ATE5 Chapter 94 BRAKE HYDRAULIC SYSTEMS

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This 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 learning objectives to students as listed below: 1. Explain how the non-compressibility of liquids is used in brakes and state Pascal's law. 2. Explain how hydraulic force can be used to supply high pressures to each individual wheel brake. 3. Describe the function, purpose, and operation of the master cylinder. 4. Discuss dual split, diagonal split, and quick take-up master cylinders. 5. Describe the process of diagnosing and servicing master cylinders.
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 the 5th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

LINK CHP 94: ATE5 Chapter Images

ICONS	Chapter 94 Brake Hydraulics
	1. **SLIDE 1 CH94 BRAKE HYDRAULIC SYSTEMS** 2. **SLIDE 2 EXPLAIN Figure 94-1** Hydraulic brake lines transfer the brake effort to each brake assembly attached to all four wheels. 3. **SLIDE 3 EXPLAIN Figure 94-2** Because liquids cannot be compressed, they are able to transmit motion in a closed system. 4. **SLIDE 4 EXPLAIN Figure 94-3** Hydraulic system must be free of air to operate properly. If air is in system, air is compressed when brake pedal is depressed and brake fluid does not transmit the force to wheel brakes.
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @** **http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED**
	**Videos**
	**DISCUSSION: discuss the general principles of hydraulics or mechanical properties of fluids.**
	**DEMONSTRATION: Show pistons cannot compress liquids in closed system. Ask them to explain how air can contaminate hydraulic system & what problems result from such contamination** **Pascal's Law, Area (View) (Download)** **Pascal's Law, Force (View) (Download)** **Pascal's Law, Pressure (View) (Download)**
	5. **SLIDE 5 EXPLAIN Figure 94-4** one-pound force exerted on a small piston in sealed system transfers pressure to each square inch throughout system. In this example, 1-lb force is able to lift a 100-lb weight because it is supported by piston that is 100 x larger in area than small piston. 6. **SLIDE 6 EXPLAIN Figure 94-5** amount of force (F) on the piston is the result of pressure (P) multiplied by the surface area (A). In this example, the driver is applying a force of 150 pounds but through the mechanical advantage of the brake pedal (3.3 to 1 ratio), the force is increased to 500 pounds into master cylinder.
	

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	7. **SLIDE 7 EXPLAIN Figure 94-6** Drum brake illustrating the typical clearance between the brake shoes (friction material) and the rotating brake drum represented as the outermost black circle. 8. **SLIDE 8 EXPLAIN Figure 94-7** brake pad (friction material) is pressed on both sides of the rotating rotor by the hydraulic pressure of the caliper. 9. **SLIDE 9 EXPLAIN Figure 94-8** Mechanical force and the master cylinder piston area determine the hydraulic pressure in the brake system 10. **SLIDE 10 EXPLAIN Figure 94-9** Hydraulic pressure is the same throughout a closed system and acts with equal force on equal areas. 11. **SLIDE 11 EXPLAIN Figure 94-10** Differences in brake caliper and wheel cylinder piston area have a major effect on brake application force. 12. **SLIDE 12 EXPLAIN Figure 94-11** The increase in application force created by the large brake caliper piston is offset by a decrease in piston travel.
	**DEMONSTRATION: Show students an application of Pascal's Law by demonstrating that a force applied to a piston in a sealed system displaces equal amounts of force in every direction. Use a single master cylinder & 2 wheel cylinders with different piston area measurements. Ask students to interpret results in accordance with Pascal's Law. How does this demonstration correspond to operation of a braking system?**
	**DISCUSSION: Ask student to talk about Pascal's Law and how it is the central principle upon which hydraulic systems work.**
	**DISCUSSION: Ask students to talk about the relationship between hydraulic pressure and piston size. Why does increasing the piston size reduce the hydraulic pressure achieved?**
	**Using clear medical syringes and clear plastic tubing can help students visualize hydraulic principles**

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	**DISCUSSION: Ask students to discuss why, although mechanical force available to apply disc brakes is greater, the amount of hydraulic energy converted into mechanical motion is less. What are implications of this fact for disc-brake design?**
	**HANDS-ON TASK: Using equation below & textbook pages 1027-1031, have students calculate the movement of a disc-brake caliper when the area of the master-cylinder piston is 0.95 sq. in., the area of the wheel cylinder or caliper piston is 3.75 sq. in., and the master cylinder piston stroke length is 0.9 in. (*Answer*: 0.228 in.)** $d_1 = \frac{A_2}{A_1} d_2 \quad \frac{.95}{3.75} \times .9 = 0.228$
	**DISCUSSION: Ask students to talk about the implications of hydraulics for brake-system design. Have them focus on selection of correct piston size to provide driver with proper brake-pedal feel.**
	**13. SLIDE 13 EXPLAIN FIGURE 94.12** Typical master cylinder showing reservoir and associated parts. **14. SLIDE 14 EXPLAIN FIGURE 94.13** Master cylinder with brake fluid level at "max" (maximum) line. **15. SLIDE 15 EXPLAIN FIGURE 94.14** typical brake pedal is supported by a mount and attached to the pushrod by U-shaped bracket. **16. SLIDE 26 EXPLAIN FIGURE 94.15** The composite master cylinder is made from two different materials—aluminum for the body and plastic materials for the reservoir and reservoir cover. **17. SLIDE 17 EXPLAIN FIGURE 94.16** Note names for vent port (front port) and replenishing port (rear port). **18. SLIDE 18 EXPLAIN FIGURE 94-17** The vent ports must remain open to allow brake fluid to expand when heated by friction material and transferred to the caliper and/or wheel cylinder. **19. SLIDE 19 EXPLAIN FIGURE 94-18** As the brake pedal is depressed, the pushrod moves the primary piston forward, closing off the vent port.

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	20. **SLIDE 20 EXPLAIN FIGURE 94-19** The purpose of the replenishing port is to keep the volume behind the primary piston filled with brake fluid from the reservoir as the piston moves forward during a brake application. 21. **SLIDE 21 EXPLAIN** FIGURE 94-20 When the brake pedal is released, the master cylinder piston moves rearward. 22. **SLIDE 22 EXPLAIN Figure 94-21** Rear-wheel-drive vehicles use a dual split master cylinder. 23. **SLIDE 23 EXPLAIN Figure 94-22** primary outlet is the outlet closest to the pushrod end of the master cylinder and the secondary outlet is closest to the nose end of the master cylinder. 24. **SLIDE 24 EXPLAIN Figure 94-23** In the event of a primary system failure, no hydraulic pressure is available to push the second piston forward. As a result, the primary piston extension rod contacts the secondary piston and pushes on the secondary piston mechanically rather than hydraulically. The loss of pressure in the primary system is usually noticed by the driver by a lower-than-normal brake pedal and the lighting of the red brake warning lamp.
	**Show ANIMATION: Brake Hydraulic System (View) (Download)**
	**DEMONSTRATION: Show students the master cylinder of a vehicle, and ask them to describe how it works. Why is the master cylinder the heart of the braking system? Show students the see-through reservoir of a master cylinder, and point out the minimum and maximum fill markings**
	**Never fill the master cylinder higher than the recommended full mark to allow for brake-fluid expansion.**
	**DEMONSTRATION: Show master cylinder when brakes are not applied, or in the at-rest position. Discuss how brake-fluid expansion and contraction can occur with changes in temperature. Show students what changes occur within the master cylinder when brakes are applied, and ask them to**

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	explain the results. Show students what changes occur within master cylinder when brakes are released & returned to at-rest position. What is impact of pumping brakes?
	**If mineral based fluids (motor oil or hydraulic fluid) have been introduced to the brake system the rubber diaphragm will swell over sized. This will show that there are extensive repairs to be made.**
	**DISCUSSION: discuss purpose and function of vent and replenishing ports in the master cylinder. How is outside air and moisture prohibited from entering the master cylinder through these vents?**
	25. **SLIDE-25 EXPLAIN Figure 94-24** FWD vehicles use a diagonal split master cylinder. In this design one section of the master cylinder operates the right front and the left rear brake and the other section operates the left front and right rear. In the event of a failure in one section, at least one front brake will still function.
	**DEMONSTRATION: Show an example of a diagonal-split master cylinder, and discuss how it enables front and rear braking action in the event of the failure of one cylinder**
	**DISCUSSION: what % of braking that would be supplied in the event that one half of a diagonally split brake system fails.**
	**When hydraulic switch turns light on during ½ of system failure light switch may have to be re-centered manually to get light off**
	26. **SLIDE 26 EXPLAIN Figure 94-25** Quick take-up master cylinder can be identified by the oversize primary low-pressure chamber.
	**OPTIONAL DEMONSTRATION: Show students an example of a QUICK TAKE-UP master cylinder if one is available.**
	**DEMONSTRATION: Show student how to check for proper fluid movement in the master cylinder reservoir.**

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	**HANDS-ON TASK: Have students perform a visual inspection of a master cylinder. Have students check position & operation of brake pedal following inspection. Select a student to present results of inspection to class, identifying any problems & suggesting possible causes & solutions.** 27. **SLIDE 27 EXPLAIN Figure 94-26** brake pedal depressor like this can be used during a wheel alignment to block the flow of brake fluid from the master cylinder during service work on the hydraulic system. 28. **SLIDE 28 EXPLAIN Figure 94-27** Some seepage is normal when trace of fluid appears on the vacuum booster shell. 29. **SLIDE 29 EXPLAIN Figure 94-28** Pedal height is usually measured from the floor to the top of the brake pedal. Some vehicle manufacturers recommend removing the carpet and measuring from the asphalt matting on the floor for an accurate measurement. Always follow the manufacturer's recommended procedures and measurements. 30. **SLIDE 30 EXPLAIN Figure 94-29** Brake pedal free play is the distance between the brake pedal fully released and the position of the brake pedal when braking resistance is felt. 31. **SLIDE 31 EXPLAIN Figure 94-30** Brake pedal reserve is usually specified as the measurement from the floor to the top of the brake pedal with the brakes applied. A quick-and-easy test of pedal reserve is to try to place your left toe underneath the brake pedal while the brake pedal is depressed with your right foot. If your toe will not fit, then pedal reserve may not be sufficient.
    	**DEMONSTRATION: Show students how to check brake pedal free play. Explain the importance of this specification.** **ON-VEHICLE NATEF TASK: Measure brake pedal height; determine necessary action. Page 289** **Brake fluid is highly corrosive. Always use fender covers to protect the vehicle's finish from contact with brake fluid.**

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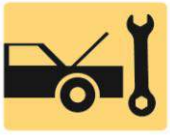
	32. **SLIDE 32 EXPLAIN Figure 94-31** Using a prybar to carefully remove reservoir from the master cylinder. 33. **SLIDE 33 EXPLAIN Figure 94-32** Whenever disassembling a master cylinder, note the exact order of parts as they are removed. Master cylinder overhaul kits (when available) often include entire piston assemblies rather than the individual seals. 34. **SLIDE 34 EXPLAIN Figure 94-33** Piston assembly. 35. **SLIDE 35 EXPLAIN Figure 94-34** To reinstall the reservoir onto a master cylinder, place the reservoir on a clean flat surface and push the housing down onto the reservoir after coating the rubber seals with brake fluid. 36. **SLIDE 36 EXPLAIN Figure 94-35** Bleeding a master cylinder before installing it on the vehicle. The master cylinder is clamped into a bench vise while using a rounded end of a dowel rod to push on the pushrod end with bleeder tubes down into the brake fluid. Master cylinders should be clamped on the mounting flange as shown to prevent distorting the master cylinder bore. 37. **SLIDE 37 EXPLAIN Figure 94-36** Installing a master cylinder. Always tighten the retaining fastener and brake lines to factory specifications.
	**DISCUSSION: Ask students to discuss how to diagnose and correct spongy brake pedal. Ask how to test & fix a lower-than-normal brake pedal. Ask students to discuss how to diagnose and correct a problem that would cause a brake pedal to go all the way to the floor. Ask students to talk about the phenomenon of bypassing, or internal leak within the master cylinder. How can a technician determine an external leak within braking system versus bypassing within master cylinder?**
	**DEMONSTRATION: Show students how to bench bleed a master cylinder.**
	**HANDS-ON TASK: Have students bench bleed a master cylinder with the proper bypass tubing and punch.**

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	ON-VEHICLE NATEF TASK: Check master cylinder for external and internal leaks and proper operation; remove, bench bleed, and reinstall master cylinder. Page 290
	ON-VEHICLE NATEF TASK: Identify and interpret brake system concern and determine necessary action. Page 284
	Crossword Puzzle (Microsoft Word) (PDF) Word Search Puzzle (Microsoft Word) (PDF)