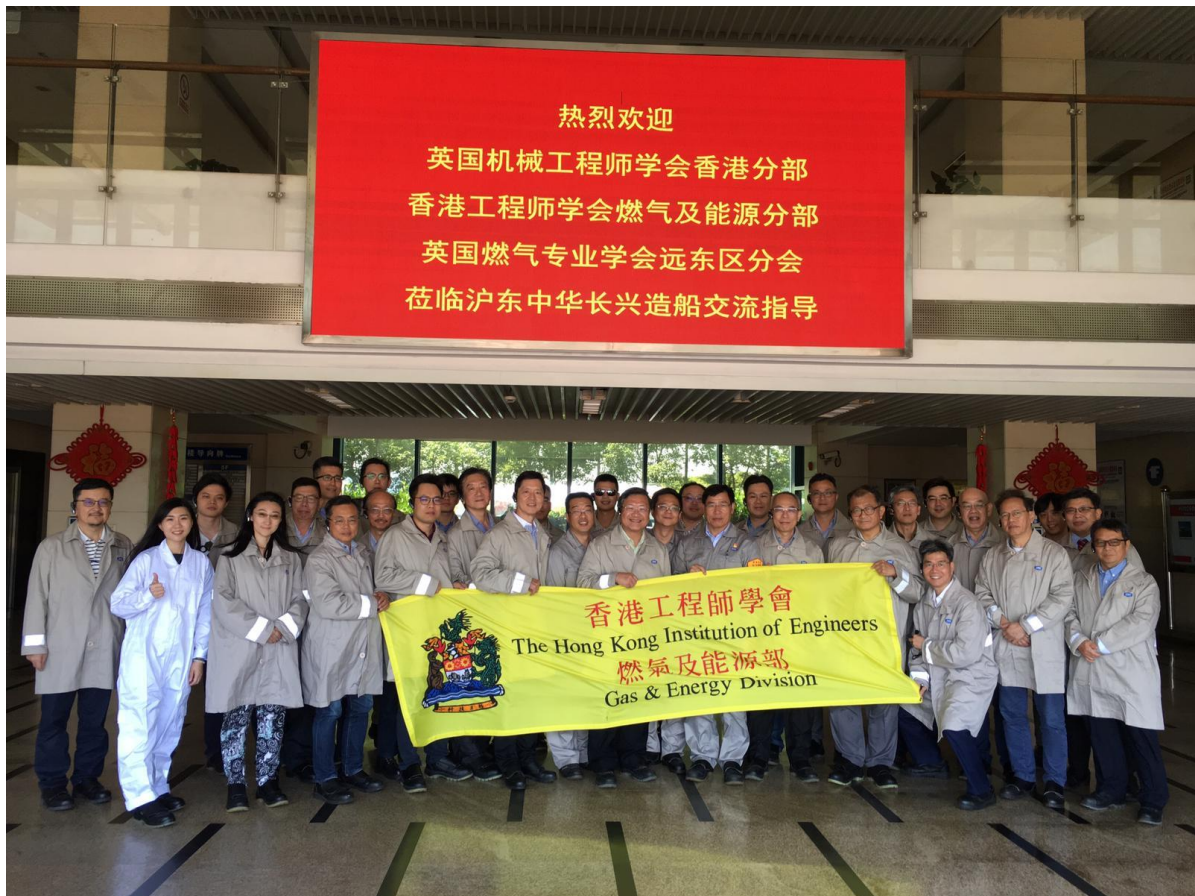


INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH  
THE HONG KONG INSTITUTION OF ENGINEERS GAS AND ENERGY DIVISION  
INSTITUTION OF GAS ENGINEERS & MANAGERS FAR EAST DISTRICT SECTION  
JOINT DELEGATION TO SHANGHAI IN 2019  
TECHNICAL VISIT TO HUDONG ZHONGHUA SHIPBUILDING CO., LTD.



China embarked on the design and construction of liquefied natural gas carrier (LNGC) in 1997. Over the past two decades of continuous development, apart from South Korea, China has become the only country in the world with the capability to deliver LNGC, and the championship falls on Hudong Zhonghua Shipbuilding Co., Ltd. (HZ).

### LNGC Journey

While HZ has accumulated delivery of 26 LNGC, HZ received its first contract for the first generation of steam-powered LNGC, the 147,000 m<sup>3</sup> class Ever Spring Series, in 2004. The first vessel of its kind, featuring single propeller powered by a single two-stage steam turbine was launched in 2008 and total six (6) vessels were delivered. Then the first order of the second generation LNGC, the 172,000 m<sup>3</sup> class Ever Sturdy Series, the first type wholly designed by HZ, was placed in 2010 and the first of the total four (4) vessels was delivered in 2015. Endowed with the provision for converting the main engine fuel from marine diesel to natural gas and full-sized reliquefaction plant to convert the boil-off gas (BOG) in ambient temperature into cryogenic liquefied natural gas (LNG) and return LNG to the cargo tanks, all four (4) vessels were owned by Mitsui O.K.K. Lines (MOL) on long term charterhip with ExxonMobil.

The third generation, the 174,000 m<sup>3</sup> class Ever Reliant Series which intellectual property fully owned by HZ, featuring five (5) M.A.N. 8L51/60DF dual fuel-enabled diesel-electric (DFDE) units, have recorded six (6) vessels delivered to China Shipping between 2016 and 2018. The Ever Reliant Series derivative, which four (4) vessels were delivered to China National Offshore Oil Company (CNOOC), incorporates a reliquefaction plant, two (2) M.A.N. 8L51/600F DFDE units and two (2) M.A.N. 12V51/600F DFDE units as well as short bow design for the optimised multi-speed performances.

The latest fourth generation, the 174,000 m<sup>3</sup> class Ever Thriving Series, equips with low speed X-DF dual fuel propulsion system and GTT NO96 L03+ cargo containment system (CCS). The main engines and generators are coupled with selective catalytic reducer to reduce nitrogen oxide emissions to Tier III compliance. The vessel particulars are as follows:-

Particular	Value
Length Overall (LOA)	Approximate 295 m
Breadth (B)	45 m
Depth (D)	26.25 m
Designed Draft (Td)	11.50 m
Speed	19.5 knots
Energy Efficiency Design Index (EEDI)	Phase 3

Being a LNGC derivative, Floating, Storage and Re-gasification Unit (FSRU) is LNGC equipped with re-gasification trains to convert LNG in the vessel cargo tanks into natural gas send-out in high pressure. HZ commenced the FSRU business with the completion of adding the fourth re-gasification train on an existing FSRU of Höegh in 2015, and HZ has added in its order book the conversion of an aged 142,000 m<sup>3</sup> LNGC to become FSRU for Golar LNG.

The HZ purpose build FSRU is same as LNGC in the particulars, apart from B and Td is 1.95 m wider and 0.1 m deeper respectively. The cargo tanks with GTT NO96 GW CCS are dual function in LNGC and FSRU modes and can carry the internal pressure of 0.25 bar and 0.7 bar respectively. The three (3) re-gasification trains of each 250 million standard cubic feet per day (MMSCFD) capacity, using either glycol or steam as heating medium, can deliver re-gasified LNG at maximum 750 MMSCFD.

HZ also develops the largest LNG-powered container vessel in the world. The 22,000 twenty-foot equivalent unit container ship order by CMA CGM is powered by the 12-cylinder X92DF engines with low pressure gas admission, which LNG tank is formed by GTT Mark III containment system. Pairing the HZ built mega LNG-powered container vessel is the MOL owned largest membrane type LNG bunkering vessel, also built by HZ.

### **LNGC Build**

The current site of the former Expo 2010 Shanghai on the Huangpu River bank in the heart of the Shanghai municipal was where the HZ shipyard was until 2010. Now HZ builds vessels in its dedicated shipyard under Changxing Shipbuilding Co., Ltd., owned jointly by HZ and Baosteel Group, along the 14 m deep, 8 km coastline of Changxing Island at the

Yangtze River estuary northeast of Shanghai with the endowed shipbuilding facilities listed as follows:-

Shipbuilding Facility	Dimension (Length, Width, Depth)	Equipment/Remark
Dry Dock No. 1	520 m x 76 m x 11.6 m	With two (2) 600 ton gantry cranes for the construction of very large crude carrier
Dry Dock No. 2	510 m x 106 m x 11.6 m	With two (2) 600 ton gantry cranes for the construction of LNGC and FSRU
Jetty No. 1	250 m (L)	With a 32 ton portal crane
Jetty No. 2	324.8 m (L)	With a 50 ton portal crane
Jetty No. 3	367 m (L)	ditto
Jetty No. 4	-	-
Material Unloading Jetty	360 m (L)	With a 80 ton portal crane and two (2) 25 ton electromagnetic lifting magnets

In addition to the tabled shipyard infrastructures, HZ has dedicated workshops for LNG facilities on LNGC, such as GTT Invar CCS pre-fabrication workshop, insulation box production line and pump tower workshop. The CCS mock-up workshop and training centre can mock-up NO96 L03+, NO96 MAX and Mark III FLEX CCS.

With the above hardware and about 15,000 HZ employees (3,500 of them are research and development personnel and engineers) and contractor personnel of 50,000, HZ can currently deliver four (4) LNGC every year in a 30 to 36 month cycle, while the annual capacity of eight (8) LNGC is being developed. The prevailing model is the 170,000 m<sup>3</sup> to 180,000 m<sup>3</sup> class LNGC which optimises the cargo capacities, navigation constraints such as the Panama Channel width and available technologies.

The design of the HZ built LNGC and FSRU comply with the codes and standards of International Maritime Organisation (IMO) and the class societies such as American Bureau of Shipping of the U.S., Lloyds Register of the U.K., Bureau Veritas of France and China Classification Society of the mainland China which are appointed by the owner. Any special requirement from the flag state and owner, for instance, compliance with the standards and guidelines of The Society of International Gas Tanker and Terminal Operators, is also duly satisfied.

LNGC prices vary according to demand and supply of LNGC, financing costs, materials and equipment prices and other factors. While the first generation HZ-built LNGC was priced USD160 million, the current Korean-built LNGC market price has dropped from USD 230 million to the record low USD 175 million.

### **LNGC Particulars**

#### *Propulsion Power*

LNGC propulsion power is converted from gas by the dual fuel X-DF, ME-GI or DFDE engines which particulars are tabled as below:-

Description	X-DF	DFDE	ME-GI
Principle	Otto Cycle Two stroke	Four stroke	Diesel Cycle Four stroke
Gas Admission Pressure in Cylinder	16 bar	6 bar	300 bar
Gas Supply System	Centrifugal gas compressor with cooling pump	Centrifugal gas compressor with cooling pump	Piston gas compressor with
IMO Tier III Emission Compliance	Yes in gas mode	Yes in gas mode	SCR/EGR required

### Cargo

A typical HZ built LNGC of 170,000 m<sup>3</sup> class has four (4) octagonal cross sectioned cargo tanks, while each cargo tank is equipped with the following flange-connected cargo handling pumps:-

Pump Type	Quantity	Capacity [m <sup>3</sup> /h]	Discharge [kg/cm <sup>2</sup> ]
Main Cargo	2	1,500 to 2,000	150 to 180
Spray / Sweep	1	50 to 60	140 to 150
Fuel	1	10 to 15	100 to 250
Emergency Cargo	1	550 to 650	160

BOG level is dictated by the CCS insulation performance. The replacement of perlite with glass wool for insulation in GTT NO96 GW has improved the BOG level from 0.15 % of volume per day to 0.125 % of volume per day, while the combination of Styrofoam and glass wool, which resulted density of 130 kg/m<sup>3</sup>, adopted in GTT NO96 L03+ further reduces the BOG level to 0.10 % of volume per day. China is alleged successfully indigenising Styrofoam and the indigenised Styrofoam has applied in the passenger seats in the China-built B.M.W. cars.

The insulation is cased inside the plywood-made panels which sandwich between the inner hull and the primary membranes in 300 mm thickness, as well as between the primary and secondary membranes in 200 mm thickness. The plywood is imported from Finland and Russia for their higher attitude and hence higher material density. The panel positions are held by 304 grade stainless steel-made bolts and nuts

Invar, the 36 % nickel alloy steel, is the principle membrane material for the GTT NO96 series CCS, while GTT Mark III is based upon 304 grade stainless steel. Baosteel Group has alleged achieved indigenising Invar. 80 % of the Invar joints are automatic welded.

CCS tightness is tested by pressurising the layer between the primary and secondary membranes with nitrogen. It is alleged that the Korean shipbuilders accept maximum 25 leak points found in a cargo tank during the leak test, and HZ has achieved 13 and once zero (0). The completed cargo tanks, after passing the leak test, are not further tested by filling

LNG, while the cryogenic process lines are tested to the cryogenic condition for examining the movements at the pipe supports.

*Safety*

Safety is paramount to all LNG vessels and the HZ built units are embedded suitable emergency release systems. A three (3) tier separation detection levels is in place for responding abnormalities. While the first and second level is alarm and suspension of LNG transfer respectively, in case of the most severe third level, the emergency release coupling (ERC) on each cryogenic hose will decouple the connection and release the hoses. In addition to ERC, FSRU is also endowed quick release hooks to instantly disengage the mooring lines and permit emergency departure.

In case of fire in the vessel, fire-fighting provisions are in place according to their location to combat against it:-

Fire Location	Fire-Fighting Provision
Trunk Deck in the cargo area	Dry chemical powder
Engine Room	High expansion foam (water for important positions)
Engine Control Room	3M Novec 1230 fire protection fluid
Cargo Machine Room, Electric Motor Room and other separate spaces	Carbon dioxide gas
Cargo Valves, Dome and Accommodation Front	Water spray

**Remarks**

Globally, only China and South Korea build LNGC in commercial scale. While South Korea has championed the construction of LNGC, China is catching-up and striving to become the market leader. The gap between two countries is being narrowed, and the effort of HZ is obvious and tremendous. The Institution of Mechanical Engineers (IMechE) delegates, together with their fellow colleagues in The Hong Kong Institution of Engineers Gas and Energy Division (HKIE-G&E) and the Institution of Gas Engineers & Managers – Far Eastern District Section (IGEM-FEDS), were privileged to gain an overview of the LNGC industry from the HZ and China perspective and embark LNGC IMO09834313 being outfitted for observing the CCS under construction in their delegation to Shanghai 3/6/2019.

IMechE Hong Kong Branch, HKIE-G&E and IGEM-FEDS thank HZ for its hospitality in receiving the delegation.

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