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## Evaporative Tests

Prepared For  
**Frisby Technologies**

*Frisby Technologies Report FT-TR-01-04*

Note: This report is for general release.

### **Prepared by**

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1/01

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## 1 Project Summary

Tests were performed at Frisby Technologies to determine the reduction in temperature caused by the evaporative effect of certain composite evaporative materials. Evaporative Composite Materials (ECMs) from Frisby Technologies (Evaporator™) and Auquatex (Hydroweave™) were evaluated. Three series of tests were conducted using selected materials in controlled environments.

The first test compared the length of time that the Frisby ECM and Auquatex ECM held water for evaporation in a 100°F (37.8°C), 30% Relative Humidity (RH) environment.

The second test measured the correlation of the inner microclimate temperature of the Frisby ECM to various levels of humidity at a constant 100°F (37.8°C) ambient temperature.

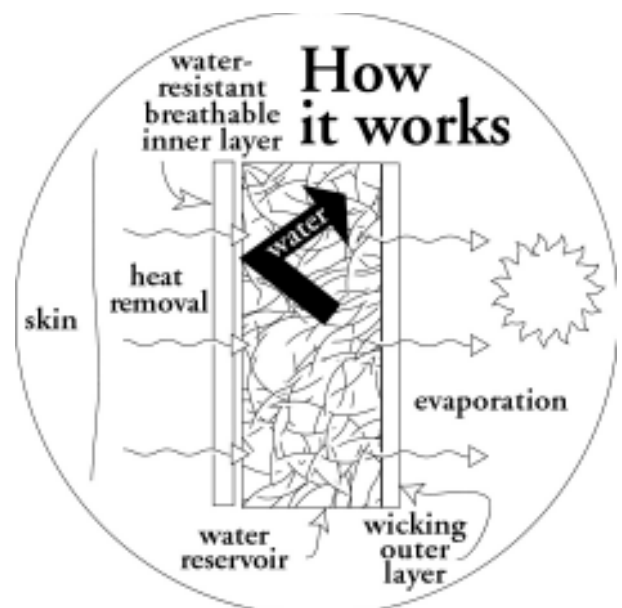
The third test evaluated the ability of ECMs to reduce the temperature of the microclimate inside the vest while a human test subject walked on a treadmill at a 2.5 mph pace in a 90°F (32.2°C) ambient temperature at 30, 50 and 70% relative humidities (RH) environment. This situation was repeated to compare the Frisby ECM with the Auquatex ECM.

Results from all three tests showed that the Frisby ECM is capable of providing a cooling benefit at various temperatures and humidities. Tests showed that the Frisby ECM provided similar cooling benefit compared to Auquatex ECM at a fraction of the cost.

## 2 Project Objective

Frisby performed these tests from March 2000 to September 2000 to evaluate the ability of ECMs to provide cool microclimates in hot environments and to compare Frisby's ECM to the leading brand ECM.

ECMs work to supplement the body's natural sweating process by providing water for additional evaporation, which keeps an individual cooler and more hydrated (Figure 1).



### **3 Test Sample Summary**

Sample 1 was the Aquatex ECM.

Sample 2 was the Frisby ECM.

Laboratory samples were placed on a 1-inch thick piece of expanded polystyrene insulation.

### **4 Test Procedure**

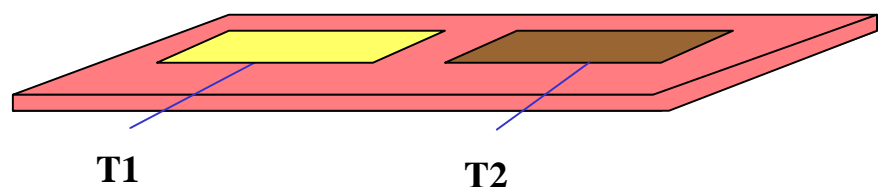
#### **4.1 Equipment**

- 30AWG copper/constantan (type T) thermocouples.
- Omega RH411 Digital Thermo-Hygrometer.
- DataLogger 600 portable data taker.
- Keithley-Metrabyte K500 series data acquisition hardware with supporting LabView software.
- Espec 684 ft<sup>3</sup> (interior) environmental chamber.
- Tenny Jr. 1.0 ft<sup>3</sup> (interior) environmental chamber equipped with humidifier.
- Precision Scientific oven.
- Precor C964I treadmill.

#### **4.2 Setup, Conditions, and Procedure**

##### **4.2.1 Comparison Tests**

The first test setup consisted of using three thermocouples, Keithley-Metrabyte acquisition system and an oven. Thermocouples (one each, T1 & T2) were placed between the ECMS and the expanded polystyrene (see Figure 2). A third thermocouple measured ambient oven temperature.



**Figure 2**

The data acquisition was initiated and instrumentation was checked to make sure that parameters were measuring correctly. Both materials were saturated with water, then hung vertically, allowed to drip for one minute, and then placed on the thermocouples. The test platform was placed into an oven set at 100°F (37.8°C), 30% RH. Data was acquired every thirty seconds for 4 hours and 30 minutes.

#### **4.2.2 Humidity Tests**

The second test setup consisted of the two thermocouples, Digital Thermo-Hydrometer, Keithley-Metrabyte acquisition system, and a 1.0 ft<sup>3</sup> environmental chamber. Frisby ECM was hydrated as per placed on 1-inch expanded polystyrene insulation.

The data acquisition was initiated and instrumentation was checked to make sure that parameters were measuring correctly. The Frisby ECM was hydrated as per 4.2.1 and then placed over the thermocouple. The test platform was placed into an environmental chamber set at 100°F (37.8°C), 30% RH. Data acquisition was initialized. After the thermocouple under the ECM stabilized, the humidity was increased 10%. This procedure was repeated in increments of 10% until the relative humidity stabilized at 80%. The entire procedure was repeated in the reverse order (80%RH to 30%RH).

#### **4.2.3 Human Testing**

In this test, the subject wore a vest made from ECM material. The test was conducted in the Espec environmental chamber set at an ambient temperature of 90°. The test consisted of two parts; Frisby ECM (30, 50, 70%RH) and Aquatex ECM (50%RH). In both tests, thermocouples were placed between the vest and the test subject's body in the following locations:

- Left pectoral
- Right pectoral
- Left scapula
- Right scapula

These locations were chosen because most of the body's heat is generated there (see Figure 3).

The test participant then donned a saturated vest made out of the Frisby ECM (Figure 4) and entered the environmental chamber that was set to 90°F (32.2°C), 30% RH. While acquiring data, the test participant walked at a 2.5 mph pace on a

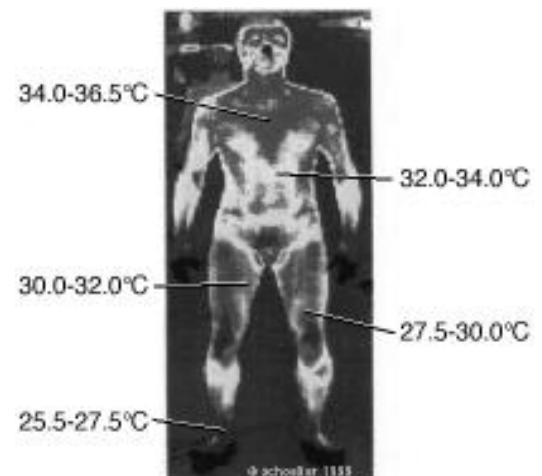


Figure 3

*Evaporative  
Comparison Tests*

treadmill for 30 minutes. The test was repeated at 50 and 70% RH.

The test was then repeated with a vest made from Aquatex ECM material (Figure 3), allowing 24 hours (+/- 1/2 hour) to pass within testing to ensure like body temperatures.

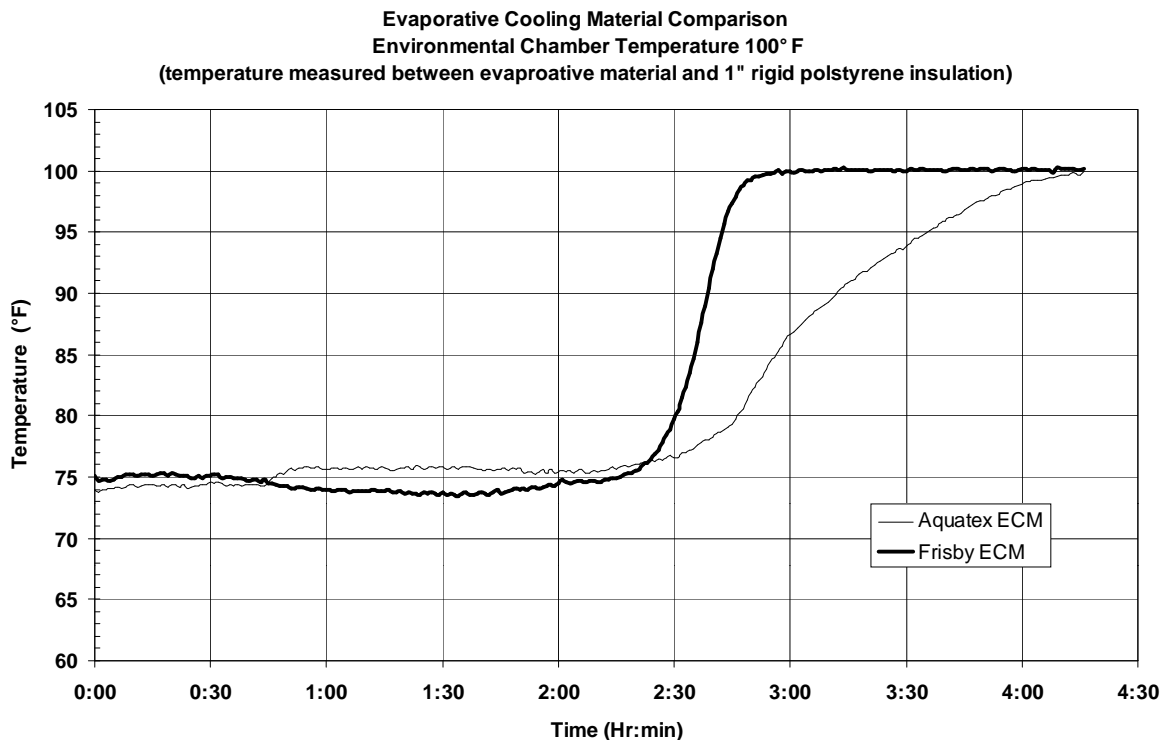


Figure 4

## 5 Test Results

### 5.1 Comparison Tests

Graph 5.1 compares the Frisby ECM to the Aquatex ECM. The test showed that both materials provided cooling for approximately 2 1/2 hours. After this time period, the thermocouple temperatures rise to ambient in about 20 minutes whereas the Aquatex material temperature rises gradually.

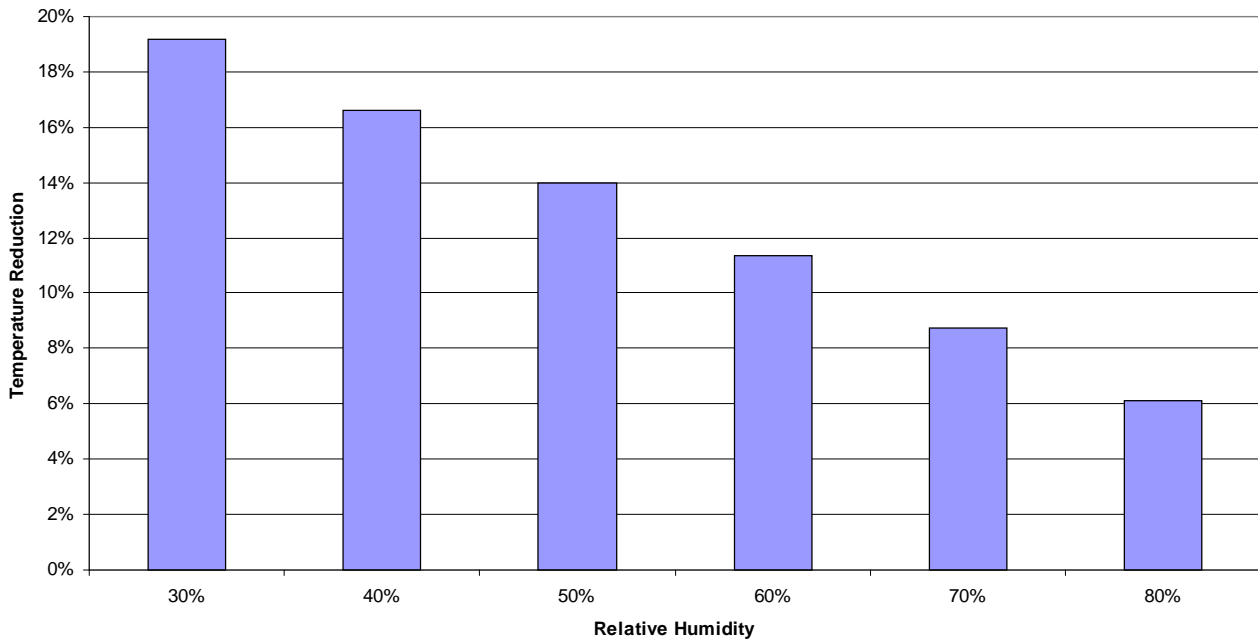


Graph 5.1

## 5.2 Humidity Tests

Graph 5.2 shows the results of humidity testing on the ability of the Frisby ECM to provide cooling. The results showed a roughly linear relationship between humidity and cooling ability. The Frisby ECM provided a 19% to 6% cooler microclimate for relative humidities of 30% to 80%, respectively.

**Effect of humidity on Frisby ECM cooling ability**  
**100 F ambient - environmental chamber**  
(temperature measured between  
1" expanded polystyrene insulation  
and ECM)



Graph 5.2

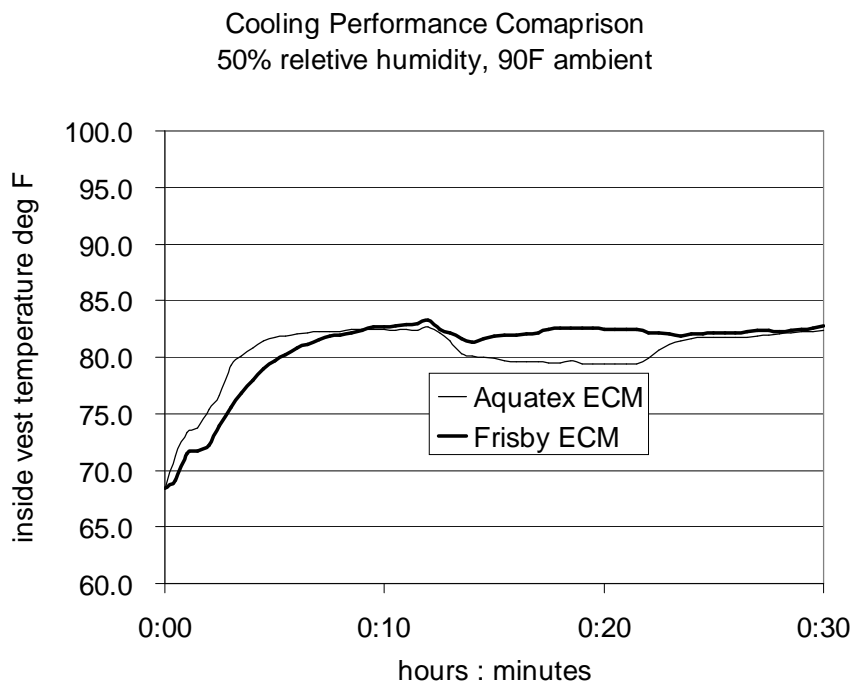
Table 5.2 shows the average *high* temperature and the average *afternoon* relative humidity of several different cities within the United States. This data is historical data based on the months June through September<sup>1</sup>.

<b>City / State</b>	<b>Average High Temperature</b>	<b>Average Relative Humidity</b>
Daytona Beach, Fla	88°F	65%
New York City, NC	81°F	56%
Santé Fe, N.M	84°F	48%
Winston-Salem, NC	84°F	59%
Topeka, Kansas	85°F	59%

**Table 5.2**

### **5.3 Human Testing**

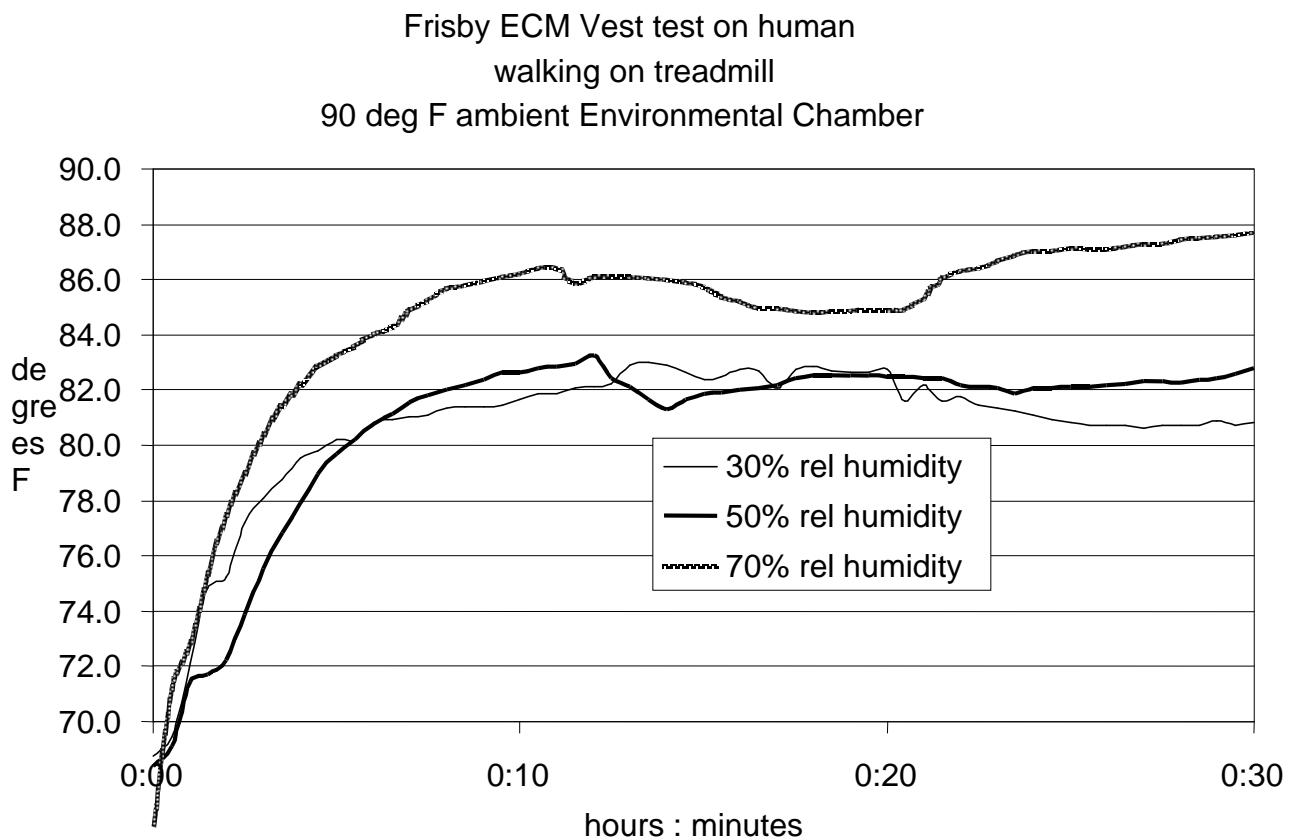
Graph 5.3A compares cooling of the Frisby ECM vest to the Aquatex ECM vest. This graph shows that the Frisby ECM vest provided similar cooling performance to the Aquatex ECM vest.



**Figure 5.3A**

<sup>1</sup> Historical data gathered from the Washington Post- <http://www.washingtonpost.com>

Graph 5.3B plots the inner temperature of the Frisby ECM vest in different RH conditions. The results shows the ability of the Frisby ECM to provide a cooler microclimate at all relative humidity settings.



Graph 5.3B

## 6. Summary

These tests demonstrated that:

- *The Frisby ECM material can provide a cool microclimate in a variety of ambient temperatures and humidities. The Frisby ECM performs similarly to Aquatex ECM.*