

## Chapter 5

### Components, Symbols, and Circuitry of Air-Conditioning Wiring Diagrams

## Objectives

- Upon completion of this course, you will be able to:
  - Explain what electrical loads are and their general purpose in heating, cooling, and refrigeration systems
  - Give examples of common loads used in heating, cooling, and refrigeration systems
  - Identify the symbols of common loads used in heating, cooling, and refrigeration systems

## Objectives (cont'd.)

- Explain the purpose of relays and contactors in heating, cooling, and refrigeration systems
- Identify the symbols of relays and contactors in heating, cooling, and refrigeration systems
- Explain the purpose of switches and the types used in heating, cooling, and refrigeration systems

## Objectives (cont'd.)

- Identify the symbols of switches in heating, cooling, and refrigeration systems
- Identify the symbols and purpose of other miscellaneous controls in heating, cooling, and refrigeration systems
- Identify the different types of wiring diagrams used in the industry and the purpose of each

## Key Terms

- Contactor
- De-energized
- Disconnect switch
- Energized
- Factual diagram
- Fuse
- Heater
- Installation diagram
- Load
- Magnetic overload
- Magnetic starter
- Motor

## Key Terms (cont'd.)

- Normally
- Normally closed
- Normally open
- Pictorial diagram
- Pilot duty device
- Pole
- Pressure switch
- Push-button switch
- Relay
- Schematic diagram
- Signal light
- Solenoid

## Key Terms (cont'd.)

- Switch
- Thermal overload
- Thermostat
- Throw
- Transformer

## Introduction

- Electric wiring diagrams
  - Wealth of information
    - Electrical installation
    - Operation of equipment
  - Depended upon for correct installation of wiring to the unit
  - Used as a guide in troubleshooting
  - Symbols are used to represent components

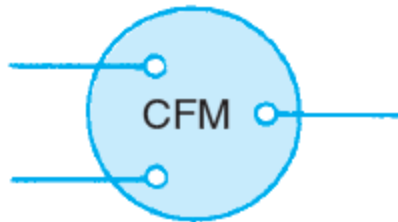


## Loads

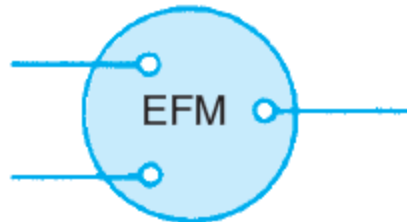
- Electrical devices that consume electricity to do useful work
  - Motors, solenoids, resistance heaters, and other current-consuming devices
- Most important part of a heating, cooling, or refrigeration system
  - They do all the work

## Motors

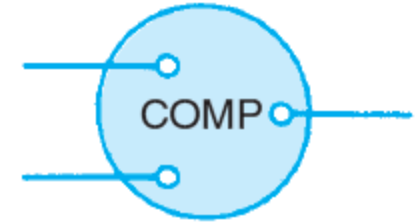
- Electrical devices that consume electric energy to rotate a device
  - Used to rotate compressors, condenser fan motors, pumps, etc.
- Largest and most important loads in heating, cooling, and refrigeration systems



(a) Condenser fan motor



(b) Evaporator fan motor



(c) Compressor motor



(d) Compressor motor



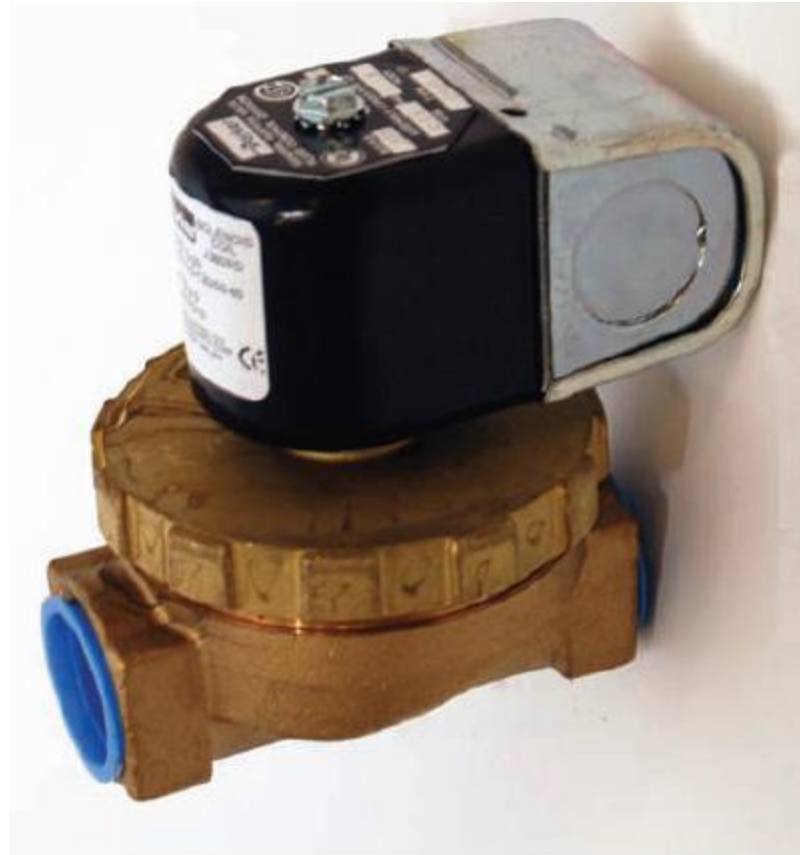
(e) Compressor motor with  
internal overload

Figure 5.8 Symbols representing some common letter designations.  
(Delmar/Cengage Learning)

## Solenoids

- Devices that create a magnetic field when energized
  - Cause some action to an electric component (e.g., relay or valve)
- Considered to be loads
  - Consume electricity to do useful work

Figure 5.10  
(a) Solenoid valve with coil;  
(b) Symbol for Solenoid.  
*(Delmar/Cengage Learning)*



## Heaters

- Loads found in many systems and wiring diagrams
  - Convert electrical energy to heat
    - In some cases, electric resistance heaters are used to heat homes
    - May be used to heat a small object or area

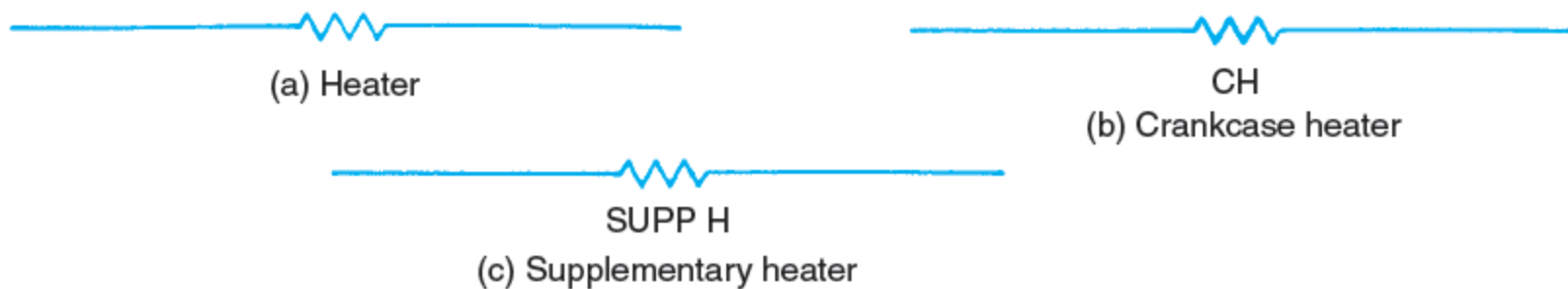


Figure 5.11 Symbols for commonly used electric heaters.  
*(Delmar/Cengage Learning)*

## Signal Lights

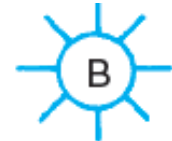
- Lights that are illuminated to denote a certain condition in a system
  - Show that equipment is operating or is operating in an unsafe condition



(a) Red



(b) Green



(c) Blue

Figure 5.12 Symbols for signal lights showing the color of the light.  
(Delmar/Cengage Learning)



## Contactors and Relays

- Open and close a set or sets of electric contacts by action of solenoid coil
  - Composed of a solenoid and contacts
    - When solenoid is energized contacts open or close, depending on original position
- Main difference between a contactor and relay is size
  - Contactor is simply a large relay

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Figure 5.13 Relay.  
(Delmar/Cengage Learning)

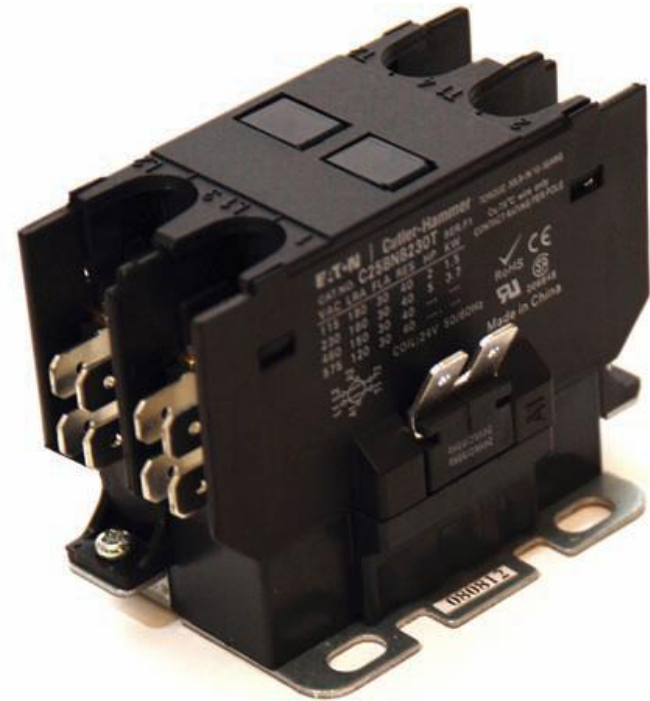


Figure 5.14 Contactor.  
(Delmar/Cengage Learning)

## Contactors and Relays (cont'd.)

- Composed of three parts
  - Contact
    - Pole is one set of contacts
  - Coil or solenoid
    - Is energized and closes the contact(s)
  - Mechanical linkage
- Symbols
  - Usually shown in de-energized position

## Contactors and Relays (cont'd.)

- Important terms
  - Normally: position of a set of contacts when device is de-energized
  - Normally open: set of contacts that are normally open
    - When relay is energized, contacts close
  - Normally closed: set of contacts that are normally closed
    - When relay is energized, contacts open



Figure 5.15 Symbol for a normally open pole of a relay or contactor.  
(Delmar/Cengage Learning)



Figure 5.16 Symbol for a normally closed pole of a relay or contactor.  
(Delmar/Cengage Learning)

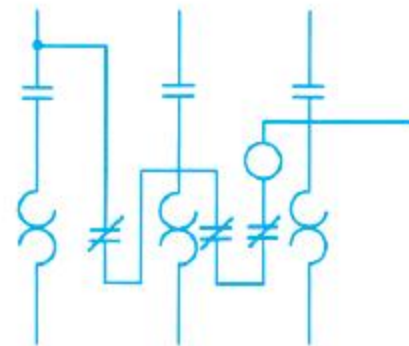


Figure 5.17 Symbols for relay or contactor coil; either symbol may be used for each device.  
(Delmar/Cengage Learning)

## Magnetic Starters

- Same type of device as a contactor in terms of ampere rating
  - Also has a means of overload protection

Figure 5.20 (a) Magnetic starter;  
(b) Symbol.  
(Delmar/Cengage Learning)



## Switches

- Open and close to control some load in an electric circuit
  - Can be opened and closed by temperature, pressure, humidity, flow, or manually
  - Throw indicates how the switch may be operated

## Switches (cont'd.)

- Important terms
  - Disconnect switch: opens and closes the main power source
  - Push-button switch: opens and closes a set of contacts by pressing a button
  - Thermostats: mechanically operated switches used in most control systems
  - Pressure switches: used for different functions in modern control circuits



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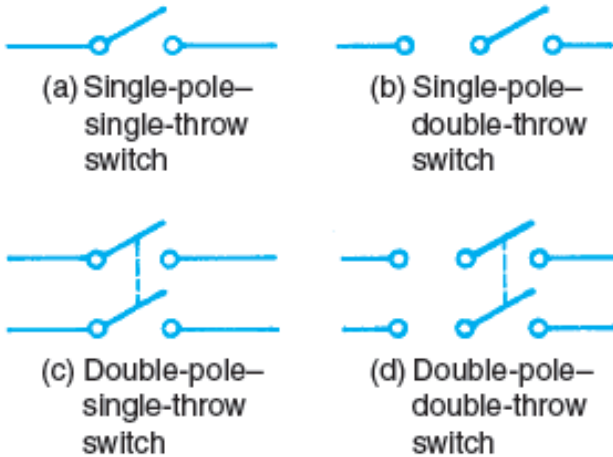


Figure 5.23 Symbols for manual switches.  
(Delmar/Cengage Learning)



(a)

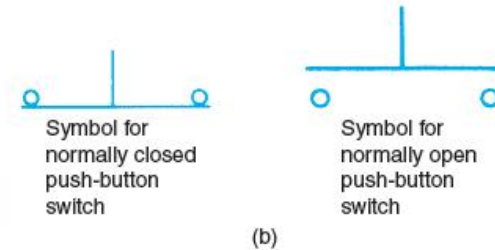


Figure 5.25 (a) Push-button switch; (b) Symbol.  
(Delmar/Cengage Learning)



(a) Heating thermostat; opens on temperature rise



(b) Cooling thermostat; closes on temperature rise

Figure 5.26 Symbols for heating and cooling thermostats.  
(Delmar/Cengage Learning)



(a) Opens on rise in pressure



(b) Closes on rise in pressure



Figure 5.29 Pressure switches.  
(Delmar/Cengage Learning)

Figure 5.28 Symbols for pressure switches.  
(Delmar/Cengage Learning)

## Safety Devices

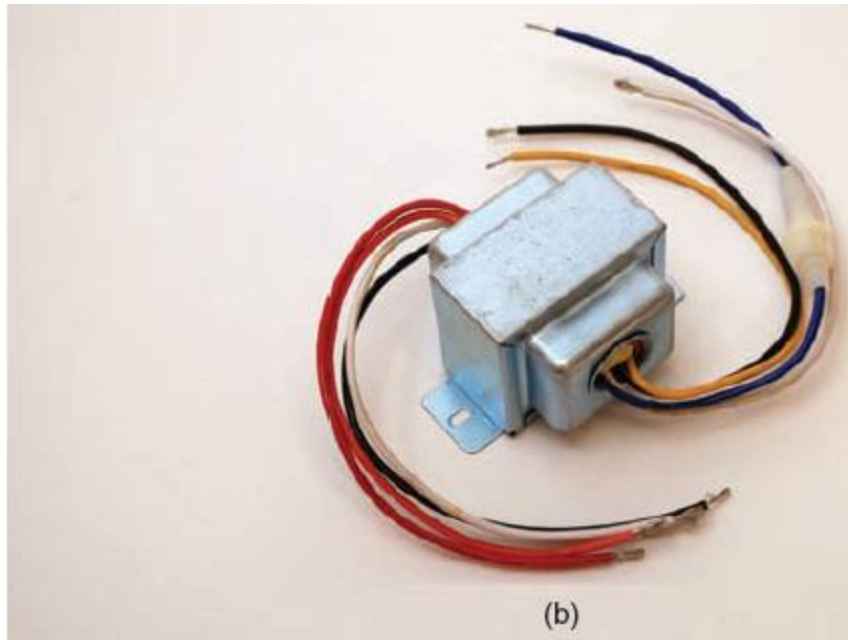
- Important in today's modern systems
  - Fuse: simplest type of overload device
    - Effective against a large overload, but less effective against small overloads
  - Thermal overload: operated by heat
    - Example: bimetal element
  - Magnetic overload: operated by magnetism
    - Directly proportional to current draw

## Transformers

- Decrease or increase incoming voltage to a desired voltage



(a)



(b)

Figure 5.36  
(a) Symbol;  
(b) Transformer.  
(Delmar/Cengage Learning)

## Schematic Diagrams

- Modern heating, cooling, and refrigeration systems
  - Becoming more complex with more controls and safety devices
- Schematic diagram
  - Most useful and easiest to follow
    - Tells how, when, and why a system works
    - Includes symbols and line representations

## Pictorial Diagrams

- Also known as label or line diagrams
  - Intended to show actual internal wiring
    - Shows all control panel components as a blueprint
    - Components not shown in the control panel are shown outside the panel and labeled
- Factual diagram
  - Consists of a pictorial diagram along with a schematic diagram

## Installation Diagrams

- Used to help wire the unit properly
  - Give specific information about terminals, wire sizes, color coding, and breaker or fuse sizes
  - Do not provide details about equipment operation
  - Show little internal wiring