ARC FLASH – A GUIDE TO STANDARDS AND REQUIREMENTS FOR PROTECTIVE CLOTHING

This document sets out to demystify the issues involved with the selection of PPE and clothing for protection against arc flash risks.

It assumes that you have already carried out all reasonably practical adjustments to your systems and work procedures to minimise such risks and that **you understand that PPE and clothing really are the "last line of defence!**

What is an arc flash:

An arc flash occurs when there is a short circuit through the air between conductors or conductors and ground, such a flash will result in numerous hazards including, amongst others:

- Extreme temperature (up to 12000 deg C at the core)
- Explosive forces (pressure wave)
- High noise levels
- Very bright light including Ultra Violet light
- Emission of plasma
- Toxic smoke and fumes
- Fast moving debris
- Hot liquids (in oil cooled or insulated equipment)

As a result injuries can include burns, blindness, lung damage, blunt trauma injury, hearing damage.

Products used to protect people have to be CE certified. For example, hearing and respiratory protective devices are CE certified to long established European Norms.

The norms for clothing which protects against arc flash are relatively new and often misunderstood or misquoted.

Here we set out to simplify these standards to help you understand which products you should choose to protect against the risks identified in your arc flash study.

Old standard:

ENV 50354
This standard tested fabrics and garments against an arc which was generated in a box made of plaster to simulate what would happen if an electrical arc of 4 kA or 7 kA happened within switch gear or other enclosed low voltage equipment. This test standard did not include the recording of heat transfer measurements through the tested protective clothing material and did not include the analysis of the differential between the measured heat transfer data and the Stoll curve, which is now an essential part of the new standards. Stoll curve analysis is utilised to predict the likelihood of second degree burns (for more details please see appendix).
However already in the past, testing had sometimes not only been carried out according to ENV 50354, but also according to an additional heat transfer measurement test protocol similar, but nevertheless different to the testing procedure which is now part of the new standards.

New standards :

IEC 61482-1 and the identical EN 61482-1 are split into two parts, which cover the methods for testing of clothing fabrics and garments that are designed to protect against arc flashes.

IEC 61482-1-2 and the identical **EN 61482-1-2**, which now supersedes ENV 50354, have become known as the "box test".
There exist two test method versions: The "material box test", which includes heat transfer measurements and Stoll curve differential analysis, and the "garment box test", which requires only a visual assessment of the garment performance.

The box-test standard defines two testing conditions, namely Class 1 and Class 2:

- Class 1 tests at an arc current of 4 kA and arc duration of 500 ms.
- Class 2 tests at an arc current of 7 kA and arc duration of 500 ms.

Note: The current of an actual electrical arc event is usually lower than the fault current of the equipment.

The box test gives a pass or fail result with respect to the selected specific box test conditions and assessment criteria and does not give the value of the incident energy (e.g. usually expressed calories per centimetre squared (cal/cm2)) against which the fabric and therefore the garment shall have to offer protection. Nevertheless, the standard EN 61482-1-2 (or the identical IEC 61482-1-2) enables garments to be CE certified with respect to their box test class performance.
This box test method is intended to be referred to for Low Voltage Systems only. For instance to replicate potential hazards in service entrance boxes, cable distribution, cabinets, distribution substations or comparable installations, where arc is directed to the front of a worker at the height of the breastbone.
However, it is left up to the user to assess for himself, whether the actual potential arc exposure situation in front of his low voltage equipment can be considered to be sufficiently simulated by an electrical arc of either 4 kA (Class 1) or 7 kA (Class) and duration 500 ms generated between an aluminium and copper electrode inside a plaster box of specific dimensions, with the distance between the electrodes being 3 cm and the distance of 30 cm between the electric arc and the person in front of it.
There exist no published tools or guidelines for making the link between the results of the box test and the actual live-working situations in front of actual low voltage systems.
Most commonly users simply assume that as long as their fault currents are below 4 / 7 kA, clearance time settings less than 500ms and distances towards the arc greater than 30cm, the worker will be well protected by a Class 1 / 2 rated clothing. Actual risk analysis studies have shown that this simple assumption is NOT always true.

You should note at this point that the risk analysis and arc flash studies will usually result in incident energy values at various working distances in front of an eventual arc flash for each piece of equipment on site and each live working activity. These incident energy values are usually given in units of **cal/cm^2**.
It is therefore important to choose protective clothing that will provide (as a minimum) a level of protection against incident energy which exceeds the incident energy value provided by your arc flash study.

IEC 61482-1-1 and the identical **EN 61482-1-1** are the test method standards by which the garment manufacturer can assess the protective performance of a fabric according to Test Method A. Garments made of arc rated fabrics are then tested according to Test Method B. The protection property of a fabric or garment against the thermal effects of an electric arc event is defined as its **Arc Thermal Protection Value**, usually expressed in cal/cm^2. It is more commonly known as the **ATPV**.
The ATPV is determined by exposing a statistically significant number of test specimens to varying, directly measured incident energy levels caused by electrical arcs; the levels of exposure are being selected during testing as appropriate for obtaining the heat transfer measurements needed for a full Stoll curve differential analysis.
The standard EN 61492-1-1 (or IEC 61482-1-1) enables garments to be CE certified to an ATPV level. There is no pass / fail with respect to a simulated equipment arrangement as in the box test, and the statistical meaningfulness and reliability of the ATPV results with respect to second degree burn predictions is higher than for the box test.

The most commonly used tool and guideline for calculating incident energy levels at various working distances in front of an eventual arc flash for each piece of equipment on site and each live working activity and the most commonly used guideline for selecting appropriate clothing are IEEE 1684 and NFPA 70E.

It can be seen from the above that only the result of IEC 61482-1-1 (EN 61482-1-1) enables the user to choose with confidence a product that offers protection against incident energies, which would cause second degree burns, i.e. to choose a product that has a quantified ATPV, which must be at least as high and preferably higher than the level derived from an actual risk analysis and calculated in the arc flash study.

In other words the minimum requirement shows that

Garment ATPV must be > Arc flash energy level as calculated

Ideally the garments chosen would be CE certified to both IEC 61482-1-1 (EN 61482-1-1) and IEC 61482-1-2 (EN 61482-1-2).

In the absence of a garment being available to both of the above, it could be considered best practice to choose a garment that is CE certified to IEC 61428-1-1 as this is the only means by which it can be shown to be tested (both as fabric and a complete garment) in order to carry an ATPV.

Please also note the IEC standard containing all the requirements for protective clothing against the thermal hazards of an electrical arc:

IEC 61482-2 - Performance Requirements for Garments
Clothing offering protection against the thermal effects of an electrical arc event shall be CE marked to the IEC 61482-2. This standard contains performance requirements for protective clothing in addition to being tested according to either IEC 61482-1-1 or IEC 61482-1-2 or both.
The standard requires the following:

- A garment must have at least an ATPV = 4 cal/cm2 (167.5 kJ/m²) according to IEC 61482-1-1 or Class 1 when tested according to IEC 61482-1-2;
- Garments must be sewn with inherently Flame Resistant threads;
- When garments have a higher rating of arc protection on the front than the back, the torso, sleeves and legs must be in the same arc rated material; the back can have a lower arc rating;
- Garments must have no exposed external metal (any internal metal or melting parts are to be covered inside to avoid contact with the skin);
- The garment label has to show the lowest ATPV or Class if different panels on the garment are used; more detailed information about areas of the garment with higher protection may be given as well on the label or in the manufacturer's instructions of use.
- The protective clothing material must have some minimum tensile, tear and/or burst resistance and minimum dimensional stability to cleaning

and last but not least:

- The protective clothing material must have life-long flame resistance

Please also note:

It is the opinion of UK technical committee PEL/78, as published in the BS National Foreword of BS EN 61482-1-2 (i.e. the UK version of EN 61482-1-2, with BS EN 61482-1-2 otherwise being identical to EN 61482-1-2 (IEC 61482-1-2)) , that the
"*box test does not provide the user with a realistic and reliable test. A premise of this test is that the fault currents will not exceed 4000 A or 7000 A and the worker will not be closer than the specified distance from the arc (in reality this cannot be guaranteed).*

The energy on the worker's body is directly proportional to the length of the arc, the current and the duration of the arc. For example, if a worker positioned at 60cm from the arc is exposed to 4 cal/cm2, at 30cm from the arc the energy will be approximately16 cal/cm2. Experience in the field has shown that hazards can range in strength starting from 3 or 4 cal/cm2 to levels higher than 40 cal/cm2."
One shall add that other severely restricting premises of the box test are that the clearance time will not exceed 500 ms and that the environment / eventual enclosure around the electric arc event be best simulated by the plaster box.

The BS National Forward of BS EN 61482-1-2 further states:
"UK technical committee PEL/78 believes that IEC 61482-1-1 provides the best way to determine whether a particular material will provide the best protection for the worker for any given job."

FOR FURTHER INFORMATION PLEASE VISIT:

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