



**16572000**  
Edition 2  
May 2014

# Air Percussive Drill

JRD50 Jackhammer™

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## Maintenance Information



Save These Instructions

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## Product Safety Information

### WARNING

- Failure to observe the following warnings, and to avoid these potentially hazardous situations, could result in death or serious injury.
- Read and understand this and all other supplied manuals before installing, operating, repairing, maintaining, changing accessories on, or working near this product.
- Always wear eye protection when operating or performing maintenance on this tool. The grade of protection required should be assessed for each use and may include impact-resistant glasses with side shields, goggles, or a full face shield over those glasses.
- Always turn off the air supply, bleed the air pressure and disconnect the air supply hose when not in use, before installing, removing or adjusting any accessory on this tool, or before performing any maintenance on this tool or any accessory.

**Note:** When reading the instructions, refer to exploded diagrams in parts Information Manuals when applicable (see under Related Documentation for form numbers).

## Lubrication

Each time a Series JRD50 Jackhammer is disassembled for maintenance, repair or replacement of parts, inject approximately 3 cc of the appropriate **Ingersoll Rand** Rock Drill Oil into the air inlet of the tool before attaching the air hose.

## Disassembly

### General Instructions

1. Do not disassemble the tool any farther than necessary to replace or repair damaged parts.
2. Do not remove any part that is a press fit in or on a subassembly unless the removal of that part is necessary for repairs or replacement.
3. Do not disassemble the tool unless you have a complete set of new gaskets and O-rings for replacement.
4. Never attempt major maintenance of the tool on the job. Always send it to a repair shop.
5. Clean the exterior of the tool before disassembly.
6. Provide a clean work area for disassembling the tool.
7. Handle all parts carefully. Hardened parts can chip or break when dropped onto a hard surface.
8. Place small parts in a clean box to prevent loss.
9. Do not allow dirt or chips from a soft drift or hammer to enter the tool.
10. If the Backhead (1) or Fronthead (67) is frozen, use a rubber mallet to loosen it.

### Disassembly of the Tool

#### CAUTION

**In the following step, excessive clamping pressure may crack the cylinder housing.**

1. Firmly grasp the jackhammer horizontally in the vice jaws clamping on the cylinder below the side rods.
2. Using a wrench, unscrew and remove the Handle Bolt Nut (92). Remove the Handle Bolt Washer (93) and the Handle Grip (94) from the nut end of the Handle Bolt (91). Pull the remaining handle parts out of the opposite side of the Back Head (1).
3. Using a wrench, loosen the Air Connection Nut (12) and the Tube Gland (16).
4. Using a wrench, loosen and remove the two Side Rod Nuts (65).
5. Grasp the Back Head with both hands while applying pressure to the heads of both Side Rods (66) with your thumbs. Pull the assembled Back Head off the Cylinder (37) being careful not to disturb any internal cylinder parts.
6. Set the Back Head assembly on the work bench.
7. Insert the index finger of one hand into the Chuck (59) and apply pressure with the thumb to keep the Chuck and Front Head together. While supporting the underside of the Front Head with the free hand, pull the assembled Front Head off and set it on the work bench.
8. Pull the Rifle Bar (51) out half way, being careful not to release the Pawls (52) from their seats in the Ratchet Ring (55).
9. To prevent the Pawls from flying out, grasp the Pawls in a squeezing grip and pull the Rifle Bar assembly out.

10. The Ratchet Ring (55) and Valve Group (46-49) are removed by pushing the Piston (57) upward against them. A wooden dowel pushed against the end of the piston will aid in pushing the whole assembly out.
11. Remove the Piston (57) from the Cylinder (37).
12. If the Front Washer (44) is frozen and must be removed, invert the Piston and use a rubber mallet against the Piston to drive the Front washer from the Cylinder (37).
13. Remove the Blowing Connection (39) from the Cylinder (37).

### Disassembly of the Backhead

1. Slide the two Side Rods (66) out of the Back Head (1).
2. Grasp the Back Head in leather covered or copper covered vise jaws and remove the Blow Tube Gland (16), the Tube Gland Gasket (17) and the Blow Tube (20). If the rubber Tube Gasket (18) is nicked or damaged, replace it.
3. Using a wrench, remove the Air Connection Nut (12) and the Air Connection Nut Washer (13).
4. Remove the Air connection Elbow (11) and the Air Connection O-ring (14).
5. Using a wrench, unscrew and remove the Throttle Bolt Nut (9) and remove the Throttle Bolt Lock Washer (10).
6. Push the Throttle Valve Bolt (8) out of the Throttle Valve (4) and Throttle Valve Handle (5). Remove the Throttle Valve Handle.
7. To remove the Throttle Valve Plunger (6) and the Throttle Valve Spring (7), depress the Plunger with a screw driver and at the same time push the Throttle Valve (4) out of the Back Head (1). The Throttle Valve Spring (7) can then be removed from its seat inside the Back Head by snagging the coil end with the aid of a small flat head screw driver.

### Disassembly of the Fronthead

1. Grasp the Front Head (67) vertically in leather covered or copper covered vise jaws with the cylinder end facing upward.
2. Pull the Chuck Driver (58) along with the Sleeve Nut (61) and Chuck Bushing (59) out of the Cylinder end of the Front Head.

#### NOTICE

**In the following step, the Sleeve Nut has a left-hand thread. Rotate the wrench clockwise to remove the Nut.**

3. If the Sleeve Nut (61) must be removed, insert a cut-down piece of drill steel into the Chuck Bushing (59). Clamp down on the hex shank of the steel in the vise in order to keep it from rotating. Use the splined section of an old Piston to remove the Sleeve Nut - loosen by turning clockwise as the Sleeve Nut has a left hand thread.
4. If the Chuck Bushing (59) needs to be replaced press it out of the Chuck Driver (58).
5. Using a wrench, tighten the Steel Holder Nuts (75) down on the

Steel Holder Bolts (74) far enough to expose the Steel Holder Clips (76). Using a flat head screw driver and a hammer, remove the clips from the bolts.

6. Remove the Steel Holder Nuts (75) and the Steel Holder Springs (73) from the Steel Holder Bolts (74). Pull the Steel Holder Bolts away from the Front Head - clamping the Bolts and the Steel Holder Assembly in your grip.
7. Pull the Steel Holder Bolts off the ends of the Steel Holder Pin (72) and slide the Steel Holder (68) off the Steel Holder Pin.
8. To remove the Front Head Bushings (70) from the Front Head (67) use a 20mm steel drift pin and a hammer to drive the bushings out.
9. Remove the Front Head from the vise.

### Disassembly of the Valve Chest

1. Separate the Valve Chest (49) from the Valve Chest Cover (46). It may be necessary to use two screw drivers (180° apart) to carefully pry the Cover from the Chest.
2. Remove the Automatic Valve (48).
3. Be careful not to loose the Valve Dowel (50).

### Disassembly of the Cylinder

1. Clamp the Cylinder (37) horizontally in a vise exhaust side up.
2. Work the Exhaust Deflector (38) out of the opening in the Cylinder (37).
3. To remove the Front Washer (44) from the Cylinder, insert an old piston upside down so that it seats against the Front Washer and gently tap it out with a hand hammer.
4. If the Front Washer Bushing (43) needs to be replaced, press it out the Cylinder end of the Front Washer.

### Component Inspection

1. Wash all metal parts using a suitable, non-toxic, non-flammable cleaning solution in a well-ventilated area.
2. Examine and remove all dust and dirt particles from all porting and close fitting parts.
3. Valve Fit - Check the clearance between the Automatic Valve and the Valve Chest. Clearance between the outer radial edge of the Valve and the large central bore in the Valve Chest should be between 0.0019" and 0.0023" (0.05 and 0.06 mm). Performance will drop when clearances are between 0.0027" and 0.0031" (0.07 and 0.08mm). Make certain all valve parts are free of gall, dents and rust before reassembling the tool. Valve life should equal Cylinder life with proper maintenance.
4. Piston to Cylinder Fit - Wear is excessive when clearance between the head of the Piston and the Cylinder wall is greater than 0.0045" to 0.006" (0.1 to 0.15 mm). To determine which part is worn, install a new Piston in the Cylinder and check the clearance with a feeler gauge. Pistons will wear four times as quickly as the cylinder wall.
5. Front Washer Bushing to Piston Fit - Determine the amount of clearance between the shaft of the Piston at the central opening

of the Front Washer Bushing. Replace the Bushing when the clearance exceeds 0.006" (0.152 mm). Clearance in excess of the specified maximum reduces the front over travel cushion of the tool and will enable the Piston to violently impact the face of the Front Washer resulting in premature damage or breakage of the components. Check the clearance whenever a new Piston is installed.

6. Rotation Pawls - When the edges on one side of the Pawls become rounded about .039"R (1mm) they can be flipped and used again.
7. Pawl Springs - Replace the Springs when they become weak.
8. Rifle Nut to Rifle Bar Fit - Check the clearance between the splines on the Rifle Nut and the Rifle Bar - if either of these exceed .90" (2mm) when mated with a new part, they should be replaced (typically the wear ratio is (3) Nuts to (1) Bar). The Rifle Nut and Rotation Pawls are the most frequently replaced wear items. Wear can be reduced by using 85-90 psig (5.9 to 6.2 bars) air pressure at the tool as well as adhering to the throttling sequence.
9. Sleeve Nut to Piston Fit - Check the clearance between the splines on the Sleeve Nut and the Piston - if either of these exceeds .90" (2mm) when mated with a new part, they should be replaced (typically the wear ratio is (3) Sleeve Nuts to (1) Piston).
10. Heat Checking - Examine the Piston and Rifle Nut for heat checks resulting from improper lubrication. Replace any part showing signs of heat checking to prevent damage to other components. In addition, investigate, evaluate and implement a field lubrication policy that will prevent future heat checking problems. Since this tool does not have a built-in lubricator, the use of an external line lubricator is imperative for even minimal operation.
11. Piston Face Cupping - Examine the face of the Piston for cupping. Cupping is caused by improper operating procedures or improper steel shank geometry. Mild cupping can be corrected by carefully grinding, without burning, as little material as possible off the face of the Piston until it is flat and square. Do not grind more than 0.040" (1.02 mm) off the face of the Piston. Removing more material could remove the hard surface from the face of the Piston. If the striking end of the Piston is cupped, examine the shanks of the steels that were used with it to make certain the striking ends are flat and square.
12. Chuck - Replace the Chuck when the ends of the chuck bore are worn to the extent that the drill steel cocks in the drill assembly. When the Chuck is worn, the drill steel can no longer be held in alignment with the Piston. The loss of support for the shank allows the Piston to strike the steel shank on an angle which can damage the Piston, Tube and steel shank.
13. Throttle Valve - Remove any rust and gall from the ground surface of the Backhead. Use a fine emery cloth to remove any rust or gall from the Throttle Valve. If the tip of the Throttle Valve Plunger is worn or the Throttle Valve Spring is weak, replace them.

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## Assembly

### General Instructions

1. Wash all metal parts using a suitable, non-toxic, non-flammable cleaning solution in a well-ventilated area.
2. Wipe all metal parts with a thin film of Rock Drill Oil before installing them in the tool.
3. Apply a film of O-ring lubricant to all O-rings before final assembly.
4. Remove all dust and dirt particles from all internal components.
5. Examine all components for cracks, chips or wear and replace any worn or damaged part.
6. Make certain all internal moving parts are not binding or sticking. Pay particular attention to valve chest parts, throttle valve and throttle parts and the piston.

### Assembly of the Backhead

1. Insert the Throttle Valve Spring (7) followed by Throttle Valve

Plunger (6), peak end trailing, into the cross-hole in the throttle valve opening at the inlet end of the Backhead (1).

2. Using a small screwdriver or probe against the end of the Plunger, compress the Spring with the Plunger while inserting the Throttle Valve (4), spline end leading, into the Backhead. Maintain the pressure until the Valve is inserted far enough into the opening to engage the Plunger with the spline on the Valve.
3. Position the Throttle Valve Handle (5) on the end of the Throttle Valve and insert the Throttle Valve Bolt (8) through the Handle and Valve. Insert the Bolt so that the nut end is toward the handle side of the Backhead. Install the Throttle Bolt Lock Washer (10) and Throttle Bolt Nut (9) on the threaded end of the Bolt and tighten the Nut to secure the assembly.
4. Install the Air Connection Nut Washer (13) over the threads of the Air Connection Nut (12) and the Air Connection O-ring (14) in the internal groove of the Air Connection Nut.
5. Slide the assembled Air Connection Swivel (11), threaded end

## NOTICE

**The thread in the following step is a left-hand thread. Rotate the Nut counterclockwise to install it.**

- first, through the assembled Air Connection Nut.
- Using a wrench thread the complete Air Connection assembly (11, 12, 13, 14) into the Back Head.
- Install the Blow Tube Gasket (18) onto the shaft of the Blow Tube (20) and slide it up the length of the shaft until it seats against the flared head of the Blow Tube.
- Install the Tube Gland Gasket (17) over the threads of the Tube Gland (16) against the head of the Gland.
- Insert the headed end of the Blow Tube into the Tube Gland and then insert and thread the assembly into the top of the Backhead. Use a wrench to tighten the Gland in the Backhead.
- Insert the two Side Rods (66) through the corresponding holes in the Back Head
- Slide a Handle Bolt Washer (93) and one Handle Grip (94) onto the Handle Bolt (91). Insert the Bolt into the Back Head and install the remaining Handle Grip and Washer on the opposite side of the Back Head. Secure the Bolt and Handle in position by threading the Handle Bolt Nut (92) onto the Bolt and tightening it.

### Assembly of the Fronthead

- If the Chuck Bushing (59) was removed, stand the large end of the Chuck Driver (58) on the table of a hydraulic press and press the replacement Chuck Bushing into the Driver. The Chuck Bushing should be flush with the end of the Chuck driver when finished.

## NOTICE

**The thread in the following step is a left-hand thread. Rotate the Nut counterclockwise to install it.**

- Using the spline end of an old Piston (57), thread the Sleeve Nut (61) into the Chuck Driver (58). Hand tight is sufficient because operating the tool will naturally tighten the Nut.
- Clamp the Front Head (67) vertically in a vise with the cylinder end upward.
- If the Front Head Bushings (70) need to be replaced, tap the new ones in with a hand hammer (Make sure that the milled flat section of the Bushing matches that of the Front Head and the compression split is pointing towards the Front Head).
- Slide the Steel Retainer (68) over the Steel Retainer Pin (72). Cup the Steel Retainer Pin on each end with the mating ends of the Steel Retainer Bolts (74), grasp this whole assembly and insert the Steel Retainer bolts into the Front Head (67).
- Slide the Steel Retainer Springs (73) over the Bolts and thread the Retainer Bolt Nuts (75) on the Bolts. Thread the Nuts down far enough to expose the recessed groove for the Retainer Bolt Lock Clips (76).
- Line up the Retainer Bolt Lock Clip the groove in the Bolt. With the help of a small open end wrench cup the end of the Retainer Bolt Lock Clip and tap the wrench end with a hammer until the Clip seats into the groove.
- Loosen the Retainer Bolt Nuts (75) so that the Retainer Bolt Lock Clip seats into the corresponding counter-bore in the top of the Nut.
- Lubricate the assembled Chuck Driver and insert into the Front Head.

### Assembly of the Valve Chest

- Insert the Automatic Valve (48) into the Valve Chest (49) it should be able to move in and out of the Valve Chest freely.
- Mate the Valve Chest Cover (46) to the Valve Chest making sure that the Valve Dowel Pin slot in both parts lines up.

### Assembly of the Cylinder

- If the Front Washer Bushing (43) was removed, press a new Bushing into the hub end of the Front Washer (44) until it seats completely in the Front Washer.
- Align the Side Rod notches on the Front Washer with those on the Cylinder (37) making sure that the porting holes of the Front Washer line up with those on the Cylinder.

- Using the Rifle Bar (51), thread the Rifle Nut (56) into the Piston (57) in a counterclockwise motion. Hand tight is sufficient as operating the tool will naturally tighten the Nut.
- Insert the Piston (57), spline end first, into the Cylinder (37) until the spline can be grasped. Pull the Piston into the Cylinder assembly until the large diameter of the Piston seats on the Front Washer Bushing.
- Lay the Cylinder down horizontally on a work bench with the Valve Dowel slot at the top. Using the Valve Dowel Pin (50) as a guide, carefully slide the Valve assembly and Valve Dowel Pin into the Cylinder (a little bit of grease may be applied to the slot on the Valve assembly to keep the Valve Dowel in place).
- Using the Valve Dowel Pin as a guide, slide the Ratchet Ring (55) into the Cylinder. When properly seated the Ratchet Ring should stick out above the Cylinder about 3/8" (9.5mm).
- Assemble the Rifle Bar (51) by inserting the Pawl Spring (54) followed by the Pawl Plunger (53) into the corresponding hole on the Rifle Bar. With your finger, depress the plunger and Spring and slide the Rotation Pawl (52) in to it's mating key-way. The Plunger assembly should put enough tension on the Pawls to keep them in a sprung position.
- With your hand, grasp the Rifle Bar, squeezing the Pawls in against the Pawl Springs and insert the rifle bar spline end first into the Cylinder carefully nesting the Pawls into the Ratchet Ring.
- Reinsert the Blowing Connection (39) (short side in the Cylinder, long side up).

### Assembly of the Tool

- Lay the assembled Back Head (1) horizontally on a clean workbench and insert the side rods.
- Slide the assembled Cylinder over the Blow Tube (20) of the Back Head using the Side Rods to line the two sections up. The throttle valve, the exhaust port, and the Steel retainer must be on the same side.
- While holding the Front Head up, carefully turn the Piston in the assembled Front Head until it mates with the Rifle Bar. Slide the assembled Front Head on to the Cylinder using the Side Rods as a guide until this seats against the Front Washer.

## CAUTION

**The Side Rods must be tight and under equal tension. Loose or unequal Side Rod tension will cause misalignment of internal parts and will promote breakdown of the tool. Alternately tighten the Side Rod Nuts a little at a time until they are between 30 and 35 ft-lb. (40.7 and 47.5 Nm) torque.**

- Thread the Side Rod Nuts (65) on the Side Rods (66) until hand tight. With a wrench, tighten the Nuts alternately and evenly to an equal torque (30-35 ft-lb.) to avoid one sided over-tightening.

### Performance Testing

A reconditioned Jackhammer must be tested before it is sent back to the job. Before connecting the air hose, make certain the air line lubricator is filled with the proper grade of Ingersoll-Rand Rock Drill Oil. Pour a small amount of Rock Drill Oil directly into the air inlet of the tool for initial lubrication. Start the Jackhammer with little air pressure and the piston reciprocating smoothly. Let the Jackhammer run-in slowly at reduced pressure long enough to determine that it is in good working order. If the Jackhammer stalls, immediately turn off the air supply. Stalling indicates binding due to tight fits or unevenly tightened Side Rods. Check the rod tension first. Slowly start the Jackhammer again. If erratic operation or stalling persists, disassemble the Jackhammer and check for binding parts. After a short period of operation, a definite rhythm should develop and an even exhaust note will be heard. The Jackhammer may become warm, but should

not overheat. After the initial period of low-pressure operation, check the performance of the reconditioned Jackhammer with that of a new jackhammer by comparing its speed under similar conditions and with

normal air pressure. Once testing is completed, install plastic plugs or caps in all ports to keep out dirt until the tool is back in service.

## Troubleshooting Guide

Trouble	Probable Cause	Solution
Jackhammer will not start	Plugged exhaust port or air passages caused by dirt or hose particles.	Dismantle Jackhammer, clean out all ports and air passages. Keep the air hose in good condition; never use a soft deteriorated hose.
	Stuck valve due to gummy oil or incorrect assembly.	Remove Backhead completely. Dismantle Valve and clean parts. Never use dirty oil or oil that does not conform to the recommended specifications.
	Frozen piston due to improper lubrication.	Dismantle Jackhammer to remove piston. Repair piston by placing in a high speed lathe and dressing with fine emery cloth. Never run Jackhammer without the proper lubricating oil in the air line lubricator.
	Side Rods tightened unevenly, causing binding.	Check Jackhammer for correct assembly and retighten Side Rods evenly. Torque Side Rod Nuts between 30 and 35 ft-lb. (40.7 and 47.5 Nm) torque.
Jackhammer loses power rapidly	Restriction in air supply line.	Never allow the air supply to kink or make sharp bends.
	Air supply line too long.	As a general rule, keep the air supply line under 50 ft. (15 m).
	Diameter of air supply line too small.	A 3/4 in. (19 mm) diameter air supply is recommended for the Jackhammer.
Freezing at exhaust ports	Excessive moisture in the air supply line	Install moisture traps in the air supply line or add antifreeze lubricant directly through the air inlet. Use "KILFROST"™ anti-freeze lubricant or equivalent.
Jackhammer lacks power	Low air supply pressure.	The air supply pressure at the inlet should be 90 to 100 psi (6.2 to 6.9 bar).
	Running on fronthead cushion.	Keep shank fed-up to the work. Always maintain a constant pressure when operating the Jackhammer.
	Plugged air passages.	Dismantle the Jackhammer and clean out all ports and passages.
	Lack of lubricating oil.	Maintain the proper oil level in the air line lubricator. Steel shank must show a film of oil.
	Short Drill Steel shank due to wear or regrinding.	Replace Drill Steel if shank is worn excessively.
	Worn components.	Check and replace parts that show wear.
Jackhammer will not start	Plugged exhaust port or air passages caused by dirt or hose particles.	Dismantle Jackhammer, clean out all ports and air passages. Keep the air hose in good condition; never use a soft deteriorated hose.
Fogging	Excessive moisture in the air supply line.	Blow out air lines. If moisture traps are installed in the air supply line, drain the moisture.
Overheating of Jackhammer	Over lubrication.	Adjust the air line lubricator for proper rate of feed.
	Running on fronthead cushion.	Keep shank or hammer block fed-up to work. Always maintain constant pressure when operating the Jackhammer.
	Lack of lubrication or improper lubricating oil.	Before operating the Jackhammer make sure the air line lubricator is full of proper lubricant.
	Piston not hitting the shank because of short shank.	Remove the Drill Steel with the short shank from the Jackhammer and install a new Drill Steel.
	Pulling Drill Steel at full throttle.	When pulling Drill Steels, always use minimum throttle.

<b>Trouble</b>	<b>Probable Cause</b>	<b>Solution</b>
Erratic or sluggish operation	Lubricating oil too heavy.	Use only the recommended lubricating oil.
	Gummed oil or dirt in operating parts.	Dismantle Jackhammer and clean out dirt and gummy residue. Service the Jackhammer with clean oil. Protect the Jackhammer from dirt when idle.
Stuck Drill Steel	Driving Drill Steel after bit is dull or has lost its gauge.	Sharpen or replace with a new bit.
	Crowding bit in soft formation.	Use down pressure cautiously in soft formations; be certain the Drill Steel is rotating freely.
	Cuttings not being blown from hole.	Use blow air frequently.
	Misalignment of Drill Steel with hole causing binding.	Keep Jackhammer, Drill Steel and hole in alignment at all times.
Slow drilling speed	Dull bit.	Replace the bit.
	Cuttings not being removed from hole.	Use blow air more frequently to keep the bit working on fresh rock.
	Plugged Drill Steel or Blow Tube.	Remove Tube and Drill Steel; clean out air passages.
	Jackhammer and Drill Steel not aligned in hole; Drill Steel or bit binding in hole.	Check alignment while drilling to prevent binding and to avoid a stuck Drill Steel.
	Insufficient down pressure.	Increase down pressure.
No Drill Steel rotation or rotation is weak	Steel binding in hole.	Apply correct amount of down pressure and keep Drill Steel and hole in alignment. Replace worn bits.
	Worn rotation parts.	Disassemble Jackhammer and replace worn parts.
Side Rod breakage	Uneven tension on Rods or loose Rods.	Keep Side Rods tight and at even tension. Tighten Rods alternately.
	Loss of fronthead cushion which allows Piston to strike Front Washer Bushing with hard impact.	Replace worn Cylinder, Piston or Front Washer Bushing.
Chipping or breakage of Piston	Bad Drill Steel shank which is too hard or rounded on end allowing minimum contact with Piston striking face.	Take bad shanks out of service. One bad shank can ruin many Pistons.
	Worn Chuck which permits Drill Steel to cock in Chuck so that Piston strikes shank a glancing blow.	Replace worn Chuck.
	Heat cracking due to faulty lubrication.	Keep Jackhammer well lubricated with proper type of oil.
	Failure in neck of Piston due to loss of fronthead cushion. Piston striking Front Washer Bushing.	Check Cylinder, Piston and Front Washer Bushing for maximum wear tolerances.

## Related Documentation

For additional information refer to:

Air Percussive Drill Product Safety Information Manual Form 04584975,

Air Percussive Drill Product Information Manual Form 04581591,

Air Percussive Drill Parts List Manual Form 16572018.

Manuals can be downloaded from [ingersollrandproducts.com](http://ingersollrandproducts.com)

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**Notes:**

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