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FENTEK • MARINE FENDERING SYSTEMS

ISSUE 08/02

Marine Fendering Systems

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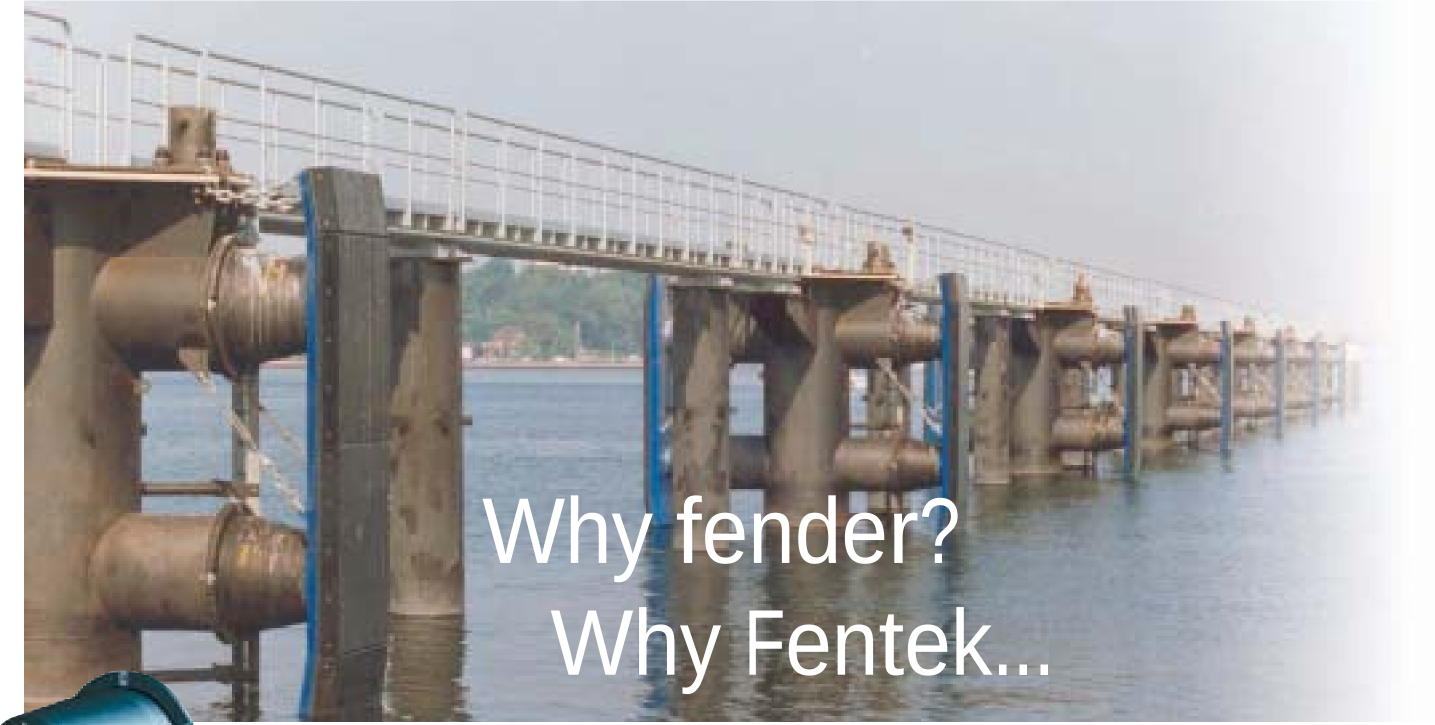


Why fender? Why Fentek...

WHY FENDER?
Fenders are a form of insurance – giving day-to-day peace of mind, but offering real protection when they are needed most during heavy or abnormal impacts. Like any insurance, the protection a fender system provides will depend on the supplier, their experience, the product quality and the level of service and support they provide.

A well conceived fender system should provide many other advantages – such as reduced reaction forces which can help save considerable amounts on new-build structures or by extending the life and usefulness of existing berths.
When it comes to construction, well-designed fenders will be easier, faster and less expensive to install. The right fenders can also give the competitive edge to contractors' tenders, by saving on other material costs like steel and concrete. Or they may be more versatile, providing extra benefits to the end user at no additional cost.
Ports and their customers – the shipping lines – stand to gain or lose most from good or mediocre fenders. Quality designs made from the best materials and with attention to detail will last longer and require less maintenance. They will help to improve operational efficiency and turnaround times. Better protection from damage for both ships and structures goes without saying, but it is sometimes overlooked that a well designed and visually attractive fender system can be a real and positive asset when attracting new users to a facility.

WHY FENTEK?
Fentek is the market leader in advanced fendering solutions. With a history dating back three decades and a track record covering hundreds of thousands of individual fenders around the globe, the expertise and experience available to Fentek's customers is truly second to none.
Virtually every component of Fentek's fenders are made in-house – from simple extrusions to the world's largest and most sophisticated systems – giving us control over designs and engineering that is impossible to match with third-party suppliers.
Headquartered in Hamburg, Germany, the division has strategically located technical and sales offices plus a network of trained agents in most markets. To develop the business further, Fentek came under the umbrella of the Trelleborg Group of Sweden in April 2001. Since then, customers have continued to benefit from Fentek's entrepreneurial attitude to fender challenges backed up by the extensive technical and financial resources of Trelleborg.
Fentek's success is primarily due to the effort and careful thought put into the large and small details of each and every design. Our goal is to achieve the best value for money and lowest full life cost on every project – something our many satisfied customers can testify to.
Every Fentek system, large or small, is designed and checked by qualified engineers. Our aim is to go further than mere compliance with specifications. We refine designs to make best use of modern materials and manufacturing practices, they are easier to install, more robust and last longer with less maintenance.
Fentek fender systems make the difference.

This catalogue is primarily intended for users with some experience of fender selection and calculation procedures. Ideally it should be used in conjunction with appropriate international standards and codes, as well as project specific information about vessels, environmental conditions and quay structures.
There are three principle sections to the catalogue:-

PRODUCTS (Pages 4-65)
This section details all the principle products and systems manufactured by Fentek. It includes details on energies and reactions including performance curves, as well as fixing and attachment details. Photographic examples are given of many different applications to demonstrate the versatility of the various products.

DESIGN (Pages 66-86)
This section is an aid to selecting and specifying appropriate fender systems for various common applications. It provides typical ship dimensions and characteristics, and commonly used calculation methods for determining berthing energies. Also provided is guidance on design of hull pressures, chains and other fender accessories.

OTHER INFORMATION (Pages 87-93)
This section includes additional information useful to designers such as material specifications, references to other codes and standards, conversion tables etc.
Because of the great diversity of ports and vessels around the world, it would be impossible to cover every conceivable fendering requirement within a single catalogue. Fentek is always happy to assist with all aspects of fender design – please contact us for further information.

PRODUCT MATRIX

This matrix is intended as a guide to the suitability of Fentek fenders to various applications as follows:

● Generally suitable

❍ Possibly Suitable

	Tankers	Gas Carriers	Bulk cargo	General Cargo	Container	RoRo	Passenger Ferry	Cruise Ship	High Speed Ferries	Naval Vessels	Submarines	Fishing Boats	Pleasure Craft	Pontoons	Pile Guides	Lock Entrances	Dry Docks	Jetty Corners	Linkspans	Bridge Protection	Tugs (Berths)	Tugs (Ship Mounted)	Page
Super Cones	●	●	●	●	●	●	●	●	●	●	❍	❍	●	❍	❍	❍	❍	❍	●	●	❍		4
Unit Element	●	●	●	●	●	●	●	●	●	●	❍	●	●	●	●	●	●	●	●	●	●		10
Unit Element V-Fenders	❍	❍	●	●	●	●	●	●	❍	❍	❍	●	●	●	●	●	●	●	●	●	●		16
Parallel Motion	●	●	●	❍	❍	●	❍	●	●	❍	❍			❍		●		●		❍			18
Arch Fenders (AN)	❍	❍	●	●	❍	●	●	❍	❍	●		●	●	●		●	●	❍	●	●	●	❍	22
Arch Fenders (ANP)	❍	❍	●	●	❍	●	●	❍	❍	●		●	●	●	❍	●	●	❍	●	●	●	❍	22
Cylindricals (Larger)	❍	❍	●	●	❍	●	●	❍		❍				●		❍	❍	❍	❍	❍	●		26
Cylindricals (Small)	❍	❍	❍	●			●			❍		●	●	●		❍	❍	❍	❍	❍	●		26
Pneumatic Fenders	●	●	●	●	❍	●	●	●	❍	❍		❍	❍	❍						❍	❍		30
Hydro-pneumatic Fenders									❍		●												33
Foam Fenders	●	●	●	●	❍	●	●	●	❍	❍		❍	❍	❍						❍	❍		34
Donut Fenders	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍								●		●			36
Shear Fenders						❍	❍		❍	❍		❍		❍	●								37
Wheel Fenders																●	●	●					38
Roller Fenders														●			●						42
UHMW Polythene	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	44
HD-PE Sliding Fenders	❍	❍	❍	❍	❍	❍	❍	❍	❍	●	●	●	●	●	●	●	❍	●		●	●	●	46
D & Square Fenders							●		❍	●	❍	●	●	●			❍	❍	●	❍	●	●	48
Composite Fenders									❍	❍	●	●	●	●	●	❍	❍	❍	●	❍	❍	●	50
M-Fenders															❍	❍		●		●		●	53
Block fenders															❍	❍		●		●		●	54
Cube Fenders															❍	❍						●	55
Tug Cylindricals																						●	56
Wing-D Fenders																						●	59
Chains & Accessories	●	●	●	●	●	●	●	●	●	●	●	❍	❍	❍		❍	❍	❍	❍	●	❍		60
Anchors	●	●	●	●	●	●	●	●	●	●	●	●	●			●	●	●		●	●		63

▲ Nhava Sheva (INDIA)

Super Cone Fenders

Super Cones are the latest generation of "cell" fender combining excellent energy capacity with low reaction force to give the most efficient performance of any fender type. The conical shape keeps the body stable under all combinations of axial, shear and angular loading, making it ideal for berths where large berthing angles and heavy impacts need to be accommodated.

All Super Cones are single piece mouldings – unlike traditional "cell" types – so they are robust, long lasting and easy to install. Optional overload stops can be moulded inside the cone to prevent over compression, making the Super Cone extremely reliable and resistant to accident damage.

Soft structures such as monopiles, dolphins and open piled jetties can often be built more economically due to the very low loads generated by Super Cones. UHMW-PE faced steel frontal frames are generally used in conjunction with Super Cones, although they have also been used with great success behind fender piles, in Parallel Motion systems and for numerous other applications.

Core Attributes

- **Highly efficient shape**
- **Excellent under large berthing angles and shear**
- **Large range of sizes**
- **Versatile design suits numerous applications**
- **Choice of standard & intermediate compounds**
- **Stable geometry maintains performance under all loading combinations**
- **Well proven design – thousands in use**
- **Easy and fast to install**
- **Optional overload stop (unique to Super Cones).**

▼ Pontile Elba, Livorno (ITALY)

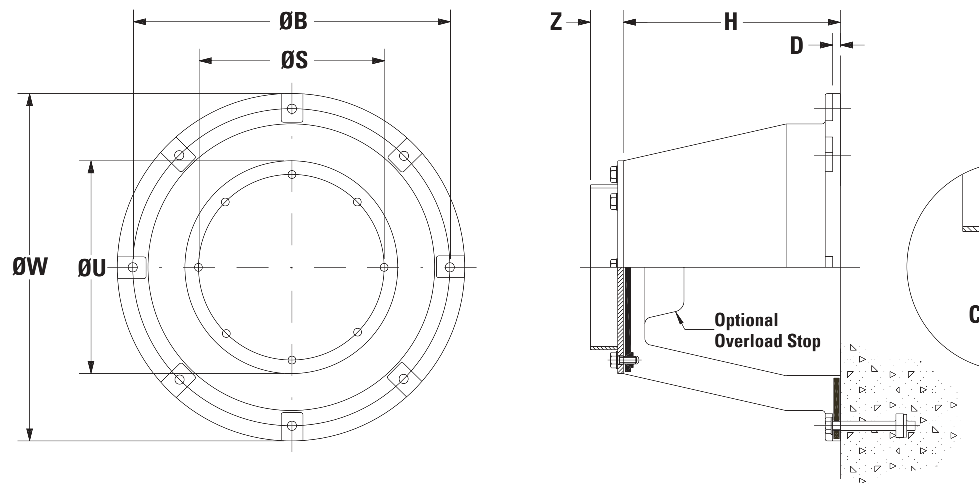
▼ Star Cruise Berth, Langkawi (MALAYSIA)

SUPER CONE FENDER DIMENSIONS

Fender	H	ØW	ØU	C	D	ØB	Anchors	ØS	Head Bolts	Z	Weight (kg)
SCN 300	300	500	295	27~37	15	440	4-M20	255	4-M20	45	31
SCN 350	350	570	330	27~37	15	510	4-M20	275	4-M20	52	40
SCN 400	400	650	390	30~40	20	585	4-M24	340	4-M24	60	74
SCN 500	500	800	490	32~42	25	730	4-M24	425	4-M24	75	144
SCN 550	550	880	540	32~42	25	790	4-M24	470	4-M24	82	195
SCN 600	600	960	590	40~52	30	875	4-M30	515	4-M30	90	240
SCN 700	700	1120	685	40~52	35	1020	4-M30	600	4-M30	105	395
SCN 800	800	1280	785	40~52	35	1165	6-M30	685	6-M30	120	606
SCN 900	900	1440	885	40~52	35	1313	6-M30	770	6-M30	135	841
SCN 1000	1000	1600	980	50~65	35	1460	6-M36	855	6-M36	150	1120
SCN 1050	1050	1680	1030	50~65	40	1530	6-M36	900	6-M36	157	1360
SCN 1100	1100	1760	1080	50~65	40	1605	8-M36	940	8-M36	165	1545
SCN 1200	1200	1920	1175	57~80	40	1750	8-M42	1025	8-M42	180	1970
SCN 1300	1300	2080	1275	65~90	40	1900	8-M48	1100	8-M48	195	2455
SCN 1400	1400	2240	1370	65~90	50	2040	8-M48	1195	8-M48	210	3105
SCN 1600	1600	2560	1570	65~90	60	2335	8-M48	1365	8-M48	240	4645
SCN 1800	1800	2880	1765	75~100	60	2625	10-M56	1540	10-M56	270	6618
SCN 2000	2000	3200	1955	80~105	90	2920	10-M56	1710	10-M56	300	9560

All dimensions in millimetres.

Anchor and head bolt locations are equispaced on the same pitch circle diameter.



Application

Super Cone systems can be used by most vessels on almost any berthing structure including:-

- **Container Terminals**
- **Tanker Berths**
- **RoRo & Cruise Berths**
- **Dolphins & Monopiles**
- **Bulk Terminals**
- **General Cargo Facilities**
- **Parallel Motion Fenders**
- **Fender Walls**
- **Many other applications**

▲ Ferry Terminal, Kiel (GERMANY)

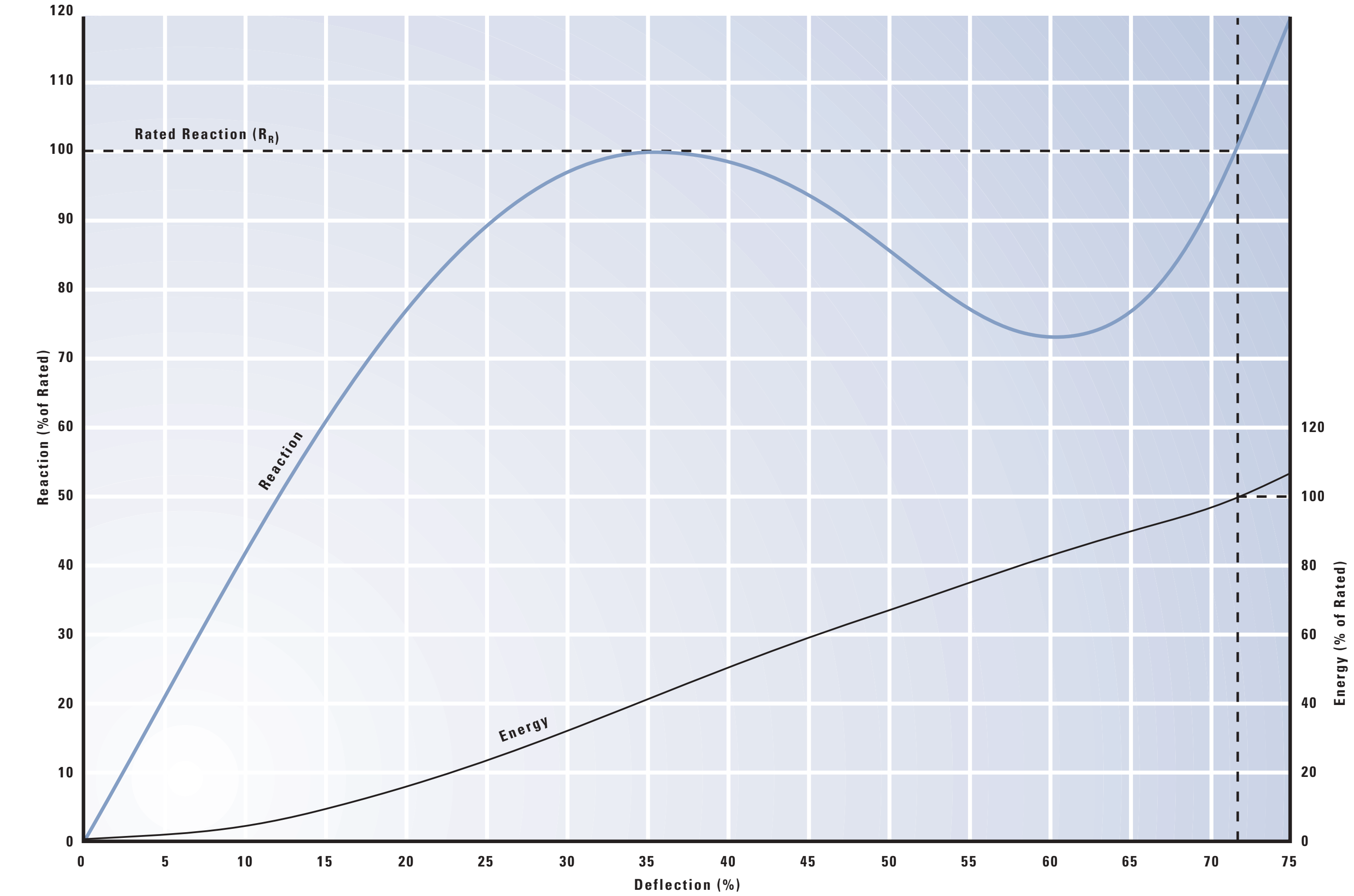
▲ Barry Lock Entrance (WALES)

SUPER CONE FENDERS PERFORMANCE

Energy Index		SCN 300	SCN 350	SCN 400	SCN 500	SCN 550	SCN 600	SCN 700	SCN 800	SCN 900	SCN 1000	SCN 1050	SCN 1100	SCN 1200	SCN 1300	SCN 1400	SCN 1600	SCN 1800	SCN 2000
E0.9	E_R	7.7	12.5	18.6	36.5	49	63	117	171	248	338	392	450	585	743	927	1382	1967	2700
	R_R	59	80	104	164	198	225	320	419	527	653	720	788	941	1103	1278	1670	2115	2610
E1.0	E_R	8.6	13.9	20.7	40.5	54	70	130	190	275	375	435	500	650	825	1030	1535	2185	3000
	R_R	65	89	116	182	220	250	355	465	585	725	800	875	1045	1225	1420	1855	2350	2900
E1.1	E_R	8.9	14.4	21.4	41.9	56	72	134	196	282	385	447	514	668	847	1058	1577	2244	3080
	R_R	67	91	119	187	226	257	365	478	601	745	822	899	1073	1258	1459	1905	2413	2978
E1.2	E_R	9.2	14.8	22.1	43.2	58	74	137	201	289	395	458	527	685	869	1085	1618	2303	3160
	R_R	68	93	122	191	231	263	374	490	617	764	843	923	1101	1291	1497	1955	2476	3056
E1.3	E_R	9.5	15.3	22.8	44.6	59	76	141	207	296	405	470	541	703	891	1113	1660	2362	3240
	R_R	70	96	125	196	237	270	384	503	633	784	865	947	1129	1324	1536	2005	2539	3134
E1.4	E_R	9.8	15.7	23.5	45.9	61	78	144	212	303	415	481	554	720	913	1140	1701	2421	3320
	R_R	72	98	128	200	242	276	393	515	649	803	886	971	1157	1357	1574	2055	2602	3212
E1.5	E_R	10.1	16.2	24.2	47.3	63	80	148	218	310	425	493	568	738	935	1168	1743	2480	3400
	R_R	74	100	131	205	248	283	403	528	665	823	908	995	1185	1390	1613	2105	2665	3290
E1.6	E_R	10.4	16.7	24.8	48.6	65	82	151	223	317	435	504	581	755	957	1195	1784	2539	3480
	R_R	75	102	133	209	253	289	412	540	681	842	929	1019	1213	1423	1651	2155	2728	3368
E1.7	E_R	10.6	17.1	25.5	50.0	67	84	155	229	324	445	516	595	773	979	1223	1826	2598	3560
	R_R	77	104	136	214	259	296	422	553	697	862	951	1043	1241	1456	1690	2205	2791	3446
E1.8	E_R	10.9	17.6	26.2	51.3	68	86	158	234	331	455	527	608	790	1001	1250	1867	2657	3640
	R_R	79	107	139	218	264	302	431	565	713	881	972	1067	1269	1489	1728	2255	2854	3524
E1.9	E_R	11.2	18.0	26.9	52.7	70	88	162	240	338	465	539	622	808	1023	1278	1909	2716	3720
	R_R	80	109	142	223	270	309	441	578	729	901	994	1091	1297	1522	1767	2305	2917	3602
E2.0	E_R	11.5	18.5	27.6	54.0	72	90	165	245	345	475	550	635	825	1045	1305	1950	2775	3800
	R_R	82	111	145	227	275	315	450	590	745	920	1015	1115	1325	1555	1805	2355	2980	3680
E2.1	E_R	11.8	19.0	28.3	55.4	74	93	169	252	355	488	565	652	847	1074	1341	2003	2851	3904
	R_R	84	114	149	233	283	324	462	606	765	945	1042	1145	1361	1597	1853	2418	3060	3778
E2.2	E_R	12.1	19.4	29.0	56.7	76	96	173	258	364	501	580	669	869	1102	1376	2056	2926	4008
	R_R	86	117	153	239	290	332	474	621	785	969	1069	1174	1396	1638	1901	2480	3139	3876
E2.3	E_R	12.4	19.9	29.7	58.1	77	99	177	265	374	514	595	686	891	1131	1412	2109	3002	4112
	R_R	89	120	157	246	298	341	486	637	805	994	1096	1204	1432	1680	1949	2543	3219	3974
E2.4	E_R	12.7	20.3	30.4	59.4	79	102	181	271	383	527	610	703	913	1159	1447	2162	3077	4216
	R_R	91	123	161	252	305	349	498	652	825	1018	1123	1233	1467	1721	1997	2605	3298	4072
E2.5	E_R	13.0	20.8	31.1	60.8	81	105	185	278	393	540	625	720	935	1188	1483	2215	3153	4320
	R_R	93	126	165	258	313	358	510	668	845	1043	1150	1263	1503	1763	2045	2668	3378	4170
E2.6	E_R	13.3	21.3	31.8	62.2	83	108	189	284	402	553	640	737	957	1216	1518	2268	3228	4424
	R_R	95	129	169	264	320	366	522	683	865	1067	1177	1292	1538	1804	2093	2730	3457	4268
E2.7	E_R	13.5	21.7	32.5	63.5	85	111	193	291	412	566	655	754	979	1245	1554	2321	3304	4528
	R_R	97	132	173	270	328	375	534	699	885	1092	1204	1322	1574	1846	2141	2793	3537	4366
E2.8	E_R	13.8	22.2	33.2	64.9	86	114	197	297	421	579	670	771	1001	1273	1589	2374	3379	4632
	R_R	100	135	177	277	335	383	546	714	905	1116	1231	1351	1609	1887	2189	2855	3616	4464
E2.9	E_R	14.1	22.6	33.9	66.2	88	117	201	304	431	592	685	788	1023	1302	1625	2427	3455	4736
	R_R	102	138	181	283	343	392	558	730	925	1141	1258	1381	1645	1929	2237	2918	3696	4562
E3.0	E_R	14.4	23.1	34.6	67.6	90	120	205	310	440	605	700	805	1045	1330	1660	2480	3530	4840
	R_R	104	141	185	289	350	400	570	745	945	1165	1285	1410	1680	1970	2285	2980	3775	4660
E3.1	E_R	15.9	25.4	38.1	74.4	99	132	226	341	484	666	770	886	1150	1463	1826	2728	3883	5324
	R_R	114	155	204	318	385	440	627	820	1040	1282	1414	1551	1848	2167	2514	3278	4153	5126
E/R (ϵ)		0.138	0.163	0.186	0.232	0.256	0.290	0.364	0.414	0.466	0.518	0.544	0.571	0.622	0.674	0.725	0.830	0.932	1.036
		SCN 300	**SCN 350**	**SCN 400**	**SCN 500**	**SCN 550**	**SCN 600**	**SCN 700**	**SCN 800**	**SCN 900**	**SCN 1000**	**SCN 1050**	**SCN 1100**	**SCN 1200**	**SCN 1300**	**SCN 1400**	**SCN 1600**	**SCN 1800**	**SCN 2000**

All Energy Absorption and Reaction Force values are at nominal Rated Deflection of 72%.(see p.88)
Maximum deflection is 75%.
Energies (E_R) are in kNm.
Reactions (R_R) are in kN.
Performance values are for a single Super Cone.
Super Cones are usually used with a steel frontal panel, faced with UHMW-PE pads.
Standard tolerances apply. (see p.89)

GENERIC PERFORMANCE CURVE



INTERMEDIATE DEFLECTION TABLE

D(%)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	**72**	75
E(%)	0	1	4	8	15	22	31	40	50	59	67	75	82	89	96	**100**	106
R(%)	0	19	39	59	75	89	97	100	98	92	84	77	73	77	91	**100**	118

▲ Calculation Example

The graph and table can be used to estimate the fender performance at intermediate deflections as follows:-

EXAMPLE:SCN900(E2.5)

Rated Energy from performance table,
E_R: 393kNm
Rated Reaction from performance table,
R_R: 845kN

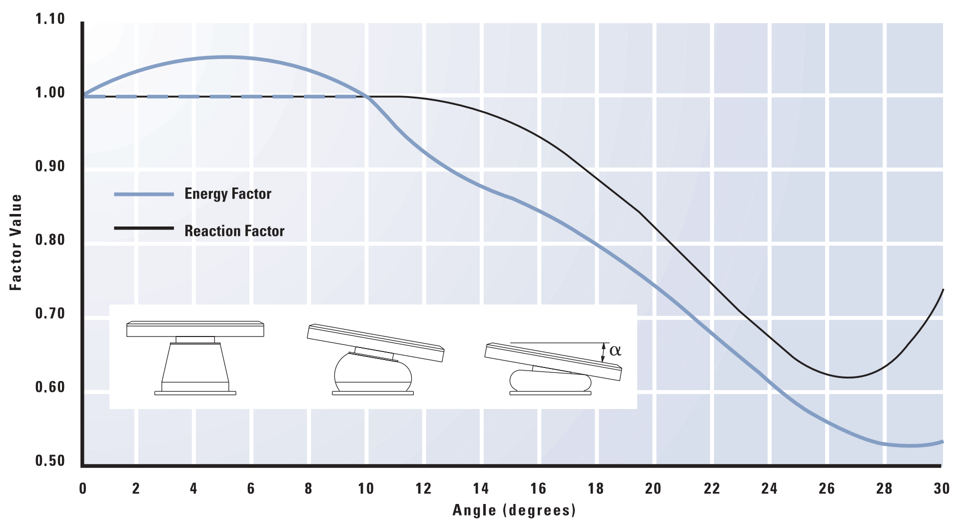
Performance at 45% deflection:

Energy ⟶ E_{45} = 0.59 x 393 = 232kNm
Reaction ⟶ R_{45} = 0.92 x 845 = 777kN

ENERGY & REACTION ANGULAR CORRECTION FACTORS

Angle(°)	0	2	4	6	8	**10**	12	14	16	18	20	22	24	26	28	30
E(%)	100	103	105	105	103	**100**	92	88	84	80	74	67	61	56	53	53
R(%)	100	100	100	100	100	**100**	100	98	94	89	82	74	67	62	63	74

ENERGY & REACTION ANGULAR CORRECTION FACTORS



◀ Calculation Example

The adjacent graph can be used to estimate the fender performance under angular compression (due to bow flares, berthing angles etc) as follows:-

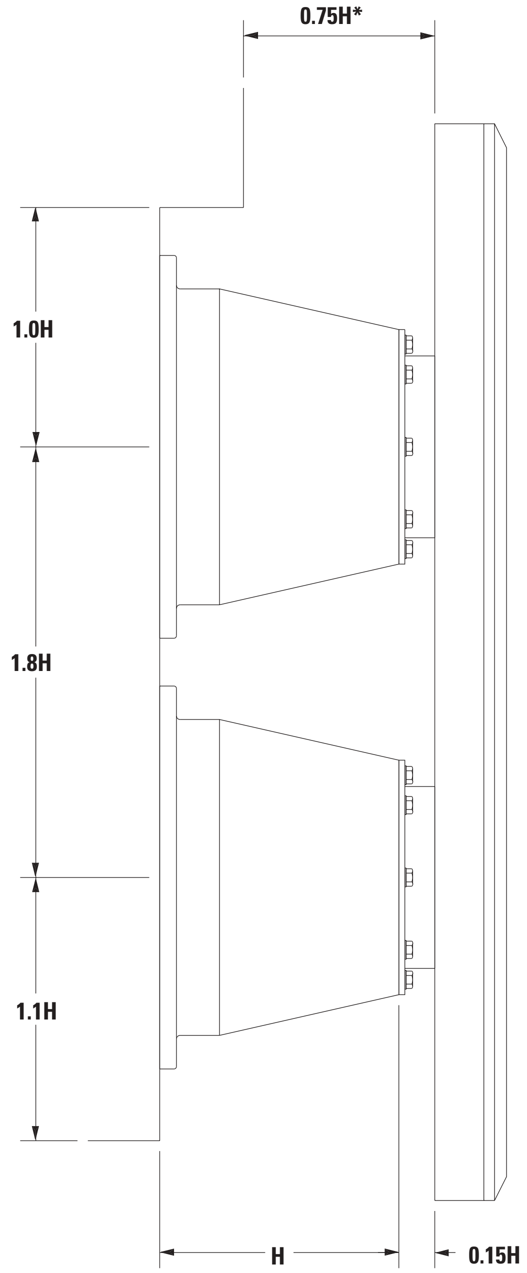
EXAMPLE: SCN1000(E2)

Rated Energy from performance table,
E_R: 475kNm
Rated Reaction from performance table,
R_R: 920kN

Performance at 15°angular compression:

Energy ⟶ E_α = 0.86 x 475 = 409kNm
Reaction ⟶ R_α = 0.96 x 920 = 883kN

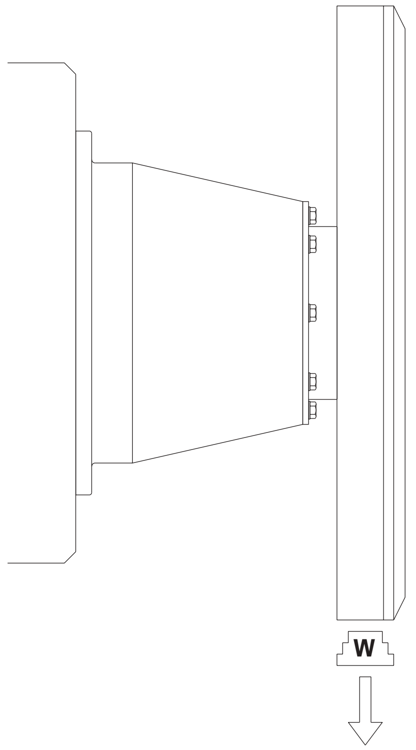
SUPER CONE FENDER CLEARANCES



As the Super Cone is compressed, the body diameter increases. To ensure that the Super Cone does not contact adjacent fenders or structures, adequate clearances must be provided.
The rear of the fender panel must also clear adjacent structures – the indicated value* does not allow for bow flares, berthing angles and other effects which may reduce clearances. Exact panel clearance may vary from project to project.
Appropriate edge distances for anchor bolts are also important for secure fixing of the fender. Minimum edge distance will depend on concrete grade, level of reinforcement and structural loads, though the indicated value is suitable for most cases. Note that fenders can be rotated about their axis to maximise anchor bolt edge distances.

These diagrams are intended as a guide only.
If in doubt, please consult a Fentek office.

SUPER CONE FENDER WEIGHT SUPPORT CAPACITY

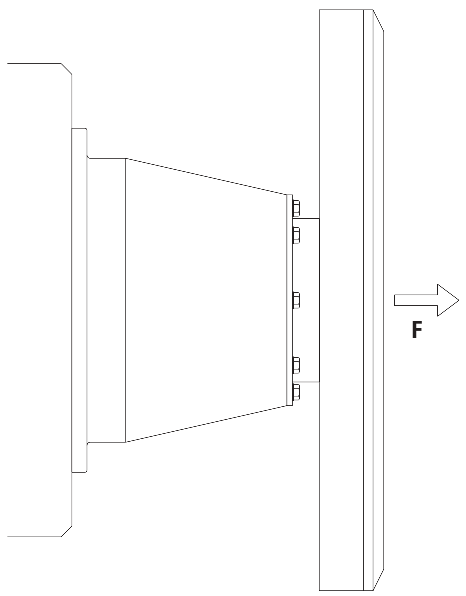


Each Super Cone fender can support a significant weight.
The following table gives a guide to the permissible panel weight before support chains are required.

Energy Index	Permissible Panel Weight (kg)
E1	n x 1.0 x Super Cone weight
E2	n x 1.3 x Super Cone weight
E3	n x 1.5 x Super Cone weight

n = Number of Super Cone fenders
Intermediate Energy Indices may be interpolated.

SUPER CONE FENDERS IN TENSION



Super Cones can cope with axial tension. As a guide, the tensile force should not exceed the rated reaction of the fender. If this is likely then tension chains should be used.

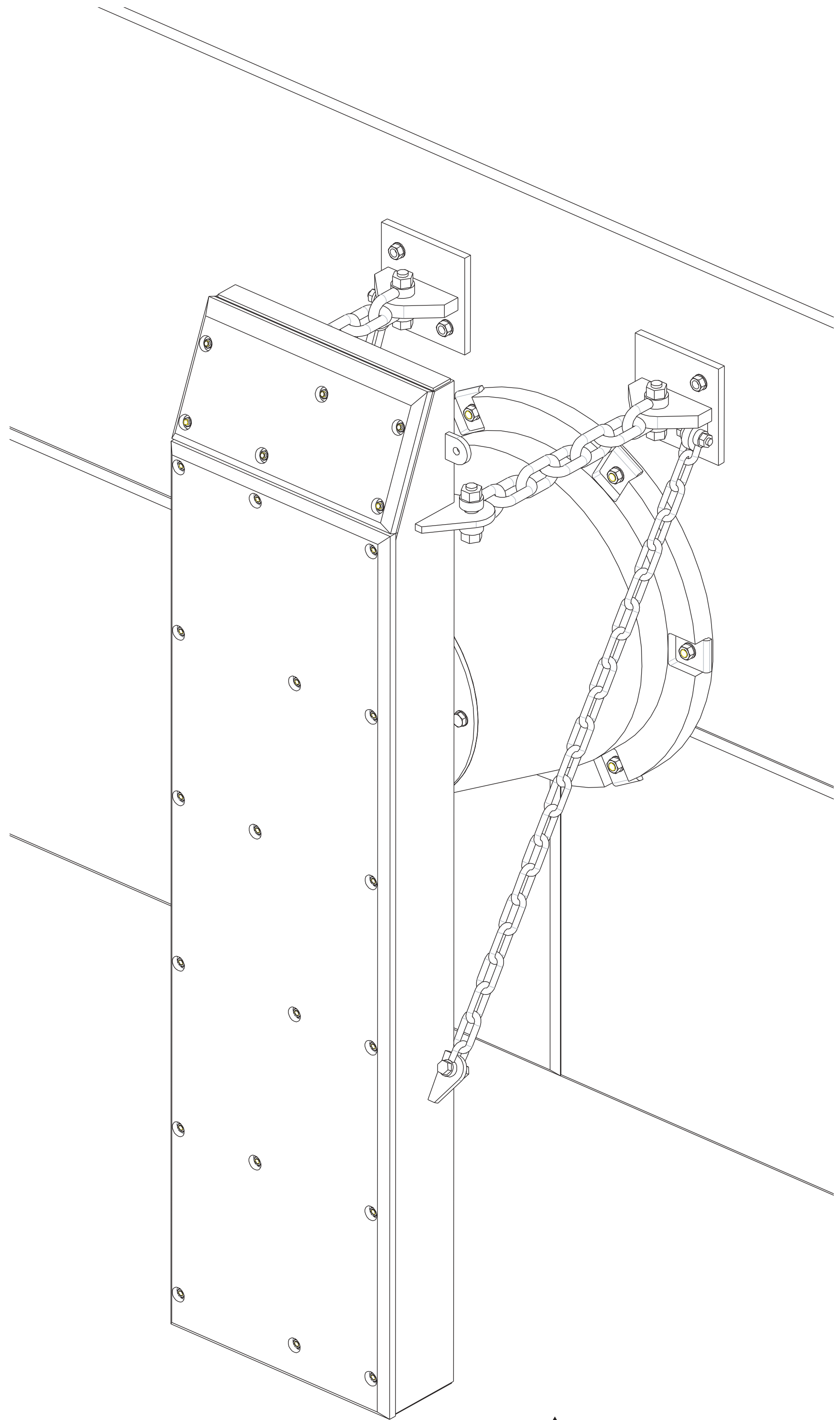
SUPER CONE FENDER INSTALLATION EXAMPLES

▲ **Multipurpose Quay, Rostock (GERMANY)**

▲ **Mukran Fender Wall, Sassnitz (GERMANY)**

▲ **Kelang Container Terminal (MALAYSIA)**

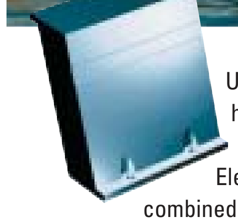
▲ **Canal Bridge Barrier (GERMANY)**



▲ **Typical Super Cone Cantilever fender system with tension and weight chains**

Unit Element Fenders

▲ Qafac Berth (QATAR)



Unit Elements are a high performance, modular system. Elements can be combined in unlimited permutations of length, orientation and Energy Index to suit a wide variety of applications.
The simplest Unit Element system is the UE-V fender which employs pair(s) of elements and a structural UHMW-PE face shield in a choice of black or high visibility colours – all non-marking.
UE-V fenders combine high energy capacity with low friction face and high wear resistance. They make an economic alternative to cylindrical and Arch fenders for a variety of general purpose applications suitable for many ship types including Ferries, General Cargo, Barges etc.
System fenders combine the same Unit Elements with steel frames (fender panels) and UHMW-PE face pads. These systems are widely used for where larger vessels berth – including Container Quays, Tanker Terminals, Bulk Cargo and RoRo berths.
The versatility of Unit Element fenders makes them suitable for almost all applications.

Core Attributes

- **Modular design allows limitless setting out arrangements**
- **Efficiency buckling column profile for high energy and low reaction**
- **Choice of symmetrical and asymmetric bolting arrangements**
- **Excellent shear resistance in lengthwise plane**
- **Thicker section body means lower stresses**
- **Small bolt pockets do not trap water and are easy to access**
- **UE-V fender shields can be bolted from the front using asymmetric elements**
- **Sizes to suit every application**
- **Choice of standard and intermediate compounds**
- **Standard and non-standard lengths available**
- **Easy and quick to install**

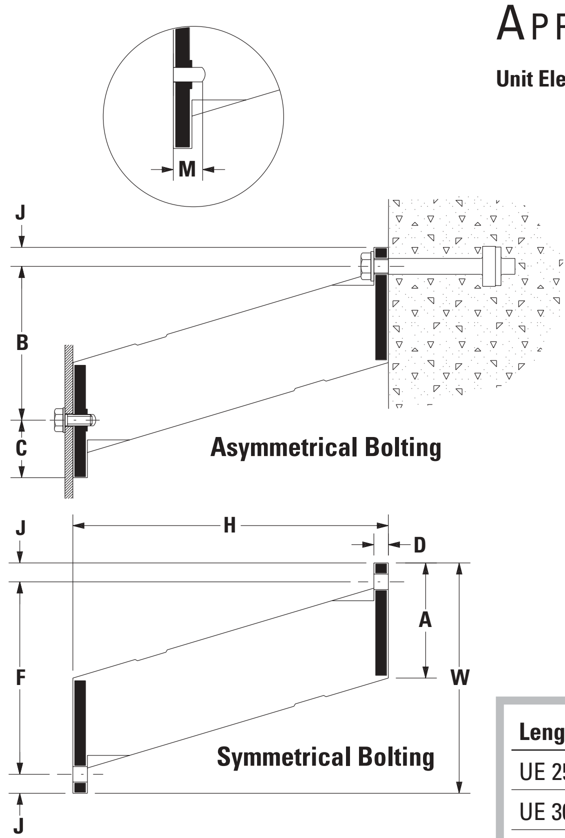
▼ West Lead-In Jetty, Immingham (ENGLAND)

▼ Pinto Wharf Cruise Terminal (MALTA)

Unit Element Fender Dimensions

Fender	H	A	B	C	D	F	J	M	W	K	E	Anchors	Weight (kg/m)
UE 250	250	107	114	69	20	152	31	25~35	214	50	300	M20	30
UE 300	300	130	138	84	25	184	38	30~40	260	50	300	M24	42
UE 400	400	160	183	99	25	244	38	30~40	320	250	500	M24	93
UE 500	500	195	229	119	30	306	42	40~52	390	250	500	M30	130
UE 550	550	210	252	126	32	336	42	40~52	420	250	500	M30	160
UE 600	600	225	275	133	35	366	42	40~52	450	250	500	M30	174
UE 700	700	270	321	163	35	428	56	50~65	540	250	500	M36	258
UE 750	750	285	344	170	38	458	56	50~65	570	250	500	M36	296
UE 800	800	300	366	178	38	486	57	50~65	600	250	500	M36	310
UE 900	900	335	412	198	42	550	60	57~80	670	250	500	M42	400
UE 1000	1000	365	458	212	46	610	60	57~80	730	250	500	M42	476
UE 1200	1200	435	557	252	46	736	61	65~90	870	250	500	M48	653
UE 1400	1400	495	641	282	50	856	67	65~90	990	250	500	M48	955
UE 1600	1600	565	733	321	50	978	76	75~100	1130	250	500	M56	1220

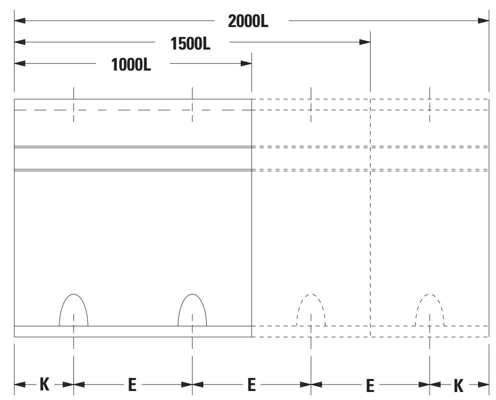
All dimensions in millimetres.



Application

Unit Element designs can be used by most vessels on almost any berthing structure including:-

- **Container Terminals**
- **Tanker Berths**
- **RoRo & Cruise Berths**
- **Dolphins & Monopiles**
- **Bulk Terminals**
- **General Cargo Facilities**
- **Parallel Motion Fenders**
- **Fender Walls**
- **Small Ship Berths**
- **Many other applications**



Designers are not limited to standard Unit Element lengths. Typical non-standard sizes are indicated, although other lengths and special bolting patterns are also available upon request. It is generally preferred to keep element length greater than its height. Please consult Fentek for further guidance.

Lengths	600	750	900	1000	1200	1500	1800	2000
UE 250	◌	●	◌	●	◌	●	◌	●
UE 300	◌	◌	◌	●	◌	●	◌	●
UE 400	x	◌	◌	●	◌	●	◌	●
UE 500	x	◌	◌	●	◌	●	◌	●
UE 550	x	◌	◌	●	◌	●	x	x
UE 600	x	◌	◌	●	◌	●	◌	●
UE 700	x	◌	◌	●	◌	●	◌	●
UE 750	x	◌	◌	●	◌	●	◌	●
UE 800	x	x	◌	●	◌	●	x	x
UE 900	x	x	◌	●	◌	●	x	x
UE 1000	x	x	◌	●	◌	●	x	x
UE 1200	x	x	◌	●	◌	●	x	x
UE 1400	x	x	x	●	◌	●	◌	●
UE 1600	x	x	x	●	◌	●	◌	●

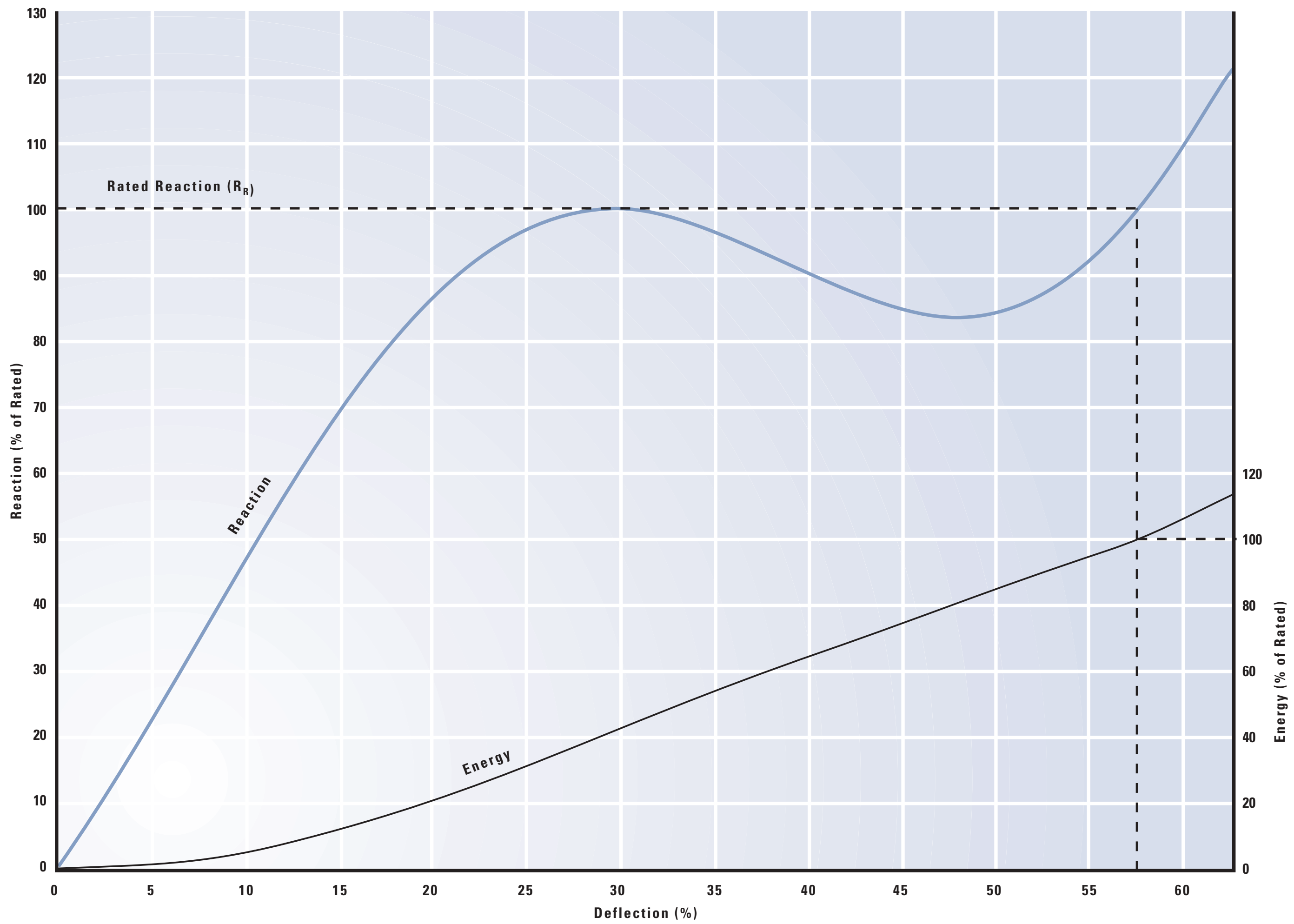
● Preferred Lengths
◌ Common Non-Standard Lengths
x Refer to Fentek

UNIT ELEMENT FENDERS PERFORMANCE

Energy Index		UE 250	UE 300	UE 400	UE 500	UE 550	UE 600	UE 700	UE 750	UE 800	UE 900	UE 1000	UE 1200	UE 1400	UE 1600
E0.9	E_R	8.1	11.7	21	32.4	40	47	63	73	84	106	131	186	257	337
	R_R	79	95	113	142	157	171	199	214	228	256	284	340	398	455
E1.0	E_R	9.0	13.0	23	36.0	44	52	70	81	93	118	146	207	286	374
	R_R	88	105	126	158	174	190	221	238	253	284	316	378	442	506
E1.1	E_R	9.3	13.4	24	37.1	45	54	72	84	96	122	150	213	294	385
	R_R	90	108	130	163	179	196	228	245	261	293	326	389	455	521
E1.2	E_R	9.6	13.8	24	38.2	47	55	74	86	99	125	155	220	303	396
	R_R	93	111	134	167	184	201	234	252	268	301	335	401	469	536
E1.3	E_R	9.9	14.2	25	39.3	48	57	77	89	101	129	159	226	311	407
	R_R	95	114	137	172	190	207	241	259	276	310	345	412	482	552
E1.4	E_R	10.2	14.6	26	40.4	49	58	79	91	104	132	163	232	320	418
	R_R	98	117	141	177	195	212	247	266	283	318	354	424	495	567
E1.5	E_R	10.5	15.0	27	41.5	51	60	81	94	107	136	168	239	328	429
	R_R	100	121	145	182	200	218	254	274	291	327	364	435	509	582
E1.6	E_R	10.8	15.4	27	42.6	52	62	83	96	110	139	172	245	336	440
	R_R	103	124	149	186	205	224	261	281	299	336	373	446	522	597
E1.7	E_R	11.1	15.8	28	43.7	53	63	85	99	113	143	176	251	345	451
	R_R	106	127	153	191	210	229	267	288	306	344	383	458	535	612
E1.8	E_R	11.4	16.2	29	44.8	54	65	88	101	115	146	180	257	353	462
	R_R	108	130	156	196	216	235	274	295	314	353	392	469	548	628
E1.9	E_R	11.7	16.6	29	45.9	56	66	90	104	118	150	185	264	362	473
	R_R	111	133	160	200	221	240	280	302	321	361	402	481	562	643
E2.0	E_R	12.0	17.0	30	47.0	57	68	92	106	121	153	189	270	370	484
	R_R	113	136	164	205	226	246	287	309	329	370	411	492	575	658
E2.1	E_R	12.3	17.5	31	48.5	59	70	95	109	125	158	195	278	381	499
	R_R	117	140	169	211	233	253	296	318	339	381	423	507	592	678
E2.2	E_R	12.6	18.0	32	50.0	61	72	98	112	128	162	200	286	392	513
	R_R	120	144	174	217	240	261	305	328	349	392	436	522	610	697
E2.3	E_R	12.9	18.5	33	51.5	62	74	100	115	132	167	206	294	404	528
	R_R	124	149	179	224	246	268	313	337	358	403	448	537	627	717
E2.4	E_R	13.2	19.0	34	53.0	64	76	103	118	135	171	212	302	415	542
	R_R	127	153	184	230	253	276	322	347	368	414	460	552	644	736
E2.5	E_R	13.5	19.5	35	54.5	66	79	106	122	139	176	218	311	426	557
	R_R	131	157	189	236	260	283	331	356	378	426	473	567	662	756
E2.6	E_R	13.8	20.0	35	56.0	68	81	109	125	143	181	223	319	437	572
	R_R	134	161	194	242	267	290	340	365	388	437	485	582	679	776
E2.7	E_R	14.1	20.5	36	57.5	70	83	112	128	146	185	229	327	448	586
	R_R	138	165	199	248	274	298	349	375	398	448	497	597	696	795
E2.8	E_R	14.4	21.0	37	59.0	71	85	114	131	150	190	235	335	460	601
	R_R	141	170	204	255	280	305	357	384	407	459	509	612	713	815
E2.9	E_R	14.7	21.5	38	60.5	73	87	117	134	153	194	240	343	471	615
	R_R	145	174	209	261	287	313	366	394	417	470	522	627	731	834
E3.0	E_R	15.0	22.0	39	62.0	75	89	120	137	157	199	246	351	482	630
	R_R	148	178	214	267	294	320	375	403	427	481	534	642	748	854
E3.1	E_R	16.5	24.2	43	68.2	83	98	132	151	173	219	271	386	530	693
	R_R	163	196	235	294	323	352	413	443	470	529	587	706	823	939
E/R (ε)		0.103	0.124	0.183	0.230	0.254	0.276	0.319	0.341	0.368	0.414	0.461	0.548	0.645	0.737
		UE 250	UE 300	UE 400	UE 500	UE 550	UE 600	UE 700	UE 750	UE 800	UE 900	UE 1000	UE 1200	UE 1400	UE 1600

All Energy Absorption and Reaction Force values are at nominal Rated Deflection of 57.5%. (see p.88)
Maximum deflection is 62.5%
Energies (E_R) are in kNm.
Reactions (R_R) are in kN.
Performance values are for a single element, 1000mm long.
Unit Elements are usually employed in pairs with either a steel frontal panel or a UHMW-PE face shield.
Standard tolerances apply. (see p.89)

GENERIC PERFORMANCE CURVE



INTERMEDIATE DEFLECTION TABLE

D(%)	0	5	10	15	20	25	30	35	40	45	50	55	**57.5**	62.5
E(%)	0	1	5	12	21	32	43	54	65	75	84	95	**100**	113
R(%)	0	23	47	69	87	97	100	97	90	85	84	92	**100**	121

▲ CALCULATION EXAMPLE

The graph and table can be used to estimate the fender performance at intermediate deflections as follows:-

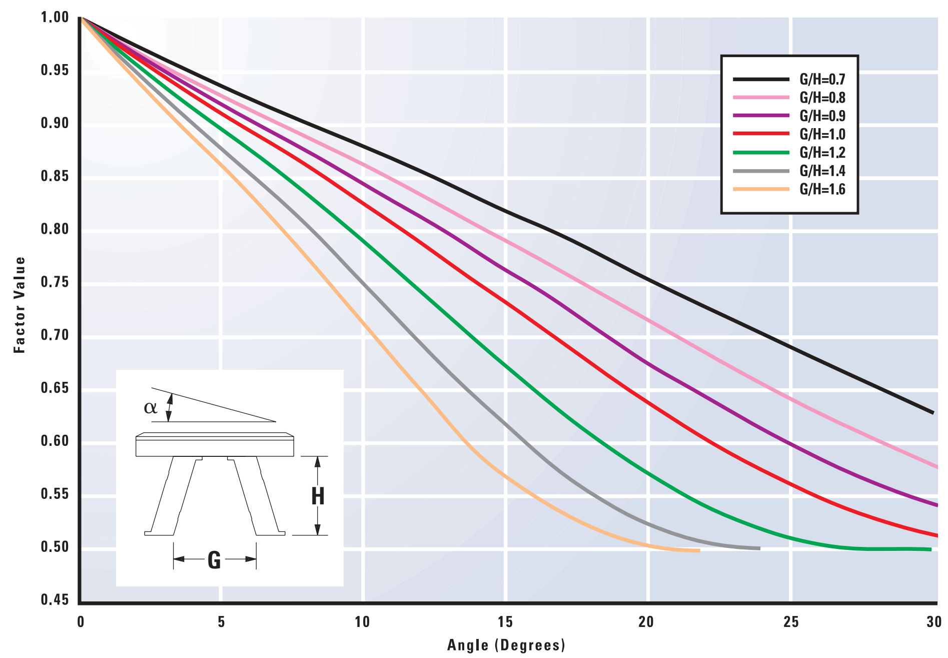
EXAMPLE: UE700x1500(E1.5) – 2 Elements

Rated Energy from performance table,
E_R: 1.5 x 2 x 81kNm = 243kNm
Rated Reaction from performance table,
R_R: 1.5 x 2 x 254kN = 762kN

Performance at 55% deflection:

Energy → E_{55} = 0.95 x 243 = 231kNm
Reaction → R_{55} = 0.92 x 762 = 701kN

ENERGY & REACTION ANGULAR CORRECTION FACTORS



◀ CALCULATION EXAMPLE

The graph can be used to estimate the fender performance under sectionwise angular compression (due to bow flares, berthing angles, ship beltings etc) as follows:-

EXAMPLE: UE1200x1000(E2.3) – 2 Elements

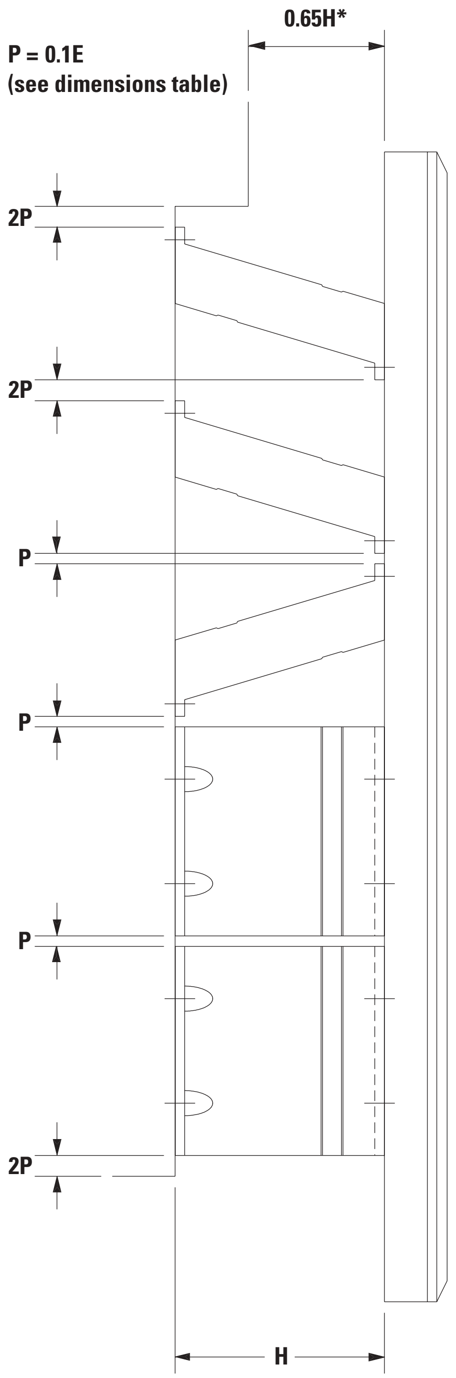
Rated Energy from performance table,
E_R: 1.0 x 2 x 294kNm = 588kNm
Rated Reaction from performance table,
R_R: 1.0 x 2 x 537kN = 1074kN

Performance at 5° angular compression and G/H ratio 0.9:

Energy → $E\alpha$ = 0.92 x 588 = 541kNm

Reaction also reduces under angular compression so worst case reaction occurs at 0° compression angle.

UNIT ELEMENT FENDER CLEARANCES

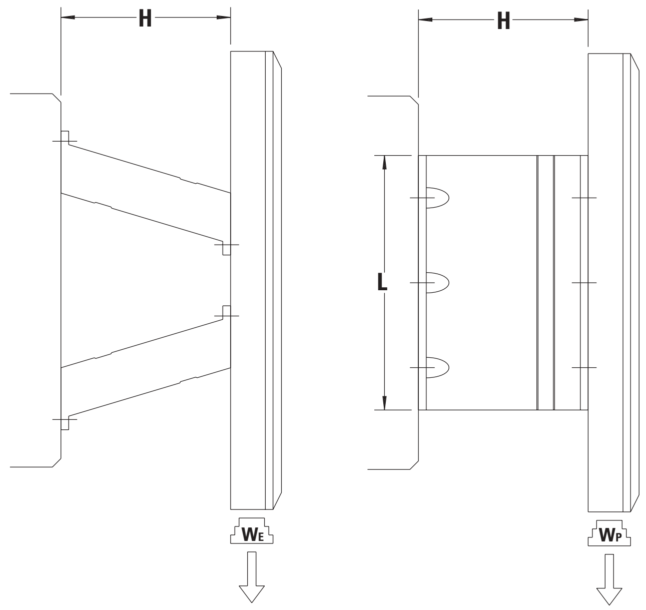


As the Unit Element fender is compressed, its width increases. To ensure that the Unit Element does not contact adjacent fenders or structures, adequate clearances must be provided. The rear of the fender panel must also clear adjacent structures – the indicated value* does not allow for bow flares, berthing angles and other effects which may reduce clearances. Exact panel clearance may vary from project to project.

Appropriate edge distances for anchor bolts are also important for secure fixing of the fender. Minimum edge distance will depend on concrete grade, level of reinforcement and structural loads, though the indicated value is suitable for most cases. Note that fenders can be mounted horizontally or vertically, and the direction of the “V” can be reversed to minimise footprint size and maximise anchor bolt edge distances.

These diagrams are intended as a guide only.
If in doubt, please consult a Fentek office.

UNIT ELEMENT FENDER WEIGHT SUPPORT CAPACITY



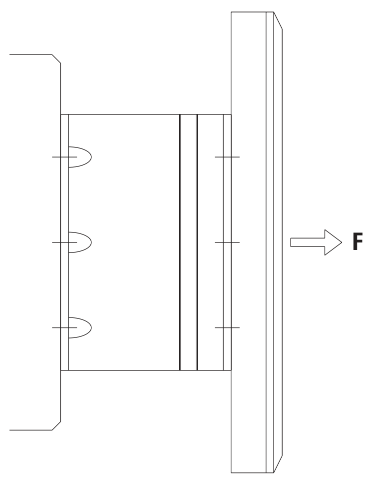
‘V’ on Elevation ‘V’ on Plan

Unit Elements can support a significant weight.
The following table gives a guide to the permissible panel weight before support chains are required, depending on orientation of the elements.

Energy Index	Permissible Panel Weight (kg)	
E1	W_E = n x 690 x H x L	W_P = n x 1230 x H x L
E2	W_E = n x 900 x H x L	W_P = n x 1600 x H x L
E3	W_E = n x 1170 x H x L	W_P = n x 2080 x H x L

Dimensions “H” & “L” are in metres.
“n” is the number of element pairs.
Values are based on a pair of elements.
Intermediate Energy Indices may be interpolated.

UNIT ELEMENT FENDERS IN TENSION



Unit Elements can cope with axial tension. As a guide, the tensile force should not exceed the rated reaction of the fender. If this is likely then tension chains should be used.

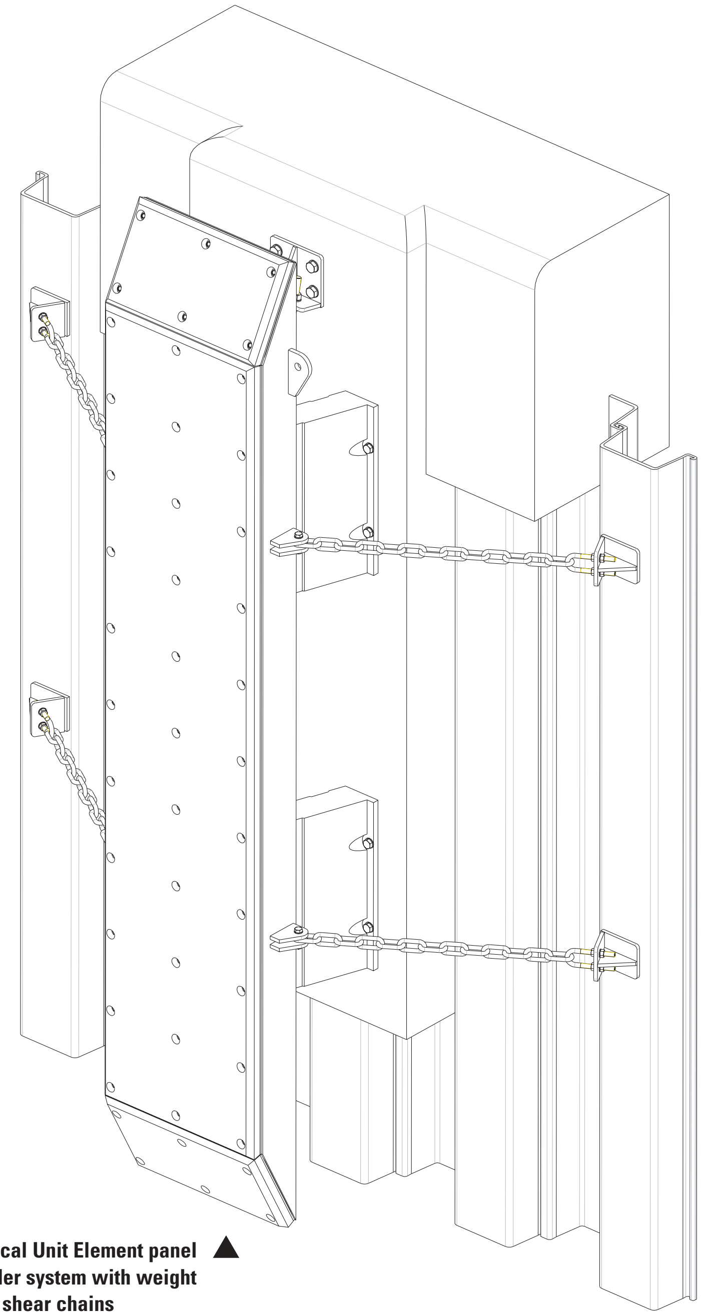
UNIT ELEMENT FENDER INSTALLATION EXAMPLES

▲ Port Said Container Terminal (EGYPT)

▲ 207 Berth, Southampton Container Terminal (ENGLAND)

▲ Corner Fender, Marseille (FRANCE)

▲ Hydrolift Dry Dock, Setubal (PORTUGAL)

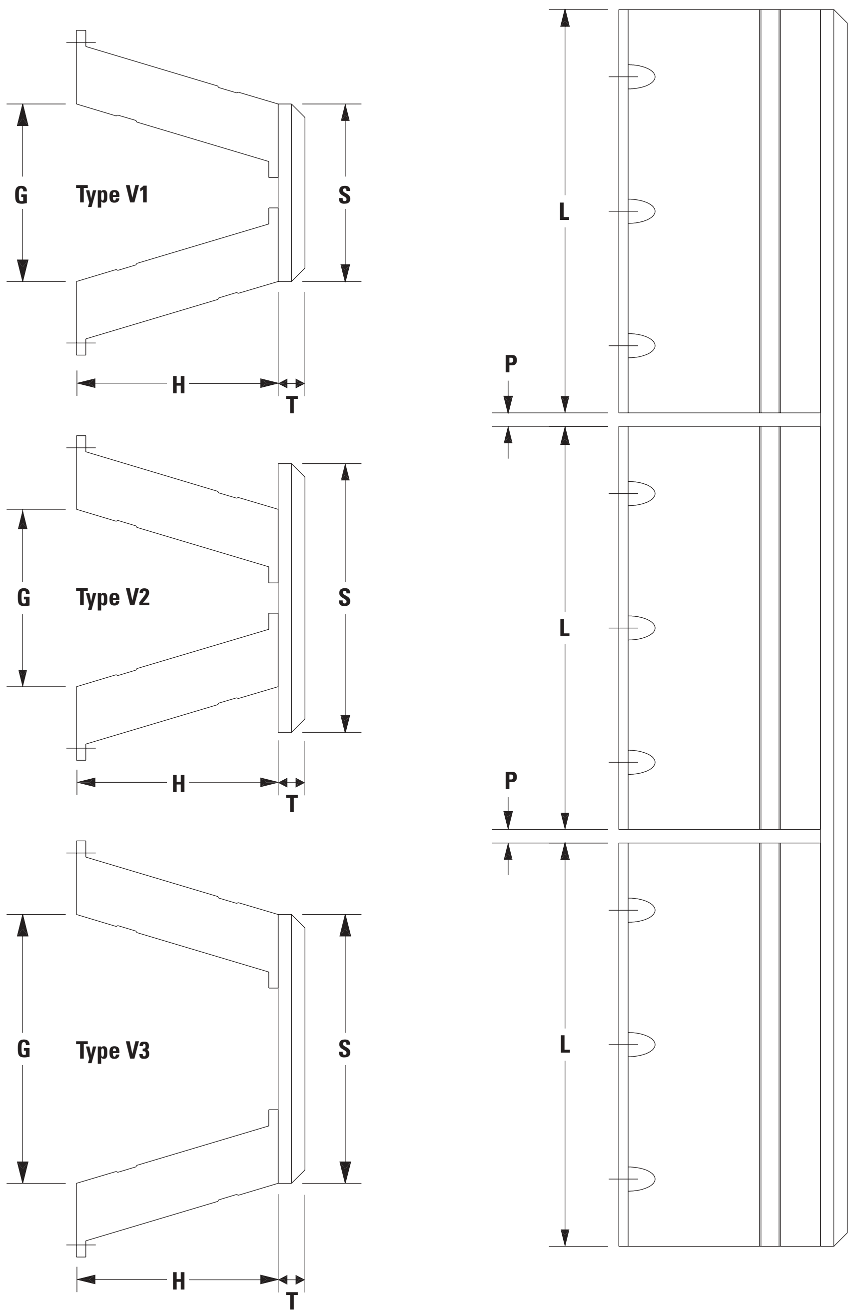


Typical Unit Element panel fender system with weight and shear chains ▲

UNIT ELEMENT V-FENDERS

Unit Element V-fenders (UE-V) consist of pairs of elements with a UHMW-PE shield to make a simple but highly versatile design.
The shield width can be increased and reduced, element spacing may be adjusted to suit each application. By combining several pairs of elements with a continuous shield, UE-V fenders in excess of 6000mm long can be constructed. Please consult Fentek for advice on UE-V fenders 900mm high and above.

▲ Jebel Ali (DUBAI)



UE-V FENDER TYPICAL DIMENSIONS

Fender UE-V Fender	H	Type V1 S	Type V1 G	Type V2 S	Type V2 G	Type V3 S	Type V3 G	P	T	Anchors
UE 250	250	250	250	460	250	460	460	30	70	M20
UE 300	300	290	290	550	290	550	550	30	70	M24
UE 400	400	370	370	690	370	690	690	50	80	M24
UE 500	500	440	440	830	440	830	830	50	90	M30
UE 550	550	470	470	890	470	890	890	50	90	M30
UE 600	600	500	500	950	500	950	950	50	90	M30
UE 700	700	590	590	1130	590	1130	1130	50	100	M36
UE 750	750	620	620	1190	620	1190	1190	50	100	M36
UE 800	800	640	640	1230	640	1230	1230	50	100	M36

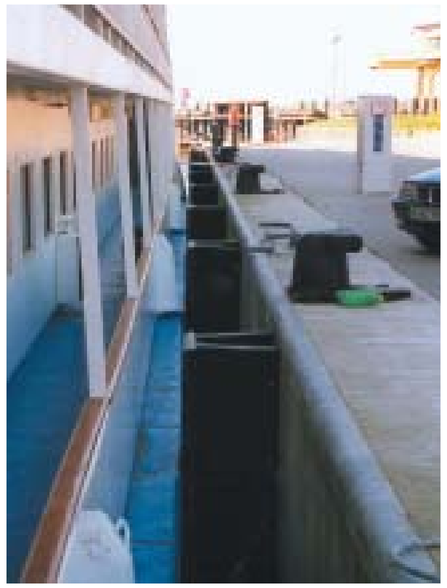
All dimensions in millimetres.
Many other shield widths and element spacings are possible with UE-V fenders.

UNIT ELEMENT V-FENDERS

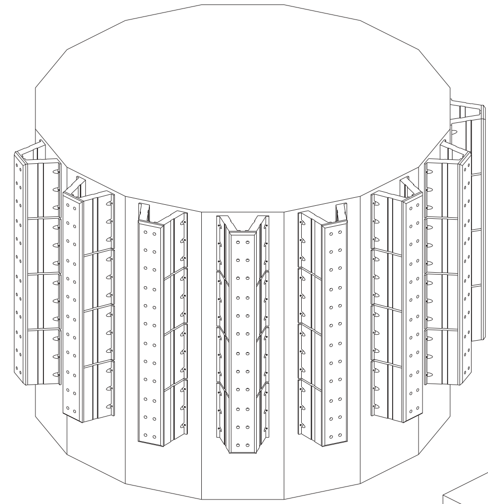
▲ Jebel Ali, Dubai (UAE)

▲ Type V2 UE-V fender

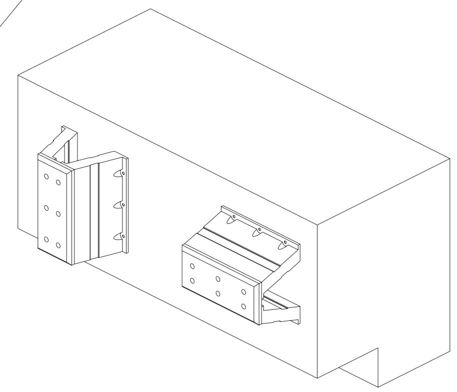
▲ UE-V fender pontoon pile guide



▲ Passenger Quay, Mukran (GERMANY)



◀ UE-V Fenders on circular turning dolphin



▼ UE-V Fenders mounted vertically or horizontally on linear quay face

UE-V FENDERS PERFORMANCE

Fender UE-V Fender	E1 R	E1 E	E2 R	E2 E	E3 R	E3 E
UE 250	158	18	206	24	266	30
UE 300	190	26	246	34	320	44
UE 400	252	46	328	60	428	78
UE 500	316	72	410	94	534	124
UE 550	348	88	452	114	588	150
UE 600	380	104	492	136	640	178
UE 700	442	140	574	184	750	240
UE 750	476	162	618	212	806	274
UE 800	506	186	658	242	854	314

All Energies (E_R) are in kNm and Reactions (R_R) are in kN.
Rated deflection is 57.5%.
UE-V fenders are also available in intermediate Energy Indices.
Performance values are for a single UE-V fender, 1000mm long.
Standard tolerances apply. (see p.89)

Parallel Motion Fenders

▲ HST, Immingham (UK)

Fentek Parallel Motion fender systems are the zenith of modern fender technology. They combine high energy absorption with reaction forces 30~60% lower than conventional designs. Parallel Motion systems use a non-tilt torsion arm mechanism which keeps the frontal panel vertical at all times irrespective of impact level, yet allows the panel to rotate freely to cope with large berthing angles.

Non-tilt technology eliminates undesirable double contacts when belted vessels use the fenders. Forces are evenly spread to reduce contact loads – particularly important with new generations of aluminium hulled fast ferries coming into service.

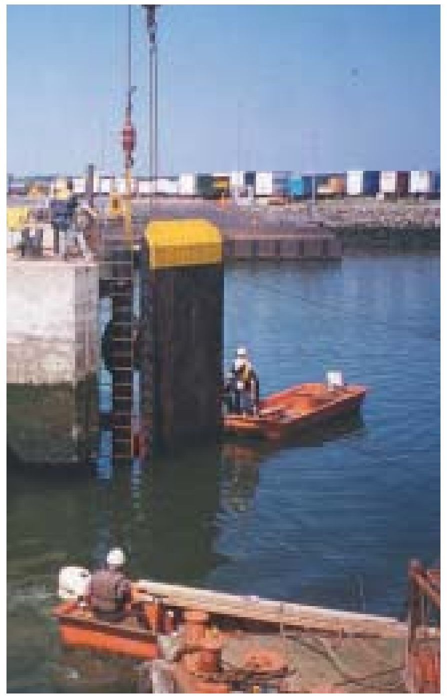
Parallel Motion systems are equally suited to tanker and bulk terminals serving large and small ships. Low freeboard vessels frequently contact below the centreline of fenders, causing conventional designs to tilt and impose line loads at deck level. Parallel Motion fenders always remain vertical to provide low and uniform hull pressures.

Installation is very simple since there are only three bracket connections and supporting chains are eliminated. Even the largest Parallel Motion systems can be fitted within an hour or two.

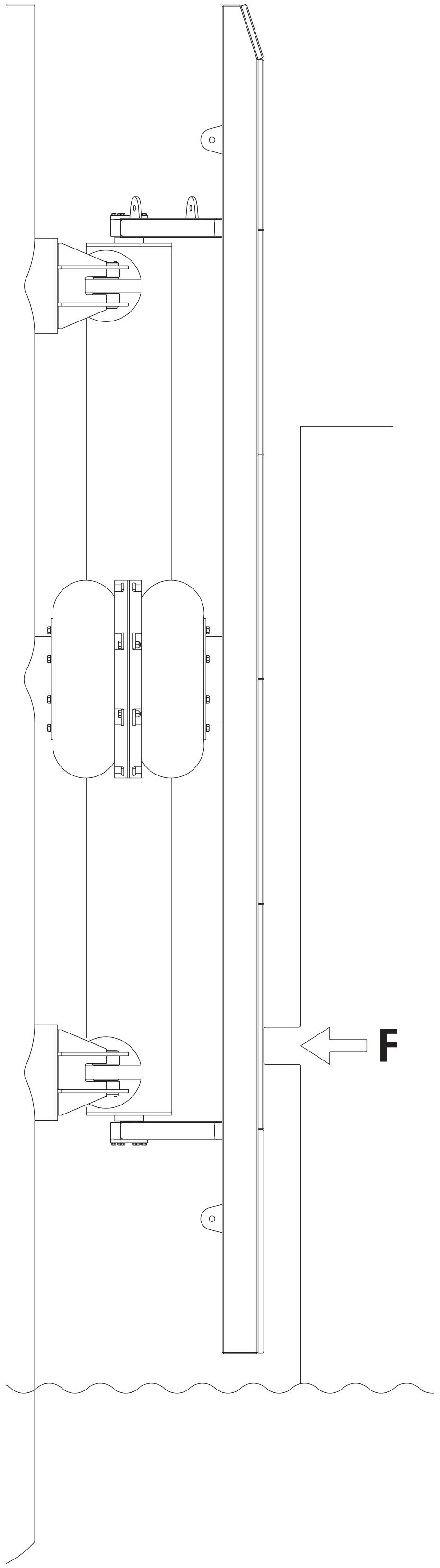
Berths using Parallel Motion systems are more economic to build since less concrete is needed and smaller piles can be used to withstand the reduced berthing forces. Full life costs are less because Parallel Motion systems are virtually maintenance free and do not require periodic adjustment. Best use is made of corrosion resistant stainless steels, whilst self lubricating composite bearing materials eliminate steel-to-steel contact. All bearings are fully sealed to prevent ingress of water and debris. Frontal panels are closed-box construction with advanced paint coatings and low-friction UHMW-PE face pads.

Core Attributes

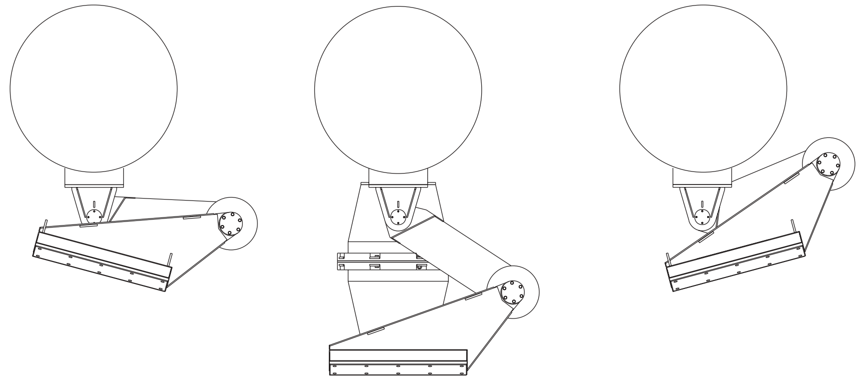
- **Berthing forces 30~60% lower than conventional designs**
- **Reduced constructions costs**
- **Non-tilt technology eliminates double contacts for low belting loads and hull pressures**
- **Can accommodate very large berthing angles without loss of performance**
- **Easy and fast to install**
- **Low maintenance design and materials for reduced full life costs**
- **Integrated or wall mounted torsion arms suit monopile and conventional berth structures**
- **High speed ferries and conventional RoRo ships can share the same facilities**
- **Sealed-for-life bearings on all hinge connections**



Merchant Ferries, Dublin (IRELAND) ▶



Irrespective of impact level, Parallel Motion systems remain vertical. They are ideal for terminals used by low freeboard vessels to ensure uniform hull pressure distributions and also on RoRo berths to eliminate double impacts.



Parallel Motion systems accept large berthing angles without loss of performance.

▲ HSS Berth, Hoek van Holland (NETHERLANDS)

Application

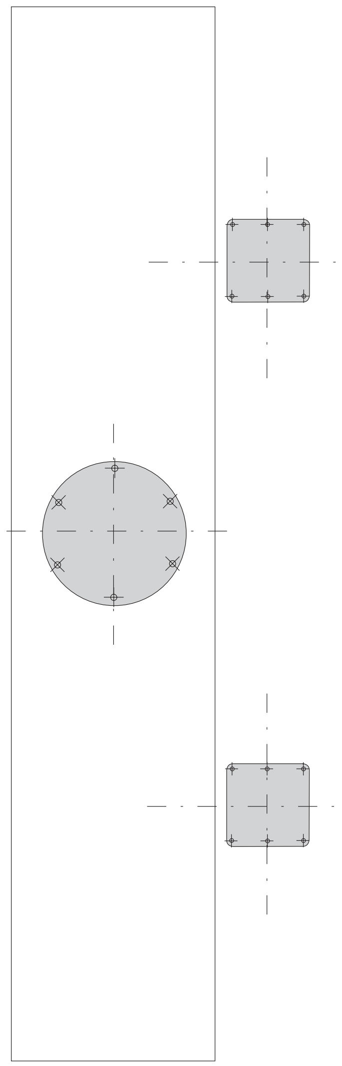
- **Fast ferries and catamaran berths**
- **Conventional RoRo berths**
- **Oil, liquid and bulk terminals**
- **Multi-user facilities**
- **Monopile and elastic dolphin structures**
- **Open pile jetties and wharves**
- **Locations with very large tidal range**
- **Lead-in structures and turning dolphins**

▲ HSS Berth, Hoek van Holland (NETHERLANDS)

SINGLE CONE PMF SYSTEMS – STANDARD SIZES AND PERFORMANCES

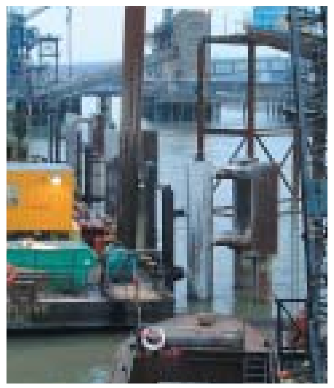
Rated Energy (kNm) Rated Reaction (kN)		Compound Index E2
SCN300	E	11.5
	R	82
SCN350	E	18.5
	R	111
SCN400	E	28
	R	145
SCN500	E	54
	R	227
SCN550	E	72
	R	275
SCN600	E	90
	R	315
SCN700	E	165
	R	450
SCN800	E	245
	R	590
SCN900	E	34
	R	745
SCN1000	E	475
	R	920
SCN1050	E	550
	R	1015
SCN1100	E	635
	R	1115
SCN1200	E	825
	R	1325
SCN1300	E	1045
	R	1555
SCN1400	E	1305
	R	1805
SCN1600	E	1950
	R	2355
SCN1800	E	2775
	R	2980
SCN2000	E	3800
	R	3680

Compound Correction	
E 0.7	0.543
E 0.8	0.621
E 0.9	0.699
E 1.0	0.776
E 1.1	0.799
E 1.2	0.821
E 1.3	0.843
E 1.4	0.866
E 1.5	0.888
E 1.6	0.911
E 1.7	0.933
E 1.8	0.955
E 1.9	0.978
E 2.0	1.000
E 2.1	1.027
E 2.2	1.055
E 2.3	1.082
E 2.4	1.110
E 2.5	1.137
E 2.6	1.164
E 2.7	1.192
E 2.8	1.219
E 2.9	1.247
E 3.0	1.274
E 3.1	1.399



▲ Typical fender footprint

Single cone and Unit Element based Parallel Motion fender systems can reduce structural loads by 30~50%. They are ideal for most ferry applications as well as for tanker terminals and bulk cargo berths where uniform hull pressure at all states of the tide is desirable. These systems are most easily installed onto concrete decks of jetties and dolphins, though can also be installed onto monopiles and jackets.



▲ BICC Cables,Erith (ENGLAND)

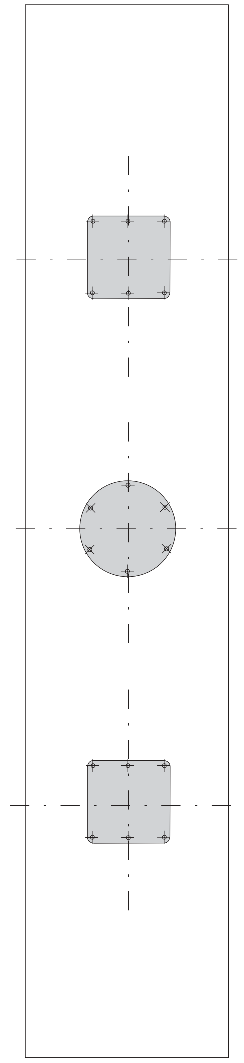
▲ During installation of Dunlaoghaire HSS Berth (IRELAND)

▲ Åaro Faergefart (DENMARK)

TWIN CONE PMF SYSTEMS – STANDARD SIZES AND PERFORMANCES

Rated Energy (kNm) Rated Reaction (kN)		Compound Index E2
SCN300	E	23
	R	82
SCN350	E	37
	R	111
SCN400	E	55
	R	145
SCN500	E	108
	R	227
SCN550	E	144
	R	275
SCN600	E	180
	R	315
SCN700	E	330
	R	450
SCN800	E	490
	R	590
SCN900	E	690
	R	745
SCN1000	E	950
	R	920
SCN1050	E	1100
	R	1015
SCN1100	E	1270
	R	1115
SCN1200	E	1650
	R	1325
SCN1300	E	2090
	R	1555
SCN1400	E	2610
	R	1805
SCN1600	E	3900
	R	2355
SCN1800	E	5550
	R	2980
SCN2000	E	7600
	R	3680

Compound Correction	
E 0.7	0.543
E 0.8	0.621
E 0.9	0.699
E 1.0	0.776
E 1.1	0.799
E 1.2	0.821
E 1.3	0.843
E 1.4	0.866
E 1.5	0.888
E 1.6	0.911
E 1.7	0.933
E 1.8	0.955
E 1.9	0.978
E 2.0	1.000
E 2.1	1.027
E 2.2	1.055
E 2.3	1.082
E 2.4	1.110
E 2.5	1.137
E 2.6	1.164
E 2.7	1.192
E 2.8	1.219
E 2.9	1.247
E 3.0	1.274
E 3.1	1.399



▲ Typical fender footprint

Twin cone Parallel Motion fender systems can reduce structural loads by 40~60%. They are ideally suited to larger displacement ferries as well as latest generations of high speed catamarans and monohulls. These systems are generally installed onto monopiles or jackets which benefit most from the low reaction force.

▲ Mukran (GERMANY)

▲ Harwich (ENGLAND)

▲ HIT, Immingham (ENGLAND)

Arch Fender

▲ Ro-Ro Terminal, Lübeck (GERMANY)

Fentek Arch Fenders have been consistently popular for many years. Their rugged construction, simplicity and versatility suits them to a wide variety of berths and wharves where they will give many years of trouble-free service under even the most adverse of conditions.

The latest AN and ANP series Arch Fenders offer improved efficiency and angular performance, whilst the new anchor layout pattern give better stability and a stronger attachment to the supporting structure even under very heavy impacts. All Arch Fenders share the same single piece construction with encapsulated steel mounting plate vulcanised into the base flanges.

The AN fender has a rubber contact face ideal for all general purpose applications. The higher friction of the rubber surface can be used to good effect to dampen the movements between vessel and wharf in sea swells and similar conditions.

Where friction must be low or when a facing panel is required, the ANP fender is ideal with its encapsulated steel head plate with integral bolting points. The ANP has two fixing arrangements to suit either UHMW-PE low-friction face pads or for attaching to a steel fender panel or pile. A major benefit of the ANP design is strength under static and dynamic shear loads – this allows large panels to be supported without chains.

AN and ANP Arch Fenders are available in many sizes from 150mm to 1000mm high and in lengths of 1000mm to 3000mm (in 500mm increments). Energy Indices E1, E2 and E3 are available as standard. For special or unusual applications, AN and ANP fenders can be made in intermediate compounds, non-standard lengths, with special end profiles and different bolting patterns. Please consult Fentek for further details.

Fentek also makes special Arch fenders for wharf corner protection. For refurbishment programmes, the previous A-H and A-HTP series Arch Fenders are available upon request.

CORE ATTRIBUTES

- **Rugged single piece moulding for long service life**
- **Strong bolting arrangement is easy and quick to install**
- **Choice of AN and ANP designs**
- **Excellent shear resistance means shear chains rarely needed**
- **Good weight support panels generally eliminates weight chains**
- **Large range of sizes, lengths and Energy Indices**
- **Non-standard lengths, Energy Index and profile available**

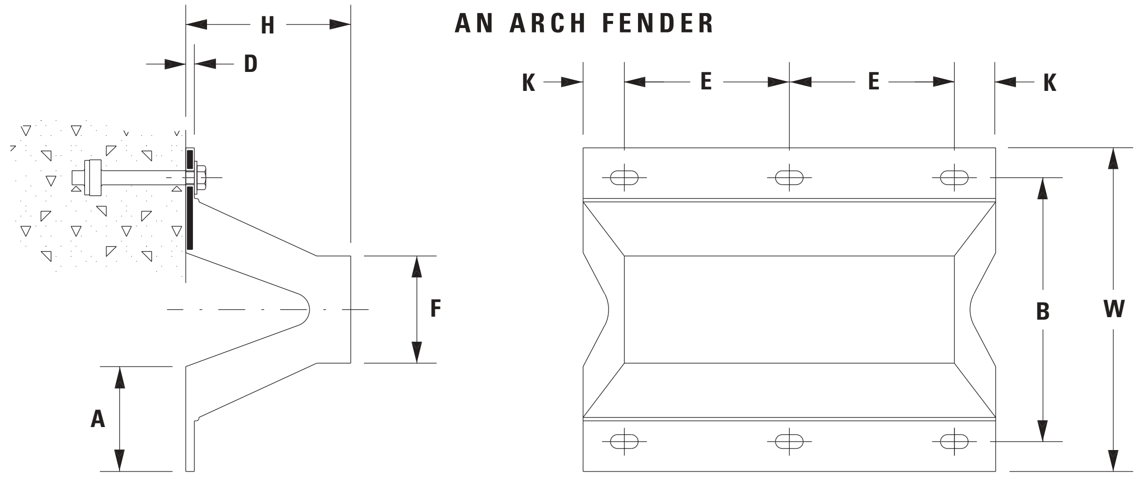
Al Sukhna Tug Haven (EGYPT) ▶

AN & ANP ARCH FENDERS BODY DIMENSIONS

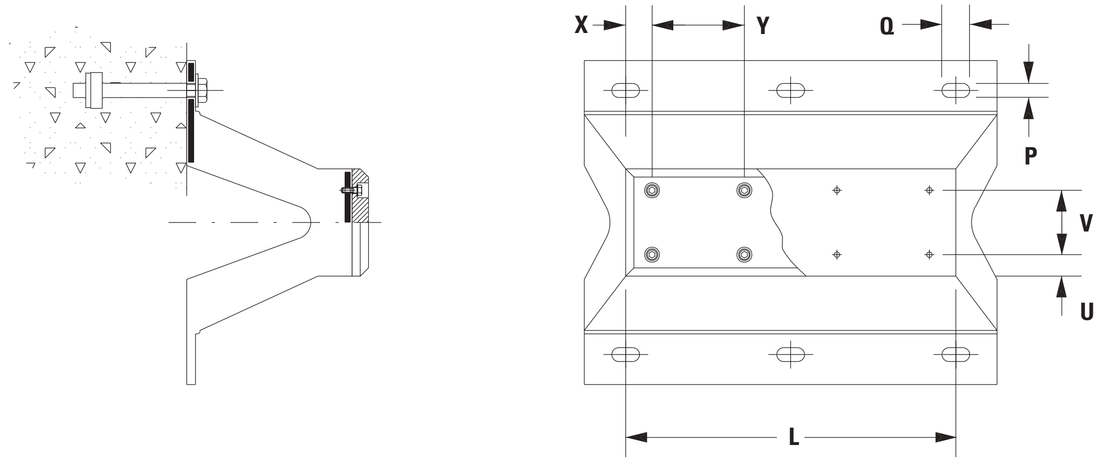
Body Dimensions		H	A	B	W	F	D	K	E	P x Q	Anchors	Weight (kg/m)
AN 150	ANP 150	150	108	240	326	98	16	50	500	20 x 40	M16	28
AN 200	ANP 200	200	142	320	422	130	18	50	500	25 x 50	M20	46
AN 250	ANP 250	250	164	400	500	163	26	62.5	500	28 x 56	M24	68
AN 300	ANP 300	300	194	480	595	195	24	75	500	28 x 56	M24	106
AN 400	ANP 400	400	266	640	808	260	20	100	500	35 x 70	M30	185
AN 500	ANP 500	500	318	800	981	325	26	125	500	42 x 84	M36	278
AN 600	ANP 600	600	373	960	1160	390	28	150	500	48 x 96	M42	411
AN 800	ANP 800	800	499	1300	1550	520	41	200	500	54 x 108	M48	770
AN 1000	ANP 1000	1000	580	1550	1850	650	52	250	500	54 x 108	M48	1298

All dimensions in millimetres.

AN ARCH FENDER



ANP ARCH FENDER



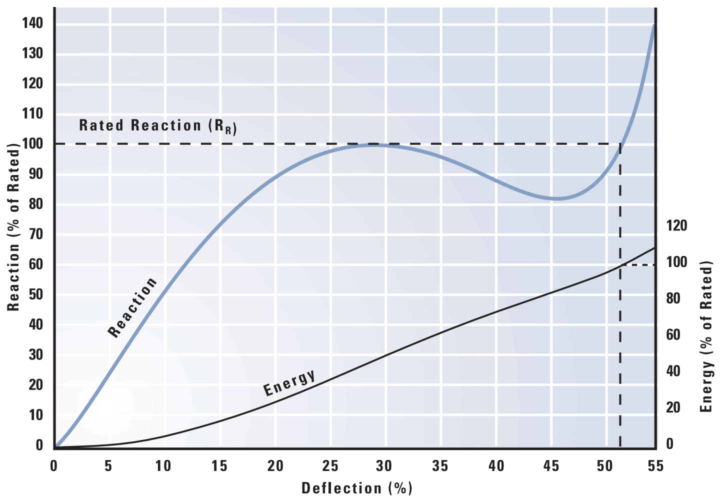
ANP	U	V	UHMW-PE Face Pads X	UHMW-PE Face Pads Y	Steel Frame Connection X	Steel Frame Connection Y
150	49	0	60~70	330~410	70~90	250~300
200	65	0	60~70	330~410	70~90	250~300
250	45	73	70~85	330~410	70~90	250~300
300	50	95	70~85	330~410	70~90	250~300
400	60	140	70~85	330~410	70~90	250~300
500	65	195	70~85	330~410	70~90	250~300
600	65	260	70~85	330~410	70~90	250~300
800	70	380	70~85	330~410	70~90	250~300
1000	80	490	70~85	330~410	70~90	250~300

All dimensions in millimetres.

L	Anchors
1000	6 No
1500	8 No
2000	10 No
2500	12 No
3000	14 No

Non-standard lengths, profiles and bolting patterns available upon request.

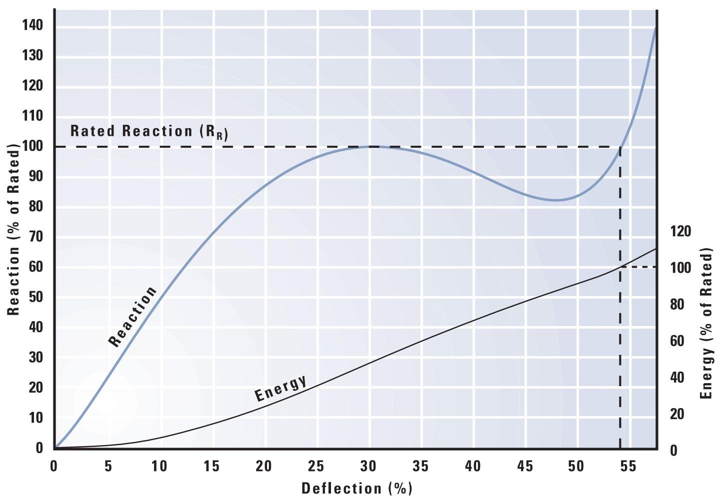
AN GENERIC PERFORMANCE CURVE



AN ARCH FENDER PERFORMANCE							
	E1		E2		E3		
AN	E_R	R_R	E_R	R_R	E_R	R_R	Efficiency Ratio (ϵ)
150	4.3	74	5.6	96	7.4	127	0.058
200	7.6	99	10.0	128	13.1	169	0.078
250	11.9	123	15.6	160	20.5	211	0.097
300	17.1	148	22.5	192	29.5	253	0.117
400	30.5	197	40.0	256	52.5	338	0.155
500	47.6	247	62.4	321	82.0	422	0.194
600	68.6	296	89.9	385	116	507	0.231
800	122	394	160	513	210	675	0.311
1000	191	493	250	641	328	844	0.389

Performance values are for a 1000mm long fender.
Energies (E_R) are in kNm. Reactions (R_R) are in kN.
Nominal Rated Deflection is 51.5%. (see p.88)
Standard tolerances apply. (see p.89)

ANP GENERIC PERFORMANCE CURVE



ANP ARCH FENDER PERFORMANCE							
	E1		E2		E3		
ANP	E_R	R_R	E_R	R_R	E_R	R_R	Efficiency Ratio (ϵ)
150	5.6	89	7.3	115	9.5	150	0.063
200	9.9	118	12.9	154	16.8	200	0.084
250	15.6	148	20.2	192	26.3	250	0.105
300	22.4	178	29.1	231	37.8	300	0.126
400	39.8	237	51.7	308	67.2	400	0.168
500	62.1	296	80.8	385	105.0	500	0.210
600	89.3	355	116.0	462	151	600	0.251
800	159	473	207	615	269	800	0.336
1000	249	592	323	769	420	1000	0.420

Performance values are for a 1000mm long fender.
Energies (E_R) are in kNm. Reactions (R_R) are in kN.
Rated deflection is 54%.
Standard tolerances apply.

▲ Åaro Faergefart (DENMARK)

▲ City Harbour, Rostock (GERMANY)

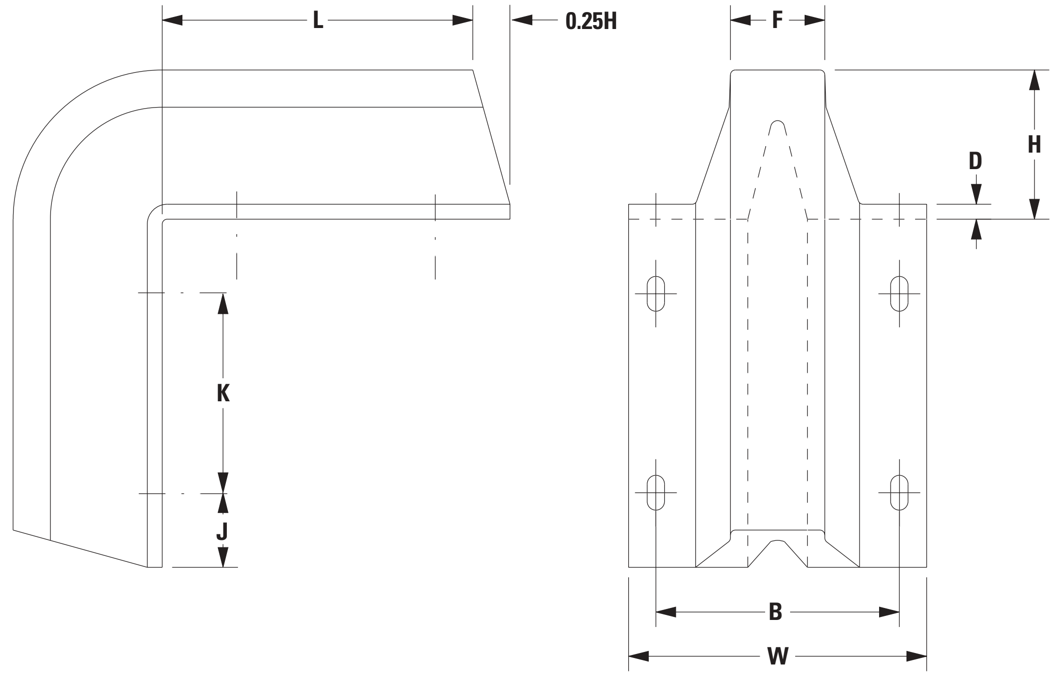
▲ Pier 8, Travemunde (GERMANY)

Arch Fenders, Göteborg (SWEDEN) ▶

CORNER ARCH FENDERS

Berth corners are one of the most difficult areas to protect. Corner Arch fenders provide a simple, easily installed solution to prevent damage from smaller vessels.

Corner Arch fenders work on the same principles as the AN-series Arch fender. They are of moulded, single-piece construction with encapsulated steel flanges which provides a strong connection to the supporting structure.

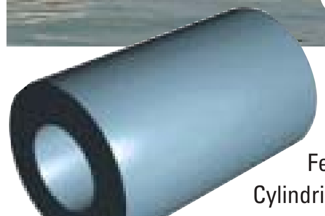


CORNER ARCH FENDER DIMENSIONS										
Model	H	L	W	B	D	F	J	K	Anchors	Weight (kg)
CA 150	150	1000	300	240	25	95	110	690	8 x M20	80
CA 250	250	750	500	410	40	160	130	420	8 x M24	142
CA 300	300	700	600	490	44	190	140	360	8 x M30	208

All dimensions in millimetres.

Cylindrical Fenders

▲ Al Sukhna Container Terminal (EGYPT)



For many years, Fentek Cylindrical Fenders have protected ships and wharves. They are simple to install and operate which makes these units an economical solution for remote locations and for multi user berths where vessel types cannot always be predicted. Their progressive load-deflection characteristics make the same fender suitable for both large and small vessels, and with a wide choice of sizes and diameter ratios, performance can be closely matched to requirements in each case. Cylindrical fenders can be fixed to many types of structure and attached in several different ways – horizontally, vertically or diagonally and can also be adapted to suit wharf corners. The fenders are suspended either by chains, support bars or brackets depending on their size and intended application.
Fentek Cylindrical Fenders are manufactured by two processes; smaller sizes are extruded which allows very long lengths to be produced; larger sizes are mandrel wrapped so that different diameters can be easily produced. Fentek make the world's largest cylindricals up to 2700mm in diameter.

Core Attributes

- **Simple and economical design, easy to install**
- **Choice of mounting systems to suit different structures and applications**
- **Sizes from 100mm to 2700mm diameter in almost any length**
- **Thick fender wall resists abrasion, even after years of heavy use**
- **Progressive load-deflection characteristics**
- **Large track record of installations**

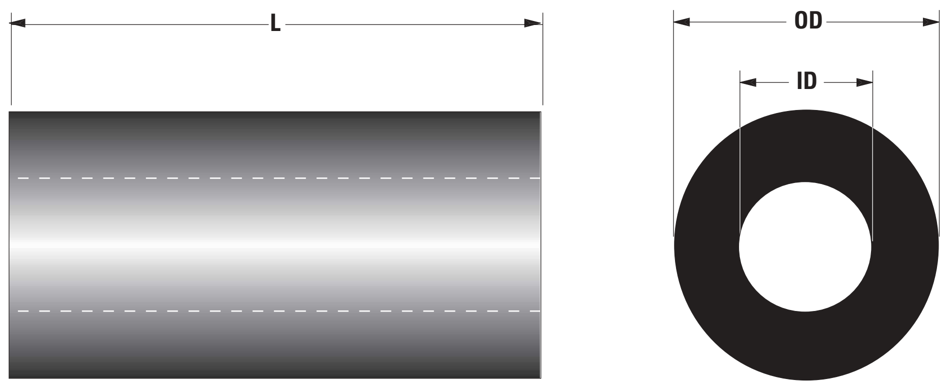
All cylindricals are produced as standard in E3 Energy Index compounds, but softer grades are also available on request. Please speak with your local Fentek office.

▲ Power Station Coal Berth

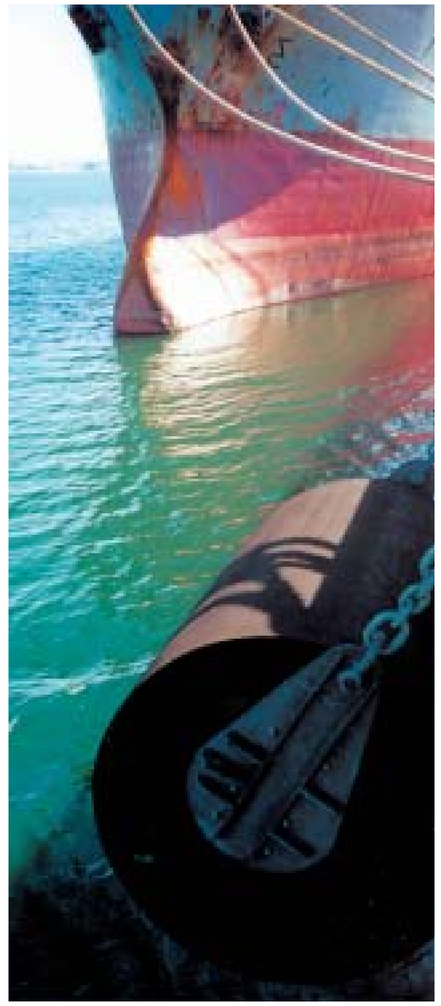
CYLINDRICAL FENDER DIMENSIONS & PERFORMANCE

OD x ID (mm)	OD/ID	R (kN)	E (kNm)	P (kNm²)	∈	Weight (kg/m)	
100 x 50	0.50	43	0.8	547	0.019	7.0	
125 x 65	0.52	51	1.3	500	0.025	10.6	
150 x 75	0.50	65	1.8	552	0.028	15.6	
175 x 75	0.43	92	2.7	781	0.029	23.2	
200 x 90	0.45	98	3.5	693	0.036	29.6	
200 x 100	0.50	86	3.3	547	0.038	27.8	Extruded
250 x 125	0.50	108	5.1	550	0.047	43.4	
300 x 150	0.50	129	7.4	547	0.057	62.6	
380 x 190	0.50	164	11.8	550	0.072	100.4	
400 x 200	0.50	172	13.1	547	0.076	111.2	
450 x 225	0.50	194	16.6	549	0.086	140.8	
500 x 250	0.50	275	28	700	0.102	175	
600 x 300	0.50	330	40	700	0.121	253	
700 x 400	0.57	325	52	517	0.160	309	
750 x 400	0.53	380	61	605	0.161	377	
800 x 400	0.50	440	72	700	0.164	449	
875 x 500	0.57	406	81	517	0.200	482	
925 x 500	0.54	461	93	587	0.202	567	
1000 x 500	0.50	550	112	700	0.204	702	
1050 x 600	0.57	487	117	517	0.240	695	
1100 x 600	0.55	541	131	574	0.242	795	
1200 x 600	0.50	660	162	700	0.245	1010	
1200 x 700	0.58	542	151	493	0.279	889	
1300 x 700	0.54	650	184	591	0.283	1122	
1300 x 750	0.58	595	178	505	0.299	1055	
1400 x 700	0.50	770	220	700	0.286	1375	
1400 x 750	0.54	705	214	598	0.304	1307	Wrapped
1400 x 800	0.57	649	208	516	0.320	1235	
1500 x 750	0.50	825	253	700	0.307	1579	
1500 x 800	0.53	760	246	605	0.324	1506	
1600 x 800	0.50	880	288	700	0.327	1796	
1600 x 900	0.56	757	273	535	0.361	1637	
1650 x 900	0.55	812	295	574	0.363	1789	
1750 x 900	0.51	929	340	657	0.366	2107	
1750 x 1000	0.57	811	325	516	0.401	1929	
1800 x 900	0.50	990	364	700	0.368	2273	
1850 x 1000	0.54	921	372	586	0.404	2266	
2000 x 1000	0.50	1101	450	701	0.409	2806	
2000 x 1200	0.60	871	415	462	0.476	2395	
2100 x 1200	0.57	974	467	517	0.479	2778	
2200 x 1200	0.55	1083	524	575	0.484	3180	
2400 x 1200	0.50	1321	647	701	0.490	4041	

All Energy Absorption (E_R) and Reaction Force (R_R) values are at deflection equal to ID of fender.
Standard tolerances apply.
Performances values are for a 1000mm long fender



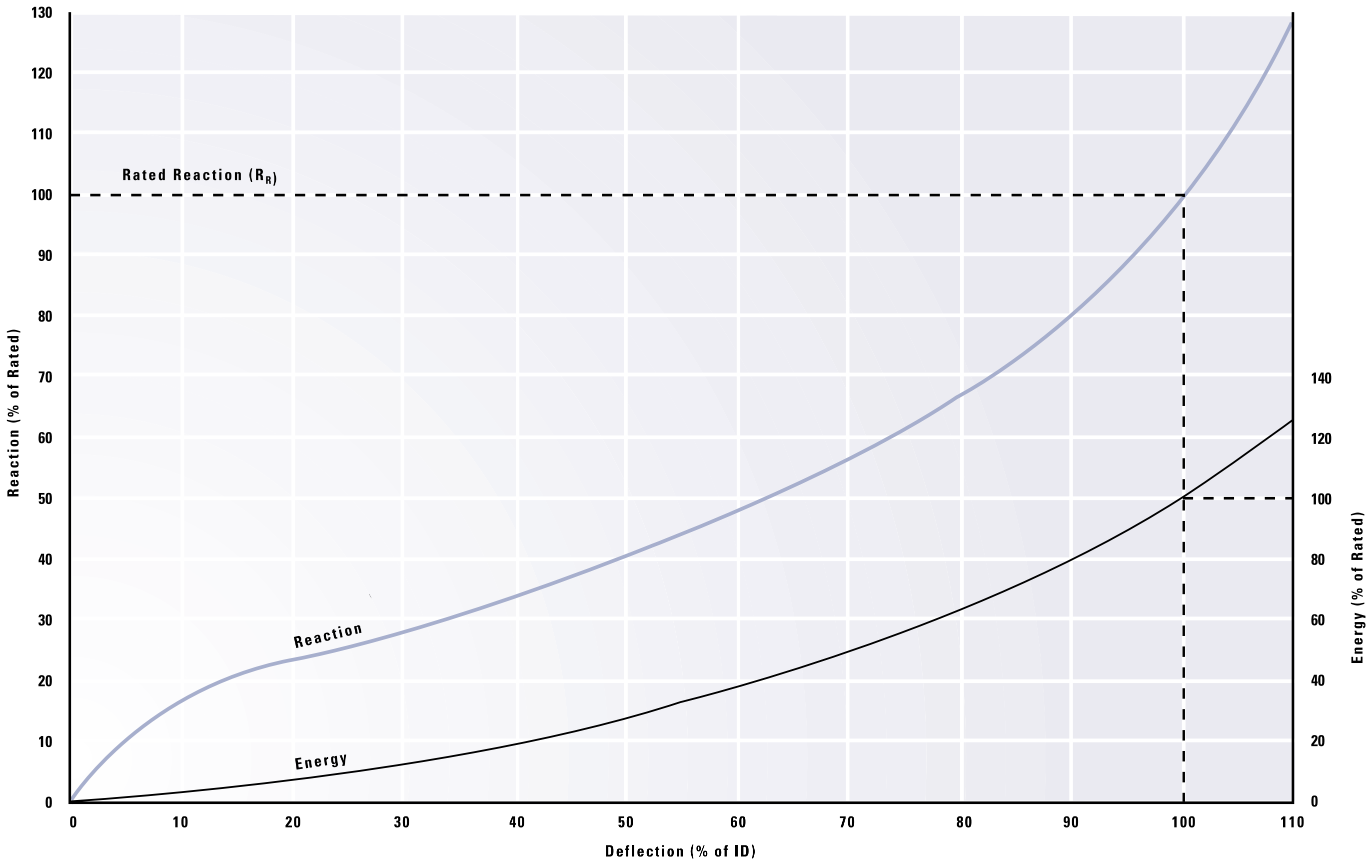
▲ Toulon, (FRANCE)



▲ Durban (SOUTH AFRICA)

CYLINDRICAL FENDERS

GENERIC PERFORMANCE CURVE



SMALL CYLINDRICALS			
OD	ID	Chain	Shackle
100	50	14	16
125	65	14	16
150	75	16	16
175	75	16	16
200	90	18	19
200	100	18	19
250	125	20	22
300	150	24	28
380	190	28	35
400	200	28	35
450	225	28	35
500	250	32	38
600	300	35	44

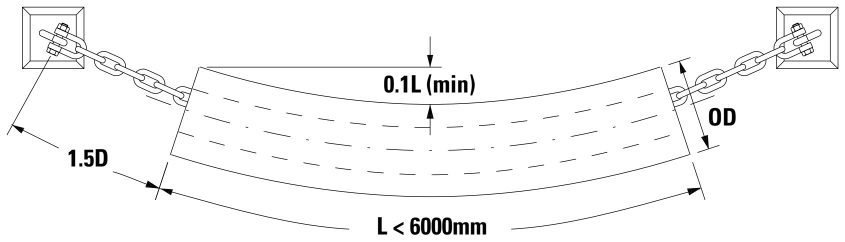
SMALL CYLINDRICALS

Small cylindrical fenders, typically up to 600mm OD, are suspended with chains through their bore connected to brackets or U-anchors each end. With small tidal ranges, the fenders are usually mounted horizontally. In larger tidal ranges small cylindricals can be diagonally slung. Typical chain and shackle sizes are indicated in the table.

LARGE CYLINDRICALS

Large cylindrical fenders up to approximately 1600mm OD are usually suspended using central bars with chain supports at each end connecting back to wall brackets or U-anchors. Typical bar, chain and shackle sizes are indicated in the table. For very heavy duty applications and for fenders above 1600mm OD, ladder bracket mounting systems are recommended – these are specifically designed on a case to case basis. Please ask Fentek for further details.

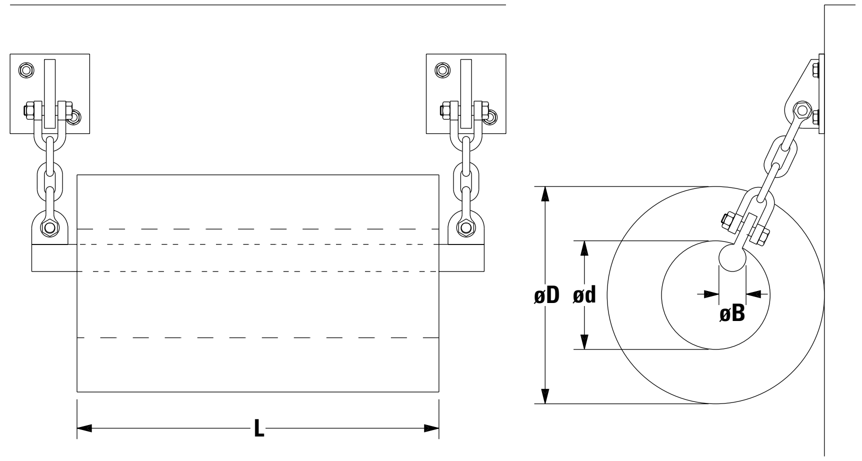
LARGE CYLINDRICALS					
OD	ID	L	øB	Chain	Shackle
800	400	1000	35	24	28
		1500	45	28	35
		2000	55	32	38
		2500	65	34	44
		3000	70	40	50
1000	500	1000	45	28	35
		1500	55	32	38
		2000	65	38	44
		2500	75	40	50
		3000	85	44	50
1200	600	1000	50	28	35
		1500	65	34	44
		2000	75	40	50
		2500	85	44	50
		3000	100	50	56
1400	800	1000	65	38	44
		1500	70	38	44
		2000	80	44	50
		2500	90	48	56
		3000	100	52	64
1600	800	1000	75	40	50
		1500	80	40	50
		2000	90	46	50
		2500	110	48	56
		3000	120	54	64



▲ Small cylindrical suspended with chain

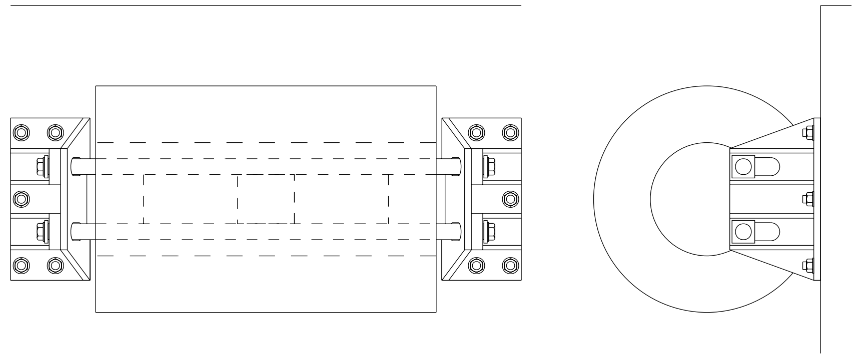
▲ Chain suspension

▲ Bar suspension



▲ Large cylindrical suspended with central bar

▲ Hamburg (GERMANY)



▲ Large cylindrical suspended with ladder brackets

▲ Coal Terminal Dolphins

Pneumatic Fenders

▲ Gozo RoRo Terminal (MALTA)

Fentek Pneumatic Fenders are ideal for permanent and semi-permanent port applications where there is a solid faced quay structure or suitable supporting frame. Since pneumatic fenders are very easy to install, they can quickly be redeployed to wherever they are needed. Pneumatic fenders are also useful as supplementary protection and for special vessels when the permanent fixed fenders may be unsuitable. They are also widely used for ship to ship transfer operations.

Pneumatic fenders are available in a range of diameters and pressure ratings to provide the required energy. The large diameter maintains safe clearances between hulls and structures. Their low reaction and large contact area make them ideal for "soft" vessels such as bulk carriers, tanker and aluminium fast ferries.

The body of the fender gets its strength from the cord reinforced rubber fabric layers. The outer surface has an extra thick layer to protect the body against abrasion whilst the inner layer is of an air impermeable compound. End flanges incorporate the inflation points and, on larger fenders (typically 2500mm diameter and greater) there is also a pressure relief valve.

Sling-type pneumatic fenders are best suited to light and medium duty applications. Optional chain tyre net units are ideal for heavy duty and exposed locations as the net prevents wear directly to the fender body.

Pneumatic fenders are generally moored from brackets on the jetty with chains and swivels. For very high tide locations, Fentek can provide special mooring guide systems which prevent the fenders from drifting off position – please ask Fentek for further details.

Core Attributes

Pneumatic Fenders have many advantages including:-

- **Easy and fast to deploy.**
- **Very low reaction and hull pressure**
- **Performance adjustable by varying initial pressure**
- **Suitable for areas with large or small tides**
- **Maintains large clearances between hull and structure**
- **Optional chain-tyre nets for heavy duty applications**

▲ Setubal Cargo Terminal (PORTUGAL)

PNEUMATIC FENDER PERFORMANCE AND DIMENSIONS

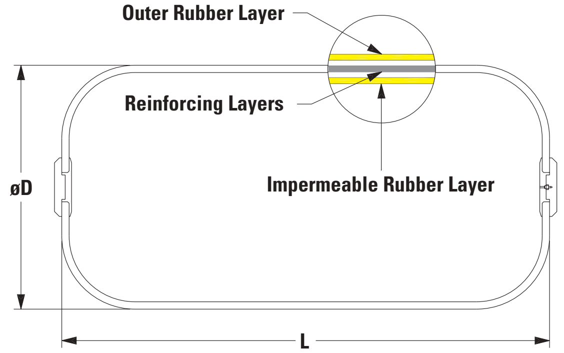
Fender Size øD x L		Hook Type (kg)	CTN Type (kg)	Chain (mm)	Energy (kNm)	0.5kgf/cm² Reaction (kN)	Hull Pressure (kN/m²)	Energy (kNm)	0.8kgf/cm² Reaction (kN)	Hull Pressure (kN/m²)
300 x 500		10	10	10	1.3	22.6	189	1.7	29.4	246
300 x 600		15	15	10	1.5	26.5	180	2.0	35.3	239
500 x 800		25	25	13	5.7	58.9	187	7.4	78.5	249
500 x 1000		35	35	13	7.2	73.6	179	9.1	98.1	239
800 x 1200		75	175	16	21.6	141	188	28.1	187	250
800 x 1500		95	205	16	27.5	186	191	35.1	235	241
1000 x 1500		140	310	16	40.2	222	190	52.7	281	240
1000 x 2000		170	370	16	54.0	295	180	70.2	374	228
1200 x 1800		180	390	19	69.7	320	190	91.0	404	240
1200 x 2000		200	420	19	77.5	354	185	101	449	235
1350 x 2500		270	530	19	125	496	181	175	650	238
1500 x 2500		300	700	22	152	554	186	196	697	234
1500 x 3000		350	790	22	182	658	178	235	837	227
2000 x 3000		550	1430	25	324	883	189	422	1122	240
2000 x 3500		650	1570	29	378	1030	183	491	1315	234
2000 x 6000		950	2170	32	647	1766	171	843	2246	217
2500 x 4000	P	1100	2610	32	675	1481	188	872	1864	236
2500 x 5500	P	1350	2970	35	928	2037	178	1197	2560	224
3000 x 5000	P	1700	4320	38	1226	2207	185	1570	2786	233
3300 x 4500	P	1800	4160	38	1324	2197	194	1712	2764	244
3300 x 6500	P	2250	5370	44	1913	3169	181	2472	3993	228
3300 x 10500	P	2800	6850	51	3090	5121	171	4297	6612	220
4500 x 10500	P	4300	4850	51	4689	5690	144	6563	7465	189

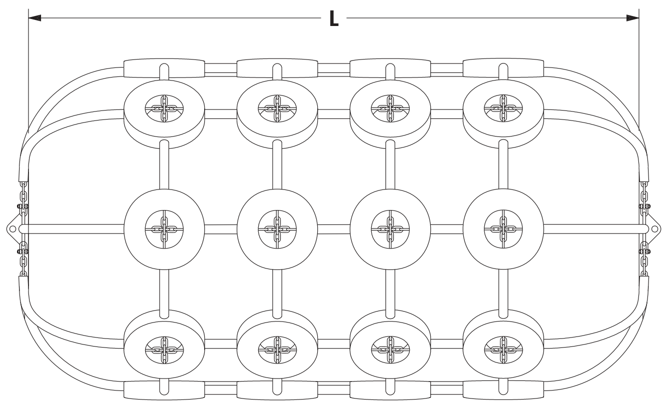
P = Pressure Relief Valve fitted as standard.
Mooring chains should be used in conjunction with appropriate swivels and shackles.
Standard tolerances apply.
Rated deflection is 60%

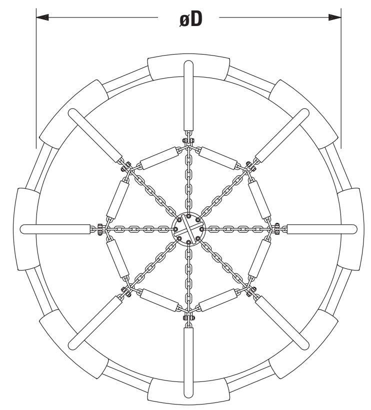
Application

Pneumatic Fenders are suitable for many applications including:-

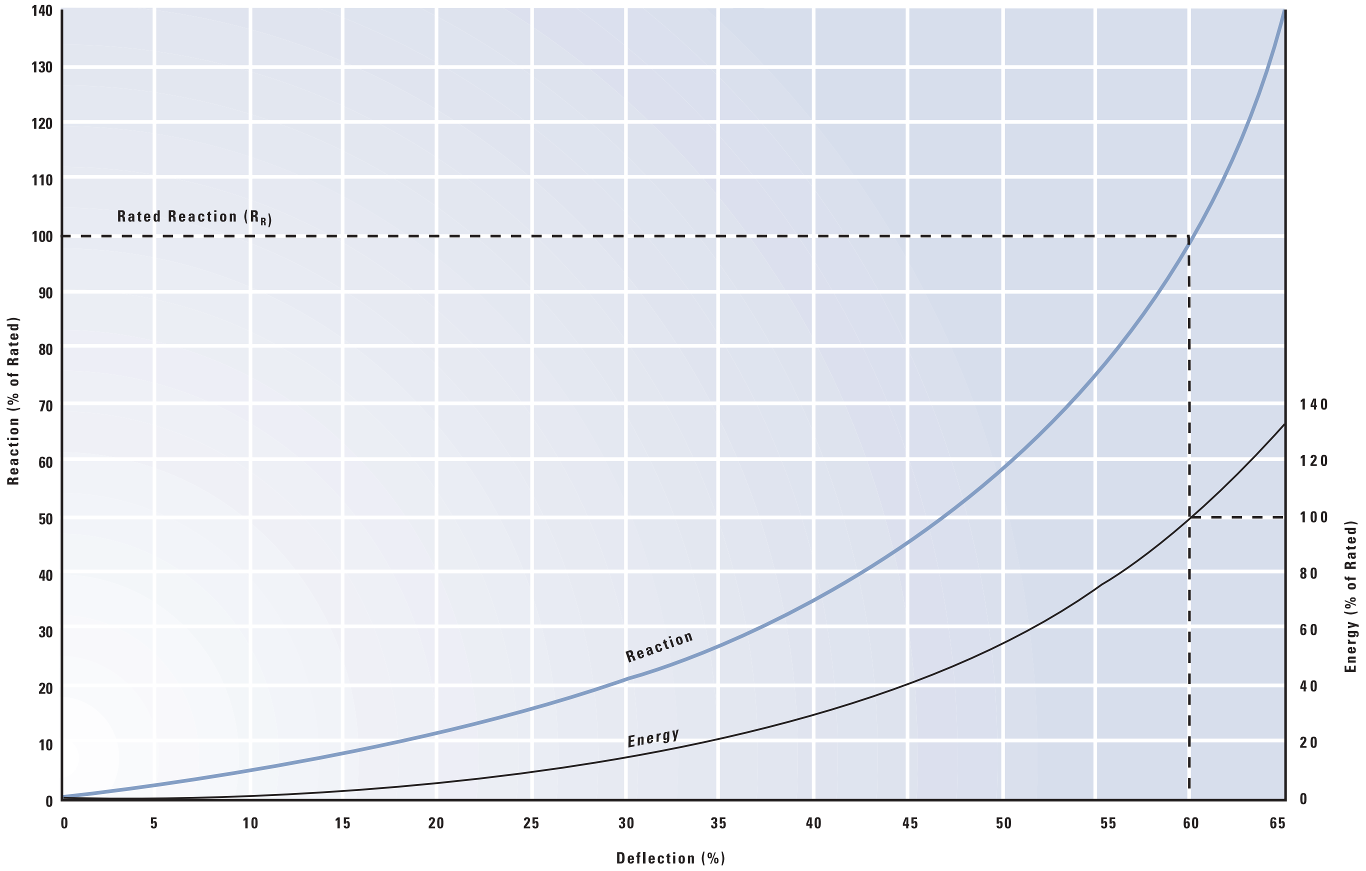
- **Tankers, Gas Carriers and Bulk Cargo Ships**
- **Fast ferries and aluminium hulled vessels**
- **Temporary or permanent installations**
- **Rapid response and emergency fendering**
- **As stand-off fenders to realign ships with shore facilities.**



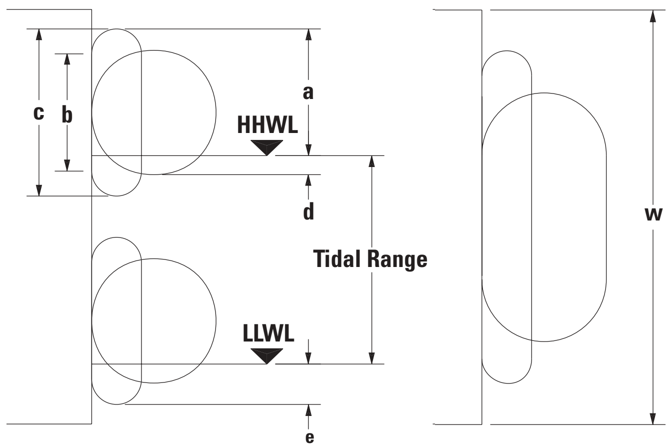




GENERIC PERFORMANCE CURVE



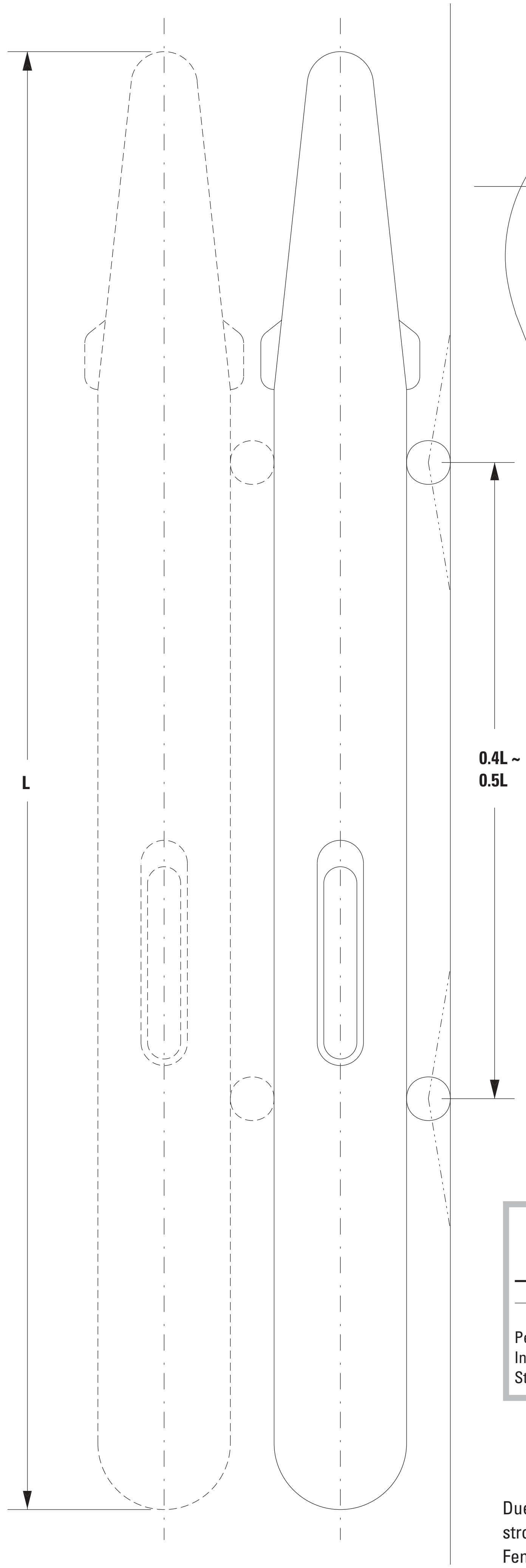
Pneumatic fenders must be installed onto a solid structure or reaction panel. Indicative layout and dimensions are given right and below.

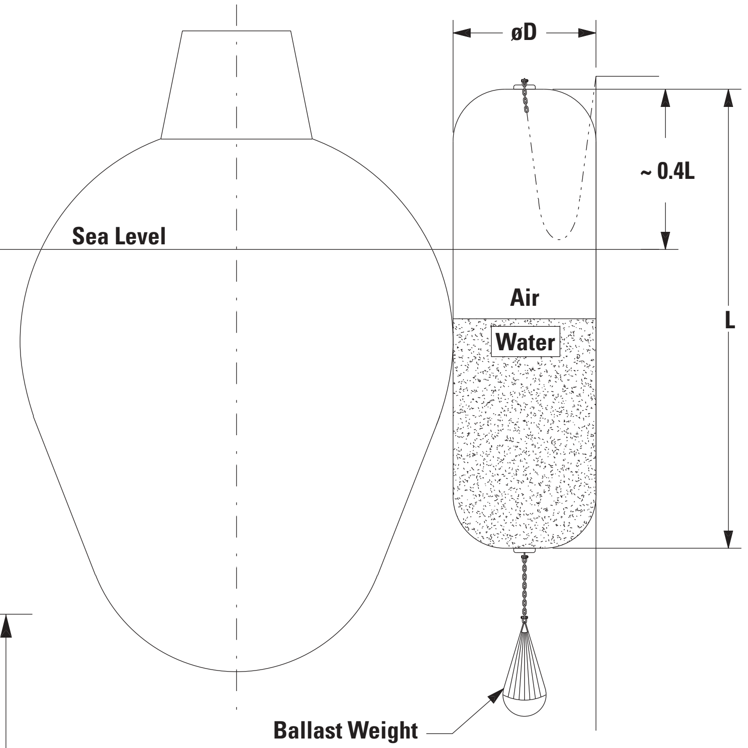


PNEUMATIC FENDER INSTALLATION DIMENSIONS

Fenderø	D (mm)	L (mm)	a (mm)	b (mm)	c (mm)	d (mm)	e (mm)	w (mm)
1000 x 1500	1000	1500	975	950	1350	200	375	2000
1200 x 2000	1200	2000	1200	1140	1620	220	430	2600
1500 x 2500	1500	2500	1525	1420	2050	250	525	3250
2000 x 3500	2000	3500	2050	1900	2700	300	650	4500
2500 x 4000	2500	4000	2490	2380	3380	450	890	5200
3300 x 6500	3300	6500	3380	3140	4460	500	1080	8500

All dimensions are in millimetres.





▲ Typical fender arrangement for submarine.

◀ Hydro-pneumatic fenders can also be used for vessel-to-vessel applications.

HYDRO-PNEUMATIC FENDERS

Fentek Hydro-pneumatic fenders are intended for vessels where the main point of contact is below the water, such as submarines and semi-submersible oil platforms. Hydro-pneumatic fenders are partially water filled and then pressurised with air. This makes them deep draft, stable and very soft for delicate hulls.

A ballast weight is suspended from the fender and this can be used to vary the fender level to suit different classes of vessel. Fender performance can also be carried to some extent by altering the water:air ratio and by the initial inflation pressure.

HYDROPNEUMATIC FENDERS

øD (mm)	L (mm)	Water:Air (Ratio)	Defn (mm)	R (kN)	E (kNm)
1700	7200	60:40	920	660	163
3300	10500	55:45	1750	1275	589

Performance may vary for different hull shapes and radii.
Initial air pressure 0.5kg/cm².
Standard draft is 0.6~0.65L, but may be adjusted by varying the ballast weight.

Due to the very specialist applications of Hydro-pneumatic fenders, it is strongly advised that a detailed study be carried out for each case. Fentek will be pleased to assist with this.

Foam Fenders

▲ Woltmannkaje, Cuxhaven (GERMANY)

Foam fenders are unsinkable with their thermo-laminated, closed cell polyethylene foam core. They have a tough outer skin of reinforced polyurethane elastomer which is available in black and a variety of colours including Orange and Navy Grey.

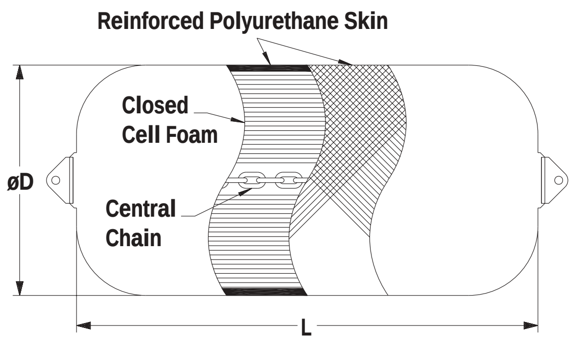
Two types of foam fender are available, depending on the severity of operating conditions; Hook type with a chain tension member through the centre of the fender and pad eyes each end, and chain-tyre net (CTN) type for the heavy duty applications.

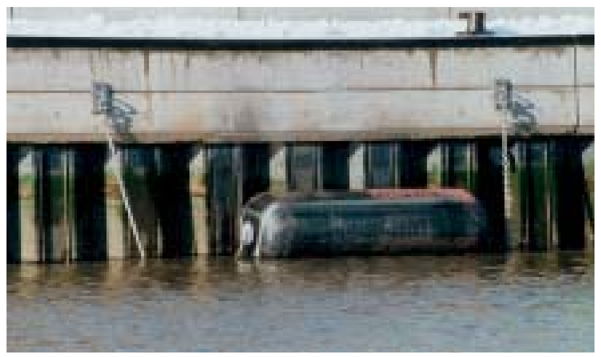
The FF30 series provides good energy capacity with lowest reaction force and hull pressures, whereas the FF50 series provides higher energy capacity for more arduous applications. Extra thick skins are also available for offshore use.

FOAM FENDER PERFORMANCE AND DIMENSIONS

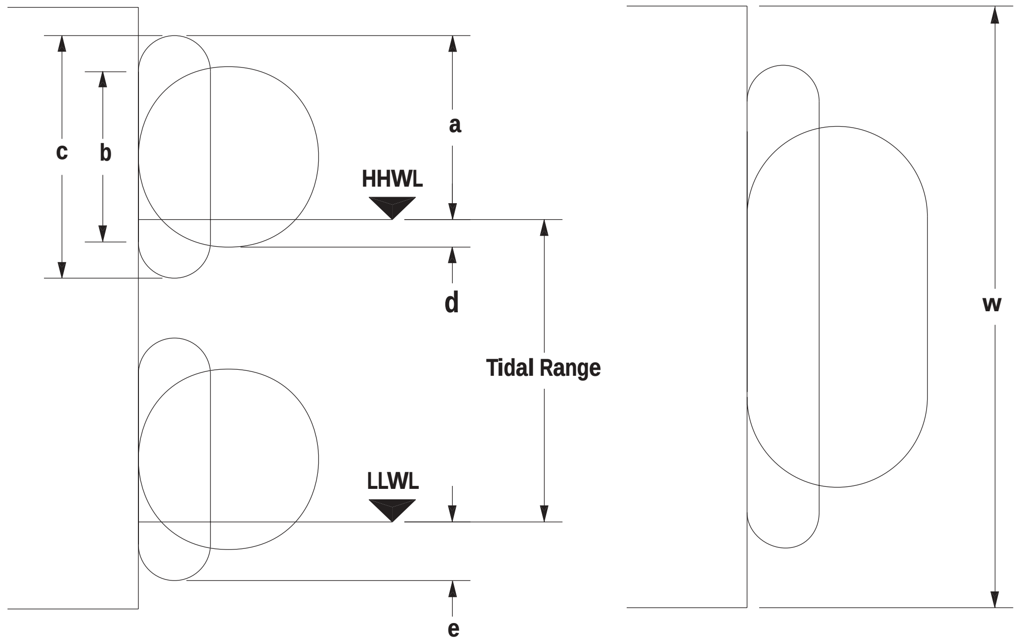
Fender Size	FF-30 Series		FF-50 Series	
ØD x L	R(kN)	E(kNm)	R(kN)	E(kNm)
500 x 1000	66	8	88	10
600 x 1000	80	11	106	15
750 x 1500	150	26	198	35
1000 x 1500	199	47	264	62
1000 x 2000	266	62	352	82
1200 x 2000	319	90	422	119
1200 x 2500	399	112	528	148
1500 x 3000	598	210	792	278
1700 x 3000	678	270	897	357
2000 x 3000	797	373	1060	494
2000 x 3500	930	435	1230	576
2000 x 4000	1060	498	1410	659
2200 x 4500	1320	677	1740	897
2500 x 4000	1330	777	1760	1030
2500 x 5000	1660	972	2200	1290
2500 x 5500	1830	1070	2420	1420
3000 x 5000	1990	1400	2640	1850
3000 x 6000	2390	1680	3170	2220
3300 x 6500	2850	2200	3770	2910

All performance values given at 60% deflection.
Performances may vary due to operating temperature, compression speed, material properties and dimensional tolerances.
Foam fenders can be manufactured in virtually any size.
Contact Fentek for details.





Foam fenders must be installed onto a solid structure or reaction panel. Indicative layout and dimensions are given right and below.

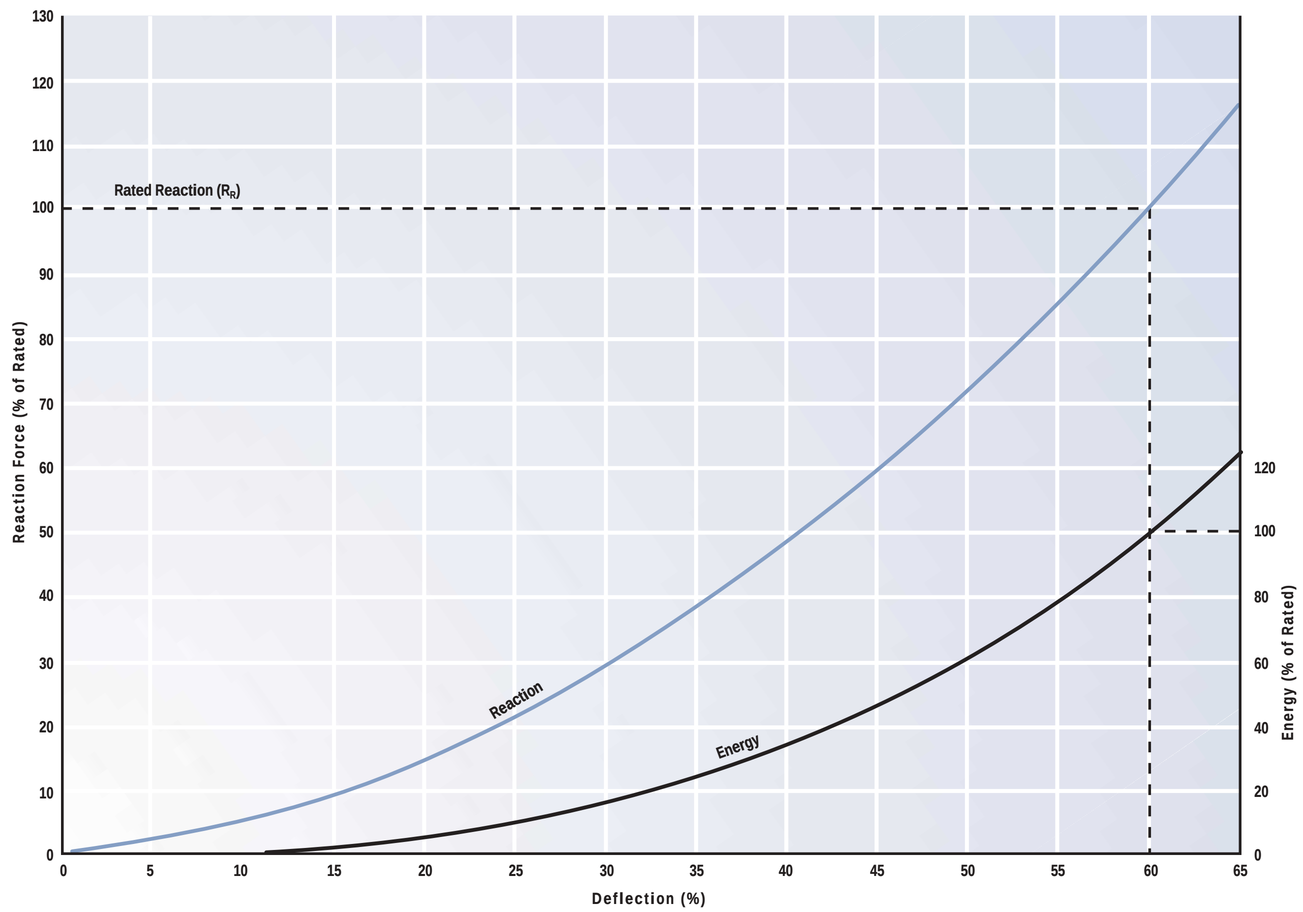


FOAM FENDER INSTALLATION DIMENSIONS

Fender	D (mm)	L (mm)	a (mm)	b (mm)	c (mm)	d (mm)	e (mm)	w (mm)
1000 x 1500	1000	1500	965	950	1350	210	385	2000
1200 x 2000	1200	2000	1190	1140	1620	230	440	2600
1500 x 2500	1500	2500	1515	1420	2050	260	535	3250
2000 x 3500	2000	3500	2030	1900	2700	320	670	4500
2500 x 4000	2500	4000	2470	2380	3380	470	910	5200
3300 x 6500	3300	6500	3350	3140	4460	530	1110	8500

All dimensions are in millimetres.

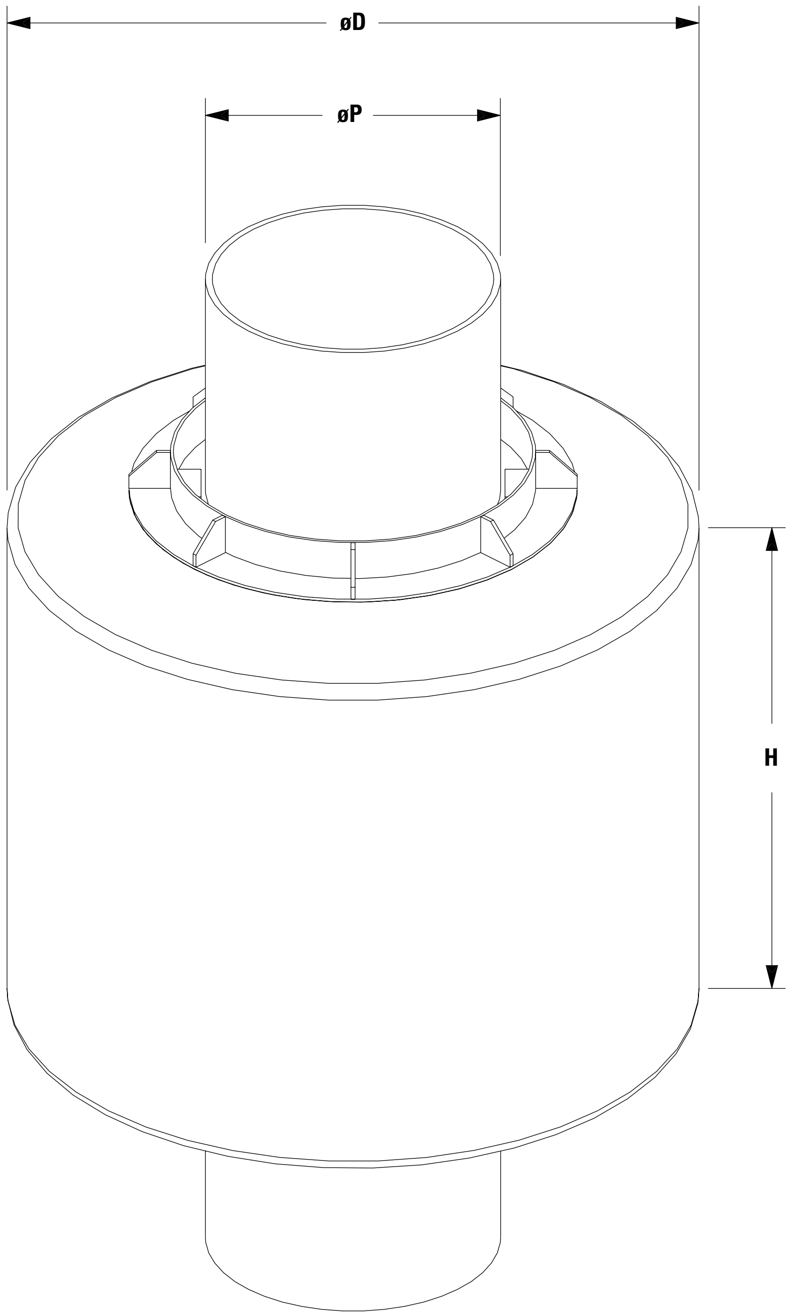
GENERIC PERFORMANCE CURVE



DONUT FENDERS

Fentek 'Donut' fenders provide a simple and versatile solution to protecting exposed corners and channels in tidal zones.
Installation could not be simpler.
The Donut simply drops over a tubular pile and is ready for use.
The Donut uses well proven foam fender technology with its closed cell polyethylene foam core and a wear resistant, flexible skin of reinforced polyurethane elastomer.
The Donut has a steel core lined with a series of low-friction bearings which allow the fender to rise and fall with the tide and to rotate freely around the pile.
Apart from standard dimensions, Fentek can design special Donuts to suit most applications. Contact your Fentek office for further details.

▲ Montoir, St. Nazaire (FRANCE)



DONUT PERFORMANCE & DIMENSIONS

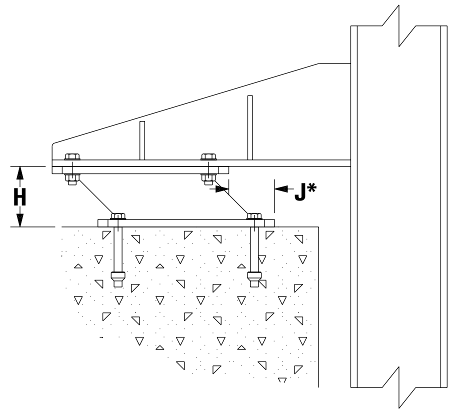
øP	øD	R (kN)	E (kNm)
610	1330	126	8.2
660	1420	134	9.4
711	1500	141	10.7
762	1590	149	12.0
813	1670	157	13.3
864	1750	165	14.7
914	1830	172	16.1
965	1910	180	17.5
1016	1990	188	19.0
1067	2070	195	20.5
1118	2150	202	22.0
1168	2230	210	23.6
1220	2310	217	25.3
1320	2450	231	28.5
1420	2600	245	32.0
1520	2750	258	35.5
1620	2890	271	39.2
1820	3160	297	47.0
2020	3420	322	55.3

All dimensions in millimetres.
Nominal deflection is 60% of Donut wall.
Energies and reactions are per 1000mm body height.
Typically $H_{min} \geq$ Pile Diameter
$H_{max} \leq$ 5000mm

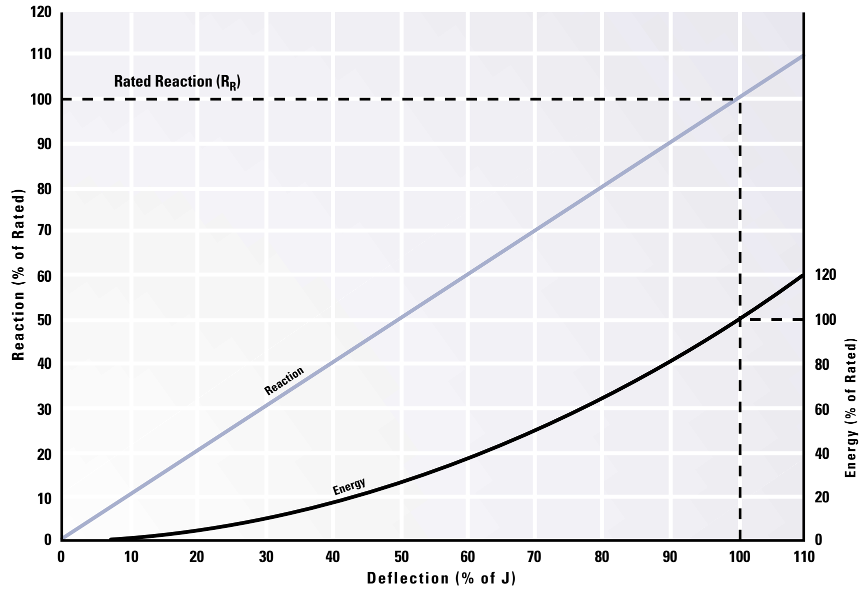
SHEAR FENDERS

Shear fenders provide omni-directional performance combined with linear load characteristics. They are simple in concept, easy to install and are ideal for lower energy applications. Shear fenders are used in conjunction with piles or simple frontal panels of steel or timber. All shear fenders are produced as standard in E3 Energy Index compounds, but softer grades are also available on request.
Please speak with your local Fentek office.
* It is recommended that movement in any horizontal direction is limited by means of a mechanical restraint.

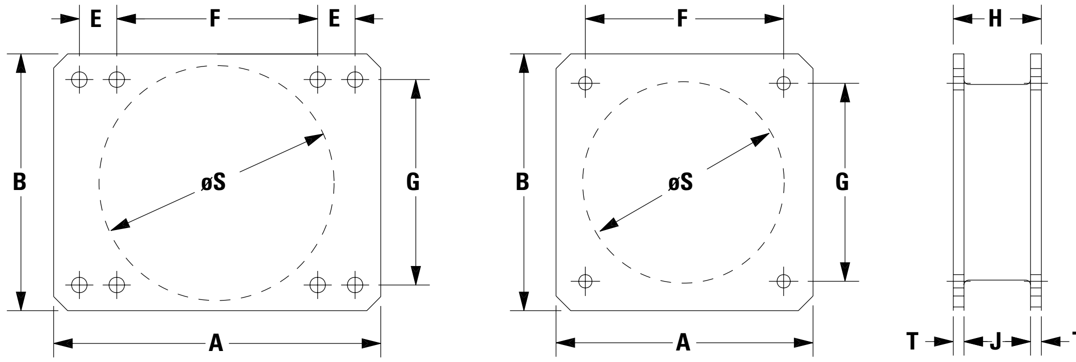
▲ Array of shear fenders awaiting installation, Portopetroli (ITALY)



GENERIC PERFORMANCE CURVE



▲ Superseacat berth upgrade, Newhaven Harbour (ENGLAND)



SHEAR FENDER PERFORMANCE AND DIMENSIONS

Fender	A	B	E	F	G	H	J	T	øS	Bolt	Energy (kNm)	Reaction (kN)
SF 400-180	525	525	—	405	405	180	136	22	400	M24	10.0	147
SF 500-250	700	550	80	430	440	260	190	35	500	M30	25.5	250
SF 500-275	610	610	—	510	510	275	231	22	500	M24	24.9	216

All dimensions in millimetres.
Standard tolerances apply.

Wheel Fenders

▲ Lock Entrance, Dieppe (FRANCE)

Fentek Wheel Fenders help vessels manoeuvre into berths and narrow channels. Different configurations are used for a variety of locations such as locks and dry dock entrances and exposed corners.

The wheel has a sliding axle in front of two idler rollers to absorb the greatest possible energy during compression of the wheel into the casing. Composite bearings eliminate metal to metal contact and allow the wheel to rotate freely, even at full deflection, without substantial friction.

Wheel fenders combine high energy with low reaction at a range of berthing angles. Large contact areas from the tyre ensure reasonable hull pressures. Performance can be modified where required by adjusting the initial pressure.

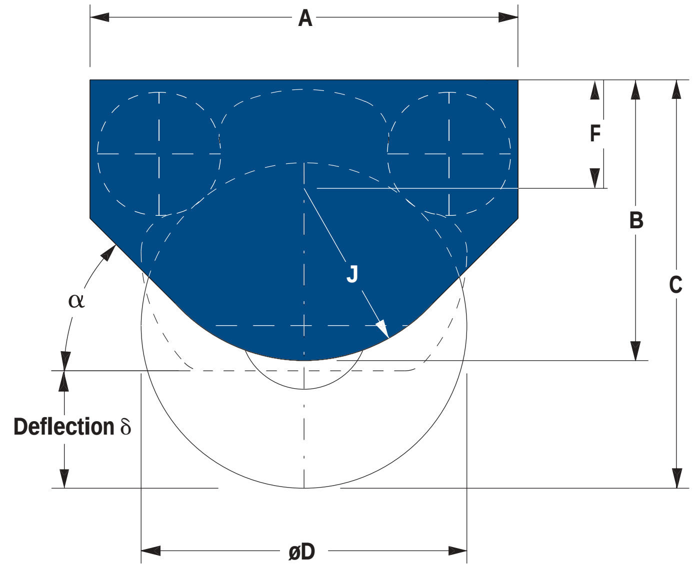
The heavy duty steel casing is designed to allow easy access to moving parts. Corrosion traps are eliminated, contributing to a long and low maintenance service life.

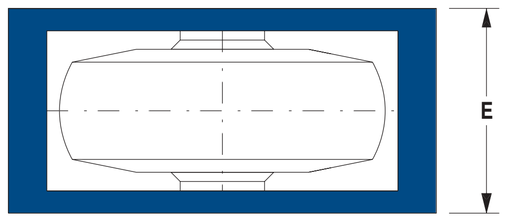
Please ask Fentek about other available sizes, special fixing arrangements and mounting configurations

ATTRIBUTES

- **High energy absorption**
- **Gentle contact face**
- **Low rolling resistance**
- **Composite bearings eliminate metal to metal contact**
- **Low maintenance casing design**
- **Can be used singly or in stacks**

▲ Lisnave Hydrolift Facility, Setubal (PORTUGAL)





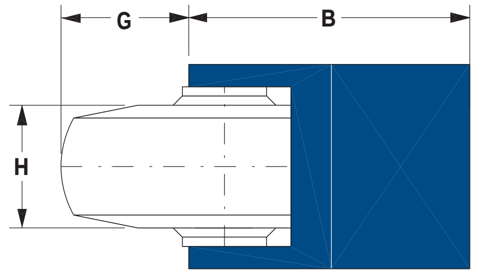
APPLICATIONS

- **Drydock entrances and bodies**
- **Locks approaches**
- **Exposed corners**

WHEEL FENDER PERFORMANCE

Fender	Energy (kNm)	Reaction (kN)	Deflection (mm)	Pressure (bar)
110-45WF	33	150	400	5.5
130-50WF	61	220	500	3.5
175-70WF	100	315	600	4.8
200-75WF	220	590	700	5.5
250-100WF	440	920	925	5.5
290-110WF	880	1300	1200	5.8

Standard tolerances apply.



Typical wheel fender casing dimensions are indicated in the table. For special applications and unusual corners, the casing shape can be modified for a perfect fit. Please ask Fentek for details.

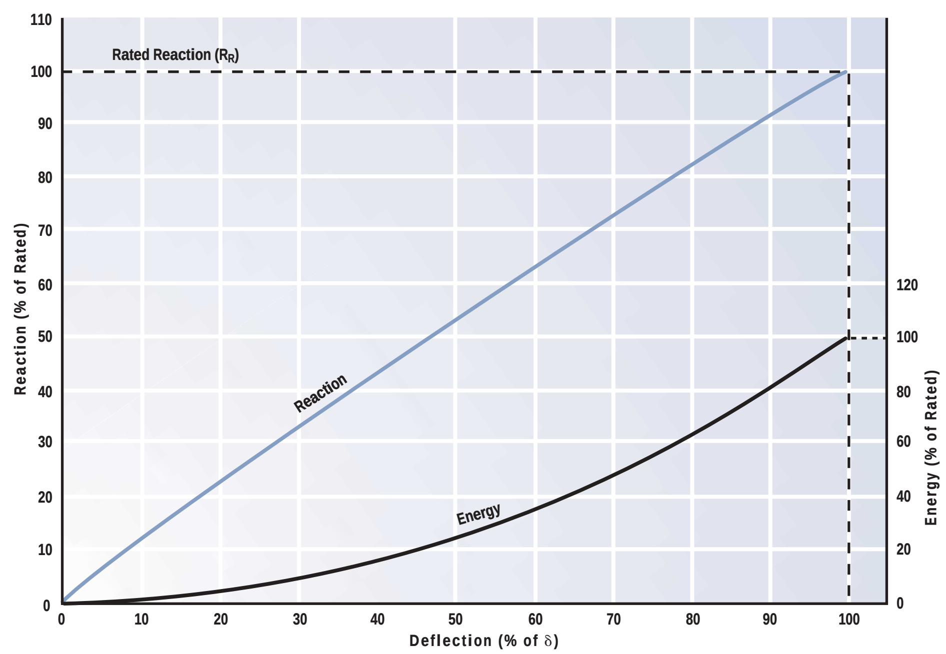
WHEEL FENDER DIMENSIONS

Fender	A	B	C	D	E	F	G	H	J	K	L	α
110-45WF	1700	1000	1450	1080	900	350	450	460	650	50	150	0~40°
130-50WF	2000	1200	1750	1300	1000	350	550	510	850	50	200	0~40°
175-70WF	2650	1500	2200	1750	1150	550	700	690	950	50	200	0~40°
200-75WF	2750	1750	2550	1980	1250	500	800	760	1250	50	250	0~45°
250-100WF	3350	2200	3200	2550	1600	850	1000	970	1350	50	250	0~45°
290-110WF	4200	2500	3750	2900	1700	1000	1250	900	1500	50	250	0~45°

All dimensions in millimetres

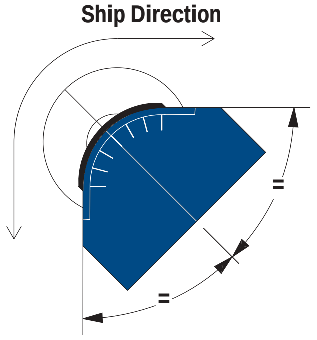
Dimensions are for guidance only and should be checked for each installation.

GENERIC PERFORMANCE CURVE

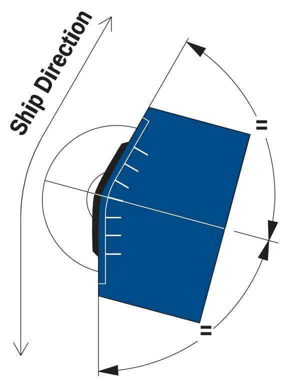


▲ Immingham (ENGLAND)

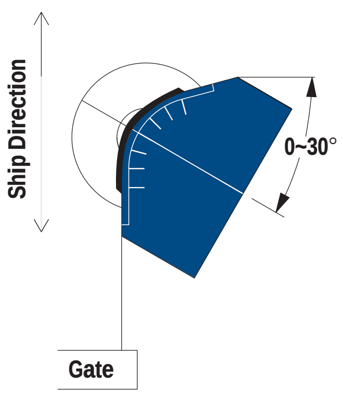
Wheel Fenders can be installed in various positions on jetty corners, angled knuckles, at the entrance or within the body of locks and dry docks. Correct orientation and casing profile is important to extract maximum performance from the Wheel fender.



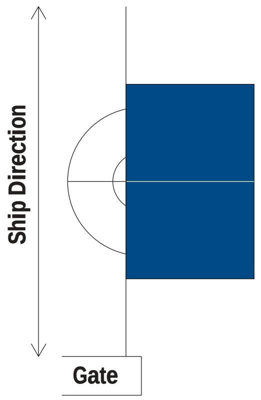
On the 90° corner of a jetty for warping



On an angled knuckle corner for alignment

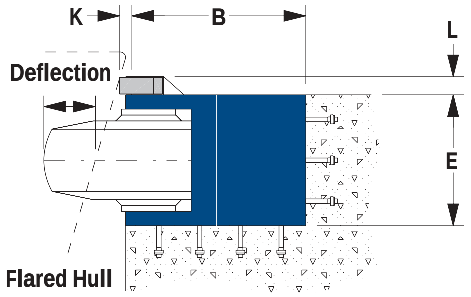


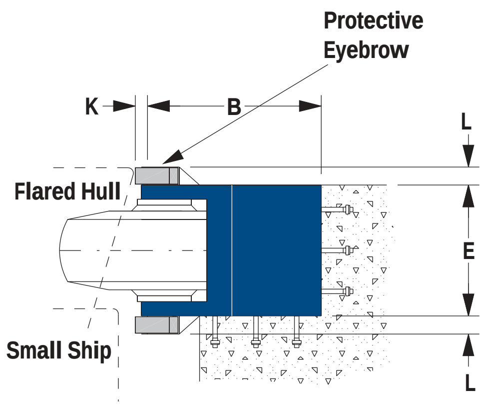
At the 90° entrance of a lock or dry dock

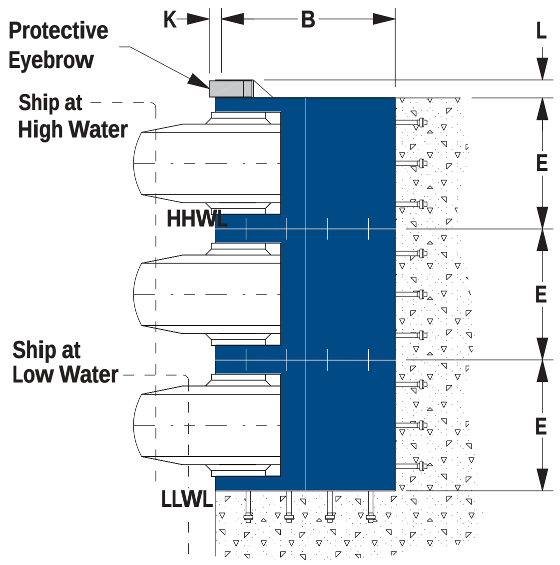


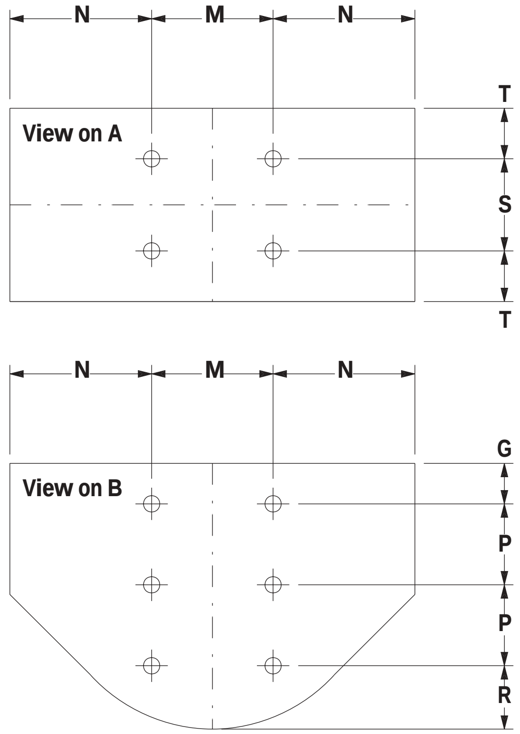
Within the body of a lock or dry dock.

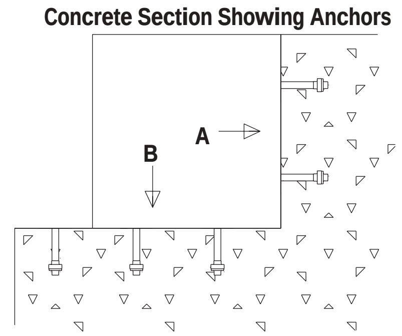
Single Wheel Fenders can be installed at cope level where there is little variation in water level. Several units can be stacked to give greater vertical coverage when installing Wheel Fenders in tidal zones. Protective 'eyebrows' are available as an option to accommodate smaller ships and flared bows.







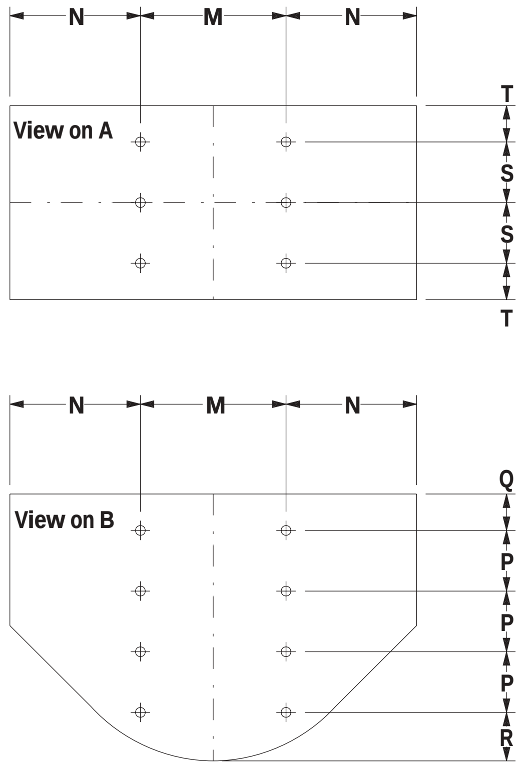


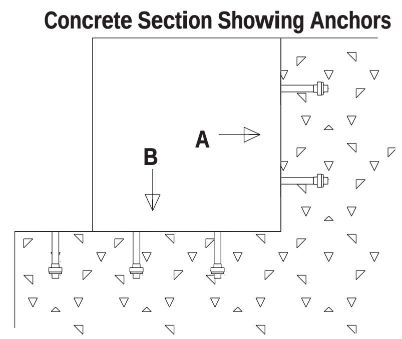


WHEEL FENDER ANCHOR LOCATIONS

Fender	M	N	P	Q	R	S	T	Anchor
110-45WF	500	600	300	200	200	500	200	10 x M24
130-50WF	600	700	400	200	200	500	250	10 x M24
175-70WF	800	925	500	250	250	650	250	10 x M30

All dimensions in millimetres.





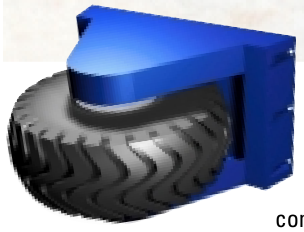
WHEEL FENDER ANCHOR LOCATIONS

Fender	M	N	P	Q	R	S	T	Anchor
200-75WF	450	925	400	300	250	400	225	14 x M30
250-100WF	600	1075	500	300	400	500	300	14 x M36
290-110WF	650	1350	500	500	500	500	300	14 x M42

All dimensions in millimetres.

Roller Fenders

▲ MTW Wismar (GERMANY)



Fentek Roller Fenders are commonly installed along the walls of dry docks and other restricted channels to help guide vessels and prevent hull damage. Roller Fenders are also used on berth corners and lock entrances where lower energy capacity is required.

The wheel is mounted on a fixed axle supported by a special frame. Composite bearings eliminate metal to metal contact and allow the wheel to rotate freely, even at full deflection, without substantial friction.

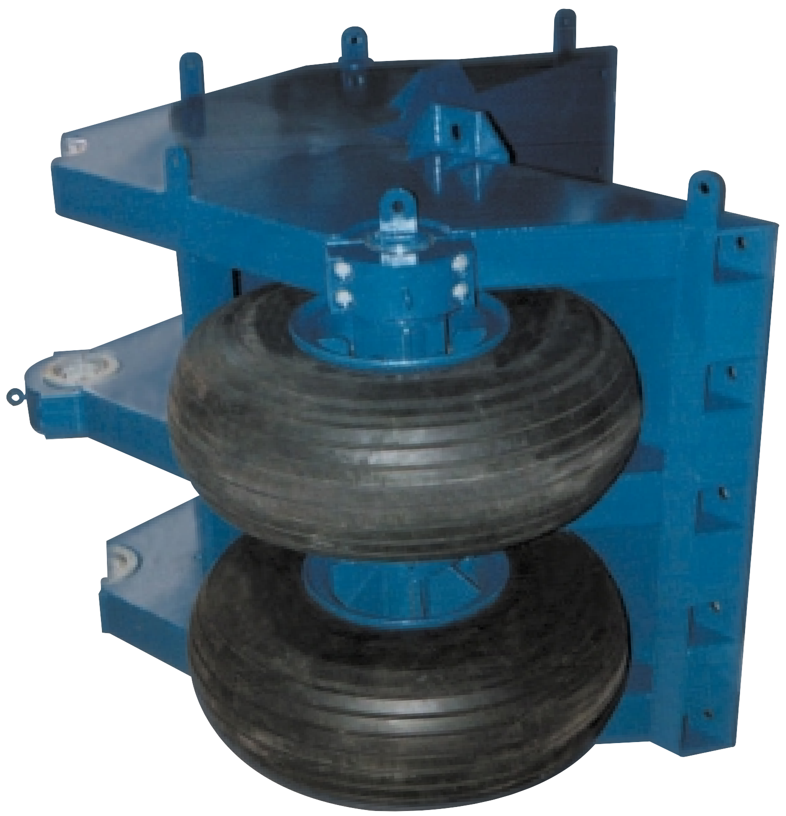
Roller Fenders combine reasonable energy absorption with low reaction at all berthing angles. Large contact areas from the tyre ensure reasonable hull pressures. Performance can be modified where required by adjusting the initial pressure.

The heavy duty steel supporting frame is designed to allow easy access to all moving parts. Corrosion traps are eliminated, contributing to a long and low maintenance service life.

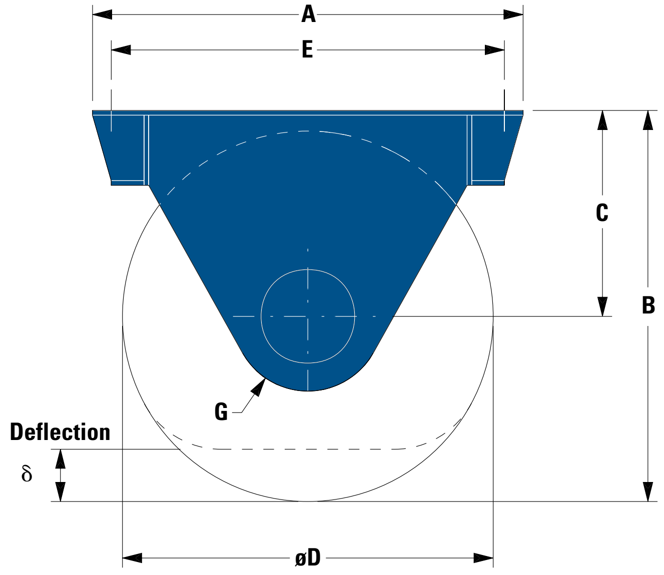
Please ask Fentek about other available sizes, special fixing arrangements and mounting configurations.

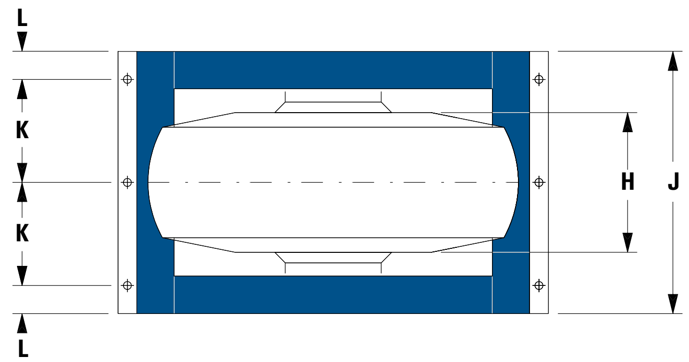
Core Attributes

- **Good energy absorption**
- **Gentle contact face**
- **Low rolling resistance**
- **Composite bearings eliminate metal to metal contact**
- **Low maintenance frame design**
- **Can be used singly or in stacks**
- **Large load bearing capability**



▲ 6-wheeled roller corner fender ready for installation (HONG KONG)





Applications

- **Drydock walls**
- **Restricted channels**
- **Some exposed corners and lock entrances**

ROLLER FENDER PERFORMANCE

Fender	Energy (kNm)	Reaction (kN)	Deflection (mm)	Pressure (bar)
110-45RF	13	175	152	5.5
130-50RF	22	200	230	3.5
140-60RF	20	210	205	3.5
175-70RF	37	345	225	4.8
200-75RF	100	765	270	5.5
250-100RF	170	1000	345	5.5

Standard tolerances apply.

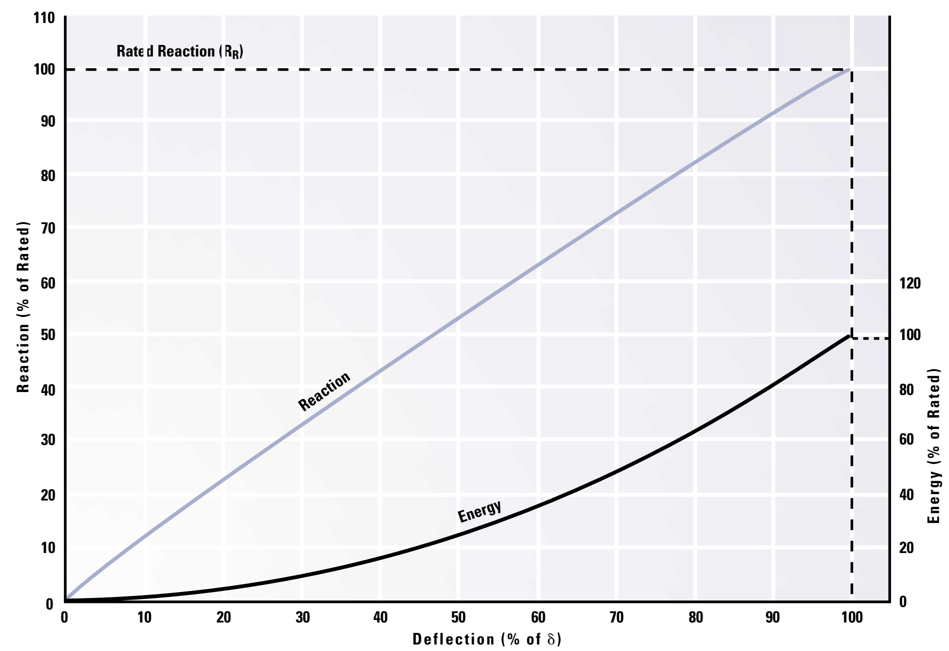
Typical roller fender frame dimensions are indicated in the table.
For special applications and unusual corners, the frame shape can be modified for a perfect fit.
Please ask Fentek for details.

ROLLER FENDER DIMENSIONS

Fender	A	B	C	D	E	G	H	J	K	L	Anchor
110-45RF	1250	1150	610	1080	1150	220	460	800	340	60	6 x M30
130-50RF	1530	1400	740	1320	1450	260	510	950	400	75	6 x M30
140-60RF	1600	1450	765	1370	1500	270	610	1000	425	75	6 x M30
175-70RF	2050	1850	975	1750	1900	350	690	1250	500	125	6 x M36
200-75RF	2300	2100	1110	1980	2100	400	765	1400	550	150	6 x M42
250-100RF	3000	2700	1425	2550	2700	500	895	1800	700	200	6 x M48

All dimensions in millimetres

GENERIC PERFORMANCE CURVE



UHMW-PE Facings

▲ Catamaran Berth, Langkawi (MALAYSIA)

Ultra High Molecular Weight Polyethylene (UHMW-PE) has become the material of choice for facing steel fender panels and where the combination of very high impact and abrasion resistance with low-friction properties is needed. Fentek UHMW-PE is the strongest and toughest of all polyethylene grades for marine applications – even outlasting steel as a facing material, and many times better than timber facings.

UHMW-PE does not decay or rot, and is unaffected by marine borers. It is grain-free so will not splinter or crush, and can be cut, drilled and machined with ease.

Most UHMW-PE is supplied as Black – not just because this is the most economic choice, but also because black is manufactured using a double sintering process which work hardens the UHMW-PE to further increase its abrasion resistance.

UHMW-PE is available in many other colours yellow, white, blue, green, red, grey or orange which can be used to make the fender system highly visible in poor weather or to demarcate zones along a berth.

Application

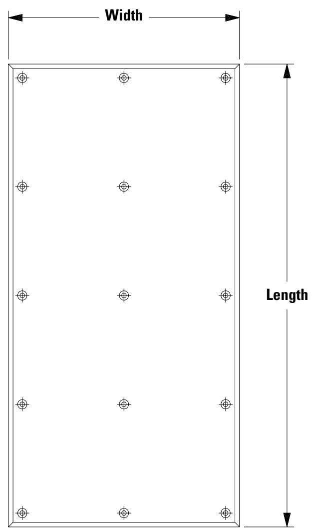
- **Fender panel facing pads**
- **Fender pile rubbing strips**
- **UE-V fender shields**
- **Facing strips for jetties and wharves**
- **Lock entrance and lock wall protection**
- **Mitres on lock gates**
- **Bridge buttress protection**
- **Pontoon pile guide bearings**
- **Fast-launch lifeboat slipways**
- **Beltings for smaller workboats**

▲ Tower Pier, London (ENGLAND)

STANDARD SHEET SIZES FOR UHMW-PE

Length	Width	Thickness
10000	1000	15~70
6100	1220	15~120
6100	1330	15~120
6000	1250	30~120
5000	2000	15~70
4000	2000	15~140
3000	2000	15~150
2700	1300	10~60
2000	1000	10~200

Preferred thicknesses are 30mm, 40mm, 50mm, 70mm, 100mm & 120mm.
Other thickness available upon request.
Please consult Fentek.
All dimensions in millimetres.
Standard tolerances apply.

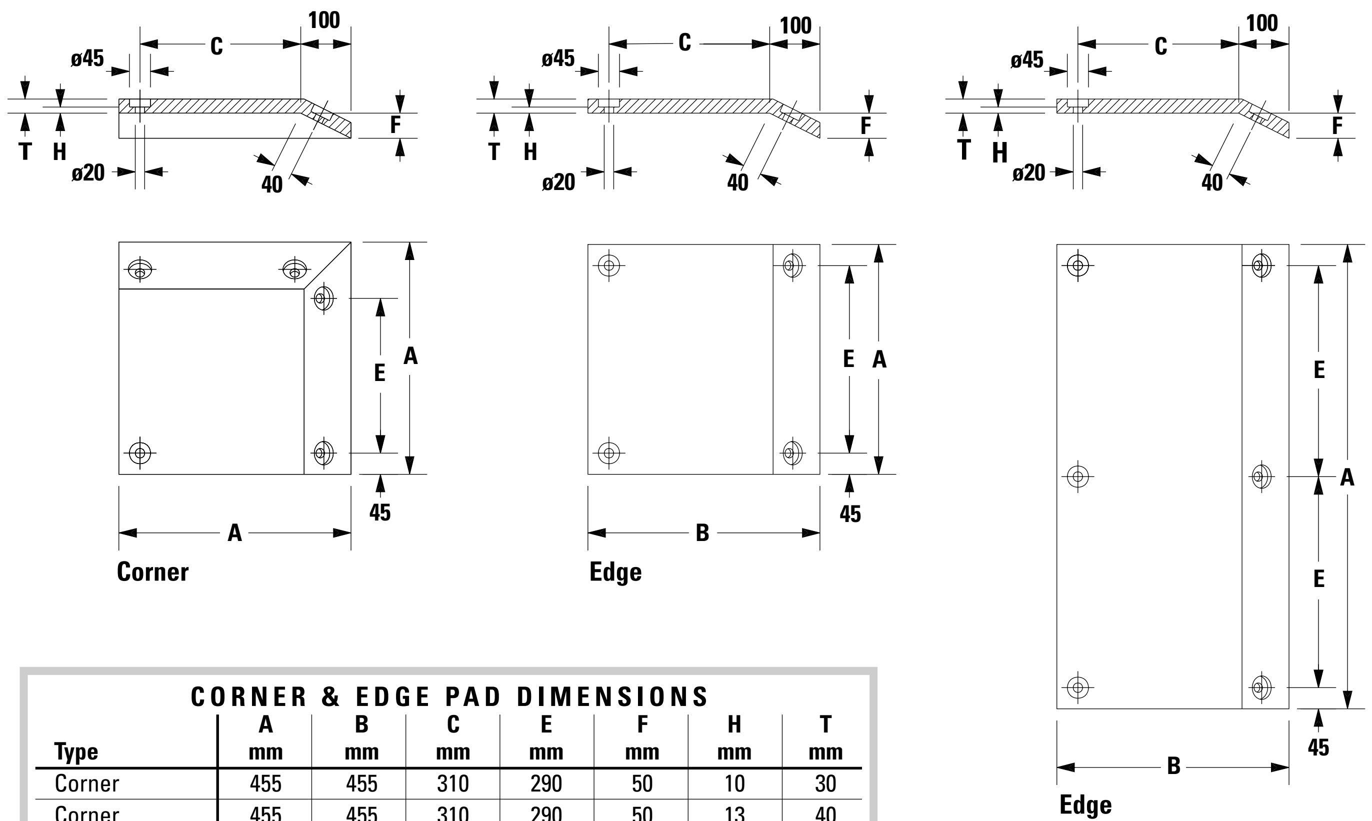


UHMW-PE PHYSICAL PROPERTIES

Property	Test Method (pre-1993)	Typical Value (pre-1993)	Unit (pre-1993)	Test Method (post-1993)	Typical Value (post-1993)	Unit (post-1993)
Density	DIN 53479	0.93~0.95	g/cm³	**ISO 1183**	**0.93~0.95**	**g/cm³**
Molecular Weight	Viscosimetric	~4,000,000	g/mol	**Viscosimetric**	**~5,000,000**	**g/mol**
Friction Coefficient	DIN 53375	0.10~0.15	—	**DIN 53375**	**0.10~0.15**	**—**
Yield Strength	DIN 53455	≥20	N/mm²	**ISO 527**	**≥17**	**N/mm²**
Ultimate Strength	DIN 53455	≥40	N/mm²	**not measured**	**not measured**	**—**
Elongation at Break	DIN 53455	>350	%	**ISO 527**	**>50**	**%**
Ball Indentation Hardness	DIN 53456	38	N/mm²	**ISO 2039**	**38**	**N/mm²**
Shore Hardness	DIN 53505	64~67	—	**ISO 868**	**60**	**15 sec**
V-Notch Impact Strength	DIN 53453	≥130	mJ/mm²	**ISO FDIS 11542**	**≥210**	**kJ/m²**
Abrasion Index	Sand Slurry	100	—	**Sand Slurry**	**100**	**—**
Operating Temperature		-80 to +80	°C	**—**	**-80 to +80**	**°C**
Crystalline Melting Point	Polarisation Microscope	130~133	°C	**ISO 3146**	**130~135**	**°C**
Linear Expansion Coefficient	DIN 52328	~2 x10⁻⁴	K⁻¹	**DIN 52328**	**~2 x10⁻⁴**	**K⁻¹**

Values given are for Virgin FQ1000 UHMW-PE
ISO test methods now supersede previously used DIN test methods
Material samples used in pre-1993 and post-1993 tests are identical
Different values are due to changes in test pressure only

UHMW-PE CORNER & EDGE PADS



CORNER & EDGE PAD DIMENSIONS

Type	A mm	B mm	C mm	E mm	F mm	H mm	T mm
Corner	455	455	310	290	50	10	30
Corner	455	455	310	290	50	13	40
Corner	495	495	350	330	50	10	30
Corner	495	495	350	330	50	13	40
Edge	640	495	350	550	50	10	30
Edge	640	495	350	550	50	13	40
Edge	855	495	350	383	50	10	30
Edge	855	495	350	383	50	13	40
Edge	868	495	350	389	50	10	30
Edge	868	495	350	389	50	13	40
Edge	990	495	350	450	50	10	30
Edge	990	495	350	450	50	13	40

Apart from flat sheets, specially moulded corner and edge pads are also available.

Sliding Fenders

▲ Canal protection, Schafstedt (GERMANY)

HD-PE Sliding Fenders are a superior alternative to timber and other facing materials and have many uses in waterway, harbour and ship construction. HD-PE is especially useful when low-friction contact during docking and mooring is advantageous.

Unlike timber, HD-PE does not decay or rot, and is unaffected by marine borers. It is grain-free so will not splinter or crush, and can be cut, drilled, machined and curved.

HD-PE is an environmentally friendly material and can be totally recycled at the end of its service life. As a substitute for tropical hardwoods, HD-PE Sliding Fenders last longer and reduce dependence on increasingly scarce natural resources.

Core Attributes

- **Does not decay or rot**
- **Resistant to marine borers, algae and crustaceans**
- **High resistance to abrasion and wear**
- **Resistant to UV, climate extremes, oil spills and pollutants**
- **Easily machined and drilled**
- **Wide choice of standard profiles**
- **Extruded profile with no sharp edges**
- **100% recyclable**

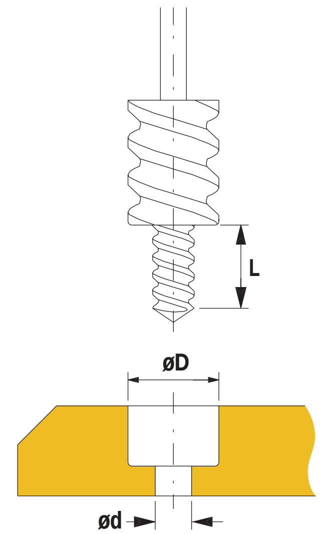
Application

Applications of HDPE Sliding Fenders include:-

- **Fender pile rubbing strips**
- **Facing strips for jetties and wharves**
- **Beltings for smaller workboats**
- **Lock entrance and lock wall protection**
- **Mitres on lock gate**

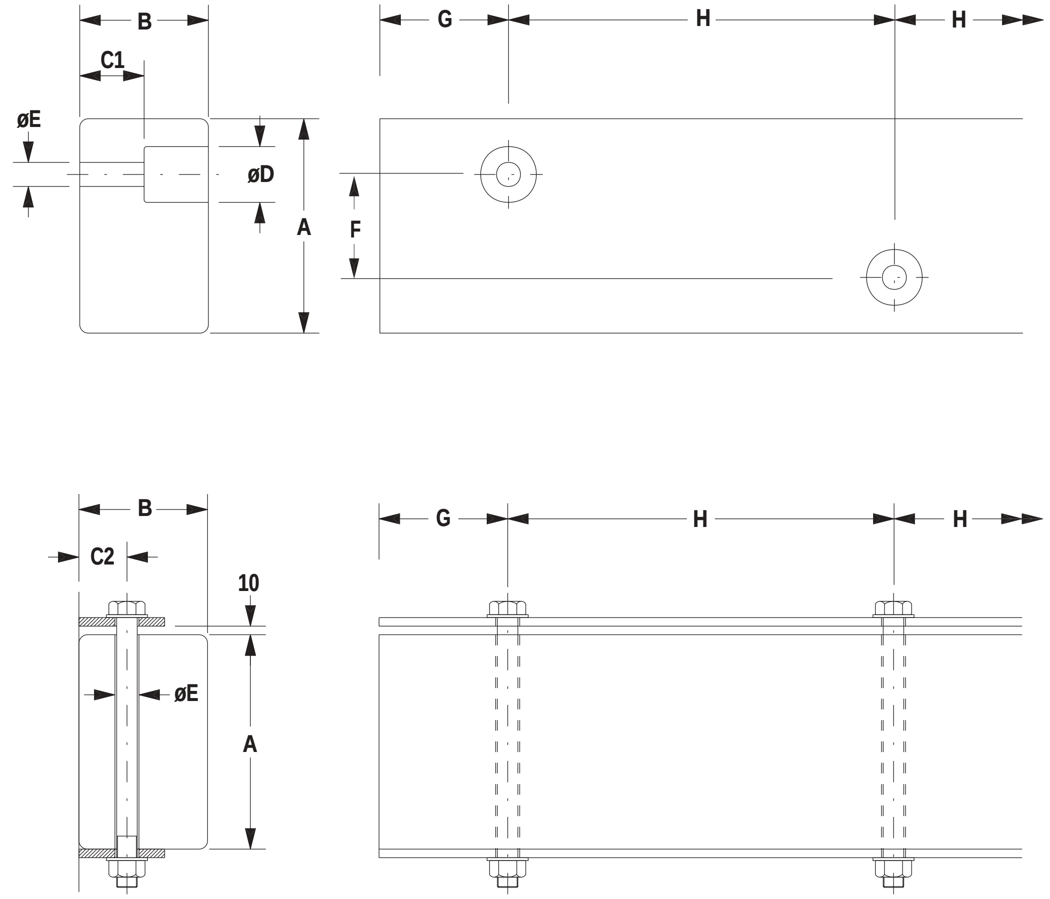
HD-PE PHYSICAL PROPERTIES

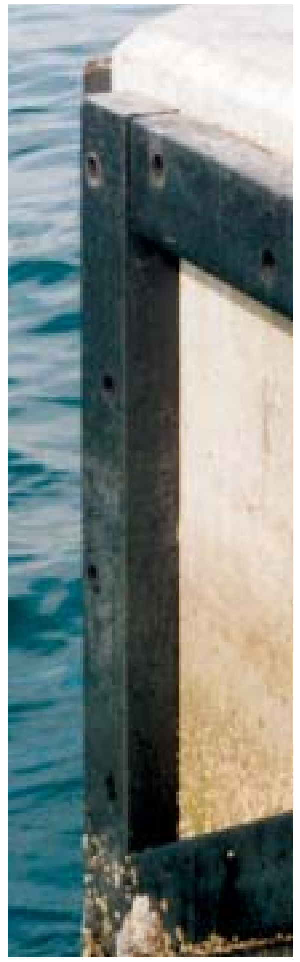
Property	Test Method	Typical Results	Unit
Density	DIN 53479	~930	kg/m³
Molecular Weight	Light Diffusion Method	~200,000	g/mol
Friction Coefficient	DIN 53375	0.20~0.25	–
Yield Strength	DIN 53455	≥12	N/mm²
Elongation at Break	DIN 53455	~450	%
Ball Indentation Hardness	DIN 53456	≥20	N/mm²
Shore Hardness	DIN 53505	55~60	Shore D
V-Notch Impact Strength	DIN 53453	No Break	mJ/mm²
Operating Temperature		-40 to +80	°C
Linear Expansion Coefficient	DIN 52328	~2.0 x 10^{-4}	K^{-1}



STANDARD DRILLING DIAMETERS

D mm	d mm	L (max) mm
27	13	75
32	16	85
32	12	32
32	16	45
32	18	80
40	20	80
50	21	95
50	23	95
60	21	70
65	27	105
70	28	110
70	32	115
70	26	50





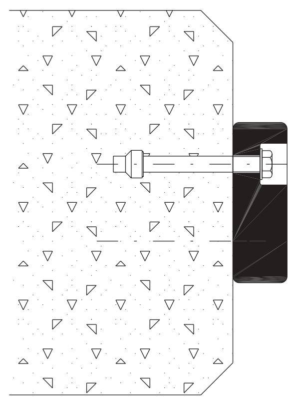
▲ Corner protection (DUBAI)

HD-PE SECTION SIZES AND FIXING DIMENSIONS

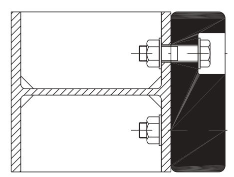
A (mm)	B (mm)	L (mm)	C1 (mm)	C2 (mm)	D (mm)	E (mm)	F (mm)	G (mm)	H (mm)	Flat Bar (mm)	Bolt Size	Weight (kg/m)
70	**50**	**2500**	**25**	**–**	**32**	**16**	**0**	**75~125**	**250~300**	**–**	**M12**	**3.3**
80	**60**	**5000**	**30**	**–**	**32**	**16**	**0**	**75~125**	**250~300**	**–**	**M12**	**4.5**
100	**50**	**5500**	**25**	**–**	**32**	**16**	**0**	**75~125**	**250~300**	**–**	**M12**	**4.7**
100	65	5500	30	–	32	16	0	75~125	250~300	–	M12	6.1
100	100	6000	50	32	32	16	0	75~125	250~300	50 x 6	M12	9.3
120	**80**	**5000**	**40**	**–**	**40**	**20**	**0**	**100~150**	**300~350**	**–**	**M16**	**8.9**
120	120	6000	60	40	40	20	0	100~150	300~350	65 x 10	M16	13.4
140	**70**	**5500**	**35**	**–**	**40**	**20**	**0~50**	**100~150**	**300~350**	**–**	**M16**	**9.1**
160	**70**	**5000**	**35**	**–**	**40**	**20**	**0~70**	**100~150**	**300~350**	**–**	**M16**	**10.4**
160	160	6000	80	40	40	20	0~80	100~150	300~350	80 x 10	M16	24.1
170	**120**	**5500**	**60**	**40**	**40**	**20**	**0~80**	**100~150**	**300~350**	**65 x 10**	**M16**	**19.0**
180	**70**	**5000**	**35**	**–**	**50**	**23**	**0~80**	**125~175**	**350~450**	**–**	**M20**	**11.7**
180	180	6000	90	46	50	23	0~80	125~175	350~450	80 x 10	M20	30.2
190	**110**	**5000**	**55**	**46**	**50**	**23**	**0~90**	**125~175**	**350~450**	**80 x 10**	**M20**	**19.4**
200	**75**	**5000**	**35**	**46**	**50**	**23**	**0~100**	**125~175**	**350~450**	**–**	**M20**	**14.0**
200	**100**	**6000**	**50**	**46**	**50**	**23**	**0~100**	**125~175**	**350~450**	**80 x 10**	**M20**	**18.6**
200	**150**	**5500**	**75**	**46**	**50**	**23**	**0~100**	**125~175**	**350~450**	**80 x 10**	**M20**	**27.9**
200	200	6000	100	46	50	23	0~100	125~175	350~450	80 x 10	M20	37.6
250	150	6500	75	46	65	28	0~130	150~200	450~550	80 x 10	M24	34.8
250	**160**	**5000**	**80**	**46**	**65**	**28**	**0~130**	**150~200**	**450~550**	**80 x 10**	**M24**	**37.2**
270	270	5000	125	56	65	28	0~130	150~200	450~550	100 x 10	M24	68.5
300	**100**	**5500**	**50**	**–**	**65**	**28**	**0~160**	**150~200**	**450~550**	**–**	**M24**	**27.9**
300	210	5000	105	56	70	36	0~160	175~225	500~600	100 x 12	M30	58.6
320	270	5000	105	72	70	36	0~160	175~225	500~600	120 x 12	M30	81.2

Preferred sizes (regular stock items) in **bold**.
Sections are available in full or half lengths as standard.
Other lengths available on request. Please consult Fentek.

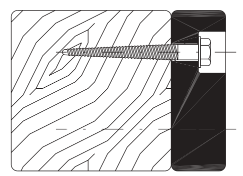
Fixing to concrete



Fixing to steel columns



Fixing to timber



▲ Grey D-Fender for yacht harbour (LEBANON)

Extruded Fenders

Extrusion is a manufacturing process involving pushing unvulcanised rubber through a special die to form a constant cross-section profile. This is a simple and cost effective production method for smaller fenders and allows sections to be made in very long lengths. Special profiles can also be produced economically to customer's specific requirements.

DD-Fenders

DD-Fenders come in many sizes to suit a wide variety of general purpose applications. They are ideal for smaller quays and wharves serving fishing boats, tugs, barges and other work craft. DD-fenders are also commonly used on pontoons and on inland waterways for lock protection.

The flat rear face of DD-fenders makes them easy to install with a flat bar down the bore. DD-fenders can be supplied in long lengths with maximum length restricted only by transport and handling limitations. They can be cut to length, angle cut at the ends, drilled or pre-curved as required for each application.

SD-Fenders

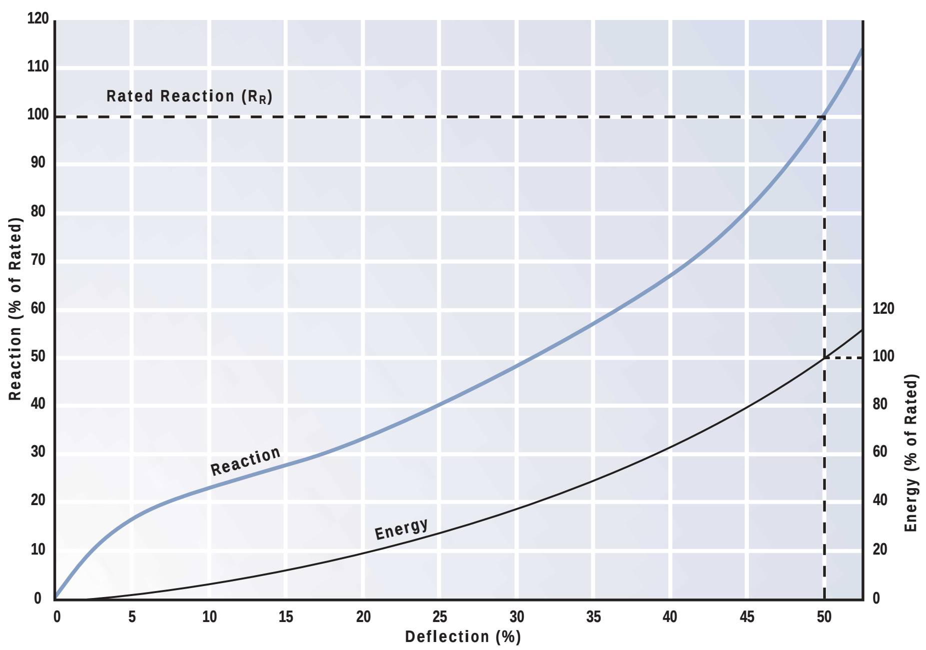
Square section SD-fenders offer similar advantages to DD-fenders and are typically used where a stiffer fender is required. The square profile gives these fenders heavier shoulders which make them ideal for tougher service environments.

Square fenders are also commonly used on the bow or stern of smaller tugs as pushing fenders since they can be fitted closely together to reduce the risk of ropes or protrusions catching between adjacent sections.

Fender Size	E (kNm)	R (kN)	E (kNm)	R (kN)
100	1.4	77	2.7	136
150	3.2	115	6.4	206
200	5.7	153	11.3	275
250	8.9	191	17.6	343
300	12.9	230	25.5	412
350	17.6	268	34.3	471
400	23.0	306	45.2	589
500	35.9	383	70.7	736

Standard tolerances apply.
Performance values are for a 1000mm long fender.

GENERIC PERFORMANCE CURVE



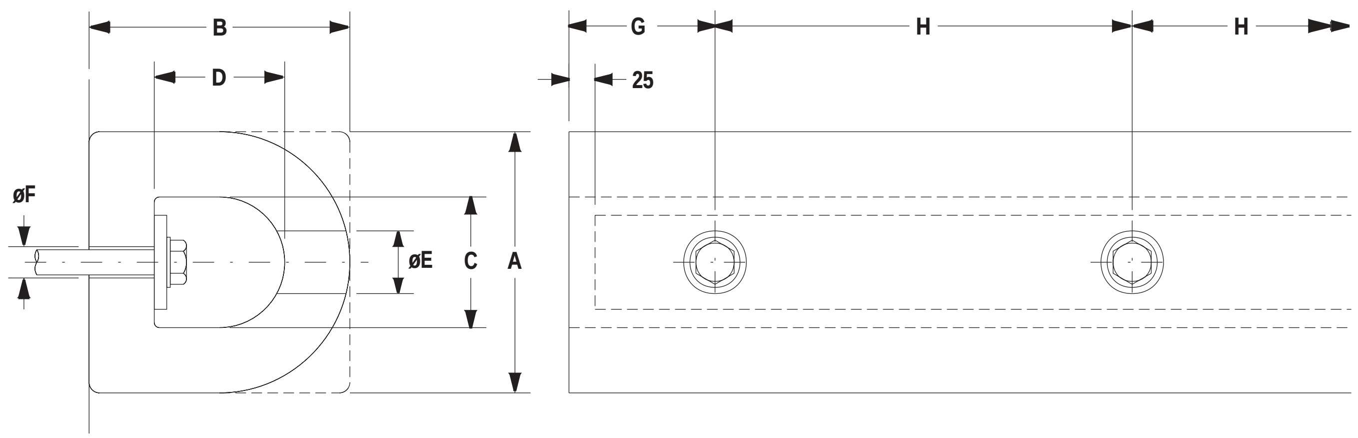
FIXING DIMENSIONS

DD – FENDERS

A	B	C	D	øE	øF	G	H	Flat Bar	Bolt Size	Wt (kg/m)
80	70	45	30	30	15	90~130	200~300	35 x 5	M12	4.4
100	100	50	45	30	15	90~130	200~300	40 x 5	M12	8.1
125	125	60	60	40	20	110~150	250~350	50 x 6	M16	12.5
150	150	75	75	40	20	110~150	250~350	60 x 8	M16	17.5
200	150	100	80	50	25	130~180	300~400	80 x 10	M20	21.9
200	200	100	100	50	25	130~180	300~400	80 x 10	M20	31.2
250	200	125	100	60	30	140~200	350~450	90 x 12	M24	37.8
250	250	125	125	60	30	140~200	350~450	90 x 12	M24	48.7
300	300	150	150	60	30	140~200	350~450	110 x 12	M24	70.2
350	350	175	175	75	35	140~200	350~450	130 x 15	M30	95.5
380	380	190	190	75	35	140~200	350~450	140 x 15	M30	112.6
400	300	175	150	75	35	140~200	350~450	130 x 15	M30	93.0
400	400	200	200	75	35	140~200	350~450	150 x 15	M30	124.8
500	500	250	250	90	45	160~230	400~500	180 x 20	M36	195.0

SD – FENDERS

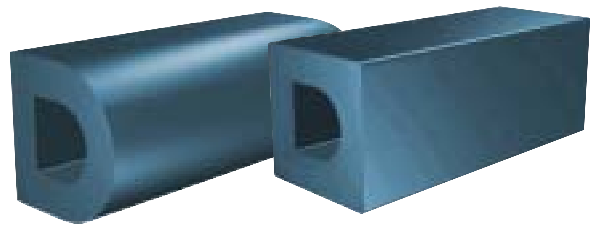
A	B	C	D	øE	øF	G	H	Flat Bar	Bolt Size	Wt (kg/m)
100	100	50	45	30	15	90~130	200~300	40 x 5	M12	9.3
150	150	70	65	40	20	110~150	250~350	50 x 8	M16	21.5
165	125	80	60	40	20	110~150	250~350	60 x 8	M16	19.2
200	150	90	65	50	25	130~180	300~400	70 x 10	M20	29.1
200	200	90	95	50	25	130~180	300~400	70 x 10	M20	37.7
250	200	120	95	60	30	140~200	350~450	90 x 12	M24	46.8
250	250	120	120	60	30	140~200	350~450	90 x 12	M24	57.8
300	250	140	115	60	30	140~200	350~450	100 x 12	M24	71.1
300	300	125	135	60	30	140~200	350~450	100 x 12	M24	87.1
400	400	200	200	75	35	140~200	350~450	150 x 15	M30	144.8
500	500	250	250	90	45	160~230	400~500	180 x 20	M36	226.3



APPLICATION

Extruded Fenders are ideal for:-

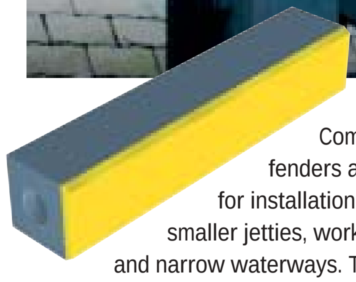
- **Smaller jetties and wharves**
- **Workboats and service craft**
- **Mooring pontoon protection**
- **Inland waterways**
- **General purpose applications**



▲ SD-Fenders, Portsmouth (ENGLAND)

Composite Fenders

▲ RNLI Berth, Tobermory (SCOTLAND)



Composite fenders are ideal for installation on smaller jetties, workboats and narrow waterways. They combine the benefits of an energy absorbing rubber body with the low friction properties of UHMW-PE in a single moulded product.

The special manufacturing technique forms a permanent bond between the elastomer section and the UHMW-PE during vulcanisation, eliminating the need for mechanical fixings to give much greater wear allowance on the polyethylene face.

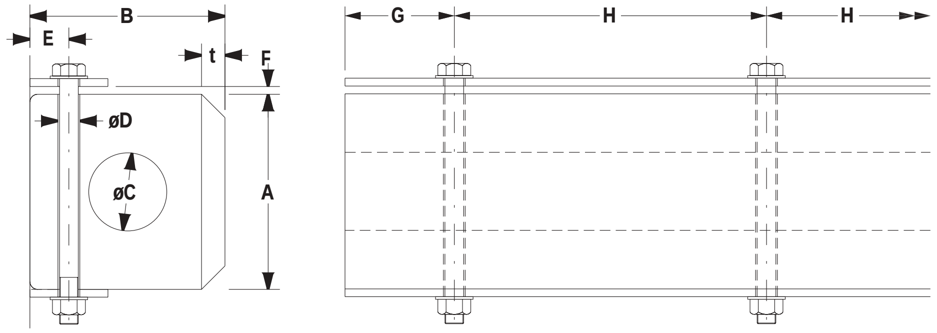
Composite fenders are available in a variety of standard sections and lengths, but can be cut and drilled to suit a variety of other applications including pontoon yoke guides and marina pontoon fenders. If required, steel base plates can also be moulded into some of the sections. Please consult Fentek for any special requirements.

APPLICATIONS

Composite Fenders are ideal for:-

- **Workboats and service craft**
- **Lock entrances and lock walls**
- **Inland waterways**
- **Smaller jetties and wharves**
- **Pontoon yoke guides**
- **Mooring pontoon protection**

▲ Humber Sea Terminal (ENGLAND)



CF-A

FIXING DIMENSIONS – COMPOSITE FENDERS

CF-A

A	B	øC	t	øD	E	F	G	H	Flat Bar	Bolt Size	Std Length	Wt (kg/m)
100	100	30	20	15	25	10	90~130	200~300	50 x 6	M12	3000	10.3
150	150	65	20	20	30	12	110~150	250~350	60 x 8	M16	3000	21.5
165	125	65	20	20	35	15	110~150	250~350	60 x 8	M16	3000	19.2
200	200	75	25	25	45	20	130~180	300~400	80 x 10	M20	2000	40.2
200	200	100	25	25	45	20	130~180	300~400	80 x 10	M20	2000	36.2
250	250	100	30	30	50	25	140~200	350~450	100 x 10	M24	2000	60.2
300	300	125	30	30	60	30	140~200	350~450	110 x 12	M24	3000	92.1

FIXING DIMENSIONS – COMPOSITE FENDERS

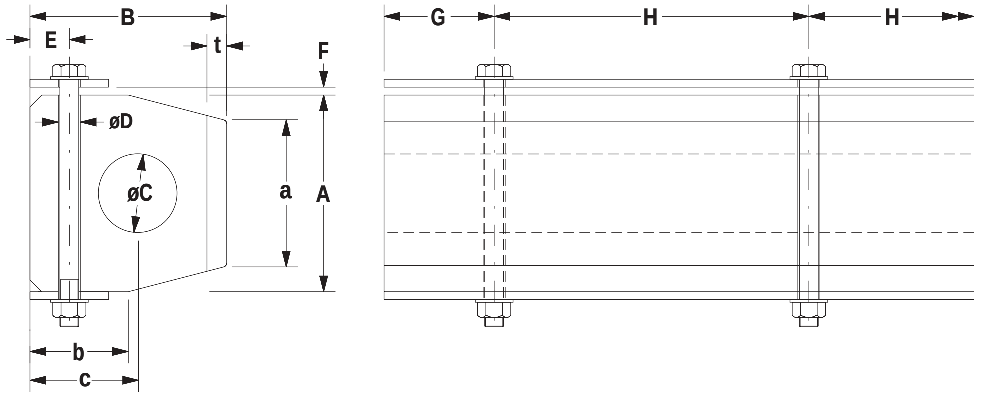
CF-C

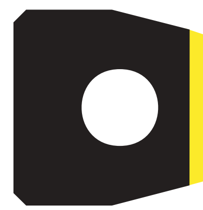
A	B	øC	a	b	c	t	øD	E	F	G	H	Flat Bar	Bolt Size	Std Length	Wt (kg/m)
80	80	42	60	40	44	10	15	25	6	90~130	200~300	45 x6	M12	2000	5.4
100	100	45	74	50	56	10	15	25	8	90~130	200~300	45 x 6	M12	2000	8.4
120	120	62	88	60	67	12	20	30	10	110~150	250~350	60 x 8	M16	2000	12.2
150	150	73	110	75	83	15	20	30	12	110~150	250~350	60 x 8	M16	3000	19.7

CF-D

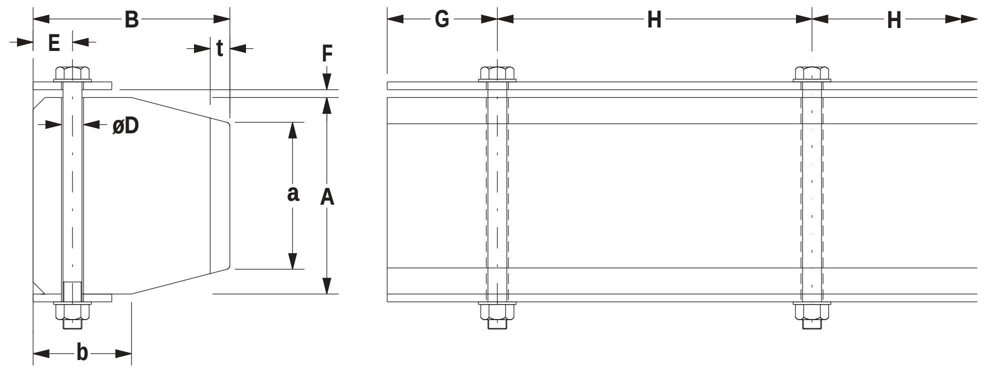
A	B	øC	a	b	c	t	øD	E	F	G	H	Flat Bar	Bolt Size	Std Length	Wt (kg/m)
80	80	–	60	40	44	10	15	25	6	90~130	200~300	45 x 6	M12	2000	7.0
100	100	–	74	50	56	10	15	25	8	90~130	200~300	45 x 6	M12	2000	11.0
120	120	–	88	60	67	12	20	30	10	110~150	250~350	60 x 8	M16	2000	15.8
150	150	–	10	75	83	15	20	30	12	110~150	250~350	60 x 8	M16	3000	24.8

All dimensions are in millimetres



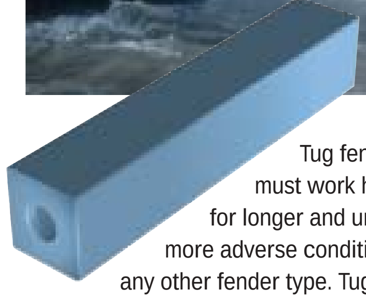


CF-C



CF-D

Tug Fenders



Tug fenders must work harder, for longer and under more adverse conditions than any other fender type. Tugs may be fitted with up to four types of fenders – each serving a particular function.

1 Cylindrical Fenders
Fitted to the bow and/or stern of tugs and usually used for pushing against flared hulls and in open sea conditions.

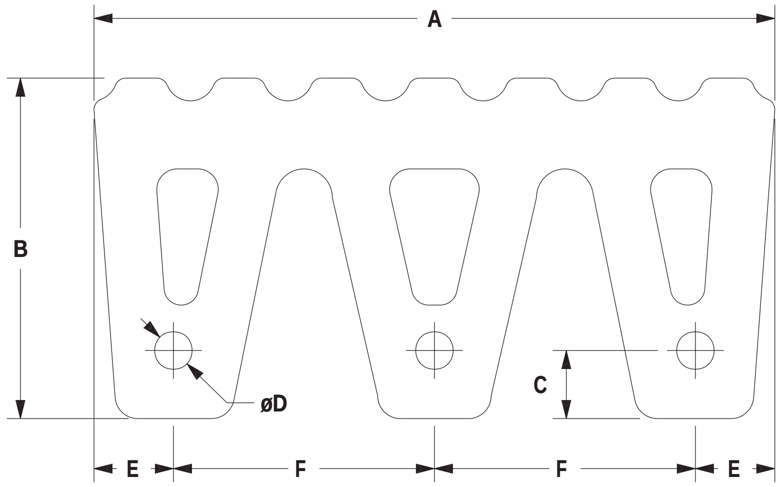
2 Pushing Fenders
Block, Cube and M-Fenders provide a large contact surface for low hull pressures. The grooved surface provides exceptional grip.

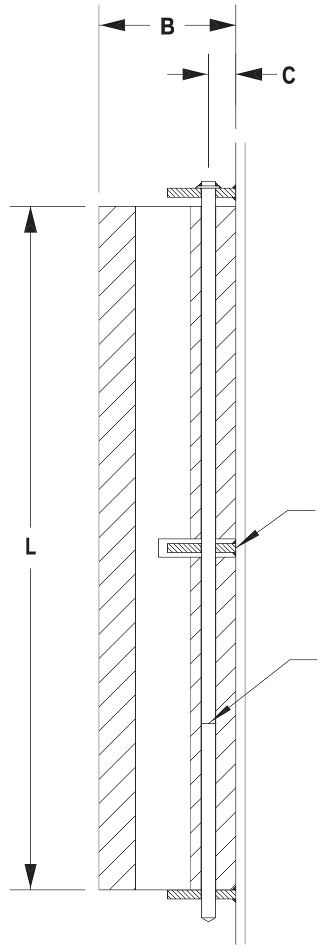
3 Side Beltings
D-Fenders, Square Fenders and Wing-D are often used as side beltings to protect the vessel during escort duties and when coming alongside.

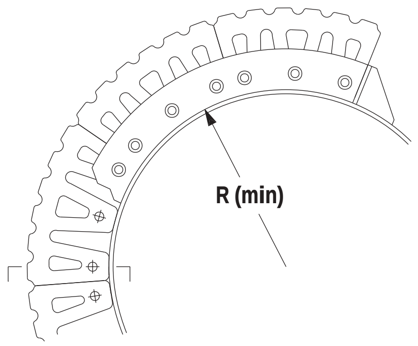
4 Transition Blocks
Transition Blocks are used to provide a smooth interface between side beltings and bow/stern fenders.

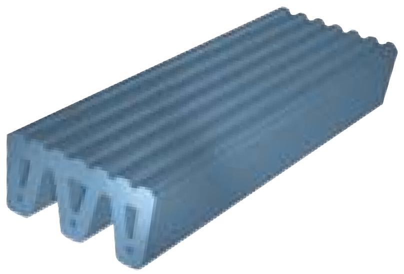
M-FENDERS

M-fenders are also used for pushing. They provide a large flat contact face for very low hull pressures – useful when working with soft hulled ships such as tankers and bulk carriers. The grooved profile gives extra grip and the M-fender can easily be mounted around on straight sections and fairly small radii at the bow and stern quarters of a tug.

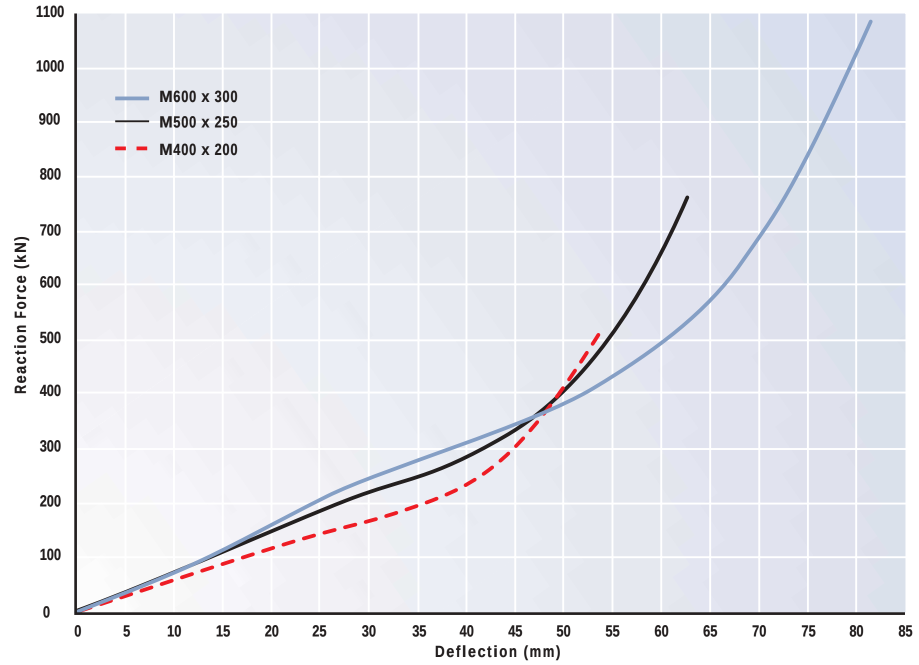






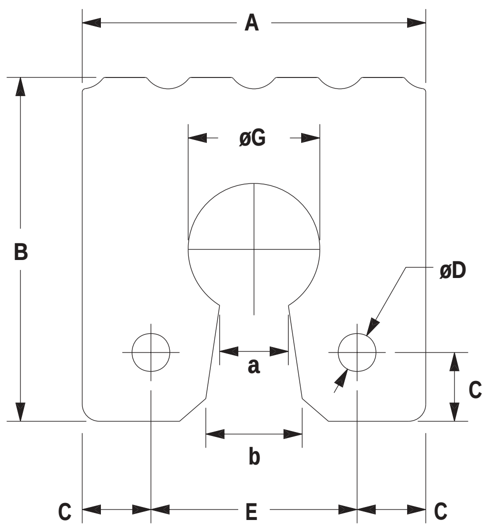


GENERIC PERFORMANCE CURVE (FOR REACTION)



A (mm)	B (mm)	C (mm)	øD (mm)	E (mm)	F (mm)	øP (mm)	L(max) (mm)	Flat Bar (mm)	R(min) (mm)	Weight (kg/m)
400	200	40	23	50	150	20	2000	100 x 15	450	56
500	250	50	27	60	190	24	2000	125 x 20	550	89
600	300	60	33	70	230	30	2000	150 x 20	650	132

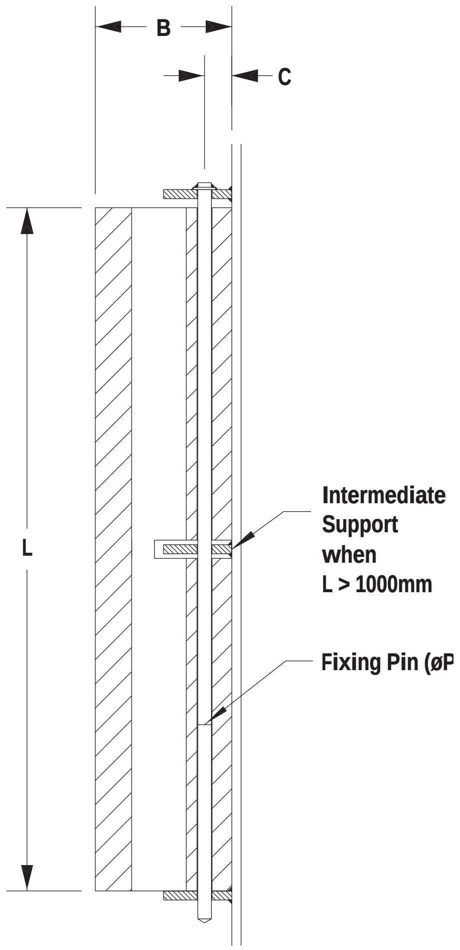
BLOCK FENDERS

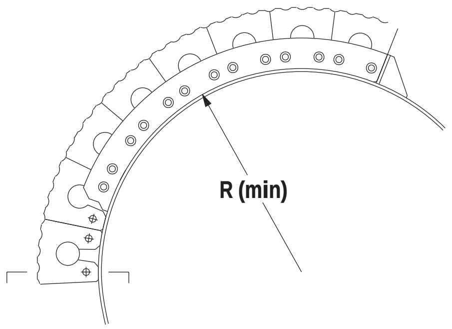


Block and Cube fenders are used as an alternative to M-fenders where extremely heavy loads are expected. Their 'keyhole' cross-section is very tough, but can again be curved around the hull of tugs if required.

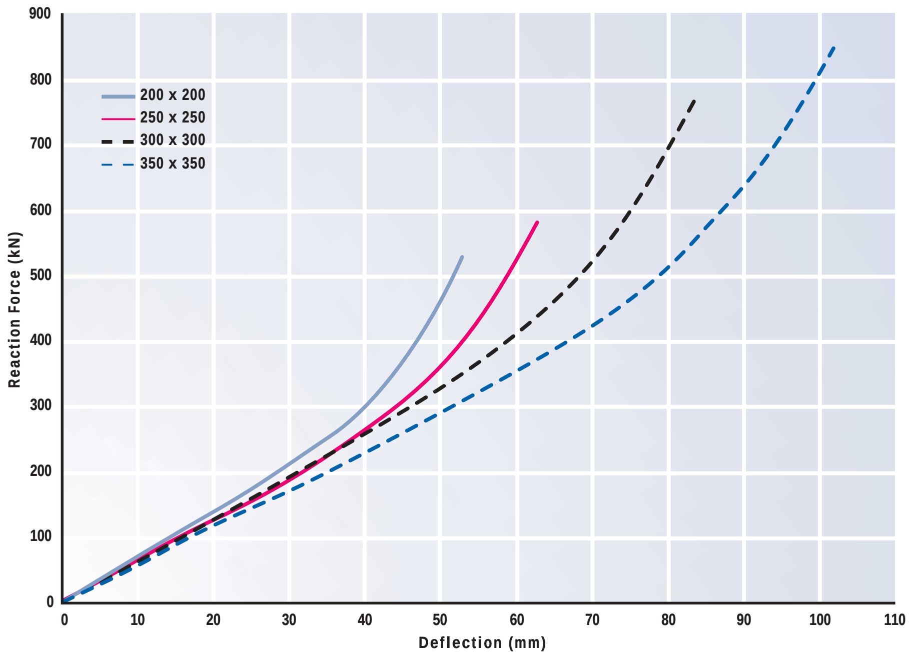
A grooved, high grip profile is supplied as standard, but block fenders are also available with a flat face. Another option is the Composite Block fender which has an integral UHMW-PE low-friction face – these are useful when tugs operate largely in open water or in large sea swells.

A (mm)	B (mm)	C (mm)	øD (mm)	E (mm)	øG (mm)	øP (mm)	L(max) (mm)	Flat Bar (mm)	R(min) (mm)	Weight (kg/m)
200	200	35	28	130	90	25	2000	100 x 15	450	33
250	250	50	33	150	100	30	2000	125 x 20	600	54
300	300	60	33	180	115	30	1750	150 x 20	800	80
350	350	70	33	210	125	30	2000	175 x 25	1000	114

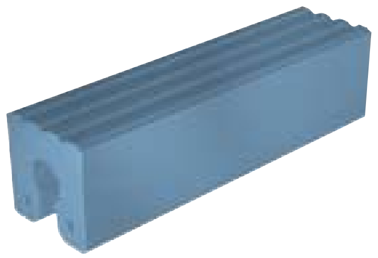




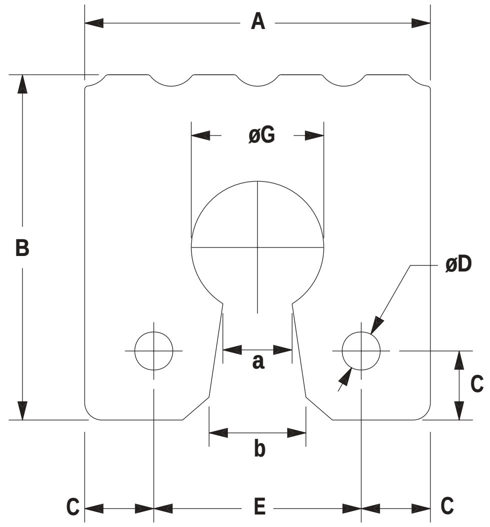
GENERIC PERFORMANCE CURVE (FOR REACTION)



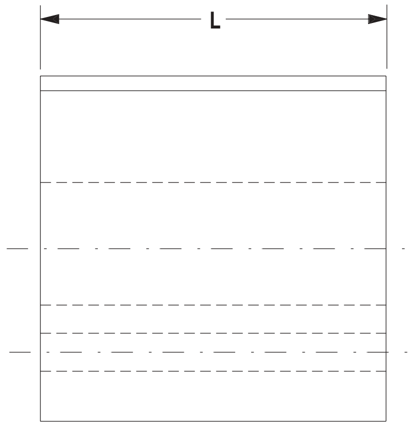
Standard tolerances apply.



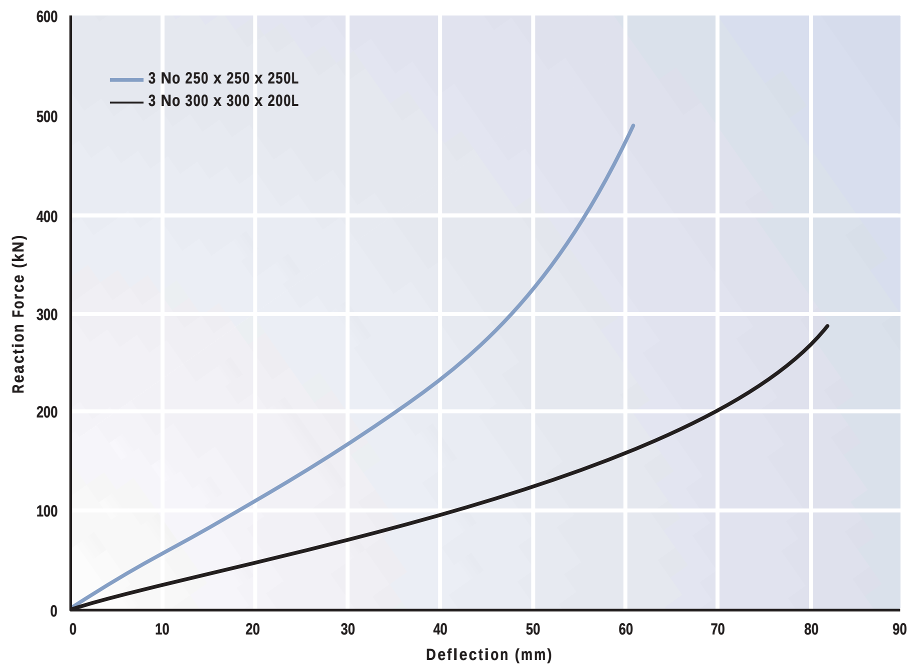
CUBE FENDERS



A (mm)	B (mm)	C (mm)	øD (mm)	F (mm)	øG (mm)	øP (mm)	L (mm)	Weight (kg each)
250	250	50	28 or 33	150	100	25 or 30	250	13
300	300	60	28 or 33	180	115	25 or 30	200	16



GENERIC PERFORMANCE CURVE (FOR REACTION)

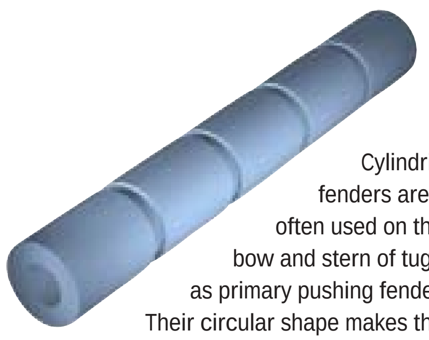


Standard tolerances apply.

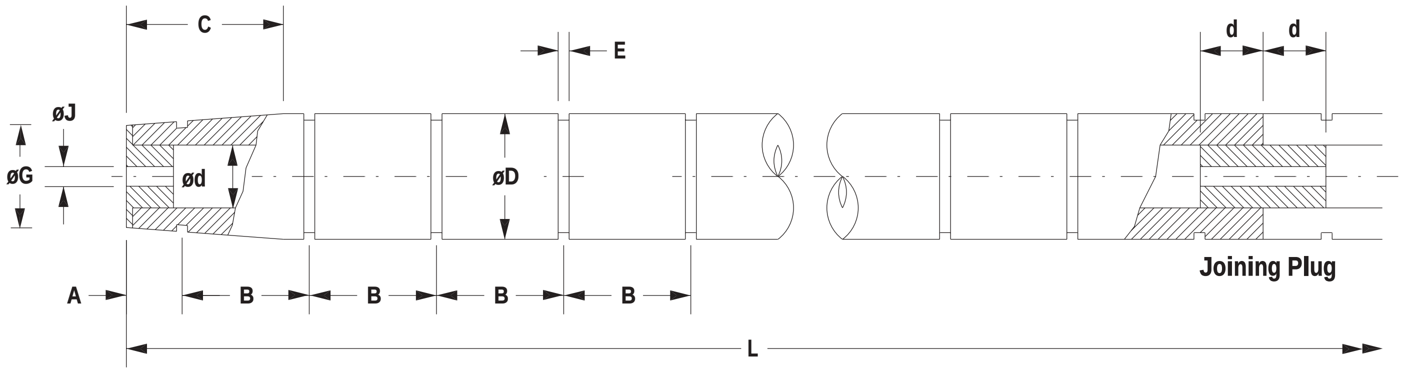
CORNER PROTECTION

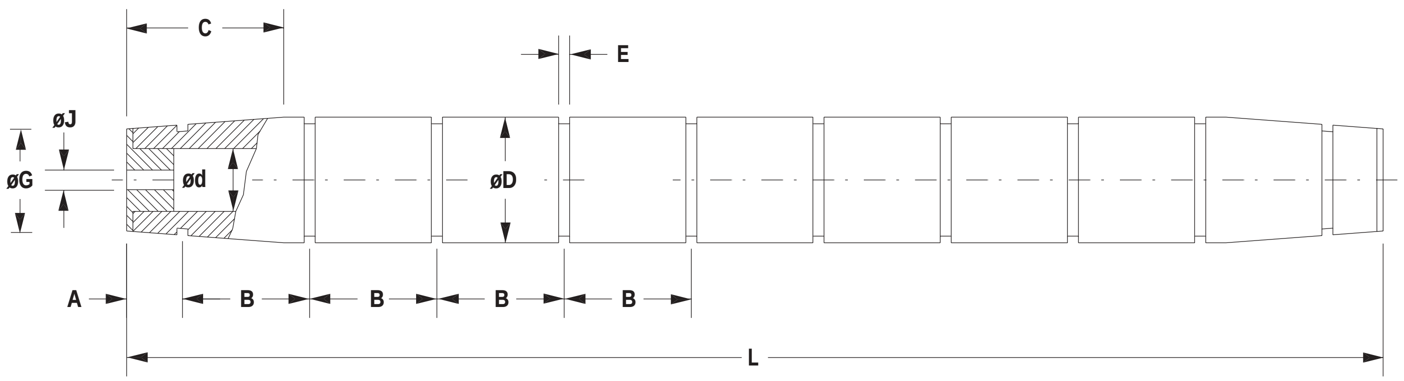
Block and M-Fenders are also useful for corner protection on jetties and pontoons.

BOW & STERN CYLINDRICAL FENDERS



Cylindrical fenders are often used on the bow and stern of tugs as primary pushing fenders. Their circular shape makes them ideal when working with large bow flares such as container ships, but they are equally suited to pushing flat sided vessels. Available in diameters of up to 1000mm and in very long lengths, Cylindricals are fitted to the tug hull with a longitudinal chain running down the fender bore. On larger fenders, these chain are supplemented by circumferential restraints – either sleeved chains or webbing straps – which sit in special grooves moulded into the fender body at intervals along its length. The ends of the Cylindrical fenders can be tapered to help fair them into the hull.





TUG CYLINDRICAL FENDERS

øD	200	250	300	350	400	500	600	700	800	900	1000
L	**2~13 metres in one section or joined for longer lengths**										
A	150	200	225	250	300	300	350	350	350	350	350
B(max)	530	570	600	630	670	730	800	860	930	1000	1060
C	500	500	700	800	800	900	900	1000	1000	1100	1200
E	**Varies in width according to size and type of circumferential attachment**										
øG	150	190	225	260	300	375	450	525	600	675	750
ød	100	125	150	175	200	250	300	350	400	450	500
øj	75	75	75	100	100	100	125	125	125	150	150

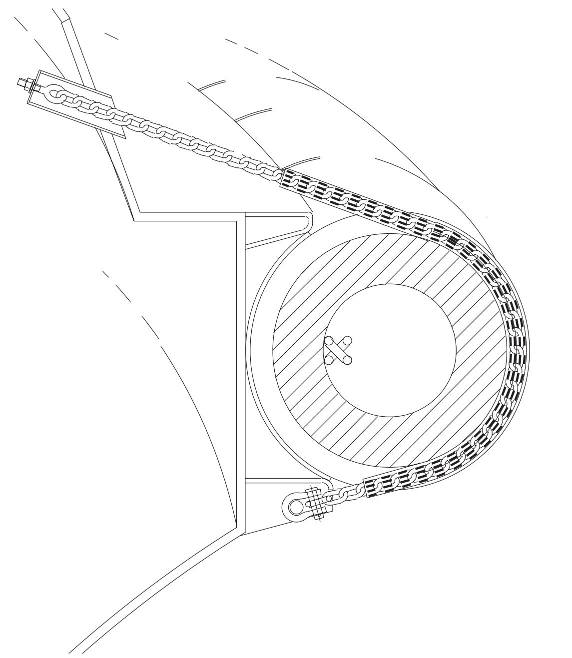
All dimensions in millimetres

ATTACHMENT METHODS

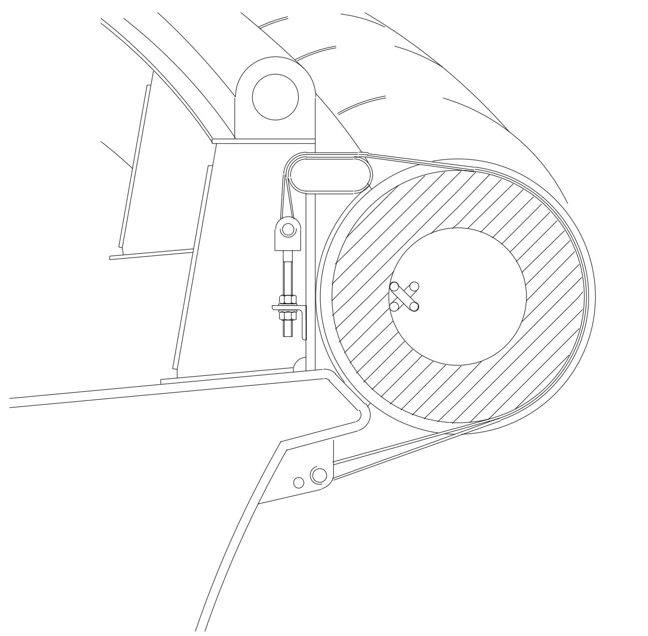
Various attachment methods are used for securing cylindrical fenders to the hull. Smaller cylindrical fenders up to 500mm diameter are usually fixed using a longitudinal chain running down the bore of the fender, which is connected back to the hull with turnbuckles to tension the chain.

Larger cylindrical fenders also use a longitudinal chain down the bore, but this is generally supplemented by circumferential chains or straps which assist in holding the fender into the vessel bulwark.

SLEEVED CHAIN

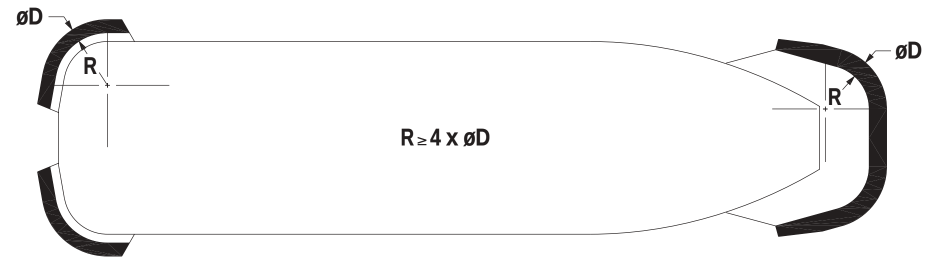


WEBBING STRAP

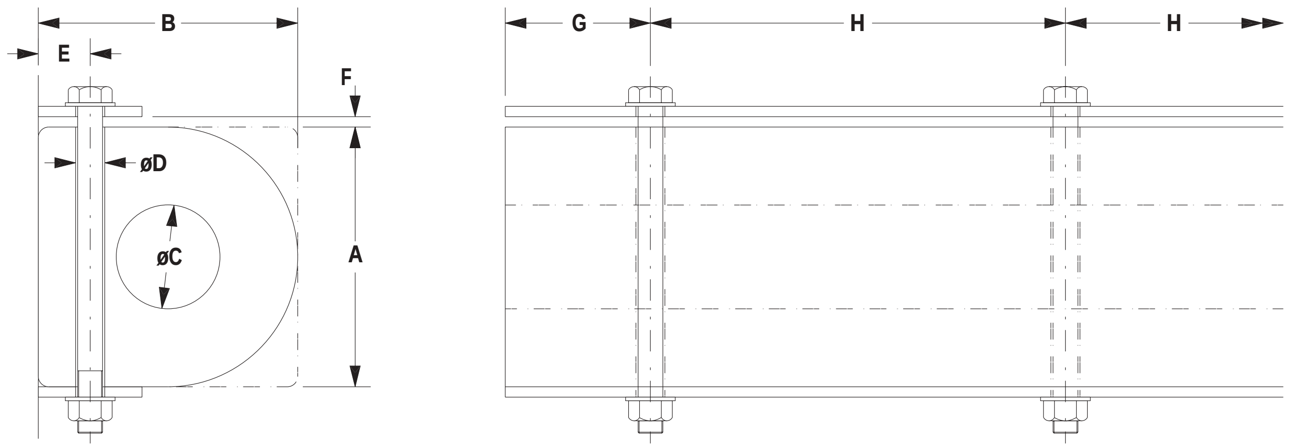


CURVE RADIUS

Tug Cylindrical Fenders are produced in straight lengths but can be pulled around radiused hulls provided that the inside radius is at least four times the outside diameter of the fender. Where the radius is smaller than this, please consult Fentek for advice.



ATTACHMENT METHODS – DC & SC FENDERS



FIXING DIMENSIONS

DC-FENDERS

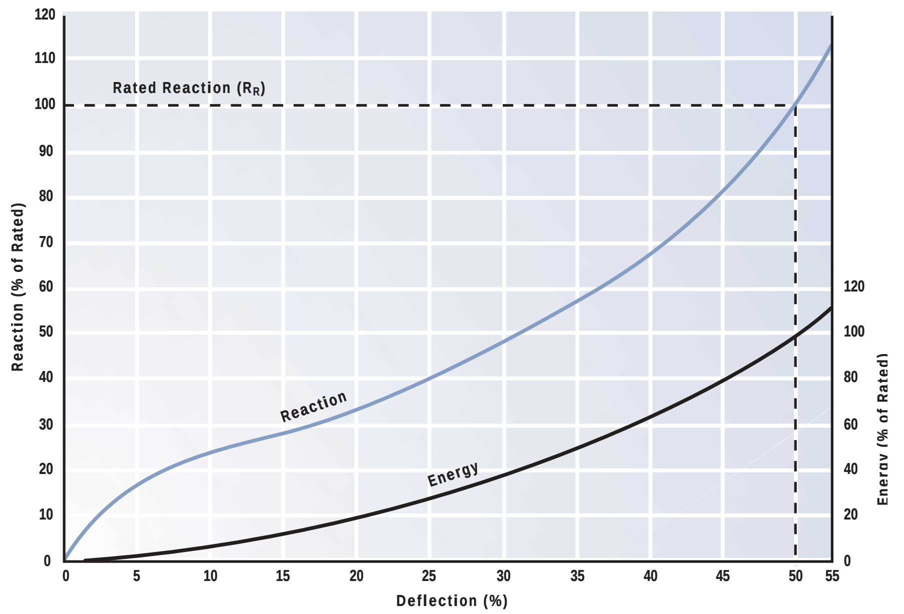
A	B	øC	øD	E	F	G	H	Flat Bar	Bolt Size	Weight
100	100	30	15	25	10	90~130	200~300	50 x 6	M12	9.6
150	150	65	20	30	12	110~150	250~350	60 x 8	M16	19.5
200	200	75	25	45	15	130~180	300~400	80 x 10	M20	36.5
250	250	100	30	50	20	140~200	350~450	100 x 10	M24	55.8
300	300	125	30	60	25	140~200	350~450	110 x 12	M24	79.3
350	350	150	35	70	25	140~200	350~450	120 x 12	M30	106.8
400	400	175	35	80	30	140~200	350~450	130 x 15	M30	138.4
400	400	200	35	80	30	140~200	350~450	130 x 15	M30	129.8
500	500	250	45	90	40	150~230	400~500	150 x 20	M36	202.8

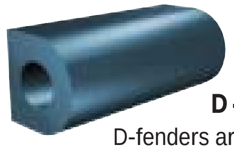
SC-FENDERS

A	B	øC	øD	E	F	G	H	Flat Bar	Bolt Size	Weight
100	100	30	15	25	10	90~130	200~300	50 x 6	M12	10.8
150	150	65	20	30	12	110~150	250~350	60 x 8	M16	22.3
165	125	65	20	30	15	110~150	250~350	60 x 8	M16	20.2
200	200	75	25	45	15	130~180	300~400	80 x 10	M20	41.5
200	200	100	25	40	15	130~180	300~400	80 x 10	M20	37.5
250	200	80	30	45	20	140~200	350~450	90 x 10	M24	52.4
250	250	100	30	50	20	140~200	350~450	100 x 10	M24	63.7
300	250	100	30	50	25	140~200	350~450	100 x 10	M24	78.2
300	300	125	30	60	25	140~200	350~450	110 x 12	M24	90.6
350	350	175	35	70	25	140~200	350~450	120 x 12	M30	114.7
400	400	200	35	80	30	140~200	350~450	130 x 15	M30	149.8
500	500	250	45	90	40	150~230	400~500	150 x 20	M36	234.1

All dimensions in millimetres.

GENERIC PERFORMANCE CURVE





D-FENDERS

D-fenders are widely used as beltings and protective fenders on many tugs and workboats. D-fenders are available with a circular bore (DC) or as a solid profile (DS), but both share the same flat rear face which makes them easy to install between parallel flat bars or angles with transverse bolt fixings. DC- and DS- fenders can be supplied in long sections with maximum length restricted only by transport and handling limitations. They can be cut to length, angle cut at the ends, drilled or pre-curved as required for each application.

SQUARE FENDERS

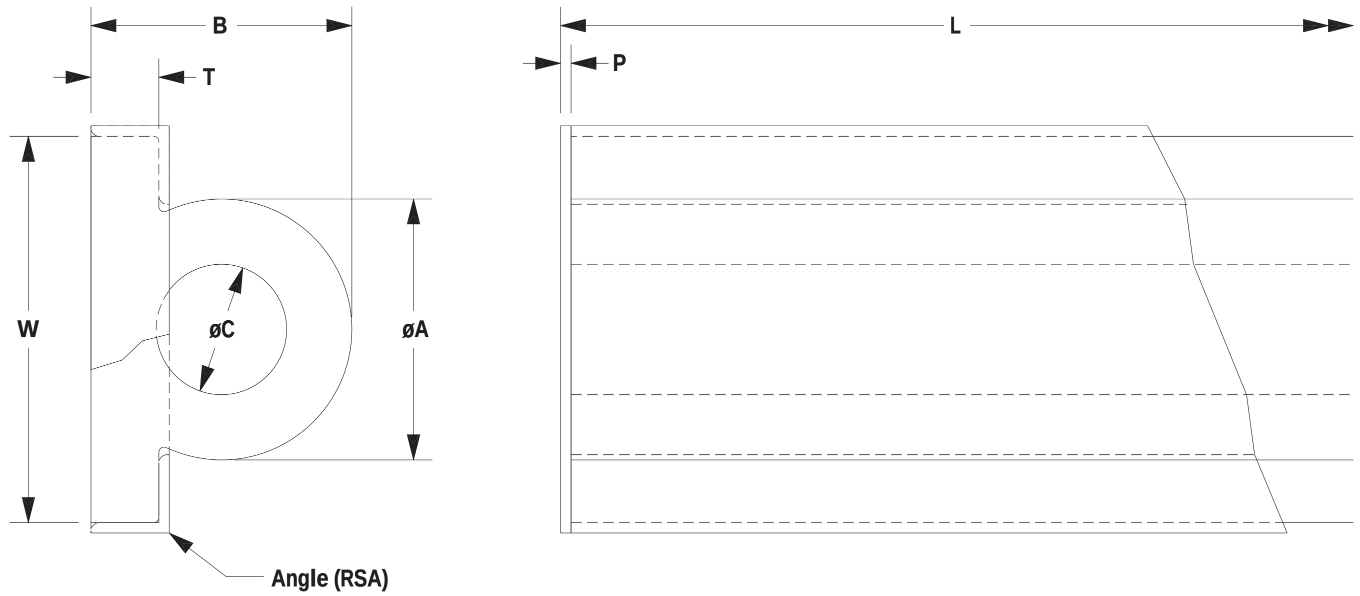
Square fenders offer similar advantages to D-fenders, but are typically used where a stiffer section is required. The square profile gives these fenders heavier shoulders which make them ideal for tougher service environments.

Square fenders are commonly used as beltings and also on the bow or stern of smaller tugs as pushing fenders since they can be fitted closely together to reduce the risk of ropes or protrusions catching between adjacent sections.

Fender Size	E (kNm)	R (kN)	E (kNm)	R (kN)
100	1.9	157	2.7	157
150	4.2	235	6.4	235
200	7.5	314	11.3	314
250	11.7	392	17.7	392
300	16.9	471	25.5	471
350	22.9	549	34.3	589
400	29.4	628	45.1	628
500	46.0	785	70.5	785

Standard tolerances apply.

ATTACHMENT METHODS – WING-D FENDERS

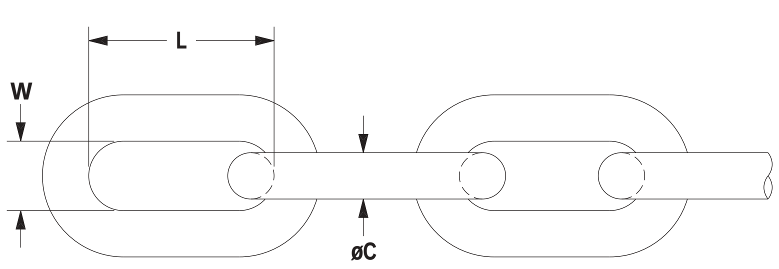


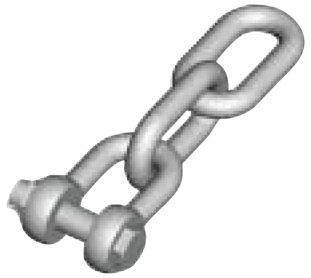
WING-D FENDERS

Wing-D fenders are used as an alternative to other profiles as beltings for tugs and workboats. Instead of drilling the fender, the wings are retained by steel angles. The fenders are forcibly jacked into the angles during installation and joints between adjacent sections are "plugged" to achieve a smooth and continuous contact face. Once fitted, the "wings" sit tightly within the angles making this arrangement very resistant to longitudinal and transverse shear – ideal for tugs performing escort duties and similar applications.

W (mm)	øA (mm)	B (mm)	øC (mm)	T (mm)	P (mm)	RSA (mm)	Weight (kg/m)
180	100	100	50	25	6	40 x 40 x 6	10.5
215	150	150	75	30	6	40 x 40 x 6	20.3
245	150	150	75	30	8	40 x 40 x 8	21.3
280	200	200	100	40	8	50 x 50 x 8	35.8
320	200	200	100	40	8	50 x 50 x 8	37.6
370	250	250	125	50	10	60 x 60 x 8	57.0
410	250	250	125	50	10	60 x 60 x 8	59.4

All dimensions in millimetres

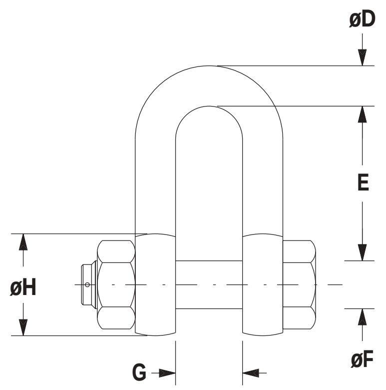


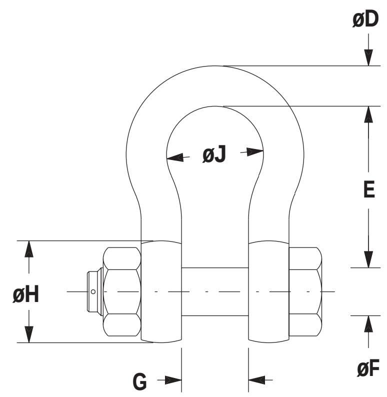


CHAINS

Size	3.0D Links			3.5D Links			4.0D Links			5.0D Links			SL2
øC mm	L mm	W mm	Weight kg/link	L mm	W mm	Weight kg/link	L mm	W mm	Weight kg/link	L mm	W mm	Weight kg/link	MBL kN
18	54	23	0.4	63	25	0.4	72	25	0.5	90	25	0.5	192
20	60	26	0.5	70	28	0.6	80	28	0.6	100	28	0.7	264
22	66	29	0.7	77	31	0.8	88	31	0.8	110	31	1.0	304
24	72	31	0.9	84	34	1.0	96	34	1.1	120	34	1.3	362
26	78	34	1.2	91	36	1.3	104	36	1.4	130	36	1.6	424
28	84	36	1.4	98	39	1.6	112	39	1.7	140	39	2.0	492
30	90	39	1.8	105	42	2.0	120	42	2.1	150	42	2.5	566
32	96	42	2.2	112	45	2.4	128	45	2.6	160	45	3.0	644
34	102	44	2.6	119	48	2.9	136	48	3.1	170	48	3.6	726
36	108	47	3.1	126	50	3.4	144	50	3.7	180	50	4.2	814
38	114	49	3.6	133	53	4.0	152	53	4.3	190	53	5.0	900
40	120	52	4.2	140	56	4.6	160	56	5.0	200	56	5.8	1010
42	126	55	4.9	147	59	5.4	168	59	5.8	210	59	6.8	1110
44	132	57	5.6	154	62	6.2	176	62	6.7	220	62	7.8	1220
46	138	60	6.4	161	64	7.1	184	64	7.7	230	64	8.9	1330
48	144	62	7.3	168	67	8.0	192	67	8.7	240	67	10.1	1450
50	150	65	8.2	175	70	9.1	200	70	9.8	250	70	11.4	1570

All dimensions in millimetres.





SHACKLES

		D-Type						Bow Type						
øC mm	øD mm	E mm	øF mm	G mm	øH mm	MBL kN	Weight kg each	E mm	øF mm	G mm	øH mm	øJ mm	MBL kN	Weight kg each
16	16	51	20	27	40	128	0.7	60	20	27	40	42	128	0.7
18	19	60	22	32	44	190	1.1	71	22	32	44	51	190	1.3
19~20	22	71	25	37	50	255	1.5	84	25	37	50	58	255	1.7
22	25	81	30	43	60	335	2.6	95	30	43	60	68	335	2.8
24	28	90	32	46	64	375	3.4	108	32	46	64	74	375	3.8
26	32	100	35	52	70	470	4.8	119	35	52	70	83	470	5.0
28	35	111	38	57	76	530	6.2	132	38	57	76	89	530	7.3
30~32	38	122	42	60	84	670	7.6	146	42	60	84	98	670	7.8
34~38	44	146	50	73	100	980	13.0	178	50	73	100	110	980	14.0
40~46	50	171	56	83	112	1375	18.2	197	56	83	112	120	1375	20.0
48~50	56	180	65	95	130	1770	27.8	235	65	95	130	130	1770	30.0
—	64	203	70	105	140	2160	35.0	267	70	105	140	150	2160	41.0
—	76	216	82	127	164	3340	60.0	330	82	127	164	170	3340	65.5
—	89	266	95	133	190	4710	93.0	371	95	133	190	200	4710	110
—	102	305	108	140	216	5890	145	371	108	140	216	240	5890	153
—	110	360	121	184	242	7848	180	394	121	184	242	280	7848	210
—	120	390	130	216	260	9810	225	508	130	216	260	305	9810	260

All dimensions in millimetres.

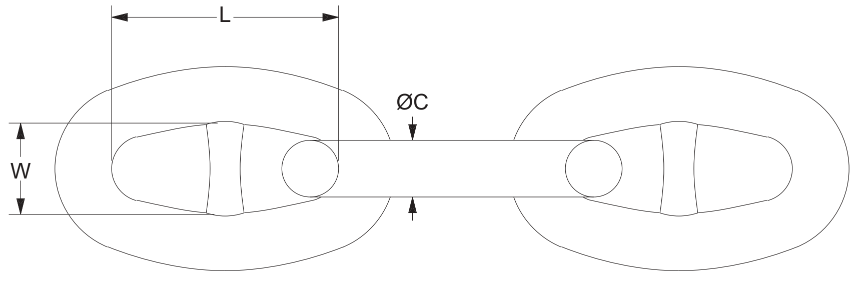
CHAINS & ACCESSORIES

Chains are used for two reasons – to suspend/support the fender or to control the deflection geometry during horizontal or vertical shear (see Fender Design section). Open link and stud link chains are available in various strength grades. Open link chains can also be supplied with different link lengths from 3D to 5D to suit each specific design.

Shackles and other accessories are all referenced to the nominal chain diameter (øC) for equivalent strength and typically of larger diameter material. However, it is common to use shackles the same size as the SL2 grade open link chain to provide an easily replaceable "weak link" in the system.

Chain properties are based on Bureau Veritas rules (Table 10-II for stud link and table 10-III fpr open link), which are generally similar to Lloyds and ASB standards. However, chains can also be supplied to many other international standards such as DIN, BS and JIS if preferred.

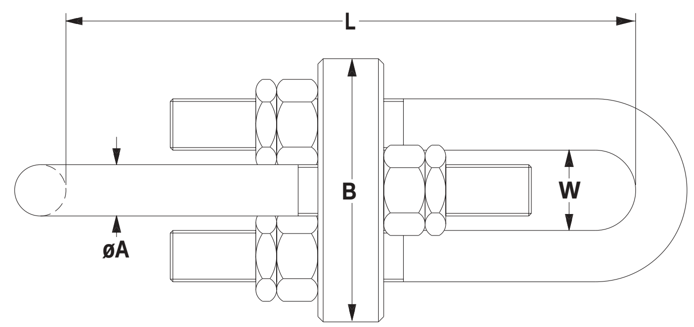
Chains are an important component of a fender system and require careful design. Please ask Fentek for further advice on selecting and specifying chains.



STUD LINK

Size	Common Link			MBL	
øC mm	L mm	W mm	Weight kg/link	SL2 (U2) kN	SL3 (U3) kN
16	64	26	0.4	150	216
19	76	30	0.6	211	301
22	88	35	1.0	280	401
24	96	38	1.3	332	476
26	104	42	1.6	389	556
28	112	45	2.0	449	642
30	120	48	2.5	514	735
32	128	51	3.0	583	833
34	136	54	3.6	655	937
36	144	58	4.2	732	1050
38	142	61	4.9	812	1160
40	160	64	5.8	896	1280
42	168	67	6.7	981	1400
44	176	70	7.7	1080	1540
46	184	74	8.8	1170	1680
48	192	77	10.1	1280	1810
50	200	80	11.3	1370	1960

All dimensions in millimetres.

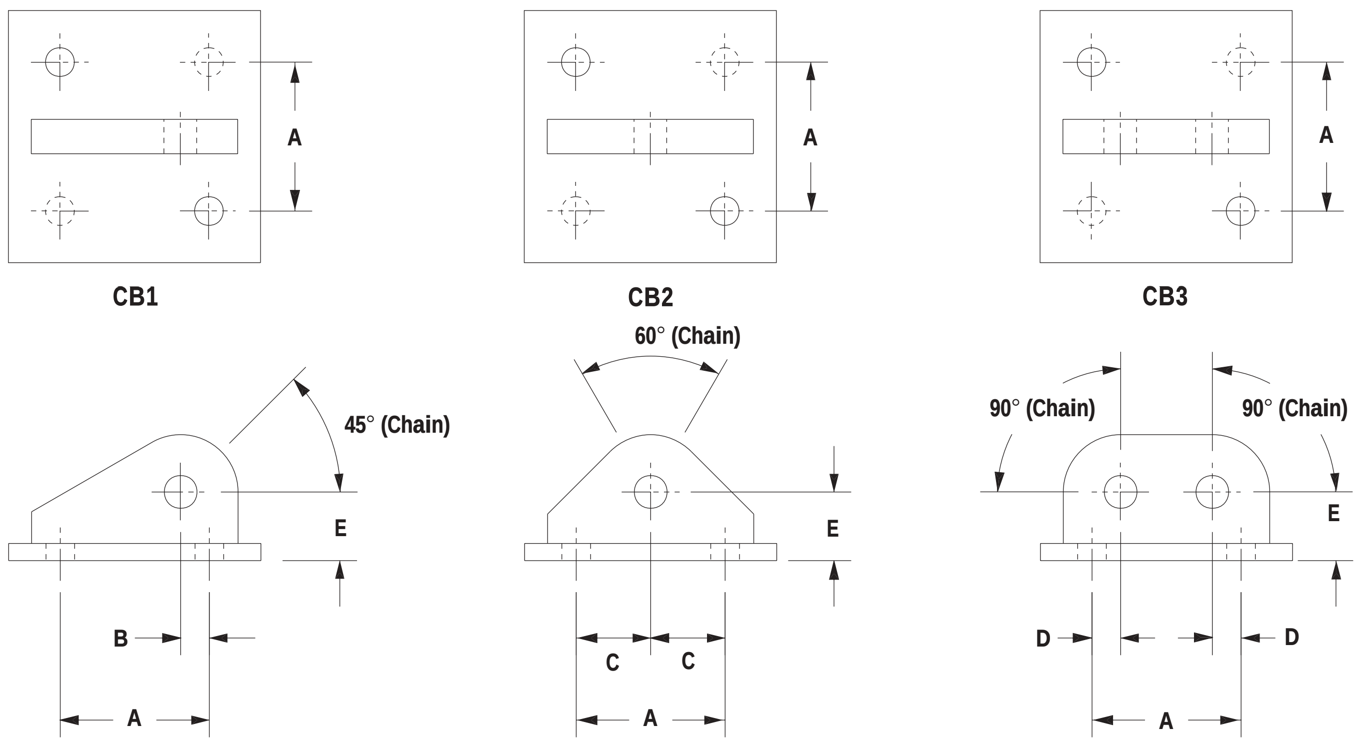


CHAIN TENSIONER

øC mm	øA mm	B mm	W mm	Weight kg each	L mm
18~24	24	160	60	9	270~350
26~30	30	200	76	17	340~420
32~36	36	230	90	27	400~500
38~42	42	270	106	44	470~600
44~48	48	300	120	63	540~680
—	56	350	140	96	620~800
—	64	400	160	146	700~900

All dimensions in millimetres.

CHAIN BRACKETS



øC mm	A mm	B mm	C mm	D mm	E mm	Anchor mm	Types CB1 & CB2 kg each	Type CB3 kg each
18	110	15	55	15	55	2/4 M20	6	7
20	110	15	55	15	55	2/4 M20	6	7
22	130	20	65	20	60	2/4 M20	9	10
24	130	20	65	20	60	2/4 M20	9	10
26	150	25	75	25	70	2/4 M24	14	16
28	160	25	80	25	80	2/4 M24	18	21
30	160	25	80	25	80	2/4 M24	18	21
32	190	35	95	35	90	2/4 M30	30	32
34	190	35	95	35	90	2/4 M30	30	32
36	210	35	105	35	95	2/4 M30	35	39
38	220	35	110	35	110	2/4 M36	47	53
40	220	35	110	35	110	2/4 M36	47	53
42	250	40	125	40	115	2/4 M36	61	69
44	260	40	130	40	120	2/4 M36	67	78
46	260	40	130	40	120	2/4 M42	67	78

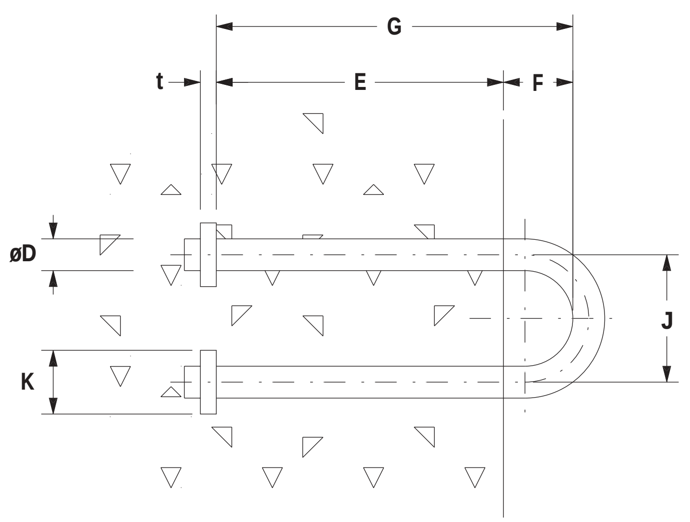
All dimensions in millimetres.

CHAIN BRACKETS

Chain brackets are often designed on a project by project basis to suit the chain system and load combinations. Type CB1 brackets are generally used for shear and weight support chains, Type CB2 are usually used with tension chains and Type CB3 are used to simultaneously connect weight and tension chains.

All brackets are designed with either two or four anchor holes as required to suit the applied loads. Larger holes (for bigger anchors), different hole positions and orientations are all possible – please ask Fentek for details.

U-ANCHORS



øC mm	øD mm	E mm	F mm	G mm	J mm	K mm	t mm	Weight kg each
18	26	260	60	320	104	50	12	3.4
20	30	300	70	370	120	50	15	5.1
22	34	340	70	410	136	60	15	7.3
24	36	360	70	430	144	60	20	8.6
26	38	380	90	470	152	70	20	10.7
28	42	420	90	510	168	70	20	13.7
30	44	440	100	540	176	80	20	16.1
32	48	480	100	580	192	80	25	20.5
34	50	500	110	610	200	90	25	23.7
36	54	540	120	660	216	90	30	29.7
38	56	560	120	680	224	100	30	33.4
40	60	600	130	730	240	110	30	41.1
42	62	620	130	750	248	110	30	44.7
44	66	660	140	800	264	120	35	54.8
46	68	680	150	830	272	120	35	59.6
48	72	720	160	880	288	130	35	70.9
50	74	740	160	900	296	130	40	76.9

All dimensions in millimetres.

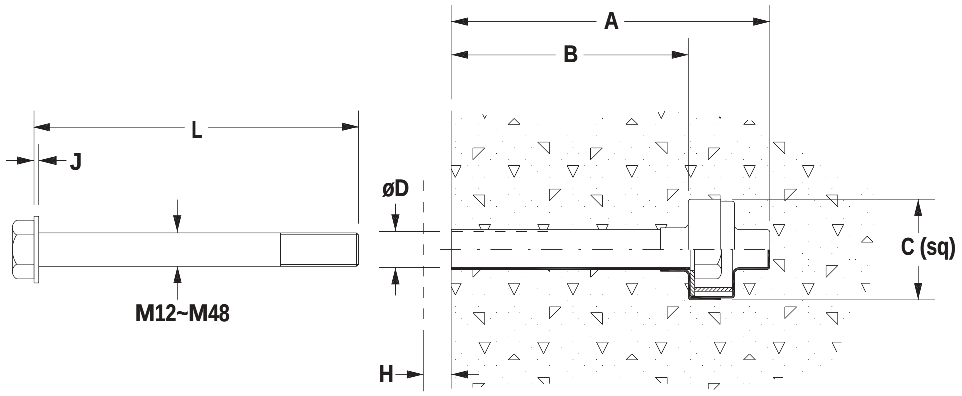
INTRODUCTION

Fenders rely on good anchoring systems and Fentek provides a range of anchors to suit both new and existing structures in either galvanised finish or stainless steel. Non-standard sizes and materials are also available for special applications – please ask Fentek for further details.

CLA ANCHORS

CLA anchors have a high strength plastic housing which insulates against steel to steel contact between the anchor and reinforcement bars. The captive nut is set well into the concrete where it is better protected against corrosion. The cast-in body is light weight so can be economically air freighted if necessary.

A temporary protective cap keeps the housing free from debris until the fenders are ready to install.



CLA	M10	M12	M16	M20	M24	M30	M36	M42	M48
A	131	131	131	152	187	288	344	388	444
B	95	95	95	115	140	200	256	300	356
C(sq)	36	36	36	36	43	109	109	109	109
øD	17	17	17	21	25	39	39	52	52
G	110	110	110	140	170	240	300	350	410
H	clamping thickness of fender or bracket								
J	2	2.5	3	3	4	4	5	7	8
L	= G + H + J (rounded up to nearest 5mm)					= G + H + J (rounded up to nearest 10mm)			

All dimensions in millimetres.

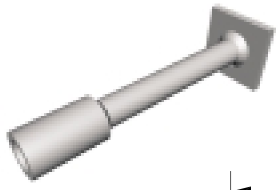
INSTALLATION ADVICE

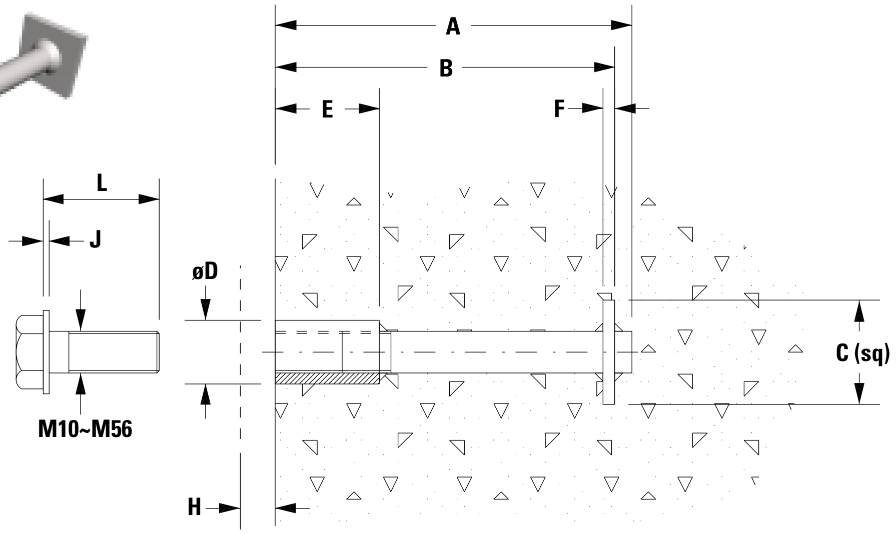
To ensure the best quality installation and longest service life, certain points should be noted when specifying or fitting anchor systems:-

- Embedment depths indicated (dimension "B") are based on reinforced 30N concrete with adequate edge and anchor-to-anchor distances.
- Fenders do not generally apply tension to anchors, but large tensile and/or shear forces may be imposed on chain bracket anchors and some other connections. Anchor diameter, grade and embedment should be checked for each application.
- Galvanised threads should be lubricated with a polysulphide grease or similar non-drying lubricant before final assembly.
- Stainless steel threads should be treated with an anti-galling paste prior to final assembly. To prevent loosening from vibration, a lock nut should be used or the bolt head tack welded to the washer.
- Grouts should be specified to suit local temperatures. Curing times may be much longer below 5°C and may be impractically short above 30°C. Special grouts are available for extreme climates and for damp or underwater applications.

NC3 ANCHORS

The NC3 is a traditional cast-in anchor design with threaded female ferrule, tail and square anchor plate. Available in standard sizes from M10 to M56, larger NC3 anchors (M64 and above) can be made to order. NC1 "L-tail" and EC1 retrofit versions are also available on request for special applications. Please ask for details.





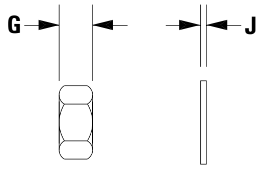
NC3 ANCHORS

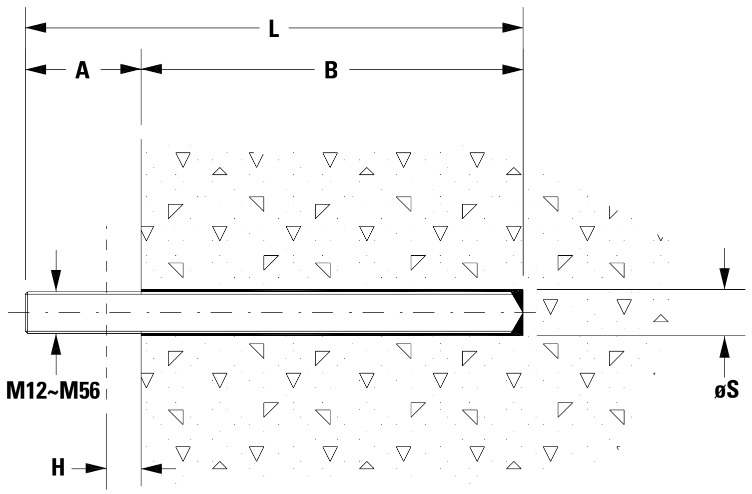
NC3	M10	M16	M20	M24	M30	M36	M42	M48	M56
A	117	152	198	240	300	308	397	408	420
B	104	139	180	220	278	283	370	377	389
C(sq)	30	40	60	70	80	90	100	120	130
øD	20	25	30	35	45	55	65	75	85
E	25	40	50	60	75	90	105	120	140
F	5	5	8	8	10	10	12	16	16
G	11~14	18~23	22~28	27~34	33~42	40~51	47~59	53~68	62~79
H	clamping thickness of fender or bracket								
J	2	3	3	4	4	5	7	8	9
L	= G + H + J (rounded up to nearest 5mm)					= G + H + J (rounded up to nearest 10mm)			

All dimensions in millimetres.

EC2 ANCHORS

The EC2 anchor is used for fixing fenders to existing concrete and where cast-in anchors are unsuitable. After drilling the concrete, the anchor is installed using epoxy or polyester grout capsules as standard. Injected grout systems and cementitous grouts (for larger anchor sizes) are available on request.

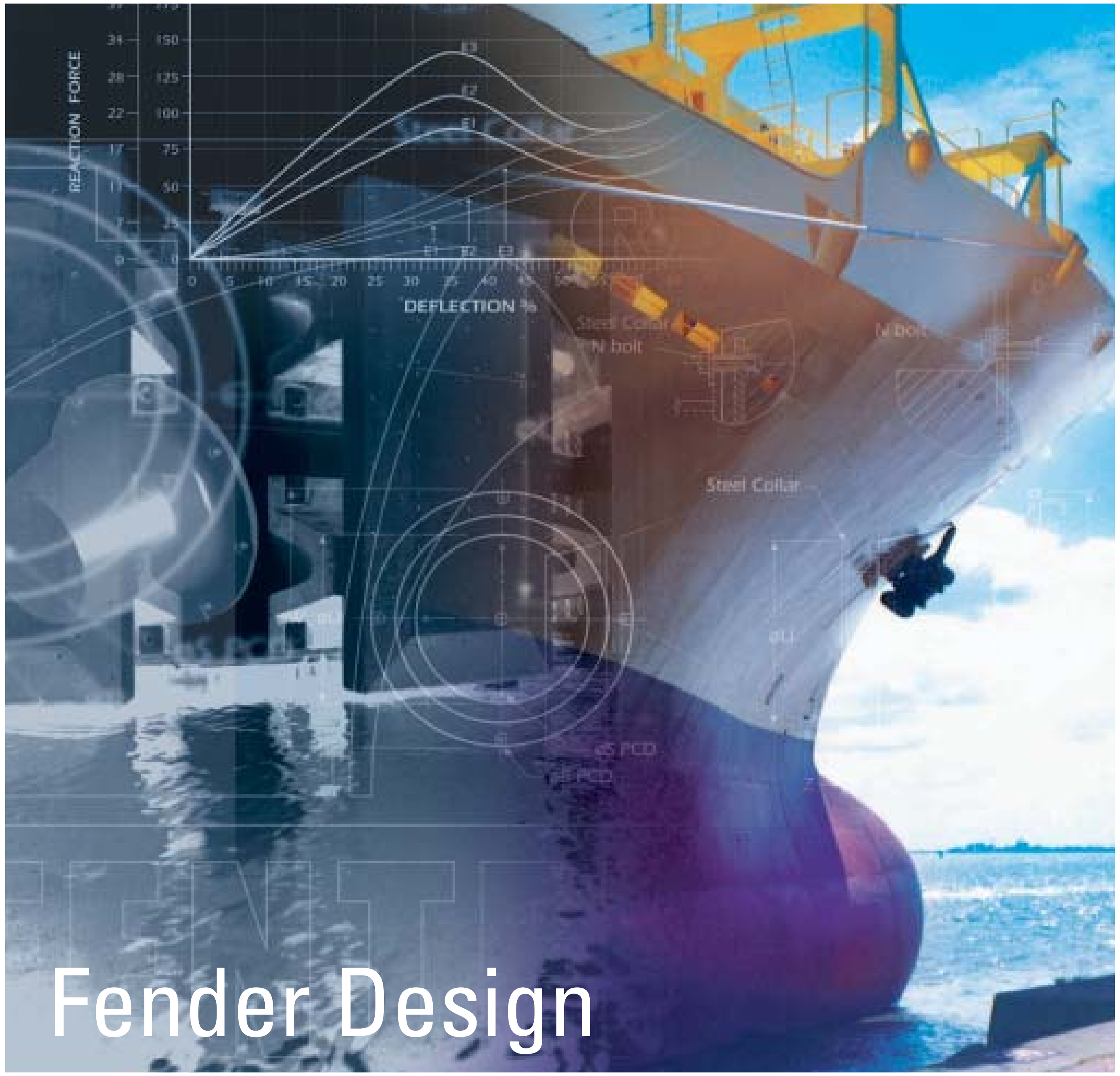




EC2 ANCHORS

EC2	M12	M16	M20	M24	M30	M36	M42	M48	M56
A	= E +G + H + J (rounded up to nearest 10mm)								
B	110	140	170	210	280	330	420	480	560
E	5~8	6~9	6~9	8~12	8~12	10~15	14~21	16~24	18~27
G	10	13	16	19	24	29	34	38	45
H		clamping thickness of fender or bracket							
J	2.5	3	3	4	4	5	7	8	9
L	—	175	240	270	360	420	500	580	—
øS	15	20	25	28	35	40	50	54	64
Capsule	1 x C12	1 x C16	1 x C20	1 x C24	1 x C30	1 x C30	2 x C30	2 x C30 1 x C24	4 x C30

All dimensions in millimetres.
Typical ex-stock dimensions for "L" are as indicated. In all cases required length should be checked by calculation.



Fender Design

Fenders must reliably protect ships, structures and themselves – day after day for many years in severe environments with little or no maintenance. Good fender design demands an understanding of ship technology, civil construction methods, steel fabrications, materials, installation techniques and innumerable regulations and codes. This design guide should assist with many of the frequently asked questions which arise during fender design. It is best used in conjunction with suitable international Codes of Practice such as BS_1, EAU_2, $PIANC_3$ and ROM_4 as well as other sources of information. Fentek is always available and willing to assist with every aspect of fender design.

References

Code of Practice for Design of Fendering and Mooring Systems
BS 6349 : Part 4 : 1994 (ISBN 0-580-22653-0)

PIANC WG33 Guidelines for the Design of Fenders : 2002 (ISBN 2-87223-125-0)

Recommendations of the Committee for Waterfront Structures
EAU 1996 7th Edition (ISBN 3-433-01790-5)

Report of the International Commission for Improving the Design of Fender Systems
Supplement to Bulletin No.45 (1984) PIANC

Maritime Works Recommendations – Actions in the Design of Maritime and Harbour Works
ROM 0.2-90 (ISBN 84-7433-721-6)

Ship Dimensions of Design Ship under Given Confidence Limits
Technical Note of the Port and Harbour Research Institute, Ministry of Transport, Japan
No. 911, Sept 1998 (ISSN 0454-4668)

THE DESIGN PROCESS

Many factors contribute to the design of a fender.

SHIPS

Ship design is constantly evolving – their shapes change and many vessel types are getting larger. Fenders must suit current ships as well as those expected to arrive in the foreseeable future.

STRUCTURES

Fenders impose loads onto the berthing structure. Many berths are being built in more exposed locations where fenders can play a crucial role in the overall construction costs. Local practice, materials and conditions may influence the choice of fender.

BERTHING

Many factors will affect how vessels approach the berth, the corresponding kinetic energy and the load applied to the structure. Berthing mode may affect the choice of ship speed and the safety factor for abnormal conditions.

INSTALLATION & MAINTENANCE

Installation of fenders should be considered early in the design process. Accessibility for maintenance may influence choice of materials, wear allowances and the protective coatings specified. The right fender choice may improve turnaround times and reduce downtime. Safety of personnel, structure and vessels must be considered at all stages – before, during and after commissioning.

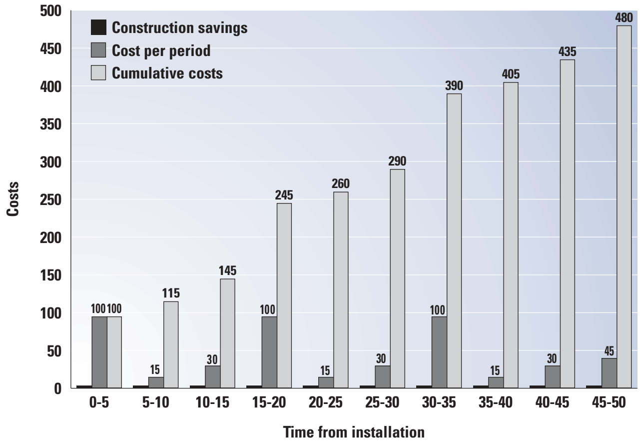
FULL LIFE COSTS

All designers, contractors and operators want the best value for money from their investment in fenders. But when the initial purchase cost of fenders is looked at in isolation, this does not give the full picture.

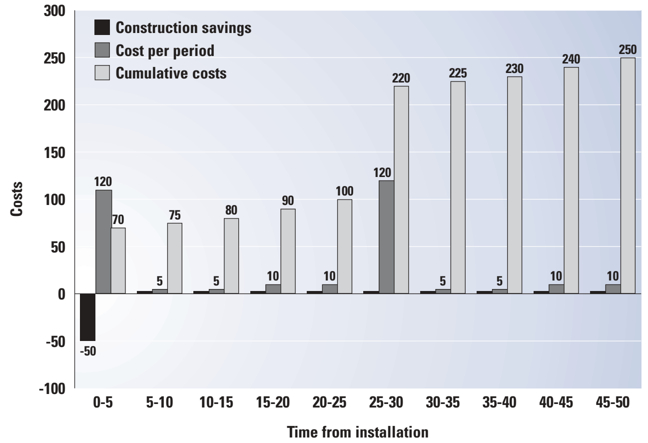
Many structures are designed to last 50 years or more. Depending on the quality of the materials and design, fenders typically last 15-30 years so will need replacing at least once during the lifetime of the berth. Maintenance can also add substantial amounts to the overall costs.

As the following examples show, a high quality and well designed fender system can yield savings from the very beginning.

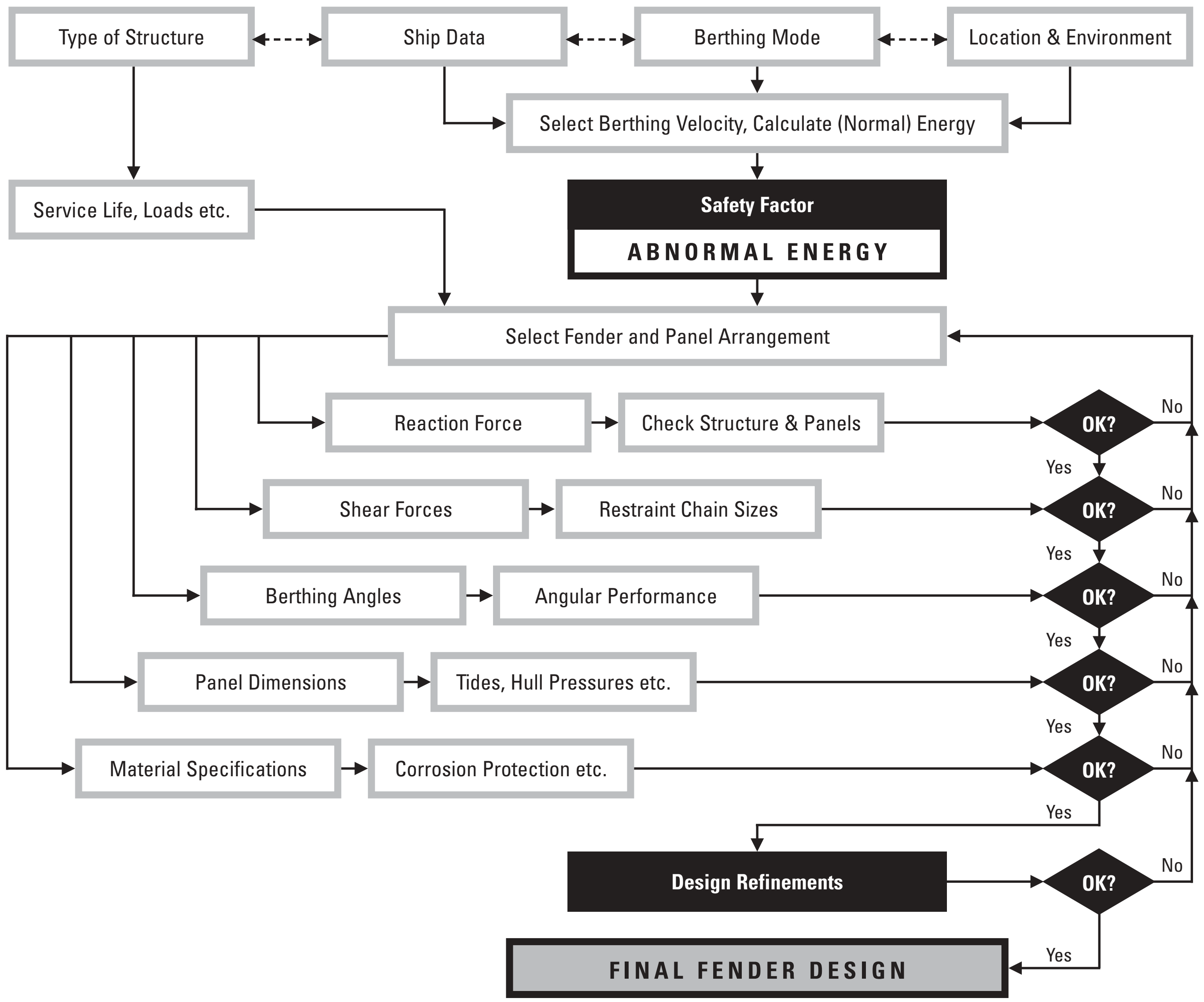
'CHEAPEST' FENDER DESIGN



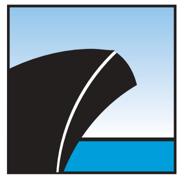
LOWEST 'FULL LIFE COST' DESIGN



DESIGN FLOW CHART



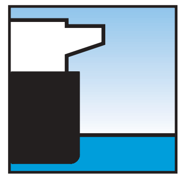
SHIP FEATURES & TABLES



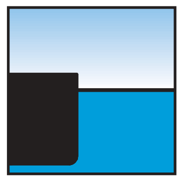
Large bow flares are common on Container and Cruise ships. The flare angle can reduce fender energy capacity. Larger fender projection may be needed to keep vessels clear of the quay face and cranes. Care is also needed when ships have stern flares.

Bulbous bows are a feature of most modern ships. Care is needed when fenders are widely spaced to ensure the bulbous bow cannot catch behind fenders. Also ensure the bulbous bow cannot contact the front row of piles on the structure.

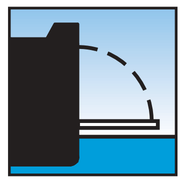
Most ferries, general cargo vessels and many container ships have beltings. These can be intermittent and/or fitted at many levels. Beltings in poor condition can cause fender damage. Belting sections vary – square or half-round are most common.



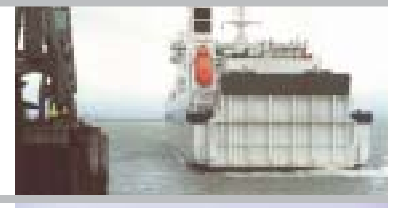
Many RoRo and Cruise ships have a flying bridge. In large tidal zones, care should be taken to ensure these do not sit on top of the fender panel.



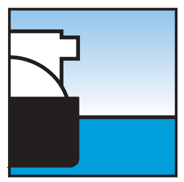
Low freeboard vessels include barges, coastal tankers and some general cargo ships. Ensure that the vessel cannot get caught underneath fenders at very low tides, when fully laden and in poor weather conditions.



Stern doors are common on RoRo ships, often accompanied by various designs of large stern belting. Side doors are fitted to most Car Carriers. These are usually recessed which can snag fenders, especially when negotiating lock entrances.

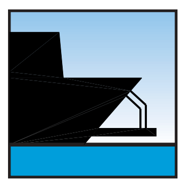


High freeboard ships can be difficult to manoeuvre in strong winds so berthing speeds may be higher. Affected vessels include RoRo, Car Carriers and laden Container ships.



Gas Carriers, Tankers, Bulk Cargo and some other vessels require low hull contact pressures, achieved with large fender panels. Care should be taken when designing for large tidal zones and with 'tilting' fender systems.

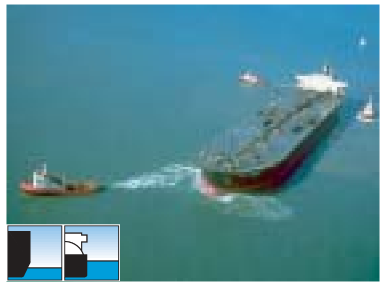
High speed catamarans and monohulls are often built of aluminium, so can only accept limited loads on their belting which may be high above waterline. Care is needed if accommodating high speed and conventional ferries on the same berth.



Protrusions such as 'cow catchers' and other modifications can be prone to snagging on fenders. Large lead-in bevels or continuous fender wall systems may be needed.

ULCC & VLCC TANKERS

dwt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
500,000	590,000	415	392	73.0	24.0	14.5	0.838
400,000	475,000	380	358	68.0	23.0	13.5	0.828
350,000	420,000	365	345	65.5	22.0	12.6	0.824
300,000	365,000	350	330	63.0	21.0	11.7	0.816
275,000	335,000	340	321	61.0	20.5	11.2	0.814
250,000	305,000	330	312	59.0	19.9	10.7	0.812
225,000	277,000	320	303	57.0	19.3	10.2	0.811
200,000	246,000	310	294	55.0	18.5	9.5	0.802
175,000	217,000	300	285	52.5	17.7	8.8	0.799
150,000	186,000	285	270	49.5	16.9	8.2	0.803
125,000	156,000	270	255	46.5	16.0	7.5	0.802
100,000	125,000	250	236	43.0	15.1	6.8	0.796
80,000	102,000	235	223	40.0	14.0	6.0	0.797
70,000	90,000	225	213	38.0	13.5	5.6	0.804
60,000	78,000	217	206	36.0	13.0	5.3	0.789



PRODUCT AND CHEMICAL TANKERS

dwt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
50,000	66,000	210	200	32.2	12.6	5.0	0.793
40,000	54,000	200	190	30.0	11.8	4.5	0.783
30,000	42,000	188	178	28.0	10.8	3.9	0.761
20,000	29,000	174	165	24.5	9.8	3.2	0.714
10,000	15,000	145	137	19.0	7.8	2.2	0.721
5,000	8,000	110	104	15.0	7.0	1.8	0.715
3,000	4,900	90	85	13.0	6.0	1.3	0.721

BULK CARRIERS

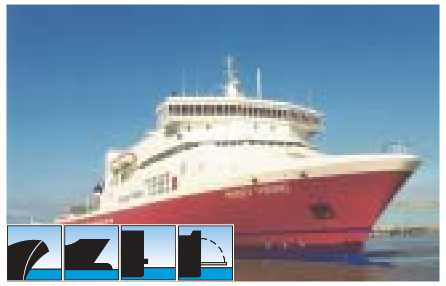
dwt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
400,000	464,000	375	356	62.5	24.0	9.5	0.848
350,000	406,000	362	344	59.0	23.0	9.1	0.848
300,000	350,000	350	333	56.0	21.8	8.6	0.840
250,000	292,000	335	318	52.5	20.5	8.1	0.832
200,000	236,000	315	300	48.5	19.0	7.4	0.833
150,000	179,000	290	276	44.0	17.5	6.8	0.822
125,000	150,000	275	262	41.5	16.5	6.4	0.816
100,000	121,000	255	242	39.0	15.3	5.9	0.817
80,000	98,000	240	228	36.5	14.0	5.4	0.821
60,000	74,000	220	210	33.5	12.8	4.9	0.802
40,000	50,000	195	185	29.0	11.5	4.4	0.791
20,000	26,000	160	152	23.5	9.3	3.5	0.763
10,000	13,000	130	124	18.0	7.5	2.9	0.758

CONTAINER SHIPS (POST PANAMAX)

dwt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
70,000	100,000	280	266	41.8	13.8	9.2	0.636
65,000	92,000	274	260	41.2	13.5	8.9	0.621
60,000	84,000	268	255	39.8	13.2	8.6	0.612
55,000	76,500	261	248	38.3	12.8	8.1	0.614

CONTAINER SHIPS (PANAMAX)

dwt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
60,000	83,000	290	275	32.2	13.2	8.6	0.693
55,000	75,500	278	264	32.2	12.8	8.1	0.677
50,000	68,000	267	253	32.2	12.5	7.8	0.651
45,000	61,000	255	242	32.2	12.2	7.5	0.626
40,000	54,000	237	225	32.2	11.7	6.9	0.622
35,000	47,500	222	211	32.2	11.1	6.3	0.614
30,000	40,500	210	200	30.0	10.7	5.9	0.615
25,000	33,500	195	185	28.5	10.1	5.3	0.614
20,000	27,000	174	165	26.2	9.2	4.4	0.662
15,000	20,000	152	144	23.7	8.5	3.8	0.673
10,000	13,500	130	124	21.2	7.3	2.7	0.686



FREIGHT RO-RO

dwt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
50,000	87,500	287	273	32.2	12.4	14.8	0.783
45,000	81,000	275	261	32.2	12.0	14.2	0.783
40,000	72,000	260	247	32.2	11.4	13.4	0.775
35,000	63,000	245	233	32.2	10.8	12.6	0.758
30,000	54,000	231	219	32.0	10.2	11.7	0.737
25,000	45,000	216	205	31.0	9.6	10.9	0.719
20,000	36,000	197	187	28.6	9.1	10.2	0.722
15,000	27,500	177	168	26.2	8.4	9.2	0.726
10,000	18,400	153	145	23.4	7.4	7.8	0.715
5,000	9,500	121	115	19.3	6.0	5.8	0.696

GENERAL CARGO SHIPS

dwt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
40,000	54,500	209	199	30.0	12.5	4.5	0.712
35,000	48,000	199	189	28.9	12.0	4.3	0.714
30,000	41,000	188	179	27.7	11.3	4.1	0.714
25,000	34,500	178	169	26.4	10.7	4.0	0.705
20,000	28,000	166	158	24.8	10.0	3.8	0.697
15,000	21,500	152	145	22.6	9.2	3.5	0.696
10,000	14,500	133	127	19.8	8.0	3.2	0.703
5,000	7,500	105	100	15.8	6.4	2.7	0.724
2,500	4,000	85	80	13.0	5.0	2.3	0.750

CAR CARRIERS

dwt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
30,000	48,000	210	193	32.2	11.7	13.8	0.644
25,000	42,000	205	189	32.2	10.9	12.7	0.618
20,000	35,500	198	182	32.2	10.0	11.4	0.591
15,000	28,500	190	175	32.2	9.0	10.0	0.548

DEFINITIONS

gross registered tonnage (grt)
The gross internal volumetric capacity of the vessel measured in units of 2.83m³ (100ft³).

deadweight tonnage (dwt)
The total mass of cargo, stores, fuels, crew and reserves with which the vessel is laden when submerged to the summer loading line. Note that this is not an exact measure of the cargo load.

lightweight tonnage (lwt)
The total mass of the ship, excluding cargo. stores, fuels, crew and reserves. Note that lightweight tonnage + deadweight tonnage = displacement tonnage.

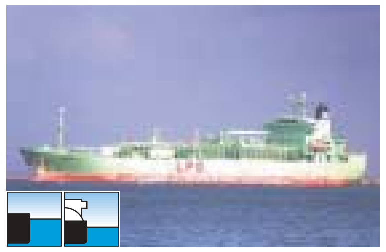
M_D = Displacement
L_{OA} = Length Overall
L_{BP} = Length Between Perpendiculars
B = Beam
D = Laden Draft
F = Laden Freeboard

FERRIES

grt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
50,000	25,000	197	183	30.6	7.1	4.6	0.613
40,000	21,000	187	174	28.7	6.7	4.3	0.612
35,000	19,000	182	169	27.6	6.5	4.2	0.611
30,000	17,000	175	163	26.5	6.3	4.0	0.609
25,000	15,000	170	158	25.3	6.1	3.9	0.600
20,000	13,000	164	152	24.1	5.9	3.7	0.587
15,000	10,500	155	144	22.7	5.6	3.5	0.559

CRUISE LINERS

grt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
80,000	44,000	272	231	35.0	8.0	8.6	0.664
70,000	38,000	265	225	32.2	7.8	8.4	0.656
60,000	34,000	252	214	32.2	7.6	8.1	0.633
50,000	29,000	234	199	32.2	7.1	7.4	0.622
40,000	24,000	212	180	32.2	6.5	6.5	0.621
35,000	21,000	192	164	32.2	6.3	6.2	0.616



GAS CARRIERS

grt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
100,000	144,000	294	281	45.8	12.3	16.9	0.887
70,000	105,000	263	251	41.2	12.3	13.4	0.805
50,000	78,000	237	226	37.2	12.3	10.5	0.736
30,000	49,700	203	192	32.0	12.3	6.7	0.642
20,000	34,800	179	169	28.4	11.0	5.5	0.643
15,000	27,000	164	154	26.0	10.1	4.8	0.651
10,000	18,900	144	136	23.1	9.0	3.9	0.652
7,000	13,800	129	121	20.8	8.1	3.2	0.660
5,000	10,200	117	109	18.8	7.4	2.6	0.656
3,000	6,530	100	93	16.1	6.4	2.0	0.665
2,000	4,560	88	82	14.3	5.7	1.5	0.666
1,000	2,480	71	66	11.7	4.6	1.1	0.681

PASSENGER SHIPS

grt (t)	M_D (t)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)	C_B ---
10,000	8,010	142	128	21.6	6.4	5.3	0.442
7,000	5,830	125	114	19.8	5.5	4.7	0.458
5,000	4,320	112	102	18.2	4.8	4.2	0.473
3,000	2,740	93	86	16.0	4.0	3.4	0.486
2,000	1,910	81	75	14.4	3.4	2.9	0.507
1,000	1,030	64	60	12.1	2.6	2.3	0.532

FAST FERRIES

Type	Name	M_D (m)	L_{OA} (m)	L_{BP} (m)	B (m)	D (m)	F (m)
Catamaran	HSS 1500	4000	125.0	107.50	40.00	4.60	15.10
Monohull	Aries	3800	145.0	128.00	22.00	4.00	8.60
Catamaran	Pacificat	1825	122.0	96.00	25.80	3.90	11.55
Catamaran	Jonathon Swift	1400	86.6	74.10	24.00	3.10	4.20
Monohull	Pegasus One	1275	94.5	82.00	16.00	2.90	7.60
Monohull	Super SeaCat	1250	100.3	88.00	17.10	2.70	8.00
Catamaran	Boomerang	1230	82.3	69.60	23.00	3.50	4.00
Catamaran	SeaCat	950	73.7	63.70	26.00	3.30	3.60

STRUCTURES

The jetty structure will have a large influence on the choice of fendering system, and sometimes vice versa. Structure design will depend to a large degree on local practice, geology and materials. The right choice of fender, when considered at an early stage, can often have a significant effect on the overall cost of the berth.
Below are some examples of some typical berth structures and considerations for the fender design:-

OPEN PILE JETTIES

Open pile construction is an economic means of building simple berths as well as large jetty structures. Vertical piles are less expensive to drive, but these are more susceptible to loads, so low reaction fenders are often specified. This is even more relevant to jetties built with concrete piles.
Fenders are usually installed onto the concrete deck and, if necessary, additional fender supports are either bracketed off the piles or a local extension to the concrete face is provided. Lower fender connections direct from the piles may need to incorporate a means of adjustment to suit piling tolerances.

DOLPHIN

Dolphins are typically used for tanker berths, RoRo terminals and wherever a continuous quay face is not required. They comprise of vertical and/or raking piles with a heavy concrete cap. As loads are distributed over a relatively few piles, fender reaction is critical.
Where dolphins are designed as elastic structures (with vertical piles), the spring stiffness of the structure can be used to good effect to absorb a proportion of the berthing energy.

MONOPILE

Monopile dolphins are perhaps the most economic means of constructing a berth, provided soil conditions are suitable and installation plant for the large diameter steel tubes is locally available. As with conventional dolphins, fender reaction is critical.
Monopile structures are often built in remote locations, so fenders need to be fast and simple to install. Maintenance and repair will be more difficult so these factors need to be carefully considered early in the design process.

MASS STRUCTURE

Mass structures are more common in regions with lower tidal variations and where the large volumes of construction materials are readily available.
Fender reaction is less important, but as these berths often accommodate a wide range of vessel classes and sizes, the fenders will need adequate stand-off and sometimes fitted at closer centres to avoid contact between structure and ship.

SHEET PILE

Sheet pile construction lies somewhere between an open pile and mass structure. Where tidal variations are small, fenders are generally installed directly to the concrete cope. In large tidal zones, it may be necessary to attach fenders directly or via brackets to the sheet piles.
Even at accepted piling tolerances, the face for mounting fenders can be far from uniform. It is more difficult to attach fenders (or brackets) on Z-profile piles as the pile clutch is on the outpan. Thought should be given to connections near low water as near waterline (or underwater) welding can be difficult and expensive.

Location

Berthing structures are sited in a variety of locations, from sheltered basins to unprotected open waters. Local conditions will play a large part in deciding the berthing speeds and approach angles, in turn affecting the type and size of suitable fenders.

1) Non-Tidal Basins

With minor changes in water level, these locations are usually sheltered from strong winds, waves and currents. Ship sizes may be restricted due to lock access.

2) Tidal Basins

Larger variations in water level (depends on location), but still generally sheltered from winds, waves and currents. May be used by larger vessels than non-tidal basins.

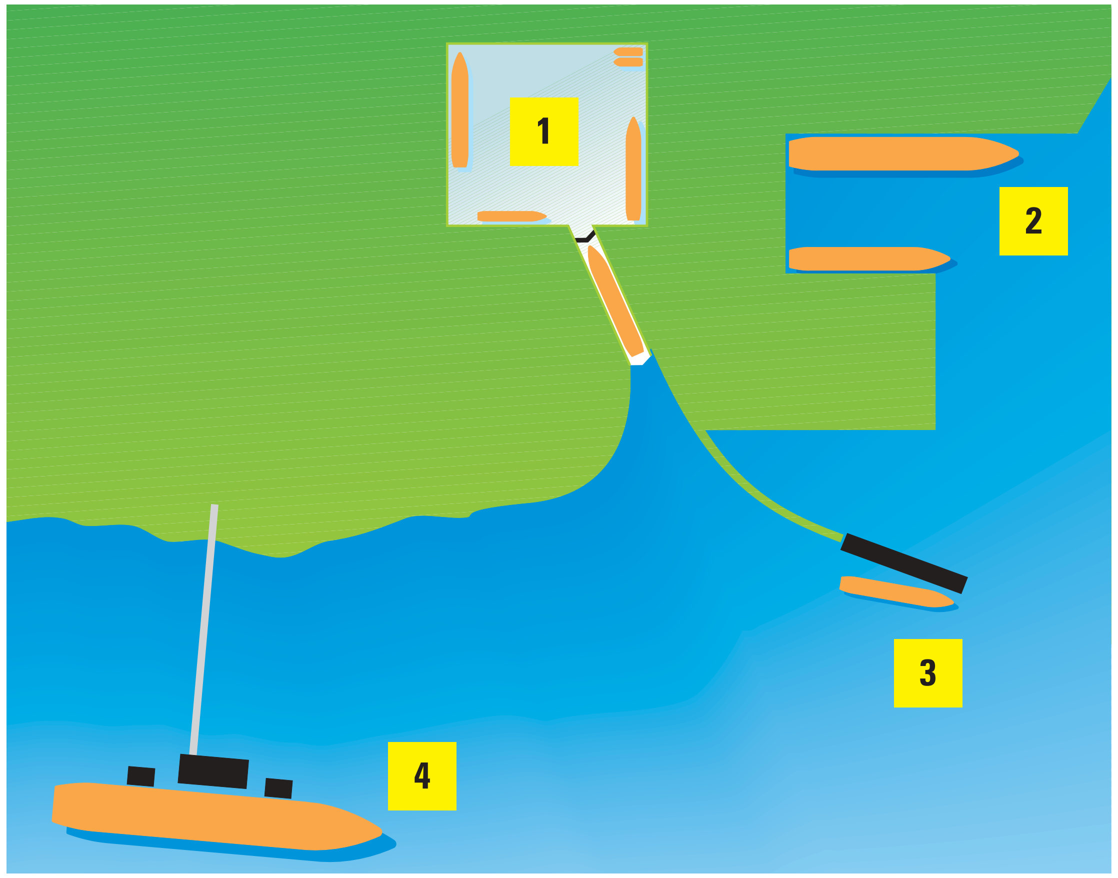
3) River Berths

Largest tidal range (depends on location), with greater exposure to winds, waves and currents. Approach mode may be restricted by dredged channels and the effects of flood and ebb tides. Structures on river bends may complicate berthing manoeuvres.

4) Coastal Berths

Maximum exposure to winds, waves and currents. Berths generally used by single classes of vessel, such as oil, gas or bulk.

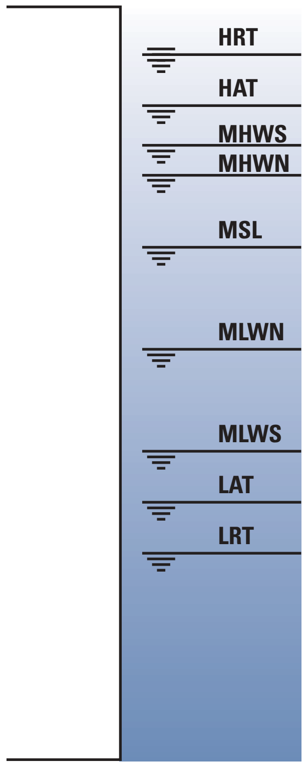
Typical Berthing Locations



Tides

Tides vary greatly with location and may have extremes of just a few centimetres (Mediterranean, Baltic etc) to upwards of 15 metres (parts of UK and Canada).
Tidal variations will influence the structure design and selection of fenders.

HRT	Highest Recorded Tide
HAT	Highest Astronomical Tide
MHWS	Mean High Water Spring
MHWN	Mean High Water Neap
MSL	Mean Sea Level
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
LAT	Lowest Astronomic Tide
LRT	Lowest Recorded Tide



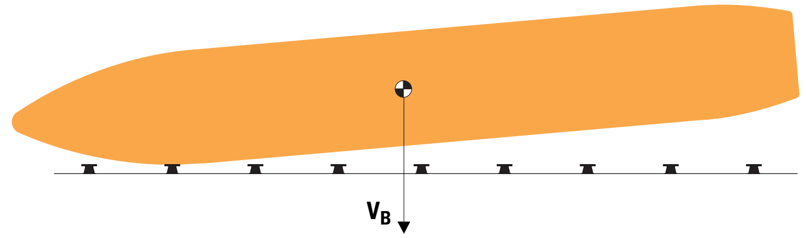
Currents and Winds

Current and wind forces, depending on their direction, can push vessels onto or off of the berth – this can influence the selection of berthing speed. Once berthed and provided the vessel is in contact with a number of fenders, these forces are generally less critical but special cases do exist, particularly on very soft structures. As a general guide, deep draught vessels (Tankers etc) will be more greatly affected by currents and high freeboard vessels (RoRo, Container Ships) will be more greatly affected by strong winds.

Berthing Energy Calculations

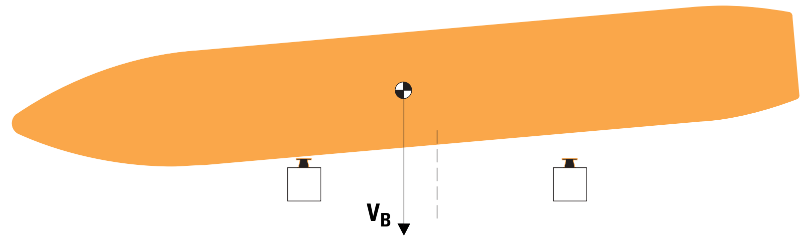
Side Berthing

This is the most common method of approach along continuous quays. Berthing speeds are typically in the range of 150-300mm/s and berthing angles in the region of 5-15°, depending on ship size and berth



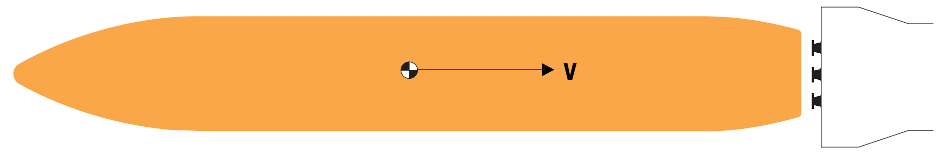
Dolphin Berthing

Dolphins are common on oil and bulk berths. Vessels are usually tug assisted during their approach. Berthing speeds are fairly well controlled and typically in the range of 100-250mm/s. Berthing angles are normally in the region of 5-15°.



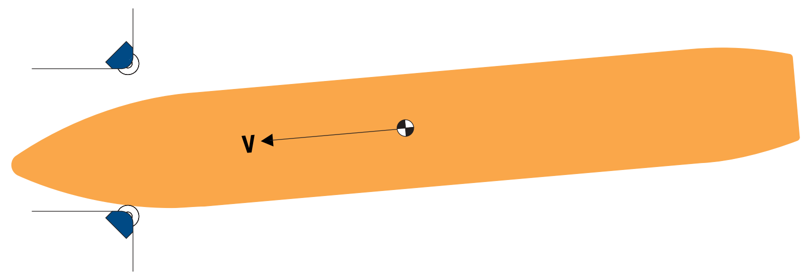
End Berthing

End berthing is normally restricted to RoRo vessels and similar ships with stern or bow doors for unloading vehicles. End fenders are infrequently used, but when they are the berthing speeds tend to be high – typically 200-500mm/s.



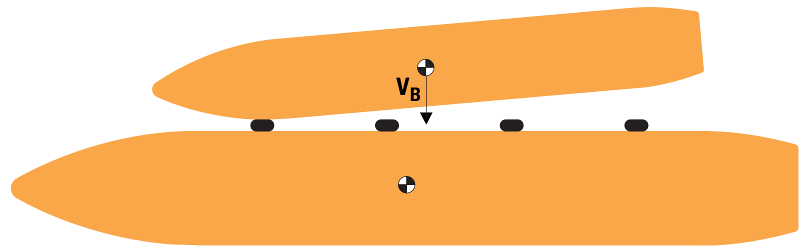
Lock Entrances

Vessels tend to approach lock entrances and similar restricted channels at fairly high forward speeds to maintain steerage – typically 0.5-2.0m/s. Transverse velocity and berthing angles tend to be fairly small. The forward motion can generate large shear on the fenders.



Ship-to-Ship Berthing

Ship-to-ship berthing commonly occurs in exposed, open waters. If both vessels are moving forward at the time of berthing, a venturi effect can cause the two ships to be pulled together very rapidly during the final stages of berthing. Typical relative transverse velocities are 150-300mm/s at angles of 5-15°.



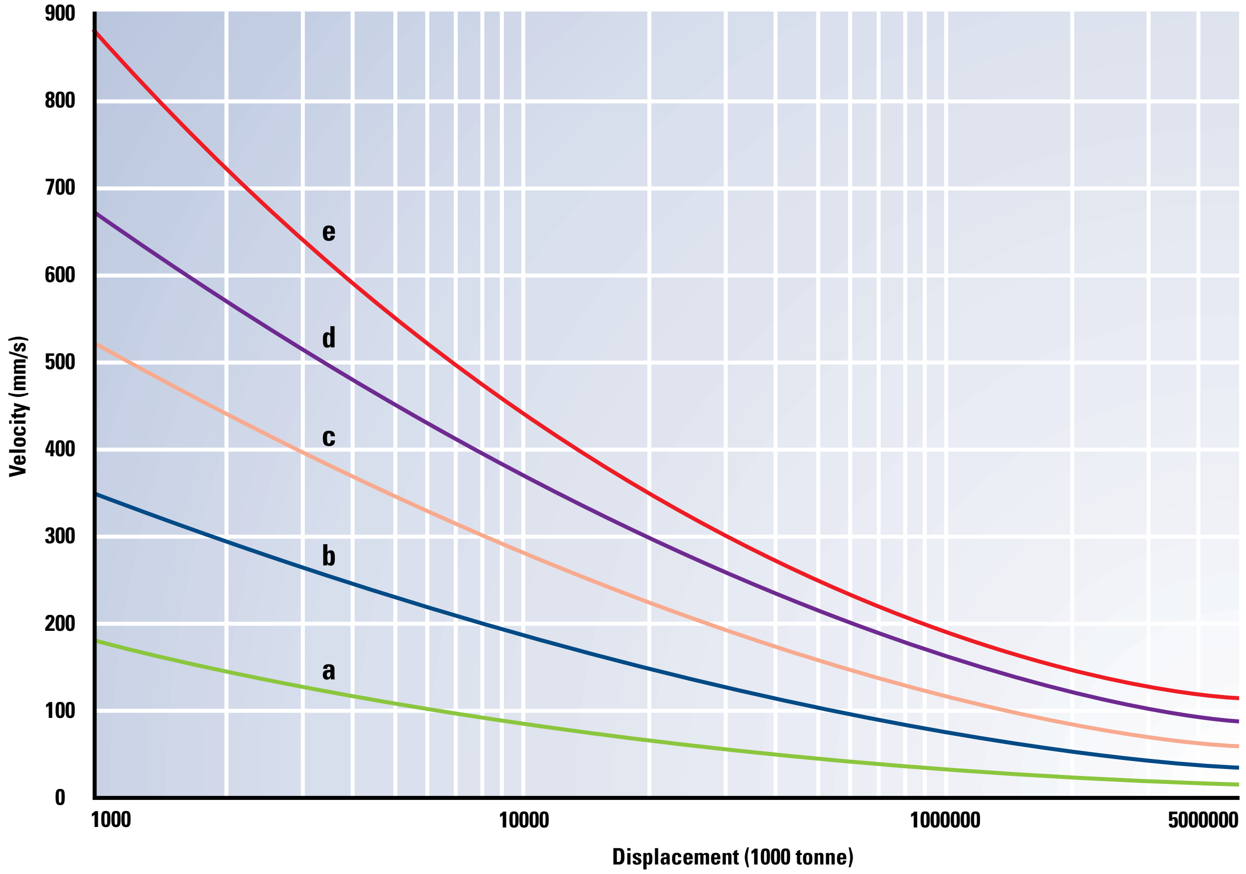
BERTHING VELOCITIES (V)

Berthing velocities will depend upon the ease or difficulty of the approach, exposure of the berth and the size of the vessel. Conditions are normally divided into five categories as on the right.

The most widely used guide to berthing speeds is the Brolsma table, adopted by BS[1], PIANC[2] and other standards. For ease of use, speeds for main vessel sizes are tabulated.

a	Easy berthing, sheltered
b	Difficult berthing, sheltered
c	Easy berthing, exposed
d	Good berthing, exposed
e	Difficult berthing, exposed

BERTHING VELOCITIES



To estimate berthing velocity, the following formulae can be used:-

$$V_{(a)} = \frac{392.6 \times 13.8 - 11.8\,M_D^{0.397}}{13.8 + M_D^{0.397}}$$

$$V_{(b)} = \frac{586.2 \times 32.9 - 5.4\,M_D^{0.454}}{32.9 + M_D^{0.454}}$$

$$V_{(c)} = \frac{902.0 \times 31.8 - 0.9\,M_D^{0.458}}{31.8 + M_D^{0.458}}$$

$$V_{(d)} = \frac{1210.4 \times 25.1 - 2.7\,M_D^{0.435}}{25.1 + M_D^{0.435}}$$

$$V_{(e)} = \frac{1853.3 \times 19.3 - 26.0\,M_D^{0.452}}{19.3 + M_D^{0.452}}$$

BERTHING VELOCITIES

MD	V(a)	V(b)	V(c)	V(d)	V(e)
(tonne)	(mm/s)	(mm/s)	(mm/s)	(mm/s)	(mm/s)
1000	179	343	517	669	865
2000	151	296	445	577	726
3000	136	269	404	524	649
4000	125	250	374	487	597
5000	117	236	352	459	558
10000	94	192	287	377	448
20000	74	153	228	303	355
30000	64	133	198	264	308
40000	57	119	178	239	279
50000	52	110	164	221	258
100000	39	83	126	171	201
200000	28	62	95	131	158
300000	22	52	80	111	137
400000	19	45	71	99	124
500000	17	41	64	90	115

ADDED MASS COEFFICIENT (C_M)

The Added Mass Coefficient allows for the body of water carried along with ship as it moves sideways through the water. As the ship is stopped by the fender, the momentum of the entrained water continues to push against the ship and this increases the ship's apparent mass.

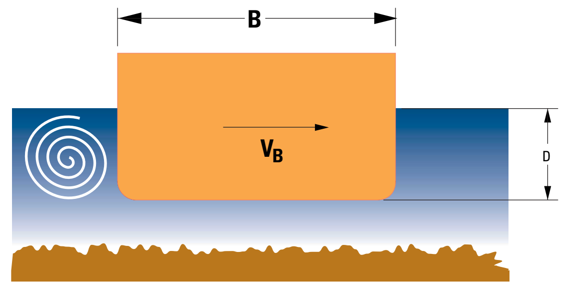
The Vasco Costa method is the most widely used by design codes for ship to shore berthing, usually where under keel crearance is more than 10% of the vessel draft and when berthing velocity exceed 80mm/s.

The Shigeru Ueda method is used for both ship to shore and ship to ship berthing situations.

VASCO COSTA METHOD ▶

$$C_M = 1 + \frac{2 \cdot D}{B}$$

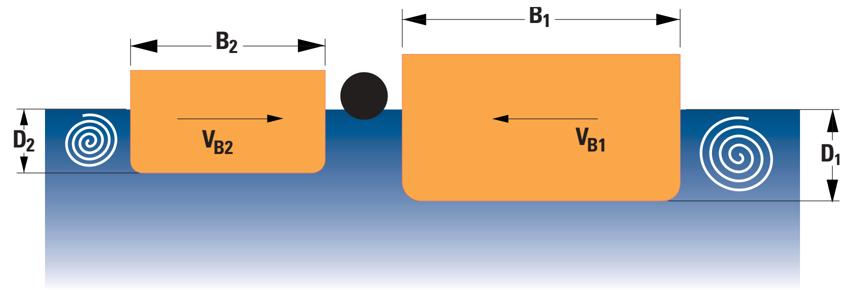
where,
D = Draft (m)
B = Beam (m)



SHIGERU UEDA METHOD ▶

$$C_M = 1 + \frac{\pi \cdot D}{2 \cdot C_B \cdot B}$$

where,
D = Draft (m)
C_B = Block Coefficient (see below)
B = Beam (m)



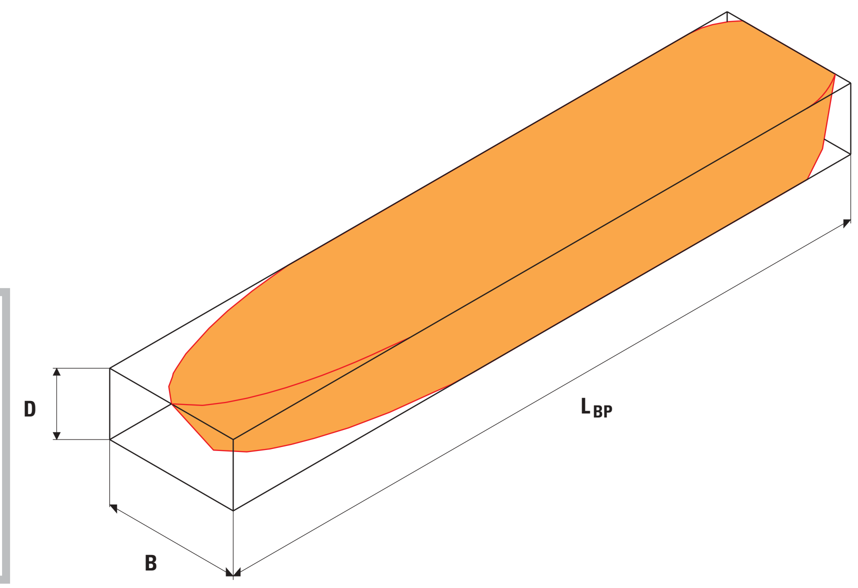
BLOCK COEFFICIENT

The Block Coefficient (C_B) is a function of the hull shape and is expressed as follows:-

$$C_B = \frac{M_D}{L_{BP} \cdot B \cdot D \cdot \rho_{SW}}$$

where,
M_D = Displacement of vessel (t)
L_{BP} = Length between perpendiculars (m)
B = Beam (m)
ρ_{SW} = Seawater density = 1.025t/m³

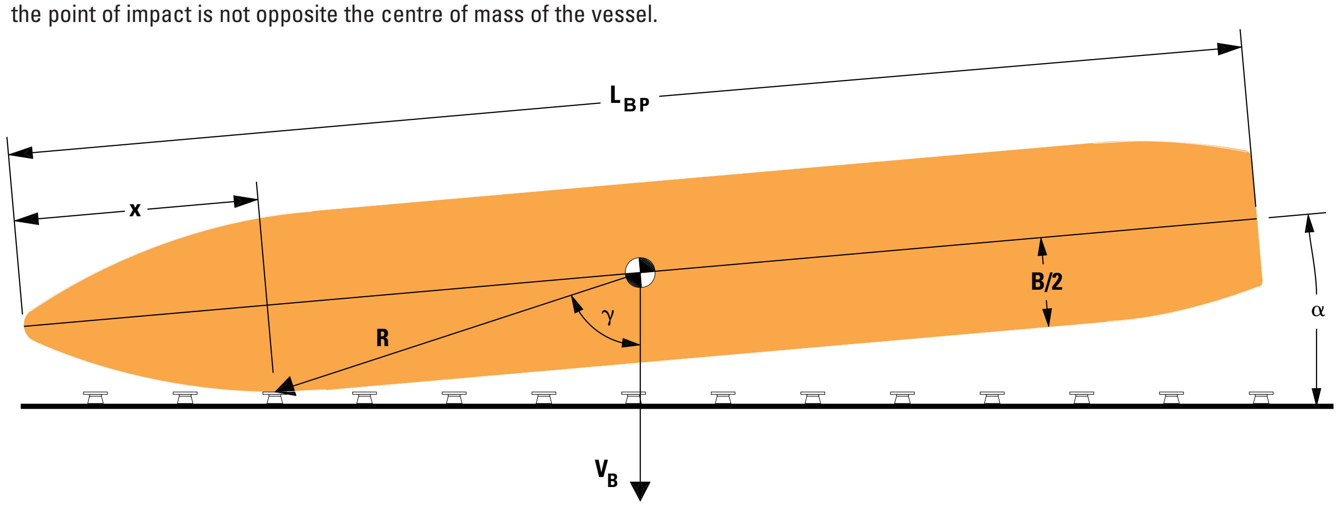
Typical Block Coefficients (C_B)	BS 6349	PIANC
Tankers	0.72~0.85	0.85
Bulk Carriers	0.72~0.85	0.72~0.85
Container Ships	0.65~0.75	0.60~0.80
General Cargo	0.60~0.75	0.72~0.85
RoRo Vessels	0.65~0.70	0.70~0.80
Ferry	0.50~0.65	0.55~0.65



Note that if length, beam and draft are known, the table can be used to estimate displacement.

ECCENTRICITY COEFFICIENT (C_E)

The Eccentricity Coefficient allows for the energy dissipated in rotation of the ship when the point of impact is not opposite the centre of mass of the vessel.



To determine the Eccentricity Coefficient, you must firstly calculate the radius of gyration (K), the distance from the vessels centre of mass to point of impact (R) and the velocity vector angle (γ) using the following formulae:-

$$C_E = \frac{K^2 + (R^2 \cdot \cos^2(\gamma))}{K^2 + R^2}$$

$K = [(0.19 \cdot C_B) + 0.11] \cdot L_{BP}$	where,
$R = \sqrt{\left[\frac{L_{BP}}{2} - x\right]^2 + \left[\frac{B}{2}\right]^2}$	C_B = Block coefficient L_{BP} = Length between perpendiculars (m) x = Distance from bow to point of impact B = Beam (m) α = Berthing angle
$\gamma = 90° - \alpha - a\sin\left[\frac{B}{2 \cdot R}\right]$	

The Eccentricity Coefficient is calculated using the following formula:-

$$C_E \approx \frac{K^2}{K^2 + R^2}$$

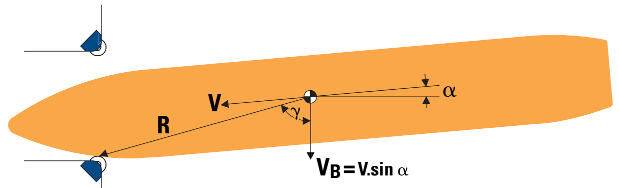
Values for the Eccentricity Coefficient generally fall within the following limits:-

Quarter-point berthing	$x = \frac{L_{BP}}{4}$	$C_E \approx 0.4 \sim 0.6$
Third-point berthing	$x = \frac{L_{BP}}{3}$	$C_E \approx 0.6 \sim 0.8$
Mid-ships berthing	$x = \frac{L_{BP}}{2}$	$C_E \approx 1.0$

Some designers use the simplified formula for the Eccentricity Coefficient below. Care should be used as this method can lead to an underestimation of berthing energy when the berthing angle is large ($\alpha \geq 10°$) and/or the point of impact is aft of quarter-point ($x > L_{BP}/4$).

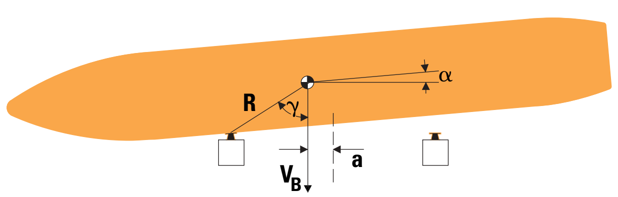
LOCK ENTRANCES AND GUIDING FENDERS

In cases where the ship has a significant forward motion, it is suggested by PIANC that the ship's speed parallel to the berthing face (V.cos α) is not decreased by berthing impacts and it is the transverse velocity component (V.sin α) which must be resisted by the fenders. When calculating the Eccentricity Coefficient, the velocity vector angle (γ) is taken between V_B and R.



DOLPHIN BERTHS

Ships will rarely berth exactly centrally against the berthing dolphins. The dolphin pairs are usually placed at 0.3-0.4 times the length of the design vessel. When calculating R and γ, a dimension (a) of approximately 4-6% of the design vessel length is commonly assumed. Larger offsets will increase the Eccentricity Coefficient. In extreme cases where V_B is coaxial with the fender, $C_E = 1$.



BERTH CONFIGURATION COEFFICIENT (C_C)

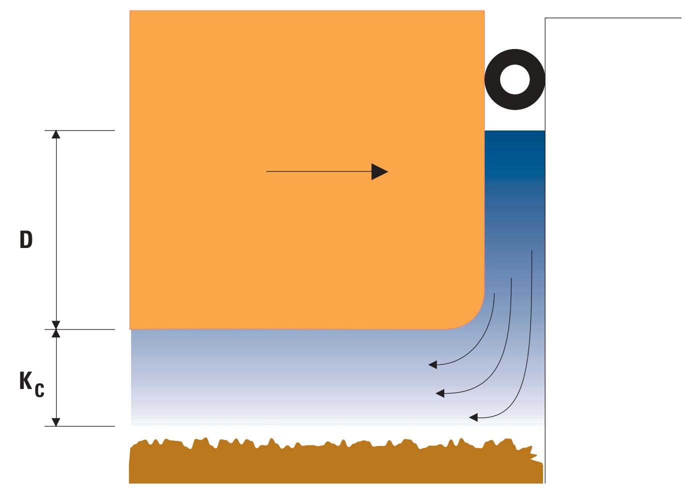
The Berth Configuration Coefficient (C_C) allows for the cushioning effect of water trapped between the vessel and the berth. The value of C_C will also be affected by the berthing angle of the vessel. If this is greater than about 5°, then C_C should be taken as unity. Similarly, if the under keel clearance (K_C) is large relative to the draft of the ship, then the trapped water can easily escape under the vessel which also reduces the coefficient.

CLOSED STRUCTURES ▶

for $\frac{K_C}{D} \leq 0.5 \Rightarrow C_C \approx 0.8$

for $\frac{K_C}{D} > 0.5 \Rightarrow C_C \approx 0.9$

For $\alpha > 5°$, $C_C = 1$

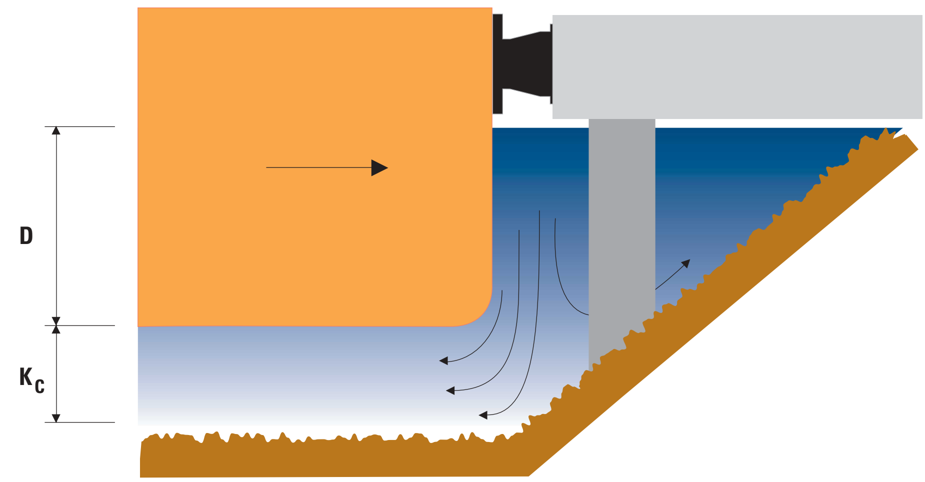


SEMI-CLOSED STRUCTURES ▶

for $\frac{K_C}{D} \leq 0.5 \Rightarrow C_C \approx 0.9$

for $\frac{K_C}{D} > 0.5 \Rightarrow C_C = 1.0$

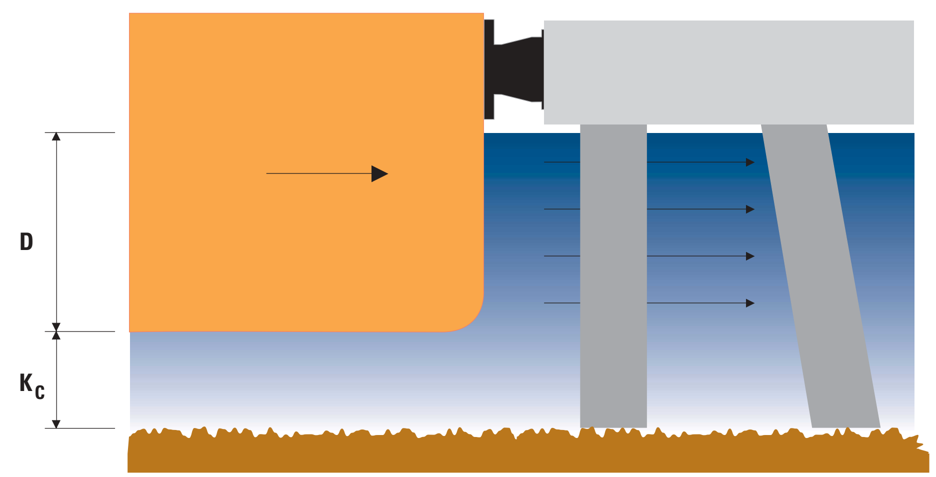
For $\alpha > 5°$, $C_C = 1$



OPEN STRUCTURES ▶

$C_C = 1.0$

where,
K_C = Under keel clearance (m)
D = Draft (m)



SOFTNESS COEFFICIENT (C_S)

The Softness Coefficient (C_s) allows for the energy absorbed by elastic deformation of the ship hull or by its rubber belting. When a 'soft' fender is used (defined as having a deflection, δ_F, of more than 150mm) then C_s is ignored.

for $\delta_F \leq 150\text{mm} \Rightarrow C_S \approx 0.9$

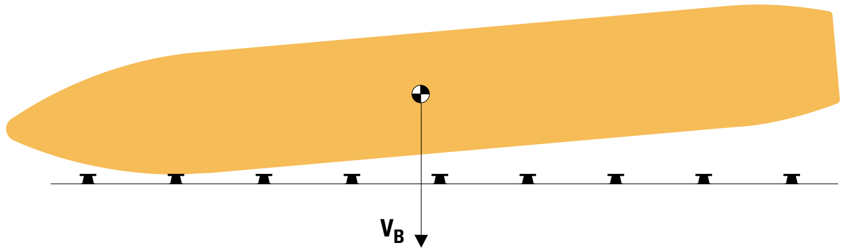
for $\delta_F > 150\text{mm} \Rightarrow C_S = 1.0$

Normal Berthing Energy (E_N)

Once all of the criteria and coefficients have been established, the formula can be used to calculate the 'normal' kinetic energy (E_N) of the ship according to the mode of berthing.

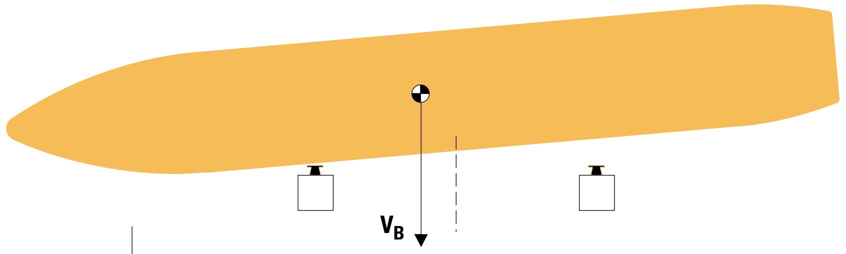
SIDE BERTHING

$E_N = 0.5 \cdot M_D \cdot (V_B)^2 \cdot C_M \cdot C_E \cdot C_S \cdot C_C$



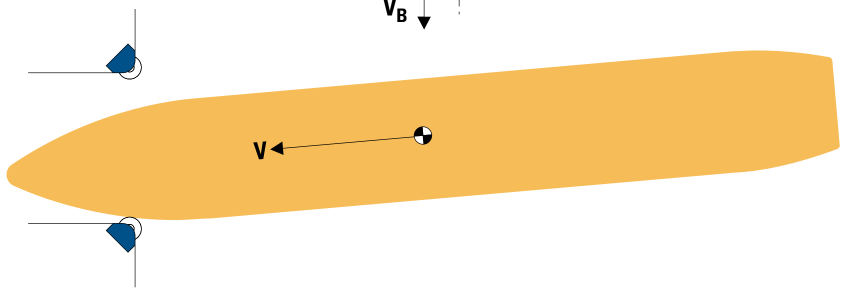
DOLPHIN BERTHING

$E_N = 0.5 \cdot M_D \cdot (V_B)^2 \cdot C_M \cdot C_E \cdot C_S \cdot C_C$



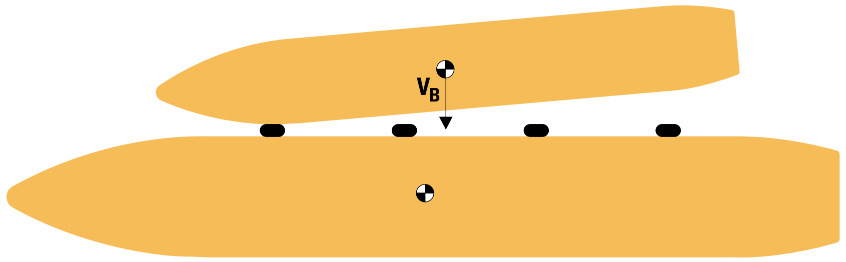
LOCK ENTRANCES

$E_N = 0.5 \cdot M_D \cdot (V \cdot \sin\alpha)^2 \cdot C_M \cdot C_E \cdot C_S \cdot C_C$



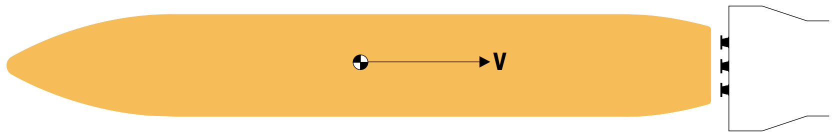
SHIP-TO-SHIP BERTHING

$E_N = 0.5 \cdot \left[\frac{(M_{D1} \cdot C_{M1}) \cdot (M_{D2} \cdot C_{M1})}{(M_{D1} \cdot C_{M1}) + (M_{D2} \cdot C_{M1})}\right] \cdot (V_B)^2 \cdot C_E$



END BERTHING

$E_N = 0.5 \cdot M_D \cdot V^2$



Load Factors

In limit state designs, the load factors applied to fender reactions under normal berthing are higher than those applied under abnormal berthing. Fenders are generally designed to absorb the full abnormal energy, and the reaction will be similar for both normal and abnormal impacts. In this instance, factored normal reactions often yield the worst design case. It is important to check both the normal and abnormal cases to determine which results in the highest structural loads, moments and stresses.

It is sometimes possible, depending on the fender and structure types, to balance the normal and abnormal reactions of the fender. This will optimise the design of both fender and structure. Fentek can advise on whether this is feasible in each case.

Abnormal Berthing Energy (E_A)

Abnormal impacts may occur for many reasons – engine failure, breakage of towing lines, sudden weather changes or human error. BS1 suggests fenders be designed to include a safety factor of "up to" two times the normal berthing energy. PIANC11 suggests abnormal impact safety factors be applied to the design (normal) energy according to the table below:-

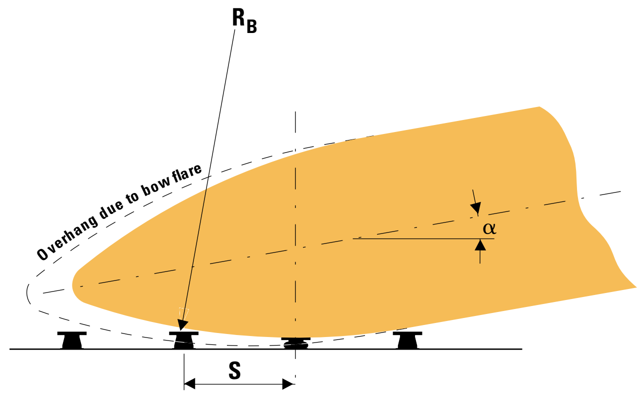
Type of Berth	Vessel	Safety Factor
Tankers and Bulk Cargo	Largest	1.25
	Smallest	1.75
Container	Largest	1.5
	Smallest	2.0
General Cargo		1.75
RoRo and Ferries		2.0 or higher
Tugs, Workboats etc		2.0

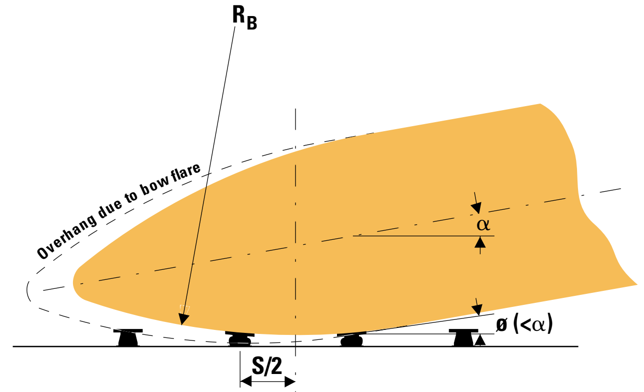
Fender Selection

When selecting fenders for an application, the designer needs to consider how the fender will be used in service and the effects this may have on performance. Depending on the project, factors may include:-

- Single or multiple fender contacts
- Effects of angular compression
- Fender efficiency (E/R)
- Temperature extremes
- Speed of approach

SINGLE OR MULTIPLE FENDER CONTACTS





SINGLE FENDER CONTACT

- All energy absorbed by a single fender
- Full fender deflection likely
- Bow flare angle (β) is important
- 3-fender contact also possible when fenders are installed closer together

TWO FENDER CONTACT

- Energy shared over two fenders
- Compound angle (ϕ) is important
- Hull-structure clearance (C) may be less, especially for small bow radii

COMPRESSION ANGLES

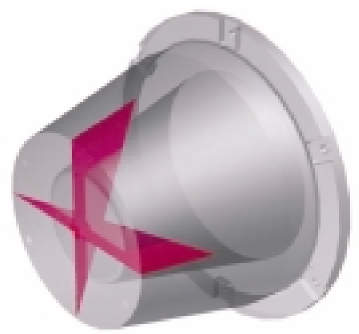
Where vessels berth with their curved bow against the fender, the true contact angle (θ) will be less than the berthing angle (α) due to the bow radius of the hull (R_B). When the parallel mid-body of the ship contacts the fender (i.e. on Dolphin berths), the compression angle of the fender is the same as the berthing angle. The compound angle (ϕ) of α and β can be estimated from the table below:-

$$\theta = \operatorname{asin}\left[\frac{S}{2 \cdot R_B}\right]$$

α = Berthing angle
β = Bow flare angle
S = Fender to fender spacing
R_B = Bow radius
θ = Hull contact angle (on plan)
ϕ = Compound angle

Compound Angle : $\phi = \cos^{-1}(1+\tan^2\theta+\tan^2\beta)^{-0.5}$

θ: 2	4	6	8	10	12	14	16	18	20	β (Degrees)
2.8	4.5	6.3	8.2	10.2	12.2	14.1	16.1	18.1	20.1	2
	5.7	7.2	8.9	10.7	12.6	14.5	16.4	18.4	20.3	4
		8.5	10.0	11.6	13.4	15.2	17.0	18.9	20.8	6
			11.3	12.7	14.3	16.0	17.7	19.5	21.3	8
				14.0	15.5	17.0	18.6	20.3	22.0	10
					16.8	18.2	19.7	21.2	22.9	12
						19.5	20.8	22.3	23.8	14
							22.1	23.5	24.9	16
								24.7	26.1	18
									27.3	20

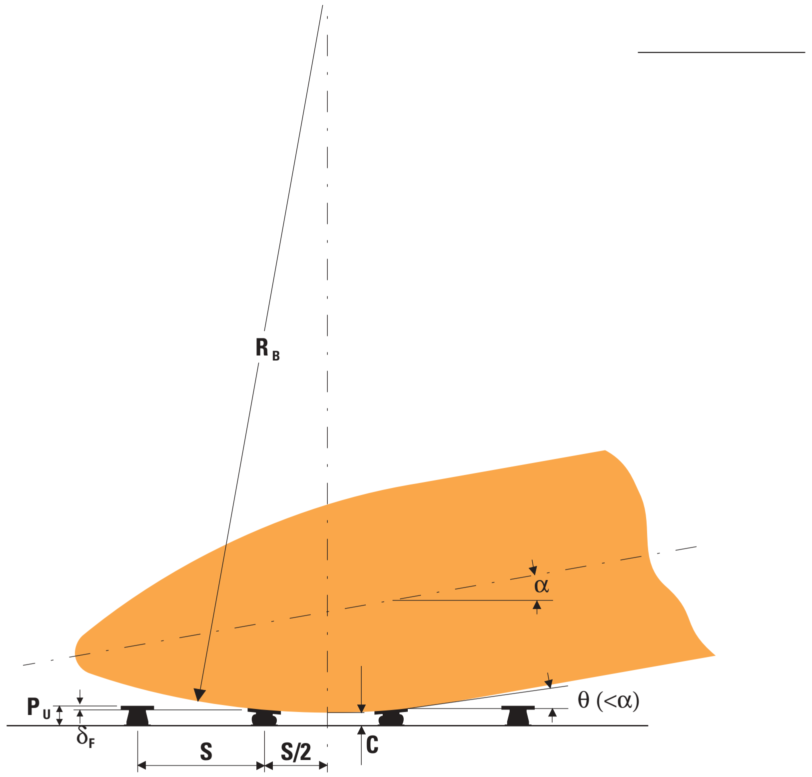


Fender Spacing

If fenders are spaced too far apart, it is possible for ships with small bow radii to contact the structure when berthing at an angle to the quay face. The optimum clearance dimension (C) will vary from project to project according to vessel types, berthing conditions and the design of the structure. The minimum clearance is often in the range of 5~15% of the uncompressed fender projection.

To calculate the maximum fender spacing, the bow radius (R_B), fender projection (P_U) and deflection (δ_F) should first be determined.
The graphs below can be used to estimate the bow radius for different vessel types. In the absence of adequate information about the ships, fender centres should not be more than 15% of the overall length of the smallest ship.
where,

$$S \le 2 \cdot \sqrt{R_B^2 - (R_B - P_U + \delta_F + C)^2}$$



S	=	Centre to centre spacing of fenders (m)
R_B	=	Bow radius (m)
P_U	=	Uncompressed fender projection including rubber, panel etc (m)
δ_F	=	Fender deflection (m)
C	=	Clearance distance (m)

Bow radius can be estimated with the following formula:-

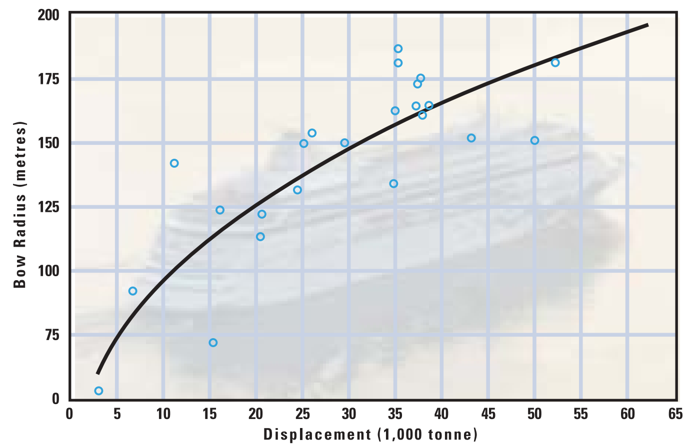
$$R_B \approx \frac{1}{2}\left[\left(\frac{B}{2}\right) + \left(\frac{L_{OA}^2}{8B}\right)\right]$$

TYPICAL BOW RADII

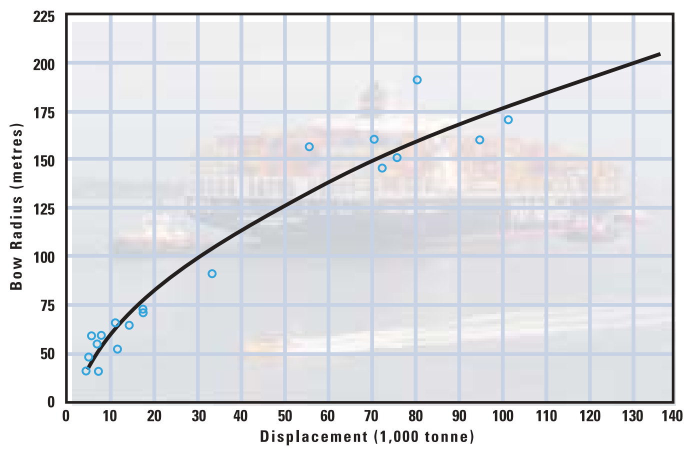
Notes:-

- Smaller ships usually have a smaller bow radius, but often have a lower berthing energy as well so will not compress the fenders as much.
  A range of vessels which may use the berth should be checked to determine the worst design case.
- The clearance distance will also need to take account of any bow flare angles.
- Bow flares are larger closer to the bow. However, the point of hull contact with the fender is further away from the centre of mass of the vessel. This means that whilst the bow flare angle may be larger, the energy to be absorbed may be smaller.

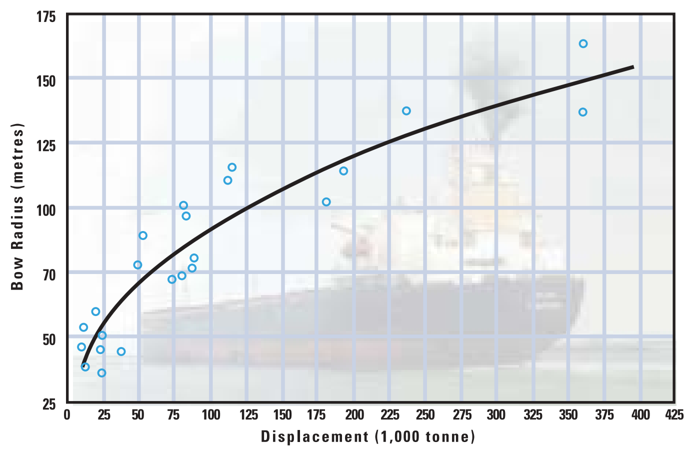
CRUISE LINER



CONTAINER SHIP



BULK CARRIER & GENERAL CARGO SHIP



Fender Panel Design

Fender panels (or 'frames') are used to distribute the reaction forces from the rubber fender units into the ship's hull. They are generally of fabricated steel composite beam construction and are designed to suit each individual berth. The loads and stresses applied to the panels will depend on many factors - the type of ship, berthing mode, characteristics of the rubber fender unit, tidal range, positioning of restraint chains and many other variables.

Detail design is generally carried out using limit state design codes in conjunction with finite element and other computer modelling software which needs to be specifically adapted for fender panels. Irrespective of the project, the general design requirements remain the same in each case:-

- Resistance to bending moments and shear forces
- Resistance to local buckling of internal member and webs
- Stability of the front/back plates when in compression
- Distribution of loads and stresses across panel members
- Adequate weld types and sizes
- Suitable corrosion protection for the intended environment

Most fender panels are now specified as "closed box" structures comprising of front and back plates plus a series of vertical and horizontal stiffening members. Correctly designed closed box panels (as opposed to open box panels) are popular because:-

- Better strength to cost ratio
- Lower maintenance (no corrosion traps)
- Easier to inspect
- Less prone to damage
- Longer lasting

Design Cases

There are a number of commonly occurring cases which designers needs to consider when specifying fender panels.

FULL FACE CONTACT

This case often arises with high freeboard vessels. Assuming basic dimensions and rubber fender unit characteristics are know, other loads and worst case bending moment may be calculated as follows:-

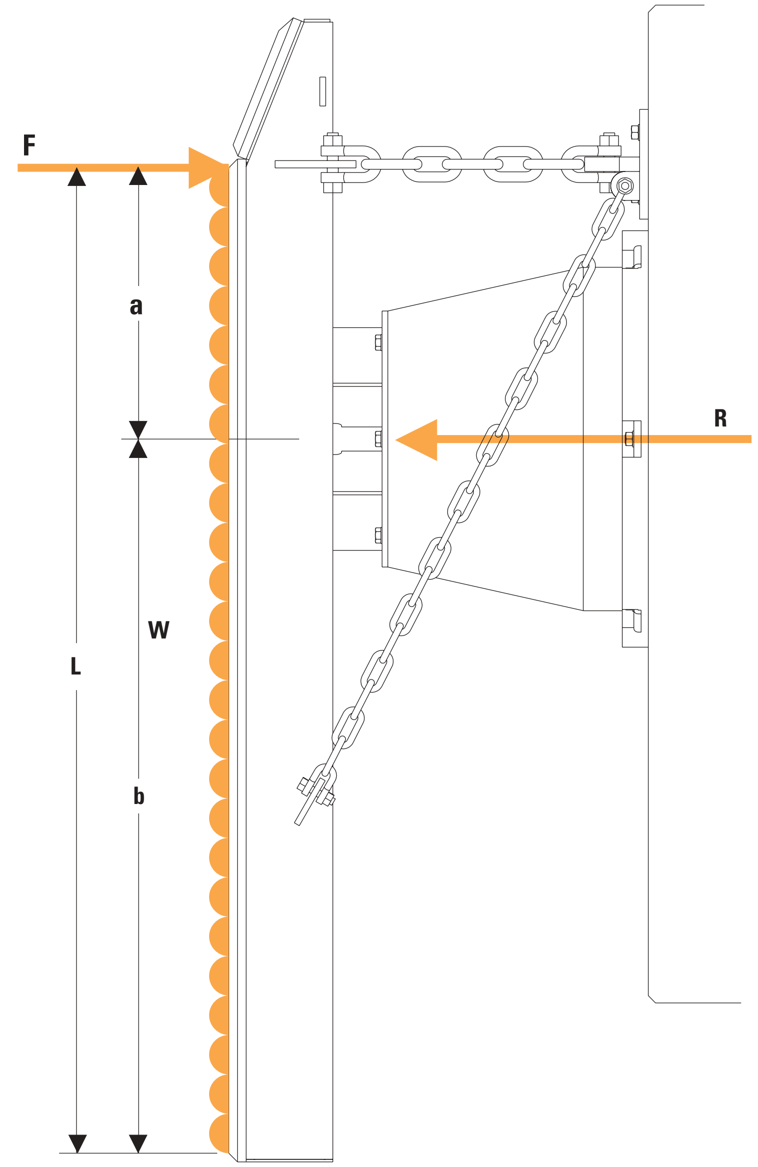
$$R = W + F$$

$$F = \frac{2 \cdot R}{L}\left[\frac{L}{2} - a\right]$$

$$W = \frac{2 \cdot R \cdot a}{L}$$

$$M_{max} = M_R = \frac{W \cdot b^2}{2 \cdot L} = \frac{W \cdot a^2}{2 \cdot L} + F \cdot a$$

$$\text{for } a = b = \frac{L}{2} \Rightarrow F = 0$$



where,

R	=	Reaction of rubber unit (kN)
W	=	Uniform load across panel face (kN)
F	=	Equilibrium load (kN)
L	=	Contact length of panel face (m)
M_{max}	=	Maximum bending moment (kNm)
M_R	=	Moment at R (kNm)

LOW LEVEL IMPACT

This case can often arises with low freeboard vessels berthing at low tide. Assuming basic dimensions and rubber fender unit characteristics are know, chain tension, other loads and worst case bending moment may be calculated as follows:-

$$R = F + n \cdot T$$

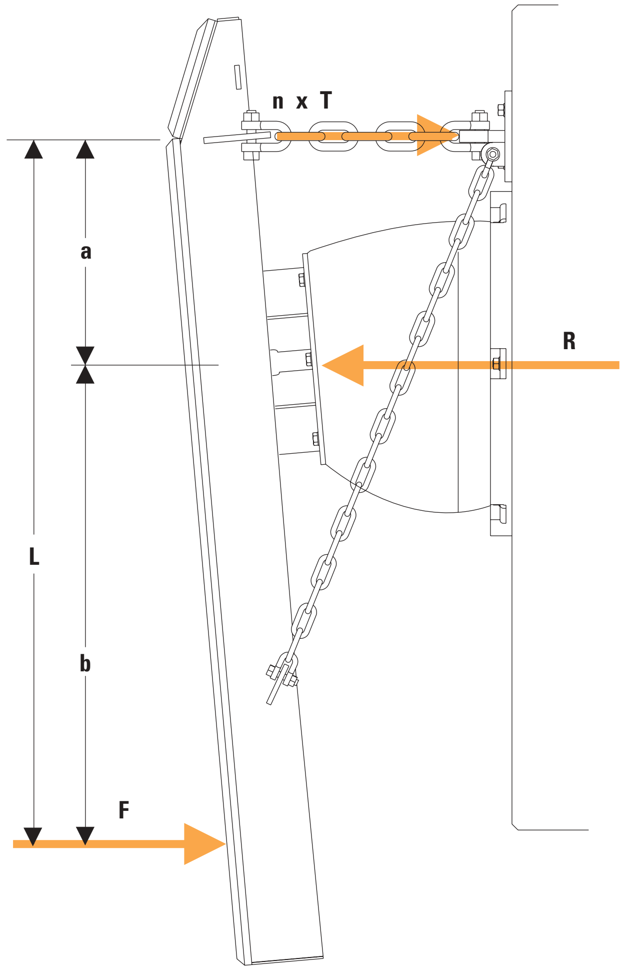
$$F = \frac{R \cdot a}{L}$$

$$T = \frac{R \cdot b}{n \cdot L}$$

$$M_{max} = M_R = n \cdot T \cdot a = F \cdot b$$

where,

R	=	Reaction of rubber unit (kN)
F	=	Impact load (kN)
n	=	Number of tension chains
T	=	Tension chain load (kN)
L	=	Contact length of panel face (m)
M_{max}	=	Maximum bending moment (kNm)
M_R	=	Moment at R (kNm)



DOUBLE IMPACT

This case can often arise with belted vessels. Assuming basic dimensions and rubber fender unit characteristics are know, other loads and worst case bending moments may be calculated as follows:-

$$R_1 + R_2 = F_1 + F_2$$

$$R_1 = f(\delta_{F1})$$

$$R_2 = f(\delta_{F2})$$

$$F_1 = \frac{(R_1 \cdot (b+c)) + (R_2 \cdot c)}{L}$$

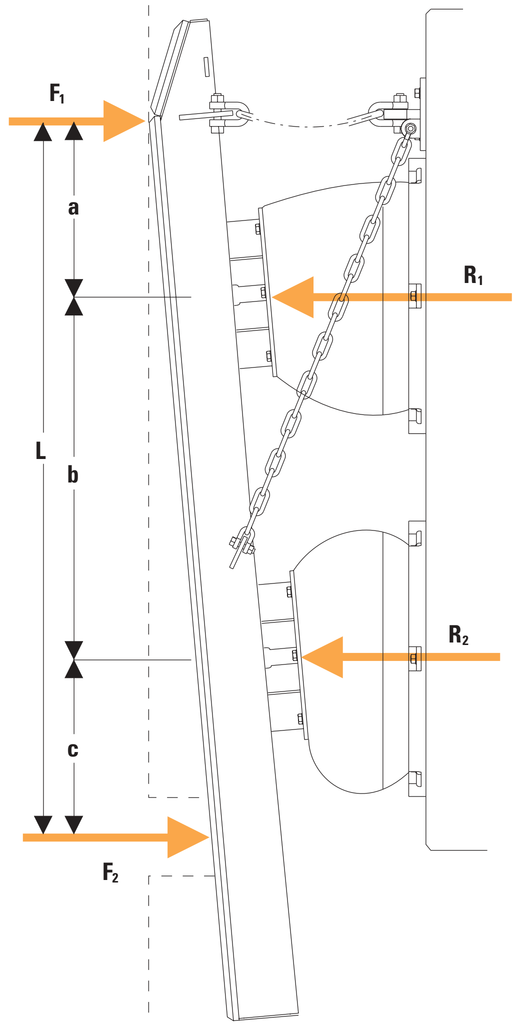
$$F_2 = \frac{(R_1 \cdot a) + (R_2 \cdot (a+b))}{L}$$

$$M_1 = F_1 \cdot a = (F_2 \cdot (b+c)) - R_2 \cdot b$$

$$M_2 = F_2 \cdot c = (F_1 \cdot (a+b)) - R_1 \cdot b$$

where,

R_1	=	Reaction of upper rubber unit (kN)
R_2	=	Reaction of lower rubber unit (kN)
L_1	=	Deflection of upper rubber unit (m)
L_2	=	Deflection of lower rubber unit (m)
F_1	=	Upper impact load (kN)
F_2	=	Lower impact load (kN)
L	=	Contact length of panel face (m)
M_1	=	Bending moment at R_1 (kNm)
M_2	=	Bending moment at R_2 (kNm)
M_R	=	Moment at R (kNm)



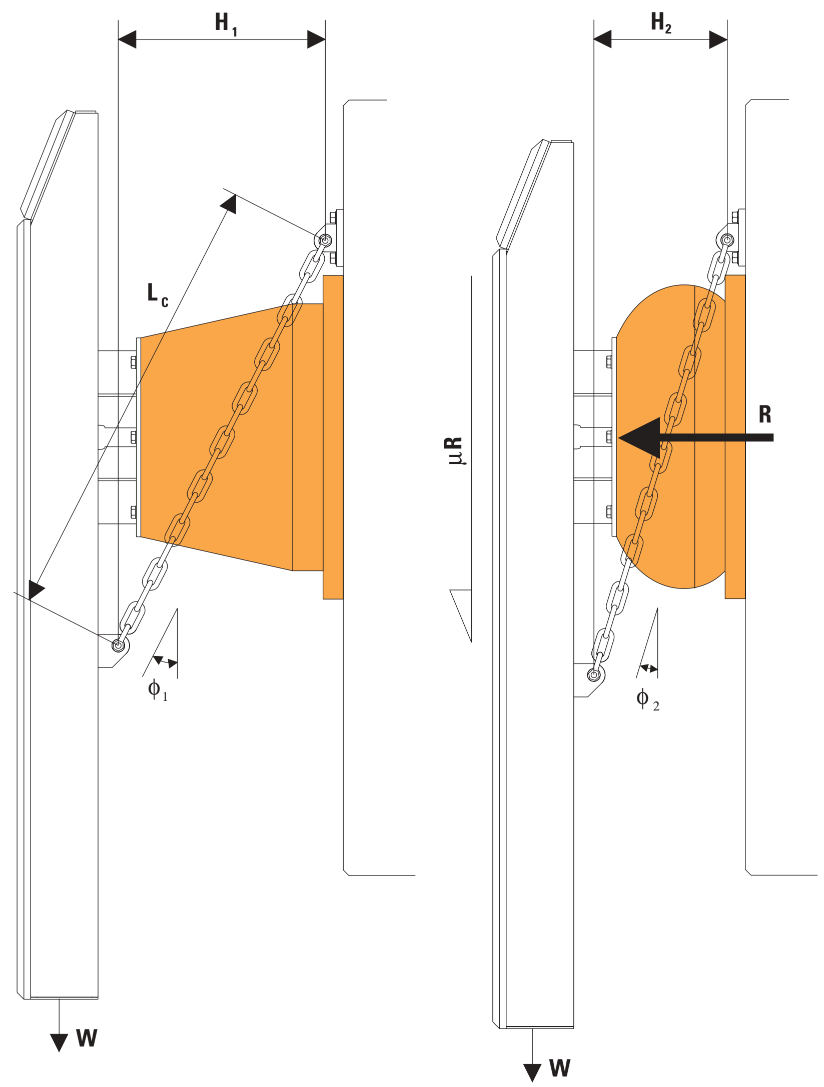
RESTRAINT CHAINS

Weight and shear chains are used to resist large vertical and horizontal forces. These forces are a function of the fender reaction, friction coefficient of the front face pads and the weight of the fender panel plus pads (weight chains only).

Well designed chain assemblies are important for the good performance of the fender system. Excessive slack should be avoided by careful dimensioning of the chains and, if necessary, an adjuster. Chains should not be twisted as this reduces their load capacity - instead, the brackets should be oriented in the correct plane.

Restraint chains must resist snatch loads and for this reason open link rather than stud link chains are preferred, as studs tend to work loose after repeated loadings resulting in significant loss of strength.

The initial (static) angle of the chain is important. Normally weight chains are set at a static angle of 15~25° to the vertical and shear chains are set 20~30° to the horizontal. If set at larger angles, the arc the chain transcribes during fender compression will either allow excessive shear, or it will go slack and be ineffective.



SAFETY FACTORS

A safety factor should always be applied to the safe working load (SWL) of the chain to minimise the risk of breakage and to allow for wear and tear. Safety factors of between 2~3 are typical, though for very heavy duty applications, factors above these are sometimes applied.

SHACKLES

It is wise to include a "weaker" link in the chain assembly. In the event of accidental overload due to snagging or other reasons, the weak link will fail first and prevent damage to other components such as chain brackets, anchors and fender panels that might be much more costly to repair or replace.

This can be achieved by specifying shackles that are the same diameter and grade as the chains. If the same breaking load is required for both chains and shackles, then a larger diameter shackle is required.
(See Chain & Shackle Tables)

CHAIN CALCULATIONS

Both weight and shear chain loads are determined in the same manner as follows:-

$$\phi_1 = a\sin\left[\frac{H_1}{L_C}\right] \quad \text{or} \quad H_1 = L_C \cdot \sin\phi_1$$

$$H_2 = H_1 - \delta_F$$

$$\phi_2 = a\sin\left[\frac{H_2}{L_C}\right] \quad \text{or} \quad \phi_2 = a\sin\left[\frac{H_1 - \delta_F}{L_C}\right]$$

$$SWL = \frac{(\mu \cdot (\Sigma R)) + W}{9.81 \cdot n \cdot \cos\phi_2}$$

$$MBL = F_S \cdot SWL$$

where,

ϕ_1	=	Static angle of chain (degrees)
H_1	=	Static offset between brackets (m)
L_C	=	Bearing length of chain (m)
H_2	=	Dynamic offset between brackets at δ_F (m)
δ_F	=	Fender compression (m)
ϕ_2	=	Dynamic angle of chain (degrees)
SWL	=	Safe Working Load of chain (tonne)
μ	=	Friction coefficient of face pad material
	=	0.15 for UHMW-PE facings, typically
ΣR	=	Combined reaction of all rubber fenders (kN)
n	=	Number of chains acting together
MBL	=	Minimum Breaking Load of chain (tonne)
F_S	=	Factor of safety = 2~3 (typically)

FRICTION COEFFICIENTS

Friction coefficients have a large influence on the size of shear chains. It is recommended that low friction materials such as UHMW-PE are used to face fender panels which will reduce shear forces applied to the berth structure.

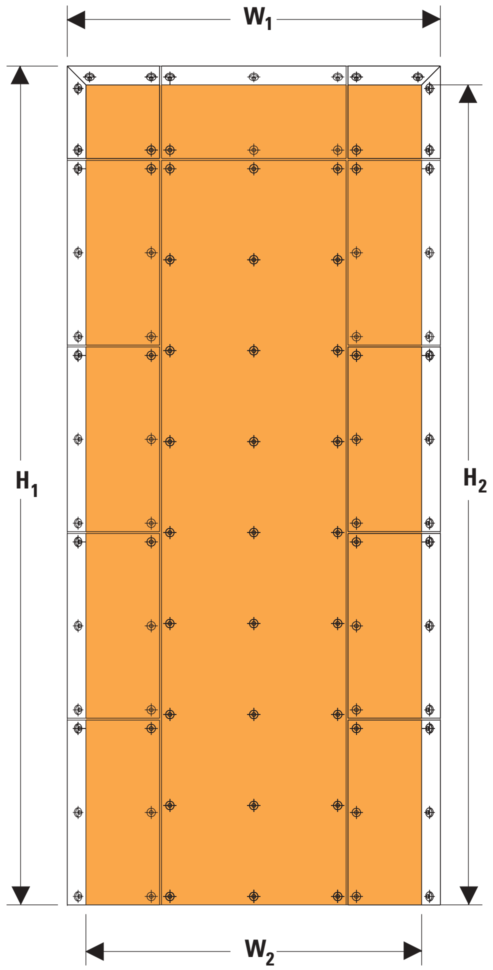
Typical friction coefficients for different materials are given below:-

Material	Friction Coefficient (μ)
UHMW-PE to Steel (wet)	≤0.10
UHMW-PE to Steel (dry)	0.10~0.15
HD-PE to Steel	0.20~0.25
Rubber to Steel	0.50~1.00
Timber to Steel	0.30~0.50

HULL PRESSURES

Permissible hull pressures vary greatly with the class and size of ship.
The best guide to hull pressures is experience of similar installations.
Where this information is unavailable, then the following table may be used as an approximate guide for design (refer to Ship Tables on pages 70-72 for vessel sizes).

ULCC & VLCC	150~250 kN/m²
Tankers	250~350 kN/m²
Product & Chemical Tankers	300~400 kN/m²
Bulk Carriers	150~250 kN/m²
Post-Panamax Container Ships	200~300 kN/m²
Panamax Container Ships	300~400 kN/m²
Sub-Panamax Container Ships	400~500 kN/m²
General Cargo (un-belted)	300~600 kN/m²
Gas Carriers	100~200 kN/m²



Hull pressures are calculated using the nett panel area (excluding lead-in chamfers) as follows:-

$$P = \frac{\Sigma R}{W_2 \cdot H_2} \leq P_P$$

where,
- P = Hull pressure (kN/m²)
- ΣR = Combined reaction of all rubber fenders (kN)
- W_2 = Panel width excluding lead-in chamfers (m)
- H_2 = Panel height excluding lead-in chamfers (m)
- P_P = Permissible hull pressure (kN/m²)

OTHER FENDER TYPES

The above calculations and table apply to berths fitted with fender panel systems. However, many berths have used Cylindrical and Arch fenders successfully and without ship damage, despite the fact that these fenders exert higher hull pressures, typically:-

Arch Fenders:	760~1300kN/m²
Cylindrical Fenders:	460~780kN/m²

Also bear in mind that when cylindrical fenders are used with large chain or bar fixings through the central bore, these may locally increase hull pressures to approximately double the above figures. Again there is no evidence to show that this causes hull damage.

RUBBER PROPERTIES

Fentek rubber fender components are manufactured from the highest quality Natural Rubber (NR), optionally Styrene Butadiene SBR based compounds which meet or exceed the performance requirements of European Union specification EAU-E 62 "Acceptance Requirements for Fender Elastomers". Typical specifications are listed in the table below.

In addition to NR and SBR, other rubber compounds in Butyl, EPDM, and Polyurethane are available on request for specialist applications. Please consult Fentek for further details.

Property	Testing Standard	Condition	Requirement
Tensile Strength	ASTM D412 Die C; AS 1180.2; BS 903.A2; ISO 37; JIS K6301 Item 3, Dumbell 3	Original	16MPa (Min)
		Aged for 96 hours at 70˚C	12.8MPa (Min)
	DIN 53504	Original	15N/mm² (Min)
		Aged for 168 hours at 70˚C	12.75N/mm² (Min)
Elongation at Break	ASTM D412 Die C; AS 1180.2; BS 903.A2; ISO 37; JIS K6301 Item 3, Dumbell 3	Original	400% (Min)
		Aged for 96 hours at 70˚C	320% (Min)
	DIN 53504	Original	300% (Min)
		Aged for 168 hours at 70˚C	280% (Min)
Hardness	ASTM D2240; AS 1683.15.2; BS 903.A6; ISO 815; JIS K6301 Item 5A Tester	Original	78° (Max) Shore A
		Aged for 96 Hours at 70˚C	Original Value + 6° points increase
	DIN 53505	Original	75° (Max) Shore A
		Aged for 168 hours at 70˚C	Original Value + 5° points increase
Compression Set	ASTM D395; AS 1683.13B; BS 903.A6; ISO 815; JIS K6301 Item 10	Aged for 22 hours at 70˚C	30% (Max)
	DIN 53517	Aged for 24 hours at 70˚C	40% (Max)
Tear Resistance	ASTM D624; AS 1683.12; BS 903.A3; ISO 34.1; JIS K6301 Item 9, Test Piece A	Die B	70kN/m (Min)
	DIN 53507		80 N/cm (Min)
Ozone Resistance	ASTM D1149; AS 1683.24; BS 903.A43; DIN 53509; ISO 143/1	1ppm at 20% strain at 40°C for 100 hours	No cracking visible by eye
Seawater Resistance	DIN 86076, Section 7.7	28 days in artificial seawater at 95˚C ±2˚C	Hardness ±10° (Max) Shore A Volume +10/-5% (Max)
Abrasion Resistance	BS 903.A9	Method B, 1000 revolutions	0.5cc (Max)
	DIN 53516		100mm³ (Max)
Bond Strength Steel to Rubber	BS 903.A21	Method B	7N/mm (Min)

The above values are for tests carried out under strict laboratory conditions using specimens taken from batches of unvulcanised rubber compound.

PERFORMANCE TESTING

Moulded[1] and wrapped cylindrical[2] fenders are routinely tested as a part of Fentek's commitment to quality. All testing is conducted in-house, with the option of third party witnessing, using full size fenders in accordance with the PIANC[3] guidelines below.

i) All fender units shall be given a unique serial number which can be traced back to manufacturing and testing records.
ii) Fenders shall be tested under direct (vertical) compression.
iii) Compression speed shall be 2~8 cm/min.
iv) Test temperature shall be 23°C ±5°C[4].
v) Reaction force[5] shall be recorded at intervals to at least a deflection at which the permitted[6] minimum energy absorption is achieved.
vi) Energy absorption[5] shall be determined as the integral of reaction and deflection, calculated using Simpson's Rule.
vii) The result of the first compression cycle shall not be recorded.
viii) The average performance from the second and third compression cycles shall be less than the permitted[6] maximum reaction and more than the permitted[6] minimum energy absorption.
ix) Sampling shall be 1 in 10 fenders (rounded up to a unit)
x) If any sample does not satisfy the specifications, sampling of the remainder shall be increased to 1 in 5 fenders (rounded up to a unit), excluding non-compliant units.
xi) If any further sample does not satisfy the specifications, all remaining samples shall be tested. Only units which satisfy the specifications shall be passed for shipment.
xii) Non-compliant units shall be clearly marked and isolated.

Where Super Cone and Unit Element fenders are required for "load sensitive" structures, it is suggested that fender testing frequency be increased[8] in accordance with the following tables:-

PERFORMANCE TESTING

Fender Height	Pre-Compression[9]	PIANC Testing
H ≤ 900mm	20~25% of units	10% of units
900mm < H ≤ 1300mm	100% of units	20~30% of units
H > 1300mm	N/A	100% of units

1 Moulded fenders include Super Cones, Unit Elements and AN/ANP Arch fenders. Super Cone and AN/ANP Arch fenders are tested singly, Unit Element fenders are tested in pairs.
2 Excluding tug cylindrical fenders.
3 PIANC – Permanent International Association of Navigation Congresses
Report of the International Commission for Improving the Design of Fender Systems
Supplement to Bulletin No 45 (1984) – Annex 4.1 (pages 85~87)
4 Where ambient temperature is outside of this range, fenders shall be normalised to this temperature range in a conditioning room for an appropriate period (dependent upon fender size) or performance values may be corrected according to temperature correction factor tables.
5 Reaction force (and corresponding calculated energy absorption) shall be the exact recorded value and not corrected or otherwise adjusted for speed correction unless required by the project specifications.
6 Permitted values for reaction and energy are catalogue values and applicable manufacturing tolerances.
7 The deflection at which minimum energy permitted energy absorption is achieved may differ from the nominal "rated" deflection indicated in the catalogue for the relevant fender type.
8 Standard PIANC testing is included within the fender price. Additional testing frequency, third party witnessing and temperature conditioning costs are borne by the purchaser.
9 Pre-compression testing involves a single "run in" cycle up to catalogue rated deflection. Reaction force is not recorded for pre-compression testing.

CHANGES TO FENDER TESTING

In April 2002, PIANC Working Group 33 of the Maritime Navigation Commission published its report on "Guidelines for the Design of Fender Systems : 2002" which has been widely welcomed and adopted by fender designers and specifiers. It also introduces a new "Procedure to Determine and Report the Performance of Marine Fenders" in Appendix A.

This new test protocol requires manufacturers to undergo a series of type approval tests for each significant fender type they make, to define the effects on performance of different deflection rates, temperatures, berthing frequencies and compression angles. In addition, the protocol suggests more stringent and frequent quality control testing.

Due to its complexity, it will take manufacturers some time to phase in the new protocol. Please contact Fentek for further details and timescale, as well as copies of type approval certificates.

To order a copy of the PIANC WG33 Report or to join the PIANC organisation, please visit www.pianc-aipcn.org.

TOLERANCES

All Fentek fenders are subject to standard manufacturing and performance tolerances. For specific applications, smaller tolerances may be agreed on a case by case basis.

Manufacturing Tolerances		
Moulded Fenders	All dimensions Bolt hole spacing	±3% or ±2mm[1] ±2mm
Composite Fenders	Cross-section Length	±3% or ±2mm[1] ±2% or ±25mm[1]
	Drilled hole centres Counterbore depth	±4mm (non-cumulative) ±2mm (under head depth)
Block Fenders Cube Fenders M Fenders	Cross-section Length	±2% or ±2mm[1] ±2% or ±10mm[1]
	Fixing hole centres Fixing hole diameter	±3mm ±3mm
Cylindricals Fenders	Outside diameter Inside diameter Length	±4% ±4% -0/+40mm
Extruded Fenders	Cross-section Length	±4% -0/+40mm
	Drilled hole centres Counterbore depth	±4mm (non-cumulative) ±2mm (under head depth)
HD-PE Sliding Fenders[2]	Cross-section Length	±4% or ±1mm (planed) ±10mm
	Drilled hole centres Counterbore depth	±2mm (non-cumulative) ±2mm (under head depth)
UHMW-PE Face Pads[2]	Length & width & width	±5mm (cut pads) ±20mm (uncut sheets)
	Thickness: ≤ 30mm (Planed) 31~100mm ≥ 101mm	±0.2mm ±0.3mm ±0.5mm
	Thickness: ≥ 30mm (Unplaned) 31~100mm ≥ 101mm	±2.5mm ±4.0mm ±6.0mm
	Drilled hole centres Counterbore depth	±2mm (non-cumulative) ±2mm (under head depth)

Performance Tolerances[3]		
SCN, UE, AN & ANP	Reaction, Energy & Deflection	±10% (E1, E2 & E3)
Cylindricals (Wrapped)	Reaction, Energy & Deflection	±10%
Cylindricals (Extruded)	Reaction, Energy & Deflection	±20%
Extruded Fenders	Reaction, Energy & Deflection	±20%
Pneumatic Fenders	Reaction & Energy Deflection	±10% ±5%
Foam Fenders	Reaction & Energy Deflection	±15% ±5%
Block, Cube & M-Fenders	Reaction & Deflection	±10%

1 Whichever is the greater dimension.
2 All values are measured at 18°C and subject to thermal expansion coefficients (see material properties).
3 Please consult Fentek for performance tolerance on fender types not listed above.

OTHER USEFUL INFORMATION

CONVERSION TABLES

DISTANCE	km	mile	nm
1 km =	1	0.6214	0.5400
1 mile =	1.6093	1	0.8690
1 nm =	1.8519	1.1508	1

LENGTH	m	in
1 m =	1	39.372
1 in =	0.025	1
1 ft =	0.3048	12
1 yd =	0.9144	36

VELOCITY	m/s	km/h	ft/s	mph	knot
1 m/s =	1	3.600	3.281	2.237	1.944
1 km/h =	0.2778	1	0.9114	0.6214	0.5400
1 ft/s =	0.3048	1.0972	1	0.6818	0.5925
1 mph =	0.4470	1.6093	1.4667	1	0.8690
1 knot =	0.5144	1.8518	1.6877	1.1507	1

DENSITY
1 kg/m^3 = 0.06243 lb/ft^3
1 lb/ft^3 = 16.0185 kg/m^3

MASS	kg	tonne	lb	kip
1 kg =	1	0.0010	2.205	0.002205
1 tonne =	1000	1	2205	2.2046
1 lb =	0.4536	0.000453	1	0.0010
1 kip =	453.6	0.4536	1000	1

ENERGY	1 kNm (kJ)
1 kNm (kJ) =	1
1 tonne-m =	9.807
1 ft.kip =	1.356

PRESSURE	bar	MPa	lb/in^2	t/m^2	kip/ft^2
1 bar =	1	0.1	14.5	0.102	2.089
1 MPa =	10	1	145	1.019	20.89
1 lb/in^2 =	0.06897	0.006897	1	0.7031	0.144
1 t/m^2 =	9.807	0.9807	1.4223	1	0.2048
1 kip/ft^2 =	0.4787	1	6.9444	4.8828	1

FORCE
1 kN = 0.2248 kipf
1 kipf = 4.449 kN

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 =	0.0311	0.3048	1

AREA	m^2	in^2
1 m^2 =	1	1550
1 in^2 =	0.000645	1
1 ft^2 =	0.0929	144
1 yd^2 =	0.8361	1296

STEEL EQUIVALENTS TABLES

A comparison between former national steel designations, now superseded by EN 10 025

EN 10 025:1993	Formerly	Yield (N/mm^2)	Temp (°C)	Germany	France	UK	Spain	Italy	Belgium	Sweden	Portugal	Norway
S 185	Fe 310-0	185	—	St 33	A 33		A 310-0	Fe 320	A 320	13 00-00	Fe 310-0	
S 235	Fe 360 A	235	—	St 37-1	E 24-1			Fe 360 A	AE 235-A		Fe 360-A	
S 235JR	Fe 360 B	235	+20	St 37-2	E 24-2			Fe 360 B	AE 235-B	13 11-00	Fe 360-B	NS 12 120
S 235JRG1	Fe 360 B(FU)	235	+20	USt 37-2		40 A	AE 235 B-FU					NS 12 122
S 235JRG2	Fe 360 B(FN)	235	+20	RSt 37-2		40 B	AE 235 B-FN			13 12-00		NS 12 123
S 235JO	Fe 360 C	235	0	ST 37-3 U	E 24-3	40 C	AE 235 C	Fe 360 C	AE 235-C		Fe 360-C	NS 12 124
S235JOG3	Fe 360 D1	235	-20	ST 37-3 N	E 24-4	40 D	AE 235 D	Fe 360 D	AE 235-D		Fe 360-D	NS 12 124
S235JOG4	Fe 360 D2	235	-20		E 24-4	40 D	AE 235 D	Fe 360 D	AE 235-D		Fe 360-D	NS 12 124
S 275	Fe 430 A	275	—	St 44-1	E 28-1	43 A	AE 275 A	Fe 430 A	AE 255-A		Fe 430-A	
S 275JR	Fe 430 B	275	+20	St 44-2	E 28-2	43 B	AE 275 B	Fe 430 B	AE 255-B	14 12-00	Fe 430-B	NS 12 142
S 275JO	Fe 430 C	275	+0	St 44-3 U	E 28-3	43 C	AE 275 C	Fe 430 C	AE 255-C		Fe 430-C	NS 12 143
S 275J2G3	Fe 430 D1	275	-20	St 44-3 N	E28-4	43 D	AE 275 D	Fe 430 D	AE 255-D	14 14-00	Fe 430-D	NS 12 143
S 275J2G4	Fe 430 D2	275	-20		E28-4	43 D	AE 275 D	Fe 430 D	AE 255-D	14-14-01	Fe 430-D	NS 12 143
S 355	Fe 510 A	355	—		E 36-1	50 A	AE 355 A	Fe 510 A	AE 355-A		Fe 510-A	
S 355JR	Fe 510 B	355	+20		E 36-2	50 B	AE 355 B	Fe 510 B	AE 355-B		Fe 510-B	
S 355JO	Fe 510 C	355	0	St 52-3 U	E 36-3	50 C	AE 355 C	Fe 510 C	AE 355-C		Fe 510-C	NS 12 153
S 355J2G3	Fe 510 D1	355	-20	St 52-3 N		50 D	AE 355 D	Fe 510 D	AE 355-D		Fe 510-D	NS 12 153
S 355J2G4	Fe 510 D2	355	-20			50 D	AE 355 D	Fe 510 D	AE 355-D		Fe 510-D	NS 12 153
S 355K2G3	Fe 510 DD1	355	-20		E 36-4	50 DD			AE 355-DD		Fe 510-DD	
S 355K2G4	Fe 510 DD2	355	-20		E 36-4	50 DD			AE 355-DD		Fe 510-DD	

Information is provided for guidance only.
Reference should be made to EN 10 025 : 1993 for more specific properties.

PROJECT REQUIREMENTS

FENTEK REF: ____________

PORT ____________

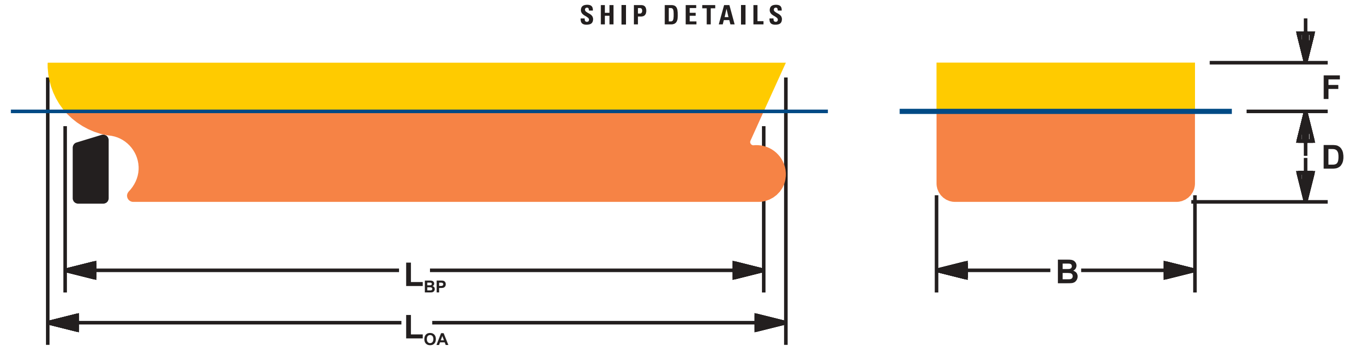
PROJECT ____________

CONSULTANT ____________

CONTRACTOR ____________

- ❑ **PROJECT STATUS**
- ❑ **PRELIMINARY**
- ❑ **DETAIL DESIGN**
- ❑ **TENDER**

SHIP DETAILS



Largest Vessel..........

Vessel Type..........

Deadweight..........(t)

Displacement..........(t)

Length Overall (L_{OA})..........(m)

Length Between Perps (L_{BP})..........(m)

Beam (B)..........(m)

Draft (D)..........(m)

Freeboard (F)..........(m)

Hull Pressure (P)..........(t/m^2)

Smallest Vessel..........

Vessel Type..........

Deadweight..........(t)

Displacement..........(t)

Length Overall (L_{OA})..........(m)

Length Between Perps (L_{BP})..........(m)

Beam (B)..........(m)

Draft (D)..........(m)

Freeboard (F)..........(m)

Hull Pressure (P)..........(t/m_)

BERTH DETAILS

- ❑ **CLOSED STRUCTURE**
- ❑ **SEMI-OPEN**
- ❑ **OPEN STRUCTURE**
- ❑ **OTHER (PLEASE DESCRIBE)**

Structure . . . .

Length of Berth . . . . (m)

Fender/Dolphin Spacing . . . . (m)

Permitted Fender Reaction . . . . (kN)

Quay Level . . . . (m)

Cope Thickness . . . . (m)

Seabed Level . . . . (m)

Tide Levels . . . .

Tidal Range . . . . m

Highest Astronomic Tide (HAT) . . . . m

Mean High Water Spring (MHWS) . . . . m

Mean Sea Level (MSL) . . . . m

Mean Low Water Spring (MLWS) . . . . m

Lowest Astronomic Tide (LAT) . . . . m

BERTHING MODE

❑ Side Berthing

❑ Dolphin Berthing

❑ End Berthing

❑ Dolphin Berthing

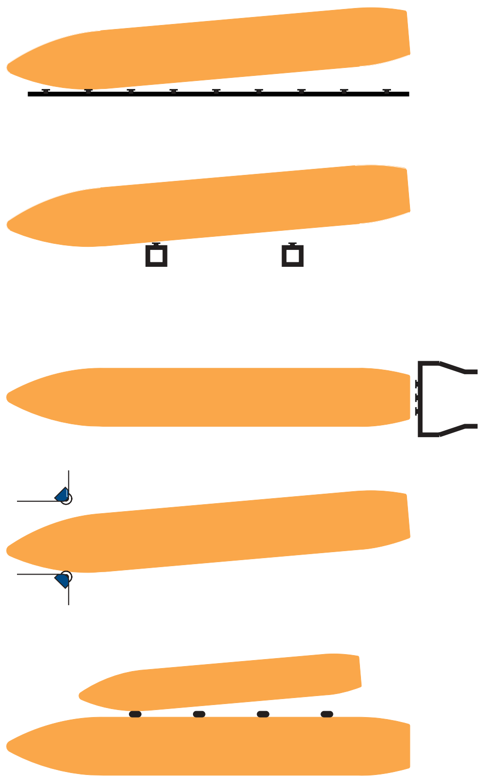
❑ Lock or Dock Entrance

❑ Ship-to-Ship Berthing

❑ Other Berthing Mode ....

....

....



BERTHING APPROACH

Approach Conditions

❑ a) Easy berthing, sheltered

❑ b) Difficult berthing, sheltered

❑ c) Easy berthing, exposed

❑ d) Good berthing, exposed

❑ e) Difficult berthing, exposed

Largest Ship

Berthing Speed .... (m/s)

Berthing Angle.................. (deg)

Safety Factor on Energy ....

Smallest Ship

Berthing Speed .... (m/s)

Berthing Angle.................. (deg)

Safety Factor on Energy ....

OTHER INFORMATION

FURTHER INFORMATION IS AVAILABLE FROM

Name	Name ....
....	....
Position	Position ....
Company	Company ....
Tel..	Tel..
Fax	Fax ....
Email...	Email...

SOURCES OF FURTHER INFORMATION

1. Code of Practice for Design of Fendering and Mooring Systems
   BS 6349 : Part 4 : 1994 (ISBN 0-580-22653-0)
2. Recommendations of the Committee for Waterfront Structures
   EAU 1990 (ISBN 3-433-01237-7)
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   Supplement to Bulletin No.45 (1984) PIANC
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   ROM 0.2-90 (ISBN 84-7433-721-6).
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   Technical Note of the Port and Harbour Research Institute, Ministry of Transport, Japan
   No. 911, Sept 1998 (ISSN 0454-4668)
6. Approach Channels – A Guide to Design
   Supplement to Bulletin No.95 (1997) PIANC (ISBN 2-87223-087-4)
7. Port Design – Guidelines and Recommendations
   Carl A. Thoresen (ISBN 82-519-0839-6)
8. On Fender Design and Berthing Velocities – 24th PIANC Congress
   J.U. Brolsma et al
9. The Berthing Ship
   F. Vasco Costa
10. Significant Ships - Royal Institute of Naval Architects
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