

Course 206

HVAC Systems  
Inspection and Maintenance

Module 4:  
Heaters, HVAC and Electronic Controls

INSTRUCTOR GUIDE

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## Slide 4

Inspection and Maintenance of HVAC Systems

## Objectives

- Demonstrate knowledge of basic elements of a control system
- Demonstrate ability for the inspection and maintenance of:
  - heaters
  - temperature sensors
  - Low Pressure Switch, High Pressure Switch, Flow Switch
  - Relays and Contactors
  - Control Boards
  - Overcurrent Protection
  - GFCI Protection
- Demonstrate ability to:
  - work between laptop and PLC programs
  - work with HVAC communications networks

 RAIL CAR TRAINING CONSORTIUM

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**INSTRUCTIONAL ACTIVITY:** List objectives for Module 4

**TIME:** 1 minute

**INSTRUCTION METHOD:** Lecture

**SAY:** Here are the learning objectives for Module 4. Each is animated in the slide. Read each objective to participants then mouse-click to the next.

**DO:** Read (or ask for a volunteer to read) each objective. **Click on mouse to advance to next objective.**

**PARTICIPANT GUIDE (COURSEBOOK) PAGE REFERENCE:** \_\_\_\_

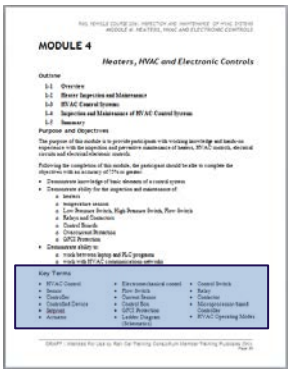
**ADVANCE SLIDE**

Instructor Notes

## Slide 5

**Inspection and Maintenance of HVAC Systems**

## Key Terms



- HVAC Control
- Sensor
- Controller
- Controlled Device
- Setpoint
- Actuator
- Electromechanical control
- Flow Switch
- Current Sensor
- Control Box
- GFCI Protection
- Ladder Diagram (Schematics)
- Control Switch
- Relay
- Contactor
- Microprocessor-based Controller
- HVAC Operating Modes

**RAIL CAR TRAINING CONSORTIUM**

**INSTRUCTIONAL ACTIVITY:** List objectives for Module 4

**TIME:** 2 minutes

**INSTRUCTION METHOD:** Lecture with discussion

**SAY:** This module contains several key terms. They are listed on the bottom of the Page \_\_\_\_ in the Participant Guide. Some you may know and some you may not know. I am going to pull up the list of each key term. As I do so, make a note of which term you would like to know more about by circling that in your Participant Guide.

**DO:** Read each key term. **Click on mouse to advance to next term.**

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## Heater Inspection and Maintenance


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Inspection and Maintenance of HVAC Systems

**Recall**

**From previous courses, what do you already know about the different types of heaters used in rail cars and cabs?**



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**INSTRUCTIONAL ACTIVITY:** Encourage recall of known topics.

**TIME:** 5 minutes

**INSTRUCTION METHOD:** Discussion

**SAY:** From previous courses, what do you already know about the different types of heaters used in rail cars and cabs?

**DO:** Facilitate discussion on some of the responses offered by participants.

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Instructor Notes

Slide 9

Inspection and Maintenance of HVAC Systems

## Heater Inspection and Maintenance (3)

- Resistance test:
  - Verify resistance values
  - Check for properly rated fuses
  - Verify resistance element mounting, insulators and hardware
  - Examine resistance to ground.
- Inspect heater contactor operation
- Verify operation of air flow switch device
- Inspect motors used on the heater

 RAIL CAR TRAINING CONSORTIUM

**INSTRUCTIONAL ACTIVITY:** Present the content**TIME:** 1 minutes**INSTRUCTION METHOD:** Lecture with hands-on demonstration in lab or during field trip

**SAY:** If heaters are checked with a resistance test, verify resistance values. Check that properly rated fuses are installed in the heating system. Verify that heating resistance element mounting, insulators and hardware are properly installed and not damaged. Be sure to examine the resistance to ground.

Inspect and verify the heater contactor operation.

Make sure that the air flow switch device is operating properly.

Inspect and verify operating conditions of any motors used on the heater (see Module 1 of Course 206 for motor inspection and maintenance)

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Inspection and Maintenance of HVAC Systems

### Flow Switches

- Monitor flow of air or liquid and send trip signal to other devices (e.g. compressor) for protection
- Used in rail HVAC for measuring air flow to switch on:
  - Compressor
  - Heater
  - Defrost cycle (Pressure difference across coil)

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**INSTRUCTIONAL ACTIVITY:** Present the content**TIME:** 1 minutes**INSTRUCTION METHOD:** Lecture

**SAY: Flow switches** are devices that monitor flow and send a trip signal to other devices, like a compressor, for protection. These switches can be used for the measurement of air and liquids. Flow switches can also be used to trigger an alarm and provide protection to a system if necessary. While all flow switches are flow meters, not all flow meters are flow switches because they are not all equipped with the ability to control flow rate. The switch consists of a valve body, sensing device, and a switching unit that is connected to a pipeline. Flow switches are most commonly used in rail HVAC for measuring air flow. A compressor or a heater will not be switched on if the flow switch detects no air flow. Flow switches can also be used for the defrost cycle. It measures the pressure difference across the coil. If pressure difference exists, the flow switch will activate the defrost cycle. Some systems do not use flow switches. Instead, motor current is monitored using a **current sensor** to verify air flow.

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**Inspection and Maintenance of HVAC Systems**

### Microprocessor-based Controls

Thermo King Light Rail Vehicle HVAC Service Software - Setting Temperature Setpoints (Courtesy of Denver RTD)

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**INSTRUCTIONAL ACTIVITY:** Present the content**TIME:** 1 minutes**INSTRUCTION METHOD:** Lecture

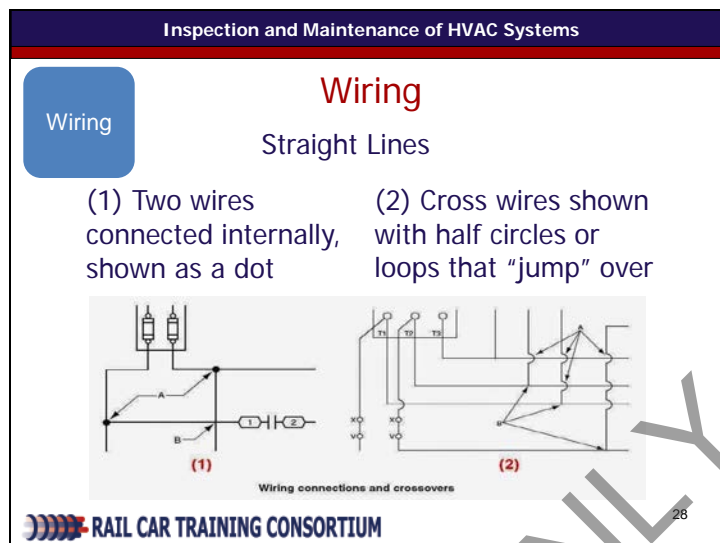
**SAY:** This is a screenshot of the Thermo King Light Rail Vehicle HVAC Service Software for Setting Temperature Setpoints.

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**INSTRUCTIONAL ACTIVITY:** Present the content**TIME:** 1 minutes**INSTRUCTION METHOD:** Lecture

**SAY:** Most schematics use straight lines to represent the wires that connect components to each other.

If two wires are connected internally, the connection usually is shown as a dot (a solid black circle), as illustrated at those points marked "A" in (1) of the Figure. But note that there is no dot to indicate a junction or connection at point "B." This means that one wire simply crosses over the other wire.

Now look at (2) in the Figure, crossover wires are shown with half circles or loops that "jump" over other wires (see those points marked "A"). Note also that in this type of diagram, junctions are shown without connection dots (see those points marked "B").

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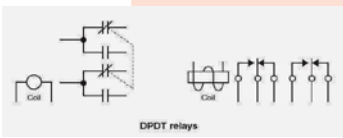
Inspection and Maintenance of HVAC Systems

Switches

## Electronically Controlled Switches

### Relays

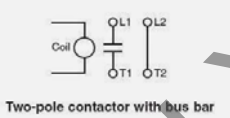
- Symbols similar to manually operated switches
- Often include a solenoid coil



DPDT relays

### Contactors

- Heavy-duty relay that handles higher voltages and higher currents than a control relay
- Symbols identical to relay in schematics



Two-pole contactor with bus bar

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**INSTRUCTIONAL ACTIVITY:** Present the content**TIME:** 1 minutes**INSTRUCTION METHOD:** Lecture

**SAY: Relays** are electrically operated control switches. The schematic symbols used to represent relays are the same as those for manually operated switches, except that relay symbols often include a solenoid coil.

There are several possible ways of depicting the solenoid coil. Figure on the left shows two different schematic representations of a DPDT (double-pole, double throw) relay.

A **contactor** is a type of heavy-duty relay that handles higher voltages and higher currents than a control relay. Contactors appear nearly identical to relays on schematic diagrams.

Some manufacturers employ contactors that use a single set of contacts. A “bus bar” is placed over the connection where the other set would be, as shown in Figure on the right. Bus bars can also be used to provide power across a series of circuit breakers.

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Instructor Notes

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Inspection and Maintenance of HVAC Systems


## HVAC Schematics


### Knowledge Check

Choose the correct answer

4. Which of the following describes contactors in HVAC control?

- Contactors are heavy-duty relays
- Contactors normally handle higher voltages and higher currents than a control relay
- Symbols of contactors are generally identical to relay in HVAC schematics
- All of the above.



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**INSTRUCTIONAL EVENT:** Assess participants' grasp of content presented so far.

**TIME:** 1 minutes

**SAY:** Here's the Knowledge Check. What do you think the answer is?

**DO:** This should be easily answered by all participants. When they decide on the answer, advance the slide to reveal the correct answer.

**Answer:** d.

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Instructor Notes

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Inspection and Maintenance of HVAC Systems


## Reading and Understanding HVAC Electrical Schematics

**Classroom Activity**

In small groups or pairs, use the CATS HVAC electrical schematic diagram in Handout 1. Circle and number the following in the schematic:

- (1) High voltage source
- (2) Control voltage source
- (3) K20 contactor coil
- (4) Fans controlled by Condenser Fan Relay CFR
- (5) Fuse for left Evaporator Fan Motor
- (6) Two compressor circuit breakers
- (7) Temperature controls

You have 10 minutes

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**INSTRUCTIONAL EVENTS:** Elicit performance

**TIME:** 12 minutes

**DO:** Have participants work with a partner to work on Classroom Activity in their coursebook giving them 10 minutes to complete this activity. Once completed walk participants through the correct answers on the screen using the instructor marked version.

**\*\*** This exercise can be adapted by the instructor using the property specific HVAC schematics.

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**Other Tools/Media/Materials:** Property specific HVAC electrical schematic diagram

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Instructor Notes

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Inspection and Maintenance of HVAC Systems

### Control Inspection and Maintenance - Controller

- Test the control boards and perform function tests with portable test equipment. Replace if necessary.
- Test relays and connectors for load. Examine the current protection
- Check and test the GFCI protection



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**INSTRUCTIONAL ACTIVITY:** Present the content

**TIME:** 1 minutes

**INSTRUCTION METHOD:** Lecture with hands-on demonstration in lab or during field trip

**SAY:** Controller inspection and maintenance continued:

- Test the control boards and perform function tests with portable test equipment. Determine if the control boards need to be replaced and follow your transit system guidelines.
- Be sure to examine relays and connectors. Test to see if relays and connectors can hold load. Replace if necessary.
- Examine the current protection and replace, as needed.
- Check and test the GFCI protection. Replace if necessary.
- Remember to always inspect and replace components in accordance with your agency's guidelines and OEM recommendations.

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