KUALA LUMPUR 2012 WORLD GAS CONFERENCE

25th world gas conference

"Gas: Sustaining Future Global Growth"

REDUCTION OF BOIL-OFF GENERATION IN CARGO TANKS OF LNG CARRIERS

Recent Developments of GTT Cargo Containment Systems

By: David COLSON, Commercial VP

Date: June 5th 2012

Venue: Kuala Lumpur

Patron

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INTERNATIONAL GAS UNION
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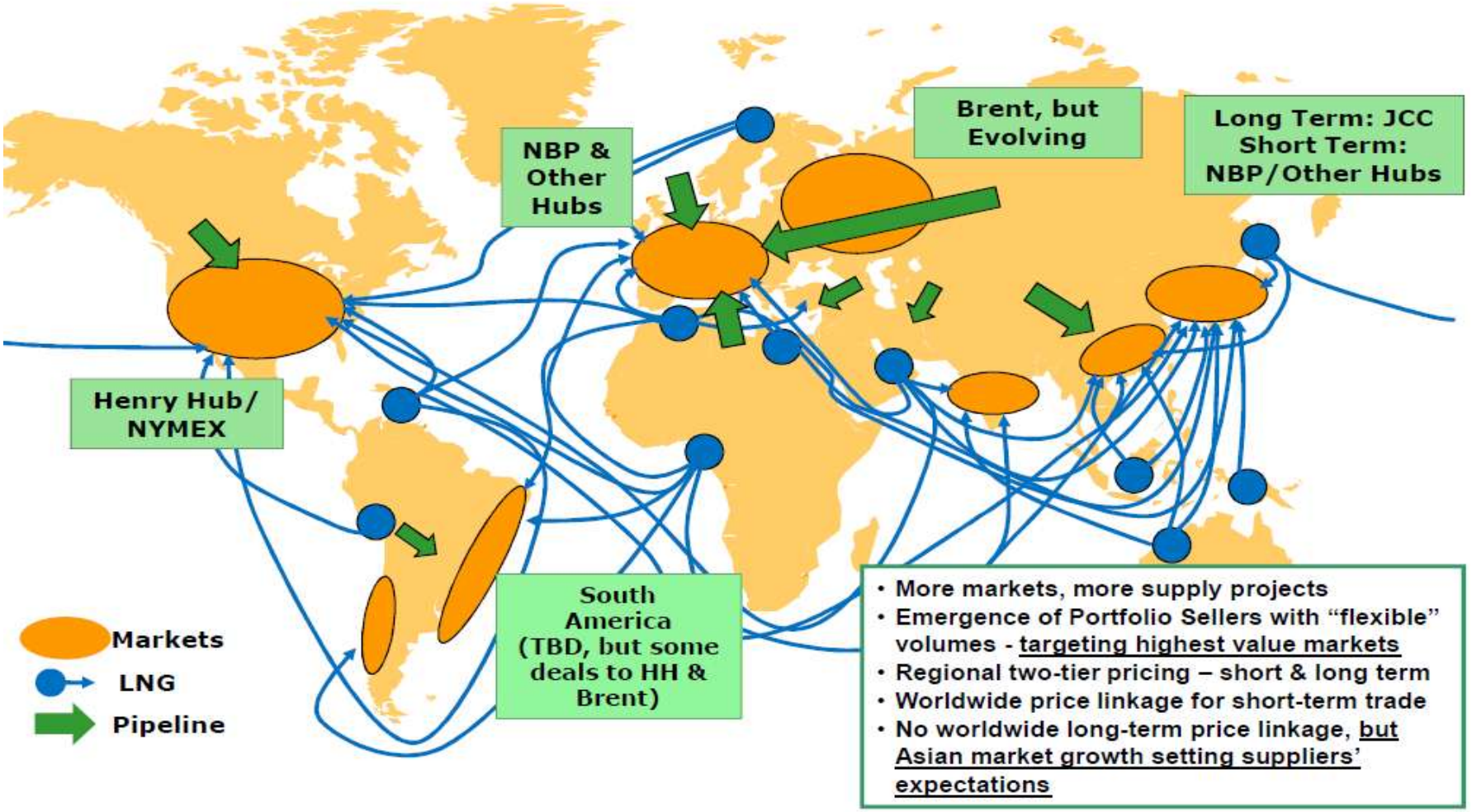
Presentation overview

- Trends in LNG Trade
- Changes in Propulsion Systems
- Optimization of Fuel Consumption
- Greener Fleet
- GTT Low Boil-Off Developments
- Conclusion

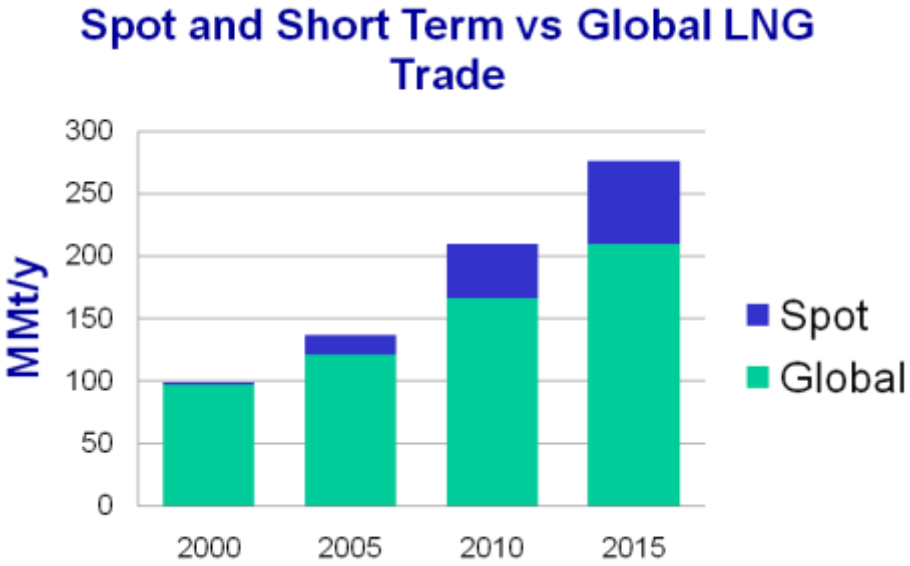
A new Dynamic Market



Source: Galway Group, 2012

A new Dynamic Market

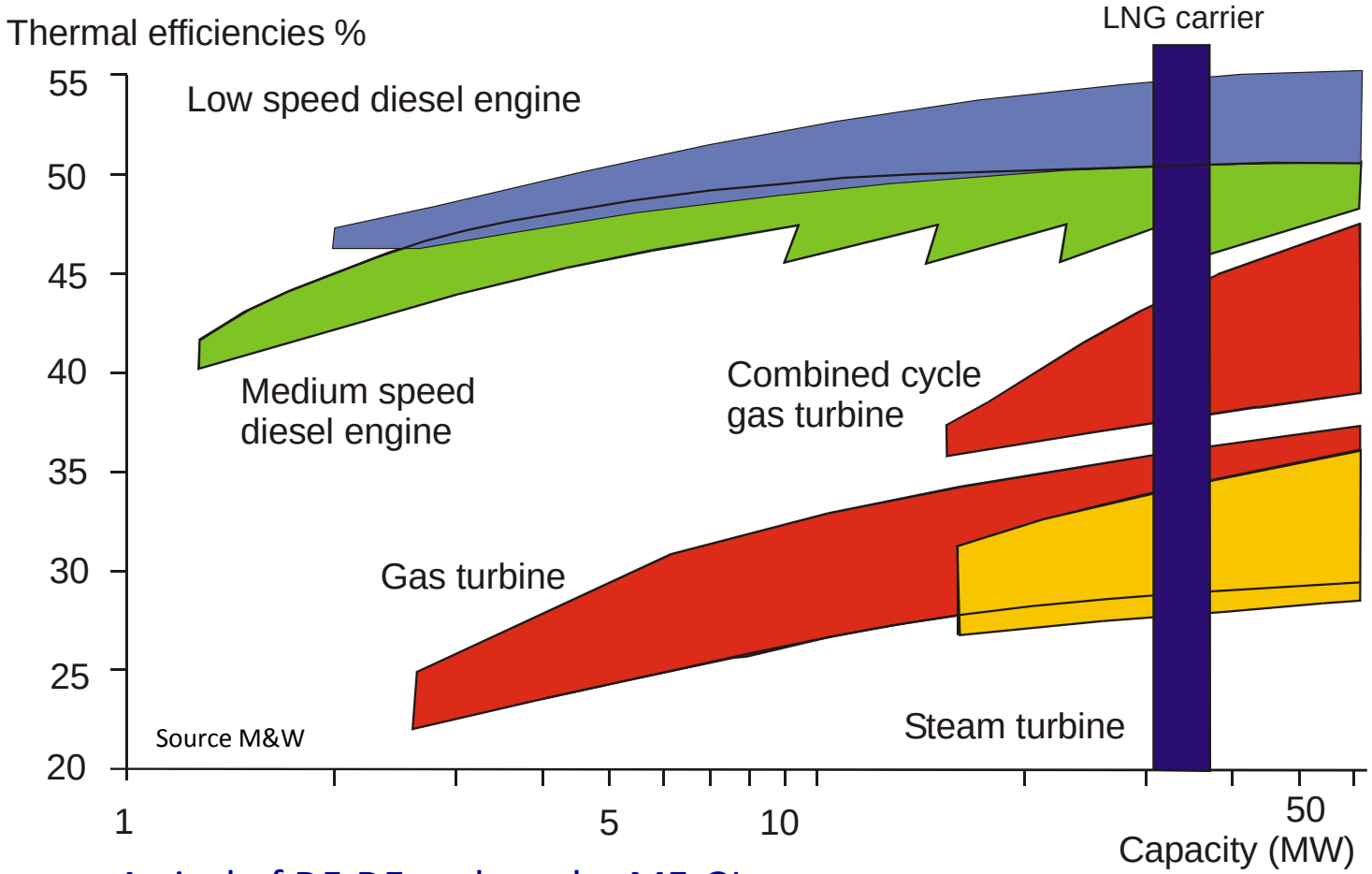
- Largest share will remain intra-regional trade
- Cross-basin trades are the most ship intensive
- Spot and short-term trades could rise to 24% by 2015



Source Poten & Partners

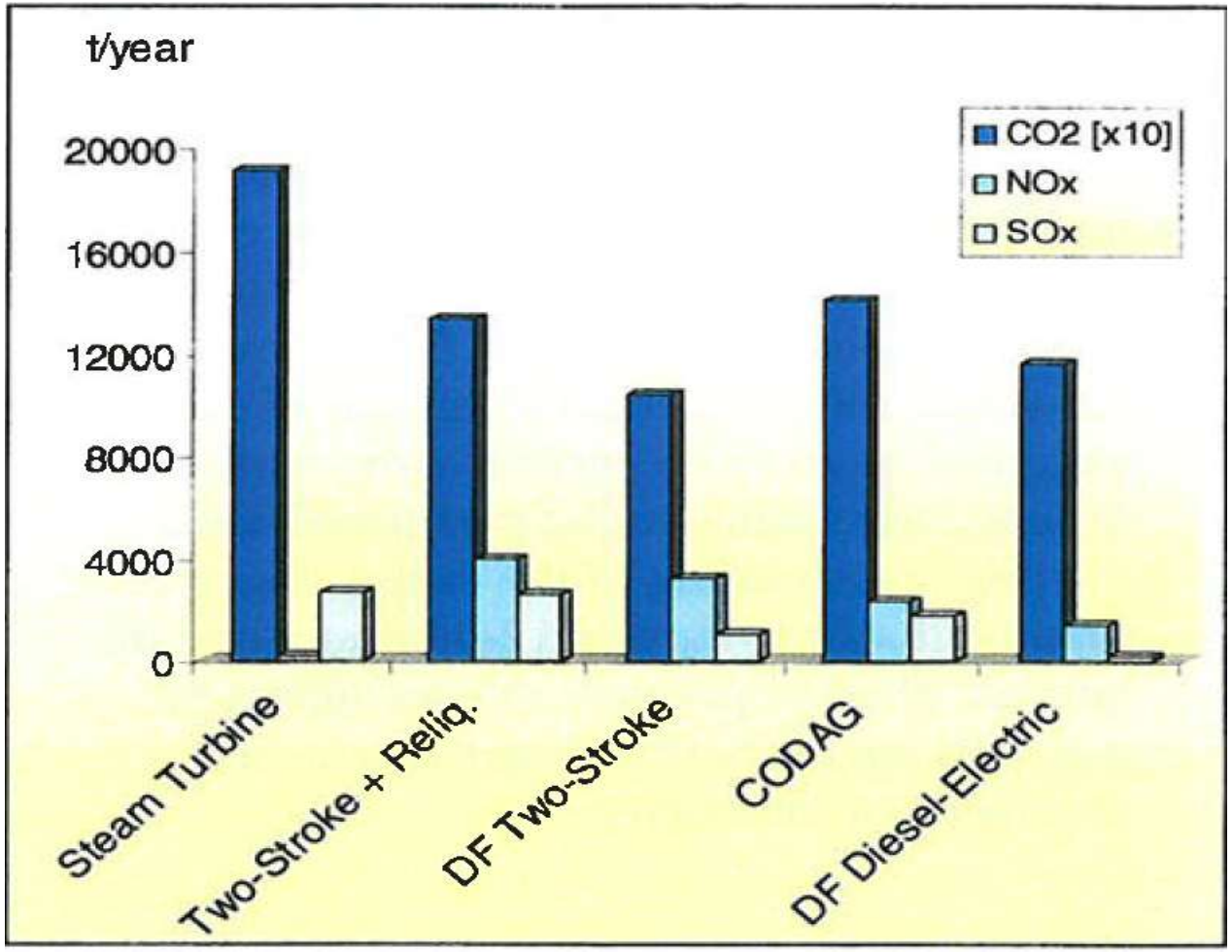
- Average shipping distance for LNG trade is projected to rise to around 4.200 nm in 2015
- In 2000, 63% of trade was at distances less than 3.000 nm.
- Increase due to a more dynamic LNG market and increasing cross-basin trade

New Propulsion - Typical thermal efficiency of prime mover



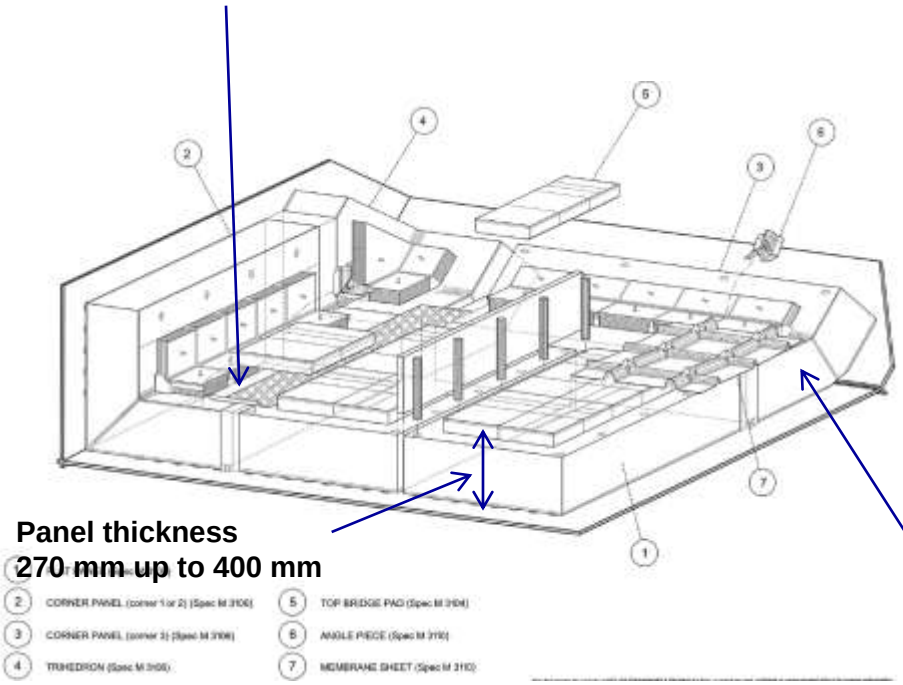
Arrival of DF-DE and maybe ME-GI

Green - Exhaust emissions for a 150 000 m3 LNG carrier



Mark III Flex : Requirements & Developments

All « PU » adhesive for bonding of secondary barrier



Panel thickness
270 mm up to 400 mm

- Strength Increase
  - The main evolution retained consists in increasing the foam density which provides higher compressive strength
  - The MARK III FLEX project will take benefit from the "all PU" bonding development

- **BOR Performance**
  - The thickness of insulation panels will have to be increased to comply with the conventional 0.15% BOR in case of higher density foam
  - The increase of insulation thickness will also provide lower BOR in case of standard density foam use in order to reach an objective of **0.1% BOR**

Foam density
130 kg/m3
up to 210 kg/m3

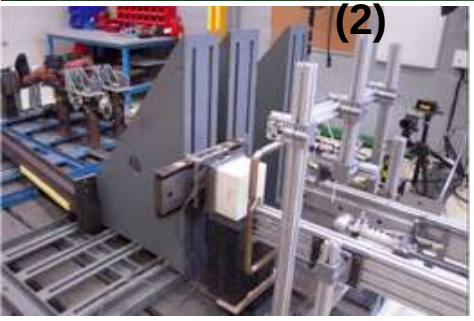
Mark III Flex : Qualification Program

(1)

- This extensive qualification program includes :

  Static and fatigue tests (1), bending tests(2), impact tests (3), material tests (4), finite element analyses (5) and mock-up tests (6)

(2)



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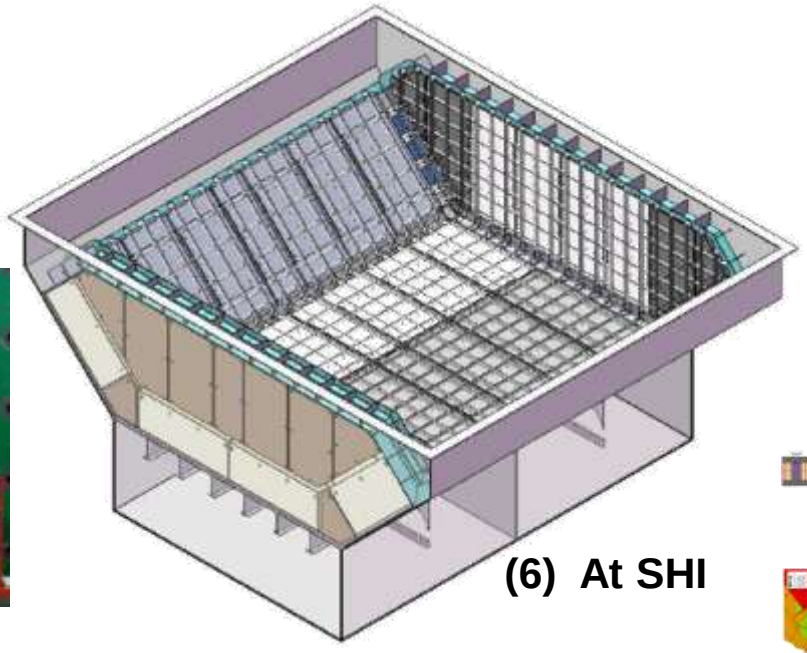

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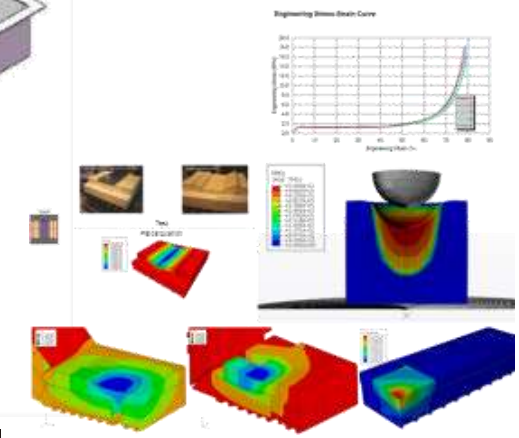
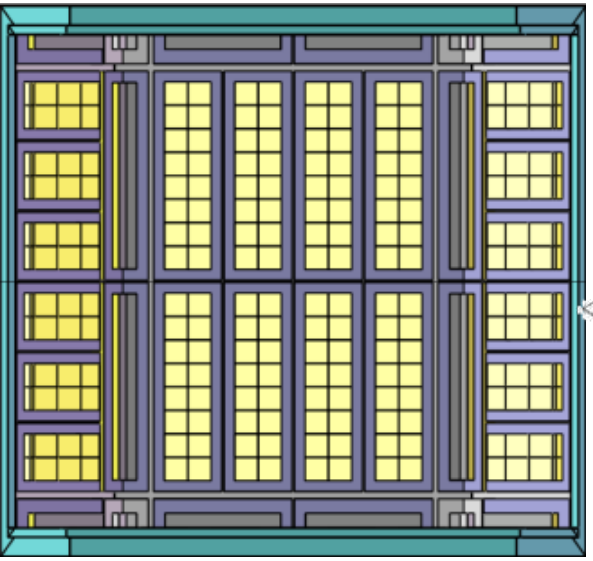
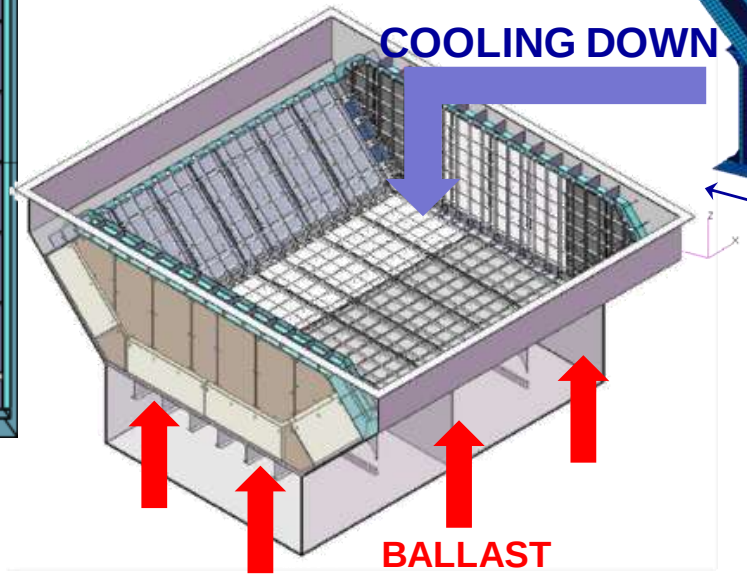


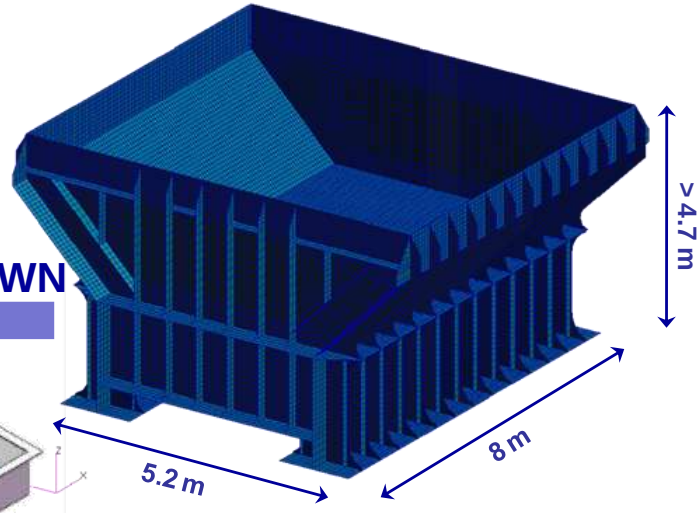
(5)

Mark III Flex : Mock-up tests (6)

- The purpose of these tests was to check that the global functions of the new CCS Mark III Flex are fulfilled under ballast conditions :
  - Secondary barrier tightness
  - Panel / hull anchoring







Mark III Flex : Summary results

- All the studies have provided satisfactory results.

- Fatigue tests demonstrated the ability of the CCS Mark III Flex made with HD foam and PU glue to withstand :
  - Full thermal cycles;
  - Ship bending cycles;
  - Repetitive sloshing events .

- The panel / hull anchoring was remaining fully satisfactory when submitted to bending test and mock-up ballast tests.

- Flooding tests have proven satisfactory behaviour of the secondary membrane in accordance with IGC requirements.

NO96: Requirements & Developments

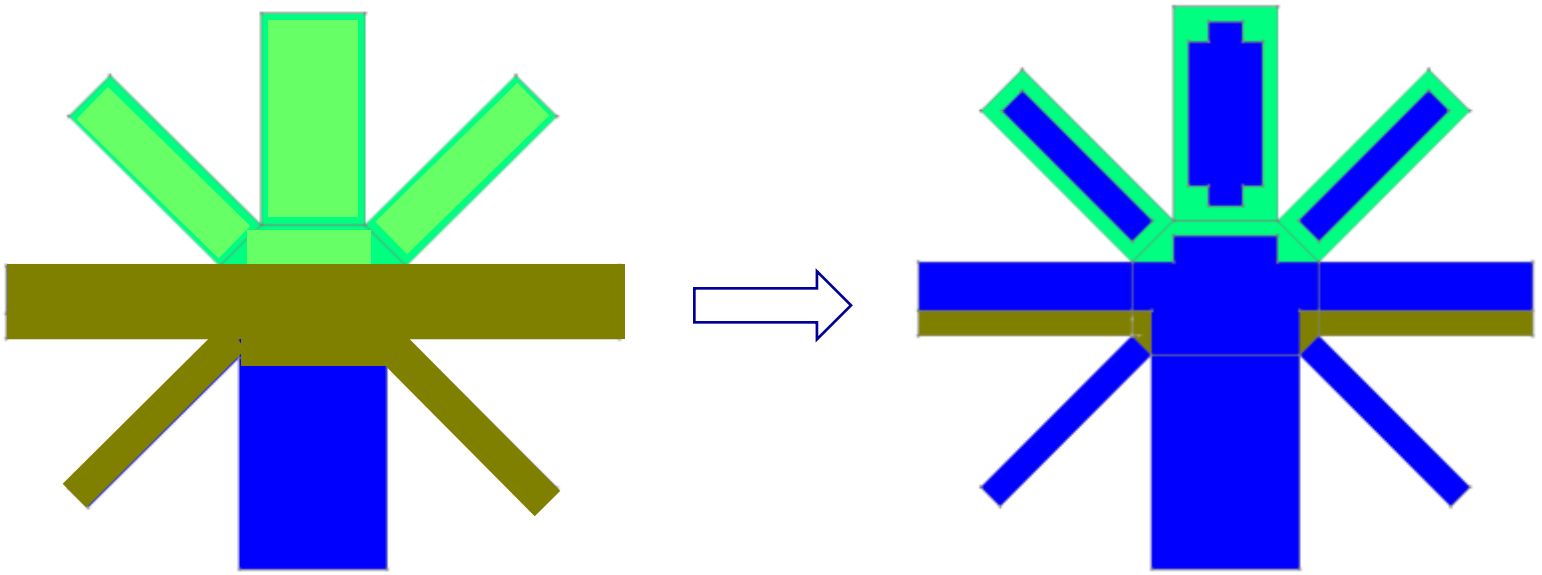
BOR Performance

Many options have been assessed:

- Optimizing the Cargo Containment Sytem reinforced areas
- Using different insulation material such as Glass Wool
- Solutions including modifications of the insulation layers in order to reach an objective of **0.1% BOR.**

Optimization of box configuration

Reinforcement are limited to sloshing areas



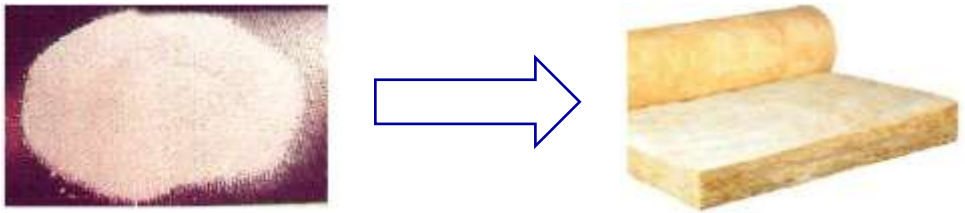
Standard box

Reinforced box

Ultra-reinforced box

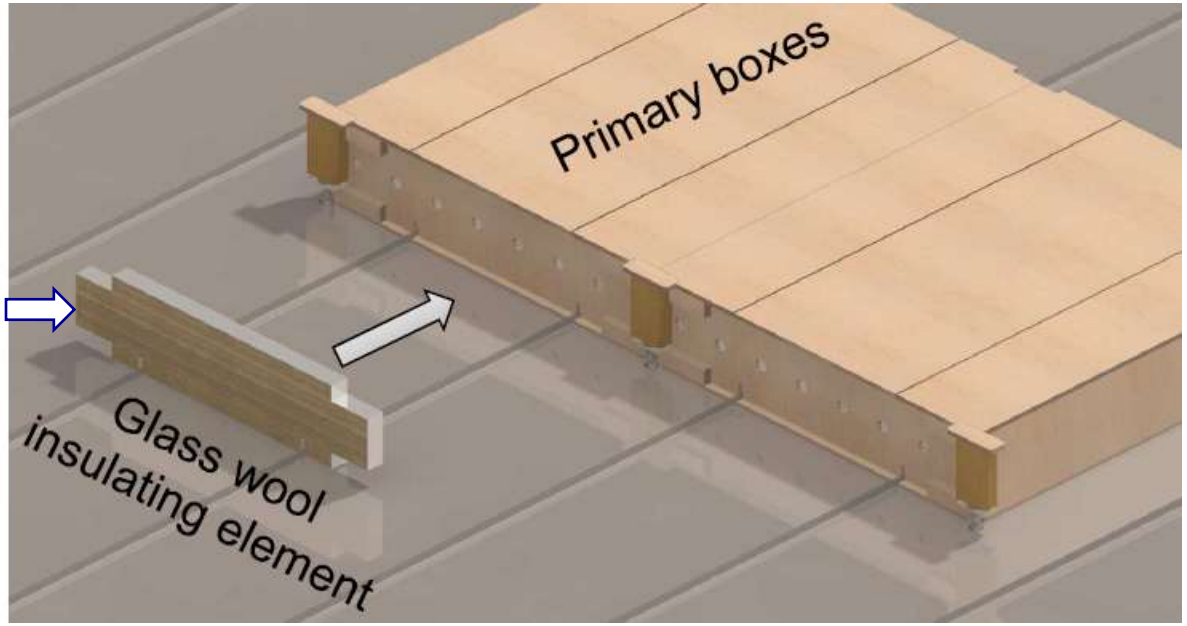
Change of insulation material inside boxes

Usual Insulation inside boxes: Perlite

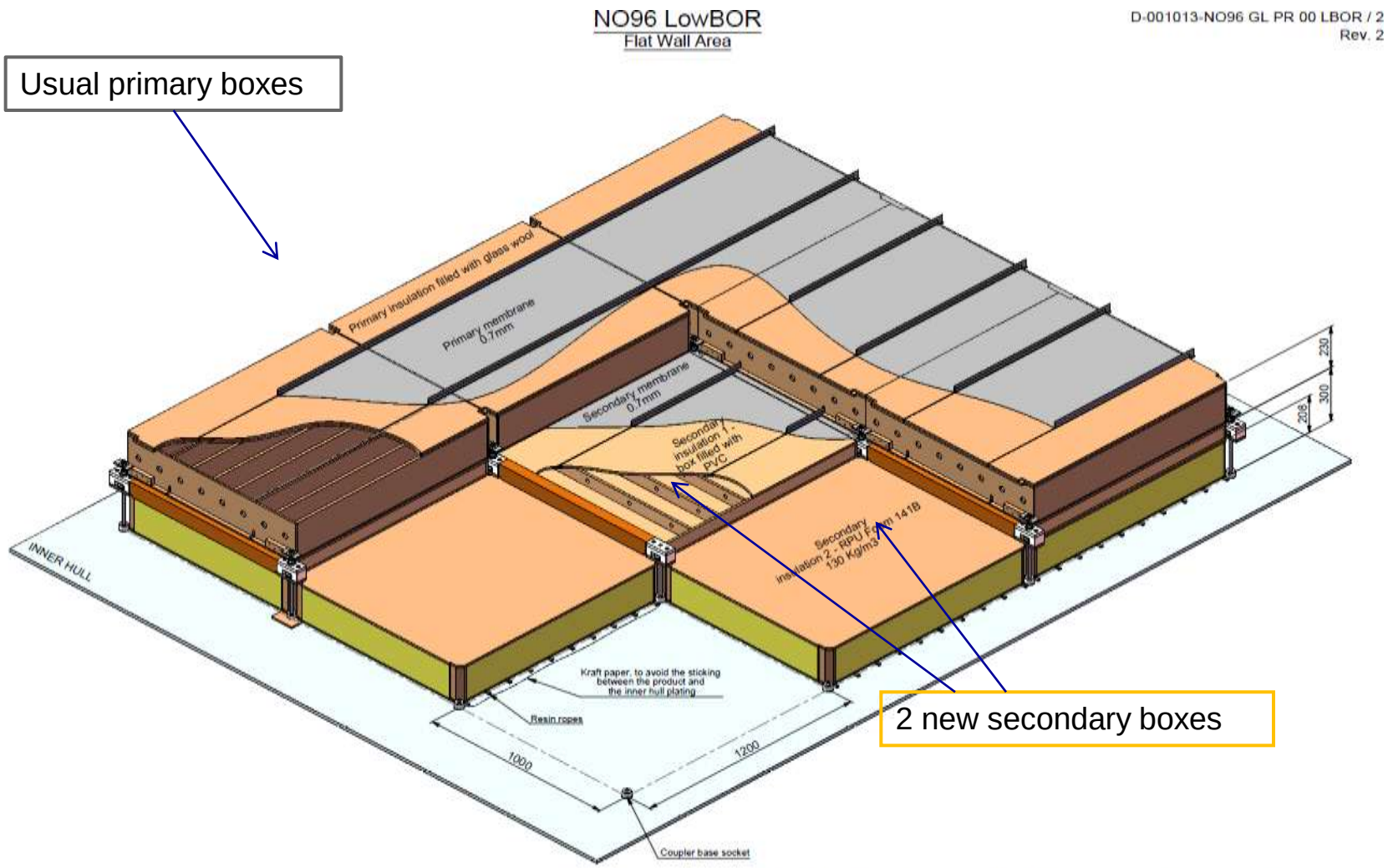


Change of material inside boxes: Glass Wool

Already used in the NO96 technology



New secondary boxes for the Flat Wall area



NO96 improvements: Lower BOR

For a typical 170K LNGC

- Standard NO96 CCS BOR around 0.15%
- Optimization of boxes distribution BOR around 0.14%
- Optimization of boxes distribution and glass wool instead of perlite in the primary and secondary boxes BOR around 0.12%
- 3 layer solution BOR around 0.10%

Class AIP recieved

Marine Design Appraisal Document

APPROVAL IN PRINCIPLE

ABS

Ref.: TASK# 788432 - AIP
Date: 26 August 2011

Approval in Principle

Gaztransport & Technigaz, France

GTT Mark III Flex Concept

ABS CORPORATE Technology

Yung S. Shin,
Head of Cargo Containment
Systems Group

DET NORSKE VERITAS

APPROVAL IN PRINCIPLE

This is to verify that the design principles of the

Mark III FLEX membrane type containment system for LNG

have upon request by:

Gaztransport & Technigaz S.A.s

Basis for Approval

- DNV Rules for Ships Pt.5 Ch.5, January 2011
- IMO IGC Code

Conditions and Assumptions for Approval

- The conditions for the Approval in Principle and General Approval for Ship Applications are given in letter NACNO385/TOOE/P13803-I-49, dated 2011-06-24.
- Before construction and installation onboard any particular ship or object subject to classification, a complete set of documentation relevant for the particular ship is to be approved by the Society according to normal classification procedures.

DET NORSKE VERITAS AS

Cargo Handling and Piping Systems

MK III Flex & NO96 Conclusion

- Mark III Flex has been ordered for 0,1% BOR for 25 vessels since April 2011
- NO 96 with Glass Wool with a BOR around 0,125% has been ordered for 2 vessels in 2012
- NO96 with 3 layers and a BOR of 0,108% (160k LNGC) has been ordered for 11 vessels since September 2011
- First deliveries in 2014
- GTT are looking at further future improvements.

Thank You

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