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.

Motor Branch-Circuit Short-Circuit and Ground Fault Protection. NEC Articles 430.51 - 430.58

Motor Overload Protection
NEC Articles 430.31 - 430.44

Integral Thermal Protector/s (if used) are inside motor and sense motor winding temperature. See NEC Article 430.32

High temperature on overload heater due to excessive current opens control circuit OL contact, drops-out the M contactor, and stops the motor.

Motor Control Circuit NEC Articles 430.71 - 430.74

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.
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).

**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

**Bimetallic Type**

- Shown Plugged into Bottom of Contactor

- Factory installed coil jumper from overload contact (red wire).
- Overload Heaters
- One per phase
- Motor “T-Lead” Connections at bottom of each heater.

**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.
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.

Switch Box Mounting Ears

On-Off Toggle Switch

Plug-in Heater
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>
<thead>
<tr>
<th>TABLE ST-1</th>
<th>TABLE ST-2</th>
<th><strong>TABLE ST-3</strong></th>
<th>TABLE ST-4</th>
<th>TABLE ST-5</th>
<th>TABLE ST-6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NEMA Sizes 00-0-111 1/2</strong></td>
<td><strong>NEMA Size 2</strong></td>
<td><strong>NEMA Size 3</strong></td>
<td>Heater Coil Cat. No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>For Open Type Cat. No.</strong></td>
<td><strong>For Enclosed Type Cat. No.</strong></td>
<td><strong>For Enclosed Type Cat. No.</strong></td>
<td><strong>For Open Type Cat. No.</strong></td>
<td><strong>For Enclosed Type Cat. No.</strong></td>
<td></td>
</tr>
<tr>
<td>A10, A50, A700, B10, B50, C300</td>
<td>A10, A50, A700</td>
<td>A10, A50, A700</td>
<td>A10, A50, A700</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>For Enclosed Type Cat. No.</strong></td>
<td><strong>A406, A490, A700</strong></td>
<td><strong>A406, A490, A700</strong></td>
<td><strong>A406, A490, A700</strong></td>
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</tr>
<tr>
<td>B10, B50, C300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Heater Coil Ampere Range

<table>
<thead>
<tr>
<th>1.15</th>
<th>1.35</th>
<th>1.55</th>
<th>1.75</th>
<th>1.95</th>
<th>2.15</th>
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</thead>
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<tr>
<td>0.85</td>
<td>1.00</td>
<td>1.15</td>
<td>1.30</td>
<td>1.45</td>
<td>1.60</td>
</tr>
<tr>
<td>1.20</td>
<td>1.35</td>
<td>1.50</td>
<td>1.65</td>
<td>1.80</td>
<td>1.95</td>
</tr>
</tbody>
</table>

### Notes

- The table above provides the selection criteria for the Overload Relay.
- The FLA for your motor is 11.0 amps.
- 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.
- Look across to the Heater Coil Catalog Number column to select the correct heater.
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.