Hybrids & Alternative Fuel Vehicles 4/E

Chapter 12 Hybrid Vehicle Heating and Air Conditioning

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of **Hybrid and Alternative Fueled Vehicles**. It correlates material to task lists specified by ASE and NATEF.
Motivate Learners	Explain how the knowledge of how something works translates into the ability to use that knowledge to figure why the engine does not work correctly and how this saves diagnosis time, which translates into more money.
State the learning objectives for the chapter or course you are about to cover and explain this is what they should be able to do as a result of attending this session or class.	Explain the chapter learning objectives to the students. 1. Explain the operation of the ICE cooling system. 2. Explain the operation of the motor/electronics cooling system in a hybrid electric vehicle. 3. Explain the operation of a coolant heat storage system. 4. Describe the function of a vehicle's heating and A/C system. 5. Discuss the operation and unique service procedures for electric-drive A/C compressors.
Establish the Mood or Climate	Provide a *WELCOME,* Avoid put downs and bad jokes.
Complete Essentials	Restrooms, breaks, registration, tests, etc.
Clarify and Establish Knowledge Base	Do a round robin of the class by going around the room and having each student give their backgrounds, years of experience, family, hobbies, career goals, or anything they want to share.

NOTE: This lesson plan is based on Hybrids 4th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

LINK CHP 12: Chapter Images

ICONS	Ch12 Hybrid Vehicle Heating & A/C
	**1. SLIDE 1 Hybrid Vehicle Heating & A/C**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED** **At the beginning of this class, you can download the crossword puzzle & Word Search from the links below to familiarize your class with the terms in this chapter & then discuss them**
	**2. SLIDE 2 EXPLAIN FIGURE 12.1** Coolant flow in a Toyota V-8. Coolant flows through the water jacket in the block and upward into the cylinder head to remove excess heat. The heat is then dissipated to the atmosphere at the radiator. **3. SLIDE 3 EXPLAIN FIGURE 12.2** Major components and coolant flow in a typical ICE cooling system. Note that the heater core also dissipates heat from the coolant.
	**DEMONSTRATION: SHOW STUDENTS PARTS OF AN HEV COOLING SYSTEM. POINT OUT THE COMPRESSOR AND EXPLAIN HOW IT WORKS.**
	**4. SLIDE 4 EXPLAIN FIGURE 12.3** Approximately 1/3 of the total heat released by the fuel must be absorbed by the ICE cooling system. **5. SLIDE 5 EXPLAIN FIGURE 12.4** DEX-COOL uses organic acid technology (OAT) as a corrosion inhibitor. **6. SLIDE 6 EXPLAIN FIGURE 12.5** Ethylene-glycol-based coolants are sweet to taste but highly toxic. Some OEMS "embitter" coolant to prevent animals from drinking it. **7. SLIDE 7 EXPLAIN FIGURE 12.6** A water pump that is driven by the ICE timing belt
	**DISCUSS FREQUENTLY ASKED QUESTIONS**

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	**8. SLIDE 8 EXPLAIN FIGURE 12.7** This water pump impeller will turn CCW (as shown) and will take coolant from the center of the impeller and "throw" it outward. The coolant then flows to the right, where it is directed into the ICE block. **9. SLIDE 9 EXPLAIN FIGURE 12.8** electric helper pump is turned on whenever cabin heating is requested and the ICE is in idle stop mode. The pump is plumbed in series with the hoses running to the vehicle heater core. **10. SLIDE 10 EXPLAIN FIGURE 12.9** Coolant returns to the water pump inlet via the bypass tube (a) until the thermostat starts to open (b) and allows it to flow to the radiator. **11. SLIDE 11 EXPLAIN FIGURE 12.10** The pressure cap is responsible for maintaining pressure as well as making sure the system is always full of liquid coolant
	**12. SLIDE 12 EXPLAIN FIGURE 12.11** coolant recovery reservoir does not have a pressure cap. Note that the coolant is currently on the "cold" line in this photo, but will rise to the "hot" line as the ICE warms up. **13. SLIDE 13 EXPLAIN FIGURE 12.12** The surge tank has a pressure cap and is located at the highest point in the cooling system. **14. SLIDE 14 EXPLAIN FIGURE 12.13** The radiator core is made up of tubes and fins that maximize the surface area for heat rejection. **15. SLIDE 15 EXPLAIN FIGURE 12.14** aluminum radiator has plastic tanks that are crimped in place with a gasket to seal them. **16. SLIDE 16 EXPLAIN FIGURE 12.15** Coolant flows from top to bottom in a downflow radiator. Note that in most cases the radiator cap is located on the upper tank.
	**17. SLIDE 17 EXPLAIN FIGURE 12.16** Coolant flows horizontally in a crossflow radiator. **18. SLIDE 18 EXPLAIN FIGURE 12.17** The fan is needed to move air across the radiator when the vehicle is moving slowly or stopped with the ICE running. **19. SLIDE 19 EXPLAIN FIGURE 12.18** A thermostatic fan clutch forms the hub of this fan assembly. **20. SLIDE 20 EXPLAIN FIGURE 12.19** An electric fan can be located either in front of or behind the radiator. The fan shroud helps direct airflow toward the fan to

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	enhance cooling efficiency
	**EXPLAIN TECH TIP**
	**21. SLIDE 21 EXPLAIN FIGURE 12.20** Radiator hose construction showing two types of reinforcement using woven textile.
	22. SLIDE 22 EXPLAIN FIGURE 12.21 Toyota's coolant heat storage system. Note that the electric storage tank pump is located behind the coolant storage tank.
	**EXPLAIN TECH TIP**
	**23. SLIDE 23 EXPLAIN FIGURE 12.22** A vacuum exists between the inner and outer casing of the coolant heat storage tank. The outlet temperature sensor and the drain plug are located in the manifold at the bottom of the tank.
	24. SLIDE 24 EXPLAIN FIGURE 12.23 The valve position sensor in the water valve provides feedback to the ECM concerning the position of the water valve
	25. SLIDE 25 EXPLAIN FIGURE 12.24 storage tank and pump as seen from under vehicle. Pump energized when coolant must be moved through tank but ICE is shut off
	**26. SLIDE 26 EXPLAIN FIGURE 12.25** During preheat mode, the ICE remains off while the coolant heat storage pump is turned on. The water valve directs hot coolant from the storage tank to the ICE cylinder head
	27. SLIDE 27 EXPLAIN FIGURE 12.26 Coolant bypasses coolant heat storage tank during engine warm-up mode.
	28. SLIDE 28 EXPLAIN FIGURE 12.27 The coolant heat storage tank is filled with hot coolant when the ICE reaches operating temperature. This coolant is then used to warm the engine before the next cold start.
	29. SLIDE 29 EXPLAIN FIGURE 12.28 Storage operation (ignition off) mode. This takes place if the ICE is shut off while the coolant tank is being filled.
	30. SLIDE 30 EXPLAIN FIGURE 12.29 The heater core is located in the plenum chamber. Air temperature in this system is controlled by the position of the air mix valve (blend door).
	31. SLIDE 31 EXPLAIN FIGURE 12.30 PTC heaters can be located on the heater core itself to help boost heat to

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	the passenger compartment when coolant temperature is low. **32. SLIDE 32 EXPLAIN FIGURE 12.31** Two PTC heaters are located in the foot well air ducts in the Toyota Prius. These are energized when the coolant temperature is low and MAX HOT is requested in the FOOT or FOOT/DEF modes. **33. SLIDE 33 EXPLAIN FIGURE 12.32** motor and HV battery electronics on Honda hybrid vehicles are air-cooled. Note the cooling fins for the modules. **34. SLIDE 34 EXPLAIN FIGURE 12.33** electric motors & motor controls are cooled using a separate cooling system. This Toyota Hybrid Synergy Drive (HSD) system uses a radiator that is integral with the ICE cooling system radiator **DISCUSS FREQUENTLY ASKED QUESTIONS** **35. SLIDE 35 EXPLAIN FIGURE 12.34** This first generation Prius (01–03) transaxle has cooling passages for both of the motor-generators. Note the coolant pipes (two on each assembly) on the lower left of this photograph. **36. SLIDE 36 EXPLAIN FIGURE 12.35** SGCM on a GM hybrid pickup has its own liquid cooling system. Pump turns on when SGCM temperature above 140° F **37. SLIDE 37 EXPLAIN FIGURE 12.36** motor electronics cooling system in a Ford Escape Hybrid. Electric pump (1) circulates coolant through eCVT & DC-DC converter and dissipates the excess heat at the radiator (2). ECVT connects to hoses (3) and (4), & DC-DC converter is connected to hoses beside coolant reservoir bottle (5). **EXPLAIN TECH TIP** **DISCUSS FREQUENTLY ASKED QUESTIONS**

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	**38. SLIDE 38 EXPLAIN FIGURE 12.37** Liquid propane in this cylinder is expanding into a gas for fueling a camp stove. Liquid absorbs heat energy as it changes state, evidenced by frost and condensation on cylinder
	**DISCUSSION: ASK STUDENTS TO TALK ABOUT HOW HEAT IS ABSORBED BY AN AUTOMOTIVE A/C SYSTEM.**
	**DISCUSSION: DISCUSS 3 STATES OF WATER AND HOW THEY RELATE TO AUTOMOTIVE HEATING AND AIR-CONDITIONING SYSTEMS. EXPLAIN HOW MOLECULES OF WATER ARE MOVING AT DIFFERENT STATES. ASK WHY THERE HAS TO BE AN UNBALANCED FORCE FOR MOLECULES TO TRANSFER HEAT.**
	**39. SLIDE 39 EXPLAIN FIGURE 12.38** basic air conditioning system. Heat is absorbed in the evaporator and dissipated by the condenser. **40. SLIDE 40 EXPLAIN FIGURE 12.39** A/C compressor clutch allows the compressor to engage and disengage as necessary while ICE continues to run. **41. SLIDE 41 EXPLAIN FIGURE 12.40** basic air distribution system. Air can enter the system from outside the vehicle, or from the passenger compartment while in the recirculation mode. **42. SLIDE 42 EXPLAIN FIGURE 12.41** Coolant can circulate through heater core when thermostat is closed
	**43. SLIDE 43 EXPLAIN FIGURE 12.42** Basic components of a scroll compressor. Note the “pockets” of refrigerant that occupy the spaces labeled with arrows. **44. SLIDE 44 EXPLAIN FIGURE 12.43** The movable scroll orbits inside the stationary scroll and moves the refrigerant from the outside toward the delivery port in the center. **45. SLIDE 45 EXPLAIN FIGURE 12.44** Hybrid electric vehicle A/C compressor. Note that this unit is primarily belt-driven but has a high-voltage electric motor built in to allow A/C system operation during idle stop

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	**DEMONSTRATION: USE LAB VEHICLE SHOW STUDENTS PARTS OF HEV HEATING & COOLING SYSTEM, INCLUDING HEATER HOSES & HEATER CORE. ALSO SHOW THEM BLOWER MOTOR THAT SENDS HEATED AIR INTO PASSENGER COMPARTMENT. USE AN INFRARED THERMOMETER TO SHOW TEMPERATURE DIFFERENCES ON HIGH AND LOW SIDES OF AC SYSTEM & HEATING SYSTEM.** **46. SLIDE 46 EXPLAIN FIGURE 12.45** high-voltage electric drive A/C compressor. The compressor is mounted to the engine block in the same location as a conventional engine –driven compressor. This mounting helps reduce noise and vibration. **47. SLIDE 47 EXPLAIN FIGURE 12.46** AC compressor oil designed for use in Honda hybrid vehicle **48. SLIDE 48 EXPLAIN FIGURE 12.47** A label showing A/C system service information is often located under the hood on the vehicle radiator support. Note that the type and amount of refrigerant is shown, along with the specific type of compressor oil to be used **DISCUSS FREQUENTLY ASKED QUESTIONS** **EXPLAIN TECH TIP** **49. SLIDE 49 EXPLAIN FIGURE 12.48** hybrid vehicle A/C compressor uses two scrolls; one being belt-driven (left) and other driven by brushless DC motor (right). **50. SLIDE 50 EXPLAIN FIGURE 12.49** A/C compressors with electric drive motors require nonconductive oil. Do not use ordinary PAG oils in these systems. **51. SLIDE 51 EXPLAIN FIGURE 12.50** Refrigerant flow in a condenser. **52. SLIDE 52 EXPLAIN FIGURE 12.51** Condenser construction. Surface area is maximized with cooling fins and partitioned tubes to increase cooling capacity. **53. SLIDE 53 EXPLAIN FIGURE 12.52** Condenser location on a Ford Escape Hybrid.

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	**DISCUSSION:** ASK STUDENTS TO TALK ABOUT ROLE OF REFRIGERANT OILS IN LUBRICATING COMPRESSOR. WHAT ARE THE TYPES OF REFRIGERANT OIL AND THEIR CHARACTERISTICS? HYBRID VEHICLES OFTEN USE SPECIAL OIL THAT IS NONCONDUCTIVE. USING WRONG OIL COULD CAUSE DEATH OR INJURY FROM ELECTRICAL SHOCK. HEVS USE 200 VOLTS TO DRIVE COMPRESSOR RATHER THAN WITH A BELT.
	
	54. **SLIDE 54 EXPLAIN FIGURE 12.53** Basic components and refrigerant flow in an expansion-valve system and an orifice-tube system.
	55. **SLIDE 55 EXPLAIN FIGURE 12.54** Operation of a thermostatic expansion valve (TXV). Higher evaporator temperature will cause refrigerant flow to increase (left), whereas lower evaporator temperature will cause the flow to decrease (right)
	56. **SLIDE 56 EXPLAIN FIGURE 12.55** fixed orifice tube has no moving parts.
	57. **SLIDE 57 EXPLAIN FIGURE 12.56** battery zone valve used in the Ford Escape Hybrid will open when traction battery cooling is requested by PCM. This can take place independent of the operation of the passenger zone valve
	**DEMONSTRATION:** SHOW STUDENTS A FIXED ORIFICE TUBE, DESCRIBE ITS PURPOSE, AND EXPLAIN HOW IT WORKS
	58. **SLIDE 58 EXPLAIN FIGURE 12.57** Cabin filters are sometimes serviced from inside the vehicle, whereas others may be accessed from under the hood.
	59. **SLIDE 59 EXPLAIN FIGURE 12.58** The battery zone filter for a Ford Escape Hybrid is located in the rear left of the vehicle's interior. This filter should be serviced regularly to prevent traction battery overheating.
	60. **SLIDE 60 EXPLAIN FIGURE 12.59** Flexible lines are used to attach compressor to remainder of A/C system.
	**DISCUSS FREQUENTLY ASKED QUESTIONS**

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	**61. SLIDE 61 EXPLAIN FIGURE 12.60** R-134a systems use quick-disconnect fittings for the service valves. Note that this fitting is on the low side of the system and it is smaller than the fitting used on the system's high side