A Report

to

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on

Characterization of Test Garments Using the PyroMan System

from

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Multiple ensembles were submitted by Silver Needle to the Textile Protection and Comfort Center (T-PACC) in the College of Textiles at North Carolina State University. These garments were evaluated for resistance to a simulated flash fire exposure employing procedures similar to ASTM F 1930-08 *Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin.* The purpose of this report is to describe the testing system used and to present the results.

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.

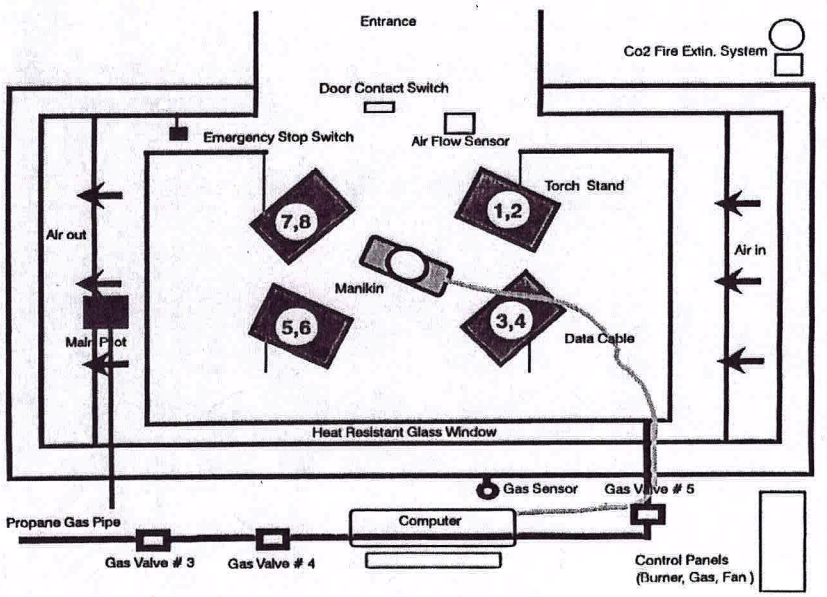

Figure 1. Fire Chamber and Gas Delivery System

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.

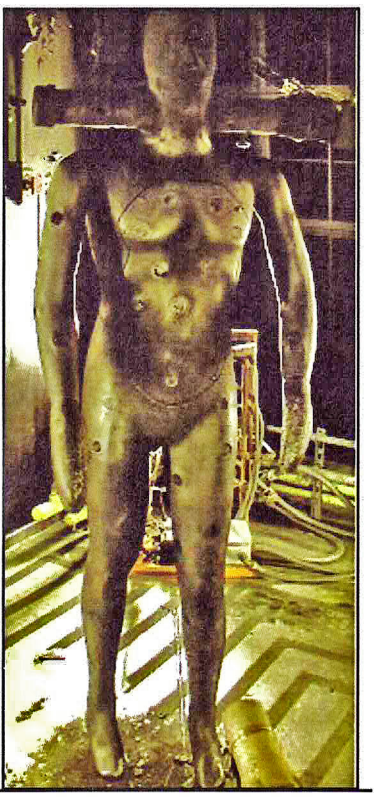

Figure 2. PyroMan Manikin

Test Materials

Tested as received, ensembles were similar in size but varied in fiber content and weight. Test garments were conditioned for 24 hours prior to testing.

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 four seconds exposure. All test garments were evaluated with an average heat flux of 2.00 cal/cm^{2}sec ± 0.05 cal/cm^{2}sec with a flash fire exposure of 8, 10, or 12 seconds. Ensembles were not tested in triplicate as required by the standard. Test results are summarized in Table 1. Detailed data, including test summary,

comment sheet, burn injury prediction graphic, and before and after pictures, 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	101203D	8	3015A-7/8 Seconds	**6.557**	**9.016**	**15.57**
2	101203E	10	3015A-7/10 Seconds	**18.033**	**13.934**	**31.97**
3	101203F	12	3015A-7/12 Seconds	**14.754**	**29.508**	**44.26**