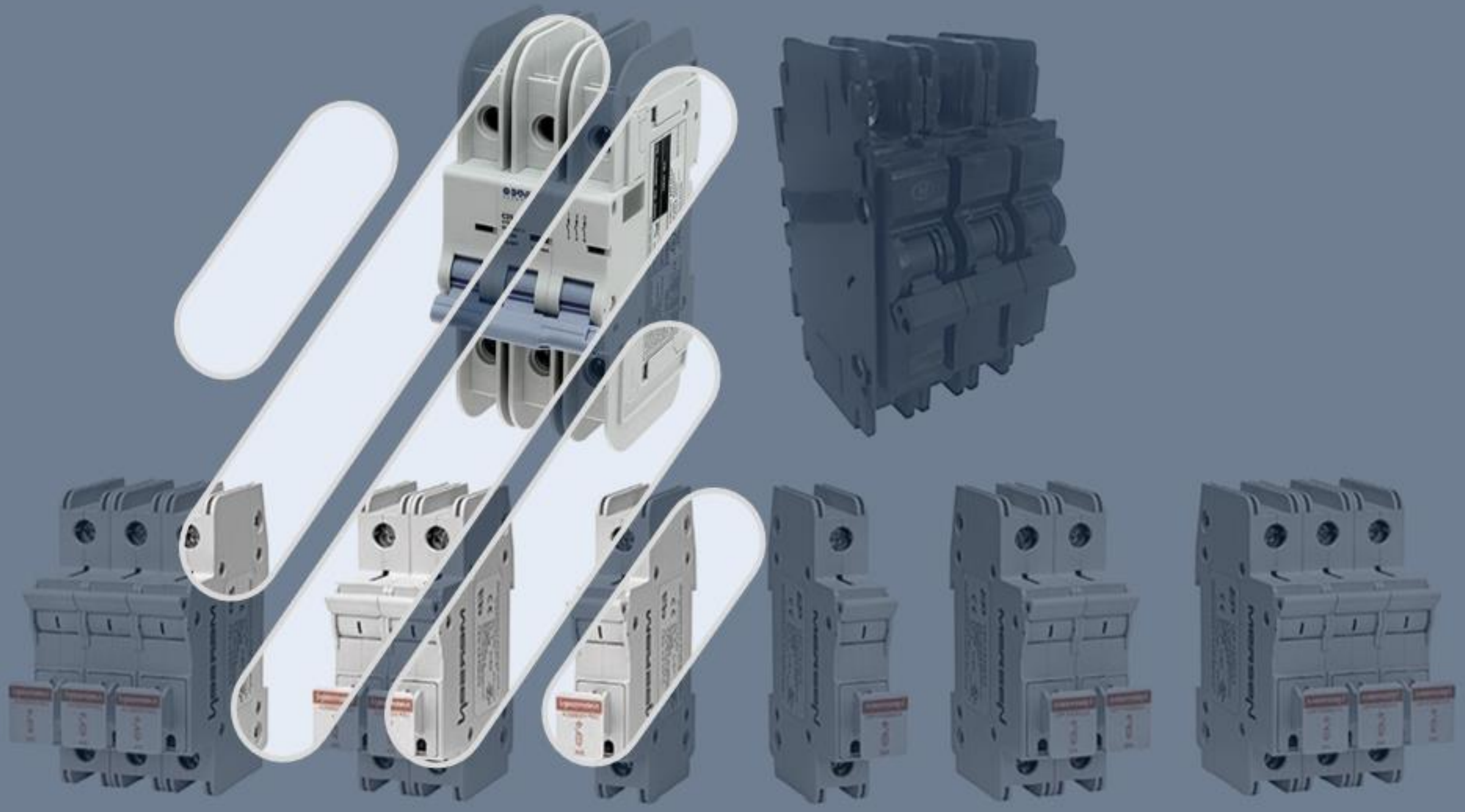


MCA

Electrical Distribution . Controls . Metal Fabrication

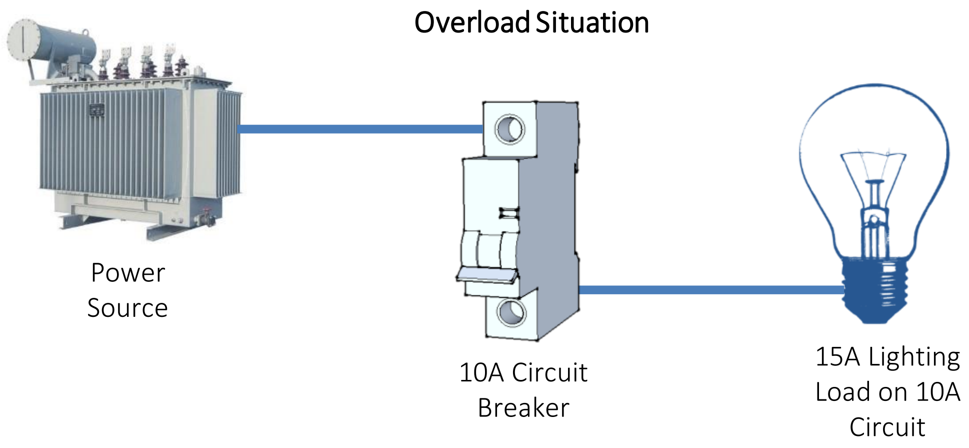
CIRCUIT BREAKER APPLICATION GUIDE

MCA FABRICATION Circuit Breaker Function

Overload Protection

An overload occurs when a circuit begins to slowly and slightly exceed the rating of the breaker's circuit breaker rating. This event is usually due to the load on the circuit drawing more current than would be expected during normal operation. The overload is characterized by a slight increase in ampacity over time and the circuit breaker will take multiples of seconds to open the circuit.

Example: A light ballast draws 10A of current under normal conditions. The ballast is at the end of its service life and begins to draw 15A of current. The thermal element of the circuit breaker will recognize the increase in ampacity and will open the electrical circuit if the overload condition persists for many seconds.



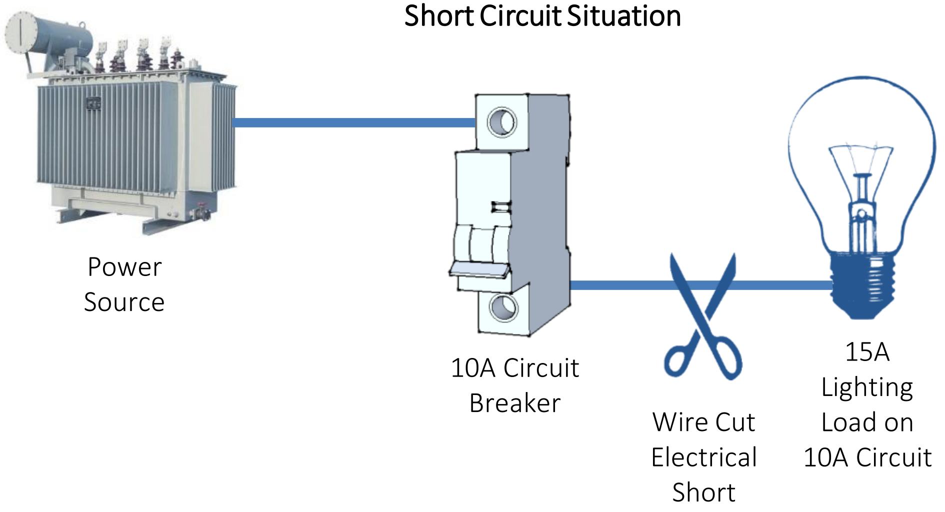
MCA FABRICATION Circuit Breaker Function

Short Circuit Protection

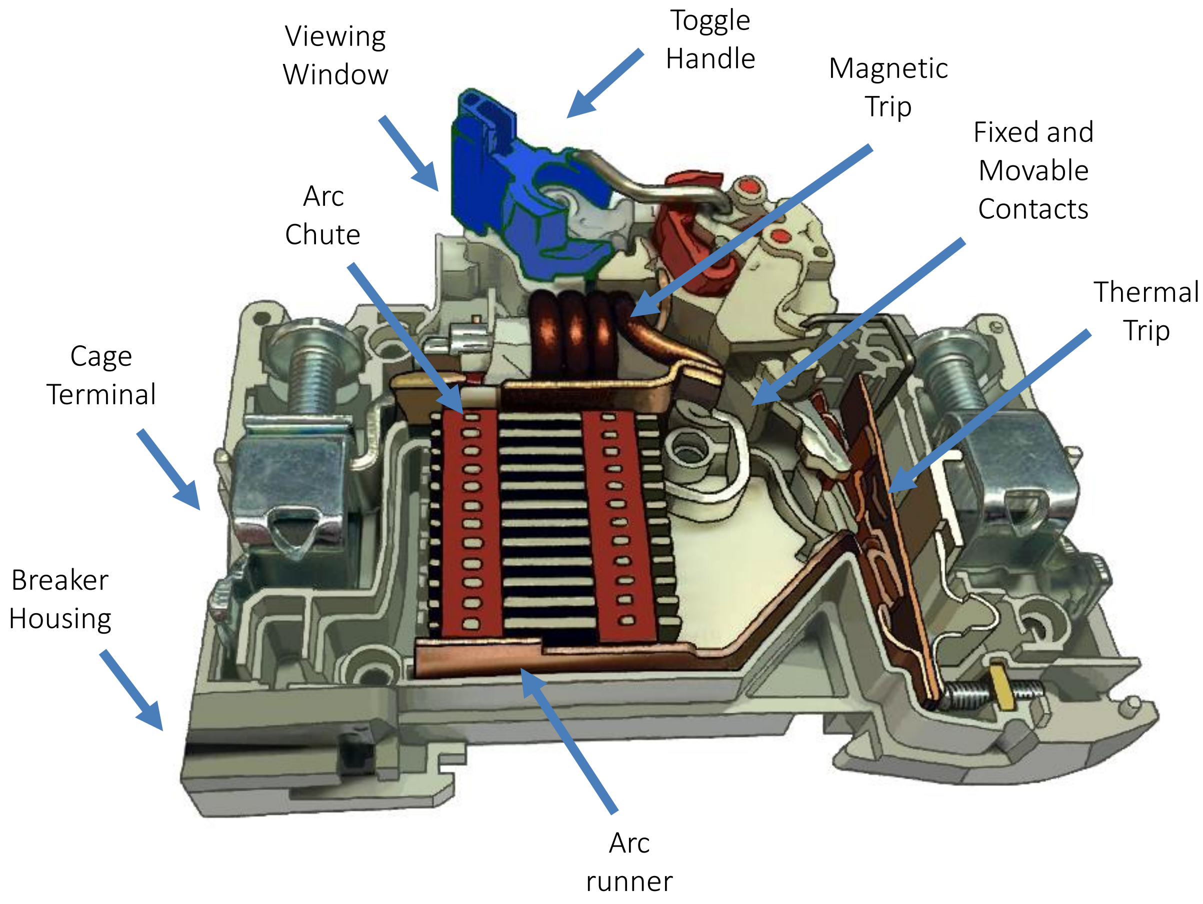
A short circuit occurs when an electrical component or wire shorts between a phase to ground or between phases. This event is due to a component failure, equipment failure, or human error. The short circuit is characterized by a rapid increase in ampacity in a short period of time, and the circuit breaker will take milliseconds to open the circuit.

Example: A light ballast draws 10A of current under normal conditions. The wire between the circuit breaker and ballast is cut by operating personnel, and it shorts to ground. The magnetic element of the circuit breaker will recognize the increase in ampacity and will open the electrical circuit instantaneously.

Short Circuit Situation



MCA FABRICATION Circuit Breaker Construction

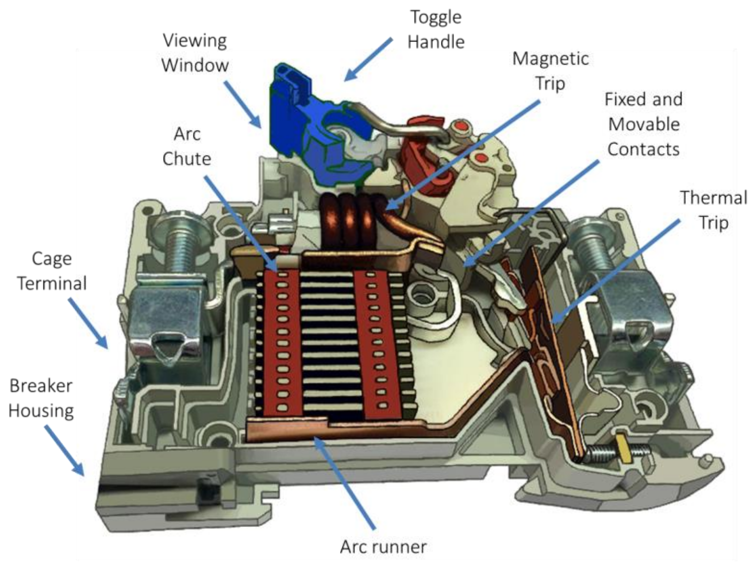


MCA FABRICATION Circuit Breaker Construction

The toggle handle operator is attached to the movable contacts. The operator allows the electrical circuit to be opened and closed manually.

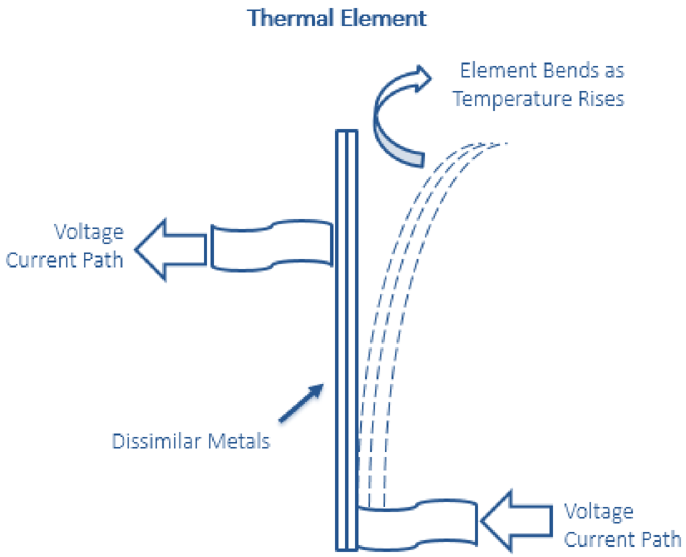
The viewing window displays the status of the breaker's fixed and movable contacts. The status displayed is not an indication of the toggle handle operator but rather the position of the breaker's contacts. There is a scenario where the breaker contacts can be welded together while the operator is in the off position. The viewing window is helpful to prevent injury to personnel by displaying contact status and by extension whether the breaker terminals are energized or non-energized.

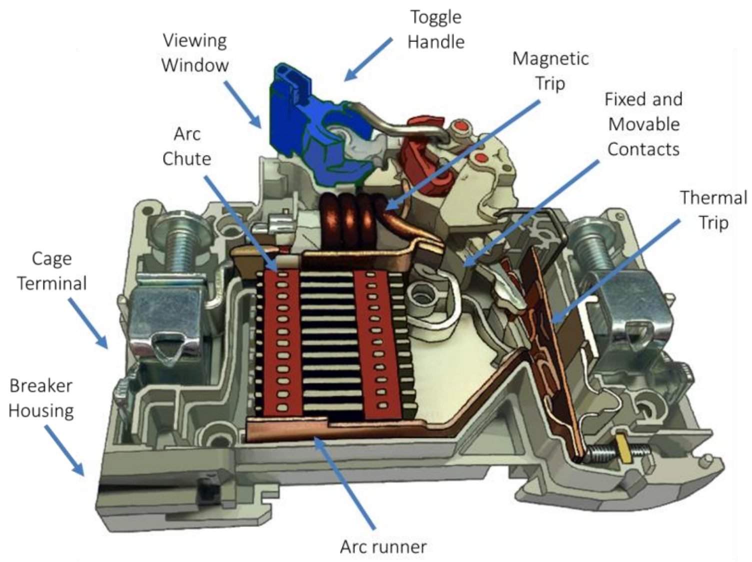
The housing provides a casing for the breaker's mechanical and electrical components. The housing also has the function of creating the geometry for the breaker to effectively expel pressurized ionized gas during a short circuit.



MCA FABRICATION Circuit Breaker Construction

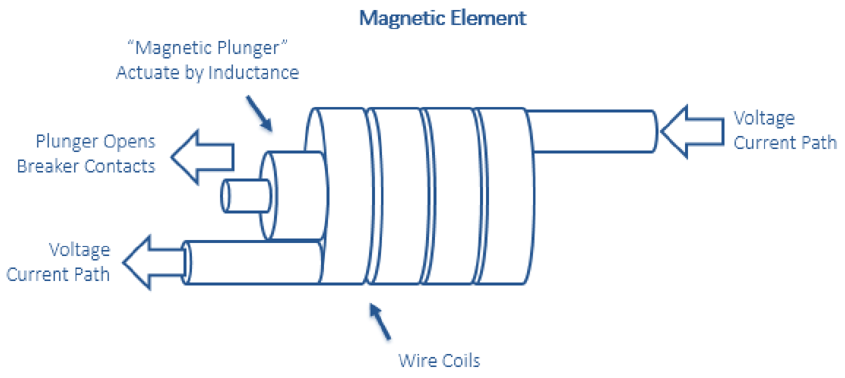
The thermal element reacts to overload situations and trips the breaker when there is a slow increase in ampacity over time. The element is composed of two dissimilar metals "sandwiched" together that have different expansion rates when heat is applied. A rise in ampacity increases the heat value in the current carrying path. The thermal element heats up and bends due to the properties of the dissimilar metals. The bend in the thermal element actuates the breaker's tripping mechanism and opens the circuit.

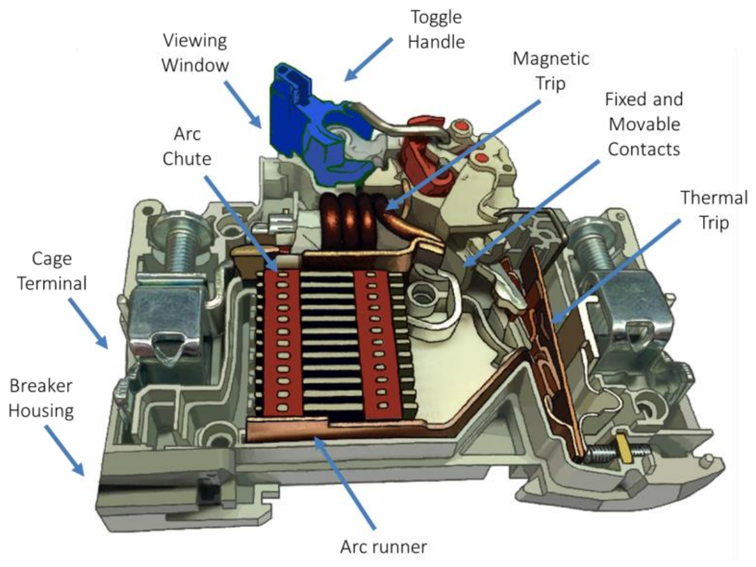




MCA FABRICATION Circuit Breaker Construction

The magnetic element reacts to short circuit situations and trips the breaker when there is a rapid increase in ampacity. The element is composed of a series of wire coils wrapped around a movable plunger mechanism. When the energy level of the circuit rises rapidly, a magnetic field is created. The magnetic field "pushes" the plunger which actuates the breaker's tripping mechanism and opens the circuit.



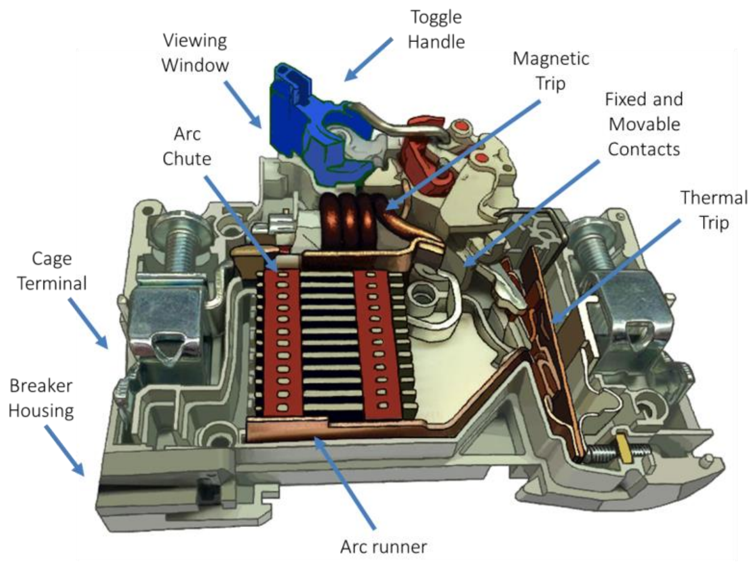


MCA FABRICATION Circuit Breaker Construction

The arc runner and arc chute help extinguish the energy during a tripping event. The energy travels along the arc runner and is pushed into the arc shoot to be distinguished.

The fixed and movable contacts allow the electrical circuit to be opened and closed. The circuit is manually opened or closed by an operator via the toggle mechanism, automatically by the thermal trip element, or automatically by the mechanical trip element.

The cage terminals provide a means for the operator to attach wires from a power source and wires feeding an electrical load.



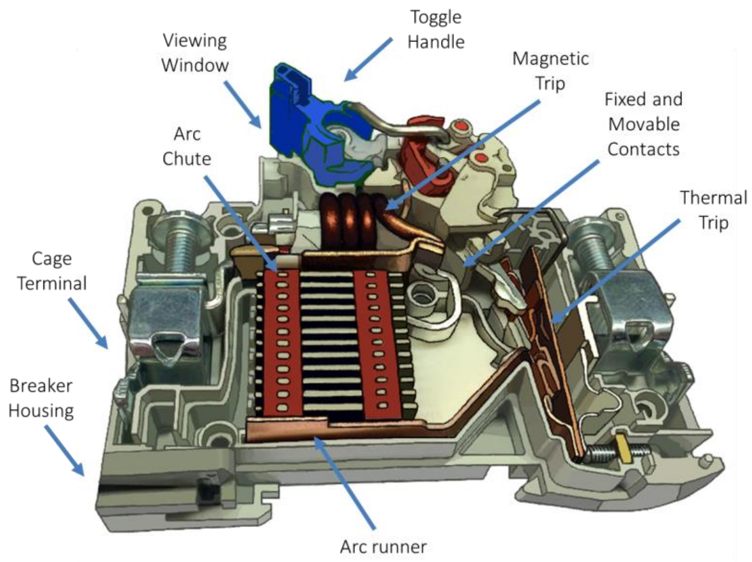
MCA FABRICATION Circuit Breaker Construction

The magnetic element reacts to short circuit situations and trips the breaker when there is a rapid increase in ampacity.

There are two types events when a breaker opens the electrical circuit; low energy and high energy.

When an operator manually opens a breaker or when the thermal element automatically trips a breaker, the action is a low energy event. In both cases the energy level is small and limited. The breaker only has to open under the load applied to the circuit. The movable contacts open, a small arc is formed, and the arc extinguishes itself in a few milliseconds.

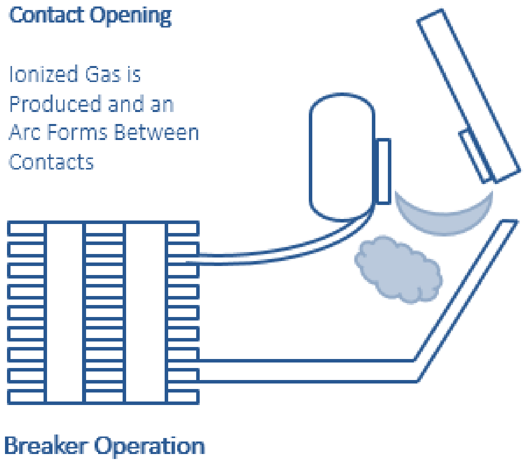
When a short circuit is present on the electrical circuit, the magnetic element trips the breaker. This action is a high energy event. The breaker must open the circuit and actively limit the circuit's energy during a rise in total energy amplitude.

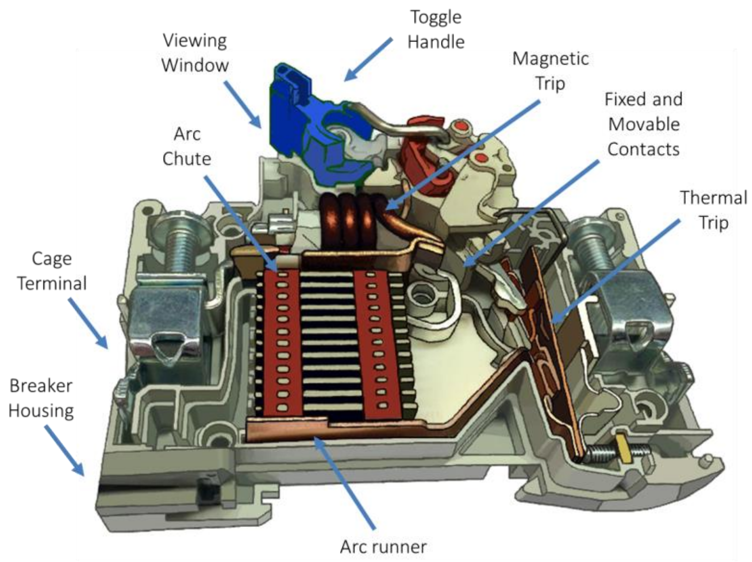


MCA FABRICATION Circuit Breaker Construction

Contact Opening

When the fixed and movable contacts open, an arc is formed between the two contacts. The arc is a result of the short circuit energy removing small particles from each contact's surface and suspending them in air. The particles create a conducting path in the air for the energy to continue to flow forming an arc. The act of the arc forming also produces ionized gas pressure that is contained in the area of the contacts by the geometry of the breaker housing.

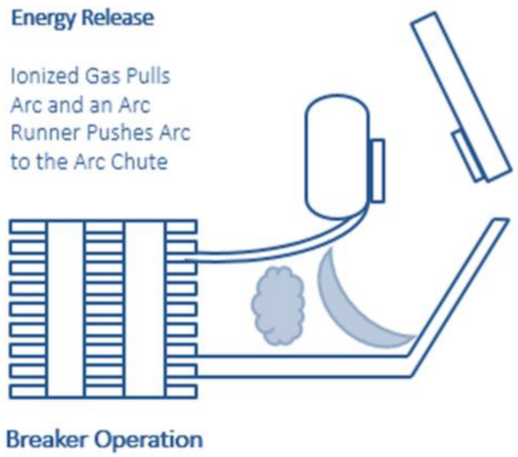


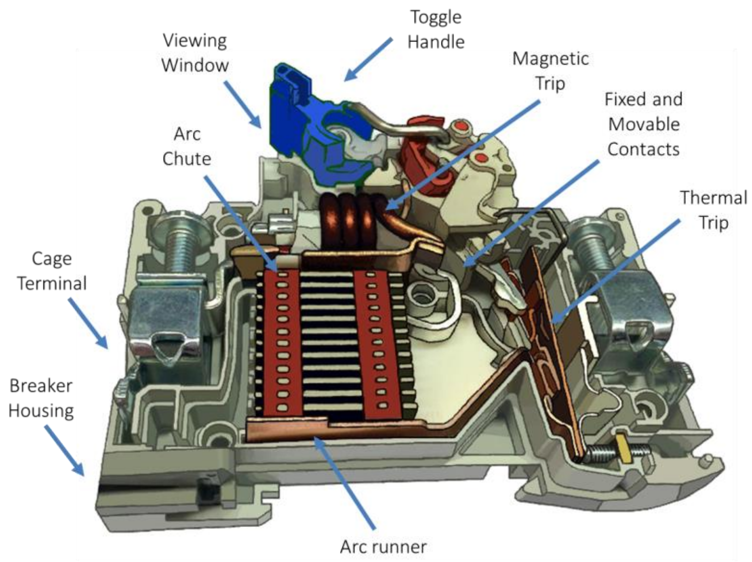


MCA FABRICATION Circuit Breaker Construction

Energy Release

The short circuit energy is released and begins to move towards the breaker arc chute. There are two factors that drive the arc energy towards the arc chute; ionized gas pressure and the arc runner. The ionized gas is pressurized and has bits of metal suspended in the air. The geometry of the breaker housing routes the gas on a path through the arc chute and outside the breaker. The gas travels quicker than the arc and pulls the energy towards the arc chute. The arc runner is designed to use the arc energy itself to push it on a path towards the arc chute.

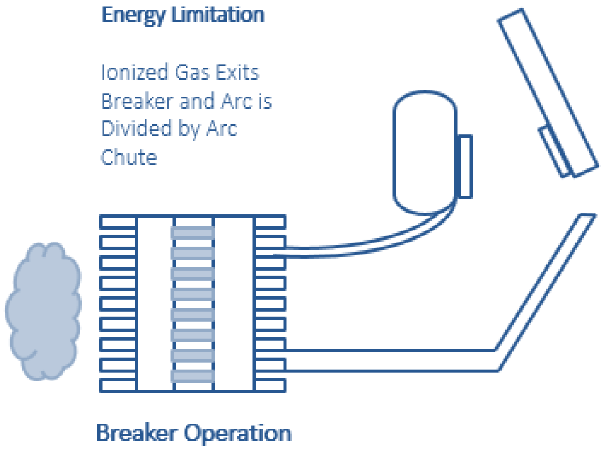


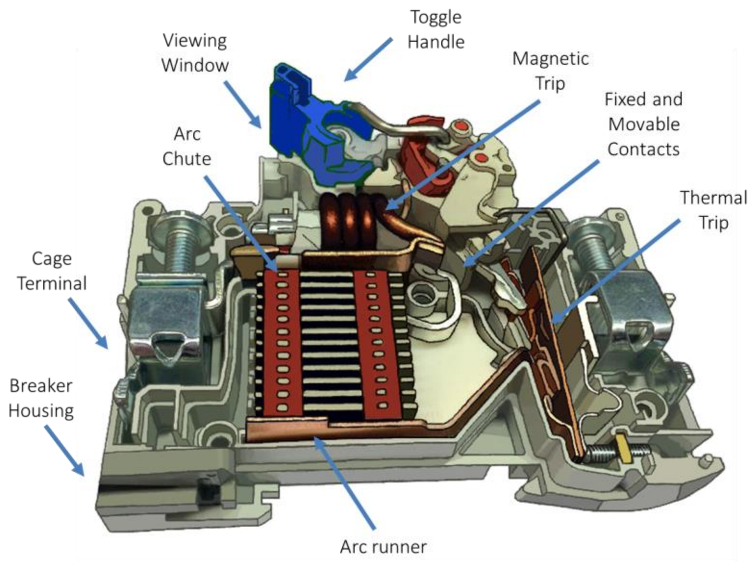


MCA FABRICATION Circuit Breaker Construction

Energy Limitation

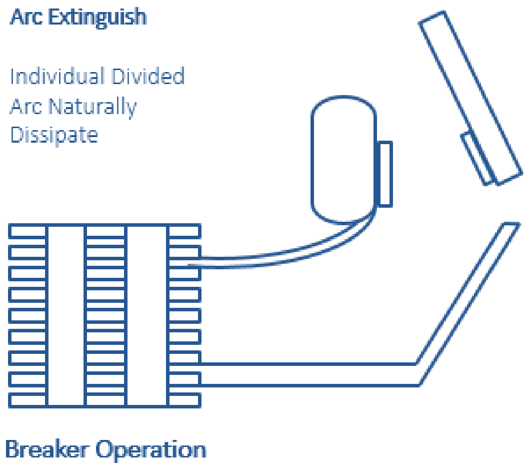
The arc energy is limited when entering the arch chute and the ionized gas is expelled from the breaker. Energy limitation is accomplished by the arc chute subdividing the arc into many smaller arcs. Dividing the arc interrupts the current carrying path of the arc itself and prevents any individual arc from having a value no greater than 25V.

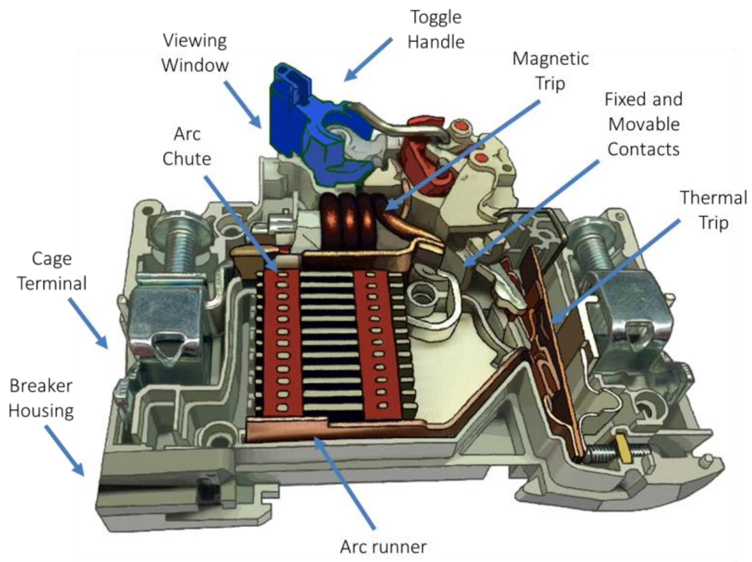




Arc Extinguish

The arc naturally extinguishes itself after entering the arc chute. An electrical arc can not sustain itself if its voltage is less than 25V. The arc chute divides the one big arc into many smaller arcs less than 25V, and they naturally dissipate.



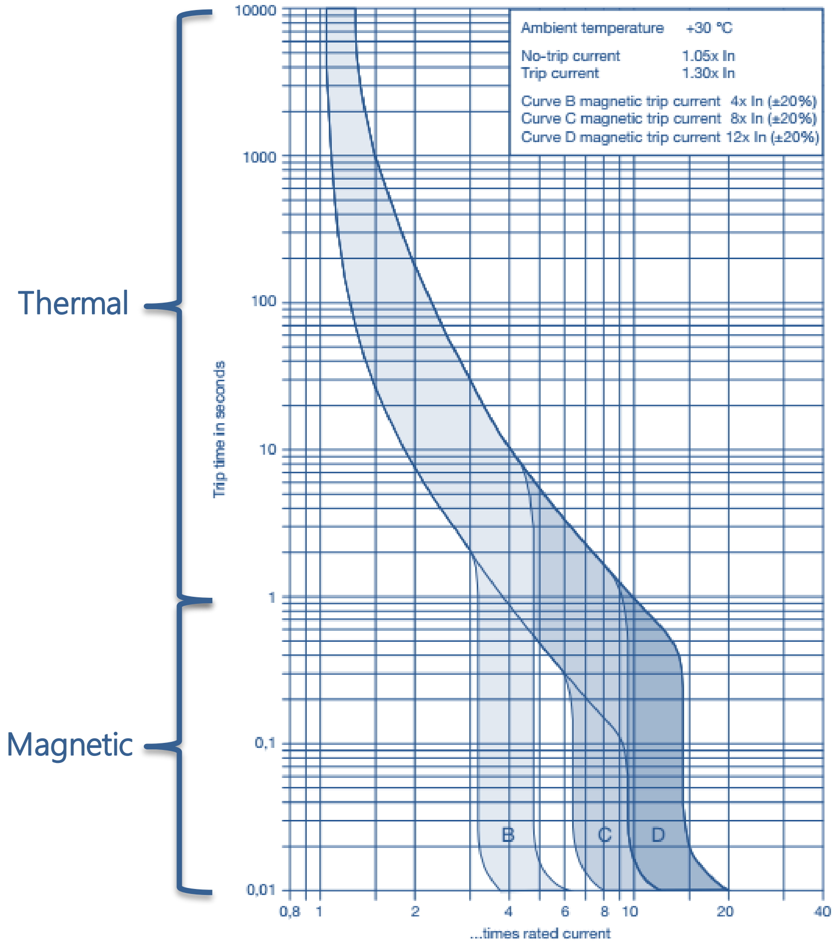


MCA FABRICATION Circuit Breaker Application

Tripping Characteristics

The thermal section of the curve displays the time for the bi-metal to heat, bend, and actuate the breaker’s trip unit.

The magnetic section of the curve displays the time for the magnetic to actuate the breaker’s trip unit.



Magnetic tripping currents are increased by 30 % on DC supplies.

MCA FABRICATION Circuit Breaker Application

Tripping Characteristic Example

The thermal element will trip at 3X rated current between 10 and 100 seconds.

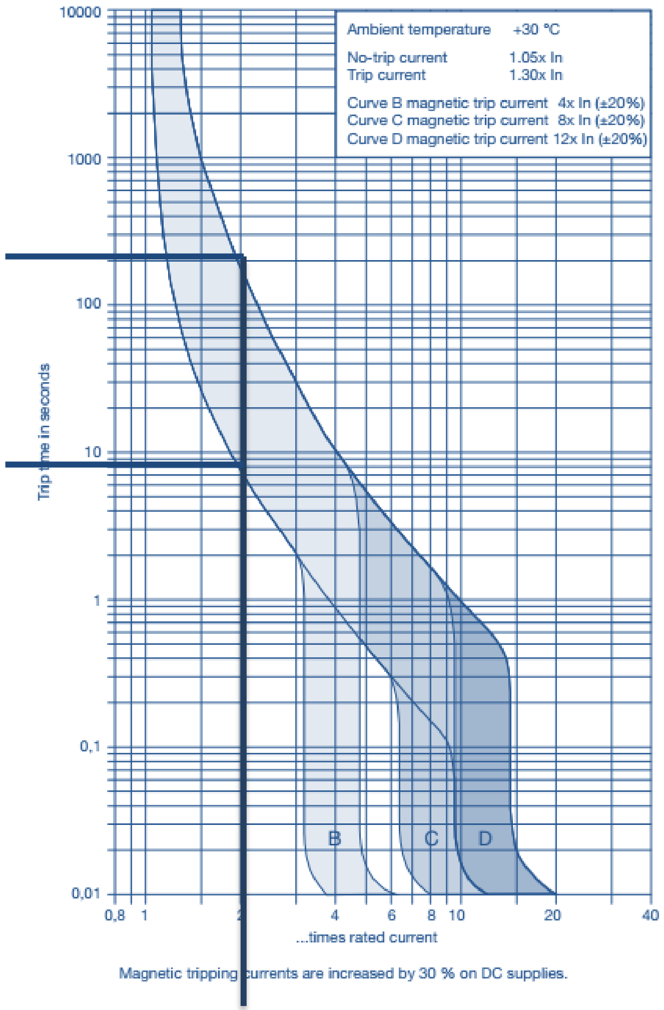
Example:
A 10A breaker experiencing a 30A overload will trip between 9 and 200 seconds.

Note:
Breaker trip curve charts are not linear and are plotted on a logarithmic scale.

The thermal portion of the curve is calculated by one breaker tested in open air.

No additional contributing factors are considered such as effect of other breakers, effect of an enclosure, or undesirable ambient conditions.

Thermal Trip



MCA FABRICATION Circuit Breaker Application

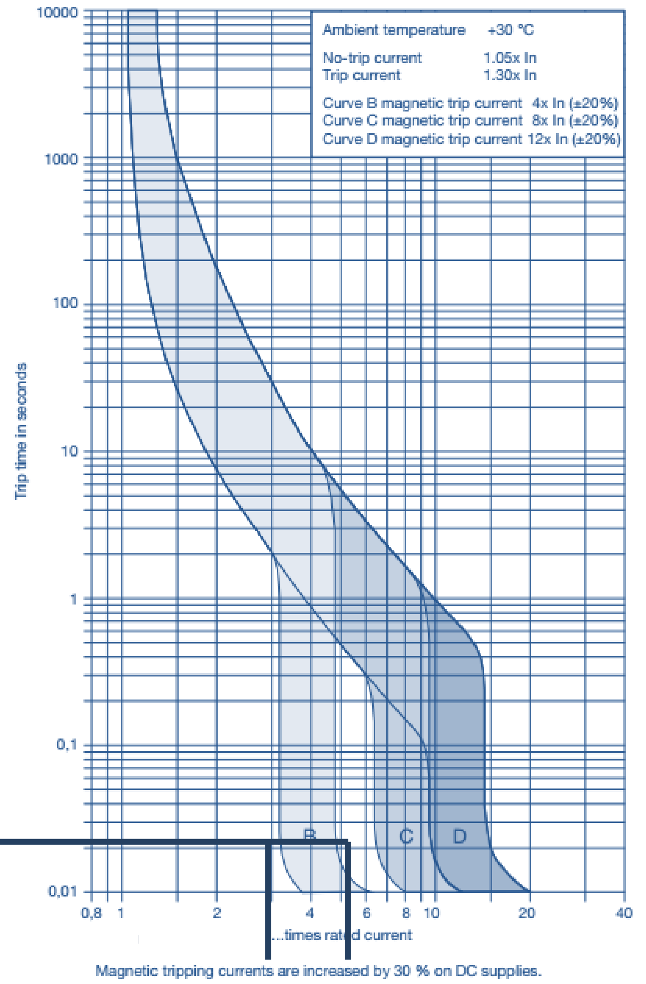
Tripping Characteristic Example

The magnetic element will trip at 3X rated current in milliseconds.

Example:
A 10A breaker experiencing a 30A short circuit will trip in less than 1/4 of an AC cycle.

Note:
The typical "European Style" circuit breaker is current limiting and will actively open a circuit and limit the short circuit energy.

Magnetic Trip



Breaker De-Rating

A breaker's thermal element has a calibration value set by the manufacturer. The calibration value is the tripping "set point" for the element in a particular environment. Each manufacturer specifies a breaker's calibration value for each breaker.

The calibration value is the maximum ampacity that a breaker thermal element can withstand at laboratory conditions and not be affected (bend). A thermal element will bend or resist bending when placed in environmental conditions different than laboratory conditions.

The following factors change the breaker's thermal element performance:

- High Temperature
- Low Temperature
- Number of Circuits
- Hertz
- Altitude
- AC vs DC

MCA FABRICATION Circuit Breaker Application

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Breaker De-Rating

Example: Ambient Temperature
The chart specifies a calibration temperature of 30 degrees C.

- If a 10A breaker is applied above 30 degrees C then the thermal element will **trip faster** due to the temperature placing it in an already bent state. The breaker will not be able to carry a full load of 10A continuously without tripping.

- If a 10A breaker is applied below 30 degrees C then the thermal element will **trip slower** due to the temperature cooling it and its ability to resist heating. The breaker will be able to carry more than 10A without tripping.

Influence of the Ambient Temperature on the Thermal Tripping Behavior
Corrected values of the rated current dependent on the ambient temperature

	Ambient Temperature T																
I_n (A)	–40°C	–30°C	–20°C	–10°C	0°C	10°C	20°C	30°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C	70°C	75°C
0.16	0.20	0.20	0.19	0.19	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.13
0.25	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21
0.50	0.64	0.62	0.60	0.58	0.56	0.54	0.52	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41
0.75	0.96	0.93	0.90	0.87	0.84	0.81	0.78	0.75	0.74	0.73	0.71	0.69	0.68	0.66	0.65	0.64	0.62
1.00	1.30	1.20	1.20	1.20	1.10	1.10	1.00	1.00	0.99	0.97	0.95	0.93	0.90	0.89	0.87	0.85	0.83
1.50	1.90	1.90	1.80	1.70	1.70	1.60	1.60	1.50	1.50	1.50	1.40	1.40	1.40	1.30	1.30	1.30	1.20
1.60	2.00	2.00	1.90	1.90	1.80	1.70	1.70	1.60	1.60	1.50	1.50	1.50	1.40	1.40	1.40	1.40	1.30
2.00	2.60	2.50	2.40	2.30	2.20	2.20	2.10	2.00	2.00	1.90	1.90	1.90	1.80	1.80	1.70	1.70	1.70
2.50	3.20	3.10	3.00	2.90	2.80	2.70	2.60	2.50	2.50	2.40	2.40	2.30	2.30	2.20	2.20	2.10	2.10
3.00	3.80	3.70	3.60	3.50	3.40	3.30	3.10	3.00	3.00	2.90	2.80	2.80	2.70	2.70	2.60	2.50	2.50
3.50	4.50	4.40	4.20	4.10	3.90	3.80	3.70	3.50	3.40	3.40	3.30	3.20	3.20	3.10	3.00	3.00	2.90
4.00	5.10	5.00	4.80	4.70	4.50	4.30	4.20	4.00	3.90	3.90	3.80	3.70	3.60	3.50	3.50	3.40	3.30
5.00	6.40	6.20	6.00	5.80	5.60	5.40	5.20	5.00	4.90	4.80	4.70	4.60	4.50	4.40	4.30	4.20	4.10
6.00	7.70	7.50	7.20	7.00	6.70	6.50	6.30	6.00	5.90	5.80	5.70	5.60	5.40	5.30	5.20	5.10	5.00
7.00	9.00	8.70	8.40	8.20	7.80	7.60	7.40	7.00	6.90	6.80	6.70	6.50	6.30	6.20	6.10	6.00	5.80
8.00	10.20	9.90	9.60	9.30	9.00	8.70	8.40	8.00	7.90	7.70	7.60	7.40	7.20	7.10	6.90	6.80	6.60
10.00	13.00	12.00	12.00	12.00	11.00	11.00	10.00	10.00	9.90	9.70	9.50	9.30	9.00	8.90	8.70	8.50	8.30
12.00	15.00	15.00	14.00	14.00	13.00	13.00	13.00	12.00	12.00	12.00	11.00	11.00	11.00	11.00	10.00	10.00	10.00
13.00	17.00	16.00	16.00	15.00	15.00	14.00	14.00	13.00	13.00	13.00	12.00	12.00	12.00	12.00	11.00	11.00	11.00
15.00	19.00	19.00	18.00	17.00	17.00	16.00	16.00	15.00	15.00	15.00	14.00	14.00	14.00	13.00	13.00	13.00	12.00

Selective Breaker Coordination

The **National Electrical Code** (NEC) requires Emergency Power Circuits to be selectively coordinated in the following applications:

NEC 620.62 Elevator Circuits
NEC 700.27 (28) Emergency Systems
NEC 701.18 (27) Legally Required Standby Systems
NEC 708.54 Critical Operations Power Systems
NEC 517.26 Essential Electrical Systems

Selective Coordination Definition

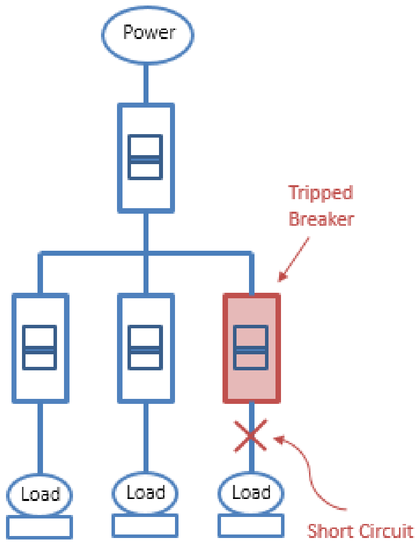
Selective coordination is defined by the NEC in Article 100 as:

"Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the choice selection and installation of overcurrent protective devices and their ratings or settings for the full range of available overcurrents, from overload to the maximum available fault current, and for the full range of overcurrent protective device opening times associated with those overcurrents."

MCA FABRICATION Circuit Breaker Application

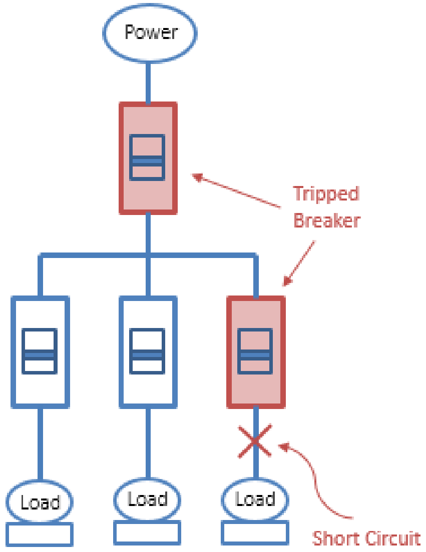
A selectively coordinated system is one where a branch circuit or "downstream" breaker experiences a short circuit. The breaker **isolates** the fault while all other breakers are not affected and remain energized. Only the "downstream" breaker opens and all "upstream" breakers remain operational.

A non-selectively coordinated system is one where a branch circuit or "downstream" breaker experiences a short circuit. The breaker **does not isolate** the fault, and the "downstream" breaker and the "upstream" breaker both open and the entire system is no longer operational.



Coordinated System

A short circuit situation where the immediately affected breaker opens the circuit and isolates the fault. All other breakers remain closed and the system is operational.



Non-Coordinated System

A short circuit situation where the immediately affected breaker opens the circuit and does not isolate the fault. The main breaker also opens and the entire system is no longer operational.

MCA FABRICATION Circuit Breaker Application

Series Rated Breaker Combination

The **National Electrical Code** (NEC) defines series rating combinations for circuit breakers working together to limit fault currents.

Series Rating is defined by the NEC in Article 110.22 and 240.86:

"A short-circuit interrupting rating assigned to a combination of two or more overcurrent protective devices which are connected in series and in which the rating of the downstream device(s) in the combination is less than the series rating."

Example: Applying Breakers Not Series Rated
A power system has a main breaker rated 35kA and the downstream breaker is rated 14kA. The breakers can be applied to an electrical network with a potential short circuit of 14kA or lower due to the downstream breaker's rating.

Example: Applying Breakers Approved by UL as Series Rated
A power system has a main breaker rated at 35kA and the downstream breaker is rated 14kA and the manufacturer has tested the combination via UL for a 18kA combination rating. The breaker can be applied to an electrical network with a potential short circuit of 18kA or lower due to the UL approved short circuit combination rating.

Both the upstream and downstream breakers will trip during a short circuit event at the series rated combination value. Series rated combinations are not selectively coordinated.

Series Rated Breaker Combination

All breaker manufacturers publish breaker series combination values that are tested and approved by UL.
Series rated breaker combinations do not have coordination.