Infection Protection – ABSTRACT

In 2014, we were studying disease transmission and learned about the Ebola epidemic that has killed almost 90% of infected people. We learned that currently available protective suits trap too much heat and moisture, so they can only be worn for 30-45 minutes at a time, and are very expensive. Our team decided to design a more comfortable and less expensive suit that prevents transmission of viruses and bacteria and can be worn longer. Our solution is 100% vinyl-coated cotton fabric, treated with antibacterial aluminum oxide and a preservative to reduce the growth of organisms such as Aspergillus niger and Staphylococcus aureus. We also treated it with a superhydrophobic spray, NeverWet, that we found is 10 times more breathable than the popular Tychem material. The aluminum oxide reflects and transmits heat away from the fabric's surface, keeping it cooler in hot and humid weather. We also built cold gel packs into our design to further cool the suit. Even with these improvements, our design costs less than half of what commercially available suits cost. We used science to research and identify the materials that we constructed our suit with, engineering to design, treat, and thermally map the suit, and mathematics to analyze our data and costs. We hope to make our suit available to developing countries and to extend our idea to gloves, masks, and shoes, taking advantage of aluminum and NeverWet coating. We believe our new design could save millions of lives by reducing the spread of infectious disease.

[Mission Folder]: View Mission for 'Infection Protection'

State
California
Grade
6th
Mission Challenge
Food, Health and Fitness
Method
Engineering Design Process
Students

ram2003
rjm2003
sws2003
ncb2003

Team Collaboration

Uploaded Files:

- [**View**] **Times we met for the Project** (By: rjm2003, 02/27/2015, .pdf)

  Times we met for the Project

- [**View**] **Typical Meeting at home over the weekend** (By: rjm2003, 02/27/2015, .JPG)

  Typical Meeting at home over the weekend

(1) Describe the plan your team used to complete your Mission Folder. Be sure to explain the role of each team member and how you shared and assigned responsibilities. Describe your team's process to ensure that assignments were completed on time and deadlines were met.
Our team had 4 members: Natalie, Rhea, Rohan, and Siji. Since August 2014, we have met as a team approximately 2-4 hours per week. We have placed our work to make sure we would have enough time to identify a problem to investigate, design, and test. All four of us were involved in the design and construction of the suit, and the design and running of the tests. We divided assigned some specific areas of focus based on our strengths.

Natalie- Researching the ideas, recording test data and observations, writing and editing the Mission Folder
Rhea- Corresponding with experts, researching and gathering materials for testing
Rohan- Researching the ideas, corresponding with experts, researching and gathering materials for testing
Siji- Researching the ideas, sketching out possible suit prototypes, writing and editing the Mission Folder

To ensure that we completed our project tasks on time, we met at least two times per week to work jointly on various tasks. We also worked on tasks independently. We used Google Drive to share our work and collaborate in writing the Mission Folder. Our meetings were focused, but we also made sure to keep them fun. We divided up writing assignments for the Mission Folder, but we each provided input on all the sections.

Our plan:
When we formed our team in September, we started by using the engineering design process. We brainstormed a variety of topics that we were passionate about, and that we would be interested in researching more deeply. We came up with a list of about twenty topics. We narrowed the list down to the top ten topics, and then the top four. Throughout October we researched each of the top five topics to find the one we liked best. Our top five topics were spread of disease, animal protection, concussions, health, and pollution. We chose transmission of bacterial and viral infections because Ebola was a major world crisis and a relevant and current topic in the news. We assigned different parts of the mission folder to each teammate. We then started the process of editing and refining each other's sections.

Each team member's responsibilities: Around mid November to December we were all in charge of researching various technologies and researching issues pointed to us by the Centers for Disease Control (CDC). Rohan and Rhea contacted experts and gathered materials for our testing. In January, after we had researched other suits, Siji drew our suit design prototype that we would create for testing. He also wrote about each specific test we did. Natalie documented data for us, including the hydrophobicity data, Upright Cup method data, temperature and comfort data that we collected and our observations. All four of us were involved in the design, construction of the suit, and running the tests. Below is another document with all of the dates/times we met.

Engineering Design

Uploaded Files:

- [View] **Email_1_Dr. Baltimore_Caltech** (By: rjm2003, 02/28/2015, .pdf)

  Email_1_Dr. Baltimore_Caltech
- [View] **Email_2_Dr. Morelli_CDC** (By: rjm2003, 02/28/2015, .pdf)

  Email_2_Dr. Morelli_CDC
- [View] **Email_3_Dr. Morelli_CDC** (By: rjm2003, 02/28/2015, .pdf)

  Email_3_Dr. Morelli_CDC
- [View] **Email_4_Dr. Morelli_CDC** (By: rjm2003, 02/28/2015, .pdf)

  Email_4_Dr. Morelli_CDC
- [View] **Email_5_Jodie Price_DuPont** (By: rjm2003, 02/28/2015, .pdf)

  Email_5_Jodie Price_DuPont
- [View] **Email_6_Jodie Price_DuPont** (By: rjm2003, 02/28/2015, .pdf)

  Email_6_Jodie Price_DuPont
- [View] **Email_7_Kevin Crean_Graniteville Fabric** (By: rjm2003, 02/28/2015, .pdf)

  Email_7_Kevin Crean_Graniteville Fabric
- [View] **Email_8_NeverWet Inventor_Andrew Jones** (By: rjm2003, 02/28/2015, .pdf)

  Email_8_NeverWet Inventor_Andrew Jones
- [View] **Email_9_Lawrence Livermore National Lab** (By: rjm2003, 02/28/2015, .pdf)

  Email_9_Lawrence Livermore National Lab
- [View] **Design_Prototype** (By: rjm2003, 02/28/2015, .pdf)

  Design_Prototype
- [View] **Design_Final** (By: rjm2003, 02/28/2015, .pdf)

  Design_Final
- [View] **Bibliography** (By: rjm2003, 02/28/2015, .pdf)

  Bibliography
- [View] **Testing Fabrics at the Michael Levine store** (By: rjm2003, 02/28/2015, .jpg)

  Testing Fabrics at the Michael Levine store
- [View] **NeverWet** (By: rjm2003, 02/28/2015, .JPG)

  NeverWet
- [View] **Hydrophobicity Test** (By: rjm2003, 02/28/2015, .JPG)

  Hydrophobicity Test
- [View] **Upright Cup Experiment Setup** (By: rjm2003, 02/28/2015, .JPG)

  Upright Cup Experiment Setup

- [**View**] **Upright Cup Experiment** (By: rjm2003, 02/28/2015, .JPG)

  Upright Cup Experiment
- [**View**] **Miniature Ice Gel Pack (3 oz.)** (By: rjm2003, 02/28/2015, .jpg)

  Miniature Ice Gel Pack (3 oz.)
- [**View**] **Jobar Cooling Pad** (By: rjm2003, 02/28/2015, .jpg)

  Jobar Cooling Pad
- [**View**] **All of our data in this file** (By: rjm2003, 03/01/2015, .xls)

  All of our data in this file
- [**View**] **Table_1_Test Results on Hydrophobic Testing** (By: rjm2003, 03/01/2015, .pdf)

  Table_1_Test Results on Hydrophobic Testing
- [**View**] **Table_2_Test Results of Upright Cup Method** (By: rjm2003, 03/01/2015, .pdf)

  Table_2_Test Results of Upright Cup Method
- [**View**] **Table_3_Test Results on Thermometer Accuracy Testing** (By: rjm2003, 03/01/2015, .pdf)

  Table_3_Test Results on Thermometer Accuracy Testing
- [**View**] **Table_4_Trial 1_Test Results on Themal Stress_Cost** (By: rjm2003, 03/01/2015, .pdf)

  Table_4_Trial 1_Test Results on Themal Stress_Cost
- [**View**] **Table_5_Trial 2_Test Results on Themal Stress_Cost** (By: rjm2003, 03/01/2015, .pdf)

  Table_5_Trial 2_Test Results on Themal Stress_Cost
- [**View**] **Table_6_Cost Calculation on Various Design** (By: rjm2003, 03/01/2015, .pdf)

  Table_6_Cost Calculation on Various Design
- [**View**] **Table_7_Surface Area Calculation** (By: rjm2003, 03/01/2015, .pdf)

  Table_7_Surface Area Calculation
- [**View**] **Figure 1_Water Vapor Transmitted_Test Results_ASTM E 96_Procedure B** (By: rjm2003, 03/01/2015, .pdf)

  Figure 1_Water Vapor Transmitted_Test Results_ASTM E 96_Procedure B
- [**View**] **Figure 2_ Thermometer Accuracy Test Results** (By: rjm2003, 03/01/2015, .pdf)

  Figure 2_ Thermometer Accuracy Test Results
- [**View**] **Video Links** (By: rjm2003, 03/01/2015, .pdf)

  Video Links
- [**View**] **Powerpoint Presentation** (By: rjm2003, 03/01/2015, .pptx)

  Powerpoint Presentation

Problem Statement

(1) What problem in your community did your team try to solve? Why is this problem important to your community?

We want to stop the spread of diseases as much as possible. The hazmat suits that are currently available to aid workers are made of a plastic-like material that does not allow heat and sweat to escape. The buildup of heat inside the suit can impair the thinking ability of the person wearing it, cause heat stroke, and most importantly risk contamination as the wearer would need to take off the suit frequently to cool himself. Our goal was to make a suit out of a material that is inexpensive, readily accessible, has antibacterial properties, is breathable, heat resistant to keep the wearer comfortably cool. The publicity of the Ebola outbreak and complaints over ineffective suits has lead us into a deep interest in fixing this problem in our community and around the world.

(2) List at least 10 resources you used to complete your research (e.g., websites, professional journals, periodicals, subject matter experts).

Subject Matter Experts:

Dr. David Baltimore, President Emeritus; Robert Andrews Millikan Professor of Biology at Caltech
Email Correspondence #1. Dr. David Baltimore, Nobel Laureate. Communication. Caltech. Oct 12, 2014. 12:47 PM

Dr. Jeff Morelli, Associate Director for Policy at Centers for Disease Control / National Center for Environmental Health / Division of Emergency and Environmental Health Services
Email Correspondence #2. Dr. Jeff Morelli. Discussion on our idea. Center for Disease Control
Email Correspondence #3. Dr. Jeff Morelli. Requesting how to test our design. Center for Disease Control (CDC). Nov 10, 2014, 1:39 PM
Email Correspondence #4. Dr. Jeff Morelli providing us with ideas to test. Center for Disease Control (CDC). Nov 10, 2014, 3:23 PM

Dr. Francesco Fornasiero, Staff Scientist at Lawrence Livermore National Laboratory
Email Correspondence #9. Lawrence Livermore National Lab, Dr. Francesco Fornasiero. Feb 22, 2015, 2:27 PM

Industry Experts:
Jodie Price, DuPont Protection Technologies.
Email Correspondence #5. Jodi Price. Providing us info on Suit. Du Pont. Jan 14, 2015, 8:12 AM
Email Correspondence #6. Jodi Price. No Bacterial Data exists on Suit. Du Pont. Feb 4, 2015, 8:54 AM
She arranged for DuPont to donate several DuPont Tychem hazmat suits to our Mission Challenge and provided information about the Tychem material properties.

Chris Louisos, Senior Vice President at Alpha ProTech
Email Correspondence #11. Alpha ProTech on Implementation. Feb 25, 2015, 6:58 AM

Kevin Crean, Executive Vice President at Graniteville Specialty Fabrics
Email Correspondence #7. Kevin Crean. Technical Data on Fabric we used. Graniteville. Feb 4, 2015, 5:03 AM
Email Correspondence #10. Graniteville Specialty Fabrics on Implementation. Feb 23, 2015, 5:06 PM

Andrew Jones, President of Ross Nanotechnology (inventor and manufacturer of NeverWet)
Email Correspondence #8. NeverWet Inventor, Andrew Jones. Feb 17, 2015, 9:06 AM

Marc Bieler, V.P. Sales at James Thompson & Co., Inc.

Michael Levine, Inc., Los Angeles, California (specialty fabric store)

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(3) Describe what you learned in your research.
We learned a variety of relevant information in the course of doing research for our project.

We decided to get advice about our project from Dr. David Baltimore, a Nobel laureate in Medicine at Caltech. We organized and sent our research to Dr. Baltimore. He reviewed it and encouraged us to pursue it.

From Dr. Jeff Morelli, a scientist that works for the Centers for Disease Control, we learned about specific problems with hazmat suits that CDC sees for the people who treat infectious diseases or work with harmful chemicals. He told us some things that happen to make germs spread, and how to minimize ways of spreading bacteria.

Both in our research and communications with Dr. Morelli, we learned that there were four main problems with the current hazmat suits. First, it gets really hot inside the suits when worn. A person can only stay in the suit for a maximum of 30 to 45 minutes because of this problem with buildup of heat and moisture. We learned that this is important because each time a person takes the suit off when it gets too hot, he or she is exposed to contamination. Because of that, we researched which parts of the body were the hottest, and we found that they were the arm/armpit area, back area, feet/leg area, and neck, so we decided to strategically place cooling pads/ice packs in our suit to cool those areas down. Lastly, the suits are very expensive. We designed our suit to address all of these issues.

We learned from this research process that silver, copper, aluminum ions have antibacterial properties, which helps us to make an antibacterial suit. This led us to wonder if we could coat a suit with such ions and combine it with a Teflon cloth, as Teflon will not allow liquids to go through. That way, if the tester spills liquid on his suit, the liquid wouldn't seep through and make the tester uncomfortable, making it hard to focus while testing.

After all of our research, we were ready to make our suit along with testing it. Rhea and Rohan went to a specialty fabric store to buy our materials. The only problem was that we couldn't find any Teflon fabric. We solved this problem by spraying the Therma Flec material with the Teflon. But when we came to spraying the actual suit that we had tailored, and the spray didn't work and water seeped through the fabric easily. We needed to find a new material or spray, so we learned about a hydrophobic spray called "NeverWet." We treated a sample piece of the Therma Flec fabric with NeverWet, and when we tested the treated fabric by spraying colored water on the material, the spray immediately formed into little droplets of water, showing that the fabric was now hydrophobic. Through this process, we learned about the wide variety of treated fabrics available and about various sprays that you can use to treat fabrics yourself.

This is our first science competition and we learned that teamwork and research can be exciting and more fun when we come across information that is new and unexpected (like learning that we might be able to use aluminum oxide to improve our project). When we could not find the material we were actually looking for and came up with our own idea of creating a hydrophobic fabric that also had antibacterial properties, we were very happy. The more we researched and discussed possible material solutions, the more focused our ideas became.

We also learned about value of observing, asking questions and just spending some time on our research. When we were at the Michael Levine fabric store in downtown Los Angeles, we spotted the Therma Flec silver cloth and realized that we might want to use silver cloth in our design, as by now we knew that silver ions have antibacterial properties. Therma Flec fabric has the added benefit of being heat resistant (and for that reason is used as the cover on ironing boards). We then researched and contacted the manufacturer, learned more about the fabric's properties, and arrived what we have today: cloth that has antibacterial properties due to Aluminum Oxide, is breathable, is cooler as it resists heat due to Aluminum Oxide and even includes a preservative that aids in reducing growth of organisms. We were surprised that experts were so responsive to our emails and were so helpful. From this, we learned how to research manufacturers, how to contact them, how to write emails, and to be persistent.

We learned the reason why Aluminum Oxide has antibacterial properties. The positive surface charge on Aluminum particles interacts with the negative charge of outer membrane of bacteria. This leads to the rupture of outer membrane, which kills the bacteria. In addition, the Aluminum Oxide is the reason to reflect and transmit heat away from the fabric's surface, providing more heat protection to the wearer than ordinary apparel items.

We learned that when we were disappointed, the four of us actually came up with better solution. When we were originally thinking that we should test Teflon fabric as a possible material for our suit, we were disappointed that we could not find it anywhere. We almost gave up but then we thought of Teflon spray and decided to make our own Teflon fabric by using the spray on 100% Kona cotton fabric. When Teflon Spray failed, we found NeverWet Spray. Similarly, we found that the Therma Flec Fabric did not have silver ions but Aluminum Oxide that not only acted as Antibacterial but also heat resistant. Moreover the fabric was coated with a preservative that aids in reducing growth of organisms. We just had to ask the right people and keep looking.

We learned that people were very helpful. We sent emails to a Nobel Laureate and a CDC scientist, and they not only responded but encouraged us with suggestions and guidance. Companies like DuPont not only provided us with information about the suits but also gave us several samples of their suits. We learned from a DuPont representative that DuPont has not done any bacterial testing on their suits. This made our job easier as we were wondering how we would test our suit with bacteria (something we were not allowed to test). Our liquid penetration test with colored water was good enough for us to test if anything would even go through and the Upright Cup Method would help us in seeing which fabric would be cooler.

Whenever we got together in our school lab or at each others' houses, we came up with new ideas, like using miniature 3-oz. cooling packs and figuring out that we should place them in different parts of the suit, near the body's "hot spots," to modulate how cool the suit would feel. We also learned about the range of cold packs that are available, and that they have different properties depending on the type of gel used in the pack. This led us to use "Jobar" cold gel packs, which are colder than room temperature even when they have not been refrigerated. We learned a lot in this project.

<u>Experimental Design</u>

(4) Develop a design statement. Be sure to describe what exactly your device should be able to do. Do not describe HOW it's going to do what it needs to do.

Our suit is going to make the person stay inside the Hazmat Suit cool so that he or she does not have to take the suit off frequently. According to the World Health Organization, (WHO), as of August 2014, more than 240 healthcare workers have developed the Ebola disease in Guinea, Liberia, Nigeria, and Sierra Leone, and more than 120 died. Healthcare workers can only stay in their hazmat suits for about 30-45 minutes before reaching irritating heat conditions. They are forced to take their suit off because of their sweat, which turns into water vapor and has nowhere to escape of the non-breathable hazmat suit. During this process, the risk of contamination increases, and they can get infected, as well as spread the disease to others. Our suit will be designed to avoid those problems by making them cooler and comfortable to wear. We would also like to make these suits with a fabric that has Antibacterial properties. Our fabric should not absorb heat but rather reflect so that it could be cooler in very hot and humid weather. Lastly, these suits cost more than what an average person makes in a year in most developing nations and we hope to make them inexpensive.

(5) Determine the criteria for a successful solution and identify constraints for your design. Discuss what the device must have in order to accomplish its job and the restrictions of the device (i.e. the size, the cost, the weight, etc.).

Criteria: Our design for the suit will be successful if it meets the following six criteria. First, the suit is hydrophobic (preventing liquids such as sneezes, coughs, and other respiratory and nasal secretions from entering the interior of the suit). Second, the suit has antibacterial properties (which can kill bacteria on the exterior of the suit). Third, the suit is comfortable to wear and easy to put on. Fourth, the suit is very breathable (allowing sweat, which turns into water vapor, to escape the interior of the suit). Fifth, the suit is relatively easy to manufacture. Finally, the suit is affordable. The suits with which we would compare our design are DuPont's Tychem SL and Tychem QC protective suits. Both are widely used by CDC and others.

Constraints: We could not test the suit for its antimicrobial properties but we know that the Therma Flec fabric is coated with aluminum oxide, and that aluminum oxide is an antibacterial. The aluminum oxide would act as antibacterial due to the interaction between positive surface charge on aluminum particles and the bacterial outer membrane that is negatively charged leading to the rupture of outer membrane, thus killing the bacteria. The bacterial testing would be our only limitation. (We note that commercially available hazmat suits likewise have not been tested for its antimicrobial properties. See Email #6-DuPont has not tested its hazmat suits to assess their antibacterial properties.).

(6) Identify the relevant variables you will use to test your prototype or model and explain how you will measure your variables.
Relevant variables: We tested our prototype for three variables: (1) water permeability of the material, (2) breathability of the fabric, and (3) effect of ice on the body temperature and the wearability of the suit (comfort).

Methodology for testing our variables:

Water Permeability/Hydrophobicity Test: We tested the water permeability, or hydrophobicity, of the our suit material (Therma Flec) and the DuPont Tychem fabrics by spraying the materials with a fine mist spray of colored water to see if the liquid would soak through the fabric. We watched for signs of color on the absorbent white paper towel that we placed on the other side of the fabric. By doing this, we were attempting to mimic the effect of exposure to a sneeze or a spill, to help us see if bacteria or a virus could pass through. We also tested the hydrophobicity of: (1) Therma Flec fabric that we treated with DuPont Teflon spray, and (2) Therma Flec fabric that we treated with Never Wet spray.

Breathability Test: We measured the breathability of the aluminum oxide coated fabric using "Upright Cup Method" ASTM E 96 Procedure B Method. In this method, we filled a cup with water and sealed the cup opening with the fabric that we wanted to test. The breathable fabric would allow the water vapor to escape the cup through the fabric and the weight of the cup should drop over time. We measured the weight of the cup by grams to the hundredths place at two points: (1) at the beginning of experiment, and (2) when 24 hours had passed. The fabric that allows the most water to go through it will weigh the least and should be the coolest. Our hypothesis is that this fabric would allow heat to go through, preventing buildup of heat and sweat and avoiding the uncomfortable feeling that people usually have when they wear a hazmat suit. We calculated our data in terms of grams of water dissipated per hour and per square meter of fabric (gm/hr.m2).

Body Temperature and Comfort Test: Finally, we measured the effect of our complete design by having us and our parents actually wear them. We measured the body temperature variable with a thermometer and also noted the wearer's reactions and opinions as to the comfortableness of the suits. We used the temporal thermometer at first, and realized that the thermometer wasn't reliable, and that we needed to test our temperatures with a different, more reliable temperature. Then, we tested with a glass mercury thermometer, realizing that it was too hard to read due to graduations on it. Finally, we went with a Veridian mercury-free digital thermometer, which ended up working the best for us. We took body temperatures before wearing the suit, then at 10, 20, 35, and 45 minutes, to see if there was any change in body temperature.

Through our research, we learned that outside temperature and humidity can be measured using the "Steadman Apparent Temperature Index," and that both have a large effect on the apparent temperature of firefighting suits worn by firefighters. For example, with an environmental temperature of 90°F (32°C) and a relative humidity of 90%, the Apparent Temperature is 122°F (50°C). Thus, a firefighter exposed to these conditions will experience discomfort similar to that associated with an environmental temperature of 122°F (50°C) at low humidity. Additionally exposure to direct sunlight as well as the use of protective clothing will each increase Apparent Temperature by about 10°F (2°C). This fact would be very critical in communities where both temperature and humidity are very high. There, adding some cooling packs may prove to be particularly useful.

As part of our evaluation of comfort, therefore, we also tested the cooling attributes of our suit with the addition of cooling gel packs. We tested two types of cooling gel packs, and also tested differences in body temperature and comfort depending on the number, type, and placement of the cooling gel packs. In determining where on the suit to place the cooling gel packs, we researched the parts of the body that are most likely to get overheated the fastest.

Build Prototype or Model
(7) Develop a design and list the materials you used in your design. Include technologies you used (e.g., scientific equipment, internet resources, computer programs, multimedia, etc.).
Kona 100% cotton: Catalog # 211, 45" width, $6.00, H4F80 ZMT 012015, C208-45-Natura. Purchased from Michael Levine, Inc. (specialty fabric store), Los Angeles

Therma Flec Heat Resistant Silver Cloth: Catalog # Therma flec silver, $8.00, G054-45-Silver, H6F40 ZTM 072014.

Purchased from Michael Levine, Inc., Los Angeles

Teflon Spray, 10 oz.: Catalog # DNS616601, DuPont Teflon Non-Stick Dry-Film Lubricant Aerosol Spray, Purchased from Amazon.com

Never Wet Spray, 18 oz. Base Coat and Top Coat: Model # 274232. Home Depot Purchase ($9.97)

Ohaus Scout Balance, 200 g weighing capacity, resolution: 0.01 g Catalog # SC2020

Kal-Clear PET Drinking Cups, 3.6 inch (Top width) x 4.2 inch (Height) x 2.3 inch (Bottom width), Catalog # 9502053

Exergen Temporal Artery Thermometer: Model # TAT-2000C. Purchased from Amazon.com

Mercury Oral Thermometer: model number not available

2 Non-mercury Oral Thermometers: model number not available

Veridian 08-352 60-second Digital Thermometer: Model # 08-352. Purchased from Amazon.com

Fine Mist Creating Spray Bottle: Catalog # ABS13. Purchased from ABAspray.com

Jobar International Cooling Pads (they don't need to be frozen before use): Catalog # JB6001. Purchased from Amazon.com

Freezable Gel Packs - 6 oz. (Size: 4" x 6" x 3/4"): Catalog # IB6. Polar Tech Industries. $20.14 for a case of 96 ($0.20/pc)

Wallet-size Freezable Gel Packs - 3 oz. (Size: 2 1/2" x 5" x 1/2"): Catalog # IB3. Polar Tech Industries. $30.03 for a case of 192 ($0.156/pc)

Timer Traceable Benchtop: Catalog # 06-662-40. Fisher Scientific.

Lab Notebook: Catalog # 28196-344. VWR Scientific.

Gloves, Evolution, Medium: Catalog # 32916-534. VWR Scientific.

Bouffant Caps hood: Catalog # 10832-830. VWR Scientific

Color water (food coloring)

Camera

DuPont™ Tychem® QC protective suit (no hood). Yellow. Cat # QC125T YL XL000400, Tyvek® fabric and a polyethylene coating. http://safespec.dupont.com/safespec/productDetail?prodId=71&showRelProds=Y&verify=Y

DuPont™ Tychem® QC protective suit (hooded). Yellow. Cat # Suit QC127T YL XL000400. Tyvek® fabric and a polyethylene coating. http://safespec.dupont.com/safespec/productDetail?prodId=76&showRelProds=Y&verify=Y

DuPont™ Tychem® SL protective suit. White. Cat # Suit SL120T WH LG000600. Saranex™ 23-P film laminated to Tyvek® fabric. http://safespec.dupont.com/safespec/productDetail?prodId=89&showRelProds=Y&verify=Y

DuPont™ Tychem® SL protective suit (hooded). White. Cat # Suit SL127T WH LG000600. Saranex™ 23-P film laminated to Tyvek® fabric. http://safespec.dupont.com/safespec/productDetail?prodId=97&showRelProds=Y&verify=Y

DuPont™ Tyvek Dual protective suit (no hood). White/Blue. Cat # TD125S WB MD0025CM. Tyvek® fabric on the front and the comfort, softness and breathability of DuPont™ ProShield® fabric on the back. http://safespec.dupont.com/safespec/productDetail?prodId=157&showRelProds=Y&verify=Y

DuPont™ Tyvek Dual protective suit (hooded). White/Blue. Cat # TD127S WB MD0025CM. Tyvek® fabric on the front and the comfort, softness and breathability of DuPont™ ProShield® fabric on the back. http://safespec.dupont.com/safespec/productDetail?prodId=158&showRelProds=Y&verify=Y

Velcro: $0.75/yard. Purchased from Michael Levine, Inc., Los Angeles

Elastic: $0.75/yard. Purchased from Michael Levine, Inc., Los Angeles

Zipper: $3.60. Purchased from Michael Levine, Inc., Los Angeles

Fabric netting (to make pockets to hold cooling gel packs)

(8) Explain how you built your prototype(s) or model(s)? Include each of the steps in your process.

1. Research - We researched about spread of disease, current solutions, and antibacterial and hydrophobic materials through a variety of sources.
2. Conceptualization - We studied the features and limitations of the standard DuPont protective suits.
3. Assessing the feasibility of the solution - We organized our data and sent it to Dr. David Baltimore of CalTech, who helped guide us to a realistic project. We also had many specific ideas for this topic, which we narrowed down by the most helpful to society.
4. Determine the design requirements for solution - We found that cooling pads and a light layer of materials were needed to reduce the heat.
5. Preliminary design/Rapid Prototyping - We drew a rough design with a specific list of materials. Our prototype design is included here.
6. Detailed design - We drew a detailed design after a variety of tests on the materials we were going to use. We also planned out the locations of the cooling pads, and how we were going to allow temperature flexibility. Our final design of suit is included here.
7. Planning how to create prototype - After we had our final design, we bought the materials and cut them into buildable sizes and patterns.
8. Creating prototype - We sent it to a professional tailor, who sewed our suit together according to the specific design we drew.
9. Testing final prototype - We tested our final prototype, which proved effective. We also filled out an IRB form to test it.

In arriving at the above steps, we used the design thinking process to begin brainstorming project ideas, and we found six problems based on our individual passions, and then we assigned two problems each to three of our team members. The design thinking process is when you think of problems you want to solve, subject interests you have, and the capabilities of current materials or solutions, to come up with an idea for testing and creating a prototype.

Every Wednesday afternoon, we would meet together to discuss and analyze the information we had researched throughout the week. We also met every week outside of school. Having frequent meetings at least 2-3 times a week was vital in the development of our research. We then organized our research so that we could find experts to help us improve, refine, and execute our ideas. We looked at university websites and medical information websites like Mayo Clinic and PubMed to identify experts. We sent over 29 emails to various scientific and industry professionals and heard back from many of them.

To build our prototype, we researched what the problems were with the regular hazmat suits. We decided what features we wanted in our suit and started to look for different kinds of materials we would need. This included the heat resistant, aluminum oxide coated fabric called “Therma Flec” that we finally settled on and that is typically used as the material covering ironing boards. This also included various types and sizes of cooling gel packs. We gathered the materials from several sources, including Michael Levine, Inc., Joann’s Fabrics, Home Depot, Amazon, Polar Tech, and Dupont.

<u>Test Prototype</u>

(9) Describe the data you collected and observed in your prototype testing (use of data tables, charts, and/or graphs are encouraged).

To test the effectiveness of our suit, we conducted three different tests:
(a) Three trials of the Water Permeability/Hydrophobicity Test using Teflon and NeverWet, as shown in Table 1
(b) Three trials of Fabric Breathability Test (ASTM E 96 Method) with five fabrics as shown in Table 2, Table 7 and Figure 1 .
(c) Two trials of the Body Temperature/Comfort Test (with 7 scenarios tested for each trial), as shown in Tables 3, 4, and 5, and in Figure 2.

We also did cost calculations for each of the seven scenarios, as shown in Table 6 and as well in Table 4 and 5.

Data on Water Permeability/Hydrophobicity Tests: We tested five fabrics for water permeability/hydrophobicity: (1) Tychem SL fabric; (2) Tychem QC fabric; (3) Therma Flec fabric (untreated); (4) Therma Flec fabric (treated with Teflon); and (5) Therma Flec fabric (treated with NeverWet). We sprayed the suit fabric with colored water. If the suit absorbed the colored water, it would show up on the white paper towel. However, if the suit maintained its hydrophobic qualities, we would see the water sliding on the surface of the suit. As shown in Table 1, the Tychem SL fabric, Tychem QC fabric, and the Therma Flec fabric treated with NeverWet were hydrophobic in all three trials. The untreated Therma Flec fabric was not hydrophobic in any of the three trials. The Therma Flec fabric treated with Teflon was hydrophobic in the first trial, but not in the second two trials.

Data on Breathability Test (ASTM E 96 Procedure B): Once we found the proper Hydrophobic coating, we then moved on the 'Upright Cup Method" ASTM E 96 Procedure B Method, as suggested to us by Dr. Fornasiero of the Lawrence Livermore National Laboratory (Email #9). We tested the breathability of five fabrics: (1) Kona 100% cotton fabric; (2) DuPont Tychem QC fabric; (3) DuPont Tychem SL fabric; (4) untreated Therma Flec fabric; (5) Therma Flec treated with 3 applications of NeverWet.
We used Kal-Clear PET Drinking Cups because of their wide mouth (3.6 inches in diameter). Wider cups would mean we could cover it with a larger surface area cloth and thus water loss would be faster.
We used a weighing scale that is sensitive enough to report weight changes as small as 0.01 grams (see Table 7). (Based on our review of a research paper provided to us by Dr. Fornasiero on the breathability of a similar nylon fabric, we determined that we would need a weighing scale that could detect changes to the one-hundredth of a gram.
We set up 15 cups and filled each with 180 ml water. So that we could run 3 trials on each fabric, we covered three cups with each fabric, for a total of 15 cups.
As shown in our raw data (see uploaded Excel file), we took weight measurements at several points: hour 0, hour 1, hour 3, hour 6, hour 9, hour 12, and hour 24. We then subtracted each cup's final weight (at hour 24) from its initial weight (at hour 0), and calculated the vapor transmission rate in grams per hour meter squared (gm/hr.m2), as shown in Table 2 and plotted in Figure 1.

Data on body temperature and wearability (comfort) test: We tested our final design with real people wearing them and we would measure temperature to see how hot they got. We experimented with four different types of thermometers before we found one that worked reliably. We compared the results of all three as can be seen in Table 3 and Figure 2.
We tested the following 7 suits in two 45-minute trials:
(1) Dupont Tychem QC (Yellow Suit)
(2) Dupont Tychem SL (White Suit)
(3) Our Therma Flec suit, treated with NeverWet (no cooling elements)
(4) Our Therma Flec suit, treated with NeverWet, with 3 of miniature frozen gel packs (3 oz. each)
(5) Our Therma Flec suit, treated with NeverWet, with 13 of the miniature frozen gel packs (3 oz. each)
(6) Our Therma Flec suit, treated with NeverWet, with 1 room temperature Jobar Cooling Pad
(7) Our Therma Flec suit, treated with NeverWet, with Jobar Cooling Pad chilled with ice cubes
The data from our body temperature and wearability (comfort) testing is shown in Table 4 and Table 5.

Cost of the Suits: Table 6 lists the cost calculations of various components and various scenarios that we tested. They are also listed in Table 4 and Table 5.

(10) Analyze the data you collected and observed in your prototype testing. Does your data support or refute your design statement? Do not answer with yes or no. Explain your answer using 'Our data supports/refutes the design statement because...'
Our data supports our design statement because our suit material had an average breathability of 7.99 grams per hour and square meter (gm/hr.m2) whereas DuPont's Tychem QC and Tychem SL fabrics have breathability of 0.80 gm/hr.m2 and 0.67 gm/hr.m2, as can be seen in Table 2 and Figure 1. Our design is 10 times more breathable than the DuPont Tychem Suits used by CDC.

Our design statement was further supported by the Body Temperature and Wearability (Comfort) Test (Table 4 and Table 5). It shows that people wearing Design #1 (DuPont Tychem QC suit) and Design #2 (DuPont Tychem SL suit) were very hot and sweaty and wanted to take them off. Their temperature dropped as they started to sweat. But they remained comfortable in Design #3 (the Therma Flec suit we designed, treated with NeverWet, without any cooling elements).

Further supporting our design statement is our data showing that our addition of gel cooling packs to strategic areas in the suit improved comfort even more. As shown in Tables 3 and 4, our testers felt very comfortable wearing our Design #4 (the Therma Flec suit we designed, treated with NeverWet, with 3 of the miniature frozen gel packs) and design #5 (the Therma Flec suit we designed, treated with NeverWet, with 13 of the miniature frozen gel packs). They felt very comfortable wearing with 3 miniature freezable cooling packs or 13 miniature freezable cooling packs. Our testers did not sweat but also did not feel too cold. This cooling feature would particularly important working in hot and humid conditions. Table 4 and 5 also show our next wearability tests i.e. Design #6 (the Therma Flec suit we designed, treated with NeverWet, with 1 room temperature Jobar Cooling Pad) and Design #7 (the Therma Flec suit we designed, treated with NeverWet, with chilled Jobar Cooling Pad). Both Designs #6 and #7 were better than Designs #1, #2 and #3, with Design #7 being superior to Design #6. The Design #6 would be very useful where freezing of cooling gel pack is not possible (such as in locations with unreliable sources of electricity). Design #7 is also a useful option, as it only uses ice cubes to chill it. Thus our Designs #4-#7 provide a superior alternative when compared to currently available hazmat suits.

Table 6 lists the raw material costs associated with our suits (Designs #3-#7). Table 4 and Table 5 show that our suits (Designs #3-#7) are less expensive than DuPont's suits and perform better. Our cost was between $57 and $64 with cooling whereas the DuPont suits cost $166 and $326 i.e. 3 to 5 times less expensive.

The Therma Flec fabric used in our suit is 100% vinyl coated cotton fabric, treated with both a preservative to reduce the growth of organisms such as Aspergillus niger and Staphylococcus aureus and aluminum oxide that would acts as antibacterial. The aluminum oxide in our fabric also helps to reflect and transmit heat away from the fabric's surface, providing more heat protection to the wearer than ordinary apparel items. This is especially important for suits used in high temperature and humidity conditions, as discussed in Email #7. As shown in Table 1, our suit was also coated with NeverWet that is effective in making the suit hydrophobic.

Therefore, our final suit design (drawing and pictures attached) supports our design statement. It is a cooler and more breathable suit that will be more comfortable even in extreme weather conditions, is antibacterial, and less expensive than the suits that are currently available for purchase.

(11) Explain any sources of error and how these could have affected your results
In our experiment, we did our best to ensure that what we were testing was not affected by variable that we did not control for; however, we had a few possible sources of error. One possible source of error is that when we sprayed NeverWet on three different samples of fabric, we may have sprayed differently. We may have sprayed more on one, and less on another. The amount of NeverWet used on the Therma Flec fabric does make a difference in breathability, as we can see in Table 2 (see the last column, where it was 5.8 gm/hr.m2, 7.8 gm/hr.m2 and 10.34 gm/hr.m2). But we also know all three were adequately coated as they passed the Water Permeability/Hydrophobicity Test, as seen in Table 1. Thus, amount of NeverWet spray used is a source of variability in the breathability test.

In the Breathability Test (using the Upright Cup method), we did not take measurements at exactly one hour, as we had 15 cups to measure. So there may be a small difference in time. But we tried to take the measurements quickly to minimize this as a source of error.

In measuring temperature, we experimented with different types of thermometers to see which was the most reliable. We first measured the temperature using an "Exergen Temporal" digital thermometer. We found that this thermometer, even though relatively expensive at $37, gave inconsistent readings, with differences of 0.2°F or even 0.4°F for readings taken within seconds of each other. We also used mercury and mercury-free glass oral thermometers. We found that readings from these thermometers varied a little depending on how well we placed the thermometer under the tongue and the graduations on the thermometer were not of good visibility making it hard to read small changes in temperature. Finally, we used a "Veridian 08-352 60-second Digital" thermometer. As shown in Figure 2, this thermometer gave readings which were quite close to the readings from our mercury and mercury-free glass oral thermometers, while having the advantage of working faster and being easier to read than the mercury and mercury-free glass oral thermometers. So we think we eliminated thermometers as a source of error as best we could.

Our frozen gel pack temperature could also vary a bit depending upon how long the gel packs were out of the freezer before we placed them in the suit and were able to start our experiment. In addition, we were not able to measure how much we were able to cool the Jobar cooling pad that we inserted into the back panel of the suit.

Finally, we recognize that the amount of movement by the person wearing the suit could affect the temperature measurement as well and be a source of error. To minimize this as a source of error, we tried to have the people wearing the suit exert a similar amount of movement for each trial.

Drawing Conclusions

(12) Interpret and evaluate your results and write a conclusion statement that includes the following: Describe what you would do if you wanted to retest or further test your design. Evaluate the usefulness of your prototype or model. What changes would you make to your prototype or model for the future, if any?

Ideas to retest or further test on our prototype: We think our suit is well designed and functional. However, if we had unlimited resources, we would like to implement some of the suggestions that we noted when people tried our suit. We would sew the cooling gel pack more snugly and use a different netting fabric for the suit pockets, so that the gel packs do not touch skin directly. We would also position the Jobar cooling pad a little higher on the back of the suit. Based on our observations that the Therma Flec fabric's breathability dropped to an average of 7.99 grams per hour meter squared (gm/hr. m2) from 29.15 gm/hr. m2 once we coated it with NeverWet, we would also like to do further testing as to how the amount of NeverWet sprayed onto the suit affects the suit's breathability. We would also research how much time we should give it to dry after we apply the NeverWet base and top coats. Finally, we would test how we could wash these suits and reuse them without affecting our coating (most Hazmat suits are only meant for one-time use). We think if we could not wash them in a washing machine, at least we could wipe them with clean water and soap. If we could reuse the suit, it would lower the cost even more.

Usefulness of our prototype: Our protective suit design provides a better alternative to suits that are currently available. It is more breathable (and thus cooler), is liquid resistant, heat resistant, anti-bacterial, and of lower cost. It is cooler even in hot and humid weather. It can be worn longer without the wearer getting hot and sweaty, therefore reducing the chances that the wearer will become infected because of frequently taking off and re-donning the suit to cool himself or herself. Our protective suit also provides additional cooling options, through the use of either miniature frozen gel packs or room temperature cooling pads.

Changes we would make to our prototype: Right now we only have the suit covering arms, legs, and body, so another improvement we would want to design would be a full-body suit that covers the neck, head, hands, and feet. Alternatively, we would be interested in designing a helmet, gloves, and footwear to wear with our suit, to provide more protection.

Community Benefit

Uploaded Files:

- [View] **Email_10_Implement_Graniteville.pdf** (By: ram2003, 02/27/2015, .pdf)

  Email Implement_Graniteville.pdf
- [View] **Email_11_Implement_AlphaProtec** (By: rjm2003, 02/27/2015, .pdf)

  Email_11_Implement_AlphaProtec
- [View] **Provisional Patent Filing** (By: rjm2003, 03/01/2015, .pdf)

  Provisional Patent Filing

(1) How could your design help solve your problem and benefit your community? Describe next steps for further research/design and how you have or how you could implement your solution in the future.

Scientists, researchers, healthcare workers and infected patients could use our new and improved suit which allows the wearer to stay in the suit longer and be more comfortable while in it. According to our research, scientists can only stay in their hazmat suits for about 30-45 minutes at a time before getting too hot, sweaty, uncomfortable, or under heat stress, thus not been able to think clearly and work. When they become uncomfortable, they try to take it out and wear it again. During this process, the risk of contamination increases and they can get sick and make people around them sick.

Our suit would change that. Our design is cooler in hot weather and more comfortable to wear due to its breathability (which we determined to be 10 times more breathable than the Dupont Tychem hazmat suits worn by many, including at the CDC). The suit is also antibacterial due to its Aluminum Oxide coating that acts as antibacterial, as well as a preservative embedded in the fabric that aids in reducing the growth of organisms such as Aspergillus niger and Staphylococcus aureus. The Aluminum Oxide in our fabric also helps to reflect and transmit heat away from the fabric’s surface, providing more heat protection to the wearer than ordinary apparel items. This is especially important where the suit is being used in a hot or humid setting. Also, liquid cannot penetrate the suit due to the fact that we are treating our suit with a NeverWet hydrophobic coating. All of these features are incorporated in one single piece of fabric, making it very light and inexpensive when compared to other suits.

Another benefit of our suit is that it includes several pockets in which the wearer can place small cooling packs. The wearer can reap this benefit even if he does not have access to refrigeration, if he uses special cooling packs like the Jobar cooling packs which do not require refrigeration. This will be especially helpful in places where access to electricity is not consistent or reliable, or where refrigeration is not available.

Our suit will be the most affordable option available, making it more accessible even to those with more limited resources. Our cost was between $57 and $64 with cooling whereas the DuPont suits cost $166 and $326, i.e., 3 to 5 times less expensive. The average salary in Liberia is only $655 per year, for example, and thus the cost really becomes an issue. In addition to the benefits above that would avoid infection and contamination, our suit is easy to put on and take off, as compared to a typical hazmat suit that is bulky and heavy.

By way of example, a scientist who is conducting research could be at a critical phase of testing and not want to stop his or her train of thought. If this coincided with the end of the 30-45 minute time period for wearing the suit, s/he would need to take it off soon, which could interfere with his or her train of thought. Removing and redressing the suit would expose him or her to a higher risk of being infected. With our design, it will not only be cooler in the first place but would also have provision for inexpensive built-in cooling pads, so the scientist could stay in the suit for a much longer period of time without being hot or uncomfortable.

Our design may first appear to be a small deal, but it can have a domino effect. We are constructing a suit that will help scientists with their studies, community members to protect themselves and the people around them, while reducing the risk of heat stress.

Next steps for research/design: Our next steps would include reaching out to CDC, Doctors Without Borders, and various manufacturers to explore the possibility of mass producing our design. We have already identified a few manufacturers such DuPont, Honeywell Safety Products, Lakeland Industries, Grainger and Alpha Protech. We have contacted Graniteville Specialty Fabric Mills, which makes the Therma-Flec fabric we identified and we already heard back that they are looking into it (Email #10, copy attached). Chris Louisos, Senior Vice President of Alpha Protech, one of the largest manufacturer of suits, also responded to us in an Email by saying “Your concept and design is very intriguing and altruistic. Albeit Alpha Pro Tech is purely in the non-woven marketplace, let me review your concept with our Manufacturing Team who specializes in material physical properties & design.” (See Email #11.) We are also thinking of selling it on Amazon. We would also expand our suit to have a full body suit, including a cover for the head, the hands, and the feet, to eliminate the need to wear separate gloves, hood, and protective socks for the openings in the suit.

On February 26, 2015, we filed a provisional patent with the four of us as inventor (Application No. 62120990, receipt attached). This filing allows us to expand on our idea over the next 12 months and will facilitate working with a manufacturer to mass produce the suit, so we can provide it inexpensively to those who are in real need in various developing nations.

Mission Verification

Uploaded Files:

- [**View**] **IRB Form** (By: ram2003, 02/27/2015, .pdf)

  We tested how hot we would be in our suit versus Dupont's suits. We tested on ourselves and our parents.

(1) Does your Mission Folder project involve vertebrate testing, defined as animals with backbones and spinal columns (which includes humans)? If yes, team must complete and attach an IRB.
Yes

(2) Did your team use a survey for any part of your project? If yes, team must complete and attach a survey approval form.
No

(3) You will need to include an abstract of 250 words or less. As part of the abstract you will need to describe your project and explain how you used STEM (Science, Technology, Engineering and Mathematics) to improve your community

In 2014, we were studying disease transmission and learned about the Ebola epidemic that has killed almost 90% of infected people. We learned that currently available protective suits trap too much heat and moisture, so they can only be worn for 30-45 minutes at a time, and are very expensive. Our team decided to design a more comfortable and less expensive suit that prevents transmission of viruses and bacteria and can be worn longer. Our solution is 100% vinyl-coated cotton fabric, treated with antibacterial aluminum oxide and a preservative to reduce the growth of organisms such as Aspergillus niger and Staphylococcus aureus. We also treated it with a superhydrophobic spray, NeverWet, that we found is 10 times more breathable than the popular Tychem material. The aluminum oxide reflects and transmits heat away from the fabric's surface, keeping it cooler in hot and humid weather. We also built cold gel packs into our design to further cool the suit. Even with these improvements, our design costs less than half of what commercially available suits cost. We used science to research and identify the materials that we constructed our suit with, engineering to design, treat, and thermally map the suit, and mathematics to analyze our data and costs. We hope to make our suit available to developing countries and to extend our idea to gloves, masks, and shoes, taking advantage of aluminum and NeverWet coating. We believe our new design could save millions of lives by reducing the spread of infectious disease.

Times We Met for eCybermission

Wednesday, August 6 (3:30-4:30 p.m.)
Friday, August 15 (7-8 p.m.)
Wednesday, August 20
Friday, August 22 (10:15-11:15 a.m.)
Friday, October 24 (3:15-4:30 p.m.)
Wednesday, October 29 (3:15-5 p.m.)
Friday, November 14
Sunday, December 7 (4-6 p.m.)
Tuesday, December 9 (3:30-5 p.m.)
Friday, December 12 (3:40-5p.m.)
Monday, January 5 (3:15-4:30 p.m.)
Friday, January 9 (3:15-4:45 p.m.)
Friday, January 16 (6-8 p.m.)
Sat., Jan.31 (4-6:30 p.m.)
Every Wednesday for 45 minutes (time sometimes varied)
Friday, February 6 (3:45-7 p.m.)
Saturday, February 14 (3:30-6:30)
Every Wednesday during school for 45 minutes (time varied)
Friday, February 27 (11:00-5:05)

Note:
Every week all four of us worked on our own on Mission Folder that we uploaded and shared on Google Drive. We did not keep track of time but may be 2-4 hours a week.

From: **David Baltimore** <baltimo@caltech.edu>
Date: Sun, Oct 12, 2014 at 12:47 PM
Subject: Re: For Dr. Baltimore: From a middle school student: Can you help?
To: Rohan Madhogarhia <romadhogarhia2018@mirmanmustangs.org>

Rohan-- Disease transmission is a good topic, especially now when the Ebola virus is so much in the news. Clearly we need a vaccine against it and other viruses like HIV. As a middle school student you probably can't do much about making a vaccine but you could investigate how your community has prepared for dealing with infectious diseases. Where are there isolation facilities? Are hospital personnel prepared to deal with very sick and dangerous patients? Could you and your friends draw up a battle plan for providing protection against transmission?

Just a thought.

Good luck to you,

David Baltimore

On Oct 12, 2014, at 9:56 AM, Rohan Madhogarhia <romadhogarhia2018@mirmanmustangs.org> wrote:

Hi Dr.Baltimore, I am a 6th grade student at Mirman School and was hoping you can help me. I want to participate in ecybermisson science fair competition and was considering to submit an entry in preventing the transmission of diseases.

My School : https://mirman.org/

Ecybermisson: http://www.ecybermission.com/

I wanted your feedback on what possible things I could experiment with that would make an impact? I would like to decide on it by the end of next week to submit my entry.

I got your name by searching on Google on possible experts.

Thank you ,

Rohan Madhogarhia, Mirman School

romadhogarhia2018@mirmanmustangs.org

Upper School I Student

From: **Morelli, Jeff (CDC/OID/NCEZID)** <zrc6@cdc.gov>
Date: Fri, Oct 31, 2014 at 7:39 AM
Subject: RE: Hello from the Centers for Disease Control (CDC)!
To: Rohan Madhogarhia <romadhogarhia2018@mirmanmustangs.org>

Wow! You certainly have an ambitious and cool project in the works.

In addition to the suit you are designing, here are some proven ways to prevent becoming ill and for reducing the chances of transmitting infectious diseases:

- Wash your hands with soap and water for at least 20 seconds. Do this several times each day since your hands touch many things that are likely contaminated with germs. Washing your hands after going to the bathroom and before preparing food is especially important.
- Get the vaccinations recommended by your medical doctor.
- Drink water that has been treated with chlorine or another reliable disinfectant that kills bacteria, viruses, parasites, and other disease-causing microbes commonly found in untreated water. Don't drink untreated water!
- When you have to sneeze, make sure you sneeze into your elbow instead of your hands. This way, you limit the spread of the germs in your sneeze and your hands don't become contaminated.
- Make sure your food is cooked thoroughly. High temperatures kill germs.
- Don't use antibiotics if you don't have an infection caused by bacteria. Antibiotics don't stop infections caused by viruses or parasites. The overuse of antibiotics is leading to "super bacteria" that resist antibiotics, making bacterial infections in people harder to treat.

As for your suit, you might want to get ideas from the equipment used by an organization called Doctors Without Borders, an organization that has helped lead the fight against the spread of Ebola in Africa. I recommend that you go to google.com, then search for Doctors Without Borders Ebola Africa, and then hit the search button. Then, hit the "Images" button at the top of your screen to see pictures of doctors and nurses who are treating Ebola patients in Africa. I recognize that the suit you are creating doesn't have to be as complicated or expensive as what you see in these pictures, but you might get some ideas from the equipment you see that you might want to integrate into the suit you and your team are creating. For example, the masks that cover the nose and mouth of the health care workers is something you might want to consider. This mask helps to prevent the spread of airborne viruses and bacteria. Another thing to consider is whether the suit you are designing is easy to put on and take off without becoming infected. My understanding is that taking off suits like the ones you see in the pictures is particularly difficult to do since you have to assume that all of the outer surfaces of your suit might be contaminated with germs that will infect you if you touch them.

Anyway, good luck with creating your suit! I'm glad that you're interested in public health and health care. Maybe you'll become a public health doctor someday and help prevent diseases!

Jeff Morelli

CDC

From: Rohan Madhogarhia [mailto:romadhogarhia2018@mirmanmustangs.org]
Sent: Thursday, October 30, 2014 10:54 PM
To: Morelli, Jeff (CDC/OID/NCEZID)
Subject: Re: Hello from the Centers for Disease Control (CDC)!

Hi Dr. Morelli, Sorry I could not write to you in the morning, I had school and exams. Thank you so much for your time in helping me. I also want to say hi to Dr. Frieden. I have a phone but we are not allowed to use cell phone in school. I can talk over the weekend when I am home but not sure if you have time. I am home after 4:00 PM California time if that would work. Would it be possible we can try this through email first. Easier for me.

We want to do something that will help prevent transmission of diseases, like we have a situation with Ebola. Something that can be used to prevent spreading of any kind of disease not just Ebola, ideally. One idea we were thinking of was to design a suit or an overall. We thought we could design something that is inexpensive, very light, easy to wear and biodegradable. This could be worn by infected person so that they are isolated with their family and pets before help arrives. This could also be used by family members who may need to protect themselves from another family member or neighbors. What do you think? But I see that many versions of these suits already exist, so we thought we may design something that doesn't exist, have unique features but should be inexpensive and easily available like on Amazon. If you have any idea on unique features that are missing would be great. If you know of issues in this area that have not been solved would be great to know. We would love to try.

If you think this may not be a good project than we would love to work on something else as we want to make something really nice that will help people in preventing spreading of disease around the world. Any ideas would be lovely. Thank you, hope you have a very nice day and a happy Halloween! .

Rohan Madhogarhia, Mirman School

romadhogarhia2018@mirmanmustangs.org

Upper School I Student

On Thu, Oct 30, 2014 at 10:32 AM, Morelli, Jeff (CDC/OID/NCEZID) <zrc6@cdc.gov> wrote:

Rohan: My name is Jeff Morelli and I work in the part of CDC that works on stopping foodborne and waterborne disease outbreaks. I saw your email to Dr. Frieden and I've been asked to help you with your ecybermission project.

Because time is short, it seems to me that the best way I can help you is if we talk on the telephone between 9:00 and 5:00 Monday – Friday (east coast time). You can call me directly at 404-639-3403. If I don't answer the phone when you call, please leave me a voice mail and I'll return your call as soon as possible.

One suggestion I have is that you ask a parent to be on the phone with you when we talk.

I look forward to talking with you!

Jeff Morelli

CDC

404-639-3403

From: Morelli, Jeff (CDC/OID/NCEZID)
Sent: Monday, November 10, 2014 1:39 PM
To: 'Rohan Madhogarhia'
Subject: RE: Hello from the Centers for Disease Control (CDC)!

Hello, Rohan. It's nice to hear from you again.

You are asking very important questions that are part of the scientific process. Gathering and analyzing data is crucial to understanding what works well and what doesn't work well. CDC scientists gather lots of data and analyze it carefully to figure out how to stop diseases. So, I think you are on the right track.

As you probably know from news sources, lots of CDC scientists are involved in stopping the Ebola epidemic in Africa. I will look for somebody who knows how to conduct these kinds of tests so you can gather the data you need. I'll get back to you soon.

From: **Morelli, Jeff (CDC/OID/NCEZID)** <zrc6@cdc.gov>
Date: Mon, Nov 10, 2014 at 3:23 PM
Subject: RE: Hello from the Centers for Disease Control (CDC)!
To: Rohan Madhogarhia <romadhogarhia2018@mirmanmustangs.org>

Hello, Rohan. I've done a little bit of investigation and have decided that your team has likely chosen a very complicated project! It turns out that testing materials can be very tricky.

First, let's talk about how your suit is constructed. Is it made like a "moon suit" with only one material that covers the entire body? Or does it contain many different parts made of different materials?

Here is a picture of a CDC scientist wearing a one-piece suit that hooks up to an air hose so the scientist can breathe and stay cool:

The red coil in the background is the air hose that plugs into the suit. These suits are made of a rubber-like material that doesn't let any kind of microbe penetrate it, including viruses that are in liquids or floating in the air. Thse blue suits are highly specialized and designed to be worn by trained scientists in laboratories where very dangerous germs are studied.

And, here is a link to pictures of all of the materials used to create a suit worn by medical staff at the University of Nebraska to treat Ebola patients:

http://app1.unmc.edu/nursing/heroes/pdf/vhfppe/donningBiologicalPPE-EbolaPatients-8.5x11-CC-v1.02.pdf

Be sure to scroll all the way down this web page. As you can see, when you create a suit out of many different materials, such as those featured on this web site, testing becomes more complicated.

Here is an article that describes in lots of details how seven brands of gloves used in health care facilities were tested for penetration by chemicals used in hospitals and other health care facilities.

http://annhyg.oxfordjournals.org/content/47/4/313.full?sid=347730ef-d245-4747-ad04-8a26af27a417

When you scroll down about one-quarter of the way in this long article, there is section titled “Materials and Methods” that describes how the testing was done. Maybe this article will give you a good idea of how testing of different materials is done by professionals.

Generally, it seems to me that it would be easier for you to use the fewest number of materials possible for your suit because then you wouldn’t have to test too many materials.

One easy way to test a material might be to use a spray bottle that sprays a mist of colored water onto each material (this would simulate the mist that comes out of people when they sneeze). You could measure the amount of water that comes out each time you squirt the bottle. Then spray the material you are using to see if any of the colored water penetrates the material. If no colored water is seen on the inside of the suit, then that is a good indication that your suit probably blocks fluids that might be contaminated with viruses and bacteria. If some of the colored water penetrates your material, then you can measure the amount that comes through with something small, like a one-quarter teaspoon spoon. Then compare the amount that comes out when you squeezed the bottle to the amount that penetrates the material. That will tell you the approximate percentage of the total spray that penetrates the material. Then do the same test for other materials to see which materials perform the best.

Like I said, your team might have selected a complicated project. I’m going to let you and your team do the rest of the research and testing for your suit. Another option for you and your team to consider is to select a less complicated project that is easier to research and test. Regardless, good luck to you and your team!

Jeff Morelli

On Wed, Jan 14, 2015 at 8:12 AM, <Jodie.K.Price@dupont.com> wrote:

Good morning, Rhea! Glad I was able to hear your voice this morning and wanted to take a few moments to say, thank you and to let you know I am proud of you. Keep up the hard work and make a difference in this world. You are our future and I am happy that you are leading the way! I admire you very much and wish you nothing but the best of luck on your project.

I will speak with Daddy in regards to getting some sample garment sent to you in order to view the fabric and do some testing on the fabric itself, but I wanted to send you a few quick links that you are able to view with your classmates and your Dad that are in reference to our fast and furious conversation this morning. ☺

The link is in regards to the garments that meet ASTM Bloodborne Pathogen Standards.

http://www.safespec.dupont.com/safespec/productHome?filter6=ASTM.astmf1671

This link takes you directly to the Library tab which includes information from the CDC and product data:

http://www.safespec.dupont.com/safespec/productDetail?prodId=71&showRelProds=Y&verify=Y#

This link shows you the Cool-Guard Vest:

http://www.safespec.dupont.com/safespec/productDetail.action?prodId=152

This link shows you the cool packs that are inserted into the vest, itself:

http://www.safespec.dupont.com/safespec/productDetail.action?prodId=154

This link is the Product Q&A tab that has the option to view information on how to avoid heat stress:

http://www.safespec.dupont.com/safespec/productDetail?prodId=71&showRelProds=Y&verify=Y

This link is available for all garment and shows you all tests that are performed, along with the results:

http://www.safespec.dupont.com/safespec/productDetail?prodId=71&showRelProds=Y&verify=Y

I hope this is useful to you and please don't hesitate ask for further assistance. I look forward to hearing how well you all have done on this project!

GO GET EM KIDDOS!!!!!!!!!!!!!!

Jodie Kay Price

DPT Garments Customer Service

DuPont Protection Technologies

Customer Svc: (800) 931-3456 (select option 1)

Fax: (843)335-8599

DPPOrders@Dupont.com

http://safespec.dupont.com

From: <Jodie.K.Price@dupont.com>
Date: Wed, Feb 4, 2015 at 8:54 AM
Subject: RE: THANK YOU
To: rhmadhogarhia2018@mirmanmustangs.org

Good afternoon, Rhea.

I heard back from Technical and they confirmed the TD does not have any biological testing that was performed on them.

The ASTM F1670 and F1671 are the results of the biological tests that have been performed on the QC and SL garments that you received. That is the information that can be located on SafeSPEC.dupont.com under the "ASTM Bloodborne Pathogen" standards link on the left-hand side of the home page.

I hope this helps.

Regards,

Jodie Kay Price

DPT Garments Customer Service

DuPont Protection Technologies

Customer Svc: (800) 931-3456 (select option 1)

Fax: (843)335-8599

DPPOrders@Dupont.com

http://safespec.dupont.com

From: Rhea Madhogarhia [mailto:rhmadhogarhia2018@mirmanmustangs.org]
Sent: Tuesday, February 03, 2015 11:49 PM
To: Price, Jodie K
Subject: Re: THANK YOU

Hi Jodie, Thank you so much for sending us the suits. We already started working with them. We want to confirm that no bacterial test data exists with any of these suits? Thanks Rhea

On Wed, Feb 4, 2015 at 5:03 AM, Crean, Kevin <Kevin.Crean@graniteville.net> wrote:

Rhea,

Please see the following response that we have put together regarding our Iron Quik coated fabric that James Thompson sells under the name Therma-Flec. Marc Bieler from James Thompson had forwarded your e-mail to us. Good luck with your science project.

Kevin Crean

Graniteville Specialty Fabrics

POB 520, 511 Leitner Street

Graniteville, SC 29829

Phone: 803-663-2609

Fax: 803-663-2839

e-mail: kevin@graniteville.net

<image004.gif>

Hopefully, this information will help answer some of the questions raised concerning the science project.

The Iron Quik Product (also known as Therma-Flec) is an aluminized vinyl coated cotton fabric. It was initially developed for the Ironing Board Industry to be used as a cover material. The product is pigmented with aluminum oxide. The aluminum oxide helps to reflect and transmit heat away from the fabric's surface up to 340 °F, thus preventing the cotton substrate of the Iron Quik product from scorching during the ironing process. If used as a protective suit, the Iron Quik Product would work in the same manner providing more heat protection to the wearer than ordinary apparel items. The product also has some degree of breathability allowing for air permeability flows of up to two cubic feet per minute. As far as the product preventing bacterial growth, the aluminum coating is not considered resistant but does contain a proprietary preservative that will aid in reducing the growth of organisms such as *Aspergillus niger* and *Staphylococcus aureus*. Lastly, even though the product is not considered water proof it does have some water resistant properties due to one of the coating components, PTFE (polytetrafluoroethylene). The PTFE allows for a smooth finish and helps to prevent the adherence of water molecules to the surface of the Iron Quik Product.

From: Rhea Madhogarhia [mailto:rhmadhogarhia2018@mirmanmustangs.org]
Sent: Monday, January 19, 2015 1:46 PM
To: Marc Bieler
Subject: Re: Therma-Flec Fabric

Hi Marc, Thank you so much. Can you give me some more information on silver coating? Silver ions are used to prevent bacterial growth, so this may be beneficial to know as it will help our research (like silver chloride, silver nitrate, which one is used and any other information on how it is made).

Do you think it will allow body heat to pass through as it is heat resistant? We do want body heat to go through and keep the body cool. Any information on it's properties, how it's made, composition would immensely help us. Thank you. Rhea

Rhea Madhogarhia

Mirman School

On Mon, Jan 19, 2015 at 9:34 AM, Marc Bieler <marc@jamesthompson.com> wrote:

Hi Rhea,

Thanks for your inquiry on one of our fabrics!

The 44" Therma-Flec Cloth is actually designed as fabric for ironing board covers.

It is not certified as a waterproof fabric, although I think with its heavy silver coating it would offer some degree of waterproofing.

The materiel is a 100% Cotton base fabric with a vinyl coating.

It does offer heat resistance- it will start to scorch at 340 degrees. This not very high a standard. There are other fabrics that offer a much higher degree of heat resistance.

I will be happy to send you a couple of yards of this free of charge for your science project. If you want to buy this in the SoCal area, I believe that M. Levine Fabrics in L.A. carries this. Also, Hancock Fabrics and fabric.com has this.

Hope this helps you out!

Marc A. Bieler

James Thompson & Co.

P# 623 476 0407

marc@jamesthompson.com

From: **Andrew Jones** <ajones@neverwet.com>
Date: Tue, Feb 17, 2015 at 9:06 AM
Subject: Re: new white paper
To: Rhea Madhogarhia <rhmadhogarhia2018@mirmanmustangs.org>

Hi, Rhea,

I recommend you look up our early patents. They are all published. If you look for phrases superhydrophobic and Andrew Jones, you should find a lot of detail.

Good luck.
Andy

On Mon, Feb 16, 2015 at 10:45 PM, Rhea Madhogarhia <rhmadhogarhia2018@mirmanmustangs.org> wrote:
Hi Andrew, Where would it say what it is made up of? We thought it is made of nanopartcles. Please help as we would like to write what it is made up of and how it works in simple language. In Fifure 2, it says Aluminium Coated Surface. We also coated on a fabric that is coated with Aluminum Oxide. Do you think that is why it worked? or is that just one example? Thanks Rhea

Rhea Madhogarhia
Mirman School

On Mon, Feb 16, 2015 at 7:29 PM, Andrew Jones <ajones@neverwet.com> wrote:
Here it is. Good luck.
Andy

NeverWet

Andrew Jones
President
ajones@neverwet.com
717-656-2200 ext 602
www.NeverWet.com

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NeverWet

Andrew Jones
President
ajones@neverwet.com
717-656-2200 ext 602
www.NeverWet.com

From: **Fornasiero, Francesco** <fornasiero1@llnl.gov>
Date: Sun, Feb 22, 2015 at 2:27 PM
Subject: RE: Our Data
To: Rhea Madhogarhia <rhmadhogarhia2018@mirmanmustangs.org>

Hello Rhea,

The data look good!

You can definitely state that your design with coating is 10x more breathable than Tychem.

Do you know what was the relative humidity in the room?

Francesco

From: Rhea Madhogarhia [mailto:rhmadhogarhia2018@mirmanmustangs.org]
Sent: Wednesday, February 18, 2015 6:28 PM
To: Fornasiero, Francesco
Subject: Our Data

Hi Dr, Fornaseiro, We would appreciate to let us know of any comments, suggestions on our data on the Upright Cup Method. I have enclosed them. Thank you. Rhea

From: **Crean, Kevin** <Kevin.Crean@graniteville.net>
Date: Mon, Feb 23, 2015 at 5:06 PM
Subject: Re: Therma-Flec Fabric
To: Rhea Madhogarhia <rhmadhogarhia2018@mirmanmustangs.org>

Rhea - we will need to go through all of this and get back to you.

Sent from my iPhone

On Feb 23, 2015, at 6:59 PM, Rhea Madhogarhia <rhmadhogarhia2018@mirmanmustangs.org> wrote:

Hi Kevin, We made some changes to the Abstract. Thank you. Rhea

In 2014, we were studying disease transmission and learned about the Ebola epidemic that has killed almost 90% of infected people. We learned that currently available suits are very expensive and quickly get hot and sweaty. Our team decided to investigate the possibility of designing a more comfortable and less expensive protective suit that would be effective in preventing transmission of the virus as well as bacteria. Our solution is 100% vinyl coated cotton fabric, treated with aluminum oxide that is antibacterial and a preservative to reduce the growth of organisms such as *Aspergillus niger* and *Staphylococcus aureus*. We also treated it with a superhydrophobic spray, NeverWet, that we found is 10 times more breathable than the popular Tychem material. The aluminum oxide reflects and transmits heat away from the fabric's surface, keeping it cooler in hot and humid weather. We also built ice gel packs into our design to further cool the suit. Even with these improvements, our design still cost less than half of what commercially available suits cost. We used science to research and identify the materials that we constructed our suit with, engineering to design, treat, and thermally map the suit, and mathematics to analyze our data and costs. We hope to make our suit available to third world countries and to extend our idea to gloves, masks, and shoes, taking advantage of aluminum and NeverWet coating. We believe our new design could save millions of lives by reducing the spread of infectious disease.

Rhea Madhogarhia
Mirman School

On Sun, Feb 22, 2015 at 9:36 PM, Rhea Madhogarhia <rhmadhogarhia2018@mirmanmustangs.org> wrote:

Hi Kevin, We have finally made our Hazmat suit and tested it. Our results look very promising. One of the question eCybermission competition asks us:

"How could your design help solve your problem and benefit your community? Describe next steps for further research/design **and how you have or how you could implement your solution in the future**."

Would Graniteville Specialty Fabrics be interested in implementing it? Our project abstract and final design is below and we can send you all of our work once we hear back from you. Thank you. Rhea

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Abstract

In 2014, Ebola Epidemic could kill up to 90% of infected people causing terror in the infected communities. During this time, we were studying bacteria and transmission of diseases in science class. So, we thought of an inexpensive anti-bacterial suit that could be used by anyone and solve issues that currently exist. Doctors get very hot in these suits, taking it out and wearing it again thus risking contamination and falling sick. Our solution is 100% vinyl coated cotton fabric, coated with aluminum oxide that would acts as antibacterial, also coated with preservative to reduce the growth of organisms such as *Aspergillus niger* and *Staphylococcus aureus* and coated with NeverWet thus making it hydrophobic. The aluminum oxide helps to reflect and transmit heat away from the fabric's surface, thus keeping it cool in hot and humid weather in Africa. Our suit would cool it further by using miniature ice gel packs and would still costs less than half the money than other suits cost. We used science to research and arrive at the materials that we decided to construct our suit with, used engineering to design, coat and thermally map the suit and used mathematics to analyze our data including its cost. Next we plan to have our suit made available to third world countries. We plan to extend our idea to gloves, masks and shoes taking advantage of aluminum and NeverWet coating. We believe our new design will save lives of millions by minimizing the spread of infectious disease.

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Rhea Madhogarhia
Mirman School

From: **Chris Louisos** <clouisos@alphaprotech.com>
Date: Wed, Feb 25, 2015 at 6:58 AM
Subject: RE: For Mr. Louisos: From a Middle School Student
To: Rhea Madhogarhia <rhmadhogarhia2018@mirmanmustangs.org>

Hi Rhea,

Your concept and design is very intriguing and altruistic. Albeit Alpha Pro Tech is purely in the non-woven marketplace, let me review your concept with our Manufacturing Team who specializes in material physical properties & design.

Good luck with the ecybermission contest.

Sincerely,

Chris Louisos

Sr. Vice President

Sales & Marketing

Office: 716-741-8920

www.alphaprotech.com

AlphaProTech

INCORPORATED

From: Rhea Madhogarhia [mailto:rhmadhogarhia2018@mirmanmustangs.org]
Sent: Tuesday, February 24, 2015 9:01 PM
To: Chris Louisos
Subject: For Mr. Louisos: From a Middle School Student

Hi Mr. Louisos, I am a middle school student at Mirman School. We are working on a science fair project on designing a protective suit to prevent the spread of diseases. We are submitting the project to ecybermission contest.

My School : https://mirman.org/

Ecybermisson: http://www.ecybermission.com/

We have finally made our Hazmat suit and tested it (picture enclosed). Our results look very promising. One of the question eCybermission competition asks us:

“How could your design help solve your problem and benefit your community? Describe next steps for further research/design **and how you have or how you could implement your solution in the future**.”

Would AlphaProtech be interested in implementing it? Our project abstract and final design is below and we can send you all of our work once we hear back from you. Thank you.

Rhea Madhogarhia, Mirman School

rhmadhogarhia2018@mirmanmustangs.org

Upper School I Student

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Abstract

In 2014, Ebola Epidemic could kill up to 90% of infected people causing terror in the infected communities. During this time, we were studying bacteria and transmission of diseases in science class. So, we thought of an inexpensive anti-bacterial suit that could be used by anyone and solve issues that currently exist. Doctors get very hot in these suits, taking it out and wearing it again thus risking contamination and falling sick. Our solution is 100% vinyl coated cotton fabric, coated with aluminum oxide that would acts as antibacterial, also coated with preservative to reduce the growth of organisms such as *Aspergillus niger* and *Staphylococcus aureus* and coated with NeverWet thus making it hydrophobic. The aluminum oxide helps to reflect and transmit heat away from the fabric’s surface, thus keeping it cool in hot and humid weather in Africa. Our suit would cool it further by using miniature ice gel packs and would still costs less than half the money than other suits cost. We used science to research and arrive at the materials that we decided to construct our suit with, used engineering to design, coat and thermally map the suit and used mathematics to analyze our data including its cost. Next we plan to have our suit made available to third world countries. We plan to extend our idea to gloves, masks and shoes taking advantage of aluminum and NeverWet coating. We believe our new design will save lives of millions by minimizing the spread of infectious disease.

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Our first Design

Improved Design of Hazmat Suit

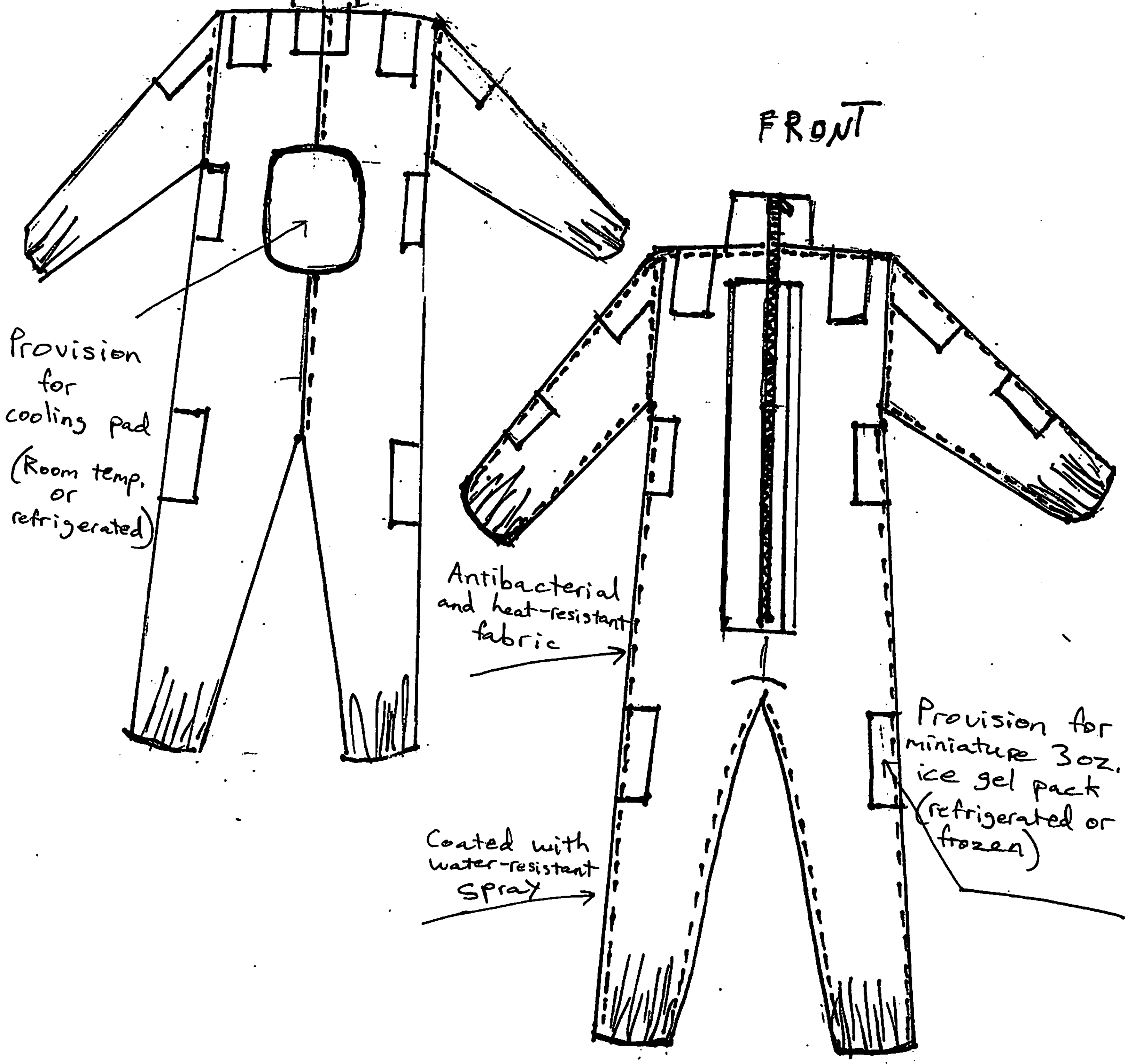
Outer layer = Teflon: hydrophobic, non-reactive because of carbon-flourine bonds

Inner layer = thin layer of rubber

Cooling Gel System in shaded regions to allow longer time for doctors to work in suit.
Shaded regions = areas where cooling gel pads will be.

Infection Protection

Our Final Design



Infection Protection

Email Communications (Copy enclosed as pdf)

(1) Email Correspondence #1. Dr. David Baltimore, Nobel Laureate. Communication. Caltech. Oct 12, 2014. 12:47 PM

(2) Email Correspondence #2. Dr. Jeff Morelli. Discussion on our idea. Center for Disease Control

(3) Email Correspondence #3. Dr. Jeff Morelli. Requesting how to test our design. Center for Disease Control (CDC). Nov 10, 2014, 1:39 PM

(4) Email Correspondence #4. Dr. Jeff Morelli providing us with ideas to test. Center for Disease Control (CDC). Nov 10, 2014, 3:23 PM

(5) Email Correspondence #5. Jodi Price. Providing us info on Suit. Du Pont. Jan 14, 2015, 8:12 AM

(6) Email Correspondence #6. Jodi Price. No Bacterial Data exists on Suit. Du Pont. Feb 4, 2015, 8:54 AM

(7) Email Correspondence #7. Kevin Crean. Technical Data on Fabric we used. Graniteville. Feb 4, 2015, 5:03 AM

(8) Email Correspondence #8. NeverWet Inventor, Andrew Jones. Feb 17, 2015, 9:06 AM

(9) Email Correspondence #9. Lawrence Livermore National Lab, Dr. Francesco Fornasiero. Feb 22, 2015, 2:27 PM

(10 Email Correspondence #10. Graniteville Specialty Fabrics on Implementation. Feb 23, 2015, 5:06 PM

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O9fMu5kcVWZ7kKILM&hl=en&sa=X&ei=uzbWVISaL8v0oASM54CYAQ&ved=0CDcQ6AEwCQ#v=onepage&q=how%20to%20measure%20heat%20in%20hazmat%20suit&f=false>.

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Implementation (Emails Enclosed as pdf)

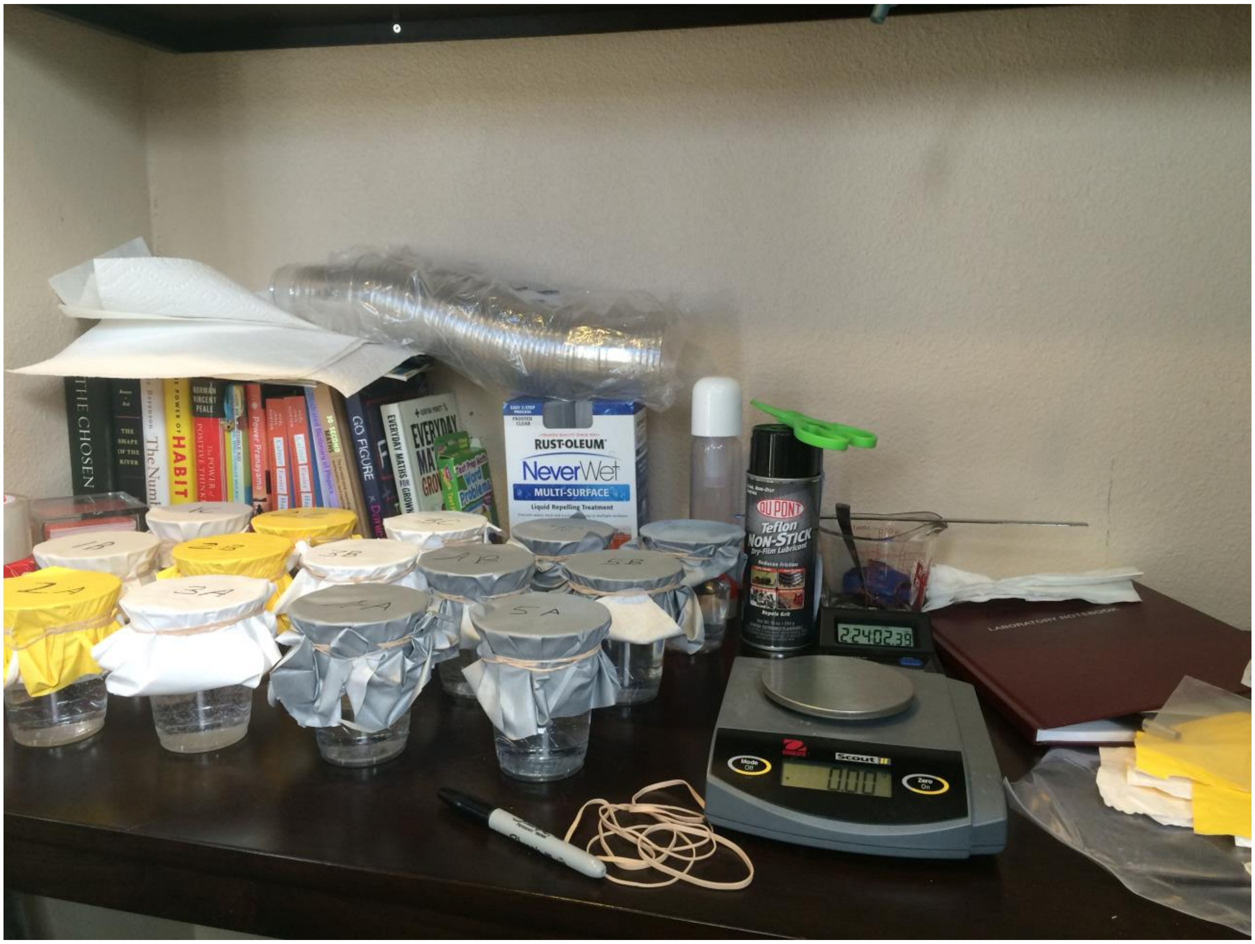
(1) Email Correspondence #10. Graniteville Specialty Fabrics on Implementation. Feb 23, 2015, 5:06 PM

(2) Email Correspondence #11. Alpha ProTech on Implementation. Feb 25, 2015, 6:58 AM


MUD CLOTH
45"
Price as Marked
MUD CLOTH
IKAT
45"/54"
Price as Marked
IKAT
45"/54"
Price as Marked


EASY 2-STEP PROCESS
FROSTED CLEAR
TRUSTED QUALITY SINCE 1921
RUST-OLEUM
NeverWet
MULTI-SURFACE
Liquid Repelling Treatment
Prevents water, mud and ice from sticking to multiple surfaces
METAL
CONCRETE
WOOD
Also great for aluminum, galvanized metal, PVC, masonry, asphalt, vinyl siding, plastic, fabric, leather, canvas and more.
STOPS RUST
RUST-OLEUM
NeverWet
MULTI-SURFACE
Liquid Repelling Barrier
STEP 1
Base Coat
PASO 1 Capa Base
RUST-OLEUM
NeverWet
MULTI-SURFACE
Liquid Repelling Barrier
STEP 2
Top Coat
PASO 2 Capa Superior


RUST-OLEUM
NeverWet
MULTI-SURFACE
Liquid Repelling Treatment


RUST-OLEUM
NeverWet
MULTI-SURFACE
Liquid Repelling Treatment
DUPONT
Teflon
NON-STICK
Dry-Film Lubricant
Scout II
GO FIGURE
HABIT


MUSTANGS
Be Your Physical Best
Field Day
2A
1A


ICE-BRIX


WARNING:
TO BE OPERATED BY ADULTS, ONLY
KEEP AWAY FROM CHILDREN
IF NYLON BARRIER BREAKS,
THEN DISCARD THE UNIT
IN ITS ENTIRETY.

	Kona Cotton Fabric	DuPont™ Tychem® QC (Yellow)
Trial 1	4.92	0.11
Trial 2	4.78	0.15
Trial 3	4.75	0.12

DuPont™ Tychem® SL (White)	Our Design (No Coating)	Our Design (with coating of NeverWet)
0.08	4.66	1.23
0.12	4.59	1.63
0.12	4.53	0.92

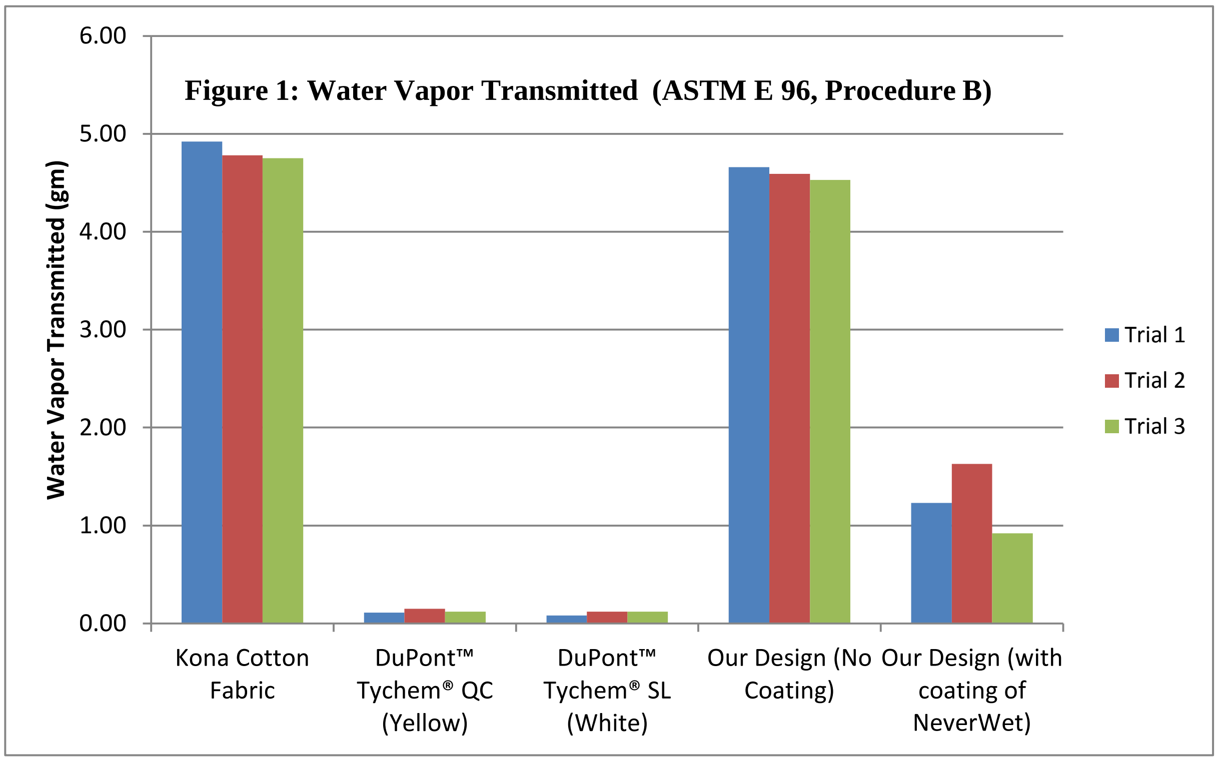


Figure 1: Water Vapor Transmitted (ASTM E 96, Procedure B)

	Trial 1	Trial 2	Trial 3
No Coat	Permeated	Permeated	Permeated
Teflon Spray Coat	Did not Permeate	Permeated	Permeated
NeverWet Spray	Did not Permeate	Did not Permeate	Did not Permeate

Table 1: Effect of coating Therma Flec Silver Cloth with Teflon Spray and NeverWet Spray and Testing with Colored Water

	Kona Cotton Fabric	DuPont™ Tychem® QC (Yellow) Cat # QC125T YL XL000400	DuPont™ Tychem® SL(White) Cat # Suit SL120T WH LG000600	Our Design No Coating	**Our Design Hydrophobic Coating with NeverWet**
Trial 1	31.23286002	0.698295651	0.507851382	29.58234302	7.808215004
Trial 2	30.3441201	0.952221342	0.761777074	29.13797306	10.34747192
Trial 3	30.15367583	0.761777074	0.761777074	28.75708453	5.840290897
Average	**30.57688531**	**0.804098022**	**0.677135176**	**29.15913354**	**7.998659272**

Table 2 : Water Vapor Transmission Rate (gm/hr. m2)
ASTM E 96, Procedure B, upright cup tests with water

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Mercury Glass Thermometer (^oF)	97.6	98.6	98.4	98.8	98.8
Exergen Temporal Thermometer (^oF)	97.4	97.9	95.3	98.7	98.7
Veridian Digital Non Mercury Thermometer (^oF)	97.4	98.6	98.4	98.6	98.8

Table 3 : Accuracy of Various Thermometer (^oF)

Trial 1

	#1 DuPont™ QC Yellow QC125T YL	#2 DuPont™ SL White SL120T WH	#3 Our Design Room Temp **Without ice**	#4 Our Design Frozen Mini Ice **3 packs, 3 oz each**	#5 Our Design Frozen Mini Ice **13 packs, 3 oz each**	#6 Our Design One Jobar Cooling Pad Room Temp	#7 Our Design One Jobar Cooling Pad Cooled (not frozen)
Temp (0 mins)	97.9	97.9	97.2	98	97.2	97.9	98.2
Temp (10 mins)	98.3	98.2	97.2	98.2	97.6	97.2	98.4
Temp (20 mins)	98.5	98.6	97.1	98.2	98	97.3	98.2
Temp (35 mins)	98.4 (Sweating, Very uncomfortable)	98.8 (Sweating)	97.3	98	98 (Feels Good)	97.9 (Feels the same)	98 (Nice)
Temp (45 mins)	98.2 (Sweating, Very comfortable)	98.4 Sweating Heavily)	97.3	97.9	97.9	98	98
Cost	$166.00	$326.75	$57.37	$57.82	$59.32	$64.25	$64.25
Comfort Level & Notes	Very hot Plastic Material	Very Very hot Cannot wear it anymore	ok	ok, Can wear it longer if we want	Feeling very Good. No Sweat. Ice feels very good, not feeling too cold at all. Comfortable and can continue. Feels elbow should be covered than ice directly touching skin via the pocket net	OK, Doesn't sweat. S same issue with pad, falling down, not sown well into the suit	Very Comfortable, not hot, not sweating. Says the pocket needs to be sowed better as falling down to lower back level. So sew the pocket well and close to the neck

Table 4 : Trial 1: Heat Stress Study with different suits including effect of ice and Cost

Trial 2

	#1 DuPont™ QC Yellow QC125T YL	#2 DuPont™ SL White SL120T WH	#3 Our Design Room Temp **Without ice**	#4 Our Design Frozen Mini Ice **3 packs, 3 oz each**	#5 Our Design Frozen Mini Ice **13 packs, 3 oz each**	#6 Our Design One Jobar Cooling Pad Room Temp	#7 Our Design One Jobar Cooling Pad Cooled (not frozen)
Temp (0 mins)	97.9	98.3	98.4	97.8	97.4	98.1	98.1
Temp (10 mins)	98.5	98.5	98.3	98	97.9	97.3	98.2
Temp (20 mins)	98.6 (uncomfortable to wear)	98.4 (very uncomfortable)	98.4	98.2	98.3 (says but not feeling hot)	97.2 (says 'feels the same')	98.1
Temp (35 mins)	98.2 (sweating heavily)	98.6) (started to sweat)	98.3 (no sweating)	97.9 (no sweating, now ice effect kicking in?)	98.3 (Feels Good)	98.1 (says but feels the same)	98.2 (Nice)
Temp (45 mins)	Stopped as uncomfortable (Sweating, Very comfortable)	stopped as uncomfortable (Sweating Heavily)	98.4 (no sweating but around 40 mins said they would like to stop if we could)	97.9 (no sweating, still quite comfortable still)	98.3	98.3	98.2
Cost	$166.00	$326.75	$57.37	$57.82	$59.32	$64.25	$64.25
Comfort Level & Notes	Very hot within 10 mins, sweating in about 20 mins, sprained back		ok	ok,	Feels very good and continue if we want. Same comment about the ice on elbow touching it directly, so make it such that ice does not touch skin through the netting	ok but the one with cooled pad was better	Comfortable. Same comment about pocket pulling to lower back

Table 5 : Trial 2: Heat Stress Study with different suits including effect of ice and Cost

Suit with No Ice	
Materials Used	Cost
Silver Flec Material ($4.06/yard, used 5 yard)	$20.30
Sewing Cost (Wholesale)	$22.00
Zipper	$3.60
Velcro	$0.75
Elastic	$0.75
Never Wet Spray (Home Depot)	$9.97
Total	***$57.37***

Suit with 3 Ice Packs	
Materials Used	Cost
Silver Flec Material ($4.06/yard, used 5 yard)	$20.30
Sewing Cost (Wholesale)	$22.00
Zipper	$3.60
Velcro	$0.75
Elastic	$0.75
Never Wet Spray (Home Depot)	$9.97
3 oz. Ice ($0.15/pc), 3 pcs	$0.45
Total	***$57.82***

Suit with 13 Ice packs	
Materials Used	Cost
Silver Flec Material ($4.06/yard, used 5 yard)	$20.30
Sewing Cost (Wholesale)	$22.00
Zipper	$3.60
Velcro	$0.75
Elastic	$0.75
Never Wet Spray (Home Depot)	$9.97
3 oz. Ice ($0.15/pc), 13 pcs	$1.95
Total	***$59.32***

Suit with Jobar Cooling Pad	
Materials Used	Cost
Silver Flec Material ($4.06/yard, used 5 yard)	$20.30
Sewing Cost (Wholesale)	$22.00
Zipper	$3.60
Velcro	$0.75
Elastic	$0.75
Never Wet Spray (Home Depot)	$9.97
Jobar Cooling Pad	$6.88
Total	**$64.25**

Table 6: Cost Calculation

ASTM E 96 , Procedure B, upright cup tests with water

Diameter of Cloth Used	3.6 inches	0.09144 meter
Radius of Cloth Used	1.8 inches	0.04572 meter
Area	0.0065636	
Area (m^2)	0.0065636	
Example		
eVent (Nylon)	984.8 g/24 h/m^2	41.03 g/ h/m2 (i.e. per hour)
In 0.0065636 m^2	0.2693	g/hr

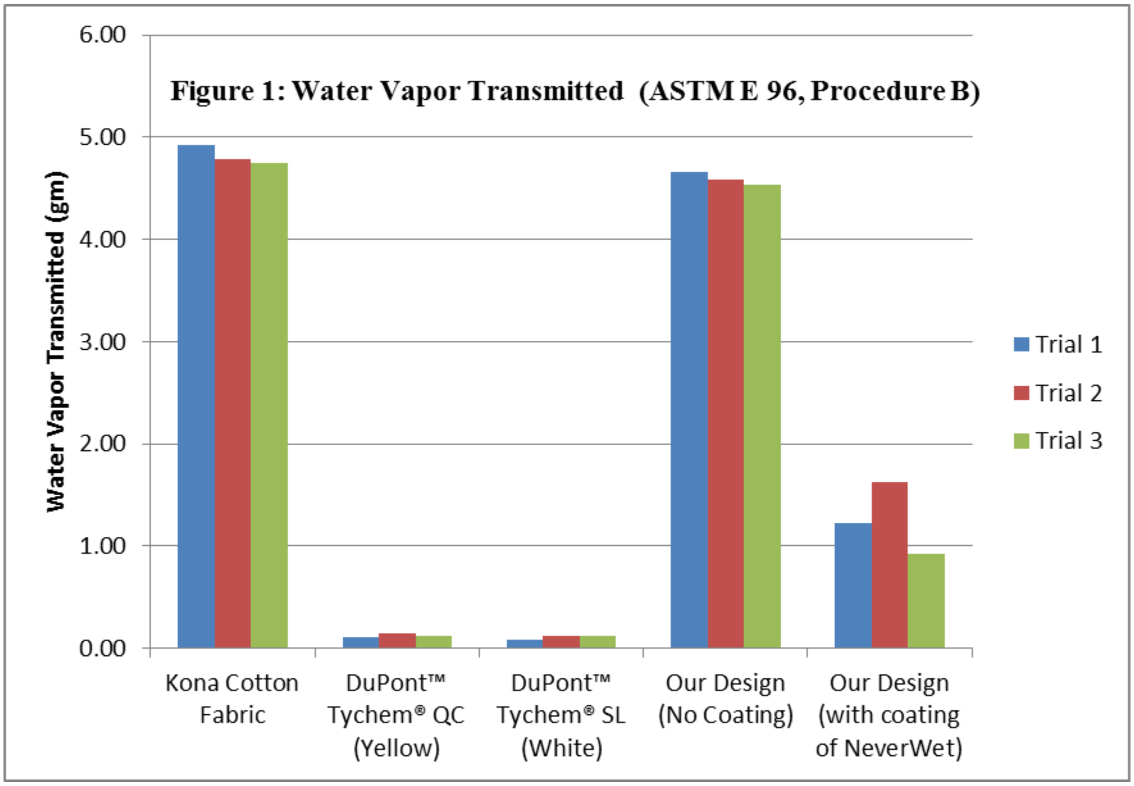


Figure 1: Water Vapor Transmitted (ASTM E 96, Procedure B)
Water Vapor Transmitted (gm)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Kona Cotton Fabric
DuPont™ Tychem® QC (Yellow)
DuPont™ Tychem® SL (White)
Our Design (No Coating)
Our Design (with coating of NeverWet)
Trial 1
Trial 2
Trial 3

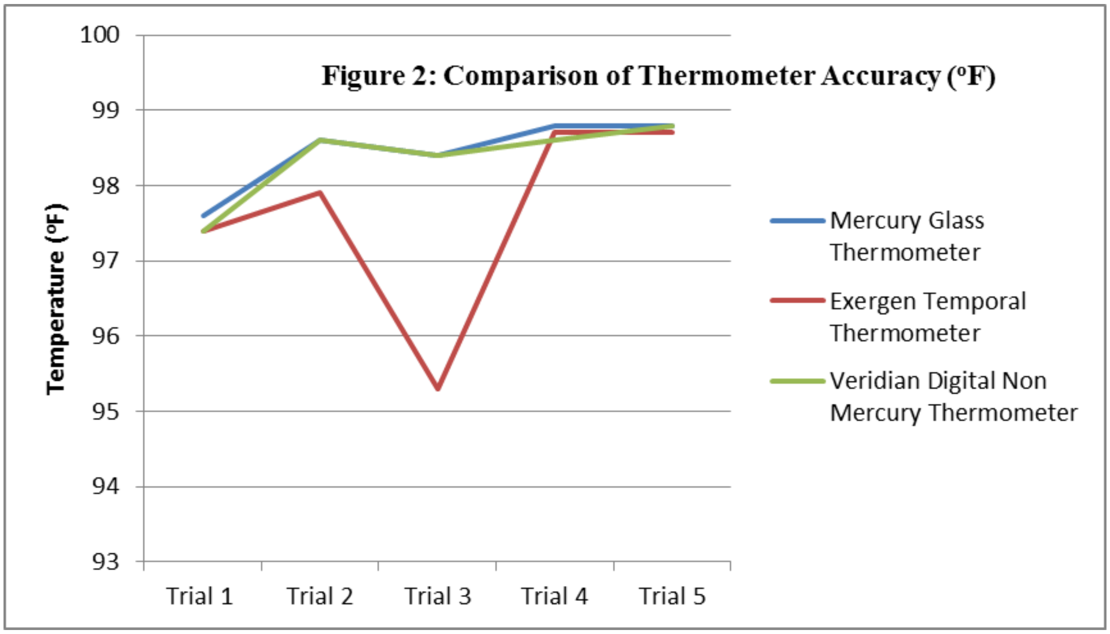


Figure 2: Comparison of Thermometer Accuracy (°F)
Temperature (°F)
100
99
98
97
96
95
94
93
Trial 1
Trial 2
Trial 3
Trial 4
Trial 5
Mercury Glass Thermometer
Exergen Temporal Thermometer
Veridian Digital Non Mercury Thermometer

Hydrophobicity Test Video1
http://youtu.be/xqyhxgA00Xo

Hydrophobicity Test Video2
http://youtu.be/Bp2pagJfaio

Upright Cup Test Video
http://youtu.be/JeUCcdmOS6Q

Demo of Different Suits

http://youtu.be/qfJYw1mewmg

Infection Protection

In our 6th grade class, we learned about the spread of disease, bacteria, infections, and antibiotics such as penicillin. We learned that the flu spreads when people who have the flu don't cover mouth when they sneeze. We also learned that there were 17,290 Ebola cases, 6,128 with deaths. Many bacterial infections such as E. Coli are deadly and can cause severe disease. We wanted to know more as to how bacteria spread, and we wondered: Can we stop them from spreading?

Explore

From communicating with Nobel Laureate David Baltimore and with Dr. Jeff Morelli of CDC, we learned that one pressing community need is a comfortable and inexpensive Hazmat suit that can be available to anyone, not just to hospitals. We thought that there must be issues with current Hazmat Suit designs, as more than 240 healthcare workers have developed Ebola, and 120 of them died despite taking precautions like wearing Hazmat suits.

Problem

We learned that healthcare workers can stay in Hazmat Suits only about 30-45 minutes. The suits are not breathable, so there is no escape for heat and the suits get very hot. This leads to two problems:

(1) It is hard to think straight under heat stress

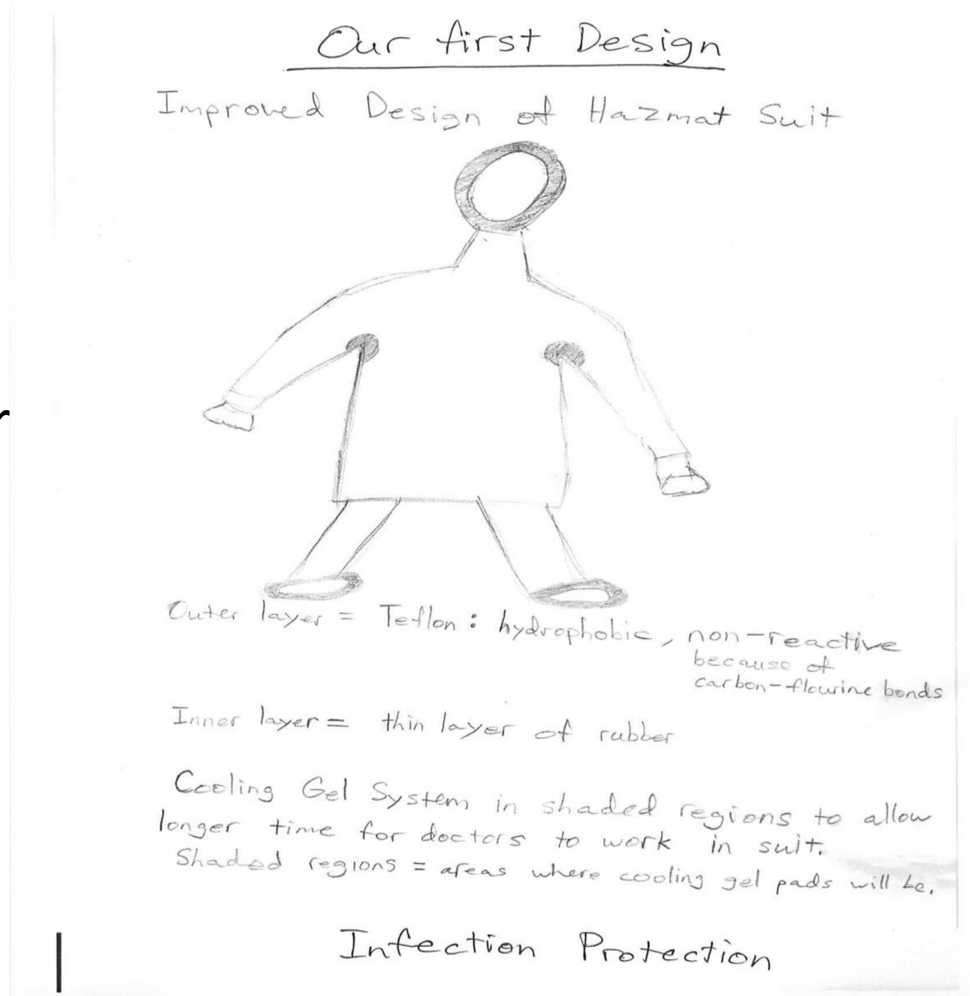
(2) The heat also makes the suits uncomfortable, leading to the risk of contamination and infection when healthcare workers take the suits off to cool down and then put the suit back on again.

More Problems

We also learned that these suits are not antibacterial, are even hotter in areas with scorching heat and humidity (like in West Africa), and can cost between $600-$800, an amount that is higher than an average worker gets paid in an entire year (the average salary in Liberia is $655). We decided we could design a hazmat suit that fixes these problems.

Our Proposed Solution

A suit that has antibacterial properties (i.e. would kill bacteria that comes in contact with it), would resist heat, would keep the wearer cool and not cost as much. So we sketched our prototype to look for materials that we would use to make our suit.



Research

We went to Michael Levine Fabric Store to look at fabrics to use in our suit and saw a silver-tone fabric, known as Therma Flec. We had learned earlier that silver had antibacterial properties. On contacting the manufacturer, Graniteville, we found that Therma Flec Fabric is not silver but is coated with both Aluminum Oxide and a preservative that aids in reducing the growth of organisms such as Aspergillus niger and Staphylococcus aureus.

Research

We learned in our research that Aluminum Oxide has antibacterial properties. The positive surface charge on Aluminum particles interacts with the negative charge of outer membrane of bacteria. This leads to the rupture of outer membrane, which kills the bacteria. In addition, the Aluminum Oxide in our chosen fabric helps to reflect and transmit heat away from the fabric's surface, providing more heat protection to the wearer than ordinary apparel items.

Research

We decided we should treat our suit material with a hydrophobic coating to prevent liquids, chemicals, and blood from passing through.

We tested the Therma Flec heat resistant material in a swatch format (with and without Teflon spray). Teflon Spray did not work, so we tried NeverWet Spray. NeverWet creates a hydrophobic coating so that the water or oil droplets' contact angles exceed 150°, preventing water, dirt, and/or ice from attaching to the surface.

Research

We learned that outside temperature and humidity can have a huge combined effect on suits worn by firefighters, and that this was measured by the Steadman Apparent Temperature Index. It says that with an environmental temperature of 90˚F (32˚C) and a relative humidity of 90%, the apparent temperature is 122 ˚F (50°C). Thus, a firefighter exposed to these conditions will experience discomfort similar to that associated with an environmental temperature of 122°F (50˚C) at low humidity. Additionally, exposure to direct sunlight as well as the use of protective clothing will each increase apparent temperature by about 10°F (2°C). This fact would be very critical in choosing a heat resistant fabric like Therma Flec, especially for use in countries like West Africa, or firefighters and the military.

Materials (Partial List)

- Therma Flec Heat Resistant Silver Cloth
- Teflon Spray , 10 oz. Catalog # DNS616601, DuPont
- Never Wet Spray, 18 oz. Base Coat and Top Coat Model # 274232.
- Ohaus Scout Balance, 200 g weighing capacity, resolution: 0.01 g Catalog # SC2020
- Thermometers (3 Types)
- Jobar International Cooling Pads (they don’t need to be frozen before use) Cat # JB6001.
- 3 oz Wallet size Gel Packs (Size: 2 1/2" x 5" x 1/2") Catalog # IB3. Polar Tech Industries.
- Color water (food coloring)
- DuPont™ Tychem® QC. No hood. Yellow. Cat # QC125T YL XL000400,
- DuPont™ Tychem® SL.. White. Cat # Suit SL120T WH LG000600
- Velcro, Elastic, Zipper, Netting for ice pocket

Methods

- **Hydrophobicity**: Test with a fine mist spray of colored water and see if it soaks through fabric.

- **Fabric Breathability**: Use ‘Upright Cup Method” ASTM E 96 Procedure B Method . In this method, we will fill a cup with some water and seal the cup opening with the fabric that we want to test. The breathable fabric would allow the water vapor to escape the cup through the fabric and the weight of the cup should drop with time. We would measure the weight of the cup just before the start of experiment and over 24 hours. The fabric that will make most water go through it, will weigh the least and should be the coolest

- **Effect of Gel Ice Pack and Cooling Pads on Comfort**: We constructed the suit with 13 pockets to hold miniature 3 oz. ice gel packs. We would vary the type and number of such cold gel packs and then measure the body temperature and comfort.

- **Effect of Room temperature Cooling Pads**: We designed a larger pocket that will hold Jobar Cooling Pad that does not require freezing or cooling. If this would work, it could be useful in countries where refrigeration is not an easy task.

Test Results: Hydrophobicity

	Trial 1	Trial 2	Trial 3	
No Coat	Permeated	Permeated	Permeated	
Teflon Spray Coat	Did not Permeate	Permeated	Permeated	
NeverWet Spray	Did not Permeate	Did not Permeate	Did not Permeate	
		Table 1: Effect of coating Therma Flec Silver Cloth with Teflon Spray and NeverWet Spray and Testing with Colored Water		

Test Results: Fabric Breathability

Our Upright Cup method testing demonstrated that our Therma Flec heat resistant fabric, coated with NeverWet hydrophobic spray, has an average breathability of 7.99 gm/hr.m2 whereas DuPont's Tychem QC (in yellow) and Tychem SL (in white) fabrics have breathability of 0.80 gm/hr. m2 and 0.67 gm/hr. m2. Our design is 10 times more breathable than the Tychem Suits used by CDC and others.

Test Results: Breathability of Various Fabrics

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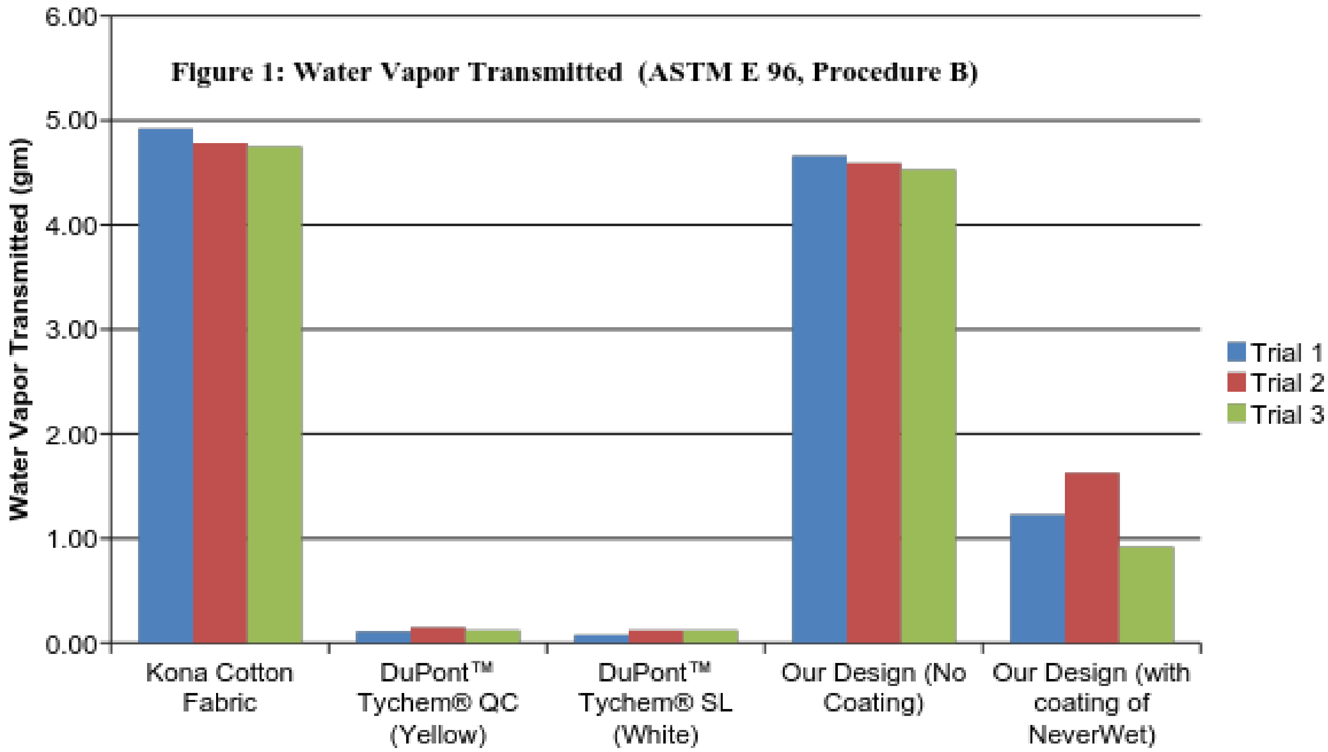


Test Results: Effect of ice and Comfort (First Trial)

Trial 1							
	#1 DuPont™ QC Yellow QC125T YL	#2 DuPont™ SL White SL120T WH	#3 Our Design Room Temp **Without ice**	#4 Our Design Frozen Mini Ice **3 packs, 3 oz each**	#5 Our Design Frozen Mini Ice **13 packs, 3 oz each**	#6 Our Design One Jobar Cooling Pad Room Temp	#7 Our Design One Jobar Cooling Pad Cooled (not frozen)
'emp (0 mins)	97.9	97.9	97.2	98	97.2	97.9	98.2
emp (10 mins)	98.3	98.2	97.2	98.2	97.6	97.2	98.4
emp (20 mins)	98.5	98.6	97.1	98.2	98	97.3	98.2
emp (35 mins)	98.4 (Sweating Very uncomfortable)	98.8 (Sweating)	97.3	98	98 (Feels Good)	97.9 (Feels the same)	98 (Nice)
emp (45 mins)	98.2 (Sweating Very comfortable)	98.4 Sweating Heavily)	97.3	97.9	97.9	98	98
Cost	$166.00	$326.75	$57.37	$57.82	$59.32	$64.25	$64.25
omfort Level & Notes	Very hot Plastic Material	Very Very hot Cannot wear it anymore	ok	ok, Can wear it longer if we want	Feeling very Good. No Sweat. Ice feels very good, not feeling too cold at all. Comfortable and can continue. Feels elbow should be covered than ice directly touching skin via the pocket net	OK, Doesn't sweat. S same issue with pad, falling down, not sown well into the suit	Very Comfortable, not hot, not sweating. Says the pocket needs to be sowed better as falling down to lower back level So sew the pocket well and close to the neck

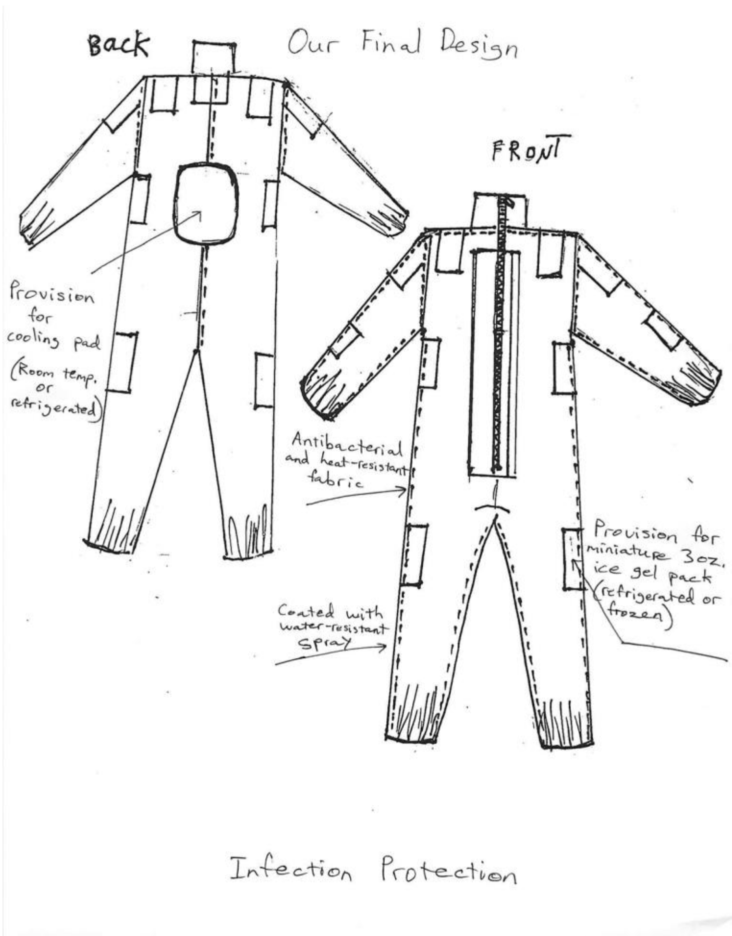
Table 4 : Trial 1: Heat Stress Study with different suits including effect of ice and Cost

Test Results: Effect of ice and Comfort

Tychem QC and SL is very hot. The temperature starts to drop as a result of sweating. Our design is comfortable without any cooling elements and even more cooler when we use miniature frozen gel packs (3 oz.) or the Jobar cooling pad that does not require refrigeration. The wearer does not feel cold even when all 13 of the miniature frozen gel packs are inserted, and feels comfortable with even as few as one gel pack. The Jobar cooling pad performs even better when it is cooled with ice cubes (which may be important in developing nations which have access to ice cubes but not refrigeration).

Our design was substantially less expensive than commercially available Hazmat suits. Our cost is between $57 and $64 with cooling, whereas the commercially available suits that we tested and that are used by the CDC cost $166 and $326.

Final Design



How is our suit different than Existing ones?

- Antibacterial properties due to Aluminum Oxide Coating
- Heat Resistant Due to Aluminum oxide reflecting heat , important in hot and humid weather
- Coated with preservative to reduce the growth of organisms such as Aspergillus niger and Staphylococcus aureus
- Coated with NeverWet to make it hydrophobic
- 10 times higher breathability once coated than traditional Hazmat Suits thus making them cooler and comfortable
- Provides options for additional cooling using frozen ice packs or even with room temperature stored Jobar cooling pads
- Our design was least expensive. Our cost was between $57 and $64 with cooling whereas the suits that are so hot and sweaty cost $166 and $326 on the ones we tested and used by CDC and many others
- Our suit design can keep them cool no matter where and who they are: West Africa, Military, Fire Fighters, Paramedics

Interested Manufacturers

- We contacted various manufacturers that we found and have heard from two. We learned of these manufacturers during lots of press coverage during Ebola crisis in October 2014.

- On Feb 25th, Alpha Protech, one of the largest manufacturer of suits wrote to us in email that they are intrigued by our design and will be discussing it with their manufacturing.

- Graniteville Specialty Fabrics manufacturer of fabric has also told us in an email that they are discussing it.

- On Feb 26, 2015, we filed a provisional patent with four of us as inventor (Application No. 62120990). It costs us only $65.00 as we are students and we now have 12 months to continue working more on it.

It was Fun!!

Please watch our videos on YouTube

Hydrophobicity Test Video1
http://youtu.be/xqyhxgA00Xo

Hydrophobicity Test Video2
http://youtu.be/Bp2pagJfaio

Upright Cup Test Video
http://youtu.be/JeUCcdmOS6Q

Demo of Different Suits
http://youtu.be/qfJYw1mewmg

AEOP ARMY EDUCATIONAL OUTREACH PROGRAM | eCYBERMISSION ACCEPT THE CHALLENGE | U.S. ARMY

INSTITUTIONAL REVIEW BOARD

APPROVAL FORM

Student(s) Name(s): Natalie Barnouw, Rhea Madhogarhia, Rohan Madhogarhia, Siji Smolev

Grade: 6th Science Teacher: Ms. Arpa Ghazarian

Title of Project: Infection Protection

Brief Description of Project: Testing of infection protection hazmat type suits and suits made by other manufactures such as DuPont. The testing would involve wearing the suit and measuring vital signs such as the temperature of the body.

Teacher: Please sign here if the project proposed is a viable eCYBERMISSION Project in which neither animals nor humans will be harmed.

Science Teacher Approval Signature: [signature]

IRB Waiver of Written Informed Consent for Human or Animal Participation

The IRB may waive the requirement for documentation of written informed consent/assent/parental permission if the research involves **only minimal risk *and* anonymous data collection *and* if it is one of the following:**

- Research involving normal educational practices.
- Research on individual or group behavior or characteristics of individuals where the researcher does not manipulate the subjects' behavior and the study does not involve more than minimal risk.
- Surveys, questionnaires, or activities that are determined by the IRB to involve perception, cognition, or game theory and do NOT involve gathering personal information, invasion of privacy or potential for emotional distress.
- Studies involving physical activity where the IRB determines that no more than minimal risk (Daily Activity) exists and where the probability and magnitude of harm or discomfort anticipated in the research are not greater than those ordinarily encountered in DAILY LIFE or during performance of routine physical activities.

If there is any uncertainty regarding the appropriateness of waiving written informed consent/assent/parental permission, it is strongly recommended that documentation of written informed consent/assent/parental permission be obtained.

For School/Site Use Only:

HUMAN or ANIMAL SUBJECTS
Permission Slips needed? ____ Yes X No (Scan and attach slips to Mission Folder)
Check-up of Human or Animal Subjects required by Doctor, school nurse or Veterinarian? [signature] Yes X No If yes, Doctor's, Nurse's or Veterinarian's (before and after experimentation) check-up must be attached to Mission Folder.

APPROVALS –

Sheila Summons — 2-25-15

Principal / Administrator Signature — Date Reviewed

Rachel Esmond MD — 2/13/2015

Doctor or Medical Professional Signature — Date Reviewed

[signature] — 2/10/15

Science Fair Coordinator Signature — Date Reviewed