

## ATE5 Chapter 125 DIFFERENTIALS

### Opening Your Class

KEY ELEMENT	EXAMPLES
<b>Introduce Content</b>	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.
<b>Motivate Learners</b>	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.
<b>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.</b>	Explain learning objectives to students as listed below: <ol style="list-style-type: none"><li>1. Describe the operation of a differential and the gear ratios set types.</li><li>2. Compare the operation of a standard open differential and a limited slip differential.</li><li>3. Describe the components of a differential and the types of bearings used in drive axles.</li><li>4. Explain how to diagnose, inspect, and disassemble a drive axle.</li><li>5. Explain how to set the drive pinion depth and replace the pinion shaft bearing.</li><li>6. Describe the procedure to check backlash and set the side bearing preload.</li></ol>
<b>Establish the Mood or Climate</b>	Provide a <b>WELCOME</b> , Avoid put downs and bad jokes.
<b>Complete Essentials</b>	Restrooms, breaks, registration, tests, etc.
<b>Clarify and Establish Knowledge Base</b>	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 5<sup>th</sup> Edition Chapter Images found on Jim's web site @**

**[www.jameshalderman.com](http://www.jameshalderman.com)**

**LINK CHP 125: [ATE5 Chapter Images](#)**

## ICONS



## Chapter 125 DIFFERENTIALS

### 1. SLIDE 1 Chapter 125: Differentials

Check for ADDITIONAL VIDEOS & ANIMATIONS @  
<http://www.jameshalderman.com/>  
WEB SITE IS CONSTANTLY UPDATED

### Videos

2. SLIDE 2 EXPLAIN Figure 125-1 differential assembly changes the direction of engine torque and increases the torque to the drive wheels.
3. SLIDE 3 EXPLAIN Figure 125-2 difference between the travel distance of the drive wheels is controlled by the differential.

### 2WD Differentials (View) (Download)

**DEMONSTRATION:** Show an example of a complete differential asm. Demonstrate how turning pinion transfers rotation of axle shafts 90 degrees from rotation of pinion.

### Hypoid Ring & Pinion Gear Set (View) (Download)

4. SLIDE 4 EXPLAIN Figure 125-3 When the vehicle turns a corner, the inner wheel slows and the outer wheel increases in speed to compensate. This difference in rotational speed causes the pinion gears to “walk” around the slower side gear.
5. SLIDE 5 EXPLAIN Figure 125-4 hypoid gear set uses a drive pinion that meshes with the ring gear below the center line of the ring gear

**DISCUSSION:** Ask the students to discuss reason for using a hypoid gear set as compared to a standard beveled gear arrangement

### FIGURE 125-4

## ICONS



## Chapter 125 DIFFERENTIALS

**DISCUSSION:** Ask the students to discuss the design of ring and pinion that qualifies it as a hypoid gear assembly. **FIGURE 125-4**

6. **SLIDE 6 EXPLAIN** Figure 125-5 differential case provides the support for the ring gear, side bearings, and side gears.

**DEMONSTRATION:** Show the students the inside workings of the differential and point out the major components. **FIGURE 125-5**

7. **SLIDE 7 EXPLAIN** Figure 125-6 relationship among the ring gear and drive pinion as well as side and spider gears

### **Differential Action (View) (Download)**

**DEMONSTRATION:** Show an example of a pinion gear and carrier assembly. Show location of all major components of the carrier assembly **FIGURE 125-6**

8. **SLIDE 8 EXPLAIN** Figure 125-7 The drive side is the convex side of the ring gear except for some front axles used in four-wheel vehicles, and they often use the concave side on the drive side

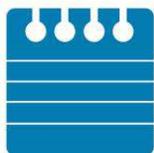
**DEMONSTRATION:** Show the students a ring gear. Demonstrate nomenclature of a ring gear, including heel, toe, root, drive side, and deceleration side. **FIGURE 125-7**

**HANDS-ON-TASK:** Have the students identify the Components of a typical differential assembly.

9. **SLIDE 9 EXPLAIN** Figure 125-8 A close-up view of the side gears and spider (pinion) gear. Note the ridges on the gear teeth. These ridges are manufactured into the gear teeth to help retain lubricant so that no metal-to-metal contact occurs.

**DISCUSSION:** Ask the students to discuss gear ratios and advantages and disadvantages of low and high ratios.

## ICONS



## Chapter 125 DIFFERENTIALS

**DISCUSSION:** Ask the students to discuss advantages and disadvantages of hunting and non-hunting gear combination. Have them discuss why non-hunting gear sets have timing marks.

**HANDS-ON-TASK:** Have the students use mathematics to figure ratio of several gear sets. Give them diagrams of a dozen ring and pinion sets. Have them determine whether each set is **hunting, non-hunting, partial non-hunting.**

**DEMONSTRATION:** Show how the torque flows through a standard open differential. Show them a standard open differential with the cover off. While turning pinion flange, have a student hold one axle. Torque flows to free axle. As student releases held axle, both will begin to turn. **FIGURE 125-9**

**DISCUSSION:** Have students discuss how torque flows through differential during straight-ahead & turning maneuvers

10. **SLIDE 10 EXPLAIN** **FIGURE 125-9** (a) A two-wheel-drive vehicle equipped with an open differential. (b) A 2-wheel-drive vehicle equipped & limited-slip differential.
11. **SLIDE 11 EXPLAIN** **Figure 125-10** Trac-loc limited-slip differential. This type of limited-slip differential uses the preload force from a spring and the torque generated by the side gears as the two axles rotate at different rates to apply the clutches and limit the amount of difference in the speed of two axles.

**DEMONSTRATION:** Show limited slip differential assembly. Show them how the clutches connect small pinion gears to case. **FIGURE 125-10**

Because of clutches & springs in differential, you can usually tell if a vehicle has a limited slip differential by rotating tires when car is lifted. If both tires rotate in same direction, car has a limited slip differential.

12. **SLIDE 12 EXPLAIN** **Figure 125-11** Eaton locker differential
13. **SLIDE 13 EXPLAIN** **Figure 125-12** Eaton design differential uses torque-limiting disc to prevent possibility of breaking axle in event of high-torque demand

## ICONS

## Chapter 125 DIFFERENTIALS

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14. **SLIDE 14 EXPLAIN** Figure 125-13 Torsen differential. This type of differential provides torque to both drive wheels even if one tire is on ice. The complex system of gears allows this smooth transfer of torque without the use of clutches.

**DEMONSTRATION:** Show disassembled limited slip differential. Show them how compression of the clutch packs locks the gears to the case

**DEMONSTRATION:** Show cone differentials disassembled so they can see how the cone is forced into its seat to make a direct link between gear and the case

**DISCUSSION:** Ask the students to discuss the advantages of the limited slip differential in certain situations.

**ON-VEHICLE NATEF TASK:** Inspect and clean clutch components. Page 416

**ON-VEHICLE NATEF TASK:** Measure rotating torque; determine necessary action. Page 417

15. **SLIDE 15 EXPLAIN** Figure 125-14 This pinion flange is equipped with a damper weight to help dampen driveline vibrations.

16. **SLIDE 16 EXPLAIN** Figure 125-15 collapsible spacer-type drive pinion shaft.

**DEMONSTRATION:** Show drive pinion from overhung and straddle mounted pinions. Demonstrate how two differ in length and bearing surface. **FIGURE 125-15**

**DISCUSSION:** Ask the students to discuss similarities and differences of overhung and straddle mounted pinions. What are the advantages and disadvantages of both types of pinions?

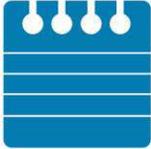
17. **SLIDE 17 EXPLAIN** Figure 125-16 Side bearings are press fit on the differential case.

18. **SLIDE 18 EXPLAIN** Figure 125-17 Some side bearings use threaded adjusters to adjust preload.

## ICONS

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## Chapter 125 DIFFERENTIALS

**DEMONSTRATION:** Show ring and pinion and demonstrate the importance of proper depth placement of the pinion gear into ring gear.

**DEMONSTRATION:** Show the students an example of a threaded and shimmed adjustment for preload on side bearings:

**FIGURES 125-16 & 17**

When installing shims, a coating of grease will help hold them in place.

**DISCUSSION:** Hold a discussion on the advantages or disadvantages of threaded or shimmed preload adjustment

**SEARCH INTERNET:** Have the students search Internet to research an electronically controlled active differential. Ask them TO DISCUSS advantage of an active differential, how it works, and what sensors control its operation

19. SLIDE 19 EXPLAIN Figure 125-18 (a) axle shaft itself is the inner race if a straight roller bearing is used.
20. SLIDE 20 EXPLAIN Figure 125-18 (b) straight roller bearings are lubricated by the rear axle fluid, and a leak at the rear axle seal can cause this fluid to get onto brake components

**Remove and Replace Axle Shaft, Bearing Retained (View) (Download)**

**Remove and Replace Axle Shaft, C-Lock (View) (Download)**

**DEMONSTRATION:** Show examples of axle shafts with tapered roller bearings, ball bearings, and straight roller bearings: **FIGURE 125-18**

**DEMONSTRATION:** Show how to roughly **determine gear ratio** of a differential as described in the text.

**DISCUSSION:** Ask the students to discuss the procedure for determining gear ratio without opening the differential. Have them explain why this might be helpful for service

## ICONS



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## Chapter 125 DIFFERENTIALS

**HANDS-ON-TASK:** Have students determine gear ratio of a differential without opening differential. Have them compare their result with the OEM information on the gear ratio of the differential. Have a local shop that does a lot of differential work save old parts that can be used for demonstration in classroom.

**ON-VEHICLE NATEF TASK:** Diagnose **DIFFERENTIAL** noise and vibration concerns; determine necessary action Page 403

**ON-VEHICLE NATEF TASK:** Diagnose fluid leakage; determine necessary action. Page 404

21. **SLIDE 21 EXPLAIN Figure 125-19** The pinion gear thrust washers can be Destroyed by spinning one wheel for an extended period of time
22. **SLIDE 22 EXPLAIN Figure 125-20** differential has obviously been leaking. If the differential lubricant is low, wear may have occurred that would require further inspection.
23. **SLIDE 23 EXPLAIN Figure 125-21 (a)** Backlash is determined by mounting a dial indicator to the differential housing and placing the button of the gauge against a tooth of the ring gear. Moving the ring gear back and forth will indicate on the dial indicator the amount of backlash.
24. **SLIDE 24 EXPLAIN Figure 125-21 (b)** Backlash is clearance between drive pinion and the ring gear teeth.

**DEMONSTRATION:** Show the setup and procedure for checking ring gear backlash. Explain importance of this reading: **FIGURE 125-21**

**DISCUSSION:** Hold a discussion on checking ring gear backlash and what it means **FIGURE 125-21**

25. **SLIDE 25 EXPLAIN Figure 125-22** Ring gear runout should be less than 0.002 inch (0.05 mm) as measured by a dial indicator.

## ICONS

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## Chapter 125 DIFFERENTIALS

**DEMONSTRATION:** Show the set-up and procedure for checking ring gear runout. Explain importance of this reading. **FIGURE 125-22**

**HANDS-ON-TASK:** Have the students set up and take ring gear and backlash readings on several differentials.

26. **SLIDE 26 EXPLAIN** Figure 125-23 Force has to be applied to the ring gear to achieve a proper contact pattern.

**DEMONSTRATION:** Show how to do a tooth contact pattern test on a differential by using either iron oxide compound or white lithium grease.

**FIGURE 125-23**

White lithium grease works very well on a gear tooth contact pattern test

27. **SLIDE 27 EXPLAIN** Figure 125-24 Tooth contact pattern

Have a local shop that does a lot of differential work save old parts that can be used for demonstration in classroom.

**DISCUSSION:** Ask the students to discuss what the pattern test is telling them.

Use **Figure 125-24** to analyze the pattern results

**ON-VEHICLE NATEF TASK:** Check ring and pinion tooth contact pattern; perform necessary action **Page 411 Fig. 125-24**

**ON-VEHICLE NATEF TASK:** Diagnose noise, slippage, and chatter concerns; determine necessary action. **Page 414**

**SEARCH INTERNET:** Have students use Internet to research the Belleville spring. Ask them to report information that includes information on the inventor and how the spring works.

## ICONS



## Chapter 125 DIFFERENTIALS

28. **SLIDE 28 EXPLAIN Figure 125-25** Mark the differential bearing caps before removing them to make sure that they are replaced in the same location.

29. **SLIDE 29 EXPLAIN Figure 125-26** Pinion gear and associated parts. The pinion end yoke is also called the pinion flange.

### **ON-VEHICLE NATEF TASK: (A3-E-10)** **Disassemble, inspect, and replace differential pinion gears, side bearing, and case.** **(P-2) Page 412**

30. **SLIDE 30 EXPLAIN Figure 125-27** pinion on the left uses a collapsible spacer, and the pinion on the right uses shims to provide the necessary preload to the pinion shaft bearings.

31. **SLIDE 31 EXPLAIN Figure 125-28** ring and pinion gears are a matched set and are marked for correct pinion depth variance.

### **DEMONSTRATION: Show the students match markings on a ring and pinion gear set.** **FIGURE 125-28**

**DISCUSSION: Have the students discuss importance of numbers in above demonstration. Ask them to discuss ramifications of just replacing one gear in the set** **FIGURE 125-28**

**Adjust Carrier (View) (Download)**

**Assemble Carrier (View) (Download)**

32. **SLIDE 32 EXPLAIN Figure 125-29** Special tool kit used for determining the correct pinion shaft shim thickness.

### **DEMONSTRATION: Show 3 ways of setting drive pinion depth. Explain importance of this setting.** **See FIGURE 125-27, 28, 29**

33. **SLIDE 33 EXPLAIN Figure 125-30** Using an inch-pound torque wrench to check the rotating torque of the drive pinion. This procedure is very important if the axle uses a collapsible spacer. The drive pinion nut should be gradually tightened and the rotating torque checked to prevent overtightening the nut. If the rotating torque is

## ICONS



## Chapter 125 DIFFERENTIALS

higher than specifications, the collapsible spacer will require replacement and the installation procedure must be repeated.

**DEMONSTRATION:** Show how to set and check drive pinion preload.

**DISCUSSION:** Ask the students to discuss the importance of proper drive pinion preload as it relates to bearing wear.

**HANDS-ON-TASK:** Have the students check preload on several drive pinion setups.

**ON-VEHICLE NATEF TASK** Replace pinion seal; measure companion flange runout. Page 405

**ON-VEHICLE NATEF TASK** Measure ring gear runout; determine necessary action. Page 406

**ON-VEHICLE NATEF TASK** Remove, inspect, and reinstall ring gear, drive pinion, and bearings. Page 407

**ON-VEHICLE NATEF TASK** Measure and adjust drive pinion depth. Page 408

**ON-VEHICLE NATEF TASK** Measure and adjust drive pinion preload. Page 409

34. **SLIDE 34 EXPLAIN** Figure 125-31 If the ring gear has been removed from the differential case or if a new ring gear is being installed, always replace the ring gear bolts.

35. **SLIDE 35 EXPLAIN** Figure 125-32 Backlash should be between 0.005 and 0.008 inch on most differentials. If the backlash is too great, add shim thickness to the ring gear side and subtract shim thickness from the opposite side.

## ICONS

## Chapter 125 DIFFERENTIALS



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36. **SLIDE 36 EXPLAIN** Figure 125-33 (a) Some vehicle manufacturers recommend using a housing spreader tool that fits into the round openings on both sides.

37. **SLIDE 37 EXPLAIN** Figure 125-33 (b) The spreader tool being installed. The housing is spread a specified amount and the differential is then installed into the housing.

**DEMONSTRATION:** Show housing spreader used to install the differential into the housing  
**FIGURE 125-33**

**DISCUSSION:** Ask the students to discuss why some differentials need a housing spreader and others do not

38. **SLIDE 38 EXPLAIN** Figure 125-34 (a) Note the hex shape of the threaded adjuster used to adjust side bearing preload and ring gear backlash on a Dodge Dakota truck.

39. **SLIDE 39 EXPLAIN** Figure 125-34 (b) A long handled adjuster tool is needed to turn the side bearing adjuster on this truck.

**OPTIONAL SEARCH INTERNET:** Have students use Internet to research Detroit Locker differential. Ask them to create a presentation for the class, describing the advantages of this kind of differential.

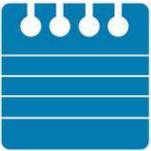
40. **SLIDE 40 EXPLAIN** Figure 125-35 On many axles, it is necessary to use a special tool to install steel spacers (shims) to achieve the specified backlash and side bearing preload.

**DEMONSTRATION:** Show the students how to set and adjust side bearing preload. Show them the procedure for both screw-cap & shim differentials

**DISCUSSION:** Ask the students to discuss the importance of setting the preload on the side bearing. Ask them to discuss the negative impact if the preload is not set correctly.

**ON-VEHICLE NATEF TASK** Measure and adjust side bearing preload. **Page 410**

## ICONS



## Chapter 125 DIFFERENTIALS

41. **SLIDE 41 EXPLAIN** Figure 125-36 A spool used in a rear end for drag racing only
42. **SLIDE 42 EXPLAIN** Figure 125-37 Install axle shaft, being careful to not damage the seal.
43. **SLIDE 43 EXPLAIN FIGURE 125-38** A container of GL-5 SAE 80W-90 gear lubricant.
44. **SLIDE 44 EXPLAIN FIGURE 125-39** The beginning automotive student did not realize that the axle housing cover could fit wrong way.

**DEMONSTRATION:** Show how to replace an axle seal on a C-type differential. Show them the proper tools to use to install new seal so it seats straight and to the correct depth **FIGURE 125-37**

To remove the seal from axle tub, use the C-ring end of the axle to pry the seal out with little effort.

**DEMONSTRATION:** Show proper way to clean the mating surfaces of the cover and housing area. Discuss with students any necessary sealant that the manufacturer may recommend.

**DEMONSTRATION:** Show proper way to check the differential for correct fluid level.

**ON-VEHICLE NATEF TASK:** Assemble and install differential case assembly and measure runout; determine necessary action. **Page 413**

**DEMONSTRATION:** Show importance of using appropriate additive for limited slip differentials. Show them differential clutches that were destroyed because appropriate additives were not used

**HANDS-ON-TASK:** Have students use mathematics to determine weight of a vehicle. Set all tires to 30 PSI. Raise vehicle so the tires just clear the ground. Moisten each tire slightly with water. Place a piece of construction paper under each tire and lower the vehicle back to the ground. After several seconds, raise the vehicle and remove the construction paper. Measure square inches of

## ICONS



## Chapter 125 DIFFERENTIALS

tire patch and multiply that number by the 30 PSI in each tire. Add value from all four tires. The number will be the weight of vehicle.

**ON-VEHICLE NATEF TASK** Clean differential and refill with correct lubricant. Page 415

**SEARCH INTERNET:** Use Internet to research suppliers of high-performance differential components. Ask them to create a presentation for class that describes the components used in high performance industry that are different from those used in passenger cars

**Crossword Puzzle (Microsoft Word) (PDF)**

**Word Search Puzzle (Microsoft Word) (PDF)**