Motor Control
Motor Overload Protection

Purpose of Motor Overload Protection

The National Electric Code (NEC) defines *Motor Overload Protection* as that which is intended to protect motors, motor-control apparatus, and motor branch-circuit conductors against excessive heating due to motor overloads and failure of the motor to start. *Motor Overload Protection* is also commonly referred to as "*Running Protection*".

Note: *Motor Overload Protection* is not intended to protect against motor branch-circuit short-circuit and ground faults. In a combination starter, this type of protection is provided by fuses, a circuit breaker, or a Motor Circuit Protector (MCP). This protection is commonly referred to as "*Short Circuit Protection*" and is shown circled in red in the schematic below.

Fractional horsepower single-phase motor overload protection may be by: the *Branch Circuit Protection*, a *Separate Overload Device*, an *Integral Thermal Protector*, or *Impedance Protected*, or a combination of these methods, depending on whether or not the motor is permanently installed, is continuous-duty, and is manually or automatically started. Refer to the NEC Articles 430.32 - 430.34 for details and exceptions.

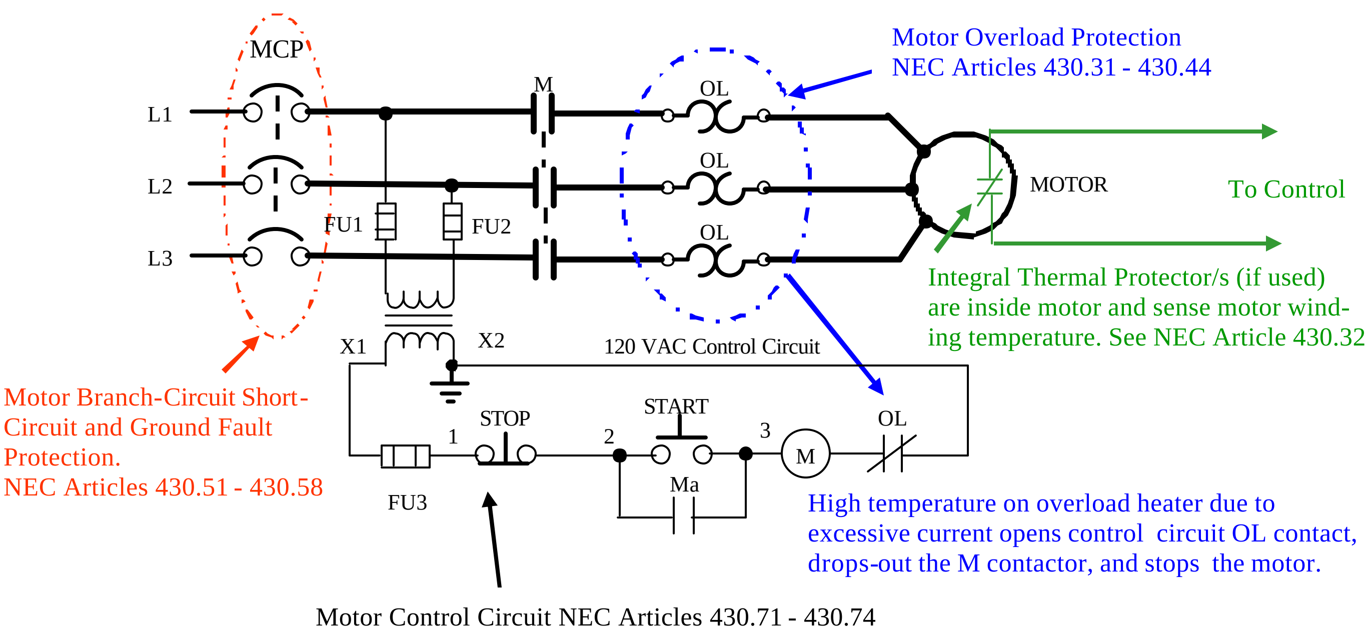
Overload protection for single and three-phase AC motors in the small (above 1 horsepower) and medium horsepower range is typically provided by one of two methods: *Thermal Overload Relays*, or *Solid-state Overload Relays*.

Overload protection for large three-phase motors is sometimes provided by *Thermal Overload Relays* which are connected to Current Transformers (CT's). However, most new installations utilized microprocessor-based motor protective relays which can be programmed to provide both overload and short-circuit protection. These protective relays often also accept inputs from Resistance Temperature Devices (RTD's) imbedded in the motor windings (usually two per phase) and the relays are capable of displaying the winding and motor bearing temperatures, and provide both alarm and trip capability.

Typical Schematic Diagram

Three-Phase Across-the-Line Starter with Thermal Overload Protection

See Sheet 5 for an operational description of this circuit.



Schematic Diagram Notes

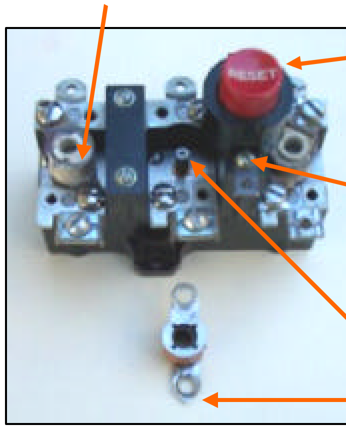
- The three-phase power circuit is shown in bold black.
- The single-phase 120 volt control circuit is shown with light-weight black lines.
- The bold black dashed lines indicate a mechanical connection and show that all three poles of the MCP operate simultaneously as do the three poles of the Main (M) Contactor .

Motor Overload Protection
Thermal Overload Blocks

Overload heaters work on principle that motor load (and therefore motor temperature) is directly related to the current drawn by the motor. Current flowing from the motor contactor to the motor passes through the motor overload heaters (one per phase) which are mounted in the control overload block. If the motor current exceeds the desired value, the heat produced by the motor overload heater will cause a control circuit contact in the overload block to open, drop out the contactor coil, and stop the motor. Manufacturers provide Heater Selection Charts from which the correct heater is chosen based on the motor *nameplate* Full Load Amps (FLA).

Overload Heater
Schematic Symbol

Overload Heater - Shown in installed position.



Overload Reset Push Button

Overload Contact Connection Terminal

Eutectic Alloy Barrel (Heater Removed)

Pointed Heater Position Tab

Eutectic Alloy Type

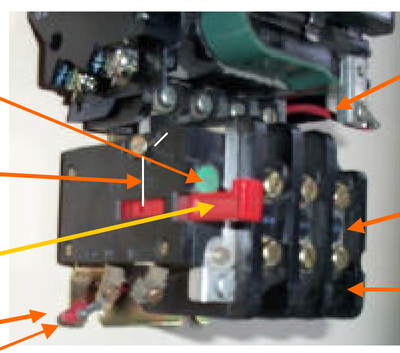
Center phase heater shown removed. On this style of overload block the heater can be mounted in one of four possible positions for fine adjustment of the trip value. Each position places the heater in a slightly different proximity to the melting alloy barrel. The heater has a pointed position indicator tab which shows the selected mounting orientation.

Calibration Adjustment Varies OL trip setting from 85% - 115% of heater table value.

Wire spring position sets OL unit for manual or automatic reset.

Reset Push Button

Overload Contact Terminals One side of OL contact is factory wired to coil terminal (red wire).



Factory installed coil jumper from overload contact (red wire).

Overload Heaters One per phase

Motor “T-Lead” Connections at bottom of each heater.

Bimetallic Type
Shown Plugged into Bottom of Contactor

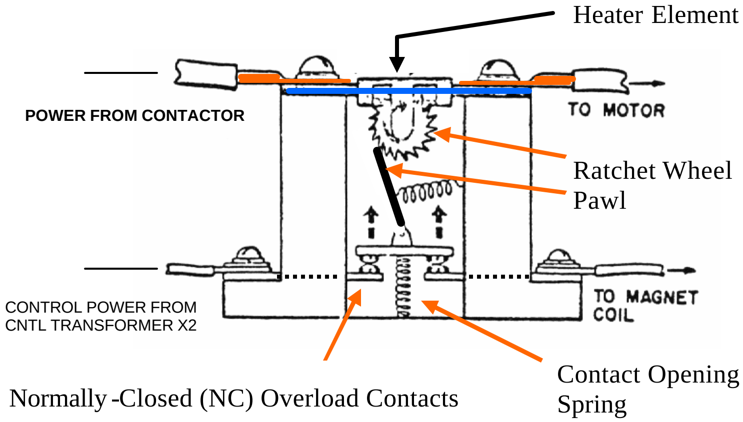
Ratchet Wheel

Overload Heaters

Assortment of various types. Two units on left are eutectic alloy type, other three are for bimetallic overload blocks. Heater on left incorporates ratchet wheel and alloy barrel into heater element.

Motor Overload Protection
Thermal Relay Operation

Melting Alloy Type Overload



Operating Principle

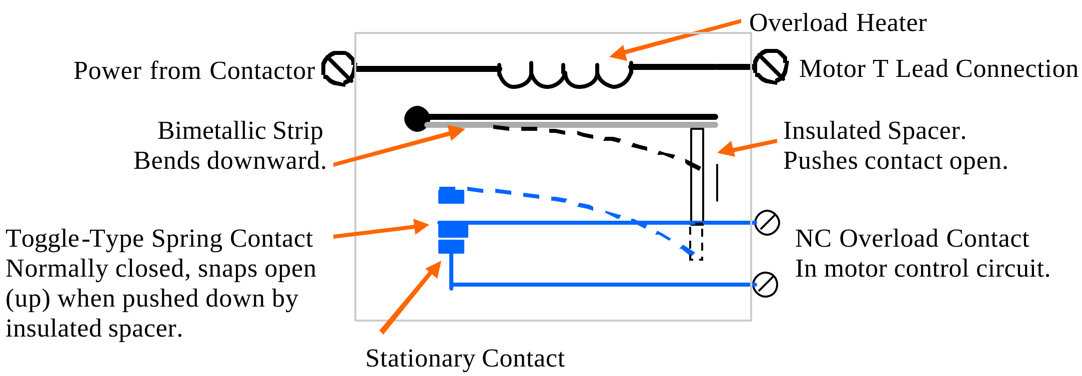
The term *eutectic* means "easily melted". The eutectic alloy in the heater element is a material that goes from a solid to liquid state without going through an intermediate putty stage.

When the motor current exceeds the rated value, the temperature will rise to a point where the alloy melts; the ratchet wheel is then free to rotate, and the contact pawl moves upward under spring pressure allowing the control circuit contacts to open.

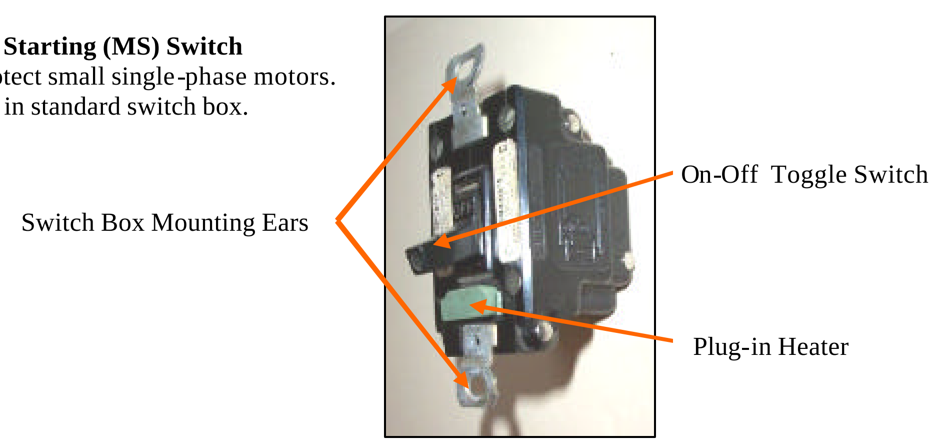
After the heater element cools, the ratchet wheel will again be held stationary and the overload contacts can be reset.

Severe fault currents can damage the heater element and they should be replaced after such an occurrence. However, normal overloads, usually, will not affect the heater element or alter its accuracy.

Bimetallic Type Overload



Motor Starting (MS) Switch
Designed to protect small single-phase motors.
Mounts in standard switch box.



Motor Overload Protection

Typical Heater Selection Chart

System Protection

How to Use the Overload Selection Chart

Shown below is an overload chart for Cutler Hammer, Citation Line Starters. Assume you have an Enclosed Type C300, NEMA Size 2 Starter, and that the motor *nameplate* Full-Load-Amps (FLA) is 11.0 amps. For this example you will use TABLE ST-3. Look down the TABLE ST-3 column until you find the heater range that includes the FLA for your motor and then look across to the Heater Coil Catalog Number column to select the correct heater.

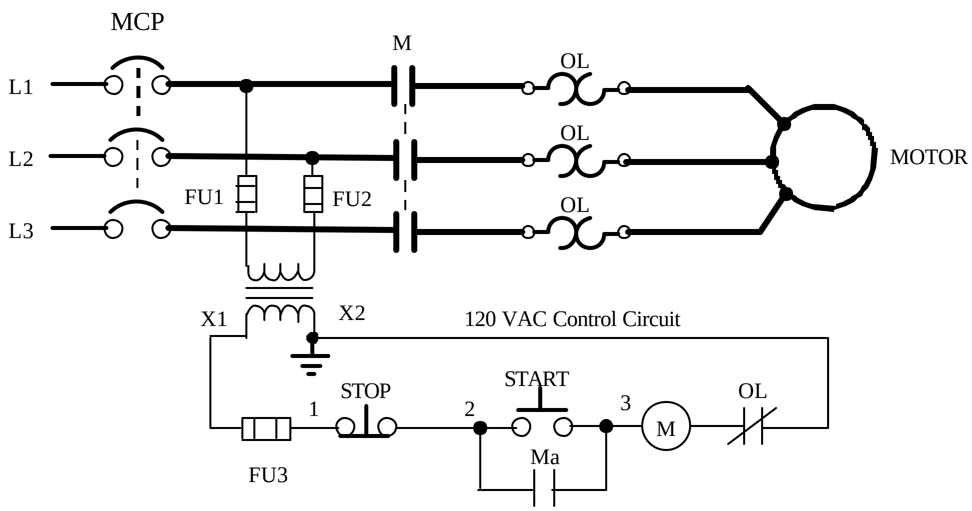
Selection Tables for Type ST Standard Trip Eutectic Alloy Overload Relay

For Motors With 1.15 Service Factor

TABLE ST-1	TABLE ST-2	TABLE ST-3	TABLE ST-4	TABLE ST-5	TABLE ST-6	
NEMA Sizes 00-0-1-1½		NEMA Size 2		NEMA Size 3		
For **Open** Type Cat. No. A10, A50, A700, B10, B50, C300 For **Enclosed** Type Cat. No. B10, B50, C300	For **Enclosed** Type Cat. No. A10, A50, ❶A460, ❷A490, A700	For **Open** Type Cat. No. A10, A50, A700, C300 For **Enclosed** Type Cat. No. B10, C300 A30, A40, A70, A80, A800-A803	For **Enclosed** Type Cat. No. A10, A50, ❶A460, ❷A490, A700	For **Open** Type Cat. No. A10, A50, A700, C300 For **Enclosed** Type Cat. No. B10	For **Enclosed** Type Cat. No. A10, A30, A40, A50, A70, A80, ❶A460, ❷A490, A700, A800-A803	Heater Coil Cat. No.
Heater Coil Ampere Range						
.167— .187	.155— .173					H1101
.188— .210	.174— .195					H1102
.211— .237	.196— .220					H1103
.238— .266	.221— .247					H1104
.267— .298	.248— .278					H1105
.299— .334	.279— .310					H1106
.335— .376	.311— .349					H1107
.377— .422	.350— .391					H1108
.423— .474	.392— .441					H1109
.475— .532	.442— .495					H1110
.533— .598	.496— .555					H1111
.599— .672	.556— .624					H1112
.673— .757	.625— .703					H1113
.758— .855	.704— .795					H1114
.856— .959	.796— .895					H1115
.960— 1.07	.896— .999					H1116
1.08 — 1.21	1.00 — 1.12					H1117
1.22 — 1.35	1.13 — 1.25					H1018
1.36 — 1.52	1.26 — 1.41					H1019
1.53 — 1.70	1.42 — 1.58					H1020
1.71 — 1.90	1.59 — 1.77					H1021
1.91 — 2.10	1.78 — 1.96					H1022
2.11 — 2.33	1.97 — 2.17					H1023
2.34 — 2.62	2.18 — 2.44					H1024
2.63 — 2.93	2.45 — 2.72					H1025
2.94 — 3.27	2.73 — 3.04					H1026
3.28 — 3.64	3.05 — 3.38					H1066
3.65 — 4.06	3.39 — 3.73	3.72— 4.10				H1027
4.07 — 4.55	3.74 — 4.18	4.11— 4.59	3.86 — 4.31			H1028
4.56 — 5.03	4.19 — 4.63	4.60— 5.07	4.32 — 4.77			H1029
5.04 — 5.59	4.64 — 5.15	5.08— 5.65	4.78 — 5.31			H1030
5.60 — 6.25	5.16 — 5.68	5.66— 6.29	5.32 — 5.90			H1031
6.26 — 6.92	5.69 — 6.30	6.30— 7.00	5.91 — 6.55			H1032
6.93 — 7.75	6.31 — 7.05	7.01— 7.82	6.56 — 7.33			H1033
7.76 — 8.63	7.06 — 7.76	7.83— 8.79	7.34 — 8.15	8.32— 9.27	8.24— 9.19	H1034
8.64 — 9.59	7.77 — 8.63	8.80— 9.67	8.16 — 9.00	9.28—10.1	9.20—10.1	H1035
9.60 —10.6	8.64 — 9.51	9.68—10.8	9.01 —10.1	10.2 —11.4	10.2 —11.3	H1036
10.7 —11.9	9.52 —10.5	10.9 —12.0	10.2 —11.2	11.5 —12.8	11.4 —12.7	H1037
12.0 —13.3	10.6 —11.8	12.1 —13.4	11.3 —12.5	12.9 —14.3	12.8 —14.1	H1038
13.4 —14.7	11.9 —13.1	13.5 —14.9	12.6 —13.9	14.4 —16.0	14.2 —15.8	H1039
14.8 —16.6	13.2 —14.8	15.0 —17.6	14.0 —15.7	16.1 —17.8	15.9 —17.7	H1040
16.7 —18.8	14.9 —16.7	17.7 —19.0	15.8 —17.5	17.9 —20.3	17.8 —20.1	H1041
18.9 —21.2	16.8 —18.9	19.1 —21.5	17.6 —19.8	20.4 —22.9	20.2 —22.7	H1042
21.3 —23.9	19.0 —21.3	21.6 —24.5	19.9 —22.3	23.0 —26.0	22.8 —25.5	H1043
24.0 —27.0	21.4 —24.1	24.6 —27.9	22.4 —25.4	26.1 —29.5	25.6 —28.9	H1044
	24.2 —27.0	28.0 —32.0	25.5 —28.7	29.6 —33.5	29.0 —32.5	H1045
		32.1 —36.6	28.8 —32.5	33.6 —37.8	32.6 —36.7	H1046
		36.7 —41.8	32.6 —36.6	37.9 —42.8	36.8 —41.0	H1047
		41.9 —45.	36.7 —41.0	42.9 —48.5	41.1 —46.0	H1048
			41.1 —45.	48.6 —55.1	46.1 —51.8	H1049

Schematic Diagram
Three-Phase Across-the-Line Starter

Schematic Diagram



Circuit Description
In the schematic above, the three-phase power circuit is shown in bold lines and the single-phase control circuit is shown by a lighter weight line. This circuit employs a standard START/STOP push button station and is know as a **Three Wire Control Scheme** because it requires three wires (shown numbered above) from the push button station to the other control components.

- For safety, this circuit uses a standard single-phase control transformer to provide low voltage (120 VAC) control and the X2 bushing is normally grounded.
  CAUTION: Some systems do not have a grounded X2! (This is sometimes done for continuity of service reasons - so that a control system ground will not shut the system down.)
- The transformer primary is connected downstream of the Motor Circuit Protector (MCP) so that when the motor control is turned off, the control circuit will also be de-energized - another important safety feature.
- After the fuse, the first control component is the STOP button.
- The normally closed Overload Contact is placed on the X2 side of the Main Contactor Coil M.
- Additional STOP push buttons are always wired in series, and additional START push buttons are always wired in parallel.

Circuit operation is as follows:

- Close **MCP** to apply power to the circuit.
- Depress momentary **START** push button. This causes the Main Contactor **Coil M** to be energized.
- Main Contactor **Coil M** closes **M** contacts (3) to start motor and also closes the **Ma** auxiliary contact.
- Auxiliary Contact **Ma** seals around the momentary **START** push button which can now be released.
- The motor continues to run until the normally closed **STOP** push button is momentarily depressed.
- In the event of an overload, the overload heaters will open the normally closed **OL** contact and drop-out the Main Contactor **M** and stop the motor.
- After an overload trip, the overload heaters must cool to permit resetting of the overload contact.