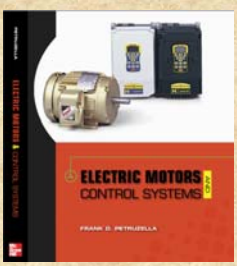


Chapter 6

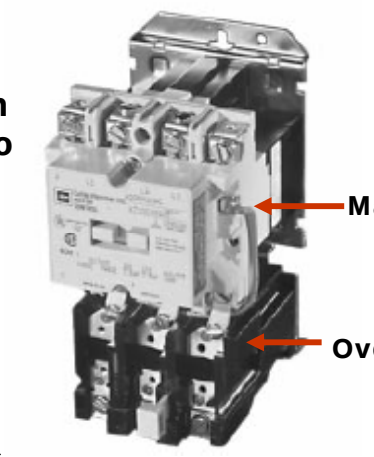
Electric Motors

PART 3 Motor Starters

MAGNETIC MOTOR STARTERS

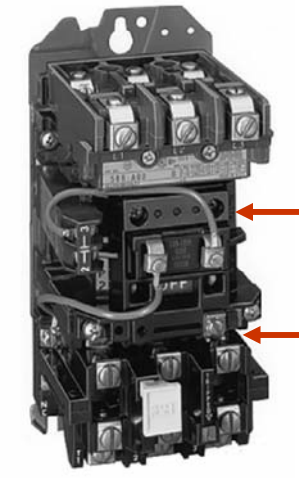
The basic use for the magnetic contactor is for switching power in resistance heating elements, lighting, magnetic brakes, or heavy industrial solenoids.

Contactors can also be used to switch motors if separate overload protection is supplied.

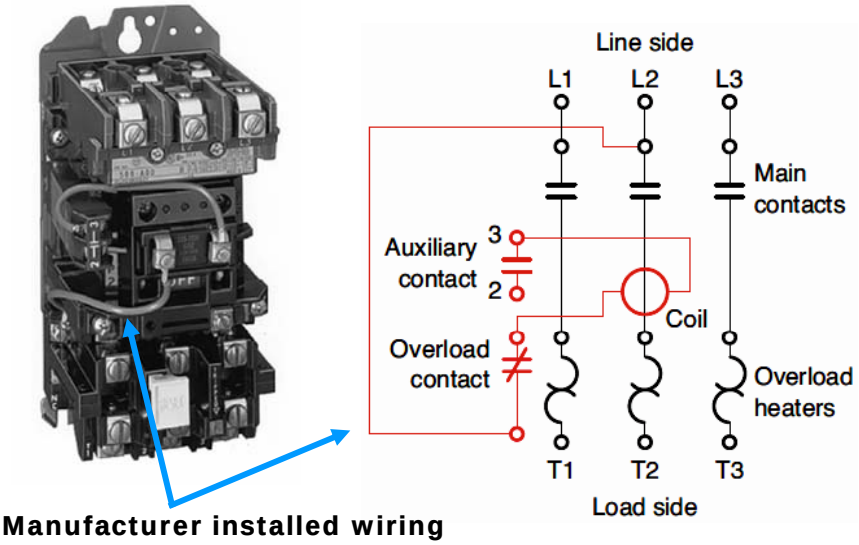


A magnetic motor starter is a contactor with an overload protective device, known as an overload relay (O.L.), physically and electrically attached.

The overload relay protects the motor from overheating and burning up.

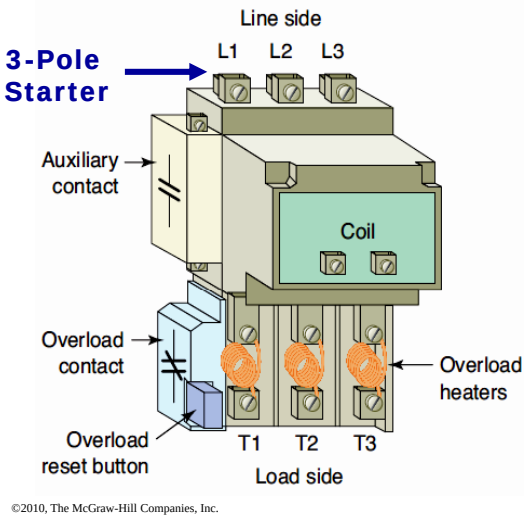


Normally magnetic starters come equipped with some manufacturer installed pre-wiring.



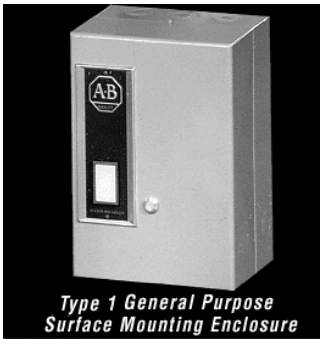
Manufacturer installed wiring

Starters consist of a two, three- or four-pole magnetic contactor and an overload relay mounted in a suitable enclosure.



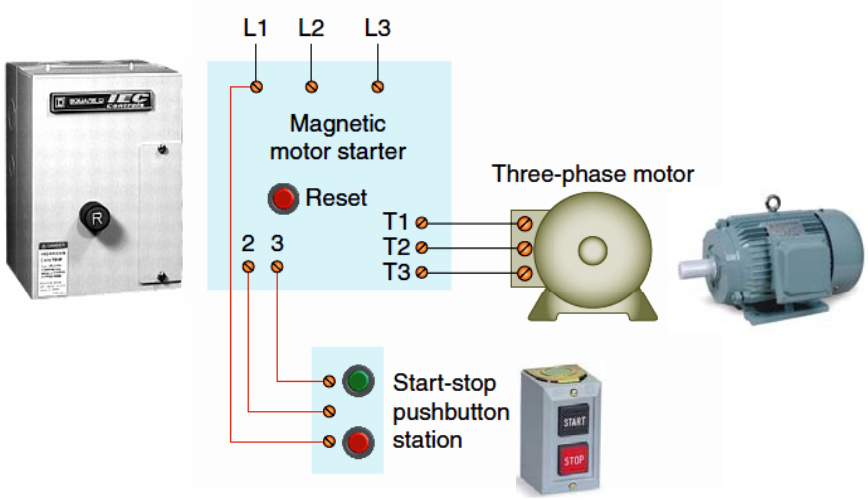
Start and stop pushbuttons may be mounted in the cover of the enclosure.

Enclosures are essentially boxes that *enclose* motor control devices such as contactors, motor starters, and pushbuttons.

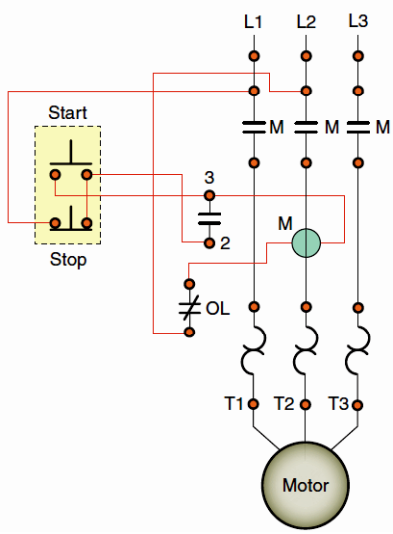


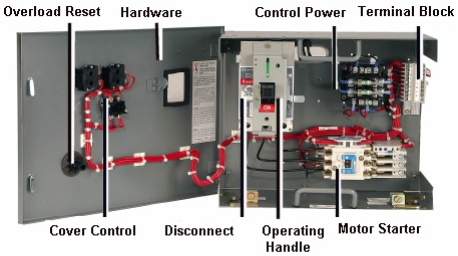
They may be of general-purpose sheet-metal construction; dust-tight, water-tight, or explosion-resisting; or whatever may be required by the installation to protect motor control equipment and people.

A separately mounted start/stop pushbutton may also be used, in which case only the reset button would be mounted in the cover.

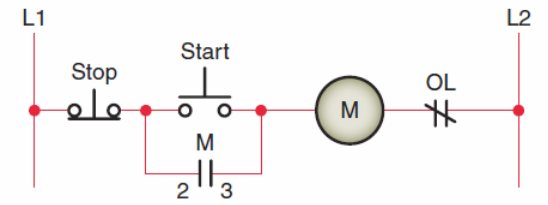


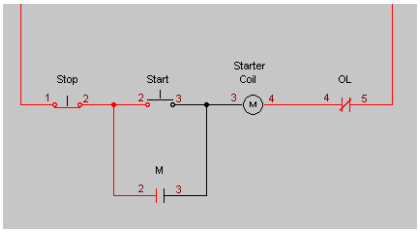
The starters are also built in skeleton form for mounting in a motor control center.





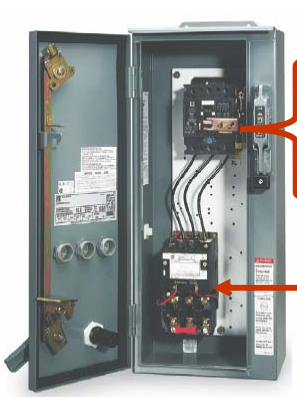
The starter control circuit consists of energizing the starter coil M when the start button is pressed and de-energizing it when the stop button is pressed or when the overload relay trips.

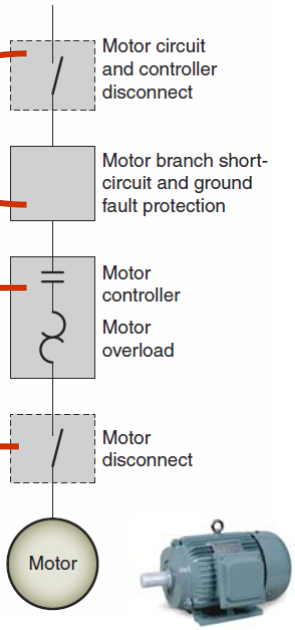




MOTOR OVERCURRENT PROTECTION

Motor branch circuits can be broken down into several major NEC requirements for motor installations.

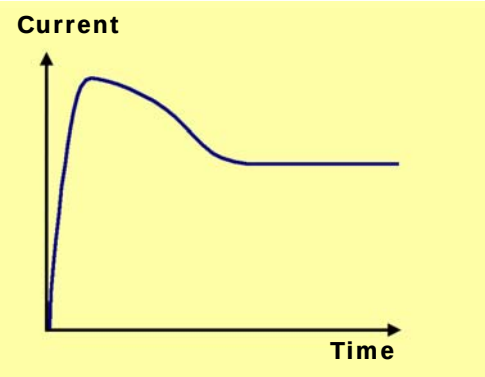




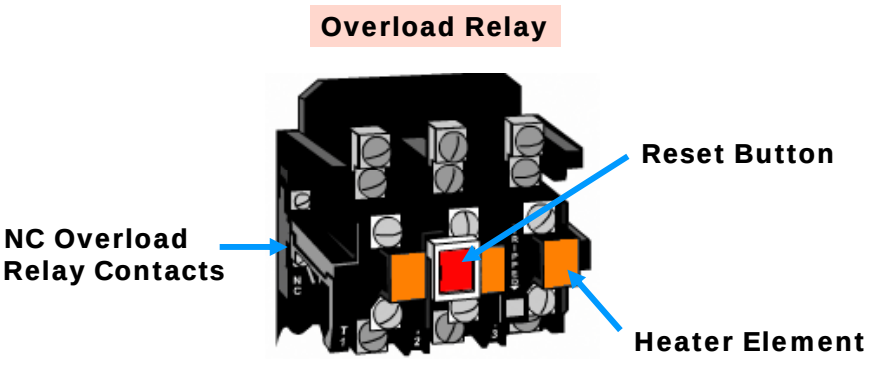
Often referred to as the at the motor disconnecting means

When an AC motor is first energized, a high inrush of current occurs.

- The initial inrush current is often 20 times the normal full load current.
- After the first half cycle the motor begins to rotate and the starting current subsides to 4 to 8 times the normal current for several seconds.
- As a motor reaches running speed, the current subsides to its normal running level.

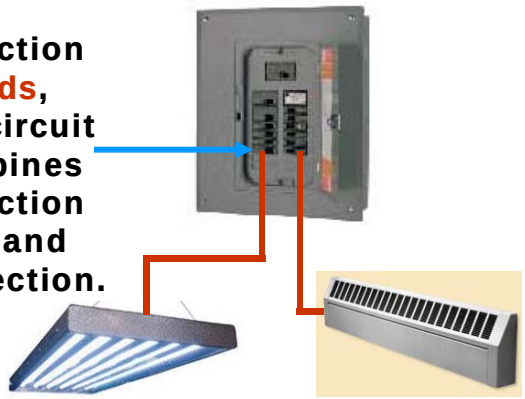


Due to the high inrush current, motors require special overload protective devices that can withstand the temporary overloads associated with starting currents and yet protect the motor from sustained overloads.



Motor starting characteristics make motor protection requirements different from that required for non-motor loads.

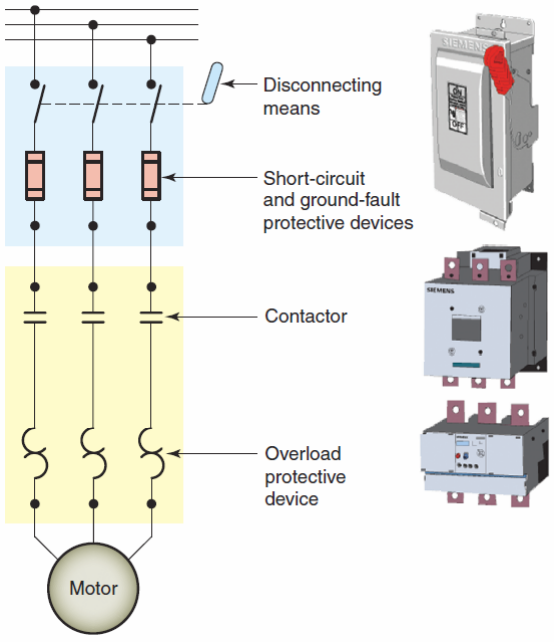
When providing overcurrent protection for non-motor loads, we use a fuse or circuit breaker that combines overcurrent protection with short-circuit and ground fault protection.

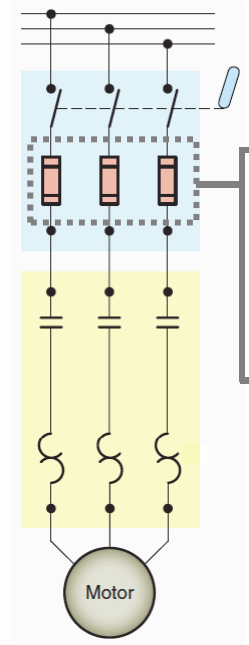


Lighting Load

Heating Load

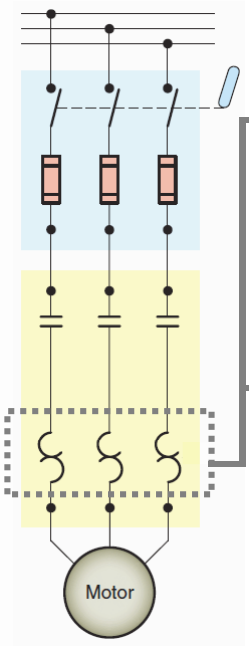
Motor overcurrent protection is normally provided by *separating* the overload protection devices from the short-circuit and ground-fault protection devices





Short-Circuit and Ground-Fault Motor Protection.

- Branch and feeder fuses and circuit breakers protect motor circuit against the very high current of a short circuit or a ground fault.
- Fuses and circuit breakers connected to motor circuits must be capable of ignoring the initial high inrush current and allow the motor to draw excessive current during startup and acceleration.

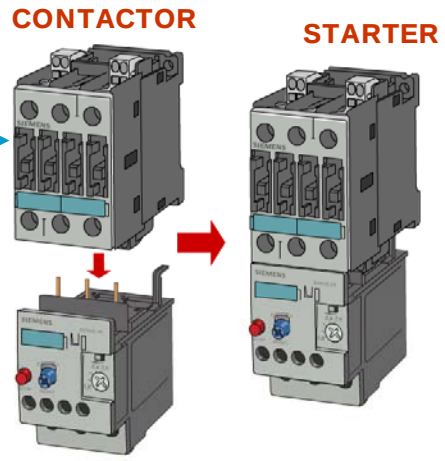


Overload Protection

- Overload devices are intended to protect motors, motor control apparatus, and motor-branch circuit conductors against excessive heating due to motor overloads and failure to start.
- Motor overload may include conditions such as a motor operating with an excessive load or a motor operating with low line voltages or a loss of a phase on a 3-phase motor.

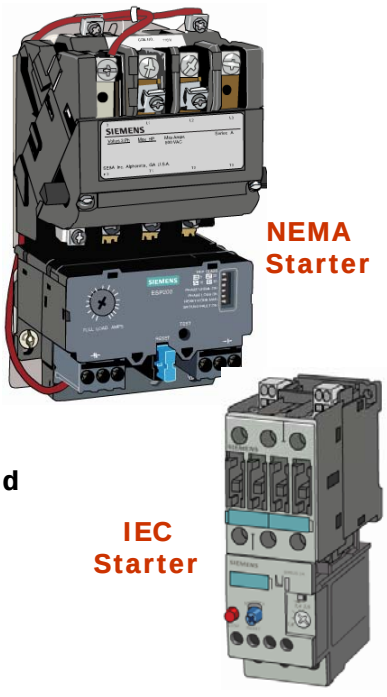
The basic difference between a contactor and motor starter is the addition of overload relays.

Contactor use is restricted to fixed lighting loads, electric furnaces, and other resistive loads that have set current values.



- Motors are subject to high starting currents and periods of load, no-load, short duration overload, and so on. They must have protective devices with the flexibility required of the motor and driven equipment.

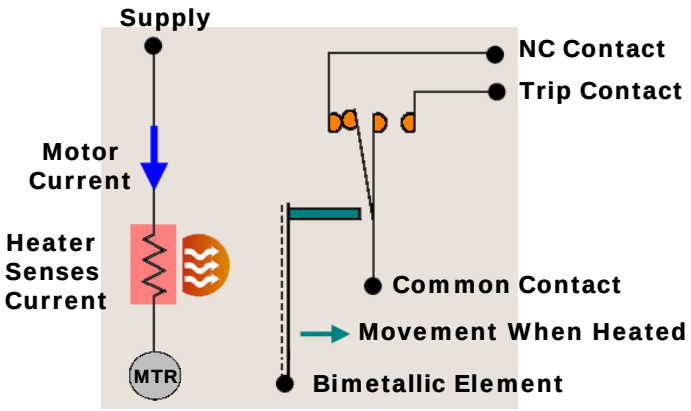
- Overload protection is used to protect the motor windings from excessive heat resulting from motor overloading. The motor windings will not be damaged when overloaded for a short period of time. If the overload should persist, however, the sustained increase in current should cause the overload relay to operate, shutting off the motor.



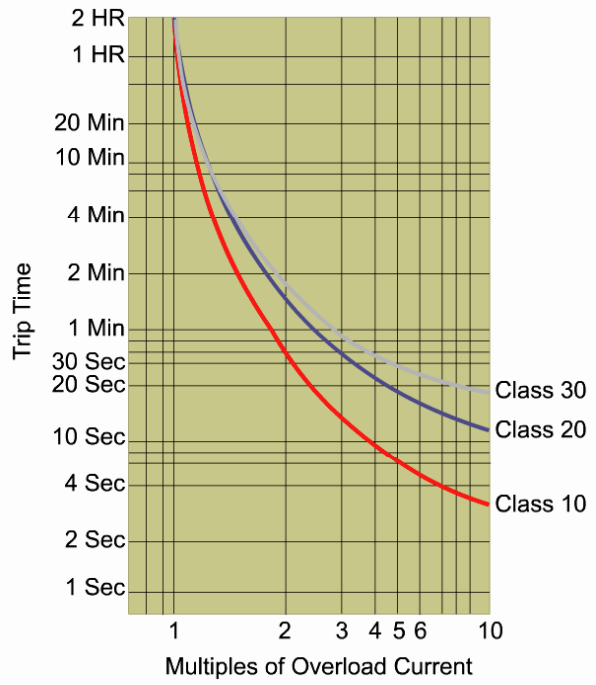
MOTOR OVERLOAD RELAYS

Motor Overload Relays

- Allow harmless temporary overloads without disrupting the circuit.
- Will open a circuit if current is high enough over a period of time.
- Can be reset once the overload is removed

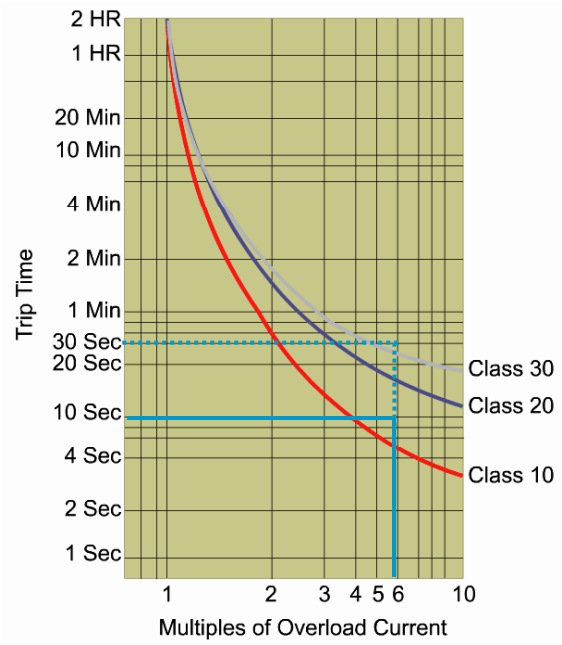


Overload relays are rated by a trip *Class*, which defines the length of time it will take for the relay to trip in an overload condition. The most common trip classes are Class 10, Class 20, and Class 30.



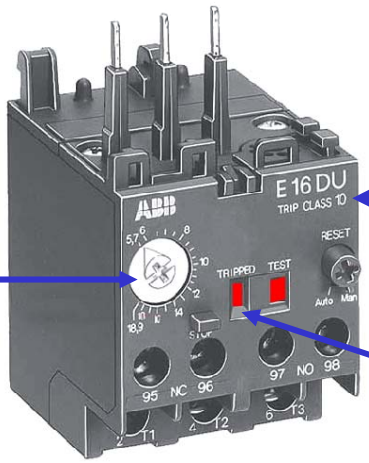
- **A Class 10 overload relay has to trip the motor off line in 10 seconds or less at 600% of the full load amps.**

- **The class designation is an important consideration. For example, a high inertia industrial load may require a Class 30 overload relays that trip in 30 seconds rather than a class 10 or 20.**



Normally overload protection devices have a *trip indicator* built into the unit to indicate to the operator that an overload has taken place.

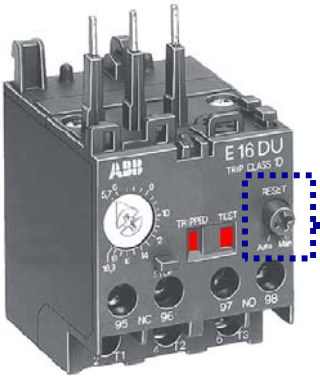
The nominal current setting allows the relay to be set to the full-load current shown on the motor rating plate and can be adjusted to the desired trip point.



Trip Class

Trip Indicator

Overload relays can have either a manual or an automatic reset.

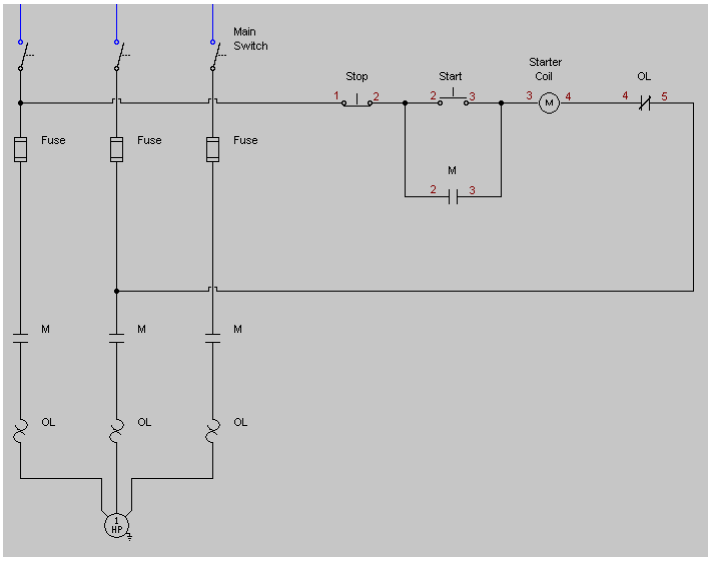


A manual reset requires operator intervention, such as pressing a button, to restart the motor.

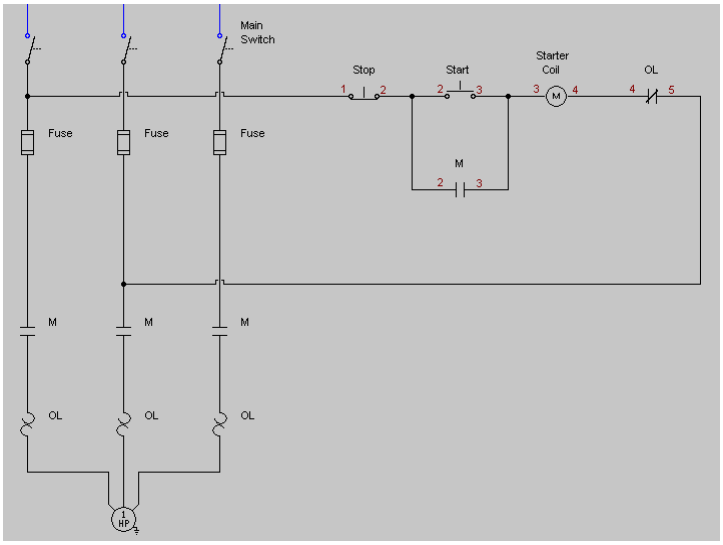
An automatic reset allows the motor to restart automatically, usually after a cooling off period.

After an overload relay has tripped, the cause of the overload should be investigated. Motor damage can occur if repeated resets are attempted without correcting the cause of the overload relay tripping.

Simulated Manual Reset OL Relay Action



Simulated Automatic Reset OL Relay Action



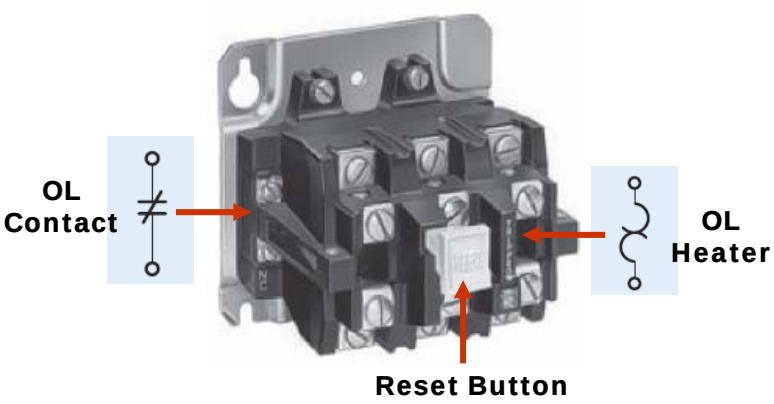
External-overload protection devices, which are mounted in the starter, attempt to simulate the heating and cooling of a motor by sensing the current flowing to it.

- The current drawn by the motor is a reasonably accurate measure of the load on the motor and thus of its heating.

- Overload relays can be classified as being thermal, magnetic, or electronic.

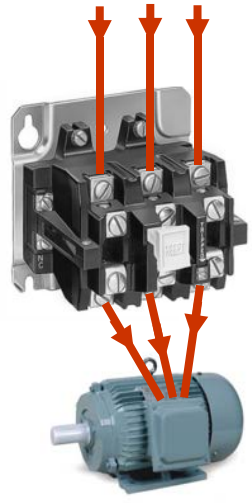
THERMAL OVERLOAD RELAYS

A *thermal-overload* relay uses a heater connected in series with the motor supply.



The **overload block** houses the contacts, a tripping mechanism with reset button, and interchangeable heaters sized for the motor being protected.

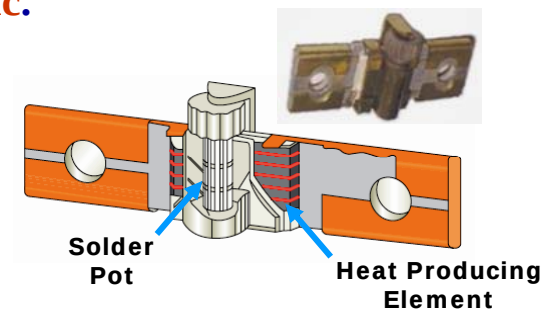
Current flowing from the motor contactor to the motor passes through the motor overload heaters.



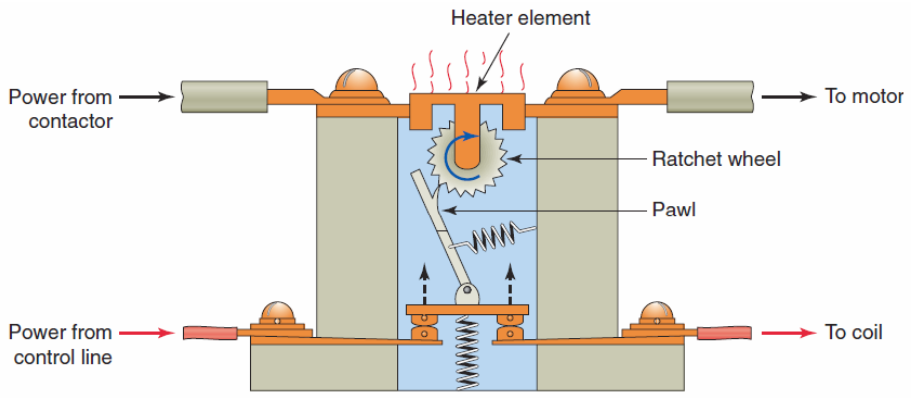
- The amount of heat produced increases with supply current.
- If an over-load occurs, the heat produced causes the set of OL contacts to open, interrupting the circuit.
- Installing a different heater for the required trip point changes the tripping current. The heater closely approximates the actual heating within the windings of the motor and has a thermal memory to prevent immediate reset and restarting.

The two types of thermal overload are the melting alloy and bimetallic.

The ***melting alloy*** type utilizes the principle of heating solder to its melting point.

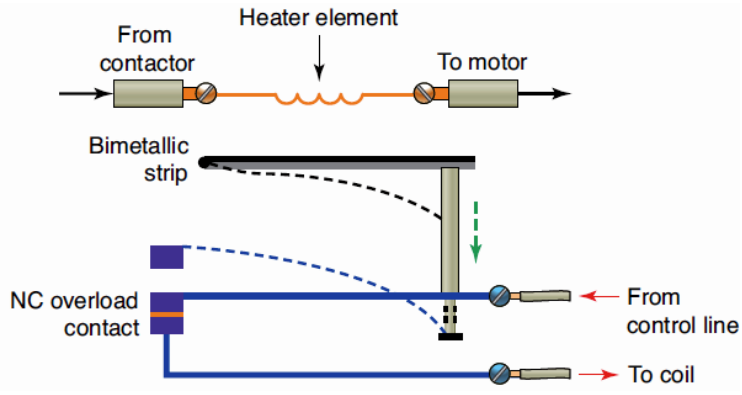


- It consists of a heater coil, eutectic alloy, and mechanical mechanism to activate a tripping device when an overload occurs.
- The term "eutectic" means easily melted.
- The eutectic alloy in the heater element is a material that goes from a solid to liquid state without going through an intermediate putty stage.

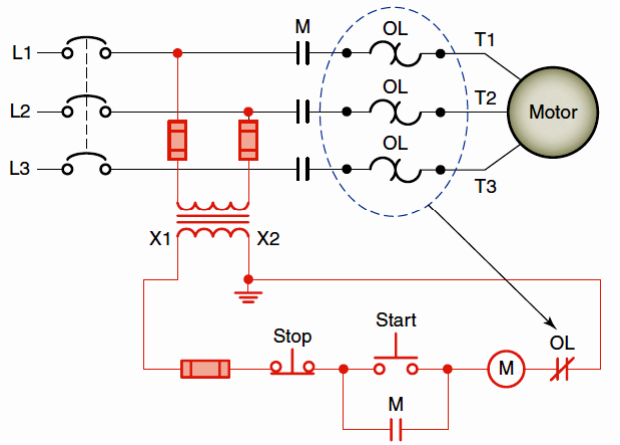


- When the temperature rises to a point where the alloy melts the ratchet wheel rotates to open the OL contacts.
- After the heater element cools, the ratchet wheel will again be held stationary and the overload contacts can be reset.

The *bimetallic* type of thermal overload relay uses a bimetallic strip made up of two pieces of dissimilar metal that are permanently joined by lamination.



- **Heating the bimetallic strip causes it to bend.**
- **Overload heating elements connected in series with the motor circuit heat the bimetal tripping elements.**
- **The movement of the bimetallic strip operates the trip mechanism and open the OL contacts.**



- The OL contact is connected in series with the M control coil of the starter.
- When the contact opens, the starter coil is de-energized.
- In turn, the starter's main power contacts open to disconnect the motor from the line.

Selecting the *proper heater size* for thermal OL relays is important for ensuring maximum motor protection.

Heater Type No.	Full Load Amps.							
	Size 00	Size 0	Size 1	Size 1P	Size 2	Size 3	Size 4	Size 5
W10	0.19	0.19	0.19					
W11	0.21	0.21	0.21					
W12	0.23	0.23	0.23					
W13	0.25	0.25	0.25					
W14	0.28	0.28	0.28					
W15	0.31	0.31						
			4.08					
W43	4.52	4.52	4.52					226
W44	4.98	4.98	4.98					249
W45	5.51	5.51	5.51		5.80			276
W46	6.07	6.07	6.07					
W47	6.68	6.68	6.68					

Overload heaters for motors are selected from manufacture's tables based on compliance with Section 430.20 of the NEC.

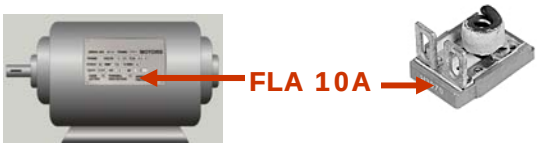
Selection tables normally list OL heaters according to motor FLC (full load current).

Heater Type No.	Full Load Amps.							
	Size 00	Size 0	Size 1	Size 1P	Size 2	Size 3	Size 4	Size 5
W10	0.19	0.19	0.19					
W11	0.21	0.21	0.21					
W12	0.23	0.23	0.23					
W13	0.25	0.25	0.25					
W14	0.28	0.28	0.28					
W15	0.31	0.31	0.31					
			4.08					
W43	4.52	4.52	4.52					226
W44	4.98	4.98	4.98					249
W45	5.51	5.51	5.51		5.80			276
W46	6.07	6.07	6.07					
W47	6.68	6.68	6.68					

Range

Tables show the range of motor currents available. These may be in increments of from 3 to 15 percent of full-load current. The smaller the increment, the closer the selection can be to match the motor to its actual work.

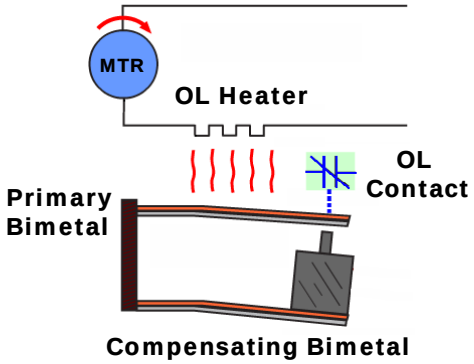
When the overload heater element is rated according to the motor FLC, the calculations required by the NEC to determine the necessary level of protection have already been completed.



For example, an OL heater rated at 10A in the selection table is intended for use with a motor that has a 10A FLC.

Typically, it is assumed that the motor has a service factor of 1.15 or greater and a temperature rise not over 40° C, which allows the motor to be protected up to 125% of the nameplate FLC rating.

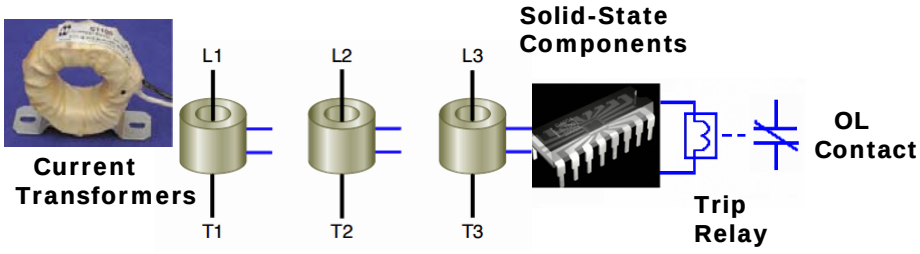
Thermal overload relays react to heat, regardless of the origin of the heat. Cooler ambient temperatures increase tripping times, while warmer temperatures decrease tripping times.



Ambient compensated bimetal overload relays are designed to overcome this problem. A compensating bimetal strip is used along with the primary bimetal. As the ambient temperature changes, both bimetals will bend equally and the overload relay will not trip.

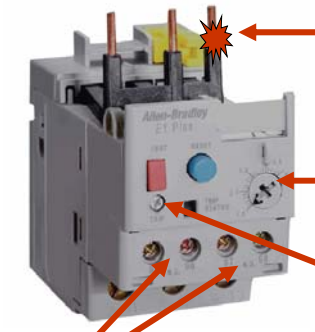
ELECTRONIC OVERLOAD RELAYS

An electronic overload relay measures motor current directly through a current transformer.



Outputs from the current transformers along with solid-state circuitry are used in determining the motor's thermal condition. When a motor overload occurs the coil of the trip coil is energized and opens the OL contact.

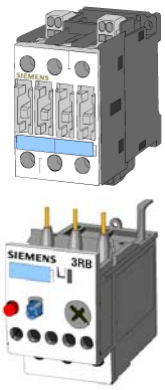
Features Of Electronic OL Relays



- A separate phase loss detection circuit is incorporated into the overload relay allows it to respond quickly to phase loss conditions.
- Instead of installing heaters, full-load current is set with a dial.
- DIP switch settings allow the selection of trip class and the reset mode (manual or automatic).
- Trip relay contains a set of isolated NC and NO contacts that provide trip and reset functions for control circuits.
- Energy savings through the elimination of heater coils.
- Reduction in the heat generated by the starter.
- Insensitivity to ambient temperature changes.

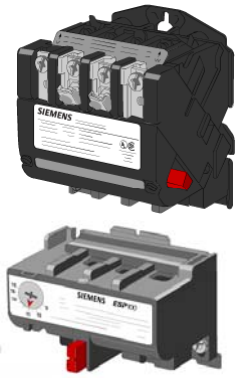
There is little difference between solid-state overload relays used for either NEMA or IEC starters.

IEC



In some applications, the same solid-state overload relay can be used in NEMA and in IEC units, leaving the contactor and enclosure the main differences between the two.

NEMA

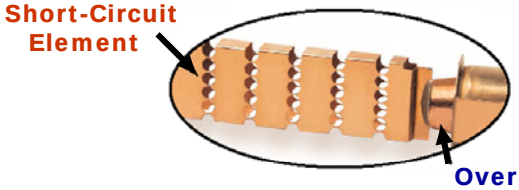


Microprocessor-based electronic overload relays are used in adjustable speed drives. In addition to motor overload protection, other protective features may include:

- Over temperature protection.
- Overvoltage protection.
- Undervoltage protection.
- Phase reversal protection.
- Phase unbalance current protection.
- Instantaneous overcurrent protection.
- Ground fault protection.
- Phase loss protection.
- Phase unbalance voltage protection.
- Tabulate the number of starts and lock out of the starting sequence to prevent excessive cycling.

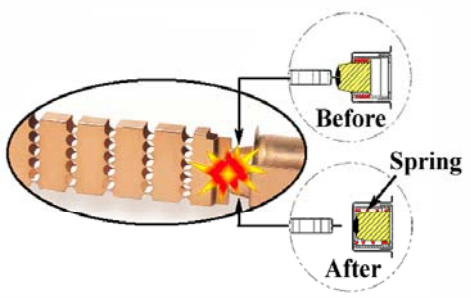
DUAL ELEMENT FUSES

Dual-element (time delay) fuses, when properly sized, provide both overload and fault protection.



They contains dual fuse elements with both thermal and instantaneous trip features that allow the high motor starting current to flow for a short time without blowing the fuse.

Under **sustained overload** conditions, the trigger spring fractures the calibrated fusing alloy of the overload element releasing the connector.



A **short-circuit** causes the restricted portions of the short-circuit element to vaporize. The arc-quenching filler material quenches the arcs creating an insulating barrier.