Phase III Report: Development and Validation of a Physical Fitness Test and Maintenance Standards for Canadian Forces Diving Personnel

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March 2007

Project commissioned and funded by the Canadian Forces Personnel Support Agency (CFPSA)
Ottawa, Canada
CFPSA Director: Dr. Wayne Lee
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- Port Inspection: CPO1 Munro, CPO2 Jones, PO1 Magwood and all Port Inspection divers involved in this phase;
- Director of Dive Safety: LCdr Latus.

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There is no doubt that we have gained much insight into the important work performed by the Canadian Forces and especially those involved with dive duties. Their commitment and belief in what they do is most impressive, as are the sacrifices they and their families make to serve Canada and all its citizens.

David Docherty, Lindsay Goulet, Kathy Gaul, Paula McFadyen, & Stewart Petersen

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EXECUTIVE SUMMARY

Background information on the Canadian Forces Diving Project

The University of Victoria (UVic) was contracted by the Canadian Support Personnel Support Agency (CFPSA) in August 2002 to develop and validate a physical fitness test and maintenance standards for Canadian Forces (CF) Diving Personnel. The project was divided into three phases:

- *Phase I - Task Analysis*
  A comprehensive task analysis to describe the work performed by the different diving groups in the CF and to identify a representative subset of physically demanding tasks for each diving group.
- *Phase II* - *Physical and Physiological Demands*
  Documentation of the physical and physiological demands of the representative subset of demanding tasks identified in Phase I.
- *Phase III – Physical Fitness Test Battery and Standards*
  Based on the data and work samples from Phases I and II, a fitness test battery was developed and standards were established to help ensure that CF divers are able to perform their duties in a safe and efficient manner.

At the outset of the project it was decided by the CFPSA, in consultation with the Project Management Team (PMT), that the project would be delimited to four diving groups, including a) Clearance divers, b) Combat divers, c) Port Inspection divers, and d) Ship's Team divers.

Recommended guidelines for the development of *Bona Fide* Occupational Requirements (BFORs) for physically demanding occupations were developed during a "Consensus Forum" in 2001 by a group of Canadian experts in this field (Gledhill et el., 2001) and used as a template for this project. The 2001 *Consensus Guidelines* include:

1. Formation of a Project Management Team (PMT).
2. Job familiarization.

3. Job review and physical demands analysis.
4. Selection of a representative subset of the essential, physically demanding tasks reported and identified in the job review.
5. Physiological assessment and characterization of the representative tasks.
6. Development of test protocol based on the representative tasks.
7. Establishment of standardized testing procedures.
8. Determine the reliability and validity of the test protocol.
9. Develop performance standards and cut scores.
10. Evaluate the results of applying the test to incumbents.
11. Implement the test protocol.
12. Continuously review new technology brought into the workplace and re-evaluate protocol.

The objectives of Phase I entailed:

1. Identification and briefing of a project management team (PMT) consisting of representatives from all stakeholders.
2. A review of diving physiology, especially applications to diving work in the CF.
3. Identification and description of the four diving groups including an organizational structure.
4. Knowledge of the diving tests and standards used by the military in other countries.
5. Thorough understanding of the duties and tasks performed by the four diving groups through the use of interview with divers from the four groups, completion of survey questionnaires, analysis of training manuals, observation of specific diving exercises and viewing of instructional videos.

Phase I fulfilled steps one through four of the *Consensus Guidelines,* including:

- ♦ Development of the PMT.
- ♦ Job familiarization.
- ♦ Job review and physical demands analysis.

- Development of a representative subset of the essential, physically demanding tasks identified in the job review.

Based on the analysis of all the information, the most physically demanding and most commonly performed tasks were identified. Subsequently, the research team presented these finding to representatives from each of the four diving groups holding supervisory positions (e.g., Commanding Officers, Training Officers) for validation purposes. Members of this group were recognized as subject matter experts (SMEs) with respect to the work performed within their specific dive group.

The SMEs validated the selected tasks and confirmed they were representative of the most physically demanding aspects of the work-related tasks for each of the diving groups. Additionally, the SMEs provided further recommendations and offered input on the planning for Phase II. The final report for Phase I was submitted to the PMT on December 23, 2003 and approved by the PMT shortly thereafter (McFadyen et al., 2003).

The objectives for Phase II entailed:

1. The physical and physiological characterization of the most physically demanding tasks identified for each of the four CF dive groups.
2. Update review of associated physiological factors that occur with diving.
3. Update review of the validation and implementation procedures for BFORs utilized by international militaries.
4. Review of environmental factors and other variables (e.g., sleep deprivation) that may contribute additional physiological stress on divers.

Phase II fulfilled step five of the *Consensus Guidelines:*

- Selection of a representative subset of the essential, physically demanding tasks reported and identified in the job review.

Information was gathered during simulated ("work samples") and live dive operations in which physiological information was recorded using a variety of methods (e.g., heart rate monitors, oxygen consumption, video analysis, observations and interviews). Recently acquired CF diver-related equipment, or equipment changes that occurred after the final report of Phase I were identified, weighed and documented. In addition, interviews and observations were used to gather information necessary to integrate the physiological data with the physical characteristics of the work (e.g., duration of effort, the weight of the equipment that is carried, distances traveled to work sites, rest periods between work tasks, etc.). Further review of the effects of sleep deprivation and psychological stress were also considered.

The results of Phase II were presented at the PMT meeting in January 2005. Subsequently, the report was circulated and approved by representatives from the four dive groups (Docherty et al., 2005).

The research in Phase III involved steps six through ten of the *Consensus Guidelines.* These included:

- Development of a test battery based on representative physically demanding tasks
- Standardization of assessment procedures required during test protocol implementation.
- Validation and reliability of the test protocols.
- Development of the minimum performance standards of the tests.
- Validation of the minimum performance standards by the SME. This included the potential “adverse impact” from implementation of the tests and standards based on the performance of the divers involved in this part of the project. Input from the SMEs was essential in the development and refinement of the tests and standards.

Statement of Work for Phase III

The primary objectives of Phase III were to:

1. Develop and validate a physical fitness test battery and maintenance standards. It is important to note that each dive group was interviewed separately, and validation procedures were completed independently with the four dive groups because it was possible that the physical demands of each group and performance expectations may differ. Development and validation procedures took place through the use of focus groups, task and video analyses, interviews and observations. In addition, the physiological characteristics of each test/task item were measured and used to confirm that the test protocol characteristics resulted in similar physiological responses compared to work-related duties.

2. Phase III concludes with recommendations for a CF Diver Physical Fitness Test (CF DPFT) and Standards for each dive group and completes the Phase III contract between the Staff of the Non-Public Funds, Canadian Forces Personnel Support Agency (the "Agency") and University of Victoria (the "Contractor").

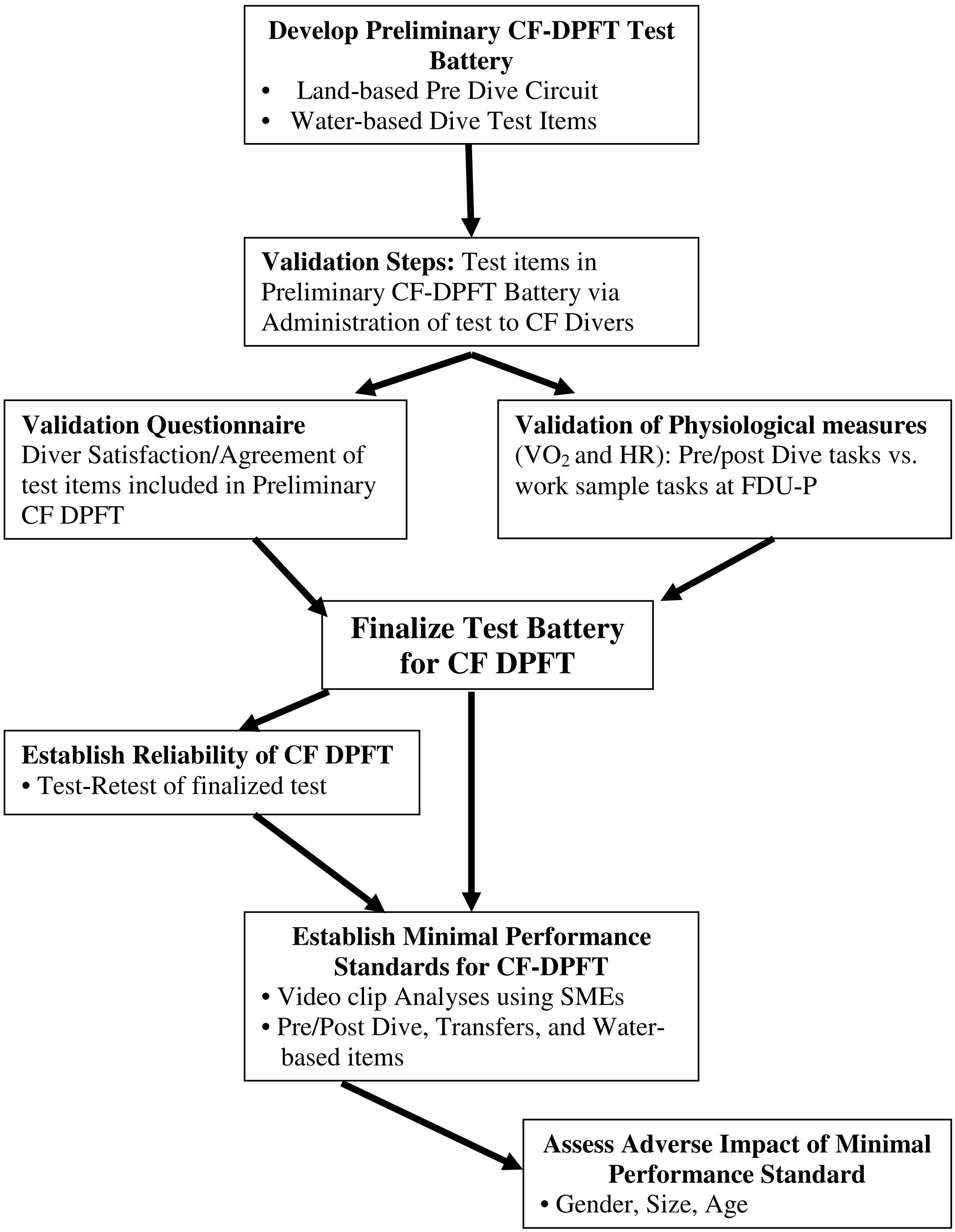
Summary for Phase III

The objectives of Phase III were to develop a physical fitness test battery and maintenance standards for Canadian Forces Diving Personnel, specifically Clearance (Cl), Ships' Team (ST), Port Inspection (PID) and Combat (Cbt) divers. Phases I and II were used to identify potential test items that could be administered as a battery of tests reflecting the physical and physiological demands of diving in the Canadian Forces (CF).

Phase III involved a number of sequential stages in order to validate the test as a Bona Fide Occupational Requirement (BFOR) should it ever be legally challenged. The validation process involved the use of "convergent validity" in which a variety of sources of information are used to help establish that the test battery is measuring what it purports to measure (i.e. ensuring that CF divers have the fitness to perform their duties in a safe and efficient way). The sources of information used in this project included a comprehensive task analysis, focus groups, individual interviews, questionnaires, video analysis, physiological assessment, and consideration of tests used by other international military diving groups. The reliability of the tests was also established, as a test cannot be valid if it is not reliable.

The project also involved establishing valid standards of performance for each task of the test battery. This part of the project relied heavily on the use of Subject Matter Experts (SMEs) consisting of supervisors for each of the dive groups. The SMEs were fundamental in identifying acceptable levels of performance of the test battery. It was also important to provide some information on the potential impact of the test implementation and standards based on the population that assisted in the validation of the test battery. Figure A.1 provides a diagram describing the chronology of the steps that were followed during Phase III.

Figure A.1 Flow chart of steps followed in Phase III



Stage 1: Development of a preliminary test battery

Based on the information from Phases I and II the UVic Research Team (UVicRT) identified potential test items for inclusion within a test battery for CF divers. The potential test items were presented to focus groups with representation from each dive group. A questionnaire was developed to help direct the feedback and input from the focus group participants. The composition of the focus groups included CF representation from across Canada, gender, rank, and years of dive experience. In addition, the various tests were piloted using civilian and military individuals to assess feasibility of the testing procedures and the order of the tests.

Based on the feedback and the pilot test results, a preliminary test battery was developed that included both land-based and water-based components.

Stage 2: Establishing the validity of the test battery

The preliminary test battery was administered to the four dive groups at their respective work sites. Site visits included the Fleet Dive Unit Atlantic (FDU-A), Fleet Dive Unit Pacific (FDU-P), CFB Esquimalt, CFB Gagetown and CFB Petawawa. During these site visits, information was obtained from the divers with respect to each test item and its similarity to their CF dive duties. Using a 5-point Likert scale, the divers were asked to rate the different test items in regard to how well each test item reflected the physical demands of their CF diving duties, and the level of importance of the fitness components being tested for the safe and efficient performance of their diving duties.

Divers were also invited to make recommendations on how the tests could be modified. Heart rates (HR) were monitored during the performance of the land and water-based tests. Heart rate data were used to determine how well performance of the test battery reflected the physiological demands of the work samples in Phase II.

At the conclusion of this stage of the procedures the divers strongly agreed that the tests were representative of their CF diving duties. In addition, the physiological responses were very similar to those required by the work samples.

Stage 3: Confirmation of the pre/post dive test battery validity

An additional step was taken to confirm the validity of the pre/post dive circuit. Oxygen consumption (VO_2) and heart rate (HR) responses of CF diving personnel were compared between typical pre/post dive activities completed at FDU-P and the pre/post dive test circuit that had been developed during Stage 2.

The results further confirmed that the physiological demands of the pre/post dive circuit were very similar to the physiological demands during the work samples performed in the field.

Stage 4: Standardized testing protocols for the proposed Canadian Forces Diver Physical Fitness Test (CF DPFT)

As a result of the first three stages, a final test battery was established. **Prior to finalizing the test battery, the feasibility of implementation across Canada to four different dive groups was extensively reviewed in consultation with CFPSA**. The components of the tests consist of:

Land-based Components

- Pre/post dive circuit that involves the divers manipulating, lifting and carrying a selected set of CF diver related equipment three times around a 100 m circuit including over and around obstacles.
- Diver casualty simulation (simulated stretcher carry) around a 100 m circuit.
- Line pull that requires pulling a weighted milk crate (equivalent to 100 lbs of force) a distance of 20 m two times.

Water-based Components

- Vertical weighted fin kick.
- 400 m underwater swim.
- 100 m surface swim.

[Note: A full description of the test protocols and procedures is included in Appendix A.]

Stage 5: Establishing reliability of the CF DPFT

Reliability is the relative consistency of test scores such that repeated measures of the test will produce the same results. Reliability is considered an integral part of validity. This stage involved a sub-study undertaken to determine the reliability of the proposed CF DPFT.

Based on the results of this sub-study, the proposed CF DPFT, including both land-based and water-based test items, is considered to be reliable. Results indicate that this reliability could be enhanced by providing divers with more opportunity to practice the tests.

Stage 6: Establishing Minimal Performance Standards

Once the test battery had been validated, the next step was to identify the levels of performance, or standards, that the incumbent divers would be required to attain and maintain. The procedures for developing the standards for the land and water-based components were slightly different due to the nature of the tasks and the environments in which they were conducted.

Land-based Components

Pre/post dive circuit: Four steps were followed to identify the minimal standards for each test item included in the land-based portion of the CF DPFT.

Step 1: The objective of step one was to determine the average time and standard deviation (SD) CF diving personnel took to complete the simulated pre/post dive circuit.

Step 2: The objective of step two was to develop a video showing seven different paces of the pre/post dive circuit based on the average time and standard deviations of completion times obtained from step one.

Step 3: The third step involved the use of SMEs to define a minimally acceptable pace from the seven videotaped options for moving through the pre/post dive circuit and the diver casualty simulation with a sense of purpose or with purposeful movement.

Step 4: The final step involved the use of SMEs to determine the minimally acceptable rate of work for transferring and maneuvering equipment throughout the circuit.

The final standards were determined from combining the minimally acceptable pace for the circuit with the minimally acceptable time to transfer all equipment included in the circuit. The line pull was not included in this determination as it is a completion test for which divers pass or fail based on correct completion of the task.

Water-based Components

The water-based test items were conducted in a pool and one of the test items required subjects to swim under water, changes in pace were difficult to observe. Therefore, video analyses, which were used in establishing the standards for the land-based tests, were not appropriate in establishing the underwater swimming standards. Mathematical computation of the meters of progression a diver would attain swimming at different rates were used to establish the standards for the 400 m underwater swim and the 100 m surface swim. SMEs were asked to rate the different progressions they would expect against a 1 knot current underwater and on the surface.

The vertical weighted fin-kick test was a completion test for which a 5 minute standard was established as reflecting the physical demands required in working unsupported underwater for prolonged periods of time.

Based on the SMEs responses the following standards were established for the CF DPFT land and water-based tests:

CF DPFT Test Items	Dive Group	Minimum Standards
Pre/post dive circuit (min:s)	All	6:35
Diver casualty simulation (min:s)	All	1:01
Line pull	All	Pass/Fail
Vertical weighted fin-kick	All	Pass/Fail
400 m underwater swim (min:s)	Clearance	13:00
	Ship's Team Port Inspection Combat	13:16
100 m surface swim (min:s)	Clearance Ship's Team Port Inspection	2:54
	Combat	2:47

Stage 7: Assessing Adverse Impact

Implementation of tests and standards may result in direct or adverse effect discrimination, which is a violation of the Canadian Human Rights Act. Adverse affect discrimination, also known as adverse impact, occurs when a standard is implemented and at face value is neutral when applied to all employees but in fact unfairly discriminates against specific groups. An additional study was undertaken to determine whether implementation of the minimum standards established for the CF DPFT would result in any adverse impact specifically related to gender, size, or age.

Based on the several different methods of assessing adverse impact, including the 80% test and a Fisher's Exact Test, it was concluded that the current proposed standards did not adversely affect any of individuals that have been tested to date in regard to gender, size, or age.

Conclusion:

The UVic Research Team recommends the implementation of the CF DPFT and standards in the belief that it is a valid method for assessing the fitness of military divers to safely and efficiently perform their diving duties.

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Phase III Report:

Development and Validation of a Physical Fitness Test and Maintenance Standards for Canadian Forces Diving Personnel

1. Introduction to the Canadian Forces Dive Project

1.0 Bona Fide Occupational Requirements and the Human Rights Act

The *Canadian Human Rights Act* established in 1985 states that all individuals should have equal opportunity for employment and have their needs accommodated without being hindered by discrimination. This is a prohibitory act opposing discriminatory practices against individuals on the basis of race, national origin, ethnic origin, color, religion, age, gender, sexual orientation, marital status, family status, disability or a pardoned conviction. However, in section 15 (1a) of the Act, an exception is made for standards successfully defended as a bona fide occupational requirement (BFOR) in which it is stated that "it is not a discriminatory practice if any refusal, exclusion, expulsion, suspension, limitation, specification or preference in relation to employment is established by an employer based on a BFOR" (Government of Canada, 1985).

In the past, lawsuits claiming discrimination were assessed as being either direct or indirect (adverse effect) discrimination. A standard or rule that has definite discriminatory actions is considered to be direct discrimination. Indirect or adverse effect discrimination occurs when a standard is implemented and at face value is neutral when applied to all employees; however, when this rule is applied to particular individuals, or groups of individuals, the population may be affected in a discriminatory way due to certain characteristics that do not occur for other employees (Sheppard, 2001). Prior to 1999, a BFOR defence was applied only to cases of direct discrimination, that is, only standards or rules that had definite prohibited discriminatory actions could be defended in a court of law and subsequently labeled as a BFOR. However, two cases brought to the Supreme Court of Canada (*British Columbia Government and Service Employees' Union [B.C.G.S.E.U.], the "Meiorin Grievance", [1993]* 3 S.C.R.3 & *Terry Grismer v. British Columbia Council of Human Rights,* [1999] 3 S.C.R. 868) brought forward modifications in the approach to investigating complaints related to employment standards. Following the ruling on these two cases, allegedly discriminatory employment standards must be defended as a BFOR regardless of whether it is direct or indirect discrimination (Government of Canada, 2003).

Not only does the employer who imposed the allegedly direct or indirect discriminatory standard have to prove that the standard was a) connected to the work or service, b) made in good faith, and c) was reasonably necessary, the employer must also prove that accommodation of the individual affected would cause undue hardship to the employer (Eid, 2001). Undue hardship must be "significant" and is determined by objective criteria, such as costs, health and safety requirements, or disruption to the public and business efficacy, in order for an employer to claim accommodation was not viable (Government of Canada, 2003).

An employer should be aware that the development and implementation of any type of standard might result in legal action if it is deemed discriminatory. As a result, employers must be able to meet the criteria the courts have established to rule the standard as a BFOR. Employers are responsible for defending an impugned standard by demonstrating the following (Gledhill et al., 2001):

1. The standard was implemented for a purpose rationally connected to safe and efficient performance on the job.
2. The standard was implemented in an honest and good faith belief that is was necessary for the legitimate work related purpose, and
3. The standard implemented was reasonably necessary to the accomplishment of the work related purpose. In order to show the standard was reasonably necessary, the employer must demonstrate that accommodation of individual employees with the same characteristics of the claimant is not viable without undue hardship to the employer.

1.1 Developing Fitness Tests and Standards - Meeting the BFOR Criteria

An employer must ensure that prior to implementing a new standard, the criteria for defending a standard as a BFOR in a court of law could be met if legal action occurred. Increasingly, in occupations requiring employees to complete tasks that are physically demanding, employers are implementing physical fitness tests and standards (Dunsmore & Hunter, 2001; Gledhill & Jamnik, 1992; Sharkey & DeLorenzo-Green, 1995; Deakin et al., 1999; Pethick et al., 2001; Taylor et al., 2003). As is the case with other forms of standards (e.g. hearing, vision), applying guidelines to defend a physical fitness standard as a BFOR is important to the legal defence. In their *Consensus Guidelines* Gledhill et al. (2001) outlined twelve steps to follow when developing a fitness test and subsequent standards in order to meet the criteria for a BFOR defence:

1. Formation of a Project Management Team (PMT).
2. Job familiarization.
3. Job review and physical demands analysis.
4. Selection of a representative subset of the essential, physically demanding tasks reported and identified in the job review.
5. Physiological assessment and characterization of the representative tasks.
6. Development of test protocol based on the representative tasks.
7. Establishment of standardized testing procedures.
8. Determine the reliability and validity of the test protocol.
9. Develop performance standards and cut scores.
10. Evaluate the results of applying the test to incumbents.
11. Implement the test protocol.
12. Continuously review new technology brought into the workplace and re-evaluate protocol.

While this list is not exhaustive, it provides a sufficient outline to follow throughout the development and implementation of new physical fitness tests and standards for occupations that are potentially physically demanding. These guidelines were used as the template for the CF Diving Project and supplemented where necessary by additional methods and techniques that were believed to enhance the validity of the tests and standards.

1.2 Canadian Forces Diving Personnel

All CF members must complete an annual Exercise Prescription (CF EXPRES) evaluation. This evaluation includes a 20 m shuttle run, a hand grip assessment and standard push-ups and sit-ups (Canadian Forces Personnel Support Agency, 2002). The standards determined for the CF EXPRES evaluation for younger personnel (i.e. 34 years of age and younger) were developed from a study that included male and female subjects (66 and 144, respectively) from the civilian population (Stevenson et al., 1992). Subjects completed the CF EXPRES evaluation and researchers determined that the 75th percentile defined the point in which they were able to differentiate between subjects who passed and subjects who failed. Subsequently, the minimum physical fitness standards were determined from the fifth percentile fitness scores of the "passing group" (Table 1.1). Standards for older personnel (i.e. 35 years of age and older) were determined using the same protocol as with younger personnel, however in consideration of safety, subjects were restricted to 90% of their maximum age-predicted heart rate (Stevenson et al., 1994) (Table 1.1). All CF members are required to pass the CF EXPRES evaluation annually.

Table 1.1 CF EXPRES Standards.

Gender/Age	20 m Shuttle Run (last stage)	Hand grip (combined)	Push-ups (n)	Sit-ups (1 min)
Men (yrs)				
34 and under	6	75	19	19
35 and over	5	73	14	17
Women (yrs)				
34 and under	4	50	9	15
35 and over	3	48	7	12

Canadian Forces Personnel Support Agency, 2002

The CF acknowledge that CF divers require an increased level of fitness to complete all job duties safely and efficiently by requiring higher standards for each test item included in the CF EXPRES evaluation (Table 1.2). Information regarding the development and validation of the CF dive standards is unclear and any documentation regarding these standards cannot be found. Although the CF does account for the need for an increased level of fitness in the diving trade, the CF EXPRES evaluation is not task specific, and neither the tests nor standards have been validated against the physical demands encountered by CF Divers.

Table 1.2 CF EXPRES Dive Standards.

Gender/Age	20 m Shuttle Run (last stage)	Hand grip (combined)	Push-ups (n)	Sit-ups (1 min)
Men(yrs)				
17-19	10.5	101	35	40
20-29	9.5	105	30	40
30-39	7.5	106	25	34
40-49	5.5	103	21	29
50-55	5.5	96	18	25
Women (yrs)				
17-19	6.0	61	21	35
20-29	5.0	60	23	31
30-39	4.0	60	22	24
40-49	4.0	59	18	20
50-55	4.0	55	15	14

Canadian Forces Personnel Support Agency, 2002

Several units of Maritime, Land Force and Air Commands perform diving duties in the CF to meet a wide variety of operational and training commitments. While the primary tasks of each diving unit are determined by the roles of its Command, there are considerable similarities among Commands with respect to various dive tasks and duties. CFPSA has identified CF diving as being potentially physically demanding and, therefore, requiring a high level of physical fitness specific to their diving duties.

In order to ensure CF divers have the capacity to perform their duties in a safe and efficient manner it is important to identify the relationship between diver tests and standards and the physical requirements of all dive tasks. Such information could help to defend the tests and standards should it be necessary. In addition, the Defence Administrative Orders and Directive (DAOD) 8009 states, “The (dive) standard is only an interim one until a study of a diver's true physical fitness requirements is made. Therefore, this interim standard should not be accepted as the gold standard and diving personnel should endeavor to attain a higher level of aerobic fitness” (DAOD 8009, 2006). Currently, there is no “gold standard” physical fitness requirement for the CF diving trade.

1.3 The Canadian Forces Dive Project

In August 2002, our research team at the University of Victoria (UVicRT) was contracted by CFPSA to develop and validate a physical fitness test and minimum standards for CF diving personnel. At the outset of the project it was decided by CFPSA, in consultation with the CF Diving Units, that the project would be delimited to four diving units: a) Clearance divers (Cl); b) Combat divers (Cbt); c) Port Inspection divers (PID); and d) Ship’s Team (ST) divers. Search and Rescue Technicians and Joint Task Force 2 both include diving operations but felt their current fitness standards would exceed the standards for the dive test and, therefore, opted out of participating in the study. However, both trades have been kept informed about the project, as it has progressed.

1.3.1. Phase I - Task Analysis

As McFadyen et al. (2003) reported, the objectives of Phase I included:

1) Identification and briefing of a project management team (PMT) consisting of representatives from all stakeholders.
2) A review and understanding of diving physiology, especially as it relates to diving work in the CF.
3) Identification and description of the four diving units including the organizational structure.
4) Knowledge of the diving tests and standards used by the military in other countries.

5) Thorough understanding of the duties and tasks performed by the four diving units through: interviews with divers from the four dive groups; completion of questionnaires; analysis of training manuals; observation of specific diving exercises and viewing of instructional videos.
6) Identification of the most physically demanding tasks and the most frequently performed tasks on land and in water for each dive group.
7) Identification of the tasks considered essential, but not necessarily frequently performed.
8) Identification of the similarities and differences of the tasks and the physical demands across all four dive groups.

Information on the four dive groups was gathered through site visits, interviews, job shadowing, review of dive manuals, equipment measurement, and questionnaires. Divers of varying experience and rank participated in interviews and job shadowing. To ensure complete representation of all four diving groups, questionnaires were distributed to divers posted across Canada and abroad. Divers completed a detailed questionnaire specific to their particular dive trade.

Table 1.3 summarizes the equipment used by each dive group. PID and ST divers are qualified to use the Compressed Air Breathing Apparatus (CABA) and Moderately Contaminated Water (MCW) systems and dive to a depth of 30 m and 45 m, respectively. Both Cl and Cbt divers, qualified to dive to a depth of 100 m and 30 m, respectively, are also certified to use the Lightweight Surface Supply Diving System (LWSS-DS) and the Canadian Clearance Diving Apparatus (CCDA). Only Cl divers are qualified to use the Canadian Underwater Mine Apparatus (CUMA) and the Surface Supply Breathing Apparatus (SSBA).

Phase I identified the most frequently performed tasks conducted by the four dive groups, which are summarized in Table 1.4. In addition, divers were asked to indicate what they perceived to be the most physically demanding tasks, using both frequently performed tasks as well as activities that may not occur often but would be considered

Table 1.3 Summary of Dive Equipment used by CF Divers.

Dive Systems	Depth Limit (m)	Gas Mixture(s)	Diving Groups Qualified
Compressed Air Breathing Apparatus (CABA)	45	Air	All
Canadian Clearance Diving Apparatus (CCDA)	42	Pure O_2, Or Nitrox	Clearance Combat
Canadian Underwater Mine Apparatus (CUMA)	82	Oxygen, & Helium	Clearance
Lightweight Surface Supply Diving System (LWSS-DS)	55	Air	Clearance Combat
Surface Supplied Breathing Apparatus (SSBA)	100	Air or Heliox	Clearance
Moderately Contaminated Water (MCW)	30	Air	All

Note: Air (21%O2, 79%N_2); Pure O_2 (100%O_2); Nitrox (60%O_2, 40%N_2 or 40%O_2, 60%N2); Heliox (84%H_e,16%O_2).

(Modified from McFadyen et al., 2003)

physically demanding and/or essential (e.g. diver casualty situations). Table 1.5 summarizes the nine most physically demanding tasks and activities reported by the four diving groups. Divers also identified the fitness components they perceived as important in the completion of these tasks.

Table 1.4 Most Frequently Performed Tasks by CF Divers.

Clearance Divers	Ship's Team Divers	Port Inspection Divers	Combat Divers
Mine countermeasures (MCM): -Floating mines -Underwater Mines **Battle Damage Repair (BDR)**: -Sonar dome repair -Clear fouled propeller -Sonar performance function & boom -Hull maintenance -Salvage operations -Remote operated vehicle **Explosive Ordnance Disposal (EOD)**: -Patrol -Work in bomb suit -Marine location marker	**Searches**: -Hull -Seabed -Jetty **Underwater Maintenance**: -Hull inspection -Sonar dome routine **Rescue Swim** **Deep Dive**	**Searches**: -Hull -Seabed -Jetty -Buoy **Underwater Maintenance**: -Hull inspection -Sonar dome routine -Sonar performance function & boom	**Reconnaissance**: -Patrol -Swim **Demolitions** Obstacles: -Construction -Emplacement **Construction in water** **Search and recovery**

(McFadyen et al., 2003)

Table 1.5 Physically Demanding Tasks and Associated Fitness Components for CF Divers.

Most Physically Demanding Tasks	Associated Fitness Components	Physical Demands Common to All Dive Groups	Tasks Specific to Dive Groups*
Carry equipment	Muscular strength Muscular endurance	CABA tanks Shot line, anchor & clump	Clearance & Combat: K cylinders Hydraulic tools Clearance only: SSBA & bomb suit
Load equipment into boat	Muscular strength Flexibility Agility	Load from an unstable platform into the boat.	
Dress and prepare	Flexibility Agility	Quickly dress on an unstable platform or shoreline.	
Diver casualty	Muscular strength Aerobic fitness Flexibility	Tow and lift diver into boat and transport to safety immediately.	
Work unsupported in water	Muscular strength Muscular endurance Aerobic fitness Flexibility Agility	Maintain body position during maintenance tasks.	Clearance only: Salvage Operation Combat only: Underwater Construction Search and recovery
Surface swim	Muscular endurance Aerobic fitness	Performed during diver casualty.	
Underwater swim	Muscular endurance Aerobic fitness Agility	Searches for lost equipment or covert sabotage devices. Duration of swim is dependent on the type of exercise and the environmental conditions.	Maximum Dive Depth: Clearance: 100 m Port Inspection: 45 m Ship's Team: 30 m Combat: 30 m
Swim in current	Muscular endurance Aerobic fitness	Duration and intensity of tasks may be increased by current.	
Swim with Equipment	Muscular endurance Aerobic Fitness Agility	Swim with tools and equipment.	Clearance & Combat: Hydraulic tools Explosives Clearance only: Explosive lift bags

Note: * Equipment, activities or environments specific to selected dive groups **(McFadyen et al., 2003)**

The results of Phase I were reported to members of the Project Management Team (PMT), with representation from the four dive groups. Each group recognized these representatives as being subject matter experts (SMEs) based on their dive experience and knowledge of diving in the CF.

The SMEs validated the results of Phase I and indicated that, in their opinion, the list compiled by the UVicRT captured their perception of the physically demanding duties performed by CF divers.

1.3.2. Phase II - Physical and Physiological Demands of CF Diving Tasks.

Phase I of the UVic Dive Project involved completing steps one through four as outlined by Gledhill et al. (2001). The next step in the development towards a physical fitness test and minimal standards that would meet the criteria for a BFOR was to measure the physiological demands of the tasks identified in Phase I.

The objectives for Phase II reported by Docherty et al. (2005) included:

1) Physical and physiological characterization of the tasks perceived to be physically demanding by divers from each of the four dive groups.
2) Continued review of the environmental factors divers may experience throughout a dive task.
3) Continued review of previous and current research taking place internationally on developing tests and standards that may satisfy the criteria for a BFOR, including international militaries as well as occupations outside the military deemed physically demanding.
4) Further review of diving physiology.

Step five of the *Consensus Guidelines,* which is the characterization of the subset of representative physically demanding tasks (Gledhill et al., 2001), was fulfilled at the completion of Phase II. Work samples were developed in collaboration with SMEs from each of the dive groups and information was gathered during simulated work samples and dive operations. Physiological information was recorded using a variety of methods (e.g., heart rate monitors, oxygen consumption, video analysis, observations, and interviews). Recently acquired equipment, or equipment changes that had occurred after the final report of Phase I were identified, weighed, documented and used in the work samples. Further interviews and observations were conducted by the UVicRT to create a clearer depiction of the job and associated physical demands. For example, information on the duration of tasks, the weight of equipment carried, the distance divers must travel carrying equipment, and the duration of rest periods between dives were documented.

The physiological responses in performing the dive tasks perceived as physically demanding by CF divers were measured using heart rate (HR) and oxygen consumption (VO_2). The guidelines used by the UVicRT for determining a rating of work intensity were modified in Table 1.6 from Astrand et al., (2003). The information reported in Tables 1.4-1.9 is from data presented in the final report submitted to CFPSA in July 2005 (Docherty et al., 2005).

Table 1.6 Work Intensity Classifications.

Work Intensity	Oxygen Uptake ($L \cdot min^{-1}$)	Heart rate response ($beats \cdot min^{-1}$)	Approx %MHR*
Light work	Up to 0.5	Up to 90	Up to 45
Moderate work	0.5-1.0	90-110	45-54
Heavy work	1.0-1.5	110-130	55-64
Very heavy work	1.5-2.0	130-150	65-74
Extremely heavy work	2.0-2.5	150-170	75-85

* percent of Maximal Heart Rate — Modified from Astrand et al., 2003

Land-based activities identified in Phase I as being physically demanding were collapsed into a category defined as “pre/post dive activities”. Pre/post dive activities included carrying equipment, loading equipment into a boat, and dressing and preparing to dive. For the purposes of this document, these activities will be categorized as “pre/post dive activities”. Tables 1.7 and 1.8 summarize the work intensity rating of the land-based dive activities.

Table 1.7 Work Intensity Ratings determined by % Maximal Heart Rate (%MHR) for CF Diver Land-Based Activities.

Dive Group	Observations (n)	%MHR	Work Intensity Rating (light-extremely heavy)
Clearance	33	61	Heavy
Ship's Team	39	71	Very heavy work
Port Inspection	43	64	Heavy
Combat	41	59	Heavy

Table 1.8 Work Intensity Ratings determined by Oxygen Consumption for CF Diver Land-Based Activities.

Carrying Equipment	Divers (n)	VO_2 ($L \cdot min^{-1}$)	VO_2 ($mL \cdot kg.^{-1} min^{-1}$)	Time (min)	Work Intensity Rating (light-extremely heavy)
Clearance CCDA	2	2.21	26.3	9.0	Extremely heavy
Ship's Team CABA	7	2.51	31.3	3.6	Extremely heavy
Combat CABA	5	2.36	28.5	3.4	Extremely heavy

Note: No oxygen consumption data was collected on the PIDs.

Water-based activities perceived as being physically demanding, including working unsupported, swimming underwater, swimming against current and swimming with equipment, were collapsed into a category defined as "dive activities". Table 1.9 summarizes the work intensity rating for dive activities.

Table 1.9 Work Intensity Ratings Determined by %MHR for CF Dive Activities.

Dive Group	Observations (n)	%MHR	Work Intensity Rating (light-extremely heavy)
Clearance	30	72	Very heavy work
Ship's Team	32	75	Extremely heavy work
Port Inspection	32	74	Very heavy work
Combat	20	68	Very heavy work

Surface swimming was also included on the list of physically demanding tasks from Phase I. Due to the effect of depth and submergence underwater on physiological variables such as HR and oxygen consumption, the task of surface swimming was individually categorized and was not incorporated into the data for "dive activities". The work intensity ratings for surface swimming for Cl, PID and Cbt divers are summarized in Table 1.10. Information on surface swimming for ST divers will be included in the summary for emergency response.

Table 1.10 Work Intensity Ratings Determined by HR for CF Surface Swimming.

Dive Group	Divers (n)	%MHR	Work Intensity Rating (light-extremely heavy)
Clearance	3	76	Extremely heavy work
Port Inspection	6	79	Extremely heavy work
Combat	12	75	Extremely heavy work

In Phase I, CF divers were asked to identify both the most commonly performed tasks and the most physically demanding tasks performed during their diving duties. A number of tasks were classified in both categories; however, emergency situations, although they did not occur regularly, were reported as being essential physically demanding tasks that CF divers must be able to complete safely. Physiological data were obtained for both land and water portions of the diver casualty and emergency situations (Table 1.11).

Table 1.11 Work Intensity Ratings Determined by HR and VO_2 for CF Emergency Taskings.

Emergency Response	Divers (n)	VO_2 ($L \cdot min^{-1}$)	VO_2 ($mL \cdot kg^{-1} min^{-1}$)	%MHR	Time (min)	Work Intensity Rating
Port Inspection Divers						
Diver Casualty						
Simulation #1 - land	11			84	5.6	Extremely heavy
water	7			78	4.4	
Simulation #2 - land	4	3.48	41.7	90	1.3	
Ship's Team Divers						
Rescue Swim						
Simulation #1 - land	10	3.14	39.3	89	3.6	
Simulations #2 – land	9			80	4.3	
water	9			92	3.5	

From the data collected in Phase II, the UVicRT was able to validate the results from Phase I by measuring the actual physiological demands in performing the different tasks. The HR, oxygen consumption and work intensity data obtained during Phase II support the conclusions of Phase I and demonstrate that the perceived physically demanding tasks of the four dive groups were, in fact, physically demanding. These results suggest that CF divers require an above average level of aerobic fitness, muscular strength, muscular endurance and flexibility in order to complete the required CF diving duties safely and efficiently. Test battery development and validation processes are the next steps in developing a valid physical fitness test and minimum.

1.4 Purpose of Current Research

Currently aerobic fitness, muscular strength and muscular endurance are assessed using the CF EXPRES Test, which are considered to be fitness component tests (e.g. shuttle run, hand grip strength, push-ups, and sit-ups) (Canadian Forces Personnel Support Agency, 2006). Although these tests provide an overview of fitness levels, using this type of fitness evaluation may not be a valid method for predicting job performance in diving. Beckett and Hodgdon (1987) used fitness component tests to predict the carrying capacity of U.S. Naval personnel. The ability to lift and carry various pieces of equipment over distance was predicted from a 1.5 mile run and number of push-ups in two minutes. The highest multiple correlation between lifting and carrying tasks and the fitness component tests was 0.71.

Marcinik et al., (1995) examined the extent to which the performance of five representative physically demanding job tasks could be predicted from the U.S. Navy fleet diver physical screening test. The task simulations included a 60 m swim in SCUBA gear while carrying a tool bag, treading water using fins, descending and ascending a ladder and lifting and carrying SCUBA tanks. A poor relationship, with virtually no association between the fitness component tests and the task simulations, resulted from this research.

The US Navy completed a series of fitness component tests and a set of four job task simulations on 47 active duty U.S. Navy Explosive Ordnance Disposal (EOD) personnel (Hodgdon et al., 1998). The fitness component tests included: a) a sit and reach evaluation; b) maximum number of push-ups in two minutes; c) maximum number of curl-ups in two minutes; d) maximum number of pull-ups; e) standing long jump distance; f) time to run 1.5 and 3.0 miles; g) time to swim 500 yards in a pool; and h) time to swim 1000 yards in the open ocean. The job task simulations included: a) carrying 360 pounds of dive equipment out and back in a 25 yard course; b) lifting five sets of twin-80 SCUBA tanks from the ground to the side of a Boston Whaler; c) swimming a distance of 500 yards in open water using a snorkel and wearing a full wetsuit, twin 80s, partially inflated life vest and fins; and d) swimming in open water with a disabled partner for a distance of 100 yards. The only significant correlation was between weight and performance on the lifting and swimming tasks, suggesting that size may influence the ability to complete these tasks. From the results of this study, the authors concluded that these fitness component tests did not predict the ability of Navy EOD personnel to complete tasks considered representative of their job.

More recently Taylor et al. (2003) completed a study in which they developed a fitness test and standards, referred to as a "Trade-Specific Barrier Test" for the Royal Australian Navy (RAN) Clearance divers. Their final test battery consisted of a multi-stage shuttle run, a task specific circuit (including a 500 m fin-swim with a resistance simulator), and weighted chins. The standards were based on standard deviations and the assumption that a certain percentage of the incumbents (5%) were not able to perform the required tasks in a safe and reliable manner. It is doubtful this approach would be defensible as a BFOR in Canada. In addition, the test is performed outdoors on a dockside and involves swimming in the ocean, which would be difficult to implement in countries such as Canada due to variable weather conditions, seasonal and geographical differences in water temperature and state, and the effect of tides and currents.

The purpose of this phase of the research project was, therefore to develop and validate a physical fitness test battery and subsequent minimal standards for CF divers that are reflective of their job demands. It is also important that this test battery meets the criteria for a BFOR in the event it will need to be defended if discriminatory action is ever brought forward.

2. Development of a Preliminary Test Battery for CF Divers

2.0 Introduction

CF divers, specifically Cl, ST, PID and Cbt divers, were involved in two previous related projects. The first project produced a list of tasks perceived by the divers in each dive group as being physically demanding (McFadyen et al., 2003). The second project measured the physiological responses of the divers performing these tasks in order to validate them as physically demanding (Docherty et al., 2005). Heart rate (HR), oxygen consumption (VO_2) and rate of perceived exertion (RPE) were used to monitor the physiological demands of the tasks.

Following the physiological validation of the most physically demanding tasks, the next step towards developing a physical fitness test was to develop a preliminary test battery and a protocol for each of the tests that were representative of the tasks performed by the CF divers (Gledhill et al., 2001). In order to ensure the physical fitness tests being developed for inclusion in the test battery were reflective of the diving duties, the knowledge and expertise of incumbents working in the area were included and considered an important step in finalizing the preliminary test battery.

CF incumbent divers provided suggestions and advice on the test items to be included in the test battery. This information was acquired through focus groups and interviews with incumbents.

Linhorst (2002) conducted a review on the use of focus groups and found researchers used this method to study a wide range of topics, with diverse populations, and in combination with other qualitative and quantitative methods of data collection. There is considerable variance in age, rank and demographics within the CF diving trade, so the focus groups were helpful in obtaining information from a diverse population. This method was used to capture information on a variety of issues and proved to be a valuable tool. Kitzinger and Barbour (1999) suggest that focus groups are useful in carrying out descriptive research, evaluating projects, exploring the adequacy of theoretical models, or carrying out action research. The preliminary test battery was developed and finalized using the results and analysis of Phase I (i.e. task analysis) and Phase II (i.e. physiological analysis). Modifications of test items or test item confirmation as reflective of CF diving duties were based on the input of incumbent divers through the use of focus groups.

The purpose of this study was to develop a preliminary test battery for CF divers that reflected the physical demands required to complete all physically demanding duties safely and efficiently. Information required to identify potential test items for inclusion in a preliminary test battery was obtained through previously gathered information, including a task analysis and physiological data assessing the demands of performing the most physically demanding CF diving tasks. It was apparent that the physical demands related to diving occurred during the pre/post dive activities as well as the tasks performed in water.

2.1 Methodology

2.1.1. Focus Groups

Using the information obtained during the first two phases of this project, the UVicRT identified potential test items for inclusion within a test battery for CF divers. The potential test items were presented to focus groups with representation from each dive group. A questionnaire was developed to help direct the feedback and input from the focus groups (Appendix B). The composition of the focus groups included CF diver representation from across Canada, gender, rank, and years of dive experience (Table 2.1).

Table 2.1 Summary of CF divers Involved in Focus Groups for Test Battery Development.

Dive Group	Location of Focus Groups	Representations from CF Bases/HMCS	Focus Groups (n)	Divers (n)	Rank	Years of CF Dive Experience Mean (range)
Clearance	Colwood Shearwater	FDU-P FDU-A	6	25	LS-CPO1; Lt(N)	9 (1-25)
Ship's Team	Esquimalt Shearwater	Regina Vancouver Calgary Base Dive Teams	2	10	OS-PO2; Lt(N)	2 (1-5)
Port Inspection	Colwood Vancouver Shearwater	Standing PIDT Discovery Standing PIDT	4	8	LS-CPO1	18 (8-35)
Combat	Gagetown	Gagetown ValCartier Edmonton	3	15	Pte-Sgt	4 (1-13)
TOTAL	N/A	N/A	15	58	N/A	8 (1-25)

Note: Fleet Dive Unit Pacific (FDU-P); Fleet Dive Unit Atlantic (FDU-A)

Focus groups were organized through the respective Commanding Officers (CO's) and held in meeting rooms at various military bases across Canada. Each focus group included between 2-7 divers, with an average of 4 divers in each session, depending on the availability of divers at the session time. The duration of each focus group ranged from 1.5 to 2.5 hours, depending on the size of the group and the amount of discussion between the divers and the researchers. The UVicRT conducted the focus groups in an open format in which 1-2 members of the research team were present. Divers were able to discuss various ideas with each other in regard to the suggested test items that were being considered. The information provided by the divers was recorded by written summary and a hand-held tape recorder. Taped discussions were reviewed to complete and confirm the written summaries and conclusions of each focus group session. Divers were informed that the interview would be confidential and names would not be released in any summaries or reports.

2.1.2. Preliminary Test Battery Development

Based on the results of the research from two previous projects, and input from the focus groups, the UVicRT developed a preliminary test battery. The development of this test battery resulted from numerous meetings and discussions between the members of the UVicRT. Ideas and information were recorded as a written summary after each meeting and revisited at subsequent research team meetings.

Throughout the development of the preliminary test battery, continued literature reviews were conducted on other international military physical fitness tests. The U.S. Navy developed a job performance assessment battery based on a survey and interview data provided by fleet divers, objective work-site measurements, and videotape data (Marcinik et al., 1994). One of the test items included in the U.S. job performance battery included a 5 minute vertical fin-kick. CF divers are required to work unsupported for prolonged periods of time (e.g. propeller changes, sonar dome routines) using the same type of vertical kick. UVicRT adopted this test to pilot various protocols and determine its validity with respect to reflecting working unsupported for a prolonged period of time.

In addition to discussing the preliminary test battery, the feasibility of the test battery was piloted using civilian and military individuals. The land-based circuit was set up as performance trials in a field house in the Ian Stewart Complex at the University of Victoria to ensure the flow of the circuit from one test item to another was efficient and reflected CF pre/post dive activities. The water-based portion of the test battery was conducted in a swimming pool and consisted of two surface tests and one submerged test. Due to the busy schedule of the CF divers, both military and non-military divers participated in piloting the water-based test items. Similar to the land-based test items, the purpose of this pilot work in the pool was to ensure efficiency and feasibility of the testing procedures prior to finalizing the test items for further validation.

2.2 Results

Results from the focus group discussions regarding task validation are summarized in Appendix C. Based on the information obtained from the various focus groups and information obtained from the two previous projects mentioned earlier, the UVicRT developed a preliminary test battery. The test items included in the test battery involved both pre/post dive (land-based) and dive (water-based) activities, reflective of the duties performed by CF divers. The pre/post and dive-related test items summarized in Table 2.2 were agreed upon and confirmed by the focus groups as essential test items that all divers should be able to complete in order to perform their duties safely and efficiently.

Table 2.2 Land and Water-based Test Items Supported by CF divers for Inclusion in a Preliminary Test Battery.

Pre/post Dive Circuit	Pool Tests
Walk carrying tanks (SCUBA twin 80's) by manifold	Vertical weighted fin-kick
Walk 100 m obstacle course with tanks on back	Exit water with tanks on back
Maneuver tanks	400 m Underwater (aerobic) swim
Walk 100 m obstacle course with 2, 25 lb Dumbbells	100 m Surface swim
Lift weighted milk crate to a 4' height	
Carry weighted dive bag (60 lbs) through 100 m obstacle course	
Transfer dive bag onto a table	
Diver casualty simulation - carry 50 lb kettle bell through 100 m circuit	
Line pull	

2.3 Discussion

The preliminary test battery was developed based on a previous task analysis of CF diving duties, physiological validation of the most physically demanding duties, and a number of focus group discussions with incumbent divers. Previously, research teams involved in developing physical fitness tests for other trades within the CF have also used various sources of information during the development of prototypes, or preliminary test batteries. The team involved in developing the Land Forces Command Physical Fitness Test (LFCPFT) identified tasks for inclusion in a test battery based on field observations and interviews (Singh et al., 1991). Subsequently, a committee of Army experts made recommendations on the tasks that were identified and subsequently selected the final list of tasks to be included in the test battery.

Similar to the current study, a study on CF Firefighters (FF) used a triangulation of data, in which information from different sources (including the task analysis, information on the physiological requirements of CF duties, and ideas and suggestions from focus groups) were used to determine the final test items to be included in a preliminary test battery (Deakin, 1994). Both the current study and FF study used information obtained from extensive literature reviews, assessments of physical and physiological demands on those tasks deemed as the most physically demanding, and feedback from incumbents required to complete all job duties. Additionally both studies piloted test items to refine the lists of potential tasks for inclusion in the test battery until the tests and protocols were finalized. Various concepts were proposed to the incumbents and their input and feedback were instrumental in developing the test battery that was to be validated. Throughout the process, many changes or ideas occurred and items were added, omitted and changed based on the feedback from the focus groups as well as the incumbents who were involved in the pilot testing.

Similarly, literature reviews, military occupational code (MOC) related duties, physiological data and interviews were used to develop the test battery used for CF Search and Rescue Technicians (SAR-Techs) (Deakin et al., 1999). During the process of developing a physical fitness test for SAR-Techs, the research team relied on literature reviews to develop a list of the most physically and most commonly performed duties for these personnel. Physiological information, including measurements of HR and VO_2, were obtained from work samples designed using the list of demanding and representative tasks provided by an expert panel (11 SAR-Techs). Similar to both the current dive study and the FF study, the final tasks chosen for inclusion in the preliminary test battery were based on extensive on-site discussion with SAR-Techs, physiological data, and input from subject matter experts.

One source of information that was not obtained for the CF divers was injury reports. Taylor et al., (2000) used injury reports, as well as physiological data, on-site observations, video analysis, survey and interviews to develop a representative physical fitness test battery for Cl divers in the Royal Australian Navy. Although injury reports proved to be useful for the Australian study, documentation of workplace injuries within the CF does not include information on the activities of the individual when the injury occurred and where the injury occurred. Therefore, this information was not considered useful in regard to the development of the test battery.

The major difference between the development of other physical fitness tests and the procedures used to develop the preliminary test battery for the CF divers is the number of personnel involved in determining the test items for inclusion in the prototype. Much of the research reported involves using incumbents, or expert panels, in the task analysis phase of test development. In addition, these experts are used to approve or validate the test items included in a test battery, but are often not a part of the process of developing the actual test. The current study for the CF diver physical fitness test utilized 15 focus groups, comprised of 58 CF incumbents, to develop a test representative of their diving duties. Although the task analysis and physiological data are important, input from incumbent divers ensuring that the test is representative of their job demands is regarded as an important part of the validation process. Because the divers were involved in each step of the process towards the development of the preliminary test battery, the research team has confidence that it is representative of the tasks and duties required of CF divers.

2.4 Conclusion

Using a variety of sources of information, the UVicRT developed a preliminary test battery considered to be representative of the tasks identified as physically demanding by CF diving personnel. The final selection process took into consideration potential logistical problems that may be encountered during the implementation of the test battery such as the cost and availability of operational equipment and facilities, the time needed for testing, the number of staff needed to administer the test battery, and safety issues. Test items that were included in the preliminary battery consisted of tasks that are frequently performed or regarded as essential, require minimal level of skill, and can be individually performed.

The preliminary test battery developed for CF diving personnel was subsequently administered to incumbent divers for validation.

3. Validation of a Test Battery to Assess the Physical Fitness of Canadian Forces (CF) Diving Personnel

3.0 Introduction

A preliminary test battery for CF diving personnel, including Cl, ST, PID and Cbt divers, was developed using various sources of information, including: an extensive task analysis; physiological validation of tasks perceived as physically demanding; and focus groups and interviews with incumbent divers. Ideas and suggestions for test item inclusion and concepts with respect to the overall physical fitness test from the divers themselves proved to be an important source of information. The preliminary test battery included a pre/post dive circuit and a 40 m line pull for the land-based test items, and a vertical weighted fin-kick, 400 m underwater swim and a 100 m surface swim for the water-based test items.

In order to satisfy the criteria for defending a test and subsequent minimal performance standard as a bona fide occupational requirement (BFOR) in a court of law, each test item included in the preliminary test battery must be validated by CF diving personnel as being reflective of the tasks performed and the physical demands in performing the tasks. Physical fitness tests can be classified into two categories; a) task simulation tests (TST) that replicate important work tasks identified as being physically demanding or essential and b) fitness component tests (FCT) which identify physiological constructs underlying the successful completion of essential job duties (Bonneau, 2001). Content and construct validation may be achieved using either task simulation or fitness component test items.

In the development of physical fitness tests, it is important to ensure the test battery measures the ability to perform the physically demanding tasks required for the occupation and also meets objective validity (Gledhill & Jamnik, 1992). The purpose of this study was to validate each test item included in the preliminary test battery developed for CF diving personnel. Interview, questionnaire and physiological data were used to help validate each test item as being reflective of the tasks and physical demands encountered by the incumbents.

3.1 Methodology

Subsequent to finalizing the protocols and procedures for both the land and water-based test items, the preliminary test battery was administered to the four dive groups. Site visits included the Fleet Dive Unit Atlantic (FDU-A), Fleet Dive Unit Pacific (FDU-P), and CF Bases Esquimalt, Gagetown and Petawawa. These site visits were used to obtain information from the divers with respect to each test item and its similarities to their CF dive duties. Table 3.1 summarizes the information on the subjects who participated in this study.

Table 3.1 Test Item Validation Site Visits.

Dive Group	Divers (n)	Gender (M:F)	Age (yrs)	Dive Experience (yrs)	Representation
Clearance	26	25:1	34 (23-46)	12 (1-26)	FDU-A FDU-P
Ship's Team	23	22:1	32 (21-52)	6 (1-25)	Algonquin Ottawa Base Dive Team Halifax Windsor MOG 5 Cornerbrook St. John's Ville de Quebec Toronto
Port Inspection	11	7:4	28 (22-34)	5 (2-9)	FDU-P FDU-A
Combat	21	21:0	33 (24-42)	8 (0.5-19)	4ESR 2CER D Div S
Total	81	M- 74 F- 5	33 (21-52)	8 (0.5-26)	N/A

Note: Range is stated in brackets for age and dive experience.

The land-based and water-based test items were set up in gym and pool facilities at each Canadian Forces base. The equipment required for the test battery was available from the FDU and Base gymnasiums where testing was being conducted. The equipment, distance measurements and obstacle placements were standardized and the layout of the pre/post dive circuit was the same at each testing location.

A Preliminary Validation Questionnaire, including 57 items, was developed and used to help validate each test item (Appendix D). Subsequent to the completion of each test item, divers were asked a series of questions from the questionnaire. A 5-point Likert scale (ranging from Strongly Agree to Strongly Disagree) was used to rate the level of agreement with respect to how similar the test items were to CF diving duties. Divers were also asked to rank the "level of importance" on a 5-point Likert scale (ranging from Unimportant to Very Important) for each test item. Rate of perceived exertion (RPE) was recorded after each pass of the circuit, at the completion of the entire circuit, and after the completion of each water-based test. Perceived effort was rated on a modified 10-point Borg scale (Borg, 1998). Responses to each question were recorded on a summary sheet (Appendix E) and later entered into a spreadsheet using *Microsoft Excel*^{XP} for statistical analyses.

Prior to beginning the preliminary test battery, divers were briefed on the purpose of the testing session. In addition, both the scale used for RPE and the Likert scale used in the questionnaire were verbally explained. Following the explanation of the questionnaire, the pre/post dive circuit protocol was described in detail. The divers were given an opportunity to ask questions, lift the different pieces of equipment, and walk through the circuit to familiarize themselves with the tasks and the circuit.

Each diver individually completed the pre/post dive circuit. There were 2-4 members of the UVicRT at each testing session and each member was responsible for collecting and recording the questionnaire results for one diver at a time. In addition to the questionnaire, the UVicRT recorded the time it took to complete each pass of the circuit using split times and the cumulative time of the entire circuit. Time was measured using hand-held stopwatches and recorded on a summary sheet.

Subsequent to the pre/post dive circuit, the UVicRT member and CF diver transferred to the pool to complete the water-based test items. Similar to the pre/post dive circuit, all questionnaire results, completion times for timed test items and RPE were recorded on a summary sheet.

Heart rate was recorded while each diver completed both the pre/post dive circuit and the water-based tests using the Polar S610 heart rate monitor. The HR monitor was secured around the chest of the diver and communication with the receiver was checked. Prior to beginning the test battery, the receiver was started to record and store heart rate data. Members of the UVicRT kept a log of the activities conducted by the divers, including the running-time on the HR monitor. The receivers were stopped upon completion of the entire preliminary test battery. HR monitors were set at 5 s recording intervals and downloaded using Polar Software for further analysis.

During the validation of the test items included in the preliminary test battery, recommendations from the divers (e.g. changes in the weight of certain pieces of equipment, distances traveled, and height of some lifts) were recorded and subsequently discussed by members of the UVicRT. Changes to the test battery protocol were made if either safety was an issue or if a suggestion was made by a number of divers to either omit or change a test item to make it more reflective of CF diving duties. After changes to the test battery were made, further testing was conducted to ensure the changes the UVicRT made resulted in increased agreement of the test items and CF diving duties.

3.2 Results

CF divers from the four dive groups (n=81) completed all test items included in the preliminary test battery and verbally responded to a Preliminary Validation Questionnaire designed to determine whether the test items were reflective of CF diving duties (Appendix D). Throughout the test item validation process, recommendations regarding omissions, additions and/or changes to specific test items from the incumbent divers were taken under advisement and altered accordingly. Appendix F provides a summary of all changes that were made in the test battery based on diver feedback. Table 3.2 summarizes the level of agreement (combined responses ranged from important to very important for the following question: "This test item reflects the physical demands I encounter during land-based or water-based activities".

Table 3.2 Summary of the Level of Agreement for Each Test Item Included in the Preliminary Test Battery.

Test Items	% Level of Agreement
Land-based activities	
Overall	100
Walk carrying tanks by manifold	99
Walk 100 m obstacle course with tanks on back	100
Maneuver tanks	99
Walk 100 m obstacle course with 2, 25 lb dumbbells	97
Lift weighted milk crate to a 4' height	97
Carry weighted dive bag through 100 m obstacle course	97
Transfer dive bag onto a table	99
Diver casualty: carry 50 lb kettle bell through 100 m circuit	93
Line pull	97
Water-based activities	
Vertical weighted fin-kick	92
Ladder climb out of water	87
400 m Underwater swim	99
100 m Surface swim	96

The level of agreement between the physical demands of the preliminary test battery and CF diving duties ranged from 92-100% except for one question (ladder climb out of water) which was 87%. A summary of all CF diver responses to the test item Validation Questionnaire can be found in Appendix G.

Responses for the level of importance for each test item are summarized in Table 3.3. The percent of divers that indicated each test item was either “Important” or “Very Important” ranged from 87-100% and averaged 96%.

Table 3.3 Summary of the Level of Importance for Each Test Item Included in the Preliminary Test Battery.

Test Items	% Response of“% Response of “Important” or “Very Important” Important
Land-based activities	
Overall	100
Walk carrying tanks by manifold	96
Walk 100 m obstacle course with tanks on back	99
Maneuver tanks	96
Walk 100 m obstacle course with 2, 25 lb dumbbells	95
Lift weighted milk crate to a 4’ height	97
Carry weighted dive bag through 100 m obstacle course	96
Transfer dive bag onto a table	96
Diver casualty simulation - Carry 50 lb kettle bell through 100 m circuit	99
Line pull	93
Water-based activities	
Vertical weighted fin-kick	93
Ladder climb out of water	87
Underwater aerobic swim	100
Surface swim	93

HR and RPE data were also recorded as divers completed the preliminary test battery. The pre/post dive circuit (excluding the diver casualty) elicited average heart rates of 139, 137, 138 and 142 beats per minute ($b \cdot min^{-1}$) for Cl, ST, PID and Cbt divers, respectively. The most common (mode) rate of perceived exertion for all dive groups was seven. Table 3.4 summarizes duration, heart rate and RPE data for the preliminary test battery. Duration of the line-pull and vertical weighted fin-kick were not included in the data set as it was decided, because of the nature of the tests, that they would be considered as completion tasks with specific criterion that had to be met in order to "pass" the test item.

3.3 Discussion

The results from the Validation Questionnaire support the preliminary test battery as being reflective of CF diving duties, with an average level of agreement of 97%. From the questionnaire responses given by the incumbent divers, the UVicRT is confident that each test item has been validated and includes tasks that are important to safe and efficient completion of CF diving duties.

Throughout the validation process a number of modifications to individual test items were made based on diver feedback (Appendix F). Subsequent to any change, divers provided feedback on the level of agreement for the modified test item. The Validation Questionnaire data reported contains data from before and after test item modifications and it was noted that each modification produced a higher level of agreement. Modifications to the land-based test items included: a) changes in the weight of equipment; b) changes in the height of lifts, c) changes in obstacle placement, and d) an equipment change from one 50 lb piece of equipment carried with both hands to two 25 lb pieces of equipment carried in each hand. Using the results from the Validation Questionnaire and diver feedback and recommendations, the protocol for the water-based test items was altered until agreement levels were above 90%.

Gledhill and Jamnik (1992) used a similar Likert scale Validation Questionnaire in which firefighters rated the similarities between each job related performance test and on-the-job tasks. Incumbent firefighters were also asked to rate the similarity of the physical demands between the performance tests and on-the-job tasks. Likert scale responses ranged from 1-7, with 1 being "Strongly agree" and 7 being "Strongly disagree". Average ratings of 1.4/7 to 2.5/7 resulted from questions regarding the similarity between each test item and the physical demands elicited from each test item compared to on-the-job tasks.

Table 3.4 Mean (SD) Duration, Heart Rate and Most Commonly Reported RPE for the Land-based and Water-based Activities.

Test Items		Clearance	Ship's Team	Port Inspection	Combat	All Groups
Pre/post dive circuit (excluding diver casualty)	Duration	6:06 (0:42)	6:16 (0:40)	6:27 (0:35)	5:48 (0:33)	6:15 (0:36)
	Heart rate	139 (13.0)	137 (15.2)	138 (9.1)	142 (18.9)	139 (14.9)
	RPE	7	7	7	7	7
Diver casualty	Duration	0:42 (0:08)	0:39 (0:09)	0:43 (0:08)	0:45 (0:07)	0:42 (0:08)
	Heart rate	164 (14.9)	165 (16.4)	162 (13.4)	167 (16.4)	165 (15.4)
	RPE	7	8	7	8	7
Line pull	Duration	N/A	N/A	N/A	N/A	N/A
	Heart rate	143 (24.0)	156 (14.4)	122 (11.8)	156 (12.2)	144 (18.7)
	RPE	8	8	7	8	8
Vertical weighted fin-kick	Duration	N/A	N/A	N/A	N/A	N/A
	Heart rate ($b \cdot min^{-1}$)	132 (24.2)	145 (17.8)	133 (16.8)	146 (18.2)	139 (21.0)
	RPE	9	8	7	8	8
400 m Underwater swim	Duration	11:27 (1:13)	12:02 (1:02)	12:03 (1:20)	11:54 (1:01)	11:48 (1:07)
	Heart rate	154 (16.6)	157 (16.0)	157 (14.0)	155 (14.3)	156 (16.3)
	RPE	8	8	7	8	8
100 m Surface swim	Duration	2:05 (0:24)	2:17 (0:25)	1:59 (0:11)	2:11 (0:22)	2:10 (0:23)
	Heart rate	167 (16.2)	172 (12.8)	168 (13.9)	168 (14.3)	169 (14.3)
	RPE	8	8	7	9	8

Note Units. Duration: min:sec; Heart Rate, $b \cdot min^{-1}$; RPE, out of 10

Physiological comparisons were also made between the test battery and on-the-job tasks and resulted in similar physiological demands. From the results of the Validation Questionnaire and the physiological comparisons, the authors concluded that the test battery was reflective of on-the-job tasks and received high criterion validity ratings from experience firefighters.

In addition to the Validation Questionnaire, the physiological data obtained during the current study supported the similarities between the preliminary test battery and on-the-job tasks. Docherty et al. (2005) used work intensity ratings, modified from Astrand et al. (2003), to summarize the physiological data obtained from on-the-job tasks (Table 3.5). A comparison between the ratings of on-the-job tasks and the ratings for the preliminary test battery is shown in Table 3.6.

Table 3.5 Prolonged Physical Work Classified by Work Intensity and Cardiovascular Response.

Work Intensity	Oxygen Uptake ($L \cdot min^{-1}$)	Heart rate response ($b \cdot min^{-1}$)
Light work	Up to 0.5	Up to 90
Moderate work	0.5-1.0	90-110
Heavy work	1.0-1.5	110-130
Very heavy work	1.5-2.0	130-150
Extremely heavy work	2.0-2.5	150-170

Modified from Astrand et al., 2003

The “work unsupported” and “underwater swim” data were combined into one category, “dive activities” for the CF diving duties. This may be one of the reasons that the work intensity ratings are slightly different in comparing the preliminary test items to CF dive duties. Additionally, the duration of the tasks is somewhat different with on-the-job tasks lasting for a longer duration compared to the preliminary test items. As an example, the average time for underwater search (i.e. underwater swimming) in the CF is 28 minute compared to an average 12 minute completion time for the 400 m underwater swim included in the preliminary test battery.

Table 3.6 Comparison of Work Intensity Ratings for CF Diving Duties and a Preliminary Test Battery for CF Divers.

	Pre/post dive activities	Diver casualty	Work unsupported	Underwater swim	Surface swim
CF Diving Duties	Heavy to Very Heavy	Extremely Heavy	Very Heavy-Extremely Heavy	Very Heavy-Extremely Heavy	Extremely Heavy
Preliminary Test Battery	Very Heavy	Extremely Heavy	Very Heavy	Extremely Heavy	Extremely Heavy

3.4 Conclusion

Test validation is defined by the *American Psychological Association* (1985) as the process of accumulating evidence to support inferences based on individual performance on a particular test evaluation. The *Society for Industrial and Organization Psychology* (1987) state that content validity is an appropriate strategy when the "job domain is defined through job analysis by identifying important tasks, behaviors, or knowledge and the test . . . is a representative sample of tasks, behaviors, or knowledge drawn from that domain". Using information from two previous studies, which included in-depth task analyses, literature reviews, and physiological analysis, the UVicRT developed a physical fitness test battery reflective of CF diving duties.

CF diving personnel agreed, at a high percentage, that each test item included in the preliminary test battery was representative of their CF diving duties. In addition, physiological data also supported the test items as being physiologically similar to on-the-job tasks. Using various sources of information, the final modified test is proposed to be a valid test for CF divers in the four dive groups for which the test has been designed.

(See Appendix A for a full description of the test protocols and administration of the tests).

4. VO_2 and HR Responses of Canadian Forces Diving Personnel during Field Pre/post Dive Activities and a Simulated Pre/post Dive Circuit

4.0 Introduction

A pre/post dive circuit was developed to simulate essential tasks required of CF diving personnel. Using a 5-point Likert scale to determine level of agreement, each test item included in the simulated pre/post dive circuit was validated by CF divers as being reflective of those tasks required in the field. In addition, the divers perceived the physical demands of the simulated pre/post dive circuit to be similar to the physical demands required during their field pre/post dive activities.

The CF divers indicated that each test item included in the simulated pre/post dive circuit reflected their job, with a level of agreement ranging from 93-99% and averaging 98% for each test item included in the simulated pre/post dive circuit. Although this provides substantial face validity, further validation can be obtained by measuring the physical demands of the circuit compared to field pre/post dive activities using physiological measurements such as heart rate (HR) and oxygen consumption (VO_2). Docherty et al. (2005) reported VO_2 requirements of 26.3-28.5 $ml \cdot kg^{-1} \cdot min^{-1}$ for pre/post dive activities ranging from 10-26 minutes. Mean HR responses ranged from 59-71% of maximum HR (MHR) for pre/post dive activities completed by the four CF dive groups studied, including Cl, ST, PID and Cbt divers. Although these represent the physiological requirements for completing field pre/post dive activities, some of the data included in this analysis involved field activities in which time and/or urgency was not an important factor. However, divers are often required to complete their pre/post dive activities with a sense of purpose or purposeful movement when responding to emergency or critical situations encountered in their job (McFadyen et al., 2003).

In developing the simulated pre/post dive circuit, the objective was to create a circuit that was as physically and physiologically similar to CF pre/post dive activities as possible. The purpose of this study was to compare VO_2 and HR responses of CF diving personnel during field pre/post dive activities to a circuit designed to simulate these specific job activities in situations where the diver was required to work using "purposeful movements" or "with a sense of purpose". A comparison between the physiological responses of the field pre/post dive activities and the simulated pre/post dive circuit will aid in determining if the simulated circuit is a valid replication of the physical and physiological demands associated with pre/post dive activities for CF diving personnel.

4.1 Methods

4.1.1 Subjects

A total of 15 male and 5 female PID, ST and Cbt divers, participated in this study. Table 4.1 summarizes the descriptive characteristics of the subjects. Testing for the field pre/post dive activities took place at the Fleet Diving Unit-Pacific (FDU-P), Victoria and the simulated pre/post dive circuit took place in a local CF gymnasium. At the beginning of each testing session, the physical characteristics of each diver were recorded on a data sheet (Appendix H) and a heart rate monitor was assigned.

Table 4.1 Summary of Results for Subjects Involved in the Oxygen Consumption Sub-study.

Dive Group	Gender ratio (n, M:F)	Age (yrs)	Height (cm)	Weight (kg)	CF Dive Experience (yrs)
Port Inspection	9:5	24.6 (3.2)	170.4 (12.3)	76.0 (16.9)	2.7 (1.9)
Ship's Team	1:0	28 .0	190.0	100.0	2.0
Combat	5:0	25.4 (1.1)	175.9 (6.1)	83.6 (7.5)	2.2 (1.1)
Combined	15:5	25.0 (2.8)	172.8 (11.6)	79.0 (7.5)	2.6 (1.6)

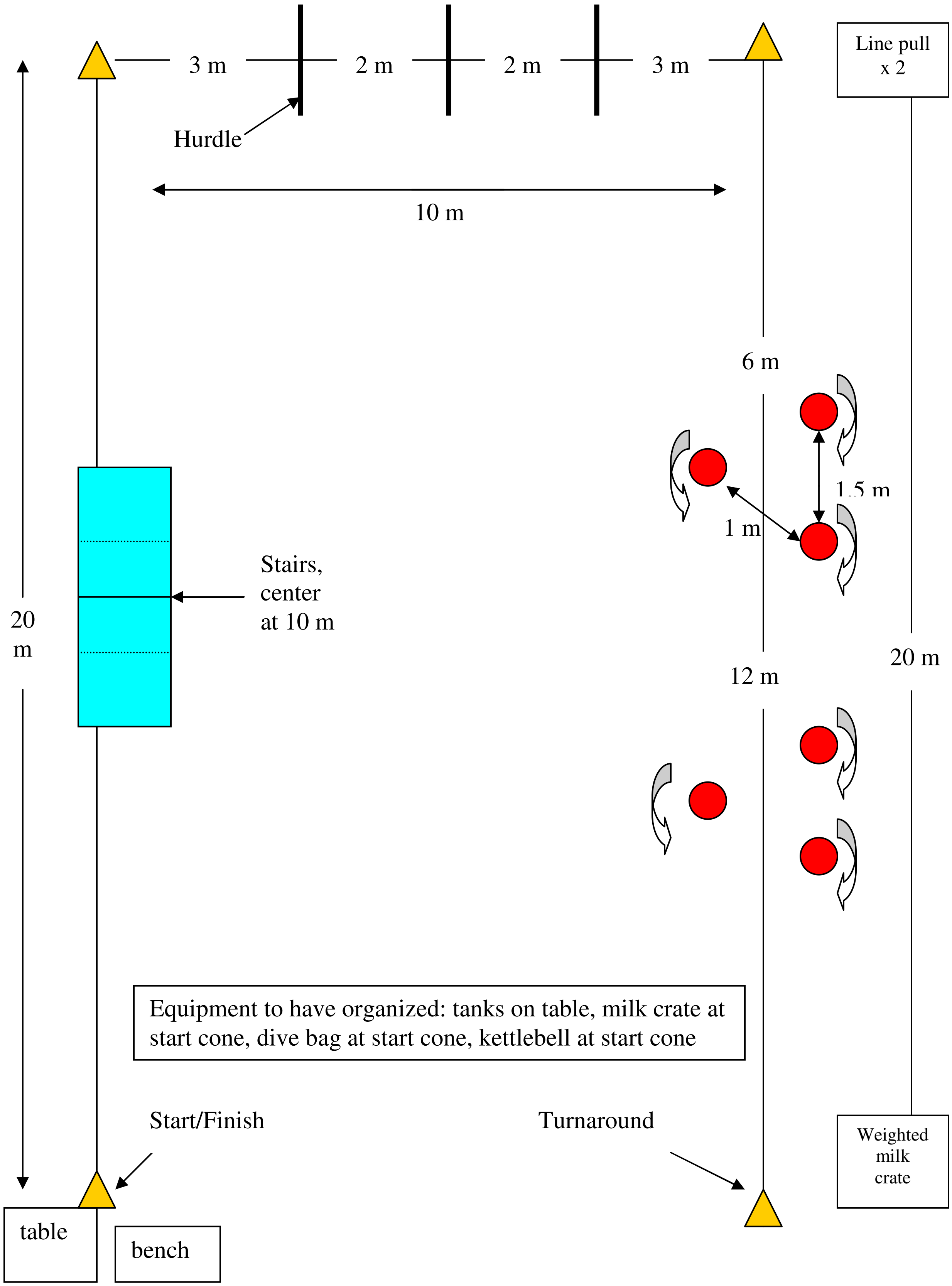
Note: all data include mean (SD) except Gender ratio

4.1.2 Field Pre/Post Dive Activities and Simulated Pre/post Dive Circuit Protocol

The subjects were asked to refrain from eating, smoking, or drinking caffeine beverages two hours prior to participating in each condition. In addition, they were asked to refrain from drinking alcoholic beverages or exercising six hours prior to testing. These standardized instructions were given to control for the effects of extraneous variables.

Each subject was required to complete both the field pre/post dive activities and the simulated pre/post dive circuit (Figure 4.1). The field pre/post dive activities required completion of pre/post dive tasks, including carrying various pieces of equipment from a jetty to their dive locker at the FDU-P, a distance of 100 m. Divers carried three pieces of pre-weighted equipment in the field, including dive tanks, dive weights and pouches, and their personal dive bag. Time to complete each task and cumulative time, as well as RPE for each task was recorded (Appendix H).

Due to difficulties scheduling divers during working hours, the two conditions were not randomized in regard to order. However, the field pre/post dive activities were considered submaximal and three hours between testing allowed for sufficient time to recover. After the allotted recovery time, divers completed a simulated pre/post dive circuit set up in a gym. The simulated pre/post dive circuit requires divers to complete a 100 m obstacle course carrying and maneuvering various pieces of equipment. Figure 4.1 illustrates the layout for the simulated pre/post dive circuit. Subjects were required to complete the circuit in its entirety. To begin the simulated pre/post dive circuit, divers were required to carry the twin 80 tanks by the manifold a distance of 40 m. Divers were then required to sequentially carry the tanks on their back, two 25 lb dumbbells and a 60 lb dive bag a distance of 100 m each. Between each of the equipment carries, the diver was required to walk a distance of 40 m without any equipment. Embedded throughout the simulated pre/post dive circuit are tasks requiring the diver to maneuver the equipment; this is reflective of field pre/post dive activities.



3 m
2 m
2 m
3 m
Line pull x 2
Hurdle
10 m
6 m
1.5 m
1 m
Stairs, center at 10 m
20 m
12 m
20 m
Equipment to have organized: tanks on table, milk crate at start cone, dive bag at start cone, kettlebell at start cone
Start/Finish
Turnaround
Weighted milk crate
table
bench

Figure 4.1. Gym Floor Layout for Land-based Pre/Post Dive Circuit

4.1.3 Experimental Measurements

Heart rate. After explaining the procedures for the field pre/post dive activities at FDU-P, a heart rate monitor was secured around the chest of each diver and communication with the receiver was checked. Just prior to beginning the field pre/post dive activities, the receiver was started to record and store heart rate data. A log was kept for each diver, including the running-time and a detailed description of activities and tasks as they were performed. Upon completion of the field activities, the receiver was stopped and heart rate data were downloaded using Polar software. Heart rate printouts for each diver were matched to the dive activity log. Any spurious or incomplete data were not included in the final heart rate analysis. This process was repeated prior to beginning the simulated pre/post dive circuit.

Oxygen consumption. To record oxygen consumption, a portable, calibrated oxygen consumption analyzer (Sensormedics Vmax_{ST} 1.0) was secured around the shoulders of the diver and the proper sized mask was fitted over the face (Figure 4.2). As with heart rate, a log of running time for the field pre/post dive activities and simulated pre/post dive circuit were kept for each diver. Upon completion of the test, the oxygen consumption printout (averaged over 20 s) from Metasoft software was matched to the activity log.

Figure 4.2 Diver performing a pre/post dive task with portable Vmax_{ST}.

Rate of perceived exertion (RPE). Each diver was asked to rate their perceived exertion on a modified Borg scale (Borg, 1998) for both the field pre/post dive activities and the simulated pre/post dive circuit. RPE was recorded for each pass of both trials, as well as a cumulative RPE for each trial.

Time. Each pre/post dive circuit was timed using a handheld stopwatch. Split times, as well as cumulative times, were recorded for each piece of equipment the divers carried. All information was recorded and later transferred to a summary sheet.

4.1.4 Statistical Analysis

Data from the field pre/post dive activities and simulated pre/post dive circuit were analyzed and descriptive statistics were computed using an SPSS statistical package to determine the mean, SD, and range of values for heart rate and VO_2 ($L \cdot min^{-1}$ and $ml \cdot kg^{-1} \cdot min^{-1}$). Mode was computed for RPE. Analyses of variance (ANOVA) were used to test for significant differences between the two conditions and a significance level of 0.05 was deemed to be statistically significant.

4.2 Results

No significant differences in physiological responses were found between the field pre/post dive activities and the simulated pre/post dive circuit using ANOVA ($p \leq 0.05$). Table 4.2 summarizes the results of the physiological measurements (mean ± SD) and the duration of the field activities compared to the simulated pre/post dive circuit.

Rate of perceived exertion for each condition was most commonly reported as 7 and ranged from 5-7 and 6-8 for the field pre/post dive activities and simulated pre/post dive circuit, respectively.

Table 4.2 Summary of the Physiological Responses for Field Pre/Post Dive Activities and Simulated Pre/Post Dive Circuit.

Dive Activities	Field HR $b \cdot min^{-1}$	Circuit HR $b \cdot min^{-1}$	Field VO_2 $L \cdot min^{-1}$	Circuit VO_2 $L \cdot min^{-1}$	Field VO_2 $ml \cdot kg^{-1} \cdot min^{-1}$	Circuit VO_2 $ml \cdot kg^{-1} \cdot min^{-1}$	Field Duration min	Circuit Duration min
Carry tanks by manifold	145 (9.2)	146 (11.0)	2.0 (0.4)	2.03 (0.3)	27.8 (3.0)	27.4 (3.9)	Not timed	Not timed
Carry tanks on back	156 (11.4)	158 (11.9)	2.6 (0.3)	2.4 (0.3)	33.1 (3.0)	31.3 (4.0)	1.8 (0.5)	1.7 (0.4)
Carry dumbbells	154 (11.5)	153 (13.0)	2.5 (0.4)	2.5 (0.3)	31.1 (3.5)	30.8 (4.3)	1.6 (0.3)	1.6 (0.4)
Carry dive bag	153 (15.5)	153 (14.9)	2.4 (0.4)	2.5 (0.3)	32.0 (4.3)	32.2 (4.8)	1.7 (0.6)	1.7 (0.6)
Transition walks	133 (17.6)	133 (12.6)	2.0 (0.4)	2.2 (0.3)	27.0 (3.8)	28.6 (4.4)	1.3 (0.3)	1.4 (0.5)
Avg Field pre/post dive activities	148 (13.0)	147 (14)	2.3 (0.4)	2.3 (0.4)	30.2 (3.9)	30.1 (4.2)	6.4 (0.6)	6.3 (0.7)

Note: 20 divers participated in the pre/post dive activities and simulated pre/post dive circuit. Data are Mean (SD).

4.3 Discussion

Based on a combination of incumbent and physiological validation, the simulated pre/post dive circuit provides a valid replication of the physical and physiological demands associated with pre/post dive activities for CF diving personnel. All test items were previously validated by CF divers and perceived to be reflective of CF diving demands. The results of this study provide further evidence that the demands of the pre/post dive circuit reflect the demands of the job and are an important part of the process in validating the proposed CF DPFT (Gledhill et al., 2001). In developing a test for CF Firefighters (FF), Pelot et al. (1999) found that a simulated activity (i.e. simulated forcible entry) was both physically and physiologically similar to a field activity (i.e. striking a reinforced structure). Incumbent personnel were studied to ensure that the simulation resembled a task required while firefighting. Heart rate information obtained throughout the simulation was compared to heart rate information obtained when the firefighter struck a reinforced structure. No significant differences were found between the simulated forcible entry and the field activity.

The purpose of the current study was to determine whether the physical and physiological demands of the simulated pre/post dive circuit were similar to the demands of field activities for CF diving personnel. The U.S. Navy compared the U.S. Navy fleet diver physical screening test to a job performance assessment battery (Marcinik et al., 1995). The diver physical screening test included a 500 yard swim, push-ups, sit-ups, pull-ups and 1.5 mile run. A job performance assessment battery was developed from survey and interview data, objective work-site measurements and videotape analysis. Included in the job performance assessment battery were task specific tests including a tool bag swim, vertical weighted fin-kick, ladder climb, self contained underwater breathing apparatus (SCUBA) bottle carry and an umbilical pull simulating equipment recovery from a depth of 50 ft. The U.S. study found that the current entry-level U.S. Navy fleet diver physical screening test provided a poor estimate of physically demanding water-based and shipboard job tasks representative of diver duties. Additionally, a substantial number of diver candidates who passed the current U.S. Navy physical screening test standards were unable to complete the tool bag swim and vertical fin-kick. Although the U.S study required divers to conduct a number of water-based test items, the results indicated that fitness component tests did not identify individuals unable to complete required dive-related activities.

Many of the pre/post dive activities required of CF diving personnel require muscular strength and endurance (Docherty et al., 2005) and the simulated pre/post dive circuit includes test items that require divers to lift and maneuver various pieces of equipment they work with on a daily basis. Similarly, Taylor et al., (2000) conducted a task analysis and physical assessment study of Cl divers working in the Royal Australian Navy (RAN) and found muscular strength, muscular endurance, and flexibility were the primary fitness components involved in lifting tasks. Muscular endurance, aerobic fitness and strength were reported to be important components when carrying a 40 kg load over varied terrain (e.g. walking with tanks on the back). CF divers are required to carry such loads, repeatedly, throughout a working day.

Heart rate and oxygen consumption have both been used to reflect intensity of work (Astrand et al., 2003; Table 4.3). Both the physiological responses in the field pre/post dive activities and the physiological data obtained from the simulated pre/post dive circuit would be classified at a work intensity rating of “extremely heavy” for HR and VO_2. Docherty et al. (2005) have reported work intensity ratings of “heavy” and “very heavy” for pre/post dive HR responses and “extremely heavy” for VO_2 responses during CF field pre/post dive activities. The HR responses may be somewhat lower for the pre/post dive activities reported by Docherty et al. (2005) as data were collected for a longer period of time and may have included periods of rest or work without “purposeful movement”. However, the duration of activities reported when VO_2 response was measured was similar to the current study.

Table 4.3 Prolonged Physical Work Classified by Work Intensity and Cardiovascular Response.

Work Intensity	Oxygen Uptake ($L \cdot min^{-1}$)	Heart rate response ($b \cdot min^{-1}$)
Light work	Up to 0.5	Up to 90
Moderate work	0.5-1.0	90-110
Heavy work	1.0-1.5	110-130
Very heavy work	1.5-2.0	130-150
Extremely heavy work	2.0-2.5	150-170

Modified from Astrand et al., 2003

Field pre/post dive activities require CF divers to carry, lift and maneuver equipment over varied terrain. The simulated pre/post dive circuit incorporates obstacles in which divers must maneuver over or around in order to duplicate the physical and physiological responses that occur while moving over varied terrain. When walking on an unstable surface (i.e. boat, shoreline, riverbanks, forested area or snow) an increase in muscular strength, muscular endurance and balance may be required. Ainsworth et al. (2000) found that walking up a 5% grade may increase VO_2 up to 40%; therefore, it was important to incorporate obstacles in the simulated pre/post dive circuit. Additionally, the type of terrain (grass, gravel, rocks, sand, or mud) and topography may significantly increase the physical demands of carrying a load. Nieman (1995) found up to a 50% increase in VO_2 when walking on an unstable surface due to a change in stride length and foot lift, and the additional musculature recruited to maintain balance.

No significant differences were found for any of the variables between the pre/post dive circuit and the field activities. Therefore, the obstacles incorporated throughout the simulated pre/post dive circuit helped elicit the same physiological demands compared to field pre/post dive activities over varied terrain (e.g. steep inclines and moving on and off unstable surfaces). Based on the lack of significant difference between any variables, the circuit (as part of a physical fitness test battery) effectively predicts safe and efficient performance of required CF pre/post dive duties.

4.4 Conclusion

The pre/post dive circuit consisting of task simulation tests (TSTs) provides an accurate replication of the physical and physiological demands associated with CF field pre/post dive activities. Although divers may be required to complete these duties repeatedly throughout a dive evolution in the field, the simulated pre/post dive circuit would help ensure diving personnel have the minimum level of muscular strength and the physical endurance required to complete various pre/post dive lifting and maneuvering tasks.

The similar physiological responses of the two conditions support the pre/post dive circuit as being reflective of CF field pre/post dive activities and add to the previous validation methods that confirm the simulated pre/post dive circuit is an accurate representation of the physical demands encountered by CF diving personnel during pre/post dive activities.

5. Determining a Minimum Standard for a Simulated Pre/Post Dive Circuit for Canadian Forces Diving Personnel

5.0 Introduction

One of the most important steps in developing and validating a physical fitness test battery for physically demanding occupations is establishing a minimally acceptable standard (Gledhill et al., 2001). This standard serves as a guideline that enables employers to differentiate between individuals with the physical ability to complete essential job duties safely and efficiently and those without.

Legal considerations are of utmost importance to those individuals responsible for implementing and enforcing any type of rule or standard. Physical fitness test batteries must include valid test items and a valid minimal standard in order to meet the criteria of a *bona fide* occupational requirement (BFOR) in a court of law. Once a standard has been determined as a BFOR, further challenges pertaining to the standard suggesting any type of discrimination (i.e. direct or indirect discrimination) would be waylaid as the rule and/or standard would have already been legally accepted as non-discriminatory (Sheppard, 2001).

Several processes for developing a test battery for physically demanding occupations has been well documented (Gledhill and Jamnik, 1992; Stevenson et al., 1992; Marcinik et al., 1994; Deakin et al., 1999). However, there are substantial differences in the methodologies used to determine the minimally acceptable standard for these test batteries. Commonly, the development of minimal standards for physical fitness tests has been achieved using either norm-referenced testing or criterion-referenced testing (Zumbo, 2001). However, determination of a minimal standard for a test battery that includes a number of different test items may best be achieved using various sources of information.

The process for developing the proposed physical fitness test for CF diving personnel has been previously discussed (Sections 2-4). Each test item included in the land-based components has been validated by CF diving personnel and physiologically validated using heart rate (HR) and oxygen consumption (VO_2). Standardized protocols have been established for the Canadian Forces Diver Physical Fitness Test (CF DPFT). Having validated the test battery, the next step was to determine and validate performance standard. The purpose of this study was to determine the minimally acceptable standard for the land-based test items included in the CF DPFT.

Four steps were followed to identify the minimal standards for each test item included in the land-based portion of the CF DPFT. The objective of step one was to determine the average time and standard deviation (SD) CF diving personnel took to complete the simulated pre/post dive circuit. The objective of step two was to develop a set of video clips showing various paces of the pre/post dive circuit based on the average time and standard deviations of completion times obtained from step one. The third step involved the use of SMEs to determine a minimally acceptable pace for moving through the pre/post dive circuit and diver casualty simulation. The final step involved the use of SMEs to determine the minimally acceptable rate of work for transferring and maneuvering equipment throughout the circuit. The final minimal standards were determined from combining the minimally acceptable pace with the total time to transfer all equipment included in the circuit.

5.1 Methods - Step One: Incumbent Testing

5.1.1 Subjects

Clearance, Ship's Team, Port Inspection and Combat divers participated in Step One of this study. At the beginning of each testing session the physical characteristics of each diver were recorded on a data sheet. Table 5.1 summarizes these results.

Table 5.1 Physical Characteristics of CF Diving Personnel Involved in Step One: Incumbent Testing.

Physical Characteristics		Clearance n=23	Ship's Team n=13	Port Inspection n=8	Cbt n=32	Combined Groups n=86
Age (yrs)	X	36.6	33.5	25.6	31.3	32.0
	SD	6.5	6.0	4.2	6.4	7.1
	Min	23.0	21.0	22.0	23.0	21.0
	Max	48.0	41.0	36.0	46.0	48.0
Height (cm)	X	181.1	182.0	170.5	183.0	179.0
	SD	5.7	10.9	11.1	6.3	9.8
	Min	173.5	164.0	154.0	172.0	154.0
	Max	200.0	200.0	187.0	194.0	200.0
Weight (kg)	X	89.9	82.0	75.2	85.8	83.7
	SD	8.3	9.4	15.1	11.3	12.4
	Min	74.6	70.4	53.5	70.8	53.6
	Max	108.0	97.0	120.4	113.6	120.4
Years of CF Dive Experience	X	14.0	5.5	4.6	7.8	8.7
	SD	6.4	4.3	4.5	6.3	12.4
	Min	4.0	1.0	1.0	1.0	1.0
	Max	24.0	17.0	16.0	26.0	26.0
Ranks Represented		LS- 7 MS- 1 PO2- 2 PO1- 6 Lt(N)- 5 LCdr- 2	LS- 4 MS- 5 Lt(N)- 1 LCdr- 3	LS- 9 MS- 5 PO1- 4	Pte- 1 Cpl- 10 MCpl- 4 Sgt- 2 WO- 7 MWO- 1 Lt- 1 Capt- 5 Major- 1	

5.1.2. Experimental Procedures for Step One: Incumbent testing

Subjects were asked to refrain from eating, smoking or drinking caffeine beverages two hours prior to completing the simulated pre/post dive circuit. In addition, they were asked to refrain from drinking alcoholic beverages or exercising six hours prior to testing. These standardized instructions were given to minimize the effects of extraneous variables.

The simulated pre/post dive circuit was set up according to the standardized protocols described in Appendix A). Testing was conducted at military bases across Canada to ensure geographical representation. Subjects were instructed on the proper procedures for completing the circuit and were asked to move with “a sense of purpose” or with a “purposeful movement”. Divers were instructed to walk at a pace they felt showed “purposeful movement”. Jogging or running was not allowed during the pre/post dive circuit with the exception of the diver casualty simulation, in which they were allowed to move into a slow jog. All subjects were able to practice the circuit and lift the various pieces of equipment prior to being timed. Each diver completed the circuit individually.

The circuit was timed by a member of the UVicRT using a hand-held stopwatch. Split and cumulative times were recorded on a data sheet (Appendix I) for each pass of the pre/post dive circuit.

5.1.3 Statistical Analysis

Split and cumulative times were recorded on a data sheet and entered into *Microsoft Excel*^{XP}. Descriptive statistics were computed to determine the mean, SD and range of values for each pass of the simulated pre/post dive circuit. All statistical information was computed for each dive group and for the four groups combined.

5.2 Methods - Step Two: Development of the Pre/Post dive Circuit and Diver Casualty Video

Filming of the video clips took place over one day and one male CF diver volunteered as the subject in the video. The subject was filmed completing the pre/post dive circuit at seven different paces, including the mean performance pace obtained from step one, 1 SD faster than the mean pace and 1, 1.5, 2, 2.5 and 3 SD slower than the mean performance pace. Half SDs were included in these videos to ensure the minimally acceptable pace determined by the SMEs was as accurate as possible.

Although the diver casualty simulation was previously included as part of the pre/post dive circuit, different paces for this test item were filmed because divers are permitted to jog during diver casualty situations. The diver was filmed completing the diver casualty simulation at five difference paces, including the mean performance pace, one SD faster than the mean pace and 1, 2 and 3 SD slower than the mean pace. Full SD were filmed for the diver casualty simulation as divers were allowed to move into a slow jog for this test item, creating a much faster average pace and smaller SD. Therefore, it would have been difficult for the SMEs to differentiate between half SDs.

The video was edited to decrease the amount of time required for the SMEs to complete the assessment. The final version showed seven clips of a diver completing the 100 m circuit carrying twin-80 tanks on his back. Subsequently, five clips of the diver casualty simulation were shown to the SMEs. The order of the paces for both the pre/post dive circuit and diver casualty simulation were randomly assigned. A 30 s pause was placed between each pace to allow the SMEs time to record their level of agreement related to the appropriateness of performance pace on a data sheet.

A separate video was produced showing a diver completing the entire circuit at an average pace. The purpose of this video was to show the pre/post dive circuit in its entirety. A number of the SMEs had yet to see the finalized test battery and it was important that they were able to see all the test items included in the circuit and diver casualty simulation. This video clip was shown to the SMEs first in order to ensure they understood the protocol for the simulated pre/post dive circuit.

5.3 Methods - Step Three: Determining the Minimal Standards for the Pre/Post Dive Circuit and Diver Casualty Simulation

Subjects - Pre/post Dive Circuit and Diver Casualty. Cl, ST, PID and Cbt divers participated as SMEs in determining the acceptable pace for the pre/post dive circuit and diver casualty simulation, with representation from across Canada. In order to be considered as an SME, the following criteria had to be met: 1) at least five years of CF dive experience; 2) qualified as a dive supervisor; and 3) for Cl divers only, currently or previously in the Training Department. Table 5.2 provides a summary of the number of divers, years of dive experience, and the ranks of the SMEs who participated in identifying the minimally acceptable paces for the pre/post dive circuit and diver casualty simulation.

Table 5.2. Summary of years of CF dive experience and ranks of SME participants involved in the video analysis of circuit pacing and performance.

	Clearance (n=17)	Ship's Team (n=2)	Port Inspection (n=10)	Combat (n=17)	Total (n=46)
CF Dive Experience (yrs)	18.5 (7.6)	7.0 (2.8)	14.1 (7.6)	11.4 (6.3)	11.8 (6.5)
Ranks Represented	LS- 5 MS-1 PO2- 3 PO1-2 CPO2-5 Lt(N)- 1	MS-1 Lt(N)- 1	LS- 3 MS-3 PO2-2 PO1-1 CPO2-1	Cpl-1 MCpl- 4 Sgt-2 WO-3 MWO-2 Capt-4 Maj-1	

Data are Means (SD)

Experimental Procedures - Pre/post dive Circuit and Diver Casualty. Twelve video analysis sessions were conducted during which the pre/post dive video and diver casualty video were viewed. No more than 5 SMEs were present per session. Representation from more than one dive group per session was not perceived as problematic as discussion between the SMEs was not allowed. Each diver was responsible for providing individual written responses. A script was developed and included information about the process the UVicRT had used to develop and validate the test items included in the CF DPFT (Appendix J). In addition, a description of the purpose of the video analysis, the role of each SME, and directions on how to record their responses was included. The script was read prior to showing the videos and any questions, comments or concerns voiced by the divers were answered.

Experienced and specially trained Cl divers are responsible for training Cl, ST and PID divers and were, therefore, considered to be SMEs for these groups of divers. In addition to providing information on acceptable paces, prior to viewing the videos the Cl diver SMEs were asked to indicate on a data sheet if they felt that ST and PID divers should have different standards for the land-based activities (i.e. pre/post dive circuit and diver casualty simulation) compared to the Cl divers.

A video of a diver completing the pre/post dive circuit in its entirety, including the diver casualty simulation, was shown first. A member of the UVicRT provided clarification of any questions regarding the protocol for the pre/post dive circuit and diver casualty simulation. Subsequently, the video of the different paces for the pre/post dive circuit was shown. Each SME was given a Video Analysis data sheet (Appendix K) to record whether each pace was "acceptable" or "unacceptable". This information was obtained by asking the question "Was the pace at which the diver in the video moved acceptable or unacceptable for a diver moving with a sense of purpose or with purposeful movement?". After obtaining the data sheets for the pre/post dive video, a video showing the different paces for the diver casualty simulation was presented and the SMEs completed the same procedures as with the pre/post dive circuit for determining a minimally acceptable pace.

Statistical Analysis: Determining the Minimally Acceptable Pace. Information from the data sheets was entered into *Microsoft Excel*^{XP}. For each pace, the number of SMEs who felt the pace was "acceptable" and the number of SMEs who felt the pace was "unacceptable" was totaled for each dive group. A regression equation was determined to calculate the point at which the pace shifted from “acceptable” to “unacceptable” for each dive group and for the four dive groups combined, using an SPSS statistical package (Version 14). Using this equation, the minimally acceptable pace based on the level of acceptability for the various paces was determined. This statistical procedure was computed for both the pre/post dive circuit and diver casualty simulation.

5.4 Methods - Step Four: Development of Minimal Standards

5.4.1 Development of Acceptable Time to Complete Equipment Transfers

Throughout the pre/post dive circuit, divers are required to transfer, lift and maneuver various pieces of equipment. As the SD of equipment transfers were short, development of a video based on various SDs was inappropriate. A focus group consisting of SMEs was organized to discuss criteria required of divers to ensure safe and effective lifting techniques. The focus group was led by a member of the UVicRT and included six Cl divers who met the SME criteria previously described.

During the focus group meetings the SMEs identified and described five criteria important to safe and efficient equipment lifts, transfers and maneuvers. Using these criteria, a video was produced showing a CF diver completing the lifting, transferring, and maneuvering tasks included in the pre/post dive circuit. The slowest possible rate at which a diver could lift, transfer and maneuver equipment, yet still meet the criteria for safe and efficient equipment transfers outlined by the focus group was videoed. The diver was also filmed completing the equipment transfers at two faster paces because it was possible that the pace on the video may have been considered as “unacceptable” by the SMEs.

The equipment transfer video of the slowest pace for each equipment transfer was shown to 14 SMEs from Fleet Dive Unit (Pacific) (FDU-P) who were currently or had previously been in the Training Department. Each SME was given a data sheet (Appendix L) to record whether each pace shown was “acceptable” or “unacceptable”. This information was obtained by asking the question “Keeping in the mind the five safety criteria previously outlined and the importance of a diver moving with a sense of purpose or with purposeful movement, was the pace at which the diver in the video transferred equipment acceptable or unacceptable?" The SMEs identified each pace as either acceptable or unacceptable.

5.4.2 Determining the Minimum Standard for the Pre/post dive Circuit and Diver Casualty Simulation

Cl divers indicated that the pace for all dive groups for the land-based components of the CF DPFT should be the same. Once the minimally acceptable pace (m/s) was obtained from the linear regression analysis, and the minimally acceptable paces for safe and efficient equipment transfers were obtained, the following equation was used to determine the minimally acceptable standard for the full pre/post dive circuit:

MINIMAL COMPLETION TIME FOR THE PRE/POST DIVE CIRCUIT =

Pace (m/s) x 386 m (total distance of pre/post dive circuit) + time for equipment transfer

Although the diver casualty simulation is integrated into the pre/post dive circuit as the final test item in completing the circuit, it was decided that it should be timed separately from the rest of the circuit. Consequently, the completion time for the pre/post dive circuit does not include the diver casualty simulation. The minimally acceptable standard for the diver casualty simulation was determined using the statistical analysis described in Section 5.3.

5.5 Results

5.5.1 Step one: Incumbent Testing

A total of 86 CF diving personnel completed the simulated pre/post dive circuit in its entirety. A summary of the lap times for each pass and the total time to complete the circuit is provided in Table 5.3. The heaviest piece of equipment carried through the 100 m obstacle course is the twin-80 tanks. The lap time for this equipment-carry averaged 1 min 30 s (±10 s) for the four groups combined. Cumulatively, the total time to complete the pre/post dive circuit was 5 min 25 s (± 31 s) for all groups combined. The average diver casualty simulation time for the groups was 45 s (± 7 s).

Table 5.3 Lap Times and Cumulative Time for Simulated Pre/Post Dive Circuit Test Items and Diver Casualty Simulation.

Pre/post dive circuit item		Clearance (n= 23)	Ship's Team (n= 13)	Port Inspection (n= 18)	Combat (n= 32)	All Groups (n= 86)
Tanks on back time (min:s)	X	1:34	1:33	1:31	1:28	1:30
	SD	0:10	0:08	0:08	0:08	0:10
	Min	1:11	1:16	1:20	1:04	1:04
	Max	1:55	1:47	1:54	1:48	1:55
Transition time (min:s)	X	0:30	0:28	0:27	0:26	0:28
	SD	0:04	0:02	0:03	0:03	0:04
	Min	0:24	0:24	0:20	0:20	0:20
	Max	0:41	0:33	0:34	0:34	0:41
25 lb. dumbbell - time (min:s)	X	1:21	1:16	1:22	1:19	1:20
	SD	0:08	0:05	0:06	0:08	0:09
	Min	0:59	1:07	1:08	1:03	0:59
	Max	1:32	1:28	1:33	1:39	1:39
Transition time (min:s)	X	0:30	0:29	0:27	0:26	0:28
	SD	0:04	0:05	0:04	0:04	0:04
	Min	0:24	0:21	0:20	0:21	0:20
	Max	0:42	0:40	0:35	0:35	0:42
Dive bag - time min:s)	X	1:27	1:27	1:32	1:30	1:29
	SD	0:11	0:11	0:08	0:13	0:12
	Min	0:59	1:08	1:18	1:09	0:59
	Max	1:47	1:46	1:51	2:21	2:21
Total Time (min:s)	X	5:30	5:19	5:30	5:17	5:25
	SD	0:30	0:20	0:25	0:34	0:31
	Min	4:16	4:21	4:51	4:21	4:16
	Max	6:28	6:02	6:06	6:47	6:47
Diver casualty time (min:s)	X	0:47	0:44	0:44	0:42	0:45
	SD	0:09	0:08	0:07	0:07	0:07
	Min	0:33	0:31	0:26	0:33	0:26
	Max	1:12	1:01	1:07	1:21	1:21

Note: all participants were male.

5.5.2 Step Two: Development of the Pre/Post Dive Circuit and Diver Casualty Video

Using the information obtained from step one, a video was produced showing seven paces for the pre/post dive circuit and five paces for the diver casualty simulation as well as a video analysis script (Appendix J). The paces filmed for the tank carry were 1 min:20 s, 1 min30 s, 1 min 40 s, 1 min 45 s, 1 min 50 s, 1 min 55 s and 2 min 00s. The paces filmed for the diver casualty simulation were 38 s, 45 s, 52 s, 59 s and 1 min 6 s.

5.5.3 Development of a Minimally Acceptable Pace for the Pre/post Dive Circuit and Diver Casualty Simulation

A total of 46 SMEs participated in the video analysis. The duration of each of the 12 sessions was between 50-60 min. A summary of the SME responses for the seven paces shown for the pre/post dive circuit is provided in Table 5.4 and Figure 5.1. The majority of SMEs agreed that both the mean pace and one SD slower than the mean were acceptable paces for a diver required to work with a sense of purpose or with purposeful movement. The first pace the majority of SMEs felt was unacceptable was at two SD slower than the mean.

Table 5.4 Results of the SME Video Analysis for the Simulated Pre/Post Dive Circuit.

	Pace (min:s)	Clearance (n=17)		Ship's Team (n=2)		Port Inspection (n=10)		Combat (n=17)		Total (n=46)	
		A	U	A	U	A	U	A	U	A	U
Pre/post Dive Circuit	-1SD (1:08)	14	3	2	0	7	3	14	3	37	9
	X (1:18)	17	0	2	0	10	0	16	1	45	1
	+1SD (1:28)	16	1	2	0	8	2	14	3	40	6
	+1.5SD (1:33)	6	11	2	0	7	3	10	7	25	21
	+2SD (1:38)	3	14	1	1	2	8	0	17	6	40
	+2.5SD (1:43)	1	16	0	2	0	8	0	17	1	45
	+3SD (1:48)	1	16	0	2	0	10	0	17	1	45

A=Acceptable, U=Unacceptable

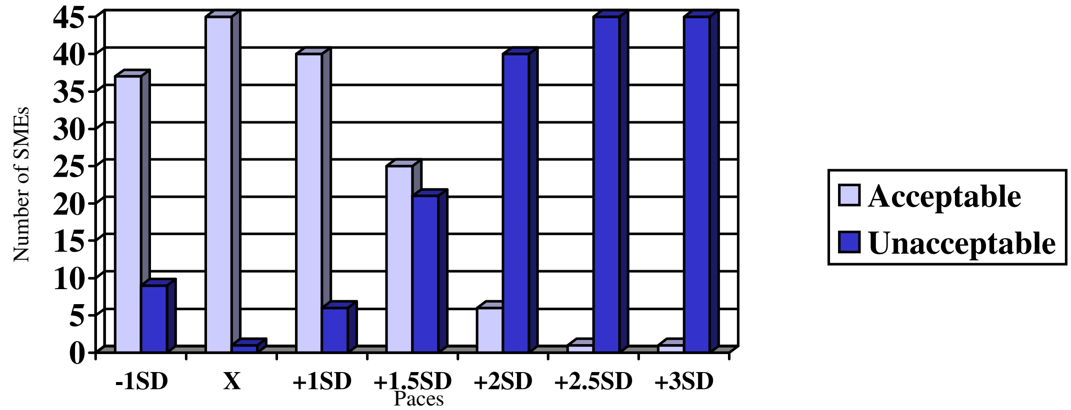


Figure 5.1. Video analysis results for simulated pre/post dive circuit.

The majority of SMEs perceived +1.5SD (1 min 33 s) as an acceptable pace and +2SD (1 min 38 s) as unacceptable pace for the pre/post dive circuit. A regression equation was generated to identify the crossover point from acceptable to unacceptable between these two paces (Figure 5.2). Using this equation, the minimally acceptable standard for pacing for the pre/post dive circuit was calculated as 1 min 33.5 s for 102 m (i.e. 1 min 33.5 s for one pass through the pre/post dive circuit).

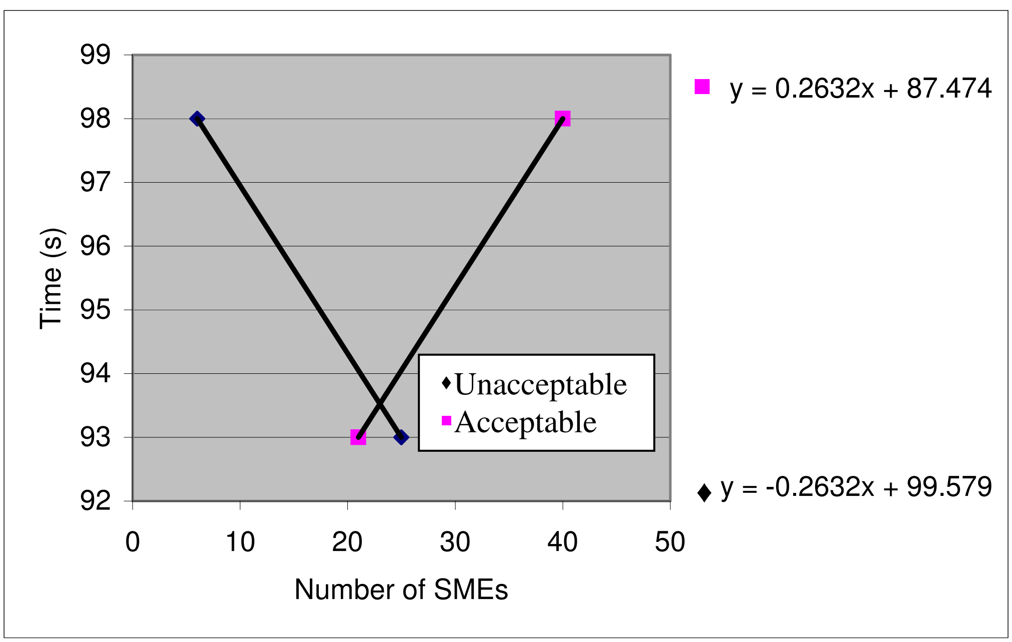


Figure 5.2. Regression Equations to Determine the Minimally Acceptable Pace for the Pre/Post Dive Circuit.

A summary of the SME responses for the five paces shown for the diver casualty simulation is provided in Table 5.5 and Figure 5.3. The majority of Cl, ST, PID and Cbt SMEs agreed that the mean, one and two SD slower than the mean were acceptable paces for the diver casualty simulation. However, the Cl SMEs were divided on the acceptability of the pace of 2 SD slower than the mean with 10 "acceptable" responses and 7 "unacceptable" responses. The pace showing 3 SD slower than the mean was clearly unacceptable with only 3 SMEs judging 1:06 (66 s) as acceptable.

Table 5.5 Results of the SME Video Analysis for the Diver Casualty Simulation.

	Pace	Clearance (n=17)		Ship's Team (n=2)		Port Inspection (n=10)		Combat (n=17)		Total (n=46)	
		A	U	A	U	A	U	A	U	A	U
Diver Casualty	-1SD (38s)	7	10	0	2	4	6	11	6	22	24
	X (45s)	12	5	2	0	10	0	17	0	41	5
	+1SD (52s)	16	1	2	0	9	1	17	0	44	2
	+2SD (59s)	10	7	1	1	6	4	13	4	30	16
	+3SD (66s)	2	15	1	1	0	10	0	17	3	43

A= Acceptable; U= Unacceptable

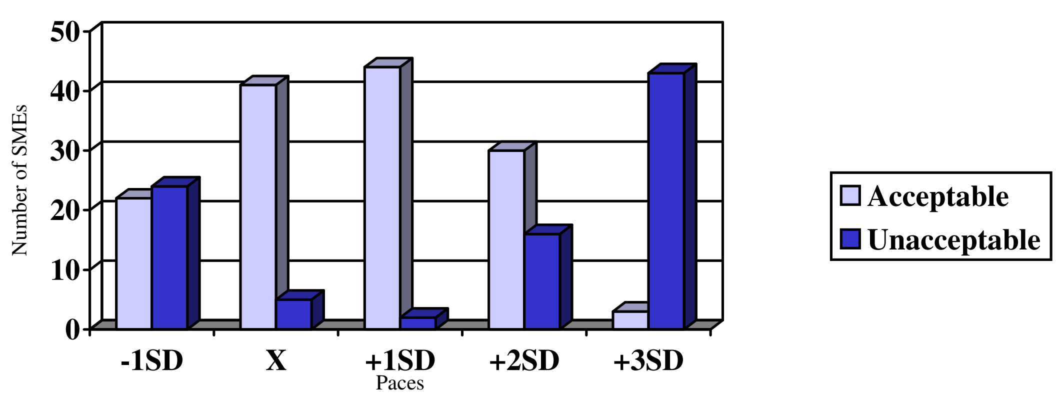


Figure 5.3. Video Analysis Results for Diver Casualty Simulation.

The majority of SMEs perceived 2SD (59 s) as an acceptable pace and +3SD (1 min 06 s) as unacceptable. A regression equation was calculated to find the crossover point from acceptable to unacceptable between these two paces (Figure 5.4). The minimally acceptable standard for the diver casualty simulation was calculated to be 1 min.

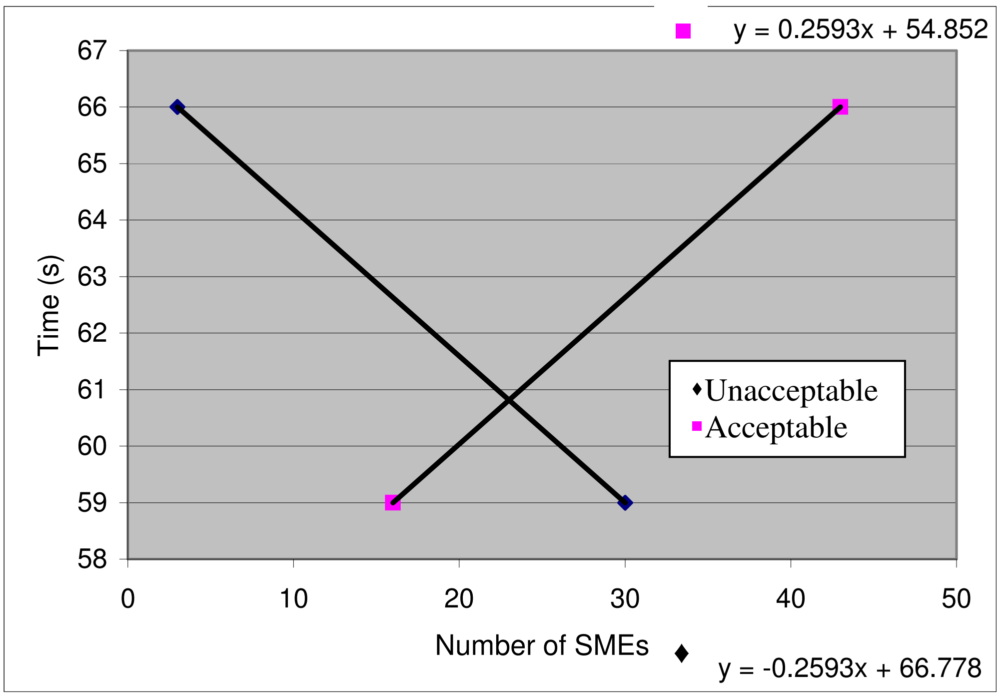


Figure 5.4 Regression Equations to Determine the Minimally Acceptable Pace for the Diver Casualty Simulation.

5.5.4 Development of Acceptable Time to Complete Equipment Transfers

From the SME responses (Appendix L) the slowest pace shown for each equipment transfer was unacceptable because the pace did not meet the criteria of moving with a sense of purpose or with purposeful movement. All 14 SMEs indicated that the second slowest pace for all transfers met the five safety requirements with a sense of purpose or moving with purposeful movement. Table 5.6 shows the time to complete each equipment transfer, as well as the total time that should be added to the acceptable pace to complete the 386 m circuit.

Table 5.6 Acceptable Equipment Transfer Times

Equipment Transfer	Time (s)
Tanks (lifting and maneuvering)	18
Crate (2 lifts)	8
Dive bag onto table and on diver's back	8
Dive bag off diver's back and onto floor	6
TOTAL TIME	**40**

5.5.5 Determining the Minimum Standard for the Pre/Post Dive Circuit and Diver Casualty Simulation

The minimum standard for the land-based circuit was calculated by adding the acceptable 386 m circuit time considered acceptable for the equipment transfers. The minimum standard was determined as follows:

0.92m/s x 386 m (total distance of pre/post dive circuit) + 40 s (equipment transfer) = 415.1 s (6 min 35 s)

This translates into a minimum standard for the pre/post dive circuit, excluding the diver casualty simulation, of 6 min 35 s. The minimum standard for the diver casualty simulation is 1 min 1 s.

5.6 Discussion

A single standard was developed for the four CF dive groups for the simulated pre/post dive circuit and diver casualty simulation. Although some of the required pre/post dive tasks differ between groups, all groups were required to lift, transfer, maneuver and walk with equipment, which are considered to be essential job demands. During the video analysis, representation for ST divers was low due to operational duties. However, because Cl divers are responsible for training ST and PID divers they were considered as SMEs for Cl, ST and PID divers. The SMEs indicated that all CF divers should be able to work at the same pace for the land-based components of the CF DPFT, therefore the minimum standard for the pre/post dive circuit for all CF divers was established at 6 min 35 s and 1 min 1 s for the diver casualty simulation.

Determining the minimal standard is recognized as one of the most critical steps in developing a valid fitness test. This standard is the point of reference that employers use to make personnel decisions. Standards may be implemented for various reasons. They may be used to determine whether an individual achieves or is denied certification, passes or fails a performance test, or as with the CF DPFT, demonstrates the ability or inability to meet the physical requirements of completing essential job tasks safely and efficiently. These standards have been developed using numerous techniques in which no discernable guidelines have been established to ensure valid and legal testing standards (Cizek, 1996).

Although definitive guidelines have yet to be established on how to "legally" define minimal standards, the use of incumbents and subject matter experts to provide physiological data, performance times or performance feedback are included in most methods for establishing standards. For example, the Canadian Forces developed the CF Exercise Prescription (EXPRES) standards using percentiles of norms based on CF personnel (Stevenson et al., 1992). Search and Rescue Technicians were monitored and a minimal standard was established at a point that reflected the same physiological costs of performing their work duties (Deakin et al, 1999). The development of a test for British Columbia Conservation Officers used various sources of information obtained during physiological assessments on incumbents, including run times, time on task and heart rates, to determine the cut-score for an obstacle course (Pethick et al., 2001). Standards developed for wildland firefighters were determined by comparing the results of personnel who did well on a task versus the results of personnel who did not do well; the cut-score was determined where there was the biggest gap between the two (Sharkey & DeLorenzo-Green, 1995).

Various sources of information were used to determine the minimal standards for the CF DPFT. A logical sequence of obtaining important information was used to determine the minimal standard of 6 min 35 s for the pre/post dive circuit and 1 min 1 s for the diver casualty simulation. Incumbent performance on the simulated pre/post dive circuit was used to develop a video of a diver working at different paces. SMEs were used to determine the acceptability of each pace. This process has been used previously to determine minimum standards for a *Candidate Physical Ability Test* (CPAT) (International Association of Fire Fighters, 1999). Training officers, considered SMEs, viewed multiple videos showing various paces of firefighter events included in a physical fitness test battery and indicated if each pace was “acceptable”, “marginally acceptable”, “marginally unacceptable” or “completely unacceptable”. The majority of SMEs (58%) viewed the speed of 10 min 11 s as an acceptable pace for the test battery and 55% of the SMEs viewed the speed of 10 min 30 s as marginally acceptable. Researchers concluded that the “pass point” was somewhere between those two times and the standard was identified through the use of interpolation of the time-weighted averages.

Similarly, Sothmann et al. (2004) used video analysis to determine a minimally acceptable standard for a Fire Suppression Evolution. SMEs viewed six different paces of the Fire Suppression Evolution and were asked to indicate if they felt the pace was “acceptable” or “unacceptable”. The majority of SMEs (53%) rated ½ SD slower than the mean as acceptable, whereas 22% of the SMEs rated 1SD slower than the mean as acceptable. The minimum standard for the Fire Suppression Evolution was established at ½ SD slower than the mean based on the marked drop in acceptance at 1SD slower than the mean.

The proposed minimum standard for the CF DPFT was determined using video analysis and regression equations to determine the point where the shift from “acceptable” to “unacceptable” occurred. This approach is similar to that used in establishing the minimum standard for the CPAT (International Association of Fire Fighters, 1999) and although the minimum standard fell at a point which was not actually displayed on the video, but between two paces, it seems reasonable that the acceptability rate, using statistical analysis, could be determined. Conversely, Sothmann et al., (2004) used the point where a marked drop in acceptability was reported and included a pace that was displayed on the video. Although 53% felt the pace was acceptable, another 47% felt it was unacceptable and the standard may be seen as not “reasonably necessary” with regard to the legal criteria required to defend the standard as a BFOR.

There is little additional published information on the use of video analysis to determine minimal standards; however, the recent use of this technique for the CF DPFT may provide a guideline for future studies. The major challenging in establishing valid and physical fitness tests for physically demanding occupations is establishing the minimally acceptable standard.

The methods used to determine the minimum standard of 6 min 35 s for the pre/post dive circuit and 1 min 1 s for the diver casualty should provide a logical method in determining minimal standards.

6. *Identifying and Establishing a Minimal Standard for Water-Based Fitness Tests for Canadian Forces Diving Personnel*

6.0 Introduction

Working in an underwater environment causes different physiological responses compared to working on land. Studies have shown marked bradycardia occurs with increases in depth (Dwyer, 1977, Brubakk and Neuman, 2003). Additionally, increased work of breathing occurs due to changes in gas density and osmotic pressure on the chest wall causing increased sub-maximal oxygen consumption underwater compared to tasks completed on land or at shallower depths (Dwyer, 1977; Dwyer and Pilmanis, 1978; Fagreus and Linnarsson, 1973).

CF diving personnel have previously indicated that completing many of the tasks they are required to perform in an underwater environment is physically demanding (McFadyen et al., 2003). Water-based tasks required of all CF dive groups, including Cl, ST, PID and Cbt divers, were validated as being physiologically demanding (Docherty et al., 2005). Tasks included working unsupported, surface swimming, swimming with equipment, swimming underwater and swimming against a current. According to a work intensity rating scale, modified from Astrand et al. (2003), CF underwater tasks were classified as “very heavy” and “extremely heavy” and surface tasks were classified as “extremely heavy”.

The physiological responses in water differ to those on land; therefore, test items that assess these capacities need to be included in a fitness test battery for CF diving personnel. Three water-based test items were developed by the UVicRT and validated by CF divers, including a vertical weighted fin-kick, a 400 m underwater swim and a 100 m surface swim. The protocol for the vertical weighted fin-kick was validated by the CF divers as being representative of the physical demands encountered while working unsupported for a prolonged period of time. The minimally acceptable standard for this test item was determined during the validation process. Divers were asked if the physical demands of the protocol used for the vertical weighted fin-kick (e.g. maintain vertical position, loaded with 8 lbs of weight for five minutes) reflected the physical demands of working unsupported for a prolonged period of time. Ninety-two percent of the divers felt the protocol used for the vertical weighted fin-kick reflected the physical demands they experience while working unsupported for a prolonged period of time. Consequently, this test item was determined to be a task completion test. Validation of the protocol for this test item established the minimally acceptable standard (i.e. maintain standardized position for five minutes).

The two other water-based test items were timed events. The purpose of this study was to determine the minimally acceptable standards for the 400 m underwater swim and 100 m surface swim included in the CF Diver Physical Fitness Test (CF DPFT) for each dive group.

Cl divers are required to work with heavier pieces of equipment and are qualified to work at deeper depths, resulting in increased physical demands (McFadyen et al., 2003). Cl divers are full-time divers whereas diving is a secondary duty for ST and Cbt divers, and part-time work for PID divers. The minimal standard required of the four dive groups may be different. Therefore, a secondary purpose of this study was to determine whether different standards were required for the four dive groups

6.1 Methods

6.1.1 Subjects

Forty-six Cl, ST, PID and Cbt divers participated in this study, with representation from across Canada. In order for CF diving personnel to participate and qualify as a subject matter expert (SME), the following criteria were required: 1) at least five years of CF diving experience; 2) qualification as a Dive Supervisor; and 3) for Cl divers only, currently or have previously been employed in the Training Department as an instructor. Table 6.1 provides a summary of the number of SMEs who participated in establishing the minimal standards for the water-based test items and their years of dive experience and rank.

Table 6.1. Summary of Years of CF dive Experience and Ranks of SMEs Involved In Establishing the Minimum Standard for the Water-based Test Items.

	Clearance (n=17)	Ship's Team (n=2)	Port Inspection (n=10)	Combat (n=17)	Total (n=46)
CF Dive Experience (yrs)	18.5 (7.6)	7.0 (2.8)	14.1 (7.6)	11.4 (6.3)	11.8 (6.5)
Ranks Represented	LS- 5 MS-1 PO2- 3 PO1-2 CPO2-5 Lt(N)- 1	MS-1 Lt(N)- 1	LS- 3 MS-3 PO2-2 PO1-1 CPO2-1	Cpl-1 MCpl- 4 Sgt-2 WO-3 MWO-2 Capt-4 Maj-1	

Data are Means (SD)

6.1.2 Experimental Procedures

Data for this study were collected in 12 SME sessions. No more than 5 SMEs were present per session, no SME was involved in more than one session and each session took place in a classroom. Representation from more than one dive group per session was not perceived as problematic because discussion between the SMEs was not allowed. The video analysis script was read to each group prior to commenting on the different pacing for each test item (Appendix J). Data used to establish the minimum standards for the water-based test items were collected during the same sessions used to establish the minimal standards for the land-based test items (Appendix I).

The water-based tests were conducted in a pool and one of the test items required subjects to swim under water, making changes in pace difficult to observe. Therefore, video analyses, which were used in establishing the standards for the land-based tests, were not appropriate in establishing the underwater swimming standards. Instead mathematical calculations indicating the progression a diver would attain swimming at different rates were used. Tables 6.2 and 6.3 provide summaries of the progression a diver would attain swimming at different paces for the underwater and surface swim, respectively.

Table 6.2. Progression Against Current for Various Underwater Swim Completion Times for a Distance of 400 m.

Lap time (min)	Time to Complete 400 m Swim	Progression Against 1 Knot (m)	Progression Against 0.75 (m)	Progression Against 0.5 Knots (m)
1:25	11.3 min	50.3	137.4	225.1
1:30	12.0 min	30.2	122.4	215.3
1:35	12.7 min	9.1	106.4	204.4
1:40	13.3 min	-11.2	91.2	194.4
1:45	14.0 min	-31.9	75.6	134.0

Sample of computation to establish swim progression:

1 Knot of current = 0.514 $m \cdot s^{-1}$
Lap time = 1:30 (90 s), time to complete entire 400 m in 12 min
Lap time = 50 m divided by 90 s = 0.556 $m \cdot s^{-1}$
Swimming against 1 Knot of current:
0.556 $m \cdot s^{-1}$ – 0.514 $m \cdot s^{-1}$ = **0.042 $m \cdot s^{-1}$ progression**
0.042 $m \cdot s^{-1}$ = x/720 s = 30.2 m of progression in 400 m

0.75 Knots of current = 0.386 $m \cdot s^{-1}$
Lap time = 1:30 (90 s)
Lap time = 50 m divided by 90 s = 0.556 $m \cdot s^{-1}$
Swimming against 0.75 Knots of current:
0.556 $m \cdot s^{-1}$ – 0.386 $m \cdot s^{-1}$ = **0.170 $m \cdot s^{-1}$ progression**
0.170 $m \cdot s^{-1}$ = x/720sec = 122.4 m

Table 6.3. Progression Against Current for Various Surface Swim Completion Times.

Time to Complete 100 m Swim	Progression Against 1 Knot (m)	Progression Against 0.75 Knots (m)	Progression Against 0.5 Knots (m)
2:20	28	46	64
2:30	23	42	62
2:40	18	38	59
2:50	13	34	56
3:00	8	30	54

The SMEs were instructed on how to interpret the tables of progression for both the underwater and surface swims. Any questions raised by the SMEs were answered by a member of the UVicRT and no discussion was permitted between the SMEs. All answers were recorded individually on the data sheets provided (Appendix M) and treated as confidential. SMEs were asked to indicate if each pace, with its respective progression against current, was acceptable or unacceptable for a diver required to complete tasks both underwater (e.g. jetty searches) or on the surface (e.g. rescue swim). Upon completion, and before any discussion between the SMEs, a member of UVicRT collected the data sheets.

Cl divers are responsible for training ST and PID divers. Therefore, in order to determine if a different standard was required for ST and PID divers, the Cl diver SMEs were asked to indicate if they felt that the pace at which each dive group moved in water should be different than that of a Cl diver.

6.1.3 Statistical Analysis

Information from the data sheets was entered into *Microsoft Excel*^{XP}. For each pace, the number of SMEs who felt the pace was "acceptable" and the number of SMEs who felt the pace was "unacceptable" was totaled for each dive group. A regression equation was determined to calculate the point at which the pace shifted from "acceptable" to "unacceptable" for each dive group and for the four dive groups combined, using an SPSS statistical package (Version 14). Using this equation, the minimal standard based on the level of acceptability for the various paces was determined. This statistical procedure was computed for both the underwater swim and surface swim.

6.2 Results

A total of 46 SMEs provided feedback on acceptable rates of progression for underwater and surface swimming. A summary of the SME responses for acceptable underwater swim times is shown in Tables 6.4 and Figure 6.1. A limited number of PID and ST divers who met SME criteria were available for this study due to operational demands. However, as previously noted, Cl divers are responsible for all ST and PID diver training and were used to help establish acceptable standards for these dive groups.

Table 6.4 Results of the SME Responses for Acceptable Rates of Progression for the 400 m Underwater Swim for Each CF Dive Group.

	Pace (min:s)	Clearance (n=17)		Ship's Team (n=2)		Port Inspection (n=10)		Combat (n=17)		Total (n=46)	
		A	U	A	U	A	U	A	U	A	U
400 m Underwater Swim	1:25	10	7	0	2	7	3	12	5	29	17
	1:30	14	3	1	1	10	0	15	2	40	6
	1:35	14	3	2	0	9	1	17	0	42	4
	1:40	3	14	0	2	4	6	9	8	16	30
	1:45	1	16	0	2	4	6	0	17	5	41

A= Acceptable, U = Unacceptable

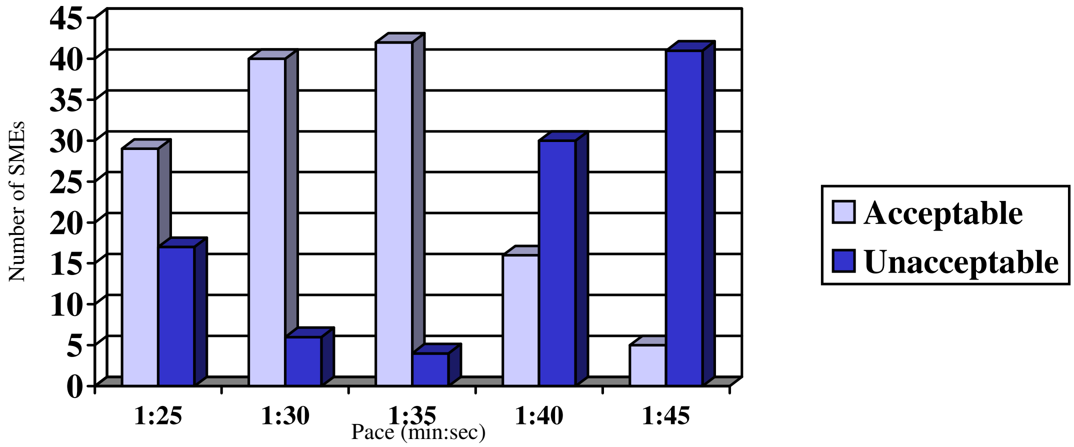


Figure 6.1. SME response for underwater swim lap times.

The majority of Cl, ST and PID diver SMEs reported 1 min 35 s as an acceptable lap time and a 1 min 40 s as unacceptable. The majority of SMEs for the Cbt dive group determined that a 1 min 40 s lap time was acceptable, whereas a lap time of 1 min 45 s was not. Cl divers also indicated that ST and PID divers should not be required to obtain the same standards as Cl divers because diving is not their full-time duty and the job demands of Cl diving are greater than those for ST and PID. Diving is also a secondary duty for Cbt divers, therefore grouping the SMEs for ST, PID and Cbt divers was deemed reasonable.

A regression equation was generated to find the crossover point from acceptable (1 min 35 s) to unacceptable (1 min 40 s) for Cl divers using only Cl diver SMEs (Figure 6.2). ST, PID and Cbt SMEs were combined and a regression equation was calculated to find the point where the shift from acceptable to unacceptable occurred for these dive groups (Figure 6.3).

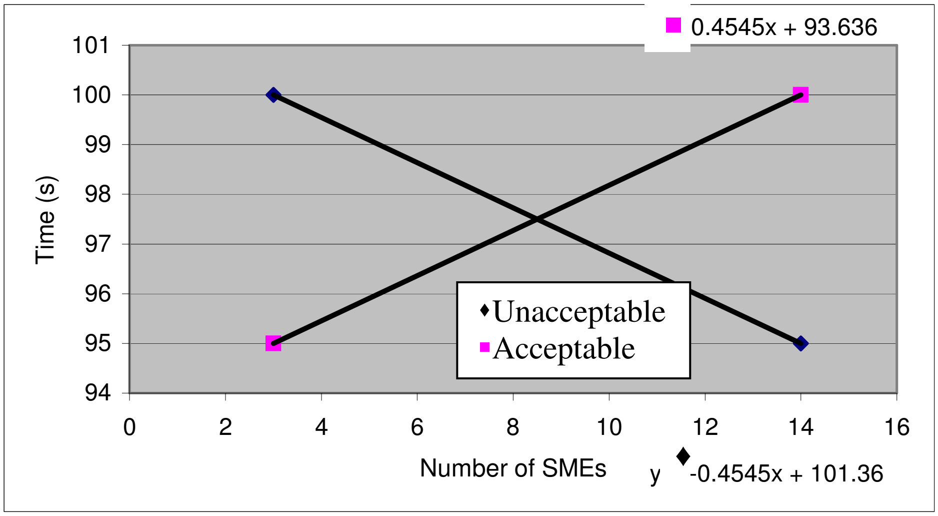


Figure 6.2. Regression equations to determine the minimally acceptable pace for the underwater swim for Cl divers.

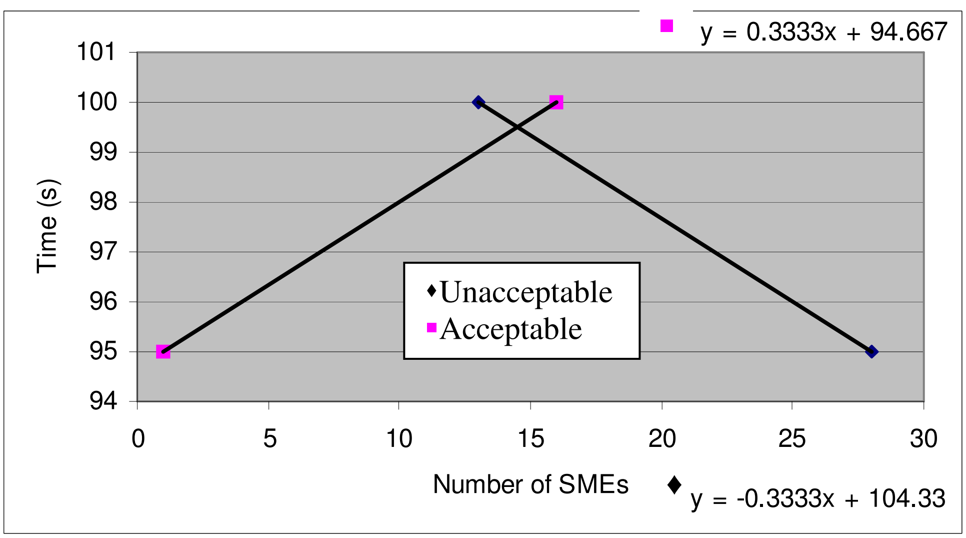


Figure 6.3. Regression equations to determine the minimally acceptable pace for the underwater swim for ST, PID and Cbt divers.

The minimally acceptable lap time was 1 min 37.5 s for Cl divers and 1 min 39.5 s for ST, PID and Cbt divers. There are 8 laps of a 50 m circuit for the underwater swim test, therefore the minimal standard for Cl divers was identified as 13 min. Using the lap time determined as acceptable by ST, PID and Cbt divers, the time to complete the 400 m underwater swim would be 13 min 16 s.

A total of 46 SMEs provided input on the acceptable rate of progression for surface swimming. A summary of the data is provided in Table 6.5 and Figure 6.4.

Table 6.5 Results of SME Responses for Acceptable Rates of Progression for the Surface Swim for Each CF Dive Group.

100 m Surface Swim	Pace (min:s)	Clearance (n=17)		Ship's Team (n=2)		Port Inspection (n=10)		Combat (n=17)		Total (n=46)	
		A	U	A	U	A	U	A	U	A	U
	2:20	10	7	1	1	5	5	11	6	27	19
	2:30	13	4	2	0	9	1	12	5	36	10
	2:40	11	6	2	0	10	0	16	1	39	7
	2:50	5	12	0	2	6	4	12	5	23	23
	3:00	2	15	0	2	0	10	3	14	5	41

A= Acceptable, U = Unacceptable

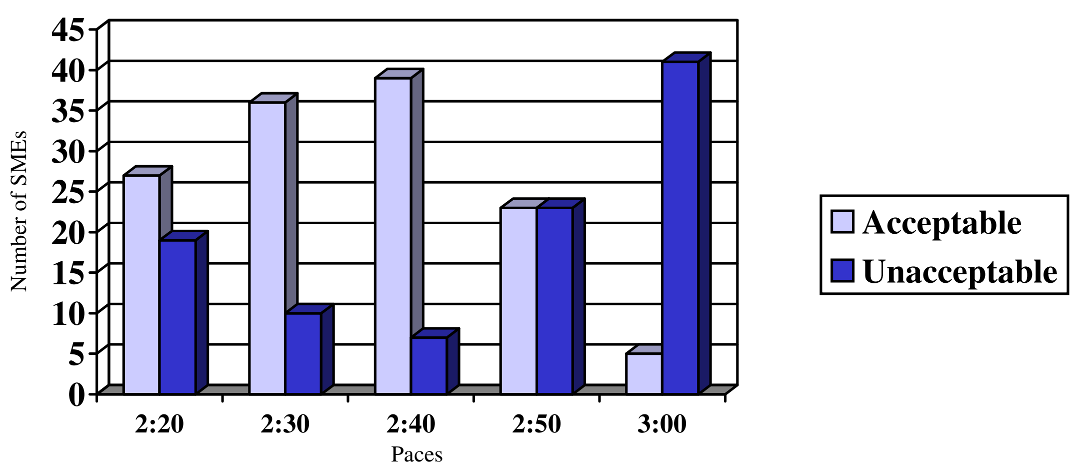


Figure 6.4. SME Response for Surface Swim Completion Times.

The majority of Cl and ST SMEs perceived 2 min 40 s as an acceptable 100 meter surface swim and 2 min 50 s as unacceptable. The majority of SMEs for the PID and Cbt dive groups determined that 2 min 50 s was an acceptable time for a 100 m surface swim and 3 min was unacceptable.

Cbt divers are required to complete the surface swim using a different protocol than the three groups and, therefore, the standard for the surface swim for Cbt divers was determined using Cbt diver SMEs only and the modified test specifically designed for them. A regression equation was developed to find the crossover point from acceptable (2 min 50 s) to unacceptable (3 min 00 s) for Cbt divers in order to identify the minimal standard (Figure 6.5). The regression equation identified the minimal acceptable pace to be 2 min 54 s.

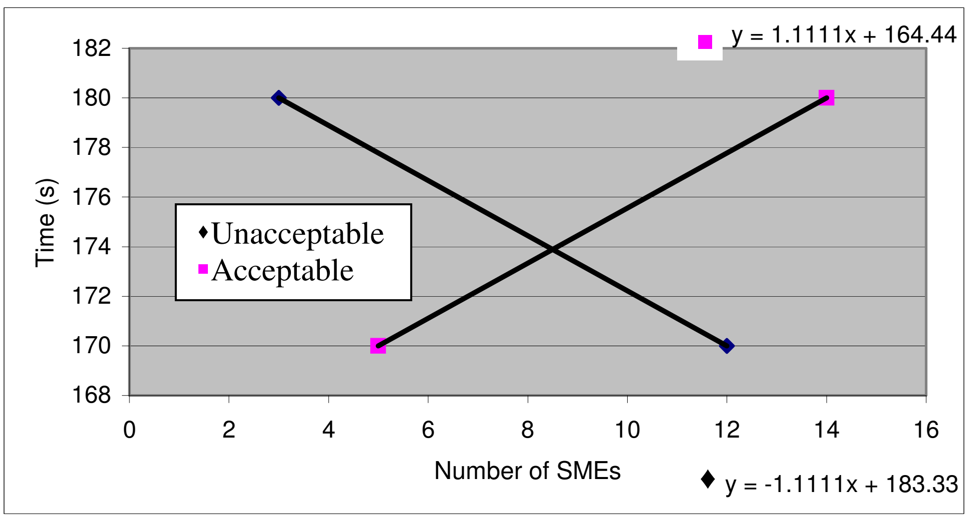


Figure 6.5. Regression Equations to Determine the Minimally Acceptable Pace for the Surface Swim for Cbt divers.

Cl, ST and PID SMEs responses were combined and a regression equation was developed to identify when the shift from acceptable (2 min 40 s) to unacceptable (2 min 50 s) occurred (Figure 6.6). A minimum acceptable pace of 2 min 47 s was established for Cl, ST and PID divers

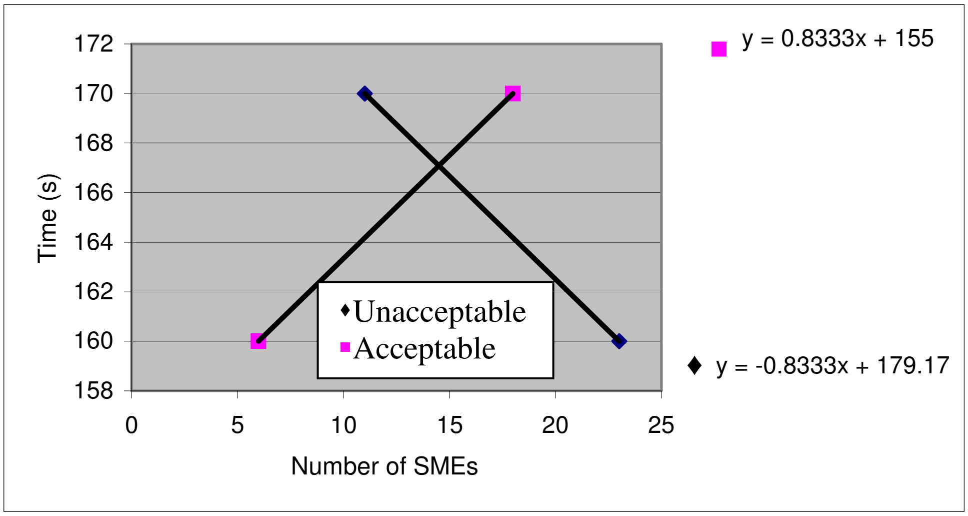


Figure 6.6 Regression Equations to Determine the Minimally Acceptable Pace for the Surface Swim for Cl, ST and PID divers.

6.3 Discussion

The minimal standards for both the underwater and surface swim were established using the SME feedback. Table 6.6 provides a summary of the minimal standards developed for the three water-based test items included in the CF DPFT.

Table 6.6 Summary of Minimally Acceptable Standards for the Water-Based Test Items Included in the CF DPFT.

	Vertical Weighted Fin-Kick (min:s)	400 m Underwater Swim (min:s)	100 m Surface Swim (min:s)
Cl	5:00	13:00	2:47
ST	5:00	13:16	2:47
PID	5:00	13:16	2:47
Cbt	5:00	13:16	2:54

Results from the current and previous studies have identified the need for different standards between the dive groups for two of the water-based test items included in the CF DPFT. In addition to the SME feedback from this study, previous research has reported that Cl divers have higher job performance requirements than the other three dive groups for tasks such as swimming against current or swimming with equipment (i.e. underwater swimming) (McFadyen et al., 2003; Docherty et al., 2005).

The information presented in Table 6.7 provides a summary of the fitness components associated with the physically demanding tasks identified in a previous study (McFadyen et al., 2003). The associated fitness components reported by the researchers support the inclusion of test items that require aerobic and anaerobic fitness as well as muscular endurance and agility and have been incorporated into the CF DPFT.

Table 6.7 Physically Demanding Water-Based Tasks and Associated Fitness Components for CF Divers.

Physically Demanding Task	Associated Fitness Component
Surface swim	Muscular endurance Aerobic fitness Anaerobic fitness
Underwater swim	Muscular endurance Aerobic fitness Agility
Swim in current	Muscular Endurance Aerobic Fitness
Swim with equipment	Muscular endurance Aerobic fitness Agility

Cl divers are full-time divers and experience increased physical demands compared to the three other CF diving groups. They are often required to complete tasks faster than the other groups, work at greater depths, and work with heavy pieces of equipment not used by the other groups. For example, Cl divers are solely responsible for working with explosive lift bags (45 kg), which involves maneuvering the bags around an object at depth; this task may take a prolonged period of time (e.g. >60 min). Cl divers are also required to work at greater depths (up to 100 m) compared to ST (30 m), PID (45 m) and Cbt (30 m) divers. This increases their exposure to various environmental factors such as increased gas density, water pressure, and exposure to cold. Due to these differences, it is recommended that Cl divers have higher standards for underwater work compared to the other CF diving groups.

Depth affects a number of physiological responses, including ventilation (Ve), heart rate (HR), and oxygen consumption (VO_2). Heart rate response during submaximal and maximal underwater exercise bouts resulted in the expected heart rate progression observed during exercise. However, marked bradycardia can occur at depth compared to on land (Dwyer & Pilmanis, 1978). Fagraeus and Linnarsson (1973) found a 3% and 6% decrease in maximum heart rates at 3 and 6 ATA, respectively, and concluded that this resulted in a 4-5% decrease in cardiac output. Dwyer and Pilmanis (1978) reported an increased oxygen consumption of 4-5 $ml \cdot min^{-1}$ for each atmosphere (ATA) divers were required to work (1 ATA = 10 m of sea water). Furthermore, the oxygen cost of breathing increases due to additional dead space in the lungs that occurs with regulators or surface supplied systems. The increase in dead space and turbulent gas flow requires divers to expend more energy to move the same amount of air underwater compared to on land.

The average time to complete the underwater swim for the four dive groups was 11 min 48 s (± 1min 7 s) and 2 min 10 s (± 23 s) for the surface swim. A minimal standard has been established for the water-based test items included in the CF DPFT through the use of SMEs and their work-related knowledge and experience. The water-based test items were important to include as physiological responses in water differ from on land (Dwyer & Pilmanis, 1978; Kang et al., 1983; Hall et al., 1998; Schipke & Pelzer, 2001.

The various sources of information used throughout the process of developing the CF DPFT not only support the minimum standard, but also inclusion of the actual test items. The water-based tests and the related minimal standards suggested in this study will help Commanding Officers identify divers who are able to work safely and efficiently in water.

7. Establishing Reliability of the Canadian Forces Diver Physical Fitness Test

7.0 Introduction

It has previously been established that the proposed Canadian Forces Diver Physical Fitness Test (CF DPFT) is a valid test that accurately represents the physical and physiological demands encountered by divers performing land and water-based tasks required for safe and effective performance of their job (see Section 3). The test battery was developed and validated using various sources of information, including: observations; interviews; focus groups; literature reviews; video analyses; physiological measurements (heart rate and oxygen consumption); questionnaire responses; subject matter expert feedback; and continuous consultation with CF diving personnel. However, in order to complete the validation process for the CF DPFT a reliability study was conducted.

Reliability is the relative consistency of test scores such that repeated measures of the test will produce the same results (Traub & Rowley, 1980) and is considered an integral part of validity. In order to be considered valid a test must be reliable (Thomas & Nelson, 2001). Test-retest procedures in which the same test is given to an individual two or more times are often used to determine a reliability coefficient for a test battery or for individual test items included in a test battery (Tsigilis et al., 2002; Suderland et al., 2006). If test results are inconsistent from one day to the next and/or successive trials fail to yield the same results, the test would be considered unreliable and, therefore, not valid.

In order to consider a physical fitness test and standard as a *bona fide* occupational requirement, employers must ensure that the following three criteria are met: 1) the standard was implemented for a purpose rationally connected to the safe and efficient performance of the job; 2) the standard was implemented in an honest and good faith belief that is was necessary for the legitimate work related purpose; and 3) the standard implemented was reasonably necessary to the accomplishment of the work related purpose. The validity of the test battery must be established in order to meet the criteria of the third point and reliability is an integral part of validity.

The proposed CF DPFT consists of three land-based and three water-based test items. Included in the land-based test items is a circuit simulating pre- and post-dive activities, a diver casualty simulation (DC), and a 40 m line pull (LP). The water-based test items include a vertical weighted fin-kick, a 400 m underwater swim, and a 100 m surface swim (SS). Though the CF DPFT has been validated by CF diving personnel as being representative of their job demands, the reliability of the test battery has yet to be determined. As this test battery may be used as a tool to determine whether CF diving personnel are fit to dive, consistent and reliable results are critical. The purpose of this study was to determine the reliability of the CF DPFT in order to complete the validation process.

7.1 Methods

7.1.1 Subjects

Six Cl, three ST and two PID divers participated in this study. No combat divers participated in this sub-study. All testing took place in Victoria, BC. Prior to testing, the physical characteristics and years of dive experience were recorded on a Reliability Study Data Sheet (Appendix N). Subjects were instructed on, and familiarized with the protocol for each test item and subsequently signed a consent form. Prior to beginning each test item subjects were reminded of the protocol for each test and any questions asked were answered by a member of the UVicRT. The physical characteristics of the participants are listed in Table 7.1.

Table 7.1. Summary of Subjects Involved in CF DPFT Reliability Sub-Study.

Dive Group	Divers (n)	Age (yrs)	Height (cm)	Weight (kg)	CF Dive Experience (yrs)
Clearance	6	27.7 (4.5)	174.1 (4.1)	80.0 (6.5)	4.7 (0.8)
Ship's Team	3	35.7 (3.1)	179.5 (2.4)	80.3 (11.5)	4.7 (3.2)
Port Inspection	2	31.0 (9.9)	180.1 (6.8)	73.9 (4.8)	3.0 (2.8)
Combined	11	30.5 (5.9)	176.7 (4.8)	79.0 (9.5)	4.4 (1.9)

Data are Means (SD).

7.1.2 Procedures

Test-retest procedures were used to determine the reliability of the CF DPFT. Two testing sessions, in which subjects completed the CF DPFT, were administered with one week separating the two trials (see Appendix A for a detailed description of the test items included in the evaluation). A standardized script was used for both trials. Subjects were encouraged to ask questions prior to beginning each test item. In addition, subjects completed an initial familiarization practice of the pre/post dive circuit (first test item) which included picking up the various pieces of equipment used in the test battery.

The CF DPFT includes both timed test items and task completion test items. A hand-held stopwatch was used for the timed items and the results were recorded on a data sheet (Appendix N). Results for the task completion items were recorded on the same log sheet as either "pass" or "fail" according to the standardized protocol previously established.

Subjects were tested at the same time of day and in the same order for trial two as they were tested in trial one. Results for each test item were not released or discussed until all subjects had completed both trials.

7.1.3 Statistical Analysis

Data from both trials were analyzed and descriptive statistics were computed using an SPSS package (Version 14.0) to determine the mean time and standard deviation. Paired t-tests were used to test for significant differences between the two trials. Significance was set at $p < 0.05$. One-way random, single measures intraclass correlation coefficients (ICC) were computed between trials for each test item. In addition, the standard error of measurement (SEM) and the coefficient of variation (CV) were computed for each test item.

7.2 Results

Table 7.2 summarizes the average time and standard deviation for each trial for the land-based test items included in the CF DPFT. All 11 subjects were able to successfully complete the 40 m LP. No significant differences were found using paired t-tests between trials for any of the test items.

Table 7.2. Mean values (SD) for land-based test items included in the CF DPFT.

Test Items	Trial One	Trial Two
	Time (min:s)	Time (min:s)
Pre/post dive circuit	5:14 (0:34)	5:11 (0:35)
Diver casualty	0:38 (0:04)	0:37 (0:04)
Line Pull (Task completion)	All completed	

Note: for both Trial one and two n=11

Table 7.3 summarizes the performances, times and standard deviations for the three water-based test items included in the CF DPFT. All subjects were able to carry out the protocol for successful completion of the vertical weighted fin-kick test, complete the 400 m underwater swim and 100 m surface swim.

Table 7.3. Means Values (SD) for the Water-based Test Items Included in the CF DPFT.

Test Items	Trial One	Trial Two
	Time (min:s)	Time (min:s)
Vertical Weighted Fin-Kick (task completion)	All completed	
400 m Underwater Swim	11:42 (0:41)	11:32 (0:43)
100 m Surface Swim	1:59 (0:12)	1:58 (0:13)

Note: no combat divers participated in this part of the study.

The ICC, SEM and CV for each test item are summarized in Table 7.4. The ICC for the pre/post dive circuit was 0.72 with an SEM of 17.8 s and a CV of 5.7%. Analysis of the diver casualty simulation resulted in an ICC of 0.90 with an SEM of 1.3 s and CV of 3.5%. The ICC for the U/W swim was 0.86 with an SEM of 15.4 s and CV of 2.2%, and for the SS the ICC was 0.89 with an SEM of 4.1 s and a CV of 3.5%.

Table 7.4. ICC, SEM and CV for test items included in the CF DPFT.

CF DPFT Test Item	ICC	SEM (s)	CV (%)
Pre/post dive circuit	0.72	17.8	5.7
Diver casualty	0.90	1.3	3.5
400 m Underwater Swim	0.86	15.4	2.2
100 m Surface Swim	0.89	4.1	3.5

7.3 Discussion

The ICC indicated that all test items included in the CF DPFT were reliable. The ICCs for DC, U/W swim and SS showed high levels of consistency between trials, whereas the ICC for the pre/post dive circuit showed acceptable levels of consistency (Thomas and Nelson, 2001). The CF DPFT battery, including all test items is, therefore, considered reliable.

The SEM is an estimate of error used in interpreting test scores of individuals and is important in determining the reliability of a test (Weir, 2005). A small SEM indicates that an individual would perform similarly from trial to trial, thus helping to assess the reliability of the test. SEM is used to determine the CV, which is the SEM expressed as a percentage of the mean score of the subjects. The SEM for each test item was relatively low, therefore the CV for each test item were low, indicating acceptable test score reliability.

Although the pre/post dive is considered reliable, the lower ICC and higher SEM could be attributed to the fact that there was some variability in the performance times from trial one to trial two. Five subjects slightly improved their time on the pre/post dive circuit (improvement times ranged from 6-42 s), three subjects had similar performance times on trial one and two, and three subjects had slower times on the second compared to the first trial (times slowed by 6-18 s).

The majority of the subjects who participated in this study (8 of 11) were individuals currently on a CF diver training course. CF diver training courses often result in increased stress levels, sleep deprivation, and increased physical demands on the body (McFadyen et al., 2003). Although divers indicated that they were fully rested and followed all preliminary instructions, some fatigue from their training course may have affected their performance on the second trial. Martin (1981) found a 5-40% decrease in performance time for treadmill testing after a period of sleep deprivation. Although the Martin study had a longer period of sleep deprivation (e.g. 36 hours), divers on course may experience the some level of sleep deprivation that may have impacted their performance times in the second trial.

Five of the eleven divers improved their performance time on their second trial of the simulated pre/post dive circuit. This improvement may be due to a number of factors, including motivation, competition, and a possible learning effect. Subjects were not informed of their previous results prior to completing the second trial in an attempt to decrease competition between subjects as well as their first score.

Although the SEMs were relatively small (2.2-5.7%) for the pre/post dive circuit and U/W swim, test performance may involve a small amount of skill and, therefore, a small learning effect may exist. The circuit involves maneuvering and walking with equipment, and although the divers are working with dive equipment daily, some skill in maneuvering the equipment in the test conditions may be required. Similarly, there was a small improvement in performance times for the majority of subjects for the U/W swim; again, a small learning effect on pacing or comprehension of the tests may have been present. Although the small SEM does demonstrate acceptable reliability, due to the potential of these small learning effects, it is recommended that all divers should be given the opportunity to practice all test items prior to their annual CF DPFT. Gledhill et al., (2001) suggest trial test opportunities for incumbent workers to educate themselves on the protocol and the equipment that is used for the test.

Development of a physical fitness test that would meet the criteria of a BFOR in a court of law requires the test to be valid (Eid, 2001); policy and procedure requires that decisions be objective and based on expert opinion and scientific evidence (Deakin, et al., 2001). Task specific physical fitness tests have been developed for CF Firefighters (FF) (Deakin, 1994) and CF Search and Rescue Technicians (SAR-Techs) (Deakin et al., 1999). Both reports outlined the procedures used to develop each test; however, no reliability studies were reported. A comparison of our data to previous reliability results of other physical fitness tests for CF personnel, therefore, was not possible. However, based on the findings of this study the proposed CF DPFT, including both land-based and water-based test items, is considered to be reliable but reliability could be enhanced if the divers are allowed more opportunity to practice the tests.

7.4 Future Considerations

One of the limitations of this reliability study was the small sample size due to the increased operational demands of all CF personnel during the current levels of deployment and global conflict. The number of divers available for this reliability testing project was limited and although the time commitment was not excessive, recruitment of subjects proved to be difficult. In addition, there were no Cbt divers involved in the current reliability study due to the current deployment of soldiers in Afghanistan. The reliability of all test items, with the exception of the SS, would be expected to be similar as all divers undergo similar training. However, due to the unique SS test for Cbt divers, it is recommended that this test be assessed for reliability with this CF diver population.

It is recommended that during, or just prior to, the initial implementation of the CF DPFT, another reliability study should be conducted with a larger sample size, including all four dive groups. Although the current study demonstrated acceptable levels of reliability for all test items using ICC and SEM analyses, the sample population was small. An expanded reliability study with a larger sample should confirm the findings of this study and enhance the validity of the proposed CF DPFT. In addition a CV can be established and used as means of assessing the individual's score and determining if it is within an acceptable range for the test to be redone without penalty.

8. *Analysis of Adverse Impact Using the Canadian Forces Diver Physical Fitness Test*

8.0 Introduction

Human rights legislation stipulates that people should be assessed on individual merit. However, standards, policies or rules may be employed when they are established through objective means. Implementation of such standards or policies may generate unintentional barriers resulting in either direct or adverse effect discrimination; this is a violation of the Canadian Human Rights Act (Deakin et al., 2001). Adverse affect discrimination, also known as adverse impact, occurs when a standard is implemented and at face value is neutral when applied to all employees. However, this standard could affect particular individuals, or group of individuals due to certain characteristics of the individual or group that do not occur for other employees in the same area of work (Eid, 2001).

Historically, many physically demanding occupations were held by able-bodied, white males and perceived to be too difficult for women, persons with disabilities, and some minority groups (Eid, 2001). These assumptions, however, have been challenged and proven invalid with more women and minority groups successfully entering into occupations considered physically demanding. Although physical fitness tests may be implemented with an "honest and good faith belief" that they are required for safe and efficient completion of job duties, many previously established standards were determined on white, able-bodied males (Eid, 2001). These standards may adversely impact minority groups. If a standard is challenged, employers must prove that although a standard may cause adverse impact on particular minority groups, the standard should be termed a *bona fide* occupational requirement (BFOR) and demonstrated that it is reasonably necessary for safe and efficient completion of all job demands. It is also possible that the standard will not cause any adverse impact but this should be objectively determined.

Suggested processes for developing valid physical fitness tests and standards, in order to assess the ability of an employee or applicant to successfully perform a physically demanding job, has been well documented (Gledhill and Jamnik, 1992; Jamnik and Gledhill, 1992; Sharkey and De-Lorenzo, 1995; Zumbo, 2001; McFadyen et al., 2003; Sothhmann et al., 2004; Docherty et al., 2005). The test items and standards included in a test battery must be validated and demonstrate that the ability to perform these tests at the required standard is related to the ability to perform the job in a safe and proficient manner. The effect of imposing the tests and standards on individuals or minority groups must be considered before being implemented to the applicants or incumbent workers because any adverse impact on an individual or minority group may be cause for legal action. Adverse impact statistics are often required in the implementation of selection standards (Morris, 2001). Although adverse impact statistics may play a central role in discrimination claims, there are no clear legal guidelines in Canada for determining if the application of the standards for these tests adversely impacts a particular individual or group.

In the United States, Uniform Guidelines on Employee Selection Procedures (1978) is the current document that is used to investigate adverse impact and may be used in Canada in determining if the imposition of a standard constitutes adverse impact. These guidelines suggest that an 80% Test should be used as a "rule of thumb" when determining whether a test or standard causes adverse impact on particular groups. The 80% Test is calculated by dividing the passing rate of a minority group on a particular standard by the passing rate of the majority group; any value less than 80% would be considered to have an adverse impact.

Statistical significance is also used in the U.S. for analyzing adverse impact of particular tests or standards (Biddle, 2005). Any probability value that is less than 0.05, indicating a difference in the passing rate between the majority and minority group is considered statistically significant and constitutes adverse impact. Although the U.S. has adopted these practices, both the 80% Test and analysis of statistical significance between passing rates, Canadian courts have yet to define precise guidelines to determine adverse impact. Canadian employers are required to examine newly developed tests and standards to determine, as best they can, if any group may be adversely impacted.

A Canadian Forces Diver Physical Fitness Test (CF DPFT) has been developed and validated for the four groups of divers in the CF: Cl; ST; PID; and Cbt. Minimum standards for each test item included in the test battery have been established using various sources of information, including incumbent performance trials and feedback from subject matter experts (SMEs) (Table 8.1). The purpose of this study was to determine whether implementation of the minimum standards established for the CF DPFT (Table 8.1) would result in any adverse impact related to gender, size, or age.

Table 8.1. Recommended Minimum Standards for the CF DPFT.

CF DPFT Test Items	Dive Group	Minimum Standards
Pre/post dive circuit (min:s)	All	6:35
Diver casualty simulation (min:s)	All	1:01
Line pull	All	Pass/Fail
Vertical weighted fin-kick	All	Pass/Fail
400 m underwater swim (min:s)	Clearance	13:00
	Ship's Team Port Inspection Combat	13:16
100 m surface swim (min:s)	Clearance Ship's Team Port Inspection	2:54
	Combat	2:47

8.1 Methods

8.1.1 Experimental Procedures

Previously gathered performance and personal characteristic data of subjects who had completed all CF DPFT test items were reviewed. Gender, age, and size were used to classify subjects as being part of a minority group. The minimum standards (Table 8.1) were applied to each minority group to determine the number of incumbent divers within each group who would fail to meet the standards for each test item.

Interclass correlations were computed to determine the effect of age, height and weight on performance times. An impact ratio was calculated for the following minority groups: women; individuals >34 years of age; and individuals <179 cm in height (i.e. individuals smaller than the average height of the CF divers analyzed for the current study).

An impact ratio for each minority group was determined to establish whether the proposed standards would adversely impact any particular group using the following calculation:

$$IR = SR_{min}/SR_{max}$$

where IR is the impact ratio, SR_{min} is the pass rate for the minority group and SR_{max} is the pass rate for the majority group (Biddle, 2005).

To determine statistical significance a Fisher Exact probability statistic for 2 X 2 contingency tables was used to determine any difference of pass rate between the majority group and each minority group. Statistical significance was set at $p < 0.05$.

8.2 Results

8.2.1 Interclass Correlations

The effect of age, height and weight on performance for each timed test item included in the CF DPFT (i.e. pre/post dive circuit, diver casualty, underwater swim and surface swim) was determined using interclass correlation (Table 8.2). There was a low correlation (r = 0.36) between age and performance time for the diver casualty simulation and height had a low negative correlation with performance time for the pre/post dive circuit, diver casualty simulation and underwater swim, r = -0.46, -0.19 and -0.24, respectively. No significant correlation was found between body weight and CF DPFT performance.

Table 8.2. Interclass Correlations for Age, Height and Weight to Performance Time on Timed Test Items Included in the CF DPFT.

	Pre/post dive circuit	Diver casualty	400 m Underwater swim	100 m Surface swim
Age	0.17	0.36	0.03	0.06
Height	-0.46	-0.19	-0.24	0.03
Weight	0.20	-0.06	-0.12	0.04

8.2.2 Specific groups

Five groups were analyzed to determine if the minimum standards of the CF DPFT caused any adverse impact. These analyses were conducted on the following five groups: females; individuals >34 years of age; individuals 170-178 cm in height; individuals 160-169 cm in height; and individuals <160 cm in height. Females are a minority group in the CF diving trade and were underrepresented in the data used for the current analysis. The CF classifies individuals 35 years and above as “older personnel” (Stevenson et al., 1994). Therefore, individuals >34 years of age were analyzed as a minority group. Finally, three groups with various ranges in height were analyzed as minority groups due to the significant relationships found between height and performance times on three test items.

The physical characteristics of the majority groups and each of the minority groups are summarized in Table 8.3. The average height for the incumbent population for this analysis was 179.1 ± 9.8 cm. To assess the effects of size on passing rate, three separate analyses were conducted to identify if individuals within three selected heights (170-178 cm; 160-169 cm; and <159 cm) were adversely impacted by the proposed standards.

Table 8.3. Mean (SD) Physical characteristics and Performance Results for the Majority Group and Each Minority Group.

	Divers (n)	Age (yrs)	Height (cm)	Weight (kg)
Majority group	50	27.8 (4.0)	181.1 (7.8)	83.2 (10.0)
Females	10	26.0 (3.9)	162.3 (3.2)	66.1 (5.4)
Individuals over 34 yrs of age	30	40.0 (3.3)	180.7 (8.1)	89.5 (11.1)
Height (170-178 cm)	22	34.3 (7.7)	175.8 (2.4)	86.4 (10.8)
Height (160-169 cm)	7	27.1 (5.8)	163.0 (3.2)	68.1 (5.0)
Height (<159 cm)	3	25.0 (3.6)	156.3 (2.0)	58.8 (4.5)

8.2.3 Impact Ratio

The impact ratio for each minority group was determined by dividing the pass rate for each minority group by the pass rate of the majority group. The results are by any of summarized in Table 8.4. Weight was not included in this analysis as the effect of weight on performance was minimal (r = 0.2, -0.06, -0.12 and –0.04 for the pre/post dive circuit, diver casualty, underwater swim and surface swim, respectively).

Table 8.4. Impact Ratio for Minority Groups.

Group	Met Minimal Standards (n minority/n majority)	Passing Rate	IR (%)
Majority	41/50	0.82	N/A
Females	8/10	0.80	98
Individuals >34 yrs of age	25/30	0.83	101
Height (170-178 cm)	17/22	0.77	94
Height (160-169 cm)	5/8	0.63	77
Height (<160 cm)	2/3	0.67	82

8.2.4 Fisher Exact Test (FET)

No significant differences were found using the FET for pass rate comparisons between the majority group and any of the minority groups (p = 0.59 for females; p = 0.57 for individuals over 34 years of age; p = 0.43 for individuals <179 cm in height; p = 0.21 for individuals with a height of 160-196 cm; p = 0.64 for individuals <160 cm in height).

8.3 Discussion

According to the 80% Test used in the U.S., four of the five minority groups analyzed would not be adversely impacted by the CF DPFT. However, the difference between pass rates for the majority group and all minority groups was not statistically significant, according to the FET. From a statistical standpoint, the CF DPFT did not adversely impact any of the minority groups. In addition, the correlations for the effect of age, height and weight were small, and performance on the test was not highly affected by any of these three variables. The correlations indicated that only 10-25% of the variance could be accounted by to gender, size, or age indicating that performance in the tests was more dependent on other factors.

Due to the availability of divers beyond the control of the researchers some of the groups had small sample sizes which may result in higher sampling error. Two of the minority groups had a small sample size (individuals 160-169 cm in height, n=8; and individuals <160 cm in height, n=3). Biddle (2005) recommends a sample size with a minimum of 30 subjects in each minority group to ensure that the analysis of adverse impact would be defensible in a court of law. Although the current study has a smaller sample size, the recommendation from Biddle (2005) was for an analysis with the 80% Test, exclusively. Statistical significance, which was also used in the current study, is less likely to falsely identify adverse impact (Morris, 2001).

Adverse impact has become a pejorative term as it is often linked with court cases, legal action and accusations of discriminatory practice (Biddle, 2005). However, it should be noted that this term is not a legal term that implies unfairness or test bias. Adverse impact is often generated when employers implement a standard to test for relevant job skills (Morris, 2001). Although Canadian courts have yet to provide any guidelines on how to determine whether a standard or test causes adverse impact on any minority group, it is an important step in the validation process. A valid and reliable standard may adversely impact a particular group or individual, but if it is legally defended as a BFOR any discriminatory case brought against the standard would be dismissed.

The reality of implementing a new rule or standard, in most cases, is that the standard will be legally challenged and an employer must be ready to defend each standard in a court of law. One of the issues surrounding adverse impact analyses is that there is no absolute threshold regarding the minimum sample size necessary for conducting statistical evaluations (Biddle, 2001). Although the sample size for the current study was small, the 80% Test determined no adverse impact for four of the five minority groups. The statistical test for significant differences in pass rates found no adverse impact for any of the minority groups. It is, however, recommended that further impact analyses be conducted with larger sample sizes for all minority groups.

The post hoc analysis was carried out on data obtained when a standard had yet to be established for any of the items included in the test battery. It is possible that once a standard is implemented, more incumbents may achieve the minimal standards due to psychological variables such as motivation and competition between individuals. It may also be of use for the Department of National Defence to record the rank of each incumbent tested and analyze the percentage of divers in an administrative position who meet the minimal standards compared to the percentage of non-administrative divers (e.g. working divers) who meet the minimal standards.

Continual reviews of new job performance-related technology available to divers, new standard operating procedures, and modified job demands due to changes in operational duties should be conducted on all CF diving groups. The CF DPFT and the minimum standards recommended are based on the current dive-trade job demands; changes within the trades should be reflected in changes to the CF DPFT. Adverse impact analyses also need to be reviewed when any change to the test occurs to ensure the standards do not adversely impact any minority group working as a CF diver.

The results of this preliminary study indicate that the implementation of the CF DPFT test and standards would not cause any adverse impact in regard to gender, age, weight or height. It is recommended that the issue related to adverse impact be continually monitored.

9. Final Recommendations for the CF DPFT

9.0 Recommendations Prior to Implementation

The following list provides recommendations for steps that should be taken prior to implementing the Canadian Forces Diver Physical Fitness Test (CF DPFT):

1) The final test and minimum standards should be presented at the Annual Dive Meeting to members of the Project Management Team, with representation from the UVicRT and a member of the CFPSA.
2) Any comments, questions or concerns regarding implementation should be addressed by CFPSA.

9.1 Recommendations for Implementation

The following list provides recommendations for steps that should be taken during the implementation phase of the CF DPFT:

1) Identification of CFPSA personnel and qualifications required to conduct the CF DPFT.
2) A member of the UVicRT should carry out training of personnel responsible for implementing and conducting the CF DPFT.
3) Training sessions should be conducted across Canada at every unit where the test will be implemented
4) Site visits where the test will be implemented should be conducted to determine possible complications or issues that may arise.
5) All testing should be conducted exactly as the protocol for each test item has been outlined.
6) All equipment required for testing should be assembled and stored at or near each testing location.
7) The CF DPFT should be an annual test, with no "exemption" standards. However, CFPSA may want to determine an "optimal" standard for the test in which additional points may be given to personnel for their merit listing.

9.2 Recommendation for Additional Research

The following list provides recommendation for further research on CF diving personnel and the CF DPFT:

1) Study of Adverse Impact - the first year of testing should be used for additional data collection to determine adverse impact on minority groups or individuals. The CF DPFT should not be implemented as the official CF diver fitness test prior to further adverse impact studies.

2) Study of Reliability – during the first year of testing an additional study should be undertaken to further establish reliability of all test items included in the CF DPFT. The Combat divers should be included in this analysis to establish reliability of the alternate surface swim protocol.

3) Optimal standard - CFPSA should determine, using information from the report of the UVicRT, an "optimal" standard for divers to ensure divers receive consistent merit recognition and promotion similar to other CF trades.

4) Development of a fitness training program - a fitness program should be developed for incumbents to accommodate individuals who cannot meet the minimum standards of the CF DPFT.

5) Based on the comments made by Dive Supervisors and divers an applicant test and standards should be developed, possibly based on modifications to the incumbent test.

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Appendices

Appendix A. Standardized Testing Protocols for Canadian Forces Diver Physical Fitness Test

1.0 Land- based tests

1.1 Pre/post dive circuit

The gym floor layout for the land-based pre/post dive circuit, including distance measurements, is illustrated on page 133.

The layout of the pre/post dive circuit is in the shape of a "U" and totals 50 m (20 m in length and 10 m wide). The diver is instructed to go through the circuit one way, turn around at the 50 m mark and then complete the circuit in reverse order, totaling 100 m in distance for each pass. There are few occasions when a diver is required to complete pre/post dive activities in a straight line and on stable terrain so obstacles have been included in the circuit to reflect this challenge. The following obstacles are included in the pre/post dive circuit: 1) two sets of stairs, with two steps going up and down to simulate a small incline and decline; 2) three hurdles (six inches high) spaced 2 m apart to simulate stepping over logs, hatchways and rocks; and 3) two sets of three cones with four foot dowelling through the center to simulate moving equipment in a confined space.

Rationale for inclusion of the Simulated Pre/post dive Circuit: All tasks included in the pre/post dive circuit were validated by CF divers as being reflective of their CF diving job demands. CF divers validated all distances and weights. The layout of the pre/post dive circuit, including all obstacles places throughout the circuit, created a varied terrain, which was important because CF divers rarely work in a straight line or on flat terrain.

The protocols and criteria for successful completion of the pre/post dive circuit are as follows:

Step One:

- Diver lifts a set of twin 80 SCUBA tanks from a table, places them onto the ground, and slides them underneath the table so the manifold is completely underneath the table.
- Diver slides the tanks out from underneath the table and lifts the tanks back onto the table, placing them so they are laying flat on the table.
- Diver picks up the tanks and carries them using either the manifold or out in front with both arms; the diver is not allowed to carry the tanks on the shoulders or head.
- Diver carries the tanks 40 m beginning at the start line, walking 20 m to a marked cone and back; diver is required to complete the stair obstacles in both directions.
- Diver places the tanks on a bench (30.5 cm in height) sits down and puts the stab jacket and tanks on, ensuring all buckles and straps are clasped.
- Diver stands up with tanks on back.

Although this portion of the CF DPFT is not timed, divers are required to move with a sense of purpose, or with purposeful movement. This portion is not times because divers are required to don dive tanks and, for safety purposes, the evaluator is required to ensure that all buckles and straps are done up correctly before the diver begins walking through the 100 m course.

Step Two:

- The timed portion of the test begins when the diver crosses the start cone and begins walking through the 100 m circuit.
- Evaluator must use a stop watch that has split times.
- Once the diver completes the 100 m, including all obstacles, he/she will sit on the bench and take the tanks and stab jacket off.
- Diver lifts the tanks off the bench, places them on the ground and slides them underneath the table so the manifold is completely underneath the table.
- Diver slides the tanks out from underneath the table and lifts the tanks back onto the table, placing them so they are laying flat.
- Diver begins a 40 m transition walk where the diver will walk without any equipment from the start line, up and over the steps to the 20 m cone where he/she will circle around the cone and return to the start line. Transition walks simulate the time after a diver drops off a piece of equipment at the dive site and has to walk back to the dive locker or truck to pick up another piece of equipment; the divers are still required to work with a sense of purpose or with purposeful movement.

Step Three:

- Diver lifts a crate weighted to 50 lbs to a height of 1.2 m, marked by a dowelling; diver must touch the bottom of the crate to the top of the dowelling and set the milk crate back onto the floor.
- Diver picks up a 25 dumbbell in each hand and completes the 100 m circuit, completing all obstacles.
- Diver sets down the dumbbells and picks up the 50 lb crate and lifts the crate to the 1.2 m height, setting it back onto the floor after the lift is complete.
- Diver completes the 40 m transition walk.

Step Four:

- Diver lifts a CF issued dive bag (weighted to 60 lbs) from the floor onto a table (1 m in height).
- Diver carries the dive bag through the 100 m course; divers are allowed to carry the dive bag any way, except on top their shoulders or head. Most divers choose to wear the dive bag like a rucksack on their back.
- Once the 100 m circuit is complete, the diver places the dive bag onto the table and lowers it back onto the floor.
- The timed portion of the simulated pre/post dive circuit ends once the diver places the dive bag back onto the floor; the evaluator will press the “Start/Split” button on the stop watch and record the time for the pre/post dive circuit, leaving the cumulative time running for the “Diver Casualty” simulation.
- Diver will not complete a transition walk and will move directly into the “Diver Casualty” simulation.

Step Five

- Diver picks up the 50 lb kettle bell and completes the circuit carrying the kettle bell in one hand at the side.

- The steps are included to simulate a small incline and decline and the diver is instructed to walk/jog through the circuit, omitting the hurdles and cones for safety purposes.
- Once the diver reaches the 50 m turn-around point, he/she must switch the kettle bell to the opposite hand and carry the weight through the circuit using the other hand.
- The timed portion of the “Diver Casualty” will end when the diver sets the kettle bell on the floor. The evaluator presses “Stop” on the stop watch and records the split time for the “Diver Casualty”.

1.2 Line pull

Rationale for inclusion of the line pull: CF divers may be required to use a hand-over-hand motion to recover a number of items, including dive clumps, anchors, or a diver during a diver casualty situation. CF divers identified this type of recovery as being physically demanding and an important aspect of their job as it is a task that may be required during an emergency situation. A cable tensiometer was used at FDU-P in order to find out the amount of force that is required to lift a 25 lb clump from a depth of 30’. The weight in the crate may vary at each location depending on the floor surface on which the test is conducted. The 3 min recover period was imposed because divers are rarely required to complete a line pull task directly after carrying the equipment required for diving.

Note: A cable tensiometer will need to be used at each gym location to determine how much weight is required in the crate to equal 100 lbs of horizontal force.

The protocols and criteria for successful completion of the line pull are as follows:

After a 3 min recovery period following the pre/post dive circuit the diver pulls a weighted milk crate (weighted to 100 lbs of force), using ¾” width line. The diver uses a hand-over-hand motion to pull the weighted crate 20 m towards them. The crate must fully cross the 20 m line. The diver then walks to the opposite end and pulls the crate another 20 m. The diver must keep his/her feet planted once the line pull has begun and may only pull the crate using the hand-over-hand technique.

Subsequent to the line pull, the diver has 12 min to move to the pool for the three water-based tests.

2. Water-based Tests

Three water-based tests have been included in the test battery for the CF DPFT. One of the tests requires the diver to breathe compressed air from their breathing apparatus; therefore, due to CF dive regulations a Dive Supervisor must be present during all testing where divers are submerged. A standby diver is not required as the test is conducted in a controlled environment (i.e. pool) where a lifeguard will be present. Protocols for successful completion of the water-based tests are as follows:

2.1 Vertical Weighted Fin-kick

Rationale for inclusion of the Vertical Weighted Fin-kick: CF divers are required to work unsupported underwater for prolonged periods of time. To maintain position underwater, CF divers use a vertical fin-kick to complete tasks such as hull scraping, propeller changes and sonar dome repairs/removals (McFadyen, Docherty, Gaul and Gellhaus, 2003).

The protocols and criteria for successful completion of the vertical weighted fin-kick are as follows:

- Diver dresses in swimsuit, stab jacket, twin 80 tanks and fins, no weight should be added to the buoyancy control device (BCD).
- Diver enters the water and finds neutral buoyancy, which is defined as the point at which a diver maintains their position after full exhalation where water is at eye level. The diver may have to add or remove air from the BCD to find neutral buoyancy. It is the responsibility of the Dive Supervisor to verify the diver is neutrally buoyant.
- Six pounds of weight, using CF issued dive weights, is added to the weight pouches and placed in the BCD; a two pound dive weight is held in one hand out of the water.
- The diver is instructed to maintain a vertical position**,** with the head, both hands and both wrists held out of the water. Divers are to use a vertical fin-kick similar to what they would use while working unsupported.
- The 2 lb weight is transferred from hand to hand approximately every 20 seconds.
- Two warnings may be given to the diver to either keep their hands and wrists out of the water, maintain a vertical position, and/or keep their head above water. After two warnings, the diver has failed to complete this test.
- Successful completion of the vertical fin-kick involves maintaining a vertical position with the additional weight while fin-kicking for 5min.
- After the required 5 min of vertical fin-kicking, the diver may either swim to the side of the pool or inflate their BCD.
- Divers are required to take off their fins, set them on the pool deck and exit the water using the ladder; the dive weights are to be removed from the BCD subsequent to the ladder climb.
- 5 min of recovery time, in which the diver is resting comfortably sitting on the side of the pool, has been allotted between each water-based test.

2.2 Underwater Swim

Rationale for inclusion of the Underwater Swim: CF divers are required to swim underwater, against current, for a number of CF diving tasks, including seabed searches, jetty searches, search and recovery, navigation swim and reconnaissance. Although it is ideal to swim with the current, many divers indicated that they are required to swim against current for a number of these tasks. It is important for a diver to be able to move against a current in order to complete required CF dive tasks. Divers may be required to swim between 10-1000 m against a current, and they must complete these tasks in a timely manner (McFadyen et al., 2003).

The protocols and criteria for successful completion of the underwater swim are as follows:

- A 50 m rectangular circuit, usually running 20 m in length and 5 m wide, is marked in the pool using buoys with line attached to a weight on the bottom of the pool.
- Diver is dressed in a stab jacket, weights (if required for diving), tanks, fins and mask.
- Diver is instructed to submerge to three to four feet underwater and complete one 50 m circuit to familiarize themselves with the layout of the test, adjust buoyancy and determine pace.
- Following the warm-up lap the diver surfaces to ask any questions he/she may have and to receive final instructions from the tester.
- A method of communication between the evaluator and the diver (preferably an underwater microphone) needs to be agreed upon in which the diver can verify the number of laps he/she has completed and/or if he/she has slowed to an unacceptable pace. If an underwater microphone is not available, the evaluator may use a series of taps to communicate with the diver (e.g. 2 taps on the metal stairs means the diver needs to move more quickly), or some kind of signage could be used to communicate to the diver their lap times (e.g. waterproof whiteboard).
- Diver submerges to three to four feet below the surface, breathing from the regulator, and completes eight laps of the 50 m circuit.
- The tester is responsible for keeping track of the number of times the diver has completed the 50 m circuit.
- This is a timed test and the tester will use a handheld stopwatch to record the final time of the test after the diver has completed the required eight laps.
- Once the diver has completed the underwater test, he/she will surface and swim to the side of the pool.
- Divers are required to take their fins off, set them on the pool deck and exit the water using the ladder.
- 5 min of recovery time, in which the diver is resting comfortably sitting on the side of the pool, has been allotted between each water-based test.

2.3.1 Surface Swim (Cl, ST, PID)

Rationale for inclusion of the 100 m Surface Swim: CF divers may be required to swim on the water's surface for a number of diving tasks, including a rescue swim, diver casualty, or they may be required to swim to a dive site that a vehicle cannot get to. The average surface swim is 100 m (McFadyen et al., 2003).

The protocols and criteria for successful completion of the pre/post dive circuit are as follows:

- Wearing a swimsuit and fins, and carrying a mesh bag weighted with six pounds of dive weights, the diver is required to surface swim 100 m (e.g. four laps of a

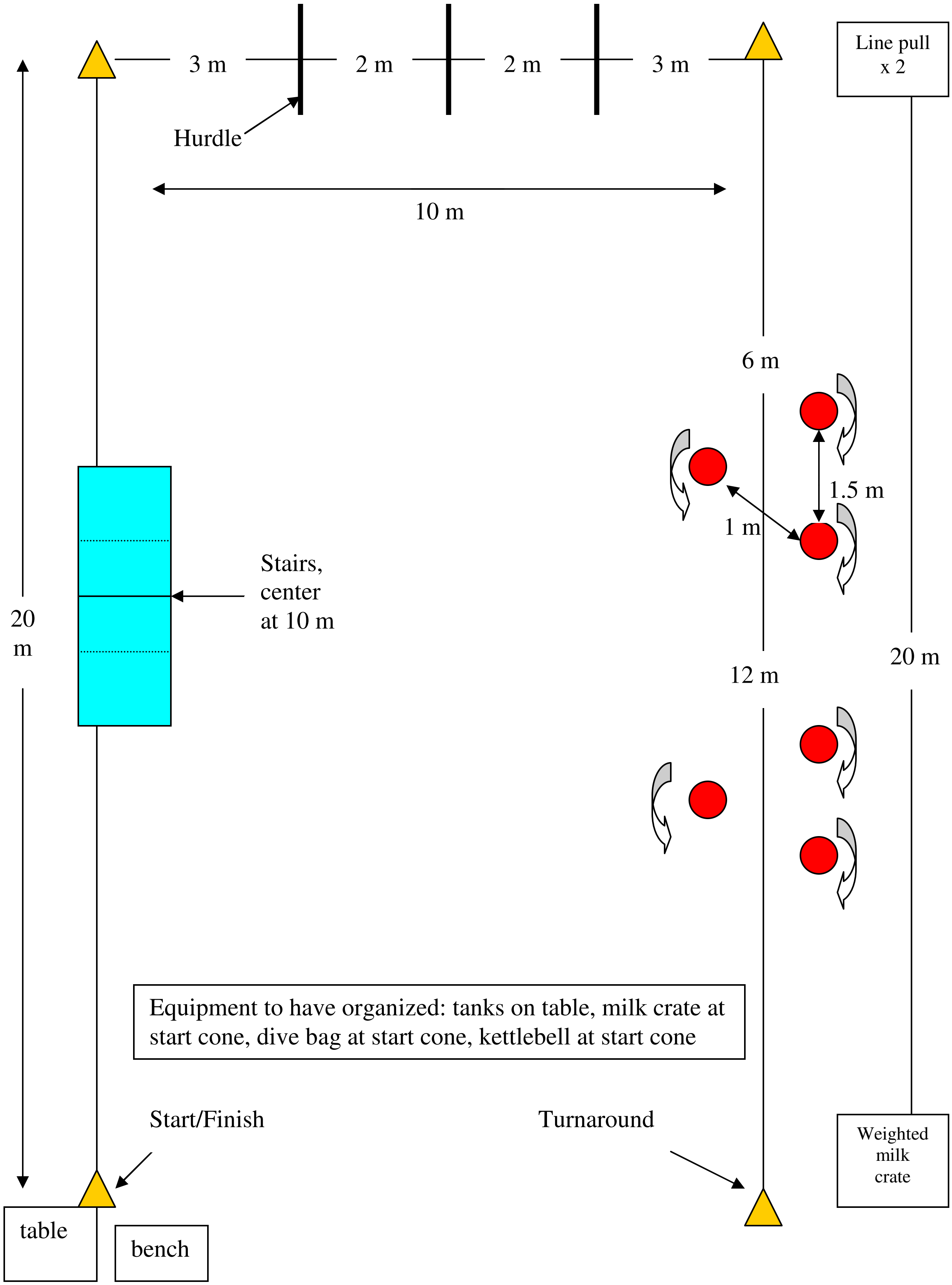
25m pool). The mesh bag is included in this test to give the diver something to work against. As the test is completed in a pool environment, the diver does not have to work against current, chop on the surface, wind or other environmental issues. The 6 lbs in the mesh bag was validated by the divers as creating the same physical demands as surface swimming in the ocean.

- Diver uses the surface swim technique taught during their CF dive training, in which they swim on their side with one hand extended overhead.
- The diver may carry the weighted mesh bag in one hand any way he/she feels is the most comfortable.
- Diver must touch each end of the pool but may not push off the side for additional power and speed.
- This is a timed test and the evaluator will use a handheld stopwatch to record the final time to complete 100 m of surface swimming.
- The test is complete when the diver completes 100 m.
- Diver then places the weighted mesh bag on the side of the pool, takes off his/her fins and exits the pool using the ladder.
- Completion of this test signifies the end of the CF DPFT.

2.3.2 Surface Swim (Cbt)

Rationale for inclusion of the Surface Swim for Cbt divers: Cbt divers indicated that one of the most important and urgent tasks requiring surface swimming was exiting after a mine placement. Divers may swim underwater with the mine to the emplacement site, but swim on the surface following emplacement. According to CF Standard Operating Procedures (SOPs), vehicles (e.g. zodiacs) are required to stop 100 m from an emplacement site; Cbt divers swim on the surface after emplacement in order to swim directly to the vehicle. Cbt divers would keep their tanks on and swim on their backs for this task, therefore the surface swim for this group of divers differs from the other three.

- Wearing a swimsuit, tanks, stab jacket and fins, and carrying a mesh bag weighted to six pounds using dive weights, the diver is required to surface swim 100 m (four laps of a 25 m pool).
- Diver fully inflates their BCD prior to beginning the surface swim.
- Diver uses the surface swim technique taught during their CF dive training, in which they swim on their back.
- The diver may carry the weighted mesh bag in one hand any way he/she feels is the most comfortable.
- Diver must touch each end of the pool but may not push off the side for additional power and speed.
- This is a timed test and the evaluator will use a handheld stopwatch to record the final time to complete 100 m of surface swimming.
- The test is complete when the diver completes 100 m.
- Diver then places the weighted mesh bag on the side of the pool, takes off their tanks and fins and exits the pool using the ladder.
- Completion of this test signifies the end of the CF DPFT.



Gym Floor Layout for the Land-Based (Pre/Post Dive) Circuit

RECOMMENDED STANDARDS FOR THE CF DPFT

CF DPFT Test Items	Dive Group	Minimum Standards
Pre/post dive circuit (min:s)	All	6:35
Diver casualty simulation (min:s)	All	1:01
Line pull	All	Pass/Fail
Vertical weighted fin-kick	All	Pass/Fail
400 m underwater swim (min:s)	Cl	13:00
	ST, PID, Cbt	13:16
100 m surface swim (min:s)	Cl, ST, PID	2:54
	Cbt	2:47

Appendix B : Focus Group Questionnaire – Potential Test Items

Name:	Dive Group:	Rank:	Yrs. Exp:	Current Dep:	Previous Dep:
___________________	_______	____	_______	__________	___________
___________________	_______	____	_______	__________	___________
___________________	_______	____	_______	__________	___________
___________________	_______	____	_______	__________	___________
___________________	_______	____	_______	__________	___________
___________________	_______	____	_______	__________	___________

<u>Pre/post Dive Tasks</u>:

Physical Demands: Muscular strength, muscular endurance, anaerobic capacity, agility
Tasks include:

- lifting, carrying equipment
- transferring equipment
- loading/unloading equipment down a certain distance, up to a certain height

1) Pick up and put on tanks, walk 100 m, set tanks down.

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

**TS- Time Sensitive, TC- Task Completion

2) Transfer tanks over and down (similar to loading a boat).

- use tire from FF Test and put tank into middle of tire.

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

3) Walk back to start, 100 m:

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

4) Pick up dive gear (or a weight equal to), walk 100 m

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

5) Transfer dive gear over and down:

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

6) Walk back to start, 100 m

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

7) Pick up additional dive equipment, walk 100 m

a) Cl- lead clump
b) Cbt- ammunition
c) ST-
d) PIDT- lead clump (lighter than Cl)

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

8) Pick up dive tanks, put them on, climb a ladder (?? rungs).

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

9) Walk 100 m, take tanks off, transfer the tanks up to a height of 1.5 m

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

Possibilities:

- have the divers walk up/down stairs, on mats (to simulate uneven terrain), through tires, stepping over (dowels raised a certain level), under (higher dowels).

Additional Comments/Ideas:

Post-Dive/Diver Casualty

Physical Demands: Muscular strength, muscular endurance, anaerobic capacity, agility
Tasks include:

- lifting, carrying equipment
- transferring equipment
- loading/unloading equipment down a certain distance, up to a certain height
- Diver Casualty- lifting/hauling a diver, running with a weighted stretcher

1) Haul up a shot line- use a pulley system
   - different weight for each dive groups (i.e. Cl and PIDT heavier weight)

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

2) Go over a 6’ platform (simulate pulling yourself into the boat)

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

3) Sit/kneel on top of the platform, lift a set up tanks up onto the platform from 3 ft below x 2

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

4) Push a weighted wheel barrow (simulating pushing the stretch) 100 m

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

Additional Comments/Ideas:

Dive

Physical Demands: Muscular endurance, aerobic capacity
Tasks include:

- swimming with equipment
- swimming for a prolonged amount of time
- working underwater, unsupported

1) Swim 100 m with equipment (i.e. weight of tool bag)
   - different weights depending on dive group…focus group discussion

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

2) Vertical fin kick- with tanks, no buoyancy control, 5 minutes, hands out of water

Agree	Disagree	Dist.	Wt.	TS/TC	Comments/Ideas

Additional Comments/Ideas:

Aerobic Component:

Run vs. Swim??

1) Shuttle Run

Comments: ____

____

____

____

____

____

____

____

2) Tethered Swim

Time: ______________

Load: ______________

Comments: ____

____

____

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Appendix C: Task Validation Questionnaire - Focus Group Summary Data

	Clearance Divers			**Ship's Team Divers**			**Port Inspection Divers**			**Combat Divers**		
	Agree	***Disagree***	***Suggestions***	***Agree***	***Disagree***	***Suggestions***	***Agree***	***Disagree***	***Suggestions***	***Agree***	***Disagree***	***Suggestions***
Pre/post dive												
Agility Course	**X**			**X**			**X**			**X**		
Walk 100 m	**X**			**X**			**X**			**X**		
Wear tanks	**X**			**X**			**X**			**X**		
Transfer tanks over and down	**X**	**X**	-no tire -use a bench to lift and transfer over	**X**	**X**	- thought tire was a good idea for transfer - bench would be good	**X**		- liked the tire idea, as long as they were able to kneel on the tire of put their foot on it.	**X**	**X**	- agreed with the tire simulation - could just use a bench, as well
Carry dive gear	**X**			**X**			**X**			**X**		
Pick up add'l equip	**X**		- not tanks - lost diver marker - line, anchor	**X**		- carry tanks and be able to maneuver with them - one small girl said she would never carry the tanks in front, she would always wear them…it's not essential	**X**		- carry tanks in front, they do it a lot - lost diver marker would also be good, in a milk crate	**X**		- agreed, carry tanks in front of them all the time - could also carry a lost diver marker in a milk crate

	Clearance Divers			Ship's Team Divers			Port Inspection Divers			Combat Divers		
	Agree	***Disagree***	***Suggestions***	***Agree***	***Disagree***	***Suggestions***	***Agree***	***Disagree***	***Suggestions***	***Agree***	***Disagree***	***Suggestions***
Climb ladder	**X**		- not with tanks - weighted vest, okay - backpack with wts. - some groups felt this was unnecessary	**X**	**X**	- some agreed, some disagreed - most said they wouldn't be wearing their tanks, not necessary		**X**	- no, never, unsafe, would never climb with tanks on		**X**	NO! They never have to climb ladders, ever.
Transfer equip up (truck ht)	**X**		- transfer up is very NB - incorporate the transfer after each pass through agility course		**X**	- one ship said they never transfer up, always down and over. -other ships said a transfer up was necessary	**X**		- agreed, always have to load gear into trucks,	**X**		- agreed, just use the same equipment they were just carrying
Post-dive and Diver Casualty												
Shot line simulation	**X**		- agreed - Line length: 150-300 ft Weight: 15-30 lb - idea: go to the pool with this and pull a weight from the bottom of the deep end to the opposite edge of the pool	**X**		- agreed - Line length: 50' to 100' - Weight: 15-25 lb - what about moving this to the pool and pulling an Oscar dummy in from the deep end to the side of the pool (i.e. 25 m)?	**X**		- agreed - Line length: 50-150 m Weight: 30-50 lbs	**X**		- agreed - Line length: 50-100 m - Weight: 30-50 lbs
6' platform	**X**	**X**	- 6' wall - pull-ups - seated row - go to pool and do this task there		**X**	- no 6' wall - one ship felt this was unimportant; , skill-based, you learn it or you get laughed at -if it was necessary, do it in the pool	**X**	**X**	- agreed, like the 6' wall - understood why pull-ups could not be used		**X**	- some agreed, some disagreed with the 6' wall. - would rather see this done in the pool to have to actually pull yourself up with additional water weight. - needs to be a test item

	Clearance Divers			Ship's Team Divers			Port Inspection Divers			Combat Divers		
	Agree	*Disagree*	*Suggestions*	*Agree*	*Disagree*	*Suggestions*	*Agree*	*Disagree*	*Suggestions*	*Agree*	*Disagree*	*Suggestions*
Lift equip up onto platform	X	X	- unsafe - idea of lifting tanks over into the center of tire, followed by lifting a 100 lb Oscar dummy up and over (diver casualty)	X	X	- safety was an issue again. - agreed with hauling a dummy up and over	X	X	- agreed with transferring equipment up and over, concerned about the safety of this item	X		- agree, - lift items up and over, ie tanks, 100 lb Oscar dummy
Diver casualty-stretcher	X	X	- wheelbarrow - run with a dumbbell or body bar	X	X	- run with dumbbell - run with bodybar - run with Russian Kettle (dockyard gym has some)			- suggested dragging a weight line behind them.	X	X	- agree - no to wheelbarrow - run with a piece of 50 lb equipment at side, one hand, cannot switch hands or stop
Dive												
100 m swim w/ equip	X	X	- some agreed, some disagreed - would like to try it	X		- simulate rescue swim, surface swim with an Oscar, discussion surrounding this ended with the divers agreeing that they would be pulled in with the diver, would not have to surface swim with one on their own. - 100 m swim with tool bag a good idea	X		- need to try this out to see how it feels and if it is necessary	X	X	- try 100 m swim - some would like to see a lot longer surface swim, i.e. 300-1000 m, with fins, weapon, equipment bag
Vertical fin kick	X	X	- some agreed, some disagreed - would like to try it	X	X	- not sure about this, need to try it.	X	X	- need to try it	X	X	- most said they couldn't visualize this test, would need to try it, but they don't think they'll like it.

	Clearance Divers			Ship's Team Divers			Port Inspection Divers			Combat Divers		
	Agree	*Disagree*	*Suggestions*	*Agree*	*Disagree*	*Suggestions*	*Agree*	*Disagree*	*Suggestions*	*Agree*	*Disagree*	*Suggestions*
Aerobic Component												
Shuttle Run	**X**	**X**		**X**	**X**		**X**	**X**		**X**	**X**	-1.5 mile run would be a very good test for them, due to their reconnaissance (recce) requirements
Swim	**X**	**X**		**X**	**X**		**X**	**X**		**X**		

Appendix D: Preliminary Validation Questionnaire

Initial Pre/Post Dive Circuit (#1) – Preliminary Validation
Answers recorded on Data Sheet (Appendix E)

SA= Strongly agree; A= Agree; U=Undecided; D=Disagree; SD=Strongly Disagree
VI=Very important; I=Important; MI=Moderately Important; OLI=Of little importance; UI= Unimportant

OVERALL PRE/POST DIVE CIRCUIT	
1) Overall, the pre/post dive circuit reflects tasks I perform in my regular diving duties	___SA ___ A ___ U ___D ___ SD
2) Overall, the physical requirements to complete the pre/post dive circuit are similar to the physical requirements of my CF pre/post diving duties.	___SA ___ A ___ U ___D ___ SD
3) My RPE for the pre/post dive circuit is similar to my RPE when completing my CF pre/post diving duties.	___SA ___ A ___ U ___D ___ SD

Are there any modifications you would make to this circuit? If yes, please make suggestions.	

TEST ITEM #1- Put on tanks, walk 100 m obstacle course	
4) This test item reflects a tasking related to my diving duties.	a)___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an "x" on the appropriate line: 5) The weight of the tanks is reflective of the weight I carry during pre/post dive activities 6) The distance I carried the tanks is reflective of the distance I walk during pre/post dive activities. 7) The obstacles placed throughout the 100 m course are reflective of those encountered during pre/post dive activities. 8) This test item reflects the physical demands I encounter during pre/post dive activities.	___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
9) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	a) ___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item? If yes, please make suggestions.	

TEST ITEM #2- Tanks off, transfer down, maneuver into space	
10) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an “x” on the appropriate line: 11) I would maneuver tanks into a small space at a low level (e.g. ground, floor of RHIB). 12) This test item reflects the physical demands I encounter during pre/post dive activities.	___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
13) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item to make it more similar to your dive duties? If yes, please make suggestions.	

TEST ITEM #3- Pick up and carry weighted milk crate through 100 m obstacle course	
14) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an "x" on the appropriate line: 15) The weight of the milk crate is reflective of the weight of a lost diver marker carried during pre/post dive activities. 16) This test item reflects the physical demands I encounter during pre/post dive activities.	 ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
17) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item? If yes, please make suggestions.	

TEST ITEM #4- Transfer piece of equipment to an overhead platform (~5 ft)	
18) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an “x” on the appropriate line: 19) I transfer equipment to a similar height during pre/post dive activities (e.g. out of a RHIB or onto a shelf in the pod). 20) This test item reflects the physical demands I encounter during pre/post dive activities.	___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
21) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item to make it more similar to your dive duties? If yes, please make suggestions.	

TEST ITEM #5- Pick up and carry weighted dive bag through 100 m obstacle course	
22) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an "x" on the appropriate line: 23) The weight of the dive bag is reflective of the weight I carry during pre/post dive activities. 24) This test item reflects the physical demands I encounter during pre/post dive activities.	 ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
25) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item? If yes, please make suggestions.	

TEST ITEM #6- Put dive gear down and transfer to a medium height (e.g. ht. of flatbed or shelf in a pod	
26) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an “x” on the appropriate line: 27) I transfer equipment to a similar height during pre/post dive activities (e.g. height of the flatbed on a truck). 28) This test item reflects the physical demands I encounter during pre/post dive activities.	 ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
29) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item to make it more similar to your dive duties? If yes, please make suggestions.	

TEST ITEM #7- 100 m course with weighted kettle bell	
30) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an "x" on the appropriate line:	
31) This test item simulates the land-based portion of a diver casualty situation.	___SA ___ A ___ U ___D ___ SD
32) The weight of the kettle bell is reflective of the weight I move on a stretcher.	___SA ___ A ___ U ___D ___ SD
33) The 100 m course is reflective of the distance I transfer a stretcher during diver casualty situations.	___SA ___ A ___ U ___D ___ SD
34) This test item reflects the physical demands I encounter during pre/post dive activities.	___SA ___ A ___ U ___D ___ SD
35) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item? If yes, please make suggestions.	

TEST ITEM #8- Line pull	
36) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an "x" on the appropriate line: 37) The length of the line is reflective of the length of a shot line or anchor recovery, or lifting tanks from a jetty onto the quarterdeck. 38) The weight of the pull is reflective of the weight of a line recovery. 39) This test item reflects the physical demands I encounter during pre/post dive activities.	___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
40) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item? If yes, please make suggestions.	

POOL TESTS- Initial Trials and Validation

TEST ITEM #9- Vertical Weighted Fin-kick	
41) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an "x" on the appropriate line: 42) The kicking action required for this test is similar to that required when working unsupported. 43) Although during dive duties we would not be required to conduct an activity like this, I understand its relevance with respect to simulating leg endurance requirements. 44) This test item reflects the physical demands I encounter during activities where I work unsupported. 45) The ladder exit incorporated at the end of this test reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
46) Please indicate the level of importance of the vertical weighted fin kick with respect to the ability of a diver to complete required job demands safely and efficiently. 47) Please indicated the level of importance of the ladder exit with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U ___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item? If yes, please make suggestions?	

TEST ITEM #10- 1-Knot Aerobic Swim	
48) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an "x" on the appropriate line: 49) The distance swam is similar to the distance I may be required to swim against a 1 knot current. 50) In order to complete the entire distance within the required time, the physical requirements were similar to swimming against a 1-knot current. 51) This test item reflects the physical demands I encounter during activities where I swim against a current.	___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
52) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item? If yes, please make suggestions.	

TEST ITEM #11- 100 m Surface Swim	
53) This test item reflects a tasking related to my diving duties.	___SA ___ A ___ U ___D ___ SD
For each of the statements below, please indicate the extent of your agreement or disagreement by placing an "x" on the appropriate line: 54) The weight in the tool bag is reflective of the weight I would carry during a surface swim. 55) The distance of 100 m is reflective of an average distance I would surface swim. 56) This test item reflects the physical demands I encounter during activities where I work unsupported.	___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD ___SA ___ A ___ U ___D ___ SD
57) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.	___ VI ___I ___MI ___OLI ___ U
Are there any modifications you would make to this test item? If yes, please make suggestions.	

Appendix E: Test Battery Performance & Impression Data Sheet

Name: ____

ID#: __________ Rank: ___________ Age: ____________ Gender: ___________

Dive Group: ______________________________ Years Experience: _______

Testing Location: ____

Pre/Post Dive Circuit:

Lap:	Time on HR Monitor	Split Time	Cumulative Time	RPE
Carry tanks				
Carry LDM	N/a			
Carry dive gear	N/a			
Diver casualty	N/a			
TOTAL Time Circuit	N/a	N/a		
Line Pull				

Pool Tests

Test Item	Time on HR Monitor	Time (min)	RPE
Vertical Weighted Fin-Kick		**5 min Y/N**	
Aerobic Test: **Warm-up** **1 Knot Swim** **50 m** **100 m** **150 m** **200 m** **250 m** **300 m** **350 m** **400 m**			
100 m Surface Swim			

Completed with Answers to Questions included in Appendix D:

TEST ITEM:	Statement:	LS Rating:	Suggestions:
Overall	1		
	2		
	3		
1	4		
	5		
	6		
	7		
	8		
	9		
2	10		
	11		
	12		
	13		
3	14		
	15		
	16		
	17		
4	18		
	19		
	20		
	21		
5	22		
	23		
	24		
	25		

TEST ITEM:	Statement:	LS Rating:	Suggestions:
6	26		
	27		
	28		
	29		
7	30		
	31		
	32		
	33		
	34		
	35		

ARE YOU READY TO GO ONTO THE NEXT TASK?
____YES

____NO : Why do you need more time? ____
How much more time do you need? ___________________________________

8	36		
	37		
	38		
	39		
	40		

Comments/Modifications/Suggestions:

____

____

____

____

____

POOL TESTS

ARE YOU READY TO GO ONTO THE NEXT TASK?
____YES
____NO : Why do you need more time? ________________________________
How much more time do you need? ________________________________

TEST ITEM:	Statement:	LS Rating:	Suggestions:
1	41		
	42		
	43		
	44		
	45		
	46		
	47		

ARE YOU READY TO GO ONTO THE NEXT TASK?
____YES

____NO : Why do you need more time? ________________________________
How much more time do you need? ________________________________

2	48		
	49		
	50		
	51		
	52		

ARE YOU READY TO GO ONTO THE NEXT TASK?
____YES
____NO : Why do you need more time? ________________________________
How much more time do you need? ________________________________

3	53		
	54		
	55		
	56		
	57		

Comments/Modifications/Suggestions:

Appendix F: Summary of Test item modifications

Initial Test Battery Changes from Diver Suggestions and Observations:

Comments:	*Changes Made:*	*Dive Group*	*Date Changes Made:*	*Comments after change:*
SS finning for aerobic test is completely different from swimming U/W	Changed to U/W swim	**ALL**	First day of testing	U/W is very reflective of the jobs the divers do: Strongly agree/agree (SA/A)
Dry suit and wetsuit issues: will be hard to standardize	No wetsuit, no dry suit, just swim trunks, tanks, fins, mask, etc.		December, 2005	None with respect to wetsuit, dry suit, easier to standardize.
Dowelling in cones may not be necessary to simulate confined space.	Tried having divers walk through obstacle course with cones and no dowelling		December, 2005	Divers did not have the same body movements with cones vs. using the dowelling in cones. Dowelling better simulated confined spaces
Fin kick-weighting has been an issue	Find neutral buoyancy, add weight; went from 10 lbs to 6 lbs to 9 lbs to 8 lbs		January 17, 2006	Fin kick causes the fatigue in legs similar to that experienced after working submerged for hours unsupported
LDM too light-was mentioned during first 15-18 tests	40 lbs LDM to 50 lbs LDM		Jan. 17, 2006	No complaints about the LDM weight; weight was SA & A
SS- tool bag too cumbersome, try horse collar	Tried horse collar with STD		Jan. 10, 2006	Horse collar will be obsolete in less than a year, use tool bag
SS-horse collar will be obsolete in a year	Back to tool bag		Jan 17, 2006	8 lbs in the tool bag reflects the work of SS in dry suit

Initial Test Battery Changes from Diver Suggestions and Observations (Con't):

Comments:	***Changes Made:***	***Dive Group:***	***Date Changes Made:***	***Comments after change:***
SS-Tool bag weight change from 8-6-8 lbs	8 lbs was too light for 3 lbs , changed to 6 lbs , which was too light, switched back to 8 lbs	**ALL**	Jan. 18, 2006	Too heavy, too light, changed back to previous 8 lb.
SS- Suggestion, try a weighted stab jacket if we are looking for drag	Weighted a stab jacket with 6 lbs		January 19, 2006	Jacket was too big, divers could inflate BC halfway down if they so chose…went back to 6 lb mesh bag
SS- stab jacket causes too many variables testers can't control (adding air)	Went back to 6 lb, not 8 lb as we reflected on the divers who said 6 lbs was too light, and wanted more input on weight from additional divers Body position too low in water		January 20, 2006	SA & A
Cones with doweling are not reflective of the movements	Separated the cones, starting at 6 m have 3 cones, 12 m have 3 cones		January 24, 2006	No more comments about it being not being reflective; SA & A
5' height may cause injury and could be unsafe	Changed to a 4' height for LDM lift		January 25, 2006	More reflective and safer
Sliding the tanks under the bench is too cumbersome	Slide the tanks under the table at the beginning and at the end		January 25, 2006	No further comments
Standardization	Standardized 1 m from start cone to bench		January 25, 2006	Good

Initial Test Battery Changes from Diver Suggestions and Observations (Con't):

Comments:	***Changes Made:***	***Dive Group:***	***Date Changes Made:***	***Comments after change:***
Need to incorporate a task where the divers carry tanks by manifold out in front	Added a 40 m carry to the first set of cones and back (w/ stairs) as a task completion item	**COMBAT**	January 26, 2006	SA & A…good change
Never carry a 50 lb load out in front like the milk crate carry	Changed to 2, 25 lb dumbbells carried in either hand around 100 m course		January 26, 2006	SA & A
UVic Team- difficult to lift 2, 25 lb dumbbells to 4'	Divers now lift 50 lb milk crate to 4', put it down, pick up 2, 25 lb dumbbells, go through course, put them down, pick up m.c. lift to 4'		January 26, 2006	SA & A

Appendix G: Summary of Test Item Validation Data

Initial Pre/Post Dive Circuit (#1) – Preliminary Validation

SA= Strongly agree; A= Agree; U=Undecided; D=Disagree; SD=Strongly Disagree
VI=Very important; I=Important; MI=Moderately Important; OLI=Of little importance; UI= Unimportant

OVERALL PRE/POST DIVE CIRCUIT

1) Overall, the pre/post dive circuit reflects tasks I perform in my regular diving duties

	SD	**D**	**U**	**A**	**SA**
Cl (/26)	0	0	0	17	9
ST (/23)	0	0	0	16	7
PIDT (/11)	0	0	0	7	4
Cbt (/21)	0	0	0	13	8
Total *(/81)*	0	0	0	53	28

Overall, the physical requirements to complete the pre/post dive circuit are similar to the physical requirements of my CF pre/post diving duties.

	SD	D	U	A	SA
Cl (/26)	0	0	0	19	7
ST (/23)	0	0	0	19	4
PIDT (/11)	0	0	0	7	4
Cbt (/21)	0	0	0	16	5
Total *(81)*	0	0	0	61	20

My RPE for the pre/post dive circuit is similar to my RPE when completing my CF pre/post diving duties.

	SD	D	U	A	SA
Cl (/26)	0	0	1	19	6
ST (/23)	0	0	0	19	4
PIDT (/11)	0	0	0	7	4
Cbt (/21)	0	1	1	13	6
Total *(/81)*	0	1	2	58	20

TEST ITEM #1- Put on tanks, walk 100 m obstacle course

4) This test item reflects a tasking related to my diving duties.

	SD	D	U	A	SA
Cl (/26)	0	0	1	19	6
ST (/23)	0	0	0	17	6
PIDT (/11)	0	0	0	5	6
Cbt (/21)	0	1	0	10	10
Total *(/81)*	0	1	1	51	28

5) The weight of the tanks is reflective of the weight I carry during pre/post dive activities

	SD	D	U	A	SA
Cl (/26)	0	1	2	17	6
ST (/23)	0	0	0	14	9
PIDT (/11)	0	0	1	5	6
Cbt (/21)	0	0	0	7	14
Total *(/81)*	0	1	3	43	35

6) The distance I carried the tanks is reflective of the distance I walk during pre/post dive activities.

	SD	D	U	A	SA
Cl (/26)	0	0	0	19	7
ST (/23)	0	2	0	14	7
PIDT (/11)	0	0	0	4	7
Cbt (/21)	0	1	0	10	10
Total *(/81)*	0	3	0	47	31

7) The obstacles placed throughout the 100 m course are reflective of those encountered during pre/post dive activities.

	SD	D	U	A	SA
Cl (/26)	0	0	2	20	4
ST (/23)	0	1	0	17	5
PIDT (/11)	0	0	0	5	6
Cbt (/21)	0	0	0	10	11
Total *(/81)*	0	1	2	52	26

8) This test item reflects the physical demands I encounter during pre/post dive activities.

	SD	D	U	A	SA
Cl (/26)	0	0	0	19	7
ST (/23)	0	0	0	16	7
PIDT (/11)	0	0	0	6	5
Cbt (/21)	0	0	0	13	8
Total *(/81)*	0	0	0	54	27

9) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.		UI	OLI	MI	I	VI
	Cl (/26)	0	0	0	7	19
	ST (/23)	0	1	2	13	7
	PIDT (/11)	0	0	0	0	11
	Cbt (/21)	0	0	0	3	18
	Total *(/81)*	0	1	2	23	55

TEST ITEM #2- Tanks off, transfer down, maneuver into space

10) This test item reflects a tasking related to my diving duties.		SD	D	U	A	SA
	Cl (/26)	0	0	0	14	12
	ST (/23)	0	0	1	1	21
	PIDT (/11)	0	0	0	2	9
	Cbt (/21)	0	0	0	8	13
	Total *(/81)*	0	0	1	25	55

11) I would maneuver tanks into a small space at a low level (e.g. ground, floor of RHIB).		SD	D	U	A	SA
	Cl (/26)	0	0	1	13	12
	ST (/23)	0	1	0	10	12
	PIDT (/11)	0	0	0	5	6
	Cbt (/21)	0	0	0	2	19
	Total *(/81)*	0	1	1	30	49

12) This test item reflects the physical demands I encounter during pre/post dive activities		SD	D	U	A	SA
	Cl (/26)	0	0	1	13	12
	ST (/23)	0	0	0	13	10
	PIDT (/11)	0	0	0	4	7
	Cbt (/21)	0	0	0	9	12
	Total *(/81)*	0	0	1	39	41

13) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.		UI	OLI	MI	I	VI
	Cl (/26)	0	0	1	6	19
	ST (/23)	0	0	0	8	15
	PIDT (/11)	0	0	0	2	9
	Cbt (/21)	0	0	0	2	19
	Total *(/81)*	0	0	1	18	62

TEST ITEM #3- Pick up and carry weighted milk crate through 100 m obstacle course

14) This test item reflects a tasking related to my diving duties.

	SD	D	U	A	SA
Cl (/26)	0	0	2	12	12
ST (/23)	0	0	0	13	10
PIDT (/11)	0	0	0	4	7
Cbt (/21)	0	0	0	14	7
Total *(/81)*	0	0	2	43	36

15) The weight of the milk crate is reflective of the weight of a lost diver marker carried during pre/post dive activities.

	SD	D	U	A	SA
Cl (/26)	0	2	0	11	13
ST (/23)	0	0	0	14	9
PIDT (/11)	0	0	1	5	6
Cbt (/21)	0	1	0	9	11
Total *(/81)*	0	2	1	39	39

16) This test item reflects the physical demands I encounter during pre/post dive activities.

	SD	D	U	A	SA
Cl (/26)	0	0	0	13	13
ST (/23)	0	1	0	14	8
PIDT (/11)	0	0	0	6	5
Cbt (/21)	0	1	0	11	9
Total *(/81)*	0	2	0	44	35

17) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.

	UI	OLI	MI	I	VI
Cl (/26)	0	0	2	6	18
ST (/23)	0	0	1	10	12
PIDT (/11)	0	0	0	2	9
Cbt (/21)	0	0	0	8	13
Total *(/81)*	0	0	3	26	52

TEST ITEM #4- Transfer piece of equipment to an overhead platform (~4ft)

18) This test item reflects a tasking related to my diving duties.

	SD	D	U	A	SA
Cl (/26)	0	0	1	16	9
ST (/23)	0	1	1	15	6
PIDT (/11)	0	0	0	4	7
Cbt (/21)	0	0	2	11	8
Total *(/81)*	0	1	4	46	30

19) I transfer equipment to a similar height during pre/post dive activities (e.g. out of a RHIB or onto a shelf in the pod).		SD	D	U	A	SA
	Cl (/26)	0	1	2	16	7
	ST (/23)	0	0	2	14	7
	PIDT (/11)	0	0	0	5	6
	Cbt (/21)	0	0	4	8	9
	Total *(/81)*	0	1	8	39	29

20) This test item reflects the physical demands I encounter during pre/post dive activities.		SD	D	U	A	SA
	Cl (/26)	0	0	1	17	8
	ST (/23)	0	0	1	16	6
	PIDT (/11)	0	0	0	6	5
	Cbt (/21)	0	0	0	11	10
	Total *(/81)*	0	0	2	50	29

21) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.		UI	OLI	MI	I	VI
	Cl (/26)	0	0	1	17	8
	ST (/23)	0	1	2	7	13
	PIDT (/11)	0	0	0	5	6
	Cbt (/21)	0	0	0	6	15
	Total *(/81)*	0	1	3	35	42

TEST ITEM #5 Pick up and carry weighted dive bag through 100 m obstacle course

22) This test item reflects a tasking related to my diving duties.

	SD	D	U	A	SA
Cl (/26)	0	0	0	17	9
ST (/23)	0	0	0	14	9
PIDT (/11)	0	0	0	4	7
Cbt (/21)	0	1	0	11	9
Total *(/81)*	0	1	0	46	34

23) The weight of the dive bag is reflective of the weight I carry during pre/post dive activities.

	SD	D	U	A	SA
Cl (/26)	0	0	1	15	10
ST (/23)	0	0	0	14	9
PIDT (/11)	0	0	0	6	5
Cbt (/21)	0	2	0	10	9
Total *(/81)*	0	2	1	45	33

24) This test item reflects the physical demands I encounter during pre/post dive activities.

	SD	D	U	A	SA
Cl (/26)	0	0	0	18	8
ST (/23)	0	0	0	15	8
PIDT (/11)	0	0	0	6	5
Cbt (/21)	0	2	0	9	10
Total *(/81)*	0	2	0	48	31

25) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.

	UI	OLI	MI	I	VI
Cl (/26)	0	0	1	6	19
ST (/23)	0	0	0	6	17
PIDT (/11)	0	0	0	4	7
Cbt (/21)	0	1	0	3	17
Total *(/81)*	0	1	1	19	60

TEST ITEM #6- Put dive gear down and transfer to a medium height (e.g. ht. of flatbed or shelf in a pod

26) This test item reflects a tasking related to my diving duties.

	SD	D	U	A	SA
Cl (/26)	0	0	0	17	9
ST (/23)	0	1	0	12	10
PIDT (/11)	0	0	0	5	6
Cbt (/21)	0	0	0	10	11
Total *(/81)*	0	1	0	44	36

27) I transfer equipment to a similar height during pre/post dive activities (e.g. height of the flatbed on a truck).		SD	D	U	A	SA
	Cl (/26)	0	0	0	18	8
	ST (/23)	0	1	0	13	9
	PIDT (/11)	0	0	0	6	5
	Cbt (/21)	0	0	0	12	9
	Total *(/81)*	0	1	0	49	31

28) This test item reflects the physical demands I encounter during pre/post dive activities.		SD	D	U	A	SA
	Cl (/26)	0	0	0	18	8
	ST (/23)	0	0	0	13	10
	PIDT (/11)	0	0	1	3	7
	Cbt (/21)	0	0	0	13	8
	Total *(/81)*	0	0	1	47	33

29) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.		UI	OLI	MI	I	VI
	Cl (/26)	0	0	1	8	17
	ST (/23)	0	0	1	8	14
	PIDT (/11)	0	0	1	4	6
	Cbt (/21)	0	0	0	3	18
	Total *(/81)*	0	0	3	23	55

TEST ITEM #7- 100 m course with weighted kettle bell

30) This test item reflects a tasking related to my diving duties.		SD	D	U	A	SA
	Cl (/26)	0	1	0	12	13
	ST (/23)	0	0	0	10	13
	PIDT (/11)	0	0	0	4	7
	Cbt (/21)	0	1	2	6	11
	Total *(/80)*	0	2	2	32	44

31) This test item simulates the land-based portion of a diver casualty situation.		SD	D	U	A	SA
	Cl (/26)	0	1	0	12	13
	ST (/23)	0	1	0	11	11
	PIDT (/11)	0	0	0	4	7
	Cbt (/20)	0	1	1	7	11
	Total *(/80)*	0	3	1	34	42

32) The weight of the kettle bell is reflective of the weight I move on a stretcher.		SD	D	U	A	SA
	Cl (/26)	0	2	1	10	13
	ST (/23)	0	1	1	13	8
	PIDT (/11)	0	0	0	5	6
	Cbt (/20)	0	2	1	7	10
	Total *(/80)*	0	5	3	35	37

33) The 100 m course is reflective of the distance I transfer a stretcher during diver casualty situations.		SD	D	U	A	SA
	Cl (/26)	0	1	2	10	13
	ST (/23)	0	0	1	14	8
	PIDT (/11)	0	0	0	5	6
	Cbt (/20)	0	2	1	6	11
	Total *(/80)*	0	3	4	35	38

34) This test item reflects the physical demands I encounter during pre/post dive activities.		SD	D	U	A	SA
	Cl (/26)	0	1	1	14	10
	ST (/23)	0	2	1	10	10
	PIDT (/11)	0	0	0	4	7
	Cbt (/20)	0	0	1	8	11
	Total *(/80)*	0	3	3	36	38

35) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.		UI	OLI	MI	I	VI
	Cl (/26)	0	0	1	3	22
	ST (/23)	0	0	0	3	20
	PIDT (/11)	0	0	0	2	9
	Cbt (/20)	0	0	0	1	19
	Total *(/80)*	0	0	1	9	70

TEST ITEM #8- Line pull

36) This test item reflects a tasking related to my diving duties.		SD	D	U	A	SA
	Cl (/26)	0	0	0	14	12
	ST (/23)	0	0	0	11	12
	PIDT (/11)	0	0	0	7	4
	Cbt (/21)	0	0	0	9	12
	Total *(/81)*	0	0	0	41	40

37) The length of the line is reflective of the length of a shot line or anchor recovery, or lifting tanks from a jetty onto the quarterdeck.

	SD	D	U	A	SA
Cl (/26)	0	0	0	20	6
ST (/23)	0	0	2	10	11
PIDT (/11)	0	0	0	5	6
Cbt (/21)	0	0	0	8	13
Total *(/81)*	0	0	2	43	36

38) The weight of the pull is reflective of the weight of a line recovery.

	SD	D	U	A	SA
Cl (/26)	0	0	0	16	10
ST (/23)	0	1	0	11	11
PIDT (/11)	0	0	0	6	5
Cbt (/21)	0	0	1	9	11
Total *(/81)*	0	1	1	42	37

39) This test item reflects the physical demands I encounter during pre/post dive activities.

	SD	D	U	A	SA
Cl (/26)	0	0	0	15	11
ST (/23)	0	0	1	11	11
PIDT (/11)	0	0	0	6	5
Cbt (/21)	0	1	0	9	11
Total *(/81)*	0	1	1	41	38

40) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.

	UI	OLI	MI	I	VI
Cl (/26)	0	0	3	11	12
ST (/23)	0	1	1	6	15
PIDT (/11)	0	0	0	6	5
Cbt (/21)	0	0	1	6	14
Total *(/81)*	0	1	5	29	46

POOL TESTS- Initial Trials and Validation

TEST ITEM #1- Vertical Weighted Fin-kick

41) This test item reflects a tasking related to my diving duties.		SD	D	U	A	SA
	Cl (/26)	0	1	0	18	7
	ST (/22)	0	0	0	11	11
	PIDT (/11)	0	0	0	3	8
	Cbt (/20)	0	0	1	13	6
	Total *(/79)*	0	1	1	45	32

42) The kicking action required for this test is similar to that required when working unsupported.		SD	D	U	A	SA
	Cl (/26)	0	2	1	16	7
	ST (/22)	0	0	1	11	10
	PIDT (/11)	0	0	0	6	5
	Cbt (/20)	0	0	1	11	8
	Total *(/79)*	0	2	3	44	30

43) Although during dive duties we would not be required to conduct an activity like this, I understand its relevance with respect to simulating leg endurance requirements.		SD	D	U	A	SA
	Cl (/26)	0	1	2	18	5
	ST (/22)	0	0	0	13	9
	PIDT (/11)	0	0	0	4	7
	Cbt (/20)	0	0	2	9	9
	Total *(/79)*	0	1	4	44	30

44) This test item reflects the physical demands I encounter during activities where I work unsupported.		SD	D	U	A	SA
	Cl (/26)	0	2	2	14	8
	ST (/22)	0	0	2	12	8
	PIDT (/11)	0	0	0	6	5
	Cbt (/20)	0	0	0	16	4
	Total *(/79)*	0	2	4	48	25

45) The ladder exit incorporated at the end of this test reflects a tasking related to my diving duties.		SD	D	U	A	SA
	Cl (/26)	0	1		18	7
	ST (/23)	0	2	2	13	6
	PIDT (/11)	0	0	0	6	5
	Cbt	-	-	-	-	-
	Total *(/60)*	0	3	2	37	18

46) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.		UI	OLI	MI	I	VI
	Cl (/26)	0	1	3	7	15
	ST (/22)	0	0	0	7	15
	PIDT (/11)	0	0	0	3	8
	Cbt (/20)	0	0	1	7	12
	Total *(/79)*	0	1	4	24	50

47) Please indicate the level of importance of the ladder exit with respect to the ability of a diver to complete required job demands safely and efficiently.		UI	OLI	MI	I	VI
	Cl (/26)	0	0	3	3	20
	ST (/23)	0	1	3	7	12
	PIDT (/11)	0	0	0	0	11
	Cbt	-	-	-	-	-
	Total *(/60)*	0	1	6	10	43

TEST ITEM #1- 1-Knot Aerobic Swim

48) This test item reflects a tasking related to my diving duties.		SD	D	U	A	SA
	Cl (/26)	0	0	0	14	12
	ST (/23)	0	0	0	13	10
	PIDT (/11)	0	0	0	10	1
	Cbt (/21)	0	0	0	3	18
	Total *(/81)*	0	0	0	40	41

49) The distance swam is similar to the distance I may be required to swim against a 1 knot current.		SD	D	U	A	SA
	Cl (/26)	0	1	0	14	11
	ST (/23)	0	0	1	15	7
	PIDT (/11)	0	0	0	10	1
	Cbt (/21)	0	0	0	9	12
	Total *(/81)*	0	1	1	48	31

50) In order to complete the entire distance within the required time, the physical requirements were similar to swimming against a 1-knot current.		SD	D	U	A	SA
	Cl (/26)	0	1		18	7
	ST (/23)	0	0	1	17	5
	PIDT (/11)	0	0	0	7	4
	Cbt (/21)	0	0	0	3	18
	Total *(/81)*	0	1	1	45	34

51) This test item reflects the physical demands I encounter during activities where I swim against a current		SD	D	U	A	SA
	Cl (/26)	0	1	0	16	9
	ST (/23)	0	0	0	16	7
	PIDT (/11)	0	0	0	7	4
	Cbt (/21)	0	0	0	8	13
	Total *(/81)*	0	1	0	47	33

52) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.		UI	OLI	MI	I	VI
	Cl (/26)	0	0	0	8	18
	ST (/23)	0	0	0	7	16
	PIDT (/11)	0	0	0	7	4
	Cbt (/21)	0	0	0	4	17
	Total *(/81)*	0	0	0	26	55

TEST ITEM #1- 100 m Surface Swim

53) This test item reflects a tasking related to my diving duties.		SD	D	U	A	SA
	Cl (/26)	0	3	1	16	6
	ST (/23)	0	0	0	11	12
	PIDT (/11)	0	0	0	3	8
	Cbt (/21)	0	1	1	7	12
	Total *(/81)*	0	4	2	37	38

54) The weight in the tool bag is reflective of the weight I would carry during a surface swim.		SD	D	U	A	SA
	Cl (/26)	0	4	1	15	6
	ST (/23)	0	0	2	14	7
	PIDT (/11)	0	0	1	9	1
	Cbt (/21)	0	0	3	10	8
	Total *(/81)*	0	4	7	48	22

55) The distance of 100 m is reflective of an average distance I would surface swim		SD	D	U	A	SA
	Cl (/26)	0	1	0	19	6
	ST (/23)	0	1	0	16	6
	PIDT (/11)	0	0	0	7	4
	Cbt (/21)	0	0	1	13	7
	Total *(/81)*	0	2	1	55	23

56) This test item reflects the physical demands I encounter during activities where I swim on the surface.		SD	D	U	A	SA
	Cl (/26)	0	1	0	17	8
	ST (/23)	0	0	0	14	9
	PIDT (/11)	0	0	0	4	7
	Cbt (/21)	0	0	2	7	12
	Total *(/81)*	0	1	2	42	36

57) Please indicate the level of importance of this test item with respect to the ability of a diver to complete required job demands safely and efficiently.		UI	OLI	MI	I	VI
	Cl (/26)	0	0	2	11	13
	ST (/23)	0	0	2	5	16
	PIDT (/11)	0	0	0	4	7
	Cbt (/21)	0	0	1	6	14
	Total *(/81)*	0	0	5	26	50

Appendix H: VO_2 Sub-Study Data Sheet.

Name: ____ Date ____________________

Age: ______ Rank: ________ Dive Experience: _______ Dive Group ___________

Gender: ______

HR monitor: ______

Dive Site:

	Split Time	Cumulative Time	RPE
Carry tanks by manifold	Task complete: Y____ N____	N/A	
Carry tanks with stab jacket			
Transition			X
Carry dive equipment (2x25 lbs)			
Transition			X
Carry dive bag			
TOTAL			

At Naden:

	Split Time	Cumulative Time	RPE
Carry tanks by manifold	Task complete: Y____ N____	N/A	
Carry tanks with stab jacket			
Transition			X
Carry dive equipment (2x25 lbs)			
Transition			X
Carry dive bag			
Diver Casualty			

Appendix I: CF DPFT Data Sheet

CF Diver Physical Fitness Test

Name: ____________________________________ Date _________________

Rank: ______ Gender: _____Age: _____ Ht: _______ Wt: _______

Dive Group: ______________________ Years of CF Dive Experience: __________

Clearance Divers Only:
Current Dept: ________ Previous Depts: EOD, MCM, BDR, REPAIR, TRAINING, other ______

____

PRE/POST DIVE CIRCUIT

	Split Time	**Cumulative Time**	**RPE**
Carry tanks by manifold	Task Complete Y N	**N/A**	
Carry tanks on back	**N/A**		
Transition time			
Carry 25 lb dumbbells			
Transition time			
Carry dive bag			
Diver Casualty			
TOTAL Overall	**N/A**		

LINE PULL: ______Start Time **HR Monitor: _______** Completion: Y N RPE: ______

POOL TESTS: **Start Time HR Monitor: __________**

Vertical Weighted Fin-kick	*Completed 5 minutes: ___Y ___N*		*RPE: _________*
Underwater Aerobic Test	**Split Time**	**Cumulative Time**	**RPE**
Start time **HR Monitor:** ______	*W/U: ________* *Lap 1: _______* *Lap 2: _______* *Lap 3: _______* *Lap 4: _______* *Lap 5: _______* *Lap 6: _______* *Lap 7: _______* *Lap 8: _______*	*Final Time:* ____________	*Overall RPE:* ________
Surface Swim *Start time* **HR Monitor:** ______	**N/A**		

RPE FOR THE ENTIRE TEST BATTERY: _________

Questions:

Chose one descriptor: Strongly Agree (SA)
Agree (A)
Undecided (U)
Disagree (D)
Strongly Disagree (SD)

1) The pre/post dive circuit reflects the physical demands I encounter during my CF pre/post dive duties:

____SA ____A ____U ____D _____SD

2) The pool tests reflect the physical demands I encounter while working unsupported, swimming against current and surface swimming.

____SA ____A ____U ____D _____SD

3) Overall, the entire test including both the pre/post dive circuit and the pool tests, provides a better representation of our CF diving duties and their physical demands compared to the CF EXPRES. *____SA ____A ____U ____D _____SD*

Comments:

Appendix J: Video Analysis Script for Assessment of Pacing

CF Diver Physical Fitness Maintenance Standards
Script for Determining Acceptable Pacing

As you are all aware, the University of Victoria has been contracted by CFPSA to develop a physical fitness maintenance standard for CF diving personnel. Clearance, Ship's Team. Port Inspection and Combat divers have been involved in this project for the past four years. From previous research, including a task analysis, physiological validation of the most physically and most commonly performed diving tasks and incumbent validation of a preliminary test battery, the CF Diver Physical Fitness Test (CFDPFT) has been developed. The test battery has been validated by CF diving personnel and resulted in 97% of the divers agreeing that is it reflective of their pre- and post-diving duties, as well as reflective of the physical demands encountered during dive activities.

While the testing protocol has been standardized, the minimum acceptable rate of work has yet to be determined. You have been chosen as subject matter experts, based on your dive experience and/or your time in the Training department. Your input today is extremely important and it is important that you take this seriously. If you have any questions at this time, please ask.

If there are no further questions (or no questions) I am going to show you a short video of the Pre/post dive Circuit. This circuit is the first test item in the CFDPFT and it is necessary that you initially see the entire pre/post dive circuit.

(Show Pre/post dive Circuit Video ~6 minutes)

Are there any questions about the protocol of the Pre/post dive Circuit?

~Pre/post dive Circuit~ (Hand out form #1)

I am now going to show you a video with a diver completing the Pre/post dive Circuit at different paces. The video does not show the entire Pre/post dive Circuit, but is an edited version of portions of the circuit. As subject matter experts, I ask that you observe each pacing carefully and indicate on the form provided whether you feel each pace shown is an "Unacceptable rate of work" or an "Acceptable rate of work". I would like you to indicate of the "Acceptable" paces, which pace is the minimally acceptable pace? The situation I would like you to compare these different paces with would be that required of CF diving personnel working with a sense of purpose, or with purposeful movement. That is to say, the diver does not have one hour to prepare for the dive, but must prepare and be ready to go as quickly as possible. You must indicate which pace is acceptable in this situation and which pace is not. You may indicate more than one pace as acceptable and more than one pace as unacceptable, but **only one pace may be chosen as "minimally acceptable"** We are looking for you to indicate the minimum rate of work that you, as a supervisor/officer in charge, would expect a diver to be able to perform in order to do their job safely and efficiently, with a sense of purpose/urgency. I must be very clear that while observing the different paces, you must indicate the pace you feel is the *minimally* acceptable work rate.

The choices on your form for each of the seven different paces include "Unacceptable rate of work" and "Acceptable rate of work". I ask that you choose only one of the two options. In addition, please indicate if you feel that the pace is too fast, too slow or is the minimally acceptable pace in the area provided. One minute will be given between each pace for your decision and written comments are more than welcome in the "Comments" area provided. Are there any questions?

From this point on, it would be appreciated if there were no further discussion until the video has been shown in its entirety and all forms have been handed back to me. Please refrain from any discussion and provide an independent response to each pace on the questionnaire. Thank you.

~Diver Casualty~

The following five paces you will observe are of the final lap through the circuit, which is a diver casualty simulation. The diver will carry a 50 lb kettle bell, which simulates carrying a stretcher and completes the 100 m course, simulating the stretcher carry portion of a diver casualty situation. As you will notice that the diver omits all obstacles in the course except for the stairs. This has been done for safety purposes. At this point in the circuit, the diver may go into a slow jog due to the fact that this type of movement is permissible when completing this CF dive task on site.

The choices on your form for each of the five different paces include "Unacceptable rate of work" and "Acceptable rate of work". I ask that you choose only one of the two options. In addition, please indicate if you feel that the pace is too fast, too slow or is the minimally acceptable rate of work in the area provided. One minute will be given between each pace for your decision and written comments are more than welcome in the "Comments" area provided. Are there any questions?

In-Water Tests

~Underwater Swim~ (Hand out form #2)

The first in-water test is a vertical weighted fin-kick. This is a task completion test and has been validated by the CF diving personnel as reflective of working unsupported for a prolonged period of time. The standard has already been determined for this test item.

The second in-water test included as part of the CFDPFT is the underwater swim, which simulates underwater searches, navigation swim, swimming away from a threat, mine countermeasure, etc. Divers submerge to 3-4 feet and complete 8 laps of a 50 m rectangular circuit, totally 400 m of underwater swimming. On Form #2, a summary of the progress a diver would make at different paces swimming against 1 Knot, 0.75 Knots and 0.5 Knots of current at various completion times has been included for you. Please examine each pacing and the progress a diver would make and choose a time you feel a diver would have to achieve to be able to swim underwater against current in a safe and efficient manner. Again, you need to choose the *minimum* pace CF divers must be able to achieve.

The following is an example of how to interpret the table on Form #2:

If a diver completed each lap in 1:30 (please look under the "Split time for 50 m course" and find 1:30), it would take 12 minutes for the diver to complete the 400 m underwater swim test. In this time, if the diver was swimming against 1 knot of current, they would progress a total of 30.2 m in 12 minutes, against 0.75 knots the diver would progress 122.4 m in 12 minutes and 215.3 m against 0.5 knots of current. As a subject matter expert, you need to identify which pace would elicit an acceptable rate of progression swimming against current.

To maintain position:
1 Knot: 0.514 m/sec = 400 m/778 s = 13 minutes
0.75 Knots: 0.386 m/sec = 400 m/1036 s = 17 minutes
0.5 Knots: 0.257 m/sec = 400 m/1556 s = 26 minutes

Split time for 50 m course (min)	Time to Complete 400 m Swim	Progression Against 1 Knot (m)	Progression Against 0.75 (m)	Progression Against 0.5 Knots (m)
1:25	11.3 min (680sec)	50.3	137.4	225.1
1:30	12.0 min (720sec)	30.2	122.4	215.3
1:35	12.7 min (760sec)	9.1	106.4	204.4
1:40	13.3 min (800sec)	-11.2	91.2	194.4
1:45	14.0 min (840sec)	-31.9	75.6	134.0

Please refrain from any discussion and provide an independent response to each pace on the questionnaire. Thank you.

~Surface Swim~ (Hand out form #3)

The third and final test of the CFDPFT is a 100 m surface swim, which simulates a rescue swim, swimming to an insertion point, etc. Divers are asked to swim on their side with 6 lbs placed in a mesh bag. The mesh bag must be held in one of the hands throughout the 100 m. The additional weight is not meant to simulate anything, but is there to provide resistance to the diver and give them something to "fight" against. The pool has little to no current and the diver does not have to swim against wind, current or waves, therefore the additional weight increases the intensity of this test item.

On Form #3, a summary of the progress a diver would move against 1 knot, 0.75 Knots and 0.5 Knots of current in 100 m swimming at different paces. Please indicate the *minimum* acceptable rate a diver must be able to surface swim to complete surface swimming duties safely and efficiently.

The following is an example of how to interpret the table on Form #3:

If a diver completed the 100 m surface swim in 2:30 (please find 2:30 in the "Time to Complete 100, Swim" column), the diver would progress 23, 42, 62 and 81 m against 1, 0.75, 0.5 and 0.25 knots of current. As a subject matter expert, you need to identify which pace would elicit an acceptable rate of progression for swimming on the surface against current.

Time to Complete 100 m Swim (min:s)	Progression Against 1 Knot (m)	Progression Against 0.75 (m)	Progression Against 0.5 Knots (m)	Progression Against 0.25 Knots (m)
2:20	28	46	64	82
2:30	23	42	62	81
2:40	18	38	59	79
2:50	13	34	56	78
3:00	8	30	54	76

Again, it would be appreciated if there were no further discussion at this point until all forms have been handed back to me. Thank you.

This concludes our meeting for today. Thank you for your time. Your input as subject matter experts has been extremely important to this project.

Appendix K: Video Analysis-Pacing Assessment Data Sheet

Video Analysis: Land-Based Test Items

Name: ____

Rank: _________

Date: _________________________________

Dive Group: ___________________________

Years of Dive Experience: ________________

Cl Divers Only: Current Department: _______

Previous Departments: ______________________________________

As part of the training staff for ST and PID divers, do you feel that the pace for these groups requires a different rate of work?

___ YES It should be faster. ___ YES It should be slower.

___ NO

Please explain your answer:

____

____

____

FORM #1:
Pre/post dive Circuit

Please indicate in the area provided if you feel the pace is acceptable/unacceptable for a diver working with "a sense of purpose".

PACE #1:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #2:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #3:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #4:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #5:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:

PACE #6:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:

PACE #7:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:

Diver Casualty

Please indicate in the area provided if you feel the pace is acceptable/unacceptable for a diver working with "a sense of purpose".

PACE #1:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #2:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #3:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #4:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #5:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

Appendix L: Equipment Transfer Pacing Assessment Data Sheet

Video Analysis- Equipment Transfers

Name: ____

Rank: _________

Date: ________________________________

Dive Group: __________________________

Years of Dive Experience: ________________

CF divers previously outlined the following 5 safety criteria for safely maneuvering, transferring and lifting dive equipment:

1) Safe lifts, supporting the back

2) Lift with the knees

3) Biomechanically correct

4) Continuous movement

5) Efficient and smooth donning of equipment

Keeping in the mind the five safety criteria outlined above and also recognizing the importance of moving with a sense of purpose or with purposeful movement, for each equipment transfer, please indicate if the pace at which the diver moved met the safety criteria and moved with purposeful movement or with a sense of purpose.

Keeping in the mind the five safety criteria previously outlined and the importance of a diver moving with a sense of purpose or with purposeful movement, was the pace at which the diver in the video transferred equipment acceptable or unacceptable?

Equipment Transfer #1- Working with dive tanks:

PACE #1:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #2:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #3:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

Keeping in the mind the five safety criteria previously outlined and the importance of a diver moving with a sense of purpose or with purposeful movement, was the pace at which the diver in the video transferred equipment acceptable or unacceptable?

Equipment Transfer #2- Lifting a crate to a 4' height:

PACE #1:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #2:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #3:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

Keeping in the mind the five safety criteria previously outlined and the importance of a diver moving with a sense of purpose or with purposeful movement, was the pace at which the diver in the video transferred equipment acceptable or unacceptable?

Equipment Transfer #3: Lifting dive bag onto table and preparing to walk

PACE #1:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
___
___
___
___

PACE #2:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
___
___
___
___

PACE #3:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
___
___
___
___

Keeping in the mind the five safety criteria previously outlined and the importance of a diver moving with a sense of purpose or with purposeful movement, was the pace at which the diver in the video transferred equipment acceptable or unacceptable?

Equipment Transfer #4- Taking off dive bag and placing back on floor:

PACE #1:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #2:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

PACE #3:
___ Acceptable ___Too Fast ___Too Slow
___ Unacceptable ___Too Fast ___Too Slow

Comments:
____
____
____
____

Appendix M: Pacing Assessment of Water-Based Test Items- Data Sheet

FORM #2
Underwater Swim

To maintain position:
1 Knot: 0.514 m/s = 400 m/778 s= 13 minutes
0.75 Knots: 0.386 m/ s = 400 m/1036 s = 17 minutes (approx)
0.5 Knots: 0.257 m/s = 400 m/1556s = 26 minutes

Lap time (min:s)	Time to Complete 400 m Swim	Progression Against 1 Knot (m)	Progression Against 0.75 (m)	Progression Against 0.5 Knots (m)
1:25	11.3 min (680sec)	50.3	137.4	225.1
1:30	12.0 min (720sec)	30.2	122.4	215.3
1:35	12.7 min (760sec)	9.1	106.4	204.4
1:40	13.3 min (800sec)	-11.2	91.2	194.4
1:45	14.0 min (840sec)	-31.9	75.6	134.0

Lap time (min:s)		Too Fast	Too Slow
1:25	___Unacceptable rate of work		
	___Acceptable rate of work		
1:30	___Unacceptable rate of work		
	___Acceptable rate of work		
1:35	___Unacceptable rate of work		
	___Acceptable rate of work		
1:40	___Unacceptable rate of work		
	___Acceptable rate of work		
1:45	___Unacceptable rate of work		
	___Acceptable rate of work		

Comments:
____
____
____
____

FORM #3
Surface Swim

Time to Complete 100 m Swim	Progression Against 1 Knot (m)	Progression Against 0.75 (m)	Progression Against 0.5 Knots (m)	Progression Against 0.25 Knots (m)
2:20	28	46	64	82
2:30	23	42	62	81
2:40	18	38	59	79
2:50	13	34	56	78
3:00	8	30	54	76

Lap time (min)		Too Fast	Too Slow
2:20	___Unacceptable rate of work		
	___Acceptable rate of work		
2:30	___Unacceptable rate of work		
	___Acceptable rate of work		
2:40	___Unacceptable rate of work		
	___Acceptable rate of work		
2:50	___Unacceptable rate of work		
	___Acceptable rate of work		
3:00	___Unacceptable rate of work		
	___Acceptable rate of work		

Comments:

____

____

____

____

____

____

Appendix N: Reliability Study Data Sheets

CF Diver Physical Fitness Test
Information for Reliability Study:
TRIAL ONE

Name: ______________________________________ Date __________________

Rank: ______ Gender: _____Age: _____ Ht: _______ Wt: _______

Dive Group: _______________________ Years of CF Dive Experience: __________

Clearance Divers Only:
Current Dept: ________ Previous Depts: EOD, MCM, BDR, REPAIR, TRAINING, other ______

PRE/POST DIVE CIRCUIT

	Split Time	**Cumulative Time**
Carry tanks by manifold	Task Complete Y N	**N/A**
Carry tanks on back	**N/A**	
Transfer tanks		
Transition time		
Transfer crate		
Carry 25 lb dumbbells		
Transfer crate		
Transition time		
Transfer dive bag		
Carry dive bag		
Transfer dive bag		
Diver Casualty		
TOTAL Overall	**N/A**	

LINE PULL: **Start Time** **HR Monitor**: _______ Completion: Y N

POOL TESTS: **Start Time HR Monitor: __________**

Vertical Weighted Fin-kick	*Completed 5 minutes: ___Y ___N*	
Underwater Aerobic Test	**Split Time**	**Cumulative Time**
	W/U: ________ *Lap 1:* _______ *Lap 2:* _______ *Lap 3:* _______ *Lap 4:* _______ *Lap 5:* _______ *Lap 6:* _______ *Lap 7:* _______ *Lap 8:* _______	*Final Time:* ___________
Surface Swim *Start time*	**N/A**	

CF Diver Physical Fitness Test
Information for Reliability Study:
TRIAL TWO

Name: ____ Date __________________

Rank: ______ Gender: _____Age: _____ Ht: _______ Wt: _______

Dive Group: _______________________ Years of CF Dive Experience: __________

Clearance Divers Only:
Current Dept: ________ Previous Depts: EOD, MCM, BDR, REPAIR, TRAINING, other ______

____

PRE/POST DIVE CIRCUIT

	Split Time	**Cumulative Time**
Carry tanks by manifold	Task Complete Y N	**N/A**
Carry tanks on back	**N/A**	
Transfer tanks		
Transition time		
Transfer crate		
Carry 25 lb dumbbells		
Transfer crate		
Transition time		
Transfer dive bag		
Carry dive bag		
Transfer dive bag		
Diver Casualty		
TOTAL Overall	**N/A**	

LINE PULL: **Start Time** **HR Monitor:** _______ Completion: Y N

POOL TESTS: **Start Time HR Monitor: __________**

Vertical Weighted Fin-kick	*Completed 5 minutes: ___Y ___N*	
Underwater Aerobic Test	**Split Time**	**Cumulative Time**
	W/U: ________ *Lap 1: _______* *Lap 2: _______* *Lap 3: _______* *Lap 4: _______* *Lap 5: _______* *Lap 6: _______* *Lap 7: _______* *Lap 8: _______*	*Final Time:* ___________
Surface Swim *Start time*	**N/A**	