

New evidence shows that some fall protection doesn't stand-up to an electric arc as well as once thought. Are you getting the protection you think you are?

# Falling to Pieces

## Fall Protection Harnesses in the Electric Arc

by Hugh Hoagland

Since 1994 and the introduction of 1910.269, I have received many questions about what would happen to fall protection harnesses and personal climbing equipment exposed to an electric arc. I had been testing for Bashlin Industries for years and had never seen a harness ignite or drip in arc testing. I had also seen testing performed by Buckingham Manufacturing so I thought there was little reason for concern. As it turns out, however, I had tested the harnesses and climbing equipment at levels that were too low to see any potential problems.

Early Buckingham testing did show that if non-FR clothing was worn under the harness, the clothing could ignite and consume the harness. But, if FR clothing was worn, their harnesses fared well in testing. Some harnesses I tested for utilities had failed my requirements in testing, but the ignition was usually a minor non-FR component, such as a keeper. These events had never reduced the fall protection ability of the harness, but had produced a localized ignition that could have caused a limited burn injury to a worker.

### New Tests

In mid-2001, an IBEW safety professional told me about a few accidents where workers were burned by fall protection harnesses. His description of the accident sounded like there had been a harness ignition. I contacted my friends at Buckingham and Bashlin and asked if they would pay the costs of testing harnesses from as many manufacturers as they could acquire, along with their own different designs. Both companies felt this could be a valid research project and I donated my time to write the report and perform the testing. The intent was to help ASTM develop a test method for the ASTM F887 Specifications for Personal Climbing Equipment to evaluate harnesses for resistance to ignition, melting and dripping in electric arc exposure. I was truly surprised at the findings. We chose to test the harnesses using the ASTM F1956-99 test set-up for clothing ignition. This test utilizes a test mannequin exposed to an 8,000 Amp, 12-inch long electric arc with the mannequin 12 inches away from the arc for a chosen duration. The basic results of the testing are below:

1. All of the polyester harnesses and most of the lightweight nylon harnesses tested (which met the ANSI Z359.1-1992 Standard), ignited, burned, melted and dripped in most of the electric arc exposures.
2. Nylon type 6,6 (DuPont brand) harnesses (which met the ASTM F887 Standard and the ANSI Z359.1-1992 Standard) passed all our test criteria.
3. There was a distinctive difference in the ANSI compliant harnesses and the ASTM compliant harnesses. Those meeting the ASTM requirements did better in the testing.

### Standard Differences

There are differences in the two fall protection standards commonly used in electric utilities. The most common in utilities is Specification F887-97 Standard Specifications for Personal Climbing Equipment (available from [www.astm.org](http://www.astm.org)). This standard specification covers "acceptance testing of climbers and climber straps, body belts and positioning straps, and harnesses used by workers in the climbing of poles, trees, towers, and other structures." It

## Fall Protection

currently does not have an arc test requirement, but the committee will be entertaining a draft in 2002. This standard requires 7,000 lb. tensile strength nylon. This was likely the difference in the performance. See below for a discussion of the two types of available nylon.

The other standard for fall protection devices is ANSI Z359.1-

1992 (R 1999) Safety Requirements for Personal Fall Arrest Systems (available from American Society of Safety Engineers, [www.asse.org](http://www.asse.org)). This standard is more commonly used in construction and many other industries and many utilities have chosen harnesses that meet this standard. Polyester harnesses have become much more popular in the recent years along with

lighter weight nylon harnesses. This standard "establishes requirements for the performance, design, marking, qualifications, instruction, training, inspection, use, maintenance, and removal from service of connectors, full body harnesses, lanyards, energy absorbers, anchorage connectors, fall arresters, vertical lifelines, etc., comprising personal fall arrest systems within the capacity range of 130 to 310 pounds (59-140 Kg). Body belts, window cleaner belts, and chest waist harnesses are not addressed by the provisions of this standard." This standard has no plans to add an arc test requirement since most of the users of the standard have no such exposure.

### Why the Difference?

In researching why there could be a difference in polyester and nylon, generically, I found that they have very similar melting points. Both polyester and nylon melt around 490°F and their self-ignition points are both about 840°F. However, the self ignition for DuPont Nylon 6,6 is 990°F and its melting point is also higher than polyester and nylon 6 (All nylon's are not created equal. There is a chemical structure difference in the two nylons). But since many of the nylon harnesses that passed used type 6 nylon, the most likely difference in the performance in the arc tests was in the mass and thickness of the harnesses. The heavy nylon (10,000 lb. tensile strength) tested and the medium nylon (7,000 lb. tensile

| Results of the testing performed at Kinectrics High Current Lab |                                   |  |              |                 |                               |
|---|-----------------------------------|--|--------------|-----------------|-------------------------------|
| Energy Level<br>Side A: E, cal/cm                               | Energy Level<br>Side B: E, cal/cm | Mfg./Material  | Harness Type | Ignition<br>Y/N | ASTM F887<br>Drop Test<br>P/F |
| 54.2  | 58.4                              | Bashlin 662XD Nylon<br>D Polyester                       | X Style      | N<br>Y          | P<br>F                        |
| 54.8  | 51.8                              | Bashlin 662RD Nylon<br>E Polyester                       | H Style      | N<br>Y          | P<br>F                        |
| 55.6  | 53.8                              | Buckingham 6393700-M Nylon<br>*P Nylon                   | H Style      | N<br>N          | P<br>F                        |
| 41.7  | 42.1                              | Bashlin 662XD Nylon<br>D Nylon                           | X Style      | N<br>Y          | P<br>F                        |
| 43.4  | 40.6                              | Buckingham 6393700-M Nylon<br>M Polyester Stretch        | H Style      | N<br>Y          | P<br>F                        |
| 41.2  | 39                                | Bashlin 662RD Nylon<br>**E Polyester                     | H Style      | N<br>Y          | P<br>F                        |
| 44.6  | 40.8                              | Buckingham 6393700-M<br>*P Nylon                         | X Style      | N<br>Y          | P<br>F                        |
| 31.4  | 32.1                              | D Nylon<br>**E Polyester                                 | H Style      | Y<br>Y          | P<br>F                        |
| 32  | 29.7                              | Buckingham 6393700-M<br>M Polyester Stretch              | X Style      | N<br>Y          | P<br>F                        |
| 34.4  | 30.3                              | ** R Polyester<br>** E Polyester                         | H Style      | Y<br>Y          | F<br>F                        |
| 32.5  | 30.3                              | **F Polyester<br>**R Polyester                           | X Style      | N<br>Y          | F<br>F                        |
| 51.6  | 59.2                              | Bashlin 662RD Nylon<br>Bashlin 663XD Nylon               | H Style      | N<br>N          | P<br>P                        |
| 52.5  | 49.4                              | Buckingham 6393700-M<br>Nylon B<br>*P Nylon              | X Style      | N<br>Y          | P<br>F                        |
| 57.1  | 47.7                              | Bashlin 662RD Nylon<br>Bashlin 663XD Nylon               | X Style      | N<br>N          | P<br>P                        |
| 52.4  | 50.1                              | Buckingham 6393700R Nylon<br>Buckingham 6393602BN1 Nylon | H Style      | N<br>N          | P<br>P                        |
| 25.3  | 27.6                              | Bere<br>D Nylon or Polyester                             | X Style      | Y<br>Y          | P<br>F                        |
| 46.4  | 50.3                              | Buckingham 6393700<br>Buckingham 6393700 Nylon           | H Style      | N<br>N          | P<br>P                        |
| 44  | 44.7                              | Buckingham 6393700 Nylon<br>Buckingham 6393700 Nylon     | H Style      | N<br>N          | P<br>P                        |

\* P was medium weight nylon.  
 \*\* These harnesses either stated they were polyester or were assumed to be. The companies' websites didn't give indication as to the webbing material type.  
 Note: Kevlar® aramid which does not melt or drip has been used in fall protection harnesses, but was not included in this set of testing. Additional testing is recommended to determine what weight and design Kevlar® aramid will work in these high-energy arc exposure applications. As noted here, there appears to be a relationship between the weight and thickness of the harness webbing and its arc performance.

strength) seem to perform much better than the other harnesses. Most of the harnesses that failed used 5,000 lb. webbing, which is not as thick as the other webbings. The 5,000 lb. is the ANSI standard minimum. This is the critical difference in the standards.

#### The Bare Minimum

It should be common sense, but not everyone knows that standards are usually minimum requirements. You should determine if the minimum standard is adequate by asking yourself if the standard tests for all the hazards identified in your hazard assessment. Preventing accidents is a goal of hazard assessment and making sure the minimum standard tests for the type of hazards and the severity of hazards you may encounter is critical to successfully choosing PPE and other equipment. One test is not enough and a low level test might be unrealistic.

We chose 30-50 cal/cm<sup>2</sup>, since the NFPA 70E standard set 40 cal/cm<sup>2</sup> as the Hazard/Risk Category 4 minimum. Testing the product you actually use is a good idea if the manufacturer hasn't adequately tested it. I'm recommending to ASTM to test six harnesses in the electric arc from 40-45 cal/cm<sup>2</sup> for ignition, melting and dripping, and to make sure they can pass the drop test after the exposure. Any failures would necessitate a redesign. This would help keep line workers from getting additional injuries from their harnesses or from getting a fall injury added to the arc injuries. Some utilities require wearing a harness in enclosed spaces, a harness that can't take an arc could make retrieval for medical attention difficult.

Chemical resistance needs must also be taken into consideration as they could affect the materials you would use. Polyester, Nylons (type 6 and 6,6) and Kevlar® have different resistances to chemicals. See manufacturer information for specific resistance issues.

#### Under Cover

One way to temporarily, or permanently, avoid some arc exposures is to cover the harness with arc and flame resistant clothing. NASCO's ArcLite™ ProSeries™ and switching jackets from Steelgrip and NSA have fall protection access in a covered back flap which allows the harness to be worn under the garment for arc protection and

# THEY NEED YOU!!



## MAKE SURE YOU COME HOME TONIGHT !!

You have chosen the **3rd most dangerous profession** according to recent US Department of Labor statistics.

Every day, electricians are killed or receive serious burn injuries as a result of an Electrical Arc explosion. Yet these injuries can be avoided with training, proper work practices and using protective faceshields, hoods and clothing that are NFPA 70E-2000 compliant.

Oberon Company is the pioneer and leader in Arc Flash protection. We have made significant R&D and product design investments to provide you with the highest levels of protection available in the market today.



Only Oberon provides a Certificate of Compliance, which guarantees the garment meets or exceeds all aspects of NFPA 70E, ASTM F1506 and OSHA 29CFR 1910.269. Others may tell you a story, but only Oberon puts it in writing... with every garment we sell. Don't risk your life on a story. Work safe... Be Safe... with Oberon.

**FOR PEACE OF MIND, FOR YOURSELF AND YOUR FAMILY, LOOK FOR THE ARC-X™ LOGO AND THE CERTIFICATE OF COMPLIANCE™... ONLY FROM OBERON COMPANY.**



**OBERON**

1-800-322-3348

[www.arcflash.com/us](http://www.arcflash.com/us)



For your **FREE** copy of the ARC Trainer CD-ROM, covering Electrical Safety Standards & Electrical Arc PPE, visit us on the web.

## Fall Protection



If involved in an electric arc incident, this harness could not offer fall protection.

still perform its fall protection functions in the event of a fall or to be used for egress in the event of an accident. (note FR rainwear may not be arc resistant. Rainwear should meet ASTM F1891-2000 if using it for protection against electric arc).

Covering polyester or other materials with leather or FR materials may extend

the limits of the harness material, but you must ensure that doing so doesn't degrade the fall protection performance. Covering polyester or other materials with leather or FR materials should not be done without testing on the part of the fall protection manufacturer. Retrofits should be done by the harness/fall protection manufacturer and be certified to meet the applicable fall protection standard.

### Other Considerations...

Low-static hardware is now available for almost all applications. Nylon replacements or coated hardware has been found to reduce the static build-up when working near energized parts. However, many companies still use metal hardware and, when used properly, this has been considered safe.

Keepers have caused fires in some nylon harnesses in the past and they should be exposed to arc testing.

Location of labels has also been an issue since some labels have ignited and burned

the webbing enough to cause a failure.

Thickness of the load bearing material seems to be the most critical factor in ignition and harness failure, though the nylon vs. polyester (and brand of nylon) could be an issue. Check with the manufacturer on their testing to make sure it meets your requirements.

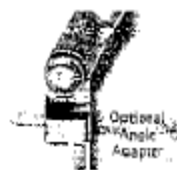
### Free Speech

We are drafting language now to add to the ASTM F887 standard for the next revision to be voted on by ASTM in September 2002. This could make a standard specification which would offer a level of tested arc performance in fall protection harnesses. But, until such a standard is in place, test your harnesses and be aware that all fall protection harnesses are not created equal when it comes to electric arc exposure. ♦

*Hugh Hoagland is the principal consultant at ArcWear.com. E-mail: hugh@arcwear.com or Phone: (502) 314-7158.*

## CABLE PLACING SOLUTIONS GMP

# SPLICER'S & DIELECTRIC UMBRELLAS



- ▶ Tough plastic 68 in. (173 cm) dia. cover
- ▶ Safety yellow top, reflective white inside
- ▶ Improved construction includes self-sealing waterproofed, waxed stitching
- ▶ Nylon rib-end pockets keep frame from ripping cover
- ▶ Collapsible fiberglass ribs slide easily, locking with a twist over the set-pin
- ▶ 43 in. (109 cm) pole lengthens to 6 ft (1.8 m) with 29 in. (74 cm) extension

TOOLS BUILT TO GO THE DISTANCE

9231  
CERTIFIED

### HERE'S A TIP

To assure long umbrella life, store in a protective case when not in use.

+1.215.357.5500

www.GMPtools.com

# Full Results of Harness Study Published only on ArcWear.com

| Test #   | Current (A) | Duration (cycles) | E <sub>i</sub> cal/cm <sup>2</sup> | Description                         | Harness Type | Ignition Yes/No | ASTM F887 Drop Test Pass/Fail |
|----------|-------------|-------------------|------------------------------------|-------------------------------------|--------------|-----------------|-------------------------------|
| 01-1944A | 8,171       | 70                | 54.2                               | A: Bashlin 683XD Nylon              | X Style      | No              | Pass                          |
| 01-1944B | 8,171       | 70                | 58.4                               | B: DBI 1102010 Polyester            | X Style      | Yes             | Fail                          |
| 01-1945B | 8,171       | 71                | 53.2                               | B: Miller E650-U Polyester          | H Style      | Yes             | Fail                          |
| 01-1946A | 8,123       | 71                | 54.8                               | A: Bashlin 662RD Nylon              | H Style      | No              | Pass                          |
| 01-1946B | 8,123       | 71                | 51.8                               | B: Elk 48103 Polyester              | H Style      | Yes             | Fail                          |
| 01-1947A | 8,154       | 71                | 55.6                               | A: Buckingham 603B3700-M Nylon      | X Style      | No              | Pass                          |
| 01-1947B | 8,154       | 71                | 53.8                               | B: Protecta AB108AM* Nylon          | H Style      | No              | Fail                          |
| 01-1948A | 8,147       | 56                | 41.7                               | A: Bashlin 683XD Nylon              | X Style      | No              | Pass                          |
| 01-1948B | 8,147       | 56                | 42.1                               | B: DBI - 1102010 Polyester          | X Style      | Yes             | Fail                          |
| 01-1949A | 8,166       | 55                | 43.4                               | A: Buckingham 6393700-M Nylon       | H Style      | No              | Pass                          |
| 01-1949B | 8,166       | 55                | 40.6                               | B: Miller E650-U DuraFlex           | H Style      | Yes             | Fail                          |
| 01-1950A | 8,183       | 55                | 41.2                               | A: Bashlin 662RD Nylon              | H Style      | No              | Pass                          |
| 01-1950B | 8,183       | 55                | 39                                 | B: Elk 48103 **Polyester            | H Style      | Yes             | Fail                          |
| 01-1951A | 8,206       | 55                | 44.6                               | A: Buckingham 603B3700-M            | X Style      | No              | Pass                          |
| 01-1951B | 8,206       | 55                | 40.6                               | B: Protecta AB108AM* Nylon          | X Style      | Yes             | Fail                          |
| 01-1952A | 8,208       | 45                | 31.4                               | A: DBI 1102010 Polyester            | H Style      | Yes             | Pass                          |
| 01-1952B | 8,208       | 45                | 32.1                               | B: Elk 48103 **Polyester            | H Style      | Yes             | Fail                          |
| 01-1953A | 8,226       | 44                | 32                                 | A: Buckingham 6393700-M             | H Style      | No              | Pass                          |
| 01-1953B | 8,226       | 44                | 29.7                               | B: Miller E650-U DuraFlex           | X Style      | Yes             | Fail                          |
| 01-1954A | 8,183       | 44                | 34.4                               | A: Rose 502734 **Polyester          | H Style      | Yes             | Fail                          |
| 01-1954B | 8,183       | 44                | 30.3                               | B: Elk 47319 **Polyester            | H Style      | Yes             | Fail                          |
| 01-1955A | 8,203       | 44                | 32.5                               | A: French Creek 631M-XL **Polyester | X Style      | No              | Fail                          |
| 01-1955B | 8,203       | 44                | 30.3                               | B: Rose 415947A **Polyester         | X Style      | Yes             | Fail                          |
| 01-1956A | 8,169       | 76                | 61.6                               | A: Bashlin 662RD Nylon              | H Style      | No              | Pass                          |
| 01-1956B | 8,169       | 76                | 59.2                               | B: Bashlin 683XD Nylon              | H Style      | No              | Pass                          |
| 01-1957A | 8,187       | 68                | 52.5                               | A: Buckingham 603B3700-M Nylon      | X Style      | No              | Pass                          |
| 01-1957B | 8,187       | 68                | 49.4                               | B: Protecta AB108AM* Nylon          | X Style      | Yes             | Fail                          |
| 01-1958A | 8,197       | 68                | 57.1                               | A: Bashlin 662RD Nylon              | X Style      | No              | Pass                          |
| 01-1958B | 8,197       | 68                | 47.7                               | B: Bashlin 683XD Nylon              | X Style      | No              | Pass                          |
| 01-1959A | 8,164       | 68                | 52.4                               | A: Buckingham 6393700FR Nylon       | H Style      | No              | Pass                          |
| 01-1959B | 8,164       | 68                | 50.1                               | B: Buckingham 6393502GN1 Nylon      | H Style      | No              | Pass                          |
| 01-1960B | 8,238       | 34                | 27.6                               | B: DBI Polyester                    | X Style      | Yes             | Fail                          |
| 02-692   | 8,559       | 60                | 49.4                               | A: Buckingham 6393700 Nylon         | H Style      | No              | Pass                          |
| 02-692   | 8,559       | 60                | 50.3                               | B: Buckingham 603B3700 Nylon        | X Style      | No              | Pass                          |
| 02-693   | 8,570       | 54                | 44                                 | A: Buckingham 6393700 Nylon         | H Style      | No              | Pass                          |
| 02-693   | 8,570       | 54                | 44.7                               | B: Buckingham 603B3700 Nylon        | X Style      | No              | Pass                          |

\*We believe the Protecta AB108AM tested was medium weight nylon.

\*\* These harnesses either said they were polyester or we were relatively sure. Companies websites didn't indicate webbing type.

# Buckingham Mfg. Co.

Arc Exposure Testing

Kevlar Harnesses

April 16, 2003

| Test #   | Current (A) | Duration (cycles) | E <sub>i</sub> cal/cm <sup>2</sup> | Description                 | Harness Type | Ignition Yes/No | ASTM F887 Drop Test Pass/Fail | Comments       |
|----------|-------------|-------------------|------------------------------------|-----------------------------|--------------|-----------------|-------------------------------|----------------|
| 03-1134A |             |                   | 43.7                               | Buckingham 6393700NK Kevlar | X Style      | No              | Pass                          | Front Exposure |
| 03-1134B |             |                   | 39.0                               | Buckingham 6393700NK Kevlar | X Style      | No              | Pass                          | Back Exposure  |
| 03-1135A |             |                   | 44.4                               | Buckingham 6393700NK Kevlar | X Style      | No              | Pass                          | Front Exposure |
| 03-1135B |             |                   | 39.9                               | Buckingham 6393700NK Kevlar | X Style      | No              | Pass                          | Back Exposure  |
| 03-1136A |             |                   | 42.8                               | Buckingham 6393700NK Kevlar | X Style      | No              | Pass                          | Front Exposure |
| 03-1136B |             |                   | 44.9                               | Buckingham 6393700NK Kevlar | X Style      | No              | Pass                          | Back Exposure  |