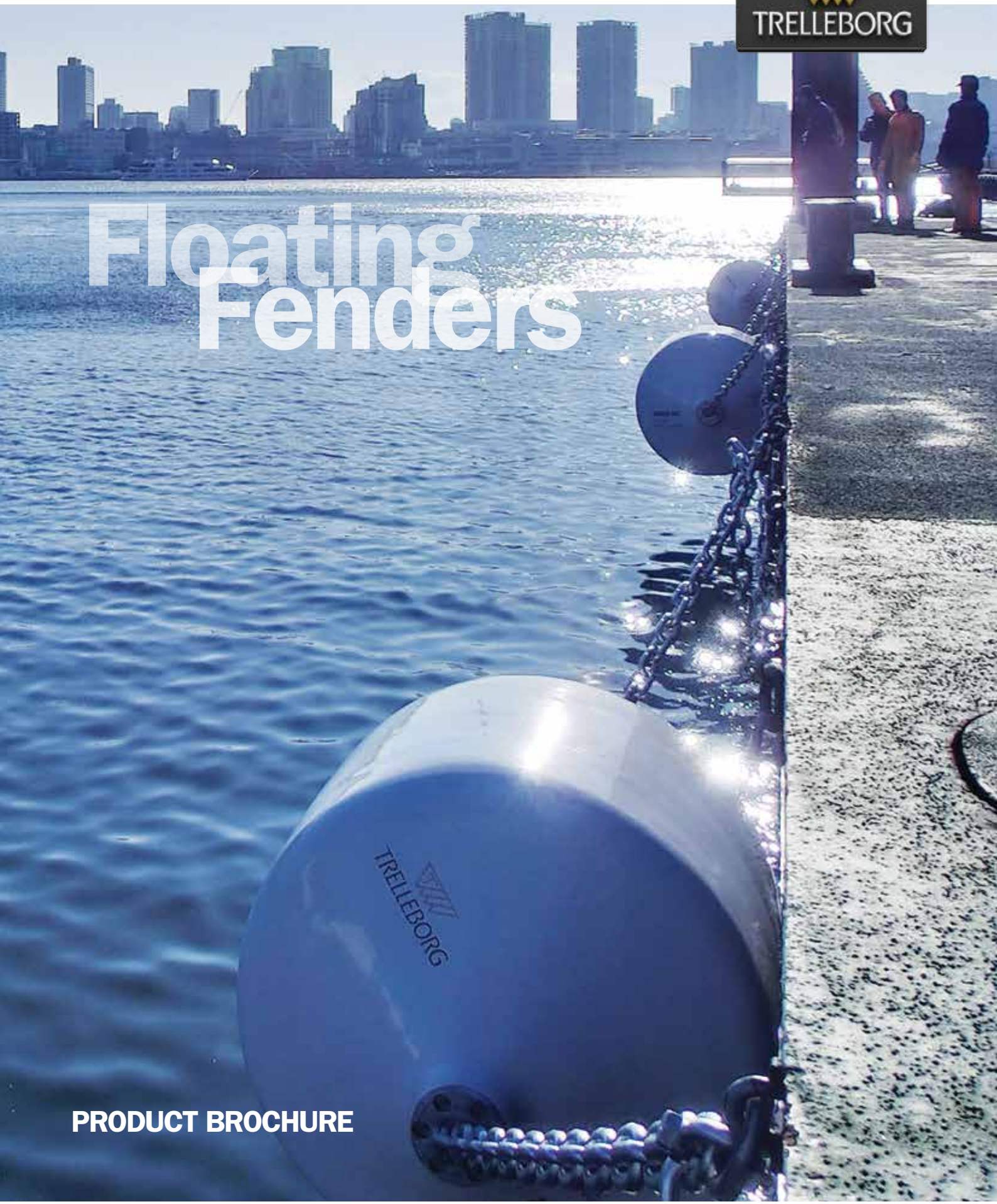
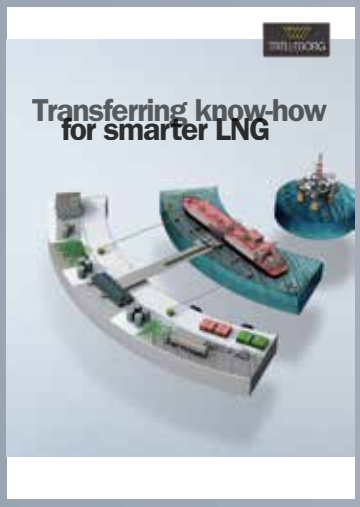
TRELLEBORG MARINE AND INFRASTRUCTURE

Floating Fenders



PRODUCT BROCHURE

The Smarter Approach



Connect with **The Smarter Approach**

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

Our Smarter Approach combines global reach with feet-on-the-ground local presence, delivering solutions that continually enhance your operations.

Smart technologies are at the forefront of improving operational efficiencies. Trelleborg's innovative SmartPort offering deploys the latest in marine technology applications to help ports and terminals optimize their operations.

Connect with a partner that combines smart solutions, proven product capability and industry expertise to maintain and enhance port and vessel performance.

Take a Smarter Approach, with Trelleborg Marine Systems.

Floating Fenders

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

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

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

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

Take a Smarter Approach to fender performance with Trelleborg.

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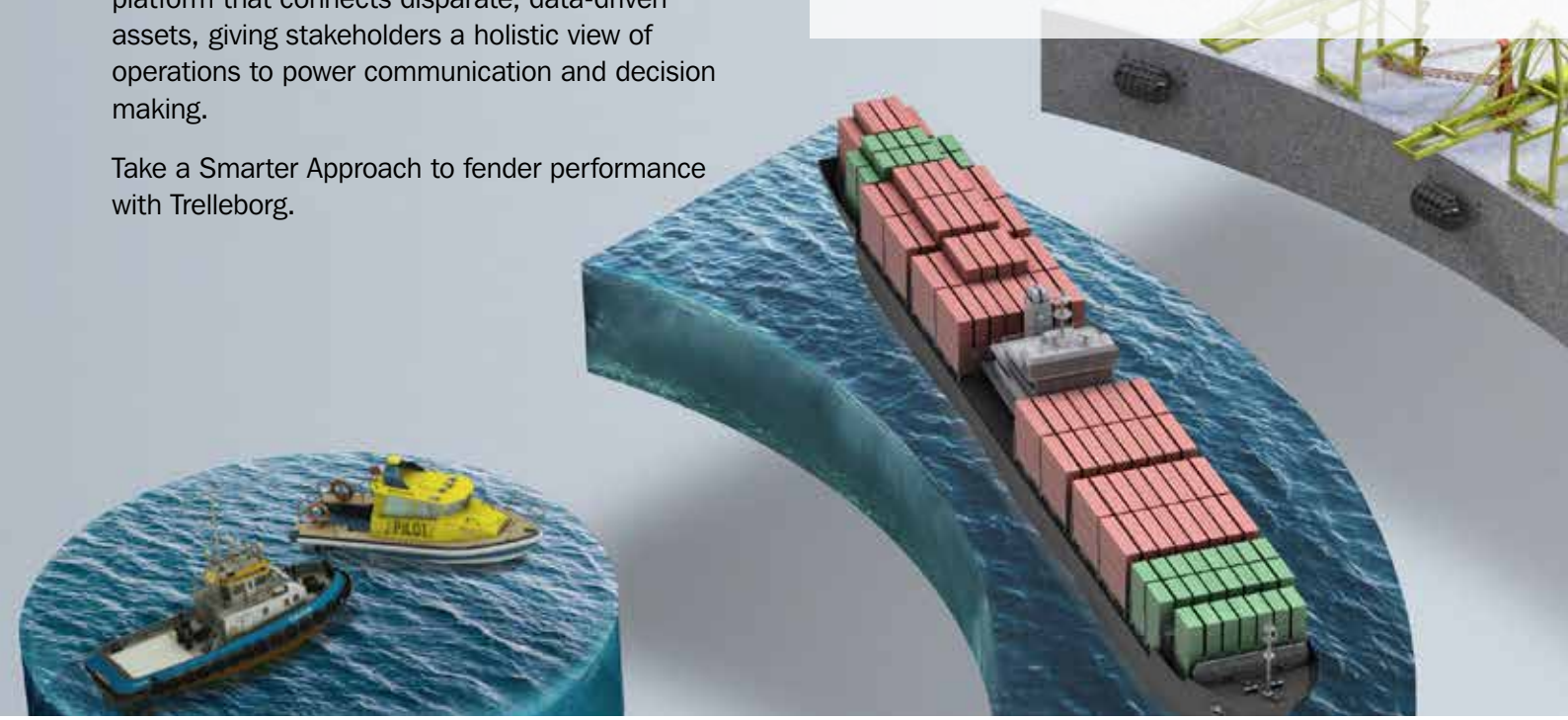


A Smarter Approach at every stage

A smarter approach to…

CONSULTATION

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

CONCEPTS

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

DESIGN

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

MANUFACTURE

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

TESTING

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

INSTALLATION

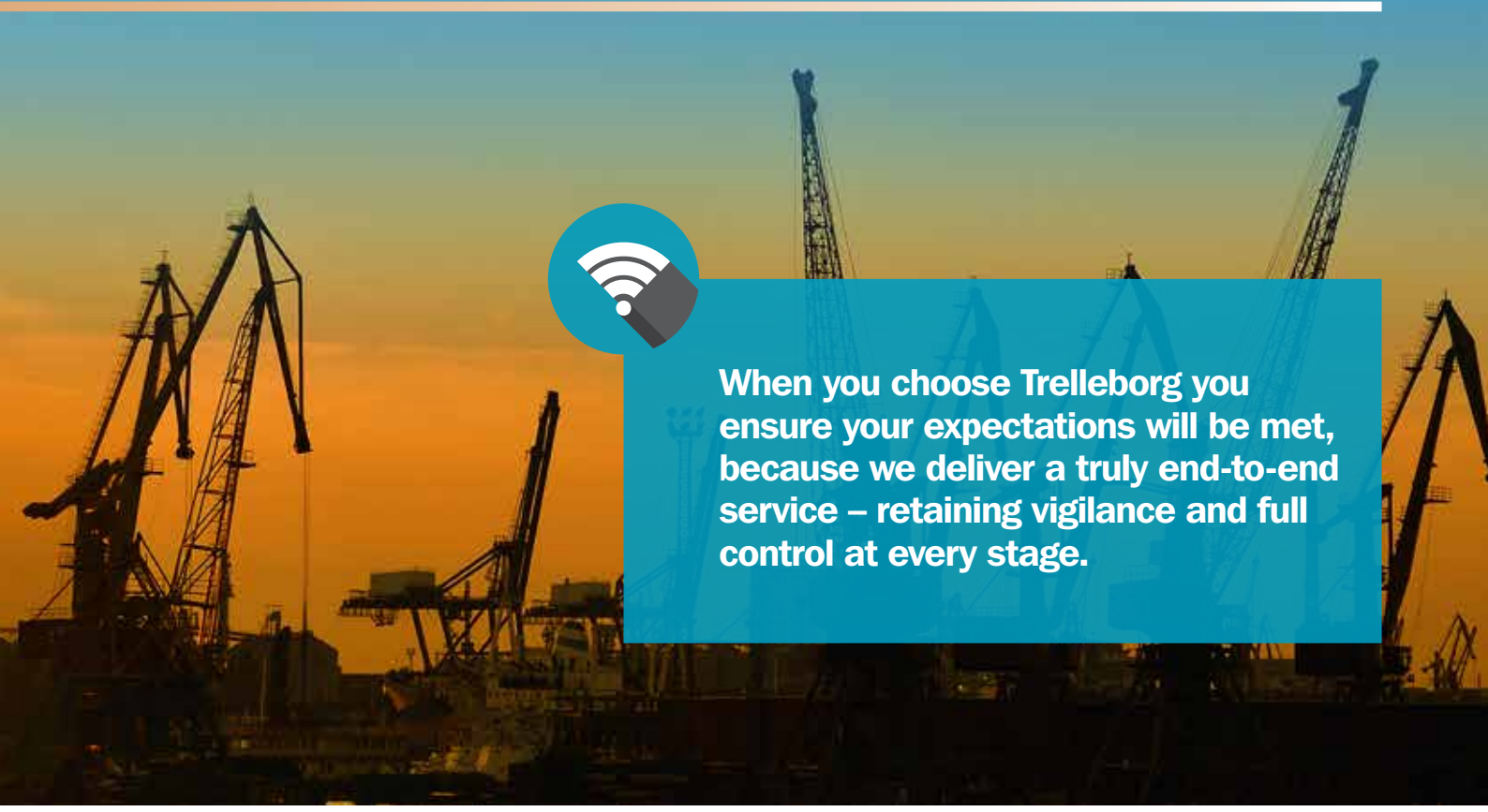
Dedicated project management, from solution design right the way through to on site installation support. We design products and solutions that always consider ease of installation and future maintenance requirements.

SUPPORT

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

THE FUTURE

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



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

Foam Fenders

Trelleborg foam fenders absorb impact while resisting wear and tear in an aggressive environment.

SeaGuard®, SeaCushion® and Donut fenders share a construction technology centered on a closed-cell polyethylene foam core and an outer skin of reinforced polyurethane elastomer. The closed-cell foam structure retains performance even if a fender's skin is punctured. The closed cell internal structure prevents water ingress into the foam.

Even after many years of active service, foam fenders can often be returned to the factory, reskinned and fully refurbished to an almost new condition. Ask your local TMS office for details.

Rental options are available for foam fenders. Installation can be done within days to any location worldwide. Rental is highly cost effective for temporary applications and with Trelleborg you get a fender rental service second to none.

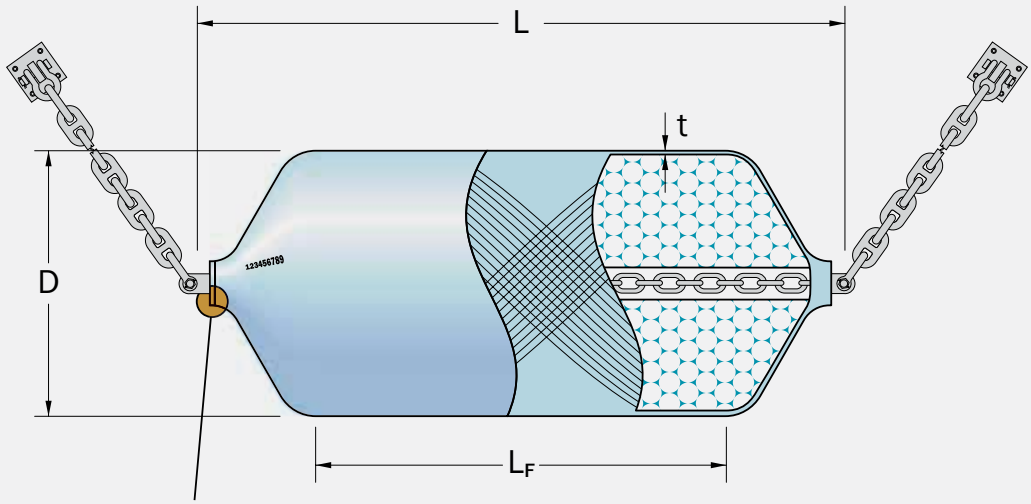
FENDER	FEATURES	APPLICATION
***SeaGuard®**	Fully compliant with US Navy specifications Wide range of standard and custom sizes Low reaction and high energy options Operate floating or suspended No chain/tire net required Non-marking even against white hulls Unsinkable design	Cruise ships Container vessels Bulk cargo RoRo and ferries Oil and gas tankers General cargo Navy berths Ship-to-ship transfers
SeaCushion®	Ultra-tough, unsinkable design Wide range of standard and custom sizes Low reaction and high energy options Low hull pressures Maintains safe stand-off distances Low maintenance Well proven design	LNG and oil terminals Ship-to-ship operations Offshore boat landings Shipyards Military applications
Donut Fenders	Freely rotates around a pile Rises and falls with water level Simple installation Requires minimal maintenance High performance Low hull pressures Will not mark ship hulls	Corner protection Turning structures Lead-in jetties Simple breasting dolphins Bridge protection RoRo berths

* SeaGuard® Fenders are ABS Type approved based on ABS rules and ASTM standard. It is voluntary and denotes excellence in manufacturing quality and performance.

Consistent with its quality and environmental policies, Trelleborg Marine Systems maintains both ISO 14001:2004 (Environmental) and ISO 9001:2008 (Quality) certifications.

TAA Compliant
TAA refers to the Trade Agreements Act (19 U.S.C. & 2501-2581), which is intended to foster fair and open international trade.

Foam Fenders – SeaGuard®



Integrated end terminals

Closed cell foam core

Polyurethane skin

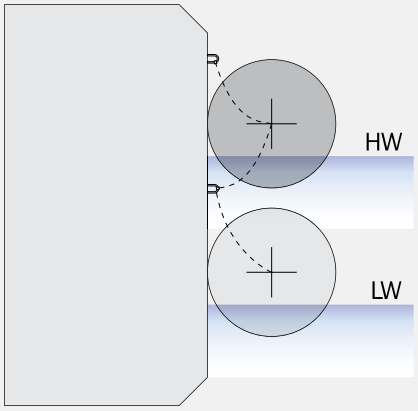
Fixings

Filament reinforcement

Internal chains

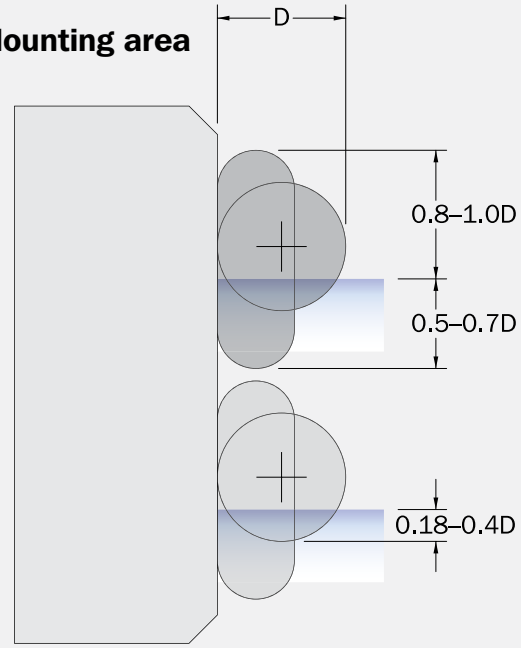
Serial number

Mooring applications



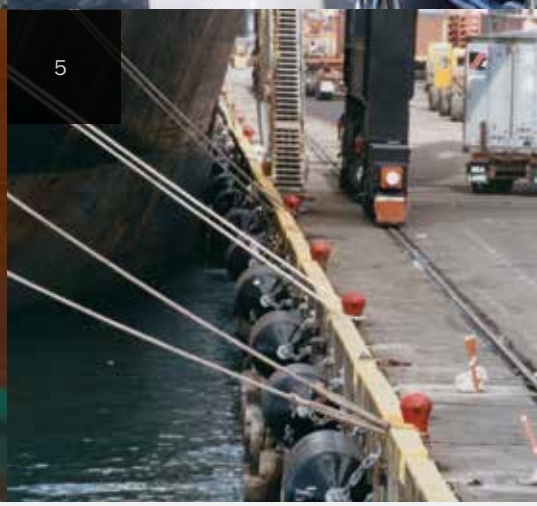
Floating or suspended

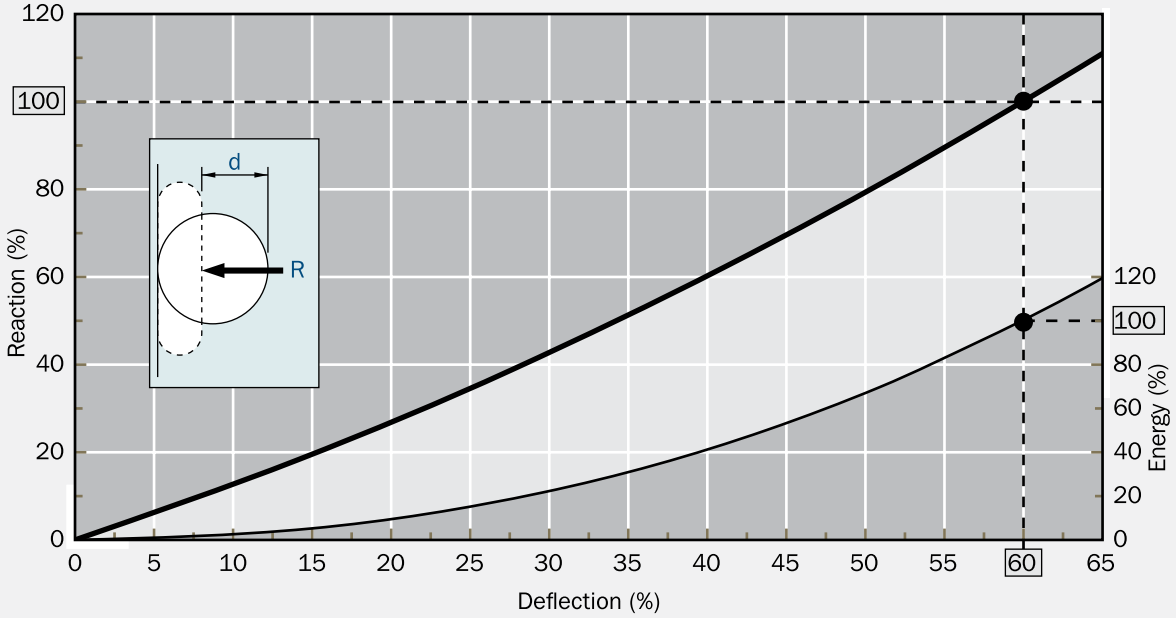
Mounting area



Supporting structures must be large enough to cope with tides and the fender footprint when compressed.

1. JAPAN
2. JAPAN
3. CHINA
4. USA
5. PUERTO RICO





Note: Standard manufacturing and performance tolerance:
Energy: 100%, Reaction: 100%, Tolerance: ± 10%

Foam Fenders – SeaGuard®

PERFORMANCE AT 60% DEFLECTION (METRIC)

DIAMETER X LENGTH		STANDARD CAPACITY			
(m)	(ft)	ENERGY (kNm)	REACTION (kN)	ENERGY (ft-kip)	REACTION (kip)
0.7 x 1.5	2.3 x 4.9	26	133	19	30
1.0 x 1.5	3.3 x 4.9	47	173	35	39
1.0 x 2.0	3.3 x 6.6	68	254	50	57
1.2 x 2.0	3.9 x 6.6	91	280	67	63
1.35 x 2.5	4.4 x 8.2	152	418	112	94
1.5 x 3.0	5 x 10	244	596	180	134
1.7 x 3.0	5.6 x 9.8	282	618	208	139
2.0 x 3.5	6.6 x 11.5	454	845	335	190
2.0 x 4.0	6.6 x 13.1	540	1005	398	226
2.0 x 4.5	6.6 x 14.8	624	1161	460	261
2.2 x 3.5	7.2 x 11.5	541	915	399	206
2.2 x 4.0	7.2 x 13.1	643	1088	474	245
2.2 x 4.5	7.2 x 14.8	746	1263	550	284
2.2 x 5.0	7.2 x 16.4	847	1437	625	323
2.2 x 6.0	7.2 x 19.7	1052	1784	776	401
3.0 x 4.9	10 x 16	1464	1788	1080	402
3.0 x 6.1	10 x 20	1946	2375	1435	534
3.3 x 4.5	10.8 x 14.8	1498	1690	1105	380
3.3 x 6.5	10.8 x 21.3	2421	2731	1786	614

Refer to Notes on page 13.

For increased energy use high, extra high or super high capacity foam grades.

FOAM GRADES		RATIO	AVERAGE REACTION PRESSURE *	
			KPa	KSF
Low reaction	LR	0.6	<103	<2.2
Standard	STD	1.0	<172	<3.6
High capacity	HC	1.3	<224	<4.7
Extra high capacity	EHC	1.9	<327	<6.8
Super high capacity	SHC	2.6	<447	<9.4

*Reaction pressure varies depending on fender size. Contact Trelleborg for details.

Foam Fenders – SeaGuard®

PERFORMANCE AT 60% DEFLECTION (IMPERIAL)

DIAMETER X LENGTH		STANDARD CAPACITY			
(ft)	(m)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kN)
2 x 4	0.6 x 1.2	11	20	15	89
2 x 6	0.6 x 1.8	18	33	24	147
2 x 8	0.6 x 2.4	25	47	34	209
2 x 10	0.6 x 3.0	32	60	43	267
3 x 5	0.9 x 1.5	31	38	42	169
3 x 6	0.9 x 1.8	39	48	53	214
3 x 8	0.9 x 2.4	55	68	75	302
3 x 10	0.9 x 3.0	71	88	96	391
3 x 12	0.9 x 3.7	87	108	118	480
3 x 14	0.9 x 4.3	103	128	140	569
4 x 6	1.2 x 1.8	61	57	83	254
4 x 8	1.2 x 2.4	89	83	121	369
4 x 10	1.2 x 3.0	118	110	160	489
4 x 12	1.2 x 3.7	146	136	198	605
4 x 16	1.2 x 4.9	203	189	275	841
4 x 20	1.2 x 6.1	260	242	353	1076
5 x 8	1.5 x 2.4	136	101	184	449
5 x 10	1.5 x 3.0	180	134	244	596
5 x 12	1.5 x 3.7	224	167	304	743
5 x 14	1.5 x 4.3	269	200	365	890
5 x 16	1.5 x 4.9	313	233	424	1036
5 x 18	1.5 x 5.5	357	266	484	1183
6 x 12	1.8 x 3.7	300	186	407	827
6 x 16	1.8 x 4.9	427	265	579	1179
6 x 18	1.8 x 5.5	491	305	665	1354
6 x 20	1.8 x 6.1	554	344	751	1530
7 x 14	2.1 x 4.3	487	259	660	1152
7 x 16	2.1 x 4.9	574	305	778	1357
7 x 18	2.1 x 5.5	660	351	895	1561
7 x 20	2.1 x 6.1	747	397	1013	1766
8 x 14	2.4 x 4.3	619	288	839	1281
8 x 16	2.4 x 4.9	733	341	994	1517
8 x 18	2.4 x 5.5	847	394	1148	1753
8 x 20	2.4 x 6.1	961	447	1303	1988
8 x 22	2.4 x 6.7	1075	500	1458	2224
9 x 16	2.7 x 4.9	889	368	1205	1637
9 x 18	2.7 x 5.5	1032	427	1399	1899
9 x 20	2.7 x 6.1	1175	486	1593	2162
9 x 22	2.7 x 6.7	1318	545	1787	2424
10 x 16	3.0 x 4.9	1080	402	1464	1788
10 x 18	3.0 x 5.5	1257	468	1704	2082
10 x 20	3.0 x 6.1	1435	534	1946	2375
10 x 22	3.0 x 6.7	1613	600	2187	2669
10 x 24	3.0 x 7.3	1790	666	2427	2963
11 x 18	3.4 x 5.5	1482	501	2009	2229
11 x 20	3.4 x 6.1	1696	573	2299	2551
11 x 22	3.4 x 6.7	1910	646	2590	2874
12 x 24	3.7 x 7.3	2595	850	3518	3781
13 x 26	4.0 x 7.9	3240	985	4393	4381

Refer to Notes on page 13.

Foam Fenders – SeaGuard®

PERFORMANCE AT 60% DEFLECTION (METRIC)

DIAMETER X LENGTH		LOW REACTION				HIGH CAPACITY			
(m)	(ft)	ENERGY (kNm)	REACTION (kN)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kN)	ENERGY (ft-kip)	REACTION (kip)
0.7 x 1.5	2.3 x 4.9	15	80	11	18	33	173	24	39
1.0 x 1.5	3.3 x 4.9	28	102	21	23	61	227	45	51
1.0 x 2.0	3.3 x 6.6	41	151	30	34	88	329	65	74
1.2 x 2.0	3.9 x 6.6	54	169	40	38	118	365	87	82
1.35 x 2.5	4.4 x 8.2	91	249	67	56	197	543	145	122
1.5 x 3.0	5 x 10	146	356	108	80	317	774	234	174
1.7 x 3.0	5.6 x 9.8	169	369	125	83	366	801	270	180
2.0 x 3.5	6.6 x 11.5	273	507	201	114	591	1099	436	247
2.0 x 4.0	6.6 x 13.1	324	601	239	135	701	1303	517	293
2.0 x 4.5	6.6 x 14.8	374	698	276	157	811	1508	598	339
2.2 x 3.5	7.2 x 11.5	324	549	239	123	703	1189	518	267
2.2 x 4.0	7.2 x 13.1	386	653	285	147	836	1415	617	318
2.2 x 4.5	7.2 x 14.8	447	757	330	170	969	1640	715	369
2.2 x 5.0	7.2 x 16.4	509	861	375	194	1102	1865	813	419
2.2 x 6.0	7.2 x 19.7	632	1069	466	240	1368	2316	1009	521
3.0 x 4.9	10 x 16	879	1072	648	241	1904	2326	1404	523
3.0 x 6.1	10 x 20	1167	1423	861	320	2530	3087	1866	694
3.3 x 4.5	10.8 x 14.8	899	1014	663	228	1948	2193	1437	493
3.3 x 6.5	10.8 x 21.3	1452	1637	1071	368	3148	3550	2322	798

Refer to Notes on page 13.

Foam Fenders – SeaGuard®

PERFORMANCE AT 60% DEFLECTION (IMPERIAL)

DIAMETER X LENGTH		LOW REACTION				HIGH CAPACITY			
(ft)	(m)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kN)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kN)
2 x 4	0.6 x 1.2	7	12	9	53	14	26	19	116
2 x 6	0.6 x 1.8	11	20	15	89	23	43	31	191
2 x 8	0.6 x 2.4	15	28	20	125	33	61	45	271
2 x 10	0.6 x 3.0	19	36	26	160	42	78	56	347
3 x 5	0.9 x 1.5	19	23	25	101	40	49	55	220
3 x 6	0.9 x 1.8	23	29	31	129	51	62	69	276
3 x 8	0.9 x 2.4	33	41	45	182	72	88	98	391
3 x 10	0.9 x 3.0	43	53	58	236	92	114	125	507
3 x 12	0.9 x 3.7	52	65	71	288	113	140	153	625
3 x 14	0.9 x 4.3	62	77	84	342	134	166	182	740
4 x 6	1.2 x 1.8	36	34	49	151	79	74	107	329
4 x 8	1.2 x 2.4	53	50	72	222	116	108	157	480
4 x 10	1.2 x 3.0	71	66	96	294	153	142	207	632
4 x 12	1.2 x 3.7	88	82	119	365	190	177	258	787
4 x 16	1.2 x 4.9	122	113	165	504	264	246	358	1093
4 x 20	1.2 x 6.1	156	145	212	646	338	315	458	1399
5 x 8	1.5 x 2.4	82	61	111	271	177	131	240	583
5 x 10	1.5 x 3.0	108	80	146	356	234	174	317	774
5 x 12	1.5 x 3.7	135	100	183	445	292	217	396	965
5 x 14	1.5 x 4.3	161	120	218	534	349	260	473	1157
5 x 16	1.5 x 4.9	188	140	254	622	407	303	551	1347
5 x 18	1.5 x 5.5	214	160	290	710	464	346	629	1538
6 x 12	1.8 x 3.7	180	112	244	498	390	242	529	1076
6 x 16	1.8 x 4.9	256	159	347	707	555	345	752	1535
6 x 18	1.8 x 5.5	294	183	399	813	638	396	865	1761
6 x 20	1.8 x 6.1	332	206	450	916	720	447	976	1988
7 x 14	2.1 x 4.3	292	155	396	689	633	337	858	1499
7 x 16	2.1 x 4.9	344	183	466	814	745	397	1010	1766
7 x 18	2.1 x 5.5	396	211	537	937	858	456	1163	2030
7 x 20	2.1 x 6.1	448	238	607	1059	971	516	1317	2295
8 x 14	2.4 x 4.3	371	173	503	770	805	374	1091	1664
8 x 16	2.4 x 4.9	440	205	597	912	953	443	1292	1971
8 x 18	2.4 x 5.5	508	236	689	1052	1101	512	1493	2278
8 x 20	2.4 x 6.1	577	268	782	1192	1249	581	1693	2584
8 x 22	2.4 x 6.7	645	300	875	1334	1398	650	1895	2891
9 x 16	2.7 x 4.9	533	221	723	982	1156	478	1567	2128
9 x 18	2.7 x 5.5	619	256	839	1139	1342	555	1820	2469
9 x 20	2.7 x 6.1	705	292	956	1297	1528	632	2071	2810
9 x 22	2.7 x 6.7	791	327	1072	1455	1713	709	2323	3154
10 x 16	3.0 x 4.9	648	241	879	1072	1404	523	1904	2326
10 x 18	3.0 x 5.5	754	281	1022	1250	1635	608	2217	2705
10 x 20	3.0 x 6.1	861	320	1167	1423	1866	694	2530	3087
10 x 22	3.0 x 6.7	968	360	1312	1601	2096	780	2842	3470
10 x 24	3.0 x 7.3	1074	400	1456	1778	2327	866	3155	3851
11 x 18	3.4 x 5.5	889	301	1205	1339	1926	651	2611	2896
11 x 20	3.4 x 6.1	1018	344	1380	1530	2205	745	2989	3316
11 x 22	3.4 x 6.7	1146	388	1554	1726	2483	840	3367	3737
12 x 24	3.7 x 7.3	1557	510	2111	2269	3374	1105	4575	4915
13 x 26	4.0 x 7.9	1944	591	2636	2629	Please consult Trelleborg Marine Systems			

Refer to Notes on page 13.

Foam Fenders – SeaGuard®

PERFORMANCE AT 60% DEFLECTION (METRIC)

DIAMETER X LENGTH		EXTRA HIGH CAPACITY				SUPER HIGH CAPACITY			
(m)	(ft)	ENERGY (kNm)	REACTION (kN)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kN)	ENERGY (ft-kip)	REACTION (kip)
0.7 x 1.5	2.3 x 4.9	47	249	35	56	65	343	48	77
1.0 x 1.5	3.3 x 4.9	89	329	66	74	122	449	90	101
1.0 x 2.0	3.3 x 6.6	129	480	95	108	178	658	131	148
1.2 x 2.0	3.9 x 6.6	172	534	127	120	236	734	174	165
1.35 x 2.5	4.4 x 8.2	287	792	212	178	393	1085	290	244
1.5 x 3.0	5 x 10	464	1130	342	254	635	1548	468	348
1.7 x 3.0	5.6 x 9.8	536	1174	395	264	732	1606	540	361
2.0 x 3.5	6.6 x 11.5	864	1606	637	361	1182	2197	872	494
2.0 x 4.0	6.6 x 13.1	1025	1904	756	428	1402	2607	1034	586
2.0 x 4.5	6.6 x 14.8	1185	2206	874	496	1622	3016	1196	678
2.2 x 3.5	7.2 x 11.5	1027	1738	758	391	1405	2378	1037	535
2.2 x 4.0	7.2 x 13.1	1222	2068	901	465	1672	2829	1233	636
2.2 x 4.5	7.2 x 14.8	1416	2397	1045	539	1938	3280	1429	737
2.2 x 5.0	7.2 x 16.4	1611	2726	1188	613	2204	3730	1626	839
2.2 x 6.0	7.2 x 19.7	2000	3385	1475	761	2737	4631	2019	1041
3.0 x 4.9	10 x 16	2782	3398	2052	764	3807	4648	2808	1045
3.0 x 6.1	10 x 20	3697	4515	2727	1015	5059	6174	3731	1388
3.3 x 4.5	10.8 x 14.8	2847	3207	2100	721	3895	4390	2873	987
3.3 x 6.5	10.8 x 21.3	4600	5187	3393	1166	Please consult Trelleborg Marine Systems			

Refer to Notes below.

Notes for tables page 9 to 14:

- Energy and reaction provided in the tables are based on Trelleborg's new testing protocol for foam fenders.
- 150 mm/s speed
- 0ºC compound angle
- 23ºC ± 5ºC test temperature

Foam Fenders – SeaGuard®

PERFORMANCE AT 60% DEFLECTION (IMPERIAL)

DIAMETER X LENGTH		EXTRA HIGH CAPACITY				SUPER HIGH CAPACITY			
(ft)	(m)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kN)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kN)
2 x 4	0.6 x 1.2	21	38	28	169	29	52	39	231
2 x 6	0.6 x 1.8	34	63	46	280	47	87	64	387
2 x 8	0.6 x 2.4	48	89	65	396	65	121	88	538
2 x 10	0.6 x 3.0	61	114	82	507	83	156	113	694
3 x 5	0.9 x 1.5	59	72	80	321	81	99	109	439
3 x 6	0.9 x 1.8	74	91	100	405	101	125	137	556
3 x 8	0.9 x 2.4	105	129	142	574	143	177	194	787
3 x 10	0.9 x 3.0	135	167	183	743	185	229	251	1019
3 x 12	0.9 x 3.7	165	205	224	913	226	281	307	1249
3 x 14	0.9 x 4.3	196	243	265	1082	268	333	363	1480
4 x 6	1.2 x 1.8	115	107	156	476	157	147	213	654
4 x 8	1.2 x 2.4	168	158	228	703	231	216	313	961
4 x 10	1.2 x 3.0	223	208	302	925	306	285	415	1268
4 x 12	1.2 x 3.7	277	258	376	1148	380	354	515	1575
4 x 16	1.2 x 4.9	386	359	523	1597	528	491	716	2186
4 x 20	1.2 x 6.1	494	460	670	2045	676	629	917	2799
5 x 8	1.5 x 2.4	258	192	350	854	353	263	479	1170
5 x 10	1.5 x 3.0	342	254	464	1130	468	348	635	1548
5 x 12	1.5 x 3.7	426	317	578	1410	583	434	790	1931
5 x 14	1.5 x 4.3	510	380	691	1690	698	520	946	2313
5 x 16	1.5 x 4.9	594	443	806	1969	813	606	1103	2695
5 x 18	1.5 x 5.5	678	505	920	2248	928	692	1258	3076
6 x 12	1.8 x 3.7	570	354	773	1575	780	484	1058	2153
6 x 16	1.8 x 4.9	811	504	1100	2242	1110	689	1505	3065
6 x 18	1.8 x 5.5	932	579	1264	2574	1275	792	1729	3522
6 x 20	1.8 x 6.1	1053	654	1428	2909	1440	894	1952	3977
7 x 14	2.1 x 4.3	925	492	1254	2189	1266	673	1716	2994
7 x 16	2.1 x 4.9	1090	580	1478	2580	1491	793	2022	3527
7 x 18	2.1 x 5.5	1254	667	1700	2967	1716	913	2327	4059
7 x 20	2.1 x 6.1	1418	754	1923	3354	1941	1032	2632	4591
8 x 14	2.4 x 4.3	1176	547	1594	2433	1609	749	2182	3332
8 x 16	2.4 x 4.9	1393	648	1889	2882	1906	887	2584	3946
8 x 18	2.4 x 5.5	1609	749	2182	3330	2202	1024	2986	4557
8 x 20	2.4 x 6.1	1826	849	2476	3777	2499	1162	3388	5169
8 x 22	2.4 x 6.7	2043	950	2769	4226	2795	1300	3790	5783
9 x 16	2.7 x 4.9	1689	699	2290	3110	2311	957	3134	4256
9 x 18	2.7 x 5.5	1960	811	2657	3608	2683	1110	3638	4938
9 x 20	2.7 x 6.1	2233	923	3027	4107	3055	1264	4142	5621
9 x 22	2.7 x 6.7	2504	1036	3395	4608	3427	1417	4646	6303
10 x 16	3.0 x 4.9	2052	764	2782	3398	2808	1045	3807	4648
10 x 18	3.0 x 5.5	2389	889	3239	3954	3269	1217	4432	5413
10 x 20	3.0 x 6.1	2727	1015	3697	4515	3731	1388	5059	6174
10 x 22	3.0 x 6.7	3064	1140	4154	5071	Please consult Trelleborg Marine Systems			
10 x 24	3.0 x 7.3	3401	1265	4612	5629	Please consult Trelleborg Marine Systems			
11 x 18	3.4 x 5.5	2815	952	3817	4235	3852	1302	5223	5792
11 x 20	3.4 x 6.1	3222	1090	4368	4846	Please consult Trelleborg Marine Systems			
11 x 22	3.4 x 6.7	3629	1227	4920	5458	Please consult Trelleborg Marine Systems			
12 x 24	3.7 x 7.3	Please consult Trelleborg Marine Systems							
13 x 26	4.0 x 7.9	Please consult Trelleborg Marine Systems							

Refer to Notes on page 13.

Foam Fenders – SeaGuard®

TESTING PHOTOS

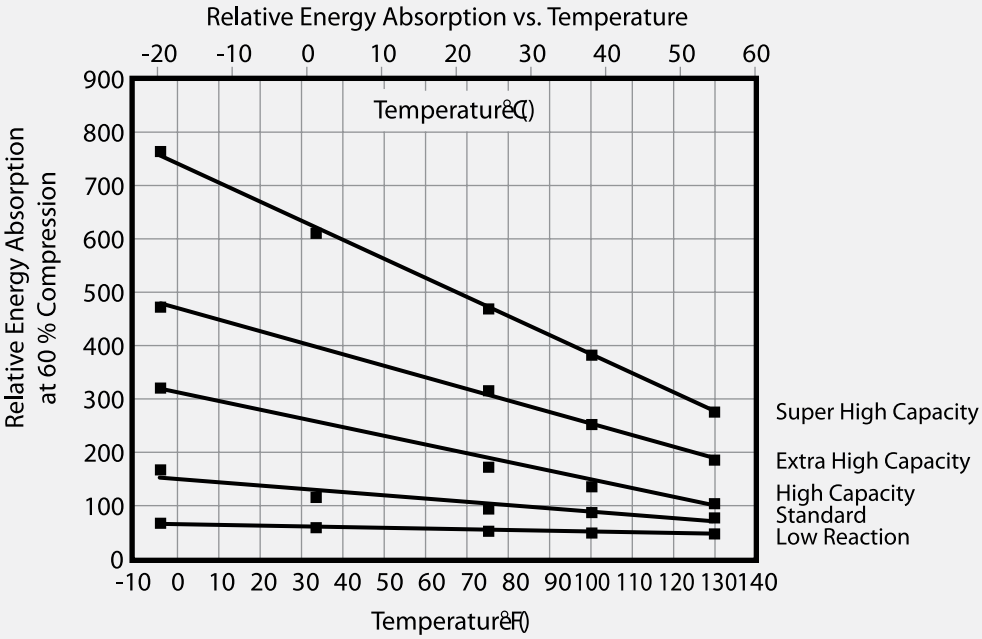
TESTING DETAILS

Foam Fenders – SeaGuard®

ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

EFFECT OF TEMPERATURE

Polyolefin foams, which are used in SeaGuard® fenders, can temporarily lose some of their compression resistance, and therefore lose some energy absorption capacity, when subjected to high temperatures. Likewise, when these foams are subjected to low temperatures, they become stiffer and gain energy capacity. In both cases the effect is temporary, if not carried to the extreme.



The graph above shows the effect of temperature on the various types of foams used in SeaGuard® fenders. The energy absorption is shown relative to the foam in a standard fender compressed at a rate of 2 in/min (51 mm/min) at 75 °F (24 °C), which is assigned a rating of 100. This does not reflect the performance of the fender as a whole, because other factors come into play in determining the energy absorption capacity, such as skin thickness and the confining effect of the skin on the foam. However, the general trend will be evident. In general, if a fender will be constantly exposed to elevated temperatures, such as in installations in hot climates, a slightly larger fender size than normal may be recommended. Consult Trelleborg for advice.

Foam Fenders – SeaGuard®

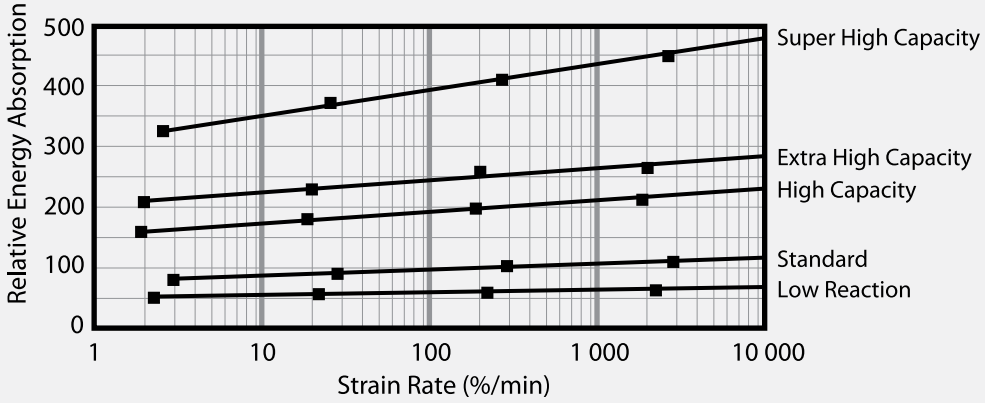
ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

EFFECT OF COMPRESSION SPEED

Polyolefin foams compressed at high strain rates are stiffer than when compressed at low strain rates, where strain rate is defined as the fraction of the foam thickness compressed in a given time interval. Therefore, at a given percent compression, foam compressed at a high strain rate will absorb more energy than foam compressed at a low strain rate. This trend shows up in fender performance, although other factors come into play in determining fender energy absorption, such as skin thickness, temperature, and the confining effect of the skin on the foam.

The graph below shows the effect of compression rate on the energy absorption capacity for foams compressed to 40 % of their initial thickness (60 % compression). The energy absorption is shown relative to the foam in a Standard fender compressed at a rate of 285 %/min at 70 °F (21 °C), which is assigned a rating of 100. This data shows the general trend for fenders, although different parts of a fender are compressed at different rates during a single compression, and the fender itself is compressed at a decreasing rate as the vessel comes to a stop. The skin thickness, length-to-diameter ratio, and temperature also have a considerable effect on fender performance.

Relative Energy Absorption at 60 % Compression vs. Compressive Strain Rate

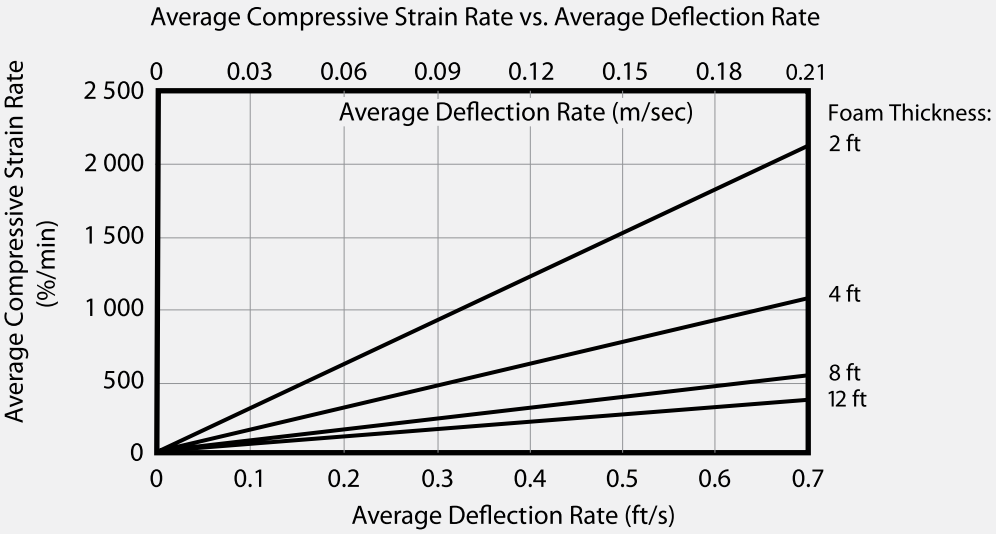


Foam Fenders – SeaGuard®

ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

EFFECT OF COMPRESSION SPEED

For a given approach velocity, a small fender is compressed at a higher rate than a large fender. The graph below shows the effect of speed of compression on the strain rate for various thicknesses of foam. For example, at an average vessel velocity of 0.5 ft/s (0.15 m/s), a 2 ft (0.61 m) diameter fender has an average strain rate (at the center of contact) of 1 500 %/min, whereas a 12 ft (3.66 m) diameter fender has an average strain rate of only 250 %/min. This results in approximately 10 % more energy absorption for a given volume of foam in the smaller fender than in the larger fender.



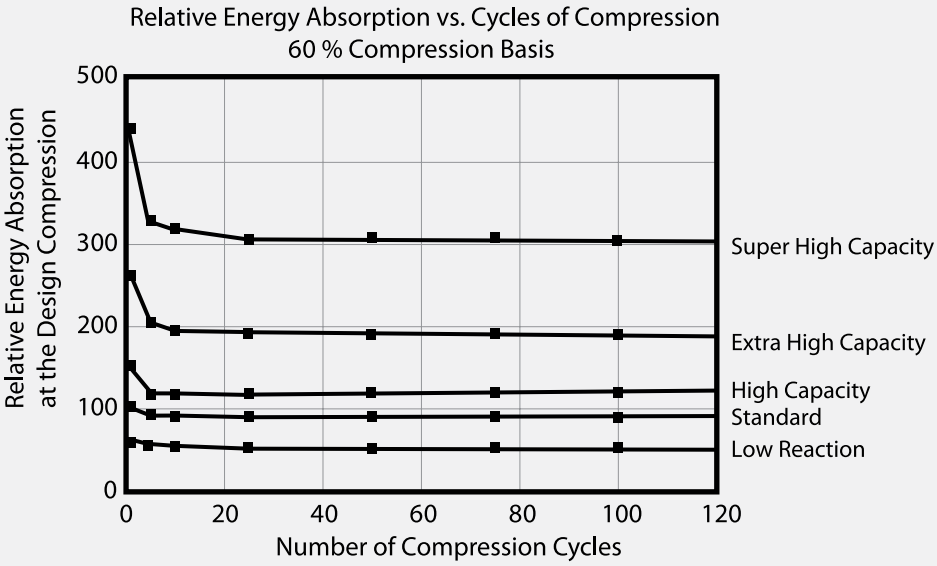
Large fenders are generally tested at low compression rates because of the limitations of available testing facilities. This will underestimate the energy absorption that may be experienced in practice. For example, the two graphs above show that the foam in an 8 ft (2.44 m) diameter Standard fender tested at a rate of 0.03 ft/s (0.009 m/s) has only about 85 % of the energy absorption of the same fender compressed at a practical rate of 0.5 ft/s (0.15 m/s). Again, note that foam data alone is indicative of only part of the fender performance.

Foam Fenders – SeaGuard®

ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

CYCLIC COMPRESSION

When a plastic foam such as polyolefin foam is compressed repeatedly to a given thickness, it can lose a small amount of its energyabsorbing capacity over a period of time. This effect is shown below, where foams were repeatedly compressed to 40 % of their original thickness (60 % compression) at a frequency of one cycle every hour. The energy values are shown relative to the performance of standard foam during its first compression, which is assigned a rating of 100. The drop-off in performance is higher during the first few cycles, but eventually levels off. The performance decrease for standard foam between the first cycle and the steady state level is approximately 12 %. The same percentage decrease was also observed when the compression tests were conducted to only 60 % and 80 % of the original foam thickness (40 % and 20 % compression, respectively). Again, note that foam data alone is indicative of only part of the fender performance.



In an actual fender, this effect is partially compensated by the higher performance obtained at higher rates of compression, and is also partially compensated by the conservative rating of the fender performance. For example, in a full scale test of a standard 7 ft by 14 ft (2.13 m x 4.27 m) SeaGuard® fender conducted at Lehigh University, the fender reached its rated energy absorption at 54.75 % compression, rather than at the 60 % rated compression. At 60 % compression, this fender had 22 % more energy than the catalog rating. (These numbers are for the first compression, and were obtained at a relatively low compression speed.) If the fender lost 12 % of its energy after repeated compression (as suggested by the standard foam data), it would still maintain 107 % of the catalog energy value. Compression at a speed typical of actual service would add to this value. Therefore, we are confident that fender systems can be designed using catalog ratings with full assurance of adequate performance. Note that because of slight differences between fenders which may arise from manufacturing and material variations, as well as slight differences in test conditions, there is a 15 % tolerance on energy absorption and reaction force in the catalog ratings.

Foam Fenders – SeaGuard®

ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

VELOCITY FACTOR (VF) TABLE

COMPRESSION TIME (SECONDS)	BLEND OF NATURAL AND SYNTHETIC RUBBER (CATALOG COMPOUND)	100% NATURAL RUBBER	100% SYNTHETIC RUBBER (SBR)
	VF	VF	VF
1	1.20	1.14	1.31
2	1.16	1.10	1.25
3	1.14	1.09	1.22
4	1.13	1.07	1.20
5	1.11	1.06	1.19
6	1.10	1.06	1.17
7	1.09	1.05	1.16
8	1.09	1.04	1.15
9	1.08	1.04	1.14
10	1.07	1.03	1.14
11	1.07	1.03	1.13
12	1.06	1.02	1.12
13	1.06	1.02	1.12
14	1.05	1.02	1.11
15	1.05	1.01	1.11
16	1.05	1.01	1.10
17	1.04	1.01	1.10
18	1.04	1.01	1.09
19	1.04	1.00	1.09
20	1.03	1.00	1.08

Compression time needs to be calculated using the following formula: $t = d/(f*Vd)$

Where:
t = compression time (seconds)*
d = rated deflection (mm)
Vd = initial berthing velocity (mm/s)
f = 0.74 deceleration factor (Peak reaction force occurs at between 30% - 40% deflection, where there has been a deceleration due to energy absorption. f represents the factor associated with deceleration.)

* Applicable for both partial deflection and rated deflection.

Foam Fenders – SeaGuard®

ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

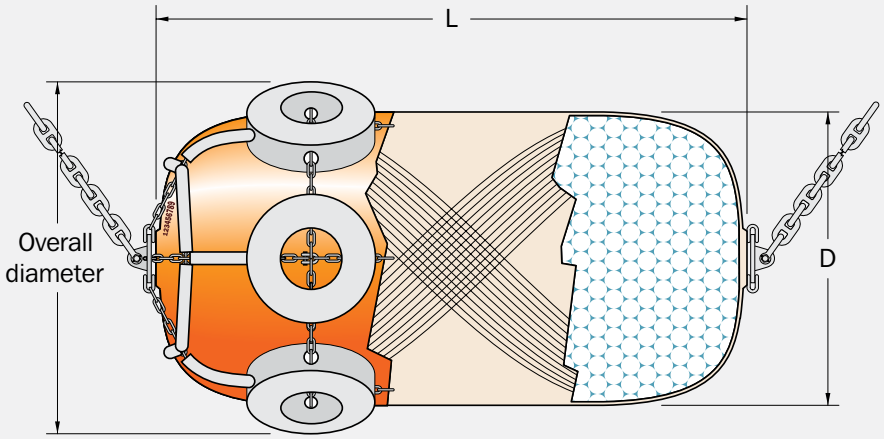
TEMPERATURE FACTOR (TF) TABLE

TEMPERATURE (°C)	BLEND OF NATURAL AND SYNTHETIC RUBBER (CATALOG COMPOUND)	100% NATURAL RUBBER	100% SYNTHETIC RUBBER (SBR)
	TF	TF	TF
+50	0.916	0.914	0.918
+40	0.947	0.946	0.948
+30	0.978	0.978	0.979
+23	1.000	1.000	1.000
+10	1.030	1.025	1.038
+0	1.075	1.053	1.108
-10	1.130	1.080	1.206
-20	1.249	1.142	1.410
-30	1.540	1.315	1.877

ANGLE FACTOR (AF) TABLE

ANGLE (°)	ENERGY FACTOR	REACTION FACTOR
0	1.000	1.000
3	0.977	1.000
5	0.951	1.000
8	0.909	1.000
10	0.883	1.000
15	0.810	1.000
20	0.652	1.000

Foam Fenders – SeaCushion®



Unsinkable foam core

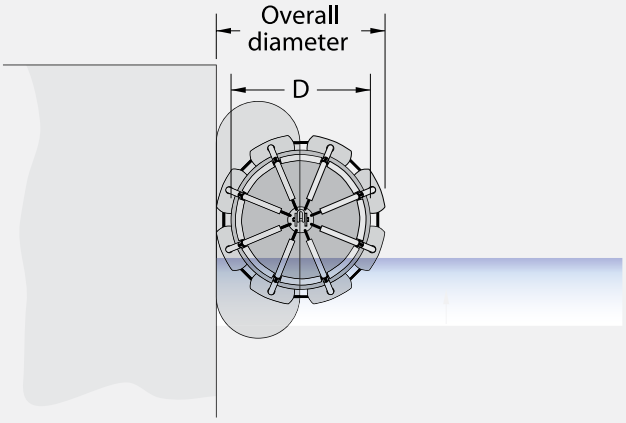
Tough polyurethane skin

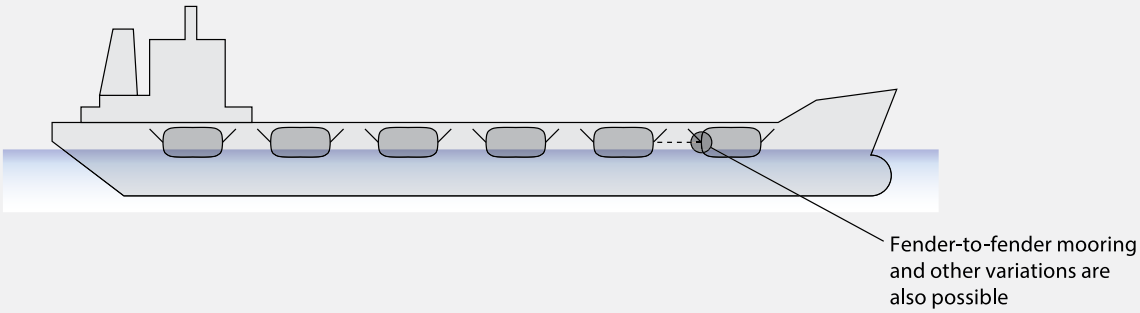
Various mooring options

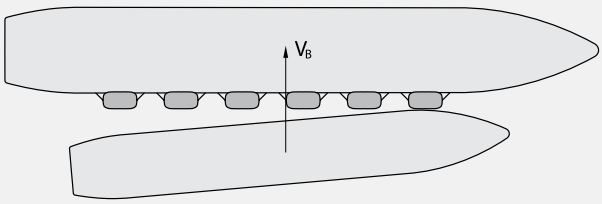
Filament reinforcement matrix

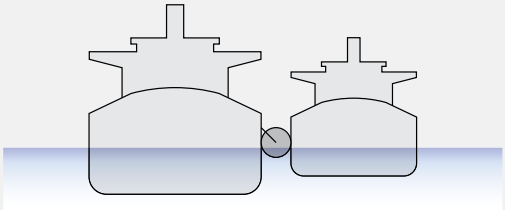
Chain-tyre net

Unique serial number

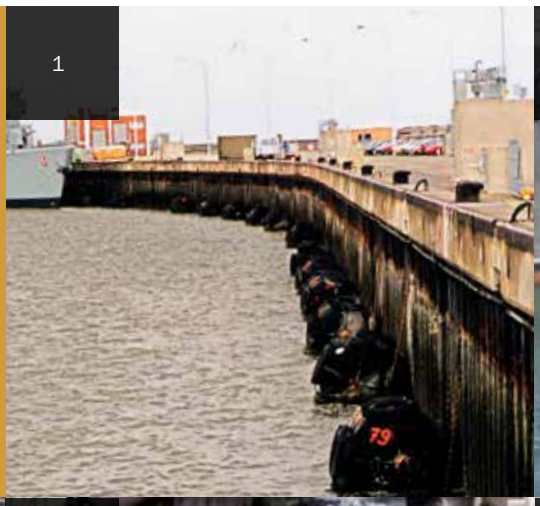


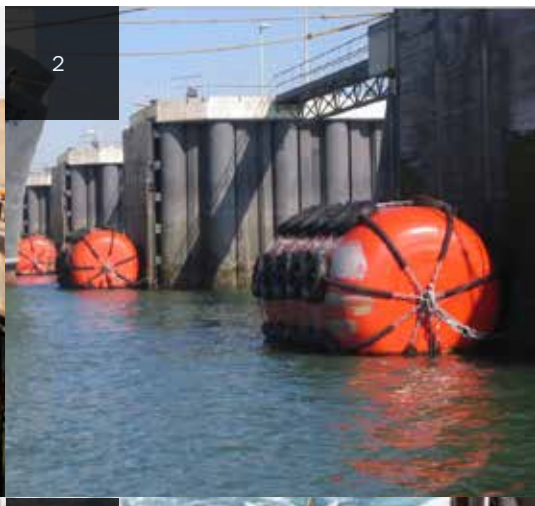


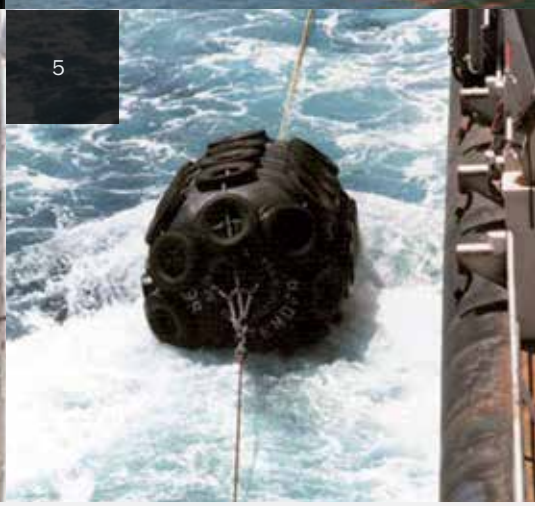


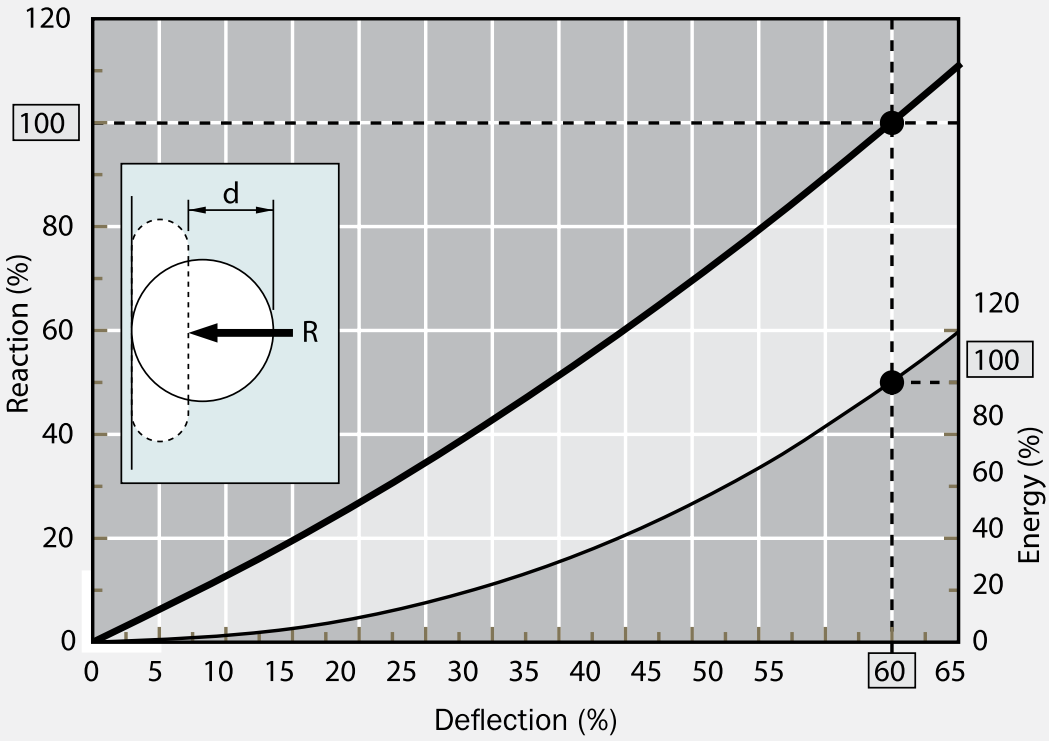


1. GERMANY
2. NETHERLANDS
3. USA
4. USA
5. USA









Note: Standard manufacturing and performance tolerance:
Energy: 100%, Reaction: 100%, Tolerance: ± 10%

Foam Fenders – SeaCushion®

PERFORMANCE AT 60% DEFLECTION, STANDARD CAPACITY

METRIC

DIAMETER X LENGTH		OVERALL DIAMETER		STANDARD CAPACITY			
(ft)	(m)	(ft)	(m)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kNm)
1.0 x 2.0	3.3 x 6.6	1.5	4.9	64	294	47	66
1.2 x 2.0	3.9 x 6.6	1.7	5.6	88	338	65	76
1.35 x 2.5	4.4 x 8.2	1.9	6.1	142	485	105	109
1.5x 3.0	4.9 x 9.8	2.0	6.6	213	654	157	147
1.7x 3.0	5.6 x 9.8	2.2	7.2	264	721	195	162
2.0 x 3.5	6.6 x 11.5	2.5	8.2	424	979	313	220
2.0 x 4.0	6.6 x 13.1	2.5	8.2	498	1152	367	259
2.2 x 4.5	7.2 x 14.8	2.7	8.9	679	1423	501	320
2.5 x 4.0	8.2 x 13.1	3.0	9.9	735	1357	542	305
2.5 x 5.5	8.2 x 18.0	3.0	9.9	1079	1993	796	448
3.0 x 6.0	9.8 x 19.7	3.5	11.5	1655	2544	1221	572
3.3 x 4.5	10.8 x 14.8	3.8	12.5	1367	1908	1008	429
3.3 x 6.5	10.8 x 21.3	3.8	12.5	2154	3011	1589	677

IMPERIAL

DIAMETER X LENGTH		OVERALL DIAMETER		STANDARD CAPACITY			
(ft)	(m)	(ft)	(m)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kNm)
3 x 6	0.9 x 1.8	4.7	1.4	36	56	49	249
4 x 8	1.2 x 2.4	5.7	1.7	85	98	115	436
5 x 10	1.5 x 3.0	6.7	2.0	164	152	222	676
6 x 12	1.8 x 3.7	7.7	2.3	282	217	382	965
7 x 14	2.1 x 4.3	8.7	2.6	445	294	603	1308
8 x 12	2.4 x 3.7	9.7	2.9	465	268	630	1192
8 x 16	2.4 x 4.9	9.7	3.3	661	381	896	1695
9 x 18	2.7 x 5.5	10.7	3.3	937	480	1270	2135
10 x 16	3.0 x 4.9	11.7	3.6	976	450	1323	2002
10 x 20	3.0 x 6.1	11.7	3.6	1280	590	1735	2624
11 x 22	3.4 x 6.7	12.7	3.9	1697	712	2301	3167

Energy and reaction provided in the tables are based on Trelleborg's new testing protocol for foam fenders.

Foam Fenders – SeaCushion®

PERFORMANCE AT 60% DEFLECTION, HIGH CAPACITY

METRIC

DIAMETER X LENGTH		OVERALL DIAMETER		HIGH CAPACITY			
(m)	(ft)	(m)	(ft)	ENERGY (kNm)	REACTION (kNm)	ENERGY (ft-kip)	REACTION (kip)
1.0 x 2.0	3.3 x 6.6	1.5	4.9	93	416	68	94
1.2 x 2.0	3.9 x 6.6	1.7	5.6	127	478	94	107
1.35 x 2.5	4.4 x 8.2	1.9	6.1	205	684	152	154
1.5x 3.0	4.9 x 9.8	2.0	6.6	308	922	227	207
1.7x 3.0	5.6 x 9.8	2.2	7.2	384	1013	283	228
2.0 x 3.5	6.6 x 11.5	2.5	8.2	614	1379	453	310
2.0 x 4.0	6.6 x 13.1	2.5	8.2	721	1619	532	364
2.2 x 4.5	7.2 x 14.8	2.7	8.9	981	2003	724	450
2.5 x 4.0	8.2 x 13.1	3.0	9.9	1065	1911	786	430
2.5 x 5.5	8.2 x 18.0	3.0	9.9	1559	2797	1150	629
3.0 x 6.0	9.8 x 19.7	3.5	11.5	2397	3581	1768	805
3.3 x 4.5	10.8 x 14.8	3.8	12.5	1978	2686	1459	604
3.3 x 6.5	10.8 x 21.3	3.8	12.5	3122	4239	2303	953

IMPERIAL

DIAMETER X LENGTH		OVERALL DIAMETER		HIGH CAPACITY			
(ft)	(m)	(ft)	(m)	ENERGY (ft-kip)	REACTION (kip)	ENERGY (kNm)	REACTION (kNm)
3 x 6	0.9 x 1.8	4.7	1.4	52	79	71	350
4 x 8	1.2 x 2.4	5.7	1.7	123	138	167	614
5 x 10	1.5 x 3.0	6.7	2.0	238	214	323	951
6 x 12	1.8 x 3.7	7.7	2.3	408	306	554	1359
7 x 14	2.1 x 4.3	8.7	2.6	645	413	874	1838
8 x 12	2.4 x 3.7	9.7	2.9	673	378	913	1679
8 x 16	2.4 x 4.9	9.7	3.3	958	537	1298	2388
9 x 18	2.7 x 5.5	10.7	3.3	1357	676	1840	3007
10 x 16	3.0 x 4.9	11.7	3.6	1414	634	1917	2818
10 x 20	3.0 x 6.1	11.7	3.6	1854	831	2514	3696
11 x 22	3.4 x 6.7	12.7	3.9	2459	1001	3333	4454

Small standard duty fenders

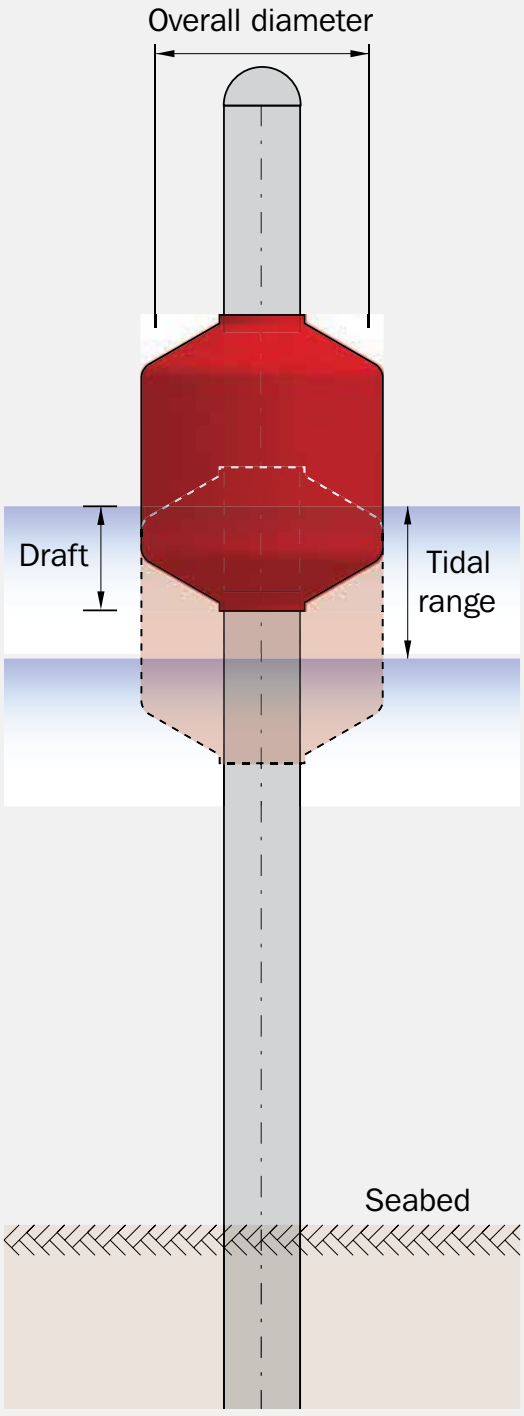
PERFORMANCE AT 60% DEFLECTION

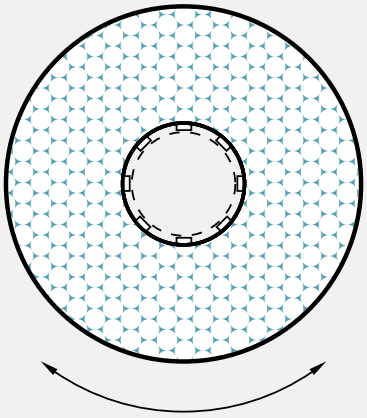
DIAMETER X LENGTH		STANDARD CAPACITY			
(in)	(mm)	ENERGY (kNm)	REACTION (kNm)	ENERGY (ft-kip)	REACTION (kip)
16 x 36	400 x 900	4.2	48.0	3.1	10.8
24 x 36	600 x 900	8.4	63.6	6.2	14.3
24 x 48	600 x 1200	12.7	97.0	9.4	21.8
32 x 50	800 x 1250	22.1	125.9	16.3	28.3
32 x 60	800 x 1500	28.5	162.4	21.0	36.5
36 x 60	900 x 1500	34.8	176.6	25.7	39.7
36 x 72	900 x 1830	44.6	226.0	32.9	50.8
40 x 60	1000 x 1500	41.6	189.9	30.7	42.7

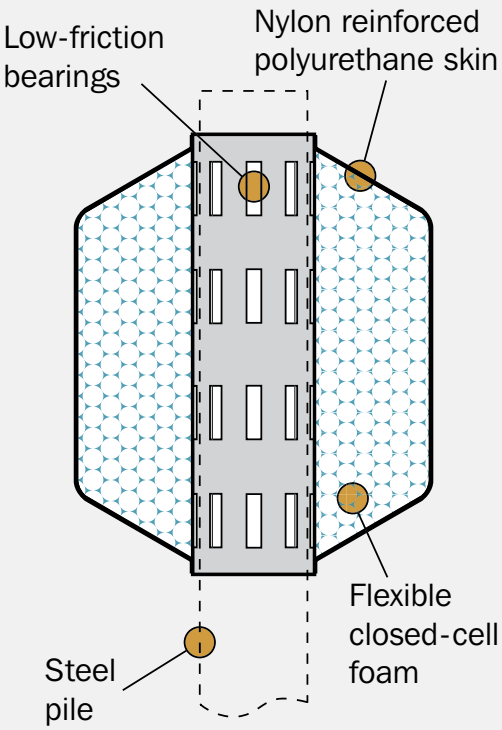
Other sizes, material grades and performance available upon request. Please contact Trelleborg Marine Systems' local offices.

Energy and reaction provided in the tables are based on Trelleborg's new testing protocol for foam fenders.

Foam Fenders – Donut Fenders

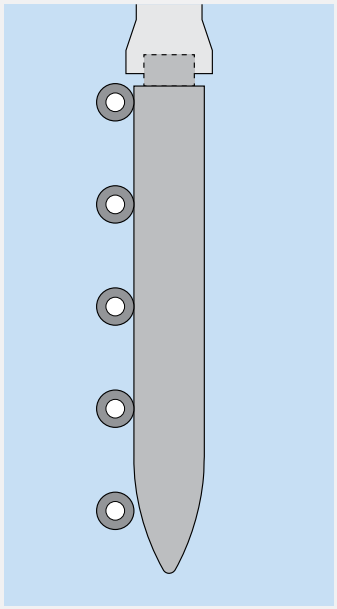




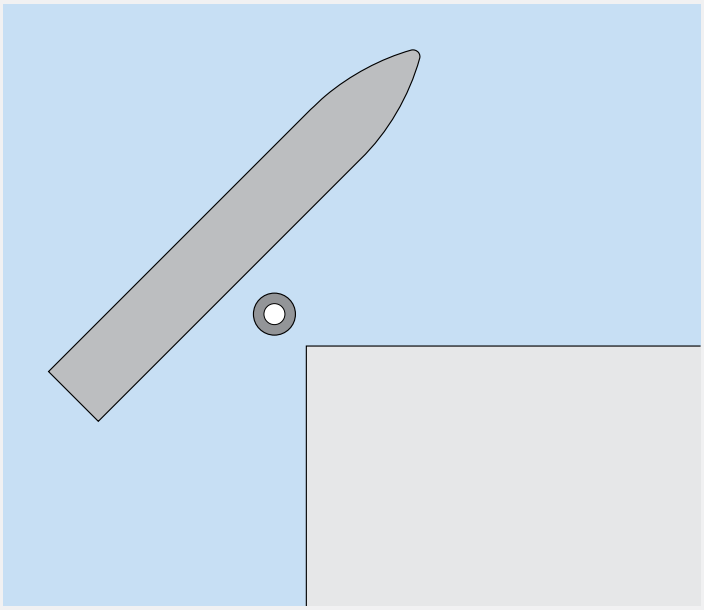


Foam Fenders – Donut Fenders

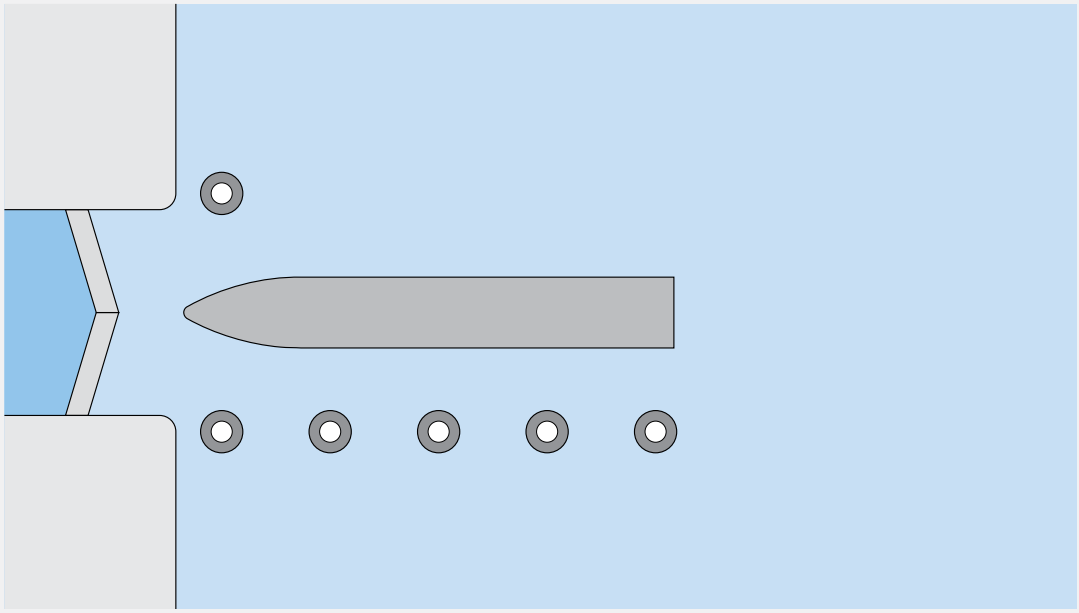
APPLICATIONS



Breasting dolphins



Corner protection

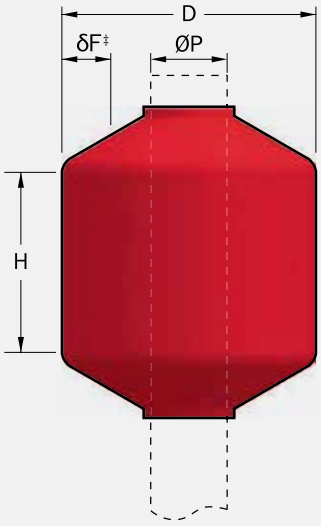


Guiding structures

Foam Fenders – Donut Fenders

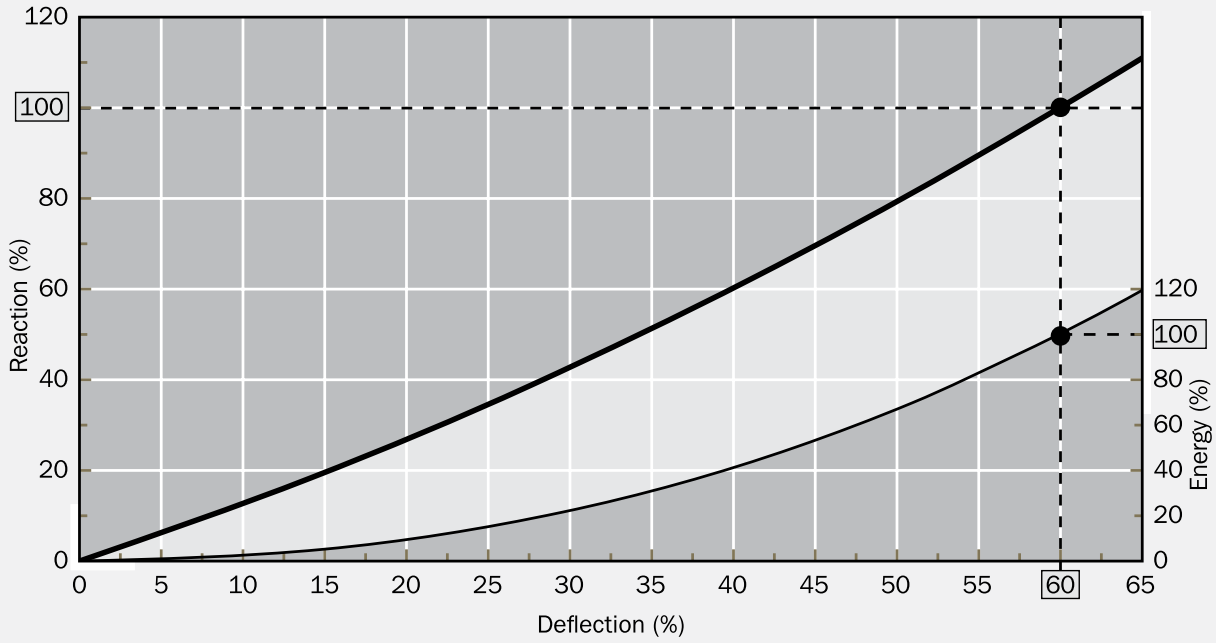
PERFORMANCE AT 60% DEFLECTION, STANDARD GRADE

DONUT SIZE D		MAXIMUM PILE ØP		ENERGY*	REACTION*	ENERGY†	REACTION†
mm	ft	mm	ft	kNm	kN	ft-kip	kip
1270	4.2	610	2.0	7.2	116	1.6	7.9
1450	4.8	710	2.3	9.2	131	2.1	9.0
1520	5.0	762	2.5	10.5	140	2.4	9.6
1780	5.8	914	3.0	14.1	162	3.2	11.1
1910	6.3	995	3.3	16.4	175	3.7	12.0
2030	6.7	1067	3.5	18.6	186	4.2	12.8
2210	7.3	1185	3.9	22.3	204	5.0	14.0
2290	7.5	1219	4.0	23.6	210	5.3	14.4
2490	8.2	1345	4.4	28.0	229	6.3	15.7
2540	8.3	1372	4.5	29.3	234	6.6	16.0
2790	9.2	1524	5.0	35.3	256	7.9	17.6
2970	9.7	1636	5.4	40.1	273	9.0	18.7
3050	10.0	1676	5.5	42.1	280	9.5	19.2
3300	10.8	1829	6.0	49.5	304	11.1	20.8
3450	11.3	1933	6.3	54.6	319	12.3	21.9
3530	11.6	1981	6.5	57.2	327	12.9	22.4
3810	12.5	2134	7.0	65.9	350	14.8	24.0
3960	13.0	2241	7.4	72.1	366	16.2	25.1
4060	13.3	2286	7.5	75.1	374	16.9	25.6
4220	13.8	2388	7.8	81.3	389	18.3	26.7



Increasing Donut height (H) will increase reaction and energy proportionately.

Other sizes, material grades and performance available upon request.
Please contact Trelleborg Marine Systems' local offices.
* values for H = 1000mm.
† values for H = 1 foot.
‡ all performances at δF = 60% of Donut resilient foam wall thickness.



Note: Standard manufacturing and performance tolerance:
Energy: 100%, Reaction: 100%, Tolerance: ± 10%

1. GERMANY
2. UK
3. USA
4. USA
5. BAHAMAS
6. ROTTERDAM
7. IRELAND
8. UK

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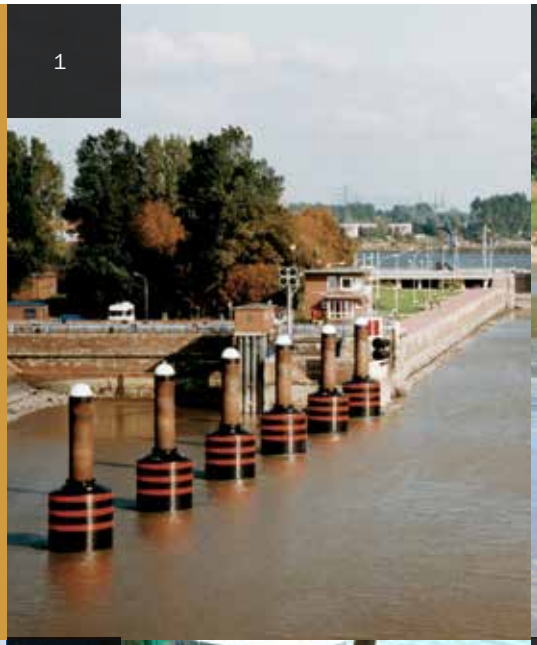

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SeaBarrier®

Floating Barrier Systems are designed to provide a reliable, highly visible floating physical barrier that is easy to install and maintain.

FEATURES

- Utilizes proven SeaGuard® technology
- Low maintenance
- High visibility, high freeboard
- Durable, long life materials
- Easy to transport, deploy and relocate
- Foam filled construction will not lose buoyancy if punctured
- High pull-through strength

APPLICATIONS

- Military facilities and vessels
- Ports and harbors
- Cruise ship and marine casino facilities
- Refineries and petrochemical plants
- Power plants
- Airports
- Temporary blockades of vital waterways
- Other marine security applications

The design of Trelleborg's SeaBearier® is founded on the proven technology, materials and tested performance of SeaGuard® foam filled marine fenders that have set the international industry standard for over 30 years. It is designed to provide the energy absorption, unsinkable buoyancy, and ease of deployment to effectively and quickly create a barrier to any intruder.

The smaller sizes are primarily intended for use as a demarcation or delineation barrier to mark an exclusionary zone while larger sizes add a significant physical barrier to meet specific security requirements.

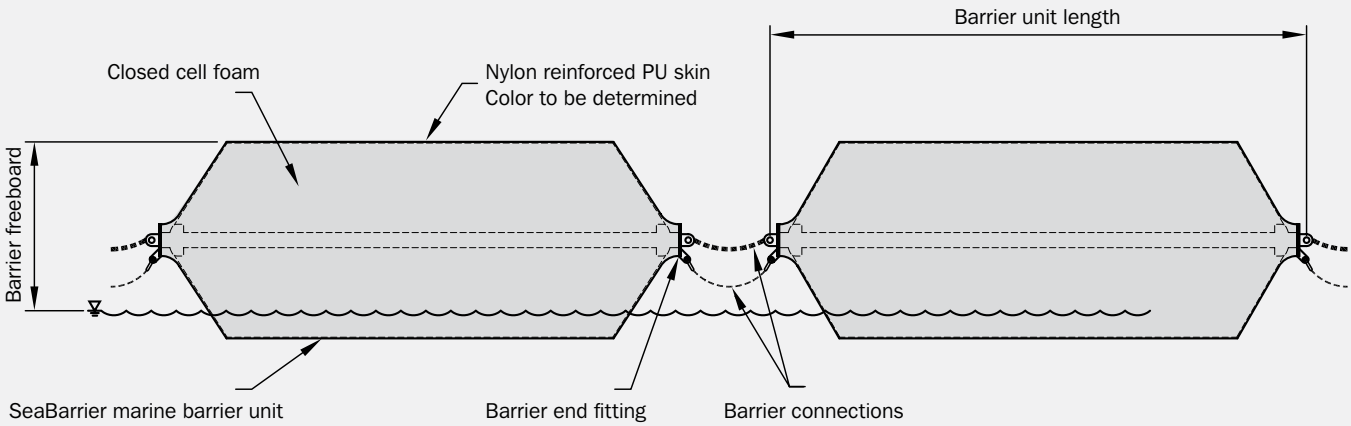
Available in various sizes, profiles and colors, the SeaBarrier® can be custom designed to meet your specific requirements. Standard units are delivered with a bright, highly visible international orange color and include connection hardware. Optional accessories include buoys and modified donut fender style moorings, anchorage devices, capture net systems and a wide range of interconnecting fittings designed to work with the SeaBarrier® units.

USA

Specification

Dimensions are for one SeaBarrier® module. Overall length includes hardware supplied with the unit. Weight is per module, including hardware.

	MODEL NUMBER	DIAMETER (ft)	OVERALL LENGTH (ft)	PULL-THROUGH SWL (pounds)
IMPERIAL SIZES	SB220	2.0	20	30,000
	SB420	4.0	20	50,000
	SB620	6.0	20	50,000
	SB820	8.0	20	70,000
	MODEL NUMBER	**DIAMETER (meters)**	**OVERALL LENGTH (meters)**	**PULL-THROUGH SWL (tons)**
METRIC SIZES	SB500	0.5	6.6	13.6
	SB1000	1.0	6.7	22.7
	SB2000	2.0	6.7	22.7
	SB3000	3.0	7.0	31.8



Foam Fenders – Product Material Tables

CONSTRUCTION

*Standard Foam Material Properties

TEST ITEM	TEST METHOD	REQUIRED VALUE
Density	ASTM D-3575 Suffix W	62 kg / cu m (+/-10%)
Tensile strength	ASTM D-3575 Suffix T	289 kPa Min.
Elongation	ASTM D-3575 Suffix T	95 % Min.
Tear resistance	ASTM D-3575 Suffix G	2.2 kN/m Min.
Compressive strength	ASTM D-3575 Suffix D	
10% Deflection		27 kPa Min.
25% Deflection		48 kPa Min.
40% Deflection		77 kPa Min.
50% Deflection		110 kPa Min.
Compression set average	ASTM D-3575 Suffix B	17.2 %
Thermal stability	ASTM D-3575 Suffix S	<0.5 % change (24 hrs at 70 deg C)
Water absorption	ASTM D-3575 Suffix L	<0.34 kg / sq m (skived)
Flammability	FMVSS302	Pass
	PPP-C-1752B	-54 deg C to 99 deg C

Polyurethane Elastomer Skin Material Property Requirements

TEST ITEM	TEST METHOD	REQUIRED VALUE
Shore A durometer hardness	ASTM D-2240	75-95
Tensile strength	ASTM D-412	13.8 MPa Min.
Elongation	ASTM D-412	300% Min.
Tear strength	ASTM D-624	32.4 kN/m Min.
Flex life (ross)	ASTM D-1052	100,000 Cycles Min. Break
Abrasion resistance (NBS)	ASTM D-1630	100

Nylon Filament Reinforcement Material Property Requirements

TEST ITEM	TEST METHOD	REQUIRED VALUE
Nylon cord weight	ASTM D-885	0.280 g/m avg.
Breaking strength	ASTM D-885	231 N avg.
Elongation (ultimate)	ASTM D-885	16% avg.

Nylon Filament Reinforced Elastomer Skin Material Property Requirements

TEST ITEM	TEST METHOD	REQUIRED VALUE
Tensile strength	ASTM D-412	31.0 Mpa Min.
Elongation	ASTM D-412	16% Min.
Tear strength	ASTM D-624	78.8 kN/m Min.

*Foam Material Properties vary based on the Material grades used. Contact your local office for Foam Fender specification.

Foam Fenders – Manufacturing Facilities

Trelleborg Marine Systems Berryville, Inc.

In March 2016, Trelleborg Marine Systems officially opened its state of the art foam fender manufacturing facility in Berryville VA (Trelleborg Marine Systems Berryville, Inc.) Prior to this, foam fenders were produced a few miles away in Clearbrook VA over the past 40 years.

The Berryville facility was designed to accommodate all the production needs of foam products as well as to provide world class office facility. With over 50,000 sq-ft (5,000m^2) of combined production and office space, the new state of the art facility was designed specifically for the production of Trelleborg's industry leading range of foam filled fenders, donut fenders and buoys.

The facility holds ISO 9001:2008 and ISO 14001:2004 certification as well as ABS type approval for its Sea Guard™ Product.

HALO Fenders

HALO fender is a premium pneumatic fender from Trelleborg Marine Systems and Teekay Marine Solutions designed to meet the demands of the Ship to Ship (STS) transfer market and the wider marine industry.

FEATURES

- ISO 17357-1:2014 compliant
- Easy and fast to deploy
- Very low reaction and hull pressure
- Suitable for small and large tidal ranges
- Maintains large clearances between hull and structure

APPLICATIONS

- Oil and gas tankers
- Fast ferries and aluminium vessels
- Temporary and permanent installations
- Rapid response and emergencies

HALO Fenders

STRENGTHENING PROTECTION THROUGH PARTNERSHIP

Combining the strength and experience of two industry leaders, HALO fenders from Trelleborg Marine Systems and Teekay Marine Solutions enable operators to source, deploy and maintain pneumatic fenders safely and efficiently, with a reassuring service structure that ensures these high quality solutions are supported for the life of the project.

THE HALO EFFECT

HALO fenders bring together Trelleborg's manufacturing capability and Teekay's operations expertise to offer a host of operational, technical and service benefits, including:

- Full compliance with ISO 17357-1:2014
- A wide range of fender sizes stocked at strategic locations around the world
- Fast and convenient delivery
- Available to buy or rent
- Backed by exceptional technical and service support

COMMERCIAL FLEXIBILITY

The expanded HALO fender offering also extends to enhanced commercial support with options to both purchase and rent fenders so that operators can align solutions to their operations and financial situation, selecting whichever option that best fits their overall needs.

UNIQUE SERVICING AND SUPPORT

The new HALO fender offering provides customers with a single point of contact for consulting and supply, from product specification, to delivery, through to comprehensive field services.

Support services include:

- Fender selection
- Specification advice
- Chain tire net fitting
- Mobilization
- Certification and documentation
- Maintenance
- Repair

SUPPORT WHEREVER YOU NEED IT

With HALO, we hold new stock in three strategic locations, ensuring fast global delivery through our comprehensive transport and logistics network. we also have 32 rental and service bases with a fleet of 400 fenders to ensure we can provide fast, local maintenance and repair.

For more information and full technical details of HALO fenders, please refer to the HALO fender brochure.

Hydro Pneumatic Fenders

Submarines and other vessels which contact fenders below waterline require a unique solution. Hydro pneumatic fenders are specially adapted to this application.

The fender body is partially water-filled, then pressurized with air and ballasted to make it stand vertically. Fender draft and performance can be tuned by altering the water : air ratio and inflation pressure.

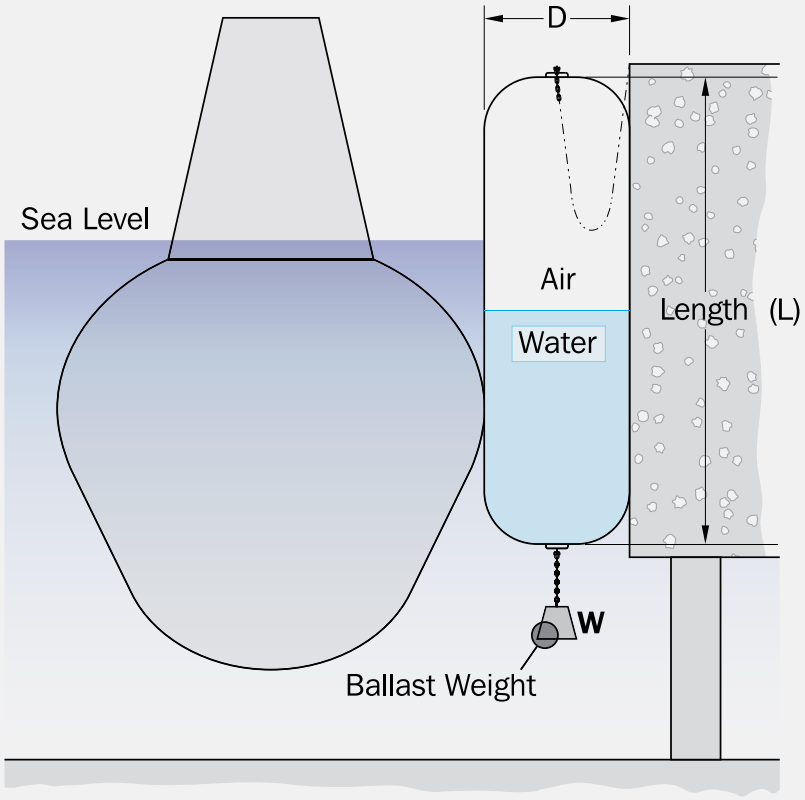
FEATURES

- Sub-surface contact face
- Very low hull pressures
- Variable draft
- Prevents acoustic tile damage

APPLICATIONS

- Submarines
- Some fast ferries
- Semi-submersible oil rigs

Hydro Pneumatic Fenders



FENDER		WATER (%)	D (%)	INITIAL PRESSURE 0.5BAR (7.1psi)	
DIAMETER D(mm)	LENGTH L(mm)			ENERGY (kNm)	REACTION (kN)
2000	6000	65	45	155	599
		0	60	647	1766
2500	5500	65	45	223	687
		0	60	928	2037
3300	6500	60	45	616	1247
		0	60	1913	3169
3300	10500	55	45	589	1275
		0	60	3120	5170

Due to the very specialist nature of Hydro-pneumatic fenders, it is strongly advised that a detailed study be carried out for each case. Please ask for assistance with this.

Low Pressure Pneumatic Fenders

Trelleborg's low-pressure (LP) floating pneumatic fenders play an essential role in the safe berthing of ships at sea in an emergency or other operations such as refuelling.

FEATURES

- Avoids high hull pressure during berthing
- Spreads berthing loads over a large area to produce the lowest reaction force of any fender
- Lowest reaction force of any fender
- Ideal for non-metallic or thin-hulled vessels and vessels with sensitive electronic systems

APPLICATIONS

- Ship to ship transfer and refuelling
- Offshore mooring
- Naval applications
- Salvage and cargo recovery
- Emergency floatation
- Military operations at sea

Low Pressure Pneumatic Fenders

GENERAL DESCRIPTION

UNIT SPECIFICATION	Manufactured in diameters from 1.0m to 4.5m; lengths of fenders can be made to customer requirements.
MATERIALS AND CONSTRUCTION	Constructed from a woven high tenacity, continuous filament nylon-based fabric, coated on both sides with an abrasion resistant synthetic rubber compound. Individual sections are constructed such that they are of strength equivalent to the base material or fabric.
LOAD REACTION	The maximum specific load reaction pressure that can be developed from a LP fender occurs at at 60% compression and is 11 tonnes per m2.
ENERGY ABSORPTION	Dependent on the size of the fender.
INFLATION AND DEFLATION	Units operate at a nominal pressure of 70mbar (1Psi). Any convenient air supply, compressor or blower can be used for inflation.

Trelleborg's LP pneumatic fenders are made to the ISO 17357-2:2014 specification.

LP Fender units can easily be carried, inflated and deployed in a range of emergency applications via air, sea or land. This flexibility makes them particularly suited to ship to ship operations and has a significant impact on time and costs of transport. As they can be transported and deployed quickly, the fenders are key to preventing oil spill from damaged vessels, thereby minimizing damage to people and the environment.

Easy to deflate and store for later use. When deflated they can be rolled into small, lightweight packages and are therefore increasingly becoming a permanent Health and Safety requirement onboard ships. This can in turn reduce the insurance costs for vessel operation. As they operate at a nominal pressure of 70mbar (1Psi), any convenient air supply, compressor or blower, can be used for inflation. The low pressure also makes repairs and maintenance easier to carry out.

Durable and unencumbered by external fittings, the units can be towed while inflated and attachments suitable for towing and mooring can be provided at each end of the fender. In addition girthing ropes are fitted for ease of handling, and are easily maneuvered with ordinary ships' mechanical handling gear.

Low Pressure Pneumatic Fenders

PERFORMANCE DATA

Low pressure fender size and performance requirements

NOMINAL SIZE		GUARANTEED ENERGY ABSORPTION (GEA)	REACTION FORCE AT GEA DEFLECTION (R)	HULL PRESSURE AT GEA DEFLECTION (P)
DIAMETER	LENGTH	MIN VALUE AT DEFLECTION 60% +/- 5%	TOLERANCE +/- 10%	REFERENCE VALUE
m	m	kj	kN	kPa
1.0	3	26	190	80
1.0	5	52	380	89
1.0	6	65	477	91
1.0	8	91	661	94
1.5	4	90	361	78
1.5	5	126	501	85
1.5	6	162	641	90
1.5	8	235	932	97
1.8	6	169	721	79
1.8	8	261	1082	87
1.8	10	350	1452	91
1.8	12	440	1803	94
2.3	8	381	1227	81
2.3	10	511	1673	85
2.3	12	651	2123	88
2.3	16	922	3005	91
2.75	10	676	1886	80
2.75	14	1051	2985	86
2.75	18	1422	4007	88
2.75	22	1803	5108	91
3.2	12	1112	2684	81
3.2	16	1623	3906	86
3.2	20	2123	5108	88
3.2	24	2624	6330	90
4.5	16	3055	4960	84
4.5	18	3607	5810	86
4.5	20	4055	6639	87
4.5	22	4667	7562	89
4.5	30	6813	11020	93

Low pressure fender rubber coating compound requirements

	TEST	SPECIFICATION	TEST METHOD
Unaged	Hardness	60 - 70 IRHD	ISO 48
	Tensile strength	>14 Mpa	ISO 37
	Elongation at break	> 300%	ISO 37
	Compression set (24 h, 40ºC)	<40%	ISO815-1
Static ozone ageing	168 h, 20% extension, 50 pphma, 30ºC	No visible cracks	ISO 1431-1

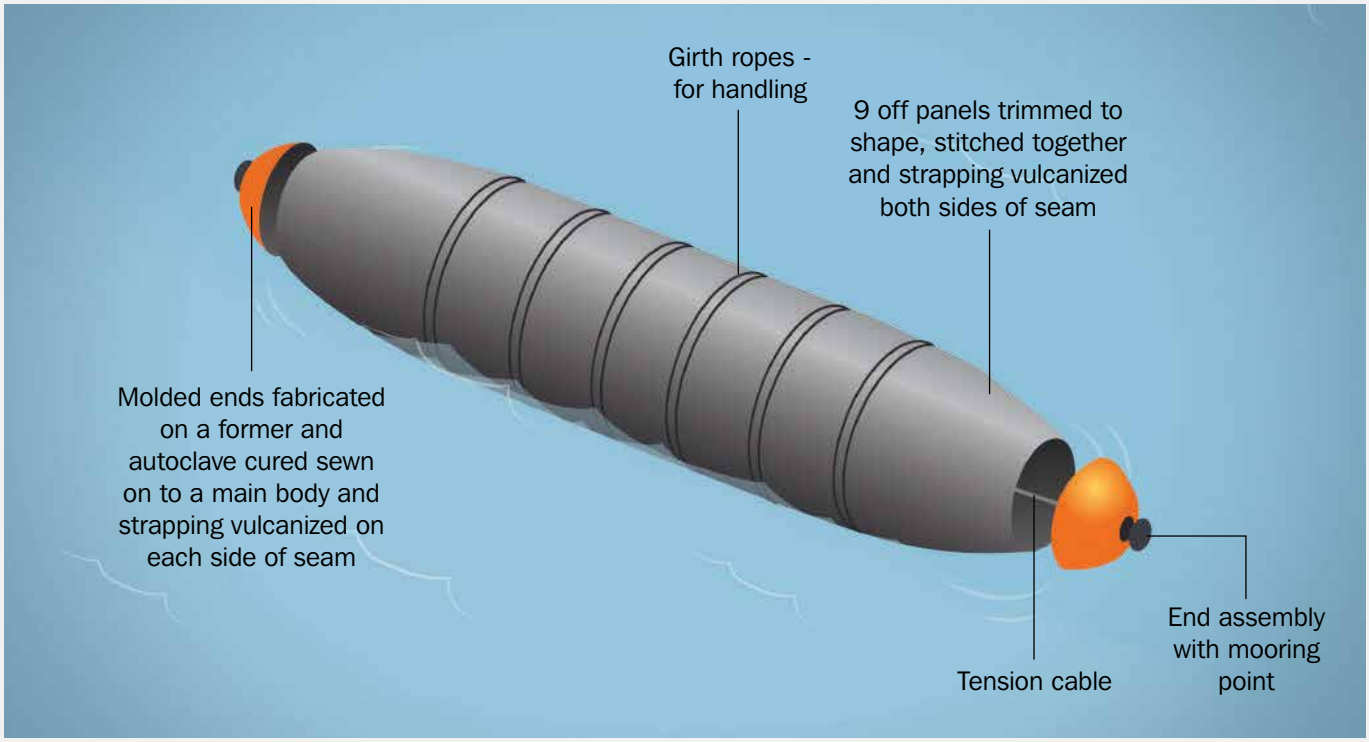
Low Pressure Pneumatic Fenders

ACCESSORIES

- Blower unit
- Medium duty delivery and suction hose
- Inflation adaptor
- Transportation / storage case
- Repair kits
- Pressure gauge assembly
- Lifting slings
- Cargo nets

NOMINAL SIZE (m)		NOMINAL WEIGHT (kg)	APPROX. FOLDED SIZE (m) LENGTH X WIDTH X HEIGHT	(TYPICAL) FENDER END CONSTRUCTION
DIAMETER	LENGTH			
1.0	5.0	90	1.5 x 0.8 x 0.7	Parcel End
1.0	6.0	110	1.5 x 0.9 x 0.7	
1.0	8.0	140	1.5 x 0.9 x 0.8	
1.5	4.0	110	1.6 x 0.8 x 0.7	
1.5	5.0	135	1.6 x 0.9 x 0.8	
1.5	6.0	160	1.6 x 1.0 x 0.9	
1.5	8.0	210	1.6 x 1.0 x 1.0	
1.8	6.0	210	1.8 x 1.0 x 0.9	
1.8	8.0	270	1.8 x 1.0 x 1.0	Clamped End
1.8	10.0	330	1.8 x 1.2 x 1.1	
1.8	12.0	390	1.8 x 1.2 x 1.2	
2.3	8.0	360	2.0 x 1.0 x 1.0	
2.3	10.0	440	2.0 x 1.2 x 1.0	
2.3	12.0	520	2.0 x 1.2 x 1.2	
2.3	16.0	680	2.0 x 1.4 x 1.3	
2.75	10.0	600	3.8 x 1.3 x 1.25	
2.75	14.0	800	3.8 x 1.45 x 1.35	Molded End
2.75	18.0	1200	3.8 x 1.6 x 1.4	
2.75	22.0	1600	3.8 x 1.7 x 1.55	
3.2	12.0	800	3.8 x 1.4 x 1.3	
3.2	16.0	1040	3.8 x 1.5 x 1.4	
3.2	20.0	1280	3.8 x 1.65 x 1.5	
3.2	24.0	1520	3.8 x 1.75 x 1.6	
4.5	18.0	1600	3.8 x 1.6 x 1.45	
4.5	22.0	2000	3.8 x 1.7 x 1.6	
4.5	26.0	2400	3.8 x 1.8 x 1.75	
4.5	30.0	2800	3.8 x 1.9 x 1.9	

Low Pressure Pneumatic Fenders



TEST	STANDARD	DESCRIPTION	REMARKS
Material testing	Various international standards.	Properties of the rubber coating compound	Hardness / tensile / elongation before aging to be tested on every batch. Static Ozone Aging, type approval for any new formulations.
Dimensional inspection	ISO 17357-2	Properties of the coated textile	Abrasion resistance / breaking and tear strength. Surface coat adhesion to be tested on every production lot.
		Length +10%, -5% Diameter +15%, -5%	Dimensional inspection to be carried out at the working pressure.
Air leakage		Pressure drop and soapy water test carried out at the working pressure	All fenders to be tested for each and every order.
Hydrostatic test		1.6 x 0.9 x 0.8	The frequency of the test shall be one in 20 fenders for each size.

Trelleborg's low pressure pneumatic fenders have also undergone third party type approval testing based on the requirements of ISO 17357:2002.

These tests included parallel plate compression, compression recovery, angular compression and durability testing. The results of these tests confirmed previous test data and theoretical performance ratings and were witnessed, reviewed and endorsed by the American Bureau of Shipping. Further details of the testing procedures and the results can be provided on request.

APPLICATIONS

1. 4.5M FENDER ON AIR TEST
2. COASTGUARD RECOVERY AT SEA
3. SHIP TO SHIP LNG TRANSFER
4. FENDER PREPARATION AT SEA
5. SHIP TO SHIP RECOVERY

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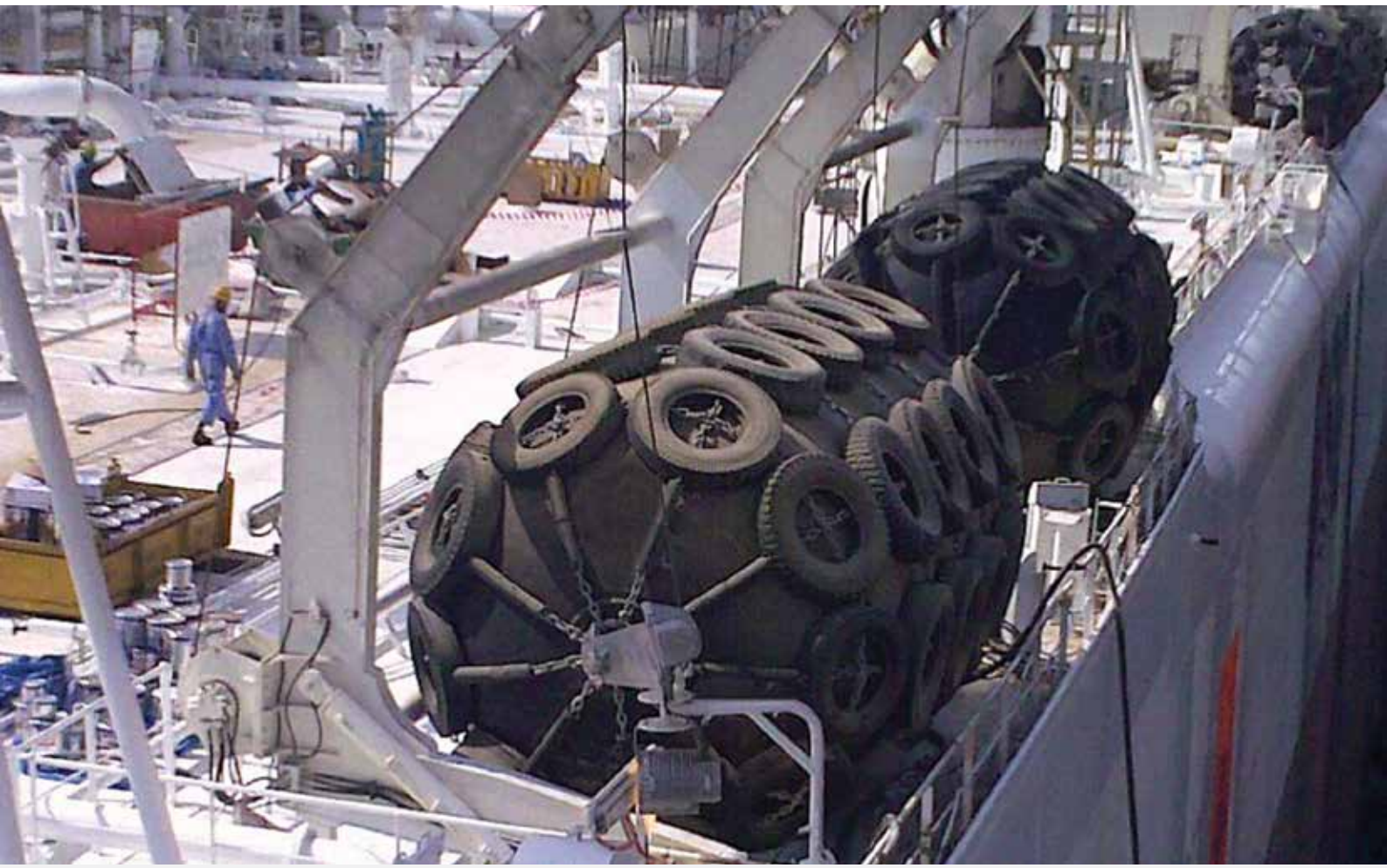
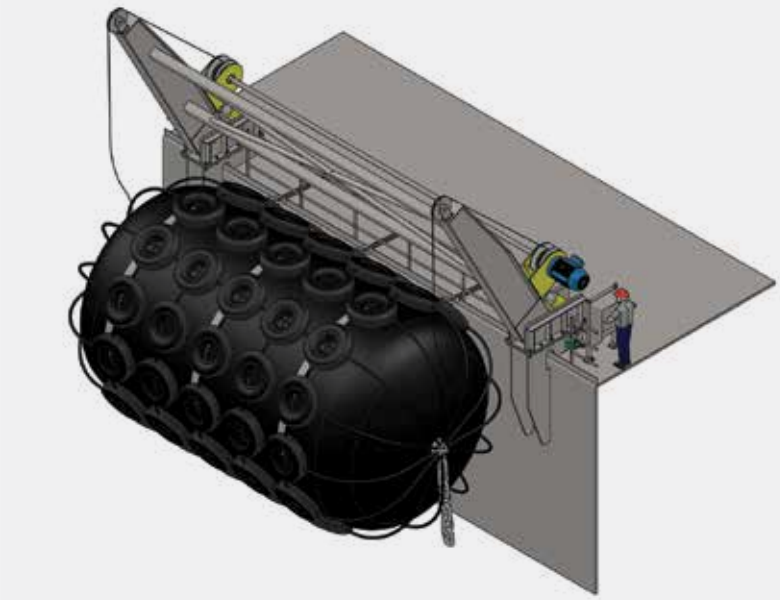
Fender Deployment Systems

Trelleborg Marine Systems not only supplies easy-to-deploy floating fenders, we also offer fender deployment systems to deploy, retrieve and store fenders.

In recent years Trelleborg Marine Systems focused on the development of fender deployment systems for the growing FSRU and FLNG applications. This market niche offers unique challenges due to the space restrictions on board FLNG and FSRU, which are driving the re-think of the common fender deployment system: current solutions explore telescopic arms or A-frame type davits to safely store the fenders on deck or over the hull during bad weather or routine maintenance inspections. Other features are: pneumatic fender pressure monitoring, hazardous rating and auto-tension system for lifting wire.

Trelleborg Marine Systems' expertise in fender manufacture, rubber technology and marine engineering mean an integrated solution from one supplier.





Davit suitable for pneumatic and foam fenders.
Standard sizes to suit 3.3 x 6.5 and 4.5 x 9.0 fenders.

Accessories

Chains

Some fender systems need chains to help support heavy components or to control how the fender deflects and shears during impact. Open link or stud link chains are commonly used and these can be supplied in several different strength grades.

FEATURES

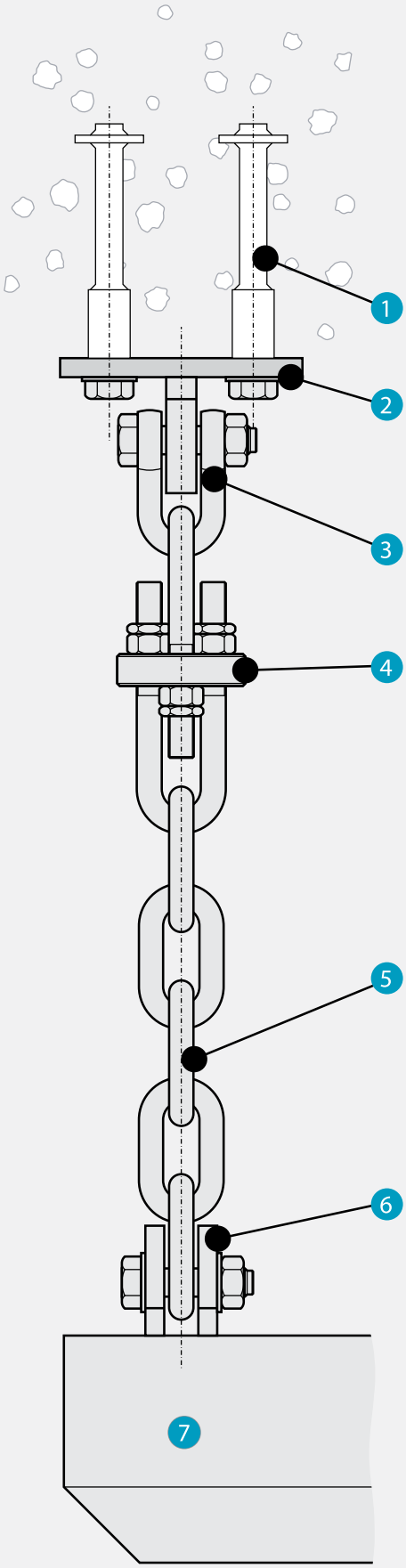
- Choice of open or stud link chains
- Various link lengths available
- Proof load tested and certified
- Galvanized as standard
- Variety of matched accessories

APPLICATIONS

- Large fender panels
- Cylindrical fenders
- Floating fender moorings
- Safety applications
- Lifting and installing

TYPICAL CHAIN SYSTEM

1. Anchors and fixing bolts
2. Chain bracket
3. Alloy D or bow-shackle with safety pin
4. Chain tensioner
5. Open or stud link chain
6. Frontal frame bracket
7. Frontal frame

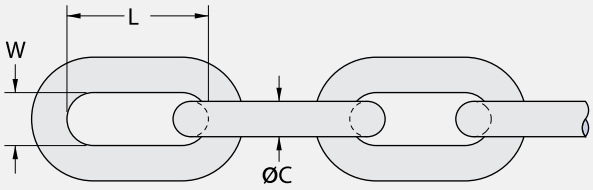


Chains

OPEN LINK CHAINS

ØC	3.0D LINKS			3.5D LINKS			4.0D LINKS			5.0D LINKS			MBL	
	L	W	WEIGHT	L	W	WEIGHT	L	W	WEIGHT	L	W	WEIGHT	SL2	SL3
14	42	18	0.2	49	20	0.2	56	20	0.2	70	21	0.3	124	154
16	48	21	0.3	56	22	0.3	64	22	0.3	80	24	0.4	160	202
18	54	23	0.4	63	25	0.4	72	25	0.5	90	27	0.5	209	262
20	60	26	0.5	70	28	0.6	80	28	0.6	100	30	0.8	264	330
22	66	29	0.7	77	31	0.8	88	31	0.8	110	33	1.0	304	380
25	75	33	1.1	88	35	1.1	100	35	1.2	125	38	1.5	393	491
28	84	36	1.4	98	39	1.6	112	39	1.7	140	42	2.0	492	616
30	90	39	1.8	105	42	2.0	120	42	2.1	150	45	2.5	566	706
32	96	42	2.2	112	45	2.4	128	45	2.5	160	48	3.0	644	804
35	105	46	2.8	123	49	3.1	140	49	3.3	175	53	4.0	770	964
38	114	49	3.6	133	53	3.9	152	53	4.3	190	57	5.1	900	1130
40	120	52	4.2	140	56	4.6	160	56	5.0	200	60	6.0	1010	1260
45	135	59	6.0	158	63	6.5	180	63	7.1	225	68	8.5	1275	1590
50	150	65	8.2	175	70	8.9	200	70	9.7	250	75	12	1570	1960
55	165	72	11	193	77	12	220	77	13	275	83	16	1900	2380
60	180	78	14	210	84	15	240	84	17	300	90	20	2260	2770

[Units: mm, kg/link, kN]

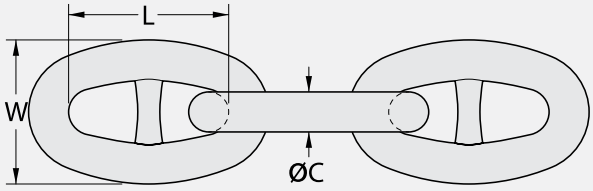


MBL = Minimum Breaking Load (kN)
NBL = Nominal Breaking Load (kN)
Tolerance: all dimensions ± 2.5%

STUD LINK CHAINS

ØC	COMMON LINK			MBL	
	L	W	WEIGHT	SL2 (U2)	SL3 (U3)
19	76	68	0.6	210	300
22	88	79	0.9	280	401
26	104	94	1.5	389	556
28	112	101	1.9	449	642
32	128	115	2.8	583	833
34	136	122	3.4	655	937
38	152	137	4.7	812	1160
42	168	151	6.3	981	1400
44	176	158	7.3	1080	1540
48	192	173	9.4	1270	1810
52	208	187	12	1480	2110
58	232	209	17	1810	2600
64	256	230	22	2190	3130
70	280	252	30	2580	3690
76	304	274	38	3010	4300
90	360	324	63	4090	5840

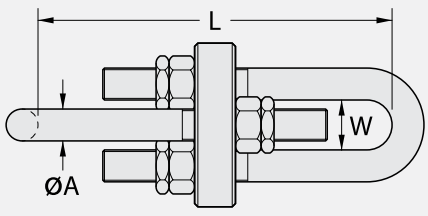
[Units: mm, kg/link, kN]



CHAIN TENSIONERS

CHAIN SIZE	ØA	L	W	WEIGHT
16	M16	200–240	40	2.7
18	M18	220–280	45	2.5
20	M20	235–305	50	5.3
22	M22	265–345	56	6.6
22	M24	280–370	60	8.8
25	M27	310–420	68	12
30	M30	345–465	76	17
32	M33	385–525	82	21
35	M36	420–560	90	27
40	M42	480–650	106	45
45	M48	545–745	120	64
50	M52	595–805	130	80
55	M56	640–880	140	99
60	M60	685–945	150	122
60	M64	730–1010	160	147

[Units: mm, kg]



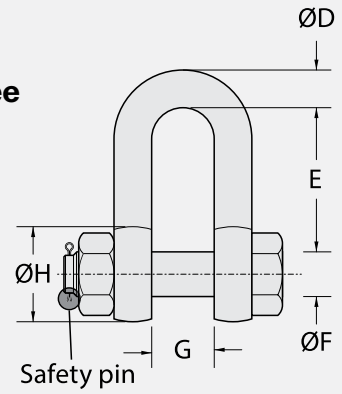
High Strength Shackles

ØD	ØF	ØH	G	DEE SHACKLE		BOW SHACKLE			NBL
				E	WEIGHT	E	ØJ	WEIGHT	
13	16	26	22	43	0.4	51	32	0.4	120
16	19	32	27	51	0.7	64	43	0.8	195
19	22	38	31	59	1.1	76	51	1.3	285
22	25	44	36	73	1.5	83	58	1.9	390
25	28	50	43	85	2.6	95	68	2.8	510
28	32	56	47	90	3.3	108	75	3.8	570
32	35	64	51	94	4.7	115	83	5.3	720
35	38	70	57	115	6.2	133	95	7.0	810
38	42	76	60	127	7.6	146	99	8.8	1020
45	50	90	74	149	13	178	126	15	1500
50	57	100	83	171	18	197	138	21	2100
57	65	114	95	190	28	222	160	29	2550
65	70	130	105	203	35	254	180	41	3330
75	80	150	127	230	60	330	190	65	5100
89	95	178	146	267	93	381	238	110	7200
102	108	204	165	400	145	400	275	160	9000

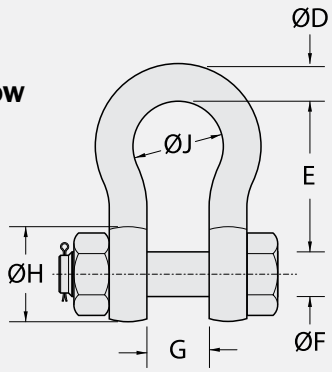
Please refer to your local office for detailed information

[Units: mm, kg, kN]

Dee

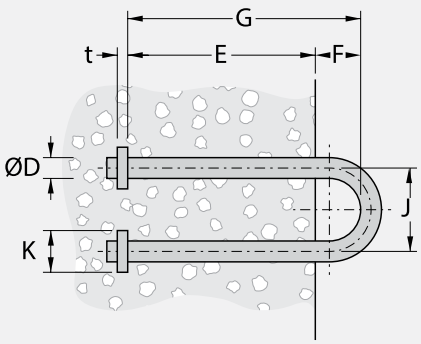


Bow



U-Anchors

ØD	E	F	G	J	K	t	WEIGHT	NBL
26	260	60	320	104	50	12	3.4	209
30	300	70	370	120	50	15	5.1	264
34	340	70	410	136	60	15	7.3	304
36	360	70	430	144	60	20	8.6	393
42	420	90	510	168	70	20	14	492
44	440	100	540	176	80	20	16	566
48	480	100	580	192	80	25	21	644
50	500	110	610	200	90	25	24	770
56	560	120	680	224	100	30	33	900
60	600	130	730	240	110	30	41	1010
66	660	140	800	264	120	35	55	1275
74	740	160	900	296	130	40	77	1570



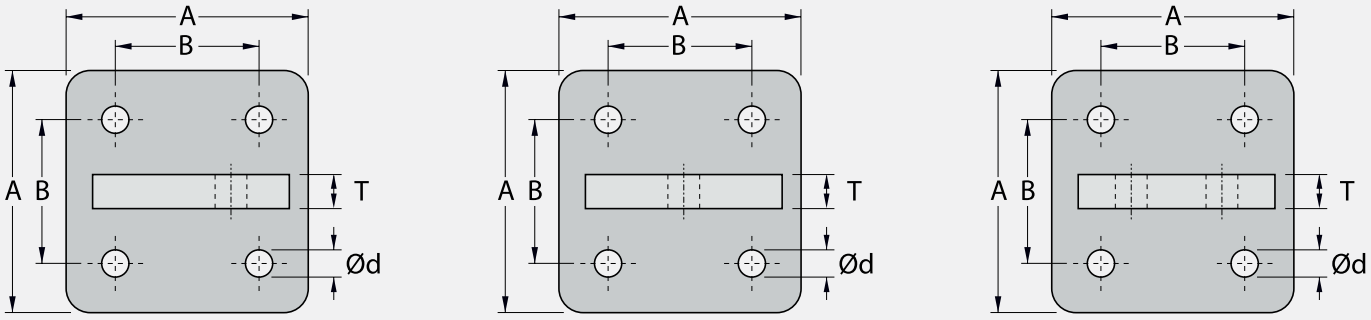
[Units: mm, kg, kN]

Brackets

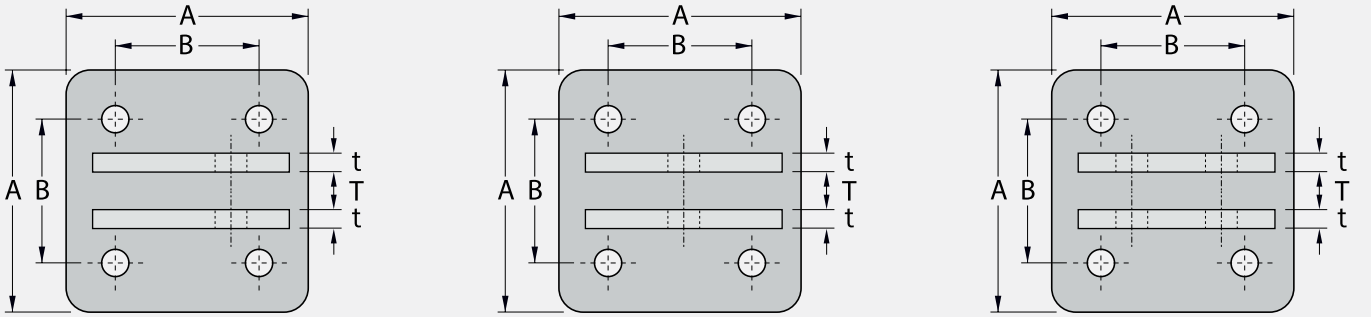
A	B	C	E		F	Ød	R	t	T	SINGLE LUG		TWIN LUG		ANCHOR
			CB1/CB3	CB2						SHACKLE	ØD	BOLT PIN	ØD	
190	110	40	20	75	160	24	40	15	30	19	28	M24 x 90	28	2/4 x M20
220	130	45	20	90	190	24	50	15	30	22	28	M24 x 90	28	2/4 x M20
250	150	50	25	100	210	28	55	20	40	25	36	M30 x 120	36	2/4 x M24
280	160	60	25	115	240	28	65	20	40	28	36	M30 x 120	36	2/4 x M24
320	190	65	35	130	270	36	75	25	45	32	42	M36 x 140	42	2/4 x M30
350	210	70	35	140	300	36	80	25	50	35	42	M36 x 140	42	2/4 x M30
380	220	80	35	155	320	42	85	30	50	38	50	M42 x 160	50	2/4 x M36
420	250	85	40	170	360	42	95	30	60	42	50	M42 x 170	50	2/4 x M36
440	260	90	40	180	360	50	100	30	60	44	60	M48 x 180	60	2/4 x M42

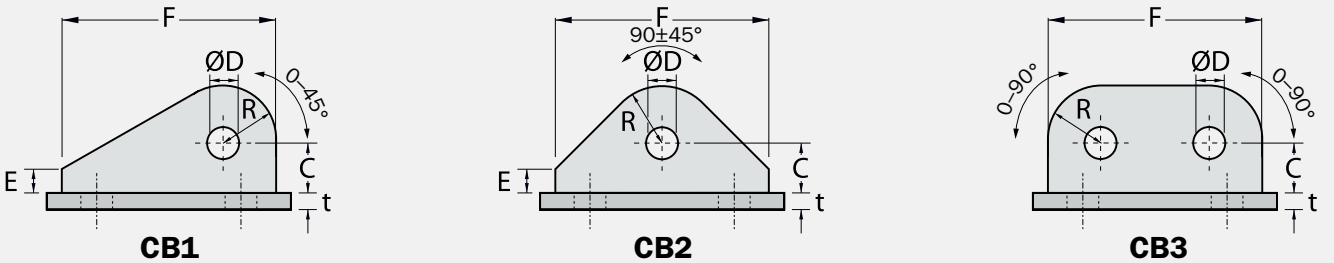
[Units: mm, kN]

S-Series



T-Series





CB1 **CB2** **CB3**

- All chain and accessory information is for guidance only.
- Every chain design should be checked to confirm suitability for the intended application.
- Select chain system components so MBL ≈ NBL.
- Every chain system is different. Check all dimensions for fit, clearance and tolerance.
- Chain brackets can be specified with 2 or 4 anchors to suit application and loads.
- If extra long life is required, add a corrosion allowance.
- Some slack in the chain is unavoidable and will not affect operation.
- For special sizes and applications, please refer to Trelleborg Marine Systems' local office.

Anchors

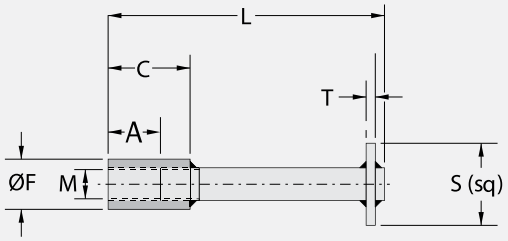
NC3 ANCHORS

THREAD	A	C	ØF	L	S (sq)	T	WEIGHT
M20	40	60	30	200	63	10	1.1
M22	44	66	32	225	63	10	1.4
M24	48	73	36	250	75	10	1.9
M27	54	84	40	265	75	10	2.4
M30	60	95	45	270	100	10	3.5
M36	72	112	54	320	100	12	5.5
M42	84	134	63	360	100	12	8.1
M48	96	156	72	400	100	15	12
M56	112	182	84	550	120	15	20
M64	128	208	100	600	130	20	30
M76	152	242	114	700	150	20	46

Anchors available in mid steel, HDG, SS 316 or super duplex

[Units: mm, kg]

The NC3 is a traditional cast-in anchor design used for installing fenders to new concrete. The NC3 anchor has a threaded socket, a long tail and a square anchor plate. Non-standard sizes and other cast-in anchor types are available on request.



Always check min/max clamping thickness and socket depths actual threaded length on bolts.

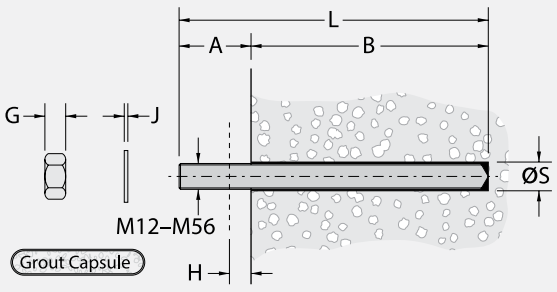
EC2 ANCHORS

THREAD	B	E	G	J	L (typ.)	ØS	CAPSULE	WEIGHT
M12	110	5 – 8	10	2.5	–	15	1 × C12	0.15
M16	140	6 – 9	13	3	175	20	1 × C16	0.26
M20	170	6 – 9	16	3	240	25	1 × C20	0.57
M24	210	8 – 12	19	4	270	28	1 × C24	0.92
M27	240	8 – 12	22	4	330	30	1 × C24	1.42
M30	280	8 – 12	24	4	360	35	1 × C30	1.91
M36	330	10 – 15	29	5	420	40	1 × C30	3.21
M42	420	14 – 21	34	7	500	50	2 × C30	5.21
M48	480	16 – 24	38	8	580	54	2 × C30 + 1 × C24	7.90
M56	560	18 – 27	45	9	–	64	4 × C30	13.0

[Units: mm, kg]

A = E + G + H + J, rounded up to nearest 10mm.
E = clear threads after assembly.
H = clamping thickness of fender.

The EC2 anchor is used for installing fenders onto existing concrete or where cast-in anchors are unsuitable. The anchor is usually secured into a drilled hole using special grout capsules. Non-standard sizes and other grout systems are available on request.



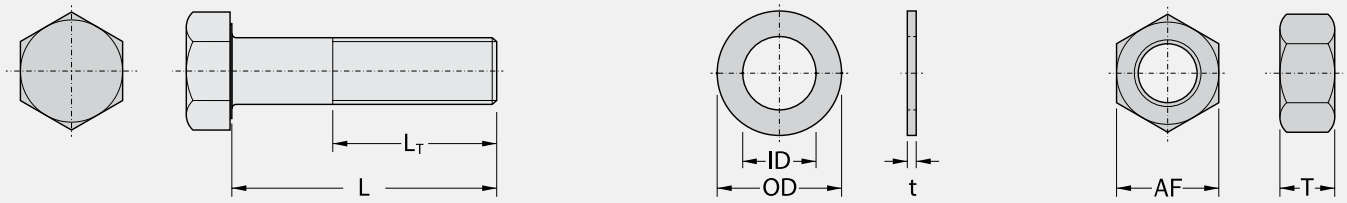
Always follow the manufacturer's instructions when installing EC2 anchors.

Fender Fixings

BOLTS, NUTS AND WASHERS

SIZE	THREAD AREA *	WASHERS †				NUTS #			TYPICAL THREAD LENGTHS ‡		THREAD PITCH
	(mm^2)	OD	ID	t	WEIGHT	AF	T	WEIGHT	L≤125	L>125	
M16	157	30	18	3	0.01	24	13	0.04	38	44	2.0
M20	245	37	22	3	0.02	30	16	0.07	46	52	2.5
M24	353	44	26	4	0.03	36	19	0.12	54	60	3.0
M27	459	52	29	4	0.05	41	22	0.23	60	66	3.0
M30	561	56	33	4	0.06	46	24	0.24	66	72	3.5
M36	817	66	39	5	0.09	55	29	0.40	78	84	4.0
M42	1120	78	45	7	0.18	65	34	0.63	90	96	4.5
M48	1470	92	52	8	0.28	75	38	0.90	102	108	5.0
M56	2030	105	62	9	0.40	85	45	1.43	118	124	5.5
M64	2680	115	70	9	0.45	95	51	2.09	134	140	6.0

* Standard bolts given according to DIN933. [Units: mm, kg]
† Standard washers given according to DIN125. Larger OD washers available on request.
‡ Thread lengths may vary depending on standard. Other lengths available.
# Standard nuts given according to DIN934.



Grades

	ISO 898 GALVANIZED		ISO 356 STAINLESS STEEL *	
Bolt grade	4.6	8.8	A-50 †	A-70 ‡
Nut grade	4	8	A-50 †	A-70 ‡
Tensile strength (MPa)	400	800	500	700
0.2% yield stress (MPa)	240	640	210	450

* Refer to Fender Application Design Manual for further details about PREN and galling.
† Size ≤ M39 unless agreed with manufacturer.
‡ Size ≤ M24 unless agreed with manufacturer.

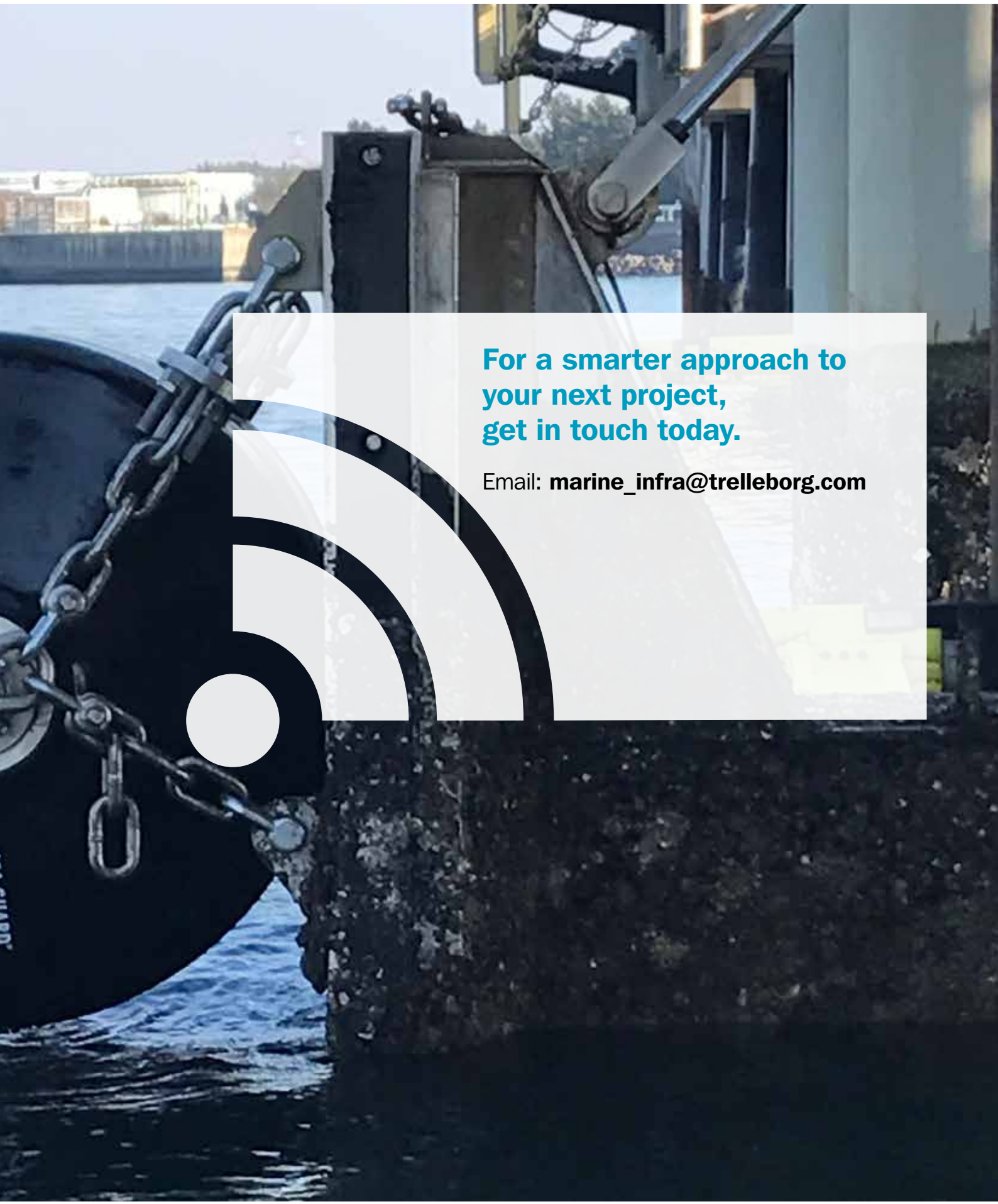
Fenders must be properly fixed to operate correctly. Anchors are supplied to suit new or existing structures, in various strength ratings and with the choice of galvanized or various stainless steels.

DISCLAIMER

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

The responsibility or liability for errors and omissions cannot be accepted for any reason whatsoever. Customers are advised to request a detailed specification and certified drawing prior to construction and manufacture. In the interests of improving the quality and performance of our products and systems, we reserve the right to make specification changes without prior notice. All dimensions, material properties and performance values quoted are subject to normal production and testing tolerances. This catalogue supersedes the information provided in all previous editions. If in doubt, please check with Trelleborg Marine Systems.

BC-FEN-v2.2-EN, 2017



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