

New:
AFDD + MCB in
1 modular width

Preventive fire protection in electrical installations



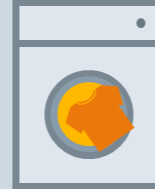
12
deaths due to fires
in Europe per day¹⁾



2,000,000
fires are reported in
Europe per year²⁾



5,000
fire accidents
per day²⁾



34 %
of all fires are caused
by electricity³⁾

Source: 1) Fire Safe Europe (2014)

2) Report No. 10 of CTIF Centre of Fire Statistics, World Fire Statistics (2006)

3) IFS Brandursachenstatistik (2015)

Increasingly automated building infrastructures, a growing number of electrical loads, partly involving new technical characteristics, as well as stricter standards, are all putting a focus on the proper protection of electrical installations. Existing electrical installations are hardly capable of meeting the growing requirements. The possible consequences range from the failure of electrical loads to electrical fires, which are responsible for more than 30 percent of building fires throughout Europe, some of which cause serious injuries and property damage.

The electrical installations in many existing buildings were configured decades ago in accordance with the state-of-the-art technology at that time and have not been adapted since. In Germany alone, 30 million residential buildings are more than 35 years old, and 11 million of these are more than 60 years old. Yet, according to the Association of German Engineers (VDI), the average service life of electrical systems is only 30 to 35 years. When buildings are overhauled, the electrical installations are often neglected. A similar picture exists in commercial and industrial buildings.

New risks through new technology

Largely, this does not take into account that the number of electrical loads has drastically increased over the past decades: Whereas there used to be roughly eight electrical devices, today there are often more than 70 electrical loads in a given household. Dishwashers, dryers or microwave ovens were previously rare commodities up into the 1980s; entertainment electronics in their current form, computers, heat pumps and power generators such as photovoltaic systems did not exist. The outdated electrical installations in many buildings can hardly cope with these loads anymore. Another point to consider is that modern electrical devices often have different power consumption characteristics or have frequency converters. In the event of a fault, these can create residual currents with higher frequencies or smooth DC residual currents, requiring special protective devices, which many people do not know.

What's more, the antiquated electrical systems designed for the range of appliances in the 1960s and 1970s can hardly be connected to the Smart Grid or regularly supply electric vehicles with electricity over a longer period of time. That is why the modernization of electrical installations is not only the prerequisite for electrical safety but also the basis for sustainable energy concepts.

Types and possible causes of arcing faults

So-called arcing faults in electric cables or systems are among the most frequent causes of fires. We distinguish between serial and parallel arcing faults. Parallel arcing faults occur between phase conductors and earth or a protective conductor (PC), between two phase conductors or between a phase conductor and a neutral conductor. Serial arcing faults can be caused in the event of an interruption in a conductor or as a result of loose contacts.

The most common causes of serial arcing faults include damaged cable insulation (for example caused by nails, screws or fastening clamps), crushed cables when laid through open doors and windows, cable breakage due to excessively tight bending radii, kinks in plugs and cables (possibly due to furniture being moved carelessly) and loosened contacts and connections in switches or socket outlets.

Additionally, environmental influences such as heat, moisture and gases can affect cables, as can UV radiation and rodents if the cables are outside. Conductive soiling and condensation can also give rise to undesired contact.

If damage to a cable causes a narrow point where the cable has a reduced cross-section, this can lead to a temperature increase when the cable is subjected to current loading, which can in turn lead to the oxidation of the hot copper and the formation of copper oxide. The insulation is then heated and carbonized. As the heating becomes more intense, the copper melts and gasifies, creating an air gap and causing sporadic arcs to occur. At around 6,000 °C, these can stabilize via the carbonized insulation.

Comprehensive experiments into the origins of serial arcing faults at the normal European voltage of 230 volts (V) and using the most common cable type in Germany, NYM, yielded the following result: fault locations need a certain level of energy to carbonize and to reach significant arc stability. The time taken for flames to occur depends greatly upon the load current. For currents under 3 amps (A), arcs are very unstable, with only a glow usually being visible. However, over a longer period this can carbonize the fault location such that a stable arc forms for a period lasting between a few tenths of a second and a few seconds. The ignition energy for this lies at around 300 joules. At currents below 2 A, even a stable arc frequently does not have the power required to ignite the cable.

The probability of hazardous arcing faults occurring is greatest in the mid-range between 3 and 10 A – and the majority of common domestic electrical appliances fall into this category. Here, the occurrence of the first significant flames (i.e. sustained flames lasting over 5 or 50 ms) lies at around 80 percent. In the upper range above 10 A, the power of the arc is so high that flames occur very quickly and without carbonization. On the other hand, the arc stability is extremely low. At the same time, the probability of significant flames lies below 35 and the probability of stable flames below 5 percent.

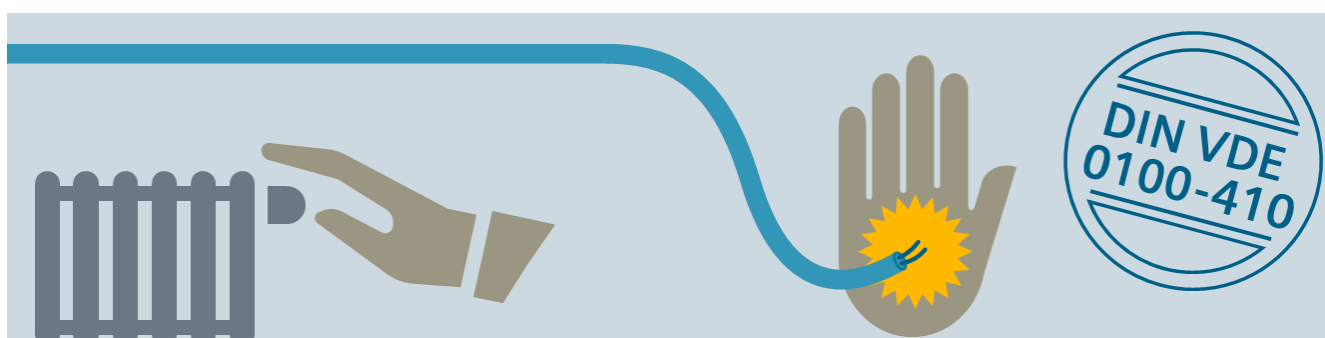
One reason for this is the vaporization of the carbonized

material, which prevents the formation of a carbon path. Moreover, high-power serial arcs sometimes melt the two copper conductors back together and "repair" the fault point. Even if stable arcs at above 10 A are rare, the brief and powerful flames that can occur in this range, however, represent a serious danger.

Detection of arcing faults

A portfolio of interacting protective components geared towards personal, line, and preventive fire protection is required for complete protection of electrical installations. Miniature circuit breakers and fuse systems are designed to protect cables, systems and devices in case of overload and short-circuit. They disconnect the current, depending upon the fault impedance, usually between phase conductors or between a phase conductor and a neutral conductor in the event of parallel arcs.

Residual current protective devices (RCDs) protect against dangerous electric shocks from indirect and direct contact by disconnecting the monitored circuit quickly and safely from the mains supply when a certain residual current is exceeded. The cause of the fault can be a defective electrical device, for example. Residual current operated circuit breakers (RCCBs) detect residual currents and arcing faults to earth and can provide additional fire protection in this case, depending upon the rated residual current. For many areas of application, the installation of RCCBs with rated residual currents of maximum 30 mA has therefore become mandatory in new buildings: for example, since 1984 in rooms with a bathtub or shower (DIN VDE 0100-701) and since 2009 also for all socket outlet circuits with a rated current up to 20 A if they are intended for use by non-experts and for general use (DIN VDE 0100-410).



Fault protection
»Protection against indirect contact«

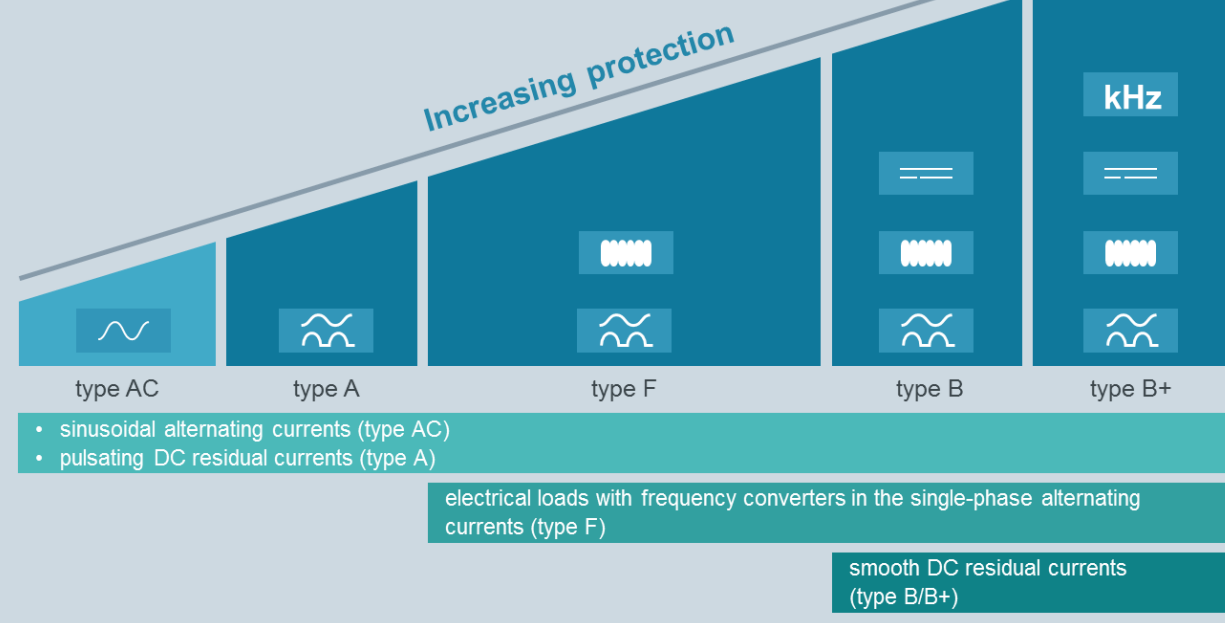
Protects people in the event of contact with extraneous electrically conductive parts (such as heating, water pipe) through automatic power shutdown – if a risk exists as a result of a fault due to the magnitude or duration of the touch voltage.

Additional protection
»Protection in case of direct contact«
with $I_{\Delta n} = 30 \text{ mA}$

Protects individuals if they come into direct contact with an active live part under normal operation conditions if the basic and/or fault protection fails.

When to use which residual current operated circuit breaker?

RCCBs – the right type for all cases



5SV3 RCCBs Type B/B+ are used in devices such as frequency converters, medical devices and UPS systems. Smooth DC residual currents or currents with low residual ripple may occur in the event of a fault on these devices. RCCBs type A are unable to detect these smooth DC residual currents.

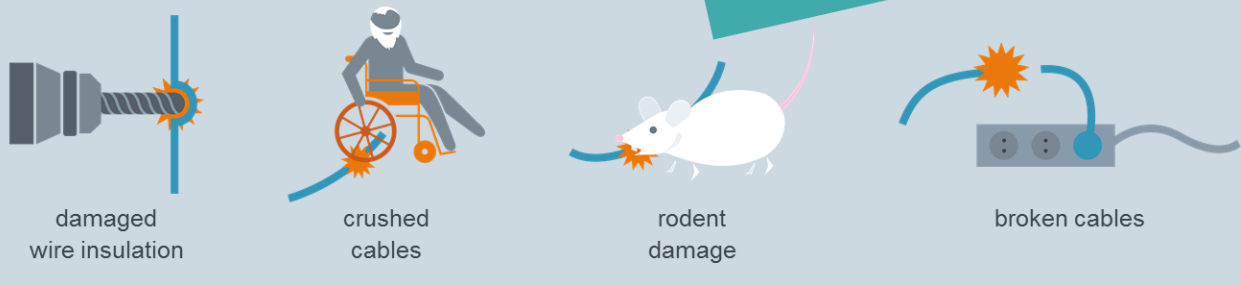
UC-sensitive RCCBs SIQUENCE of types B/B+ have an additional transformer with a control signal. By means of this additional installation, smooth DC residual currents can be evaluated, thus safeguarding the targeted protection function. With the patented SIGRES function, the RCCB is also suitable for use under harsh ambient conditions such as on building sites, in agriculture and in unheated rooms. Moreover, these devices only require a test interval of 24-months.

AFDDs for preventive protection

These standard protection devices available to date cannot detect serial arcing faults as these faults do not lead to an increase in the load current or to a residual current. If parallel arcing faults occur in connection with very high system impedance, the flowing current in the case of a short-circuit may, however, lie below the tripping characteristic of the overcurrent protective device, meaning a shutdown is not triggered or triggered too late.

Thanks to innovative SIARC technology, the AFDD is the only protection device that detects parallel as well as serial arcing faults. Common causes are, among others:

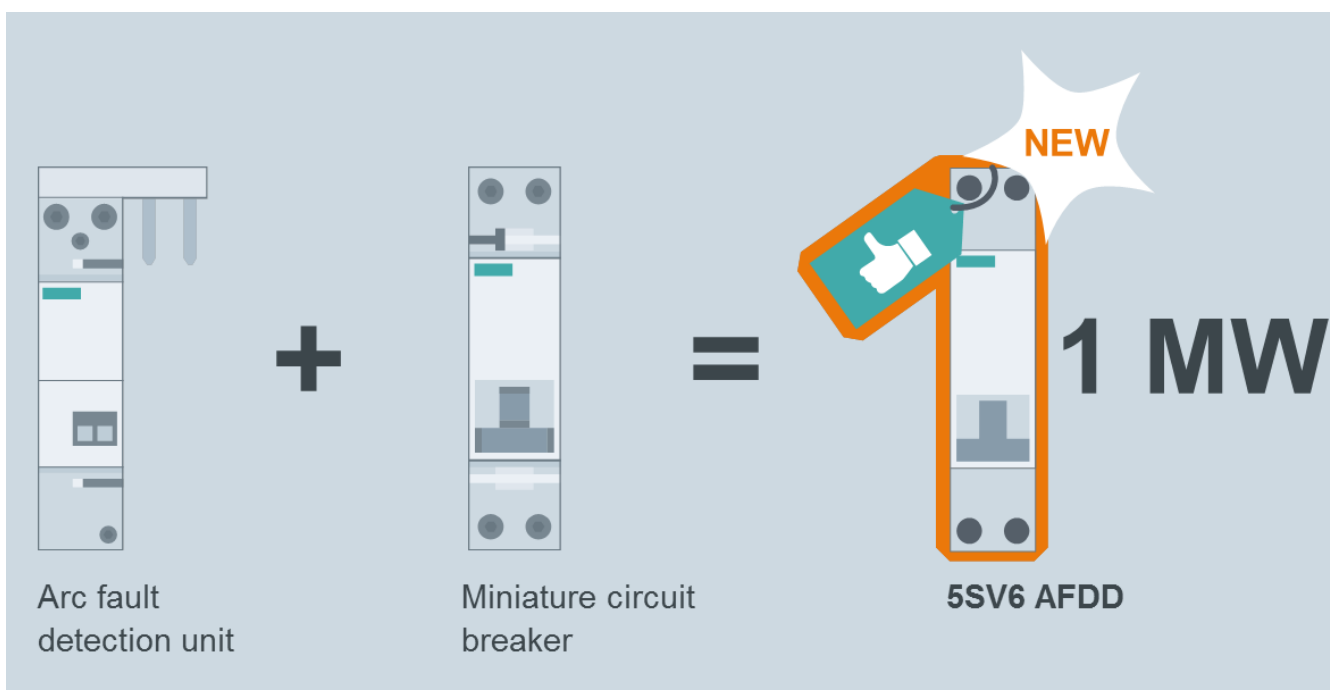
- + First arc fault detection device (AFDD) in the IEC market (2012) for preventive fire protection
- + First AFDD with integrated MCB in 1 modular width (MW)
- + World's smallest AFDD



AFDDs (arc fault detection devices), as offered by Siemens with the 5SM6 AFD unit und 5SV6 AFDD, close this previous safety gap. The devices are capable of detecting all types of arcing faults. Based upon technology that has been tried and tested for many years in the U.S., they not only detect current and voltage: The AFDD from Siemens also continuously measures the level, stability and duration of high-frequency noise thanks to the patented SIARC detection methodology. Integrated filters work with intelligent software to process, analyze and evaluate these signals according to numerous criteria in order to determine, for example, the total energy, arc energy, plateau arc voltage, arc stability and flame occurrence. If the conditions for an arcing fault are fulfilled, the connected circuit is shut down within a fraction of a second. Fire hazards, from electrical cables to terminal equipment, can thus be recognized and prevented at an early stage.

Arc-fault protection in the standards

In the United States, AFD units are known as AFCIs (arc-fault circuit interrupters) and have been mandatory for many years now. The International Electrotechnical Commission (IEC), the European Committee for Standardization (CENELEC), and the German Commission for Electrical, Electronic & Information Technologies (DKE) have also recognized the urgency of the matter and adopted arcing fault protection as a recommendation:



With the 5SM6 AFD units, which can be combined with MCBs or RCBOs, since 2012 Siemens has offered preventive protection in the IEC market against hazardous serial arcing. As an innovation, the 5SV6 AFDD is now the smallest arc fault detection device worldwide: The new version is the first device on the IEC market with an integrated miniature circuit breaker in only one modular width (MW). The 5SV6 is thus not only easily installable in new buildings, but as the first product for preventive fire protection, it also features straight-forward retrofitting in existing buildings. The standards-compliant extension of the electrical installation to include protection against electrical fires is thus quickly possible at any time.

The new standard IEC 60364-4-42 strongly recommends the installation of AFDDs in specific locations of use as the recognized state-of-the-art technology.

With the publishing of the German standard DIN VDE 0100-420:2016-02 "Low voltage electrical installations – Part 4–42: Protection for safety – Protection against thermal effects", the installation of AFDD has become mandatory as the state-of-art technology for many locations.

1. in bedrooms or recreation rooms in care homes or daycare centers for children, disabled and old people (e.g. child daycare centers and retirement homes)
2. in bedrooms or recreation rooms in apartments with unhindered access according to DIN VDE 18040-2
3. in rooms and other locations
 - Posing a fire risk due to processed or stored materials (as detailed in Section 422.3 of the standard)
 - With flammable building materials (as detailed in Section 422.4 of the standard)
 - In locations where irreplaceable goods are endangered (as detailed in Section 422.6 of the standard)

AFDDs are strongly recommended!

In Europe for many locations of use such as: wood-working shops, wooden buildings and barns, stores of combustible materials, airports¹⁾, museums¹⁾, and many more

Already mandatory in Germany acc. to DIN VDE standard

daycare centers²⁾, retirement homes²⁾, barrier-free apartments²⁾



1) with irreplaceable goods
2) in bedrooms and lounges

Specifically: In all electrical installations planned after publishing the current version of DIN VDE 0100-420 in February 2016, the installation of arc-fault protection devices is mandatory in the defined areas of application.

The DIN VDE 0100-420 standard describes the requirements for the protection of humans, assets and plants against thermal effects and fire hazards due to faults in electrical equipment and systems. It is to be used for new installations, as well as for expansions of existing electrical installations.

Section 421.7 has been supplemented in the new version of the standard. It describes the deployment of so-called arc-fault detection devices, i.e. AFDDs. With the adoption of this protection device, the deployment of AFDDs became a generally accepted engineering practice, and its installation is now mandatory for the following applications in single-phase alternating voltage systems with an operational current not higher than 16 A:

This also includes wood-processing plants, paper and textile factories, wooden houses, laboratories*, public buildings*, museums, railway stations and airports. The installation of AFDDs is recommended in additional areas, for example, all rooms with sleeping quarters, or for rooms or locations with fire-spreading structures (e.g. in high-rise buildings).

You can find more information on advanced protection of electrical installations and AFDDs at:

[siemens.com/protection-concept](https://www.siemens.com/protection-concept)
[siemens.com/afdd](https://www.siemens.com/afdd)

* With irreplaceable goods or materials