2002 Workshop Manual

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F-150

VOLUME 1 AND 2

Ford Motor Company

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F-150
VOLUME 1

Ford Motor Company

2002 F-150

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NOTE: The descriptions and specifications contained in this manual were in effect at the time this manual was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications or design without notice and without incurring any obligation.

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2002 F-150

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INTRODUCTION

NOTE: The descriptions and specifications contained in this manual were in effect at the time this manual was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications or design without notice and without incurring any obligation.

IMPORTANT SAFETY NOTICE

Appropriate service methods and 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 performing service with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedure, 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 the 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.

NOTES, CAUTIONS, AND WARNINGS

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 perform 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 you 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.**
- **MAKE 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 IN PARK UNLESS INSTRUCTED OTHERWISE FOR A SPECIFIC OPERATION. IF YOU HAVE A MANUAL TRANSMISSION, IT SHOULD BE IN REVERSE (ENGINE OFF) OR NEUTRAL (ENGINE ON) UNLESS INSTRUCTED OTHERWISE FOR A SPECIFIC OPERATION. PLACE WOOD BLOCKS (4" X 4" OR LARGER) AGAINST THE FRONT AND REAR SURFACES OF THE TIRES TO HELP PREVENT THE VEHICLE FROM MOVING.**
- **OPERATE THE ENGINE ONLY IN A WELL-VENTILATED AREA TO AVOID THE DANGER OF CARBON MONOXIDE POISONING.**
- **KEEP YOURSELF AND YOUR CLOTHING AWAY FROM MOVING PARTS WHEN THE ENGINE IS RUNNING, ESPECIALLY THE DRIVE BELTS.**
- **TO PREVENT SERIOUS BURNS, AVOID CONTACT WITH HOT METAL PARTS SUCH AS THE RADIATOR, EXHAUST MANIFOLD, TAIL PIPE, THREE-WAY CATALYTIC CONVERTER AND MUFFLER.**
- **DO NOT SMOKE WHILE WORKING ON A VEHICLE.**
- **TO AVOID INJURY, ALWAYS REMOVE RINGS, WATCHES, LOOSE HANGING JEWELRY AND LOOSE CLOTHING BEFORE BEGINNING TO WORK ON A VEHICLE.**
- **WHEN IT IS NECESSARY TO WORK UNDER THE HOOD, KEEP HANDS AND OTHER OBJECTS CLEAR OF THE RADIATOR FAN BLADES!**

GROUP

General Information 1

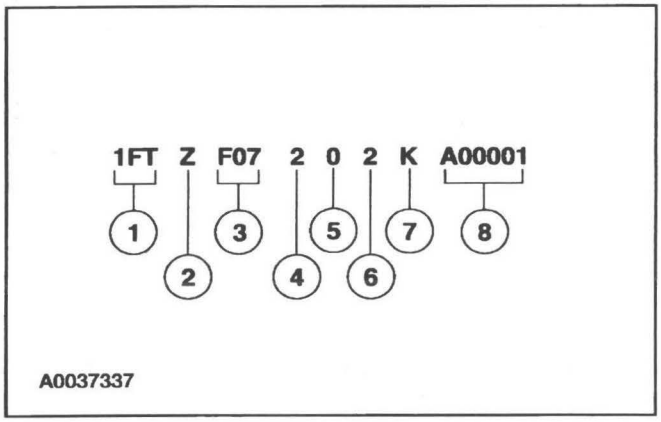
SECTION 100-01 Identification Codes

CONTENTS PAGE

DESCRIPTION AND OPERATION

Identification Codes

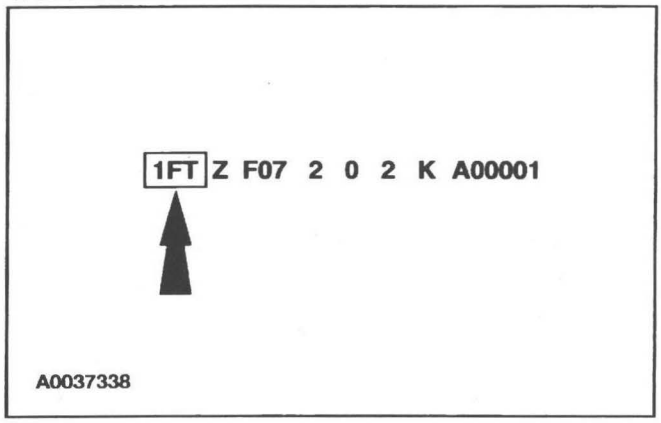
The vehicle identification number (VIN) is a 17-digit combination of letters and numbers. The VIN is stamped on a metal tab riveted to the instrument panel, top upper left of the dash. The VIN number is also found on the vehicle certification (VC) label.



Item	Description
1	World manufacturer identifier (WMI)
2	Brake type and gross vehicle weight rating (GVWR), may also include the vehicle restraint type code
3	Vehicle line, series, body type code
4	Engine type code
5	Computer-generated check digit
6	Model year code
7	Assembly plant code
8	Production sequence number

Vehicle Identification Number

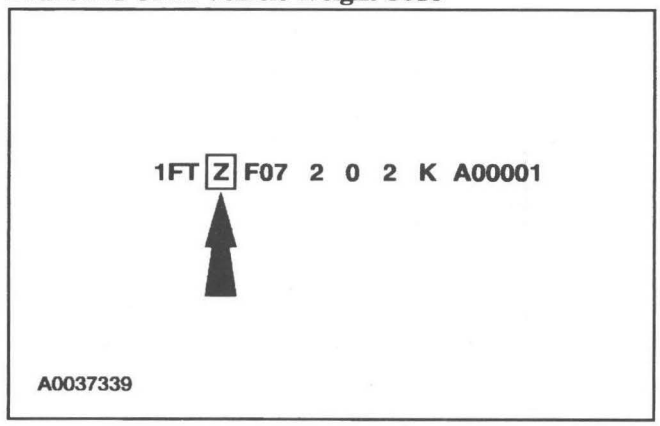
World Manufacturer Identifier



The first three vehicle identification number (VIN) positions are the world manufacturer identifier.

- 1FT — Ford Motor Company, USA, truck, completed vehicle
- 2FT — Ford Motor Company, Canada, truck, completed vehicle
- 3FT — Ford Motor Company, Mexico, truck, completed vehicle

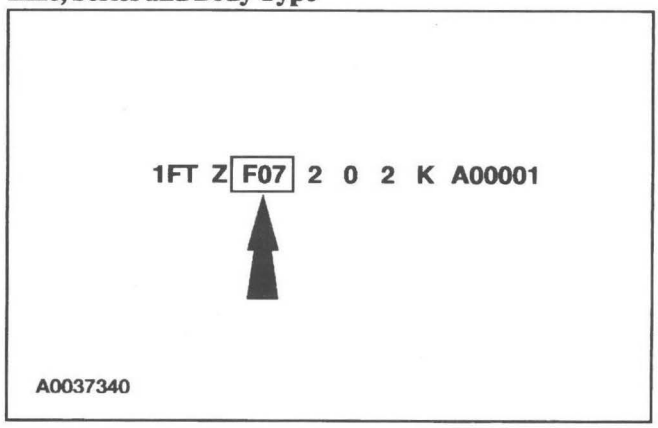
Brake and Gross Vehicle Weight Code



The fourth VIN position is the vehicle brake type and GVWR code (all vehicles use hydraulic brakes).

- Z — 5,001-6,000 pounds GVWR with driver and front passenger air bags
- R — 6,001-7,000 pounds GVWR with driver and front passenger air bags
- P — 7,001-8,000 pounds GVWR with driver and front passenger air bags

Line, Series and Body Type

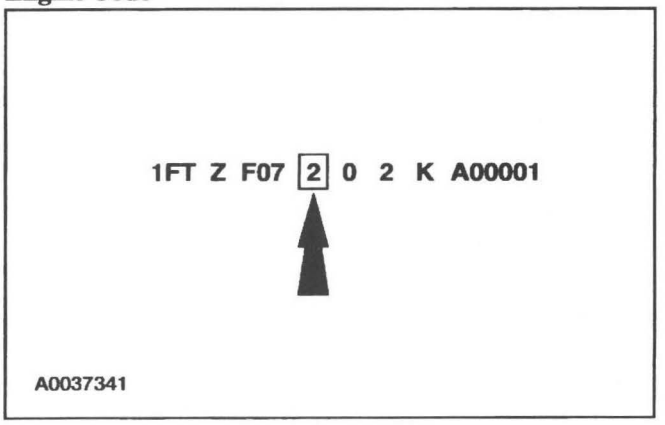


DESCRIPTION AND OPERATION (Continued)

Positions 5 through 7 indicate vehicle line, series and body type.

- F07 — Regular Cab, 4x2, Flareside
- X07 — SuperCab, 4x2, Flareside
- F08 — Regular Cab, 4x4, Flareside
- X08 — SuperCab, 4x4, Flareside
- F17 — Regular Cab, 4x2, Styleside
- X17 — SuperCab, 4x2, Styleside
- F18 — Regular Cab, 4x4, Styleside
- X18 — SuperCab, 4x4, Styleside
- W07 — Crew Cab, 4x2, Flareside
- W08 — Crew Cab, 4x4, Flareside

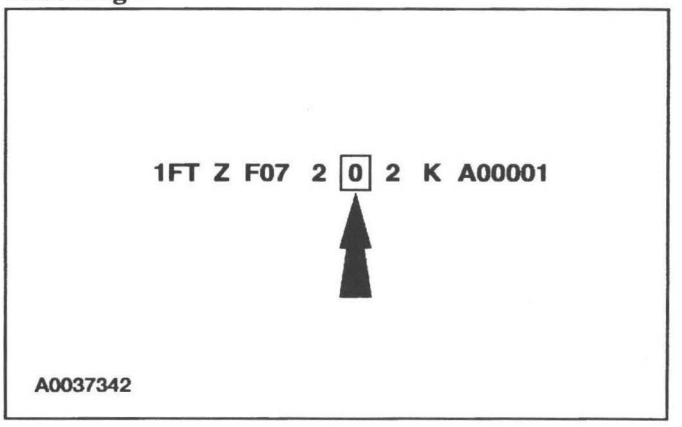
Engine Code



The eighth VIN position is the engine displacement and number of cylinders.

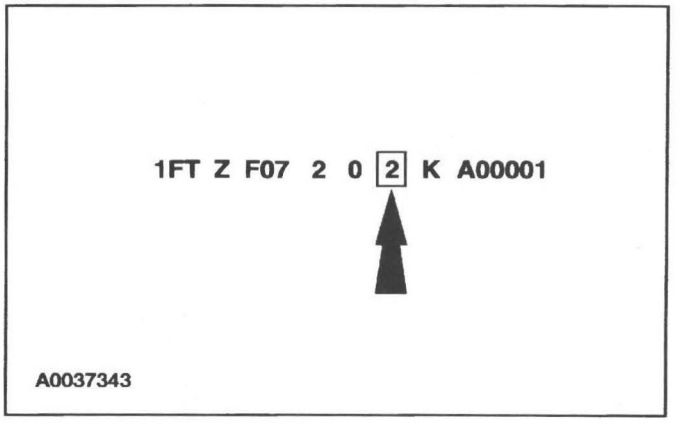
- 2 — 4.2L, OHV, V6, Gas
- W — 4.6L, SOHC, V8, Gas
- L — 5.4L, SOHC, V8, Gas
- M — 5.4L, SOHC, V8, Natural Gas
- Z — 5.4L, Bi-Fuel, V8 (Natural Gas/Propane)
- 3 — 5.4L, SOHC, V8, Gas (Lightning)

Check Digit



The ninth VIN position is a government assigned, computer-generated check digit.

Model Year

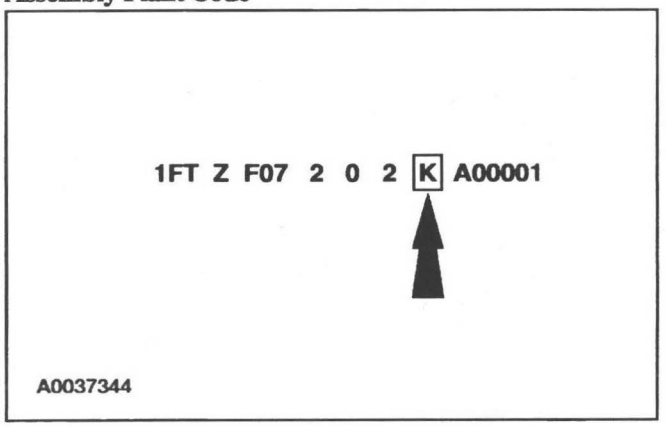


DESCRIPTION AND OPERATION (Continued)

The tenth VIN position is the model year code.

- 2 — 2002

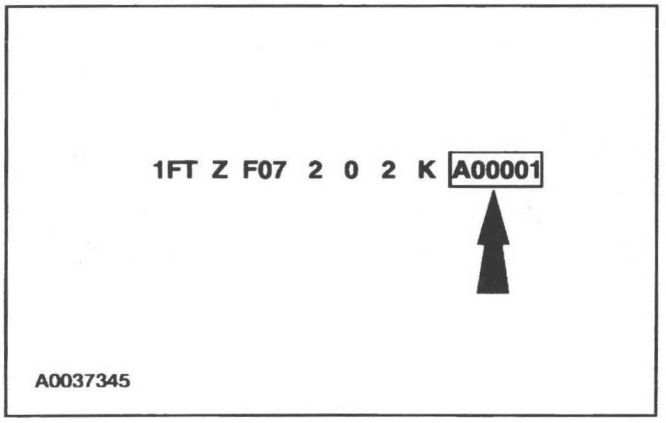
Assembly Plant Code



The eleventh VIN position is the assembly plant code.

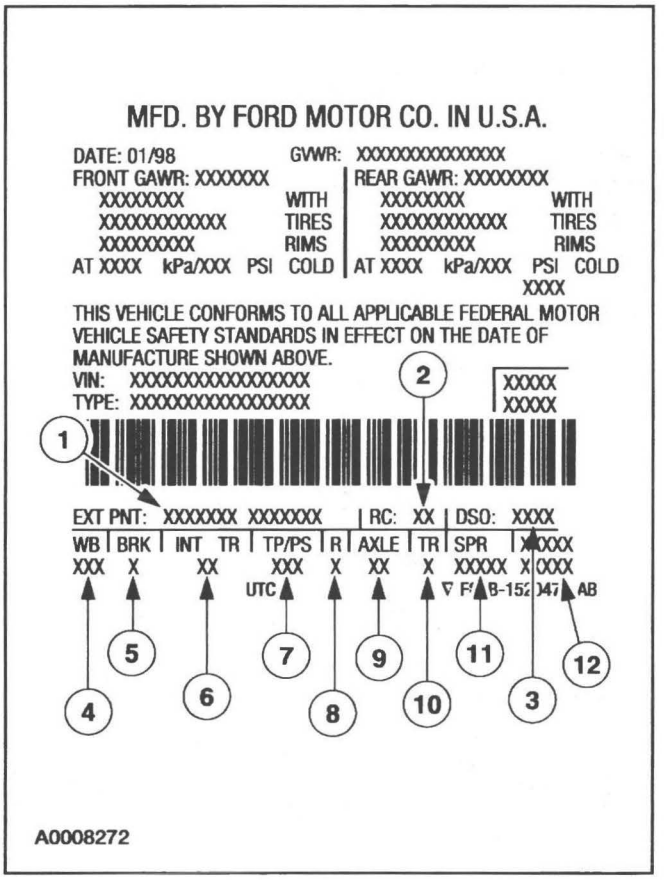
- C — Ontario Truck (Oakville, Ontario)
- K — Kansas City (Claycomo, Missouri)
- N — Norfolk (Norfolk, Virginia)
- M — Cuautitlan (Cuautitlan, Mexico)

Vehicle Serial Number



The last six VIN positions are an alphanumeric code for the vehicle build sequence. This is also the vehicle serial and warranty number.

Vehicle Certification (VC) Label



Item	Description
1	Exterior paint code
2	Region code
3	Domestic special order (DSO) code
4	Wheelbase code
5	Brake type code
6	Interior trim code
7	Tape/paint stripe code
8	Radio code
9	Axle code

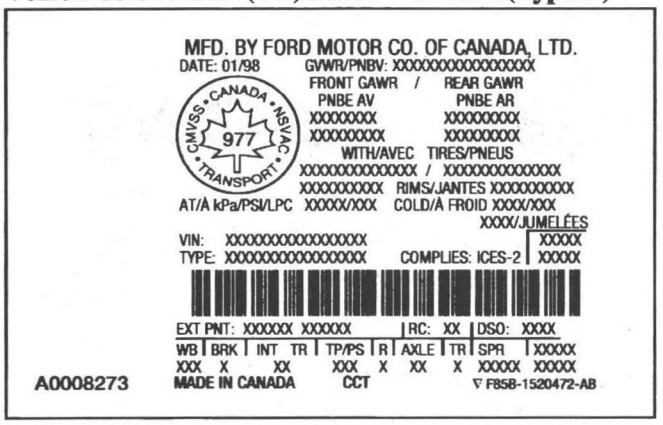
(Continued)

DESCRIPTION AND OPERATION (Continued)

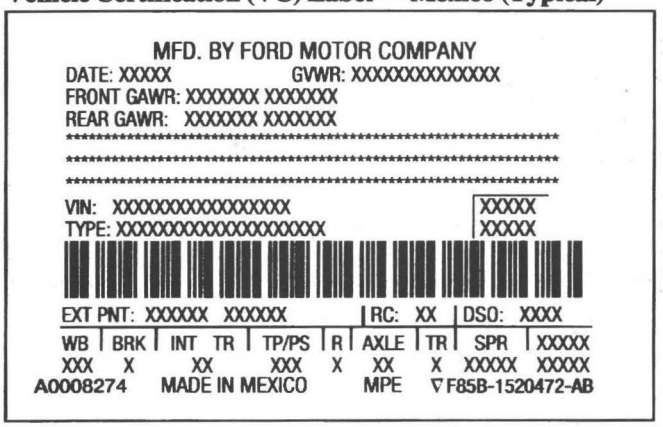
Item	Description
10	Transmission code
11	Spring code
12	Powertrain calibration information

The vehicle certification (VC) label contains the manufacturer name, the month and year of manufacture, the certification statement, and the VIN. It also includes gross vehicle weight ratings (GVWR).

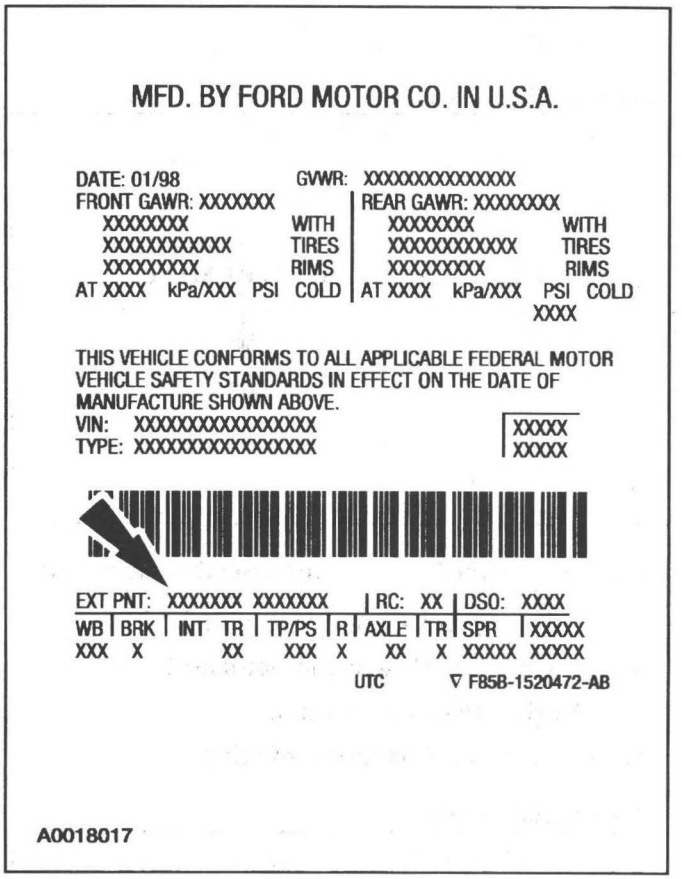
Vehicle Certification (VC) Label — Canada (Typical)



Vehicle Certification (VC) Label — Mexico (Typical)



Exterior Paint



Paint Codes

Exterior paint color codes may be listed as a two-part code. The first set of paint code characters indicate the primary body color. The second set of paint code characters (if applicable), indicate a two-tone body color or accent body color.

DESCRIPTION AND OPERATION (Continued)

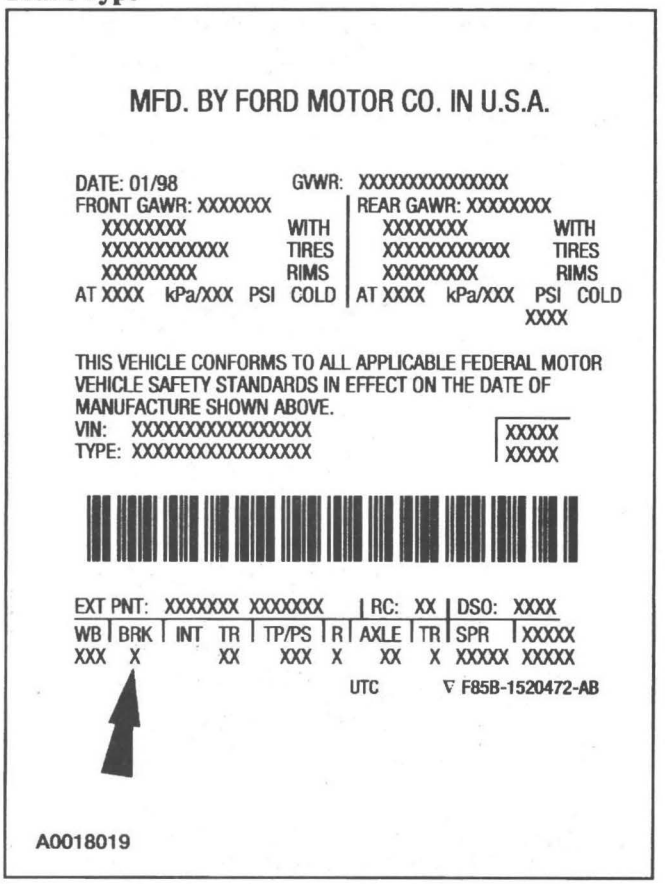
Primary Body Color

- E4 — Vermilion, clear coat
- B4 — Chestnut, clear coat
- FL — Medium Toreador Red, clear coat
- YN — Silver Metallic, clear coat
- UA — Ebony, clear coat
- YZ — Oxford White, clear coat
- Y1 — Prime
- AQ — Arizona Beige
- PX — Dark Highland Green
- ST — Estate Green (King Ranch)
- KW — Charcoal Blue (King Ranch)
- L2 — True Blue
- CX — Dark Shadow Gray

Wheelbase

- 120 — 120-inch wheelbase, regular cab
- 139 — 139-inch wheelbase, regular cab, SuperCab, Crew Cab
- 157 — 157-inch wheelbase, SuperCab

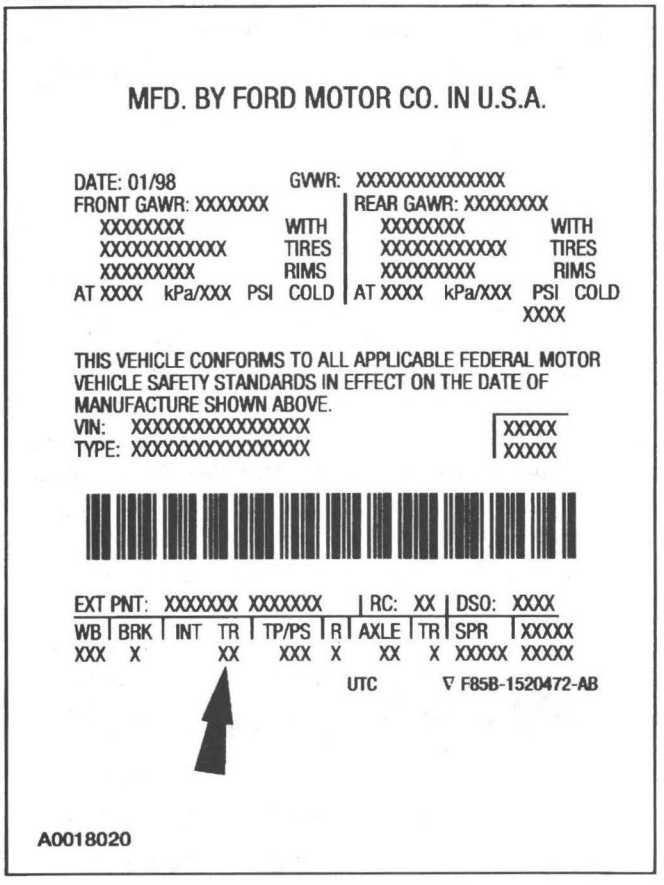
Brake Type



- B — Four-wheel anti-lock brake system (ABS)

DESCRIPTION AND OPERATION (Continued)

Interior Trim



Interior trim codes are listed as a two-part code. The first character identifies the interior trim type. The second character identifies the interior trim color.

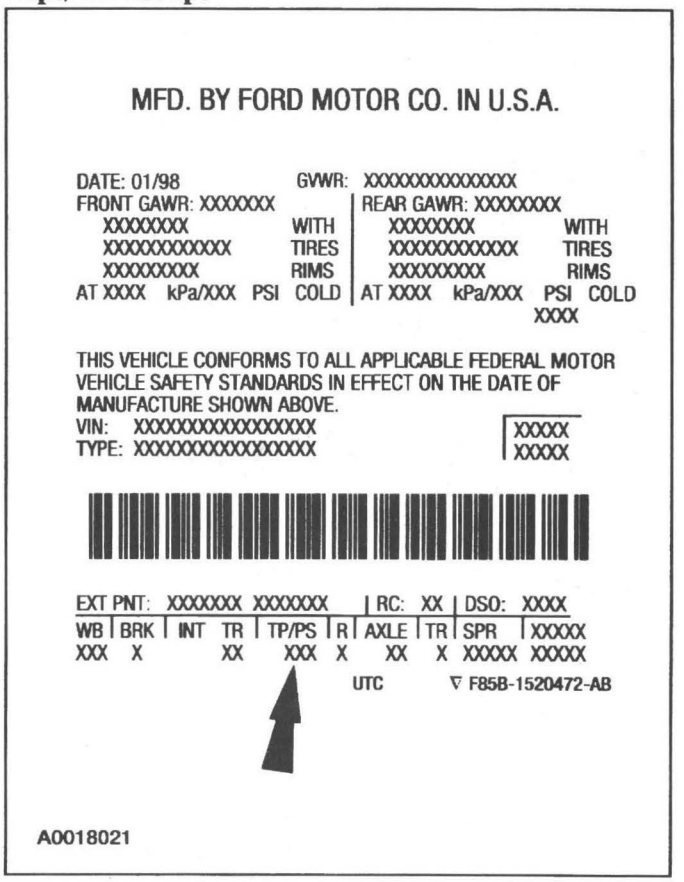
Interior Trim Type

- A — Vinyl full bench split-back
- C — Poly knit full bench
- F — Cloth captains chairs with console
- H — Leather captains chairs with console
- M — Cloth 40/60
- E — Leather 40/60
- L — Cloth/leather (Lightning)
- S — 60/40 split bench (Sport)
- T — Captains chairs (Sport)
- D — Leather captains chairs (Harley-Davidson edition)
- K — Leather captains chairs (King Ranch)

Interior Color Code

- T — Dark Graphite
- 2 — Medium Graphite
- H — Medium Parchment
- B — Ebony

Tape/Paint Stripe

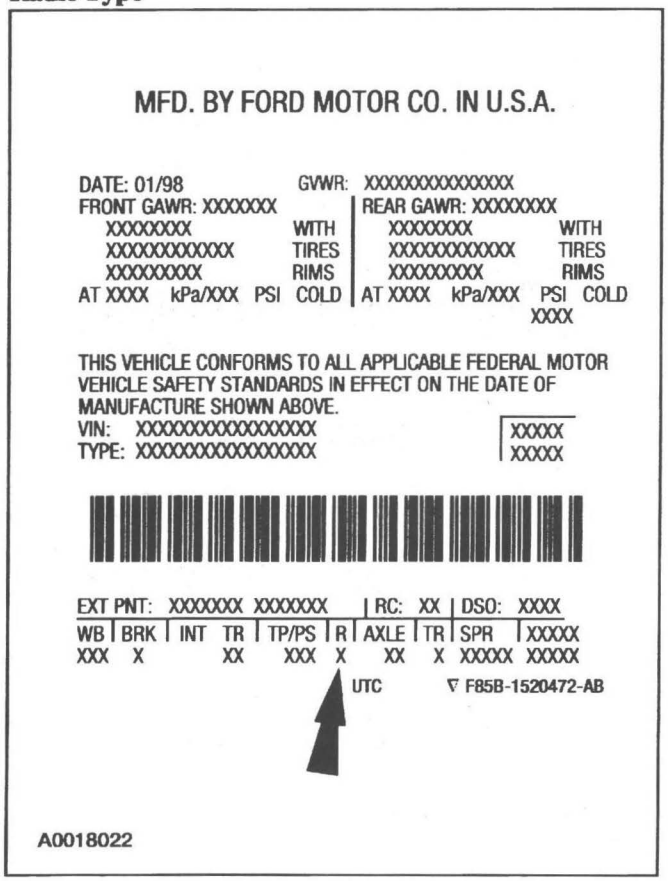


- A — Light Argent/Medium Platinum
- B — Arizona Beige/Deep Sandlewood Metallic
- Z — NASCAR tapestripes
- O — Orange (Harley-Davidson edition)
- X — Tapestripe delete
- C — Light Argent/Medium Platinum (Lariat)
- D — Medium Platinum/Light Argent (Lariat)

DESCRIPTION AND OPERATION (Continued)

- E — Arizona Beige/Deep Sandlewood Metallic (Lariat)
- F — Deep Sandlewood Metallic/Arizona Beige (Lariat)

Radio Type



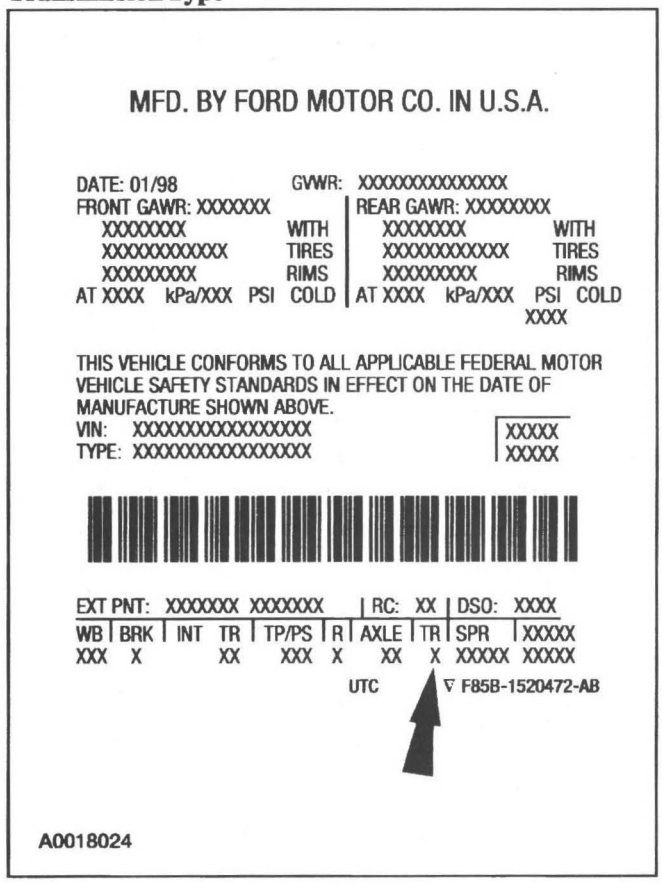
- 9 — AM/FM stereo with clock and cassette (Mexico)
- 5 — AM/FM premium stereo with clock and compact disc (CD) player
- 8 — AM/FM premium stereo with compact disc (CD) changer and cassette
- Y — Delete standard AM radio with clock
- D — Delete radio chassis only (AM/FM stereo with compact disc (CD) changer and cassette)
- E — Delete radio chassis only (AM/FM premium stereo with clock and compact disc (CD) player)
- R — Delete radio chassis only (AM/FM stereo with clock and cassette)

Axle Type

- 18 — 3.08, non-limited slip
- 19 — 3.55, non-limited slip
- 26 — 3.73, non-limited slip
- 27 — 3.31, non-limited slip
- H9 — 3.55, limited slip
- B6 — 3.73, limited slip
- B5 — 4.10, limited slip

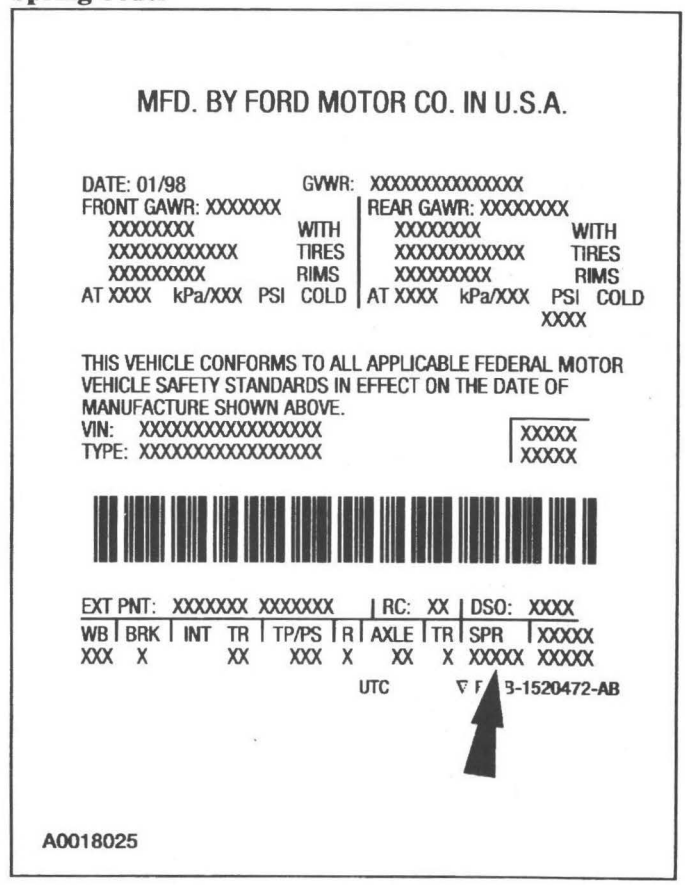
DESCRIPTION AND OPERATION (Continued)

Transmission Type



- M — five-speed manual overdrive (Mazda M5R2-C)
- U — four-speed automatic (AODE, W/4R70W)
- E — four-speed automatic (4R100)
- 7 — four-speed automatic (4R100), Lightning

Spring Codes



Spring codes are listed as a two-part code. The first characters listed identify the front springs or torsion bars. The second character listed identifies the rear springs.

DESCRIPTION AND OPERATION (Continued)

Front Springs

- Base part number — 5310

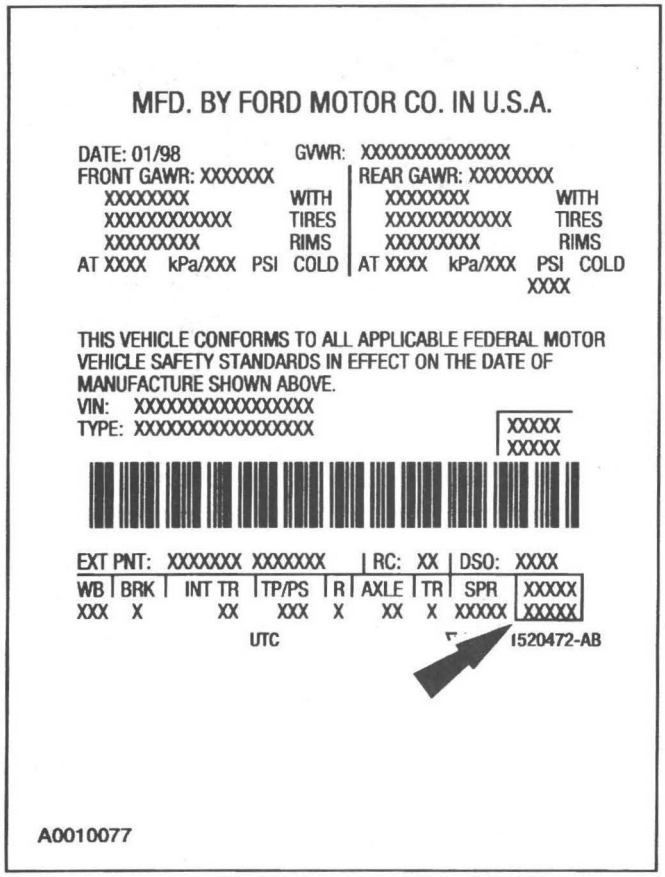
Front Torsion Bars

- Base part number — 5B326 (right-hand), 5B327 (left-hand)

Rear Springs

- Base part number — 5560

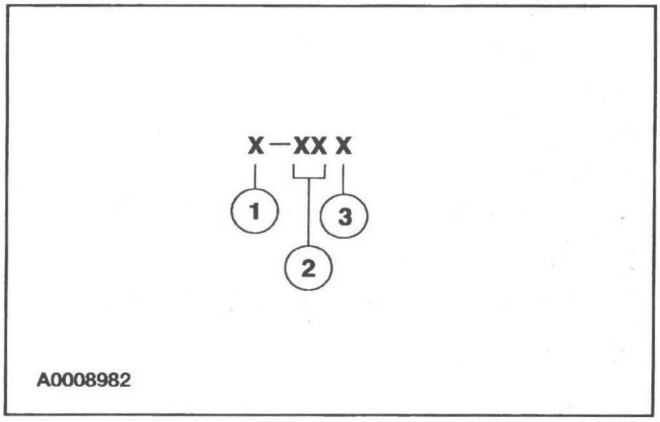
Powertrain Calibration Information



NOTE: Powertrain calibration information is limited to a maximum of five characters per line on the vehicle certification label. Because of this, calibration identification consisting of more than five characters will wrap to the second line on the VC label.

Powertrain calibration information is printed in the lower right corner of the vehicle certification label. Only the base calibration information is printed. Revision levels will not appear, however, they can be found in On Line Automotive Service Information System (OASIS). For the current model year, Ford Motor Company is using three different protocols which describe powertrain base calibration. These protocols are designed to provide worldwide standardization for vehicle calibration. If the electronic calibration strategy was introduced in 1998 and carried into the current model year, Protocol 1 will be used. Refer to Protocol 1 below. If the electronic calibration strategy was introduced in 1999 and is carried into the current model year, Protocol 2 will be used. Refer to Protocol 2 below. For new electronic calibration strategies introduced in 2000 or 2001 use Protocol 3. Refer to Protocol 3 below.

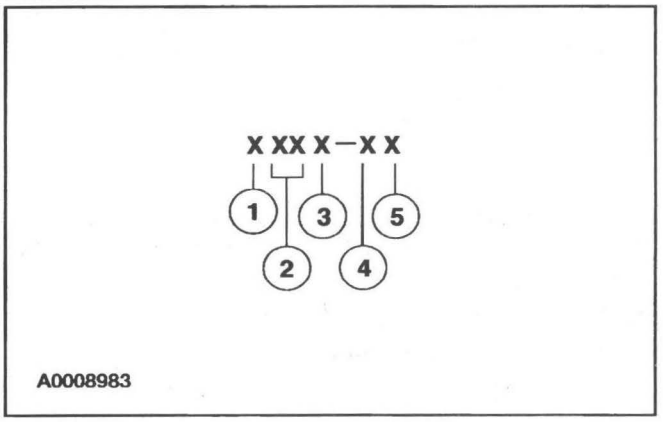
Protocol 1



DESCRIPTION AND OPERATION (Continued)

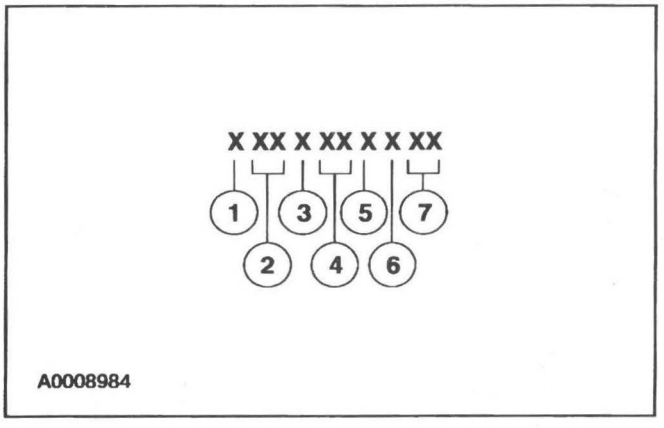
Item	Description
1	Model year (model year in which calibration strategy was first introduced)
2	Engine code
3	Engine revision level

Protocol 2



Item	Description
1	Model year (model year in which calibration strategy was first introduced)
2	Engine code
3	Transmission code
4	Emission standard (designates the specific country emission standard)
5	Design level (design level assigned to the engine)

Protocol 3



Item	Description
1	Model year (model year in which calibration strategy was first introduced)
2	Vehicle code

(Continued)

Item	Description
3	Transmission code
4	Unique calibration (designates different hardware to similar vehicles). Example: tires, drive ratios, etc.
5	Fleet code (describes fleet to which the vehicle belongs). Example: 6 - evaporative emissions
6	Certification region (lead region where multiple regions are included in one calibration). Example: A - U.S. federal
7	Revision level (will advance as revisions occur). Not printed on label

Protocol 3

The following offers a more detailed explanation of the coding strategy used in Protocol 3.

Model Year

- 0 — 2000
- 1 — 2001
- 2 — 2002

Vehicle Line

- F5 — F-150

Transmission

- 1 — Automatic transmission
- 2 — Manual transmission

Unique Calibration

The Emissions/CAFE/CO2 Compliance Department is responsible for assigning these calibration numbers. Unique calibration identification identifications are assigned to cover similar vehicles to differentiate tires, drive configurations, final drive ratios and other calibration-significant factors.

These two characters are chosen by the analyst to provide identifiable information unique to each calibration. For example, using the number 2 to denote a two-valve engine versus using the number 4 to denote a four-valve engine, offers an easily identifiable difference.

Fleet Code

- 1 — HDGE/Dyno
- 2 — Fast AMA, U.S.
- 3 — ADP, U.S.
- 4 — Not assigned
- 5 — Not assigned

DESCRIPTION AND OPERATION (Continued)

- 6 — Evaporative emissions
- 7 — MACAA
- 8 — On-board diagnostics (OBD)
- 9 — Not assigned

Certification Region

Where multiple regions are included in one calibration, only the lead region will be listed.

- 5 — U.S. fifty states
- A — U.S. federal, including altitude, may include Canada and/or Mexico
- B — U.S. California standard, includes U.S. green states
- C — Canada
- D — China
- E — European Community (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom)
- F — Extended European Community (E plus Croatia, Czech Republic, Estonia, Hungary, Norway, Poland, Romania, Russian Federation, Slovakia, Slovenia, Switzerland and Yugoslavia)
- G — Gulf Cooperative Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE)
- H — Hong Kong
- J — Japan
- K — Korea
- L — Malaysia
- M — Mexico
- N — New Zealand
- P — Australia
- Q — South America (Brazil)
- S — Singapore
- T — Taiwan
- U — South America (unleaded fuel regions)
- V — Vietnam
- Y — Military
- Z — Israel

Revision Level (not printed on label)

- 91-99 — Hardware calibration levels
- 01-04 — Preliminary levels
- 00 — Job 1 production (initial calibration)
- 05-09 — Pre-job 1 revisions to calibrations
- 10-89 — Post-job 1 revisions to calibrations
- 0B — Durability test level
- BD — On-board diagnostics (OBD) intermediate level (pre-05)

SECTION 100-02 Jacking and Lifting

CONTENTS **PAGE**

DESCRIPTION AND OPERATION

Jacking

⚠ WARNING: The electrical power to the air suspension system must be shut down prior to hoisting, jacking or towing an air suspension vehicle. This can be accomplished by turning off the air suspension switch located in the RH kick panel area. Failure to do so may result in unexpected inflation or deflation of the air springs which may result in shifting of the vehicle during these operations.

⚠ WARNING: Do not run the engine when jacking the vehicle. The wheels contacting the ground could cause the vehicle to move.

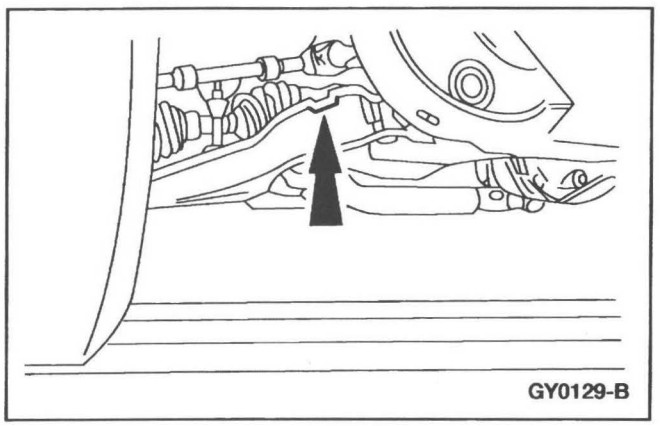
⚠ WARNING: Support the vehicle prior to performing any procedure requiring the vehicle to be jacked off the ground.

⚠ WARNING: Make sure the jack and jack stands are properly located to prevent the vehicle from falling.

⚠ WARNING: Wheel chocks should be used to prevent the vehicle from rolling and falling off the jack.

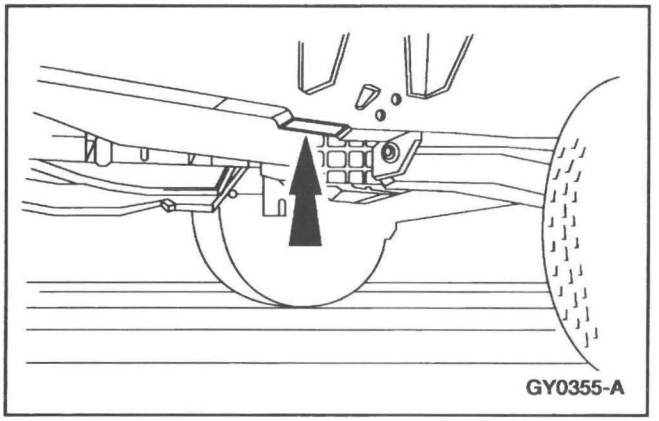
⚠ CAUTION: Never use a halfshaft as a lifting point.

Jacking Points — Front, 4x4



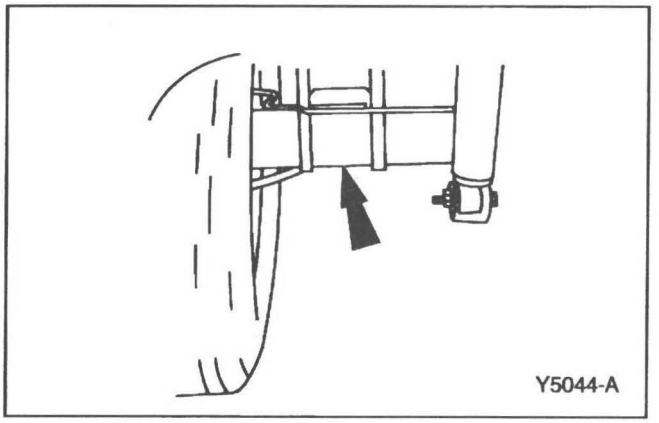
The jacking point is a raised boss located on the front suspension lower arm (3079).

Jacking Points — Front, 4x2



The jacking point is a flat portion on the frame indicated by the arrow cut out. The jacking point is located behind the front tire and wheel assembly.

Jacking Points — Rear



⚠ CAUTION: Never use the differential housing as a lifting point.

The rear jacking points are located on the rear axle (4001).

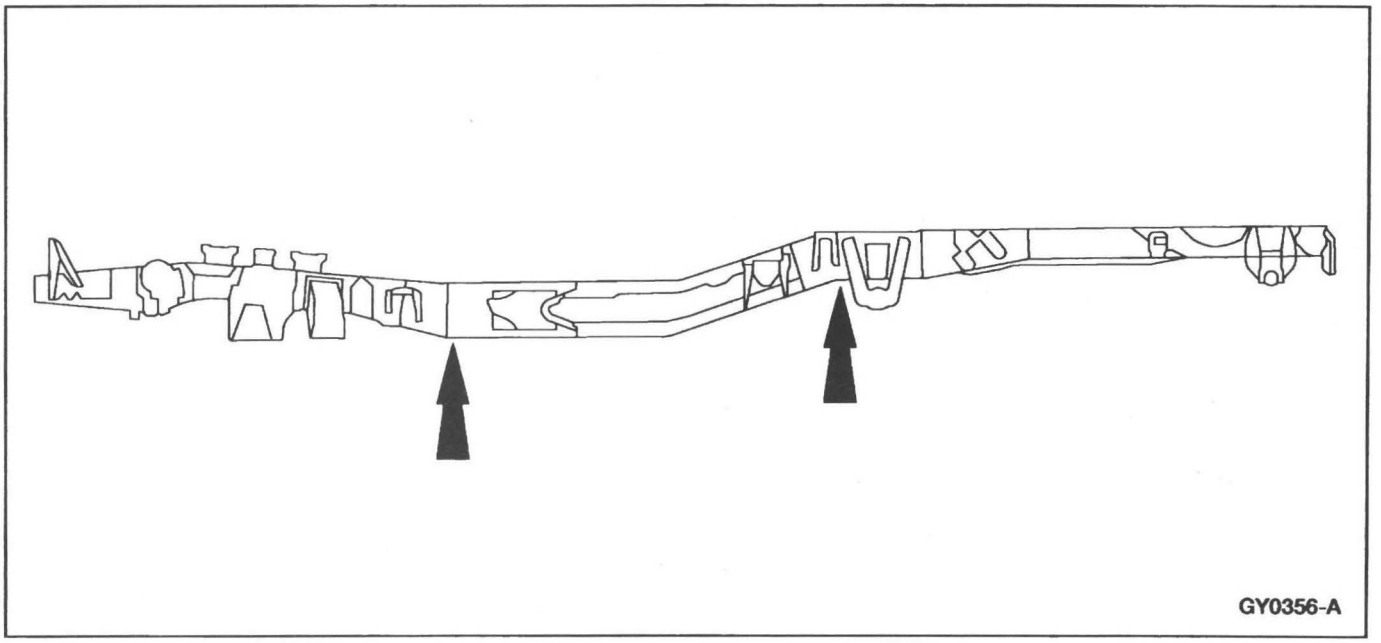
DESCRIPTION AND OPERATION (Continued)

Lifting

⚠ WARNING: The electrical power to the air suspension system must be shut off prior to hoisting, jacking or towing an air suspension vehicle. This can be accomplished by turning off the air suspension switch located in the RH kick panel area. Failure to do so may result in unexpected inflation or deflation of the air spring which may result in shifting of the vehicle during these procedures.

⚠ CAUTION: Damage to suspension, exhaust and steering linkage components may occur if care is not exercised when positioning the hoist adapters prior to lifting the vehicle.

Lifting Points — Twin Post Hoist



Locate the front hoist adapters and rear hoist adapters (top of frame arc) as indicated.

SECTION 100-04 Noise, Vibration and Harshness

CONTENTS **PAGE**

DESCRIPTION AND OPERATION

Noise, Vibration And Harshness (NVH)

Noise is any undesirable sound, usually unpleasant in nature. Vibration is any motion, shaking or trembling, that can be felt or seen when an object moves back and forth or up and down. Harshness is a ride quality issue where the vehicle's response to the road transmits sharply to the customer. Harshness normally describes a firmer than usual response from the suspension system. Noise, vibration and harshness (NVH) is a term used to describe these conditions, which result in varying degrees of dissatisfaction. Although, a certain level of NVH caused by road and environmental conditions is normal. This section is designed to aid in the diagnosis, testing and repair of NVH concerns.

Acceptable Noise, Vibration and Harshness

All internal combustion engines and drivelines produce some noise and vibration; operating in a real world environment adds noise that is not subject to control. Vibration isolators, mufflers and dampers reduce these to acceptable levels. A driver who is unfamiliar with a vehicle can think that some sounds are abnormal when actually the sounds are normal for the vehicle type. For example, Traction-Lok® differentials produce a slight noise on slow turns after extended highway driving. This is acceptable and has no detrimental effect on the locking axle function. As a technician, it is very important to be familiar with vehicle features and know how they relate to NVH concerns and their diagnosis. If, for example, the vehicle has automatic overdrive it is important to test drive the vehicle both in and out of overdrive mode.

Diagnostic Theory

The shortest route to an accurate diagnosis results from:

- system knowledge, including comparison with a known good system.
- system history, including repair history and usage patterns.
- condition history, especially any relationship to repairs or sudden change.
- knowledge of possible sources.
- using a systematic diagnostic method that divides the system into related areas.

The diagnosis and correction of noise, vibration and harshness concerns requires:

- a road or system test to determine the exact nature of the concern.
- an analysis of the possible causes.
- testing to verify the cause.
- repairing any concerns found.
- a road test or system test to make sure the concern has been corrected or brought back to within an acceptable range.

Glossary of Terms

Acceleration-Light
An increase in speed at less than half throttle.

Acceleration-Medium
An increase in speed at half to nearly full throttle, such as 0-97 km/h (0-60 mph) in approximately 30 seconds.

Acceleration-Heavy
An increase in speed at one-half to full throttle, such as 0-97 km/h (0-60 mph) in approximately 20 seconds.

Ambient Temperature
The surrounding or prevailing temperature.

Amplitude
The quantity or amount of energy produced by a vibrating component (G force). An extreme vibration has a high amplitude. A mild vibration has a low amplitude.

Backlash
Gear teeth clearance.

Boom
Low frequency or low pitched noise often accompanied by a vibration. Also refer to Drumming.

Bound Up
An overstressed isolation (rubber) mount that transmits vibration/noise instead of absorbing it.

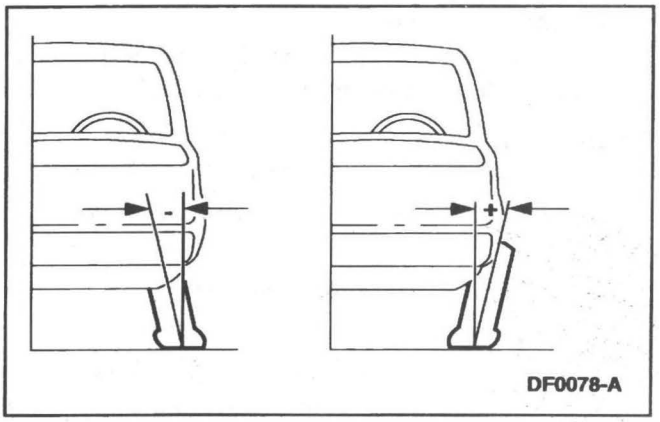
Brakes Applied
When the service brakes are applied with enough force to hold the vehicle against movement with the transmission in gear.

DESCRIPTION AND OPERATION (Continued)

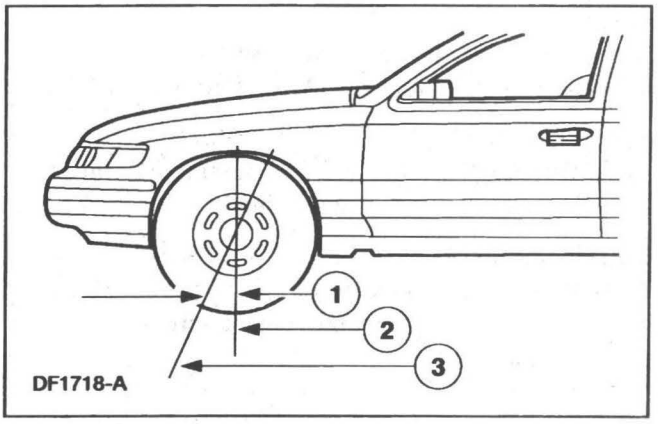
Buffet/Buffeting
Strong noise fluctuations (less than 1000 Hz) caused by gusting winds. An example would be wind gusts against the side glass.

Buzz
A low-pitched sound like (200-5000 Hz) that from a bee. Often a metallic or hard plastic humming sound. Also describes a high frequency (200-800 Hz) vibration. Vibration feels similar to an electric razor.

Camber
The angle of the wheel in relation to the true vertical as measured looking from the front of the vehicle. Camber is positive when the wheel angle is offset so that the top of the wheel is positioned away from the vehicle.



Caster
The angle of the steering knuckle in relation to the true vertical as measured looking from the side of the vehicle.



Item	Description
1	Positive caster
2	True vertical
3	Steering axis

Chatter
A pronounced series of rapidly repeating rattling or clicking sounds.

Chirp
A short-duration high-pitched noise associated with a slipping drive belt.

Chuckle
A repetitious low-pitched sound. A loud chuckle is usually described as a knock.

Click
A sharp, brief, non-resonant sound, similar to actuating a ball point pen.

Clonk
A hydraulic knocking sound. Sound occurs with air pockets in a hydraulic system. Also described as hammering.

Clunk/Driveline Clunk
A heavy or dull, short-duration, low-frequency sound. Occurs mostly on a vehicle that is accelerating or decelerating abruptly. Also described as a thunk.

Coast/Deceleration
Releasing the accelerator pedal at cruise, allowing the engine to reduce vehicle speed without applying the brakes.

Coast/Neutral Coast
Placing the transmission range selector in NEUTRAL (N) or depressing the clutch pedal while at cruise.

Constant Velocity (CV) Joint
A joint used to absorb vibrations caused by driving power being transmitted at an angle.

Controlled Rear Suspension Height
The height at which a designated vehicle element must be when driveline angle measurements are made.

Coupling Shaft
The shaft between the transfer case and the front drive axle or, in a two-piece rear driveshaft, the front section.

CPS
Cycles per second. Same as hertz (Hz).

Cracks
A mid-frequency sound, related to squeak. Sound varies with temperature conditions.

Creak
A metallic squeak.

DESCRIPTION AND OPERATION (Continued)

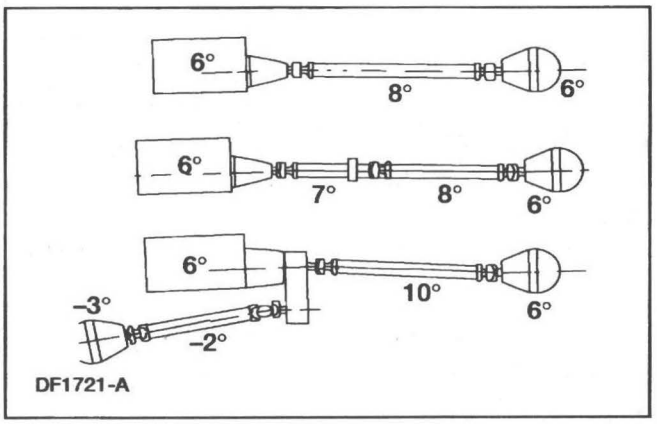
Cruise
Constant speed on level ground; neither accelerating nor decelerating.

Cycle
The process of a vibrating component going through a complete range of motion and returning to the starting point.

Decibel
A unit of measurement, referring to sound pressure level, abbreviated dB.

Drive Engine Run-Up (DERU) Test
The operation of the engine through the normal rpm range with the vehicle standing still, the brakes applied and the transmission engaged. This test is used for noise and vibration checks.

Driveline Angles
The differences of alignment between the transmission output shaft, the driveshaft, and the rear axle pinion centerline.



Driveshaft
The shaft that transmits power to the rear axle input shaft (pinion shaft). In a two-piece driveshaft, it is the rearmost shaft.

Drivetrain
All power transmitting components from the engine to the wheels; includes the clutch or torque converter, the transmission, the transfer case, the driveshaft, and the front or rear drive axle.

Drivetrain Damper
A weight attached to the engine, the transmission, the transfer case, or the axle. It is tuned by weight and placement to absorb vibration.

Drone
A low frequency (100-200 Hz) steady sound, like a freezer compressor. Also described as a moan.

Drumming
A cycling, low-frequency (20-100 Hz), rhythmic noise often accompanied by a sensation of pressure on the ear drums. Also described as a low rumble, boom, or rolling thunder.

Dynamic Balance
The equal distribution of weight on each side of the centerline, so that when the wheel and tire assembly spins, there is no tendency for the assembly to move from side-to-side (wobble). Dynamically unbalanced wheel and tire assemblies can cause wheel shimmy.

Engine Imbalance
A condition in which an engine's center mass is not concentric to the rotation center, causing excessive motion.

Engine Misfire
When combustion in one or more cylinders does not occur or occurs at the wrong time.

Engine Shake
An exaggerated engine movement or vibration that directly increases in frequency as the engine speed increases. It is caused by non-equal distribution of mass in the rotating or reciprocating components.

Flexible Coupling
A flexible joint.

Float
A drive mode on the dividing line between cruise and coast where the throttle setting matches the engine speed with the road speed.

Flutter
Mid to high (100-2000 Hz) intermittent sound due to air flow. Similar to a flag flapping in the wind.

Frequency
The rate at which a cycle occurs within a given time.

Gravelly Feel
A grinding or growl in a component, similar to the feel experienced when driving on gravel.

Grind
An abrasive sound, similar to using a grinding wheel, or rubbing sand paper against wood.

Hiss
Steady high frequency (200-800 Hz) noise. Vacuum leak sound.

Hoot
A steady low frequency tone (50-500 Hz), sounds like blowing over a long neck bottle.

DESCRIPTION AND OPERATION (Continued)

Howl
A mid-range frequency (200-800 Hz) noise between drumming and whine. Also described as a hum.

Hum
Mid-frequency (200-800 Hz) steady sound, like a small fan motor. Also described as a howl.

Hz
Hertz; a frequency measured in cycles per second.

Imbalance
Out of balance; heavier on one side than the other. In a rotating component, imbalance often causes vibration.

Inboard
Toward the centerline of the vehicle.

Intensity
The physical quality of sound that relates to the strength of the vibration (measured in decibels). The higher the sound's amplitude, the higher the intensity and vice versa.

Isolate
To separate the influence of one component to another.

Knock
A heavy, loud, repetitious sound, like a knock on the door.

Moan
A constant, low-frequency (100-200 Hz) tone. Also described as a hum.

Neutral Engine Run-Up (NERU) Test
The operation of the engine through the normal rpm range with the vehicle standing still and the transmission disengaged. This test is used to identify engine related vibrations.

Neutralize/Normalize
To return to an unstressed position. Used to describe mounts. Refer to Bound Up.

Outboard
Away from the centerline of the vehicle.

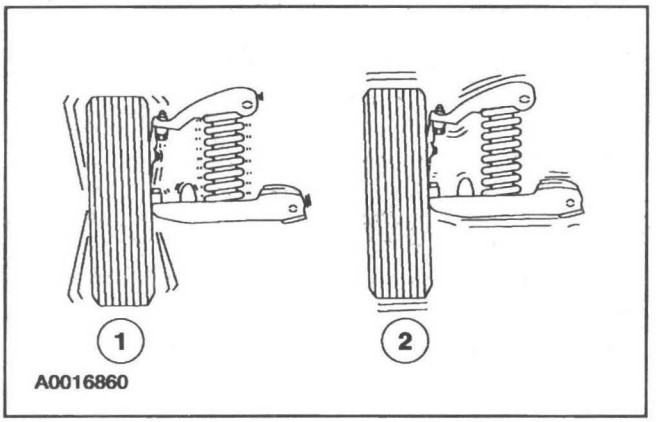
Ping
A short duration, high-frequency sound, which has a slight echo.

Pinion Shaft
The input shaft in a driving axle that is usually a part of the smaller driving or input hypoid gear of a ring and pinion gearset.

Pitch
The physical quality of sound that relates to its frequency. Pitch increases as frequency increases and vice versa.

Pumping Feel
A slow, pulsing movement.

Radial/Lateral
Radial is in the plane of rotation; lateral is at 90 degrees to the plane of rotation.



Item	Description
1	Lateral runout
2	Radial runout

Rattle
A random and momentary or short duration noise.

Ring Gear
The large, circular, driven gear in a ring and pinion gearset.

Road Test
The operation of the vehicle under conditions intended to produce the concern under investigation.

Roughness
A medium-frequency vibration. A slightly higher frequency (20 to 50 Hz) than a shake. This type of vibration is usually related to drivetrain components.

Runout
Lateral runout means measuring the movement or ''wobble'' of a wheel or tire at the sidewall. Radial runout means measuring the out-of-round at the tread surface.

DESCRIPTION AND OPERATION (Continued)

Rustling
Intermittent sound of varying frequency (100-2000 Hz), sounds similar to shuffling through leaves.

Shake
A low-frequency vibration (5-20 Hz), usually with visible component movement. Usually relates to tires, wheels, brake drums or brake discs if it is vehicle speed sensitive, or engine if it is engine speed sensitive. Also referred to as a shimmy or wobble.

Shimmy
An abnormal vibration or wobbling, felt as a side-to-side motion of the steering wheel in the driveshaft rotation. Also described as waddle.

Shudder
A low-frequency vibration that is felt through the steering wheel or seat during light brake application.

Slap
A resonance from flat surfaces, such as safety belt webbing or door trim panels.

Slip Yoke/Slip Spline
The driveshaft coupling that allows length changes to occur while the suspension articulates and while the driveshaft rotates.

Squeak
A high-pitched transient sound, similar to rubbing fingers against a clean window.

Squeal
A long-duration, high-pitched noise.

Static Balance
The equal distribution of weight around the wheel. Statically unbalanced wheel and tire assemblies can cause a bouncing action called wheel tramp. This condition will eventually cause uneven tire wear.

Tap
A light, rhythmic, or intermittent hammering sound, similar to tapping a pencil on a table edge.

Thump
A dull beat caused by two items striking together.

Tick
A rhythmic tap, similar to a clock noise.

Tip-In Moan
A light moaning noise heard during light vehicle acceleration, usually between 40-100 km/h (25-65 mph).

TIR
The acronym for total indicated runout is TIR.

Tire Deflection
The change in tire diameter in the area where the tire contacts the ground.

Tire Flat Spots
A condition commonly caused by letting the vehicle stand while the tires cool off. This condition can be corrected by driving the vehicle until the tires are warm. Also, irregular tire wear patterns in the tire tread resulting from wheel-locked skids.

Tire Force Vibration
A tire vibration caused by variations in the construction of the tire that is noticeable when the tire rotates against the pavement. This condition can be present on perfectly round tires because of variations in the inner tire construction. This condition can occur at wheel rotation frequency or twice rotation frequency.

Transient
A noise or vibration that is momentary, a short duration.

Two-Plane Balance
Radial and lateral balance.

Vibration
Any motion, shaking or trembling, that can be felt or seen when an object moves back and forth or up and down.

Whine
A constant, high-pitched noise. Also described as a screech.

Whistle
High-pitched noise (above 500 Hz) with a very narrow frequency band. Examples of whistle noises are a turbocharger or airflow around an antenna.

Wind Noise
Any noise caused by air movement in, out or around the vehicle.

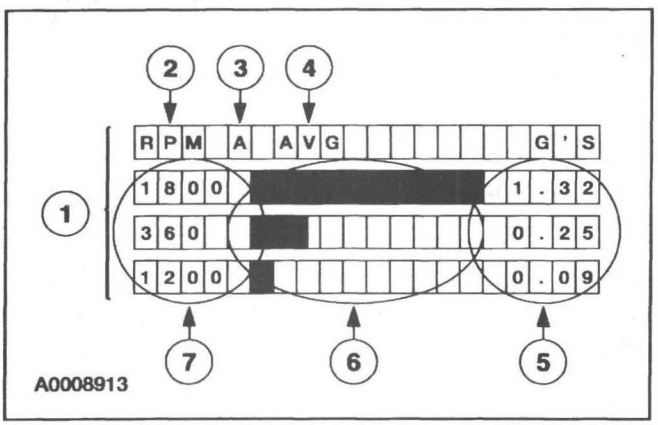
WOT
The acronym for wide open throttle is WOT.

DESCRIPTION AND OPERATION (Continued)

Tools and Techniques

Electronic Vibration Analyzer (EVA)

The EVA is a hand-held electronic diagnostic tool which will assist in locating the source of unacceptable vibrations. The vibration sensor can be remotely mounted anywhere in the vehicle for testing purposes. The unit displays the three most common vibration frequencies and their corresponding amplitudes simultaneously. A bar graph provides a visual reference of the relative signal strength (amplitude) of each vibration being displayed and its relative G force. The keypad is arranged to make the EVA simple to program and use. Some of the functions include the ability to average readings as well as record, play back and freeze readings. The EVA has a strobe balancing function that can be used to detect imbalance on rotating components such as a driveshaft or engine accessories.



Item	Description
1	EVA screen
2	Frequency mode displayed in rpm or Hz
3	Active sensor input (A or B)
4	Current active mode
5	G force indicators or the strongest frequencies in descending strength of each vibration

(Continued)

Item	Description
6	Strength of each vibration
7	Frequency in rpm/Hz of each vibration

The EVA allows for a systematic collection of information that is necessary to accurately diagnose and repair NVH problems. For the best results, carry out the test as follows:

a. Test drive the vehicle with the vibration sensor inside the vehicle.

b. Place the sensor in the vehicle according to feel.
   - — If the condition is felt through the steering wheel, the source is most likely in the front of the vehicle.
   - — A vibration that is felt in the seat or floor only will most likely be found in the driveline, drive axle or rear wheels and tires.

c. Record the readings. Also note when the condition begins, when it reaches maximum intensity, and if it tends to diminish above/below a certain speed.
   - — Frequencies should be read in the "average" mode.
   - — Frequencies have a range of plus or minus 2. A reading of 10 Hz can be displayed as an 8 Hz through 12 Hz.

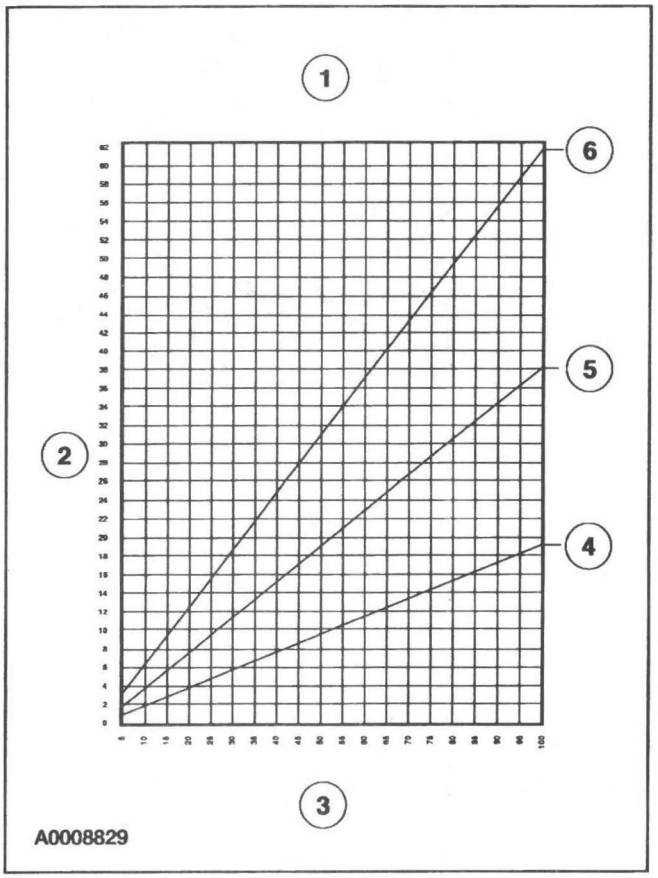
d. Determine what the normal frequency is for the vehicle at a specified speed. Multiply the rear axle ratio by the Hz (1 Hz per every 5 mph). Example: A vehicle travelling 50 mph with a 3.08 rear axle ratio, the acceptable amount of Hz for the vehicle at that speed would be 10 (1 Hz per every 5 mph) X 3.08 (rear axle ratio) = 30.8 Hz.

e. Place the vibration sensor on or near the suspect area outside the vehicle.

f. Continue the road test, driving the vehicle at the speed the symptom occurs, and take another reading.

DESCRIPTION AND OPERATION (Continued)

g. Compare the readings.
   - — A match in frequency indicates the problem component or area.
   - — An unmatched test could indicate the concern is caused by the engine, torque converter, or engine accessory. Use the EVA in the rpm mode and check if concern is rpm related.
   - — Example: A vibration is felt in the seat. Place the sensor on the console. Record the readings. Place the vibration sensor on the rear axle. Compare the readings. If the frequencies are the same, the axle is the problem component. Also refer to the following chart as a reference to acceptable vibration and noise ranges for the specified components.



Item	Description
1	Acceptable vibration ranges for specified components
2	Hertz (Hz)

(Continued)

Item	Description
3	Miles per hour (mph)
4	First order tire (one disturbance for each revolution)
5	Second order tire (two disturbances for each revolution)
6	Driveline

Vibrate Software®

Vibrate Software® (Rotunda tool number 215-00003) is a diagnostic aid which will assist in pinpointing the source of unacceptable vibrations. The engine's crankshaft is the point of reference for vibration diagnosis. Every rotating component will have an angular velocity that is faster, slower, or the same as the engine's crankshaft. Vibrate Software® calculates the angular velocity of each component and graphically represents these velocities on a computer screen and on a printed vibration worksheet. The following steps outline how Vibrate Software® helps diagnose a vibration concern:

- Enter the vehicle information. Vibrate will do all the calculations and display a graph showing tire, driveshaft and engine vibrations.
- Print a Vibration Worksheet graph. The printed graph is to be used during the road test.
- Road test the vehicle at the speed where the vibration is most noticeable. Record the vibration frequency (rpm) and the engine rpm on the worksheet graph. The point on the graph where the vibration frequency (rpm) reading and the engine rpm reading intersect indicates the specific component group causing the concern.
  - — An EVA or equivalent tool capable of measuring vibration frequency and engine rpm will be needed.
- Provide pictures of diagnostic procedures to aid in testing components.

Combination EngineEAR/ChassisEAR

An electronic listening device used to quickly identify noise and the location under the chassis while the vehicle is being road tested. The ChassisEARs can identify the noise and location of damaged/worn wheel bearings, CV joints, brakes, springs, axle bearings or driveshaft carrier bearings.

DESCRIPTION AND OPERATION (Continued)

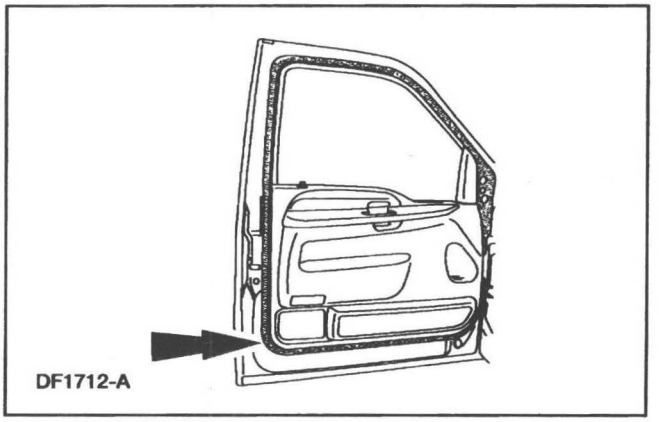
EngineEAR Basic Unit
An electronic listening device used to detect even the faintest noises. The EngineEARs can detect the noise of damaged/worn bearings in generators, water pumps, A/C compressors and power steering pumps. They are also used to identify noisy lifters, exhaust manifold leaks, chipped gear teeth and for detecting wind noise. The EngineEAR has a sensing tip, amplifier, and headphones. The directional sensing tip is used to listen to the various components. Point the sensing tip at the suspect component and adjust the volume with the amplifier. Placing the tip in direct contact with a component will reveal structure-borne noise and vibrations, generated by or passing through, the component. Various volume levels can reveal different sounds.

Ultrasonic Leak Detector
The Ultrasonic Leak Detector is used to detect wind noises caused by leaks and gaps in areas where there is weather-stripping or other sealing material. It is also used to identify A/C leaks, vacuum leaks and evaporative emission noises. The Ultrasonic Leak Detector includes a multi-directional transmitter (operating in the ultrasonic range) and a hand-held detector. The transmitter is placed inside the vehicle. On the outside of the vehicle, the hand-held detector is used to sweep the area of the suspected leak. As the source of the leak is approached, a beeping sound is produced which increases in both speed and frequency.

Squeak and Rattle Repair Kit
The squeak and rattle repair kit (Rotunda tool number 164-R4900) contains lubricants and self-adhesive materials that can be used to eliminate interior and exterior squeaks and rattles. The kit consists of the following materials:

- PVC (soft foam) tape
- Urethane (hard foam) tape
- Flocked (black fuzzy) tape
- UHMW (frosted) tape
- Squeak and rattle oil tube
- Squeak and rattle grease tube

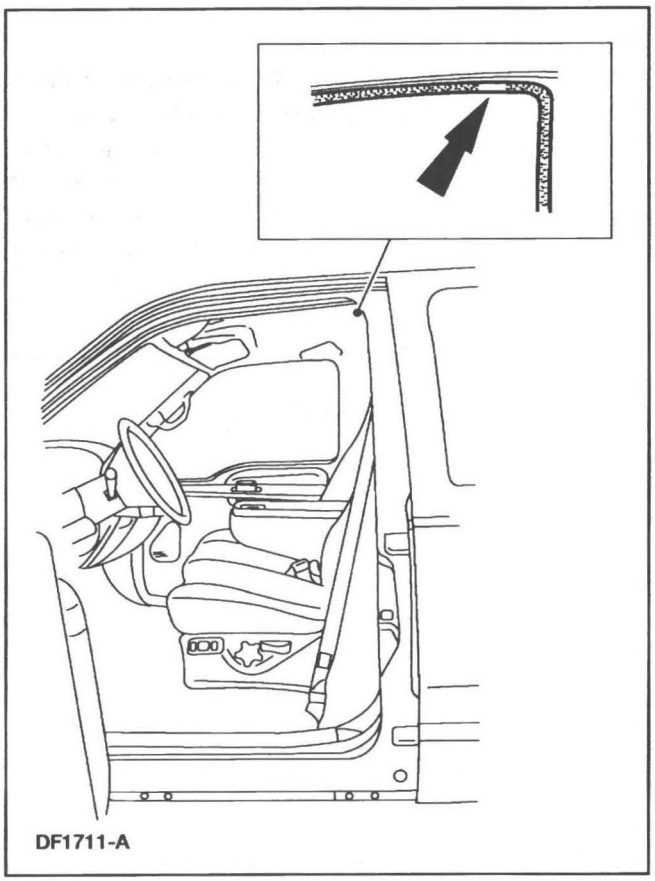
Tracing Powder
Tracing powder is used to check both the uniformity of contact and the tension of a seal against its sealing surface. These tests are usually done when a suspected air leak/noise appears to originate from the seal area or during the alignment and adjustment of a component to a weatherstrip. Tracing powder can be ordered from Crest Industries as ATR Leak Trace. Carry out the tracing powder test as follows:



a. Clean the weatherstrip.
b. Spray the tracing powder on the mating surface only.
c. Close the door completely. Do not slam the door.

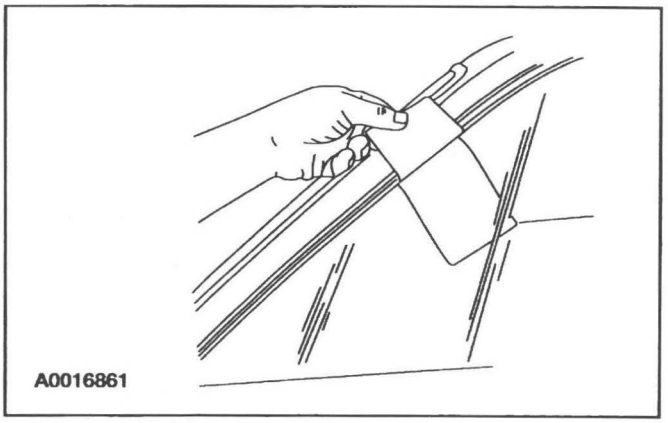
DESCRIPTION AND OPERATION (Continued)

d. Open the door. An imprint is made where the weatherstrip contacted the mating surface seal. Gaps or a faint imprint will show where there is poor contact with the weatherstrip.



Index Card

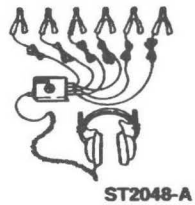
Place an index card or a piece of paper between the weatherstrip and the sealing surface, then close the door. Slowly withdraw the index card or paper after the door is closed and check the amount of pressure on the weatherstrip. There should be a medium amount of resistance as it is withdrawn. Continue around the entire seal area. If there is little or no resistance, this indicates insufficient contact to form a good seal. At these points, the door, the glass, or the weatherstrip is out of alignment.



DIAGNOSIS AND TESTING

Noise, Vibration And Harshness (NVH)

Special Tool(s)

 ST2048-A	ChassisEAR 107-R2102 or equivalent
 ST2311-A	Electronic Vibration Analyzer 100-F027 (014-00344) or equivalent
 ST2312-A	EngineEAR 107-R2100 or equivalent
 ST2314-A	Ultrasonic Leak Detector 134-R0135 or equivalent

To assist the service advisor and the technician, a Write-up Job Aid and an NVH Diagnostic Guide are included with this material. The Write-up Job Aid serves as a place to record all important symptom information. The NVH Diagnostic Guide serves as a place to record information reported on the Write-up Job Aid as well as data from the testing to be carried out.

DIAGNOSIS AND TESTING (Continued)

To begin a successful diagnosis, fill out the NVH Diagnostic Guide, record the reported findings, then proceed to each of the numbered process steps to complete the diagnosis.

"WRITE-UP" JOB AID

REPAIR ORDER #_____

CUSTOMER CONCERN #_____

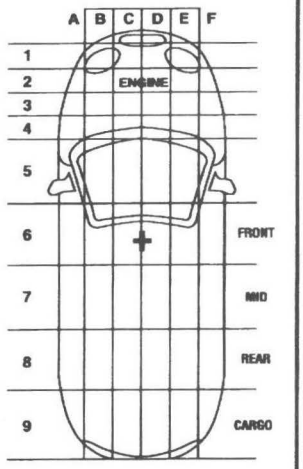
SPECIFIC SENSE IDENTIFICATION AND LOCATION ON VEHICLE OF CUSTOMER SYMPTOM(S)

INSTRUCTIONS: Check below sense affected and location of concern on the generic vehicle illustration (darken the vehicle area). Plus circle appropriate responses to the right.

NOTE: Shaded backgrounds indicate caution areas. Selection of two or more caution areas "flag" difficult repairs. In general, shaded areas are the more difficult to verify and repair, and require all applicable columns to be completed.

SEE YES ☐ FEEL YES ☐

HEAR YES ☐ SMELL YES ☐



VEHICLE SYMPTOM AREA	HOW OFTEN?	VEHICLE OPERATING MODE	VEHICLE CONDITIONS	VEHICLE SPEED (mph)	WHEN VEHICLE IS:	AMBIENT CONDITION
Front of Vehicle	Always	Start Up	Accessories On	0	Turning Left	____° Below Zero
Engine Compartment	Daily A.M. P.M.	Idle	(define below)	1-9	Turning Right	Below Freezing (0°-19°)
Dash	Conditional	Gear Selection	Windows Open	10-19	Over Bumps	Below Freezing (20°-32°)
Steering Wheel	Weekly	Accel Light	4x4	20-29	Up Hills	33°-49°
Accelerator Pedal	Monthly	Accel Moderate	Hauling	30-39	Down Hills	50°-69°
Brake Pedal	Intermittent	Accel Heavy	Towing	40-49	Shifting	70°-89°
Clutch Pedal	Unknown	Steady Speed	Snow Plowing	50-59	Parked	90°+
Seat		Deceleration	Other	60-69	In Traffic	Sunny
Rear of Vehicle		Neutral	(define below)	70+		Dry
Top of Vehicle		Reverse		ENGINE		Windy
Floor Pan		Stopping/Braking		TEMP		Wet/Humid
Under Vehicle				Cold		Rain
Other (define below)				Normal		Snow
				Hot		Ice

DEALER VERIFICATION

	YES	NO
SERVICE ADVISOR	☐	☐
SHOP FOREMAN	☐	☐
SERVICE MANAGER	☐	☐
QC MANAGER	☐	☐
TECHNICIAN	☐	☐
VERIFIED WITH CUSTOMER	☐	☐

WHAT THE CUSTOMER SAID

OASIS SYMPTOM CODE(S) ☐☐☐☐☐☐ ☐☐☐☐☐☐

VIN NUMBER ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

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DIAGNOSIS AND TESTING (Continued)

NVH DIAGNOSTIC GUIDE

Dealer: _____ Date: _____

P.A. Code: _____ Order No. _____ Technician: _____

Owner's Name: _____ Address: _____

Phone No. Home: _____ Work: _____

Vehicle Make: _____ Model: _____ Year: _____

VIN: _____ Mileage: _____ Engine: _____ Trans: _____ Axle: _____

OWNER'S DESCRIPTION OF COMPLAINT:

Did Condition Exist When Vehicle Was New? **Yes / No** (circle one)

How Did Condition Begin? Gradually ☐ Suddenly ☐

At What Mileage Did It Occur Or Begin Occuring? _____

Which Driving Conditions Affect The Vehicle?

Light Accel ☐ Closed Throttle Decel ☐ Brakes Applied/Released ☐

Medium Accel ☐ Coast (Float) ☐ Driving The Vehicle: Straight ☐

Heavy Accel ☐ Constant Speed ☐ Cornering ☐

Is Vibration Noticed? If So, Where:

Seat ☐ Steering Wheel ☐ Instrument Panel ☐ Floor ☐ Body Panels ☐ Ft/Rr of Vehicle ☐

Is There Sound Or Sensation Of Sound? **Yes / No** (circle one)

If So, Describe The Sound :

Boom ☐ Hum ☐ Whine ☐ Growl ☐ Other: _____

Drone ☐ Tip-In-Moan ☐ Squeak ☐ Rattle ☐

PREDRIVE CHECKS

Tire Condition/Pressure: _____

Vehicle Body Damage? _____

Other: _____

ROAD TEST:

Vibration/Noise Occurs:

Vehicle Speed _____ Accel _____ Vibration Frequency _____ Hz/RPM

Gear Range _____ Decel/Coast _____ Engine Speed _____ RPM

ENGINE RUN-UP TESTS

Neutral Engine Run-Up (NERU) **Yes / No** Engine RPM _____ Vibration/Frequency _____ Hz/RPM

Drive Engine Run-Up (DERU) **Yes / No** Engine RPM _____ Vibration/Frequency _____ Hz/RPM

Drivetrain Run-Up (DTRU) **Yes / No** Engine RPM _____ Vibration/Frequency _____ Hz/RPM

Indicate Suspected Area of Concern:

Tire/Wheel/Brakes ☐ Engine/Accessory ☐ Rear ☐

Driveline/Axle ☐ Susp/Steering ☐ Right ☐

Body ☐ Front ☐ Left ☐

Other _____

Equipment Used:

Reed Tachometer ☐ Electronic Noise Detector ☐ Tape ☐

Engine Tachometer ☐ Ultrasonic Leak Detector ☐ Other _____

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DIAGNOSIS AND TESTING (Continued)

WHEEL/TIRE/BRAKES CHECK:

Balance Check **Yes / No**

Maximum Runout Allowed:

Wheel: Radial _____ Lateral _____

Tire: Radial _____ Lateral _____

Measured Runout:

Tire/Wheel	Radial:	LF _____	LR _____	RF _____	RR _____
	Lateral:	LF _____	LR _____	RF _____	RR _____
Wheel Only	Radial:	LF _____	LR _____	RF _____	RR _____
	Lateral:	LF _____	LR _____	RF _____	RR _____

SUSPENSION INSPECTION:

Can Cause: Shimmy ☐ Clunk ☐ Squeak ☐ Harshness ☐

Suspension Bushings: Loose ☐ Worn ☐ Missing ☐ OK ☐

Front Upper Control Arm ☐ Stabilizer (sway bar) ☐ Rear Lower Control Arm ☐

Front Lower Control Arm ☐ Rear Upper Control Arm ☐ Rear Upper Control Arm ☐

Other _____

Suspension/Steering Components:	Loose	Worn	Missing	OK
Ball Joints	☐			
Shock Absorbers F/R	☐			
Springs F/R	☐			
Idler Arm	☐			
Center Link	☐			
Tie Rod Ends/Sleeve	☐			
Pitman Arm	☐			
Steering Gear	☐			
Steering Coupler	☐			

DRIVESHAFT CONDITION: Noise ☐ Vibration ☐

Balance Weights Missing/Other Visual Defects? **Yes / No**

Maximum Allowable Runout: _____

Actual Runout: Front _____ Middle _____ Rear _____

Two-Piece Driveshaft Runout: Front _____ Rear _____

Middle Support Bearing: Loose ☐ Damaged ☐ Worn ☐ Other _____

Suspect Driveshaft Balanced? **Yes / No**

Pinion Angle: Engine Height: Specification _____ Actual _____

Pinion Angle: Specification _____ Actual _____

Driveline Angle - Truck: Specification _____ Actual _____

ENGINE/ACCESSORY CHECK:

Visual Inspection for Damage or Grounded Condition:

Powertrain Mounts ☐ Fuel Lines ☐ A/C Lines ☐ Power Steering/Cooler Lines ☐

Air Intake ☐ Accessories ☐ Exhaust ☐ Radiator/Condensor ☐

BODY (NOISE/RATTLE)

Indicate Suspected Area of Concern: Doors ☐ Windows ☐ Dash Panel ☐ Other _____

Tests Used to Isolate

NVH Concern: Vacuum/Leak Detector ☐ Ultrasonic Leak Detector ☐ Tracing Powder ☐

Electronic Noise Detector ☐ Other _____

ROAD/ENGINE RUN-UP TESTS: Improved? **Yes / No** Vehicle Acceptable? **Yes / No**

Comments: _____

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DIAGNOSIS AND TESTING (Continued)

1: Customer Interview

The diagnostic process starts with the customer interview. The service advisor must obtain as much information as possible about the problem and take a test drive with the customer. There are many ways a customer will describe NVH concerns and this will help minimize confusion arising from descriptive language differences. It is important that the concern is correctly interpreted and the customer descriptions are recorded. During the interview, ask the following questions:

- When was it first noticed?
- Did it appear suddenly or gradually?
- Did any abnormal occurrence coincide with or proceed its appearance?

Use the information gained from the customer to accurately begin the diagnostic process.

2: Pre-Drive Check

It is important to do a pre-drive check before road testing the vehicle. A pre-drive check verifies that the vehicle is relatively safe to drive and eliminates any obvious faults on the vehicle.

The pre-drive check consists of a brief visual inspection. During this brief inspection, take note of anything that will compromise safety during the road test and make those repairs/adjustments before taking the vehicle on the road.

3: Preparing for the Road Test

Observe the following when preparing for the road test:

- Review the information recorded on the NVH Diagnostic Guide. It is important to know the specific concern the customer has with the vehicle.
- Do not be misled by the reported location of the noise/vibration. The cause can actually be some distance away.
- Remember that the vibrating source component (originator) may only generate a small vibration. This small vibration can in turn cause a larger vibration/noise to emanate from another receiving component (reactor), due to contact with other components (transfer path).
- Conduct the road test on a quiet street where it is safe to duplicate the vibration/noise. The ideal testing route is an open, low-traffic area where it is possible to operate the vehicle at the speed in which the condition occurs.
- If possible, lower the radio antenna in order to minimize turbulence. Identify anything that could potentially make noise or be a source of wind noise. Inspect the vehicle for add-on items that create vibration/noise. Turn off the radio and the heating and cooling system blower.
- The engine speed is an important factor in arriving at a final conclusion. Therefore, connect an accurate tachometer to the engine, even if the vehicle has a tachometer. Use a tachometer that has clearly defined increments of less than 50 rpm. This ensures an exact engine speed reading.

4: Verify the Customer Concern

Verify the customer concern by carrying out a road test, an engine run-up test, or both.

The decision to carry out a road test, an engine run-up test, or both depends on the type of NVH concern. A road test may be necessary if the symptom relates to the suspension system or is sensitive to torque. A drive engine run-up (DERU) or a neutral engine run-up (NERU) test identifies noises and vibrations relating to engine and drivetrain rpm. Remember, a condition will not always be identifiable by carrying out these tests, however, they will eliminate many possibilities if carried out correctly.

DIAGNOSIS AND TESTING (Continued)

5: Road Test

NOTE: It may be necessary to have the customer ride along or drive the vehicle to point out the concern. During the road test, take into consideration the customer's driving habits and the driving conditions. The customer's concern just may be an acceptable operating condition for that vehicle.

The following is a brief overview of each test in the order in which it appears. A review of this information helps to quickly identify the most appropriate process necessary to make a successful diagnosis. After reviewing this information, select and carry out the appropriate test(s), proceeding to the next step of this process.

- The Slow Acceleration Test is normally the first test to carry out when identifying an NVH concern, especially when a road test with the customer is not possible.
- The Heavy Acceleration Test helps to determine if the concern is torque-related.
- The Neutral Coast Down Speed Test helps to determine if the concern is vehicle speed-related.
- The Downshift Speed Test helps to determine if the concern is engine speed-related.
- The Steering Input Test helps to determine how the wheel bearings and other suspension components contribute to a vehicle speed-related concern.
- The Brake Test helps to identify vibrations or noise that are brake related.
- The Road Test Over Bumps helps isolate a noise that occurs when driving over a rough or bumpy surface.
- The Engine Run-Up Tests consist of the Neutral Run-Up Test and the Engine Load Test. These tests help to determine if the concern is engine speed-related.
- The Neutral Run-Up Test is used as a follow-up test to the Downshift Speed Test when the concern occurs at idle.
- The Engine Load Test helps to identify vibration/noise sensitive to engine load or torque. It also helps to reproduce engine speed-related concerns that cannot be duplicated when carrying out the Neutral Run-Up Test or the Neutral Coast Down Test.
- The Engine Accessory Test helps to locate faulty belts and accessories that cause engine speed-related concerns.
- The Vehicle Cold Soak Procedure helps to identify concerns occurring during initial start-up and when an extended time lapse occurs between vehicle usage.

Slow Acceleration Test

To carry out this test, proceed as follows:

- Slowly accelerate to the speed where the reported concern occurs. Note the vehicle speed, the engine rpm and, if possible, determine the vibration frequency.
- Attempt to identify from what part of the vehicle the concern is coming.
- Attempt to identify the source of the concern.
- Proceed as necessary.

Heavy Acceleration Test

To carry out this test, proceed as follows:

- Accelerate hard from 0-64 km/h (0-40 mph).
- Decelerate in a lower gear.
- The concern is torque related if duplicated while carrying out this test.
- Proceed as necessary.

Neutral Coast Down Speed Test

To carry out this test, proceed as follows:

- Drive at a higher rate of speed than where the concern occurred when carrying out the Slow Acceleration Test.
- Place the transmission in NEUTRAL and coast down past the speed where the concern occurs.
- The concern is vehicle speed-related if duplicated while carrying out this test. This eliminates the engine and the torque converter as sources.
- If the concern was not duplicated while carrying out this test, carry out the Downshift Speed Test to verify if the concern is engine speed related.
- Proceed as necessary.

Downshift Speed Test

To carry out this test, proceed as follows:

- Shift into a lower gear than the gear used when carrying out the Slow Acceleration Test.
- Drive at the engine rpm where the concern occurs.

DIAGNOSIS AND TESTING (Continued)

- The concern is engine speed related if duplicated while carrying out this test. This eliminates the tires, wheels, brakes and the suspension components as sources.
- If necessary, repeat this test using other gears and NEUTRAL to verify the results.
- Proceed as necessary.

Steering Input Test

To carry out this test, proceed as follows:

- Drive at the speed where the concern occurs, while making sweeping turns in both directions.
- If the concern goes away or gets worse, the wheel bearings, hubs, U-joints (contained in the axles of 4WD applications), and tire tread wear are all possible sources.
- Proceed as necessary.

Brake Test

To carry out this test, proceed as follows:

- Warm the brakes by slowing the vehicle a few times from 80-32 km/h (50-20 mph) using light braking applications. At highway speeds of 89-97 km/h (50-60 mph), apply the brake using a light pedal force.
- Accelerate to 89-97 km/h (55-60 mph).
- Lightly apply the brakes and slow the vehicle to 30 km/h (20 mph).
- A brake vibration noise can be felt in the steering wheel, seat or brake pedal. A brake noise can be heard upon brake application and diminish when the brake is released.

Road Test Over Bumps

To carry out this test, proceed as follows:

- Drive the vehicle over a bump or rough surface one wheel at a time to determine if the noise is coming from the front or the back and the left or the right side of the vehicle.
- Proceed as necessary.

Neutral Engine Run-Up (NERU) Test

To carry out this test, proceed as follows:

- Install a tachometer.
- Increase the engine rpm up from an idle to approximately 4000 rpm while in PARK on front wheel drive vehicles with automatic transmissions, or NEUTRAL for all other vehicles. Note the engine rpm and, if possible, determine the vibration frequency.
- Attempt to identify what part of the vehicle the concern is coming from.
- Attempt to identify the source of the concern.
- Proceed as necessary.

Drive Engine Run-Up (DERU) Load Test

To carry out this test, proceed as follows:

- ⚠ **WARNING: Block the front and rear wheels, and apply the parking brake and the service brake, or injury to personnel can result.**

⚠ **CAUTION: Do not carry out the Engine Load Test for more than five seconds or damage to the transmission or transaxle can result.**
Block the front and rear wheels.

- Apply the parking brake and the service brake.
- Install a tachometer.
- Shift the transmission into DRIVE, and increase and decrease the engine rpm between an idle to approximately 2000 rpm. Note the engine rpm and, if possible, determine the vibration frequency.
- Repeat the test in REVERSE.
- If the vibration/noise is duplicated when carrying out this test, inspect the engine and transmission or transaxle mounts.
- If the concern is definitely engine speed-related, carry out the Engine Accessory Test to narrow down the source.
- Proceed as necessary.

DIAGNOSIS AND TESTING (Continued)

Engine Accessory Test

To carry out this test, proceed as follows:

- ⚠ **WARNING: Block the front and rear wheels, and apply the parking brake and the service brake, or injury to personnel can result.**

⚠ **CAUTION: Limit engine running time to one minute or less with belts removed or serious engine damage will result.**

NOTE: A serpentine drive belt decreases the usefulness of this test. In these cases, use a electronic vibration analyzer, such as the electronic vibration analyzer (EVA), to pinpoint accessory vibrations. An electronic listening device, such as an EngineEAR, will also help to identify noises from specific accessories.
Remove the accessory drive belts.

- Increase the engine rpm to where the concern occurs.
- If the vibration/noise is duplicated when carrying out this test, the belts and accessories are not sources.
- If the vibration/noise was not duplicated when carrying out this test, install each accessory belt, one at a time, to locate the source.

Vehicle Cold Soak Procedure

To carry out this procedure, proceed as follows:

- Test preparations include matching customer conditions (if known). If not known, document the test conditions: gear selection and engine rpm. Monitor the vibration/noise duration with a watch for up to three minutes.
- Park the vehicle where testing will occur. The vehicle must remain at or below the concern temperature (if known) for 6-8 hours.
- Before starting the engine, conduct a visual inspection under the hood.
- Turn the key on, but do not start the engine. Listen for the fuel pump, anti-lock brake system (ABS) and air suspension system noises.
- Start the engine.
- ⚠ **CAUTION: Never probe moving parts.**

  Isolate the vibration/noise by carefully listening. Move around the vehicle while listening to find the general location of the vibration/noise. Then, search for a more precise location by using a stethoscope or EngineEAR.
- Refer to Idle Noise/Vibration in the Symptom Chart to assist with the diagnosis.

6: Check OASIS/TSBs/Repair History

After verifying the customer concern, check for OASIS reports, TSBs and the vehicle repair history for related concerns. If information relating to a diagnosis/repair is found, carry out the procedure(s) specified in that information.

If no information is available from these sources, carry out the vehicle preliminary inspection to eliminate any obvious faults.

7: Diagnostic Procedure

Qualifying the concern by the particular sensation present can help narrow down the concern. Always use the ''symptom'' to ''system'' to ''component'' to ''cause'' diagnosis technique. This diagnostic method divides the problem into related areas to correct the customer concern.

- Verify the ''symptom''.
- Determine which ''system(s)'' can cause the ''symptom''.
  - — If a vibration concern is vehicle speed related, the tire and wheel rpm/frequency or driveshaft frequency should be calculated.
  - — If a vibration concern is engine speed related, the engine, engine accessory or engine firing frequencies should be calculated.
- After determining the ''system'', use the diagnostic tools to identify the worn or damaged ''components''.
- After identifying the ''components'', try to find the ''cause'' of the failure.

DIAGNOSIS AND TESTING (Continued)

Once the concern is narrowed down to a symptom/condition, proceed to NVH Condition and Symptom Categories.

NVH Condition and Symptom Categories

A good diagnostic process is a logical sequence of steps that lead to the identification of a causal system. Use the condition and symptom categories as follows:

- Identify the operating condition that the vehicle is exhibiting.
- Match the operating condition to the symptom.
- Verify the symptom.
- Identify which category or system could cause the symptom.
- Refer to the diagnostic symptom chart that is referred to.

Operating Condition—Vehicle is Not Moving

1. Static operation
   - Noise occurs during component/system functioning. GO to **Symptom Chart — Squeak and Rattle**.
2. While cranking
   1 Grinding or whine, differential ring gear or starter motor pinion noise. GO to **Symptom Chart — Engine Noise/Vibration**.
   2 Rattle. Exhaust hanger, exhaust heat shield or A/C line noise. GO to **Symptom Chart — Squeak and Rattle**.
   3 Vibration. Acceptable condition.
3. At idle
   - Idle noise. GO to **Symptom Chart — Idle Noise/Vibration**.
   - Idle vibration or shake. GO to **Symptom Chart — Idle Noise/Vibration**.
4. During Gear Selection
   1 Vehicle parked on a steep incline. Acceptable noise.
   2 Vehicle parked on a flat surface. GO to **Symptom Chart — Driveline Noise/Vibration**.
   3 Vehicle with a manual transmission. GO to **Symptom Chart — Transmission (Manual) and Transfer Case Noise/Vibration**.

Operating Condition—Vehicle is Moving

1. Depends more on how the vehicle is operated
   1 Speed related
   - Related to vehicle speed
     — Pitch increases with vehicle speed. GO to **Symptom Chart — Tire Noise/Vibration**.
     — Noise occurs at specific vehicle speed. A high-pitched noise (whine). GO to **Symptom Chart — Driveline Noise/Vibration**.
     — Loudness proportional to vehicle speed. Low-frequency noise at high speeds, noise and loudness increase with speed. GO to **Symptom Chart — Driveline Noise/Vibration**.
     — A low-pitched noise (drumming). GO to **Symptom Chart — Engine Noise/Vibration**.
     — Vibration occurs at a particular speed (mph) regardless of acceleration or deceleration. GO to **Symptom Chart — Tire Noise/Vibration**.
     — Noise varies with wind/vehicle speed and direction. GO to **Symptom Chart — Air Leak and Wind Noise**.
   - Related to engine speed.
     — Noise varies with engine rpm. GO to **Symptom Chart — Engine Noise/Vibration**.
     — Vibration occurs at a particular speed (mph) regardless of engine speed (rpm).
   2 Acceleration
   - Wide open throttle (WOT)
     — Engine induced contact between components. Inspect and repair as necessary.
     — Noise is continuous throughout WOT. Exhaust system or engine ground out. GO to **Symptom Chart — Engine Noise/Vibration**.

DIAGNOSIS AND TESTING (Continued)

- Light/moderate acceleration
  - — Tip-in moan. Engine/exhaust noise. GO to **Symptom Chart — Engine Noise/Vibration.**
  - — Knock-type noise. GO to **Symptom Chart — Engine Noise/Vibration.**
  - — Driveline shudder. GO to **Symptom Chart — Driveline Noise/Vibration.**
  - — Engine vibration. GO to **Symptom Chart — Engine Noise/Vibration.**

3 Turning noise GO to **Symptom Chart —Steering Noise/Vibration.**

4 Braking
- Clicking sound is signaling ABS is active. Acceptable ABS sound.
- A continuous grinding/squeal. GO to **Symptom Chart — Brake Noise/Vibration.**
- Brake vibration/shudder. GO to **Symptom Chart — Brake Noise/Vibration.**

5 Clutching
- A noise occurring during clutch operation. GO to **Symptom Chart — Transmission (Manual) and Transfer Case Noise/Vibration.**
- Vibration. GO to **Symptom Chart — Transmission (Manual) and Transfer Case Noise/Vibration.**

6 Shifting
- Noise or vibration condition related to the transmission (automatic). GO to **Symptom Chart — Transmission (Automatic) Noise/Vibration.**
- Noise or vibration related to the transmission (manual). GO to **Symptom Chart — Transmission (Manual) and Transfer Case Noise/Vibration.**

7 Engaged in four-wheel drive. GO to **Symptom Chart — Transmission (Manual) and Transfer Case Noise/Vibration.**

8 Cruising speeds
- Accelerator pedal vibration. GO to **Symptom Chart — Engine Noise/Vibration.**
- Driveline vibration. GO to **Symptom Chart — Driveline Noise/Vibration.**
- A shimmy or shake. GO to **Symptom Chart — Tire Noise/Vibration.**

9 Driving at low/medium speeds
- A wobble or shudder. GO to **Symptom Chart — Tire Noise/Vibration.**

2. Depends more on where the vehicle is operated

1 Bump/pothole, rough road or smooth road. GO to **Symptom Chart — Suspension Noise/Vibration.**
- Noise is random or intermittent occurring from road irregularities. GO to **Symptom Chart — Squeak and Rattle.**
- Noise or vibration changes from one road surface to another. Normal sound changes.
- Noise or vibration associated with a hard/firm ride. GO to **Symptom Chart — Suspension Noise/Vibration.**

Symptom Charts

Symptom Chart — Air Leak and Wind Noise

Condition	Possible Sources	Action
• Air leak around door perimeter	• Loose fit seal.	• PINCH the seal carrier to improve retention on the seal flange.
	• Seal installed incorrectly.	• REINSTALL the seal.
	• Door misaligned.	• REALIGN the door. CHECK door gaps and fit in the door opening and ADJUST as necessary.
	• Scuff plate installed incorrectly.	• REINSTALL the scuff plate.
	• Seal or seal push pins damaged.	• INSTALL a new seal.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Air Leak and Wind Noise (Continued)

Condition	Possible Sources	Action
• Air leak around glass run	• Door glass misaligned. • Glass run installed incorrectly. • Leak path behind glass run. • Glass run channel spread wide. • Blow-out clip bent or contacting door glass. • Glass run damaged.	• ADJUST the door glass. • ADJUST the glass run. INSERT foam in the glass run carrier. • INSTALL foam rope behind the glass run. • PINCH the glass run channel to reduce the size of the opening. • ADJUST the blow-out clip or INSTALL a new glass run/blow-out clip molding assembly. • INSTALL a new glass run.
• Air leak at inner belt line	• Belt line seal installed incorrectly on flange. • Belt line seal integrated with door trim installed incorrectly (no glass contact). • No contact with side glass. • No contact with glass runs at both ends of belt line seal. • Belt line seal damaged.	• ADJUST the seal. (Do not bend the flange.) • REINSTALL the door trim. • ADJUST the door glass. • ADJUST the belt line seal or ADD foam at the seal ends. • INSTALL a new seal.
• Air leak at outer belt line	• Belt line seal installed incorrectly on flange (no glass contact). • Belt line seal does not contact the glass. • No contact with glass runs at both ends of belt line seal. • Belt line seal damaged.	• ADJUST the seal. • ADJUST the door glass. • ADJUST the belt line seal/ADD foam at the seal ends. • INSTALL a new seal.
• Draft at inner door handle/speaker opening	• Hole in watershield. • Watershield misaligned. • Exterior door handle seal misaligned/damaged.	• SEAL the hole with a suitable tape. • REALIGN the watershield. INSTALL a new watershield if the pressure sensitive adhesive fails. • REALIGN or INSTALL a new seal as necessary.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Air Leak and Wind Noise (Continued)

Condition	Possible Sources	Action
• Wind noise from side view mirror	• Outside mirror housing misaligned. • Mirror sail gasket folded/misaligned. • Mirror housing trim cap installed incorrectly. • Air leak through mirror housing hinge. • Inner sail trim installed incorrectly. • Inner sail gasket/barrier installed incorrectly. • Air path through wiring bundle/fastener access holes. • Exposed fastener access hole on mirror housing/sail.	• REALIGN with the edges shingled correctly and no gaps. • REINSTALL with the gasket unfolded and aligned correctly. • REINSTALL with the edges shingled to the air flow. • Fully ENGAGE the mirror into its operating position/USE foam to block the air path through the hinge. • REINSTALL the sail trim/ADJUST the door trim. • REINSTALL the trim cover with the gasket/barrier aligned correctly. • BLOCK the air path(s) with foam/tape. • INSTALL a new cap if it is missing.
• Air leak around perimeter of fixed glass	• Gaps in the sealant bead. • Air traveling up windshield molding along A-pillar. • Windshield/backlite misaligned or not installed correctly. • Rear hood seal at base of windshield misaligned/damaged.	• APPLY approved sealant. • INSTALL foam rope the full length of the A-pillar. • REINSTALL the windshield/backlite. • REALIGN or INSTALL a new seal as necessary.
• Air leak at cowl	• Cowl gasket misaligned/damaged.	• REALIGN or INSTALL a new seal as necessary.
• Air leak around liftgate perimeter	• Loose fit seal. • Seal misaligned. • Liftgate misaligned. • Scuff plate misaligned. • Seal or seal push pins damaged.	• PINCH the seal carrier to improve retention on the seal flange or INSERT foam in the carrier. • REINSTALL the seal. • REALIGN the liftgate. CHECK the liftgate fit in the body opening and ADJUST as necessary. • REINSTALL the scuff plate. • INSTALL a new seal.
• Air leak around the liftgate flip window perimeter	• Loose fit seal. • Seal misaligned. • Glass misaligned. • Seal damaged.	• PINCH the seal carrier to improve the retention to the seal flange. • REINSTALL the seal. • REALIGN the glass. • INSTALL a new seal.
• Wind noise from antenna	• Shape of antenna. • Air leak around antenna cable access hole.	• INSTALL an antenna boot or a spiral antenna. • INSPECT the antenna access hole grommet. REPAIR as necessary.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Air Leak and Wind Noise (Continued)

Condition	Possible Sources	Action
• Air leak from closed roof opening panel	• Seal installed incorrectly. • Roof opening panel glass/door misaligned. • Roof opening panel damaged.	• REINSTALL the seal. • REALIGN the roof opening panel glass/door. • INSTALL a new roof opening panel.
• Buffeting from an open roof opening panel	• Wind deflector inoperative/damaged. • Wind deflector height incorrect.	• REPAIR or INSTALL a new wind deflector as necessary. • ADJUST the wind deflector higher.
• Wind noise created by airflow over or behind body panels	• Fender splash shield misaligned. • Body panel misaligned (exposed edge). • Hood misaligned (front margin). • Front grille edge noise.	• REALIGN the fender splash shield. • REALIGN the appropriate body panel. • CHECK hood gaps and fit. ADJUST the hood as necessary. • APPLY foam in the hollow areas behind the louvers.
• Wind noise created by grille opening panel	• Grille relationship to leading edge on hood. • Sharp edges due to material imperfections.	• ADJUST the grille opening panel forward to eliminate wind noise. • REMOVE the sharp edges (no damage to visible surface).
• Wind noise from air extractor	• Air extractor housing seated incorrectly. • Air extractor housing or flaps damaged.	• REINSTALL the air extractor housing. • INSTALL a new air extractor.
• Air leak at top of A-pillar — vehicles with a convertible top	• Seal at windshield header installed incorrectly. • Seal pinched. • Gap between side rail and header seal at A-pillar.	• REINSTALL the seal. • FILL the seal with foam to reshape it. • ADJUST the J-hook/vinyl top.
• Air leak at rear quarter glass (division bar) — vehicles with a convertible top	• No contact between front side glass and quarter glass division bar.	• ADJUST the front side glass regulator and the rear quarter glass regulator.
• Air leak or wind noise from top of side glass — vehicles with a convertible top	• Gap between side rail and vinyl top. • Seal at windshield header installed incorrectly. • Seal damaged between side rail and vinyl top. • Vinyl top damaged.	• ADD additional foam tape to seal between the side rail and the vinyl top. • REINSTALL the seal. • INSTALL a new seal. • INSPECT the vinyl top. INSTALL a new vinyl top as necessary.
• Air leak or wind noise at windshield header — vehicles with a convertible top	• Vinyl top not flush with header. • Seal at windshield header installed incorrectly. • Header seal not flush with header.	• ADJUST the J-hook to lower the top to achieve a flush condition. • REINSTALL the seal. • REINSTALL the seal.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Air Leak and Wind Noise (Continued)

Condition	Possible Sources	Action
• Convertible top flapping with the top up	• Vinyl top contacting interior headliner.	• Working from front to back, INSTALL a 6.35 mm (0.25 in) foam sheet between the headliner and the vinyl top at the suspected area. Allow a clearance of 50 mm (2 in) - 75 mm (3 in) away from the roof bows and the side rails.
• Noise from roof rack	• Roof rack rails or crossbars loose. • Roof rack fasteners missing. • Roof rack crossbars installed backward. • Roof rack rub strips partially lifting from roof. • Roof rack gaskets loose or misaligned.	• TIGHTEN the fasteners. • INSTALL the approved fasteners. • REINSTALL the crossbars. • REAPPLY adhesive or fasteners or INSTALL new rub strips as necessary. • REINSTALL the gasket.
• Wind noise from bug shield/exterior windshield sun visor	• Turbulence created by location and shape.	• REMOVE per customer direction if it is a dealer installed option.

Symptom Chart—Brake Noise/Vibration

Condition	Possible Sources	Action
• Rattling noise	• Caliper mounting bolts loose.	• CHECK the caliper bolts. TIGHTEN to specifications. REFER to Section 206-03 for front disc brakes or Section 206-04 for rear disc brakes.
	• Damaged or worn caliper pins or retainers.	• CHECK the caliper pins and retainers for lubrication and correct fit. LUBRICATE or INSTALL new components as necessary. REFER to Section 206-03 for front disc brakes or Section 206-04 for rear disc brakes.
	• Missing or damaged anti-rattle clips or springs.	• CHECK the brake pads for missing clips or broken springs. INSTALL new components as necessary. REFER to Section 206-03 for front disc brakes or Section 206-04 for rear disc brakes.
	• Loose brake disc shield.	• TIGHTEN the brake disc shield bolts to specification. REFER to Section 206-03.
• Clicking noise—with brakes applied with ABS brakes	• ABS hydraulic control unit.	• Acceptable condition.
• Squealing noise—occurs on first (morning) brake application	• Disc brake pads.	• Acceptable condition. Caused by humidity and low disc brake pad temperature.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Brake Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Squealing noise—a continuous squeal	• Disc brake pads or linings worn below minimum thickness.	• INSTALL new disc brake pads. REFER to Section 206-03 for front disc brakes or Section 206-04 for rear disc brakes.
• Squealing noise—an intermittent squeal brought on by cold, heat, water, mud or snow	• Disc brake pad.	• Acceptable condition.
• Groaning noise—occurs at low speeds with brake lightly applied (creeping)	• Disc brake pads.	• Acceptable condition.
• Grinding noise—continuous	• Disc brake pads or linings worn below minimum thickness.	• INSPECT the disc brake pads, brake discs/drums and attaching hardware for damage. REPAIR or INSTALL new components as necessary. REFER to Section 206-03 for front disc brakes or Section 206-04 for rear disc brakes.
• Moaning noise	• Brake linings contaminated with grease or oil.	• INSPECT the brake pads and shoes for contamination. REPAIR or INSTALL new components as necessary. REFER to Section 206-03 for front disc brakes or Section 206-04 for rear disc brakes.
• Brake vibration/shudder—occurs when brakes are applied	• Uneven disc or drum wear. • Uneven disc brake pad or lining transfer. • Suspension components.	• GO to Pinpoint Test A.
• Brake vibration/shudder—occurs when the brake pedal is released	• Brake drag.	• INSPECT the disc brake pads or linings for premature wear. REPAIR or INSTALL a new caliper or wheel cylinder as necessary. REFER to Section 206-03 for front disc brakes or Section 206-04 for rear disc brakes.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Driveline Noise/Vibration

Condition	Possible Sources	Action
• Axle howling or whine—front or rear axle	• Axle lubricant low.	• CHECK the lubricant level. FILL the axle to specification.
	• Axle housing damage.	• INSPECT the axle housing for damage. REPAIR or INSTALL a new axle as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
	• Damaged or worn wheel bearings or axle bearings.	• CHECK for abnormal wheel bearing play or roughness. REFER to Wheel Bearing Check in this section. ADJUST or INSTALL new wheel bearings as necessary.
	• Damaged or worn differential ring and pinion.	• INSPECT the ring and pinion ring for abnormal wear patterns or broken teeth. INSTALL a new ring and pinion as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
	• Damaged or worn differential side or pinion bearings.	• CHECK for abnormal bearing play or roughness. INSTALL new bearings as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
	• Damaged or worn differential side gears and pinion gears.	• DISASSEMBLE the differential carrier. INSPECT the side and pinion gears for abnormal wear patterns or broken teeth. INSTALL new gears as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Driveline Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Driveline clunk—loud clunk when shifting from reverse to drive	• Incorrect axle lubricant level.	• CHECK the lubricant level. FILL the axle to specification.
	• Excessive backlash in the axle or transmission.	• CARRY OUT a total backlash check. REFER to Section 205-00.
	• Damaged or worn pinion bearings.	• CHECK for abnormal bearing play or roughness. INSTALL new bearings as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
	• Damaged or worn universal joints (U-joints).	• INSPECT the U-joints for wear or damage. INSTALL new U-joints as necessary. REFER to Section 205-01.
	• Loose suspension components.	• INSPECT the suspension for damage or wear. REPAIR or INSTALL new components as necessary.
	• Broken powertrain mounts.	• INSPECT the powertrain mounts. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines. INSTALL new mounts as necessary.
	• Idle speed too high.	• CHECK for the correct idle speed.
• Driveline clunk—occurs as the vehicle starts to move forward following a stop	• Worn or galled driveshaft slip-yoke splines.	• CLEAN and INSPECT the splines of the yoke for a worn or galled condition. INSTALL a new yoke as necessary. REFER to Section 205-01.
	• Worn or galled driveshaft and coupling shaft splines.	• CLEAN and INSPECT the splines of the driveshaft and coupling shaft for a worn or galled condition. INSTALL a new driveshaft assembly as necessary. REFER to Section 205-01.
	• Loose rear leaf spring U-bolts.	• CHECK the U-bolts for loose nuts. TIGHTEN to specification. REFER to Section 204-02.
• Driveline clunk (FWD vehicles)—occurs during acceleration or from cruise to coast/deceleration	• Damaged or worn inboard constant velocity (CV) joint.	• INSPECT the inboard CV joint and boot. REPAIR or INSTALL a new CV joint as necessary.
• Driveline clunk (4WD vehicles)—occurs during shift-on-the-fly engagement	• Clutch relay. • Shift motor. • Transfer case. • GEM.	• CHECK the 4WD engagement system. REPAIR or INSTALL new components as necessary. REFER to Section 308-07A and Section 308-07B.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Driveline Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Clicking, popping or grinding—occurs while vehicle is turning	• Inadequate or contaminated lubrication in the (CV) joints.	• CHECK the CV boots and joints for wear or damage. REPAIR or INSTALL new components as necessary. REFER to Section 205-04.
	• Another component contacting the halfshaft.	• CHECK the halfshafts and the area around the halfshafts. REPAIR as necessary.
	• Brake components.	• INSPECT the front brakes for wear or damage. REPAIR as necessary. REFER to Section 206-03.
	• Steering components.	• INSPECT the drag link, inner and outer tie-rods or idler arm for wear or damage. REPAIR as necessary. REFER to Section 211-03.
	• Suspension components.	• INSPECT the upper and lower ball joints for wear or damage. REPAIR as necessary. REFER to Section 204-01A for 2-wheel drive vehicles or Section 204-01B for 4-wheel drive vehicles.
	• Damaged or worn wheel bearings.	• CHECK for abnormal wheel bearing play or roughness. REFER to Wheel Bearing Check in this section. ADJUST or INSTALL new wheel bearings as necessary.
• Clicking or snapping—occurs when accelerating around a corner	• Damaged or worn outboard CV joint.	• INSPECT the outboard CV joint and boot. REPAIR or INSTALL a new CV joint as necessary. REFER to Section 205-04.
• High pitched chattering—noise from the rear axle when the vehicle is turning	• Incorrect or contaminated lubricant.	• CHECK the vehicle by driving in tight circles (5 clockwise, 5 counterclockwise). FLUSH and REFILL with the specified rear axle lubricant and friction modifier as necessary.
	• Damaged or worn differential (differential side gears and pinion gears).	• DISASSEMBLE the differential assembly. INSPECT the differential case, pin and gears for wear or damage. REPAIR or INSTALL a new differential as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Driveline Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Buzz—buzzing noise is the same at cruise or coast/deceleration	• Damaged or worn tires.	• CHECK for abnormal tire wear or damage. INSTALL new tire(s) as necessary. REFER to Section 204-04.
	• Incorrect driveline angles.	• CHECK for correct driveline angles. REPAIR as necessary. REFER to Section 205-00.
• Rumble or boom—noise occurs at coast/deceleration, usually driveshaft speed related and noticeable over a wide range of speeds	• Driveshaft is out-of-balance.	• CHECK the driveshaft for damage, missing balance weights or undercoating. CHECK the driveshaft balance. CARRY OUT a driveline vibration test. REFER to Section 205-00.
	• U-joints binding or seized.	• ROTATE the driveshaft and CHECK for rough operation or seized U-joints. INSTALL new U-joints as necessary. REFER to Section 205-01.
	• Excessive pinion flange runout.	• CARRY OUT a runout check. REPAIR as necessary. REFER to Section 205-00.
• Grunting—normally associated with a shudder experienced during acceleration from a dead stop	• Driveshaft slip yoke binding.	• CLEAN and LUBRICATE the male and female splines.
	• Loose rear spring U-bolts.	• INSPECT the rear suspension. TIGHTEN the U-bolt nuts to specification. REFER to Section 204-02.
• Howl—can occur at various speeds and driving conditions. Affected by acceleration and deceleration	• Incorrect ring and pinion contact, incorrect bearing preload or gear damage.	• CHECK the ring and pinion and bearings for damage. INSPECT the ring and pinion wear pattern. REFER to Checking Tooth Contact Pattern and Condition of the Ring and Pinion component test in this section. ADJUST or INSTALL new components as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Driveline Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Chuckle—heard at coast/deceleration. Also described as a knock	• Incorrect ring and pinion contact or by damaged teeth on the coast side of the ring and pinion.	• CHECK the ring and pinion for damage. INSPECT the ring and pinion wear pattern. REFER to Checking Tooth Contact Pattern and Condition of the Ring and Pinion component test in this section. ADJUST or INSTALL new components as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
• Knock—noise occurs at various speeds. Not affected by acceleration or deceleration	• Gear tooth damage to the drive side of the ring and pinion.	• CHECK the differential case and ring and pinion for damage. INSTALL new components as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
	• Excessive axle shaft end play. (Vehicles with integral axles).	• CHECK the axle end play using a dial indicator. INSTALL a new axle shaft or side gears as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
• Scraping noise—a continuous low pitched noise starting at low speeds	• Worn or damaged pinion bearings.	• CHECK the pinion bearings. INSTALL new pinion bearings as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Driveline Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Driveline shudder—occurs during acceleration from a slow speed or stop	• Rear drive axle assembly mispositioned.	• CHECK the axle mounts and the rear suspension for damage or wear. REPAIR as necessary.
	• Loose rear spring U-bolts.	• INSPECT the U-bolts. TIGHTEN the U-bolt nuts to specification. REFER to Section 204-02.
	• Incorrect or high CV joint operating angle.	• CHECK vehicle ride height is within limits. REPAIR as necessary.
	• Damaged or worn front suspension components.	• CHECK for a loose stabilizer bar, damaged or loose strut/strut bushings or loose or worn ball joints. INSPECT the steering linkage for wear or damage. REPAIR or INSTALL new components as necessary.
	• Driveline angles out of specification.	• CHECK for correct driveline angles. REPAIR as necessary. REFER to Section 205-00.
	• U-joints binding or seized.	• ROTATE the driveshaft and CHECK for rough operation or seized U-joints. INSTALL new U-joints as necessary. REFER to Section 205-01.
	• Binding, damaged or galled splines on the driveshaft slip-yoke.	• CLEAN and INSPECT the splines of the slip-yoke, driveshaft and coupling shaft for a worn, damaged or galled condition. INSTALL a new slip-yoke or driveshaft assembly as necessary. REPAIR as necessary. REFER to Section 205-01.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Driveline Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Driveline vibration—occurs at cruising speeds	• U-joints are worn.	• CHECK for wear or incorrect seating. INSTALL new U-joints as necessary. REFER to Section 205-01.
	• Worn or damaged driveshaft center bearing support.	• CHECK the insulator for damage or wear. ROTATE the driveshaft and CHECK for rough operation. INSTALL a new center bearing support as necessary. REFER to Section 205-01.
	• Loose axle pinion flange bolts.	• INSPECT the axle pinion flange. TIGHTEN the pinion flange bolts to specification. REFER to Section 205-01.
	• Excessive axle pinion flange runout.	• CARRY OUT a Runout Check. REPAIR as necessary. REFER to Section 205-01.
	• Driveshaft is out-of-balance.	• CHECK the driveshaft for damage, missing balance weights or undercoating. CHECK driveshaft balance. CARRY OUT a driveline vibration test. REFER to Section 205-00. REPAIR as necessary.
	• Binding or damaged splines on the driveshaft slip-yoke.	• CLEAN and INSPECT the splines of the slip-yoke, driveshaft and coupling shaft for wear or damage. INSTALL a new slip-yoke or driveshaft assembly as necessary. REFER to Section 205-01. REPAIR as necessary.
	• Driveshaft runout.	• CARRY OUT a Runout Check. REFER to Section 205-00. REPAIR as necessary.
	• Incorrect lateral and radial tire/wheel runout.	• INSPECT the tire and wheels. MEASURE tire runouts. REPAIR or INSTALL new components as necessary. REFER to Section 204-04.
	• Driveline angles out of specification.	• CHECK for correct driveline angles. REPAIR as necessary. REFER to Section 205-00.
	• Incorrectly seated CV joint in the front wheel hub.	• CHECK the outer CV joint for correct seating into the hub. REPAIR as necessary. REFER to Section 205-04.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Engine Noise/Vibration

Condition	Possible Sources	Action
• Grinding noise—occurs during engine cranking	• Incorrect starter motor mounting.	• INSPECT the starter motor for correct mounting. REPAIR as necessary. REFER to Section 303-06.
	• Starter motor.	• CHECK the starter motor. REPAIR or INSTALL a new starter motor as necessary. REFER to Section 303-06.
	• Incorrect starter motor drive engagement.	• INSPECT the starter motor drive and flexplate/flywheel for wear or damage. INSTALL a new starter motor drive or flexplate/flywheel as necessary. REFER to Section 303-06.
• Engine ticking noise	• Fuel injector. • Fuel line. • Oil pump. • Valve lifter. • Belt tensioner. • Water pump. • Obstruction of cooling fan.	• GO to Pinpoint Test B.
• Engine drumming noise—normally accompanied by vibration	• Powertrain mount.	• CARRY OUT Powertrain/Drivetrain Mount Neutralizing in this section.
	• Damaged or misaligned exhaust system.	• INSPECT the exhaust system for loose or broken clamps and brackets. CARRY OUT Exhaust System Neutralizing in this section.
• Whistling noise—normally accompanied with poor idle condition	• Air intake system.	• CHECK the air intake ducts, air cleaner, throttle body and vacuum hoses for leaks and correct fit. REPAIR or ADJUST as necessary. REFER to Section 303-12.
• Clunking noise	• Water pump has excessive end play or imbalance.	• CHECK the water pump for excessive end play. INSPECT the water pump with the drive belt off for imbalance. INSTALL a new water pump as necessary. REFER to Section 303-03A for standard cooling or Section 303-03B for supercharger cooling.
	• Generator has excessive end play.	• CHECK the generator for excessive end play. REPAIR or INSTALL a new generator. REFER to Section 414-02.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Engine Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Pinging noise	• Exhaust system leak.	• INSPECT the exhaust system for leaks. REPAIR as necessary.
	• Gasoline octane too low.	• VERIFY with customer the type of gasoline used. CORRECT as necessary.
	• Knock sensor operation.	• CHECK the knock sensor. INSTALL a new knock sensor as necessary. REFER to Section 303-14.
	• Incorrect spark timing.	• CHECK the spark timing. REPAIR as necessary.
	• High operating temperature.	• INSPECT cooling system for leaks. CHECK the coolant level. REFILL as necessary. CHECK the coolant for the correct mix ratio. DRAIN and REFILL as needed. CHECK engine operating temperature is within specifications. REPAIR as necessary.
	• Foul-out spark plug.	• CHECK the spark plugs. REPAIR or INSTALL new spark plugs as necessary.
	• Catalytic converter.	• Acceptable noise.
• Knocking noise—light knocking noise, also described as piston slap. Noise is most noticeable when engine is cold with light to medium acceleration. Noise disappears as engine warms	• Excessive clearance between the piston and the cylinder wall.	• Engine cold and at high idle. Using an EngineEAR, pull a spark plug or fuel injector connector until the noise goes away. CARRY OUT a cylinder bore clearance to piston check. INSTALL a new piston. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines.
• Knocking noise—light double knock or sharp rap sound. Occurs mostly with warm engine at idle or low speeds in DRIVE. Increases in relation to engine load. Associated with poor lubrication history	• Excessive clearance between the piston and the piston pin.	• INSTALL a new piston or piston pin. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines.
• Knocking noise—light knocking noise is most noticeable when engine is warm. Noise tends to decrease when vehicle is coasting or in neutral	• Excessive clearance between the connecting rod bearings and the crankshaft.	• Engine warm and at idle. Using an EngineEAR, PULL a spark plug or fuel injector connector until the noise goes away. INSTALL new bearings. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Engine Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Knocking—deep knocking noise. Noise is most noticeable when engine is warm, at lower rpm and under a light load and then at float	• Worn or damaged crankshaft main bearings.	• CARRY OUT Drive Engine Run-Up (DERU) Test. CHECK for noise with vehicle at operating temperature, during medium to heavy acceleration. CHECK at idle with injector disconnected, noise does not change. INSTALL new main bearings. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines.
• Knocking noise—occurs mostly with warm engine at light/medium acceleration	• Spark plugs. • Carbon accumulation in combustion chamber.	• CHECK the spark plugs for damage or wear. INSTALL new spark plugs as necessary. • REMOVE carbon from combustion chamber.
• Whine or moaning noise	• Air intake system. • Generator electrical field or bearings.	• CHECK the air cleaner and ducts for correct fit. INSPECT the air intake system for leaks or damage. REPAIR as necessary. • CARRY OUT generator load test. REPAIR or INSTALL a new generator as necessary. REFER to Section 414-02.
• Drone type noise	• Exhaust system. • A/C compressor. • Powertrain mounts.	• CARRY OUT the Exhaust System Neutralizing in this section. REPAIR as necessary. • CHECK for noise with vehicle at constant speeds. CYCLE the compressor on and off and listen for a change in pitch. REPAIR as necessary. REFER to Section 412-03. • CARRY OUT the Powertrain/Drivetrain Mount Neutralizing in this section.
• Sputter type noise—noise worse when cold, lessens or disappears when vehicle is at operating temperature	• Damaged or worn exhaust system components.	• INSPECT the exhaust system for leaks or damage. REPAIR as necessary. REFER to Section 309-00.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Engine Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Rattling noise—noise from the upper engine (valve train). Worse when engine is cold	• Low oil level.	• CHECK oil level. FILL as necessary.
	• Thin or diluted oil.	• INSPECT the oil for contamination. If oil is contaminated, CHECK for the source. REPAIR as necessary. CHANGE the oil and filter.
	• Low oil pressure.	• CARRY OUT an oil pressure test. If not within specifications, REPAIR as necessary. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engine.
	• Worn rocker arms/fulcrums or followers.	• CARRY OUT a valve train analysis. INSTALL new valve train components as necessary. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines.
	• Worn valve guides.	• CARRY OUT a valve train analysis. INSTALL new valve guides as necessary. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines.
	• Excessive runout of valve seats on the valve face.	• CARRY OUT a valve seat runout test. INSPECT the valve face and seat. INSTALL new valves as necessary. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines.
• Rattling noise—from the bottom of the vehicle	• Loose muffler shields or catalytic converter shields.	• CHECK the exhaust system for loose shields. REPAIR as necessary.
• Thumping noise—from the bottom of the vehicle, worse at acceleration	• Exhaust pipe/muffler grounded to chassis.	• CHECK the exhaust system to chassis clearance. CHECK the exhaust system hangers for damage. REPAIR as necessary. REFER to Section 309-00.
• Whoosh—occurs during light vehicle acceleration. Heard inside the vehicle	• Throttling late, creating turbulence transmitted through the plastic manifold.	• CHECK for leaks or missing seal in the dash panel.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Engine Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Engine vibration—increases intensity as engine rpm is increased	• Engine out-of-balance.	• CARRY OUT Neutral Engine Run-Up (NERU) Test. ROTATE the torque converter, 120° for 3 bolt and 180° for 4 bolt. INSPECT the torque converter pilot outer diameter to crankshaft pilot inner diameter. REPAIR as necessary. REFER to Section 307-01A for 4R100 transmissions. REFER to Section 307-01B for 4R70W transmissions.
• Engine vibration—is felt with increases and decreases in engine rpm	• Strain on exhaust mounts. • Damaged or worn powertrain/drivetrain mounts. • Engine or transmission grounded to chassis.	• CARRY OUT the Exhaust System Neutralizing in this section. REPAIR as necessary. • CHECK the powertrain/drivetrain mounts for damage. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines. REPAIR as necessary. • INSPECT the powertrain/drivetrain for correct clearances. REPAIR as necessary.
• Engine vibration—vibration felt at all times	• Excessive engine pulley runout. • Damaged or worn accessory component.	• CARRY OUT Engine Accessory Test. INSTALL a new engine pulley as necessary. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines. • CARRY OUT Engine Accessory Test. REPAIR or INSTALL a new component as necessary.
• Accelerator pedal vibration—felt through the pedal as a buzz	• Throttle cable loose or misrouted.	• INSPECT the throttle cable. REPAIR as necessary. REFER to Section 310-02.
• Engine vibration—mostly at coast/neutral coast. Condition improves with vehicle accelerating	• Combustion instability.	• CHECK the ignition system. INSTALL new components as necessary.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart — Engine Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Engine vibration or shudder—occurs with light to medium acceleration above 56 km/h (35 mph)	• Worn or damaged spark plugs.	• INSPECT the spark plugs for cracks, high resistance or broken insulator. INSTALL a new spark plug(s) as necessary.
	• Plugged fuel injector.	• REPAIR or INSTALL a new injector as necessary.
	• Damaged spark plug wire.	• INSPECT the spark plug wires for damage. INSTALL a new spark plug wire(s) as necessary.
	• Contaminated fuel.	• INSPECT the fuel for contamination. DRAIN the fuel system and refill.
	• Worn or damaged torque converter.	• CHECK the torque converter. INSTALL a new torque converter as necessary. REFER to Section 307-01B for 4R70W transmissions. REFER to Section 307-01A for 4R100 transmissions.

Symptom Chart—Idle Noise/Vibration

Condition	Possible Sources	Action
• Idle air control (IAC) valve moan — occurs on throttle tip-out	• IAC valve is contaminated with oil.	• GO to Component Tests in this section.
• Accessory drive belt chirp — occurs at idle or high idle, cold or hot. Most common occurrence is during humid weather	• Accessory drive belt worn, or pulley is misaligned or loose.	• INSPECT for loose or misaligned pulleys. CHECK the drive belt for wear or damage. INSTALL new pulley(s)/accessory drive components or drive belt, as necessary. REFER to Section 303-05.
• Accessory drive bearing hoot — occurs at idle or high idle in cold temperatures of approximately +4°C (+40°F) or colder at first start of the day	• Accessory drive idler or tensioner pulley bearing is experiencing stick/slip between ball bearings and bearing race.	• GO to Pinpoint Test C.
• Power steering moan — occurs at high idle and possibly at idle during the first cold start of the day in temperatures of approximately -18°C (0°F) or colder. Noise can even be a severe screech for less than one minute in very cold temperatures of approximately -29°C (-20°F) or colder	• High fluid viscosity, or plugged reservoir screen in power steering reservoir starves pump causing cavitation.	• GO to Pinpoint Test D.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Idle Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Generator whine — during high electrical loads at idle or high idle, a high pitch whine or moan is emitted from the generator	• Generator electrical field noise.	• Using an EngineEAR, PROBE near the generator housing. LISTEN for changes in the noise level while changing electrical loads (such as rear defrost, headlamps, etc.). CARRY OUT a generator load test. If the system passes the load test, the noise is from the generator bearings. INSTALL new bearings. If the system fails the load test, INSTALL a new generator. REFER to Section 414-02.
• Engine-driven cooling fan moan — occurs during the first start of the day. It is most objectionable near idle speeds up to 2000 rpm. The noise increases with rpm	• The viscous cooling fan clutch engages until the fluid in the clutch reaches normal operating temperature, causing the fan to fully engage.	• GO to Pinpoint Test E.
• Drumming noise — occurs inside the vehicle during idle or high idle, hot or cold. Very low-frequency drumming is very rpm dependent	• Exhaust system vibration excites the body resonances inducing interior noise. • Engine vibration excites the body resonances inducing interior noise.	• GO to Pinpoint Test F.
• Hissing noise — occurs during idle or high idle that is apparent with the hood open	• Vacuum leak or idle air control (IAC) valve flow noise. • Vehicles with a plastic intake manifold.	• Use the Ultrasonic Leak Detector/EngineEAR to locate the source. Scan the air intake system from the inlet to each cylinder intake port. DISCARD the leaking parts, and INSTALL a new component. • Acceptable condition. Some plastic manifolds exhibit this noise, which is the effect of the plastic manifold.
• Automatic transmission buzz or hiss	• Incorrect driveline angles. • Worn or damaged main control solenoids or valves.	• CHECK for correct driveline angles. REPAIR as necessary. REFER to Section 205-00. • Using a transmission tester, activate the solenoids to duplicate sound. INSTALL new components as necessary. REFER to Section 307-01B for 4R70W transmissions. REFER to Section 307-01A for 4R100 transmissions.
• Manual Transmission Clutch throw-out bearing whine. A change in noise pitch or loudness while depressing the clutch pedal	• Worn throw-out bearing.	• INSTALL a new throw-out bearing. REFER to Section 308-01.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Idle Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Heating, vacuum and air conditioning (HVAC) system chirp — most audible inside the vehicle. Listen for a change in noise pitch or loudness while changing the HVAC system blower speed	• Damaged or worn HVAC blower bearing.	• INSTALL a new blower motor. REFER to Section 412-02.
• Air conditioning (A/C) clutch ticking — occurs when the compressor clutch engages	• Acceptable noise. • Incorrect air gap.	• LISTEN to the clutch to determine if the noise occurs with clutch engagement. A small amount of noise is acceptable. If the noise is excessive, CHECK the A/C clutch air gap. INSPECT the A/C clutch for wear or damage. INSTALL a new clutch as necessary. REFER to Section 412-03.
• Intermittent rattle, or scraping/rubbing noise	• Loose exhaust heat shield(s). • Wiring, hose or other part interfering with accessory drive, drive belt or pulley.	• INSPECT the exhaust system for loose parts using a glove or clamps to verify cause. REPAIR as necessary. REFER to Section 309-00. • INSPECT accessory drive system closely verifying there is adequate clearance to all rotating components. REPAIR as necessary.
• Engine ticking or knocking noise — occurs during idle or high idle during the first cold start of the day	• Piston noise or valvetrain noise (bled down lifter/lash adjuster).	• GO to Pinpoint Test G.
• A continuous, speed-dependent rattle from the engine — occurs during idle or high idle during the first cold start of the day and disappears as the engine warms up	• Piston noise or valvetrain noise (bled down lifter/lash adjuster).	• GO to Pinpoint Test G.
• Idle vibration—a low-frequency vibration (5-20 Hz) or mild shake that is felt through the seat/floorpan	• Cylinder misfire. • Engine or torque converter out of balance.	• Using a scan tool, CHECK the ignition system. CARRY OUT a cylinder power test. REFER to Section 303-00. • VERIFY the torque converter to crankshaft pilot clearance is correct, REPAIR as necessary. RE-INDEX the torque converter on the flex plate by 120° on a 3 bolt converter or 180° for a 4 bolt converter. REFER to Section 307-01B for 4R70W transmissions. REFER to Section 307-01A for 4R100 transmissions. RETEST the vehicle.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Idle Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Idle vibration—a high-frequency vibration (20-80 Hz) or buzz, that is felt through the steering wheel or seat	• Exhaust system mounts bound up.	• VERIFY concern occurs at engine firing frequency. CHECK that the exhaust system vibrates at the same frequency as the engine. ADD 9-14 km (20-30 lb.) to the tail pipe to test. CARRY OUT Exhaust System Neutralizing in this section.
	• Body mounts loose.	• INSPECT the body mounts. REPAIR as necessary.
	• Power steering lines grounded out.	• INSPECT that the power steering lines are not contacting the chassis or each other. REPAIR as necessary.

Symptom Chart—Squeak and Rattle

Condition	Possible Sources	Action
• Squeak—heard inside the vehicle when closing/opening the door	• Insufficient lubrication on the door hinge or check strap.	• LUBRICATE the hinge or check strap.
	• Internal door components loose, rubbing or misaligned.	• CHECK the inside of the door. TIGHTEN or ALIGN as necessary. USE the Squeak and Rattle Repair Kit to isolate any rubbing components.
• Squeak—heard inside the vehicle when closing/opening the window	• Worn or damaged glass run/channel.	• REPAIR or INSTALL a new glass run/channel. REFER to Section 501-11.
• Squeak—heard outside of vehicle when closing/opening the door	• Exhaust shield rubbing against the chassis or exhaust pipe.	• CHECK the exhaust system. REPAIR as necessary. Section 309-00.
• Squeak—occurs with initial brake pedal application	• Disc brake pads.	• Under certain conditions, asbestos free pads can generate a squeak noise. This noise is normal and does not indicate a concern.
• Squeak—a constant noise that occurs with brake pedal applications	• Damaged or worn disc brake pads.	• INSPECT the pads for oil, grease or brake fluid contamination. CHECK for glazed linings. A brake disc with hard spots will also cause a squeak type noise. REPAIR or INSTALL new pads as necessary. REFER to Section 206-03 for front disc brakes or Section 206-04 for rear disc brakes.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Squeak and Rattle (Continued)

Condition	Possible Sources	Action
• Squeak—noise occurs over bumps or when turning	• Worn control arm bushings.	• INSPECT the control arm bushings. Spray with lubricant and CARRY OUT a ''bounce test'' to determine which bushing. REPAIR as necessary. REFER to Section 204-01A for 2-wheel drive vehicles or Section 204-01B for 4-wheel drive vehicles.
	• Worn or damaged shock absorber/strut.	• INSPECT the shock absorber for damage. CARRY OUT a ''bounce test'' to isolate the noise. INSTALL a new shock absorber/strut as necessary. REFER to Section 204-01A for 2-wheel drive vehicles and Section 204-01B for 4-wheel drive vehicles front shock absorber/strut or Section 204-02 for the rear shock absorber/strut.
• Rattle—heard when closing/opening the door or window	• Loose internal door mechanism, bracket or attachment.	• REPEAT the motion or CARRY OUT a ''tap test'' to duplicate the noise. INSPECT the door for loose components. TIGHTEN loose components or USE the Rotunda Squeak and Rattle Kit to isolate any rattling components.
• Squeak or rattle—heard inside the vehicle over rough roads/bumps	• Misaligned glove compartment door/hinge.	• ALIGN the glove compartment door.
	• Instrument panel trim loose or misaligned.	• INSPECT the instrument panel trim for missing or loose clips or screws. REPAIR as necessary.
	• Loose interior component or trim.	• CARRY OUT a ''touch test''. ELIMINATE the noise by pressing or pulling on interior trim and components. USE the Rotunda Squeak and Rattle Kit to isolate any rattling/squeaking components.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Squeak and Rattle (Continued)

Condition	Possible Sources	Action
• Squeak or rattle—noise with a vibration concern	• Damaged or worn body mounts.	• INSPECT the upper and lower absorbers and washers for damage or wear. CHECK the body mount brackets for damage. CHECK the nuts and bolts are tightened to specifications. TIGHTEN as necessary.
	• Damaged or worn sub-frame mounts.	• INSPECT the upper and lower absorbers for damage or wear. CHECK the sub-frame for damage. CHECK the nuts and bolts are tightened to specifications. TIGHTEN as necessary.

Symptom Chart—Steering Noise/Vibration

Condition	Possible Sources	Action
• Steering grunt or shudder — occurs when turning into or out of a turn at low speeds (temperature sensitive)	• Steering gear or power steering hoses.	• GO to Steering Gear Grunt/Shudder Test component test in this section.
• Steering System clonk—hydraulic knocking sound	• Air in the steering hydraulic system.	• CHECK for leaks in the system. PURGE the air from the system. REFER to Section 211-00.
• Power steering pump moan — loud humming noise occurs when the steering wheel is rotated to the stop position. Produces a 120-600 Hz frequency that changes with rpm	• Power steering hose grounded out to chassis.	• INSPECT the power steering hoses. REPAIR as necessary.
	• Aerated fluid.	• CHECK for leaks in the system. PURGE the air from the system. REFER to Section 211-00.
	• Steering gear isolators.	• INSPECT the isolators for wear or damage. REPAIR as necessary.
	• Low fluid.	• CHECK the fluid level. REFILL as necessary.
	• Power steering pump brackets loose or misaligned.	• CHECK bolts, brackets and bracket alignment. TIGHTEN bolts to specification. REPAIR or INSTALL new brackets as necessary. REFER to Section 211-02.
• Steering gear clunk — occurs only while cornering over a bump (can be temperature sensitive)	• Steering gear.	• INSPECT the steering gear for loose mounting bolts. TIGHTEN as necessary. REFER to Section 211-02.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Steering Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Feedback (rattle, chuckle or knocking noise in the steering gear) — a condition where roughness is felt in the steering wheel when the vehicle is driven over rough surfaces	• Column intermediate/flexible shaft joints damaged or worn.	• INSTALL a new intermediate/flexible shaft. REFER to Section 211-04.
	• Loose, damaged or worn tie-rod ends.	• TIGHTEN the nuts to specification or INSTALL new tie-rod ends as necessary. REFER to Section 211-03.
	• Steering gear insulators or mounting bolts loose or damaged.	• TIGHTEN the bolts or INSTALL new bolts as necessary. REFER to Section 211-02.
	• Steering column intermediate shaft bolts are loose.	• TIGHTEN the bolts to specification. REFER to Section 211-04.
	• Steering column damaged or worn.	• REPAIR or INSTALL a new steering column as necessary. REFER to Section 211-04.
	• Loose suspension bushings, bolts or ball joints.	• INSPECT the suspension system. TIGHTEN or INSTALL new components as necessary. REFER to Section 204-01A for 2-wheel drive vehicles or Section 204-01B for 4-wheel drive vehicles.
• Feedback (nibble at the steering wheel) — a condition where slight rotational movement is felt in the steering wheel when the vehicle is driven over rough or grooved surfaces	• Lateral runout in the tire or wheel.	• GO to Pinpoint Test H.
	• Yoke spring in the steering gear.	• CHECK TSBs for revised yoke spring for applicable vehicles.
• Accessory drive belt squeal/chirp—when rotating the steering wheel from stop to stop	• Loose or worn accessory drive belt.	• ADJUST or INSTALL a new accessory belt as necessary. REFER to Section 303-05.
• Power steering gear hiss	• Steering column intermediate/flexible shaft-to-steering gear is binding or misaligned.	• REPAIR or INSTALL a new intermediate/flexible shaft as necessary. REFER to Section 211-04.
	• Grounded or loose steering column boot at the dash panel.	• REPAIR as necessary.
	• Damaged or worn steering gear input shaft and valve.	• REPAIR or INSTALL a new steering gear as necessary. REFER to Section 211-02.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Steering Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Steering column rattle	• Loose bolts or attaching brackets. • Loose, worn or insufficiently lubricated column bearings. • Steering shaft insulators damaged or worn. • Intermediate/flexible shaft compressed or extended.	• TIGHTEN the bolts to specifications. • LUBRICATE or INSTALL new steering column bearings as necessary. REFER to Section 211-04. • INSTALL new insulators. REFER to Section 211-04. • INSPECT the rubber spider coupling for damage. INSTALL a new intermediate/flexible shaft. REFER to Section 211-04.
• Steering column squeak or cracks	• Insufficient lubricated steering shaft bushings. • Loose or misaligned steering column shrouds. • Steering wheel rubbing against steering column shrouds. • Insufficient lubricated speed control slip ring. • Upper or lower bearing sleeve out of position.	• LUBRICATE the steering shaft and shaft tube seals. • TIGHTEN or ALIGN the steering column shrouds. • REPOSITION the steering column shrouds. • LUBRICATE the speed control slip ring. • REPOSITION the bearing sleeves.
• Power steering pump noisy	• Incorrect assembly of components. • Imperfections on the outside diameter or end surface of the power steering pump rotor. • Damaged or worn power steering pump rotor splines. • A crack on the inner surface of the power steering pump cam. • Interference between the power steering pump rotor and cam. • Damaged or worn power steering pump rotor and pressure plates.	• REPAIR or INSTALL a new power steering pump as necessary. REFER to Section 211-02.
• Power steering pump swish noise	• Power steering fluid flow into the bypass valve of the pump valve housing with fluid temperature below 54°C (130°F).	• Acceptable condition.
• Power steering pump whine noise	• Aerated fluid. • Damaged power steering pump cam. • Damaged valve cover O-ring seal.	• CHECK for a leak in the system. PURGE the air from the system. REFER to Section 211-00. • REPAIR or INSTALL a new power steering pump as necessary. REFER to Section 211-02. • REPAIR or INSTALL a new power steering pump as necessary. REFER to Section 211-02.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Steering Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Power steering pump clicking (mechanical) noise	• Power steering pump rotor slippers too long, excessive rotor slipper-to-slot clearance or damaged or worn rotor assembly.	• REPAIR or INSTALL a new power steering pump as necessary. REFER to Section 211-02.
• Power steering pump clatter noise	• Damaged corners on the outside diameter or the power steering rotor or distorted rotor slipper ring.	• REPAIR or INSTALL a new power steering pump as necessary. REFER to Section 211-02.

Symptom Chart—Suspension Noise/Vibration

Condition	Possible Sources	Action
• Squeak or grunt—noise from the front suspension, occurs more in cold ambient temperatures. More noticeable over rough roads or when turning	• Front stabilizer bar insulators.	• Under these conditions, the noise is acceptable. CHECK TSBs for applicable vehicle.
• Clunk—noise from the front suspension, occurs in and out of turns	• Loose front struts or shocks.	• INSPECT for loose nuts or bolts. TIGHTEN to specifications. REFER to Section 204-01A for 2-wheel drive vehicles or Section 204-01B for 4-wheel drive vehicles.
• Clunk—noise from the rear suspension, occurs when shifting from reverse to drive	• Loose rear suspension components.	• INSPECT for loose or damaged rear suspension components. REPAIR or INSTALL new components as necessary. REFER to Section 204-02.
• Click or pop—noise from the front suspension. More noticeable over rough roads or over bumps	• Worn or damaged ball joints.	• CARRY OUT a ball joint inspection. INSTALL new ball joints or control arms as necessary REFER to Section 204-01A for 2-wheel drive vehicles or Section 204-01B for 4-wheel drive vehicles.
• Click or pop (FWD vehicles)—noise occurs when vehicle is turning	• Worn or damaged ball joints.	• CARRY OUT a ball joint inspection. INSTALL new ball joints or control arms as necessary.
• Click or snap—occurs when accelerating around a corner	• Damaged or worn outboard CV joint.	• INSPECT the outboard CV joint and boot. REPAIR or INSTALL a new CV joint as necessary. REFER to Section 204-01B.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Suspension Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Front suspension noise—a squeak, creak or rattle noise. Occurs mostly over bumps or rough roads	• Steering components. • Loose or bent front struts or shock absorbers. • Damaged spring or spring mounts. • Damaged or worn control/radius arm bushings. • Worn or damaged stabilizer bar bushings or links.	• GO to Pinpoint Test H.
• Rear suspension noise—a squeak, creak or rattle noise. Occurs mostly over bumps or rough roads	• Loose or bent rear shock absorbers. • Damaged spring or spring mounts. • Damaged or worn control arm bushings. • Worn or damaged stabilizer bar bushings or links.	• GO to Pinpoint Test I.
• Shudder—occurs during acceleration from a slow speed or stop	• Rear drive axle assembly mispositioned. • Incorrect or high CV joint operating angle. • Damaged or worn front suspension components.	• CHECK the axle mounts and the rear suspension for damage or wear. REPAIR as necessary. • CHECK vehicle ride height is within limits. REPAIR as necessary. • CHECK for a loose stabilizer bar, damaged or loose strut/strut bushings or loose or worn ball joints. INSPECT the steering linkage for wear or damage. REPAIR or INSTALL new components as necessary.
• Shimmy—most noticeable on coast/deceleration. Also hard steering condition	• Excessive positive caster.	• CHECK the caster alignment angle. CORRECT as necessary. REFER to Section 204-00.

Symptom Chart—Tire Noise/Vibration

Condition	Possible Sources	Action
• Tire noise—hum/moan at constant speeds	• Abnormal wear patterns.	• SPIN the tire and CHECK for tire wear. INSTALL new tire(s) as necessary. INSPECT for damaged/worn suspension components. CARRY OUT wheel alignment.
• Tire noise—noise tone lowers as the vehicle speed is lowered	• Out-of-balance tire.	• BALANCE the tire and road test. INSTALL a new tire as necessary. REFER to Section 204-04.
• Tire noise — ticking noise, changes with speed	• Nail puncture or stone in tire tread.	• INSPECT the tire. REPAIR as necessary.
• Wheel and tire—vibration and noise concern is directly related to vehicle speed and is not affected by acceleration, coasting or decelerating	• Damaged or worn tire.	• GO to Pinpoint Test J.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Tire Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Tire wobble or shudder — occurs at lower speeds	• Damaged wheel bearings.	• SPIN the tire and CHECK for abnormal wheel bearing play or roughness. ADJUST or INSTALL new wheel bearings as necessary. REFER to Section 204-01A for 2-wheel drive vehicles or Section 204-01B for 4-wheel drive vehicles.
	• Damaged wheel.	• INSPECT the wheel for damage. INSTALL a new wheel as necessary. REFER to Section 204-04.
	• Damaged or worn suspension components.	• INSPECT the suspension components for wear or damage. REPAIR as necessary.
	• Loose wheel nuts.	• CHECK the wheel nuts. TIGHTEN to specification. REFER to Section 204-04.
	• Damaged or uneven tire wear.	• SPIN the tire and CHECK for abnormal tire wear or damage. INSTALL a new tire as necessary. REFER to Section 204-04.
• Tire shimmy or shake— occurs at lower speeds	• Wheel/tire out of balance.	• BALANCE the wheel/tire assembly.
	• Uneven tire wear.	• CHECK for abnormal tire wear. INSTALL a new tire as necessary. REFER to Section 204-04.
	• Excessive radial runout of wheel or tire.	• CARRY OUT a radial runout test of the wheel and tire. INSTALL a new tire as necessary. REFER to Section 204-04.
	• Worn or damaged wheel studs or elongated stud holes.	• INSPECT the wheel studs and wheels. INSTALL new components as necessary. REFER to Section 204-01A for 2-wheel drive front wheels, Section 204-01B for 4-wheel drive front wheels and Section 204-02 for all rear wheels.
	• Excessive lateral runout of the wheel or tire.	• CARRY OUT a lateral runout test of the wheel and tire. CHECK the wheel, tire and hub. REPAIR or INSTALL new components as necessary.
	• Foreign material between the brake disc and hub or in the brake disc fins.	• CLEAN the mounting surfaces of the brake disc and hub. CHECK the brake disc fins for material.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Tire Noise/Vibration (Continued)

Condition	Possible Sources	Action
• High speed shake or shimmy—occurs at high speeds	• Excessive wheel hub runout. • Damaged or worn tires. • Damaged or worn wheel bearings. • Worn or damaged suspension or steering linkage components. • Brake disc or drum imbalance.	• GO to Pinpoint Test K.

Symptom Chart—Transmission (Manual) and Transfer Case Noise/Vibration

Condition	Possible Sources	Action
• Clutch rattling noise—occurs with clutch engaged, noise changes/disappears with clutch pedal depressed	• Flywheel bolts, clutch housing bolts or clutch pressure plate bolts loose.	• TIGHTEN the bolts to specifications. CHECK the bolts for damage.
• Clutch squeaking noise—noise is heard when the clutch is operated. Vehicle moves slowly or creeps when the clutch is disengaged. Can also be difficult to shift into first and reverse gear	• Pilot bearing seized or damaged.	• INSTALL a new pilot bearing. REFER to Section 308-01.
• Clutch squeaking noise—occurs with clutch pedal depressed/released	• Worn clutch pedal shaft or bushings.	• INSPECT the clutch pedal for wear or damage. REPAIR as necessary. REFER to Section 308-02.
• Clutch whirring/rattle noise—occurs when clutch pedal is depressed	• Worn, damaged or misaligned clutch release bearing.	• INSTALL a new clutch release bearing. REFER to Section 308-01.
• Clutch grating/grinding noise—occurs when clutch pedal is depressed	• Clutch pressure plate fingers bent or worn. • Contact surface of clutch release bearing worn or damaged.	• INSPECT the clutch pressure plate release fingers. INSTALL a new pressure plate as necessary. REFER to Section 308-01. • INSTALL a new clutch release bearing. REFER to Section 308-01.
• Clutch chatter—a small amount of noise when clutch pedal is released at initial take-off	• Clutch engagement.	• Acceptable operating condition.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Transmission (Manual) and Transfer Case Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Clutch chatter/grabs—in some cases a shudder is felt. Occurs with clutch pedal depressed/released	• Damaged or worn powertrain/driveline mounts.	• INSPECT the powertrain/drivetrain mounts. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines. INSTALL new mounts as necessary.
	• Binding or dragging plunger of the clutch master cylinder or slave cylinder.	• CHECK the master and slave cylinder operation. INSPECT the components for damage or wear. INSTALL a new master or slave cylinder as necessary. REFER to Section 308-02.
	• Grease or oil on the clutch disc facing.	• CHECK the input shaft seal and rear main oil seal. REPAIR as necessary. INSTALL a new clutch disc. REFER to Section 308-01.
	• Clutch disc surface glazed or damaged.	• INSPECT the clutch disc surface for a glazed, hardened or damage condition. CARRY OUT a disc check. INSTALL a new clutch disc as necessary. REFER to Section 308-01.
	• Damaged or worn clutch pressure plate.	• INSPECT the clutch pressure plate for wear or damage. INSTALL a new clutch pressure plate as necessary. REFER to Section 308-01.
	• Flywheel surface damaged or glazed.	• INSPECT the flywheel for damage or wear. CARRY OUT a flywheel runout check. INSTALL a new flywheel as necessary. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines.
• Clutch chatter noise—noise when clutch pedal is released at initial take-off. Clutch is hard to engage and disengage	• Pilot bearing worn, damaged or not correctly aligned in bore.	• INSPECT the clutch pressure plate release fingers for uneven wear, clutch components burnt or a seized pilot bearing. INSTALL a new pilot bearing as necessary. REFER to Section 308-01.
• Clutch vibration	• Loose flywheel bolts. • Damaged or loose clutch pressure plate. • Excessive flywheel runout.	• GO to Pinpoint Test L.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Transmission (Manual) and Transfer Case Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Transmission rattling/clattering noise—noise at idle or on light acceleration from a stop. Gear selection difficult	• Gearshift lever joint worn or damaged.	• INSTALL a new gearshift lever. REFER to Section 308-03.
	• Gearshift lever loose.	• TIGHTEN the bolts to specification. REFER to Section 308-03.
	• Gearshift linkage rods worn or damaged.	• CHECK the linkage bushings for wear. INSTALL new linkage rods as necessary.
• Transmission rattling/clattering noise—occurs in neutral or in gear, at idle	• Incorrect fluid level or fluid quality.	• CHECK that the transmission is filled to the correct level and with the specified fluid. REFER to Section 308-00.
• Transmission rattling/clattering noise—noise at idle in neutral	• Worn or rough reverse idler gear.	• CHECK the reverse idler gear. REPAIR as necessary. REFER to Section 308-03.
	• Rough running engine, cylinder misfire.	• CHECK the ignition system. CARRY OUT a cylinder power test. REFER to Section 303-00.
	• Excessive backlash in gears.	• CHECK the gear backlash. ADJUST as necessary. REFER to Section 308-03.
	• Worn countershaft gears.	• REPAIR as necessary. REFER to Section 308-03.
• Transmission whine—a mild whine at extreme speeds or high rpm	• Rotating gears/geartrain.	• Acceptable noise.
• Transmission whine—a high pitched whine, also described as a squeal	• Transmission gears are worn (high mileage vehicle).	• Result of normal gear wear. REPAIR as necessary. REFER to Section 308-03.
	• Mismatched gear sets.	• INSPECT the gear sets for an uneven wear pattern on the face of the gear teeth. REPAIR as necessary. REFER to Section 308-00.
	• Damaged or worn transmission bearing.	• INSPECT the transmission bearings. INSTALL new bearings as necessary. REFER to the Section 308-03.
• Transmission growling/humming—noise occurs in the forward gears. The noise is more prominent when the gear is loaded. The problem gear can be located as the noise occurs in a specific gear position	• Gear is cracked, chipped or rough.	• INSPECT the transmission gears for damage or wear. INSTALL new gears as necessary. REFER to Section 308-03.
• Transmission hissing—noise in neutral or in forward gears. As bearings wear or break up, the noise changes to a thumping noise	• Damaged or worn bearings.	• INSPECT the transmission bearings. INSTALL new bearings as necessary. REFER to Section 308-03.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Transmission (Manual) and Transfer Case Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Transmission knocking/thudding—noise at low speeds in forward gears	• Bearings with damaged balls or rollers or with pitted and spalled races.	• INSPECT the transmission bearings. INSTALL new bearings as necessary. REFER to Section 308-03.
• Transmission rumble/growl—noise at higher speeds in forward gears, more pronounced in a coast/deceleration condition	• Incorrect driveline angle.	• CHECK the driveline angle. REPAIR as necessary. REFER to Section 205-00.
	• Driveshaft out of balance or damaged.	• CHECK the driveshaft for damage, missing balance weights or undercoating. Using the electronic vibration analyzer (EVA), CHECK the driveshaft balance. CARRY OUT a driveline vibration test. For additional information, REFER to Section 205-00. REPAIR as necessary.
• Transmission rumble/growl—noise at all speeds in forward gears, more pronounced in a heavy acceleration condition	• Damaged or worn transmission bearing or gears (high mileage vehicles).	• CHECK transmission fluid for excessive metal particles. REPAIR as necessary. REFER to Section 308-03.
• Transfer case whine—noise at all ranges	• Incorrect fluid level or fluid quality.	• CHECK that the transfer case is filled to the correct level and with the specified fluid. REFER to Section 308-07B.
	• Worn oil pump.	• DISASSEMBLE the transfer case. CHECK the oil pump for wear or damage. REPAIR as necessary. REFER to Section 308-07B.
	• Under-inflated or oversized tires.	• CONFIRM that the tires and wheels are correct for the vehicle. CHECK that the tire inflation pressures are correct.
• Transfer case growl/rumble—noise at all ranges (A small amount of planetary noise can be heard when the transfer case is operated in low range.)	• Damaged or worn bearings or planetary gear.	• DISASSEMBLE the transfer case. CHECK the bearings or planetary gear for wear or damage. REPAIR as necessary. REFER to Section 308-07B.
• Transfer case scraping/grating—noise at all ranges	• Excessively stretched drive chain hitting the case.	• DISASSEMBLE the transfer case. CHECK the drive chain for wear or damage. REPAIR as necessary. REFER to Section 308-07B.
• Transfer case howl/hum—noise at all ranges or high range only	• Worn or damaged sun (input) gear, clutch pack (intermediate) gear or output shaft gear.	• DISASSEMBLE the transfer case. CHECK the gears for wear or damage. REPAIR as necessary. REFER to Section 308-07B.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Transmission (Manual) and Transfer Case Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Transfer case howl/hum—noise at low range only	• Worn or damaged intermediate gear and sliding gears (clutch pack).	• DISASSEMBLE the transfer case. CHECK the gears for wear or damage. REPAIR as necessary. REFER to Section 308-07B.
• Transfer case vibration—vibration felt with vehicle in 4WD	• Transfer case mounting. • Driveshaft out of balance. • Excessive pinion flange runout.	• GO to Pinpoint Test M.

Symptom Chart—Transmission (Automatic) Noise/Vibration

Condition	Possible Sources	Action
• Rattle—occurs at idle or at light acceleration from a stop	• Damaged engine or transmission mounts.	• CHECK the powertrain/drivetrain mounts for damage. CARRY OUT Powertrain/Drivetrain Mount Neutralizing in this section.
	• A loose front pipe heat shield.	• REPAIR or INSTALL a new heat shield as necessary.
	• Loose inspection plate or dust cover plate.	• CHECK for loose bolts. TIGHTEN to specifications. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
	• Loose flexplate to converter nuts.	• CHECK for loose nuts. TIGHTEN to specifications. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
• Whine—pitch increases with vehicle speed. Starts in first and second gear, decreases or goes away at higher gears	• Damaged or worn low one-way clutch. • Damaged or worn intermediate one-way clutch. • Friction elements. • Damaged or worn planetary or sun gear.	• INSPECT the transmission for wear or damage. REPAIR or INSTALL new components as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Transmission (Automatic) Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Whine—the pitch changes with engine speed	• A worn or damaged accessory drive component.	• CARRY OUT the Engine Accessory Test. REPAIR or INSTALL new components as necessary.
	• Incorrect fluid level.	• CHECK that the transmission is filled to the correct level. ADD fluid as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
	• Partially blocked filter.	• INSPECT the filter. CLEAN or INSTALL a new filter as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
	• Worn or damaged torque converter.	• CARRY OUT the torque converter service and replacement check. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
	• Worn or damaged front pump.	• INSPECT the front pump. INSTALL a new front pump as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
• Whine—pitch changes with vehicle speed	• Speedometer cable or gears.	• REPAIR or INSTALL new cables or gears as necessary.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Transmission (Automatic) Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Whine/moan type noise—pitch increases or changes with vehicle speed	• Damaged engine or transmission mount.	• CHECK the powertrain/drivetrain mounts for damage. CARRY OUT Powertrain/Drivetrain Mount Neutralizing in this section.
	• U-joints worn or damaged.	• INSPECT the U-joints for wear or damage. INSTALL new U-joints as necessary. REFER to Section 205-01.
	• Damaged or worn differential ring and pinion.	• INSPECT the differential ring and pinion for damage. CARRY OUT the Checking Tooth Contact Pattern and Condition of the Ring and Pinion component test in this section. REPAIR or INSTALL a new differential ring and pinion as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
	• Planetary gears nicked or chipped.	• CHECK the planetary gears for damage. INSTALL new components as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
• Whistle—noise is high pitched, constant. Changes in pitch with throttle position	• Hydraulic pressure in the main control.	• INSPECT the main control. REPAIR or INSTALL new components as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
	• Incorrect band/clutch apply pressure.	• CARRY OUT the line pressure tests. REPAIR or INSTALL components as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
	• Worn or damaged torque converter.	• CARRY OUT the torque converter service and replacement check. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Transmission (Automatic) Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Clunk—occurs when shifting from PARK to a drive or reverse position	• Damaged powertrain mounts.	• INSPECT the powertrain mounts for damage. INSTALL new mounts as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
	• Damaged or worn pinion bearings.	• CHECK for abnormal bearing play or roughness. INSTALL new bearings as necessary. REFER to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
	• Worn or galled driveshaft slip yoke splines.	• CLEAN and INSPECT the splines of the yoke. INSTALL a new slip yoke as necessary. REFER to Section 205-01.
	• Worn friction elements or excessive clutch pack end plate play.	• INSPECT the transmission for wear. CHECK that all end play and clearances are within specification. REPAIR or INSTALL new components as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
• Bump—occurs when shifting from PARK to a drive or reverse position. Similar to Clunk but with no sound	• Initial gear engagement.	• Acceptable condition.
• Buzz or hiss	• Incorrect driveline angles.	• CHECK for correct driveline angles. REPAIR as necessary. REFER to Section 205-00.
	• Worn or damaged main control solenoids or valves.	• Using a transmission tester, ACTIVATE the solenoids to duplicate sound. INSTALL new components as necessary. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart—Transmission (Automatic) Noise/Vibration (Continued)

Condition	Possible Sources	Action
• Vibration—a high frequency (20-80 Hz) that is felt through the seat or gear shifter. Changes with engine speed	• Transmission cooler lines grounded out.	• CHECK the transmission cooler lines. REPAIR as necessary.
	• Flexplate to torque converter nuts loose.	• CHECK the flexplate. TIGHTEN to specification. REFER to Section 307-01B for 4R70W transmissions or Section 307-01A for 4R100 transmissions.
	• Fluid filler tube grounded out.	• CHECK the fluid filler tube. REPAIR as necessary.
	• Shift cable incorrectly routed, grounded out or loose.	• CHECK the shift cable. REPAIR as necessary. REFER to Section 307-05.
• Shutter or chatter—occurs with light to medium acceleration from low speeds or a stop	• Electrical inputs/outputs. • Vehicle wiring harness. • Incorrect inputs/outputs from the powertrain control module (PCM), digital transmission range (TR) sensor, brake pedal position (BPP) sensor, throttle position (TP) sensor, transmission speed sensor (TSS), output speed shaft (OSS) sensor or the torque converter clutch (TCC).	• CARRY OUT a Torque Converter Clutch Operation Test. RUN on-board diagnostics or self-test. REFER to Section 307-01A for 4R100 transmissions or Section 307-01B for 4R70W transmissions. CLEAR the DTC's, road test and rerun on-board diagnostics or self-test.

Pinpoint Tests

The pinpoint tests are a step-by-step diagnostic process designed to determine the cause of a condition. It may not always be necessary to follow a pinpoint test to its conclusion. Carry out only the steps necessary to correct the condition. Then, test the system for normal operation. Sometimes, it is necessary to remove various vehicle components to gain access to the component requiring testing. For additional information, refer to the appropriate section for removal and installation procedures. Reinstall all components after verifying system operation is normal.

PINPOINT TEST A: BRAKE VIBRATION/SHUDDER

CONDITIONS	DETAILS/RESULTS/ACTIONS
A1 ROAD TEST THE VEHICLE—LIGHT BRAKING	
	1 Check that the wheel and tires are correct for the vehicle. Inspect the tires for abnormal wear patterns.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST A: BRAKE VIBRATION/SHUDDER (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
A1 ROAD TEST THE VEHICLE—LIGHT BRAKING (Continued)	
	2 Road test the vehicle. Warm the brakes by slowing the vehicle a few times from 80-32 km/h (50 to 20 mph) using light braking applications. At highway speeds of 89-97 km/h (55-60 mph), apply the brake using a light pedal force. • Is there a vibration/shudder felt in the steering wheel, seat or brake pedal? → **Yes** GO to **A4**. → **No** GO to **A2**.
A2 ROAD TEST THE VEHICLE—MODERATE TO HEAVY BRAKING	
	1 Road test the vehicle. At highway speeds of 89-97 km/h (55-60 mph), apply the brake using a moderate to heavy pedal force. • Is there a vibration/shudder? → **Yes** For vehicles with ABS, GO to **A3**. For vehicles with standard brakes, GO to **A4**. → **No** Vehicle is OK. VERIFY condition with customer. TEST the vehicle for normal operation.
A3 NORMAL ACTUATION OF THE ABS SYSTEM DIAGNOSIS	
	1 During moderate to heavy braking, noise from the hydraulic control unit (HCU) and pulsation in the brake pedal can be observed. Pedal pulsation coupled with noise during heavy braking or on loose gravel, bumps, wet or snowy surfaces is acceptable and indicates correct functioning of the ABS system. Pedal pulsation or steering wheel nibble (frequency is proportioned to the vehicle speed) indicates a concern with a brake or suspension component. • Is the vibration/shudder vehicle speed sensitive? → **Yes** GO to **A5**. → **No** The brake system is operating correctly.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST A: BRAKE VIBRATION/SHUDDER (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
A4 APPLICATION OF THE PARKING BRAKE	
	1 **NOTE:** Begin at the front of the vehicle unless the vibration or shudder has been isolated to the rear. This test is not applicable to vehicles with drum-in-hat type parking brakes. For vehicles with drum-in-hat parking brakes, proceed to the next test. For all other vehicles, apply the parking brake to identify if the problem is in the front or rear brake. At highway speeds of 89-97 km/h (55-60 mph), lightly apply the parking brake until the vehicle slows down. Release the parking brake immediately after the test. • Is there a vibration/shudder? → **Yes** GO to **A8**. → **No** GO to **A5**.
A5 CHECK THE FRONT WHEEL BEARINGS	
	1 Check the front wheel bearings. Refer to Wheel Bearing Check in this section. • Are the wheel bearings OK? → **Yes** GO to **A6**. → **No** INSPECT the wheel bearings. ADJUST or REPAIR as necessary. TEST the system for normal operation.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST A: BRAKE VIBRATION/SHUDDER (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
A6 CHECK THE FRONT SUSPENSION	
	1 Check the front suspension for: • Broken or loose bolts. • Damaged springs. • Worn or damaged upper and lower control arm bushings. • Loose or rough front bearings. • Uneven tire wear. • Are all the suspension components in satisfactory condition? → **Yes** GO to **A7**. → **No** REPAIR or INSTALL new components as necessary. TEST the system for normal operation.
A7 RESURFACE THE FRONT BRAKE DISCS	
	1 ⚠ **CAUTION: Do not use a bench lathe to machine brake discs.** **NOTE:** Follow the manufacturer's instructions to machine the brake discs. After machining, make sure the brake disc meets the thickness specification. Resurface the front brake discs or drums. Refer to Brake Disc Machining in this section. Road test the vehicle. • Is the vibration/shudder present? → **Yes** GO to **A8**. → **No** Vehicle is OK.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST A: BRAKE VIBRATION/SHUDDER (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
A8 CHECK THE REAR SUSPENSION	
	1 Check the rear suspension for: • Broken or loose bolts. • Damaged or worn springs or spring bushings. • Worn or damaged upper and lower control arm bushings. • Worn or damaged trailing arms. • Loose or rough rear bearings. • Uneven tire wear. • Are all the suspension components in satisfactory condition? → **Yes** GO to **A9**. → **No** REPAIR or INSTALL new components as necessary. TEST the system for normal operation.
A9 RESURFACE THE REAR BRAKE DISC OR DRUM	
	1 ⚠ **CAUTION: Do not use a bench lathe to machine brake discs.** **NOTE:** Follow the manufacturer's instructions to machine the brake discs. After machining, make sure the brake disc meets the thickness specification. Resurface the front brake discs. Refer to Brake Disc Machining in this section. Road test the vehicle. • Is the vibration/shudder present? → **Yes** CHECK the front suspension for wear or damage. RESURFACE the front brake discs. TEST the system for normal operation. → **No** Vehicle is OK.

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST B: ENGINE TICKING NOISE

CONDITIONS	DETAILS/RESULTS/ACTIONS
B1 CHECK FOR TICKING NOISE AT THE FUEL RAIL	
	[1] Disconnect the first fuel line clip. • Is the ticking noise gone? → **Yes** CHECK for TSB for applicable vehicle. REPAIR as necessary. TEST the system for normal operation. → **No** GO to **B2**.
B2 CHECK FOR TICKING NOISE AT THE FUEL INJECTOR	
	[1] Using an EngineEAR, listen at the fuel injectors by placing a probe on each injector. To isolate the faulty injector, disconnect the injector electrical connector and listen for the noise. • Is the fuel injector the source of the ticking noise? → **Yes** INSTALL a new fuel injector. REFER to Section 303-04A for 4.2L engines or Section 303-04B for 4.6L and 5.4L engines. TEST the system for normal operation. → **No** GO to **B3**.
B3 CHECK THE BELT TENSIONER FOR TICKING NOISE	
	[1] Inspect the accessory drive. Check for the belt tensioner bottoming at end of travel or not at end of stroke. [2] Using an EngineEAR, listen at the belt tensioner. • Is the belt tensioner the source of the noise? → **Yes** INSTALL a new belt tensioner. TEST the system for normal operation. → **No** GO to **B4**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST B: ENGINE TICKING NOISE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
B4 CHECK THE WATER PUMP FOR TICKING NOISE	
	1 Using an EngineEAR, listen at the water pump for ticking noise. • Is the water pump the source of the noise? → **Yes** INSTALL a new water pump. REFER to Section 303-03A for standard cooling or Section 303-03B for supercharger cooling. TEST the system for normal operation. → **No** GO to **B5**.
B5 CHECK FOR AN OBSTRUCTION OF THE COOLING FAN	
	1 Inspect the cooling fan for obstructions. 2 Check the cooling fan and shroud for wear or damage. • Was there an obstruction or does the cooling fan show signs of damage? → **Yes** REPAIR or INSTALL a new cooling fan. REFER to Section 303-03A for standard cooling or Section 303-03B for supercharger cooling. TEST the system for normal operation. → **No** GO to **B6**.
B6 CHECK THE OIL PUMP FOR TICKING NOISE	
	1 Check the oil pump using EngineEARs and probe at the oil filter adapter to verify the oil pump as a source. • Is the oil pump the source of the noise? → **Yes** INSTALL a new oil pump. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines. TEST the system for normal operation. → **No** GO to **B7**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST B: ENGINE TICKING NOISE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
B7 CHECK VALVE LIFTERS OR LASH ADJUSTERS FOR CORRECT OPERATION	
	1 Check valve lifter/lash adjuster for correct operation, using EngineEARs. • Are the valve lifters/lash adjusters operating correctly? → **Yes** VERIFY customer concern. CONDUCT a diagnosis of other suspect components. → **No** INSTALL a new valve lifter/lash adjuster(s). TEST the system for normal operation.

PINPOINT TEST C: ACCESSORY DRIVE BEARING HOOT

CONDITIONS	DETAILS/RESULTS/ACTIONS
C1 CHECK THE ACCESSORY DRIVE IDLER AND TENSIONER PULLEY BEARINGS	
	1 Carry out the Vehicle Cold Soak Procedure in this section.
2 	
	3 Place an EngineEAR probe directly on the pulley center post or bolt to verify which bearing is making the noise.
4 	
	• Is either bearing making the noise? → **Yes** INSTALL a new pulley/idler. CARRY OUT the Vehicle Cold Soak Procedure and TEST the system for normal operation. → **No** CONDUCT a diagnosis on other suspect accessory drive components.

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST D: POWER STEERING MOAN

CONDITIONS	DETAILS/RESULTS/ACTIONS
D1 CHECK THE POWER STEERING SYSTEM	
	1 Carry out the Vehicle Cold Soak Procedure in this section.
2 	
	3 Turn the steering wheel while the noise is occurring and listen for changes in sound pitch or loudness.
4 	
	• Does the sound pitch or loudness change while turning the steering wheel? → **Yes** GO to **D2**. → **No** CONDUCT a diagnosis on other suspect accessory drive components.
D2 VERIFY THE SOURCE	
1 	
	2 Place an EngineEAR probe near the power steering pump/reservoir while the noise is occurring. While an assistant turns the steering wheel, listen for changes in sound pitch or loudness.
3 	

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST D: POWER STEERING MOAN (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
D2 VERIFY THE SOURCE (Continued)	
	• Does the sound pitch or loudness change while turning the steering wheel? → **Yes** VERIFY that the supply tube to the pump is unobstructed. CHECK the fluid condition and level. DRAIN the fluid and REFILL. REFER to Section 211-02. CARRY OUT the Vehicle Cold Soak Procedure and TEST the system for normal operation. → **No** Normal system operation.

PINPOINT TEST E: ENGINE DRIVEN COOLING FAN MOAN

CONDITIONS	DETAILS/RESULTS/ACTIONS
E1 CHECK THE ENGINE DRIVEN COOLING FAN AFTER A COLD SOAK	
	1 Carry out the Vehicle Cold Soak Procedure in this section.
2 	
	3 Assess the airflow.
	4 Raise the engine speed to 1500 rpm while listening for the moan to increase in proportion to the airflow.
5 	
	• Does the moan increase in proportion to the airflow? → **Yes** TEST the fan for normal operation. If the fan tests normal, GO to **E2**. Otherwise, REPAIR as necessary. → **No** Normal system operation.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST E: ENGINE DRIVEN COOLING FAN MOAN (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
E2 CHECK THE ENGINE DRIVEN COOLING FAN AT NORMAL OPERATING TEMPERATURE	
1  3 	2 Run the engine to normal operating temperature while listening for the moan to stop. • Does the moan stop? → **Yes** Normal clutch operation. → **No** INSTALL a new fan clutch. TEST the system for normal operation.

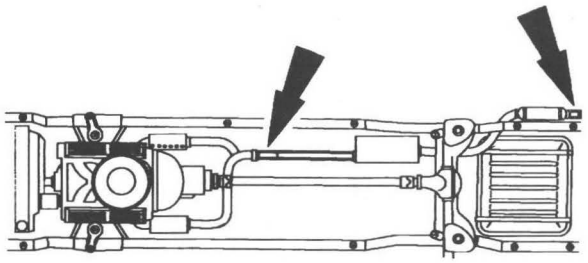
PINPOINT TEST F: DRUMMING NOISE

CONDITIONS	DETAILS/RESULTS/ACTIONS
F1 CHECK THE EXHAUST SYSTEM	
1  3 	2 Increase the engine rpm until the noise is the loudest. Note the engine rpm.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST F: DRUMMING NOISE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
F1 CHECK THE EXHAUST SYSTEM (Continued)	
4  DF1768-A	4 Add approximately 9 kg (20 lb) of weight to the exhaust system. First place the weight at the tail pipe and test, then place it at the front pipe.
5 	6 Increase the engine rpm and listen for the drumming noise. Note the engine rpm if the noise occurs.
7 	8 Using an electronic vibration analyzer (EVA), determine the amount of vibration that occurs with the drumming noise. • Is the noise/vibration reduced or eliminated, or does the noise/vibration occur at a different rpm? → **Yes** CARRY OUT Exhaust System Neutralizing in this section. TEST the system for normal operation. → **No** GO to **F2**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST F: DRUMMING NOISE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
F2 POWERTRAIN/DRIVETRAIN MOUNT NEUTRALIZING	
	1 Carry out Powertrain/Drivetrain Mount Neutralizing in this section. Test the system for normal operation. • Is the noise reduced or eliminated? → **Yes** Vehicle OK. TEST the system for normal operation. → **No** CONDUCT diagnosis of other suspect components.

PINPOINT TEST G: ENGINE TICKING, KNOCKING OR CONTINUOUS RATTLE

CONDITIONS	DETAILS/RESULTS/ACTIONS
G1 CHECK FOR NOISE AT THE VALVE COVERS AND THE FRONT COVERS (OHC ENGINES)	
	1 Carry out the Vehicle Cold Soak Procedure in this section.
2 	
	3 **NOTE:** For a short-duration ticking noise, multiple engine starts may be necessary. Using an EngineEAR, listen closely at the valve covers and the front covers (OHC engines) by placing the probe near the surface of the valve cover and then on the surface front cover.
4 	
	• Is the noise source apparent? → **Yes** REMOVE the appropriate cover and INSPECT for loose, worn/broken components. REPAIR as necessary. TEST the system for normal operation. → **No** GO to **G2**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST G: ENGINE TICKING, KNOCKING OR CONTINUOUS RATTLE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
G2 CHECK FOR NOISE AT THE CYLINDER BLOCK	
1  3 	2 Using an EngineEAR, listen closely at the cylinder block by placing a probe on or near each freeze plug. • Is the noise source apparent? → **Yes** REPAIR or INSTALL new components as necessary. → **No** GO to **G3**.
G3 CHECK FOR NOISE WHILE DISCONNECTING EACH FUEL INJECTOR ELECTRICAL CONNECTOR, ONE AT A TIME	
1  3 	2 Disconnect each fuel injector electrical connector, one at a time, to decrease piston force and listen for the noise.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST G: ENGINE TICKING, KNOCKING OR CONTINUOUS RATTLE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
G3 CHECK FOR NOISE WHILE DISCONNECTING EACH FUEL INJECTOR ELECTRICAL CONNECTOR, ONE AT A TIME (Continued)	
	• Is the noise reduced or eliminated? → **Yes** INSTALL a new fuel injector. REFER to Section 303-04A for 4.2L engines or Section 303-04B for 4.6L and 5.4L engines. TEST the system for normal operation. → **No** INSPECT accessory drive or the transmission as a possible source.

PINPOINT TEST H: FRONT SUSPENSION NOISE

CONDITIONS	DETAILS/RESULTS/ACTIONS
H1 ROAD TEST THE VEHICLE	
	1 Test drive the vehicle. 2 **NOTE:** An assistant will be needed for this road test. During the road test, drive the vehicle over a rough road. Using ChassisEARs, determine from which area/component the noise is originating. • Is there a squeak, creak or rattle noise? → **Yes** GO to **H2**. → **No** The suspension system is OK. CONDUCT a diagnosis on other suspect systems.
H2 INSPECT THE STEERING SYSTEM	
	1 ⚠ **WARNING: The electrical power to the air suspension system must be shut off prior to hoisting, jacking or towing an air suspension vehicle. This can be accomplished by turning off the air suspension switch. Failure to do so can result in unexpected inflation or deflation of the air springs, which can result in shifting of the vehicle during these operations.** Raise and support the vehicle. 2 Check the steering system for wear or damage. Carry out a steering linkage test. Refer to Section 211-00.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST H: FRONT SUSPENSION NOISE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
H2 INSPECT THE STEERING SYSTEM (Continued)	
	[3] Inspect the tire wear pattern. Refer to Tire Wear Chart in Tire Wear Patterns and Frequency Calculations in this section. • Are the steering components worn or damaged? → **Yes** REPAIR the steering system. INSTALL new components as necessary. TEST the system for normal operation. → **No** GO to **H3**.
H3 FRONT SHOCK ABSORBER/STRUT CHECK	
	[1] Check the front shock absorbers/strut mounts for loose bolts or nuts. [2] Check the front shock absorbers/struts for wear or damage. Carry out a ''bounce test'' • Are the front shock absorbers/struts loose or damaged? → **Yes** TIGHTEN to specifications if loose. INSTALL new front shock absorbers/struts if damaged. TEST the system for normal operation. → **No** GO to **H4**.
H4 CHECK THE FRONT SPRINGS	
	[1] Check the front spring and front spring mounts/brackets for wear or damage. • Are the front springs or spring mounts/brackets worn or damaged? → **Yes** REPAIR or INSTALL new components as necessary. TEST the system for normal operation. → **No** GO to **H5**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST H: FRONT SUSPENSION NOISE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
H5 CHECK THE CONTROL ARMS/RADIUS ARMS	
	1 Inspect the control arm bushings for wear or damage. 2 Inspect for twisted or bent control arms/radius arms. • Are the control arms/radius arms damaged or worn? → **Yes** REPAIR or INSTALL new components as necessary. TEST the system for normal operation. → **No** GO to **H6**.
H6 CHECK THE STABILIZER BAR/TRACK BAR	
	1 Check the stabilizer bar/track bar bushings and links for damage or wear. 2 Check the stabilizer bar/track bar for damage. 3 Check for loose or damaged stabilizer bar isolators or brackets. • Are the stabilizer bar/track bar components loose, worn or damaged? → **Yes** REPAIR or INSTALL new components as necessary. TEST the system for normal operation. → **No** Suspension system OK. CONDUCT diagnosis on other suspect systems.

PINPOINT TEST I: REAR SUSPENSION NOISE

CONDITIONS	DETAILS/RESULTS/ACTIONS
I1 ROAD TEST THE VEHICLE	
	1 Test drive the vehicle.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST I: REAR SUSPENSION NOISE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
I1 ROAD TEST THE VEHICLE (Continued)	
	2 **NOTE:** An assistant will be needed for this road test. During the road test, drive the vehicle over a rough road. Using ChassisEARs, determine from which area/component the noise is originating. • Is there a squeak, creak or rattle noise? → **Yes** GO to **I2**. → **No** The suspension system is OK. CONDUCT a diagnosis on other suspect systems.
I2 REAR SHOCK ABSORBER/STRUT CHECK	
	1 ⚠ **WARNING: The electrical power to the air suspension system must be shut off prior to hoisting, jacking or towing an air suspension vehicle. This can be accomplished by turning off the air suspension switch. Failure to do so can result in unexpected inflation or deflation of the air springs, which can result in shifting of the vehicle during these operations.** Raise and support the vehicle. 2 Check the rear shock absorber/strut mounts for loose bolts or nuts. 3 Check the rear shock absorbers/struts for damage. Carry out a shock absorber check. • Are the rear shock absorbers/struts loose or damaged? → **Yes** TIGHTEN to specifications if loose. INSTALL new rear shock absorbers/struts if damaged. TEST the system for normal operation. → **No** GO to **I3**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST I: REAR SUSPENSION NOISE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
I3 CHECK THE REAR SPRINGS	
	1 Check the rear springs and rear spring mounts/brackets for wear or damage. • Are the rear springs or spring mounts/brackets worn or damaged? → **Yes** REPAIR or INSTALL new components as necessary. TEST the system for normal operation. → **No** GO to **I4**.
I4 CHECK THE CONTROL ARMS/TRAILING ARMS	
	1 Inspect the control arm/trailing arm bushings for wear or damage. Check for loose control arm/trailing arm bolts. 2 Inspect for twisted or bent control arms/trailing arms. • Are the control arms/trailing arms loose, damaged or worn? → **Yes** REPAIR or INSTALL new components as necessary. TEST the system for normal operation. → **No** GO to **I5**.
I5 CHECK THE STABILIZER BAR/TRACK BAR	
	1 Check the stabilizer bar/track bar bushings and links for damage or wear. 2 Check the stabilizer bar/track bar for damage.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST I: REAR SUSPENSION NOISE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
I5 CHECK THE STABILIZER BAR/TRACK BAR (Continued)	
	3 Check for loose or damaged stabilizer bar isolators or brackets. • Are the stabilizer bar/track bar components loose, worn or damaged? → **Yes** REPAIR or INSTALL new components as necessary. Test the system for normal operation. → **No** Suspension system OK. CONDUCT diagnosis on other suspect systems.

PINPOINT TEST J: WHEEL AND TIRE

CONDITIONS	DETAILS/RESULTS/ACTIONS
J1 ROAD TEST THE VEHICLE	
	1 **NOTE:** Wheel or tire vibrations felt in the steering wheel are most likely related to the front wheel or tire. Vibration felt through the seat are most likely related to the rear wheel or tire. This may not always be true, but it can help to isolate the problem to the front or rear of the vehicle. Test drive the vehicle at different speed ranges. 2 During the road test, if the vibration can be eliminated by placing the vehicle in neutral or is affected by the speed of the engine, the cause is not the wheels or tires. • Is there a vibration and noise? → **Yes** GO to **J2**. → **No** The wheel and tires are OK. CONDUCT a diagnosis on other suspect systems.

(Continued)

DIAGNOSIS AND TESTING (Continued)

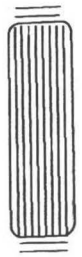
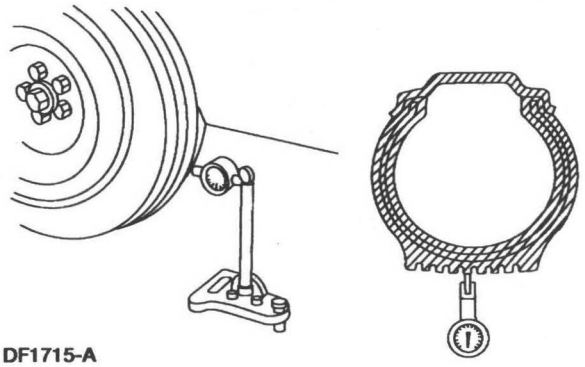
PINPOINT TEST J: WHEEL AND TIRE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
J2 CHECK THE FRONT WHEEL BEARINGS	
	1 Check the front wheel bearings. Refer to Wheel Bearing Check in this section. • Are the wheel bearings OK? → **Yes** GO to **J3**. → **No** INSPECT the wheel bearings. ADJUST or REPAIR as necessary. TEST the system for normal operation.
J3 INSPECT THE TIRES	
	1 Check the tires for missing weights. 2 Check the wheels for damage. 3 Inspect the tire wear pattern. Refer to the Tire Wear Patterns chart in this section. • Do the tires have an abnormal wear pattern? → **Yes** CORRECT the condition that caused the abnormal wear. INSTALL new tire(s). TEST the system for normal operation. → **No** GO to **J4**.
J4 TIRE ROTATION DIAGNOSIS	
1  DF1713-A	1 Spin the tires slowly and watch for signs of lateral runout.

(Continued)

DIAGNOSIS AND TESTING (Continued)

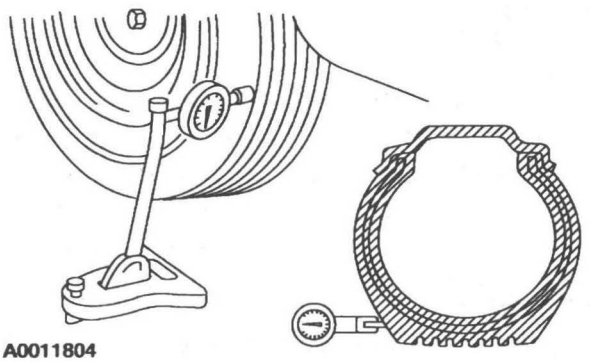
PINPOINT TEST J: WHEEL AND TIRE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
J4 TIRE ROTATION DIAGNOSIS (Continued)	
2  DF1714-A	2 Spin the tires slowly and watch for signs of radial runout. • Are there signs of visual runout? → **Yes** GO to **J5**. → **No** CHECK the wheel and tire balance. CORRECT as necessary. TEST the system for normal operation.
J5 RADIAL RUNOUT CHECK ON THE TIRE	
1  DF1715-A	1 Measure the radial runout of the wheel and tire assembly. A typical specification for total radial runout is 1.14 mm (0.04 in). • Is the radial runout within specifications? → **Yes** GO to **J8**. → **No** GO to **J6**.
J6 RADIAL RUNOUT CHECK ON THE WHEEL	
	1 Measure the radial runout of the wheel. A typical specification for total radial runout is 1.14 mm (0.04 in). • Is the radial runout within specifications? → **Yes** INSTALL a new tire. TEST the system for normal operation. → **No** GO to **J7**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST J: WHEEL AND TIRE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
J7 CHECK THE HUB/BRAKE DISC OR DRUM PILOT RUNOUT OR BOLT CIRCLE RUNOUT	
	[1] Measure the pilot or bolt circle runout. A typical specification for radial runout is: • Pilot runout— less than 0.15 mm (0.006 inch). • Bolt circle runout— less than 0.38 mm (0.015 inch). • Is the radial runout within specifications? → **Yes** INSTALL a new wheel. TEST the system for normal operation. → **No** REPAIR or INSTALL new components as necessary. REFER to Section 204-01A for 2-wheel drive front wheels, Section 204-01B for 4-wheel drive front wheels or Section 204-02 for the rear wheels.
J8 LATERAL RUNOUT CHECK ON THE TIRE	
[1]  A0011804	[1] Measure the lateral runout of the wheel and tire assembly. A typical specification for total lateral runout is 1.14 mm (0.04 in). • Is the lateral runout within specifications? → **Yes** Wheel and tires OK. CONDUCT diagnosis on other suspect systems. → **No** GO to **J9**.
J9 LATERAL RUNOUT CHECK ON THE WHEEL	
	[1] Measure the lateral runout of the wheel. A typical specification for total radial runout is 1.14 mm (0.04 in). • Is the lateral runout within specifications? → **Yes** INSTALL a new tire. TEST the system for normal operation. → **No** GO to **J10**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST J: WHEEL AND TIRE (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
J10 CHECK THE FLANGE FACE LATERAL RUNOUT	
	1 Measure the flange face lateral runout. A typical specification for lateral runout is: • Hub/brake disc— less than 0.13 mm (0.005 inch). • Axle shaft— less than 0.25 mm (0.010 inch). • Is the lateral runout within specifications? → **Yes** INSTALL a new wheel. TEST the system for normal operation. → **No** REPAIR or INSTALL new components as necessary. REFER to Section 204-01A for 2-wheel drive front wheels, Section 204-01B for 4-wheel drive front wheels or Section 204-02 for the rear wheels.

PINPOINT TEST K: HIGH SPEED SHAKE OR SHIMMY

CONDITIONS	DETAILS/RESULTS/ACTIONS
K1 CHECK FOR FRONT WHEEL BEARING ROUGHNESS	
	1 Chock the rear wheels. 2 Raise and support the front end of the vehicle so that the front wheel and tire assemblies can spin. 3 Spin the front tires by hand. Refer to Wheel Bearing Check in this section. • Do the wheel bearings feel rough? → **Yes** INSPECT the wheel bearings. REPAIR as necessary. TEST the system for normal operation. → **No** GO to **K2**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST K: HIGH SPEED SHAKE OR SHIMMY (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
K2 CHECK THE END PLAY OF THE FRONT WHEEL BEARINGS	
	1 Check the end play of the front wheel bearings. Refer to Section 204-01A for 2-wheel drive front wheels, Section 204-01B for 4-wheel drive front wheels or Section 204-02 for the rear wheels. • Is the end play OK? → **Yes** GO to **K3**. → **No** ADJUST or REPAIR as necessary. TEST the system for normal operation.
K3 MEASURE THE LATERAL RUNOUT AND THE RADIAL RUNOUT OF THE FRONT WHEELS ON THE VEHICLE	
	1 Measure the lateral runout and the radial runout of the front wheels on the vehicle. GO to Pinpoint Test J. • Are the measurements within specifications? → **Yes** GO to **K4**. → **No** INSTALL new wheels as necessary and BALANCE the assembly. TEST the system for normal operation.
K4 MEASURE THE LATERAL RUNOUT OF THE FRONT TIRES ON THE VEHICLE	
	1 Measure the lateral runout of the front tires on the vehicle. GO to Pinpoint Test J. • Is the runout within specifications? → **Yes** GO to **K5**. → **No** INSTALL new tires as necessary and BALANCE the assembly. TEST the system for normal operation.

(Continued)

DIAGNOSIS AND TESTING (Continued)

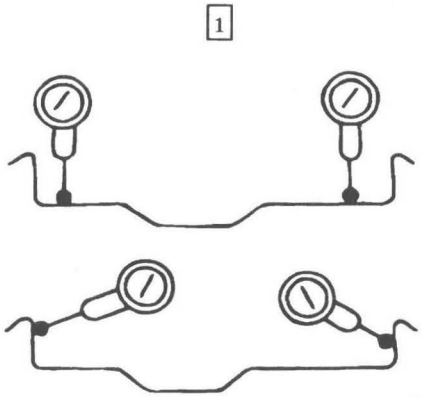
PINPOINT TEST K: HIGH SPEED SHAKE OR SHIMMY (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
K5 MEASURE THE RADIAL RUNOUT OF THE FRONT TIRES ON THE VEHICLE	
	1 Measure the radial runout of the front tires on the vehicle. GO to Pinpoint Test J. • Is the runout within specifications? → **Yes** BALANCE the front wheel and tire assemblies. If any tire cannot be balanced, INSTALL a new tire. TEST the system for normal operation. → **No** GO to **K6**.
K6 MATCH MOUNT THE TIRE AND WHEEL ASSEMBLY	
	1 Mark the high runout location on the tire and also on the wheel. Break the assembly down and rotate the tire 180 degrees (halfway around) on the wheel. Inflate the tire and measure the radial runout. • Is the runout within specifications? → **Yes** BALANCE the assembly. TEST the system for normal operation. → **No** If the high spot is not within 101.6 mm (4 inches) of the first high spot on the tire, GO to **K7**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST K: HIGH SPEED SHAKE OR SHIMMY (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
K7 MEASURE THE WHEEL FLANGE RUNOUT	
 DG0199-A	1 Dismount the tire and mount the wheel on a wheel balancer. Measure the runout on both wheel flanges. Refer to Section 204-04. • Is the runout within specifications? → **Yes** LOCATE and MARK the low spot on the wheel. INSTALL the tire, matching the high spot on the tire with the low spot on the wheel. BALANCE the assembly. TEST the system for normal operation. If the condition persists, GO to **K8**. → **No** INSTALL a new wheel. CHECK the runout on the new wheel. If the new wheel is within limits, LOCATE and MARK the low spot. INSTALL the tire, matching the high spot on the tire with the low spot on the wheel. BALANCE the assembly. TEST the system for normal operation. If the condition persists, GO to **K8**.
K8 CHECK FOR VIBRATION FROM THE FRONT OF THE VEHICLE	
⚠ WARNING: If only one drive wheel is allowed to rotate, speed must be limited to 55 km/h (34 mph) using the speedometer reading, since actual wheel speed will be twice that indicated on the speedometer. Exceeding a speed of 55 km/h (34 mph) or allowing the drive wheel to hang unsupported can result in tire disintegration or differential failure, which can cause serious personal injury and extensive vehicle damage.	
	1 Spin the front wheel and tire assemblies with a wheel balancer while the vehicle is raised on a hoist. Feel for vibration in the front fender or while seated in the vehicle. • Is the vibration present? → **Yes** SUBSTITUTE known good wheel and tire assemblies as necessary. TEST the system for normal operation. → **No** GO to **K9**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST K: HIGH SPEED SHAKE OR SHIMMY (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
K9 CHECK FOR VIBRATION FROM THE REAR OF THE VEHICLE	
⚠ WARNING: If only one drive wheel is allowed to rotate, speed must be limited to 55 km/h (34 mph) using the speedometer reading, since actual wheel speed will be twice that indicated on the speedometer. Exceeding a speed of 55 km/h (34 mph) or allowing the drive wheel to hang unsupported can result in tire disintegration or differential failure, which can cause serious personal injury and extensive vehicle damage.	
	[1] Chock the front wheels. [2] Raise and support the rear end of the vehicle so that the rear wheel and tire assemblies can spin. [3] Engage the drivetrain and carefully accelerate the drive wheels while checking for vibration. • Is the vibration present? → **Yes** GO to **K10**. → **No** TEST the system for normal operation.
K10 CHECK THE DRIVETRAIN	
⚠ WARNING: If only one drive wheel is allowed to rotate, speed must be limited to 55 km/h (34 mph) using the speedometer reading, since actual wheel speed will be twice that indicated on the speedometer. Exceeding a speed of 55 km/h (34 mph) or allowing the drive wheel to hang unsupported can result in tire disintegration or differential failure, which can cause serious personal injury and extensive vehicle damage.	
	[1] Remove the rear wheel and tire assemblies. Refer to Section 204-04. [2] Secure the brake drums (if so equipped), by installing wheel hub bolt nuts, reversed. [3] Carefully accelerate the drivetrain while checking for vibration. • Is the vibration present? → **Yes** CHECK/TEST the drivetrain and driveline components. TEST the system for normal operation. → **No** SUBSTITUTE known good wheel and tire assemblies as necessary. TEST the system for normal operation.

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST L: CLUTCH VIBRATION

CONDITIONS	DETAILS/RESULTS/ACTIONS
L1 CHECK ENGINE COMPONENTS FOR GROUNDING	
	1 **NOTE:** Make sure the clutch is the cause of the vibration concern. The vibration should occur during clutch operation. The clutch can also be difficult to engage or disengage. Eliminate all related systems before checking the clutch components. **NOTE:** Check the driveline angles and driveshaft runout before disassembling the clutch system. Refer to Section 205-00 for the correct driveline angle specifications. Check the powertrain/drivetrain mounts, exhaust manifolds or other engine components for grounding on the chassis. • Are any mounts or engine components grounded? → **Yes** REPAIR as necessary. TEST the system for normal operation. → **No** GO to **L2**.
L2 CHECK THE ACCESSORY DRIVE BELT	
	1 Remove the accessory drive belt. • Does the vibration stop with the accessory drive belt removed? → **Yes** DIAGNOSE the accessory drive components. → **No** GO to **L3**.
L3 CHECK FOR LOOSE CLUTCH PRESSURE PLATE BOLTS	
	1 Check for loose clutch pressure plate bolts. Inspect the clutch pressure plate for damage or for material between the pressure plate and flywheel. • Are there any loose bolts or damage? → **Yes** TIGHTEN the bolts to specifications or if damaged, INSTALL a new clutch pressure plate. REFER to Section 308-01. TEST the system for normal operation. → **No** GO to **L4**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST L: CLUTCH VIBRATION (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
L4 CHECK THE CLUTCH DISC SPRINGS	
	1 Check for worn, broken or loose clutch disc springs. • Are the clutch springs worn, broken or loose? → **Yes** INSTALL a new clutch disc. REFER to Section 308-01. TEST the system for normal operation. → **No** GO to **L5**.
L5 CHECK THE CLUTCH DISC SPLINES	
	1 Inspect the clutch disc splines for damage or wear. • Is there damage or wear? → **Yes** INSTALL a new clutch disc. REFER to Section 308-01. TEST the system for normal operation. → **No** GO to **L6**.
L6 CHECK THE FLYWHEEL BOLTS	
	1 Check for loose flywheel bolts. • Are the bolts loose? → **Yes** TIGHTEN the bolts to specifications. TEST the system for normal operation. → **No** GO to **L7**.
L7 CHECK THE FLYWHEEL SURFACE	
	1 Inspect the flywheel surface for wear or damage. Check the flywheel runout. • Is there any damage or excessive wear? → **Yes** INSTALL a new flywheel. REFER to Section 303-01A for 4.2L engines or Section 303-01B for 4.6L and 5.4L engines. TEST the system for normal operation. → **No** Clutch system normal. CONDUCT a diagnosis on other suspect systems.

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST M: TRANSFER CASE VIBRATION

CONDITIONS	DETAILS/RESULTS/ACTIONS
M1 INSPECT THE TRANSFER CASE	
	1 ⚠ **WARNING: The electrical power to the air suspension system must be shut off prior to hoisting, jacking or towing an air suspension vehicle. This can be accomplished by turning off the air suspension switch. Failure to do so can result in unexpected inflation or deflation of the air springs, which can result in shifting of the vehicle during these operations.** Inspect the transfer case for loose or missing mounting bolts. Check for fluid seepage between the transfer case and the transmission. • Are the mounting bolts missing or loose? → **Yes** TIGHTEN to specifications or INSTALL new bolts as necessary. TEST the system for normal operation. → **No** GO to **M2**.
M2 INSPECT THE REAR DRIVESHAFT	
	1 **NOTE:** Verify that the driveshaft and pinion flange index marks are aligned. Inspect the driveshaft for missing weights, damage or undercoating. 2 Inspect the U-joints for freedom of movement. 3 Check driveshaft runout and, if necessary, check the pinion flange runout. • Is the driveshaft or U-joints worn or damaged or misaligned? → **Yes** REPAIR or INSTALL a new driveshaft as necessary. TEST the system for normal operation. → **No** GO to **M3**.
M3 CHECK THE DRIVELINE ANGLES	
	1 Measure the rear driveshaft and pinion angles. Refer to Section 205-00.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST M: TRANSFER CASE VIBRATION (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
M3 CHECK THE DRIVELINE ANGLES (Continued)	
	2 Measure the front driveshaft and pinion angles. Refer to the appropriate workshop manual for the service procedures. • Are the driveline angles incorrect? → **Yes** REPAIR as necessary. TEST the system for normal operation. → **No** GO to **M4**.
M4 INSPECT THE FRONT DRIVESHAFT	
	1 **NOTE:** Verify that the driveshaft and pinion flange index marks are aligned. Inspect the front driveshaft for missing weights, damage or undercoating. 2 Inspect the U-joints and slip yoke for freedom of movement. 3 Check driveshaft runout and, if necessary, check the pinion flange runout. Refer to Section 205-00. • Is the driveshaft or U-joints worn or damaged? → **Yes** REPAIR or INSTALL a new driveshaft as necessary. TEST the system for normal operation. → **No** GO to **M5**.
M5 ROAD TEST WITH THE FRONT DRIVESHAFT ONLY	
	1 **NOTE:** Index mark the driveshaft to the pinion flange and to the output shaft before removal. Remove the rear driveshaft. 2 Plug the transfer case with an output shaft seal plug.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST M: TRANSFER CASE VIBRATION (Continued)

CONDITIONS	DETAILS/RESULTS/ACTIONS
M5 ROAD TEST WITH THE FRONT DRIVESHAFT ONLY (Continued)	
	3 **NOTE:** Shift the transfer case into 4WD high so the vehicle is driven by the front driveshaft only. Test drive the vehicle. • Is the vibration gone? → **Yes** INSTALL and BALANCE the rear driveshaft. TEST the system for normal operation. → **No** GO to **M6**.
M6 ROAD TEST WITH THE REAR DRIVESHAFT ONLY	
	1 **NOTE:** Index mark the front driveshaft to the pinion flange. Remove the front driveshaft. 2 Test drive the vehicle. • Is the vibration gone? → **Yes** INSTALL and BALANCE the front driveshaft. TEST the system for normal operation. → **No** GO to **M7**.
M7 TRANSFER CASE TAIL SHAFT INSPECTION	
	1 Inspect the splines of the output shaft for wear or damage. 2 Inspect the splines of the driveshaft slip yoke for wear or damage. • Are the splines worn or damaged? → **Yes** REPAIR or INSTALL new components as necessary. TEST the system for normal operation. → **No** The transfer case is OK. CONDUCT a diagnosis on other suspect systems.

DIAGNOSIS AND TESTING (Continued)

Component Tests

Idle Air Control (IAC) Valve

1. Open the hood.
2. **NOTE:** Key symptom is elevated idle speed while noise is occurring.

   NOTE: "Snapping" the throttle can induce the noise.

   Verify the condition by operating the vehicle for a short time.
3. Inspect the IAC valve. If physical evidence of contamination exists, install a new IAC valve.
4. While the noise is occurring, either place an EngineEAR probe near the IAC valve and the inlet tube, or create a 6.35 mm (0.25 in)-12.7 mm (0.50 in) air gap between the inlet tube and the clean air tube. If the IAC valve is making the noise, install a new IAC valve.
5. Test the vehicle for normal operation.

Steering Gear Grunt/Shudder Test

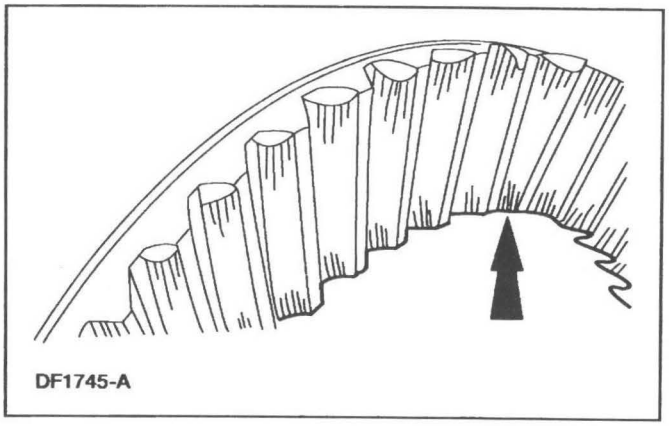
1. Start and run the vehicle to operating temperature.
2. Set engine idle speed to 1200 rpm.
3. ⚠ **CAUTION: Do not hold the steering wheel against the stops for more than three to five seconds at a time. Damage to the power steering pump will occur.**

   Rotate the steering wheel to the RH stop, then turn the steering wheel 90° back from that position. Turn the steering wheel slowly in a 15° to 30° arc.
4. Turn the steering wheel another 90°. Turn the steering wheel slowly in a 15° to 30° arc.
5. Repeat the test with power steering fluid at different temperatures.
6. If a light grunt is heard or a low (50-200 Hz) shudder is present, this is a normal steering system condition.
7. If a loud grunt is heard or a strong shudder is felt, fill and purge the power steering system.

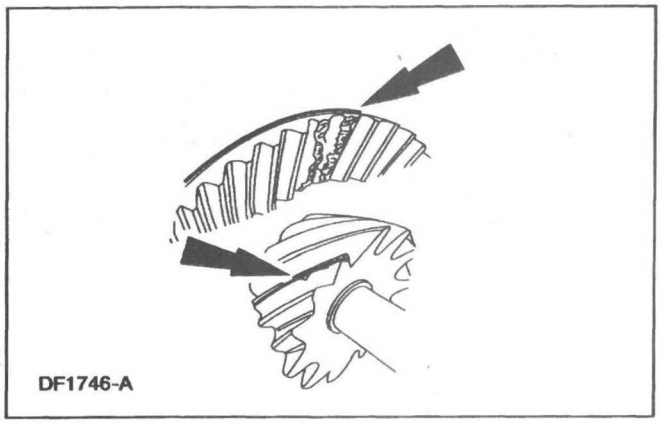
Checking Tooth Contact Pattern and Condition of the Ring and Pinion

There are two basic types of conditions that will produce ring and pinion noise. The first type is a howl or chuckle produced by broken, cracked, chipped, scored or forcibly damaged gear teeth and is usually quite audible over the entire speed range. The second type of ring and pinion noise pertains to the mesh pattern of the gear pattern. This gear noise can be recognized as it produces a cycling pitch or whine. Ring and pinion noise tends to peak in a narrow speed range or ranges, and will tend to remain constant in pitch.

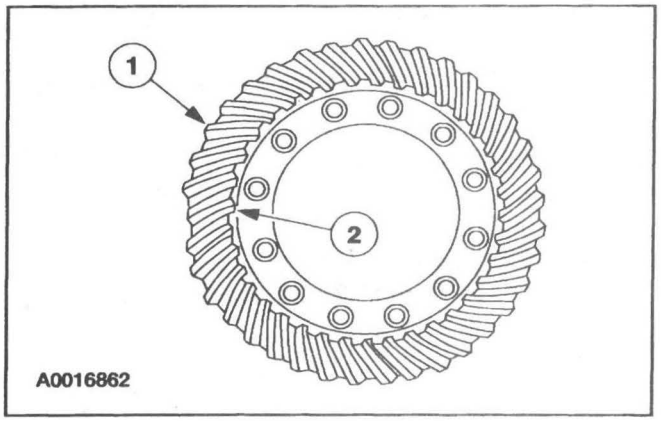
1. Raise and support the vehicle. For additional information, refer to Section 100-02.
2. Drain the axle lubricant. Refer to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
3. Remove the carrier assembly or the axle housing cover depending on the axle type. Refer to Section 205-02A for Ford 8.8 rear axles, Section 205-02B for Ford 9.75 rear axles, Section 205-02C for Ford 10.25 rear axles or Section 205-03 for front axles.
4. Inspect the gear set for scoring or damage.


DF1745-A

DIAGNOSIS AND TESTING (Continued)


DF1746-A

5. In the following steps, the movement of the contact pattern along the length is indicated as toward the" heel" or "toe" of the differential ring gear.



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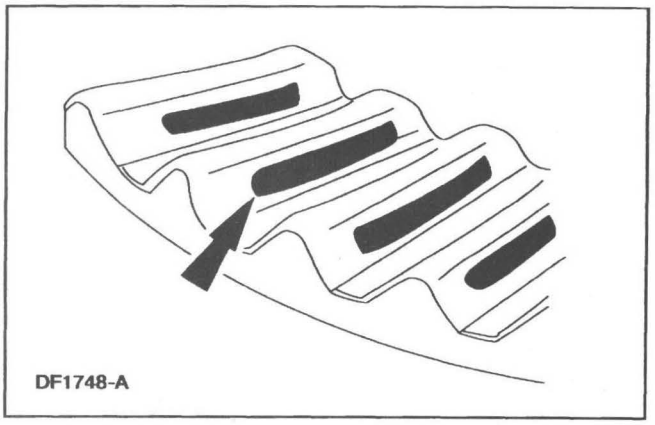
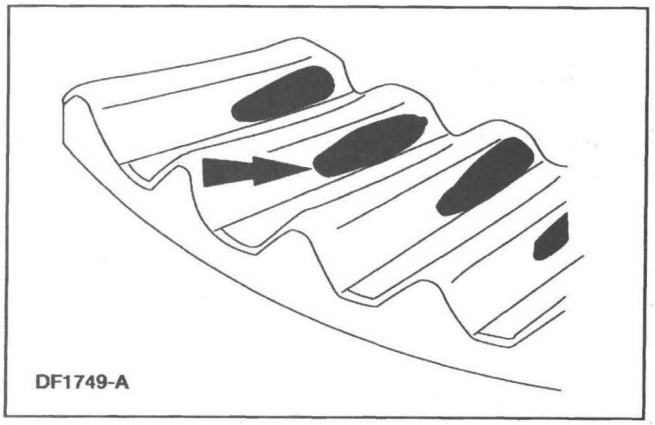
Item	Description
1	Heel
2	Toe

6. Apply a marking compound to a third of the gear teeth on the differential ring gear. Rotate the differential ring gear several complete turns in both directions until a good, clear tooth pattern is obtained. Inspect the contact patterns on the ring gear teeth.
7. A good contact pattern should be centered on the tooth. It can also be slightly toward the toe. There should always be some clearance between the contact pattern and the top of the tooth.
   - Tooth contact pattern shown on the drive side of the gear teeth.

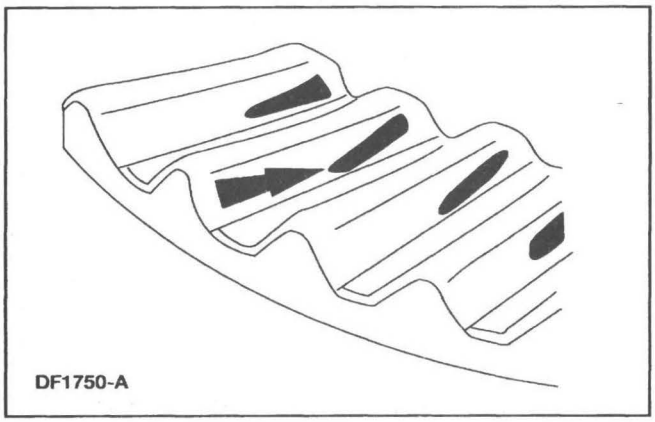

DF1748-A

8. A high, thick contact pattern that is worn more toward the toe.
   - Tooth contact pattern shown on the drive side of the gear teeth.
   - The high contact pattern indicates that the drive pinion is not installed deep enough into the carrier.
   - The differential ring gear backlash is correct, a thinner drive pinion shim is needed. A decrease will move the drive pinion toward the differential ring gear.

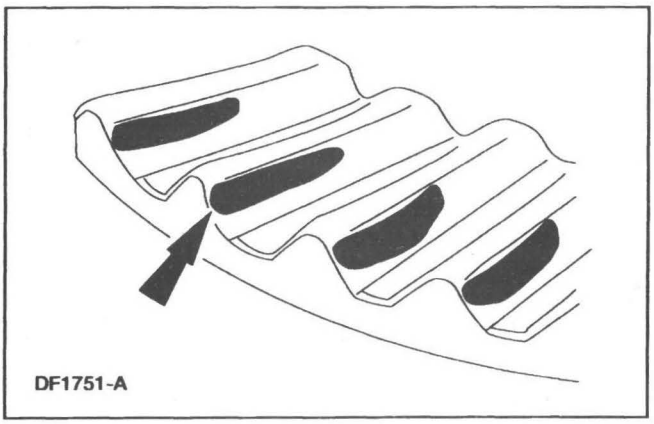

DF1749-A

DIAGNOSIS AND TESTING (Continued)

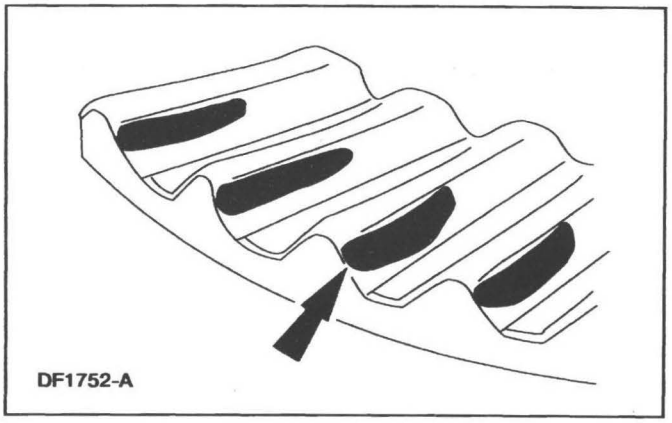
9. A high, thin contact pattern that is worn toward the toe.
   - Tooth contact pattern shown on the drive side of the gear teeth.
   - The drive pinion depth is correct. Increase the differential ring gear backlash.


DF1750-A

10. A contact pattern that is worn in the center of the differential ring gear tooth toward the heel.
    - Tooth contact pattern shown on the drive side of the gear teeth.
    - The low contact pattern indicates that the drive pinion is installed too deep into the carrier.
    - The differential ring gear backlash is correct. A thicker drive pinion shim is needed.


DF1751-A

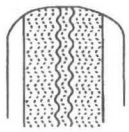
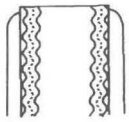
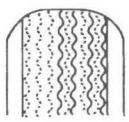
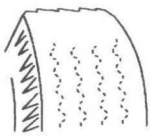
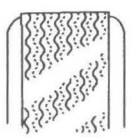
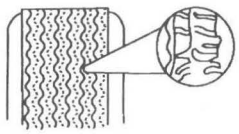
11. A contact pattern that is worn at the top of the differential ring gear tooth toward the heel.
    - Tooth contact pattern shown on the drive side of the gear teeth.
    - The pinion gear depth is correct. Decrease the differential ring gear backlash.


DF1752-A

DIAGNOSIS AND TESTING (Continued)

Tire Wear Patterns and Frequency Calculations

Tire Wear Chart

TIRE WEAR	CONDITION	POSSIBLE CAUSES
	• Rapid wear at both shoulders.	• Tires underinflated. • Worn suspension components. • Excessive cornering speeds. • Lack of rotation.
	• Rapid wear at the center.	• Tires overinflated. • Lack of rotation. • Excessive toe on drive wheels. • Heavy acceleration on drive wheels.
	• Wear at one shoulder.	• Toe adjustment out of specification. • Camber out of specification. • Damaged strut. • Damaged lower control arm.
	• Feather edges.	• Toe adjustment out of specification. • Damaged or worn tie rods. • Damaged spindle or knuckle.
	• Bald spots or cupping.	• Unbalanced wheel. • Excessive radial runout. • Worn strut or shock absorber.
	• Tire scalloped.	• Toe adjustment out of specification. • Camber out of specification. • Worn or damaged suspension components.
	• Wear pattern - FWD vehicles.	• Excessive toe on non-drive wheels. • Lack of rotation.
	• Wear pattern - FWD vehicles. Edge of thread blocks worn.	• Excessive toe on non-drive wheels. • Lack of rotation.

DF1717-A

DIAGNOSIS AND TESTING (Continued)

Wheel and tire NVH concerns are directly related to vehicle speed and are not generally affected by acceleration, coasting or decelerating. Also, out-of-balance wheel and tires can vibrate at more than one speed. A vibration that is affected by the engine rpm, or is eliminated by placing the transmission in NEUTRAL is not related to the tire and wheel. As a general rule, tire and wheel vibrations felt in the steering wheel are related to the front tire and wheel assemblies. Vibrations felt in the seat or floor are related to the rear tire and wheel assemblies. This can initially isolate a concern to the front or rear.

Careful attention must be paid to the tire and wheels. There are several symptoms that can be caused by damaged or worn tire and wheels. Carry out a careful visual inspection of the tires and wheel assemblies. Spin the tires slowly and watch for signs of lateral or radial runout. Refer to the tire wear chart to determine the tire wear conditions and actions.

For a vibration concern, use the vehicle speed to determine tire/wheel frequency and rpm. Calculate tire and wheel rpm and frequency by carrying out and following:

- Measure the diameter of the tire.
- Record the speed at which the vibration occurs.
- Obtain the corresponding tire and wheel rpm and frequency from the Tire Speed and Frequency Chart.
  - — If the vehicle speed is not listed, divide the vehicle speed at which the vibration occurs by 16 km/h (10 mph). Multiply that number by 16 km/h (10 mph) tire rpm listed for that tire diameter in the chart. Then divide that number by 60. For example: a 40 mph vibration with 835 mm (33 in) tires. 40 ÷10 = 4. Multiply 4 by 105 = 420 rpm. Divide 420 rpm by 60 seconds = 7 Hz at 40 mph.

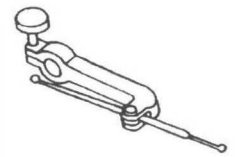
Tire Speed and Frequency Chart

Tire Diameter	Tire RPM/Hz	Tire RPM/Hz	Tire RPM/Hz	Tire RPM/Hz
mm (inch)	@ 16 km/h (10 mph)	@ 80 km/h (50 mph)	@ 97 km/h (60 mph)	@ 113 km/h (70 mph)
483 (19)	182	910/15	1092/18	1274/21
508 (20)	173	865/14	1038/17	1211/20
533 (21)	165	825/14	990/16	1155/19
560 (22)	158	790/13	948/16	1106/18
585 (23)	151	755/13	906/15	1057/18
610 (24)	145	725/12	870/14	1015/17
635 (25)	139	695/12	834/14	973/16
660 (26)	134	670/11	804/13	938/16
685 (27)	129	645/11	774/13	903/15
710 (28)	124	620/10	744/12	868/14
735 (29)	119	595/10	714/12	833/14
760 (30)	115	575/10	690/11	805/13
785 (31)	111	555/9	666/11	777/13
810 (32)	108	540/9	648/11	756/13
835 (33)	105	525/9	630/10	735/12
864 (34)	102	510/8	612/10	714/12

GENERAL PROCEDURES

Brake Disc Machining

Special Tool(s)

 ST1348-A	Gauge, Clutch Housing 308-021 (T75L-4201-A)
 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

Materials

Item	Specification
Metal Surface Cleaner F4AZ-19A536-RA or equivalent	WSE-M5B392-A
High Temperature Nickel Anti-Seize Lubricant F6AZ-9L494-AA or equivalent	ESE-M12A4-A

⚠ WARNING: The electrical power to the air suspension system must be shut off prior to hoisting, jacking or towing an air suspension vehicle. This can be accomplished by turning off the air suspension switch. Failure to do so can result in unexpected inflation or deflation of the air springs, which can result in shifting of the vehicle during these operations.

⚠ CAUTION: Do not install brake discs that are less than the minimum thickness specified. Do not machine a brake disc below the minimum thickness specification.

1. Check wheel bearing end-play and correct as necessary.

2. **NOTE:** Begin at the front of the vehicle unless the vibration has been isolated to the rear.

   Remove the tire and wheel assembly.

3. Remove the brake caliper and the brake caliper anchor plate. Refer to the appropriate section in Group 206 for the procedure.

4. Inspect the brake linings. Install new brake linings if below specification. For additional information, refer to the appropriate brake section.

GENERAL PROCEDURES (Continued)

5. Measure and record the brake disc thickness. Install a new brake disc if the thickness after machining will be at or below specification. The specification is molded into the brake disc.
   - Do not machine a new brake disc.

6. For vehicles with a two-piece hub and brake disc assembly:
   - Match-mark before disassembly.
   - Remove the brake disc.
   - Clean the hub and brake disc mounting surfaces with metal surface cleaner.
   - Using a die grinder with a mild abrasive (Scotch Brite® type), remove any rust or corrosion from the hub and brake disc mounting surfaces.
   - Align the match-marks and reinstall the brake disc on the hub.

7. ⚠ **CAUTION: Do not use a bench lathe to machine brake discs.**

   NOTE: The depth of cut must be between 0.10 and 0.20 mm (0.004 and 0.008 inch). Lighter cuts will cause heat and wear. Heavier cuts will cause poor brake disc surface finish.

   Using an on-car brake lathe, machine the brake discs. Follow the manufacturer's instructions. After machining, make sure the brake disc still meets the thickness specification.

8. Using the special tools, verify that the brake disc lateral runout is now within specification. For additional information, refer to Section 206-00.

9. Remove the special tool hub adapter.

10. Remove any remaining metal chips from the machining operation.

GENERAL PROCEDURES (Continued)

11. For vehicles with a two-piece hub and brake disc assembly:
    - Remove the brake disc from the hub.
    - Remove any remaining metal chips from hub and brake disc mounting surfaces and from the ABS sensor.
    - Apply a liberal amount of lubricant to the hub flange, pilot area and to the brake disc-to-hub mounting surface.
    - Using the match marks, mount the brake disc on the hub.
12. Install the brake caliper anchor plate and the brake caliper.
13. Install the tire and wheel assembly.
14. Test the system for normal operation.

Powertrain/Drivetrain Mount Neutralizing

⚠ **WARNING: The electrical power to the air suspension system must be shut off prior to hoisting, jacking or towing an air suspension vehicle. This can be accomplished by turning off the air suspension switch. Failure to do so can result in unexpected inflation or deflation of the air springs, which can result in shifting of the vehicle during these operations.**

1. Raise and support the vehicle.
2. Loosen, but do not remove, the powertrain/drivetrain mount fasteners.
3. Lower the vehicle.
4. ⚠ **CAUTION: Do not twist or strain the powertrain/drivetrain mounts.**

   Move the vehicle in forward and reverse 0.6-1.2 meters (2-4 ft).
5. Raise and support the vehicle.
6. Tighten the powertrain/drivetrain mount fasteners.

GENERAL PROCEDURES (Continued)

7. Lower the vehicle.

8. Test the system for normal operation.

Exhaust System Neutralizing

⚠ **WARNING: Exhaust gases contain carbon monoxide, which is harmful to health and potentially lethal. Repair exhaust system leaks immediately. Never operate the engine in an enclosed area.**

⚠ **WARNING: Exhaust system components are hot.**

NOTE: Neutralize the exhaust system to relieve strain on mounts which can be sufficiently bound up to transmit vibration as if grounded.

1. ⚠ **WARNING: The electrical power to the air suspension system must be shut off prior to hoisting, jacking or towing an air suspension vehicle. This can be accomplished by turning off the air suspension switch. Failure to do so can result in unexpected inflation or deflation of the air springs, which can result in shifting of the vehicle during these operations.**

   ⚠ **CAUTION: Make sure the system is warmed up to normal operating temperature, as thermal expansion can be the cause of a strain problem.**

   Raise and support the vehicle.

2. Loosen all exhaust hanger attachments and reposition the hangers until they hang free and straight.

3. Loosen all exhaust flange joints.

4. Place a stand to support the muffler parallel to the vehicle frame with the muffler pipe bracket free of stress.

5. Tighten the muffler connection.

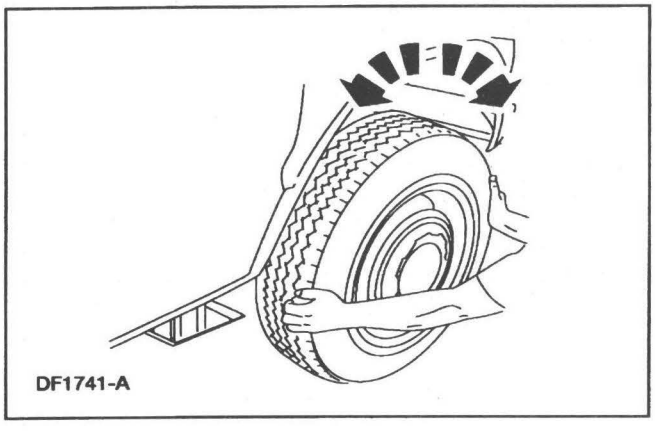
GENERAL PROCEDURES (Continued)

6. Tighten all the exhaust hanger clamps and flanges (tighten the exhaust manifold flange joint last).
   - Verify there is adequate clearance to prevent grounding at any point in the system. Make sure that the catalytic converter and heat shield do not contact the frame rails.
   - After neutralization, the rubber in the exhaust hangers should show some flexibility when movement is applied to the exhaust system.
   - With the exhaust system installed securely and cooled, the rear hanger should be angled forward.
7. Lower the vehicle.
8. Test the exhaust system for normal operation.

Wheel Bearing Check

1. **⚠ WARNING: The electrical power to the air suspension system must be shut off prior to hoisting, jacking or towing an air suspension vehicle. This can be accomplished by turning off the air suspension switch. Failure to do so can result in unexpected inflation or deflation of the air springs, which can result in shifting of the vehicle during these operations.**

   Raise the vehicle until the front tires are off the floor.
   - Make sure the wheels are in a straight forward position.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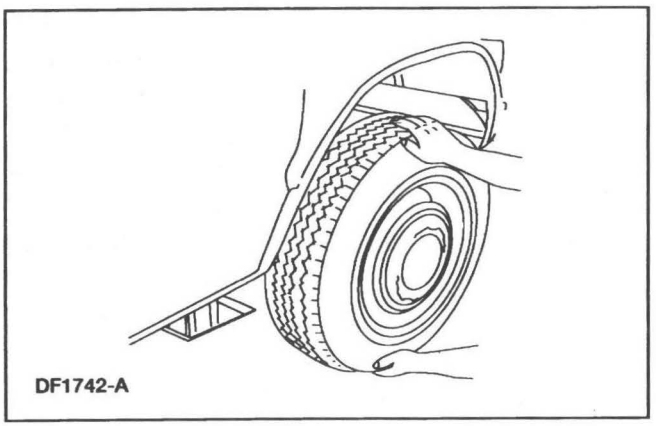
2. **NOTE:** Make sure the wheel rotates freely and that the brake pads are retraced sufficiently to allow free movement of the tire and wheel assembly.

   Spin the tire by hand to check the wheel bearings for roughness.

GENERAL PROCEDURES (Continued)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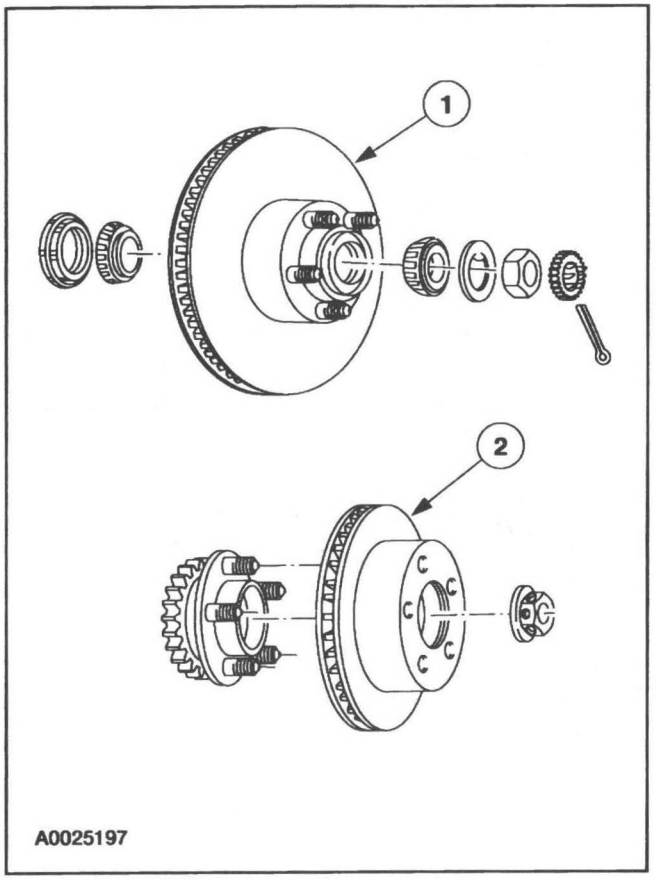
3. Grip each front tire at the top and bottom and move the wheel inward and outward while lifting the weight of the tire off the front wheel bearing.



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4. If the tire and wheel (hub) is loose on the spindle, does not rotate freely, or has a rough feeling when spun, carry out one of the following:
   1 On vehicles with inner and outer bearings, inspect the bearings and cups for wear or damage. Adjust or install new bearings and cups as necessary.
   2 On vehicles with one sealed bearing, install a new wheel hub.

GROUP

Chassis 2

SECTION 204-00 Suspension System — General Information

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Ford Motor Company

TECHNICAL
SUPPORT OPERATIONS
Automotive Consumer Services Group

AUGUST 2001

LITHO IN U.S.A.
PG-2608

FCS-12272-02-1

2002 Workshop Manual

Official Licensed Product
License #84356800

F-150
VOLUME 2

Ford Motor Company

2002 F-150

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NOTE: The descriptions and specifications contained in this manual were in effect at the time this manual was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications or design without notice and without incurring any obligation.

PUBLICATIONS ORDERING INFORMATION

To obtain information about ordering additional copies of this publication or to order any other Ford or Lincoln/Mercury publications, call 1-800-782-4356. Available publications include workshop manuals, wiring diagrams, PC/ED Manuals and Owner Guides.

In addition, you can obtain a publications order form by writing to: Ford Publications, care of Helm Inc., P.O. Box 07150, Detroit, MI 48207.

2002 F-150

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INTRODUCTION

NOTE: The descriptions and specifications contained in this manual were in effect at the time this manual was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications or design without notice and without incurring any obligation.

IMPORTANT SAFETY NOTICE

Appropriate service methods and 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 performing service with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedure, 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 the 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.

NOTES, CAUTIONS, AND WARNINGS

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 perform 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 you 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.**
- **MAKE 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 IN PARK UNLESS INSTRUCTED OTHERWISE FOR A SPECIFIC OPERATION. IF YOU HAVE A MANUAL TRANSMISSION, IT SHOULD BE IN REVERSE (ENGINE OFF) OR NEUTRAL (ENGINE ON) UNLESS INSTRUCTED OTHERWISE FOR A SPECIFIC OPERATION. PLACE WOOD BLOCKS (4" X 4" OR LARGER) AGAINST THE FRONT AND REAR SURFACES OF THE TIRES TO HELP PREVENT THE VEHICLE FROM MOVING.**
- **OPERATE THE ENGINE ONLY IN A WELL-VENTILATED AREA TO AVOID THE DANGER OF CARBON MONOXIDE POISONING.**
- **KEEP YOURSELF AND YOUR CLOTHING AWAY FROM MOVING PARTS WHEN THE ENGINE IS RUNNING, ESPECIALLY THE DRIVE BELTS.**
- **TO PREVENT SERIOUS BURNS, AVOID CONTACT WITH HOT METAL PARTS SUCH AS THE RADIATOR, EXHAUST MANIFOLD, TAIL PIPE, THREE-WAY CATALYTIC CONVERTER AND MUFFLER.**
- **DO NOT SMOKE WHILE WORKING ON A VEHICLE.**
- **TO AVOID INJURY, ALWAYS REMOVE RINGS, WATCHES, LOOSE HANGING JEWELRY AND LOOSE CLOTHING BEFORE BEGINNING TO WORK ON A VEHICLE.**
- **WHEN IT IS NECESSARY TO WORK UNDER THE HOOD, KEEP HANDS AND OTHER OBJECTS CLEAR OF THE RADIATOR FAN BLADES!**

GROUP

Powertrain 3

SECTION TITLE PAGE

SECTION 303-00 Engine System — General Information

CONTENTS PAGE

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SPECIFICATIONS

General Specifications

Item	Specification
Threadlock® 262 E2FZ-19554-B	WSK-M2G351-A6
Lubricants	
Super Premium SAE Motor Oil	Refer to owner literature
Diesel engine oil	Refer to owner literature
Gasoline Engine Oil Dye 164-R3705	ESE-M99C103-B1

DESCRIPTION AND OPERATION

Engine

NOTE: This section contains information, steps and procedures that may not be specific to your engine.

This section covers general procedures and diagnosis and testing of the engine system, except for exhaust emission control devices, which are covered in the Powertrain Control/Emissions Diagnosis Manual.

The engine incorporates the following features:

- a closed positive crankcase ventilation (PCV) system. For additional information, refer to Section 303-08.
- an exhaust emission control system. For additional information, refer to Section 303-08.
- an evaporative emission control system. For additional information, refer to Section 303-13.

Some engines incorporate a fail-safe cooling system. Refer to the appropriate section in Group 303 for the procedure.

The engine, fuel system, ignition system, emissions system and exhaust system all affect exhaust emission levels and must be maintained according to the maintenance schedule. Refer to the scheduled Maintenance Guide.

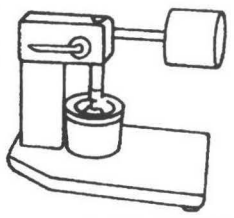
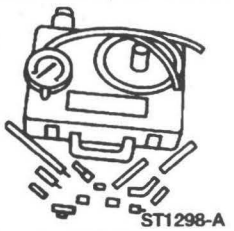
Correct engine identification is required to order parts. Refer to the appropriate section in Group 303 for the procedure.

For complete vehicle and engine identification codes, refer to Section 100-01.

DIAGNOSIS AND TESTING

Engine

Special Tool(s)

	Commercially Available Leakdown Tester —
 ST1299-A	Quick Disconnect Compression Tester 134-R0212 or equivalent
 ST1272-A	Dial Indicator Gauge Adapter 303-007 (TOOL-6565-AB) or equivalent
 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent
 ST1298-A	Engine Cylinder Leak Detection/Air Pressurization Kit 014-00708 or equivalent
 ST1296-A	Oil Pressure Gauge 303-088 (T73L-6600-A)

(Continued)

Special Tool(s)

 ST1300-A	UV Leak Detector Kit 164-R0756 or equivalent
 ST1297-A	Vacuum/Pressure Tester 164-R0253 or equivalent

Materials

Item	Specification
Gasoline Engine Oil Dye 164-R3705 or equivalent	ESE-M99C103-B1
Engine Oil	Refer to owner literature

Inspection and Verification

1. Verify the customer concern by operating the engine to duplicate the condition.
2. Visually inspect for obvious signs of mechanical damage. Refer to the following chart.

Visual Inspection Chart

Mechanical
• Engine coolant leaks • Engine oil leaks • Fuel leaks • Damaged or severely worn parts • Loose mounting bolts, studs and nuts

3. If the inspection reveals obvious concerns that can be readily identified, repair as necessary.
4. If the concerns remain after the inspection, determine the symptoms and go to the Symptom Chart.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart

Symptom Chart

Condition	Possible Sources	Action
• Difficult starting	• Damaged ignition system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [1].
	• Damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [1].
	• Damaged starting system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [1].
	• Damaged charging system/battery.	• REFER to Section 414-00.
	• Burnt valve.	• INSTALL a new valve.
	• Worn piston.	• INSTALL a new piston.
	• Worn piston rings.	• INSTALL new piston rings.
	• Worn cylinder.	• REPAIR or INSTALL a new cylinder block.
	• Damaged head gasket.	• INSTALL a new head gasket.
	• Damaged cooling system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [1].
• Poor idling	• Vacuum leaks.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [1].
	• Malfunctioning or damaged ignition system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [1].
	• Malfunctioning or damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [1].
	• Damaged valve tappet or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Damaged valve tappet guide or lash adjuster.	• INSTALL a new valve tappet guide or valve tappet.
	• Incorrect valve-to-valve seat contact.	• REPAIR or INSTALL a new valve or valve seat.
	• Damaged head gasket.	• INSTALL a new head gasket.

1 Can be purchased as a separate item.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart (Continued)

Condition	Possible Sources	Action
• Abnormal combustion	• Malfunctioning or damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [2].
	• Malfunctioning or damaged ignition system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [2].
	• Malfunctioning or damaged air intake system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [2].
	• Damaged valve tappet or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Damaged valve tappet guide or valve tappet.	• INSTALL a new valve tappet guide or valve tappet.
	• Burnt or sticking valve.	• REPAIR or INSTALL a new valve.
	• Weak or broken valve spring.	• INSTALL a new valve spring.
	• Carbon accumulation in combustion chamber.	• ELIMINATE carbon buildup.
• Excessive oil consumption	• Leaking oil.	• REPAIR oil leakage.
	• Malfunctioning PCV system.	• REPAIR or INSTALL new necessary components.
	• Worn valve stem seal.	• INSTALL a new valve stem seal.
	• Worn valve stem or valve guide.	• INSTALL a new valve and valve guide.
	• Sticking piston rings.	• REPAIR or INSTALL new piston rings.
	• Worn piston ring groove.	• INSTALL a new piston and piston pin.
	• Worn piston or cylinder.	• REPAIR or INSTALL a new piston or cylinder block.

2 Can be purchased as a separate item.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart (Continued)

Condition	Possible Sources	Action
• Engine noise	• Leaking exhaust system.	• REPAIR exhaust leakage.
	• Incorrect drive belt tension.	• REFER to Section 303-05.
	• Malfunctioning generator bearing.	• Refer to the appropriate section in Group 414 for the procedure.
	• Malfunctioning water pump bearing.	• REFER to Section 303-03A.
	• Malfunctioning or damaged cooling system.	• REFER to Section 303-03A.
	• Malfunctioning or damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [3].
	• Loose timing chain/belt (6268).	• ADJUST or INSTALL a new timing chain/belt.
	• Damaged timing chain tensioner (6L266).	• INSTALL a new timing chain tensioner.
	• Excessive main bearing clearance.	• ADJUST clearance or INSTALL a new crankshaft main bearing (6333).
	• Seized or heat damaged crankshaft main bearing.	• INSTALL a new crankshaft main bearing.
	• Excessive crankshaft end play.	• INSTALL a new thrust bearing or crankshaft (6303).
	• Excessive connecting rod bearing clearance.	• INSTALL a new connecting rod bearing or connecting rod (6200).
	• Heat damaged connecting rod bearing (6211).	• INSTALL a new connecting rod bearing.
	• Damaged connecting rod bushing (6207).	• INSTALL a new connecting rod bushing.
	• Worn cylinder.	• REPAIR or INSTALL a new cylinder block (6010).
	• Worn piston (6108) or piston pin (6135).	• INSTALL a new piston or piston pin.
	• Damaged piston rings.	• INSTALL new piston rings.
	• Bent connecting rod.	• INSTALL a new connecting rod.
	• Malfunctioning valve tappet (6500) or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Excessive valve tappet or lash adjuster clearance.	• ADJUST clearance or INSTALL a new valve tappet guide or valve tappet.
	• Broken valve spring (6513).	• INSTALL a new valve spring.
	• Excessive valve guide clearance.	• ADJUST clearance or INSTALL a new valve guide (6510) or valve.

3 Can be purchased as a separate item.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart (Continued)

Condition	Possible Sources	Action
• Insufficient power	• Malfunctioning or damaged ignition system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [4].
	• Malfunctioning or damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [4].
	• Malfunctioning or damaged air intake system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual [4].
	• Damaged or plugged exhaust system.	• INSPECT exhaust system.
	• Incorrect tire size.	• REFER to Section 204-04.
	• Dragging brakes.	• REFER to Section 206-00.
	• Slipping transmission.	• Refer to the appropriate section in Group 307 for the procedure.
	• Malfunctioning valve tappet or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Damaged valve tappet guide or valve tappet.	• INSTALL a new valve tappet guide or valve tappet.
	• Compression leakage at valve seat.	• REPAIR or INSTALL a new valve, valve seat or cylinder head (6049).
	• Seized valve stem.	• INSTALL a new valve.
	• Weak or broken valve spring.	• INSTALL a new valve spring.
	• Worn or damaged camshaft.	• INSTALL a new camshaft.
	• Damaged head gasket (6051).	• INSTALL a new head gasket.
	• Cracked or distorted cylinder head.	• INSTALL a new cylinder head.
	• Damaged, worn or sticking piston ring(s).	• REPAIR or INSTALL a new piston ring(s).
	• Worn or damaged piston.	• INSTALL a new piston and piston pin.

Component Tests

Engine Oil Leaks

NOTE: When diagnosing engine oil leaks, the source and location of the leak must be positively identified prior to repair.

Prior to carrying out this procedure, clean all sealing surface areas with a suitable solvent to remove all traces of oil.

Engine Oil Leaks—Fluorescent Oil Additive Method

Use the UV Leak Detector Kit to carry out the following procedure for oil leak diagnosis.

1. Add gasoline engine oil dye. Use a minimum 14.8 ml (0.5 ounce) to a maximum 29.6 ml (1 ounce) of fluorescent additive to all engines. If the oil is not premixed, fluorescent additive must first be added to crankcase.
2. Run the engine for 15 minutes. Stop the engine and inspect all seal and gasket areas for leaks using the UV Leak Detector Kit. A clear bright yellow or orange area will identify the leak. For extremely small leaks, several hours may be required for the leak to appear.

4 Can be purchased as a separate item.

DIAGNOSIS AND TESTING (Continued)

Leakage Points—Underhood

Examine the following areas for oil leakage:

- valve cover gaskets
- intake manifold gaskets
- cylinder head gaskets
- oil bypass filter
- oil filter adapter
- engine front cover
- oil filter adapter and filter body
- oil level indicator tube connection
- oil pressure sensor

Leakage Points—Under Engine—With Vehicle on Hoist

- oil pan gaskets (6710)
- oil pan sealer
- oil pan rear seal (6723)
- engine front cover gasket
- crankshaft front seal (6700)
- crankshaft rear oil seal (6701)
- crankshaft main bearing cap side bolts
- oil filter adapter and filter body
- oil cooler, if equipped

Leakage Points—With Transmission and Flywheel Removed

- crankshaft rear oil seal
- rear main bearing cap parting line
- rear main bearing cap and seals
- flywheel mounting bolt holes (with flywheel installed)
- camshaft rear bearing covers (6266) or pipe plugs at the end of oil passages

Oil leaks at crimped seams in sheet metal parts and cracks in cast or stamped parts can be detected when using the dye method.

Compression Test—Compression Gauge Check

1. Make sure the oil in the crankcase is of the correct viscosity and at the correct level and that the battery (10655) is correctly charged. Operate the vehicle until the engine is at normal operating temperature. Turn the ignition switch to the OFF position, then remove all the spark plugs (12405).
2. Set the throttle plates in the wide-open position.
3. Install a compression gauge such as the Compression Tester in the No. 1 cylinder.
4. Install an auxiliary starter switch in the starting circuit. With the ignition switch in the OFF position, and using the auxiliary starter switch, crank the engine a minimum of five compression strokes and record the highest reading. Note the approximate number of compression strokes required to obtain the highest reading.
5. Repeat the test on each cylinder, cranking the engine approximately the same number of compression strokes.

Compression Test—Test Results

The indicated compression pressures are considered within specification if the lowest reading cylinder is within 75 percent of the highest reading. Refer to the Compression Pressure Limit Chart.

Compression Pressure Limit Chart

Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure
924 kPa (134 psi)	696 kPa (101 psi)	1131 kPa (164 psi)	848 kPa (123 psi)	1338 kPa (194 psi)	1000 kPa (146 psi)	1544 kPa (224 psi)	1158 kPa (168 psi)
938 kPa (136 psi)	703 kPa (102 psi)	1145 kPa (166 psi)	855 kPa (124 psi)	1351 kPa (196 psi)	1014 kPa (147 psi)	1558 kPa (226 psi)	1165 kPa (169 psi)
952 kPa (138 psi)	717 kPa (104 psi)	1158 kPa (168 psi)	869 kPa (126 psi)	1365 kPa (198 psi)	1020 kPa (148 psi)	1572 kPa (228 psi)	1179 kPa (171 psi)
965 kPa (140 psi)	724 kPa (106 psi)	1172 kPa (170 psi)	876 kPa (127 psi)	1379 kPa (200 psi)	1034 kPa (150 psi)	1586 kPa (230 psi)	1186 kPa (172 psi)
979 kPa (142 psi)	738 kPa (107 psi)	1186 kPa (172 psi)	889 kPa (129 psi)	1303 kPa (202 psi)	1041 kPa (151 psi)	1600 kPa (232 psi)	1200 kPa (174 psi)

(Continued)

DIAGNOSIS AND TESTING (Continued)

Compression Pressure Limit Chart

Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure
933 kPa (144 psi)	745 kPa (109 psi)	1200 kPa (174 psi)	903 kPa (131 psi)	1407 kPa (204 psi)	1055 kPa (153 psi)	1055 kPa (153 psi)	1207 kPa (175 psi)
1007 kPa (146 psi)	758 kPa (110 psi)	1214 kPa (176 psi)	910 kPa (132 psi)	1420 kPa (206 psi)	1062 kPa (154 psi)	1627 kPa (154 psi)	1220 kPa (177 psi)
1020 kPa (148 psi)	765 kPa (111 psi)	1227 kPa (178 psi)	917 kPa (133 psi)	1434 kPa (208 psi)	1075 kPa (156 psi)	1641 kPa (238 psi)	1227 kPa (178 psi)
1034 kPa (150 psi)	779 kPa (113 psi)	1241 kPa (180 psi)	931 kPa (135 psi)	1448 kPa (210 psi)	1083 kPa (157 psi)	1655 kPa (240 psi)	1241 kPa (180 psi)
1048 kPa (152 psi)	786 kPa (114 psi)	1255 kPa (182 psi)	936 kPa (136 psi)	1462 kPa (212 psi)	1089 kPa (158 psi)	1669 kPa (242 psi)	1248 kPa (181 psi)
1062 kPa (154 psi)	793 kPa (115 psi)	1269 kPa (184 psi)	952 kPa (138 psi)	1476 kPa (214 psi)	1103 kPa (160 psi)	1682 kPa (244 psi)	1262 kPa (183 psi)
1076 kPa (156 psi)	807 kPa (117 psi)	1282 kPa (186 psi)	965 kPa (140 psi)	1489 kPa (216 psi)	1117 kPa (162 psi)	1696 kPa (246 psi)	1269 kPa (184 psi)
1089 kPa (158 psi)	814 kPa (118 psi)	1296 kPa (188 psi)	972 kPa (141 psi)	1503 kPa (218 psi)	1124 kPa (163 psi)	1710 kPa (248 psi)	1202 kPa (186 psi)
1103 kPa (160 psi)	827 kPa (120 psi)	1310 kPa (190 psi)	979 kPa (142 psi)	1517 kPa (220 psi)	1138 kPa (165 psi)	1724 kPa (250 psi)	1289 kPa (187 psi)
1110 kPa (161 psi)	834 kPa (121 psi)	1324 kPa (192 psi)	993 kPa (144 psi)	1631 kPa (222 psi)	1145 kPa (166 psi)	—	—

If one or more cylinders reads low, squirt approximately one tablespoon of engine oil on top of the pistons in the low-reading cylinders. Repeat the compression pressure check on these cylinders.

Compression Test—Interpreting Compression Readings

1. If compression improves considerably, piston rings are faulty.
2. If compression does not improve, valves are sticking or seating incorrectly.
3. If two adjacent cylinders indicate low compression pressures and squirting oil on each piston does not increase compression, the head gasket may be leaking between cylinders. Engine oil or coolant in cylinders could result from this condition.

   Use the Compression Pressure Limit Chart when checking cylinder compression so that the lowest reading is within 75 percent of the highest reading.

Cylinder Leakage Detection

When a cylinder produces a low reading, use of the Engine Cylinder Leak Detection/Air Pressurization Kit will be helpful in pinpointing the exact cause.

The leakage detector is inserted in the spark plug hole, the piston is brought up to dead center on the compression stroke, and compressed air is admitted.

Once the combustion chamber is pressurized, a special gauge included in the kit will read the percentage of leakage. Leakage exceeding 20 percent is excessive.

While the air pressure is retained in the cylinder, listen for the hiss of escaping air. A leak at the intake valve (6507) will be heard in the throttle body (9E926). A leak at the exhaust valve (6505) can be heard at the tail pipe. Leakage past the piston rings will be audible at the positive crankcase ventilation (PCV) connection. If air is passing through a blown head gasket to an adjacent cylinder, the noise will be evident at the spark plug hole of the cylinder into which the air is leaking. Cracks in the cylinder block or gasket leakage into the cooling system may be detected by a stream of bubbles in the radiator (8005).

Oil Consumption Test

The following diagnostic procedure is used to determine the source of excessive internal oil consumption.

DIAGNOSIS AND TESTING (Continued)

1. **NOTE:** Oil use is normally greater during the first 16,100 km (10,000 miles) of service. As mileage increases, oil use generally decreases. Vehicles in normal service should get at least 1,450 km per liter (900 miles per quart) after 16,000 km (10,000 miles) of service. High speed driving, towing, high ambient temperature and other factors may result in greater oil use.

   Define excessive oil consumption, such as the number of miles driven per liter (quart) of oil used. Also determine customer's driving habits, such as sustained high speed operation, towing, extended idle and other considerations.
2. Verify that the engine has no external oil leak as described under Engine Oil Leaks in the Diagnosis and Testing portion of this section.
3. Verify that the engine has the correct oil level dipstick (6750).
4. Verify that the engine is not being run in an overfilled condition. Check the oil level at least five minutes after a hot shutdown with the vehicle parked on a level surface. In no case should the level be above MAX or the letter F in FULL. If significantly overfilled, carry out Steps 6a through 6d.
5. Verify the spark plugs are not oil saturated. If the spark plugs are oil saturated and compression is good it can be assumed the valve seals or valve guides are at fault.
6. Carry out an oil consumption test:
   a. Drain the engine oil, remove the oil bypass filter (6714) and refill with one liter (quart) less than the recommended amount.
   b. Run the engine for three minutes (10 minutes if cold), and allow the oil to drain back for at least five minutes with the vehicle on a level surface.
   c. Remove oil level dipstick and wipe clean. (Do not wipe with anything contaminated with silicone compounds.) Reinstall the oil level dipstick, being sure to seat it firmly in the oil level indicator tube (6754). Remove the oil level dipstick and draw a mark on the back (unmarked) surface at the indicated oil level. This level should be about the same as the MIN or ADD mark on the face of the oil level dipstick.
   d. Add one liter (quart) of oil. Restart the engine and allow to idle for at least two minutes. Shut off the engine and allow the oil to drain back for at least five minutes. Mark the oil level dipstick, using the procedure above.
   e. Record the vehicle mileage.
   f. Instruct the customer to drive the vehicle as usual and perform the following:
      — Check the oil level regularly at intervals of 160 to 240 km (100-150 miles).
      — Return to the service point when the oil level drops below the lower (MIN or ADD) mark on the oil level dipstick.
      — Add only full liters (quarts) of the same oil in an emergency. Note the mileage at which the oil is added.
   g. Check the oil level under the same conditions and at the same location as in Steps 6c and 6d.
      — Measure the distance from the oil level to the UPPER mark on the oil level dipstick and record.
      — Measure the distance between the two scribe marks and record.
      — Divide the first measurement by the second.
      — Divide the distance driven during the oil test by the result. This quantity is the approximate oil consumption rate in kilometers per liter or in miles per quart.
   h. If the oil consumption rate is unacceptable, go to Step 7.
7. Check the positive crankcase ventilation (PCV) system. Make sure the system is not plugged.
8. Check for plugged oil drain-back holes in the cylinder heads and cylinder block.
9. If the condition still exists after performing the above steps, go to Step 10.
10. Perform a cylinder compression test or perform a cylinder leak detection test with Engine Cylinder Leak Detection/Air Pressurization Kit. This can help determine the source of oil consumption such as valves, piston rings or other areas.

DIAGNOSIS AND TESTING (Continued)

11. **NOTE:** After determining if new parts should be installed, make sure correct parts are used.

    Check valve guides for excessive guide clearance. Install new all valve stem seals (6571) after verifying valve guide clearance.

12. Worn or damaged internal engine components can cause excessive oil consumption. Small deposits of oil on the tips of spark plugs can be a clue to internal oil consumption. If internal oil consumption still persists, proceed as follows:

    a. Remove the engine from the vehicle and place it on an engine work stand. Remove the intake manifolds (9424), cylinder heads, oil pan (6675) and oil pump (6600).

    b. Check piston ring clearance, ring gap and ring orientation. Repair as necessary.

    c. Check for excessive bearing clearance. Repair as necessary.

13. Repeat the oil consumption test (Step 6) to confirm the oil consumption concern has been resolved.

Intake Manifold Vacuum Test

Bring the engine to normal operating temperature. Connect the Vacuum/Pressure Tester to the intake manifold. Run the engine at the specified idle speed.

The vacuum gauge should read between 51-74 kPa (15-22 in-Hg) depending upon the engine condition and the altitude at which the test is performed. Subtract 4.0193 kPa (1 in-Hg) from the specified reading for every 304.8 m (1,000 feet) of elevation above sea level.

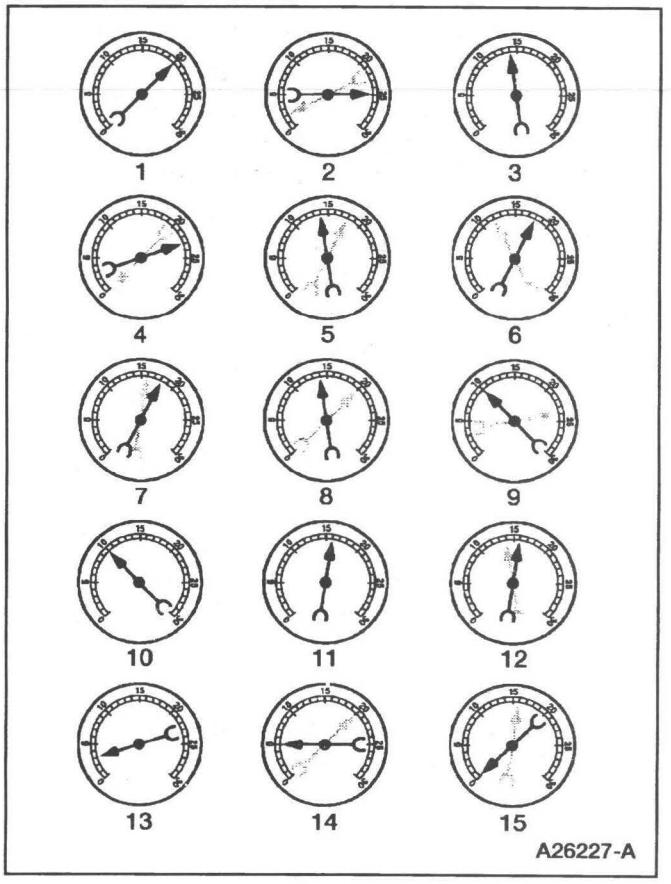
The reading should be steady. If necessary, adjust the gauge damper control (where used) if the needle is fluttering rapidly. Adjust the damper until the needle moves easily without excessive flutter.

Intake Manifold Vacuum Test—Interpreting Vacuum Gauge Readings

A careful study of the vacuum gauge reading while the engine is idling will help pinpoint trouble areas. Always conduct other appropriate tests before arriving at a final diagnostic decision. Vacuum gauge readings, although helpful, must be interpreted carefully.

Most vacuum gauges have a normal band indicated on the gauge face.

The following are potential gauge readings. Some are normal; others should be investigated further.



1. NORMAL READING: Needle between 51-74 kPa (15-22 in-Hg) and holding steady.
2. NORMAL READING DURING RAPID ACCELERATION AND DECELERATION: When the engine is rapidly accelerated (dotted needle), the needle will drop to a low reading (not to zero). When the throttle is suddenly released, the needle will snap back up to a higher than normal figure.
3. NORMAL FOR HIGH-LIFT CAMSHAFT WITH LARGE OVERLAP: The needle will register as low as 51 kPa (15 in-Hg) but will be relatively steady. Some oscillation is normal.
4. WORN RINGS OR DILUTED OIL: When the engine is accelerated (dotted needle), the needle drops to 0 kPa (0 in-Hg). Upon deceleration, the needle runs slightly above 74 kPa (22 in-Hg).
5. STICKING VALVES: When the needle (dotted) remains steady at a normal vacuum but occasionally flicks (sharp, fast movement) down and back about 13 kPa (4 in-Hg), one or more valves may be sticking.

DIAGNOSIS AND TESTING (Continued)

6. BURNED OR WARPED VALVES: A regular, evenly-spaced, downscale flicking of the needle indicates one or more burned or warped valves. Insufficient hydraulic lash adjuster or hydraulic lash adjuster (HLA) clearance will also cause this reaction.
7. POOR VALVE SEATING: A small but regular downscale flicking can mean one or more valves are not seating.
8. WORN VALVE GUIDES: When the needle oscillates over about a 13 kPa (4 in-Hg) range at idle speed, the valve guides could be worn. As engine speed increases, the needle will become steady if guides are responsible.
9. WEAK VALVE SPRINGS: When the needle oscillation becomes more violent as engine rpm is increased, weak valve springs are indicated. The reading at idle could be relatively steady.
10. LATE VALVE TIMING: A steady but low reading could be caused by late valve timing.
11. IGNITION TIMING RETARDING: Retarded ignition timing will produce a steady but somewhat low reading.
12. INSUFFICIENT SPARK PLUG GAP: When spark plugs are gapped too close, a regular, small pulsation of the needle can occur.
13. INTAKE LEAK: A low, steady reading can be caused by an intake manifold or throttle body gasket leak.
14. BLOWN HEAD GASKET: A regular drop of fair magnitude can be caused by a blown head gasket or warped cylinder head-to-cylinder block surface.
15. RESTRICTED EXHAUST SYSTEM: When the engine is first started and is idled, the reading may be normal, but as the engine rpm is increased, the back pressure caused by a clogged muffler (5230), kinked tail pipe or other concerns will cause the needle to slowly drop to 0 kPa (0 in-Hg). The needle then may slowly rise. Excessive exhaust clogging will cause the needle to drop to a low point even if the engine is only idling.
16. When vacuum leaks are indicated, search out and correct the cause. Excess air leaking into the system will upset the fuel mixture and cause concerns such as rough idle, missing on acceleration or burned valves. If the leak exists in an accessory unit such as the power brake booster (2005), the unit will not function correctly. Always fix vacuum leaks.

Excessive Engine Oil Consumption

The amount of oil an engine uses will vary with the way the vehicle is driven in addition to normal engine-to-engine variation. This is especially true during the first 16,100 km (10,000 miles) when a new engine is being broken in or until certain internal engine components become conditioned. Vehicles used in heavy-duty operation may use more oil. The following are examples of heavy-duty operation:

- trailer towing applications
- severe loading applications
- sustained high speed operation

Engines need oil to lubricate the following internal components:

- cylinder block cylinder walls
- pistons and piston, pin and rings (6102)
- intake and exhaust valve stems
- intake and exhaust valve guides
- all internal engine components

When the pistons move downward, a thin film of oil is left on the cylinder walls. As the vehicle is operated, some oil is also drawn into the combustion chambers past the intake and exhaust valve stem seals and burned.

The following is a partial list of conditions that can affect oil consumption rates:

- engine duty cycle
- operator driving habits
- ambient temperature
- quality and viscosity of the oil

Operation under varying conditions can frequently be misleading. A vehicle that has been run for several thousand miles on short trips or in below-freezing ambient temperatures may have consumed a "normal" amount of oil. However, when checking the engine oil level, it may measure up to the FULL or MAX on the oil level dipstick due to dilution (condensation and fuel) in the engine crankcase. The vehicle might then be driven at high speeds on the highway where the condensation and fuel boil off. The next time the engine oil is checked, it may appear that a liter (quart) of oil was used in about 160 km (100 miles). This perceived 160 km (100 miles) per liter (quart) oil consumption rate causes customer concern even though the actual overall oil consumption rate is about 2,400 km (1,500 miles) per liter (quart).

DIAGNOSIS AND TESTING (Continued)

Make sure the selected engine oil meets the current recommended API performance category with SAE viscosity grade as shown in the vehicle Owner's Guide. It is also important that the engine oil is changed at the intervals specified. Refer to the vehicle Owner's Guide.

Oil Pressure Test

1. Disconnect and remove the oil pressure sensor (9278) from the engine.
2. Connect the Oil Pressure Gauge to the oil pressure sender oil galley port.
3. Run the engine until normal operating temperature is reached.
4. Run the engine at the specified rpm and record the gauge reading.
5. The oil pressure should be within specifications; refer to the specification chart in the appropriate engine section.
6. If the pressure is not within specification, check the following possible sources:
   - insufficient oil
   - oil leakage
   - worn or damaged oil pump
   - oil pump screen cover and tube (6622)
   - excessive main bearing clearance
   - excessive connecting rod bearing clearance

Valve Train Analysis—Engine Off—Valve Cover Removed

Check for damaged or severely worn parts and correct assembly. Make sure correct parts are used with the static engine analysis as follows.

Valve Train Analysis—Engine Off, Rocker Arm

- Check for loose mounting bolts, studs and nuts.
- Check for plugged oil feed in the rocker arms (6564) or cylinder head.

Valve Train Analysis—Engine Off, Camshaft Roller Followers and Hydraulic Lash Adjusters, Overhead Camshaft

- Check for loose mounting bolts on camshaft carriers.
- Check for plugged oil feed in the camshaft roller followers, lash adjusters or cylinder heads.

Valve Train Analysis—Engine Off, Camshaft—Engines

- Check for broken or damaged parts.

Valve Train Analysis—Engine Off, Push Rods

- Check for bent push rods (6565) and restricted oil passage.

Valve Train Analysis—Valve Springs

- Check for broken or damaged parts.

Valve Train Analysis—Engine Off, Valve Spring Retainer and Valve Spring Retainer Keys

- Check for correct seating of the valve spring retainer key (6518) on the valve stem and in valve spring retainer (6514).
- Check for correct seating on the valve stem.

Valve Train Analysis—Engine Off, Valves and Cylinder Head

- Check for plugged oil drain back holes.
- Check for worn or damaged valve tips.
- Check for missing or damaged guide-mounted valve stem seal.
- Check collapsed valve tappet gap.
- Check installed valve spring height.
- Check for missing or worn valve spring seats.
- Check for plugged oil metering orifice in cylinder head oil reservoir (if equipped).

Static checks (engine off) are to be made on the engine prior to the dynamic procedure.

Valve Train Analysis—Engine Running

- Start the engine and, while idling, check for correct operation of all parts. Check the following:

Valve Train Analysis—Engine Running, Valves and Cylinder Head

- Check for plugged oil drain back holes.
- Check for missing or damaged valve stem seals or guide mounted valve stem seals.
- Check for a plugged oil metering orifice in the cylinder head oil reservoir (4.6L engine only).

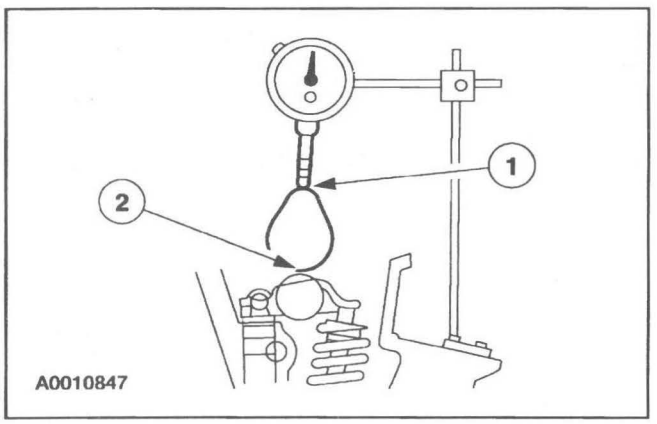
DIAGNOSIS AND TESTING (Continued)

If insufficient oiling is suspected, check oil passages for blockage, then accelerate the engine to 1,200 rpm with the transmission in NEUTRAL and the engine at normal operating temperature. Oil should spurt from the rocker arm oil holes such that valve tips and camshaft roller followers are well oiled. With the valve covers (6582) off, some oil splash may overshoot camshaft roller followers.

Valve Train Analysis—Engine Running, Camshaft Lobe Lift—OHC Engines

Check the lift of each camshaft lobe in consecutive order and make a note of the readings.

1. Remove the valve covers.
2. Remove the spark plugs.
3. Install the Dial Indicator Gauge with Holding Fixture so the rounded tip of indicator is on top of the camshaft lobe and on the same plane as the valve tappet.
4. Rotate the crankshaft using a breaker bar and socket attached to the crankshaft pulley retainer bolt. Rotate the crankshaft until the base circle of the camshaft lobe is reached.



5. Zero the dial indicator. Continue to rotate the crankshaft until the (1) high-lift point of the camshaft lobe is in the fully-raised position (highest indicator reading).
6. To check the accuracy of the original indicator reading, continue to rotate crankshaft until the (2) base circle is reached. The indicator reading should be zero. If zero reading is not obtained, repeat Steps 1 through 6.
7. **NOTE:** If the lift on any lobe is below specified service limits, install a new camshaft, and new camshaft roller followers.

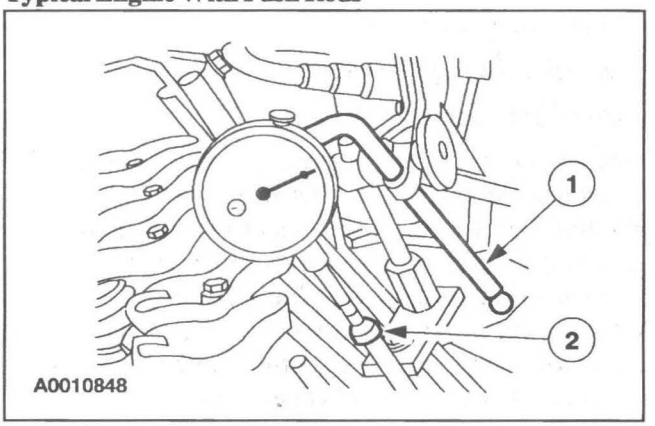
   Remove the Dial Indicator Gauge with Holding Fixture.
8. Install the spark plugs.
9. Install the valve covers.

Valve Train Analysis—Engine Running, Camshaft Lobe Lift—Push Rod Engine

Check the lift of each lobe in consecutive order and make a note of the readings.

1. Remove the valve covers.
2. Remove the rocker arm seat bolts, rocker arm seat (6A528) and rocker arms.

Typical Engine With Push Rods



3. Make sure the valve tappet is seated against camshaft (6250). Install (1) Dial Indicator Gauge with Holding Fixture so the ball socket adapter of the indicator is on top of the valve tappet or (2) Dial Indicator Gauge Adapter is on top of push rod and in same plane as valve tappet push rod movement.
4. Remove the spark plugs.
5. Connect an auxiliary starter switch in the starting circuit. Crank the engine with ignition switch in OFF position. Bump crankshaft over until valve tappet is on base circle of camshaft lobe. At this point, valve tappet will be in its lowest position. If checking during engine assembly, turn crankshaft using a socket or ratchet.
6. Zero the dial indicator. Continue to rotate crankshaft slowly until valve tappet is in fully-raised position (highest indicator reading).
7. **NOTE:** If lift on any lobe is below specified service limits, install a new camshaft, and new valve tappets.

   Remove the Dial Indicator with Holding Fixture, Dial Indicator Gauge Adapter, and auxiliary starter switch.

DIAGNOSIS AND TESTING (Continued)

8. Install rocker arm seats, rocker arms and rocker arm seat bolts.
9. Install valve covers.
10. Install spark plugs.

Valve Train Analysis—Engine Running, Valve Tappet

Valve tappet noise can be caused by any of the following:

- excessive valve tappet gap (collapsed)
- incorrectly functioning valve tappet
- air in lubrication system
- excessive valve guide wear
- low oil pressure

Excessive collapsed valve tappet gap can be caused by loose rocker arm seat bolts/nuts, incorrect initial adjustment or wear of valve tappet face, or worn roller valve tappets, push rod (6565), rocker arm (6564), rocker arm seat or valve tip. With valve tappet collapsed, check gap between the valve tip and the rocker arm to determine if any other valve train parts are damaged, worn or out of adjustment.

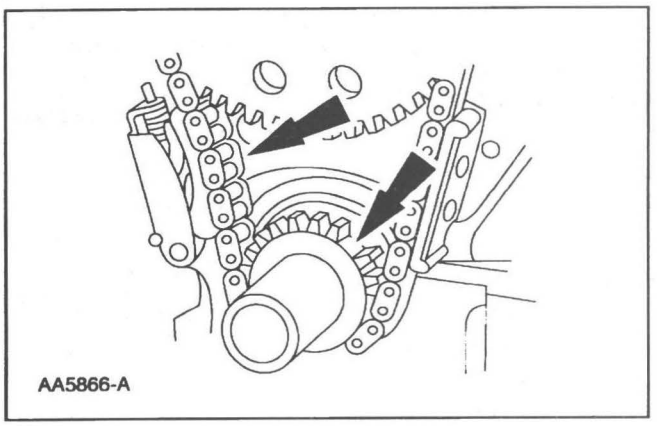
An incorrectly functioning valve tappet can be sticking, caused by contaminants or varnish inside the tappet. The tappet can have a check valve that is not functioning correctly, which can be caused by an obstruction, such as dirt or chips that prevent the check valve from closing, or a broken check valve spring. A tappet with a leakdown time out of specification can cause tappet noise. If no other cause for noisy valve tappets can be found, the leakdown rate should be checked and new valve tappets installed if found to be out of specification.

Assembled valve tappets can be tested with Hydraulic Tappet Leakdown Tester to check the leakdown rate. The leakdown rate specification is the time in seconds for the plunger to move a specified distance while under a 22.7 kg (50 lb) load.

Air bubbles in the lubrication system will prevent the valve tappet from supporting the valve spring load. This can be caused by too high or too low an oil level in the oil pan or by air being drawn into the system through a hole, crack or leaking gasket on the oil pump screen cover and tube.

GENERAL PROCEDURES

Sprockets


AA5866-A

1. ⚠ **WARNING: To avoid the possibility of personal injury or damage to the vehicle, do not operate the engine with the hood open until the fan blade has been examined for possible cracks and separation.**

   NOTE: Specifications show the expected minimum or maximum condition. Refer to the appropriate section in Group 303 for the procedure.

   NOTE: If a component fails to meet the specifications, it is necessary to install a new component or refinish. If the component can be refinished, wear limits are provided as an aid to making a decision. A new component must be installed for any component that fails to meet specifications and cannot be refinished.

   Inspect the timing chain/belt and the sprockets.

   - Install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Rocker Arms — Cleaning

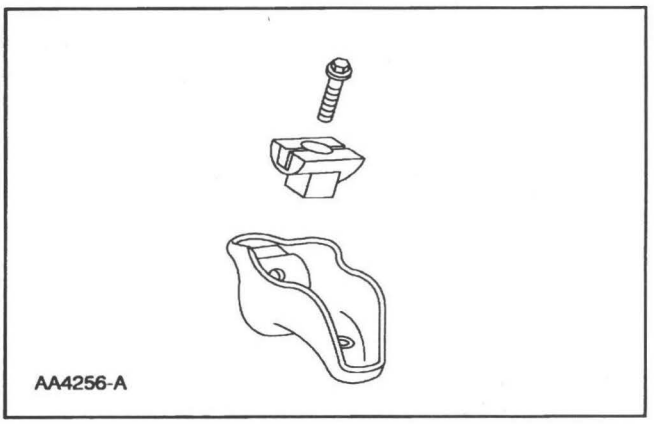
1. Clean all parts thoroughly. Make sure all oil passages are open.

2. Make sure oil passage in the push rod/valve tappet end of the rocker arm (6564) is open.

GENERAL PROCEDURES (Continued)

Rocker Arms — Inspection

⚠ **CAUTION: Do not attempt to true surfaces by grinding. Check the rocker arm pad, side rails and seat for excessive wear, cracks, nicks or burrs. Check the rocker arm seat bolt for stripped or broken threads. Install new components as ncessary or possible damage may occur.**


AA4256-A

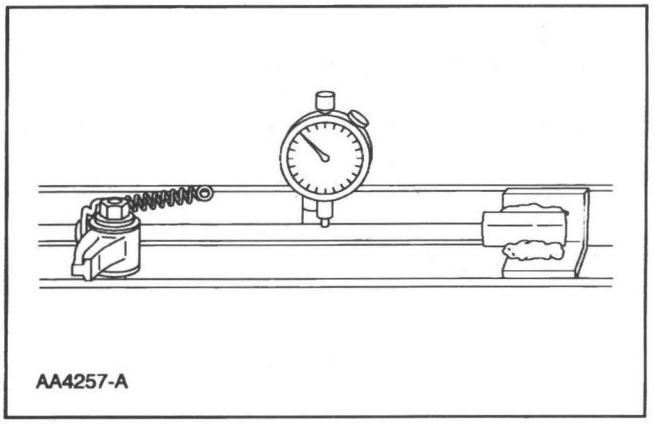
1. Inspect the rocker arm push rod bore for nicks, scratches, scores or scuffs. Install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

2. Inspect the pad at the valve end of the rocker arm for indications of scuffing or abnormal wear. If the pad is grooved, install a new rocker arm. Refer to the appropriate section in Group 303 for the procedure.

Push Rods — Cleaning

1. Clean the push rods (6565) in a suitable solvent. Blow out the oil passage in the push rods with compressed air.

Push Rods — Inspection


AA4257-A

1. ⚠ **CAUTION: Do not attempt to straighten push rods.**

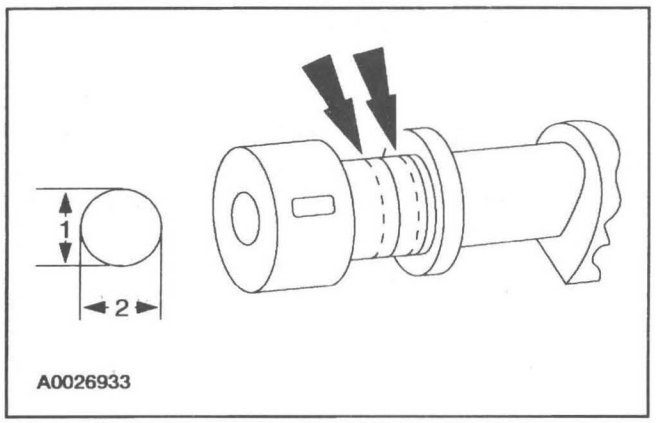
   Check the ends of the push rods for nicks, grooves, roughness or excessive wear. Install new push rods as necessary. Refer to the appropriate section in Group 303 for the procedure.

   - The push rods can be checked for straightness while they are installed in the engine by rotating them with the valve closed.
   - They also can be checked using a Dial Indicator with Bracketry.

GENERAL PROCEDURES (Continued)

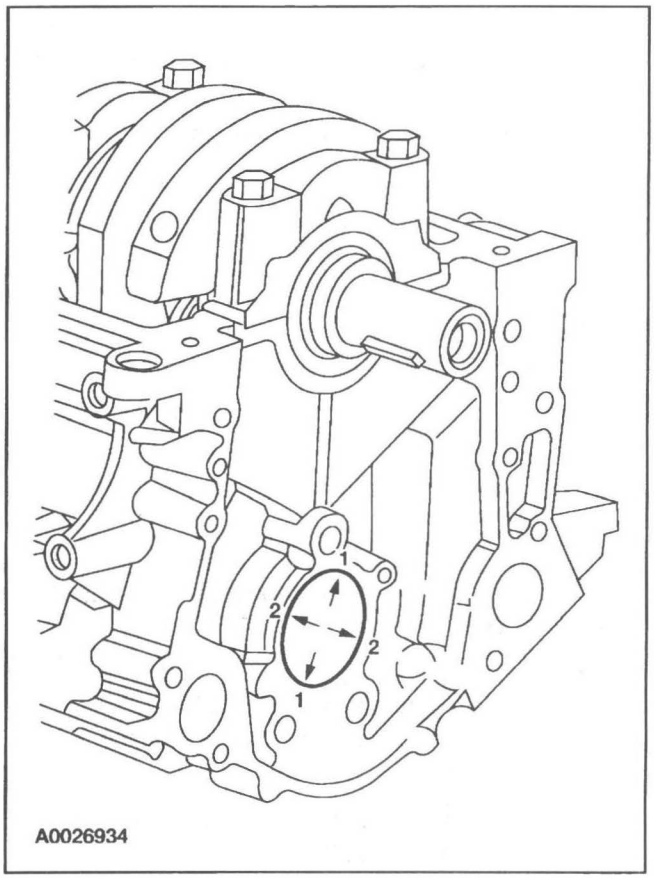
2. If the push rod is bent beyond specifications, install a new push rod. Refer to the appropriate section in Group 303 for the procedure.

Camshaft Journal — Diameter



1. Measure each camshaft journal diameter in two directions.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Camshaft Journal — Clearance, Push Rod Engines, Micrometer Method



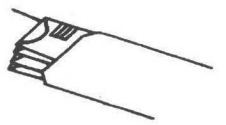
1. **NOTE:** The camshaft journals must meet specifications before checking camshaft journal clearance.

   Measure each camshaft bearing (6261) in two directions.
   - Subtract the camshaft journal diameter from the camshaft bearing diameter.

GENERAL PROCEDURES (Continued)

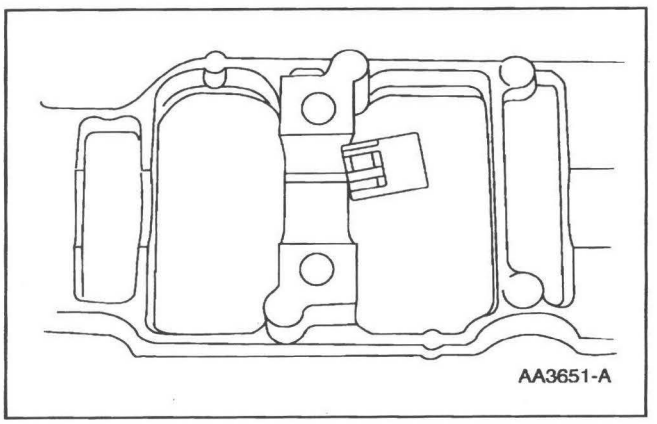
Camshaft Journal — Clearance, Plastigage Method

Special Tool(s)

 ST1280-A	Plastigage 303-D031 (D81L-6002-B) or equivalent

NOTE: The camshaft journals must meet specifications before checking camshaft journal clearance.

1. Remove the camshaft bearing cap and lay Plastigage across the surface. Refer to the appropriate section in Group 303 for the procedure.



2. **NOTE:** Do not turn the camshaft while carrying out this procedure.

   Position the camshaft bearing cap and install the bolts. Refer to the appropriate section in Group 303 for the procedure.

3. Use Plastigage to verify the camshaft journal clearance.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

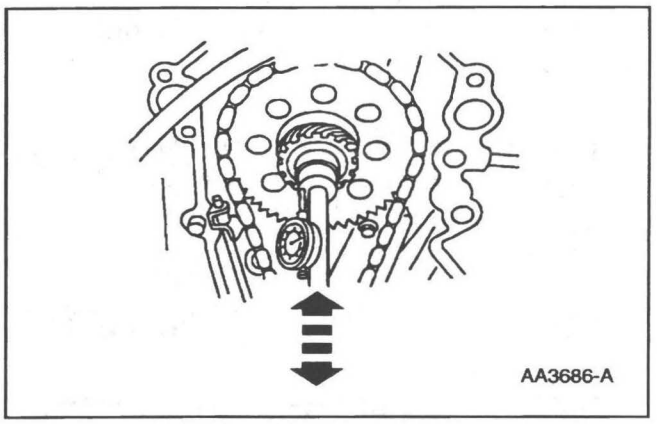
Camshaft End Play — Push Rod Engines

Special Tool(s)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

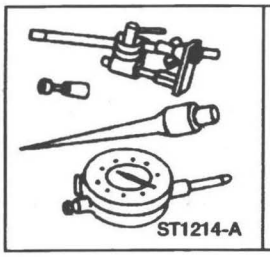
GENERAL PROCEDURES (Continued)

1. Remove the valve tappets. Refer to the appropriate section in Group 303 for the procedure.
2. Use a Dial Indicator Gauge with Holding Fixture to measure camshaft end play.
3. Position the camshaft to the rear of the cylinder block.
4. Zero the indicator.
5. Move the camshaft to the front of the cylinder block. Note and record the camshaft end play.
   - If the camshaft end play exceeds specifications, install a new camshaft thrust plate. Refer to the appropriate section in Group 303 for the procedure.



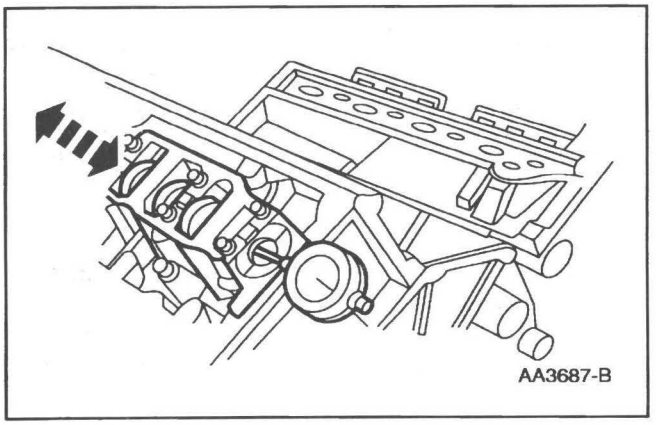
Camshaft End Play — OHC Engines

Special Tool(s)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

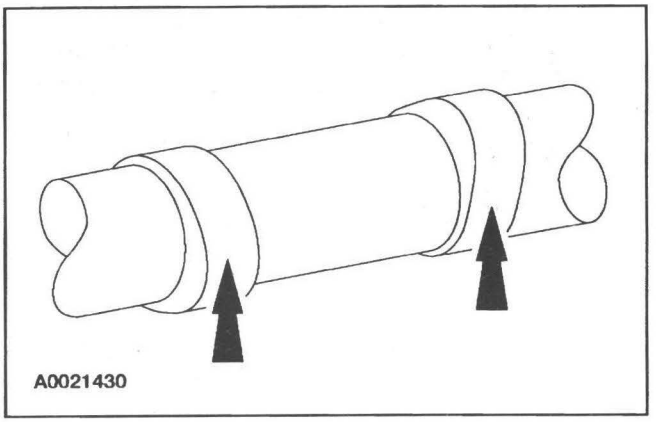
1. Remove the roller followers. Refer to the appropriate section in Group 303 for the procedure.
2. Use a Dial Indicator Gauge with Holding Fixture to measure camshaft end play.
3. Position the camshaft to the rear of the cylinder head.
4. Zero the indicator.

GENERAL PROCEDURES (Continued)



5. Move the camshaft to the front of the cylinder head. Note and record the camshaft end play.
   - If camshaft end play exceeds specifications, install new camshaft and recheck end play. Refer to the appropriate section in Group 303 for the procedure.
   - If camshaft end play exceeds specification after camshaft installation, install a new cylinder head. Refer to the appropriate section in Group 303 for the procedure.

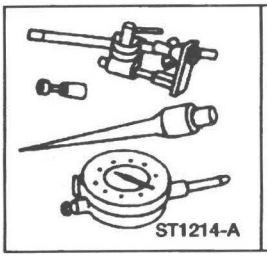
Camshaft — Lobe Surface

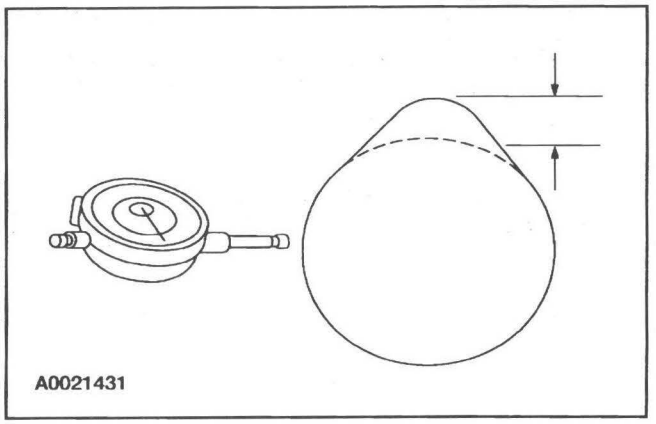


1. Inspect camshaft lobes for pitting or damage in the contact area. Minor pitting is acceptable outside the contact area.
   - If excessive pitting or damage is present, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Camshaft Lobe Lift

Special Tool(s)

	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

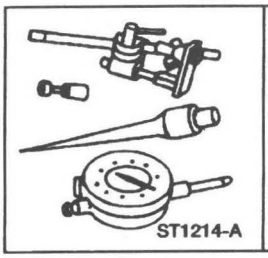


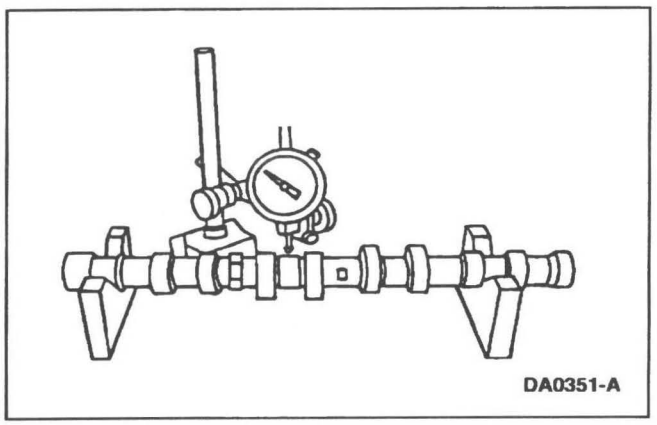
1. Use a Dial Indicator Gauge with Holding Fixture to measure camshaft intake/exhaust lobe lift.
   - Rotate the camshaft and subtract the lowest indicator reading from the highest indicator reading to figure the camshaft lobe lift.
   - Refer to the appropriate section in Group 303 for the procedure.

GENERAL PROCEDURES (Continued)

Camshaft Runout

Special Tool(s)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

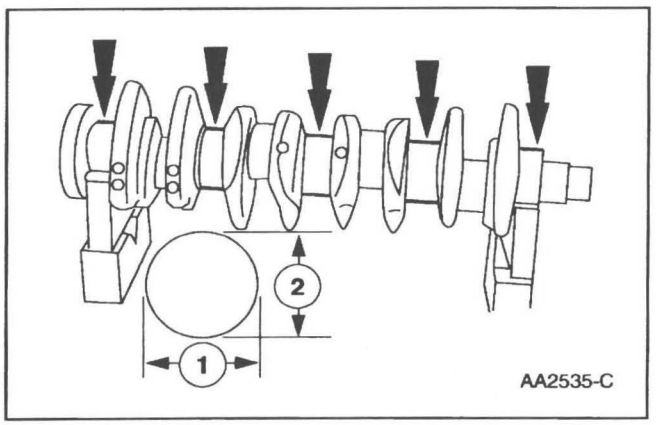

DA0351-A

1. **NOTE:** Camshaft journals must be within specifications before checking runout.

   Use a Dial Indicator Gauge with Holding Fixture to measure the camshaft runout.

   - Rotate the camshaft and subtract the lowest indicator reading from the highest indicator reading.
   - For additional information, refer to the specification chart in the appropriate engine section.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

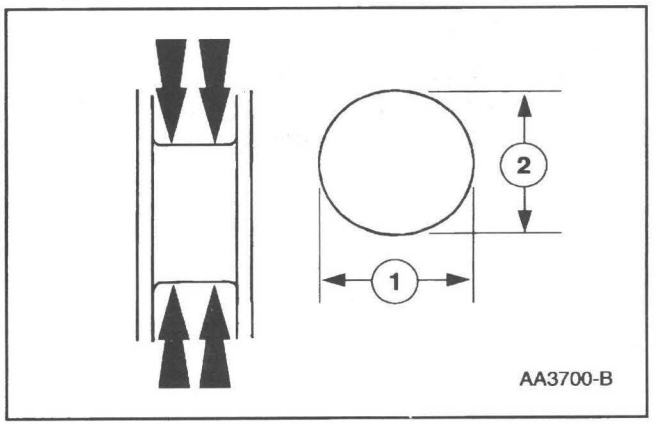
Crankshaft Main Bearing Journal — Diameter



1. Measure each of the crankshaft main bearing journal diameters in at least two directions.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

GENERAL PROCEDURES (Continued)

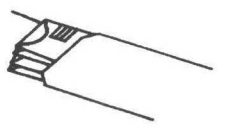
Crankshaft Main Bearing Journal — Taper



1. Measure each of the crankshaft main bearing journal diameters in at least two directions at each end of the main bearing journal.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

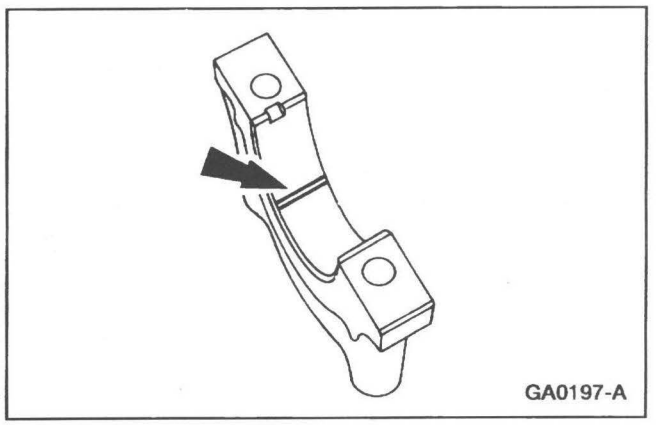
Crankshaft Main Bearing Journal — Clearance

Special Tool(s)

 ST1280-A	Plastigage 303-D031 (D81L-6002-B) or equivalent

NOTE: Crankshaft main bearing journals must be within specifications before checking journal clearance.

1. Remove the crankshaft main bearing caps and crankshaft main bearing.

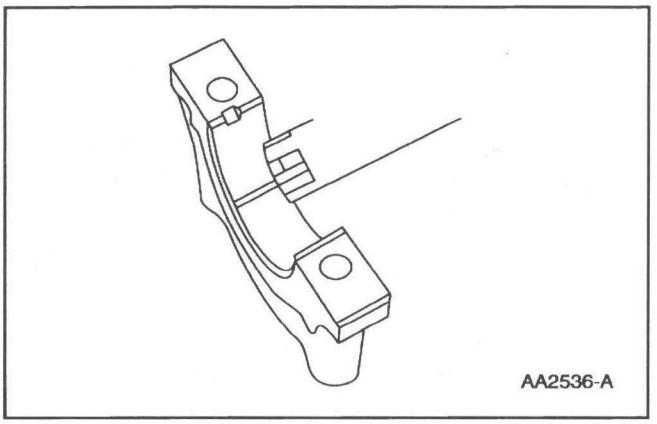


2. Lay a piece of Plastigage across the face of each crankshaft main bearing surface.

3. **NOTE:** Do not turn the crankshaft while carrying out this procedure.

   Install and remove the crankshaft main bearing cap.

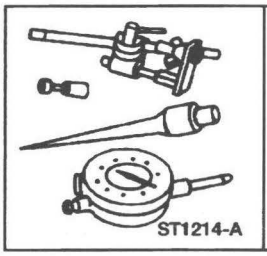
GENERAL PROCEDURES (Continued)


AA2536-A

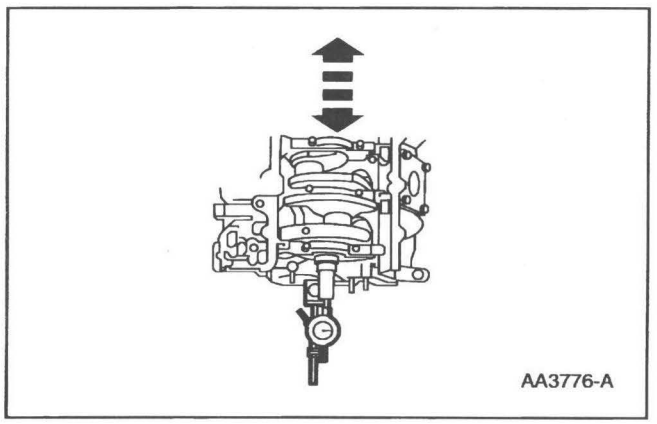
4. Verify the crankshaft journal clearance.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Crankshaft End Play

Special Tool(s)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

1. Measure the crankshaft end play. Use a Dial Indicator Gauge with Holding Fixture to measure crankshaft end play.
2. Position the crankshaft to the rear of the cylinder block.
3. Zero the indicator.

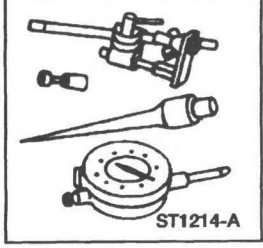

AA3776-A

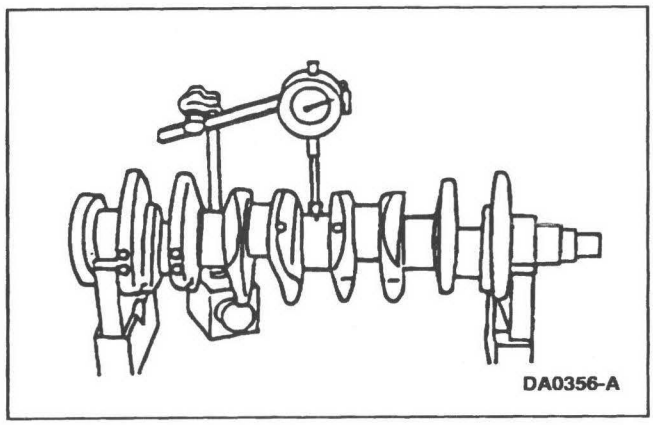
4. Move the crankshaft to the front of the cylinder block. Note and record the crankshaft end play.
   - If crankshaft end play exceeds specifications, install a new crankshaft thrust washer (6334) or crankshaft thrust main bearing (6337). Refer to the appropriate section in Group 303 for the procedure.

GENERAL PROCEDURES (Continued)

Crankshaft Runout

Special Tool(s)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

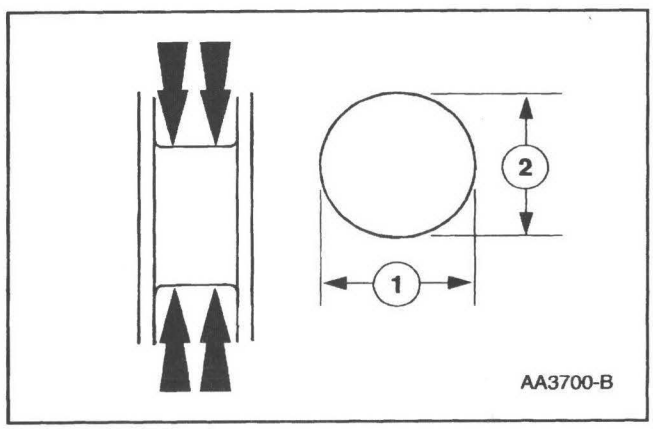

DA0356-A

1. **NOTE:** Crankshaft main bearing journals must be within specifications before checking runout.

   Use the Dial Indicator Gauge with Holding Fixture to measure the crankshaft runout.

   - Refer to the appropriate section in Group 303 for the procedure.
   - Rotate the crankshaft and subtract the lowest dial indicator reading from the highest dial indicator reading to figure the crankshaft runout. If it is out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

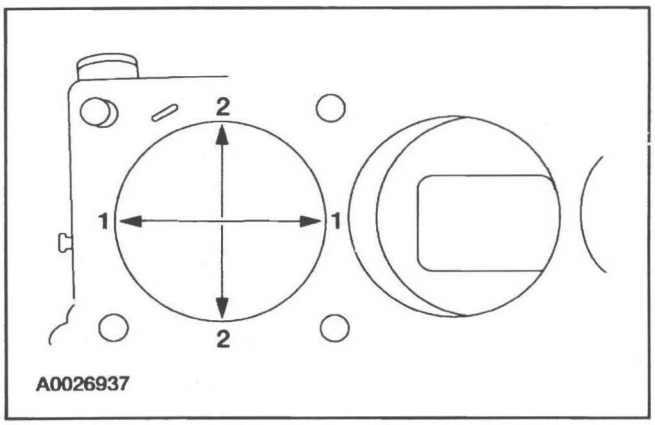
Crankshaft — Connecting Rod Journal Taper, Out of Round



1. Measure the crankshaft connecting rod journal diameters in two directions perpendicular to one another at each end of the connecting rod journal. The difference in the measurements from one end to the other is the taper. Verify measurement is within the wear limit.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

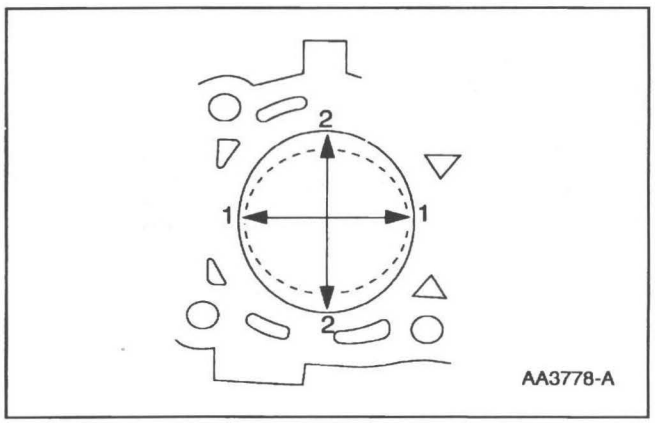
GENERAL PROCEDURES (Continued)

Cylinder Bore — Taper



1. Measure the cylinder bore at the top, middle, and bottom of piston ring travel in two directions as indicated. Verify the cylinder bore is within the wear limit. The difference indicates the cylinder bore taper. Bore the cylinder to the next oversize.
   - Refer to the appropriate section in Group 303 for the procedure.

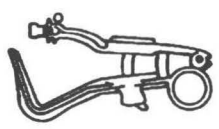
Cylinder Bore — Out-of-Round



1. Measure the cylinder bore in two directions. The difference is the out-of-round. Verify the out-of-round is within the wear limit and bore the cylinder to the next oversize limit.
   - Refer to the appropriate section in Group 303 for the procedure.

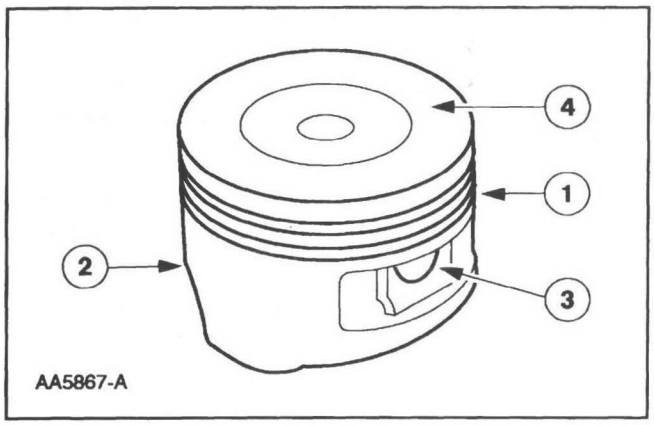
Piston Inspection

Special Tool(s)

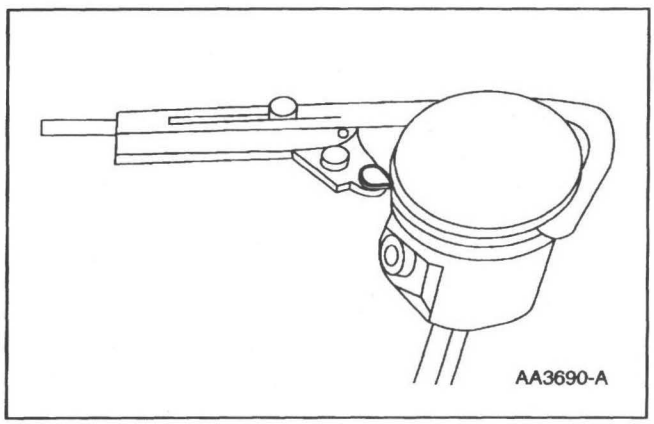
 ST1279-A	Scraper, Piston Ring Groove 303-D033 (D81L-6002-D) or equivalent

GENERAL PROCEDURES (Continued)

⚠ CAUTION: Do not use a caustic cleaning solution or a wire brush to clean the pistons or damage can occur.

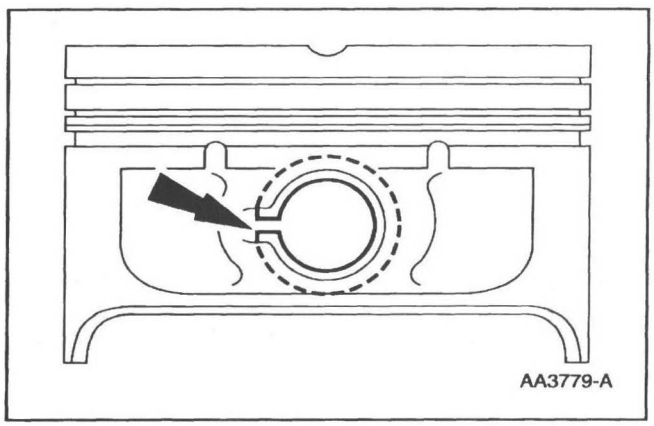


1. Clean and inspect the (1) ring lands, (2) skirts, (3) pin bosses, and the (4) tops of the pistons. If wear marks, scores or glazing is found on the piston skirt, check for a bent or twisted connecting rod.



2. Use the Piston Ring Groove Scraper to clean the piston ring grooves.
   - Make sure the oil ring holes are clean.

Piston — Pin to Bore Diameter

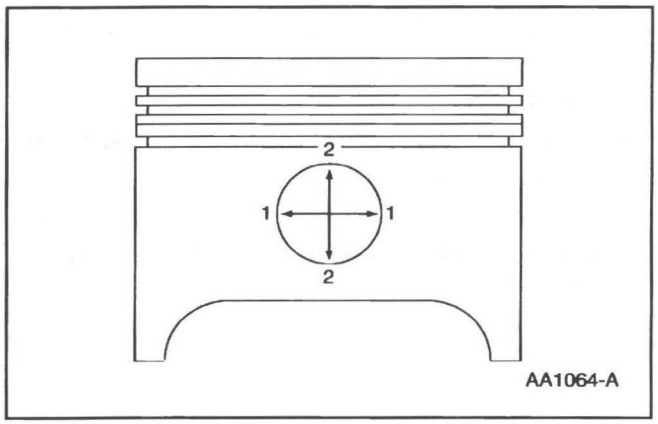


1. **⚠ WARNING: Cover the end of the pin bore with a hand or shop rag when removing the retainer ring, since it has a tendency to spring out. Wear eye protection.**

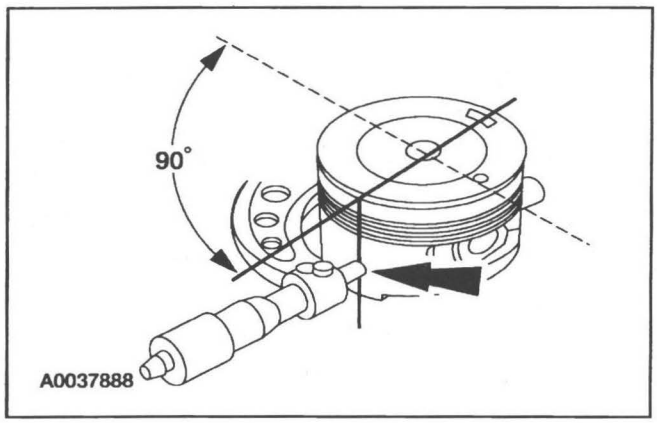
   NOTE: Piston and piston pins are a matched set and should not be interchanged.

   Measure the piston pin bore diameter in two directions on each side. Verify the diameter is within specification.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

GENERAL PROCEDURES (Continued)



Piston — Diameter



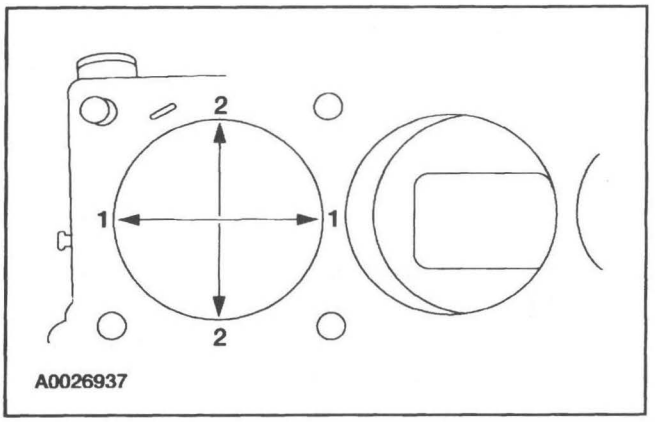
1. Measure the piston diameter 90 degrees from the piston pin at the point indicated. Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Piston — to Cylinder Bore Clearance

1. Subtract the piston diameter from the cylinder bore diameter to find the piston-to-cylinder bore clearance.

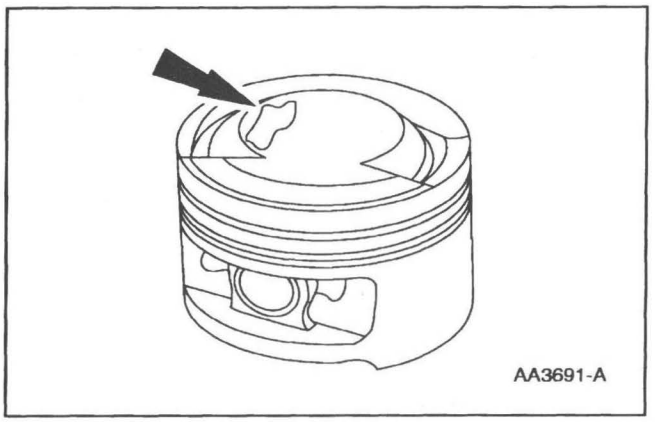
GENERAL PROCEDURES (Continued)

Piston — Selection



NOTE: The cylinder bore must be within the specifications for taper and out-of-round before fitting a piston.

1. Select a piston size based on the cylinder bore.



2. **NOTE:** For precision fit, new pistons are divided into three categories within each size range based on their relative position within the range. A paint spot on the new pistons indicates the position within the size range.

   Choose the piston with the correct paint color.

   - Refer to the appropriate section in Group 303 for the procedure.

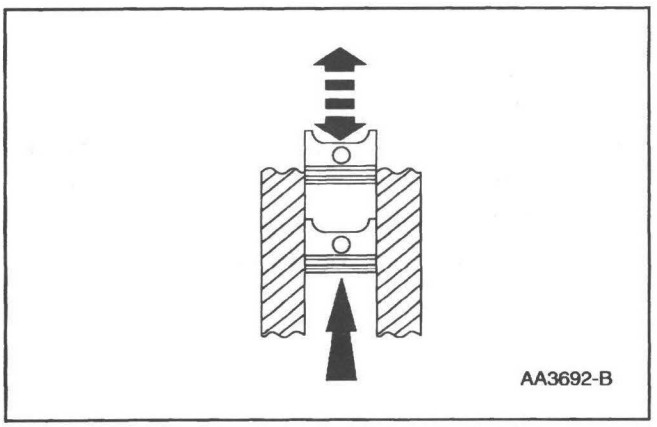
Piston — Ring End Gap

⚠ **CAUTION: Use care when fitting piston rings to avoid possible damage to the piston ring or the cylinder bore.**

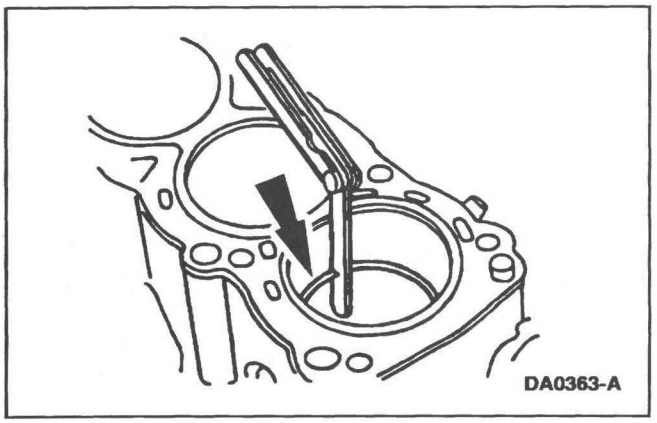
⚠ **CAUTION: Piston rings should not be transferred from one piston to another.**

NOTE: Cylinder bore must be within specification for taper and out-of-round.

GENERAL PROCEDURES (Continued)

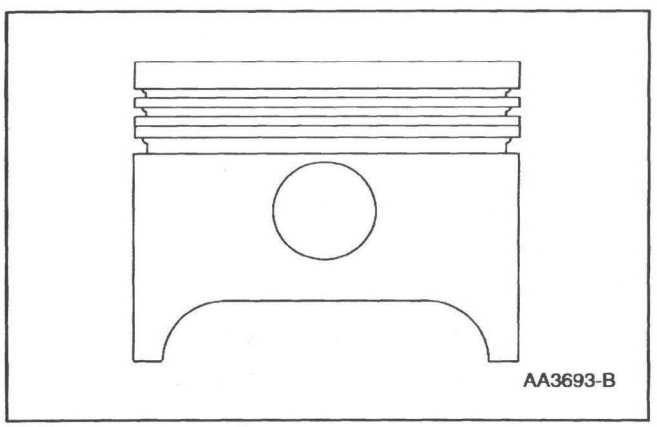


1. Use a piston without rings to push a piston ring in a cylinder to the bottom of ring travel.

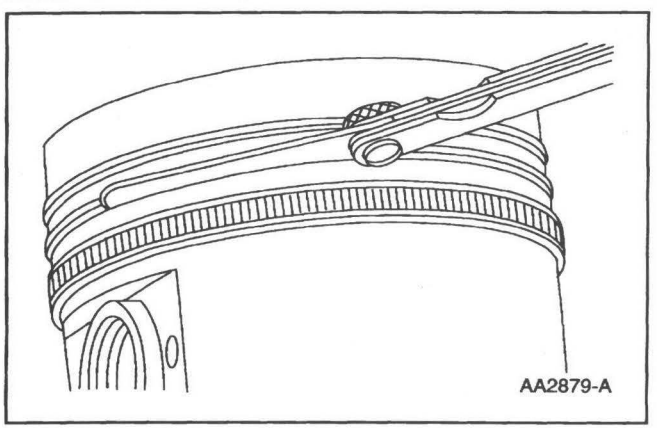


2. Use a feeler gauge to measure the top piston ring end gap and the second piston ring end gap.
   - Refer to the appropriate section in Group 303 for the procedure.

Piston — Ring-to-Groove Clearance



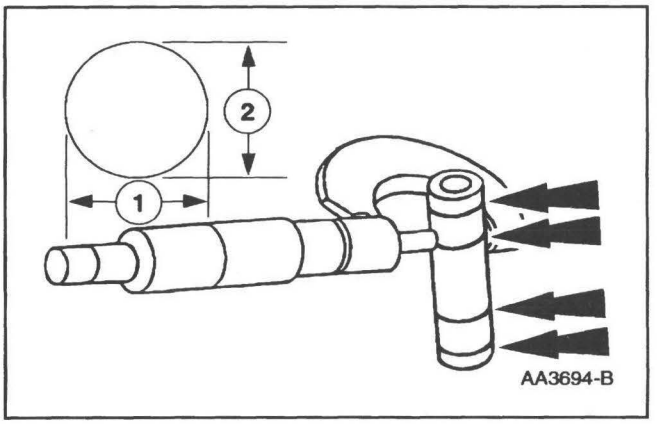
1. Inspect the piston for ring land damage or accelerated wear.



2. Measure the piston ring-to-groove clearance.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

GENERAL PROCEDURES (Continued)

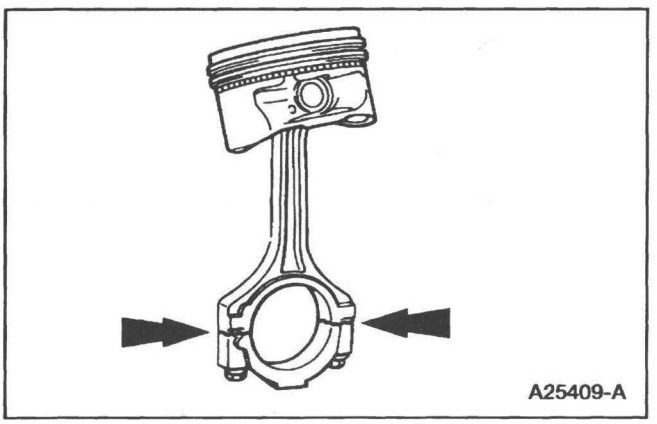
Piston — Pin Diameter



1. Measure the piston pin diameter in two directions at the points shown. Verify the diameter is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Connecting Rod — Cleaning

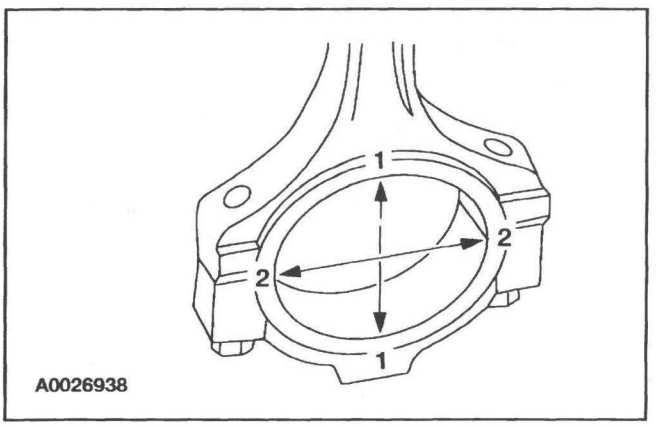
⚠ **CAUTION: Do not use a caustic cleaning solution or damage to connecting rods can occur.**



1. **NOTE:** The connecting rod large end is a matched set. The connecting rod cap must be installed on the original connecting rod in the original position. Do not reverse the cap. Parts are not interchangeable.

   Mark and separate the parts and clean with solvent. Clean the oil passages.

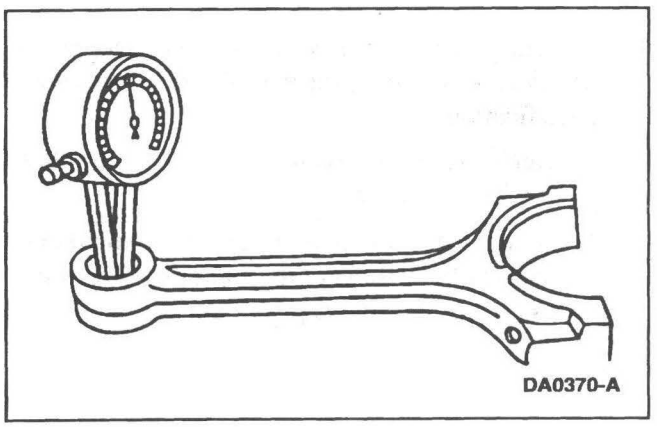
Connecting Rod — Large End Bore



1. Tighten the bolts to specification, then measure the bore in two directions. The difference is the connecting rod bore out-of-round. Verify the out-of-round is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

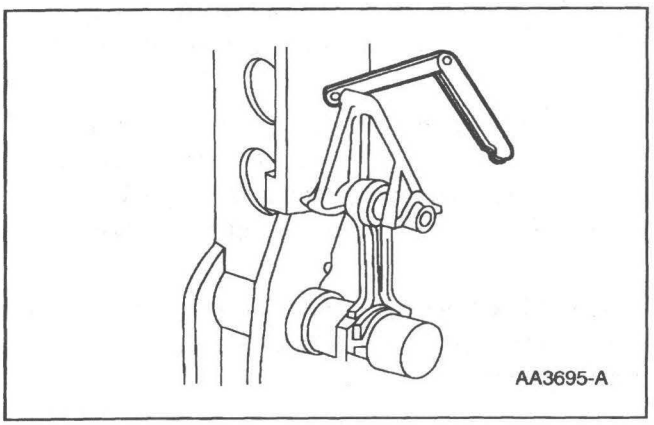
GENERAL PROCEDURES (Continued)

Connecting Rod — Bushing Diameter


DA0370-A

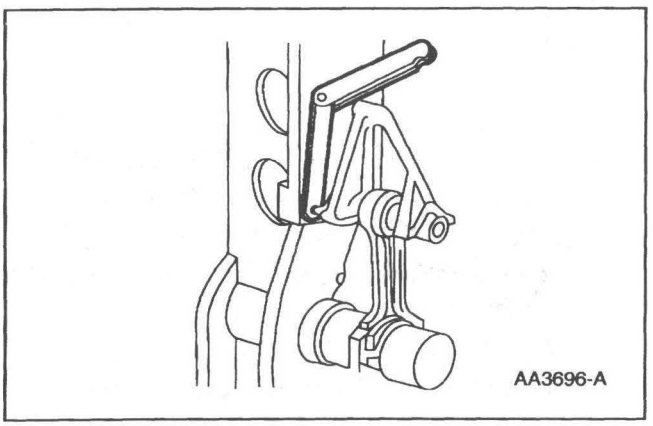
1. Measure the inner diameter of the connecting rod bushing, if equipped. Verify the diameter is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Connecting Rod — Bend


AA3695-A

1. Measure the connecting rod bend on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. Verify the bend measurement is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

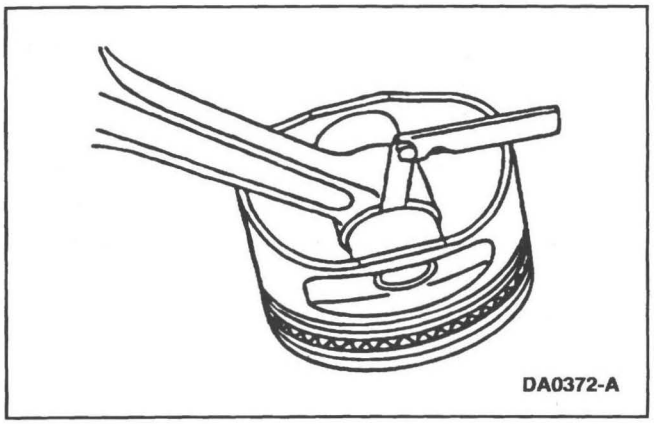
Connecting Rod — Twist


AA3696-A

1. Measure the connecting rod twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. Verify the measurement is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

GENERAL PROCEDURES (Continued)

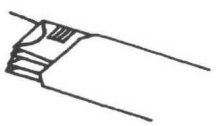
Connecting Rod — Piston Pin Side Clearance


DA0372-A

1. Measure the clearance between the connecting rod and the piston. Verify the measurement is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

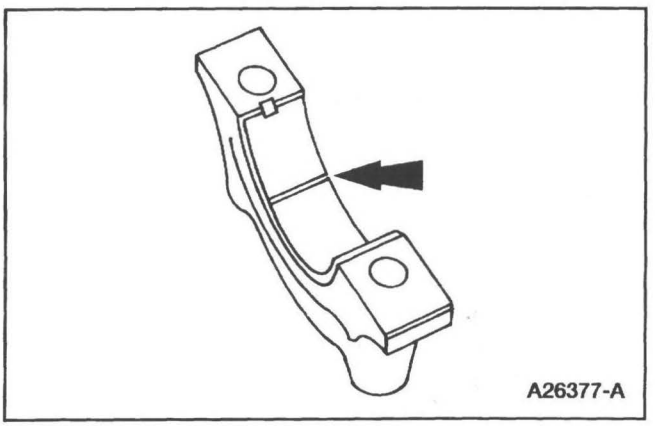
Connecting Rod — Bearing Journal Clearance

Special Tool(s)

 ST1280-A	Plastigage 303-D031 (D81L-6002-B) or equivalent

NOTE: The crankshaft connecting rod journals must be within specifications to check the connecting rod bearing journal clearance.

1. Remove the connecting rod bearing cap.

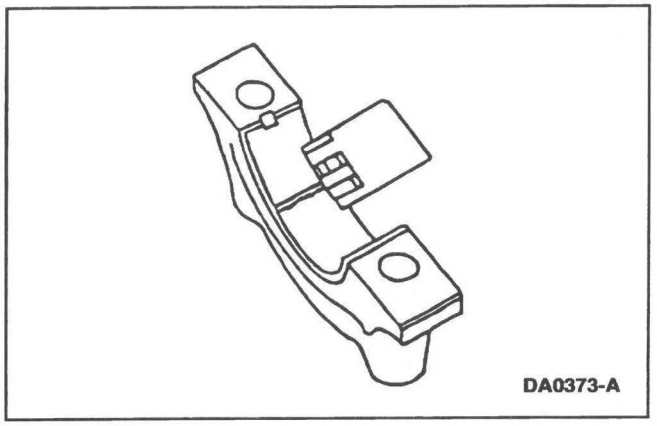

A26377-A

2. Position a piece of Plastigage across the bearing surface.

3. **NOTE:** Do not turn the crankshaft during this step.

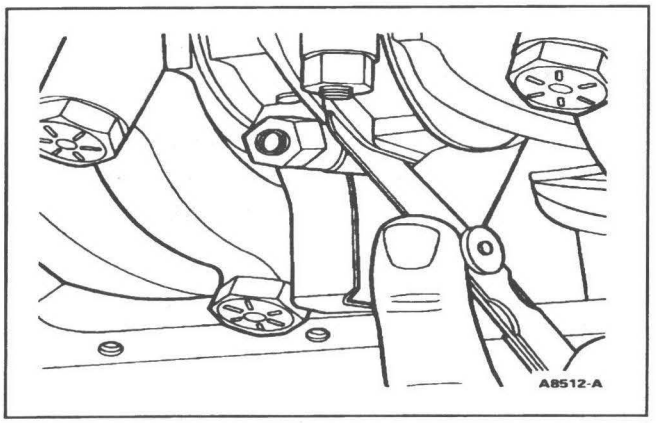
   Install and tighten to specifications, then remove the connecting rod bearing cap.

GENERAL PROCEDURES (Continued)


DA0373-A

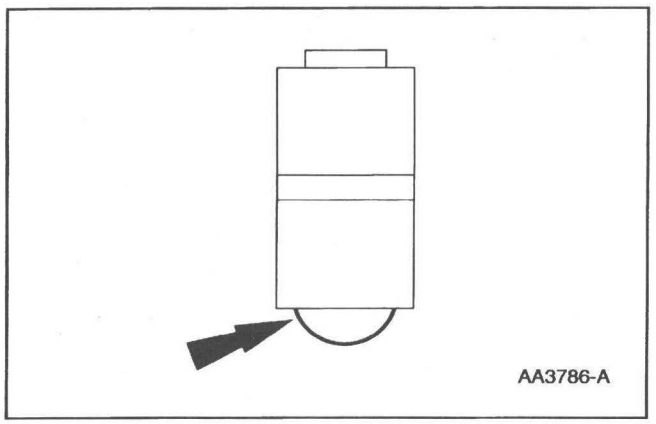
4. Measure the Plastigage to get the connecting rod bearing journal clearance. The Plastigage should be smooth and flat. A changing width indicates a tapered or damaged connecting rod or connecting rod bearing.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Connecting Rod — Side Clearance


A8512-A

1. Measure the clearance between the connecting rod and the crankshaft. Verify the measurement is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Roller Follower — Inspection

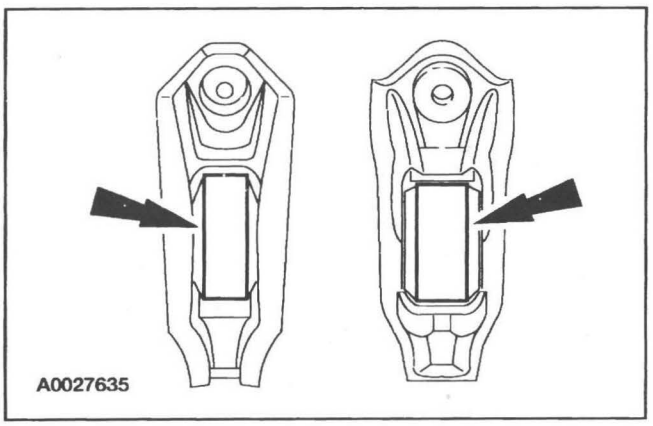

AA3786-A

Push rod engines

1. Inspect the roller for flat spots or scoring. If any damage is found, inspect the camshaft lobes and valve tappet for damage.

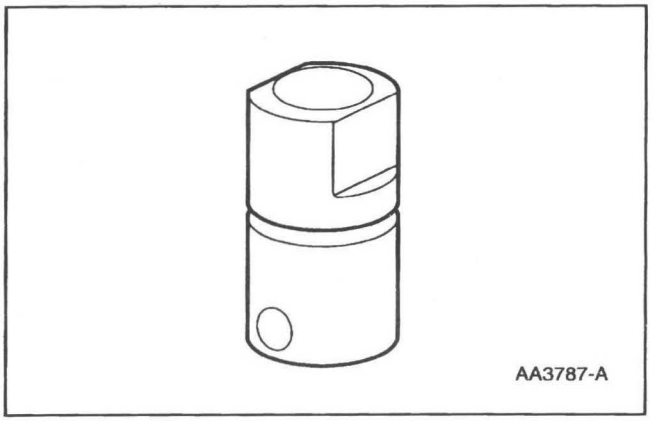
GENERAL PROCEDURES (Continued)

OHC engines



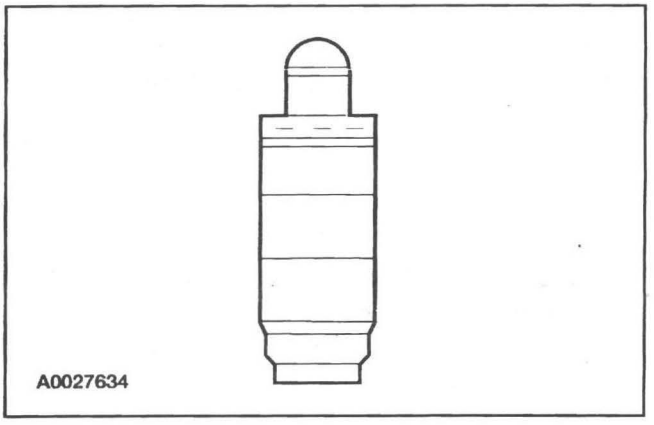
Valve Tappet — Inspection

Push rod engines



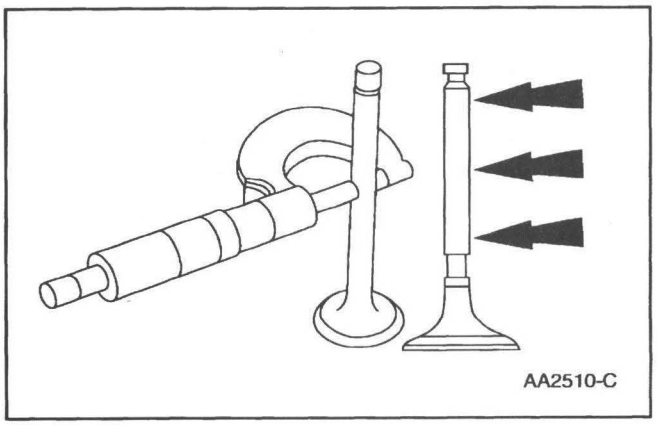
1. Inspect the hydraulic valve tappet and roller for damage. If any damage is found, inspect the camshaft lobes and valves for damage.

OHC engines



GENERAL PROCEDURES (Continued)

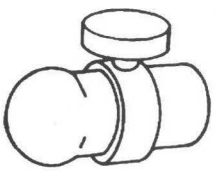
Valve — Stem Diameter


AA2510-C

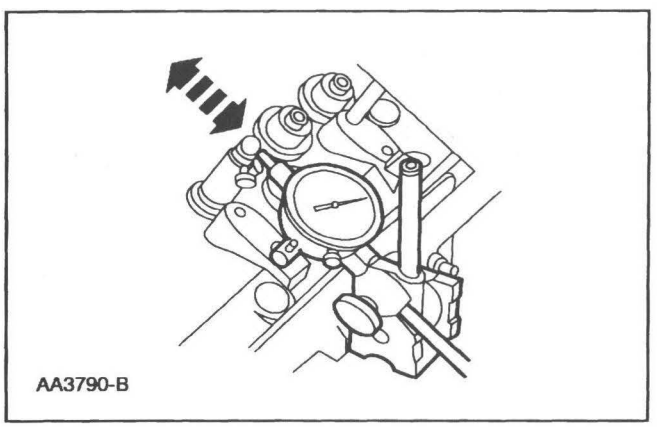
1. Measure the diameter of each intake and exhaust valve stem at the points shown. Verify the diameter is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Valve — Stem to Valve Guide Clearance

Special Tool(s)

 ST1214-A	Dial Indicator with Bracketry 100-002 (TOOL-4201-C) or equivalent
 ST1251-A	Valve Stem Checking Tool 303-004 (TOOL-6505-E) or equivalent

NOTE: Valve stem diameter must be within specifications before checking valve stem to valve guide clearance.


AA3790-B

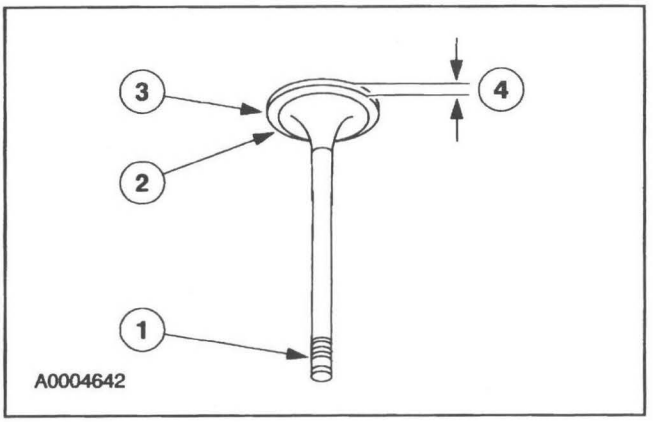
1. **NOTE:** If necessary, use a magnetic base.

   Install a Valve Stem Clearance Tool on the valve stem and install a Dial Indicator with Bracketry. Lower the valve until the Valve Stem Clearance Tool contacts the upper surface of the valve guide.

GENERAL PROCEDURES (Continued)

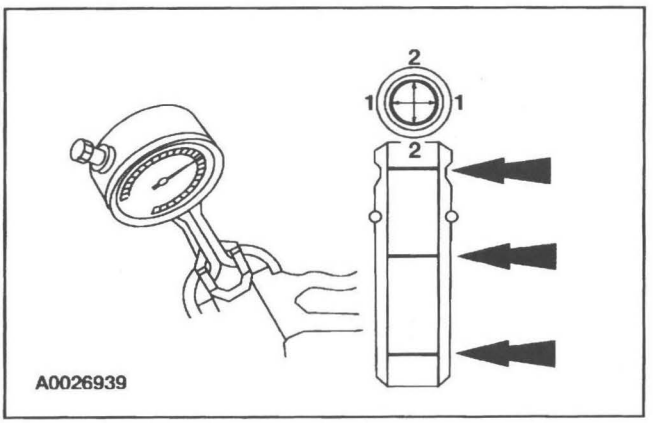
2. Move the Valve Stem Clearance Tool toward the indicator and zero the indicator. Move the Valve Stem Clearance Tool away from the indicator and note the reading. The reading will be DOUBLE the valve stem-to-valve guide clearance. Valves with oversize stems will need to be installed if out of specification.

Valve — Inspection



1. Inspect the following valve areas:
   1 the end of the stem for grooves or scoring
   2 the valve face and the edge for pits, grooves or scores
   3 the valve head for signs of burning, erosion, warpage and cracking
   4 the valve margin for wear

Valve — Guide Inner Diameter

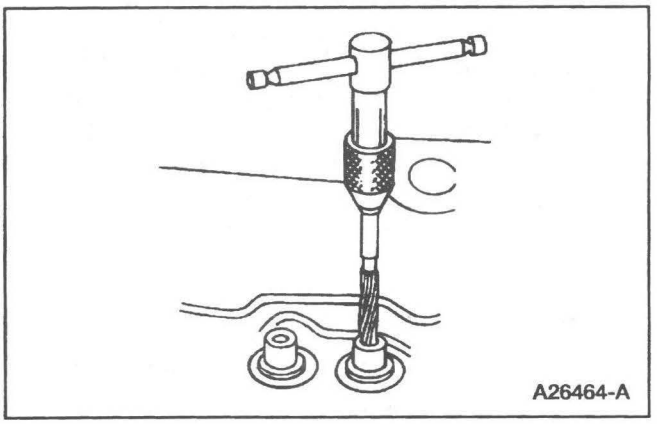


1. Measure the inner diameter of the valve guides in two directions where indicated.
   - Refer to the appropriate section in Group 303 for the procedure.

2. If the valve guide is not within specifications, ream the valve guide and install a valve with an oversize stem or remove the valve guide and install a new valve guide.

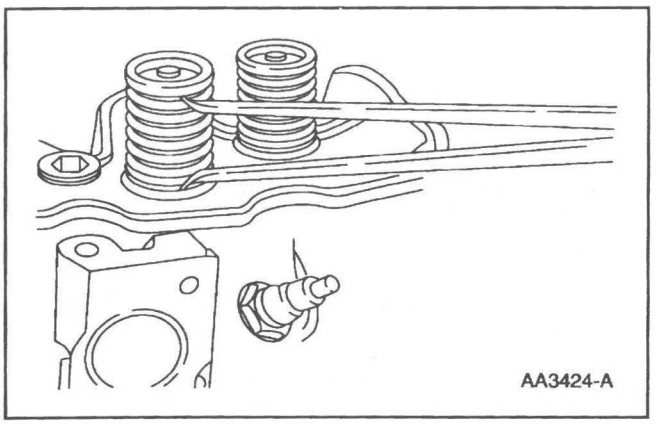
GENERAL PROCEDURES (Continued)

Valve — Guide Reaming



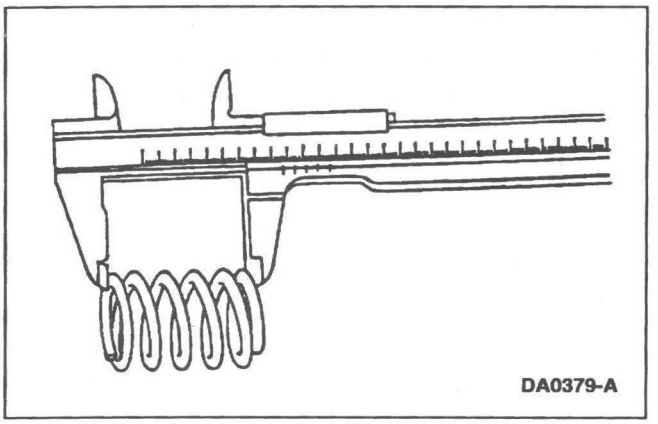
1. Use a hand-reaming kit to ream the valve guide.
2. Reface the valve seat.
3. Clean the sharp edges left by reaming.

Valve — Spring Installed Length



1. Measure the installed length of each valve spring.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components. Refer to the appropriate section in Group 303 for the procedure.

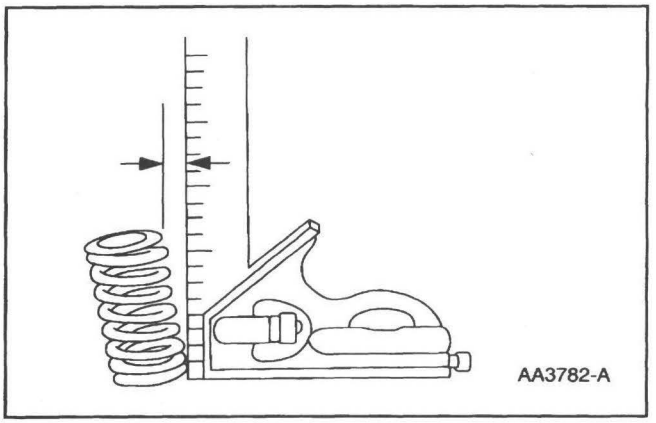
Valve — Spring Free Length



1. Measure the free length of each valve spring.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

GENERAL PROCEDURES (Continued)

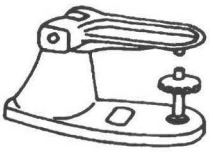
Valve — Spring Squareness

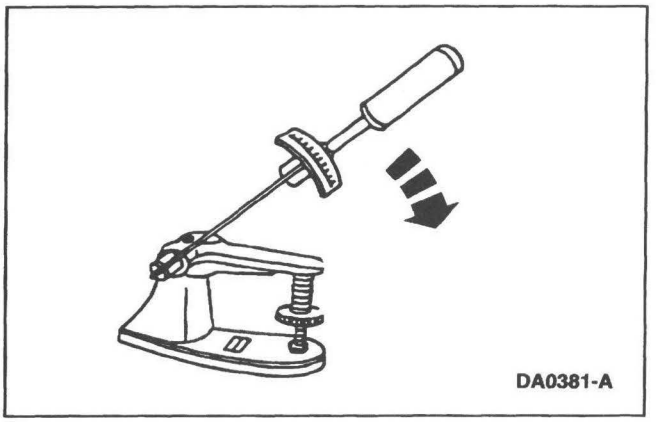


1. Measure the out-of-square on each valve spring.
   - Turn the valve spring and observe the space between the top of the valve spring and the square. Install a new valve spring if out of square. Refer to the appropriate section in Group 303 for the procedure.

Valve Spring Strength

Special Tool(s)

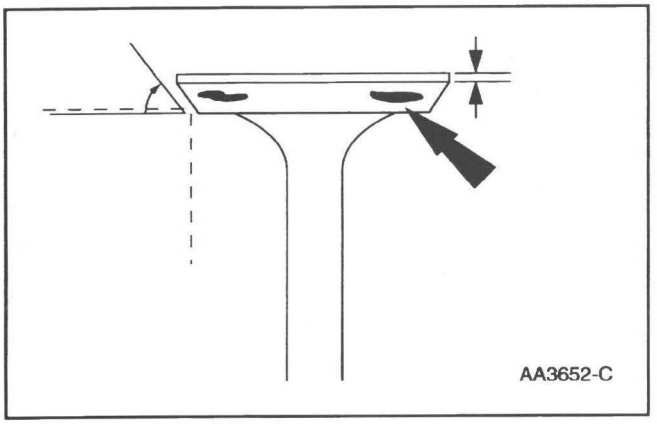
 ST1278-A	Pressure Gauge, Valve/Clutch Spring 303-006 (TOOL-6513-DD) or equivalent



1. Use a Valve/Clutch Spring Pressure Gauge to check the valve spring for correct strength at the specified valve spring length.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

GENERAL PROCEDURES (Continued)

Valve — Seat Inspection



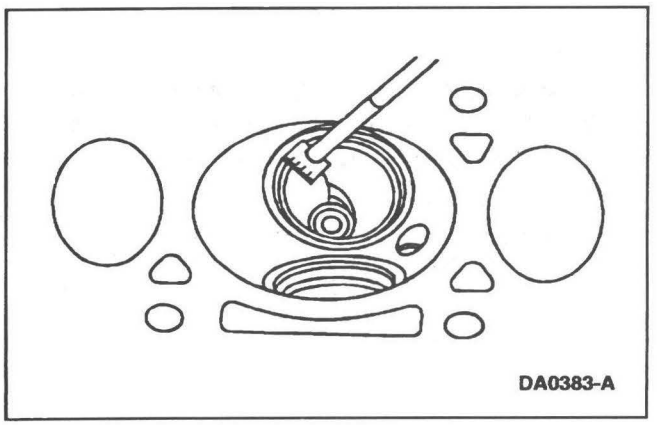
Valve and Seat Refacing Measurements

⚠ CAUTION: After grinding valves or valve seats, check valve clearance.

1. Check the valve head and seat.
   - Check valve angles.
   - Check margin width.
   - Refer to the appropriate section in Group 303 for the procedure.
   - Be sure margin width is within specification.

2. Inspect for abnormalities on the valve face and seat.

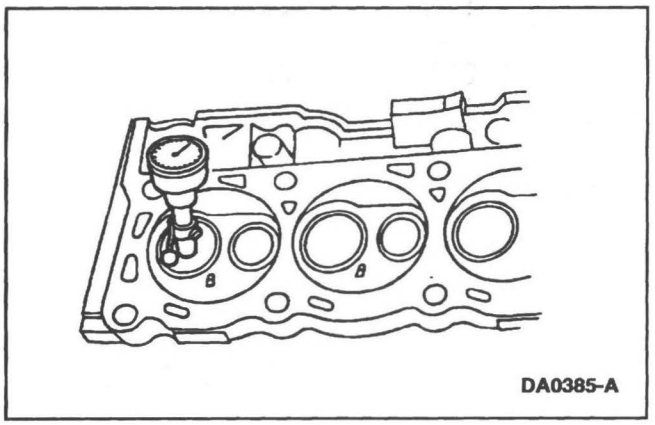
Valve — Seat Width



1. Measure the valve seat width. If necessary, grind the valve seat to specification.
   - Measure the intake valve seat width.
   - Measure the exhaust valve seat width.
   - Recheck the valve spring installed length after the seats have been ground, and shim the valve springs as necessary to achieve the correct installed spring length.
   - Refer to the appropriate section in Group 303 for the procedure.

GENERAL PROCEDURES (Continued)

Valve — Seat Runout

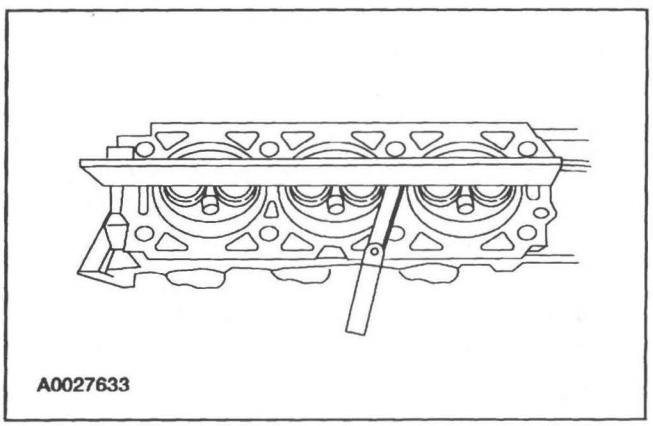

DA0385-A

1. Use the Valve Seat Runout Gauge to check valve seat runout.

Cylinder Head — Distortion

Special Tool(s)

 ST1246-A	Straight Edge 303-D039 (D83L-4201-A) or equivalent


A0027633

1. Use a straight edge and a feeler gauge to inspect the cylinder head for flatness. If the cylinder head is distorted, install a new cylinder head.

Cylinder Bore — Cleaning

1. ⚠ **CAUTION: If these procedures are not followed, rusting of the cylinder bores may occur.**

   Clean the cylinder bores with soap or detergent and water.

2. Thoroughly rinse with clean water and wipe dry with a clean, lint-free cloth.

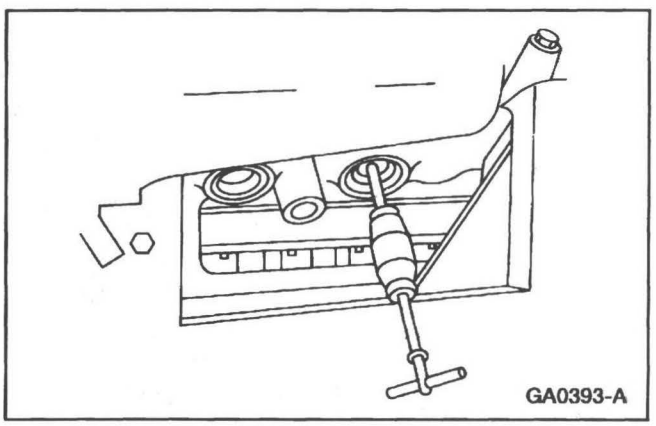
GENERAL PROCEDURES (Continued)

3. Use a clean, lint-free cloth and lubricate the cylinder bores.
   - Use clean engine oil meeting Ford specification.

Cylinder Block Core Plug Replacement

Special Tool(s)

 ST1185-A	Slide Hammer 100-001 (T50T-100-A)



Materials

Item	Specification
Threadlock® 262 E2FZ-19554-A or equivalent	WSK-M2G351-A6

1. Use a slide hammer or tools suitable to remove the cylinder block core plug.

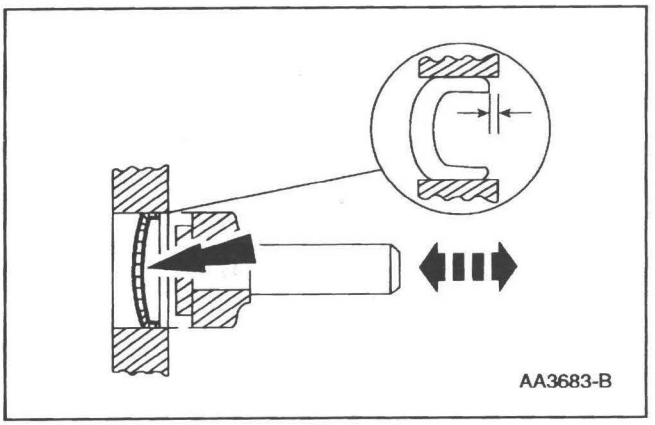
2. Inspect the cylinder block plug bore for any damage that would interfere with the correct sealing of the plug. If the cylinder block plug bore is damaged, bore for the next oversize plug.

3. **NOTE:** Oversize plugs are identified by the OS stamped in the flat located on the cup side of the plug.

   Coat the cylinder block core plug and bore lightly with Threadlock® 262 and install the cylinder block core plug.

GENERAL PROCEDURES (Continued)

Cup-Type

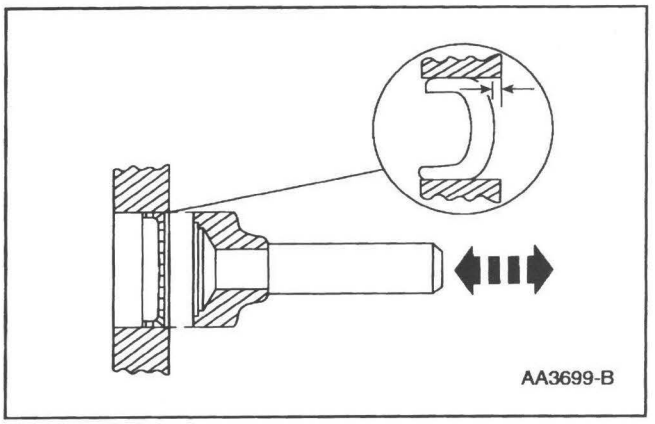


1. ⚠ **CAUTION: Use care during this procedure so as not to disturb or distort the cup sealing surface.**

   ⚠ **CAUTION: When installed, the flanged edge must be below the chamfered edge of the bore to effectively seal the bore.**

   Use a tool suitable to seat the cup-type cylinder block core plug.

Expansion-Type



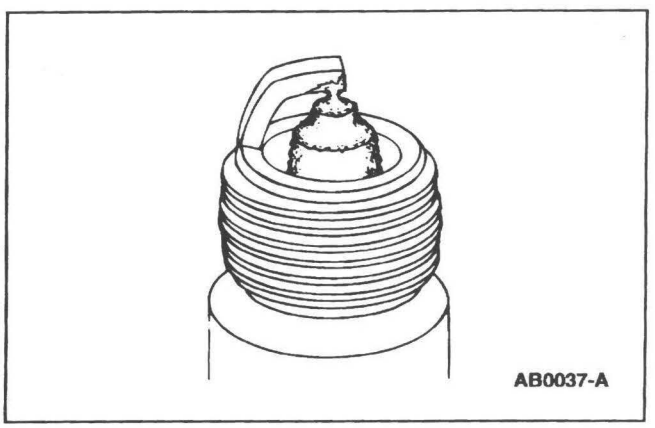
1. ⚠ **CAUTION: Do not contact the crown when installing an expansion-type cylinder block core plug. This could expand the plug before seating and result in leakage.**

   Use tool suitable to seat the expansion-type cylinder block core plug.

Spark Plug Hole Thread Repair

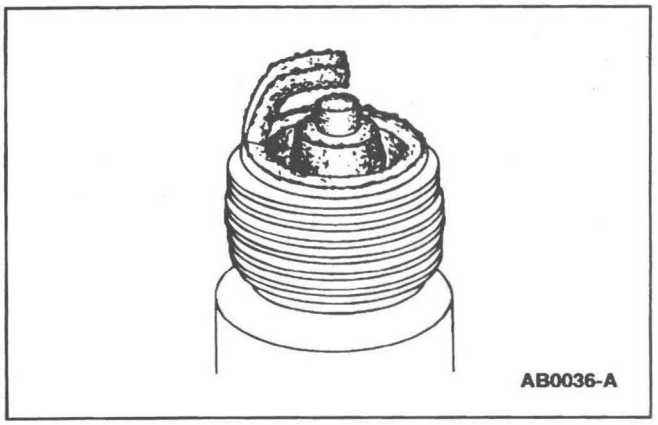
1. There is no authorized repair for spark plug hole threads. If the threads are damaged, install a new cylinder head.

Spark Plug — Inspection

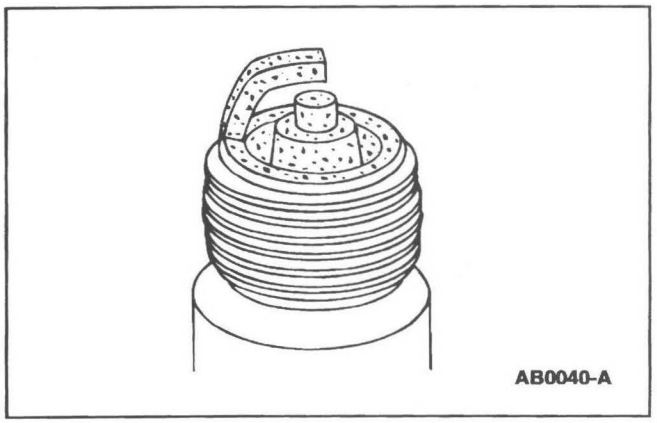


1. Inspect the spark plug for a bridged gap.
   - Check for deposit build-up closing the gap between the electrodes. Deposits are caused by oil or carbon fouling.
   - Clean the spark plug.

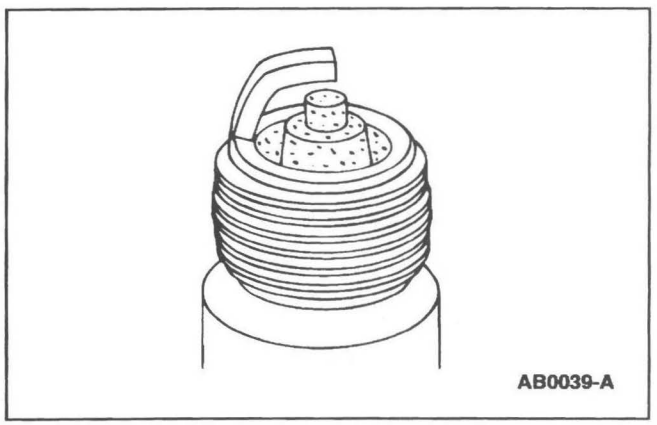
GENERAL PROCEDURES (Continued)


AB0036-A

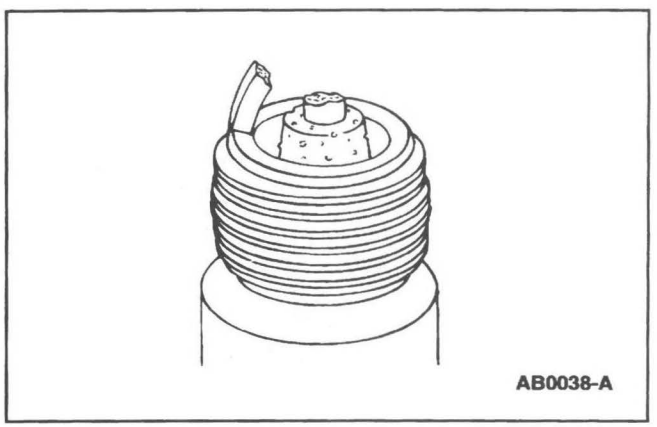
2. Check for oil fouling.
   - Check for wet, black deposits on the insulator shell bore electrodes, caused by excessive oil entering the combustion chamber through worn rings and pistons, excessive valve-to-guide clearance or worn or loose bearings.
   - Correct the oil leak concern.
   - Install a new spark plug.


AB0040-A

3. Inspect for carbon fouling. Look for black, dry, fluffy carbon deposits on the insulator tips, exposed shell surfaces and electrodes, caused by a spark plug with an incorrect heat range, dirty air cleaner, too rich a fuel mixture or excessive idling.
   - Clean the spark plug.

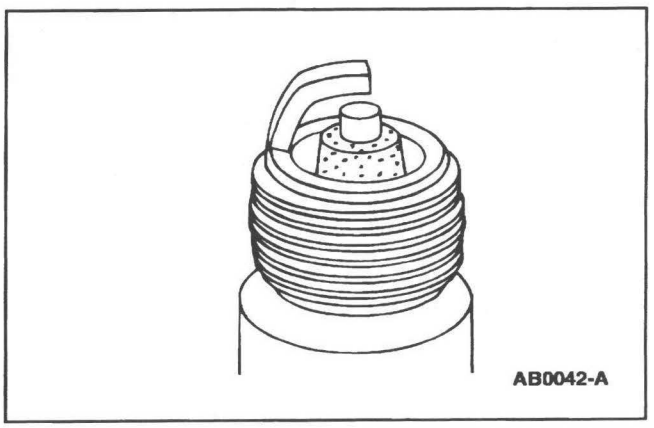

AB0039-A

4. Inspect for normal burning.
   - Check for light tan or gray deposits on the firing tip.

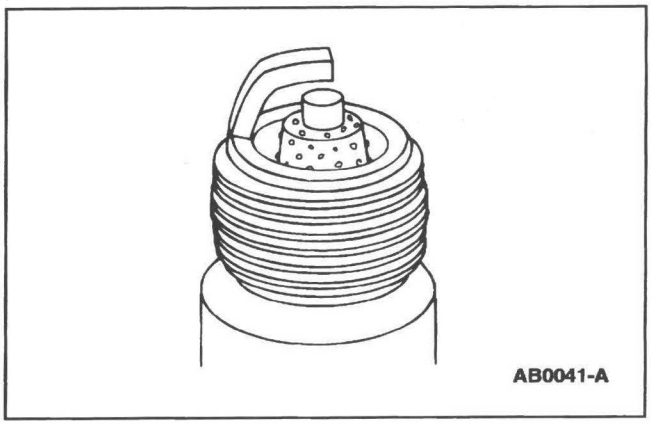

AB0038-A

5. Inspect for pre-ignition, identified by melted electrodes and a possibly damaged insulator. Metallic deposits on the insulator indicate engine damage. This may be caused by incorrect ignition timing, wrong type of fuel or the unauthorized installation of a heli-coil insert in place of the spark plug threads.
   - Install a new spark plug.

GENERAL PROCEDURES (Continued)



6. Inspect for overheating, identified by a white or light gray spots and with bluish-burnt appearance of electrodes. This is caused by engine overheating, wrong type of fuel, loose spark plugs, spark plugs with an incorrect heat range, low fuel pump pressure or incorrect ignition timing.
   - Install a new spark plug.

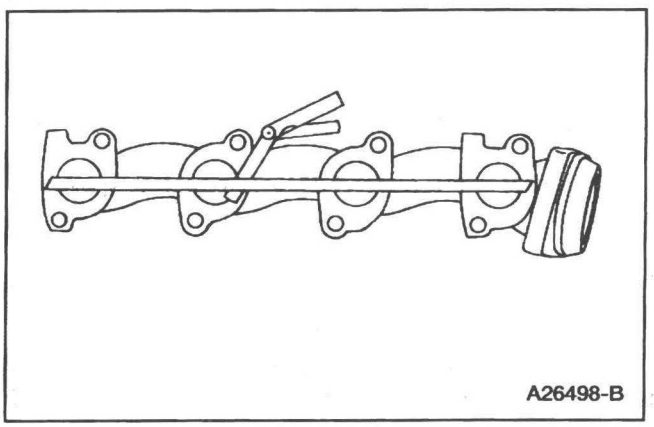


7. Inspect for fused deposits, identified by melted or spotty deposits resembling bubbles or blisters. These are caused by sudden acceleration.
   - Clean the spark plug.

Exhaust Manifold — Inspection

Special Tool(s)

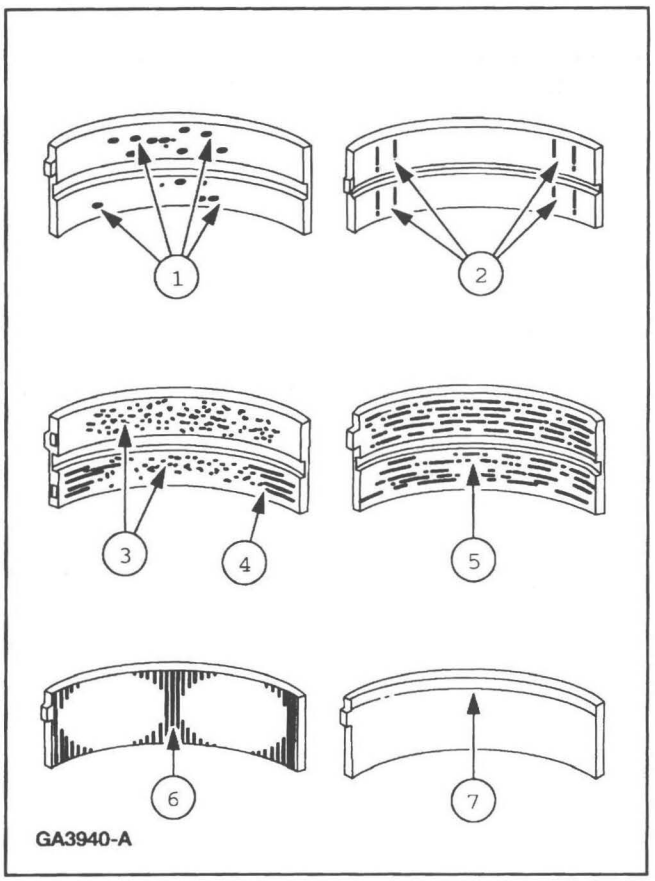
 ST1246-A	Straight Edge 303-D039 (D83L-4201-A) or equivalent



1. Place a straight edge across the exhaust manifold flanges and check for warping with a feeler gauge.

GENERAL PROCEDURES (Continued)

Bearing — Inspection



1. Inspect bearings for the following defects. Possible causes are shown:
   - 1 Cratering — fatigue failure.
   - 2 Spot polishing — incorrect seating.
   - 3 Imbedded dirt engine oil.
   - 4 Scratching — dirty engine oil.
   - 5 Base exposed — poor lubrication.
   - 6 Both edges worn — journal damaged.
   - 7 One edge worn — journal tapered or bearing not seated.

SECTION 303-01A Engine — 4.2L

CONTENTS PAGE

SPECIFICATIONS

General Specifications

Item	Specification
Displacement	4.2L
Number of Cylinders	6
Bore	96.8325 mm (3.81 in)
Stroke	95.0 mm (3.8 in)
Firing Order	1-4-2-5-3-6
Oil Pressure (HOT 2500 rpm)	40-125 psi
Cylinder Head and Valve Train	
Cylinder Head Volume	61.5-64.5
Valve Guide Bore Diameter Intake and Exhaust	7.015-7.044 mm (.276-.277 in)
Valve Seats Width — Intake and Exhaust Angle Runout (T.I.R.)	1.5-2.0 mm (0.06-0.08 in) 44.75 degrees 0.076 mm (0.003 in)
Bore Diameter (Bearing Counterbore Diameter) Intake Exhaust 	47.097 mm (1.8542 in) MAX 47.072 mm (1.8532 in) MIN 39.739 mm (1.5645 in) MAX 39.714 mm (1.5635 in) MIN
Gasket Surface Flatness	0.18 mm (0.007 in)
Gasket Surface Finish [a]	
Valve Stem to Guide Clearance Intake Exhaust	0.020-0.069 mm (0.045-0.090 in) 0.038-0.083 mm (0.0015-0.0033 in)
Valve Head Diameter Intake Exhaust	47.27 mm (1.86 in) 37.1 mm (1.46 in)
Valve Face Runout Limit	0.05 mm (0.002 in)
Valve Face Angle	45.675 degrees
Valve Stem Diameter (STD) Intake Exhaust 	6.955-6.988 mm (0.2738-0.2751 in) 6.929-6.962 mm (0.2728-0.2741 in)

(Continued)

General Specifications

Item	Specification
Oversize Intake Exhaust Oversize Intake Exhaust 	 9.075-9.055 mm (0.3573-0.3565 in) 9.063-9.043 mm (0.3568-0.3560 in) 9.456-9.436 mm (0.3723-0.3715 in) 9.444-9.424 mm (0.3718-0.3710 in)
Valve Springs	
Compression Pressure (N [Lb] @ Spec Length) Valve Open (Without Damper) Valve Closed (Without Damper) Assembled Height Service Limit	 1000 N (224 lbs) @ 29.2 mm (1.16 in) 350 N (79 lbs) @ 40.7 mm (1.62 in) 40.7 mm (1.62 in) 10% Force Loss @ Specified Height
Rocker Arm Ratio	 1.73
Valve Tappet, Hydraulic Diameter (Std) Clearance to Bore Service Limit Hydraulic Leakdown Rate Collapsed Tappet Gap Intake Exhaust 	 22.195-22.212 mm (0.8738-0.8745 in) 0.018-0.068 mm (0.0007-0.0027 in) 0.127 mm (0.005 in) (a) (Nominal) 2.25-4.79 mm (0.089-0.189 in) 2.25-4.79 mm (0.089-0.189 in)
Camshaft Synchronizer Shaft Bearing Bore Diameter Bore Diameter	 22.268-22.230 mm (0.8767-0.8752 in)
Camshaft Bore Inside Diameter No. 1 No. 2 No. 3 	 55.689-55.664 mm (2.192-2.191 in) 55.308-55.283 mm (2.177-2.176 in) 55.308-55.283 mm (2.177-2.176 in)

(Continued)

SPECIFICATIONS (Continued)

General Specifications

Item	Specification
No. 4	55.684-55.664 mm (2.192-2.191 in)
Camshaft	
Lobe Lift	
Intake	6.22 mm (0.24 in)
Exhaust	6.57 mm (0.26 in)
Allowable Lobe Lift Loss	0.127 mm (0.005 in)
Theoretical Valve Lift @ Zero Lash	
Intake	11.30 mm (0.45 in)
Exhaust	11.47 mm (0.45 in)
End Play	
Service Limit	0.025-0.150 mm (0.001-0.006 in)
Journal to Bearing	
Clearance	0.025-0.076 mm (0.001-0.003 in)
Journal Diameter	
All	52.502-52.704 mm (2.067-2.074 in)
Cam Bearing I.D.	52.158-52.133 mm (2.0535-2.0525 in)
Runout Limit	0.05 mm (0.002 in) Runout of #2 or #3 relative to #1 and #4
Out-of-Round Limit	0.025 mm (0.001 in)
Balance Shaft Bore	
Inside Diameter	55.689-55.664 mm (2.192-2.191 in)
End Plug	0.16-0.075 mm (0.006-0.003 in)
Balance Shaft	
End Play	0.075-0.200 mm (0.003-0.008 in)
Journal Diameter	52.108-52.082 mm (2.0515-2.0505 in)
Runout	0.025 mm (0.001 in)
Camshaft Drive	
Assembled Gear Face Runout	
Crankshaft	0.10 mm (0.004 in)
Camshaft	0.25 mm (0.010 in)
Timing Chain Deflection	12.7 mm (0.5 in)
Cylinder Block	
Head Gasket Surface Flatness	0.08 mm (0.003 in) in 152.0 mm (6.00 in)
Head Gasket Surface Finish (RMS)	2.0 @ 0.85.5 @ 2.5

(Continued)

General Specifications

Item	Specification
Cylinder Bore	
Diameter	96.813 mm (3.81 in)
Surface Finish (RMS)	0.45-0.96
Out-of-Round Limit	0.025 mm (0.001 in)
Out-of-Round Service Limit	0.050 mm (0.002 in)
Taper Service Limit	0.050 mm (0.002 in)
Main Bearing Bore Diameter	68.905 mm (2.713 in) 68.885 mm (2.712 in)
Crankshaft and Flywheel	
Main Bearing Journal	
Diameter 1, 2, 3	63.983-64.003 mm (2.5190-2.5198 in)
Out-of-Round Limit	0.008 mm (0.0003 in) MAX in 45 degrees, 0.015 mm (0.006 in) TOTAL
Taper Limit	0.008 mm (0.0003 in) per 25 mm (1 in)
Journal Runout Limit	0.05 mm (0.002 in) (2) 0.05 mm (0.002 in) (3)
Surface Finish (RMS)	0.3 micrometers (11.8 micro in)
Thrust Bearing Journal	
Length	29.725-29.775 mm (1.703-1.722 in)
Connecting Rod Journal	
Diameter	58.682-58.702 mm (2.3103-2.3111 in)
Out-of-Round Limit	0.008 mm (0.0003 in) MAX in 45 degrees, 0.015 mm (0.0006 in) TOTAL
Taper Limit	0.008 mm per 25 mm (0.0003 in per in)
Surface Limit (RMS)	0.3 micrometers (11.8 micro in)
Main Bearing Thrust Face	
Surface Finish (RMS)	0.9 micrometers (0.354 micro in) FRONT; 0.6 micrometers (0.236 micro in) REAR
Runout Limit	0.025 mm (0.001 in)
Flywheel Ring Gear Lateral Runout (T.I.R.)	
Automatic Transmission	1.778 mm (0.07 in)
Crankshaft End Play	0.10-0.20 mm (0.004-0.008 in)
Connecting Rod Bearings	
Clearance to Crankshaft	
Desired	0.025-0.035 mm (0.001-0.0014 in)

(Continued)

SPECIFICATIONS (Continued)

General Specifications

Item	Specification
Allowable	0.022-0.069 mm (0.00086-0.0027 in)
Bearing Wall Thickness (Std)	1.453-1.466 mm (0.0572-0.0577 in)
Main Bearings	
Clearance to Crankshaft	
Desired	0.025-0.035 mm (0.001-0.0014 in)
Allowable	0.013-0.058 mm (0.0005-0.0023 in)
Bearing Wall Thickness	2.435-2.443 mm (0.0959-0.0962 in)
Connecting Rod, Piston and Rings	
Connecting Rod	
Piston Pin Bore Diameter	22.94-22.98 mm (0.90315-0.90472 in)
Crankshaft Bearing Bore Diameter	61.635-61.655 mm (2.4266-2.4274 in)
Out-of-Round Limit—Piston Pin Bore	0.003 mm (0.00012 in)
Taper Limit Piston Bore	0.003 per 25 mm (0.0001 per in)
Length (Center-to-Center)	154.66-154.74 mm (6.08896-6.09211 in)
Alignment (Bore-To-Bore Max. Diff.)	
Twist	0.059 per 25 mm (0.002 per in)
Bend	0.04 per 25 mm (0.0016 per in)
Side Clearance (Assembled to Crank)	
Standard	0.11-0.49 mm (0.0047-0.01929 in)
Service Limit	0.36 mm MAX (0.014 in MAX)
Piston	
Diameter	
Coded Red	96.795-96.782 mm (3.81082-3.81031 in)
Coded Blue	96.808-96.795 mm (3.81133-3.81082 in)
Coded Yellow	96.821-96.808 mm (3.81184-3.81133 in)
Piston-to-Bore Clearance (Uncoated Clearance)	0.018-0.044 mm (0.00071-0.00173 in)
Service Piston Selection	
I.D. Code of Service Piston Bore Diameter	Piston Required

(Continued)

General Specifications

Item	Specification
Red	96.826-96.813 mm (3.81204-3.811528 in)
Blue	96.839-96.826 mm (3.81255-3.81204 in)
Yellow	96.852-96.839 mm (3.81306-3.81255 in)
When replacing pistons, measure the cylinder bore as described in Section 303-00. Install the service piston matched to the piston bore diameter above.	
Pin Bore Diameter	23.014-23.018 mm (0.90606-0.90622 in)
Ring Groove Width	
Compression (Top)	1.54-1.52 mm (0.0606-0.0598 in)
Compression (Bottom)	1.54-1.52 mm (0.0606-0.0598 in)
Oil	3.05-3.03 mm (0.12001-0.11929 in)
Piston Pin	
Length	63.55-63.05 mm (2.5096-2.4823 in)
Diameter	23.000-23.003 mm (0.90551-0.90563 in)
Pin to Piston Clearance	0.011-0.018 mm (0.00043-0.00071 in)
Pin to Rod Clearance	Press Fit 8 Kilonewtons (1800 lbs)
Piston Rings	
Ring Width	
Compression (Top)	1.460-1.490 mm (0.05748-0.05866 in)
Compression (Bottom)	1.460-1.490 mm (0.05748-0.05866 in)
Oil Ring	Side Seal—Snug Fit
Service Limit	Side Clearance 0.015 mm MAX (0.0006 in MAX)
Ring Gap	
Compression (Top) (In Gauge)	0.17-0.33 mm (—in)
Compression (Bottom) (In Gauge)	0.3-0.55 (—in)
Oil Ring (Steel Rail) (In Gauge)	0.15-0.165 (0.0059-0.0065 in)
Side Clearance	
1st Ring	0.030-0.080 mm (0.00118-0.00315 in)
2nd Ring	0.030-0.080 mm (0.00118-0.00315 in)

(Continued)

SPECIFICATIONS (Continued)

General Specifications

Item	Specification
(a) 20-200 seconds to leakdown 3.18 mm (0.125 in) with 225 Newtons (50 pounds) load and tappet filled with leak-down fluid.	
(1) Smaller than pin bore measured along center to center axis.	
(2) Runout of journals No. 2 and No. 3 to journals No. 1 and No. 4.	
(3) Runout of adjacent journals to each other.	
Lubrication System	
Oil Pump	
Relief Valve Spring Tension (Force @ Length)	76.2-67.6 N (17.1-15.2 lbs) @ 30.5 mm (1.20 in)
Relief Valve to Bore Clearance	0.073-0.043 mm (0.0029-0.0017 in)
Oil Pump Gear Backlash	0.02-0.03 mm (0.008-0.012 in)
Oil Pump Gear Radial Clearance (Idler and Drive)	0.125-0.050 mm (0.0055-0.002 in)
Oil Pump Gear End Height	0.100-0.010 mm (—in)
Idler Shaft to Idler Gear Clearance	0.044-0.010 mm (0.0017-0.0005 in)
Driver Shaft to Housing Clearance	0.076-0.038 mm (0.0030-0.0015 in)
Oil Capacity	5.5 quarts + 1/2 quart with filter change (6.0 quarts total).

a Head Gasket Surface - WT=12/2.5. Head Gasket Surface Finish-RZU-13.5 micron. Filter cut off at .08 min TPI @ 3.5 microns below the peak 63 % min. Cut off at .08 mm (0.031496 in), O Ref=2V.

General Specifications

Item	Specification
Super Premium SAE 5W-20 Motor Oil (XO-5W20-QSP)	WSS-M2C153-H
Gasket and Trim Adhesive (F3AZ-19B508-AA)	ESE-M2G52-A
Pipe Sealant with Teflon® (D8AZ-19554-A)	WSK-M2G350-A2
Silicone Gasket and Sealant (F7AZ-19554-EA)	WSE-M4G323-A4
Metal Surface Cleaner (F4AZ-19A536-RA)	WSE-M5B392-A

Torque Specifications

Description	Nm	Lb-Ft	Lb-In
EGR transducer bracket-to-intake manifold bolts	10	—	89
Ignition coil-to-valve cover	6	—	53
Water outlet tube-to-intake manifold stud bolt	10	—	89
EGR tube-to-EGR valve nut	40	30	—
Water outlet tube-to-front water pump bolt	10	—	89
Fuel supply manifold bolts	10	—	89
LH valve cover-to-cylinder head bolts	10	—	89
LH valve cover-to-cylinder head stud bolts	10	—	89
EGR tube-to-exhaust manifold nut	40	30	—
RH valve cover-to-cylinder head bolts	10	—	89
RH valve cover-to-cylinder head stud bolts	10	—	89
Coolant recovery reservoir-to-cylinder head stud bolts	10	—	89
Coolant recovery reservoir-to-bracket bolts	5	—	44
Crankshaft damper bolt	150	111	—
Exhaust manifold flange nuts	40	30	—
Camshaft position sensor bolts	3	—	27
Camshaft synchronizer-to-front-cover bolt	25	18	—
Front cover-to-cylinder block bolts	a	—	—
Radiator fan shroud-to-radiator bolts	9	—	80

(Continued)

SPECIFICATIONS (Continued)

Torque Specifications

Description	Nm	Lb-Ft	Lb-In
Camshaft thrust plate-to-cylinder block bolts	12	9	—
Camshaft synchronizer drive gear-to-camshaft bolt	45	33	—
Timing chain tensioner-to-cylinder block bolts	12	9	—
Power steering pump bolts	25	18	—
IMRC mounting bracket	10	—	89
Power steering pump reservoir bolts	10	—	89
A/C compressor manifold bolt	21	15	—
Exhaust manifold-to-cylinder head nuts	33	24	—
Power steering pump bracket-to-water pump nuts	20	15	—
Power steering pump bracket-to-generator bracket bolts	20	15	—
Generator bracket-to-cylinder head bolts	40	30	—
Exhaust manifold studs	8	—	71
A/C compressor bracket-to-cylinder head bolts	48	35	—
A/C compressor bracket-to-cylinder head nut	48	35	—
A/C compressor bracket-to-cylinder head stud bolt	25	18	—
Oil level indicator tube-to-cylinder head bolt	10	—	89
Coolant recovery reservoir bracket-to-GOP bolts	9	—	80
Motor mount-to-subframe nuts	115	85	—
Oil pan drain plug	26	19	—
Wire harness bracket to motor mount nut	27	20	—
Steering column pinch bolt	47	35	—

(Continued)

Torque Specifications

Description	Nm	Lb-Ft	Lb-In
Front subframe-to-body bolts	90	66	—
Front subframe-to-shock tower bolts	115	85	—
Oil pan-to-cylinder block bolts	*	—	—
Oil pan-to-transmission bell housing	45	33	—
Oil pan baffle nuts	48	35	
Oil pump cover-to-engine front cover bolts	25	18	—
Oil pump cover-to-engine front cover bolt	10	89	—
Oil pickup tube-to-cylinder block bolts	25	18	—
Oil pickup tube-to-oil pan baffle nut	48	35	—
Flywheel-to-crankshaft bolts	80	59	—
Wire harness bracket-to-motor mount stud-nut	27	20	—
Engine ground strap-to-motor mount nut	27	20	—
Motor mount-to-motor mount bracket bolts	70	52	
RH motor mount-to-motor mount bracket nut	70	52	—
Hood ground strap-to-hood hinge bolt	12	9	—
Hood hinge nuts	12	9	—
Generator positive cable nut	10	—	89
Power steering pressure tube to pump nut	40	30	—
42-pin connector bolt	10	—	89
Transmission oil cooler tube bracket-to-motor mount bracket nut	27	20	
Torque converter-to-flywheel nuts	36	27	—
Engine-to-transmission bolts	40	30	—

(Continued)

SPECIFICATIONS (Continued)

Torque Specifications

Description	Nm	Lb-Ft	Lb-In
Motor mount bracket-to-engine bolts	70	52	—
Motor mount bracket-to-engine nuts	70	52	—
Water pump pulley bolts	25	18	—
Oil bypass filter	a	—	—
Upper intake manifold-to-lower intake manifold bolts	a	—	—
Lower intake manifold-to-cylinder head bolts	a	—	—

(Continued)

Torque Specifications

Description	Nm	Lb-Ft	Lb-In
Rocker arm pivot-to-cylinder head bolts	a	—	—
Intake manifold spacer assembly	a	—	—
Cylinder head bolts	a	—	—
Crankshaft main bearing bolts	a	—	—
Connecting rod cap bolts	a	—	—

a Refer to the procedure.

DESCRIPTION AND OPERATION

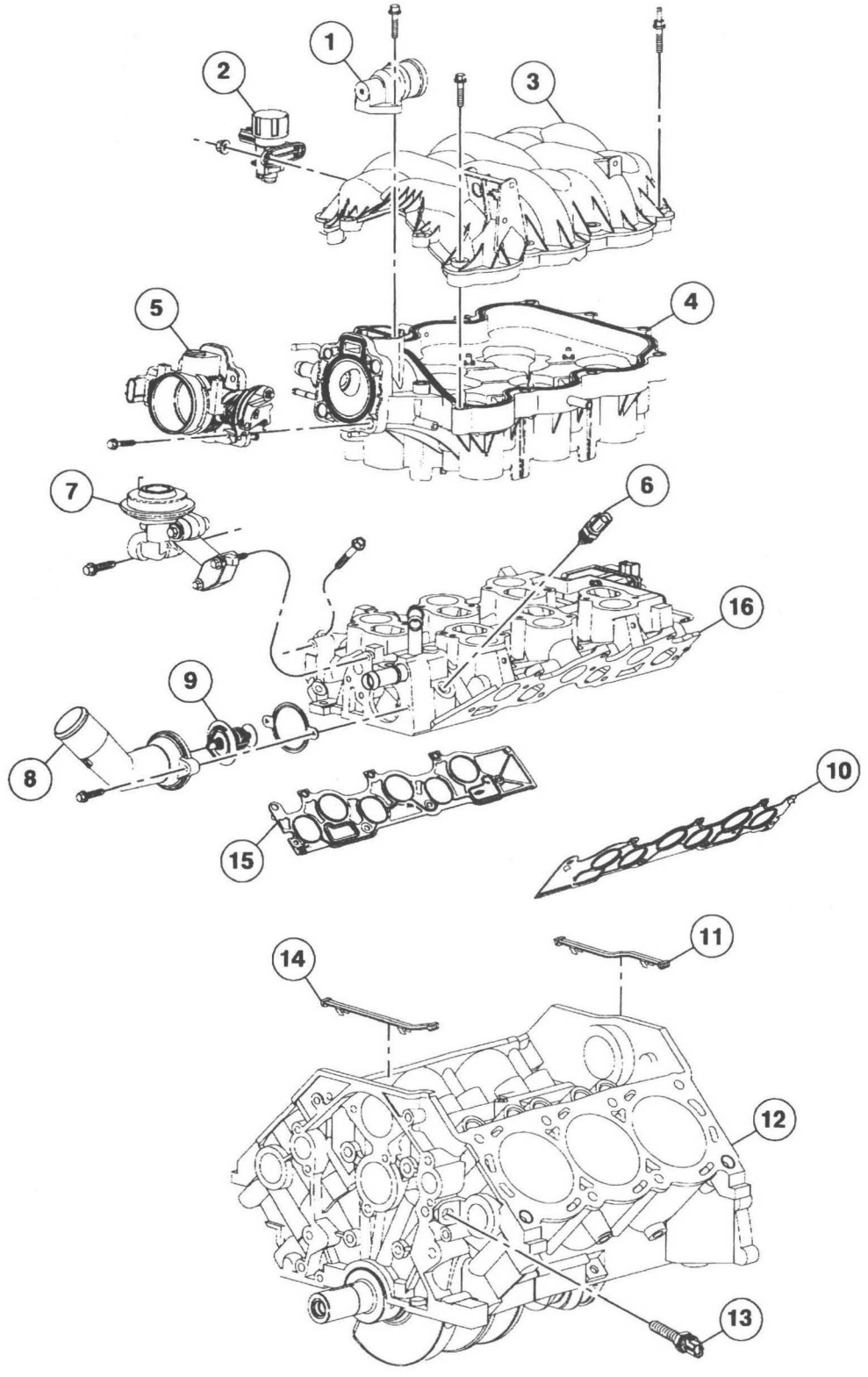
Engine

The 4.2L engine has:

- a V-block with six cylinders and splayed crankpins
- a distributorless ignition system
- a multiport, sequential fuel injection (SFI) system
- a variable length induction system (intake manifold runner control)
- overhead valves
- hydraulic valve tappets (6500) for automatic lash adjustment
- connecting rod parting faces that are unique with an interference fit
- an engine dynamic balance shaft (6A311)

DESCRIPTION AND OPERATION (Continued)

Major Upper Engine Components



METRICS

ENGLISH/METRIC CONVERSION

DESCRIPTION	MULTIPLY	BY	FOR METRIC EQUIVALENT
Acceleration	ft/s^2	0.3048	m/s^2
	in/s^2	0.0254	m/s^2
Torque	lb-in	0.11298	N·m
	lb-ft	1.3558	N·m
Power	horsepower	0.746	kW
Pressure or Stress	inches of water	0.2491	kPa
	psi	6.895	kPa
	psi	0.069	bar
Energy or Work	BTU	1055.0	Joules(J)
	lb-ft	1.3558	Joules(J)
	kiloWatt-hour	3,600,000 or 3.6×10^6	Joules(J)
Light	foot candle	10.764	lumens/square meter (lm/m^2)
Fuel Performance	miles/gal	0.4251	kilometers/liter (km/L)
	gal/mile	2.3527	liters/kilometer (L/km)
Velocity	mph	1.6093	kilometers/hour (km/h)
Length	inch	25.4	mm
	foot	0.3048	m
	yard	0.9144	m
	mile	1.609	km
Area	square inch (in^2)	645.2	mm^2
		6.45	cm^2
	square ft (ft^2)	0.0929	m^2
	square yard	0.8361	m^2
Volume	cubic inch (in^3)	16387.0	mm^3
		16.387	cm^3
		0.0164	liters (L)
	quart	0.9464	liters (L)
	gallon	3.7854	liters(L)
	cubic yard	0.7646	m^3
Mass	pound	0.4536	kg
	ton	907.18	kg
	ton	0.9078	tonne (t)
Force	kilogram	9.807	N
	ounce	0.2780	N
	pound	4.448	N
Temperature	degree Farenheit (˚F)	(˚F-32) 0.556	degree Celsius (˚C)

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