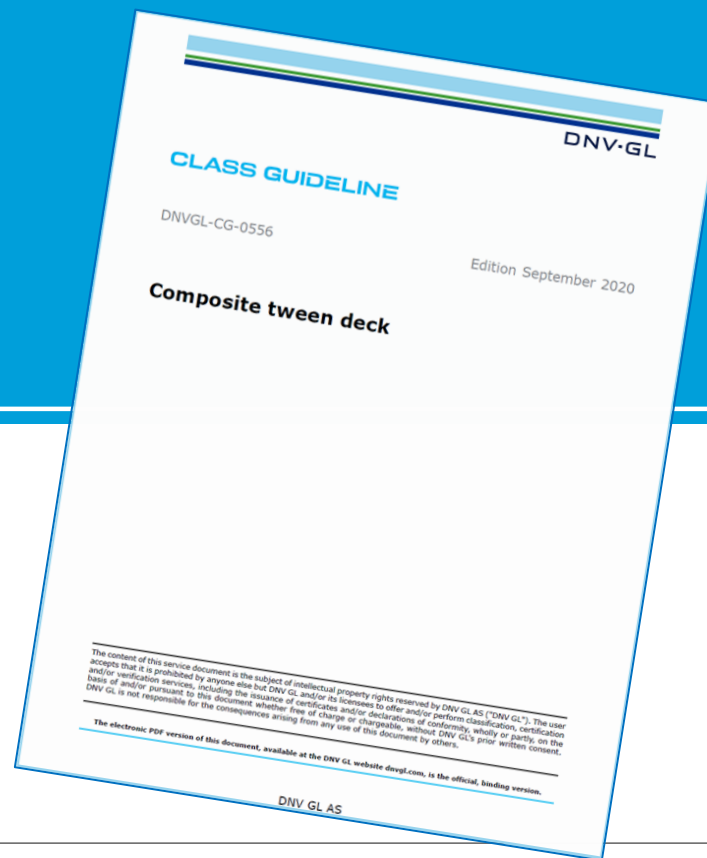


New Classification Rules for Composite Tween Deck

ELASS Seminar

Dr. Philippe Noury

28 January 2021



Content



Tween deck



Background



Motivations



Rules for classification of ships



Class guideline



Future work



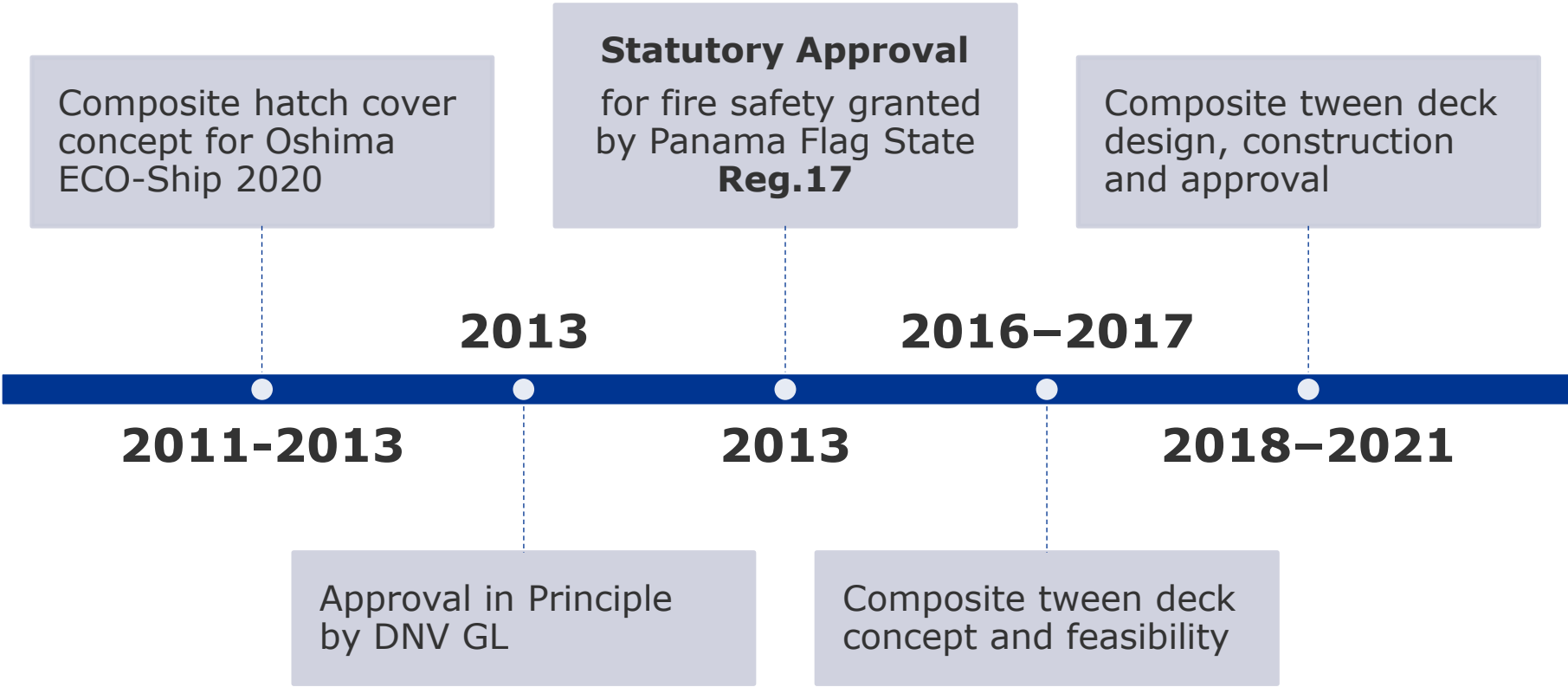
In (Be)Tween deck



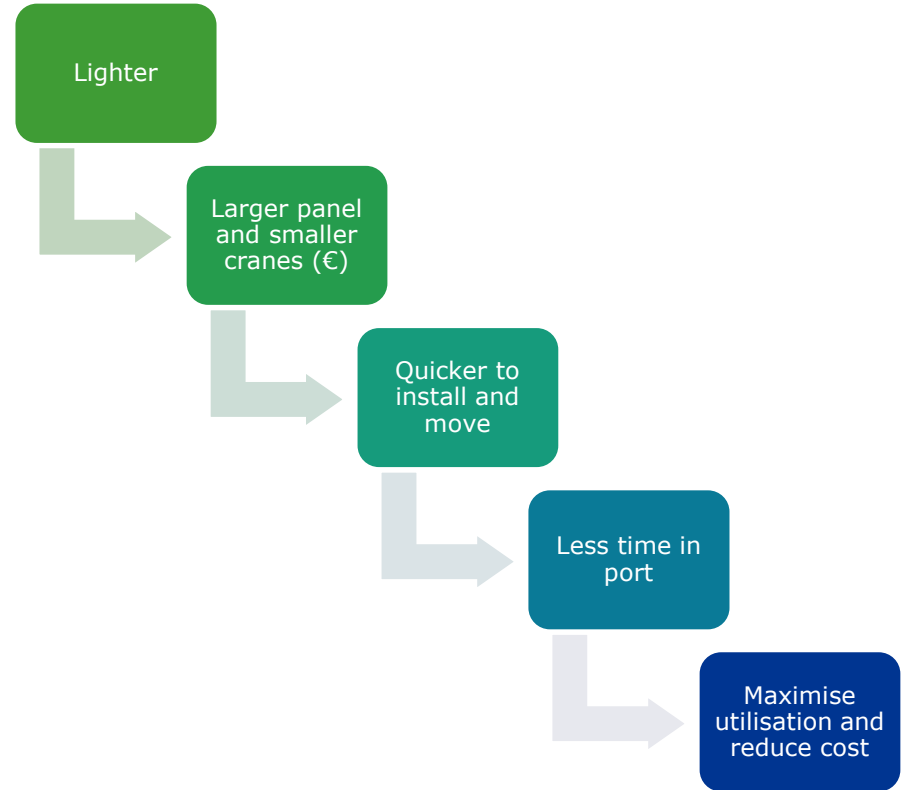
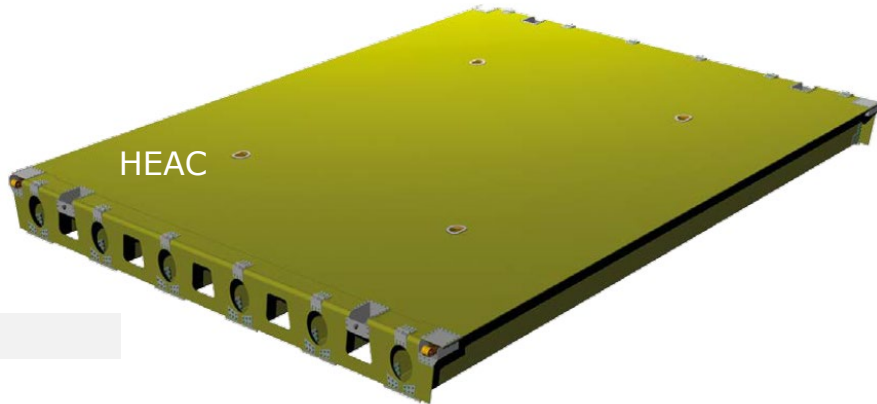
IKNOW

Tween deck

Background



Motivations for a composite design



LOW HANGING FRUIT: Technology easier to implement than hatch covers as low risk i.e. stepping stone

Why new rules for composite tween deck?

Fibre-reinforced-polymer composite materials behave differently

Different failure mechanism as opposed to just yielding and buckling

Lower stiffness, nonlinear behaviour

Viscoelastic response

Limited means available for NDE

Sensitive to localised lateral loads due to the lower stiffness

Connections between different materials composite / steel elements

Combustible resin and fire safety

Figure 9-1 Typical stress-strain relation for a laminate containing 0, 45 and 90 layers

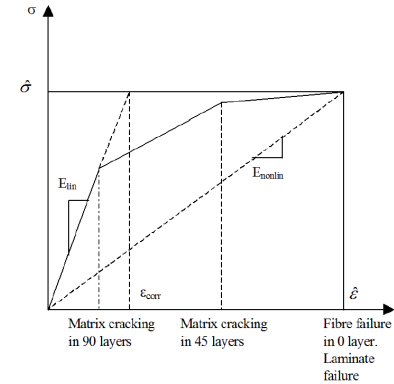


Table 6-1 Failure mechanisms for different materials

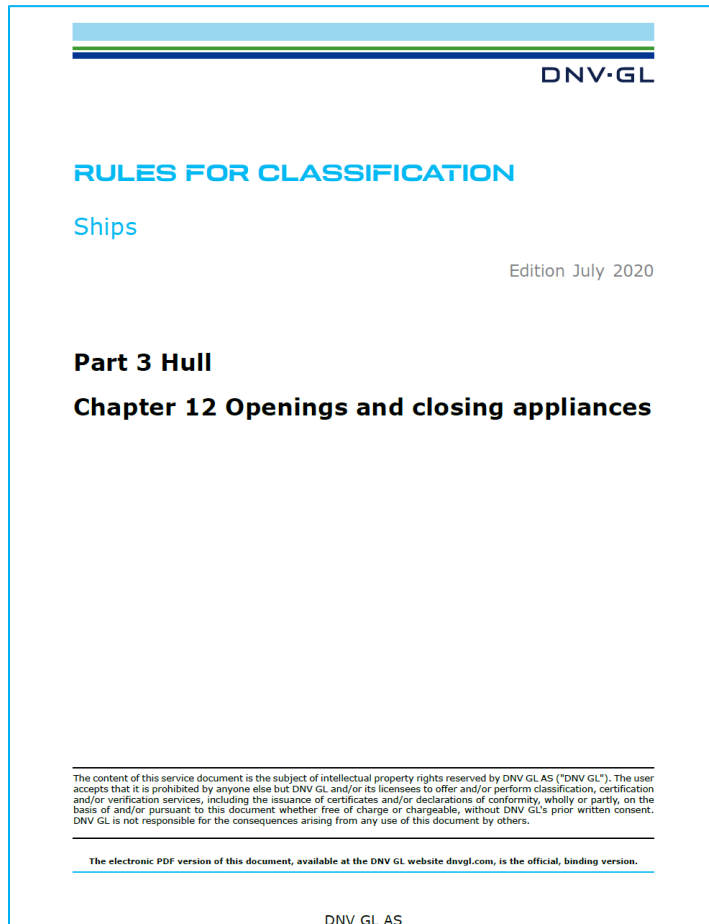
Failure mechanisms	Material type
Fibre failure	Laminates and sandwich skins
Matrix cracking	Laminates
Delamination	Laminates and sandwich core/skin interface
Yielding	Core materials, liners, resin rich areas
Ultimate failure of isotropic or anisotropic homogenous materials	Core materials
Elastic buckling	All materials
Unacceptably large displacements	All materials
Stress rupture	All materials, all failure mechanisms.
Fatigue	All materials, all failure mechanisms.
Wear	All materials
Fire*	All materials
Explosive decompression*	All materials
Impact*	All materials
Chemical decomposition	All materials

* these items are load conditions, but are treated here as failure mechanisms to simplify the approach in the standard.

DNVGL-ST-C501, Composite components

New rules – 2 Documents

Rules



DNV·GL

RULES FOR CLASSIFICATION

Ships

Edition July 2020

Part 3 Hull

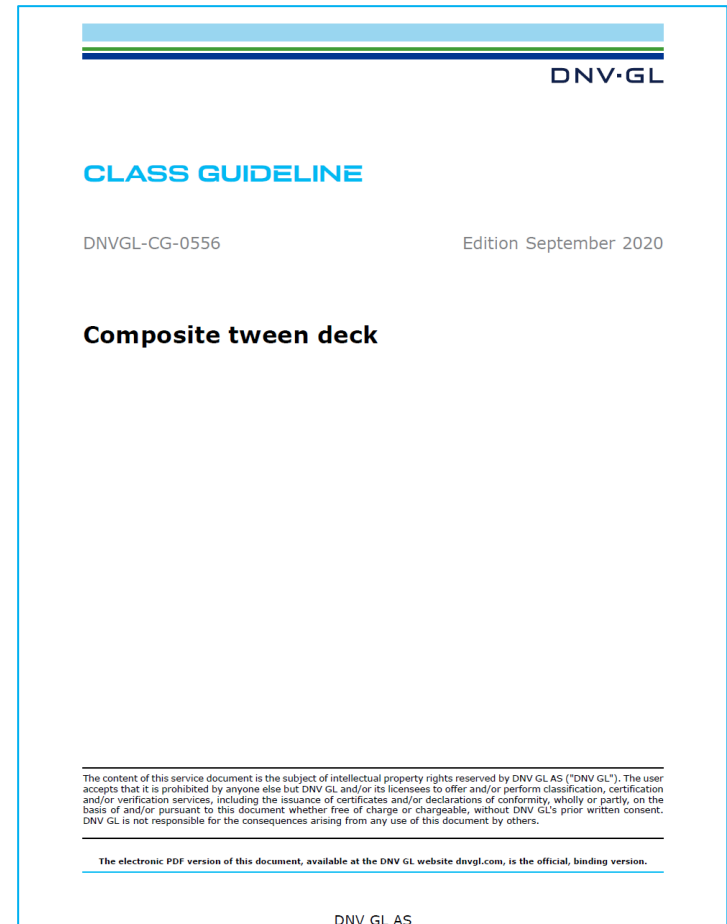
Chapter 12 Openings and closing appliances

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Class guidelines



DNV·GL

CLASS GUIDELINE

DNVGL-CG-0556

Edition September 2020

Composite tween deck

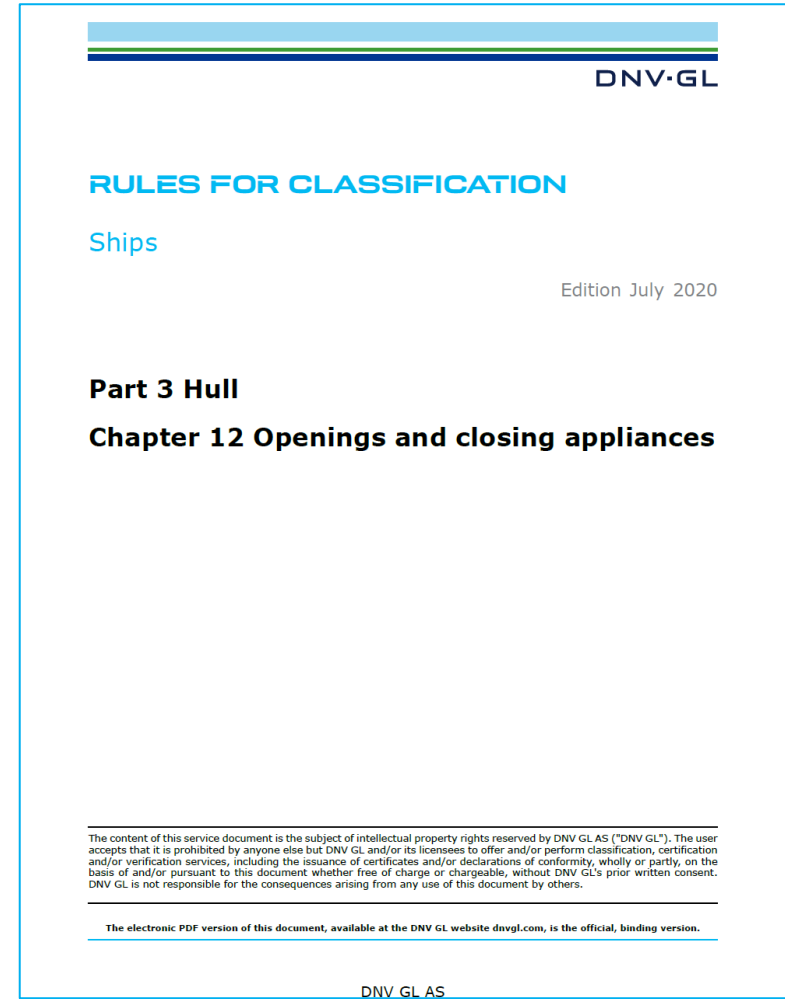
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Rules - Foremost requirements

- A **short** section in the rules for classification of ships
- Rules reference are introduced
- Material, loads, structural capacity, fire safety etc.
- Part 3, Chapter 12, Section 3.3 of DNV GL Rules for Ships



3.3 Composite tween deck hatch

3.3.1 General

This subsection gives requirements to approval for composite tween deck constructed from fibre reinforced composites (FRP), in single skin and/or sandwich construction using glass, carbon or aramid fibres.

Composite tween deck shall comply with the requirements given in [DNVGL-CG-0556 Composite tween deck](#).

3.3.2 Materials

Composite raw materials and adhesives shall comply with the requirements given in [Pt.2 Ch.3](#).

3.3.3 Design loads

Design loads shall comply with the requirements of [\[3.1\]](#).

3.3.4 Structural design

For composites components, structural design shall comply with [DNVGL-RU-HSLC Pt.3 Ch.4](#). Alternatively, [DNVGL-ST-C501 Composite components](#) may be used subject to case-by-case agreement with the Society.

Failure mode and mechanism for single skin construction and for sandwich construction shall be evaluated including laminate rupture, local buckling, global buckling, core shear failure, face wrinkling, failure of bonded joints, failure of bolted connections and long-term performance.

For metallic components, structural design shall comply with [\[3.2.5\]](#) and [\[3.2.6\]](#).

3.3.5 Fire safety

Fire safety requirements shall be evaluated on a case-by-case basis.

3.3.6 Construction

Construction shall be carried out according to [Pt.2 Ch.3 Sec.3](#).

3.3.7 Installation on board

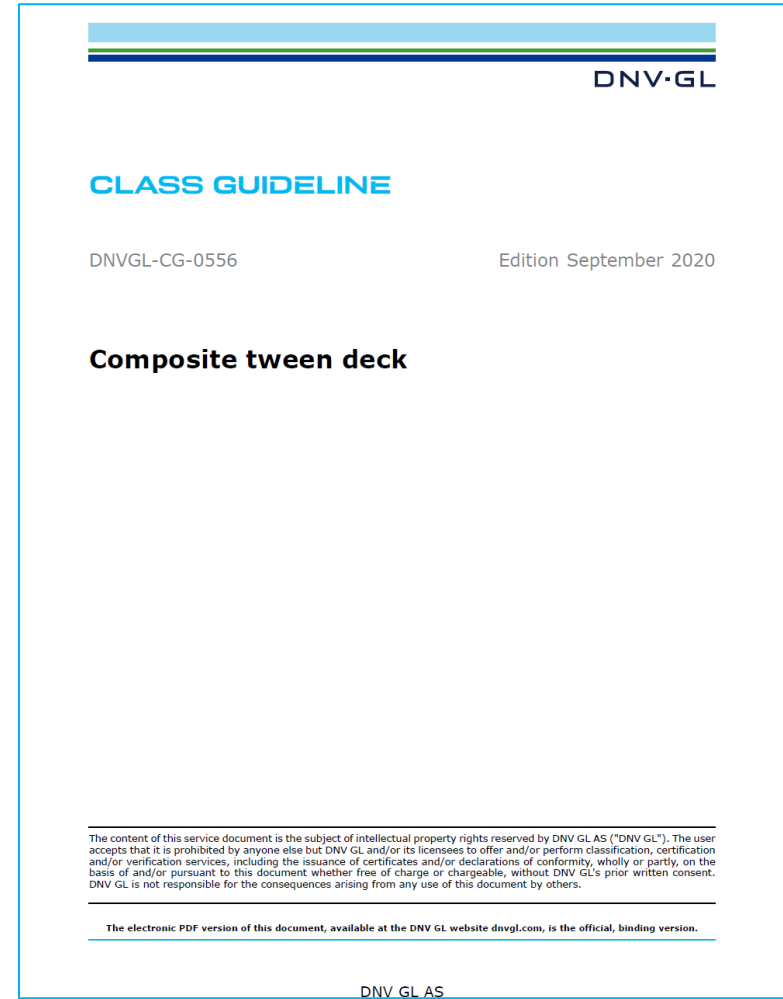
Installation on board shall be witnessed by a DNV GL surveyor.

3.3.8 Inspection and maintenance program

An inspection and maintenance program shall be in place prior to entering in service.

Class guideline - Detailed requirements

- Detailed requirements
- DNVGL-CG-0556
 - Composite Tween Deck
 - published in September 2020
- Many references to existing rules
 - concise, 22-pages document
- 8 main sections:
 - General
 - Materials
 - Loads
 - Structural capacity
 - Connections
 - Metallic components
 - Fire safety
 - Manufacturing



Section 1 - General

- Provides general information i.e. purpose, scope, applicability, documentation and certification to be submitted for approval
- Application for **bulk carrier** and **dry cargo ships**
- Documentation requirements
 - Vessel GA
 - Tween deck: design basis, GA, equipment, design analysis, material specs, data sheets etc.
- Compliance requirements

Table 2 Compliance documents

Object	Compliance document type	Compliance standard ^(*)	Additional description
Glass fibre reinforcements	TAC	DNVGL-CP-0082	
Carbon fibre reinforcements	TAC	DNVGL-CP-0096	
Aramid fibre reinforcements	TAC	DNVGL-CP-0092	
Polyester resins	TAC	DNVGL-CP-0083	
Vinyl ester resins	TAC	DNVGL-CP-0083	
Epoxy resins	TAC	DNVGL-CP-0089	
Gelcoat and topcoat	TAC	DNVGL-CP-0083	
Sandwich core materials	TAC	DNVGL-CP-0084	
Sandwich core adhesives	TAC	DNVGL-CP-0085	
Adhesives	TAC	DNVGL-CP-0086	
Steel	MC		
Bolt	PC		
Lashing eye	PC		
Inserts	PC		
Manufacturer	AoM	DNVGL-CP-0421	

(*): unless otherwise specified, the approval procedures for the materials covered in this section are specified in the respective Society type approval programmes.
 PC = product certificate, TAC = type approval certificate, MC = material certificate, AoM = approval of manufacturers

Section 2 - Materials

Table 3 Glass fibre reinforcements

<i>Property</i>	<i>Test method</i> ¹⁾	<i>Acceptance criteria</i>
Moisture content ²⁾	ISO 3344	Maximum 0.2% on delivery
Loss on ignition ²⁾	ISO 1887	The manufacturer's nominal value. Tolerance limits for the various materials are subject to approval in each separate case
Linear density (tex)	ISO 1889	The arithmetic mean \pm 2 standard deviation shall be within the manufacturer's value \pm 10%
Average diameter (μm)	ISO 1888	mean
Tensile strength of impregnated rovings	ISO 9163	msmv
Mass per unit area ²⁾	ISO 3374	The arithmetic mean \pm 2 standard deviation shall be within the manufacturer's value \pm 10%
Interlaminar shear strength (ILSS), Short-Beam Test ³⁾	ISO 14130	msv
Tensile strength of laminate ^{2) 3)}	ISO 527-1,4,5	To be agreed with the Society prior to testing
Tensile modulus		
Tensile elongation ²⁾		
1) other standards may be used if agreed upon with the Society prior to testing 2) unless otherwise agreed, these parameters shall be tested and documented in W certificate 3) fibre volume content according to ISO 1172 of the actual laminate to be tested and reported		

- Short section and specifies requirements to quality of (raw) composite materials and metallic materials.
- References to existing ship rules and high speed craft (HSC) rules for steel materials and raw composite materials.
- Type Approval Certificates need for all raw materials

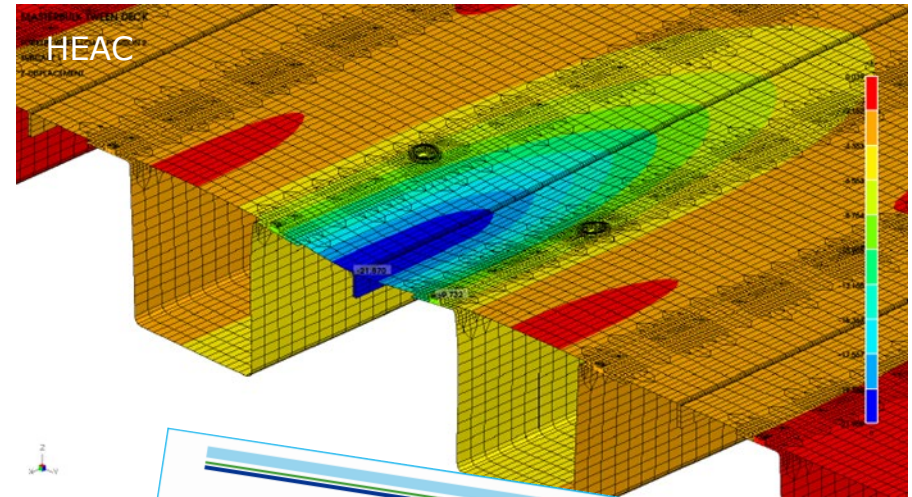
Section 3 - Loads

- Reference to existing ship rules for loads, load cases and cargo lashing
- List of load types to be considered as minimum
 - selfweight, uniform cargo load, project cargo, ship acceleration, thermal expansions ...
- Accidental loads
 - dropped object
- Design load cases
 - beams seas, head seas and oblique seas
 - highest accelerations with fully loaded tween deck
 - lifting
 - when stored on deck, sea pressure, stacking
 - forklift
 - lashing



Section 4 - Structural capacity

- Metallic components
 - Reference to existing ship and HSC rules for structural design and structural assessment
- Composites components:
 - For simple approach, reference to existing rules for structural design and structural assessment of high speed craft
 - More advanced approach: reference to standard DNVGL-ST-C501
- Importance of addressing all relevant failure modes and mechanism and not only fibre failure.

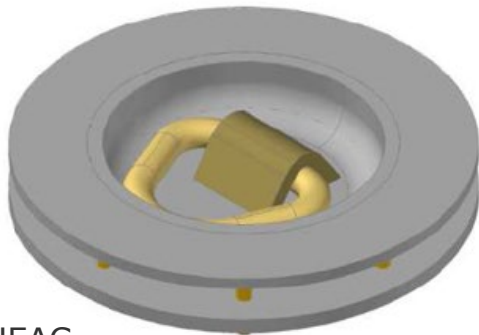


Section 5 - Connections

- Important chapter
- Reference to existing rules
- Connections types:
 - hull connection
 - insert
 - between deck component
- Examples of local connections
 - lifting points
 - lashing points
 - stacking socket or pins, when tween decks stored on weather deck
 - between panels, for composite tween deck composed of several panels
 - resting sockets or pins
- Bolted connections
- Bonded connections



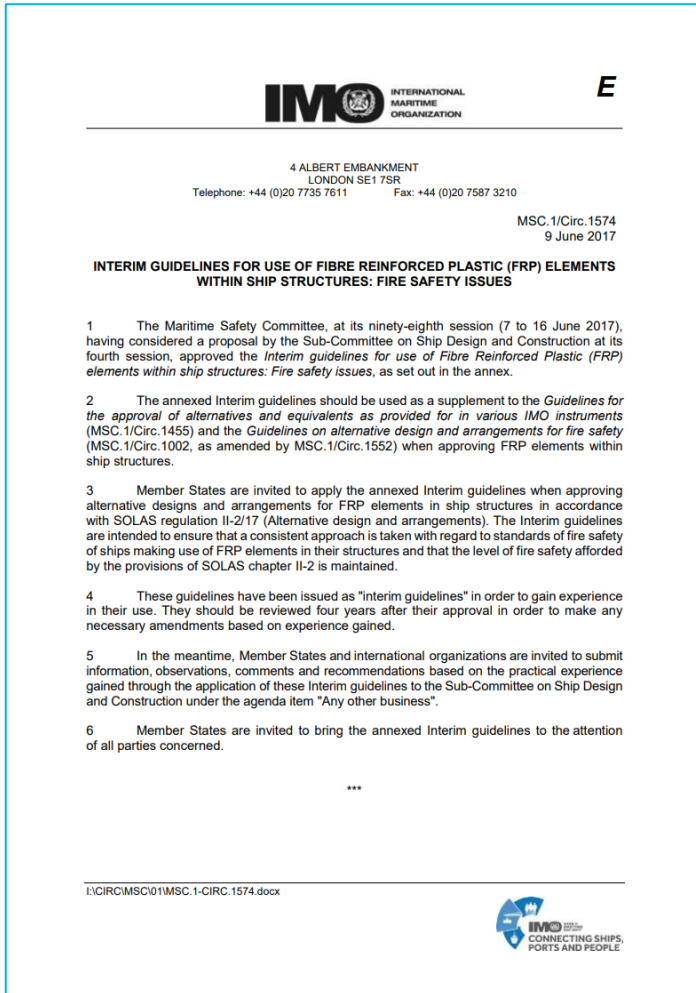
Section 6 - Metallic components



HEAC

- For all essential structural elements
 - steel plates
 - lifting eye and sockets
 - bolts
- Reference to existing ship rules
- Type-approved and from an approved manufacturer as per DNV GL rules for classification of ships

Section 7 - Fire safety



- Reference to existing ship rules
- Alternative design
 - To be evaluated on a case-by case basis if there is a need for an alternative design approach on fire safety, by DNV GL or Flag State
 - References
 - Ch.II-2 Reg.17 of SOLAS
 - IMO MSC/Circ.1002
 - IMO MSC.1/Circ.1574

Section 8 – Manufacturing

- Reference to existing ship rules
- Requirements for manufacturers to be approved by DNV GL as per DNVGL-CP-0421.
- Quality is safety!



The image shows the cover page of a DNV GL Class Programme document. At the top right, the DNV GL logo is displayed. Below it, the title 'CLASS PROGRAMME' is written in blue, followed by the subtitle 'Approval of manufacturers' in a smaller blue font. The document number 'DNVGL-CP-0421' is on the left, and the edition date 'Edition May 2017' is on the right. The main title 'Fibre reinforced plastics' is centered in bold black text. At the bottom, there is a disclaimer in small text and a note about the electronic PDF version being available for free at a specific URL.

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CLASS PROGRAMME

Approval of manufacturers

DNVGL-CP-0421 Edition May 2017

Fibre reinforced plastics

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Production quality and production damage

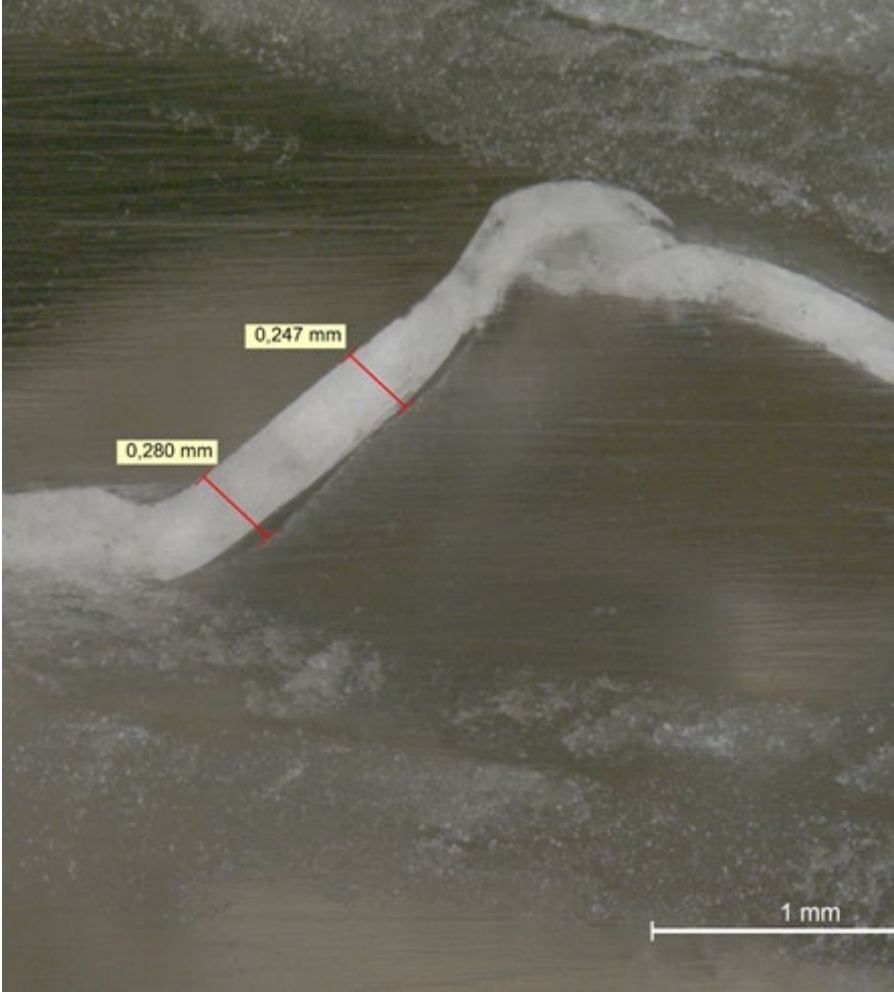
Resin-rich corners



Wrinkles



Microscopy of resin-rich corners



Future work

For 2021, new sections:

- Section 8 – Improvement on assembly and factory acceptance tests (FATs)
- Section 9 – Installation onboard



2022–2023

2021



For 2022-2023, additional scope hatch cover

- New title: DNVGL-CG-0556, Composite Hatch Cover and Tween Deck

JIP / Acknowledgement

- JIP consortium
 - DNV GL (Norway)
 - Oshima Shipbuilding (Japan)
 - Compocean (Norway)
 - HEAC (Norway)
 - Masterbulk (Norway)
 - Innovation Norway (Norway)



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COMPOSITE SOLUTIONS



Thank you !

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