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13. ABSTRACT (Maximum 200 Words)

During the first fiscal year of the project, research has been directed towards redesigning and rebuilding the Snellen Air Calorimeter. At this time, we are on schedule having completed the reconstruction of the calorimeter and the installation of the mechanical operating system. The system is designed to be operational in a wide range of ambient conditions (5-30°C). Preliminary calibration has been started and will continue over the next months. Once completed the air calorimeter will be used to quantify the heat loss during physical work. The calorimeter will also be used to validate a portable calorimeter, the liquid-cooled garment calorimeter. By the end of this fiscal year, rebuilding of a liquid-cooled garment calorimeter will be completed. This system will offer temperature control based on cooling with offsetting proportional heating of the water flowing through the garment. Heat extraction can be measured separately for six body regions (head, upper torso, lower torso, arms, thighs, and legs). Regional heat extraction measurement will allow establishment of regional correspondence between muscle temperatures associated with work and the heat produced.

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PROGRESS REPORT - UNIVERSITY OF OTTAWA

Introduction

The first phase of our research program was directed at re-designing and re-constructing the Snellen air calorimeter for operational use in a wide range of ambient conditions (5-30°C). The objective of the research conducted at the University of Ottawa was to complete the construction of the air calorimeter and to begin the calibration and validation of the system.

Research Progress

A Cooperative Research Agreement (CRADA) between the University of Ottawa and the Naval Health Research Center (NHRC) was developed and approved by both institutions.

Phase 1 – Air calorimeter construction

The following is a description of the progress related to this phase of the research program:

1. The calorimeter chamber is complete, including flooring approved by occupational health and safety.

2. The equipment required to produce the controlled conditions of temperature and humidity is installed, commissioned, calibrated and fully operational.

3. The software to run the environmental system including graphics is installed in a separate computer/monitor. The graphics depict all of the components, the temperature and humidity set-points.

The actual temperature and humidity (and dew point) as well as fan speed and damper positions are displayed in real time.

The user interface permits the adjustments of set points, damper positions and fan speed directly from the environmental control computer.

B. Instrumentation

At the moment two separate LabVIEW programs on the Analysis Computer have been integrated to read, display in graphical format and store data from:

1. The Dew-Point Mirror
2. The precision thermometers (thermistors) +/-0.0025 °C .

Data collected is stored in EXCEL spreadsheet format.

Exhaust duct has been insulated. This resulted in dramatic improvement of ΔT used to measure calorimeter heat. For a 100 Watt heat source in the calorimeter, resulted in a ΔT of 0.38 °C, approximate flow rate of 382 CFM resulted in a reading of 82.7 Watts.

C. Work in progress

We are currently calibrating the instrumentation. At this point, humidity sampling circuit is giving erroneous values. We suspect that one sample is contaminating the other. According to the Dew-Point instrument designer, this is the first time the Dew-Point Mirror has been used in such an arrangement. We are in the process of correcting this problem. However, given that this is the only air calorimeter in the world, we expect to face similar on-going problems that will require additional work to correct.

A used Wattmeter for mass flow measurement has recently been purchased. The Wattmeter has accuracy of 0.05% and was calibrated prior to shipping. The data from the Wattmeter will be sent to the Analysis Computer to calculate mass-flowrate. When Wattmeter arrives, mass-flow sensor will need to be calibrated. This is considered the MOST DIFFICULT task remaining in this phase of the instrumentation of the air calorimeter.

We have found that we must account for losses in heat energy in the exhaust duct. Even with the duct insulated, there is heat being absorbed (and released) by the metal duct. The figure below depicts this problem. Based on our preliminary work, we will be required to add a temperature probe above the calorimeter in the exhaust duct to account for this. Note that on the second graph (Temperature sensor 3- Temperature sensor 2), the mass-flow heater is NOT on.

The 2nd graph (bottom) shows a temperature difference between temperature sensor 2 and temperature sensor 3 of .008 °C (in steady state). These two probes are only 4 feet apart in the exhaust duct, hence the reason for the additional temperature probe directly above the calorimeter.

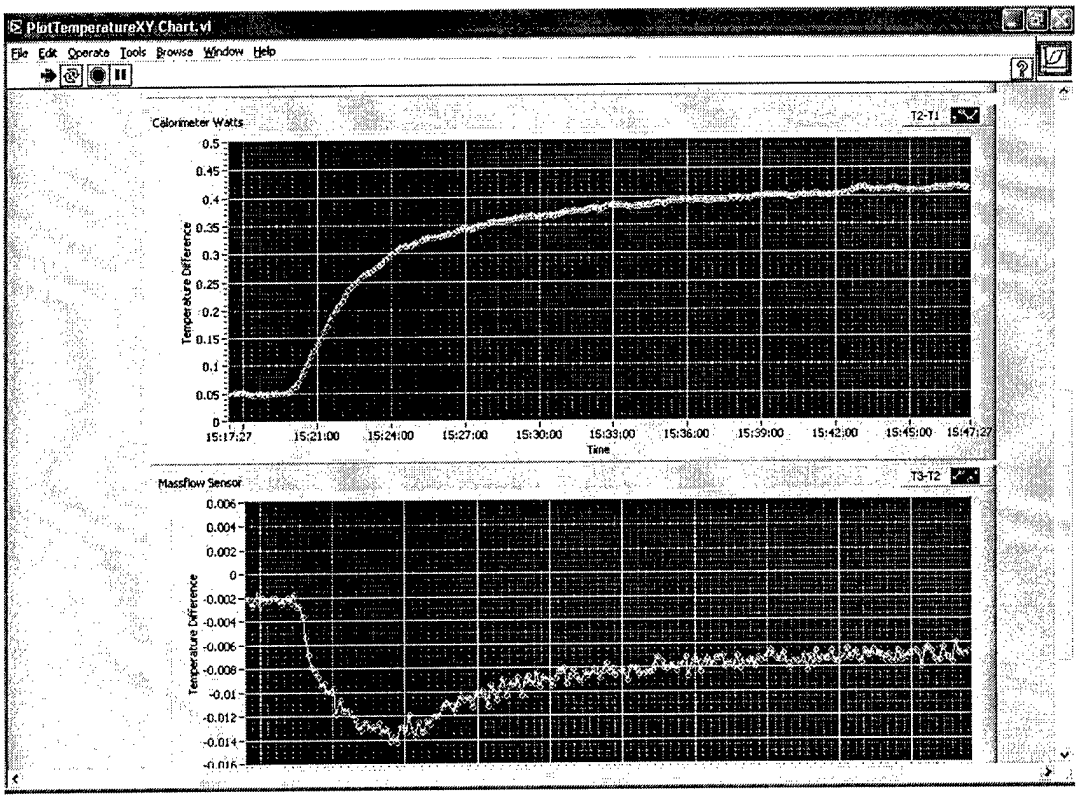

Figure 1 Calorimeter 100 W Heat Source Test

<u>Key research accomplishments:</u>

- None

Reportable outcomes:

- Project funding has resulted in the re-design and re-construction of the Snellen Air Calorimeter. We recently received verbal communication that our research protocols have received ethics clearance and that we will be able to proceed in the next months with human experimentation in the air calorimeter.

Conclusions:

We have completed all objectives set in the original submission which entails making the air calorimeter operational by the end of the first year. At this time, we are on schedule having completed the reconstruction of the calorimeter and the installation of the mechanical operating system. The system is designed to be operational in a wide range of ambient conditions (5-30°C). Preliminary calibration has been started and will continue over the next months. Once completed the air calorimeter will be used to quantify the heat loss during physical work. The calorimeter will also be used to validate a portable calorimeter, the liquid-cooled garment calorimeter. Subsequent work will now be directed at calibrating all systems such that preliminary human experimentation may begin.

References:

None

Expenses

Item	Purpose
In-house Labor	Investigator
	Engineer
Construction of air calorimeter	Air calorimeter construction
Equipment	
Supplies	Teleconference, paper, etc.
Travel	
TOTAL EXPENDITURES	

* Includes all fringe and overhead costs

PROGRESS REPORT – DRDC - TORONTO

Introduction

One deliverable from this research effort is to provide a practical, non-invasive method to measure change in body heat content and to improve the current method of measuring mean body temperature during work in the heat. The objective of the research conducted at DRDC Toronto during the reporting period was to investigate if such a method exists, and if this is the case, to evaluate and validate it against standard calorimetric techniques.

Research Progress

During the reporting period, a literature review was conducted to investigate the best technique to estimate non-invasively, the temperature of a third compartment of the body for a more accurate estimation of the mean body temperature. An extensive literature review showed that the only readily available non-invasive method to estimate the temperature of the third compartment, i.e. muscle tissues, was to use the zero flux gradient thermometer.

The zero flux gradient thermometer is a technique available since the 70's and was principally developed for the non-invasive measurement of deep body temperature in newborns and infants. Although the device could be used for the non-invasive measurement of deep tissues in adults, few validation studies are available, particularly for work in the heat. A second objective during the reporting period was to validate the device during work in the heat in adults.

An experimental protocol was developed for the validation of the device. The selected standard was the direct measurement of muscle tissues temperatures in the quadriceps muscle using multicouple probes providing a temperature reading every 5 mm inside the muscle for a maximum depth of 20 mm. The protocol involves measurement of muscle temperatures from the multicouple probe and the zero flux gradient during exercise in the heat at 2 different intensities in addition to resting.

The protocol was submitted to the DRDC Toronto and the University of Ottawa Human Research Ethics Committees and recently approved. We are waiting for the approval from the US Army Granting Agency before formally proceeding with the study. Over the last month of the reporting period, we prepared for the study by selecting and screening the subjects, ordering equipment and material, building the multicouple probes, testing the procedures, etc.

References:

None

PROGRESS REPORT – NHRC – San Diego

Introduction:

The development of heat injury during military ground operations in hot environments is a serious risk, particularly when operations in chemical defense ensembles are required. The objective of the research is to develop a model of body heat storage from readily available field and clinical measures that can be used to predict response to work in the heat, with or without the inclusion of impermeable or semi-impermeable garments. Unique aspects of these models will be the use of a three-compartment approach, in which muscle-mass temperature will be measured in addition to skin and non-muscle core temperature values, and measurement of heat storage by direct and indirect calorimetry.

Research Progress

A Cooperative Research Agreement (CRADA) between the University of Ottawa and the Naval Health Research Center (NHRC) was developed and approved by both institutions.

Study 1 – Calibration of Calorimeters

Rebuilding of the Liquid-cooled calorimetry garment system is almost complete. The system plumbing had to be completely disassembled, reconfigured and reassembled. All control elements of the system have been checked out and parts that were not functioning properly replaced. An existing tube suit was modified to work with the plumbing and sensor harness of the control system. Initial tests of the software provided with the system have been completed, and it appears to work properly. A problem with fluid flow to two of the cooling has emerged and traced to flaking of particles from the heaters in those lines. Parts are on order and the system should be operational within two weeks.

Human use protocols for the initial calorimeter calibration studies to be conducted at the University of Ottawa have been submitted to the NHRC Institutional Review Board for review. This review is required to allow NHRC researchers to participate in the University of Ottawa research.

Key research accomplishments:

- None

Reportable outcomes:

- Project funding applied for with the Defense Advanced Research Projects Agency (DARPA) utilizing the liquid-cooled garment calorimeter system that was rebuilt under this project

Conclusions:

By the end of this fiscal year, rebuilding of a liquid-cooled garment calorimeter will be completed. This system will offer temperature control based on cooling with offsetting proportional heating of the water flowing through the garment. Heat extraction can be measured separately for six body regions (head, upper torso, lower torso, arms, thighs, and legs). Regional heat extraction measurement will allow establishment of regional correspondence between muscle temperatures associated with work and the heat produced.

References:

None

Table 1. Expenditures by NHRC

Item	Purpose
In-house Labor	Investigator
Contract Labor	Liquid-cooled garment calorimeter reconstruction
Consultant contract	Paul Webb
Total from Univ. of Ottawa	
Supplies	Liquid-cooled garment calorimeter system parts
TOTAL FROM NHRC	
TOTAL EXPENDITURES	

* Includes all fringe and overhead costs