



Fixed and PMF Fender Systems Operation and Maintenance Manual



QUAYQUIP

A EUROTECH BENELUX
COMPANY

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1 Introduction to Fender Maintenance

This manual provides general guidance on inspection and maintenance procedures and routines which, if adopted, will help to ensure long and trouble free service of the fenders, accessories and related hardware.

Fender systems are usually safety critical items on a quay, wharf or terminal. They are subjected to frequent impacts, abrasive surfaces, vibration and environmental extremes. Even the very best fenders require periodic inspections and routine maintenance to continue providing the design levels of protection (see Appendix A).

The service life of a properly maintained fender will vary due to many factors. Some of the common causes of fender damage and reduced service life include:

- Inadequate installation of anchors and fixing points
- Overloads due to berthing speeds and compression angles beyond design criteria
- Snagging by ship protrusions, particularly poorly designed or maintained beltings
- Damage caused during assembly or installation
- Mooring ropes
- Excessively slack chains
- Inadequately tightened fixings
- Excessively tightened fixings
- Unauthorised modifications
- Grinding and other works in close proximity to fenders
- Spillages of paint and solvents
- Bird guano

During installation an 'as installed' drawing or diagram should be prepared indicating each fender position on the structure and the corresponding fender panel and rubber fender serial numbers. This allows cross referencing with manufacturing quality records.

All inspection and maintenance procedures should be adapted by the user and/or operator to conform to relevant or applicable safety, operational and regulatory requirements at local, national and international level.

It is strongly advised that berthing, mooring and operational procedures at the facility incorporate references to fender design limits, particularly permissible berthing speeds and angles for the range of vessels likely to be encountered.

Despite all reasonable precautions, accidents can still happen. To quickly return the berth to full service, owners and operators should consider investing in a minimum spare parts package. Apart from a few standard items, fenders are bespoke items and purpose designed for each facility. Spare rubber units and fender panels take time to manufacture and transport – often as long as the original supply so limited spare parts stocks will reduce the risk of disruptions. PIANC 2002 advises that 'easily replaceable components should fail first' and it is important to stock or have easy access to a supply of these items.

2 Rubber Fender Units

QuayQuip rubber fenders are moulded units from high quality natural rubber, synthetic rubber or blends of natural and synthetic rubber. All rubber fender units are vulcanised at controlled high temperatures to ensure excellent product homogeneity and physical properties as well as high rubber to steel bond strengths. Rubber compounds include carbon black for strength and reinforcement as well as other additives needed for processing and to resist the effects of ozone and ultra violet light.

QuayQuip rubber fenders need minimal maintenance and should provide long service life without deterioration provided they are correctly installed and used within design limits. Rubber fenders should have periodic visual checks as well as more thorough inspections after any heavy berthings.

Submerged and tidal installations

All cone and cell type fenders have an internal 'chamber' which reduces in volume as the rubber unit is deflected. There are a number of radial flutes on the head and base flanges of QuayQuip QCN Cone and QCL Cell fenders that allow air to vent out of and into the chamber. When cone and cell type fenders are installed underwater or become fully submerged by tides, the flutes allow water into the chamber. At normal deflection speeds the flutes may not allow water to be expelled fast enough which, without alternative design measures, can increase fender reaction significantly.

QuayQuip QCN Cone and QCL Cell fenders which may become submerged are fitted with special measures to allow rapid water expulsion. These must be periodically cleaned by water blasting to remove debris, silt and marine growth.

Rubber inspections

Rubber units may suffer localised damage during installation, from mooring lines dragged across the fender and a variety of other causes.

Small cuts and grazes will have negligible effect on longevity and performance. Any larger cuts, cracks, delaminations or splits require closer inspection. In all cases of doubt, it is recommended these be photographed and referred to QuayQuip with a report on circumstances (see report form – Appendix B).

Overload inspections

Whenever a suspected heavy berthing has taken place, rubber fender units should be closely inspected for signs of damage. In normal compressions the rubber fender body will not contact fender panel or structure. Possible overloads can often be confirmed by witness marks left by the rubber fender body where it has contacted steel or concrete surfaces. Indentations left by bolts or brackets are other signs of a possible overload.

Routine inspections

All rubber fender unit surfaces should be periodically inspected for cuts, cracks and other damage. These should be reported to QuayQuip immediately for advice on rectification or replacement. Small repairs can be made with special repair putties such as Devcon Flexane or Loctite Fixmaster Flex 80 (see Appendix C). Details of other compounds should be referred to QuayQuip before use.

3 Steelwork

In normal operating conditions, fender panels, frames and related steel elements are not designed to make direct contact with the ship side, berth structure and brackets.

Steelwork does not require any periodic maintenance other than periodic visual checks as well as more thorough inspections after any heavy berthings. Inspections should check for signs of damage, loose or missing bolts and corrosion (see Section 4).

Overload inspections

During accidental and overload conditions applied forces can over-stress the steel and cause localised bending, deformation and dents. In most cases this damage can be repaired locally or sometimes in-situ by approved local welding contractors using compatible and appropriate steel grades, weld details and welding consumables.

Any damage caused by repairs to protective coatings should be made good (see Section 4).

The integrity of fender fixings should be checked to ensure there are no missing, bent or loose bolts.

Accident damage must be made good at the earliest opportunity as continued use before the fender is properly repaired can cause further damage to steelwork and / or vessels using the berth. This may void the system warranty. In all cases of doubt, it is recommended damage be photographed and referred to QuayQuip with a report on circumstances (see report form - Appendix B).

4 Paint Systems and Corrosion Protection

High performance paint systems are routinely used to protect panels and larger fabricated items from corrosion. Paint manufacturers cannot guarantee the precise life expectancy of their paint systems before first major maintenance in seawater immersion and splash zones. Coating life expectancy in temperate climates is typically 10–20 years under normal use and with routine touching up of local paint damage. In hotter and more corrosive environments, coating life may be reduced.

Paint coating type

Various paint systems are used according to client specifications and application. Many systems are modified epoxy meeting class C5M of ISO 12944, but this may vary case by case. Please refer to fender manufacturing drawings or project specifications.

In-situ repairs

Most paint coatings can, with care, be locally repaired and made good in-situ. Paint manufacturers often update their formulations and their current recommendations on repair systems should be sought before undertaking paint repairs.

Surface preparation requires special care to ensure good adhesion between old and new coatings. Underwater paint repair systems are available to suit some coatings. Again, advice should be sought from the paint manufacturer on types, procedures. And health and safety requirements.

Quality Control

- Quality control shall be carried out in accordance with the specification and the material supplier's recommendations and data sheets.
- Work shall not proceed if any of the controlling conditions in the specification cannot be achieved and maintained.
- Daily reports shall be completed and filed in preparation for signing off and release.

Health, Safety and Environment

- Operatives shall be equipped with suitable protective clothing, gloves, masks and eyewear.
- Copies of the COSHH Assessments for the materials and safety data sheets shall be issued to site operatives prior to work commencing.
- Only suitably qualified and experienced personnel shall carry out paint repair works.
- All debris shall be cleared on a daily or more frequent basis.
- Empty paint containers shall be disposed of in the correct manner.

Should areas of paint degradation be substantial, it is preferable that the steelwork be removed to a suitable workshop, stripped down, blast cleaned and re-painted before re-installing onto the berth.

5 UHMW-PE Facings

Ultra High Molecular Weight Polyethylene (UHMW-PE) is compression moulded in a sintering process into plates which are then cut and machined into appropriate size pads commonly installed as close fitted tiles on the front face and lead-in edges of fender panels.

UHMW-PE provides a low friction wear face and comes into direct contact with the hull of the ship. As a facing material, UHMW-PE is subject to gradual wear with rates depending on the grade of material, thickness and design wear allowance (the depth between bolt head and outer surface of the facing). UHMW-PE pads should last for many years, often for the full life of the fender system.

It is impossible to exactly predict wear rates as berthing frequency, ship type, hull shape and form shape will all have an effect. Wear is rarely a problem, but gouging and scoring can arise from ship hulls with sharp edges or projections and also if beltings (strakes) are discontinuous, poorly faired or in poor condition.

Regular close inspection of visiting vessels is recommended to identify potential causes of damage to UHMW-PE pads before problems arise.

Misalignment of ships against the panel face is another cause of uneven pad wear. If vessels bear with uneven

pressure against the UHMW-PE pads then localised wear will occur.

Routine inspections

UHMW-PE facings do not require any periodic maintenance other than routine visual checks of the surface for wear and tear and condition of fasteners.

UHMW-PE facings cannot generally be repaired so any damaged or missing parts must be replaced immediately. Missing tiles may lead to accelerated wear and/or damage to adjacent facings.

Prolonged use before the proper repairs are carried out can cause further damage and may void the system warranty. In all cases of doubt, it is recommended damage be photographed and referred to QuayQuip with a report on circumstances (see report form - Appendix B).

6 Anchors and Fasteners

QuayQuip fenders are connected to the structure and assembled using galvanised or stainless steel anchors and fasteners. The most common materials are grade 8.8 spun galvanised or 316 (1.4401) stainless steel. Depending on the application and client specifications, other grades and finishes may also be used. In most cases threads are metric coarse pitch.

Galvanised fixings

Galvanising relies on zinc to provide cathodic protection of the fixing. The spin galvanising process clears threads of excess zinc during manufacture but also leaves a reduced thickness of zinc (a smaller zinc reservoir to provide cathodic protection). In temperate climates galvanised coatings will provide protection for about 5 years in the seawater immersion and splash zones. In hotter and more corrosive climates this time may be substantially shorter. Once the zinc is depleted, corrosion of the fixing begins and this will weaken the connection.

Stainless fixings

Stainless steels used in marine applications must resist pitting corrosion which is why only austenitic grades with moderate to high molybdenum contents are used. Lower grade and reduced molybdenum stainless steels such as 304 are not recommended for marine use. In very corrosive areas or where fasteners are inaccessible for maintenance, higher grade duplex or super duplex stainless steels may be employed.

It is incorrect to say that stainless steel does not corrode. Staining may occur from ferritic contamination due to the manufacturing process of cutting threads and forming in steel tools. This is a localised effect that does not harm the longevity or performance of the material.

Stainless steel fixings may also work loose when fenders are subject to vibrations (from wave action, ship engines and other causes). Exact causes are unknown but the solution is to use a locking nut, locking tab or bolt adhesive such as Loctite. A tack weld between bolt head and washer is another common solution.

Galling or 'cold welding' is another phenomenon affecting stainless steel fixings. This arises as torque is applied to fixings, the oxide coating of the stainless steel on mating threads is breached, high friction then creates heat on the threads which welds the male and female portions permanently together. In this case there is no alternative but to cut out or burn off the fixing. Anti-galling pastes such as Loctite 567 or equivalent can reduce the risk of galling if applied to threads before assembly.

Routine inspections

Anchors and fasteners should be routinely inspected for tightness as well as for damage, corrosion and missing nuts, bolts or washers. Due to their critical role and low cost, any suspect fasteners should be replaced immediately. In case of any uncertainties, please refer to QuayQuip.

7 Chain Systems

Chain systems may comprise of chains, shackles, tensioners and brackets. Their function is to control the deflection geometry of the fender system during normal compressions. Chain systems have three main purposes:

- Shear chains to resist friction induced lateral shear forces
- Weight chains to support the system weight and (commonly) to resist friction induced vertical shear forces
- Tension chains used in cantilever fender designs and to restrain the top of fender panels, preventing excessive 'droop'.

All chain system components are usually hot dip galvanised, relying on zinc to provide cathodic protection of the chain. In temperate climates galvanised coatings will provide protection for about 5 years in the seawater immersion and splash zones. In hotter and more corrosive climates this time may be substantially shorter. Once the zinc is depleted, corrosion of the chain system components begins and they will weaken over time, depending on any supplementary corrosion allowance built into the chain design.

Chain system components showing signs of corrosion may be removed, cleaned and either re-galvanised or dip painted to prolong their life. Heavily corroded chain system components should be replaced at the first opportunity.

A weak link – often a slightly smaller shackle - is commonly designed into a chain system in accordance with PIANC 2002 guidelines. This ensures an easily replaceable component fails before more significant structural damage arises, bearing in mind the minimum breaking load of a chain will be several times the design working of the system.

Most chain systems are designed to include a small amount of slack (except some weight support chains). The slack is typically less than 25mm and serves to reduce snatch and shock loads during fender impacts. Small amounts of slack in a tension or shear chain are acceptable – this may appear as larger 'droop' in the chain which, unless excessive, is perfectly normal. Longer chains may include a tensioning device to adjust the bearing length. During the life of a chain system it may be necessary to shorten the tensioners. If in doubt, please ask QuayQuip.

Routine maintenance

Chain systems should be routinely inspected for damage, wear at the contact surfaces and for corrosion. Due to their critical role and low cost, any suspect chain components should be replaced immediately. In case of any uncertainties, please refer to QuayQuip.

8 Hinges and Bearings

Complex fender systems such as Parallel Movement Fenders (PMF) rely on a mechanism of hinges to control their movements and performance. For various reasons, these hinges are not simple pin joints, but are quite sophisticated ball joints which articulate in several planes at once. This is because the PMF system is structurally elastic and it can flex and twist within predetermined limits during its operation. These internal movements require hinges that can rotate omnidirectionally and slide axially.

Quayquip's hinge designs employ high tensile, forged and heat treated stainless steel ball shafts rotating in a precision fit spherical bronze bushing. This arrangement provides the greatest force transfer through this critical component. To ensure trouble free operation, it is fully sealed and protected from the ingress of abrasive particles carried in turbid waters, and it further seals against corrosion caused by the seawater itself.

The hinges are designed to be maintenance free, but a very high frequency of ship berthings may require the hinges to be lubricated with a marine grade grease. This should be discussed and agreed with Quayquip at the time of order. Even if lubrication is not required, it may be better to incorporate a greasing system to occasionally purge the bearings and create an additional anti-corrosion barrier outside the hinge. If this is the case, accessible lubrication points can be provided and Quayquip will advise on a suitable grease.

9 Inspection Schedule

During the full term of the fender warranty, annual inspection reports (Appendix A) and incident reports (Appendix B) should be submitted to QuayQuip to comply with warranty conditions.

Component	Visual Inspections	Maintenance Interval		See Notes
		Interim	Full	
Rubber fender units	Annual	As required	15–25 years	A-B-H
Steel panels	Annual	As required	15–25 years	A-C-H-I
Other steel structures	Annual	As required	15–25 years	A-C-H-I
Paint system	Annual	As required	10 years	A-C-H
UHMW-PE facings	Annual	As required	15–25 years	A-D-H
Anchors and fixings	Annual	As required	15–25 years	A-E-H
Chain systems	Annual	As required	5–10 years	A-F-H
Hinges and Bearings	Annual	As required	15–25 years	A-C-E-H

Notes

- A** In addition to periodic visual inspections, a close visual inspection should also be conducted after any berthing incident, mishap or exceptional impact of the fenders. The circumstances of each such event should be immediately recorded in case damage is sustained but not visible or obvious straight away. An incident report (Appendix B) should be submitted to QuayQuip.
- B** Interim maintenance includes localised repair to small cuts and other surface damage(s) to the rubber caused by mooring ropes, dropped objects and other causes. All paint and solvent spillages should be removed by water-jet blasting. Also the replacement of rubber units damaged by accident, overload or other unforeseen events and factors.
- C** Interim maintenance includes localised touch up of steel paintwork damage caused by mooring ropes, flotsam and jetsam, bird fouling etc. Also repairs to dents and other minor damages caused by accidents, overload or other unforeseen events and factors.
- D** Interim maintenance includes replacement of any heavily damaged, cut or dislodged UHMW-PE pads and associated fixings.
- E** Interim maintenance includes retightening of loose fixings (with addition of locking tabs or other mechanism to prevent reoccurrence) and replacement of all damaged or missing fixings.
- F** Interim maintenance includes replacement of all damaged or missing chain system components. Pay particular attention to 'weak' links where fitted.
- G** Intermediate maintenance includes a routine periodic inspection plus special inspections after heavy berthing incidents or accidents, as well as the replacement of pads damaged by accident, overload or other unforeseen events and factors.
- H** Full maintenance follows a detailed inspection and decision on possible repair, refurbishment or replacement of fender system components, coatings and fixings. It is suggested this be carried out in conjunction with a QuayQuip engineer.
- I** Unless otherwise specified, no allowances for corrosion of steel are made in the designs.

If in doubt on any aspect of inspection or maintenance, please consult QuayQuip.

Fender System Inspection Form

Client's Name		Inspector's Name	
Installation Site		Inspector's Position	
Year Installed		Telephone	
Date Inspected		Email	

RUBBER FENDER UNITS	
Damage	<input type="checkbox"/> Yes <input type="checkbox"/> No
Cuts, splits, tears	<input type="checkbox"/> Yes <input type="checkbox"/> No
Surface cracks	<input type="checkbox"/> Yes <input type="checkbox"/> No
Missing fixings	<input type="checkbox"/> Yes <input type="checkbox"/> No
Flutes clear	<input type="checkbox"/> Yes <input type="checkbox"/> No

STEELWORK	
Damage:	
Dents	<input type="checkbox"/> Yes <input type="checkbox"/> No
Bending	<input type="checkbox"/> Yes <input type="checkbox"/> No
Other deformations	<input type="checkbox"/> Yes <input type="checkbox"/> No
Missing fixings	<input type="checkbox"/> Yes <input type="checkbox"/> No

PAINT & CORROSION PROTECTION	
Minor paint damage	
Local wear & scrapes	<input type="checkbox"/> Yes <input type="checkbox"/> No
Impact damage	<input type="checkbox"/> Yes <input type="checkbox"/> No
Installation damage	<input type="checkbox"/> Yes <input type="checkbox"/> No
Heavy corrosion & major damage	<input type="checkbox"/> Yes <input type="checkbox"/> No

UHMW-PE FACINGS	
Missing pads	<input type="checkbox"/> Yes <input type="checkbox"/> No
Missing fixings	<input type="checkbox"/> Yes <input type="checkbox"/> No
Damaged pads:	
Heavy scoring	<input type="checkbox"/> Yes <input type="checkbox"/> No
Gouging or breaks	<input type="checkbox"/> Yes <input type="checkbox"/> No
Localised abrasion	<input type="checkbox"/> Yes <input type="checkbox"/> No

ANCHORS & FIXINGS	
Correctly tightened	<input type="checkbox"/> Yes <input type="checkbox"/> No
Thread damage	<input type="checkbox"/> Yes <input type="checkbox"/> No
Bent or deformed	<input type="checkbox"/> Yes <input type="checkbox"/> No
Missing fixings	<input type="checkbox"/> Yes <input type="checkbox"/> No
Corrosion (galvanised)	<input type="checkbox"/> Yes <input type="checkbox"/> No
Pitting (stainless steel)	<input type="checkbox"/> Yes <input type="checkbox"/> No

CHAIN SYSTEMS	
Excessive chain slack	<input type="checkbox"/> Yes <input type="checkbox"/> No
Broken chains or shackles	<input type="checkbox"/> Yes <input type="checkbox"/> No
Bracket damage	<input type="checkbox"/> Yes <input type="checkbox"/> No
Light corrosion	<input type="checkbox"/> Yes <input type="checkbox"/> No
Heavy corrosion	<input type="checkbox"/> Yes <input type="checkbox"/> No

HINGES & BEARINGS	
Deformed metal parts	<input type="checkbox"/> Yes <input type="checkbox"/> No
Trapped debris	<input type="checkbox"/> Yes <input type="checkbox"/> No
Loose bolts	<input type="checkbox"/> Yes <input type="checkbox"/> No

Please return this form duly completed by email to QuayQuip Ltd (info@quayquip.com) after each periodic inspection. Failure to provide timely self certified inspections may invalidate fender warranties.

CLIENT SIGNATURE

Fender Incident Report Form

Client's Name		Inspector's Name	
Installation Site		Inspector's Position	
Year Installed		Telephone	
Date of Damage		Email	

DAMAGED COMPONENTS	
Rubber fender units	<input type="checkbox"/> Yes <input type="checkbox"/> No
Steel panels	<input type="checkbox"/> Yes <input type="checkbox"/> No
Other steel structures	<input type="checkbox"/> Yes <input type="checkbox"/> No
Paint system	<input type="checkbox"/> Yes <input type="checkbox"/> No
UHMW-PE facings	<input type="checkbox"/> Yes <input type="checkbox"/> No
Anchors & fixings	<input type="checkbox"/> Yes <input type="checkbox"/> No
Chain systems	<input type="checkbox"/> Yes <input type="checkbox"/> No

LOCAL CONDITIONS	
Time of day	<input type="checkbox"/> Yes <input type="checkbox"/> No
Tide level	<input type="checkbox"/> Yes <input type="checkbox"/> No
Current speed	<input type="checkbox"/> Yes <input type="checkbox"/> No
Current direction	<input type="checkbox"/> Yes <input type="checkbox"/> No
Temperature	<input type="checkbox"/> Yes <input type="checkbox"/> No
Wind speed	<input type="checkbox"/> Yes <input type="checkbox"/> No
Wind direction	<input type="checkbox"/> Yes <input type="checkbox"/> No

VESSEL DETAILS	
Name of vessel	<input type="checkbox"/> Yes <input type="checkbox"/> No
Type of vessel	<input type="checkbox"/> Yes <input type="checkbox"/> No
Deadweight	<input type="checkbox"/> Yes <input type="checkbox"/> No
Displacement	<input type="checkbox"/> Yes <input type="checkbox"/> No
Length	<input type="checkbox"/> Yes <input type="checkbox"/> No
Tug Assisted	<input type="checkbox"/> Yes <input type="checkbox"/> No
Berthing speed	<input type="checkbox"/> Yes <input type="checkbox"/> No
Berthing angle	<input type="checkbox"/> Yes <input type="checkbox"/> No
Docking Aid used	<input type="checkbox"/> Yes <input type="checkbox"/> No

PLEASE DESCRIBE INCIDENT CIRCUMSTANCES

Attach photos, diagram, etc if possible.

Please return this form duly completed within 7 days of each accident or incident by email to QuayQuip Ltd (info@quayquip.com). Failure to report damage promptly may invalidate fender warranties.

CLIENT SIGNATURE

9 Disclaimer

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