Lightweight Structures at Sea

A Classification Perspective

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MANAGING RISK DNV

Short Time-Out

As of 12 September 2013, DNV and GL have merged to DNV GL.

The new company DNV GL has started operating as one company with effect from 12 September 2013.

DNV GL forms the world's largest ship and offshore classification society, the leading technical advisor to the global oil & gas industry and a leading expert for the energy value chain including renewables.

DNV GL also takes the position as one of the top three certification bodies in the world.

Read more here: www.dnv.com/merger

Presentation Overview

- Prepared for Marine Lightweight Structures?
- Six Application Examples
- Future Work – Regulatory, Engineering, Manufacture and Materials

Disclaimer: the veracity of the factual content is not guaranteed by DNV and opinions are not necessarily those of DNV, but of the Author. Otherwise it is just fine.

Prepared for Marine Lightweight Structures?

1

A Definite Maybe:

- Aluminium
- Composites (Fibre Reinforced Plastics)
- Extra Extra Extra High Strength Steels.

Prepared for Marine Lightweight Structures?

2

Aluminium:

RULES FOR CLASSIFICATION OF

High Speed, Light Craft and Naval Surface Craft

PART 3 CHAPTER 3

STRUCTURES, EQUIPMENT

Hull Structural Design, Aluminium Alloy

JULY 2012

B. Structural Aluminium Alloy

B 100 General

101 Aluminium alloy for marine use may be applied in hulls, superstructures, deckhouses, hatch covers and sundry items.

B 200 Aluminium grades

201 Aluminium alloys are to have a satisfactory resistance to corrosion in marine environments. Grades for welded structures are to be weldable, applying one of the welding methods approved by the Society.

202 For major hull structural components, alloys with temper H116/H321 for rolled products, and alloys with temper T5/T6 for extruded products, are normally to be used. The use of 0- or F temper must be agreed with the Society.

203 The use of 6000 series aluminium alloys in direct contact with sea water may be restricted depending on application and corrosion protection system. The use of these alloys are to be agreed with the Society.

204 In weld zones (HAZ) of rolled or extruded products, the factor f_1 given in Table B4 may in general be used as basis for the scantling requirements.

205 Welding consumables are to be chosen according to Table C2 in Pt.2 Ch.3 Sec.2. The consumable chosen are to have minimum mechanical properties not less than specified for the parent alloy in the welded condition.

B 300 Chemical composition

301 The chemical composition is to satisfy the requirements in Pt.2 Ch.2. Other alloys or alloys which do not fully comply with Pt.2 Ch.2, may be accepted by the Society after consideration in each particular case. Special tests and/or other relevant information, e.g. which confirm a satisfactory corrosion resistance and weldability, may be required.

Focus areas:

Sea water resistance

Welding processes

Fatigue

HIGHLY DEVELOPED RULES AND PRACTICES

Prepared for Marine Lightweight Structures?

3

Composites:

RULES FOR CLASSIFICATION OF

High Speed, Light Craft and Naval Surface Craft

PART 3 CHAPTER 4

STRUCTURES, EQUIPMENT

Hull Structural Design, Fibre Composite and Sandwich Construction

JANUARY 2013

B. Application of Materials

B 100 Hull and superstructure

101 The resin in hull and superstructure may be polyester, vinylester or epoxy. Other types of resins may be accepted based on special consideration.

102 When using polyester, Grade 1 polyester is to be used for the hull shell laminate in single skin constructions and for the outer hull skin laminate in sandwich construction. For the inner skin laminate and superstructure Grade 2 polyester may be accepted. Specifications for Grade 1 and Grade 2 resins are given in Pt.2 Ch.4.

103 The outer reinforcement ply of the hull laminate (outer skin on sandwich panels) shall provide an adequate barrier against the penetration or absorption of water in the laminate. This also applies for areas inside the hull expected to be continuously exposed to water submersion (i.e. bilge wells, etc.).

Focus areas:

Transverse strength of twin-hull craft
Delamination, peeling, laminate reinforcement ratio, core shear strength
Axial inertia forces in transverse-framed fore bodies
Thrust bearing supports
Stiffness in general

HIGHLY DEVELOPED RULES AND PRACTICES

Prepared for Marine Lightweight Structures?

Composites Offshore:

DNV

OFFSHORE STANDARD
DNV-OS-C501

COMPOSITE COMPONENTS

OCTOBER 2010

H. Qualification of material properties

H 100 Introduction

101 All material properties needed to describe the performance of a component shall be documented.

102 As a general principal, material properties should be obtained form test results of laminates that represent the laminates of the component as closely as possible.

Focus areas:

Degradation

Fire

Dimensional stability (e.g. buckling)

Gap:

Hull structures (whether primary or secondary) are not explicitly covered in the Offshore Standards

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Steel:

RULES FOR CLASSIFICATION OF

High Speed, Light Craft and Naval Surface Craft

PART 3 CHAPTER 2

STRUCTURES, EQUIPMENT

Hull Structural Design, Stee

JULY 2012

B 100 General

101 Where the rules for material grade in this section are dependent on plate thickness, the requirements are based on the thickness as built.

B 200 Material designations and material factors

201 Hull materials of various strength groups will be referred to as follows:

— NV-27 denotes high strength structural steel with yield point not less than 265 N/mm^2.
— NV-32 denotes high strength structural steel with yield point not less than 315 N/mm^2.
— NV-36 denotes high strength structural steel with yield point not less than 355 N/mm^2.
— NV-40 denotes high strength structural steel with yield point not less than 390 N/mm^2
— NV420 denotes extra high strength structural steel with yield point not less than 420 N/mm^2.
— NV460 denotes extra high strength structural steel with yield point not less than 460 N/mm^2.
— NV500 denotes extra high strength structural steel with yield point not less than 500 N/mm^2.
— NV550 denotes extra high strength structural steel with yield point not less than 550 N/mm^2.
— NV620 denotes extra high strength structural steel with yield point not less than 620 N/mm^2.
— NV690 denotes extra high strength structural steel with yield point not less than 690 N/mm^2.

Normal, high strength and extra high steel may also be referred to as NS-steel, HS-steel and EHS-steel respectively.

Focus areas:

Corrosion protection / fatigue (thin scantlings)
Fabrication tolerances (alignment)
Buckling

Gap:

EHS with yield point above 690 N/mm2 not explicitly covered in the rules

HIGHLY DEVELOPED RULES AND PRACTICES…but

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Let's Open a Regulatory Can of Worms:

- The High Speed Craft (HSC) Code applies to vessels '*engaged on restricted voyages under restricted operational weather conditions and with approved maintenance and supervision schedules.'*
- The HSC Code presupposes management of risk in addition to technical arrangements
- The HSC Code allows composites and aluminium

- SOLAS applies to vessels '*built of steel and with the minimum of operational controls…engaged on long international voyages…'*
- SOLAS presupposes technical protection arrangements.
- SOLAS presupposes steel…
- …*however, alternatives can be justified.*

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What's the Problem with Composites in SOLAS?

- SOLAS was conceived in 1914…as response to 'Titanic'. 'Composite' meant wood on steel
- Fire integrity is considered à priori generally inadequate in un-insulated composite structures
- 'Rule 17' offers a work-around, but the common solution is insulation or other forms of structural fire protection, which reduces the weight advantage
- The SAFEDOR project contained a study of a composite superstructure for a RoPax vessel, with 60% weight saved compared to a conventional design
- Risk Based Design is the gateway to innovation, and there is certain pressure on IMO to move that way.

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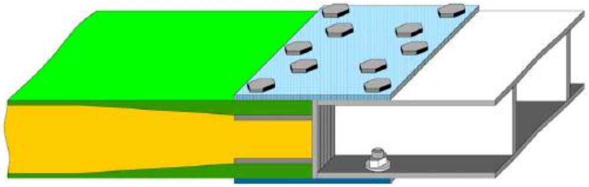
What's the Problem with Composites in Ship Building?

- Conventional shipyard environments are not conducive to handling composites
- Logistics, tools, infrastructure, competence not traditionally apt
- Other activities like hot work are a threat to composites parts
- Integration of large parts is still a challenge even if proven practice exists. A steel-to-composites joint is often the critical factor of overall integrity.



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Prepared for Marine Lightweight Structures?

What's the Problem with Composites in Naval Ship Building?

- Naval ships made entirely or partly of composites already exist – no regulation prevents it since SOLAS does not necessarily apply and many vessels are LC or HSLC by definition
- Yards are specialised for the trade
- Specific technical challenges arise, eg. EMS, blast strength, radhaz and so on
- Requirements to stringency in design, modelling/test correlation, documentation, special needs, durability, weight etc tend to be significantly higher, but this is driven by a highly informed and demanding customer.

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What's the Problem with Composites in Naval Ship Building?

- Naval ships are just as susceptible to fire as other ships, SOLAS or no SOLAS…

KRI 'Klewang-625', launched and destroyed by fire in 2012

Six Application Examples

'Cape St George' class patrol boats for Australian Customs and Border Protection Services

LC (Light Craft), aluminium structure

A particular challenge was achieving a light, efficient vessel while also meeting the many stringent SOLAS and Load Lines requirements to enable unrestricted international voyages.

Where typical large ship solutions to meet SOLAS and Load Lines proved impractical due to size, weight or design constraints, alternative solutions were implemented by the builder and a successful outcome achieved due to the high level of support provided by DNV in co-operation with the Flag Administration.

Cape St George class, 8 vessels delivered by Austal (Australia) and classed by DNV

Six Application Examples

'Carbo Clyde' wind farm service vessel for Fintry Marine Ltd

HSLC (High Speed Light Craft), CFRE sandwich structure

The vessel was built using the same carbon fibre and PVC core concept as has been developed by and for the RSwN, promoting properties such as robustness, impact resistance and ease of repair, with additional lightweight advantages such as fuel economy and large payload

Carbo Clyde, delivered by CarboCAT (ThyssenKrupp Kockums) (Sweden) 2010 and classed by DNV

Six Application Examples

'Inukshuk' sailing yacht for private owner

LC (Light Craft, Yacht), CFRE sandwich structure

This Baltic Yachts built and German Frers designed yacht is a lightweight, high performance sloop and its prime purpose is fast, efficient and comfortable cruising.

The total displacement is 78 tonnes of which 31 tonnes ballast.

The structure is extremely weight optimized with selective use of different sandwich cores and judicious application of local laminate reinforcements.

Baltic 107 type yacht, delivered by Baltic Yachts (Finland) 2013 and classed by DNV

Six Application Examples

'Visby' class stealth corvettes for RSwN

LC (Light Craft), CFRE sandwich structure

This is the latest design in a long composites development beginning with GRP mine sweepers in the 70's.

The 'Visby' class hull represents state of the art as far as the size of naval vessel is concerned.

DNV has worked with the RSwN and Karlskronavarvet/Kockums/ThyssenKrupp for over thirty years, and was recently selected to class the 'Visby' vessels post-delivery, as part of a strategy to 'internationalise' the larger surface combatants of the RSwN.

Visby class, 5 vessels delivered by ThyssenKrupp (Kockums) (Sweden) and classed in-operation by DNV

Six Application Examples

‘P28’ class stealth corvettes for Indian Navy

CFRE sandwich superstructure

The Project 28 (P28) ASW corvette will be the Indian Navy's new anti-submarine warfare (ASW) surface combatant for the 21st century. Four units were ordered in 2003 and 12 units are planned in all.

P28 class ASW Corvette INS ‘Kiltan’, superstructure delivered by ThyssenKrupp Kockums (Sweden) and verified by DNV

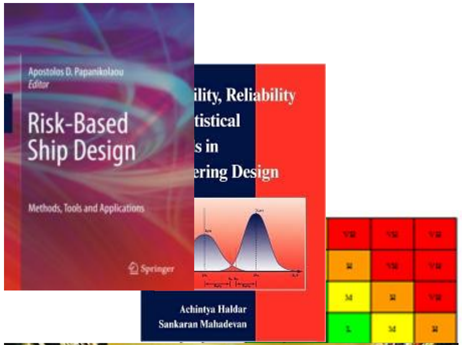
Six Application Examples

Components Good for Use in Ships or Mobile Offshore Units:

- Propeller or rudder shafts
- Propeller blades
- Ladders and gratings (note fire resistance requirement)
- Masts
- Piping for non-flammable liquids
- Life boats
- Blast, impact, wear or (even) fire protection structures
- Hatch covers, doors
- Caissons, accumulators, tanks
- Risers or parts of risers.

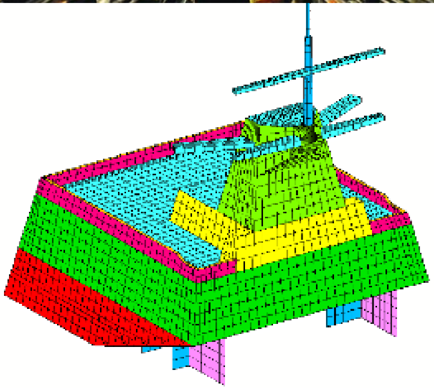
Future Work

Regulatory



- Develop the concept of Risk Based Design; risk models, acceptance criteria, cost-benefit models etc

- Establish a common ’approvable’ practice for fire safety in non-steel ships through a ‘critical mass’ of Rule 17 analyses, with the aim of eventually enabling SOLAS to incorporate composites as proven alternative

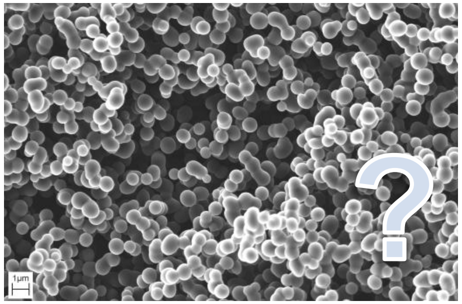


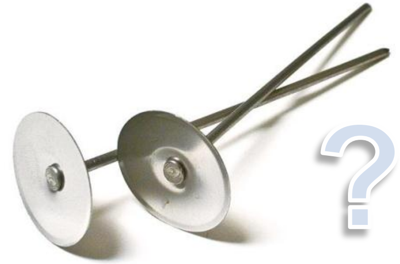
- Integrate the use of large composites parts (at least the size of superstructures) in the regular steel ships rules, possibly also the Offshore Standards, and yard quality standards.

Future Work

Engineering

- Develop lighter off-the-shelf solutions for SOLAS & IMO Modu compliant fire divisions, specifically adapted for easy application to lightweight structures.





Future Work

Manufacture

- Develop / refine manufacturing processes to reduce quality scatter, especially for field joints

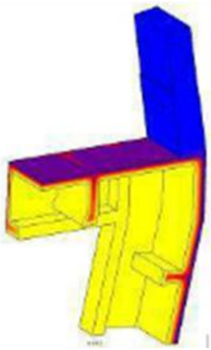
- Develop NDT equipment further to ensure ease of use and the reliability of output.

Future Work

Materials

- Steels of 'XXXHS' type must be qualified along the lines of existing EHS steels to ensure they fit strength and weldability requirements. Certain issues will come up, such as specific practices for slab manufacture which result in extremely low sulphur content, for example. The existing rules have to be re-written to accommodate such steels, rather than leave it to ad hoc approval

- Continue the qualification of composite materials and construction details which may answer the future needs for fire resistance, durability, strength or other properties. This probably involves both predictive analysis and large scale testing.



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