DESIGN OF THE EVOLUTIONARY LNG CARRIER “SAYAENDO”

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1. MHI has developed a next-generation spherical tank LNG carrier with a continuous tank cover, nicknamed SAYAENDO, meaning “peas in a pod”.

2. SAYAENDO has many advantages, such as lighter steel weight, improved fuel consumption, better terminal compatibility, better maintainability.

3. This presentation introduces the design of SAYAENDO and the state-of-the-art engineering verification methodologies applied.
CONTENTS OF PRESENTATION

1. Design concept of SAYAENDO (comparison with conventional)
2. Technical key points
3. Advanced Structural Analysis
4. Application to 155 km³ LNGC
5. Application to cold region
1. Forty-two LNG carriers delivered since 1983.

2. Epoch making “2nd generation LNGC” with a lower BOR with a forcing vaporizer.

3. Continuous development with 3rd generation (137km$^3$) and 4th generation (147km$^3$)
Reduction of steel weight by 5-10%, for ship over 147 k-m³ due to new structural concept.

The Sayaendo continuous tank cover offers high structural strength.

Larger deck surface that supports strength.

Improved structural depth.

A conventional tank cover contributes little to structural strength.
Increase of height of tank cover

→ Increase of steel weight of non hull girder member
OVERALL CONFIGURATION OF SAYAENDO

- Cargo machinery room integrated into tank cover
- Conventional Moss carrier
- Complex support structure not required
- LNG cargo piping
- Electric cables
- Shore manifold (LNG cargo loading/unloading)
- Helicopter deck (optional)
KEY POINTS IN DEVELOPMENT

1. Structural design and assessment
   - Longitudinal strength assessment
   - Detail connection design
   - Tank cover and main hull connections including fore and aft ends
   - Interaction between cargo tank and hull
   - Fatigue assessment for structural detail

2. Aerodynamic assessment with wind-tunnel tests

3. Manoeuvrability simulation and mooring analysis
1. Advanced structural analysis by MHI-DILAM carried out for yield, buckling and fatigue criteria.

2. Yield and buckling strength confirmed acceptable against maximum load in ship lifetime.
1. 50 years of design fatigue life fit for world-wide LNG trading has been confirmed.

2. Reduced hull girder stress has favourable effect in SAYAENDO, allowing possibility of efficient structural design to achieve the given fatigue design specification.
1. Comparison of hull girder stress (Deck and Bottom)

2. Comparison of hull / tank interaction force
## THE 155k-m³ SAYAENDO (1)

<table>
<thead>
<tr>
<th></th>
<th>Conventional 147 k-m³</th>
<th>Sayaendo 155 k-m³</th>
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<tbody>
<tr>
<td>Tank capacity</td>
<td>Approx. 147,200 m³</td>
<td>Approx. 155,300 m³ (stretched)</td>
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<tr>
<td>Loa</td>
<td>288 m</td>
<td>288 m</td>
</tr>
<tr>
<td>B (mld.)</td>
<td>49.0 m</td>
<td>48.94 m</td>
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<tr>
<td>D (mld.)</td>
<td>26.8 m</td>
<td>26.0 m</td>
</tr>
<tr>
<td>Speed</td>
<td>Approx. 19.5 knot</td>
<td>Approx. 19.5 knot</td>
</tr>
<tr>
<td>Main Propulsion Plant</td>
<td>Conventional steam turbine</td>
<td>UST (Ultra steam turbine)</td>
</tr>
</tbody>
</table>
THE 155k-m³ SAYAENDO (2)

1. MHI-UST (Ultra Steam Turbine plant), a new turbine plant
2. 25% reduction in fuel consumption compared with conventional ships
ICE BREAKING SAYAENDO

1. Independent tank system: tolerant to local ice impact

2. Overall hull girder strength: highly effective in resisting global ice impact loads.
1. State-of-the-art engineering verification methodologies by the shipyard and the classification society were applied to validate the new design to meet the stringent technical, regulatory and safety requirements of the LNG shipping industry.

2. As a product, SAYAENDO has the following advantage.

- New structural concept offering more rigidity with less light weight.
- Compact design, especially in ship’s depth.
- Lower maintenance cost, due to omission of flying passage.
- Suitability for navigation in cold region.
Notable Aspects of Class Consideration

Class notation for standard ship:

✻ 100A1 Liquefied Gas Carrier, Ship Type 2G, Methane (LNG) in independent spherical tanks type B, Maximum vapour pressure 0.25 bar, Minimum temperature \(-163\)\(^\circ\)C, ShipRight(SDA, FDA plus(50,WW), CM, ACS(B)), *IWS, LI, ✻ LMC, UMS, ICC with the descriptive notes ShipRight(SCM, BWMP(T)), ETA.

Structural Consideration focusing on the Tank Cover:

1. Tank Cover as a Protective Structure for the Cargo Tanks
2. Tank Cover as a Primary Hull Strength Member

Design Verification using LR’s ShipRight Procedures

Safety of overall ship arrangement in respect of:

1. LNG cargo manifold system
2. Arrangement of the cargo machinery room
Typical Fatigue Checking Locations on Tank Cover

- Upper and Lower Corners
- iwo Manifold Recess
- Aft Scarphing Structure
- Forward Scarphing Structure
- Opening iwo Cargo Tank Dome
- Knuckles iwo Cofferdam BHD

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Typical LNG Trading Pattern for ShipRight(FDA) notation

Trading Routes
North Sea – NE USA
North Africa – NE USA
North Africa – Gulf of Mexico
North Africa – N Europe
Middle East – NE Asia
NW Australia – NE Asia
SE Asia – NE Asia