AUTO-2350: AUTOMOTIVE HVAC

Cuyahoga Community College

Viewing: AUTO-2350 : Automotive HVAC

Board of Trustees:
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Academic Term:
Fall 2022

Subject Code
AUTO - Automotive Technology

Course Number:
2350

Title:
Automotive HVAC

Catalog Description:
This course covers the theory of refrigeration and heating, electrical/electronic/pneumatic controls, and diagnosis and repair of climate control systems. Topics include diagnosis and repair of climate control components and systems, recovery/recycling of refrigerants, and safety and environmental regulations. Upon completion, students should be able to diagnose and repair vehicle climate control systems.

Credit Hour(s):
2

Lecture Hour(s):
1

Lab Hour(s):
3

Other Hour(s):
0

Requisites

Prerequisite and Corequisite
AUTO-1502 Automotive Electrical Fundamentals; or departmental approval: industry-related expereince.

Outcomes

Course Outcome(s):
Diagnose and Isolate Problems in an Automotive A/C System; perform Diagnosis and Repair

Essential Learning Outcome Mapping:
Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):
1. Identify and interpret heating and air conditioning problems; determine necessary action.
2. Research vehicle service information including refrigerant/oil type, vehicle service history, service precautions, and technical service bulletins.
3. Performance test A/C system; identify problems.
4. Identify refrigerant type; select and connect proper gauge set/test equipment; record temperature and pressure readings.
5. Leak test A/C system; determine necessary action.
6. Identify abnormal operating noises in the A/C system; determine necessary action.
7. Inspect condition of refrigerant oil removed from A/C system; determine necessary action.
8. Determine recommended oil and oil capacity for system application.
9. Inspect, remove, and/or replace A/C compressor drive belts, pulleys, tensioners and visually inspect A/C components for signs of leaks; determine needed action.

10. Remove, inspect, reinstall, and/or replace A/C compressor and mountings; determine recommended oil type and quantity.
11. Inspect for proper A/C condenser airflow; determine needed action.

Course Outcome(s):

Recognize Refrigeration System Components; Perform Diagnosis and Repair

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Identify hybrid vehicle A/C system electrical circuits and service/safety precautions.
2. Determine need for an additional A/C system filter; perform necessary action.
3. Remove and inspect A/C system mufflers, hoses, lines, fittings, O-rings, seals, and service valves; perform necessary action.
4. Inspect A/C condenser for airflow restrictions; perform necessary action.
5. Remove, inspect, and install expansion valve or orifice (expansion) tube.
6. Inspect evaporator housing water drain; perform necessary action.
7. Diagnose A/C system conditions that cause the protection devices (pressure, thermal, and Powertrain Control Motor (PCM)) to interrupt system operation; determine necessary action.
8. Determine procedure to remove and reinstall evaporator; determine required oil quantity.
9. Inspect and replace A/C compressor drive belts, pulleys, and tensioners; determine necessary action.
10. Inspect, test, service or replace A/C compressor clutch components and/or assembly; check compressor clutch air gap; adjust as needed.

Course Outcome(s):

Recall the operation of Heating, Ventilation, and Engine Cooling Systems Components; Perform Diagnosis and Repair of said Subsystems.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Inspect engine cooling and heater systems hoses and pipes; perform needed action.
2. Inspect and test heater control valve(s); perform necessary action.
3. Diagnose temperature control problems in the heater/ventilation system; determine necessary action.
4. Determine procedure to remove, inspect, and reinstall heater core.
5. Inspect and test coolant; drain and recover coolant; flush and refill cooling system with recommended coolant; bleed air as required.
6. Remove and replace radiator.
7. Inspect and test fan(s) (electrical or mechanical), fan clutch, fan shroud, and air dams.

Course Outcome(s):

Diagnose and Repair Manual and Automatic HVAC Control System Concerns.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Inspect and test HVAC system blower motors, resistors, switches, relays, wiring, and protection devices; determine needed action.
2. Diagnose A/C compressor clutch control systems; determine necessary action.
3. Diagnose malfunctions in the vacuum, mechanical, and electrical components and controls of the heating, ventilation, and A/C (HVAC) system; determine necessary action.
4. Inspect and test HVAC system control panel assembly; determine needed action.
5. Inspect and test HVAC system control cables, motors, and linkages; perform needed action.
6. Inspect A/C-heater ducts, doors, hoses, cabin filters, and outlets; perform necessary action.
7. Identify the source of A/C system odors.
8. Check operation of automatic or semi-automatic heating, ventilation, and air-conditioning (HVAC) control systems; determine necessary action.

Course Outcome(s):

Perform Proper Refrigerant Recovery, Recycling, and Handling Operations Using the Proper Equipment

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Perform correct use and maintenance of refrigerant handling equipment according to equipment manufacturer's standards.
2. Identify A/C system refrigerant; test for sealants; recover, evacuate, and charge A/C system; add refrigerant oil as required.
3. Recycle, label, and store refrigerant.
4. Evacuate and charge A/C system; add refrigerant oil as required.

Course Outcome(s):

Shop and personal safety is a primary and ongoing concern while in the repair environment for automotive HVAC; including using tools and equipment, working around supplemental restraint (SRS) or high voltage circuits, wearing personal protection equipment, awareness of personal clothing, adornments and body, and knowledge of fire safety and evacuation routes.

Objective(s):

1. Identify general shop safety rules and procedures.
2. Utilize safe procedures for handling of tools and equipment.
3. Identify and use proper placement of floor jacks and jack stands.
4. Identify and use proper procedures for safe lift operation.
5. Utilize proper ventilation procedures for working within the lab/shop area.
6. Identify marked safety areas.
7. Identify the location and the types of fire extinguishers and other fire safety equipment; demonstrate knowledge of the procedures for using fire extinguishers and other fire safety equipment.
8. Identify the location and use of eye wash stations.
9. Identify the location of the posted evacuation routes.
10. Comply with the required use of safety glasses, ear protection, gloves, and shoes during lab/shop activities.
11. Identify and wear appropriate clothing for lab/shop activities.
12. Secure hair and jewelry for lab/shop activities.
13. Demonstrate awareness of the safety aspects of supplemental restraint systems (SRS), electronic brake control systems, and hybrid vehicle high voltage circuits.
14. Demonstrate awareness of the safety aspects of high voltage circuits (such as high intensity discharge (HID) lamps, ignition systems, injection systems, etc.).
15. Locate and demonstrate knowledge of material safety data sheets (MSDS).

Methods of Evaluation:

1. Participation and discussion
2. Observation
3. Written assignments
4. Exams
5. Quizzes
6. Lab tasks
7. Classroom recitations

Course Content Outline:

1. Automotive HVAC Concepts
   a. Heating and cooling principles and theory
   b. HVAC operating system and components
   c. Engine cooling system and components
   d. Operating systems and mechanical and electronic controls
   e. Refrigerant system component descriptions and repair techniques
   f. Refrigerant recovery, evacuation and charging techniques
   g. Refrigerant recycling and the safe handling of refrigerant
2. Work Related Concepts
   a. Shop and personal safety
   b. Tools and equipment

c. Preparing vehicle for service
d. Preparing vehicle for customer

TOPICAL OUTLINE

1. Course overview
   a. Modern HVAC systems
   b. Changes in HVAC service
2. Comfort and safety
   a. The HVAC system increases safety by keeping the windows free of ice and condensation
3. Sources of heat and cold
   a. Solar radiation
   b. Weather
   c. Engine and drivetrain heat
   d. Passengers
4. The purpose of automotive HVAC systems
   a. Regulate temperature
   b. Control humidity
   c. Circulate the air
5. Refrigerant and the environment
   a. The ozone layer
   b. Ultraviolet light
   c. Precautions against the greenhouse effect
6. Refrigerant regulations
   a. Alternative refrigerants
   b. Technician certification
   c. Non-compliance penalties
7. Engine coolant and the environment
   a. Environmental concerns
   b. Disposal of engine coolant
8. Physics of matter
   a. The building blocks of matter
   b. Molecules and chemical compounds
9. States of matter: solid, liquid, and vapor
   a. Changes of state: boiling and condensation
   b. Heat and temperature
      i. definitions
      ii. measurement of heat and temperature
      iii. converting temperatures
   c. Specific heat is a characteristic which indicates heat transfer capacity
   d. Sensible heat causes a change in temperature
   e. Latent heat is added or given off during a change of state
10. Temperature, pressure, and volume
   a. Temperature and volume of a solid or liquid
   b. Temperature, volume, and pressure of a vapor
   c. Pressure-temperature relationships
   d. Boiling points and pressure
   e. Pressures in a sealed system
   f. Vacuum
      i. understanding pressure and vacuum
11. Heat flow and humidity
   a. Conduction is the energy transfer that occurs as heat moves through a substance, or from object to object by direct contact.
   b. Convection is energy transfer in which a liquid or gas carries the heat from one place to another.
   c. Radiation is energy transfer through electromagnetic energy.
   d. Humidity
      i. measuring humidity
         1. absolute humidity
         2. relative humidity
         3. dew point
         4. the psychrometer and hygrometer
      ii. the psychrometric chart

12. Heating and cooling in a vehicle
    a. The heat exchanger
    b. The refrigerant system
        i. the compressor is a refrigerant pump
        ii. the condenser is a heat exchanger which removes heat from the system
        iii. the receiver-drier or accumulator provide filtering and storage
        iv. the expansion device controls the pressure and rate of refrigerant flow
        v. the evaporator is a heat exchanger which adds heat to the refrigerant
        vi. the refrigerant (R-134a or R1234yf) is the medium for heat transfer
    c. Air conditioning operation
        i. the compressor pressurizes the refrigerant in the high side by pumping against the restriction of the thermostatic expansion valve or tube expansion.
        ii. the hot gas is cooled to below its boiling point in the condenser.
        iii. in a receiver-drier the liquid is temporarily stored and any moisture and contaminants are removed.
        iv. in the thermostatic expansion valve or expansion tube, the refrigerant expands into the low side as a low-pressure mist.
        v. in the evaporator the refrigerant mist boils by absorbing the heat of vaporization from the air blowing into the passenger compartment.
        vi. in expansion tube systems, the refrigerant finishes boiling in the accumulator before flowing back into the compressor.
        vii. the low-pressure gas then flows to the inlet, or low side, of the compressor.
13. Cooling system function
    a. The water jackets
    b. Coolant flow
14. Engine coolant
    a. The development of engine coolant
    b. Coolant mixtures
    c. Other engine coolants
        i. propylene glycol
        ii. DEX-COOL
        iii. Honda coolant
        iv. VW/Audi coolant
15. Cooling system components
    a. The water pump
        i. centrifugal
        ii. engine-driven
    b. The thermostat
        i. normal operation
        ii. symptoms of improper operation
        iii. thermostat bypass operation
    c. The radiator
        i. heat exchanger
        ii. downflow design
        iii. crossflow design
        iv. internal automatic transmission coolers
    d. The radiator cap
        i. greater system pressure raises boiling point and system efficiency
        ii. pressure relief valve operation and ratings
        iii. vacuum valve operation
    e. The coolant recovery tank
    f. The radiator fan
        i. electric
        ii. rigid blade
        iii. flex-blade
        iv. clutch fans
    g. Hoses
    h. Core plugs
    i. The heater core
        i. heater control valves
        ii. blend air doors
    j. Cooling systems for air-cooled engines

16. Fresh air ventilation
    a. Open windows for ventilation
    b. Ram air ventilation
        i. cowl air intake
        ii. pressure release grille
17. Heating and ventilation system components
    a. Blower motor
    b. The heater core
    c. Heater control valves
        i. cable-operated
        ii. vacuum-operated
        iii. electric solenoid operated
    d. Heater hoses
    e. Ducting and doors
    f. Plenum chamber
18. Heating system operation
    a. Coolant control
    b. Air control
    c. Temperature regulation
        i. coolant control
        ii. air control
        iii. combination control
    d. Heating system and ducts
19. Control devices
    a. The control head
        i. temperature control
        ii. mode selection
        iii. fresh air versus recirculated air
        iv. air conditioning controls
    b. Cable controls
    c. Vacuum controls
    d. Electronic controls
20. Vacuum control devices
    a. Motors
    b. Valves
    c. Reservoirs
    d. Lines
    e. Reading vacuum diagrams
21. Rear window defrosters
22. Compressor, condenser, and evaporator interaction
    a. Refrigerant flow
    b. Low-side characteristics
    c. High-side characteristics
23. Types of compressors
    a. positive-displacement piston compressors
    b. Variable-displacement compressors
    c. Rotary-vane compressors
    d. Scroll compressor
24. Compressor clutches
    a. Components and function
    b. Compressor clutch electrical circuit
        i. cycling-clutch controls
        ii. other electric clutch controls
            1. switches and sensors
            2. diode and spike protection
25. Condensers and evaporators
    a. Condenser and evaporator construction
    b. The condenser
    c. The evaporator

        i. heat exchange
        ii. humidity control
        iii. evaporator designs
26. Expansion devices
    a. Basic functions
        i. pressure control
        ii. flow control
    b. Thermostatic expansion valves
        i. variable orifice
        ii. evaporator outlet temperature
        iii. internal versus external equalization
        iv. superheat
    c. Combination valves
    d. Fixed-orifice tubes
27. Receiver-driers and accumulator
    a. Receiver-driers
    b. Accumulators
28. Refrigeration hoses, connections, and other assemblies
    a. Types of refrigeration lines and hoses
        i. rigid lines
        ii. barrier hoses in R-134a systems
    b. Refrigeration line connections
        i. flare fittings
        ii. o-ring seals
        iii. spring-lock coupling
    c. Service valves
        i. the Schrader valve
        ii. quick-disconnect valves
    d. Mufflers
    e. Filters.
29. Types of control devices
    a. Sensors and switches
    b. Control modules and relays
    c. Compressor control solenoids
30. Preventing compressor damage
    a. The potential for damage
    b. Sensing ambient temperature
        i. ambient temperature sensor
    c. Sensing refrigerant pressure and temperature
        i. low-pressure cutout switch
        ii. high- and low-side temperature sensors
        iii. pressure-cycling switch
        iv. pressure-relief valve
        v. high-pressure cutoff switch
        vi. thermostatic-control switch
        vii. dual-pressure switch
        viii. thermal-control switch
31. Preventing damage to other systems
32. Maintaining driveability
    a. Heavy-load or cold-start conditions
        i. wide-open throttle switch
        ii. throttle-position sensor
        iii. power-steering pressure switch
    b. Delay devices
        i. delay relay
        ii. power-brake delay relay
        iii. anti-dieseling relay
        iv. constant-run relay
33. Preventing overheating

    a. Devices that prevent air-conditioning operation
        i. coolant-temperature switch
        ii. coolant-temperature sensor
    b. Controls that operate the electric engine fan
        i. coolant-temperature fan switch
        ii. constant-control relay module (CCRM)
        iii. air-conditioning system pressure fan switch
34. Temperature control system types
    a. Manual systems
    b. Semiautomatic temperature control
    c. Electronic automatic temperature control
35. Semiautomatic temperature control
    a. Components
        i. control head and temperature sensors
        ii. programmer or control assembly
        iii. blower speed and compressor power module
        iv. electronically or vacuum-operated actuators
    b. The programmer
    c. General Motors tempmatic control system
36. Automatic temperature control systems
    a. Control modes
    b. Sensors
        i. ambient temperature sensors
        ii. in-car temperature sensor
        iii. sun-load (solar) sensor
    c. Actuators
    d. Blower and air-conditioning clutch controls
37. Manual air-conditioning system controls
    a. Thermostatic expansion valve systems
        i. thermostatic control switch
        ii. suction throttling device
        iii. variable-displacement compressor
    b. Fixed-orifice tube systems
        i. pressure-cycling switch
38. Understanding microprocessor control systems
    a. Computer functions
        i. input
        ii. processing
        iii. storage
        iv. output
39. Laboratory Topics
40. Safe work practices
    a. Shop clothing
    b. The work area
    c. Tool safety, maintenance, and use
    d. Hazardous materials
    e. Electrical hazards
    f. Fire hazards
    g. When an accident occurs
    h. Shop safety programs and legal requirements
    i. Safety for heating and air-conditioning systems
    j. Common sense and thinking ahead
41. Special tools
    a. Vacuum pump and pressure gauge
    b. Belt tensioners and tension gauge
    c. Electronic refrigerant identifier
    d. Manifold gauge set
        i. the manifold
        ii. the gauges

e. The recovery/recycling station
f. Leak detectors
    i. electronic leak detector
    ii. dye leak detectors
g. Thermometers
    i. rotary-dial thermometer
    ii. electronic thermometer
    iii. temperature test box
h. Vacuum pump
i. Clutch and component service tools
    i. shaft seal and bearing service tools
    ii. special refrigerant hose adapters
    iii. fin straightener
j. Scan tools
k. Test meters
l. Other electronic diagnostic tools
m. Other special air-conditioning service tools

42. Compliance with the Clean Air Act
    a. Technician certification
    b. Proper service equipment for different A/C systems
43. Environmental friendliness
    a. Disposal of hazardous waste
    b. Recycling
44. Organize your repair approach
    a. Identify the complaint
    b. Verify the complaint
    c. Familiarize yourself with the system
    d. Test systematically
    e. Verify the test results
    f. Make your repairs
    g. Verify a successful repair
45. Cooling system inspection
    a. Drive belts
    b. System hoses
    c. Leaks
    d. Radiator
    e. Radiator cap
    f. Heater assembly
    g. Water pump
    h. Radiator fan
    i. Fan shrouds and air deflectors
    j. Unusual noises
    k. Cooling system inspection check list
46. Cooling system service
    a. Coolant disposal and recycling
    b. Cleaning the cooling system
        i. cooling system flushing
        ii. flushing with plain water
        iii. back-flushing
        iv. chemical cleaning
    c. Cooling system bleeding
        i. Chrysler
        ii. Ford
        iii. General Motors
    d. Belt replacement
        i. v-belt
        ii. serpentine belt
    e. Water pump service
47. Cooling system diagnosis

a. Coolant concentration testing
b. Pressure testing
c. Testing the thermostat
d. Testing the radiator fan
    i. testing clutch fans
    ii. testing electric fans
e. Testing the temperature switch
f. Testing the radiator fan relay
    i. ohmmeter testing
    ii. voltmeter testing
g. Testing the radiator flow rate
    i. flow meter quick test
    ii. testing without a flow meter
h. Cooling system troubleshooting chart

48. Heating systems
    a. Heating system types
        i. heater-control valve system
        ii. blend door system
        iii. combination system
    b. Heating problems
        i. no heat
        ii. insufficient heat
        iii. excessive heat
    c. Heating system service
        i. pressure testing
        ii. bench testing
        iii. flushing
        iv. heater-control valve service
49. Ventilation systems
    a. Ventilation system problems
        i. no airflow
        ii. insufficient airflow
        iii. other ventilation problems
    b. Ventilation system service
        i. removing vents
        ii. control cable service
        iii. blower motor troubleshooting
            1. blower motor does not operate at all
            2. blower motor operates on HI, but not other speeds
            3. blower motor operates on lower speeds, but not on HI
        iv. blower motor circuit tests
            1. blower switch continuity test
            2. blower motor current draw test
            3. resistor block testing
            4. blower motor relay check
        v. vacuum system service
            1. vacuum control system diagnosis
            2. vacuum component service and replacement
        vi. Defrosting systems
50. Manifold gauge set
    a. Functions
        i. diagnosis
        ii. charging
        iii. evacuating
    b. Description
        i. gauge layout
        ii. valve operation
        iii. gauge scales
    c. Shut-off valves

    d. Gauge calibration and altitude adjustment
    e. Attaching the manifold gauge set
    f. Reading system pressures
        i. stabilizing the air-conditioning system
        ii. normal pressure readings
51. Refrigerant recovery and recycling
    a. Equipment types
        i. recovery-only
        ii. recovery and recycling
        iii. recovery, recycling, and recharging
    b. Refrigerant identification
    c. Checking refrigerant for air contamination
    d. Evacuating the system
        i. deep vacuum
    e. evacuation procedure
    f. Charging the system
        i. charging tips
        ii. charging with liquid and vapor
        iii. charging procedure
52. System identification
    a. Expansion devices
        i. thermostatic expansion valve systems
        ii. fixed-orifice tube
53. systems
    a. Suction-throttling devices
    b. Variable-displacement compressors
    c. Identifying temperature control systems
54. Inspecting the air-conditioning system
55. Air-conditioning performance test
56. System diagnosis
    a. Diagnosing by temperature
    b. Diagnosing by sight
    c. Sight glass diagnosis
    d. Diagnosing by sound
        i. mechanical noise
        ii. compressor clutch noise
        iii. compressor noise
        iv. blower motor noise
        v. drive belt noise
        vi. refrigerant noise
57. Refrigerant leak detection
    a. Leak detection strategies
    b. Leak detection tools
        i. electronic leak detectors
        ii. dye leak detection
58. Alternative refrigerant considerations
    a. Automobile manufacturers'' recommendations
    b. EPA approval and regulations
    c. Customer concerns
    d. Determining when to retrofit
59. Component compatability
    a. Compressor
    b. Refrigerant pressure controls
    c. Hoses, o-rings, and gaskets
    d. Evaporators and condensers
    e. Receiver-drier, accumulator, and desiccant
60. Perfomance of retrofit systems
    a. Manufacturer retrofit procedures
    b. "Least-cost" retrofit

61. Performing a system retrofit
    a. System evaluation
    b. System refrigerant recovery
    c. System repair and retrofit
        i. service valves
        ii. saddle clamp adapter
        iii. high-pressure cutoff switch
        iv. retrofit labels
        v. evacuation and recharge
    d. System performance test
62. Other sources of retrofit information
63. General compressor diagnosis
    a. Failure types
    b. Inspect the components
64. Compressor failures
    a. Clutch failures
    b. Seal failures
    c. Bearing failures
    d. Reed valve failure
    e. Mechanical failure
    f. Contamination
65. Compressor replacement
    a. Discharging a compressor
    b. Removing and replacing compressors
66. Compressor testing
    a. Checking compressor operating pressures
    b. Compressor noise and vibration
    c. Checking cycling-clutch compressors
    d. Checking for seal leaks
    e. Checking the compressor clutch operation
    f. Compressor protection devices
        i. high-pressure cutoff switches
        ii. high-pressure relief valves
        iii. low-pressure cutoff switches
        iv. thermal protection devices
        v. lock-up protection devices
67. Compressor service procedures
    a. Checking the oil level
        i. stabilizing the compressor
        ii. checking the oil level with a dipstick
        iii. checking the compressor oil level without a dipstick
    b. Servicing compressor clutches
        i. clutch removal
        ii. clutch pulley bearing replacement
        iii. field coil replacement
        iv. compressor clutch installation
    c. Servicing compressor seals
68. Diagnostic and repair procedures
    a. Before the repair checklists
        i. information
        ii. diagnosis
        iii. materials
        iv. tools
        v. cleaning
    b. After the repair checklists
        i. assembly
        ii. flushing
        iii. recover and recharge
        iv. leak and performance tests

69. Identifying systems, refrigerants, and oils
    a. System type
        i. manual or automatic
        ii. expansion device
        iii. compressor type
    b. Refrigerant and refrigerant oil
        i. refrigerant identification
        ii. refrigerant oil identification
        iii. oil replacement amount
70. Hose and line service
    a. Refrigerant hose failure
        i. vibration
        ii. high pressure
        iii. collision damage
        iv. chemical attack
        v. improper installation
    b. Refrigerant hose and line service procedures
        i. hose replacement
        ii. line replacement
        iii. line fitting repair
        iv. o-ring replacement
        v. Ford spring-lock coupling
71. System flushing
    a. Flushing solvents
    b. Flushing equipment
    c. Flushing procedure
72. Condenser and evaporator service
    a. Condenser and evaporator replacement procedures
        i. evaporator
        ii. condenser
73. Accumulator service
    a. Accumulator replacement guidelines
    b. Accumulator replacement procedures
74. Receiver-drier service
    a. Receiver-drier replacement guidelines
    b. Receiver-drier replacement procedures
75. Expansion device service
    a. Expansion valve
        i. symptoms and indicators
        ii. expansion valve testing
        iii. expansion valve replacement
    b. Fixed-orifice tube service
        i. symptoms and indicators
        ii. fixed-orifice tube testing
        iii. fixed-orifice tube replacement
76. Suction-throttling devices
77. Specialized electrical test equipment
    a. Using a scan tool
        i. independent manufacturers'' scan tools
        ii. vehicle manufacturers'' diagnostic testers
    b. Vehicle test and diagnostic connectors
78. Electrical switch diagnosis and testing
    a. Wide-open throttle (WOT) switch testing
    b. Air-conditioning selector and blower-motor switch testing
    c. Cycling-clutch switch testing and replacement
        i. capillary-sensed cycling-clutch switch
        ii. fin-sensed cycling-clutch switch
        iii. electronic cycling-clutch switch (ECCS)
    d. Pressure switch testing and replacement

i. low-pressure cutoff switch
ii. cycling-clutch pressure switch
e. Temperature switch testing and replacement
i. ambient-temperature switch
ii. thermostatic switch
79. Compressor clutch electrical troubleshooting
a. Failure to engage
b. Clutch troubleshooting procedure
80. Automatic temperature controls
a. Components
b. Functions and operation
81. Diagnostic codes in electronically controlled systems
a. Code retrieval and interpretation
b. Diagnostic and control data
82. Testing parts
a. Sensors
b. Actuators
83. Electrostatic discharge (ESD)

Resources

Schnubel, Mark. *Today's Technician: Automotive Heating & Air Conditioning Classroom Manual and Shop Manual*. 7th ed. Boston, MA: Cengage Learning, 2021.

Schnubel, Mark . *Today's Technician: Automotive Heating & Air Conditioning Classroom Manual and Shop Manual* . 7th ed. Boston, MA: Cengage Learning Inc., 2020.

Johanson, Chris. *Auto Heating & Air Conditioning*. 5th ed. Tinley Park, IL: Goodheart-Willcox, 2019.

Halderman, James D. *Automotive Heating and Air Conditioning*. 8th ed. Boston; Pearson Education , 2018.

Resources Other

1. Automotive Repair Help (aa1car.com) (https://www.aa1car.com/)
2. http://www.aircondition.com/tech/questions/82/Troubleshooting-with-Gauges-FAQ (http://www.aircondition.com/tech/questions/82/Troubleshooting-with-Gauges-FAQ/) - Troubleshooting Automotive Air Conditioning with Gauges
3. http://acprocold.com/faq/r-134a-system-pressure-chart/ - R134a System Pressure Chart
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