FINAL REPORT 2010

Functional Task Analysis of Lifeboat/BA Integration

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Survival Systems Training

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LIST OF ABBREVIATIONS

BA	**Breathing Apparatus**
BST	**Basic Survival Training**
FRC	**Fast Rescue Craft**
H_2S	**Hydrogen Sulfide**
IMO	**International Maritime Organization**
IDLH	**Immediately Dangerous to Life and Health**
M.I.R.T.™	**Mobile Industrial Rescue Trainer**
OIM	**Offshore Installation Manager**
SET^{1}	**Simulated Evacuation Time (worst case)**
SET^{2}	**Simulated Evacuation Time (best case)**
$SET^{(slow36)}$	**Simulated Evacuation Time (5 minute slow time 36 person boat)**
$SET^{(fast36)}$	**Simulated Evacuation Time (3 minute fast time 36 person boat)**
SPSS	**Statistical Package for the Social Sciences**
SSI	**Survival Systems International**
SSTL	**Survival Systems Training Limited**
$T_{p\text{-}s}$	**Time to travel from primary to secondary muster station**
T_{cm}	**Time to connect to simulated air manifold**
T_{don}	**Time to don immersion suit**
T_{dm}	**Time to disconnect from simulated air manifold**
$T_{s\text{-}l}$	**Time to travel from secondary muster to lifeboat muster station**
T_{load}	**Time to load the 36 person lifeboat**
T_{confirm}	**Time to confirm load and gain permission**
T_{launch}	**Time to launch the lifeboat**
T_{100m}	**Time to travel 100 meters crosswind**
T_{500m}	**Time to travel 500 meters crosswind**
T_{1000m}	**Time to travel 1000 meters crosswind**
$T_{p\text{-}l}$	**Time to travel from primary muster to lifeboat muster station**
TEMPSC	**Totally Enclosed Motor Propelled Survival Craft**
TSR	**Temporary Safe Refuge**

1.0 INTRODUCTION

Based on previous reports, offshore drilling in areas known to contain hydrogen sulfide (H_2S) require a contingency plan for emergency evacuation (Ocean Drilling Program, 2002; Mills, Malone, & Graber, 2006). These reports have indicated that environmental conditions having greater than 100 parts per million (ppm) H_2S is considered Immediately Dangerous to Life and Health (IDLH) and constitutes a need to evacuate personnel to a safe location (Canadian Association of Petroleum Producers, 2003). As an example of possible concentration levels in offshore drilling environments, EnCana (2010) indicates that Deep Panuke wells contain average concentrations of H_2S at 1800 ppm. In order to mitigate the risks associated with H_2S, breathing apparatus (BA) use is recommended in environments that contain concentrations from 1 to 19 ppm (Mills et al., 2006) and EnCana (2010) mandates their use in levels exceeding 10 ppm. Therefore, the need for escape BAs (15 minutes of self contained air) represents a unique situation in which an added piece of safety equipment may influence task performance during evacuation. The primary objective of this study, therefore, was to evaluate potential difficulties associated with donning an immersion suit, BA and loading a 36 person lifeboat.

In order to examine the possible effects of the BA on evacuation skill performance, relevant research regarding the available space for passengers within a Totally Enclosed Motor Propelled Survival Crafts (TEMPSC – Lifeboat) was examined. During the review of pertinent research it was noted that Kozey, Reilly, and Brooks (2005) indicate that the anthropometric measures of the offshore workforce in Atlantic Canada has increased beyond the average body size indicated by the International Maritime Organization (IMO) regulations and that these changes should be considered when preparing an emergency response plan (see also Kozey, Brooks, Dewey, Brown, Howard, Drover, MacKinnon, & McCabe, 2009). Additionally, Taber, Simões Ré, and Power (in press) also expressed concerns about the overall design and habitability of lifeboats and suggested that functional task analyses should be carried out to ensure that the human/survival equipment interface meets the needs of individuals evacuating an offshore installation or cruise ship.

1.1 Purpose/Objectives

This report outlines the findings from a functional task analysis in which the integration between the human, a lifeboat harness system, immersion suit, and escape breathing apparatus was examined. Particular attention was focused on the amount of time required to fully load the lifeboat as well as any factors that influenced this overall evacuation time.

In order to identify the influence of these factors, a worst case scenario was examined in which the test personnel had extremely limited experience performing the required skill set and the majority had never been inside a lifeboat or worn an immersion suit. With this worst case scenario in mind, understanding and documentation of lifeboat evacuation skill sets is believed to be critical to the development of an overall emergency abandonment timeline.

1.2 Deliverables

In order to accomplish the objectives of this research, the following list of items were considered essential to the risk management and mitigation decision process associated with offshore lifeboat/BA integration during evacuation:

Detailed documentation of lifeboat/BA evacuation requirements

- Placement of BA bottles (suggested alternatives locations if required)
- Capabilities/difficulties associated with seat harness integration
- Allocation of seat positions (prior to evacuation)
- Capabilities to perform supplemental tasks (close off fresh air supply, turn on compressed air system, etc…)

Detail snag analysis of lifeboat personnel loading (performed in slow-time)

- Photo documentation highlighting any snagging of BA on seat harnesses
- Participant ratings (1 to 10 scale of difficulty) associated with strapping in procedures

Detail snag analysis of lifeboat personnel loading (performed in real-time)

- Photo/video documentation highlighting any snagging of BA on seat harnesses
- Participant ratings (1 to 10 scale of difficulty) associated with strapping in procedures

Suggested evacuation protocol

- Comparison of pre-assigned seating positions versus unrestricted allocation
- Time to evacuate
- Number of personnel exceeding suggested evacuation time

2.0 METHODS

2.1 Participants

Recruitment for this study was through word of mouth and the 36 volunteers (24 male and 12 female) had varying levels of lifeboat experience although none had experience with fully loading the 36 person boat to capacity. Three volunteers were SSTL qualified lifeboat coxswains and were responsible for directing other participants as they entered the lifeboat. Table 1 identifies the descriptive statistics related to anthropometric and age data. Combined mass of all 36 participants was 2840.35 kg (average of 78.89 kg). In order to identify differences between the current sample population and previously studied offshore groups, Reilly, Kozey, & Brooks (2005) report that the average male offshore worker has a mass of approximately 90.5 kg and the average female worker was 54.5 kg. It has also been noted that the ratio between men and women in an Atlantic offshore population is ~10:1 (Reilly et al., 2005). The current sample population differs with regard to male and female mass; however, when compared to the Reilly et al. (2005) data, the difference of 6.4 kg in average male participants is made up for by the increase of 13.9 kg for the average female participants. Therefore, although the sample group has a ratio of 2:1 (male: female), the differences (approximately 270 kg overall) are not considered to have a significant affect on the time to load the boat or the difficulties experienced during the load.

Table 1. Descriptive statistics.

Measure	Males (n = 24)		Females (n = 12)		Combined (n = 36)	
	Mean	SD	Mean	SD	Mean	SD
Age (yr)	30.65	8.85	26.91	3.97	29.92	9.729
Mass (kg)	84.1	9.59	68.4	10.64	78.90	12.36

2.2 Testing Protocol

Prior to data collection, a site visit to Survival Systems Training Limited (SSTL) harbour-side training island facility in Halifax Nova Scotia (Figure 1) was conducted to identify evacuation task parameters based on known travel distances from a primary to secondary muster station (personal communication with EnCana representative, 2010). During the SSTL site visit, measurements were taken to establish the number of stairs and route to be taken in order to simulate the evacuation conditions that might be experienced on the Rowan Gorilla III. During the three days of testing, a total of six (6) complete capacity loadings of personnel into a 36 person Survival Systems International (SSI) lifeboat were completed. As lighting inside and around the lifeboat is limited, loading of the boat only occurred during day light hours and testing was suspended at approximately 20:30 each day. Of the six (6) loading sequences, the lifeboat was launched to the surface of the water three (3) times. A maintenance pennant was installed during all loading trials and only removed once participants were safety strapped into their seats and the engine was running. Additionally, a fast rescue craft (FRC), with a coxswain and crewmember, was stationed in the water near the lifeboat launch position and travelled alongside the lifeboat throughout the 10 minute traverse sequences (2 crosswind and 1 into wind).

The first day of testing included a brief outline of the proposed research and informed consent process. Once informed written consent was given (Appendix A), participants were asked to complete a general health questionnaire. Participants were then transported to the SSTL training island. After arriving at the SSTL island, participants were weighed and asked to don a survival suit (Helly Hansen E-452) in slow-time to ensure that they understood how to wear the suit as well as ensure that they had a size (i.e. x-small, small, medium, large, or x-large) that would fit them. The slow-time donning was not recorded. In order to replicate similar conditions that would be expected during an actual abandonment, participants were asked to complete the tasks of donning equipment, loading the lifeboat, and traveling to muster points during subsequent testing as though their life was in danger. Therefore, participants were instructed to walk briskly, but no running was allowed.

Figure 1. SSTL harbour-side training facility.

In order to establish a general understanding of the required skills to be performed, baseline testing included slow time demonstrations of the following tasks:

- Don BA
- Muster at appropriate station
- Plug into supplementary air supply manifold
- Completion of head count
- Don immersion suit
- Disconnect from supplementary air supply manifold
- Move from muster station to lifeboat

- Enter lifeboat
- Don lifeboat seat harness

Figure 2 outlines the test protocol and study design for the functional task analysis. Slow-time procedures were only carried out once, while real-time task performances were conducted several times to ensure that post-test analyses could be carried out.

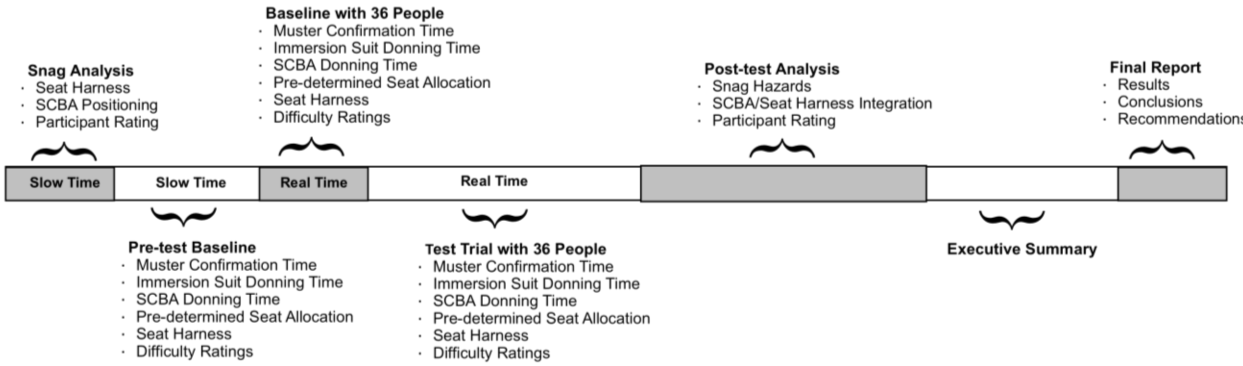


Figure 2. Study design and test protocol.

During the three (3) days of testing, tasks were completed while wearing abandonment suits and simulated BA evacuation bottles (Figure 3) to ensure ecological validity (i.e. realistic conditions that are valid in a real-world setting) and that an examination of a worst case scenario could be carried out. The worst case scenario was considered as it would represent the longest time it might take for a full abandonment to occur.

Escape BA systems were simulated as the actual systems were unavailable (due to operational requirements) for the timing trials. Figure 3 shows the actual escape BA system (Panel A) and the simulated BA system (Panel B). The simulated BAs were the same weight (6.35 kg – 14 lbs) and overall dimensions of the actual system. A standard 500 ml plastic soda bottle was used to simulate the air cylinder and give rigidity to the simulated system, while the majority of the mass consisted of two sand bags.

A B

Figure 3. Escape breathing apparatus (BA) (Panel A) and simulated BA (Panel B).

Task performance was completed during baseline and full test sequences in order to identify a possible learning effect as well as to develop a realistic timeline for the entire evacuation sequence. The slow-time testing was also used to identify possible snag hazards and integration difficulties with regard to lifeboat seat harness and immersion suit donning. Set harnesses consisted of two shoulder straps and two lap belt straps that were alternately colour coded either all blue or all orange for each seat. Testing protocols listed by day show the sequence of task performance/learning that took place.

Day 1 Testing (11 May 2010):

- Sizing of all participant suits
- Participant weights (kg)
- Donning of immersion suits slow-time (no simulated BA)
- Loading of lifeboat slow-time
- Donning of suits real-time (no simulated BA)
- Connecting/disconnection air supply lines from manifold
- Travel time from secondary to primary muster station
- Full load of 36 person boat through forward starboard door only

Day 2 Testing (12 May 2010):

- Slow-time snag hazard analysis of fast mask system and simulated BA with suits in muster station and lifeboat
- Donning of immersion suits (simulated BA) – groups of 8 participants
- Donning of suits real-time (simulated BA) – all 36 dressed in muster station
- Travel time from primary to secondary muster/lifeboat station
- Full load of 36 person boat through aft starboard door only

Day 3 Testing (13 May 2010):

- Travel time from primary muster to secondary muster station, don immersion suit, travel to lifeboat station and load lifeboat
- Donning of immersion suit (simulated BA and connections to manifold)
- Full load of 36 person lifeboat through forward and aft starboard door
- Launch full lifeboat and steam crosswind for 10 minutes (x2)
- Repeat donning of suits, loading and launch procedures into wind (x1)

Participants donned the immersion suit a total of six (6) times throughout the testing. Initial donning was completed without the simulated BA twice and these evolutions were considered practice trials. Once slow and one (1) initial real-time donning of suits while wearing the simulated BAs was completed, participants were tested under realistic conditions in which all 36 individuals donned their immersion suits in a 13’ 10” x 14’ room. Additionally, the participants completed these tasks while connected to a simulated emergency cascade air manifold. The simulated manifold comprised of 36 rope attachment points in the muster station and small pieces (approximately 30 cm) of rope attached to the simulated BAs. During these donning trials, participants were required to be attached by a simple overhand knot to the simulated air manifold and only disconnect once they had fully donned their immersion suit.

2.3 Task Performance Difficulty Ratings

After carrying out all of the simulated evacuation tasks, participants were asked to complete a performance difficulty rating questionnaire (Appendix B). The self-rating scale was designed to identify difficulties associated with particular task completion. The self-rating scale ranged from 1 (no problems) to 10 (could not complete the task). In order to identify specific difficulties, participants were also asked to comment on any task rating scored above a 5 (some problems).

2.4 Equipment

In order to ensure that all data was collected under realistic conditions, the list of equipment in Table 2 was used to carry out the lifeboat evacuation trials. Video footage was captured during the donning and loading process.

Table 2. Equipment list for FTA.

Quantity of Items	Description of Item
1	Lifeboat (36 person)
36	BA Escape Bottles and masks
36	Offshore Abandonment Suits (Helly Hansen E-452)
1	Scale (participant's mass)
1	Digital Camera/Video (top view and interior boat view)
2	Standby Boat (FRC)
1	Advanced First-aid kit
1	AED
1	Backboard and straps
36	Participant Consent Form (Appendix A)
36	Participant Data Collection Sheet
36	Participant Performance Difficulty Rating Scale (Appendix B)
2	Stopwatches
1	Testing Matrix/Testing Schedule

Figure 4 shows a top view of the loading positions of all 36 people while Figure 5 shows two individuals seated on the port side of the lifeboat near the forward exit. As can be seen in both figures, personnel are required to sit within close proximity to one another in order to accommodate all 36 positions. Figure 5 also shows the position of the BA air cylinder once seated.

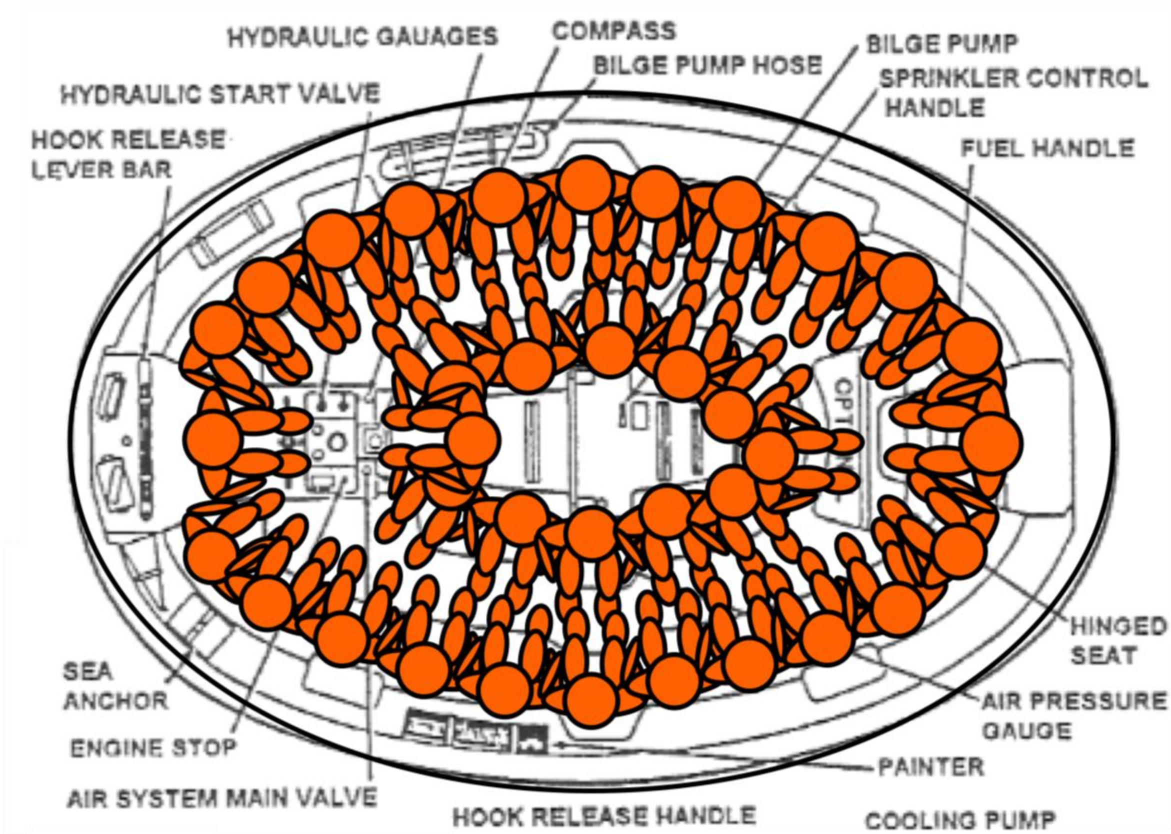


Figure 4. Top view of 36 person lifeboat seating arrangement.

Figure 5. Forward seats on the port side of the 36 person lifeboat.

2.5 Calculation of Evacuation Time

Total simulation evacuation time was calculated by measuring each of the evacuation components in isolation and then times for the average or total time to complete the tasks were combined. For example, the *average* time to connect and disconnect from the simulated air manifold was used where as the *total* amount of time to don the immersion suit and load the lifeboat were included in the calculation. Given the basic task parameters, the equation shown below was used to establish the overall simulation evacuation time (*SET*). Evacuation times were also calculated by substituting the slow and fast times to travel between muster stations provided by EnCana (EnCana 2010).

Simulated Evacuation Time = $T_{p\text{-}s} + T_{cm} + T_{don} + T_{dm} + T_{s\text{-}l} + T_{load} + T_{confirm} + T_{launch} + T_{100m}$

Where:

$T_{p\text{-}s}$ = time to travel from primary to secondary muster station
T_{cm} = time to connect to simulated air manifold
T_{don} = time to don immersion suit
T_{dm} = time to disconnect from simulated air manifold
$T_{s\text{-}l}$ = time to travel from secondary to lifeboat station
T_{load} = time to load the 36 person lifeboat
$T_{confirm}$ = time to confirm load and gain permission to launch
T_{launch} = time to launch the lifeboat
T_{100m} = time to travel 100 meters crosswind

2.5.1 Evacuation Phases

In addition to each component being measured in isolation, the overall evacuation time (***SET***) also considered with regard to three (3) separate phases. The separation of evacuation time into phases represents the fact that at the beginning of each phase, a new air supply is provided to personnel and is considered a separate block of time within the overall evacuation sequence. For example, escape BAs are located at both the primary and secondary muster station which can be refilled through the air manifold system in the secondary muster station and the lifeboat is equipped with 10 minutes of positive pressure air. It should noted however, that the 10 minutes of positive pressure used for this equation is based on a basic SOLAS requirement for TEMPSC and may vary depending on system type and lifeboat design.

Phase 1 of the evacuation would involve the movement of personnel to their appropriate muster station (primary – Temporary Safe Refuge – TSR). Once in the TSR (positive air pressure environment), personnel would be made aware of the conditional status of the installation and be directed to remain there until further notice. If however, ingress of H_2S were detected in the TSR, personnel would don their escape BA (starting the 15 minute countdown of available air) and make their way to the secondary muster station located under the helideck where they could connect to an emergency air manifold which contains 90 minutes of air, and wait for further instructions (technician have the capability to refill the BAs from the manifold). Phase 1 of the evacuation could also involve a situation in which personnel are immediately instructed to don escape BAs and immersion suits, and move to a designated lifeboat station which could include moving directly from the primary muster station in the event that abandonment is imminent.

Phase 2 of the evacuation sequence includes the time it takes for personnel to reach and load the lifeboat, strap into the restraint harnesses, and dog down (close and latch) the doors. This second phase also has a time constraint that is in addition to the travel time from the muster station. If personnel move directly from the TSR to the lifeboat (due to a breach of H_2S), their time limit of 15 minutes could include the time to don the immersion suit as well as move to the lifeboat. However, if personnel are in the secondary muster station, Phase 2 does not include donning of the immersion suit as personnel would already be connected to the emergency air cascade system.

Phase 3 of the evacuation sequence includes the amount of time it takes to confirm the loading of personnel, gain approval to launch, release and lower the boat, and drive at least 100 meters crosswind from the installation. In order to ensure that the lifeboat is fully clear of the H_2S plume, an additional calculation of ***SET*** has been completed for 500 and 1000 meters of crosswind travel distance. During this final phase of evacuation, it is assumed that the 10 minutes of positive pressure air supply located within the lifeboat will be used to ensure fresh air is supplied to all of the passengers and crew of the lifeboat. It may be possible that the BAs still contain residual/remaining air at this stage of the abandonment; however, the ***SET*** has been calculated for only the 10 minutes of positive pressure air contained in the lifeboat system.

3.0 RESULTS

All data was collated and standard descriptive statistics (mean, maximum, minimum, and standard deviation) were calculated using Statistical Package for the Social Sciences (SPSS). Using these values, predicted times for donning immersion suits and loading a different sized lifeboat could be calculated with linear regression curve estimations. However, any predictions should take into consideration differences in lifeboat design and seat harness configurations.

3.1 Simulated Time to Travel from Primary to Secondary Muster Station (T_{p-s}, T_{p-l}, T_{s-l})

Travel time between muster stations was measured three (3) times. The first measurement was taken from the primary muster station (considered the TSR) at the top of the SSTL island to the secondary muster station at the base of the island. This first measurement was considered a baseline as it was the first time participants had the chance to see the route and were not wearing immersions suits. On average the time for each person to travel the 225' (which included descending a total of 55 steps) was 44.02 seconds during this first trial. The last two travel times were completed in a similar manner to what would be expected during a real evacuation. That is, all 36 participants climbed or descended the stairs as a large group. Traveling from the primary muster point (TSR) to the secondary muster point was completed while wearing a BA mask and bottle as well as carrying the immersion suit over the shoulder. The total time to travel (T_{p-s}) was 127.96 seconds. Travelling from the primary muster station directly to the lifeboat (T_{p-l}) while wearing the BA mask, bottle and immersion suit donned required a total of 187.01 seconds. Therefore, T_{s-l} is considered the difference between the two travel times (59.05 seconds). These times (T_{p-s}, T_{p-l}, T_{s-l}) would occur within Phase 1 of the evacuation sequence and will be examined in more detail at the end of this section.

3.2 Manifold Connection/Disconnection Time (T_{cm} & T_{dm})

Given the fact that escape BAs were not available for the simulation trials, SSTL provided a Mobile Industrial Rescue Trainer (M.I.R.T.™) for testing the connection/disconnection of the air manifold. Figure 6 shows the required time for each participant to connect and then disconnect from the supplied air manifold. Time to connect to the manifold ranged from a maximum of 11.94 seconds to a minimum of 3.43 seconds. The mean time to connect was 6.78 seconds. Time to disconnect ranged from a maximum of 13.55 seconds to a minimum of 2.25 seconds. The mean time to disconnect was 4.43 seconds. Generally, participants were faster at disconnecting from the manifold then they were to connect. The additional time needed to connect to the manifold, was related to a lack of experience and understanding of how hard to push on the connection sleeve to fully engage the valve. As with the T_{p-s}, T_{s-p} times, T_{cm} & T_{dm} also fall within Phase 1 of the evacuation sequence.

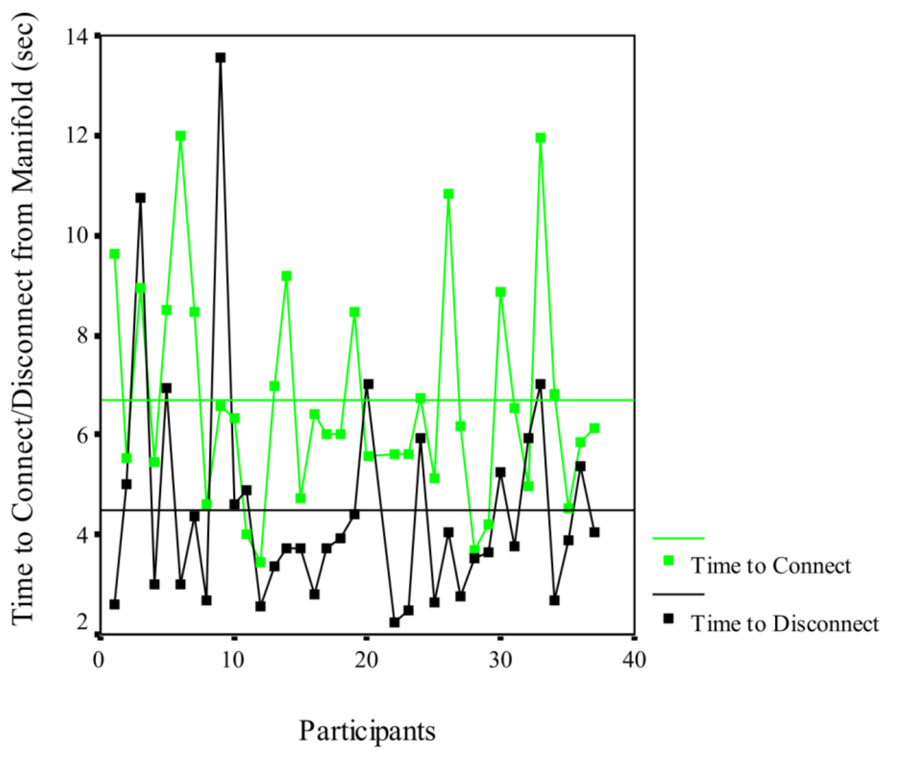


Figure 6. Time to connect/disconnect from manifold. *Note*: horizontal bars represent mean values.

3.3 Immersion Suit Donning Times (T_{don})

Immersion suit donning times are divided into two categories in order to identify learning effects as well as differences in the way the suits were donned. As the majority of the participants had never donned an immersion suit, the first attempt was not recorded. However, the remaining attempts were divided by baseline and final donning times.

3.3.1 Baseline Immersion Suit Donning Times

Figure 7 shows the immersion suit donning times for participants wearing the simulated BA system in two different conditions. The first attempt to don the immersion suit while wearing the simulated BA was completed in groups of eight and no assistance was provided by other participants. However, due to the position of the BA hanging around the neck, it was originally believed that having someone hold the weight off to the side or directly out in front of the person trying to don the suit would reduce the tendency to tip forward while trying to insert a leg into the immersion suit (Figure 7). Therefore, the second attempt was also completed in groups of eight; however, individuals were paired in order to identify whether holding the weight of the BA would aid in donning times. Figure 8 clearly shows that this is not the case. Average donning time without assistance was 70.97 seconds while average donning with assistance was 130.37 seconds.

Figure 7. Simulated BA system interference while donning immersion suit.

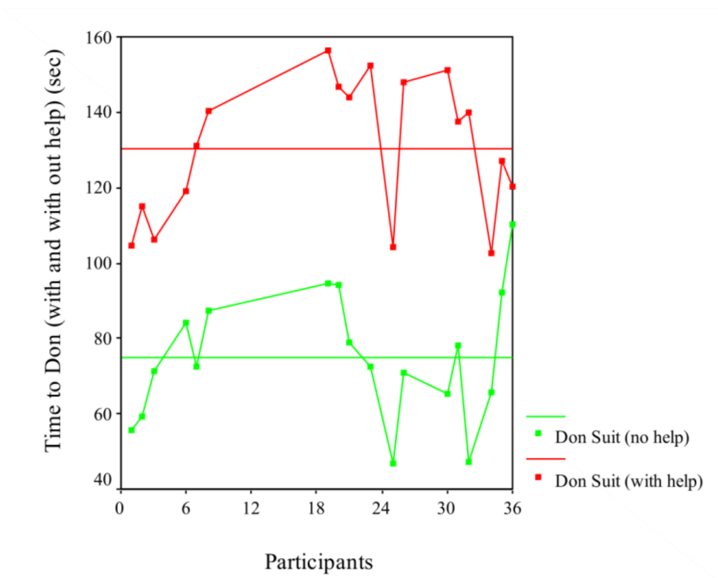


Figure 8. Baseline immersion suit donning times (with and without help). *Note*: horizontal lines represent mean values.

3.3.2 Final Immersion Suit Donning Times (T_{don})

After completing baseline donning of the immersion suit in groups of eight, participants were asked to complete the same task with all 36 people in the muster station (Figure 9). As space was limited within the muster station, participants were asked to make their way out of the room as soon as they had donned the immersion suit. This task proved to be more difficult during the last two donning times when participants were connected to the simulated air manifold. Difficulties stemmed primarily from the fact that the simulated air connection whips restricted the distance that individuals could move out of the way. Furthermore, it was noted that shoes, lifejackets and immersion suit bags represented tripping hazards throughout the muster station.

Figure 9. All 36 participants donning immersion suits in muster station.

Figure 10 shows that the two last donning times are very similar. As the participants have donned the suit as quickly as they could four times by this stage in the testing, these results can be considered the point at which further reduction in T_{don} is unlikely under these same conditions. Final donning time #1 average was 61.66 seconds and final time #2 was 59.93 seconds. However, in order to predict the total amount of time it would take to get everyone dressed in his or her immersion suit, total maximum donning time (the last person dressed in the immersion suit) was averaged between the two final times. Therefore, the total overall donning time (T_{don}) used to complete the ***SET*** equation was 62.75 seconds.

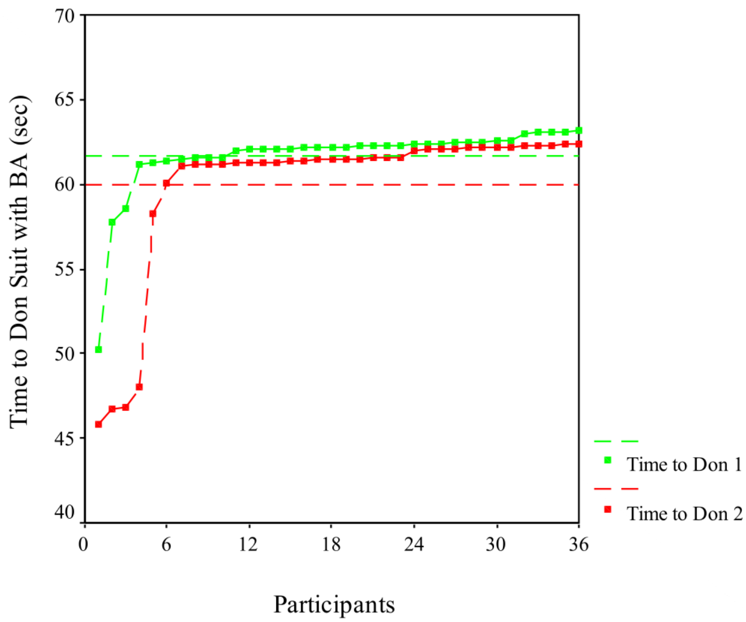


Figure 10. Immersion Suit donning time for last 2 trials.

3.4 Lifeboat Loading Time (T_{load})

Lifeboat loading was carried out a total of six (6) times over the course of the testing (Figure 11) and represents the portion of time included in Phase 2 of the overall evacuation sequence. Although participants had been given the opportunity to sit in the lifeboat prior to any testing (considered a pre-test load and timing was not recorded), loading #1 was their first time strapping into the seat harness system. This first load time could be considered the worst case scenario as well as a realistic estimate of loading time for individuals who have little experience completing this task. The total time for loading #1 was 605.95 seconds. As participants became more familiar with the shoulder and lap harness system, load times became quicker (Figure 12). This initial learning effect was expected; however, loading #4 and #5 show that this effect is no longer as obvious as it was between the first and third trial. Since participants had completed as many lifeboat loadings as someone who has completed a Basic Survival Training (BST) and 3 recurrent training courses (9 years of offshore training experience assuming a 3 year renewal schedule); it can reasonably be assumed that the last two loading times (mean = 369.06 seconds) represent a point at which no further reductions in T_{load} performance would be expected.

Figure 11. Participants locating shoulder and lap harnesses.

The final lifeboat load time should be considered the best possible time given the experience the participants gained during testing. Therefore, when calculating the ***SET*** for the worst case (load #1) and best case (load #4) times were considered. The total best time to load the lifeboat was 369.02 seconds.

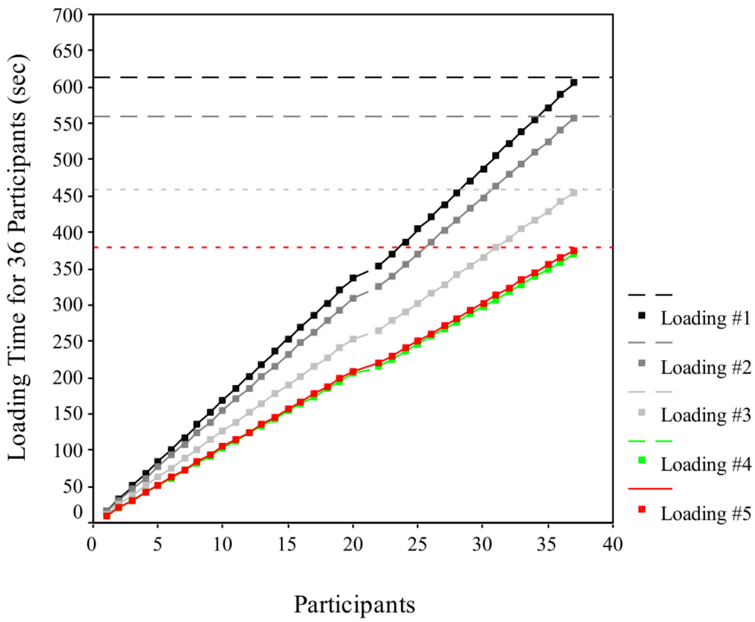


Figure 12. Total loading time for 36 person lifeboat. *Note*: times are based on first person in the doorway until last person was completely strapped in and doors are dogged shut (total load time/36).

3.5 Time to Confirm the Load and Gain Permission to Launch ($T_{confirm}$)
Once the loading of the lifeboat was completed (all participants strapped in and doors dogged), timing was suspended until the maintenance pennant had been removed. After removal of the pennant, timing was resumed and radio confirmation of the loading and head count was passed to the FRC coxswain. The FRC coxswain confirmed a clear launch area below the lifeboat and permission to launch was granted. This set of tasks required an average of 35.60 seconds. With only one lifeboat launch occurring, this time to confirm was minimal and should be considered a best case situation in that loading and launching multiple boats will require the additional time needed to clear the first boat from the launch area. Furthermore, this launch confirmation did not require multiple radio communications between other lifeboats and an Offshore Installation Manager (OIM).

3.6 Time to Launch (T_{launch})
The total time to launch the lifeboat depends on the distance between the loading point and the surface of the water. As the launch system is gravity driven, the time to launch is also affected by the speed at which the boat is lowered. Given the fact that the lifeboat was loaded to maximum capacity, the launch time would never be faster than it was during the three lowering/launching trials. The standard loading point of the SSTL island 36 person lifeboat was approximately 12.19 meters above the surface of the water. The average total time to launch the lifeboat was 10.02 seconds. Given the height of lifeboats located on the RGIII, the estimated launch time has been reported as 60 seconds (EnCana, 2010); therefore, this value was used when estimating the final launch times for the 36 person lifeboat.

3.7 Time to Travel 500 m (T_{100m}, T_{500m}, T_{1000m})
The time it takes the lifeboat to travel 100 (best case), 500 or 1000 (worst case) meters away from the installation is also dependent on several factors: speed of the lifeboat, total draft in the water (affected by weight of equipment and personnel), and environmental conditions (wind, waves, and current).

3.7.1 Speed of Lifeboat
Based on the requirements of IMO (2006), lifeboats must be able to reach speeds of 6 knots when the boat is fully loaded. The speed of the 36 person lifeboat used during this testing exceeded the required standard and traveled at approximately 7.829 knots (14.5 km/hour) when travelling crosswind. However, when travelling upwind the speed of the lifeboat met the standard and traveled at 6 knots (11.12 km/hour).

3.7.2 Draft of Lifeboat
Given the maximum loading capacity of the lifeboat, the draft of the lifeboat was approximately 121.9 cm (Figure 13).

3.7.3 Environmental Conditions
Halifax Harbour Authority reported wind on the day of launch as being NNW at 20 knots, gusting to 40knots. Waves were less than 1 meter and no current was recorded.

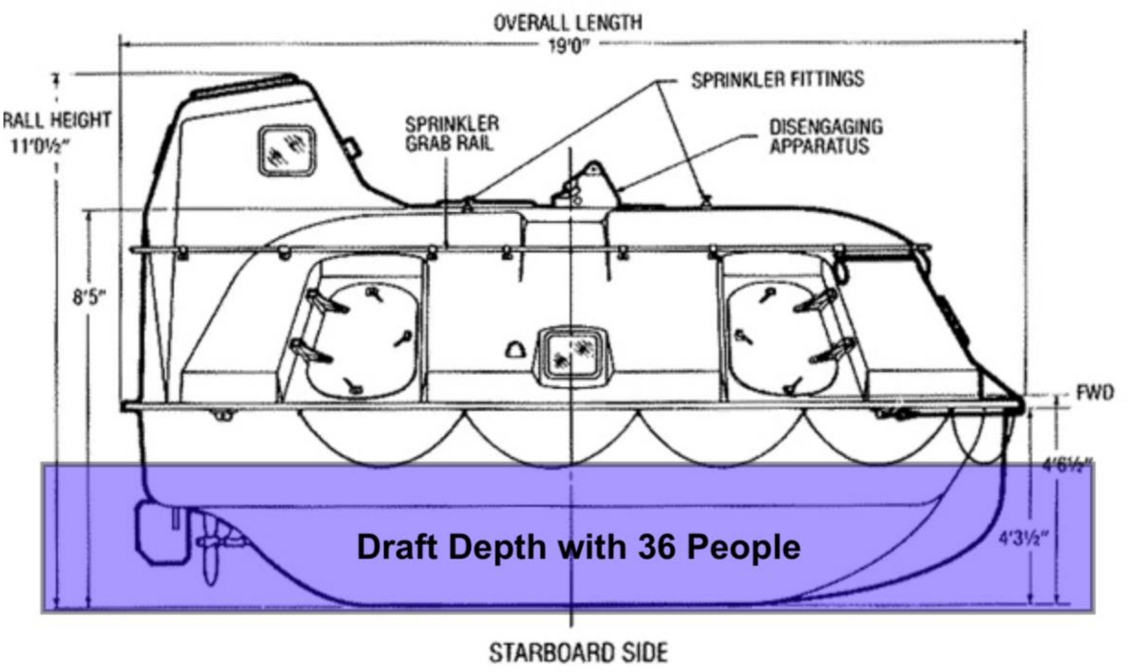


Figure 13. 36 person lifeboat with approximate draft indicated (blue box). Image modified from http://www.survivalsystemsinternational.com/prod_capsules_3638.html.

3.7.4 Effect of Wind on Distance Travelled

Two (2) crosswind trials and one (1) upwind trial were completed to determine how far the lifeboat could travel in the 10 minute (600 seconds) positive air pressure time limit. Figure 14 shows the track taken by the lifeboat coxswain during one of the crosswind and one the upwind trials. Based on the distances travel, it would take 124.8 seconds to travel 500 meters crosswind in weather conditions similar to those experienced on the day of testing. The 1000 meter travel distance is considered a worst case scenario in which there is no wind and the H_2S plume has settle on the surface of the water. In a best case scenario, it could be assumed that there is a breeze which dissipates the H_2S plume and the lifeboat only needs to travel 100 meter away from the installation. Based on the speed of the lifeboat during testing, it would take 24.96 seconds to travel 100 meters Depending on the size of the H_2S plume and the environmental conditions, the distance would need to be adjusted to ensure that the boat moves clear of the airborne contaminates. If the lifeboat needed to travel in a designated direction (assuming the speed of the lifeboat under crosswind conditions) in an attempt to clear the plume that is not being moved by wind, traveling 1000 meters would take 249.38 seconds.

Figure 14. Ten minute crosswind and upwind tracks taken by the lifeboat.

3.8 Calculation of Simulated Evacuation Time (*SET*)

Table 3 shows the recorded and estimated times used to calculate the simulation evacuation time (***SET***). The values in the table show both the best and worst case times used for the time required to load and launch a 36 person lifeboat.

Table 3. Recorded evacuation times for the 36 person lifeboat.

Variable		Recorded Times for 36 person Lifeboat (seconds)
T_{p-s}		127.96
T_{cm}		6.87
T_{don}	Best	62.75
	Worst	70.97
T_{dm}		4.43
T_{s-l}		59.05
T_{load}	Best	369.02
	Worst	605.95
T_{confirm}		35.60
T_{launch}		10.02
T_{100m}	Crosswind	24.96
	Upwind	37.2
T_{500m}	Crosswind	124.8
	Upwind	166.7
T_{1000m}	Crosswind	249.38
	Upwind	333.33

Based on the equation detailed above and the division of phases, the modified simulated evacuation time for a worst case scenario (***SET¹***) includes the first donning and first lifeboat loading time; however, the crosswind travel time was used as this represents the most likely evacuation condition. This evacuation time assumes that the last individual moving from the TSR to the secondary station is told that they need to don an immersion suit and travel down to the lifeboat station immediately after connecting to the manifold and that there is no wind, thus requiring the lifeboat to move 500 meters away from the installation. In this worst case situation, it should be noted that the last individuals arriving at the secondary muster station would be given a new BA to ensure that they have a full 15 minutes of available air. Therefore, any evacuation sequence occurring within a 40 minutes (15 minutes of air in the first BA + 15 minutes from the second BA+ 10 minutes of air in the lifeboat) time frame would indicate an acceptable timeline. All times that fall within the 40 minutes of available air have been marked in “green” while all times that fall outside the available air have been marked in “red”.

$$SET^{1} = \underset{\text{15 minutes of air}}{\overset{\text{Phase 1}}{\boxed{T_{p\text{-}s} + T_{cm}}}} + T_{don} + \underset{\text{15 minutes of air}}{\overset{\text{Phase 2}}{\boxed{T_{dm} + T_{s\text{-}l} + T_{load}}}} + \underset{\text{10 minutes of air}}{\overset{\text{Phase 3}}{\boxed{T_{confirm} + T_{launch} + T_{1000m}}}}$$

SET^{1} = (127.96s) + (6.78s) + (70.97s) + (4.43s) + (59.05s) + (605.95s) + (35.60s) + (10.02s) + (249.38s)

SET^{1} = 1170.15 s (19.50 minutes)

$$SET^{2} = \underset{\text{15 minutes of air}}{\overset{\text{Phase 1}}{\boxed{T_{p\text{-}s} + T_{cm}}}} + T_{don} + \underset{\text{15 minutes of air}}{\overset{\text{Phase 2}}{\boxed{T_{dm} + T_{s\text{-}l} + T_{load}}}} + \underset{\text{10 minutes of air}}{\overset{\text{Phase 3}}{\boxed{T_{confirm} + T_{launch} + T_{500m}}}}$$

SET^{2} = (127.96s) + (6.78s) + (70.97s) + (4.43s) + (59.05s) + (605.95s) + (35.60s) + (10.02s) + (124.8s)

SET^{2} = 1045.56s (17.43 minutes)

If the same time were calculated with best case scenario times (averaged total donning time and load #4), the simulated time to evacuate would be as follows:

$$SET^{3} = \underset{\text{15 minutes of air}}{\overset{\text{Phase 1}}{\boxed{T_{p\text{-}s} + T_{cm}}}} + T_{don} + \underset{\text{15 minutes of air}}{\overset{\text{Phase 2}}{\boxed{T_{dm} + T_{s\text{-}l} + T_{load}}}} + \underset{\text{10 minutes of air}}{\overset{\text{Phase 3}}{\boxed{T_{confirm} + T_{launch} + T_{100m}}}}$$

SET^{3} = (127.96s) + (6.78s) + (62.75s) + (4.43s) + (59.05s) + (369.02s) + (35.60s) + (10.02s) + (24.96s)

SET^{3} = 727.57s (12.13 minutes)

If slow and fast times required to move from the primary (TSR) to secondary muster station (EnCana, 2010) are substituted for those recorded during the evacuation simulation trials, the estimated time to evacuate including the first recorded load time (worst case) would be as follows:

$$SET^{(slow36)} = \underset{\text{15 minutes of air}}{\overset{\text{Phase 1}}{\boxed{T_{p\text{-}s} + T_{cm}}}} + T_{don} + \underset{\text{15 minutes of air}}{\overset{\text{Phase 2}}{\boxed{T_{dm} + T_{s\text{-}l} + T_{load}}}} + \underset{\text{10 minutes of air}}{\overset{\text{Phase 3}}{\boxed{T_{confirm} + T_{launch} + T_{1000m}}}}$$

$SET^{(slow36)}$ = (300s) + (6.78s) + (62.75s) + (4.43s) + (59.05s) + (605.95s) + (35.60s) + (10.02s) + (333.33s)

$SET^{(slow36)}$ = 1417.91s (23.63 minutes)

$SET^{(slow36)}$ = 1467.89s (24.46 minutes) (with 60 second T_{launch})

The fast estimated evacuation time (best case) would be as follows:

$$\boldsymbol{SET}^{(fast36)} = \underbrace{\overbrace{\boxed{T_{p\text{-}s} + T_{cm}}}^{\text{Phase 1}}}_{\text{15 minutes of air}} + T_{don} + \underbrace{\overbrace{\boxed{T_{dm} + T_{s\text{-}l} + T_{load}}}^{\text{Phase 2}}}_{\text{15 minutes of air}} + \underbrace{\overbrace{\boxed{T_{confirm} + T_{launch} + T_{100m}}}^{\text{Phase 3}}}_{\text{10 minutes of air}}$$

SET $^{(fast36)}$ = (180s) + (6.78s) + (62.75s) + (4.43s) + (59.05s) + (369.02s) + (35.60s) + (10.02s) + (24.96s)

SET $^{(fast36)}$ = 752.61s (12.54 minutes)

SET $^{(fast36)}$ = 802.59s (13.38 minutes) (with 60 second T_{launch})

Given the fact that these ***SET*** times include all possible tasks involved in the evacuation sequence it is important to considered the amount of time needed for each phase to ensure that the available air in both the escape BAs and the lifeboat is sufficient to complete the tasks. Therefore, Table 4 shows the combination of times for each phase as well as the margin of error with regard to the available air.

Table 4. Phase of evacuation and available air. Note: green values are positive while red values are negative margins of error.

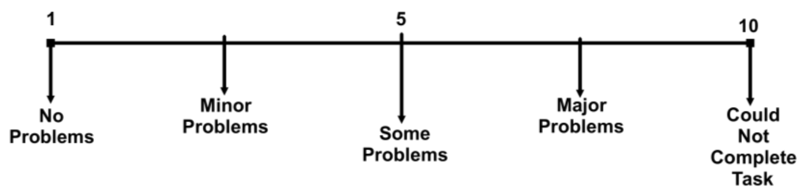
Evacuation Phase and Available Air		Task		Time to Complete	Margin of Error (min)
Phase 1 (15 min)	Scenario 1	Don escape BA and move from TSR to secondary muster station	Best	$T_{p\text{-}s} + T_{cm}$ 180s + 6.78s = 186.78s (3.11 min)	15 – 3.11 = **11.89 min**
			Worst	$T_{p\text{-}s} + T_{cm}$ 300s + 6.78s = 306.78s (5.11 min)	15 – 5.11 = **9.89 min**
	Scenario 2	Don escape BA and immersion suit and move directly to lifeboat station and load lifeboat	Best	$T_{don} + T_{load}$ 62.75s + 369.02s = 431.77s (7.20 min)	15 – 7.20 = **7.8 min**
			Worst	$T_{don} + T_{load}$ 70.97s + 605.95s = 676.92s (11.28 min)	15 – 11.28 = **3.7 min**
Phase 2 (15 min)	Scenario 1	Don immersion suit, disconnect from emergency air cascade in secondary muster station, move to lifeboat station, and load lifeboat	Best	$T_{dm} + T_{s\text{-}l} + T_{load}$ 4.43s + 59.05s + 369.02s = 432.5s (7.21 min)	15 – 7.21 = **7.79 min**
			Worst	$T_{dm} + T_{s\text{-}l} + T_{load}$ 4.43s + 59.05s + 605.95s = 669.43s (11.16min)	15 – 11.16 = **3.84 min**
Phase 3 (10 min)	Scenario 1	Confirm lifeboat load, gain permission to launch, launch, and drive clear of H_2S plume	100 meters	$T_{\mathrm{confirm}} + T_{launch} + T_{100m}$ 35.60s + 10.02s + 24.96s = 70.58s (1.18 min)	10 – 1.18 = **8.82 min**
			500 meters	$T_{\mathrm{confirm}} + T_{launch} + T_{500m}$ 35.60s + 10.02s + 124.8s = 170.42 (2.84 min)	10 – 2.84 = **7.16 min**
			1000 meters	$T_{\mathrm{confirm}} + T_{launch} + T_{1000m}$ 35.60s + 10.02s + 249.38s = 263 (4.38 min)	10 – 4.38 = **5.62 min**

3.9 Task Performance Difficulties

In order to understand where difficulties in performing tasks affected time to travel up or down stairs, don immersion suits, and load the 36 person lifeboat, task performance ratings have been collated and are reported in Table 5. Difficulty rating averages where generally lower on the second and third time that a skill was performed; however, even after strapping into the shoulder and lap harness of the lifeboat several times and traveling with the simulated BA, participants rated these activities as being somewhat difficult.

No snag hazards associated with the BA system were recorded during slow or real-time assessments. It was noted however, that the position of the BA strap around the neck creates some minor problems pulling the hood of the suit up to a point that it could be donned quickly. Therefore, during the real-time trials, participants were asked to place the BA strap over the immersion suit hood material while making their way to the lifeboat.

Table 5. Task performance difficulty ratings for threes of testing.



Task	Day1 Mean	Day 2 Mean	Day 3 Mean	Overall Mean
Donning the escape air pack	1.4	1.3	n/a	1.35
Donning the survival suit	2.24	1.6	n/a	1.92
Donning the survival suit while wearing the escape air pack	3.11	2.4	2.4	**2.63**
Traveling up stairs with the air pack and on and survival suit bag over shoulder	2.75	2.1	1.6	2.15
Traveling down stairs with the air pack on and survival suit bag over shoulder	n/a	1.3	1.8	1.55
Connecting/disconnecting simulated escape air whip to manifold	1.83	2.6	1.6	2.01
Strapping into the lifeboat	4.40	3.22	3.29	**3.64**
Donning the immersion suit with air pack connected to simulated manifold	n/a	n/a	2.53	**2.53**
Interference associated with air pack while donning immersion suit	n/a	n/a	2.71	**2.71**
Interference of air pack with strapping into lifeboat	n/a	n/a	2.61	**2.61**
Interference of air pack when climbing stairs	n/a	n/a	1.59	1.59

General comments from the participants indicated that the simulated BA created some minor difficulties when donning the immersion suit, walking up or down the stairs, and strap into the lifeboat (highlighted values in Table 5). Specifically, during donning of the immersion suit, participants indicated that the added weight of the BA caused them to loose their balance. It was also noted that while climbing stairs, the BA interfered with the participants' sight of the next step and it continually impacted the stair or person in front of them. When strapping into the lifeboat, it was noted that the BA made it difficult to locate the shoulder straps and lap belt connection. However, in order to compensate for these difficulties, most participants had begun to rotate the BA 90° on their lap so that it was easier to see the buckles and to make more room for the next person strapping in. Additionally, it was noted that during the last two lifeboat loading sequences, participants had become more proficient at holding open the shoulder strap of the next person to be seated beside them. This minor adjustment to loading technique will be further addressed in the final section of this report.

4.0 DISCUSSION

The purpose of this study was to identify the amount of time it would take to safely load a 36 person lifeboat with the intent to document aspects of the required abandonment skills that influence the overall evacuation time. To provide a representative estimate of the time required to abandon, participants were trained how to complete the required skills in slow-time and then tested in real-time conditions. Given that the opportunity to load the lifeboat while wearing an immersion suit and escape BA are not normally carried out in a typical offshore setting, the recorded worst case time for full evacuation represents the most likely conditions that might be experienced during a real-world emergency. However, more ideal conditions such as reduced lifeboat capacity percentage (i.e. less than 100%), easier lifeboat boarding requirements, and greater level of practice/experience may reduce the time needed to complete the necessary tasks.

While completing evacuation tasks it was noted that the BA pack presented several challenges to performing the basic skills needed during evacuation. Based on these difficulties, recommendations for placement and adjustments of the BA are made in the next section. These recommendations are applicable to the loading of a 36 person SSI lifeboat; however, they may also prove to be beneficial when loading different sized lifeboats.

Finally, the data collected for this study clearly shows that sufficient air is currently provided during all but one scenario for every phase of the evacuation sequence. The only time that tasks exceeded the available air was in an estimate of worst case scenario in which the participants had never strapped into the lifeboat harness and the longest time to travel from the secondary muster station to the lifeboat were used. Even under these conditions, the time to complete the tasks only exceeded the available air by 10.2 seconds. As noted in the results section, participants continually decreased their loading time until they had reduced their overall T_{load} by nearly 4 minutes. Based on these results, it can be assumed that if offshore personnel are regularly given an opportunity to familiarize themselves with abandonment drills and lifeboat arrangements such that they practice abandoning from designated muster stations to the lifeboat and load in groups of 3 to 4, their overall T_{load} will be reduced to a level that would be within the available air limitations.

5.0 RECOMMENDATIONS

The following recommendations are based on the results of the present study and apply directly to the tested evacuation skills and the loading of the SSI 36 person lifeboat.

1. BA straps should be extended to their maximum length while donning the immersion suit as this lowers the center of gravity and reduces the likelihood of losing one's balance.

2. BA air cylinder bags should be turned 90° when sitting in the lifeboat to ensure that lap buckles can be easily connected and the space between air cylinders does not impede donning of shoulder harnesses.

3. When loading the 36 person lifeboat, personnel should hold the shoulder harness of the seat next to them open so that the next person entering the lifeboat will not have difficulties finding their straps.

4. Whenever possible, offshore personnel should be given the opportunity to load representative lifeboats. This will ensure that any difficulties associated with strapping into the seat harnesses are well understood and aid can be offered to those needing it. Familiarization with loading and buckling into harnesses could be completed in groups of several people to simulate shoulder to shoulder loading and harness fastening.

5. Operators should test the amount of air used to travel from the TSR to the secondary muster station. Similar testing should be carried out from the secondary muster station to the lifeboat station. This will aid in establishing an average air consumption value that can be considered during the development of an overall evacuation timeline.

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Appendix A
Participant Consent Form

A FUNCTIONAL TASK ANALYSIS OF LIFEBOAT/SCBA EVACUATION AND INTEGRATION SKILLS

PARTICIPANT CONSENT FORM

PRINCIPAL INVESTIGATOR AND CONTACT:

MICHAEL TABER, PHD (CANDIDATE)
SCHOOL OF HEALTH AND HUMAN PERFORMANCE
mtaber@inbox.com
905-401-7421

INTRODUCTION

Although current oil and gas regulations standardize both the equipment and the procedures deemed necessary for emergency evacuation, relatively little investigation has been completed to identify the specific skills required to don an emergency breathing apparatus (BA), and load a 36 person survival craft (lifeboat). Therefore, the primary purpose of this functional task analysis is designed to address specific aspects of evacuation skills and equipment integration for abandonment from an offshore oil installation in the North Atlantic. Specifically, this analysis seeks to identify the step-by-step tasks needed to effectively and efficiently move individuals safety from their point of muster in a temporary safe refuge (TSR) through a series of corridors and stairways while wearing a Canadian General Standards Board (CGSB) approved immersion suit and BA to a lifeboat located outside the main living quarters. This analysis will also be used to identify any snagging of the suits and BA during donning, transit to the lifeboat, and while securing individuals inside the lifeboat. Finally, this analysis will be used to identify possible integration difficulties associated with the BA manifold system used while waiting to enter the lifeboat.

I____
(print name)

hereby volunteer to participate as a test participant in the Survival Systems Training Limited (SSTL) testing protocol for this study. I have read and understand the information described by the researchers and, where appropriate, have directed any questions to the Principal Investigator. All of my questions concerning this testing have been fully answered to my satisfaction. Any additional information I may require can be obtained by contacting Michael Taber at 905-401-7421. Contact can also be made through email: mtaber@inbox.com.

Objectives of Study

The object of this analysis is to document emergency equipment integration and evacuation protocols utilized during lifeboat abandonment. Specifically, it is intended that this analysis will be used to inform oil and gas health and safety management decisions related to risk mitigation and emergency planning.

Who will be conducting the research?

Mr. Michael Taber (Project Coordinator) is the principal investigator and is the main contact person for this study. Mr. Taber should be contacted if you have any questions or concerns. The study will be conducted at Survival Systems Training facility in Dartmouth, Nova Scotia.

What I will be asked to do

I understand that I will be asked to take part in practical lifeboat evacuation trials at Survival Systems Training Limited (SSTL). I understand that each trial session will be conducted at the SSTL's harbour-side island. I understand that there will be considerable physical requirements associated with this study and that I will be asked to don an immersion suit and self contained breathing apparatus while completing the evacuation trials. I also understand that I will asked to load and be launched from the SSTL island in a 36 person lifeboat.

I understand that I will be asked to evacuate from several different muster station points and I may be required to climb several sets of stairs that lead to a training tower approximately 40 feet over the surface of the water. I understand that my progress will be monitored by Survival Systems Training Instructors and Safety Personnel. I understand that I will be ask to rate each of the practical evacuation trials on a scale from one (1 – No problem) to ten (10 – Needed considerable help – could not complete the required skills without assistance) and that my performance will be video taped for further analysis.

I also understand that I will be asked to demonstrate the use of a self contained breathing apparatus (SCBA) while simulating the abandonment drills. I understand that for my records and reference, I will be provided with a copy of this Volunteer Consent form. I have also been made aware that the lifeboat evacuation trial results will be manually recorded by the principal investigator and one of two research assistants and will be used in a final report. I have been made aware that all data related to my involvement will be transcribed to a compact disc (CD) and locked in a metal filing cabinet located at Survival Systems Training.

I am aware that at any point during the study I may withdraw my consent without hard feelings or prejudice. Should I withdraw my consent, my participation as a subject will cease immediately.

Possible Risks and Discomforts

The investigator does not perceive there to be risks beyond existing offshore oil and gas operational requirements. However, if I experience any discomfort while completing the evacuation trials, I understand that I will be given the opportunity to pause the testing until I am ready to continue.

Possible Benefits

I understand that my participation in this study will not provide me with any direct benefits.

Confidentiality

The information I reveal and the experimental data concerning me will be treated as confidential and will not be revealed to anyone other than the study researchers. An identification code will be used during the analyses of the data to ensure that my identity is not revealed. Mr. Taber will securely store my experimental data in a locked cabinet in his office as well as at SSTL. I have the right to ask questions or request further explanation about the procedure at any time before, during and/or after the investigation. I have the right to request that my information be excluded from the study up until the time that the analysis is completed (tentatively scheduled for 21st May 2010).

Problems or concerns

In the event that I have any difficulties with, or wish to voice concern about, any aspect of my participation in this study, I may contact Survival Systems Training Training and Operations Manager for assistance: (902) 465-3888 ext 133, joelc@sstl.com.

A Functional Task Analysis of Lifeboat/scba evacuation and Integration Skills

Voluntary Consent

Volunteer's Name____

Volunteer's Signature____

Date____________

Witness Name____

Witness Signature____

Date_____________

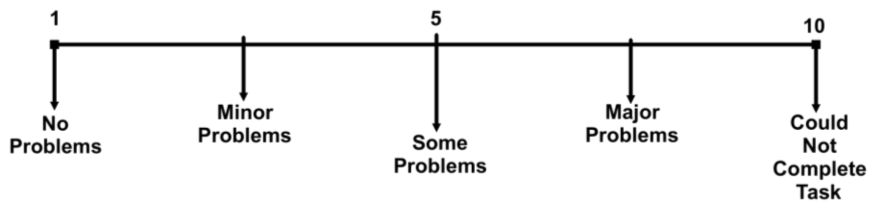
Appendix B

Participant Task Rating Questionnaire

Participant ID #: ______________________

Please rate your experience performing the following tasks by placing a line (/) on the scale below.

Donning the survival suit with air pack connected to simulated air manifold.



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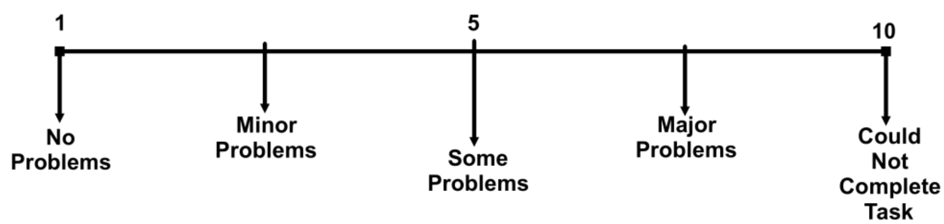
Donning the survival suit while wearing the escape air pack



Comments:____
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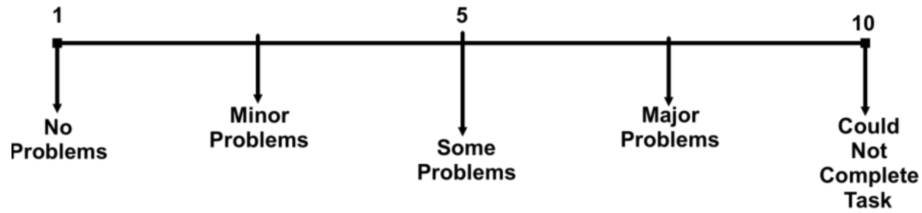
Traveling up stairs with the air pack and on and survival suit bag over shoulder.



Comments:____
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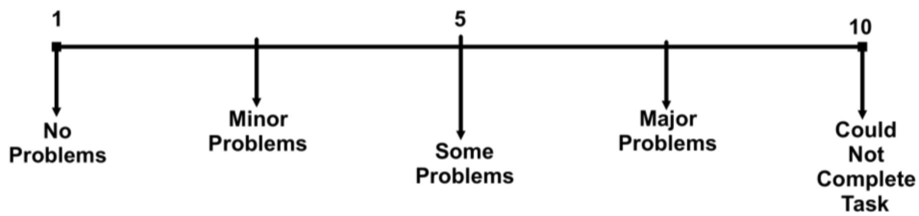
Traveling down stairs with the air pack on and survival suit bag over shoulder.



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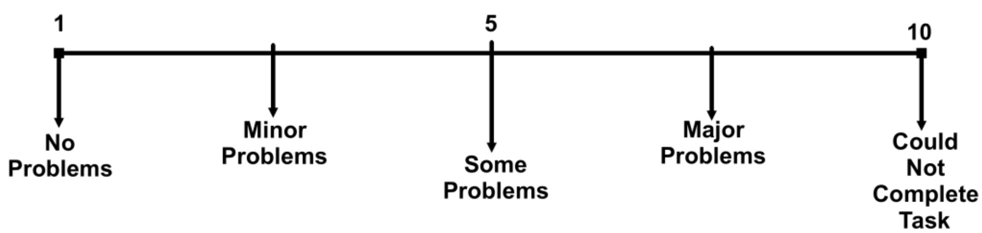
Connecting/disconnecting simulated escape air whip to manifold.



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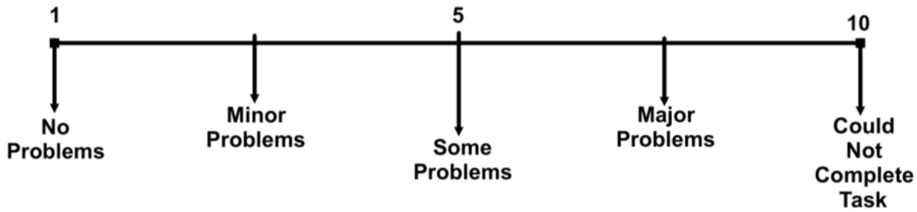
Strapping into the lifeboat.



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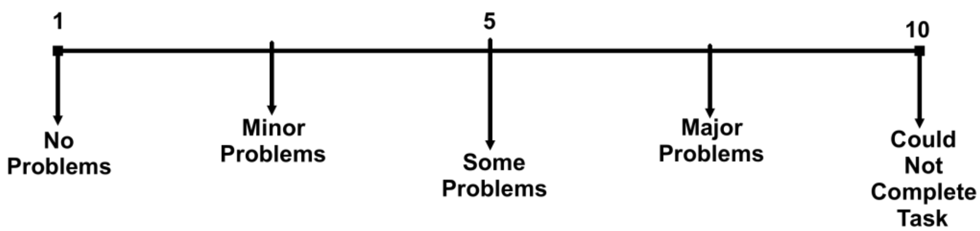
Closing off fresh air ventilation, operation of fresh air supply, or deluge system in lifeboat (crew seats only).



Comments:____

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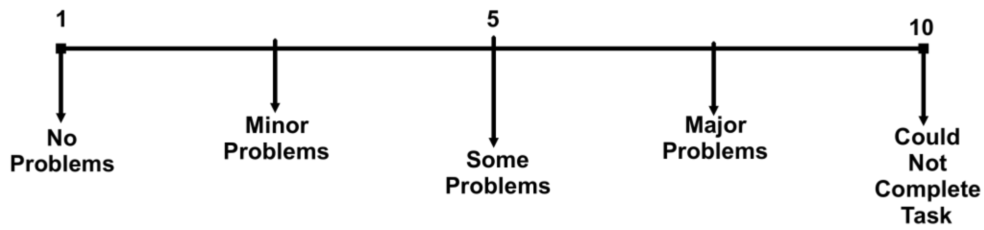
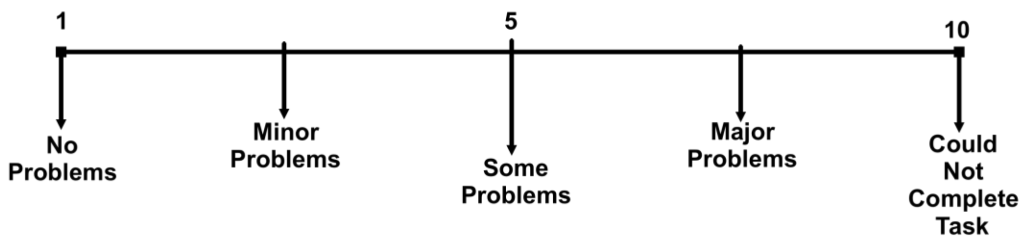
Interference associated with air pack while donning immersion suit



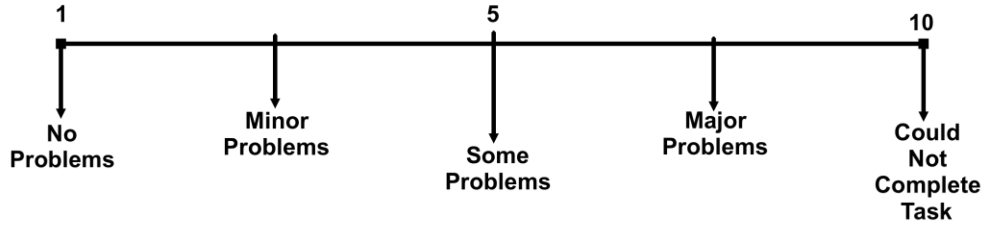
Comments:____

Interference of air pack with strapping into lifeboat.



Comments:____

Interference of air pack when climbing stairs.



Comments:____