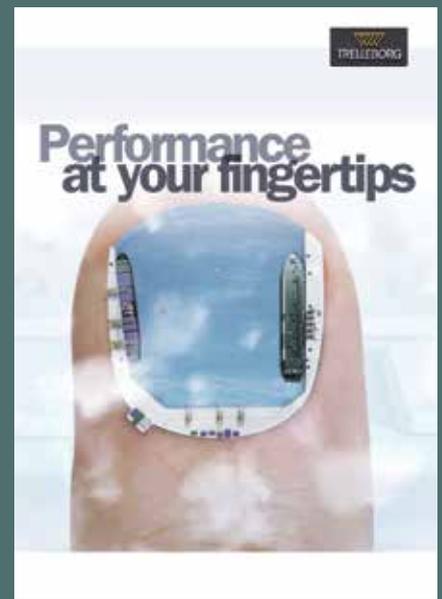
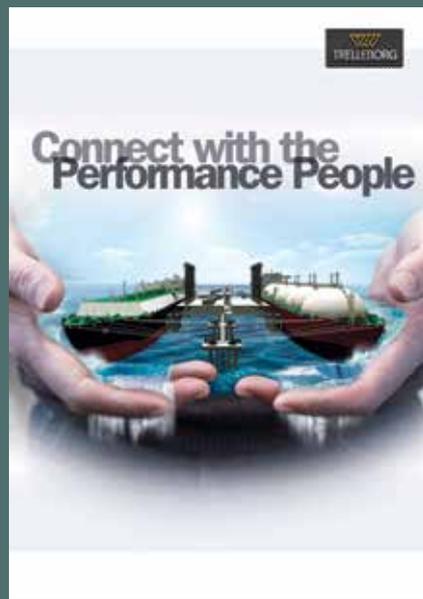


Bollard Application Design Manual



DESIGN MANUAL

Performance People



The demanding nature of commercial ports and terminals means you need to connect with a partner 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.

This global reach combined with feet on the ground local presence helps to make Trelleborg the Performance People that ensure solutions continually enhance your operations.

Connect with a partner that provides Performance Assurance services from conception to completion of every project and beyond to maintain and enhance port and vessel performance.

**Connect with the Performance People,
Trelleborg Marine Systems.**

Bollard Application Design Manual

Whatever bollard type your application requires, Trelleborg has a range of seven high-performance styles to suit you.

Trelleborg bollards are precision engineered and manufactured in a variety of metals including premium grade SG ductile iron and cast steel to offer unprecedented levels of service life and resistance to corrosion and impact. We understand that safety is your number one priority. That's why Trelleborg Marine Systems provides bespoke safety critical bollard, anchoring and fixing solutions quickly, to our customers' exact specifications.

This guide will provide you with detailed and specific information of our full range of bollard solutions including installation, maintenance and specification advice, plus much more.

Contents

BOLLARD APPLICATION DESIGN MANUAL

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What end-to-end really means



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.

CONSULTATION

Consultation to assist you at the earliest stage of your project, with full technical support available from our global office network.

CONCEPT

Conceptual design in our local office – with full knowledge of local standards and regulations, delivered in your language.

DESIGN

Concepts taken to our Engineering Center of Excellence in India where our team generates 3D CAD designs, application-engineering drawings, bill of materials, finite engineering analysis and calculations.

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 capacity.

TESTING



Across our entire product range, stringent testing comes as standard at every step in our in-house manufacturing process. We ensure that life-cycle 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.

GLOBAL 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 on-site service and support.

Bollard Range And Technical Information

Trelleborg bollards come in many popular shapes and sizes to suit most docks, jetties and wharves. They also provide a great deal of flexibility as they can be moved between locations as and when this is required. 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.

However, with cast steel remaining popular in specific regions, Trelleborg also manufactures cast steel bollards which provide high impact resistance but require regular painting to prevent corrosion.

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



1 Tee Bollard



2 Horn Bollard



3 Kidney Bollard



4 Cleat Bollard



5 Double Bitt Bollard



6 Single Bitt Bollard



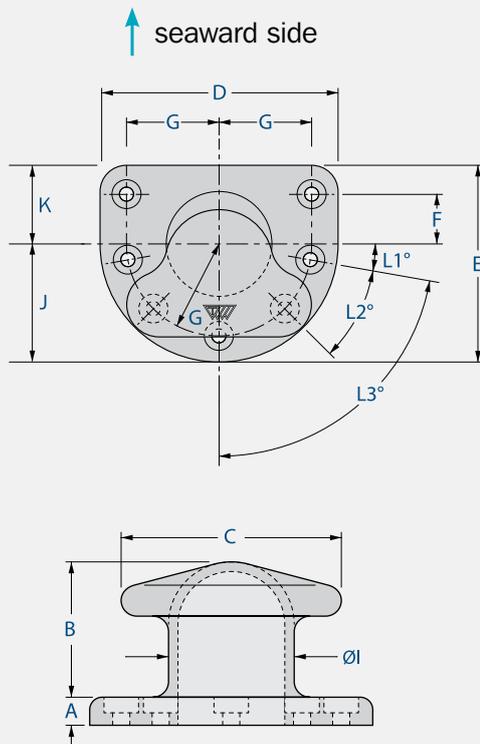
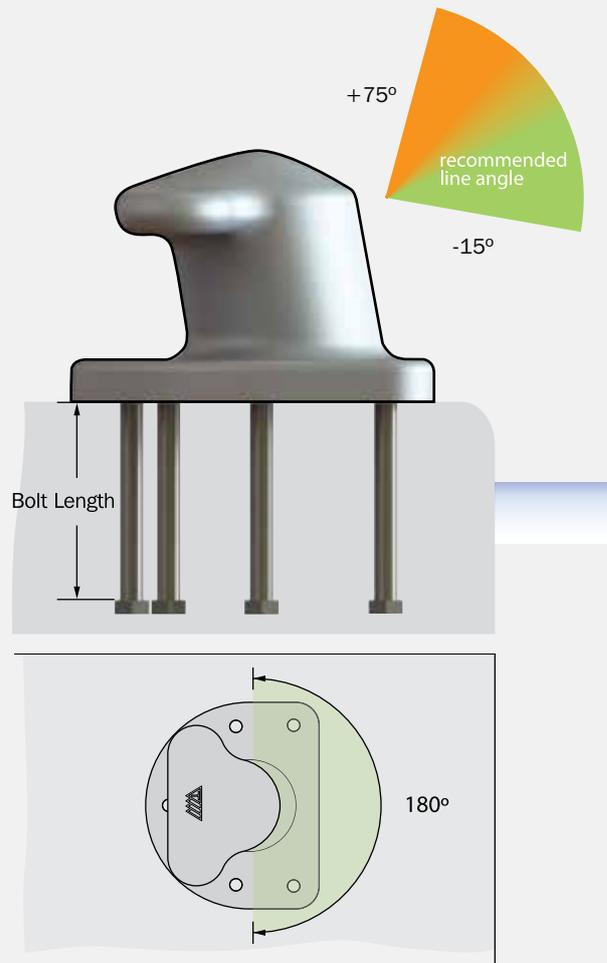
7 Pillar Bollard



TEE BOLLARD

FEATURES

- General purpose applications up to 300 tonnes
- Suitable for steeper rope angles



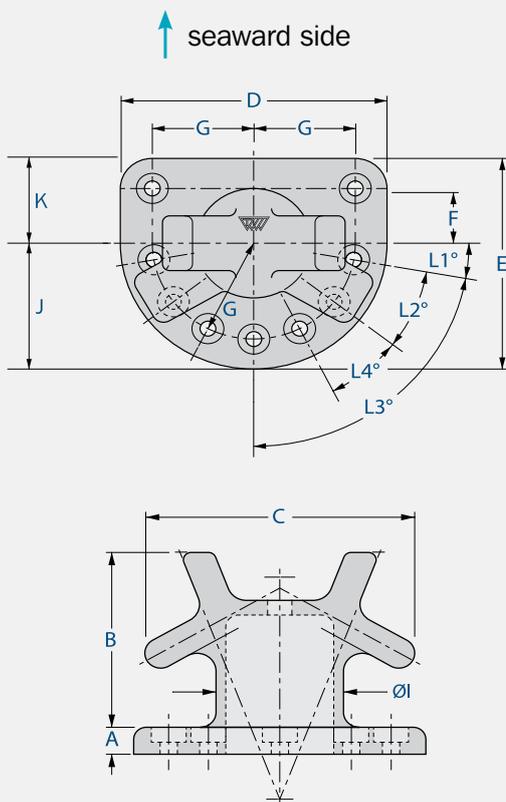
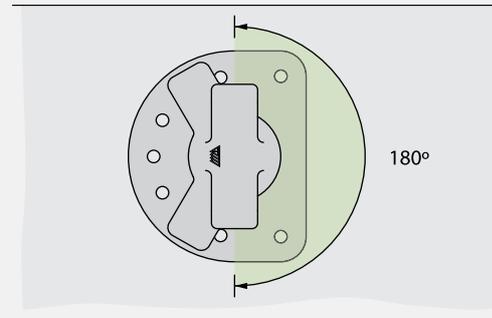
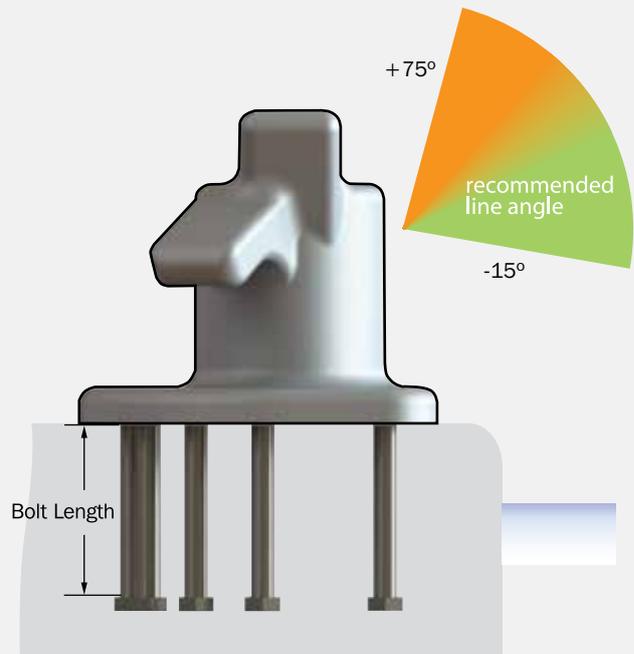
DIMENSION	BOLLARD CAPACITY (tonnes)											
	10	15	22.5	30	50	80	100	125	150	200	250	300
A	32	40	40	40	50	70	80	80	90	90	120	155
B	205	235	255	255	350	380	410	410	435	500	610	670
C	220	340	350	350	500	550	600	600	700	800	930	980
D	216	410	430	450	640	640	790	850	900	1000	1090	1200
E	236	335	355	375	540	550	640	700	750	850	915	925
F	75	80	90	100	150	160	175	175	200	225	250	200
G	65	155	165	175	250	250	325	325	350	375	425	475
ØI	120	160	180	200	260	280	350	350	400	450	500	500
J	118	205	215	225	320	320	395	425	450	500	545	600
K	118	130	140	150	220	230	245	275	300	350	370	325
L1°	-	30°	30°	30°	30°	15°	10°	10°	10°	0°	5°	23°
L2°	-	-	-	-	-	45°	40°	40°	40°	36°	34°	26°
L3°	-	60°	60°	60°	60°	-	80°	80°	80°	72°	68°	52°
Bolts	M20	M24	M30	M30	M36	M42	M42	M48	M48	M56	M64	M64
Bolt Length	450	500	500	500	500	800	800	900	1000	1000	1375	1550
P*	47	55	55	55	65	85	95	95	105	105	135	170
Quantity	4	5	5	5	5	6	7	7	7	8	8	10

P* = bollard base recess mounting depth = hold-down bolt protrusion height [units: mm]

HORN BOLLARD

FEATURES

- General purpose applications up to 250 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	125	150	200	250
A	40	40	50	70	80	80	90	90	120
B	370	410	500	520	570	595	585	660	690
C	400	440	600	660	750	775	850	930	930
D	410	480	640	650	800	820	920	1000	1000
E	335	405	540	560	650	670	770	850	850
F	80	100	150	160	175	175	200	225	225
G	155	175	250	250	325	325	350	375	375
ØI	160	200	260	300	350	375	400	450	450
J	205	240	320	325	400	410	460	500	500
K	130	165	220	235	250	260	310	350	350
L1°	30°	30°	30°	15°	10°	10°	10°	0°	0°
L2°	-	-	-	45°	40°	40°	40°	36°	36°
L3°	30°	60°	60°	-	80°	80°	80°	-	-
L4°	-	-	-	-	-	-	-	36°	36°
Bolts	M24	M30	M36	M42	M42	M48	M48	M56	M64
Bolt Length	500	500	500	800	800	900	1000	1000	1375
P*	55	55	65	85	95	95	105	105	135
Quantity	5	5	5	6	7	7	7	8	8

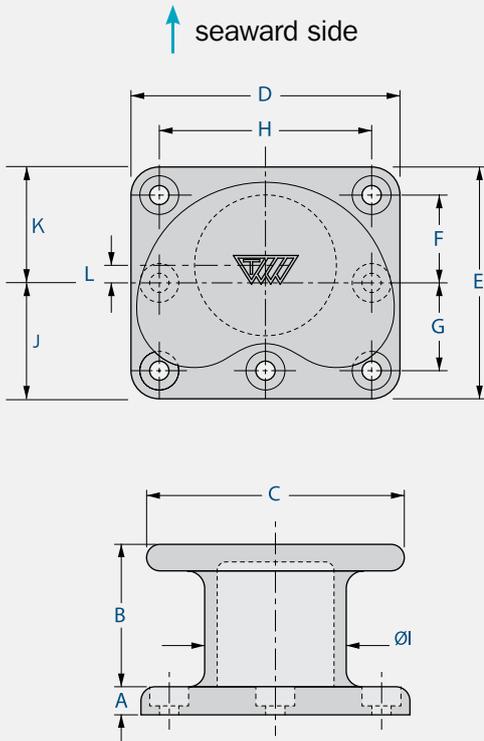
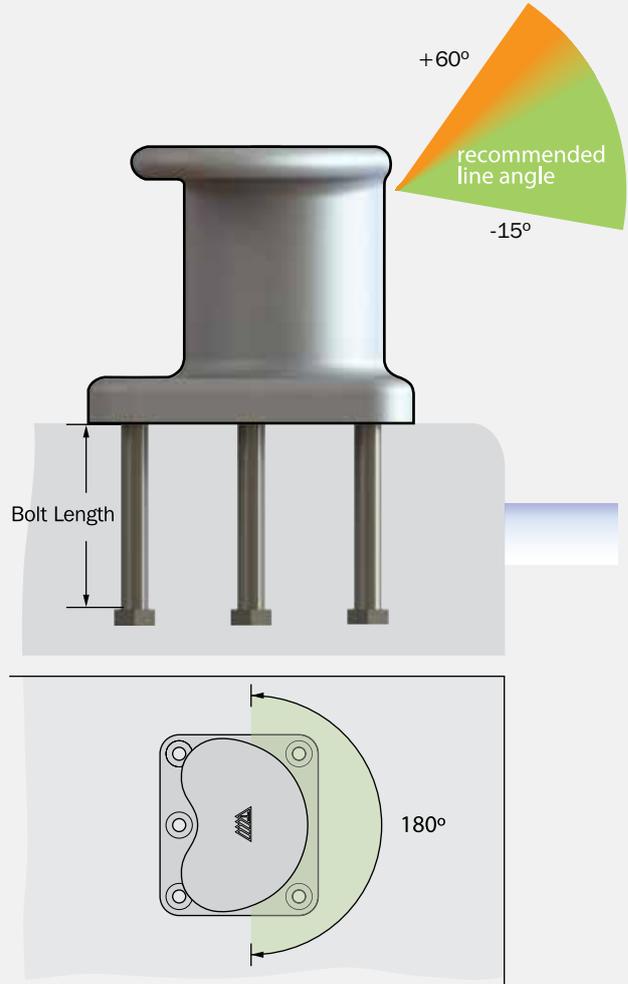
P* = bollard base recess mounting depth
 = hold-down bolt protrusion height

[units: mm]

KIDNEY BOLLARD

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	125	150	200
A	40	40	50	70	70	80	80	90
B	260	280	320	330	350	375	405	435
C	340	370	480	530	550	640	728	800
D	320	360	540	560	590	680	760	1000
E	320	360	540	460	490	580	660	850
F	-	-	-	-	175	210	250	300
G	-	-	-	-	175	210	250	300
F+G	220	260	400	320	350	420	500	600
H	220	260	400	420	450	520	600	750
ØI	160	200	260	280	300	325	400	450
J	160	180	270	280	295	340	380	475
K	160	180	270	180	195	240	280	375
L	-	-	-	-	50	50	50	50
Bolts	M24	M30	M36	M42	M42	M48	M48	M56
Bolt Length	500	500	500	800	800	1000	1000	1000
P*	55	55	65	85	85	95	95	105
Quantity	4	4	4	5	7	7	7	7

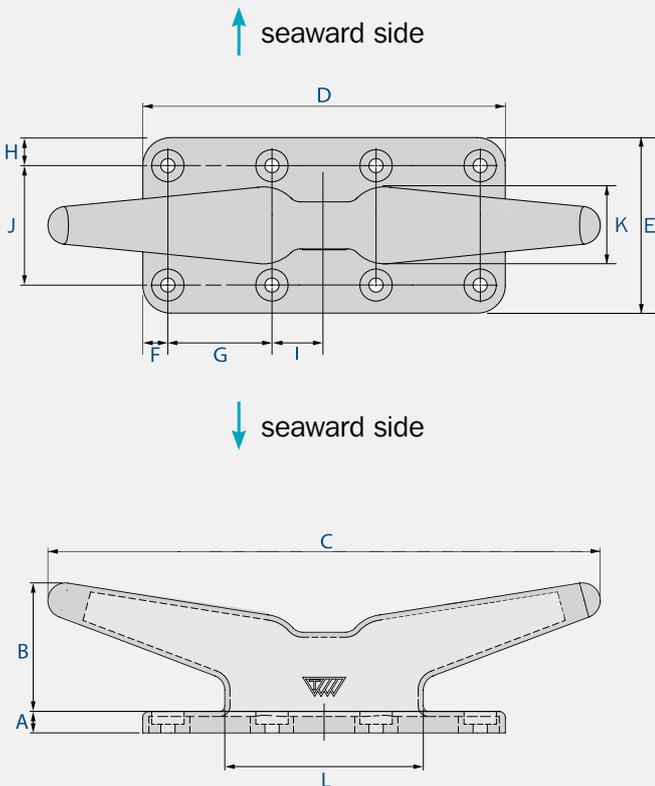
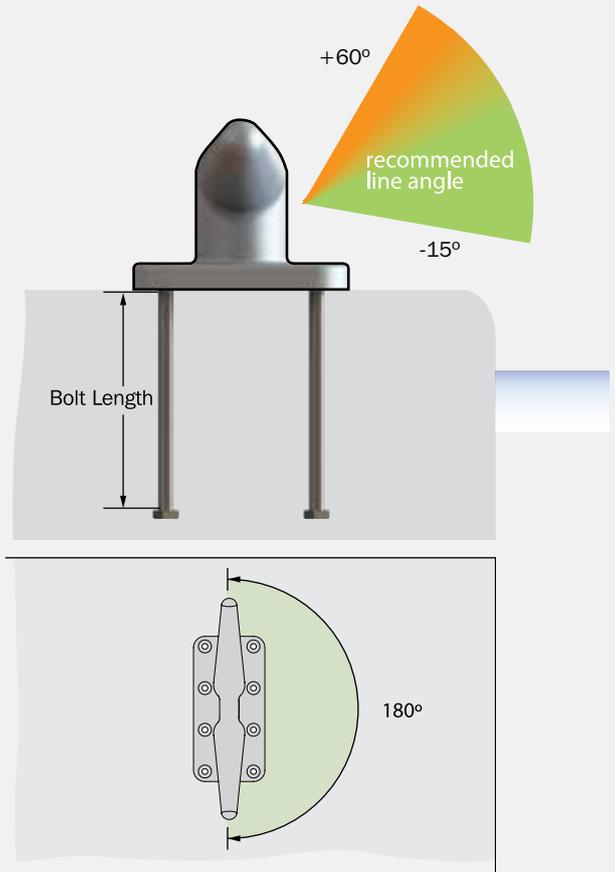
P* = bollard base recess mounting depth
 = hold-down bolt protrusion height

[units: mm]

CLEAT BOLLARD

FEATURES

- General purpose applications up to 35 tonnes
- Suitable for steep rope angles
- Suitable for small wharves or jetties and marinas



DIMENSION	BOLLARD CAPACITY (tonnes)				
	15	20	25	30	35
A	30	40	45	45	50
B	165	180	210	250	270
C	510	665	810	960	1120
D	410	510	610	660	840
E	220	280	310	310	400
F	40	50	50	45	60
G	165	205	255	190	240
H	40	50	50	45	60
J	140	180	210	220	280
K	90	110	130	150	170
L	235	280	325	370	430
Bolt	M20	M24	M24	M24	M30
Bolt Length	350	460	460	460	460
P*	45	55	60	60	65
Quantity	6	6	6	8	8

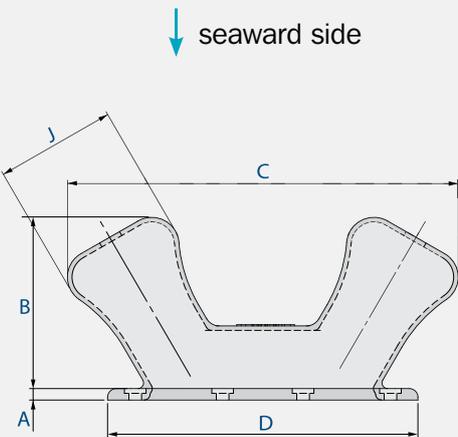
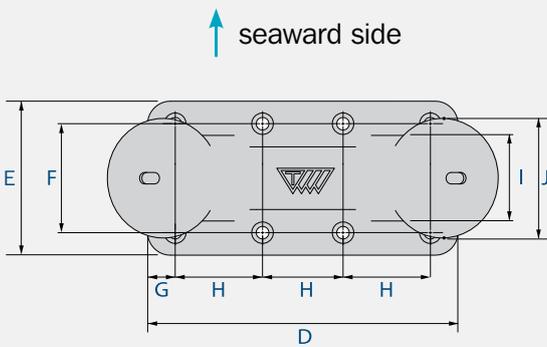
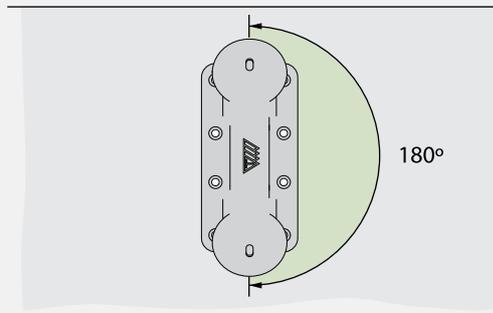
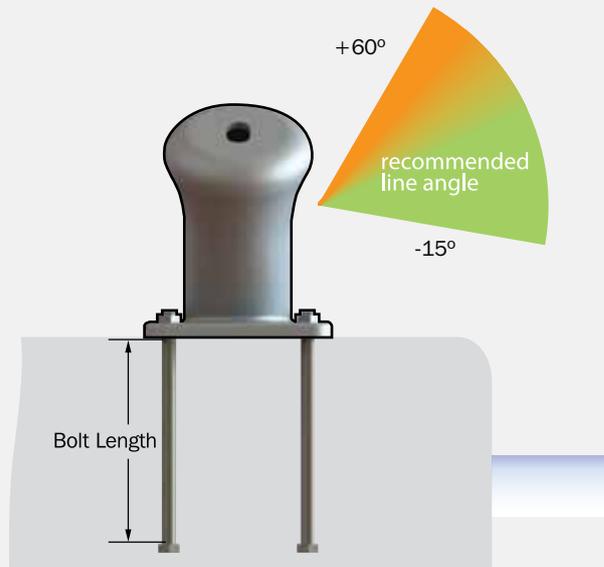
P* = bollard base recess mounting depth
 = hold-down bolt protrusion height
 I = 1/2 dimension G

[Units: mm]

DOUBLE BITT BOLLARD

FEATURES

- General purpose applications up to 200 tonnes
- Suitable for mooring multiple lines (subject to bollard capacity)
- Concrete filled (optional)



DIMENSION	BOLLARD CAPACITY (tonnes)							
	20	30	50	75	100	125	150	200
A	20	20	25	40	50	60	60	60
B	300	350	420	510	600	700	750	840
C	680	780	950	1140	1330	1535	1670	1860
D	540	610	720	870	1020	1170	1270	1430
E	280	310	360	440	520	590	640	720
F	190	220	270	330	390	440	490	530
G	45	45	45	55	65	75	75	95
H	150	180	210	190	222.5	255	280	310
I	150	180	210	250	300	340	370	410
J	210	240	310	350	410	470	510	570
Bolt	M20	M22	M30	M36	M42	M42	M48	M56
Bolt Length	300	300	450	500	600	750	850	1070
P*	35	35	40	55	65	75	75	75
Quantity	8	8	8	10	10	10	10	10

P* = bollard base recess mounting depth
 = hold-down bolt protrusion height

[units: mm]

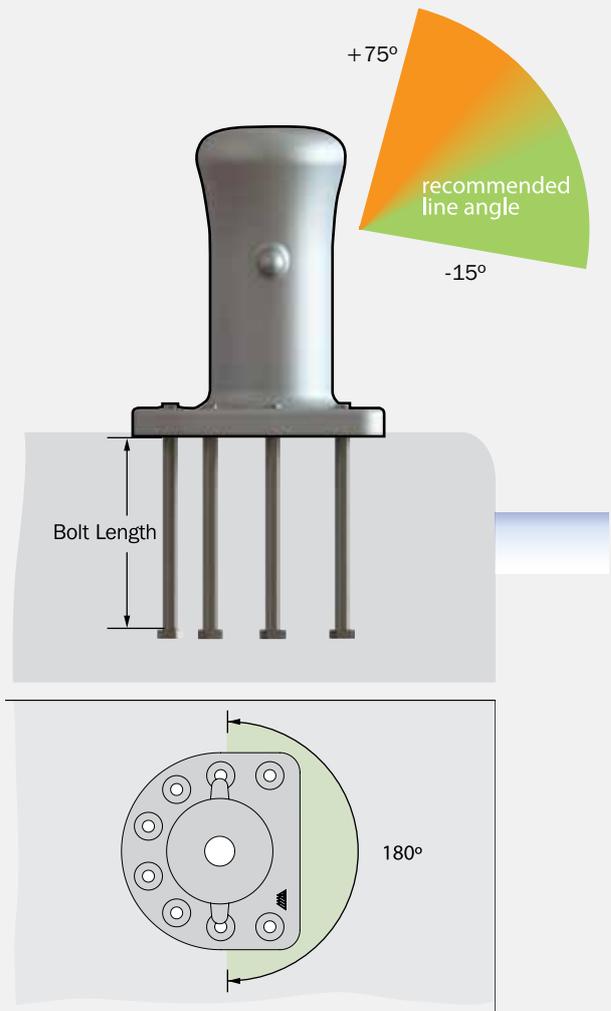
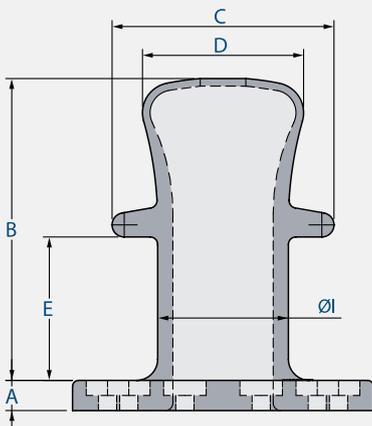
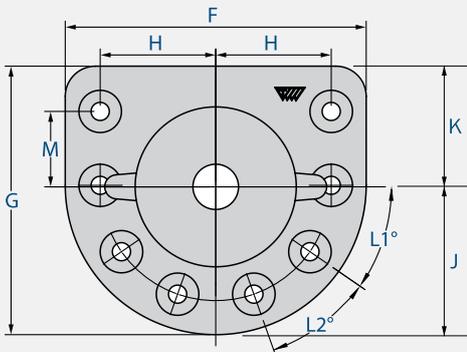
SINGLE BITT BOLLARD

FEATURES

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



↑ seaward side



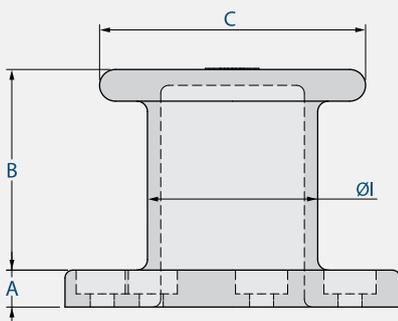
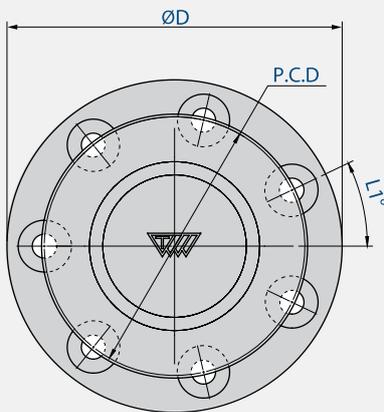
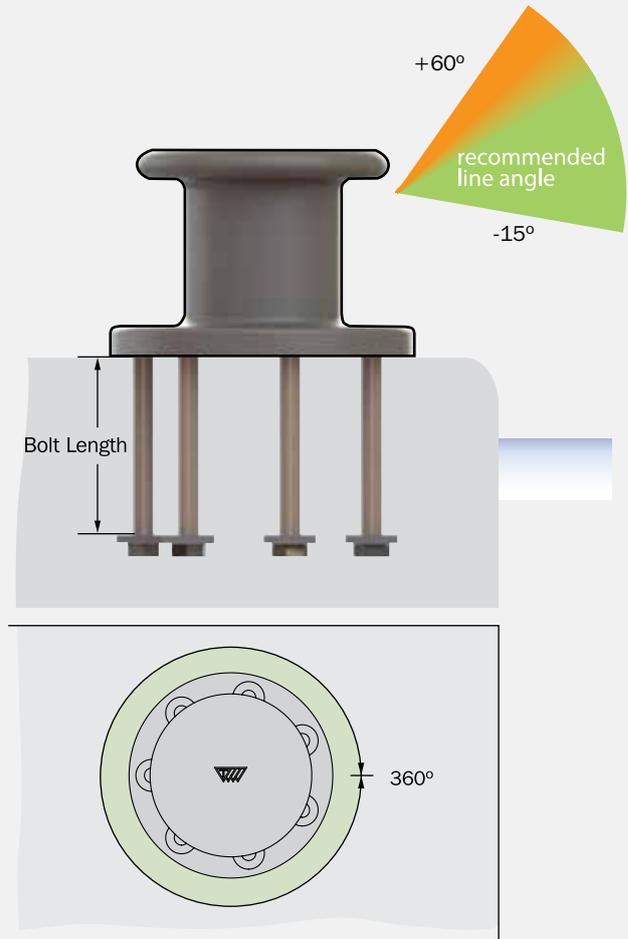
DIMENSION	BOLLARD CAPACITY (tonnes)						
	15	30	50	75	100	150	200
A	45	60	70	80	80	100	110
B	370	490	630	740	790	900	1000
C	260	340	450	500	550	650	750
D	220	260	340	390	415	460	530
E	145	160	260	285	325	380	465
F	360	420	530	650	760	900	990
G	315	380	480	580	685	810	890
H	130	160	205	250	290	345	380
ØI	160	200	260	290	320	370	430
J	180	210	265	325	380	450	495
K	135	170	215	255	305	360	395
M	75	120	155	180	215	255	280
L1	46.5	24	12.4	11.3	5	5	35
L2	-	66	50.8	50.8	43	43.5	36
Bolt	M24	M30	M36	M42	M48	M56	M56
Bolt Length	400	500	600	600	750	1000	1000
P*	60	75	85	95	95	115	125
Quantity	4	5	6	6	7	7	8

P* = bollard base recess mounting depth = hold-down bolt protrusion height [units: mm]

PILLAR BOLLARD

FEATURES

- General purpose applications up to 200 tonnes
- Avoid steep rope angles where possible
- Suitable for warping operations
- 360 degree horizontal line angle use
- Can be utilised from all sides of jetty



DIMENSION	BOLLARD CAPACITY (tonnes)							
	10	15	30	50	75	100	150	200
A	35	40	50	60	70	70	80	90
B	180	280	320	350	380	410	450	480
C	200	300	390	430	500	580	680	740
ØD	270	420	500	580	630	700	800	900
P.C.D	190	300	365	450	490	550	600	700
ØI	125	200	240	280	320	360	400	450
L1	0	0	0	12.9°	12.9°	25.7°	0	0
Bolt	M20	M24	M30	M36	M42	M48	M56	M64
Bolt Length	350	400	550	800	1000	1000	1000	1000
P*	50	55	65	75	85	85	95	105
Quantity	4	4	4	7	7	7	8	8

P* = bollard base recess mounting depth = hold-down bolt protrusion height [units: mm]

Bollard Materials and Manufacture

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: 1-4 (2013): Part 4	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.

MATERIALS	BENEFITS	DISADVANTAGES
Ductile Cast Iron (Spheroidal Graphite)	<ul style="list-style-type: none"> Lowest service life cost High strength Good impact resistance High corrosion resistance 	
Grey Cast Iron	<ul style="list-style-type: none"> Low cost per weight Excellent corrosion resistance 	<ul style="list-style-type: none"> Low strength Low impact resistance
Cast Steel	<ul style="list-style-type: none"> High strength High impact resistance Good cost per weight 	Needs regular maintenance to prevent corrosion

The standard material for Trelleborg bollards is ASTM A536 Grade 65/45/12 Spheroidal Graphite Cast Iron.

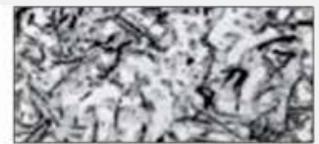
This material has been selected as it has superior corrosion resistance over cast steel and is the best consolidation of price, performance and material strength.

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 outweighs this. Cast steel remains popular in some countries but needs regular painting to prevent corrosion.

MICRO STRUCTURE



Ductile cast iron (SG)



Grey iron

SG IRON VS CAST STEEL BOLLARDS

There is a perception that a stronger material means a stronger bollard. When steel is selected however, the bollards are generally made smaller to achieve the same SWL capacity and safety factors. Smaller bollards have the disadvantage of having a smaller bend radii for the mooring lines. As longevity of mooring ropes is a factor of their loading cycle and bend radii, decreased mooring line life can be expected.

Where cast steel bollards must be used, please contact Trelleborg for pricing, availability and lead time. It may be possible to utilize the relevant SG iron pattern for a cast steel bollard.

DUCTILE CAST IRON (SPHEROIDAL GRAPHITE)	GREY CAST IRON	CAST STEEL
Lowest service life cost	Low cost per weight	Good cost per weight
High strength	Low strength	High strength
Good impact resistance	Low impact resistance	High impact resistance
High corrosion resistance	Excellent corrosion resistance	Regular maintenance to prevent corrosion

MATERIAL SPECIFICATION

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

MATERIALS	STANDARD(S)*	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
Cast Steel	ASTM A148 IS 1030	80-50 340-570
Anchor bolts (galvanized)	ISO 898 BS 3692 ASTM	Gr 8.8 (galvanized) Gr 8.8 (galvanized) ASTM F1554 Gr 105 (galvanized)
Blasting (standard) Blasting (high performance)†	SSPC-SP10 NACS no. 2	SA2.5
Paint (standard) Paint (high performance)†	BS 3416 ISO 12944	High Build Epoxy (300 microns)

* In all cases equivalent alternative standards may apply.

† Please contact Trelleborg for other grades and high performance paint systems.



QUALITY ASSURANCE

Bollards are safety critical items and quality is paramount. Independent 3rd party witnessing of test is available at additional cost on request. A typical quality documentation package will include:

- Dimensioned drawings of bollard and accessories
- Bollard and anchorage calculations (if required)
- Inspection and test plan
- Certificate of conformance
- Physical, chemical and materials properties report for casting and anchorages
- Installation instructions

COATING SYSTEMS

Bollards are supplied as factory standard with a protective coating suitable for most projects. High performance epoxy or other specified paint systems can be factory applied on request in a choice of colors and thicknesses. Standard available coatings include (uncoated, zinc oxide primer or high performance epoxy).

Bituminous coatings (Coal Tar) are no longer commercially available and in most countries no longer allowed in marine installation. They have been discontinued on Trelleborg bollards.

Bollard are also available and supplied with Hot Dip Galvanized (HDG) on special request basis. High strength stainless steel anchors may be available on request.

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.

Bollard Selection

SELECTION

Bollards should be selected and arranged according to local regulations or recognized 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.

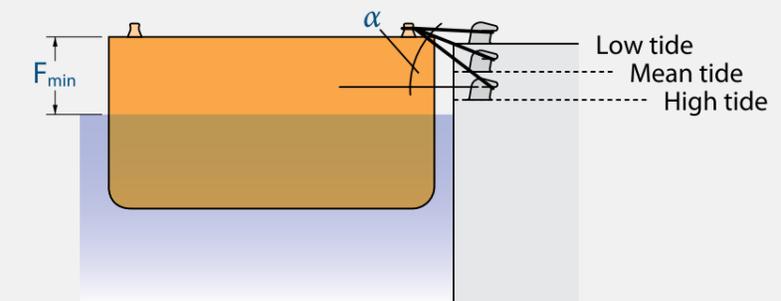
Trelleborg bollards can cope with horizontal angles of $\pm 90^\circ$ and vertical angles up to 75° . Please check with your local office about applications where expected line angles exceed those given in the table as these may need additional design checks on anchorages and concrete stresses.

SUGGESTED LINE ANGLES (BS6349, ROM 0.2-90, PIANC)

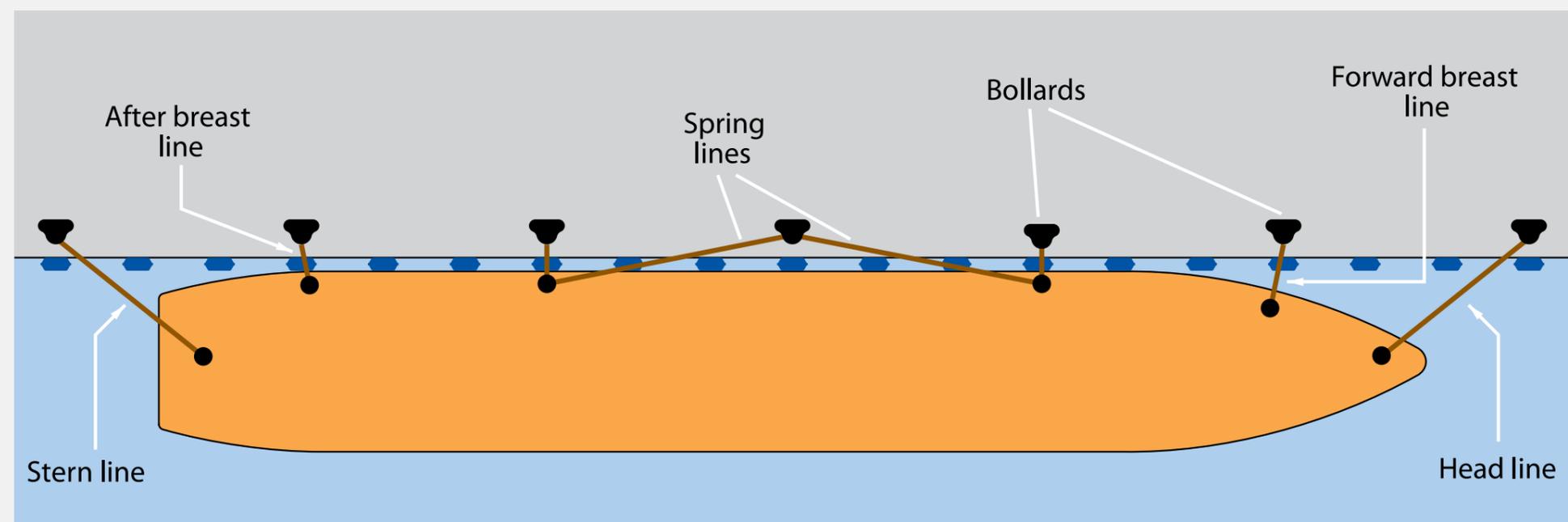
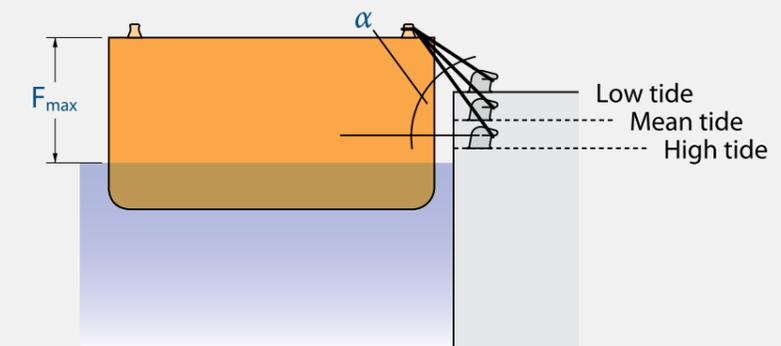
Head & stern lines*	$45^\circ \pm 15^\circ$
Breast lines*	$90^\circ \pm 30^\circ$
Spring lines*	$5-10^\circ$
Vertical line angle (α)	$< 30^\circ$

* Relative to mooring angle

Fully laden case



Light draught case

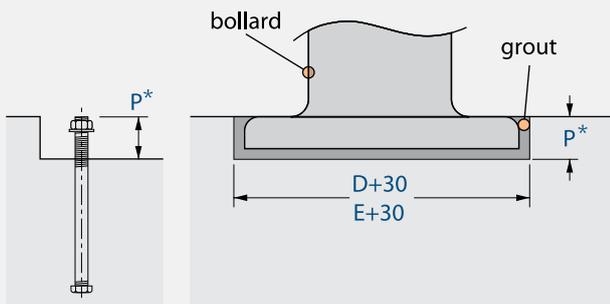


Installation

INTRODUCTION

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

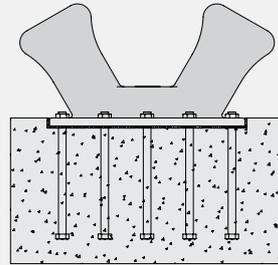


*refer to dimensions tables

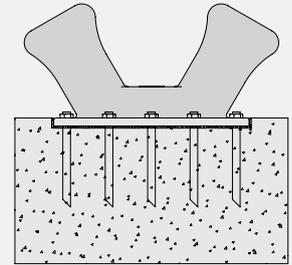
Recessing the bollard is generally recognized as superior to surface mounting. Recessing the base prevents the bollard from working loose on its bolts or cracking the grout bed – especially relevant for high use locations.



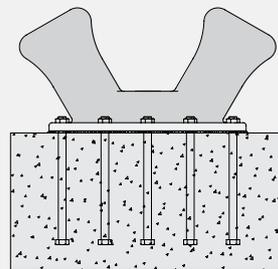
FIXING OPTIONS



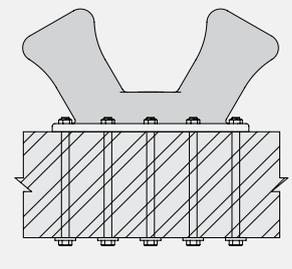
Recess Mounting Type



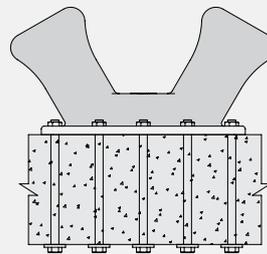
Retrofit Mounting Type
(using EC 2 epoxy anchors)



Surface Mounting Type



Steelwork Mounting Type



Through Bolting Type

Maintenance

Like all equipment in the marine environment, regular inspection and maintenance is critical to achieving maximum life expectancy.

Trelleborg recommends a regular scheduled inspection of equipment such as bollards as part of any berth. Key items that need to be focussed on during the inspection and maintenance include:

PROTECTIVE COATING

Bollards are supplied as factory standard with a protective coating suitable for most projects. High performance epoxy or other specified paint systems are usually applied at the factory on request in a choice of colors and thicknesses.

Wear and abrasion from ropes means paint coatings need regular maintenance. Like all epoxy coating systems, maintenance is integral to increasing life expectancy. Trelleborg recommends regular inspection of the bollards

Repair and upkeep of the coating system is dependant upon the coating system selected. Trelleborg tries to utilize commercially available coating systems to ensure local products can be sourced and system repair procedures are in line with the coating system manufacturers guidelines.



GROUT

Installation and grout filling requires extra care to avoid damage to factory applied coatings. Similarly regular inspection and possible repair of grout under and around the bollard is critical to the ongoing integrity of bollard performance. Should grout be cracked or damaged, it is recommended that it be replaced.

HOLD DOWN BOLTS

Holding down bolt anchor sets are crucial to bollard performance. Nuts shall be tightened using full manual effort with a 1m long spanner extension to approximately 200Nm. Ensuring correct torque settings will ensure bollards and hold down bolts achieve optimum performance. These are critical to be checked during installation.

Visual checks on hold down bolts should be undertaken during regular maintenance to ensure no loosening of bolts has occurred.

BOLLARD MATERIALS

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. Regular inspection of the bollard materials is recommended.

Trelleborg is happy to assist in providing inspection services on berthing and mooring equipment.

Bollard Information

STANDARD DESIGNS

The standard bollard range has been developed based on the requirements of many facilities throughout the world. Some clients may request different designs based on familiarity, history, etc. However the Trelleborg range meets most functional mooring requirements. The ReadyMoor and SmartMoor Quick Release Hooks are also available for instances where a more advanced safety solution is required.

CUSTOM DESIGNS

As well as our standard bollard range, we also offer custom-built bollards. Whatever your project, we will design and deliver bespoke solutions to your exact specifications.

CALCULATIONS

Bollards are provided with engineering calculations, which describe bolt group pullout forces, shear loadings and bolt tensions.

JETTY DESIGN

The suitability of a new or existing jetty design to include bollards as part of the structure should be verified by appropriately qualified marine structural engineers or consultants. This includes concrete or steel structure reinforcement for additional tensile and shear loads, reduced edge distances, and fastening/anchor-bolt arrangements.

JETTY CONSTRUCTION MATERIALS

Calculations are based on a concrete strength of 40MPa as this is commonly used at many new facilities.

A higher safety factor has been applied to the concrete strength to allow for special variations in jetty structures, which means that it is acceptable to use 30MPa concrete. However, the safety factor for this part of the system is reduced. Final design of the jetty including steel reinforcement, edge distances, shear bracing and concrete strength is always the responsibility of the jetty designer.

BOLLARD SELECTION

The engineering required to select, locate and orientate bollards is dependent on a range of parameters including vessel size, local weather, bathymetry, currents, tides and the jetty configuration. The analysis to determine the layout of the jetty is the responsibility of the jetty designer and not the bollard supplier.

TECHNICAL SUPPORT

Technical advice, design and enquiries should be directed to your local Trelleborg Marine Systems office.

GROUT TYPE

Trelleborg recommends a non shrink grout, either cementitious or epoxy type, with a minimum compressive strength of 60MPa.

For recessed bollards, Trelleborg recommends low viscosity high flow grouts to ensure full penetration around and under the base plate.

HOLDING DOWN BOLT SPECIFICATION

The holding down bolts are described in the product list and each general arrangement drawing.

The bolts are all ISO 898-1 Grade 8.8 and hot dip galvanized, with one nut and washer set. It should be noted that as bollard bolts are so large that the testing criteria in most fastener codes are therefore not applicable. Proportional testing methods are used at half the bolt radius according to ASTM F606.

HOLDING DOWN BOLT GRADES

Standard bollards use Grade 8.8 bolts only. Alternative bolt materials can be used but require re-engineering, including calculations and drawings. Any modification to holding down bolt materials should be reviewed and approved by a qualified and certified engineer.

BREAKAWAY BOLLARDS

Due to the magnitude of the loads applied to bollards, it is extremely dangerous to have them breakaway in an uncontrolled manner. Due to variations in material properties and tolerances, it is impossible to calculate actual breakaway load, making it highly unpredictable.

Numerous injuries, deaths and damage to equipment have occurred due to broken mooring lines and mooring equipment. As a responsible manufacturer, Trelleborg Marine Systems will not recommend these types of devices.

USE OF ANCHOR PLATES

Extensive testing by European, Australian and American design institutes has determined that a standard bolt head will produce the same pullout cone as similar bolts with an anchor plate. Trelleborg does not provide anchor plates with their standard bollard systems. Anchor plates may be added if required without any detriment to the system.

LOAD TESTING

Trelleborg does not carry out any physical load testing of bollards. The bollards and holding down bolt systems are designed to sustain the applied tension and shear with adequate safety factors and physical testing is considered unnecessary.

MATERIALS TESTING

Each foundry heat is accompanied by a destructive material mechanical property test report to evidence that the material has met the minimum strength requirement.

Non-destructive test such as 'Magnetic Particle Inspections', 'Die Penetrant Inspection' or 'Ultrasonic Testing' may be applied at an additional cost dependent on the extent of testing.

CODES AND GUIDELINES

ACI 318-11 Building Code Requirements for Structural Concrete A - Appendix D, Anchoring to Concrete
BS6349: 1-4 (2013): Part 4 Code of Practice for Design of Fendering and Mooring Systems
EAU (2004) Recommendations of the Committee for Waterfront Structures
ETAG 001 (1997) Guideline for European Technical Approval of Metal Anchors for use in Concrete
Ministry of Transport, Japan (1999) Technical Note No.911 – Ship Dimensions of Design Ships under given Confidence Limits
PIANC Report of PTC II-30 (1997) Approach Channels: A Guide for Design (Appendix B – Typical Ship Dimensions)
PIANC Report of WG24 (1995) Criteria for Movements of Moored Ships in Harbours – A Practical Guide (1995)
PIANC Report of WG33 (2002) Guidelines for the Design of Fender Systems (2002)
ROM 0.2-90 (1990) Actions in the Design of Maritime and Harbor Works
ROSA – Defenses D'accostage (2000) Recommendations pour Le Calcul Aux Etats-Limitesdes Ouvrages En Site Aquatique defenses D'accostage
Unified Facilities Criteria UFC 4-159-03 Design: Moorings (2005)



DISCLAIMER

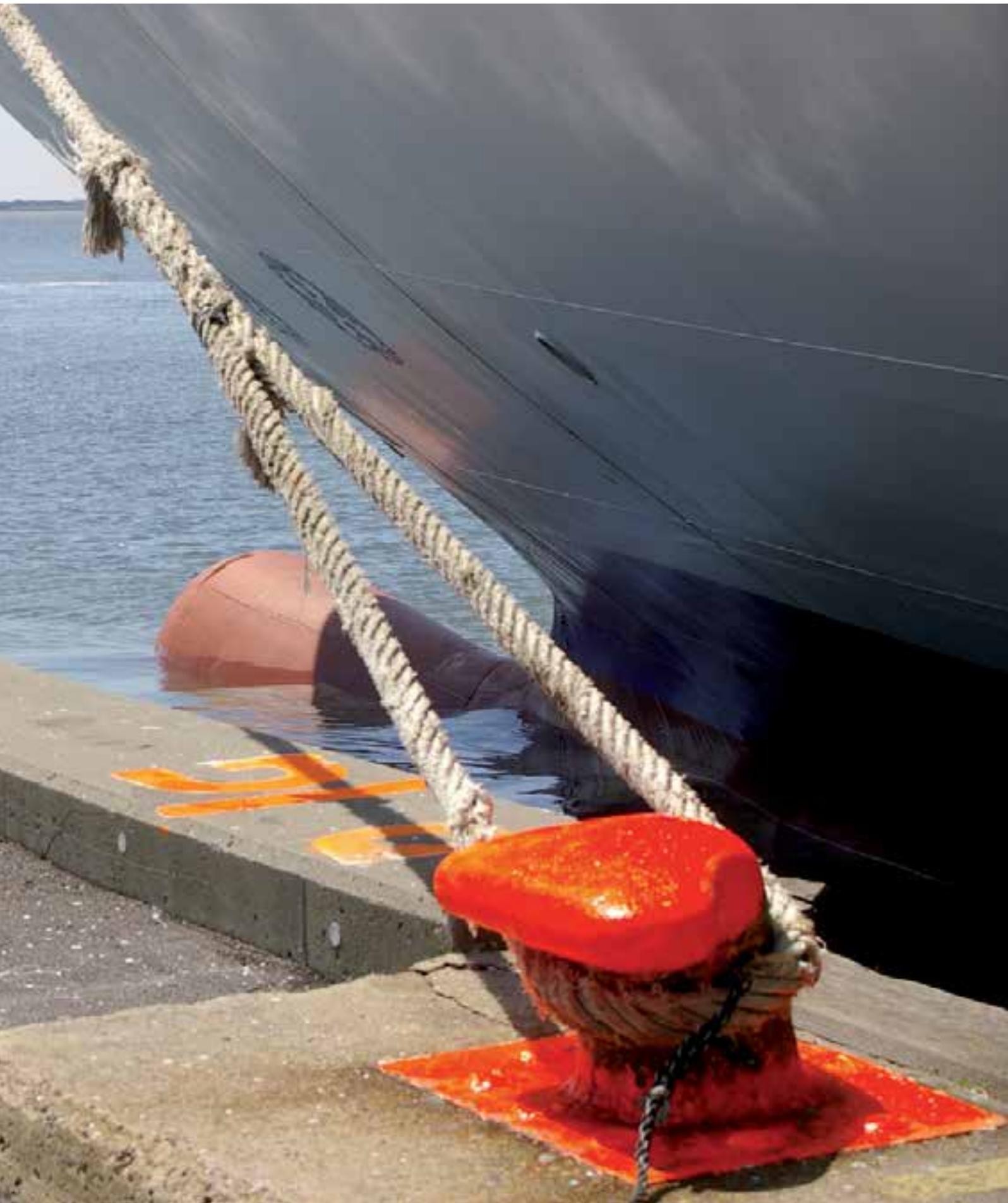
Trelleborg AB has made every effort to ensure that the technical specifications and product descriptions in this brochure are correct.

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 brochure supersedes the information provided in all previous editions. If in doubt, please check with Trelleborg Marine Systems.

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Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative engineered solutions accelerate performance for customers in a sustainable way. The Trelleborg Group has annual sales of about SEK 21 billion (EUR 2.3 billion, USD 3.2 billion) in over 40 countries. The Group comprises five business areas: Trelleborg Coated Systems, Trelleborg Industrial Solutions, Trelleborg Offshore & Construction, Trelleborg Sealing Solutions and Trelleborg Wheel Systems. In addition, Trelleborg owns 50 percent of TrelleborgVibracoustic, a global leader within antivibration solutions for light and heavy vehicles, with annual sales of approximately SEK 15 billion (EUR 1.7 billion, USD 2.3 billion) in about 20 countries. The Trelleborg share has been listed on the Stock Exchange since 1964 and is listed on NASDAQ OMX Stockholm.

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