whether or not you were for or against LNG deliveries into urban areas. Fortunately, midway into the work, both the ABS and Sandia Labs studies were released. These studies provided key information and guidelines with which to scope the work. Additionally, the LNG proposals were quite controversial and required a tremendous amount of communication and outreach to the public and to elected officials to communicate the process being used. Nothing was officially established, and the NVIC had not been published yet, so a tremendous amount of time was spent explaining the workshop process being used for input to the FERC's Environmental Impact Statement (EIS). The opportunity was also used to explain the post-9/11 port security procedures that were in place.

The Coast Guard's key role in the workshops and in outreach efforts became "honest broker" among many competing interests. It was continually expressed that the Coast Guard was neutral about the decision of whether or not the facility should be permitted. The Captain of the Port's job was to outline necessary safety and security requirements for the applicant, as part of the Coast Guard's input to FERC's EIS under the National Environmental Policy Act (NEPA) and as part of the Coast Guard's required Letter of Recommendation process. It was FERC's duty to balance the need for energy and permitting against the significant safety and security requirements the Coast Guard established.

Tremendous pressure was exerted on the Coast Guard to just say "no." It was consistently communicated both in writing and through public and personal meetings that the Coast Guard would regulate with a "go/no go" position if, and only if, the applicant could not meet the extensive safety and security requirements that are outlined. The Coast Guard's statutory authority is under 33 CFR Parts 101 through 105, and Part 127. While the prevention of

Figure 2: A 25-foot defender class boat from Coast Guard Station Boston escorts the liquefied natural gas (LNG) tanker *Berger Boston* out of Boston Harbor. An LNG tanker is escorted into Boston Harbor on average every three days. PA3 Kelly Newlin, USCG.

terrorist incidents cannot be guaranteed, the requirements provide a deterrent, mitigate the risks to an acceptable level, and ensure that the evolution is in the category of low probability.

The Coast Guard will continue its work with port safety and security and rely heavily on fostering relationships across federal, state, local, and private sector entities to ensure that maritime safety and security are maximized. As processes mature, and guidance becomes more clear and understandable, the Coast Guard will continue to play the role of "honest broker" among many competing interests. Whether it is LNG, waterfront development, or waterways management, the competing interests will only become more complicated and the debates more intense. The Coast Guard has to stay the course and focus on its appropriate role as the federal agency charged with overseeing port safety and security.

About the Author: *Capt. Mary E. Landry is Chief, First U.S. Coast Guard District Marine Safety Division in Boston, Mass. She recently completed a three-year tour as Commanding Officer, Marine Safety Office Providence, R.I. Capt. Landry holds master's degrees in management and transportation management from Webster and the University of Rhode Island. She also completed the Harvard National Security Fellowship.*

Cove Point Risk Assessment

Coordination, risk-based decision making, and outreach were the keys to success.

by Lt. Cmdr. Mark Hammond
Chief, Security Information Branch
U.S. Coast Guard Office of Port, Vessel, and Facility Security (G-MPS)

In fall 2000 Williams Cove Point LNG Limited Partnership announced plans to reactivate its Cove Point liquefied natural gas (LNG) offshore marine terminal located in the Chesapeake Bay off Lusby, Md. Resuming the terminal to operational status would represent the return of LNG shipping to the Upper Chesapeake for the first time in over 20 years. Upon receiving Williams' letter of intent (LOI), Coast Guard Captain of the Port (COTP) Baltimore began the process of conducting an analysis to determine waterway suitability for LNG marine traffic as required by Title 33 Code of Federal Regulations, Part 127.009.

The proposal to bring LNG ships into the Chesapeake Bay bound for the Cove Point Terminal presented unique challenges for the Coast Guard as the vessels would be required transit through two COTP zones: Hampton Roads and Baltimore. Adding to this unique challenge were the tragic events of September 11, 2001, which thrust port security and resource constraint concerns to the forefront of the ongoing assessment process. Through highly coordinated efforts between the respective COTP offices and the support of Atlantic Area, District staff members, and the Coast Guard's Research and Development (R&D) Center, plans were developed for a systematic approach to identify and assess the risks associated with the proposed reactivation. Adhering to sound risk-based decision making (RBDM) principles and incorporating public and stakeholder input, critical security and waterway suitability issues were adequately addressed in determining an appropriate recommendation regarding the resumption of LNG operations on the Chesapeake Bay.

Facility History, Description

The Cove Point facility was built in the 1970s through a partnership between the former Consolidated Natural Gas Company, the parent of what is now Dominion Transmission, and the Columbia Gas System to receive, store, and process supplies of LNG shipped from such producing countries as Algeria and Trinidad. Cove Point received approximately 90 ship-borne LNG imports between 1978 and 1980. However, substantial market changes as the result of price deregulation under the Natural Gas Policy Act of 1978 reduced the need for LNG imports, and, subse-

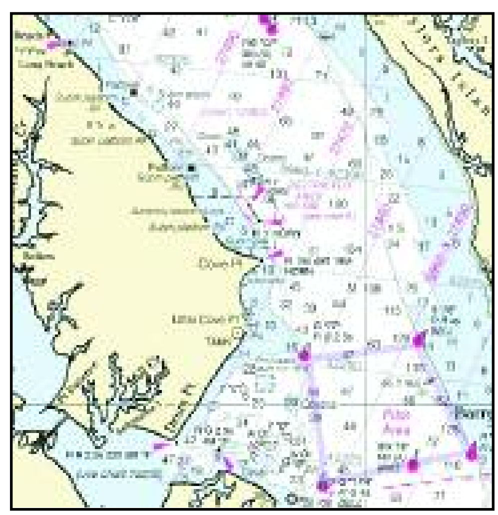

Figure 1: Charted approach to Cove Point. Courtesy C2-PC.

Figure 2: Cove Point facility's offshore LNG marine terminal. Courtesy Dominion, Cove Point.

quently, the Cove Point terminal was closed.

In 1988 Consolidated sold its interest in the Cove Point terminal and pipeline to Columbia, and in 1995 Columbia Gas reopened the shore facility for storage and during periods of peak consumption. The facility was used to liquefy, store, and distribute domestic natural gas for use in the growing Mid-Atlantic region.

Williams purchased Cove Point from Columbia in 2000, and ownership subsequently changed hands to Dominion in 2002. Growing national demand for natural gas, fueled in part by increasing use of natural gas-fired electrical generation stations, once again has required increased imports of LNG.

The 1,017-acre facility is located in Lusby, Md., approximately 50 miles southeast of Washington, D.C. The 2,470 foot-long marine terminal is located approximately one mile offshore and is connected to the storage tanks by a three-section tunnel. Personnel access to the marine terminal is typically accomplished via bicycle. The approach to the terminal pier covers a 90-mile expanse of the Chesapeake Bay that is removed from densely populated areas. An 87-mile, 36-inch pipeline links the Cove Point LNG terminal to interconnections with distribution and transmissions systems in northern Virginia.

Letter of Intent Process

Regulations require an owner of an inactive facility to submit a letter of intent (LOI) to the COTP of the zone in which the facility is located prior to transferring LNG. Upon receiving an LOI under this part, the cognizant COTP office issues an LOR to the facility owner as well as state and local government agencies having jurisdiction as to the suitability of the waterway. In November 2000 COTP Baltimore received a LOI from Williams for the reactivation of Cove Point's marine terminal operations to resume import shipments of LNG. In preparing the LOR, public comments were solicited through the Federal Register. In response to the request for comments, 20 comments were received, nine of which requested that the Coast Guard hold a public meeting on the issue.

Based on the amount of interest, a public meeting sponsored by COTP Baltimore was conducted in August 2001, with an eye toward achieving two goals: 1) to educate the public, stakeholders, and interested parties on the current regulations guiding the waterside component of the facility since its initial opening in 1978, and 2) to receive comments on the proposed resumption of LNG marine traffic in the Chesapeake Bay. The format of the public meeting was structured to address the three distinct phases of the proposed operation: 1) vessel transit—to address the transit of LNG vessels bound for, or departing, the landside facility; 2) facility cargo loading/offloading—to address the transfer of LNG from delivering vessels; and 3) environmental interest/other concerns—to address the various economic and environmental interests and to receive any oral comments by individuals who responded to the Federal Register notice.

The majority of comments received expressed concern regarding the public impact of safety or hazard zones that would likely be imposed around LNG vessels and the offshore terminal and the effect that such regulations would have on other vessels using the bay. Other comments primarily focused on the safety and security of LNG vessels and associated risks presented by their cargo. Comments filed with the Federal Register and those comments received during the public meeting were to be used as inputs to a series of three risk assessment workshops sponsored by the Atlantic Area Commander in Portsmith, Va.; the first of which was scheduled for the end of September 2001.

Changes due to 9/11

Following the September 11, 2001, terrorist attacks, maritime security became a top priority mission for the Coast Guard and a major concern for Congress as well. As such, the prospect of resuming LNG operations on the Chesapeake Bay within close proximity to a nuclear power plant, particularly within relative close proximity to the National Capital Region, drew the attention and scrutiny of lawmakers and local politicians.

Senator Barbara Mikulski (Democrat, Maryland), expressed serious concern over the proposed reopening and petitioned federal agencies, including the Commandant of the Coast Guard, to "rigorously review the Cove Point proposal." Speaking before the Senate on November 7, 2001, she stated: "I want to make sure that LNG shipments into Cove Point and other American terminals are thoroughly considered as a national security issue not just an energy issue." Further, she expressed that she was "not confident that those who gave preliminary approval to reopen Cove Point gave this matter the rigorous review it deserves." [1]

Specifically, the Federal Energy Regulatory Commission (FERC) drew sharp criticism from Senator Mikulski for issuing preliminary approval to reopen the Cove Point facility on the one-month anniversary of the 9/11 attacks. This prompted FERC to hold a technical conference to further assess the plans to reopen Cove Point with a specific focus on security risks and mitigating strategies. It became abundantly clear that, to appropriately address public and political concerns, maritime security would need to be a primary consideration during the Coast Guard's risk assessment process.

Risk Communications

Effective risk communications were critical to separating fact from fiction regarding the real risks and vulnerabilities associated with the handling of LNG. A persistent concern expressed throughout the assessment process, particularly after the 9/11 terrorist attacks, was the proximity of the Cove Point marine terminal relative to the Calvert Cliffs Nuclear Power Plant (CCNPP), located 3.5 miles to the north. A common misconception is that LNG tankers are large floating bombs and as such would pose an unacceptable risk to the CCNPP.

To effectively address this issue, COTP Baltimore engaged with representatives from the Department of Energy (DOE) in the process early on. DOE provided informative briefings to workshop participants and emphasized that the most significant threat from any potential incident would be thermal radiation from a fire. DOE presented results of scientific modeling of potential release scenarios based on a catastrophic breaching of a LNG carrier tank and concluded that even a worse case scenario would not pose a significant threat to the CCNPP. DOE reported that "LNG tankers have been run aground, experienced loss of containment, suffered weather damage, been subject to low temperature embrittlement from cargo spillage, suffered engine room fires, and been involved in serious collisions with other vessels. However, no cargo explosions have been reported." [2]

Risk Assessment Process

The purpose of the risk assessment was to evaluate the suitability of the Chesapeake Bay for LNG marine traffic, including security, navigational, environmental, and public safety concerns associated with vessel transits and cargo operations. On the advice of the Coast Guard's R&D Center, the change analysis methodology was selected for the risk assessment process. The change analysis approach looks systematically for possible risk impacts and appropriate risk strategies to help identify and effectively manage changes to the current operational environment. This was accomplished through a series of three workshops incorporating valuable input from a variety of stakeholders; federal, state, and local law enforcement; and emergency response agencies. Additionally, the workshops considered the results of previous ports and waterways safety and port security assessments as well as comments obtained from the public meeting.

The first two workshops lasted two days, with the better part of the first day dedicated to training participants on the risk-based decision making process and the use of analysis tools and techniques. The first workshop comprised of port stakeholders sought to characterize the inherent risks associated with the three phases of LNG transport—inbound transit, cargo operations, and outbound transit—and to identify prevention and surveillance actions to manage such risks. Utilizing the "what-if" analysis technique enabled the group to address specific high-risk or high-concern scenarios in greater detail.

Workshop two was comprised of federal, state, and local law enforcement; shippers and operators; and representatives from the nearby CCNPP. The objective of this workshop was to focus on unique maritime security issues, evaluate law enforcement resources/capabilities, and identify any gaps and potential vulnerabilities. The third workshop incorporated emergency planners/responders, along with the participants of the second workshop, to study immediate and subsequent consequences to public safety and the environment.

Outputs from the three assessment workshops formed the basis for development of the LOR and operations and management plan. However, they were also intended to serve as a model risk-assessment tool for other LNG operations to promote area-wide consistency.

Results of the workshops also served to validate the findings of previous studies. Prior to receiving any LNG shipments at Cove Point, the original owners of the facility prepared a study in 1976 to determine the potential hazards posed by LNG relative to the nuclear power plant; it was determined that the safety of the public was not endangered. Additionally, in 1993 while planning to reactivate the facility, a subsequent hazard analysis was conducted, and, similarly, the study concluded that the operations at Cove Point did not pose an undue hazard.

COTP's Letter of Recommendation

Federal regulations clearly describe what the LOR must address in terms of a waterway's suitability for LNG traffic. Specifically, it addresses density and character of marine traffic; locks, bridges, or other man-made obstruction; depth of water; tidal range; protection from high seas; natural hazards; underwater pipelines and cables; distance of berthed vessels from the channel; and the width of channel.[3]

The letter of recommendation process for Cove Point was unique from other U.S. ports that handle LNG in that the majority of the transit route for vessels bound for Cove Point occurs within COTP Hampton Roads zone, but the facility resides in COTP Baltimore's zone. As such, the LOR is signed by both COTPs. A careful review of the physical characteristics of the waterway from Cape Henry to Cove Point determined that the Chesapeake Bay was considered suitable and that a favorable recommendation for reactivation was fully supported by the risk assessment. An important factor in this case was that the Cove Point facility was an existing facility, and, therefore, this was not the first time that these issues had been examined.

Due to the sensitive political issues surrounding the reactivation project, prior to issuance of the final LOR, COTP Baltimore conducted a series of high-level briefings including the Coast Guard's Commandant, Atlantic Area Commander, and members of Congress. These briefings highlighted the LOR and risk assessment process and were instrumental in garnering operational support in way of personnel and resources to conduct safety and security operations associated with the LNG shipments.

Chesapeake Bay LNG Operations and Management Plan Development

During the original importation of LNG to Cove Point between March 1978 and April 1980, LNG shipping operations were controlled by the Chesapeake Bay LNG Operations and Management Plan (OPLAN), issued jointly by the COTP's Baltimore and Hampton Roads. The OPLAN established procedures to ensure the safe arrival, transit, and departure of LNG ships on the Chesapeake Bay and the safe transfer of LNG at the Cove Point terminal. The plan contained specific requirements for the ship, transit, berthing, waterfront facility, transfer operations, minimum visibility, maximum sustained winds speeds, and emergency plans. Significant revisions were required to bring the original plan up to date to reflect the changes that occurred over the more than 20 years such as the Port State Control Program, advance notice of arrival requirements, and high-interest vessel movement policy.

Once the LOR was drafted, COTPs Baltimore and Hampton Roads, with the support of the Fifth District staff, began refining the Chesapeake Bay LNG OPLAN. This process built upon existing relevant portions of the original plan and incorporated key findings, recommendations, and response mitigation strategies generated by the risk assessment workshops. The planning team consulted with other U.S. ports that handle LNG such as Boston, Lake Charles, and Savannah and solicited valuable feedback and critical buy-in from key members of the workshops, including the Maryland Bay and Docking Pilots and industry representatives. The result was the development of a comprehensive, meaningful, user friendly plan that was fully supported by all parties involved. The Chesapeake Bay LNG Operations and Management Plan is a living document signed by both COTPs Baltimore and Hampton Roads and continues to be evaluated and updated as needed annually.

Recommended control strategies identified during the risk assessment process were instrumental in the development of the new operations and management plan. Use of the what-if analysis technique served to identify safety and security risk mitigation strategies and helped to clarify jurisdictional boundaries and command and control issues for various emergency response scenarios.


Figure 3: LNG storage tanks, Cove Point facility. Courtesy Dominion, Cove Point.

One such risk mitigation strategy identified was the need for a moving security zone around each inbound LNG vessel and the implementation of a permanent, fixed security zone around the marine terminal. To assess impact, COTP Baltimore once again solicited public input and, once again, the public requested a hearing on the issue. The security zone proposal was met with staunch opposition from the local charter fishing industry. For the better part of the last two decades, the waters adjacent to the Cove Point marine terminal had become a popular site for both commercial and recreational fishing. Prior to plans for reactivation, a published safety zone extended 50 yards from the landside portion and 200 yards seaward of the terminal; however, it was only in effect when a vessel was at the berth. The current security zone is permanent and extends 500 yards in all directions. Local charter fishing representatives argued that the permanent, expanded zone could have potential devastating economic impact on their businesses.

Resumption of LNG Operations

During summer 2003 Cove Point resumed LNG shipments. The return of LNG cargo operations was commemorated with a cargo commissioning event attended by the Department of Energy Secretary, chief executive officer of Dominion, Commander of the Fifth Coast Guard District, and various members of the media. Since that time, the facility has received routine import shipments on an average of two vessel arrivals per week. Plans are currently underway for expansion of the Cove Point facility, and the number of vessel arrivals is expected to double by 2008.

The systematic approach to the Cove Point risk assessment, along with aggressive outreach to the public, port and industry stakeholders and federal, state, and local partners, was key to the success of the LOR and contingency planning process. Effective use of RBDM principles helped to identify key risks associated with the reactivation and led to the development of sound strategies to enable the resumption of operations, while ensuring the utmost level of safety and security for the protection of the public and the environment.

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2. "Properties of LNG" - presentation by Don Juckett, U.S. Department of Energy, February 12, 2002.
3. Title 33 Code of Federal Regulations, Part 127.009.

About the author: *Since 1990, Lt. Cmdr. Mark Hammond has served in a wide variety of positions within the U.S. Coast Guard's Marine Safety program. At the time this article was written, he served as the Chief, Prevention Department, at Sector Baltimore. He is currently Chief of the Security Information Branch, Office of Port, Vessel, and Facility Security (G-MPS), at Coast Guard Headquarters.*

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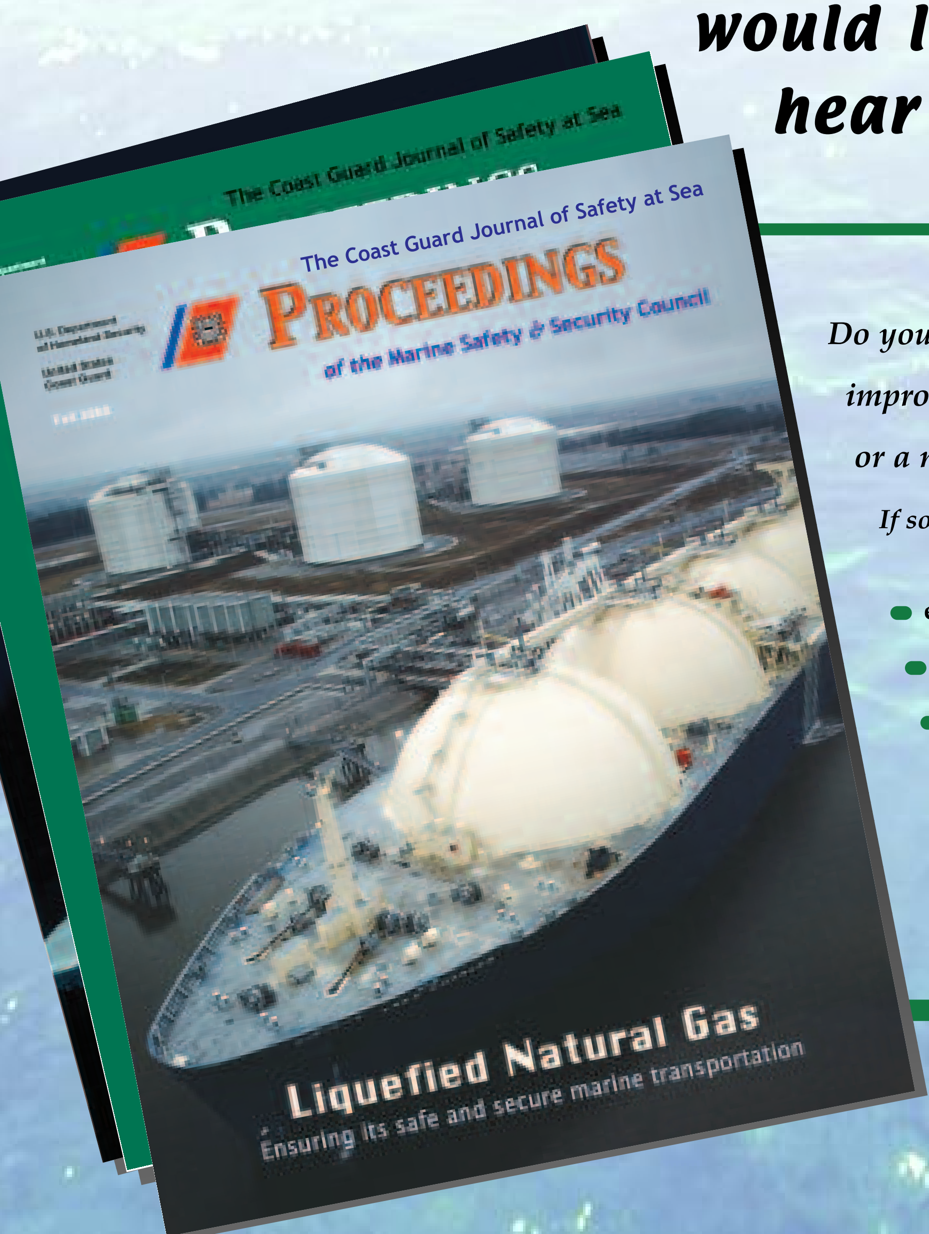

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We look forward to hearing from you soon, and we hope you have enjoyed this issue of PROCEEDINGS!

Harbor Safety Committees

Enhancing Waterway Suitability Assessments.

by LT. CMDR. MARK MCCADDEN
Commanding Officer, U.S. Coast Guard Marine Safety Unit Lake Charles

The Waterway Suitability Assessment (WSA) outlined in the Navigation Vessel and Inspection Circular (NVIC) No. 05-05: "Guidance on Assessing the Suitability of a Waterway for Liquefied Natural Gas Marine Traffic," is a qualitative assessment of a waterway. The WSA is considered crucial to the objective evaluation of proposals to build and operate shoreside LNG terminals. The Coast Guard Captain of the Port (COTP) reviews and validates the applicant's assessment, ensuring it adequately addresses the inherent safety, security, and environmental risks associated with the terminal and LNG marine traffic. Recognizing that the quality and accuracy of a WSA are dependent on considerations and factors unique to the local waterway and port community, stakeholder and local Harbor Safety Committee involvement are essential to successful development and validation.

Access NVIC 05-05: Guidance on Assessing the Suitability of a Waterway for LNG Marine Traffic at:

http://www.uscg.mil/hq/g-m/nvic/index00.htm

Coast Guard Roles & Responsibilities
As a regulator of maritime commerce, the Coast Guard assumes a variety of roles and responsibilities associated with proposals for constructing and operating LNG facilities. The Coast Guard enforces regulatory requirements found in 33 Code of Federal Regulations, Part 127: Waterfront Facilities Handling Liquefied Natural Gas and Liquefied Hazardous Gas, which mandate, among other things, that owners of proposed LNG facilities submit a letter of intent (LOI) to the local COTP. Regulations also require the COTP to issue a letter of recommendation (LOR) to the applicant after completing the assessment of suitability of the waterway for LNG marine traffic.

In February 2004 the Coast Guard, Federal Energy Regulatory Commission (FERC), and U.S. Department of Transportation (DOT) entered an interagency agreement to ensure the agencies work cohesively to ensure that land and marine safety and security issues are addressed in a coordinated and comprehensive manner. This agreement identifies the Coast Guard as a cooperating agency to FERC for the development of environmental review documents including environmental impact statements (EIS). Serving in this capacity, the Coast Guard is considered the subject matter expert for maritime safety and security and is tasked with providing input to FERC and the applicant regarding the suitability of the waterway.

The Coast Guard has earned the reputation of being an authority in maritime safety and security with the assistance of extremely knowledgeable and experienced stakeholders. A Coast Guard Captain of the Port knows that the best decisions made are those made after seeking and considering stakeholder input. One of the most effective ways to obtain quality stakeholder input is to tap into the local Harbor Safety Committee.

Harbor Safety Committees
Harbor Safety Committees (HSCs) are recognized as key to safe, efficient, and environmentally sound operations. HSCs are often the only local bodies available for the marine industry and other port users to meet and discuss mutual safety, mobility, and environmental protection issues. They are diverse in membership and have varying degrees of scope and effectiveness throughout the country. Historically, the cooperative and productive relationships developed between the Coast Guard and local HSCs have helped further common goals for the maritime transportation system.

The Calcasieu River Waterway Harbor Safety Committee is one of the many well-structured and highly effective HSCs found at U.S. ports and waterways (Figure 1). Comprised of three subcommittees (Navigation, Infrastructure, and Area Maritime Security Committee), the HSC and each subcommittee meet on a quarterly basis or more frequently if the need arises. The advantages of placing subcommittees under the umbrella of the HSC are readily apparent to the local port community. The subcommittees and port stakeholders work collaboratively and systematically rather than independently. Quarterly HSC meetings include progress briefings from each subcommittee chairperson, which provides effective one-stop shopping for the sharing of information and addressing matters of concern. This process allows the HSC Managing Board to make informed decisions regarding subcommittee tasking and local maritime transportation system initiative management. A current HSC initiative is providing assistance and support for the two new LNG facility applicants and to the Coast Guard for completing and verifying the required WSAs, respectively.

Waterway Suitability Assessments
The WSA described in NVIC 05-05 is a relatively new process for the LNG industry and the Coast Guard. Prior to the NVIC's release, existing regulations addressed safety and environmental aspects but did not contemplate the maritime security challenges faced today. The new process calls for the applicant to complete a comprehensive WSA that considers all aspects of safety, security, and the marine environment. Some of the factors and risks assessed include density and character of marine traffic, identification of critical infrastructure and key assets along the transit route, consequences resulting from possible LNG spills, and availability of resources for maintaining security and safety, to name only a few.

In addition, the process outlined in the new NVIC requires the Coast Guard to conduct a review and validation of the applicant's WSA to ensure it presents a realistic and credible analysis of the public safety and security implications for introducing LNG marine traffic into the port and evaluates the measures intended to responsibly manage identified risks. The results and findings from the validated WSA are carefully considered by the Coast Guard in the development of the applicant's LOR to operate the proposed LNG facility.

HSC Involvement in WSAs
The new NVIC specifically addresses the role of

HSCs and Area Maritime Security Committees in the WSA process and encourages their involvement. Recognizing HSCs were created as operational committees, they are exempted from the provisions of the Federal Advisory Committee Act, which formalizes the process for establishing, operating, overseeing, and terminating advisory bodies. The exemption may no longer apply in cases where it appears that the primary function of the HSC is changing from operational to advisory to the Coast Guard or other federal agencies.

Figure 1: The Navigation Subcommittee of the Calcasieu River Waterway Harbor Safety Committee discusses the Waterway Suitability Assessment process with representatives from the Coast Guard, Sempra LNG, Cheniere LNG, and Trunkline LNG. Lt. Cmdr. Mark McCadden, USCG.

The Coast Guard Captain of the Port must also be alert to potential conflicts among committee members or other stakeholders who may participate in the WSA development and subsequent WSA review and validation processes. The NVIC suggests that potential conflicts may be avoided by having those members who participated in one aspect of the process excuse themselves from taking part in the other.

Precautionary measures aside, the involvement of the HSC in the WSA process will ensure that crucial input from local stakeholders is taken into account for producing the realistic and credible analysis that is required. The support received from the Calcasieu River Waterway HSC for assessing navigation safety issues associated with the Cameron LNG terminal proposal was instrumental. The HSC assisted with coordinating an ad-hoc workgroup that brought together representatives from the Coast Guard, pilots, local refineries, consultants, and four different LNG companies. The workgroup meetings facilitated open and frank dialogue among participants that led to the efficient and effective assessment of all perceived risks. As a result, communication, knowledge, and understanding were improved for all parties involved, and the Captain of the Port was armed with the information needed to make informed decisions regarding the proposed facility and the issuance of the Coast Guard LOR.

Conclusion

Many ports throughout the nation have reaped the rewards that come from an effective Harbor Safety Committee. HSCs possess the talent, diversity, and local knowledge crucial to making sound decisions that affect U.S. coasts and waterways. Given the complexity and demands associated with the completion of a WSA, LNG applicants and the Coast Guard must join forces with HSCs to ensure assessments adequately address safety, security, and environmental risks associated with a proposed terminal and LNG marine traffic.

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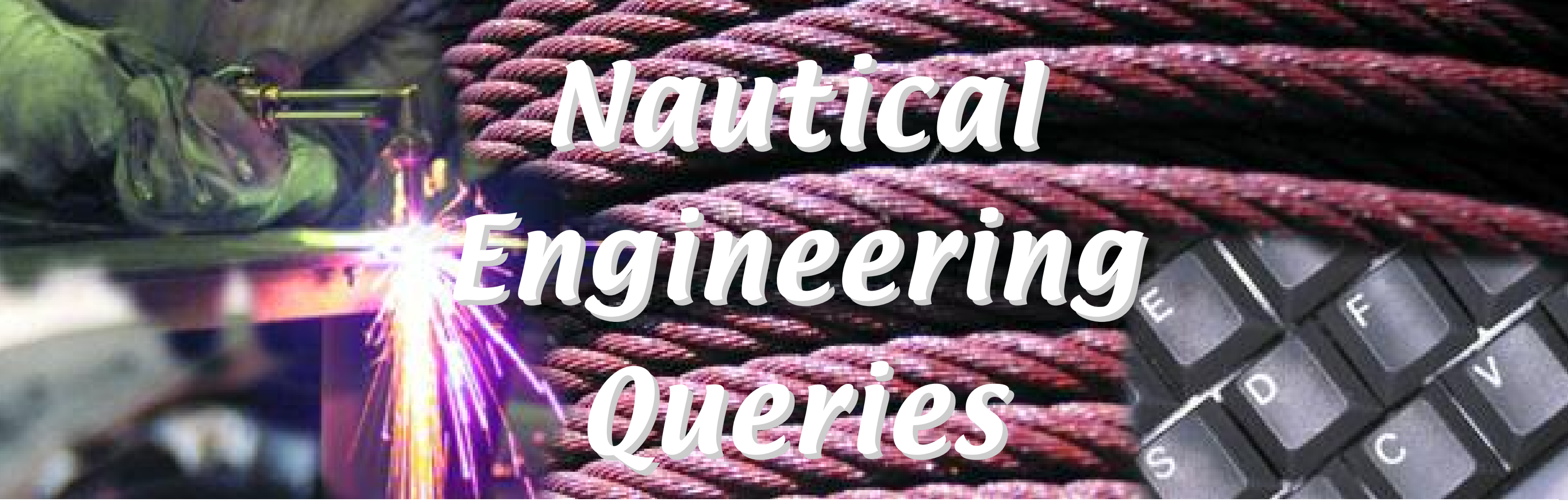
Nautical Engineering Queries



1. In a three-phase, squirrel-cage type induction motor, the rotating magnetic field is established by the _____________.

A. current induced in the rotor windings
Incorrect: The rotor of an induction type motor does not induce a magnetic field in the stator. AC voltages are induced in the rotor circuit as the result of the rotating magnetic field in the stator.

B. application of a three-phase voltage supply to the stator windings
Correct Answer: The principle of a rotating magnetic field is the key to the operation of most AC induction motors. The sequential AC phase angle relationships are used to alternately magnetize adjacent stator coils. The sequential shift in magnetization between adjacent stationary stator coils creates the effect and appearance of a rotating magnetic field. The apparent shifting of the magnetic field in the stator induces an internal rotor current creating a second interacting magnetic field in the rotor producing shaft torque.

C. laminated steel core and aluminum conductors in the rotor
Incorrect: A laminated steel core is used in place of a solid iron core for the construction of the rotor to minimize the effect of "eddy" currents. Small stray electrical currents generated within the core material of the rotor by the induced magnetic field results in the buildup of heat. The resultant electrical energy loss or "eddy current loss" and can be reduced by increasing the resistance of the eddy current path by a production process achieved through laminating the core.

D. interaction of the magnetic field caused by the induced current in the squirrel-cage bars with the magnetic field of the stator.
Incorrect: The interaction of the generated magnetic fields between the stator and rotor causes the motor shaft to rotate as a result of applying AC current to the stator windings and the resultant induced magnetic field interaction with the squirrel cage rotor.

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2. When charging a 100 amp-hour lead acid battery, ___________.

Note: The practical limitations to the charging rate for batteries are: (1) excessive temperature rise and (2) excessive gassing

A. the temperature of the electrolyte should not be allowed to exceed 90 degrees Fahrenheit.
Incorrect: Care should be taken to keep the electrolyte temperature from exceeding 125ºF, as such, 90ºF is satisfactory.

B. the charging rate should be no greater than 125% of the battery amp-hour rating.
Incorrect: The maximum charging rate (in amperes) should be limited to approximately 30% of the amp-hour rate, or 30 ampsfor a 100 amp-hour battery.

C. the source of power for charging should be 2.5 volts per cell.
Correct Answer: Applying approximately 2.5 volts charge per cell is recommended and ideal for lead acid batteries. This is slightly higher than the normal no load voltage of 2.1 volts per cell.

D. gassing within the battery decreases when nearing full charge and it will be necessary to reduce the charging cur rent to a low finishing rate.
Incorrect: Gassing will increase and not decrease when more charging current is being fed to the battery than it can use. The excess current produces hydrogen and oxygen gases and contributes to high electrolyte temperatures. Batteries normally begin to release gas at about 80-90% of its full charge. Some battery chargers automatically reduce the current to a trickle charge when the battery reaches this point to limit excess gassing.

3. The process of reversing any two of the three "rotor" leads of a wound-rotor induction motor will ________.

Note: The stationary "stator" field windings are energized from a three phase power source which produce the effect of a rotating stator field. Reversing the position of any two power leads to the stator will cause the motor to reverse direction of rotation. A "wound rotor" induction motor is constructed with segregated rotor windings which are closed circuited through slip rings with a variable rheostat which provides a means of controlling the induced rotor current. This allows for control of the motor's output torque.

A. increase motor performance

Incorrect: Motor performance would not be affected because the rotor windings of a wound rotor induction motor are segregated closed circuits that only provide for a control of induced rotor current through slip rings and a rheostat. In effect, reversing any two leads would be similar to reversing the leads of a resistor in a closed circuit.

B. decrease motor performance

Incorrect: Motor performance would not be affected for the above reason. Only a change in the "resistance value" of the rotor circuit will change the strength of the induced current and resulting rotor magnetic field, which in turn will change output torque.

C. reverse the motor rotation

Incorrect: Reversing the rotor windings on a wound-rotor motor will not change the direction of motor rotation. Changing any two lines of the three voltage sources to the stator coils will reverse the directional sequence of the generated magnetic fields in the stator, thereby reversing the direction of the rotating field and motor rotation.

D. have no effect on the direction of rotation or motor performance.

Correct Answer: The windings or bars on a simple squirrel-cage rotor are short-circuited by end rings. The windings on a "wound-rotor" motor are not short-circuited, but are connected in a delta arrangement to a rheostat. Each winding is brought out via leads to three separate slip rings, which are mounted on the end of the shaft. Stationary brushes ride on each slip ring, forming an external "secondary" circuit into which any desired value of resistance may be inserted, changing the amount of induced current produced in the rotor, changing the motor performance.

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4. Sparking of D.C. motor brushes can be caused by _________.

A. an open commutating winding

Correct: An open winding would cause an alternating interruption of current flow, thereby causing sparking of the brushes at the point of brush contact with the open commutator bar.

B. many mechanical, electrical or operating faults

Correct: A variety of mechanical or electrical faults may cause sparking at the brushes including motor vibration, bearing wear, impurities embedded on the brush surface, faulty brush adjustments, unbalanced armature currents, etc.

C. an open interpole

Correct: Interpoles are similar to the main field poles and located on the yoke between the main field poles and have windings in series with the armature winding. Interpoles have the function of reducing the effect of armature reaction, which would cause a shift in the magnetic field in the commutating zone. They eliminate the need for shifting the brush assembly with changes in load conditions.

D. all of the above

Correct Answer: Answers A, B, and C could all contribute to sparking of DC motor brushes.

Nautical Deck Queries

1. Instructions to the crew in the use of all the ship's lifesaving equipment shall be completed __________.

Note: The regulations pertaining to drills involving lifesaving equipment aboard cargo ships are incorporated in Subchapter "W" of 46 CFR: Part 199.180.

A. before sailing

Incorrect: Crewmembers are only required to become familiar with the emergency duties assigned to them on the muster list before sailing: 199.180(b)(1). Drills are only required before sailing if a vessel enters service for the first time or when a new crew is engaged: 46 CFR 199.180(b)(3).

B. within one week of sailing

Incorrect: Crewmembers joining a vessel for the first time must be instructed in the use of firefighting and lifesaving equipment within two weeks of joining the vessel: 46 CFR 199.180(g)(1).

C. in one month and repeated quarterly

Incorrect: Every crewmember must participate in at least one abandon-ship and one fire drill every month. The drills must take place within 24 hours of the vessel leaving port if more than 25% of the crew has not participated in drills aboard that particular vessel in the previous month: 46 CFR 199.180(c)(2). These drills are required to be repeated at least weekly aboard passenger vessels: 46 CFR 199.250.

D. within any two month period

Correct Answer: The regulations require that "The crew must be instructed in the use of the vessel's fire-extinguishing and lifesaving appliances and in survival at sea at the same intervals as the drills. Individual units of instruction may cover different parts of the vessel's lifesaving and fire-extinguishing appliances, but all the vessel's lifesaving and fire-extinguishing appliances must be covered within any period of 2 months": 46 CFR 199.180(g)(3).

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2. The belt of light and variable winds between the westerly wind belt and the northeast trade winds is called the _________.

Note: The earth's atmosphere consists of three major circulation belts per hemisphere that each span 24˚ - 26˚ of latitude. They are: the polar easterlies, the westerlies, and the trades. Between these major belts are narrower belts (4˚ - 6˚ of latitude) consisting of light and variable air circulation. They are centered near 60˚ N&S (low pressure), 30˚ N&S (high pressure) and near the equator (low pressure). Prevailing winds flow from areas of high pressure to areas of low pressure deflected by Coriolis force.

A. subtropical high pressure belt

Correct Answer: This is the narrow belt of high pressure in the vicinity of 30°N, nicknamed the "horse latitudes." This belt is characterized by clear skies with light and variable winds. The weather is generally good because the descending air is warmed and dried as it approaches the earth's surface. There is a corresponding high-pressure belt at latitude 30°S.

B. intertropical convergence zone

Incorrect: This is the narrow belt of low pressure in the vicinity of the equator, nicknamed the "doldrums." This belt is characterized by cloudy skies with light and variable winds. The weather is generally poor as a result of ascending warm, moist air, which cools as higher elevations are reached condensing the water vapor to form clouds. The moisture is inevitably released as rain.

C. doldrums belt

Incorrect: Same as above for the intertropical convergence zone, which is the technical name for the "doldrums."

D. polar frontal zone

Incorrect: There are two of these zones. These narrow belts of low pressure in the vicinity of latitudes 60°N&S are at the limit of the polar easterlies where they meet the westerly wind belt of each hemisphere. The polar fronts are on the side toward the poles of the westerly wind belts while the subtropical high-pressure belts are on the tropical side of the westerly wind belts.

3. A towing vessel becomes tripped while towing on a hawser astern. What factor is MOST important when assessing the risk of capsizing?

Note: A tug is in imminent danger of capsizing when she is "tripped". Tug boats are designed with their after decks as low as possible in order to minimize the effect of the tripping force. A tug could become tripped and rendered unable to maneuver when it is pulled athwartships (sideways) by the force that the towed vessel exerts on the towline. As an example, tripping is more likely to occur to a harbor tug when the vessel it has under tow moves ahead too rapidly under her own power while being assisted in leaving a pier. It could also be caused by the momentum of a seagoing barge carrying it alongside the tug if the tug were to suddenly reduce speed, such as losing propulsion. As the towed vessel comes alongside of the tug the capsizing force would become prominent and would be intensified as the height of the hawser connection on the tug increased.

A. Length of the towline

Incorrect: A longer towline will contribute to less maneuverability and greater difficulty in recovering from the tripped condition. However, this is not a significant factor in causing the tripping of a tug.

B. Height of the towline connection

Correct Answer: This is a prominent factor that can contribute to the capsizing of a tripped tug. The higher the towline connection is made above the center of flotation (vertical lever-arm), the greater its effect will be on the capsizing moment. The tug will capsize if the connection is high enough to cause the capsizing moment to overcome the righting moment.

C. Longitudinal position of the towline connection

Incorrect: The farther aft the longitudinal connection is from the center of flotation, the less effect it will have on transverse stability of a tug. Although the longitudinal position of the towline connection may become a factor, the height of the towline connection is the more critical of these two elements when assessing the risk of capsizing.

D. Direction of the tripping force

Incorrect: The horizontal direction of the force increases and will contribute to the danger of capsizing, as the lead becomes more athwartships. Although the factors in "C" and "D" are important considerations in the tripping of a tug, they are not by themselves the most critical with regard to capsizing.

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4. Frames to which the tank top and bottom shell are fastened are called __________.

Note: Frames are transverse structural members which act as stiffeners to the shell and bottom plating.

A. floors

Correct Answer: The transverse vertical members supporting and compartmenting the double-bottom are called floors. Floors may be solid to form a water and/or oil tight boundary to form double-bottom or inner-bottom tanks, or they may have lightening holes to economize weight.

B. intercostals

Incorrect: Intercostals are vertical longitudinal parts of the hull's structure and are cut in comparatively short lengths between transverse structural members.

C. stringers

Incorrect: Stringers are longitudinal girders or stiffeners bridging transverse beams or frames. Stringers are fore-and-aft strength member girders. They may be used as the keelsons or longitudinals at the bottom of the vessel.

D. tank top supports

Incorrect: This term is not part of the nautical nomenclature used in ship construction.

U.S. Department
of Homeland Security

United States
Coast Guard

Office of Operating and Environmental Standards G-MSO

G-MSO-1
Maritime Personnel Qualifications Division

G-MSO-3
Hazardous Materials Standards Division

G-MSO-4
Environmental Standards Division

G-MSO-5
Deepwater Ports Standards Division

G-MSO-2
Vessel and Facility Operating Standards Division