Graphical analysis: lifeboat evacuation test program in ice

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GRAPHICAL ANALYSIS: LIFEBOAT EVACUATION
Test Program In Ice

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SUMMARY

In an event of an emergency situation on an offshore vessel or installation, the evacuation must occur in the conditions that prevail at the time of the emergency. Very little, to date is known about the effects of ice conditions on the performance of a lifeboat in an evacuation. In 2003, Research Officers Antonio Simões Ré, and Dr. Brian Veitch headed an experimental study with the purpose of establishing performance limits for conventional lifeboats in ice. The variables tested were the concentration, thickness and size of the ice floes, as well as the effect that additional power had on the lifeboats performance. Testing involved the operation of a 1:13 model scale lifeboat inside the Institute for Marine Dynamics ice tank. This wide scope of research involved multiple other smaller analysis projects, including the analysis of the path length and time required for the lifeboat to reach certain critical boundaries from danger.

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GRAPHICAL ANALYSIS: LIFEBOAT EVACUATION TEST PROGRAM IN ICE

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1.0 SUMMARY

In an event of an emergency situation on an offshore vessel or installation, the evacuation must occur in the conditions that prevail at the time of the emergency. Very little, to date is known about the effects of ice conditions on the performance of a lifeboat in an evacuation. In 2003, Research Officers Antonio Simões Ré, and Dr. Brian Veitch headed an experimental study with the purpose of establishing performance limits for conventional lifeboats in ice. The variables tested were the concentration, thickness and size of the ice floes, as well as the effect that additional power had on the lifeboats performance. Testing involved the operation of a 1:13 model scale lifeboat inside the Institute for Marine Dynamics ice tank. This wide scope of research involved multiple other smaller analysis projects, including the analysis of the path length and time required for the lifeboat to reach certain critical boundaries from danger.

Using position graphs produced by the computer program IGOR Pro, the path lengths and times were found at the splash-down boundary (15m radius from the splash down point), as well as 25, 50, and 75m from splash down - point at which the lifeboat initially enters the water. It was found that the variable with the most effect was the concentration of the ice. Higher concentrations generally lead to longer path lengths as well as more time required to reach the listed boundaries. Ice thickness also resisted the motion of the lifeboat but had more effect on the time then it did on the path length. Surprisingly, it was discovered that the addition of power to the lifeboat had very little effect to its path length, while providing only small declines in its time.

This being a project used in conjunction with others in a larger scope of research, recommendations need to be made to ensure that improvements are made in each successive phase of the overall research study. These suggestions include the elimination of solid barriers surrounding the pack ice during testing, and more consistency with the production of graphs with each test run.

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ACKNOWLEDGEMENTS

A Special thank you is offered to Mr. Antonio Simões Ré for providing the opportunity to take part in this project and also for his extended help in the development of this report and throughout the work term.

1.0 INTRODUCTION

1.1 ABSTRACT

In an incident of emergency on an offshore vessel or installation, the evacuation must occur in the conditions that exist at the time of the crisis. Common sense would tell us that the presence of ice could limit the utility and effectiveness of conventional evacuation systems.

1.2 BACKROUND

In 2003, Antonio Simões Ré and Dr. Brian Veitch carried out an experimental study attempting to help define the effects of ice conditions on the operation of a TEMPSC (totally enclosed motor propelled survival craft– shown in Appendix A) commonly known as a lifeboat. The experiments main objective was to define the performance boundaries of a common type of lifeboat, and therefore focused on a limited number of variables. Firstly, the effect of ice conditions (namely the concentration, size, and thickness of the pack ice) on the lifeboat's performance was tested. A second variable involved the effect that additional power had on the lifeboat's performance. The results obtained by this experiment are an initial step in establishing performance limits for conventional lifeboats in ice.

1.3 PROJECT INFORMATION

During the testing process, x, y graphs of each test run, such as the one shown in Figure 1.1 were created using the computer program Igor Pro. One of the points of interest of the experiments research officer, Antonio Simões Ré, and Dr. Brian Veitch was the path length of each test run, as well as the time required to reach certain boundaries from the initial point where the lifeboat enters the water. These boundaries where at splash down border, (15m radius from splash point) 25, 50, and 75 meters from the splash point. This analysis required new knowledge of the Igor Pro computer program, as well as background information as to what types of graphs each test run included, and what each graph represented. All results were to be recorded in an excel spreadsheet and reported to the research officers within a two week period of when the project was assigned.

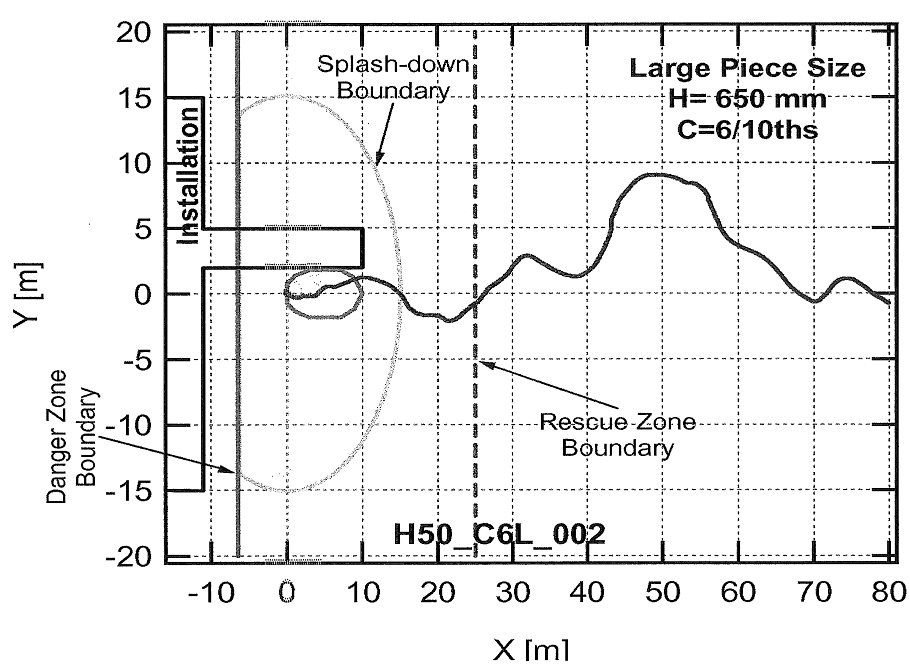


Figure 1.1: X, Y graph created in Igor Pro

2.0 GRAPHICAL ANALYSIS OF TEMPSC EXPERIMENTAL RUNS IN ICE

2.1 FAMILIARIZATION

Being a newcomer to the Institute for Ocean Technology, and therefore a newcomer to the EER research team, a lot of initial work leading up to this project was of familiarization. A lot of reading needed to be done, about such things as prior ice evacuation reports that both Simões Ré and Veitch had published, as well as publications outlining the basics of the Launch system used in these experimental tests. Also, videos and pictures, such as the one shown in appendix D were observed to become familiar with the manner in which these tests were conducted. In addition to this, in order to analyze the position graphs and convert their data into numbers, a certain comfort level needed to be acquired using the computer program Igor Pro. Once all the required learning was complete, actual analysis began.

2.2 USE OF IGOR PRO

In this particular study, information was collected from the lifeboat in the form of an Igor Pro experiment, meaning that each test run that was conducted created multiple graphs, supplying information such as the x, y, and z position coordinates of the lifeboat in relation to the davit release point (point at which the lifeboat begins to be lowered). All of the position information comes from an optical tracking system, Qualisys, which operates under the idea of tracking several markers on the lifeboat as it travels, picking up the reflective signal 50 times per second (each signal represents a separate Igor point) creating a smooth graph of the path the lifeboat takes through the ice covered water.

2.3 PROCESS OF FINDING PATH LENGTH AND TIME

The Igor Pro program also allows you to plot any measured value of qualisys against any other measured value it has collected within the experiment. This aspect of the program was used to find additional information about each test run. For example, plotting the z position against time created a graph that was used to find the Igor points and time of the lifeboats *Splash Down*, and *Davit Release*, which are defined below.

1. Splash Down: Point at which the lifeboat first enters the water.
2. Davit Release: Point at which the lifeboat is released from the davit launching system and free in the water.

This information was essential to the analysis because all the motion of the lifeboat prior to these points were of no interest to this project. Instead, all of these Igor points and the time elapsed during the lowering process were removed from further analysis. Next, the Igor points corresponding to the splash down border, as well as the 25, 50, and 75m borders were found and recorded. Using these points, and a tracking tool from the computer program, the path length (distance) of the lifeboat from the splash down point was established. If the progress of the lifeboat ceased (usually due to higher concentrations of pack ice), prior to reaching a predetermined distance of 75m, then the test run was recorded as a fail, and no further analysis was conducted. An example of a fail run is shown in Appendix B.

Igor Pro also provides the option to write procedures within an experiment, which will automatically perform certain tasks so they do not have to be performed manually. This aspect of the program was especially taken advantage of when loading graphs needed to find the Splash Down and Davit Release times and Igor points.

In addition, knowing that 50 Igor points were collected per second, the time at each boundary was found by a simple calculation relating the Igor point at that position to time. These results of path length and time were then recorded in an excel spreadsheet containing the results of all 87 test runs, shown in Appendix C.

2.4 RESULTS AND ANALYSIS

The next component of the project was that of analysis. It was found that the path lengths and times of the TEMPSC test runs in ice were directly proportional to the concentration, and thickness of the ice. In the lowest concentrations and thickness used in the testing process, the path length (distance) of the lifeboat to reach certain points was very smooth, and very similar to the horizontal displacement of the boat from its splash point. In higher concentrations and thickness however, the path lengths were substantially greater than the horizontal displacement. It was interpreted that these results were due to the resistance that the ice floes imposed on the lifeboat model. With thinner, less concentrated ice coverage, the path of the lifeboat was very straight, as exposure to this ice offered little opposition to the lifeboat. In thicker, more concentrated ice floes however, the course of the lifeboat could be described as very meandering, as the boat zigzagged through the ice floe's in search of a path of less resistance. In addition to this, it was discovered that the concentration of the ice had a much larger impact on the performance of the lifeboat than that of the ice piece size or thickness, with regards to path length and time. It was concluded that this was due to the ice locking together as the lifeboat attempted to plow through the ice. The lifeboat would then be forced to maneuver around the highly packed ice to make any progress. Although thicker, larger pieces of ice were heavier and therefore created more resistance, in lower concentrations this trend of ice pieces locking together wouldn't occur and the lifeboat was able to make its destination without substantial meandering.

The effect of additional power on the path length and time was also analyzed, producing somewhat surprising results. Firstly, additional power seemed to have very little influence on the path length of the lifeboat. In some cases, increasing the power by a factor of four and testing it in the same concentration and thickness of ice resulted in almost identical path lengths. Although the lifeboat had more power, it seemed like the type of ice coverage still ultimately controlled the course of the boat. Small changes however, were found in the time required to reach each boundary as the power increased. Although the time decreased a little, it was not substantial considering that the powers were increasing by two, three, and four fold.

2.0 CONCLUSIONS

This particular sub-project is one that is required for use in conjunction with other similar projects for a larger scope of research. This research is a study to help define the effects that certain ice conditions have on the performance of a TEMPSC, commonly known as a lifeboat. The main variables tested in this project were the concentration, size, and thickness of ice coverage, as well as additional power to the lifeboat. The main objective was to learn how these variables affected the path length as well as the time required to reach splashdown, 25, 50, and 75m borders within the ice field. The effects of each variable are described below:

3.1 ICE CONCENTRATION

Ice concentration seemed to be the largest factor with regards to resisting the lifeboats movement. Results showed that in higher concentrations of ice, both path lengths and time required to reach each destination point were substantially greater. This was largely due to the locking together of ice pieces, gradually creating a higher concentration ice barrier. If this barrier didn't totally prevent the lifeboat from operating, it would at least cause it to maneuver to an area of less resistance.

3.2 ICE SIZE AND THICKNESS

Ice size and thickness also impeded the motion of the lifeboat, but not too as large of scale as some higher concentrations. In thicker, larger pieces of ice, the lifeboat seemed to have less of a problem remaining on a straight course. Instead, the problem occurred in the lifeboats ability to power through the ice floes. The heavier pieces of ice were more difficult to move, but when in lower concentrations, time was much more effected than the lifeboats path length.

3.3 ADDITIONAL POWER

Additional power to the TEMPSC proved to have minor effects on its performance, if any. Testing showed that an increase of power had almost no effect on the lifeboats path length. Regardless of the power added, it seemed as if the type of ice coverage still determined the course of the lifeboat. The time required to reach the splashdown border, 25, 50, and 75m boundaries, did decrease a little with the additional power. This change was not substantial, considering the power was increased by factors of two, three, and even four. These results will be combined with those of other sub-projects within this experimental study. Once all of the results are obtained, they will be used as an initial step in establishing performance limits for conventional lifeboats in ice.

3.0 RECOMMENDATIONS

Due to the fact that this particular sub-project is one that is required for use in conjunction with other sub-projects, it is important that improvements be made in each successive phase of the overall research study. This is necessary in order to be successful in producing accurate results, and eventually establishing performance limits for conventional lifeboats in ice. Similar to most projects conducted at IOT, the Ice Evacuation project must improve test set up and analysis with every successive phase the project enters. Below are a few suggestions where improvements should be made.

- In creating the testing area in ice, there should be no boundaries preventing the ice pieces from moving (i.e. the test area should be increased so effects are minimized). The suggestion is to make the test area larger, or to at least have one end of the test area free of a barrier.

- With regards to analysis, for each test run conducted, the same type of graphs should be produced, regardless of the type of run. Information such as splash down point as well as the davit release would have been more consistent with each run, if the same type of graphs were available to use.

5.0 REFERENCES

- M. Lau, S. Henley, (June 22, 2004) *"Numerical Simulation of Lifeboat Performance in Pack Ice"*

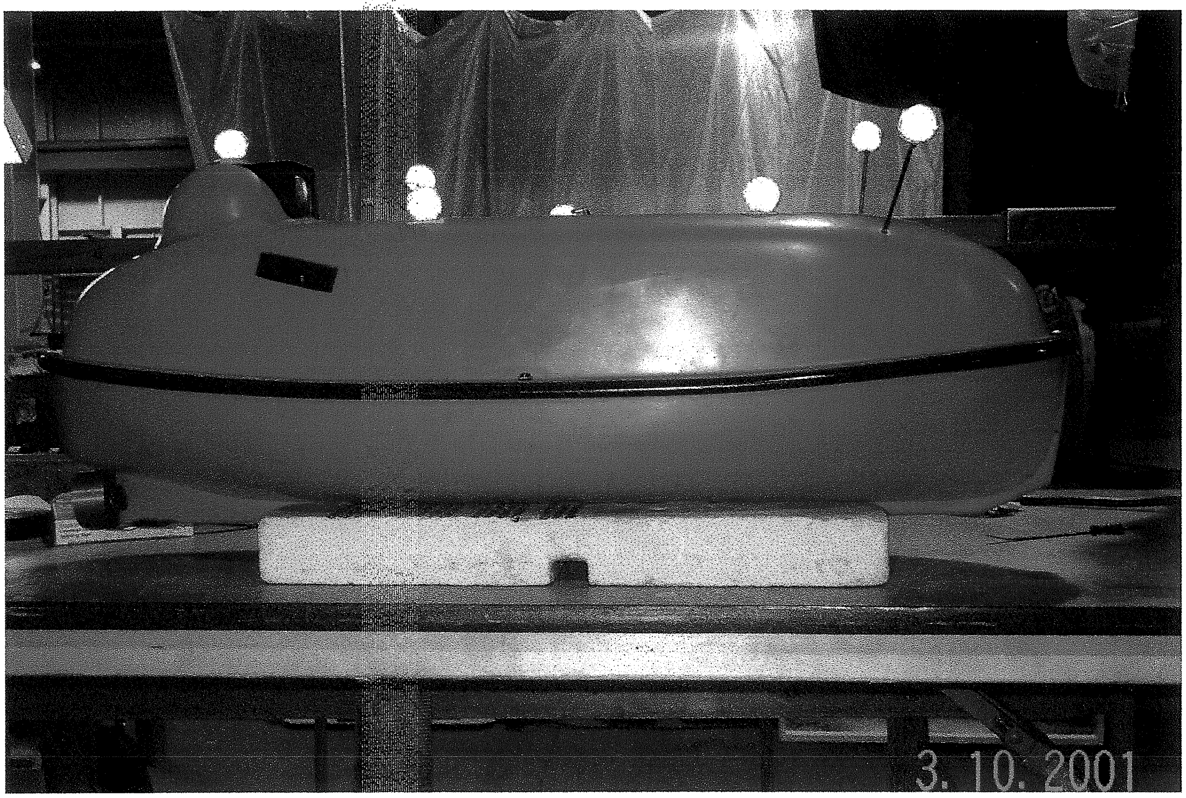
- Simões Ré, A., Veitch, B. 2003. "*Performance Limits for Evacuation Systems in Ice*" Proceedings, Port and Ocean Engineering under Arctic Conditions '03

- Simões Ré, A., Veitch, B., Elliot, B., Mulrooney, S. 2003. *"Model Testing of an Evacuation System in Ice Covered Waters."* IOT/NRC Report TR-2003-03, 31pp.

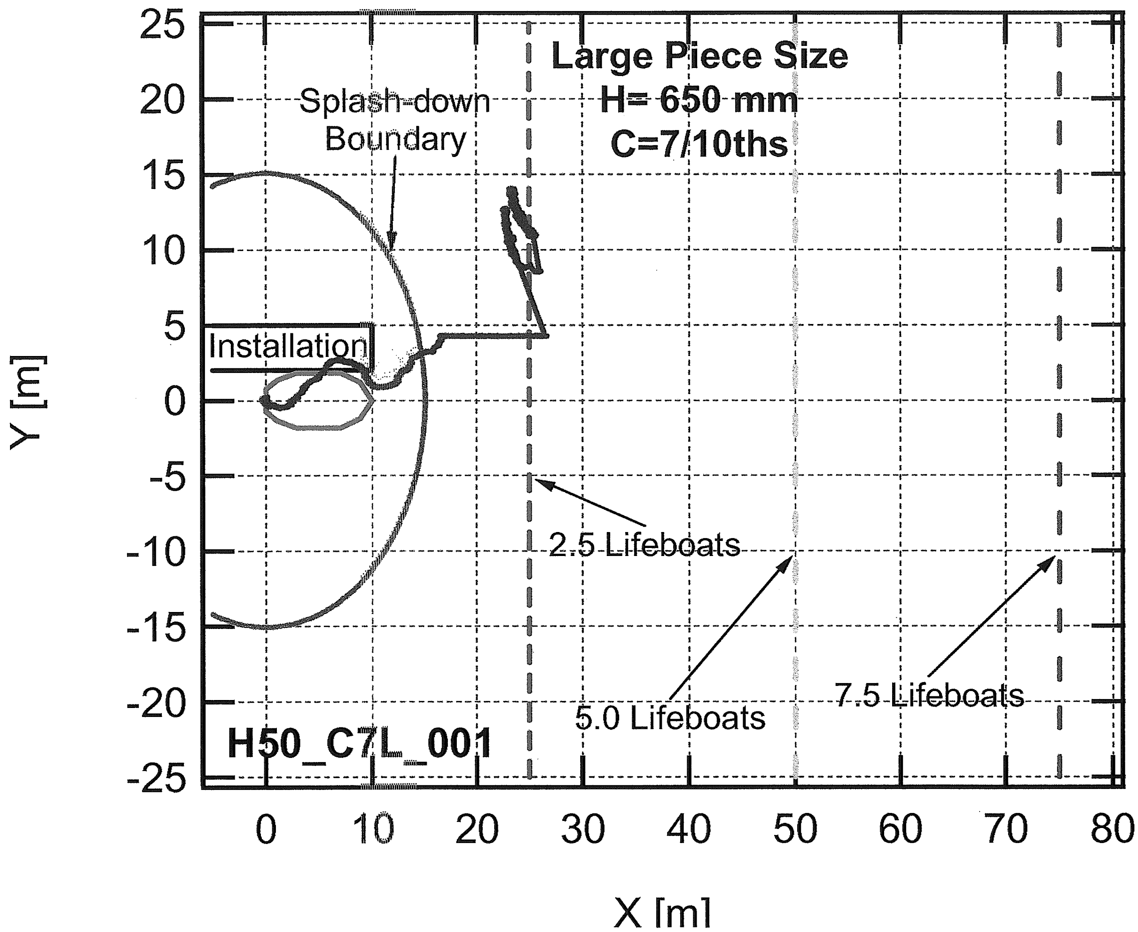
- Simões Ré, A., Veitch, B., *"Lifeboat Evacuation Performance in a Range of Environmental Condidions*," Institute for Marine Dynamics, St. John's, NL, (2001)

APPENDICES

Appendix A: The 1:13 Model Scale TEMPSC used in testing



Appendix B: Position Graph of a Failed Test Run



Appendix C: Table of Results Obtained from Path length / Time Project

Run Number	Boundary Crossing Time [s]				TEMPSC Travel [m]			
	Splash [s]	25m [s]	50m [s]	75m [s]	Splash Splash	Splash 25m	Splash 50m	Splash 75m
H25_C9S_001	-	-	-	-	F @ 0.509m	-	-	-
H25_C8S_001	-	-	-	-	F @ 11.24m	-	-	-
H25_C8S_002	-	-	-	-	F @ 1.626m	-	-	-
H25_C8S_003	-	-	-	-	F @ 0.410m	-	-	-
H25_C7S_001	102.40	150.64	290.82	335.24	23.833	43.008	78.148	105.913
H25_C7S_002	-	-	-	-	F @ 5.831m	-	-	-
H25_C7S_003	27.83	39.73	81.774	132.035	15.847	26.344	53.303	81.868
H25_C7S_004	28.77	47.45	128.790	269.623	16.092	27.684	56.408	94.177
H25_C7S_005	38.22	51.56	84.226	121.796	15.944	26.035	52.268	77.787
H25_C6S_001	24.66	32.02	52.14	-	16.009	26.398	51.728	F @ 70.7m
H25_C6S_002	26.03	36.56	61.006	82.279	16.41	26.85	52.14	77.55
H25_C6S_003	23.72	36.49	60.357	84.586	15.79	25.94	51.41	77.09
H25_C6S_004	37.57	53.00	76.221	97.783	15.88	26.11	51.51	76.90
H25_C6S_005	27.19	35.98	58.987	85.163	15.92	26.32	51.49	76.86
H25_C5S_001	21.06	31.30	59.85	80.04	15.575	25.817	51.371	77.298
H25_C5S_002	22.14	32.52	57.112	81.197	15.54	25.53	51.08	76.63
H25_C5S_003	18.32	25.67	44.348	71.318	15.19	25.40	50.55	75.71
H25_C4S_001	23.80	33.24	55.31	78.24	15.597	25.593	51.095	76.546
H25_C4S_002	17.67	25.67	41.464	58.915	15.41	25.38	50.89	76.27
H25_C4S_004	18.97	24.81	39.012	54.444	15.09	25.08	50.28	75.84
H25_C7L_001	77.30	-	-	-	23.466	F @ 22.79m	-	-
H25_C7L_002	38.58	78.38	-	-	17.942	36.040	F @ 29.99m	-
H25_C7L_003	77.88	-	-	-	18.644	F @ 24.78m	-	-
H25_C6L_001	42.47	55.31	115.31	204.87	15.901	26.648	53.628	85.970
H25_C6L_002	30.21	40.81	91.797	187.344	15.37	26.12	52.52	92.64
H25_C5L_001	25.89	47.02	95.04	146.24	15.974	27.365	54.011	81.834
H25_C5L_002	29.06	42.91	67.784	94.610	16.12	26.99	52.86	79.50
H25_C4L_001	22.64	30.43	46.80	72.90	16.272	26.727	52.734	78.223
H25_C4L_002	21.56	30.43	60.645	91.004	15.74	26.55	56.23	82.86
H25_C4L_004	20.62	29.35	48.675	64.611	16.32	26.77	52.71	79.40

H25_C7S_T1_001	26.18	42.98	78.24	114.30	15.540	27.532	52.585	79.006
H25_C7S_T1_002	29.20	41.82	65.765	94.033	16.46	27.88	53.52	79.40
H25_C7S_T1_003	29.35	41.03	69.948	101.172	15.61	26.04	51.63	78.17
H25_C7S_T2_001	19.18	29.20	49.11	80.91	17.563	28.023	53.609	82.767
H25_C7S_T2_002	16.66	24.01	49.901	73.770	17.25	27.48	53.99	80.04
H25_C8S_T4_001	-	-	-	-	F @ 3.436m	-	-	-
H25_C8S_T4_002	-	-	-	-	F @ 1.665m	-	-	-
H25_C7L_T1_001	16.73	30.21	110.76	152.37	15.023	26.384	68.195	99.308
H25_C7L_T1_002	30.65	47.02	90.644	155.471	20.998	35.015	65.065	95.028
H25_C7L_T1_003	18.39	29.20	58.770	90.499	16.793	29.550	36.309	82.964
H25_C7L_T2_001	24.66	33.24	76.22	159.87	20.883	32.886	72.714	115.528
H25_C7L_T2_002	16.66	26.90	51.776	80.043	16.698	28.792	56.698	85.626
H25_C7L_T2_003	33.03	48.10	73.553	-	18.757	31.108	57.044	F @ 60.26m
H25_C7L_T3_001	21.49	35.05	60.07	86.82	15.740	30.547	58.163	86.157
H25_C7L_T3_002	34.11	41.10	66.991	102.614	23.851	34.611	64.688	99.465
H25_C7L_T3_003	19.54	30.14	48.026	65.260	17.935	31.592	60.009	86.935
H25_C7L_T4_001	23.00	27.69	64.68	91.36	23.951	34.413	64.547	90.881
H25_C7L_T4_002	15.22	23.44	39.012	57.328	18.17	31.20	63.39	91.35
H50_C7S_002	-	-	-	-	F @ 4.888m	-	-	-
H50_C7S_003	-	-	-	-	F @ 4.441m	-	-	-
H50_C7S_004	-	-	-	-	F@ 2.378m	-	-	-
H50_C6S_002	35.12	46.37	88.84	125.69	15.887	26.085	52.943	79.685
H50_C6S_003	33.24	45.57	94.826	140.112	16.105	26.887	53.761	80.603
H50_C5S_002	63.46	79.54	108.60	132.04	20.071	32.421	57.810	84.269
H50_C5S_003	25.09	36.13	71.101	107.085	16.008	26.644	52.758	78.665
H50_C4S_001	18.24	27.33	51.49	75.14	15.595	26.529	52.036	77.555
H50_C4S_002	20.26	27.91	47.305	64.107	15.546	26.176	51.550	77.807
H50_C4S_003	27.40	35.69	58.698	72.544	16.005	27.230	53.989	79.86
H50_C7L_001	63.53	126.63	-	-	18.051	30.769	F @ 26.20m	-
H50_C7L_002	40.24	-	-	-	15.829	F @ 17.26m	-	-
H50_C7L_003	-	-	-	-	F @ 8.107m	-	-	-
H50_C6L_001	-	-	-	-	F @ 1.345m	-	-	-

H50_C6L_002	25.17	45.00	91.581	130.809	22.423	33.191	62.941	91.489
H50_C5L_001	26.39	38.80	66.56	116.03	16.919	27.748	56.228	87.217
H50_C5L_002	41.46	60.07	90.067	131.170	16.817	27.771	54.302	81.811
H50_C5L_003	51.99	80.55	-	-	16.446	31.701	F @ 35.83m	-
H50_C4L_002	25.24	33.32	49.90	59.71	16.697	27.743	53.751	78.863
H50_C4L_003	19.33	25.17	46.872	65.116	16.165	27.259	53.424	78.466
H50_C4L_004	16.44	34.04	61.727	93.889	15.601	26.213	53.431	79.40
H50_C7S_T2_002	101.96	134.13	-	-	16.819	36.420	F@ 39.60m	-
H50_C7S_T2_003	85.38	107.52	156.120	258.013	16.119	28.443	56.916	100.119
H50_C7S_T3_001	80.91	92.66	113.503	183.450	15.181	26.154	55.419	86.994
H50_C7S_T3_002	80.12	91.00	118.334	-	17.472	28.433	53.763	F @ 67.74m
H50_C7S_T4_001	102.04	129.80	182.441	209.915	20.365	31.499	70.011	98.422
H50_C7S_T4_002	68.51	76.01	94.538	119.921	15.815	27.488	55.195	86.607
H50_C6L_T1_001	79.18	98.72	152.73	203.64	15.539	28.690	60.759	94.491
H50_C6L_T1_002	79.39	95.33	125.329	154.462	16.847	29.754	56.927	83.648
H50_C6L_T2_001	77.59	101.68	136.94	190.45	16.698	38.247	70.107	108.002
H50_C6L_T3_001	76.73	86.61	136.07	-	16.419	27.513	70.855	F @ 62.8m
H50_C6L_T3_002	85.45	97.35	126.339	155.904	27.773	37.890	71.125	98.259
H50_C6L_T4_001	90.14	106.87	142.06	162.83	23.747	36.034	65.933	92.337
H50_C6L_T4_002	80.76	85.81	99.081	114.080	21.673	32.292	58.070	84.233
H50_C7L_T3_001	114.87	126.99	-	-	20.464	30.828	-	-
H50_C7L_T3_003	-	-	-	-	F @ 6.12m	-	-	-
H50_C7L_T4_001	84.87	242.44	-	-	15.642	49.322	F@ 28.43m	-
H50_C7L_T4_002	80.48	-	-	-	20.269	F @ 23.72	-	-
H50_C7L_T4_003	80.12	-	-	-	15.608	F @ 24.92	-	-

Appendix D: Picture of Lifeboat in Ice Tank Taken During Testing