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PROTECTING LIVES

WHAT IS AN ARC FLASH?

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Experts in Safety

WHAT IS ARC FLASH?

Faulty equipment, corrosion, accidental cable strikes, a dropped tool causing a short circuit... Wherever there's live electricity, there's a risk of an arc flash incident.

An arc flash is an electric arc (or arc discharge) which happens when an electrical current runs through something which isn't normally conductive – such as the air.

When this happens, it results in an electrical breakdown of gas and produces an ongoing discharge of plasma with a high-pressure blast and extremely high levels of radiant heat which can cause first, second, or third-degree burns with devastating consequences.

Any live electrical environment presents an arc flash risk, but the risk in some situations is less obvious than others. For example, construction workers accidentally striking an underground cable could cause a flash strong enough to kill, or cause life changing injuries, to anyone close by.

Why does an arc flash occur?

- Tools or equipment accidentally touch live conductors, or are dropped
- Faults or mistakes in isolating equipment
- Equipment failure due to faulty parts, improper installation, or normal wear and tear
- Dust, corrosion, or other impurities on conductor surfaces

An extremely fast, deafening and intense explosion

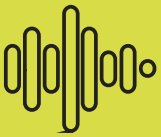
Reaching over

19,000°C

Hotter than the surface of the sun - within seconds

57%

57% of workers had witnessed or been involved in an arc flash first-hand



Superheated shrapnel explodes with a supersonic concussive force

Intense high energy radiation capable of vaporising nearby materials

Appropriate PPE is a critical last line of defence

ARC FLASH INCIDENT REPORTING

According to HSE Data, it's likely that 60-70% of arc flash incidents go under-reported. This could be through miscategorising them among the more general 1,000 electrical incidents reported a year – around 25 of which are fatalities.

Of the 400 reports of arc flash specific incidents a year, these result in an average of:

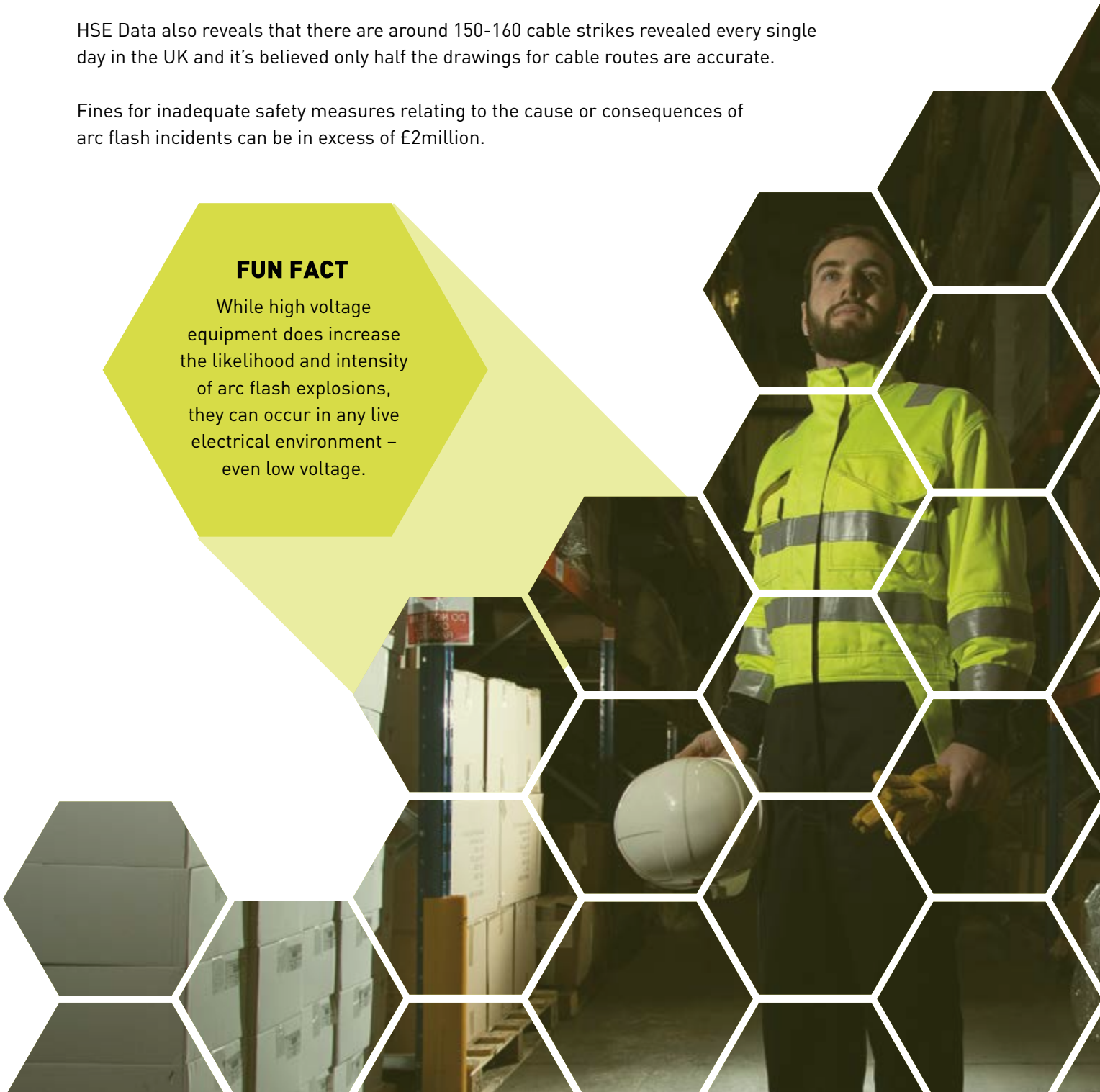
- 230 7-day injuries
- 36 burn injuries
- 2 workplace fatalities

HSE Data also reveals that there are around 150-160 cable strikes revealed every single day in the UK and it's believed only half the drawings for cable routes are accurate.

Fines for inadequate safety measures relating to the cause or consequences of arc flash incidents can be in excess of £2million.

FUN FACT

While high voltage equipment does increase the likelihood and intensity of arc flash explosions, they can occur in any live electrical environment – even low voltage.



RISKS AND CONSEQUENCES OF ARC FLASH EVENTS

Many instances of arc flash are reported as electrical RIDDOR incidents making it impossible to know exactly how many arc flash incidents occur each year in the UK. Research suggests they're likely to be far more common than most people realise.

Despite 57% people admitting they, or someone they work with, has suffered from an arc flash strike, a staggering 78% of respondents were still unaware of the correct Government safety standard HSG47 (Avoiding danger from underground services) which covers working when arc flash is a risk.

The consequences of an arc flash incident can be devastating for those involved as the injuries sustained can be life changing or life ending. But, as well as the legal and moral duties to safeguard employees, there's also a financial case and directors could face severe fines and even criminal prosecution charges if an HSE investigation finds failings.

In April 2018, the HSE recorded two cable strike incidents including one which caused major burns resulting in a fine of £600,000 plus costs and another which caused serious burns to the worker's hands, arms and face which resulted in a fine of £80,000 plus costs.

SECTORS WHERE ARC FLASH IS A RISK

PROGARM ARC FLASH AND FLAME-RESISTANT CLOTHING PROTECTS LIVES IN...

RAIL MAINTENANCE
As well as teams working specifically on the electrification side of rail, trackside maintenance workers are also exposed to risks of both underground and overhead cabling. Rail maintenance teams require orange arc rated high vis PPE.

UTILITIES
Breaking ground near to or to access underground services, live cable jointing, racking in and out of switchgear... employees, contractors and sub-contractors put themselves at risk every day to keep our gas, power and water flowing. Teams require appropriate indoor and weather appropriate outdoor garments to stay safe in all environments and conditions.

INDUSTRIAL ELECTRICAL
Large organisations needing continuous and high levels of power (such as food processing plants, hospitals, pharmaceutical companies, car manufacturers) will need maintenance teams to work in live, sometimes confined, environments to keep operations ticking. Workers need clothing and base layers that are appropriately arc rated to stay safe and comfortable.

TELECOMS
Installation and maintenance teams working on new and existing connections including broadband, fibre and 5G will need electrical teams to work anywhere from at height on a mast to inside a customer's living room to keep homes and businesses connected.

SUSTAINABLE TECHNOLOGIES:
Demand is increasingly emerging from sustainable technology providers (such as wind and solar farms, and teams installing electric vehicle charging points) to protect workers who are meeting our growing demand for green.

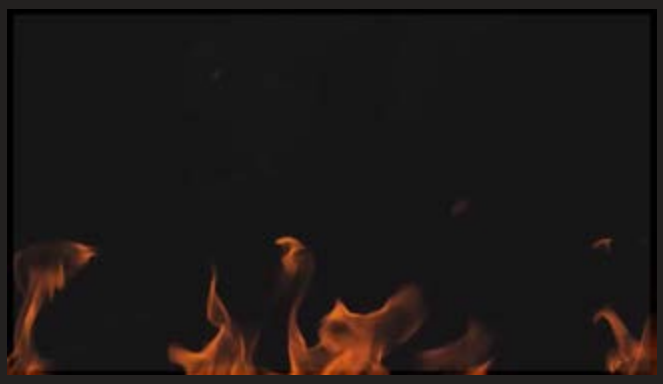
PPE – THE VITAL LAST LINE OF DEFENCE
After accidentally striking a low voltage underground cable with a pneumatic drill, a construction worker sustained serious arc flash injuries. His arc flash polo shirt took the worst of the impact however, ultimately saving his life.

SAFETY TESTING

When advising customers of the best products to protect them against the arc flash risks identified in their risk assessments, it's important to look at the test results of each garment first.

OPEN ARC TEST METHOD

The Open Arc method determines the maximum thermal energy a garment can withstand before the wearer is subject to second degree burns.



The measurement is converted into calories per square centimetre (cal/cm2), allowing procurement teams to choose the appropriate safety garments for their teams in line with risk assessments.

The Open Arc testing method is a proven way of determining how our garments will protect the wearer from the risks of an arc flash incident.

ProGARM®
Protect the BEST

BOX TEST METHOD

There are two versions of the Box Test method. The 'material box test' indicates how much radiant heat will cause second degree burns to the wearer while the 'garment box test' is a visual assessment only.

Garments tested using the Box Test method are tested against an arc duration of 500ms and are tested to either Class 1 (an arc current of 4kA) or Class 2 (an arc current of 7kA).

TESTING FOR QUALITY ASSURANCE

All arc flash safety wear products should be tested to the new IEC 61482-2 standards using Open Arc and Box Test methods. This safety standard was updated in 2019 and resulted in a new acronym of ELIM joining APTV and EBT to indicate different risk threshold levels.

DEMYSTIFYING THE JARGON

CAL/CM2 – CALORIES PER SQUARE CENTIMETRE
One calorie represents the amount of heat energy needed to increase one gram of water by one degree Celsius at one standard atmosphere. Without protection, second degree burns can happen when a square centimetre is exposed to 1.2 calories per second.

CAL RATING
It's industry standard for arc flash PPE garments to have a Calorie Rating, more commonly referred to as a Cal Rating. This shows the maximum calories a product can withstand – in other words how much heat energy that could be delivered to a square centimetre of the garment per second at a given distance from an arc flash incident before it's deemed to provide insufficient protection.

THAT'S WHERE A NUMBER OF OTHER VALUES COME IN:

APTV - ARC THERMAL PROTECTIVE VALUE
An Arc Thermal Protective Value on a garment indicates the maximum incident energy level safety clothing can be exposed to (per centimetre squared per second) before there's a 50% probability the wearer will sustain second degree burns.

EBT – ENERGY BREAKOPEN THRESHOLD
EBT indicates the maximum incident energy (per centimetre squared per second) a material can withstand before there's a 50% probability that at least 1.6cm2 of it will break open.

ELIM – ENERGY LIMIT VALUE
The Energy Limit Value is a relatively new measure introduced in the IEC 61482-2 standards in 2019. This value shows the maximum incident energy level the garment can be exposed to with 0% probability of the wearer sustaining second degree burns.

FACTORS THAT AFFECT WHAT LEVEL OF ARC PROTECTION YOU NEED:

There are many factors which will affect the level of protection your customers need. This includes:

- The nature of the workplace – the severity of an arc flash increases the more confined the space.
- How far away the worker is able to be from the equipment presenting the arc flash risk. The further away they can be in the event of an incident, the lower the incident energy will be by the time it hits them.
- The nature of the system the person will be working on can influence the potential scale of an arc flash and helps determine the Cal Rating needed.

HOW TO DETERMINE WHAT LEVEL OF ARC FLASH PROTECTION YOUR CUSTOMERS NEED:

- Your customers will need to consult their own risk assessment and method statement documents to understand arc flash risks and determine the nature of the garments needed.
- They will need to understand the worker's environment and if there's a requirement for layers. Cal rating protection can be made up using a number of layers, remembering that all layers (including underwear) must be arc rated to provide protection to the wearer.
- Any workers responsible for breaking ground should always receive arc flash protection.
- Your customers will need to consider that items which are arc rated provide fire resistance by default. But items which are sold as flame resistant do not provide arc flash protection.

ADVISING ON FABRIC

Some companies tie themselves to a particular brand of fabric blend, or only test the fabric rather than testing and certifying the finished garment as a whole. It's important to choose a supplier that focuses on the performance, quality, durability and comfort of each product and sources exactly the right fibres and components that will provide safety in the event of an arc flash.

SHRINKAGE AND COLOURFASTNESS

Check laundry guidelines (which may include information for using domestic washing machines, dry cleaners and laundry service providers), and look for guarantees that garments can withstand the number of washes your customer requires with minimal shrinkage and colourfastness.

UNDERSTANDING THE DIFFERENCE BETWEEN NHERENT AND TREATED FABRICS FOR FLAMERESISTANCE

Products can be made using fabrics which are inherently flame-resistant or fabrics that have been chemically treated to provide fire retardance.

With inherent fabrics, a garment's ability to protect wearers from heat and flames comes directly from the nature of the polymer fibres it's made from.

Inherent fire-resistant fabrics won't ignite (at normal oxygen levels), but may char as a protective mechanism. They also don't shrink when exposed to heat – this helps maintain the protection afforded by air layers between fabrics and makes it easier to remove garments after an incident to deliver swift first aid.

Because the protection is provided by the fibres, flame resistance can't be affected by washing.

Treated fibres and fabrics still have a time and a place and the flame resistance offered by these garments comes about through chemistry.

Fabrics with a flammable base fibre can still be made into effective safety garments by spraying them with fire-retardant chemicals.

It's important to check the supplier's safety test data for how many times a treated garment can be washed before it starts to lose its fire resistance. It's also important to let the customer know that this means they will need to keep accurate laundry records to keep track of how many times a garment has been washed and when it will need to be replaced.

UNDERSTANDING THE DIFFERENCE BETWEEN FR AND ARC FLASH

FR can stand for flame or fire resistance or flame or fire retardance. Different suppliers may use different terms, but they all mean the same thing and can also be used interchangeably.

While there's no difference between the words behind the abbreviation, there are different levels and types of FR protection required for different fire risks including:

- Flash fire
- Foundry
- Firefighters (structural, wildland and rescue)
- Police and military
- Formula 1

For any tasks which have a risk assessment identifying arc flash incidents as a possibility, only arc rated garments should be used.

By default, arc rated clothing will also provide FR protection. But FR clothing is not sufficient to protect against the 19,000oC high-pressure explosion of an arc flash incident.

ADVISING ON LAYERS

BENEFITS OF LAYERING

- Allows workers to move between different work areas with the flexibility to scale up or downgrade their protection levels to suit the task in hand.
- Wearing a 7 Cal polo shirt combined with a 14 Cal sweatshirt has been shown in some cases to provide a 31 Cal overall protection thanks to the additional air layer between the garments.
- Allows workers to add warmth or to cool down while still working safely.

CONSIDERATIONS OF LAYERING

- It's vital that all layers are the appropriate level of PPE as wearing under layers made of other kinds of non-melting fabric (such as cotton, silk, wool or leather) will offer no protection from ignition and could cause serious burns in a fire or arc flash incident.
- There are no shortcuts to working out how negligible or substantial different layering makes. It can only be calculated by rigorously testing the specific combination.

MYTH BUSTING:

"I'M WEARING AN ARC RATED COVERALL, SO I'M SAFE"

While it's fantastic that an employer has considered the risk and provided appropriate arc rated and flame-resistant PPE, safety at work is everybody's responsibility – including the wearer.

Ordinary clothes (such as personal t-shirts, trousers, socks and underwear) are often made using synthetic fibres, such as polyester, which would melt and burn within fractions of a second in an arc flash blast.

While an outer arc flash garment will provide a substantial and potentially life-saving degree of protection, this could be severely compromised by wearing 'normal clothes' as base layers.

To survive the intensity of an arc flash, it's essential that all base layer clothing – including underwear – is also safety approved and appropriately flame-resistant.

Lab tests have also proven that layering with appropriate protective garments is substantially more effective at reducing burns.

GLOSSARY

ARC FLASH	An explosive release of energy caused by an electrical arc from either a phase to ground or a phase to phase fault. This could be caused by accidental contact with electrical systems, build-up of conductive dust, corrosion, dropped tools, improper work procedures or a number of other reasons. During an Arc flash, the temperature can reach 19,400oC in seconds and the resulting supersonic concussive blast and exposure to the flash event can result in serious burn injury, severe shrapnel injuries and death.
ARC RATING	An Arc Rating represents the value of the energy necessary to pass through any given fabric to cause with 50% probability a second or third degree burn. This value is measured in calories/cm^2. The necessary Arc Rating for an article of clothing is determined by an Arc/Risk Assessment and the resulting Arc value. This is usually measured in terms of Arc Thermal Performance Value (ATPV) or Energy Break-open Threshold (EBT).
ARC RISK CATEGORY	There are five Arc Risk Categories which are specified in the lookup tables given in the NFPA 70E guidelines. The chart, based on specific job tasks, ranges from HRC 1 (which is low risk and allows for 100% treated cotton), up to HRC 4 (which is high risk and requires flame-resistant clothing with a minimum arc rating of 40). The HRC is used to determine the necessary arc rating of a garment worn during a given job task.
CALORIE	A calorie is the energy required to raise one gram of water one degree Celsius at one atmosphere pressure. Second-degree burns occur at 1.2 calories per centimetre squared (cal/cm2) per second.
CE MARK	The CE Mark indicates a product conforms with health, safety, and environmental protection standards within the European Economic Area. The CE marking can also be found on products sold outside the EEA that have been manufactured to EEA standards.
FLASH HAZARD ANALYSIS	A study investigating the potential exposure to Arc flash energy that a worker faces while performing a specific job task. The data collected in a Flash Hazard Analysis aims to determine safe work practices and the required level of flame-resistant clothing and PPE to prevent injury.
FLASH PROTECTION BOUNDARY	The distance from an exposed live part within which a person could receive a second-degree burn if an electrical Arc were to occur.
FLAME RESISTANT	Flame Resistant refers to the ability of a material to self-extinguish when the source of ignition is removed. Treated fabrics are made from ordinary materials and given a flame resistant coating during production.
NFPA 70E	A work standard published by the National Fire Protection Association (NFPA) that covers aspects of electrical safety in the workplace. It includes the recommendation that those who work with, on, or around, energised equipment use adequate protection, including flame-resistant clothing.
UKCA MARK	The UKCA Mark (UK Conformity Assessed) is the UK equivalent standard to the CE Mark which came into force on 1 January 2021 after the European exit transition period ended on 1 January 2021.

RESOURCES

HSE GUIDE
Electricity at work: Safe working practices

PROGARM PRODUCTS
Online catalogue of products

IEEE & NFPA RESEARCH
Arc Flash Phenomena: Collaborative Research Project

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