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Testing PPE with the Flash Fire Cylinder and Hand Devices

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INTRODUCTIONS

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Today’s Goals

- Learn about the “why?” and the “what?” behind a new family of flash fire testing devices
- Understand what the equipment and typical lab setup looks like
- See the devices in action and what the measurement output looks like
- Hear about the progress and timelines for test methods and performance standards

What would you like to learn today?

About Thermetrics – Bringing Comfort to Life

- Seattle-based manufacturer of specialty thermal instrumentation
  - Thermal and moisture properties
  - Thermal protection
  - Human thermal simulation and comfort
- Equipment and services to demystify the in-use performance of garments and textiles
- Developing research tools in response to industry needs
  - Extending these tools into standard products
- Technology, service, support partner for life

About ArcWear

- Founded in 1997 by Hugh Hoagland as an Arc Flash Testing provider, partnering with the Kinectrics High Current Lab in Toronto
- Consulting Services include:
  - Accident investigations
  - Product Development
  - Expert Witnessing
- Gradually grew and expanded testing capabilities to include
  - Full ASTM F1506 testing
  - All NFPA 2112 small scale testing
  - Some NFPA 1971 small scale testing
  - ANSI 105 Glove Classification testing
  - ANSI 107 Testing of HVSA
- In 2014 Became an ISO 17025 Accredited for all test methods and standards above, and partnered with SEI for NFPA 2112 testing.
- In 2019 we entered the UL Third Party Data Acceptance Program for ASTM F1506, NFPA 2112, and NFPA 1971
- In 2020 Became part of the Kinectrics family of companies
- In 2021 Became Kinectrics AES Inc. as part of a corporate restructuring
  - Still operating under the ArcWear name as a Division of Kinectrics

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DEVICE EVOLUTION

HTP/TPP

Why do this? Industry Need

- All the basis for fire service protection was based on TPP
- Industrial Flash Fire market considered both HTP and Flash Fire Manikin
- HTP/TPP have a single thermal energy sensor and expose a flat swatch of fabric
- Flash Fire Manikin testing uses a full-sized body form and over 120 thermal energy sensors
- No practical go-between Test Method that provides more detailed information than TPP/HTP, but also more accessible than the Manikin test.

Flash Fire Manikin

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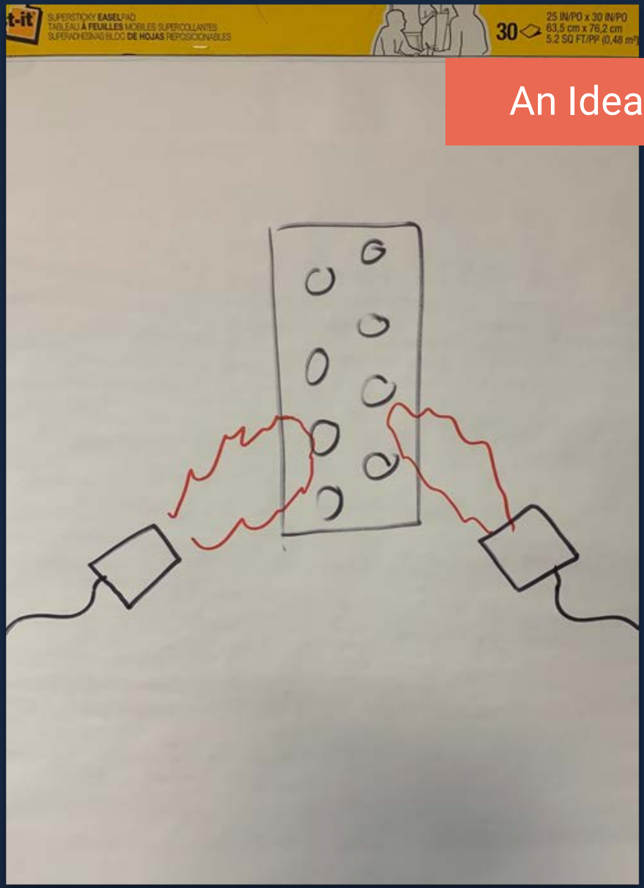
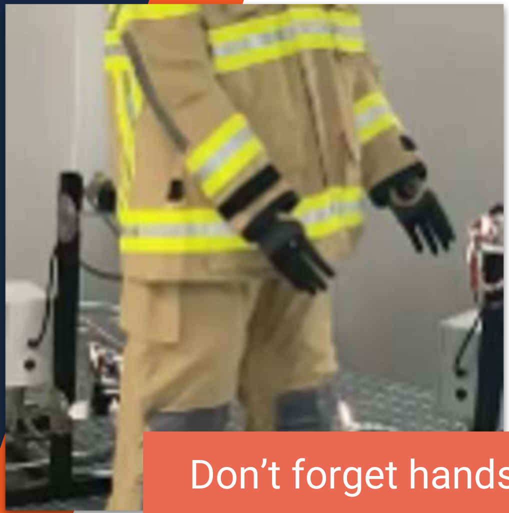
DEVICE EVOLUTION





Why do this? Industry Need

- Not a new idea: The research community has been experimenting with curved samples on TPP and cylinder forms
- No means currently to evaluate whole gloves for thermal insulation in a flash fire
- 2017 – sketched out an idea on a flip chart at PBI Performance Products
- The sweet spot was the intersection of capability and laboratory-scale implementation
- Cylinder size between arm and leg circumference range
- Engaged Thermetrics to develop it into reality.

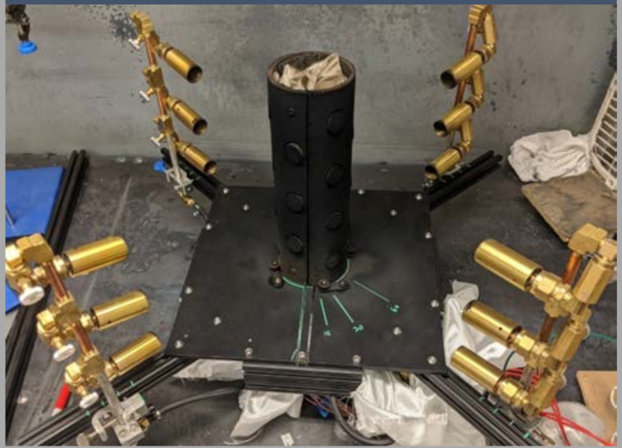
SYSTEM DEVELOPMENT

Optimizing Safety, Performance, Useability

- Isolating electrical and fuel systems
- Optimizing burner design and quantity
- Integrating control software and computations
- Same positioning and retention
- Flexibility – interchangeable cylinder/hand

2018: First Prototype Unit

More Torches = Better?



2020: Production FFC System

FFC - OVERVIEW

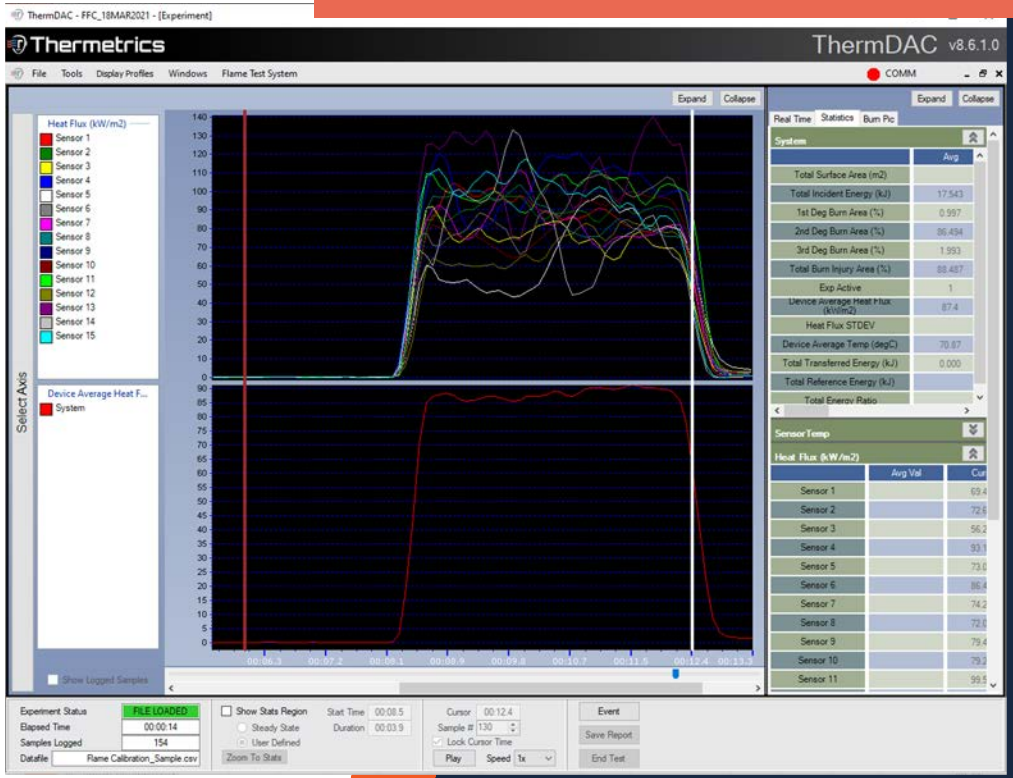
Flash Fire Cylinder System

- Fully self-contained lab-scale system. Just add power, propane, and ventilation
- Flame-proof ceramic composite shell does not degrade under flame exposure
- 15 thermal energy sensors
- Engineered operator and device safety functions
- 8 Adjustable burners on 4 risers
- Metering valves per burner for precise flame profile tuning
- Built-in sample spacer to create controlled air gap

Measurement and Results Output

- Sensors and Data Collection
  - Guarded copper disc calorimeter, durable, accurate, and widely used on flame manikins
- Heat Flux Calculation
  - In-situ calibration of sensors using handheld heat source, referenced to NIST-traceable Schmidt-Boelter heat flux transducer
- Computes Predicted Skin Burn and Energy Ratio Value (ERV)
  - For each sensor
  - Combined for entire device
- Automatic selection of data region of interest for nude burns and sample burns
- Same methodology for both Cylinder and Hand

ThermDAC Control/Logging Software



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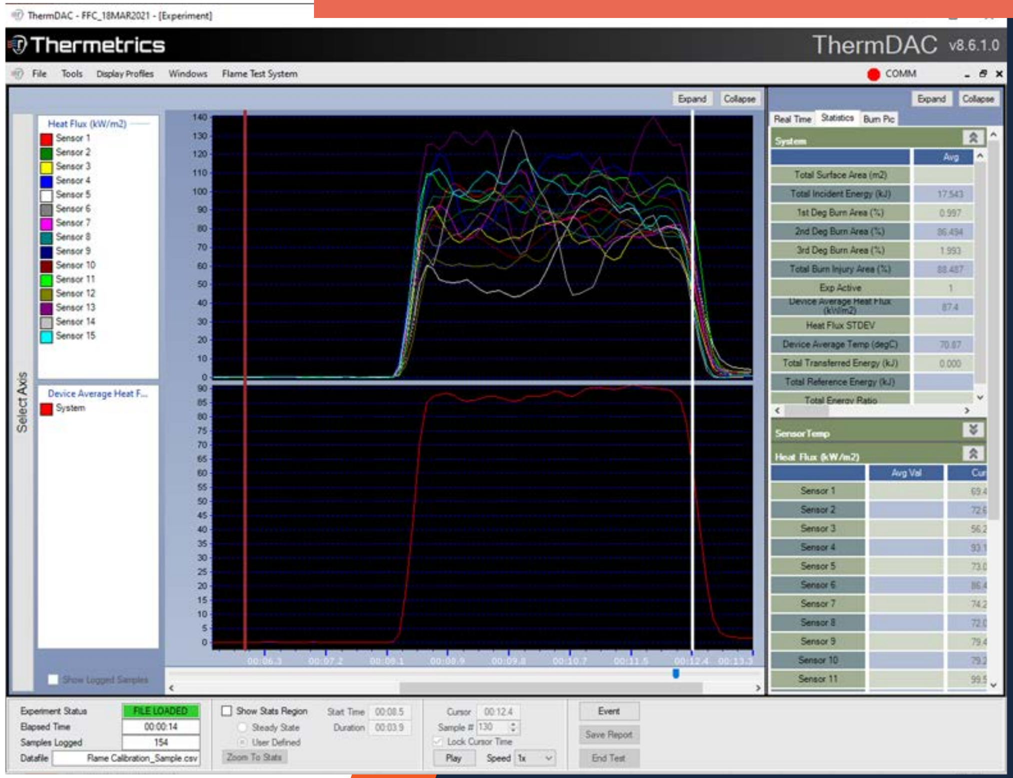
$$ERV = \frac{Q_{transferred}}{Q_{incident} \times \frac{t_{test}}{t_{cal}}}$$

ERV? What is it and why?

- Percent Body Burn as used on flame manikin is a discretized result
  - Each sensor can have four states: no burn, 1st, 2nd, 3rd degree burn
  - No burn and 3rd degree burn can represent a wide range
  - 15 sensors on the cylinder (10 on hand) results in poor resolution
- Energy Ratio Value (ERV) is a quantitative result indicating how much of the incident energy is passing through the sample
  - Potential range from 0 to 1
  - Lower value indicates less energy transmitted = better performance/protection
- Similar to Energy Transmission Factor from ISO 13506-1
- Automatic computation in ThermDAC by loading nude exposure results as reference(s)

ThermDAC Control/Logging Software



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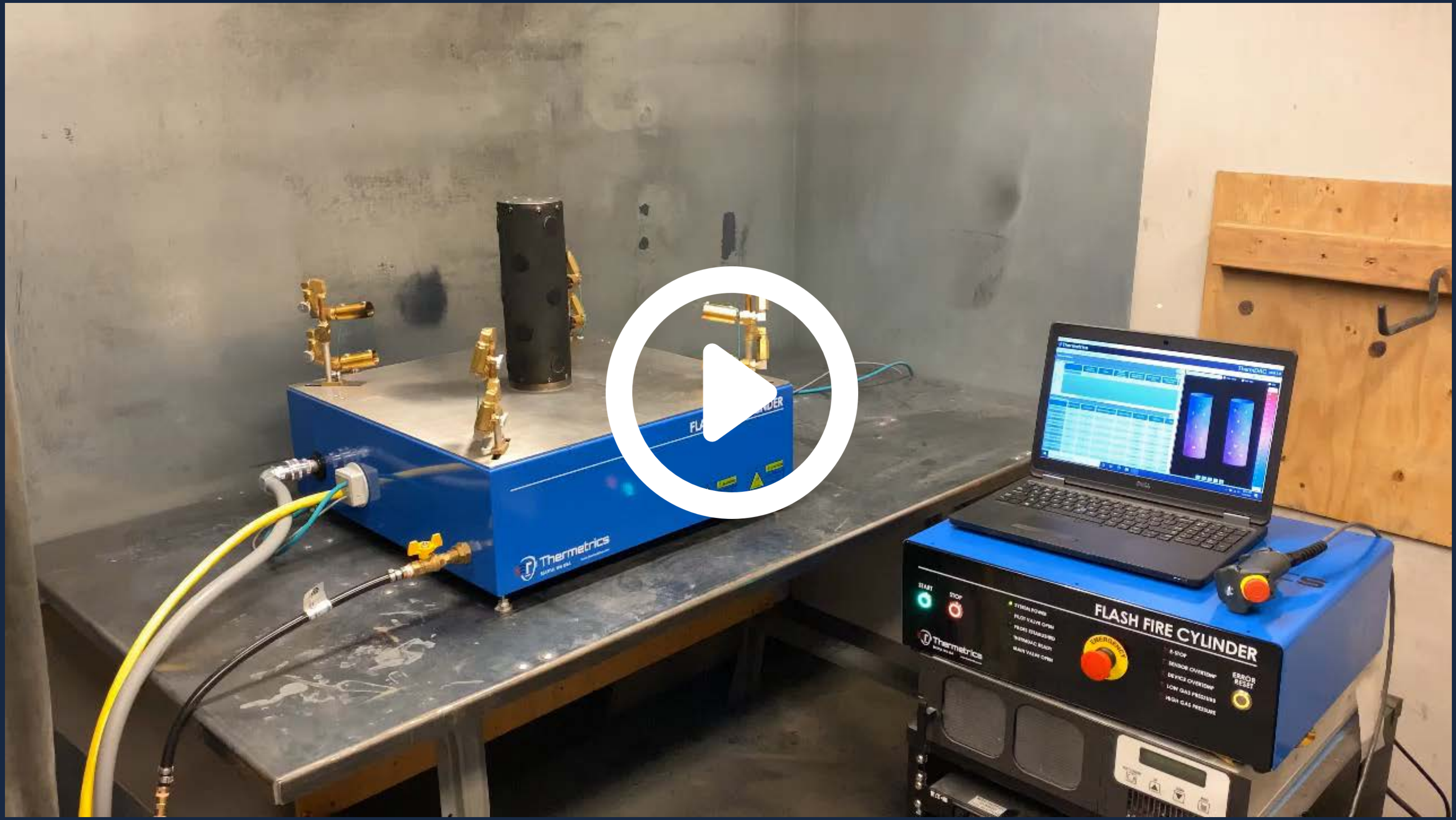
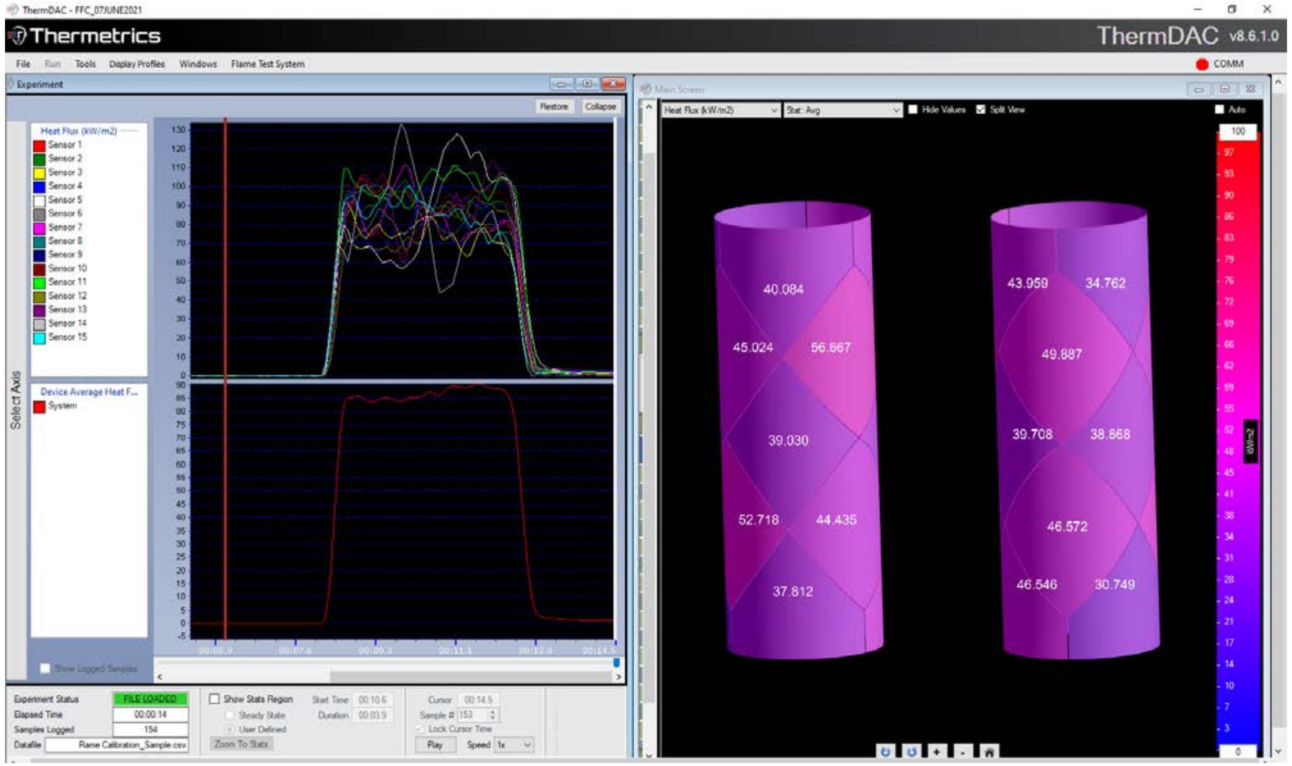
FFC Overview and Nude Burn



Click the image to play the linked video

Test Results – Software flythru



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FFH - OVERVIEW

Flash Fire Hand

- No prior means of evaluating a whole glove for thermal insulation in a flash fire
- 10 thermal energy sensors
- Burn injury prediction or Energy Ratio Value
- Left or right hand
- Same burner configuration as FFC
- Allows for impact of flame shrinkage – a known issue with leather gloves

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FFH/FFC Lab Setup

Click the image to play the linked video

FFH Demo with NFPA 1971 Glove Specimen - 10 sec Exposure

Click the image to play the linked video

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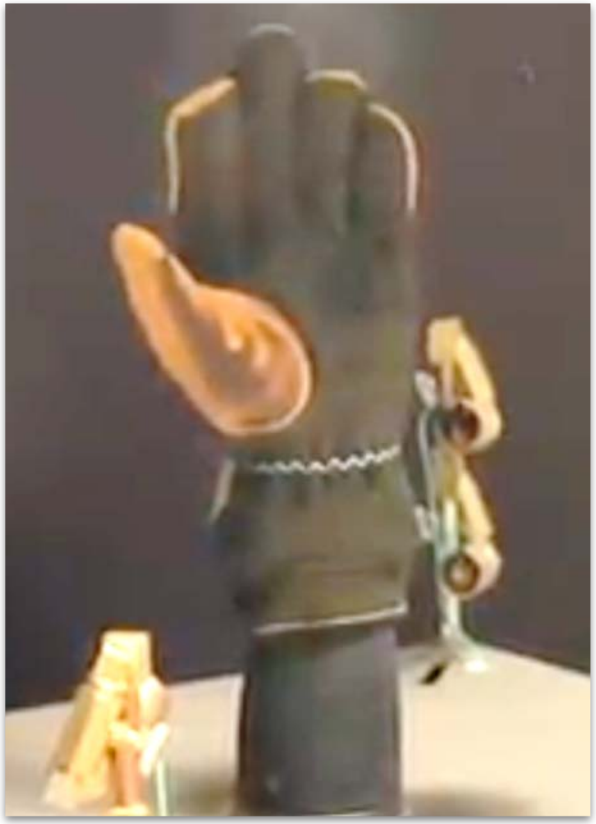

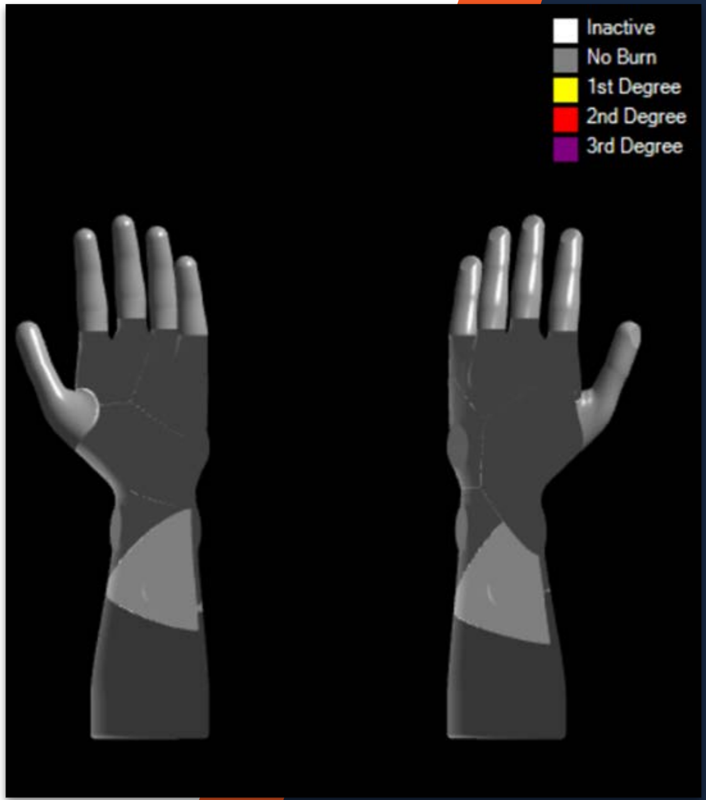

$$ERV = \frac{Q_{transfered}}{Q_{incident}\ x\ \frac{t_{test}}{t_{cal}}}$$

$$ERV = \frac{3.116}{9.090x\ \frac{10}{3}} = 0.103$$

Validation and Repeatability Testing

- Large number of tests were performed to validate the device performance and inform standards development
  - Is ERV an appropriate device output vs % body burn?
  - What is the repeatability with a single laboratory?
- 3 different samples, 30 specimens each
  - 2 different single-layer materials (3 sec exposure)
  - 3-layer composite (10 sec exposure)
- All specimens laundered 1x prior to testing

Data courtesy of:

Josh Ingram,
PBI Performance Products

Single-Layer Sample A

	% 2nd and 3rd degree body burn	Transferred Energy (kJ)	Energy Ratio Value
Average	54.0%	11.76	0.46
Standard Deviation	13.7	0.47	0.02
CV	0.3	0.04	0.05

Single-Layer Sample B

	%2nd + 3rd degree body burn	Transferred Energy (kJ)	Energy Ratio Value
Average	1.6%	7.36	0.28
Standard Deviation	3.3	0.42	0.02
CV	2.1	0.06	0.06

Data courtesy of:

Josh Ingram,
PBI Performance Products

Three-Layer Turnout Composite

	% 2nd and 3rd degree body burn	Transferred Energy (kJ)	Energy Ratio Value
Average	15.56%	15.636	0.182
Standard Deviation	9.64	0.643	0.007
CV	0.62	0.041	0.041

Data courtesy of:

Josh Ingram, PBI Performance Products

A Pathway to Standardization

- EARLY Standardization was key, based on learnings from ASTM F1930 history
  - Standardize before too many devices are in the field and may become obsolete by Standards Revisions
- ASTM F23.80 Task Group
  - Direction from TG to have two parallel efforts for Flash Fire Cylinder and Flash Fire Hand
- WK70964 – Work Item to develop the Flash Fire Cylinder Test Method
- WK76082 – Work Item to develop the Flash Fire Hand Test Method
- Both have been balloted 3x to the Subcommittee and 1x to the Main Committee
  - Excellent feedback each time, working toward consensus
- Both were proposed to NFPA 2112 but ultimately tabled due to novelty
- Both were recently proposed to NFPA 1971

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Most Recent ASTM Ballot Action - Closed Nov. 30

Item	Sub	Action		Committee	AFF	NEG
002	80	NEW STANDARD Test Method for Bench-Scale Evaluation of Flame-Resistant Clothing Materials for Protection Against Fire Simulations (Cylinder Method)		F23	69.00	1.00
		TECHNICAL CONTACT: Brian P Shiels		F23.80	31.00	2.00
		WORK ITEM: WK70964				

Main - 99% Affirm.

Sub - 94% Affirm.

Item	Sub	Action		Committee	AFF	NEG
003	80	NEW STANDARD Test Method for Bench-Scale Evaluation of Flame-Resistant Gloves for Protection Against Fire Simulations (Hand Form Method)		F23	66.00	2.00
		TECHNICAL CONTACT: Brian P Shiels		F23.80	30.00	3.00
		WORK ITEM: WK76082				

Main - 96% Affirm.

Sub - 91% Affirm.

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Wrap-Up

- FFC and FFH Systems were developed to fill the existing gap between TPP/HTI and Flash Fire Manikin testing
- Instruments and methodology have been optimized and validated
- ERV is a precise and intuitive measurement result
- Adoption of test methods in late-stages of approval process
- Currently available for purchase and/or contract testing

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THANK YOU + Q&A

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