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CORD

Final Report

Water Ingress Testing of the HH E-452 Helicopter Passenger Transportation Immersion Suit System In a Simulated Ditching and Survival Scenario

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2.Executive Summary

To evaluate the water ingress performance of the Helly Hansen Canada E452 Helicopter Passenger Transportation Suit system in realistic conditions, eight subjects (6 male and 2 female) were exposed to a helicopter ditching scenario in a Modular Egress Training Simulator (METS) at the Survival Training Simulation Theatre (STST) in Dartmouth, Nova Scotia. The ditching scenario involved a METS ditching in stormy conditions followed by a 20 m swim, life raft boarding, and a 30 minute immersion. Measurements of water ingress were taken after the ditching scenario (METS, 20 m swim, and liferaft boarding) and after the 30 minute immersion. Each subject completed the ditching scenario twice, once in the morning and once in the afternoon. It was recorded that the total mean water ingress values for the eight subjects was 545 g (AM) and 345 g (PM) and an overall average for the two sessions of 445 g.

3.Introduction

Prior to this test program, a preliminary set of water ingress tests were conducted on June 22, 2009, on the HH E-452 Helicopter Passenger Transportation Suit System. The tests was a simulated ditching scenario, and was conducted with three human subjects. The tests were observed by CAPP representatives. The objectives of the preliminary test plan were to;

- develop a realistic scenario, in terms of activity and conditions that would provide a good challenge to the water integrity of a suit system,
- conduct a preliminary session with one subject to work out the logistics, safety, and staffing levels required to safely conduct the simulated egress trial with human subjects,
- conduct a simulated egress trial with three subjects to collect measurements of water ingress.

After review of the preliminary testing report and discussions with CORD, CAPP requested a second set of tests, similar to the preliminary tests, with the following additions and/or modifications to the test protocol;

- conduct the helicopter egress and vital actions test as conducted in the preliminary tests, but this time, have the subjects egress from an aisle seat, rather than from a window seat,
- develop and conduct an additional test, where the subjects could be tethered in the middle of the tank, and be subjected to 30 minutes of challenging wind and wave conditions,
- conduct both of these tests with a group of eight human subjects, including two female subjects, using a wide range of available suit sizes, to collect measurements of water ingress.

The tests were conducted using the Survival Training Simulation Theatre (STST), adjacent to the CORD facilities, in Dartmouth Nova Scotia on July 15, 2009. This day of testing was observed by a number of representatives of the east coast offshore oil and gas industry.

4.Methods

Prior to the conducting the tests on July 15, 2009, a number of activities took place. The test methods to be used, needed to be modified and/or developed, and tested, and process of recruiting, screening and scheduling subjects for helicopter egress training needed to be completed. Eight, healthy, naive subjects were used in this test program, 6 males and 2 females, ranging in age from 20 to 51 years. The size range of Helly Hansen E-452 Immersion suits used for this test program were as follows; XL(1), L(1), M(2), S(3), XS(1).

The eight subjects each participated in one of the two, four hour familiarization sessions. Each of these sessions included, suit familiarization, helicopter underwater egress training, and familiarization of the actual test protocols. The training and the test program were conducted at the Survival Systems Limited, Survival Training Simulation Theater (STST) facility in Dartmouth, Nova Scotia. A METS, model 5 huet, with a S92 push out window, double high back seating configuration with four point harness was used for the test program.

Table 1 Subject Characteristics

Subject	Gender	Suit Size	Tether line Position
1	M	M	1
2	F	XS	4
3	F	S	3
4	M	L	2
5	M	S	2
6	M	M	3
7	M	XL	4
8	M	S	1

The test plan was to have each subject perform one helicopter egress test and one 30 minute survival immersion test in the morning, and then to do an exact repeat of these tests in the afternoon. The helicopter egress and vital actions test required the subject to don the E-452 suit, get on the weight scale, to determine a dry weight. The subject entered the water using the pool ladder in the shallow end of the pool, keeping their wrist seals out of the water. The subject crouched to neck level in the water and was then carefully sprayed with a water hose to wet all exterior materials of the suit. This saturation procedure continues for three minutes, at which point the subject was removed from the water and permitted to drip on the pool deck for one minute, before being weighed to determine a saturated weight for the subject. This saturation test was conducted in accordance with CAN/CGSB.65.17-99, section 8.1.6.1. After this weighing, the subject was ready to perform the egress sequence. The subject entered the METS by stepping from the shallow end into the back of the METS, where the subject was directed by the METS instructor to the correct aisle seat, along side a diver sitting in the window seat. When seated the instructor secured the seat belt and reviewed the subject's actions for egress from the

METS. While the instructor was briefing the subject the METS was raised over the water. When the subject was ready the instructor gave the command to begin the run.

The egress sequence started as a normal ditching and capsize, with the subject sitting in the aisle seat, along side a diver in the window seat. Upon hearing the command for ditching the subject assumed a crash position as the METS was lowered into the water, and rolled 180 degrees. As the ditching scenario started, the pre programmed environmental conditions for the sequence were started. After the METS stopped, the diver in the window seat egressed and the subject in the aisle seat located, released the seat belt, traversed the seats to the open 92 window, and exited the METS. During the egress sequence, the environmental effects were started. After surfacing, the subject quickly moved a short distance away from the METS, by swimming on their backs upwind, and then inflated their lifejacket. During this time the METS was raised up and clear of the water. The subject then swam on their back, 10 meters down wind and boarded a tethered 10 man SOLAS life raft. Once completely in the raft the sequence was complete and the environmental effects and sounds ended. The subject was then removed from the life raft directly on to the deck, permitted one minute dripping, and then weighed. The measured increase in weight was recorded and represented water leakage in the suit. The test sequence took approximately 2 minutes for the subject to complete, from the time they first became immersed in the METS.

The environmental conditions used for this test were;

Wind- moderately gusty (30 to 70 Km/hr)

Waves- .5 to .75 meter, random and confused

Rain – continuous and heavy

Sound- Ocean sounds

Light – delayed dim

After the first four of the eight subjects had completed the helicopter egress and vital actions test, these subjects were required to complete a 30 minute survival immersion test. This test required the subjects to enter the water with their suit completely donned, and attach their foot to a surgical tubing tethering system. Once the four subjects were secured on the tether, they were directed to don their spray shields and gloves. Once the subjects had completed this, the waves and wind were started and the 30 minute immersion commenced. During the 30 minutes the subject laid on their backs, with hands by their sides or on their stomachs. After 30 minutes, the environmental effects were turned off and the subjects were removed one at a time from the water, allowed the one minute drip time on the pool deck and then weighed. The measured increase in weight was recorded and represented water leakage in the suit.

The environmental conditions used for this test were;

Wind- 25- 40 km/hr at the location of the subject, and 55 km/hr where the wind interacts with the cresting wave,

Waves- .6 meter with approximately 2 second period.

After the first four subjects had completed the helicopter egress and vital actions test and the 30 minute survival immersion, the second four subjects completed the helicopter egress and vital actions test, and then the 30 minute survival immersion test. This complete series of test took approximately 3 and ½ hours. This morning test plan was then repeated during the afternoon.

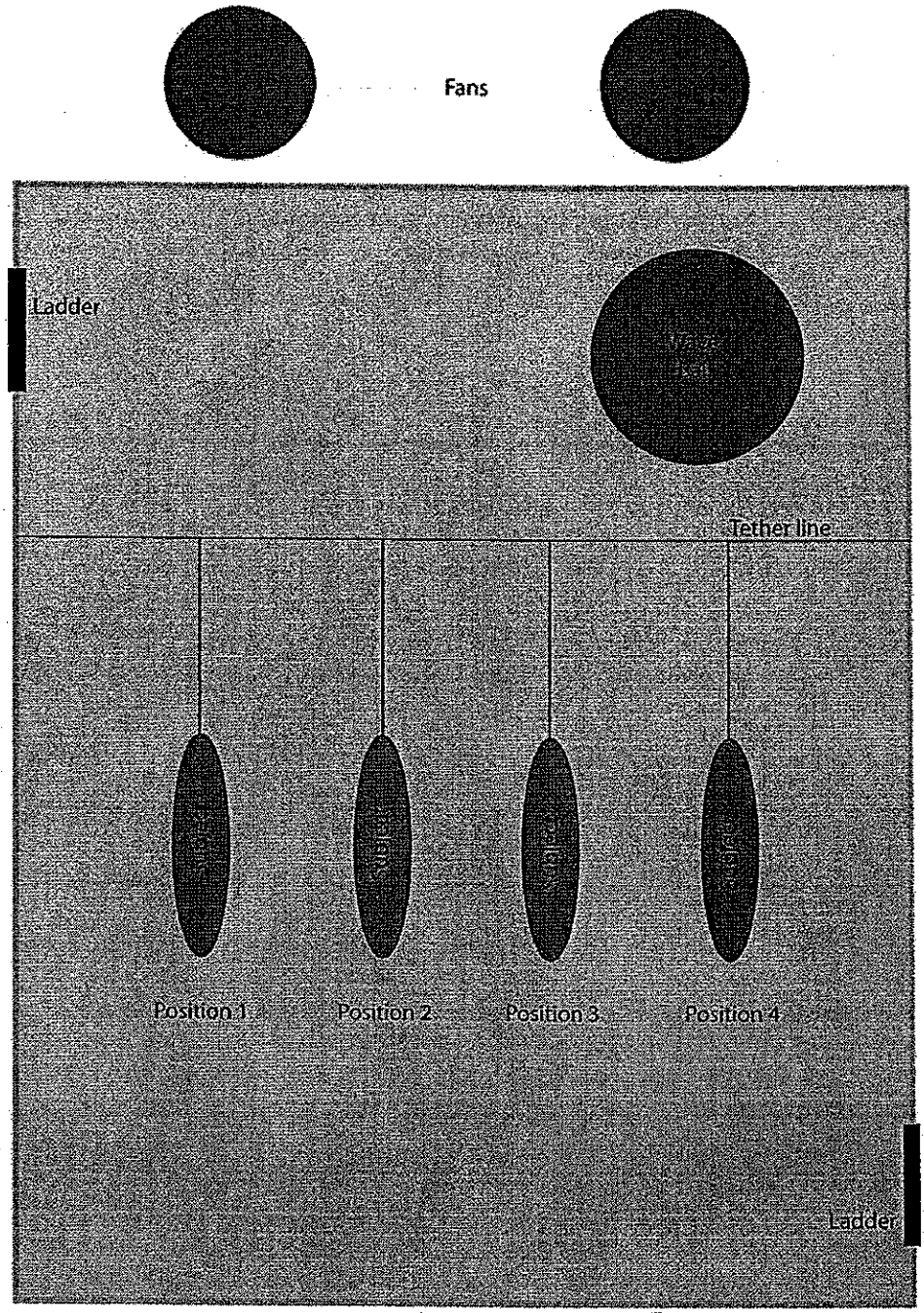

Figure 1 Diagram of the STST setup for the 30 minute immersion

5.Results

The test plan produced a total of 16 sets of data. The data is presented here in three groups. The groups are called the AM group, the PM group, and the Combined group. The AM group represents the data for each of the eight subject's first helicopter egress and vital action test and first 30 minute survival immersion test. The PM group represents the data from the subjects second set of tests in the afternoon, and the combined is the two groups, AM and PM being treated as one set of 16.

The results for the three groups are provided in the following three tables. Table 1 being the AM group, Table 2, being the PM group, and Table 3 being the Combined group.

Table 1 Measured water ingress for the two tests conducted in the AM group

Subject	Suit Size	Water Ingress-Egress (W_1)(kg)	Water Ingress-Immersion (L)(kg)	Total Water Ingress (kg)
1	M	0.240	0.580	0.820
2	XS	0.320	0.080	0.400
3	S	0.540	0.120	0.660
4	L	0.700	0.100	0.800
5	S	0.220	0.020	0.240
6	M	0.300	0.020	0.320
7	XL	0.420	0.060	0.480
8	S	0.300	0.340	0.640
Mean		0.380	0.165	0.545

Table 2 Measured water ingress for the two tests conducted in the PM group

Subject	Suit Size	Water Ingress-Egress (W_1)(kg)	Water Ingress-Immersion (L)(kg)	Total Water Ingress (kg)
1	M	0.100	0.120	0.220
2	XS	0.120	0.040	0.160
3	S	0.500	0.060	0.560
4	L	0.540	0.260	0.800
5	S	0.140	0.020	0.160
6	M	0.220	0.080	0.300
7	XL	0.120	0.260	0.380
8	S	0.140	0.040	0.180
Mean		0.235	0.110	0.345

Table 3 Measured water ingress for the two groups Combined

Subject	Suit Size	Water Ingress-Egress (W_1)(kg)	Water Ingress-Immersion (L)(kg)	Total Water Ingress (kg)
1a	M	0.240	0.580	0.820
2a	XS	0.320	0.080	0.400
3a	S	0.540	0.120	0.660
4a	L	0.700	0.100	0.800
5a	S	0.220	0.020	0.240
6a	M	0.300	0.020	0.320
7a	XL	0.420	0.060	0.480
8a	S	0.300	0.340	0.640
1b	M	0.100	0.120	0.220
2b	XS	0.120	0.040	0.160
3b	S	0.500	0.060	0.560
4b	L	0.540	0.260	0.800
5b	S	0.140	0.020	0.160
6b	M	0.220	0.080	0.300
7b	XL	0.120	0.260	0.380
8b	S	0.140	0.040	0.180
Mean		0.308	0.138	0.445

6. Discussion

The data presented in the results has been produced from tests that were designed to present a complete challenge to the water proof integrity of the suit system, and to do this by utilizing more realistic scenarios, actions and conditions. The tests developed and used for this program were novel and to the knowledge of The CORD Group Limited, no other tests on water ingress on a helicopter suit have ever been conducted similar in nature to these tests. Therefore, caution should be used when considering comparing this data to other results from different test methods, and from making assumptions that this data can be inputted into other test method formulas.

The purpose of water ingress testing is to predetermine the amount and the location of water to be introduced inside the suit, prior to the start of the thermal test. This is important as water reduces the thermal protection of a suit. The Water Ingress test is the first part of the Thermal Protection requirements in CAN-CGSB-65.17-99. The water ingress tests for the 11 subjects, in the CGSB standard, are a jump from a height of not less than 3 meters, and a 60 minute swim (approx 1200 m). These two tests provide the raw data to be used in the formula, provided in the CGSB standard, for calculating the amount of water to be introduced into the suit system prior to the thermal manikin or human testing. The formula is as follows;

> Section 8.1.6.1 of the CAN/CGSB-65.17-99 states the calculation of water ingress where, W, to be introduced at the start of the insulation measurement using the formula;
>
> $W = W_1 + 3L$
> where:
> **W**= mass of water to be introduced in grams
> W_1= water ingress, in grams, average (mean) for eleven subjects, measured at jump test
> **L**= water ingress, in grams, average (mean) for eleven subjects, measured at 60 min swim test
>
> **Note: W_1 and L should be taken as one standard deviation above the mean for the subjects**

CGSB swimming pool testing is not conducted in realistic conditions, as it consists of a jump and swim in calm water. To improve the representation of water ingress in realistic conditions, the CAN/CGSB-65.17-99 standard includes a formula to estimate leakage by including a standard deviation (error factor) to the leak values. Additionally, the CGSB leakage method estimates the leakage value after 3 hours by multiplying the 1 hour swim leak results by 3. This serves as a mechanism for valuing the thermal protection offered by protective garment for 6 hours of protection from hypothermia. However, this assumes that the ingress of water into a suit is linear, which may not be a reliable assumption, for different environmental conditions, suits, subjects, and durations of immersion. The use of the error factor and the estimation of

leakage after 3 hours from the leakage data causes the CGSB standard leakage test method to be more rigorous than the international (ISO) standards, which is also a jump/swim test (20 minute swim duration versus 60 minute duration of the CGSB standard), though it does not require an error factor or multiplication to estimate the leakage after 3 hours of immersion. To put the differences in the CGSB and ISO test methods into perspective, a previous study conducted by The CORD Group Limited determined that the CGSB leakage method estimated leakage to be 3.7 times higher than the ISO test method, which results in a suit that must be more insulated to meet the CGSB standard.

7.Summary

The total mean water ingress values for the three sets of data produced results of; 545 g (AM), 345 g (PM), and 445 g (Combined). All three of these results were below the leakage amount calculated by the CGSB water ingress method during the approval of the HH E-452 suit. Knowing that these values are lower than the value that was used for the thermal protection test, it can be safely concluded that the thermal value would increase with less water leakage, and therefore still exceed the required 0.75 immersed Clo.

This test program has pioneered some innovative, and more realistic scenarios simulations, as an approach to assessing the watertight integrity of a helicopter passenger immersion suit. This could serve well as a foundation and guide to build our knowledge, assist in setting future requirements.