An Introduction to Arc Fault Detection Devices (AFDDs) to BS EN 62606

And the current requirements of BS 7671 (18th Edition)

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AGENDA

- Introduction
- History of AFDDs
- Types of Faults
- Standards & Testing
- Positive Points
- Limitations
- Practical Implications & Future Use
- Summary

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INTRODUCTION

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INTRODUCTION – WHY NOW?

- IEC / HD 60364 and BS 7671

- Something that may have worked elsewhere (primarily the US) and produced results
- But does that mean the same is true in the UK?

- We will investigate the product standard and the testing procedures
- BS 7671 and its current requirements
- Explore reasons for using such devices

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WHAT ARE AFDDs

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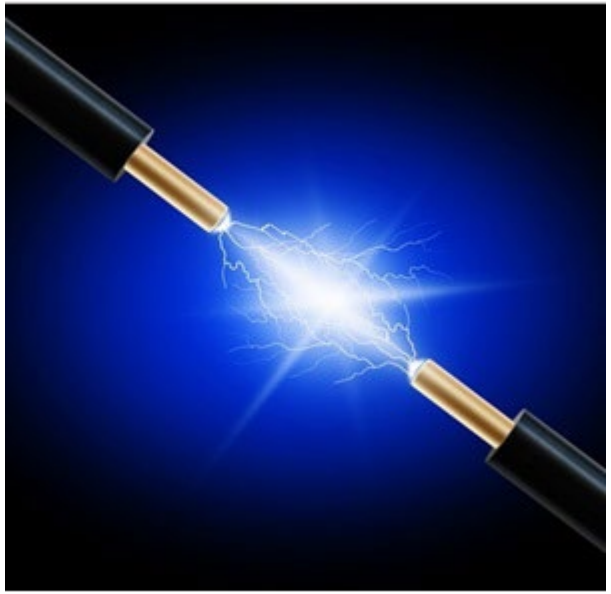
WHAT ARE AFDDs

– What is an arc?

“A luminous discharge of electricity across an insulating medium, usually accompanied by the partial volatilisation of the electrodes.”

International Electrotechnical Commission (442-05-65)



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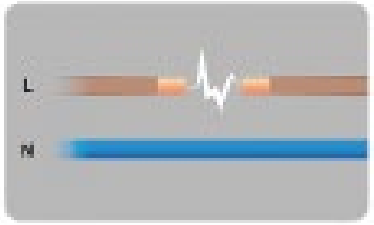
WHAT ARE AFDDs

– Types of arc faults:

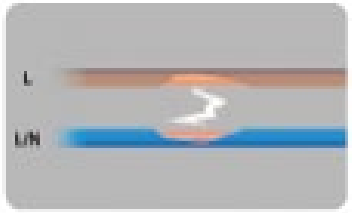
Serial



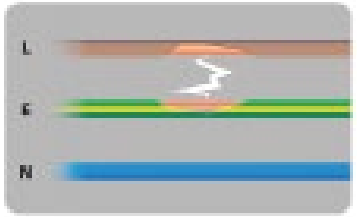
AFDDs

Damaged (crushed/broken) cables
Loose connections

Parallel



MCBs or AFDDs



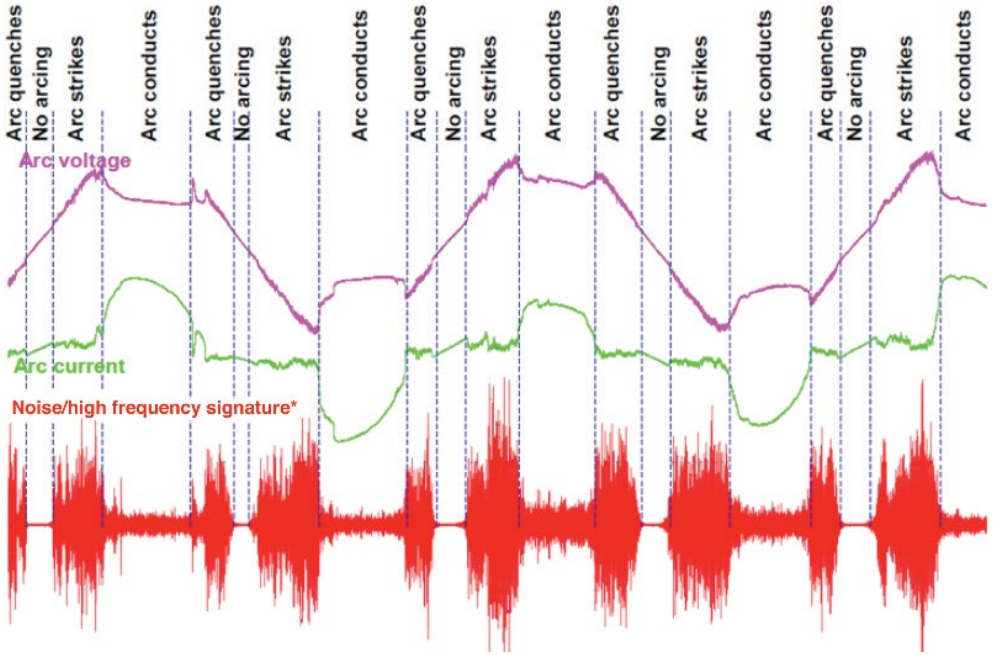
RCDs or AFDDs

Damaged insulation
Pierced Insulation
Rodent Damage
Deteriorating Insulation

BEAMA Guide to Arc Fault Detection Devices (2018)

WHAT ARE AFDDs

- Arc Fault detection devices are effectively monitoring devices
- They monitor the supply and check for harmful/ dangerous arc signatures
- Specific patterns of energy dissipation



BEAMA Guide to Arc Fault Detection Devices (2018)

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WHAT ARE AFDDs

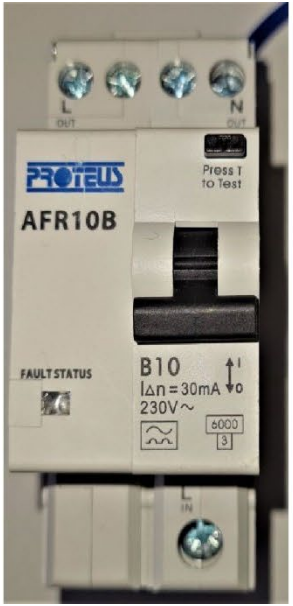
- Arcing is a normal occurrence of electrical installations.
- EG. Brushed motors, switching devices all create arc signatures

- Algorithms used by manufacturers are designed to ignore “normal” arcing to prevent nuisance tripping

- Not totally proven – and there was an acknowledgement of switching being an issue in academic works (Martel J 2013)

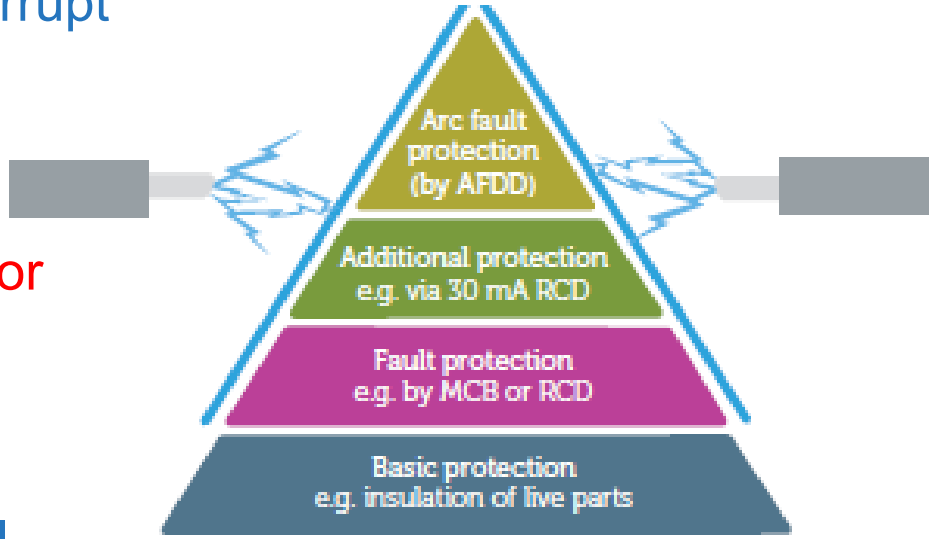
WHAT ARE AFDDs

– Different types and configurations available.



WHAT ARE AFDDs

- The AFDD monitor needs to be paired with a device that can interrupt the circuit in the event of a fault
- This switching element has been achieved by using existing technology, in the form of MCBs or RCBOs
- The combination of AFDDs and RCBOs can be described as enhanced protection for electrical installations



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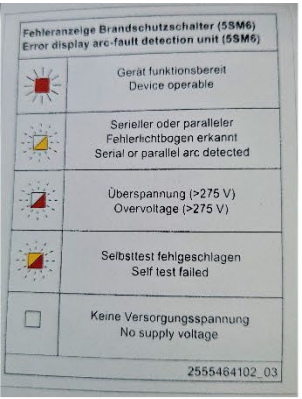
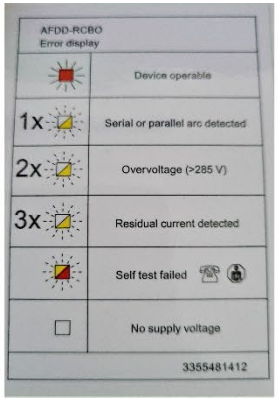
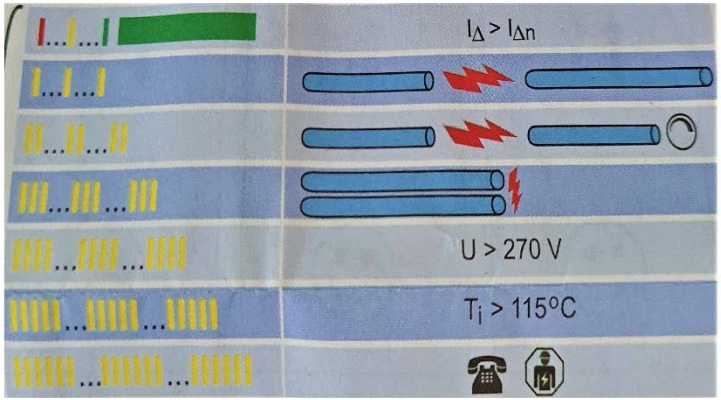
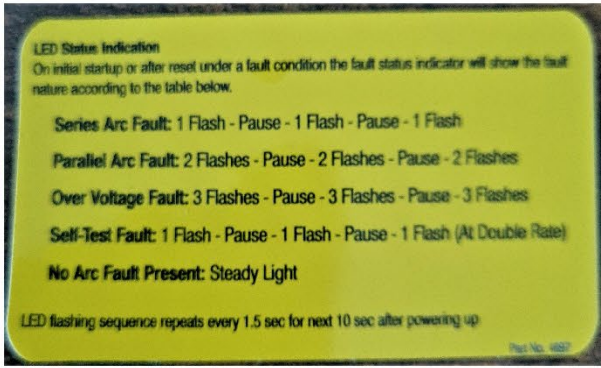
WHAT ARE AFDDs

- Standardisation?
- Different coloured LED status indicators
- Different fault sequences









HISTORY OF AFDDs

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HISTORY OF AFDDs

- Based on AFCIs – been around since 1990s in North America – to be used in bedrooms of residential premises
- Combination AFCI/GFCI mandated in new and existing residential premises from 2011 (NEC Code)
- The standard for these devices is UL1699 which is part of ANSI – the pre-cursor to our IEC 62606 for AFDDs

HISTORY OF AFDDs

- So, are we in the UK just playing catch up then?
- **NOT Necessarily**:
- America has a different electrical system
- Typically, the arc signatures are larger due to higher load currents, thus easier to detect
- The building medium within the US is of a combustible type - i.e., Wooden buildings, thus the effects of fire are more acute
- Resultantly the introduction of AFCIs and Combination AFCI/GFCIs led to improved fire stats in US
- Differences in flora and fauna
- Bending radii of flexible conductors on plugs

TYPES OF FAULTS

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TYPES OF FAULTS

– **RECAP**:

– **Parallel arcs** between live conductors or live conductors and earth
– High energy release, usually detected by MCBs, RCBOs, RCDs - current technology available

– **Serial arcs** on the same conductor –
– Low energy release, currently undetectable without using AFDDs

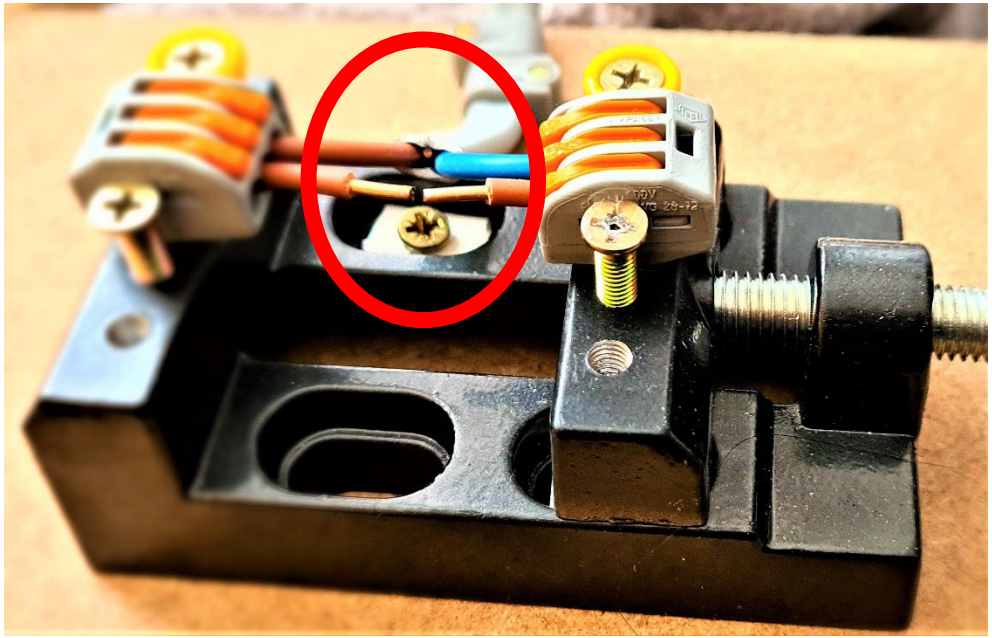
TYPES OF FAULTS

– There are two main ways of producing a serial arc

1. Voltage breakdown:

– A damaged or severed conductor where the two ends are in close proximity to each other (< 6 microns)

– Arc travels from one end to another, and “transfers” across an air-gap



TYPES OF FAULTS

2. Creepage on char:

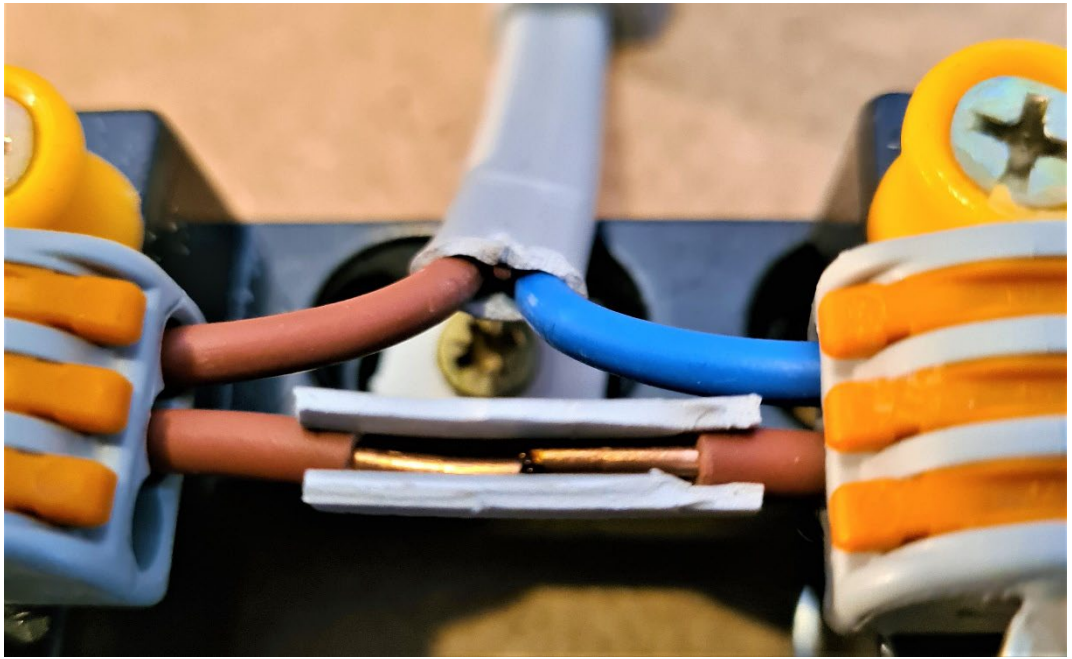
– This requires a sample to be prepared

– The sample is compromised and then charred (to lay down a carbon bed)

– Once done, the arc is then expected to track across the carbon bed

TYPES OF FAULTS

- In REALITY, both need the presence of carbon
- This is specific to the type of cable insulation
- **PVC** readily becomes carbonized / chars
- XLPE (and other insulating materials do not char)



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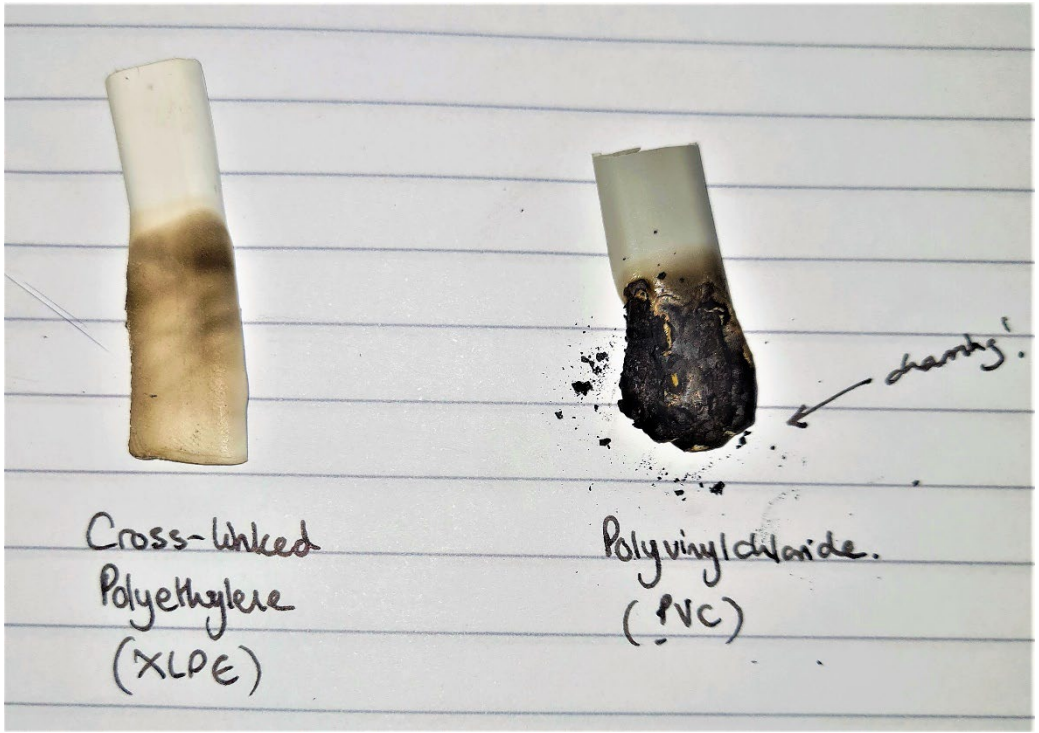
TYPES OF FAULTS

- XLPE: the cross-linking inhibits molecular movement especially when the sample is heated, providing increased stability.
- No charring on the XLPE sample.
- PVC sample starts to disintegrate due to the carbonization, partial combustion.



STANDARDS & TESTING

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STANDARDS & TESTING

– Product Standard – BS EN / IEC 62606 based on the US version for AFCIs (UL1699)

– Serial Arc Testing is all based on presence of carbon – therefore need aged conductors/cabling to be effective

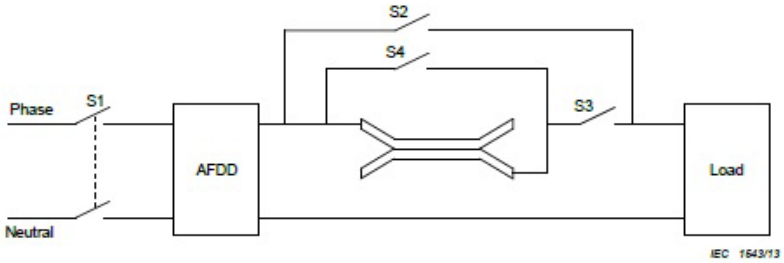

Figure 4 – Test circuit for series arc fault tests

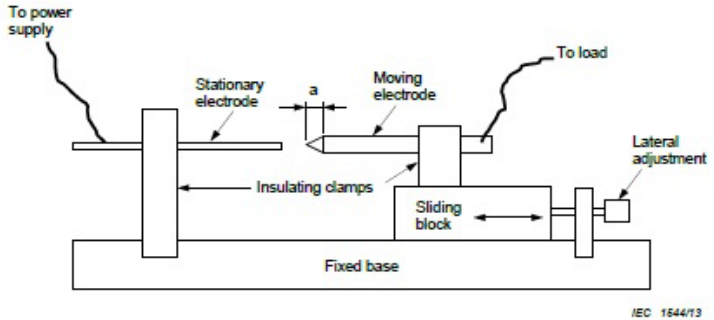

Figure 5 – Arc generator

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STANDARDS & TESTING

- BS 7671:2018+A1(2020), Requirements for Electrical Installations, IET Wiring Regulations 18th Edition
- **421.1.7**

421.1.7 Arc fault detection devices conforming to BS EN 62606 are recommended as a means of providing additional protection against fire caused by arc faults in AC final circuits.

If used, an AFDD shall be placed at the origin of the circuit to be protected.

NOTE: Examples of where such devices can be used include:

- premises with sleeping accommodation
- locations with a risk of fire due to the nature of processed or stored materials, i.e. BE2 locations (e.g. barns woodworking shops, stores of combustible materials)
- locations with combustible constructional materials, i.e. CA2 locations (e.g. wooden buildings)
- fire propagating structures, i.e. CB2 locations
- locations with endangering of irreplaceable goods.

STANDARDS & TESTING

– **532.6**

532.6 Arc fault detection devices (AFDDs)

Where specified, arc fault detection devices shall be installed:

(i) at the origin of the final circuits to be protected, and

(ii) in AC single-phase circuits not exceeding 230 V.

AFDDs shall comply with BS EN 62606. Coordination of AFDDs with overcurrent protective devices, if necessary, shall take account of the manufacturer's instructions.

– Specified by whom?

– Ideally: Competent Fire Officers, Fire Engineers etc.

– Needs to be somebody who can accurately analyse and evaluate a suitable fire risk assessment

STANDARDS & TESTING

– **643.10**

643.10 Functional testing

Equipment shall be subjected to functional testing, as appropriate, to verify that it is properly mounted, adjusted and installed and operates correctly in accordance with the relevant requirements of this Standard. Examples of such equipment are:

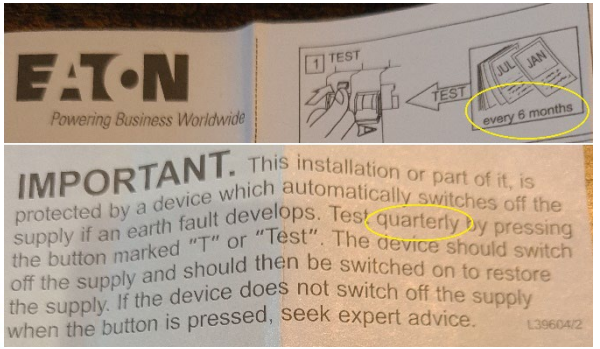
- switchgear and controlgear assemblies, drives, controls and interlocks
- systems for emergency switching off and emergency stopping
- insulation monitoring.

NOTE 1: This list is not exhaustive.

Protective devices shall be submitted to a test of their function, as necessary, to check that they are properly installed and adjusted. Where fault protection and/or additional protection is provided by an RCD, the effectiveness of any test facility incorporated in the device shall be verified.

Where an AFDD is installed the effectiveness of any manually operated test facility shall be verified in accordance with the manufacturers' recommendations.

NOTE 2: This functional test does not replace the functional test indicated by the relevant standards.



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POSITIVE POINTS

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POSITIVE POINTS

- Most AFDDs work within certain parameters
- If used correctly they can be beneficial in some instances – aged cables
- Therefore could prevent fires and thus save lives (people and property – BS7671)
- Can a cost be put on saving lives?
- Enhanced electrical protection
- Parallel arcing fault detection improved as the AFDD may operate in preference to the MCB/RCBO element

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LIMITATIONS

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LIMITATIONS

- The scope of AFDDs needs to be finessed
- They are not the silver bullet to prevent all fires within the built environment
- The USP is serial arcing, which is reliant on the presence of carbon – i.e., old/aged cabling - *but CBA of using AFDDs versus a Re-wire?*
- The carbonisation is prevalent only on PVC cabling
- Need sufficient load current above 2.5 A (Martel J 2013)

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LIMITATIONS

- Not all AFDDs are the same: algorithms | coloured indicators | size of the device per circuit
- Non-updatable
- Parasitic load – Net zero carbon?
- Cost prohibitive
- May cause nuisance tripping on “conventional arcing” from brushed motors or switching devices
- Increased maintenance – require manual operation of the test facility periodically

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PRACTICAL IMPLICATIONS & FUTURE USE

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PRACTICAL IMPLICATIONS & FUTURE USE

- The devices can need 1 – 4 ways dependant on manufacturer (and application)
- This means an increase in the size of other equipment (enclosures etc.)
- Not to mention more space in the electrical switch room / riser cupboard(s)
- Retrofit modifications to the equipment, (e.g. busbar) – manufacturer approved?
- Only the interruption in relation to product standards is the same, this may not be reproducible with real world situations

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SUMMARY

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SUMMARY

- AFDDs are a recommendation only
- AFDDs have been around for a number of years in different forms
- An electrical arc is very specific type of fault – serial and parallel
- AFDDs come all shapes and sizes
- No standardisation – LED fault indicators / interval for functional test
- A significant need for carbonisation/charring for AFDDs to detect fault signatures
- XLPE and other Fire-proof type cable insulations do not carbonise
- Non-updatable and cost prohibitive
- May be beneficial on older installations however...
- This leads to a conscious acceptance of a safety risk within an installation that is being MONITORED

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QUESTIONS?

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