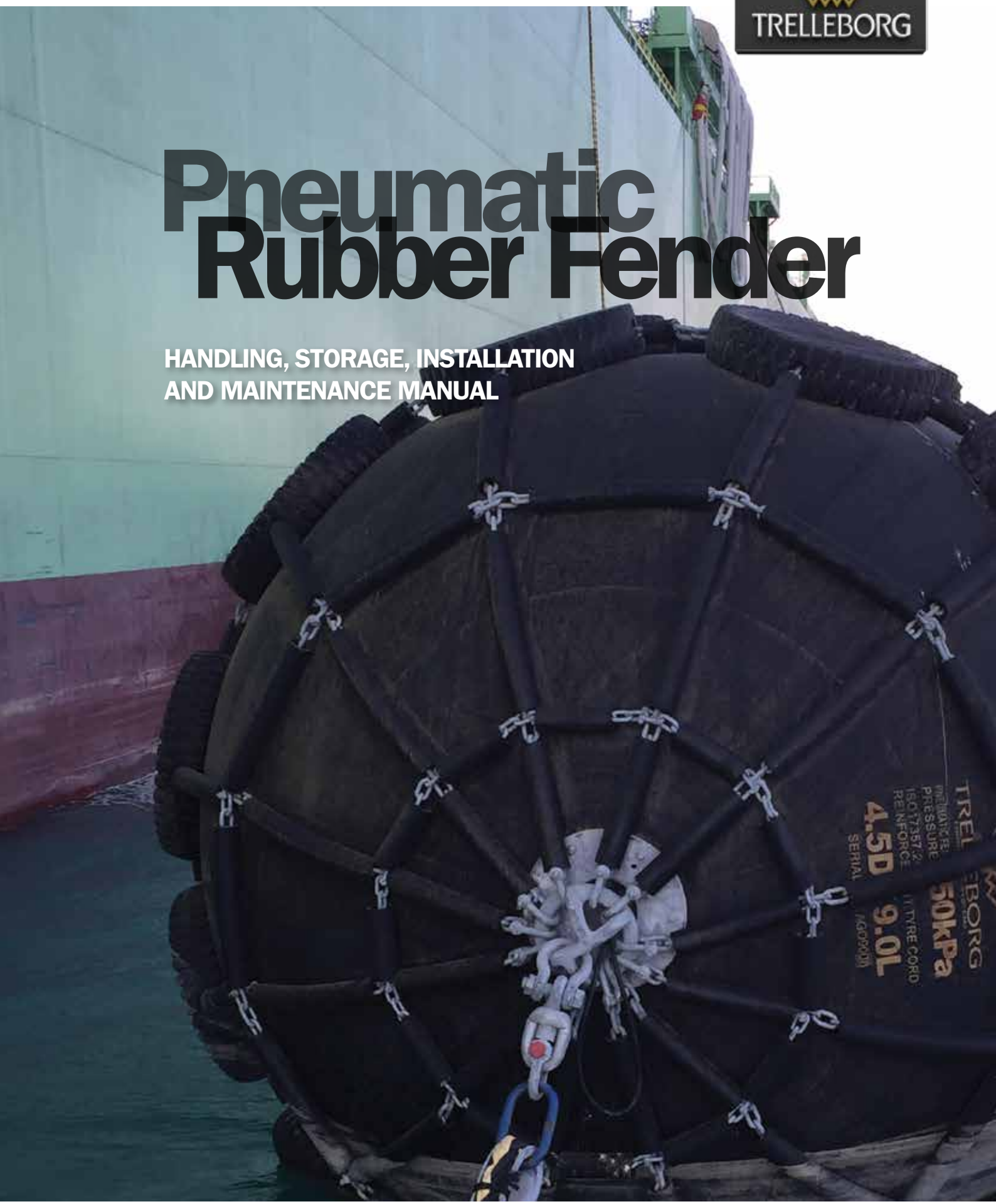
TRELLEBORG

Pneumatic Rubber Fender

HANDLING, STORAGE, INSTALLATION AND MAINTENANCE MANUAL



The Smarter Approach

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The demanding nature of commercial ports and terminals means you need partnership that provides much more than technically superior products and technologies. You need to work with a partner that combines best practice expertise gained through worldwide experience with a deep understanding of local requirements and regulations. At Trelleborg, we call this the Smarter Approach.

Our Smarter Approach combines global reach with feet-on-the-ground local presence, delivering solutions that continually enhance your operations. Smart technologies are at the forefront of improving operational efficiencies. Trelleborg's innovative SmartPort offering deploys the latest in marine technology applications to help ports and terminals optimize their operations.

Connect with a partner that combines smart solutions, proven product capability and industry expertise to maintain and enhance port and vessel performance. Take a Smarter Approach, with Trelleborg Marine and Infrastructure.

Pneumatic Rubber Fender Handling, Storage, Installation and Maintenance Manual

Trelleborg Marine and Infrastructure is a world leader in the design and manufacture of advanced marine fender systems.

We provide bespoke solutions for large and complex projects all over the world. Best practice design and quality materials ensure a long, low maintenance service life, no matter how demanding the working and environmental conditions.

All fenders are supplied fully tested and manufactured in accordance with PIANC 2002 guidelines. Our pneumatic fenders are also completely ISO17357-1:2014 compliant. Our high performance solutions combine low reaction force and hull pressure with good angular performance and rugged construction.

Trelleborg's fender systems can be integrated with SmartPort. SmartPort by Trelleborg is a technology platform that connects disparate, data-driven assets, giving stakeholders a holistic view of operations to power communication and decision making.

Take a Smarter Approach to fender performance with Trelleborg.

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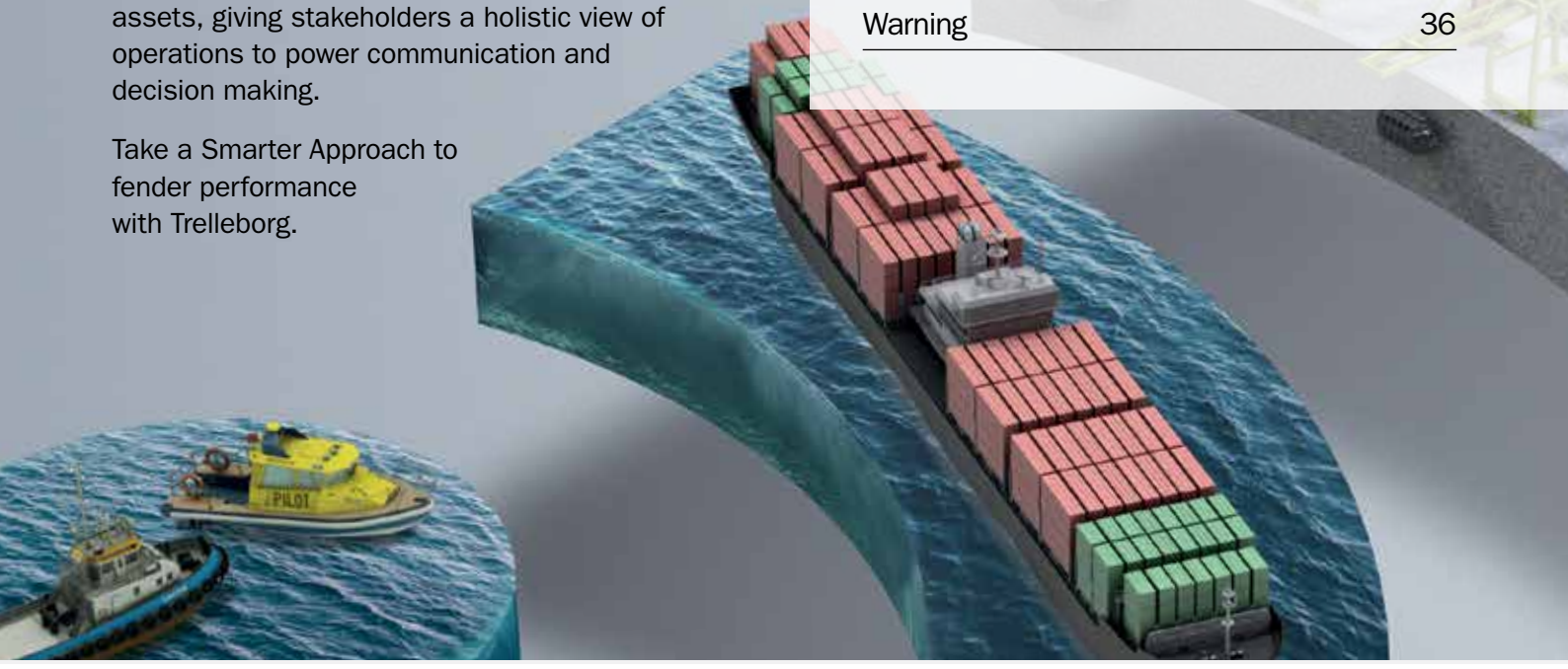


A Smarter Approach at every stage

A smarter approach to...

CONSULTATION

Consultation from the earliest project phase to ensure the optimum fender systems and marine technology solutions are specified, with full technical support from our global offices.

CONCEPT

Conceptual design in your local office – with full knowledge of local standards and regulations, delivered in your language – for optimized port and vessel solutions.

DESIGN

Concepts are taken to our Engineering Centers of Excellence in India where our team generates 3D CAD designs, application-engineering drawings, a bill of materials, finite engineering analyses and calculations for both our fender systems and marine technology solutions.

MANUFACTURE

Our entire product range is manufactured in-house, meaning we have full control over the design and quality of everything we produce. Our strategically located, state-of-the-art facilities ensure our global, industry leading manufacturing capability.

TESTING

Across our entire product range, stringent testing comes as standard at every step in our in-house manufacturing process. We ensure that lifecycle and performance of our entire product range meets your specifications, and more.

INSTALLATION

Dedicated project management, from solution design right the way through to on-site installation support. We design products and solutions that always consider ease of installation and future maintenance requirements.

SUPPORT

Local support on a truly global scale, with customer support teams all over the world. And this service doesn't stop after a product is installed. You have our full support throughout the entire lifetime of your project, including customized training programs, maintenance and onsite service and support.

THE FUTURE

Deploying the latest in smart technologies to enable fully automated, data-driven decision making that optimizes port and terminal efficiency. At Trelleborg, we're constantly evolving to provide the digital infrastructure our industry increasingly needs.

When you choose Trelleborg you ensure your expectations will be met, because we deliver a truly end-to-end service – retaining vigilance and full control at every stage.

Pneumatic Rubber Fenders

Trelleborg's Pneumatic Rubber Fenders are ideal for permanent and semi-permanent fender solutions for ports as well as ship-to-ship transfers. These fenders require minimal maintenance which keeps their operational costs down.

FEATURES

- Easy and fast to deploy
- Very low reaction and full hull pressure
- Suitable for small and large tidal ranges
- Maintain high clearances between hull and structures

APPLICATIONS

- Oil and gas tankers
- Fast ferries and aluminium vessels
- Temporary and permanent installations
- Rapid response and emergencies
- Ship-to-ship operations

Types of Fenders

The two most common types of pneumatic fenders that are compliant with the international standard ISO 17357-1:2014 are type I – chain-tire-net (CTN) type fenders and type II – sling type fenders.

The type of fender to be used depends on its application, usage and the requirements of the facility.

TYPE I: CHAIN-TIRE-NET (CTN) TYPE

CTN is a lattice of tires connected by a network of longitudinal and lateral chains for extra protection to the fender body. Trelleborg's Type I fenders use galvanized chains for greater corrosion resistance. Rubber sleeves are inserted over the chains to prevent abrasion of the rubber surface of the fenders. The chains are fastened with shackles at each intersection.

Type I Standard Protection Fender
showing the CTN

High Protection CTN has extra rows of tires on the shoulders of the fenders while Standard Protection CTN is equipped with rubber sleeves on the shoulder chains.

Type I High Protection Fender
showing the extra rolls of shoulder tires

TYPE II: SLING OR HOOK TYPE

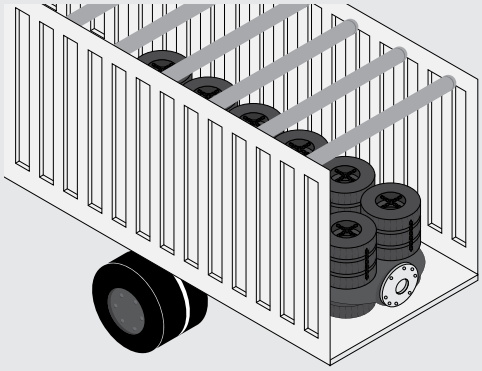
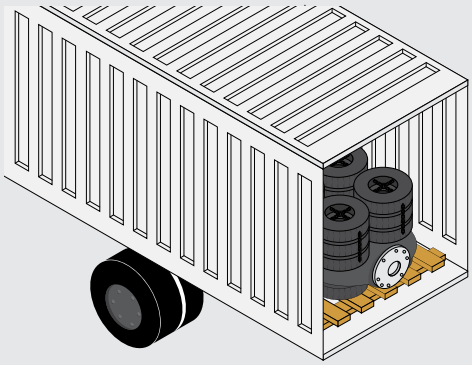
Sling or hook type fenders are effectively Type I fenders with lifting / towing eyes fitted to each end without the CTN. The fenders can be slung by chains or wire ropes during operation. Type II fenders are available across the entire range of sizes.

Type II Sing Type Fender
with lifting eye at both ends

Handling

2.1 Unloading

Extreme care must be taken to ensure that unloading is being carried out under close supervision of competent personnel. Follow the below instructions to unload Trelleborg's pneumatic fenders:

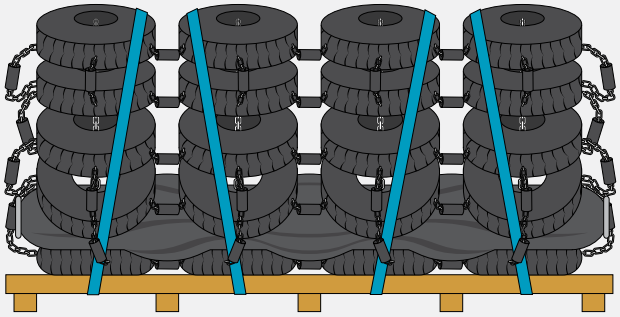
From an open-top container		1 Remove the cross beams from the top of the container. 2 Connect lifting slings to the shackles/ links that indicate 'lifting points' and gently lift the fender up with the help of a crane. 3 Move the pneumatic fender out of the container through the door and be careful not to get caught on the surrounding catch points. 4 Place the fender on a large flat area before releasing it from the crane to prepare it when fully inflated.
From a close container		1 Trelleborg's pneumatic fenders packed on wooden pallets in a close container can be unloaded using a forklift. Be careful to avoid the fender's body being cut by the fork of the forklift when lifting the wooden pallet. 2 Remove the fender from the container and place it on a flat area big enough to accommodate the fully inflated fender.

WARNING:

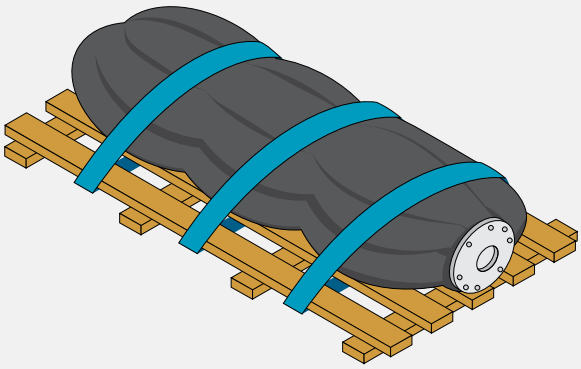
- Strictly avoid placing fenders on areas strewn with debris or where high-temperature work takes place to prevent damage to the skin of the fenders.
- The procedure should be carried out using a standard Risk Assessment amended where necessary.

2.2 Unpacking

Unpack the fenders and inflate them within the first week of receiving them. Do not store the fenders in a deflated condition for an extended period as this will greatly reduce their service life.



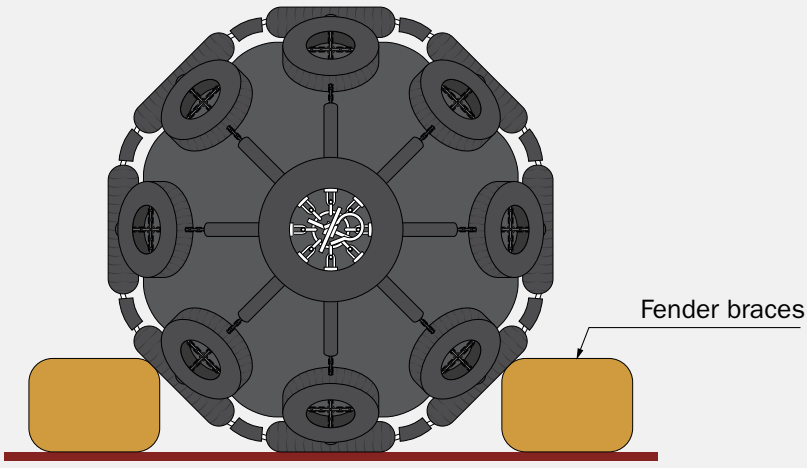
CTN Type



Sling Type

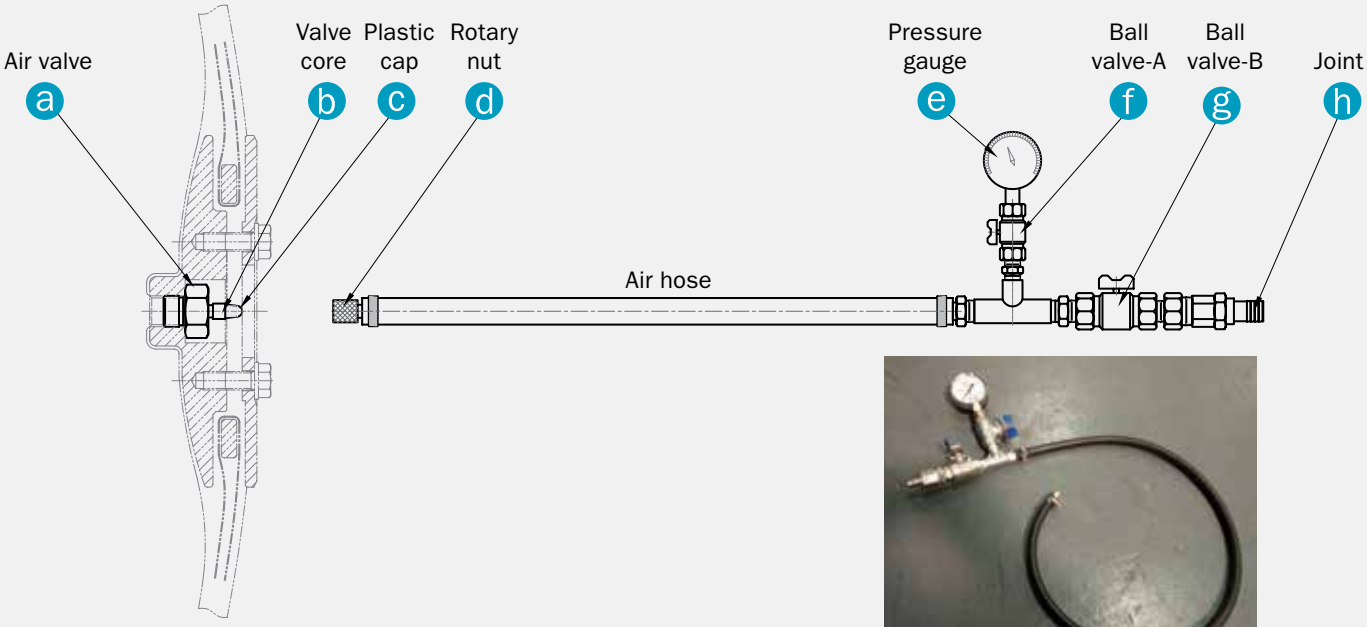
Follow the below instructions to unpack Trelleborg's pneumatic fenders:

1	The fender should be placed in an area large enough to accommodate it when fully inflated. Areas strewn with debris or near high-temperature metalwork must be strictly avoided to prevent damage to the skin of the fender.
2	Cut and remove the ropes or bands that are wrapped around the fender. Take extra care not to cut the fender's body during the process.
3	Slowly inflate the fender and adjust the internal air pressure by strictly following the instructions within section 2.3.
4	Brace the fender to prevent it from rolling as any protruding objects nearby may cause damage to the fender. The recommended height of the brace is approximately ¼ of the fender diameter. Use wooden braces or rubber tires without any sharp protrusions or edges to prevent any damage to the fender's body.



2.3 Inflation

INFLATION OF SMALL AND MEDIUM SIZE FENDERS UP TO DIAMETER 2M



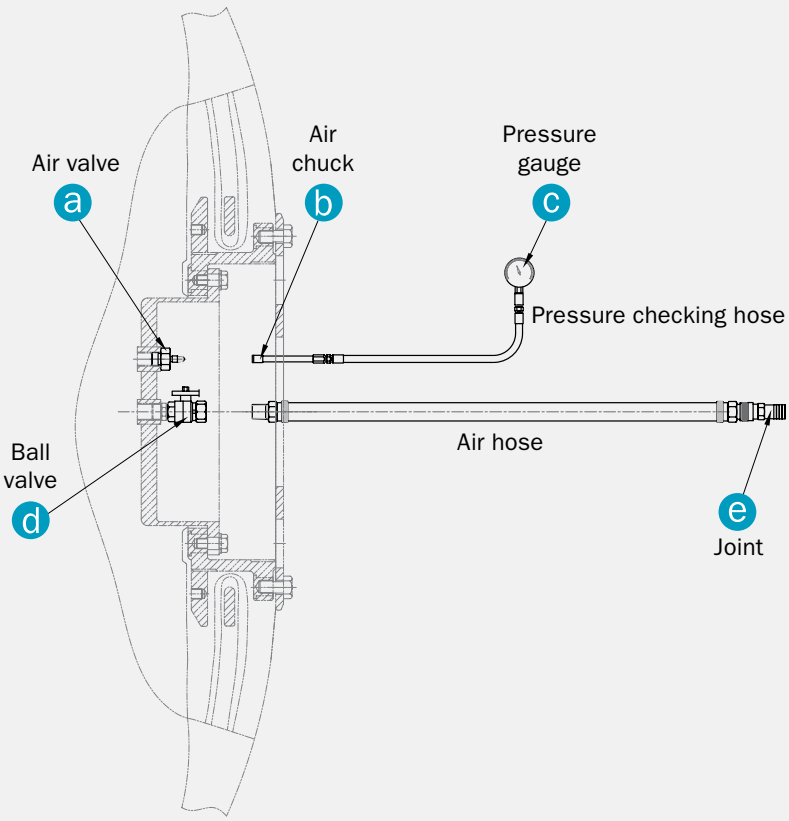
Strictly follow the below instructions to inflate Trelleborg's pneumatic fenders. Over inflating is extremely dangerous.

1	Remove the plastic cap (c) and valve core (b) from the air valve (a) at the flange opening and connect the rotary nut (d) on the air hose to the air valve of the fender.
2	Connect the joint (h) to the air compressor. Make sure that the ball valve-A (f) and ball valve-B (g) are kept closed before connecting joint (h) to the air compressor.
3	Turn on the air compressor and open the compressor valve. The pressure of the compressor should be set between 4 to 7 kg/cm^2.
4	Open the ball valve-B (g) on the air hose to release the air to the fender.
5	To check the pressure inside the fender, gradually close the ball valve-B (g) and gradually open the ball valve-A (f). The reading is on the pressure gauge (e). Make sure to check the reading periodically until the specified pressure is reached to avoid over-inflating.
6	Close the compressor valve to stop inflating when the air pressure reaches the specified pressure plus an additional 0.05 kg/cm^2.
7	Disconnect the air hose by unscrewing the rotary nut (d) and quickly screw tight the valve core (b) on the air valve (a).
8	Use soapy water to check for leaks at the air valve (a) area or the flange opening.
9	Note: the air from the compressor is warm but would soon cool off after the fender is fully inflated. Check the internal pressure of the fender one hour after inflation and again when the fender is placed in the water.
10	If the pressure is too high, release the air by pushing the tip of the valve core (b) or use the valve cap (c) to unscrew the valve core (b) to release the air.
11	Once the air pressure decreases to the required level, block the tip of the air core (b) with your finger and quickly put the valve core (b) back to prevent releasing excessive air. Screw the valve core (b) securely with the valve cap (c). Ensure the valve core (b) is firmly in place. Replace the valve core with a new one if leakage is detected after the valve core (b) is firmly fitted. Finally, close the air valve cap (c) tightly.

Note: The air pressure can be affected by the environmental temperature, hence it is recommended to check the pressure regularly.

2.3 Inflation

INFLATION OF LARGE SIZE FENDERS WITH DIAMETER OF ABOVE 2M



Strictly follow the below instructions to inflate Trelleborg's pneumatic fenders. Over inflating is extremely dangerous.

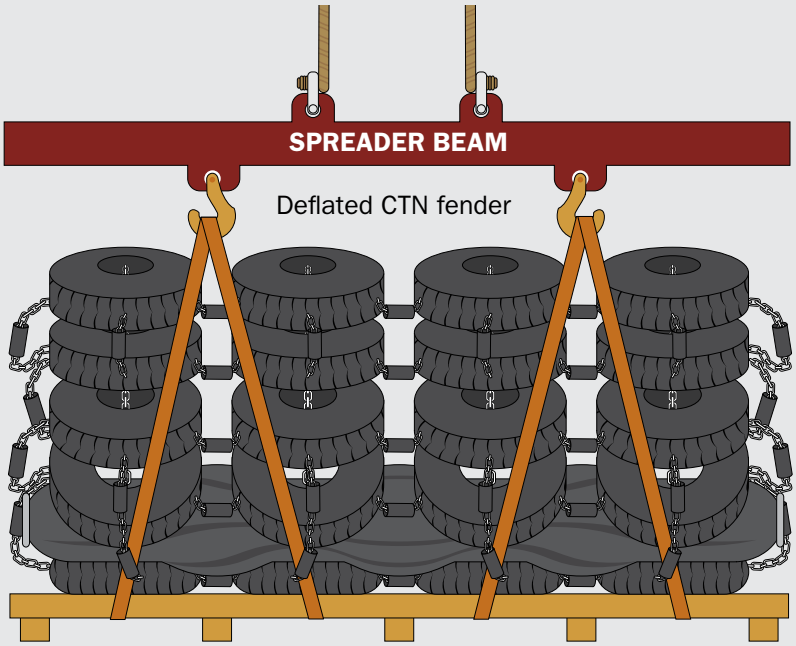
1	Connect the air hose to an air compressor with the joint (e).
2	Turn on the air compressor and open the valve (d) to release the air from the compressor to fill the fender. The pressure of the air compression should be set between 4 to 7 kg/cm^2.
3	Remove the cap of the small air valve (a) and press the air chuck (b) into the small air valve (a) to check the pressure and ascertain if an inflation is necessary. Check the internal air pressure at (c) periodically to ensure that the fender is not over-inflated.
4	Ensure that air is not leaking from the hose line. Any air leak from the air hose line will result in inaccurate measurement.
5	Stop inflating when the internal pressure of the fender reaches the specified air pressure plus an additional 0.05 kg/cm^2 by turning off the air compressor.
6	Disconnect the air hose after closing the valve (d). Caution: The air remaining in the hose has some pressure.
7	Use soapy water to check for air leakage from the valve (d), small air valve (a) and the flange opening.
8	Note that air from the compressor is warm but would soon cool off after the fender is fully inflated. Check the internal pressure of the fender one hour after inflation and again when the fender is placed in the water.

Note: The air pressure can be affected by the environmental temperature, hence it is recommended to check the pressure regularly.

2.4 Lifting

Different types of fender of varying sizes may be packed differently thus the handling methods may vary. The followings are some of the possible scenarios:

LIFTING NEW CTN TYPE FENDERS



Lifting new CTN fender using beam

Follow the below instructions to lift a new CTN pneumatic fender:

1. When lifting the fenders, extreme care must be taken to ensure that the procedure is carried out under the supervision of competent personnel.
2. New CTN type fenders shall be lifted by properly securing lifting straps shackles to the chain net shackles which are either colored or marked as “Lift Point”.
3. New long CTN fenders should be lifted horizontally using a spreader beam and two or more lifting straps with shackles. The lifting straps shackles should be secured properly to the chain net shackles which are either colored or marked as “lift point”.

Note: The weight of the fender must be established to ensure the correct size of spreader beam, lifting straps and shackles are being used. Please contact Trelleborg Marine and Infrastructure if in doubt.

2.4 Lifting

LIFTING IN-SERVICE CTN TYPE FENDERS

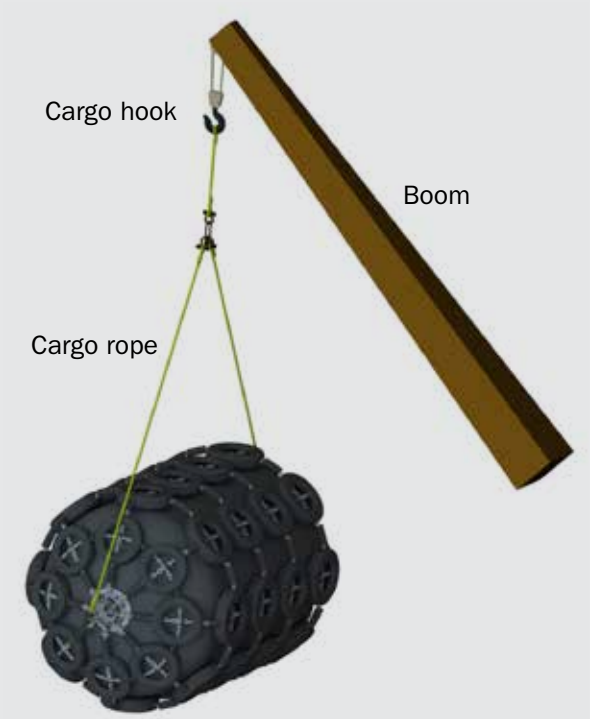


Figure-A

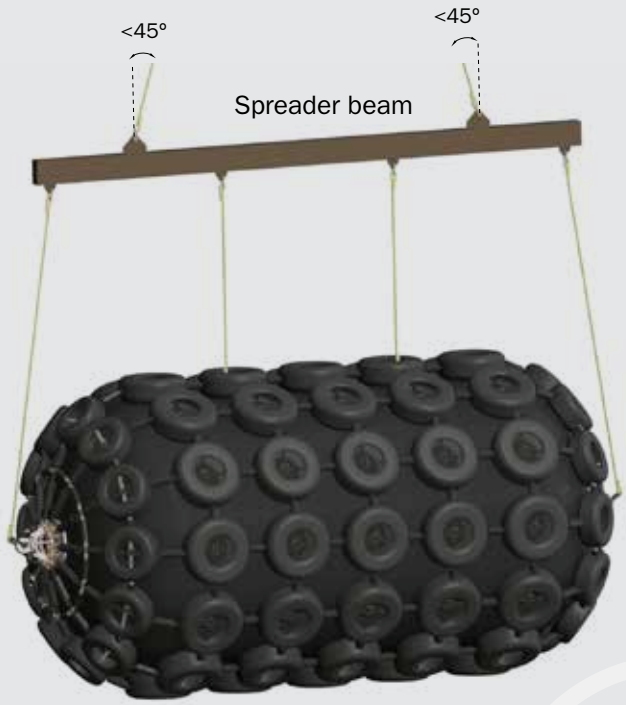


Figure-B

Follow the below instructions to lift in-service CTN pneumatic fenders.

1	When lifting the fenders, extreme care must be taken to ensure that the procedure is carried out under the supervision of competent personnel.
2	An in-service CTN fender should be lifted horizontally with lines (ropes/straps) attached to the colored shackles on the chain net.
3	An alternative method is to lift the fender by the lifting eyes at its ends as shown in Figure-A. In addition, long in-service CTN fenders should be lifted horizontally using a spreader beam and lifting straps with shackles as shown in above Figure-B.
4	After lifting an in service fender out of the water, conduct a thorough examination to assess the condition of the accessible area on the fender body and the net components.
5	Before lifting the fender, the immediate area of the operation must be cordoned off and all personnel in the area have to be informed of the impending lift.

Note: The weight of the fender must be established to ensure the correct size of spreader beam, lifting straps and shackles are being used. Please contact Trelleborg Marine and Infrastructure if in doubt.

2.4 Lifting

LIFTING NEW AND IN-SERVICE SLING TYPE FENDERS

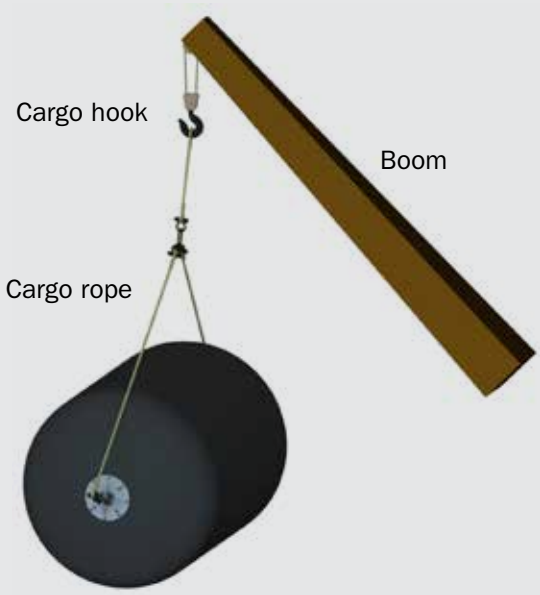


Figure-C

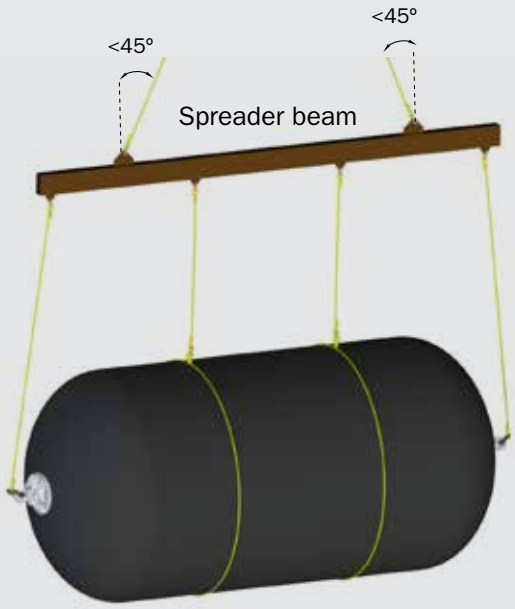


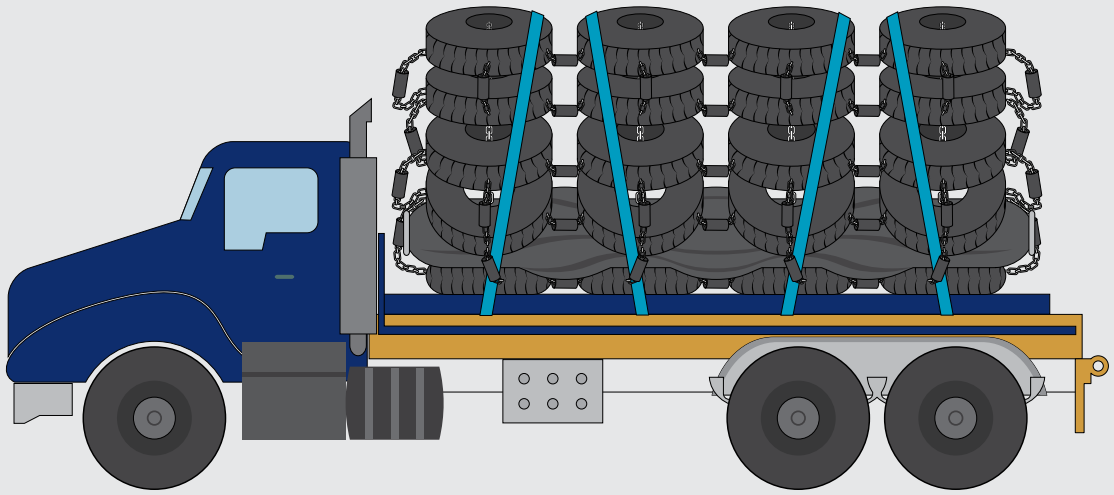
Figure-D

Follow the below instructions to lift both new and in-service sling type pneumatic fenders:

1	When lifting the fenders, extreme care must be taken to ensure that the procedure is carried out under the supervision of competent personnel.
2	New small sling type fenders should be lifted using a forklift.
3	Bigger fenders, new or in-service are normally lifted from their ends using lifting straps with shackles as shown in Figure-C.
4	Long fenders, new or in-service, should be lifted using a spreader beam and lifting straps with shackles as shown in Figure-D.
5	The procedure should be carefully carried out using internal safety protocols.

Note: The weight of the fender must be established to ensure the correct size of spreader beam, lifting straps and shackles are being used. Please contact Trelleborg Marine and Infrastructure if in doubt.

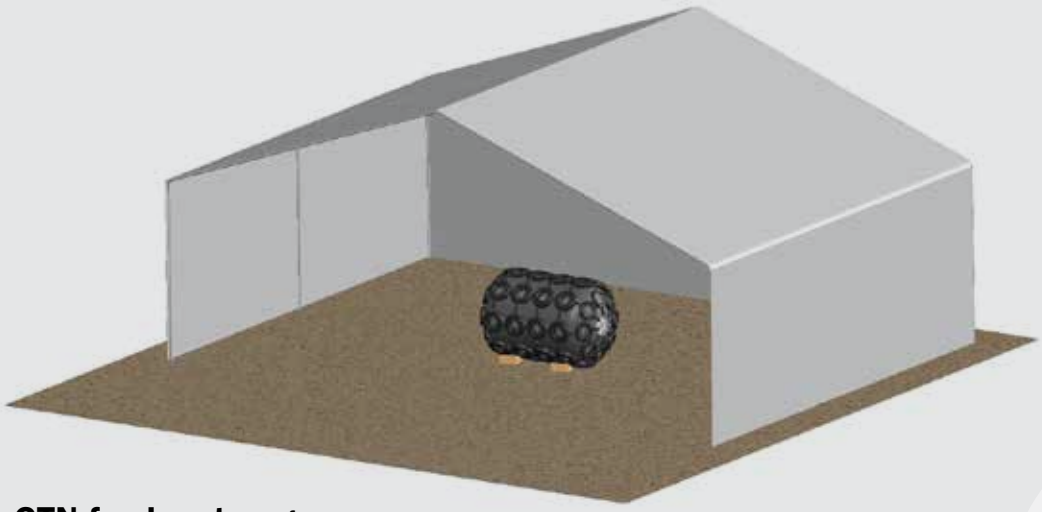
2.5 Transportation



Follow the below instructions to transport Trelleborg's pneumatic fenders:

1	Adhere strictly to the lifting instructions described in the manual. Place the fender on a trailer and make sure there are no sharp edges, protrusions or debris on the flat surface of the trailer. Secure the fender on the trailer using ropes / straps.
2	Ensure the wheels of the trailer do not come in contact with the fender during transportation.
3	While transporting with a forklift, avoid damaging the fenders, which may be caused by the forks or by dragging the fenders on the ground.
4	Avoid inserting the forks of the forklift in between the CTN assembly as it may damage the tires as well as the fender body.

Storage



CTN fender storage

Please adhere to the following instructions if the fenders need to be stored for an extended period. Whenever possible, the recommendations of ISO 2230 Guidelines for Storage of Rubber Products should be followed:

- Make sure the fender is inflated to its original shape (internal pressure 20 kPa) before storing for an extended period.
- The fenders should be stored in a cool dark place, recommended less than 25°C (77°F), away from the following:
  a. Direct sources of heat such as boilers, radiators and sunlight
  b. Ozone including combustion gases, organic vapors and equipment capable of generating ozone
  c. Light sources with high ultra-violet content
  d. Liquids such as petrol, greases, acids, disinfectants, cleaning fluids and their vapors
  e. A rodent-free area

DEFLATION :

It is recommended to examine the fender for damage, to clean it and ensure it is dry before deflating and storing it. Should the fender be kept for a long time or if its surface is greasy, clean it with detergent and water.

Deflation of fenders larger than 2m diameter is conducted using the ball valve while smaller fenders are deflated using the air valve located at the steel flange. It is not advisable to keep the fender in deflated condition. Fender should be inflated to its original shape for storage.

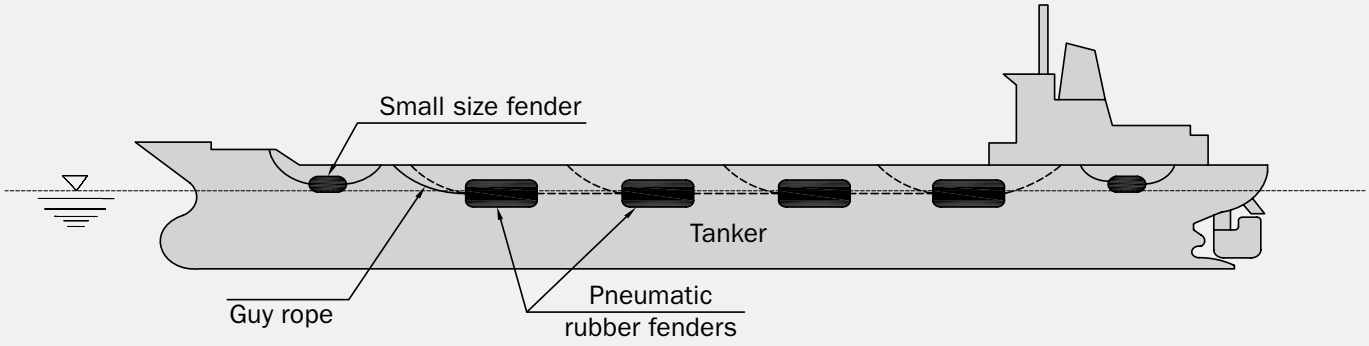
Installation

4.1 Installation

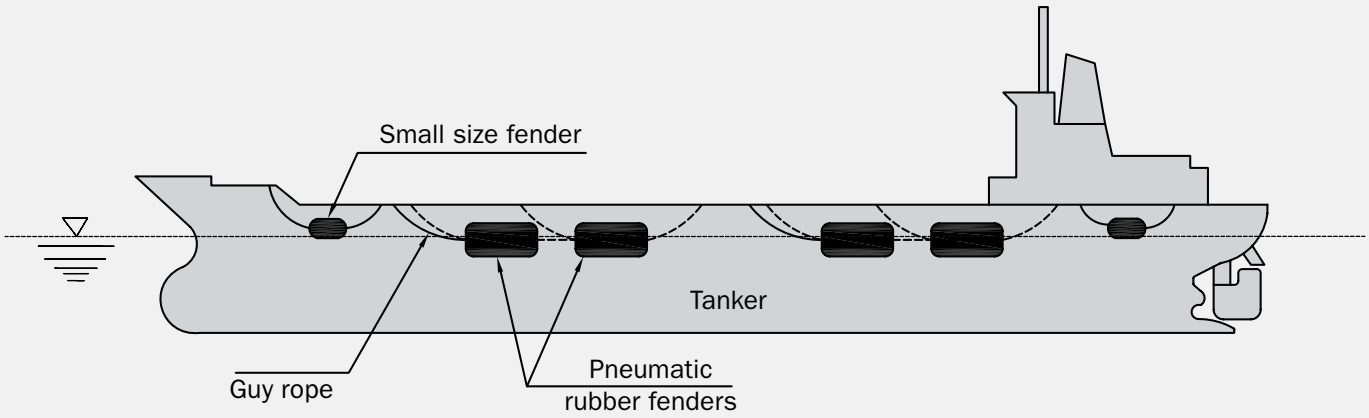
INSTALLATION ON SHIP

Fenders can be installed along the hull of a ship with one of the following methods:

Fenders rigged in a continuous string



Fenders rigged in pairs



Follow the below instructions to install the fenders on a ship:

1	Ensure that the guy rope or chain is long enough for the fender to be floating in the water to avoid sudden stress on the guy ropes or chains.
2	Secure the guy ropes or chains with the ship. Strictly, choose secure parts on the ship,such as bollards or chocks instead of the weaker hand-rails, to connect the guy ropes or chains with the ship.
3	It is recommended to use a crane or derrick to hang the fenders to ensure maximum stability.
4	Keep the fenders away from scuppers and other protrusions at all times.
5	When two ships are mooring side-by-side, take extra care to ensure at least two fenders come in contact with the parallel bodies of each ship, one at each end.
6	Avoid rigging in a continuous string when the waves are high or when the contact area cannot be fixed. It is advisable to place them at individual points along the ship hull in such situation.
7	Please ensure the guy-line is long enough for tidal variations.

4.1 Installation

INSTALLATION ON JETTY / QUAY

Fenders can be installed on the jetty / quay with one of the following methods:

Fenders secured using guide rails (Figure E)

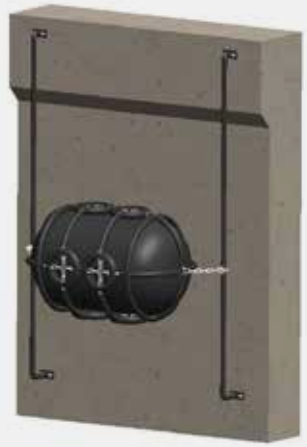


Figure E

Fenders secured using brackets or U anchors (Figure F, G, H)

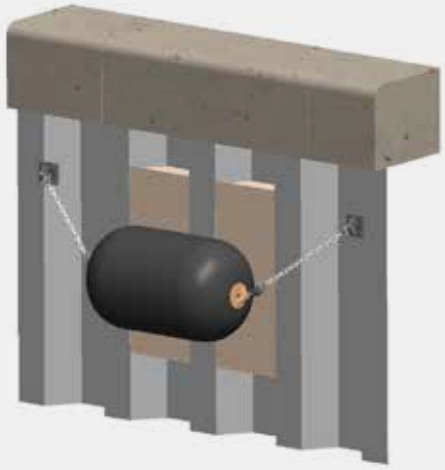


Figure F

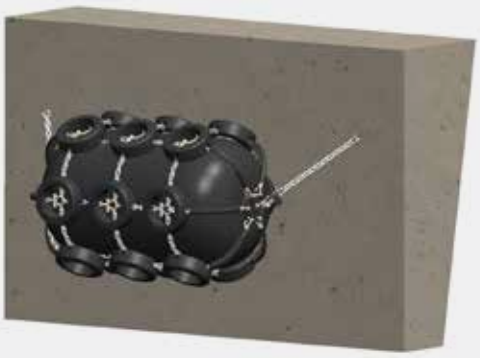


Figure G

Figure H

Follow the below instructions to install the fenders on a jetty / quay:

1	Install the fenders on a flat surface.
2	Construct the jetty wall, making sure its surface is smooth and flat by removing all protrusions such as frame hooks and steel framework. The jetty wall should be as flat as possible to avoid deforming the fender prematurely. Please contact us if the quay does not allow this for any reason.
3	The ebb and flow of the tide may cause the fender to be above or below the jetty/quay wall especially when deflected.
4	Do take into consideration the ebb and flow of the tide when securing the fender with the guy rope or chain. For installation advice, please contact Trelleborg Marine and Infrastructure.

4.1 Installation

INSTALLATION DIMENSIONS

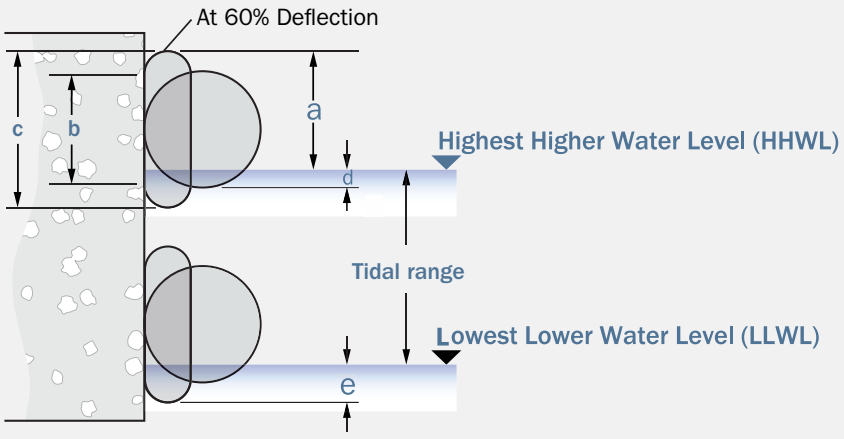
Pneumatic fenders must be installed on a solid structure or a reaction panel to ensure it is adequately supported during impacts.

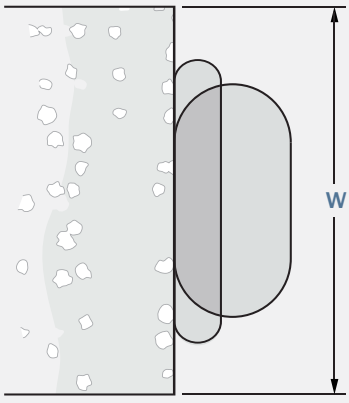
SLING FENDERS							
FENDER SIZE		a	b	c	d	e	W
DIAMETER	LENGTH						
500	1000	456	471	671	130	216	1300
1000	1500	1021	942	1342	150	321	1950
1000	2000	1031	942	1342	140	311	2600
1200	2000	1265	1131	1611	140	345	2600
1350	2500	1411	1272	1812	170	401	3250
1500	3000	1597	1414	2014	160	417	3900
1700	3000	1791	1602	2282	200	491	3900
2000	3500	2132	1885	2685	210	552	4550
2500	4000	2678	2356	3356	250	678	5200
2500	5500	2688	2356	3356	240	668	7150
3300	4500	3545	3110	4430	320	885	5850
3300	6500	3595	3110	4430	270	835	8450
3300	10600	3615	3110	4430	250	815	13780
4500	9000	4931	4241	6041	340	1111	11700
4500	12000	4961	4241	6041	310	1081	15600

CHAIN TIRE NET (CTN) FENDERS - AIRCRAFT TIRE STANDARD PROTECTION							
FENDER SIZE		a	b	c	d	e	W
DIAMETER	LENGTH						
1000	1500	836	942	1342	335	506	1950
1000	2000	881	942	1342	290	461	2600
1200	2000	1105	1131	1611	300	505	2600
1350	2500	1251	1272	1812	330	561	3250
1500	3000	1457	1414	2014	300	557	3900
1700	3000	1641	1602	2282	350	641	3900
2000	3500	1982	1885	2685	360	702	4550
2500	4000	2498	2356	3356	430	858	5200
2500	5500	2538	2356	3356	390	818	7150
3300	4500	3335	3110	4430	530	1095	5850
3300	6500	3365	3110	4430	500	1065	8450
3300	10600	3395	3110	4430	470	1035	13780
4500	9000	4701	4241	6041	570	1341	11700
4500	12000	4721	4241	6041	550	1321	15600
4500	12000	4721	4241	6041	550	1321	15600

[Units: mm]

Please contact Trelleborg Marine and Infrastructure for installation of other sizes and other CTN protection.





Maintenance

5.1 Inspection

Trelleborg's pneumatic fenders are fast and easy to deploy, requiring minimal maintenance.

Though Trelleborg's fenders are designed to last, it is advisable to carry out regular inspection on the fenders condition and internal pressure, especially when the fenders are inflated and when they are taken out of the water. Any minor cuts and abrasions on its surface can be treated if detected early, hence prolong the lifespan of the fenders.

1	Check the air pressure of each fender at least four times a year by performing a gauge check. Please refer to Section 2.3 of this manual for the procedure to increase the internal pressure. Check for leaks at the flange opening using soapy water. Perform gauge check at the specified pressure and repeat the procedure twenty-four hours later. Should you notice any drop in pressure reinflate fender to the desired internal pressure and repeat this process in twenty-four hours.*
2	Remove rust found on the metal fittings and if possible re-galvanize them and/or coat with rustproof paint for extra protection, using International or equivalent brand paint. Replace worn out metal fittings.
3	Check the net and guys for rust and wear and the shackles for loss of pins. Repair or replace when necessary.
4	Loose or worn rubber sleeves can damage the net of the fender. In such cases, fiber rope or fiber jacket can be used temporarily until the rubber sleeves are replaced.
5	Remove all protrusions from the quay / jetty wall and check periodically for any new protrusions.
6	Remove all marine growth and debris from the fender, chain and tire netting.
7	Apply grease when necessary to ensure proper rotation of the swivels. Use lithium based grease for swivels, such as Shell Gadus S5 V150XKD or equivalent.
8	Inspect and clean the safety valve once every two years. Refer to section 5.3 for the procedure to clean the safety valve.
9	Keep maintenance logs and history for future reference.
10	Please contact Trelleborg Marine and Infrastructure if in doubt.

*For STS application, it is recommended to check the condition of the fender before every use, including the air pressure.

5.1 Inspection

INSPECTION SCHEDULE

Follow the table below to inspect the fender as well as its components:

CHECKLIST	SCHEDULE
Check pressure and valves	Every 3 months or after every 3 to 4 berthings
Visual check on body	Every 6 months or more frequently, if possible, or after any abnormal berthing
Check CTN and guiding accessories	Every 12 months or more frequently, or after any abnormal berthing
Detailed check on body	Every 18 months
Check safety valve	Every 24 months or after any abnormal berthing if the safety valve releases pressure
Abnormal berthing	If any abnormal berthing occurs on the fender, proper checks must be carried out for any visible damages

5.1 Inspection

INSPECTION CHECKLIST

It is advisable to prepare a checklist for routine preventative maintenance. The template below can be used for collecting this information.

In the event that damage is identified during maintenance inspection, please contact Trelleborg Marine and Infrastructure for further advice.

GENERAL			
Fender location			
General condition	Excellent / Good / Average / Poor / Very Poor		
Port		**Berth Name**	
Date		**Time**	
Name		**Signature**	

RUBBER BODY		
Puncture	yes / no	(photos, size)
Pitting	yes / no	(photos, size)
Weeping	yes / no	(photos, size)
Pin holes	yes / no	(photos, size)
Reinforcement cord layer, damage	yes / no	(photos, size)
Cracks	yes / no	(photos, size)
End fittings tight, secure	yes / no	(photos)
Cuts or abrasions	yes / no	(photos, size)
CTN rubber sleeve, damage	yes / no	(photos)
Spillages (paint, oil)	none / minor / major	
Marine growth	yes / no	(photos, size)

CTN & END FITTINGS INCLUDING VALVES		
Corrosion, scratches	yes / no	(photos)
Paint condition, damage	yes / no	(photos)
Dents, bends	yes / no	(photos)
Welds, cracks	yes / no	(photos)
Accident damage	yes / no	(photos)
Chain diameter loss	yes / no	(photos)
Shackles, shackle pins or chain links wear	yes / no	(photos)
End fittings damage	yes / no	(photos)
Inflation valve damage	yes / no	(photos)
Safety valve damage	yes / no	(photos)
Pressure check valve damage	yes / no	(photos)
Swivel damage	yes / no	(photos)

COMMENTS & PHOTOS (FILES NAME):

FOLLOW UP			
Refer to Trelleborg	yes / no	**Warranty issue**	yes / no
Date referred		**Trelleborg contact**	

5.2 Repair

The materials and instruments provided in the repair kit box are only good for temporary repair of a fender. Depending on the degree of damage, some repairs are best carried out by a rubber company. Due to the short shelf life of cement, adhesive is not included in the repair kit. The brand “TIP TOP SC2000” is recommended and could be locally purchased if necessary.

Partly pitting Figure I

Puncture Figure J

1	If any partly pitting is found on the fender’s rubber surface as shown in Figure I or if the reinforcement cord layer is exposed due to any cut or peeling, the following method can be used to repair the fender.
	a) Buff the damaged area and the area within 100mm radius around it with sandpaper and wire brush. Dust off the rubber powder.
	b) Cut out a rubber patch roughly the same size as the buffed area. Buff away one side of the rubber patch with sandpaper and wire brush and taper the edges of the rubber patch.
	c) Clean the buffed area and the exposed reinforcement cord with a solvent such as gasoline.
	d) Mix TIP TOP Cement SC2000 with 10% of RF hardener. Apply one coat of the mixture onto both buffed areas and allow them to dry completely (about 40 minutes if ambient temperature < 30°C (86°F) then increase the curing time until both the buffed areas are completely dry. Fluorescent light or any other indirect heat source can be used to raise the temperature up to 30°C (86°F). Strictly do not use naked flame to raise the temperature as this could severely damage the body material of the fender.
	e) Apply a second coat of cement to the same area.
	f) When the second application of cement has dried sufficiently, carefully lay the patch over the damaged area.
	g) With the hand roller provided in the repair kit, roll the patch from the center working towards the edges.

2	If the fender appears to be leaking or punctured as shown in Figure J, please contact Trelleborg Marine and Infrastructure for further evaluation and assistance.
3	If the reinforcement cord layer is damaged, the correct way to repair it is by vulcanization. Please contact Trelleborg Marine and Infrastructure for evaluation and assistance.
4	It is structurally impossible to repair a cut within 300mm of the flange opening.

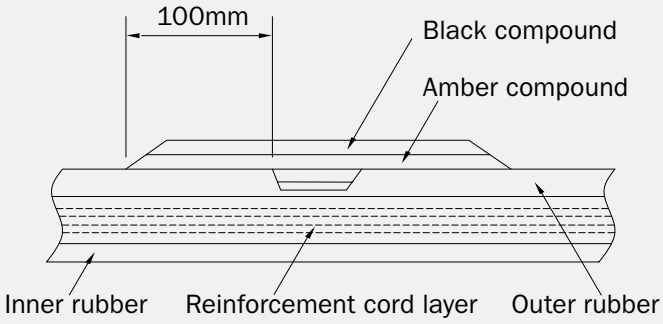


Figure K

5.2 Repair

STANDARD REPAIR KIT

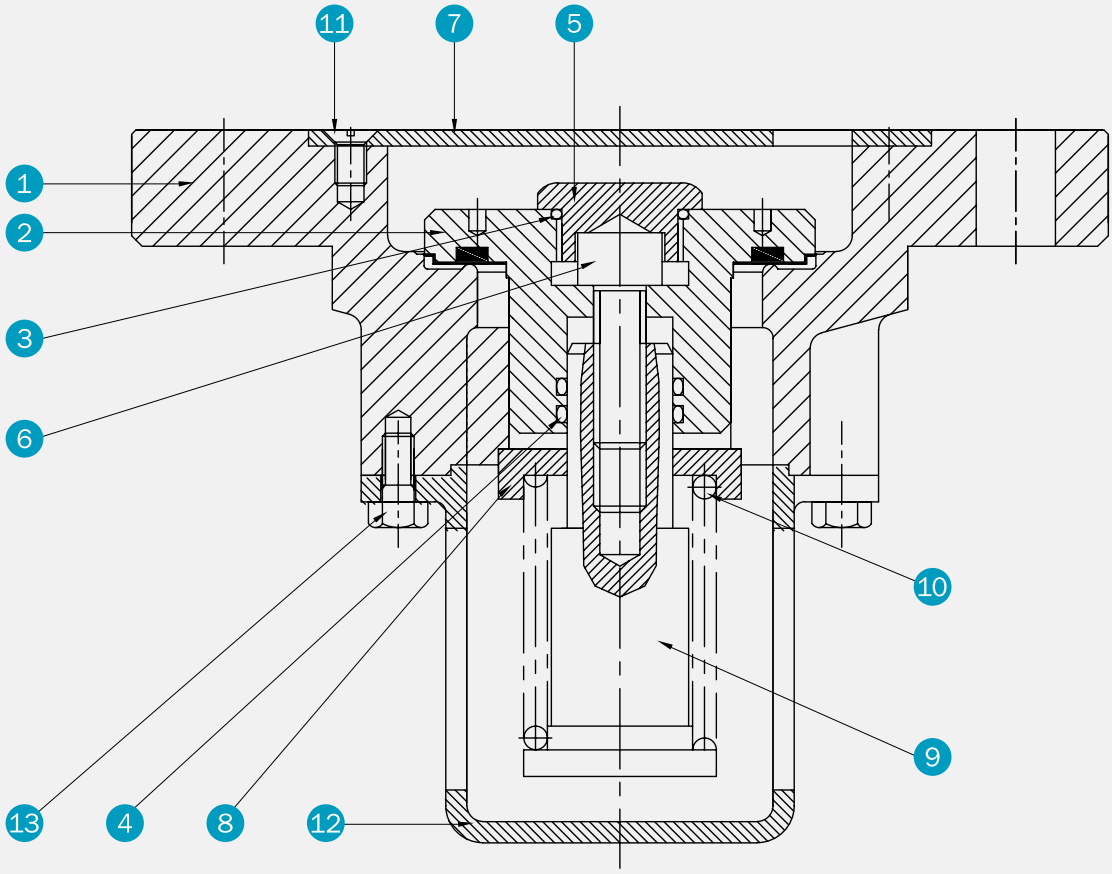
ITEM	QTY	IMAGE	A TYPE	B TYPE	C TYPE
			PNE500	PNE1000 PNE1200 PNE1350 PNE1500 PNE1700 PNE2000	PNE2500 PNE3000 PNE3300 PNE4500
Tool box	1		YES	YES	YES
Rubber sheet	1		YES	YES	YES
Brush	2		YES	YES	YES
Sand paper	2		YES	YES	YES
Wire brush	1		YES	YES	YES
Hand roller	1		YES	YES	YES

5.2 Repair

STANDARD INFLATION KIT

ITEM	QTY	IMAGE	A TYPE	B TYPE	C TYPE
			PNE500	PNE1000 PNE1200 PNE1350 PNE1500 PNE1700 PNE2000	PNE2500 PNE3000 PNE3300 PNE4500
Teflon	1		YES	YES	YES
Air valve (spare valve)	1		NO	YES	YES
Air valve nipple (spare valve)	2		YES	NO	NO
Box spanner for valve removing	2		NO	YES	YES
Box spanner for valve nipple	1		YES	YES	YES
Valve core screw driver	1		YES	YES	YES
Air pressure gauge with air filling hose	1		YES	YES	NO
Air filling hose			NO	NO	YES
Air pressure gauge with air chuck			NO	NO	YES

5.3 Safety Valves



1	Body	7	Cover
2	Disc	8	Upper Spring Seat
3	O-Ring	9	Bottom Spring Seat
4	O-Ring	10	Spring
5	Cap	11	Bolt
6	Adjust Screw	12	Spring Cover
		13	Bolt

5.3 Safety Valves

PRINCIPLE OF OPERATION

The safety valve keeps the internal pressure of the fender within a designated pressure range so it does not exceed the pre-set pressure limit.

If the internal pressure of the fender exceeds the pre-set pressure limit, parts 2, 5, 6 and 9 act to release the air until the internal pressure is reduced to the acceptable range before closing the valve again. Refer to the figure on page 27 and the table below.

PNEUMATIC-TYPE FENDER INITIAL PRESSURE	SAFETY VALVE SETTING PRESSURE
0.5 kgf/cm^2 (50 kPa)	1.8 kgf/cm^2 (175 kPa) ±10%
0.8 kgf/cm^2 (80 kPa)	2.35 kgf/cm^2 (230 kPa)±10%

CLEANING THE SAFETY VALVE

It is a good practice to give the safety valve a proper cleaning once every two years for durability and reliability sake. Please follow the instruction below:

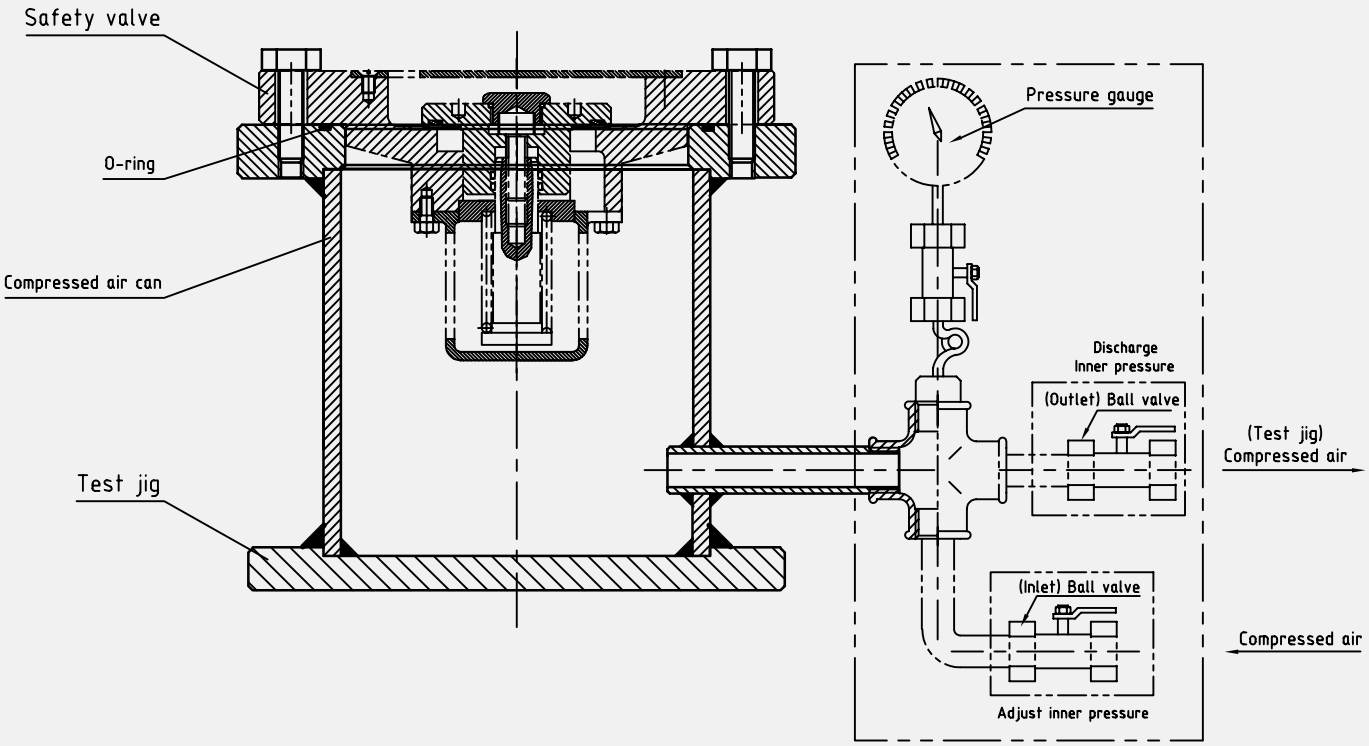
1	Release the air from the fender until it is almost deflated.
2	Unscrew the bolts that connect the safety valve to the flange.
3	Remove the safety valve from the flange.
4	Unscrew the bolts (11) followed by removing the cover of the safety valve (7).
5	Check the surface of the disc (2) and the cap (5).
6	Clean with rust remover (eg. WD-40) to get rid of any rust or pitting on the surface following the instructions given on the rust remover. Wipe clean with a piece of dry cloth if the surface is rust or pitting free.
7	Put the cover (7) back properly and tighten the bolts (11).
8	Install the safety valve back on the flange.

Please contact Trelleborg Marine and Infrastructure if in doubt.

STORAGE OF SAFETY VALVE

Store the safety valve properly in locations without excessive vibration nearby. Calibrate the safety valve regularly, even if it has not been used for a period of time.

5.4 Safety Valve Test Procedure:



1	Release the air from the fender until it is almost deflated.
2	Unscrew the bolts that connect the safety valve to the flange.
3	Remove the safety valve from the flange and install it to the test jig* taking note to use rubber O-ring for airtightness.
4	Connect the air hose to the air inlet ball valve making sure there is no air leakage at the connecting location.
5	Close the discharge ball valve and open the inlet ball valve slowly to let the compressed air in observing the reading on the pressure gauge.
6	Record the reading of the pressure on the pressure gauge when the safety valve starts releasing pressure. That is the opening pressure of the safety valve.
7	If the opening pressure fully complied with the setting pressure in the table on pg 28, install it back to the flange of the fender and get ready the fender to be in use.
8	If it does not comply with the setting pressure, please follow the instruction on ‘Calibration of setting pressure’ to set the opening pressure.

*For assistance with test jig setup contact Trelleborg Marine and Infrastructure

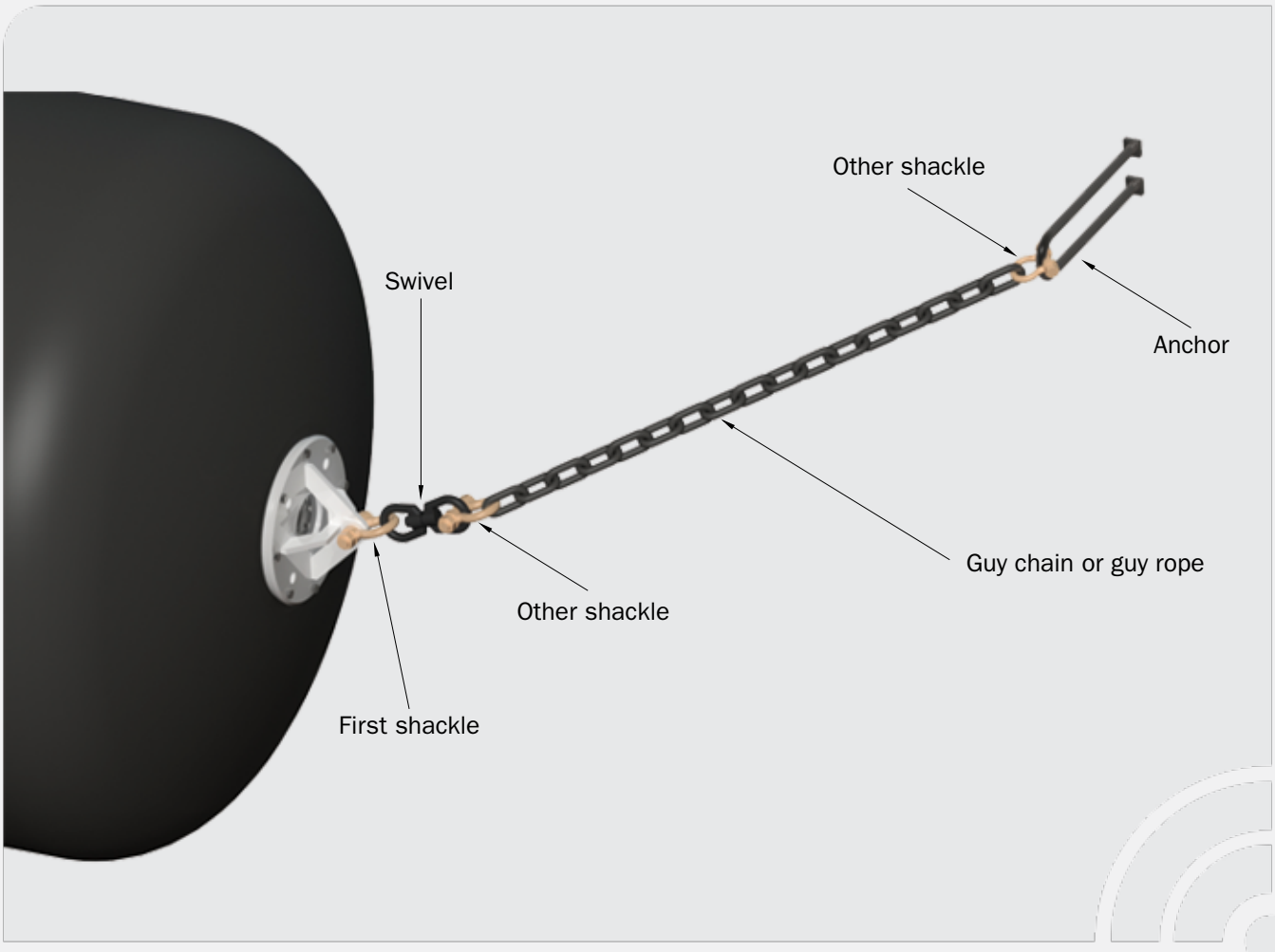
5.5 Calibration of Safety Valve Pressure Settings:

1	Refer to the safety valve drawing on page 27.
2	Unscrew the bolts (11) followed by removing the cover of the safety valve (7).
3	Remove the cap to tune the Adjust screw (6)
4	If the opening pressure is lower than the required setting pressure, tighten the Adjust Screw by turning clockwise.
5	If the opening pressure is higher than the required setting pressure, loosen the Adjust Screw by turning anti-clockwise.
6	After step 3 or 4, check the opening pressure using the instructions given in the '5.4 - safety valve test procedure'.
7	Repeat step 3 to step 5 until the required setting pressure is reached.

The safety valve is faulty if it fails to set to the required opening pressure and must be replaced immediately. Please contact your Trelleborg sales representative for assistance.

Note: Adhesive is applied to the thread of the Adjust Screw so it may be a little difficult to tighten or loosen initially.

End Fittings



Pneumatic fenders are often suspended using chains and shackles. Please refer to the table below for our recommended dimensions.

FENDER FIXING ACCESSORIES (50 kPa Initial Pressure)

DIAMETER × LENGTH	FIRST SHACKLE DIAMETER	SWIVEL DIAMETER	OTHER SHACKLE DIAMETER	GUY CHAIN DIAMETER	GUY ROPE (6 X 24) DIAMETER	U ANCHOR DIAMETER
mm x mm	mm (Inch)	mm (Inch)	mm (Inch)	mm (Inch)	mm (Inch)	mm (Inch)
500 × 1000	19 (3/4)	NA	19 (3/4)	16 (5/8)	16 (5/8)	25 (1)
1000 × 1500	22 (7/8)	19 (3/4)	22 (7/8)	16 (5/8)	16 (5/8)	25 (1)
1000 × 2000	22 (7/8)	19 (3/4)	22 (7/8)	16 (5/8)	16 (5/8)	25 (1)
1200 × 2000	25 (1)	22 (7/8)	25 (1)	19 (3/4)	18 (11/16)	25 (1)
1350 × 2500	25 (1)	22 (7/8)	25 (1)	19 (3/4)	22 (7/8)	25 (1)
1500 × 3000	25 (1)	25 (1)	25 (1)	22 (7/8)	22 (7/8)	25 (1)
1700 × 3000	25 (1)	25 (1)	25 (1)	22 (7/8)	22 (7/8)	30 (1-3/16)
2000 × 3500	25 (1)	32 (1-1/4)	25 (1)	22 (7/8)	24 (15/16)	30 (1-3/16)
2500 × 4000	32 (1-1/4)	38 (1-1/2)	32 (1-1/4)	30 (1-3/16)	30 (1-3/16)	36 (1-7/16)
2500 × 5500	38 (1-1/2)	38 (1-1/2)	38 (1-1/2)	34 (1-5/16)	36 (1-7/16)	42 (1-5/8)
3300 × 4500	38 (1-1/2)	38 (1-1/2)	38 (1-1/2)	34 (1-5/16)	36 (1-7/16)	42 (1-5/8)
3300 × 6500	45 (1-3/4)	44 (1-3/4)	45 (1-3/4)	42 (1-5/8)	42 (1-5/8)	52 (2-1/16)
3300 × 10600	65 (2-1/2)	58 (2-5/16)	65 (2-1/2)	58 (2-5/16)	58 (2-5/16)	70 (2-3/4)
4500 × 9000	65 (2-1/2)	58 (2-5/16)	65 (2-1/2)	58 (2-5/16)	58 (2-5/16)	75 (3)
4500 × 12000	75 (3)	68 (2-11/16)	75 (3)	68 (2-11/16)	68 (2-11/16)	85 (3-3/8)

FENDER FIXING ACCESSORIES (80 kPa Initial Pressure)

DIAMETER × LENGTH	FIRST SHACKLE DIAMETER	SWIVEL DIAMETER	OTHER SHACKLE DIAMETER	GUY CHAIN DIAMETER	GUY ROPE (6 X 24) DIAMETER	U ANCHOR DIAMETER
mm x mm	mm (Inch)	mm (Inch)	mm (Inch)	mm (Inch)	mm (Inch)	mm (Inch)
500 × 1000	19 (3/4)	NA	19 (3/4)	19 (3/4)	18 (11/16)	25 (1)
1000 × 1500	22 (7/8)	19 (3/4)	22 (7/8)	19 (3/4)	18 (11/16)	25 (1)
1000 × 2000	22 (7/8)	19 (3/4)	22 (7/8)	19 (3/4)	18 (11/16)	25 (1)
1200 × 2000	25 (1)	22 (7/8)	25 (1)	22 (7/8)	22 (7/8)	25 (1)
1350 × 2500	25 (1)	22 (7/8)	25 (1)	22 (7/8)	22 (7/8)	25 (1)
1500 × 3000	25 (1)	25 (1)	25 (1)	26 (1-1/16)	26 (1-1/16)	30 (1-3/16)
1700 × 3000	25 (1)	25 (1)	25 (1)	26 (1-1/16)	26 (1-1/16)	30 (1-3/16)
2000 × 3500	25 (1)	32 (1-1/4)	25 (1)	30 (1-3/16)	30 (1-3/16)	36 (1-7/16)
2500 × 4000	32 (1-1/4)	38 (1-1/2)	32 (1-1/4)	34 (1-5/16)	36 (1-7/16)	42 (1-5/8)
2500 × 5500	38 (1-1/2)	38 (1-1/2)	38 (1-1/2)	42 (1-5/8)	44 (1-3/4)	52 (2-1/16)
3300 × 4500	38 (1-1/2)	38 (1-1/2)	38 (1-1/2)	42 (1-5/8)	44 (1-3/4)	52 (2-1/16)
3300 × 6500	45 (1-3/4)	44 (1-3/4)	45 (1-3/4)	50 (2)	52 (2-1/16)	62 (2-7/16)
3300 × 10600	65 (2-1/2)	58 (2-5/16)	65 (2-1/2)	66 (2-9/16)	68 (2-11/16)	80 (3-1/8)
4500 × 9000	65 (2-1/2)	58 (2-5/16)	65 (2-1/2)	70 (2-3/4)	70 (2-3/4)	85 (3-3/8)
4500 × 12000	75 (3)	68 (2-11/16)	75 (3)	84 (3-5/16)	80 (3-1/8)	100 (4)

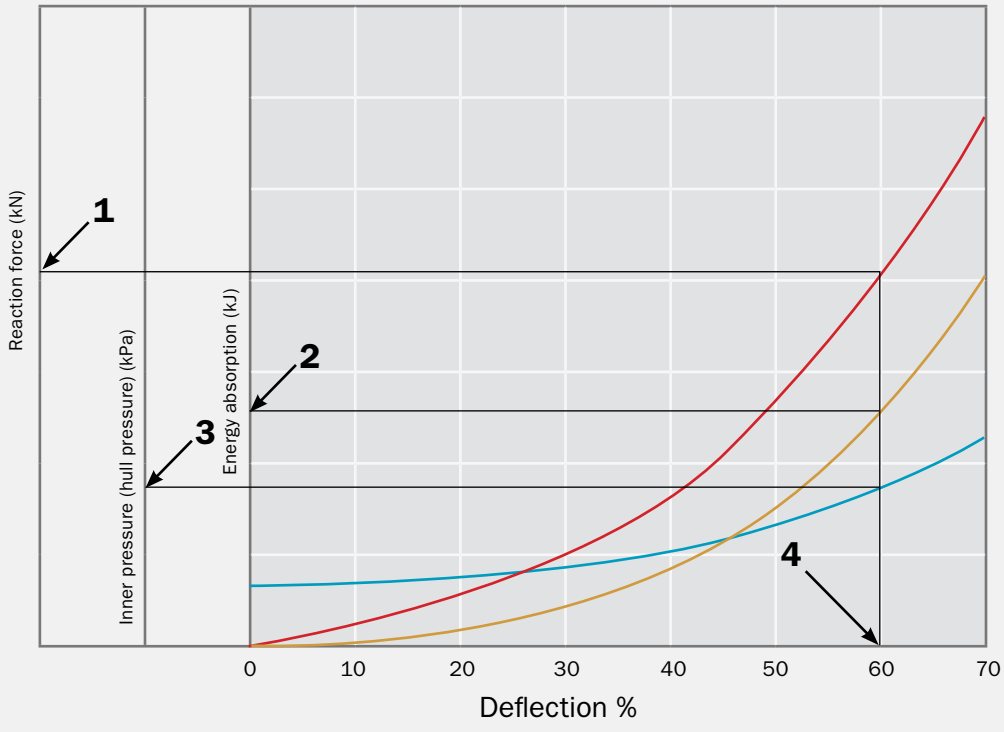
All sizes are recommended for pneumatic fenders always floating with slack chains and not suspended, for other application and fixing arrangement contact Trelleborg Marine and Infrastructure.

Performance Values

PERFORMANCE DATA

DIAMETER × LENGTH (MM X MM)	50kPa PERFORMANCE DATA			80kPa PERFORMANCE DATA		
	GEA (kNm)	RF AT GEA (kN)	HULL PRESSURE AT GEA (kN/m²)	GEA (kNm)	RF AT GEA (kN)	HULL PRESSURE AT GEA (kN/m²)
500 × 1000	6	64	132	8	85	174
1000 × 1500	32	182	122	45	239	160
1000 × 2000	45	257	132	63	338	174
1200 × 2000	63	297	126	88	390	166
1350 × 2500	102	427	130	142	561	170
1500 × 3000	153	579	132	214	761	174
1700 × 3000	191	639	128	267	840	168
2000 × 3500	308	875	128	430	1150	168
2500 × 4000	663	1381	137	925	1815	180
2500 × 5500	943	2019	148	1317	2653	195
3300 × 4500	1175	1884	130	1640	2476	171
3300 × 6500	1814	3015	146	2532	3961	191
3300 × 10600	3067	5257	158	4281	6907	208
4500 × 9000	4752	5747	146	6633	7551	192
4500 × 12000	6473	7984	154	9037	10490	202

PERFORMANCE CURVE



— Reaction force
— Energy absorption
— Inner pressure

1 Reaction force at GEA deflection
2 Guarantee energy absorption (GEA)
3 Hull pressure at GEA deflection
4 GEA deflection

PRESSURE RATINGS

Trelleborg Marine and Infrastructure manufactures fenders with two inital pressures: 50 kPa (Pneumatic 50) and 80 kPa (Pneumatic 80). Design values are given below.

PNEUMATIC 50 FENDER PRESSURE REQUIREMENTS						
DIAMETER × LENGTH (mm x mm)	INTERNAL PRESSURE (kPa)		MINIMUM ENDURABLE PRESSURE (kPa)		SAFETY-VALVE PRESSURE SETTING (kPa)	TESTING PRESSURE AT 0 % DEFLECTION (kPa)
	AT 0 % DEFLECTION	AT 60 % DEFLECTION	AT 0 % DEFLECTION	AT 60 % DEFLECTION		
500 × 1000	50	132	300	462	–	200
1000 × 1500	50	122	300	427	–	200
1000 × 2000	50	132	300	462	–	200
1200 × 2000	50	126	300	441	–	200
1350 × 2500	50	130	300	455	–	200
1500 × 3000	50	132	300	462	–	200
1700 × 3000	50	128	300	448	–	200
2000 × 3500	50	128	300	448	–	200
2500 × 4000	50	137	350	480	175	250
2500 × 5500	50	148	350	518	175	250
3300 × 4500	50	130	350	455	175	250
3300 × 6500	50	146	350	511	175	250
3300 × 10600	50	158	350	553	175	250
4500 × 9000	50	146	350	511	175	250
4500 × 12000	50	154	350	539	175	250

PNEUMATIC 80 FENDER PRESSURE REQUIREMENTS						
DIAMETER × LENGTH (mm x mm)	INTERNAL PRESSURE (kPa)		MINIMUM ENDURABLE PRESSURE (kPa)		SAFETY-VALVE PRESSURE SETTING (kPa)	TESTING PRESSURE AT 0 % DEFLECTION (kPa)
	AT 0 % DEFLECTION	AT 60 % DEFLECTION	AT 0 % DEFLECTION	AT 60 % DEFLECTION		
500 × 1000	80	174	480	609	–	250
1000 × 1500	80	160	480	560	–	250
1000 × 2000	80	174	480	609	–	250
1200 × 2000	80	166	480	581	–	250
1350 × 2500	80	170	480	595	–	250
1500 × 3000	80	174	480	609	–	250
1700 × 3000	80	168	480	588	–	250
2000 × 3500	80	168	480	588	–	250
2500 × 4000	80	180	560	630	230	300
2500 × 5500	80	195	560	683	230	300
3300 × 4500	80	171	560	599	230	300
3300 × 6500	80	191	560	669	230	300
3300 × 10600	80	208	560	728	230	300
4500 × 9000	80	192	560	672	230	300
4500 × 12000	80	202	560	707	230	300

Replacement

Fender body	Trelleborg recommends a service life of up to 15 years in line with OCIMF guidelines for Pneumatic Fenders. However, immediate replacement is required if the reinforcement cord layers are damaged beyond repair.
Chain-Tire-Net (CTN)	CTNs are consumable items and need to be replaced when there experience prolonged wear and tear. Regular inspection and maintenance can prolong their life expectancy. Please refer to the inspection schedule in section 5.1.

Warning

DANGER – HIGH PRESSURE PNEUMATIC FENDER

Handling high pressure pneumatic fenders may be hazardous, resulting in loss of life, severe body injury and / or damage of property if not installed correctly and properly maintained throughout the operation. Read, understand and apply all the guidelines given, before attempting to inflate, lift, service or operate the fender.

Failure to follow these guidelines, not taking every precaution and the absence of good engineering judgement may result in a malfunction that could result in the explosive failure of a fender.

Inflate the fender to the specified pressure following the guidelines mentioned in the inflation section of this manual. Over inflating is extremely dangerous and may result in loss of life, severe body injury and / or damage of property.

Misuse, incorrect assembly or the use of damaged or corroded components can result in the components' failure.

A highly qualified engineer or a mechanic experienced in handling high pressure fenders is recommended to inflate, lift, operate and service these type of fenders.

Strictly follow the guidelines given in the maintenance section of this manual to prolong the lifespan of the fender and for safe fender operation. To optimize safety, exercise engineering best practices along with good judgement in addition to following the guidelines in this manual.

DISCLAIMER

Trelleborg AB has made every effort to ensure that the technical specifications and product descriptions in this manual are correct.

The responsibility or liability for errors and omissions cannot be accepted for any reason whatsoever. Customers are advised to request a detailed specification and certified drawing prior to construction and manufacture. In the interests of improving the quality and performance of our products and systems, we reserve the right to make specification changes without prior notice. All dimensions, material properties and performance values quoted are subject to normal production and testing tolerances.

This manual supersedes the information provided in all previous editions. If in doubt, please check with Trelleborg Marine and Infrastructure.

MN-I&M-PNE-V2-EN,2023

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