Arc-rated gloves and the new ASTM test method

By H Hoagland and Z Jooma, e-Hazard

This article discusses the glove protection standard and concludes with advances by other international standard committees.

If one subscribes to the Hominid theory, then the importance of standing on two limbs summarises the importance of using the other two limbs for advancing mankind. Hands are critical to performing tasks. In an electrical context, tasks ranging from fault finding to switching are performed by hand. The irony is that prior to 2013, no standard had covered the arc rating of hand protection. A new standard published in 2013 has addressed this gap.

Hands and hazards

Electrical workers’ hands are exposed to many workplace hazards such as electrical shock, electrical arc flash burns, flash fires, cuts, splinters, oil, electrical solvents, pinching and crushing. The NFPA 70E - 2012 [1] requires the use of rubber insulating gloves with leather over-protectors when shock protection is required. The rubber insulating gloves provide the actual shock protection whilst the leather over-protectors serve to reduce damage to the rubber gloves. When it comes to arc flash protection, the standard requires that hand protection consisting of either leather or arc rated gloves be worn. At the time of publication of the NFPA 70E – 2012 [1], however, no standard addressing the arc rating of a glove existed. It was merely implied that arc rated fabric could be used to produce a glove. The arc rating of the leather glove is also not stipulated, but a minimum thickness of 0.7 mm is required.

The rubber insulating glove and leather over-protector of a specified minimum thickness, may have offered a definitive level of shock protection whilst addressing other hazards but no published standard existed which allowed for the arc rating of the rubber and leather combination.

The standard for insulating gloves, the ASTM D120 [2], requires a Class 00 glove for work on systems rated 500 V and below. This could be 0.5 mm with a leather over-protector of perhaps 0.7 mm and, the gloves generally become thicker with increasing voltage (increasing dielectric material to offer higher voltage withstand). However, the IEEE 1584a [3] guideline used to determine incident arc flash energies dictates that fault current and not system voltage is the dominant contributor to energy. This would imply that it is theoretically possible to receive greater arc flash energy from a 480 V system than a 4.8 kV system. From a shock perspective, however, the 480 V system glove is noticeably thinner than the 4.8 kV system glove. In other words, as the system voltage decreases, the thickness of the rubber and leather glove combination decreases, which may imply a decreased arc rating; however, a decreasing system voltage may theoretically result in higher arc flash energies.

Historically, the incident arc flash energy could be calculated but the arc rating of the glove was not stipulated on a rubber and leather combination. In certain cases, gloves were manufactured by arc rated fabric and thus assigned arc rating value. Such gloves offered arc protection but may have failed to offer shock protection or cut resistance. Another case in point would be cut-resistant gloves. Such gloves offer good finger dexterity and oil withstand, but may contain melting substrates. Some gloves may appear to be arc resistant, until exposed to an arc [4], in which case they could melt onto the user’s hands.

Legislation and the arc rating glove standard

The South African Occupational Health and Safety Act (OHSA) No 85 of 1993 as amended by the Occupational Health and Safety Amendment Act No. 181 of 1993 requires, in Section 8 (1) (b), that employers’ duties include in particular: ‘taking such steps as may be reasonably practicable to eliminate or mitigate any hazard or potential hazard to the safety or health of employees, before resorting to personal protective equipment’.

As required by NFPA 70E – 2012 [1] Section 130.2, live work is generally prohibited. This section aligns with the requirements of the OHSA in terms of eliminating the risk which in this case is shock or electrical arc flash or a combination of the two. However, Section 130.2 (A) (2) states that ‘energised work shall be permitted where the employer can demonstrate that the task to be performed is feasible in a de-energised level. Fault finding and live, dead, live testing are some tasks where de-energising is not feasible’.

The General Safety Regulations of 1986, a sub regulation of the OHSA, requires in Clause 3(a) that the employer, taking into account the nature of the hazard, in this case, electric shock and arc flash, provide the worker with gloves. Clause 5 states that: ‘an employer shall instruct his employees in the proper use, maintenance and limitations of the safety equipment’ and Clause 6 requires that: ‘an employer shall not require or permit any employee to work unless such an employee uses the required safety equipment’.

The US Occupational Safety and Health Standards (OSHA), 1910.138 (a) Subpart 1: addressing hand protection states; general requirements: ‘employers shall select and require employees to use appropriate hand protection when employees’ hands are exposed to hazards...severe cuts or lacerations; severe abrasions; punctures...thermal burns; and harmful temperature extremes’ and 1910.138(b) states; selection: ‘employers shall base the selection of the appropriate hand protection on an evaluation of the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards and potential hazards identified’.

Traditionally, legislation and standards stipulated the use of leather gloves with a minimum thickness or gloves manufactured from arc rated fabric. Arc rated fabrics are generally designed for minimal shrinkage, colour retention and comfort on skin; although these characteristics...
tics may not necessarily achieve the aims for cut resistance and grip, for example. Research and development in providing arc rated gloves which address arc flash in addition to other hazards did not progress to its potential owing to the absence of an arc rating standard for gloves. That changed in 2013 following the approval of an ASTM International standard ASTM F2675-13 (determining arc ratings of hand protective products developed and used for electrical arc flash protection [5]).

The standard has many benefits, with the most obvious being that the glove is tested as it would be used in the field. As discussed previously, gloves constructed from fabric tested on panels (using ASTM F1959 [6] or IEC 61482-1-1 [7]) are not the most comfortable and useable. The new standard allows for knit, leather and other gloves to be tested for arc flash protection. Rubber gloves are not required to be arc rated, but most manufacturers are opting to provide test data that can be critical owing to the ignition values of low voltage gloves in some colours. Specifying arc rated gloves will ensure that the desired protection is achieved by a single glove or a layered arrangement.

Requirements and limitations
ASTM F2675 [5] does not provide any validation or results for the shock protection performance of a glove. This does not prevent dielectric or insulating gloves from being tested and, in fact, a major benefit of the standard is the ability to arc test products historically designed for shock. Gloves constructed from fabric which complies with ASTM F1506 [8] do not necessarily have to be retested, however, to determine the performance as ‘used in the field’ testing may be beneficial. The test is aimed more at gloves that are not manufactured from flat panels or fabric which cannot be tested on a flat panel due to shrinkage.

Prior to arc testing, however, performance testing is required to ensure that the material does not melt or drip; the after flame is less than two seconds and the char length is less than 150 mm.

Only new size 10 gloves qualify as test specimens. Subsequent usage in the field and exposure to contaminants may reduce the arc rating of the glove. Used gloves may be tested for the purposes of field performance testing, research and development but not with the intention to offer an arc rating as the standard.

The arc generating rig setup is similar to that specified in ASTM F1959 [6] and IEC 61482-1-1 [7], however, the glove product holders and sensor arrangement (i.e. the arc measuring) setup is different.

The glove testing rig consists of a glove holder and two monitor sensors on either side of the glove holder. The incident energy is the average of the two monitor sensors. A single sensor located on the glove holder provides the measured energy through the glove. It is important that the glove rests snugly on the sensors and the test lab may use further means to ensure that satisfactory contact is made before testing.

Each glove holder and sensor is spaced 30° apart. Theoretically, this implies that six glove holders and six monitor sensors may be present, however, four test stands are recommended by the standard. A minimum of 20 data points is required by the standard. Analysis depends on the Stoll1 (refer to definition 3.1.15 of [5]) curve performance to determine a burn or no burn. A minimum of 15% of the valid data points should result in a burn while a minimum 15% of the valid data points should not result in a burn. A valid mix zone consisting of at least 50% of the data points should be within 20% of the final arc rating.

General
The biggest challenge facing industry in terms of hand protection is a glove which offers arc flash protection and shock protection. The standard has opened the way for advance in this area. Standards require that rubber gloves used for shock protection be worn with leather over-protectors. Leather, however, has some weaknesses such as it is not nearly as good at cut resistance as many other glove materials. Also, it has poor chemical resistance. Light chain hydrocarbons, such as hydraulic fluid and transformer oil or diesel fuel, pass through leather almost instantaneously and are easily held in leather allowing leather gloves to ignite and burn quite readily. This standard has opened the way to using insulating gloves according to ASTM D120 [2], however, composite over-protectors that may offer arc flash protection, cut and chemical resistance, grip and finger dexterity are on the cards.

Conclusion
ASTM F2675-13, Test Method for Determining Arc Ratings of Hand Protective Products Developed and Used for Electrical Arc Flash Protection, is a new ASTM International standard published in 2013. NFPA 70E-2012 [1] Standard for Electrical Safety in the Workplace required arc flash leather gloves to be made of a certain thickness. Now, the gloves could be made thinner and still meet minimum protection for the hazard. Some leather gloves and gloves manufactured from fabric tested on flat panels were inadequate for multi-threat hazards. Now, non-leather specialty gloves that grip when wet or oily can be engineered to make the gloves more task-specific and ergonomic. These gloves can now be arc rated, cut and chemical resistant and offer shock protection. Ergonomically designed gloves can be tested for operations where no hazard exists.
Looking ahead

An additional option that the ASTM F18 committee is currently working on is to allow OSHA-required (1910.137) protector gloves to be something other than leather. The 90-year-old technology of using rubber insulating gloves for shock and leather gloves for protection of the rubber could be a thing of the past through innovation spurred on by the cut standards, puncture standards and now the arc flash standards for gloves. Protecting workers from shock and arc flash hazards while using lighter and thinner gloves that offer better grip, may not be as far off as once believed. Numerous countries subscribe to the International Electrotechnical Commission (IEC) standards. The chairman of the ASTM F18 sub-committee responsible for ASTM F2675 [5] is also part of the IEC 78 Live Working sub-committee; this is the IEC committee that is working on the arc rating standard for hand protection. The latest feedback is that the last meeting held in Sao Paulo, Brazil, towards the end of January 2014, resulted in a draft scope, which will be forwarded to the committee members who will start formalising a standard.

References