

Methods of Applying **CIRCUIT PROTECTION**

This information is provided to aid in proper system design and utilization of circuit protection devices in North American applications. Be sure to consider all applicable local and national codes for your particular installation.

Applying L8 Supplementary Protectors in accordance with UL & NEC Guidelines

Sprecher+Schuh Series L8 Supplementary Protectors are recognized by Underwriters Laboratories (UL). Representative samples of this product have been evaluated by UL and meet applicable US safety standards. In general, the UL Component Recognition service covers the evaluation of components that will later be used in a complete product or system. L8 Supplementary Protectors are defined as UL Recognized supplementary overcurrent protective devices under the standard of UL 1077.

UL 508A, a procedure covering industrial control panels, offers guidelines in applying supplementary overcurrent protective devices. The general areas of acceptability are in the primary and secondary protection of control transformers, and also control circuit protection. Other uses of Mini-CB's may be submitted to UL for further investigation.

Per UL 508A, before utilizing a supplementary device for control transformer overcurrent protection, the supplementary device must meet the following restrictions:

Unless otherwise specified it is used with protection, either fuse or circuit breakers upstream from the supplementary device, rated at 400 percent of the supplementary protector rating but not less than 20A for device rated 150V or less and 15A for devices rated 150V or more.

(Reference: UL 508A procedure prescribed only)

Protection of Control Transformers

Control transformers can generate an almost infinite current spike on start-up while attempting to overcome core saturation. Only the resistance of the control transformer windings and the inductance of the circuit limit the large current draw. The inrush spikes are of short duration (1/8 to 1/4 of a cycle), typically reaching between 8-20 x I_n. Therefore, selecting a Mini-CB with the proper current rating and high inrush trip characteristics is ideal to avoid nuisance tripping. Sprecher+Schuh Series L8 "C" & "D" type Supplementary Protectors offer high inrush capabilities from 5-10 x I_n and 10-20 x I_n respectively.

Selecting the proper Mini-CB current ratings for the primary and secondary protection of control transformers (per UL/NEC) is as follows:

Primary Overcurrent Protection for Control Transformers

Control Circuits: If the rated primary current is less than 2 amps, the maximum rating of the overcurrent device is 500%. If the rated primary current is more than 2 amps, the maximum rating of the overcurrent device is 250%.

Secondary Overcurrent Protection for Control Transformers

Control Circuits: If the rated secondary current is less than 9 amps, the maximum rating of the overcurrent device is 167%. If 9 amps or more, the maximum rating of the overcurrent device is 125%. The next larger size of an overcurrent device may be used if 125% does not correspond to a standard size.

(Reference: UL 508 32.7, UL 845 11.16 & 11.17, NEC 430-72(c) exception No. 2, 450-3(b) 1 & 2)

Example (see table for more calculated results)

Primary & Secondary Protection of a Control Transformer:
50VA Pri. 480/ Sec. 120V

Primary Mini-CB Selection

- 50VA/480V = 0.10A rated transformer primary current
- 0.10A is less than 2, therefore may increase up to 500%
- 0.10A x 500% = 0.52A, Select L8-5/2/D (0.5 amp 2-Pole)
- Upstream BCPD must be rated at 400% of the selected Mini-CB rating
- 0.5A x 400% = 2A, since rated below 15A at 150V or more, the minimum BCPD is 15A per NEC-240.6

Primary Control Transformer Calculations (480 / 240V)

Transformer VA	Primary Volts	Rated Amps ❶	Selected L8 Mini-CB	Maximum Upstream BCPD ❷
50	480	0.10	0.5	15A
100	480	0.21	1	15A
150	480	0.31	1	15A
200	480	0.42	2	15A
250	480	0.52	2	15A
300	480	0.63	3	15A
500	480	1.04	5	25A
1000	480	2.08	5	25A
50	240	0.21	1	15A
100	240	0.42	2	15A
150	240	0.63	3	15A
200	240	0.83	4	15A
250	240	1.04	5	25A
300	240	1.25	6	25A
500	240	2.08	5	25A
1000	240	4.17	10	60A

- ❶ If the rated primary current is less than 2 amps, the maximum rating of the overcurrent device is 500%. If the rated primary current is more than 2 amps, the maximum rating of the overcurrent device is 250%.
- ❷ Minimum standard BCPD ampere rating is 15A per NEC-240.6.

Applying L8 Supplementary Protectors in accordance with UL & NEC Guidelines (continued)

Secondary Supplementary Protectors Selection

- $50VA/120V = 0.42A$ rated transformer secondary current
- 0.42A is less than 9, therefore may increase up to 167%
- $0.42A \times 167\% = 0.70A$, Select L8-1/1/D or L8-1/1/C (1 amp 1-Pole)

Secondary Control Transformer Calculations (120 / 24V)

Transformer VA	Secondary Volts	Rated Amps ❶	Selected L8 Mini-CB
50	120	0.42	1
100	120	0.83	2
150	120	1.25	2
200	120	1.67	3
250	120	2.08	4
300	120	2.50	4
500	120	4.17	7
1000	120	8.33	13
50	24	2.08	4
100	24	4.17	7
150	24	6.25	10
200	24	8.33	13
250	24	10.42	13
300	24	12.50	16
500	24	20.83	30
1000	24	41.67	50

Protection of Control Circuit Devices

Control circuit devices can also generate inrush currents during startup, though not as intense as control transformers. Devices such as control relays, starter coils, and solenoids exhibit typical inrush levels between 6-10 x In. Also, protection of conductor wires or low-level signal devices such as PLCs may exhibit even lower inrush levels ranging from 3-5 x In. Depending on the inrush, an Mini-CB with a type “B” or “C” trip characteristic will perform the task.

Control Circuit Conductor Protection

The relationship between the control circuit conductor size and rating of the protective device must be in compliance with the tabulated data per UL 508.

(Reference: UL 508A procedure prescribed only)

Where can supplementary overcurrent protectors not be used?

- Branch Circuit Protection Device (BCPD)
- Power Transformer Primary Protection
- Power Transformer Secondary Protection
- Protection of Loads such as for Motors, Heater, Lamps, and General use

Supplementary protectors may be submitted to UL for further investigation for other uses.

❶ If the rated secondary current is less than 9 amps, the maximum rating of the overcurrent device is 167%. If 9 amps or more, the maximum rating of the overcurrent device is 125%.

Applying L9 UL489 Miniature Circuit Breakers in accordance with UL & NEC Guidelines (continued)

Description

L9 Circuit Breakers for Branch Circuit protection are available one (1)-, two (2-), and three (3-) pole construction and are rated 0.5 to 40A at 240V AC and 0.5 to 32A at 480Y/277V AC for North American applications (UL 489 and CSA 22.2 No. 5.1). For IEC applications, the products are rated 415V AC 0.5 to 40A.

Thermal Magnetic Circuit Breakers

The L9 Thermal Magnetic Circuit Breakers are general-purpose devices suitable for the majority of industrial, inverse time circuit breaker applications. They combine thermal and magnetic trip actions and provide accurate overload and short-circuit protection for conductors and connected equipment.

Circuit Breaker Application Information

Selection of a L9 circuit breaker with appropriate circuit protection includes consideration of:

- Circuit Voltage
- Circuit Frequency
- Available Short Circuit Current
- Continuous Current Rating
- Application Considerations
- Special Operating Conditions

Circuit Voltage

The L9 circuit breakers are rated by voltage class. Applications should not exceed the listed voltage and current range.

Circuit Frequency

The L9 circuit breakers may be applied to frequencies of 50 and 60 Hz without derating. For applications above 60 Hz, contact Sprecher + Schuh with specific application information for the derating of the circuit breakers.

Available Short Circuit Current

The L9 circuit breakers should only be applied in those applications in which the available short-circuit (or fault) current is less than or equal to the stated kA maximum of either 10kA or 14kA models.

Region	Max. Voltage	Current Range
IEC Regions	415V AC	0.5...40 A
	48V DC	0.5...40 A
North America (UL 489 & CSA 22.2 No. 5.1)	240V AC	0.5...40A
	480Y/277V AC	0.5...32A
	1-pole 48V DC	0.5...40 A
	2-pole 96V DC	0.5...40 A

Application Considerations

The selection of a specific ampere rating for a specific application is dependent on the type of load and duty cycle and is governed by the National Electric Code (Canadian Electric Code) and UL/CSA. In general, the codes require that overcurrent protection is at the current supply and at points where wire sizes are reduced. In addition, the codes state that conductors be protected according to their current carrying capacity. There are specific situations that require application consideration, such as motor circuit, and guidelines for the selection for transformer protection.

The L9 circuit breakers are “non 100% rated” as defined UL 489, para 7.1.4.2. As such, the circuit breaker’s rating should be loaded to no more than 80% if used with continuous loads.

Branch Circuits

L9 circuit breakers may be used to protect branch circuits. A branch circuit is the wiring portion of a system extending beyond the final overcurrent device protecting the circuit. Guidelines established in NEC, CED, UL and CSA should be used to determine the specific device.

1. Motor Branch Circuit

L9 circuit breakers are not horsepower rated because they are able to safely interrupt currents far in excess of the locked rotor value for a selected motor. This ability is recognized in the codes and standards and is also established by the UL and CSA tests described in UL 489 and CSA 22.2 No 5.1 standards.

2. Transformer Protection

L9 circuit breakers may be used for transformer protection following the guidelines established. References: NEC 450 and UL 489. Also see CEC and appropriate Canadian Standards. References: NEC 450 and UL 489. Also see CEC and appropriate Canadian Standards.

Applying L9 UL489 Miniature Circuit Breakers in accordance with UL & NEC Guidelines *(continued)*

3. Heater Load, Lighting, and Other Load Protection

L9 circuit breakers may be used for protection of heater loads, lighting loads and other loads following the guidelines established. References: NED Article 31 and UL 508A. Also see CEC and appropriate Canadian Standards.

Coordinated Overcurrent Protection

Where an orderly shutdown is required to minimize the hazards to personnel and equipment, a system of coordination based upon the faulted or overloaded circuit is isolated by selective operation of only the overcurrent protective device closest to the overcurrent condition. The user should select devices that meet this requirement. References: NEC 240.12. Also see CEC.

HACR Rating

L9 Circuit Breakers are rated as Heating, Air Conditioning and Refrigeration circuit breakers as defined by UL489, paragraph 6.7 and may be used in this type of application.

SWD Rating

L9 breakers (0.5 ... 20A) are rated as SWD and as such may be applied to switch fluorescent lighting loads up to their current and voltage maximum.

Current Limiting

L9 Circuit Breakers are rated as current limiting circuit breakers as defined by UL 489, paragraph 8.6.

The L9 line features the ability to achieve short circuit interruptions far more effectively than conventional breakers. In conventional circuit breakers, the short circuit interruption time required is approximately one or two half cycles of an AC sine wave. When the contacts open, the resulting arc continues to burn until the current level passes through zero. The arc may re-ignite because of the insufficient width of the contact gap. The current that flows until the arc is extinguished produces a heating effect proportional to the I^2t value (let-through-energy) of the fault current.

The L9 device is designed to substantially reduce the amount of let-through-current and the resulting let-through-energy that can damage protected components. The L9 has the ability to interrupt short circuit current within the first half cycle of the fault. Limiting letthrough current and energy will protect against the harmful effects of overcurrent and is focused primarily on avoiding the following:

- Excessive Heat
- Mechanical Damage

Both of these factors are proportional to the square of the current. Thermal energy is proportional to the square of the RMS value and magnetic forces are proportional to the square of the peak value. The most effective way to provide protection is to substantially limit letthrough-energy. This provides the following advantages

- Far less damage at the location of the short circuit.
- Fast electric separation of a faulty unit from the system, especially power supplies connected in parallel that are switched off when the voltage of the power bus drops below a certain level.
- Far less wear on the miniature circuit breaker itself. This means more safe interruptions.
- Better protection of all components in the short circuit path.
- Far wider range of selective action when used with an upstream protective device. (No nuisance shut downs from feeder line interruptions, causing a blackout in all connected branches.)

The following values are applicable to the whole product range.

- Frequency: 50/60 Hz

The values are derived from worst case testing of D trip 40 A @ 240V AC and D trip 25 A @ 480Y/277V AC.

	Vrms	240 V (D40)	480Y/277V (D25)
Threshold Current	Symmetrical (kA)	2.6	1.625
	I peak (kA)	2.9	2.0
	I^2t (kA2s)	18.0	12.0
Intermediate Current	Symmetrical (kA)	5.0	5.0
	I peak	4.2	4.6
	I^2t (kA2s)	24.0	38.0
High Interrupt Current	Symmetrical (kA)	10.0	10.0
	I peak	6.2	6.2
	I^2t (kA2s)	43.0	60.0

Applying L9 UL489 Miniature Circuit Breakers in accordance with UL & NEC Guidelines (continued)

Determining Ratings

The standard tripping characteristics for the L9 Series is Type C. Type C has a magnetic trip activated at 5...10 times the rated current of the circuit breaker. The reference temperature for the thermal tripping characteristics is 40°C. The Type C characteristics will suit most applications.

In rare occurrences when the Type C characteristics does not fully meet the application, the following additional magnetic trip characteristics is available.

Type D allows for transient approximately twice as high as the standard Type C. Use the table and graphs to determine the current rating for the breaker if the ambient is significantly different than 40°C.

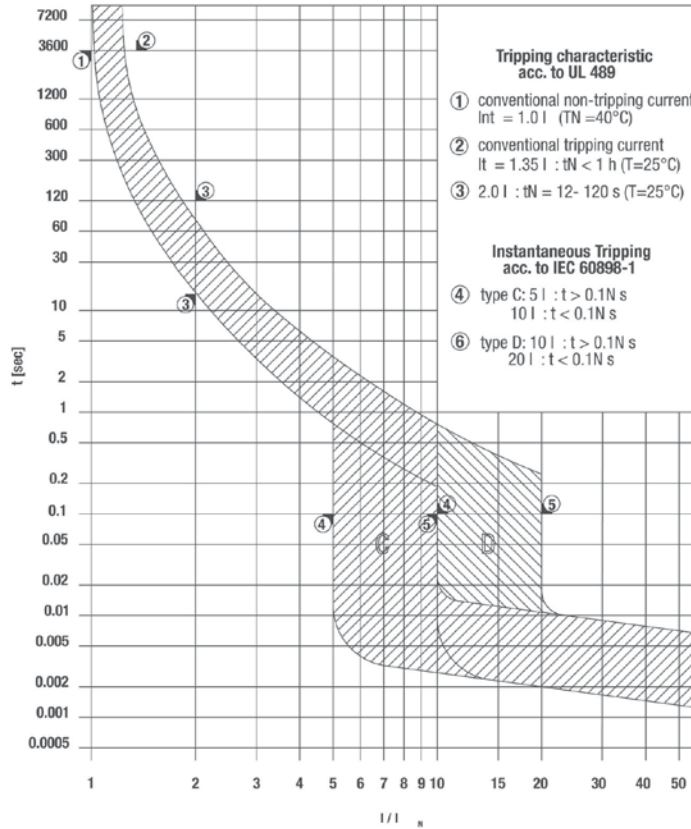
L9 Ambient Temperature Derating
Calibration Temperature 40° C (UL)
Application below 0° C is for non-condensing atmosphere

Device Marked Current Rating in (A) @ 40°C	I _n (A) at higher Ambient Temperature											
	-25	-20	-10	0	10	20	30	35	40	45	50	55
0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.50	0.5	0.5	0.5
1.0	1.3	1.2	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	0.9
1.5	1.9	1.9	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.5	1.4	1.4
2.0	2.5	2.5	2.4	2.3	2.2	2.2	2.1	2.0	2.0	2.0	1.9	1.9
3.0	3.8	3.7	3.6	3.5	3.4	3.2	3.1	3.1	3.0	2.9	2.9	2.8
4.0	5.0	5.0	4.8	4.6	4.5	4.3	4.2	4.1	4.0	3.9	3.8	3.8
5.0	6.3	6.2	6.0	5.8	5.6	5.4	5.2	5.1	5.0	4.9	4.8	4.7
6.0	7.5	7.4	7.2	7.0	6.7	6.5	6.2	6.1	6.0	5.9	5.8	5.6
7.0	8.8	8.7	8.4	8.1	7.8	7.6	7.3	7.1	7.0	6.9	6.7	6.6
8.0	10.0	9.9	9.6	9.3	9.0	8.6	8.3	8.2	8.0	7.8	7.7	7.5
10.0	12.6	12.4	12.0	11.6	11.2	10.8	10.4	10.2	10	9.8	9.6	9.4
13.0	16.3	16.1	15.6	15.1	14.6	14.0	13.5	13.3	13	12.7	12.5	12.2
15.0	18.8	18.6	18.0	17.4	16.8	16.2	15.6	15.3	15	14.7	14.4	14.1
16.0	20.1	19.8	19.2	18.6	17.9	17.3	16.6	16.3	16	15.7	15.4	15.0
20.0	25.1	24.8	24.0	23.2	22.4	21.6	20.8	20.4	20	19.6	19.2	18.8
25.0	31.4	31.0	30.0	29.0	28.0	27.0	26.0	25.5	25	24.5	24.0	23.5
30.0	37.7	37.2	36.0	34.8	33.6	32.4	31.2	30.6	30	29.4	28.8	28.2
32.0	40.2	39.7	38.4	37.1	35.8	34.6	33.3	32.6	32	31.4	30.7	30.1
40.0	43.9	43.4	42.0	40.6	39.2	37.8	36.4	35.7	35	34.3	33.6	32.9

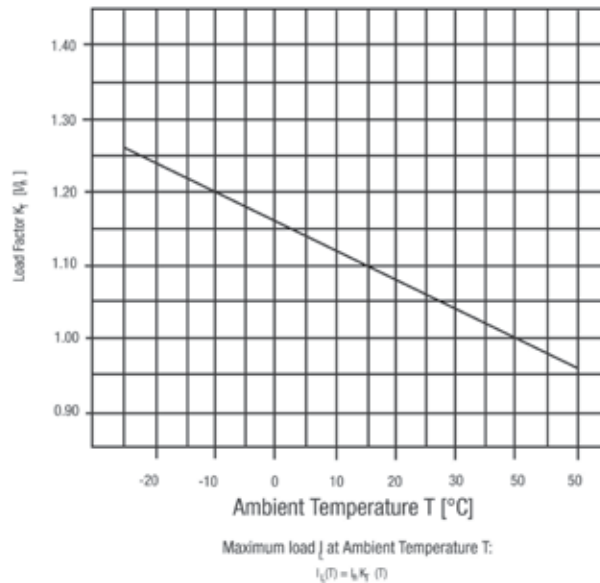
Care should be taken for application below 0 °C. These devices are not certified to operate correctly in the presence of ice. All other specifications for standard L9 products remain unchanged.

Time Current and Temperature Curves

Time-Current Characteristic L9
Type C and D
Ambient Temperature 40°C



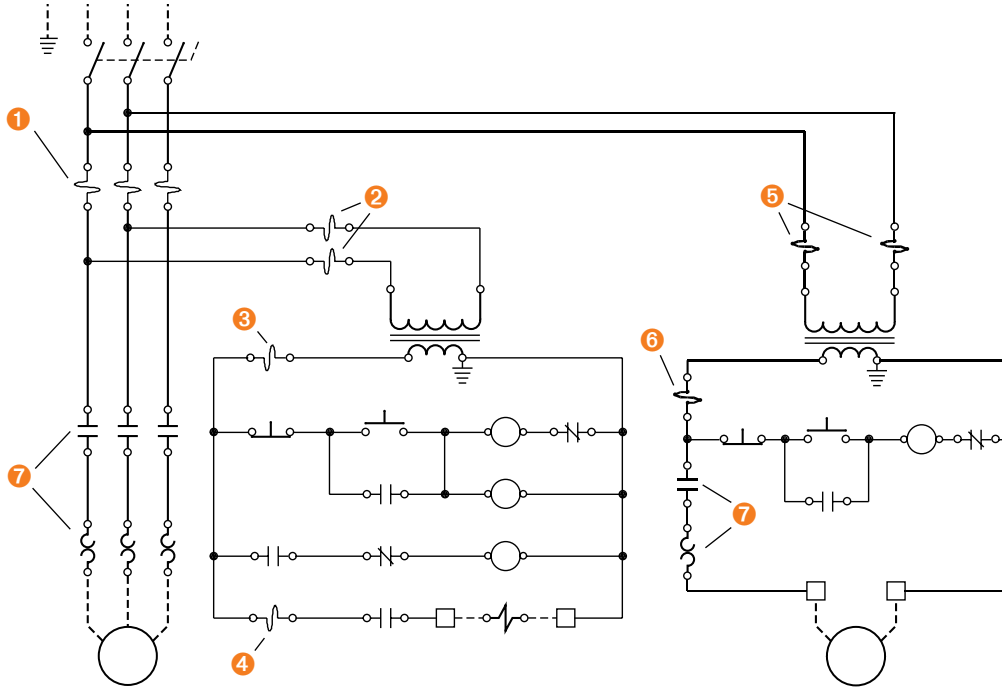
Influence of Ambient Temperature (T) on Load-Carrying Capacity



The ambient temperature derating applies to applications of the device as an IEC Miniature Circuit Breaker (MCB), following 60 947-2 and as Circuit Breaker to UL489/CSA 22.2 No 5..

Ambient temperature refers to the free air temperature in contact with the L9 device

Defining Electrical Standards Relating to Protection Devices



Sprecher + Schuh Products

1 Branch Circuit Protection Device (BCPD)

Acceptable components

- Branch circuit protection device (UL489)
- Self-protected Type E manual motor controller (UL508-E)

2 Control Transformer Primary Protection

Acceptable components

- UL-listed fuses (UL512)
- Branch circuit protection device (UL489)
- Supplementary protective device (UL1077)

3 Control Transformer Secondary Protection

Acceptable components

- Supplementary protective device (UL1077)
- Miscellaneous, miniature and micro fuses

4 Supplementary Circuit Protection

Acceptable components

- Supplementary protective device (UL1077)
- Branch circuit protection device (UL489)
- Miscellaneous, miniature and micro fuses

5 Power Transformer Fuse/Branch Circuit Protection

Acceptable components

- Branch circuit protection device or power-related transformer fuses (UL489/512)

6 Power Transformer Fuse/Branch Circuit Protection

Acceptable components

- Branch circuit protection device or power-related transformer fuses (UL489/512)

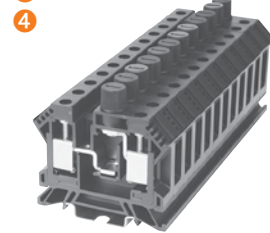
7 Motor Load Protection

- Manual motor controllers (UL508-E)

1 L11/L10 Disconnect Switch



3 V7 Fuse Blocks



1 KT7 Motor Circuit Protector



1 KTU7 Molded Case Circuit breaker



2 L8 Supplementary Protector



1 L9 Miniature Circuit Breaker



2 FH8 Fuse Holder



Defining Electrical Standards Relating to Protection Devices

Circuit protection devices should be applied in accordance with the product specifications, as well as local and national electrical codes. Sprecher+Schuh protection devices offer equipment manufacturers a product that meets both US and international protection standards. A variety of Sprecher+Schuh Protection Devices are approved by Underwriters Laboratory's standards and are applicable for use under the guidelines of the National Electric Code (NEC). Internationally, Sprecher+Schuh Protection Devices are CE marked and meet CSA and IEC standards for worldwide acceptance.

Sprecher+Schuh Protection Devices are an excellent choice for a wide variety of electrical protection circuits. See the listings below to gain a broader understanding of additional electrical standards pertaining to other types of circuit protection.

UL 508 Manual Motor Controllers



A manual motor controller is suitable for use as an ON/OFF (make/break) controller for motors and other loads. These devices also have an overload tripping function which must be compliant with applicable tests for an overload relay. In addition, an overload tripping device must operate independently of the manipulation of the handle (trip free).

A listed Manual Motor Controller, additionally marked "Suitable as a Motor Disconnect," shall be permitted as a disconnecting means where installed between the final motor branch-circuit short-circuit, transformer protection, device and the motor. General uses: control circuit, transformer protection, motor loads, general use loads, lighting loads, resistive loads.

Although Sprecher+Schuh Supplementary Protectors are not listed as UL 508 manual motor controllers, Sprecher + Schuh offers our KT7 Motor Controller series, which does meet the UL 508 standard at a competitive price.

UL 489 Branch Circuit Protection



Products UL Listed for Branch Circuit Protection, which are approved and evaluated according to the UL 489 Standard for "Molded Case Circuit Breakers" (usually applicable at 240V maximum when associated with Supplementary Protectors). General uses: Branch Circuit Protection Device (BCPD), protect motor loads, protect external loads such as receptacles or HVAC & refrigeration equipment.

CSA C22.2 No. 5.1



Products evaluated according to the Canadian Standards Association (CSA), which are intended to protect branch circuits in accordance with the Canadian Electric Code (CEC). The CSA C22.2 No. 5.1 standard is closely related to the UL 489 standard.

UL 1077 Supplementary Protection



UL recognized supplementary protectors evaluated according to UL 1077 standard. Supplementary protectors are intended for use as overcurrent protection within an appliance or other electrical equipment where branch circuit protectors shall not be used as substitutes for UL 489 branch circuit protective devices. General uses: control circuit components such as relay coils, starter coils, timers and remote solenoids... etc.; control transformers protection (primary & secondary); sensitive internal electronic circuitry.

CSA C22.2 No. 235



The CSA C22.2 No. 235 Standard is closely related to the UL 1077 Supplementary Protector standard.

IEC 60947-2 Standard



Electrical standards for industrial applications using circuit protection.