Figure 104-1 Types of brake drums. Regardless of the design, all types use cast iron as a friction surface.

Figure 104-2 The airflow through cooling vents helps brakes from overheating.
Scored drums and rotors often result in metal-to-metal contact.

Cracked drums or rotors must be replaced.

A heat-checked surface of a disc brake rotor.
TECH TIP: The Tap Test

Using a steel hammer, lightly tap a brake drum or rotor. It should ring if it is not cracked. If a dull thud is heard, the drum or rotor is likely cracked and should be replaced.

Figure 104-6 These dark hard spots are created by heat that actually changes the metallurgy of the cast-iron drum. Most experts recommend replacement of any brake drum that has these hard spots.

Figure 104-7 Bellmouth brake drum distortion.
Figure 104-8 Out-of-round brake drum distortion.

Figure 104-9 Eccentric brake drum distortion.

TECH TIP: Storing Drums and Rotors

A common cause of distortion in new brake drums and rotors is improper storage. Drums and rotors should always be stored lying flat; they should never be stood on edge. Distortion of new drums and rotors is common, so they should be routinely checked before installation.
TECH TIP: The Parking Brake Trick

Whenever attempting to diagnose a brake pedal pulsation, drive to a deserted area or parking lot and try stopping the vehicle using the parking brake. If a vibration occurs, the problem is due to a fault with the rear brakes. If a vibration does not occur except when using the service brakes, the problem is most likely due to a fault with the front brakes.

![Figure 104-10](image)

A straightedge can be used to check for brake drum warpage.

Figure 104-11

Discard diameter and maximum diameter are brake drum machining and wear limits.
**TECH TIP: Mark It to Be Sure**
Most experts recommend that brake rotors, as well as drums and wheels, be marked before removing them for service. Many disc brake rotors are directional and will function correctly only if replaced in the original location. A quick-and-easy method is to use correction fluid. This alcohol-based liquid comes in small bottles with a small brush inside, making it easy to mark rotors with an “L” for left and an “R” for right. Correction fluid (also called “white-out” or “liquid paper”) can also be used to make marks on wheel studs, wheels, and brake drums to help ensure reinstallation in the same location.

**Figure 104-12** Most brake drums have a chamfer around the edge. If the chamfer is no longer visible, the drum is usually worn (or machined) to its maximum allowable ID.

**TECH TIP**
Brake Drum Chamfer
Look at the chamfer on the outer edge of most brake drums. When the chamfer is no longer visible, the brake drum is usually at or past its maximum ID. **SEE FIGURE 104–12.** Although this chamfer is not an accurate gauge of the ID of the brake drum, it still is a helpful indicator to the technician.
Figure 104-13 Typical needle-dial brake drum micrometer. The left movable arm is set to the approximate drum diameter and the right arm to the more exact drum diameter. The dial indicator gauge reads in thousandths of an inch.

Figure 104-14 (a) A rotor or brake drum with a bearing hub should be installed on a brake lathe using the appropriate size collet that fits the bearing cups (races). (b) A hubless rotor or brake drum requires a spring and a tapered centering cone. A faceplate should be used on both sides of the rotor or drum to provide support. Always follow the operating instructions for the specified setup for the brake lathe being used.

Figure 104-15 A self-aligning spacer (SAS) should always be used between the drum or rotor and the spindle retaining nut to help ensure an even clamping force and to prevent the adapters and cone from getting into a bind. A silence band should always be installed to prevent turning-tool chatter and to ensure a smooth surface finish. (Courtesy of Ammco Tools, Inc.)
After installing a brake drum on the lathe, turn the cutting tool outward until the tool just touches the drum. This is called a scratch cut.

(Courtesy of Ammco Tools, Inc.)

After making a scratch cut, loosen the retaining nut, rotate the drum on the lathe, and make another scratch cut. If both cuts are in the same location, the drum is installed correctly on the lathe and drum machining can begin.

(Courtesy of Ammco Tools, Inc.)

Set the depth of the cut indicator to zero just as the turning tool touches the drum.

(Courtesy of Ammco Tools, Inc.)
Figure 104-19 This lathe has a dial that is “diameter graduated.” This means that a reading of 0.030 in. indicates a 0.015 in. cut that increases the inside diameter of the brake drum by 0.030 in.

Figure 104-20 Notice the chatter marks at the edge of the friction-surface of the brake drum. These marks were caused by imbalance of the drum because the technician failed to wrap the dampening strap (silencer band) over the friction-surface portion of the brake drum.

Figure 104-21 This excessively worn (thin) rotor was removed from the vehicle in this condition. It is amazing that the vehicle was able to stop with such a thin rotor.
Figure 104-22 Severely worn vented disc brake rotor. The braking surface has been entirely worn away due to brake fluid contamination. The owner brought the vehicle to a repair shop because of a "lotta noise" in the front. Notice the straight vane design.

Figure 104-23 Directional vane vented disc brake rotors. Note that the fins angle toward the rear of the vehicle. It is important that this type of rotor be reinstalled on the correct side of the vehicle.

Figure 104-24 Typical composite rotor that uses cast iron friction surfaces and a steel center section.
Figure 104-25  This Porsche is equipped with high-performance brakes including cross-drilled brake rotors.

FREQUENTLY ASKED QUESTION: What Does Cross-Drilled and Slotted Mean?

The expression cross-drilled and slotted refers to two separate processes. The first procedure involves drilling rows of holes through the friction surfaces of the rotor. The second procedure refers to milling a series of specially machined grooves from the center of the disc toward the edge. When the friction surfaces of a rotor are smooth and flat, there is no means of escape for the gases and dust, which build up between pad and rotor. This is not a huge problem in normal driving, but is an important consideration in street performance applications.

The drill holes (which are sometimes called gas relief openings) provide an exit route for the dust and gas. The holes are also commonly labeled cooling holes because of the improvements they make in this area. Better cooling means less fade during repeated heavy brake application. They also help dissipate water when driving in poor weather. - SEE FIGURE 104–25.

Slotting increases the bite of the pads and is even more effective than cross-drilling in combating the problem known as out-gassing. This is when, at very high braking temperatures, the bonding agents used in some brake pads produce a gas. Under extreme conditions, this gas can create a gas cushion between pad and rotor, giving a driver a normal pedal feel but reducing the amount of friction being generated. The slots pump away gas and restore full contact. The micro-shaving effect of the slots also serves to deglaze the pads and this is why the edges of the slots are not chamfered or radiused. It also tends to even out the wear across the brake pad faces, increasing the effective contact area.
Before measuring lateral runout with a dial indicator (gauge), remove any wheel bearing and play by tightening the spindle nut to 10 to 20 ft-lb with a torque wrench. This step helps prevent an inaccurate reading. If the vehicle is to be returned to service, be sure to loosen the spindle nut and retighten to specifications (usually, finger tight) to restore proper bearing clearance.

(a) Rotate the disc brake rotor one complete revolution while observing the dial indicator (gauge). (b) Most vehicle manufacturers specify a maximum runout of about 0.003 in. (0.08 mm).

Brake rotor lack-of-parallelism distortion.
Figure 104-30  (a) Disc brake rotor thickness variation (parallelism).  (b) The rotor should be measured with a micrometer at four or more equally spaced locations around the rotor.

TECH TIP: Braking Vibration Could Be Due to the Tires

A vibrating condition (roughness) during braking is usually caused by disc brake rotor thickness variation or an out-of-round brake drum. Both conditions should be investigated. However, the tires and/or road conditions can also cause this same vibration.

Tests performed by vehicle and tire-manufacturing engineers have shown that tires, and tires alone, could be the cause. If no other problem can be isolated, install a different brand of tire on the vehicle and retest. The cause of the tire vibration seems to be due to distortion or movement of the tire tread. A different brand of tire would have a different tread rubber compound, carcass body ply angles, or other factor that can contribute to a vibration during braking.

TECH TIP: Think of a Human Hair

Measurements and specifications do not seem to mean much unless you can visualize the size compared to something with which you are familiar. The diameter of a human hair is from 0.002 to 0.004 in. (2 to 4 thousandths of an inch).

The maximum lateral runout of a rotor is usually within this same dimension. The reason a dial indicator has to be used to measure runout, and a micrometer to measure parallelism, is that the dimensions involved are less than the diameter of a human hair. SEE FIGURE 104-31.
Figure 104-31 Sample micrometer readings. Each larger line on the barrel between the numbers represents 0.025. The number on the thimble is then added to the number showing and the number of lines times 0.025.

Figure 104-32 A digital readout rotor micrometer is an accurate tool to use when measuring a rotor. Both fractional inches and metric millimeters are generally available.

Figure 104-33 If a fingernail catches on a groove in the rotor, the rotor should be machined.
Figure 104-34 This rusted rotor should be machined.

Figure 104-35 Rotors that have deep rust pockets usually cannot be machined.

**TECH TIP: The Ballpoint Pen Test**

A smooth friction surface on a drum or rotor is necessary for proper brake operation. To quickly determine if the friction surface of a brake drum or rotor is not smooth enough, draw a ballpoint pen across the surface. If the surface is smooth enough, a solid ink line will be observed. If the line drawn by the pen is not solid, then the surface is not smooth enough.
Figure 104-36  Electronic surface finish machine. The reading shows about 140 µin. This is much too rough for use but is typical for a rough cut surface.

Figure 104-37  Most positive rake brake lathes can cut any depth in one pass, thereby saving time. A typical negative rake lathe uses a three-sided turning tool that can be flipped over, thereby giving six cutting edges.

Figure 104-38  Recommended adapters and location for machining hubbed and hubless rotors. (Courtesy of Ammco Tools, Inc.)
A damper is necessary to reduce cutting-tool vibrations that can cause a rough surface finish.
After installing the rotor on the brake lathe, turn the cutting tool just enough to make a scratch cut.

After making a scratch cut, loosen the retaining nut and rotate the rotor on the spindle of the lathe one-half turn. Tighten the nut and make a second scratch cut. The second scratch cut should be side-by-side with the first scratch if the rotor is installed correctly on the brake lathe.

**CHART 104–1** Metric/fractional chart.
Figure 104-43 (a) This technician uses two sanding blocks each equipped with 150-grit aluminum-oxide sandpaper.

(a)

Figure 104-43 (b) With the lathe turned on, the technician presses the two sanding blocks against the surface of the rotor after the rotor has been machined, to achieve a smooth microinch surface finish.

(b)
After machining and sanding the rotor, it should be cleaned. In this case brake cleaner from an air pressurized spray can is used.

With the lathe running, the technician stands back away from the rotor and sprays both sides of the rotor to clean it of the remaining grit from the sanding process. This step ensures a clean, smooth surface for the disc brake pads and a quality brake repair. Sanding each side of the rotor surface for one minute using a sanding block and 150-grit aluminum oxide sandpaper after a finish cut gives the rotor the proper smoothness and finish.

A grinder with sandpaper can be used to give a smooth, nondirectional surface finish to the disc brake rotor.
The correct final surface finish should be smooth and nondirectional.

Rust should always be cleaned from both the rotor and the hub when the
rotors are machined or replaced. An air-powered die grinder with a sanding disc makes quick work
of cleaning the hub.

A typical hub-mount on-the-vehicle lathe. This particular lathe oscillates while
machining the rotor, thereby providing a smooth and nondirectional finish at the same time.
TECH TIP: Turn or Machine?
When asked about what was done to their vehicle, a common response of customers is “They rotated my rotors.” Many customers do not understand the terms that are commonly used in the vehicle service industry. Try to use terms that are technically correct and avoid slang when talking to customers. For example, the expression machined the rotors indicates an operation, whereas the expression turned the rotors may be misinterpreted by some customers as simply meaning using your hands and moving (rotating) the rotor. Resurfacing, refinishing, and reconditioning are other terms that could be used to describe a drum or rotor machining operation.

Figure 104-49 A wheel stud was replaced on the rotor hub assembly when it was discovered to be stripped.

TECH TIP: Always Check the Wheel Studs
Before installing the wheel after brake service, check the condition of the wheel studs and lug nuts. Check for stripped threads, rust, or cracks. If necessary, replace the stud. Most studs are replaced by driving them out using a large hammer and then using washers and a lug nut to draw the serrated shoulder of the lug stud into the rotor stud hole. See Figure 104–49. Best to always use a torque wrench when installing lug nuts to ensure proper and even torque on all lug nuts. This helps to prevent rotor distortion, which can lead to vibration in the steering and/or pedal pulsation during braking.
Before starting to machine a brake drum, check the drum for any obvious damage such as heat cracks or hard spots.

Lightly tap the drum. It should ring like a bell. If a dull thud is heard, the drum may be cracked and should be discarded.

Use a drum micrometer to measure the inside diameter of the drum and compare this measurement to specifications to be sure that the drum can be safely machined.
Most brake drums have the maximum inside diameter cast into the drum as shown. Allow 0.030 inch for wear after the machining has been performed.

Thoroughly clean the outside and inside of the drum. Be sure the center hole in the drum is clean and free from any burrs that could prevent the drum from being properly centered on the shaft of the brake lathe.
DRUM MACHINING 7
A typical brake lathe used to machine drums.

DRUM MACHINING 8
Locate a tapered, centering cone that best fits inside the hole of the brake drum.

DRUM MACHINING 9
Slide the large face plate over the shaft of the brake lathe.
Slide the tapered centering cone onto the shaft with the spring between the face plate and the centering cone.

Slide the other face plate onto the shaft.

Install a bearing collet used as a spacer, then the self-aligning spacer (SAS), and left-hand-thread spindle nut.
DRUM MACHINING 13  
Tighten the spindle nut.

DRUM MACHINING 14  
Loosen the turning bar retainer.

DRUM MACHINING 15  
Carefully check the cutting bits and either rotate the bit to a new cutting point or replace it with a new part as necessary.
DRUM MACHINING 16

Turn the spindle control knob until the spindle is as short as possible (i.e., the drum as close to the machine as possible) to help reduce vibrations as much as possible.

DRUM MACHINING 17

Position the cutting bar so that the cutting bit is located at the back surface of the drum.

DRUM MACHINING 18

Install the silencer band (vibration dampener strap).
Be sure the tool bit and clothing are away from the drum and turn the brake lathe on.

Center the bit in the center of the brake surface of the drum and rotate the lathe until the bit shows light contact with the drum friction surface. This should produce a light scratch cut.

Turn the lathe off.
Observe the scratch cut.

Loosen the spindle nut.

Rotate the drum 180° (one-half turn) on the spindle.
DRUM MACHINING 25  Tighten the spindle nut.

Turn the lathe on, rotate the control knob, and run the cutter into the drum for another scratch cut.

Observe the scratch cut. If the second scratch cut is in the same place as the first scratch cut or extends all the way around the drum, the drum is correctly mounted on the lathe.
DRUM MACHINING 28
Adjust the depth gauge to zero when the cutter just touches the drum.

DRUM MACHINING 29
Run the cutter all the way to the back surface of the drum.

DRUM MACHINING 30
Adjust the depth of the cut and lock it in position by turning the lock knob. Most vehicle manufacturers recommend a rough cut depth should be 0.005–0.010 in. and a finish cut of 0.002 in.
Select a fast-feed rate if performing a rough cut (0.006–0.016 in. per revolution), or 0.002 in. per revolution for a finish cut.

Turn the lock knob to keep the feed adjustment from changing.

Engage the automatic feed.
The drum will automatically move as the tool remains stationary to make the cut.

Turn the lathe off.

If additional material must be removed, proceed with the finish cut. Clean thoroughly before installing on a vehicle.
Before machining any rotor, use a micrometer and measure the thickness of the rotor.

Check the specifications for the minimum allowable thickness.

Visually check the rotor for evidence of heat cracks or hard spots that would require replacement (rather than machining) of the rotor.
After removing the grease seal and bearings, remove the grease from the bearing races.

Clean and inspect the brake lathe spindle for damage or burrs that could affect its accuracy.

Select a tapered cone adapter that fits the inner bearing race.
Slide the cone adapter onto the brake lathe spindle.

Select the proper size cone adapter for the smaller outer wheel bearing race.

Place the rotor onto the large cone adapter and then slide the small cone adapter into the outer wheel bearing race.
Install the self-aligning spacer (SAS) and spindle nut.

Tighten the spindle nut (usually left-hand threads).

If a hubless rotor is being machined, be sure to thoroughly clean the inside surface.
Select the proper centering cone for the hole in the center of the hub.

Select the proper size cone-shaped hubless adapter and the tapered centering cone with a spring in between.
After sliding the rotor over the centering cone, install the matching hubless adapter.

Install the self-aligning spacer (SAS) and spindle nut.

After the rotor has been secured to the brake lathe spindle, install the noise silencer band (dampener).
ROTOR MACHINING 19
Carefully inspect the cutting bits and replace, if necessary.

ROTOR MACHINING 20
Loosen the tool holder arm.

ROTOR MACHINING 21
Adjust the twin cutter arm until the rotor is centered between the two cutting bits.
Turn the lathe on.

Move the cutter arm toward the center of the rotor, placing the cutting bits in about the center of the friction surface.

Turn one cutting bit into the surface of the rotor to make a scratch cut. This step checks the lathe setup for accuracy.
ROTOR MACHINING 25

Turn the lathe off.

ROTOR MACHINING 26

Observe the first scratch cut.

ROTOR MACHINING 27

Loosen the spindle retaining nut.
Rotate the rotor 180° (one-half turn) on the spindle of the brake lathe.

Tighten the spindle nut.

Turn the lathe back on and turn the cutting bit slightly into the rotor until a second scratch cut is made.
If the second scratch cut is in the same location as the first scratch cut or intersects all around the surface of the rotor, then the rotor is properly installed on the lathe.

Start the machining process by moving the twin cutters to about the center of the rotor friction surface.

Turn the cutting bits inward until they touch the rotor and zero the depth adjustment.
ROTOR MACHINING 34
Adjust the twin cutters, then dial in the amount of depth (0.005–0.010 in. per side for a rough cut or 0.002 in. for a finish cut) and lock the adjustment so that vibration will not change the setting.

ROTOR MACHINING 35
Turn the feed control knob until the desired feed rate is achieved for the first or rough cut (0.004–0.010 in. per revolution) or finish cut (0.002 in. per revolution).

ROTOR MACHINING 36
Engage the automatic feed.
Observe the machining operation.

After the cutting bits have cleared the edge of the rotor, turn the lathe off and measure the thickness of the rotor.

Readjust the feed control to a slow rate (0.002 in. per revolution or less) for the finish cut.
1. Reposition the cutting bits for the finish cut.
2. Loosen the adjustment locks.
3. Turn the depth of the cut for the finish cut (0.002 in. maximum).
Lock the adjustment.

Engage the automatic feed.

Use 150-grit aluminum-oxide sandpaper on a block of wood for 60
seconds per side or a grinder to give a nondirectional and smooth surface to both sides of the rotor.
After the sanding or grinding operation, thoroughly clean the machined surface of the rotor to remove any and all particles of grit that could affect the operation and life of the disc brake pads.

Remove the silencer band.

Loosen the spindle retaining nut and remove the rotor.
ON-THE-VEHICLE LATHE 1
Prepare to machine a disc brake rotor using an on-the-vehicle lathe by properly positioning the vehicle in the stall and raising the vehicle to a good working height.

ON-THE-VEHICLE LATHE 2
Mark the lug nut closest to the valve stem so that the wheel can be reinstalled in the same location. Remove the wheels and place them out of the way.

ON-THE-VEHICLE LATHE 3
Remove the disc brake caliper on caliper mount type lathes and use a wire to support the caliper out of the way of the rotor.
Measure the rotor thickness and compare it with factory specifications before machining. If a discard thickness is specified, be sure to allow an additional 0.015 in. for wear.

Install the hub adapter onto the hub and secure it using the wheel lug nuts. Never use an impact wrench to install the lug nuts.

Engage the drive unit by aligning the hole in the drive plate with the raised button on the adapter.
ON-THE-VEHICLE LATHE 7 Use the thumb wheel to tighten the drive unit to the adapter.

ON-THE-VEHICLE LATHE 8 Attach a dial indicator to a secure part on the vehicle and position the dial indicator on a flat portion of the lathe to measure the lathe runout.

ON-THE-VEHICLE LATHE 9 Rotate the wheel or turn the lathe motor on and measure the amount of runout. Newer models are self-adjusting.
Use a wrench to adjust the runout using the four numbers stamped on the edge of the drum flange as a guide.

After the hub runout is adjusted to 0.005 in. or less, remove the dial indicator from the vehicle.

Using a T-handle Allen wrench, adjust the cutter arms until they are centered on the disc brake rotor.
ON-THE-VEHICLE LATHE 13
Move the cutters to the center of the rotor.

ON-THE-VEHICLE LATHE 14
Adjust the cutter depth until each cutter barely touches the rotor.

ON-THE-VEHICLE LATHE 15
Position the cutters to the inside edge of the rotor surface and adjust the cutters to the desired depth of cut.
Adjust the automatic shut-off so the lathe will turn itself off at the end of the cut.

Turn the lathe on by depressing the start button.

Monitor the machining operations as the lathe automatically moves the cutters from the center toward the outside edge of the rotor.
After the lathe reaches the outside edge of the rotor, the drive motor should stop.

Measure the thickness of the rotor after machining to be certain that the rotor thickness is within service limits.

The technician is using 150-grit aluminum-oxide sandpaper and a wood block for 60 seconds on each side of the rotor to provide a smooth surface finish.
After completing the machining and resurfacing of the rotor, unclamp the drive unit from the hub adapter and clean the rotor.

After the drive unit has been removed, remove the lug nuts holding the adapter to the rotor hub.

After removing the hub adapter, the caliper with new brake pads and hardware can be reinstalled.
ON-THE-VEHICLE LATHE 25
Be sure to torque the caliper retaining bolts to factory specifications.

ON-THE-VEHICLE LATHE 26
Install the wheel and wheel cover. On this vehicle, the wheel cover must be installed before the lug nuts because the lug nuts hold the wheel cover on the wheel.

ON-THE-VEHICLE LATHE 27
Always use a torque wrench or a torque-limiting adapter with an air impact wrench as shown here when tightening lug nuts.
Be sure to clean the wheel covers of any grease or fingerprints before returning the vehicle to the customer.

Pump the brake pedal several times to restore proper brake pedal height. Check and add brake fluid as necessary before moving the vehicle.

Carefully back out of the stall and test-drive the vehicle to be assured of proper brake operation before returning the vehicle to the customer.