ATI Single-Axis, Radially-Compliant Robotic Deburring Tools Flexdeburr™

(Model 9150-RS-340)

Product Manual

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Engineered Products for Robotic Productivity
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Foreword

CAUTION: This manual describes the function, application, and safety considerations of this product. This manual must be read and understood before any attempt is made to install or operate the product, otherwise damage to the product or unsafe conditions may occur.

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Glossary

Term	Definition
Adapter Plate	Device for attaching the deburring tool to either a robot flange or a stationary mounting surface.
Air Filter	Device for removing contamination from the air supply lines. Typically refers to removal of the particulates.
Air Turbine	Air motor that drives the spindle.
Bur	Cutting tool used to remove the burrs from the work piece. Alternatively referred to as a rotary file, cutter, or bit.
Burr	Any unwanted, raised protrusion on the work piece.
Climb Milling	Cutting method where the direction of the cutter rotation and tool motion are the same.
Chattering	Machine vibrations. The cutting tool bounces as it contacts the work surface.
Coalescing Filter	Device designed to remove the liquid aerosols from the supply air lines.
Collet	Gripping device used to hold cutting tools in the spindle.
Compliance	The ability of the spindle to passively move in the response to protrusions on the or deviations of the work piece.
Conventional Milling	Method of cutting where the direction of the tool motion is opposite that of the tool rotation.
End-Effector	Tool used by the robot to perform a particular function
Flexdeburr	Product family name for ATI's line of radially compliant deburring tools.
Main Housing	The main cylindrical body of the unit which includes the mounting features.
Positive Stop	The tool has contacted a physical limitation and can no longer move.
Qty	Quantity.
Regulator	Device used to set and control the supplied air pressure to lower acceptable levels.
Rear Housing	Rear cover to the main housing. The body includes a connection port for compliance and motor air.
RS	Single-axis radially-compliant.
Solenoid Valve	Electrically controlled device for switching air supplies on and off.
Spindle	The rotating portion of the deburring tool assembly.
Turbine	Air motor that drives the spindle.

1. Safety

The safety section describes general safety guidelines to be followed with this product, explanations of the notifications found in this manual, and safety precautions that apply to the product. More specific notifications are imbedded within the sections of the manual where they apply.

1.1 Explanation of Notifications

The following notifications are specific to the product(s) covered by this manual. It is expected that the user heed all notifications from the robot manufacturer and/or the manufacturers of other components used in the installation.

DANGER: Notification of information or instructions that if not followed will result in death or serious injury. The notification provides information about the nature of the hazardous situation, the consequences of not avoiding the hazard, and the method for avoiding the situation.

WARNING: Notification of information or instructions that if not followed could result in death or serious injury. The notification provides information about the nature of the hazardous situation, the consequences of not avoiding the hazard, and the method for avoiding the situation.

CAUTION: Notification of information or instructions that if not followed could result in moderate injury or will cause damage to equipment. The notification provides information about the nature of the hazardous situation, the consequences of not avoiding the hazard, and the method for avoiding the situation.

NOTICE: Notification of specific information or instructions about maintaining, operating, installing, or setting up the product that if not followed could result in damage to equipment. The notification can emphasize, but is not limited to: specific grease types, best operating practices, and maintenance tips.

1.2 General Safety Guidelines

Prior to purchase, installation, and operation of the Flexdeburr product, the customer should first read and understand the operating procedures and information described in this manual. Never use the deburring tool for any purposes, or in any ways, not explicitly described in this manual. Follow installation instructions and pneumatic connections as described in this manual.

All pneumatic fittings and tubing must be capable of withstanding the repetitive motions of the application without failing. The routing of the pneumatic lines must minimize the possibility of stress/strain, kinking, rupture, etc. Failure of the critical pneumatic lines to function properly may result in the equipment damage.

1.3 Safety Precautions

CAUTION: Do not use spare parts other than original ATI spare parts. Use of spare parts not supplied by ATI can damage equipment and void the warranty. Always use original ATI spare parts.

CAUTION: Do not perform maintenance or repair on the Flexdeburr product unless the tool is safely supported or placed in the tool stand and air has been turned off. Injury or equipment damage can occur with tool not placed in a tool stand and air remaining on. Place the tool safely in the tool stand and turn off the air before performing maintenance or repair on the Flexdeburr product.

NOTICE: Turbine motors are not serviceable at this time. Refer to *Section 10—Terms and Conditions of Sale*. To maximize the life of turbine motor products the customer should follow closely the normal operation procedures outlined in the product manual. The air must be totally lube free and filtered to remove particulates and moisture. Exposing the turbine motors to oil in the air supply results in premature failure.

2. Product Overview

The single-axis radially-compliant (RS) Deburring tool, also known as Flexdeburr, is robust, high-speed and lightweight air turbine-driven deburring units for deburring aluminum, plastic, steel, etc. with a robot or CNC machine. The RS deburring tool is especially suited for removal of parting lines and flash from the parts. However, its flexible design allows it to be used in a wide variety of applications.

The RS deburring tool's pneumatically controlled, articulated design allows the cutting bit to follow the part profile and compensate for surface irregularities while maintaining a constant, settable force. This allows high feed rates with uniform quality in any orientation. The tool requires no oil, allowing clean exhaust air to be vented directly into the work environment.

Compliance is supported by air pressure applied to the shaft of the unit and is used to perform consistent deburring on irregular part patterns. The motors internal governor maintains high spindle speeds for optimum surface finish. The RS deburring tool also utilizes standard industrial tungsten-carbide bits which allows for adaptation to changing assembly lines and part requirements.

The RS-340 provides for (2) mounting types, a side mounting and an axial mounting. The side mounting provides (2) locating dowel pins and (4) threaded holes. The axial mounting utilizes a tapered flange that requires an adapter plate. Custom adapter plates for both side and axial mounting are available from ATI. Refer to *Section 9—Drawings* for more information.

The RS-340 is equipped with a 1/2" (12 mm on the Euro models) push-to connect fitting to supply the motor air and a 5/32" (4 mm) Push-to Connect fitting to supply the compliance air.

A tool collet system secures the bur tool. Many collet sizes and a various selection of tools are available to accommodate a wide variety of applications.

Figure 2.1—RS-340 Deburring Tool

2.1 Tool Collet Systems

All Flexdeburr products utilize removable collets to grip customer supplied cutting tools. Different collet diameters may be substituted to retain numerous cutter shank diameters. The collet retaining nut is loosened to open the collet allowing cutting tools to be removed and inserted. Once the tool is set to the desired depth, spanner wrenches are used to tighten the collet nut causing the collet to collapse and secure the cutting tool. The turbine motor design does not allow the installation of the quick-change or drawbar collet systems.

The standard tool holding system for Flexdeburr products is an economical, proprietary, single-angle collet design utilizing (3) gripping fingers. This is suitable for most applications where industry standard shank diameter cutting tools are used and runout tolerances of up to 0.001” (0.025 mm) are acceptable. Special sizes are available upon request but require custom machining.

2.2 Technical Description

A technical overview of the product is provided in the following tables and graphs. For additional technical specifications, refer to *Section 8—Specifications*.

2.2.1 Environmental Limitations

2.2.1.1 Operation

Table 2.1—Operation

Installation position	Mounted to robot by means of the side mounting pattern or rear adapter flange. Refer to *Section 3.5—Side Mounting Installation* and *Section 3.6—Axial Mounting Installation*. The flange is specific to each type of robot. This optional flange is normally supplied by ATI in a blank form suitable for customer modification. Refer to *Section 9.1—RS-340 Geometry and Mounting*.
	Mounted to a table or stand by means of the bench adapter (the robot is carrying the work piece).
Temperature range	5° C–35° C 41° F–95° F
Utilities	The tool requires the following: • Clean, dry, filtered, non-lubricated air. • A coalescing filter and filter elements rated 5 micron or better. • The motor spindle must be supplied air at 6.2 bar (90 psi). • The radial compliance (centering) air must be supplied from a regulated source between 1.0–4.1 bar (15–60 psi).

2.2.1.2 Storage

Table 2.2—Storage	
Temperature range	0° C–45° C 32° F–113° F
Conditions	The tool should be stored in its crate and in a dry place. When not in use, keep the unit in its crate If possible. Consult *Section 3.7—Storage and Preventive Maintenance during Storage* of this manual.

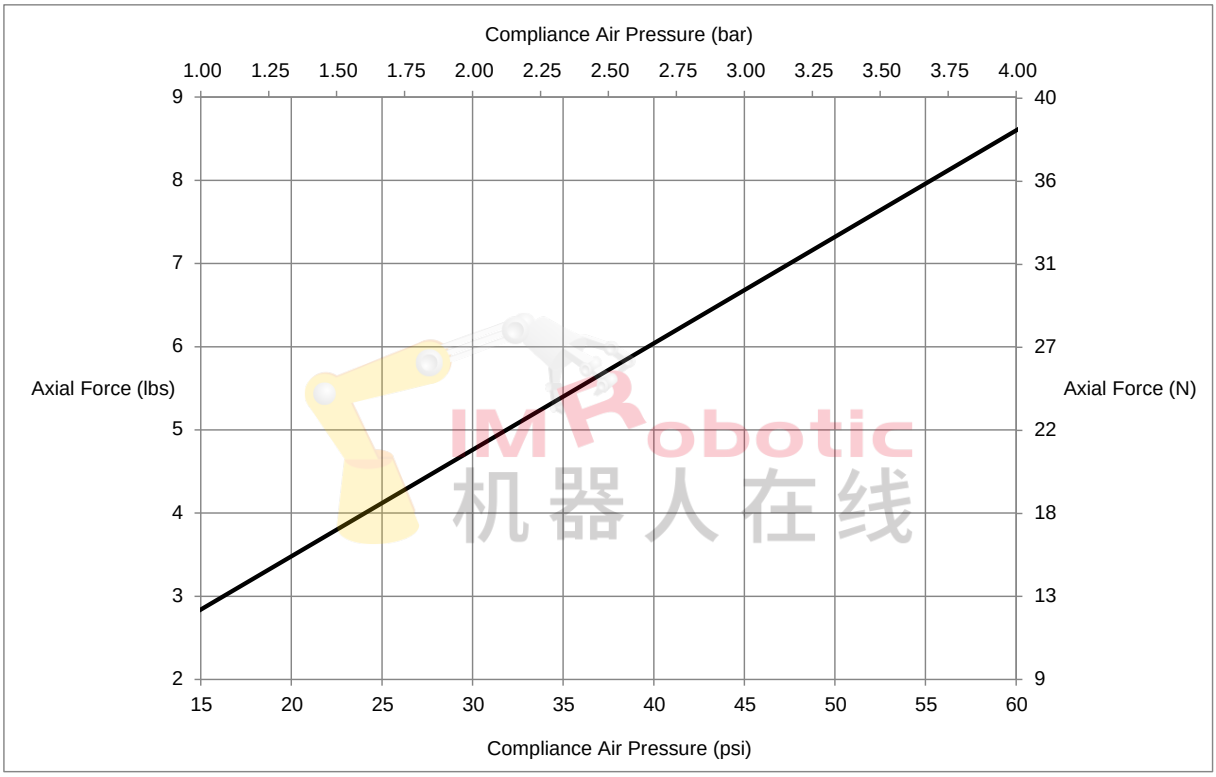
2.2.2 Compliance Unit Performance

The variation of the compliance force with applied air pressure are illustrated in the following graph. Measurements may vary from one product to another, and should only be treated as nominal.

The actual force characteristics are dependent on mounting orientation and the condition of the unit. In applications, where the deburring tool is mounted horizontally, additional compliance air pressure is required to overcome the weight of the motor. Compliance pressure is also dependent upon the material of the work piece, type of bur tool, and the amount of material that is removed.

The turbine motor attempts to maintain its full rated speed even under loaded conditions. However, when extremely heavy cuts are taken, the motor may eventually stall. Therefore, multiple, light passes are preferred over slow, heavy cuts.

Figure 2.2—RS-340 Compliance Force Curves (Measured at the Spindle Collet)



3. Installation

The RS-340 Deburring Tool is delivered fully assembled. Optional equipment such as mounting adapter plates, burr tools, additional collets will be separate.

3.1 Transportation and Protection during Transportation

The RS deburring tool arrives in packaging to secure and protect it during transportation. Always use this packaging when transporting the deburring tool in order to minimize the risk of damage.

3.2 Inspection of Condition When Delivered

Upon receipt, the following should be checked:

- Delivery is in accordance with freight documents.
- Packaging is in good condition.

If there is damage to any of the packaging, or if any of the goods have been exposed to abnormal handling, unpack those parts that may have been damaged for a closer inspection. If necessary, notify ATI for assistance in evaluation of the product condition.

3.3 Unpacking and Handling

The deburring tool should always be placed inside the accompanying packaging during transportation, storing and handling.

Pneumatic lines and electrical cables are attached, bundled, and must be strain-relieved in a manner that allows for freedom of movement during operation.

3.4 Storage and Preventive Maintenance during Storage

The deburring tool should be stored in its packaging when it is not in use. The deburring tool should also be stored in a dry place.

For long-term storage, the deburring tool should be thoroughly cleaned of any burrs or debris. It should not be disassembled. Place the deburring tool inside a sealed, plastic bag inside its packaging.

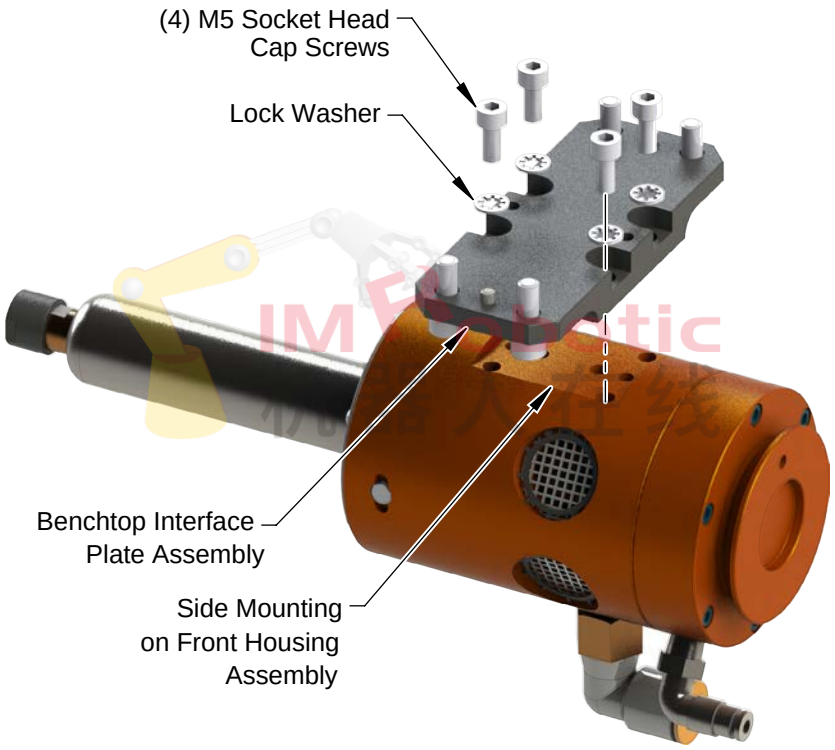
3.5 Side Mounting Installation

CAUTION: The length of the fasteners should not interfer with the compliant motion of the turbine motor spindle. Refer to *Section 9—Drawings* for the maximum fastener length. Do not use fasteners that exceed the maximum length; otherwise, damage will occur.

CAUTION: Lock washers are recommended on all mounting fasteners. Liquid thread lockers should not be used for the mounting fasteners as this may damage or remove thread inserts during disassembly.

The side mounting pattern of the RS deburring tool consists of (2) dowel pin holes and (4) of threaded holes as shown in the following figure. An optional bench mount adapter plate allows the deburring tool to be permanently attached to a bench or other work surface. If the RS deburring tool is permanently mounted to a work surface, the robot carries the part to be deburred to the deburring tool.

Figure 3.1—Bench (Side) Installation



3.6 Axial Mounting Installation

A blank robot adapter plate is also available to allow axial mounting off the rear of the deburring tool housing. This plate may be modified by the system integrator or by the owner/user of the Flexdeburr. ATI can provide custom interface plates and adapters upon request. If the RS deburring tool is permanently mounted to a work surface, the robot carries the part to be deburred to the deburring tool.

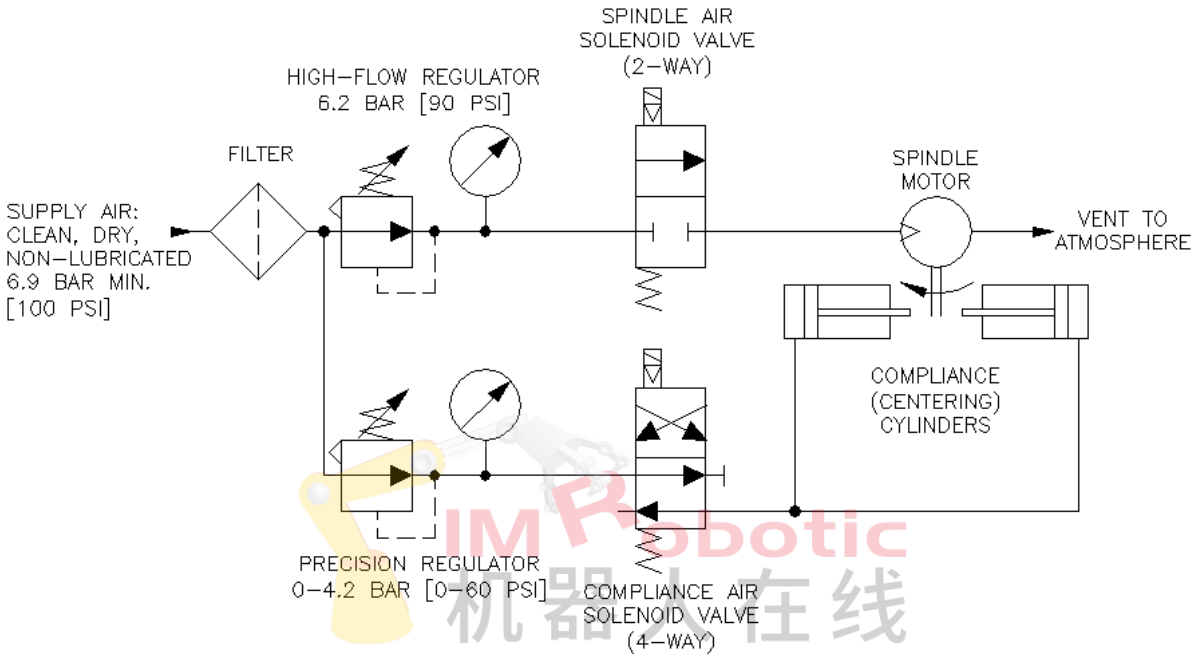
Figure 3.2—Axial Installation

3.7 Pneumatics

Connect the RS deburring tool as shown in the following figure.

> **CAUTION:** Do not use lubricated air with the Flexdeburr. Oil in the air stream will result in premature failure of the turbine motor and is not covered under warranty. It is recommended that the customer use a coalescing filter and filter elements that are rated 5 micron or better.

Figure 3.3—Pneumatic Connections



> **WARNING:** All pneumatic fittings and tubing must be capable of withstanding the repetitive motions of the application without failing. The routing of the pneumatic lines must minimize the possibility of over stressing, pullout, or kinking the lines. Failure to do so can cause some critical pneumatic lines not to function properly and may result in damage to equipment.

The air supply should be dry, filtered, and free of oil. A coalescing filter with elements rated for 5 micron or better is required.

A high-flow air pressure control regulator is required to supply the spindle motor at 6.2 bar (90 psi). A second, precision, self-relieving regulator will supply air for the compliance or centering force.

The compliance force is applied radially and is adjusted until the desired cut is made. The robot's traversing speed will also be adjusted to achieve the desired finish.

> **CAUTION:** Pneumatic components used for the motor drive circuit must be capable of meeting the air consumption requirements (see *Section 8—Specifications*). Poor performance will result, if the correct components are not used.

Conventional, customer-supplied, pneumatic components are used to control the air supply to the deburring tool. ATI recommends that the user install a high-flow pneumatic pressure regulator (ATI Part #9150-FFR-90, or equivalent. See *Section 8—Specifications* for the maximum flow requirements) and a high-flow valve to properly supply a stable air supply of the 6.2 bar (90–95 psi) to the spindle motor. The RS deburring tool will not operate properly, if the supplied air is below 6.2 bar (90 psi).

A second, precision, self-relieving regulator (ATI Part # 9150-P16-B-G, or equivalent) is used to supply the compliance (centering) mechanism. This pressure corresponds to the side force on the bur. Because very little air flow is required for the compliance mechanism, a significantly smaller valve can be used. (Consult the valve and regulator supplier's literature when selecting these components).

If the complete work piece can be deburred with equal force, a conventional, manual pressure regulator can be used for compliance. If the burrs to be removed vary from place to place on the work piece, and this variation is repeatable for all work pieces of the same type, it may be necessary to adjust the force using an analog pressure regulator controlled from the robot. An analog output port in the robot or logic controller will be needed.

Solenoid valves are actuated from the robot or program logic controller by means of a digital output signal.

Table 3.1—Pneumatic Connections

Function	Connection Type	Pressure
Motor Inlet 9150-RS-340	3/8" quick connect tube Alternates: Use 5/16" (8 mm) tubing adapter or Remove the supplied fitting to use 1/4 NPT port in the motor body	6.2 bar (90 psi)
Compliance (Radial) Force Inlet 9150-RS-340-ER & -E	5/32" (4 mm) quick connect tube Alternate: Remove the supplied fitting to use 1/8-NPT port	1.0–4.1 bar (15–60 psi) (Maximum)
Exhaust	Vented to atmosphere through the housing	Not Applicable

It is recommended that flexible plastic tubing be used for the motor air supply and the compliance force air supply. The installed fittings can be removed to expose tapped supply ports thus allowing the use of alternate, customer-supplied components. The turbine motor is extremely quiet and vents dry air to the environment through the screen-covered ports on the side of the housing. No mufflers are required. Information on the sound intensity is provided in *Section 8—Specifications*. To reduce the sound from the cutting operation in the neighboring working areas, a customer-supplied barrier surrounding the installation may be installed (Plexiglas or Lexan is preferred, see *Section 8—Specifications*).

The compliance force, air supply pressure regulator should have a 0-4.1 bar (0–60 psi) range. When testing for the proper contact force, start with about 1 bar (15 psi) of pressure and increase the pressure slowly until the desired cut is achieved.

4. Operation

These operating instructions are intended to help system integrators program, start up, and complete a robotic deburring cell containing a deburring tool. The system integrator should be familiar with the task of deburring and have extensive knowledge about automation applications that incorporate robots.

4.1 Safety Precautions

DANGER: NEVER use the Flexdeburr for purposes other than robotic deburring. If used in any other way, serious injury or damage to equipment may occur.

WARNING: All personnel, who are involved in operation of the RS deburring tool, should have a thorough understanding of the operating procedures. Failure to follow these procedures or neglecting safety precautions can create hazardous situations that may injure personnel or damage the deburring installation and the RS deburring tool.

WARNING: Never operate the Flexdeburr product without wearing hearing protection. High sound levels can occur during cutting. Failure to wear hearing protection can cause hearing impairment. Always use hearing protection while working in proximity of the deburring tool.

WARNING: Never operate the Flexdeburr product without wearing eye protection. Flying debris can cause injury. Always use eye protection while working in the proximity of the deburring tool.

CAUTION: Do not use burs rated for less than the speed of the RS deburring tool being used. Using lower rated burs may cause injury or damage equipment. Always use burs rated for at least the speed of the RS deburring tool being used.

CAUTION: Never be present near the deburring tool while it is started or in operation. Flying debris and rotating parts can cause injury. If it is necessary to approach the deburring tool while in motion, stand behind appropriate Plexiglas windows. Provide a barrier to prohibit people from approaching the deburring tool while in operation.

CAUTION: Never use or start the deburring tool without first reading and understanding the operating procedures described in this manual. Never use the deburring tool for any purposes, or in any ways, not explicitly described in this document. Using the deburring tool without fully understanding the installation and operating procedures may cause injury to personnel or damage to equipment. Mount the deburring tool and connect the pneumatic control equipment as described in this manual. Operate the deburring tool as described in the manual.

4.2 Normal Operations

The following sections describes the normal operating conditions for RS deburring tools.

4.2.1 Air Quality

The air supply should be dry, filtered, and free of oil. A coalescing filter with elements rated for 5 micron or better is required. The air must be supplied at 6.2 bar (90 psi).

Air quality affects tool performance more than almost any other factor. Particulate can block airflow or impede vane motion. If deburring tools do receive proper air pressure, the tool stalls. Any water in the system damages the housing and blades.

4.2.2 No Lubrication

No lubrication is required.

Turbine motors cannot have any oil in the motor air supply. Oil damages the speed regulator and causes the motor speed to fluctuate out of tolerance.

4.2.3 Bur Selection, Design, and Maintenance

Use a carbide media.

RS tools have higher operating speeds and the media must be rated to RS idle speed at a minimum.

Check media quality regularly to ensure it is not dull or worn. Using worn media causes a poor surface finish and increased wear on the bearings that results in premature tool failure.

Do not use shank extensions because the large moment loads combined with the high speed can be dangerous.

Brushes are not recommended because the maximum rated speed of the brush is less than the operating speed of the deburring tool. Operating the brush above its maximum rated speed can be unsafe due to unbalanced loading. Additionally, even balanced brushes can result in an excessive load on the motor and reduced motor life.

Do not use a tool that requires axial loading on the RS tool.

4.2.4 Deburring Tool Approach Path Should be Slow and at an Angle

The deburring tool should approach the workpiece slowly and at an angle.

When beginning a deburring pass, try to minimize the initial impact on the work piece by slowly approaching the tool at an angle while maintaining a slightly parallel path with the surface.

If the tool quickly approaches perpendicularly to the workpiece, the result is gouging and premature wear of the tool bearings and bur. Additionally, collisions could result and create a hazardous situation for both personnel and equipment.

4.2.5 No Axial Loading

Do not apply axial loads that are parallel to the axis of the tool's rotation.

Do not deburr shallow edges where the cutter contacts the parent material below the edge; otherwise, axial loading is applied on the tool and bearings and results in premature failing of the unit.

When deburring holes, interpolate the perimeter. Do not use a countersink tool; otherwise, axial loading occurs and causes premature wear on the bearings.

4.2.6 Perpendicular Loading

Do not apply radial loads that are perpendicular to the axis of pivot. Always keep the tool pivoting perpendicular to the deburring surface. Loading the tool along the pivot axis will damage the pivot pins and cause premature failure.

4.2.7 Program the Robot to Incorporate 50% Compliance Travel of the Tool

Program the robot to have the tool's compliance at 50% travel when on the nominal path.

As the part's edge deviates from the perfect path, the bur can use compliance to follow along high and low spots without losing contact or hitting the positive stop and gouging.

Do not "bottom out" the compliance and hit the positive stop.

Repeated impacts on the positive stop create slop in the compliance and reduce recentering repeatability.

4.3 Flexdeburr Working Environment

As described in previous sections, the RS deburring tool should only be used in conjunction with a robot in a secured work cell/chamber.

The work cell must be secured by means of barriers to prohibit personnel from entering the cell. A lockable door should be included as a part of the barrier in order to facilitate access to the cell for authorized personnel only. The barrier could consist partly or fully of Plexiglas to facilitate observation of the deburring operations.

During system or deburring tool maintenance, make sure the RS deburring tool and robot are stopped before entering the robot cell. When installing and testing, never be present in the cell when the Deburring tool is running.

Be aware of rotating parts. Use eye-protection while working around the deburring tool.

Be aware of high sound levels. While the Flexdeburr air motor is not loud, the cutting action associated with deburring frequently is loud. Always use hearing protection while working in the neighborhood of the deburring cell.

The deburring tool should not be used to deburr materials that are prone to fracture. A fracturing work piece may result in pieces of material damaging surrounding working environment and personnel. Material removed correctly should be in the form of chips.

4.4 Tool Center Point (TCP) Position and Programming

The following figure shows the RS deburring tool dimensions. The Flexdeburr provides radial compliance and performs best when the cuts taken are not excessively deep. The deburring tool spindle must never be running while programming the robot. During teaching, the compliance air must be on and supplied above a minimum of 0.35 bar (5 psi).

Two programming methods are suggested but others are possible. In the first method, a dowel pin of suitable diameter is inserted in place of a bur (simulating the cutter shank diameter) when teaching the robot path. For 6 mm collets, this will mean a 6 mm diameter pin of suitable length. The dowel pin should extend sufficiently from the collet to reach the surface on the bur where cutting is desired (refer to the following figure). The diameter of the bur should not exceed that of the dowel pin by more than the compliance of the RS deburring tool.

Another programming method is to teach the path using the centerline of the bur as a guide, following the edge of the part, and then manually or automatically adding offsets to the robot path points to achieve the final correct bur path (see *Figure 4.2*). The programming method used will depend on the robot's capabilities and programmer preferences.

Figure 4.1— Flexdeburr Dowel Teaching Tool

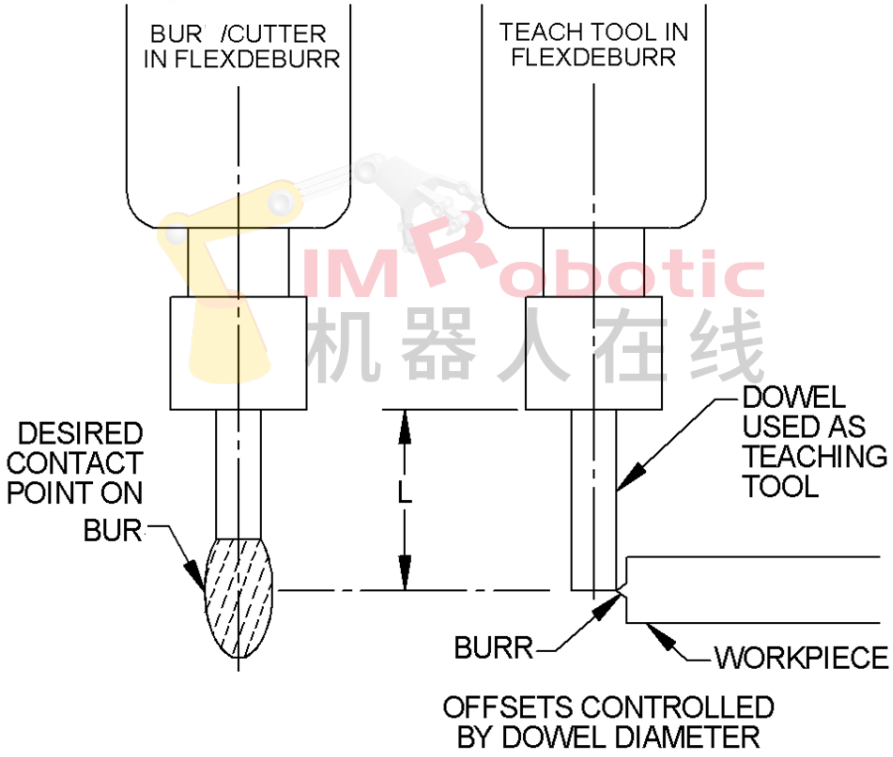
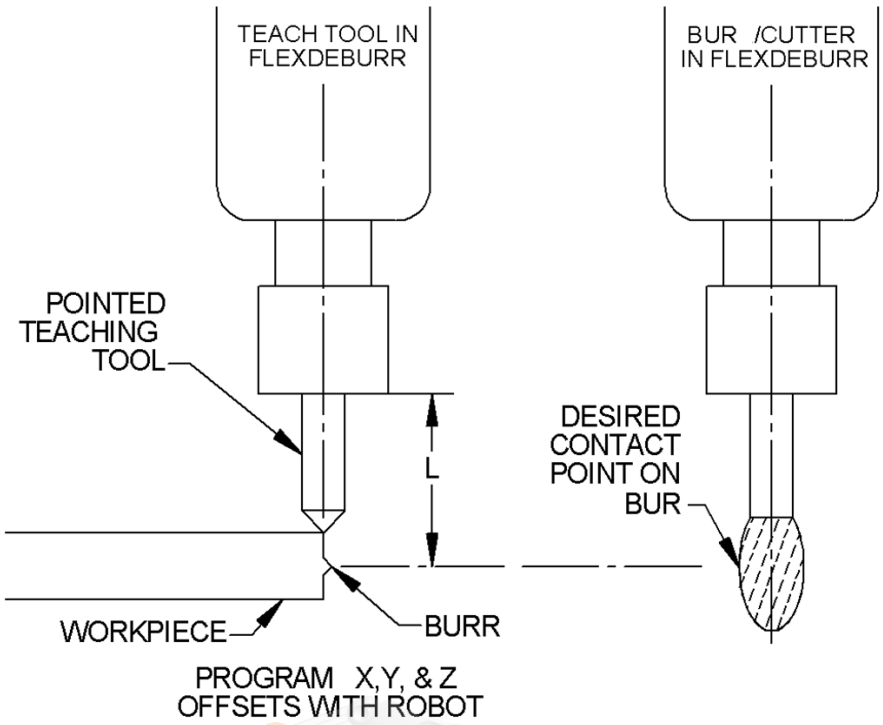


Figure 4.2— Flexdeburr Pointed Teaching Tool



Inside corners represent a complex situation for compliant deburring tools. In general, the bur must not contact simultaneously both perpendicular surfaces of an inside corner. The resulting force imbalance in two planes will cause severe tool chatter. The customer should create a tool path that will prevent the bur from simultaneously contacting two perpendicular surfaces. A tapered bur may reach further into an inside corner, if the tool is at an inclined orientation, and the surface is closer to the tip. (Note: When working near the tip of a tapered bur, the surface cutting speed is reduced.)

When deburring inside radii, a similar situation may arise. Do not attempt to deburr an inside radius less than 1.5 times the diameter of the desired bur (Rmin = 1.5 x Cutter diameter). Depending on the depth of cut, failing to follow these guidelines may result in excessive cutter contact resulting in excessive tool chatter.

When running the robot program the first time, observe the path with the radial compliance air supply turned down to approximately 0.35 bar (5 psi). When the robot path speed is increased, the robot may deviate from the programmed path. Verify that at operational robot path speed, the bur is deflected but contacts the work surface. Once the robot path is confirmed, the compliance force of the bur should be adjusted, as described in *Section 3.7—Pneumatics*, in order to achieve a correct depth of cut

4.5 Cutter Operation and Bur Selection

The RS deburring tool performs best in “climb milling”, which is when the cutter directions of traverse and rotation are the same. In the case of the RS deburring tools, the bur rotation is clockwise when viewed from above. Climb milling would therefore involve clockwise motion around the part being deburred. In climb milling, the heaviest cut is made as the tool enters the work piece and the chip becomes narrower as the cut is completed. In “conventional milling”, the cutter directions of traverse and rotation are opposite. Conventional milling may aid in cutter stability for some operations; however, the cutting edge of the tool is subjected to higher friction and cutting forces. Tool wear is accelerated in this mode, and surface finish quality is generally reduced. When conventional milling, take extra care around corners. A corner poses a potential hazard where the cutting force can deflect the bur and cause the bur to break as the robot continues along its path.

The selection of a cutting tool is highly dependent upon the part material and geometry, and the depth of cut. It is not practical to present all the possibilities in this document. Please see *Section 4.5.1—Bur Selection* for a short list of burs and suitable applications. A specific family of burs is available for working with die cast alloys, aluminum, and plastics. These burs have fewer teeth and increased relief to minimize chip loading.

Plastics represent the most difficult deburring challenge due to the phenomenon of chip re-welding. In this process, if the bur is dull or the feeds and speeds are not correct for the material removed, the chip will melt and weld to the bur or the work piece. This welding can quickly load a bur and produce unacceptable results. The traverse or feed rate of the deburring tool is higher for plastics to minimize melting and welding. A higher feed rate causes larger cuts, which more effectively remove heat from the cutter-tool interface.

4.5.1 Bur Selection

Standard length commercial burs are used with Flexdeburr products. The length of these tools is typically around 2 inches for 1/4” shank diameter burs (50 mm for 6 mm diameter). Avoid longer shank burs that are available from industrial suppliers and appear in their catalogs with descriptions such as “long” or “extended” shank. Using extended or long shank burs in the Flexdeburr will place higher loads and vibrations on the motor bearings resulting in reduced motor life. Bearing failure caused by the use of extended shank burs is not covered under warranty.

CAUTION: Do not use long or extended shank burs with the Flexdeburr. Long shank tools can lead to premature failure of the turbine motor and is not covered under warranty. Use standard length commercial burs with the Flexdeburr.

ATI can provide guidance in the bur selection, however, only experimentation will yield the results desired. The following table is presented to assist in the burr selection.

Table 4.1—Bur Selection

	Materials/Application	Features/Benefits:
	**9150-RC-B-24033 - Diamond Cut, 1/4" Bur Diameter, 5/8" Bur Length, 1/4" Shank**	
	• For hardened and tough materials, super alloys, and stainless. steel, alloyed cast steel and fiber reinforced plastics • Edge and surface working • Built up Welds of high-tensile strength in mold and die making	• Higher cutting capacity than standard cuts • Smoother finish for surface treatments • Lower axial force than ADC
	**9150-RC-B-24061 - Standard Cut, 3/8" Bur Diameter, 3/4" Bur Length, 1/4" Shank**	
	• For steels of high tensile strength die steels, cast steel, built up welds, tough materials, and welds • For beveling • For chamfering • For deburring	• Without chip breaker, for scratch-free surfaces
	**9150-RC-B-24063 - Diamond Cut, 3/8" Bur Diameter, 3/4" Bur Length, 1/4" Shank**	
	• For hardened and tough materials, super alloys, and stainless steel, alloyed cast steel and fiber reinforced plastics • Edge and surface working • Built up welds of high-tensile strength in mold and die making • Higher cutting capacity than standard cuts	• Smoother finish for surface treatments • Lower axial force than ADC·
	**9150-RC-B-24065 - Aluminum Cut, 3/8" Bur Diameter, 5/8" Bur Length, 1/4" Shank**	
	• For greasy aluminum alloys, soft non-ferrous metals and thermoplastics • For use on cast aluminum	• Easy chip flow through positive rake angle, rounded base of tooth, convex tooth back • No loading of the flutes, not even while cutting sticky metals • Smooth operation due to the peeling effect of the teeth
	**9150-RC-B-24645 - Aluminum Cut, 3/8" Bur Diameter, 5/8" Bur Length, 1/4" Shank**	
	• For greasy aluminum alloys, soft non-ferrous metals and thermoplastics • For use on cast aluminum	• Easy chip flow-through positive rake angle, rounded base of tooth, convex tooth back • No loading of the flutes, not even while cutting sticky metals • Smooth operation due to the peeling effect of the teeth

Table 4.1—Bur Selection		
	Materials/Application	**Features/Benefits:**
	**9150-RC-B-26408 - Cut FVK, 1/4” Bur Diameter, 5/8” Bur Length, 1/4” Shank**	
	• For trimming and contour milling of all glass and carbon fiber reinforced plastics	• Special cut geometry allows high feed rates due to low cutting forces
	**9150-RC-B-24862 - Alt Diamond Cut, 1/4” Bur Diameter, 3/4” Bur Length, 1/4” Shank**	
	• Universal use, for ferrous and non-ferrous metals, plastics • Rough finishing of castings • Surface working • Weld removal • Brazed welds	• Smoother operation, improved tool control • High cutting action • Non-clogging • Smaller chips, reduced slivers • Even, smooth surfaces

5. Maintenance

The RS deburring tool is designed to provide reliable service for long periods of operation. While simple in design, there are few user serviceable parts in the assembly. The user should return the unit to ATI for service. *Section 6—Troubleshooting and Service Procedures* is provided to assist the user when they choose to service the unit in the field.

5.1 Pneumatics

The air lines to the deburring tools should routinely be checked for their general condition and replaced as required. The air to the Flexdeburr must be filtered, dry, and non-lubricated. The air filters should be checked and replaced as required to maintain optimum performance. The life of the filter elements is dependent on the quality of compressed air at the customer's facility and therefore cannot be estimated.

5.2 Lubrication

Lubrication systems are not to be used. Refer to *Section 4.2.2—No Lubrication*. The Flexdeburr turbine motor must be supplied with clean, dry, filtered air. Oil in the air stream will cause the turbine motor to fail prematurely. Failure of the motor due to oil in the air stream is not covered under the warranty. See *Section 3.7—Pneumatics* for details on the air supply and quality.

5.3 Boot Inspection

The boot prevents debris from entering the housing and protects internal components. Inspect the boot regularly for damage. If necessary, replace the boot. Refer to *Section 6.2.2—Turbine Motor Replacement*.

5.4 Bur Inspection

The bur will wear depending on cut depth, feed rate, and material that is deburred. Inspect the bur regularly for wear and refer to *Section 6.1—Troubleshooting* for symptoms of a worn bur. If necessary, replace the bur. Refer to *Section 6.2.1—Bur and Collet Replacement*.

6. Troubleshooting and Service Procedures

Deburring process development is an iterative, learning task. The following table is presented to assist in the solving deburring problems.

6.1 Troubleshooting

Deburring process development is an iterative, learning task. The following table is presented to assist in solving deburring problems.

Table 6.1—Troubleshooting

Symptom	Cause	Resolution
Bur wear	Hard work material	Use better grade burr material or add coating (TiAlN).
	Too heavy a cut	Decrease width of the cut. Make multiple passes.
	Feed rate is too slow	Increase feed rate
Bur breakage	Too heavy a cut	Decrease width of the cut. Make multiple passes.
	Deflection at a corner	Climb mill or do not begin path at sharp corner.
	Impacting the part	Decrease the feed rate at contact. Enter the part at an angle.
Unequal compliance	The regulator is defective.	Replace the regulator.
	Worn ring cylinder	Replace the ring cylinder, refer to *Section 6.2.3—Ring Cylinder Assembly Replacement*
	Pivot pin(s) are worn	Replace pivot pin(s). Refer to *Section 6.2.2—Turbine Motor Replacement*
	Compliance preload screw is not set correctly.	Reinstall the set screw. Refer to *Section 6.2.2—Turbine Motor Replacement*
Poor finish on the work piece	Feed rate is too fast.	Reduce the feed rate.
	The bur is worn.	Inspect the bur. If worn, replace. Refer to *Section 6.2.1—Bur and Collet Replacement*
	Motor bearings are worn.	Inspect spindle shaft. If the shaft feels loose or has play, replace the turbine motor. Refer to *Section 6.2.2—Turbine Motor Replacement.*
Bur is chattering during cut.	The feed rate is too fast.	Reduce the feed rate.
	Lack of the rigidity	Increase the radial compliance pressure.
	Too heavy a cut	Decrease width of the cut. Make multiple passes.
	Improper bur selection	Choose a bur that is designed for work material. Refer to *Section 4.5—Cutter Operation and Bur Selection*.
	The bur is worn	Inspect bur; if worn, replace. Refer to *Section 6.2.1—Bur and Collet Replacement*
	The motor bearings are worn	Inspect the spindle shaft. If the shaft feels loose or has play, replace the turbine motor. Refer to *Section 6.2.2—Turbine Motor Replacement.*
Secondary burrs are created on the work piece after a cut.	Incorrect feed rate	Reduce the feed rate.
	Too heavy a cut	Decrease width of the cut. Make multiple passes.
	Improper bur selection	Choose a bur that is designed for work material. Refer to *Section 4.5—Cutter Operation and Bur Selection*.
	The bur is worn.	Inspect bur. If worn, replace. Refer to *Section 6.2.1—Bur and Collet Replacement*
	The motor bearings are worn.	Inspect the spindle shaft. If the shaft feels loose or has play, replace the turbine motor. Refer to *Section 6.2.2—Turbine Motor Replacement.*

Table 6.1—Troubleshooting		
Symptom	**Cause**	**Resolution**
Chip packing of the bur	Too heavy a cut	Decrease width of the cut. Make multiple passes.
	Not enough chip clearance	Use a bur with less flutes. Refer to *Section 4.5—Cutter Operation and Bur Selection*.
The bur stalls.	Not enough or no drive air	Verify that the drive air regulator is operating at 6.2 bar (90 psi) and check for leaks.
	Bur is not secure in the collet.	Properly tighten burr in the collet
	Too much side load	Decrease width of the cut. Make multiple passes.
	The turbine motor must be replaced.	Replace the turbine motor; refer to *Section 6.2.2—Turbine Motor Replacement*.
The motor spindle is sticking.	The motor bearings are worn.	Replace the turbine motor; refer to *Section 6.2.2—Turbine Motor Replacement*.

6.2 Service Procedures

CAUTION: Thread locker applied to fasteners must not be used more than once. Fasteners might become loose and cause equipment damage. Always apply new thread locker when reusing fasteners.

The following service procedures provide instructions for user-serviceable parts replacement, when the user chooses to service the unit in the field. For all service, it is recommended that the air supply (before the solenoid valves) be disconnected. Drain any trapped air pressure in the lines. It is suggested that the air supply be “locked out” to prevent accidental operation of the spindle.

6.2.1 Bur and Collet Replacement

In normal operation the bur will become worn. If improper feeds and speeds are used, the bur may become “loaded” with material. In both instances, replace the bur. During initial production, the bur and the work piece should be examined often in order to determine at what interval the bur should be replaced. Replacing the collet will not be required when the same size of bur is replaced, but a new collet is installed, when a different sized bur is required.

Refer to the following steps for replacing the bur and collet:

Refer to *Figure 6.1*.

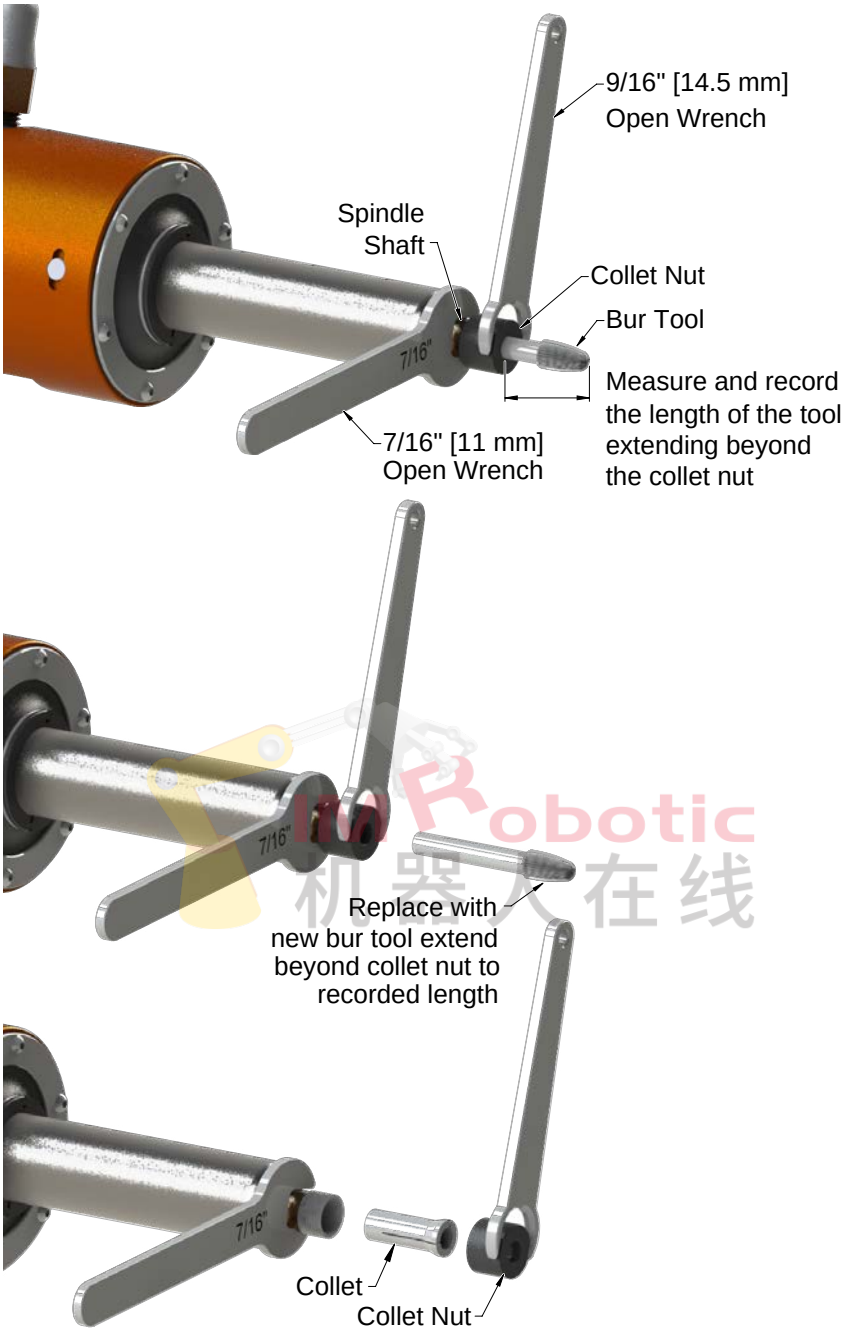
Parts required: *Refer to Section 7—Serviceable Parts.*

Tools required: *7/16” (11 mm) and 9/16” (14.5 mm) open-end wrench*

1. Remove and/or lock-out the spindle motor air supply for safety. (De-energize all energized circuits such as air and power).
2. If the bur is to be replaced with one of an identical type, measure and record the tool length extending beyond the collet lock nut. Alternatively, the optional ATI 9150-RC-T-4230 bur setting tool accessory can be used to duplicate the tool exposure length.
3. Use a 7/16” (11 mm) open-end wrench to hold the spindle just behind the collet nut.
4. Use a 9/16” (14.5 mm) collet wrench to turn the collet locknut counterclockwise (when viewed from the cutter tip) to loosen the collet.

CAUTION: During operating of the deburring tool, the bur reaches high temperatures. Failure to wear proper personal protection equipment or not allowing the bur to cool could result in serious injury to the user. Be aware that during operation, the bur becomes very hot, and when removing the bur, take necessary safety precautions to avoid injury.

Figure 6.1— Bur and Collet Replacement



5. To remove a worn bur, pull the bur out of the loosened collet.
6. If the collet is being replaced, completely remove the nut and extract the old collet. Insert the new collet and refit the nut leaving it loose.
7. If an identical new bur is replacing a worn one, insert the new bur and measure and adjust the length of the its exposed portion according to the measurement taken in the step *2*.
8. Use a 7/16” (11 mm) open-end wrench to hold the spindle just behind the collet nut.
9. Use a 9/16” (14.5 mm) collet wrench to turn the collet locknut clockwise (when viewed from the bur tip) to tighten the collet.
10. Safely resume normal operation.

6.2.2 Turbine Motor Replacement

If the turbine motor is operated using oil-laden or dirty air, it will fail, and require replacement. Failure of the motor due to contamination in the spindle air is not covered under the warranty. The motor may also require replacement after an extended operating life or following a severe collision. There are no user serviceable parts in the turbine motor. Flexdeburr units with defective motors should be returned to ATI during the warranty period. Motors are sold as complete, modular assemblies to simplify and speed user installation. Should the customer wish to replace the motor after the warranty period, perform the following steps:

Refer to *Figure 6.2*.

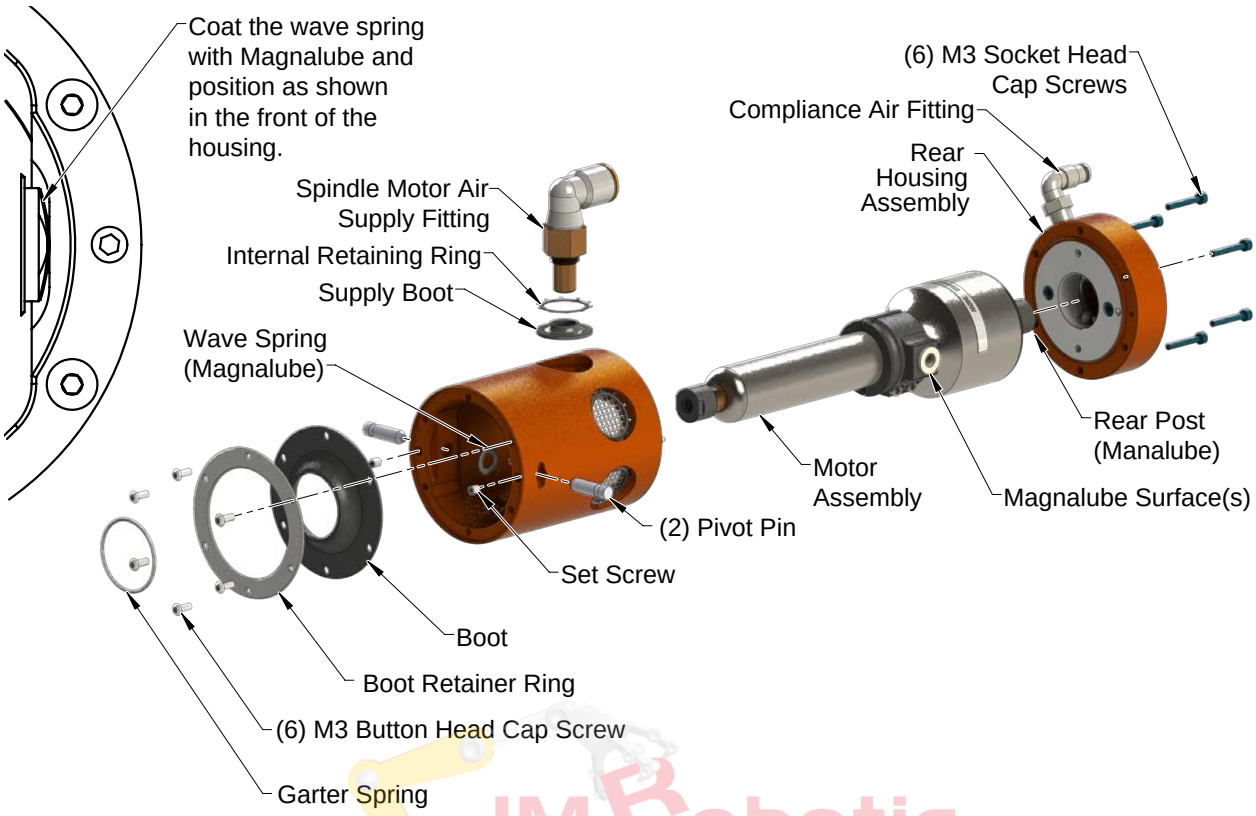
Parts required: *Refer to Section 7—Serviceable Parts.*

Tools required: *Small screwdriver, 2.5 mm and 2 mm Allen wrenches, torque wrench, needle-nose pliers*

Supplies required: *Magnalube, Loctite® Primer 7649, Loctite 222, Loctite 569*

1. Remove and/or lock-out the spindle motor air supply for safety. (De-energize all energized circuits such as air and power).
2. Disconnect the air hose from the spindle and compliance air fittings.
3. Remove the deburring tool from the robot or work location.
4. Remove the bur tool, refer to *Section 6.2.1—Bur and Collet Replacement.*
5. Remove the spindle air supply fitting from the side of the main housing by rotating the fitting counter-clockwise.
6. Remove the internal retaining ring and supply boot. ATI recommends replacing the internal retaining ring and supply boot at the air supply when the motor is replaced.
7. Ease the garter spring off the front spindle boot.
8. Using a 2.5 mm Allen wrench, remove the (6) M3 socket button head cap screws holding the boot retainer ring and boot to the front housing assembly.
9. Remove the boot retainer ring and boot.
10. Using a 2.5 mm Allen wrench, remove the (6) M3 socket head cap screws that secure the rear housing.
11. Remove the rear housing.
12. At the front of the front housing assembly, using a 2 mm Allen wrench, remove and retain the (2) M4 set screws securing the motor pivot pins.
13. Use needle-nose pliers to pull the pivot pins out of the housing.
14. Withdraw the turbine motor complete as an assembly by twisting it 45° and pulling the motor assembly backwards out of the main housing. Make sure to retain the wave washer between the turbine motor assembly and the front housing assembly.
15. Insert the new turbine motor assembly into the front housing assembly. Make sure the wave spring is held in place on the inside of the front housing assembly by coating it with Magnalube.
16. Insert the pivot pins to secure the turbine motor in place. Make sure the pins are flush with the housing diameter and the wave spring remains in place.
17. Apply Loctite primer 7649 and Loctite 222 to the (2) M4 set screws.
18. Assemble the (2) M4 set screw into the front housing assembly to secure the pivot pins. Tighten to 12 in-lbs (1.4 Nm).
19. Apply a coating of the Magnalube on the diameter of the rear post of the air motor assembly. Refer to *Figure 6.2*.

Figure 6.2— Turbine Motor Replacement



20. Apply Loctite 222 to the (6) M3 socket head cap screws, if there is not pre-applied adhesive.
21. Align the rear housing to the front housing assembly and secure with the (6) M4 socket head cap screws. Tighten to 12in-lbs (1.4 Nm).
22. Slide the boot over the turbine motor spindle and align to the front housing assembly.
23. Apply Loctite primer 7649 and Loctite 222 to the (6) M3 socket button head cap screws.
24. Install the boot retaining ring over disk boot and secure with (6) M3 socket button head cap screws. Tighten to contact and an additional 1/2 turn.
25. Assemble the garter spring over the boot. (it will seat in the groove in the turbine motor assembly)
26. Assemble the new internal retaining ring and supply boot to the spindle supply fitting as shown in *Figure 6.2*.
27. Apply Loctite 569 to the threads of the spindle supply fitting.
28. Thread the spindle supply fitting into the turbine motor assembly until it is finger tight then tighten an additional 1/2 turn.
29. Slide the supply boot into the counter bore in the front housing.
30. Push the internal retaining ring into the counter bore to secure the rubber disk.
31. Install the bur tool, refer to *Section 6.2.1—Bur and Collet Replacement.*
32. Install the deburring tool to the robot or work location.
33. Safely resume normal operation.

6.2.3 Ring Cylinder Assembly Replacement

The compliant motion of the turbine motor spindle can occur because of an array of the pistons (ring cylinder) that are installed inside the rear housing. After extended operation, this component may need replacing to ensure free motion of the pistons. The unit may be replaced as an assembly, but its subcomponents are not user serviceable. To replace the ring cylinder assembly, perform the following steps. The ring cylinder is available as a complete assembly with new O-ring seals.

Refer to *Figure 6.3*.

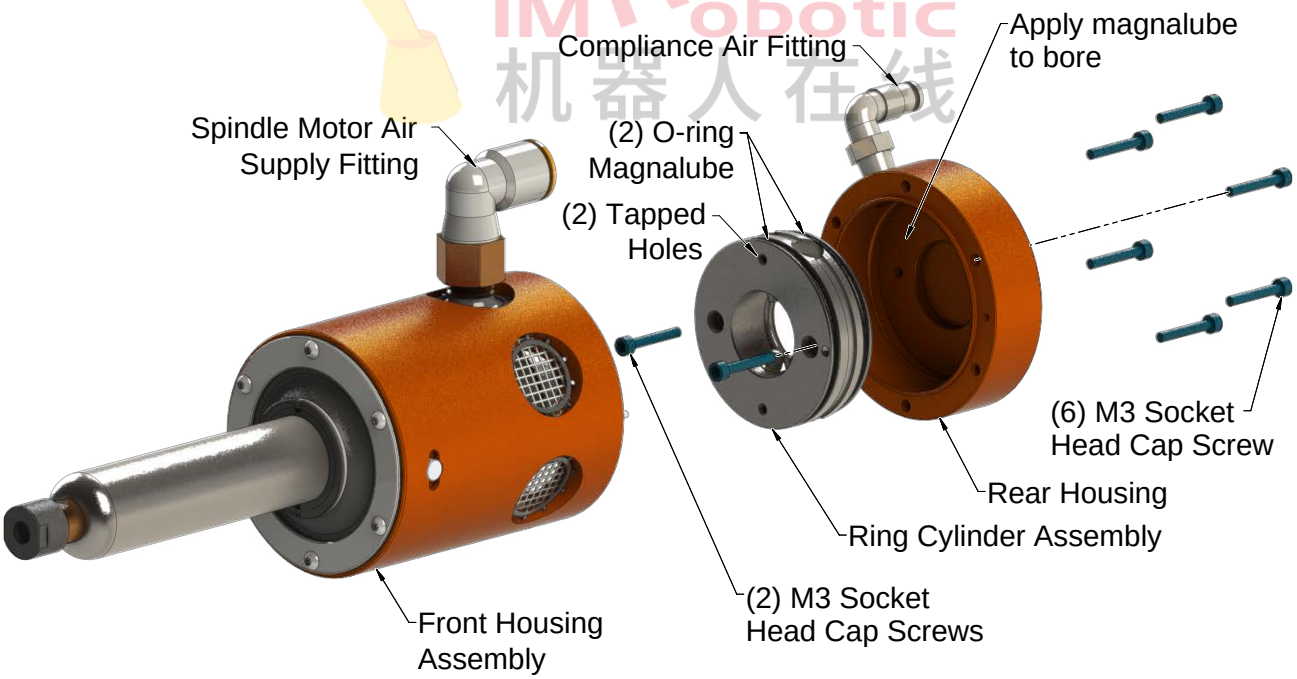
Parts required: *Refer to Section 7—Serviceable Parts.*

Tools required: *2.5 mm Allen wrench, torque wrench*

Supplies required: *Magnalube, Loctite 222*

1. Remove and/or lock-out the spindle motor air supply for safety. (De-energize all energized circuits such as air and power).
2. Disconnect the air hose from the compliance and spindle supply air fitting.
3. Remove the deburring tool from the robot or work location.
4. Remove the (6) M4 socket head cap screws that secure the rear housing to the front housing.
5. Remove the rear housing.
6. Using a 2.5 mm Allen wrench, remove the (2) M3 socket head cap screws securing the ring cylinder assembly to the rear housing.
7. Place the removed M3 screws in the tapped holes in the ring cylinder body and tighten them slowly and equally so they pull the ring cylinder assembly out of the rear housing.

Figure 6.3— Ring Cylinder Replacement

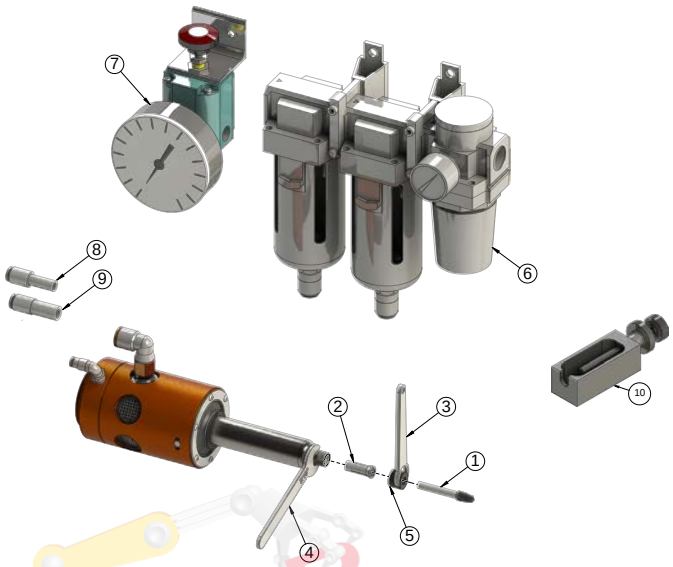


8. Apply a thin film of the Magnalube to the housing bore where the ring cylinder seats prior to installation.
9. Apply Magnalube to the (2) new o-rings, if the old unit is being reinstalled. (Do not reuse the old o-rings.)
10. Install the new o-rings to the outside of the ring cylinder assembly.
11. Align the shallow drill point on the ring cylinder body to the 2 mm dowel pin hole on the rear housing prior to pressing the ring cylinder into the bore. Insert the new ring cylinder assembly into the rear housing.
12. If the (2) M3 socket head cap screws do not have pre-applied adhesive, apply Loctite 222 to the threads.
13. Using a 2.5 Allen wrench, secure the ring cylinder assembly to the rear housing using the (2) M3 socket head cap screws. Tighten to 12 in-lbs (1.4 Nm).
14. Assemble the rear housing to the front housing.
15. If the (6) M3 socket head cap screws do not have pre-applied adhesive, apply Loctite 222.
16. Using a 2.5 Allen wrench, secure the rear housing using the (6) M3 socket head cap screws. Tighten to 12 in-lbs (1.4 Nm).
17. Install the deburring tool to the robot or workpiece location.
18. Safely resume normal operation.

7. Serviceable Parts

For repair and spare parts please contact ATI. Refer to *Section 9.2—RS-340 Serviceable Parts Drawing* for exploded drawings showing all the user replaceable components of the Flexdeburr. Available accessories, tools, and optional replacement parts are listed in*Section 7.1—Accessories Tools, and Optional Replacement Parts.* All other repairs must be performed by ATI.

7.1 Accessories Tools, and Optional Replacement Parts



Item No.	Qty	Part Number	Description
1	1	9150-RC-B-XXXXX	Refer to *Table 4.1* for bur part numbers and descriptions
2	OPT	9150-RC-C-12442	Ø 3 mm Collet
		9150-RC-C-12443	Ø 1/8” Collet
	OPT	9150-RC-C-12444	Ø 3/16” Collet
	OPT	9150-RC-C-12445	Ø 6 mm Collet (Standard on the Metric Models)
	OPT	9150-RC-C-12446	Ø 1/4” Collet (Standard on the Inch Models)
3	OPT	9150-RC-T-12479	9/16” (14.5 mm) Collet Wrench
4	OPT	9150-RC-T-12475	7/16” (11 mm) Collet Wrench
5	1	3700-50-3081	Collet Nut, RC-300/340 Motor (.450 x .318 Hole)
	1	3700-50-3082	Collet Nut, RC-300/340 Motor (.450 x .254 Hole)
6	1	9150-FFR-90	High-Flow Filter/Regulator Assembly
7	1	9150-P16-B-G	Precision Regulator
8	1	3405-1210010-01	Spindle Tubing Adapter, 3/8" to 5/16" (8 mm)
9	1	3405-1210011-01	Spindle Tubing Adapter, 1/2" to 5/16" (8 mm)
10	1	9150-RC-T-4230	Bur Setting Fixture, RC/RS Tools

Notes:
1. The images are provided for reference only, and the actual product may vary slightly in appearance.

8. Specifications

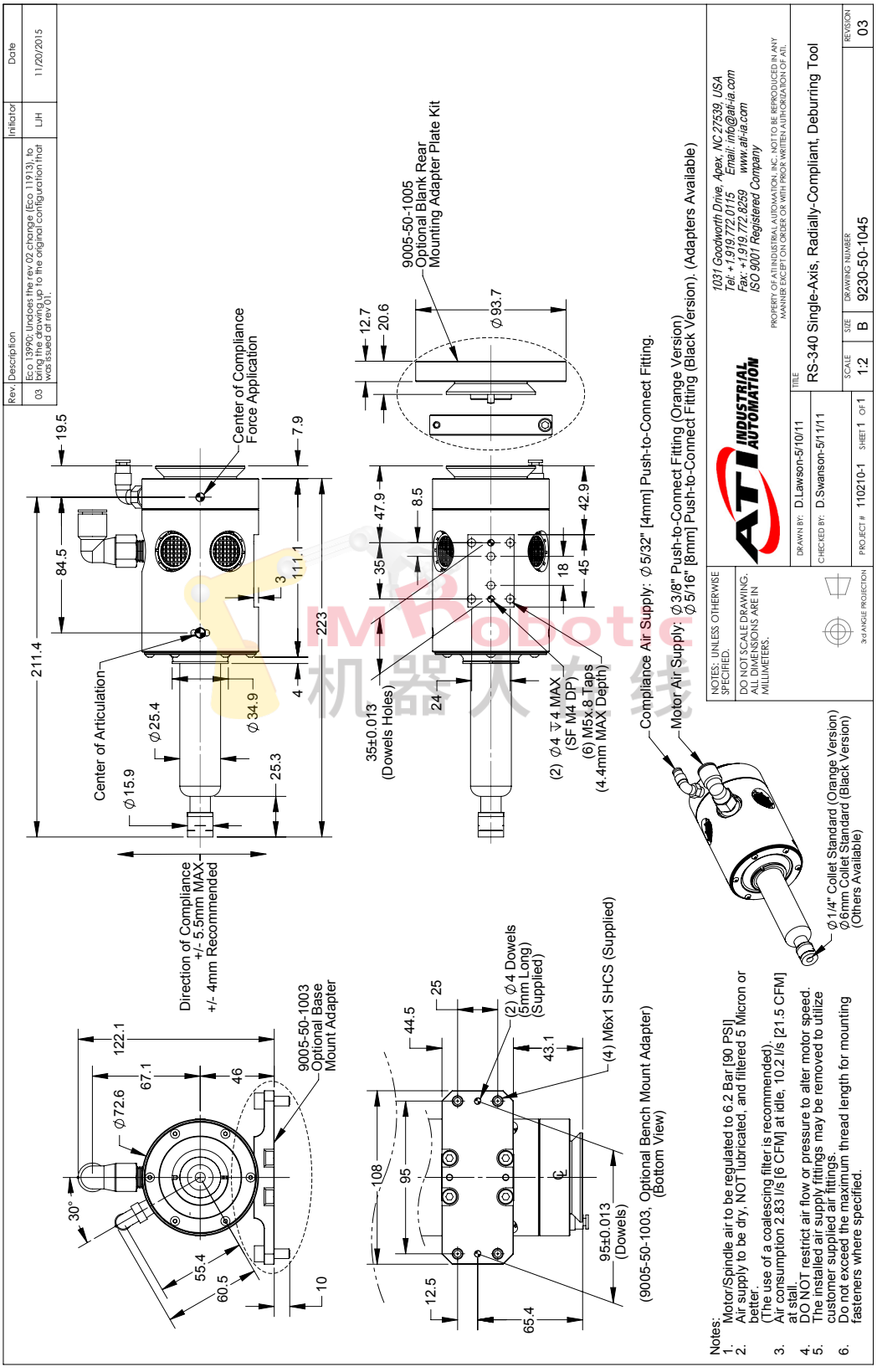
Table 8.1—RS-340 Specifications	
Parameter	**Rating**
Motor	Turbine Motor
Idle Speed (RPM)	40,000
Torque (Max.)	0.08 N-m (0.7 lb-in)
Power	340 W (0.46 hp) @ 40,000 RPM
Weight (without Adapters)	1.2 kg (2.6 lbs)
Compensation (Radial)	+/- 5.5 mm max., +/- 3 mm recommended
Compliance Force (Measured at Collet)	9.79-38.25 N (2.2–8.6 lb) at 1.0-4.1 bar (15–60 psi)
Bur Surface Speed	Dependent on the Cutter Geometry and Motor Speed
Spindle Air Pressure	6.2 bar (90 psi) (All Models)
Air Consumption (Idle)	2.8 l/s (6 CFM)
Air Consumption (Stall)	10.2 l/s (21.5 CFM)
Air Connection (Spindle)	3/8” Tube
Air Connection (Compliance)	5/32” Tube
Sound Pressure Level[1]	Less than 78 dB(A) (without Cutter)
Collet Size, Standard[2]	1/4" (6 mm on the Euro Models)
Rotary Burs [3]	Commercial Units Rated 40,000 RPM or Higher
Special Tools	Open End Wrenches 9/16” (14.5 mm) 7/16” (11 m)

Notes:

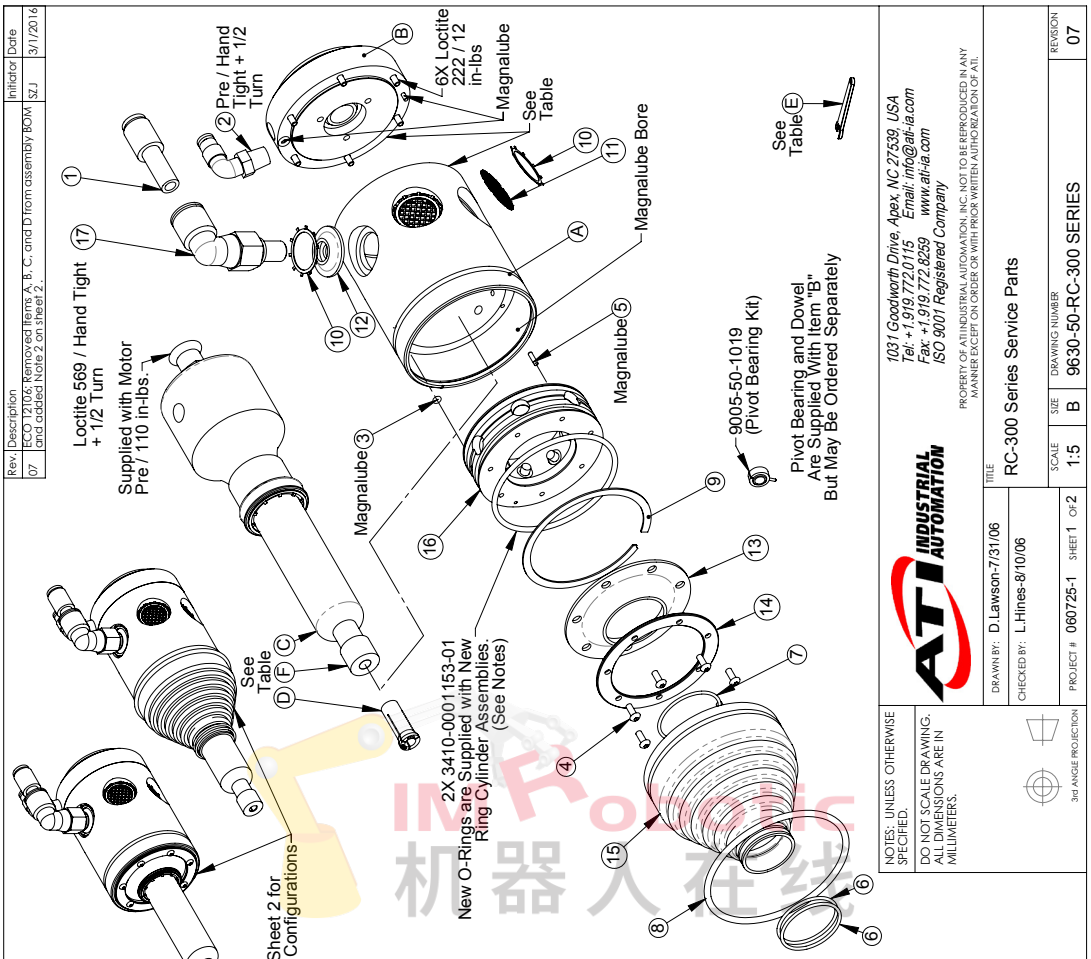
1. All noise emission measurements were taken under no load idle conditions without a cutting tool. Because the working environment is unknown, it is impossible to predict the noise that will occur during a deburring operation
2. Optional Sizes Available, See *Section 7—Serviceable Parts*
3. ATI Can Supply Burs, See *Section 4.5.1—Bur Selection*.

9. Drawings

9.1 RS-340 Geometry and Mounting



9.2 RS-340 Serviceable Parts Drawing



ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	3405-1210010-01-01	ADAPTER, 3/8x5/16[8mm], McM#51495K308
2	1	3405-2210001-01	1/8NPT Swivel Elbow, 5/32 (4mm) PL Tubing
3	1	3410-0001151-01	O-RING, 1/16 x 1/16
4	7	3500-1158008-21	M3 X 8 BHCS, SS
5	1	3540-0102008-11	Dia 2mm x 8mm Dowel Pin
6	2	3610-0235001-21	GARTER SPRING, RC 150
7	1	3610-0340001-21	GARTER SPRING, RC 340
8	1	3610-0494000-20	GARTER SPRING, SR-081 Boot
9	1	3690-1200001-11	RET.INT. 2.76", UR-268
10	5	3690-7500003-11	RET.,INT. 1" 5005-100
11	4	3700-50-3005	DISK, FILTER, FLEXDEBURR
12	1	3700-50-3006	SUPPLY BOOT, FLEXDEBURR 340
13	1	3700-50-3007	BOOT, FLEXDEBURR 340
14	1	3700-50-3008	RING, BOOT, FLEXDEBURR 340
15	1	3700-50-3079	BOOT, RC-300/340, VITON
16	1	9005-50-1000	RING CYLINDER, FLEXDEBURR 340
17	1	9005-50-1002	ELBOW FITTING ASSY., FLEXDEBURR

NOTES:
If the Old Ring-Cylinder Will Be Re-installed, New O-Rings are Recommended.

A	RC-300 & -340	1	3700-50-3000	Front Housing, Orange
	RC-300-E & -340-E	1	3700-50-3019	Front Housing, Black
B	RC-300 & -340	1	9005-50-1017	Rear Housing Assembly, Orange
	RC-300-E & -340-E	1	9005-50-1018	Rear Housing Assembly, Black
C	RC-300 & -300-E	1	9005-50-1066	300 W, 30k RPM Motor Assembly
	RC-340 & -340-E	1	9005-50-1065	340 W, 40k RPM Motor Assembly
D Optional / Spare Collets	All	OPT.	9150-RC-C-12442	3mm Collet
		OPT.	9150-RC-C-12443	1/8" Collet
		OPT.	9150-RC-C-12444	3/16" Collet
		OPT.	9150-RC-C-12445	6mm Collet (Standard on Metric Models)
		OPT.	9150-RC-C-12446	1/4" Collet (Standard on Inch Models)
E	All	OPT.	9150-RC-T-12475	7/16" Collet Wrench
		OPT.	9150-RC-T-12479	9/16" Collet Wrench
F	All	1	3700-50-3081	Collet Nut (.450 x .318 Hole)
		1	3700-50-3082	Collet Nut (.450 x .254 Hole)

10. Terms and Conditions of Sale

The following Terms and Conditions are a supplement to and include a portion of ATI's Standard Terms and Conditions, which are on file at ATI and available upon request.

ATI warrants the compliant tool product will be free from defects in design, materials, and workmanship for a period of one (1) year from the date of shipment and only when used in compliance with the manufacturer's specified normal operating conditions. This warranty does not extend to tool components subject to wear and tear under normal usage; including but not limited to those components that require replacement at standard service intervals. The warranty period for repairs made under a RMA shall be for the duration of the original warranty, or ninety (90) days from the date of repaired product shipment, whichever is longer. This warranty is void if the unit is not used in accordance with guidelines that are presented in this document. ATI will have no liability under this warranty unless: (a) ATI is given written notice of the claimed defect and a description thereof within thirty (30) days after Purchaser discovers the defect and in any event not later than the last day of the warranty period; and (b) the defective item is received by ATI not later ten (10) days after the last day of the warranty period. ATI's entire liability and Purchaser's sole remedy under this warranty is limited to repair or replacement, at ATI's election, of the defective part or item or, at ATI's election, refund of the price paid for the item. The foregoing warranty does not apply to any defect or failure resulting from improper installation, operation, maintenance or repair by anyone other than ATI.

ATI will in no event be liable for incidental, consequential or special damages of any kind, even if ATI has been advised of the possibility of such damages. ATI's aggregate liability will in no event exceed the amount paid by purchaser for the item which is the subject of claim or dispute. ATI will have no liability of any kind for failure of any equipment or other items not supplied by ATI.

No action against ATI, regardless of form, arising out of or in any way connected with products or services supplied hereunder may be brought more than one (1) year after the cause of action occurred.

No representation or agreement varying or extending the warranty and limitation of remedy provisions contained herein is authorized by ATI, and may not be relied upon as having been authorized by ATI, unless in writing and signed by an executive officer of ATI.

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10.1 Motor Life and Service Interval Statement

The air motors that are used in ATI deburring/finishing tools are subject to wear and have a finite life. Motors that fail, during the warranty period, will be repaired or replaced by ATI as long as there is no evidence of abuse or neglect and that the normal operating practices outlined in this manual have been observed.

Components such as motor vanes, bearings, any gear reduction components, and collet nuts/chucks are considered consumable and are not covered by warranty. The customer should expect to service or replace these items at designated service intervals. For any part that is not detailed in this manual, contact ATI for part numbers and pricing.

Premature bearing failure can occur from exposing the deburring tool to coolants and water or impacts from collisions. Other failure modes that are outlined in the manual and relate to improper machining practices and deburring media selection.

10.1.1 Turbine Motor Products (Flexdeburr (RS) models)

Turbine motors are not serviceable at this time. The expected life of a turbine motor in normal operation is entirely application dependent based on a multitude of factors. To maximize the life of turbine motor products, the customer should follow closely the normal operation guide in the product manual. The supplied air must be totally lube free and filtered to remove particulates and moisture. Exposing the turbine motors to oil in the air supply results in premature failure. Premature bearing failure can occur from exposing the deburring tool to coolants and water or impacts from collisions. Other failure modes are outlined in the manual and relate to improper machining practices and deburring media selection.