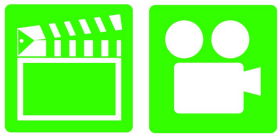
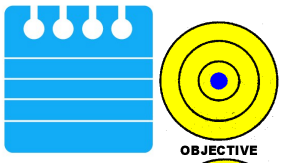
A8 Engine Performance 4th Edition

Chapter 8 Cooling System Operation & Diagnosis

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of **Automotive Engine Performance.** 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. Prepare for Engine repair (A1) ASE 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 the purpose and function of the radiator pressure cap. 5. Describe the various types of antifreeze and how to recycle and discard used coolant. 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	Ch08 Cooling System Operation & Diagnosis
	1. SLIDE 1 CH8 Cooling System Operation & Diagnosis
	Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE REGULARLY UPDATED
	POWER POINTS DONE BY INDIVIDUAL LEARNING OBJECTIVES, SO THERE IS POWER POINT FILE FOR EACH LEARNING OBJECTIVE
	2. SLIDE 2 EXPLAIN OBJECTIVE CH8 AEP_LO1 3. SLIDE 3 EXPLAIN Figure 8-1 Typical combustion and exhaust temperatures
	4. SLIDE 4 EXPLAIN Low-Temperature Engine Problems 5. SLIDE 5 EXPLAIN High-Temperature Engine Problems
	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)
	2. SLIDE 2 EXPLAIN OBJECTIVE CH8 AEP_LO2 3. SLIDE 3 EXPLAIN Cooling System Design

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	4. **SLIDE 4 EXPLAIN Figure 8-2** Coolant flow through a typical engine cooling system.. 5. **SLIDE 5 EXPLAIN Figure 8-3** Coolant circulates through water jackets in engine block and cylinder head 6. **SLIDES 6-8 EXPLAIN** Cooling System Operation **Coolant Flow-World Engine**
	**DISCUSSION: 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 WITHOUT DAMAGE DUE TO AMOUNT OF METAL.)**
	**DEMONSTRATION: SHOW 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: RESEARCH APPLICABLE VEHICLE AND SERVICE INFORMATION, VEHICLE SERVICE HISTORY, SERVICE PRECAUTIONS, AND TSBS**
	2. **SLIDE 2 EXPLAIN OBJECTIVE CH8 AEP_LO2** 3. **SLIDES 3-4 EXPLAIN** Thermostat Temperature Control
	5. **SLIDE 5 EXPLAIN Figure 8-4** cross section of a typical wax-actuated thermostat showing position of wax pellet. 6. **SLIDE 6 EXPLAIN Figure 8-5 (a)** When engine is cold, the coolant flows through the bypass. **(b)** When the thermostat opens, the coolant can flow to the radiator. 7. **SLIDE 7 EXPLAIN Figure 8-6** thermostat stuck in open position caused engine to operate too cold. If a thermostat is stuck closed, this can cause engine to overheat. 8. **SLIDES 8-9 EXPLAIN** Thermostat Temperature Control: Bypass

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	10. **SLIDE 10 EXPLAIN Figure 8-7** This internal bypass passage in thermostat housing directs cold coolant to water pump. 11. **SLIDE 11 EXPLAIN Figure 8-8** 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.**
	12. **SLIDE 12 EXPLAIN Testing Thermostat** 13. **SLIDE 13 EXPLAIN FIGURE 8–9** Setup used to check the opening temperature of a thermostat. 14. **SLIDES 14-16 EXPLAIN Thermostat Replacement** 17. **SLIDE 17 EXPLAIN Figure 8-10** Some thermostats are an integral part of housing. This thermostat and radiator hose housing is serviced as an assembly. Some thermostats snap into engine radiator fill tube underneath pressure cap
	**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.**

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   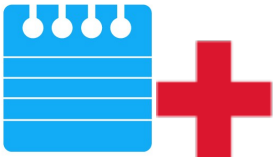  	**ON-VEHICLE NATEF TASK: INSPECT, TEST, REMOVE AND REPLACE THERMOSTAT AND GASKET/SEAL** 2. SLIDE 2 EXPLAIN OBJECTIVE CH8 AEP_LO4 3. SLIDE 3 EXPLAIN Pressure Cap 4. **SLIDE 4 EXPLAIN Figure 8-18** pressure valve maintains system pressure and allows excess pressure to vent. The vacuum valve allows coolant to return to the system from the recovery tank. 5. **SLIDE 5 EXPLAIN Figure 8-19** Some vehicles use a surge tank, which is located at the highest level of the cooling system, with a radiator cap. 6. SLIDES 6-7 EXPLAIN METRIC RADIATOR CAPS **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.** **ANIMATION RADIATOR PRESSURE CAP: WWW.MYAUTOMOTIVELAB.COM** HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYAUTOMOTIVELAB_2/ANIMATIONS/A1_ANIMATION/CHAPTER14_FIG_14_14/INDEX.HTM 8. **SLIDE 8 EXPLAIN Figure 8-20** level in the coolant recovery system raises and lowers with engine temperature. 9. **SLIDE 9 EXPLAIN FIGURE 8–21** Pressure testing the cooling system. A typical hand-operated pressure tester applies pressure equal to the radiator cap pressure. The pressure should hold; if it drops, this indicates a leak somewhere in the cooling system. An adapter is used to attach the pump to the cap to determine if the radiator can hold pressure, and release it when pressure rises above its maximum rated pressure setting. 10. **SLIDE 10 EXPLAIN FIGURE 8–22** The pressure cap should be checked for proper operation using a pressure tester as part of the cooling system diagnosis

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    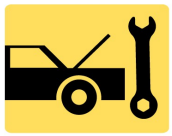   	**DEMONSTRATION:** SHOW STUDENTS DIFFERENT TYPES OF COOLANT RECOVERY BOTTLES **DISCUSSION:** DISCUSS WITH STUDENTS WHY THE RECOVERY BOTTLE IS IMPORTANT TO LONGEVITY OF THE COOLING SYSTEM'S EFFECTIVENESS. COLLAPSED HOSES MAY BE CAUSED BY PRESSURE CAP NOT VENTING CORRECTLY. **ON-VEHICLE NATEF TASK:** INSPECT AND REPLACE ENGINE COOLING AND HEATER SYSTEM HOSES. 2. SLIDE 2 EXPLAIN OBJECTIVE CH8 AEP_LO5 3. SLIDE 3 EXPLAIN Cooling System Design 4. SLIDES 4-5 EXPLAIN Thermostat Temperature Control 6. SLIDE 6 EXPLAIN FIGURE 8–7 This Internal bypass passage in the thermostat housing directs cold coolant to the water pump. 7. SLIDE 7 EXPLAIN FIGURE 8–21 Pressure testing the cooling system. A typical hand-operated pressure tester applies pressure equal to the radiator cap pressure. The pressure should hold; if it drops, this indicates a leak somewhere in the cooling system. An adapter is used to attach the pump to the cap to determine if the radiator can hold pressure, and release it when pressure rises above its maximum rated pressure setting. 8. SLIDE 8 EXPLAIN Figure 8-24 Coolant flow through impeller & scroll of coolant pump for a V-type 9. SLIDE 9 EXPLAIN Figure 8-26 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. 10. SLIDE 10 EXPLAIN Figure 8-27 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.

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	11. SLIDE 11 EXPLAIN Figure 8-28 cutaway of a typical water pump showing the long bearing assembly and the seal. The weep hole is located between the seal and the bearing. If the seal fails, then coolant flows out of the weep hole to prevent coolant from damaging bearing.
	**DEMONSTRATION: SHOW STUDENTS WATER PUMP WEEP HOLE.**
	**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.**
	**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.**
	2. SLIDE 2 EXPLAIN OBJECTIVE CH8 AEP_LO6 3. SLIDES 3-4 EXPLAIN Antifreeze/Coolant 5. SLIDE 5 EXPLAIN FIGURE 8–11 Graph showing the relationship of the freezing point of the coolant to the percentage of antifreeze used in the coolant. 6. SLIDE 6 EXPLAIN FIGURE 8–12 Graph showing how the boiling point of the coolant increases as the percentage of antifreeze in the coolant increases
	**DEMONSTRATION: SHOW EXAMPLES OF COOLANT COLORS. EXPLAIN THAT COOLANT SPILLS SHOULD BE CLEANED UP IMMEDIATELY SINCE THEY ARE VERY SLICK AND CAN BE HAZARDOUS.**

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	**SAFETY TIP:** NEVER LEAVE OPEN COOLANT CONTAINERS WHERE ANIMALS CAN REACH THEM. ANIMALS ENJOY SWEET TASTE OF COOLANT & DRIT IT. COOLANT CAN KILL PETS. EVEN EMBITTERED COOLANT SHOULD NOT BE LEFT AROUND ANIMALS. EVEN THOUGH ANIMALS MAY NOT LIKE TASTE OF THIS COOLANT, MAY NOT DRINK IT, THEY STILL MAY LICK IT BECOME ILL.
	**DISCUSSION:** DISCUSS HOW THE MIXING OF TYPES OF COOLANTS MAY HARM THE SYSTEM. DISCUSS WITH STUDENTS SOME EXAMPLES OF MANUFACTURER ISSUES WITH DEX-COOL. WHO WAS THE FIRST OEM TO USE DEX-COOL?
	7. SLIDES 7-8 EXPLAIN Antifreeze Can Freeze 9. SLIDE 9 EXPLAIN FIGURE 8–13 Checking freezing and boiling protection levels of coolant using hydrometer
	**DISCUSSION:** DISCUSS IMPORTANCE OF A PROPER COOLANT AND WATER MIX, & PROBLEMS THAT ARISE FROM INCORRECT MIXTURES.
	**DISCUSSION:** DISCUSS WITH STUDENTS WHY THE FREEZING POINT AND THE BOILING POINT ARE NOT THE ONLY THINGS TO CHECK WHEN TESTING COOLANT. WHAT IS THE DIFFERENCE BETWEEN FREEZING & BOILING POINT?
	**DISCUSSION:** DISCUSS WITH STUDENTS WHY GALVANIC ACTIVITY WAS NOT A BIG PROBLEM WITH THE OLDER STEEL ENGINES.
	**DEMONSTRATION:** SHOW STUDENTS HOW TO TEST FOR ELECTROLYSIS IN COOLING SYSTEM
	ELECTROLYSIS IN COOLING SYSTEM CAN CREATE CORROSION THAT DESTROYS COMPONENTS FROM THE INSIDE OUT
	**Coolant Replacement**

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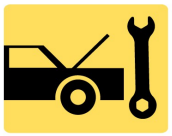
	**COOLANT COLORS VARY EVEN WITHIN OEMS MODELS. COLOR HAS NO BEARING ON THE SERVICE LIFE OF THE COOLANT. MOST OEMS RECOMMEND USING DISTILLED WATER, NOT TAP WATER, IN COOLING SYSTEMS. DISTILLED WATER DOES NOT HAVE ALL THE CHEMICALS THAT CAN HARM YOUR COOLING SYSTEM.**
	10. SLIDES 10-11 EXPLAIN Recycling Coolant 12. SLIDES 12-13 EXPLAIN Disposing of Used Coolant
	**HANDS-ON TASK: HAVE STUDENTS USE TEST STRIPS TO VERIFY THE COOLANT CONDITION**
	**ON-VEHICLE NATEF TASK: TEST COOLANT; DRAIN AND RECOVER COOLANT; FLUSH AND REFILL COOLING SYSTEM WITH RECOMMENDED COOLANT; BLEED AIR AS REQUIRED.**
	**ON-VEHICLE NATEF TASK A7C6: FLUSH COOLING SYSTEM; REFILL AND BLEED SYSTEM.**
	2. SLIDE 2 EXPLAIN **OBJECTIVE CH8 AEP_LO7** 3. SLIDE 3 EXPLAIN **FIGURE 8-14** tubes and fins of radiator core.
	4. SLIDE 4 EXPLAIN **FIGURE 8-15** radiator may be either a down-flow or a crossflow type 5. SLIDE 5 EXPLAIN **FIGURE 8–16** A 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 they did not leak. This radiator was replaced and it solved the overheating problem. 6. SLIDE 6 EXPLAIN **FIGURE 8-17** Many vehicles 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**

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    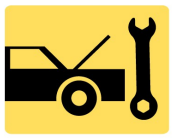 	**DEMONSTRATION: SHOW STUDENTS DIFFERENT STYLES OF RADIATORS.** **DISCUSSION: DISCUSS THE IMPORTANCE OF HEAT TRANSFER. WHAT ARE THE 3 FORMS OF HEAT TRANSFER FROM PHYSICS CLASS? (ANS: CONDUCTANCE, CONVECTION, & RADIATION. RADIATORS DESPITE THEIR NAME, GENERALLY TRANSFER THE BULK OF THEIR HEAT VIA CONVECTION, 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.** 7. **SLIDE 7 EXPLAIN FIGURE 8–23** Use dye specifically made for coolant when checking for leaks using a black light. 8. **SLIDE 8 EXPLAIN FIGURE 8–24** Coolant flow through the impeller and scroll of a coolant pump for a V-type engine. 9. **SLIDE 9 EXPLAIN FIGURE 8–25** A demonstration engine showing the amount of water that can be circulated through the cooling system. 10. **SLIDE 10 EXPLAIN FIGURE 8–26** 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. 11. **SLIDE 11 EXPLAIN FIGURE 8-27** 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. 12. **SLIDE 12 EXPLAIN FIGURE 8-28** cutaway of a typical water pump showing the long bearing assembly and the seal. The weep hole is located between the seal and the bearing. If the seal fails, then coolant flows out of the weep hole to prevent coolant from damaging bearing

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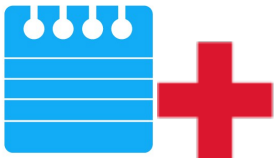
	**DISCUSSION: DISCUSS WITH STUDENTS DIFFERENCES IN COOLANT FLOW SYSTEMS.**
	**DEMONSTRATION: SHOW STUDENTS DIFFERENT HEAD GASKET DESIGNS AND THE COOLANT PASSAGES THROUGH THEM.**
	**DEMONSTRATION: SHOW STUDENTS HOW DYE ILLUMINATES WITH A BLACK LIGHT.**
	**IF USING A DYE TO LEAK TEST, IT MAY BE NECESSARY TO REMOVE BLOWER RESISTOR TO ACCESS HEATER CORE**
	13. **SLIDE 13 EXPLAIN Figure 8-29** typical engine-driven thermostatic spring cooling fan. 14. **SLIDE 14 EXPLAIN Figure 8-30** typical electric cooling fan assembly showing the radiator and related components. **EXPLAIN FIGURE 8–31** Flexible cooling fan blades change shape as the engine speed changes. 15. **SLIDE 15 EXPLAIN FIGURE 8–33** A typical electric cooling fan assembly after being removed from vehicle.
	**VIDEO CLUTCH FAN & HOSES** **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
	**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 & REPLACE A COOLING FAN ASSEMBLY.**
	**ON-VEHICLE NATEF TASK: INSPECT AND TEXT FANS(S) (ELECTRICAL OR MECHANICAL), FAN CLUTCH, FAN SHROUD, AND AIR DAMS.**

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DEMO	**DEMONSTRATION: SHOW STUDENTS HOW FAN SHROUD HELPS DIRECT AIRFLOW THROUGH RADIATOR.**
DEMO	**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.**
	16. **SLIDES 16-17 EXPLAIN** Coolant Temperature Warning Light 18. **SLIDES 18-19 EXPLAIN** Common Causes of Overheating 20. **SLIDE 20 EXPLAIN Figure 8-34** When an engine overheats, often the coolant overflow container boils
	**ON-VEHICLE NATEF TASK PERFORM COOLING SYSTEM PRESSURE TESTS; DETERMINE NECESSARY ACTION** **ON-VEHICLE NATEF TASK IDENTIFY AND INTERPRET ENGINE CONCERN; DETERMINE NECESSARY ACTION**
	**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**
	21. **SLIDE 21 EXPLAIN FIGURE 8–35** (a) Chrysler recommends that the bleeder valve be opened whenever refilling the cooling system. (b) Chrysler also recommends that a clear plastic hose (1/4" 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.

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	**DISCUSSION: DISCUSS PROPER COOLANT DISPOSAL PROCEDURES.**
	**DEMONSTRATION: SHOW STUDENTS PROPER PROCEDURE FOR USING A COOLANT EXCHANGE MACHINE.**
	**AIR POCKETS AROUND THERMOSTAT CAN CAUSE THERMOSTAT TO MALFUNCTION, CAUSING AN OVERHEATING CONDITION.**
	22. **SLIDE 22 EXPLAIN FIGURE 8–36** All cooling system hoses should be checked for wear or damage 23. **SLIDES 23-25 EXPLAIN Cleaning Radiator Exterior**
	**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.**
	**HANDS-ON TASK: HAVE STUDENTS REMOVE AND REPLACE A RADIATOR HOSE.**