## WHAT IS AFDD PROTECTION?

To keep things simple, AFDDs are a type of protective device installed at the origin of an installation (in the consumer unit) to protect the circuits from damage arising from arc faults.

AFDD devices are designed to operate with both series and parallel circuit arc faults. These protective devices do not have an electromagnetic operation, like the trigger used in circuit breakers and RCDs, but instead make use of electronic technology to evaluate the signature of an arc within the waveform of the circuit.

BS7671 2018 Amendment 2:2022 stipulates that it is now a requirement to protect single phase AC final circuits supplying socket-outlets with a rated current not exceeding 32A within certain installations.

**SCAN HERE**
To check out Hager's AFDD ProTools

## CLASSROOM ACTIVITY:

Research and write a report on the following, with regards to AFDDs:

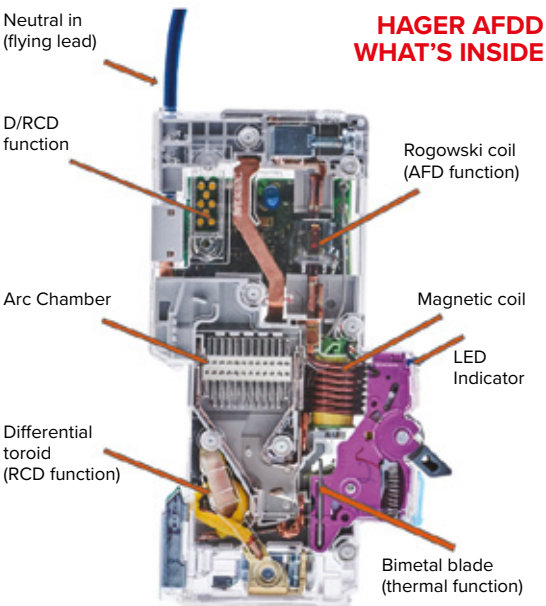
- Advantages and Disadvantages
- How are they installed?
- Are any specialist tools required?
- Give an example of where you would install AFDDs
- Are they mandatory?
- What do the Regulations say?

## YOU ARE TO....

- Utilise your session to use the internet and research these items and produce a typed assignment
- Include images in your answers
- Submit your finished assignment to your tutor.

Feedback will be given.

## HAGER AFDD WHAT'S INSIDE




**"AFDDS ARE DEVICES DESIGNED TO PROTECT CIRCUITS FROM DAMAGE CAUSED BY ARC FAULTS"**

## QUICK QUIZ

**Q1** On which circuits are AFDDs mandatory?

**Answer:** BS7671 18th Edition AMD2:2022 requires all circuits with a rated current not exceeding 32A serving socket outlets must be fitted with an AFDD

**Q2** Where should an AFDD be fitted?

**Answer:** It is a requirement that AFDDs shall be installed at the origin of the circuit they are protecting. It should be noted that there is an exception to this for busbar systems and Powertrack systems.

**Q3** What are the two types of arc fault an AFDD will detect?

**Answer:** Series and Parallel

**Q4** In which four building types are AFDD mandatory?

1. Higher Risk Residential Buildings (HRRBs)
2. Purpose Built Student Accommodation
3. Care Homes
4. Homes in Multiple Occupation

**Answer:** All of the above

Go to **sparks-magazine.co.uk** to download exercise answers for free

TEST YOUR KNOWLEDGE

ARC FAULTS & AFDDS

# ARC FAULTS & AFDDS QUIZ

**Covering:** C&Gs 2365 Level 3 Unit 305 and C&Gs 2357 Unit 605 or EAL equivalent.



| Q1 | A suitable arc fault detection device can include which one of the following? | Ans. |
|---|---|---|
| A | A residual current circuit breaker | |
| B | A miniature circuit breaker | |
| C | A single device with an integrated protective device | ✗ |
| D | A separate unit manufactured off site | |

| Q2 | A device designed to limit a transient overvoltage is called: | Ans. |
|---|---|---|
| A | A high voltage detector | |
| B | A transient overvoltage device | |
| C | A surge prevention device | |
| D | A surge protective device | ✗ |

| Q3 | The system of internal arc fault protection is typically associated with: | Ans. |
|---|---|---|
| A | A switchboard used in special applications | ✗ |
| B | A fused–switch | |
| C | A switch-fuse | |
| D | An isolator used to control a single load | |

Go to **sparks-magazine.co.uk** to download exercise answers for free.

| Q4 | The arc fault detection device must be installed: | Ans. |
|---|---|---|
| A | Between the service cut-out and the consumers control unit in a domestic dwelling | |
| B | In any D.C. circuits supplying individual loads | |
| C | At the origin of the final circuit to be protected in a domestic dwelling | ✗ |
| D | In three-phase supply systems supplying commercial electrical loads | |

| Q5 | Arc fault protection devices used in purpose-built student accommodation shall be provided for single-phase AC final circuits supplying socket-outlets with a rated current not exceeding: | Ans. |
|---|---|---|
| A | 40A | |
| B | 32A | ✗ |
| C | 16A | |
| D | 13A | |

| Q6 | The abbreviation HRRB means which one of the following? | Ans. |
|---|---|---|
| A | High Risk Retired persons Buildings | |
| B | High Risk Residential Buildings | |
| C | Higher Risk Residential Buildings | ✗ |
| D | Higher Risk Related Buildings | |

| Q7 | The appropriate British Standard associated with arc fault detection devices is: | Ans. |
|---|---|---|
| A | BS EN 36206 | |
| B | BS EN 62606 | ✗ |
| C | BS 30609 | |
| D | BS EN 30609 | |

| Q8 | In medical locations which of the following groups are arc fault detection devices subject to a risk assessment? | Ans. |
|---|---|---|
| A | Group 1 | |
| B | Group 2 | |
| C | Group 0 | ✗ |
| D | Group 1 & 2 | |

| Q9 | In electrical installations the risk of injury may result from the following, except: | Ans. |
|---|---|---|
| A | Shock currents | |
| B | Failure of an electric heating device | ✗ |
| C | Ignition of a potentially explosive atmosphere | |
| D | Arcing or burning | |

| Q10 | An end-user test button is provided for which of the following devices? | Ans. |
|---|---|---|
| A | BS 3036 semi-enclosed fuse | |
| B | BS EN 50428 switching device | |
| C | BS EN 60898 circuit-breaker | |
| D | BS EN 62606 arc fault detection device | ✗ |



The On-Site Guide enables the competent electrician to deal with installations (up to 100A, 3-phase) providing essential information in a convenient, easy-to-use format.




# ON-SITE GUIDE

## How well do you know the On-Site Guide BS 7671:2018+A2:2022



**REVISION GUIDE PROVIDED BY WAYNE TIMMINS**
Electrical Lecturer at Lincoln College

**Test your knowledge by filling in the answers to these questions. We have answered the first question for you.**

**Q1** Where is the information on the applications of flexible cables?

**Answer:** Applications for flexible cables Table C2 page 148.

**Q2** Where would you find the conduit factors for conduit incorporating multiple bends?

**Answer:** Conduit factors for runs incorporating bends and long straight runs Table E4 page 164

**Q3** Which table will provide you with the cable factors for trunking?

**Answer:** Cable factors for trunking Table E5 page 165

**Q4** You will find information on the length of an overhead span between buildings where?

**Answer:** Maximum length of spans and minimum heights above ground for overhead wiring between buildings Table D2 page 157

**Q5** Where would you find the mV/A/m for 6mm² ?

**Answer:** Table F5(I) Page 176

**Q6** Which table would you use to find the rating factor of a cable which is no greater than 300mm in length in insulation?

**Answer:** Rating factor Ci Table F2 page 169

**Q7** Which table provides you with the cable factors for use in conduit over 4m in length?

**Answer:** Cable factors for use in conduit in long straight runs over 3 m, or runs of any length incorporating bends Table E3 Page 163

**Q8** Where will you find the current-carrying capacity of cables?

**Answer:** Current carrying capacity Table F4(i) page 171, F5(i) page 174, F6 Page 177

**Q9** Where will you locate the conduit factor for a small, straight run of conduit?

**Answer:** Conduit factors for use in short straight runs Table E2 page 162

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TEST YOUR KNOWLEDGE
EV CHARGING



# EV CHARGING SYSTEMS

**REVISION GUIDE BY JAKE HARDCASTLE**
Intermediate Electrical Engineer at Thornley & Lumb Partnership Ltd

**With the ban on Internal Combustion Engine vehicles set to come into effect in 2030, the demand for EV chargers is soaring.**

Building Regulations (Approved Document S) requires all new homes built in England to have EV points installed, as well as new-build workplaces, supermarkets and buildings undergoing major renovations.




## DESIGN CONSIDERATIONS

### DO I NEED TO INSTALL AN EARTH ELECTRODE?

This depends on whether your EV charger incorporates PEN fault detection. If it doesn't, you will be required to install an earth electrode or a separate PEN fault device.

### DO I NEED TO INSTALL RCD PROTECTION?

Again, this depends on whether or not your charger incorporates RCD protection. The correct type of RCD protection is required to prevent the RCD being rendered inoperable by any DC currents. Most chargers will incorporate this so you may not need to do a separate installation. However, you will still need to install upfront RCD protection if you are installing your cable in a way that warrants it, in order to comply with BS7671.

**"TO MEET ZERO EMISSIONS BY 2050, EV CHARGERS ARE NOW REQUIRED IN ALL NEW HOMES AND BUILDINGS"**

## QUICK QUIZ

**Q1** EV charging points always require an earth electrode?

**TRUE** or **FALSE**

**Answer:** FALSE

**Q2** An RCD label should be installed adjacent to each RCD device?

**TRUE** or **FALSE**

**Answer:** TRUE

TEST YOUR KNOWLEDGE
EV CHARGING

# EV CHARGING POINTS

Go to sparks-magazine.co.uk to download exercise answers for free.

The following exercises concern electric vehicle charging points and their infrastructure. Reference can be made to the IET BS7671: 2018 Amendment 2: 2022. Additional information and guidance can be found at The Energy Saving Trust and the GOV.UK low emission and electric vehicle websites. For each question, decide if the answer or statement is true or false.



**ELECTRICAL INSTALLATION: BUILDINGS & STRUCTURES**

**Covering:** C&Gs 2365 level 2 Unit 203 / C&G 2365 Level 3 Unit 305 / C&G 2357 Units 605 / 606 / 607 and 608 or EAL equivalents.

| | | | | | | |
|---|---|---|---|---|---|---|
| Q1 | Rapid and Ultra-Rapid is one category of electric vehicle charging. | | | | | |
| ANSWER | TRUE | ✗ | FALSE | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Q2 | Electric vehicle charging points cannot be installed off-road for domestic premises. | | | | | |
| ANSWER | TRUE | | FALSE | ✗ | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Q3 | Three typical electric vehicle charging locations can be classified as: off-street, on-street and workplace. | | | | | |
| ANSWER | TRUE | ✗ | FALSE | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Q4 | Regulations regarding electric vehicle charging employing the inductive charging method, are included in the Special Installations or Locations section of BS7671. | | | | | |
| ANSWER | TRUE | | FALSE | ✗ | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Q5 | An electrical final circuit supplying charging equipment for electric vehicles must not include a PEN conductor. | | | | | |
| ANSWER | TRUE | ✗ | FALSE | | | |

| | | ANSWER | | | |
|---|---|---|---|---|---|
| Q6 | The use of obstacles to provide a suitable protective measure to electric vehicle charging equipment is considered an appropriate means of protection against electric shock. | TRUE | | FALSE | ✗ |

| | | ANSWER | | | |
|---|---|---|---|---|---|
| Q7 | If a protective conductor of an electric vehicle charging installation is connected to an earth electrode, the cross-sectional-area of the protective conductor must not be less than 25mm². | TRUE | | FALSE | ✗ |

| | | ANSWER | | | |
|---|---|---|---|---|---|
| Q8 | If one electric vehicle charging point is supplied through a fixed isolating transformer complying with BS EN61558-2-4, the protective measure afforded is known as 'Electrical Separation'. | TRUE | ✗ | FALSE | |

| | | ANSWER | | | |
|---|---|---|---|---|---|
| Q9 | Electric vehicle charging equipment installed outdoors must have a degree of protection against environmental conditions of at least IPX4. | TRUE | ✗ | FALSE | |

| | | ANSWER | | | |
|---|---|---|---|---|---|
| Q10 | The location and design of electric vehicle charging equipment must be suitable to withstand a maximum impact of IK08 in accordance with BS EN 62262, 'Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts'. | TRUE | | FALSE | ✗ |

| Q11 | With reference to electrical installations the letters DNO refer to which one of the following? | Ans. |
|---|---|---|
| A | Distribution network system operator | |
| B | District network supplier operations | |
| C | District network operator | ✗ |
| D | Distribution network operations | |

| Q13 | The connection of an electric vehicle to an AC network using a standardised socket-outlet not exceeding 16A and 250V AC is called: | Ans. |
|---|---|---|
| A | Mode 1 charging | ✗ |
| B | Mode 2 charging | |
| C | Mode 3 charging | |
| D | Mode 4 charging | |

| Q12 | The earthing system that is identified by the letters PME means that the system is which of the following? | Ans. |
|---|---|---|
| A | TT | |
| B | TN-S | |
| C | TN-C | |
| D | TN-C-S | ✗ |

| Q14 | The definition 'Charging Equipment' is which one of the following? | Ans. |
|---|---|---|
| A | An assembly including one or more charging points | ✗ |
| B | An assembly with more than one charging point | |
| C | Switchgear supplying one or more charging points | |
| D | An assembly with only one charging point | |

# MIX & MATCH

**During your career, you will need to complete various documentation. See if you can match the document name with the correct description.**

WIRING DIAGRAM

VARIATION ORDER

PURCHASE ORDER

QUOTATION

ARCHITECT'S DRAWINGS

SCHEMATIC DRAWING

ESTIMATE

PROPOSAL

JOB SHEET

**A**

A diagram showing a detailed arrangement of electrical connections between components and accessories

WIRING DIAGRAM

**B**

An initial idea regarding a development to be later planned

PROPOSAL

**C**

These show the physical details of the buildings

ARCHITECT'S DRAWINGS

**D**

This is a statement, made by a contractor, of the expected cost of the work to be carried out

ESTIMATE

**E**

This is a statement or offer outlining the cost of carrying out a particular task or set of tasks for the customer

QUOTATION

**F**

A written document identifying the materials and quantities of materials required and the address where the materials are to be delivered

PURCHASE ORDER

**G**

A document that is produced when a change is made to the original plan

VARIATION ORDER

**H**

Sometimes called a 'ladder diagram' because it resembles the rungs of a ladder in its layout

SCHEMATIC DRAWING

**I**

This document provides information concerning a particular job to be carried out

JOB SHEET



## WHY DO I NEED TO KNOW ABOUT EARTHING SYSTEMS?

Questions on earthing systems are common in your unit exams when studying to be an electrician.

You will also come across earthing systems in the design, installation, inspection and testing of electrical installations.

Try these five revision questions on earthing systems.

| Q1 | Which one of the following is not a UK earthing system? | Ans. |
|---|---|---|
| A | TN-S | |
| B | PME | |
| C | PEN | ✗ |
| D | TT | |

| Q2 | What does the abbreviation PME stand for? | Ans. |
|---|---|---|
| A | Positive Main Earth | |
| B | Protective Multiple Earth | ✗ |
| C | Protective Main Earthing | |
| D | Protection Means Earth | |

| Q3 | In a TT earthing system, which two conductors are supplied by the DNO? | Ans. |
|---|---|---|
| A | Line & Neutral | ✗ |
| B | Earth & Line | |
| C | Neutral & Earth | |
| D | L1 & L2 | |

| Q4 | Which regulation in BS7671 gives information on earthing systems? | Ans. |
|---|---|---|
| A | 522.2.1 | |
| B | 542.1.2 | ✗ |
| C | 433.1.1 | |
| D | 512.2.4 | |

| Q5 | What does DNO stand for? | Ans. |
|---|---|---|
| A | Device Not Operating | |
| B | Do Not Open | |
| C | Distributors Network Operator | |
| D | Distribution Network Operators | ✗ |

## DRAW A LINE TO MATCH THE CORRECTION DEFINITIONS:

| | |
|---|---|
| TN-C-S | Arrangement has been supplied by the DNO with a separate earth and neutral conductor. The earth is often the armouring on the supply cable. |
| TN-S | This type of earthing system is often called a Protective Multiple Earth. |
| PME | Arrangement has been supplied by the DNO with a separate earth and neutral conductor. The earth is often the armouring on the supply cable. |
| TT | Arrangement has been supplied by the DNO with a combined earth and neutral supply conductor. |

Go to **sparks-magazine.co.uk** to download exercise answers for free.

TEST YOUR KNOWLEDGE
EARTHING SYSTEMS

# EARTHING ARRANGEMENTS AND PROTECTIVE CONDUCTORS

**Covering:** Outcome 2 of Unit 304, Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91, or EAL equivalent.

**You may find it helpful to have a copy of BS 7671:2018+Amendment 2:2022 for reference to answers.**

**Q1** TN-C-S, TN-S and TT are all types of?

**Answer:** Supply system (See Part 2 Definitions)

**Q2** The 'Earthing Conductor' is the protective conductor that connects the main earthing terminal (MET), to which other points in both TT and TN systems?

**Answer:** In the TT supply system the MET connects to the earth electrode
In the TN supply systems the MET connects with the means of earthing
(See Part 2 Definitions)

**Q3** Give **three** examples of suitable earth electrodes that could be installed in a TT installation?

**Answer:** Earth rod
Earth plate
Underground structural metalwork embedded in foundations etc...
(See Part 5 Chapter 54 Regulation: 542.2.2)

**Q4** What is the minimum cross-sectional area of a buried pvc insulated copper earthing conductor protected against corrosion by a sheath and protected against mechanical damage?

**Answer:** From Table 54.1 the minimum size of cable is stated as being 2.5mm2
(See Part 5 Chapter 54 Regulation: 542.3.1 Table 54.1)

**Q5** The cross-sectional area of a protective conductor, other than a protective bonding conductor, can be determined by one of two methods. What are the two methods?

**Answer:** By calculation using a formula where S = √I²t ÷ k
By selection from Table 54.7
(See Part 5 Chapter 54 Regulations: 543.1.3 and 543.1.4 respectively)

**Q6** Identify the 'k' value to be used in the procedure to select a suitable protective conductor if the protective conductor is the steel wire armour of a 90°C thermoplastic (PVC) SWA cable.

**Answer:** See IET BS7671:2018 Amendment 2 2022, Part 5, Chapter 54, Table 54.4
The 'k' value is given as 46

**Q7** A protective conductor is to be selected to be bunched with other cables in a trunking. The protective conductor is to be copper and covered in 70°C thermoplastic insulation. If the fault current is likely not to exceed 220A with a disconnection time of 1 second, calculate the minimum size of the protective conductor to be specified.

**Answer:** Data required for use in the formulae: S = √I2t ÷ k
S to be found
I = 220 A
t = 1 s
k = 115 from Table 54.3 (the final cable size is not likely to exceed 300mm2)
S = √ 2202 x 1 S = 1.9mm2 the nearest cable size will be 2.5mm2

**Q8** Modern equipment such as switch-mode power supplies, light dimming devices and IT equipment requires a 'functional earth' to ensure satisfactory operation. State the requirements for electrical equipment which has a protective conductor current that exceeds 10mA in normal use.

**Answer:** See Regulation 543.7.1.202
Equipment shall be connected to the supply by one of the following methods:
Permanently connected
Flexible cable with a plug and socket complying to BS EN 60309-2 provided that the protective conductor is not less than 2.5mm2 for plugs rated at 16A and not less than 4mm2 for plugs over 16A rating
A protective conductor complying with Section 543 installed with an earth monitoring system to BS 4444



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**Q9** Identify the following abbreviations and symbols relating to earthing and bonding systems:

**Answers:** See IET BS7671:2018 plus Amendment 2: 2022, Part 2

**A.** BN — Bonding network

**B.** CBN — Common bonding network (see also 444.5.2)

**C.** EPR — Earth potential rise-stress voltage (see also 442.2)

**D.** PEN — Protective and Neutral conductor (combined)

**E.** PME — Protective Multiple Earthing

**F.** $I_E$ — Part of the earth fault current in the high voltage system that flows through the earthing arrangement of the transformer substation (see also 442.1.2)

**G.** $I_H$ — The fault current that flows through the earthing arrangement of the exposed conductive parts of the equipment of the low voltage installation... (see also 442.1.2)

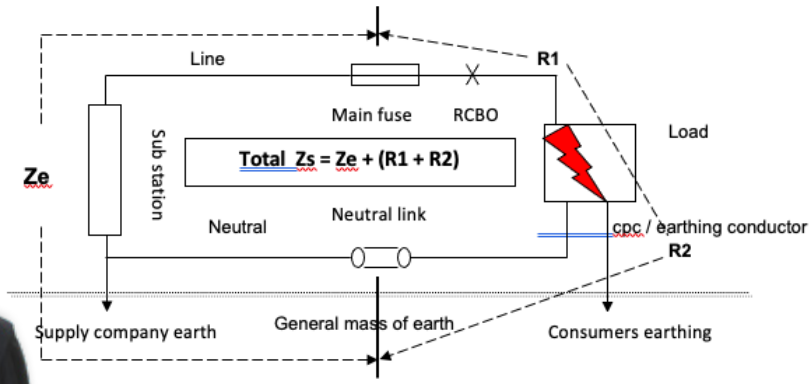
**H.** $R_A$ — The sum of the resistances of the earth electrode and the protective conductor connecting it to the exposed conductive parts (see also 411.5.3)

**I.** $R_E$ — The resistance of the earthing arrangement of the transformer substation (see also 442.1.2)

**J.** $R_2$ — Resistance of the circuit protective conductor of a distribution or final circuit

**Q10** Identify the significant sections of a single phase supply system when an earth fault occurs between the line conductor and circuit protective conductor on a Class I item of electrical equipment. Show a simple line diagram from the supply source to load and label each part.






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