



A Report

to

**FireDex**

on

**Characterization of the FireDex Model AFX Turnout System Using the PyroMan™ System**

from

Textile Protection and Comfort Center (T-PACC)  
College of Textiles  
North Carolina State University  
Raleigh, North Carolina 27695-8301

**February 7<sup>th</sup>, 2024**

## Characterization of Test Garments Using the PyroMan™ System

One turnout system was submitted for testing by FireDex to the Textile Protection and Comfort Center (T-PACC) in the College of Textiles at North Carolina State University. This garment was evaluated for resistance to a simulated flash fire exposure employing procedures similar to ASTM F1930-23 *Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin*, see the “Thermal Protective Clothing Analysis” for each test found in Appendix A for details. The purpose of this report is to describe the testing system used and to present the result.

---

### NCSU PyroMan™ Test System

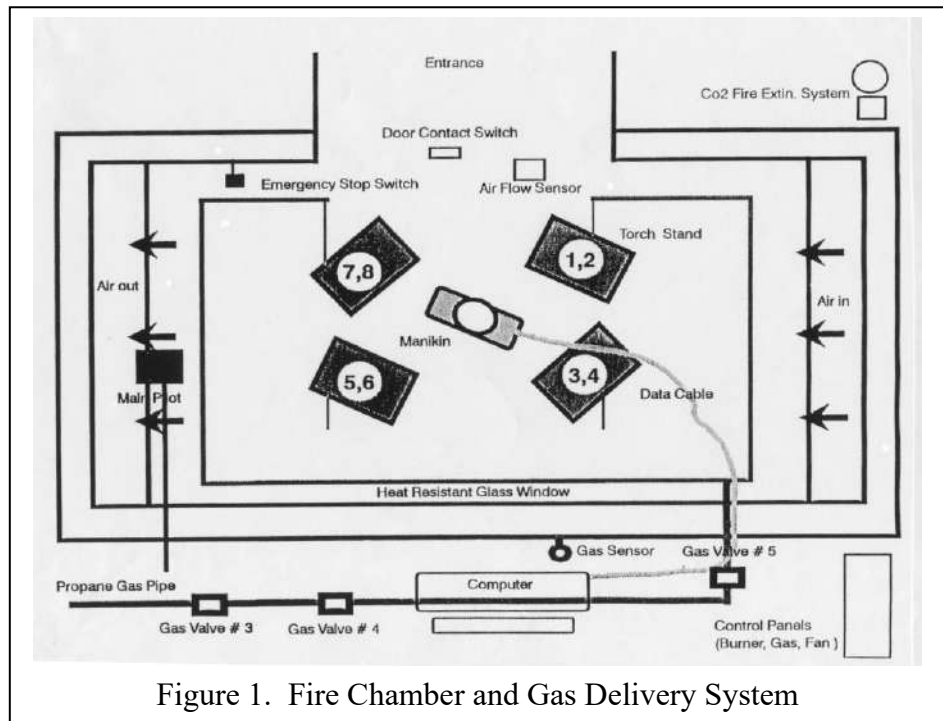
---

The PyroMan™ System consists of a number of components, designed to work together to measure the performance of protective clothing under full scale, flash fire exposure conditions. The most important requirements of this flash fire system are safe operation and reproducibility. The layout of system components is shown in Figure 1.

**Fire Chamber:** The instrumented manikin and the exposure system are housed in a flame resistant room with large viewing windows on one wall and double entrance doors on the opposite wall. The fire chamber is provided with supply and exhaust ducts and fans, which are automatically controlled to provide safe startup of the system and rapid removal of the products of combustion and degradation after a test exposure.

**Gas Supply System:** Pressure sensitive switches monitor the system to maintain safe operating conditions. Propane gas is supplied to the burner system through a series of valves and reducers. Electrically controlled valves prevent supply of high-pressure gas for the test exposure until all of the safety devices are satisfied and the test is ready to be run. The gas supply line is vented through solenoid valves, which are open, when the system is not in use.

**Burners & Gas Control Panel:** Eight industrial burners, modified to produce the flash fire, are carefully positioned to create a large volume of fire that fully engulfs the manikin. Each burner



has a pilot flame that is lighted and proven before the gas is supplied to the torch. A gas control panel monitors the state of each pilot flame to prevent opening of the exposure torch valve if there is no pilot flame present. This panel also monitors the condition of the supply line and safety devices and, in case of a malfunction, will shut the system down and vent the gas in the supply line.

Manikin: The test manikin, suspended from the ceiling of the burn chamber on an adjustable fixture, is a size 40 regular male, made from a flame resistant polyester resin reinforced with fiber glass (Figure 2). There are sockets, uniformly distributed on the surface, for 122 heat sensors. Leads from each sensor are taken to the data acquisition unit through a guarded, heat-shielded cable.

Computer System: After dressing the manikin, safe operating conditions are assured via interaction with a sophisticated computer system used to control the test procedure, to include the lighting of pilot flames, exposing the test garment to the flash fire, acquisition of data, and running the fans to vent the chamber. Data acquired by the system is used to calculate the incident heat flux, predicted burn injury for each sensor during and after the exposure, and produce a report and graphics each test.



Figure 2. PyroMan™ Manikin

---

## Test Materials

---

The ensemble was conditioned prior to testing. For clothing and laundry specifics, see the “Thermal Protective Clothing Analysis” found in Appendix A.

---

## Test Results

---

Measuring the amount of heat transfer a garment allows to a manikin during a flash fire simulation can assess flash fire resistance. This transferred heat can be expressed in terms of predicted burn damage to human skin. This can be done by using heat flux measured at the manikin surface to estimate changes in the temperature throughout the layers of human skin including the epidermis, dermis, and subcutaneous layers. These temperatures can then be used to predict if a sufficient amount of energy has been transferred to produce either a second or third degree burn.

Prior to testing, a nude manikin calibration was done with a 4 seconds exposure. The test garment was evaluated with an average heat flux of  $2.00 \text{ cal/cm}^2\text{sec} \pm 0.05 \text{ cal/cm}^2\text{sec}$  with a flash fire exposure of 4 seconds. Test results are summarized in Table 1. Detailed data, including test summary, comment sheet, burn injury prediction graphic are found in Appendix A.

The extinguish time noted in test comment section reflects the time it takes for a garment to self-extinguish from the end of the flame exposure.

Caveat: These data characterize the properties of materials or assemblies in response to radiant and convective energy under controlled laboratory conditions and should not be used to appraise the safety benefits or risk of materials, products, or assemblies under actual fire conditions. They are the results of specific laboratory exposures; extrapolations to other types of heat exposures or different combinations of radiant, convective and conductive assaults cannot be made. They are not presented to predict all types of field conditions where the nature of the thermal exposures can be physically complicated and unqualified. We wish to emphasize that it is not our intention to recommend, exclude, or predict the suitability of any commercial product for a particular end-use.

**Table 1. Summary of Test Results**

| Burn (#) | NCSU File ID | Flame Exposure (sec) | Sample ID                        | Predicted Burn (%) |              |             |
|----------|--------------|----------------------|----------------------------------|--------------------|--------------|-------------|
|          |              |                      |                                  | 2nd                | 3rd          | Overall     |
| 1        | 240207E      | 4                    | FireDex Model AFX Turnout System | <b>0.000</b>       | <b>0.000</b> | <b>0.00</b> |

## **Appendix A**

### **PyroMan™ Test Specifications, Test Remarks, Photos, and Manikin Burn Injury Predictions**

## Thermal Protective Clothing Analysis

## 3-Layer Skin Model

|                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                    |                     |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|---------------------|
| Data File Name                          | 240207E                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Test Date                                                          | 2024-02-07 9:28 AM  |
| System Identification                   | PyroMan™                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Sponsor                                                            | FIREDEX             |
| Garment Identification                  | FIREDEX MODEL AFX TURNOUT SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                    |                     |
| Garment size                            | SEE BELOW                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Conditioning Room Removal Time                                     | 2024-02-07 09:15 AM |
| N Washes                                | 1 (-1 = Unknown)                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <input checked="" type="checkbox"/> 100% Cotton Underwear & Tshirt |                     |
| Garment/Fabric Comments                 | LAYER 1: COTTON T-SHIRT AND BRIEF<br>LAYER 2: JACKET: SIZE 44 CHEST, 32 LENGTH, SLEEVE 35, OUTER SHELL: TECGEN71+/TECGEN71+, THERMAL BARRIER: RESQ/COREEXP 1L/CORE-CXP 1 LAYER, MOISTURE BARRIER: STEDAIR 4000<br>PANT: WAIST 36, INSEAM 32, OUTER SHELL: TECGEN71+/TECGEN71+, THERMAL BARRIER: RESQ/COREEXP 1L/CORE-CXP 1 LAYER, MOISTURE BARRIER: STEDAIR 4000                                                                                                        |                                                                    |                     |
| Pre Test Comments                       | GARMENTS WERE CONDITIONED BY NCSU<br>GARMENTS STORED IN CONDITIONED SPACE PRIOR TO TESTING<br>TESTING CONDUCTED ACCORDING TO ASTM F1930-18 BY SR THERMAL PROTECTION SCIENTIST JOHN MORTON-ASLANIS AND RESEARCH TECHNICIAN MARK MARTIN<br>FIREDEX PROJECT ENGINEER: MATT COLATRUGLIO, MATTCOLATRUGLIO@FIREDEX.COM<br>ITEMS PLACED IN CONDITIONING ROOM: 02/06/2024 AT 7:00 AM<br>CONDITIONING ROOM TEMP: 21°C, CONDITIONING ROOM HUMIDITY: 65% (AT TIME OF ITEM REMOVAL) |                                                                    |                     |
| Post Test Comments                      | AFTERFLAME NOT RECORDED                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                    |                     |
| Smoke Generation                        | Shrinkage                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Break-Open                                                         | Embrittlement       |
| Medium                                  | Minor                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | None                                                               | N/A                 |
| Start Room Temp (oC)                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 23                                                                 |                     |
| Start Avg Sens. Temp (oC)               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 30                                                                 |                     |
| Total DAQ time (s)                      | 120                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Avg Expos. Heat Flux (cal/(cm^2*sec)                               | 2.00                |
| Exposure Time (s)                       | 4.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Torches Used                                                       | ALL                 |
| Scan Interval (s)                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0.10                                                               |                     |
| ALL, or those used, separated by commas |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                    |                     |
| Burn Calculation Time (s)               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 90.0                                                               |                     |

% 2nd Degree Burns 0.000

% 3rd Degree Burns 0.000

% Total Burn 0.00

For More Information Contact:

North Carolina State University  
College of Textiles  
Textile Protection and Comfort Center  
1020 Main Campus Drive  
Raleigh, NC 27606

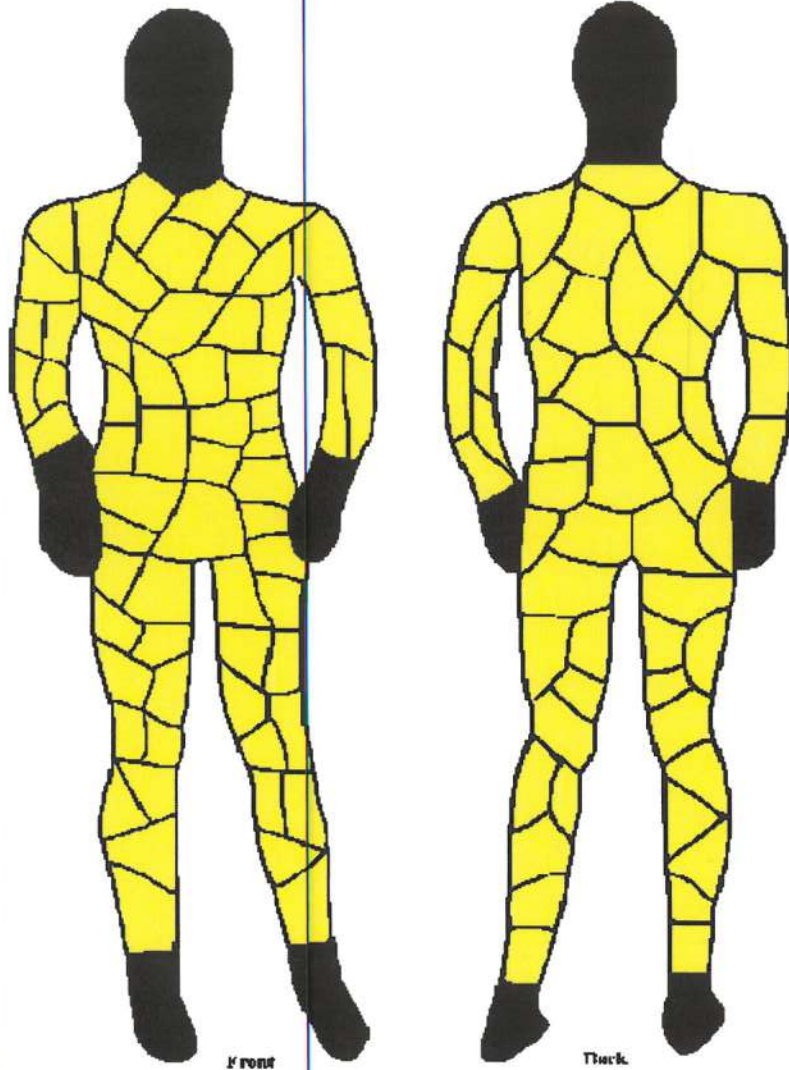
END of Thermal Protective Clothing Analysis Sheet

# NCSU PyroMan™

3-Layer Skin Model

Thermal Protective Clothing Analysis System

## Burn Injury Prediction



FIREDEX

FIREDEX MODEL AFX TURNOUT SYSTEM

Exposure Time (s)  DAQ Time (s)  Time Step (s)

% 2nd Degree Burns

% 3rd Degree Burns

% Total Burn

Burn Calculation Time (s)

Sens. Removed: 11, 12, 13, 14, 25, 26, 27, 28

|                 |                                                                                       |
|-----------------|---------------------------------------------------------------------------------------|
| Invalid Sensor  |  |
| No Burn         |  |
| 2nd Degree Burn |  |
| 3rd Degree Burn |  |

240207E

# PyroMan™

Thermal Protective Clothing Analysis System

3-Layer Skin Model

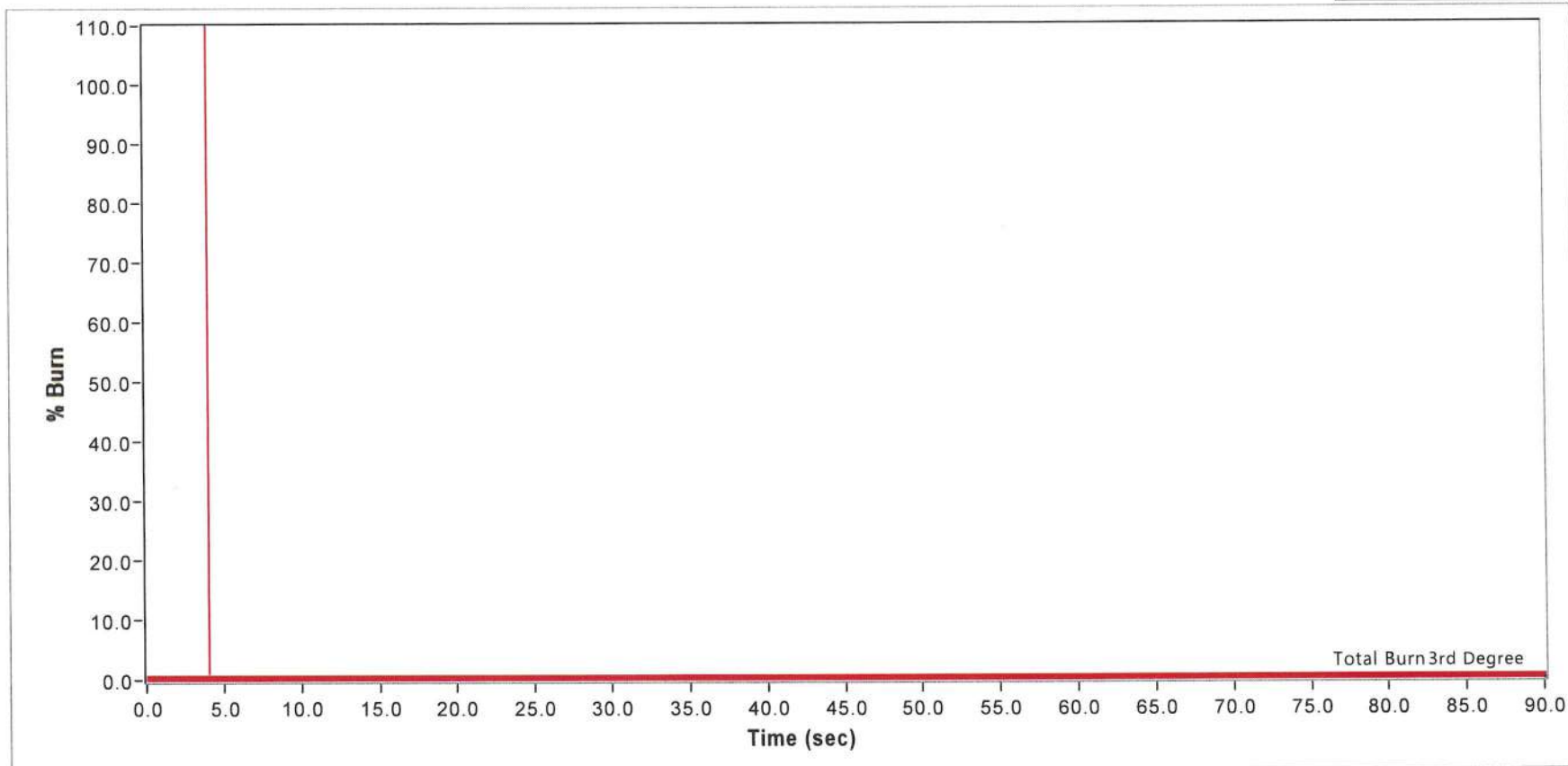
FIREDEX

FIREDEX MODEL AFX TURNOUT SYSTEM

Sens. Removed: 11, 12, 13, 14, 25, 26, 27, 28

Burn Injury vs. Time  
Resulting from 4.00 second Flash Fire

Total Burn   
3rd Degree 



Total area of manikin containing sensor was used to predict second and third degree burn injury (%) per section 13.5.1 of ASTM F1930

Burn Calculation Time (s) **90.0**

240207E

Date Printed: Printed on 02/07/2024 08:00:42 AM

Data Directory: % C:\Users\PyroMan-1\Documents\TPACC\PyroMan\data\240207D

Data File: 240207D.dat

Exposure Time (s): 4.0

Time Interval (s): 0.10

Sensor Flux Avg (cal/cm<sup>2</sup>/s): 2.05

Sensor Flux SD (cal/cm<sup>2</sup>/s): 0.41

For More Information Contact:

North Carolina State University  
College of Textiles  
Textile Protection and Comfort Center  
1020 Main Campus Drive  
Raleigh, NC 27606