

ADVANCED ELECTRICAL PROTECTION

Selection Guide



ABOUT CROUZET

Crouzet is an independent company **manufacturing mechatronic components for demanding applications in Aerospace & Transportation, Energy, Building and Machinery Industry.**

Crouzet provides **Switches and Sensors, Electromechanical Actuators, Electrical Protection Equipment, Cockpit Controls, Automation Controllers and Relays, and Instrumentation Services.**

Since 1921, Crouzet has a heritage of close collaboration with customers in the development of products, from standard components to fully customized solutions.

Crouzet's customers and partners can rely on our teams worldwide to always meet and often exceed their expectations. Driven by innovation, our experts are focused on designing and delivering the right product for the right application.

Crouzet is your trusted partner of choice to face industrial challenges of today and tomorrow.

WORLDWIDE PRESENCE



📍 HEADQUARTERS

■ SALES OFFICES

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WIRE PROTECTION

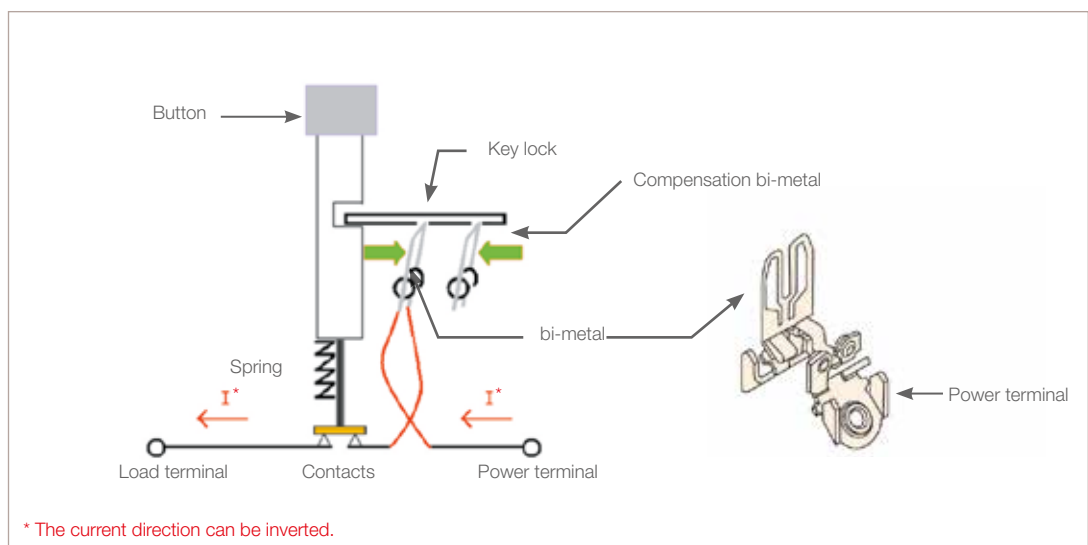
HOW DOES IT WORK?

ELECTROMECHANICAL CIRCUIT BREAKERS

In this type of Circuit Breaker, the current sensing is done by a bi-metal. The bi-metal is also part of the actuator that will open the line: the bi-metal is bent by heat coming from the current, the bi-metal moves the key lock, releases the latch and opens the line.

The Circuit Breaker bi-metal bends and releases the latch according to the overload current value and the overload duration (the bending is independant of the current direction).

If any, the auxiliary contact are galvanically isolated from the power and gives the state of the contacts (open or closed).



«LIGHT, SIMPLE AND SAFE»

Light:

Our single phase EN2495 and MIL MS33201 V compliant model is the lightest in the world (<20 g with screws, washers and nut).

Simple:

- › Designed to be reused several times, spare components are not required
- › Can sometimes be used as a switch (within the defined endurance limits), they therefore perform a dual function of switching and protecting

Safe:

- › Our intrinsic fail safe** and trip free* conception enable a high level of safety (generally 10^{-9} Flight Hours (FH) of not opening on a short circuit)
- › The temperature compensation ensures high performance over a wide temperature range (usually -60°C to +125°C)
- › Excellent resistance to mechanical stress
- › High current level peaks and high current flows tolerance

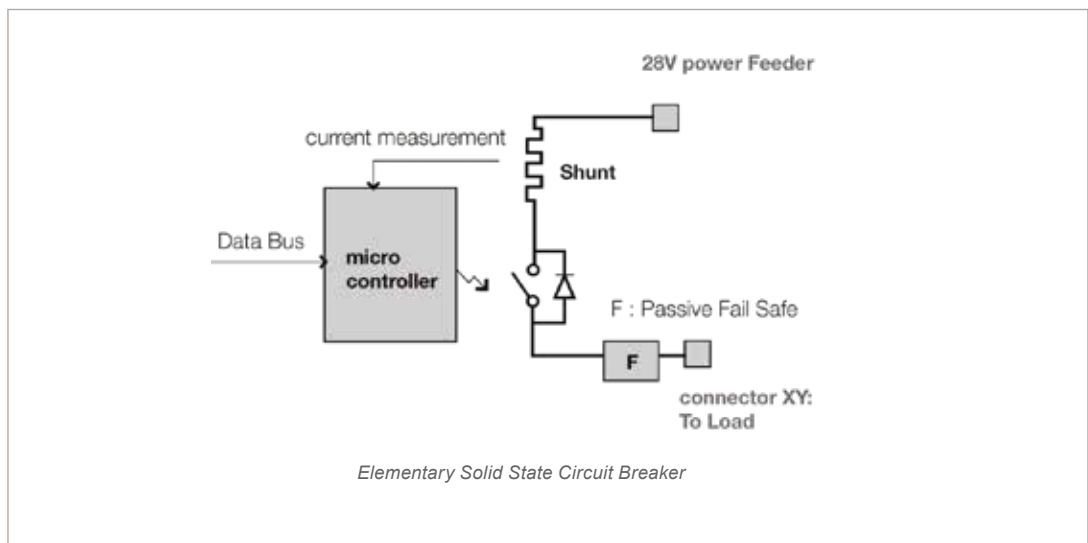
* **Trip free**: even if the pushbutton is maintained in the closed position, the opening of the contacts (and therefore of the electric circuit) is ensured in the event of a current surge or short-circuit.

** **Intrinsic safety (Fail safe)**: the Circuit Breaker has been designed with a fuse element to ensure that the electric circuit is opened in the extreme case of a blocked mechanism or glued contacts.

SOLID STATE CIRCUIT BREAKERS (SSCB)

In this type of Circuit Breaker, the current sensing is done by a shunt or a Hall sensor in DC or a Current Transformer (CT) in AC. A microcontroller or FPGA acquires the current and simulates the i^2t curve, the switch function is often done by MOSFETS, bipolar transistors, SCR (i.e. thyristors).

The microcontroller will integrate the current going through the shunt and will open the MOSFET according to the current value and overload duration.



The patented fuse **F** gives a 10^{-9} FH safety level (equivalent to mechanical Circuit Breakers) and still gives the possibility of reprogramming the Rated Current value by software.

«MORE THAN A THERMAL SWITCH»

A SSCB is more than a thermal switch because when it is connected to a data bus, it provides intrinsically functions such as:

- › A remote switching ability (useful in application: contactor or relay function)
- › Dimmer or chopper function (useful in applications such as: motor speed control, light dimming, soft start)
- › Current monitoring (prognostic applications, load failure detection)

Also,

- › They are not susceptible to vibrations (useful in applications with high acceleration (Gs): aircraft, guns...)
- › They generate no audio noise (useful in applications such as: submarines, electric tanks, medical...)
- › The micro controller can run the arc fault protection algorithm
- › They can become a PLD with a protected power output (see p. 37)
- › They can protect the load (see p. 37).

WIRE & STRUCTURE & FUEL TANK PROTECTION

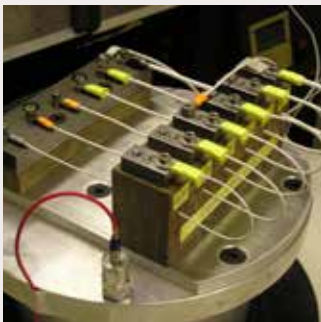
ARC FAULT DETECTION



Wet arc



Parallel arc



Series arc

EWIS PROTECTION

The 14CFR Part 25 subpart H requirements asks aircraft OEM to consider the electrical wiring interconnection as a system. This means that the airworthiness of the wiring must be guaranteed for the complete lifetime of the aircraft.

AFCBs are a way to obtain compliancy to AC 25 1701-1.

The Advisory Circular (AC 251701-1) gives guidance for subpart H compliancy and indicates that a safety analysis of the Electric Wiring Interconnection Systems (**EWIS**) has to be done.

To certify the EWIS, the constructor must show a proactive approach to mitigate risks and perform a zonal analysis (EZAP).

When performing this analysis, it is very important to keep in mind that **«regardless of probability, any single arcing failure should be assumed for any power carrying line»** (page 31 of the AC) because the traditional way of thinking which was: «optional systems, like in flight entertainment, cannot cause a catastrophic failure condition» is not a valid assumption.

Locations where arcing must be mitigated:

- A** In flight entertainment area
- B** Cargo and baggage compartment door actuators
- C** Fuel tanks
- D** SWAMP area (Severe Wind And Moisture Problem area) such as wires in landing gear well or cockpit window heater or wing defrost heaters
- E** Galleys to protect electrical socket appliances such as: Cooktop ovens, waste compacting machines, coffee machines etc...
- F** Places where due to vibration, heat, aging or after an incorrect maintenance operation there is a risk of a power line touching:
 1. a critical hydraulic actuator line
 2. pressurized air line (air duct) or flight critical data line
 3. mechanical control system cable
 4. oxygen lines
 5. fuel lines
 6. water and water/waste line (and below them in case of dripping)
 7. hot air ducts

In case of an arc inside a bundle, arc fault technology will preclude a chain reaction in the bundle from inducing the loss of the complete bundle. Instead there will be a «controlled» deterioration of the wire(s) giving time for maintenance to be aware of the fault (by using the information coming from the circuit breaker) and thus avoiding a potential catastrophic situation.

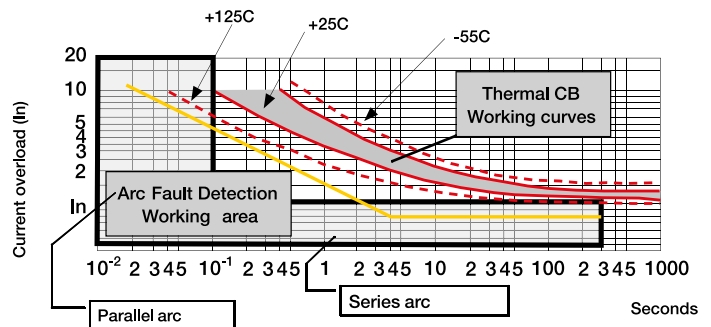


Single pole AFCB

The algorithm in the electric board works faster than the thermal bi-metal function as shown on the adjacent chart.

HOW DOES ARC FAULT PROTECTION WORK?

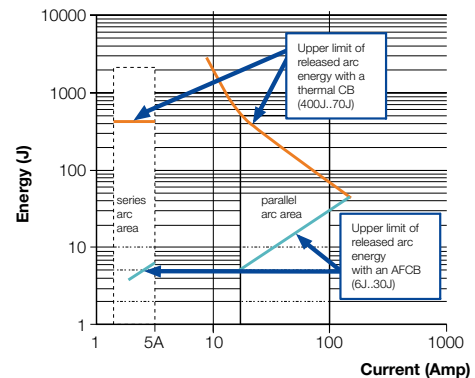
AFCBs combine the safety of standard Circuit Breakers and high accuracy electronics to mitigate arcing. Each standard thermal Circuit Breaker is equipped with an electronic board in order to analyze the current waveform in real time to detect if arcing is occurring.



ARC FAULT WILL CLEAR THE FAULT FASTER THAN THERMAL PROTECTION

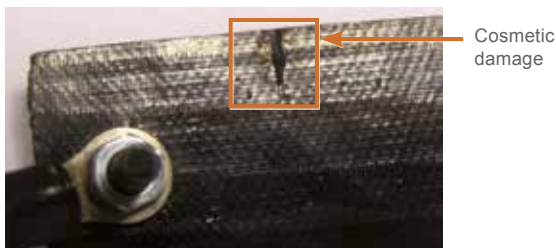
In case of an electric hazard, the arcing energy (thus mechanical damage) is divided by a magnitude (generally 10) as shown in the adjacent chart.

The quick opening time of the GFCB-AFCB (generally 12 msec) will not release sufficient energy to puncture the conduit or the tank's skin (a pure thermal circuit breaker will open on an arc or a shorting current in 200 ms, thus 10 times slower which releases sufficient energy to puncture the tank's skin or conduit).

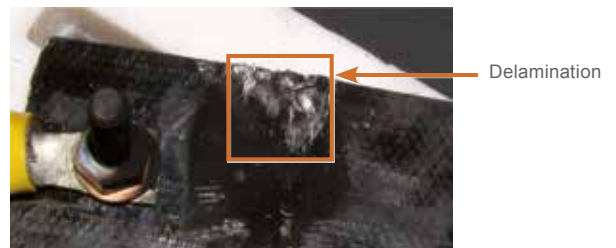


CARBON COMPOSITE (CFRP) PROTECTION

Carbon Fibres Reinforced Polymer (CFRP) can be damaged (delamination) and can **ignite** in case of arcing. The use of arc fault protection will **mitigate** damage and risk significantly as illustrated below:



230 VAC Fault with arc fault protection:
only cosmetic damages appears



230 VAC Fault without arc fault protection:
delamination of the fibers

WIRE & HUMAN & FUEL TANK PROTECTION

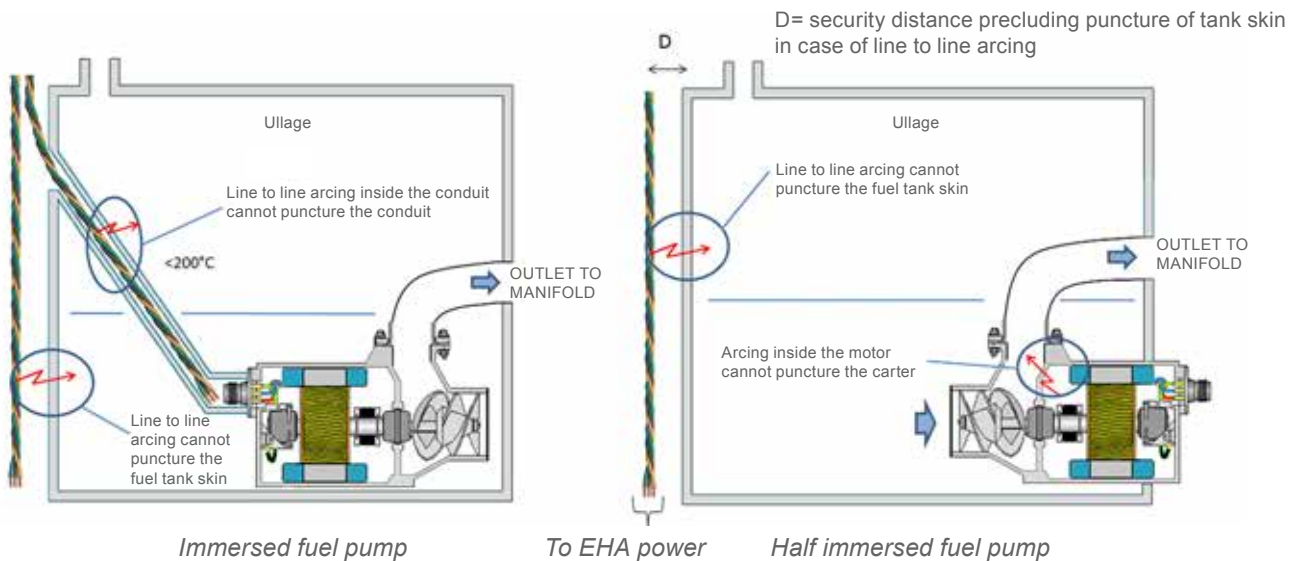
GROUND FAULT CIRCUIT BREAKER (GFCB) WITH ARC FAULT

FUEL TANK PROTECTION

Following SFAR88 recommendation, the FAA and EASA have compelled PART 25 aircraft to protect fuel tanks with Ground Fault. The purpose of these Ground Fault protection device is to preclude fuel tank puncture by reducing drastically the amount energy liberated by a fault.

Documents **AC25981** and **AMC25981(a)** state that:

«any components located in or adjacent to a fuel tank must be qualified to meet standards that assure, during both normal and failure conditions, ignition of flammable fluid vapors will not occur».



The reduction of damage concerns also:

- › Pylons & nacelles and small dimension aircraft where power line are routed near data buses or hydraulic tubes.
- › Wings where torque tube disconnections can cause severe damage to the wiring.
- › Composite wings with high power electric actuators (EHA, EBHA) in the vicinity of fuel tanks.

THE GF-AFCB: A GFI CAPTURING LINE TO LINE ARCING

Traditional Ground Fault protection do not capture series arcing or line to line arcing because these two faults do not create a leakage current to the ground (i.e. the CT that measures the homopolar current will still read «zero» with one of these 2 faults occurring). By adding arc fault detection on each line, the GF-AFCB is a GFI and a circuit breaker that detects these 2 wire faults.

THE GF-AFCB STRUCTURE

