

Prelude FLNG boiler

– World’s largest off-shore boiler delivered



Kawasaki has completed the delivery of seven boilers for use on the Prelude FLNG facility, developed by Royal Dutch Shell in Australia as the world’s first floating LNG facility. Each boiler is capable of producing 220 tons of high-temperature, high-pressure steam per hour, and boasts the world’s largest capacity in any other boilers for off-shore use. These boilers feature a robust structure and a furnace optimized to meet special, high-level specifications required for offshore applications. Following assembly at Kawasaki’s Harima Works, the seven boilers were delivered on schedule in 2013 (four in August and three in October).

Preface

Across the globe there are a wealth of untapped offshore gas fields, both large and small. While today’s changing energy demands are likely to put a greater strain on LNG resources, hopes are running high that offshore gas field development will fill the void. Floating liquefied natural gas (FLNG) is a groundbreaking solution for offshore liquefaction, storage, and offloading of natural gas. All eyes are on the technology as it paves the way to opening up new offshore gas fields at sea that have always been considered too difficult to develop.

1 Background

About 200 kilometers off Australia’s north-west coast and 250 meters below the surface of the water lies the Prelude gas field. It is above that gas field that an FLNG facility will remain moored as it operates for a period of about 25 years. The Prelude FLNG will employ boilers designed to generate electricity and process steam even under turbulent offshore conditions triggered by huge typhoons and other natural forces.

Over the years Kawasaki has delivered more than 1,000 land boilers (with a maximum steam flow of 1,200 t/h).

Table 1 Main specifications

Maximum steam flow (t/h)	220
Steam pressure (bar g)	69
Steam temperature (°C)	480
Fuel	Fuel gas or diesel oil
H x W x D (m)	Approx. 20 x 13 x 11
Weight (ton)	Approx. 500

*Figures are for a single boiler.

They have been used to generate the electricity supplied by power companies as well as for industrial and in-house power generation. Kawasaki has also supplied more than 200 marine boilers (with a maximum steam flow of 140 t/h) for LNG carriers and other applications. The boilers to be supplied to the Prelude FLNG project were contracted by the French engineering company, Technip. Kawasaki has incorporated the lessons it has learned over the years in the field of marine boilers with its outstanding land boiler technologies to meet the large capacity requirement.

These marine boilers are the largest ever to be used and each one will generate 220 t/h of high-temperature, high-pressure steam. That is 1.6 times the maximum steam flow of any marine boiler Kawasaki has previously built.

2 Product design, development, and testing

Table 1 provides the main specifications for the Prelude FLNG boiler while Fig.1 illustrates its general arrangement. The air and gas paths feature a simple design in which air and gas flow downward in a furnace and upward in the second pass, creating a large U-shaped flow path. In the water steam flow, boiler water is heated as it goes through the economizer and is fed to the steam drum. Heat is transferred to the boiler water as it naturally circulates through the steam drum, water drum, and evaporator before turning into saturated steam. The saturated steam flows through a superheater where it becomes superheated steam with the desired pressure and

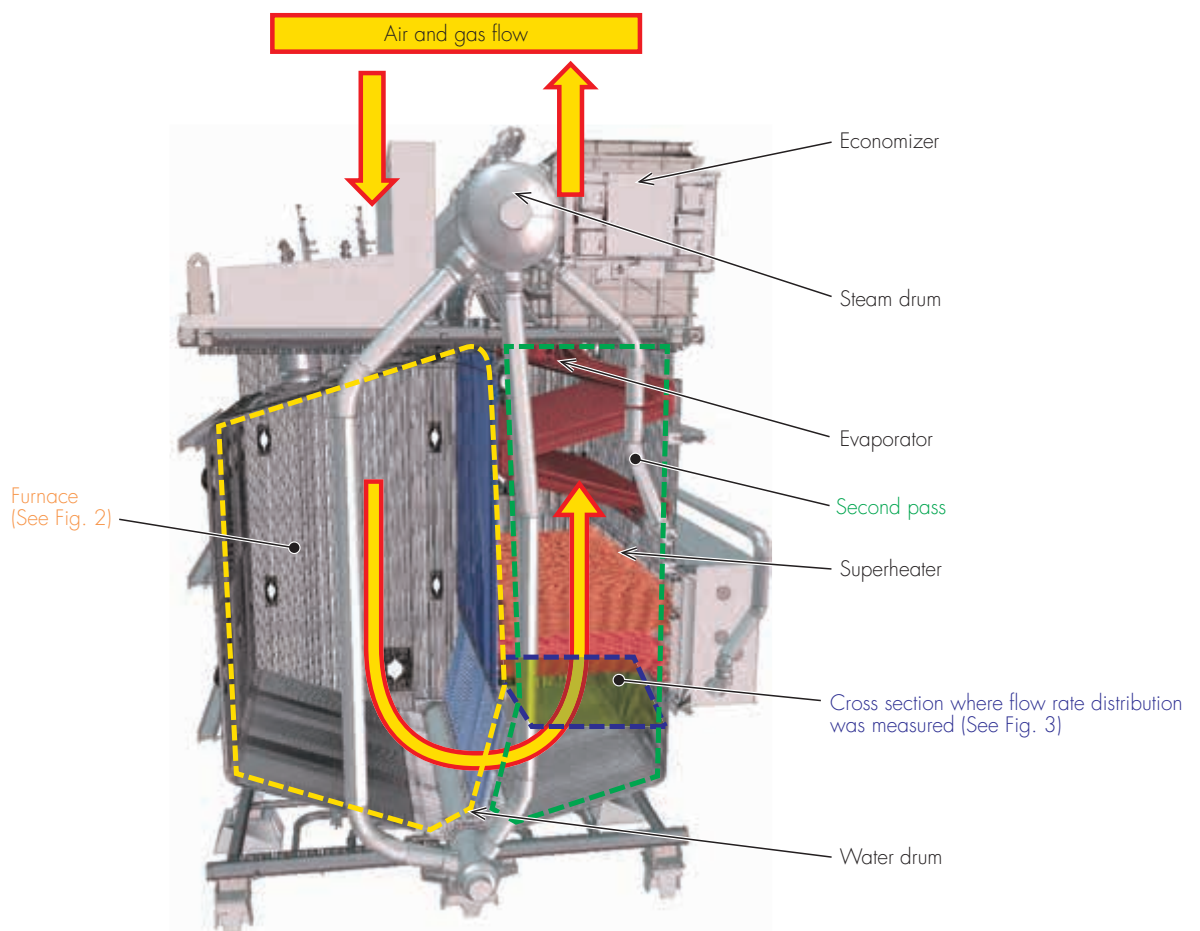


Fig. 1 General arrangement of Prelude FLNG boiler

temperature before being supplied to the user's equipment.

Designed to generate a large amount of high-temperature, high-pressure steam, the Prelude FLNG boiler is almost double the size of standard conventional marine boilers (approx. H13 m x W7 m x D4 m). The boiler was developed with a keen focus on the following two design features.

(1) Optimized furnace

Kawasaki conducted a wind tunnel test using a 1/5 scale model of the actual boiler with an eye to optimizing the furnace. The test examined the burner installation angle and the distribution of gas flow rate through the boiler's second pass.

The burner installation angle was tested in Fig. 2, and the distribution of gas flow rate on the cross section of the boiler's second pass is illustrated in Fig. 3.

The test demonstrated that the burner flames did not touch the furnace walls and that the gas flow rate was

distributed within the threshold values. The test results were used to create an optimal design for the actual boiler.

(2) Robust structure

FLNG boilers must be built sturdy enough to withstand the motion and acceleration of FLNG at sea. They must also be built blast-proof since they also serve as a shield for the vessel's accommodation space in the event of an emergency. Keeping that in mind, Kawasaki analyzed blast load from every possible angle to design boilers that were tough enough to meet the customer's requirements.

3 Advantages

The Prelude FLNG boiler offers the following advantages

(1) Short lead time

Kawasaki incorporated designs that would help shorten the production lead time right from the basic engineering

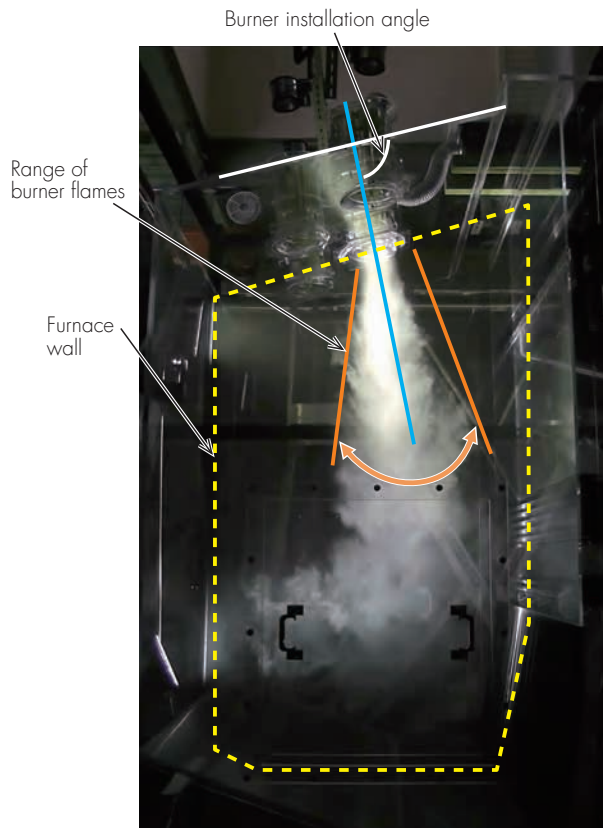


Fig. 2 Evaluation of burner installation angle

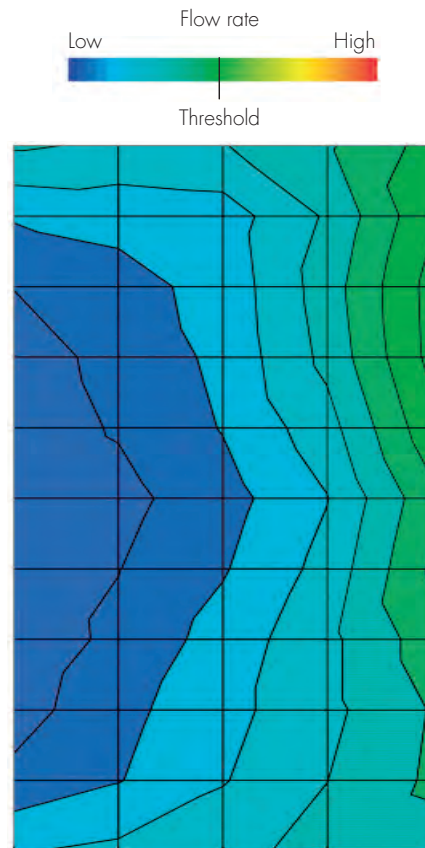


Fig. 3 Distribution of gas flow rate through the 2nd pass of boiler

stage, and constructed an assembly shop dedicated to the final assembly of FLNG boilers at its Harima Works. Teamwork between engineering and manufacturing during planning and design processes cleared away any potential bottlenecks in production and established a one-piece flow manufacturing system in which workers complete assigned tasks at their respective stages of the production line. This enabled Kawasaki to ensure quality every step of the way while shortening lead time.

(2) High quality

The Prelude FLNG project has adopted strict certification requirements set by Lloyd's Register for equipment used in everything from design to inspection. In order to meet these requirements, Kawasaki had about 40 of its Harima Works employees undergo a special training program to acquire the advanced welding skills needed to be Lloyd's Register certified. As a result, Kawasaki was able to achieve an even higher level of welding quality.

(3) Environment resistant

Project specification requirements for the Prelude FLNG boilers include heavy-duty painting and water-tight insulation under harsh offshore conditions. For this reason, painting work was performed under strict oversight by only qualified painters who passed a qualification test conducted in the presence of an inspector from the National Association of Corrosion Engineers (NACE)

International. The boilers were insulated in accordance with CINI standards (Netherlands insulation standards) as required by Shell and underwent thorough inspections by Technip and Shell inspectors.

(4) Maintainability

Due to limited deck space, a compact design and ease of maintenance were a must for the boilers. Kawasaki incorporated a maintenance area for pressure parts, burners, etc., in the boiler module blueprints to ensure that maintenance work could be carried out throughout their service life.

Postscript

After winning the contract for Shell's Prelude FLNG project in 2011, Kawasaki assembled the boilers at its Harima Works and delivered a total of seven units to the customer as planned in 2013. Shell plans to build additional FLNG facilities to follow the Prelude, its first FLNG, on an ongoing basis. Other companies also have plans to construct FLNG facilities and the market is expected to really take off.

Using this project as its foundation, Kawasaki is moving forward to supply highly reliable FLNG boilers to the market as a major player in the field of energy production and to help make the world a brighter place.

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