

# Troubleshooting HVACR System Electrical Circuits

## Unit 15

<b>Unit Contents</b>	
	<b>Teacher Page</b>
<b>Teacher Components</b>	Suggested Activities . . . . . 15–3
	Answers to Assignment Sheets . . . . . 15–9
	Written Test. . . . . 15–11
	Answers to Written Test . . . . . 15–27
	Teacher Supplements
	1—Heat Pump as Alternative for Assignment Sheets . . . . . 15–29
	Transparency Master
	1—Hopscotch Method of Troubleshooting. . . . . 15–31
	<b>Student Guide</b>
<b>Student Components</b>	Learning Activities Sheet . . . . . 15–3
	Objective Sheet . . . . . 15–7
	Information Sheet . . . . . 15–9
	Student Supplements
	1—Troubleshooting CSR Motors With an Ammeter . . . . . 15–21
	2—Troubleshooting Tree for a Standing Pilot . . . . . 15–25
	* Assignment Sheets
	1—Identify Components on HVACR System Electrical Diagrams . . . . . 309
	2—Identify Component Operations from HVACR System Electrical Diagrams . . . . . 313
	3—Select Test Instruments or Procedures for Specific HVACR System Troubleshooting. . . . . 317
	4—Solve HVACR Electrical Troubleshooting Problems. . . . . 321
	* Job Sheets
	1—Troubleshoot Series Electrical Circuits on Selected HVACR Equipment. . . . . 325

# Unit Contents

---

2—Troubleshoot Parallel Electrical Circuits on Selected HVACR Equipment . . . . .	327
3—Troubleshoot Series-Parallel Electrical circuits on Selected HVACR Equipment . . . . .	329

\* Assignment Sheets and Job Sheets are located in the Student Workbook.

Instructional  
Plan**Suggested Activities****Preparation**

- Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.
- Review “Teaching Suggestions” section that follows. Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes/CDs, and other resources to supplement instruction of this unit. See “Resources Used in Developing This Unit” and “Suggested Supplemental Resources” for more information.
- Make copies of the teacher supplement that will be provided for each student.
- Make transparencies or PowerPoint slides from the transparency masters included in this unit. These appear in the teacher edition only.  
  
TM 1—Hopscotch Method of Troubleshooting (Objective 6)
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.

**Delivery and Application**

## Unit Introduction (self-paced instruction)

- Provide student with Unit of Instruction.
- Review unit contents with student, the location of reference materials, and the procedure for accessing the Internet, if available.
- Have the student complete the steps in the Learning Activities Sheet. Initial the student's sheet where indicated as they complete each activity.

## Suggested Activities

---

### Unit Introduction (group instruction)

- Provide students with Unit of Instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

### Teaching Suggestions

- Review “Unit 1, Fundamentals of Electricity.” Have students refresh their knowledge of basic series, parallel, and series-parallel circuits. Talk about the applications of basic circuits in HVACR system electrical circuits.
- Stress the importance of the elements in Objective 3 to the overall objective of troubleshooting. Impress upon students the importance of keeping notes so they can reference them to help with similar troubleshooting problems they confront later in their service careers.
- Demonstrate the hopscotching method presented in Objective 6. Have a circuit with faults inserted so students can practice with you in hopscotching to isolate problems.
- Prepare motors or other components to demonstrate shorts and grounds as presented in Objective 9.
- Have students prepare short reports of an electrical problem they have solved or seen solved at home or someplace other than the classroom, even an automobile. Have students present their reports to the class.

### Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student’s competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

## Suggested Activities

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

### Sample A

4—**Skilled**—Can perform job with no additional training.

3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.

2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.

1—**Unskilled**—Is familiar with process, but is unable to perform job.

0—**No exposure**—No information or practice provided during training program.

### Sample B

**Yes**—Can perform job with no additional training.

**No**—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

## Suggested Activities

---

### Resources Used in Developing This Unit

#### Print Media

- Clemons, Mark. *ACR Electrical Systems*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1997.

### Suggested Supplemental Resources

#### Print Media

- *Fundamentals of Residential Controls*, Honeywell Training

This inexpensive text is one of Honeywell's programmed instruction books built around a step-by-step question/answer format. Capacitive Circuits and Analyzing Control Circuits are two of the major subjects in this text. Other topics in this well illustrated workbook include Inductive and The Nature of Electricity, Principles of Motor Operation, Power, Transformer Principles, Relay Principles, and The Rules Governing Electricity.

- Althouse, A., Turnquist, C., & Bracciano, A. *Modern Refrigeration and Air Conditioning, 18th Edition*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 2004. ISBN: 978-1-59070-280-8

Provides a blend of theory with job-qualifying skills. This comprehensive text teaches both fundamental principles and the service techniques needed to diagnose and remedy HVAC problems. This edition contains the most recent information and advances in the field needed to prepare the technician for success in today's world and provides a solid and thorough knowledge of all aspects of refrigeration and air conditioning. See <http://goodhearwillcox.com/> for more information or ordering.

- Jeffus, L. *Refrigeration and Air Conditioning, An Introduction to HVAC/R, 4th Edition*. Upper Saddle River, New Jersey: Pearson Prentice Hall, 2004. ISBN: 013-092571-3

Based on input experts, the staff of the Air-Conditioning and Refrigeration Institute, and many academic advisors, this edition reflects the state of the art, as well as solid, fundamental concepts and practical applications. See <http://mypearsonstore.com/> (Prentice Hall) for more information or ordering.

## Suggested Activities

- Whitman, W., Johnson, W., & Tomczyk, J. *Refrigeration & Air Conditioning Technology, 5th edition*. Albany, NY: Delmar Thomson Learning, 2005. ISBN 978-1-40183-765-4

Provides superior hands-on information needed to successfully maintain and troubleshoot today's complex heating, air conditioning, and refrigeration systems. It fosters a solid foundation and understanding of environmental problems and their solutions, and displays a depth and detail of theory, diagnostics, and repair procedures. It includes information on typical operating conditions, and offers ample systematic troubleshooting techniques and scenarios. See <http://www.delmarlearning.com/> for more information or ordering.

### Electronic Media

- GTE2—General Training Electricity series, Carrier Training Services

This well executed series is enhanced with full color graphics and included VHS videos, CDs, audio cassettes, and student workbooks. Quantity discounts are available for training institutions.

The module includes:

*Module 1, Introduction to Electricity*

*Module 2, Electrical Components and Their Symbols*

*Module 3, Wiring Diagrams*

*Module 4, Wiring Diagram Exercises*

*Module 5, Electric Meters and Their Uses*

*Module 6, Alternating Current Fundamentals*

*Module 7, Motor Fundamentals and Motor Protections*

*Module 8, Electronic Devices and Circuits*

*Module 9, Electrical Troubleshooting*

For a catalog of these and other training materials from Carrier, go to <http://www.training.carrier.com>, click on "training" in the left hand column, then click on "books, videos, CDs", then on "training materials catalog."



**Answers to Assignment Sheets**

**Assignment  
Sheet 1**

**Identify Components on HVACR System Electrical Diagrams**

- a. 115V, 24V, 230V
- b. Light  
Indoor blower motor low-speed winding  
Indoor blower motor high-speed winding  
Transformer primary  
Cooling contactor coil  
Cooling anticipator  
Adjustable heating anticipator  
Gas valve  
Blower relay coil  
Compressor motor run winding  
Compressor motor start winding  
Start relay coil  
Outdoor fan motor run winding  
Outdoor fan motor start winding  
Crankcase heater
- c. Thermostat temperature switch  
Heat off cool switch  
High pressure switch  
Low pressure switch
- d. Indoor blower motor 4  
Compressor motor 3  
Outdoor fan motor 2
- e. Hot leg
- f. Gas valve and adjustable heating anticipator
- g. Compressor motor start winding

**Assignment  
Sheet 2**

**Identify Component Operation from HVACR System Electrical Diagrams**

- a. No. This would indicate that 115V is not available to the IBM circuit
- b. None
- c. If the thermostat fan switch is in the AUTO position, the indoor blower motor will stop
- d. The compressor motor start capacitor

## Answers to Assignment Sheets

---

### Assignment Sheet 3

- e. Blower relay normally closed contacts  
Blower interlock switch  
Fan switch
- f. Thermostat temperature switch  
Adjustable heat anticipator  
Heat off cool switch  
Limit switch  
Rollout switch
- g. Thermostat automatic on switch  
Thermostat temperature switch  
Heat off cool switch

### Select Test Instruments or Procedures for Specific HVACR System Troubleshooting

- a. Use a voltmeter with probes at L<sub>1</sub> and L<sub>2</sub>.
- b. (1) With the hopscotch method, use voltmeter with probes where BR connects to the hot leg and where IBM connects to the neutral leg, and then at H and C on IBM.  
  
(2) With other than the hopscotch method, use an ohmmeter with probes at each side of contacts, and with power off and at least one side of contacts disconnected.
- c. Use an ohmmeter with all motor wires disconnected.
- d. Clamp an ammeter around either wire between L<sub>1</sub> or L<sub>2</sub> and the CH.
- e. Clamp an ammeter around the wire to C on the compressor and then momentarily push CC contacts closed, or with ammeter attached, turn off the power, jumper the HP and momentarily turn power back on

### Assignment Sheet 4

### Solve HVACR Electrical Troubleshooting Problems

- a. The thermostat temperature switch or the heat off cool switch  
Replace the thermostat.
- b. The compressor motor or compressor motor start components
- c. The limit switch or the rollout switch
- d. The transformer
- e. Jumper the limit switch temporarily
- f. Jumper the high pressure switch

Written Test

Name \_\_\_\_\_

Date \_\_\_\_\_ Score \_\_\_\_\_

Objective 1

Select the correct term that matches the definition.

1. A complete electrical path.
  - a. A ground
  - b. Continuity
  - c. An open
  - d. A short
  
2. An undesired path to the earth ground.
  - a. A ground
  - b. A safety ground
  - c. An open
  - d. A short
  
3. Lack of continuity in an electrical circuit.
  - a. A ground
  - b. Continuity
  - c. An open
  - d. A short
  
4. An improper path in an electrical circuit.
  - a. A ground
  - b. Continuity
  - c. An open
  - d. A short
  
5. A direct path to an earth ground to prevent damage to equipment or injury to people.
  - a. A ground
  - b. A safety ground
  - c. Continuity
  - d. A short

## Written Test

---

6. A control which responds to conditions such as temperature or pressure and opens or closes circuits when maximum or minimum conditions are reached; usually used for safety purposes.
  - a. Primary control
  - b. Operating control
  - c. Limit control
  
7. A control such as a thermostat which responds to a change in conditions and initiates action.
  - a. Primary control
  - b. Operating control
  - c. Limit control
  
8. A control such as a fan relay which responds to a signal from an operating control and stops and starts equipment such as motors or valves.
  - a. Primary control
  - b. Another control
  - c. Limit control
  
9. Any device that operates or regulates electrical or mechanical systems.
  - a. Load
  - b. Motor
  - c. Control
  
10. Any device that uses or consumes electricity by converting it into heat, light, or mechanical motion.
  - a. Load
  - b. Motor
  - c. Control

### Objective 2

**Select the correct word(s) to complete statements concerning guidelines for troubleshooting HVACR system electrical circuits.**

11. When troubleshooting HVACR system electrical circuits, identify circuit components and their \_\_\_\_\_ using electrical diagrams and information about the specific equipment.
  - a. operation
  - b. uses
  - c. manufacturer
  - d. status

12. When troubleshooting HVACR system electrical circuits, select the appropriate test meter based on the \_\_\_\_\_ of the equipment and your own experience.
- a. operation
  - b. uses
  - c. manufacturer
  - d. status
13. When troubleshooting HVACR system electrical circuits, use test instruments and \_\_\_\_\_ to establish where power is available, what is and what is not operating, how loads are operating, and where faults such as opens, shorts and grounds are located.
- a. the pictorial diagram
  - b. your senses and experience
  - c. the schematic diagram
  - d. the owner's manual
14. When troubleshooting HVACR system electrical circuits, open switches, safety devices, or loads in series may have to be \_\_\_\_\_ in order to identify the condition of the entire circuit or system.
- a. hopscotched
  - b. permanently jumpered
  - c. temporarily jumpered
  - d. removed from the circuit
15. When troubleshooting HVACR system electrical circuits, recommend corrective action only after you have determined the relative cost \_\_\_\_\_.
- a. or any additional problems
  - b. and the time it will take
  - c. and if the customer can pay for it
  - d. or if it is in warranty

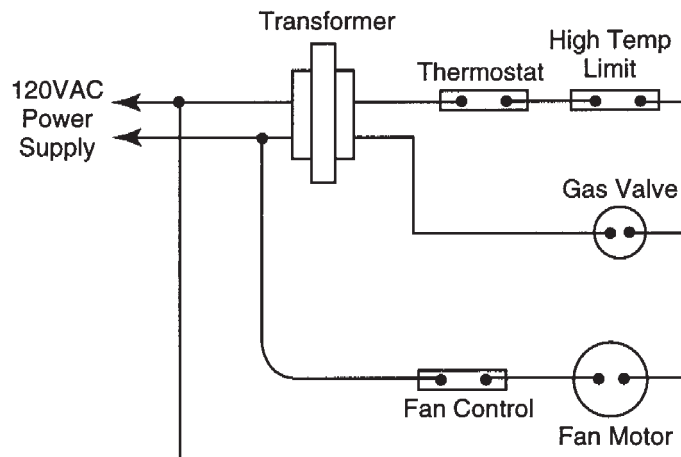
**Objective 3**

**Select whether statements concerning identifying circuit components and their operations are true or false.**

16. In an operating HVACR circuit, an operating control senses a need for a change in conditions and signals a limit control, which starts or stops the equipment that will make the change, but only if the limit control senses that it is safe to do so.
- a. True
  - b. False

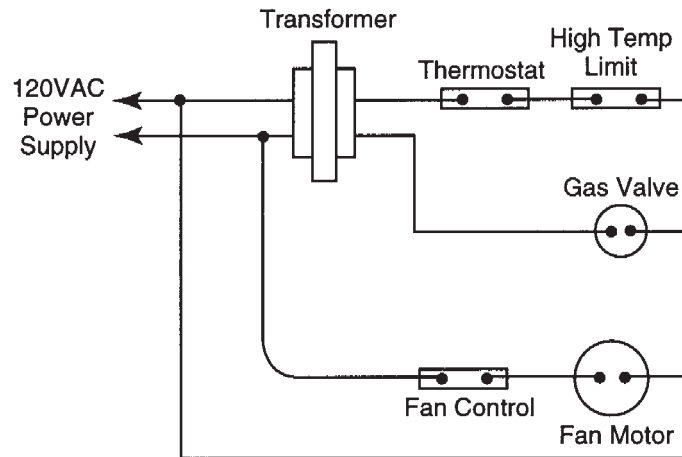
## Written Test

17. In order to troubleshoot HVACR electrical systems, a technician must identify which components are loads, what is controlling each load, and what type of controls they are.
- a. True
  - b. False
18. In order to troubleshoot HVACR electrical systems, the power supply or source and amount of voltage must also be identified.
- a. True
  - b. False
19. In the following pictorial, the source components can be identified as the 120VAC power supply and the 24VAC secondary of the transformer.



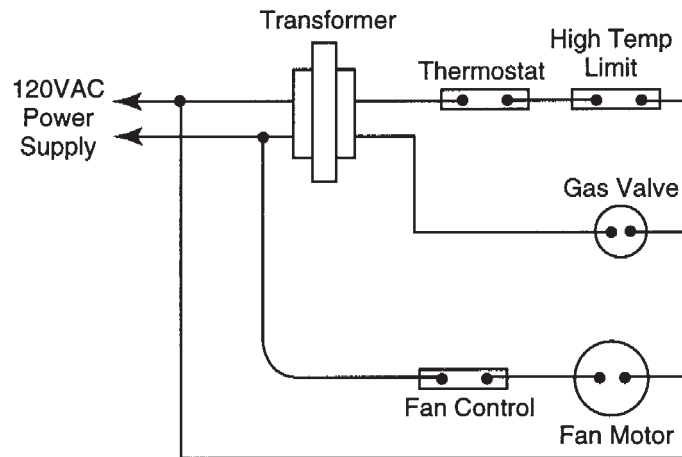
- a. True
- b. False

20. In the following pictorial, the load components can be identified as the fan motor, gas valve, and secondary of the transformer.



- a. True  
b. False

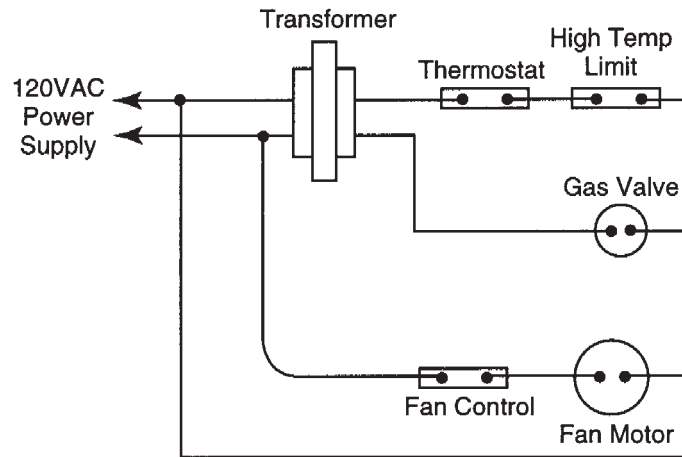
21. In the following pictorial, the control components can be identified as the fan motor controlled by fan control, gas valve controlled by thermostat and limit control, and the transformer primary has no control.



- a. True  
b. False

## Written Test

22. A single device such as the transformer in the following pictorial, often contains more than one electrical component which is treated as a load in the primary, and a source in the secondary.



- a. True  
b. False
23. Motors with more than one winding such as two-speed motors and split-phase motors are treated as single loads.
- a. True  
b. False

### Objective 4

**Select the correct word(s) to complete statements concerning guidelines for test meter selection.**

24. When troubleshooting HVACR system electrical circuits, which test meter to use in a given situation depends on the status of the equipment and \_\_\_\_\_.
- a. which meters a technician has on the truck  
b. the technician's experience  
c. the equipment model  
d. the technician's license
25. When troubleshooting HVACR system electrical circuits, use a(n) \_\_\_\_\_ to determine if source voltage is available to the equipment or to a specific component.
- a. voltmeter  
b. ammeter  
c. test light  
d. available electrical tool, such as a drill

26. When troubleshooting HVACR system electrical circuits, and the system is fully or partially operating, use a/an \_\_\_\_\_ to determine at what point the circuit is broken.
- ohmmeter
  - voltmeter
  - test light
  - available electrical tool, such as a drill
27. When troubleshooting HVACR system electrical circuits, use a/an \_\_\_\_\_ to determine whether a load such as a motor or electric heat strip is operating properly.
- voltmeter
  - ammeter
  - test light
  - available electrical tool, such as a drill
28. When troubleshooting HVACR system electrical circuits, an analog ammeter or a digital ammeter capable of reading \_\_\_\_\_ is essential in checking motor starting amps and starting components.
- locked rotor amps
  - continuous amp draw
  - back EMF
  - momentary amp draw
29. When troubleshooting HVACR system electrical circuits, use a/an \_\_\_\_\_ to check for continuity of a circuit or component.
- ohmmeter
  - voltmeter
  - ammeter
  - test light
30. When troubleshooting HVACR system electrical circuits, use a/an \_\_\_\_\_ only with the power turned off or disconnected, capacitors discharged, and the circuit or component isolated.
- ohmmeter
  - voltmeter
  - ammeter
  - test light

## Written Test

---

### Objective 5

31. When troubleshooting HVACR system electrical circuits, to use voltmeters and ammeters, power must be \_\_\_\_\_, but to use an ohmmeter, power must be \_\_\_\_\_.
- a. off/on
  - b. on/off
  - c. available/applied
  - d. applied/available

**Select whether statements concerning using a voltmeter are true or false.**

32. The first step in almost any electrical troubleshooting situation is to determine if power is available to the load.
- a. True
  - b. False
33. When troubleshooting HVACR system electrical circuits, if any line voltage components are operating, it requires no meter to come to the conclusion that power is available.
- a. True
  - b. False
34. When troubleshooting HVACR system electrical circuits, if no components are operating, use a voltmeter to check for voltage at the point where the source of supply reaches the components.
- a. True
  - b. False
35. When troubleshooting HVACR system electrical circuits, if voltage is present, the problem is in the equipment; if voltage is not present, the problem is at the source.
- a. True
  - b. False
36. When troubleshooting HVACR system electrical circuits; if the problem is at the source, use a voltmeter to check at points such as fuses or breakers to determine where power stops.
- a. True
  - b. False

37. When troubleshooting HVACR system electrical circuits, blown fuses or breakers are indications that some load is probably getting too much voltage.
- a. True
  - b. False
38. When troubleshooting HVACR system electrical circuits, if voltage is available to the equipment, use a voltmeter to check if voltage is available to individual loads.
- a. True
  - b. False
39. When troubleshooting HVACR system electrical circuits, once you have established that voltage is available to the equipment but not to the load, the simplest way to determine which component in a circuit is open is to use the hopscotch method.
- a. True
  - b. False

**Objective 6**

**Select the correct answers to questions on applying the hopscotch method for troubleshooting.**

40. You have established that voltage is available to the equipment you are troubleshooting and decide to begin the hopscotch method of troubleshooting to isolate the problem. What is the next step?
- a. You need to decide which load is most suspect of not operating.
  - b. You need to establish if power is available to the load.
41. You have just completed the first step in using the hopscotch method of troubleshooting and have decided that the first switch is open. You continue with hopscotching and move on to the second switch. What have you forgotten?
- a. You are using the method properly, but you need to make notes about the first switch because you may need to replace it.
  - b. You have isolated the problem, so check the equipment for the cause of the problem before you waste any more time hopscotching.
42. You are talking with a coworker about what causes most circuit opens and the coworker says that shorts cause the most circuit opens. What should you tell her?
- a. She needs to remember that grounds cause most circuit opens.
  - b. She needs to remember that open switches cause most circuit opens.

## Written Test

---

### Objective 7

43. You have found an open and corrected it, and now you want to operate the equipment. What have you forgotten to do?
- You need to verify that connections on either side of the open you corrected are properly secured.
  - You need to do your best to determine what caused the open before you operate the equipment.

**Select whether statements concerning using an ammeter are true or false.**

44. Use an ammeter to test the amount of current a load is drawing and compare the amp draw to OEM specifications.
- True
  - False
45. When comparing amp draw to OEM specifications, remember that the name plate rating for FLA represents amp draw under full load conditions, so be sure to evaluate the operating conditions of the load.
- True
  - False
46. Ammeter checks of a CSR motor tell a technician not only the condition of the motor, but also the condition of the starting components, but remember that an analog ammeter can not be used to evaluate the operation of many motors.
- True
  - False
47. Use an ammeter to determine if loads you cannot see are or are not operating.
- True
  - False
48. When the ammeter you are using does not have a scale small enough to read the very low current draw of some loads, switch to a different wire.
- True
  - False

Objective 8

49. To prevent damage to an ammeter, remember that motors have relatively high starting amps, so be sure to set an ammeter high enough to handle three to four times FLA and then change to a lower scale after the motor starts.
- a. True
  - b. False
50. Because of the short duration of start amps, most digital ammeters will not read start amps.
- a. True
  - b. False

**Select the correct word(s) to complete statements concerning using an ohmmeter.**

51. Use an ohmmeter to check \_\_\_\_\_ or to find opens, shorts, and grounds.
- a. current draw
  - b. voltage drop
  - c. continuity
  - d. for power
52. Before using an ohmmeter, disconnect the \_\_\_\_\_ and at least one end of the component you are checking.
- a. power
  - b. switch in the circuit
  - c. other loads
  - d. meter
53. Use an ohmmeter for checking circuits only if the circuit has been \_\_\_\_\_ other circuits and components.
- a. connected to
  - b. isolated from
  - c. in series with
  - d. in parallel with

## Written Test

---

54. To avoid misleading readings and misinterpreting ohmmeter readings, \_\_\_\_\_ before checking it with an ohmmeter.
- disconnect power from a component
  - isolate the circuit the component is in
  - connect power to a component
  - remove a component
55. \_\_\_\_\_ an ohmmeter before using it and each time you change scales because it is the only way to assure accurate readings.
- Zero
  - Try out
  - Replace batteries in
  - Turn off and on
56. A reading of \_\_\_\_\_ indicates an open fuse, switch, or wire while a reading of \_\_\_\_\_ or very near \_\_\_\_\_ indicates continuity because the ohmmeter was able to send an electrical signal through the component.
- zero ohms/infinity/infinity
  - infinity/10,000 ohms/10,000 ohms
  - infinity/zero ohms/zero ohms
  - any volts/zero ohms/zero ohms
57. An open load will have infinite resistance measured by an ohmmeter, but the proper resistance of a load can only be obtained \_\_\_\_\_.
- by testing a similar load
  - from OEM specifications
  - by using a megohmmeter
  - by calling the manufacturer
58. Do not use an ohmmeter to test most solid-state devices because solid-state devices can be damaged by the \_\_\_\_\_ of the meter.
- battery current
  - resistance
  - amp draw
  - closed circuit

Objective 9

Select the correct word(s) to complete statements concerning checking for shorts and grounds.

59. The symptoms for shorts and grounds are \_\_\_\_\_ and technicians often confuse one with the other.
- a. different
  - b. similar
60. A \_\_\_\_\_ occurs when electricity takes an alternative path or shortcut such as when motor windings touch each other where they are not supposed to.
- a. short
  - b. ground
61. A \_\_\_\_\_ occurs when electricity takes a direct path to ground such as through an equipment case.
- a. short
  - b. ground
62. Either a shorted or a grounded load will usually blow a fuse or trip a breaker because the current is allowed to flow without being \_\_\_\_\_ by the designed load.
- a. assisted
  - b. impeded
63. Resistance readings of a shorted load are \_\_\_\_\_ than OEM specifications.
- a. lower
  - b. higher
64. A shorted switch or shorted wiring will usually cause a load to \_\_\_\_\_ when it is \_\_\_\_\_ to be operating.
- a. stop operating/supposed
  - b. continue to operate/not supposed
65. The most important thing to do when checking for shorts with an ohmmeter is to \_\_\_\_\_ the circuit or the load being tested.
- a. operate
  - b. isolate

## Written Test

---

### Objective 10

66. Check for a \_\_\_\_\_ with an ohmmeter by placing one probe on the component and the other probe on a known ground such as the green wire on a safety grounded cord or copper tubing in a refrigeration system.

- a. ground
- b. short

**Select whether statements concerning using jumpers to troubleshoot are true or false.**

67. Since an open operating switch, open safety switch, or open wiring or connections will usually not allow a circuit or system to operate, the open may need to be permanently jumpered to find out if the rest of the circuit or system will operate.

- a. True
- b. False

68. Be sure to look the system over for any obvious faults, such as burnt spots, loose wiring or stuck motors before jumpering any components.

- a. True
- b. False

69. Jumpering may be as simple as manually pushing in contacts or the applying of additional wires.

- a. True
- b. False

70. Jumpers may be simply pieces of wire or manufactured jumpers with screw terminals on each end.

- a. True
- b. False

71. Be sure power is off or disconnected before using jumpers.

- a. True
- b. False

72. When a jumper is used, be prepared to turn power off quickly when restoring power to test the circuit.

- a. True
- b. False

73. When using a jumper, restore power only long enough to determine what is or is not working in the circuit or system.
- a. True
  - b. False
74. If the load does not operate after an open is jumpered, use the trial and error method to find additional opens.
- a. True
  - b. False
75. Additional jumpers must not be used if any additional opens are discovered.
- a. True
  - b. False
76. Be sure to remove all jumpers when troubleshooting checks are completed.
- a. True
  - b. False

**Objective 11**

**Select the correct answers to questions concerning troubleshooting techniques.**

77. Since the process of elimination is the basic technique for most electrical troubleshooting, a technician says that he needs to start with the right test instrument. What should you tell him?
- a. The technician should first find out what the equipment should be doing and what it is doing.
  - b. The equipment owner should first be consulted because the owner has more knowledge about what the equipment should be doing than the technician does.
78. To find what the equipment should be doing when troubleshooting, a technician says that experience in the field is the most important factor. What should she remember?
- a. Experience alone won't solve all problems; the technician needs equipment history and equipment wiring diagrams.
  - b. The equipment owner should be consulted because the owner has more knowledge about what the equipment should be doing than the technician does.

## Written Test

---

79. To find what the equipment is doing when troubleshooting, a technician says that you should rely primarily on system observations and test results. What should you tell her.
- Observations and test results mean nothing unless the system wiring diagram is available for reference.
  - Observations and test results may not reflect what has been happening so the customer complaints should also be considered.
80. Once a technician has determined which electrical circuits or which sections of the equipment contain the probable sources of the problem, a technician says that one must isolate the specific fault by using appropriate test instrument checks. What should you tell him?
- A technician isolates a specific fault by using a troubleshooting procedure found in such things as experience with similar equipment, OEM instructions, troubleshooting charts, or diagnostic tests built into the equipment.
  - A technician must first determine the exact nature of the fault and what corrective action to take.

**\*Permission to duplicate this test is granted.**

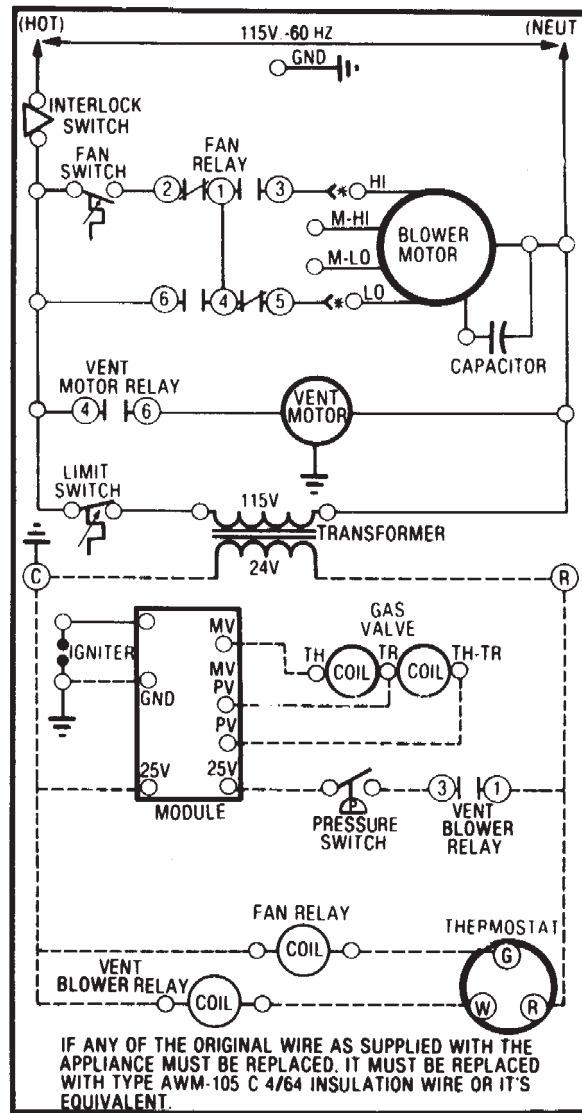
## Answers to Written Test

- |     |   |     |   |     |   |
|-----|---|-----|---|-----|---|
| 1.  | b | 31. | b | 61. | b |
| 2.  | a | 32. | b | 62. | b |
| 3.  | c | 33. | a | 63. | a |
| 4.  | d | 34. | b | 64. | b |
| 5.  | b | 35. | a | 65. | b |
| 6.  | c | 36. | a | 66. | a |
| 7.  | b | 37. | b | 67. | b |
| 8.  | a | 38. | a | 68. | a |
| 9.  | c | 39. | a | 69. | a |
| 10. | a | 40. | b | 70. | b |
| 11. | a | 41. | b | 71. | a |
| 12. | d | 42. | b | 72. | a |
| 13. | b | 43. | b | 73. | a |
| 14. | c | 44. | a | 74. | b |
| 15. | a | 45. | a | 75. | b |
| 16. | b | 46. | b | 76. | a |
| 17. | a | 47. | a | 77. | a |
| 18. | a | 48. | b | 78. | a |
| 19. | a | 49. | a | 79. | b |
| 20. | b | 50. | a | 80. | a |
| 21. | a | 51. | c |     |   |
| 22. | a | 52. | a |     |   |
| 23. | b | 53. | b |     |   |
| 24. | b | 54. | d |     |   |
| 25. | a | 55. | a |     |   |
| 26. | b | 56. | c |     |   |
| 27. | b | 57. | b |     |   |
| 28. | d | 58. | a |     |   |
| 29. | a | 59. | b |     |   |
| 30. | a | 60. | a |     |   |



**Teacher Supplement 1 – Heat Pump Diagram  
as Alternative for Assignment Sheets**

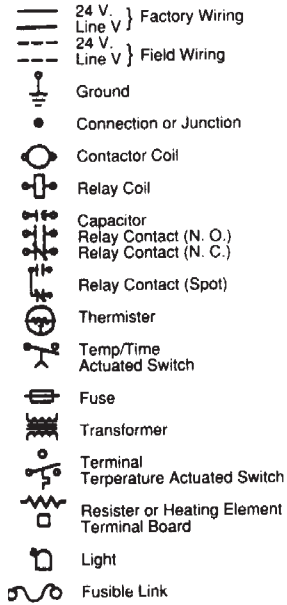
The wiring diagrams shown below and on the next page may be used as substitutes for the diagram used in the Assignment Sheets, or given as additional assignments to acquaint students with different types of equipment.



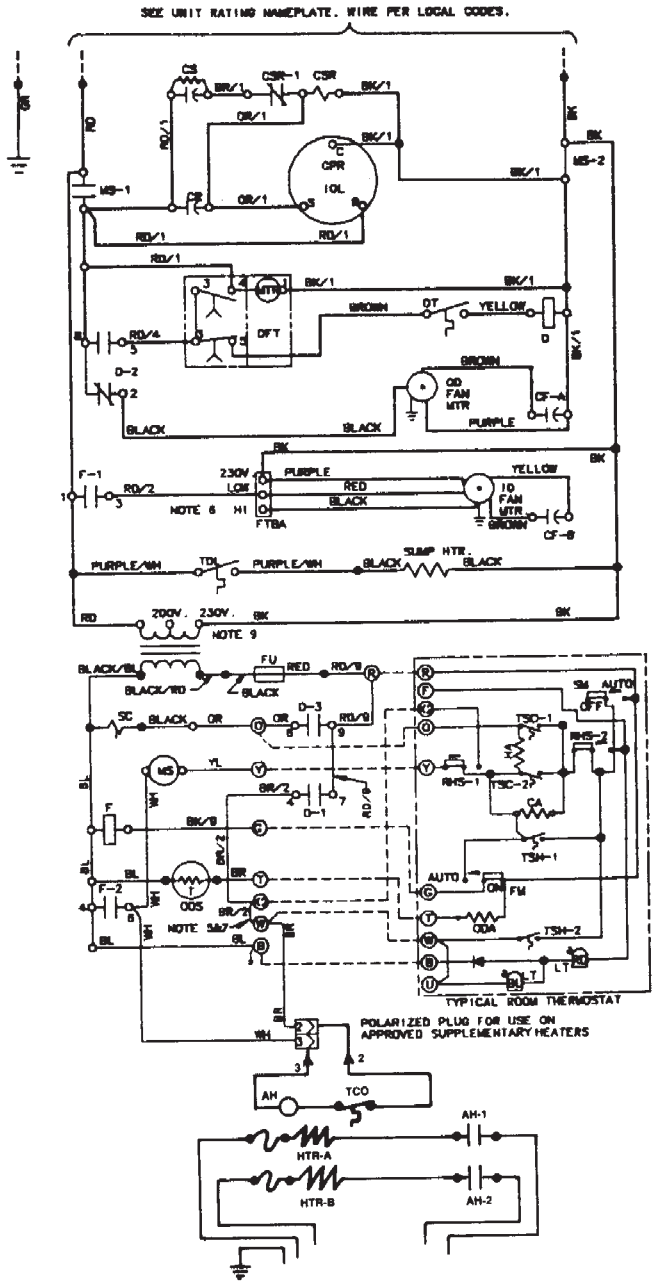
Courtesy Inter-City Products Corporation (USA)

# Teacher Supplement 1

## Legend-Equipment Diagram



- CA Cooling Anticipator
- CF Fan Capacitor
- CN Wire Connector
- CPR Compressor
- CR Run Capacitor
- CS Start Capacitor
- CSR Start Relay
- D Defrost Relay
- DFT Defrost Timer
- DT Defrost Termination Switch
- F Indoor Fan Relay
- FTB Fan Terminal Board
- FU Fuse
- HA Heat Anticipator
- HVTB High Voltage Terminal Board
- IOL Internal Overload Protector
- LT Light
- LVTB Low Voltage Terminal Board
- MS Compressor Contactor
- ODA Outdoor Temperature Anticipator
- ODF Outdoor Fan Relay
- ODS Outdoor Temperature Sensor
- ODT Outdoor Thermostat
- RHS Resistance Heat Switch
- SC Swichover Valve Sloenoid
- SM System "On-Off" Switch
- TDL Discharge Line Thermostat
- TNS Transformer
- TSC Cooling Thermostat
- TSH Heating Thermostat



Schematic from service literature provided by the Trane Company, a division of American Standard Inc.

# Hopscotch Method of Troubleshooting

