Opportunities and challenges in the LNG process

Liquefied Natural Gas (LNG) is exactly what it says: the liquid form of natural gas. The process of liquefying is performed to reduce the volume for purposes of transporting the fuel: LNG reduces volume by 600 times, making it much more economical to transport by sea aboard LNG carrier ships to destinations all over the world.

The temperature required to liquefy natural gas is -260°F (-162°C). As a result, most pipe, valves and fittings will be specified to meet cryogenic temperatures of -270°F (-168°C) to 325°F (-198°C). The development, transportation and receiving of LNG require a step-by-step process that has grown very rapidly over the last several decades. In the past, each step was treated as a different market. However, with the global economy and market for LNG expanding rapidly, the challenge of many manufacturers of pipe, valves and fittings is to expand their product ranges to cover all three areas. Valves are a critical component at each stage, and they need to be constructed of quality cast and forged materials. Valve performance and reliability are vital to the whole process, and these strengths can only be achieved through critical design, manufacturing and material selection.

Liquefaction Facilities

LNG facilities are constructed in various places in the world where an overabundance of natural gas can be converted to its liquefied state for use elsewhere. A few different facility designs have been developed for reaching the cryogenic temperatures needed. Valve design and specification may be slightly different from facility to facility, but the

Executive Summary

SUBJECT: The U.S. recently became the world’s top producer of natural gas, and the nation is now looking at selling it to other places in the world that need the fuel. The result is a growing market for liquefied natural gas (LNG) and the equipment needed for that field, as well as a debate on whether exporting that LNG is good for the country.

KEY CONCEPTS:
- Valves used in LNG
- Standards and testing
- The pros and cons of exporting LNG
- Current legislative thinking

TAKE-AWAY: Although the field is competitive, the growth presents new opportunities.
end result is the same: The volume ratio of 600 to 1 (gas to liquid) is loaded onto specially equipped carriers to be shipped to receiving terminals.

Some of the valves used in the facilities include:

**Butterfly valves.** Most butterfly valves for this use are 4 inches and larger. Some control valves will be this type, but the majority of butterfly valves are manual, on/off automated and emergency shutdown. While many of these valves are used throughout the facility, most types will be cryogenic to meet the extreme cold requirements. Most of these valves are in the 150-pound, 300-pound and 600-pound classes with flanged ends. The valves will require live loading on the packing to ensure a constant load on the packing chamber. They also will have stem extensions that are calculated in length to maintain a vapor barrier at the upper end of the extension. There are also some higher pressure valves needed that are in the 900-pound class and are cryogenic butterfly valves.

**Ball valves.** The majority of ball valves for LNG are 6 inches and smaller with pressure classes typically the same as butterfly valves. Like butterfly valves, ball valves are used for many applications and most are cryogenic. The body is typically a butt weld, three-piece design with a cryogenic extension and live loading on the packing chamber. There are many applications where a cryogenic top entry, one-piece body is preferred because of thermal cycling conditions in the process.

**Gate, globe and check valves.** These valves are also used in many areas of the facility in both cryogenic and ambient applications. The majority of cryogenic valves are going to be butterfly and ball valves, however, depending on the process design.

**LNG CARRIERS**

These vessels are specially designed to transport LNG from the liquefaction facility to the receiving or regasification terminal. The world’s need for natural gas means the LNG carrier market is booming. Because of the gas to liquid ratio, these carriers can transport enormous amounts of LNG to those areas of the world that have the demand. There also are many new innovations for floating LNG regasification terminals and liquefaction facilities, including carriers with regasification facilities on board. This means that in areas where the construction of a receiving terminal does not make sense, such as small ports, natural gas can go right from the ship to feed power plants.

**Butterfly valves.** As with facilities, the majority of butterfly valves on carriers are 4 inches and larger; some control valves are butterfly, but the majority will be manual, on/off automated and emergency shutdown. While there are many butterfly valves designed for

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“America’s energy abundance is creating employment opportunities and growth at a time when little else in the economy is going as well—and that alone is enough reason to support domestic energy production. But while this energy abundance is a source of jobs at home, it can also be a force for good around the world.”

Representative Ed Whitfield (R-KY)
Chairman of the Energy and Power Subcommittee of the House Committee on Energy and Commerce, May 7, 2013
Thanks to widespread use of techniques such as hydraulic fracturing and horizontal drilling, the United States has become the world’s largest producer of natural gas. These technological advances in hydrocarbon extraction currently support over 1.7 million jobs, and IHS, Inc. estimates the U.S. energy boom will directly or indirectly support 3.5 million American jobs by 2035.

Apart from job creation, this revolution in U.S. unconventional oil and gas production has bolstered a flagging domestic manufacturing industry, set the U.S. on a path toward energy independence and increased U.S. geostrategic opportunities. The fact the United States has turned from an importer of natural gas to a potentially powerful exporter in only a few short years is seen by many as a powerful geopolitical tool—one that can strengthen strategic alliances while undermining the grip that countries like Russia and Iran have on regional energy supplies.

Critics worry that exporting natural gas would frustrate a resurgence in manufacturing and undermine the benefits that cheap energy offers to U.S. industry and to consumers. Concern also exists that a surge in global demand could trigger a price increase and raise costs for domestic industry and consumers, and that granting exports to countries without a formal U.S. Free Trade Agreement (FTA) would weaken U.S. leverage in international trade negotiations.

Still, America appears to be sitting on a significant amount of natural gas, and the debate over whether, and how, to export it has been simmering, with recent attention turning toward getting answers through Congress, the President and the newly appointed Secretary of Energy, Ernest J. Moniz.

**THE DEPARTMENT OF ENERGY AND LNG EXPORTS**

The Natural Gas Act (NGA) requires the Department of Energy (DOE) to review all applications for exporting natural gas to countries that have an FTA with the United States. However, a 1992 amendment to the act required that trade in natural gas be “deemed to be consistent with the public interest” and “granted without modification or delay,” which removed
DOE’s discretion over exports of natural gas to such countries. It should be noted, however, that the market for export to these countries is limited, with only South Korea, Singapore, Chile and the Dominican Republic currently importing natural gas.

For non-FTA countries, such as Japan and India, the NGA authorizes DOE to grant applications for export authorizations unless the proposed exports would “not be consistent with the public interest.” On May 17, 2013 DOE granted approval to the Freeport LNG Expansion and FLNG Liquefaction LLC’s application to export LNG to non-FTA nations, including Japan, the world’s largest LNG importer. This comes a year after DOE granted the first approval to the Sabine Pass liquefaction terminal in Louisiana for the export of liquefied natural gas for a 20-year period to FTA and non-FTA nations. DOE is currently reviewing 20 similar applications.

In evaluating these applications, the “public interest” provision creates a rebuttable presumption that the designated export is in the public interest. DOE must grant the application unless opponents can refute that presumption. DOE’s public interest analysis focuses on the domestic need for the natural gas proposed to be exported. It also focuses on whether the export is consistent with DOE’s policy of promoting competition by allowing commercial parties to negotiate freely their own trade arrangements, whether a threat exists to domestic security supply, and on other factors shown in the public interest, including environmental impacts.

On Dec. 5, 2012, the DOE’s Office of Fossil Energy posted the long-awaited results of a third-party study on the potential macroeconomic impacts of LNG exports.

**STUDY RESULTS**

The study’s broad conclusions bolster arguments in support of LNG exports. Across all analyzed scenarios, projections were that the U.S. would gain economic benefits from allowing LNG exports according to the metrics of welfare, gross domestic product, aggregate consumption and trade balance. Moreover, the net benefits across all scenarios were examined, and those benefits were found to become larger as the amount of exports increased.

Opponents of LNG exports, however, point to higher domestic LNG prices as a major reason DOE should withhold authorizations. The study noted that increases in domestic LNG prices could hurt trade-sensitive industries, the electricity sector and other energy-intensive industries. Opponents are likely to highlight higher operating costs in these sectors, costs that will shift to consumers in the form of high prices for goods being produced, and onto suppliers, whose workers and owners may experience losses.

**WHAT NOW?**

Since the study’s December release, DOE has been in the process of considering more than 188,000 comments submitted by individuals, companies, trade associations, environmental groups, members of Congress and others.

Within that docket, natural gas-using stakeholders, such as Dow Chemical, alleged analytical flaws in the report and contended that domestic resources should be retained for domestic use. They were joined by certain environmental groups that oppose all hydraulic fracturing as well as LNG export that would provide a market for hydraulically-fractured natural gas.

Other constituencies argued that LNG export to non-FTA companies will not cause massive price increases or spikes, an argument backed up by findings in the DOE study as well as studies by Deloitte and the Brookings Institute. Oil and gas companies argued that artificially low natural gas prices make it uneconomical for companies to produce natural gas, and that, without adequate additional markets, the domestic energy industry will contract. Finally, free-trade constituencies argued that protectionist treatment of natural gas undermines U.S. efforts to stop such practices in China and elsewhere in the world and could cause significant compliance issues for the U.S. at the World Trade Organization.

If DOE’s review of the study and the public comments comes out in favor of LNG exports, the agency likely will begin to make decisions on the 20 pending export applications. Determining how those applications will be reviewed, whether approvals will continue to be staggered or whether limits will be imposed on export capacity also rests with DOE. As Maggie Clarke notes on page 22 of this magazine, these issues are under hot debate in both chambers of the U.S. Congress as lawmakers also await a decision. However, one fact in this debate is clear—no decision will have a more profound impact on U.S. energy policy than DOE’s ruling on LNG exports.

The issues and legislation regarding export of LNG are ongoing matters. Be sure to check VALVEMagazine.com for updates.

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vapor barrier at the upper end of the extension. This is another area where higher pressure, 900-pound cryogenic butterfly valves used with butt weld side entry design are used. Very few manufacturers currently make this type and pressure class of valves.

**Ball valves.** Most are 6 inches and smaller with pressure classes that are the same as butterfly valves. Again, many types are used, but most are cryogenic. The body is typically a butt weld three-piece design with a cryogenic extension and live loading on the packing chamber. Also, there are many applications where a cryogenic top entry one-piece body is preferred because of thermal cycling conditions in the process.

**Gate, globe and check valves.** These are used throughout the facility in both cryogenic and ambient applications, though most of the cryogenic valves are butterfly and ball valves depending on the process design used. There may be check valves of a special design used for loading and unloading LNG. These valves can be operated in reverse flow in which case the disc is mechanically overridden to lock open for reverse flow.

**BODY MATERIALS**

For LNG service, the body material is typically austenitic 316 stainless steel to maintain body strength at cryogenic temperatures. Non-cryogenic valves can be WCB-grade, stainless or high nickel alloys that are suitable for that particular service as well as for the offshore environment.

**TESTING, CERTIFICATIONS AND APPROVALS**

All valves will typically need to meet API 598 or equivalent leakage testing as a minimum. Cryogenic valves will have to meet BS 6364, which is tested with helium at -270°F (-168°C) to -325°F (198°C). While this test is an industry standard for liquefaction, receiving or regasification terminal applications, many receiving terminals will require much better leakage rates during cryogenic testing. This testing is usually random on 10% of valves or at least one of every size and class.

LNG carriers are usually more critical in regards to seat leakage rates. More specifically, testing includes:

- For BS 6364, liquefaction facility requirement is a leakage rate maximum 150 cubic centimeters (cm³) per minute per inch size of valve (cm³/minute/inch).
- With the MW Kellogg spec test, most receiving or regasification terminals have a leakage rate maximum of 15 cm³/minute/inch. This test can be very challenging for metal-seated valves, and triple offset valves typically cannot meet this test because of the torque-seated design.
- LNG carrier leakage testing requirements typically have to meet a maximum of 10 cm³/minute/ inch.
- Process valves typically have to meet fire-safe specifications BS 6755, API607 and API6FA.
- Most specifications will require valve body x-ray testing and die-penetrate testing for random valve body and parts.
- LNG carrier valves also typically have to meet one or more of many ship or carrier approval certifications such as the Bureau Veritas, DNV or ABS.

**SUMMARY**

While many of the valve requirements in the receiving terminals, liquefaction facilities and LNG carriers are redun-
vant, there are important differences in pressure class, end connections, certifications and testing.

With the LNG market growing, other markets for the product are poised to grow very quickly. For example, the transportation industry has discovered the benefits of the LNG volume ratio to natural gas: tanker trucks, service vehicles and automobiles can go much greater distances. LNG filling stations also benefit from the volume-saving advantage.

The challenge for pipe, valves and fitting manufacturers as well as other equipment designers and makers, will be public safety and perception. While LNG is not explosive in its liquid state, once it reaches a vapor form and gets between 5-15% of natural gas in air, it can ignite. (Below 5%, there is not enough natural gas to become flammable; above 15%, there is not enough oxygen in the air to be flammable.) LNG carriers as well as loading docks around water have other risks as well. If LNG is exposed to water at a very fast rate, for example, a rapid phase transition (RTP) can occur. RTP can result in a physical explosion that can release a great amount of energy. While this is not a combustion type of explosion, the energy released can be hazardous.

Because of this, valve manufacturers, as well as makers of other products for the LNG market, conduct critical research, development and production of their products to meet safety concerns and industry requirements.

What many valve manufacturers are considering is that there has been an overabundance of LNG projects in North America and around the world. In the late 1990s to mid-2000s, North America had many permit applications for receiving terminals. However, there were only a few regasification terminals actually constructed, several of which never moved much LNG into the pipelines.

Still, because of the plentiful supply of natural gas from the shale gas finds in the U.S. and Canada, North America has many projects planned for liquefaction facilities. In fact, many of the receiving terminals are now building liquefaction facilities on the same site. At the same time, there already are too many new valve manufacturers in the market producing cryogenic valves and others with plans for developing similar products on the horizon. A major challenge current valve manufacturers, as well as foundries and forge masters, face is to remain competitive in this growing market, while maintaining and improving quality and performance.

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Exporting LNG: A Legislative Update

BY MAGGIE CLARKE

The energy boom taking place across the country from North Dakota to Texas to Pennsylvania has generated an intense policy debate in Congress early in this 113th Congress with LNG exports a major focus.

Notably, during the comment period on DOE’s study, over 100 members of the U.S. House of Representatives sent a letter to then-DOE Secretary Steven Chu urging quick approval of pending LNG export applications, and a bipartisan group of Senators followed suit. On the other side of the debate, however, there are members of Congress who contend that domestic natural gas consumers would see prices rise from increased exports. Some of these congressional colleagues have simply expressed concern and urged caution while others have introduced legislation addressing the issue.

Reps. Ed Markey (D-MA) and Rush Holt (D-NJ), both senior members of the House Committee on Natural Resources, have introduced a trio of bills aimed at restricting energy exports, two of which are aimed at natural gas. The two natural gas bills are:

- H.R. 1191, the *Keep American Natural Gas Here Act*, would prohibit the Interior Department from accepting bids on new leases of Federal lands unless the bidders certify that all gas produced would be sold solely in the United States. Additionally, the bill would prevent granting of any natural gas pipeline right-of-way unless the natural gas transported via the pipeline is sold exclusively in the United States.

- H.R. 1189, the *American Natural Gas Security and Consumer Protection Act* would amend the Natural Gas Act to reform the current permitting process for LNG exports. Specifically, the legislation would require DOE approval of all natural gas exportation (DOE authorization is currently only required for exports to countries with which the U.S. does not have an FTA). The bill would also modify the existing “public interest” provision to eliminate the “rebuttable presumption.” That would mean that before granting approval, DOE would have to ensure that the proposed exportation is consistent with the public interest. The bill includes a list of factors DOE would have to consider in that evaluation—ranging from the economic impact on natural gas consumers, to the country’s energy security, to the country’s ability to reduce greenhouse gas emissions.

It is unlikely that either proposal will advance in the Republican-controlled House, particularly when there is bipartisan support in the chamber for LNG exports. While a few members have expressed general opposition to these exports, many more are either supportive or are instead seeking a so-called “sweet spot”—hoping the market will set a price that allows greater exports to both reduce our trade deficit and boost the economy, while, at the same time, continuing to provide a competitive advantage for domestic energy consumers.

Along those lines, legislation is also pending in both chambers to facilitate additional LNG exports by building upon the existing procedure for exports to FTA countries, whereby exports are deemed “consistent with the public interest” and do not need to go through the DOE approval process. Specifically, Rep. Mike Turner (R-OH) and Sen. John Barrasso (R-WY) have introduced the *Expedited LNG for American Allies Act* (H.R. 580/S. 192), which would provide the same treatment to NATO countries, Japan and any other foreign country if exportation to that country “would promote the national security interests of the United States.”

For now, however, Congress appears to be taking a “wait and see” approach in lieu of legislating. That said, the debate continues in committee rooms on both sides of the Capitol, with several hearings already held to debate the merits of LNG export.