

OPERATING & MAINTENANCE GUIDE

For

PNEUMATIC FLOATING RUBBER FENDERS

Version 1.2 - Pneumatic Floating Rubber Fenders

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Preface

Max Groups Marine Sdn Bhd is one of the max group of companies/factories, act as Global marketing of company, possessing advanced air bag technology, which is unique in China and leading in the world. Our company produces high quality precision products such as high pressure Air-bag and ship protecting fender. Our high pressure MAX Air Bag can be applied to ship launching, carrying large scale project, ship protection and etc.

We are foreign Malaysia-China joint venture enterprises possessing more on national patent technology to gather research and invention, production, sell, consultation and project based service of professional production Marine Rubber Air-gasbag and ship protecting Marine Pneumatic Rubber fender.

Our manufacture factory MaxJinan, is situated at beautiful Jinan off spring city, the base of research and invention production. We have work troop of two hundred high quality professional expert and general staff for our local government and private sector project to cater for hoisting and transporting heavy structure as well as after sales service. We provide high quality products and services by continue to improvement in line with our product and technology in domestically and international standard level.

In line with the rubber raw material is directly sourced from our own Malaysia rubber estate which is well known for its best quality and reliability material. Manufacture plant is set-up in China because of the low-cost labour with highly skilled technical personnel is our decision to ensure the Best Competitive Price & Quality in the market. We have our technology adopting the fifth generation highly durability for these unique and sophisticated precision product have won some reputation for local and international market.

1. construction features

1.1 Basic body construction

The **MAX** floating-type pneumatic rubber fenders are kind of a cylindrical air-bag with hemispherical heads at both end. Basic body construction of this fender consists of an outer rubber layer, cord layers and inner rubber layer. All of these are vulcanized together.

End flanges are at both end for convenience of air charge and other purposes.

Outer rubber layer

The outer rubber layer protects the cord layer and inner layer from abrasion and other external forces. This compound has sufficient tensile and tear strength to withstand any weather condition and hard usage.

Cord layers

The cord layers are arranged at ideal angles to hold the internal pressure and to distribute the stress evenly. The **MAX** fenders cord layer is constructed by means of integrative twine technology and consists of polyamide fiber with high tensile stress, so that the fenders have unique strength and uniformity in different directions.

Inner rubber layer

The inner rubber layer seals the air inside, utilizing a compound with airtight quality.

End flanges

A valve for air charge and a hang ring are incorporated in the end flange; its type of construction may be variety according to the size of fender and the hang mode. The type of end flange in fig. 1 is used to the fenders of medium sizes which contains a special swivel ring in itself, suits the fenders of large sizes and with tire-net.

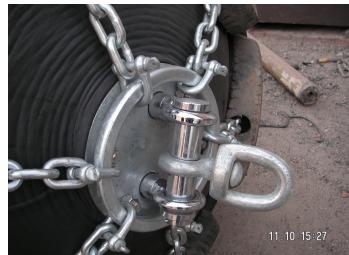


Fig 1 End flange with new developed stainless steel metal material

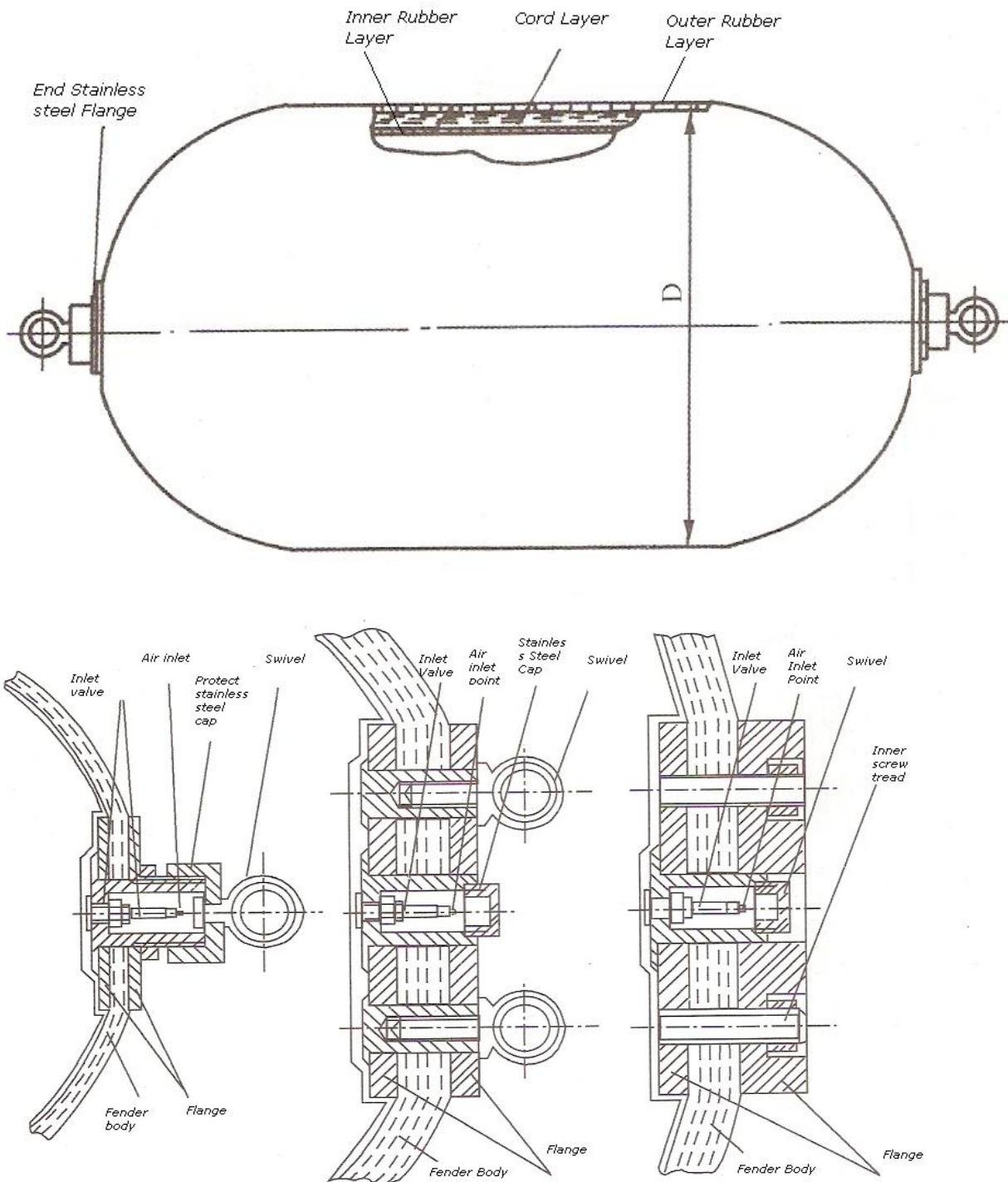


Fig 2 Typical Cross section layer Pneumatic fenders

2. The types of protective net

The basic type of **MAX** fenders is uncovered and black. Its color may be changed on request. In order to protect surface from the nick incurred by calk, three kinds of net-type fender may be selected by customer.



fig. 3a **Tire-chain net**

The tire-chain net-type fenders are covered by a chain net with used-tires; its both ends are tied by a special swivel ring, which is fit for large size fender.



fig. 3b **Rubber mat-wire net**

The rubber mat-wire net-type fenders are covered by a wire net with special rubber mats, which is fit for medium and small size fender.



fig. 3c **Fiber net**

The fiber net-type fenders are covered by a nylon string net, which is fit for small size fender.

2. Advantages and applications

2.1 Advantages

2.1.1 Advantages at inclined berthing

Ships usually make the initial contact with the dock at an oblique angle.

In the case of solid rubber fenders, energy absorption decreases considerably at inclined compression compared with parallel compression. In order to compensate for the decrease of energy absorption at inclined compression, it is necessary, in the case of solid rubber fenders of being use larger sizes.

In the case of floating type pneumatic rubber fenders energy absorption does not decrease at inclined compression. Therefore, distribution of load is comparatively even, and torque performance against the dock is very small compared to conventional solid rubber fenders.

2.1.2 Stronger against shearing force

After contacting a dock, a ship is usually shifted to the correct mooring position whereby the shifting position due to the natural characteristic exerts shearing and compression force on the fenders. These combined forces will lead to very severe damage to the solid rubber fenders because it is not well relocated against the shearing force. In contrast, floating type pneumatic fenders are well suit to the situation against such shearing force.

2.1.3 Lower mooring forces under crucial weather conditions

During mooring process is carried especially under crucial weather conditions, ship is under wave action, especially to swell, causing the ship in unbalanced up and down at the quay may result in compression with shearing force occur on the fenders. The reaction force under frequently deflection of the solid-type fender under such weather condition may cause fatigue characteristic on the solid fender. Therefore, the **MAX** floating type pneumatic fender highly absorption with its flexible area contact and its large allowable deflection do not easily reaching its life span due to the fatigue process.

2.1.4 Safe for excess load

Although all fenders should be used within the range of impact load limit, it often happens that the fenders sometimes receive excess load of impact accidentally.

The reaction force of **MAX** floating type pneumatic rubber fenders does not increase sharply even under excessive load. Therefore, pneumatic rubber fenders perform well in such cases where protecting ships and mooring facilities. In contrast, the reaction force of the solid rubber fenders, including the buckling – type fender increase very sharply under excessive of load conditions. Such phenomenon transform the solid type fenders into harden rubber block condition which can not perform well as fenders. This usually leads to the damage of ship during mooring.

2.1.5 No deterioration or variation in performance

Deterioration of **MAX** floating type fenders due to aging or fatigue process is minimizing for its utilization. It is because due to its air filled with full of compressive elasticity performance inside the body of fenders being reduce the deterioration of the rubber material itself. On the contrary, solid rubber fenders or foam-filled fenders much more depending on the rubber material hardness may result in the deterioration of solid fenders due to the temperature change tremendously.

The good performance of **MAX** floating –type pneumatic rubber fenders remain stable in performing even at extremely low temperature -50°C and extremely crucial temperature variation. (*Precaution taken should aware of air pressure is maintained properly*)

2.1.6 Adaptable to the tide

Floating-type pneumatic fenders float on the water in an unrestricted vertical plane corresponding to the tidal range and ship's vertical movement. It means energy absorption always taking place at the most suitable position.

2.1.7 Simple installation and low maintenance cost

The weight of floating-type pneumatic fender is buoyed on the surface of sea water. Therefore, the fenders can be moored simply by means of guy rope or chain at minimal extra cost. It can be removed easily from the jetty or quay when it is not use, or transferred to another mooring point as required.

Maintenance cost for the floating-type fender is very low. Schedule annually checking on the internal air pressure is required to ensure the air leakage at minimal and chain net needs to be replaced after a period of 3 to 4 years depending on the ambient working environment.

2. Application

2.1. Application to oil carriers Ship-to-Ship contact (STS)

The **MAX** fenders of diameter 3.3m have been adapted by a 300,000 DWT class tanker, which registered at Greece and had been proven successfully by docking the supertanker to another 150,000 DWT class tanker at South-China Sea (see fig. 4)

The large –scale tankers usually hang 4 ~ 6 pieces fenders in a board side as shown in fig.5



Fig. 4 Application of fenders to 300,000 DWT class Tanker

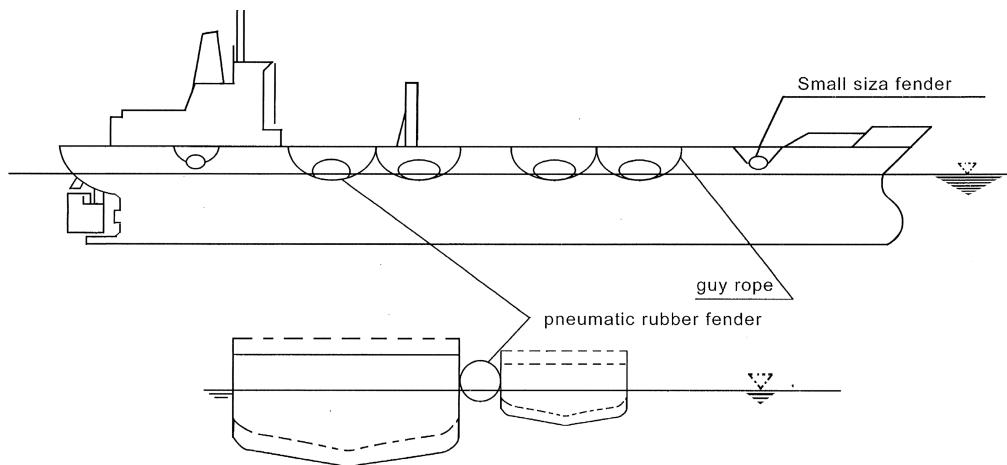


Fig 5 Standard installation of fenders for Ship-to-Ship Contact

In case of Ship-to-Ship contact, four pieces of large size fenders are usually floated on the sea water as primary fender to absorb impact energy at berthing, two pieces of small size fenders are hung on the hull at both bow and stern to prevent contact from rolling of ship due to swell.

2.2. Application to wharves

The **MAX** fenders were first introduced in manufactured with Jinan, Changlin factory plant used to Hong Kong – Macau wharves in 1997 in different sizes applied to wharves, quays, piers, jetties and dolphin use (Fig. 6). Since that, a large number of fenders have been adopted by Shanghai Base of China Navy for anti-collision device of naval harbor quay. (See fig. 7)

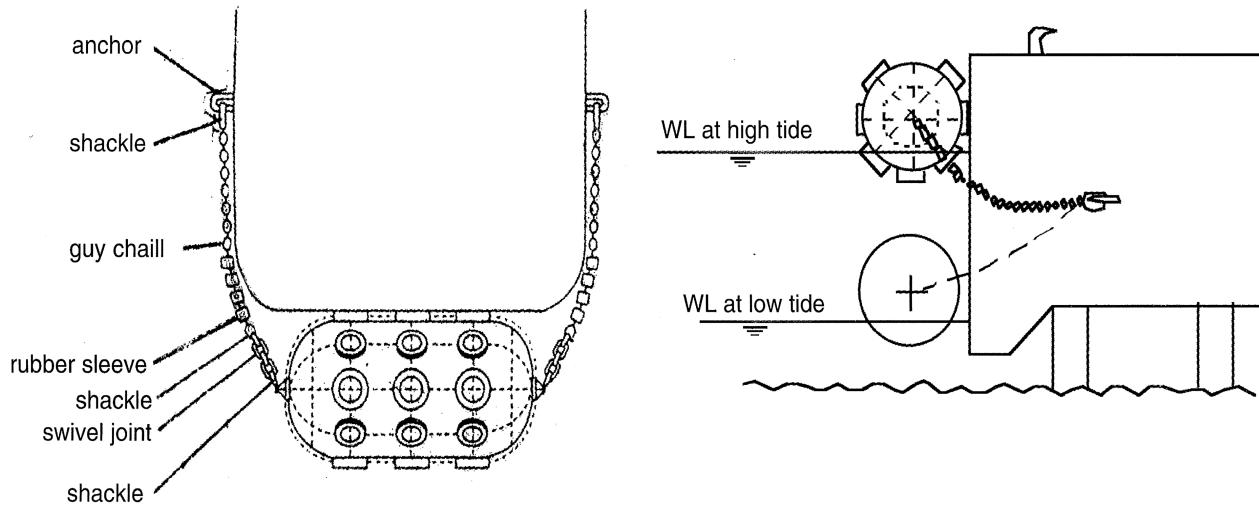


Fig. 6 shown of dolphin use and the installation method



Fig. 7 Application of fenders to a quay of naval harbor in Shanghai

Table 1 indicate different sizes of installation parts

Fender size (Diameter x Length)	Guy wire Diameter (mm)	Guy chain or Fiber rope Diameter (mm)	Shackle Diameter (mm)	Swivel joint (mm)	Anchor Diameter (mm)
0.5 x 1.0	12	14	14	18	18
0.6 x 1.0	12	14	14	18	20
0.7 x 1.5	14	16	18	18	25
1.0 x 1.5	14	16	18	18	25
1.0 x 2.0	14	16	18	18	25
1.2 x 2.0	16	16	18	22	28
1.35 x 3.0	16	18	18	22	28
1.5 x 3.0	18	18	22	24	28
1.7 x 3.0	20	20	24	24	30
2.0 x 3.5	24	24	28	28	34
2.5 x 4.0	24	26	28	32	34
2.5 x 5.5	24	26	28	34	34
3.3 x 4.5	26	28	30	38	40
3.3 x 6.5	28	30	32	44	60

3.

Specification and Performances

1. Calculation of performance

It assumed that the fender is at initial stage of static pressure condition with its inner volume equal V_0 and its inner pressure P_0 . When the fenders is compressed up to x in the diameter direction, its inner volume

changes, V_x , inner pressure P_x , with the area of contact surface S_x , then the reaction force R_x may be calculated as follows:

$$R_x = P_x \cdot S_x$$

Therefore, the energy absorption E_x at the moment is :

$$E_x = \int_0^x R_x \, dx$$

But in the actual process of compression, the body of fender probably produces tiny elastic deformation, that results in the actual values of V_x and S_x to be more than the values calculated by theoretical due to the actual value of P_x being less and the accuracy of value R_x and E_x are having variation. Thus, the reaction R_x and the energy absorption E_x are usually gained by model testing of compression. The exponential curve in Fig. 8 shows that the performances of fenders change accordance with the deflection.

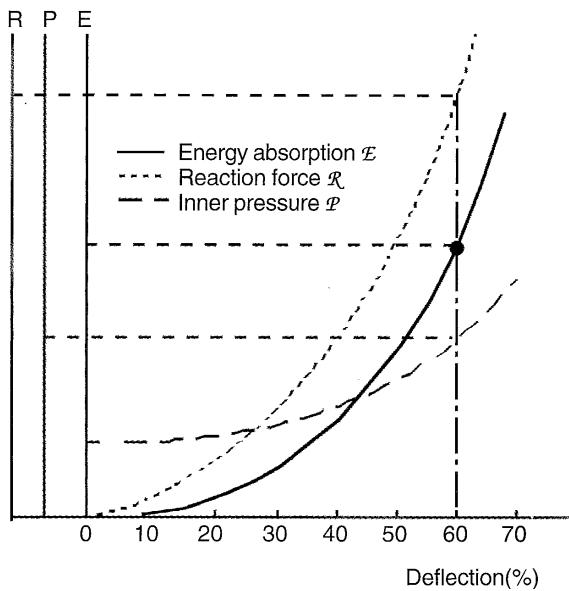


Fig 8 The performance curves gained by compressive tests

3.2 Compressive performance tests

The *Mechanical Engineering Test Center of Shandong University* conducted a series of compressive tests to examine the performance of **MAX** floating-type pneumatic rubber fenders. These tests had been conducted on a large press, incorporating with advanced precision sensor for measuring force in it, and the data collection and processing are fully automate computerized. As a result the inner pressure curve, reaction force curve and energy absorption curve are plotted depending on the deflections.

Fig. 9 is the pictures photographed pneumatic fender at different stage of deflections.



Fig. 9 Photos of Compressive tests

3.3 Specifications and Performance

The guaranteed energy absorption of **MAX** floating-type pneumatic rubber fenders are the energy absorption at 60% deflection. This value can be used in engineering design and actual operation. Table 2 gives the sizes, weights and technical performance of **MAX** floating-type pneumatic rubber fenders.

Table 2 Specification and technical performances of **MAX** fenders

Nominal size (D x L) meter	Initial internal pressure Po = 0.05 Mpa			Initial Internal pressure Po = 0.08 Mpa		
	Load (kg)	R (KN)	Energy (KJ)	Load (kg)	R (KN)	Energy (KJ)
0.5 x 1.0	25	64	6	25	83	8
0.6 x 1.0	32	74	8	32	96	11
0.7 x 1.5	50	137	17	50	178	24
1.0 x 1.5	80	182	32	80	235	44
1.0 x 2.0	100	257	45	125	335	63
1.2 x 2.0	120	297	63	165	386	86
1.35 x 2.5	165	427	102	226	554	140
1.5 x 3.0	315	597	153	370	751	211
1.7 x 3.0	405	639	191	436	830	263
2.0 x 3.5	590	875	308	632	1138	424

2.5 x 4.0	1050	1381	663	1110	1815	925
2.5 x 5.5	1333	2019	943	1410	2653	1317
3.0 x 5.0	1880	2104	1210	2155	2700	1571
3.0 x 6.0	2160	2583	1485	2470	3292	1888
3.3 x 4.5	2020	1884	1175	2300	2476	1640
3.3 x 6.0	2300	2783	1675	2600	3652	2338
3.3 x 6.5	2700	3015	1814	3080	3961	2532

Note :

- Energy represents the Guarantee energy absorption at 60% deflection.
- The weight is fender's body weight without protective net may vary ± 10%
- Reaction Force, R ± 10%; Deflection: ± 5% and each of the reaction force and energy absorption are measured under static condition.
- Special Sizes of others dimension are available upon request.

4.0 User selection

When selecting the size of fenders, it should be selected base on the consideration of kinetic energy of contact between two vessels or between vessel and berthing facilities may be absorbed by a single fender. The following tables are given for determining the energy absorption depends on approaching velocities for various ships.

4.1 Energy absorption for ship-to-Jetty

Table 3 Energy absorption of oil tankers at ¼ point berthing (kJ)

DWT	Assumed Weight(t)	Approaching velocity (m/s)							
		0.10	0.12	0.15	0.18	0.20	0.25	0.30	0.40
300	668	1.7	2.5	3.8	5.5	6.8	11.0	15.0	27.0
500	1,091	2.8	4.0	6.3	9.0	11.0	17.0	25.0	45.0

700	1,558	4.0	5.7	8.9	13.0	16.0	25.0	36.0	64.0
1,000	2,228	5.7	8.2	14.0	18.0	23.0	36.0	51.0	91.0
2,000	4,294	11.0	16.0	28.0	35.0	44.0	68.0	99.0	175
3,000	6,470	17.0	24.0	37.0	53.0	66.0	103	149	264
4,000	8,363	21.0	31.0	54.0	69.0	85.0	133	192	341
5,000	10,594	27.0	39.0	61.0	88.0	108	169	243	432
6,000	12,184	31.0	45.0	70.0	101	124	194	280	497
7,000	14,084	36.0	52.0	81.0	116	144	225	323	575
8,000	16,066	41.0	59.0	92.0	133	164	256	369	656
10,000	20,373	52.0	75.0	117	168	208	325	468	832
12,000	23,851	61.0	88.0	137	197	243	380	548	974
15,000	29,493	75.0	108	169	244	301	470	677	1200
17,000	33,056	84.0	121	190	273	337	527	759	1350
20,000	38,623	99.0	142	222	319	394	616	887	1580
25,000	45,946	117.0	169	264	380	469	733	1050	1880
30,000	56,093	143.0	206	322	464	572	894	1290	2290
35,000	63,084	161.0	232	362	521	644	1010	1450	2570
40,000	72,771	186.0	267	418	601	743	1160	1670	2970
45,000	77,986	199.0	286	448	645	796	1240	1790	3180
50,000	89,818	229.0	330	516	742	917	1430	2060	3670
60,000	104,300	266.0	383	599	862	1060	1660	2390	4260
65,000	114,637	292.0	421	658	948	1170	1830	2630	4680
70,000	122,108	312.0	449	701	1010	1250	1950	2800	4980
80,000	136,972	349.0	503	786	1130	1400	2180	3140	5590
85,000	143,359	366.0	527	823	1180	1460	2290	3290	5850
100,000	166,004	423.0	610	953	1370	1690	2650	3810	6780
120,000	200,083	510.0	735	1150	1650	2040	3190	4590	8170
150,000	251,896	643.0	925	1450	2080	2570	4020	5780	10280

200,000	327,735	836.0	1200	1880	2710	3340	5230	7520	13380
250,000	401,268	1020	1470	2300	3320	4090	6400	9210	16380
330,000	548,670	1400	2020	3150	4530	5600	8750	12600	22390
370,000	627,016	1600	2300	3600	5180	6400	10000	14400	25590
480,000	795,540	2030	2920	4570	6580	8120	12680	18260	32470

Table 4 Energy absorption of ore carriers at ¼ point berthing (kj)

DWT	Assumed Weight(t)	Approaching velocity (m/s)							
		0.10	0.12	0.15	0.18	0.20	0.25	0.30	0.40
1,000	2,360	6.0	8.7	14.0	20.0	24.0	38.0	54.0	96.0
2,000	4,429	11.0	16.0	25.0	37.0	45.0	71.0	102	181
3,000	6,453	16.0	24.0	37.0	53.0	66.0	103	148	263
4,000	8,341	21.0	31.0	48.0	69.0	85.0	133	192	340
5,000	10,301	26.0	38.0	59.0	85.0	105	164	237	420
6,000	12,574	32.0	46.0	72.0	104	128	200	289	513
8,000	16,332	42.0	60.0	94.0	135	167	260	375	667
10,000	20,516	52.0	75.0	118	170	209	327	471	837
12,000	24,345	62.0	89.0	140	201	248	388	559	994
15,000	29,572	75.0	109	170	244	302	471	679	1210
20,000	38,068	97.0	140	219	315	388	607	874	1550
25,000	45,116	115	166	259	373	460	719	1040	1840
30,000	54,874	140	202	315	454	560	875	1260	2240
40,000	71,143	181	261	408	588	726	1130	1630	2900
50,000	86,432	220	318	496	714	882	1380	1980	3530
60,000	101,383	259	372	582	838	1030	1620	2330	4140
70,000	119,062	304	437	683	984	1210	1900	2730	4860
80,000	132,125	337	485	758	1090	1350	2110	3030	5390
90,000	149,528	381	549	858	1240	1530	2380	3430	6100

100,000	175,960	449	646	1010	1450	1800	2810	4040	7180
150,000	256,357	654	942	1470	2120	2620	4090	5890	10460
200,000	319,149	814	1170	1830	2640	3260	5090	7330	13030
270,000	426,459	1090	1570	2450	3520	4350	6800	9790	17410

Table 5 Energy absorption of freighters at ¼ point berthing (kJ)

DWT	Assumed Weight(t)	Approaching velocity (m/s)							
		0.10	0.12	0.15	0.18	0.20	0.25	0.30	0.40
700	1,585	4.0	5.8	9.1	13.0	16.0	25.0	36.0	65.0
1,000	2,237	5.7	8.2	13.0	18.0	23.0	36.0	51.0	91.0
2,000	4,357	11.0	16.0	25.0	36.0	44.0	69.0	100	178
3,000	6,606	17.0	24.0	38.0	55.0	67.0	105	152	270
4,000	8,712	22.0	32.0	50.0	72.0	89.0	139	200	356
5,000	10,795	28.0	40.0	62.0	89.0	110	172	248	441
6,000	13,515	34.0	50.0	78.0	112	138	215	310	552
7,000	15,557	40.0	55.0	89.0	129	159	248	357	635
8,000	17,703	45.0	65.0	102	146	181	282	406	723
9,000	19,625	50.0	72.0	113	162	200	313	451	801
10,000	21,630	55.0	79.0	124	179	221	345	497	883
12,000	26,052	66.0	96.0	150	215	266	415	598	1060
15,000	31,477	80.0	116	181	260	321	502	723	1280
17,000	36,784	94.0	135	211	304	375	586	845	1500
20,000	41,748	107	153	240	345	426	666	959	1700
30,000	60,483	154	222	347	500	617	964	1390	2470
40,000	79,393	203	292	456	656	810	1270	1820	3240
50,000	98,306	251	361	564	813	1000	1570	2260	4010

Table 6 Energy absorption of passenger ships at ¼ point berthing (kJ)

DWT	Assumed Weight(t)	Approaching velocity (m/s)							
		0.10	0.12	0.15	0.18	0.20	0.25	0.30	0.40
500	845	2.2	3.1	4.9	7.0	8.6	13.0	19.0	34.0
1,000	1,709	4.3	6.2	9.8	14.0	17.0	27.0	39.0	70.0
2,000	3,500	8.9	13.0	20.0	29.0	36.0	56.0	80.0	143
3,000	5,282	13.0	19.0	30.0	44.0	54.0	84.0	121	216
4,000	7,105	18.0	26.0	41.0	59.0	73.0	113	163	290
5,000	8,912	23.0	33.0	51.0	74.0	91.0	142	205	364
6,000	12,083	31.0	44.0	69.0	100	123	193	277	493
7,000	13,873	35.0	51.0	80.0	115	142	221	319	566
8,000	15,346	39.0	56.0	88.0	127	157	245	352	626
9,000	16,986	43.0	62.0	97.0	140	173	271	390	693
10,000	18,661	48.0	69.0	107	154	190	298	428	762
15,000	26,283	67.0	97.0	151	217	268	419	603	1070
20,000	33,423	85.0	123	192	276	341	533	767	1360
30,000	47,952	122	176	275	396	489	765	1100	1960
50,000	71,744	183	264	412	593	732	1140	1650	2930
80,000	111,956	286	411	643	925	1140	1790	2570	4570

Table 7 Energy absorption of barges or lighters at $\frac{1}{4}$ point berthing (kJ)

G/T	Assuming Weight (t)	Approaching velocity (m/s)						
		0.20	0.25	0.30	0.35	0.40	0.50	0.60
50	85	0.9	1.4	2.0	2.7	3.5	5.4	7.8
100	161	1.6	2.6	3.7	5.0	6.6	11.0	15.0
150	241	2.5	3.8	5.5	7.5	9.8	15.0	22.0
200	319	3.3	5.1	7.3	10.0	13.0	20.0	29.0
300	496	5.1	7.9	11.0	15.0	20.0	32.0	46.0

Table 8 Energy absorption of container ships at $\frac{1}{4}$ point berthing (kJ)

G/T	DWT	Assumed Weight (t)	Approaching velocity (m/s)					
			0.10	0.15	0.20	0.25	0.30	0.40
8,000	12,000	26,752	68	154	273	427	614	1090
9,000	14,000	33,567	86	193	343	535	771	1370
16,626	16,004	38,172	97	219	390	609	876	1560
21,057	20,400	48,995	125	281	500	781	1120	2000
23,600	23,650	55,560	142	319	567	886	1280	2270
30,992	27,203	64,264	164	369	656	1020	1480	2620
38,826	33,287	79,599	203	457	812	1270	1830	3250
41,127	27,752	67,121	171	385	685	1070	1540	2740
51,500	28,900	68,664	175	394	701	1090	1590	2800
57,000	49,700	105,199	268	604	1070	1680	2420	4290

Table 9 Energy absorption of fishing vessels at $\frac{1}{4}$ point berthing (kJ)

Type	G/T	Assumed Weight (t)	Approaching velocity (m/s)					
			0.20	0.25	0.30	0.35	0.40	0.50
Whale factory ship	10,000	34,058	348	543	782	1060	1390	2170
	17,000	53,494	546	853	1230	1670	2180	3410
	20,000	66,217	676	1060	1520	2070	2700	4220
Whale ship	400	1,797	18.0	29.0	41.0	56.0	73.0	115
	800	3,263	33.0	52.0	75.0	102	133	208
	1,000	3,950	40.0	63.0	91.0	123	161	252
								363

Trawler	400	2,297	23.0	37.0	53.0	72.0	94.0	146	211
Vessel	800	3,693	38.0	59.0	85.0	115	151	236	339
	1,000	4,458	45.0	71.0	102	139	182	284	409
	2,000	7,173	73.0	114	165	224	293	457	659
	3,000	9,863	101	157	226	308	403	629	906
Skipjack vessel	20	126	1.3	2.0	2.9	3.9	5.1	8.0	12.0
	50	202	2.1	3.2	4.6	6.3	8.2	12.9	19.0
	100	390	4.0	6.2	9.0	12.0	16.0	25.0	36.0
	200	779	7.9	12.0	18.0	24.0	32.0	50.0	72.0
Mackerel vessel	20	112	1.1	1.8	2.6	3.5	4.6	7.1	10.0
	50	266	2.7	4.2	6.1	8.3	11.0	17.0	24.0
	100	525	5.4	8.4	12.0	16.0	21.0	33.0	48.0
Tuna long-liner	150	590	6.0	9.4	14.0	18.0	24.0	38.0	54.0
	200	780	8.0	12.0	18.0	24.0	32.0	50.0	72.0
	400	1,681	17.0	27.0	39.0	53.0	69.0	107	154
Round Haul netter	20	75	0.8	1.1	1.7	2.3	3.1	4.8	6.9
	50	191	1.9	3.0	4.4	6.0	7.8	12.0	18.0
	100	377	3.8	6.0	8.7	12.0	15.0	24.0	35.0
Towing net vessel	20	99	1.0	1.6	2.3	3.1	4.0	6.3	9.1
	50	204	2.1	3.3	4.7	6.4	8.3	13.0	19.0
	100	361	3.7	5.8	8.3	11.0	15.0	23.0	33.0
	300	1,138	12.0	18.0	26.0	36.0	46.0	73.0	105
	500	1,838	19.0	29.0	42.0	57.0	75.0	117	169
General fishing vessel	20	77	0.8	1.2	1.8	2.4	3.1	4.9	7.1
	50	195	2.0	3.1	4.5	6.1	8.0	12.0	18.0
	100	350	3.6	5.6	8.0	11.0	14.0	22.0	32.0
	150	500	5.1	8.0	11.0	16.0	20.0	32.0	46.0

Table 10 Energy absorption of ferry boats at ¼ point berthing (KJ)

G/T	Assumed Weight (t)	Approaching velocity (m/s)						
		0.20	0.25	0.30	0.35	0.40	0.50	0.60
50	124	1.3	2.0	2.8	3.8	5.1	7.9	11.0
100	246	2.5	3.9	5.6	7.7	10.0	16.0	23.0
200	430	4.4	6.9	9.9	13.0	18.0	27.0	39.0
300	664	6.8	11.0	15.0	21.0	27.0	42.0	61.0
500	1,012	10.0	16.0	23.0	32.0	41.0	65.0	93.0
1,000	1,796	18.0	29.0	41.0	56.0	73.0	115	165

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4.2 Energy absorption for ship-to-ship

Following tables are the “Quick Reference of Berthing Energy” for ship-to-ship operation. These tables show the berthing energy for various kinds of tankers coming alongside lightening ships at three different approaching speeds.

For calculation purpose, we recommend the approaching velocity to be within the range shown, i.e. from min. (Left side speed) to max. (Right side speed). This table shows figures for tankers, but it can be applied to other kinds of ships, if their assumed weights correspond to those in the table.

Table 11 Kinetic energy (kJ) at ship-to-ship berthing

ShipA		1,000 DWT			2,000 DWT			3,000 DWT		
Ship B	Assumed W	2,228 t			4,294 t			6,470 t		
		DWT	Assumed W	0.3m/s	0.4m/s	0.5m/s	0.3m/s	0.4m/s	0.5m/s	0.3m/s
1,000	2,228 t	26	45	71	‘	‘	‘	‘	‘	‘
2,000	4,294 t	34	60	94	49	88	137	‘	‘	‘
3,000	6,470 t	38	68	106	59	105	165	74	132	206
4,000	8,363 t	40	72	112	65	116	181	84	149	233

5,000	10,594 t	42	75	117	70	125	195	92	164	256
6,000	12,184 t	43	77	120	73	130	202	97	172	269
7,000	14,084 t	44	78	123	76	134	210	102	181	283
8,000	16,066 t	45	80	125	78	138	216	106	188	294
10,000	20,373 t	46	82	128	81	145	226	113	200	313
12,000	23,815 t	47	83	130	84	148	232	117	208	324
15,000	29,493 t	48	85	132	86	153	239	122	216	338
17,000	33,056 t	48	85	133	87	155	242	124	221	345
20,000	38,623 t	48	86	134	89	158	246	127	226	353
25,000	45,946 t	49	87	135	90	160	250	130	231	362
30,000	56,093 t	49	87	137	92	163	254	133	237	370
35,000	63,084 t	49	88	137	92	164	256	135	239	374
40,000	72,771 t	50	88	138	93	165	258	136	242	379
45,000	77,986 t	50	88	138	93	166	259	137	244	381
50,000	89,818 t	50	89	139	94	167	261	139	246	385
60,000	104,300 t	50	89	139	95	168	263	140	249	388
65,000	114,637 t	50	89	139	95	169	264	141	250	390
70,000	122,108 t	50	89	139	95	169	264	141	251	392
80,000	136,972 t	50	89	140	96	170	265	142	252	394
85,000	143,359 t	50	90	140	96	170	266	142	253	395
100,000	166,004 t	50	90	140	96	171	267	143	254	397
120,000	200,083 t	51	90	140	96	172	268	144	256	400
150,000	251,896 t	51	90	141	97	172	269	145	257	402
200,000	327,735 t	51	90	141	97	173	270	146	259	404
250,000	401,268 t	51	90	141	98	173	271	146	260	406
330,000	548,670 t	51	91	141	98	174	272	147	261	408
370,000	627,016 t	51	91	142	98	174	272	147	261	408
480,000	795,540 t	51	91	142	98	174	272	147	262	409

(Continued table 11 – Kinetic energy (kJ) at ship-to-ship berthing)

Ship B	Assumed W	ShipA			4,000 DWT		5,000 DWT			6,000 DWT		
					8,363 t t		10,594 t			12,184 t		
		DWT	Assumed W	0.3m/s	0.4m/s	0.5m/s	0.3m/s	0.4m/s	0.5m/s	0.3m/s	0.4m/s	0.5m/s

1,000	2,228 t									
2,000	4,294 t									
3,000	6,470 t									
4,000	8,363 t	96	171	267						
5,000	10,594 t	107	191	298	122	216	338			
6,000	12,184 t	114	202	316	130	231	361	140	249	388
7,000	14,084 t	120	214	335	139	247	385	150	267	416
8,000	16,066 t	126	224	351	147	260	407	159	283	442
10,000	20,373 t	136	242	378	160	284	444	175	311	486
12,000	23,851 t	142	253	395	168	299	468	185	329	514
15,000	29,493 t	150	266	415	179	318	497	198	352	550
17,000	33,056 t	153	272	425	184	327	511	204	363	568
20,000	38,623 t	158	280	438	191	339	530	213	378	590
25,000	45,946 t	162	289	451	198	351	549	221	393	614
30,000	56,093 t	167	297	464	205	364	568	230	408	638
35,000	63,084 t	169	301	471	208	370	578	234	417	651
40,000	72,771 t	172	306	478	212	377	590	240	426	665
45,000	77,986 t	173	308	482	214	381	595	242	430	672
50,000	89,818 t	176	312	488	217	387	604	246	438	684
60,000	104,300 t	178	316	494	221	392	613	250	445	695
65,000	114,637 t	179	318	497	223	396	618	253	449	702
70,000	122,108 t	180	319	499	224	398	621	254	452	706
80,000	136,972 t	181	322	502	226	401	627	257	457	713
85,000	143,359 t	181	322	504	226	402	629	258	458	716
100,000	166,004 t	183	325	508	229	406	635	261	463	724
120,000	200,083 t	184	328	512	231	411	641	264	469	732
150,000	251,896 t	186	330	516	233	415	648	267	474	741
200,000	327,735 t	187	333	520	236	419	654	270	479	749
250,000	401,268 t	188	334	522	237	421	658	271	482	754
330,000	548,670 t	189	336	525	239	424	663	274	486	760
370,000	627,016 t	189	337	526	239	425	664	274	488	762
480,000	795,540 t	190	338	528	240	427	666	275	490	765

Note: Required quantities are 3 pieces of fender & over.

(Continued table 11 – Kinetic energy (kJ) at ship-to-ship berthing)

ShipA	7,000 DWT	8,000 DWT	10,000 DWT
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Ship B	Assumed W	14,084 t			16,066 t			20,373 t		
		0.3m/s	0.4m/s	0.5m/s	0.3m/s	0.4m/s	0.5m/s	0.25m/s	0.325m/s	0.4m/s
DWT	Assumed W									
5,000	10,594 t									
6,000	12,184 t									
7,000	14,084 t	162	287	449						
8,000	16,066 t	172	306	478	184	328	512			
10,000	20,373 t	191	340	531	206	366	573	162	274	416
12,000	23,851 t	203	361	565	220	392	612	175	296	448
15,000	29,493 t	219	389	608	239	424	663	192	325	492
17,000	33,056 t	227	403	630	248	441	689	201	339	514
20,000	38,623 t	237	421	358	260	463	723	213	359	544
25,000	45,946 t	247	440	687	273	486	759	225	380	576
30,000	56,093 t	258	459	718	287	510	796	238	403	610
35,000	63,084 t	264	470	734	294	522	816	245	415	628
40,000	72,771 t	271	481	752	302	537	839	254	429	649
45,000	77,986 t	274	487	761	306	544	849	257	435	659
50,000	89,818 t	279	497	776	313	556	869	265	447	678
60,000	104,300 t	285	506	791	320	568	888	272	459	695
65,000	114,637 t	288	512	800	323	575	898	276	446	706
70,000	122,108 t	290	515	805	326	579	905	278	470	712
80,000	136,972 t	293	521	814	330	587	917	283	478	724
85,000	143,359 t	294	523	818	332	589	921	284	480	728
100,000	166,004 t	298	530	828	336	598	934	289	489	740
120,000	200,083 t	302	537	839	341	607	948	295	498	754
150,000	251,896 t	306	544	850	347	616	963	300	508	769
200,000	327,735 t	310	551	861	351	625	976	306	517	783
250,000	401,268 t	312	555	867	355	630	985	309	552	791
330,000	548,670 t	315	560	875	358	637	995	313	529	801
370,000	627,016 t	316	562	878	360	639	999	314	531	805
480,000	795,540 t	318	565	882	361	643	1004	317	535	810

Note: Required quantities are 3 pieces of fender & over.

(Continued table 11 – Kinetic energy (kJ) at ship-to-ship berthing)

ShipA	12,000 DWT	15,000 DWT	17,000 DWT
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Ship B	Assumed W	23,851 t			29,493 t			33,056 t				
		DWT	Assumed W	0.25 m/s	0.325m/s	0.4m/s	0.25m/s	0.325m/s	0.4m/s	0.25m/s	0.325m/s	0.4m/s
10,000	20,373 t											
12,000	23,851 t	190	321	487								
15,000	29,493 t	210	355	538	235	397	602					
17,000	33,056 t	221	373	565	248	420	636	263	445	674		
20,000	38,623 t	235	397	602	267	450	682	284	480	727		
25,000	45,946 t	250	423	641	286	484	733	306	518	784		
30,000	56,093 t	267	451	683	308	521	789	331	560	849		
35,000	63,084 t	276	466	706	320	541	820	346	584	885		
40,000	72,771 t	286	484	733	334	565	856	362	612	927		
45,000	77,986 t	291	492	745	341	576	873	370	625	947		
50,000	89,818 t	300	508	769	354	598	906	385	651	986		
60,000	104,300 t	309	523	792	366	619	938	400	676	1024		
65,000	114,637 t	315	532	806	374	632	957	409	691	1047		
70,000	122,108 t	318	537	814	379	640	969	415	701	1061		
80,000	136,972 t	324	547	829	387	654	990	424	717	1086		
85,000	143,359 t	326	551	834	390	659	998	428	724	1096		
100,000	166,004 t	332	562	851	339	675	1022	439	742	1125		
0	200,083 t	340	574	869	410	692	1049	452	764	1157		
120,000	251,896 t	347	587	889	421	711	1077	466	787	1192		
0	327,735 t	354	599	907	431	729	1104	479	809	1225		
150,000												
0												
200,000												
0												
250,000	401,268 t	359	606	919	435	740	1121	487	823	1246		
0	548,670 t	364	616	933	446	754	1142	497	840	1272		
330,000	627,016 t	366	619	937	449	759	1149	500	846	1281		
0	795,540 t	369	624	945	453	766	1160	506	855	1295		
370,000												
0												
480,000												
0												
Ship A		20,000 DWT			25,000 DWT			30,000 DWT				
Ship B		Assumed W			38,623 t			45,946 t			56,093 t	

DWT	Assumed W	0.25 m/s	0.325m/s	0.4m/s	0.25m/s	0.325m/s	0.4m/s	0.25m/s	0.325m/s	0.4m/s
20,000	38,623 t	308	520	788						
25,000	45,946 t	334	565	856	366	619	937			
30,000	56,093 t	365	616	933	403	680	1031	447	755	1144
35,000	63,084 t	382	645	977	424	716	1085	473	800	1212
40,000	72,771 t	402	680	1029	449	759	1149	505	853	1292
45,000	77,986 t	412	696	1054	461	779	1180	520	879	1331
50,000	89,818 t	430	727	1102	484	819	1240	550	930	1409
60,000	104,300 t	449	759	1150	508	859	1301	581	982	1488
65,000	114,637 t	460	778	1179	523	883	1338	600	1014	1537
70,000	122,108 t	468	790	1197	532	899	1362	613	1035	1568
80,000	136,972 t	480	811	1229	548	927	1404	634	1072	1624
85,000	143,359 t	485	820	1241	555	937	1420	643	1086	1645
100,000	166,004 t	499	844	1278	574	969	1468	668	1129	1711
0	200,083 t	516	872	1321	596	1006	1552	698	1180	1787
120,000	251,896 t	534	902	1366	619	1047	1585	731	1236	1872
0	327,735 t	551	931	1410	642	1085	1644	763	1290	1954
150,000										
0										
200,000										
0										
250,000	401,268 t	562	949	1437	657	1110	1682	784	1326	2008
0	548,670 t	575	972	1472	676	1142	1730	811	1371	2076
330,000	627,016 t	580	980	1484	682	1153	1747	821	1387	2101
0	795,540 t	587	992	1503	692	1170	1772	835	1411	2138
370,000										
0										
480,000										
0										

(Continued table 11 – Kinetic energy (kJ) at ship-to-ship berthing)

Ship A	Assumed W	35,000 DWT	40,000 DWT	45,000 DWT
		63,084 t	72,771 t	77,986 t
Ship B				

DWT	Assumed W	0.25m/ s	0.325m/ s	0.4m/ s	0.25m/ s	0.325m/ s	0.4m/ s	0.25m/ s	0.325m/ s	0.4m/ s
20,000	38,623 t									
25,000	45,946 t									
30,000	56,093 t									
35,000	63,084 t	503	850	1287						
40,000	72,771 t	539	910	1379	580	980	1485			
45,000	77,986 t	556	939	1423	600	1014	1536	621	1050	1591
50,000	89,818 t	591	998	1512	641	1083	1640	665	1124	1703
60,000	104,300 t	626	1059	1604	683	1155	1749	711	1202	1821
65,000	114,637 t	649	1096	1660	709	1199	1816	740	1250	1894
70,000	122,108 t	663	1120	1697	727	1228	1860	758	1282	1942
80,000	136,972 t	688	1163	1762	757	1280	1939	792	1338	2027
85,000	143,359 t	698	1180	1787	769	1300	1969	805	1360	2061
100,00 0	166,004 t 200,083 t	729 764	1231 1292	1865 1957	806 850	1363 1437	2064 2177	846 894	1429 1511	2165 2289
120,00 0	251,896 t 327,735 t	804 843	1359 1425	2058 2158	900 949	1521 1604	2304 2430	949 1004	1604 1697	2430 2570
150,00 0										
200,00 0										
250,00 0	401,268 t 548,670 t	869 902	1468 1524	2224 2308	982 1024	1659 1731	2513 2621	1041 1088	1759 1839	2664 2786
330,00 0	627,016 t 795,540 t	913 932	1544 1574	2339 2385	1039 1063	1756 1796	2660 2720	1105 1132	1868 1913	2830 2898
370,00 0										
480,00 0										
Ship A		50,000 DWT			60,000 DWT			65,000 DWT		
Ship B	Assumed W	89,818 t			104,300 t			114,637 t		
DWT	Assumed W	0.2m/s	0.25m/s	0.3m/ s	0.2m/s	0.25m/s	0.3m/ s	0.2m/s	0.25m/s	0.3m/ s

40,000	72,771 t									
45,000	77,986 t									
50,000	89,818 t	458	716	1031						
60,000	104,300 t	492	769	1108	532	831	1197			
65,000	114,637 t	514	803	1156	557	870	1253	585	914	1315
70,000	122,108 t	528	825	1188	574	897	1291	603	942	1357
80,000	136,972 t	553	865	1245	604	944	1359	637	995	1432
85,000	143,359 t	563	880	1267	616	962	1386	650	1015	1462
100,000	166,004 t	594	929	1338	653	1021	1470	692	1081	1556
0	200,083 t	632	988	1423	699	1093	1573	743	1162	1673
120,000	251,896 t	675	1055	1520	752	1176	1693	804	1256	1808
0	327,735 t	719	1124	1618	807	1261	1816	866	1354	1949
150,000										
0										
200,000										
0										
250,000	401,268 t	749	1170	1684	844	1319	1900	909	1421	2046
0	548,670 t	787	1230	1771	894	1397	2011	967	1511	2176
330,000	627,016 t	801	1252	1803	912	1425	2052	989	1545	2224
0	795,540 t	823	1286	1852	941	1470	2116	1022	1597	2300
370,000										
0										
480,000										
0										

Note: Required quantities are 4 pieces of fender & over.

(Continued table 11 – Kinetic energy (kJ) at ship-to-ship berthing)

ShipA		70,000 DWT			80,000 DWT			85,000 DWT		
Ship B	Assumed W	122,108 t			136,972 t			143,359 t		
		DWT	Assumed W	0.2m/s	0.25m/s	0.3m/s	0.2m/s	0.25m/s	0.3m/s	0.2m/s

65,000	114,637 t									
70,000	122,108 t	623	973	1401						
80,000	t	658	1029	1482	699	1091				
85,000	136,972 t	673	1051	1513	714	1116	1572	731	1142	1645
	143,359 t						1608			
100,000	166,004 t	718	1121	1615	765	1196	1722	785	1226	1765
0	t	773	1209	1740	829	1296	1866	852	1331	1917
120,000	200,083 t	839	1311	1887	905	1414	2036	932	1456	2097
0	t	907	1418	2042	985	1540	2217	1017	1589	2289
150,000	251,896 t									
0	t									
200,000	327,735 t									
0	t									
250,000	401,268 t	955	1492	2149	1042	1627	2344	1077	1683	2424
0	t	1019	1592	2292	1118	1747	2516	1159	1811	2609
330,000	548,670 t	1042	1629	2346	1147	1792	2580	1190	1860	2678
0	t	1080	1687	2429	1192	1862	2682	1239	1936	2788
370,000	627,016 t									
0	t									
480,000	795,540 t									
0	t									
Ship A		100,000 DWT			120,000 DWT			150,000 DWT		
Ship B	Assumed W	166,004 t			200,083 t			251,896 t		
DWT	Assumed W	0.15m/s	0.185	0.22m/s	0.15m/s	0.185	0.22m/s	0.15m/s	0.185	0.22m/s
100,000	166,004 t	476	724	1024						
0	t	521	792	1120	574	873	1235			
120,000	200,083 t	574	873	1235	640	973	1376	723	1099	1554
0	t	632	962	1360	713	1084	1533	817	1243	1758
150,000	251,896 t									
0	t									
200,000	327,735 t									
0	t									

250,00 0	401,268 t	674 731	1025 1112	1449 1573	766 841	1165 1280	1648 1810	888 991	1351 1507	1910 2131	
330,00 0	548,670 t	753 788	1146 1199	1620 1695	870 917	1324 1395	1872 1973	1031 1098	1568 1670	2218 2361	
370,00 0	627,016 t										
480,00 0	795,540 t										
	ShipA		200,000 DWT		250,000 DWT		330,000 DWT				
Ship B	Assumed W		327,735 t		401,268 t		548,670 t				
DWT	Assumed W		0.15m/ s	0.185	0.22m/ s	0.15m/ s	0.185	0.22m/ s	0.15m/ s	0.185	0.22m/ s
100,00 0	166,004 t										
120,00 0	200,083 t	940	1403	2022							
150,00 0	251,896 t										
200,00 0	327,735 t										
250,00 0	401,268 t	1035 1177	1574 1791	2226 2532	1151 1330	1751 2023	2476 2860	1574 1679	2394 2554	3386 3611	
330,00 0	548,670 t	1235 1332	1878 2026	2656 2865	1404 1530	2135 2328	3020 3292	1863	2834	4008	
370,00 0	627,016 t										
480,00 0	795,540 t										
	ShipA		370,000 DWT		480,000 DWT						
Ship B	Assumed W		122,108 t		136,972 t						
DWT	Assumed W		0.15m/ s	0.185	0.22m/ s	0.15m/ s	0.185	0.22m/ s			

250,00 0	401,268 t						
330,00 0	548,670 t	1799	2736	3869			
370,00 0	627,016 t	2012	6060	4328	2282	3472	4909
480,00 0	795,540 t						

Note: Required quantities are 5 pieces of fender & over.

4.3 Examples used to medium and small ships.

Table 12 shows some examples used to medium and small ships for reference to selection.

Table 12 Examples used to medium and small ships

DWT	Fender size Diameter (m) x Length (m)	Ship Kinds
50	0.5 x 1.0	Fishing vessels
100	0.7 x 1.5 ~ 1.0 x 1.5	Fishing vessels
200	1.0 x 1.8 ~ 1.0 x 2.0	Fishing vessels and towing vessels
300 ~ 500	1.2 x 2.0 ~ 1.5 x 2.5	Fishing vessels and towing vessels
1,000	1.5 x 2.5 ~ 1.5 x 3.0	Towing vessels and freighters
3,000	2.0 x 3.0 ~ 2.0 x 3.5	Ocean trawlers and freighters
10,000	2.0 x 3.5 ~ 2.5 x 5.0	Freighters

5.0 Operations and Maintenances

5.1 Adjusting internal pressure

5.1.1 Initial Internal pressure

The initial internal pressures of **MAX** floating-type pneumatic rubber fenders are divided into two kinds upon request of users. This Type A is of 0.05MPa, and the type B is of 0.08MPa.

When charging a fender with air, the user must be first determining the initial pressure according to the kind of fender purchased. The tolerance of initial pressure should be controlled in the range of $\pm 5\%$ standard figure.

5.1.2 Operation of adjusting internal pressure.

The operation of the valve for air charging is like charging a car tire.

Disassembling the protective cap on the end flange, put a pressure gauge upon the screw-joint coupling, the pressure gauge shows the data of the internal pressure. If internal pressure being higher than desirable figure, a discharge operation must be done as follows:-

5.1.3 Discharge operation

If needed a large number of discharges, please put the screw of air valve rotation in counterclockwise direction. If needed a little discharge, please press the core of the air valve for release.

5.2 Operations for charging

The arrangement of air filling hose and equipments shows in fig. 10 $\frac{1}{2}$ "iron pipe is usually used to connect a pressure accumulator or compressor at one end, and another end connects a control valve, then a pressure gauge, then an air filling rubber hose connects to the air valve with a nozzle-touch joint. The pressure of air supply must be more than 0.08MPa.

The operation steps for charging are as follows:-

- 1) Disassemble the air valve core by means of a special key and insert an air filling rubber hose connected to the air supply.
- 2) Open the control valve, charging air until the internal pressure of the fender reach a desirable figure.
- 3) Close the control valve, draw air filling rubber hose out and install the air valve core rapidly with a special key, then disassemble the nozzle-touch joint and assemble the protective cap at the end flange.

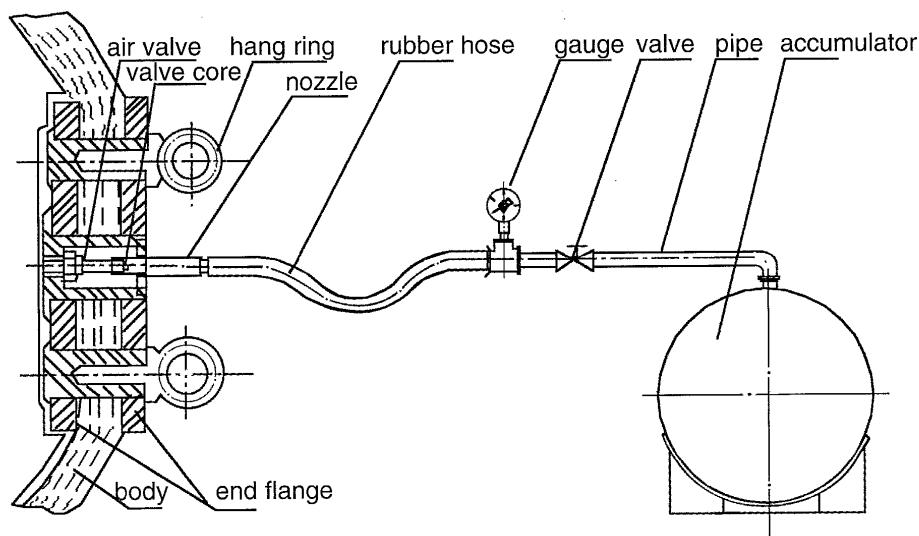


Fig. 10 the arrangement of air filling hose and equipments

5.3 Maintenances

- 1) Periodically check the fender against damages and pressure variation and replace the air valve core once every six months.
- 2) If the fender ties with wire rope, the wire rope must be cased with rubber sleeves to avoid the fender stabbed by wire.
- 3) There must be none of sharp or projecting thing on the surface in which the fenders contact to avoid the fender from being damaged.

5.4 Storage

An unused fender can be well-maintained for a long time if stored in the clear, dry and airy place. The store must be cool, dark and with good ventilation. The fenders must be kept away from hot condition.

Keep them away from acid, alkali, grease and organic solution. Avoid putting heavy loads on the fenders.
Keep all fenders individually spaced.

5.5 Fixtures and fittings

The **MAX** floating-type pneumatic rubber fenders have following fixtures and fittings ready in place upon leaving the factory (Ex-work):-

- 1) Air valve core 5 pcs
- 2) Nozzle-touch joint of air valve 1 pc
- 3) Special key for air valve core 1 pc
- 4) Rubber hose for filling air 0.5 m
- 5) Pressure gauge 1 pc.

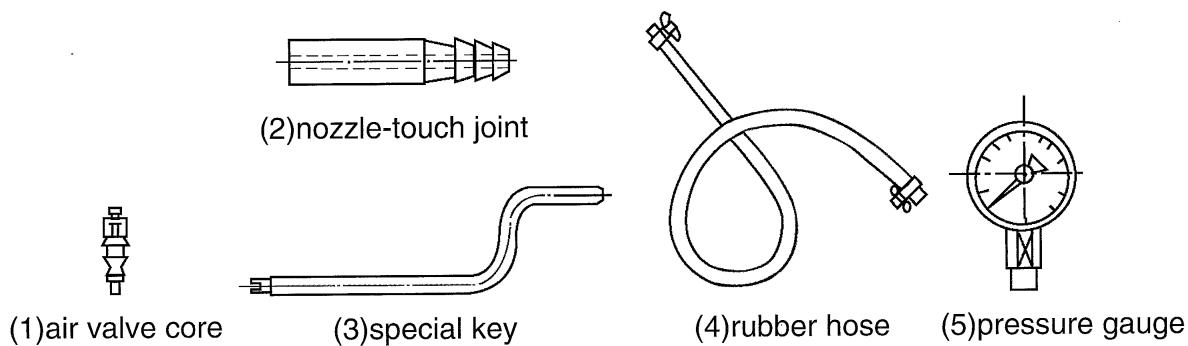


Fig 11 Fixtures and Fitting