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Delegations will find attached document SWD(2019) 23 final.

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COMMISSION STAFF WORKING DOCUMENT

For the Council Shipping Working Party

IMO - Union submission to be submitted to the 101st session of the Committee on Maritime Safety (MSC 101) of the IMO in London from 5 – 14 June 2019 concerning information in support of a review into the in-water performance of SOLAS lifejackets

COMMISSION STAFF WORKING DOCUMENT

For the Council Shipping Working party

IMO - Union submission to be submitted to the 101st session of the Committee on Maritime Safety (MSC 101) of the IMO in London from 5 – 14 June 2019 concerning information in support of a review into the in-water performance of SOLAS lifejackets

PURPOSE

The document in Annex contains a draft Union submission to the 101st session of the Committee on Maritime Safety (MSC 101) of the IMO, taking place in London from 5 – 14 June 2019, concerning information in support of a review into the in-water performance of SOLAS lifejackets. It is hereby submitted to the appropriate technical body of the Council with a view to achieving agreement on transmission of the document to the IMO prior to the required deadline of 5 March 2019¹.

Lifejackets are included in Commission Implementing Regulation (EU) 2018/773 of 15 May 2018 on design, construction and performance requirements and testing standards for marine equipment and repealing Implementing Regulation (EU) 2017/306². Reference is made in that Implementing Regulation to the LSA Code and to resolution MSC.81(70) in relation to item MED/1.4 as regards lifejackets. This equipment therefore falls in the scope of Directive 2014/90/EU of the European Parliament and of the Council of 23 July 2014 on marine equipment and repealing Council Directive 96/98/EC³.

¹ The submission of proposals or information papers to the IMO, on issues falling under external exclusive EU competence, are acts of external representation. Such submissions are to be made by an EU actor who can represent the Union externally under the Treaty, which for non-CFSP (Common Foreign and Security Policy) issues is the Commission or the EU Delegation in accordance with Article 17(1) TEU and Article 221 TFEU. IMO internal rules make such an arrangement absolutely possible as regards existing agenda and work programme items. This way of proceeding is in line with the General Arrangements for EU statements in multilateral organisations endorsed by COREPER on 24 October 2011.

² OJ L 133, 30.5.2018, p. 1.

³ OJ L 257, 28.8.2014, p. 146.

WORK PROGRAM

Information in support of a review into the in-water performance of SOLAS lifejackets

Submitted by the European Commission on behalf of the European Union

SUMMARY

Executive Summary:	This submission provides information to the Committee in support of a review into the in-water performance of SOLAS lifejackets.
Strategic Direction: if applicable	Other Work
Output:	Not yet assigned
Action to be taken:	Paragraph 4
Related documents:	Resolution A.1111(30), MSC-MEPC.1/Circ.5, MSC-MEPC.7/Circ1, and MSC 101/21/x

1. This paper is submitted in accordance with paragraph 6.12.3 of MSC-MEPC.1/Circ.5 “Guidelines on the Organization and Method of Work of the Maritime Safety Committee and the Marine Environment Protection Committee and their Subsidiary Bodies”. The submitters of this document offer information on the in-water performance of SOLAS lifejackets.

Introduction

2. This submission is set out to describe the chronological timeline of actions which began when three seafarers from the United Kingdom were found face-down in the water even though they were wearing SOLAS lifejackets. The information in this paper is written in time-order so that the reader may understand the direction taken by the investigation team and the conclusions which have been derived.

Discussion

3. The information contained in the Annex to this paper has been gathered through investigations which were initiated by the United Kingdom’s Maritime and Coastguard Agency. As the investigations developed, the membership of the investigating group expanded to include additional stakeholders who either held technical expertise on lifejacket designs and human behaviours when immersed in water, or who had a direct interest in the performance of SOLAS lifejackets. By the end of this timeline, the investigating group included a number of maritime administrations, life-saving appliance manufacturers, approved test houses, and ship owner representatives for certain SOLAS vessels.

Action requested of the Committee

4. The Committee is requested to note the information contained in the Annex to this paper when considering the proposal for a new unplanned output contained within MSC 101/21/x.

ANNEX

REVIEW OF THE IN-WATER PERFORMANCE OF SOLAS LIFEJACKETS – CHRONOLOGICAL TIMELINE OF EVENTS

Introduction

This document is set out to describe the chronological timeline of investigations which began when three UK seafarers were found face-down in the water even though they were wearing SOLAS lifejackets. The information in this paper is written in time order so that the reader may understand the direction taken by the investigation team and the conclusions which have been derived.

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Fatal incident – FV Louisa

The UK Marine Accident Investigation Branch (MAIB) reported on the deaths of three fishing vessel crew who were found floating face down in the water even though they were wearing SOLAS inherently buoyant foam lifejackets. The three individuals were wearing minimal clothing and the wind and sea were calm. The coroner reported that the deaths were caused by drowning. All three persons had conducted sea survival training and were experienced at sea. It is not deemed acceptable that a lifejacket would not maintain the victims' airways clear of the water and hence the UK implemented further investigations to identify whether an evidence base existed.

The United Kingdom Maritime and Coastguard Agency (MCA) explored the details of this accident and were aware that there were a number of failings which led to these seafarers entering the water. These failings have been explored further by the MCA but are not included within this submission, which focuses on the lifejackets. As stated within the MAIB investigation report, the victims were wearing minimal clothing and the conditions could be compared to those simulated within the SOLAS lifejacket testing requirements in IMO Resolution MSC.81(70); it would be expected that under these conditions the lifejackets should have performed to the expected standard.

The full incident report can be accessed via: <https://www.gov.uk/maib-reports/sinking-of-vivier-creel-boat-louisa-with-loss-of-3-lives>

MAIB in-water testing

As part of the MAIB investigation they conducted their own version of in-water testing whilst wearing a duplicate of the incident lifejacket, to replicate the conditions in which the rescue services found the three fatalities. They found that this lifejacket was unable to turn the two test subjects into the face-up position or to clear their airways of the water surface.

The MAIB further tested a second lifejacket from a different manufacturer and found identical results. This second make/model of lifejacket was approved to a later version of the LSA Code.

It should be noted that this testing was not carried out strictly in-accordance with the specified LSA Code protocol and was not conducted at an accredited test house.

MCA review of equipment approval

The specific make/model of lifejacket involved in the incident was type approved under the Marine Equipment Directive (MED) and it held current certification. The MCA conducted a detailed analysis of the equipment approval, including a review of the original testing results and equipment specifications. All lifejackets were accurately measured with no deficiencies found. The approval documentation was also valid.

The MCA sent the two lifejackets (i.e. the incident lifejacket and the second lifejacket from a different manufacturer used by the MAIB) to an MED/SOLAS accredited testing laboratory to conduct the exact in-water testing procedures that each lifejacket was approved against. The incident lifejacket was assessed using six test subjects; this lifejacket failed the righting test for one out of the six test subjects. The second lifejacket was assessed using 15 test subjects; this lifejacket failed the righting test for 3 test subjects. After receiving these results,

the MCA sent the incident lifejacket to repeat the same testing at a different MED/SOLAS accredited testing laboratory; again, the lifejacket failed the righting test for one test subject.

The MCA assessed that both lifejackets would have passed the required in-water performance tests if a different selection of test subjects had been used. For this reason, the MCA concluded that no further action would be taken with this product or the manufacturers.

Both of the lifejackets, when tested against the relevant versions of the IMO testing standards, showed potential issues with consistency and repeatability of results. The MCA questioned whether the in-water performance of a SOLAS lifejacket could be relied-upon following an approval against the SOLAS construction and testing requirements.

Document review of SOLAS lifejackets with lifejacket stakeholders

The MCA held meetings with the International Life-Saving Appliance Manufacturers' Association (ILAMA) and other key UK stakeholders to discuss the evidence which had been obtained. This Group identified several previous submissions to the International Maritime Organization regarding the testing of lifejackets in IMO Resolution MSC.81(70) – in particular, the ILAMA and ISO submissions to the sub-committee meetings of DE 56 and DE 57, which raised concerns about the revised testing standard that came into force in July 2010.

The MCA recognised that the amendments to the Reference Test Device (RTD), which were introduced in the amended test protocol in July 2010, promoted the performance of SOLAS lifejackets, especially with respect to the static in-water measurements for mouth freeboard, face-plane angle, and body angle. However, it was also identified that these amendments did not address the difference between the IMO Resolution MSC.81(70) testing conditions (e.g. the wearing of swimsuits in fresh, calm water, etc) and the real-life scenarios when lifejackets would be employed.

The MCA sought to better understand any differences between the requirements of IMO Resolution MSC.81(70) and the required in-water performance of a lifejacket during a real-life emergency scenario. The main recognisable difference between IMO Resolution MSC.81(70) and real-life was the wearing of clothing, and it is well known that prior to abandonment, the IMO and all maritime administrations recommend that additional warm clothing is donned.

Further evidence was gathered by the Group on the performance attributes of spray hoods and retention devices. For example, the Royal National Lifeboat Institution (RNLI) had conducted a series of in-water tests using different lifejackets fitted with and without retention devices, and had concluded that in dynamic conditions such as waves, retention devices can provide additional assurance that a lifejacket maintains a suitable in-water performance. During the Louisa incident, the skipper was lost when the rescue services attempted to recover his body and he slipped out of his lifejacket. The Group also reviewed existing information regarding the designs of retention devices; in particular, the Group noted that is at least one country who regulates against such devices if they cause a potential snagging hazard.

In-water performance testing of lifejackets at the RNLI incorporating three types of clothing

In Autumn 2017, the MCA, ILAMA and UK stakeholders initiated a team to review the in-water performance of SOLAS lifejackets, hereinafter named “the Group”. The Group derived a test method to record the effects of clothing on the righting performance of a SOLAS lifejacket. This testing was conducted within the testing pool at the RNLI. The righting tests followed the requirements of IMO Resolution MSC.81(70), conducted in swimsuits as per the prescribed requirement, with three additional separate tests conducted using different levels of clothing. Some freeboard measurements were also recorded but these were not the main priority of the exercise.

All testing was conducted using the Reference Test Device lifejacket (RTD) because the testing standard within IMO Resolution MSC.81(70) makes direct comparisons between the RTD and a manufacturer’s candidate lifejacket. All MED lifejackets placed on board SOLAS vessels since July 2010 have been tested against the RTD. It is understood that the introduction of the RTD allows comparison testing to a known entity (the RTD) and hence many variables associated with the testing conditions can be disregarded. Conducting the in-water performance tests against the RTD was considered the most suitable method for assessing the performance of SOLAS lifejackets currently placed on the market as the Group felt that testing one or more manufacturers’ candidate lifejackets, rather than the RTD, would not adequately assess whether the testing standard was itself suitable.

The four levels of clothing used during the testing were: swimsuits, light passenger clothing, deck working coveralls and heavy-weather clothing. Further details of the clothing are given in the bullet points (i to iv). The heavy weather clothing was standardised across all the test subjects and was provided by the RNLI. The trousers, shirt and shoes were provided by the test subjects. The tests in swimsuits (as per MSC.81(70)) were to provide a baseline for comparison of results.

- i. Swimsuits only - as per IMO Resolution MSC.81(70)
- ii. Light passenger clothing - trousers, shirt and shoes
- iii. Deck working clothing - trousers, shirt, shoes and coveralls
- iv. Heavy weather clothing - waterproofs, fleece underlayer, boots

Test subjects and testing conditions

IMO Resolution MSC.81(70) requires 12 test subjects to be assessed in the candidate lifejacket; the test subjects must meet the provided height and weight criteria such that an adequate range of persons are tested. The Group obtained more than double the number of test subjects normally used - 25 in total. The test subjects covered a good spread of height and weights, however neither the very short and lightweight end of the table, nor the very tall and heavy end of the table were proportionately populated, and hence it is believed that the results obtained should be considered conservative in nature. The test subjects were independent of the Group.

The testing was conducted in fresh water under still conditions as per MSC.81(70). The temperature of the water was colder than normal at only 15 degrees Celsius, and therefore the in-water status of the test subjects was closely monitored. Table 1 shows test subjects (numbered 1 to 25) positioned on the height-weight requirements of MSC.81(70). Notation “F” indicates female and notation “M” indicates male.

Table 1: Height and weight of the test subjects (Table 2.1 within MSC.81(70))

		Mass (kg)							
		40-43	43-60	60-70	70-80	80-100	100-110	110-120	>120
Height (m)	<1.5								
	1.5-1.6		16F						
	1.6-1.7		5F,15F,24F,25F	11F	2F,4F,18F				
	1.7-1.8			12M		1M,3M	9M,13M,21M		
	1.8-1.9				6M,7M	20M,22M,23M		10M	
	>1.9					8M,19M	14M	17M	

Test procedures

The righting tests were conducted as per IMO Resolution MSC.81(70) with the subject relaxed face-down in the water, simulating a state of utter exhaustion before the feet are released (see Figure 1). Each of the test subjects completed six righting tests for each of the four sets of clothing. During the righting tests, turning times were recorded for the airways to clear the water. Additional timings were taken for the test subject to achieve the full face-up position because the Group had emphasised that the safest position for a test subject is when they are face-up.

For a brief assessment of freeboard, measurements were taken for some test subjects immediately following a jump test and after a set of six righting tests.

Static balance measurements were observed during the testing and were recorded using photos and video for qualitative post analysis if needed.



Figure 1: Typical MSC.81(70) righting test once the ankles of the test subject have been released

Pass criteria for righting tests – ‘no-turns’ and righting times exceeding 5 seconds

The requirements within MSC.81(70) are for the lifejacket to “*turn the body of unconscious, face-down persons in the water to a position where the mouth is clear of the water in an average time not exceeding that of the RTD plus 1 s, with the number of persons not turned by the lifejacket no greater than that of the RTD.*” However, as this testing was conducted with test subjects only wearing the RTD, a different set of criteria was required. MSC.81(70) replaced the testing standard within IMO Resolution A.689(17) which required that “*In the righting test, the mouth should be clear of the water in not more than 5 s.*”

For this testing, if the turning time during an individual test exceeded 5 seconds and the test subject exhibited no signs of turning, then this was considered to be a failure. For overall pass/fail criteria, if the average turning time (after discarding the highest and lowest times) exceeded 5 seconds then this was considered a failure. During the testing the test subjects were not aware of a time period. If the test subject exhibited no tendency to turn long after the 5 seconds, the test was aborted and a “no-turn” was recorded.

The Group believed that the 5 second criteria within MSC.81(70) was a parameter derived from an average of 12 breaths per minute for an adult male. This criteria has been used within various standards however the Group noted that an unconscious person does not have a natural reflex to prevent the inhalation of water and hence a timed threshold for a person’s airways immersed in water should to be considered as a performance indicator rather than a statement of safety. The Group’s proposal for 5 seconds provides a baseline for assessing performance.

Righting test results

Table 2 provides the righting times for the test subjects when wearing swimsuits. The test subjects are sorted to provide the quickest righting times at the top of the table. This test was identical to the requirements of MSC.81(70). It can be seen that one of the test subjects failed to meet the 5 second righting time during their first and sixth righting tests, however the average of these results is considered by MSC.81(70) to be acceptable. The five fastest righting times were recorded by four test subjects from the lightest weight category and the five slowest times were recorded by two of the five heaviest test subjects.

Table 2: Righting times for test subjects wearing swimwear

Test subject	Mass of test subject (kg)	Height of test subject (m)	Righting time (seconds)						Average righting time (high & low values removed) (seconds)
			Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	80-100	1.7-1.8	2.7	2.5	1.7	2.3	2.9	2.7	2.6
2	70-80	1.6-1.7	1.5	0.9	0.9	0.8	0.8	0.7	0.9
3	80-100	1.7-1.8	4.4	4.2	3.2	3.8	3.8	3.5	3.8
4	70-80	1.6-1.7	2.1	1.7	2.8	2.6	1.7	1.9	2.1
5	43-60	1.6-1.7	0.9	0.8	0.6	0.7	1.1	0.7	0.8
6	70-80	1.8-1.9	2.7	2.5	2.6	1.7	3.4	2.0	2.5
7	70-80	1.8-1.9	3.3	3.4	2.8	4.5	2.4	2.7	3.1
8	80-100	>1.9	2.4	2.1	1.7	1.4	1.5	1.9	1.8
9	100-110	1.7-1.8	1.5	2.0	1.7	2.3	2.4	2.3	2.1
10	110-120	1.8-1.9	4.4	2.6	2.7	2.7	2.5	2.7	2.7
11	60-70	1.6-1.7	4.1	3.4	2.0	2.6	1.8	2.8	2.7
12	70-80	1.7-1.8	3.6	1.7	3.5	2.7	2.7	3.4	3.1
13	100-110	1.7-1.8	0.9	1.3	1.3	1.5	1.4	1.6	1.4
14	100-110	>1.9	4.0	3.5	5.0	2.9	2.5	2.2	3.2
15	43-60	1.6-1.7	2.6	2.0	2.1	1.4	1.4	1.5	1.7
16	43-60	1.5-1.6	1.5	1.9	0.7	0.9	1.2	1.2	1.2
17	110-120	>1.9	3.9	3.7	4.0	3.4	2.6	4.3	3.8
18	70-80	1.6-1.7	2.3	2.4	2.0	1.7	1.5	1.2	1.9
19	80-100	>1.9	5.2	4.6	4.9	4.4	4.7	5.0	4.8
20	80-100	1.8-1.9	4.6	2.5	2.1	2.3	3.1	2.0	2.5
21	100-110	1.7-1.8	2.6	3.0	1.6	2.1	2.0	2.3	2.2
22	80-100	1.8-1.9	2.4	2.1	1.9	2.5	3.2	2.9	2.5
23	80-100	1.8-1.9	2.2	1.9	2.1	2.5	2.3	2.3	2.2
24	43-60	1.6-1.7	1.0	1.1	1.0	1.0	1.1	1.1	1.0
25	43-60	1.6-1.7	0.8	1.0	1.2	1.2	1.3	2.5	1.2

Light clothing

Table 3 shows the righting times for test subjects wearing the light passenger clothing. Two test subjects (8%) failed to meet the average 5 second righting time, although a total of 5 test subjects (20%) incurred at least one righting time in excess of 5 seconds. Again, the five fastest righting times were recorded by 4 of the lightest test subjects, with two of the five heaviest test subjects in the slowest five times. Test subject 20 had an erroneous result for the first righting test which may be due to trapped air within the clothing.

Trapped air within clothing is already recognised within the international standard for personal flotation devices (ISO 12402) as an influencing factor which will likely alter the performance of a lifejacket, and “*waterproof clothing can trap air and further impede the self-righting action of a lifejacket*”. This international standard suggests that users, owners and employers need to ensure that this is taken into account when selecting a personal flotation device.

Table 3: Righting times for test subjects wearing light clothing

Test subject	Mass of test subject (kg)	Height of test subject (m)	Righting time (seconds)						Average righting time (high & low values removed) (seconds)
			Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	80-100	1.7-1.8	4.4	3.1	5.0	4.7	4.0	5.1	4.5
2	70-80	1.6-1.7	1.8	1.8	1.6	1.5	1.7	1.7	1.7
3	80-100	1.7-1.8	3.5	4.6	4.9	5.3	4.8	5.5	4.9
4	70-80	1.6-1.7	2.1	1.8	1.8	2.0	2.7	2.6	2.1
5	43-60	1.6-1.7	1.5	1.6	1.6	3.3	1.9	1.7	1.7
6	70-80	1.8-1.9	3.7	3.3	4.7	3.2	2.8	2.9	3.3
7	70-80	1.8-1.9	2.7	2.8	2.7	3.6	3.0	2.6	2.8
8	80-100	>1.9	2.1	1.7	3.4	4.4	4.7	3.8	3.4
9	100-110	1.7-1.8	3.5	4.2	3.5	3.0	3.5	2.8	3.4
10	110-120	1.8-1.9	3.3	3.1	3.1	3.0	3.2	3.3	3.2
11	60-70	1.6-1.7	3.8	2.8	2.3	2.3	2.4	2.4	2.5
12	70-80	1.7-1.8	3.1	4.1	3.5	3.8	4.0	3.8	3.8
13	100-110	1.7-1.8	2.5	2.9	2.5	3.0	2.8	3.0	2.8
14	100-110	>1.9	Fail	7.8	5.1	5.2	5.8	5.5	5.5
15	43-60	1.6-1.7	1.5	1.3	1.3	1.3	1.2	1.1	1.3
16	43-60	1.5-1.6	1.5	1.3	1.3	1.3	1.2	1.1	1.3
17	110-120	>1.9	Fail	14.4	17.4	20.3	13.4	6.5	15.1
18	70-80	1.6-1.7	2.5	2.7	1.9	2.1	2.0	1.8	2.1
19	80-100	>1.9	5.8	3.6	4.9	3.9	2.9	3.6	4.0
20	80-100	1.8-1.9	5.2	2.1	2.8	2.9	2.8	1.5	2.7
21	100-110	1.7-1.8	2.4	1.9	1.6	2.4	2.0	2.1	2.1
22	80-100	1.8-1.9	2.2	2.8	2.7	2.4	2.0	3.5	2.5
23	80-100	1.8-1.9	3.0	2.8	2.9	2.3	2.4	2.7	2.7
24	43-60	1.6-1.7	1.1	1.2	0.9	1.0	1.1	1.1	1.1
25	43-60	1.6-1.7	1.1	1.0	1.1	1.8	1.3	1.0	1.1

Deck working clothing

Table 4 contains the righting times for test subjects wearing deck working clothing. A total of 5 test subjects failed to pass this righting test which equates to 21% of the total. It is particularly difficult to identify any trends between the slowest and fastest righting times within this data set.

Table 4: Righting times for test subjects wearing deck working clothing

Test subject	Mass of test subject (kg)	Height of test subject (m)	Righting time (seconds)						Average righting time (high & low values removed) (seconds)
			Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	80-100	1.7-1.8	4.9	3.7	4.4	4.3	3.7	3.6	4.0
2	70-80	1.6-1.7	1.8	1.7	1.9	1.9	1.5	1.9	1.8
3	80-100	1.7-1.8	4.6	4.3	4.3	3.8	5.4	4.2	4.4
4	70-80	1.6-1.7	4.1	Fail	Fail	Fail	4.7	Fail	Fail
5	43-60	1.6-1.7	2.8	1.9	1.7	2.0	1.8	1.6	1.9
6	70-80	1.8-1.9	Fail	Fail	Fail	Fail	Fail	Fail	Fail
7	70-80	1.8-1.9	3.3	3.6	3.8	3.3	3.3	3.0	3.4
8	80-100	>1.9	3.3	2.1	3.7	2.7	2.9	3.1	2.2
9	100-110	1.7-1.8	3.6	3.9	3.7	3.1	3.1	3.2	3.4
10	110-120	1.8-1.9	3.5	3.4	2.7	2.7	2.7	3.3	3.0
11	60-70	1.6-1.7	5.5	Fail	5.0	4.3	5.5	4.8	5.1
12	70-80	1.7-1.8	4.2	3.1	3.2	3.3	3.4	3.7	3.4
13	100-110	1.7-1.8	2.6	2.4	1.8	1.6	1.5	1.9	1.9
14	100-110	>1.9	Fail	Fail	Fail	Fail	Fail	Fail	Fail
15	43-60	1.6-1.7	2.9	2.1	3.5	1.6	2.5	2.1	2.4
16	43-60	1.5-1.6	2.2	2.1	3.5	1.6	2.5	2.1	2.2
17	110-120	>1.9	Fail	Fail	Fail	Fail	Fail	Fail	Fail
18	70-80	1.6-1.7	4.6	4.4	4.2	3.0	2.3	2.2	3.5
19	80-100	>1.9	Fail	3.9	4.3	4.3	4.2	4.9	4.3
20	80-100	1.8-1.9	3.5	3.0	2.0	2.4	2.4	3.0	2.7
21	100-110	1.7-1.8	3.0	2.5	2.8	2.7	2.1	2.5	2.6
22	80-100	1.8-1.9	4.5	3.3	4.1	4.0	3.8	4.1	4.0
23	80-100	1.8-1.9	4.1	3.5	2.2	3.0	2.8	2.9	3.0
24	43-60	1.6-1.7	1.0	1.3	1.3	1.1	0.9	1.1	1.1

Heavy weather clothing

Table 5 shows how heavy weather clothing influences the righting performance of this lifejacket. A total of 14 test subjects (58%) failed to pass the righting test, and a further 3 test subjects showed individual righting failures during the testing. Five of the fastest righting times were recorded by four test subjects from the lightest weight category, however the fastest two subjects also both recorded failures on their first righting tests. **Figure 2** shows a test subject who failed to turn during the righting test whilst wearing heavy weather clothing.

Table 5: Righting times for test subjects wearing heavy weather clothing

Test subject	Mass of test subject (kg)	Height of test subject (m)	Righting time (seconds)						Average righting time (high & low values removed) (seconds)
			Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	80-100	1.7-1.8	Fail	Fail	Fail	Fail	Fail	Fail	Fail
2	70-80	1.6-1.7	2.9	3.0	2.6	2.3	3.0	2.5	2.8
3	80-100	1.7-1.8	8.9	11.6	6.3	5.2	5.1	4.7	6.4
4	70-80	1.6-1.7	7.5	Fail	Fail	8.5	3.2	4.4	Fail
5	43-60	1.6-1.7	2.6	2.4	2.7	3.1	2.9	3.1	2.8
6	70-80	1.8-1.9	3.7	4.1	3.8	3.8	5.4	3.7	3.9
7	70-80	1.8-1.9	3.8	3.2	0.0	3.8	3.6	3.5	3.5
8	80-100	>1.9	5.5	6.3	5.6	3.6	3.8	5.5	5.1
9	100-110	1.7-1.8	3.9	3.0	3.4	3.0	3.2	3.3	3.2
10	110-120	1.8-1.9	4.3	3.5	3.5	3.5	3.9	3.9	3.7
11	60-70	1.6-1.7	Fail	Fail	Fail	Fail	Fail	Fail	Fail
12	70-80	1.7-1.8	Fail	Fail	Fail	11.6	3.9	4.3	Fail
13	100-110	1.7-1.8	Fail	Fail	Fail	Fail	Fail	Fail	Fail
14	100-110	>1.9	Fail	Fail	Fail	Fail	Fail	Fail	Fail
15	43-60	1.6-1.7	Fail	4.6	2.6	2.9	2.0	2.6	2.7
16	43-60	1.5-1.6	Fail	4.6	2.6	2.9	2.0	2.6	2.7
17	110-120	>1.9	6.6	6.8	5.4	4.4	4.3	4.5	5.2
18	70-80	1.6-1.7	Fail	Fail	Fail	Fail	Fail	Fail	Fail
19	80-100	>1.9	Fail	Fail	Fail	Fail	Fail	Fail	Fail
20	80-100	1.8-1.9	Fail	Fail	Fail	Fail	Fail	Fail	Fail
21	100-110	1.7-1.8	Fail	Fail	Fail	Fail	Fail	Fail	Fail
22	80-100	1.8-1.9	4.7	6.2	5.6	4.9	4.9	4.9	5.1
23	80-100	1.8-1.9	3.7	4.5	3.8	4.0	4.2	4.0	4.0
24	43-60	1.6-1.7	2.3	2.8	2.1	3.4	3.9	2.4	2.7



Figure 2: Test subject wearing heavy weather clothing during failure of the righting tests

Number of failures during the righting tests

Table 6 provides a summary of all of the righting results for the four different sets of clothing. Within the table, green shading indicates no failures were present during the righting test, yellow indicates less than 20% failures, orange indicates less than 40% failures, red is 40% or more failures.

It can be clearly seen that the addition of more clothing has a detrimental impact on the righting performance of the lifejacket. All clothing, including the swimsuits, experienced failures.

Comparing the six consecutive righting tests performed by each test subject, the first test often showed the worst results for righting failures. It was observed that the number of

righting failures tended to reduce by the sixth righting test. This reduction in righting time was most prevalent in the heavy weather clothing which reduced from 15 failed test subjects down to 8 failures (29% improvement). This improvement was attributed to the trapped air within the clothing, which released from the clothing during the six righting tests.

A separate average is shown at the right hand side of Table 6 which is the average number of failures seen in only the first 3 righting tests. The Group noted that if a person were to enter the water, it is the first test result that may be the most important. To aid analysis of the data, the first 3 righting tests were chosen to remove any erroneous results from the first righting test. It can be seen that these averages show a greater proportion of failures.

Only 7 out of the 25 test subjects (28%) passed every righting test in all types of clothing.

Table 6: Number of failures observed during the righting tests

Type of clothing	No. of test subjects	Total no. of righting tests	Total number of test subjects not righting within 5 seconds						Failures for all righting tests (%)	Failures (average of first 3 righting tests) (%)
			Test 1	Test 2	Test 3	Test 4	Test 5	Test 6		
Swimsuit	25	150	1	0	0	0	0	1	1	1
Light passenger	25	150	4	2	2	3	2	4	11	11
Deck working	24	144	5	5	4	3	4	3	17	19
Heavy weather	24	144	15	14	14	10	9	8	49	60

Further testing regarding air trapped inside the heavy weather clothing

6 test subjects were asked to perform a 1 metre jump test in heavy weather clothing which was left unpurged of air before starting a separate set of righting tests. Unsurprisingly these 6 subjects showed a 67% no-turn failure rate when compared to the <5s requirement.

Time for airways to clear and time to fully right to a face up position

In addition to the standard self-righting measurement for the time taken for the airway to become clear of the water, a time was also measured for a full self-right, i.e. the time taken from leg release for the subject to arrive at the static balance position required for all other performance measurements, this being the full face-up position with the subject at rest on their back. More analysis is required, however it is expected that graphical plots will show this time to be proportional to the time for the airways to become clear of the water. Although it was not observed during this testing, there are concerns that some lifejackets may bring a test subject's airways clear of the water but fail to bring the test subject to a full face-up position.

Freeboard measurements

Freeboard measurements were only taken for eight test subjects wearing swimsuits prior to and after a 1m jump. For one of the test subjects the freeboard measurement reduced from 160mm to 83mm after the 1m jump.

Static balance measurements

One test subject was wearing footwear intended for use during water sports. This footwear was observed to provide some buoyancy to the test subject's feet and was believed to influence the in-water movements of this test subject. No other test subjects showed irregular static balance positions during the testing. Further assessments are needed for the effects of footwear.

Other observations

There are two principle movements which can lead to a face-up position; a rolling motion about an axis through the head and ankles (a roll turn), and a pitching motion about a horizontal axis between the hips (a pendulum turn). On occasion there is a combined movement involving both roll and pitch. The pitching motion appears to incur a longer time to right into the face-up position but further evidence is required. It was not possible to predict which test subject would perform a rolling or pitching movement.

Analysis of the in-water testing

2 of the 150 righting tests whilst wearing the RTD failed to achieve the 5 second righting time in swimsuits. The MCA has been informed that during other approval tests some test subjects have failed all 6 righting tests whilst wearing the RTD even though these test subjects also met the height and weight criteria of IMO Resolution MSC.81(70). As explained in paragraph 0, some test subjects behave differently in the water by either rolling or pitching into a face-up position, and although we have a general understanding of human morphology and the variables associated with in-water testing (see paragraph 0), it is very difficult to predict the results of in-water testing.

As soon as clothing was worn by the test subjects, the turning times were seen to increase with a growing number of failures to turn a test subject within the 5 seconds. The quantity of clothing was directly related to the righting performance, with the heavy weather clothing having the most substantial impact on the righting performance with 49% of all righting tests failing.

It could be considered that the first righting test is the most important because in a real scenario when a person enters the water they would not be expected to purge any trapped air. On the other hand, a total of six righting tests are currently required to obtain consistent results (see Figure 3). This is supported in Table 6 where we can see that the percentage of failures, taken using the average of the first three righting tests is more severe.

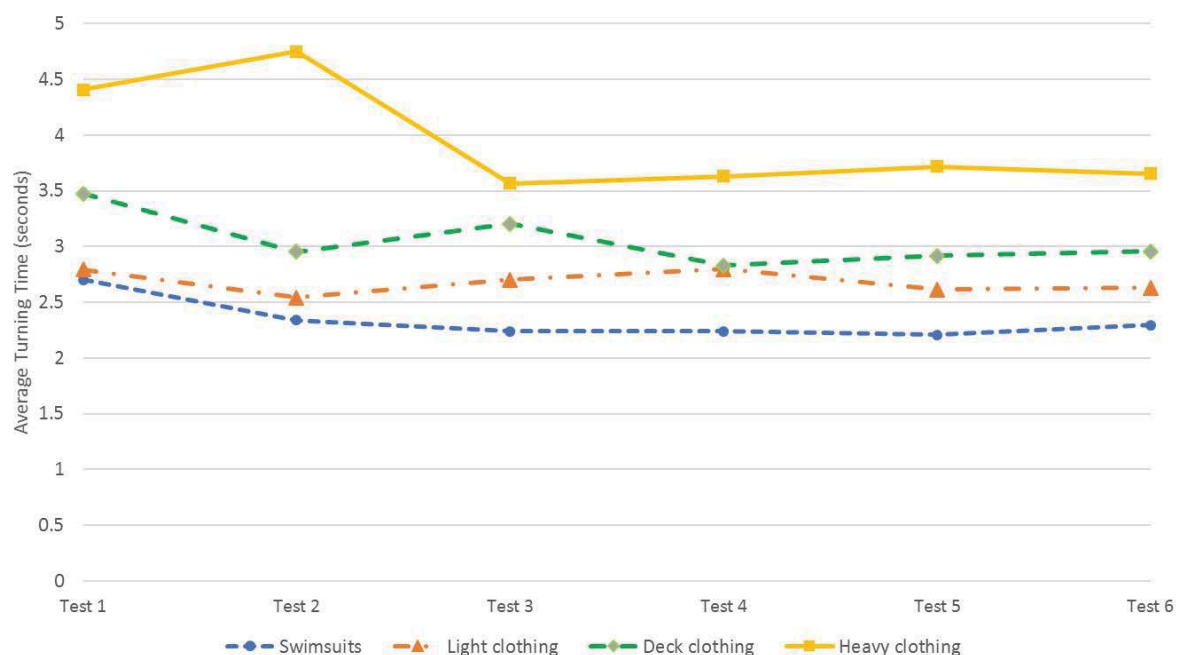


Figure 3: Average turning time for each set of six righting tests

It was not possible to accurately predict results, or to predict which test subjects would fail the tests. In general, the heavier and taller test subjects incurred slower turning times with a subsequent higher probability of not turning however there are always anomalous test subjects. More testing needs to be done with footwear which due to inherent buoyancy may effect the position of a test subject in the water and may potentially affect whether a test subject rolls or pitches during turning.

The RTD provides approximately 150N of buoyancy force which is a larger proportion of the total displacement for a test subject of lighter mass. For swimsuits there was a clear correlation between the fastest/slowest turning times and the mass of the test subjects. There was not such a clear correlation between mass and turning time for the other types of clothing.

During the testing a few experiments were conducted to assess the in-water stability of a test subject when in the face-up position. Although MSC.81(70) has a test procedure for this, there may be benefit in determining a more suitable stability test to assess the tendency of a lifejacket to keep a person in the face-up position.

The results show that only 7 out of the 25 test subjects (28%) passed every righting test in all types of clothing.

Preliminary conclusions from the RNLI testing

IMO Resolution MSC.81(70) assesses the performance of a lifejacket when the test subjects are wearing swimsuits. Testing in swimsuits is the least onerous requirement for a lifejacket. The assessment of righting performance within IMO Resolution MSC.81(70) permits the number of persons not turned by a lifejacket to be no greater than that of the RTD. This means that a SOLAS lifejacket is allowed to fail to right an undefined number of the 12 test subjects whilst wearing swimsuits if the RTD also fails to right them. Therefore IMO Resolution MSC.81(70) allows a clear possibility that a lifejacket can fail to right a seafarer whilst wearing swimsuits or any other form of clothing.

The types of clothing worn during these tests were a close representation of the clothing worn by seafarers on vessels trading internationally. The results from testing in swimsuits as per IMO Resolution MSC.81(70) do not provide a clear indication of the performance of a lifejacket under more realistic conditions (wearing clothing) when a person might be found in the water during an emergency. The results imply that a successful result under IMO Resolution MSC.81(70) may not result in a performance which maritime stakeholders would expect of a lifejacket in an emergency scenario.

Further testing may be beneficial to assess the tendency of a test subject to roll or pitch during the righting movement. It was observed that the pitching movement (which is alike to a pendulum) can appear visibly slower and may result in less stability in the water.

There has been a considerable debate about whether it is possible to test in-water performance whilst a test subject is wearing clothing, and this has always been avoided due to the perceived problems with repeatability and consistency of test results. Testing in swimsuits has always been the prescribed and accepted test method in all European and international standards for this reason, and it provides a level benchmark without adding another variable into the testing standard. However, the results from this limited set of tests whilst wearing clothing clearly show that the testing requirements for SOLAS lifejackets will

not result in all persons being turned into a face-up position within 5 seconds, and the effect of a person's clothing will increase the righting time and result in some persons not righting at all.

Three types of clothing were assessed in order to gain a better understanding of the effects of clothing on in-water performance of SOLAS lifejackets. These clothing types were aimed at passengers in warmer climates, crews working on open decks, and crews working in heavy weather. There are many other permutations of clothing (and worn equipment such as tool belts) which may benefit from further assessment.

Limitations, assumptions and variables not fully-considered within the lifejacket testing standard

During the investigations, the following items were identified as factors which could influence or effect the in-water performance of a lifejacket; not all of these items are well-recognised within the existing testing procedures or standards and this is not an exhaustive list:

- i. The effects of human morphology (height, weight, body-mass index, dimensions of limbs, etc)
- ii. The physical and psychological state of the test subjects when they begin testing, such that they simulate a state of utter exhaustion
- iii. Lifejacket donning procedures in the testing environment and in real-life emergency scenarios
- iv. The effects of wind and sea conditions
- v. Dynamic stability when a user is in the face-up position such as rolling and dunking
- vi. The effects of cold water temperatures on a user's body position in the water (e.g. foetal position)
- vii. Dynamic assessment of the lifejacket securing arrangements (other than the single jump test)
- viii. Protection of the user's airways in rough water
- ix. The wearing of watertight, multilayer clothing or buoyant clothing that may trap air
- x. The wearing of equipment with additional weight (such as tool belts)
- xi. Compatibility with other life-saving equipment (e.g. personal location devices, safety harnesses, etc)
- xii. Manoeuvrability and user comfort for continuous wear operations
- xiii. Extremes of temperature which may affect the lifejacket
- xiv. Lifejacket performance for persons who do not meet the height and weight criteria within IMO Resolution MSC.81(70)

Questions Arising from RNLI Testing

Below are the main questions which were raised by the Group following the testing conducted at the RNLI. The Group sort answers for these questions and proposed the actions in the following paragraphs.

- i. What do maritime stakeholders expect from the performance of a lifejacket?
- ii. Should it be allowed for a lifejacket to not turn a test subject within testing conditions even if the RTD has also failed to turn the subject?
- iii. Is it acceptable for a lifejacket to turn a person with a turning time greater than 5 seconds?
- iv. Should the focus be on turning times when a person first enters the water (trapped air), or after a sustained period of time in the water (air purged)?
- v. Is there an acceptable percentage for the number of failures to right a person?
- vi. Are maritime stakeholders aware of the performance limitations of a lifejacket such as those incurred when a person wears clothing?

Actions To Be Taken Following Lifejacket Testing at the RNLI

The Group agreed to the following actions after the in-water testing conducted at the RNLI.

- i. Question maritime stakeholders about their expectation of lifejacket performance.
- ii. Identify key International stakeholders and consult on the investigations to date.
- iii. Conduct further in-water tests to identify areas of improvement for the testing standard and to identify areas of the testing standard which are susceptible to repeatability issues. Develop these into firm proposals.
- iv. Collate existing data from RTD testing (i.e. turning times, mouth freeboard, torso angle, face-plane angle and list angle) to support further analysis.
- v. Report to next European Union MED Experts Group meeting with a long-term view for a possible IMO submission.

Consultation with Member States

In October 2017 the European Commission circulated a letter from the UK to the Marine Equipment Directive (MED) Experts Group Members and Observer Organizations. This letter referred to the testing of SOLAS lifejackets and alluded to the in-water performance observed during testing at the RNLI. Three responses were received from Member States and one response from an Observer Organization.

One Member State identified repeatability issues which had been witnessed between test subjects of the same height and weight, and also repeatability issues between different test laboratories. One Member State noted that the RTD is used differently for lifejackets complying with the EU PPE Directive (as per ISO 12402) in comparison to the test methods within the IMO's LSA Code and Resolution MSC.81(70). The Observer Organization highlighted that lifejackets cannot guarantee a real-life performance due to the many variable and influencing factors affecting in-water performance.

In late October 2017 the UK presented the available information to the European Union's MED Experts Group. The objective of this consultation was to better understand the expectations of other maritime administrations with regards to the in-water performance of SOLAS lifejackets. The MED Experts Group were asked of their view on the functional requirements of a lifejacket, and were subsequently presented with a short summary of the in-water performance tests conducted at the RNLI. The MED Experts Group believed that these indicative results were not as expected and they were interested in receiving further information from the additional planned testing.

A similar presentation was given to the EU Administrative Cooperation (ADCO) Group in November 2017, with identical responses from the different attendees of this meeting.

In-water performance testing at a nationally accredited test house incorporating one set of standardised clothing

In December 2017, the MCA together with ILAMA and UK stakeholders carried out further tests at a Nationally Accredited Laboratory (Fleetwood Testing Laboratory). The primary objectives of this testing were to:

- I. Provide evidence to support the introduction of an in-water performance test with test subjects wearing standardised clothing
- II. Reinforce the results from the RNLI testing which concluded that clothing had a significant impact on the in-water righting performance of a SOLAS lifejacket.

- III. Determine if in-water righting tests whilst wearing clothing are repeatable and thereby provide results that are suitably consistent to be utilised within IMO Resolution MSC.81(70).

Test subjects and testing conditions

Alike to the testing conducted at the RNLI, this in-water performance testing was conducted using the RTD, for the same reasons as agreed by the Group previously. The only other deviation from Resolution MSC.81(70), as amended by Resolution MSC.200(80) was that one series of tests were conducted with test subjects wearing standardised clothes.

A number of proposals were made regarding the standardised clothes, including using the definition already in existence for heavy weather clothing. Unfortunately, the Group found that the parka, which is defined in the heavy weather clothing, may not be suitable for entering the water on repeat occasions.

It was determined that the standardised clothing would consist of the following: underwear (short sleeved and short legged); long sleeved shirt; woollen jumper; cotton trousers (not woollen), woollen socks, a waterproof jacket and trainers. Both the swimsuit and standardised clothes are shown in **Figure 4**.



Figure 4: Test subject wearing a swimsuit (left) and the standardised clothing (right)

For this testing, all of the in-water tests were repeated during a second set of independent tests to provide evidence as to whether testing in clothing would provide consistent results.

Although IMO Resolution MSC.81(70) only requires 12 test subjects to be assessed, during these tests a total of 24 test subjects were used as highlighted in

Table 7. In order to better understand how the morphology of a test subject affects the in-water performance observed for a lifejacket, a wide range of additional test subject measurements were taken as highlighted in **Table 8**. Notation “F” or colour red indicates female and notation “M” or colour blue indicates male.

Table 7: Height and weight of test subjects (Table 2.1 extracted from MSC.81(70))

	Weight range - kg								
Height range (m)	40-43	43-60		60-70	70-80	80-100	100-110	110-120	>120
<1.5	1	X	X	X	X				
1.5-1.6	X	1	1	1	X	X			
1.6-1.7		X		X	X	X	X		
1.7-1.8				X	X	X	1	X	X
1.8-1.9				X	X	X	1	1	1
>1.9						X	X	X	1

Ref: Table taken from Resolution MSC.200(80)

Table 8: Additional anthropometric measurements for the 24 test subjects

Additions to the Required Test Procedure

The required six righting tests were conducted as per IMO Resolution MSC.81(70) with each test subject relaxed face-down in the water, simulating a state of utter exhaustion before the feet are released (see **Figure 5**). During the righting tests, turning times were recorded for the airways to clear the water. Additional timings were taken for the test subject to achieve the full face-up position. The 5 second threshold criteria for righting times was again used as a performance indicator although test subjects were not informed of the existence of a time period.



Figure 5: MSC.81(70) righting test once the ankles of the test subject have been released

Additionally, static balance mouth freeboard measurements were taken three times even though Resolution MSC.81(70) only requires one measurement to be taken. The three measurements were:

- i. As per IMO Resolution MSC.81 (70) in a normal relaxed state
- ii. With lungs at lowest volume, i.e. exhaled
- iii. With lungs at maximum volume i.e. inhaled

Also, the in-water weight for each test subject was measured in both swimwear and standardised clothing using the procedures detailed in EN ISO 12402-9. Five measurements were taken; one inhaled, one exhaled and three with the subject in a relaxed state i.e., static balance. An average was taken of the three static balance measurements. Please see **Table 9**.

Table 9: In-water Weight Measurements for the Test Subjects

Subject	Clothing	Inhaled (kg)	Exhaled (kg)	Static balance 1 (kg)	Static balance 2 (kg)	Static balance 3 (kg)	Average static balance (kg)
1	Swimwear	1.40	3.75	2.55	2.00	2.65	2.40
	Test clothing	0.50	2.45	2.60	2.20	2.10	2.30
2	Swimwear	1.50	4.00	2.15	2.05	2.00	2.07
	Test clothing	0.20	2.00	0.80	0.70	0.75	0.75
3	Swimwear	0.75	3.50	2.95	3.15	2.95	3.02
	Test clothing	0.50	3.95	0.60	0.65	0.70	0.65
4	Swimwear	1.90	2.50	2.20	2.35	2.45	2.33
	Test clothing	0.60	1.50	0.90	0.95	0.90	0.92
5	Swimwear	2.00	3.00	2.35	2.30	2.35	2.33
	Test clothing	0.30	1.70	1.00	1.10	1.10	1.07
6	Swimwear	1.75	3.75	3.00	3.15	3.00	3.05
	Test clothing	1.00	2.10	1.00	1.10	1.40	1.17
7	Swimwear	0.10	2.60	1.10	1.15	1.50	1.25
	Test clothing	1.20	2.55	1.70	1.60	1.80	1.70
8	Swimwear	0.40	3.75	2.60	2.65	2.75	2.67
	Test clothing	0.45	3.45	2.20	2.25	2.20	2.22
9	Swimwear	0.35	2.80	1.40	1.55	1.60	1.52
	Test clothing	0.60	2.90	1.85	2.50	1.70	2.02
10	Swimwear	0.50	3.05	1.75	1.65	1.80	1.73
	Test clothing	0.95	2.85	2.80	2.70	2.80	2.77
11	Swimwear	1.15	3.20	2.00	1.85	1.90	1.92
	Test clothing	3.50	5.20	3.30	3.30	3.40	3.33
12	Swimwear	1.55	3.40	2.40	2.45	2.30	2.38
	Test clothing	2.20	4.15	2.75	2.85	2.70	2.77
13	Swimwear	1.60	4.30	2.95	3.15	3.25	3.12
	Test clothing	0.35	3.15	2.65	2.70	2.70	2.68
14	Swimwear	2.40	3.40	3.50	3.50	3.55	3.52
	Test clothing	0.30	4.50	3.40	3.65	3.30	3.45
15	Swimwear	1.60	5.50	4.50	4.40	4.75	4.55
	Test clothing	0.80	3.10	2.45	2.90	2.65	2.67
16	Swimwear	1.10	3.00	2.90	2.60	2.75	2.75
	Test clothing	0.60	3.10	1.20	1.25	1.20	1.22
17	Swimwear	1.05	2.20	1.35	1.55	1.45	1.45
	Test clothing	0.45	1.85	1.40	2.00	1.90	1.77
18	Swimwear	1.60	3.95	3.90	3.15	3.60	3.55
	Test clothing	1.61	3.54	2.80	2.95	2.75	2.83
19	Swimwear	1.50	3.10	2.50	2.65	2.70	2.62
	Test clothing	2.55	3.21	2.75	2.80	3.10	2.88
20	Swimwear	0.25	1.21	1.00	0.25	0.70	0.65
	Test clothing	0.65	1.32	0.95	1.25	1.05	1.08
21	Swimwear	0.35	3.30	2.50	1.90	2.10	2.17
	Test clothing	0.30	2.50	2.20	2.50	2.60	2.43
22	Swimwear	1.70	4.40	2.70	3.30	3.40	3.13
	Test clothing	0.70	3.40	1.80	2.20	1.90	1.97
23	Swimwear	1.30	4.40	3.80	3.20	3.60	3.53
	Test clothing	1.10	4.40	2.70	2.50	2.90	2.70
24	Swimwear	1.60	3.20	1.80	2.10	2.50	2.13
	Test clothing	3.60	4.30	3.20	3.45	3.50	3.38

In-water Test Results

Table 10 shows the average self righting times recorded for achieving the airways clear and the face-up position in both swimwear and standardised clothing for the first set of tests. As per the requirements within IMO resolution MSC.81(70), the averages were obtained by discarding the fastest and slowest righting times for each test subject before summing an average time for the airways to be clear of the water. There was a general trait that the first righting test for each test subject was the slowest. The second set of repeated tests show very similar results.

Table 10: Average self righting test results in swimwear and with standardised clothing

Test Subject	Average Self Righting Times after removing Max and Min Values as per MSC.81(70) (seconds)			
	Swimwear - Airways Clear	Swimwear - Face Up	Standardised Clothing - Airways Clear	Standardised Clothing - Face Up
1	0.7	1.4	1.1	2.7
2	2.0	3.4	3.1	4.9
3	1.0	1.8	1.2	2.4
4	1.7	4.2	6.8	7.0
5	2.4	3.9	2.1	5.7
6	1.7	2.7	4.9	6.5
7	1.7	5.2	2.8	11.1
8	1.5	3.9	2.3	5.3
9	1.9	3.3	6.2	7.9
10	2.0	3.2	2.9	3.6
11	3.1	6.6	NT	NT
12	1.3	2.6	2.0	3.4
13	2.8	4.4	4.6	7.0
14	3.4	6.2	6.7	9.5
15	2.1	3.0	1.6	2.9
16	2.1	3.4	2.5	3.8
17	1.1	2.2	0.8	2.2
18	0.8	1.5	1.1	2.2
19	1.3	2.3	1.9	3.2
20	1.1	2.6	1.5	3.4
21	1.6	3.7	2.7	5.7
22	2.8	4.8	6.4	10.7
23	1.7	3.2	2.1	3.3
24	2.1	5.3	1.7	5.4

There was a strong trend between the height and weight of a test subject and the self righting time, with taller and heavier test subjects observing longer self righting times or greater number of no-turn results. This trend was witnessed across both the results for swimwear and standardised clothing however it should be noted that there are a few anomalous test subjects within these results. There was not such a clear trend between subject height or weight and mouth freeboard measurements.

The freeboard measurements showed a difference between the inhaled, exhaled and resting positions – enough to influence the outcome of an approval test. There was no obvious trend between freeboard measurements and the morphologies of the test subjects.

During the self righting tests with test subjects wearing swimwear, zero "no-turns" were recorded. However, during the first set of self righting tests in standardised clothing, a total of 15 no-turn results were recorded with 5 test subjects recording self righting times greater than 5 seconds. During the second set of self righting tests in standardised clothing, a total of 19 no-turn results were recorded with 7 test subjects recording self righting times greater than 5 seconds.

In addition to taking the standard self righting measurements, a time was recorded for a subject to reach a face up position. These times were often very close together which caused difficulties for recording; however the recording of this data showed that for a few test subjects the additional time to achieve the face-up position was prolonged. As the face up position takes a longer period than the time recorded for airways to clear the water, the recording of this time in swimwear provides an insight as to which test subjects may experience slower self righting times in standardised clothing; this can be seen visually by the red cells in **Table 10**.

The results obtained from this testing were very similar and directly comparable to those results obtained from the tests which were conducted at the RNLI. It was observed that the self righting results for test subjects wearing the standardised clothing was approximately comparable to the RNLI tests with test subjects wearing deck working clothing.

Table 11 shows a comparison between the first and second sets of in-water tests for self righting and mouth freeboard measurements. There was a good correlation between those test subjects which provided self righting times in excess of 5 seconds or no-turns in the first set of tests, and those test subjects which recorded similar results in the repeated second set of tests. There is a slightly larger variance between the average self righting times whilst wearing standardised clothing, which is attributable to the increased self righting times, and the number of no-turns recorded during the repeat tests. The results for mouth freeboard shows very good correlation between the first and second sets of in-water tests, both for swimwear and standardised clothing.

Table 11: Comparison of average results after repeating the self-righting and mouth freeboard tests a second time

	Average self righting time for all test subjects	Average mouth freeboard for all test subjects
First set of tests in swimwear	1.83 seconds*	133 mm
Second set of tests in swimwear	1.79 seconds*	136 mm
First set of tests in standardised clothing	3.01 seconds**	120 mm
Second set of tests in standardised clothing	3.93 seconds***	120 mm

*zero "no-turns" were recorded. **Average results were affected by recording of 15 no-turn results with 5 test subjects recording self righting times greater than 5 seconds. ***Average results were affected by recording of 19 no-turn results with 7 test subjects recording self righting times greater than 5 seconds

Due to the conducting of repeat tests, plus the additional freeboard measurements and clothing tests, there were a substantial number of test results and hence these have not included within this information paper.

Fourth meeting of the group and review of the draft proposals

In February 2018 the Group held their fourth meeting to review the in-water performance of SOLAS lifejackets. The Group decided to invite those Member States who showed interest during the MED Experts Group meeting to join these discussions.

Over the Group's previous meetings, a range of issues had been identified with the SOLAS requirements for lifejackets and in order to resolve or mitigate these issues the Group had developed a number of draft proposals. During this fourth meeting the Group presented the evidence gathered and the draft proposals to these EU stakeholders.

At this meeting there was a good interaction from EU members and support for addressing the identified problems. The whole Group contributed to the development of the draft proposals, and a suggestion was made to order the proposals according to whether they were aimed at amendments to the LSA Code or Resolution MSC.81(70), or aimed at guidance which could, for example, be provided in an IMO MSC Circular. An initial agreement was reached on the list of proposals and the proposed strategy leading to an IMO submission.

The main draft Proposals were as follows:

- a. Improve stakeholder awareness of self righting capabilities of lifejackets via MSC Circular, user manuals, and markings on a lifejacket.
- b. Introduce a minimum buoyancy requirement of 150 Newtons for all SOLAS lifejackets.
- c. Prohibit a candidate lifejacket from recording a no-turn during approval testing.
- d. Reinstate a maximum self-righting time of 5 seconds during approval testing and require a candidate lifejacket to turn the test subject into the full face-up position.
- e. Introduce an additional in-water performance test for self-righting with test subjects wearing standardised test clothing

Other Proposals included:

- f. Introduce separate lifejacket standards for different applications (e.g. higher performing lifejackets for high risk activities)
- g. Introduce requirements for spray hoods and crotch straps (retention devices)
- h. Mandate the fitting of personal location devices
- i. Prescribing maintenance and servicing requirements, including the provision of a maximum service life

This meeting acted as the pre-cursor to the subsequent meeting with key IMO stakeholders during the IMO's sub-committee on Ship Systems and Equipment in March 2018.

Informal Meeting at the International Maritime Organization

In March 2018 the UK organised a meeting at the International Maritime Organization during the fifth Ship Systems and Equipment sub-committee meeting (SSE 5). The attendees included a wide range of IMO stakeholders including Flag States, representatives of Ship Operators, external consultants and subject matter experts, the Maritime Accident Investigation Branch, life-saving equipment manufacturers and industry bodies.

The attendees were provided with a summary of all of the actions taken during the review of lifejackets, including results from the in-water testing and some of the initial conclusions. The attendees had detailed discussions about the expectation of a lifejacket to: save your life, to keep your airways clear of the water, to act as the final safeguard to protect life, etc. The attendees quickly concluded that a safety level of 100% could never be achieved and this would be unrealistic to expect. Key influencing factors were identified such as: the wearing of clothing and heavy items, the morphology of humans, or the impact of extreme weather conditions.

The attendees were introduced to the draft list of proposals which had originated from the Group's thorough review of issues identified during this review of lifejacket performance. Good discussion was had on each Proposal, with some suggestions on how to take these forward or amend them as appropriate. The proposals were amended accordingly after the meeting.

The attendees were further informed of the next stage of in-water testing which was planned to be conducted in April-May 2018. The attendees noted that the majority of testing conducted to date utilised the RTD. Although the RTD is used as the comparative benchmark for all SOLAS lifejacket approvals, some attendees were particularly interested to see how existing lifejackets performed against the Group's proposed tests. It was agreed that this question would be addressed within the next stage of in-water testing.

One attendee raised a caution about using the term "failure" when assessing the performance of a lifejacket because of the loose definition of this term. For clarity, the attendees noted that during the testing a failure had been defined as not turning a test subject into a face-up position, or a righting time greater than 5 seconds, as previously required in Resolution A.689(17) prior to the introduction of the RTD.

On several occasions the attendees referred to the unrealistic expectations of stakeholders regarding the performance of a lifejacket. There was agreement that stakeholder awareness should be improved to address any unrealistic expectations. It was noted that the Group had prepared a questionnaire which could be sent to key maritime stakeholders to identify their views on the key characteristics of a lifejacket, however there had been concerns about asking such questions in an open forum before the Group had decided upon submitting a paper to the IMO.

Further in-water testing using existing SOLAS lifejackets for verification of the Group's proposals

Following the questions received during the meetings with the international stakeholders, it was deemed necessary to conduct further formal in-water testing against existing SOLAS lifejackets. The objectives of this in-water testing would be to assess the suitability of the Group's draft proposals for the in-water testing of lifejackets by conducting these tests on a representative sample of lifejackets which held current SOLAS approval against the 2010 LSA Code. An additional objective was to provide further evidence whether existing SOLAS lifejackets, present an in-water performance which is deemed acceptable to maritime stakeholders. This testing was conducted at a Nationally Accredited Laboratory (Fleetwood Testing Laboratory) during April and May 2018.

Eight SOLAS lifejackets were selected for testing and all the lifejackets held valid approval against the 2010 LSA Code and the latest amendments to IMO Resolution MSC.81(70). Of the eight lifejackets, two were inflatable lifejackets and six were inherently buoyant foam lifejackets. The selected lifejackets provided a range of different buoyancies to provide additional evidence whether the provision of buoyancy had a direct impact on the in-water performance.

Since the objective of this testing was to identify whether the Group's draft proposals were appropriate, and there was no intention to evaluate specific products, it was decided that the makes and models of the eight selected lifejackets would remain confidential. It should be noted that these eight lifejackets were manufactured and approved across a range of IMO Member States and Classification Societies.

Test subjects and testing conditions

All testing was conducted against Resolution MSC.81(70) as amended by MSC.200(80) (thereinafter referred to as MSC.81(70)) with the RTD being used as the comparative testing tool. The in-water tests conducted were as follows:

- j. Each test subject wearing a swimsuit and the RTD (as per MSC.81(70))
- k. Each test subject wearing a swimsuit and one of the selected lifejackets (as per MSC.81(70)) – these tests were repeated for each of the eight lifejackets
- l. Each test subject wearing the standardised clothing and the RTD (as per MSC.81(70))
- m. Each test subject wearing the standardised clothing and one of the selected lifejackets (as per MSC.81(70)) – these tests were repeated for each of the eight lifejackets

Again the standardised clothing consisted of the following: underwear (short sleeved and short legged); long sleeved shirt; woollen jumper; cotton trousers (not woollen), woollen socks, a waterproof jacket and trainers.

Due to the number of righting tests associated with testing eight SOLAS lifejackets and the RTD, the eight lifejackets were split into two batches. For each batch, the same 14 test subjects were used. Although the two batches were separated by only a few days, all of the RTD tests were repeated to ensure a baseline for comparison. The test subjects' heights, weights and other anthropometric measurements are shown in Table 12 and

Table 13. Notation “F” or colour red indicates female and notation “M” or colour blue indicates male.

Table 12: Height and weight of test subjects (Table 2.1 extracted from MSC.81(70))

Height range (m)	Weight range (kg)							
	40-43	43-60	60-70	70-80	80-100	100-110	110-120	>120
<1.5	1	X	X	X				
1.5-1.6	X	1	1	X	X			
1.6-1.7		X	X	1	X	X		
1.7-1.8			X	X	1	X	X	X
1.8-1.9			X	X	X	1	1	X
>1.9					X	X	X	1

Table 13: Additional anthropometric measurements for the 14 test subjects

Subject	Sex	Height (m)	Height to shoulder (m)	Weight (kg)	Neck height (cm)	Neck girth (cm)	Shoulder width (cm)	Chest (cm)	Waist (cm)	Corner mouth (cm)	Head circumference (cm)
1	M	1.68	1.41	78.88	10	39.5	53	108	93	45	55.5
2	M	1.8	1.52	110.78	10	42	59	120	112	46	57
3	M	1.74	1.47	92.58	9	40	57	109	96	44	58
4	F	1.44	1.16	50.62	9	31	47	85	66	37.5	54
5	F	1.71	1.36	67.96	10	34.5	50	93	75	41	56.5
6	M	1.88	1.56	105.9	11	42	50	119	101	46	60
7	F	1.59	1.29	61.28	8	33	43	92	81	41	53
8	M	1.6	1.32	52.72	8	32	46	80	71	39	54
9	F	1.56	1.28	42.82	9	29	41	71	59	35	54
10	M	1.41	1.15	40.94	7	32	39	74	68	40	55
11	F	1.83	1.49	69.26	12	32	44	87	74	37	53
12	F	1.6	1.31	56.66	7	31	45	86	70	37	54
13	M	1.92	1.65	131.16	10	47	61	121	115	49	59
14	F	1.5	1.25	88.2	8	38	45	108	109	41	54

Additions to the Required Test Procedure

The six righting tests were conducted as per IMO Resolution MSC.81(70) with each test subject relaxed face-down in the water, simulating a state of utter exhaustion before the feet are released. During the righting tests, turning times were recorded for the airways to clear the water. Additional timings were taken for the test subject to achieve the full face-up position. The 5 second threshold criteria for righting times was again used as a performance indicator although test subjects were not informed of the existence of a time period.

Each test subject performed tests wearing the RTD in standardised test clothing; these tests were a repeat of the tests which were conducted during the earlier formal in-water performance testing at the nationally accredited laboratory. This data provided a further assessment of the effects of clothing upon the in-water performance of the RTD, and provided a comparison between the RTD in-water performance and the SOLAS lifejackets.

Additionally, static balance mouth freeboard measurements were taken three times even though Resolution MSC.81(70) only requires one measurement to be taken. The three measurements were:

- iv. As per IMO Resolution MSC.81 (70) in a normal relaxed state
- v. With lungs at lowest volume, i.e. exhaled
- vi. With lungs at maximum volume i.e. inhaled

Two samples of each of the eight lifejackets were provided for the in-water testing. Each of the lifejackets were measured for buoyancy, with the two inflatable lifejackets measured with only a single chamber inflated as the “worst case scenario”. For the two inflatable lifejackets, after the first in-water test in swimwear, the lifejacket was deflated, rearmed and repacked in accordance with the manufacturer’s instructions, prior to undertaking the next in-water test with clothing.

Test Results

The results of the buoyancy tests for each of the two samples of each lifejacket are shown in **Table 14**. All lifejacket models showed a percentage difference between sample buoyancies of less than 1%, except lifejacket 4 which showed a 4.4% difference between the two samples.

Table 14: Buoyancy measurements for the eight lifejackets

Lifejacket	Buoyancy (Newtons)	
	Sample 1	Sample 2
RTD	147.85	
1	178.21	179.93
2	156.14	155.26
3	191.65	190.57
4	136.92	143.10
5	179.49	180.74
6	186.30	187.87
7	147.19	147.68
8	175.45	170.50

As previously mentioned, the eight lifejackets were split into three batches, with each test subject assessed in the RTD prior to the testing of each batch.

Table 15 shows a summary of the data obtained during this in-water testing. The full results are included in the Appendix to this paper. For each lifejacket, **Table 15** includes the average righting time (to airways clear of the water and to the face-up position), average static balance freeboard and the number of no-turns recorded with test subjects wearing both swimwear and the standardised clothing. The swimwear tests are currently required within Resolution MSC.81(70) with the exception of the recording of time to the face-up position. The tests using standardised clothing show an increase in average righting times, however the calculation of these averages do not take into account when no-turns were recorded. If no-turns were theoretically recordable, they would have the effect of increasing the average righting time.

Table 15: In-water performance data for Batch 1 and Batch 2 for the Reference Test Device

Lifejacket	Swimwear				Clothed			
	Righting Time - Airways Clear (seconds)	Righting Time - Face-up (seconds)	Free-board (mm)	No-turns	Righting Time - Airways Clear (seconds)	Righting Time - Face-up (seconds)	Free-board (mm)	No-turns
RTD (batch 1)	1.62	3.26	131	0	4.62	7.08	124	13
1	1.05	2.66	126	0	1.67	4.23	114	2
2	1.85	3.54	156	0	4.21	7.79	158	8
3	1.10	2.45	152	0	2.04	4.20	147	0
4	2.11	3.17	111	7	4.51	5.99	103	11
RTD (batch 2)	1.73	3.46	133	0	4.65	6.88	128	15
5	1.88	3.39	114	0	3.25	5.16	127	10
6	1.63	3.25	125	0	3.53	5.36	130	11
7	1.94	3.13	85	0	3.54	5.03	90	6
RTD (batch 3)	1.80	3.59	140	0	4.20	6.05	124	13
8	1.31	2.40	131	0	2.08	3.38	129	0

Analysis of Test Results

The following paragraphs are written to analyse the results from the in-water testing of each lifejacket, including the RTD. It should be noted that the same test subjects (1 to 14) were used for each lifejacket, although the lifejacket testing was separated into three batches of testing. All test subjects conducted in-water tests with the RTD three times, once for each batch of testing.

The RTD provides approximately 148 Newtons of buoyancy and it exhibited the following performance in swimwear and the standardised clothing:

Swimwear – the RTD provided a good turning performance in swimwear, with every test subject recording righting times to a position where the airways are clear of the water in less than 5 seconds. There were a few results where test subjects recorded times in-excess of 5 seconds to achieve the face-up position. The static balance freeboard measurement for batch 1 was 131mm which changed when inhaled and exhaled to 148mm and 124mm respectively. Almost identical results were seen for batches 2 and 3, except for batch 3 the average static balance freeboard measurement increased to 140mm; none of the individual static balance measurements for batch 3 were remarkable.

Clothing – over the three batches of testing using the RTD, 41 no-turns were recorded whilst wearing standardised test clothing. There is some evidence that some of the initial no-turn results could have been influenced by trapped air, however there are several results where test subjects incurred multiple no-turns intermixed with other deficient results. For batch 1m the average freeboard measurement reduced to 124mm in standardised clothing compared to swimwear only, with one test subject recording a freeboard of 78mm. This same test subject recorded freeboards of 115mm and 113mm during batches 2 and 3.

It can be seen in **Table 15** that the RTD tests for batches 1 to 3 in swimwear (as required within Resolution MSC.81(70)) for the average righting time and static balance freeboard measurements were within 0.18 seconds and 9mm respectively, and would have resulted in almost identical criteria for the assessment of lifejackets. The righting times of 1.62 to 1.80 seconds obtained during this testing upon 14 test subjects in swimwear is atypical of righting times recorded by the RTD and is very close to the average righting times recorded during the RNLI testing (2.3 seconds) and the previous formal testing (1.8 seconds). The static balance freeboard measurements of 131mm to 140mm is also similar to previous testing, and varied as expected when test subjects adopted the inhaled and exhaled positions.

The number of no-turns recorded by the RTD was very similar between all of the batches, although there were some differences in the test subjects which recorded these no-turns. More importantly, it is clearly observed that the RTD produced 13 no-turns out of 84 righting tests (15%) in batch 1, 15 no-turns out of 84 righting tests (18%) in batch 2 and 13 no-turns out of 84 righting tests (15%) in batch 3. This data strongly supports the findings from the RNLI in-water performance testing for test subjects wearing the RTD and deck working clothing, which recorded 24 no-turns out of 144 righting tests (17%); the deck working

clothing was considered to be a similar level of clothing in terms of weight and volume to the standardised clothing.

It can also be seen in **Table 15** that the average righting times produced by the RTD in swimwear of approximately 1.7 seconds was midway between the fastest and slowest righting times for the eight SOLAS lifejackets of 1.05 and 2.11 seconds respectively. However, the righting times recorded by the RTD when tested with clothing during batches 1 and 2, found the RTD to have the worst righting time of all the lifejackets at approximately 4.6 seconds. The RTD also recorded the most number of no-turns when compared to all of the eight SOLAS lifejackets. These results emphasise that the RTD is not suitable for use as a comparative tool for assessing the in-water performance of lifejackets with test subjects wearing clothing.

Assessment against the testing requirements

Using these RTD results, Resolution MSC.81(70) provides assessment criteria for the eight lifejackets:

Righting time in swimwear – the minimum average righting time would be “*that of the RTD plus 1 second*”, i.e. 2.62 seconds for batch 1, 2.73 seconds for batch 2 and 2.80 seconds for batch 3 (see paragraph 0). No lifejacket would be allowed to record a no-turn.

Freeboard in swimwear – “*lift the mouth of exhausted or unconscious persons by an average height of not less than the average provided by the adult RTD minus 10mm*”. This would require a minimum average static balance freeboard measurement of 121mm for batch 1, 123mm for batch 2 and 130mm for batch 3.

Freeboard after 1m jump test – “*surface the test subject in a face up position with an average freeboard for all the subjects of not less than the average determined for the RTD after the turning test minus 15 mm*”. This would require a minimum freeboard measurement of 116mm for batch 1, 118mm for batch 2 and 125mm for batch 3.

Noting that the Group has developed additional proposals to amend the assessment criteria within Resolution MSC.81(70), the following additional assessment criteria can be derived:

Proposed requirement 1: Righting time in swimwear – the maximum average righting time would be the lesser of the following: 5 s, or the average time of the RTD plus 1. Additionally, each test subject must conclude the righting tests in the face-up position.

Proposed requirement 2: Righting time in standardised clothing – each test subject must conclude the righting tests in the face-up position, and the average time to achieve this face up position must not exceed 5 seconds.

Lifejacket 1 – the two samples of this lifejacket provided 178.21 and 179.93 Newtons of buoyancy.

Swimwear – out of the eight SOLAS lifejackets, this lifejacket achieved the fastest average righting time of 1.05 seconds with an average time to the face-up position of 2.66 seconds. Test subject 7 began the righting test with their airways clear of the water even though they were in the face-down position, but they quickly turned to the

face up position in an average of 1.77 seconds. The average freeboard for the group was measured at 126mm which reduced slightly to 124mm after the 1m jump test.

Clothing – two test subjects each reported one no-turn result, although both of these test subjects achieved righting times below 5 seconds for their other righting tests. Test subject 14 began the test with airways clear in the face down position but still turned to the face-up position. Noting that two no-turn results were included, the average righting time was 1.67 seconds. The average freeboard measurement reduced to 114mm whilst wearing clothing, with test subject 14 recording 85mm freeboard. The average freeboard measurement after the 1m jump was 119mm.

Lif Jacket 2 – the two samples of this lifejacket provided 156.14 and 155.26 Newtons of buoyancy.

Swimwear – this lifejacket achieved an average righting time to airways clear of 1.85 seconds with all test subjects achieving the face-up position in less than 5 seconds. The average freeboard was 156mm which reduced after the 1m jump test to an average of 143mm.

Clothing – five test subjects incurred no-turn results; one of these test subjects incurred the no-turn on the first righting test and then recorded righting times below 5 seconds for the remaining tests, however the other four test subjects recorded consistently high righting times or no-turns for the other righting tests. Test subject 14 began the test with airways clear, but due to being stable in this position, on four occasions did not achieve the face-up position. The average freeboard measurement was 158mm was very similar to that of swimwear. The average freeboard after the 1m jump test was 152mm.

Lif Jacket 3 – the two samples of this lifejacket provided 191.65 and 190.57 Newtons of buoyancy.

Swimwear – this lifejacket recorded the 2nd fastest righting time with an average time to the airways clear of 1.1 seconds and an average time to face-up of 2.45 seconds. The average static balance freeboard was 152mm which reduced to 147mm after the 1m jump test.

Clothing – all test subjects turned in the standardised clothing with only one test subject incurring an average righting time over 5 seconds. The group's average righting time was 2.04 seconds. The average freeboard was 147mm and the average freeboard after the 1m jump test was 150mm.

Lif Jacket 4 – the two samples of this lifejacket provided 136.92 and 143.10 Newtons of buoyancy.

Swimwear – in swimwear this lifejacket recorded one test subject which recorded no-turns for all six righting tests. A further test subject recorded one no-turn on the last righting test. Two further test subjects recorded righting times in-excess of 5 seconds although these were removed after discarding the highest and lowest results. The average righting time (noting that no-turns could not be included in the average) was 2.11 seconds. This lifejacket recorded an average static balance freeboard measurement in swimwear of 111mm and an average freeboard after the 1m jump test

of 98mm. During the three static balance freeboard measurements, the test subject which recorded no-turn righting tests, also recorded a zero freeboard measurement when exhaled.

Clothing – five test subjects incurred no-turn results, however the test subject which recorded no-turns in swimwear, recorded six valid righting tests with an average righting time of 4.45 seconds to airways clear. In clothing the average static balance freeboard further reduced to 103mm and the average freeboard after the 1m jump test was 108mm.

Lifejacket 5 – the two samples of this lifejacket provided 179.49 and 180.74 Newtons of buoyancy.

Swimwear - this lifejacket recorded an average righting time in swimwear of 1.88 seconds however test subject 10 recorded several longer righting times with an average of 5.49 seconds. The average freeboard for this lifejacket was 119mm. The average freeboard after the 1m jump test was 114mm.

Clothing – four test subjects recorded no-turns whilst wearing this lifejacket and one test subject recorded an average righting time in excess of 5 seconds; test subject 11 recorded no-turns only. The average freeboard measurement was 127mm which was 8mm larger than in swimwear. Although test subject 14 showed six relatively quick turning times for airways clear, longer periods were recorded to right to the face-up position. The average freeboard after the 1m jump test was 126mm.

Lifejacket 6 – the two samples of this lifejacket provided 186.30 and 187.87 Newtons of buoyancy.

Swimwear - this lifejacket recorded an average righting time of 1.63 seconds. On four occasions test subject 14 floated with airways clear in the face-down position. The average freeboard measurement was 125mm. The average freeboard measurement after the 1m jump test reduced to 116mm.

Clothing – three test subjects recorded no-turns, with test subjects 2 and 11 recording five no-turns each. Test subject 10 recorded a no-turn for the first righting test and then recorded an average of 6.49 seconds for airways clear for the remaining five tests. The average freeboard was recorded as 130mm. During the 1m jump test in clothing, the average freeboard measurement remained at 130mm, however this average does not recognise that the lifejacket was found to rise over the top of the head of test subject 11.

Lifejacket 7 – the two samples of this lifejacket provided 147.19 and 147.68 Newtons of buoyancy.

Swimwear - this lifejacket recorded an average righting time of 1.94 seconds. Ten test subjects recorded a static balance freeboard under 100mm with a lowest freeboard measured as 43mm. This resulted in an average static balance freeboard of 85mm. The average freeboard measurement after the 1m jump test further reduced to 77mm.

Clothing – two test subjects recorded no-turns, with the remaining test subjects recording an average righting time of 3.54 seconds. The average freeboard whilst

wearing clothing was 90mm and the average freeboard after the 1m jump test was 87mm.

Lifejacket 8 – the two samples of this lifejacket provided 175.45 and 170.50 Newtons of buoyancy.

Swimwear - this lifejacket recorded an average righting time of 1.31 seconds, with all test subjects achieving the face-up position in less than 5 seconds. The average freeboard was 131mm which reduced after the 1m jump test to an average of 129mm.

Clothing – all test subjects turned in the standardised clothing with all test subjects recording average righting times less than 5 seconds. The group's average righting time in clothing was 2.08 seconds. The average freeboard was 129mm and the average freeboard after the 1m jump test was 130mm.

Table 16: Pass/fail results for the eight existing SOLAS lifejackets against the existing requirements of Resolution MSC.81(70) and the Group's proposed requirements

	Pass/fail Criteria	Existing SOLAS Lifejackets (test model number)							
		1	2	3	4	5	6	7	8
Existing requirements from Resolution MSC.81(70)	Did the lifejacket achieve a minimum average righting time in swimwear less than the RTD plus 1 second?	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass
	Did the lifejacket achieve an average freeboard in swimwear not less than the RTD minus 10mm?	Pass	Pass	Pass	Fail	Fail	Pass	Fail	Pass
	Did the lifejacket achieve an average freeboard in swimwear for the 1m jump test not less than the RTD minus 15mm?	Pass	Pass	Pass	Fail	Fail	Fail	Fail	Pass
Proposed requirement 1	Did the lifejacket achieve an average righting time in swimwear less than the following: 5 seconds or the RTD average plus 1 second?	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Proposed requirement 2:	Did the lifejacket turn each test subject into the face-up position, and achieve an average righting time in standardised clothing less than 5 seconds?	Fail	Fail	Pass	Fail	Fail	Fail	Fail	Pass

Further Analysis

Proposed requirement 1: The existing text in Resolution MSC.81(70) allows the average righting time in swimwear to be up to a second longer than that in the RTD – therefore this requirement could allow for a lifejacket to record an average righting time greater than 5 seconds if the RTD recorded a time greater than 4 seconds. The group had proposed that this would not be acceptable and had developed proposed requirement 1. After reviewing the results from the eight lifejackets, it is seen that the slowest average righting time in swimwear was 2.11 seconds, and it would be highly unlikely for any lifejacket to exhibit an average

righting time near to 5 seconds. The group subsequently questioned whether this proposed requirement would benefit lifejacket performance.

Table 16 shows that seven of the eight lifejackets recorded average righting time requirements which achieved the existing SOLAS requirements against the RTD in swimwear. One lifejacket did not meet these requirements because it recorded more no-turn results than the RTD (i.e. more than the zero no-turns recorded by the RTD).

It was noted that the average righting times recorded for each of the eight lifejackets with test subjects in swimwear were very close together, with the eight averages between 1.05 and 2.11 seconds. The Group had considered whether the average righting time results in swimwear could be extrapolated to provide a theoretical performance in clothing, however the average righting times in swimwear are probably too close to provide accurate predictions, especially if these predictions would be used as approval criteria.

Proposed requirement 2: The tests with test subjects wearing standardised clothing concluded with six out of the eight lifejackets not being able to provide an in-water performance capable of turning all of the 14 test subjects into the face up position. Two lifejackets were able to achieve this criteria in addition to the existing requirements in Resolution MSC.81(70).

It can be seen within the raw test results for the six lifejackets with test subjects wearing standardised clothing that 48 no-turns were recorded. Resolution MSC.81(70) does not define a no-turn result, and hence it can be seen that some of the recorded righting times were very lengthy; longer righting times increase the risk that an unconscious casualty inhales water (see paragraph 0). It was observed during this testing that if a test subject incurs a righting time in-excess of 5 seconds then the turning process has become noticeably slow. Therefore, to provide consistency when recording results, the Group proposed that any righting time longer than 10 seconds should be identified as not exhibiting the correct righting behaviour and could be recorded as a no-turn.

The face up position had been defined by the Group as the safe posture associated with measurements for the static balance freeboard and body angles. The Group had raised concerns that from their previous experiences, test subjects had been observed to achieve their airways clear of the water, but had not necessarily attained the full face up position. During these in-water tests, there were several occasions when test subjects incurred an extended period of time to achieve the face-up position after achieving their airways clear of the water, however none of the test subjects exhibited a righting test where they achieved their airways clear, but didn't achieve the face up position. For all of the lifejackets including the RTD, the average time between achieving the airways clear and achieving the face-up position was 1.3 seconds in swimwear, and 1.93 seconds in standardised clothing. There is a correlation that longer times to achieve airways clear result in a longer lag period to achieve the face up position; i.e. if a test subject turns slowly to the airways clear position, this slow rate of turn continues into the face up position. Another aspect highlighted during these tests is that certain combinations of test subject and lifejacket can be stable in the face down position; for example, test subject 14 was found to be very stable in the face-down position when wearing lifejacket 2, and hence did not achieve the face-up position. The Group have experience of this scenario when test subjects wear a lifejacket with a large symmetrical buoyancy distribution (e.g. 275N buoyancy), which results in a high stability in the face-down position.

Freeboard measurements were taken in the static balance position and after the 1m jump test. The existing tests in Resolution MSC.81(70) provide an assessment of the clearance of a person's airways from the water surface, which is known to affect the level of safety offered by a lifejacket. The 1m jump test offers a further assessment of the lifejacket securing arrangements. If similar readings are obtained for freeboard during the static tests and after the 1m jump test then this is an indication that the securing arrangements are not adversely affected by the addition of clothing. Such results were obtained for most of the lifejackets, however one test subject whilst wearing lifejacket 6 found the lifejacket to come over their head during the 1m jump test. The static balance freeboard measurements in swimwear and clothing varied slightly, but a trend was not shown for whether clothing increased or decreased the average freeboard measurements. Although not the purpose of these tests, it should be noted that four lifejackets did not achieve the existing assessment criteria in Resolution MSC.81(70) for freeboard.

Two additional measurements of freeboard were measured for the inhaled and exhaled lung positions both in the static balance position and after the 1m jump test. The majority of these results showed that a test subject in the fully inhaled position would give a higher freeboard than the static balance freeboard, and that the static balance would give a higher freeboard than the fully exhaled freeboard. However, throughout the testing it was noticed that fully inhaling or exhaling could have an effect on other floatation characteristics such as body angle. The freeboard measurement is not independent of a test subject's body angle and some lifejackets were found to place a greater emphasis on supporting the test subjects head. Therefore, it was observed that some combinations of test subject and lifejacket had an unexpected change in freeboard, and there are results where a static balance freeboard measurement was less than both the fully exhaled and fully inhaled freeboards.

The buoyancy values for the eight lifejackets ranged from 140 to 191 Newtons, with the RTD providing approximately 148 Newtons.

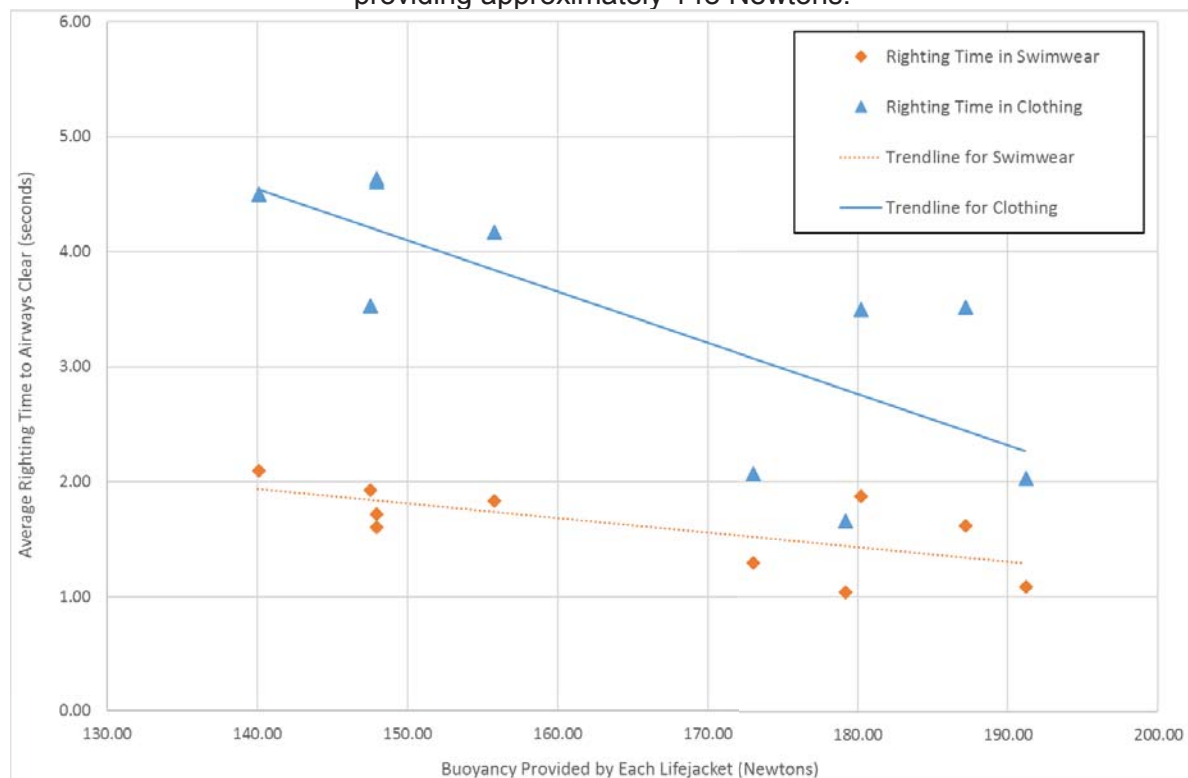


Figure 6 shows a trend in the average righting times recorded for each lifejacket when these are compared against the lifejacket buoyancy readings. It can be seen that an increase in buoyancy levels correlates with improved average righting times provided by a lifejacket. Conversely, a lifejacket with lesser buoyancy is more likely to provide slower righting times.

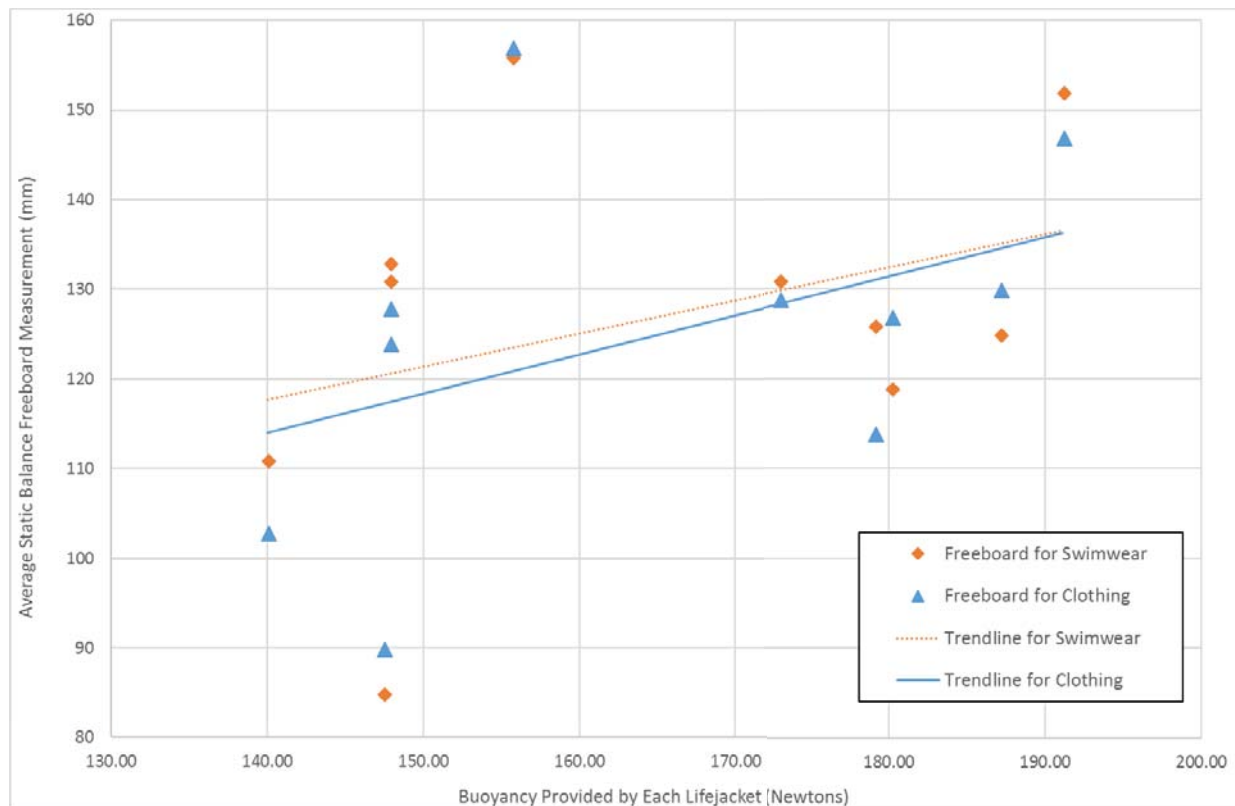


Figure 7 shows a comparison between the average static balance freeboard measurement and the buoyancy of a lifejacket. Although this data shows a larger variance, there are trends that a larger buoyancy provides for an increased average static balance freeboard measurement. Conversely, a reduced buoyancy would be more likely to produce a reduced average freeboard measurement. This greater variance in the data may be influenced by the design of the lifejackets as it was observed that head and neck supports could affect the flotation angles of a test subject (see paragraph 0).

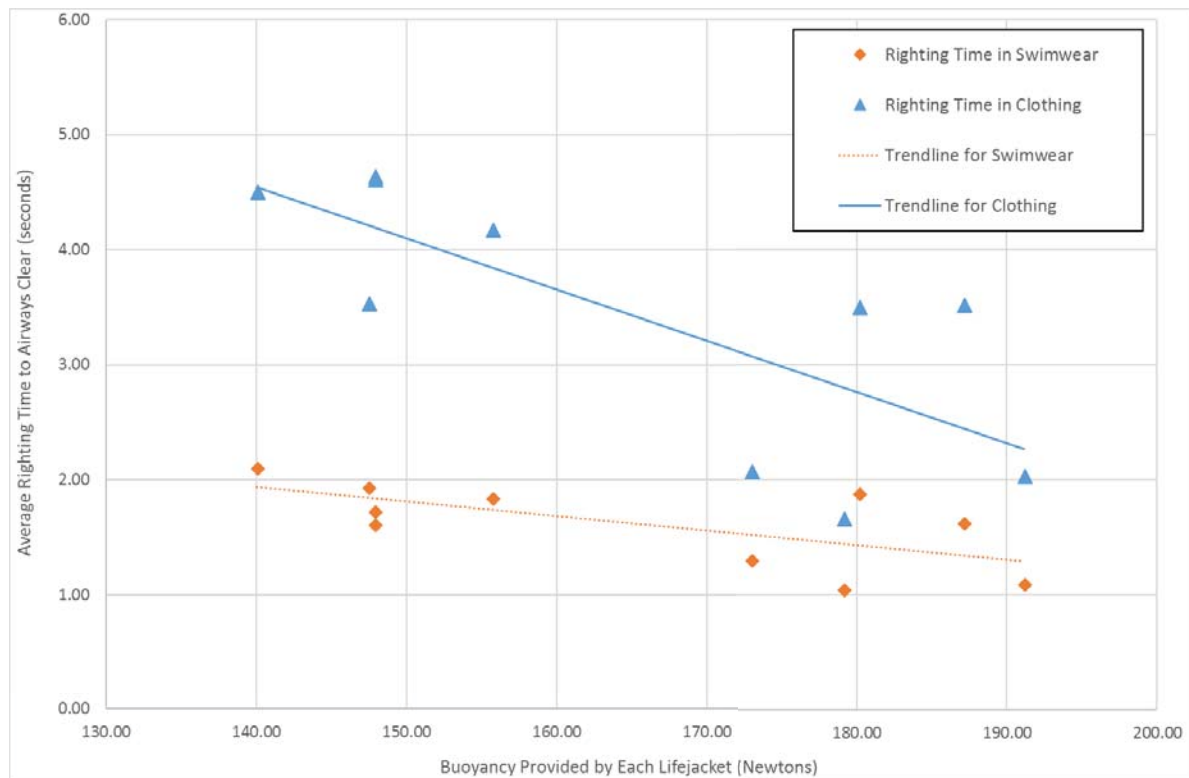


Figure 6: Average righting time versus lifejacket buoyancy

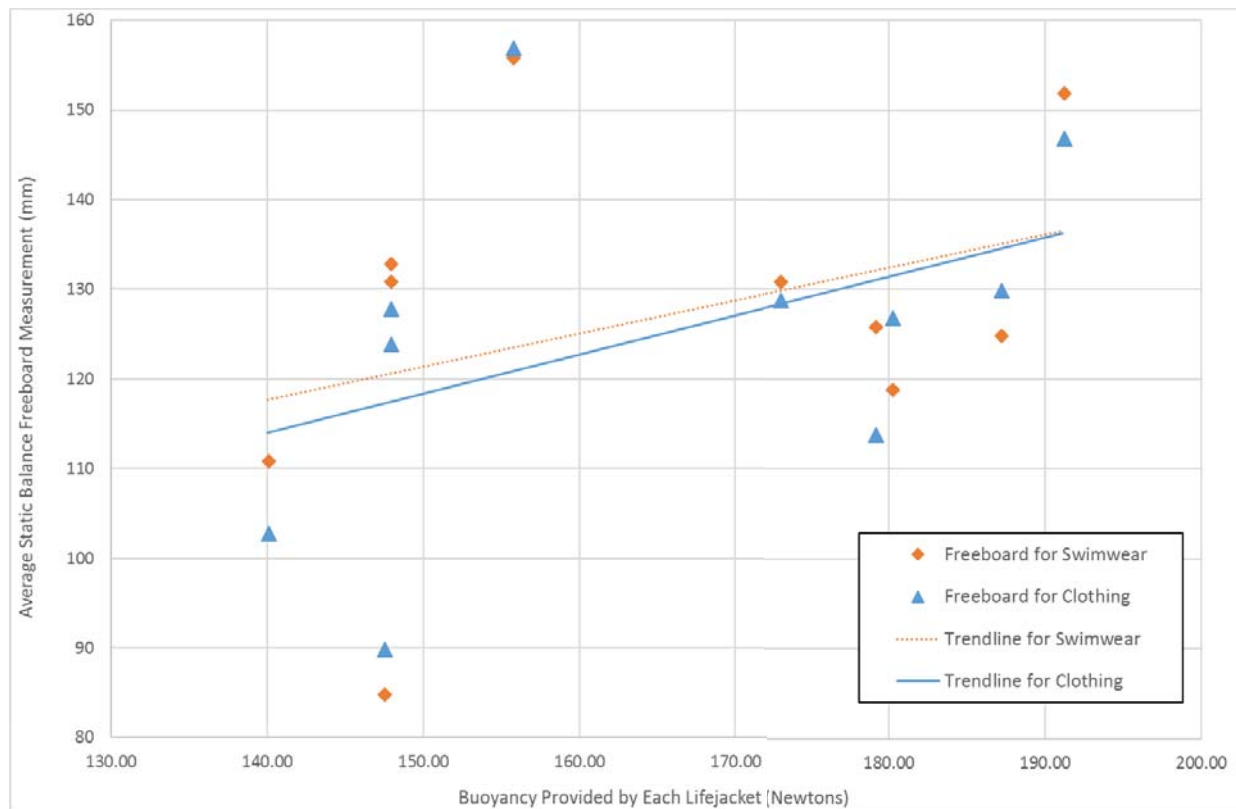


Figure 7: Average static balance freeboard measurements versus lifejacket buoyancy

Conclusions

All SOLAS lifejackets are currently assessed against the testing requirements contained within the 2010 LSA Code and Resolution MSC.81(70). These tests are conducted using persons who meet specific height and weight categories, and all tests are conducted in controlled environment with calm, fresh water. The testing requires that a lifejacket's performance is comparatively assessed against the performance of the Reference Test Device (RTD) lifejacket such that a lifejacket provides a performance within a certain tolerance of the RTD result. This method of comparative testing assists to remove many of the variables associated with in-water testing, which promotes more consistent and repeatable test results.

Even with the incorporation of these testing methods into the 2010 LSA Code and Resolution MSC.81(70), there remain concerns for the reliability and repeatability of in-water testing of lifejackets. It was not the intention of this review to reassess the approval status of existing SOLAS lifejackets, however during the testing of eight lifejackets which held the latest approvals, half of these lifejackets failed the existing requirements within Resolution MSC.81(70). For the majority of these lifejackets, it was found that one or two test subjects skewed the results to generate a failing result, and if the testing was repeated using different test subjects then the final result may have been different. A similar situation regarding the repeatability of testing was also highlighted during the review of the Fishing Vessel Louisa's lifejackets.

There is a general consensus that the introduction of the RTD for comparative testing within Resolution MSC.81(70) has provided a useful benchmark from which to assess the in-water performance of a lifejacket, and the RTD-related requirements for static balance measurements have promoted a step-change in lifejacket performance (with test subjects wearing swimwear). However, it has been highlighted during the testing at the RNLI and Fleetwood Test House that the RTD does not guarantee a self-righting performance with persons wearing clothing. Thereby, the RTD should not be used as a comparative testing tool for any additional tests that might involve clothing.

This review has highlighted that the wearing of clothing has a substantial impact on the in-water performance of a lifejacket. From the testing at the RNLI it was observed how the wearing of additional clothing had a proportionately detrimental impact on the righting performance of a lifejacket. For example, with test subjects wearing swimwear only, no failures were recorded for the righting tests. However, when wearing light passenger clothing, 11% of the righting tests were recorded as a failure to turn, and when wearing heavy weather clothing, such as that expected to be worn on cargo or fishing vessels in heavy weather, the percentage of no turns increased to 49% of the righting tests.

The Group developed a new proposal to amend Resolution MSC.81(70) to incorporate an in-water test using a set of standardised clothes. The standardised clothes were defined in detail to include trousers, socks, shoes, a shirt, a jumper and a waterproof jacket. Following consultation with international stakeholders it was decided to assess the suitability of this new test against a selection of existing SOLAS lifejackets.

Eight SOLAS lifejackets with existing 2010 LSA Code approvals were selected for this assessment, with the lifejackets coming from a range of manufacturers and IMO Member States. Out of the eight SOLAS lifejackets, six of these incurred no-turn results with test

subjects wearing standardised clothing and therefore failed to achieve the acceptance criteria specified by the Group. Of concern was that four of these lifejackets failed to meet the existing requirements of Resolution MSC.81(70) (see Further Analysis starting at paragraph 0). Two of the existing SOLAS lifejackets passed all of the criteria specified by the Group, and thereby provided an in-water performance with standardised clothing expected by the Group.

From consultations with other maritime stakeholders, the Group believes that the inclusion of no-turn results in a controlled assessment is unacceptable, (albeit noting that there may be a justifiable reason to discount erroneous test results). There is limited justification for why a lifejacket should be permitted to record no-turn results within the prescribed SOLAS testing conditions, when other test parameters such as the selection of test subjects are already limited in their scope when compared to a realistic emergency scenario. The results from the in-water tests raise doubts whether the existing test requirements within Resolution MSC.81(70) are sufficient to assess the in-water performance of SOLAS lifejackets. The additional proposed tests incorporating clothing have shown that they provide a more representative assessment of the performance of SOLAS lifejackets, and the Group's new proposed tests in clothing could be incorporated such that lifejackets are required to turn all test subjects into a face up position within 5 seconds, with zero no-turns recorded. (In the event of recording a no-turn result, the two-test-subject-substitution method could be used to replace a test subject who was producing spurious results.)

Although not assessed during this review, the Group noted that other influencing factors or equipment, such as tool belts, are likely to have similar effects to clothing upon in-water performance. The Group discussed how the compatibility between life-saving equipment is key to ensuring the safety of life at sea, and equipment testing standards should be cognisant of equipment used or worn simultaneously.

In summary, the Group believes that two main actions need to be taken:

- (1) Improvements should be made to the design and testing requirements for SOLAS lifejackets to ensure that they provide an adequate in-water performance when used in more representative conditions such as when subjects wear clothing
- (2) Maritime stakeholders would benefit from an improved awareness of the factors which may affect the in-water performance of lifejackets

Further actions, such as retrospective application of a new testing standard, may be deemed necessary if maritime stakeholders consider the in-water performance of existing SOLAS lifejackets to be a significant risk to maritime safety.

Appendix: Results from the Further In-water Testing Using Existing SOLAS Lifejackets

RTD (Batch 1) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting a) Airways clear, b) full face up position								Initial Freeboard (mm)		
		1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance
1	a)	1.31	1.42	1.33	1.48	1.59	1.33	1.39	145	172	150
	b)	1.21	2.63	2.60	3.60	3.36	3.30	2.97			
2	a)	1.91	2.33	1.48	1.46	1.46	1.80	1.66	148	160	148
	b)	6.52	6.15	6.69	6.21	6.12	5.61	6.25			
3	a)	3.26	2.80	2.71	2.00	2.34	2.63	2.62	129	155	143
	b)	5.24	4.92	4.13	3.00	4.96	4.70	4.68			
4	a)	1.08	1.17	0.54	0.77	0.65	0.73	0.83	122	137	128
	b)	1.78	1.73	1.26	1.58	1.21	1.35	1.48			
5	a)	1.93	1.50	1.63	1.34	1.48	1.56	1.54	145	158	146
	b)	3.49	2.72	3.47	3.27	4.12	2.55	3.24			
6	a)	2.40	1.71	2.05	1.50	1.40	1.45	1.68	118	165	135
	b)	3.86	3.50	4.12	3.43	3.18	3.66	3.61			
7	a)	2.33	1.54	1.31	1.71	1.25	1.45	1.50	132	146	134
	b)	3.78	2.81	2.58	3.00	2.24	2.58	2.74			
8	a)	3.17	2.22	3.03	3.13	2.23	2.33	2.68	97	142	119
	b)	3.69	3.44	4.12	4.30	2.93	3.41	3.67			
9	a)	2.81	1.11	1.83	0.83	0.96	1.08	1.25	115	139	126
	b)	3.76	1.76	1.91	1.46	1.49	1.50	1.67			
10	a)	0.97	0.60	1.72	0.51	1.60	0.29	0.92	116	103	111
	b)	1.50	1.18	1.79	1.18	2.64	1.03	1.41			
11	a)	2.33	2.33	2.30	1.64	1.90	2.48	2.22	120	152	126
	b)	4.96	5.52	5.54	4.49	5.52	5.12	5.28			
12	a)	1.16	0.85	0.79	0.82	1.57	1.03	0.97	122	154	133
	b)	2.33	1.92	1.83	1.86	2.47	1.92	2.01			
13	a)	2.25	1.94	3.01	2.02	2.75	2.20	2.31	105	154	118
	b)	4.27	3.41	4.30	3.47	4.40	4.04	4.02			
14	a)	1.20	1.17	1.17	1.17	1.03	0.87	1.14	128	131	122
	b)	3.92	3.06	2.72	2.49	2.35	2.06	2.66			
Averages of all subjects:							a)	1.62	124 mm	148 mm	131 mm
							b)	3.26			

NT = No Turn (Total number of no turns in RTD in Swimwear = 0)

RTD (Batch 1) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting a) Airways clear, b) full face up position								Initial Freeboard (mm)		
		1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance
1	a)	3.00	2.74	2.39	2.23	2.73	2.39	2.56	130	163	143
	b)	7.36	5.56	4.60	4.67	5.09	4.00	4.98			
2	a)	NT	4.51	4.46	2.23	7.50	4.56	4.51	133	136	120
	b)	NT	6.86	6.63	10.95	9.29	6.12	7.59			
3	a)	7.97	5.37	4.02	3.28	2.59	3.02	3.92	126	150	133
	b)	8.53	7.44	5.70	4.78	4.41	4.66	5.65			
4	a)	2.80	2.02	1.06	1.11	1.40	1.19	1.43	124	143	132
	b)	6.75	3.33	2.15	2.33	2.63	2.64	2.73			
5	a)	5.54	1.50	1.25	1.86	1.79	2.73	1.97	159	177	168
	b)	6.46	3.10	2.66	3.33	3.21	4.66	3.58			
6	a)	3.33	4.60	3.50	3.42	3.31	2.40	3.39	128	159	133
	b)	8.23	6.76	6.13	7.69	6.46	5.50	6.76			
7	a)	13.94	4.70	3.14	3.68	3.20	1.65	3.68	103	118	109
	b)	15.46	6.12	4.73	5.15	4.52	3.12	5.13			
8	a)	NT	NT	NT	NT	2.83	7.81	5.32	108	215	112
	b)	NT	NT	NT	NT	4.12	8.43	6.28			
9	a)	2.39	2.02	1.59	1.06	1.30	1.02	1.49	113	118	108
	b)	3.63	3.29	2.81	2.01	2.38	2.02	2.63			
10	a)	3.65	1.40	3.46	1.54	1.25	1.65	2.01	111	114	78
	b)	4.32	2.03	4.36	1.92	1.86	2.69	2.74			
11	a)	NT	NT	NT	NT	NT	11.65	11.65	124	151	138
	b)	NT	NT	NT	NT	NT	18.32	18.32			
12	a)	3.97	2.50	2.31	2.34	2.31	2.26	2.37	116	141	126
	b)	4.67	4.06	3.60	3.61	3.58	3.53	3.71			
13	a)	NT	NT	13.43	7.26	7.34	6.51	7.30	130	148	133
	b)	NT	NT	15.36	9.52	10.76	11.03	10.90			
14	a)	4.77	14.36	26.76	20.23	NT	1.39	13.12	110	114	107
	b)	6.24	16.29	29.47	23.75	NT	14.15	18.06			
Averages of all subjects:							a)	4.62	123 mm	149 mm	124 mm
							b)	7.08			

NT = No Turn (Total number of no turns in RTD in Test clothing = 13)

Lifejacket Model 1 (Batch 1) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position							Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	0.50	0.54	0.65	0.40	0.54	0.50	0.52	136	156	139	131	157	139
	b)	2.47	2.40	2.26	2.52	2.47	2.29	2.37						
2	a)	0.63	0.63	0.82	0.34	0.36	0.86	0.61	147	169	147	146	163	141
	b)	3.41	3.60	3.46	3.32	3.27	3.69	3.45						
3	a)	1.64	1.91	1.62	1.54	1.74	1.96	1.73	128	150	138	121	144	130
	b)	3.47	3.93	3.50	3.03	3.60	3.72	3.57						
4	a)	0.34	0.50	0.40	0.63	0.40	0.32	0.41	128	142	128	131	141	133
	b)	1.16	1.35	1.16	1.44	1.03	1.07	1.19						
5	a)	0.90	0.77	1.11	0.96	0.86	0.73	0.87	129	144	129	115	144	128
	b)	2.24	1.81	2.15	2.06	1.78	1.67	1.95						
6	a)	1.97	0.83	1.11	1.02	1.16	0.82	1.03	114	157	128	110	141	113
	b)	2.63	2.67	3.09	2.47	2.61	2.20	2.60						
7	a)	1.85	1.50	1.45	1.48	1.40	1.50	1.48	115	128	115	113	133	118
	b)	3.23	2.90	2.72	3.09	3.01	3.24	3.06						
8	a)	1.06	1.50	1.43	1.31	1.88	1.17	1.35	118	143	119	121	153	123
	b)	2.06	2.35	2.06	1.91	3.07	1.78	2.10						
9	a)	1.06	0.51	0.50	0.59	0.82	0.77	0.67	117	131	118	115	119	120
	b)	1.35	1.00	1.21	1.44	1.40	1.40	1.34						
10	a)	0*	0*	0*	0*	0.65	0.70	0.16	102	124	95	99	111	106
	b)	1.64	1.46	2.06	1.83	2.26	1.55	1.77						
11	a)	1.63	1.36	1.76	1.39	1.59	1.53	1.54	118	149	135	128	150	137
	b)	3.66	3.61	3.50	3.60	3.04	3.60	3.58						
12	a)	1.54	1.91	2.03	2.22	2.05	2.34	2.05	127	147	138	117	129	120
	b)	3.15	3.33	3.30	3.81	3.93	3.81	3.56						
13	a)	1.63	1.93	1.93	1.73	1.71	1.56	1.75	128	159	134	119	139	118
	b)	4.13	4.20	3.63	3.89	4.03	3.44	3.92						
14	a)	0.46	0.45	1.33	0.65	0.50	0.45	0.52	97	110	99	116	120	111
	b)	2.67	2.70	2.73	2.40	2.84	3.13	2.74						
Averages of all subjects:							a)	1.05	122 mm	144 mm	126 mm	120 mm	139 mm	124 mm
							b)	2.66						

NT = No Turn (Total number of no turns in Model 1 in Swimwear = 0) * Airways clear

Lifejacket Model 1 (Batch 1) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry		
	a) Airways clear, b) full face up position							Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
	1	2	3	4	5	6	Ave							
1	a)	1.23	1.34	1.43	1.65	1.20	1.30	121	143	125	✓	124	140	123
	b)	4.01	3.92	4.18	3.32	3.30	4.07	121	143	125		124	140	123
2	a)	1.17	0.91	1.25	1.20	0.74	0.77	121	134	121	✓	125	125	112
	b)	5.44	5.43	6.87	4.85	5.26	5.80	112	127	118	✓	120	134	126
3	a)	2.97	2.06	1.85	2.37	2.13	1.60	118	130	123	✓	144	149	143
	b)	4.33	4.29	4.07	4.63	4.38	4.07	114	134	119	✓	135	149	136
4	a)	1.96	0.88	0.88	0.96	0.87	1.06	91	120	102	✓	111	137	119
	b)	2.23	2.26	2.21	2.33	2.04	2.43	99	109	101	✓	79	90	86
5	a)	1.73	1.08	1.62	1.34	1.39	1.94	108	120	106	✓	108	121	106
	b)	3.52	2.72	3.46	3.41	3.50	3.87	115	128	116	✓	121	132	119
6	a)	1.37	1.40	1.30	1.74	1.85	1.54	116	134	123	✓	112	134	123
	b)	3.53	3.15	3.50	3.53	3.50	3.43	124	138	124	✓	137	145	133
7	a)	NT	4.34	3.40	3.02	2.26	2.40	127	143	122	✓	109	127	113
	b)	NT	10.90	8.29	5.50	4.70	5.32	89	99	85	✓	97	103	97
8	a)	1.66	1.34	1.68	1.72	2.97	1.28	112	120	112	✓	128	139	124
	b)	3.00	2.38	2.76	2.61	3.07	2.41	112	128	116	✓	121	132	119
9	a)	1.11	1.11	1.20	3.03	1.56	0.96	115	120	112	✓	128	139	124
	b)	2.47	2.14	2.15	3.96	2.41	1.86	112	128	116	✓	121	132	119
10	a)	2.70	4.20	NT	3.21	1.22	1.39	116	134	123	✓	112	134	123
	b)	3.46	5.93	NT	4.01	3.15	2.43	124	138	124	✓	137	145	133
11	a)	1.84	2.25	2.16	2.02	1.60	1.70	127	143	122	✓	109	127	113
	b)	6.72	5.72	5.26	5.07	4.87	5.00	89	99	85	✓	97	103	97
12	a)	2.06	1.93	2.45	2.13	2.11	2.27	112	120	112	✓	128	139	124
	b)	3.20	3.16	3.53	3.72	3.75	3.72	124	138	124	✓	137	145	133
13	a)	2.79	2.22	6.39	2.50	2.36	3.28	127	143	122	✓	109	127	113
	b)	7.35	6.38	5.41	7.24	6.26	7.04	89	99	85	✓	97	103	97
14	a)	0*	0*	0*	0*	0*	0.00	112 mm	127 mm	114 mm		118 mm	130 mm	119 mm
	b)	4.78	6.04	6.46	5.44	6.52	6.18	112 mm	127 mm	114 mm		118 mm	130 mm	119 mm
Averages of all subjects:														
							a)	1.67	127 mm	114 mm		118 mm	130 mm	119 mm
							b)	4.23	127 mm	114 mm		118 mm	130 mm	119 mm

NT = No Turn (Total number of no turns in Model 1 in Test Clothing = 2) *Airways clear

Lifejacket Model 2 (Batch 1) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting								Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position														
		1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	1.54	1.20	1.22	1.02	0.85	0.96	1.10	133	164	148	125	158	139	
	b)	2.95	2.75	3.06	2.84	2.43	2.89	2.86							
2	a)	1.85	1.53	1.77	1.63	1.43	1.40	1.59	155	173	156	168	191	173	
	b)	4.63	4.63	4.52	4.32	4.53	4.41	4.52							
3	a)	1.80	1.65	1.78	2.17	2.11	2.02	1.93	160	177	158	118	148	131	
	b)	3.87	3.58	3.96	3.95	4.04	4.13	3.96							
4	a)	0.82	0.63	0.63	0.65	0.68	0.50	0.65	161	173	162	149	158	149	
	b)	2.06	1.76	1.63	1.64	1.63	1.49	1.67							
5	a)	1.36	2.03	2.11	2.62	2.08	2.03	2.06	130	142	139	93	113	90	
	b)	2.49	4.24	3.47	4.04	4.15	3.63	3.82							
6	a)	2.02	1.39	1.54	1.53	1.40	1.50	1.49	122	171	139	97	136	113	
	b)	3.47	3.27	3.29	3.04	3.10	3.15	3.20							
7	a)	2.40	2.51	2.43	2.08	1.69	1.62	2.15	153	164	148	153	168	157	
	b)	4.33	3.81	3.93	3.86	2.80	2.93	3.63							
8	a)	5.91	3.08	4.23	2.71	2.56	3.51	3.38	175	193	183	168	188	176	
	b)	7.01	4.95	5.04	3.84	3.92	4.69	4.65							
9	a)	1.14	1.11	1.16	1.03	0.91	0.77	1.05	146	160	158	152	161	153	
	b)	2.03	1.63	1.90	1.69	1.67	1.53	1.72							
10	a)	1.48	2.17	4.19	6.20	2.52	1.11	2.59	158	173	168	136	148	147	
	b)	2.80	3.58	4.84	8.54	3.32	1.86	3.64							
11	a)	1.72	2.02	2.31	1.91	2.40	1.76	2.00	139	180	156	137	175	153	
	b)	3.95	4.73	4.15	4.27	4.89	3.69	4.28							
12	a)	2.48	3.37	2.67	2.91	3.23	2.74	2.89	158	179	165	119	145	140	
	b)	4.01	5.12	4.04	4.24	4.78	3.80	4.27							
13	a)	2.28	2.45	2.37	2.28	1.90	2.22	2.29	142	175	147	149	180	148	
	b)	3.73	3.53	3.60	3.60	3.36	3.86	3.62							
14	a)	0.86	0.86	0.77	0.70	0.67	0.76	0.77	171	167	159	133	145	131	
	b)	3.92	3.64	3.41	4.09	3.66	3.36	3.66							
Averages of all subjects:									150 mm	171 mm	156 mm	136 mm	158 mm	143 mm	

Lifejacket Model 2 (Batch 1) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position							Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	3.14	2.48	2.31	2.25	2.53	2.40	163	189	173	✓	178	192	173
	b)	8.12	5.81	6.03	2.07	6.20	6.09	6.03						
2	a)	NT	NT	12.88	21.36	7.97	6.26	163	176	165	✓	148	157	153
	b)	NT	NT	16.46	24.73	10.69	10.26	13.58						
3	a)	3.76	3.82	3.83	3.54	3.76	3.25	135	161	144	✓	142	161	149
	b)	7.61	9.64	7.95	7.53	7.29	6.44	7.60						
4	a)	3.45	2.48	2.70	1.94	4.76	3.23	157	165	156	✓	170	173	168
	b)	5.75	5.04	5.06	4.12	3.69	5.46	4.92						
5	a)	3.74	2.80	2.74	2.53	3.20	3.93	173	191	179	✓	148	164	152
	b)	6.38	6.38	5.70	4.46	5.70	6.93	6.04						
6	a)	2.46	2.56	4.82	2.66	2.00	2.51	115	154	134	✓	145	170	147
	b)	5.43	5.66	5.16	5.89	5.38	5.15	5.41						
7	a)	8.13	2.66	2.65	2.52	4.76	2.31	148	158	152	✓	139	148	145
	b)	11.00	4.60	4.53	4.44	3.87	4.47	4.51						
8	a)	NT	NT	7.37	6.14	7.31	6.40	148	173	152	✓	173	181	175
	b)	NT	NT	10.04	8.07	9.47	7.64	8.77						
9	a)	NT	4.02	3.43	5.36	4.76	2.71	160	166	164	✓	163	177	170
	b)	NT	5.84	4.93	6.72	3.73	4.92	5.23						
10	a)	NT	7.39	NT	7.97	NT	6.06	159	163	161	✓	143	157	145
	b)	NT	9.00	NT	8.35	NT	7.53	8.35						
11	a)	9.34	8.22	7.45	6.14	5.73	4.63	138	173	157	✓	153	173	164
	b)	10.55	12.40	10.55	10.27	8.53	8.58	9.99						
12	a)	3.50	2.65	2.30	2.46	2.33	2.56	160	173	160	✓	128	143	132
	b)	4.49	4.15	3.89	3.64	3.69	4.16	3.97						
13	a)	5.13	5.59	5.76	4.60	4.05	4.28	175	185	176	✓	115	140	115
	b)	11.78	9.16	7.50	8.50	7.61	7.55	8.21						
14	a)	0*	0*	0*	0*	0*	0*	130	149	135	✓	138	154	137
	b)	NT	NT	18.64	NT	14.23	NT	16.44						
Averages of all subjects:														
								152 mm	170 mm	158 mm		149 mm	164 mm	152 mm

NT = No Turn (Total number of no turns in Model 2 in Test Clothing = 8. Note: On 12 occasions, subjects did not achieve a full face up position)

Lifejacket Model 3 (Batch 1) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position							Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	0.63	0.79	0.70	0.63	0.65	0.59	0.65	155	181	✓	170	170	168
	b)	2.40	2.44	2.12	2.01	1.87	2.15	2.17						
2	a)	0.63	0.59	1.26	0.68	0.59	0.91	0.70	161	178	✓	155	160	155
	b)	3.18	3.13	3.29	2.89	2.84	2.70	3.01						
3	a)	1.66	1.37	0.90	1.16	1.03	1.36	1.23	155	177	✓	145	163	150
	b)	3.36	3.30	1.89	2.24	1.86	2.49	2.48						
4	a)	0.50	0.54	0.31	0.45	0.31	0.50	0.44	148	158	✓	151	155	151
	b)	1.12	1.17	1.21	1.26	0.83	1.30	1.19						
5	a)	1.17	0.74	0.77	1.25	0.76	0.86	0.89	170	183	✓	138	156	143
	b)	2.24	1.73	1.72	2.52	1.63	1.95	1.91						
6	a)	1.89	1.53	1.59	1.48	1.43	1.26	1.51	144	177	✓	143	175	153
	b)	3.61	3.46	6.03	3.23	3.46	3.20	3.44						
7	a)	1.82	1.76	2.06	1.02	1.08	0.91	1.42	114	123	✓	133	144	136
	b)	2.76	3.09	3.70	1.86	2.12	2.06	2.51						
8	a)	1.17	1.48	2.88	1.31	1.16	1.57	1.38	154	173	✓	136	153	139
	b)	1.55	2.02	3.66	1.92	2.01	2.46	2.10						
9	a)	0.96	0.77	0.86	0.45	1.22	1.48	0.95	134	144	✓	139	150	136
	b)	1.64	1.39	1.66	1.07	2.03	2.15	1.68						
10	a)	4.09	1.43	1.25	4.62	1.59	0.82	2.09	149	139	✓	135	143	128
	b)	4.60	2.06	1.95	6.69	2.67	1.53	2.82						
11	a)	1.02	0.86	0.91	1.08	1.05	1.59	1.00	155	165	✓	153	170	155
	b)	2.01	1.81	1.60	2.95	1.89	2.35	2.02						
12	a)	1.17	0.89	0.91	1.06	1.25	1.17	1.08	156	165	✓	144	165	149
	b)	2.42	1.53	1.63	1.81	1.95	2.03	1.86						
13	a)	2.06	2.26	1.76	2.10	2.59	1.75	2.05	149	173	✓	135	161	146
	b)	4.04	4.15	3.09	3.69	4.52	4.29	4.04						
14	a)	0.91	0.91	0.91	0.91	0.91	0.91	0.91	134	146	✓	153	151	153
	b)	2.80	3.61	2.13	4.73	3.73	4.18	3.07						
Averages of all subjects:														
NT = No Turn (Total number of no turns in Model 3 in Swimwear = 0) * Airways clear														

Lif jacket Model 3 (Batch 1) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting a) Airways clear, b) full face up position							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a) 1.10	1.62	1.33	1.16	1.39	1.06	1.25	167	188	173	✓	159	174	158
	b) 4.84	4.53	4.61	4.49	3.69	3.27	4.33							
2	a) 2.17	3.17	2.45	1.74	1.73	2.10	2.12	150	153	145	✓	141	146	138
	b) 6.26	7.29	6.40	5.60	6.06	5.06	6.08							
3	a) 1.16	1.68	1.45	1.76	1.36	1.16	1.41	143	155	142	✓	148	160	152
	b) 2.52	3.29	2.76	3.32	2.81	2.56	2.86							
4	a) 1.06	0.90	0.82	0.86	1.17	0.77	0.91	132	143	135	✓	160	166	166
	b) 3.36	2.21	1.86	2.15	4.46	2.33	2.51							
5	a) 3.57	2.97	1.34	1.39	1.42	2.02	1.95	177	181	172	✓	165	179	166
	b) 5.04	3.49	2.75	3.00	2.87	4.32	3.42							
6	a) 2.82	2.28	2.31	2.45	1.85	1.82	2.22	141	177	154	✓	140	166	152
	b) 5.13	4.16	4.24	4.75	3.64	3.52	4.20							
7	a) 2.73	1.74	1.79	1.63	1.31	2.30	1.87	130	145	138	✓	123	138	128
	b) 4.15	3.07	3.46	3.29	2.53	3.80	3.41							
8	a) 8.03	1.81	0.88	1.40	1.66	1.20	1.52	143	155	138	✓	144	155	148
	b) 4.63	2.78	1.96	2.86	2.89	3.04	2.89							
9	a) 1.03	1.01	1.01	1.06	0.91	1.26	1.03	129	138	128	✓	143	148	146
	b) 1.96	1.93	1.81	1.62	1.76	2.00	1.87							
10	a) 2.93	2.34	3.26	2.11	0.59	1.17	2.14	155	168	155	✓	165	175	167
	b) 3.50	3.24	3.73	3.01	1.16	2.03	2.95							
11	a) 8.94	5.48	4.39	5.68	5.43	3.90	5.25	118	150	136	✓	139	153	146
	b) 15.81	7.87	8.15	9.58	9.56	5.70	8.79							
12	a) 2.62	1.50	1.62	1.70	1.60	2.00	1.73	136	167	148	✓	141	154	141
	b) 4.00	2.76	2.89	2.83	2.60	2.89	2.84							
13	a) 6.23	4.36	4.16	4.20	4.85	3.13	4.39	152	162	153	✓	148	155	148
	b) 10.46	7.38	7.44	8.36	8.24	6.04	7.86							
14	a) 0.90	0.60	0.82	0.86	0.59	0.78	0.77	139	149	138	✓	139	143	137
	b) 4.78	3.80	6.18	4.03	6.23	3.96	4.74							
Averages of all subjects:							a) 2.04 b) 4.20	144 mm	159 mm	147 mm		147 mm	158 mm	150 mm

NT = No Turn (Total number of no turns in Model 3 in Test Clothing = 0)

Lifejacket Model 4 (Batch 1) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position							Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
	1	2	3	4	5	6	Ave							
1	a)	1.39	1.37	1.76	1.74	2.14	2.40	1.76	130	166	✓	117	151	122
	b)	2.84	3.21	2.38	3.21	4.07	4.24	3.33						
2	a)	2.83	3.37	4.39	1.72	2.40	3.96	3.14	109	131	✓	122	133	116
	b)	4.87	6.01	6.18	3.30	4.56	6.73	5.41						
3	a)	1.34	1.26	1.28	1.71	1.53	1.17	1.35	127	155	✓	108	133	110
	b)	2.61	2.29	2.50	3.00	2.66	2.46	2.56						
4	a)	0.36	0.40	0.40	0.57	0.45	0.50	0.44	130	135	✓	100	118	103
	b)	1.16	1.21	1.07	1.36	1.30	1.16	1.21						
5	a)	1.82	1.42	2.03	0.96	1.52	0.91	1.43	149	157	✓	126	145	134
	b)	2.53	2.49	2.87	2.01	2.64	1.90	2.42						
6	a)	NT	NT	NT	NT	NT	NT	-	84	144	✓	0	57	19
	b)	NT	NT	NT	NT	NT	NT	-						
7	a)	6.08	4.39	2.45	2.00	1.30	1.26	2.54	94	109	✓	67	74	60
	b)	6.96	5.52	3.49	3.04	2.52	2.41	3.64						
8	a)	2.25	2.70	2.65	1.80	4.08	3.20	2.70	111	116	✓	96	113	102
	b)	2.72	3.41	3.38	2.61	4.73	4.33	3.46						
9	a)	1.02	1.02	1.56	1.02	3.08	1.60	2.20	88	106	✓	88	103	96
	b)	1.67	1.72	2.32	1.76	3.87	2.41	2.05						
10	a)	0.26	1.86	1.83	8.05	2.28	5.30	2.82	120	99	✓	148	83	75
	b)	1.53	3.06	4.43	9.32	3.41	7.41	4.58						
11	a)	1.51	2.05	3.03	5.28	3.75	NT	2.94	130	156	✓	136	165	141
	b)	2.20	2.67	3.64	5.93	4.63	NT	2.74						
12	a)	2.17	2.02	1.84	1.73	1.86	1.76	1.87	113	131	✓	102	125	108
	b)	3.12	2.72	2.73	2.67	2.63	2.33	2.69						
13	a)	2.57	2.17	3.46	3.36	2.17	2.54	2.66	88	127	✓	91	122	100
	b)	4.55	3.67	5.26	5.38	3.90	4.24	4.49						
14	a)	1.53	1.30	1.66	2.26	1.39	1.48	1.52	97	120	✓	85	103	85
	b)	2.66	2.43	2.75	3.40	2.47	2.61	2.62						
Averages of all subjects:														
a) 2.11														
b) 3.17														
112 mm									132 mm			111 mm		
NT = No Turn (Total number of no turns in Model 4 in Swimwear = 7)														
99 mm									116 mm			98 mm		

Lif Jacket Model 4 (Batch 1) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting a) Airways clear, b) full face up position							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	2.63	2.43	2.53	2.59	3.97	3.85	2.90	120	156	125	145	160	140
	b)	4.10	4.44	4.00	3.72	3.78	5.18	4.08						
2	a)	3.91	NT	5.88	4.14	4.28	3.37	4.11	118	133	109	131	131	115
	b)	6.32	NT	7.84	6.81	6.63	5.03	6.59						
3	a)	1.88	2.08	1.53	1.53	1.68	1.50	1.66	111	126	113	98	108	94
	b)	3.58	3.67	3.32	3.10	3.33	3.10	3.33						
4	a)	0.82	0.82	0.69	0.70	1.19	1.25	0.88	116	128	116	129	143	146
	b)	2.24	2.06	2.20	2.12	2.84	2.75	2.33						
5	a)	2.66	2.62	3.53	2.83	1.88	1.66	2.50	148	154	153	132	143	133
	b)	4.18	4.27	5.27	4.63	4.01	3.50	4.27						
6	a)	5.77	4.85	2.82	2.36	4.36	5.97	4.45	34	113	72	38	100	54
	b)	8.87	7.81	5.50	5.50	6.09	6.90	6.58						
7	a)	12.42	4.66	4.20	3.40	3.73	6.97	4.89	73	88	73	68	78	71
	b)	14.07	5.90	6.18	5.24	5.93	8.29	6.58						
8	a)	NT	8.00	5.41	10.50	4.46	2.74	5.96	83	101	85	98	117	102
	b)	NT	10.35	6.32	12.24	5.60	4.26	5.57						
9	a)	2.54	1.70	1.94	1.16	1.39	1.79	1.71	93	111	94	118	128	126
	b)	4.01	3.26	2.89	2.33	2.84	3.21	3.05						
10	a)	6.28	0.86	11.21	NT	2.46	NT	4.37	68	88	84	72	89	95
	b)	8.03	1.95	12.40	NT	3.55	NT	5.79						
11	a)	NT	NT	12.66	NT	NT	NT	12.66	106	148	128	119	143	134
	b)	NT	NT	13.92	NT	NT	NT	13.92						
12	a)	2.55	2.05	1.79	2.59	2.72	2.57	2.44	103	118	103	121	132	121
	b)	4.01	3.15	2.78	3.63	3.84	3.69	3.58						
13	a)	7.51	6.59	5.17	5.10	5.71	4.08	5.64	99	125	100	90	125	94
	b)	9.67	8.20	7.66	6.41	7.60	5.81	7.47						
14	a)	5.60	12.31	NT	NT	4.63	18.28	8.96	91	108	92	87	101	89
	b)	7.21	14.29	NT	NT	6.70	20.21	10.75						
Averages of all subjects:							a)	4.51	97 mm	121 mm	103 mm	103 mm	121 mm	108 mm
							b)	5.99						

NT = No Turn (Total number of no turns in Model 4 in Test Clothing = 11)

RTD (Batch 2) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting a) Airways clear, b) full face up position								Initial Freeboard (mm)		
		1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance
1	a)	1.89	1.57	1.42	1.65	0.88	1.53	1.54	117	174	125
	b)	4.75	4.49	4.24	4.21	3.70	4.26	4.30			
2	a)	1.46	2.11	1.40	1.50	1.46	1.93	1.59	143	158	143
	b)	6.26	5.67	6.10	5.67	5.27	5.55	5.75			
3	a)	1.94	1.59	1.82	1.83	1.59	2.14	1.80	147	165	146
	b)	2.89	3.52	3.43	3.90	3.47	3.78	3.55			
4	a)	0.68	0.63	0.73	0.59	0.59	0.56	0.62	125	166	128
	b)	1.63	1.49	1.58	1.30	1.35	1.44	1.47			
5	a)	2.26	2.34	0.86	1.03	1.34	1.25	1.47	158	179	160
	b)	3.90	4.09	1.90	2.03	2.53	2.29	2.69			
6	a)	2.40	1.71	2.05	1.50	1.40	1.45	1.68	118	165	135
	b)	3.86	3.50	4.12	3.43	3.18	3.66	3.61			
7	a)	2.54	2.16	2.03	2.31	2.20	2.48	2.29	129	135	126
	b)	3.95	3.70	3.84	3.95	3.52	3.84	3.83			
8	a)	3.02	3.68	3.39	2.59	3.02	2.26	3.01	132	167	144
	b)	3.82	4.90	4.60	3.16	4.14	2.93	3.93			
9	a)	2.28	1.11	0.93	1.02	0.77	0.91	0.99	123	141	125
	b)	2.95	1.67	1.60	1.72	1.58	1.63	1.66			
10	a)	2.43	1.66	7.45	2.68	3.91	2.05	2.77	143	140	117
	b)	3.24	2.61	8.49	3.40	5.38	3.38	3.85			
11	a)	2.97	1.62	1.76	1.84	1.62	1.77	1.75	126	169	137
	b)	3.90	4.44	3.46	4.84	4.86	4.87	4.51			
12	a)	1.93	1.34	1.14	1.25	1.08	1.25	1.25	135	161	138
	b)	3.67	2.80	2.41	2.75	2.16	2.47	2.61			
13	a)	2.25	1.94	3.01	2.02	2.75	2.20	2.31	105	154	118
	b)	4.27	3.41	4.30	3.47	4.40	4.04	4.02			
14	a)	1.20	1.17	1.17	1.17	1.03	0.87	1.14	128	131	122
	b)	3.92	3.06	2.72	2.49	2.35	2.06	2.66			
Averages of all subjects:							a)	1.73	131 mm	158 mm	133 mm
							b)	3.46			

NT = No Turn (Total number of no turns in RTD in Swimwear = 0)

RTD (Batch 2) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting a) Airways clear, b) full face up position								Initial Freeboard (mm)		
		1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance
1	a)	3.63	2.48	2.41	2.37	1.85	1.96	2.31	138	146	144
	b)	5.84	5.53	4.70	7.30	5.10	5.95	5.61			
2	a)	NT	NT	NT	NT	NT	NT	-	135	137	128
	b)	NT	NT	NT	NT	NT	NT	-			
3	a)	NT	7.02	6.71	6.68	8.20	6.14	6.80	124	143	130
	b)	NT	8.63	8.60	8.56	10.92	8.30	8.60			
4	a)	6.93	1.48	1.47	0.89	1.08	1.96	1.50	138	147	135
	b)	8.81	2.66	2.69	2.07	2.35	3.38	2.77			
5	a)	3.08	1.85	1.91	1.45	1.70	1.46	1.73	149	172	148
	b)	4.40	3.32	3.24	2.90	3.30	2.87	3.19			
6	a)	3.33	4.60	3.50	3.42	3.31	2.40	3.39	128	159	133
	b)	8.23	6.76	6.13	7.69	6.46	5.50	6.76			
7	a)	NT	3.80	4.65	1.36	3.36	3.54	3.57	109	123	111
	b)	NT	5.70	6.44	3.01	5.47	5.56	5.58			
8	a)	NT	11.51	8.08	4.22	5.03	5.33	6.15	122	134	120
	b)	NT	13.23	9.58	5.81	5.49	6.58	7.32			
9	a)	NT	4.76	1.54	1.43	1.43	1.63	1.53	121	148	123
	b)	NT	5.47	2.40	2.33	2.32	2.67	2.47			
10	a)	9.16	1.76	1.67	5.51	2.31	2.48	3.02	113	133	115
	b)	10.33	2.70	2.86	6.53	3.67	3.43	4.12			
11	a)	NT	NT	15.74	8.69	6.83	5.91	7.76	128	141	130
	b)	NT	NT	19.92	11.09	9.78	8.09	10.44			
12	a)	2.77	6.46	2.63	1.74	1.88	2.00	2.32	147	151	140
	b)	4.20	8.58	3.95	2.96	3.12	3.28	3.64			
13	a)	NT	NT	13.43	7.26	7.34	6.51	7.30	130	148	133
	b)	NT	NT	15.36	9.52	10.76	11.03	10.90			
14	a)	4.77	14.36	26.76	20.23	NT	1.39	13.12	110	114	107
	b)	6.24	16.29	29.47	23.75	NT	14.15	18.06			
Averages of all subjects:							a)	4.65	128 mm	143 mm	128 mm
							b)	6.88			

NT = No Turn (Total number of no turns in RTD in Test clothing = 15)

Lif jacket Model 5 (Batch 2) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting								Initial Freeboard (mm)				Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position													Fully exhaled	Fully inhaled	Static balance
		1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance	Fully exhaled		Fully inhaled	Static balance	
1	a)	1.30	1.11	1.31	0.77	0.91	1.74	1.16	137	148	129	119	143	121		
	b)	3.69	3.04	3.70	2.80	2.24	2.83	3.09								
2	a)	1.48	1.48	1.57	1.43	1.34	1.13	1.43	132	144	128	119	137	116		
	b)	4.53	3.69	4.35	3.83	3.78	3.61	3.91								
3	a)	1.34	1.97	1.97	0.81	0.86	0.74	1.25	128	151	129	114	142	124		
	b)	3.83	2.26	2.16	2.16	2.10	1.87	2.17								
4	a)	0.50	0.40	0.43	0.45	0.45	0.59	0.46	119	130	123	128	137	124		
	b)	1.26	1.11	1.21	1.12	1.40	1.35	1.24								
5	a)	1.57	1.34	1.08	0.86	0.91	1.97	1.23	139	166	149	111	131	115		
	b)	3.09	2.75	2.26	2.01	2.15	2.21	2.34								
6	a)	2.37	2.08	2.40	1.79	2.33	2.16	2.24	98	152	115	100	156	117		
	b)	3.83	3.44	3.67	3.49	3.60	3.33	3.55								
7	a)	1.43	1.50	3.31	2.95	1.56	2.17	2.05	98	109	95	87	108	93		
	b)	2.61	2.26	4.53	4.23	2.50	3.21	3.14								
8	a)	5.62	3.46	2.84	4.10	3.66	3.73	3.74	111	152	112	95	140	110		
	b)	6.38	4.36	1.06	5.41	4.78	4.56	4.78								
9	a)	1.10	2.26	1.08	0.93	0.93	1.26	1.09	91	115	95	95	109	102		
	b)	1.61	2.73	1.60	1.37	1.64	2.07	1.73								
10	a)	8.94	4.82	4.85	2.76	1.17	3.33	5.49	128	149	112	126	127	113		
	b)	9.93	5.67	6.32	3.66	12.30	4.18	6.53								
11	a)	2.08	1.50	1.68	1.71	1.74	1.22	1.66	98	153	112	92	141	109		
	b)	5.46	4.41	4.69	3.46	3.49	2.58	4.01								
12	a)	1.65	1.37	2.65	1.26	1.53	1.63	1.55	120	148	118	126	150	122		
	b)	3.44	2.83	4.76	2.63	2.70	3.10	3.02								
13	a)	2.19	2.26	2.37	2.88	2.28	2.54	2.36	114	149	125	116	147	123		
	b)	3.69	4.06	4.43	4.53	4.07	3.81	4.09								
14	a)	0.63	0.63	0.45	0.59	0.59	0.45	0.57	115	136	119	89	119	100		
	b)	3.83	4.16	4.16	3.60	3.64	3.46	3.81								
Averages of all subjects:									116 mm	143 mm	119 mm	108 mm	135 mm	114 mm		

NT = No Turn (Total number of no turns in Model 5 in Swimwear = 0)

Lifejacket Model 5 (Batch 2) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position							Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	1.90	2.06	1.36	1.82	1.51	1.90	1.78	152	164	150	126	145	135
	b)	4.95	5.03	4.27	4.60	4.80	5.20	4.85						
2	a)	NT	12.14	5.91	3.40	5.79	4.20	5.30	139	144	136	143	148	140
	b)	NT	14.43	8.27	5.93	7.86	6.55	7.56						
3	a)	NT	NT	19.23	5.86	3.87	4.19	5.03	115	131	121	121	140	124
	b)	NT	NT	20.64	8.00	5.55	6.07	3.52						
4	a)	0.63	0.26	0.45	0.74	0.68	0.59	0.59	132	145	133	128	144	135
	b)	2.38	1.63	1.81	2.40	2.53	2.15	2.19						
5	a)	1.84	1.43	2.59	2.16	2.00	1.96	1.99	129	153	134	126	139	126
	b)	3.30	2.84	3.90	3.29	3.23	3.24	3.27						
6	a)	3.88	4.03	2.86	3.10	3.08	3.22	3.32	126	154	129	108	149	114
	b)	6.52	6.80	5.83	5.67	5.47	6.27	6.07						
7	a)	2.90	2.77	2.77	2.20	1.62	4.13	2.66	118	136	118	112	123	111
	b)	4.30	4.29	4.35	3.84	3.00	5.49	4.20						
8	a)	8.43	5.22	4.90	3.50	5.51	3.71	4.84	117	152	131	119	145	127
	b)	9.75	6.40	6.27	4.76	6.64	4.81	6.03						
9	a)	9.02	2.10	2.77	5.08	3.13	1.83	3.27	94	114	109	106	123	110
	b)	10.06	2.89	3.81	6.30	3.78	2.86	4.20						
10	a)	NT	5.26	1.76	2.25	2.59	7.13	3.37	118	127	113	124	139	124
	b)	NT	6.40	2.84	3.64	3.90	8.49	4.65						
11	a)	NT	NT	NT	NT	NT	NT	-	116	141	115	123	143	123
	b)	NT	NT	NT	NT	NT	NT	-						
12	a)	2.37	3.94	2.71	2.54	2.23	2.25	2.48	134	147	129	138	151	139
	b)	4.35	5.69	3.84	3.86	3.70	3.60	3.94						
13	a)	8.23	7.34	5.11	6.02	7.50	5.10	6.49	135	156	128	133	149	134
	b)	10.41	9.00	7.41	8.04	9.61	6.96	8.52						
14	a)	0.86	1.65	1.20	0.93	1.20	1.20	1.13	133	144	133	121	137	122
	b)	13.44	12.81	6.78	5.63	6.83	5.84	8.07						
<div> <div>Averages of all subjects:</div> <div> <div>a)</div> <div>b)</div> </div> </div> <div> 126 mm 143 mm 127 mm </div>														

NT = No Turn (Total number of no turns in Model 5 in Test Clothing = 10)

Lifejacket Model 6 (Batch 2) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position							Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	1.40	1.30	1.17	1.03	0.73	0.77	1.07	129	175	✓	110	145	105
	b)	3.66	3.46	2.63	2.76	3.78	3.52	3.35						
2	a)	1.54	1.46	1.22	1.03	1.06	1.16	1.23	134	149	✓	118	151	124
	b)	4.83	4.01	3.15	2.80	3.36	3.09	3.40						
3	a)	1.63	2.17	1.91	2.10	1.85	2.22	2.01	146	162	✓	114	141	131
	b)	2.46	3.16	3.01	3.69	3.78	4.04	3.41						
4	a)	0.50	0.35	0.36	0.45	0.65	0.36	0.42	155	164	✓	123	136	127
	b)	1.26	1.21	0.96	1.12	1.64	1.07	1.17						
5	a)	0.88	1.08	0.93	0.77	1.36	1.08	0.99	133	157	✓	95	125	103
	b)	1.92	2.35	1.87	1.86	2.58	2.03	2.04						
6	a)	1.96	1.89	1.71	1.73	1.39	1.56	1.72	119	173	✓	109	158	125
	b)	4.04	3.76	3.60	3.47	3.00	3.40	3.56						
7	a)	2.34	2.37	2.45	2.68	2.43	2.51	2.44	130	146	✓	130	141	124
	b)	3.33	3.50	4.56	4.66	4.13	4.21	4.10						
8	a)	4.40	5.19	3.51	3.14	2.31	2.96	3.50	104	159	✓	101	161	118
	b)	5.07	5.84	4.46	4.16	3.16	3.76	4.36						
9	a)	0.86	2.03	0.80	0.82	0.83	0.66	0.83	103	118	✓	90	120	109
	b)	1.53	2.60	1.27	1.44	1.73	1.55	1.56						
10	a)	6.73	2.77	1.17	1.39	2.93	1.96	2.26	132	129	✓	113	133	108
	b)	7.67	3.53	1.78	2.20	3.73	2.67	3.03						
11	a)	1.61	2.13	1.59	1.79	1.52	0.91	1.63	111	168	✓	127	177	133
	b)	2.78	5.23	4.92	4.56	3.16	2.01	3.86						
12	a)	1.64	1.10	0.88	1.08	1.48	1.08	1.19	115	138	✓	106	130	104
	b)	2.80	2.32	1.83	2.49	2.70	2.03	2.39						
13	a)	3.39	2.91	3.61	3.45	3.91	2.70	3.34	115	153	✓	98	127	108
	b)	6.30	5.36	6.47	5.78	5.66	6.32	6.02						
14	a)	0.3	0.3	0.3	0.63	0.54	0.3	0.14	97	129	✓	114	131	110
	b)	2.35	3.56	3.84	2.88	3.46	3.21	3.28						
Averages of all subjects:							a)	1.63	123 mm	151 mm		111 mm	141 mm	116 mm
							b)	3.25	125 mm	125 mm				

NT = No Turn (Total number of no turns in Model 6 in Swimwear = 0) * Airways clear

Lifejacket Model 6 (Batch 2) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting								Initial Freeboard (mm)				Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position								Fully exhaled	Fully inhaled	Static balance	Fully exhaled		Fully inhaled	Static balance	
	1	2	3	4	5	6	Ave									
1	a)	2.30	2.08	2.06	2.45	1.53	4.45	1.99	141	162	139	151	167	145		
	b)	4.23	4.33	4.18	4.24	6.46	5.63	4.61								
2	a)	NT	NT	NT	NT	NT	11.17	11.17	138	153	143	131	140	134		
	b)	NT	NT	NT	NT	NT	13.58	13.58								
3	a)	2.88	5.66	6.87	2.13	3.00	3.16	3.68	121	139	118	119	137	119		
	b)	3.92	6.89	9.04	3.81	4.53	4.56	4.98								
4	a)	0.50	0.59	0.54	0.59	0.28	0.54	0.54	133	155	134	133	143	137		
	b)	2.01	1.72	1.67	1.63	1.36	1.48	1.63								
5	a)	2.08	1.83	1.71	1.50	1.54	1.26	1.65	160	178	161	132	148	137		
	b)	3.32	3.35	3.32	2.72	2.89	2.49	3.06								
6	a)	3.60	4.11	3.26	2.39	2.40	3.11	3.09	129	168	139	121	152	127		
	b)	8.07	6.36	5.01	3.92	4.52	5.04	5.23								
7	a)	3.73	3.17	3.71	2.33	3.93	3.76	3.59	120	132	120	112	127	114		
	b)	5.33	4.81	5.27	3.78	5.44	5.32	5.18								
8	a)	7.85	3.14	4.06	5.43	2.77	3.39	4.01	92	148	118	106	141	129		
	b)	9.13	4.13	5.15	6.38	4.06	4.38	5.01								
9	a)	1.50	1.31	1.31	1.13	1.43	1.40	1.36	103	122	127	113	130	116		
	b)	2.53	2.13	2.26	1.92	2.10	2.26	2.19								
10	a)	NT	3.40	3.93	7.48	9.60	8.06	6.49	140	132	113	129	131	120		
	b)	NT	8.76	6.20	9.36	14.35	11.30	9.81								
11	a)	NT	NT	NT	NT	5.33	NT	5.33	142	164	137	128	165	141		
	b)	NT	NT	NT	NT	7.63	NT	7.63								
12	a)	1.06	1.51	1.76	1.26	1.86	1.54	1.52	120	143	123	11	11	11		
	b)	2.15	2.87	2.93	2.35	2.95	2.76	2.73								
13	a)	3.37	4.22	3.93	3.25	4.97	3.43	3.74	107	138	110	132	165	131		
	b)	4.95	5.49	5.49	4.75	5.53	4.75	5.17								
14	a)	2.20	2.40	1.02	0.75	1.02	0.82	1.27	133	151	143	130	146	135		
	b)	6.07	7.15	4.30	2.75	2.24	3.60	4.18								
Averages of all subjects:								a)	3.53	127 mm	149 mm	130 mm	126 mm	146 mm	130 mm	
								b)	5.36							

NT = No Turn (Total number of no turns in Model 6 in Test Clothing = 11) 1Lifejacket came over subjects head, measurement could not be taken.

Lif jacket Model 7 (Batch 2) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting								Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)							
	a) Airways clear, b) full face up position												Fully exhaled	Fully inhaled	Static balance					
		1	2	3	4	5	6	Ave		Fully exhaled	Fully inhaled		Static balance	Fully exhaled	Fully inhaled	Static balance				
1	a)	3.91	3.65	4.36	1.90	1.71	2.59	3.01		97	153	95	98	125	104					
	b)	4.72	5.81	6.93	2.61	2.20	3.34	4.12												
2	a)	1.97	1.34	1.79	1.59	1.63	1.39	1.60		95	112	90	83	103	95					
	b)	2.12	2.75	4.26	3.24	3.23	2.89	3.03												
3	a)	1.57	0.70	0.63	2.14	1.13	1.06	1.12		94	140	105	87	116	88					
	b)	2.47	1.36	1.30	2.93	2.12	1.95	1.98												
4	a)	0.68	0.33	0.46	0.39	0.40	0.50	0.44		119	131	115	99	115	107					
	b)	1.53	1.12	1.27	0.92	1.07	0.96	1.11												
5	a)	1.45	1.51	1.39	1.77	1.54	1.16	1.47		91	121	101	58	93	61					
	b)	2.10	2.41	2.43	2.67	2.49	2.20	2.38												
6	a)	3.88	3.17	4.17	3.63	3.85	3.51	3.72		67	120	59	10	63	25					
	b)	8.53	5.75	5.95	5.75	6.12	5.67	5.89												
7	a)	2.11	3.94	4.73	1.94	1.76	6.28	3.18		83	89	80	70	79	73					
	b)	3.10	5.04	5.81	2.84	2.70	7.21	4.20												
8	a)	2.83	1.82	1.57	2.79	2.63	2.20	2.36		92	29	103	70	100	75					
	b)	3.36	2.67	2.29	3.46	3.44	3.01	3.12												
9	a)	1.91	2.03	1.06	1.11	1.11	1.17	1.33		53	80	68	47	81	62					
	b)	2.35	2.60	1.63	1.63	1.76	1.64	1.85												
10	a)	3.19	1.25	1.50	0.86	0.86	1.06	1.12		115	146	43	38	51	37					
	b)	3.89	2.15	2.03	1.53	1.72	1.73	1.91												
11	a)	4.42	1.43	2.08	2.87	2.30	2.46	2.43		111	129	95	88	136	99					
	b)	5.13	2.09	2.78	3.53	3.01	3.18	3.13												
12	a)	2.78	1.97	1.17	1.26	1.39	1.06	1.45		86	103	88	98	125	98					
	b)	3.86	1.78	2.16	2.29	2.26	2.10	2.20												
13	a)	3.54	2.43	2.59	3.26	3.08	2.60	2.88		67	109	77	69	106	86					
	b)	5.24	4.49	5.92	5.52	3.65	3.50	4.73												
14	a)	1.54	1.31	1.06	0.88	0.96	0.88	1.05		78	93	74	54	80	62					
	b)	3.10	4.97	5.43	5.40	3.09	2.30	4.14												
Average freeboard of all subjects:																				
															89 mm	111 mm	85 mm	69 mm	98 mm	77 mm

NT = No Turn (Total number of no turns in Model 7 in Swimwear = 0)

Lifejacket Model 7 (Batch 2) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting								Initial Freeboard (mm)			Initial face up after 1 m jump?	Freeboard after 1 m water entry (mm)		
	a) Airways clear, b) full face up position								Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	1	2	3	4	5	6	Ave	84	118	94	✓	86	93	82
	b)	5.35	4.52	4.87	5.23	5.30	4.15	4.98							
2	a)	15.79	3.10	2.31	3.36	2.11	2.42	2.80	114	134	104	✓	118	119	103
	b)	18.29	4.87	4.38	5.66	4.55	4.49	4.89							
3	a)	3.50	1.23	1.22	1.39	1.70	1.97	1.57	98	111	93	✓	88	98	88
	b)	4.63	2.50	2.58	2.61	2.83	2.96	2.75							
4	a)	0.91	0.45	0.54	0.63	0.45	0.73	0.59	105	113	106	✓	110	120	107
	b)	2.01	1.35	1.63	1.53	1.35	1.49	1.50							
5	a)	1.36	1.39	1.11	1.81	1.31	1.39	1.36	105	124	105	✓	78	102	85
	b)	2.67	2.61	2.38	2.87	2.40	2.38	2.52							
6	a)	5.23	4.28	4.25	4.00	3.37	3.66	4.05	60	111	76	✓	66	109	72
	b)	7.58	6.26	6.29	6.03	5.30	5.55	6.03							
7	a)	3.26	4.88	4.11	5.10	NT	NT	4.50	90	93	78	✓	71	85	69
	b)	5.24	6.12	5.47	6.36	NT	NT	5.80							
8	a)	4.19	2.42	2.90	2.40	2.88	2.51	2.68	73	119	90	✓	75	99	86
	b)	5.00	3.23	3.84	3.35	3.87	3.55	3.65							
9	a)	2.80	2.75	1.93	2.31	2.00	2.13	2.30	56	85	78	✓	68	79	72
	b)	3.52	3.46	2.60	3.21	2.75	2.87	3.07							
10	a)	8.81	6.26	2.86	6.33	5.70	6.91	6.30	84	108	73	✓	91	105	68
	b)	10.12	7.21	4.05	7.27	6.92	8.63	7.51							
11	a)	NT	16.20	9.73	NT	NT	NT	12.97	80	125	103	✓	87	130	106
	b)	NT	17.93	11.24	NT	NT	NT	14.59							
12	a)	1.33	1.80	1.50	1.59	2.47	1.56	1.61	100	117	98	✓	111	130	113
	b)	2.46	2.93	2.53	2.53	3.32	2.60	2.65							
13	a)	5.22	3.79	3.37	3.60	3.42	3.51	3.58	82	118	73	✓	90	109	87
	b)	7.75	5.63	4.96	5.16	5.12	4.92	5.22							
14	a)	12.09	1.36	1.80	2.20	2.03	1.02	1.85	93	106	92	✓	91	101	82
	b)	14.38	4.78	4.58	6.56	4.84	4.76	5.24							
Averages of all subjects:									87 mm	113 mm	90		88 mm	106 mm	87 mm
									a)	b)					
									3.54	5.03					

NT = No Turn (Total number of no turns in Model 7 in Test Clothing = 6)

RTD (Batch 3) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting a) Airways clear, b) full face up position								Initial Freeboard (mm)		
		1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance
1	a)	1.40	1.19	1.30	1.39	1.25	1.22	1.29	131	176	143
	b)	3.92	3.12	4.21	3.64	3.96	3.24	3.69			
2	a)	2.25	3.02	1.57	2.34	2.16	2.51	2.32	139	153	145
	b)	6.10	5.20	5.86	6.29	5.86	6.73	6.03			
3	a)	2.48	1.74	2.26	2.22	2.08	2.53	2.26	140	164	152
	b)	6.01	3.12	4.43	4.29	4.43	5.03	4.55			
4	a)	1.11	0.59	0.77	0.79	0.45	0.80	0.74	130	139	134
	b)	1.86	1.16	1.40	1.32	0.87	1.21	1.27			
5	a)	2.17	2.10	1.00	1.88	1.59	1.33	1.73	154	169	157
	b)	4.61	4.67	1.52	2.83	2.40	2.16	3.00			
6	a)	2.18	1.85	1.85	1.95	1.90	2.11	1.95	124	173	140
	b)	4.47	4.07	4.21	3.76	4.58	4.09	4.21			
7	a)	2.36	1.46	1.63	2.22	1.79	2.25	1.97	129	137	133
	b)	4.10	2.96	2.87	3.67	3.30	4.78	3.51			
8	a)	3.08	2.65	2.73	2.40	2.25	2.77	2.64	122	155	143
	b)	4.16	3.50	4.24	3.90	3.24	4.01	3.89			
9	a)	1.20	1.45	2.48	1.53	0.89	1.30	1.37	122	141	128
	b)	1.90	2.16	2.95	2.10	1.41	2.01	2.04			
10	a)	2.59	0.96	1.02	0.63	1.50	0.40	1.03	119	137	126
	b)	3.26	1.86	1.63	1.21	1.92	0.83	1.66			
11	a)	2.11	2.28	2.34	2.13	2.25	1.90	2.19	120	156	132
	b)	3.78	4.04	3.75	5.18	5.16	3.46	4.18			
12	a)	1.85	1.77	1.57	1.70	1.56	1.51	1.65	157	167	157
	b)	3.29	2.93	2.64	2.48	2.52	2.38	2.64			
13	a)	2.66	2.80	2.46	2.77	2.48	2.62	2.63	125	167	139
	b)	5.40	5.69	6.36	5.36	5.21	5.67	5.53			
14	a)	1.14	1.74	1.50	0.70	1.16	1.97	1.39	135	143	135
	b)	34.81	6.44	4.13	2.67	3.04	2.35	4.07			
Averages of all subjects:							a)	1.80	132 mm	156 mm	140 mm
							b)	3.59			

NT = No Turn (Total number of no turns in RTD in Swimwear = 0)

RTD (Batch 3) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting a) Airways clear, b) full face up position								Initial Freeboard (mm)		
		1	2	3	4	5	6	Ave	Fully exhaled	Fully inhaled	Static balance
1	a)	2.74	2.16	2.10	1.76	1.59	1.74	1.94	130	156	133
	b)	6.90	4.69	5.20	4.30	3.46	4.33	4.63			
2	a)	11.26	9.65	4.02	5.00	4.56	1.16	5.81	122	122	113
	b)	37.89	11.12	5.84	7.35	7.47	5.89	7.96			
3	a)	10.45	3.26	2.48	3.30	3.34	4.05	3.49	110	137	118
	b)	12.70	4.72	3.81	4.89	4.80	5.46	4.97			
4	a)	1.93	0.77	0.82	0.73	0.83	1.06	0.87	128	145	131
	b)	3.03	1.21	1.49	1.63	1.32	1.76	1.55			
5	a)	2.19	1.45	1.40	2.92	1.17	1.08	1.55	152	161	152
	b)	3.70	2.80	2.63	4.15	2.35	2.30	2.87			
6	a)	4.39	2.91	3.23	2.78	2.94	3.22	3.08	124	164	133
	b)	9.46	7.80	7.27	6.86	6.89	7.53	7.37			
7	a)	5.03	1.84	2.59	1.66	1.90	2.23	2.14	111	123	113
	b)	7.10	3.63	4.06	3.46	3.69	3.92	3.83			
8	a)	NT	NT	7.53	9.17	5.28	6.06	6.80	118	152	123
	b)	NT	NT	10.12	10.86	7.40	7.61	8.87			
9	a)	NT	3.08	2.23	1.45	1.63	2.30	2.05	113	121	114
	b)	NT	4.40	3.23	2.12	2.53	3.47	3.08			
10	a)	NT	9.43	NT	NT	2.73	4.65	4.65	114	135	113
	b)	NT	10.61	NT	NT	4.20	6.27	6.27			
11	a)	NT	NT	NT	NT	7.02	19.96	13.49	121	131	121
	b)	NT	NT	NT	NT	9.00	21.47	15.24			
12	a)	7.60	2.59	2.50	2.20	2.06	1.96	2.34	133	152	138
	b)	9.04	3.66	3.57	3.23	3.13	3.16	3.41			
13	a)	NT	NT	NT	8.59	11.30	6.56	8.59	123	143	125
	b)	NT	NT	NT	11.00	13.13	8.67	11.00			
14	a)	1.96	2.45	2.96	2.00	1.66	1.59	2.02	110	122	113
	b)	4.50	3.81	3.76	3.64	3.60	3.23	3.70			
Averages of all subjects:								a) b)	122 mm	140 mm	124 mm
								4.20 6.05			

NT = No Turn (Total number of no turns in RTD in Test clothing = 13)

Lifejacket Model 8 (Batch 3) Clothing Combination 1 – Subjects wearing swimsuits only

Subject	Self-righting							Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position							Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	0.64	0.97	0.54	0.83	0.77	0.46	124	150	131	✓	132	154	132
	b)	1.35	1.55	1.58	1.46	2.43	1.23							
2	a)	2.16	1.99	1.93	2.16	2.17	2.12	138	155	140	✓	136	146	141
	b)	4.36	4.49	3.95	4.06	4.56	4.24							
3	a)	1.93	1.51	1.03	1.28	1.36	1.82	127	151	137	✓	124	140	132
	b)	3.49	2.83	2.03	2.00	2.13	2.63							
4	a)	0.36	0.45	0.36	0.50	0.68	0.50	125	139	133	✓	127	137	127
	b)	0.83	0.83	0.87	0.83	1.03	0.83							
5	a)	1.17	0.59	0.96	0.75	0.65	0.54	119	140	131	✓	119	139	125
	b)	2.12	1.44	1.86	1.49	1.41	1.21							
6	a)	2.13	2.00	1.76	1.82	1.59	1.82	113	151	119	✓	117	155	123
	b)	4.10	4.35	3.60	4.00	3.52	3.67							
7	a)	2.34	2.05	1.51	0.96	1.45	1.02	118	127	119	✓	121	128	117
	b)	3.84	3.60	2.55	2.01	2.58	2.10							
8	a)	3.48	1.34	4.34	1.56	1.59	1.11	115	140	125	✓	108	132	120
	b)	3.95	1.90	4.81	2.44	2.40	1.86							
9	a)	0.46	0.77	0.77	0.57	0.82	0.63	124	125	125	✓	119	135	123
	b)	1.23	1.23	1.35	1.13	1.30	1.26							
10	a)	0.45	0.82	2.00	0.49	0.70	0.82	129	145	129	✓	123	140	124
	b)	0.92	1.49	2.66	0.95	1.23	1.32							
11	a)	2.14	1.57	2.13	1.71	2.47	2.03	126	149	136	✓	121	149	128
	b)	3.36	2.84	5.15	2.80	3.90	4.01							
12	a)	1.30	1.03	1.08	1.19	0.82	0.60	128	143	127	✓	121	143	123
	b)	1.80	1.63	1.63	1.83	1.51	1.29							
13	a)	2.30	2.33	2.31	2.14	2.83	2.56	135	155	143	✓	130	158	143
	b)	4.50	4.12	3.90	4.12	4.30	3.78							
14	a)	0.79	0.54	0.66	0.51	1.03	0.70	127	147	132	✓	135	148	142
	b)	2.90	1.53	1.81	1.82	2.33	1.87							
Averages of all subjects:														
							a)	125 mm	144 mm	131 mm		124 mm	143 mm	129 mm
							b)							

NT = No Turn (Total number of no turns in Model 8 in Swimwear = 0)

Lifejacket Model 8 (Batch 3) Clothing Combination 2 – Subjects wearing test clothing

Subject	Self-righting (s)						Initial Freeboard (mm)			Initial face up after 1m jump?	Freeboard after 1m water entry (mm)		
	a) Airways clear, b) full face up position						Fully exhaled	Fully inhaled	Static balance		Fully exhaled	Fully inhaled	Static balance
1	a)	1.06	1.57	0.91	0.88	1.34	134	149	138	✓	140	159	145
	b)	2.80	3.41	2.38	2.16	2.24							
2	a)	4.48	2.86	3.31	2.94	3.06	139	137	134	✓	128	137	130
	b)	6.46	4.33	4.63	5.81	4.50							
3	a)	2.42	2.97	1.65	1.74	1.83	124	144	131	✓	123	143	127
	b)	4.07	3.26	3.21	2.92	3.07							
4	a)	0.82	0.63	0.73	0.83	0.82	133	144	136	✓	134	143	134
	b)	1.53	1.49	1.58	1.46	1.63							
5	a)	1.83	1.20	1.20	0.79	0.63	138	154	143	✓	137	147	141
	b)	2.92	2.20	2.24	1.50	1.55							
6	a)	3.35	2.73	2.36	1.83	2.45	113	138	120	✓	109	135	119
	b)	5.20	5.00	4.70	3.95	4.46							
7	a)	6.16	2.19	2.34	2.22	2.40	118	126	118	✓	113	126	115
	b)	8.00	4.21	4.04	3.72	4.01							
8	a)	3.54	5.22	4.20	3.62	3.23	113	144	126	✓	112	141	126
	b)	4.26	6.12	2.01	4.47	4.04							
9	a)	2.88	1.85	1.80	0.86	1.50	106	116	109	✓	113	119	114
	b)	3.60	2.56	2.69	1.86	2.12							
10	a)	0.36	1.08	1.11	0.76	3.22	125	141	122	✓	128	146	128
	b)	1.21	1.64	1.67	1.50	8.61							
11	a)	2.20	2.02	1.68	3.08	2.08	121	139	128	✓	128	140	130
	b)	3.52	3.43	3.23	4.44	3.72							
12	a)	1.68	1.45	1.59	1.36	1.59	115	132	122	✓	115	140	129
	b)	2.46	2.09	2.55	2.23	2.51							
13	a)	7.50	4.13	4.48	4.56	3.31	132	160	138	✓	142	160	145
	b)	9.93	6.15	6.55	6.06	5.20							
14	a)	0.96	1.02	1.66	1.66	1.50	131	140	136	✓	128	143	134
	b)	4.35	3.04	3.36	3.83	3.56							
Averages of all subjects:													
NT = No Turn (Total number of no turns in Model 8 in Test Clothing = 0)													
						a)	124 mm	140 mm	129 mm		125 mm	141 mm	130 mm
						b)							