CNG Transportation under the GASVESSEL project perspective

EASTERN MEDITERRANEAN GAS CONFERENCE

ABS CNG Carrier Experience

- Major Ship Class Society, Leader in Oil and Gas and Offshore industry
- In the forefront of CNG Technology development, consistently with our mission
- Approved more than 13 design concepts either at AiP or FDA stage
- FPC Lincoln – 40ft pressure vessels (cargo containers) certified by ABS 8 years ago for ship, truck and train tranportation without any major incidents recorded
- Regular Interaction with USCG and other Flag Administrations regarding CNG Projects

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ABS CNG Carrier Experience

- Dedicated engineering and survey staff to handle CNG Projects – more than 15 years of experience
- Participated in many studies and analysis for CNG Projects:
  - HAZID/HAZOP
  - Emergency Systems and Survivability analysis
  - Temporary Refuge, Escape and Rescue
  - Gas Dispersion and Gas Dynamics
  - Fire and Explosion
  - Smoke and Gas Ingress
  - Inspectabilty
- First CNG Carrier in the world delivered in China with ABS Class in 2017
- ABS is currently participating in EU funded project – GASVESSEL www.gasvessel.eu

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ABS CNG Carrier - Experience

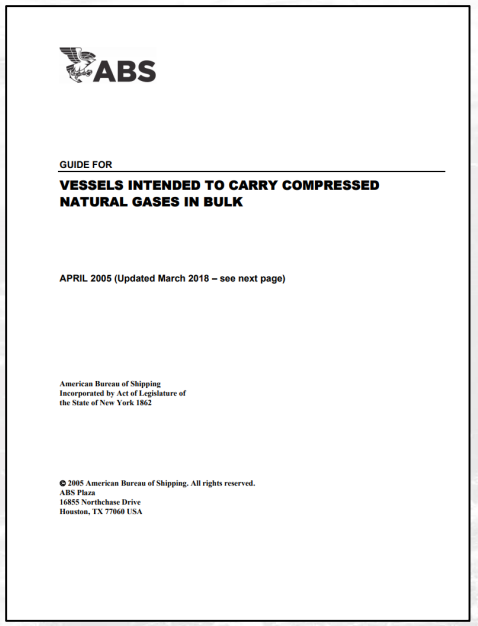
SYSTEM	CIMC-CNG Carrier	Sea NG	GEV	Ener Sea	Sea One	Neptune	Trans Canada	Trans Ocean Gas	Blue Power	FPC	Lincoln	Naval Progetti - CNGV	CS & Ass.
Type	Cylinder	Coiled pipe	Cylinder	Cylinder	Cylinder	Cylinder	Cylinder	Cylinder ISO Container	Pressure vessels	Cylinder ISO Container	Cylinder ISO Container	Cylinder	Cylinder ISO Container
Approval Status	Full Approval – 1st vessel built	Full Approval	Basic Design Approval	Full Approval	AIP	AIP	AIP	AIP	AIP	AIP	Full Approval – Container Certification	AIP	AIP
Design Basis	ISO 11120	ABS CNG Guide						ABS CNG Guide – ISO 11439	ASME / ISO	Code Case 2390/ ISO 11115-1 / ABS	ABS / ASME	ABS CNG Guide – ISO 11515 / 2013	ABS CNG Guide
Material	Steel cylinder	Steel pipe			Steel API SLX75	Composite reinforced steel pipe		Comp. glass or carbon fiber	Steel	Comp. Reinforced steel pipe	Comp. glass or carbon fiber with liner	Comp. glass & carbon fiber with steel liner	Comp. glass or carbon fiber
Pressure	300 bar	275 bar	250 bar	90-130 bar	199 bar	200 bar	250 bar	240 bar	275 bar	250 bar		250-300 bar	250 bar
Temp.	Ambient			-30 ºC	-40 ºC	Ambient		-40 ºC	-30 ºC	Ambient			
Diameter	610 mm	150 mm	500mm	1040 mm			1067 mm	2000 mm		1067 mm In containers		2500 mm	1067 mm

Regulatory Issues

- No International (IMO) code for CNG transportation in bulk
- Most flag States signatory to IGC applicable to liquefied gases (LNG)
- Provision for equivalents
- Receptive to Probabilistic Approach
- Use IMO Formal Safety Assessment (FSA) and Tripartite Agreement
- Tripartite Agreement – (Flag State + Export State + Import State)
- Early communication with Flag State and Local authorities is recommended

ABS Guide for CNG Carriers

- Developed based on same philosophies of IGC Code with equivalent level of safety
- Modified IGC code to account for:
  - Extended use of risk assessment (in line with FSA)
  - CNG containment system
    - Materials' requirements in fatigue and fracture limited applications
    - In-service inspection
    - Specific safeguards
    - Pressure protection in cargo holds
    - PV codes as applicable
  - Active and passive fire safety
- USCG was on the ABS CNG Guide technical committee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GUIDE FOR

VESSELS INTENDED TO CARRY COMPRESSED NATURAL GASES IN BULK

APRIL 2005 (Updated March 2018 – see next page)

American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862

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16855 Northchase Drive
Houston, TX 77060 USA

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ABS Approach to the Flag Administration

- ABS approach formally discussed with various Flag Administrations (Bahamas, Marshal Island and others) and USCG
- Ship design complies with
  - All SOLAS requirements applicable to a “cargo ship”
  - Applicable international (Load Line and MARPOL) and national regulations
- CNGC Ship will be designed, constructed and maintained in compliance with the structural, mechanical and electrical requirements of ABS
- CNGC design comply with ABS Rules and ABS CNG Guide
- Local requirements of export port and import state
- Formal Safety Assessment (FSA)

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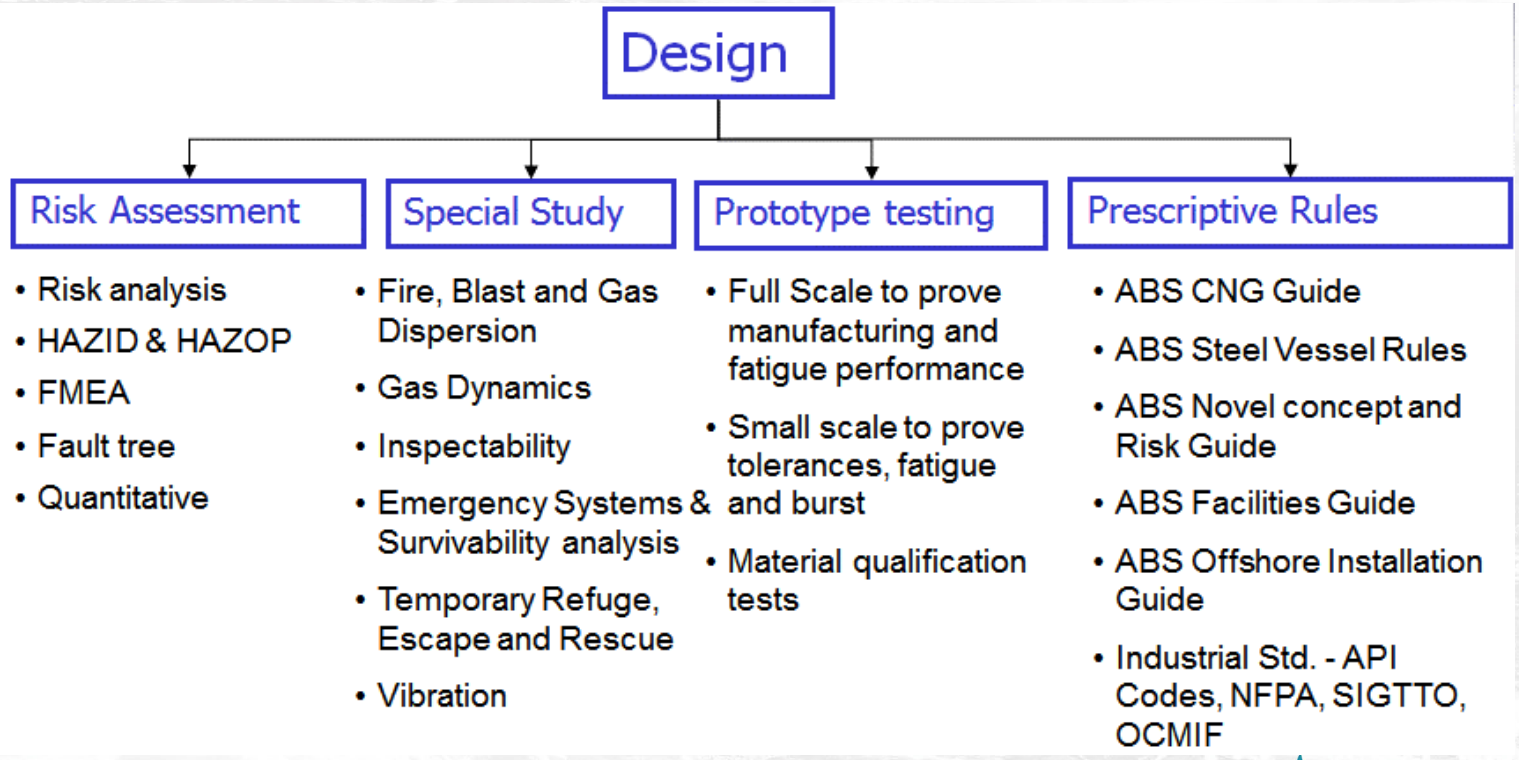
Design Assessment for CNG Carrier



Necessary Steps on a New CNG project

- Risk Assessment Plan
  - Provides a clear Road Map on how each aspect of the system will be addressed with regard to risk
  - Initiates the process of identifying and describing the novel aspects of the system as well as the associated interfaces with other conventional aspects of the ship
  - Provides the framework for ensuring all hazards and failure modes are identified and adequately addressed during the design development
- Quantitative Risk Assessment (QRA) of CNG Carrier Critical Systems
  - Containment system
  - Loading and cargo handling systems
  - Additional systems based HAZID, HAZOP or other risk studies

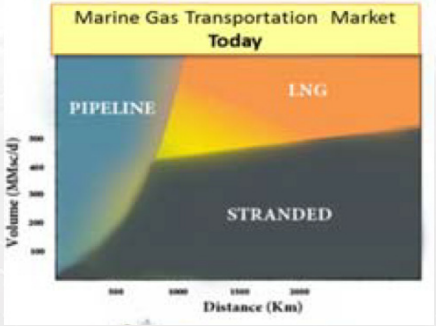
Risks / Hazards

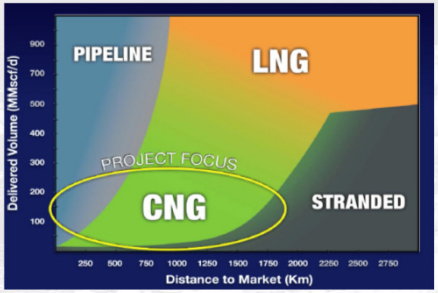
- Safety studies such as Gap Analysis and Risk Analysis to identify CNG hazards and requirements such as:
  - Over pressure of cargo hold from accidental gas release
  - JT effect and impingement of cooled gas
  - Dispersion of released high pressure gas
  - Jet fire
  - Radiant heat from fire
  - Asphyxiation due to dispersed CNG and N2
  - Corrosion by gas contaminants and marine environment (H2O, H2S, CO2)
  - Fatigue and fracture
  - Inspectability – during manufacturing and in-service
  - Fabrication and welding
  - Materials

GASVESSEL – EU H2020 funded project

Motivation

- EU dependency on imported Gas in 2014 was 70%
  (40% by one single supplier)
- Removing barriers to cost-effective transport will reduce the dependency from external sources
- EU consumption of Natural gas is increasing
- There are huge amounts of stranded gas and associated gas which is not used or wasted (flared)
- GASVESSEL Project concerns the development of a novel method for waterborne/land transportation and distribution of natural gas





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GASVESSEL – EU H2020 funded project

Outline

- Patented concept of CNG (Compressed Natural Gas) Pressure Vessel – 300 bar
- New conceptual ship design
- CONSORTIUM formed by 13 Partner Companies
- 8 EU Countries represented (Belgium, Cyprus , Germany, Greece, Italy, Norway, Slovenia, Ukraine)
- Project duration: 48 months (started June 1st 2017)
- EU contribution = Project's financial value = 12 M€

NAVAL PROGETTI TRIESTE

CNG-VD

ESTECO

cEnergy

SINTEF

PNO Connecting Ambitions

CHC

Hanseatic Lloyd

bm plus s.r.l.

DOW

DOWAKSA

PUBLIC JOINT STOCK COMPANY ENGINEERING AND PRODUCTION ENTERPRISE VNIPITRANSGAZ

ABS

GASVESSEL

European Commission

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GASVESSEL – EU H2020 funded project

Work Packages

- WP2: Analysis of 3 real-life geo-economical gas exploitation scenarios (East Mediterranean, Barents Sea, Black Sea)
- WP3: Design of Pressure Vessels and optimization process (Stainless steel liner + carbon/glass fibers Cylinder 300 bar, 70% lighter than any other previous technology)
- WP4: Pre-industrial Prototyping Pressure Vessels (custom built/self designed facilities in Italy, L= 11.5m, diameter 2.5 m)
- WP5: CNG Ship Design
- WP6: Loading/unloading systems
- WP7: Cost Benefit Analysis: define optimal composition of a fleet in order to minimize the transportation tariff.
- WP8: Class design review, Risk and Safety Assessments

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Achievements

- Full completion of the hydroforming equipment (design, construction, erection and testing).
- Complete knowledge of the technological behavior of liner base material.
- Identification of the necessary types of carbon fiber filament and resins suitable for the pressure cylinders.
- Validation of the welding process and methods for the liners.

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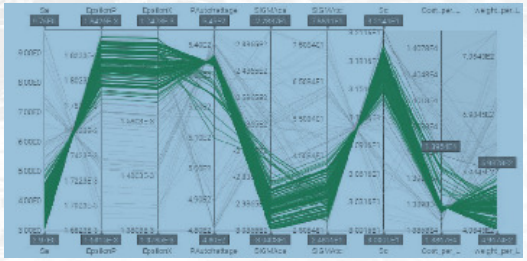
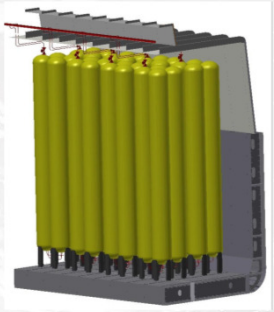
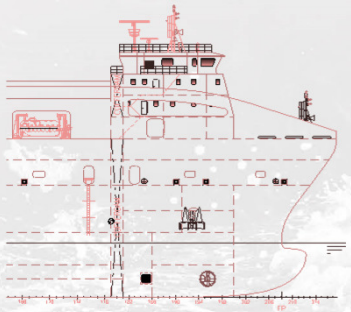
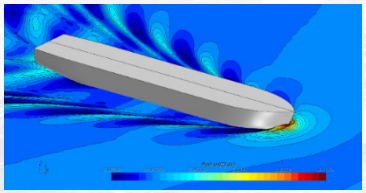
Achievements

- Development of the filament winding optimization software completed.
- 3 geo-logistic scenarios identification, and Decision Support Model realization.
- Project web-site realization and communication and exploitation systems set up
- CNG Ship Basic Design and tank tests
- HAZID workshop completed









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GASVESSEL – EU H2020 funded project

Goals and Prospects

- GASVESSEL concept is expected to open-up important business opportunities for European industry from shipbuilding, shipping, pressure vessels manufacturers, epoxy resin and carbon fiber manufacturers as well as oil and gas and energy production companies
- Perspective of initially 1 – 2 fully operational CNG ships by 2025
- GASVESSEL project will make the actual flaring of associated gas economically unattractive by delivering a commercially sustainable alternative to transport and utilize this gas

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Thank you