Technological Guidance on LNG Bunker Vessels & Barges

Stavros Niotis
Senior Engineer, Piraeus Tech & Business Development
Hamburg, Germany
10 September 2015

Bunkering Scenarios

1. Terminal Tank to Vessel
2. Truck to Vessel
3. Vessel to Vessel
4. Portable Tank Transfer
What is an LNG Bunker Vessel or Barge?

- Applicable Standards, Regulations and Guides
- Cargo Containment Systems
- Overview of Cargo / Discharge Operations
- Bunkering Operations
- Safety Considerations and Personnel Training

**What is an LNG Bunker Vessel?**

Self-propelled bunker vessels are considered LNG carriers

*A1, Liquefied Gas Carrier*

- Rule Sets
  - ABS Rules for Building and Classing Steel Vessels (Jan. 2015)

What is an LNG Bunker Barge?

Bunker barges are considered LNG barges

**A1, Liquefied Gas Tank Barge**

- Rule Sets
  - ABS Rules for Building and Classing Steel Barges (Jan. 2015)

What is an LNG Bunker Vessel?

As far as the LNG activities are concerned EMSA uses the following classification:

<table>
<thead>
<tr>
<th>Activity/Aspect</th>
<th>Large scale</th>
<th>Medium scale</th>
<th>Small-scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>On shore storage capacity</td>
<td>Import terminal $\geq$ 100,000 m$^3$</td>
<td>Intermediary terminal 10,000-100,000 m$^3$</td>
<td>Intermediary terminal &lt; 10,000 m$^3$</td>
</tr>
<tr>
<td>Ship size, LNG capacity</td>
<td>LNG carriers 100,000 – 270,000 m$^3$</td>
<td>LNG feeder vessels 10,000-100,000 m$^3$</td>
<td>LNG bunker vessels 1,000-10,000 m$^3$, LNG bunker vessels/barges 200 – 1,000 m$^3$</td>
</tr>
<tr>
<td>Tank trucks</td>
<td></td>
<td></td>
<td>40 – 80 m$^3$</td>
</tr>
</tbody>
</table>

This presentation will mainly cover Small-Scale LNG Bunker vessels.
Content

- What is an LNG Bunker Vessel or Barge?
- **Applicable Standards, Regulations and Guides**
  - Cargo Containment Systems
  - Overview of Cargo / Discharge Operations
  - Bunkering Operations
  - Safety Considerations and Personnel Training

Applicability to Bunkering Vessels

- For Liquefied Gas Carriers or Liquefied Gas Tank Barge
- IMO International Gas Code (IGC)

Note:
- New IGC to enter into force for vessels with keel laying after 1 January 2016
- Vessel interface with gas fueled ships and IGF code may be required by the flag Administration
ABS Guide for Dual Fueled Vessels

- ABS has published on May 2011 and last updated on May 2015 a “Guide for Propulsion and Auxiliary Systems for Gas Fueled Ships”
- Section 4 of this Guide covers “Fuel Gas Bunkering Systems”
- This Section can be taken as a reference also for the design of the bunkering vessels

Bunker Station Requirements

- No gas is to be discharged to air during bunkering operations
- Key bunker station requirements
  - Sufficient natural ventilation
  - Physical separation and structural protection
  - Stainless steel drip trays
  - Class A-60 protection
  - Vapour return line provision
  - Manifold filters
  - Manual and remote ESD valves
  - ESD valve closing speed

Source: Wartsila
Bunker Station Requirements

- Key bunker station requirements
  - ESD and bonding connections
  - Remote control and monitoring
  - Local pressure gauges
  - Draining/purging/inerting provision
  - Gas detection of enclosed or semi-enclosed bunker stations
  - Ventilation and gas detection of enclosed bunkering lines
  - Fixed fire detection and extinguishing system

ABS Technology Initiatives on Bunkering

- ABS is preparing a new “Guide for Remote Control and Monitoring and Systems on Barge Installations”
- Other on-going initiative of ABS Technology are studies on:
  - Parametric motion simulation of ship-to-ship LNG fuel bunkering
  - Various projects on containment systems
    - Cumulative fatigue analysis
    - Longevity
    - New generation
    - Sloshing
    - BOR estimation
Content

- What is an LNG Bunker Vessel or Barge?
- Applicable Standards, Regulations and Guides
- **Cargo Containment Systems**
- Overview of Cargo / Discharge Operations
- Bunkering Operations
- Safety Considerations and Personnel Training

## IMO IGC Classification of Containment systems

<table>
<thead>
<tr>
<th>Type</th>
<th>p &lt; 700 mbar</th>
<th>p &gt; 2000 mbar</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Full Secondary barrier</td>
<td>No Secondary barrier</td>
</tr>
<tr>
<td>B</td>
<td>Partial Secondary barrier</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>No Secondary barrier</td>
<td></td>
</tr>
</tbody>
</table>

### Independent Tanks

- **Type A**
  - p < 700 mbar
  - Full Secondary barrier
  - **Spherical (Moss)**
  - **Prismatic (IHI SPB)**

- **Type B**
  - p < 700 mbar
  - Partial Secondary barrier
  - **Cylindrical**

- **Type C**
  - p > 2000 mbar
  - No Secondary barrier
  - **Bilobe**

### Integrated tanks

- **Membrane Tanks**
  - p < 700 mbar
  - Full Secondary barrier
  - **GTT No 96**
  - **GTT Mark III**

### Other Systems:

- **Based on classical ship structure design rules**
- **Based on first-principle analysis and model tests**
  - "Leak Before Failure"
- **Pressure vessels, based on pressure vessel code**
- **None in operation**
- **New systems under development:**
  - Aker ADBT
  - LNT A-Box
  - Torgy

Sources: Moss Maritime, IHI, TGE, GTT

Confidential
Tank Types on LNG Carriers

- Membrane Type
  - By courtesy of GTT

- Type B Tanks

- Type C tanks / Bilobe Tanks

New Cargo Containment Systems?

- LNT A-Box IMO type A tank
  - Complete double hull
  - Independent type A tank located in the holds
  - Insulation arranged on the internal surface of the inner hull of the vessel
  - Secondary barrier membrane on top of insulation

By courtesy of LNT
Key Factors on Selecting Tank Type

- Design Pressure
  - Vessel’s operational profile
  - BOG handling equipment requirements
- Volume space efficiency (ship’s main dimensions)
- Secondary barrier – inerting requirements
  - Additional equipment
  - Operators skills
- Filling limits restrictions (sloshing)
- Loading limits restrictions (design pressure)
- Design and building specialized workforce (availability of shipyards / builders)
- Cost

LNG Bunker Vessels

- The ‘Seagas’ is the only LNG bunkering vessel currently in operation serving seagoing vessels
  - Converted ferry
  - IGC Code
  - Type C tank 187m³
  - No vapor return
  - Pressure decant
- Other concepts/projects
  - Conrad Shipyard project
  - White Smoke
  - Wilhemsen
  - Kawasaki
  - Argos Oil – LNG membrane tanks 2x935m³ and MGO
  - Inland LNG carrier 2250m³
LNG Bunker Barge Designs

- Elliott Bay Design Group
  - ABS AIP
  - 2000 m³

- LNG America
  - Jensen Maritime Design
  - ABS AIP
  - Mercury – 1000 m³
  - Gemini – 3000 m³

Photo Source: Jensen Maritime Consultants / LNG America / World Maritime News

Argent Marine Bunker Barge

Intermodal Bunker Vessel (IBV)

Patented
Conrad to Build First LNG Bunker Barge in NA (February 2015)

- Serve TOTE’s Orca-class RO-ROs and Marlin-class containerships
- 2,200 cubic meter (cbm) barge
- Expected delivery in early 2016; ABS Class
- Deployed in Tacoma (Washington State)
- 1 MARK III Flex tank (GTT - Gaztransport & Technigaz)
- Bristol Harbor Group Inc. design

Approval-In-Principle (AIP)

- General scope of review:
  - General arrangement
  - Engine selection
  - Gas system equipment selection
  - Hazardous areas plan
  - LNG fuel containment type
  - Tank location and supporting structure
  - Fuel gas and ventilation systems routing plan
  - Bunkering operation philosophy
Content

- What is an LNG Bunker Vessel or Barge?
- Applicable Standards, Regulations and Guides
- Cargo Containment Systems
- Overview of Cargo / Discharge Operations
- Bunkering Operations
- Safety Systems and Personnel Training

Preparing Cargo Tank after Drydocking

Aeration (dry air)

Inerting (dry IG)

Gassing up

Notes:
- Aeration/Inerting dew point to be kept below – 45 °C
Cooling Down Prior to Loading

- Notes:
  - Cooling down process generates boil off
    - To be sent back to shore, vented or burned

Loading & Unloading

- Notes:
  - Loading/unloading can be performed with or without vapour return
  - If no vapour return is used:
    - The discharging ship will need to generate vapour to avoid vacuum
    - The loading ship must control the tank pressure through use of spray
Preparing Cargo Tank before Drydocking

Warming up

Inerting

Notes:
- Warming up process will generate boil off gas. To be sent to shore or burned

Aeration

Content

- What is an LNG Bunker Vessel or Barge?
- Applicable Standards, Regulations and Guides
- Cargo Containment Systems
- Overview of Cargo / Discharge Operations
- Bunkering Operations
- Safety Considerations and Personnel Training
Main Components

- Transfer systems
  - Cryogenic composite hoses
  - Mechanical cryogenic arms
  - Hybrid systems with hose manipulators
- Quick couplings/ dry-break couplings

Fuel Transfer

- GTT
  - REACH4 (Refueling Equipment Arm, Methane [CH4])
    - Ensures simple and safe transfer of LNG fuel to the client vessel
    - Features break-away couplings for safe and reliable emergency disconnections
    - Patented configuration prevents rapid disconnections and keeps the breakaway couplings in a fixed position on the mast to ensure simple and safe deployment
LNG Transfer Systems

- Loading rates
- Local requirements
  - Exclusion zones
  - Hazardous area, safety zone, security
  - Simultaneous operations
  - Firefighting requirements
  - Environmental issues
- Fuel delivery measurements
  - Quantity
  - Gas properties

Industry Experience with STS LNG Transfer

- LNG STS transfer is now common practice, e.g. for several FSRU projects
- SIGTTO/OCIMF STS bunkering guide developed leveraging on the existing experience
- LNG bunkering barge operating in Sweden
Industry Initiatives on Bunkering & Use of LNG

- Swedish Maritime Technology Forum published LNG STS bunkering procedures
- EMSA study on LNG bunkering to assess viability of EU wide guidelines for LNG bunkering
- European Sustainable Shipping Forum (ESSF)
  - LNG as fuel sub-group
- MPA in Singapore study on the technical procedures for LNG bunkering in the Port of Singapore
- Society for Gas as Marine Fuel (SGMF)
  - LNG-Bunkering Safety Guidelines
- USCG Guidelines for LNG Bunkering
- Class Advice and Guidance


- Guidance on the minimum requirements for the design and operation of the LNG bunkering facility, including the interface between the LNG supply facilities and receiving ship
- Requirements and recommendations for:
  - Operator and crew competency training
  - Roles and responsibilities of the ship crew and bunkering personnel
- Functional requirements for equipment necessary to confirm safe LNG bunkering operations of LNG fuelled ships
- Covers
  - Ship-to-ship, Shore-to-ship, Truck-to-ship
- ABS part of new ISO TC8 / WG8 Committee
  - Create a bunkering standard
  - Include criteria for class society systems certification
ISO/TS 18683:2015

- The main requirements to the bunkering system are presented as a number of functional requirements
- The document addresses:
  - All equipment between the supplier shutdown valve and the presenting flange on the ship
  - The necessary information exchange between supplier and ship in order to ensure a safe operation
  - The key characteristics and differences between LNG and other marine fuels and give reference to other relevant codes and regulations
  - The main requirements to the bunkering system are presented as a number of functional requirements

Bunker Transfer with Vapor Return Line

- The LNG in the fueled vessel will likely be at a higher vapour pressure and temperature than the LNG bunkering vessel
- Design pressure of the bunkering vessel can be lower than the design pressure of the LNG fuel tank on the LNG fueled vessel
- The LNG bunker tank normal operating pressure can be in the range of 6 barg, the bunker vessel may be operating at near atmospheric pressure
- A connected vapour space will potentially result in:
  - Excessive boiling of the LNG in the LNG fueled vessel
  - Overpressure in the bunkering vessel
  - LNG fueled vessel may need to maintain pressure in its fuel tanks to feed its power generation plant
- Some sort of pressure control will be required on the vapour return line
**Bunker Transfer without Vapor Return Line**

- The pressure in the LNG fueled tank must be controlled by the LNG fueled ship, through use of top spray and bottom filling line
- Loading rates can be restricted in this operation
- Requires good understanding of the process from the LNG fueled vessel crew

**STS Considerations**

- Ship compatibility
- Transfer area
- Environmental conditions and Navigation warnings
- Cargo sloshing considerations
- Electrical Isolation
- STS operations Risk Assessment
- Safety Issues during transfer
- Emergency Response
- Communications
**Bunker Quality Considerations**

- ISO 8217:2010 Specifications of marine fuels
  - TC28/SC4/WG6 now has a sub group for LNG technical specification
- LNG is sold based on its energy content
- The energy content of LNG is dependent on its actual composition AND temperature
- The LNG composition is likely to change in time ("aging")
- Gauging method to be determined (level gauging, flow metering…?)
- Universal standards for sale and purchase of LNG bunkers need to be developed. Meanwhile terms need to be agreed between seller and buyer.

**Content**

- What is an LNG Bunker Vessel or Barge?
- Applicable Standards, Regulations and Guides
- Cargo Containment Systems
- Overview of Cargo / Discharge Operations
- Bunkering Operations
- **Safety Considerations and Personnel Training**
What is so Special about LNG?

- Very low temperature (abt. -160 °C)
  - Any contact with carbon steel will lead to brittle fractures
  - Skin contact will result in severe burn injuries
- Constantly boiling liquid
  - The LNG is kept cool by constantly boiling off cargo
  - During a cargo transfer excessive BOG is generated and must be handled
  - Ageing Cargo (Composition changes in time)
- Flammable
  - Hazardous area classification
- LNG composition can vary

Safety Issues

- Cryogenic fuel spill
  - Liquid on deck
  - Liquid on side shell
  - Pooling and pool fires
  - Personnel hazard
- Gas release
  - Migration to enclosed space
  - Exposure to ignition source
  - Environmental impact
- Interaction with loading facility
  - Overpressure and underpressure
  - Vapor return provision
  - Overfilling
Considerations on Safety

- Excellent safety record in LNG shipping industry through:
  - Accurate verification to which the design of an LNG carrier is subjected to by the designer and the classification societies
  - Construction of the vessels and in particular of cargo containment system and cargo handling system only by a few specialized shipyard (with stringent quality assurance procedures)
  - Top tier owners and operators assure a careful maintenance of high standard with respect to other vessels
  - Vessel crew made of well trained and skilled personnel

Some Safety Concerns towards LNG as Fuel

- Understanding of LNG and associated risks
- Crew competency, training, experience, understanding of gas related problems
- Lack of universally adopted international safety measures, in particular for the interfacing between bunker vessels and LNG fuelled vessel and difficulties to navigate among many standards issued by different Authorities
- Regulation and control
Personnel Training

- The LNG Bunkering operations is potentially more complex than a standard LNG carrier discharge operation:
  - Different condition of the residual LNG in the LNG fueled vessel (Higher temperature, different composition) makes control of the generated BOG more complex
  - A good coordination and cooperation between the bunker vessel crew and the LNG fueled vessel is critical
  - The LNG bunker tank is potentially at high pressure, requiring higher transfer pressures (design pressure of a fuel bunker tank generally in the range of 10 barg, normal operating pressure 6 barg)