Introduction to Design & Operation for the FLBT

FLBT: Floating LNG Bunkering Offshore Terminal

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ECO Regulation (Extension & Stringently)

I  LOCAL Regulation for Prevention of Air Pollution from Ships
II GLOBAL Regulation for Prevention of Air Pollution from Ships
III Air Pollution Regulations for IMO’s Trend
EXPANDING ECAs & SECA

(ECA: Emission Control Area)  (SECA: Sulfur Emission Control Area)

Baltic Coastal Countries and EU agreed NOx ECA
The proposal will be submitted to the IMO MEPC 70 meeting (27 Oct. 2016)

“Baltic & North Sea ECAs - SOx”

“New ECA-SOx in CHINA”

200 nm = 370.4 km

12 nm = 22 km

“North America & Hawaiian Islands ECAs – SOx & NOx”

Source, OCEANOX, ANDRITZ, Seas at Risk

ⓒ Korean Register of Shipping, All Rights Reserved
GLOBAIZATION ECAs & SECA

(ECA : Emission Control Area)
(SECA : Sulfur Emission Control Area)

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-source, OCEANOX, ANDRITZ, Seas at Risk

Global Sulfur Cap 2020
LNG (As the ECO Fuel)

I  Necessary to use LNG, its a Eco-friendly & Economical fuel
II  Forecast hereafter for LNG
III  Forecast hereafter for Marine LNG Fuel
IV  Demand Increase & More Complex
V  Status of the LNG bunkering
VI  Status of the LNG bunkering(Domestic)
VII Novel Concept
LNG as the ECO Fuel

Necessary to use LNG, its a Eco-friendly & Economical fuel

Source, MAN D&T, ‘Cost and Benefit of LNG as Ship Fuel for Container vessel,’
Emission data from 6S70ME-C & 6SME-GI(w/. EGR)

EGR, DeNOx Technology
When applied, it has a reduction capability of 80% or more.

Traditional Fuel Ship
Enables 20~25% reduction of carbon dioxide emission

Expected to be less costly
Than MGO(marine gas oil) which will be required to be used within the ECAs if no other technical measures (e.g., scrubber etc.) are implemented to reduce the SOx emissions

Emission data from 6S70ME-C & 6SME-GI(w/. EGR)

Reduce Sulfur Oxides
Emissions by 90~95% In SECA area

LNG
To be in the Spotlight

Conventional Value Chain

LNG Bunkering Technical Development Necessary

LNG Bunkering Vessel
LNG Fueled Ship
Opportunity

- LNG supply to be stagnant in the future
- Low-cost marine LNG is expected (under $6/mmBtu)
- Expect activation of LNG fuel

Global Liquefaction Capacity (build-out)

- Source: IHS, Company Announcements
  World IGU Report 2017

LNG Cost

- Source: BP Statistical Review of World Energy 2017

MTPA: Million Tons per Annum
mmBtu: Million British thermal units
**Demand**

- To meet regulatory requirements, demand for traditional fuels is declining.
- LNG fuel is being prepared in a major method with scrubber.

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**Projected Marine Fuel Demand**

- LNG market share → 2%
- 20%
- 33%

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**Projected Marine Fuel Demand For Container Segment**

- LNG market share → 2%
- 23%
- 32%

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*Source: Boston Consulting Group*  
*GE’s Report, Commercial Shipping Looks to LNG to Curb Emissions, Sep. 11, 2015*
**Demand Increase**

- LNG consumption is saturated, by the way increasing small scale LNG market
- Future expected to increase natural gas production
- Demand and supply of marine LNG and related transportation are active

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**Schematic of Small Scale(mini) LNG Value chain**

Source: World IGU (International Gas Union) Report
Vibrant LNG Bunkering

✓ According to SGMF (The Society for Gas as a Marine Fuel), currently 58 ports have completed preparation for LNG bunkering [Sep. 14, 2017]
✓ Expected to be actively driven mainly by Europe [0.1% S, Sulfur Cap. Countries]

Source: Global Infrastructure for LNG Bunkering, SEA/LNG
LNG Bunkering Plan

✓ Accomplished fact for installation of LNG at ‘Busan Port’
✓ ‘Ulsan Port’ and ‘Yeosu-Kwangyang Port’ are trying to build LNG facilities. (Relevant ‘Oil-Hub National Project’)

: LNG Terminal (w/ Bunkering)  : Only bunkering
FLBT

- Ongoing project as a governmental funded from 2014
- It is a terminal to distribute LNG as a marine fuel on the sea. (Also known as, Marine LNG service station)
- 30 institutions are participating in the development of capacity 220K CBM
- Major contributors include KOGAS, SHI, DSME, POSCO, KR, and KRISO

![FLBT Concept](source: stx corporation)
FLBT, Risk Based Design (KR Activities)

I
Feasibility Study: (Onshore/offshore) LNG Bunkering Terminal

II
Risk based design for FLBT: Introduction

III
HAZID, HAZOP & Others

IV
RAM Study

V
Gas Dispersion & Others

VI
Ship Collision
## Feasibility Study: LNG Bunkering Terminal
### Onshore vs. Offshore

### Onshore

**Pipeline (Terminal/shore) to ship**
- Land based 270K cbm inland Tank
- Chicksan arm (Loading/off-loading LNG)
- Onshore LNG Bunkering Terminal

### Offshore

**Ship to ship**
- Floating 270K cbm Storage Cargo Tank
- Chicksan arm (Loading/off-loading LNG) & flexible hose
- Offshore LNG Bunkering Terminal + LNG Bunkering Ship

### Capability

**Storage, Function, Bunkering type**

### NIMBY & Hard problem

**Civil Compliant**
- Difficult ‘Legal’ permission
- Risk element during operation / Decommissioning

### Permission Issue

**Legal trouble & Risk element**

### Relatively easy

- Consider traffic issues (need to control)
- Simplified decommissioning
- Reduced risk of bunkering

### Robust operation

30 years more (according to maintenance)
- 5~7 years (construction periods)

**CAPEX:** 613 billion KRW (harbor construction cost)
**OPEX:** about 60 billion KRW

### Durability

**Life, Cost**

30 years (design life time)
- 3 years (construction periods)

**CAPEX:** 487 billion KRW (mooring cost)
**OPEX:** 32.4 billion KRW

### Operation

**Logistics / Risk**

### Use conventional facilities

- Acceptable for all scale LNG bunkering
- Easy refueling in port
- Possible latency time in port
- Available for operation parallel with LNG import

### Diversification of risks

- Acceptable for medium and big scale LNG bunkering
- Not effect from existing port facilities & risk elements
- Possibilities of latency time at outside of port (Almost never latency time in port)
- Simple connection; relevant LNG facilities and LNG power plant
Risk Assessment-Based Design for FLBT

- Risk-based engineering for FLBT consists of follow procedure
- In this study, the qualitative risk assessment (HAZID & HAZOP) reflected the hazard registration identified in the basic design of FLBT
- Working on a quantitative risk analysis (QRA; FERA, EERA, Ship Collision etc.) work

Risk Based Design Approach

- HIPPS: High-Integrity Pressure Protection System
- PFP: Passive Fire Protection
- SIL: Safety Integrity Level
- HAZID: Hazard Identification
- HAZOP: Hazard & Operability
- FERA: Fire & Explosion Risk Analysis
- EERA: Escape, Evacuation & Rescue Analysis

Flowchart:

1. System Design
2. HAZID
3. HAZOP
4. Fire & Explosion Risk Analysis
5. QRA (Quantitative Risk Analysis)
6. PFP Analysis
7. Escape, Evacuation & Rescue Analysis
8. Emergency System Survivability Analysis
9. SIL Verification
10. HIPPS Reliability Analysis

Additional Analyses:
- Dropped Object Analysis
- Ship Collision Analysis
- Exhaust Gas Dispersion Analysis
- Production Availability
- Cryogenic Spill Analysis
Summary
✓ Through the HAZID W/S, 90 function errors due to malfunction were identified of 128 total errors
✓ HAZOP W/S was performed for 90 of these, and it was reflected in the FLBT’s design.

128 hazardous events for the current design and operation scheme of FLBT were identified identification (Function failure 90)

<table>
<thead>
<tr>
<th>Hazard Category &amp; Type</th>
<th>Cat. 1 Type 11</th>
<th>Cat. 1 Type 12</th>
<th>Cat. 1 Type 13</th>
<th>Cat. 2 Type 21</th>
<th>Cat. 2 Type 22</th>
<th>Cat. 2 Type 23</th>
<th>Cat. 2 Type 31</th>
<th>Cat. 3 Type 32</th>
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<td>Hazardous Events</td>
<td>19</td>
<td>4</td>
<td>2</td>
<td>90</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>4</td>
<td>128</td>
</tr>
</tbody>
</table>

System node for identification
LNG Storage, LNG Transfer, Structural Integrity, Accommodation, LNG Utility & Emergency Preparedness

Hazardous events related to the following categories

Category 1–Type 11: External/Environmental Hazards, Impact on the System
Category 1–Type 12: External/From the System Hazards, Impact on the Natural Environment
Category 1–Type 13: External/System Hazards, Impact on the Human Environment
Category 2–Type 21: Internal/Function Failure Hazards
Category 2–Type 22: Internal/System Failure Hazards
Category 2–Type 23: Internal/Other Hazards
Category 3–Type 31: Man-made/Threat to the Health and Life
Category 3–Type 32: Man-made/Threat to the Health and Security
Risk based design for FLBT
RAM Study

Summary
✓ 20 year life average production efficiency is 98.513% (std. ± 0.258%)
✓ Production: LNG Transfer to vessel (LNG bunkering)

RAM Study

P&ID (PFD) for FLBT’s Topside operation

*TranSGAS: Joint Development Consortium (company)
Summary

✓ Helipad and Accommodation are not exposed to the hazard of unignited natural gases from flare tower
✓ Safe from 10% LEL (0.5% CH₄ Concentration) range.

Gas dispersion analysis

Unignited natural gas flume dispersion analysis (5m/s)
Conclusion

- Collision speed was determined based on the time when the shuttle ship creates deformation on the inner hull of the FLBT. If the inner hull breaks or cracks, there is a great risk of LNG leakage.
- The inner hull was safe when colliding at a speed of 3.7 Kn

FLBT Collision analysis

Deformed shape and effective plastic strain distribution

Von Mises Stress

FLBT vs. 170K LNGC Collision

After collision time (4.5 sec)
Design for FLBT (Function & Performance)

I. Layout of Multi-body Operation
II. Preliminary General Arrangement
III. FLBT Flow Process (Topside main function)
IV. Rule Development for FLBT (Bunkering)
4 Body Mooring
✓ The design requirement is to operate four ships at a time
✓ LNG carrier size is based on 170K CBM, and LNG bunkering vessel has a size of 5K and 30K CBM
✓ Simulation is applied and the model test results are verified
Configuration of FLBT

- The FLBT has 10 CCS (Cargo containment systems) and is fixed by turret mooring system.
- Loading/off-loading Arm (Chicksan arm) is used to carry out LNG transfer operation.
- And, equipment for BOG handling process.
Topside Process of FLBT

- The main process of FLBT is shown in the figure
- Most of the LNG is transported to the ship via the tank
- The generated BOG is re-liquefies or flaring

*Be standardization LNG loading/unloading & bunkering arm

To develop Bunkering procedure
Rule Development
✓ Guidelines for FLBT was developed.
✓ 'LNG bunkering systems' has been newly developed and registered in our existing rules
✓ Currently, the design requirements of cryogenic equipment

While developing rules for LNG equipment design requirements, As follows:
✓ Cryogenic Pump
✓ Cryogenic Compressor
✓ Heat Exchanger
✓ Coupling
✓ Etc.

Industry Request
Difficulty of approval (Plan Approval Team)
Approval & Acceptance Criteria
International Standard(& code)
Technical trends
Action of FLBT (Extension & Stringently)

I Development of the Relevant Act for Operation & Business for LNG bunkering

II Issue for Korean’s LNG Bunkering
Legislation for LNG Bunkering

- With government as the center,
- KR and the KLRI (Korea legislation research institute) are jointly regulating related laws
Plan for FLBT

- Busan port & Ulsan port currently under consideration for FLBT
- Interest in countries without LNG-related infrastructure (e.g., Indonesia etc.)
- The pilot project is underway to install FLBT in Ulsan Port (UPA, KOGAS, KRISO, SHI etc.)

Relevant Activities for LNG Bunkering

Busan port
- The Busan new port installed LNG Bunkering position *(political issue)*
- Optimal location for LNG bunkering

Ulsan port
- World LNG bunkering MOU (Singapore, Oct. 2016)
- Through prepare to ‘Oil hub project of East-north Asia’ Project

In the Korean government,
- Conducting research for constructing FLBT
- And the feasibility study for FLBT demonstration

KR will be continue contributing to this project
- To classification for FLBT
- To substantiate of FLBT
Takk skal du ha ~