Bollards

Tee
Horn
Kidney

Section 10

Trelleborg Marine Systems

www.trelleborg.com/marine

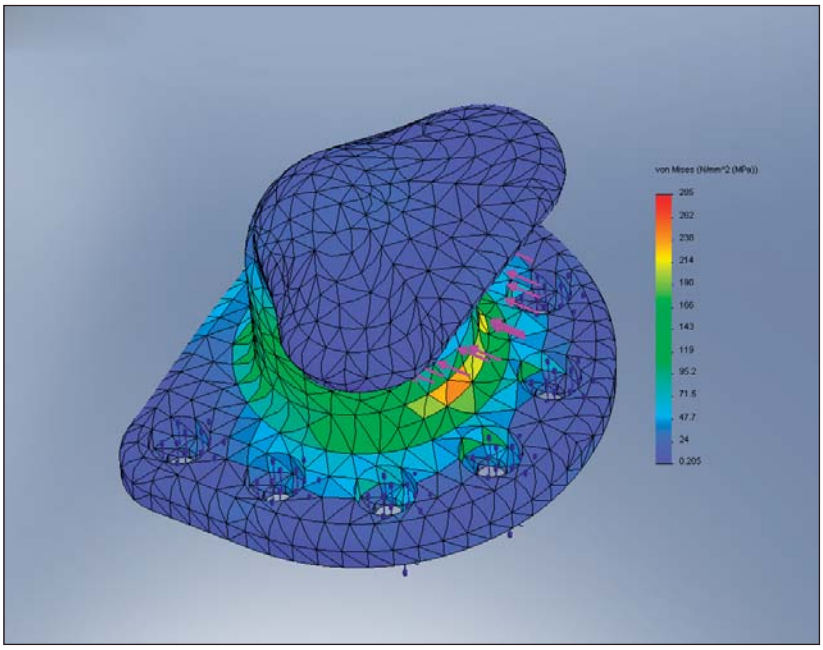
TRELLEBORG

Ref. M1100-S10-V1.1-EN

BOLLARDS

Trelleborg bollards come in many popular shapes and sizes to suit most docks, jetties and wharves. Standard material is spheroidal graphite (commonly called SG or ductile iron) which is both strong and resistant to corrosion, meaning Trelleborg bollards enjoy a long and trouble free service life.

The shape of Trelleborg bollards has been refined with finite element techniques to optimize the geometry and anchor layout. Even at full working load, Trelleborg bollards remain highly stable and provide a safe and secure mooring.



Features

- High quality SG iron as standard
- Strong and durable designs
- Very low maintenance
- Large line angles possible
- Standard and custom anchors available

Tee

Horn

Kidney

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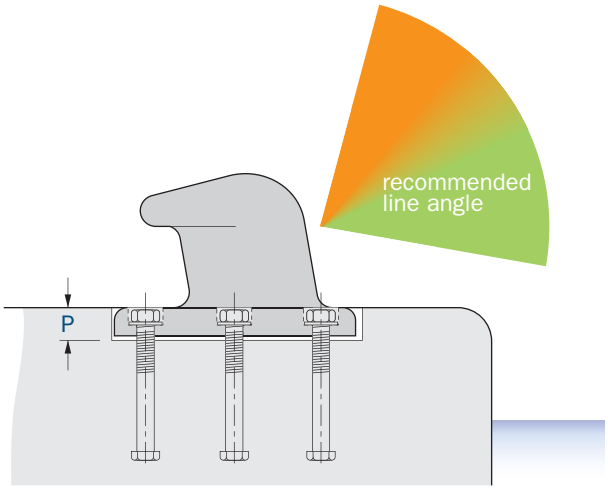
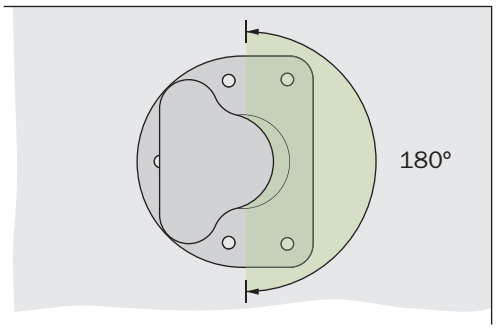
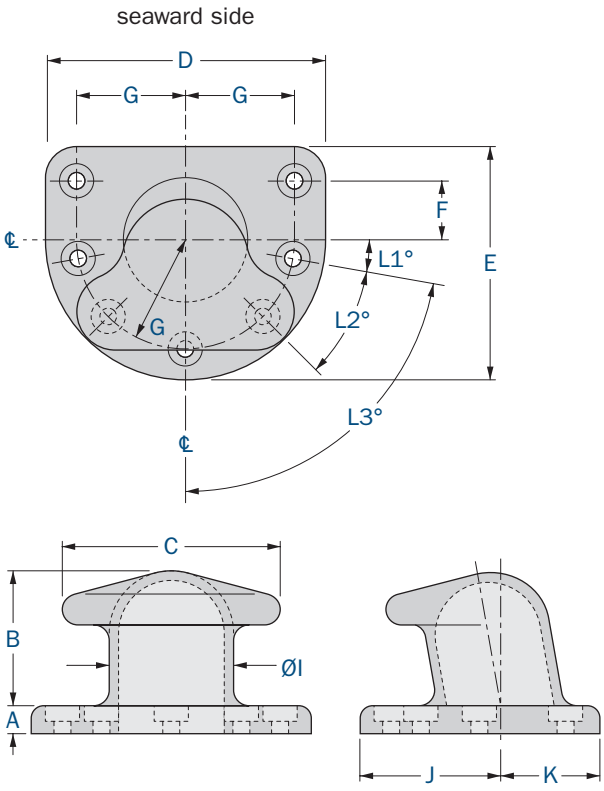
TEE BOLLARDS





Features

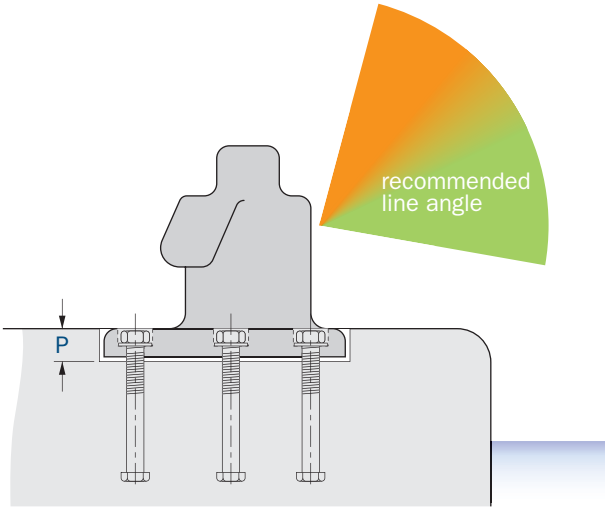
- General purpose applications up to 200 tonnes
- Suitable for steeper rope angles

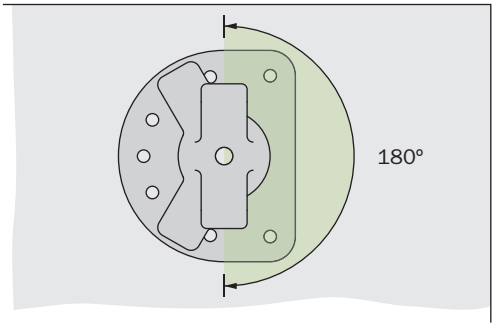


Dimension	Bollard capacity (tonnes)						
	15	30	50	80	100	150	200
A	40	40	50	70	80	90	90
B	235	255	350	380	410	435	500
C	340	350	500	550	600	700	800
D	410	450	640	640	790	900	1000
E	335	375	540	550	640	750	850
F	80	100	150	160	175	200	225
G	155	175	250	250	325	350	375
ØI	160	200	260	280	350	400	450
J	205	225	320	320	395	450	500
K	130	150	220	230	245	300	350
L1°	30°	30°	30°	15°	10°	10°	0°
L2°	–	–	–	45°	40°	40°	36°
L3°	60°	60°	60°	N/A	80°	80°	72°
Bolts	M24	M30	M36	M42	M42	M48	M56
Bolt length	500	500	500	800	800	1000	1000
P*	60	60	70	90	100	110	110
Qty	5	5	5	6	7	7	8

*P = bolt protrusion = recess depth [Units: mm]

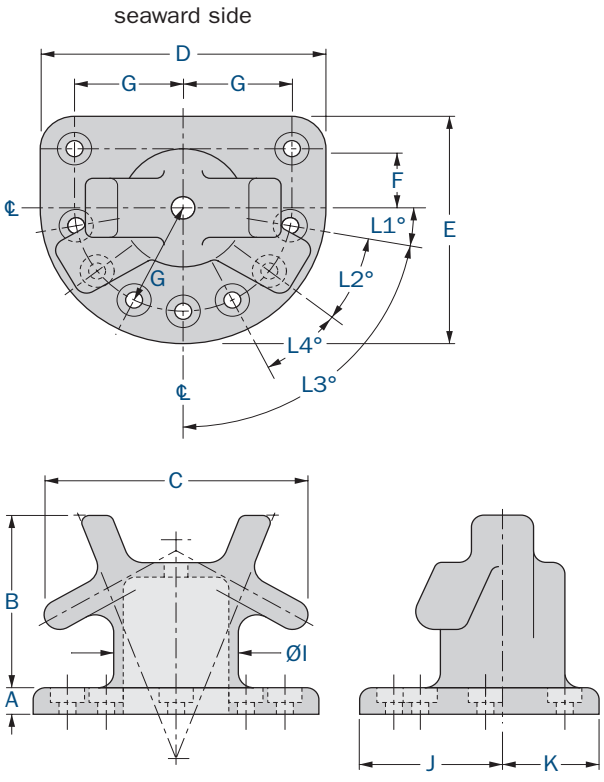
HORN BOLLARDS





Features

- General purpose applications up to 200 tonnes
- Suitable for steep rope angles
- Two lines may share a single bollard (subject to bollard capacity)

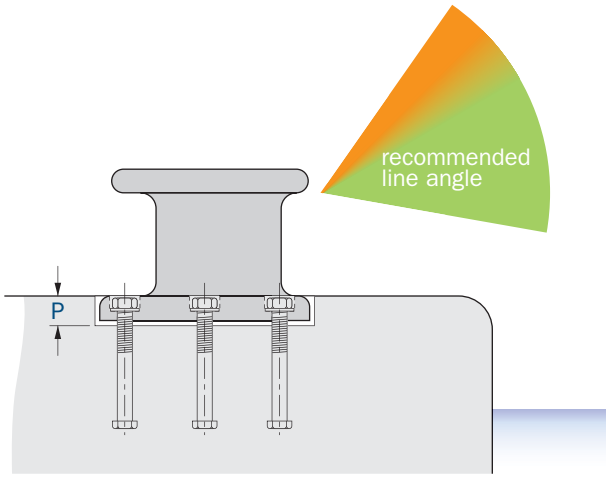


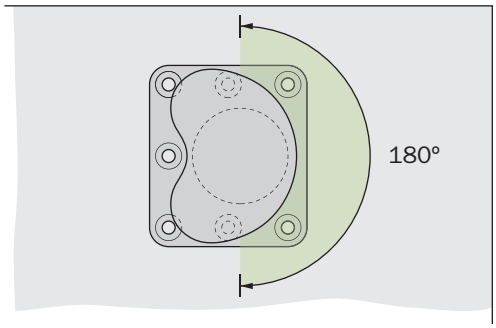
Dimension	Bollard capacity (tonnes)						
	15	30	50	80	100	150	200
A	40	40	50	70	80	90	90
B	370	410	500	520	570	585	660
C	400	440	600	660	750	850	930
D	410	480	640	650	800	920	1000
E	335	405	540	560	650	770	850
F	80	100	150	160	175	200	225
G	155	175	250	250	325	350	375
ØI	160	200	260	300	350	400	450
J	205	240	320	325	400	460	500
K	130	165	220	235	250	310	350
L1°	30°	30°	30°	15°	10°	10°	0°
L2°	–	–	–	45°	40°	40°	36°
L3°	60°	60°	60°	N/A	80°	80°	–
L4°	–	–	–	–	–	–	36°
Bolts	M24	M30	M36	M42	M42	M48	M56
Bolt length	500	500	500	800	800	1000	1000
P*	60	60	70	90	100	110	110
Qty	5	5	5	6	7	7	8

*P = bolt protrusion = recess depth [Units: mm]

M1100-S10-V1.1-EN

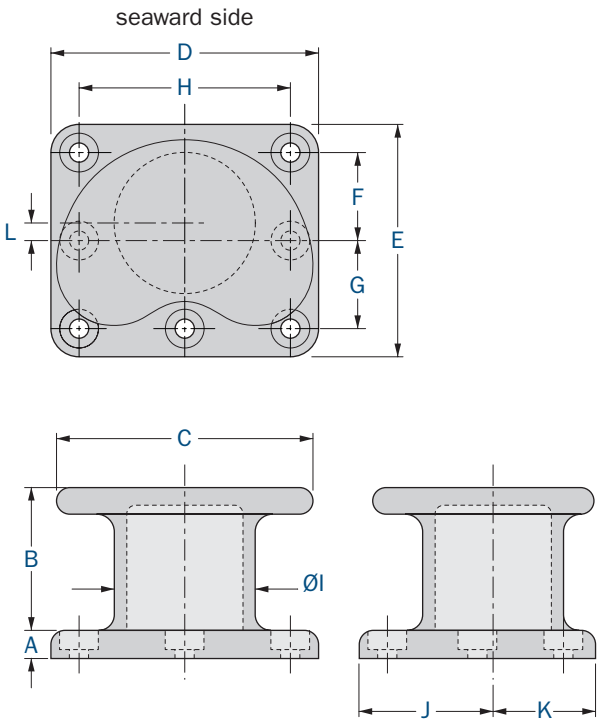
KIDNEY BOLLARDS





Features

- General purpose applications up to 200 tonnes
- Avoid steep rope angles where possible
- Suitable for warping operations



Dimension	Bollard capacity (tonnes)						
	15	30	50	80	100	150	200
A	40	40	50	70	70	80	90
B	260	280	320	330	350	405	435
C	340	370	480	530	550	728	800
D	320	360	540	560	590	760	1000
E	320	360	540	460	490	660	850
F	–	–	–	–	175	250	300
G	–	–	–	–	175	250	300
F+G	220	260	400	320	350	500	600
H	220	260	400	420	450	600	750
ØI	160	200	260	280	300	400	450
J	160	180	270	160	295	380	475
K	160	180	270	160	195	280	375
L	–	–	–	–	50	50	50
Bolts	M24	M30	M36	M42	M42	M48	M56
Bolt length	500	500	500	800	800	1000	1000
P*	60	60	70	90	90	100	110
Qty	4	4	4	5	7	7	7

*P = bolt protrusion = recess depth [Units: mm]

BOLLARD SELECTION

Design

Bollards and holding down bolts are designed with a minimum Factor of Safety against failure of 3.0 for SG Iron material grade 65-45-12.

Designs are typically based on the following:

BS 5950:2000	Structural Use of Steelwork
BS 6349 Part 2:1988	Marine Structures
AS 3990:1993	Mechanical Equipment Design

Detailed calculations can be supplied on request. Different factors of safety can be used to suit other national standards and regulations.

Materials

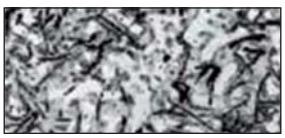
Trelleborg bollards are offered in Spheroidal Graphite Cast Iron (SG Iron), referred to as Ductile Cast Iron, because of its superior strength and resistance to corrosion. Ductile cast iron combines the best attributes of grey cast iron and cast steel without the disadvantages.

	Benefits	Disadvantages
Ductile Cast Iron (Spheroidal Graphite)	Lowest service life cost High strength Good impact resistance High corrosion resistance	
Grey Cast Iron	Low cost per weight Excellent corrosion resistance	Low strength Low impact resistance
Cast Steel	High strength High impact resistance Good cost per weight	Regular maintenance to prevent corrosion

Ductile cast iron is the preferred material for all bollard applications. Grey cast iron is cheaper per unit weight, but the need for thicker wall sections and poor impact strength outweigh this. Cast steel remains popular in some countries but needs regular painting to prevent corrosion.

Micro structure

Ductile cast iron (SG)



Grey iron

Material specifications

Trelleborg bollards are produced to the highest specifications. The table gives indicative standards and grades but many other options are available on request.

Material	Standards*	Grade(s)*
Ductile Cast Iron (Spheroidal Graphite Iron)	BS EN 1563 ASTM A 536	EN-GJS-450 or 500 65-45-12 or 80-55-6
Anchor bolts (galvanised)	ISO 898 BS 3692 ASTM	Gr 8.8 (galvanised) Gr 8.8 (galvanised) A325 (galvanised)
Blasting (standard) Blasting (high performance)†	N/A ISO 12944	Sweep blast SA2.5
Paint (standard) Paint (high performance)†	BS3416 ISO 12944	Black bitumen (1 coat) Class C5M

* In all cases equivalent alternative standards may apply.

† Other high performance paint systems available on request.

Protective coatings

Installation and grout filling requires extra care to avoid damage to factory applied coatings. Bollards are supplied as factory standard with a bituminous protective coating suitable for most projects. High performance epoxy or other specified paint systems can be factory applied on request in a choice of colours and thicknesses.

Wear and abrasion from ropes means paint coatings need regular maintenance. Ductile iron bollards are far less susceptible to corrosion than cast steel bollards, which can rust quickly and will need frequent painting to retain full strength.

M1100-S10-V1.1-EN

BOLLARD SELECTION

Bollards should be selected and arranged according to local regulations or recognised design standards. The design process should consider:

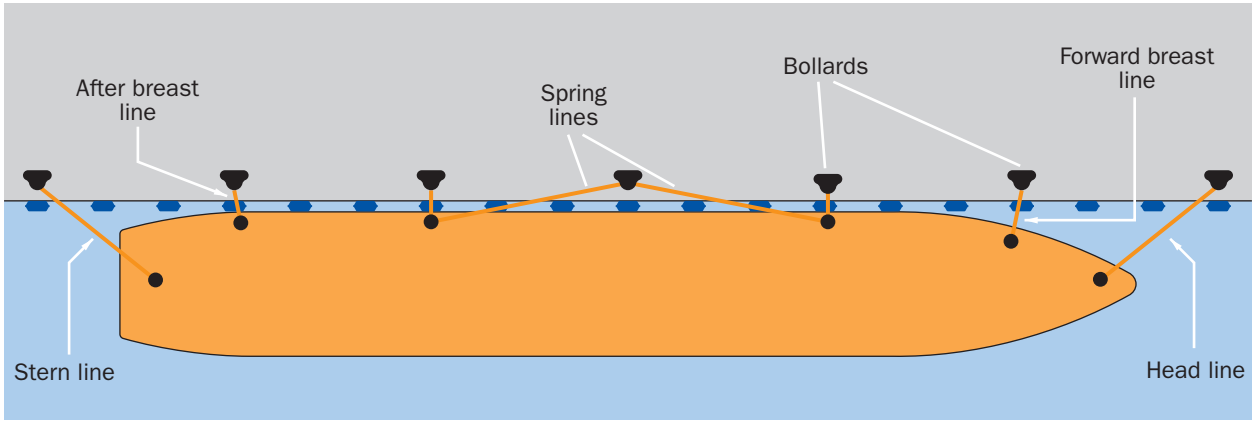
- Mooring pattern(s)
- Changes in draft due to loading and discharge
- Wind and current forces
- Swell, wave and tidal forces
- Mooring line types, sizes and angles
- Ice forces (where relevant)

Mooring loads should be calculated where possible, but in the absence of information then the following table can be used as an approximate guideline.

Displacement	Approx. bollard rating
Up to 2,000 tonnes	10 tonnes
2,000–10,000 tonnes	30 tonnes
10,000–20,000 tonnes	60 tonnes
20,000–50,000 tonnes	80 tonnes
50,000–100,000 tonnes	100 tonnes
100,000–200,000 tonnes	150 tonnes
over 200,000 tonnes	200 tonnes

Where strong winds, currents or other adverse loads are expected, bollard capacity should be increased by 25% or more.

Mooring line angles



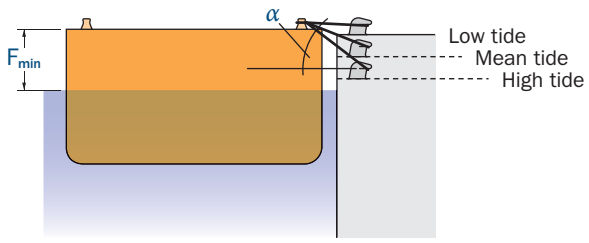
Mooring line angles are normally calculated as part of a comprehensive mooring simulation. Standards and guidelines such as BS6349: Part 4, ROM 0.2-90 and PIANC suggest mooring line angles are kept within the limits given in the table below. In some cases much larger line angles can be expected.
Trelleborg bollards can cope with horizontal angles of ±90° and vertical angles up to 75°. Please check with your local office about applications where expected line angles exceed those given in the table as these may need additional design checks on anchorages and concrete stresses.

Suggested Line Angles (BS6349, ROM 0.2-90, PIANC)

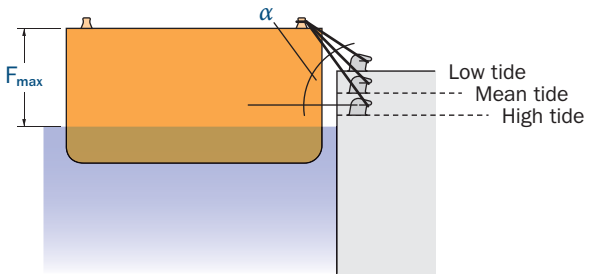
Head & stern lines*	45° ±15°
Breast lines*	90° ±30°
Spring lines*	5–10°
Vertical line angle (α)	<30°

* Relative to mooring angle

Fully laden case



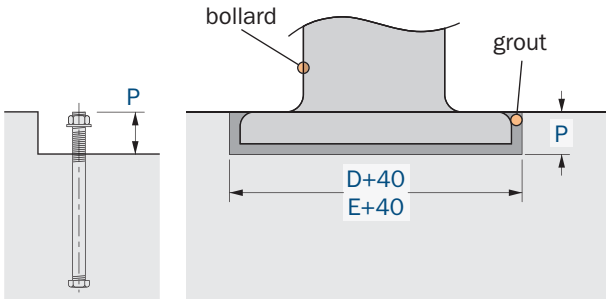
Light draught case



INSTALLATION

Bollards must be installed correctly for a long and trouble-free service life. Anchors should be accurately set out with the supplied template. Bollards can be recessed (as shown) or alternatively surface mounted. Once the grout has reached full strength, anchors can be fully tightened. Mastic is often applied around exposed threads to ease future removal.

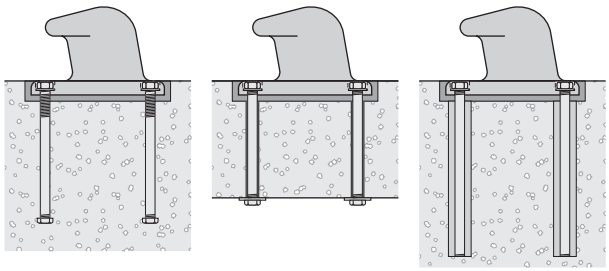
Concrete recess



* refer to dimensions tables

Recessing the bollard is generally recognised as superior to surface mounting. Recessing the base prevents the bollard from working loose on its bolts or cracking the grout bed – especially relevant for high use locations.

Fixing options



Embedded *Through* *Retrofit (epoxy grouted bolts)*

Quality assurance

Bollards are safety critical items and quality is paramount. A typical quality documentation package will include:

- Dimensioned drawings of bollard and accessories
- Bollard and anchorage calculations (if required)
- Factory inspection report
- Physical properties report for casting
- Installation instructions

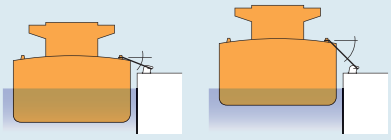
Codes and guidelines

ROM 0.2-90 (1990) Actions in the Design of Maritime and Harbor Works
BS6349: Part 4 (1994) Code of Practice for Design of Fendering and Mooring Systems
PIANC Report of WG24 (1995) Criteria for Movements of Moored Ships in Harbours – A Practical Guide (1995)
EAU (1996) Recommendations of the Committee for Waterfront Structures
PIANC Report of PTC II-30 (1997) Approach Channels: A Guide for Design (Appendix B – Typical Ship Dimensions)
Ministry of Transport, Japan (1999) Technical Note No.911 – Ship Dimensions of Design Ships under given Confidence Limits
ROSA – Defenses D'accostage (2000) Recommandations pour Le Calcul Aux Etats-Limitesdes Ouvrages En Site Aquatique defenses D'accostage
PIANC Report of WG33 (2002) Guidelines for the Design of Fender Systems (2002)

M1100-S10-V1.1-EN

PROJECT REQUIREMENTS

PROJECT DETAILS	PROJECT STATUS
Port	TMS Ref:
Project	☐ Preliminary
Designer	☐ Detail design
Contractor	☐ Tender

BOLLARD TYPE		
 Tee Horn Kidney	Quantity _____ No. Capacity/SWL _____t ☐ Tee ☐ Horn ☐ Kidney	Quantity _____ No. Capacity/SWL _____t ☐ Tee ☐ Horn ☐ Kidney
VESSEL INFORMATION		
 Overall length (L_{OA}) Displacement (M_D) Deadweight (DWT)	L_{OA} _____m M_D _____m DWT _____t	L_{OA} _____m M_D _____m DWT _____t
LINE ANGLE		
	Min _____ deg Min _____ deg	Max _____ deg Max _____ deg
MOUNTING		
 Recessed Surface	☐ Recessed ☐ Surface	☐ Recessed ☐ Surface

OTHER INFORMATION	FURTHER DETAILS AVAILABLE FROM
	Name
	Position
	Company
	Tel
	Fax
	Email

Trelleborg Marine Systems is part of Trelleborg's Engineered Systems Business Area and specialises in the safe berthing and mooring of vessels within ports and harbours, on offshore structures and in waterways around the world.

We bring together the industry's best known and respected brands for fendering and mooring systems with the unrivalled collective experience and knowledge of its sales and engineering staff. Our customers benefit from great choice and helpful support at every stage from initial concept and detailed design right through to supply, commissioning and after-sales service – all provided by our network of regional offices and local agents.

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