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MARINE FENDER PROPOSAL

PROJECT	Stad Skipstunnel – Inside (Composite)
CLIENT	Nordic Fender
DOC. NO.	CV-01-0044

0	2021-02-14	ISSUED FOR APPROVAL	L.J.M			Y.S.H
REV.	DATE	DESCRIPTION	PRE'D BY	PRE'D BY	CHK'D BY	APP'D BY

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1. Berthing energy in tunnel

$Ed = 0.5 \times M \times Vn^2 \times Ce \times Cm \times Cs \times Cc \times Cab$

where, Ed : Design berthing energy (kJ)

M : Displacement of design vessel (ton)

Vn : Approach velocity (m/s)

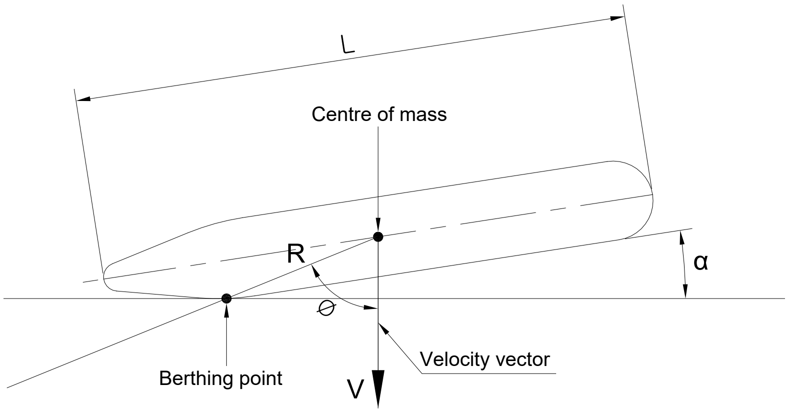
Ce : Eccentricity factor

Cm : Virtual mass factor

Cs : Softness factor

Cc : Berth configuration factor

Cab : Abnormal impact factor



Item		Formula	Largest	Smallest
Displacement	M	assumed	9050 ton	2700 ton
Length overall	Loa	assumed	140.0 m	60.0 m
Length perpendiculars	Lpp	–	135.0 m	56.1 m
Breadth	B	–	21.5 m	16.5 m
Max. Draft	D	–	5.1 m	2.7 m
Berthing angle	α	–	3.5 ˚	3.5 ˚
Berthing velocity	Vn	5 knots × sinα = 2.6 m/s × sin3.5˚	0.160 m/s	0.160 m/s
Block coefficient	Cb	$M/(Lpp \times B \times D \times 1.025)$	0.596	1.055
Radius of gyration	K	$(0.19 \times Cb + 0.11) \times Lpp$	30.1 m	17.4 m
Impact to mass center	R	1/4 point contact, $((Lpp/4)^2 + (B/2)^2)^{0.5}$	35.4 m	16.3 m
Velocity vector angle	Φ	$\sin^{-1}(B/2R)$	17.7 ˚	30.5 ˚
Water depth	Wd	–	12.0 m	12.0 m
Under keel clearance	Kc	Wd–D	6.9 m	9.3 m
Eccentricity factor	Ce	$(K^2+R^2\cos^2\Phi)/(K^2+R^2)$	0.947	0.880
Virtual mass factor	Cm	1.5	1.500	1.500
Softness factor	Cs	1.0 for general use	1.0	1.0
Berth configuration factor	Cc	1.0 for open berths	1.0	1.0
Abnormal impact factor	Cab	no additional safety factor	1.0	1.0
Design berthing energy	Ed	–	164 kJ	46 kJ

2. Fender Selection

2.1 Fender performance

Item	Size (mm)	Deflection (%)	Reaction force Rf (kN)	Energy absorption E (kJ)	Remark
Composit	300Hx1000L	50.0	494	20.8	

2.2 Energy absorption check

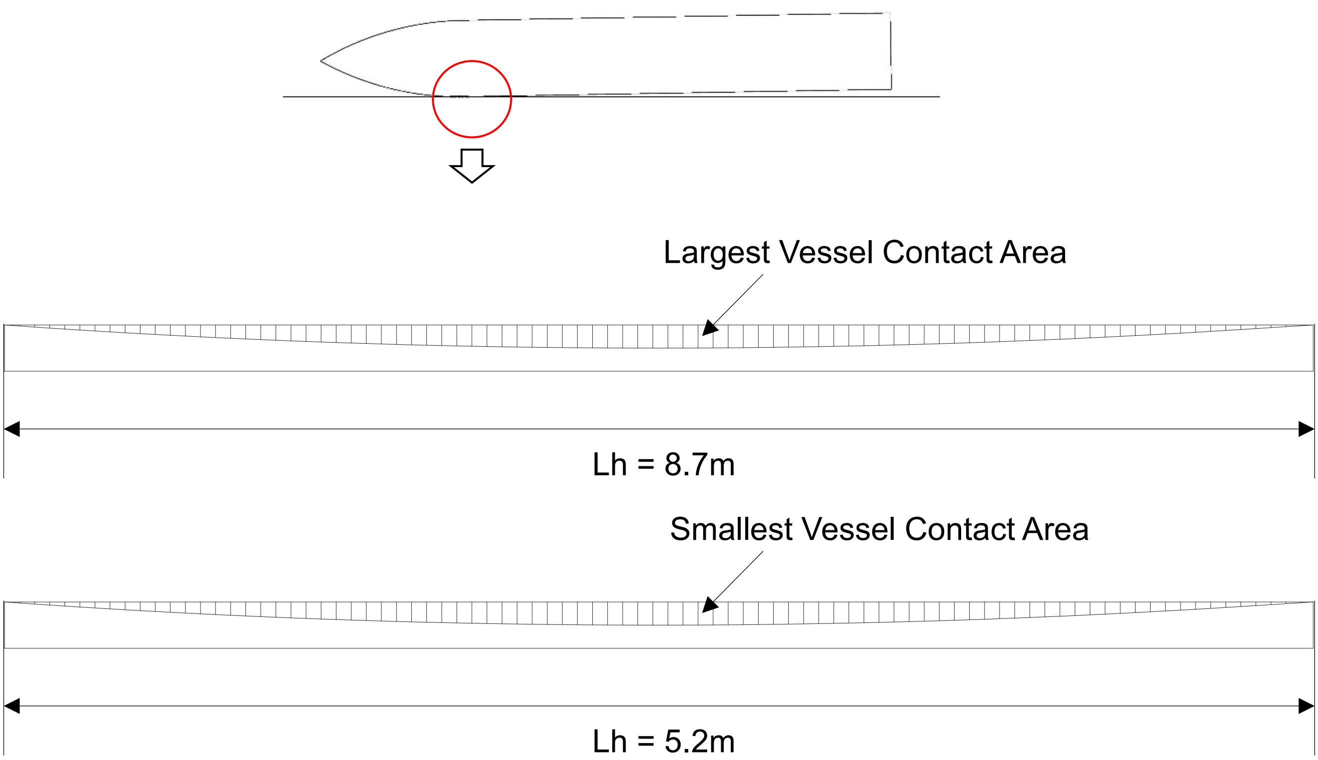
Ec = Ed / (PF × AF × TF) ≤ E

where, PF : performance tolerance factor (10%) , AF : angle factor (3.5˚)

TF : temperature factor (40℃) , CC : number of fender contact row

Item	Ed (kJ)	PF	AF	TF	CC	Ec (kJ)	Result
Largest	164	0.90	1.000	0.945	2.0	**97**	**≤ 100.6 ···O.K**
Smallest	46	0.90	1.000	0.945	1.0	**54**	**≤ 56.3 ···O.K**

2.3 Energy absorption of horizontal fenders



Item		Largest	Smallest	Remark
Max. deflection	Df	0.150 m	0.150 m	50% deflection
Contact length	Lh	8.7 m	5.2 m	
Energy abosorption	Eh	100.6 kJ	56.3 kJ	Refer to detail data

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* Detail data of energy abosorption (Largest)

X (m)	Y (mm)	Y (m)	Df (%)	Eh (kJ)
0.1	6.9	0.007	2.3	0.02
0.2	13.6	0.014	4.5	0.04
0.3	20.1	0.020	6.7	0.09
0.4	26.5	0.027	8.8	0.15
0.5	32.7	0.033	10.9	0.21
0.6	38.8	0.039	12.9	0.27
0.7	44.7	0.045	14.9	0.34
0.8	50.4	0.050	16.8	0.41
0.9	56.0	0.056	18.7	0.47
1.0	61.4	0.061	20.5	0.54
1.1	66.7	0.067	22.2	0.60
1.2	71.8	0.072	23.9	0.66
1.3	76.7	0.077	25.6	0.72
1.4	81.5	0.081	27.2	0.78
1.5	86.1	0.086	28.7	0.84
1.6	90.5	0.091	30.2	0.90
1.7	94.8	0.095	31.6	0.96
1.8	99.0	0.099	33.0	1.01
1.9	102.9	0.103	34.3	1.06
2.0	106.7	0.107	35.6	1.12
2.1	110.4	0.110	36.8	1.17
2.2	113.9	0.114	38.0	1.23
2.3	117.2	0.117	39.1	1.28
2.4	120.4	0.120	40.1	1.33
2.5	123.4	0.123	41.1	1.40
2.6	126.2	0.126	42.1	1.46
2.7	128.9	0.129	43.0	1.51
2.8	131.4	0.131	43.8	1.57
2.9	133.8	0.134	44.6	1.62
3.0	136.0	0.136	45.3	1.67

X (m)	Y (mm)	Y (m)	Df (%)	Eh (kJ)
3.1	138.0	0.138	46.0	1.73
3.2	139.9	0.140	46.6	1.78
3.3	141.6	0.142	47.2	1.84
3.4	143.2	0.143	47.7	1.88
3.5	144.6	0.145	48.2	1.92
3.6	145.8	0.146	48.6	1.96
3.7	146.9	0.147	49.0	1.99
3.8	147.8	0.148	49.3	2.02
3.9	148.6	0.149	49.5	2.04
4.0	149.2	0.149	49.7	2.06
4.1	149.6	0.150	49.9	2.07
4.2	149.9	0.150	50.0	2.08
4.3	150.0	0.150	50.0	2.08
4.4	150.0	0.150	50.0	2.08
4.5	149.7	0.150	49.9	2.07
4.6	149.4	0.149	49.8	2.06
4.7	148.9	0.149	49.6	2.05
4.8	148.2	0.148	49.4	2.03
4.9	147.3	0.147	49.1	2.00
5.0	146.3	0.146	48.8	1.97
5.1	145.2	0.145	48.4	1.94
5.2	143.8	0.144	47.9	1.90
5.3	142.3	0.142	47.4	1.86
5.4	140.7	0.141	46.9	1.81
5.5	138.9	0.139	46.3	1.76
5.6	136.9	0.137	45.6	1.70
5.7	134.8	0.135	44.9	1.64
5.8	132.5	0.132	44.2	1.59
5.9	130.0	0.130	43.3	1.54
6.0	127.4	0.127	42.5	1.48

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X (m)	Y (mm)	Y (m)	Df (%)	Eh (kJ)
6.1	124.7	0.125	41.6	1.42
6.2	121.7	0.122	40.6	1.36
6.3	118.6	0.119	39.5	1.30
6.4	115.4	0.115	38.5	1.25
6.5	112.0	0.112	37.3	1.20
6.6	108.4	0.108	36.1	1.14
6.7	104.6	0.105	34.9	1.08
6.8	100.8	0.101	33.6	1.03
6.9	96.7	0.097	32.2	0.98
7.0	92.5	0.092	30.8	0.92
7.1	88.1	0.088	29.4	0.87
7.2	83.6	0.084	27.9	0.81
7.3	78.9	0.079	26.3	0.75
7.4	74.0	0.074	24.7	0.69
7.5	69.0	0.069	23.0	0.63
7.6	63.8	0.064	21.3	0.57
7.7	58.4	0.058	19.5	0.50
7.8	52.9	0.053	17.6	0.44
7.9	47.3	0.047	15.8	0.37
8.0	41.4	0.041	13.8	0.30
8.1	35.5	0.035	11.8	0.24
8.2	29.3	0.029	9.8	0.17
8.3	23.2	0.023	7.7	0.12
8.4	17.1	0.017	5.7	0.07
8.5	11.0	0.011	3.7	0.04
8.6	4.9	0.005	1.6	0.02
8.7	0.0	0.000	0.0	0.00
Sum				100.6

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* Detail data of energy abosorption (Smallest)

X (m)	Y (mm)	Y (m)	Df (%)	Eh (kJ)
0.1	12.8	0.013	4.3	0.04
0.2	25.0	0.025	8.3	0.13
0.3	36.6	0.037	12.2	0.25
0.4	47.7	0.048	15.9	0.37
0.5	58.2	0.058	19.4	0.50
0.6	68.1	0.068	22.7	0.62
0.7	77.5	0.077	25.8	0.73
0.8	86.3	0.086	28.8	0.85
0.9	94.5	0.094	31.5	0.95
1.0	102.1	0.102	34.0	1.05
1.1	109.2	0.109	36.4	1.15
1.2	115.7	0.116	38.6	1.26
1.3	121.6	0.122	40.5	1.36
1.4	127.0	0.127	42.3	1.47
1.5	131.8	0.132	43.9	1.57
1.6	136.1	0.136	45.4	1.67
1.7	139.7	0.140	46.6	1.78
1.8	142.9	0.143	47.6	1.87
1.9	145.4	0.145	48.5	1.95
2.0	147.4	0.147	49.1	2.00
2.1	148.8	0.149	49.6	2.05
2.2	149.7	0.150	49.9	2.07
2.3	150.0	0.150	50.0	2.08
2.4	149.7	0.150	49.9	2.07
2.5	148.9	0.149	49.6	2.05
2.6	147.5	0.148	49.2	2.01
2.7	145.6	0.146	48.5	1.95
2.8	143.1	0.143	47.7	1.88
2.9	140.0	0.140	46.7	1.79
3.0	136.3	0.136	45.4	1.68

X (m)	Y (mm)	Y (m)	Df (%)	Eh (kJ)
3.1	132.1	0.132	44.0	1.58
3.2	127.4	0.127	42.5	1.48
3.3	122.0	0.122	40.7	1.37
3.4	116.1	0.116	38.7	1.26
3.5	110.0	0.110	36.7	1.17
3.6	103.9	0.104	34.6	1.07
3.7	97.8	0.098	32.6	0.99
3.8	91.6	0.092	30.5	0.91
3.9	85.5	0.086	28.5	0.84
4.0	79.4	0.079	26.5	0.76
4.1	73.3	0.073	24.4	0.68
4.2	67.2	0.067	22.4	0.61
4.3	61.1	0.061	20.4	0.53
4.4	55.0	0.055	18.3	0.46
4.5	48.8	0.049	16.3	0.39
4.6	42.7	0.043	14.2	0.32
4.7	36.6	0.037	12.2	0.25
4.8	30.5	0.030	10.2	0.18
4.9	24.4	0.024	8.1	0.13
5.0	18.3	0.018	6.1	0.08
5.1	12.1	0.012	4.0	0.04
5.2	6.0	0.006	2.0	0.02
Sum				56.3

2.4 Hull pressure check

P = Rc / A = Rf×PF×TF / A ≤ Pa

where, P : hull pressure, Rf : reaction force of fender

PF : performance factor (10%), TF : temperature factor (-20℃)

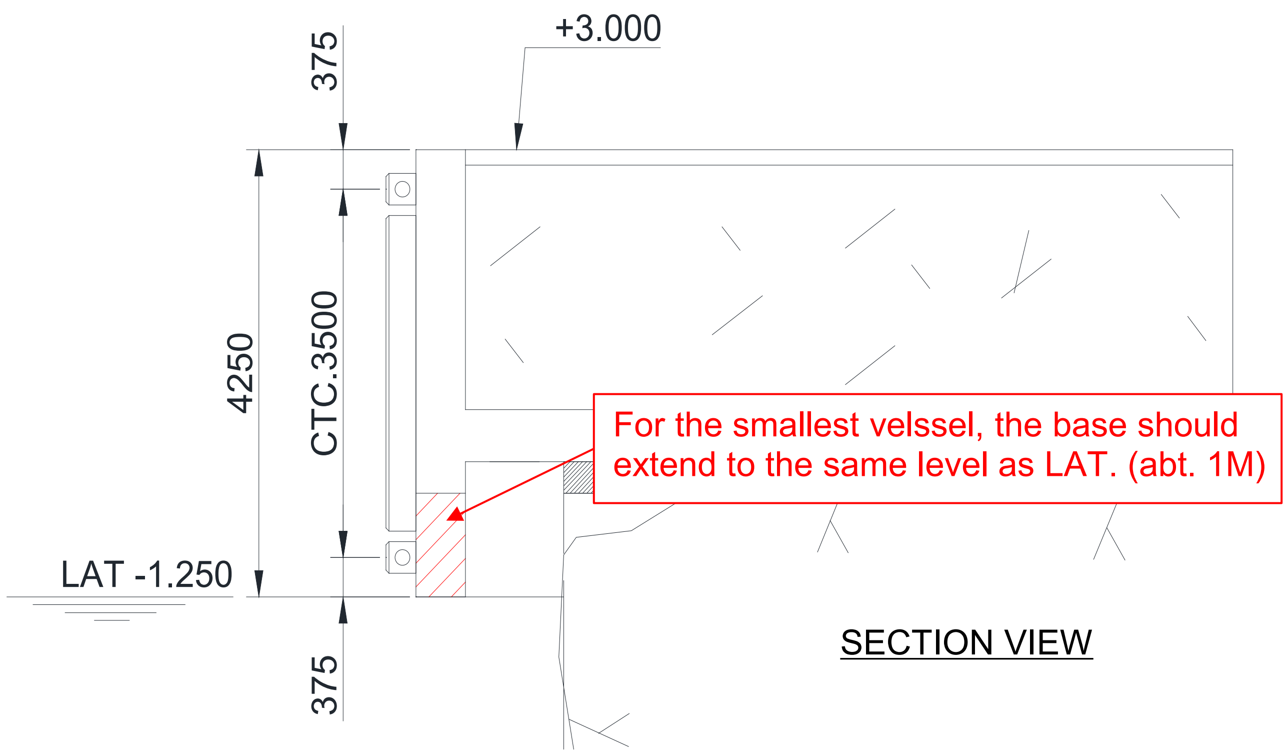
A : contact area : Panel size (0.3m x 1.0m), Pa : allowable hull pressure (200 kN/m2)

Item	Rf (kN)	PF	TF	A (m^2)	Rc (kN)	P (kN/m^2)	Result
Composit	494	1.100	1.165	0.3	633	2110	≤ 200...NG

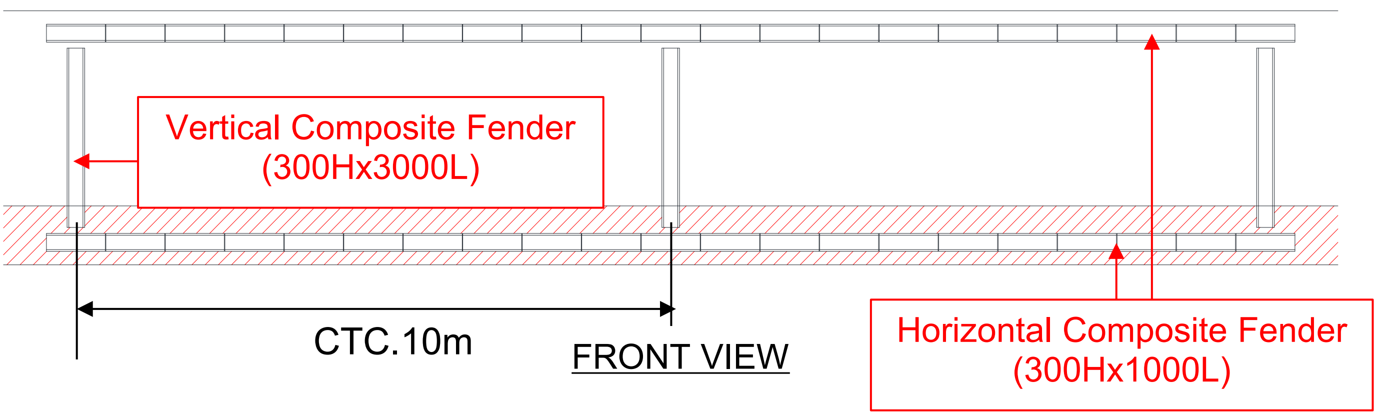
* Since the panel is not used, the hull pressure requirement cannot be satisfied.

Attachment

- Essential requirements for using the Composite Fender

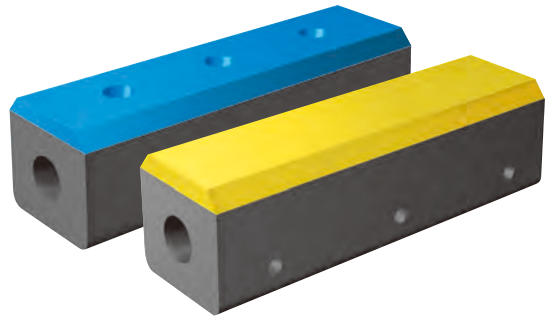


- Composite Fender Layout

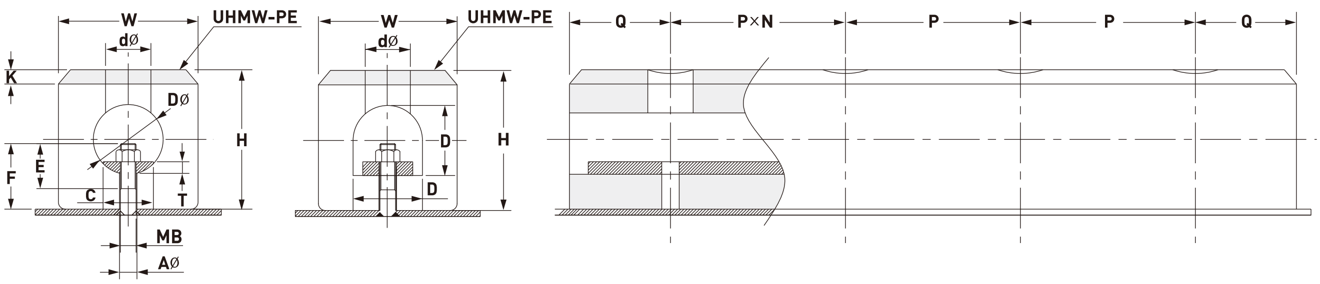


■ Composite-Type Fender

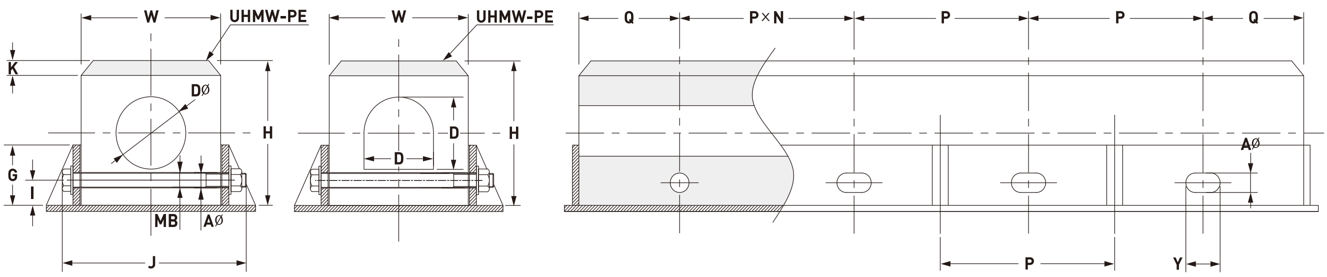
Composite fenders are applicable to installation on workboats and narrow waterways. The benefit of composite fender is a great energy absorption with low friction properties owing to the fact that rubber body and UHMW-PE are made into a single moulded product. The special manufacturing technique is applied to make strong adhesion between the elastomer section and UHMW-PE during vulcanization process. Therefore no more mechanical fixings are needed.



Vertical Fitting Bolt Method



Cross Fitting Bolt Method



● Dimension

(Unit:mm)

Size	Fender											Frame					
	C	DØ	dØ	G	H	I	K	P	Q	T	W	AØ	MB	E	F	J	Y
150H×75Ø	50	75	60	60	150	26	20	250~350	150~200	16	150	22	M16 (5/8)	40	80	220	32
200H×100Ø	65	100	65	75	200	35	25			19	200	25	M20 (3/4)	50	95	280	38
250H×125Ø	80	125	70	100	250	43	30			22	250	28	M24 (1)	60	112	350	42
300H×150Ø	90	150	80	125	300	52	30			25	300	32	M24 (1)	70	132	400	48