Differentials
Purposes of a Drive Axle Assembly

- To transmit power from the drive shaft to the wheels
- To turn the power flow 90-degrees on RWD cars
- To allow the wheels to turn at different speeds while cornering
RWD Live Axle Components

• Rear axle housing
  – Holds all other components and attaches to the vehicle’s suspension

• Ring and pinion gears
  – Provide a final gear reduction
  – Transfer power 90-degrees to the wheels
RWD Live Axle Components (Cont’d)

• Differential assembly
  – Contains the differential case which attaches to the ring gear
  – Includes the side gears and differential pinion gears that allow wheels to turn at different speeds

• Axles
  – Transmit power from the differential to the wheels
Differential Operation

• The drive pinion drives the ring gear which is attached to the differential case

• When going straight ahead:
  – The differential housing and its components rotate as an assembly
  – Power is transferred equally to both wheels
• When turning a corner:
  – The wheels must travel at different speeds to prevent tire scrubbing
  – Differential pinion gears “walk” around slower side gear and cause other side gear to turn faster
  – The percentage of speed that is removed from one wheel is given to the other
Pinion rotation

Axle rotation

Ring gear rotation

Equal

Differential powerflow while straight ahead

Stationary

Fast rotation

Differential powerflow with one wheel stationary

Fast rotation

Slow rotation

Differential powerflow while cornering
Types of Axle Housings

• Integral carrier type
  – The differential assembly is mounted in and supported by the axle housing
  – It is sometimes called a Salisbury-type

• Removable carrier type
  – The differential assembly can be removed from the axle housing as a unit
  – It is sometimes called a pumpkin-type
Removable Carrier
Spiral Bevel Gears

- The centerline of the drive pinion intersects the centerline of the ring gear
- They are usually used in heavy-duty truck applications
- They are usually noisier than hypoid gears

![Spiral Bevel](image1)

- ![Hypoid Gearset](image2)

Hypoid Gears

- The centerline of the drive pinion gear intersects the ring gear at a point lower than the centerline
- They are commonly used in cars and light-duty trucks
- Their design allows for a lower vehicle height and more passenger room inside the vehicle
Toe (inner end)

Heel (outer end)
Gear Ratios

- The overall gear ratio is equal to the ratio of the ring and pinion gears multiplied by the ratio of the gear the transmission is in.

- Numerically low gears are said to be “high”

- Numerically high gears are said to be “low”
Calculating Overall Gear Ratios

If the transmission gear ratio is: 1.5:1
And the final drive gear ratio is: 3:1
The total final drive ratio is: 4.5:1

\[ 1.5 \times 3 = 4.5 \]
3 Ways to Determine Final Drive Ratio

- Using the vehicle service manual, decipher the code on the tag attached to or stamped on the axle housing
- Compare the number of revolutions of the drive wheels with those of the drive shaft
- Count the number of teeth on the drive pinion gear and the ring gear
Plant code

V033A
3 08 88 4F22

MFD. By:
Date: 09/92
Front GAWR: 2713 LB. Rear GAWR: 2682 LB
1231 KG 1215 KG

GVWR: 5345 - 2425 KG

Vehicle conforms to all applicable federal motor vehicle
safety and bumper standards on the date of manufacture
shown above.

Veh. Ident No. 1FABP43H9GH052068
Type: Passenger
3H
Exterior paint colors

Axle code  Ratio
8(M*)  2:73:1
G  2:26:1
Y(Z*)  3:08:1
F(R*)  3:45:1
B  2:47:1

* Traction-Lok

Axle ID code
Gearset Classifications

• Nonhunting gearset
  – Each tooth of the pinion gear will come in contact with the same teeth on the ring gear each revolution
  – The gearset must be assembled with its index marks aligned
  – An example ratio is 3.0:1
Gearset Classifications (Cont’d)

• Partial nonhunting gearset
  – Any one tooth of the pinion gear will come in contact with some of the teeth on the ring gear each revolution
  – The gearset must be assembled with its index marks aligned
  – An example ratio is 3.5:1
Gearset Classifications (Cont’d)

• Hunting gearset
  – Any given tooth on the pinion gear contacts all of the teeth on the ring gear before it meets the same tooth again
  – The gearset does not have to be indexed
  – An example ratio is 3.73:1
Pinion Mounting Designs

• Straddle-mounted pinion
  – It has two opposing tapered-roller bearings with a spacer between them
  – It also has a straight-roller bearing supporting it

• Overhung-mounted pinion
  – It only has two opposing tapered-roller bearings
Overhung Pinion

Opposing tapered roller bearings
Methods Used to Set Pinion Bearing Preload

• Collapsible spacer method
  – The pinion nut is tightened until the spacer collapses and applies a specific preload to the bearings

• Non-collapsible Spacer method
  – Uses selective shims to set the proper preload
Differential Case Adjustments

• The differential case can be adjusted side to side to provide proper backlash and side bearing preload

• Some designs use threaded bearing adjusters

• Some designs use selective shims and spacers for adjustments
Transaxle Final Drive Features

• The differential operates basically the same as in a RWD axle

• There is no 90-degree change in direction

• The drive pinion is connected to the transmission output shaft

• The ring gear is attached to the differential case
Transaxle Final Drive Types

• Helical
  – Requires the centerline of the pinion gear to be aligned with the centerline of the ring gear

• Planetary
  – Allows for a very compact transaxle design
Limited-Slip Differentials

• Provide more driving force to the wheel with traction when one wheel begins to slip
• Still allow the wheels to rotate at different speeds when turning a corner
• Are sometimes called Posi-Traction, Traction-Lok, and Posi-Units
Limited-Slip Differential Designs

• Clutch pack type
  – It uses two sets of clutches, each consisting of steel plates and friction plates
  – The steel plates are splined to the differential case and the friction plates are splined to the side gears
  – During cornering, the plates slip, allowing the wheels to turn at different speeds
Power Train

Side Force Transfers 70% of Torque to Wheel with Good Traction

No Traction Wheel is Spinning

Press the Page Up key to repeat this slide. Press the Space Bar to continue.
Limited-Slip Differential Designs (Cont’d)

• Cone-type
  – It uses two cone clutches with one cone that has frictional material on its outer surface and the other with a grooved surface on the inside
  – Cones allow wheels to turn at different speeds during cornering, while providing torque to both wheels during straight-ahead driving
Limited-Slip Differential Designs (Cont’d)

• Gerodisc-type
  – It uses a clutch pack and a hydraulic pump
  – The pump is driven by the left axle shaft
  – The pump’s output determines how much pressure is applied to the clutch pack
  – The amount of tire slip determines the pressure delivered by the pump
Designs of Axle Bearing Support

• Full-floating axle
  – The bearings are located outside the axle housing
  – They are usually found on heavy-duty applications

• Semi-floating axles
  – The bearings are located inside the housing
  – Found on passenger cars and light trucks

• Semi-floating axles
  – Rarely used – older design
Figure 28-56 Three types of rear drive axles: (A) semi-floating; (B) three-quarter floating; (C) full-floating axle assemblies.
Types of Axle Bearings

• **Straight-Roller**
  – Only absorbs radial loads; the axle housing bears the end thrust

• **Ball**
  – Is designed to absorb radial and axial end thrust loads

• **Tapered-Roller**
  – Axle end thrust can be adjusted
HOUSING OR CASE

AXIAL OR THRUST LOADS

TORSIONAL LOADS

RADIAL LOADS
- SHAFT AGAINST BEARING
- BEARING AGAINST HOUSING
Straight-Roller
Only absorbs radial loads; the axle housing bears the end thrust
Straight-Roller
Axle shaft transfers Thrust (Axial) Load to Axle Housing through the Carrier Bearings
Straight Roller rides on Axle Shaft
Ball Bearings
Control both Radial and Axial (Thrust Load)
Full Floating Bearings ride on axle housing
Double Tapered Roller bearings control Radial and Axial loads

Figure 1: Cross Section of a Full Floater
Bearing preload adjustment is critical on Full Floating Axles.
Independent Rear Suspension Design Features

- The differential is bolted to the chassis
- The axles are similar to FWD drive axles
- Each axle has an inner and an outer constant velocity joint
Differential Lubrication

- Hypoid gear types usually use 75W to 90W gear lube
- Limited-slip differentials use a special fluid
- Some transaxles require ATF
- Some transaxles use a different lubricant for the transmission and the differential
Steps in Differential and Axle Diagnosis

1. Talk to the customer to find out where and when the problem occurs

2. Road test the vehicle, listening and feeling for anything unusual

3. Inspect the vehicle
What to Do on a Road Test

• Try to operate the vehicle under the same conditions that the customer described
• Operate the vehicle under these conditions:
  – Drive
  – Coast
  – Cruise
  – Float
Noise Definitions

• “Chuckle”
  – A rattling noise that sounds like a stick in the spokes of a bicycle wheel
  – It is normally heard during coasting
  – Its frequency will change with vehicle speed
  – It is usually caused by damaged gear teeth
Noise Definitions (Cont’d)

• “Knocking”
  – Sounds similar to chuckle, but is usually louder
  – Can occur in all driving phases
  – Is usually caused by gear tooth damage on the drive side or loose ring gear bolts
Noise Definitions (Cont’d)

• “Clunk”
  – A metallic noise often heard when an automatic transmission is shifted into drive or reverse
  – May be heard when the throttle is applied or released
  – Is usually caused by excessive backlash somewhere in the drive line
Noise Definitions (Cont’d)

• “Gear Noise”
  – The howling or whining of a ring gear and pinion
  – Can occur under various conditions and speeds
  – Is usually caused by an improperly set gear pattern, gear damage, or improper bearing preload
Noise Definitions (Cont’d)

• Bearing “rumble”
  – Sounds like marbles rolling around in a container
  – Is usually caused by a faulty wheel bearing

• Bearing “whine”
  – A high-pitched, whistling noise
  – Is usually caused by faulty pinion bearings
Noise Definitions (Cont’d)

• “Chatter”
  – Can be felt as well as heard
  – Is usually caused by excessive preload
  – On limited-slip differentials, it is caused by using the wrong type of lubricant
Some Causes of Vibrations

• Out-of-round or imbalanced tires
• Improper drive line angles
• Damaged pinion flange
• Faulty universal joint
• Bent drive pinion shaft
Axle Assembly Leaks

• Damaged pinion seal
• Leakage past the threads of the pinion nut
• Leakage past the carrier assembly stud nuts
• Leaking gaskets
• Housing porosity
• Defective ABS sensor O-ring
Diagnosing Limited-Slip Concerns

1. Locate the specification for break-away torque

2. With one wheel on the floor and the other one raised, use a torque wrench to check the torque required to turn the wheel

3. If the torque is less than specified, the differential must be checked
Fluid Level Check

- Make sure the proper fluid is being used
- The vehicle must be level
- The axle assembly must be at normal operating temperature
- The fluid level should be even with the bottom of the fill plug opening