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

Martin W. King[1,3], Robert W. Menzies[2], Erwin Dirks[2], Ruilin Chen[1] and Robert Guidoin[3]
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 3L5, Canada

INTRODUCTION

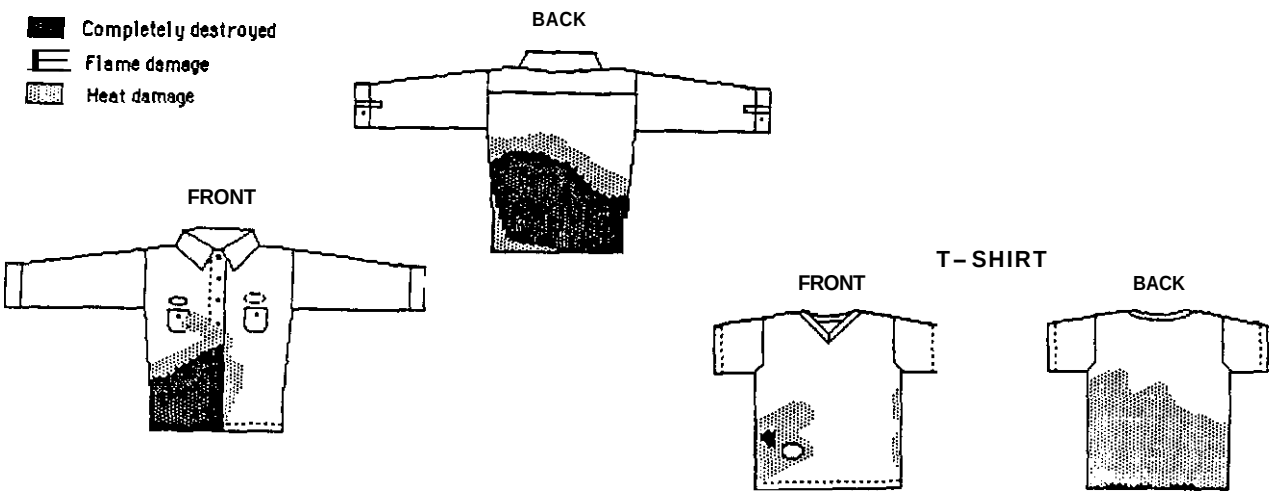
Companies that produce and distribute electricity are becoming increasingly concerned about the number of burn injuries sustained by linemen and other electrical workers due to accidents associated with arcing faults from live distribution lines, transformers and switching equipment [1]. Standards organizations 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/m^2 (0.5-3.0 $cal/cm^2.s$)[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.

THERMOGRAPHS OF DAMAGED CLOTHING



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.

Electric Arc TPP Results for Single and Double Layers

Specimen	TPP Rating (kJ/m^2)	Burning Behaviour
Polyester/cotton shirt	357 ± 25	Ignition, flame, smoke, drips, afterflame
100% FR cotton shirt	487 ± 8	No ignition, no flame
T-shirt, dry	601 ± 17	Ignition, flame, smoke, afterflame
T-shirt, wet	672 ± 21	No ignition, no flame
Poly/cotton shirt + t-shirt, dry	622 ± 8	Both ignite, flame, smoke, afterflame
FR cotton shirt + t-shirt, dry	655 ± 25	Neither ignite, no flame
Poly/cotton shirt + t-shirt, wet	550 ± 34	Poly/cotton shirt ignites, flame, smoke, drips
FR cotton shirt + t-shirt, wet	748 ± 13	Neither ignite, no flame

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

1. King M.W., Li X., Doupé B.E. & Mellish **J.A.** 1988, Thermal protective performance of single-layer and multiple-layer fabrics exposed to electrical flashovers, in S.Z. Mansdorf, R. Sager & A.P. Neilsen (eds) Performance of Protective Clothing: Second Symposium, STP 989, (American Society for Testing & Materials, Philadelphia, PA, USA) 59-81.

2. King M.W., Menzies R.W., Soroka A.J., Dirks **E,** Chen R. & Sun Y. 1992, Evaluating the TPP of clothing exposed to electric arcs: a standard laboratory test apparatus, in J.P. McBriarty & N.W. Henry (eds) Performance of Protective Clothing: **Fourth Volume,** STP 1133, (American Society for Testing & Materials, Philadelphia, PA, USA) In press.

3. Behnke W.P. 1977, Thermal protective performance test for clothing, Fire Technology, 13, 6-12.