TGE Marine Gas Engineering

LNG Bunker Vessels
- Three new vessels changing the market in 2017 -

February 2018

Björn Herweg

Content

- Introduction
- Cargo containment system
- Cargo transfer system
- Cargo handling system

Key references: small LNG carriers

7,500 m³ LNG/LEG carrier:

Owner:	Anthony Veder
Yard:	Remontowa
Classification:	BV
Completion:	2009
TGE´s scope:	- cargo system - fuel gas system - cargo tanks

16,500 m³ LNG carrier:

Owner:	Anthony Veder
Yard:	Meyer-Werft
Classification:	BV
Completion:	2012
TGE´s scope:	- cargo system - fuel gas system

30,000 m³ LNG carrier:

Owner:	CNOOC
Yard:	Jiangnan
Classification:	CCS
Completion:	2015
TGE´s scope:	- cargo system - fuel gas system - cargo tanks

CORAL METHANE

CORAL ENERGY

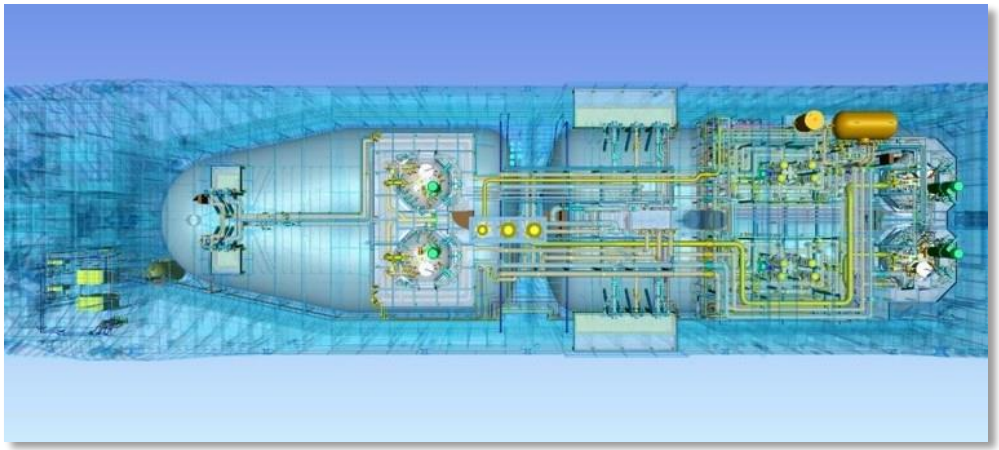
HAI YANG SHI YOU 301

Key references: LNG bunker vessels

TGE Marine Gas Engineering is the designer and supplier of

- **the complete cargo tanks**
- **the cargo handling system**
- **the fuel gas system**

for all three LNG bunker vessels which are or will be in operation in Europe during the first half of this year.



ENGIE ZEEBRUGGE

5,100 cbm LNG bunker vessel:

Owner:	Engie, Mitsubishi, NYK
Yard:	Hanjin, Korea
Classification:	BV
Completion:	June 2017
TGE's scope:	- gas handling system - fuel supply system - complete tanks
Tanks:	2 cylindrical cargo tanks
Base:	Zeegrugge´s Fluxys LNG Terminal (Belgium)
Operation:	Northern Europe

CARDISSA

6,500 cbm LNG bunker vessel:

Owner:	Shell
Yard:	STX, Korea
Classification:	LR
Completion:	2017
TGE's scope:	- gas handling system - fuel supply system - complete tanks
Tanks:	2 cylindrical cargo tanks
Base:	Rotterdam´s Gate Terminal (Netherlands)
Operation:	Northwest Europe

5,800 cbm LNG bunker vessel:

Owner:	Sirius Veder Gas AB
Yard:	Royal Bodewes, The Netherlands
Classification:	BV
Completion:	July 2017
Scope:	- gas handling system - fuel supply system - complete tanks
Tanks:	2 bilobe cargo tanks
Base:	Skangas terminals
Operation:	North sea, Skagerrak/Kattegat area, and Baltic sea

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The Small Scale LNG fleet

Vessel	Capacity	Delivery	Owner/Operator
Kayoh Maru	1,517	1988	Daiichi Tanker Co.
Aman Bintulu	18,928	1993	MISC
Surya Aki	19,474	1996	MOL
Aman Sendai	18,928	1997	MISC
Aman Hakata	18,800	1998	MISC
Surya Satsuma	23,096	2000	MOL
Shinju Maru No.1	2,513	2003	Shinwa Marine
Pioneer Kutsen	1,100	2004	Knutsen Shipping
North Pioneer	2,512	2005	Japan Liquid Gas
Sun Arrows	19,100	2007	MOL
Kakurei Maru	2,536	2008	NA
Shinju Maru No.2	2,500	2008	Japan Utilities
Coral Methane	7,500	2009	Anthony Veder
Norgas Innovation	10,000	2010	NGC

Vessel	Capacity	Delivery	Owner/Operator
Norgas Creation	10,000	2010	NGC
Norgas Vision	12,000	2011	NGC
Norgas Invention	10,000	2011	NGC
Norgas Unikum	10,000	2011	NGC
Norgas Conception	10,000	2011	NGC
Akebono Maru	3,500	2011	United
Coral Energy	15,600	2012	Anthony Veder
Coral Anthelia	6,500	2012	Anthony Veder
NB Fenghun	14,000	2015	
Engie Zebrugge	5,100	2017	Gas4Sea
Coralius	5,800	2017	Sirius Veder Gas AB
NB Conrad	2,200	2016	WesPac
Cardissa	6,500	2017	Shell
NB Neptune	18,000	2017	Anthony Veder

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- LNG carriers with type C cargo tanks –

(21 out of 28)

Cargo tanks for LNG bunker vessels

Tank Design

- Membrane Tanks
- Independent tanks
  - (Type A)
  - Type B
  - **Type C**

Type C tanks

- Self supporting pressure vessel
- Cylindrical or bilobe with outside insulation
- No secondary barrier required
- No restriction concerning partial filling
- Design pressure around 4 bar g

→ operational flexibility

(pressure increase possible)

Tank Sizing

- Cylindrical tank design
  - 2 tank design
    up to abt. 12,000 m³
  - 3 tank design
    up to abt. 20,000 m³

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Customers– where does the bunker LNG go to?

	Coastal Vessel	Passenger Vessel	Large Container Vessel
LNG volume	50 - 500 m³	2,000 – 3,000 m³	up to 13,000 m³
Tank type	Vacuum insulated or conventional insulated	Type C tanks or atmospheric tanks	Atmospheric or type C tanks
Bunker time	max. 4 h	4 h	approx. 4 - 11 h
Bunker rate	25 - 200 m³/h	750 m³/h	up to 1,500 m³/h
Bunker connection	abt. 6"	abt. 8"	estimated min. 8"
Bunker manifold height	max. 4 m above waterline	3 – 4 m above waterline	6 – 8 m above waterline
Bunker station location	approx. 50 m from steven	midships	¼ of ship length

Main components for Ship-to-Ship LNG bunker transfer systems

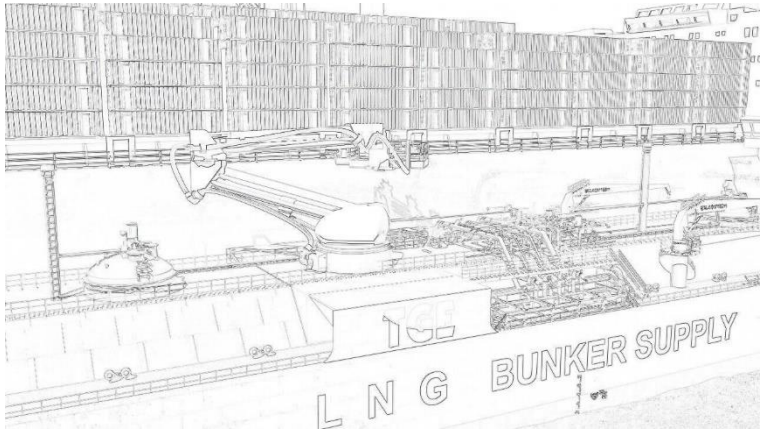
Essential / recommended equipment and components:

- Discharge/receiving valves at bunker supply/receiving vessel
- Loading arm or hose for LNG and vapour return
- Emergency break away coupling (self-sealing type)
- Connect/dry disconnect coupling
- Means for draining after completion of bunker transfer
- Means for inerting and gas freeing
- Ship-to-Ship link for communication and automatic/manual ESD

Ship-to-Ship LNG bunker transfer systems

- As the first LNG bunker vessel has been taken in operation mid of last year, the experience with transfer systems is still very limited

- Various technologies for bunker transfer systems have been developed
  - Hose based solutions
  - Hard arm solutions
  - Combined solutions



- New rules and standards were established in the recent months which need to be proved to be feasible. e.g.
  - Rule notes by classification societies
  - ISO 20519:2017(E) – Specification for bunkering of liquifed natural gas fueled vessels
  - SGMF - Safety guidelines bunkering
  - etc.

Ship-to-Ship LNG bunker custody transfer

- Standards for custody transfer systems to be established
  - Mass flow metering
  - Mass flow metering plus gas chromatograph
  - Others

- All parties involved in the bunkering process need to agree on a common understanding of the custody transfer requirements
  - Accuracy
  - Easy operation
  - Justifiable price

Ship-to-Ship LNG bunker gas handling

- Vapour return / boil off gas (BOG) handling
  - Pressure build up in typ C cargo tanks
  - Burning of vapour return / BOG in dual fuel consumers (main-/aux- engines, boilers)
  - Burning of vapour return / BOG in gas combustion units (GCU)
  - Re- liquefaction of vapour return / BOG
  - Bunkering w/o vapour return (BOG handling by receiving vessel)

Ship-to-Ship LNG bunker transfer systems

- New standards will need to be developed during the years to come, by implementing the requirements and expectations of the customers during the the first bunker operations undertaken

- Flexible solutions will be needed in regards to rules, standards, procedures and equipment
  - Easy and smooth handling of bunkering equipment
  - Procedures for short bunkering sequences required
  - Standards for both ends of the bunkering operation to be defined

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Liquid storage

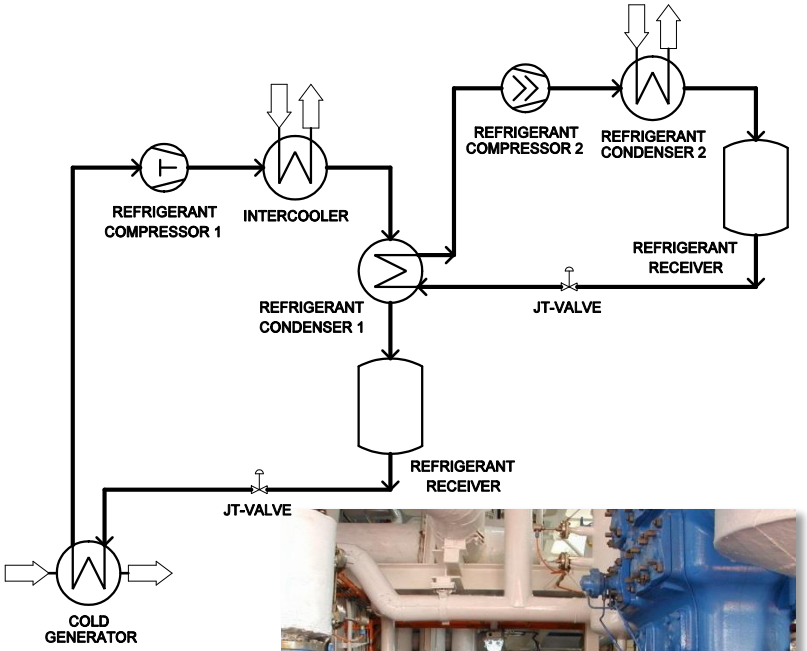
- For most customers cold LNG has to be supplied:
  - Type C tanks need cold LNG to bunker without vapor return
  - Membrane tanks, type B tanks (if used as fuel tanks) can‘t handle pressure
  - Exception: clients with (small) pressure build-up systems
- LNG source in Europe normally from Import terminals – temperature is rising along the supply chain
- Bunker vessels may have to wait at low engine load for some time
- Reducing temperature rise during loading and pressure control are major aspects
- Ageing, mixing of grades and managing heel are important issues

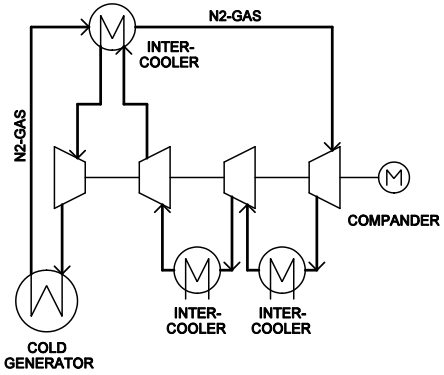
LNG IS CARGO AND FUEL

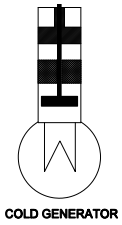
- Our simulation showed that ageing on the bunker ship has almost no impact on methane number, but the initial quality of LNG is very important

Liquid storage – cold generators for tank cooling

Cascade Process	Nitrogen Brayton Process	Stirling Cryogenerator
Ethylen / propylen (evaporating)	Nitrogen (gas only)	Helium (gas only)
40 bar / -100 °C	4 – 6 bar / -160 °C	0 – 4 bar / -196 °C to -100 °C
Taylormade capacity	< 30 kW (or too large)	N x 6 kW
robust technology (for LEG carrier)	no marine experience yet for this size	limited marine application yet
Re- liquefaction	Liquid subcooling (Re-liquefaction)	Liquid subcooling

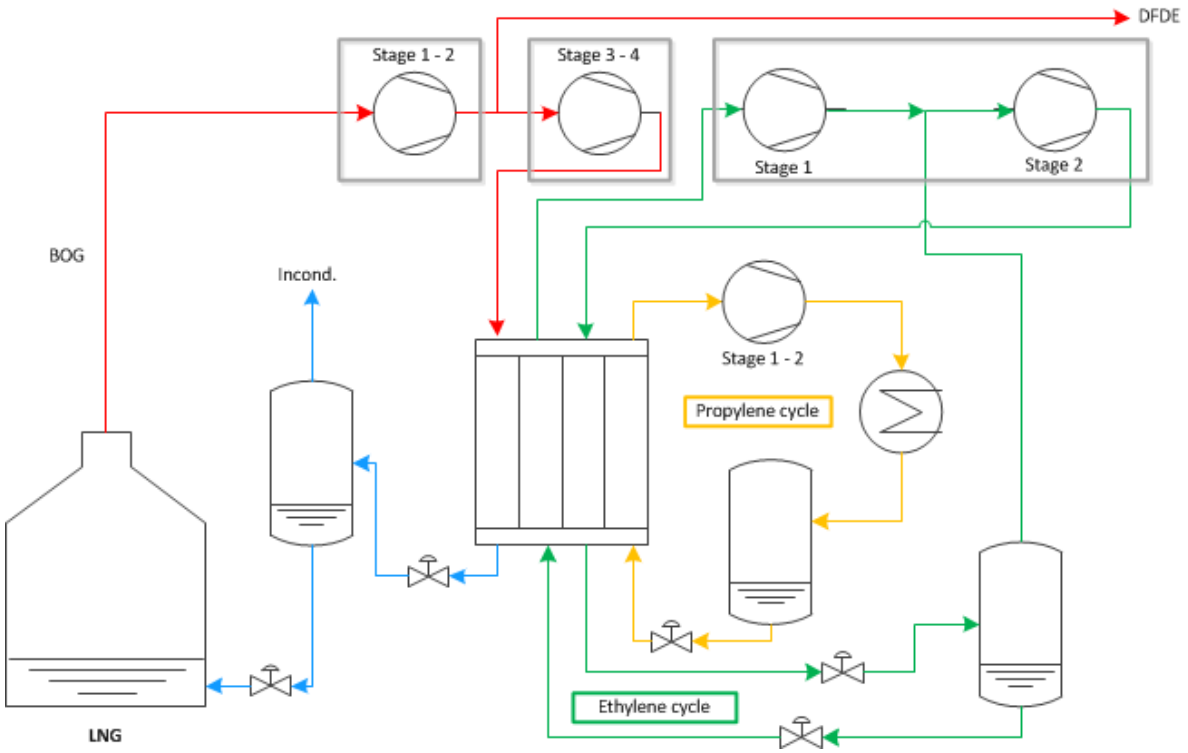






BOG reliquefaction – cascade system

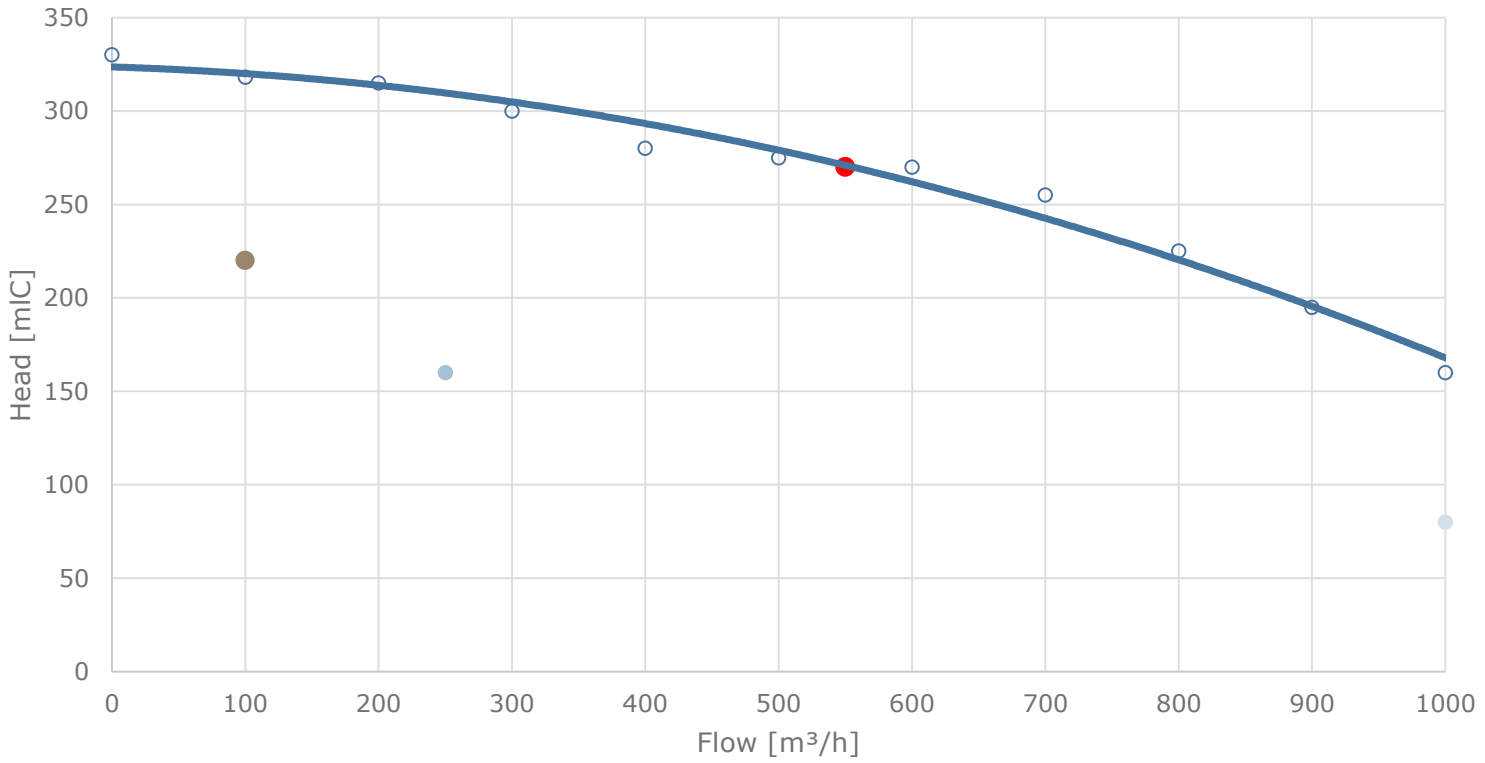
- Cascade refrigeration is mature technology on ethylene carriers
- Application for LNG using same components
- TGE developed cascade LNG reliquefaction for a wide range of capacities and for a combination with variouis propulsion systems
- Drawback: required space for installation (small bunker vessels)






Liquid Handling - Distribution

Service	Flow	Head
Bunkering small vessels (small vacuum insul. tank)	abt. 100 m³/h	220 mLC
Bunkering type C tank	> 250 m³/h	160 mLC
Bunkering membrane tank	1,000 m³/h (8" hose)	80 mLC

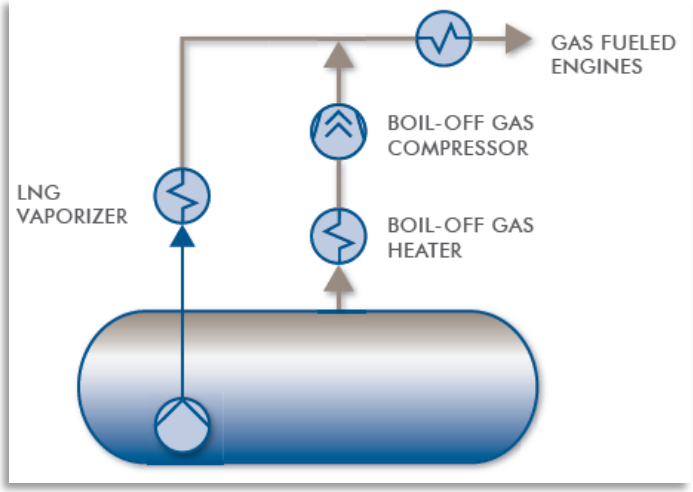


Liquid Handling - Distribution

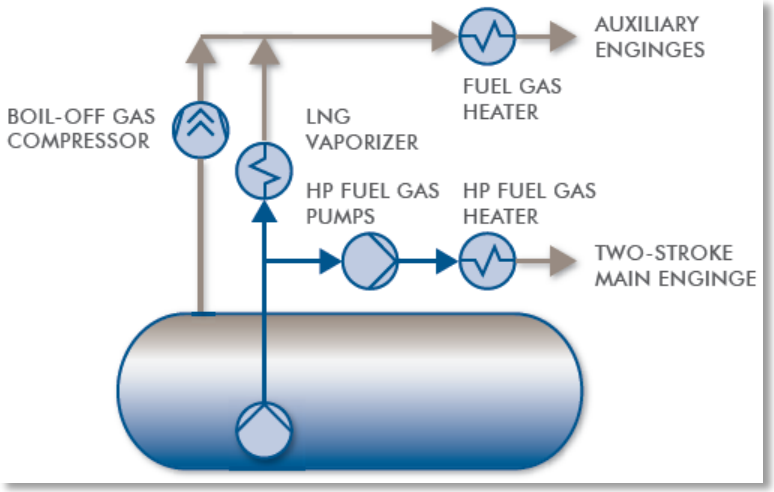
- Pumping allways puts heat into the system
- Examples
  - Heat ingress tanks: approx. 30 kW
  - Fuel gas pump: approx. 2 kW
  - Chiller feed pump:7 kW
  - Standard cargo pump (300 m³/h @ 120 mLC): 60 kW
  - Bunkering pump (550 m³/h @ 270 mLC): 264 kW
- During pump operation the heat ingress may be outweighed by the pump power which is ultimately transferred into heat and BOG.
- VFD for cargo pumps is the solution to reduce this effect.
- Deepwell pumps with motor outside tank also reduce heat input

Vapor handling – fuel gas production

- Capacity range from 0 – 100 % MCR
- Compressors are fitted with VFD to cope with the required capacity range
- Combination of 1 or 2 compressors and forcing vaporizer are possible in automatic mode
- Separation of compressor services
  (e.g. one machine in fuel gas production, 1 in vapor return) are possible



Low Pressure Fuel Gas System (4 bar g or 16 bar g)



High Pressure Fuel Gas System (350 bar g)

Summary

- LNG Bunker vessels are small gas carriers carrying a lot of equipment
  - Stripped down LNG bunker vessels plus dedicaded service barges for extra services e.g. purging, gas freeing, etc. may bring the cost down for the actual swiss army knifes of bunkering

- Existing procedures, rules and standards need to be adapted to the requiremnts showing up during the first bunker operations within this year

- Environmental friendly solutions to be choosen in order to promote the idea of green energy

TGE Marine can offer tailormade solutions for the cargo system based on experience gained from the design and supply of cargo systems for three new bunker vessels and a number of further small to mid-scale LNG carriers

Marine Gas Engineering

Thank you for your kind attention

For further information please email:

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