Statement of Need:

Heat stress and heat stroke are two medical conditions that occur when there is a buildup of body heat generated either internally by muscles, or externally through the environment. Over time elevation of core body temperature disturbs physiological functioning and can lead to adverse conditions such as heat stroke, and ultimately death. One occupational group that is especially at risk from the aforementioned conditions is firefighters because they operate in environments of immense heat and have to wear protective suits. These suits prevent metabolic heat from escaping the body and, combined with the strenuous physical demands of the work, often lead to heat related injuries. Since heat stress can severely compromise the performance of a firefighter in their critical line of duty, there has arisen the demand for a cooling device or piece of protective gear that is effective in regulating temperature for firefighters and is user-friendly.

Introduction and Overview:

Createc Consulting has identified this demand and has developed a prototype product, Coolpac, which addresses the aforementioned problem but requires testing in a controlled environment to validate its functionality.

Coolpac is a cooling sleeve firefighters can wear on their arms for the purpose of absorbing heat generated by the body so that thermoregulation is maintained. Coolpac’s functionality relies on the fact that under heat stress, the dominance of blood flow within the body is shifted to the extremities and skin in order to facilitate heat loss (Figure 1).

![Thermoregulation of the Human Body](image)

Since the temperature of the sleeve is less than the temperature of the body, heat can be absorbed by the sleeve due to the shallow blood vessels and high blood flow in the extremities. The result is that the wearer’s body is cooled down and heat stress is reduced.

The purpose of testing the prototype Coolpac sleeves is multidimensional. On a fundamental level scientifically showing that the sleeve does indeed decrease, or maintain at a healthy level, the user’s core temperature is vital in trying to commercialize the product for real life implementation. Likewise the size of the cuff on the CoolPac sleeve needs to be adjustable,
allowing for the product to fit on more than one customer. The size of one’s arm varies by person and an adjustable sleeve would be easier to produce in massive quantities, instead of one that needs to be tailored to the individual prior to production. Since the company wishes to explore further refinements in design in order better meet the demands of its target group, testing of the prototype will also allow for the exploration of the sleeve from a biomaterials standpoint to see if the material being used is the best in terms of thermoregulation efficiency, cost effectiveness, wear resistance, comfort, and other factors. Being that the primary intended users of the CoolPac sleeve are firefighters, the material needs to be light-weight and comfortable, so as to allow maximum movement for the firefighter in the field. However due to the harsh physical and environmental conditions firefighters must face, the product must be durable enough to be sustainable over a period of time.

Overall an effective test will validate the regulative capabilities of the sleeve through collected physiological data showing improved physical performance. Testing will also compare the ‘phase change material’ currently being used with other possible materials in order to create the most efficient product with respect to the aforementioned variables.

**Realistic Constraints:**

In order to successfully test and modify the Coolpac cooling sleeve one must first be aware to the expectations and limitations that revolve around this project. In fact there are many constraints to be aware of concerning the success of the project. The first constraint is the economics of the project, which deals with exactly how much money will be allotted for testing the Coolpac sleeve in terms of equipment, software, testing materials, etc. A higher budget would allow for more extensive testing and allow for more research as far as modifications are concerned. Also the product itself must be cost efficient and feasible for the manufacturer as well as the target community. Ideally the firefighter community would want a product that is high quality and durable so that it can be used over a period of time.

In terms of health and safety constraints, the Coolpac must be safe to wear for diverse group including variables such as age, weight, and abnormal health conditions within the target firefighter community. In addition side effects to the cooling sleeve must be explored so that purpose of the sleeve is not compromised. An example of this would be leaking of the phase change material which could be hazardous to the skin. This is especially important because the purpose of the device is based around improving health and safety by reducing heat stress. The device is hoped to be patented within the near future, and made manufacturable due to its potential impact for improving firefighter safety so that they can do their jobs better.

In the case of environmental and sustainability constraints the prime factor in question is the phase change material that is at the heart of Coolpac. The product can be stored in a room at room temperature, but the phase change material will automatically change from a solid to a liquid phase when introduced to higher temperatures in order to facilitate the absorption of heat. However in the case that it becomes damaged, any possible toxic or environmental effects would have to be addressed. On a similar level the phase change material must be sustainable and have an acceptable shelf life when not in use.

Finally from an ethical perspective the data concerning the testing of the Coolpac must be valid and reproducible for any experiments carried out. Likewise the user should be made aware of how to properly use and store the sleeve. Any side effects or dangers that may arise should be presented, along with the proper course of action to take.
Other Data:

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Questions:

What is the exact nature/composition of the phase change material? (Subject to manufacturer approval)

What physiological trends and data is best indicative of heat stress? How can this data be collected in scientific test setting to validate if Coolpac works?

What is our budget?

Should testing be done at a company approved lab/setting or in any general setting?

At what stage is the prototype cooling sleeve that has been manufactured?

How is the product specifically stored? What is its shelf life?

Are there any restrictions to its usage due to health concerns, age, weight, etc.?

Are there any known side effects to its usage?

Are there any other materials on the market that should be considered?

Can the arm sleeves be expanded to fit on the legs as well?

Is it better to reenergize the sleeve by dipping it in ice water or letting it cool at room temperature?

Sources Cited:

<http://circletrack.automotive.com/75054/ctrp-0808-driver-cooling/photos1-0.html>.

BME 4900 Senior Design Project Descriptions
Project Statement
CoolPac: Cooling Device for Firefighters

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