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PIANC APAC 2022

Updates of PIANC Working Group 211 Fender Guidelines

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1

Agenda

- **Background**
- **Objectives and Scope of Working Group (WG) 211**
- **New updates in WG211:**
  - Table of Contents
  - Reliability Based Design
  - Fender Panel Design
  - Manufacturing of Fenders
  - Fender Testing – Performance & Durability
  - Sustainability & Recycling

  WG211 is a major rewrite of WG33 and a significantly more comprehensive document
- **This presentation is brief overview only**

2

2

Background - Fender Design Guidelines

- 1984 PIANC published a Supplement to Bulletin No. 45, containing design methods for fender systems (18 years);
- 2002, PIANC published WG33 to update Bulletin No. 45 (20 years and counting);
- Since the WG33 guideline was published:
  - There have been further advances in design methods for fender systems
  - Vessel types and sizes have increased
  - WG145 has collected and analysed considerable berthing velocity and angle data, addressed reliability design, vessel dimensions and container vessel flare angles
  - WG186 detailing mooring requirements for large ships at quay walls has been published
  - Manufacturers have further researched materials, performance, durability and aging
  - Many improvements to WG33 guidelines have been suggested by users

WG211 was formed in 2019 to update WG33

3

3

Objectives and Scope of WG211

- PIANC WG211 is to replace WG33
- Key updates for WG211 are to include:
  - Review of fundamental principles and alignment with current practice;
  - Revised design data based on probabilistic analysis of new measurements of berthing velocity and berthing angles
  - Vessel data for port planning and design for all PIANC documents into a single publication (WG235)
  - Data on hull shapes;
  - Revisit vertical and horizontal forces on fenders;
  - Update design limits for hull pressures;
  - Addressing simulation software for evaluation of fender/vessel interaction;
  - Outline design guidelines for wheel fenders and foam filled fenders and pneumatic fenders.

4

4

Objectives and Scope of WG211

- Consider and incorporate relevant outcomes of other working groups.
- Review recent research by fender manufacturers and update guidance in relation to durability and performance;
- Provide guidance on design of other fender system components including facing panels, chains and fixings;
- Provide guidance on durability, maintenance and repair of fender system components.

5

5

Table of Contents

Design Chapters

TABLE OF CONTENTS

1.9 Use of the guidelines

Below flowchart presents a brief overview over how this report is structured and can be used.

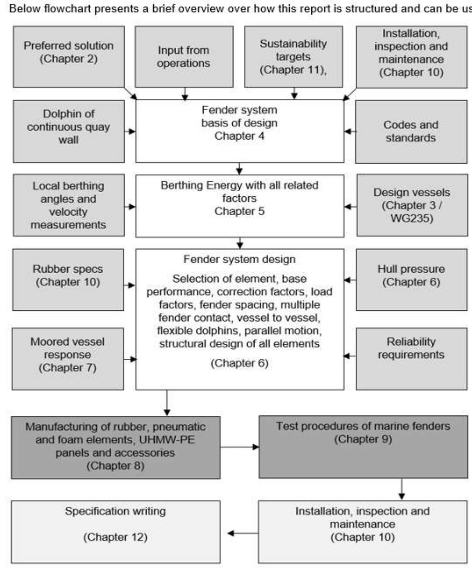


Figure 1-1: flowchart WG211 report

6

6

Reliability Based Design

- In WG33, there is no insight into the reliability of a fender system => Probabilistic assessment.
- Principles of probabilistic design is to define risk categories used in the selection of partial factors.
- Outlined in the basis of design of WG211
- Basic energy translational equation will remain unchanged apart from the specified berthing velocity
- The number of exposure conditions reduced from 5 to 3.

Reliability Based Design – Characteristic Velocity

- The characteristic berthing velocity represents a probability of being exceeded per berthing per year of 0.02%. The velocities in Figure 1 are based on 100 berthing events per annum.
- These values can be adjusted for higher or lower berthing frequencies
- There is provision for velocity reduction for monitored berths in some cases

Type of vessel	V_B (m/s)		
	Favourable	Moderate	Unfavourable
Cruise & passenger vessels	0.100	0.150	0.250
Vehicle carriers	0.120	0.225	0.275
Coaster, Feeder, Handysize	0.150	0.225	0.300
Panamax, Handymax	0.120	0.225	0.275
Post Panamax, Capesize (small), Aframax	0.100	0.175	0.275
New Panamax, Capesize (large), Suezmax	0.100	0.175	0.250
ULCV, VLBC, VLCC, ULCC	0.100	0.150	0.250

Figure 1 – Berthing Velocity Table

Reliability Based Design – Characteristic Berthing Angle

- Characteristic berthing angle is based on the type of vessel movement and the degree of tug/thruster assistance.

Characteristic Berthing Angle → α_c
Incidental Berthing Angle → α_i

Approach	Tugs	Thrusters	α_c [a]	α_i [b]	Explanation
Parallel	Yes	Yes	2	3	Vessels position off the berth and approach parallel. Vessels have sufficient tug/thruster capacity.
		No	3	5	Vessels position off the berth and approach parallel. Vessels do not have tug/thrusters or under keel clearance is very low.
Angular	Yes	Yes	3	5	Vessels have a large angle during the approach. Local current or wind is used to berth the vessel. However, at the moment of fender contact the berthing angle is low. Vessels have sufficient tug/thruster capacity.
		No	4	7	Vessels have a large angle during the approach. Local current or wind is used to berth the vessel. However, at the moment of fender contact the berthing angle is low. Vessels do not have tugs/thrusters or under keel clearance is very
	No	Yes	8	15	Smaller coastal vessels perform an angular approach, landing using spring lines and pushing the bow or stern in with engine and rudder. Vessels have some tug/thruster capacity.
		No	10	20	Smaller coastal vessels preform an angular approach, landing using spring lines and pushing the bow or stern in with engine and rudder. Vessels have nor or insufficient tug/thruster capacity.

Reliability Based Design – Partial Energy Factor

- Partial energy factor is applied to the characteristic berthing energy to cover uncertainty in the berthing energy calculation
- Consequences of failure (low, moderate, very high, e.g. class A, B, C, D & E)
- Navigation Conditions (monitored, favourable, moderate, unfavourable)
- Variation in water displacement (small and large vessels, empty or fully laden => CoV_M)
- Berthing frequency (γ_n)
- Pilots – Assisted (γ_p)
- Relationship between velocity and vessel sizes, if any (γ_p)
- Single & Multiple fender Contact

$$\gamma_E = \frac{E_{kin;d}}{E_{kin;c}} \approx C_{ab} = \frac{E_{abnomral}}{E_{nomral}}$$

$$\gamma_E = \gamma_{E_{ref}} \gamma_n \gamma_p \gamma_p$$

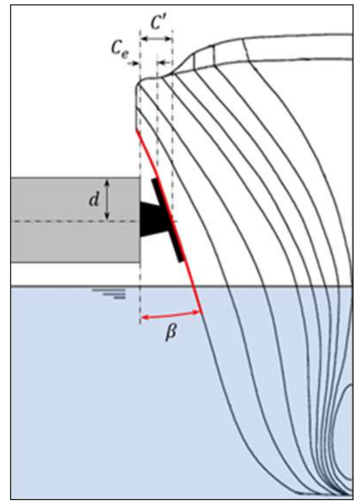
Reference partial energy factor γ_{Eref}

Navigation conditions	CoV_M	Single fender contact					Multiple fender contact				
		A	B	C	D	E	A	B	C	D	E
Monitored	≥ 50%	1.25	1.40	1.45	1.55	1.75	1.10	1.25	1.30	1.40	1.55
	≥ 15%	1.30	1.45	1.50	1.60	1.80	1.15	1.30	1.35	1.45	1.60
	< 15%	1.40	1.55	1.65	1.75	1.90	1.30	[illegible]	1.50	1.60	1.75
Favourable	≥ 50%	1.30	1.50	1.60	1.70	1.95	[illegible]	1.35	1.40	1.50	1.70
	≥ 15%	1.35	1.55	1.65	1.80	[illegible]	1.20	1.40	1.55	1.55	1.75
	< 15%	1.50	1.70	1.80	[illegible]	2.15	1.35	1.50	1.60	1.70	1.90
Moderate	≥ 50%	1.35	1.60	1.70	1.85	2.10	1.20	1.40	1.45	1.60	1.85
	≥ 15%	1.45	1.65	1.75	1.90	2.20	1.25	1.45	1.55	1.65	1.90
	< 15%	1.60	1.80	1.90	2.10	2.35	1.40	1.60	1.70	1.80	2.05
Unfavourable	≥ 50%	1.50	1.85	2.00	2.20	2.65	1.25	1.55	1.65	1.85	2.15
	≥ 15%	1.60	1.95	2.05	2.30	2.75	1.35	1.60	1.75	1.95	2.30
	< 15%	1.80	2.15	2.30	2.55	3.00	1.50	1.80	1.95	2.15	2.50

Concept

Fender Panel Design - Effects of Bow Flares

- Many vessels have considerable amounts of topside 'flare' forward and aft, below the main deck level.
- A good fender system must accommodate the differences and changes in this vertical angle at the fender contact locations.
- WG211 provides guidance of effective clearance between vessel flare angles and structure
- Guidance to combined angle of compression of fender, taking account of the angular compression due to the bow radius and the bow flare are also provided



Fender Panel Design – Multiple Fender Contact & Double Hull Contact

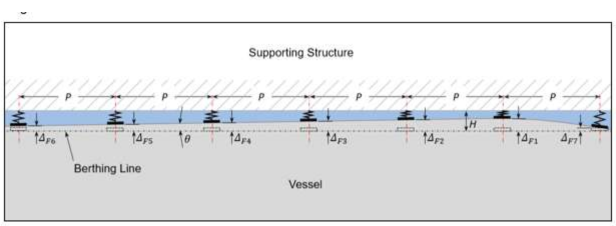


Figure 6-7: Multiple fender contacts for small berthi

- Effects on non-linear force deflection
- Result in larger overall reaction forces on the structure

- Typically occurs on vessels equipped with belting
- Concentrated line loads could cause buckling and deformation of the vessel hull plating

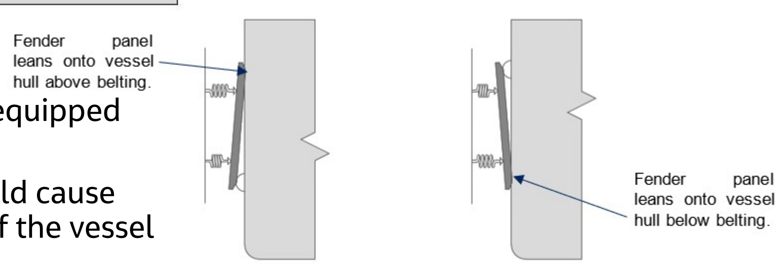
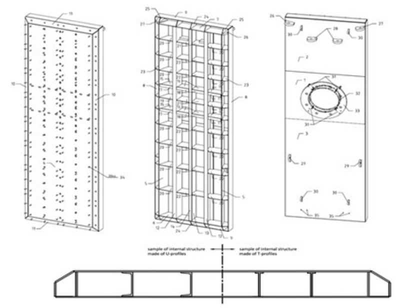
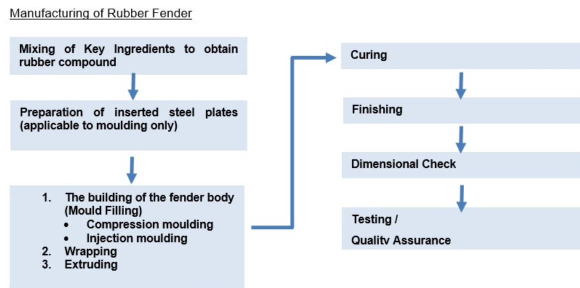


Figure 6-8: Belting causing vessel hull double contact and line loads.

Manufacturing of Fenders

- Covers:
  - Rubber compounds; mixing, different types of manufacturing processes
  - Steel panel fabrication; materials, corrosion protection
  - Fabrication of Low Friction Facing
  - Chains, anchors, other hardware
  - Manufacturer Qualifications – importance of demonstrating an acceptable level of experience with materials : Quality control





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13

Fender Testing – Performance & Durability

- Testing is very important to:
  - Maintain a standard quality assurance throughout the fendering industry;
  - Ensure materials used to manufacture fenders are durable and of high standards;
  - Performance verification for fenders in service;
- In WG33 testing is an Appendix; WG211 introduces a whole new chapter on testing requirements
- Type Approval Testing
  - is for fenders and material carried out by manufacturers to create data which is then published in their catalogues and is also an independent confirmation/approval of the fundamental testing.
- Verification Testing
  - is the testing of full-size fenders to verify that the as-manufactured fenders have the correct performance characteristics, (minimum energy absorption and maximum reaction)

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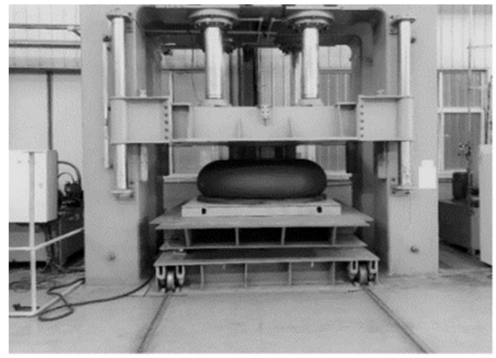
14

Fender Testing – Performance & Durability

- **WG211 Verification Testing**
  - Performance Testing
    - Recommendation of fender preparations guidelines included
    - Independent 3rd party witness recommended
    - Testing requires to be carried out in controlled environment
    - Stabilisation time Updated in WG211
    - 4 cycles compulsory
      - 1st - Break in cycle
      - 2nd & 3rd - Stabilising cycles
      - 4th - Compression cycle
    - 10% fenders require mandatory testing



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15

Fender Testing – Performance & Durability

- **WG211 Verification Testing**
  - Durability Testing
    - requires that a fender to be subjected to multiple cyclic loadings
    - Min 3000 cycles recommended by WG211
    - WG211 will provide guidance to Engineers and end users on the level of risk mitigation durability testing can offer to the overall operational of the marine terminal if carried out.
    - Compliance criteria will be spelt out more clear – when to accept and when to NOT
- Materials testing TGA - Thermo Gravimetric Analysis
- Updated physical properties testing updated
  - Tensile strength, Elongation at break, compression set, tear resistance, ozone resistance
- Testing of pneumatic and foam fenders updated in WG211
  - Rubber compound testing, hardness tear resistance, tensile strength etc.

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16

Sustainability & Recycling

- In line with United Nations Sustainable Development Goals set out in 2015

The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all

- WG211 adopts 17 of these sustainable development goals in the upcoming fender guidelines.
- Result in potential reduction of carbon footprint of ports/marine facility
- Development of Rubber recycling technologies
- Steel recycling

17

17

Thank You

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18