LNG in a cold

As LNG tanker technology continues to advance, vessels are both growing in size and becoming more specialised. Rob Tustin* discusses the next generation of LNG tankers which will be capable of ice navigation

The LNG sector is expected to continue to grow at a prodigious rate, with the global trade in LNG predicted to more than double from 170 billion m^3 in 2003 to 370 billion m^3 in 2010. The longer term prospects are similarly bullish, with the International Energy Agency forecasting a six-fold increase in LNG trade from now until 2030.

Significantly for the shipping industry, a large percentage of LNG demand after 2010 is likely to be satisfied by Russia, which currently holds the largest known and currently unexploited reserves of natural gas, comprising 31% of the world's reserves.

The Arctic and sub-Arctic regions of Russia are extremely rich in natural resources, accounting for about 90% of Russian gas, 60% of oil and a considerable proportion of other minerals. According to BP's statistics, at the end of 2003, the volume of proven reserves in the Russian Federation stood at 47 trillion m^3.

In the short term, exploitation of gas reserves in Russia is expected to focus on the Sakhalin Island reserves, specifically the Sakhalin Energy Sakhalin II project, a two-train 9.6Mt/annum LNG facility which is due to start exports in 2007. In Aniva Bay, on the southern-most shore of Sakhalin Island, where the Prigorodnoye gas export terminal is located, first-year ice conditions prevail.

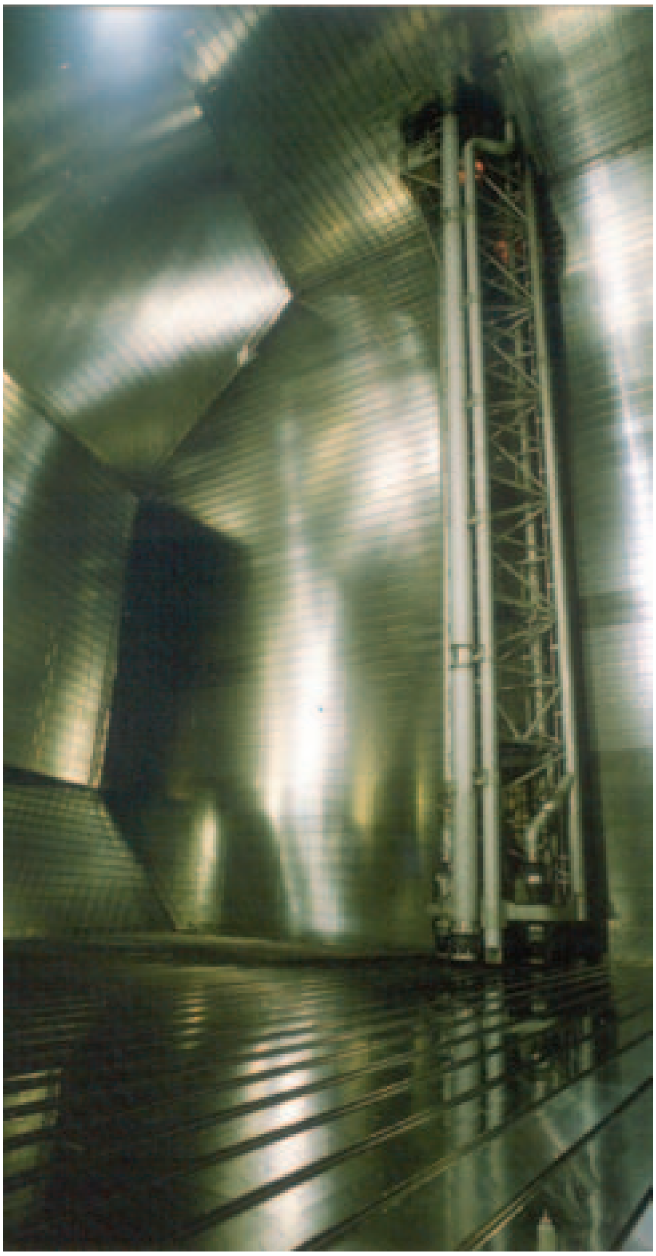
Implications for shipping

The development of gas fields in the prevailing meteorological conditions on the Arctic shelf is expected to be capital intensive. Experience of developing offshore fields on the Arctic shelf and in ice-infested areas indicates that gas production may only be profitable in the context of giant fields.

The areas currently considered the most promising for development in the Russian Arctic are:

- The Shtokman field in the Barents Sea, which is the world's largest known offshore gas field with reserves of about 3.2 trillion m^3; there are already plans to liquefy gas in Murmansk – a year-round ice-free port – piped from the Shtokman for export to US markets by 2010
- Predicted fields in the Kara Sea at technically accessible sea depths of up to 50m are likely to be a top priority for development
- Two of these projected fields – the Rusan field and the Leningrad field – are estimated to have a combined reserve of 5 trillion m^3; by way of comparison, worldwide gas production in 1999 was 2 trillion m^3.

The implication for the design, construction and operation of LNG ships is clear. In the Kara Sea, for instance, multi-year ice conditions are prevalent and any LNG shipping operating in this area would need to be technically enhanced to undertake multi-year ice operations. In the light of the untapped reserves in Russia and the advancement of marine ice-strengthening for vessels, it seems very likely that LNG ships designed for service in the Russian Arctic will soon become a reality. It is in fact estimat-



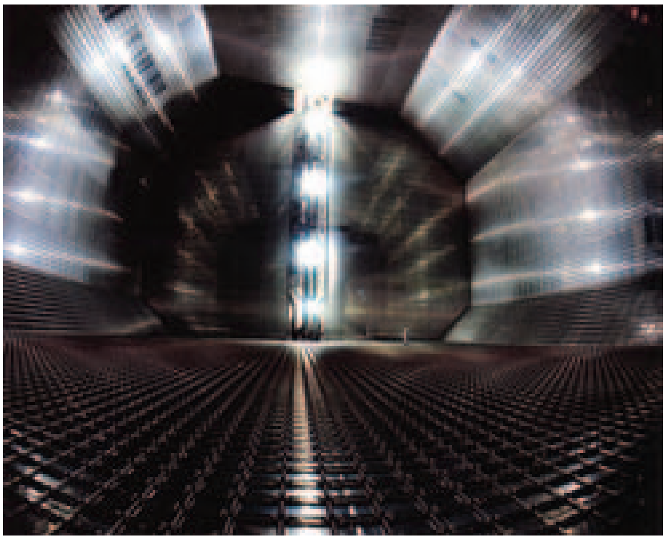
climate

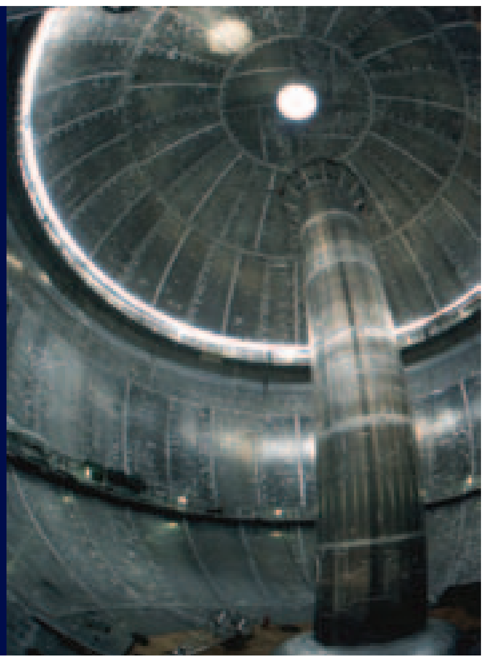
ed that up to 14 125 000 m^3 LNG carriers with multi-year ice class will eventually be required to serve gas fields in the Kara Sea.

Meanwhile, the industry has already seen the first orders for first-year ice-class LNG ships. During 2004, contracts for five ships were placed with shipyards in the Far East for ice-class LNG ships; all but one of these ships are being built to Lloyd's Register class. These ice-class LNG vessels have mainly been contracted for service to the gas export terminal at Prigorodnoye in Aniva Bay.

Three of the four ships Lloyd's Register will class are being built in Japan, at Mitsui and Mitsubishi to RMRS LU2 ice class, or the Finnish-Swedish Ice Class 1B equivalent, with Moss-type containment system. The fourth is building in Korea at Hyundai Heavy Industries, using the Technigaz Mk III membrane containment system, to Lloyd's Register class, with RMRS LU2 ice class.

■ LNG containment systems: below right Moss spherical tank (courtesy Aker Finnyards); below Technigaz Mk III membrane tank; left Gaz Transport No 96 tank





Ice conditions

The challenges associated with first-year ice navigation and those with multi-year ice navigation are very different. But in general, to navigate in ice-infested waters, LNG ships must be equipped with both adequate technical solutions (ice-strengthening of hull, shaft and propeller; increased propulsion power; application of low-temperature-proof materials) as well as appropriate support measures, such as the provision of icebreaking support and detailed sea ice meteorology data and support by the national administration (eg Northern Sea Route Administration of the Russian Federation in the case of Sakhalin Island).

First-year ice conditions prevail during an average 95-day ice season during the months of January through to April in Aniva Bay, where the Sakhalin II gas export terminal at Prigorodnoye is located. For comparison, this is a shorter ice season than prevails in the Northern Baltic, which averages 120 days.

Multi-year ice is prevalent in the Kara Sea surrounding the Rusan and Leningrad fields. For year-round navigation with icebreaker assistance in the Kara Sea, typical hull structure design values for level ice sheet thickness vary from 120cm to 170cm thickness in the summer and autumn seasons and 170cm to 320cm thickness in the winter and spring seasons.

Technical details

The technical requirements for ice-class address the safety of the hull and essential propulsion machinery, as well as the requirement for sufficient installed power for safe operation in ice-covered waters. For both first and multi-year ice operations, assisted navigation via dedicated icebreakers is considered as a basis for design (ie independent navigation is considered to be an unlikely operational scenario).

Ice-class Rules address the peculiar demands of cold climate operation by considering hull-ice interaction scenarios as a basis for design. For example, for first-year ice conditions, the breaking of a level ice sheet (of a specified thickness) is considered as the basis for designing the hull structure, and ice piece impact is used as the design basis for the propeller and shaft.

To help to ensure an adequate level of hull structural strength, side shell structures around the waterline are enhanced to meet the expected ice pressure loadings for a design thickness of level ice. Increased ice pressures are applied for zones along the length of the ship, with the highest pressures occurring at the fore end of the vessel and higher ice pressures applied for higher ice classes.

Ice-class requirements for machinery aspects typically include thicker propeller blades, higher push-up distances for propeller and shaft couplings, and increased screw shaft diameters. In the case of the highest first-year ice classes (eg Finnish-Swedish Ice Class 1A and 1AS), as well as the multi-year ice classes, intermediate shaft and gearbox arrangements may need to be given special consideration due to increased design torque values.

Additional considerations for cold climate operation include specification of design ambient temperatures for deck machinery and equipment, as well as specification of steel grades for hull structural elements. For operation in multi-year ice environments such as the Kara Sea, deck ice accumulation and stability aspects may require special features for de-icing of exposed topside structure and equipment.

For the first-year ice-class LNG ships currently being ordered, most projects involve specification modifications to existing standard designs with a conventional vessel layout and a single screw. Typically, hull form is optimised for open water performance, ie a conventional hull form is adopted with minimal ice design of the hull.

Design ambient temperatures and special operating arrangements are proposed for deck outfitting and equipment for low temperature operation similar to arrangements for vessels designed for Baltic Sea operations.

One technical challenge which national administrations that operate icebreaker escorts will have to face is the accommodation of larger LNG vessels. The current generation of icebreaking vessels create a relatively narrow channel which is too small for the size of vessel which is starting to be operated and specified for trade in these areas. A solution to this problem involving a Suezmax tanker and a pair of icebreakers was trialled in 2002 with good results.

Although small adjustments to current designs will give rise to perfectly safe ships, there is no doubt that LNG ships could be further developed for year-round assisted navigation in multi-year ice. This means the adoption of specialised hull forms which will be very different from the open water optimised arrangements which are currently being specified for first-year ice-class vessels.

■ **The double-acting design concept, seen here on the Fortum-owned Aframax tanker *Mastera*, could be applicable to multi-year ice-class vessels, including LNG carriers**

Double-acting design concepts similar to the arrangements adopted by the Fortum-owned Aframax tankers *Mastera* and *Tempera,* built to Lloyd's Register class at Sumitomo Heavy Industries in 2002, could possibly point the way toward the future design of multi-year ice-class vessels of all kinds, including LNG carriers.

ARCOP project

Lloyd's Register has explored these and other technical issues in some depth, as part of the research team involved in the Arctic Operational Platform (ARCOP) project, a research and development project co-funded by the European Union under the fifth European Community Framework Programme for Research and Technological Development.

The objective is to find practical solutions to the challenge of establishing a system of ice operation for LNG and crude oil shipping in the Russian Arctic (including the Barents and Kara Seas).

ARCOP aims to utilise the findings of three earlier research projects:

- INSROP – a Russian, Norwegian and Japanese funded project to investigate the Northern Sea Route passage
- ICE ROUTES – an EU-funded ice meteorology study for the Northern Sea Route passage
- ARCDEV – an EU-funded Arctic development voyage project using a Fortum tanker assisted in navigation by Russian icebreakers in the Northern Sea Route passage in the Russian Arctic.

Lloyd's Register is the only classification society involved in the ARCOP project. The objectives for the work package that Lloyd's Register is directly involved in are to develop a common understanding of current Rules/regulations and ship operation practices in Russia; to assess the impact of future Rules and regulations on shipping in the Russian Arctic; and to make recommendations for practical implementation in the context of a large scale integrated transport system for the Russian Arctic.

The findings of the ARCOP Project clearly have implications for the operation of LNG ships in Russian Arctic waters and may open the way for the year-round export of LNG from the Rusan and Leningrad natural gas fields in the Kara Sea.

The prospects are certainly there for those involved in the LNG industry. Lloyd's Register looks forward to working with all stakeholders to develop Russia's untapped potential as a major supplier of natural gas. □

*Rob Tustin is Lloyd's Register Asia's Technical Manager for New Construction. His responsibilities include co-ordination and development of technical activities and capabilities for Lloyd's Register Asia in Korea, Japan and China