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Executive Summary Final Report

Development of a Training Standard for Underwater Survival

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Summary

The following document discusses and summarises the findings of the research programme commissioned by The Shell Group, designed to aid the company in developing a standard for helicopter underwater escape training.

The research programme involved four stages of research. The initial stage involved a review of information relating to underwater survival, previous research and current training practices. The review indicated that passenger escape from a ditched helicopter was extremely hazardous. Given the frequency of flights in helicopters by employees in industries associated with oil production survival training is now provided. Whilst this training is widespread, the content and fidelity of training that employees receive is dependent on where in the world they work. As a result of this initial review a competency standard to be reached by trainees during training was developed in consultation with trainers and experts in the field.

Following this initial work an experimental programme was conducted. The main objective was to determine the optimum training required to enable trainees to meet the minimum competency level. Members of the public were recruited and each participant was randomly assigned to one of ten training sessions. Eight of the groups were given a variation of HUET training whilst the other two groups after HUET training were given two alternate forms of Air-Pocket training. Following their training sessions, participants were asked to perform test evacuations. These were used to evaluate their respective HUET training. The results from this study clearly indicated that the current content of some training was not sufficient to ensure trainees reached the minimum competency. The current document lists the suggested minimum content for future HUET courses.

The aims of the third stage of the research programme were to investigate the decay of procedural knowledge and skills following a HUET training session. The programme involved testing participants at various stages since their HUET training. The participants were asked to carry out a test evacuation operating representative seatbelts and exits from a fully inverted simulator and complete a questionnaire. Exceptional difficulties were encountered in recruiting participants from the offshore population and as a result, those participants who attended the test sessions were probably those individuals who felt relatively comfortable with helicopter underwater escape training. The inability to select participants from a large pool of volunteers also meant that there was a large variation in the type/fidelity of training that they had received, many had never previously operated pop out window exits. As a consequence of these variations the competency standard reached by the volunteers during their last training session varied dramatically and this appears to have masked any influence of time elapsed since last training session on escape performance. Despite the fact that it was not possible from the research programme to identify the optimum point of retraining, important and valuable information has been gained.

The final stage of the research programme involved an assessment of knowledge gained from pre flight briefings. Participants were asked to complete a questionnaire assessing their generic and aircraft specific emergency procedural knowledge with reference to the last aircraft type they flew on. Respondents were then shown a pre-flight video for the S76 aircraft (an aircraft they had not previously flown on) before completing a questionnaire assessing their generic and aircraft specific emergency knowledge of the new aircraft type.

The results indicated that, whilst passengers knowledge resulting from watching a video pre-flight briefing of generic safety procedures was generally sound, their aircraft specific knowledge was poor particularly on an unfamiliar aircraft type.

1. Introduction

In July 1997, the Human Factors Group at Cranfield University was commissioned by The Shell Group to conduct a programme of research which would enable the company to develop a standard for helicopter underwater escape training (HUET). The objectives of the research were to:

1) Assess the minimum competency levels required for successful underwater escape from a submerged, inverted helicopter cabin.

2) Assess the optimum training requirements to meet the minimum competency level and the benefits and risks associated with them.

3) Assess the requirement for refresher training and its frequency.

4) Assess the requirement for passenger briefings, including their content and the decay of knowledge gained from them.

5) Evaluate the optimum simulator fidelity.

6) Develop a draft HUET standard for offshore workers.

The programme of research involved four stages. The first stage involved a literature review of information relating to underwater survival, previous research, and current training practices. As a result of this review and interviews with experts within the field, a minimum competency to be reached from HUET was defined for use in the experimental testing in stage two. In stage two groups of participants were trained using a variety of training scenarios; following this, participants' ability to reach the minimum competency was assessed. Stage three followed the decay of knowledge and practical skills of offshore workers. Finally the fourth stage involved an assessment of knowledge gained from pre flight briefings shown to passengers flying offshore.

2. Literature review

This stage of the research involved a comprehensive review of helicopter underwater escape training (HUET) methodology and practice, accident data and previous research in the area of helicopter safety and survival.

The very nature of helicopter operations, whether they be military or civilian, place the crew or passengers in an environment where there is very little margin for error. Both military and civil helicopters generally operate at low level and in extremely hostile environments, increasing the risk of being involved in an accident. The assessment of accident statistics indicated that a large proportion of water impacts result in the aircraft inverting and/or sinking quickly, before every occupant has evacuated. As a consequence of this many survivors had to make their escape whilst underwater. Even if passengers are not injured the in-rush of water, loss of vision, disorientation, entanglement with debris and difficulties with restraint harnesses and exits were shown to significantly impede passengers escape.

Practical Underwater training has been provided for military aircrew since the second world war. In the last twenty years the civil sector, has seen the widespread introduction of 'dunker' training for offshore oil industry employees. Given the frequency of flights in helicopters by employees in industries associated with oil production it could be argued that there is a duty of care to provide these personnel with the same survival training as the aircrew who are transporting them to and from their place of employment. It should also be noted that not all companies mandate that aircrew must undergo HUET. There have been numerous studies and survivor reports testifying to the benefits of HUET

HUET is now carried out on a similar format by the majority of the training institutions. This follows a pattern of classroom training followed by some form of 'wet' practical training. Training modules are becoming more realistic with the introduction of restraint harnesses, realistic capsize rates and in many cases realistic jettisonable doors. Despite these advances in the fidelity of training, the review indicated that there is still great variation in training content and fidelity, the quality of HUET training offshore workers receive is very much dependent on where in the world they work. Due to great variation in emergency equipment on board aircraft training is also forced to be generic in nature as opposed to the type of training the military employ which is specific to aircraft type. The use of specific training can only increase the transfer of training to the operational setting.

One of the most important issues related to the provision of any training intervention is the measurement of the impact on, or change in trainees performance post-training. Currently there is no mandated measurable standard which trainees must reach as a result of the HUET session they have undergone. As a consequence, trainees may well be receiving the training required for their particular company or country, however they may not all be reaching an acceptable standard of performance.

3. Minimum Competency

As a result of the literature review carried out in stage one and consultations with experts in the field a minimum competency to be reached by trainees as a result of HUET was determined. The minimum competency required trainees to demonstrate the ability, underwater in an inverted HUET, to release a representative seat restraint and escape exit release mechanism, and effect an escape unaided.

4. Training Content Design and Evaluation

The main objective of the experimental programme was to determine the optimum training required to enable trainees to meet the minimum competency level. Members of the public were recruited and each participant was randomly assigned to one of ten training sessions. Eight of the groups were given a variation of HUET training whilst the other two groups after HUET training were given two alternate forms of Air-Pocket training. Following their training sessions, participants were asked to perform test evacuations. These were used to evaluate their respective HUET training.

The results clearly indicated that in order to meet the minimum competency level, trainees must be given practice in operating representative emergency exits during training. Furthermore trainees must also experience at least one inversion which must also include the operation of a representative exit. In order to ensure transfer of training to the operational environment the rate of inversion and force required to operate these exits must be identical or as similar as possible to reality In some areas of the world the content of the HUET training would have to be modified to ensure that passengers could meet the competency standard.

The current practice of part-task learning, whereby trainees skills are built up in an incremental fashion was strongly supported by the results of the study. The results from the testing programme indicated that trainees performance and confidence improved as a result of experiencing two inversions. For many participants their first experience of an inversion was so disorientating that they learnt more during a second inversion when they knew what to expect.

Measures of stress indicated that higher fidelity training caused more stress. However individuals in these groups were more confident as a result of their training and their stress levels during a simulated emergency were lower than those participants who had not experienced an inversion. The participants in the training groups who did not practice escaping from an inverted simulator, not only showed higher levels of stress but the unwanted symptoms of incorrect or poor performance increased.

As a result of the research the benefits of air-pocket were realised. Participants were able to remain in the helicopter simulator for longer periods and stated that the increased window of opportunity for escape due to use of the air-pocket helped reduce feelings of panic. The results suggested that both comprehensive classroom training and practical experience of Air-pocket in the water would be of benefit to trainees.

5. Frequency of Refresher Training

Training should not only produce adequate performance immediately after training but also after a subsequent period of no practice. Retention of "continuous" perceptual-motor skills, such as riding a bike, is usually almost perfect . In some cases, even after years without practice, the person can still perform the task. In contrast 'procedural' activities which require a series of steps performed in a set order are more easily forgotten over time. Research has demonstrated that a major determinant of the retention of procedural skills is the number of steps involved, with increasing number of steps leading to lower levels of retention. Skills that are infrequently practised or used such as emergency procedures can degrade to the point of being problematic. Studies have shown that procedural skills can decay even after 6 months.

In order to assess the decay of trainees knowledge and performance a programme of research was designed involving 6 groups of participants who underwent their HUET training at NUTEC either 6 months, a year, 18 months, two years, three years or four years ago. The participants were all currently employed in the offshore industry and flying to installations on a regular basis. The use of participants from the offshore working population ensured that they had all the relevant skill base, should have been trained to a suitable level at NUTEC, and had the opportunity to refresh this training through flying and pre flight briefings.

A total of 1250 letters of invitation to take part were distributed using NUTECs database of previous trainees, these yielded eighty interested applicants. Of these eighty, fifty two actually

attended the arranged research sessions. The participants were asked to carry out a test evacuation operating representative seatbelts and exits from a fully inverted simulator and complete a questionnaire. The questionnaire was used to evaluate their emergency procedures knowledge and any difficulties that they encountered during the test evacuation.

The difficulties experienced in recruiting volunteers suggested that participants who attended the test session were those individuals who felt relatively comfortable with helicopter underwater escape training. The inability to select participants from a large pool of volunteers also meant that there was a large variation in the type/fidelity of training that they had received, many had never previously operated pop out window exits. As a consequence of these variations the competency standard reached by the volunteers during their last training session varied dramatically and this appears to have masked any influence of time elapsed since last training session on escape performance. Despite the fact that it was not possible from the research programme to identify the optimum point of retraining, important and valuable information has been gained.

The results indicated that regardless of the time (6, 12, 18, 24, 36 and 48 months) since participants last training session escape knowledge and performance had degraded significantly. In total, over a third of participants in the study failed to escape from the HUET training module. Even after six months participants performance had degraded to the point where they failed to perform all of the relevant actions in the correct order, often operating their seatbelt before removing their window exit, an action which may prove fatal in a real emergency.

The results also indicated that those participants who had taken part in training several times performed no better, on average, than those who had been trained once before. This result supports the continued need for refresher training since degradation of knowledge and performance will occur to the point of being problematic, regardless of how many training sessions attended.

Whilst the current study was not designed to assess the influence of quality of training on speed of decay of skill, reported difficulties with the operation of window exits from participants suggests that for many, the lack of high fidelity training and failure to reach a suitable performance standard in their previous training session was the most important determinant of performance in this test.

6. Design of Pre Flight Briefings

Lack of standardisation on the type of emergency equipment and method of operation, (in particular emergency exits) means that passengers knowledge of helicopter specific emergency equipment and procedures (exit operation, position of life raft) are currently imparted by means of a pre-flight briefing video. Whilst CAA regulations specify what information should be included in pre-flight briefings, no guidelines are made about how the material should be presented.

Previous work investigating optimum methods of training procedural tasks has shown that when hands-on training or practice is not available, demonstration is the next preferred method of training. This research illustrated that the use of videos proved to be successful in training naive participants to operate fixed wing aircraft Type III exits.

In order to assess whether passengers understand and can recall emergency procedures following a pre-flight safety briefing video offshore workers were asked to complete two questionnaires which assessed their knowledge of emergency procedures, pre and post watching a pre-flight safety briefing video.

One hundred and four participants completed two questionnaires that were administered pre and post them watching a pre-flight briefing. During the first questionnaire, participants were asked to complete questions assessing their generic and aircraft specific emergency procedural knowledge with reference to the last aircraft type they flew on. Respondents were then shown a pre-flight video for the S76 aircraft (an aircraft they had not previously flown on) before completing a questionnaire assessing their generic and aircraft specific emergency knowledge of the new aircraft type.

The results showed that respondents knowledge of generic safety procedures was generally sound. Analysis indicated that respondents correctly remembered significantly more generic emergency

procedures than specific aircraft emergency procedures from the last aircraft they flew in. It appeared that this result was due to participants practising these procedures during HUET training, resulting in better retention. The study also showed that simpler procedures were better remembered, a result which has implications for the design of equipment.

Following the viewing of a pre-flight safety briefing for an aircraft type new to all of the respondents (S76), their knowledge of generic safety procedures improved. Their knowledge of specific procedures for the S76 following a single viewing of the pre-flight briefing did not reach the same level as a familiar aircraft type without rehearsal. This result indicates that the introduction of a new aircraft type requires more than single showing of a pre-flight briefing to ensure that passengers are competent in performing aircraft related safety procedures. Those respondents who had previously flown on the Super Puma helicopter benefited from positive transfer of emergency procedure knowledge to the S76. The procedures on these two aircraft were similar and indicates the benefits that could be accrued form standardisation of emergency equipment and procedures. Standardisation would also allow the introduction of aircraft specific training which would also increase the transfer of training.

The results from the study also indicated that briefing cards are seriously under-utilised by passengers as a form of safety information, the study concludes that there is an urgent need for the design of cards, passenger comprehension and usage to be reviewed.

Suggestions for improvements to current pre-flight briefing videos included the removal of redundant and ambiguous information and the simplification and categorisation of information. Alternative or additional approaches to help learning and aid retention of safety procedures such as repetition, mental rehearsal, mimicking and testing require further investigation.

7. Recommendations

7.1 Content of HUET Training

1. In order to provide trainees with sufficient skills to escape from an inverted helicopter they must meet the minimum training competency: "demonstrate the ability, underwater in an inverted HUET, to release a representative seat restraint and escape exit release mechanism, and effect an escape unaided".
2. When data gathering in Phase 1 of the research, the facilities visited world-wide showed the majority of classroom items below were included in the present training syllabus. However, a list is included for general reference as an indication of best practice. The minimum training programme content should therefore be:

    2.1 A detailed classroom briefing including (in no particular order):

    2.1.1 Helicopter Passenger Operations and Procedures

    Routine operations: Pre-flight, approach/departure from helicopter and in flight.

    Types of helicopters etc.

    Helicopter danger areas.

    2.1.2 Personal survival equipment

    2.1.3 Types of emergency helicopter ditchings

    2.1.4 Helicopter emergency procedures

    Preparation for impact.

    Emergency landing and use of liferaft & L/R procedures (if not covered in other practical training session).

    Ditching

2.1.5 Ditching hazards and problems

Injury.

In-rush of water

Disorientation

Poor visibility

Loss of breath hold

Cold water survival

Disorderly evacuation/survival discipline in Life raft

Winching

2.1.6 Discussion/details of the practical exercises in the swimming pool.

Clear details to be given on the practical exercises, including use of equipment. Particular emphasis should be placed on exit operation. Trainees should also be informed of the competency they must reach in order to pass the course.

2.2 Practical exercises to be included **as a minimum.** Whilst instruction should continue in the HUET itself, all students must successfully complete all of the underwater egress exercises unaided. It is suggested that a performance rating should be noted for each student. If students performance is deemed to be unsatisfactory they should be given additional assistance in order to meet the acceptable performance criteria.

2.2.1 Surface abandoment and liferaft exercise

Ideally, trainees should actually practice deploying a liferaft as well as raising the canopy. If not covered in another course, trainees should also practice liferaft procedures.

2.2.2 Partial submersion with representative exits.

Exits must have a representative operating tag and require representative force to operate.

2.2.3 Full Inversion including representative exits.

Exits must have operating tags and require representative force to operate. Inversion rate must be sufficient to create the feelings of disorientation/in rush or water etc.

3 An additional practical exercise involving a second inversion would be of great benefit to trainees. The results from the experimental programmeme showed that a second inversion could be used successfully to provide students with experience of crossing an inverted cabin.

4 Practical wet exercise with Air-pocket

5 Ground instruction in helicopter winching procedures and, simulated winching in the pool if appropriate equipment is available.

6 All of the practical exercises should be completed by students wearing representative clothing (i.e. survival suits, lifejackets) and have them operate representative equipment (i.e. seatbelts, pop-out windows).

NB Other than additional time required for wet Air pocket training, the above list should not require additional training time to that already spent on the present syllabus.

7.1.1 Management of the Risks Associated with HUET

Risks associated with HUET include contact injuries, hypothermia, stress and drowning. The extent of the risk is extreme and as a consequence stringent safety controls must be put into place. The list below reflects contains safety measures that should be taken to protect trainees (this is by no means an exhaustive list).

- A pre requisite of a current medical prior to taking part in the HUET training. During the classroom training students are asked to declare any contra indications or illnesses which may impede them or cause difficulty in HUET.
- Pool at temperature of about 22 degrees.
- Students are fully briefed on the activity and the actions required of them.
- Colour coded helmets to indicate weaker or non-swimmers.
- 2 divers outside of the simulator and 1 trainer inside. A ratio of 2 students per diver as a maximum.
- External operator with full emergency control and override for the simulator. An emergency generator should be installed so that if power to HUET fails it automatically cuts in.
- All seatbelts have additional release points to allow trainers to release trainees quickly.
- Where exits are used these can be jettisoned from both inside and out.
- Divers and trainers are first aiders.
- Employees should be given training/made aware of how to recognise and manage trainees who are finding the HUET session stressful.
- An air gap is made available at the top of the simulator.

7.1.2 Type of Simulator

1. Simulators should have a representative roll rate, that introduces the feeling of disorientation, in rush of water etc. to the trainee.
2. They should also have representative seats, harnesses and exits.
3. Ideally simulators should be capable of replicating cabins of the commonly used offshore helicopter types. In regions where only one type of aircraft is flown, it would be preferable if the simulator could represent this.

7.2 Refresher Training Periods

1. Due to the current variation content and subsequent competencies gained from HUET, the optimum retraining point has not been identified.
2. The fact that 30% of participants failed to egress during this phase of the research indicates the need for the provision of refresher training. Individuals who have undergone refresher training on multiple occasions performed no better than those who had been trained only once before. This indicates that, regardless of the number of HUET training sessions completed in the past, decay of procedural knowledge and skills will still occur. As a result, the requirement for recurrent training remains. Failure to egress may also be attributable to the quality of training content in the past e.g. without the use of representative windows.
3. A longitudinal study is required to assess the optimum retraining period. Participants of the study must be trained to a set standard removing any variation in skill acquisition as a result of initial training. By the assessment of their level of performance following training a true evaluation of degradation of performance could then be subsequently made.

7.3 *Pre Flight Briefings*

1. The current format of briefings is successful in refreshing passenger's knowledge of generic safety procedures, which they have previously experienced during HUET. However the reliance on this mode of presentation for aircraft specific emergency procedures, particularly for passengers initial flights on a new aircraft type needs to be re addressed.
2. Simplification and standardisation of emergency procedures and equipment would significantly aid passengers learning and retention of specific procedural information. This would also promote transfer of training between aircraft with similar procedures and allow practical training.
3. Given the difficulties with standardisation of equipment, in those countries who utilise a limited range of aircraft type the introduction of a 'walk-through talk-through' induction for passengers, showing where equipment is stowed and how it is released may also prove to be beneficial.
4. It is essential that pre flight briefing material is evaluated for clarity and ease of understanding by passengers and safety professionals. In order to remove the demands on working memory, redundant and ambiguous information must be removed. The use of simplification and categorisation of information may also aid retention.
5. Further evaluation of alternative or additional approaches such as repetition, mental rehearsal, mimicking and testing require further investigation.
6. A review of briefing cards, including their design, passenger comprehension and usage is urgently required.

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