HI-TECH ELASTOMERS LTD.

Floating Fenders

FOAM-FILLED FENDERS (HFFF)

Where
Innovation
is Tradition

FOAM-FILLED FENDERS (HFFF)

Foam-Filled Fenders are versatile, robust and suitable for almost all applications. The performance of foam-filled fenders can be modified to meet the specific specification requirements, its manufacturing process allows for virtually any size of fender to be constructed selecting the appropriate grade of foam core and elastomeric skin.

Foam-Filled 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 from ingressing into the foam.

FEATURES

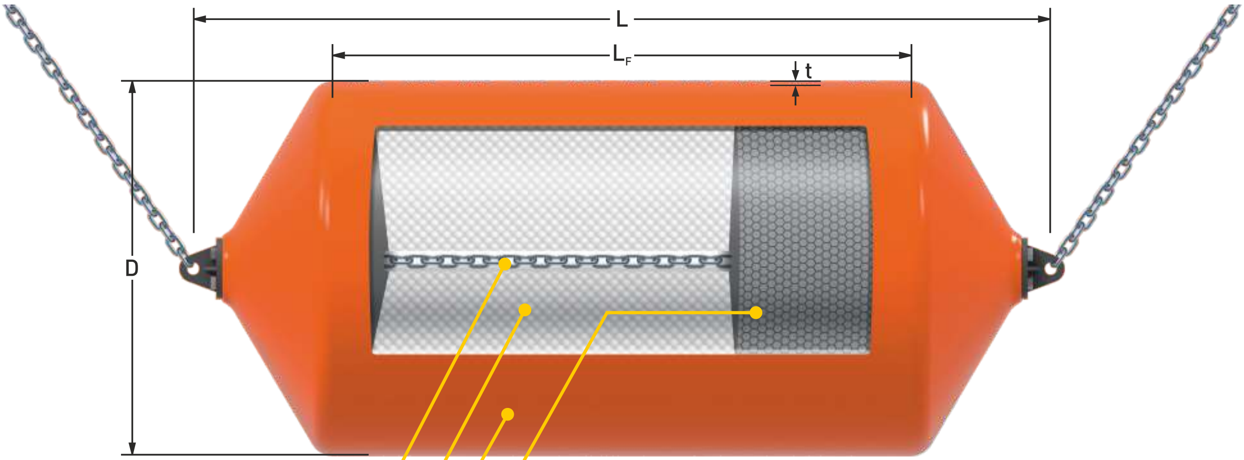
- Wide Range of Standard and Custom Sizes
- Low Reaction and High Energy Options
- Operate Floating or Suspended
- No Chain/Tyre Net Required
- Non-Marking even Against White Hulls
- Unsinkable Design
- Widely Used in Naval Application
- Since it is Not Air Filled it is Virtually Maintenance Free

APPLICATIONS

- Cruise Ships
- Container Vessels
- Bulk Cargo
- RoRo and Ferries
- Oil and Gas Tankers
- General Cargo
- Navy Berths
- Ship-to-Ship Transfers

FOAM-FILLED FENDERS (HFFF)

CONSTRUCTION



Internal Chain/Pipe/Core

Closed Cell Foam Core

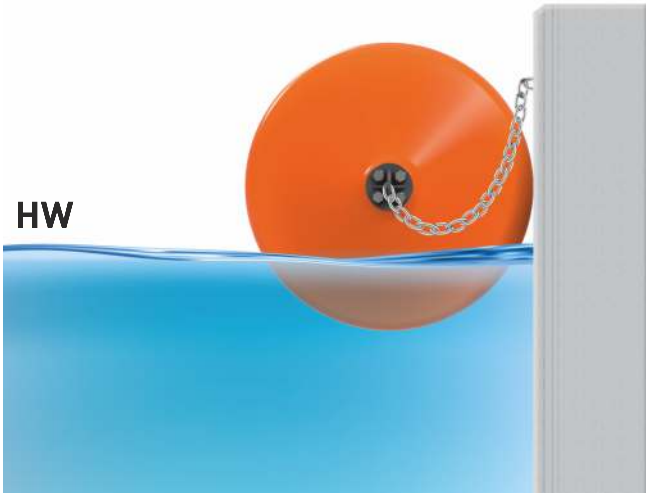
Polyurethane Skin

Fibre Reinforcement

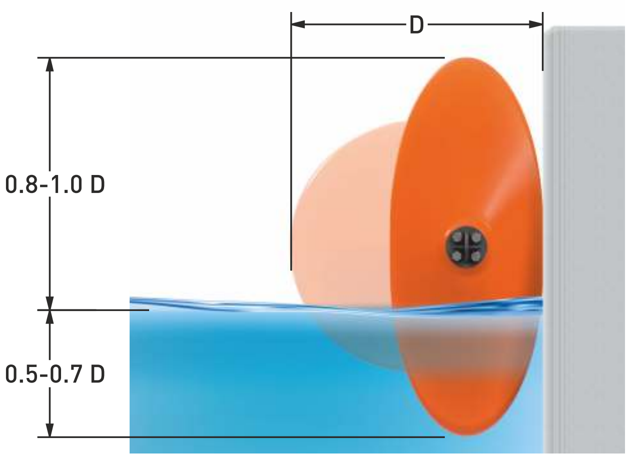
Supporting structures must be large enough to cope with tides and the fender footprint when compressed. The jetty wall or the support structure must be designed to withstand the reaction load exerted by the fender; also, the wall must be of adequate size to accommodate the fender size when it is compressed during berthing.

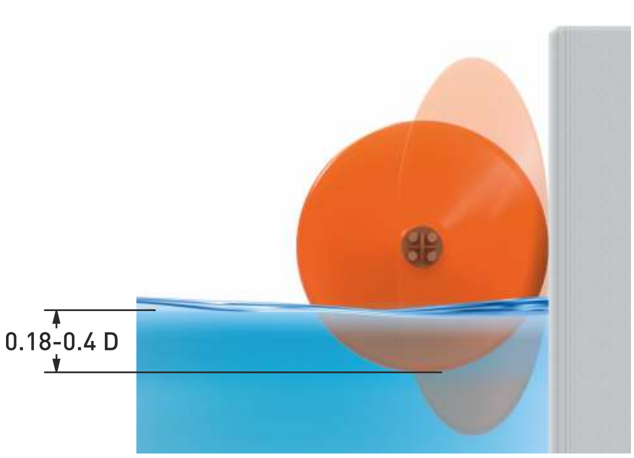
MOORING APPLICATIONS

Floating or Suspended



MOUNTING AREA





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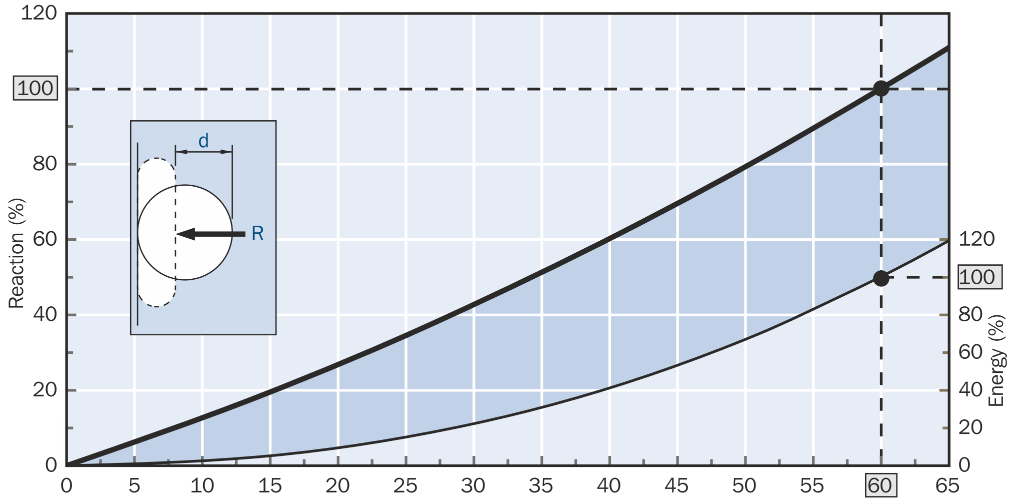
INTERMEDIATE DEFLECTIONS



- Energy: 100% • Reaction: 100%

Note:

- This is a generic curve only, the actual curve may vary depending on velocity, grade, temperature, and angle
- The above values are calculated on the bases of 150 mm/sec compression speed which is subject to variation. Actual load deflection is done at 80mm/min speed as per PIANC guidelines
- Performance/deflection tolerance may vary by ±10%
- Custom grades are available on request

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

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 Hi-Tech for details

FOAM-FILLED FENDERS (HFFF)

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

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 Hi-Tech Marine systems			

Refer to Notes

Notes for Tables

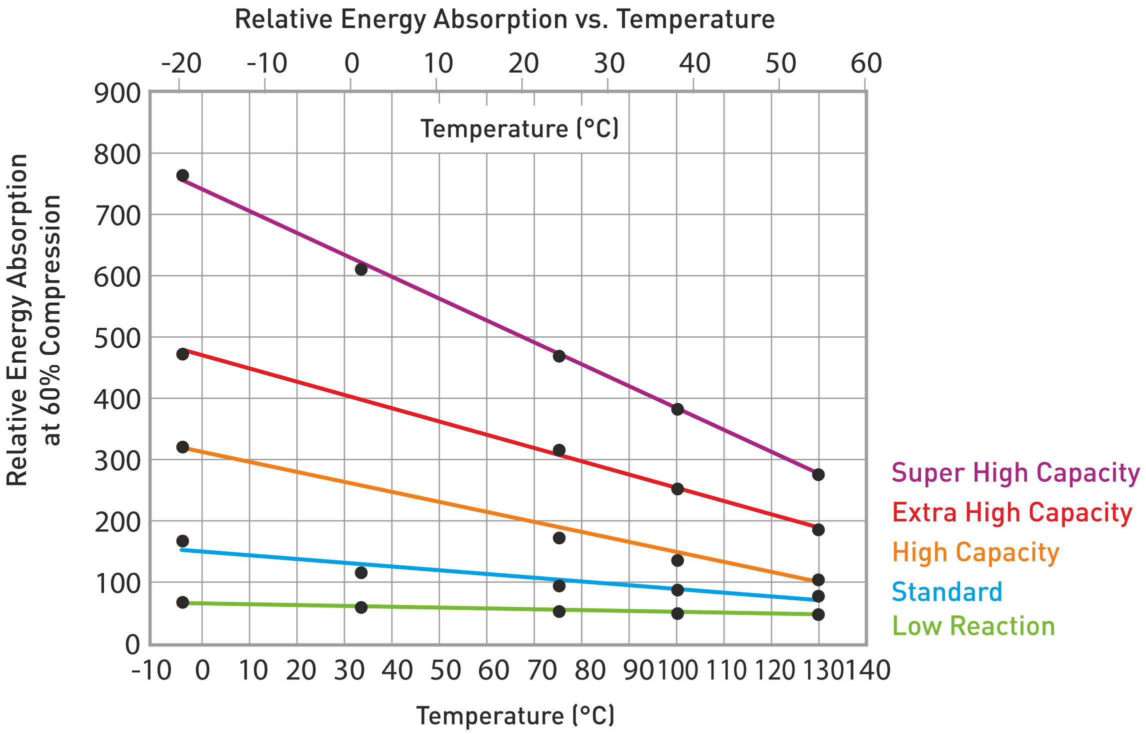
- Energy and reaction provided in the tables are based on Hi-Tech's new testing protocol for foam fenders.
- 150 mm/s speed
- 0º compound angle
- 23ºC ± 5ºC test temperature

FOAM-FILLED FENDERS (HFFF)

ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

EFFECT OF TEMPERATURE

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



The graph above shows the effect of temperature on the various types of foam used in foam-filled 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 Hi-Tech for advice.

Note:

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- The above values are calculated on the bases of 150 mm/sec compression speed which is subject to variation. Actual load deflection is done at 80mm/min speed as per PIANC guidelines
- Performance/deflection tolerance may vary by ±10%
- Custom grades are available on request

FOAM-FILLED FENDERS (HFFF)

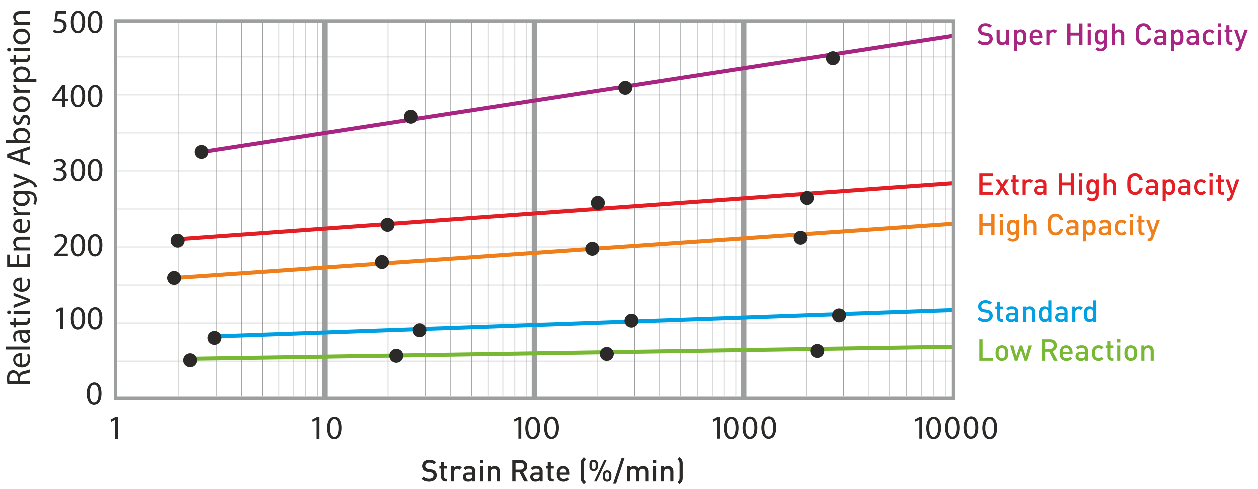
ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

EFFECT OF COMPRESSION SPEED

At a given percent compression, foam compressed at a high strain rate will absorb more energy than foam compressed at a low strain rate. 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. 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.

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



The above 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.

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ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

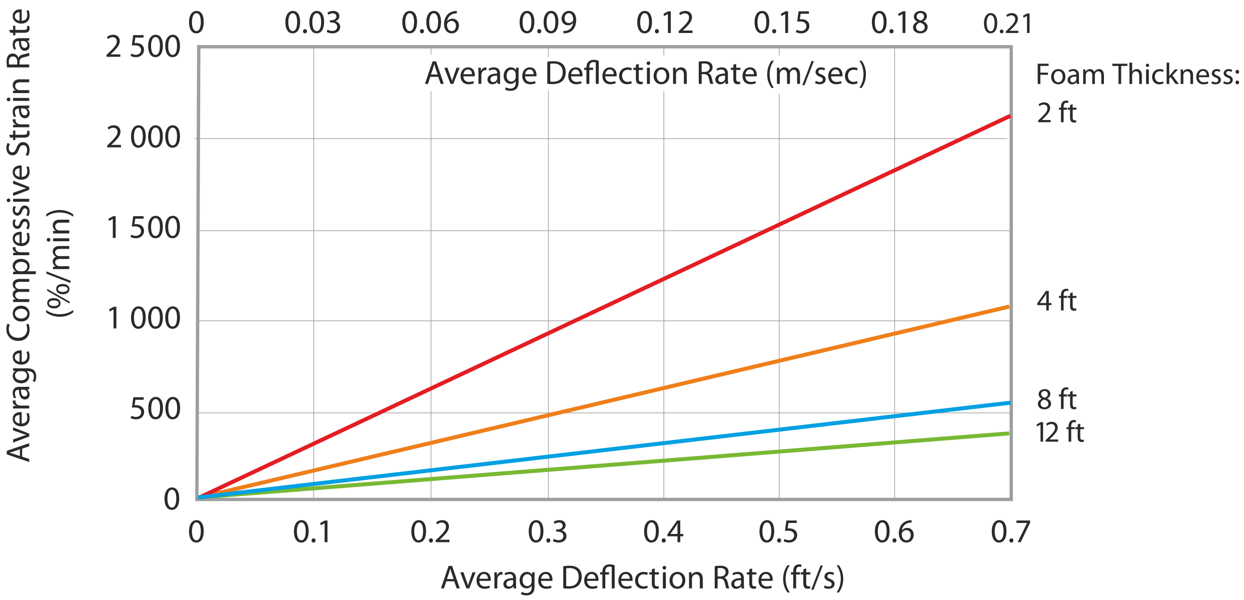
EFFECT OF COMPRESSION SPEED

A small fender is compressed at a higher rate than a large fender, for a given approach velocity. The graph below shows the effect of the 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 1500%/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 below 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.

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



Note:

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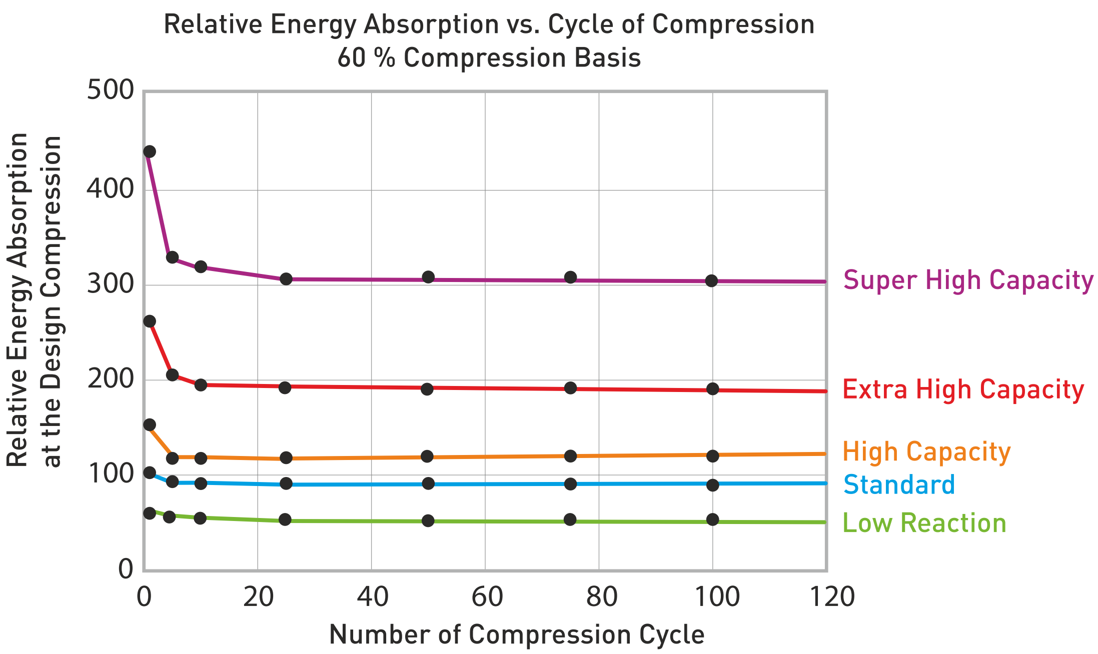
ADDITIONAL CONSIDERATIONS IN FENDER DESIGN

CYCLIC COMPRESSION

Polyolefin foam can lose a small amount of its energy absorbing capacity over a period of time when a plastic foam such as polyolefin foam is compressed repeatedly to a given thickness. 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) Hi-Tech fender conducted at our factory, 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 catalogue 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 catalogue 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 catalogue 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 catalogue ratings.

Note:

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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.

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

PRODUCT INSTALLATION PICTURES

HI-TECH ELASTOMERS LTD.

WHERE INNOVATION IS A TRADITION

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