

## Protective Clothing Durability Research

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### Outline

- introduction
- assessing turnout gear:
  - full-scale fire testing
  - destructive testing
  - non-destructive testing
- conclusions and future work

### Fire Protection Engineering Research Projects

- protective clothing
- combustion in microgravity
- wildland fire
- fire models
- fire testing
- heat transfer in human skin
- fire protection in agricultural buildings

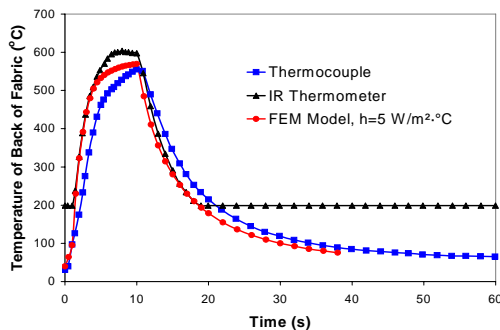


### Protective Clothing Research

- understanding heat and moisture transfer
- test standard development
- durability research



### Predicted and Measured Kevlar®/PBI Fabric Temperatures



### Durability Research

1. when do I replace my protective clothing?
2. why should we replace your protective clothing?

### *Research Objectives*

- ❑ gather temperature and heat flux data from fires
- ❑ perform destructive tests on fabrics after high heat flux exposures in the lab
- ❑ develop non-destructive tests for evaluating in-use turnout gear
- ❑ develop improved methods for determining when to retire protective clothing

### *Assessing Turnout Gear*

- ❑ full-scale fire testing
- ❑ destructive testing
- ❑ non-destructive testing



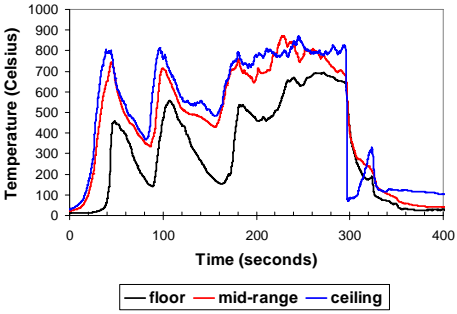
### *Full-Scale Fire Testing*

- ❑ **Saskatoon:**
  - Fire Prevention Week October, 2002
  - temperatures within training facility
- ❑ **Edmonton:**
  - Edmonton F.D., U. Alberta July, 2003
  - temperatures within house
  - heat fluxes inside and outside house

### *Saskatoon: Fire Prevention Week October, 2002*



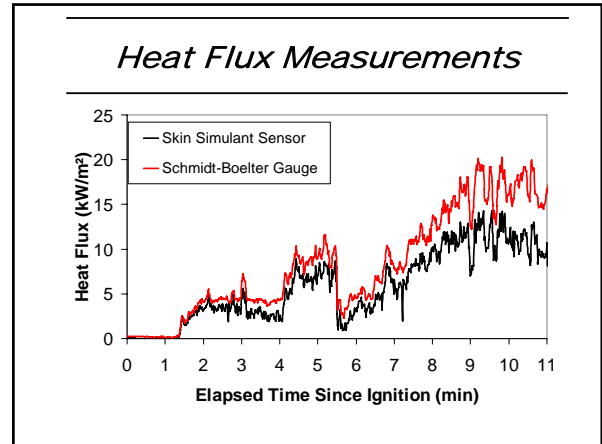
### *Saskatoon: Fire Prevention Week October, 2002*



Time (seconds)	Floor (Celsius)	Mid-range (Celsius)	Ceiling (Celsius)
0	0	0	0
50	450	650	800
100	550	700	850
150	500	650	800
200	550	700	850
250	600	750	850
300	650	750	850
350	100	100	100
400	0	0	0

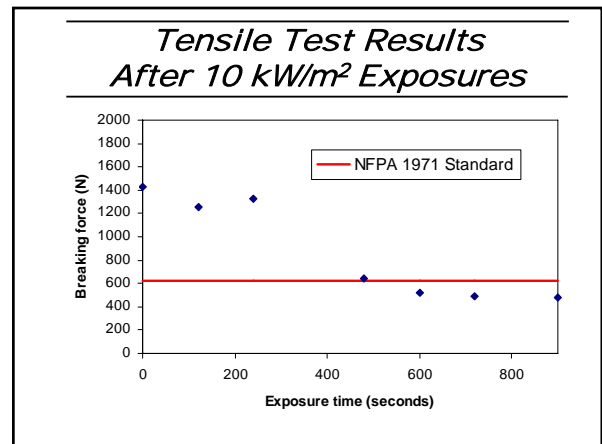
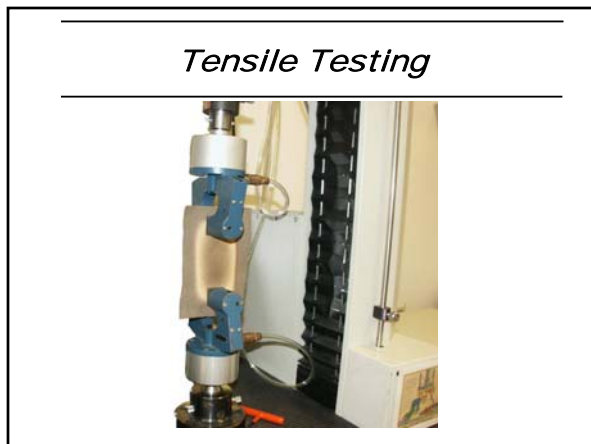
### *Edmonton, July 2003*

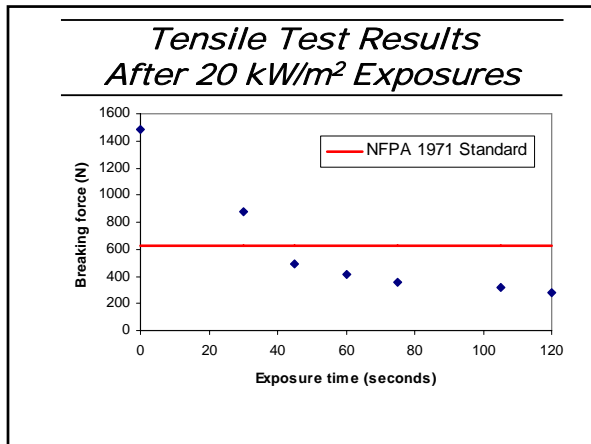




- ### Laboratory Testing
- **expose fabrics to heat fluxes indicative of “ordinary” conditions using RPP apparatus**
    - 5 to 30 kW/m<sup>2</sup>
    - 30 s to 60 min.
  - **use test protocol for new turnout gear**
    - determine degradation in performance

- ### Destructive Test Methods
1. **tensile test (outer shell)**
  2. **tear strength (moist. barrier, thermal liner)**
  3. **compressive conduction resistance test (thermal liner)**
  4. **liquid penetration test (moisture barrier)**
  5. **thermal gravimetric analysis (ensemble)**
  6. **thermal protective performance (ensemble)**





### Non-Destructive Test Methods (Outer Shell)

- visual inspection
- Raman spectroscopy
- colorimeter
- digital image analysis

**10 kW/m<sup>2</sup>**

120 s  
480 s  
720 s

### Digital Image Analysis

- use colour to assess degradation

- use colorimeter and scanner and colour recognition software

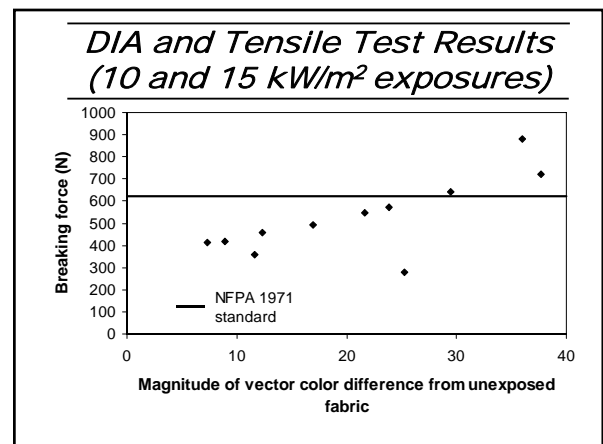
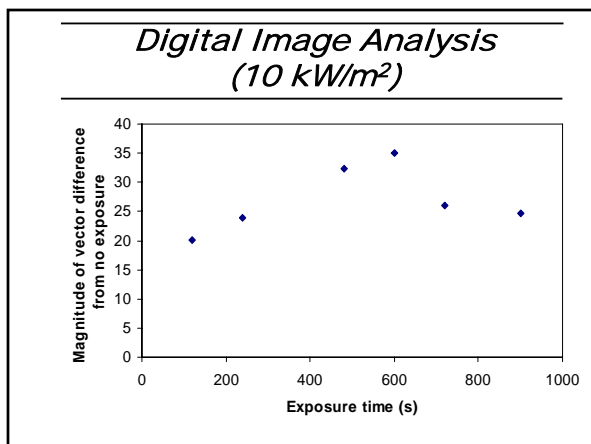
### Colour Measurement

- colour difference ( $\Delta E$ ) is defined as the Euclidean distance between two points in the CIE L\*a\*b colour space:

$$\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{1/2}$$

- compare with CIE L\*a\*b coordinates of unexposed fabric

L=100  
L=0 (lightness)  
CIE L\*a\*b system



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### *Conclusions*

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- **full-scale fire tests used to gather data on firefighting environment**
- **non-destructive methods examined in this study show some promise**
  - **have begun to correlate non-destructive and destructive test results**
- **use other colours for turnout gear?**

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### *Future Research*

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- **continue to investigate and refine non-destructive test methods**
  - **data analysis, repeatability**
- **examine degradation of other properties (e.g., moisture transfer)**
- **compare with other destructive tests**
  - **fabrics aged in laboratory**
  - **retired turnout gear**
- **conduct field studies**

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