Arc Fault Detection Devices

The capabilities of AFDD's along with the what, why and where, and the benefits of installing them

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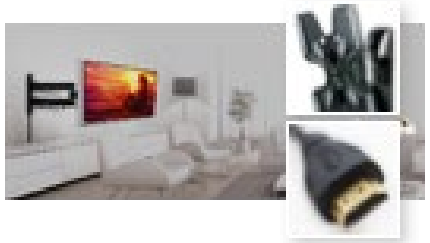

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Luceco Academy

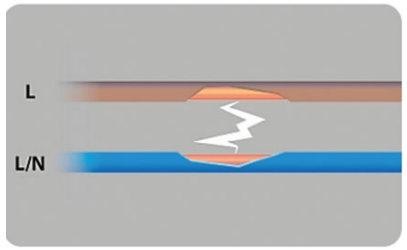
My background

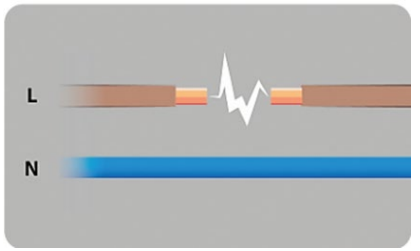
- Electrical industry for many years
- Installing within residential, commercial, agricultural and industrial environments
- Marketing & Product management covering Motor Control Gear and Automated Systems
- Marketing & Product management covering Electrical Distribution Systems
- Designing and testing Three-Phase and Single-Phase assemblies

My contact details: Colin.McAhren@luceco.com : Mobile number +44 (0) 7929357456

This webinar will cover

- Why would we need to use Arc Fault Detection Devices (AFDD's)
- What is an AFDD?
- What causes an arc fault?
- How does an AFDD work?
- What AFDD's do and cannot not do
- How are AFDD's installed?
- Testing and maintaining AFDD's
- BS7671 regulations and references to Arc Fault



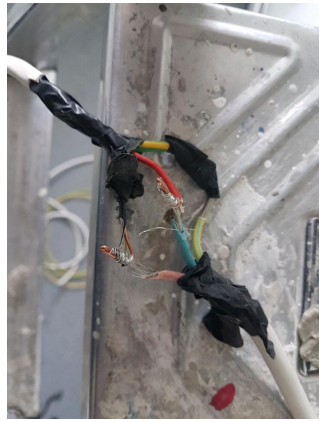


Arc Fault Detection

Arc Fault Detection Devices **provide additional protection** for **prevention of fire from electrical arc**

Why do we need an AFDD?

Electrical installations age with time.
Conditions, safety levels of installations will deteriorate.



Affected by everyday use, misuse and DIY alterations
(particularly those where unauthorized alterations are carried out by persons that are not competent for the tasks involved).

A typical installation has most of the component parts, cabling and connections hidden from view, beneath floors, in loft spaces etc.. We cannot see the condition of these parts. Except from periodic inspection??? Maybe.

Loose connections and damaged/ageing insulation on hidden cables can be a source of overheating, earth leakage current and arc faults that in turn, can lead to ignition of surrounding combustible materials leading to fires.

Without regular inspections by competent persons the types of conditions that are associated with risk and hazards cannot be recognized or acted upon.

What is an AFDD?

Arc Fault Detection Devices provide additional protection for prevention of fire from electrical arc faults.

Here are some basic types you may see for single phase circuits

What is an AFDD?

Variations in types available: **BS EN 62606:2013+A1:2017**: For detection of Arc Faults

1 **AFDD only, manual test:**
Or automatic test, any time within 24 hour period. No push button included

2 **AFDD + MCB combined:**
As 1. But includes overcurrent and fault current protection

3 **AFDD + RCBO combined:**
AFDDs will all have automatic test, RCCB included + test button, includes overcurrent and fault current protection

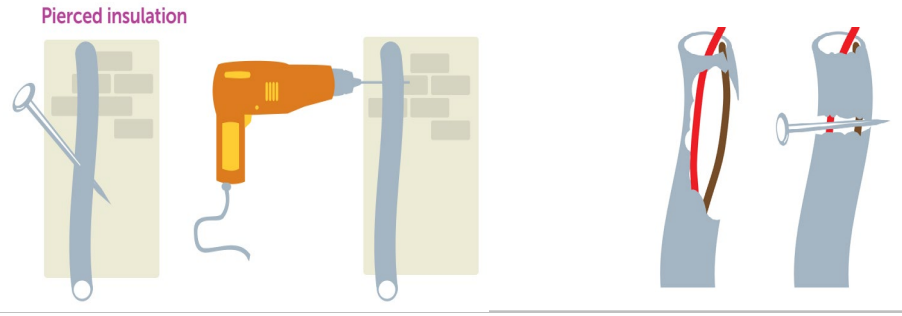
We expect the default device will be for the AFDD + RCBO protection device in one unit.

While there are 3 module. 2 module and single pole modules available at this point. We expect by the middle to the end of 2022. All suppliers with have single module devices for residential supplies.

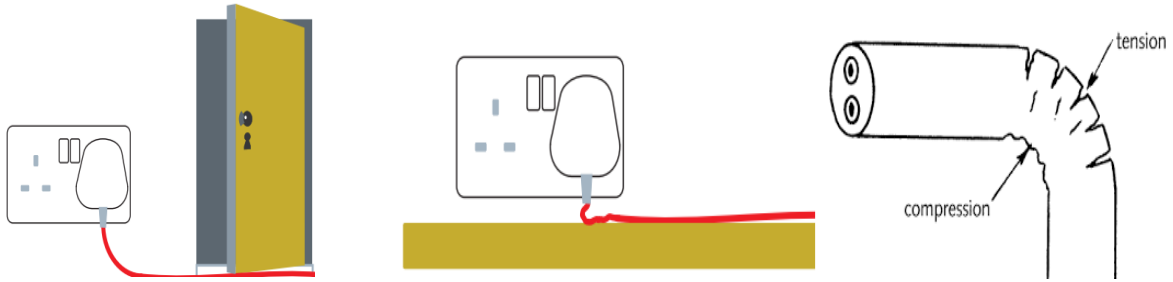
Variation may be available for the commercial industrial market where 10kA is occasionally required.

What causes an Arc Fault?

Pierced and damaged insulation



Trapped/crushed cables/incorrect bend radius

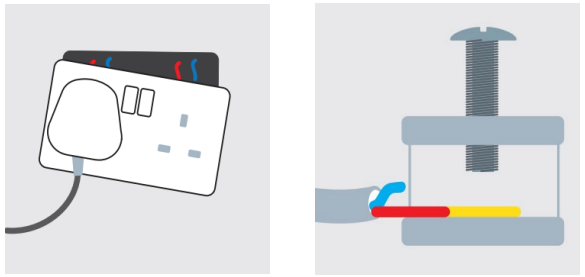


NOTE:

AFDDs will detect arcing, but not high resistance connections within loose terminations.

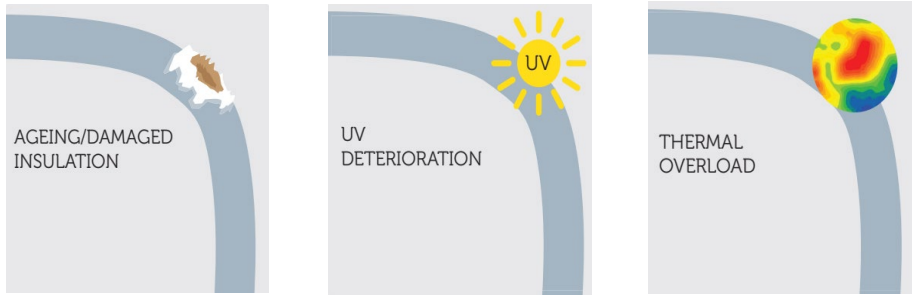
AFDDs will not detect high resistance connections due to trapped insulation.

Loose terminations/faulty plugs and sockets



What causes an Arc Fault?

Deteriorating insulation



Rodent damage

NOTE:

AFDDs will detect arcing, but not high resistance connections within loose terminations.

AFDDs will not detect high resistance connections due to trapped insulation.

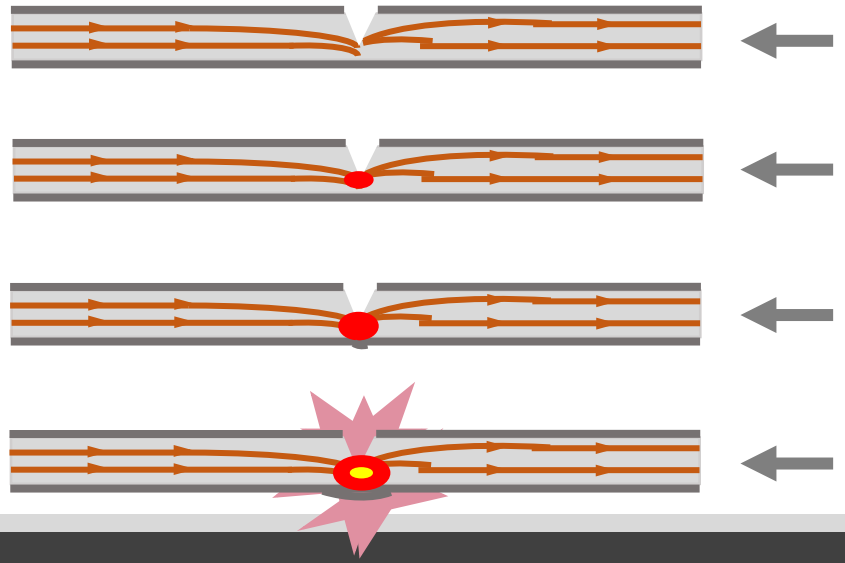
Incorrect cable stripping

What causes an Arc Fault?

Development of an arc fault

Arc faults are rarely instant and depending on a wide number of factors, can take time to develop. The time for an arc fault to form is dependent on its root cause (external influences, ageing, etc.).

Arc faults can occur immediately or over a long period (hours, days, weeks, months, years). With the arc developing, temperatures up to 6000 °C can be generated and thus the surrounding insulation starts to burn and eventually a fire develops. The illustrations below illustrate a developing arc fault.



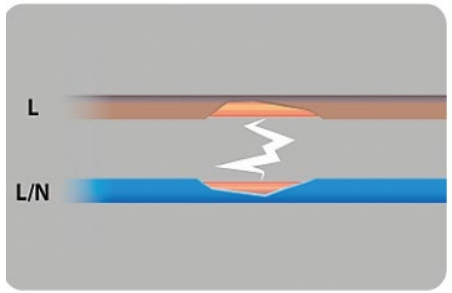
Electrical cable becomes damaged, nicked, crushed

The conductor and insulation become hot over time

The conductor's insulation gradually carbonized, heat intensifies, copper conductor melts, gap increases, heat intensifies, resulting in electrical discharge

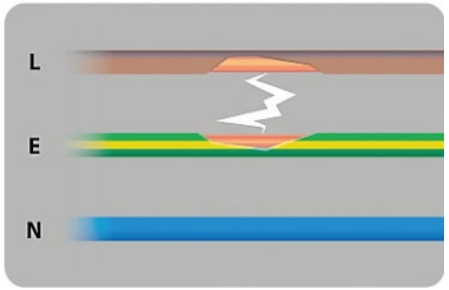
Enabling formation of arc fault, creating source of heat that can cause combustion

What causes an Arc Fault? Parallel and series arcs



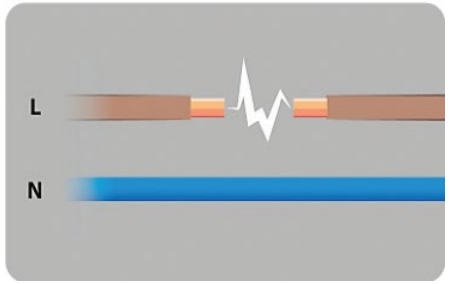
Parallel arc fault current(L-N) originates from

- High impedance due to damaged insulation, fault current is too low to trip other protection devices
- Protection is provided by AFDD'S



Parallel arc fault current L-E originates from

- Fault between L-E
- High impedance due to damaged insulation, fault current is too low to operate MCB's of fuses
- Protection is provided by AFDD's (RCDs will provide this protection)



Series arc fault current originates from

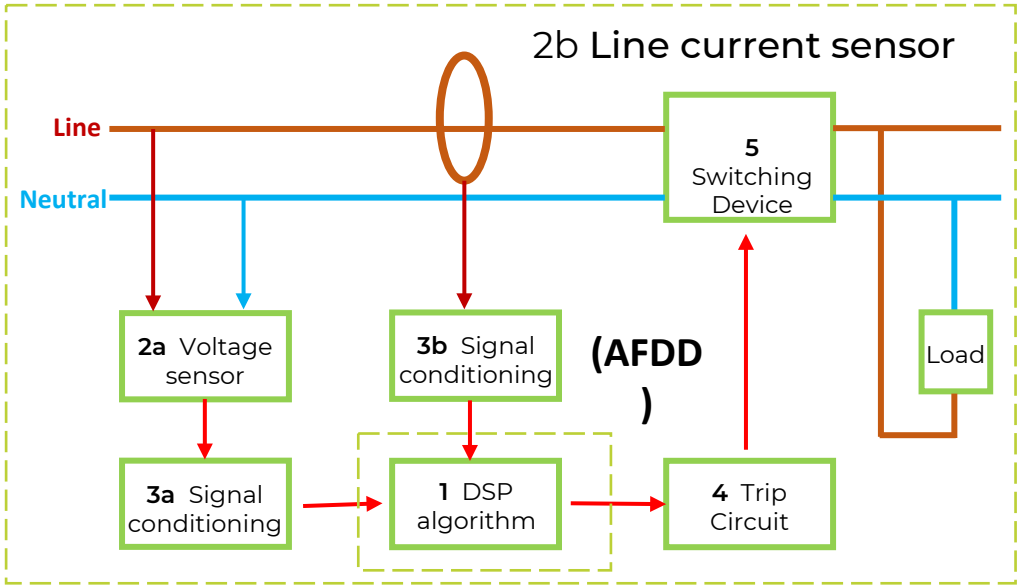
- Damaged cable (e.g. crushed, broken etc)
- Loose connections
- Protection is provided by AFDD's

How does an AFDD work?

Detection via microprocessor
Hardware and firmware layout and process

Voltage sensing
2a Voltage sensor input collected
3a Processed by signal conditioning circuit – passed to DSP
1 DSP, Digital Signal Processor

Current sensing
2b Current sensor input collected
3b Processed by signal conditioning circuit – passed to DSP
1 DSP, Digital Signal Processor : amplitude, phase information of the voltage and line current data obtained & processed



Operational and activation signal circuit
4 Trip circuit activated with output signal from DSP on detection of arc fault
5 Switching device breaks the source of power from the circuit load

How does an AFDD work?

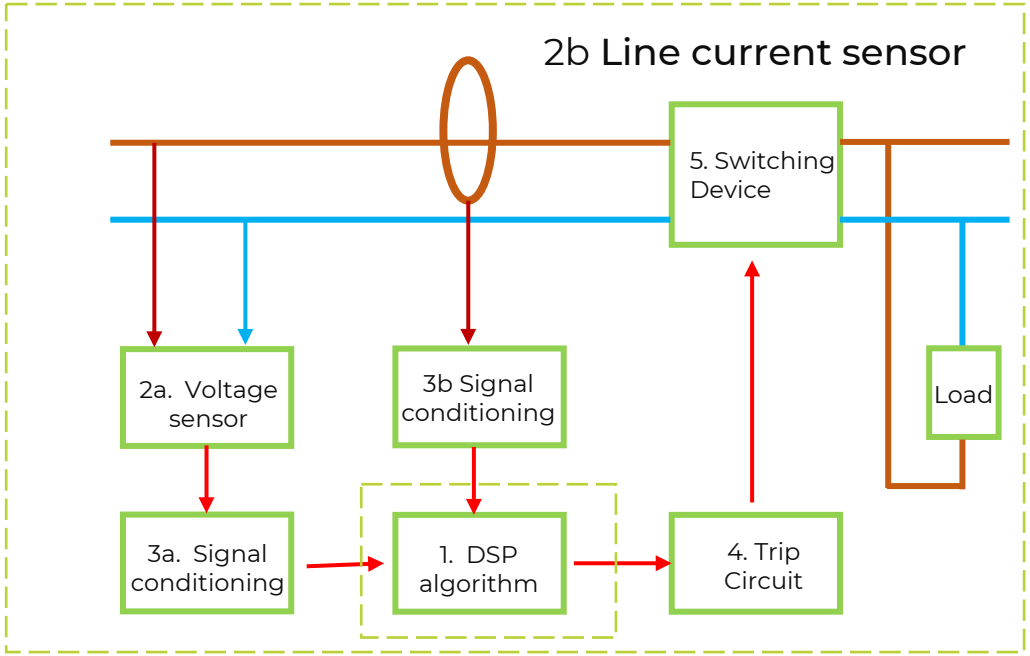
Hardware and firmware used within Arc Fault detection devices programs will follow the same basic process.

1 Voltage and current signal acquisition program
2 Arc fault detection program

The main program predominantly evaluates whether the number of given arcs in a given time meets conditions to trigger the corresponding alarm and protection program. (Digital Signal Processor)

When the number of arc events exceeds the set number of arc events required an alarm and activation tripping sequence is triggered.

The arc fault program uses the wave form “0” crossing cycle as an interrupt service to sample and save the wave form regularly. It is this interrupt cycle that can distinguish an arc caused by plugging in and withdrawing plugs from sockets. When the set time has passed it will discard this type of arc signal as too infrequent to be a fault.

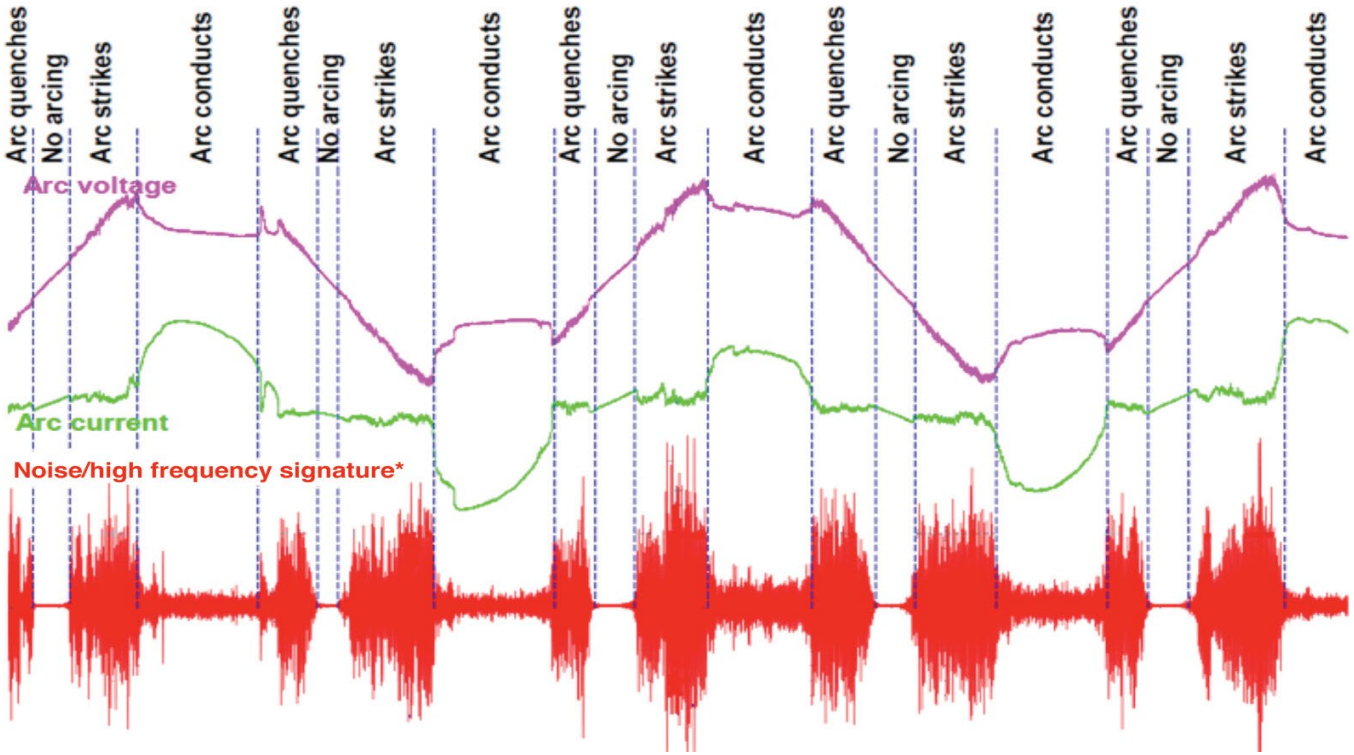


Decision to add into program as potential arc fault made every 10 ms every ½ cycle

How does an AFDD work?

AC wave form typical signature of an Arc

- Parameters analysed are both numerous and varied
- **Signature (waveform)** of Arc
- **Duration of arc** (short duration characteristic of a switch)
- **Irregularity of arc** (motors have regularity and not considered an arc fault



Noise / high frequency signature exceeding 50 Hz which can be kHz or MHz and which correspond to an electric arc fault

How does an AFDD work?

- Trip time of AFDD dependent on arcing current
- RCD 300mA for fire protection 230V X 0.3 A = 69 Watts and related to leakage current not arc current
- 100 Joules or 100 watt second @ 40V established for tripping characteristic for series arcing

$$t_B = \frac{100J}{40\ V\ I_{arc}} = \frac{2.5\ A\ s}{I_{arc}} \text{ for } I_{arc} \leq 20\ A \text{ and } t_B = 0.12s \text{ for } I_{arc} > 20\ A$$

2.5A is the derived current value based on (100 watts / 40V) 100 watts = 100 joule s

Test arc current (r.m.s. values)	2,5 A	5 A	10 A	16 A	32 A	63 A
Maximum break time	1 s	0,5 s	0,25 s	0,15 s	0,12s	0,12 s

Linea trip time to increase in current.
= 2.5/16 = 0.15s to max trip time of 0.12s or 120ms

How does an AFDD work?

From **BS EN 62606 Arc fault device standard**: standard influences design

8.17 Performance of the AFDD test device

AFDD shall be provided with a manual or an automatically initiated test function or both that checks the arc detection circuit.

The automatic test function shall be performed at every switch on and at intervals not exceeding at least once a day.

During automatic testing, it is not required to open the contacts by performing the test.

***NOTE 1 -** The mechanical parts of the mechanism are verified by the endurance tests and the contacts are verified by the short circuit tests. For that reason, these parts are expected to be highly reliable and need not to be included in a periodic test*

In case of manual test, the device shall trip (similarity to that of RCD, press button, device trips)

AFDDs including an RCD function need a test device according to the relevant product standard.

What AFDD’s can and can’t do?

AFDD - Do nots …

What can detect given fault

Detect a line to neutral fault as a circuit breaker	MCB & RCBO short circuit faults L-N
Detect a line to earth fault as RCDs or circuit breaker	MCB RCBO & RCCB short circuit faults L-E
Detect a line to earth leakage fault as RCDs	RCBO & RCCB Earth Leakage faults L-E, N-E
Detect an overload current as a circuit breaker does	MCB & RCBO Overload

AFDD - Can do’s …

Detect Arc faults L-E Where RCDs are installed will trip before Arc fault detection operates.	**What can detect given fault** AFDD RCBO RCD Parallel Arc L-E
Detect a high resistance Live to Neutral fault	**What can detect given fault** AFDD Parallel Arc fault L-N – high resistance fault
Detect an in-line high resistance fault within the Line conductor	**What can detect given fault** AFDD Series Arc fault. Only AFDD can detect in line arc fault.

Note: AFDD will detect arc faults at current of 2.5A @ 40V

What AFDD's can and can't do?

Ring circuits "Series" arcs will not be detected by AFDD. That's very interesting

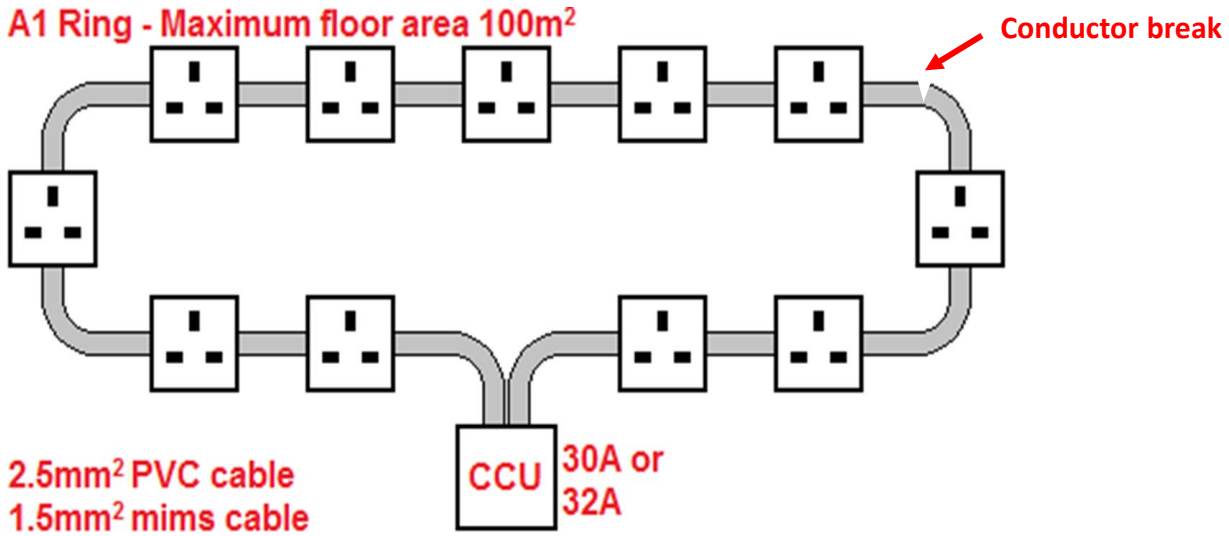
Any break in the line conductor both sides of the break will be at the same potential, No arc produced

RCDs or MCBs cannot detect this either. (nothing to detect)

If the cable is protected by 32A MCB, it may experience an overload. That's bad!

Series in-line breaks in cables on spur circuits off of the ring, will be detected.

Loose connections within the sockets or connected plugged in cables creating arcs will be detected



Note. This only applies to a series arc fault in a ring circuit not a parallel arc fault.

BS 7671 regulations testing

Consult manufacturer of AFDD for testing process for AFDD.

BG AFDD insulation resistance testing.

Dead Tests

1 Testing at 250VDC for Live to Neutral, Live to Earth, Neutral to Earth will not harm the device. But will not stress the cables in the same way as 500VDC. And may produce a false reading

2 Testing at 500VDC by connecting the Live and Neutral cables together to Earth will not harm the device

3 Insulation testing Live to Neutral at 500VDC must be performed on the load side of AFDD with conductors disconnected from device

Live Tests

4 Live testing of AFDD. On initial power on AFDD will perform a self test if there is a fault with the internal circuit an LED will flash to indicate problem. This self test will be performed every 1 hour

5 When self test finished. Press RCD test button for RCD function testing

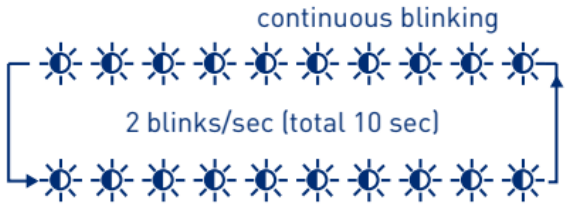
6 Perform RCD tests as RCCB or RCBO

BS 7671 regulations testing

LED indication identifying type of fault

Check each manufacture for specific indication to type of fault

AFDD self check provides indication of an internal fault to the process. No testing of AFDD operation required

LED Indication after tripping and reclosing	Description
	Overcurrent Fault or Residual Current Fault
	Series Arcing Fault or Parallel Arcing Fault
	Overvoltage Fault (U>275V)
	Internal Self-Test Fault

BS 7671 regulations testing

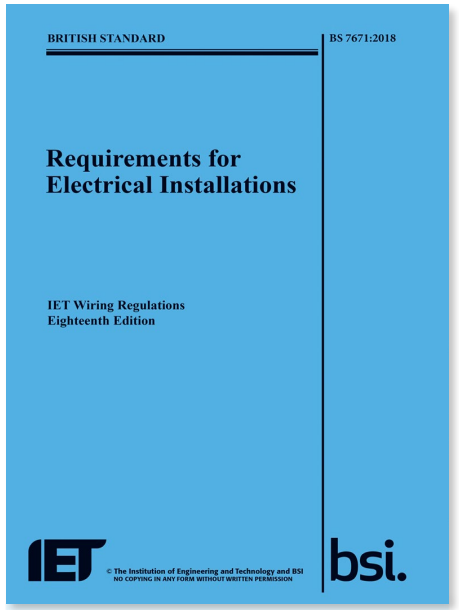
Part 1 - Chapter 13 - Fundamental Principles

131.1 The requirements of this chapter are intended to provide for the safety of persons, livestock and property shall be protected against **dangers** and damage which may arise in the reasonable use of electrical installations.

Dangers - In electrical installations the risk of injury may result from:

(vii) **arcing or** burning – likely to cause blinding, would relate to welders..

131.3.1 requires the electrical installation to be arranged so that the risk of ignition of flammable materials due to high temperature or **electric arc** is minimized



BS 7671 regulations testing

Part 4 - Chapter 42: 421 - Protection against Fire Caused by Electrical Fire

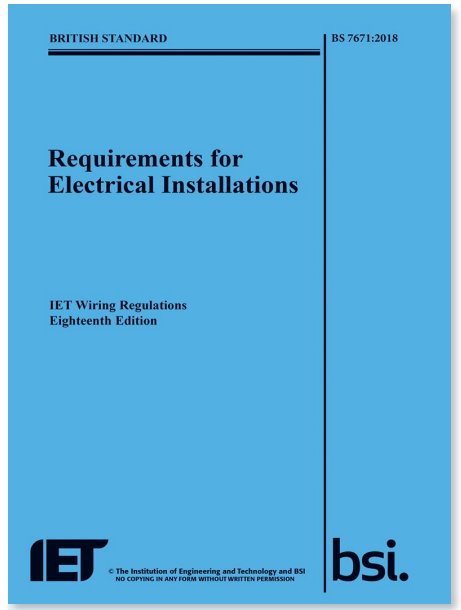
421.1.1 Persons, livestock and property shall be protected against harmful effects of heat or fire which may be generated or propagated in electrical installations. Insulation faults or arcs, sparks and high temperature particles

421.1.7 Arc fault detection devices conforming to BSEN 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 a device may be used include:

- Premises with sleeping accommodation
- Locations with 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 (high rise buildings, “chimney effect”)
- Locations with endangering of irreplaceable goods.



BS 7671 regulations testing

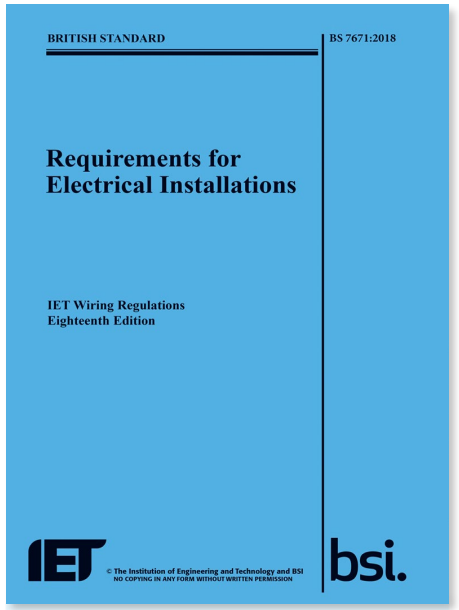
Part 5 - Selection and erection of wiring systems

Chapter 53

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 230V



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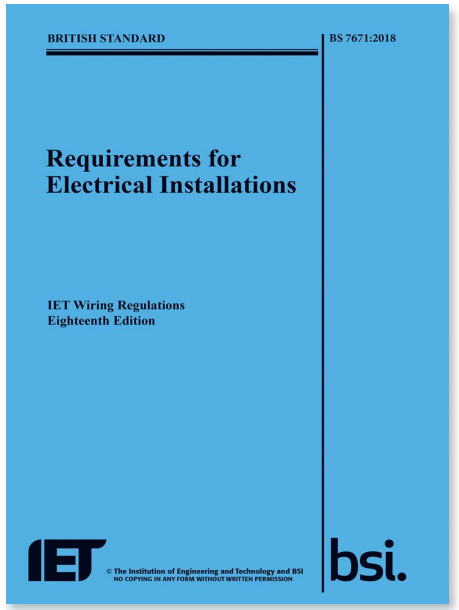
Part 7 - Special Installations or Locations

Section 710 - Medical Locations

710.421.1.201 In medical locations of Group 1 and Group 2 Arc Fault Detection Devices (AFDDs) are not required to be installed.

In medical locations of Group 0 (massage rooms).

Arc Fault Detection Devices (AFDDs) shall be used subject to a risk assessment.



Any Questions?

My contact details: Colin.McAhren@luceco.com Mobile number: +44 (0) 7929357456