

Golar LNG



Floating Storage and Regasification Unit FSRU

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1. Introduction

This document describes a Floating Storage and Regasification Unit (FSRU) for LNG. The terminal is based on conversion of an existing LNG carrier. The FSRU is to be permanently moored offshore and export gas to shore through a sub sea pipeline.

2. LNG Terminal

The proposed terminal outline is shown in Figure 1, and a 3D illustration is shown in Figure 2. The LNG terminal is a steel mono hull with Moss® LNG tanks (in the case below: six

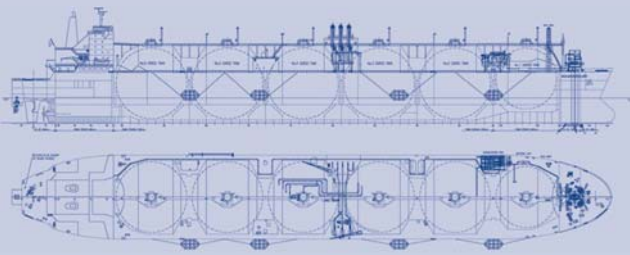


Figure 1 – General Arrangement of a 6 tank FSRU

tanks) arranged in the middle, regasification plant in the forward end and crew facilities, control room and utility machinery in the aft end. The terminal is permanently moored to the seabed with a turret mooring arrangement, and the gas send-out line is arranged through the turret down to the seabed and to shore via a seabed pipeline. The LNG tankers offloading to the floating terminal will be moored in a side-by-side configuration. Berthing, loading and unberthing will take approximately 24 hours. Process and utility systems have been chosen and designed for simplicity and least retrofit as well as for ease of operation and maintenance.



Figure 2 – 3D Illustration of a 5 tank FSRU

3. Design Basis

The terminal design shall be based on the following general requirements:

- LNG storage capacity: 129,000m³
- Accommodation as today
- Design life: Permanently moored and in operation for 20 years
- Maximum gas send-out capacity: 2.75 BSCMPA
- Nominal gas send-out pressure: 85 bar
- Water depth: 50-150m
- Terminal location: Benign environmental conditions

The limiting environmental data for the FSRU are as follows:

Condition	Wave height Hs (m)	Current speed (m/sec)	Wind speed (m/sec)
Survival (100 yr return)	8.00	1.00	30.00
Limit for LNG carrier connection to FSRU	2.50	0.75	15.00

4. Vessel Data

The LNG carrier to be converted has the following data:

Vessel type	Existing LNG Carrier of Moss design
Owner	Golar LNG
Built	1981
Capacity	129,000m ³ at -163 °C, 100% filling
Length over all	289.00m
Breadth moulded	44.60m
Depth moulded	25.00m
Draft (design)	11.40 m
Complement	Approx. 44 persons

5 Systems Description

5.1 Mooring

5.1.1 Turret mooring

The turret is to be connected in the forward part of the ship resulting in the need for modification of the bow area. The turret shall be configured to provide an essential non-rotating platform for supporting the anchor lines, flexible risers and associated control/service lines. The turret shall be equipped with a turntable which allows 360° continuous rotation of the FSRU.

5.1.2 Side-by-side mooring system

The terminal shall allow safe berthing of standard LNG carriers. There is no need for modification of these LNG carriers. Assuming that the terminal is being serviced by LNG carriers of size 125,000 to 137,000 m³ the arrival schedule will be about every 9 days. The side-by-side mooring system shall consist of the following:

- Primary and secondary fenders
- Nylon mooring lines. The lines shall be connected to the wire part of the LNG carrier line by special mooring shackles
- Roller fairleads, for guiding the nylon lines as required.
- Hydraulic quick release hooks with integrated capstan and adjustable release load

The terminal will be fitted with an azimuth thruster, for control of the terminal during LNG carrier berthing/unberthing. The approach and berthing operation on the LNG carrier will take place in a way very similar to that currently being used for onshore terminals. During berthing the cargo tanker will need the assistance from two tugs with minimum 50 tonnes bollard pull. After berthing a combination of transverse mooring lines and spring lines will be used to limit horizontal relative motions.

5.2 Loading Arms

The FSRU will be provided with standard loading arms to allow side-by-side transfer of LNG and vapor return. The FSRU shall be equipped with three 16 inch loading arms; two for LNG and one for vapor return. Operation with two LNG arms will ensure a loading time of 16 hours. Berthing, loading and unberthing will take approximately 24 hours.

The loading arms will be quite similar to the type that is used on onshore terminals however modified to account for relative motions between carrier and FSRU.

The FSRU will also be fitted with equipment for guiding the arms onto the carrier's connection flanges. This pre-coupling guide operation will be necessary to compensate for relative motion during coupling when the relative motion exceeds +/- 0.5m.

5.3 LNG Regasification System

5.3.1 Introduction

LNG is sent from the tanks to the regasification skid situated forward. The regasification skid essentially comprises booster pumps and steam heated vaporizers. The booster pumps will increase the pressure to about 90 bar, before the high pressure LNG is vaporised, after which the gas passes through a fiscal metering unit and is sent to the sub sea pipeline via the gas swivel and flexible risers.

The regasification system shall have the following key data:

- Maximum gas send-out pressure: 85 bar
- Maximum gas send-out flow: 240 tonnes/h
- Gas send-out temperature (min): 0°C

5.3.2 BOG handling

Maximum boil-off from the storage tanks is 0.25%, as per original design requirements off the existing LNG carrier. The boil-off gas is collected and used as fuel for steam generation in the FSRU boilers.

The FSRU will operate at a higher tank pressure than the offloading LNG carriers, thus avoiding the need to install unnecessary BOG handling equipment.

5.3.3 Metering

A metering station shall be arranged on the forward deck.

5.4 Onboard Power Generation

The existing equipment shall be used for onboard power generation. There are currently two steam driven turbo generators onboard, and in addition one larger steam driven turbo generator of about 6MW will be installed. In addition there is a diesel driven generator as well as a diesel driven emergency generator. The boilers will run on natural gas only, supplied by suction of BOG from the vapor header, and partly by additional fuel supplied by the LNG vaporizers.

Technical Particulars - FSRU

Principal Dimensions

Length overall	289.00m	Design draught	11.40m
Breadth moulded	44.60m	Draught scantling	12.52m
Depth moulded	25.00m	Water depth	50 - 150m

Performance

Gas send-out	240 tonnes/hr
Time for berthing, loading & unberthing	24 hours
Boil off rate	0.25% / 24 hours

Capacities

Cargo tanks (100% at -163°C)	129,000m ³
Gas send-out	
Tons/h	231
MMTPA	2.02
MMSCFD	283
BCMPA	2.75

(Gas send-out can be increased by increasing the onboard vaporisation capacity and by changing the heating medium.)

Cargo Containment System - Cargo tanks, type MOSS® spherical type, IMO class B

Number of tanks	5
Internal diameter	Tank 1 - 35.50m Tank 2, 3, 4, & 5 - 37.1m
Tank volume	129,000m ³
Material	Aluminium 5083-0
Max. cargo density	500 kg/m ³
Max. filling ratio	99.5% at reference temp.
Insulation material	Polystyrene

Cargo Handling System

In-tank cargo pumps	1,100m ³ /hr- 5 sets, 140m ³ /hr- 5 sets
Spray pumps	50m ³ /hr, 50mth - 2 sets
HD Compressors	27,000m ³ /h - 2 sets
LD Compressors	6,700m ³ /h - 1 set
LNG vapor heater	2,200 MJ/h (7,000 kg/h vapor) - 2 sets
LNG vaporiser	7,500 MJ/h (8,800 kg/h LNG) - 1 set
LNG loading arms	16 inch - 2 sets on starboard side
Vapor loading arm	16 inch - 1 set on starboard side
Inert gas plant	5,000 m ³ /h
Nitrogen plant	60 Nm ³ /h - 2 sets
LNG booster pumps	267m ³ /h, 1,980 mlc, - 3 sets
LNG Export vaporisers	80,000 - 150,000 kg/h - 4 sets

Two (2) flexible risers each of 14 inch inside diameter.

Typical calculations for send-out pipeline

Pipe inlet pressure	85 bar	Pipeline inner diameter	380 mm
Volume flow rate	2,750 m ³ /h	Pressure drop per km	0.60 bar/km
Pipeline nominal diameter	400 mm		