The latest issues on gas fuelled ship (including New IGF Code)
1. How to decide gas fuelled ship for new shipbuilding?
2. Selection of gas fuel tanks
3. Use LNG as fuel
4. Risk Assessment
5. Feasibility study
6. Technical services we can provide
1. How to decide gas fuelled ship for new shipbuilding?

1. Background – Why do we think about gas fuel?

- CO₂ – Global warming
- SOx & NOx – Make air pollution in the atmosphere.
- IMO prohibits CO₂, SOx and NOx.

- Shipping industries think an alternative fuel such as gas.
1. How to decide gas fuelled ship for new shipbuilding?

- Analyze LNG price
- Decide the Size of Ships
  - Review Gas Fuel Tank
  - Review Gas Supply System
- Perform Feasibility Study
- Develop Building Specification
Issues on Gas Fuelled Ship

2. Selection of gas fuel tank

1. Many types of gas fuel tanks (LNG)

2. Ship owners have interest on independent type C & B tanks.
2. Selection of gas fuel tank

2. Independent tank – Type C & Type B

- Independent tanks mean self-supporting tanks which do not form the ship’s hull and are not essential to the hull strength.
- All gas fuelled ships (84 vessels) have independent C type tanks so far.

[Source: Samsung Heavy Industries]
Issues on Gas Fuelled Ship

2. Selection of gas fuel tank

1. Option 1 - Independent Tank C Type

- No secondary barrier is required.

[Source: CRYOS & TGE]
2. Selection of gas fuel tank

2. Option 2 - Independent Tank B Type

[Source: Google]
# Issues on Gas Fuelled Ship

## 2. Selection of gas fuel tank

### 3. Information of Independent tank

<table>
<thead>
<tr>
<th></th>
<th>Option 1 – Type C Tank</th>
<th>Option 2 – Type B Tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Barrier</td>
<td>SUS 304 L</td>
<td>Al 5068 (Aluminum)</td>
</tr>
<tr>
<td>Secondary Barrier</td>
<td>No required</td>
<td>Partial barrier</td>
</tr>
<tr>
<td>Insulation</td>
<td>Perlite with vacuum</td>
<td>R-PUF (Polyurethane)</td>
</tr>
<tr>
<td>Partial loading</td>
<td>Possible</td>
<td>Possible</td>
</tr>
<tr>
<td>Space efficiency</td>
<td>Bad</td>
<td>Good</td>
</tr>
<tr>
<td>BOR (Vol/day)</td>
<td>0.14 % ~ 0.2 %</td>
<td>0.2 % ~ 0.6 %</td>
</tr>
<tr>
<td>Weight</td>
<td>Heavy</td>
<td>Light</td>
</tr>
<tr>
<td>Cost to make</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Total (Weight+Cost)</td>
<td>Good</td>
<td>Medium</td>
</tr>
<tr>
<td>Reference</td>
<td>Many</td>
<td>None</td>
</tr>
</tbody>
</table>

- Based on the expense and reference, independent tank C type has been recommended.

* BOR : Boil-off rate
Issues on Gas Fuelled Ship

2. Selection of gas fuel tank

4. High Mn Steel developed by South Korea

- This material has strength and is inexpensive.
- KR has developed a standard for this steel and issued the approval cert.

Fig. Strength Curve

Percentage (%)

Option.1 High Mn Steel
Option.2 SUS 304 L

60 ~ 65
100

Fig. Expense Comparison

[Source: POSCO]
Issues on Gas Fuelled Ship

3. Use LNG as fuel

1. New IGF Code Ch.9
2. MAN ME-GI Engine

Fig. General Diagram of Gas Supply System
4. Risk assessment (Failure Mode Effect Analysis)

Chapter. 4 General Requirements

4.2.1 A risk assessment shall be conducted to ensure that risks arising from the use of low-flashpoint fuels affecting persons on board, the environment, the structural strength or the integrity of the ship are addressed.

Details of risks, and the means by which they are mitigated, shall be documented to the satisfaction of the Administration*.

This requirement is aligned with IGC Code.

* IEC 60812, Edition 2.0 2006-01 “Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)”
4. Risk assessment (Failure Mode Effect Analysis)

1. KR carried out a risk assessment in 2012.

2. Target: Ocean-going gas fuelled ship
   - Gas fuel tank space
   - Ventilation system
   - Gas supply room
   - Machinery space, etc.
Issues on Gas Fuelled Ship

4. Risk assessment (Failure Mode Effect Analysis)

1. Results

<table>
<thead>
<tr>
<th>Risk ranking</th>
<th>Number of findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>3</td>
</tr>
<tr>
<td>Medium</td>
<td>6</td>
</tr>
<tr>
<td>Low</td>
<td>26</td>
</tr>
</tbody>
</table>

2. Finding: 35 cases

3. High risk: 3 cases

- Gas leak in gas supply room
- Gas leak in gas fuel tank space
- Gas leak in gas valve unit room
4. Gas leak and explosion simulation

1. In case of using LNG as fuel

2. Gas leakage/explosion in gas supply/compressor room
Issues on Gas Fuelled Ship

4. Gas leak and explosion simulation

1. Leak conditions of LNG (Pure methane)
   • Assuming a leakage at damaged gas supply pipe leading to explosion

2. Modeling Condition

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Leak duration</th>
<th>Gas cloud</th>
<th>Ignition time</th>
<th>Gas press.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>2.1 sec</td>
<td>5.3 kg</td>
<td>0.1 sec</td>
<td>330 bar</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>9.6 sec</td>
<td>41 kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Software: Flame Acceleration Simulator (FLACS)
4. Gas leak and explosion simulation

1. Scenario 1

- Max. pressure: 0.3 barg
4. Gas leak and explosion simulation

2. Scenario 2

- Max. pressure: about 3.7 barg

- It is quite high value. Anticipate that it may cause severe damage to structure.
- In general, manageable overpressure are thought to be of the order of 1 barg.
Issues on Gas Fuelled Ship

5. Feasibility study

1. 10,000 TEU gas-fuelled container ship

- Operate the vessel at NCR speed (34,700 kW at 21 knots)
- One voyage: abt. 27,000 nautical miles (55 days/voyage)
- Gas fuel tank: abt. 8,000 m³ / F.O tank: abt. 4,000 m³
5. Feasibility study

1. Gas price in the world

- Unit: mbtu (British Thermal Unit)
- C Bunker Oil: 1 ton = Abt. LNG: 41 mmmbtu

[Source: Waterborne Energy]
Issues on Gas Fuelled Ship

5. Feasibility study

1. Gas price is more expensive than bunker price in these days.

- Comparison of fuel cost for 15 years

- However, in the future, we have to use gas fuel because of environmental reasons and gas fuel price.

* Data used in this calculation has been roughly estimated by KR.*
6. Technical services we can provide

1. Help to decide the size of gas fuelled ship.

2. Review gas fuel tank

3. Feasibility study for gas fuelled ship

4. Risk Assessment

5. We can develop the building specification for gas fuelled ship.
Thank you for your attention!