WHITE PAPER

THE DETECTION OF ELECTRICAL ARCS

IN LOW VOLTAGE INSTALLATIONS

THE GLOBAL SPECIALIST IN ELECTRICAL AND DIGITAL BUILDING INFRASTRUCTURE

legrand®

In electrical installations, fire risks have always been considered as a major threat. Fires of an electrical origin and their causes are well known. One cause, the electrical arc, has not been mastered until now. To understand and fight the electrical arc, we need to characterize and differentiate its different forms. Electrical arcs can be "series", "parallel" or "to earth".

The **Arc Fault Detection Device (AFDD)** is the modular solution to prevent fire risks in residential and tertiary electrical installations, by detecting the electrical arc and opening the faulty circuit.

In some instances, standard modular protective devices can provide protection, but sometimes, they are unable to detect the electrical arc. The AFDD covers the gap, thanks to the high performance requirements defined in the product standard.

Some circuits have to be protected as a priority because of the high level of risk level or because of the potential damage which might occur. The Legrand AFDD has been engineered to meet all of these requirements.

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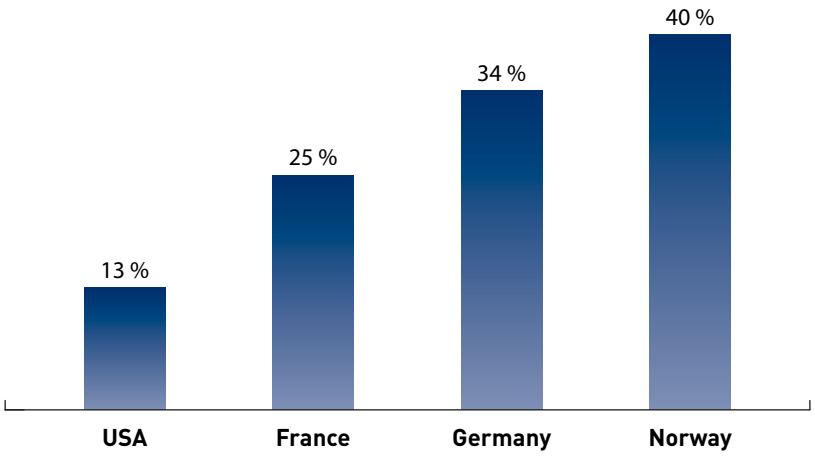
SOME FIGURES

Firefighting organizations, associations for the fire risks prevention and insurance companies collect data which help us to understand the situation.

According to insurance companies, in France, out of 250 000 household fires, 62500 (25%) were of an electrical origin.

Depending on the country, the proportion of electrical fires varies as we can see in the graph below:



In the United States , where the fire risk is very high due to the construction materials employed, a product comparable to an AFDD (called locally Arc Fault Circuit Interrupter) has been used since 1999, with positive and visible results: Statistics show that the proportion of electrical fires is much lower than in countries where AFDDs are not installed.

[2] (www.nfpa.org), (www.developpement-durable.gouv.fr), (www.ifs-kiel.de/), (www.sintef.no)

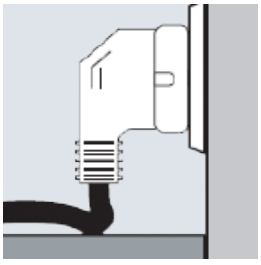
CAUSES OF ELECTRICAL FIRES

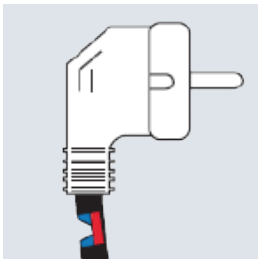
In every country, electrical installations are governed by national standards whose aim is to prevent electrical hazards thanks to strict rules for design and installation by professionals. Over the time, these installations may evolve and get older.
The causes of electrical fires are rarely visible and are generally due to overheating, or to an arc occurring between two conductive parts, but they can occur due to other reasons, which are listed below:

DEFAULT	PHENOMENA	ORIGIN	CONSEQUENCE	PROTECTION
OVERLOAD	Overcurrent circulating when there is no electrical fault in a circuit	Improper load, too many devices plugged into thesame socket, undersizing of the cables, etc.	Overheating which can lead to the destruction of cable insulation	Fuse Circuit-breaker
SHORT-CIRCUIT	Overcurrent produced by a low impedance fault between two conductors with different potentials.	Poor installation misuse, defective equipment ...	High current of short duration causing explosion and risk of fire.	Fuse, Circuit-breaker
FAULT CURRENT	Current that flows to earth via the exposed conductive parts or the protective conductor following an insulation fault.	Deterioration of the equipment casing (humidity, heat, pollution, etc.)	Low current (µarc) that can lead to conductive carbonization which allows more and more current to flow into the faulty part. Above 300mA, there is a strong risk of fire.	RCBO, RCCB
TRANSIENT OVERVOLTAGE	Very high voltage of short duration (Eg. 25000V – 50µs)	Lightening	Deterioration of the equipment with fire risk.	SPD
NETWORK OVERVOLTAGE	High voltage of long duration (Eg. 300 V – 1 min in 230 V installation).	Neutral conductor accidental opening, works on electrical grid, etc.	Destruction of electronic components with risk of fire.	Power overvoltage protection (POP)
ARC	Current flowing in the air between two conductors with different potentials.	Deterioration of cable insulation, loose electrical connection...	Risk of combustion of the materials in the vicinity with strong risks of fire.	AFDD

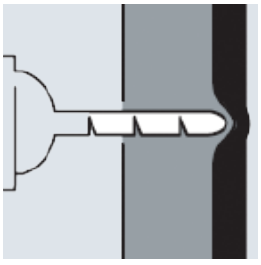
In some cases, a protective device such as an MCB or an RCCB is sufficient but these are unable to stop electrical arcs.
Residual current protective devices lower the risk of electrical fires by detecting the current flowing to the earth. This current may produce an arc and consequently, cause fire. But arcs other than those due to an earth fault are not detected.
Below are some illustrations of situations where electrical arcs can occur :

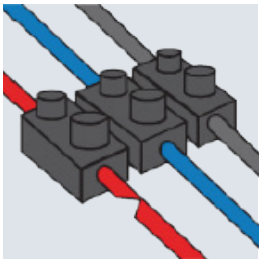
■ **Misuse**



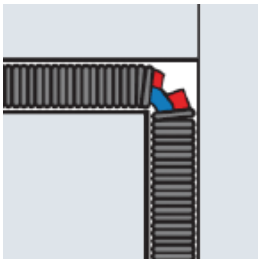


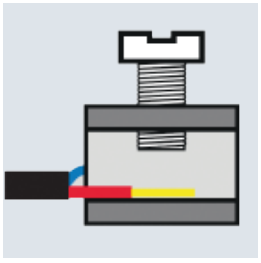
■ **Accident during works**



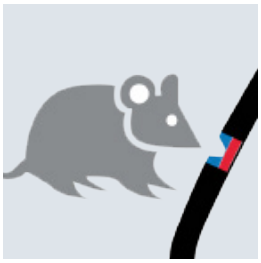


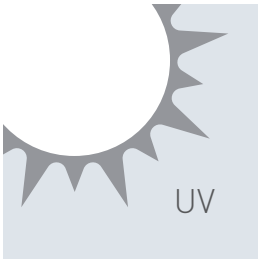
■ **Aging installations or equipment**





■ **Environment**





Some situations can be avoided by good practice, but it is difficult to prevent accidental drilling of a conductor or the abnormal aging of insulation.

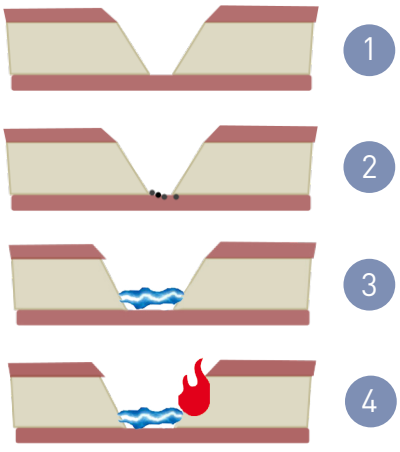
ARCS IN ELECTRICAL INSTALLATIONS

An arc occurs when two conductive parts with different potentials are close enough to let a current flow between them.
As a first step, the air becomes ionized. This phenomenon creates the conditions for the appearance of a conductive channel.

In an electrical installation, an arc can occur in two different ways:

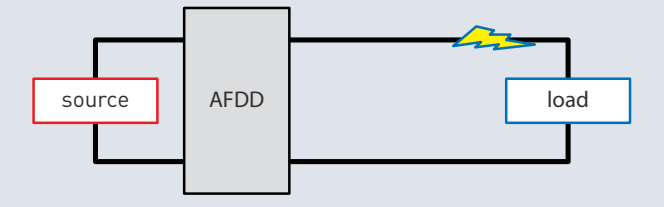
BY THE PROGRESSIVE CARBONIZATION OF A NEIGHBORING MATERIAL

This might occur when a conductor is damaged (see below) or when a terminal is not correctly tightened.
In this situation, a material in contact with conductive parts facilitates the creation of the arc.



1. Example with a cable cut or disconnected
2. Brief micro arcs occur from time to time, assisted by humidity, pollution, insulation aging, etc.
3. These arcs carbonize the insulating material. This conductive carbonization accumulates. A continuous arc appears.
4. When the energy dissipated by the arc reaches a critical level, materials in the vicinity are likely to ignite.

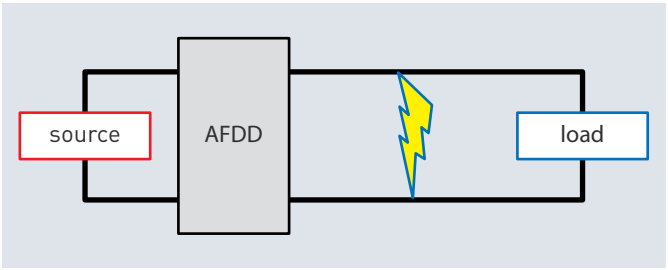
This kind of default is characterized as a serial fault.
It occurs on the same conductor.



BY A SHORT-CIRCUIT OF LOW INTENSITY

Example with two active conductors (L1/N or L1/L2) with insulation damage caused by an external factor (Eg. Corrosive environment or a tool). Current flows between the two conductors but it is too low to be interrupted by the magnetic release of the circuit breaker. Again, when the energy dissipated by the arc reaches a critical level, neighboring materials are likely to ignition.

This example is characterized as a parallel fault. It occurs between two conductors of different polarities.



These two illustrations, with similar consequences for the ignition of neighboring materials, correspond to two different types of arc in their "electrical signature".

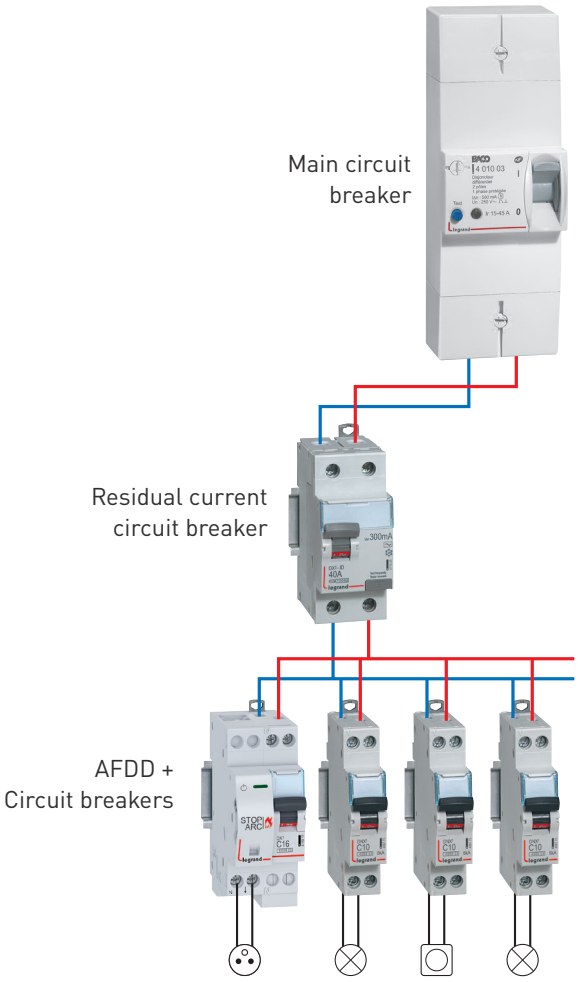
TECHNICAL SOLUTION
THE AFDD

An arc fault detection device (AFDD) is installed in the electrical distribution board or consumer unit, in a residential or similar installation. Its aim is to reduce the fire risk due to arc faults by opening the faulty circuit.

It is installed on the downstream side of the devices protecting against overloads, short-circuits and earth leakages.

It can be integrated into these functions, as Legrand's solution, for compactness and ease of installation. It is installed at the origin of the circuit to be protected and cannot be used as cabinet main incomer.

■ **Example of integration within a conventional installation (France) :**



The AFDD is designed with a microprocessor capable to analyze in real time multiple electrical signals and to differentiate the signature **of a series arc or, a parallel arc, or an arc to the earth** from the one of a parasite disturbance in order to preserve the security of the circuit and avoid any nuisance tripping.

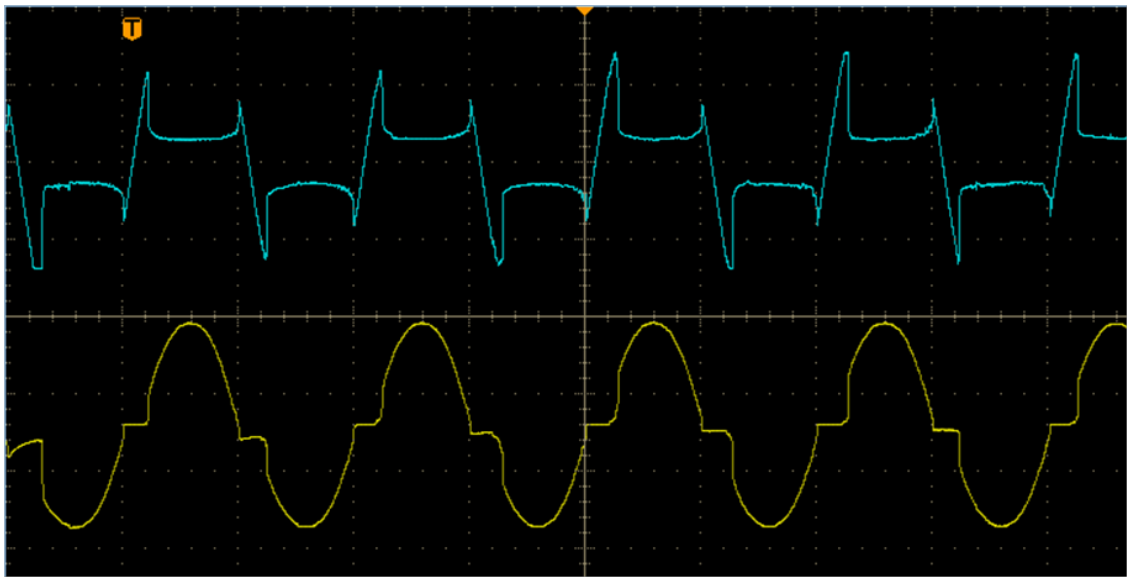
The AFDD is immune to nuisance tripping due to frequent non-dangerous arcs occur in low voltage installations, for example, during the switching of loads by means of contactors or wiring devices, or when using electrical equipment such as drills or vacuum cleaners.

The identification of dangerous electrical arcs is based on several factors, all of which are analyzed simultaneously :

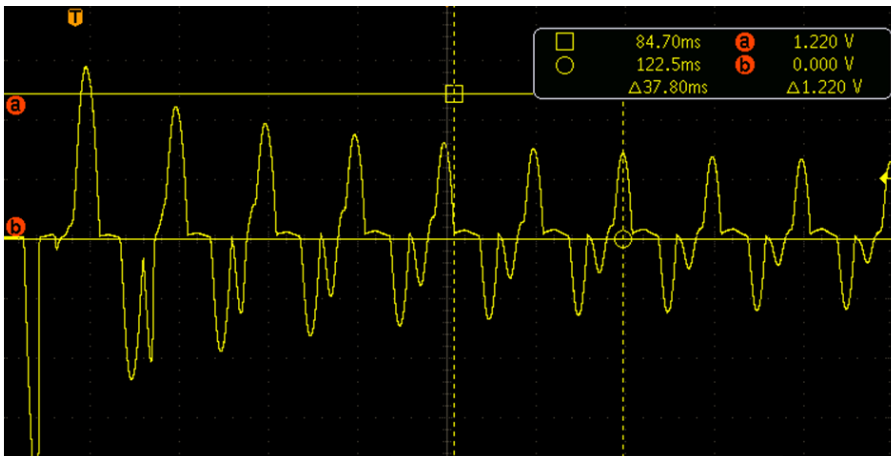
- Signature or disturbance generated by the arc,
- Duration of the phenomenon (normal switching operations generate brief arcs),
- Occurrence/regularity of the signal (an electrical motor produces arc currents with constant forms).

Legrand Arc fault detection technology is based on a patented algorithm, specifically developed to fulfill these requirements. It monitors 12 different parameters in the electrical signal in order to identify the dangers of an arc.

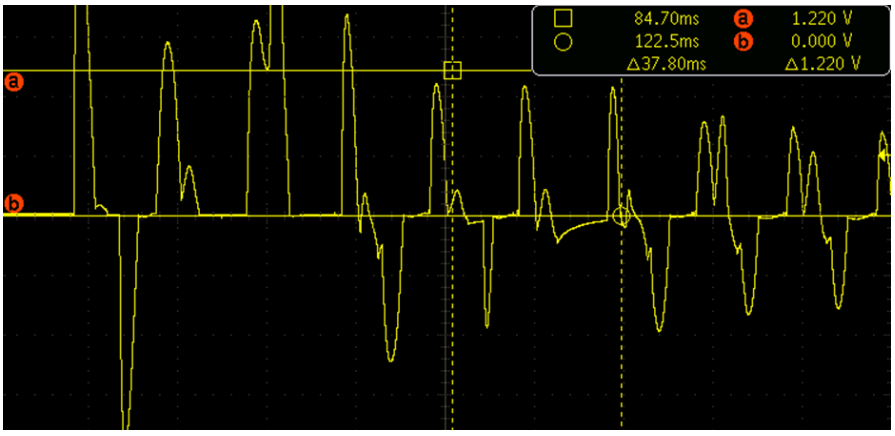
On the other hand, circuits may be polluted by electronic appliances or switching operations in the electrical grid. The functioning of Legrand AFDD is maintained despite these disturbances which may hide the presence of an electrical arc.



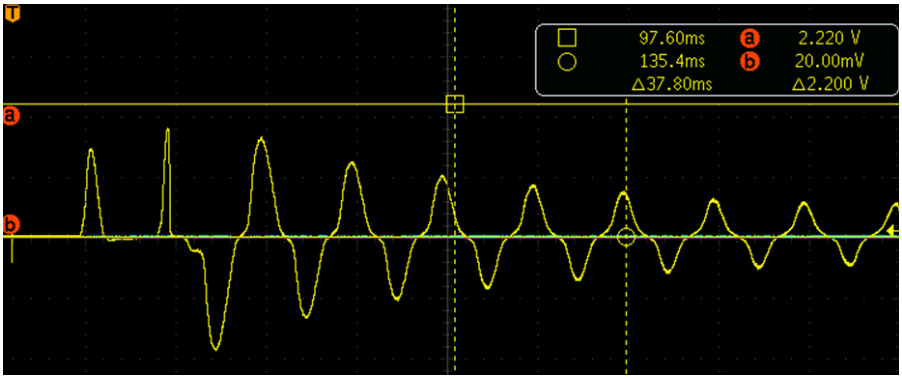
Example a series arc, whose current reaches 2.5A (yellow curve). The blue curve represents the voltage.



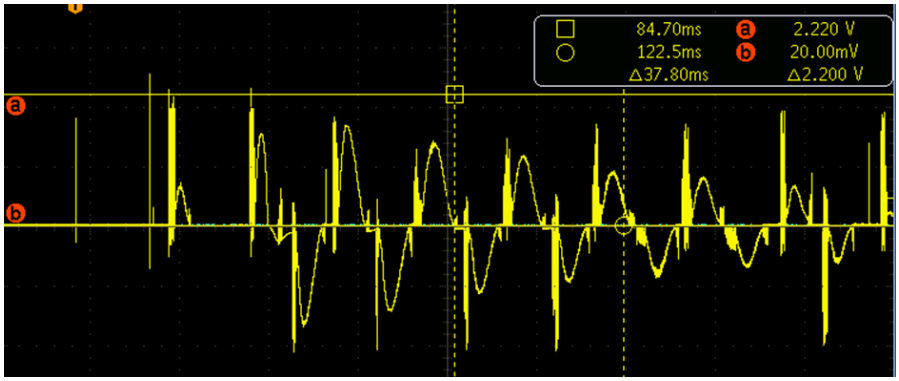
Example with disturbances generated by a halogen lamp.



Superposition of disturbances due to a halogen lamp and a series arc.



Another example: disturbances generated by a drill.



Superposition of disturbances due to a drill and a series arc.

In addition to the ability to distinguish dangerous arcs from functional arcs, the response time is also crucial. The energy dissipated by the arc, is, among other factors, proportional to current and time. The AFDD standard IEC 62606 gives the maximum tripping times according to current values :

MAXIMUM TRIPPING TIME FOR AFDDs U_N = 230 V & 400 V						
Test arc current (effective value)	2,5 A	5 A	10 A	16 A	32 A	63 A
Maximum operating time	1 s	0,5 s	0,25 s	0,15 s	0,12 s	0,12 s

The values presented below are the result of calculations and tests carried out in a laboratory. The test shown below was conducted using a damaged cable, as defined by the standard, with a current of 10 A and a voltage of 230 V AC. The protection device is an MCB :

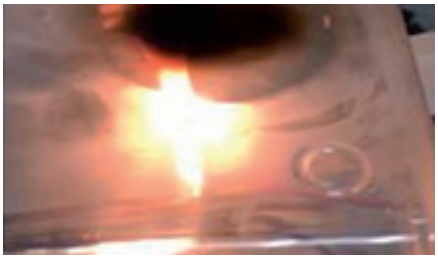
t = 0s

t = 0.4s

t = 0.53s

t = 1.26s

t = 1.93s



t = 2.76s

Installation standards as well as product

The same test carried out with an AFDD gives the following results :

t=0s

t=0.13s

t=0.23s

In less than a quarter of a second, the electric arc is extinguished and the risk removed.

If the first function of the AFDD is to detect and stop the electrical arc, it is also subject to exposure to every other kind of fault occurring in an installation: short-circuit, overloads, earth leakage, overvoltage, etc. These defaults are dealt with by other protective devices in a very short time as required by standards . The DX³ Stop Arc is capable of withstanding all of these faults without a reduction in its performance.

Designed to be combined with an MCB or an RCBO, the AFDD Legrand is tested as a complete protective device, and meets the requirements of IEC/EN 62606.

STANDARDS AS PROOF OF QUALITY

Standards have always focused on fire risks. Nowadays, the use of circuit breakers, residual current devices, and other protective devices capable of withstanding fire (test with glow wire at 650°C or 960°C) are required by installation standards to reduce the fire risk.

Installation rules, defined by experts and generally approved by external bodies, also contribute to reducing the fire risk.

Often, it is the evolution of new technologies which enables us to move forward in the prevention of fires.

At European level, the standard IEC 60 364-4-42 introduced AFDDs for the prevention from fires in 2014. AFDDs conform to **IEC 62606** or to **EN 62606**. For the time being, their use is recommended.

The priority is to focus on the circuits below as they are subject to fire risk, or to people's safety :

- Bedrooms or sleeping areas
- Premises constituting a risk of fire due to the nature of goods processed or stored therein (barns, factories, etc)
- Premises constructed with combustible building materials (wooden structure buildings, etc) or where fire might spread easily (sky scrapers)
- Premises where irreplaceable goods might be in danger

THE LEGRAND AFDD
THE DX³ STOP ARC RANGE

Based on 10 years' experience in the USA with a product of similar function, the DX³ Stop Arc meets all requirements.

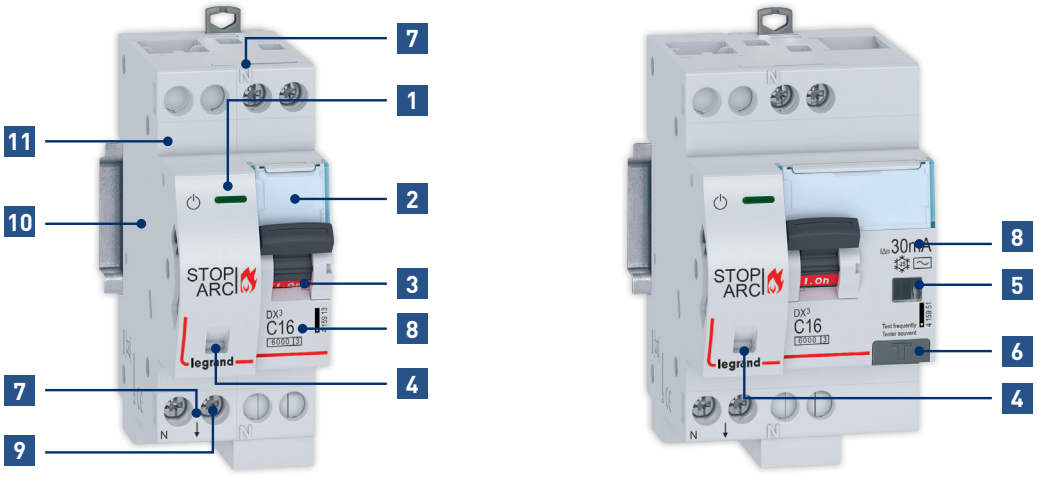
The DX³ Stop Arc is combined with an MCB or a RCBO up to 20 A, and it is factory assembled , according to classification 4.1.2 of the **IEC/EN 62606**.

The two products are connected in series. Disassembling is not permitted. This eliminates the risk of mistakes during assembly on site. The product manufactured is fully enclosed, as an additional guarantee of quality.

The DX³ Stop Arc range meets the installation wiring requirements of every country.

It is offered in two versions electrically supplied by the top or by the bottom and compatible with pin busbars or fork busbars.

Designed to give users peace of mind, these products remain faithful to Legrand philosophy: simple, intuitive, quick installation and as ever, an uncompromising level of quality.



1 Indicator light showing the product operating status
- off: the product is not powered (fault),
- green: the product is working normally
- red: the product is faulty

2 Innovative label-holder for easy circuit identification

3 Colour marking on the handle to view the status of the circuit breaker contacts: Red = I-ON (contacts closed),Green = O-OFF (contacts open).

4 Mechanical indicator for tripping on arc fault

5 Trips on residual current faults are designated by a yellow indicator

6 Manual test for residual current function

7 Neutral position and wiring direction (downstream terminals) clearly identified to prevent connection errors

8 Clear marking including the catalogue number and main technical characteristics

9 Clamping screw for flat-blade or pozidriv screwer

10 Compatible with the various control and designating auxilaries

11 Technical marking areas

Notes

Notes

Notes

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All technical data of the products inside this workshop specifications book are available on : **www.export.legrand.com/en/documentations/**

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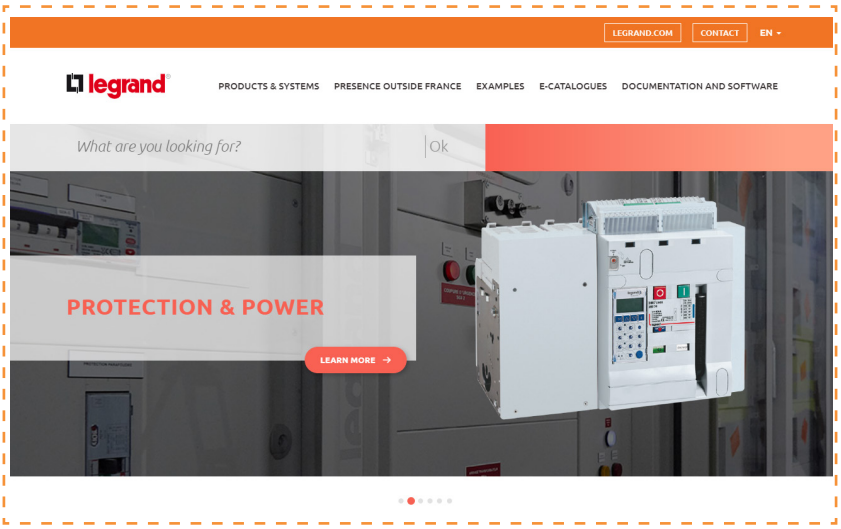
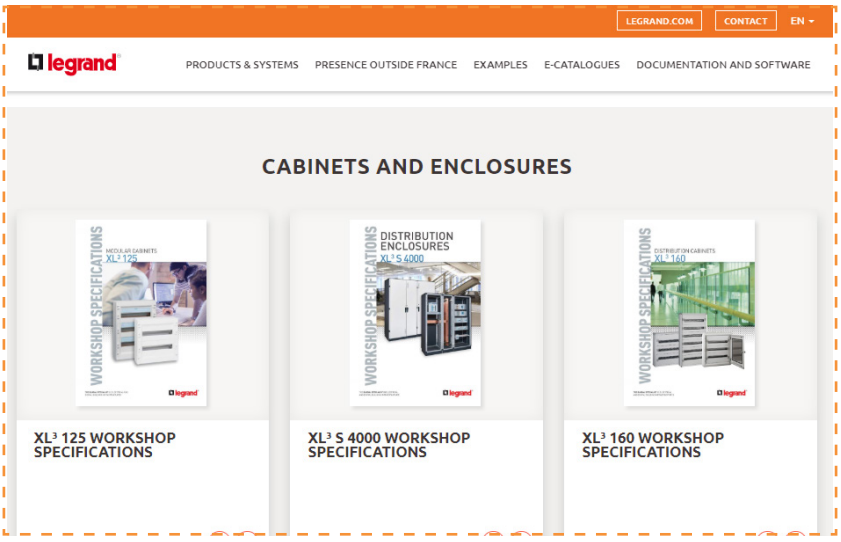


>Documentation



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