MINIMIZE ARC-BURNING INCIDENTS

Protective clothing knowledge can save lives

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In March 1997, two industrial electricians, anxious to begin a job in Norton's Hospital in Louisville, KY, entered the basement electrical room. They knew the parts they were working near were energized, but wanted to begin the measurements. They didn't know the full danger that lay behind the "Danger - High Voltage" signs. The workers were attempting to make measurements to the buss when the metal tip of their wooden ruler caused a massive electric arc in this hazardous area. The fire balloon lasted a fraction of a second, and although no one was electrocuted, one man died instantly and another ended up in the burn unit badly injured for five days. It didn't take long for substantial damage to occur, instantly igniting the polyester/cotton uniform shirts the men were wearing. The closest worker was pronounced dead on the scene. Another worker, 10 feet away, was also burned when his shirt ignited, but fortunately, not as severe as his co-worker's.

Facts on Electric Arcs

Electric arc thermal energy is determined by the following:

- Current (Amps, ground or phase-to-phase fault)
- Duration of the arc (cycles)
- Length of the arc
- Distance from the arc
- Directionality of the arc(arc-in-a-box, such as in a panel can be up to 6X open air arcs)
- Arc Voltage (fairly constant in air 70-20kA = 400-425V, Westinghouse Protective Relays) - Source voltage usually only comes into the equation in determining the length of the arc.

The most accurate and simple methods for assessing arcs are arc assessment software programs:

- ARCPRO® software, from Ontario Hydro Technologies (OHT). This software is based on an actual are model, verified by thousands of pieces of data from the OHT lab. It predicts energy produced by an arc using the above parameters in cal/cm^2 (calories per square centimeter). ARCPRO® will predict arc energies at distances above or to the side of the arc. Its Windows™ interface is very user-friendly, but assumes you have clothing data.
- Duke Heat Flux Calculator. This small, DOS-based program gives good estimates of arcs. It is not quite as accurate as ARCPRO®, based on testing which was conducted, but is free. If you want close assessments to begin with, you may want to use this simple program. It doesn't support multiple calculations, like ARCPRO®, so you will have to reenter all of the information for each scenario. This gets very tedious if you are doing several calculations. ARCPRO® has also been promising an update which will include some cotton clothing ignition levels. This is free data to help with clothing assessments, but free is tough to beat. Both programs may be run at the same time, and information can be found on the Internet at http://www.nascoinc.com/archaz.htm.

The Shifting Paradigm

What is happening in the electric industry with regard to clothing is a paradigm shift. The old paradigms

pushed safety toward one of two errors-companies would either claim that our industry was different and our service so vital we had to "face the hazards," or would take an overly-conservative approach focusing on the worst-case scenario. In the case of electrical arcs, the worst-case scenario for most utilities leaves most "flame resistant" garments in ashes. It is better understood that mere compliance with the OSHA standard will not protect workers, but options are now available to protect under many electric are conditions.

Use a continuous improvement model to look at arc hazards, and consider the following:

- Assess your scenarios and determine their consequences
- Alert engineers and line workers and provide them with training on the consequences of electrical arcs
- Analyze different engineering perspectives to reduce exposure (such as different breakers or designs)
- Appraise the problem areas and include them in the line worker training
- Apprise workers of any work practice changes, such as faster breaker settings, placing protective devices (i.e., reclosers and breakers) to "one shot" so workers will be better protected
- Assess clothing to ensure workers wear clothing which won't "increase the extent of injuries" from electric arcs under each set of conditions they will be exposed to.

Assess Clothing

Many industry members discovered existing clothing policies are adequate under 95 percent of work conditions and chose to add a switching

jacket/suit for the high-fault current situations. Testing on arc-resistant rainwear shows that ounce-for-ounce, dollar-for-dollar, it is the best protection on the market today for switching applications, especially when used in conjunction with a proper faceshield and hood assembly. Identifying areas for special protection, which reduce injury chances yet still answer concerns for heat stress from "overprotecting" is a must for all.

Clothing performance may be guided by the following:

- Ease of ignition
- Degree and ease of flame spread
- Heat produced during burning
- Rate of heat transfer
- Ease of extinguishing the flame
- Other negative effects (i.e., melting).

Non-FR synthetic fabrics can be extremely dangerous for workers exposed to electric arc. Specifically, blends of these fibers with cotton are more readily ignited, difficult to extinguish and add the damaging and complicating effects of melting to the injury sustained by the worker, greatly increasing the chance of infection. Some utilities are purchasing wool-lined coveralls. which have none of the melting characteristics of the non-FR synthetic fabrics. while others are purchasing FR-lined coveralls. Many utilities provide winterwear with FR shells or heavy cotton shells, but to determine what is best. adequate assessment information and clothing test data need to be used.

Wool, in as opposed to cotton, does not normally sustain a flame after the ignition source is removed. Testing has shown no fires in wool garments with 8kA arc, 12-inch gap, and 12 inches away from the arc for 10 cycles. Most wool face masks, however, should not be used if they contain non-FR or melting elastic around the eyeholes. Elastic tested in several facemasks has burned and melted profusely when exposed to electric arc. If cotton is used, it should be heavy cotton and either twill or denim weave. Weight and weave determine the burn rate when cotton does ignite, and affects the probability that the cotton will ignite.

OSHA Essentials

In 1994, OSHA introduced a standard covering Electric Power Generation, Transmission and Distribution (1910.269). This standard made the following provisions in its Apparel section(l)(6)(iii):

The employer shall ensure that each employee who is exposed to the hazards of flames or electric arcs does not wear clothing that, when exposed to flames or electric arcs, could increase the extent of injury that would be sustained by the employee.

Note: Clothing made from the following types of fabrics, either alone or in blends, is prohibited by this paragraph, unless the employer can demonstrate that the fabric has been treated to withstand the conditions that may be encountered or that the clothing is worn in such a manner as to eliminate the hazard involved: acetate, nylon, polyester, rayon.

This standard essentially bans polyester/cotton uniforms such as those worn by the worker killed in Louisville, but the standard is currently only applicable for the specific industry cited. OSHA has a standard for the construction side of the electric utility business, which has the same language regarding apparel. This standard, when final, most likely will contain the same performance-related language for construction that OSHA currently requires for maintenance operations in electric utilities; but what about industrial electricians who work in high amperage applications with or near energized equipment? Do electric contractors have any obligations in these work situations? Electric contractors working in the electric utility business have the same obligations as electric utilities when performing maintenance work.

Another possible-application of the standard occurred when a telephone company was cited under the 1910.269 standard for failure to maintain hotsticks properly. This standard is coming under substantial use by OSHA and the clothing portion has more interpretive letters than most other parts. Even if OSHA doesn't cite your particular industry, it is prudent to take some sensible steps to reduce the risk of electric arc burn injuries. Be aware of two important things about electric arcs: They can be just as bad with lower voltages as with high ones. Systems with 480V are often the worst electric arc systems, due to higher amperage and often longer clearing times; and electric arcs can occur with or without an electrical contact injury, so workers who get electrical contact could survive the contact and get burns from the arc, or workers who did not get contact could still be exposed to a fault.

What can you do?

What can you do to reasonably comply with the OSHA standard and protect your workers when working energized parts and equipment? There are a few practical steps you can take to move your workers from the wrong clothing:

- Contact your electric utility and find out what they are doing
- Immediately remove all non-flame resistant synthetic blend clothing from the workplace. Natural fiber is not best, but is usually better than melting synthetics or non-flame resistant blended fabrics.
- Uniforms of nylon, polyester/cotton,. acrylic facemasks or sweaters. nylon jackets, melting-substrate rainwear (FR or non-FR) and possibly any polyester insulated jackets and coveralls should be removed from use.
- Attempt to assess the hazards workers face.

For contractors, this may be difficult since you may not have access to this information. A good rule of thumb is any work above 300V has greater arc potential (high amperages at lower voltages may also be dangerous.

The higher the amperage or the longer the clearing time for a fault, the greater the danger.

At minimum, require heavy natural fiber clothing (cotton, wool, silk).

Heavy cottons, such as denim jeans, will resist ignition better than lightweight textiles, but under some conditions these can ignite- and increase injury to the worker. Some contractors are providing flame-resistant shirts or switchwear for certain work. Many electric utilities have found that arc resistant rainwear makes sense because it eliminates melting rainwear and can often serve as a switchwear alternative available to every worker at much less cost than textile based switchwear (visit the arc hazard awareness page on the internet for more information: http://www.nascoinc.com/archaz. tm

Many contractors have found that using -a uniform service helps provide a cost-effective method to ensure proper compliance with clothing policies. Cintas, ARAMARK and most larger laundry services provide information on electric arc protective clothing and can be of assistance in providing shirts or full uniforms to workers exposed to electric arcs.

Another emerging way to ensure proper clothing is a novel approach from Tyndale Company, which provides a catalog with a choice of clothing, allowing workers to purchase directly from a customized catalog. Each organization can give individual workers an allotment, purchase clothing outright, or require workers to purchase compliance clothing with personal checks or credit cards over the phone. This method, like leasing from a laundry, removes you from the clothing business, and costs are more easily limited but so are choices. Tyndale can be reached at (800) 356-3433. Another company with similar services and excellent winterwear selection is Millworks (formerly Carhartt Canada Ltd.) in Toronto, (416) 285-6992.

Direct purchase of clothing by the company is also a cost-effective option offered by many companies as worker benefits and is a strong move toward ensuring compliance. Many companies offer this service, and three of the leading clothing manufacturers are Workrite: (800) 521-1888;

Red Kap/Bulwark (800) 733-5271

Carhartt Inc., (800) 833-3118.

FR Clothing Choices

If you choose to provide flame-resistant clothing, there are four basic types:

- Treated natural fibers: FR cotton and wool are both available. Wool and silk generally do well in electric arc conditions, but wool should only be worn as an under layer in most situations, due to its propensity to break open in arc conditions. Two brand names are Indura® (Westex, Inc.) and Banox® Plus (ITEX, Inc.). It is not recommended to use FR treatments that wash out. The two above don't if following manufacturer's instructions.

- Treated blends: Eighty-eight percent cotton/Twelve percent nylon blends are very popular, especially for rugged applications and shell fabrics such as jackets and overalls. BanWear® (ITEX, Inc.) and Indura Tufstuf® (Westex, Inc.) are two brands available. They have better wear life than those without nylon.

- Inherent flame resistant blends: Nomex®-rayon blends are available from Southern Mills (800) 241-8630 and are providing strong and comfortable, and mod-acrylic/cotton blends FireWear® (Springfield) (800) 433-4522 and Valzon® (Westex Inc.) (773) 523-7000 - are both very popular, too. Kermel® (770) 977-2888 is another blend which is the 'Cadillac' of inherent blends in its hand and dyeability. Another strong player in blends is the most protective fabric on the market -PBI®/Kevlar® made by Hoechst Celanese.

- Inherent flame-resistant synthetic fibers: The leader in this category is DuPont's Nomex® (http://www.dupont.com/afs) which offers exceptional fabric life, protection and inherent flame resistance. Nomex® performs well under electric arc conditions. The downside is often said to be comfort due to its synthetic nature. Nevertheless, many utilities and petrochemical installations alike use Nomex®.

Most electric utilities provide a mixture of the above in their clothing programs or policies. Cotton jeans are still common clothing for, electric utility workers. They have risks, but many find the risks manageable.. The majority, however, are already providing FR clothing for shirting or offering it as an alternative for their workers.

A couple of other considerations in hazards of electric arc are the eyes and face. Safety glasses are a given for eye protection. Much anecdotal evidence is available that safety glasses can save eyes when workers are exposed to electric arc. Test data is also beginning to mount that there are work situations where faceshields - either alone or in conjunction with a hood assembly -are giving more protection than previously thought possible. So if your company is looking at hazard assessments, considering a clothing policy or just routinely talking about safety policies and practices, consider faceshields or faceshields with hood assemblies for your worst electric arc hazards. Many utilities are making them available for network and switching work. Look for some interesting developments in design and protection within the next year.

One new hood has been shown to decrease extremely high amperage arc burn potential (NASCO ArcShield™ ArcHood™ (800) 767-4288.

For help in assessing your arcs or choosing proper clothing, visit: http://www.nascoinc.com./archaz.htm or contact:
Hugh Hoagland, R&D Director, NASCO Rainwear
at (800) 767-4288 extension 20,
e-mail: hugh@nascoinc.com, or visit the Arc Hazard Assessment webpage at http://www.nascoinc.com/archaz.htm

ARCPRO® software is available from HD Electric in the United States at (708) 945-0801.

Reference: L. Pakkala, The Flammability of Different Textiles and Its Influence on the Severity of Skin Burns, Annales Chirurgiae et Gynaecologiae 69:240-243, 1980.