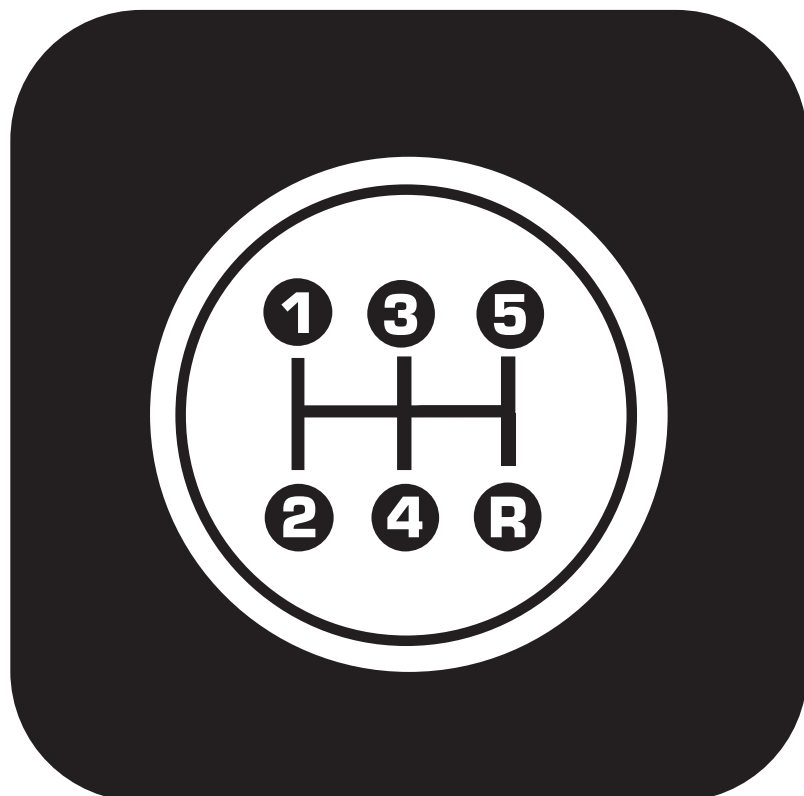


Differential and 4WD Systems Diagnosis and Repair



36 - Manual Transmission & Drivetrain

Student Guide



FCS-12973-REF

Course Code: 36S17T0

January 2008



Service Technician Specialty Training



Ford Customer Service Division
Technical Training

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles, as well as the personal safety of the individual doing the work. This manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

-  Always wear safety glasses for eye protection.
-  Use safety stands whenever a procedure requires you to be under the vehicle.
-  Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
-  Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific service operation. If you have a manual transmission it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific service operation.
-  Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
-  Keep yourself and your clothing away from moving parts when the engine is running, especially the fan and belts.
-  To help prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
-  Do not smoke while working on the vehicle.
-  To help avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind your head.
-  Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

The recommendations and suggestions contained in this manual are made to assist the dealer in improving his dealership parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual, and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual shall govern.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design, or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc. recommended for use. Equivalents, if available, may be used. The right is reserved to make changes at any time without notice.

 **DANGER:** Exposure to potentially hazardous components may occur if dusts are created during repair of friction components, such as brake pads and clutch discs. Exposure to excessive amounts of dust may be a potential cancer and lung disease hazard. Exposure may also cause irritation to skin, eyes, and respiratory tract, may cause allergic reactions, and/or may lead to other chronic health effects.

Do not breathe dust. Do not use compressed air to blow dust from storage containers or friction components. A high-efficiency (HEPA) vacuum cleaner should be used carefully to remove dust. Adherent dust should be removed with a damp rag.

If inhaled, remove to fresh air. If irritation persists, seek medical attention or advice.

If dust gets in eyes, irrigate under eyelids with water for 15 minutes and seek medical attention.



CUSTOMER EXPECTATIONS

Customer Expectations: Service

1. Make it convenient to have my vehicle serviced at your dealership.
2. The Service Advisor should demonstrate a genuine concern for my service needs.
3. Fix it right the first time, on time.
4. Complete servicing my vehicle in a timely and professional manner.
5. Provide me with a clear and thorough explanation of the service performed.
6. Call me within a reasonable amount of time after my service visit to ensure that I'm completely satisfied.
7. Be responsive to questions or concerns that I bring to your attention.

Expectation #3

“Fix It Right the First Time, on Time.”

Both service advisors and technicians are important players when it comes to Expectation #3.

Why

Customers tell us “Fixing It Right the First Time, on Time” is one of the reasons they would decide to return to a dealer to buy a vehicle and get their vehicles serviced.

Technician Training

It is our goal to help the technician acquire all of the skills and knowledge necessary to “Fix it Right the First Time, on Time.” We refer to this as “competency.”

Technician’s Role

Acquire the skills and knowledge for competency in your specialty via:

STST

- Web-Based
- Instructor Led

New Model

- Web-Based
- Instructor Led

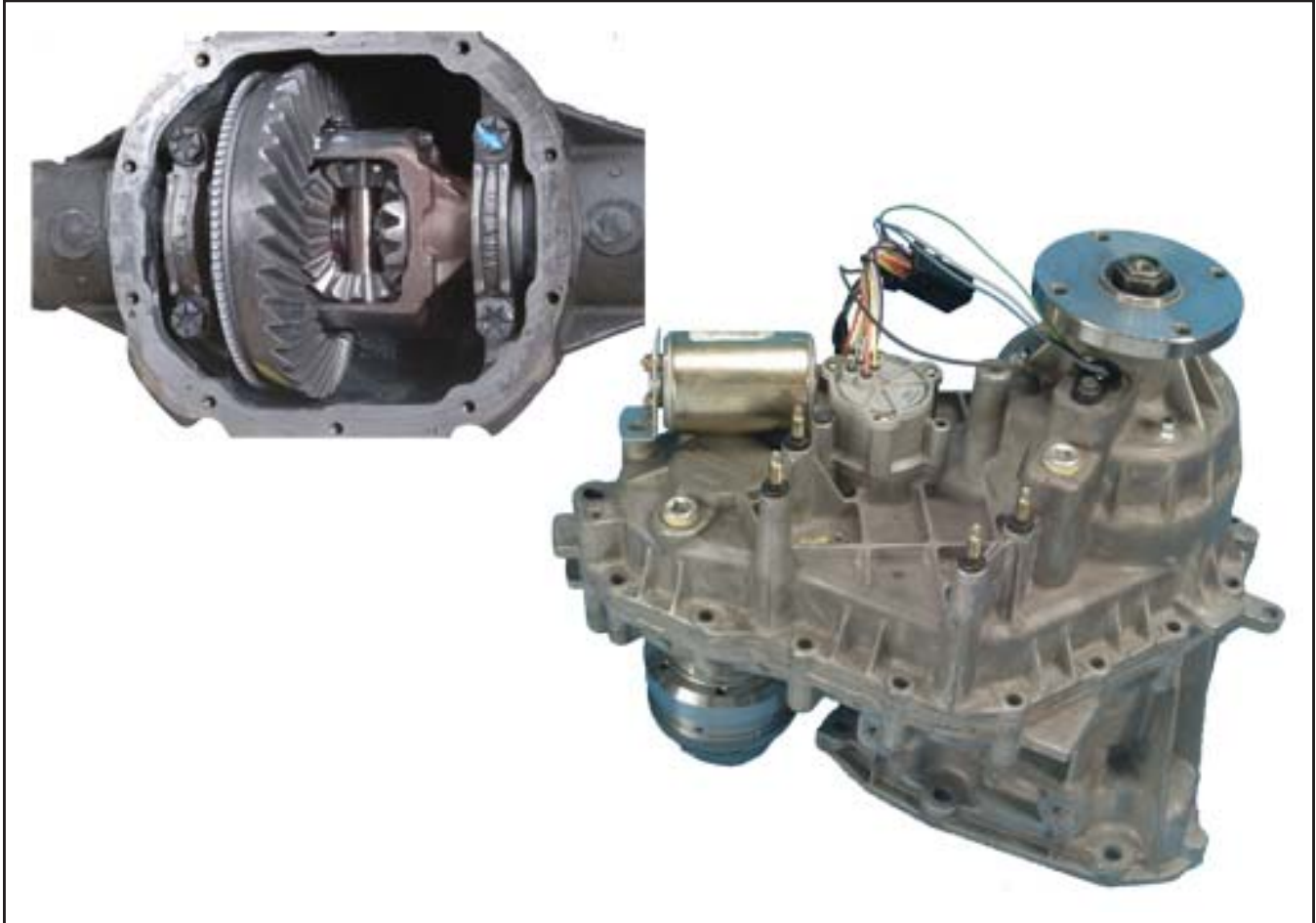
The Benefits

The successful implementation of expectations means:

- Satisfied customers
- Repeat vehicle sales
- Repeat service sales
- Recognition that Ford and Lincoln/Mercury technicians are “the Best in the Business”

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INTRODUCTION

DIFFERENTIAL AND 4WD SYSTEMS DIAGNOSIS AND REPAIR**Course Description****Rear Axle (Left) and Transfer Case (Right)**

This instructor-led course is part of the Ford Manual Transmission and Drivetrain curriculum (Specialty 36). It is a four-day course facilitated by an instructor. This course is designed to provide hands-on opportunities for technicians to learn and improve their skills using tools and equipment, and to apply knowledge learned in prerequisite courses. Each day, you will have multiple opportunities to practice selected skills. The results of your work are recorded on worksheets.

Course Requirements

Each technician attending this course is required to pass a combination of hands-on and written evaluations. These are administered after all lectures, demonstrations and/or practice sessions have been completed.

- The hands-on evaluation is a pass/fail type. It is conducted with exercises in differentials, axles, and selected diagnostic procedures, and it covers:
 - pinion gear shim selection
 - gear pattern evaluation
 - service publications navigation
 - selected special tool usage
 - 4WD On-Vehicle Diagnosis

To pass the course, you must demonstrate 100% mastery of the skills covered in the Hands-On Post-Test exercises AND you must correctly answer at least 80% of the Written Post-Test questions.

Course Objectives

Upon successful completion of this course, you will be able to:

- identify axle/differential and driveline diagnostic procedures.
- perform selected driveshaft diagnostic procedures.
- identify key axle and differential service procedures.
- perform selected axle and differential service procedures.
- diagnose RWD-based and FWD-based 4WD system concerns using IDS PID data recordings.
- perform RWD-based 4WD transfer case and 4WD system diagnosis on a vehicle.
- perform RWD-based 4WD transfer case service procedures.

Course Agenda

- Introductions
- LESSON 1: Prerequisite Review (Driveline and Axles), Conventional Axle Assembly Workstations, Workstation Review
- LESSON 2: Prerequisite Review (Transfer Case and 4WD Systems), Workstations (Transfer Case Disassembly and Assembly, Scan Tool Usage and PID Navigation), Workstation Review
- LESSON 3A: Workstations (Traction-Lok Differential Disassembly and Assembly, 4WD Concern, AWD PID Data Analysis)
- LESSON 3B: Workstations (4WD Concern, Service Publications Navigation – 4WD PID Recordings, 4WD Concern, Service Publications Navigation – 2007 AWD), Workstation Review
- LESSON 4: Workstations (Service Publications Navigation, Driveshaft Angle Measurement, and Service Publications Navigation)
- Hands-On and Written Evaluations

NOTES:

LESSON 1

PREREQUISITE REVIEW

DIRECTIONS: Answer the following questions on manual transmissions, transaxles and clutches. Questions may be related to theory, operation, diagnosis and service. These will be reviewed in class.

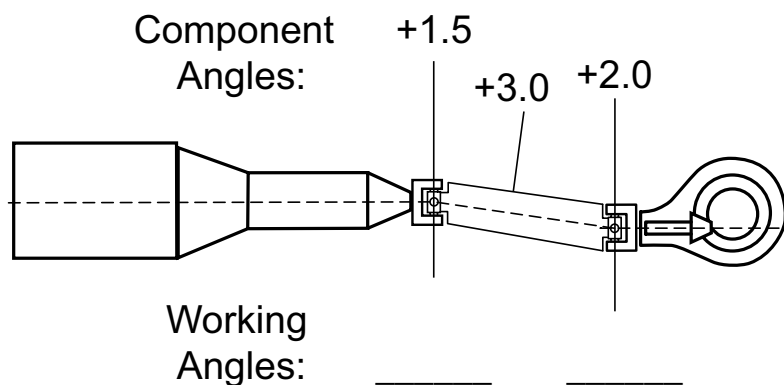
Theory and Operation Questions

1. What types of joints may be found on front and rear driveshafts?

2. What are some ways that high operating angles can be compensated for on vehicles with a driveshaft?

3. Which of the following operating angle combinations would provide the least vibration concerns?

- A. Transmission joint = +3 degrees; driveshaft angle = +5 degrees; axle pinion joint = -4 degrees
- B. Transmission joint = +1.5 degrees; driveshaft angle = +3 degrees; axle pinion joint = +2 degrees
- C. Transmission joint = +6 degrees; driveshaft angle = +3 degrees; axle pinion joint = -4 degrees
- D. Transmission joint = 0 degrees; driveshaft angle = 0 degrees; axle pinion joint = 0 degrees



4. What factors can affect driveline angles on a vehicle?

Diagnosis and Service Questions

5. List the three main types of axle assemblies:

6. Where is the crush sleeve located on a differential assembly?

What is the crush sleeve's function?

7. What components allow for differential action during turns?

8. Where can you find the ratio of the vehicle's axle?

9. What gears in the differential are used to transfer power from the driveshaft to the differential carrier?

10. What is the main advantage of a limited slip differential over a conventional differential?

11. What are the two spring types that can be found on limited slip differentials and what are their purposes?

12. When do the clutch packs in a limited slip differential become active?

Differential/Driveline Diagnosis, Measurements, Adjustments

13. List some areas of the vehicle besides the driveline that should be checked as possible noise sources:

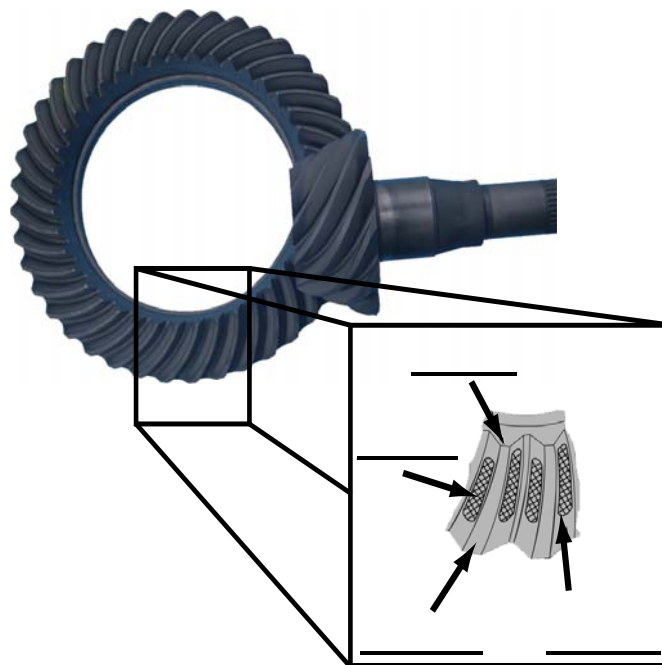
14. Define the following noise diagnosis terms:

Source: _____

Responder: _____

Transfer Path: _____

15. The illustration below is a single ring gear tooth. Label each part of the gear tooth with its correct term:



16. What can a gear pattern check tell you about the ring and pinion assembly?

17. What are the possible causes of excessive ring gear backlash variation?

18. What customer concerns can be caused by each of the following:

Excess total axle backlash: _____

Carrier bearings too loose (improper preload): _____

19. Can either of the following components be reused after removal?

Collapsible spacer (crush sleeve): **Yes** **No**

Pinion nut: **Yes** **No**

20. Why must bearing caps in the differential be marked prior to disassembly?

LESSON 1

WORKSTATIONS

Workstation: **Summary:**

- 1 Students use the Service Information Publications DVD and required special service tools to assemble a Ford 8.8 in. axle and answer related questions in the worksheet.
- 2 Students use the Service Information Publications DVD and required special service tools to assemble a Ford 9.75 in. axle and answer related questions in the worksheet.

WORKSTATION 1

FORD 8.8 IN. AXLE ASSEMBLY ON BENCH

TECH _____

DIRECTIONS: Complete Workstation 1 at the bench workstation, using the Ford aluminum 8.8 in. axle, available hand tools and special service tools, and Workshop Manual.

SUMMARY: For this activity, you will assemble an aluminum 8.8 in. axle, performing critical measurements and any necessary inspections required by the Workshop Manual. The instructor must initial each Progress Check.

- Follow the 2006 Expedition Workshop Manual, Section 205-03, to assemble the axle or use the appropriate model year Workshop Manual for the axle/differential you have in class.)
- As you perform the assembly procedures, pay attention to the following questions related to key steps.

Note: All students must be exposed to all four critical steps in the assembly process. Therefore, the instructor will divide you into groups of three; each student performing a critical step either individually or as a group. This will be monitored and progress will be indicated by the instructor signing-off at the end of each critical phase.

Assigned Technicians	Task	Aluminum 8.8 In.	Iron 9.75 In.
	Gauge Tube Reading	Tech A _____ Tech B _____	Tech B _____ Tech C _____
	Pinion Preload Rotational Check	Tech A _____ Tech B _____	Tech B _____ Tech C _____
	Carrier Shim Selection (Backlash)	Tech A _____ Tech B _____	Tech B _____ Tech C _____
	Pattern Check	Group _____	Group _____

Gauge Tube Readings

1. If the feeler gauge tool will slide between the bore and pinion bearing cup at any point, what can you conclude?

2. What is the rotational torque specification for the simulated bearing preload?

Define “rotational torque.”

3. To select the pinion shim, set the offset gauge block at what angle?

4. Inspect drive pinion bearing adjustment shims to ensure they are:

5. What is the suggested method to determine that the correct drive pinion bearing adjustment shim has been selected?

6. What is the shim thickness you selected?

Progress Check

See your instructor before you move on to the next step. Instructor initials: _____

Pinion Preload Rotational Check

7. How much torque may be required to initially begin crushing the crush sleeve?

8. To take rotational torque preload readings while installing the pinion nut, the holding tool must be:

9. What is the recommended technique for tightening the pinion nut?

10. What must be done if pinion preload is exceeded?

Progress Check

See your instructor before you move on to the next step. Instructor initials: _____

Carrier Shim Selection (Backlash)

NOTE: In FWD or RWD applications, the ring gear side of the case is always the LH side.

11. After installing the carrier into the housing, where, and what size nominal shims should be installed?

12. How do you determine the size of the shim for the other side of the carrier?

13. What is the largest preliminary shim you can install on the right side?

14. What is the process for measuring ring gear backlash?

15. Define “backlash variation,” and what is the specification?

16. Is the measurement within specifications? Yes No

17. If not, what is required to bring the readings within specification?

18. After the backlash is within specification, how is the differential bearing preload established?

Progress Check

NOTE: SEE YOUR INSTRUCTOR BEFORE USING SPREADER. Instructor initials: _____

19. What is the specification for the distance that the housing may be spread?

20. What can occur if the case is spread more than specification?

Progress Check

See your instructor before you move on to the next step. Instructor initials: _____

Pattern Check

(Refer to page 1 - 13 through 1 - 15)

21. What does your pattern indicate?

22. If an error is indicated in the pattern, what adjustment needs to be made?

23. Is this a face-mill or a face-hob gear set? _____

Progress Check

See your instructor. Instructor initials: _____

Disassemble the axle to the way you found it at the start of this Worksheet.

NOTE: YOU MUST ASK THE INSTRUCTOR FOR A DEMONSTRATION ON HOW TO USE THE D81L-4220-A (205-D036) DRIVE PINION DIFFERENTIAL CARRIER PULLER, FOR REMOVING THE PINION BEARINGS.

WORKSTATION 2
FORD 9.75 IN. AXLE ASSEMBLY ON BENCH
TECH _____

DIRECTIONS: Complete Workstation 2 at the bench workstation, using the Ford 9.75 in. axle, available hand tools and special service tools, and Workshop Manual.

SUMMARY: For this activity, you will assemble a Ford 9.75 in. axle, performing critical measurements and any necessary inspections required by the Workshop Manual. The instructor must initial each Progress Check.

- Follow the 2006 Expedition Workshop Manual, Section 205-02, to assemble the axle or use the appropriate model year Workshop Manual for the axle/differential you have in class.)
- As you perform the assembly procedures, pay attention to the following questions related to key steps.

Note: All students must be exposed to all four critical steps in the assembly process. Therefore, the instructor will divided the students into groups of three; each student performing a critical step either individually or as a group. This will be monitored and progress will be indicated by the instructor signing-off at the end of each critical phase.

Gauge Tube Readings

1. If the feeler gauge will slide between the bore and pinion bearing cup at any point, what can you conclude?

2. What is the rotational torque specification for the simulated bearing preload?

Define "rotational torque."

3. To select the pinion shim, set the offset gauge block at what angle?

4. Inspect drive pinion bearing adjustment shims to ensure they are:

5. What is the suggested method to determine that the correct drive pinion bearing adjustment shim has been selected?

6. What is the thickness of the shim you selected?

Progress Check

See your instructor before you move on to the next step. Instructor initials: _____

Pinion Preload Rotational Check

7. How much torque may be required to initially begin crushing the crush sleeve?

8. To take rotational torque preload readings while installing the pinion nut, the holding tool must be:

9. What is the recommended technique for tightening the pinion nut?

10. What must be done if pinion preload is exceeded?

Progress Check

See your instructor before you move on to the next step. Instructor initials: _____

Carrier Shim Selection (Backlash)

NOTE: In FWD or RWD applications, the ring gear side of the case is always the LH side.

11. After installing the carrier into the housing, where, and what size nominal shim should be installed?

12. When installing the left bearing cap and bolts, what must be done to ensure the cup is seated?

13. How do you determine the size of the shim for the other side of the carrier?

14. What is the largest shim you can install on the right side?

15. Before proceeding to measure ring gear backlash:

16. What is the process for measuring ring gear backlash?

17. What backlash reading did you obtain?

18. Into which specification category does your backlash result fall? (Circle one). Within Zero Not Within

19. What shim adjustments are required on each side to bring the readings within specification?

Zero

Not Within

20. After the backlash is within specifications, how is the differential bearing preload established?

Progress Check

See your instructor before you move on to the next step. Instructor initials: _____

Pattern Check

(Refer to page 1 - 13 through 1 - 15)

21. What does your pattern indicate?

22. If an error is indicated in the pattern, what adjustment needs to be made?

23. Is this a face-mill or a face-hob gear set? _____

Progress Check

See your instructor. Instructor initials: _____

Disassemble the axle to the way you found it at the start of this Worksheet.

NOTE: YOU MUST ASK THE INSTRUCTOR FOR A DEMONSTRATION ON HOW TO USE THE D81L-4220-A (205-D036) DRIVE PINION DIFFERENTIAL CARRIER PULLER, FOR REMOVING THE PINION BEARINGS.

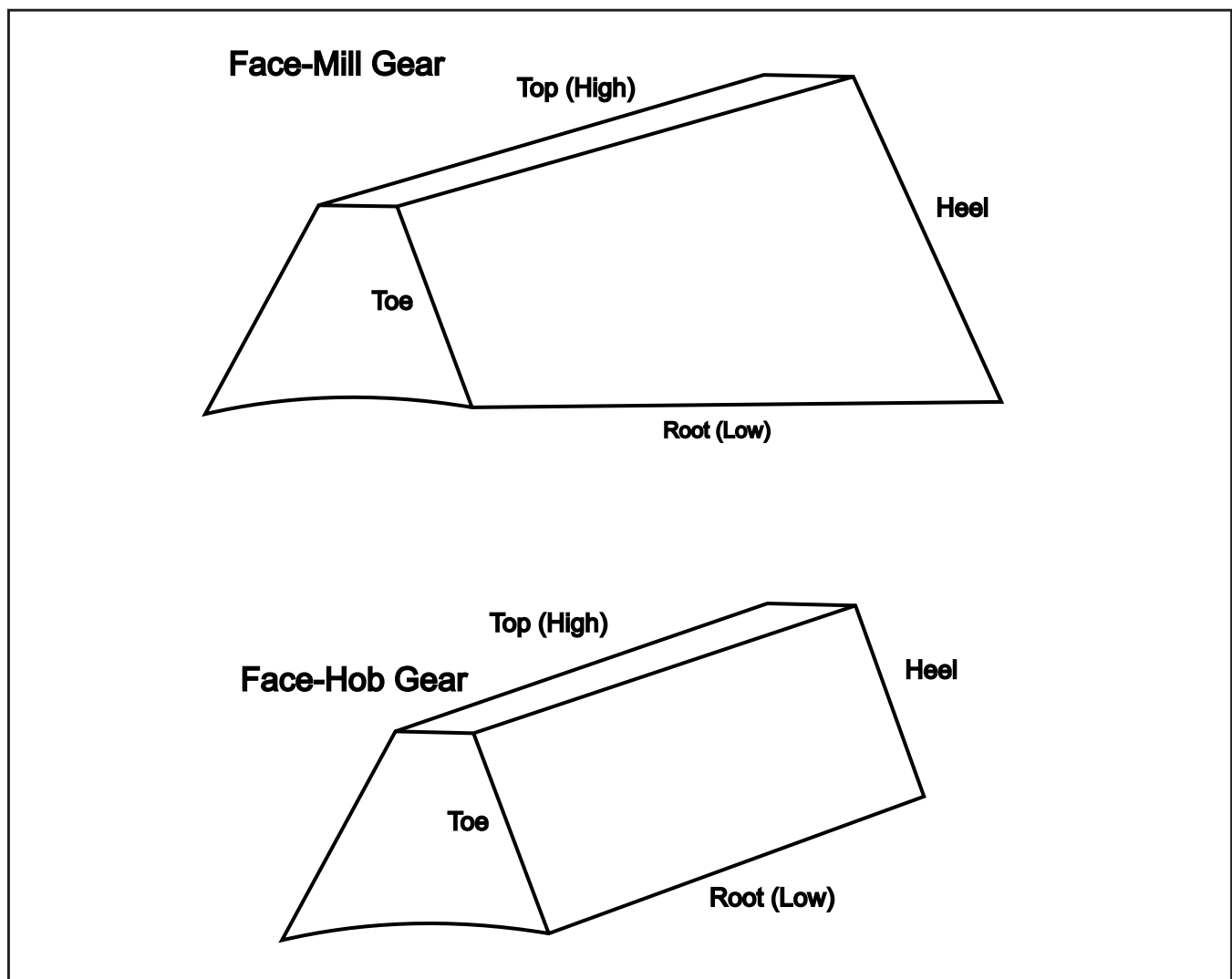
Face-Mill and Face-Hob Differences

There are two types of machining processes used in the manufacture of ring gears. One is face-mill and the other is face-hob. The two machining processes produce distinctly different shapes of ring gear teeth.

Both gear types have identical terms to define the specific areas of the tooth:

- top
- bottom
- toe (the portion facing the center of the ring)
- heel (the portion facing the outer edge of the ring)

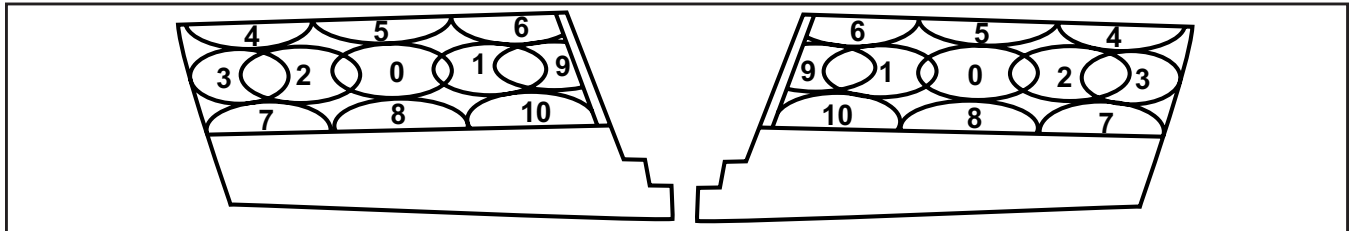
The heel of a face-mill ring gear tooth is much taller than the toe. The heel of a face-hob ring gear tooth is equal in height to the toe.



Additionally, the shape and location of the pattern varies substantially between face-mill and face-hob gears. This difference must be noted and the appropriate gear pattern chart used to obtain the correct diagnosis. Detailed charts are included on the following two pages.

GEARSET PATTERN ANALYSIS

- On the Drive Side, the heel is to the left. On the Coast Side, the Heel is to the right. The Toe for each is toward the center.
- Use the following chart to determine the action to take after running a pattern on a gearset.
- After determining the type of gearset, use the illustration to provide you with the necessary corrective steps.



Face-Hob Drive Pattern

0	Central	OK
1	Central Toe	OK
2	Central Heel	Possibly lower backlash
3	Heel	Lower backlash -- reject if backlash is already low
4	Heel and High	Add pinion shim, lower backlash
5	Central High	Add pinion shim
6	Toe and High	Add pinion shim
7	Heel and Deep	Subtract pinion shim
8	Central Deep	Subtract pinion shim
9	Toe	Raise backlash
10	Toe and Deep	Subtract pinion shim, raise backlash

Face-Mill Drive Pattern

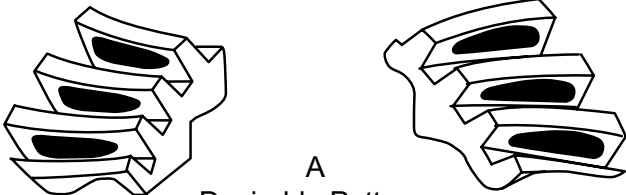
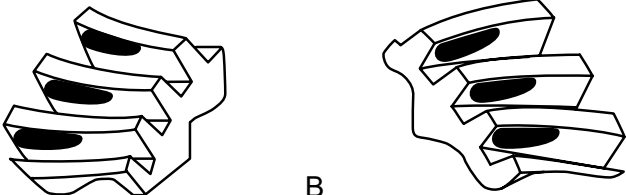
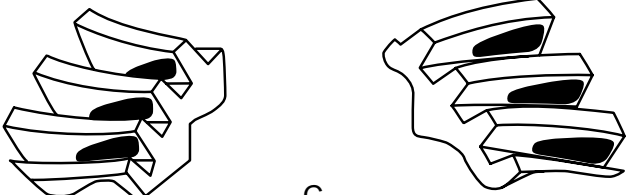
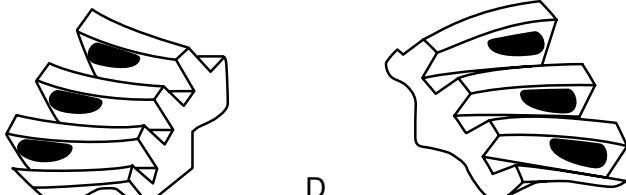
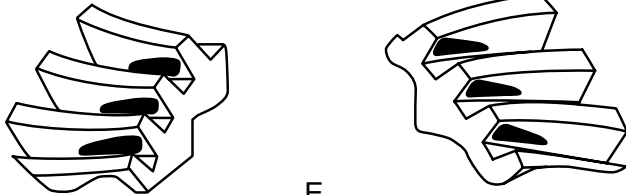
0	Central	OK
1	Central Toe	OK
2	Central Heel	Possibly lower backlash
3	Heel	Lower backlash -- reject if backlash is already low
4	Heel and High	Add pinion shim, lower backlash if it is high
5	Central High	Add pinion shim
6	Toe and High	Add pinion shim, raise backlash if necessary
7	Heel and Deep	Subtract pinion shim and lower backlash if necessary
8	Central Deep	Subtract pinion shim
9	Toe	Raise backlash
10	Toe and Deep	Subtract pinion shim, raise backlash

Face-Hob Coast Pattern

0	Central	OK
1	Central Toe	OK
2	Central Heel	Possibly raise backlash
3	Heel	Raise backlash -- reject if backlash is already high
4	Heel and High	Add pinion shim
5	Central High	Add pinion shim
6	Toe and High	Add pinion shim lower backlash if necessary
7	Heel and Deep	Subtract pinion shim raise backlash if necessary
8	Central Deep	Subtract pinion shim raise backlash if necessary
9	Toe	Lower backlash
10	Toe and Deep	Subtract pinion shim

FACE-MILL GEARSETS

- Use the following chart to determine the action to take after running a pattern on a gearset.
- After determining the type of gearset, use the illustration to provide you with the necessary corrective steps.

DRIVE	COAST	ACTION REQUIRED
 A Desirable Pattern		Normal or desirable pattern. The drive pattern should be centered on the tooth. The coast pattern should be centered on the tooth, but may be slightly toward the toe. There should be some clearance between the pattern and the top (heel) of the tooth.
 B Top Heel/Top Toe Contact		Backlash correct. Thicker pinion position shim required.
 C Root Toe (Low)/Root Heel (Low) Contact		Backlash correct. Thinner pinion position shim required.
 D Top Heel/Top Heel Contact		Pinion shim correct. Decrease backlash.
 E Root Toe (Low)/Root Toe (Low) Contact		Pinion shim correct. Increase backlash.

FACE HOB**Pinion High**

	DRIVE SIDE	CONDITION	COAST SIDE	CONDITION
	Heel Toe		Toe Heel	
		Root Heel Contact		Root Toe Contact

Normal

	DRIVE SIDE	CONDITION	COAST SIDE	CONDITION
	Heel Toe		Toe Heel	
		Desirable Pattern. The drive pattern should be centered on the tooth. There should be some clearance between the pattern and the top of the tooth.		Desirable Pattern. The coast pattern should be centered on the tooth, but may be slightly toward the toe. There should be some clearance between the pattern and the top of the tooth.

Pinion Low

	DRIVE SIDE	CONDITION	COAST SIDE	CONDITION
	Heel Toe		Toe Heel	
		Top Toe Contact		Top Heel Contact

FACE MILL**Pinion High**

	DRIVE SIDE	CONDITION	COAST SIDE	CONDITION
	Heel Toe		Toe Heel	
		Root Toe Contact		Root Heel Contact

Normal

	DRIVE SIDE	CONDITION	COAST SIDE	CONDITION
	Heel Toe		Toe Heel	
		Desirable pattern. The drive pattern should be centered on the tooth. There should be some clearance between the pattern and the top of the tooth.		Desirable pattern. The coast pattern should be centered on the tooth, but may be slightly toward the toe. There should be some clearance between the pattern and the top (heel) of the tooth.

Pinion Low

	DRIVE SIDE	CONDITION	COAST SIDE	CONDITION
	Heel Toe		Toe Heel	
		Top Heel Contact		Top Toe Contact

Dana Differential Setup

Pinion Bearing Shim

Dana axles use the same pinion depth setup tools as other Ford axles. The significant difference between a Dana and a Ford pinion is that the Dana pinion is measured and a correction factor is engraved on the end of the pinion. This engraved correction number provides a correction factor to help the shimming process.



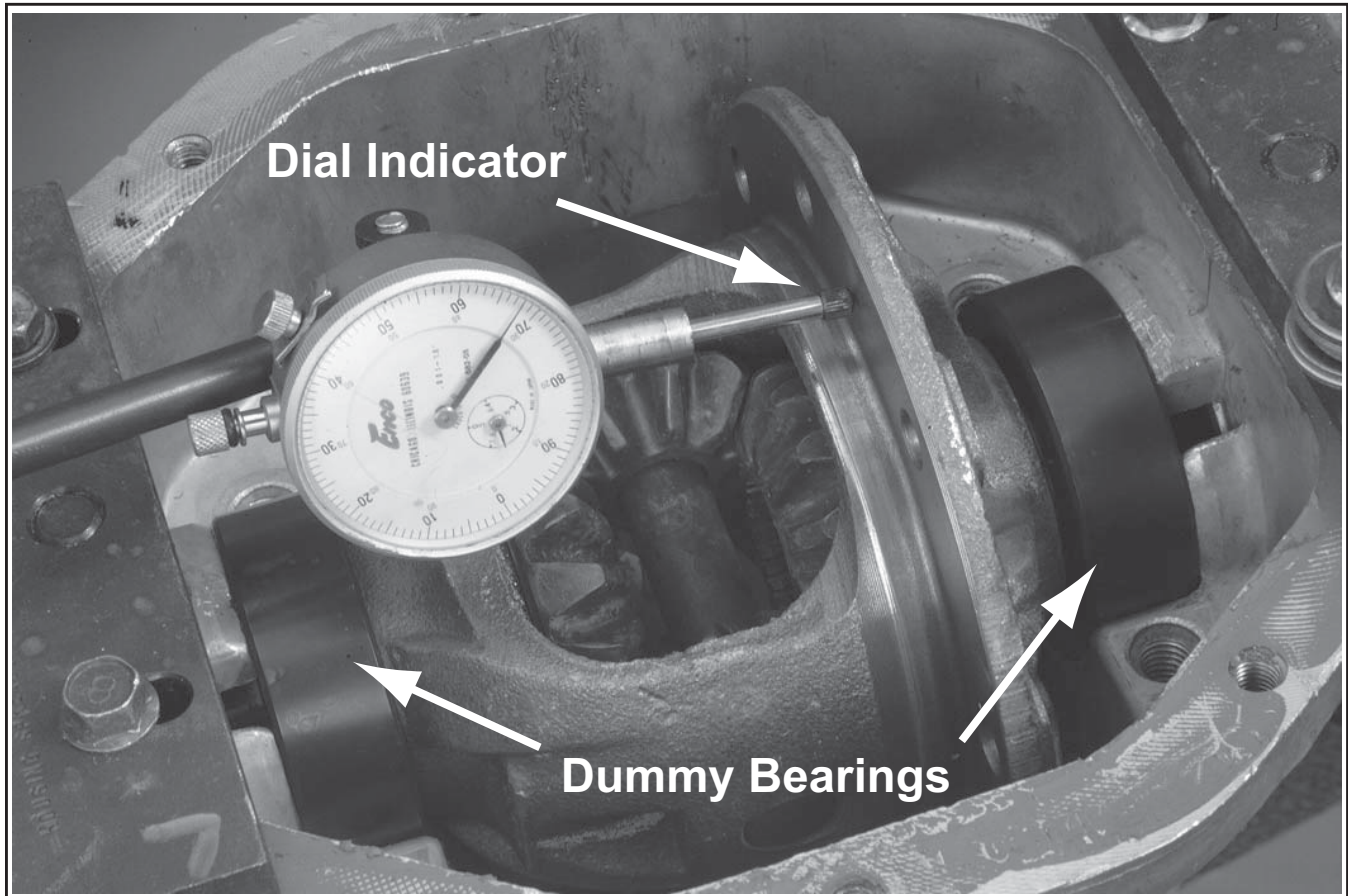
Notice the plus (+), minus (-) or zero (0) etching on the new drive pinion. Adjust the thickness of the new drive pinion position shim as follows:

- If etching is plus (+), subtract the number from the gauged drive pinion position shim thickness.
- If etching is minus (-), add the number to the gauged drive pinion position shim thickness.
- There is a metric version that is designated by an “m”

Dana Differential Setup (cont'd)

Dana Side Bearing Preload

A dial indicator (1) is used along with a set of dummy bearings (2) to measure case endplay. The dummy bearings are a fixed size, used to calculate the size of the shims needed for side bearing preload and backlash.



The Workshop Manual has a chart to help you calculate differential side bearing shim thickness that is required.

Line	Item	Result (actual)	Result (example)
A	Total endplay reading (without gears)		2.032 mm (0.080 in.)
B	Add preload	+0.2032 mm (+0.008 in.)	+0.2032 mm (+0.008 in.)
C	Total (A and B)		2.2352 mm (0.088 in.)
D	Endplay measurement (with gears)		1.0414 mm (0.041 in.)
E	Subtract the shim thickness on the ring gear side	-0.0762 mm (-0.003 in.)	-0.0762 mm (0.003 in.)
F	Total (Subtract E from D) (thickness of shims to place on the ring gear side)		0.9652 mm (0.038 in.)
G	Total (Subtract F from C) (thickness of shims to place on the drive pinion side)		1.27 mm (0.050 in.)

LESSON 2

PREREQUISITE REVIEW

DIRECTIONS: Answer the following questions on transfer cases and 4WD systems. Questions may be related to theory, operation, diagnosis and service. These will be reviewed in class.

Transfer Case and 4WD Theory and Operation Questions

1. List as many types of 4WD systems as you can identify:

2. What are the basic hublock types available?

3. What is the sequence to shift the transfer case from 4H to 4L?

4. Under what driving conditions should you NOT use any 4H or 4L modes?

5. What component(s) inside the transfer case are used to create 4L mode?

6. What components are used to transfer power from the rear tail shaft to the front driveshaft within a transfer case?

7. List some of the outputs used in an electronically-controlled A4WD system:

8. List some inputs commonly used in an electronically-controlled A4WD system:

9. What are the maximum mode switch selections that are available?

What is the function of these switch positions?

AWD Components/Operation

10. What does the acronym “DEM” stand for, and what is its function?

11. What are the four types of AWD systems used in current Ford Motor Company vehicles?

12. How are front and rear driveshaft speeds monitored in AOC and ATC systems?

13. In an ATC transfer case, where are the nested ball bearings located?

14. On the ATC, what is required to directly activate the clutch?

15. What diagnostic process is described by the term “S-S-C-C”?

16. Why is it important to verify a customer concern with the 4WD system?

17. How can you verify 4WD High or Low are operating correctly?

18. All electrical tests for an IWE hublock system have passed, but you still have a concern. What happens in this system when vacuum is lost?

19. How are PVH hubs applied and released?

20. Where should you continue your 4WD system diagnosis if all electrical checks pass?

LESSON 2

WORKSTATIONS

Workstation: **Summary:**

- 1 Students use the Service Information Publications DVD and required special service tools to disassemble down to the subassemblies, inspect and assemble a Borg-Warner 4406 4WD Transfer Case and answer related questions in the worksheet.
- 2 Students use the Service Information Publications DVD and required special service tools to disassemble down to the subassemblies, inspect and assemble a Borg-Warner 4405 4WD Transfer Case and answer related questions in the worksheet.
- 3 Students use the Service Information Publications DVD and scan tool to navigate through various 4WD PIDs to answer worksheet questions.
- 4 Students use the Service Information Publications DVD and a scan tool to navigate through various 4WD PIDs to answer worksheet questions.

WORKSTATION 1

4406 TRANSFER CASE DISASSEMBLY AND ASSEMBLY (BENCH)

DIRECTIONS: Complete Workstation 1 at the bench workstation, using the Borg-Warner 4406 4x4 Transfer Case, available hand tools and special service tools, and Workshop Manual.

SUMMARY: For this activity, you will disassemble, inspect the subassemblies, and assemble a 4406 Transfer Case, performing any necessary inspections required by the Workshop Manual.

- Follow the 2006 F-150 Workshop Manual, Section 308-07B.
- As you perform the disassembly and assembly procedures, pay attention to the following questions related to key steps.

1. How many speed sensors are located on the case? _____

Note the following during this procedure:

- **Do not remove bearings.**
- **Do not remove the seals.**
- **Do not remove the ring gear.**
- **Do not remove the field coil.**
- **DO remove the carrier.**

2. Why does the output shaft need to be lifted up? _____

3. Why is it normal to find metal shavings once the case separated?

4. What type of clutch does the unit have internally?

5. Can the ring gear be removed from the case, and how does it come out? **For this activity, DO NOT remove this component.**

6. Why do you have to remove the input seal?

7. How many shift forks does this unit have, and what are their purposes?

8. As case halves are reassembled, what might happen if too much silicone sealer is used?

Upon completion of assembly, demonstrate to the instructor that high and low ranges are available using a spare motor actuator gear.

WORKSTATION 2

4405 TRANSFER CASE DISASSEMBLY AND ASSEMBLY (BENCH)

DIRECTIONS: Complete Workstation 2 at the bench workstation, using the Borg-Warner 4405 4x4 Transfer Case, available hand tools and special service tools and the Workshop Manual.

SUMMARY: For this activity, you will disassemble, inspect the subassemblies, and assemble a 4405 Transfer Case, performing any necessary inspections required by the Workshop Manual.

- Follow the 2006 Explorer Workshop Manual, Section 308-07B. **Use the 2-speed transfer case procedures.**
- As you perform the disassembly and assembly procedures, pay attention to the following questions related to key steps.

1. How many speed sensors are located on the case? _____

Note the following during this procedure:

- **Do not remove bearings.**
- **Do not remove the seals.**
- **Do not remove the ring gear.**
- **Do not remove the field coil.**
- **DO remove the carrier.**

2. Why doesn't the current model year transfer case use speed sensors?

3. Why is it normal to find metal shavings once the case is spread?

4. When all bolts are removed, how are the case halves separated?

5. Can the ring gear be removed from the case and how does it come out?

6. What is the torque specification for the transfer case bolts? _____

7. How many shift forks does this unit have? What is its function?

8. How does the clutch operate the chain?

Upon completion of assembly, demonstrate to the instructor that high and low ranges are available using a spare motor actuator gear.

WORKSTATION 3

4WD PID NAVIGATION (ON-VEHICLE)

DIRECTIONS: Complete Workstation 3 on-vehicle, using the IDS scan tool, available hand tools, and Workshop Manual.

SUMMARY: For this activity, you will connect the IDS to the vehicle, navigate through the 4WD PIDs, and perform any necessary inspections required by the Workshop Manual.

- Follow the 2008 Expedition Workshop Manual.
 - As you complete the worksheet, pay attention to the following questions related to key steps.
1. Perform a self-test on the 4x4 Module. Are any codes present? _____
 2. Exit the self-test and select Datalogger menu. What two menus can be selected to view 4WD PIDs? Are there any numerical differences in the available PIDs?

 3. How could this information enhance your diagnostic ability?

NOTE: Turn off TracAssist before continuing to the next steps.

While in DataLogger, answer the following questions:

4. What is the driver's main input to this system?

5. What are the main inputs required to command 4L?

6. What type of 4x4 concern could these PIDs be used to diagnose?

7. What PID indicates a change in 4x4 mode?

8. What inputs will cause the 4x4 Torque On Demand relay to energize and create A4WD?

9. What output(s) is (are) required to create 4L?

10. How will the module let you know 4L has been achieved?

11. Select the following PIDs: Mode Select Switch, Clutch Pulse Width Status, Front and Rear Shaft Speeds. With the engine running, place the transmission gear selector in Drive and release the brakes. Monitor the above PIDs and transition from A4WD to 4H. What changed?

12. Which PID reflects the status of a wheel hub engagement or release command?

What is the PID status to engage the hub system?

WORKSTATION 4 4WD PID NAVIGATION (ON-VEHICLE)

DIRECTIONS: Complete Workstation 4 on-vehicle, using the IDS scan tool, available hand tools, and Workshop Manual.

SUMMARY: For this activity, connect the IDS to the vehicle, navigate through the 4WD PIDs, and perform any necessary inspections required by the Workshop Manual.

- Follow the 2008 Ranger Workshop Manual.
 - As you complete the worksheet, pay attention to the following questions related to key steps.
1. Perform a self-test on the 4x4 Module. Are any codes present? _____
 2. Exit the self-test and select Datalogger menu. What two menus can be selected to view 4WD PIDs? Are there any numerical differences in the available PIDs?

 3. How could this information enhance your diagnostic ability?

While in DataLogger, answer the following questions:

4. What is the driver's main input to this system?

5. What are the main inputs required to command 4L?

6. What type of 4x4 concern could these PIDs be used to diagnose?

7. What output(s) are required for 4WD?

8. What do these outputs control?

9. What inputs tell the module when the motor has achieved the correct status?

10. Is there an active command PID related to the above question? What is it and what is its purpose?

11. Can the 4x4 indicator lamp be manipulated by any active command/PID?

12. While in Mode Switch 2WD, select the following plate PIDs: A, B, C, D and PLATE_PWR #, then command PLATE_PWR # on. Record the values.

Plate PID	MSS PID 2WD
PLATE_A	
PLATE_B	
PLATE_C	
PLATE_D	

13. Shut off Active Command. Select 4H. Command PLATE_PWR back on. Record the values.

Plate PID	MSS PID 4WDH
PLATE_A	
PLATE_B	
PLATE_C	
PLATE_D	

14. Turn the switch from 4H to 2H. Does the transfer case transition?

15. Exit PLATE_PWR #. Command 2H. Record the values.

Plate PID	MSS PID 2WD
PLATE_A	
PLATE_B	
PLATE_C	
PLATE_D	

16. If you did not know that plate PIDs change to an open state after completion of a command, how could this affect your diagnosis?

LESSON 3A

WORKSTATIONS

Workstation: Summary:

- | | |
|----|--|
| 1A | Students use the Service Information Publications DVD and required special service tools to disassemble and assemble an 8.8 in. Traction-Lok differential and answer related questions in the worksheet. |
| 2A | Students use the Service Information Publications DVD and required special service tools to disassemble and assemble a 10.5 in. Traction-Lok differential and answer related questions in the worksheet. |
| 3A | Students use the Service Information Publications DVD and required special service tools to diagnose a 4WD Concern and answer related questions in the worksheet. |
| 4A | Students will analyze AWD PID data graphs and use the Service Information Publications DVD to answer worksheet questions. |

WORKSTATION 1A TRACTION-LOK DISASSEMBLY AND ASSEMBLY (BENCH)

DIRECTIONS: Complete Workstation 1A at the bench workstation, using the Ford 8.8 in. axle, available hand tools and special service tools, and Workshop Manual.

SUMMARY: For this activity, you will disassemble, inspect and assemble a Ford 8.8 in. Traction-Lok axle, performing any necessary inspections required by the Workshop Manual.

- Follow the 2006 Ranger Workshop Manual, Section 205-02B.
- As you perform the disassembly and assembly procedures, pay attention to the following questions related to key steps.

DISASSEMBLY

1. What should be done with the anti-lock speed sensor ring?

2. How should you position the differential case when removing the S-Spring to avoid personal injury?

3. What should be done immediately after removing the clutch packs?

4. How should clutch packs be cleaned? _____

ASSEMBLY

5. Soak clutch packs in _____ for no less than _____ minutes.
6. What is the torque specification for the nut on the Clutch Gauge Special Tool? _____
7. What is the thickest feeler gauge blade that will fit between the differential clutch pack and special tool?

What does this feeler gauge size represent? _____
8. What is recommended for the bolt that holds the differential pin in place?

9. What are the breakaway torque specifications for the clutch plates?
Reused clutch plates: _____

WORKSTATION 2A TRACTION-LOK DISASSEMBLY AND ASSEMBLY (BENCH)

DIRECTIONS: Complete Workstation 2A at the bench workstation, using the Ford 10.5 in. Traction-Lok axle, available hand tools and special service tools, and Workshop Manual.

SUMMARY: For this activity, you will disassemble, inspect and assemble a Ford 10.5 in. axle, performing any necessary inspections required by the Workshop Manual.

- For the 10.5 in. axle, follow the 2006 F-Super Duty Workshop Manual, Section 205-02D.
- As you perform the disassembly and assembly procedures, pay attention to the following questions related to key steps.

DISASSEMBLY

1. Before removing the differential case bolts, what important step must be performed?

2. What do you notice about the Belleville spring? _____

ASSEMBLY

3. What should new clutch discs be soaked in prior to Traction-Lok differential assembly?

4. Why are the Belleville spring and shim left off the clutch pack when gauging?

5. What is the largest feeler gauge that will fit between the special tool and clutch pack?

6. How should the Belleville spring be oriented on the clutch pack?

7. What is the specification for the differential side gear breakaway torque?

8. If breakaway torque is not within specification (too light), what could be the cause?

If breakaway torque is not within specification (too heavy), what could be the cause?

WORKSTATION 3A 4WD CONCERN (ON-VEHICLE)

DIRECTIONS: Complete Workstation 2A on the vehicle, using available hand tools and special service tools, and Workshop Manual.

SUMMARY: For this activity, you will work on a 2008 Expedition with a 4x4 concern, performing any necessary inspections required by the Workshop Manual.

- Follow the 2008 Expedition Workshop Manual, Section 308-07A.

A 2008 Expedition is in your service bay with the following customer concern:

“Front Drive Axle Does Not Disengage”

1. Which symptom description best matches the customer concern in the Symptom Chart?

2. What are some of the likely causes of this symptom?

Continued on next page.

NOTE: In this activity, you will NOT be installing an S-spring in the front differential.

3. What is the next step?

4. Complete the chart below.

TEST STEP	RESULT

5. List the possible purposes of each step that you performed above:

WORKSTATION 4A

AWD PID DATA ANALYSIS (TABLETOP/COMPUTER)

DIRECTIONS: Complete Workstation 3A using the recorded paper snapshots, the Workshop Manual and Wiring Diagrams.

SUMMARY: For this activity, you will use the AWD PID Data Analysis Graphs located at the workstation and interpret what is happening with the vehicle to answer the questions in this worksheet.

- Follow the 2006 Montego AWD Workshop Manual and Wiring Diagrams.

Graph 1

1. While looking at the Graph 1 data, what can you determine about the operating condition of the vehicle at minus 13 seconds?

2. What is the current oil pressure in the Active On-Demand coupling at minus 13 seconds?

3. What is the Valve Amperage at this point? _____

Graph 2

4. While looking at the Graph 2 data, what can you determine about the operating condition of the vehicle at approximately minus 0.7 seconds?

How many active command PIDs are available for this unit, and list them? _____

Graph 3

5. While looking at the Graph 3 data, what can you determine about the operating condition of the vehicle at approximately minus 0.5 seconds? (Be sure to note the value of the line.)

6. Why has the oil pressure changed? _____

7. Why has the valve amperage changed?

Workshop Manual and Wiring Diagram

8. What is the name of the module that controls the AWD system?

9. What is the number of the fuse protecting this AWD system and where is its location?

10. What is the terminal pin number at the module that receives power from this fuse?

11. How many pinpoint tests are available to diagnose the DEM for this AWD system? List them.

12. What instrument cluster indicator light illuminates when the DEM detects faults in the AWD system?

13. What are the name and locations of the grounds for the system?

14. What are the communication network circuit numbers? _____

15. What type of communication network is this? _____

NOTES:

LESSON 3B

WORKSTATIONS

Workstation: Summary:

- | | |
|----|--|
| 1B | Students will diagnose a 4WD concern on an Expedition using the Service Information Publications DVD to to complete the worksheet. |
| 2B | Students use the Service Information Publications DVD and PID data recordings at the bench to diagnose a 4WD Expedition concern to complete the worksheet. |
| 3B | Students will use the Service Information Publications DVD and available diagnostic tools to diagnose an on-vehicle 4WD concern on a Ranger to complete the worksheet. |
| 4B | Students will use the Service Information Publications DVD at the bench to navigate through an AWD concern on a 2007 Fusion to complete the worksheet. |

WORKSTATION 1B DIAGNOSE 4WD CONCERN (ON-VEHICLE)

DIRECTIONS: Complete Workstation 1B on a 2008 Expedition using the a scan tool, available hand tools and special service tools, and Workshop Manual.

SUMMARY: For this activity, you will use Service Information Publication manuals to diagnose an on-vehicle 4WD concern.

Directions: Complete the following worksheet. When you are finished return the workstation to the way you found it.

Concern: No 4WD operation. There are no TSBs related to this concern.

1. Verify concern.
2. Perform visual inspection.
3. Run On Demand/Continuous self test and record any codes present. Are any codes present?

- _____
4. If so, what are they? _____
 5. What is the next step? _____

NOTE: Answer “No” to any Pinpoint Test that requires a vehicle road test.

TEST STEP	RESULT

6. What is the root cause of the concern after following Pinpoint Test M?

7. What further tests could you perform to better determine the cause of the concern?

8. Perform these tests to determine the exact cause of the failure. What did you find?

NOTE: Do not make the above repair.

Return the vehicle and workstation to the way you found them.

WORKSTATION 2B
SERVICE PUBLICATIONS NAVIGATION
4WD PID RECORDINGS (TABLETOP/COMPUTER)

DIRECTIONS: Complete Workstation 2B at a desk computer, using a Workshop Manual. To locate the recordings on the computer:

1. Open the “WDS/IDS Desk Top Mode” icon on the computer desktop.
2. Select Previous Sessions and click the blue “Continue” checkmark.
3. Select 6LA70024 Expedition 5.4L and click the blue “Continue” checkmark.
4. Click on Toolbox tab.
5. Select Datalogger and click the blue “Continue” checkmark.
6. Select the first recording and click the blue “Continue” checkmark.

SUMMARY: For this activity, you will use service information publications to diagnose a 4WD concern.

Capture Event 8

1. While looking at the “Capture Event 8” data, what can you determine about the operating condition of the vehicle at minus 10 seconds?

2. What can you determine from the operating condition of the vehicle at minus 5 seconds?

3. What is the 4WD Controller PWM state reaction at this point? _____

4. What can you determine about the operating condition of the vehicle based on the information provided in Capture Event 8? _____

Capture Event 9

5. Compared to Capture Event #8 above, what can you determine about the operating condition of the vehicle at +7 seconds? (Be sure to note the value of the line.)

6. Why are the readings in Capture Event 9 occurring?

7. What components could possibly be causing the readings in Capture Event 9?

WORKSTATION 3B
DIAGNOSE 4WD CONCERN (ON-VEHICLE)

DIRECTIONS: Complete Workstation 3B on-vehicle, using a scan tool, available hand tools, and Workshop Manual.

SUMMARY: For this activity, you will use the scan tool, navigate the menus, and perform any necessary inspections required by the Workshop Manual.

- Follow the 2008 Ranger Workshop Manual.

Directions: Complete the following worksheet. When you are finished, return the workstation to the way you found it.

Concern: No 4WD operation. There are no TSBs related to this concern.

1. Verify concern.
2. Perform visual inspection.
3. Perform a self-test. Are any codes present? _____
4. What is the next step? _____
5. Perform the diagnostic steps in the Workshop Manual and record in the table below.

NOTE: If, while performing the diagnostics you are asked if you performed the Electronic Shift Functional Test, assume that you have and answer yes. Then continue your diagnosis as directed.

TEST STEP	RESULT

6. What is the root cause of the concern? _____
7. What is the recommended repair? _____

NOTE: Do not make the above repair.

Return the vehicle and workstation to the way you found them.

WORKSTATION 4B
SERVICE PUBLICATIONS NAVIGATION - 2007 AWD FUSION (TABLETOP/COMPUTER)

DIRECTIONS: Complete Workstation 4B using a desktop computer and Workshop Manual.

SUMMARY: For this activity, you will use the Workshop Manual to answer the following questions.

- Follow the 2007 Fusion Workshop Manual.

Directions: Complete the following worksheet.

1. What module in a 2007 Fusion AWD generates DTC P1635? _____
2. What is the actual symptom description for this DTC, and the Pinpoint Test that should be followed?

3. What are some of the likely causes that this Pinpoint Test suggests?

4. What are the first three Pinpoint Tests asking you to check?

5. What is the next check? _____
6. If one wheel speed sensor is off by 2 mph, what do you do?

7. What are the preliminary steps you need to do first?

8. Assume all initial checks pass with no ABS DTCs. Where do you go next? _____
9. What is the most likely cause for this condition?

10. An AWD unit has been overheated and has entered “locked mode.” What do you do next?

NOTES:

LESSON 4

WORKSTATIONS

Workstation: **Summary:**

- 1 Students will use the Service Information Publications DVD at the bench to navigate through a 4WD system concern on a Ranger.
- 2 Students will use the Service Information Publications DVD to perform driveline angle measurements on a vehicle using the required tools.
- 3 Students will use the Service Information Publications DVD at the bench to navigate through a 4WD system concern on a Ranger.

WORKSTATION 1
SERVICE PUBLICATIONS NAVIGATION – 2006 4WD RANGER
(TABLETOP/COMPUTER)

DIRECTIONS: Complete Workstation 1 at a desktop computer using the Service Information Publications DVD.

SUMMARY: For this activity, you will navigate a 2006 Ranger Workshop Manual and Wiring Diagram. As you complete the worksheet, pay attention to the following questions related to key steps.

1. The Workshop Manual specifies what type, weight, and amount of oil to use in the transfer case?

2. In the symptom chart for 4WD systems, how many concerns are listed? _____
3. If the 4WD indicators are always on with normal 4WD operation, what section of the Workshop Manual are you directed to go to, and what are you checking within that section?

4. What do pinpoint Tests S9 and S10 have in common?

5. Referring to the wiring diagrams, what type of module controls the 4WD system of the Ranger?

6. Where is the 4WD control module located on this vehicle?

7. According to the DTC chart in the service publications, what does DTC P1812 indicate?

8. According to Wiring Diagrams, what circuit(s) are used to connect with an IDS during diagnostic procedures?

9. If a DTC is retrieved that is not on the 4WD Control Module DTC Index, where are you directed to according to the steps listed under Inspection and Verification?

What is being tested by the above Pinpoint Test?

10. If DTC P1707 is retrieved, what action does the DTC Index direct you to take?

Describe the normal operation of the system in this test.

WORKSTATION 2

DRIVESHAFT ANGLE MEASUREMENT (ON-VEHICLE)

DIRECTIONS: Complete Workstation 2 using available hand tools, special tools and Workshop Manual.

SUMMARY: For this activity, you will describe the procedure for a driveshaft angle adjustment on a vehicle, and then perform a driveshaft angle measurement.

- Follow the 2008 Expedition Workshop Manual.
- As you complete the worksheet, pay attention to the following questions related to key steps.

Instructions: Using the Service Information Publications DVD answer the questions below.

1. What is the procedure for measuring driveshaft angle on this vehicle after the preliminary setup steps have been performed?

2. Refer to the chart in the WSM. List the specification for this measurement, your actual reading, and whether the actual reading is in or out of specifications.

Transmission Yoke Angle: _____ Driveshaft Angle: _____

Pinion Yoke Angle: _____ Specification: _____

3. What is the rule when two connected components slope in the same direction?

4. What is the rule when two connected components slope in the opposite direction?

5. What are the ideal operating angles?

WORKSTATION 3
SERVICE PUBLICATIONS NAVIGATION – 1999 4WD RANGER
(TABLETOP/COMPUTER)

DIRECTIONS: Complete Workstation 3 at a desktop computer using the Service Information Publications DVD.

SUMMARY: For this activity, you will describe the procedure for diagnosing the concern, “Vehicle gets stuck in mud or snow easily even when 4WD High or Low is commanded.” Perform the diagnosis for this vehicle using **1999 Ranger** Workshop Manual information. Compare the service publications pinpoint test steps to the pinpoint steps listed on NEXT PAGE.

- The RESULTS COLUMN of the table lists the results of the tests performed, use these results to select the next step that must be performed.
- Continue doing this until you’ve identified the cause of the concern.
- NOTE: SOME STEPS IN THE DATA TABLE ARE NOT USED IN THE DIAGNOSIS AND ARE ONLY INCLUDED AS DISTRACTORS. Select only the steps that are required.
- Write the steps in the spaces provided below in the order you would perform them. As you complete the worksheet, pay attention to the following questions related to key steps.
- No problems were located in OASIS and all TSBs that were researched.

TEST STEP	RESULT

1. What is your diagnosis using the Workshop Manual?

2. Using the S-S-C-C diagnostic strategy, what do you think are some possible causes of this symptom?

DATA SHEET

TEST STEP	RESULT
PPT E9	Vacuum check results are 6 in./Hg received after 6 seconds, then after 20 seconds went to 0 in./Hg.
Go to PPT E1	Held Vacuum at 20 in./Hg for 30 seconds.
Install scan tool and perform DATA LINK TEST	System Pass.
PPT E8	Vacuum went to 18 in./Hg after 6 seconds and after 15 seconds went to 0 in./Hg.
PPT E10	Go to ABS Diagnosis Pinpoint Test C
PPT A2	Allow system to release 8 in/hg. after 20 seconds
PPT E18	Resistance is less than 5 ohms
PPT E22	Vacuum drop exceeds 0.5 in./Hg. in 30 seconds
Visual Check	All OK. Radar detector and C.B. radio seem to be improperly installed. Vehicle is excessively muddy and appears to lack proper maintenance.
PPT E7	Vacuum stays below 1 in./Hg during test.
Go to Symptom Chart	Look for condition: Pulse Vacuum Hubs (PVH) operating improperly.
Verify Symptom	Concern exists as stated by the customer/hublocks do not engage (Transfer case motor movement and front driveshaft operate properly and halfshafts rotate but hubs do not)
PPT E2	Held Vacuum at 20 in./Hg for 30 seconds.
PPT E17	Resistance is greater than 10,000 ohms
PPT E15	Voltage on Circuit C185-2, Circuit 298 and PVH solenoid C185-3 is present for more than three seconds
PPT E11	Voltage to PVH solenoid is > 10 volts
Record DTCs and do Self Test	All Pass, No Codes
PPT E5	With engine running it reads 18 in./Hg.

NOTES: