A group of people wearing high-visibility yellow and red winter suits are walking across a snowy airfield. In the background, there is a large white hangar and a helicopter with the registration 'C-GDM' visible. The scene is set in a cold, snowy environment during what appears to be late afternoon or early morning.

A Methodology for the Evaluation of Thermal Stress Levels when wearing Extreme Cold Weather Immersion Suits During Helicopter Transit

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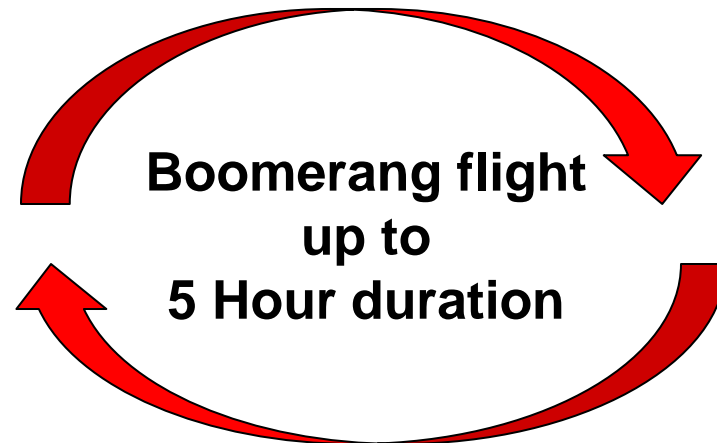
Chief Designer – Survitec Group

Introduction

- Passengers and Aircrew travelling over cold water must be equipped with the appropriate waterproof and insulating protective clothing to protect them against the worst-case cold water ditching scenario. (2° C for a 6 hour period)



- It is equally important that their protective clothing does not cause excessive thermal burden during the transit phase to maintain wearer comfort and acceptance of the suit during long periods of wear.



- To ensure that concentration, physical performance, and endurance are not comprised in the event of an Escape or Survival situation.

Performance Requirements

REGULATORY COMPLIANCE
Provide insulation for survival in water at 2°C for up to 6 hours
Full body coverage apart from eyes, nose and mouth
Immersed insulation value of .75 Clo
Comfort and Mobility
Minimal water ingress (seals)



BEYOND COMPLIANCE
Heat Stress Limits
Humidity conditions
Human Physiology
Tactical de-hydration
Helicopter Cabin Habitability
Ability to negatively influence emergency escape procedures

Design Considerations

- **Material Selection – Light weight**
- **Breathable and Moisture Vapour Permeable**
- **Improved tailoring to minimise excess material and improve comfort and mobility**
- **Thermal Liner design and material selection**
- **3D spacer fabric – in-water insulation, low bulk**
- **Ease of donning and closure**
- **Low weight**



Test Methodology

- John Moores University School of Sport and Exercise Science
- **Determination of Test Parameters**
 - **Pass / Fail criteria**
 - **Data Collection**
 - **Subject Selection Criteria**
 - **Underlying clothing layers**
 - **Realistic environmental test conditions – aligned with operational conditions**
 - **Data analysis and results**
- **Determination of Pass/Fail criteria**
 - **Hyperthermia (Core temperature rises to between 37.5 - 38.3°C (99.5 -100.9°F))**
 - **Percentage reduction in cognitive performance**
 - **Ability / in-ability to carry out emergency escape procedures following an extended period in a representative cockpit environment.**
 - **Wearer acceptance**



Subject Selection Criteria

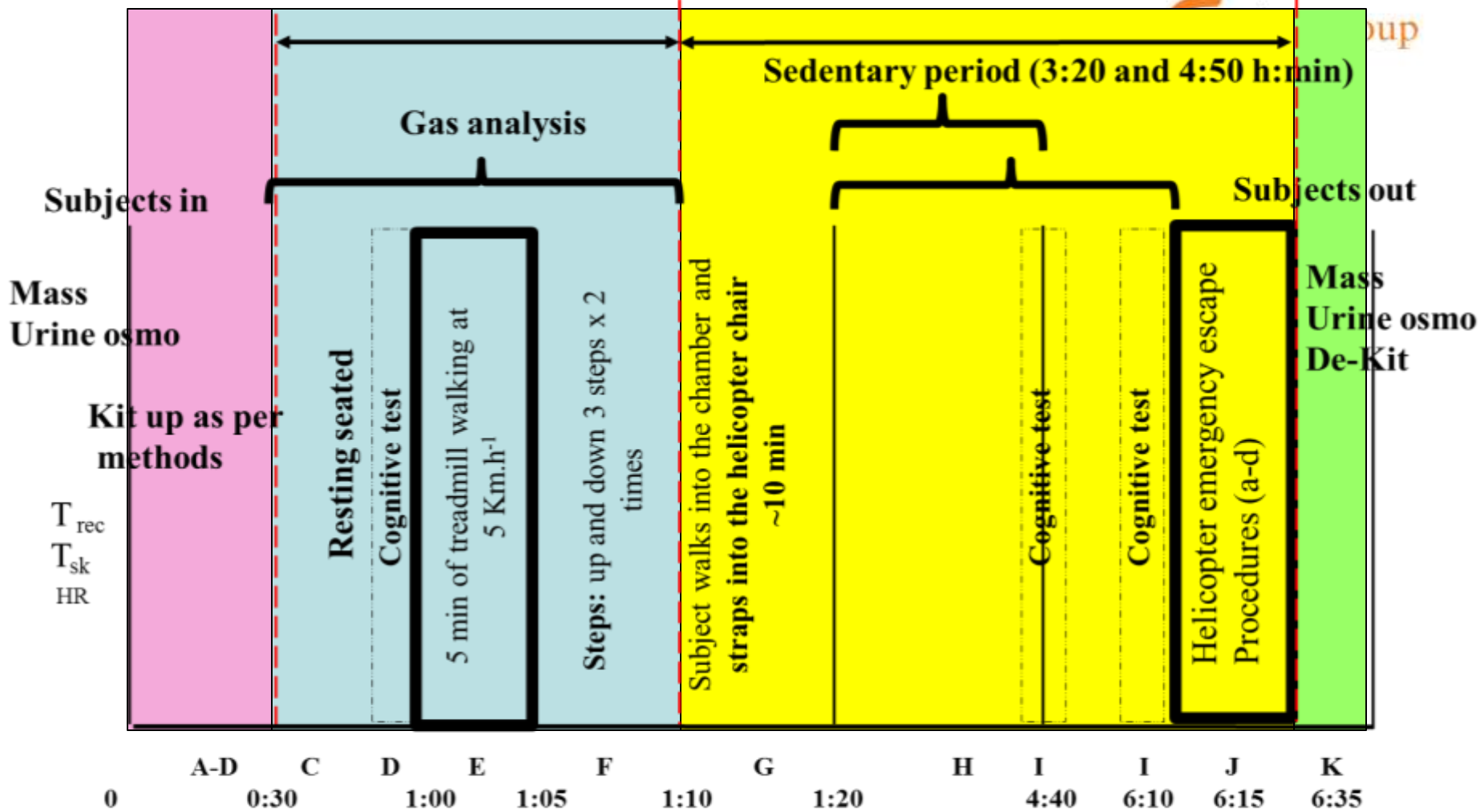
- **Gender** – Male and Female subjects
- **Number of subjects** – Minimum of six (four male subjects and two female) subjects representative of the size range of the suit system under test.
- **Age range** - Based on age range typical of the off shore sector that the suit is to be used – typically 25 and 55 years old.
- **Sizes** - Sized to fit into one of the standard suits selected from the suits size range. Represented range from small to large.

Note : Special Measures not included in study to minimise base line variances



Realistic Test Environmental Conditions – aligned with operational conditions

- **This testing was designed, based on a typical Canadian Helicopter Passenger sortie:**
- **A cognitive number cancelation or word-colour interference test. – (Stroop test)**
- **A pre-flight walk-out exercise of 5 km/hour for 5 minutes on a non powered tread mill in an ambient air temperature of $\sim 19.0^{\circ}$ C and a relative humidity of $\sim 47\%$**
- **A short step climb (step up and down on the 3 steps twice) – to replicate boarding the helicopter.**
- **A sedentary period of 5 hours strapped into a representative helicopter seat in an ambient cockpit temperature of 28.0° C and relative humidity of $\sim 47\%$. A cognitive number cancelation or word-colour interference test was then repeated.**
- **Assessment of ability to conduct Emergency and Escape procedures**



Average time lines (h:min) after start of experiment

Visual schematic from subjects entering the laboratory, getting kitted up and entering Chamber 1 at 19° C to leaving Chamber 2 after 5 hours at 28°C

Data collection

The test data collated to provide evidence of the levels of thermal burden experienced by the test subjects consisted of the following:

- The core (rectal) temperature (Thermo Regulatory Responses)
- Heart rate
- Skin temperature (Thermo Regulatory Responses)
- Thermal sensation (Thermal comfort)
- Cognitive performance (% incorrect responses) (Cognitive Assessment)
- Sweat loss (Urine Osmolarity)
- Subject narrative during the trials



Pre- test Walkout and Step Climb



A pre-flight walk-out exercise of 5 km/hour for 5 minutes walk on a non powered tread mill



A short step climb (step up and down on the 3 steps twice) – to replicate boarding the helicopter



A sedentary period of 5 hours strapped in a representative helicopter seat in an ambient cockpit temperature.

Results

TEST CRITERIA	RESULTS
The core (rectal) temperature (Thermo Regulatory Responses)	Increased as expected. Temperature rise no more than 0.18 and 0.22 °C respectively. (average and worst case)
Heart rate	No significant difference in heart rate throughout the test period.
Skin temperature (Thermo Regulatory Responses)	Thermoregulation mechanisms evident to cool the body representing only small changes of ~ 0.18 and 0.22 °C for core temperature at the 'average' and 'worst' case scenario respectively
Thermal sensation (Thermal comfort)	No reported difference in thermal comfort over the 5 hours
Cognitive performance (% incorrect responses) (Cognitive Assessment)	No effect on cognitive function in familiarised subjects at the worst case scenario time line (in 28 °C) compared to resting in a 19 °C environment. Still capable of carrying out the helicopter emergency escape procedures following a period of wear of the suit of up to 6:15 h:min. (5 hours at 28°C)
Sweat loss (Urine Osmolarity)	Because the subjects were suitably hydrated before the experiment started, even with the restricted fluid intake and because of the low thermal burden (hence low sweat loss) subjects were not dehydrated at the end of the testing.
Subject narrative during the trials	Comfort and thermal sensitivity was fully acceptable to all the subjects throughout the testing period

Further Research?

- Detailed investigation of the heat stress potential during extended helicopter excursions when wearing current suits.
- Detailed investigation into tactical de-hydration
- Potential for the use of passive and active cooling systems
- Regulators and Equipment Specifications to consider limitations of acceptable heat stress under operational scenarios

