HOW SAFE IS THE CLOTHING WORN BY ELECTRICAL WORKERS?
MEASURING THE TPP OF CLOTHING EXPOSED TO ELECTRIC ARCS.

Martin W. King¹,³, Robert W. Menzies², Erwin Dirks², Ruilin Chen¹ and Robert Guidoin³
Departments of ¹ Clothing & Textiles and ² Electrical Engineering,
University of Manitoba, Winnipeg, MB R3T 2N2 and ³ Institut des Biomateriaux,
Hôpital Saint-François d'Assise, Université Laval, Québec, QC G1L 3LS, Canada

INTRODUCTION
Companies that produce and distribute electricity are becoming increasingly concerned about
the number of burn injuries sustained by linemen and other electrical workers due to accidents
associated with arcing faults from live distribution lines, transformers and switching
equipment [1]. Standards organizations in Europe and North America responsible for
workplace safety are currently experiencing difficulties in establishing a meaningful
minimum thermal protective performance (TPP) specification for linemen's uniforms because
of the lack of suitable equipment to simulate this type of short, high energy exposure.

We have developed an appropriate piece of apparatus, called the Manitoba Electric Arc TPP
(MEAT) tester, which can generate arcs of 20s or longer and can control the power level
within ± 5% of a preset value in the 3.5-4.5 kW range. By varying its distance away from the
arc the test specimen can experience incident heat flux densities from 20 to 125 kW/m²
(0.5-3.0 cal/cm².s)[2], and by continuously monitoring the heat flux profile behind the
specimen, the specially designed software calculates and reports the protection time and TPP
rating prior to the onset of "second degree burns"[3].

CASE STUDY
We have investigated an accident in which a lineman working in a bucket, 10 m above ground,
was exposed to an electric arc that ignited his shirt and pants and resulted in him jumping from
the bucket and sustaining both broken bones and second degree burns to 30% of his body.
Examination of his clothing identified the location and type of damage sustained by his uniform
shirt and t-shirt underneath.

THERMOMAPHS OF DAMAGED CLOTHING

- Completely destroyed
- Flame damage
- Heat damage

FRONT

BACK

FRONT

T-SHIRT

BACK
LABORATORY TESTING
Analysis of the damaged clothing confirmed that the shirt was made from a 65/35 polyester/cotton blend, whereas the knitted t-shirt consisted of 100% cotton. Unused duplicate samples of the same two clothing items were acquired, washed 5 times and tested for electric arc TPP ratings together with an alternative uniform shirt made from 100% FR treated cotton. Double layers were also tested with the t-shirt fabric in the wet and dry states to simulate the situation when the worker is and is not sweating. Following a number of preliminary trials, the TPP test conditions were chosen to simulate the estimated total energy exposure of the accident and to reproduce the same level of observed damage to the two fabrics.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>TPP Rating (kJ/m²)</th>
<th>Burning Behaviour</th>
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</thead>
<tbody>
<tr>
<td>Polyester/cotton shirt</td>
<td>357 ± 25</td>
<td>Ignition, flame, smoke, drips, afterflame</td>
</tr>
<tr>
<td>100% FR cotton shirt</td>
<td>487 ± 8</td>
<td>No ignition, no flame</td>
</tr>
<tr>
<td>T-shirt, dry</td>
<td>601 ± 17</td>
<td>Ignition, flame, smoke, afterflame</td>
</tr>
<tr>
<td>T-shirt, wet</td>
<td>672 ± 21</td>
<td>No ignition, no flame</td>
</tr>
<tr>
<td>Poly/cotton shirt + t-shirt, dry</td>
<td>622 ± 8</td>
<td>Both ignite, flame, smoke, afterflame</td>
</tr>
<tr>
<td>FR cotton shirt + t-shirt, dry</td>
<td>655 ± 25</td>
<td>Neither ignite, no flame</td>
</tr>
<tr>
<td>Poly/cotton shirt + t-shirt, wet</td>
<td>550 ± 34</td>
<td>Poly/cotton shirt ignites, flame, smoke, drips</td>
</tr>
<tr>
<td>FR cotton shirt + t-shirt, wet</td>
<td>748 ± 13</td>
<td>Neither ignite, no flame</td>
</tr>
</tbody>
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The test results confirm that the polyester/cotton shirt ignited readily when exposed to the electric arc, whereas the 100% FR cotton did not. Also the dry cotton t-shirt ignited while the wet one did not. As well as using an FR treated fabric, additional protection can be obtained by wearing two layers instead of one, even though the under layer may be flammable. However if the outer layer ignites over a wet t-shirt, the rapid generation of steam reduces the TPP rating and puts the wearer at a higher risk of burn injury.

CONCLUSIONS
The MEAT tester can be used to simulate short exposures to radiant energy similar to those that occur during electric arcing faults. It can predict the TPP values of various single and multi-layer assemblies exposed to different arcing conditions, and will be useful in assisting in the development of uniform specifications for electrical workers. Polyester/cotton uniforms are not suitable for those working close to live lines and electrical equipment.

REFERENCES
