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Performance of Lifeboats in Ice

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ABSTRACT

The performance of lifeboats in ice was evaluated using model scale boats in an ice tank. Performance in a range of ice conditions was determined using simple benchmarks. Three different lifeboat hull forms were tested, and two power levels were used for each hull. While open water performance was different for the three hull forms, performance in ice was broadly similar. Ice concentrations of about 6/10^{ths} to 7/10^{ths} were found to be limiting conditions for all three. Larger floes were found to hinder performance more than smaller floes. Increasing power did not significantly improve performance in ice.

KEY WORDS: lifeboat; ice; performance; benchmark; limits.

INTRODUCTION

The basic goal of an emergency evacuation, whether of a ship or offshore installation, is to remove people from emerging hazards to a place of safety. Evacuation equipment and procedures must be suited to the range of credible emergency evacuation scenarios relevant to the situation, including various combinations of hazard, operating profile and prevailing environmental conditions. Ice cover can complicate evacuation procedures and can also limit the utility of evacuation equipment, particularly equipment originally designed for open water operations.

The main aim of the work presented here is to investigate the performance limits of lifeboats in ice. Three different displacement hull type lifeboats were tested at model scale in an ice tank. One was a conventional TEMPSC type of hull form, the second a free fall boat, and the third a modernized hard chine TEMPSC. Each vessel was tested in a range of pack ice conditions. Ice concentration was varied, as well as the size of the ice floes in the broken ice field. Simple benchmarks were used to evaluate performance, the main being the ability of the vessel to make way through pack ice over a prescribed minimum distance. A time limit was used as a second benchmark for the performance evaluation. Manoeuvring in ice and open water was also evaluated, using turning circles as a performance measure.

Ice in concentrations of about 6/10^{ths} to 7/10^{ths} was found to prevent all the lifeboats from making progress in the calm water conditions tested; the different hull forms' performance was not discernibly different in terms of limiting ice conditions. This was true both of the effects of ice concentration and of the influence of floe size. Each model was tested at two power levels, the influence of which on the limiting ice concentration was insignificant. The open water turning circles of the three hull forms were different. Turning circles in pack ice were smaller than the corresponding open water turning circle for each vessel, but were practically the same for all three vessels, again indicating the lack of influence of hull form on performance in ice. The test setup and some key results are presented following. Details can be found in the test report by Mak *et al.* (2005).

EXPERIMENTAL SETUP

Ice

The experiments were done at the Ice Tank at the National Research Council's Institute for Ocean Technology. The main test series was done using 46mm thick ice sheets. Additional tests were done in 69mm thick ice, although those results are not presented here. Once an ice sheet was grown to the target thickness over the full 12m wide × 76m long useful tank surface, two pools were cut, one for the pack ice comprised of larger ice floes and one for pack ice comprised of smaller floes. The experiments were done in these pack ice covered pools, where it was possible to adjust the ice concentration relatively easily between tests. At first, an 8m wide × 10m long pool was cut in the ice sheet and the pool sheet was cut up into floes of the smaller or larger size. A strip of ice was then removed to adjust the concentration to 9/10^{ths} and the floes were distributed around the pool before tests in that concentration were done. Following those tests, another strip of ice was cut from the end of the pool and removed in order to adjust the concentration to $8/10^{ths}$ and testing resumed. This process was repeated to change the ice concentration as required by the test program. The larger floes were roughly 1m × 1m square in shape (with the corners knocked off) and had a mass of approximately 32 to 40 kg, comparable to the mass of the lifeboats. The smaller floes were half the size of the larger floes and approximately triangular in shape. Photos of the floes are shown in Figure 1.

Figure 1. Larger and smaller ice floes.

Lifeboat models

The three model lifeboats were all made at 1:7 scale. The first, shown in Figure 2, is a conventional TEMPSC style displacement craft. The second, shown in Figure 3, is a free fall type lifeboat. The third lifeboat is shown in Figure 4. It is a modernized hard chine TEMPSC displacement craft, launched by twin falls davits like the conventional boat. All three vessels are of similar size, as indicated by the specifications in Table 1. Each model was built in two sections using molded GRP for the main hull and canopy.

Each model was fitted with instrumentation and self propulsion equipment (electric motor on batteries) with two power settings. The main power setting corresponded to the power required to meet the regulatory requirement that the vessel make 6 knots in open water, which was slightly different for each hull form (and lowest for the free fall boat). The second power level corresponded to the maximum available and was similar for each vessel, the limit being set by a motor current limit of 4 amps. In terms of bollard thrust, the second power setting provided an increase in thrust of about 10 to 25% over the main power setting.

All models were driven by a single screw in a steerable nozzle. A small video camera was fitted in the coxswain's position in each model and this view was used by a technician during the tests to operate the vessel remotely. Each model was also fitted with a Motionpak II motion sensor, Qualisys markers for optical tracking, a roll sensor, remote control hardware, a radio transmitter, and a PIC acquisition system.

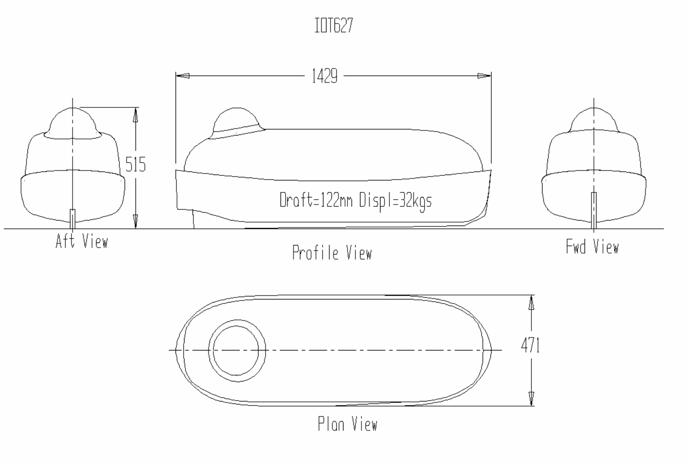

Figure 2. Conventional TEMPSC lifeboat model (627).

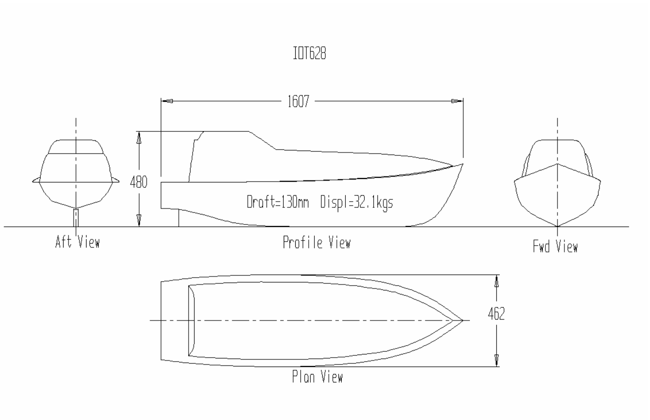

Figure 3. Free fall lifeboat model (628).

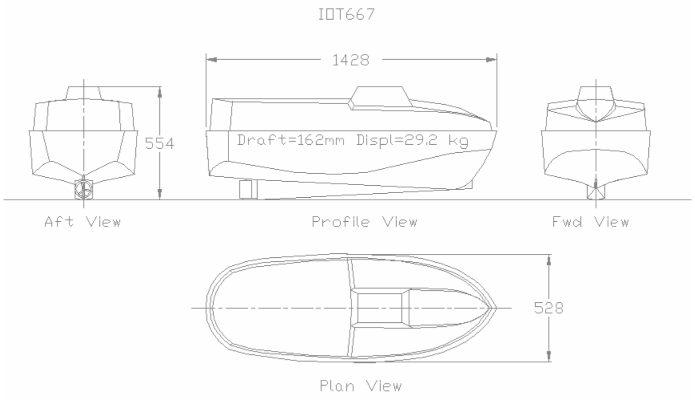

Figure 4. Hard chine modern TEMPSC lifeboat model (681).

Table 1. Boat specifications.

Condition	IOT627	IOT628	IOT681
Length overall (m)	1.429	1.607	1.429
Length on water line (m)	1.381	1.521	1.353
Breadth overall (m)	0.456	0.413	0.507
Mass (kg)	32.85	32.92	29.15
Longitudinal centre of mass (m)	0.72	0.709	0.740
Vertical centre of mass (m)	0.186	0.214	0.221

Test plan and benchmarks

The main test series involved testing all three vessels in ice of the same nominal thickness (46mm) over a range of pack ice conditions. The pack ice conditions included different combinations of ice concentration and floe size. Two floe sizes were used in combination with ice concentrations from 5/10ths to 8/10ths in steps of 1/10th. In addition, for several ice conditions, the model was tested at two different power settings. A total of 76 tests were done in the 46mm ice. Of these, 45 were tests in smaller floes and 31 in larger floes. 9 tests were done in ice concentration of 5/10ths, 51 tests in 6/10ths, 13 in 7/10ths, and 3 in 8/10ths.

While the lifeboat models were instrumented to measure a wide range of parameters, only simple performance measures are reported here. The main benchmark used was the ability of the vessel to traverse a prescribed distance through the pack ice field. Failure to do so earned a failing grade, and success earned a pass. The distance corresponded to 7.5 boat lengths. A second benchmark was also used, this one based on a maximum time allowed for the boat to reach the prescribed distance.

EXPERIMENTAL RESULTS

Limiting ice conditions and power

Results of tests in pack ice comprised of smaller and larger floes with concentrations from 5/10ths to 8/10ths are shown in Table 2 for the conventional, free fall, and hard chine boats. The table shows the performance in terms of passing and failing grades (P and F respectively) of the distance benchmark. For each combination of ice thickness, floe size, and ice concentration, the table has two spaces, one on the right for the lower power (or thrust) T_1, and the other at left for the higher power, T_2.

The limiting ice concentration for the conventional lifeboat was 7/10ths in small floes and marginally lower in larger floes. The free fall lifeboat showed similar behavior as the conventional boat in terms of limiting ice conditions. Likewise, the pass/fail grades of the hard chine lifeboat indicated similar limits as the other two vessels. Overall, there was no compelling evidence that one hull form performed better or worse than the others. In all cases, the addition of the time benchmark resulted in a few more failing grades than when the distance benchmark was used alone, although these results are not tabulated here. In terms of power, the results in Table 2 show no significant improvement from adding more power, although there are only a few relevant cases on which to base this conclusion.

A clearer picture of the effects of additional power and the limiting ice conditions emerges when we compare the present results to results of previous experiments done with a conventional lifeboat (Simões Ré & Veitch 2003). The earlier tests were done with a single 1:13 scale model and investigated performance over a wider range of ice conditions than the current tests. Those earlier results are summarized in Table 3 for comparison. They included tests at four power levels (each a multiple of the basic power setting, see legend), two ice thicknesses, two floe sizes, and four concentrations. Despite significant increases in power, the limiting ice conditions were only marginally changed (by 1/10th at most). Ice in concentrations of about 6/10ths to 8/10ths was found to prevent progress, with larger and thicker floes hindering progress more than smaller and thinner floes. The present and previous experiments that were done in nominally similar conditions with the same conventional hull form, but at two different scales, yielded similar results, giving some qualitative indication of the repeatability of the tests and the lack of obvious scale effects.

Table 2. Performance of lifeboats in pack ice (46mm).

floe size	model*	Ice concentration [10ths]							
		5		6		7		8	
small	627			6P	6P	1F			
	628			7P	7P	1F		1F	
	681			6P	5P1F	2F		2F	
large	627		2P		2P1F	5P2F			
	628	3P	4P	3P		2F		Power Legend	
	681			3P	4P			T2	T1

* The conventional lifeboat is 627, the free fall lifeboat is 628, and the hard chine modern TEMPSC is 681.

Table 3. Performance of 1:13 scale conventional lifeboat model 544 in pack ice conditions characterized by concentration, thickness, and floe size (after Simões Ré & Veitch 2003).

thickness [mm]	floe size [-]	Ice concentration [10ths]							
		5		6		7		8	
25	small							2F	
			3P		5P	2P	3P4P		3F
25	large					2P	3P		
			3P		3P	2P	3P3F		
50	small					2P	2P1F		
			2P		2P	1P1F	3F	Power legend	
50	large			2P	1P1F	3F	3F	T4	T3
			2P	1P	2P2F		3F	T2	T1

Manoeuvring

Manoeuvring in open water and in ice was evaluated using turning circle diameter as a performance measure. Ice conditions for the turning circle tests consisted of concentrations of 5/10ths to 7/10ths comprised of smaller and larger floes. All three lifeboats had larger turning circles in open water than in the ice conditions in which tests were done. The open water turning circle for the conventional lifeboat was largest (3.1 boat lengths), followed by the free fall boat (3.0 boat lengths). The hard chine lifeboat had a significantly smaller open water turning circle (2.6 boat lengths) than the other two vessels.

In ice, the turning circles for all the vessels were practically the same (2.3 to 2.4 boat lengths), suggesting that while the hull forms perform differently in open water, pack ice equalizes the performance. There was no clear effect on turning circle due to changes in ice conditions for any of the vessels, although the range of conditions in which tests were done was narrow.

Waves

Additional tests were done in combinations of pack ice and waves for all three models (Sudom *et al.* 2006). Ice thickness was constant (25mm) for all these tests, and only small floes were used. Pack ice concentrations of 5/10^{ths}, 7/10^{ths} and 9/10^{ths} were used and the wave frequency was varied. The results indicated that the presence of waves in combination with pack ice can help the vessel pick its way through the ice, even in relatively high ice concentrations (that would prevent progress in calm conditions), although this progress was often slow (and often slower than the time benchmark permitted for a pass).

The pass/fail grades for the conventional, free fall and hard chine models were similar, using as benchmarks the ability of the model to reach a minimum distance, as well as a time limit. Whether or not a model could make way in a given ice and wave regime depended mainly on the combination of wave frequency and ice concentration, not on the hull form.

The conventional and hard chine boats performed much the same in the combined ice and wave conditions and in both cases, additional power did not improve performance significantly. In terms of the distance and time benchmarks, the free fall boat performed worse than the other two boats in the combined conditions, although the addition of power yielded some improvement in the free fall boat's performance, bringing it closer to par with the other two vessels.

CONCLUSIONS AND RECOMMENDATIONS

The performance of three model scale lifeboats in pack ice was evaluated using simple performance measures. While all three lifeboats were displacement type vessels, their hull forms were significantly different. In terms of ability to make progress through pack ice conditions, and to maneuver through turning circles, hull form was found to have no significant effect. Further, adding more power to the vessel was found to yield no or only marginal improvement in performance, a result already seen in previous experimental work.

Based on these results, our conclusion is that displacement type lifeboats of the sort tested are not suitable means of evacuation in pack ice conditions that approach the performance limits delineated here. While factors such as ice thickness and floe size distributions add some complexity to the ice conditions and the precise conditions that might constitute a limit for a given vessel, it appears that the types of ice conditions that can reasonably be expected to prevent a lifeboat from making way, or to slow its progress drastically, are quite modest, and would be likely to occur with some frequency in most places that have seasonal ice cover. In areas with such environmental conditions, another means of evacuation is required, whether in place of the conventional displacement type lifeboat, or to complement it.

As there is some uncertainty associated with model scale tests, it would be worthwhile to evaluate the performance of lifeboats in pack ice and waves in the field at full scale.

ACKNOWLEDGEMENTS

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REFERENCES

Mak, L., Simões Ré, A., Sullivan, M., and Kennedy, E. 2005. Assessment of totally enclosed motor propelled survival craft (TEMPSC) hull design performance in ice covered waters. *Institute for Ocean Technology Technical Report TR-2005-06*, St. John's, 34 pp.

Simões Ré, A. and Veitch, B. 2003. Performance limits for evacuation systems in ice. *Proceedings, Ports and Oceans under Arctic Conditions POAC-2003.* Trondheim, 10 pp.

Sudom, D., Kennedy, E., Ennis, T., Simões Ré, A., Timco, G. W. 2006. Testing of evacuation system models in ice-covered water with waves. *Canadian Hydraulic Centre Report CHC-TR-37*, Ottawa, 41 pp.