Clutch: Initial Inspection and Diagnostic Overview
Diagnostic Strategies
Noise Evaluation

NOTE: Carry out this evaluation with the transmission cold and at normal operating temperature to listen for any change in noise as the transmission warms up.

1. Start the engine.
2. Evaluate the noise in NEUTRAL while the vehicle is parked.
3. Listen for any change in noise while depressing and releasing the clutch pedal.
4. Listen for any change in noise while changing the engine rpm.
5. Drive the vehicle and shift through all of the gear ranges, including reverse. Listen for any change in noise in a particular gear.
6. Drive the vehicle in the gear in which the noise is most noticeable. Depress the clutch pedal and leave the gear engaged. Listen for any change in noise. The vibration of the engine may be amplifying the noise.
7. Drive the vehicle under the same conditions identified in the previous step. Depress the clutch pedal and shift the transmission into NEUTRAL. Release the clutch pedal and allow the vehicle to coast. Evaluate the noise as the rear axle assembly turns the mainshaft.

Noise Evaluation for 4x4 Applications
^ With the vehicle at a complete stop and the transfer case in NEUTRAL, shift the transmission through all of the gear ranges and evaluate the noise at different engine rpm. Check for any noise in NEUTRAL at different engine rpm.
^ Check for any noise change when shifting the transfer case between 2H, 4H, 4L and NEUTRAL.

Clutch Slippage Inspection and Verification
1. Chock the wheels.
2. Apply the parking brake.
3. Depress and release the clutch pedal slowly to check if the pedal is binding.
   ^ If the clutch pedal is not binding, proceed to the next step in this procedure.
   ^ If the clutch pedal is binding, inspect and repair as necessary. Test the system for normal operation. Proceed to the next step in this procedure, if necessary.
4. Depress the clutch pedal.
5. Start the engine.
6. Shift the transmission to 4th gear.
7. Increase the engine rpm to **2000** and slowly release the clutch pedal. If the engine stalls **within 5 seconds,** the clutch is not slipping.
   ^ If the clutch is slipping, remove the clutch disc and pressure plate. Inspect the clutch disc and pressure plate for wear and damage. Inspect the flywheel for glazing and damage. Check the clutch release hub and bearing for binding and inspect the guide tube. Inspect the input shaft for wear and damage. Repair all components as necessary. Test the system for normal operation.

Clutch Chatter or Shudder Inspection and Verification
1. Raise and support the vehicle. Refer to Maintenance/Service and Repair.
2. Inspect the engine and transmission mounts for looseness and damage.
   ^ If the mounts are OK, proceed to the next step in this procedure.
   ^ If the mounts are loose or damaged, tighten or install new mounts as necessary. Test the system for normal operation. Proceed to the next step in this procedure, if necessary.
3. Check for loose bolts that retain the clutch pressure plate to the flywheel.
   ^ If the bolts are tightened to specification, proceed to the next step in this procedure.
   ^ If the bolts are loose, tighten the bolts to specification. Test the system for normal operation. Proceed to the next step in this procedure, if necessary.
4. Remove the clutch disc and pressure plate. Inspect the clutch disc and pressure plate for wear and damage, and check the clutch disc runout. Refer to Clutch Pressure Plate Check and Clutch Disc Check. Inspect the flywheel for glazing and damage. Check the flywheel runout. Refer to Flywheel Runout Check. Inspect the input shaft for wear, damage and eccentricity. Repair all components as necessary. Test the system for normal operation. See: Pressure Plate/Testing and Inspection See: Clutch Disc/Testing and Inspection See: Manual Transmission/Transaxle/Flywheel/Testing and Inspection/Flywheel Runout Check

Clutch Drag Inspection and Verification
1. Verify that the clutch hydraulic fluid reservoir is filled to the correct level.
   ^ If the fluid level is correct, proceed to the next step in this procedure.
   ^ If the fluid level is low, add fluid as necessary. Inspect the clutch hydraulic system for leaks and repair as necessary. Test the system for normal operation. Proceed to the next step in this procedure, if necessary.
2. Depress and release the clutch pedal to check for a spongy pedal.
   ^ If the pedal feels OK, proceed to the next step in this procedure.
   ^ If the pedal feels spongy, bleed the clutch hydraulic system. Refer to Clutch System Bleeding - In-Vehicle. Test the system for normal operation. Proceed to the next step in this procedure, if necessary.
3. Remove the clutch disc and pressure plate. Inspect the clutch disc and pressure plate for wear and damage, and check the clutch disc runout. Refer to Clutch Pressure Plate Check and Clutch Disc Check. Repair all components as necessary. Test the system for normal operation. See: Pressure Plate/Testing and Inspection See: Clutch Disc/Testing and Inspection

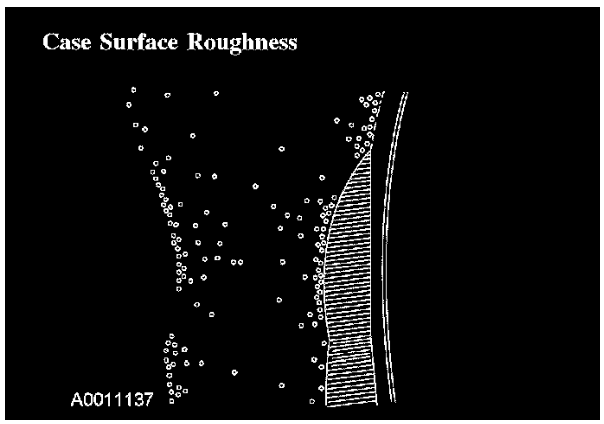
Hard Shifting Inspection and Verification

1. Verify that the clutch hydraulic fluid reservoir is filled to the correct level.
   ^ If the fluid level is correct, proceed to the next step in this procedure.
   ^ If the fluid level is low, add fluid as necessary. Check the clutch hydraulic system for leaks, and repair as necessary. Test the system for normal operation. Proceed to the next step in this procedure, if necessary.
2. Depress and release the clutch pedal to check for a spongy pedal.
   ^ If the pedal feels OK, proceed to the next step in this procedure.
   ^ If the pedal feels spongy, bleed the clutch hydraulic system. Test the system for normal operation. Proceed to the next step in this procedure, if necessary.
3. Remove the clutch disc and pressure plate. Inspect the clutch disc and pressure plate for wear and damage. Check the clutch release hub and bearing for binding and inspect the guide tube. Inspect the input shaft for wear and damage. If all of the components are OK, proceed to the next step in this procedure. Otherwise, repair all components as necessary. Test the system for normal operation.
4. Inspect the transmission housing, shafts, forks and synchronizer assemblies. Repair all components as necessary. Test the system for normal operation.

Transmission Component Inspection

NOTE: GO to Symptom Chart - Transmission Component Wear and Damage for additional information relating to these conditions. See: Symptom Related Diagnostic Procedures/Symptom Chart - Transmission Component Wear and Damage

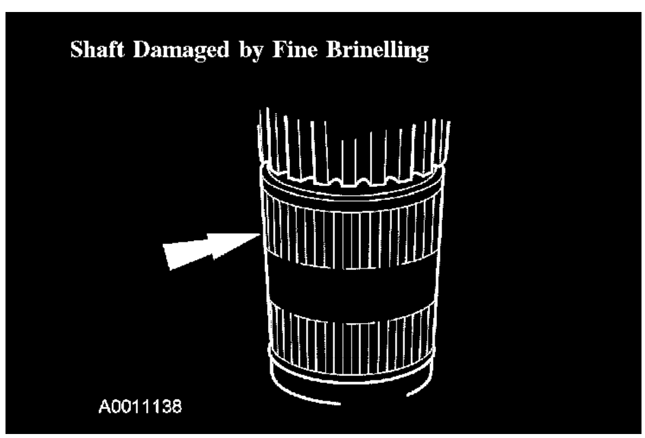
Case Surface Roughness



Case Surface Roughness

^ The term describes areas of roughness on the case. The condition occurs in production, when even after a thorough cleaning, a tough, adhesive crust of sand remains on the surface. Normally, the visual impression is misleading and the housing is usable.

Shaft Damaged by Fine Brinelling



Shaft Damaged by Fine Brinelling

^ The term describes a brightly polished race surface with signs of consecutive depressions. The damage is a combination of brinelling and wear.

Shaft Damaged by Severe Brinelling

Shaft Damaged by Severe Brinelling

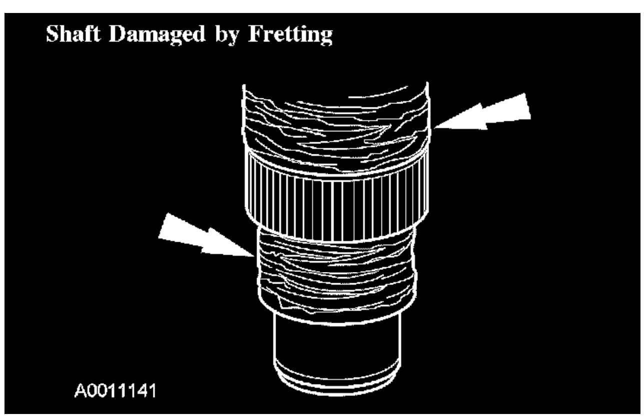
^ The term describes indentations in the race circumferential face, spaced identically to the roller bodies. The damage affects the individual gear's bore and race, and the roller bodies. This type of damage is serious due to a very high increase in radial play on helically cut gears. It can result in contact pattern displacement on the mating gears and can culminate in tooth failure.

Shaft Damaged by Tribological Oxidation (Infinitely Brinelled Surface)

Shaft Damaged by Tribological Oxidation (Infinitely Brinelled Surface)

^ The term describes a highly polished, uniform radial wear in the race surface. Material wear resulting from fretting corrosion causes this type of damage.

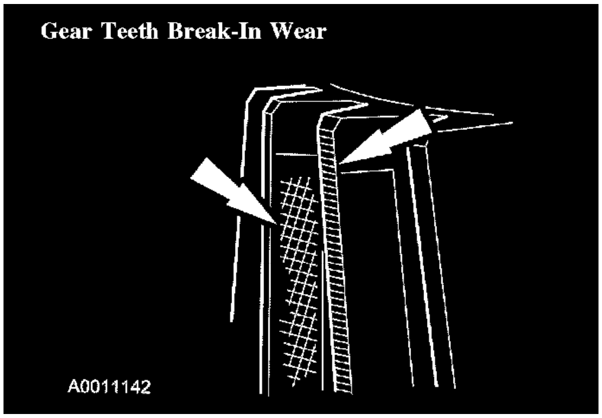
Shaft Damaged by Fretting



Shaft Damaged by Fretting

^ The term describes gnawing marks in the race surface. When combining high differential speeds with high uniformity of rotation (such as towing the vehicle with the driveshaft connected), the contact between the roller bodies and the race may develop a high proportion of slip. If cooling or lubrication in the needle bearing is no longer sufficient, this can lead to overheating and cause fretting corrosion or bearing seizure.

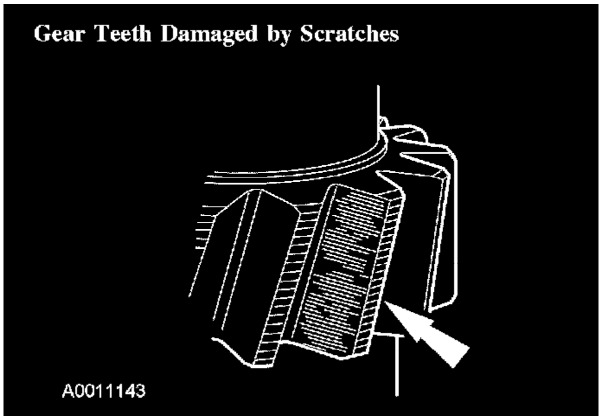
Gear Teeth Break-In Wear



Gear Teeth Break-In Wear

^ The term describes grinding and shaving marks in the gear teeth. Rough peaks, formed during production, wearing away or, to some extent, rolling into the surface cause break-in wear. This type of wear normally ceases after the running-in period has expired, without damaging the components.

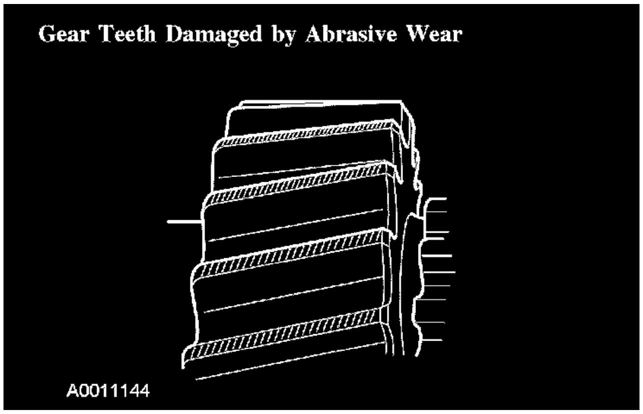
Gear Teeth Damaged by Scratches



Gear Teeth Damaged by Scratches

^ The term describes shallow linear indentations on the flank, running in the direction of sliding. Assess scratches as damage.

Gear Teeth Damaged by Abrasive Wear



Gear Teeth Damaged by Abrasive Wear

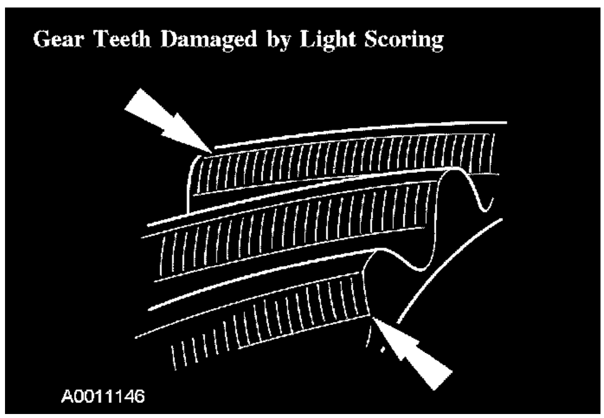
^ The term describes a matte gray appearance on the entire flank. The abrasive wear erases the machining process marks. When abrasive wear reaches an advanced stage, substantial changes in the tooth profile and clearance occur. This type of damage increases the noise level and can also cause secondary damage.

Gear Teeth Damaged by Scoring

Gear Teeth Damaged by Scoring

- The term describes extensive linear indentations in the gear teeth, running in the direction of sliding. Unlike scratching, these marks extend from the start or end of the meshing zone. These marks are particularly deep at the root or tip, where maximum sliding speeds impact the most. Unlike scuffing, the score base is smooth. Scoring wear, which may have a detrimental effect on the gear's performance, can occur if scoring develops over a longer period of time.
- This type of damage indicates the affected flank zone was subject to high sliding and rolling pressures. Fine local cold welding of the flanks and rough peaks are pressed into the mating flank where, as a result of this sliding action, they produce groove-like indentations, which, in turn, cause additional scoring on the original mating flank.

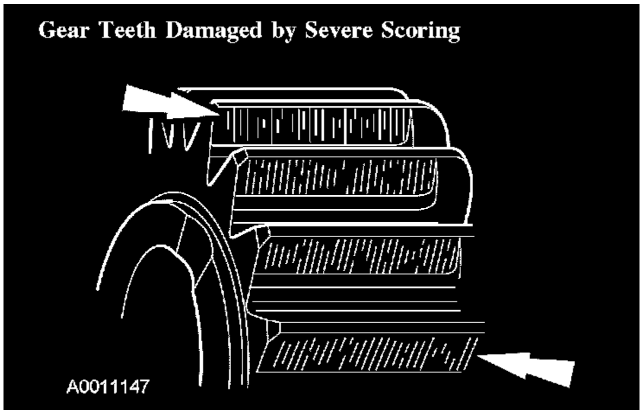
Gear Teeth Damaged by Light Scoring



Gear Teeth Damaged by Light Scoring

- The term describes rough, partially porous lines in the gear teeth, aligned in the direction of sliding. The damage initially occurs in areas subjected to high Hertzian stresses and high sliding speeds, (predominantly along the tooth root and tooth tip). This type of damage either covers a part of the entire flank surface, or is not strongly developed and causes only insignificant wear after smoothing.
- This type of damage is due to the combined effect of contact pressure and high relative contact speeds. Followed by a localized increase in temperature, the film or lubricant is torn away between the flanks, permitting direct metal-to-metal contact. This may lead to seizure (welding). Because of the relative movement, these welded zones are immediately torn apart again, producing the associated damage.

Gear Teeth Damaged by Severe Scoring

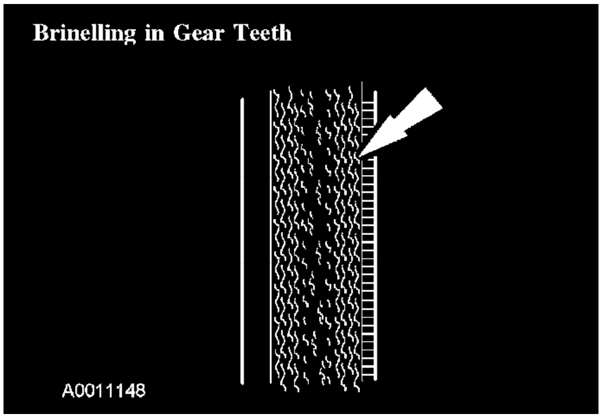


Gear Teeth Damaged by Severe Scoring

^ The term describes rough, partially porous lines in the gear teeth, aligned in the direction of sliding. The damage initially occurs in areas subjected to high Hertzian stresses and high sliding speeds, (predominantly along the tooth root and tooth tip). This type of damage affects large areas of the tooth flank. At an advanced stage, the flank may heat up to such an extent that localized discoloring occurs.

^ This type of damage is due to the combined effect of contact pressure and high relative contact speeds. Followed by a localized increase in temperature, the film of lubricant is torn away between the flanks, permitting direct metal-to-metal contact. This may lead to seizure (welding). Because of the relative movement, these welded zones are immediately torn apart again, producing the associated damage.

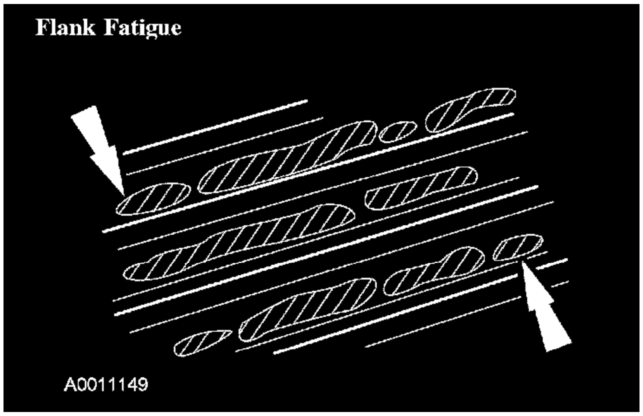
Brinelling in Gear Teeth



Brinelling in Gear Teeth

^ The term describes ripple-like alterations in the surface structure, which run perpendicular to the direction of sliding. These marks resemble a washboard with differences in height of 1 micron. Do not assess these marks as damage.

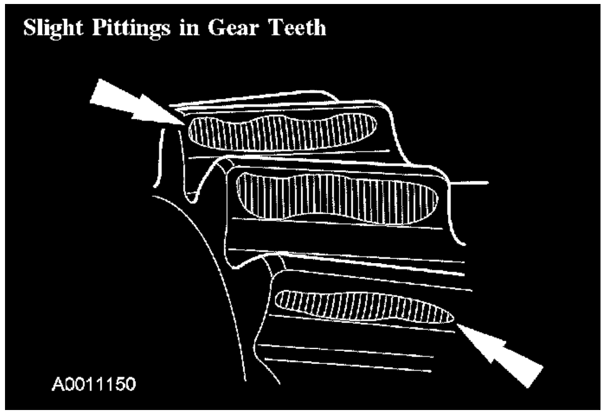
Flank Fatigue



Flank Fatigue

^ The term describes extremely fine, localized pittings in the load-bearing flanks, visible as gray spots, or as a matte gray staining when found in clusters. Material fatigue resulting from a combination of contact pressure, sliding movement, and composite friction leads to the formation of this kind of microscopic surface cracking. Pittings originating from these cracks may create the appearance of local flank wear.

Slight Pittings in Gear Teeth



Slight Pittings in Gear Teeth

^ The term describes individual, small, localized pittings that cover up to approximately 0.5% of the flank face, and pore-like areas of pitting that usually are only present in the root zone of the flank. High local contact pressures on gears, which have not yet been run-in, may lead to individual pittings. Running-in wear relieves these zones and the pitting may stop as a result. A change in operating conditions may also stop continued development of slight pittings in the same way.

Gear Teeth with Heavy Pitting Damage

Gear Teeth with Heavy Pitting Damage

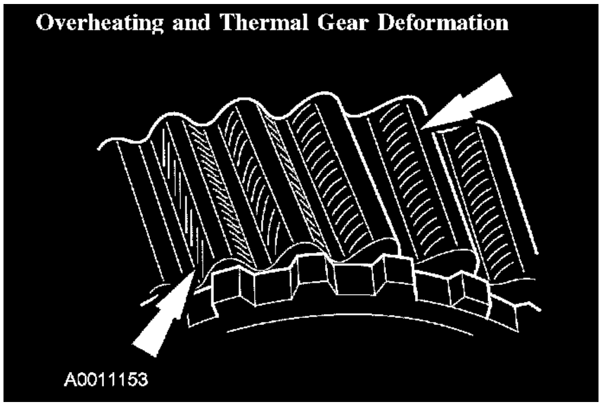
^ The term describes extensive flank pittings, which usually appear as pitting zones. The pit bases are usually shell-shaped. The total pitting surface may become so large that either smooth running is considerably impaired, or the remaining flank face, still bearing load, will soon be destroyed by wear. The pittings, attributed to material fatigue, result from a combination of contact pressure and sliding stress. The pittings occur if the local sliding and rolling stresses exceed material specification.

Gear Teeth Damaged by Spalling

Gear Teeth Damaged by Spalling

^ The term describes localized pittings on the flank caused by material fatigue, and extensive triangular pits on the flank, generating from a zone of gray spots or a fine line of pits at the root. The depth of the exposed surface is relatively constant throughout. Additional cracks may extend from the pits at an angle. In some cases, the damage may even progress into the tip zone, causing tip damage.

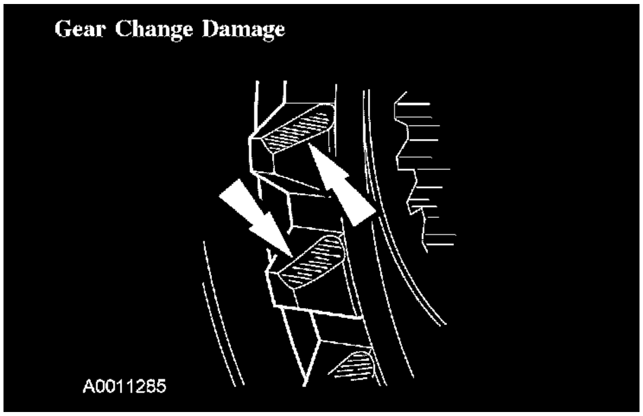
Overheating and Thermal Gear Deformation



Overheating and Thermal Gear Deformation

^ The term describes a gray to blue black discoloration of the gear. Overheating reduces the surface hardness, allowing scoring or grooving to the flank, in the direction of sliding, particularly in the tip and the root zones. If there is extreme overheating, the material softens, causing gear tooth distortion.

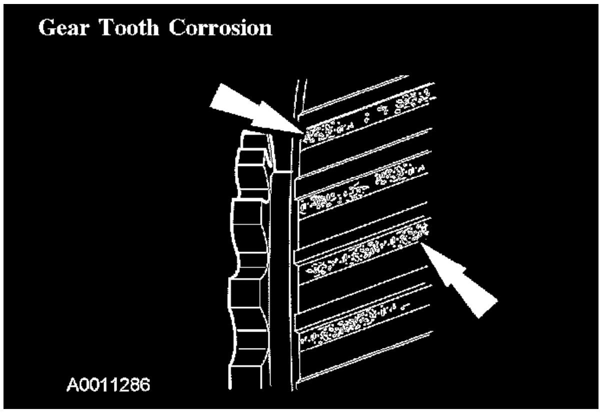
Gear Change Damage



Gear Change Damage

^ The term describes worn and chipped, and in some cases, ragged tooth edges. The spline flanks may also show signs of wear resembling fretting corrosion. Obstructed gear change operation occurs in cases of severe selector tooth edge deformation.

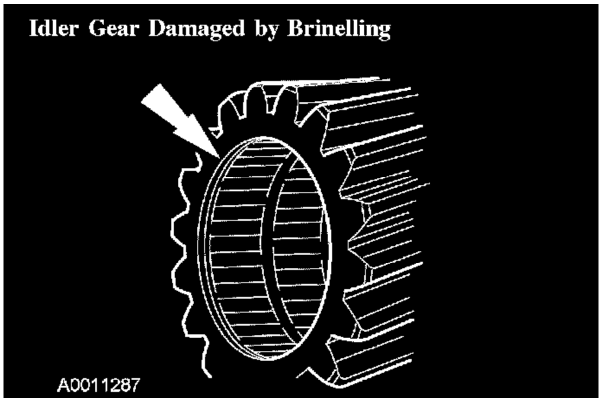
Gear Tooth Corrosion



Gear Tooth Corrosion

^ The term describes brownish red to black spots, sometimes in conjunction with local material loss on the flank.

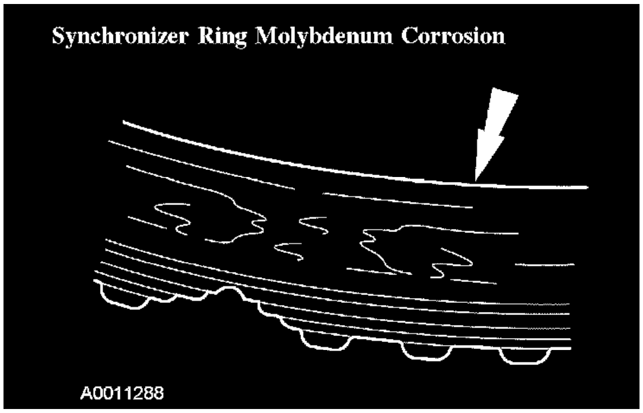
Idler Gear Damaged by Brinelling



Idler Gear Damaged by Brinelling

^ The term describes the appearance of bearing element impressions on the roller race. If the bearing only carries out a supporting function over a long period of time (there is no relative movement between the gear and the supporting shaft), the bearing contact areas may show signs of wearing away.

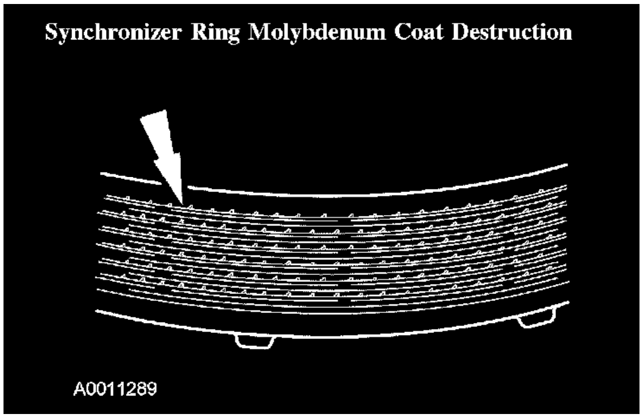
Synchronizer Ring Molybdenum Corrosion



Synchronizer Ring Molybdenum Corrosion

^ The term describes a blackened friction lining, even in the worn area. The corrosion results from contact with water. This chemical process causes substantial wear, which results in removal of the friction lining.

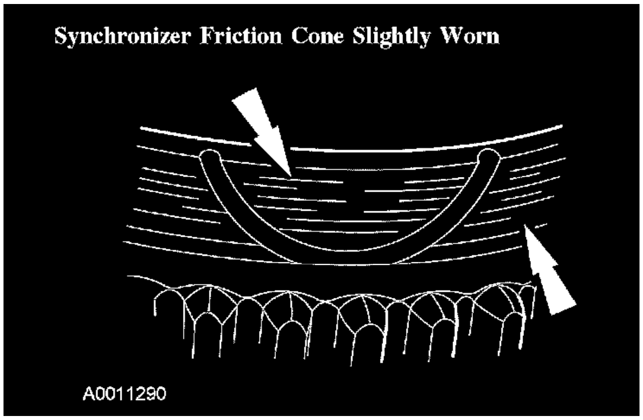
Synchronizer Ring Molybdenum Coat Destruction



Synchronizer Ring Molybdenum Coat Destruction

^ The term describes flaking of the molybdenum coat. The destruction begins from the outer threads. The disintegrated areas have a coarse, grainy structure. This condition also applies to synchronizer rings with axial grooves.

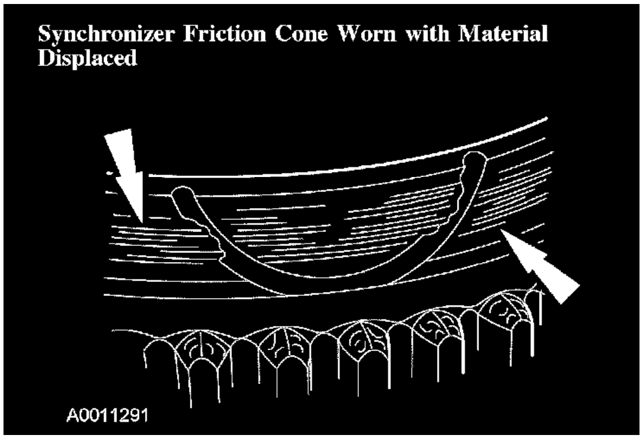
Synchronizer Friction Cone Slightly Worn



Synchronizer Friction Cone Slightly Worn

^ The term describes slight scoring in the friction cone. The scores are too light to feel and do not obstruct synchronizer unit (friction coefficient) function. Do not assess this type of wear as damage. If friction cone wear is only slight, but a severe, permanent grating condition exists, inspect the engage teeth for wear.

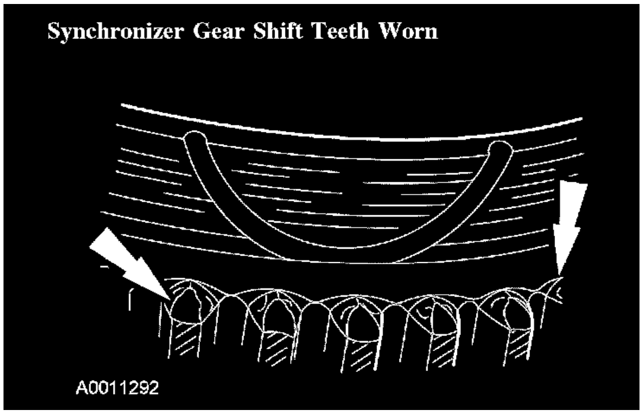
Synchronizer Friction Cone Worn with Material Displaced



Synchronizer Friction Cone Worn with Material Displaced

^ The term describes pronounced groove-shaped wear with material displacement around the friction cone circumference. The material displacement is clearly visible in the area of any oil grooves.

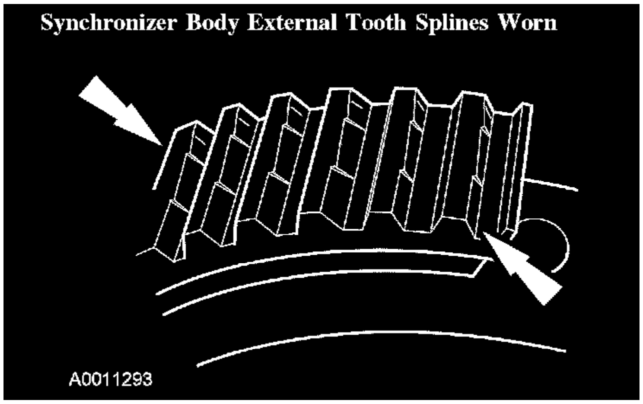
Synchronizer Gear Shift Teeth Worn



Synchronizer Gear Shift Teeth Worn

^ The term describes severe flaking or blunting of the gear shift teeth. This condition causes shift concerns.

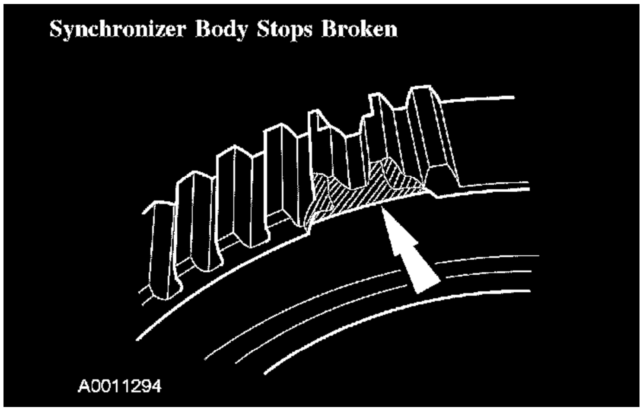
Synchronizer Body External Tooth Splines Worn



Synchronizer Body External Tooth Splines Worn

^ The term describes a stepped effect on the tooth flanks. This condition causes shift concerns.

Synchronizer Body Stops Broken



Synchronizer Body Stops Broken

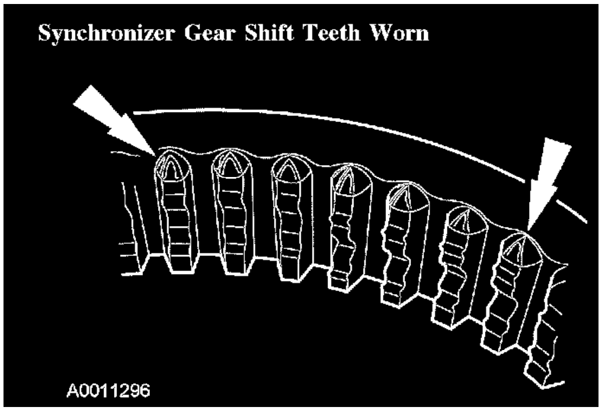
^ The broken and chipped synchronizer body stops are clearly visible.

Synchronizer Sliding Sleeve Stop Deformed

Synchronizer Sliding Sleeve Stop Deformed

^ The term describes a deformed/chipped-off detent stop on the sliding sleeve. This condition causes shift concerns.

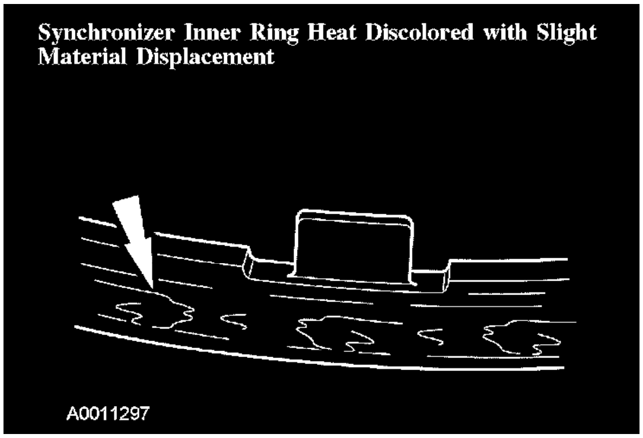
Synchronizer Gear Shift Teeth Worn



Synchronizer Gear Shift Teeth Worn

^ The term describes grated, chipped-off or blunted front edges of the gear shift teeth. This condition causes shift concerns.

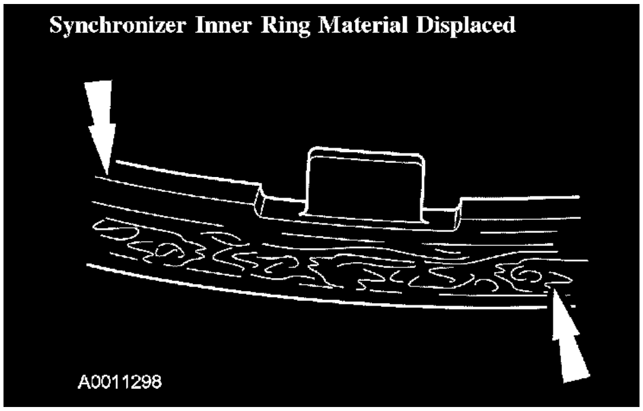
Synchronizer Inner Ring Heat Discolored with Slight Material Displacement



Synchronizer Inner Ring Heat Discolored with Slight Material Displacement

^ The term describes heat discoloration and slight material displacement that is visible on the taper of the inner ring. The intensity of the heat discoloration does not have a significant bearing on whether the component is reusable. Isolated heat discoloration occurs after just a few shifts with high shift effort and does not impair function. Only assess possible reuse of the inner ring in conjunction with the intermediate ring.

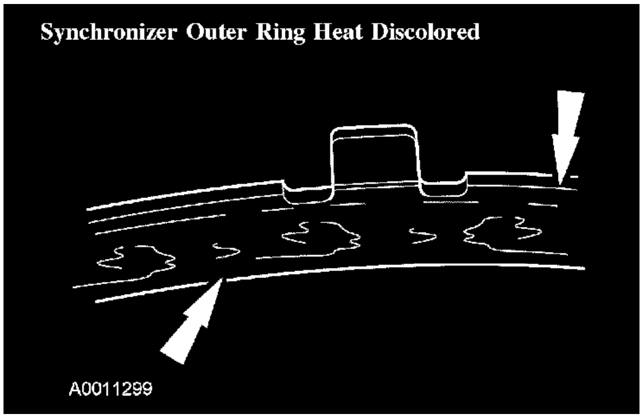
Synchronizer Inner Ring Material Displaced



Synchronizer Inner Ring Material Displaced

^ The term describes heat discoloration and slight material displacement that is visible on the cone of the inner ring.

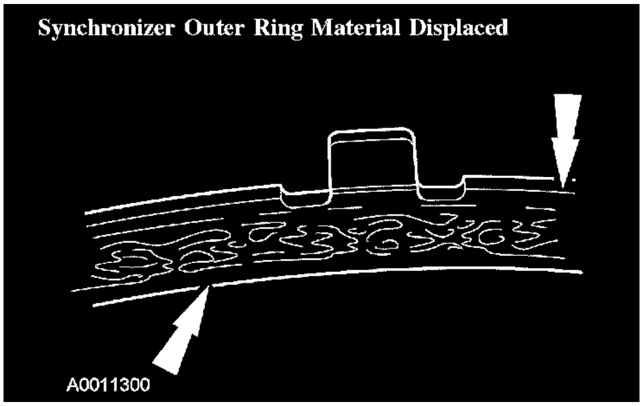
Synchronizer Outer Ring Heat Discolored



Synchronizer Outer Ring Heat Discolored

^ The term describes heat discoloration and slight material displacement that is visible on the cone of the outer ring. The intensity of the heat discoloration does not have a significant bearing on whether the component is reusable. Isolated heat discoloration occurs after just a few shifts with high shift effort and does not impair function.

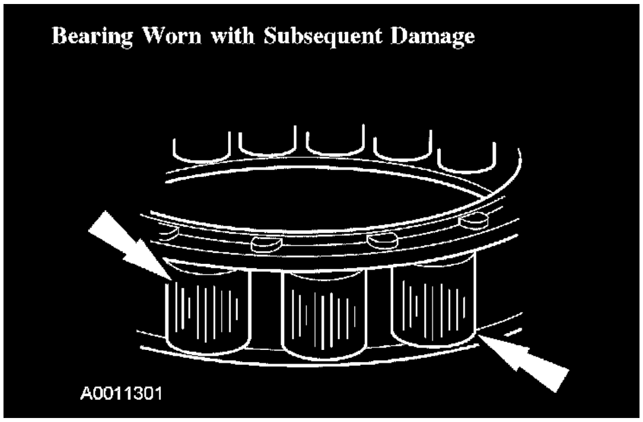
Synchronizer Outer Ring Material Displaced



Synchronizer Outer Ring Material Displaced

^ The term describes heat discoloration and material displacement that is visible on the cone of the outer ring.

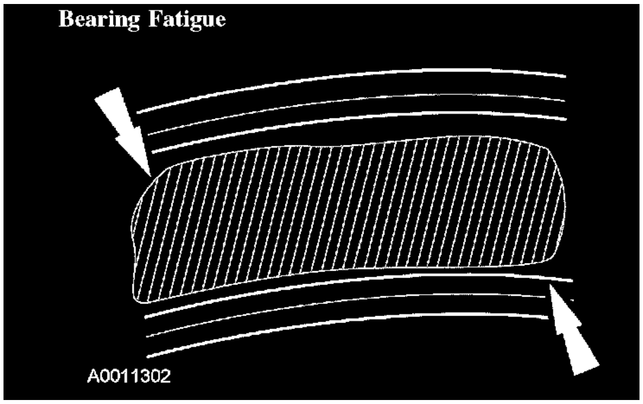
Bearing Worn with Subsequent Damage



Bearing Worn with Subsequent Damage

^ The term describes grinding burrs on the races and the bearing components undergoing plastic deformation and some clip-off. The metallic particles this process creates give rise to abrasive wear. Additional consequences include the development of scoring and scratches, through to micro-pitting. The wear process develops rapidly as the bearing play continues to increase. Finally, this leads to power rubbing or peeling of the surface layers and severe subsequent damage.

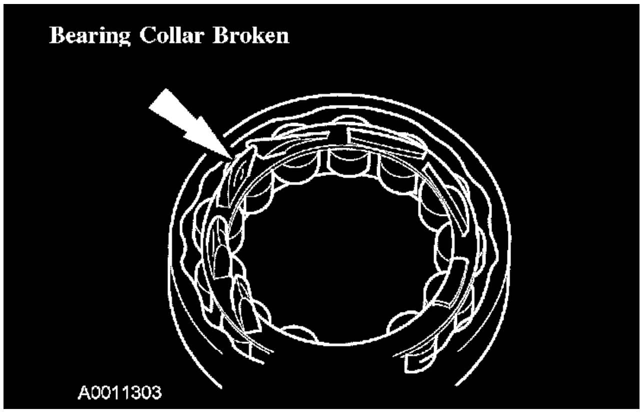
Bearing Fatigue



Bearing Fatigue

^ The term describes a matte gray appearance to the race surface.

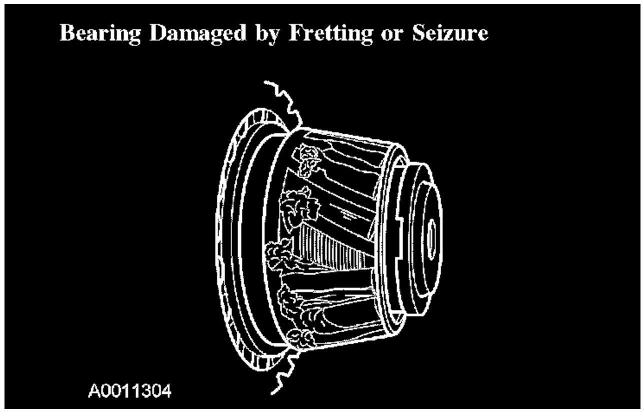
Bearing Collar Broken



Bearing Collar Broken

^ The broken bearing collar is clearly visible.

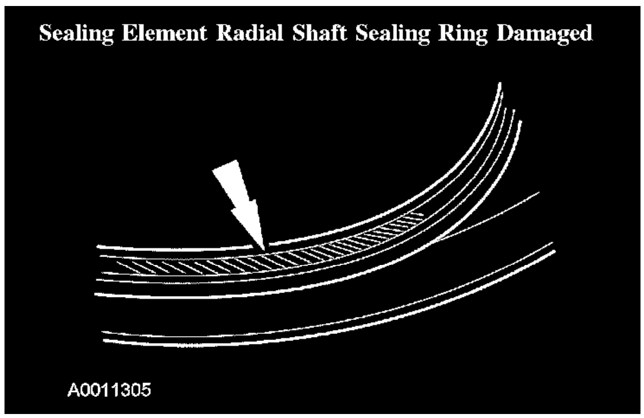
Bearing Damaged by Fretting or Seizure



Bearing Damaged by Fretting or Seizure

^ The term describes gnawing marks on the cylinder ends of the rollers or on the contact edges, and the possibility of blue discoloration. In the case of tapered roller bearings, this can lead to roller misalignment and seizure of the bearing.

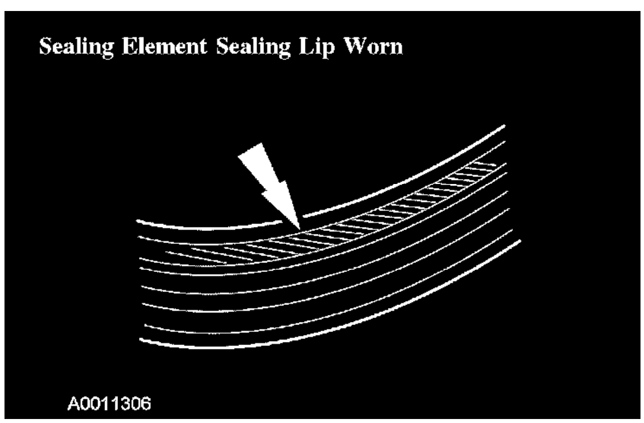
Sealing Element Radial Shaft Sealing Ring Damaged



Sealing Element Radial Shaft Sealing Ring Damaged

^ The term describes a sealing lip that has undergone plastic deformation. In some cases, it may have hardened and heat cracked and may contain carbonized oil deposits.

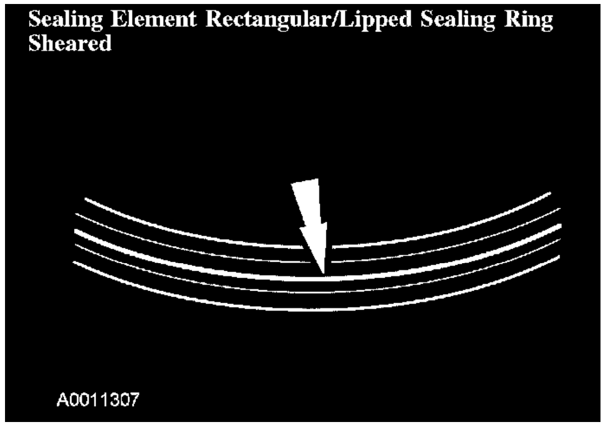
Sealing Element Sealing Lip Worn



Sealing Element Sealing Lip Worn

^ The term describes when the contact surface width of the sealing edge has worn evenly along the entire circumference. A normal, gradual degree of wear on a sealing edge is due to various friction conditions between the edge of the seal and the shaft race. Contact surface widths of **up to 0.5 mm (0.02 inch)** are acceptable in transmissions with high mileage.

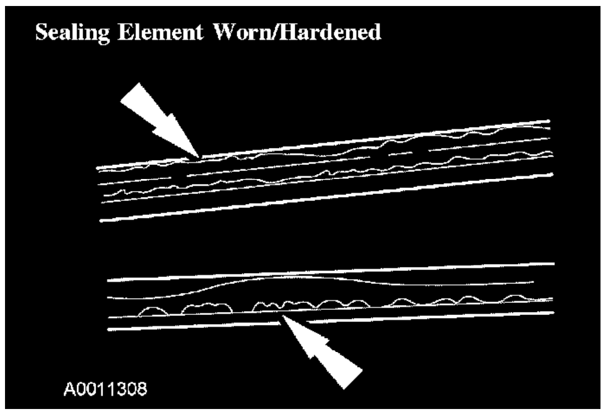
Sealing Element Rectangular/Lipped Sealing Ring Sheared



Sealing Element Rectangular/Lipped Sealing Ring

^ A slit is clearly visible in the sealing ring.

Sealing Element Worn/Hardened



Sealing Element Worn/Hardened

^ The term describes hardening and chipping of the sealing ring.