Chapter 14 Cooling System Operation & Diagnosis

Opening Your Class

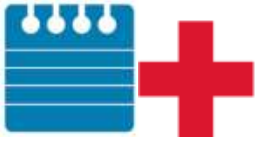
KEY ELEMENT	EXAMPLES
Introduce Content	This engine systems course or class provides complete coverage of the components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and NATEF and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Real World Fixes, Videos, Animations, and NATEF Task Sheet references.
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 as listed on the second SLIDE. 1. Prepare for ASE Engine Repair (A1) certification test content area "D" (Lubrication and Cooling Systems Diagnosis and Repair). 2. Describe how coolant flows through an engine. 3. Discuss the operation of the thermostat. 4. Explain purpose and function of the radiator pressure cap. 5. Describe the operation and service of water pumps. 6. Discuss how to diagnose cooling system problems.
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.

ICONS	CH14 Cooling System Operation & Diagnosis
	**1. SLIDE 1 CH14 COOLING SYSTEM OPERATION** **2. SLIDES 2-3 EXPLAIN Objectives & KEY TERMS**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE REGULARLY UPDATED** **VIDEOS** **Engine Operation (17 Links)**
	**4. SLIDE 4 EXPLAIN** Cooling System **5. SLIDE 5 EXPLAIN FIGURE 14-1** Typical combustion and exhaust temperatures
	**6. SLIDE 6 EXPLAIN TECH TIP**
	**DISCUSSION: Have students discuss heat generated in an engine. Ask: "If one-third of the heat is removed through the cooling system, and one-third is removed through the exhaust system, what is the other one-third used for?" (Answer: Pushing pistons down.)**
	**Engines that do not reach proper operating temperature may leave water in oil, which can cause engine failures, such as bearing failure.**
	**DISCUSSION: Discuss with students how improper coolant temperature can harm fuel economy. Why does temperature affect fuel economy? (ANS: Changes fuel vaporization rate)**
	**7. SLIDE 7 EXPLAIN** Cooling System Operation & **EXPLAIN FIGURE 14-2** Coolant circulates through water jackets in engine block and cylinder head. **8. SLIDE 8 EXPLAIN FIGURE 14-3** Coolant flow through a typical engine cooling system
	**DISCUSSION: Have students discuss possible reasons that older engines were less likely to have engine failure from overheating. (The reason is that heavy steel blocks and heads displaced heat better and were able to take higher temperatures**

ICONS	CH14 Cooling System Operation & Diagnosis
       	**without damage due to amount of metal.)** **DEMONSTRATION: Show students a bypass hose and where it is located on different engines.** **DISCUSSION: Discuss with students why the bypass hose is so important. Why is it important? (ANS: Allows for rapid engine warm up)** **ON-VEHICLE NATEF Task: (A1A1) Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins (P-1)** **9. SLIDES 9 EXPLAIN** Thermostats **10. SLIDE 10 EXPLAIN FIGURE 14-4** A cross section of a typical wax-actuated thermostat showing the position of the wax pellet and spring. **11. SLIDE 11 EXPLAIN FIGURE 14-5 (a)** When the engine is cold, the coolant flows through the bypass. **(b)** When thermostat opens, the coolant can flow to the radiator. **12. SLIDE 12 EXPLAIN Chart 14-1** temperature of the coolant depends on the rating of the thermostat. **13. SLIDE 13 EXPLAIN FIGURE 14-6** thermostat stuck in open position caused engine to operate too cold. If a thermostat is stuck closed, this can cause engine to overheat. **14. SLIDE 14 EXPLAIN FIGURE 14-7** This internal bypass passage in the thermostat housing directs cold coolant to the water pump. **15. SLIDE 15 EXPLAIN FIGURE 14-8** A cutaway of a small block Chevrolet V-8 showing the passage from the cylinder head through the front of the intake manifold to the thermostat. **Removing a thermostat may cause overheating issues because coolant flows so quickly that it cannot absorb the heat.** **16. SLIDE 16 EXPLAIN TECH TIP** **17. SLIDE 17 EXPLAIN TECH TIP**

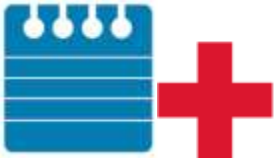
ICONS	CH14 Cooling System Operation & Diagnosis
	18. **SLIDE 18 EXPLAIN FIGURE 14–9** Checking the opening temperature of a thermostat 19. **SLIDE 19 EXPLAIN FIGURE 14-10** Some thermostats are an integral part of the housing. This thermostat and radiator hose housing is serviced as an assembly. Some thermostats snap into engine radiator fill tube underneath pressure cap
	**VIDEOS** **Lubrication and Cooling System (70 Links)**
	**Thermostat Operation ANIMATION: http://www.jameshalderman.com/animations.html#a1**
	**When checking a thermostat for an overheating condition, be sure the thermostat is installed correctly.**
	**DISCUSSION: Discuss with students the 3 methods of testing thermostats & positive and negatives of each.**
	**DEMONSTRATION: Using the hot water method, show how a thermostat opens and closes.**
	HANDS-ON TASK: Have students perform thermostat testing using at least one of 3 methods listed in the text on page 185 of Chapter 21. **When replacing thermostat, be sure sensing pellet is facing engine block.**
	
	**ON-VEHICLE NATEF TASK: Inspect, test, remove and replace thermostat and gasket/seal. PAGE 37**
	20. **SLIDE 20 EXPLAIN Radiators & EXPLAIN Figure 14-11** tubes and fins of radiator core. 21. **SLIDE 21 EXPLAIN FIGURE 14-12 (a)** radiator may be either a down-flow or a crossflow type. **(b)** radiator may be either a down-flow or a crossflow type. 22. **SLIDE 22 EXPLAIN FIGURE 14-13** Many vehicles

ICONS	CH14 Cooling System Operation & Diagnosis
        	equipped with automatic transmission use a transmission fluid cooler installed in one of radiator tanks. **Older steel radiators could often be repaired. Most newer radiators cannot be repaired, due to cost, & must be replaced** **DEMONSTRATION: Show students different styles of radiators.** **DISCUSSION: Discuss the importance of heat transfer. What are 3 forms of heat transfer from Physics Class? (ANS: Conductance, Convection, & Radiation. Radiators despite their name, generally transfer the bulk of their heat via convection, not by thermal radiation. Convection is transfer of heat from one place to another by movement of fluids. Convection is usually the dominant form of heat transfer in liquids and gases)** **ON-VEHICLE NATEF TASK: Remove and replace radiator PAGE 36** 23. **SLIDE 23 EXPLAIN Pressure Caps & EXPLAIN FIGURE 14-14** pressure valve maintains system pressure and allows excess pressure to vent. Vacuum valve allows coolant to return to the system from the recovery tank 24. **SLIDE 24 EXPLAIN TECH TIP** 25. **SLIDE 25 EXPLAIN Chart 14-2** Comparison showing metric pressure as shown on the top of the cap to pounds per square inch (PSI) **RADIATOR PRESSURE CAP ANIMATION: www.myautomotivelab.com http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter14_Fig_14_14/index.htm** **Pressure Cap Operation ANIMATION: http://www.jameshalderman.com/animations.html#a1**

ICONS	CH14 Cooling System Operation & Diagnosis
	**SAFETY TIP:** **Always remove a pressure cap slowly using rags or heavy gloves for protection. A hot cooling system can spray coolant or steam under pressure. Even a cold system may have pressure that can spray coolant into eyes or damage paint. Overheating transmissions can cause engine overheating issues.**
	
	**DEMONSTRATION:** **Demonstrate how a pressure cap vents at the pressure listed.**
	**Show RADIATOR PRESSURE CAP ANIMATION:** **www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter14_Fig_14_14/index.htm
	26. **SLIDE 26** **EXPLAIN** Coolant Recovery Systems & **EXPLAIN** **FIGURE 14-15** level in the coolant recovery system raises and lowers with engine temperature. 27. **SLIDE 27** **EXPLAIN** **FIGURE 14-16** Some vehicles use a surge tank, which is located at the highest level of the cooling system, with a radiator cap 28. **SLIDE 28** **EXPLAIN REAL WORLD FIX**
	
	**DEMONSTRATION:** **Show students different types of coolant recovery bottles**
	**DISCUSSION:** **Discuss with students why the recovery bottle is important to longevity of the cooling system's effectiveness.**
	**Collapsed hoses may be caused by pressure cap not venting correctly.**

ICONS	CH14 Cooling System Operation & Diagnosis
	**ON-VEHICLE NON-NATEF Task: Inspect and replace engine cooling and heater system hoses**
	**29. SLIDE 29 EXPLAIN Water Pumps & EXPLAIN FIGURE 14-17** Coolant flow through impeller & scroll of coolant pump for a V-type
	**30. SLIDE 30 EXPLAIN FREQUENTLY ASKED QUESTION**
	**31. SLIDE 31 EXPLAIN FIGURE 14–18** A demonstration engine running on a stand, showing the amount of coolant flow that actually occurs through the cooling system
	32. SLIDE 32 EXPLAIN FIGURE 14-19 This severely corroded water pump could not circulate enough coolant to keep the engine cool. As a result, the engine overheated and blew a head gasket.
	33. SLIDE 33 EXPLAIN FIGURE 14-20 bleed weep hole in the water pump allows coolant to leak out of the pump and not be forced into the bearing. If the bearing failed, more serious damage could result.
	**34. SLIDE 34 EXPLAIN FIGURE 14-21** cutaway of a typical water pump showing long bearing assembly and seal. The weep hole is located between seal and bearing. If the seal fails, then coolant flows out of the weep hole to prevent the coolant from damaging the bearing.
	**35. SLIDE 35 EXPLAIN TECH TIP**
	**On vehicles that use a timing belt to run water pump, it is strongly recommended that the water pump be replaced when the timing belt is replaced.**
	**DISCUSSION: Discuss water pump operation with students**
	**DEMONSTRATION: Show students different variations of a water pump.**

ICONS	CH14 Cooling System Operation & Diagnosis
	**DEMONSTRATION: Show students water pump weep hole.**
	**Be sure to install the serpentine belt correctly when replacing water pump; otherwise, pump may turn backwards.**
	**ON-VEHICLE NATEF Task: Inspect, test, remove, and replace water pump. PAGE 102**
	36. **SLIDE 36 EXPLAIN** Coolant Flow in the Engine & **EXPLAIN FIGURE 14-22** Chevrolet V-8 block that shows the large coolant holes and the smaller gas vent or bleed holes that must match the head gasket when the engine is assembled.
	**DISCUSSION: Discuss with students differences in coolant flow systems.**
	**DEMONSTRATION: Show students different head gasket designs and the coolant passages through them.**
	37. **SLIDE 37 EXPLAIN Cooling Fans & EXPLAIN FIGURE 14-23** typical electric cooling fan assembly showing the radiator and related components**.**
	38. **SLIDE 38 EXPLAIN WARNING**
	39. **SLIDE 39 EXPLAIN FIGURE 14-24** typical engine-driven thermostatic spring cooling fan.
	40. **SLIDE 40 EXPLAIN TECH TIP**
	**Show CLUTCH FAN & HOSES VIDEO: 1.5 MINUTES www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_mylabs/akamai/template/video640x480.php?title=Clutch%20Fan%20and%20Hoses&clip=pandc/chet/2012/automotive/Auto_Parts_Specialist/Exp5.mov&caption=chet/chet_mylabs/akamai/2012/automotive/Auto_Parts_Specialist/xml/Exp5.xml

ICONS	CH14 Cooling System Operation & Diagnosis
	**SAFETY: Electrical cooling fans can come on unexpectedly. Always keep hands and objects clear of them. Spring-type fans should spin freely on a cold engine.**
	**DEMONSTATION: Show students how to remove and replace a cooling fan assembly.**
	**ON-VEHICLE NATEF TASK: Inspect and text fans(s) (electrical or mechanical), fan clutch, fan shroud, and air dams. PAGE 39**
	**DEMONSTRATION: Show students how fan shroud helps direct airflow through radiator.**
	41. **SLIDE 41 EXPLAIN Heater Cores** 42. **SLIDE 42 EXPLAIN FIGURE 14-25** typical heater core installed in a heating, ventilation, and air-conditioning (HVAC) housing assembly 43. **SLIDES 43-44 EXPLAIN Heater Cores**
	**DEMONSTRATION: Show students examples of heater cores and their locations.**
	**Coolant on the passenger floor or a mist out of the vents may be caused by a leaking heater core.**
	**Some vehicles, especially hybrids, use a form of electrical heater core**
	45. **SLIDE 45 EXPLAIN Cooling System Testing** 46. **SLIDE 46 EXPLAIN FIGURE 14-26** heavily corroded radiator from a vehicle that was overheating. A visual inspection discovered that the corrosion had eaten away many of the cooling fins, yet did not leak. This radiator was replaced and it solved the overheating problem

ICONS	CH14 Cooling System Operation & Diagnosis
	**If using a dye to leak test, it may be necessary to remove the blower resistor to access the heater core for inspection.**
	**47. SLIDE 47 EXPLAIN Cooling System Testing & EXPLAIN FIGURE 14-27** Pressure testing cooling system. Hand operated pressure tester applies pressure equal to radiator cap pressure. The pressure should hold; if it drops, this indicates a leak somewhere in cooling system. An adapter is used to attach pump to cap to determine if radiator can hold pressure, & release it when pressure rises above max rated pressure setting. **48. SLIDE 48 EXPLAIN FIGURE 14-28** pressure cap should be checked for proper operation using a pressure tester as part of the cooling system diagnosis.
	**ON-VEHICLE NATEF TASK Perform cooling system pressure and dye tests to identify leaks; check coolant condition and level; inspect and test radiator, pressure cap, coolant recovery tank, and heater core; determine necessary action PAGE 31**
	**DISCUSSION: Discuss with students how incorrect ignition timing can cause overheating issues (i.e., cause a lean condition, which leads to the engine running at hotter temperatures.)**
	**ON-VEHICLE NATEF TASK Identify causes of engine overheating PAGE 40**
	**49. SLIDE 49 EXPLAIN** Cooling System Testing & **EXPLAIN FIGURE 14-29** Use dye specifically made for coolant when checking for leaks using a black light.
	**DEMONSTRATION: Show students how dye illuminates with a black light.**
	**51. SLIDE 51 EXPLAIN** Coolant Temperature Warning Light & **EXPLAIN FIGURE 14-30** When an engine overheats, often the coolant overflow container boils.
	**52. SLIDE 52 EXPLAIN** Cooling System Inspection & **EXPLAIN FIGURE 24-31** Typical marks on an accessory drive belt tensioner. **53. SLIDE 53 EXPLAIN Chart 14-3** number of ribs

ICONS	CH14 Cooling System Operation & Diagnosis
       	determines tension range of belt. **54. SLIDE 54 EXPLAIN REAL WORLD FIX** **55. SLIDE 55 EXPLAIN REAL WORLD FIX** **56. SLIDE 56 EXPLAIN TECH TIP** **DEMONSTRATION: Show students proper procedure for using a belt tension gauge.** **ON-VEHICLE NATEF TASK Inspect, replace, and adjust drive belts, tensioners and pulleys; check pulley and belt alignment PAGE 35** **57. SLIDE 57 EXPLAIN** Cooling System Service **58. SLIDE 58 EXPLAIN FIGURE 14-32 (a)** Many vehicle manufacturers recommend that the bleeder valve be opened whenever refilling the cooling system. **(b)** Chrysler recommends that a clear plastic hose (1/4 in. ID) be attached to the bleeder valve and directed into a suitable container to keep from spilling coolant onto the ground and on the engine and to allow the technician to observe the flow of coolant for any remaining oil bubbles. **59. SLIDE 59 EXPLAIN FIGURE 14-33** Using a coolant exchange machine helps eliminate the problem of air getting into the system which can cause overheating or lack of heat due to air pockets getting trapped in the system. **DISCUSSION: Discuss proper coolant disposal procedures.** **DEMONSTRATION: Show students proper procedure for using a coolant exchange machine.**

ICONS	CH14 Cooling System Operation & Diagnosis
	**Air pockets around thermostat can cause thermostat to malfunction, causing an overheating condition.**
	**60. SLIDE 60 EXPLAIN FIGURE 14-34** All cooling system hoses should be checked for wear or damage
	**61. SLIDE 61 EXPLAIN TECH TIP**
	**62. SLIDE 62 EXPLAIN TECH TIP**
	**DEMONSTRATION: Show students where radiator petcock is located and how to properly open and close it without breaking it.**
	**DEMONSTRATION: Show students different types of heater hoses.**
	**When checking radiator hoses, remember that the bottom hose may have a spring inside to keep it from collapsing.**
	**63. SLIDE 63 EXPLAIN FIGURE 14–35** The top 3/8 in. hose is designed for oil and similar liquids, whereas the 3/8 in. hose below is labeled “heater hose” and is designed for coolant
	**64. SLIDE 64 EXPLAIN TECH TIP**
	**HANDS-ON TASK: Have students remove and replace a radiator hose.**
	**HOMEWORK: Have students research the Internet and find our how hybrid vehicles keep the engine coolant warm even though the engine is not always running. Have them report their findings to class.**
	**Talk through SUMMARY and questions**

ICONS	CH14 Cooling System Operation & Diagnosis
	**HOMEWORK:** complete Ch14 crossword puzzle: http://www.jameshalderman.com/links/book_engine_theory_serv_7/cw/crossword_ch_14.pdf