



Test Report

to

UL LLC
POC: David Toshack
12 Laboratory Drive, Research Triangle Park, NC
on

Characterization of Test Garments Using the PyroMan™ System
following NFPA 2112-2023 edition, section 8.5
Report # 2023-1019 Style GDI49

from

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

Issue Date: 10/19/2023

This report has been reviewed and authorized for release to the customer. This report meets all the requirements of ISO 17025 and the UL DAP.

Anthony Shawn Deaton
Operations Director/ A. Shawn Deaton

10/20/2023
Date



Characterization of Test Garments Using the PyroMan™ System: Report # 2023-1019 Style GDI49

UL LLC submitted coveralls and undergarments to the Textile Protection and Comfort Center (TPACC) in the Wilson College of Textiles at North Carolina State University. These garments were evaluated for a resistance to a simulated flash fire exposure outlined in *NFPA 2112-2023 ed.: Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*, section 8.5 in the TPACC Thermal Lab in Raleigh NC. This test evaluates the material of construction used in a standard coverall and does not apply to a garment design evaluation or an end-use garment evaluations. Any deviations from this standard were approved by the client prior to testing and are listed in Appendix A. The purpose of this report is to describe the testing system, test items 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.

A list of all the equipment used for this testing along with the dates of calibration for the equipment that require calibration are stored internally on a North Carolina State University data storage system. This list can be provided to the client upon request.

A measurement uncertainty calculation was made for this system using 96 flame resistance garments. The measurement uncertainty was found to be 1.66% 2nd degree burn prediction or higher or this system.

Test Materials

UL LLC indicated ensembles were laundered prior to arrival. As garments are the test item, no sampling was required. Listed below is the sample ID and material description, as provided by UL LLC.

Sample ID	Description
Style GDI49	48% Tencel (Viscose)/ 38% Modacrylic/ 12% Para-Aramid/ 2% Antistatic, Twill Weave, 6.7 osy, Color- Black,

Test Results

Prior to testing, a nude manikin verification was done with a 3 seconds exposure. All test garments were evaluated with an average heat flux of 2.00 cal/cm²sec ± 0.1 cal/cm²sec with a flash fire exposure of 3 seconds. In addition, at the end of each testing day another 3 second exposure is done to ensure the calibration did not drift significantly during the testing day. Test results for each test item are summarized in Table 1. Detailed data, including Pre/Post nude manikin

verifications, test data sheet, burn injury prediction graphic, and before and after pictures, are found in Appendix B. In addition, videos related to this test will be sent along with the report.

This report indicates that Style GDI49 produced an overall average predicted burn of 14.48%. This prediction was produced from a total of 122 sensors covering the entire surface of the manikin (excluding hands and feet) with each sensor being equally weighted. This report does not provide any interpretation of the results and cannot declare if a result is passing or failing. This report is only intended to report the data from the test conducted. No test results were provided by an external provider.

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 (%)			Breakopen	
				2nd	3rd	Overall	Yes No	Max Length (cm)
1	231019K	3	Style GDI49, Rep #B-1	7.377	7.377	14.75	No	N/A
2	231019L	3	Style GDI49, Rep #B-2	5.738	7.377	13.11	No	N/A
3	231019M	3	Style GDI49, Rep #B-3	9.016	6.557	15.57	No	N/A
AVERAGE				7.377	7.104	14.48		

Appendix A

Agreed upon Deviations from NFPA 2112 and ASTM F1930-18

NFPA 2112

Section 8.5.3 – Washing Test specimens - This is completed by Underwriters Laboratories and assumed to meet the requirement but not verified. Since it cannot be verified it is listed as a deviation.

Section 8.5.8 – Pass/Fail - Being part of the North Carolina State University system we cannot identify an item as passing or failing. This will fall on the certification organization to determine.

ASTM F1930

Section 6.2.1 – Sensor Range - This section indicates that sensors must be able to have a range of 0 to 4.0 cal/s·cm². However, we cannot produce that amount of heat and we cannot find a source to verify that our sensors can achieve cal/s·cm².

Section 6.5.4.1 – Burn calculations without head burns included - This section requires calculating burn injury predictions for the entire manikin and the sections covered by a garment. NFPA 2112 supersedes this requirement by only requiring total burn injury predictions. Therefore, the predicted burn injury covered by just the garment is not reported.

Section 8.2.2 & 8.2.2.1 – Standard Garment - This is completed by Underwriters Laboratories and assumed to meet the requirement but not verified. Since it cannot be verified it is listed as a deviation.

Section 9.3 – Area Density Measurements - This is completed by Underwriters Laboratories and assumed to meet the requirement but not verified. Since it cannot be verified it is listed as a deviation.

Section 13.5.1.3 – Burn Predictions and Variation Statistic – Burn injury predictions are provided however variation statistics requirements are not defined. Therefore, we do not provide variation statistics.

Section 13.5.2 – Burn Prediction covered by garment – NFPA 2112 requires total burn injury predictions, therefore we only report total burn injury predictions for the entire manikin.

Section 13.6.1 – Afterflame intensity, location, and duration – Due to the complexity of detailing all this information in a few seconds time frame we only record the overall afterflame duration. If afterflame is extreme or located in one particular spot on the garment, these observations will be noted.

Appendix B

Pre/Post Nude Verification Results, PyroMan™ Test Specifications, Test Remarks, Photos, and Manikin Burn Injury Prediction

Thermal Protective Clothing Analysis

3-Layer Skin Model

Data File Name	231019K	Test Date	2023-10-19 9:35 AM
System Identification	PyroMan™	Sponsor	UL
Garment Identification	STYLE GDI49 COVERALL, REP# B-1		
Garment size	NFPA 2112 REFERENCE	Conditioning Room Removal Time	2023-10-19 09:31 AM
N Washes	1 (-1 = Unknown) <input checked="" type="checkbox"/> 100% Cotton Underwear & Tshirt		
Garment/Fabric Comments	LAYER 1: COTTON T-SHIRT AND BRIEF LAYER 2: STYLE GDI49 COVERALL, 48% TENCEL (VISCOSE)/ 38% MODACRYLIC/ 12% PARA-ARAMID/ 2% ANTISTATIC, TWILL WEAVE, 6.7 OSY, COLOR-BLACK COVERALLS PLACED IN CONDITIONING ROOM: 10/17/2023 AT 9:45AM		
Pre Test Comments	GARMENTS WERE PRECONDITIONED BY UL, CONDITIONED BY NCSU GARMENTS STORED IN CONDITIONED SPACE PRIOR TO TESTING TESTING CONDUCTED ACCORDING TO NFPA 2112-2023 AND ASTM F1930-18 BY SR THERMAL PROTECTION SCIENTIST JOHN MORTON-ASLANIS AND RESEARCH TECHNICIAN MARK MARTIN UL PROJECT ENGINEER: DAVID TOSHACK, DAVID.TOSHACK@UL.COM UL PROJECT#4790794697, UL CUSTOMER NAME: G D INTERNATIONAL CONDITIONING ROOM TEMP: 21°C, CONDITIONING ROOM HUMIDITY: 65% (AT TIME OF COVERALL REMOVAL)		
Post Test Comments	AFTERFLAME NOT RECORDED		
Smoke Generation	Shrinkage	Break-Open	Embrittlement
Heavy	Minor	None	N/A
Start Room Temp (oC)		21	
Start Avg Sens. Temp (oC)		32	
Total DAQ time (s)	61	Avg Expos. Heat Flux (cal/cm ² *sec)	2.00
Exposure Time (s)	3.00	Scan Interval (s)	0.10
Torches Used	ALL, or those used, separated by commas		
Burn Calculation Time (s)		60.8	

% 2nd Degree Burns 7.377
 % 3rd Degree Burns 7.377

% Total Burn 14.75

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

**Style GDI49 Coverall, Rep# B-1
231019K**



**Style GDI49 Coverall, Rep# B-1
231019K**

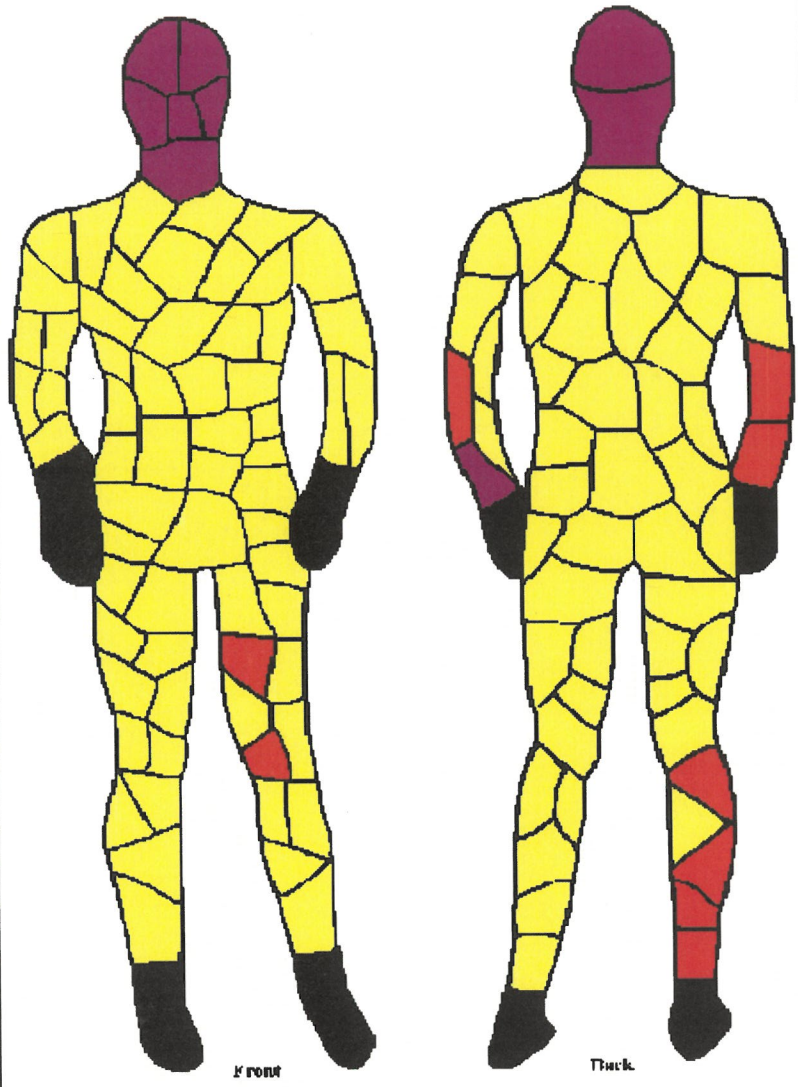


NCSU

PyroMan™
3-Layer Skin Model

Thermal Protective Clothing Analysis System

Burn Injury Prediction



UL

STYLE GDI49 COVERALL, REP# B-1

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

% 2nd Degree Burns % Total Burn
% 3rd Degree Burns

Burn Calculation Time (s)

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

231019K

PyroMan™

Thermal Protective Clothing Analysis System

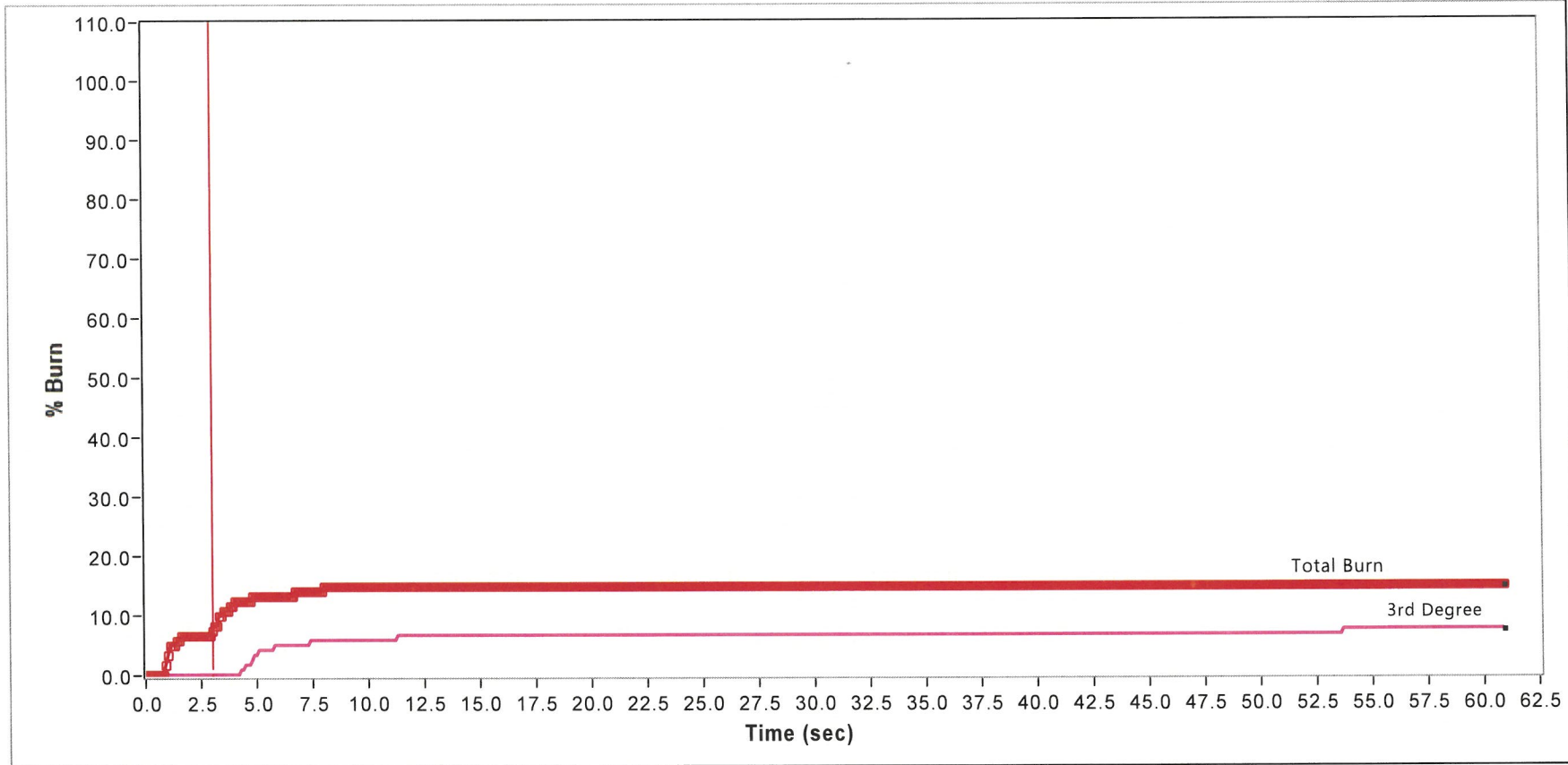
3-Layer Skin Model

UL

STYLE GDI49 COVERALL, REP# B-1

Burn Injury vs. Time
Resulting from 3.00 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) **60.8**

231019K

Thermal Protective Clothing Analysis

3-Layer Skin Model

Data File Name	231019L	Test Date	2023-10-19 9:48 AM
System Identification	PyroMan™	Sponsor	UL
Garment Identification	STYLE GDI49 COVERALL, REP# B-2		
Garment size	NFPA 2112 REFERENCE	Conditioning Room Removal Time	2023-10-19 09:43 AM
N Washes	1 (-1 = Unknown) <input checked="" type="checkbox"/> 100% Cotton Underwear & Tshirt		
Garment/Fabric Comments	LAYER 1: COTTON T-SHIRT AND BRIEF LAYER 2: STYLE GDI49 COVERALL, 48% TENCEL (VISCOSE)/ 38% MODACRYLIC/ 12% PARA-ARAMID/ 2% ANTISTATIC, TWILL WEAVE, 6.7 OSY, COLOR-BLACK COVERALLS PLACED IN CONDITIONING ROOM: 10/17/2023 AT 9:45AM		
Pre Test Comments	GARMENTS WERE PRECONDITIONED BY UL, CONDITIONED BY NCSU GARMENTS STORED IN CONDITIONED SPACE PRIOR TO TESTING TESTING CONDUCTED ACCORDING TO NFPA 2112-2023 AND ASTM F1930-18 BY SR THERMAL PROTECTION SCIENTIST JOHN MORTON-ASLANIS AND RESEARCH TECHNICIAN MARK MARTIN UL PROJECT ENGINEER: DAVID TOSHACK, DAVID.TOSHACK@UL.COM UL PROJECT#4790794697, UL CUSTOMER NAME: G D INTERNATIONAL CONDITIONING ROOM TEMP: 21°C, CONDITIONING ROOM HUMIDITY: 65% (AT TIME OF COVERALL REMOVAL)		
Post Test Comments	AFTERFLAME NOT RECORDED		
Smoke Generation	Shrinkage	Break-Open	Embrittlement
Heavy	Minor	None	N/A
		Start Room Temp (oC)	22
		Start Avg Sens. Temp (oC)	32
Total DAQ time (s)	61	Avg Expos. Heat Flux (cal/(cm ² *sec)	2.00
		Scan Interval (s)	0.10
Exposure Time (s)	3.00	Torches Used	ALL, or those used, separated by commas
		Burn Calculation Time (s)	60.8

% 2nd Degree Burns **5.738**
 % 3rd Degree Burns **7.377**

% Total Burn 13.11

For More Information Contact:

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

END of Thermal Protective Clothing Analysis Sheet

**Style GDI49 Coverall, Rep# B-2
231019L**



Style GDI49 Coverall, Rep# B-2
231019L

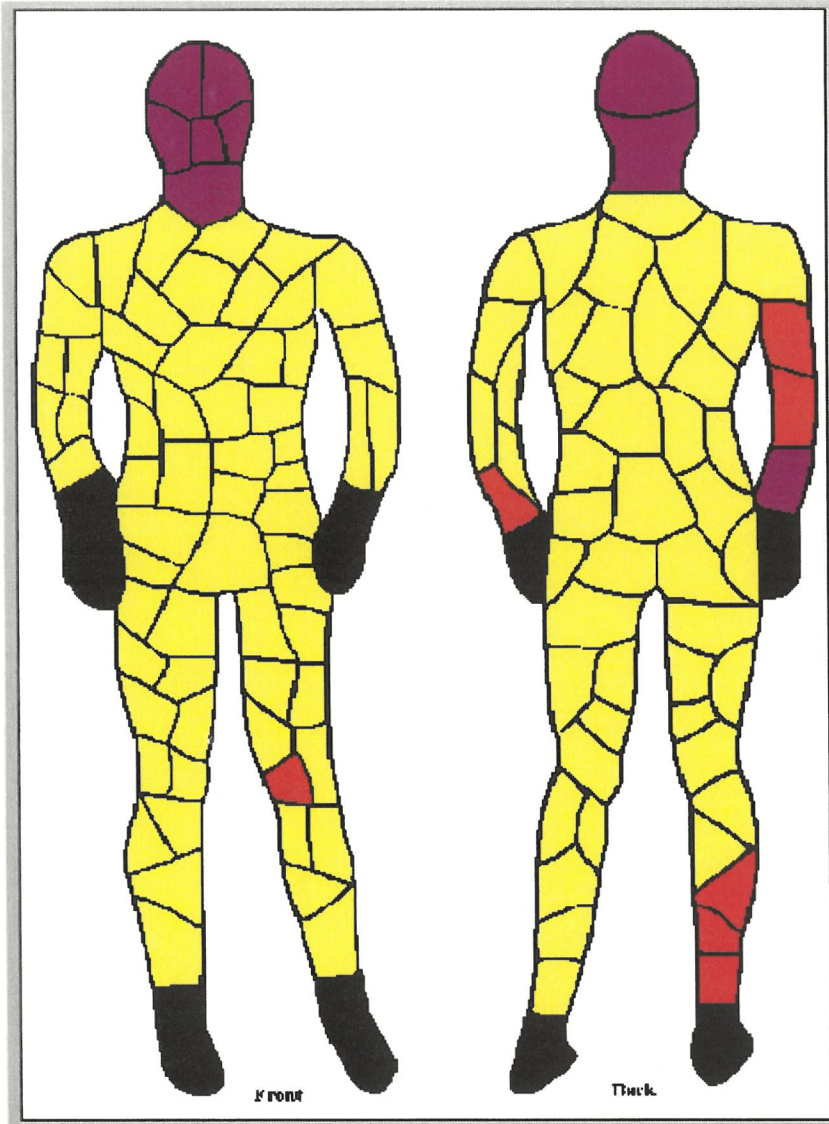


NCSU PyroMan™

3-Layer Skin Model

Thermal Protective Clothing Analysis System

Burn Injury Prediction







UL

STYLE GDI49 COVERALL, REP# B-2

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

% 2nd Degree Burns	<input type="text" value="5.738"/>	% Total Burn	<input type="text" value="13.11"/>
% 3rd Degree Burns	<input type="text" value="7.377"/>		

Burn Calculation Time (s)

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

231019L

PyroMan™

Thermal Protective Clothing Analysis System

3-Layer Skin Model

UL

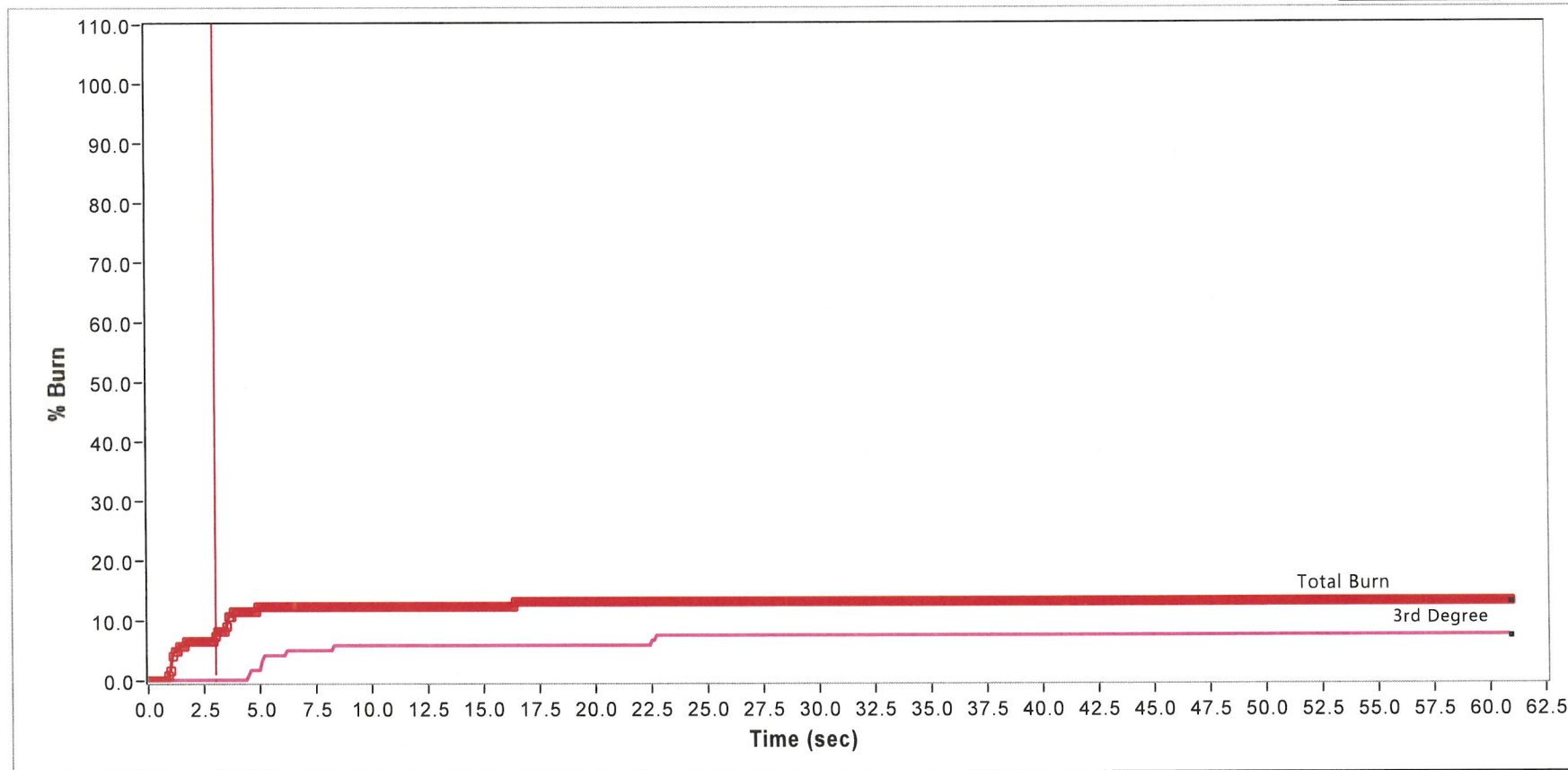
STYLE GDI49 COVERALL, REP# B-2

Burn Injury vs. Time
Resulting from 3.00 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) **60.8**

231019L

Thermal Protective Clothing Analysis

3-Layer Skin Model

Data File Name	231019M	Test Date	2023-10-19 9:59 AM
System Identification	PyroMan™	Sponsor	UL
Garment Identification	STYLE GDI49 COVERALL, REP# B-3		
Garment size	NFPA 2112 REFERENCE	Conditioning Room Removal Time	2023-10-19 09:50 AM
N Washes	1 (-1 = Unknown) <input checked="" type="checkbox"/> 100% Cotton Underwear & Tshirt		
Garment/Fabric Comments	LAYER 1: COTTON T-SHIRT AND BRIEF LAYER 2: STYLE GDI49 COVERALL, 48% TENCEL (VISCOSE)/ 38% MODACRYLIC/ 12% PARA-ARAMID/ 2% ANTISTATIC, TWILL WEAVE, 6.7 OSY, COLOR-BLACK COVERALLS PLACED IN CONDITIONING ROOM: 10/17/2023 AT 9:45AM		
Pre Test Comments	GARMENTS WERE PRECONDITIONED BY UL, CONDITIONED BY NCSU GARMENTS STORED IN CONDITIONED SPACE PRIOR TO TESTING TESTING CONDUCTED ACCORDING TO NFPA 2112-2023 AND ASTM F1930-18 BY SR THERMAL PROTECTION SCIENTIST JOHN MORTON-ASLANIS AND RESEARCH TECHNICIAN MARK MARTIN UL PROJECT ENGINEER: DAVID TOSHACK, DAVID.TOSHACK@UL.COM UL PROJECT#4790794697, UL CUSTOMER NAME: G D INTERNATIONAL CONDITIONING ROOM TEMP: 21°C, CONDITIONING ROOM HUMIDITY: 65% (AT TIME OF COVERALL REMOVAL)		
Post Test Comments	AFTERFLAME NOT RECORDED		
Smoke Generation	Shrinkage	Break-Open	Embrittlement
Heavy	Minor	None	N/A
Start Room Temp (oC)		22	
Start Avg Sens. Temp (oC)		32	
Total DAQ time (s)	61	Avg Expos. Heat Flux (cal/cm ² *sec)	2.00
Exposure Time (s)	3.00	Scan Interval (s)	0.10
Torches Used	ALL ALL, or those used, separated by commas		
Burn Calculation Time (s)			60.8

% 2nd Degree Burns 9.016
% 3rd Degree Burns 6.557

% Total Burn 15.57

For More Information Contact:

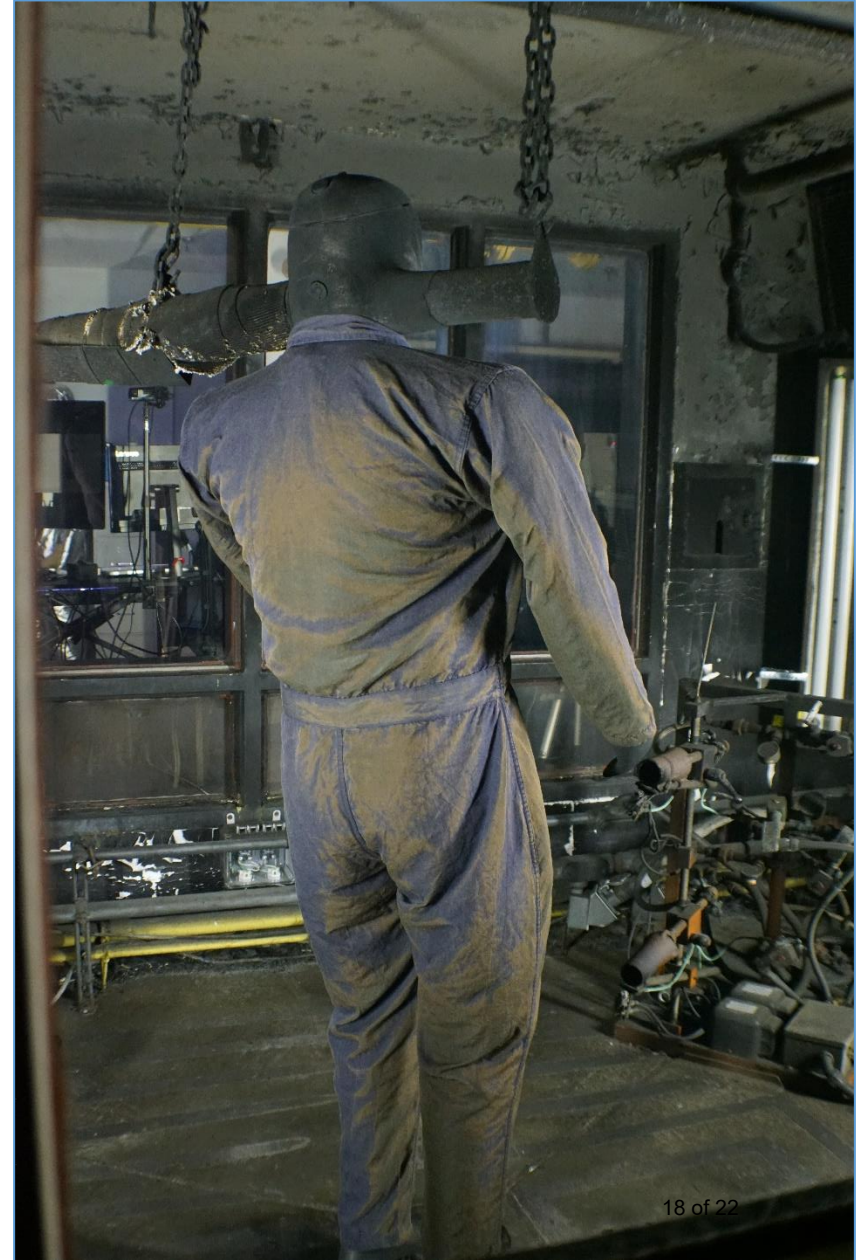
North Carolina State University
 College of Textiles
 Textile Protection and Comfort Center
 1020 Main Campus Drive
 Raleigh, NC 27606

END of Thermal Protective Clothing Analysis Sheet

**Style GDI49 Coverall, Rep# B-3
231019M**



**Style GDI49 Coverall, Rep# B-3
231019M**

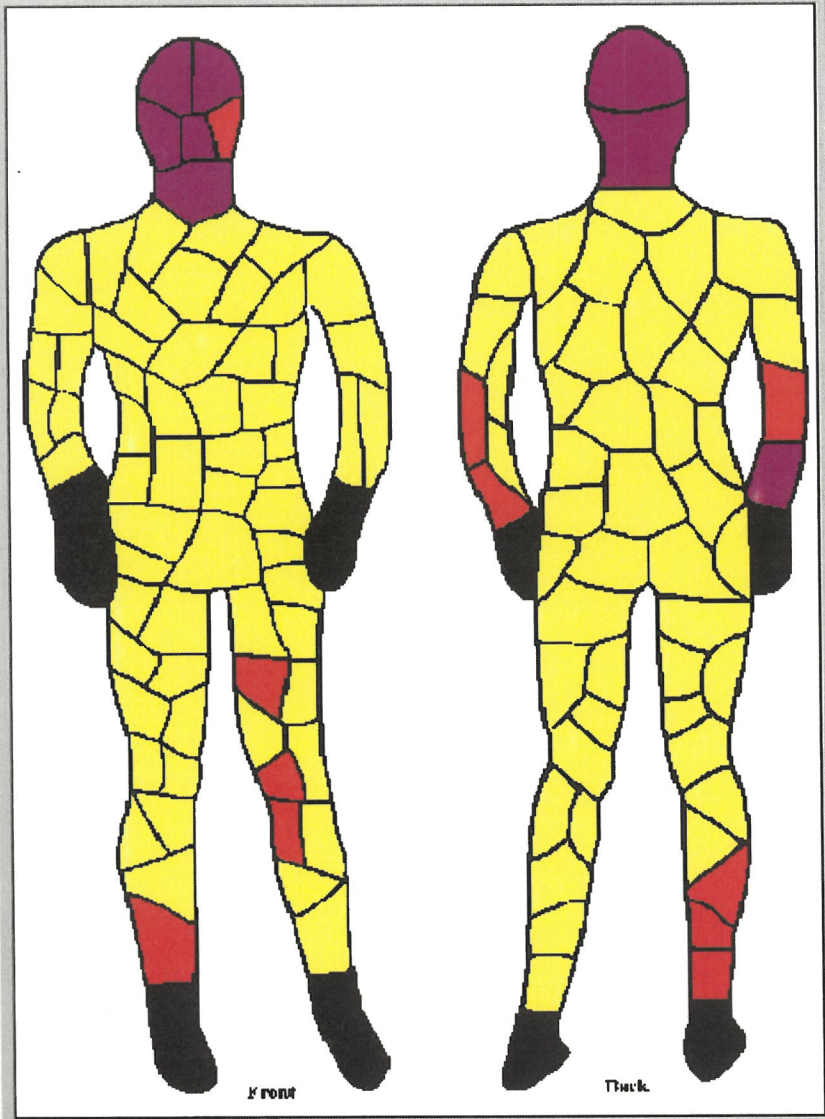


NCSU PyroMan™

3-Layer Skin Model

Thermal Protective Clothing Analysis System

Burn Injury Prediction







UL

STYLE GDI49 COVERALL, REP# B-3

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

% 2nd Degree Burns % Total Burn
 % 3rd Degree Burns

Burn Calculation Time (s)

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

231019M

PyroMan™

Thermal Protective Clothing Analysis System

3-Layer Skin Model

UL

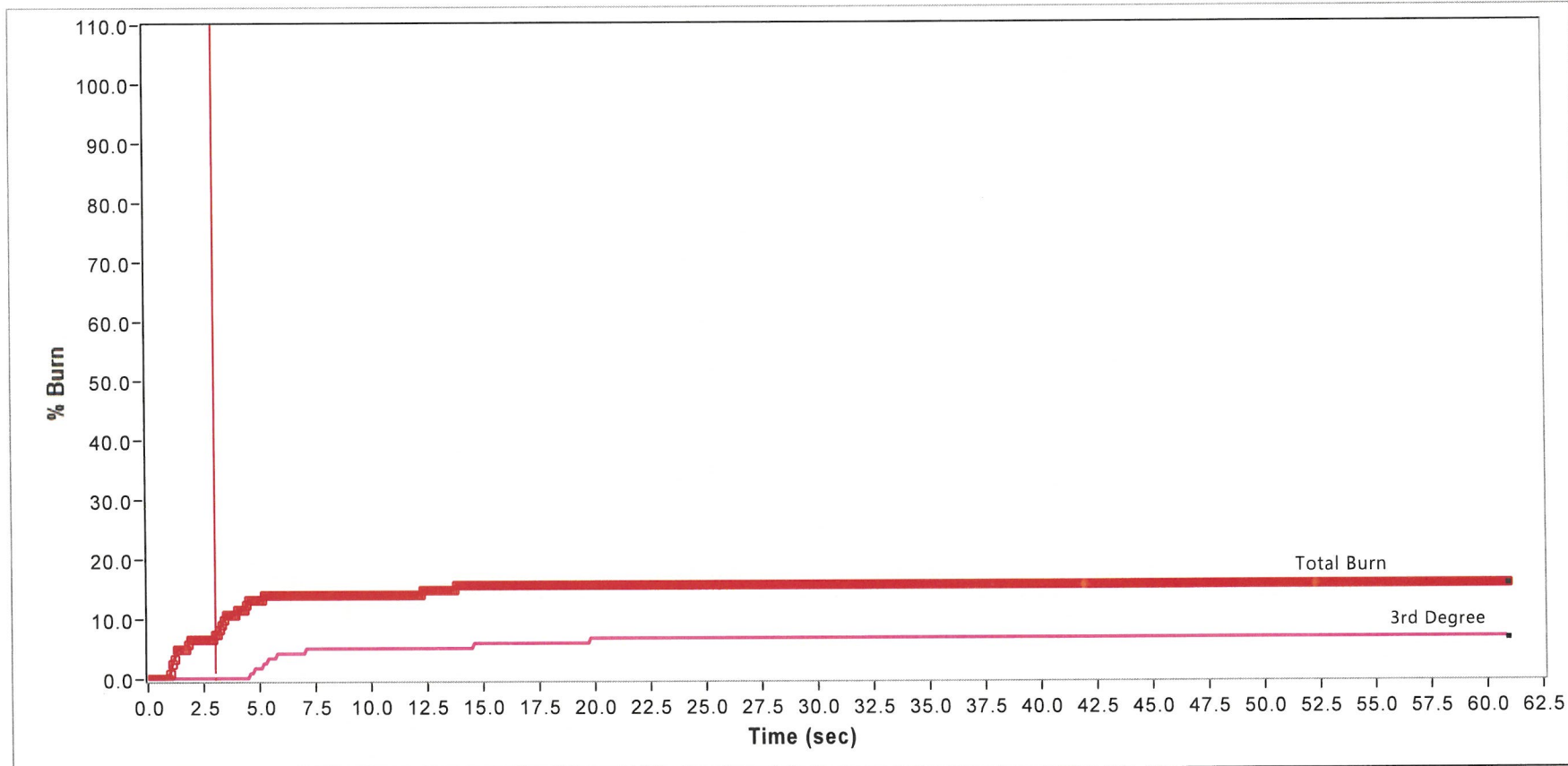
STYLE GDI49 COVERALL, REP# B-3

Burn Injury vs. Time
Resulting from 3.00 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)

60.8

231019M

Date Printed:

Data Directory:

Data File:

Exposure Time (s):

Time Interval (s):

Sensor Flux Avg (cal/cm²/s):

Sensor Flux SD (cal/cm²/s):

For More Information Contact:

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

Start of Day Calibration

Date Printed:

Data Directory:

Data File:

Exposure Time (s):

Time Interval (s):

Sensor Flux Avg (cal/cm²/s):

Sensor Flux SD (cal/cm²/s):

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 Day Calibration