Bollards

& Mooring Systems

QuayQuip
Technical Solutions BV

The QuayQuip Technical Solutions approach

QuayQuip Technical Solutions is a specialist in mooring solutions. It designs, makes and commissions engineered solutions for a vast range of marine and port construction applications. Every project makes full use of our collective expertise with steel, rubber and engineered plastics.

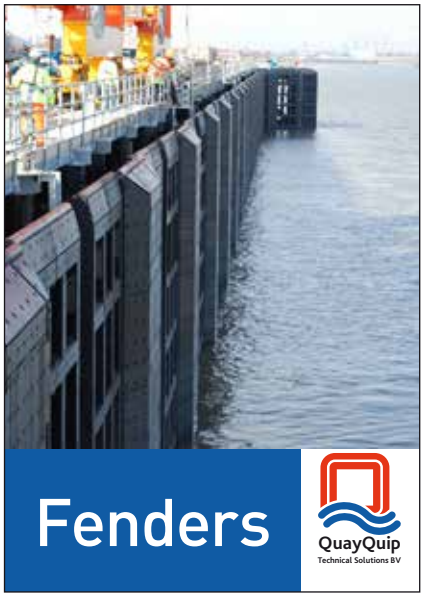
QuayQuip Technical Solutions uses the extensive resources available within the group, its sister businesses and other technical partners. The group enjoys access to over fifty engineers and specialists in disciplines which include:

- Mooring systems design
- Steel fabrication, casting and forging production
- Fender design and applications engineering
- Shiploader and bulk materials handling technology
- Structural analysis including advanced FEA
- Materials experts
- QA/QC inspection and management systems
- Third party external design checks

Projects undertaken by QuayQuip Technical Solutions are professionally designed and managed. Customer satisfaction is our first priority and we live up to our hard-earned reputation for delivery quality, technology and value for money – all backed by extended warranties.

More about QuayQuip Technical Solutions

If you want to know more about QuayQuip Technical Solutions other product ranges, or read our latest news, please visit our website at www.quayquipts.com. After registering you can download catalogues, product guides, our corporate brochure and useful utilities.



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Introduction

- The QuayQuip Technical Solutions Range
- Stronger Anchors
- Load Fuse Bollards

Bollards

- Tricorn (ETG)
- T-Head
- K-Head
- Quad -Head
- T-Horn
- Pin, Recessed and Legacy types

Mooring and Shiphauling

- Mooring Travellers
- Shiphauling Systems

Materials and Testing

- Bollard Materials
- Coatings
- Factors of Safety
- Bollard Requirements

Technical

- Choosing Bollards
- Line Angles
- Environmental Factors
- Design Codes

Tools

- Questionnaire
- Conversion Factors

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The QuayQuip Technical Solutions Range

QuayQuip Technical Solutions bollard range has developed over the last 30 years into a comprehensive choice of standard and custom units to suit every application in newly built berths or upgrades.

All QuayQuip Technical Solutions bollards incorporate the high quality materials, rigorous testing and inspection needed for safe, reliable mooring. Cast steel is the most popular material and comes with the option of Charpy testing for low temperature down to –40°C. QuayQuip Technical Solutions bollards are also available in nodular (spheroidal graphite) or regular cast iron where this is still preferred.

Tricorn bollards optionally include QuayQuip Technical Solutions unique load fuse (LF) technology – a connection between the bollard's trunk and base that limits accidental overloads and protects the berth from structural damage.

Capacity Range (kN)	Tricorn 300–3000	T-Head 150–2500	K-Head 150-2000	Quad-Head 300-3000	T-Horn 150–2500
Cast Steel (EN/ASTM/AS)	■	■	■	■	■
Low Temperature (–20°C)	□	□	□	□	□
Low Temperature (–40°C)	□	□	□	□	□
Load Fuse Base Plates	□			□	
Nodular (SG) Cast Iron	□	□	□	□	□
Cast Iron		□	□		□
Vertical Line Angles	~≤70°	Limited (~≤45°)	Limited (~≤45°)	~≤70°	Limited (~≤45°)
Horizontal Line Angles	±90°	±90°	±90°	±180°	±90°
Surface Mountable	■	■	■	■	■
Flush Mountable	■	■	■	■	■
Customised Base Plates	□			□	
Existing Anchor Retrofits	□	□	□	□	□

■ Standard □ Optional

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High Strenght Anchors

QuayQuip Technical Solutions ensure that every bollard anchor that we supply is right for the job.

Our design team will work closely with you to match your project's special requirements. Anchor systems and mounting instructions are unique to each bollard type.

If necessary, QuayQuip Technical Solutions carefully calculated designs use wide, thick anchor plates to safely distribute bollard loads into the surrounding concrete structure, as called for by the applicable standards.

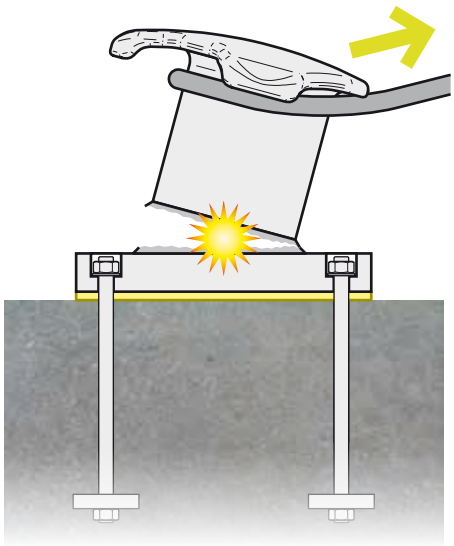
If required QuayQuip Technical Solutions can also calculate and design anchors with breaking mechanism, being the anchorage bolts or a different part of the anchorage system.

Load Fuse Bollards

A load fuse helps protect structures against overload. Traditionally bollards have been installed using break-off bolts, which will fail above a certain load. Because it is difficult to predict exactly how groups of fuse bolts will fail, QuayQuip Technical Solutions offers new designs of bollard with single, integral load fuses.

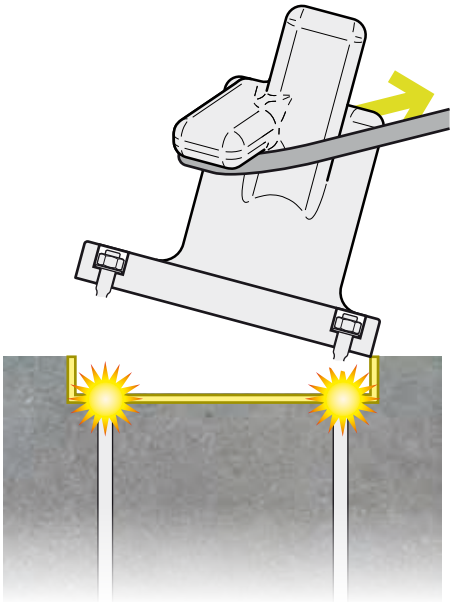
The bollard's base plate and head are joined by a load fuse (safety) weld, carefully calibrated to fail above a certain load. By contrast the explosive overload failure of ductile and cast iron bollards can be dangerous for people, structures and vessels.

Bollard with load fuse



- Consistent maximum load (±10%)
- Optional baseplate designs for custom or upgraded installations

Traditional bollard



- Maximum load ±50% increases construction costs.
- Custom baseplates are usually harder to achieve due to the one-piece design.

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Tricorn Bollards

Ideal for any mooring, QuayQuip Technical Solutions unique, triple-lobed Tricorn Bollard (sometimes called ETG Bollard) provides more holding power than any other bollard in its class, even on line angles up to 70°. Its generous trunk diameter reduces mooring line stresses. Integrated load fuses and capacities up to 3000kN are available.

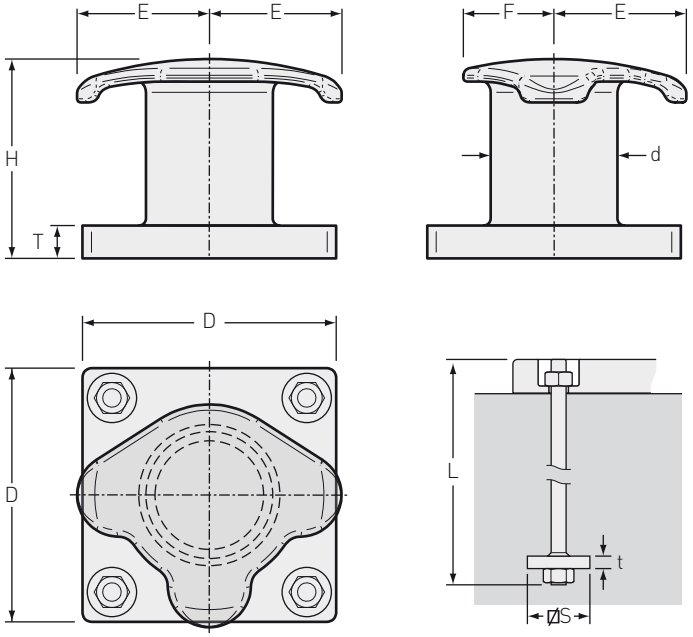
Higher capacities are available on request.

- Load fuse (safety weld) option
- High holding power
- Low temperature materials option
- Standard or custom baseplatess
- No anchor stresses
- Very high vertical line angles

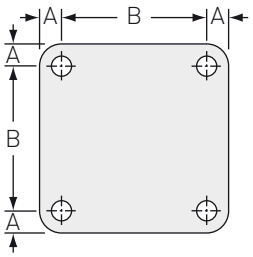
Lloyd's Register — Design calculation and physical testing witnessed and verified by Lloyd's Register

	Capacity	D	E	F	H	d	T	Bolts	A	B	L	⌀S	t
Surface & Flush mounted	300kN	410	200	140	380	200	50	4×M30	60	290	500	115	30
	500kN	480	235	175	385	270	55	4×M36	67.5	345	600	135	35
	600kN	480	235	175	390	270	60	4×M39	70	340	650	160	40
	800kN	750	365	250	530	350	70	4×M48	82.5	585	750	160	45
	1000kN	750	365	250	535	350	75	4×M52	87.5	575	850	180	50
	1250kN	750	365	250	545	350	85	4×M60	95	560	950	210	55
	1500kN	750	365	250	555	350	95	4×M64	100	550	1100	230	60
Flush mounted	1750kN	850	410	290	555	430	90	4×M52	87.5	675	1100	230	60
	2000kN	850	410	290	570	430	105	4×M56	90	670	1150	250	60
	2500kN	980	450	325	605	500	120	4×M60	95	790	1300	270	70
	3000kN	980	450	325	630	500	145	4×M68	102.5	775	1450	300	75

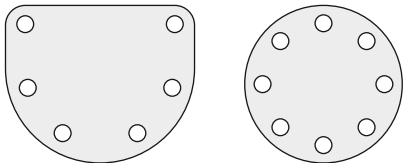
All dimensions are in mm. Angles are in degrees. Please ask QuayQuip Technical Solutions for a certified drawing with anchor details. Large diameter trunks are used for extra low mooring line stresses. Anchor lengths are based on concrete quality C30/37. Mooring line angle vertical 30°-60°.



Standard



Optional baseplates



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Quad-Head Bollards

Ideal for 360° horizontal mooring line angles, QuayQuip Technical Solutions new design, Quad-Head Bollard provides best holding power in its class, even on line angles up to 70°.

Its generous trunk diameter reduces mooring line stresses. Integrated load fuses and capacities up to 3000kN are available.

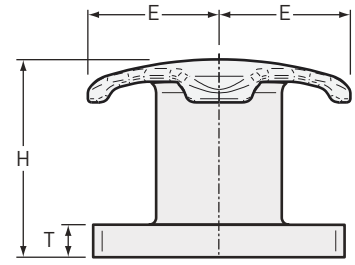
Higher capacities are available on request.

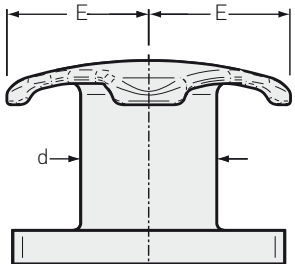
It can be applied for storm bollards, dolphin bollards and bollards placed on the corner of a quay.

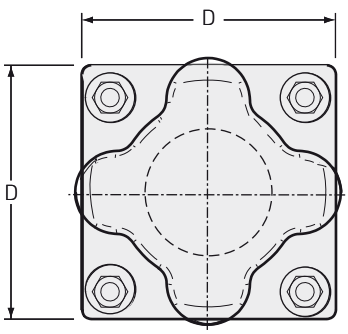
- 360° horizontal mooring line angles
- Load fuse (safety weld) option
- High holding power
- Low temperature materials option
- Standard or custom baseplates
- No anchor stresses
- Very high vertical line angles

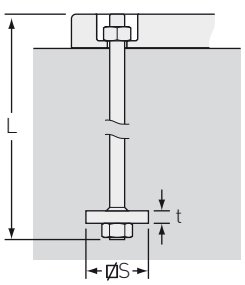
	Capacity	D	E	F	H	d	T	Bolts	A	B	L	⌀S	t
Surface & Flush mounted	300kN	410	200	140	380	200	50	4×M30	60	290	500	115	30
	500kN	480	235	175	385	270	55	4×M36	67.5	345	600	135	35
	600kN	480	235	175	390	270	60	4×M39	70	340	650	160	40
	800kN	750	365	250	530	350	70	4×M48	82.5	585	750	160	45
	1000kN	750	365	250	535	350	75	4×M52	87.5	575	850	180	50
	1250kN	750	365	250	545	350	85	4×M60	95	560	950	210	55
	1500kN	750	365	250	555	350	95	4×M64	100	550	1100	230	60
Flush mounted	1750kN	850	410	290	555	430	90	4×M52	87.5	675	1100	230	60
	2000kN	850	410	290	570	430	105	4×M56	90	670	1150	250	60
	2500kN	980	450	325	605	500	120	4×M60	95	790	1300	270	70
	3000kN	980	450	325	630	500	145	4×M68	102.5	775	1450	300	75

All dimensions are in mm. Angles are in degrees. Please ask QuayQuip Technical Solutions for a certified drawing with anchor details. Large diameter trunks are used for extra low mooring line stresses. Anchor lengths are based on concrete quality C30/37. Mooring line angle vertical 30°-60°.

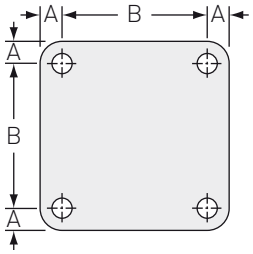




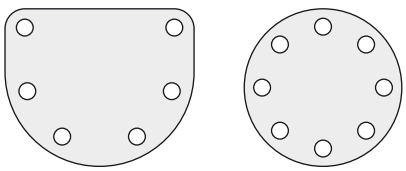




Standard



Optional baseplates



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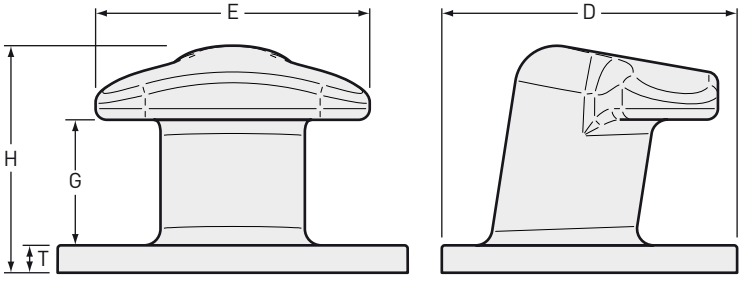
T-Head Bollards

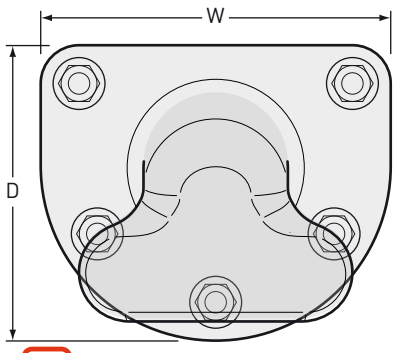
The QuayQuip Technical Solutions T-Head Bollard can handle line angles up to 45°. Bollard capacities of up to 2500kN are available.

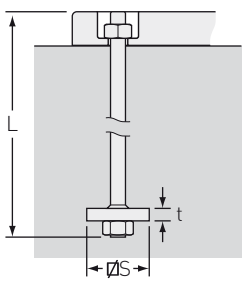
- High capacity
- Ideal for multipurpose berths

Capacity	W	D	E	H	G	T	Bolts	A	B	C	α_1	α_2	α_3	α_4	L	⌀S	t
150kN	410	335	340	275	160	40	5×M24	50	310	80	30	60	–	-	500	100	25
300kN	450	375	350	295	180	40	5×M30	50	350	100	30	60	–	-	500	110	30
500kN	640	540	500	415	230	50	5×M36	70	500	150	30	60	–	-	500	150	35
800kN	640	550	550	455	250	70	6×M42	70	500	160	15	45	30	-	800	150	35
1000kN	790	640	600	510	270	80	7×M42	70	650	175	10	40	40	-	800	150	35
1250kN	850	700	600	530	270	85	7xM42	80	690	195	10	40	40	-	800	150	35
1500kN	900	750	700	550	270	90	7×M48	100	700	200	10	40	40	-	1000	180	50
2000kN	1000	850	800	620	320	90	8xM56	125	750	225	36	36	18	-	1000	180	50
2500kN	1100	900	890	720	375	105	9xM56	125	850	225	30	30	30	-	1000	200	50
3000kN	1200	950	980	830	435	125	7xM56	125	950	225	23	26	26	15	1000	200	50

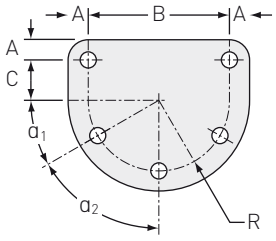
All dimensions are in mm. Angles are in degrees. Please ask QuayQuip Technical Solutions for a certified drawing with anchor details.
Anchor lengths are based on concrete quality C30/37.



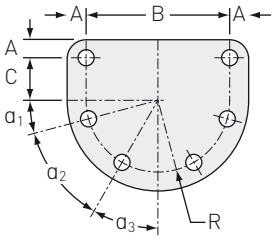




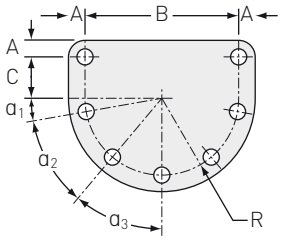
5 bolts



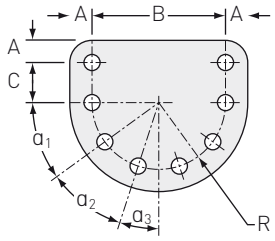
6 bolts



7 bolts



8 bolts



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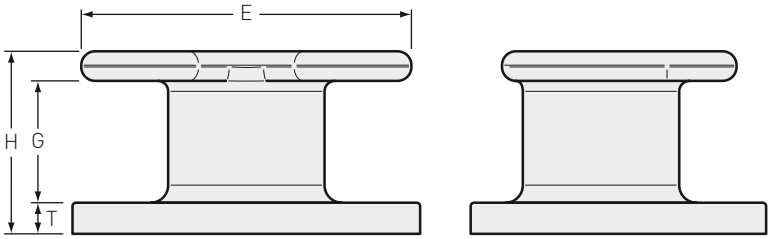
K-Head Bollards

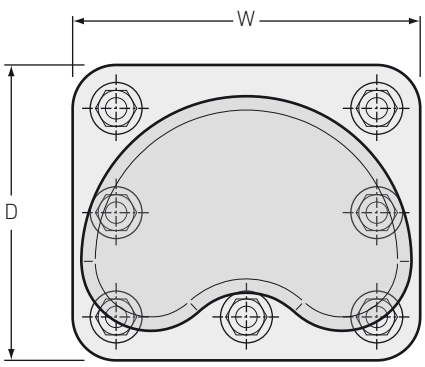
QuayQuip Technical Solutions K-Head Bollards are a popular, economical choice for applications with a single mooring line per bollard and with lower ranges of vertical line angle than T-horn Bollards.

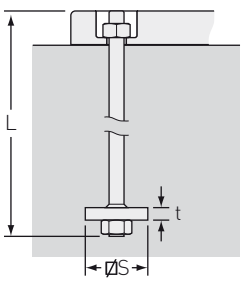
- Suitable for general applications
- Best at shallow line angles
- Ideal for warping

Capacity	W	D	E	H	G	T	Bolts	A	B	C	L	ØS	t
150kN	320	320	320	300	230	40	4×M24	50	220	–	500	100	25
300kN	360	360	360	320	250	40	4×M30	50	260	–	500	110	30
500kN	540	540	500	370	280	50	4×M36	70	400	–	500	110	30
800kN	560	460	530	400	280	70	5×M42	70	210	320	800	150	30
1000kN	590	490	570	420	300	70	7×M42	70	225	175	800	150	30
1500kN	760	660	750	485	330	80	7×M48	80	300	250	1000	150	40
2000kN	1000	850	950	525	350	90	7×M56	125	375	300	1000	180	50

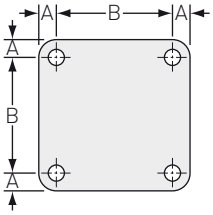
All dimensions are in mm. Please ask QuayQuip Technical Solutions for a certified drawing with anchor details.
Anchor lengths are based on concrete quality C30/37.z



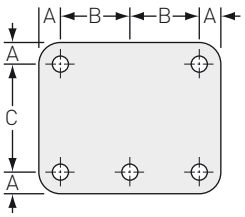




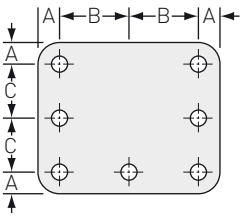
4 bolts



5 bolts



7 bolts



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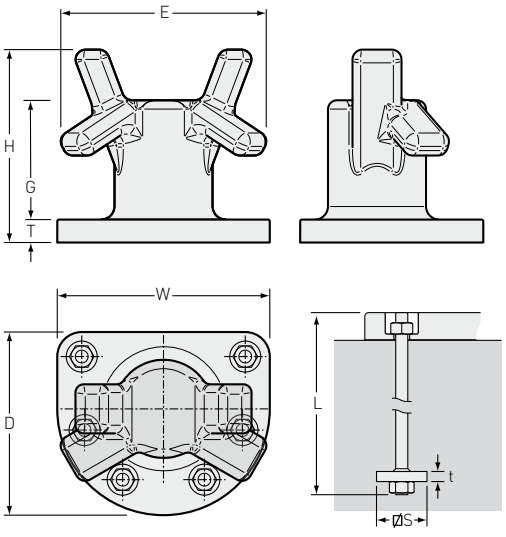
T-Horn Bollards

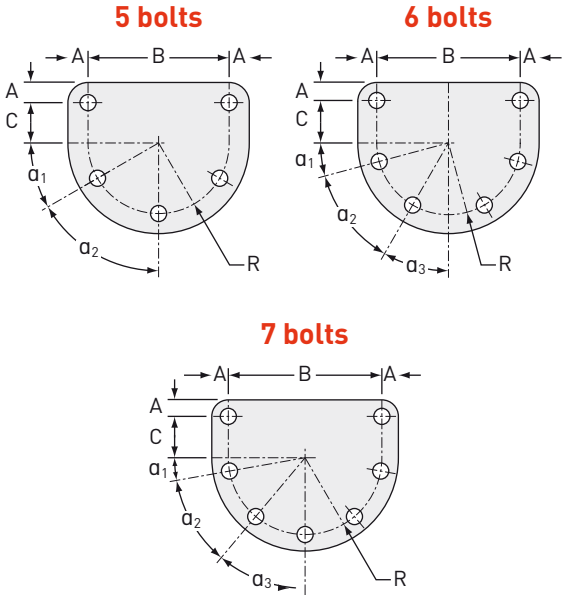
T-Horn Bollards accept multiple mooring lines from one or two vessels without interference, even at steep line angles.

- Lines from more than one vessel
- General purpose applications
- Steeper line angles than many types

Capacity	W	D	E	H	G	T	Bolts	A	B	C	α_1	α_2	α_3	L	ØS	t
150kN	410	335	351	370	240	40	5×M24	50	310	80	30	60	–	500	100	25
300kN	480	405	410	450	300	40	5×M30	65	350	100	30	60	–	500	110	30
500kN	640	540	565	550	350	50	5×M36	70	500	150	30	60	–	600	130	30
800kN	650	560	630	590	365	70	6×M42	75	500	160	15	45	30	800	160	40
1000kN	800	650	690	650	400	80	7×M42	75	650	175	10	40	40	800	160	40
1500kN	920	770	795	675	425	90	7×M48	110	700	200	10	40	40	1000	175	40
2000kN	1000	850	910	800	485	90	8×M56	125	750	225	35	35	20	1000	180	50
2500kN	1000	850	910	830	515	120	8xM64	125	750	225	35	35	20	1000	180	60

All dimensions are in mm. Angles are in degrees. Please ask QuayQuip Technical Solutions for a certified drawing with anchor details. Anchor lengths are based on concrete quality C30/37.





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Recessed and Pin Bollards

Recessed and Pin type bollards are used for flush fitting, avoiding protrusions and hull damage. Applications include locks and waterways where bollards are placed at single or multiple levels for vessels to moor without help from shore-based crew.

Modern and classic styles are available, with capacities from 40kN right up to 600kN. There are options for integral or separate anchorages, and replaceable or permanent mooring pins. Profiles units are made to suit all standard sheet pile sections. Custom designs and replacements for obsolete patterns are also available.

Legacy Types

Some regions and operators still prefer traditional multiple, high-profile or cleat bollard designs. QuayQuip Technical Solutions recommends specifying more modern designs that offer a higher performance per weight, and present less risk of operator injury from lifting heavy lines over tall bollards.

When legacy bollard designs are essential, QuayQuip Technical Solutions can offer state-of-the-art materials and coatings to minimise maintenance and extend service life.

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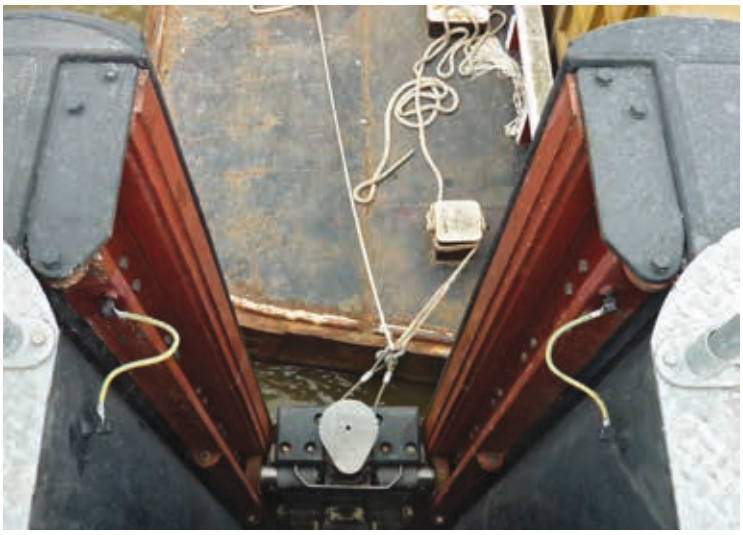
Mooring Travellers

QuayQuip Technical Solutions Mooring Travellers allow for water level changes by replacing conventional moorings with units that rise and fall with the vessel, even with tensioned mooring lines.

Hardened cast steel rails and other parts are highly durable: minimum service lives are typically 50 years. The bollard sits above a buoyant, wheeled bogie, guaranteeing that it always presents at a safe and convenient level for crew. Faster transits benefit lock and barge operators alike and save costs.

Modular rails can be provided to any height. Bollard capacities range from 100–500kN. Capacity and height above water will depend on the unique characteristics of each berth – please ask QuayQuip Technical Solutions about your requirements.

Typical applications include locks, waterways, high tidal range berths, and fast ferry berths.



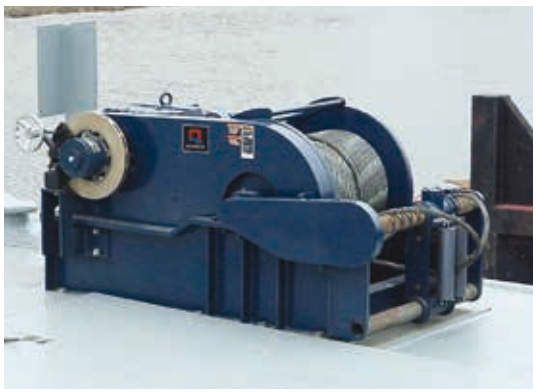
Shiphauling Systems

QuayQuip Technical Solutions design and build a range of winches and capstans for warping and hauling vessels along berths.

Winches can be deployed at each end of the berth with a rail and carriage system which acts as a 'mule' to haul the vessel in either direction. The winches can incorporate a Leadscrew Levelwind System for even spooling of the cable onto the drum.

Control options include simple foot switches or a dock-mounted consoles or handheld remote controls.

Capstans are often installed on docks for hauling in messenger lines, and can also be used to haul small vessels over short distances.



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Bollard Materials

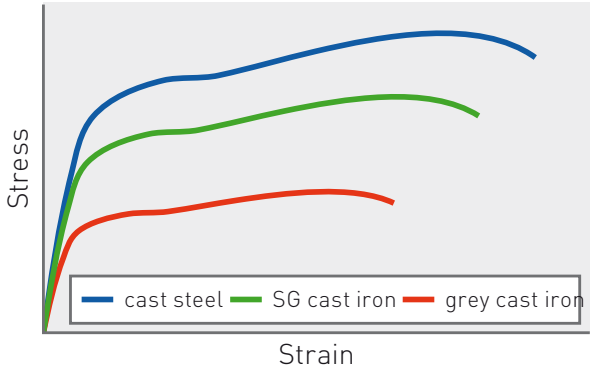
Cast Steel vs Cast and Ductile Cast Iron

Before cast steel was readily available, bollards were made in different grades of cast or ductile cast iron. Most modern ports now recognise the great benefits of cast steel but, it is important to understand the differences between the materials to appreciate the benefits and advantages of cast steel compared to any grade of cast or ductile cast iron. The main characteristics and benefits of cast steel, cast iron and ductile (SG) iron and grey iron, are defined below to help designers and specifiers of bollards make informed choices.

Common Bollard Materials

Typical material properties of cast steel and cast and ductile cast iron are given in the table. These assume high grade raw materials, proper manufacturing processes, heat treatment where applicable and effective quality management.

QuayQuip Technical Solutions is leader in high performance castings for safety critical applications. Our skilled staff employ the best raw materials and strictest process controls.



Typical Properties*	Grade	Yield		Tensile		Elongation	Charpy+
		(MPa)	(ksi)	(MPa)	(ksi)	(%)	
Cast Steel EN-10293	GE300	300	44	600	87	15	27J at +20°C‡
	G20Mn5	300	44	500	73	20	27J at -20°C‡
Cast Steel ASTM A27	65–35	240	35	450	65	24	N/A
	70–36	250	36	485	70	22	N/A
	70–40	275	40	485	70	22	N/A
Cast Steel A148	80–50	345	50	550	80	22	N/A
Ductile (SG) Cast Iron EN-1563	EN-GJS-400-15	250	36	400	58	15	N/A
Grey Iron EN-GJL-300	EN-GJL-300	Undefined		300	44	1	N/A

* Properties given are typical values for each material grade based on prepared samples.

+ Charpy testing is optional, and strongly recommended for low temperature applications.

‡ Charpy testing to lower temperatures is available on request.

Safety Factors

Bollards are designed with the following safety factors. Calculations with other safety factors can be provided on request.

	Application	Factor	Design Code
Load Factors	Bollard head and base plate	1.40	BS 6349-2
	Weld	1.30	N/A*
	Anchorage	1.40	BS 6349-2
Material Factors	Cross sections	1.00	EN 1993-1-1
	Joints	1.25	EN 1993-1-8

* Load factor is commonly used for safety welds to protect the structure and other bollard parts against overloading.

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Bollard Requirements

Bollards are specified and selected for their ability to perform safely, under a range of conditions and over long periods with little if any maintenance.

Some requirements depend on bollard shape, others on the material used. Cast steel is the most reliable. Many cast iron foundries lack the facilities to make consistently high quality ductile cast iron. Grey cast iron is not recommended for bollards.

Requirement	Grey Iron	Ductile Iron (SG)*	Cast Steel
Load capacity	Variable	Fair	Excellent
Holding power	Variable	Fair	Excellent
Load fuse designs	Not possible	Not possible	Most types
Impact strength	Poor	Fair	Excellent
Low temperature rating	Brittle	Brittle	–20°C (lower on request)
Wear resistance	Poor	Poor	Very good
Fatigue resistance	Poor	Poor	Excellent
Corrosion resistance	Excellent	Excellent	Excellent (painted)
Long service life	Variable	Good	Excellent
Cost benefit	Poor	Fair	Excellent

* Ductile cast iron is also called Spheroidal Graphite (SG) Iron or Nodular Cast Iron

Suitable Bollard Coatings

Care must be taken to avoid damaging factory-applied coatings. C5M-H (ISO 12944-5) is recommended, but other coatings are available on request. While single-piece fully casted bollards can be galvanised, we do not offer this finish for two-piece welded bollards. Coatings can be supplied in many colours and thicknesses – contact your QuayQuip Technical Solutions office.

Wear and abrasion from mooring lines is continuous. QuayQuip Technical Solutions recommends periodic repainting to protect bollards from corrosion. Cast steel bollards, which are the least prone to rust and corrosion, will need less frequent attention than bollards of less durable materials.

Typical Coating

Hempadur Quattro 17634	Colour	Thickness
Coat 1	Black	150µm
Coat 2	Red	150µm
Coat 3	Black	200µm
		500µm

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Choosing Bollards

Local regulations and accepted design standards must always be followed. Designers should take the following into account:

- Changes in draft
- Changes in water level
- Winds and currents
- Forces from swell, waves and currents
- Type and angle of mooring line
- Forces due to ice (where applicable)
- Mounting type
- Using load fuses to prevent structural overload

Where mooring load information is not available, the 'Ship Size' table can be used a guideline.

Hazardous cargoes

Bollards are not recommended for use at berths that receive hazardous cargoes including oil, LNG, coal and other volatile substances. In these cases please speak to QuayQuip Technical Solutions about our range of Quick Release Hooks.

Ship Size

Displacement	Bollard working load (approx.)
< 2,000	10
2,000–10,000	30
10,000–20,000	60
20,000–50,000	80
50,000–100,000	100
100,000–200,000	150
> 200,000	200

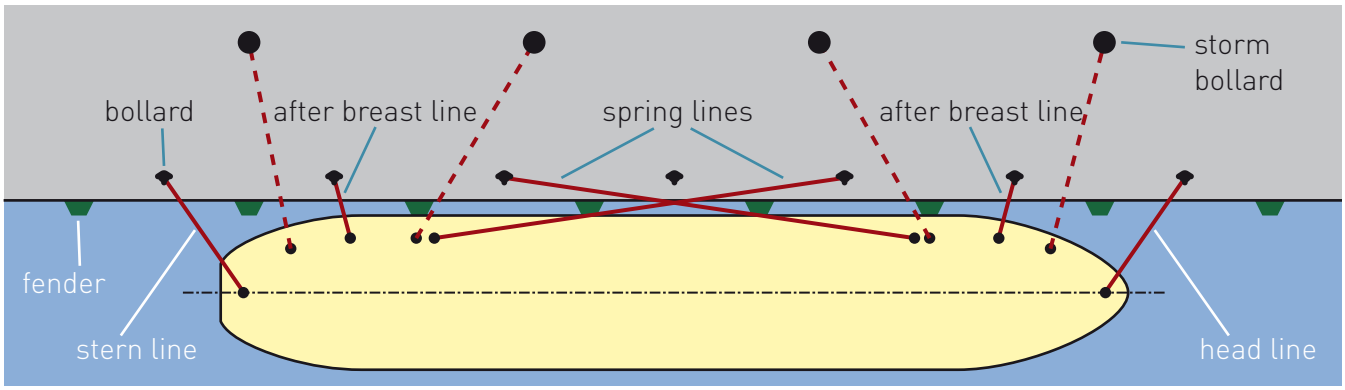
[Units: tonnes]

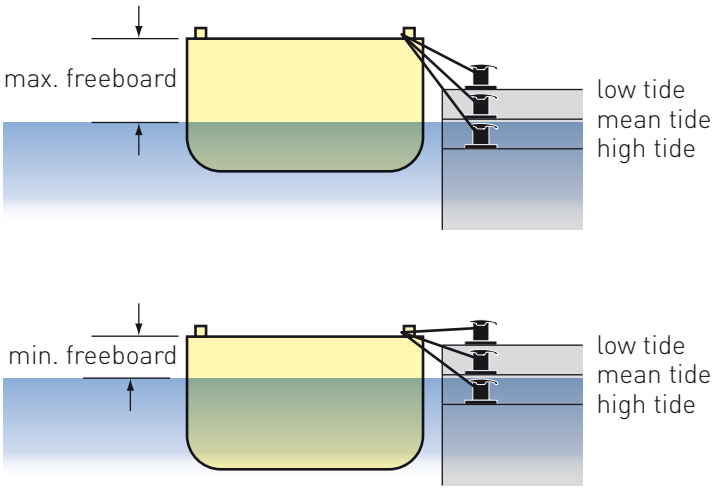
Calculations are based on EAU2004 and BS6349-4 standards. Add at least 25% to the ratings above if strong currents, winds or other hazards are anticipated.

Bollard Spacing

Design codes recommend that bollards are frequently placed at 15–30m intervals, often at the same spacing as fenders (either at the same point as fenders or midway). Another approximate guide is 15% of the length of the shortest ship. On continuous structures, this spacing may coincide with the centres between expansion joints.

Line Angles





We recommend that mooring line angles are considered during a full mooring simulation. Vertical line angles should be kept as low as possible. Horizontal angles are given relative to the ship's main axis.

Head and stern lines	45° ±15°
Breast lines	90° ±30°
Spring lines	5–10°
Vertical line angle	≤25°

Please refer to BS6349-4 and PIANC guidelines.

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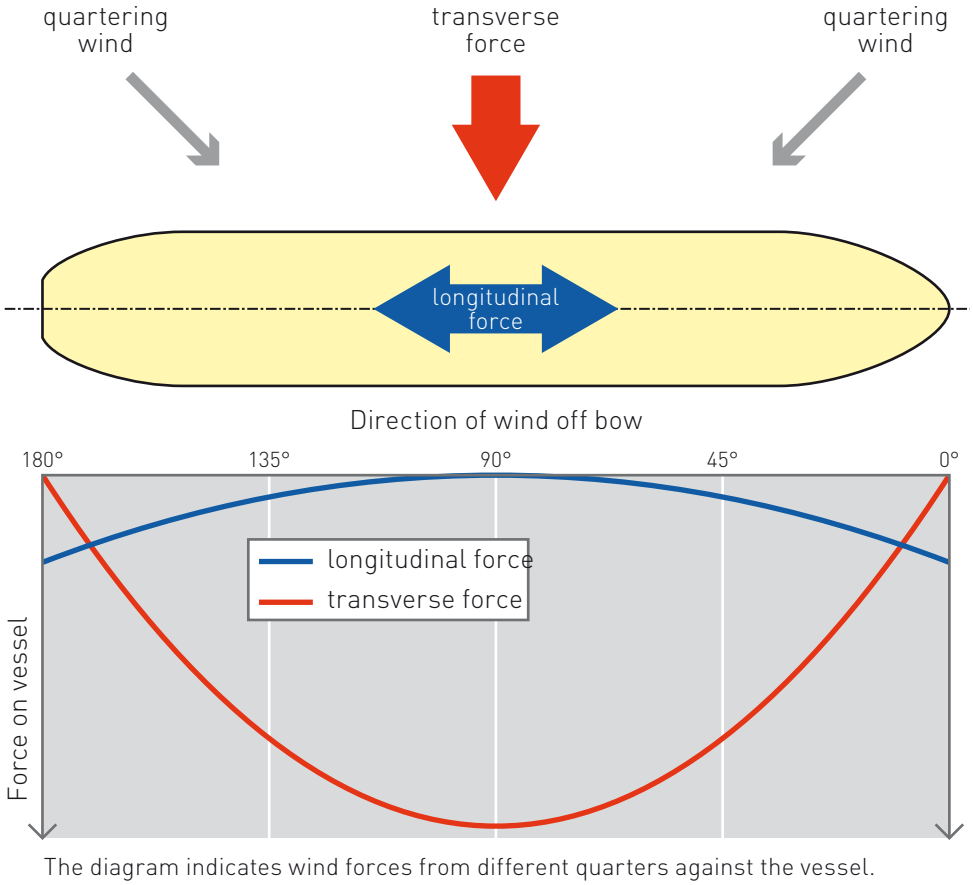
Environmental Factors

Designs must take into account many effects of the surrounding environment, such as current, tides, waves and wind.

All permutations of freeboard and ship sizes should also be considered. The forces induced by passing vessels, especially in narrow channels, can be stronger still.

Software such as Optimoor is useful in some cases, but more advanced software is needed to model passing vessels and wave forces.



The diagram indicates wind forces from different quarters against the vessel.

Design Codes

Bollards are designed according to the following design codes. Calculation with other design codes are available on request.

British Standards: Maritime Works

BS 6349-2: Code of Practice for the Design of quay walls, jetties and dolphins

BS 6349-4: Code of Practice for Design of Fendering and Mooring Sustems.

Eurocode 3: Design of Steel Structures

EN 1993- Part 1-1: General Rules

EN 1993- Part 1-8: Design of Joints

PIANC Guidelines

Report of PTC II-30: Approach Channels: A Guide for Design (Appendix B – Typical Ship Dimensions

Report of WG24: Criteria for Movements of Moored Ships in Harbours – A Practical Guide

EAU

Recommendations of the Committee for Waterfront Structures.

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Questionnaire

Port		**Contact**	
Berth		**Company**	
Country		**Tel**	
Project	☐ New Build ☐ Upgrade	**Email**	
Status	☐ Preliminary ☐ Detail ☐ Tender	**Web**	

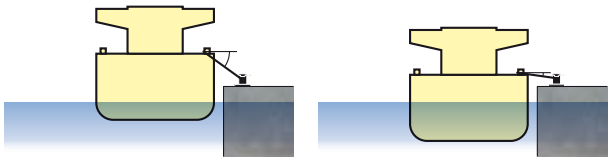
BOLLARD TYPE

☐ Tricorn	☐ T-Head	☐ Quad-Head	☐ Horn	☐ K-Head	☐ Pillar	☐ Other/legacy
Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
SWL	SWL	SWL	SWL	SWL	SWL	SWL

VESSELS

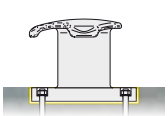
Length	L_{OA}
Displacement	
Deadweight	
Length	L_{OA}
Displacement	
Deadweight	

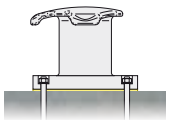
LINE ANGLES



Max (degrees)	
Min (degrees)	
Max (degrees)	
Min (degrees)	

MOUNTING


Flush mounted


Surface bolted

Flush	
Surface	

OTHER INFORMATION

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Tried and Tested

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Conversion Factors

Distance

	m	ft	in
1 m =	1	3.281	39.37
1 ft =	0.3048	1	12
1 in =	0.0245	0.0833	1

Area

	m^2	ft^2	in^2
1 m^2 =	1	10.764	1550
1 ft^2 =	0.0929	1	144
1 in^2 =	645.2×10^{-6}	6.944×10^{-3}	1

Volume

	m^3	ft^3	in^3
1 m^3 =	1	35.315	61024
1 ft^3 =	0.0283	1	1728
1 in^3 =	16.387×10^{-6}	578.7×10^{-6}	1

Acceleration

	g	m/s^2	ft/s^2
1 g =	1	9.807	32.17
1 m/s^2 =	0.102	1	3.281
1 ft/s^2 =	0.031	0.3048	1

Force

	kN	tonne-f	kip-f
1 kN =	1	0.102	0.225
1 tonne-f =	9.81	1	2.2046
1 kip-f =	4.45	0.454	1

Energy

	kJ	tf-m	kip-ft
1 kJ =	1	0.102	0.7376
1 tf-m =	9.81	1	7.23
1 kip-ft =	1.36	0.14	1

Pressure

	kPa	t/m^2	kip/ft^2
1 kPa =	1	0.102	0.0209
1 t/m^2 =	9.81	1	0.205
1 kip/ft^2 =	47.9	4.88	1

Velocity

	m/s	ft/s	km/h	knot
1 m/s =	1	3.2808	3.6	1.9438
1 ft/s =	0.3048	1	1.0973	0.5925
1 km/h =	0.2778	0.9113	1	0.54
1 knot =	0.5144	1.6878	1.852	1

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English A4 Metric v.2.5c

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