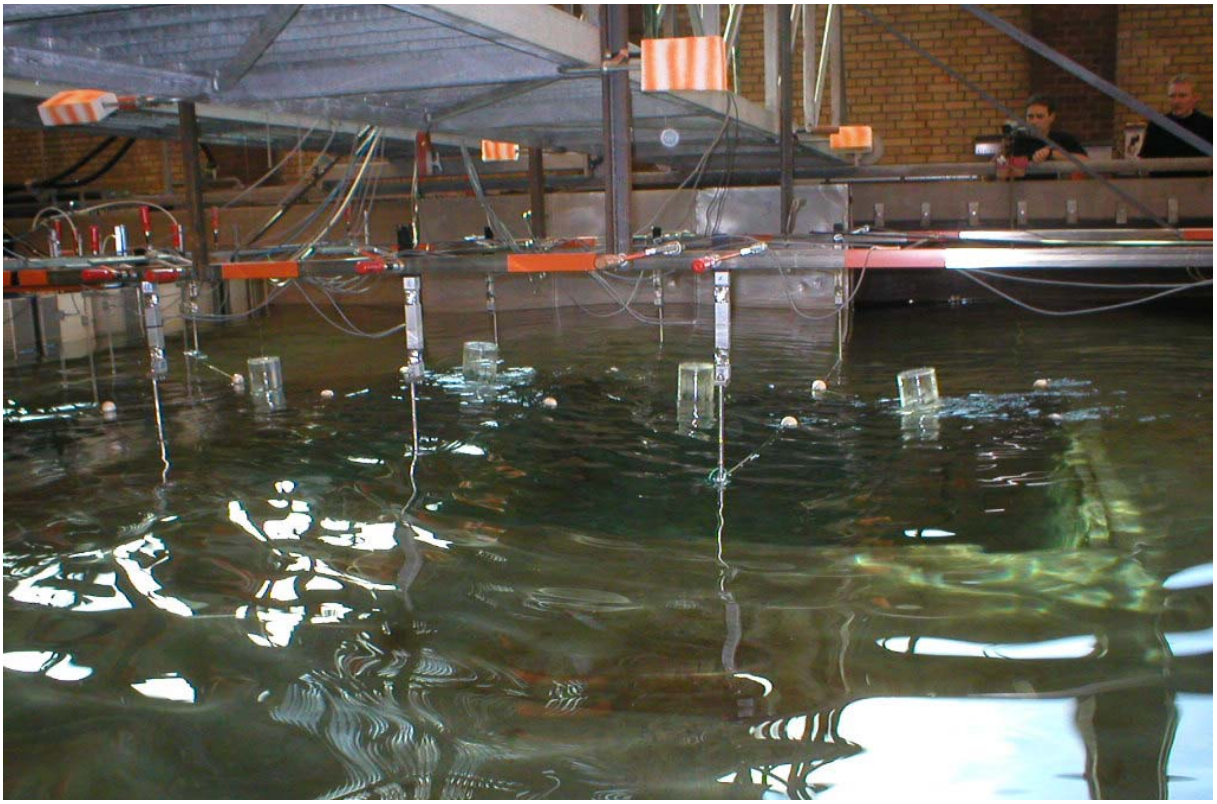
AquaBuOY

Model tests at Aalborg University



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Preface

AquaEnergy Group Ltd., USA, is developing the AquaBuOY system in cooperation with RAMBØLL, Denmark. In March 2003 the Danish Energy Authority awarded a grant for a design study that includes development of the numerical model for the AquaBuOY operation, experimental testing and design optimization. The scale model tests were carried out at Aalborg University, Denmark in order to optimize the device design, operation and installation configuration with the goal of minimizing system footprint.

The present report describes testing on AquaBuOY carried out at the Hydraulics & Coastal Engineering Laboratory, Aalborg University, from June to November 2003.

The report contains 3 parts:

1) The present written report.
2) A CD containing raw experimental data, Excel databank with analyzed data and figures, and important documents including this present report.
3) A DVD showing testing on AquaBuOY with closed tube.

The authors wish to thank Kim Nielsen and Morten Sand Jensen, Rambøll, for preparation of the test schedule, model layout and scale, and useful discussions during the planning of the experimental work. The technical staff at the Hydraulics & Coastal Engineering Laboratory; Jørgen Sørensen, Niels Drustrup and Kurt Sørensen are gratefully acknowledged for producing the models, and for help on setting up the experiments. Several people assisted during the execution of the tests, to whom we would like to express our gratitude: Anders Augustesen, Frands Nielsen, Sune Hansen, Anders Astrup Larsen, and Bogi Laksafoss.

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1 Introduction

The purpose of the experimental work was to investigate the performance of AquaBuOY with respect to the proposed mooring configuration. The target of the tests was to:

- Provide horizontal mooring forces in normal use sea conditions as well as under survival conditions
- Investigate the performance of the system in case of a broken/detached mooring line under survival conditions.
- Visually describe the behaviour of the AquaBuOY's movements subject to all wave conditions. To fulfil this goal the DVD has been produced. The contents and the menu system of this DVD is described in Appendix Y.

The system of buoys was believed to be strongly affected by the direction of the waves. To investigate the influence of wave direction all tests were carried out on three different set-ups.

In additions to the above the following work has been carried out:

- Measurements of heave motions of one of the buoys in the system. From this it is possible to get a firmly understanding of the heave magnitudes.
- Provide mooring forces and heave motions in case of regular wave attack. This information is useful in understanding the behaviour of the system, and essential in comparisons with numerical calculations.
- Investigate the influence of short crested (3D) wave attack compared to long crested (2D) wave attack.
- Measure and calculate eigenfrequencies, weight, centre of gravity and floating level for the models.

This report contains selected results with respect to wave analysis, mooring forces and heave movements. At the CD a more comprehensive set of parameters can be found.

Regular sea parameters

Wave height is calculated as the vertical distance between crest and trough. Wave amplitude is half the wave height. Heave and force amplitudes are calculated in the same way. In order to avoid influences of reflections in the basin only the first few waves of a regular wave train is used.

Irregular sea parameters, normal use wave attack

Wave heights are characterizes by the average wave height H_m or the significant wave height H_s, which is the average value of the highest 1/3 of the waves. The wave height used in this report is the total wave height which is a sum of incident and reflected waves. The reflection coefficient (amplitude) was found to be between 13% and 20%.

The average heave movement (minimum to maximum) is called X_m. The ratio X_m/H_m defines the magnification factor by which the buoy moves more or less than the wave height.

For the mooring forces a 2% fraction of the peak forces is given, meaning that only 2% of the peak forces are higher than $F_{2\%}$. Positive forces (drag, giving more tight mooring lines) as well as negative (slack, giving more loose mooring lines) are given with zero for the pre-tension value. The positive and negative values are numerically different due to drift forces.

Irregular sea parameters, survival tests

In addition to the above described parameters other fractions of the heave movements and mooring forces are included. Average values are given index "m", and 5%, 2% and 1% fractions are included.

All mooring forces in the report are wave induced mooring forces. This means that the given mooring forces does not include the pre-tension of the mooring system. Unless something else is stated all values in this report are prototype values.

2 Description of models

Four models in scale 1:50 were constructed. The geometry of the models is shown in Figure 1. The models are made of polymethylmethacrylat (PMMA) which has a density of 1.19g/cm^3.

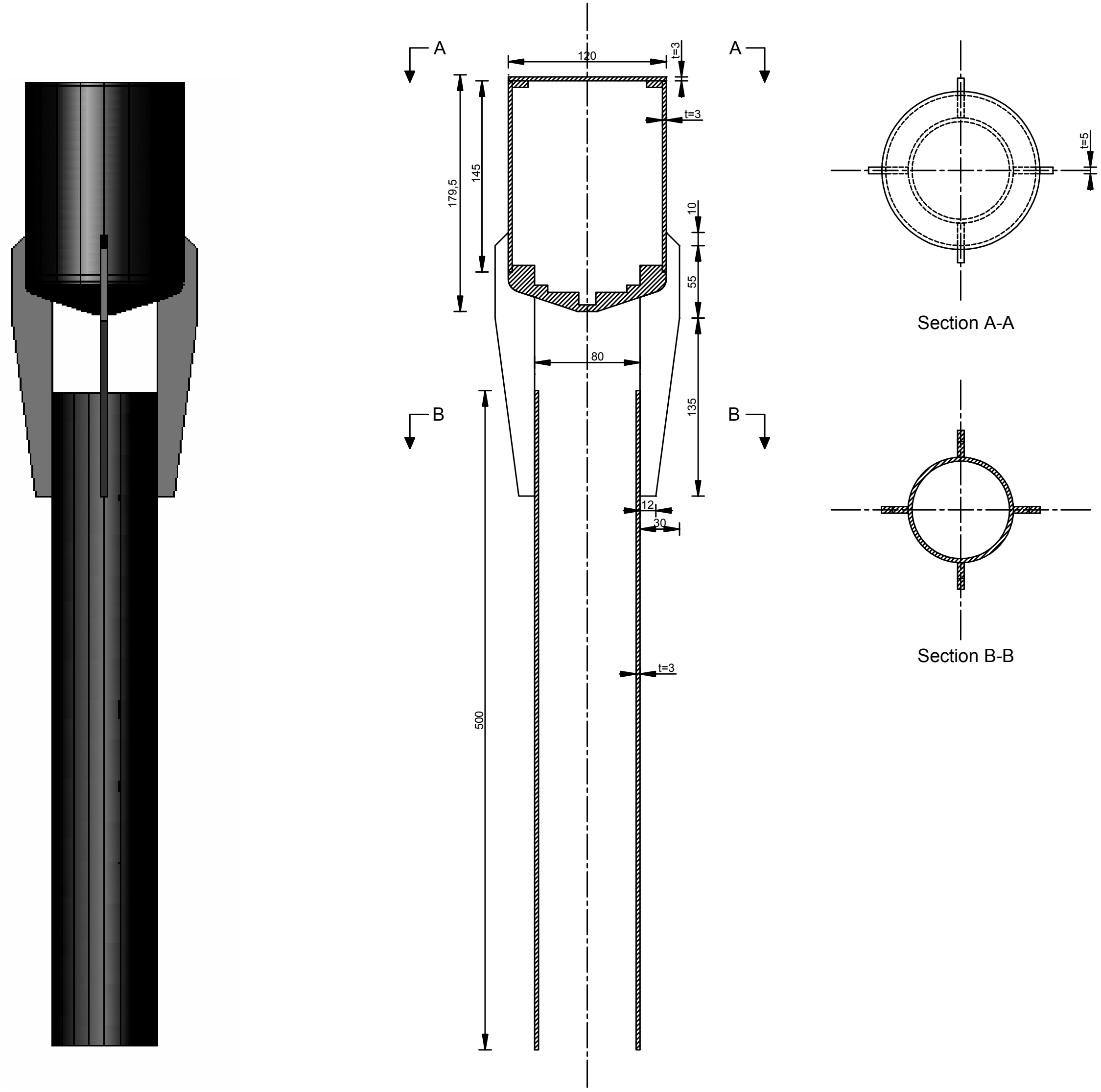


Figure 1: The AquaBuOY models. Measures in millimetre and in model scale.

A plug for the tube was made for each model so the AquaBuOY could be tested both with an open and a closed tube. The closed tube will give the AquaBuOY a smaller eigenfrequency, due to the extra mass to move. The eigenfrequency of the prototype model with a hosepump is expected to be in between these two values. However, the dampening due to the hosepumps is not modelled in the experiments.

Some simple experiments were performed to find the eigenfrequencies of the AquaBuOY models for heave and pitch movements. The heave motion was measured with a potentiometer as described in Chapter 3 and by video recordings. An example of the free heave motion measured by the potentiometer is given in Figure 2.

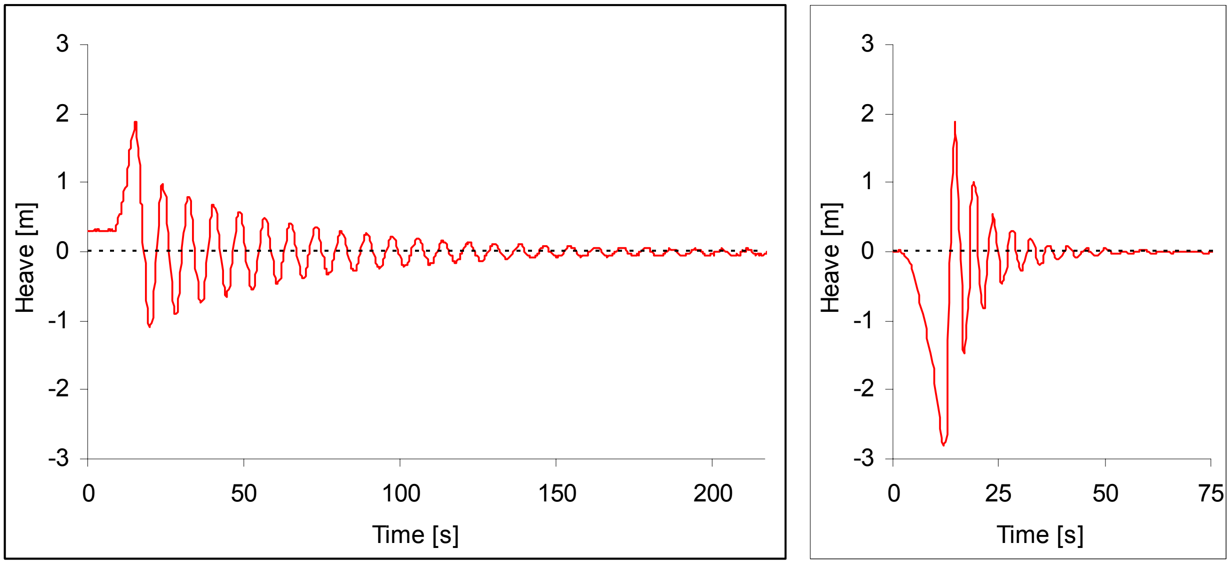


Figure 2: Free heave motion with closed (left) and open (right) tube.

The measured eigenfrequencies and some other properties for the models are given in Table 1. The eigenfrequencies were measured experimentally as descriped above, all other values in the table are calculated, but the weight and the floating level were validated experimentally.

	Model scale	Prototype scale
Weight	0.789kg	124t
Centre of gravity (above bottom of tube)	0.455m	22.8m
Floating level (above bottom of tube)	0.620m	31.0m
Heave eigenfrequency with open tube	1.5Hz	0.22Hz
Heave eigenfrequency with closed tube	0.88Hz	0.12Hz
Pitch eigenfrequency	0.15Hz	0.02Hz

Table 1: Properties of models.

The mooring lines were attached to the AquaBuOY's in the wings at the floating level.

3 Test set-up

The model tests were performed at Aalborg University, Hydraulic & Coastal Engineering Laboratory using the deep wave basin. This deep wave basin is a steel bar reinforced concrete tank with the dimensions 15.7 x 8.5 x 1.5m. A 1.5m deep section of 4.5 x 2.1m with windows for under water inspection of models allows water depths of up to app. 3m in model scale. A drawing illustrating the layout of the wave basin is shown in Figure 3. The paddle system is a snake-front piston type with a total of ten actuators, enabling generation of short-crested waves.

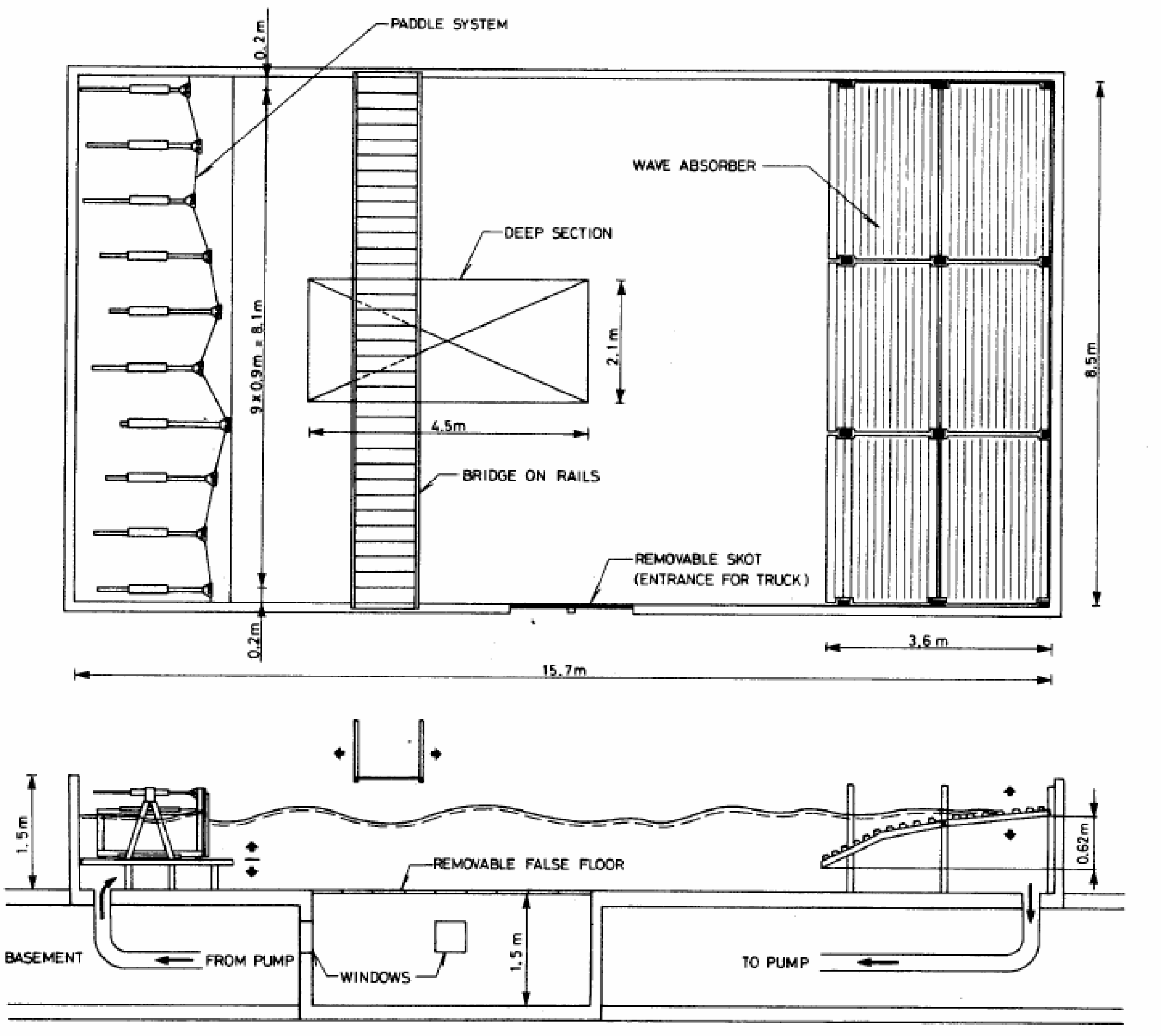


Figure 3: The basin used to test the AquaBuOY's. A detailed description is available at: http://www.civil.auc.dk/i5/engelsk/hyd/laboratory/3d_no1.htm

The AquaBuOY's were placed in the deep section of the basin were the water depth was 2.20m in model scale (110m in prototype scale). The water depth in the shallow part of the basin was 0.70m in model scale (35m in prototype scale). The initially proposed mooring system contained a system of four AquaBuOY's as sketched in the following Figure 4.

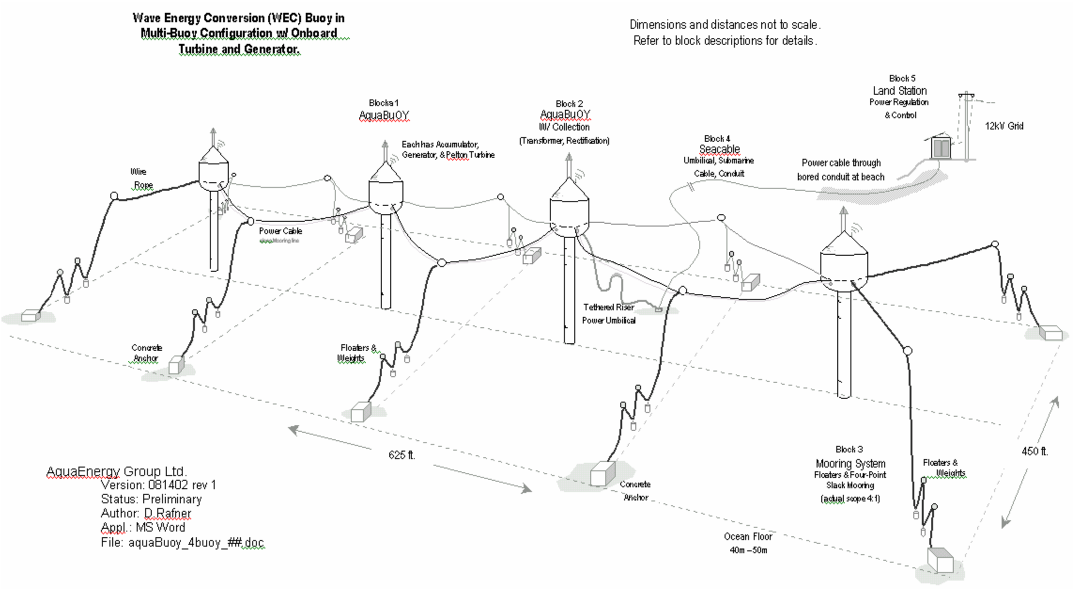


Figure 4: Sketch of suggested mooring system.

In the experiments a more simple system was set-up in a horizontal plane. In this way the horizontal stiffness can be modeled precisely and the vertical stiffness is close to zero. The mooring lines were attached to a frame via a force transducer as shown in Figure 5 and 7-9.

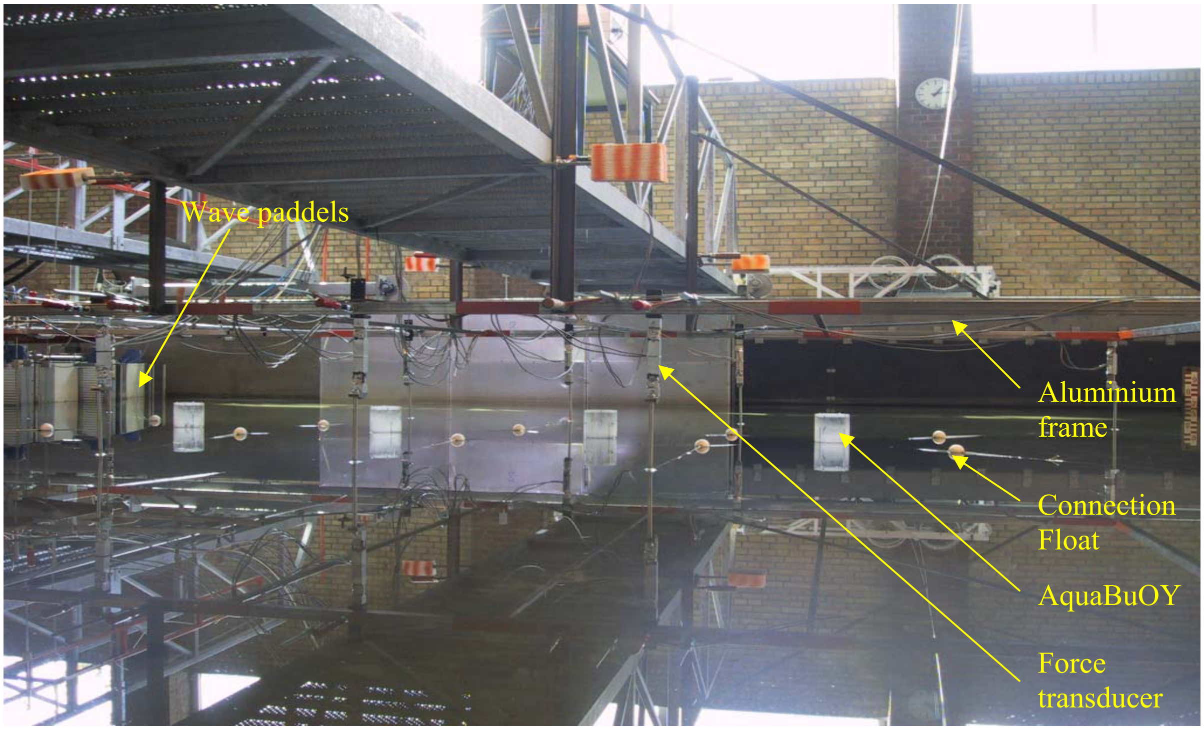


Figure 5: Test set-up.

The waves were measured with 5 resistance type wave gauges. The mooring forces were measured with 10 force transducers each consisting of a system of strain gauges in a Wheatstone bridge. The heave motion of buoy 1 was measured with a potentiometer as shown on Figure 6. The potentiometer was located 4 meters vertically above the buoy. In this way horizontal and pitch movements of the buoy did not influence the measured heave movements.

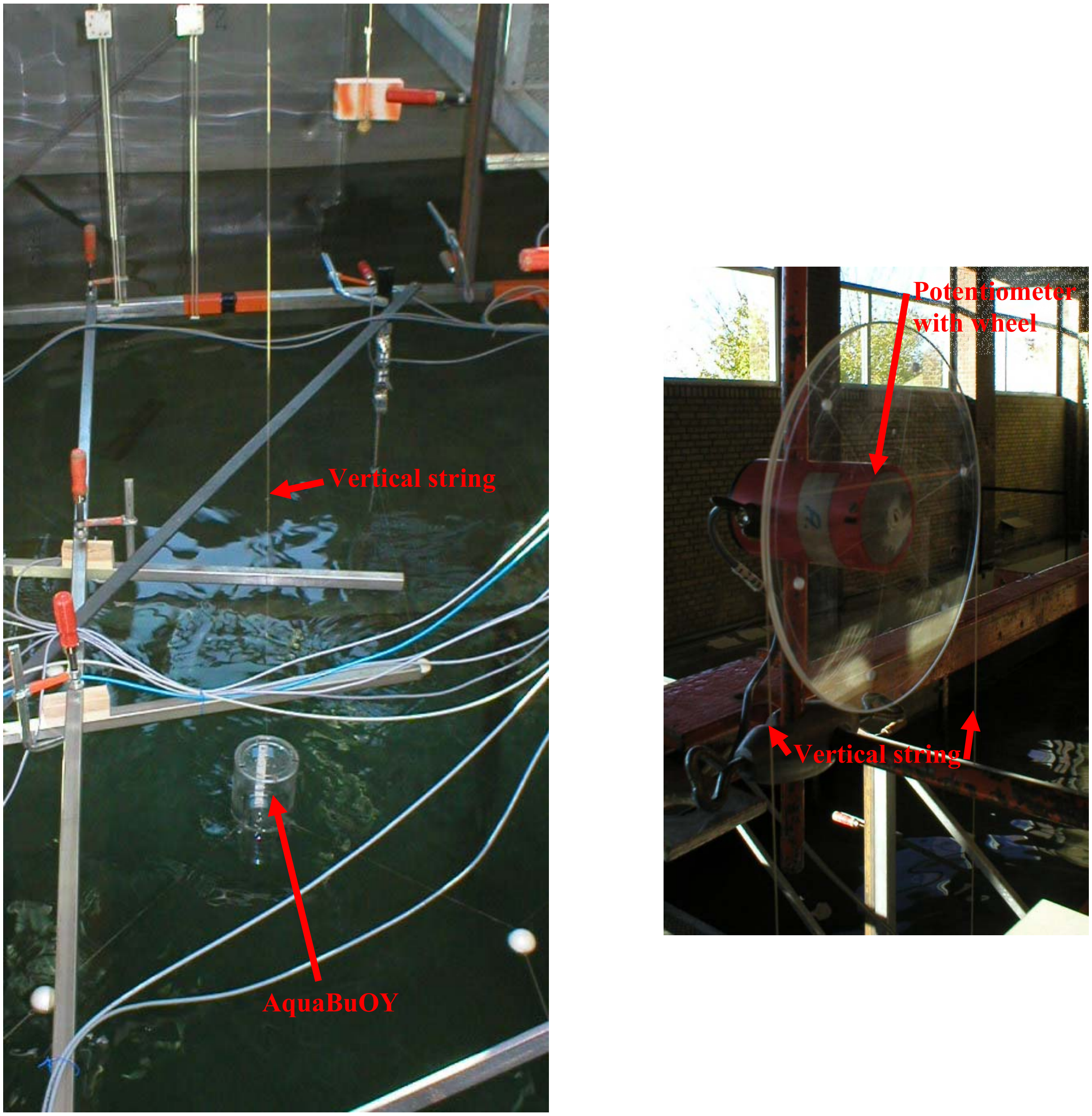


Figure 6: Set-up for heave measurements.

In order to investigate the influence of wave direction 3 set-ups were tested. In the first setup, head on sea, shown on Figure 7, the wave direction was parallel to the line of buoys. In the second setup, oblique sea, shown on Figure 8 waves were coming in from a 45° angle. In the third setup, beam sea, shown on Figure 9, the wave direction was perpendicular to the line of the buoys. In the third setup the number of buoys was reduced from 4 to 3 because there was not room for all 4 in the deep part of the basin.

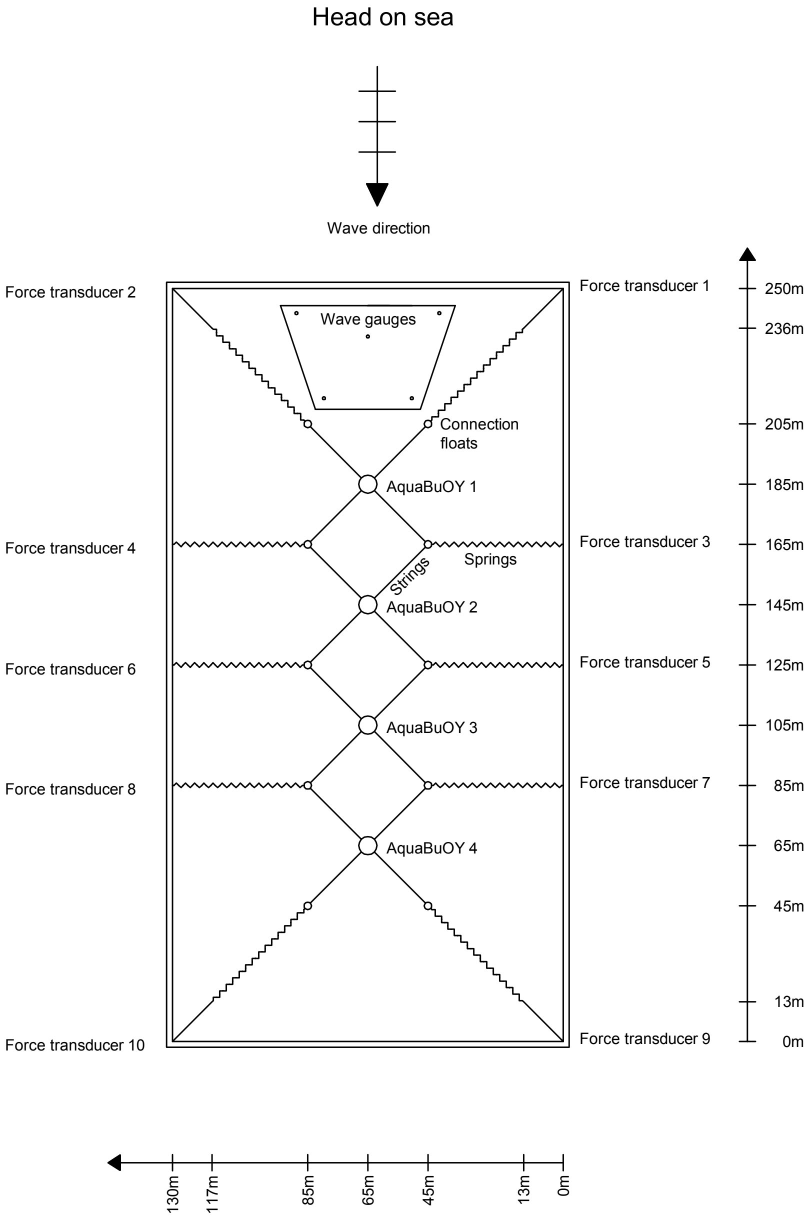


Figure 7: Head on sea test set-up viewed from above (1:250).

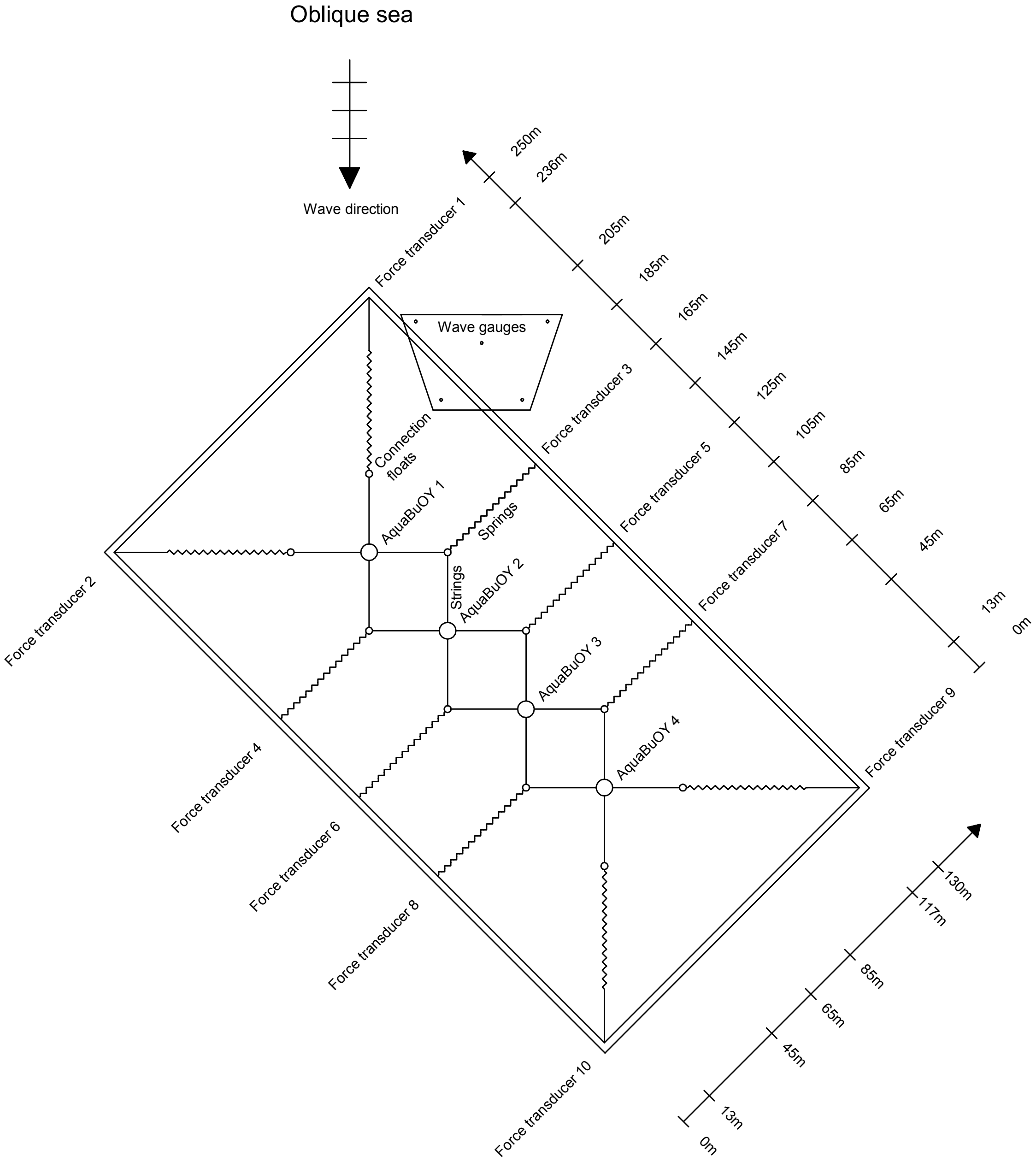


Figure 8: Oblique sea test set-up viewed from above (1:250).

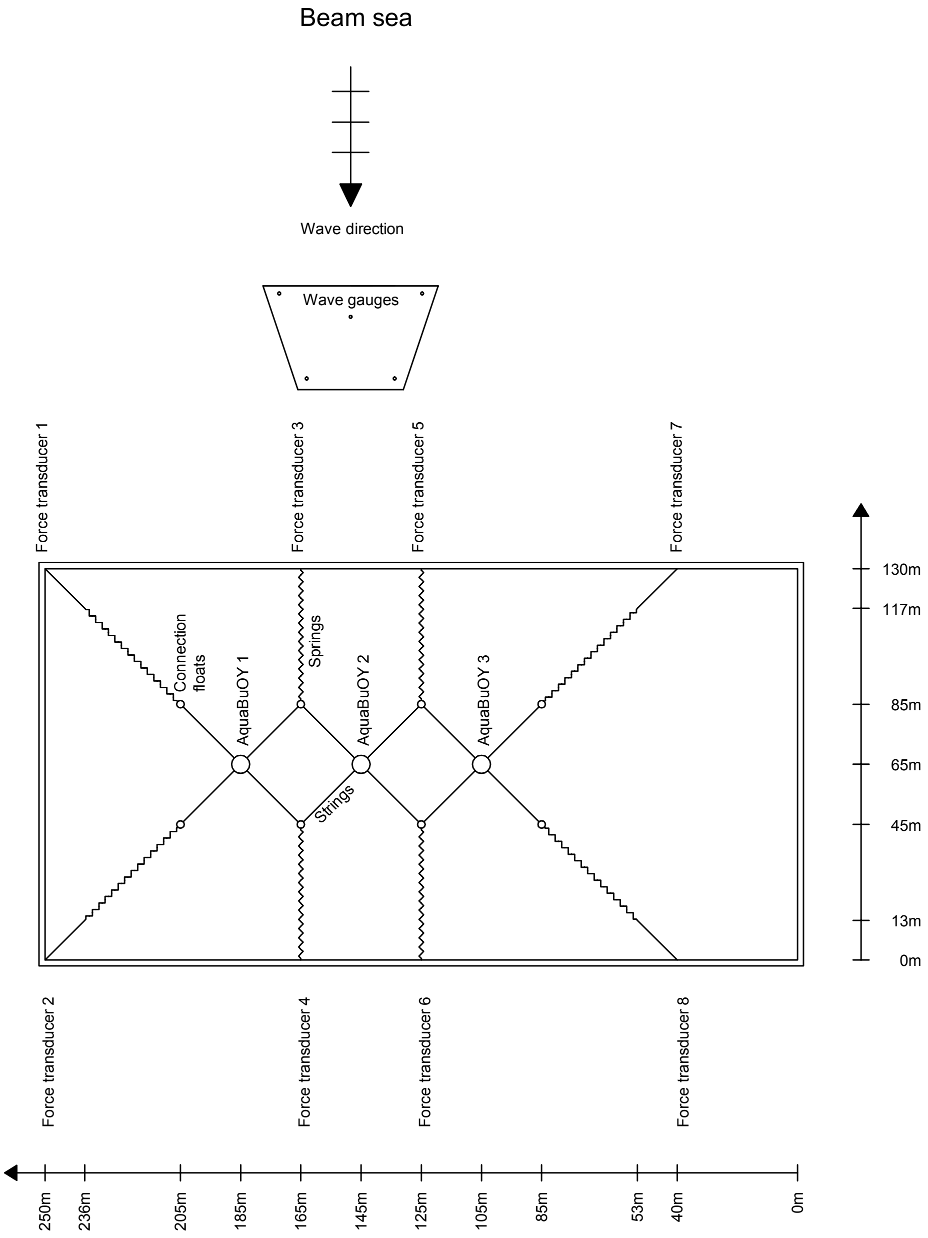


Figure 9: Beam sea test set-up viewed from above (1:250).

The connection floats were made of flamingo with diameter 2.35m. The springs were made of stainless steel, and had the characteristics in Table 2. All springs were in the set-up pre-stressed to about 750kN, and the stress-strain curve was measured and given in Figure 10.

Parameter	Model scale	Prototype scale
Diameter	5.5mm	0.28m
Weight	15g	1.9t
Free length	60cm	30m
Stiffness	0.02N/mm	50kN/m
Force needed to initiate elongation	1.6N	200kN

Table 2: Characteristics of springs

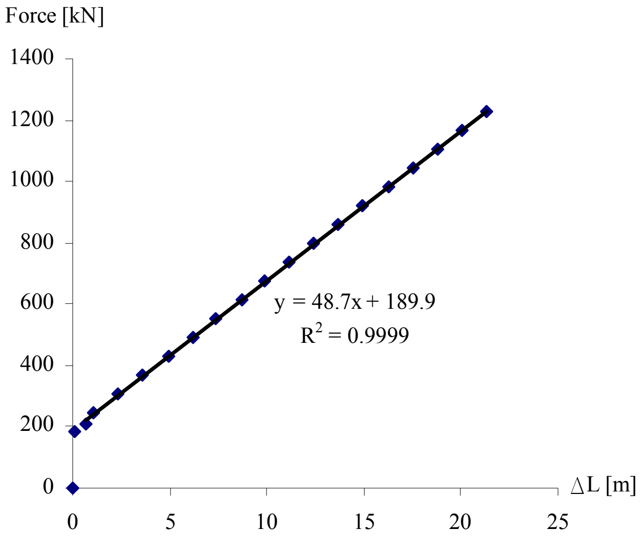


Figure 10: Stress-strain relation of springs.

4 Test programme

The mooring system was tested in both survival and normal use sea states. Further some regular waves were tested. The survival sea states were based on recommendations from the Danish Wave Energy Programme. The normal use sea states were based on the average relation between significant wave height and wave Period at Orkney and Portugal. All irregular waves were generated from the JONSWAP spectrum with a peak enhancement factor (γ) of 3.3.

Test series	Description
1	Regular wave series 1A and 1B
2	Irregular normal use series 2A and 2B
3	Irregular design series 3A, 3B and 3C
4	Disconnected mooring line series

Table 3: Test series.

All tests were performed on the three test set-ups (wave directions), with open and closed tube.

4.1 Regular waves

The purpose of the regular waves was to get some base results which were easily comparable to results from a numerical model. The mooring system was tested in regular waves with periods 7.07s (test 1A) and 8.06s (test 1B):

Wave height (H) [m]	Wave period (T) in test 1A [s]	Wave period (T) in test 1B [s]
2 3 4 5	7.07	8.06

Table 4: Regular waves.

The period for series 1A was chosen such that half a wave length was equal to the distance between buoy 1 and 2 in the setup with head on sea (40m). In this way buoy 1 and 2 would move counterphase. The period for series 1B was chosen close to the heave eigenperiod for the closed tube model.

4.2 Normal use sea states

The normal use sea states could be important for the fatigue of the mooring system and the measured heave of buoy 1 can be used in estimations of the efficiency. Two wave periods were tested corresponding to Orkney and Portugal.

Significant wave height (H_s) [m]	Peak wave period (T_p) in series 2A [s]	Peak wave period (T_p) in series 2B [s]
1	7.7	9.1
2	8.7	10.1
3	9.5	10.9
4	10.5	11.9
5	11.5	12.9

Table 5: Normal use sea states.

It was investigated whether there would be any significant differences in the mooring forces in case of short crested (3D) waves compared to long crested (2D) waves. Series 2A was therefore also performed with 3D waves in the case of head on sea and closed tube. The 3D waves were generated with a spreading parameter (s) equal to 5.

4.3 Survival sea states

Three survival sea states were tested, corresponding to approximate 100 year wave conditions in the North Sea at a water depth of 50-60 meters. The water depth in the experiments in prototype scale was 110 meters, but the influence of the water depth on the mooring forces is expected to be small.

	Significant wave Height (H_s) [m]	Peak wave period (T_p) [s]
Test 3A	11	13.7
Test 3B	11	15.2
Test 3C	11	16.7

Table 6: Survival sea states.

4.4 Survival sea states and disconnected mooring line

To check how the mooring system performs if a mooring line fails. The system was tested in survival sea state 3C with a mooring line disconnected. This was done for the model with closed tube and for all three set-ups.

5 Conclusions

158 tests were performed to investigate the performance of the system. Several repetitions of tests were done and these repetitive tests gave the same results.

In general the same trends for the mooring forces was found in case of regular sea states, normal use sea states and survival sea states. For all sea states and test set-ups there were no differences in the mooring forces in the two cases open and closed tube.

Head on sea gives the smallest mooring forces and beam sea the largest mooring forces in case of irregular sea states (normal use and survival sea states).

The drift force on the system plays an important role. The drift force is distributed among the mooring lines facing the waves giving more tension in the lines, and the mooring lines in the rear of the system gets more slack.

The maximum force is approximately the same in all mooring lines. This indicates that the forces are distributed evenly, which means the system is working in an appropriate way.

In all tests the measured wave heights were slightly smaller than the target values given in Chapter 4, see Figure 11. If the measured forces are used for design of a mooring system in the target sea states this must be taken into account, e.g. by scaling up the measured forces with respect to the measured wave height.

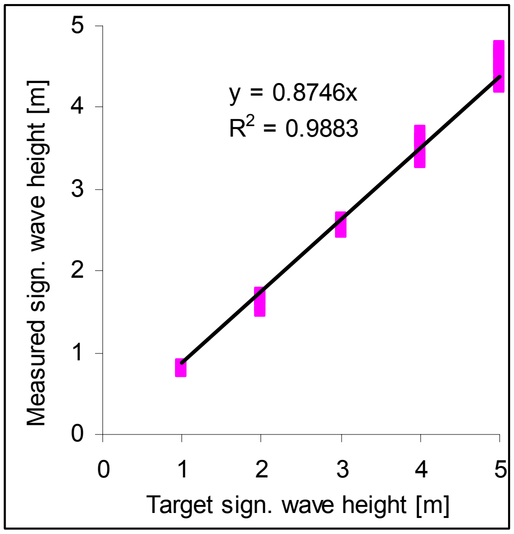


Figure 11: Comparison of target and actual wave heights for normal use sea states .

5.1 Regular waves

Figures showing mooring forces and heave movements are given in Appendix A-F.

Head on sea

All forces are linearly proportional to the wave height. In case of head on sea the largest forces are in the mooring lines in the middle of the system (line no. 3-8, parallel to the wave direction). The forces in the corner mooring lines are approximately 50% smaller than the maximum forces.
The largest forces are in test series 1A (the short wave period), which probably is due to the counterphase movements of the buoys.

Oblique sea

In the case of oblique sea the largest forces are in the rear mooring line facing the waves (line no. 10). This mooring line was connected to buoy 4, which visually was moving the most. The forces are larger than in case of head on waves. The largest forces are in test series 1B (the long wave period).

Beam sea

In the case of beam sea the largest forces are in the mooring lines in the middle facing the waves (line no. 3-6). The largest forces are approximately the same as in case of oblique sea. The maximum forces in test series 1A and 1B are almost equal, however the largest forces are in test series 1B (the long wave period).

5.2 Normal use sea states

The normal use sea states is very important when designing for fatigue of the mooring system.

Figures showing mooring forces and heave movements are given in Appendix G-M. The following extreme forces are caused by the drift force on the system. For head on sea the maximum force is approximately the same in all mooring lines. The minimum force is numerically largest in the rear mooring lines (line no. 9 and 10). For oblique sea the maximum force is in line 5, 7 and 10. The minimum force is numerically largest in the rear mooring line (line no. 10). For beam sea the maximum mooring forces are in the middle lines in the front facing the waves (lines no. 3 and 5). The minimum forces are numerically largest in the middle rear lines (lines no. 4 and 6).

The numerically largest maximum and minimum $F_{2\%}$ for all the mooring lines is given in Table 7. The largest force for the three set-ups and the two periods is marked with bold red font.

			H_s = 0.79m		H_s = 1.65m		H_s = 2.54m		H_s = 3.46m		H_s = 4.51m	
			2A	2B	2A	2B	2A	2B	2A	2B	2A	2B
Closed tube	Min	Head on sea	-39	-34	-66	-60	-84	-85	-106	-128	-150	-165
		Oblique sea	-65	**-87**	-126	-143	-179	-184	-250	-217	-282	-256
		Beam sea	-56	-81	-132	**-152**	-190	**-191**	-228	**-274**	-258	**-284**
	Max	Head on sea	43	37	67	63	93	85	109	108	149	146
		Oblique sea	59	**90**	109	124	158	155	218	195	235	207
		Beam sea	57	85	128	**150**	**192**	191	254	**297**	279	**301**
Open tube	Min	Head on sea	-42	-35	-65	-60	-84	-91	-114	-115	-144	-152
		Oblique sea	-61	**-80**	-113	**-138**	-168	-160	**-235**	-219	-266	-226
		Beam sea	-58	-78	-121	-133	**-191**	-165	-232	-198	**-294**	-222
	Max	Head on sea	43	38	71	61	93	82	112	105	139	142
		Oblique sea	59	71	99	125	139	153	198	185	237	207
		Beam sea	56	**76**	122	**137**	**200**	165	**250**	214	**298**	238

Table 7: Maximum wave induced $F_{2\%}$ mooring forces in normal use sea states. Values in kN.

The forces are smallest in case of head on sea as for regular wave attack. The influence of the wave period is small as the mooring forces are almost the same in test series 2A and 2B. The maximum forces marked with red in Table 7 is plotted in Figure 12. These values could be used when designing for fatigue of the mooring system.

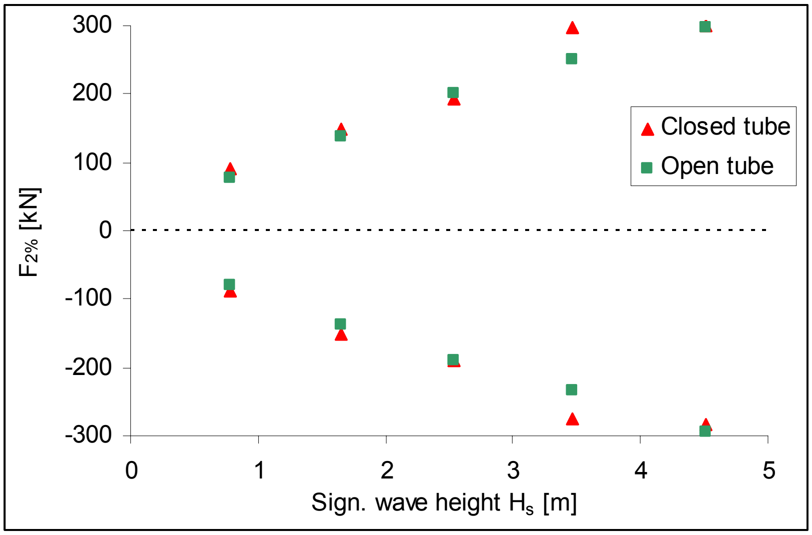


Figure 12: Maximum wave induced mooring forces in normal use sea states.

5.3 Survival sea states

Tables showing the mooring forces and the heave movements of buoy 1 are given in Appendix N-S. The most dangerous of the three survival sea states seems to be the one with the short period. A reason for this could be that more energy is present at and close to the eigenfrequency of the AquaBuOY. In Table 8 the maximum mooring force is found for all mooring lines in all survival sea states. It is seen that the largest extreme mooring forces occur in beam sea and the smallest extreme forces are in case of head on sea.

	$F_{2\%}$ min [kN]	$F_{2\%}$ max [kN]
Head on sea	-325	298
Oblique sea	-448	388
Beam sea	-535	612

Table 8: Maximum wave induced mooring forces in survival sea states

For head on sea the maximum force is approximately the same in all mooring lines. The minimum force is numerically largest in the rear mooring lines (line no. 9 and 10). For oblique sea the maximum force is approximately the same in all mooring lines. The minimum force is numerically largest in the rear mooring line (line no. 10). For beam sea the maximum mooring forces are in the middle lines in the front facing the waves (lines no. 3 and 5). The minimum force is numerically largest in the middle rear lines (lines no. 4 and 6).

In test 3A with closed tube and beam sea spring 4 and 6 gets slack one time during the test series. The springs gets slack once and therefore only the 1% fraction of the mooring forces is influenced. This shows that the tested system is very close to the design limit for the tested sea states. To give more safety the system needs more pretension.

5.4 Survival sea states and disconnected mooring line

The disconnected mooring line tests were performed on AquaBuOY with closed tube. In Table 9 the visual observation made during the survival tests with disconnected mooring lines is given.

Wave direction	Disconnected line number	Visual observations
Head on sea	2	System seems to behave fine.
	4	Line connecting front AquaBuOY 1 and 2 (with the float in between) becomes tight.
	6	Line connecting AquaBuOY 2 and 3 (with the float in between) becomes tight. (looks not as dangerous as the situation with line 2 disconnected).
	8	Line connecting AquaBuOY 3 and 4 (with the float in between) becomes tight.
	10	The spring 7 becomes loose and the line connecting AquaBuOY 3 and 4 (with the float in between) becomes tight.
Oblique sea	1	System seems to behave fine, but all buoys (especially AquaBuOY 1) is drawn shoreward about 50 cm in model scale. In that way mooring line 2 takes over the horizontal forces (from surge displacements and drift).
	10	System seems to behave fine, only the shoreward AquaBuOY 4 is significantly displaced seaward as the line is detached. The AquaBuOY 4 is moving much more in the waves (especially pitch) than when the line was connected. Visually the other buoys seems not affected at all.
Beam sea	1	System behaves fine, but AquaBuOY 1 rolls as much as pitch. Buoys moves only slightly to the side (approximately 10cm in model scale away from the disconnected line) as line 1 is detached.
	2	Systems behaves almost as if no line was disconnected. AquaBuOY 1 does not roll.
	3	Systems behaves almost as if no line was disconnected. The line connecting AquaBuOY 1 and 2 is always slack (but it almost gets tight in the largest waves).
	4	Systems behaves almost as if no line was disconnected. The line connecting AquaBuOY 1 and 2 is always slack (but it almost gets tight in the largest waves).

Table 9: Visual observations from tests with disconnected mooring line.

Tables showing wave induced mooring forces and heave movements are given in Appendix T-V. In Appendix W the wave induced mooring forces with disconnected mooring line is related to the situation with no disconnected lines. The amplification factor in Appendix W does not include changes in pre-tension due to the disconnected line. It was found that the largest raise in the positive $F_{2\%}$ is for head on sea and line no. 8 disconnected. The amplification is in this situation 158%. The largest raise in the negative $F_{2\%}$ is for beam sea and line no. 4 disconnected, where the amplification is 188%.

A very important observation is that the lines connecting the AquaBuOY's (with the float in between) becomes tight in some situations (see Table 9).

5.5 Comparison of short crested and long crested sea states

The comparison was carried out for head on sea, AquaBuOY with closed tube, and test series 2A. As seen on Figure 13 there is no significant differences between short crested (3D) and long crested (2D) waves.

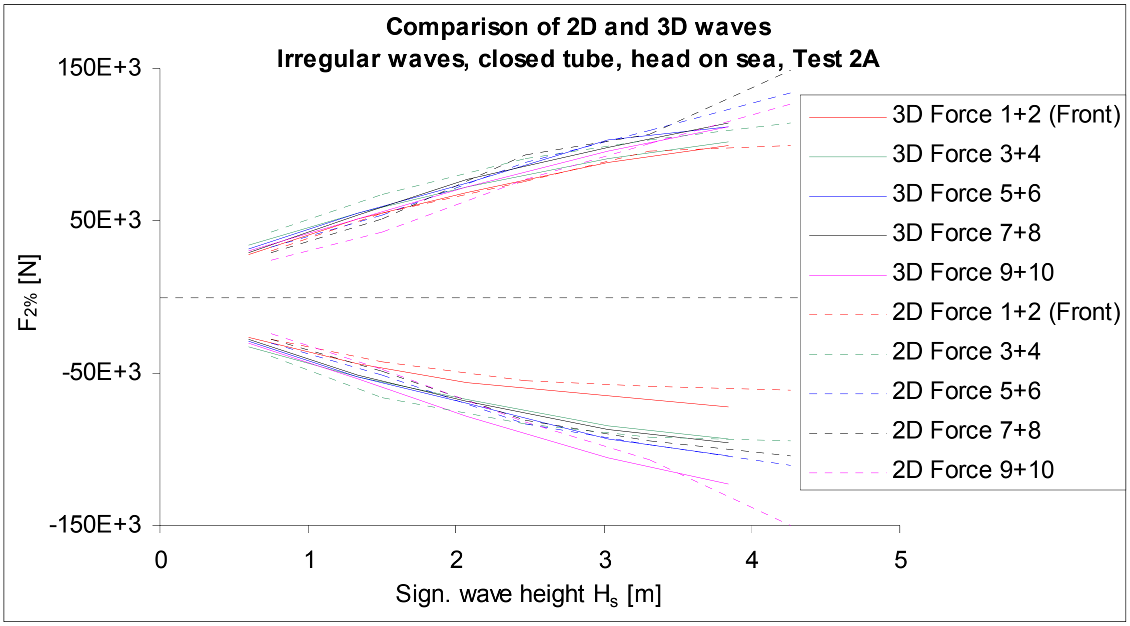


Figure 13: Comparison of mooring forces for 2D and 3D waves.

5.6 Distribution of extreme forces

In Appendix X graphs showing the distribution of extreme forces are shown for the three set-ups. Only minor differences in the three graphs is observed and therefore all test results with 2D irregular waves is included in Figure 14. The linear trend has been tested with results from the long 3D test series, which included 1500 waves and thereby calculation of $F_{0.1\%}$ was possible.

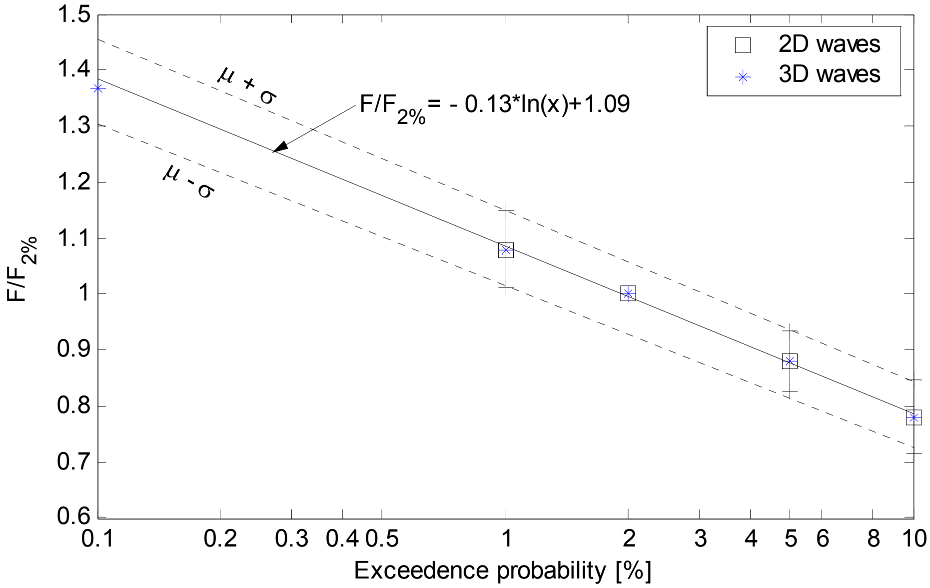


Figure 14: Distribution of extreme forces.

The graph can be used to scale mooring forces up or down according to another exceedence probability than the given 2% fraction. In Appendix N-S 1% fractions are given. The analyzed wave train contained only approximately 300 waves, and the 1% fractions are therefore quite uncertain. If a 1% fraction is wanted a factor of 1.09 should be multiplied to the 2% fractions according to Figure 14.

5.7 Movements of buoys

In general it was observed during the testing that the front buoy no. 1 had the smallest pitch, roll, surge and sway movements in case of head on and oblique sea. The following buoys had larger movements such that the rear buoy no. 4 was moving the most.

The buoys with open tube was in general following the surface elevation, giving the same heave movement as wave height. The buoy with the closed tube had the largest relative heave movements for the short period irregular sea states, where the wave period was closest to the eigenperiod of the buoy. The average heave motion of buoy 1 was up to 3 times the average wave height in case of the smallest wave height. As the wave height increases the relative heave motions are reduced reaching asymptotically one times the wave motion.

For AquaBuOY with closed tube the test series 1A (the short regular wave period) does not show a linear trend. In this case the heave amplitude seems to reach a maximum of 3m. In case of the test series 1B (the long regular wave period) the heave follows a linear trend and the heave motion is from 1.6 to 2.2 times the wave motion. The large heave motions are caused by the waves having the same period as the eigenperiod of the buoy.

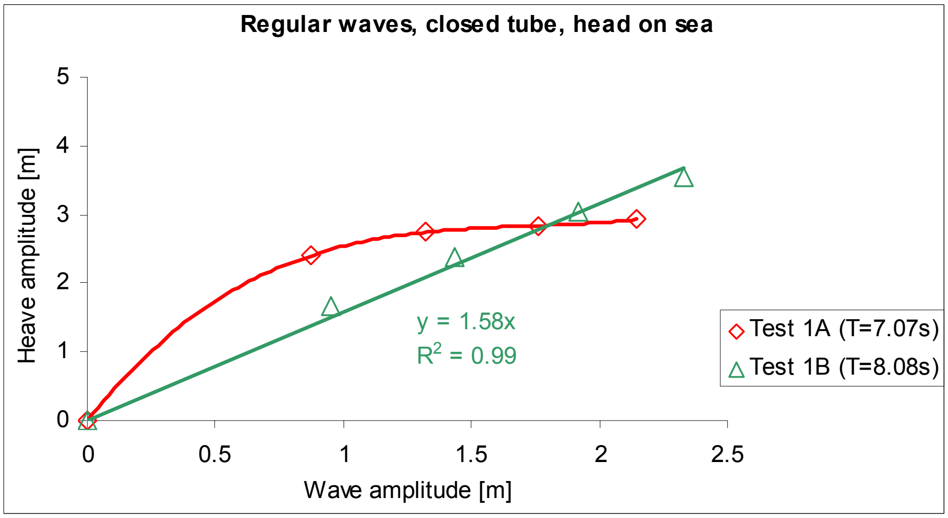
On the DVD described in Appendix Y it is possible visually to see how the system of buoys behaves subject to the different set-ups and wave conditions.

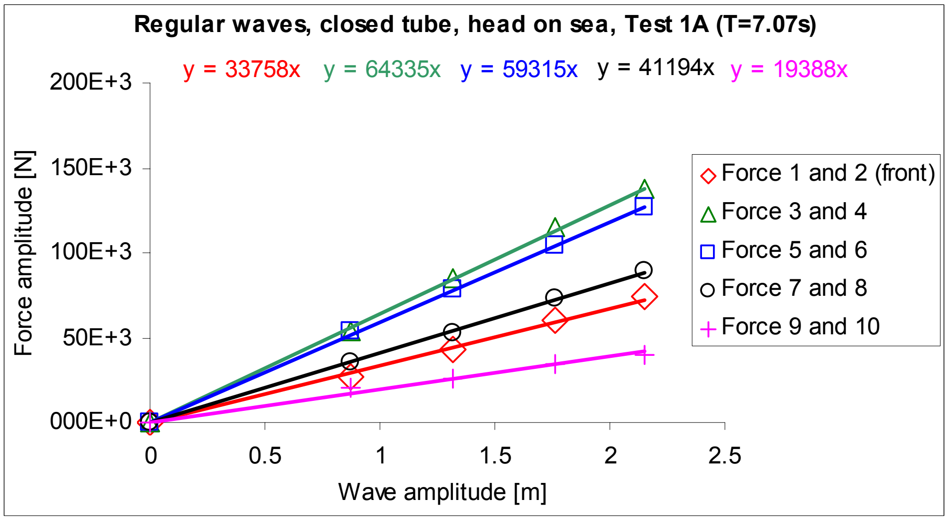
5.8 Prototype design remarks

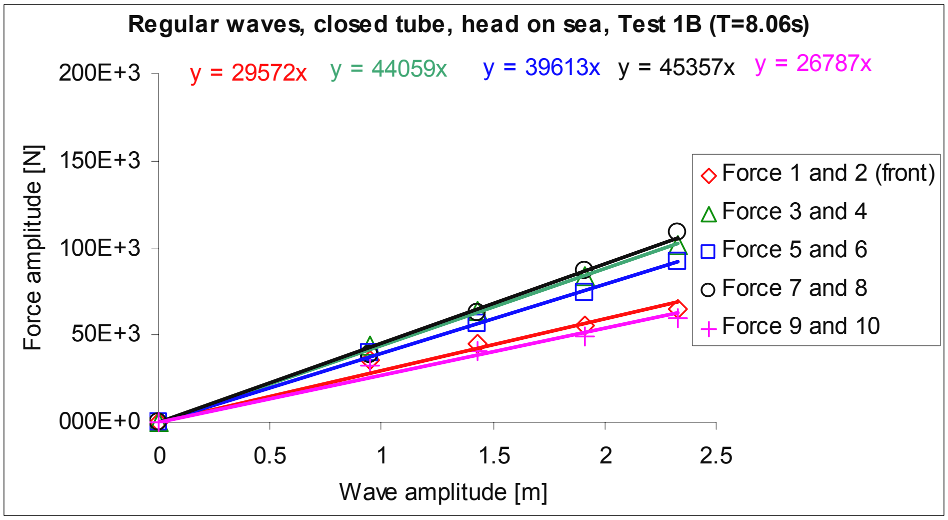
Experiences from other projects with large prototype wave energy converters shows that wave and current induced forces on the mooring lines are important. The forces on the mooring lines are increased significantly due to marine growth and seaweed. This must be taken into account when designing the mooring system.

Experiences shows that connections between differently moving parts are weak. The connections between the mooring lines and the floating structures are important, as that this connection will be weak due to wear and tear. If wires are used a sufficiently large bending radius must be applied.

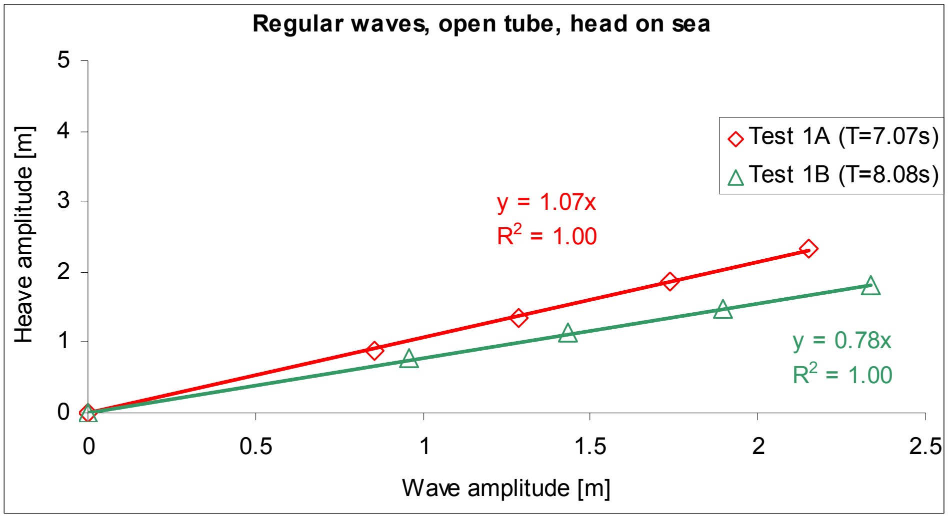
Appendix A: Regular waves, head on sea, closed tube

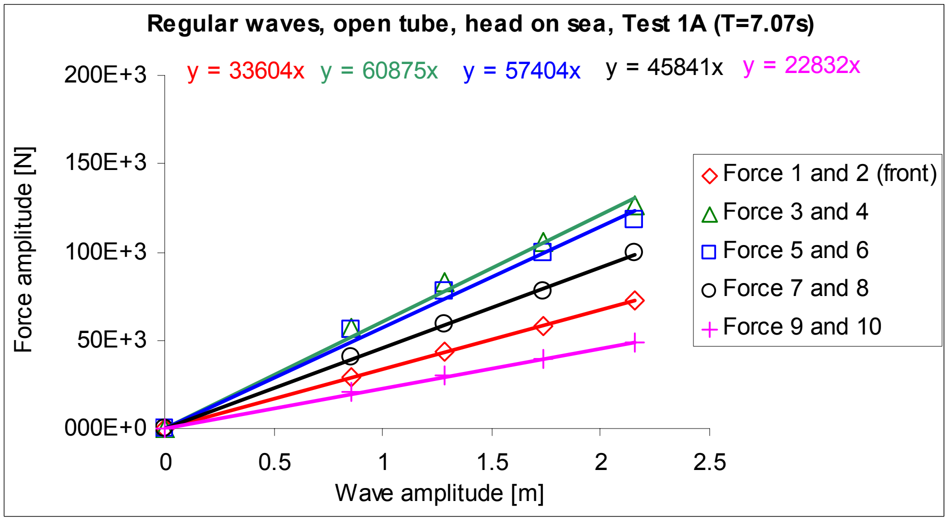


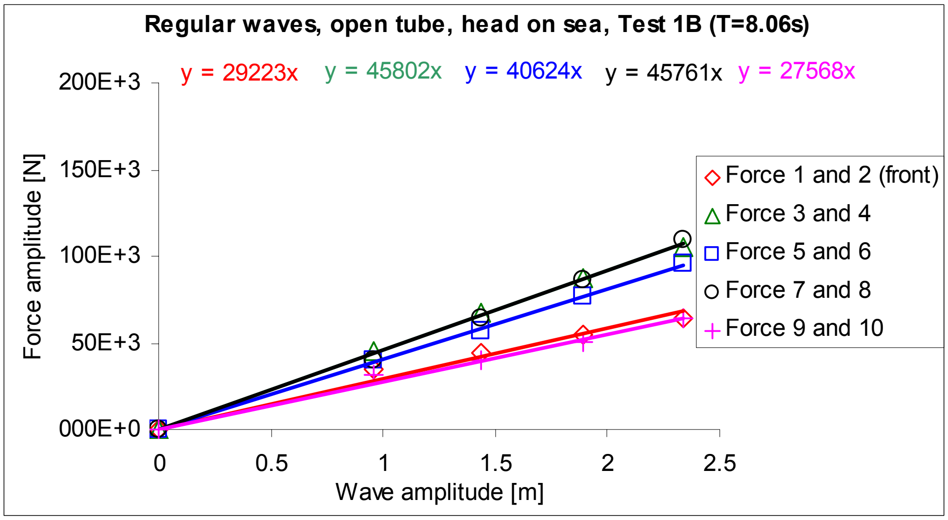




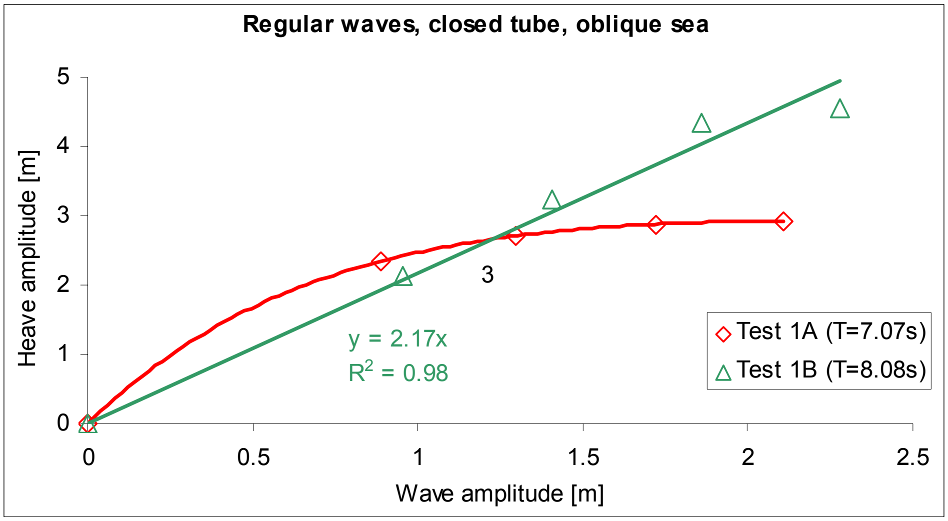
Appendix B: Regular waves, head on sea, open tube

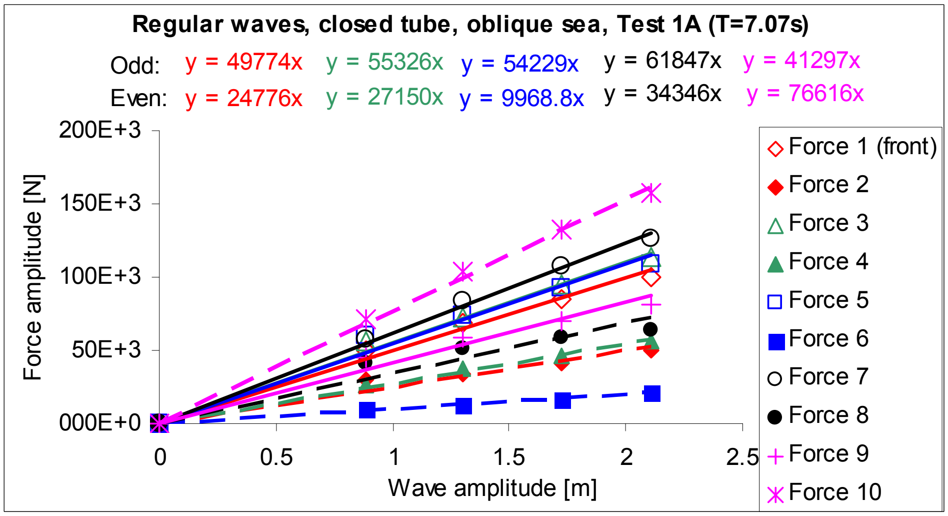


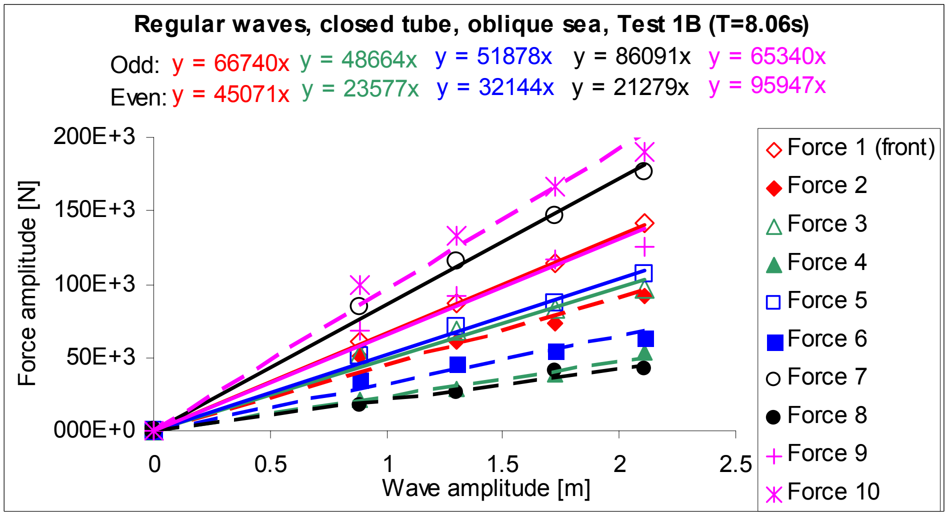




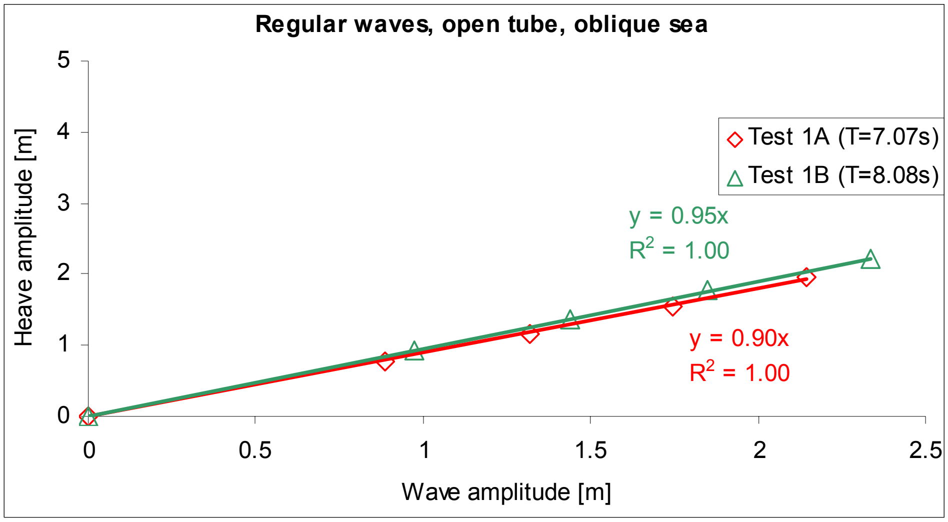
Appendix C: Regular waves, oblique sea, closed tube

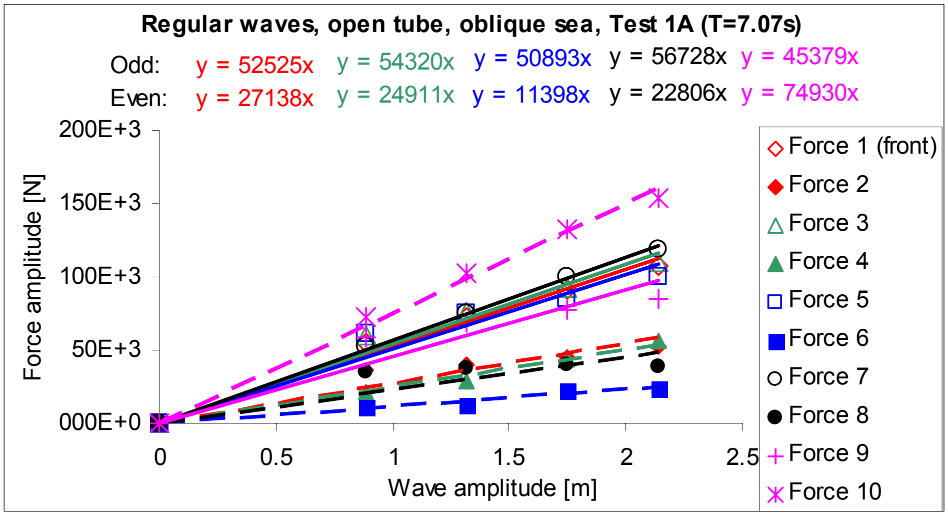


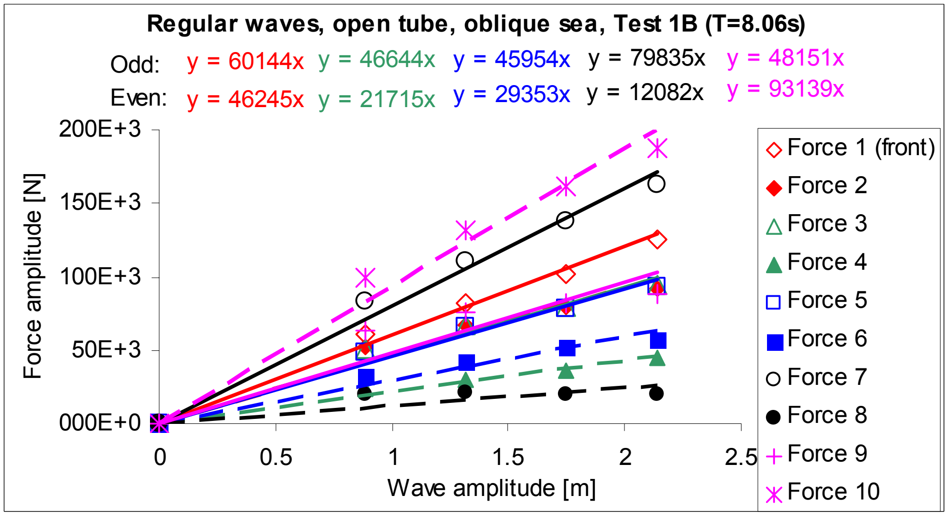




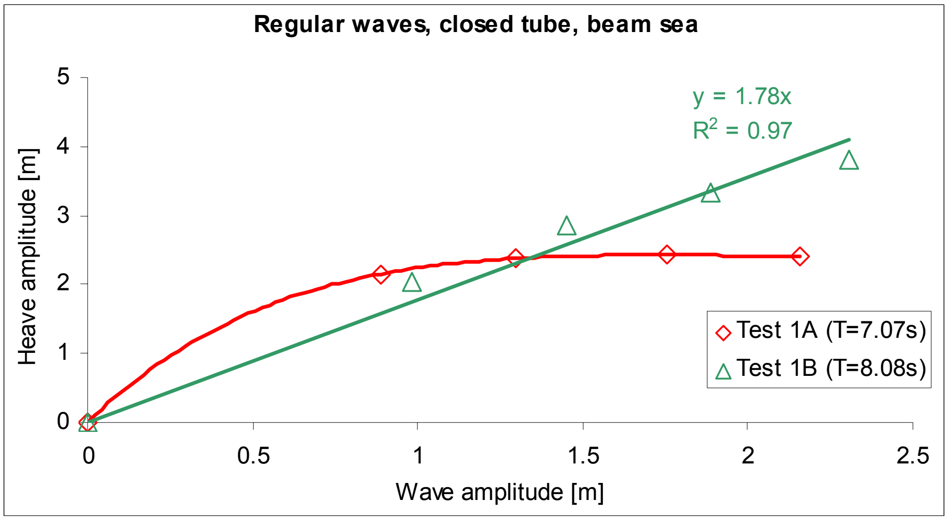
Appendix D: Regular waves, oblique sea, open tube

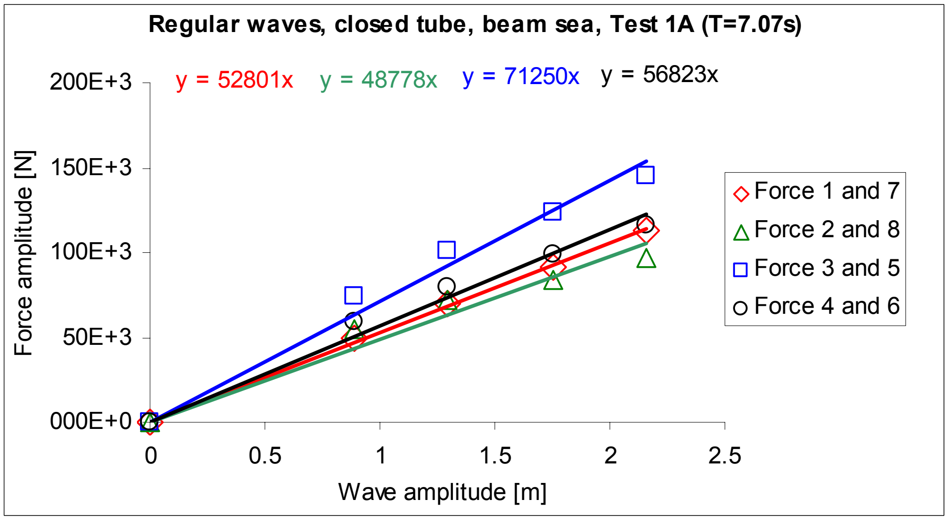


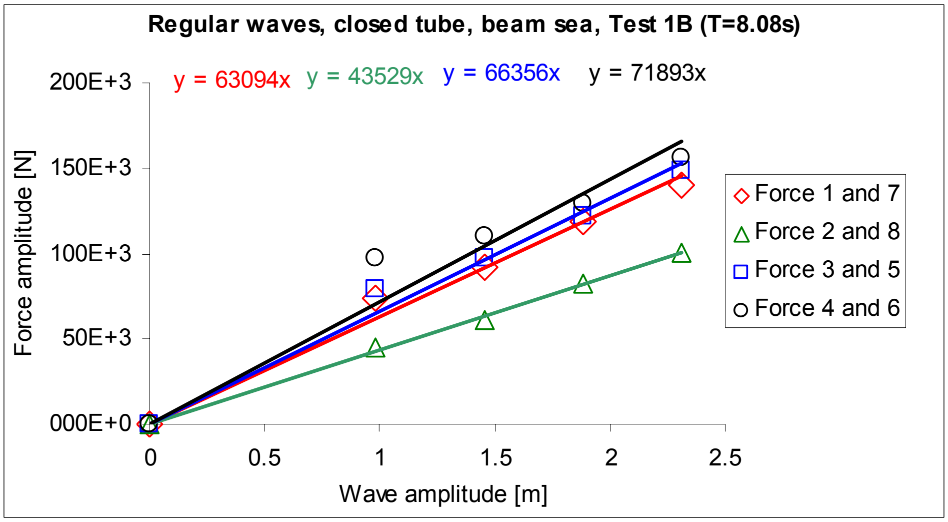




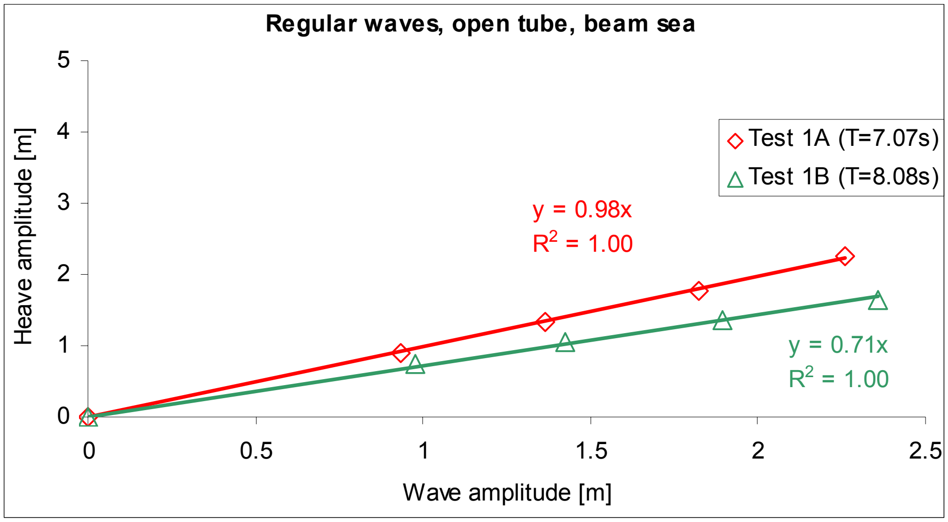
Appendix E: Regular waves, beam sea, closed tube

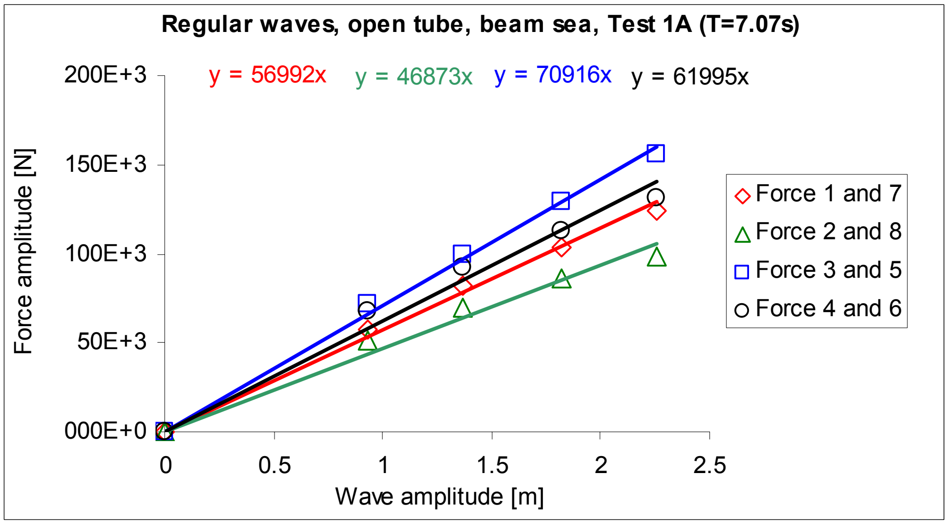


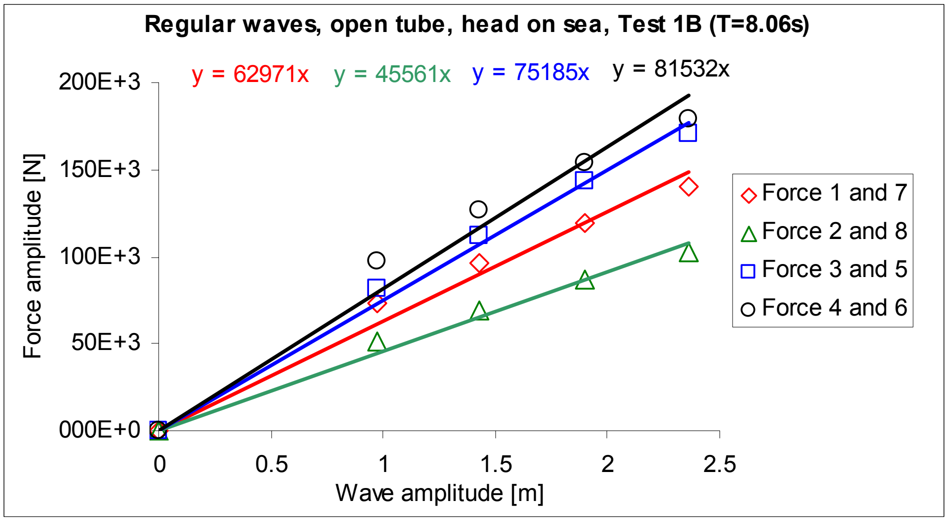




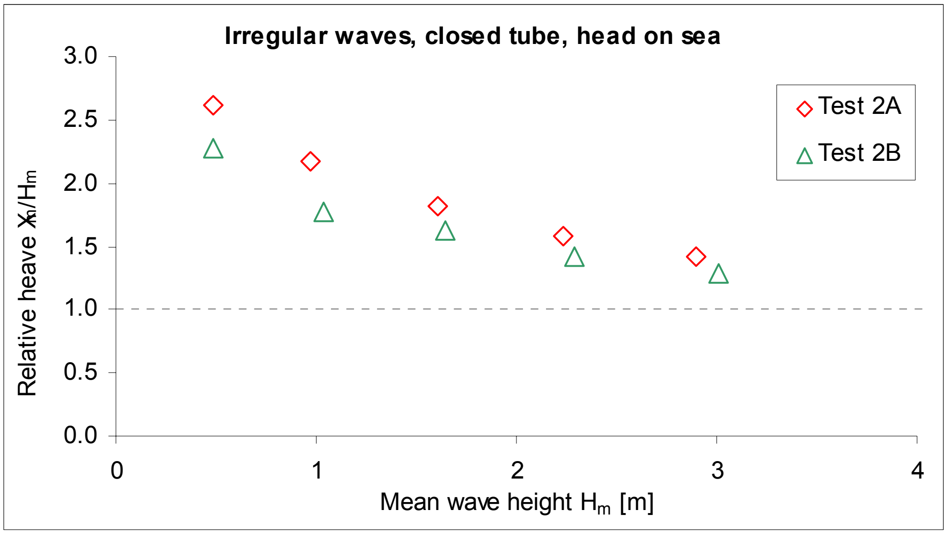
Appendix F: Regular waves, beam sea, open tube

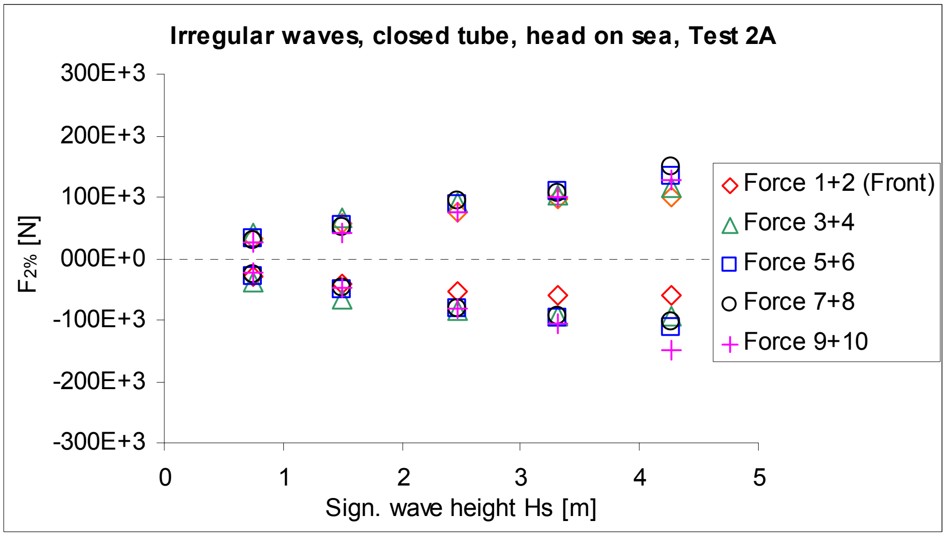


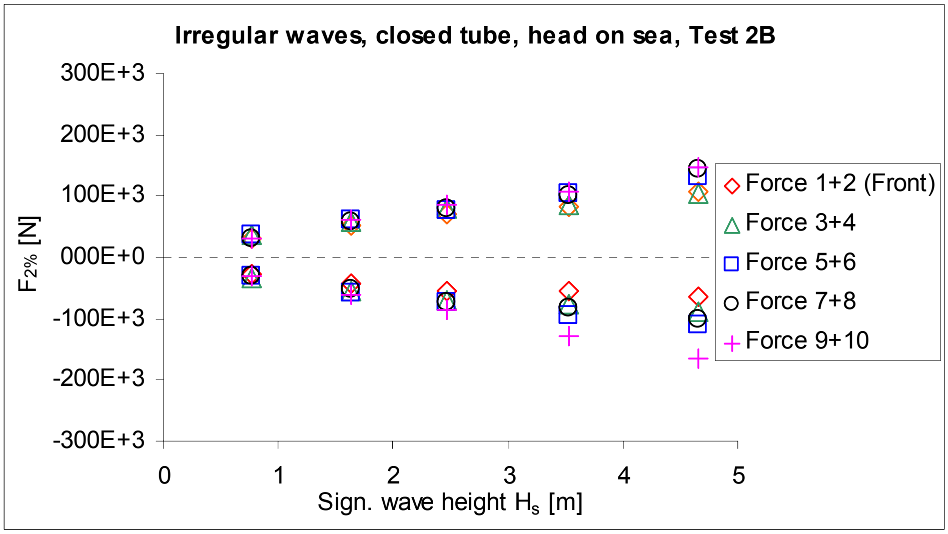




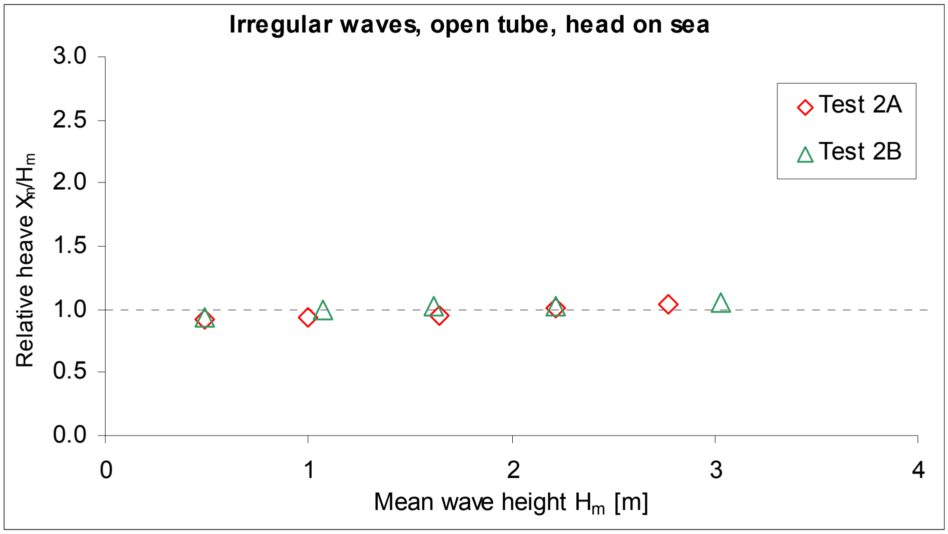
Appendix G: 2D Normal use sea, head on sea, closed tube

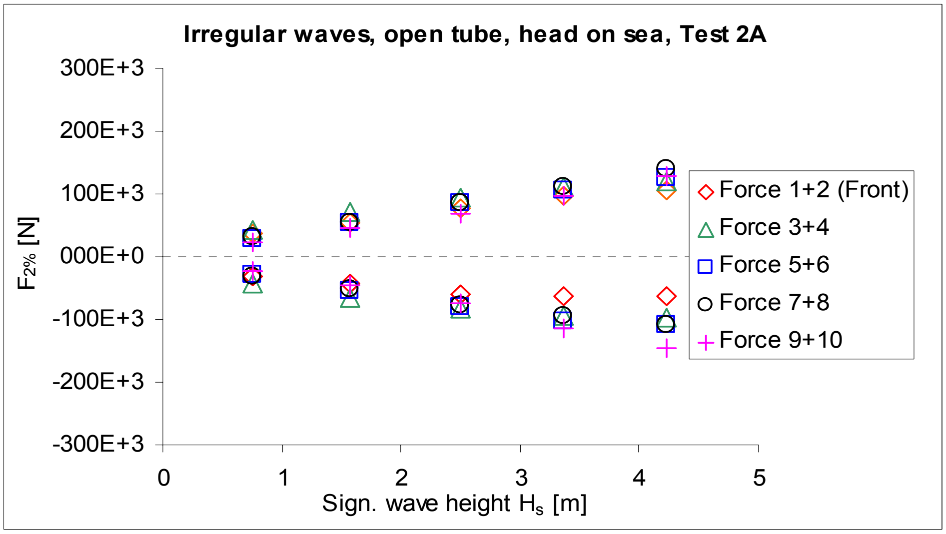


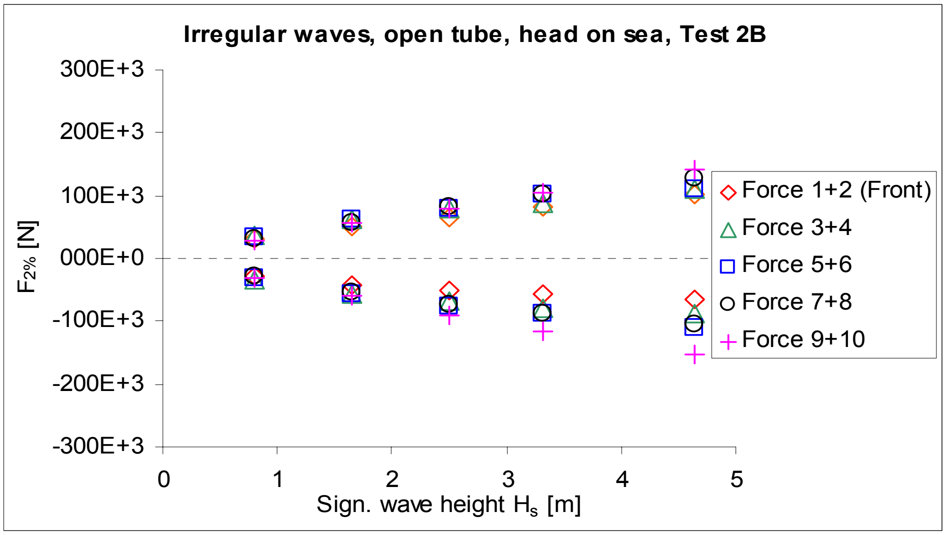




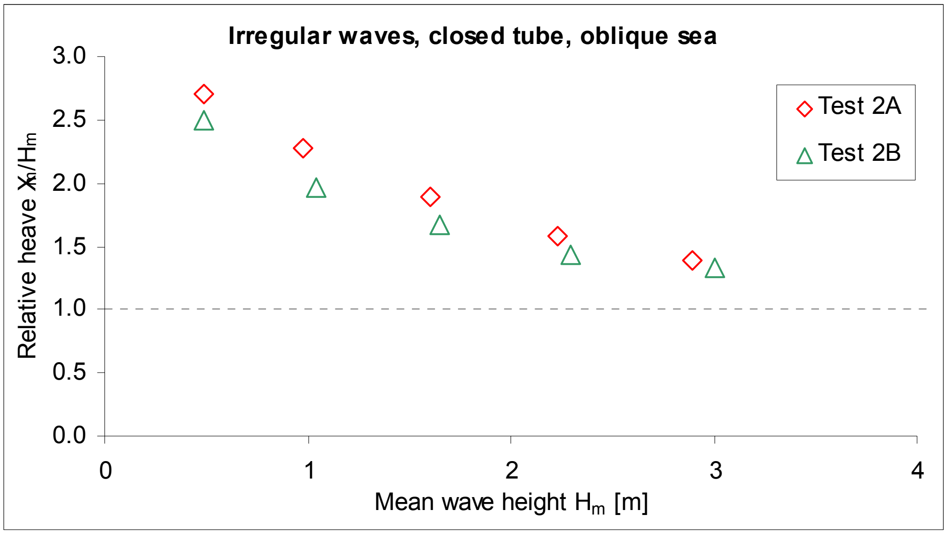
Appendix H: 2D Normal use sea, head on sea, open tube

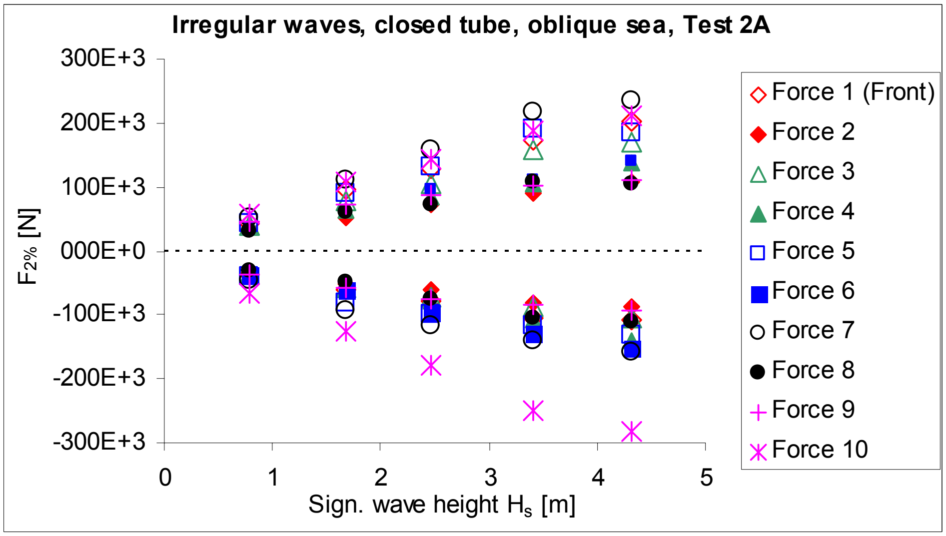


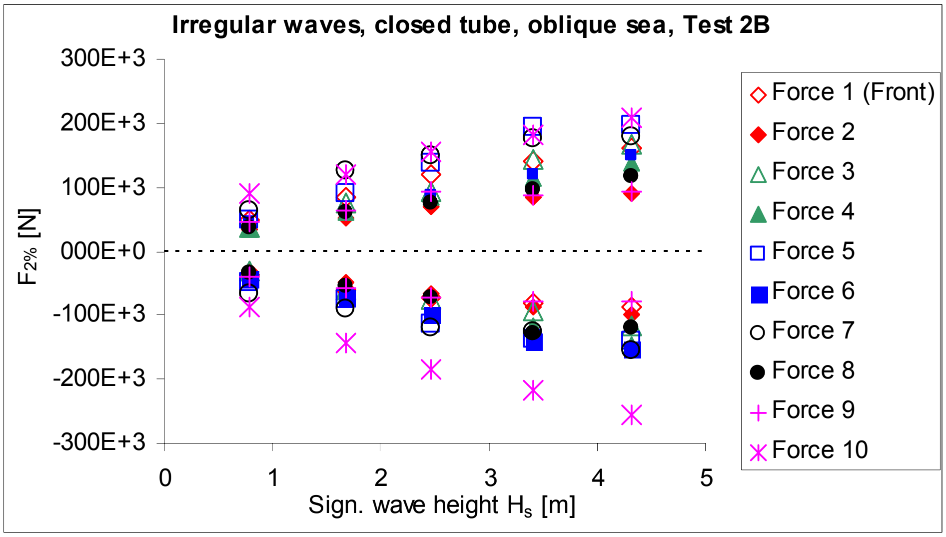




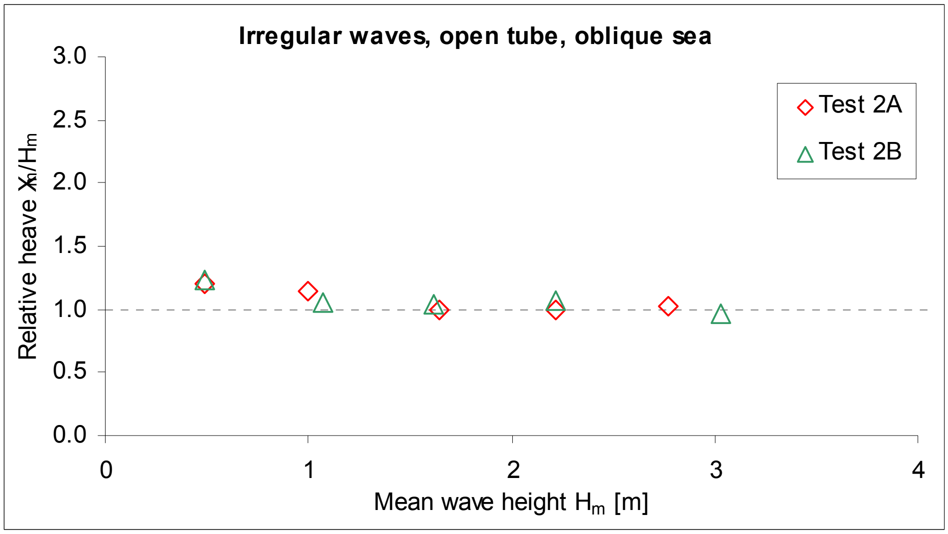
Appendix I: 2D Normal use sea, oblique sea, closed tube

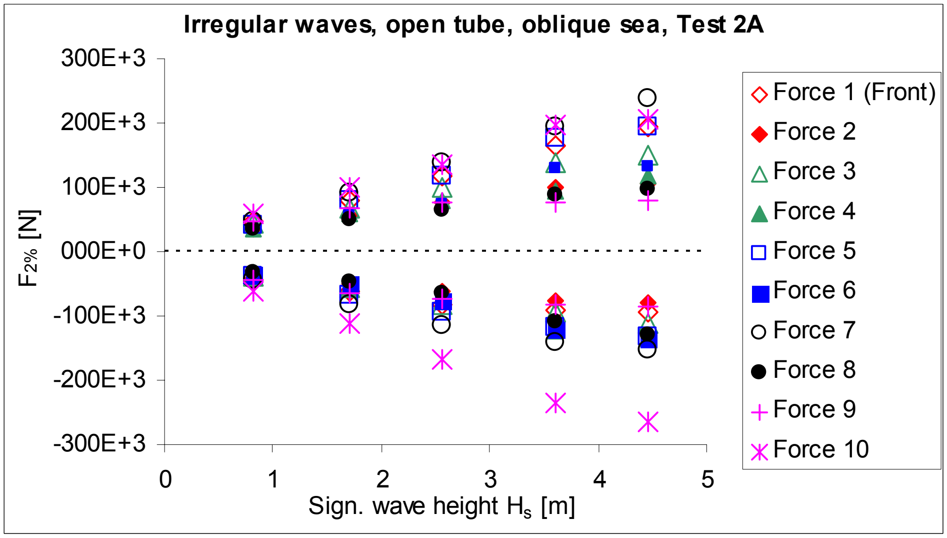


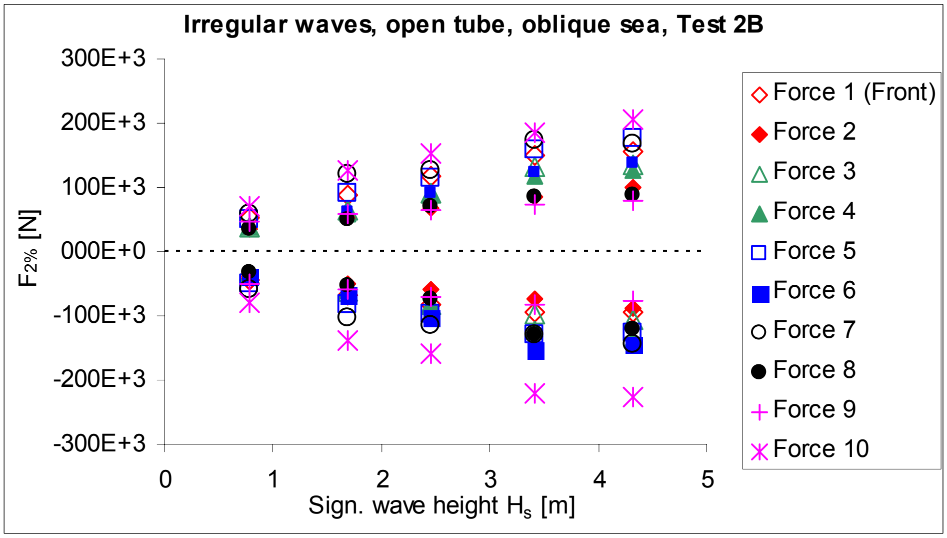




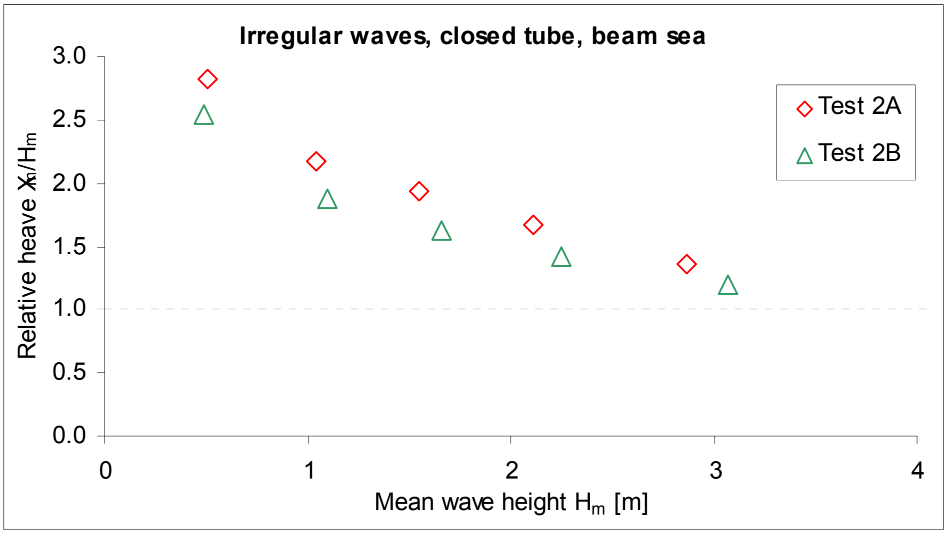
Appendix J: 2D Normal use sea, oblique sea, open tube

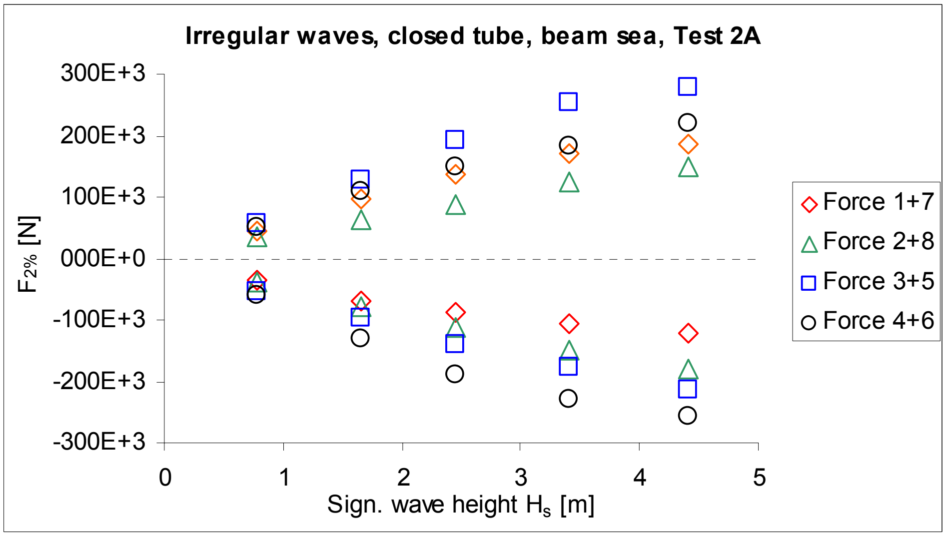


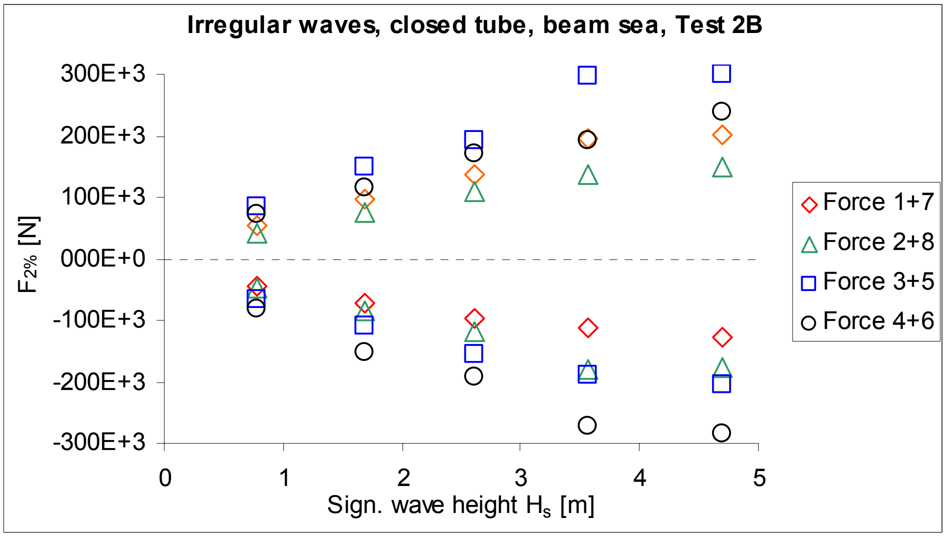




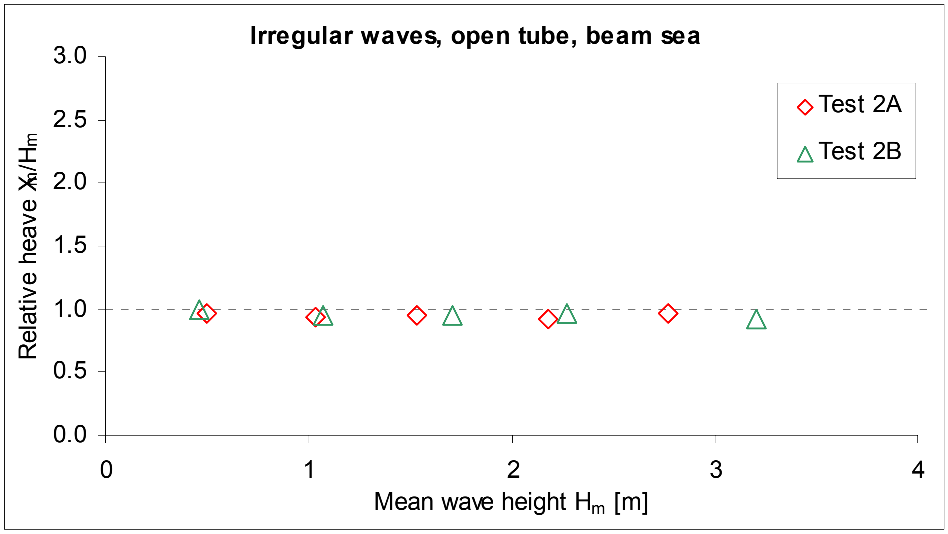
Appendix K: 2D Normal use sea, beam sea, closed tube

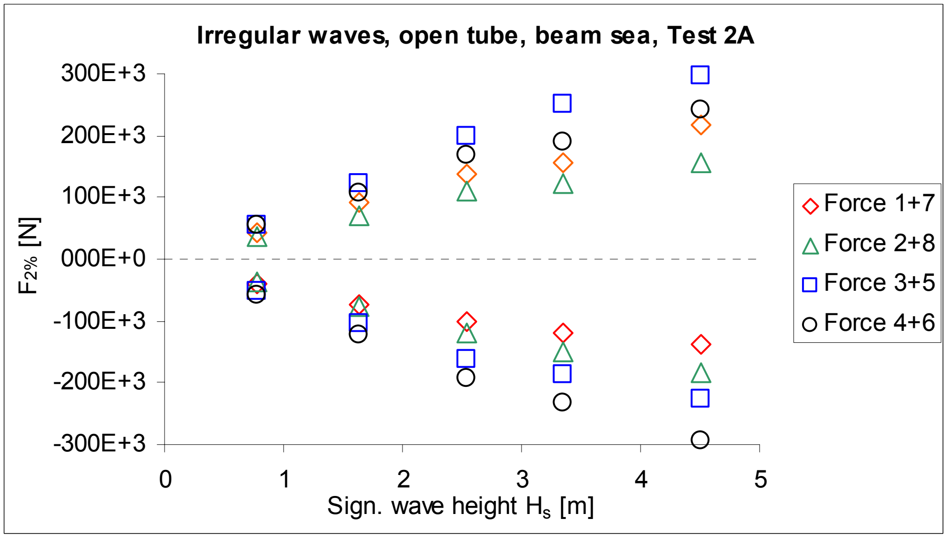


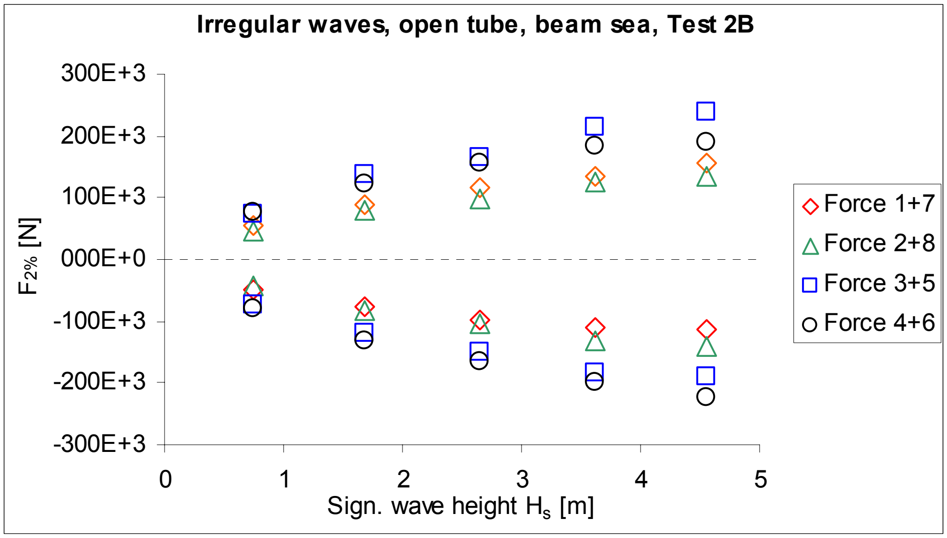




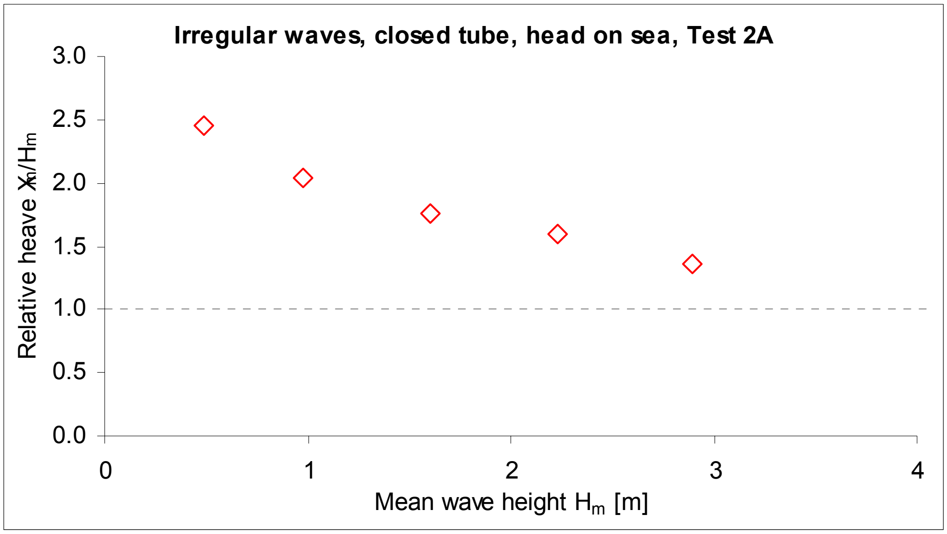
Appendix L: 2D Normal use sea, beam sea, open tube

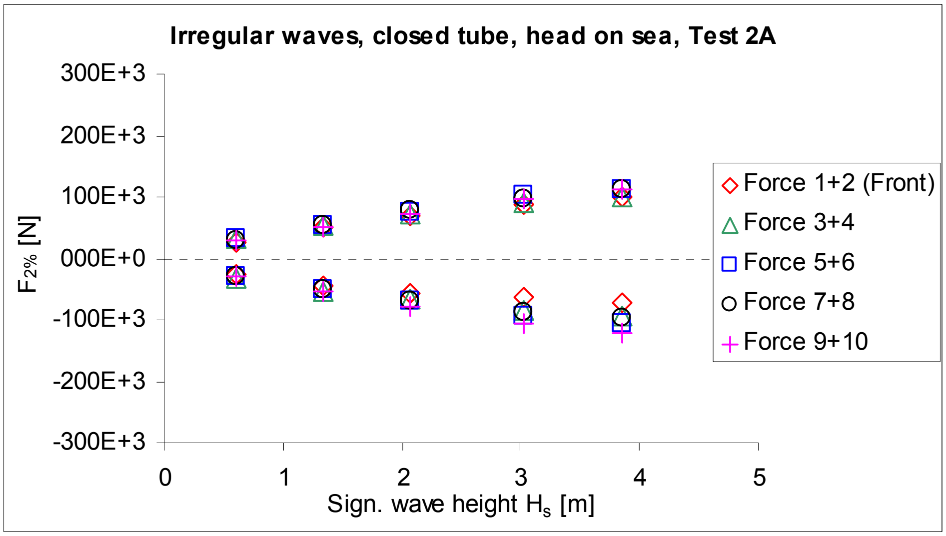






Appendix M: 3D Normal use sea, head on sea, closed tube





Appendix N: Survival tests, head on waves, closed tube

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
9.3	13.7	7.4	12.7	14.3	15.6	Minimum	1	-7E+3	-78E+3	-94E+3	-103E+3
							2	-5E+3	-67E+3	-80E+3	-89E+3
							3	-53E+3	-128E+3	-140E+3	-150E+3
							4	-53E+3	-130E+3	-155E+3	-168E+3
							5	-57E+3	-143E+3	-160E+3	-181E+3
							6	-64E+3	-181E+3	-208E+3	-225E+3
							7	-69E+3	-151E+3	-166E+3	-176E+3
							8	-77E+3	-174E+3	-199E+3	-223E+3
							9	-116E+3	-244E+3	-292E+3	-325E+3
							10	**-127E+3**	**-285E+3**	**-318E+3**	**-328E+3**
						Maximum	1	101E+3	222E+3	256E+3	300E+3
							2	78E+3	167E+3	189E+3	210E+3
							3	88E+3	196E+3	227E+3	242E+3
							4	81E+3	172E+3	202E+3	232E+3
							5	109E+3	226E+3	277E+3	**319E+3**
							6	106E+3	209E+3	233E+3	261E+3
							7	101E+3	227E+3	**298E+3**	318E+3
							8	106E+3	**246E+3**	291E+3	332E+3
							9	99E+3	203E+3	237E+3	243E+3
							10	**114E+3**	209E+3	240E+3	285E+3
10.2	15.2	7.5	13.3	14.1	15.1	Minimum	1	-7E+3	-82E+3	-99E+3	-113E+3
							2	-8E+3	-72E+3	-93E+3	-104E+3
							3	-44E+3	-109E+3	-126E+3	-132E+3
							4	-46E+3	-122E+3	-137E+3	-150E+3
							5	-49E+3	-133E+3	-150E+3	-162E+3
							6	-57E+3	-180E+3	-206E+3	-232E+3
							7	-48E+3	-119E+3	-135E+3	-146E+3
							8	-59E+3	-162E+3	-182E+3	-217E+3
							9	**-118E+3**	**-271E+3**	**-318E+3**	**-330E+3**
							10	-115E+3	-265E+3	-286E+3	-324E+3
						Maximum	1	95E+3	212E+3	289E+3	324E+3
							2	69E+3	172E+3	207E+3	232E+3
							3	76E+3	177E+3	218E+3	230E+3
							4	73E+3	178E+3	213E+3	230E+3
							5	92E+3	209E+3	248E+3	285E+3
							6	99E+3	218E+3	242E+3	252E+3
							7	80E+3	212E+3	243E+3	269E+3
							8	96E+3	234E+3	**291E+3**	**329E+3**
							9	109E+3	**247E+3**	290E+3	315E+3
							10	**111E+3**	244E+3	271E+3	286E+3
9.6	16.7	7.0	12.5	13.6	14.1	Minimum	1	-14E+3	-87E+3	-100E+3	-116E+3
							2	-12E+3	-74E+3	-87E+3	-100E+3
							3	-40E+3	-99E+3	-117E+3	-137E+3
							4	-44E+3	-109E+3	-128E+3	-142E+3
							5	-48E+3	-123E+3	-136E+3	-143E+3
							6	-57E+3	-154E+3	-171E+3	-192E+3
							7	-45E+3	-108E+3	-123E+3	-134E+3
							8	-54E+3	-140E+3	-167E+3	-177E+3
							9	**-110E+3**	-237E+3	**-270E+3**	-283E+3
							10	-109E+3	**-243E+3**	-260E+3	**-289E+3**
						Maximum	1	82E+3	196E+3	240E+3	**263E+3**
							2	59E+3	163E+3	185E+3	219E+3
							3	64E+3	147E+3	172E+3	185E+3
							4	61E+3	158E+3	193E+3	205E+3
							5	78E+3	181E+3	204E+3	219E+3
							6	85E+3	184E+3	201E+3	216E+3
							7	68E+3	171E+3	196E+3	217E+3
							8	83E+3	197E+3	229E+3	248E+3
							9	**105E+3**	225E+3	244E+3	259E+3
							10	104E+3	**227E+3**	**246E+3**	261E+3

Table 10: Head on sea and closed tube test results.

Appendix O: Survival tests, head on waves, open tube

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
9.8	13.7	7.2	13.1	14.5	15.9	Minimum	1	-8E+3	-76E+3	-93E+3	-101E+3
							2	-5E+3	-64E+3	-77E+3	-94E+3
							3	-55E+3	-122E+3	-139E+3	-144E+3
							4	-52E+3	-132E+3	-146E+3	-159E+3
							5	-63E+3	-150E+3	-176E+3	-187E+3
							6	-67E+3	-208E+3	-231E+3	-253E+3
							7	-75E+3	-144E+3	-162E+3	-174E+3
							8	-87E+3	-187E+3	-217E+3	-237E+3
							9	-122E+3	-279E+3	-312E+3	-322E+3
							10	**-140E+3**	**-298E+3**	**-325E+3**	**-361E+3**
						Maximum	1	102E+3	227E+3	272E+3	**317E+3**
							2	81E+3	169E+3	208E+3	250E+3
							3	98E+3	194E+3	233E+3	258E+3
							4	82E+3	173E+3	201E+3	224E+3
							5	106E+3	227E+3	272E+3	301E+3
							6	100E+3	200E+3	251E+3	273E+3
							7	102E+3	228E+3	254E+3	279E+3
							8	106E+3	234E+3	260E+3	288E+3
							9	106E+3	225E+3	250E+3	264E+3
							10	**122E+3**	**240E+3**	**279E+3**	285E+3
10.1	15.2	7.4	12.8	14.7	15.4	Minimum	1	-13E+3	-82E+3	-99E+3	-103E+3
							2	-7E+3	-67E+3	-80E+3	-86E+3
							3	-44E+3	-106E+3	-122E+3	-127E+3
							4	-49E+3	-117E+3	-131E+3	-141E+3
							5	-57E+3	-142E+3	-164E+3	-184E+3
							6	-67E+3	-186E+3	-209E+3	-221E+3
							7	-62E+3	-132E+3	-156E+3	-168E+3
							8	-70E+3	-160E+3	-191E+3	-207E+3
							9	-132E+3	-263E+3	-291E+3	-308E+3
							10	**-135E+3**	**-274E+3**	**-298E+3**	**-329E+3**
						Maximum	1	91E+3	202E+3	243E+3	270E+3
							2	74E+3	162E+3	183E+3	205E+3
							3	75E+3	163E+3	197E+3	214E+3
							4	74E+3	171E+3	192E+3	206E+3
							5	93E+3	198E+3	231E+3	245E+3
							6	100E+3	188E+3	212E+3	231E+3
							7	81E+3	194E+3	220E+3	230E+3
							8	90E+3	206E+3	235E+3	256E+3
							9	120E+3	217E+3	252E+3	262E+3
							10	**124E+3**	**235E+3**	**259E+3**	**282E+3**
10.6	16.7	7.1	12.6	13.4	13.9	Minimum	1	-19E+3	-88E+3	-108E+3	-115E+3
							2	-11E+3	-81E+3	-90E+3	-106E+3
							3	-41E+3	-100E+3	-114E+3	-121E+3
							4	-47E+3	-116E+3	-143E+3	-156E+3
							5	-50E+3	-121E+3	-134E+3	-159E+3
							6	-64E+3	-159E+3	-187E+3	-208E+3
							7	-55E+3	-119E+3	-136E+3	-144E+3
							8	-65E+3	-156E+3	-194E+3	-208E+3
							9	-117E+3	-244E+3	**-296E+3**	**-322E+3**
							10	**-125E+3**	**-254E+3**	-278E+3	-324E+3
						Maximum	1	89E+3	218E+3	269E+3	**306E+3**
							2	70E+3	174E+3	207E+3	234E+3
							3	68E+3	155E+3	190E+3	223E+3
							4	68E+3	164E+3	199E+3	223E+3
							5	79E+3	185E+3	204E+3	212E+3
							6	89E+3	190E+3	213E+3	230E+3
							7	71E+3	166E+3	194E+3	220E+3
							8	90E+3	206E+3	226E+3	240E+3
							9	109E+3	235E+3	**273E+3**	292E+3
							10	**112E+3**	**241E+3**	271E+3	296E+3

Table 11: Head on sea and open tube test results.

Appendix P: Survival tests, oblique sea, closed tube

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
9.8	13.7	8.3	14.0	14.6	15.2	Minimum	1	-58E+3	-129E+3	-149E+3	-172E+3
							2	-51E+3	-136E+3	-153E+3	-168E+3
							3	-79E+3	-172E+3	-187E+3	-208E+3
							4	-115E+3	-261E+3	-274E+3	-347E+3
							5	-97E+3	-181E+3	-207E+3	-210E+3
							6	-112E+3	-274E+3	-292E+3	-323E+3
							7	-101E+3	-182E+3	-195E+3	-214E+3
							8	-81E+3	-192E+3	-237E+3	-254E+3
							9	-54E+3	-113E+3	-129E+3	-135E+3
							10	**-184E+3**	**-413E+3**	**-447E+3**	**-450E+3**
						Maximum	1	141E+3	315E+3	332E+3	343E+3
							2	84E+3	171E+3	188E+3	197E+3
							3	137E+3	276E+3	320E+3	384E+3
							4	104E+3	203E+3	215E+3	225E+3
							5	148E+3	**329E+3**	**414E+3**	**424E+3**
							6	112E+3	219E+3	236E+3	258E+3
							7	139E+3	310E+3	384E+3	394E+3
							8	73E+3	174E+3	186E+3	193E+3
							9	58E+3	147E+3	157E+3	212E+3
							10	**153E+3**	271E+3	310E+3	342E+3
10.0	15.2	7.8	13.2	13.8	14.5	Minimum	1	-52E+3	-133E+3	-145E+3	-165E+3
							2	-46E+3	-134E+3	-151E+3	-180E+3
							3	-75E+3	-175E+3	-181E+3	-189E+3
							4	-102E+3	-246E+3	-276E+3	-279E+3
							5	-87E+3	-178E+3	-193E+3	-212E+3
							6	-104E+3	-229E+3	-244E+3	-256E+3
							7	-88E+3	-167E+3	-187E+3	-214E+3
							8	-65E+3	-167E+3	-189E+3	-202E+3
							9	-51E+3	-124E+3	-137E+3	-147E+3
							10	**-167E+3**	**-318E+3**	**-407E+3**	**-497E+3**
						Maximum	1	124E+3	**295E+3**	**319E+3**	330E+3
							2	76E+3	158E+3	173E+3	194E+3
							3	127E+3	279E+3	315E+3	327E+3
							4	105E+3	205E+3	219E+3	232E+3
							5	136E+3	284E+3	314E+3	349E+3
							6	110E+3	218E+3	229E+3	235E+3
							7	119E+3	253E+3	277E+3	**352E+3**
							8	67E+3	151E+3	169E+3	177E+3
							9	57E+3	148E+3	165E+3	169E+3
							10	**154E+3**	294E+3	311E+3	328E+3
10.0	16.7	8.1	13.7	14.6	14.8	Minimum	1	-54E+3	-133E+3	-144E+3	-145E+3
							2	-50E+3	-140E+3	-162E+3	-176E+3
							3	-65E+3	-158E+3	-178E+3	-180E+3
							4	-91E+3	-224E+3	-283E+3	-296E+3
							5	-76E+3	-167E+3	-178E+3	-185E+3
							6	-91E+3	-202E+3	-227E+3	-257E+3
							7	-76E+3	-149E+3	-157E+3	-158E+3
							8	-58E+3	-142E+3	-166E+3	-180E+3
							9	-51E+3	-125E+3	-159E+3	-168E+3
							10	**-157E+3**	**-307E+3**	**-357E+3**	**-365E+3**
						Maximum	1	113E+3	266E+3	**308E+3**	**342E+3**
							2	66E+3	149E+3	162E+3	162E+3
							3	115E+3	246E+3	254E+3	262E+3
							4	88E+3	193E+3	224E+3	240E+3
							5	112E+3	239E+3	267E+3	300E+3
							6	92E+3	191E+3	199E+3	201E+3
							7	103E+3	230E+3	245E+3	259E+3
							8	66E+3	167E+3	175E+3	178E+3
							9	53E+3	145E+3	163E+3	166E+3
							10	**145E+3**	**270E+3**	289E+3	301E+3

Table 12: Oblique sea and closed tube test results.

Appendix Q: Survival tests, oblique sea, open tube

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.1	13.7	6.9	13.2	15.2	17.0	Minimum	1	-62E+3	-133E+3	-152E+3	-163E+3
							2	-56E+3	-149E+3	-166E+3	-187E+3
							3	-78E+3	-170E+3	-210E+3	-215E+3
							4	-119E+3	-307E+3	-355E+3	-389E+3
							5	-100E+3	-194E+3	-225E+3	-237E+3
							6	-131E+3	-249E+3	-361E+3	-386E+3
							7	-109E+3	-202E+3	-209E+3	-230E+3
							8	-88E+3	-185E+3	-216E+3	-282E+3
							9	-54E+3	-130E+3	-172E+3	-200E+3
							10	**-201E+3**	**-383E+3**	**-448E+3**	**-455E+3**
						Maximum	1	135E+3	322E+3	353E+3	354E+3
							2	73E+3	175E+3	192E+3	222E+3
							3	133E+3	292E+3	350E+3	**389E+3**
							4	108E+3	213E+3	242E+3	263E+3
							5	155E+3	**329E+3**	**357E+3**	370E+3
							6	119E+3	237E+3	272E+3	313E+3
							7	145E+3	295E+3	354E+3	374E+3
							8	77E+3	148E+3	182E+3	192E+3
							9	44E+3	117E+3	129E+3	158E+3
							10	**180E+3**	307E+3	355E+3	379E+3
10.7	15.2	7.1	13.6	17.0	18.1	Minimum	1	-58E+3	-131E+3	-176E+3	-187E+3
							2	-55E+3	-162E+3	-184E+3	-187E+3
							3	-81E+3	-196E+3	-206E+3	-208E+3
							4	-112E+3	-289E+3	-309E+3	-426E+3
							5	-94E+3	-190E+3	-217E+3	-224E+3
							6	-114E+3	-222E+3	-264E+3	-389E+3
							7	-91E+3	-183E+3	-194E+3	-203E+3
							8	-74E+3	-153E+3	-189E+3	-302E+3
							9	-49E+3	-132E+3	-149E+3	-157E+3
							10	**-172E+3**	**-334E+3**	**-428E+3**	**-489E+3**
						Maximum	1	114E+3	309E+3	352E+3	354E+3
							2	69E+3	177E+3	211E+3	235E+3
							3	127E+3	289E+3	331E+3	336E+3
							4	102E+3	214E+3	227E+3	262E+3
							5	138E+3	301E+3	345E+3	374E+3
							6	109E+3	233E+3	241E+3	266E+3
							7	123E+3	227E+3	336E+3	352E+3
							8	64E+3	144E+3	177E+3	181E+3
							9	43E+3	122E+3	153E+3	158E+3
							10	**164E+3**	**369E+3**	**388E+3**	**393E+3**
10.3	16.7	7.4	11.8	12.5	12.5	Minimum	1	-60E+3	-143E+3	-154E+3	-180E+3
							2	-52E+3	-141E+3	-153E+3	-158E+3
							3	-65E+3	-184E+3	-201E+3	-226E+3
							4	-92E+3	-236E+3	-255E+3	-262E+3
							5	-78E+3	-171E+3	-188E+3	-199E+3
							6	-90E+3	-189E+3	-216E+3	-230E+3
							7	-76E+3	-156E+3	-162E+3	-169E+3
							8	-58E+3	-133E+3	-157E+3	-183E+3
							9	-56E+3	-126E+3	-134E+3	-140E+3
							10	**-149E+3**	**-288E+3**	**-332E+3**	**-399E+3**
						Maximum	1	110E+3	283E+3	297E+3	301E+3
							2	70E+3	154E+3	160E+3	162E+3
							3	109E+3	225E+3	251E+3	252E+3
							4	83E+3	193E+3	228E+3	268E+3
							5	119E+3	246E+3	276E+3	301E+3
							6	95E+3	202E+3	230E+3	243E+3
							7	102E+3	204E+3	231E+3	308E+3
							8	62E+3	138E+3	151E+3	160E+3
							9	48E+3	134E+3	154E+3	168E+3
							10	**149E+3**	**295E+3**	**330E+3**	**342E+3**

Table 13: Oblique sea and open tube test results.

Appendix R: Survival tests, beam sea, closed tube

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.1	13.7	7.3	13.9	15.3	15.4	Minimum	1	-82E+3	-167E+3	-180E+3	-186E+3
							2	-141E+3	-329E+3	-376E+3	-394E+3
							3	-156E+3	-292E+3	-300E+3	-317E+3
							4	**-207E+3**	**-425E+3**	-506E+3	**-740E+3**
							5	-157E+3	-289E+3	-306E+3	-313E+3
							6	-202E+3	-402E+3	**-517E+3**	-735E+3
							7	-92E+3	-171E+3	-182E+3	-184E+3
							8	-126E+3	-258E+3	-346E+3	-395E+3
						Maximum	1	136E+3	300E+3	332E+3	336E+3
							2	110E+3	236E+3	249E+3	271E+3
							3	212E+3	386E+3	391E+3	391E+3
							4	179E+3	329E+3	351E+3	359E+3
							5	**222E+3**	**448E+3**	**612E+3**	**682E+3**
							6	165E+3	306E+3	329E+3	358E+3
							7	138E+3	292E+3	400E+3	471E+3
							8	116E+3	217E+3	245E+3	269E+3
10.1	15.2	7.8	12.7	15.1	18.5	Minimum	1	-80E+3	-157E+3	-179E+3	-185E+3
							2	-135E+3	-262E+3	-280E+3	-297E+3
							3	-156E+3	-284E+3	-322E+3	-357E+3
							4	**-185E+3**	**-365E+3**	**-384E+3**	**-425E+3**
							5	-150E+3	-255E+3	-292E+3	-348E+3
							6	-174E+3	-345E+3	-380E+3	-404E+3
							7	-86E+3	-163E+3	-173E+3	-195E+3
							8	-109E+3	-235E+3	-254E+3	-281E+3
						Maximum	1	118E+3	261E+3	275E+3	313E+3
							2	114E+3	247E+3	273E+3	281E+3
							3	202E+3	381E+3	384E+3	387E+3
							4	169E+3	310E+3	330E+3	360E+3
							5	**203E+3**	**415E+3**	**444E+3**	**468E+3**
							6	154E+3	296E+3	317E+3	352E+3
							7	124E+3	257E+3	288E+3	309E+3
							8	104E+3	196E+3	221E+3	239E+3
10.1	16.7	7.8	12.9	14.4	17.3	Minimum	1	-63E+3	-148E+3	-219E+3	-247E+3
							2	-100E+3	-234E+3	-290E+3	-333E+3
							3	-123E+3	-277E+3	-390E+3	**-441E+3**
							4	**-131E+3**	**-321E+3**	**-412E+3**	-423E+3
							5	-115E+3	-252E+3	-343E+3	-402E+3
							6	**-131E+3**	-309E+3	-370E+3	-433E+3
							7	-66E+3	-143E+3	-177E+3	-192E+3
							8	-91E+3	-215E+3	-267E+3	-307E+3
						Maximum	1	103E+3	224E+3	318E+3	321E+3
							2	78E+3	206E+3	284E+3	314E+3
							3	**171E+3**	**383E+3**	390E+3	391E+3
							4	122E+3	270E+3	377E+3	401E+3
							5	161E+3	382E+3	**443E+3**	**461E+3**
							6	121E+3	248E+3	381E+3	402E+3
							7	89E+3	230E+3	260E+3	293E+3
							8	84E+3	186E+3	283E+3	334E+3

Table 14: Beam sea and closed tube test results.

Appendix S: Survival tests, beam sea, open tube

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.0	13.7	6.2	10.8	12.1	12.2	Minimum	1	-92E+3	-175E+3	-182E+3	-191E+3
							2	-147E+3	-305E+3	-376E+3	-437E+3
							3	-179E+3	-310E+3	-328E+3	-355E+3
							4	**-220E+3**	**-446E+3**	**-535E+3**	**-691E+3**
							5	-182E+3	-303E+3	-310E+3	-320E+3
							6	-216E+3	-443E+3	-496E+3	-676E+3
							7	-104E+3	-173E+3	-184E+3	-190E+3
							8	-135E+3	-276E+3	-298E+3	-322E+3
						Maximum	1	139E+3	308E+3	327E+3	332E+3
							2	138E+3	252E+3	281E+3	302E+3
							3	219E+3	376E+3	379E+3	381E+3
							4	186E+3	343E+3	368E+3	379E+3
							5	**230E+3**	**466E+3**	**519E+3**	**586E+3**
							6	182E+3	333E+3	356E+3	371E+3
							7	149E+3	332E+3	349E+3	389E+3
							8	125E+3	230E+3	246E+3	255E+3
10.4	15.2	6.9	11.6	12.4	12.6	Minimum	1	-88E+3	-173E+3	-196E+3	-214E+3
							2	-142E+3	-294E+3	-344E+3	-356E+3
							3	-177E+3	-289E+3	-309E+3	-364E+3
							4	**-194E+3**	**-402E+3**	-450E+3	**-496E+3**
							5	-170E+3	-292E+3	-302E+3	-361E+3
							6	-185E+3	-387E+3	**-452E+3**	-482E+3
							7	-85E+3	-173E+3	-193E+3	-205E+3
							8	-124E+3	-255E+3	-308E+3	-313E+3
						Maximum	1	132E+3	270E+3	316E+3	327E+3
							2	124E+3	220E+3	255E+3	317E+3
							3	**216E+3**	378E+3	381E+3	382E+3
							4	179E+3	327E+3	359E+3	437E+3
							5	212E+3	**457E+3**	**543E+3**	**559E+3**
							6	170E+3	300E+3	341E+3	402E+3
							7	121E+3	281E+3	331E+3	351E+3
							8	114E+3	210E+3	226E+3	268E+3
10.8	16.7	7.2	13.4	17.3	18.2	Minimum	1	-76E+3	-157E+3	-162E+3	-179E+3
							2	-125E+3	-247E+3	-272E+3	-299E+3
							3	-167E+3	-295E+3	-321E+3	-353E+3
							4	**-172E+3**	**-358E+3**	**-374E+3**	-377E+3
							5	-160E+3	-292E+3	-315E+3	-318E+3
							6	-166E+3	-349E+3	**-374E+3**	**-403E+3**
							7	-83E+3	-169E+3	-188E+3	-192E+3
							8	-104E+3	-238E+3	-262E+3	-265E+3
						Maximum	1	112E+3	242E+3	268E+3	269E+3
							2	114E+3	235E+3	253E+3	302E+3
							3	**193E+3**	368E+3	380E+3	380E+3
							4	167E+3	311E+3	325E+3	357E+3
							5	190E+3	**385E+3**	**436E+3**	**443E+3**
							6	153E+3	300E+3	338E+3	349E+3
							7	107E+3	248E+3	266E+3	319E+3
							8	96E+3	208E+3	242E+3	252E+3

Table 15: Beam sea and open tube test results.

Appendix T: Disconnected mooring line, head on sea, closed tube

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.3	16.7	7.1	12.8	13.5	13.7	Minimum	1	-27E+3	-106E+3	-119E+3	-131E+3
							2	-12E+3	-23E+3	-27E+3	-27E+3
							3	-25E+3	-82E+3	-100E+3	-109E+3
							4	-70E+3	-159E+3	-182E+3	-195E+3
							5	-68E+3	-150E+3	-160E+3	-166E+3
							6	-59E+3	-166E+3	-192E+3	-215E+3
							7	-49E+3	-113E+3	-125E+3	-138E+3
							8	-68E+3	-171E+3	-190E+3	-202E+3
							9	**-119E+3**	-258E+3	-267E+3	-273E+3
							10	**-119E+3**	**-272E+3**	**-284E+3**	**-295E+3**
						Maximum	1	92E+3	231E+3	270E+3	284E+3
							2	12E+3	46E+3	54E+3	59E+3
							3	72E+3	152E+3	166E+3	183E+3
							4	79E+3	245E+3	287E+3	310E+3
							5	54E+3	166E+3	186E+3	195E+3
							6	111E+3	267E+3	297E+3	319E+3
							7	72E+3	168E+3	195E+3	227E+3
							8	96E+3	212E+3	275E+3	317E+3
							9	**116E+3**	**282E+3**	**330E+3**	**344E+3**
							10	114E+3	265E+3	311E+3	320E+3

Table 16: Head on sea, closed tube and disconnected line 2.

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.6	16.7	7.3	14.2	15.8	16.2	Minimum	1	-22E+3	-96E+3	-118E+3	-139E+3
							2	-9E+3	-100E+3	-121E+3	-130E+3
							3	-50E+3	-124E+3	-149E+3	-161E+3
							4	-8E+3	-26E+3	-33E+3	-36E+3
							5	-38E+3	-105E+3	-130E+3	-137E+3
							6	-56E+3	-174E+3	-211E+3	-219E+3
							7	-41E+3	-96E+3	-115E+3	-121E+3
							8	-60E+3	-162E+3	-193E+3	-209E+3
							9	**-111E+3**	**-246E+3**	**-267E+3**	**-298E+3**
							10	**-111E+3**	-238E+3	-251E+3	-287E+3
						Maximum	1	105E+3	253E+3	287E+3	**383E+3**
							2	75E+3	180E+3	204E+3	227E+3
							3	66E+3	150E+3	174E+3	190E+3
							4	4E+3	10E+3	12E+3	15E+3
							5	69E+3	152E+3	214E+3	224E+3
							6	99E+3	225E+3	240E+3	257E+3
							7	65E+3	173E+3	201E+3	211E+3
							8	93E+3	250E+3	**310E+3**	326E+3
							9	106E+3	**267E+3**	287E+3	315E+3
							10	**109E+3**	250E+3	262E+3	320E+3

Table 17: Head on sea, closed tube and disconnected line 4.

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.3	16.7	7.8	13.8	15.2	16.0	Minimum	1	-16E+3	-81E+3	-100E+3	-103E+3
							2	-13E+3	-86E+3	-99E+3	-103E+3
							3	-49E+3	-116E+3	-135E+3	-143E+3
							4	-47E+3	-129E+3	-153E+3	-160E+3
							5	-64E+3	-142E+3	-178E+3	-182E+3
							6	-7E+3	-18E+3	-22E+3	-24E+3
							7	-32E+3	-87E+3	-97E+3	-103E+3
							8	-73E+3	-171E+3	-203E+3	-219E+3
							9	**-120E+3**	**-267E+3**	**-295E+3**	**-301E+3**
							10	-106E+3	-249E+3	-277E+3	-283E+3
						Maximum	1	85E+3	196E+3	249E+3	266E+3
							2	66E+3	156E+3	191E+3	199E+3
							3	80E+3	168E+3	191E+3	205E+3
							4	68E+3	182E+3	206E+3	230E+3
							5	87E+3	192E+3	208E+3	226E+3
							6	5E+3	11E+3	12E+3	15E+3
							7	62E+3	144E+3	164E+3	178E+3
							8	104E+3	251E+3	270E+3	277E+3
							9	**118E+3**	**266E+3**	**307E+3**	**346E+3**
							10	95E+3	233E+3	244E+3	249E+3

Table 18: Head on sea, closed tube and disconnected line 6.

Appendix U: Disconnected mooring line, oblique sea, closed tube

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.3	16.7	7.9	13.4	14.8	17.5	Minimum	1	-14E+3	-100E+3	-111E+3	-116E+3
							2	-10E+3	-71E+3	-89E+3	-93E+3
							3	-34E+3	-95E+3	-114E+3	-136E+3
							4	-44E+3	-115E+3	-188E+3	-204E+3
							5	-56E+3	-128E+3	-180E+3	-196E+3
							6	-69E+3	-167E+3	-209E+3	-236E+3
							7	-57E+3	-138E+3	-179E+3	-250E+3
							8	-7E+3	-19E+3	-24E+3	-35E+3
							9	**-172E+3**	**-425E+3**	**-436E+3**	**-438E+3**
							10	-107E+3	-212E+3	-257E+3	-292E+3
						Maximum	1	101E+3	254E+3	307E+3	311E+3
							2	68E+3	188E+3	261E+3	261E+3
							3	70E+3	191E+3	228E+3	249E+3
							4	71E+3	198E+3	267E+3	307E+3
							5	112E+3	**279E+3**	323E+3	350E+3
							6	78E+3	220E+3	247E+3	304E+3
							7	41E+3	130E+3	171E+3	204E+3
							8	5E+3	11E+3	13E+3	15E+3
							9	**113E+3**	267E+3	**345E+3**	**378E+3**
							10	70E+3	200E+3	212E+3	218E+3

Table 19: Head on sea, closed tube and disconnected line 8.

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.2	16.7	7.0	12.7	14.9	15.4	Minimum	1	-8E+3	-76E+3	-93E+3	-101E+3
							2	-5E+3	-64E+3	-77E+3	-94E+3
							3	-55E+3	-122E+3	-139E+3	-144E+3
							4	-52E+3	-132E+3	-146E+3	-159E+3
							5	-63E+3	-150E+3	-176E+3	-187E+3
							6	-67E+3	-208E+3	-231E+3	-253E+3
							7	-75E+3	-144E+3	-162E+3	-174E+3
							8	-87E+3	-187E+3	-217E+3	-237E+3
							9	-122E+3	-279E+3	-312E+3	-322E+3
							10	**-140E+3**	**-298E+3**	**-325E+3**	**-361E+3**
						Maximum	1	102E+3	227E+3	272E+3	**317E+3**
							2	81E+3	169E+3	208E+3	250E+3
							3	98E+3	194E+3	233E+3	258E+3
							4	82E+3	173E+3	201E+3	224E+3
							5	106E+3	227E+3	272E+3	301E+3
							6	100E+3	200E+3	251E+3	273E+3
							7	102E+3	228E+3	254E+3	279E+3
							8	106E+3	234E+3	260E+3	288E+3
							9	106E+3	225E+3	250E+3	264E+3
							10	**122E+3**	**240E+3**	**279E+3**	285E+3

Table 20: Head on sea, closed tube and disconnected line 10.

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.4	16.7	7.9	13.3	14.9	16.3	Minimum	1	-13E+3	-27E+3	-32E+3	-34E+3
							2	-48E+3	-154E+3	-163E+3	-167E+3
							3	-77E+3	-190E+3	-198E+3	-204E+3
							4	-122E+3	-281E+3	-314E+3	-333E+3
							5	-62E+3	-139E+3	-167E+3	-175E+3
							6	-94E+3	-226E+3	-246E+3	-278E+3
							7	-57E+3	-133E+3	-142E+3	-168E+3
							8	-59E+3	-145E+3	-181E+3	-212E+3
							9	-61E+3	-156E+3	-174E+3	-180E+3
							10	**-150E+3**	**-358E+3**	**-406E+3**	**-445E+3**
						Maximum	1	10E+3	58E+3	81E+3	96E+3
							2	72E+3	165E+3	191E+3	208E+3
							3	134E+3	290E+3	293E+3	294E+3
							4	117E+3	223E+3	239E+3	283E+3
							5	98E+3	239E+3	275E+3	289E+3
							6	100E+3	208E+3	217E+3	263E+3
							7	84E+3	231E+3	264E+3	278E+3
							8	65E+3	151E+3	166E+3	189E+3
							9	58E+3	158E+3	198E+3	212E+3
							10	**144E+3**	**299E+3**	**327E+3**	**346E+3**

Table 21: Oblique sea, closed tube and disconnected line 1.

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
9.5	16.7	6.9	12.7	14.0	15.8	Minimum	1	-55E+3	-123E+3	-140E+3	-149E+3
							2	-43E+3	-121E+3	-151E+3	-170E+3
							3	-63E+3	-152E+3	-166E+3	-179E+3
							4	-86E+3	**-217E+3**	**-265E+3**	**-316E+3**
							5	-57E+3	-138E+3	-155E+3	-172E+3
							6	**-93E+3**	-213E+3	-247E+3	-263E+3
							7	-47E+3	-105E+3	-121E+3	-130E+3
							8	-60E+3	-161E+3	-178E+3	-207E+3
							9	-56E+3	-140E+3	-159E+3	-178E+3
							10	-7E+3	-26E+3	-39E+3	-52E+3
						Maximum	1	**102E+3**	**257E+3**	**312E+3**	**379E+3**
							2	56E+3	142E+3	159E+3	171E+3
							3	99E+3	225E+3	270E+3	318E+3
							4	85E+3	188E+3	205E+3	219E+3
							5	83E+3	193E+3	239E+3	256E+3
							6	99E+3	205E+3	229E+3	243E+3
							7	85E+3	212E+3	274E+3	296E+3
							8	68E+3	157E+3	174E+3	181E+3
							9	58E+3	152E+3	177E+3	199E+3
							10	6E+3	14E+3	17E+3	18E+3

Table 22: Oblique sea, closed tube and disconnected line 10.

Appendix V: Disconnected mooring line, beam sea, closed tube

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
9.9	13.7	6.2	10.6	11.7	12.5	Minimum	1	-8E+3	-20E+3	-23E+3	-27E+3
							2	-94E+3	-212E+3	-238E+3	-254E+3
							3	-118E+3	-263E+3	-283E+3	-295E+3
							4	**-192E+3**	**-500E+3**	**-508E+3**	**-514E+3**
							5	-120E+3	-241E+3	-270E+3	-288E+3
							6	-136E+3	-304E+3	-345E+3	-365E+3
							7	-78E+3	-157E+3	-175E+3	-189E+3
							8	-92E+3	-215E+3	-247E+3	-272E+3
						Maximum	1	10E+3	44E+3	58E+3	65E+3
							2	82E+3	186E+3	213E+3	220E+3
							3	151E+3	249E+3	251E+3	251E+3
							4	128E+3	301E+3	333E+3	350E+3
							5	**164E+3**	**350E+3**	**395E+3**	**414E+3**
							6	124E+3	254E+3	285E+3	296E+3
							7	106E+3	228E+3	255E+3	284E+3
							8	84E+3	192E+3	221E+3	240E+3

Table 23: Beam sea, closed tube and disconnected line 1.

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
13.7	8.1	15.3	17.3	18.4	13.7	Minimum	1	-49E+3	-126E+3	-135E+3	-147E+3
							2	-19E+3	-71E+3	-88E+3	-106E+3
							3	**-199E+3**	**-483E+3**	**-491E+3**	**-494E+3**
							4	-163E+3	-354E+3	-398E+3	-421E+3
							5	-131E+3	-275E+3	-302E+3	-309E+3
							6	-134E+3	-299E+3	-335E+3	-347E+3
							7	-69E+3	-154E+3	-170E+3	-176E+3
							8	-99E+3	-218E+3	-246E+3	-258E+3
						Maximum	1	89E+3	202E+3	239E+3	246E+3
							2	10E+3	24E+3	29E+3	29E+3
							3	**195E+3**	**436E+3**	**485E+3**	**512E+3**
							4	153E+3	309E+3	337E+3	353E+3
							5	178E+3	388E+3	416E+3	431E+3
							6	128E+3	258E+3	294E+3	311E+3
							7	94E+3	225E+3	248E+3	262E+3
							8	101E+3	213E+3	236E+3	266E+3

Table 24: Beam sea, closed tube and disconnected line 2.

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.5	13.7	6.7	13.0	14.9	17.9	Minimum	1	-88E+3	-199E+3	-215E+3	-227E+3
							2	**-195E+3**	**-439E+3**	**-451E+3**	**-471E+3**
							3	-11E+3	-27E+3	-30E+3	-34E+3
							4	-115E+3	-280E+3	-330E+3	-366E+3
							5	-131E+3	-281E+3	-311E+3	-329E+3
							6	-139E+3	-315E+3	-380E+3	-450E+3
							7	-65E+3	-151E+3	-166E+3	-173E+3
							8	-94E+3	-222E+3	-290E+3	-295E+3
						Maximum	1	126E+3	220E+3	223E+3	225E+3
							2	89E+3	310E+3	346E+3	364E+3
							3	8E+3	53E+3	81E+3	119E+3
							4	100E+3	233E+3	268E+3	276E+3
							5	**183E+3**	**408E+3**	**473E+3**	**503E+3**
							6	127E+3	294E+3	332E+3	352E+3
							7	94E+3	204E+3	253E+3	268E+3
							8	85E+3	206E+3	230E+3	242E+3

Table 25: Beam sea, closed tube and disconnected line 3.

Sea state		Heave movements of BuOY 1				Peak mooring forces					
H_s [m]	T_p [s]	X_m [m]	$X_{5\%}$ [m]	$X_{2\%}$ [m]	$X_{1\%}$ [m]		Line No.	F_m [N]	$F_{5\%}$ [N]	$F_{2\%}$ [N]	$F_{1\%}$ [N]
10.5	13.7	8.2	14.3	16.0	18.9	Minimum	1	-126E+3	**-380E+3**	**-411E+3**	**-421E+3**
							2	-115E+3	-250E+3	-283E+3	-312E+3
							3	-109E+3	-237E+3	-261E+3	-277E+3
							4	-10E+3	-35E+3	-49E+3	-52E+3
							5	-128E+3	-274E+3	-312E+3	-330E+3
							6	**-163E+3**	-330E+3	-358E+3	-390E+3
							7	-75E+3	-158E+3	-180E+3	-189E+3
							8	-86E+3	-198E+3	-235E+3	-252E+3
						Maximum	1	163E+3	334E+3	365E+3	410E+3
							2	104E+3	229E+3	255E+3	266E+3
							3	133E+3	308E+3	342E+3	396E+3
							4	5E+3	15E+3	17E+3	17E+3
							5	**185E+3**	**382E+3**	**439E+3**	**479E+3**
							6	160E+3	314E+3	351E+3	374E+3
							7	106E+3	225E+3	249E+3	279E+3
							8	84E+3	198E+3	226E+3	243E+3

Table 26: Beam sea, closed tube and disconnected line 4.

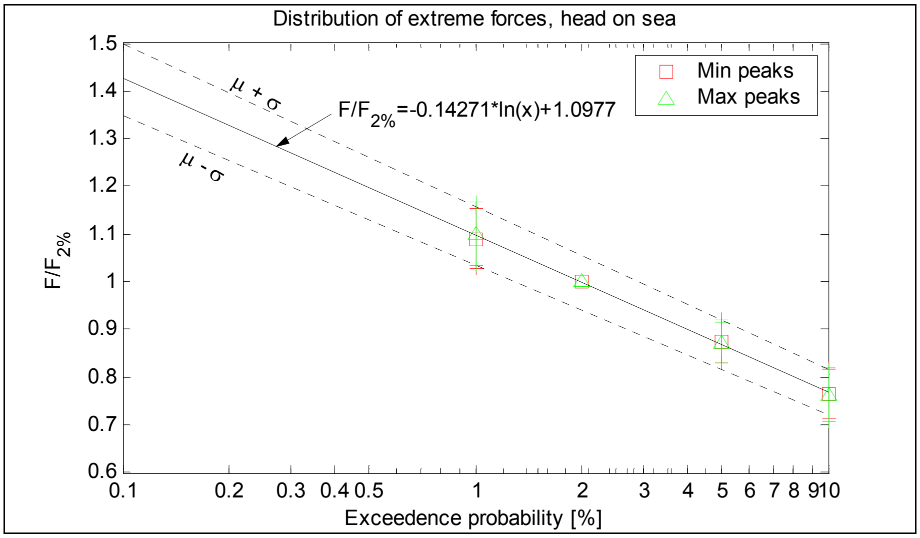
Appendix W: Disconnected mooring line, amplification factors

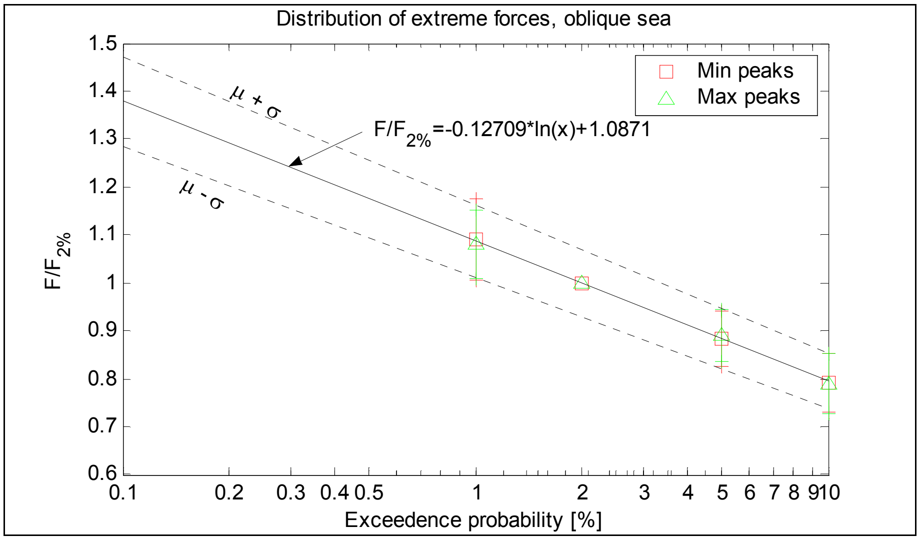
The mooring forces with disconnected mooring line is related to the situation with no disconnected lines. Amplification factors for wave induced mooring forces are given in percentage.

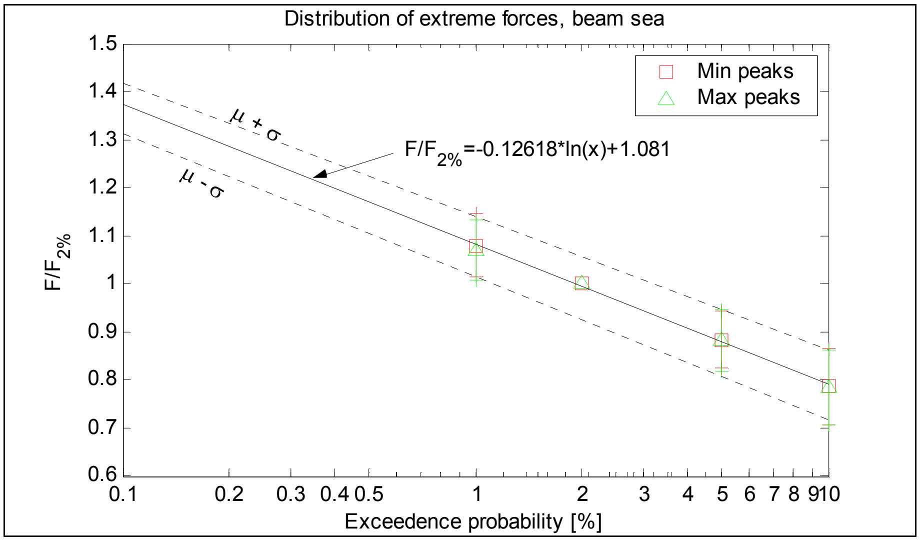
			Disconnected line no.										
			Head on sea					Oblique sea		Beam sea			
			2	4	6	8	10	1	10	1	2	3	4
Line no.	Min	1	120	119	100	111	136	0	97	0	62	98	**188**
		2	0	139	113	102	119	100	93	82	0	156	98
		3	85	128	115	97	100	111	93	72	126	0	67
		4	142	0	119	147	94	111	94	123	97	80	0
		5	118	96	131	133	105	94	87	79	88	91	91
		6	112	123	0	122	101	108	109	93	91	103	97
		7	102	93	79	146	114	91	77	99	96	94	102
		8	114	116	121	0	89	109	107	93	92	108	88
		9	99	99	109	**161**	89	109	100				
		10	109	97	107	99	0	**114**	0				
	Max	1	112	120	104	128	98	0	101	0	75	70	115
		2	0	110	103	141	114	118	98	75	0	122	90
		3	97	101	111	133	99	116	106	64	**124**	0	88
		4	148	0	106	138	104	107	91	88	90	71	0
		5	91	105	102	**158**	101	103	90	89	94	107	99
		6	148	120	0	123	120	109	115	75	77	87	92
		7	99	102	84	87	107	108	112	98	95	97	95
		8	120	136	118	0	86	95	100	78	83	81	80
		9	135	118	126	141	127	**122**	109				
		10	127	107	99	86	10	113	0				

Table 27: Amplification of wave induced mooring forces due to disconnected mooring line, closed tube tests.

Appendix X: Distribution of extreme forces



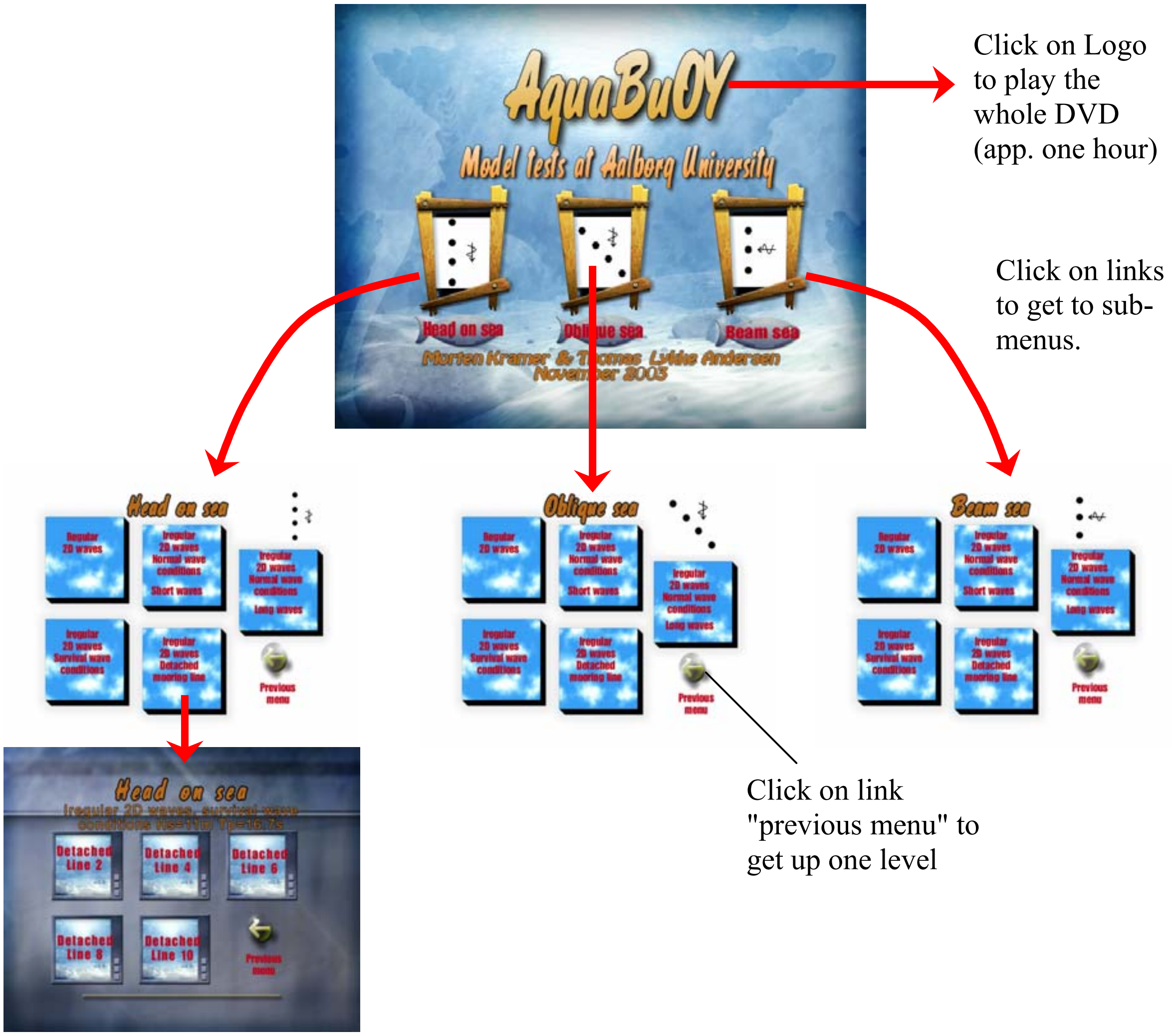




Appendix Y: DVD video contents

Video on the DVD shows testing on AquaBuOY with closed tube. The DVD contains a menu system to guide the user to a certain chapter. A certain chapter can also be reached by using the table on the following page.

The DVD is using the DVD-R format, which is compatible with about 91% of all DVD Players and most DVD-ROMs. DVD-R was the first DVD format, and it is the most universally used format.



Click on Logo to play the whole DVD (app. one hour)

Click on links to get to sub-menus.

Click on link "previous menu" to get up one level

Chapter	Direction	Test type	Wave type	Hs, H	Tp, T	Comments
1-2	Head on sea	Regular waves	2D Regular	3	7	
3	Head on sea	Regular waves	2D Regular	3	8	
4	Head on sea	Regular waves	2D Regular	3	9	
5	Head on sea	Regular waves	2D Regular	3	10	
6	Head on sea	Normal sea conditions	2D Short irregular	1	7.7	
7	Head on sea	Normal sea conditions	2D Short irregular	2	8.7	
8	Head on sea	Normal sea conditions	2D Short irregular	3	9.5	
9	Head on sea	Normal sea conditions	2D Short irregular	4	10.5	
10	Head on sea	Normal sea conditions	2D Short irregular	5	11.5	
11	Head on sea	Normal sea conditions	2D Long irregular	1	9.1	
12	Head on sea	Normal sea conditions	2D Long irregular	2	10.1	
13	Head on sea	Normal sea conditions	2D Long irregular	3	10.9	
14	Head on sea	Normal sea conditions	2D Long irregular	4	11.9	
15	Head on sea	Normal sea conditions	2D Long irregular	5	12.9	
16	Head on sea	Survival sea conditions	2D Irregular	11	13.7	
17	Head on sea	Survival sea conditions	2D Irregular	11	15.2	
18	Head on sea	Survival sea conditions	2D Irregular	11	16.7	
19	Head on sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 2
20	Head on sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 4
21	Head on sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 6
22	Head on sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 8
23	Head on sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 10
24	Oblique sea	Regular waves	2D Regular	3	7	
25	Oblique sea	Regular waves	2D Regular	3	8	
26	Oblique sea	Regular waves	2D Regular	3	9	
27	Oblique sea	Regular waves	2D Regular	3	10	
28	Oblique sea	Normal sea conditions	2D Short irregular	1	7.7	
29	Oblique sea	Normal sea conditions	2D Short irregular	2	8.7	
30	Oblique sea	Normal sea conditions	2D Short irregular	3	9.5	
31	Oblique sea	Normal sea conditions	2D Short irregular	4	10.5	
32	Oblique sea	Normal sea conditions	2D Short irregular	5	11.5	
33	Oblique sea	Normal sea conditions	2D Long irregular	1	9.1	
34	Oblique sea	Normal sea conditions	2D Long irregular	2	10.1	
35	Oblique sea	Normal sea conditions	2D Long irregular	3	10.9	
36	Oblique sea	Normal sea conditions	2D Long irregular	4	11.9	
37	Oblique sea	Normal sea conditions	2D Long irregular	5	12.9	
38	Oblique sea	Survival sea conditions	2D Irregular	11	13.7	
39	Oblique sea	Survival sea conditions	2D Irregular	11	15.2	
40	Oblique sea	Survival sea conditions	2D Irregular	11	16.7	
41	Oblique sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 1
42	Oblique sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 10
43	Beam sea	Regular waves	2D Regular	3	7	
44	Beam sea	Regular waves	2D Regular	3	8	
45	Beam sea	Regular waves	2D Regular	3	9	
46	Beam sea	Regular waves	2D Regular	3	10	
47	Beam sea	Normal sea conditions	2D Short irregular	1	7.7	
48	Beam sea	Normal sea conditions	2D Short irregular	2	8.7	
49	Beam sea	Normal sea conditions	2D Short irregular	3	9.5	
50	Beam sea	Normal sea conditions	2D Short irregular	4	10.5	
51	Beam sea	Normal sea conditions	2D Short irregular	5	11.5	
52	Beam sea	Normal sea conditions	2D Long irregular	1	9.1	
53	Beam sea	Normal sea conditions	2D Long irregular	2	10.1	
54	Beam sea	Normal sea conditions	2D Long irregular	3	10.9	
55	Beam sea	Normal sea conditions	2D Long irregular	4	11.9	
56	Beam sea	Normal sea conditions	2D Long irregular	5	12.9	
57	Beam sea	Survival sea conditions	2D Irregular	11	13.7	
58	Beam sea	Survival sea conditions	2D Irregular	11	15.2	
59	Beam sea	Survival sea conditions	2D Irregular	11	16.7	
60	Beam sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 1
61	Beam sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 2
62	Beam sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 3
63	Beam sea	Survival sea conditions	2D Irregular	11	16.7	Detached mooring line 4

Table 28: Chapters on DVD.