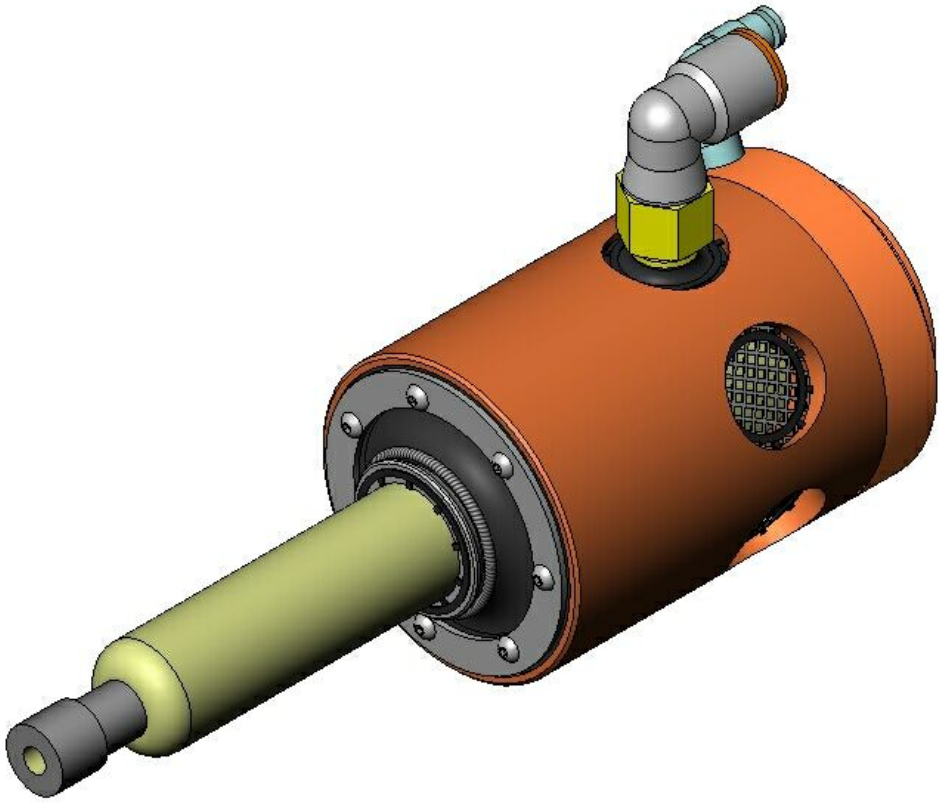
ATI Radially-Compliant Robotic Deburring Tools
Flexdeburr™

(Models 9150-RC-300, -340 & -660)

Installation and Operation Manual

US Patent # 6,974,286 B2



9150-RC-340

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Engineered Products for Robotic Productivity

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> ⚠ **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 this product, otherwise damage to this product or unsafe conditions may occur.

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Glossary of Terms

The Flexdeburr™ product family is ATI's line of **R**adially-**C**ompliant (RC) deburring tools. Articulated motion of the high-speed, air turbine-driven spindle allows for the rapid removal of parting lines and burrs while following irregular part profiles. The RC product line is available with a multitude of different motors for demanding applications, with power ratings from 150 to 660 Watts and spindle speeds from 30,000 to 65,000 RPM.

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 air supply lines. Typically refers to removal of particulates.
Air Turbine	Air motor that drives the spindle.
Bur	Any unwanted, raised protrusion on the workpiece.
Burr	Cutting tool used to remove burs from the workpiece. Alternatively referred to as a rotary file, cutter, or bit.
Climb Milling	Cutting method where the direction of cutter rotation and tool motion are the same.
Coalescing Filter	Device designed to remove 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 response to protrusions on or deviations of the workpiece.
Conventional Milling	Method of cutting where the direction of tool motion is opposite that of tool rotation.
End-Effector	Tool used by the robot to perform a particular function
Regulator	Device used to set and control the supplied air pressure to lower acceptable levels.
Solenoid Valve	Electrically controlled device for switching air supplies on and off.
Spindle	The rotating portion of the deburring tool assembly.

Table of Contents

1. General Data

1.1 Environmental Limitations

Operation:

Installation position:	Mounted to robot by means of the side mounting pattern or rear adapter flange. 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. Mounted to a table or stand by means of the bench adapter (the robot is carrying the workpiece).
Temperature range:	5° C–35° C 41° F–95° F

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 2.5 of this manual
Utilities:	The tool requires clean, dry, filtered, non-lubricated air. The use of a coalescing filter and filter elements rated 5 micron or better is required. The spindle must be supplied at 6.2–6.5 bar [90–95 psi] and the radial compliance (centering) air must be supplied from a regulated source between 1.0–4.1 bar [15–60 psi]

1.2 Cutting Tool Holding Systems (Collets)

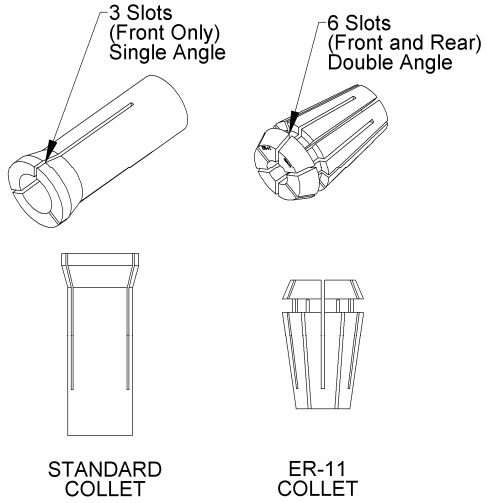
All Flexdeburr products utilize removable collets to grip customer supplied cutting tools. Different collet diameters may be substituted to retain numerous cutter shank diameters. The collet retaining nut is loosened to open the collet allowing cutting tools to be removed and inserted. Once the tool 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 air motor design does not allow the installation of quick-change or drawbar collet systems.

The standard tool holding system for Flexdeburr products is an economical, proprietary, single-angle collet design utilizing three 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” [0.025mm] are acceptable. Special sizes are available upon request but require custom machining.

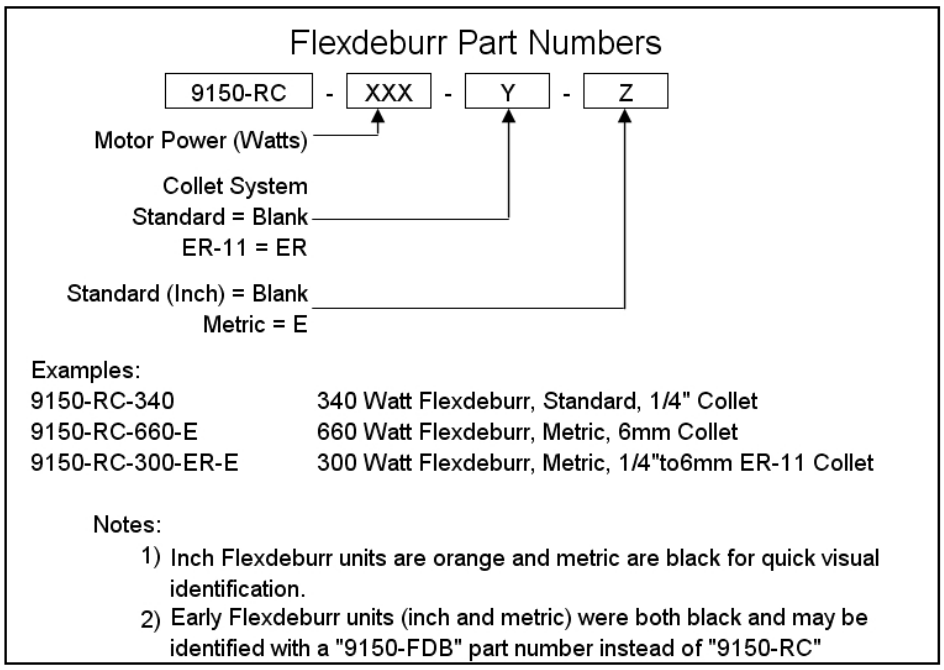
Where the cutting tool shank is not a common diameter or higher precision is required, ATI offers air motors utilizing the ER-11 collet system. The ER-11 collet is a double-angled design featuring multiple gripping sections. This allows the collet to produce more contact points along the length of the tool shank. ER-11 collets can achieve runout tolerances below 0.0005” [0.013mm] and provide a gripping range up to 0.040” [1mm]. This allows a standard 1/4 inch ER-11 collet to safely and accurately hold a metric 6mm diameter cutter. However, the ER-11

collet system represents a greater initial expense and its wrenches and collet nut are more delicate.

The two collet systems are not interchangeable. An ER-11 collet cannot be used in a standard Flexdeburr and the standard Flexdeburr collet cannot be used with an air motor designed for the ER-11 collet system. Flexdeburr units with “ER” appearing in their part number utilize ER-11 collets.



1.3 Deburring Tool Part Numbers



2. Handling, Installation, Storage and Transportation

2.1 Inspection of Condition When Delivered

Upon receipt, the following should be checked:
- Delivery in accordance with freight documents
- Damage to packaging

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.

2.2 Unpacking and Handling

The deburring tool should always be placed inside the accompanying box (crate) during transportation, storing and handling.

2.3 Installation

2.3.1 Mounting, Adapter and Interface Plate

The side-mounting pattern of the RC deburring tool consists of two dowel pin holes and a number of threaded holes as can be seen in Figure 2.1. The maximum fastener length specified must not be exceeded lest the fasteners interfere with the compliant motion of the air motor spindle. As coil-type thread inserts are used in the aluminum housing the customer is advised to use lock washers in preference to liquid thread locker on mounting fasteners.

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

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. An optional bench mount adapter plate allows the deburring tool to be permanently attached to a bench or other work surface (see Figure 2.2). If the RC deburring tool is permanently mounted to a work surface, the robot carries the part to be deburred to the deburring tool.

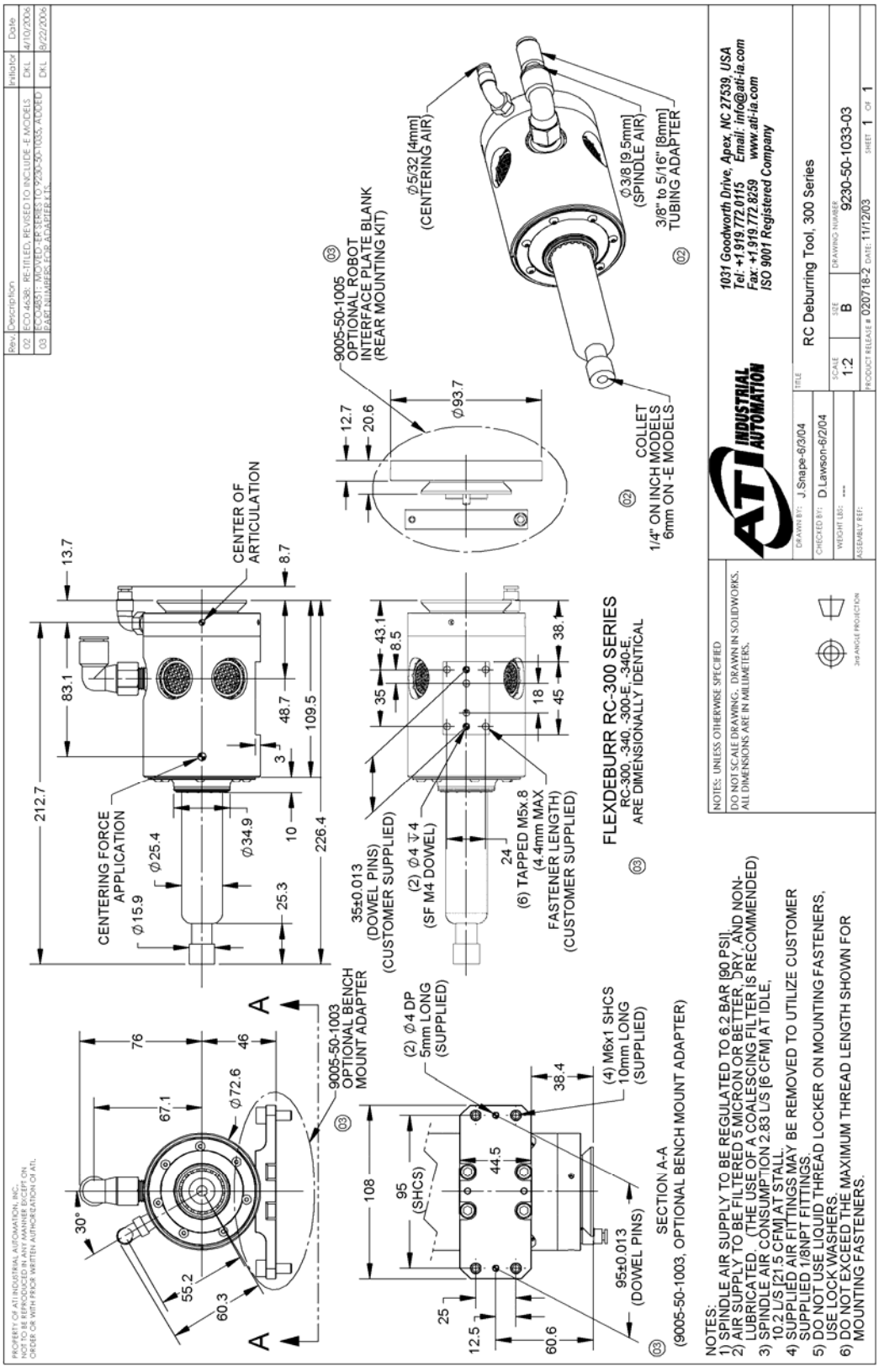


Figure 2.1—RC-300 Series Geometry and Mounting

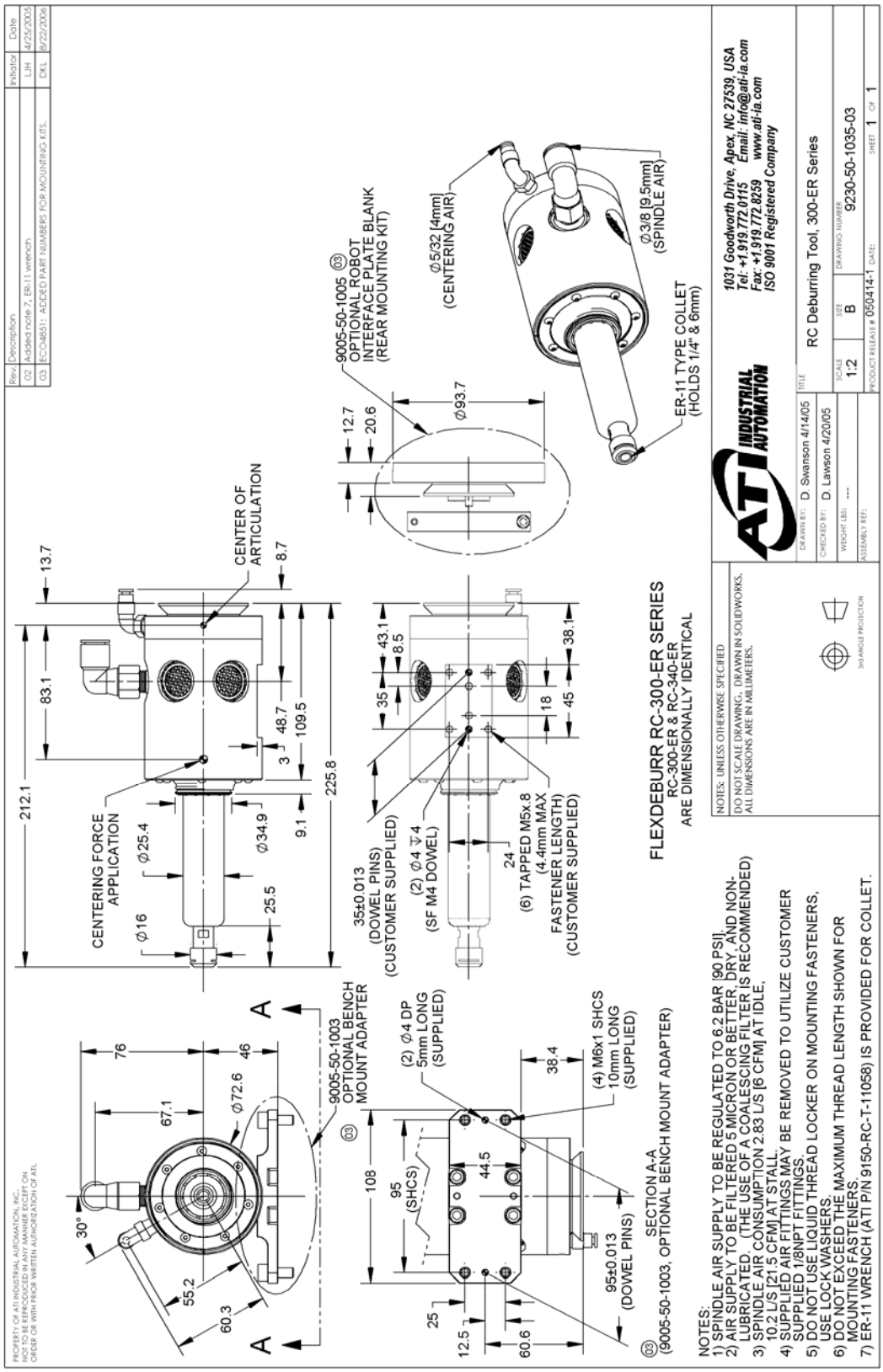


Figure 2.2—RC-300-ER Series Geometry and Mounting

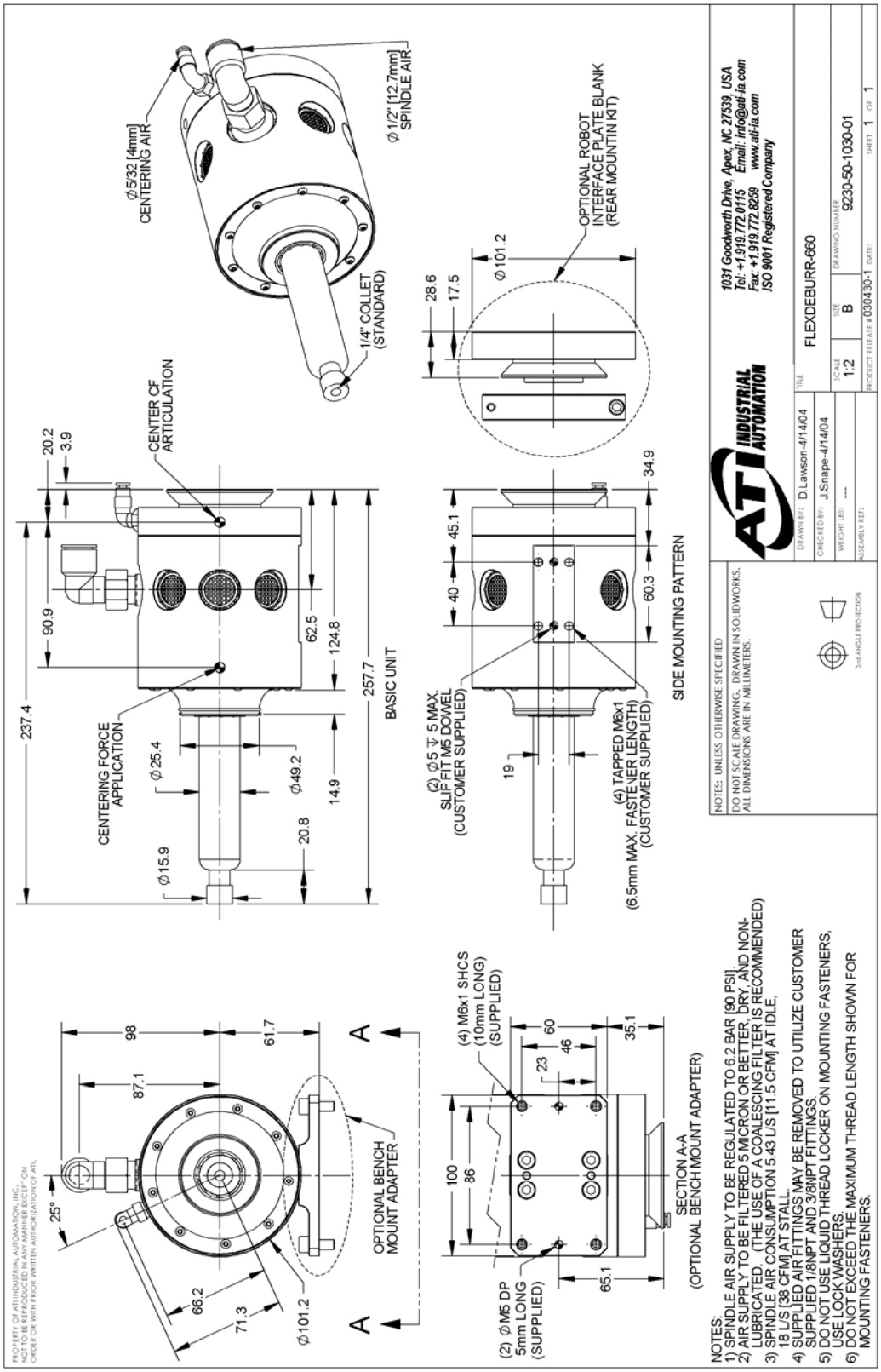


Figure 2.3—RC-660 Geometry and Mounting

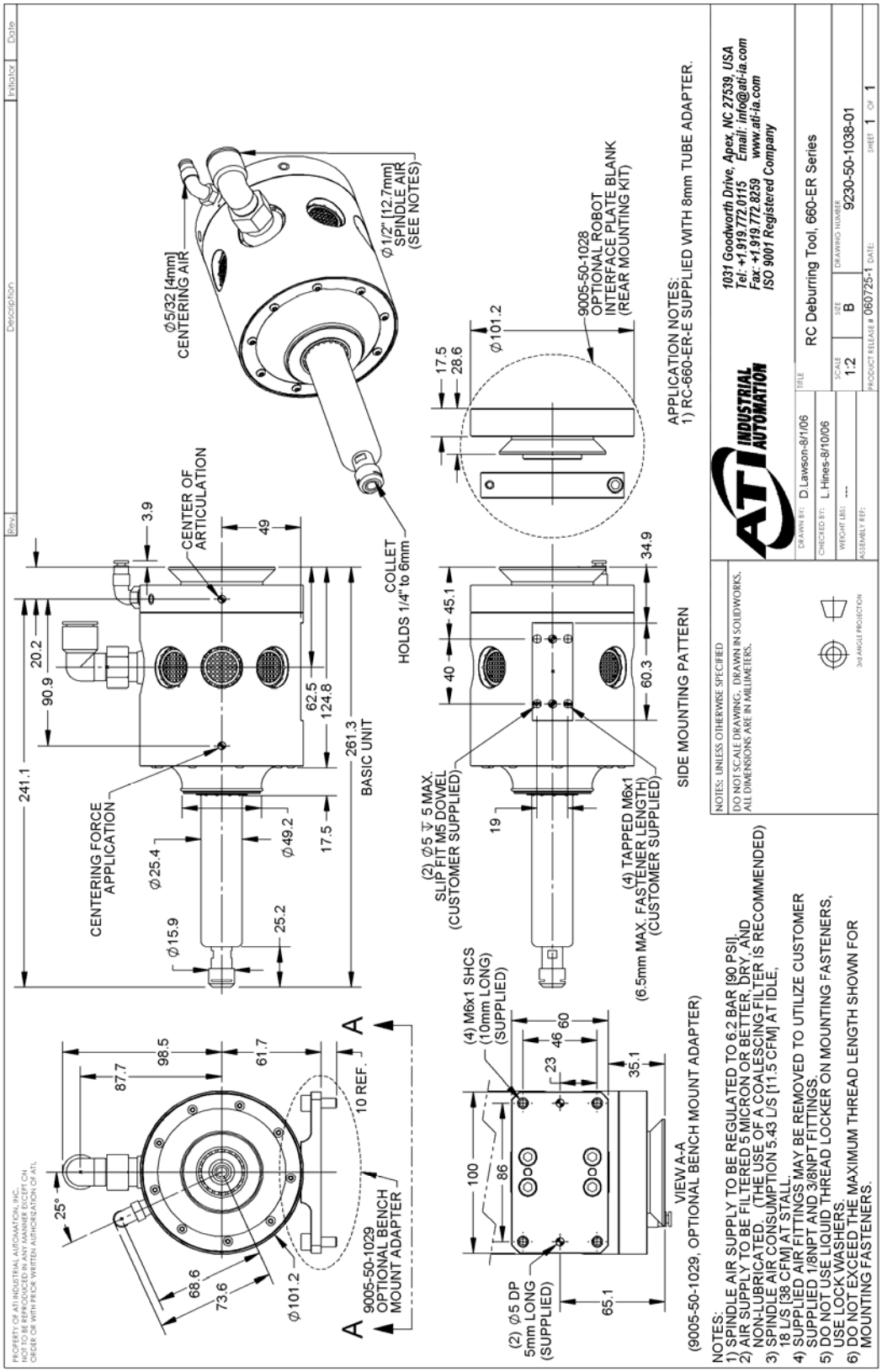


Figure 2.4—RC-660-ER Geometry and Mounting

2.3.2 Pneumatics

Connect the RC deburring tool as shown in Figure 2.3.

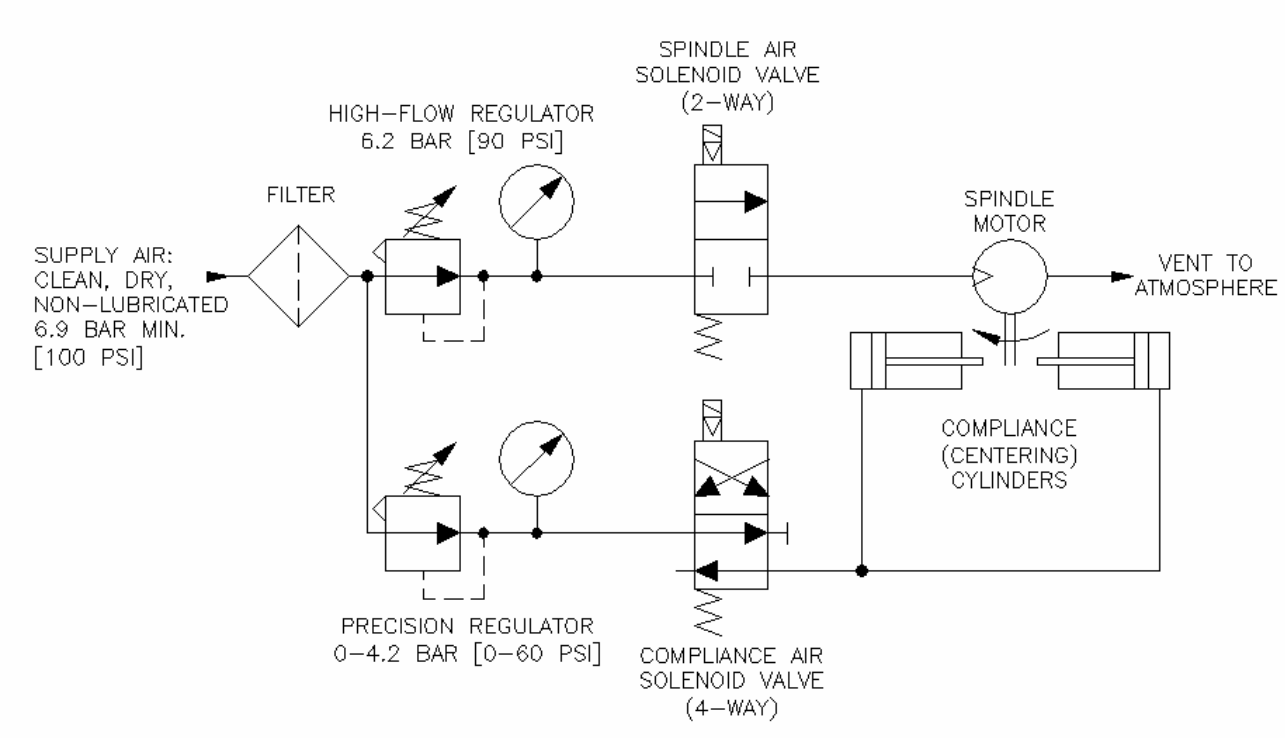


Figure 2.3—Pneumatic Connections

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 6.2-6.5 bar [90-95 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 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 Technical Specifications, Section 3.2). 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 and a high-flow valve to properly supply a stable air supply of 6.2-6.5 bar [90-95 psi] to the spindle motor. (ATI Part #9150-FFR-90, or equivalent. See Section 3.2 for the maximum flow requirements). The RC deburring tool will not operate properly if supplied air below 6.2 bar.

A second, precision, self-relieving regulator and valve are used to supply the compliance (centering) mechanism. This pressure corresponds to the side force on the rotary burr. Very little airflow is required for the compliance mechanism (ATI Part # 9150-PPR-60, or equivalent). This allows a significantly smaller valve to be used.

(Consult the valve and regulator supplier's literature when selecting these components.)

If the complete workpiece 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 workpiece, and this variation is repeatable for all workpieces 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.

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

Function	Connection Type	Pressure
Motor Inlet		
(9150-RC-300 and 340 Series)	3/8" Quick Connect Tube (Alternate: Remove Supplied Fitting to use 1/8-NPT Port, or use 5/16 (8mm) Tubing Adapter)	6.2–6.5 bar [90–95 psi]
(9150-RC-660 Series)	1/2" Quick Connect Tube (Alternate: Remove Supplied Fitting to use 3/8-NPT Port, or use 5/16 (8mm) Tubing Adapter)	
Compliance (Radial) Force Inlet		
(9150-RC-300 and 340 Series)	5/32 (4mm) Quick Connect Tube (Alternate: Remove Supplied Fitting to use 1/8-NPT Port)	1.0–4.1 bar [15–60 psi] (Maximum)
(9150-RC-660 Series)	5/32 (4mm) Quick Connect Tube (Alternate: Remove Supplied Fitting to use 1/8-NPT Port)	
Exhaust	Vented to Atmosphere through the Housing	Not Applicable

Table 2.1—Pneumatic Connections

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 air 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 3.2. To reduce the sound from the cutting operation in neighboring working areas, a customer-supplied barrier surrounding the installation may be installed (Plexiglas or Lexan is preferred, see Section 3.2).

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 a very low pressure and increase slowly until the desired cut is achieved.

2.4 Transportation and Protection during Transportation

The RC deburring tool is packaged in a crate designed to secure and protect it during transportation. Always use the crate when transporting the deburring tool in order to minimize the risk of damage.

2.5 Storage and Preventive Maintenance during Storage

The deburring tool should be stored in its crate 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 the crate.

3. Technical Description

3.1 Product Description

Attached at the end of this document you will find the RC deburring tool product description.

3.2 Technical Specifications

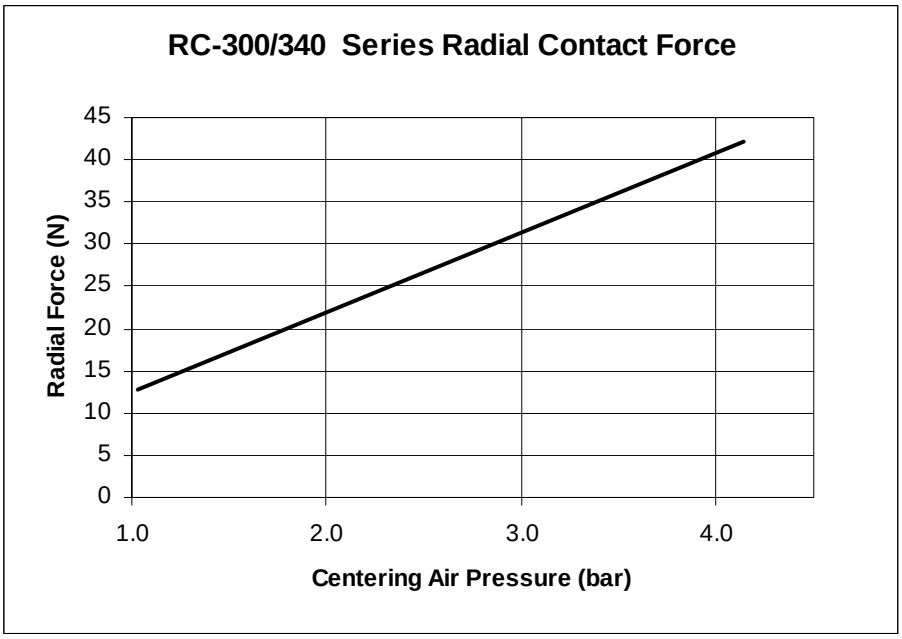
Main specifications for the RC deburring tools:

Parameter	Rating
Motor	Air Turbine
Idle Speed (RPM)	RC-300 Series: 30,000 RC-340 Series: 40,000 RC-660 Series: 40,000
Torque (Max.)	RC-300 Series: 0.09 N-m (0.8 lb-in) RC-340 Series: 0.08 N-m (0.7 lb-in) RC-660 Series: 0.16 N-m (1.4 lb-in)
Power	RC-300 Series: 300 Watts (0.40 hp) @ 30,000 RPM RC-340 Series: 340 Watts (0.46 hp) @ 40,000 RPM RC-660 Series: 660 Watts (0.88 hp) @ 40,000 RPM
Weight (without Adapters)	RC-300 Series: 1.2 kg (2.6 lb) RC-340 Series: 1.2 kg (2.6 lb) RC-660 Series: 2.2 kg (4.9 lb)
Compensation (Radial)	RC-300 Series: +/- 7.5mm max., +/- 3mm recommended RC-340 Series: +/- 7.5mm max., +/- 3mm recommended RC-660 Series: +/- 9mm max., +/- 4.5mm recommended
Compliance Force (Measured at Collet)	RC-300 Series: 12.7-42 N (2.8–9.5 lb) @ 1.0-4.1 bar (15–60 psi) RC-340 Series: 12.7-42 N (2.8–9.5 lb) @ 1.0-4.1 bar (15–60 psi) RC-660 Series: 12.8-45.4 N (2.8–10.2 lb) @ 1.0-4.1 bar (15–60 psi)
Burr Surface Speed	Dependent on cutter geometry and motor
Spindle Air Pressure	6.2-6.5 bar (90–95 psi) (All Models) [6.9 bar (100 psi) max]
Air Consumption (Idle)	RC-300 Series: 2.8 l/s (6 CFM) RC-340 Series: 2.8 l/s (6 CFM) RC-660 Series: 5.4 l/s (11.5 CFM)
Air Consumption (Stall)	RC-300 Series: 10.2 l/s (21.5 CFM) RC-340 Series: 10.2 l/s (21.5 CFM) RC-660 Series: 17.9 l/s (38 CFM)
Sound Pressure Level	Less than 70 dB(A) (All Models, without Cutter)
Collet Size (Standard)**	1/4" (All Models), -E Models Supplied with 6mm Collets
Rotary Burrs ++	Commercial Units Rated 40,000 RPM or Higher
Special Tools	Open End Wrenches (1 Pair Supplied)
	9/16" (14.5mm), 7/16" (11mm)
	10mm Narrow (Only for use with ER11 Collets, -ER Models)
Specifications applied to a series of models cover the basic “inch” designs, metric -E models, and -ER models with the ER-11 collet system.	
** Optional Sizes Available, See Section 6	
++ ATI Can Supply Burrs, See Section 7.2	

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.

Each RC deburring tool receives a thorough test procedure before it is shipped.

Below are measured forces relative to applied compliance (centering) air pressure. Measurements may vary from one product to another, and should only be treated as nominal.



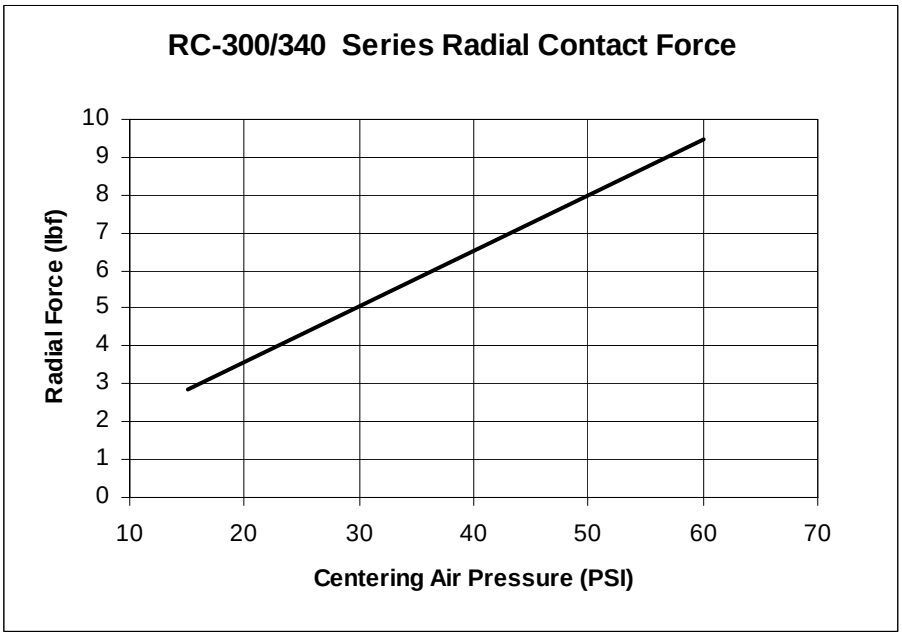
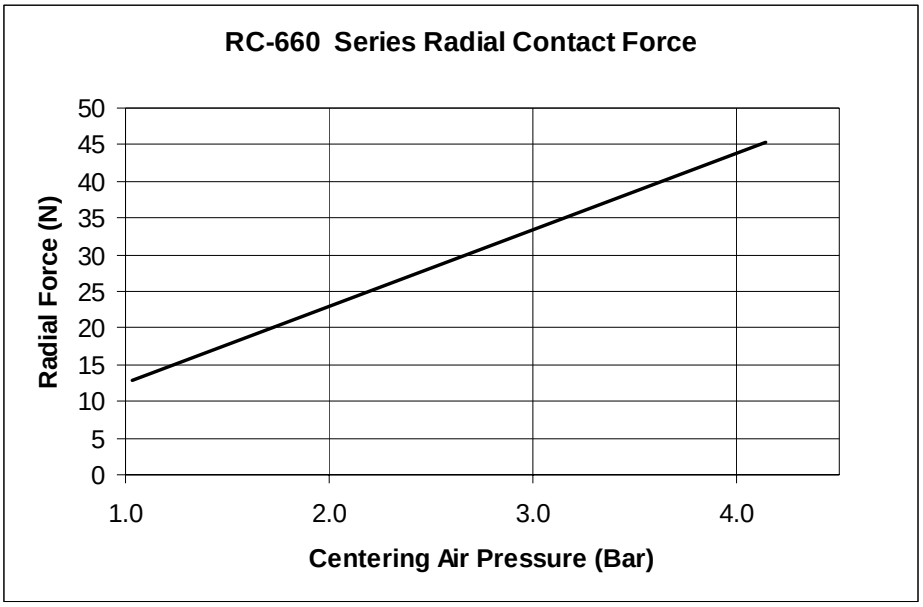


Figure 3.1—RC-300/340 Series Radial Compliance Force Curves

(Measured at the Spindle Tip)



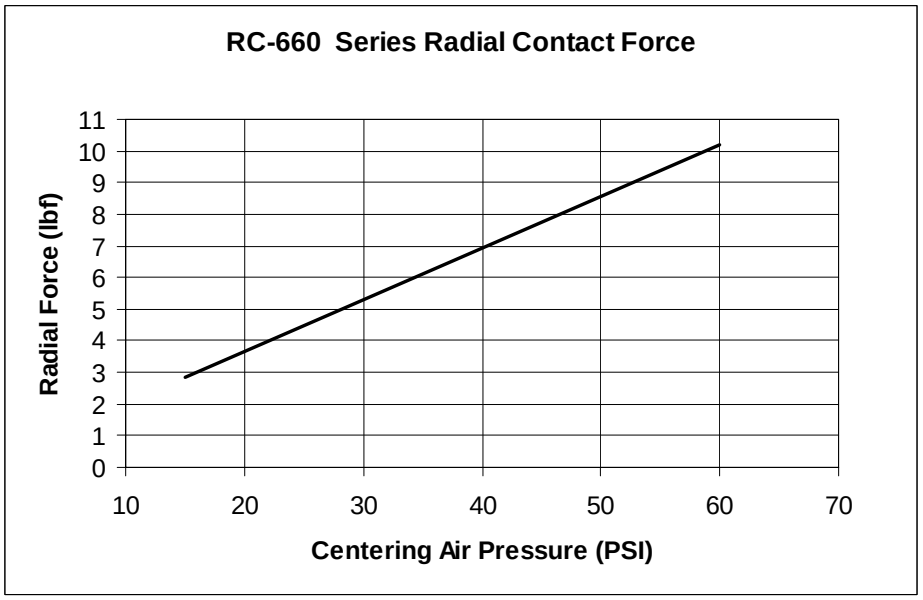
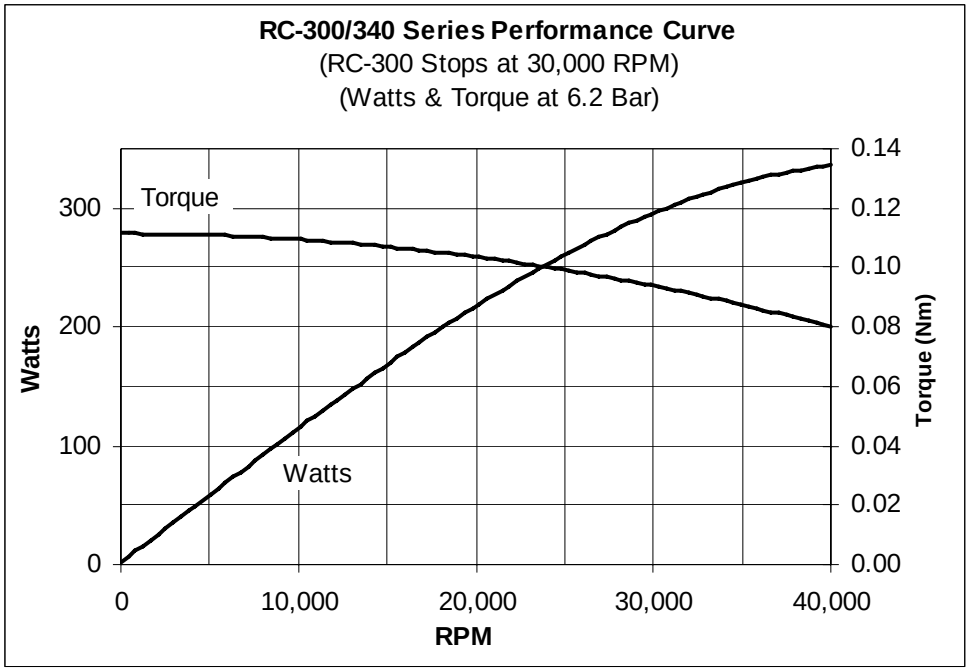


Figure 3.2—RC-660 Series Radial Compliance Force Curves

(Measured at the Spindle Tip)

The actual force characteristics will vary slightly from installation to installation due to mounting orientation and condition of the unit.

The air turbine will attempt 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. Typical motor performance is shown in the figures below.



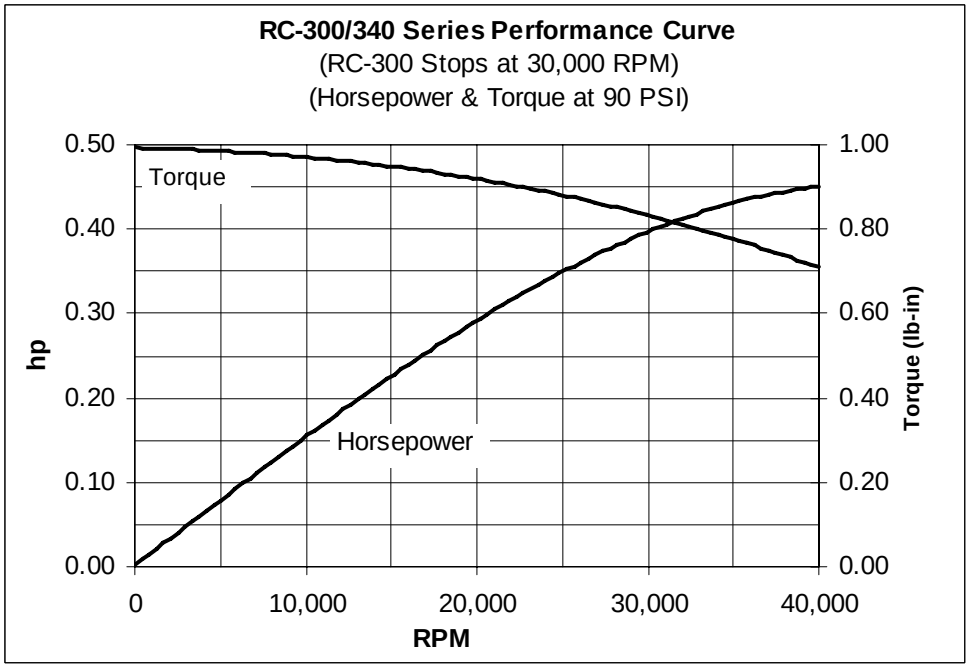
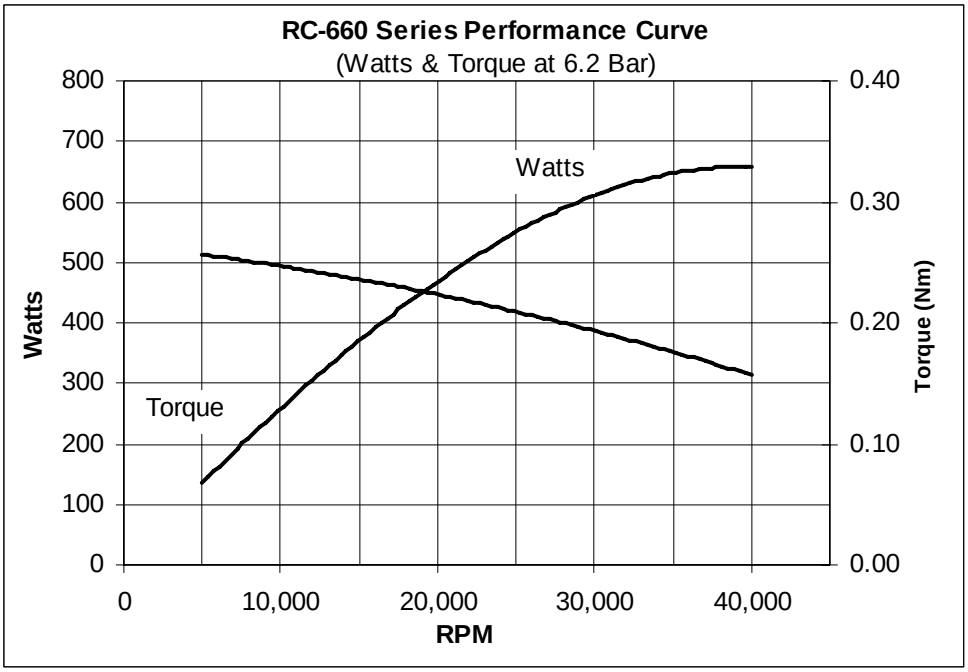


Figure 3.3—RC-300/340 Series Motor Performance Curves



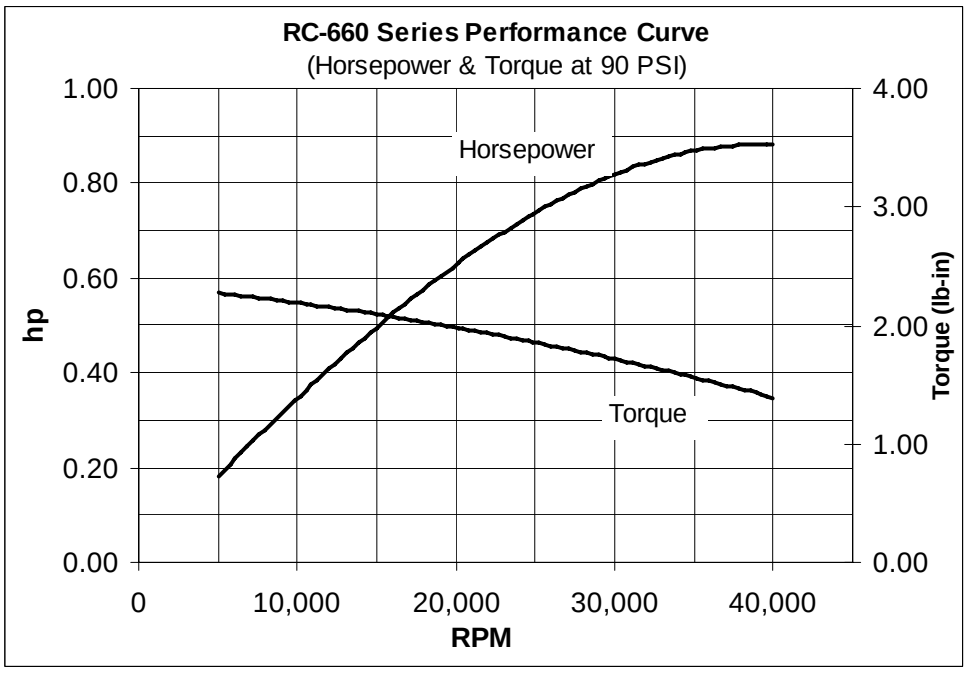


Figure 3.4—RC-660 Series Motor Performance Curves

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, in general, and should have extensive knowledge relating to robots and automation incorporating robots.

4.1 General Precautions

It is important that all personnel involved in operation of the RC deburring tool have a thorough understanding of the operating procedures. Failure to follow these or neglecting safety precautions can create hazardous situations, which may, in the worst case, injure personnel or damage the deburring installation and the RC deburring tool.

The RC deburring tool must only be used for robotic deburring applications. The Flexdeburr is a deburring tool only.

DANGER: Never use the Flexdeburr for purposes other than robotic deburring.

Countersinking and other axial metal-forming processes should not be performed by the Flexdeburr. It may be dangerous to operate the RC deburring tool for these purposes. If a failure occurs due to forces caused by improper use, hazardous situations for both personnel and equipment could be created. The RC deburring tool is intended to perform deburring only.

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

Reduce the robot velocity when the workpiece and the RC deburring tool are making initial contact. Making the contact movement between the deburring tool and the workpiece too fast may in some situations result in a collision. Collisions may create hazardous situations for both personnel and equipment.

Use lock washers with the mounting fasteners. When performing maintenance, always remember to tighten nuts and bolts. When replacing burrs, always attach the burr correctly. Please consult Section 5.3.

DANGER: Never use the Flexdeburr as a hand-held machine.

4.2 Flexdeburr Working Environment

As described in previous sections, the RC 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 RC 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. Always use hearing protection while working in the neighborhood of the deburring cell.

4.3 Operational Considerations

For instructions on how to replace the burr, please consult Section 5.1.

In many robotic deburring applications, including steel and aluminum, no cooling or lubrication of the rotary burr is necessary. For some materials and situations, the addition of coolants or compressed air may aid the cutting process. If it is determined that liquid coolants are required, a non-oil, cutting type should be used to prevent premature wear of the spindle bearing.

Burr selection is discussed in Section 4.5.

4.4 Tool Center Point (TCP) Position and Programming

Figure 2.1 shows the RC 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 cutting tool (simulating the cutter shank diameter) when teaching the robot path. For 6mm collets, this will mean a 6mm diameter pin of suitable length. The dowel pin should extend sufficiently from the collet to reach the surface on the burr where cutting is desired (see Figure 4.1). The diameter of the cutter should not exceed that of the dowel pin by more than the compliance of the RC deburring tool.

Another programming method is to teach the path using the centerline of the burr 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 burr path (see Figure 4.2). The programming method used will depend on the robot's capabilities and programmer preferences.

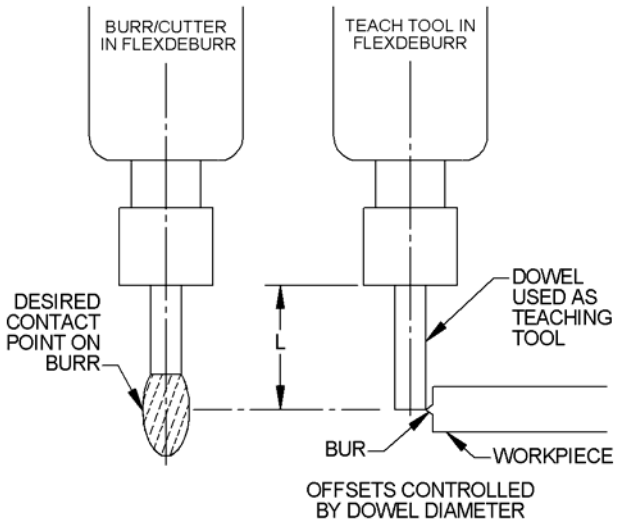


Figure 4.1—Flexdeburr Dowel Teaching Tool

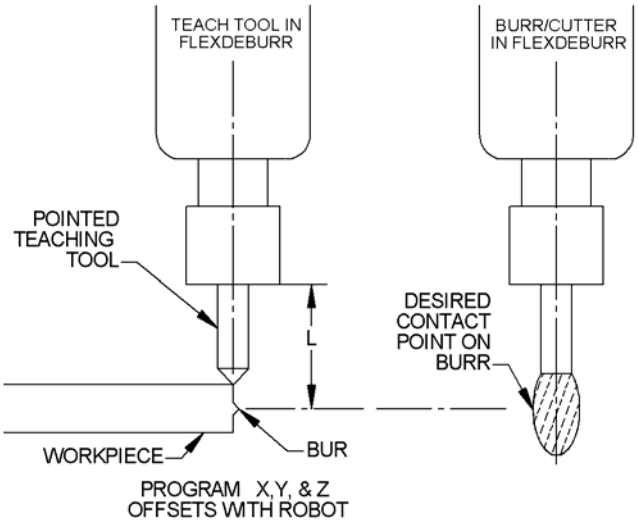


Figure 4.2—Flexdeburr Pointed Teaching Tool

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

When deburring inside radii, a similar situation may arise. The customer is advised that no attempt should be made to deburr an inside radius less than 1.5 times the diameter of the desired cutter (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, it is important to notice that robot may deviate from the programmed path. Verify that at operational robot path speed, the burr is deflected, but contacts the work surface. Once the robot path has been confirmed, the compliance force of the burr should be adjusted, as described in Section 2.3.2, in order to achieve a correct depth of cut.

4.5 Cutter Operation and Burr Selection

The RC deburring tool will perform best in “climb milling”. This refers to a cutter whose directions of traverse and cutter rotation are the same. In the case of the RC deburring tools, the cutter 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 workpiece and the chip becomes narrower as the cut is completed. In “conventional milling”, the cutter travels in a direction opposite of cutter rotation. This 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 will generally be reduced. When “conventional milling”, extra care must be taken around corners. This poses a potential hazard where the cutting force can deflect the burr and cause the burr 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 7 for a short list of burrs and suitable applications. It is worth mentioning here that a specific family of burrs is available for working with die cast alloys, aluminum, and plastics. These cutters 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 cutter is dull or the feeds and speeds are not correct for the material the removed, chip will melt and weld to the cutter or the workpiece. This can quickly load a cutter and produce unacceptable results. In general, the traverse or feed rate of the deburring tool will be higher for plastics to minimize this behavior. This results in larger cuts, which more effectively remove heat from the cutter-tool interface.

Do not use extended or long shank burrs with Flexdeburr. See Section 7 for a detailed explanation.

> ⚠ **CAUTION:** DO NOT use long or extended shank burrs with the Flexdeburr. Long shank tools can lead to premature failure of the air motor and is not covered under warranty.

4.6 Safety Precautions

- Never use or start the deburring tool without first reading and understanding the operating procedures described in this manual.
- Make sure that the deburring tool is mounted as described in this document.
- Never use the deburring tool for any purposes, or in any ways, not explicitly described in this document.
- Make sure that the pneumatic control equipment is connected as described.
- Only original spare parts supplied by ATI must be used.
- A barrier to prohibit people from approaching the deburring tool while in operation must secure the installation.
- Never be present near the deburring tool while it is started or running. If it is necessary to approach the deburring tool while in motion, stand behind appropriate Plexiglas windows.
- Be aware of rotating parts.
- Burrs must be rated for at least the speed of the RC deburring tool being used.
- Use eye protection.
- Be aware of high sound levels during cutting. Always use hearing protection while working in the neighborhood of the deburring tool.

5. Maintenance Instructions

The RC 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 is encouraged to return the unit to ATI for service. The following information is provided to assist the user when they choose 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. During maintenance operations, refer to the figures in Section 6. Service and repair parts are identified in Section 6.

5.1 Burr Replacement

In normal operation the burr will become worn. If improper feeds and speeds are used, the cutter may become “loaded” with material. In both instances, the cutter will need to be replaced. During initial production, the burr and the workpiece should be examined often in order to determine at what interval the burr should be replaced.

The following steps detail replacing the cutter.

1. If the cutter is to be replaced with one of an identical type, measure and record the length of the tool extending beyond the collet lock nut.
2. Use one of the open-end wrenches to hold the spindle shaft where it exits the air motor housing.
3. Use the second open-end wrench to turn the collet locknut counter-clockwise when viewed from the cutter tip.
4. Remove and replace the cutter. If an identical new cutter is replacing a worn one, measure and adjust the length of its exposed portion according to the measurement taken in Step 1.
5. Tighten the collet by reversing the steps above and restore the air supply.

5.2 Air Motor Replacement

If the air 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 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 air 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.

1. Remove the brass plug or hex socket screw from the center of the deburring unit's rear plate.
2. Remove the spindle air supply fitting from the side of the housing by rotating it counter-clockwise.
3. Ease the garter spring off the front spindle boot.
4. Remove the socket head cap screws that secure the rear housing cover.
5. Remove the rear cover and withdraw the air motor complete as an assembly. Retain the small o-ring and dowel pin located between the cover and housing for reuse.
6. Motors are available from ATI as a complete subassembly. Refer to the figures in Section 6 for part numbers.
7. Reassembly is the reversal of these steps noting the following important steps.
   - Insure that the small o-ring and dowel pin are in place on the housing before fitting the rear cover.
   - Apply light-weight, liquid thread locker (Loctite 222® or equivalent) to the socket head cap screws and tighten to secure the rear cover.

- Install the spindle air supply fitting in the air motor using non-hardening thread sealant.
- Insure that the spindle air supply fitting is centered in the housing (side boot) opening before tightening the fastener in the pivot post.

5.3 Pivot Bearing Replacement

The pivot bearing allows articulation of the motor assembly. The pivot bearing is subject to wear and should be replaced when excessive spindle motion is observed. Contact between the motor air supply fitting and the main housing indicates pivot bearing wear which should be corrected. To minimize possible downtime, the pivot bearing should be replaced any time the air motor is replaced. Early Flexdeburr units can be identified by their lack of radial and axial tapped holes for the pivot bearing keying dowel (see Figure 5.3). During maintenance of these units the customer should replace the entire rear housing assembly to upgrade the deburring tool. The early style of pivot bearing and rear housing are not currently supported.

The pivot bearing may be replaced in one of two ways. For quick repairs with minimal downtime the user is encouraged to replace the entire rear housing assembly. When a spare unit can be placed into service or downtime is not an issue a new pivot bearing can be installed in an existing rear housing.

Refer to the steps below to replace the pivot bearing.

Rear Housing Assembly Replacement

1. Remove the brass plug or hex socket screw from the center of the deburring unit's rear housing.
2. Remove the socket head screws securing the rear housing to the deburring tool's front housing.
3. Remove the rear cover complete with the pivot bearing. Retain the small o-ring and dowel pin between the cover and housing for reuse if desired.
4. The new rear housing assembly will be provided with new fasteners and a new o-ring. Reassembly is the reversal of the previous steps with the following points:
   - Insure the dowel pin and small o-ring that go between the housing and the rear cover are in place before refitting the rear cover.
   - Use liquid thread locker on all the socket head screws, but NOT on the brass pivot post plug (where applicable).
   - Insure that the spindle air supply fitting is centered in the housing (side boot) opening prior to tightening the fastener in the pivot bearing post.

Pivot Bearing & Keying Dowel Replacement

(NOTE: Always replace the pivot bearing keying dowel when the bearing is replaced).

1. Remove the rear housing assembly as described above.
2. Remove the three socket head screws securing the pivot bearing in the center of the rear housing.
3. Remove the large clamping washer which rests on top of the pivot bearing.
4. Locate and loosen the radially tapped bearing preload set screw in the rear housing.
5. Locate the two set screws securing the pivot bearing keying dowel in the rear housing. One will be radially tapped in the rear housing and the second will be axially tapped on the rear mounting surface. Remove both screws.
6. Use a small diameter magnet or a powerful magnet attached to the side of a hex key to reach inside the keying dowel pin hole and remove the keying dowel pin from the rear housing.
7. With the dowel pin removed the old pivot bearing can be pressed from the rear housing.
8. Reassembly is the reversal of the previous steps with the following points:
   - Insure that the hole in the outer race of the new pivot bearing lines up with the radial dowel pin hole in the rear housing and insert the pivot bearing in the rear housing bore.

- Always use a new keying dowel pin. Insert the keying dowel pin with its crowned (radiused) end first so it rests in the slot machined in the pivot bearing's ball.
- Apply low strength thread locker such as Loctite-222 to the socket head screws used to secure the clamping washer and refit both the washer and screws to the rear housing. Leave the fasteners finger-tight at this time.
- Sparingly apply a low strength thread locker to the keying dowel pin set screws and insert both set screws in the rear housing.
- Adjacent to the keying dowel pin, pivot the bearing's ball by several degrees until the ball's top surface is flush with the clamping washer. Tighten the keying dowel's radial set screw until it just contacts the end of the dowel.
- While holding the pivot bearing ball in the deflected position tighten the keying dowel's axial set screw securely to lock the dowel pin in place.
- Apply two or three drops of light machine oil (or 30 weight engine oil) to the ball of the pivot bearing and its keying slot.
- Refit the rear housing assembly as described in the previous section.

Once installed on the deburring tool, tighten the bearing preload set screw until slight resistance to motion can be felt when the spindle is articulated like a joystick. Tighten all socket head cap screws securely. Do not tighten the set screws further.

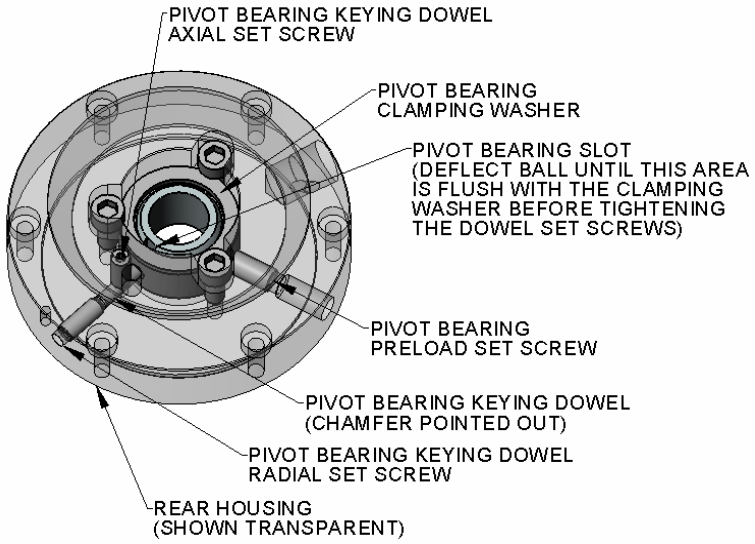


Figure 5.3—Pivot Bearing Components

5.4 Ring Cylinder Assembly

The compliant motion of the air motor spindle is accomplished using a circular array of pistons (ring cylinder) at the front of the housing. After extended operation, this component may need replacing to insure 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.

1. Remove the air motor as described previously.
2. Remove the front spindle boot and its retaining ring by extracting the socket head screws at the front of the housing.
3. Use a small flat blade screwdriver to pry the ring cylinder retaining ring free and remove it from the front of the housing.
4. From inside the housing, use a non-metallic drift to press the ring cylinder out of the housing. (After prolonged periods of use the o-ring seals may make removal of the compliance unit difficult. If this occurs, support the front of the housing on a suitable plate with a clearance hole for the ring cylinder and use an arbor press for extraction.) Retain the

small o-ring and dowel pin for reuse. Always replace the large o-rings on the outside of the ring cylinder assembly when it is reinstalled.

5. Replacing the ring cylinder assembly is the reversal of these steps with the following points.
   - Apply a thin film of grease or oil to the housing bore where the ring cylinder seats prior to installation.
   - Fit new o-rings to the outside of the ring cylinder assembly if the old unit is being reinstalled. (Do not reuse the old o-rings.)
   - Insure that the small o-ring and dowel pin are in place inside the housing before sliding the ring cylinder assembly into place.
   - Align the assembly marks on the housing entrance and the flat surface of the ring cylinder assembly prior to pressing the ring cylinder in the bore.
   - Use hand pressure and a flat plate to press the ring cylinder into the housing and past the retaining ring groove.

5.5 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.

5.6 Lubrication

Lubrication systems are not to be used. The Flexdeburr air motor must be supplied with clean, dry, filtered air. Oil in the air stream will cause the air motor to fail prematurely. Failure of the motor due to oil in the air stream is not covered under the warranty. See Section 2.3.2 for details on air supply and quality.

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

6. Recommended Spare Parts

For repair and spare parts please contact ATI. Figure 6.1 and 6.2 are exploded drawings showing all the user replaceable components of the Flexdeburr. Suggested user-replaceable, optional, and spare parts are listed in the tables below. All other repairs must be performed by ATI.

The following optional parts are available for the Flexdeburr:

Part Number	Description
9150-RC-C-12442	Ø 3mm Collet
9150-RC-C-12443	Ø 1/8” Collet
9150-RC-C-12444	Ø 3/16” Collet
9150-RC-C-12445	Ø 6mm Collet
9150-RC-C-12446	Ø 1/4” Collet
9150-RC-C-12449	Collet Nut
9150-FFR-90	High-Flow Filter/Regulator Assembly
9150-PPR-60	Precision Regulator
3405-1210010-01	Spindle Tubing Adapter, 3/8" to 5/16" [8mm]
3405-1210011-01	Spindle Tubing Adapter, 1/2" to 5/16" [8mm]
The Parts Below are Unique to the 9150-RC-###-ER Series (ER-11 Collets)	
Part Number	**Description**
9150-RC-C-11048	Ø 4mm ER-11 Collet
9150-RC-C-11054	Ø 1/4” ER-11 Collet

ATI recommends stocking the following spare parts:

Part Number	Description
3700-50-3007	RC-300/340 Series Boot
3700-50-4005	RC-660 Series Boot
9150-RC-T-12475	7/16” [11mm] Open End Wrench
9150-RC-T-12479	9/16” [14.5mm] Open End Wrench
9150-RC-T-11058	10mm Wrench for ER-11 Collet (-ER models only)

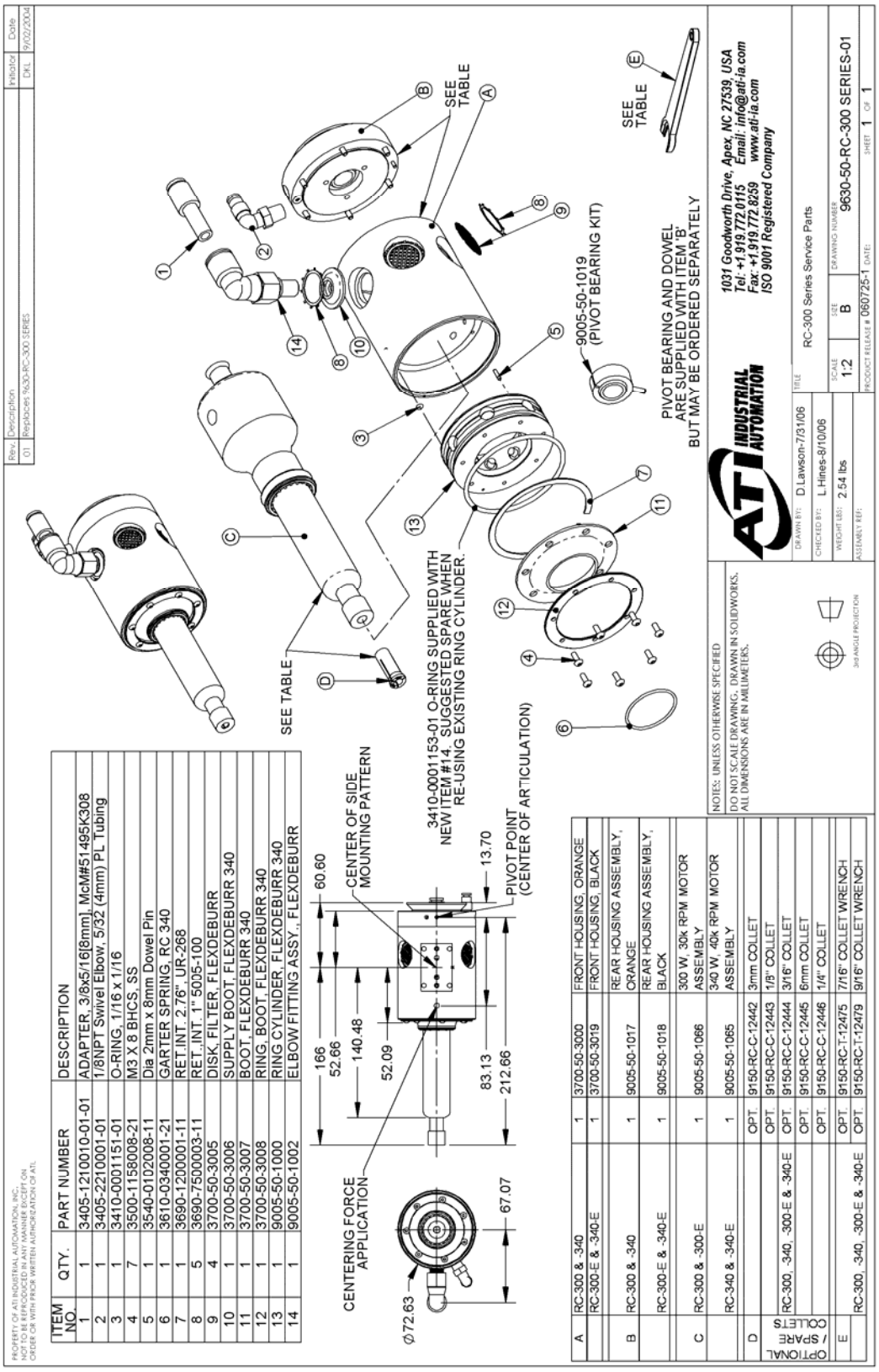
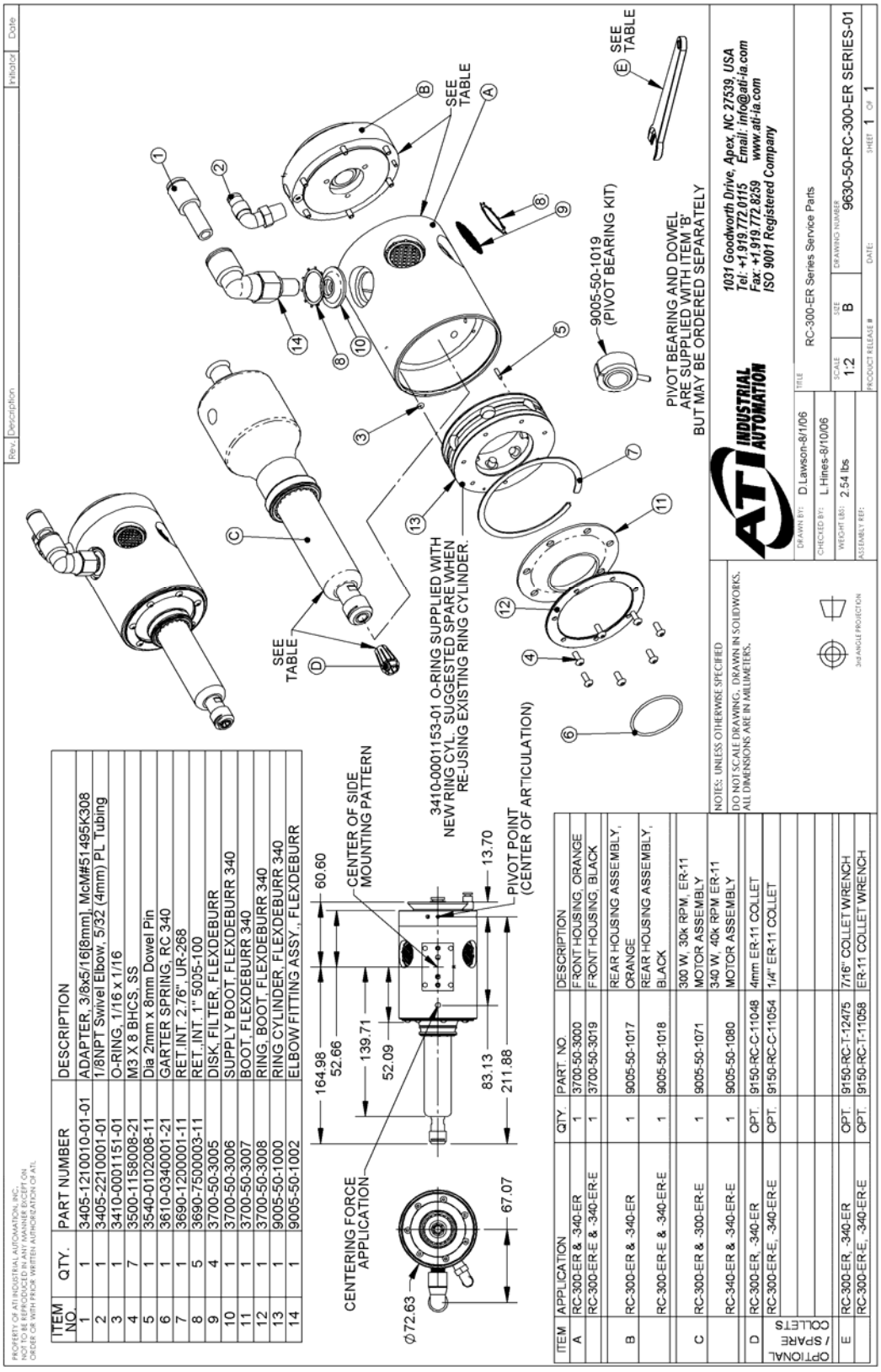


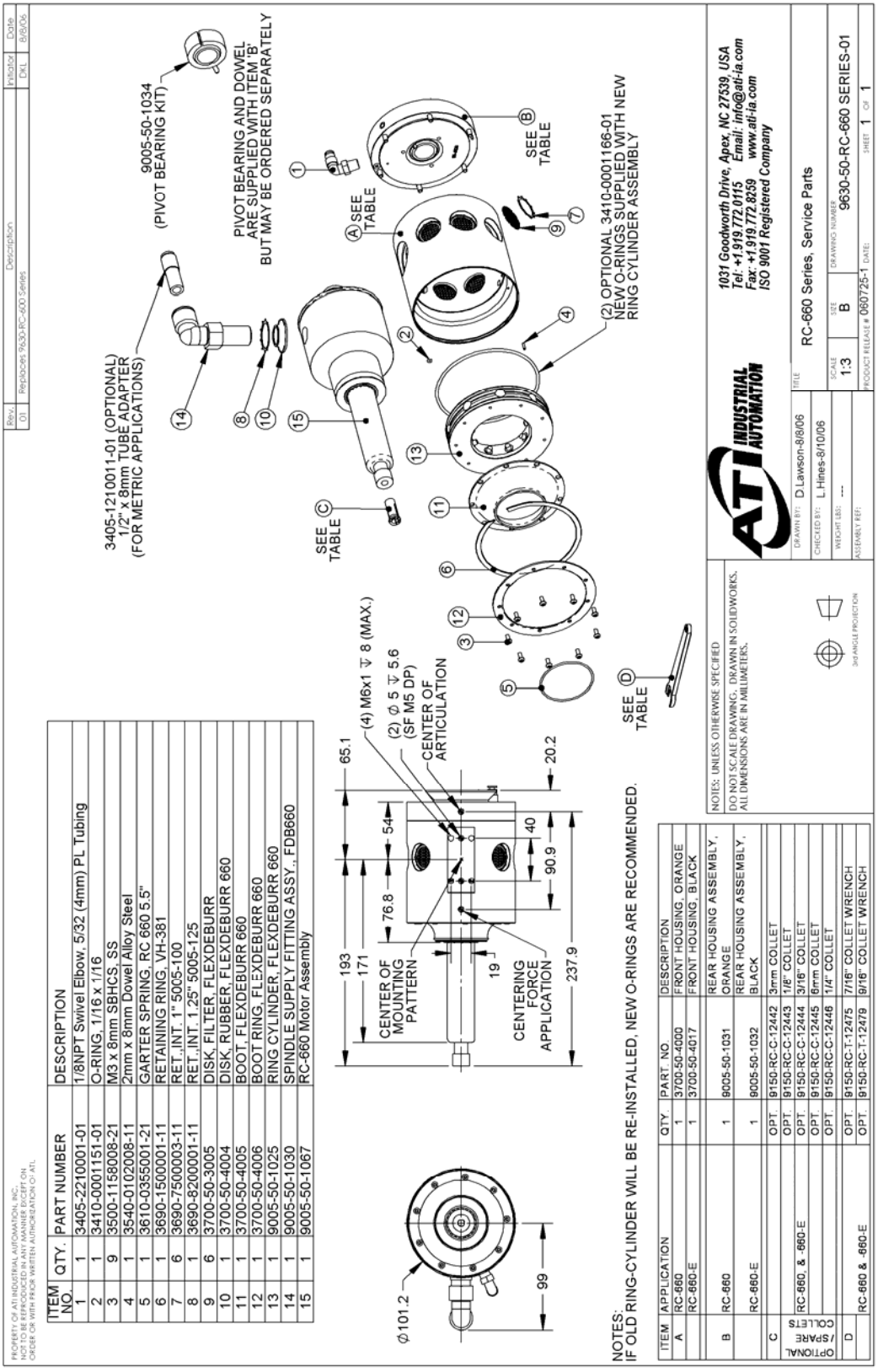
Figure 6.1—RC-300 Series Serviceable Parts



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	1	3610-0340001-21	GARTER SPRING, RC 340
7	1	3690-1200001-11	RET.INT, 2.76", UR-268
8	5	3690-7500003-11	RET., INT, 1" 5005-100
9	4	3700-50-3005	DISK, FILTER, FLEXDEBURR
10	1	3700-50-3006	SUPPLY BOOT, FLEXDEBURR 340
11	1	3700-50-3007	BOOT, FLEXDEBURR 340
12	1	3700-50-3008	RING, BOOT, FLEXDEBURR 340
13	1	9005-50-1000	RING CYLINDER, FLEXDEBURR 340
14	1	9005-50-1002	ELBOW FITTING ASSY., FLEXDEBURR

ITEM	APPLICATION	QTY	PART NO	DESCRIPTION
A	RC-300-ER & -340-ER	1	3700-50-3000	FRONT HOUSING, ORANGE
	RC-300-ER-E & -340-ER-E	1	3700-50-3019	FRONT HOUSING, BLACK
B	RC-300-ER & -340-ER	1	9005-50-1017	REAR HOUSING ASSEMBLY, ORANGE
	RC-300-ER-E & -340-ER-E	1	9005-50-1018	REAR HOUSING ASSEMBLY, BLACK
C	RC-300-ER & -300-ER-E	1	9005-50-1071	300 W, 30k RPM, ER-11 MOTOR ASSEMBLY
	RC-340-ER & -340-ER-E	1	9005-50-1080	340 W, 40k RPM ER-11 MOTOR ASSEMBLY
D	RC-300-ER, -340-ER	OPT	9150-RC-C-11048	4mm ER-11 COLLET
	RC-300-ER-E, -340-ER-E	OPT	9150-RC-C-11054	1/4" ER-11 COLLET
OPTIONAL / SPARE COLLETS				
E	RC-300-ER, -340-ER	OPT	9150-RC-T-12475	7/16" COLLET WRENCH
	RC-300-ER-E, -340-ER-E	OPT	9150-RC-T-11058	ER-11 COLLET WRENCH

Figure 6.2—RC-300-ER Series Serviceable Parts



ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	3405-2210001-01	1/8NPT Swivel Elbow, 5/32 (4mm) PL Tubing
2	1	3410-0001151-01	O-RING, 1/16 x 1/16
3	9	3500-1158008-21	M3 x 8mm SBHCS, SS
4	1	3540-0102008-11	2mm x 8mm Dowel Alloy Steel
5	1	3610-0355001-21	GARTER SPRING, RC 660 5.5"
6	1	3690-1500001-11	RETAINING RING, VH-381
7	6	3690-7500003-11	RET.,INT. 1" 5005-100
8	1	3690-8200001-11	RET.,INT. 1.25" 5005-125
9	6	3700-50-3005	DISK, FILTER, FLEXDEBURR
10	1	3700-50-4004	DISK, RUBBER, FLEXDEBURR 660
11	1	3700-50-4005	BOOT, FLEXDEBURR 660
12	1	3700-50-4006	BOOT RING, FLEXDEBURR 660
13	1	9005-50-1025	RING CYLINDER, FLEXDEBURR 660
14	1	9005-50-1030	SPINDLE SUPPLY FITTING ASSY., FDB660
15	1	9005-50-1067	RC-660 Motor Assembly

ITEM	APPLICATION	QTY.	PART. NO	DESCRIPTION
A	RC-660	1	3700-50-4000	FRONT HOUSING, ORANGE
	RC-660-E	1	3700-50-4017	FRONT HOUSING, BLACK
B	RC-660	1	9005-50-1031	REAR HOUSING ASSEMBLY, ORANGE
	RC-660-E	1	9005-50-1032	REAR HOUSING ASSEMBLY, BLACK
C		OPT.	9150-RC-C-12442	3mm COLLET
		OPT.	9150-RC-C-12443	1/8" COLLET
	RC-660 & -660-E	OPT.	9150-RC-C-12444	3/16" COLLET
		OPT.	9150-RC-C-12445	6mm COLLET
		OPT.	9150-RC-C-12446	1/4" COLLET
D		OPT.	9150-RC-T-12475	7/16" COLLET WRENCH
	RC-660 & -660-E	OPT.	9150-RC-T-12479	9/16" COLLET WRENCH

Figure 6.3—RC-660 Series Serviceable Parts

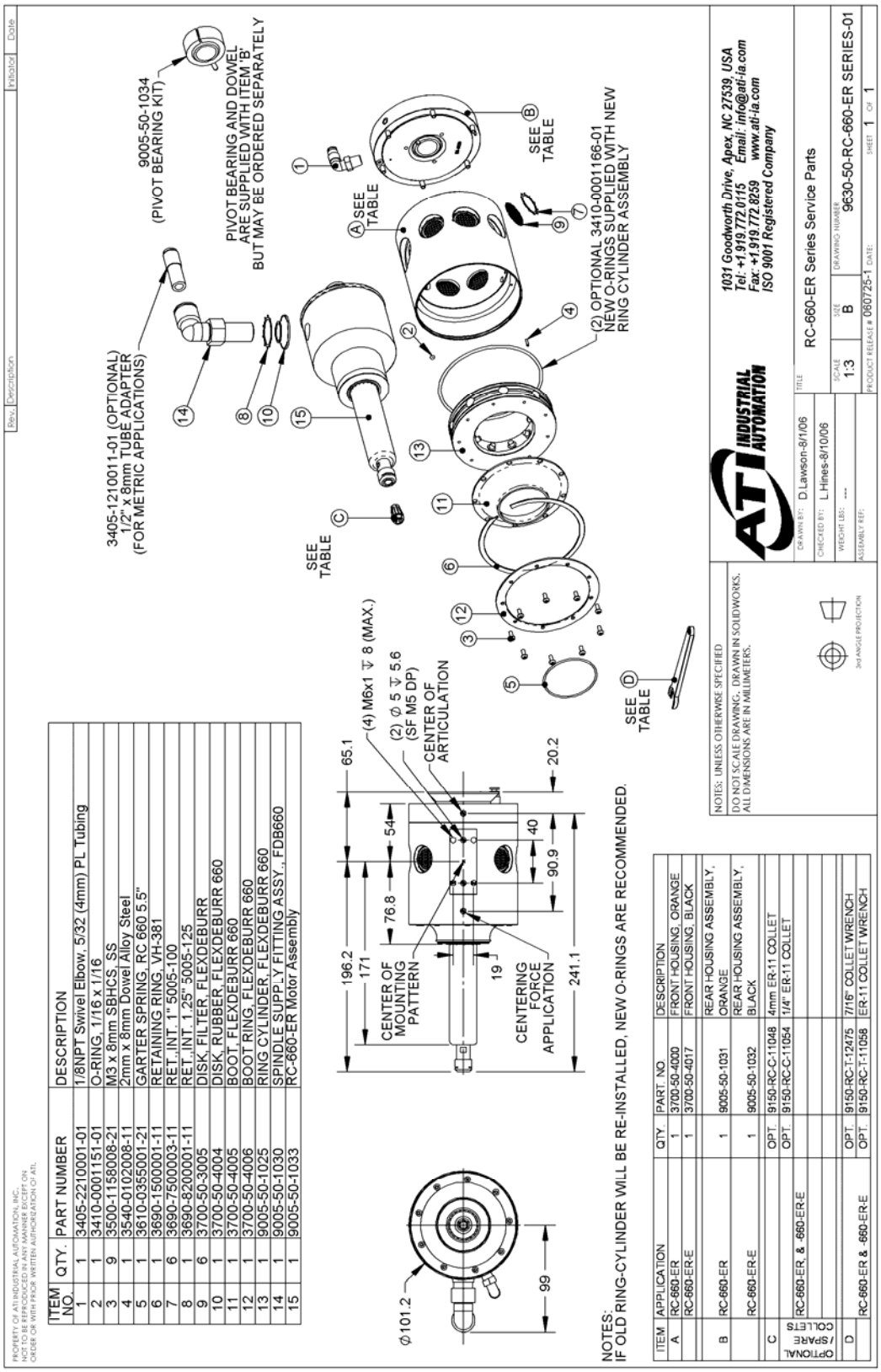


Figure 6.3—RC-660-ER Series Serviceable Parts

7. Troubleshooting and Burr Selection

7.1 Troubleshooting Matrix

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

Problem	Cause	Solution
Wear	Hard work material	Use better grade burr material add coating (TiAlN)
	Too heavy a cut	Decrease width of cut/make multiple passes
	Feed rate is too slow	Increase feed rate
Breakage	Too heavy a cut	Decrease width of cut/make multiple passes
	Deflection at corner	Climb mill/do not begin path at sharp corner
	Impacting part	Decrease feed rate at contact/ enter part at an angle
Unequal compliance	Pivot bearing worn	Replace pivot bearing Section 5.3
	Compliance preload screw not set properly	See Section. 5.3 step 7
	Worn ring cylinder	Replace ring cylinder Section 5.4
Poor finish	Feed rate is too fast	Reduce feed rate
	Burr is worn	Replace or regrind burr
Chattering	Feed rate is too fast	Reduce feed rate
	Lack of rigidity	Increase radial compliance pressure
	Too heavy a cut	Decrease width of cut/make multiple passes
	Improper Burr selection	Choose burr designed for work material
Secondary Burrs	Incorrect feed rate	Reduce feed rate
	Too heavy a cut	Decrease width of cut/make multiple passes
	Improper Burr selection	Choose burr designed for work material
Chip Packing	Too heavy a cut	Decrease width of cut/make multiple passes
	Not enough chip clearance	Use a burr with less flutes
Burr stalls	Not enough or no drive air	Check drive air regulator for 90 psi [6.2 bar] and for leaks
	Burr is not secure in collet	Properly tighten burr in collet
	Too much side load	Decrease width of cut/make multiple passes
	Air motor needs replacing	Replace air motor
Sticking spindle	Spindle bearings are worn	Replace air motor

7.2 Burr Selection Table

Standard length commercial burrs are used with Flexdeburr products. The length of these tools is typically around 2 inches for 1/4” shank diameter burrs [50mm for 6mm diameter]. Longer shank burrs are available from industrial suppliers and will appear in their catalogs with descriptions such as “long” or “extended” shank. Their use is to be avoided. Using extended or long shank burrs 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 burrs is not covered under warranty.

> ⚠ **CAUTION:** DO NOT use long or extended shank burrs with the Flexdeburr. Long shank tools can lead to premature failure of the air motor and is not covered under warranty.

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

This following table is not comprehensive, but includes many common burr types and burrs recommended for particular applications.

	**9150-RC-B-24033**	Diamond Cut, 1/4" Burr Diameter, 5/8" Burr Length, 1/4" Shank
	Materials/Application:	• 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
	Features/Benefits:	• Higher cutting capacity than standard cuts • Smoother finish for surface treatments • Lower axial force than ADC
	**9150-RC-B-24061**	Standard Cut, 3/8" Burr Diameter, 3/4" Burr Length, 1/4" Shank
	Materials/Application:	• For steels of high tensile strength die steels, cast steel, built up welds, tough materials, and welds. • For beveling • For chamfering • For deburring
	Features/Benefits:	• Without chip breaker, for scratch-free surfaces

	**9150-RC-B-24063**	Diamond Cut, 3/8" Burr Diameter, 3/4" Burr Length, 1/4" Shank
	Materials/Application:	• 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
	Features/Benefits:	• Smoother finish for surface treatments • Lower axial force than ADC
	**9150-RC-B-24065**	Aluminum Cut, 3/8" Burr Diameter, 5/8" Burr Length, 1/4" Shank
	Materials/Application:	• For greasy aluminum alloys, soft non-ferrous metals and thermoplastics • For deburring • For use on cast aluminum
	Features/Benefits:	• 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" Burr Diameter, 5/8" Burr Length, 1/4" Shank
	Materials/Application:	• For greasy aluminum alloys, soft non-ferrous metals and thermoplastics • For deburring • For use on cast aluminum
	Features/Benefits:	• 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-26408**	Cut FVK, 1/4" Burr Diameter, 5/8" Burr Length, 1/4" Shank
	Materials/Application:	• For trimming and contour milling of all glass and carbon fiber reinforced plastics
	Features/Benefits:	• Special cut geometry allows high feed rates due to low cutting forces
	**9150-RC-B-24862**	Alt Diamond Cut, 1/4" Burr Dia., 3/4" Burr Length, 1/4" Shank
	Materials/Application:	• Universal use, for ferrous and non-ferrous metals, plastics • Rough finishing of castings • Surface working. • Weld removal. • Brazed welds.
	Features/Benefits:	• Smoother operation, improved tool control • High cutting action • Non-clogging • Smaller chips, reduced slivers • Even, smooth surfaces

8. Terms and Conditions

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 to Purchaser that robotic deburring products purchased hereunder will be free from defects in material and workmanship under normal use for a period of one (1) year from the date of shipment. This warranty does not cover components subject to wear and tear under normal usage or those requiring periodic replacement. This warranty is void if the unit is not used in accordance with guidelines 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.

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9. Attachments