



LNG Vessel Longevity

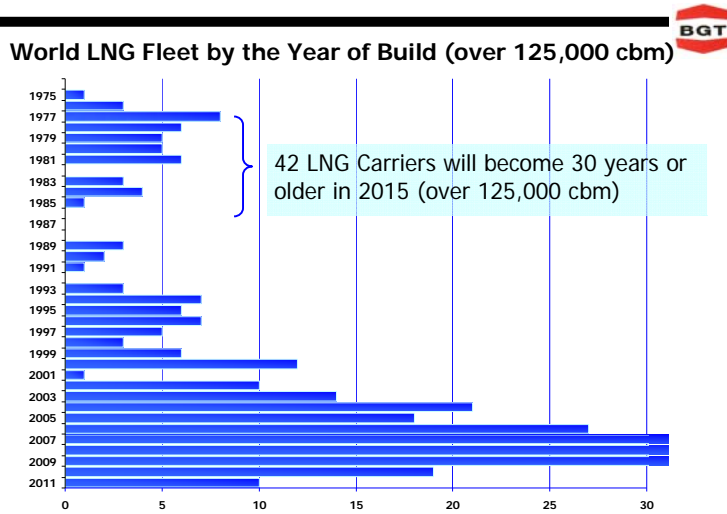
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<Introduction>

The working life of an LNG Carrier has the ability to go well beyond that of an Oil Tanker or Bulk Carrier. LNG is a non corrosive liquid and the vessels are over engineered and scrupulously maintained by an industry that guards its safety record. The question in the industry is, until what age is it viable for LNG vessels to trade in a safe and reliable manner.

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By 2010, 1st generation conventional size (125,000cbm -) LNG vessels over the age of 30 will total to 28 and within five years 14 more will join the club. As membership in the club is increasing, we foresee that ships' reliability and condition of those mature vessels will be of more concern by all stake holders of LNG transportation. Charterers have developed their own chartering standards, to guard the safety record of the industry. This can dynamically influence potential shipping procurement and replacement demands.



BGT fleet (8 sister ships)

MOSS 5 Tanks 125,000 cbm class
Steam Turbine Driven LNG Carrier
Builder: General Dynamics (Quincy)



Vessel	Year Built	Trade
LNG Aquarius	1977	Ind.. – Korea
LNG Aries	1977	Qatar – Spain
LNG Capricorn	1978	Ind.. – Japan
LNG Gemini	1978	Ind.. – Japan
LNG Leo	1978	Ind.. – Japan
LNG Libra	1979	Ind.. – Japan
LNG Taurus	1979	Ind.. – Japan
LNG Virgo	1979	Ind.. – Japan

BGT Limited controls and operates a fleet of eight identical 125,000cbm class Moss Rosenberg type LNG carriers. These vessels were built in succession between 1977 and 1979 by the Quincy Shipbuilding Division of General Dynamics in the US. From each vessel's delivery until the end of 1999, all eight vessels served in the Indonesia to Japan trade under a transportation agreement with PERTAMINA.

From January 2000, six of the eight vessels were extended in the Indonesia to Japan trade under a long term time charter arrangement. This charter arrangement will run to the end of 2010. The remaining two vessels were employed under alternative short term charters and are now employed on long term charters in LNG projects, serving Europe and Korea from Qatar and Indonesia. At the end of 2007, the BGT fleet has successfully delivered more than 4,500 cargoes.

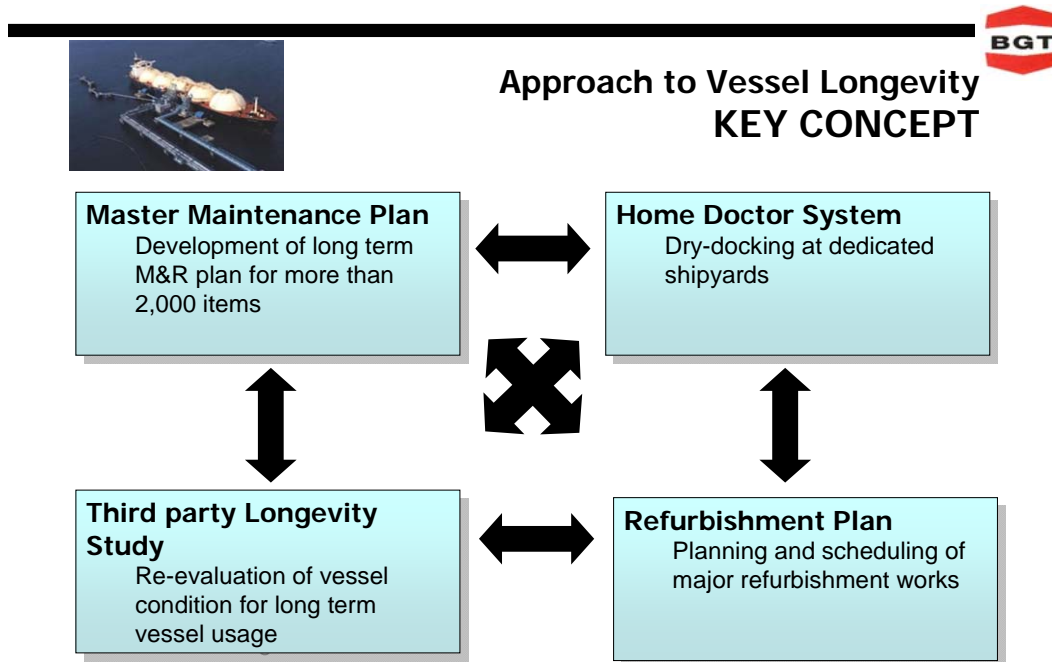


Approach to Vessel Longevity

In past conferences, philosophy and techniques have been introduced to identify vessel longevity, this time as an owner of a mature fleet, BGT would like to share its approach and experiences to LNG Vessel longevity.

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<BGT's approach to vessel longevity>



There are four key approaches;

In 1985, under a Home Doctor system, a long term drydocking contract was established with KHI Sakaide and MHI Nagasaki. This arrangement had numerous advantages. It assured the timely availability of yard space and workers, and allowed the shipyards to familiarize themselves with the ships' unique characteristics, such as ship equipment, operating requirements, structure and coatings, which gave a huge advantage in reassessing the vessels' condition at every drydocking cycle.

In 1988, with support by the Home Doctors and the project partners, a Master Maintenance Plan was established to cover the maintenance and repair specifications up to 2000. This plan was developed in order to conduct a technically and economically efficient maintenance and repair plan for both onboard and periodical drydocking, for more than 2,000 items on a long term basis, including preventive maintenance. Criteria to repair, replace and upgrading of equipment and systems was determined for all the items to be satisfactory over the years. Since then, the Master Maintenance Plan is continually updated, considering the vessels' conditions and the results of the third party longevity study.

Regarding the Longevity Study

In 1994 to 1995, when the fleet was on average 17 years old, the 1st longevity study was conducted to ensure the reliability of the fleet up to at least 2010, at which time the fleet will be on average 32 years old. Although the BGT fleet is classed by ABS, BGT appointed Lloyd's Register as the third party class society, to conduct a longevity study on the BGT fleet. Lloyd's Register performed extensive inspection surveys, as well as reviews of maintenance records and a stress/fatigue analysis for both, hull and cargo containment systems. A similar study was performed by Lloyd's in 2005 to ensure the reliability of the fleet up to at least 2020, at which time the BGT fleet will be on average 42 years old. Appointment of a third party consultant was to leave out the economics

and purely concentrate on the technical aspects to re-assess the condition of the fleet and to obtain a recommendation of vessel longevity and required refurbishment to ensure safe and reliable operations for the duration of the period.

In addition to the continuous and comprehensive preventive maintenance program, certain refurbishment work is planned and scheduled under the following categories

- Major maintenance work being conducted once in a life time for extended usage of the fleet;
- Renewal and modification of equipment, which is considered to be obsolete; and
- Recommended items from Lloyd's structural work.



Approach to Vessel Longevity BGT's ONE DECADE APPROACH

2nd DECADE of vessel life (1990 to 2000)

- Full recoating of Water ballast tanks were performed in 1985 - 1989
- Master Maintenance Plan for the 1990's was developed in 1988

3rd DECADE of vessel life (2000 to 2010)

- 1st Longevity Study was conducted by Lloyds Register in 1994
- Master Maintenance Plan was reviewed for the 2000' in 1999

4th DECADE of vessel life(2010 to 2020)

- 2nd Longevity Study was conducted by Lloyds Register in 2005
- Master Maintenance Plan for the period beyond 2010 is under review

<BGT's one decade approach>

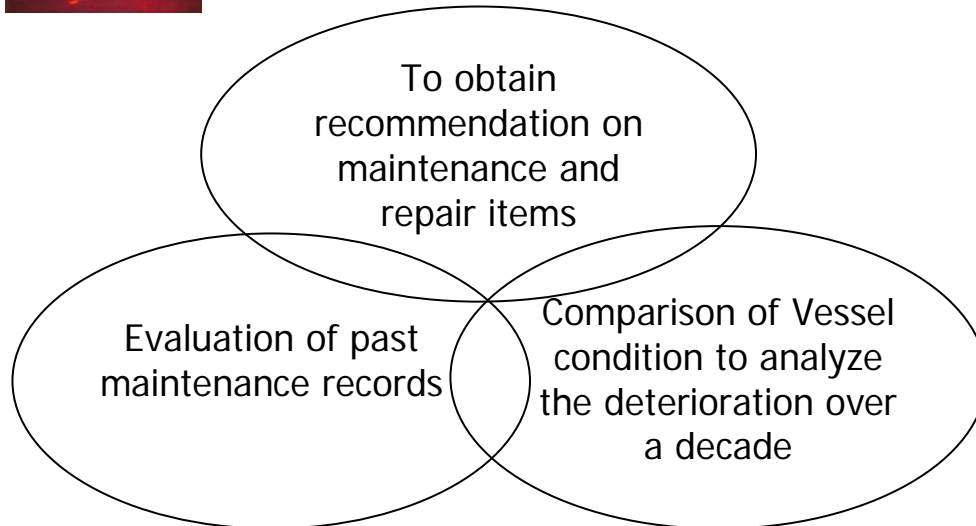
Maintenance plans of vessels differ by the expected working life set by the owners. BGT has taken a one decade at a time approach to ensure safe and reliable transportation.

The First step is to establish a Master maintenance plan to cover the coming decade. Then in the middle of the decade, by the longevity study approach, re-assessment will be made to update the Master Maintenance Plan to reflect unpredicted vessel condition, and to receive an opinion whether the vessel will be suitable for another decade along with the technical requirements to fulfill. Finally, in the latter part of the decade, considering the vessel condition, a longevity refurbishment execution plan and Master Maintenance Plan to cover the following decade will be made.



Third party Longevity Study

Objective to obtain purely technical analysis



<Third Party Longevity Study>

BGT decided to appoint a third party consultant to perform a longevity study, with an objective to obtain a purely technical recommendation on maintenance and repair items, to evaluate the past maintenance records and to compare the vessel condition with the past study, in order to analyze the deterioration occurrence over a decade.

Principle procedures were (1) examination of the classification society's records to identify recurring defects from historical records, (2) examination of the vessels' and onboard operational records to determine the history of equipment failures, record keeping procedures and condition of machinery equipment during sailing, (3) condition assessment program to analyze the current condition of the vessels, (4) structural integrity analysis to evaluate the life of the hull structure using ultrasonic thickness gauging of the steel coatings and (5) a machinery maintenance management study to provide a regime and identify strengths and weakness of the current maintenance system, in order to indicate that current maintenance management is suitable to control related risks during the life extension period up to at least 2020.



Comparison of Vessel condition (Hull dept.)

Items	Hull structure	Water ballast tank coating
1994 Study	Steel renewal is not required due to diminution of materials but certain areas required future inspection and maintenance planning, mainly connection areas.	Steel work and detailed inspection and maintenance program was recommended.
2005 Study	Free from major defects. Recommend to continue regular inspection and maintenance.	Paint condition to be good albeit with minor places of paint breakdown (rust ratio approx. 1%).

<Comparison of Vessel condition>

Let me point out the significant items of the vessels condition when comparing the results of the 1994 and 2005 longevity studies;

Regarding the Hull Structure;

The fleet experienced continuous fractures in the areas of connections between cargo tank covers and main deck. Trials and errors to rectify the situation were carried out, and finally we reached the method to release and absorb the stress. After the modification, fractures were not experienced. Another area where we have been experiencing fractures is inside the water ballast tanks. During the 2005 Longevity Study, small cracks were found by the inspector and were rectified in accordance with the recommendations.

Regarding the Water Ballast Tank Coating;

From 1985 to 1989, full blasting and painting to the entire area of the Water ballast tanks were conducted. In addition, stripe coats were applied by using rollers to the edges of the plates in order to maintain enough dry film thickness of Tar Epoxy paint. During the 1994 study, the vessels performed steel works following the given recommendation by the inspector.

After, evaluating the good paint film condition and low rust ratio, in 2005 sacrificial anodes were installed in all of the ballast tanks. The specification of sacrificial anode installation was concluded on the assumption of 3-% rust ratio although the visual rust ratio is 1 %. With proper maintenance, paint adhesion power to the steel still remains in good condition.



Comparison of Vessel condition (Machinery / Cargo tank)

Items	Machinery	Cargo Tank Insulation
1994 Study	Recommended to continue and upgrade the Master Maintenance Plan to form an essential ingredient in the operation of the fleet.	Renewing the insulation along with the fitting of an effective vapor barrier was recommended.
2005 Study	Satisfactory condition. Effectiveness of the Master Maintenance Plan can be seen from the machinery conditions.	No deterioration in figures of BOG rate. Cold spot inspection revealed several areas of frost on each tank.

Continuing on with the comparison;

Regarding Machinery;

Considering the results of the Longevity study, BGT is confident with the maintenance program it has adopted over the years. Both the 1994, and 2005 results were satisfactory.

And finally regarding Cargo Tank Insulation

Cold spots were indicated during the 1994 study, thereafter modifications were made to the dome neck insulation, replacement of expansion rubber on the dome top and the inspection and reinforcement to the dome-neck plywood in order to prevent the moisture ingress into the cargo tank insulation. In the 2005 study, some cold spots were indicated, but, considering there was no deterioration of BOG rate, BGT decided to only monitor the condition of the insulation.



Structural integral analysis Key items for Longevity (Hull Structure)

Basic hull structure possess satisfactory strength and fatigue endurance to at least age of 42.5 years.

- Continual maintenance to deal with local cracks are required;
- Connection to longitudinal in the ballast tanks
- Transverse frame connections
- Transverse bulkhead stiffener connections
- Expansion boxes in the cargo tank covers
- Fairing plates attached to the bulbous bow

<Structural Integrity Analysis>

Hull Structure

Structural analysis of one hold, typical of the No. 2, 3 and 4 holds were carried out and hull section thickness measurements at three girths and associated calculations of hull section moduli for comparison with required standards were also included in the assessment.

By the analysis, the basic hull structure is considered to possess satisfactory strength and fatigue endurance to 42.5 years age, provided coatings are maintained. The critical areas with attention are concluded to be

- Connection to the longitudinals in the ballast tank spaces;
- Transverse frame connections;
- Longitudinal girder connections;
- Transverse bulkhead stiffener connections to longitudinals;
- Expansion boxes in the cargo tank covers; and
- Fairing plates attached to the bulbous bow.

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Key items for Longevity (Cargo tanks)



Non-destructive examination in Cargo tank No. 1
In-cargo tank inspection (equator zone to the tank bottom)



Following the fatigue and crack propagation analysis, full Non-destructive examination of the No.1 cargo tank was conducted, to re-assess critical welds. It was reported that no crack like defects were identified by ultrasonic testing.

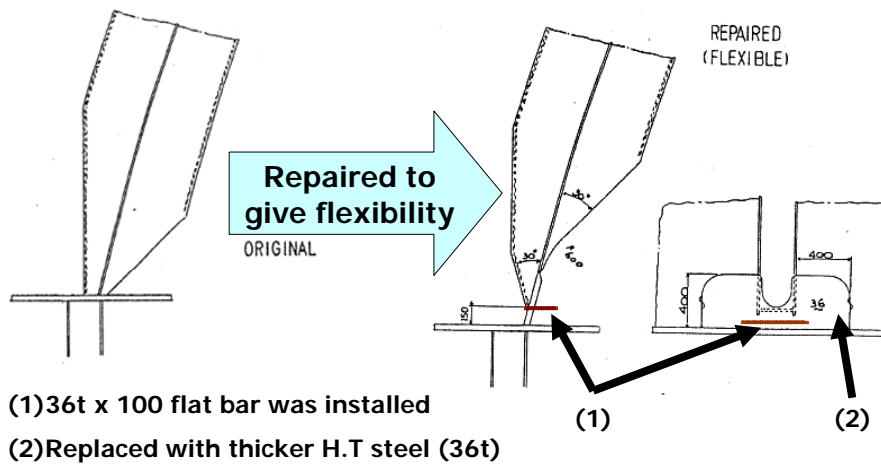
From the evaluation given on the No.1 tank, where the biggest stress occurs among the 5 tanks, it was concluded that the shell structure of the no.1 to 5 tanks were found to be safe for operation until 2020. Considering trading on severe conditions, it is recommended to have a Non-destructive examination around 2015, for re-evaluation of the condition.

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<Connection of Main Deck and Dome Cover>



**Example of repair work carried out for Longevity
Connection of Main Deck and Dome Cover**



Experiencing trials and errors to reinforce the area of connection of main deck and dome cover, BGT decided (1) to install flat bar on the end part of box girder and (2) to employ thicker plate to dome cover plate on the end part of box girder. By employing the modifications to the area to release and absorb the stress, ship has not experienced cracks on the areas. We believe the experience has contributed to new ship buildings at the home doctors.



Major Refurbishment Works (prior to 2000)

- Refurbishment of Water Ballast Tanks
 - Recoating of Tanks
 - Installation of brackets and stiffeners
- Replacement of
 - Cargo / Ballasting Consoles
 - Liquid Header Insulation
 - Rudder Carrier Bearings
- Repair of Cargo Dome Insulation
- Upgrading of
 - Steering Gear Systems
 - Bow Thruster

<Major Refurbishment Works>

Major refurbishment items prior to 2000 included the refurbishment of water ballast tanks including full recoating of the tanks and installation of brackets and stiffeners, replacement of the cargo and ballasting consoles identified to be obsolete, the liquid header insulation and the Rudder Carrier Bearings, upgrading of the steering gear system and the Bow thruster and repair of cargo dome insulation.



Major Refurbishment Works (post 2000)

- Installation of Sacrificial Anode in Water Ballast Tanks
- Replacement of
 - Control Air Compressors
 - Main Switchboard Breakers
 - Insulation of Cool Down Lines
 - Integrated Throttle Control Systems
 - Anchor chain and cable
 - Boiler tubes
 - BOG line insulation
- Upgrading of Boiler Management Systems
- Reinforcements to Cargo Tank Dome Necks



Major refurbishment items post 2000 included installation of sacrificial anodes in water ballast tanks, replacement of control air compressors, main switchboard breakers, insulation of cool down lines, integrated throttle control systems, anchor chain and cables, boiler tubes, BOG line insulation, upgrading of boiler management systems to increase boiler quality and reinforcements to cargo tanks' dome necks.



KEY FACTORS

- Proper Long term maintenance program and its Execution
- Vessel Life Expectation Target
- Third party technical assessment
- A proper Monitoring and Feed-back System

Conclusion

- Vessel Age should ***not*** be the key factor of evaluation, actual vessel condition and proper maintenance program should be evaluated.

<Key factors and conclusion>

From BGT's experience over 30 years in the LNG Shipping Industry, the key factors for vessel longevity are

- To establish an extensive long term maintenance program and its execution;
- To elect vessel life expectation targets;
- Third party technical assessment to purely focus on the technical side to assess vessel useful life; and
- To implement a monitoring and feed back system which allows continuous updates in the maintenance plan.

In conclusion,

Vessel age should not be the key factor of evaluation, actual vessel condition and proper maintenance programs should be evaluated.

If age restrictions cloud the market, none of the parties will benefit. Shipowners of mature vessels will not be able to seek long term charters, which will discourage the extensive maintenance program, thus impacting safety and reliability. This can eventually damage all the stakeholders in the LNG market. It is our sincere hope that vessels will be evaluated based on actual conditions, not solely on age.

Thank you.

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