

Reference Materials: Note: This exam may contain some "accepted practice" type questions not found in the reference material listed below.

Mobil Air Conditioning Society (MACS) Worldwide: macsw.org

Modern Automotive HVAC Systems:

[Systemshttps://www.macsw.org/web/ItemDetail?iProductCode=4428-0&Category=MANUAL&WebsiteKey=d89ff0bc-ce9d-41d9-a243-d885ad993b37](https://www.macsw.org/web/ItemDetail?iProductCode=4428-0&Category=MANUAL&WebsiteKey=d89ff0bc-ce9d-41d9-a243-d885ad993b37)

Modern Automotive HVAC: Electrical & Electronic Systems

<https://www.macsw.org/web/ItemDetail?iProductCode=4429-0&Category=MANUAL&WebsiteKey=d89ff0bc-ce9d-41d9-a243-d885ad993b37>

OSHA Bloodborne Pathogens - https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10051

OSHA Global Harmonized System of Classification and Labeling of Chemicals (GHS) <https://www.osha.gov/dsg/hazcom/ghsguideoct05.pdf>

NFPA 1900: Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances (**NFPA 1917 Chapters**) 2024 edition (800) 344-3555 or www.nfpa.org

NFPA 1910: Standard for the Inspection, Maintenance, Refurbishment, Testing and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels (**NFPA 1911 Chapters**) 2024 edition (800) 344-3555 or www.nfpa.org

LEARNING OBJECTIVES FOR THE E-3 EXAM

1. Definitions or Terms

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|---|---------------------------------|-----------------------------------|
| a. Heat exchanger | i. FFOT-Ford Fixed Orifice Tube | r. Latent heat |
| b. Evacuate | j. Evaporator | (1) Evaporation |
| c. Conduction | k. Condenser | (2) Condensation |
| d. Convection | l. Refrigerants | s. In-Line filter |
| e. Radiation | m. Receiver-dryer | t. Diagnostic codes |
| f. Orifice tube | n. Accumulator-dryer | u. Compressor head pressure |
| g. FOT- Fixed Orifice Tube | o. Desiccant bag | v. Supplemental coolant additives |
| h. FOTCC-Fixed Orifice Tube
Cycling Clutch | p. Ambient temperature | w. Law of heat transfer |
| | q. Compressor
(1) types | x. Induction |

2. Specification and Design

- | | | |
|---|---|---|
| a. Environmental systems
(1) Controls
(2) Electrical wiring | c. Auxiliary A/C condenser | h. Patient compartment insulation
(1) rates and specifications |
| b. Heating and cooling criteria
(1) Sufficient capacity
(2) Temperature ranges
(a) out of service criteria
(3) Performance test
(a) HVAC Settings during
electrical load test
(4) Patient Compartment
Requirements
(5) NFPA 1917 | d. Sound level requirements
(1) Interior Levels, 1917
Standard | i. Electronic/computer controlled systems |
| | e. Windshield defrosting | j. Compressor design types |
| | f. Component installation & routing
(1) Hoses and lines
(2) Accessibility
(3) Securing hoses | k. Paint effect of temperature |
| | g. Ventilation requirements & criteria
(1) Ambient air exchange | l. Special Design Considerations (1917) |
| | | m. Driver's compartment
(1) air box blend doors |
| | | n. Condenser
(1) contaminated (cleaning) |
| | | o. Electrical Systems
(1) Loads
(2) Testing
(3) Wiring Types |

3. Heating and air conditioning theory

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|--|--|--|
| a. Heat & heat transfer
(1) Movement/transfer of heat
(2) Principles | d. Pressure and temperature
(1) System performance
(2) Function of compressor
(3) Relationship between pressure
and temperature
(4) Effect of air in refrigerant during
recovery
(5) Effect of air in operation A/C
system | e. Basic A/C theory of operation
(1) Compressor controls
(a) Variable displacement
compressors
(2) Expansion device
a. Orifice tube
b. TXV
(3) "Highside-Lowside" |
| b. Matter
(1) Compressibility
(2) Solid, liquids, and gases
(3) Physical states of matter | | f. Physical comfort |
| c. Evaporation and Condensation
(1) B.T.U.
(2) Desiccants
(a) When to replace | | g. Refrigerant control |

4. Operation Systems Components and Controls-Describe or identify:

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|---|---|---|
| a. Types of clutch cycling systems
(1) FOT
(2) FCCOT-FFOT | f. Electronic temperature control systems
(1) High idle controls | k. New Refrigerant Types (R-1234YF)
(1) Tanks (color-fittings) |
| b. Expansion Device
(1) TXV
(2) Orifice tube | g. Refrigerant filter systems
(1) Filter dryer
(2) In-line filters
a. Service life length
b. Installatin location | l. Refrigerant oils
(1)Type
(2) Quantity |
| c. A/C pressure cycling controls
(1) Low pressure cut off controls
(2) High pressure cut off controls | (3)Accumulator | m. Windshield defrosting |
| d. Rear HVAC system
(1) Auxiliary condensers | h. Compressor clutch | n. Refrigerant recovery |
| e. Patient compartment air distribution
system
(1) Purpose of blower motor
function | i. Electric cooling fans | o. Out of Service Criteria
(1)HVAC
(2)Engine Coolant System |
| | j. A/C Performance Testing Methods
(1) Using a Manifold Gauge Set
(2) Diagnosis by "Sight, Sound, Smell &
Touch" | |

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5. Troubleshooting, Repair and Service

- a. Identify types and use of leak detectors
- b. Describe the use of gauges and test equipment used in troubleshooting A/C systems
 - (1) Compound gauge
- c. Reclaiming/recycling & recharging unit identifiers
 - (1) Certification and specification
 - (2) Describe the use of reclaiming/recycling & recharging units
- d. Hoses, fittings, belts, and components
 - (1) Hose fitting and connections
 - (2) Identify visual checks of
 - (3) Refrigerant identifier
- e. Compressor & clutch
 - (1) Service valves/isolation valves
 - (2) Other necessary component replacement
 - (3) Identification
 - (4) repair & replacement
- f. Diagnosis/repair of expansion valve/orifice tube system
- g. Condenser & evaporator diagnosis and replacement
- h. Engine cooling/heater - defrosting systems
 - (1) Preventative maintenance
 - (a) Inspections per NFPA 1911
 - (2) diagnosis, repair and replacement of components
 - (3) ATC control system
 - (4) SATC control system
 - a. Locate N.T.C. sensor
 - (5) EATC control system
- i. Evacuation and recharging of A/C systems
 - (1) Temperature/pressure ranges
 - (2) Describe evacuation and recharging
 - (a) Time required
 - (b) Amounts of refrigerants
- j. Diagnosis and repair of A/C cooling performance problems
 - (1) Air duct temperature ranges
 - (2) Blocked orifice tube
 - (3) Ambient temperature switch
 - (4) TXV controlled system
 - (5) Passenger compartment
 - (6) Air flow duct filters
 - (7) Air flow doors
 - (8) Engine coolant assemblies
- k. Electrical system repair and troubleshooting
 - (1) Components and functions
 - (2) System limit controls
 - (3) Load manager/high idle control
 - (4) Reading electrical schematics
- l. Heating system troubleshooting and repair
 - (1) Control valves
 - (2) Performance
- m. Retrofit to R134A refrigerant systems
 - (1) Component replacement
 - (2) In-line filter
- n. Proper flushing of A/C systems
 - (1) Components
- o. Identify proper use of refrigerants
 - (1) contaminants
 - (2) OEM requirement
- p. Refrigerant oils
 - (1) 134a
 - (2) Checking and adding oil (compatibility)
 - (a) OEM requirements
 - (3) Desiccant material compatibility
- q. Engine coolant systems
 - (1) Types of coolant
 - (a) OEM requirements
 - (2) Frequency of change
 - (3) Altitude variations - pressurized systems
- r. Disable air bag system
- s. Refrigerant dye for leaks
- t. Out of Service Criteria
 - (1) HVAC
 - (2) Engine Coolant System
- u. Condenser fan
- v. Service ports

6. Safety and Environmental Concerns

- a. Refrigerant recovery and recycling
 - (b) skin & eye irritant
 - (c) harmful to animals
- b. Federal Clear Air Act
 - (1) Technician Certification requirements
 - (2) Equipment certification requirements
- c. Equipment and tool specifications
 - (1) Charging hoses, manifolds, and connections
 - (2) Refrigerant container
 - (3) Recovery & recharging machines
- d. Refrigerant compatibility
- e. Use & maintenance of recharging station
- f. Leak detector safety
 - (1) Flame leak detector
 - (2) Electronic leak detector
 - (a) Probe tip damage and safety
 - (b) Explosive atmosphere
 - (3) Best practices & equipment
 - (4) UV leak detectors
- g. Personal protective equipment
 - (1) Refrigerants
 - (2) Oils
- h. Refrigerant safety and handling
 - (1) Container capacity
 - (2) Container specifications
 - (3) Flamibility of R-134a
 - (a) relative to atmospheric pressure
 - (b) introduction of compressed air
 - (4) Container disposal
- i. Environmental awareness
 - (1) Refrigerants
 - (2) Coolants
 - (a) disposal
- j. Engine Cooling - Heater - Defroster Safety
 - (1) Radiator Cap
- k. Environment system filters
 - (1) Pathogens
- l. Patient compartment windows & doors
 - (1) Tinting
 - (2) Seals for carbon monoxide
- m. Safety Data Sheets
 - (1) Suppliers responsibility
 - (2) Users responsibility
- n. Medical waste in ambulances
 - (1) Shop procedures
- o. European refrigerant rules
- p. Automatic cooling fan
- q. R-1234YF
 - (1) Equipment & tools
 - (2) Flamibility