ATI INDUSTRIAL AUTOMATION

Compensator Manual

Universal Compliance Compensator

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Engineered Products for Robotic Productivity

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Foreword

Please contact ATI Industrial Automation with any questions concerning your particular model.

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.

How to Reach Us

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Table of Contents

Glossary

Term	Definition
Air Fitting Connection	A connection for a customer supplied air fitting on the master body through which air is supplied to the air chamber.
Centered	The physical action of supplying air to the pressure chamber in the compensator so that the device becomes rigid and is not fully compliant.
Compensator	A device with the ability to passively move in response to a force exerted on it, for example by robot tool misalignments.
Compliant	The physical action of releasing air from a pressure chamber in the compensator so that the device is not rigid and is fully compliant.
Compliant Plate	The body that allows for lateral, compressive, torsional, and angular compliance.
Chamber Cap	A circular plate that attaches to the bottom of the master body and interfaces with the compliance mechanisms, which attach to the compliant plate.
Customer tooling	The customer's tooling that attaches to the compensator's tool plate and is used to perform a particular function.
Master Body	The part of the Universal Compliance Compensator that is mounted to a robot.
Moment	The applied force multiplied by the distance it is from a point.
Piston	Circular plate, within the master body and serves as an end cap for the air chamber. The plate provides lateral support for the piston stem.
Piston Stem	The piston stem is located in the piston plate of the master body. When actuated with the piston plate, the device is centered.
Piston Chamber Vent	Vent allowing trapped air to escape the non-pressurized side of the piston within the air chamber in the master body.
Robot	Any multi-axis automated articulated arm that can be reprogrammed.
Interface plate	The interface plate between the robot flange and the compensator.
Sensing	A sensor mounted in the master body that detects the proximity of the piston and sends a signal that the compensator is compliant.
Tool Plate	The part of the universal compliance compensator that attaches to the customer tooling.
Tool Interface Plate	Interface plate between the compensator and customer tooling or customer tooling.

1. Safety

The safety section describes general safety guidelines to be followed with this product, explanation of the notification found in this manual, and safety precaution 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 notifications included here 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, installation, or setup of the product that if not followed could result in damage to equipment. The notification can emphasize but is not limited to specific grease types, good operating practices, or maintenance tips.

1.2 General Safety Guidelines

Prior to purchase and installation, the customer should verify that the Universal Compliance Compensator selected is rated for the maximum loads moments expected during operation. Refer to *Section 9—Specifications* for specific ratings, or contact ATI for assistance. Particular attention should be paid to dynamic loads caused by robot acceleration and deceleration. These forces can be many times the value of static forces in high acceleration or deceleration situations.

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

All electrical power, pneumatic and fluid circuits should be disconnected during servicing.

1.3 Safety Precautions

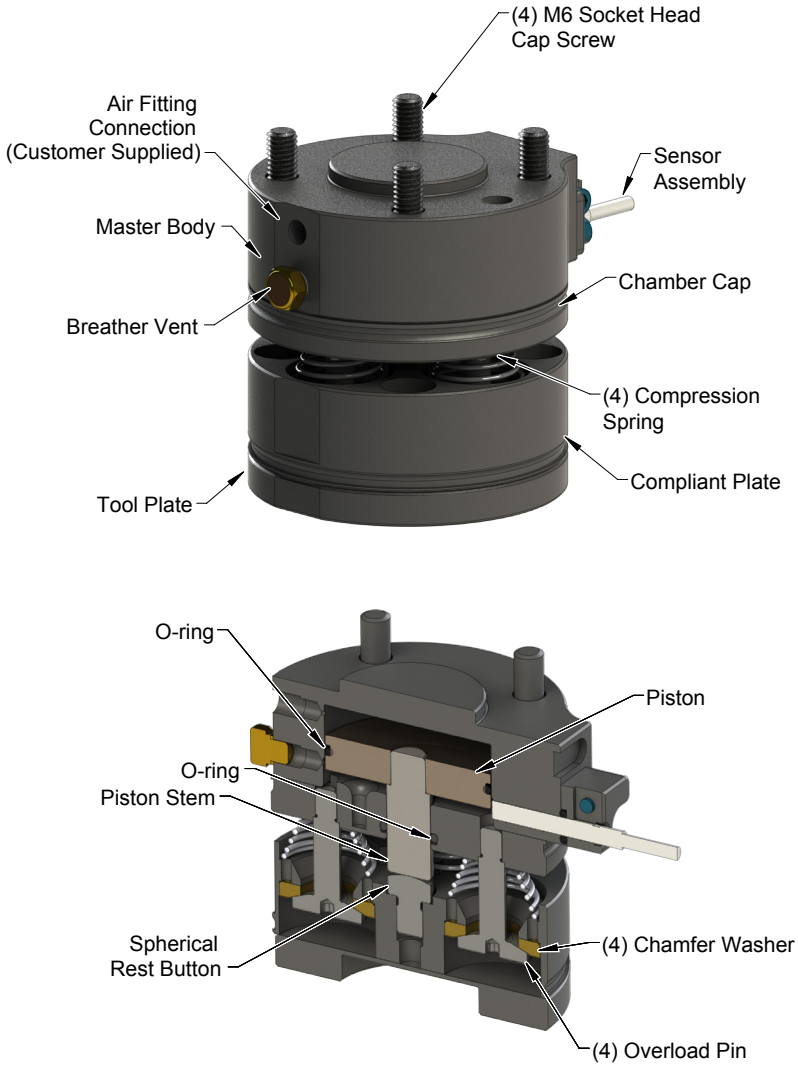
WARNING: Do not perform maintenance or repair on Universal Compliance Compensator with power or air on. Injury or equipment damage can occur with power or air on. Turn off power and air before performing maintenance or repair on Compensator.

CAUTION: The Compensator is only to be used for intended applications and applications approved by the manufacturer. Using the compensator in applications other than intended will result in damage to compensator or end-of-arm tooling and could cause injury to personnel.

2. Product Overview

The Universal Compliance Compensator (UCC) is a compliance device that enhances the flexibility and reliability of a robot or assembly machine. Compensators are used in automated assembly applications to provide compliance for misalignment during assembly.

Figure 2.1—Universal Compliance Compensator



The master body interfaces with the customer's robot arm with (4) captive mounting screws, which are accessed through the tool plate. The tool plate has a 50 mm diameter bolt circle (BC) mounting pattern for direct customer tool mounting using (4) M6 tapped holes, (1) dowel pin location, and 31.5 mm recess. Refer to *Section 10—Drawings* for mounting details. The compensator plate provides lateral, compressive, torsional, and angular compliance. Refer to *Section 3.1—Compliance* for additional information on the different types of compliance. The compliant plate is restrained by (4) overload pins and (4) chamfer washers. Between the compliant plate and chamber cap there are (4) conical compression springs, which provide a minimum amount of resistance to compliance. To increase this resistance, or in other words to increase the stiffness of the device, air pressure can be applied to the chamber which forces the piston, and therefore the piston stem, into contact with the spherical rest button. The spherical contact between the rest button and piston stem also serves to provide smooth, ball-joint-like compliance when air pressure is maintained. Extreme pressure grease is applied to the (4) overload pins, chamfer washers, spherical rest button, and piston stem to enhance performance and maximize the life of the assemblies.

A PNP or NPN sensor monitors the position of the internal piston. As the compensator returns to a center reset position, the piston fully extends and the sensor switches “ON”. Under compliance, the piston is pushed back and switches “OFF”.

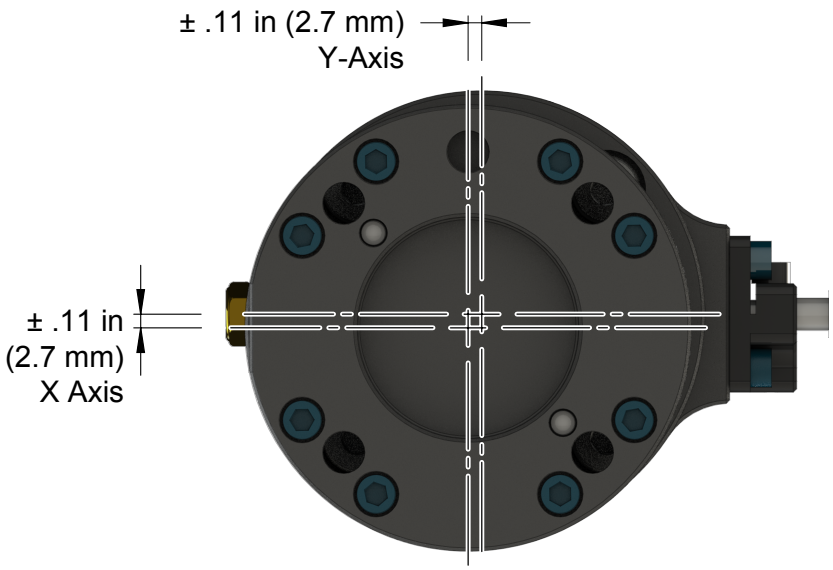
3. Product Information

3.1 Compliance

The Universal Compliance Compensator is designed to provide lateral, compressive, torsional, and angular compliance.

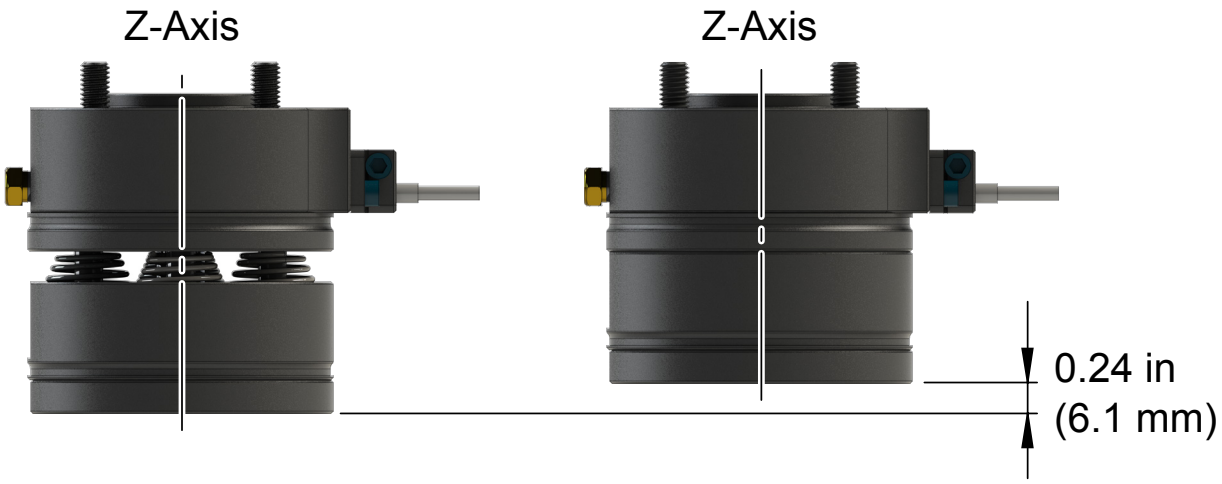
During lateral compliance, the compliant plate deviates from a center position by moving along the X and Y axis (see *Figure 3.1*). A small amount of compression along the Z axis due to unseating of the conical reset surfaces. Refer to *Section 9—Specifications*.

Figure 3.1—Lateral Compliance (X and Y Axis)



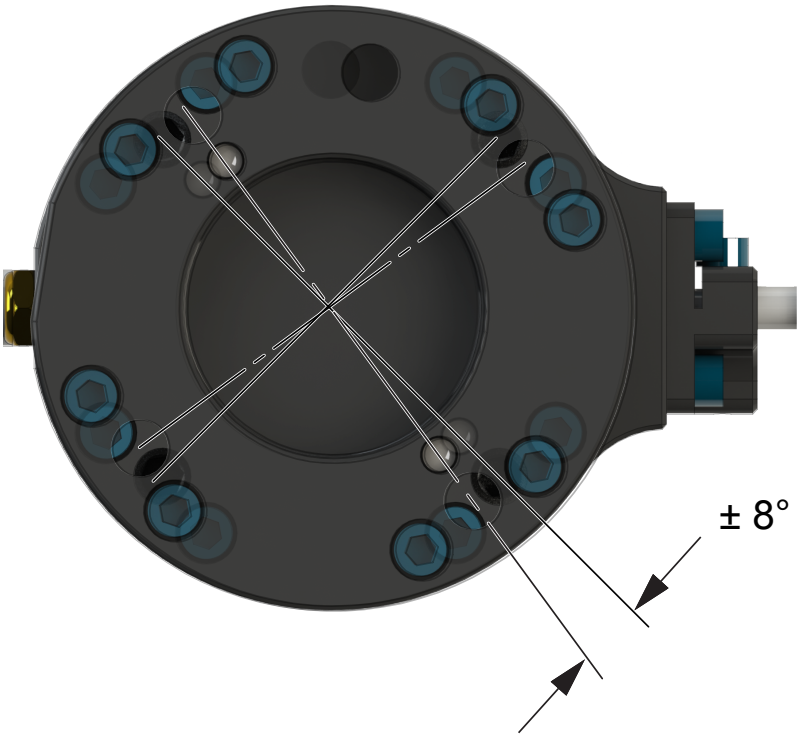
During compressive compliance, the compliant plate moves toward the master body along the Z-axis (See *Figure 3.2*). Refer to *Section 9—Specifications*.

Figure 3.2—Compressive Compliance (Z Axis)



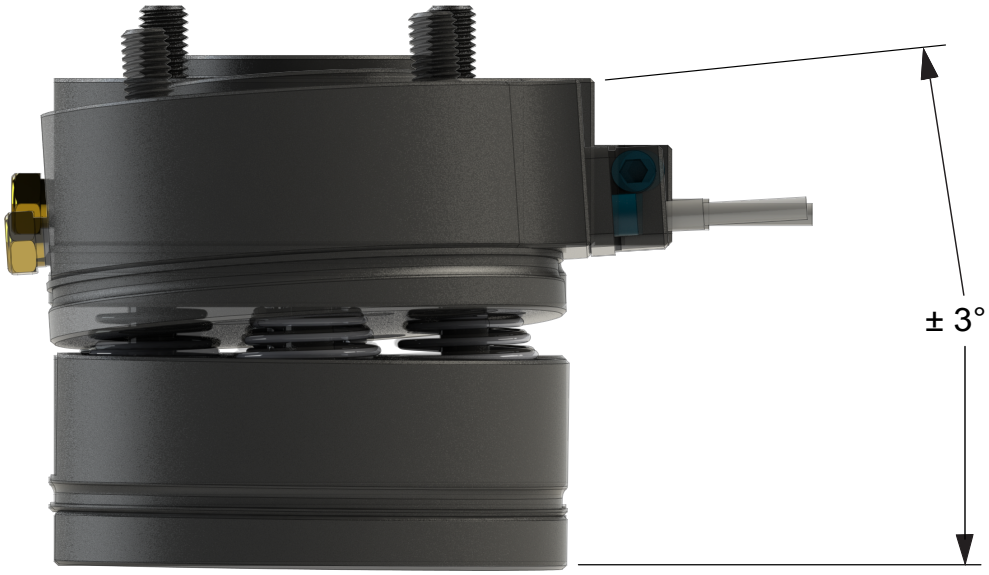
During torsional compliance, the compliant plate rotates about the Z axis, relative to the master body (see *Figure 3.3*). A small amount of compression along the Z axis due to unseating of the conical reset surfaces. Refer to *Section 9—Specifications*.

Figure 3.3— Torsional Compliance (Theta Z)



During angular compliance, the compliant plate pivots about the X or Y axis (see *Figure 3.4*). Refer to *Section 9—Specifications*.

Figure 3.4— Angular Compliance (Theta X and Theta Y)

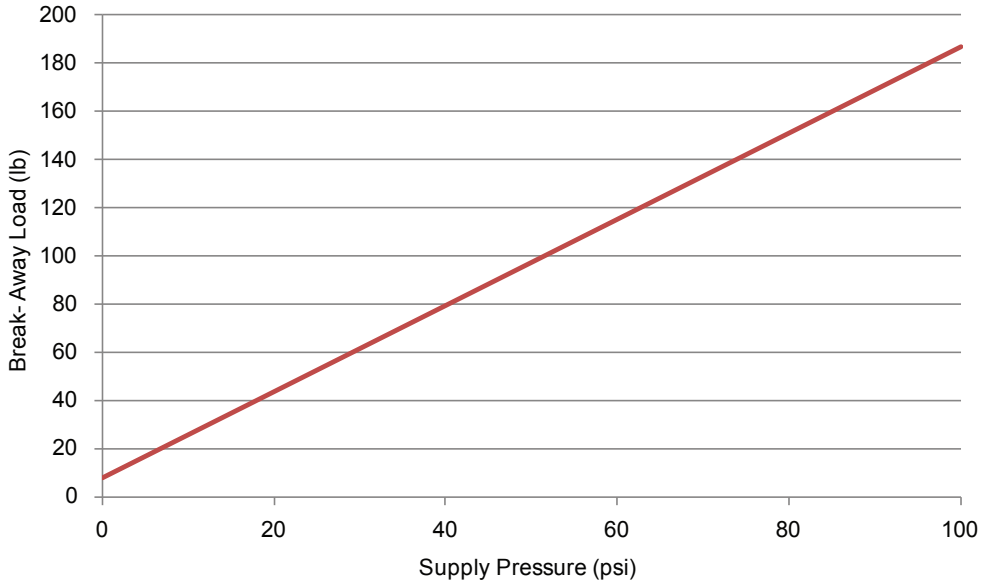


3.2 Payload Capacity (Break-Away Point) and Compliance Stiffness

The Universal Compliance Compensator's payload capacity refers to the applied load at which compliance begins and is also referred to as the break-away point. This applied load must include the weight of the customer tooling, the weight of the customer workpiece, and any external loads applied to the tooling or workpiece INCLUDING from acceleration. An applied load equal to or greater than this break-away point can result in undesirable payload deflection (sag) and should be avoided.

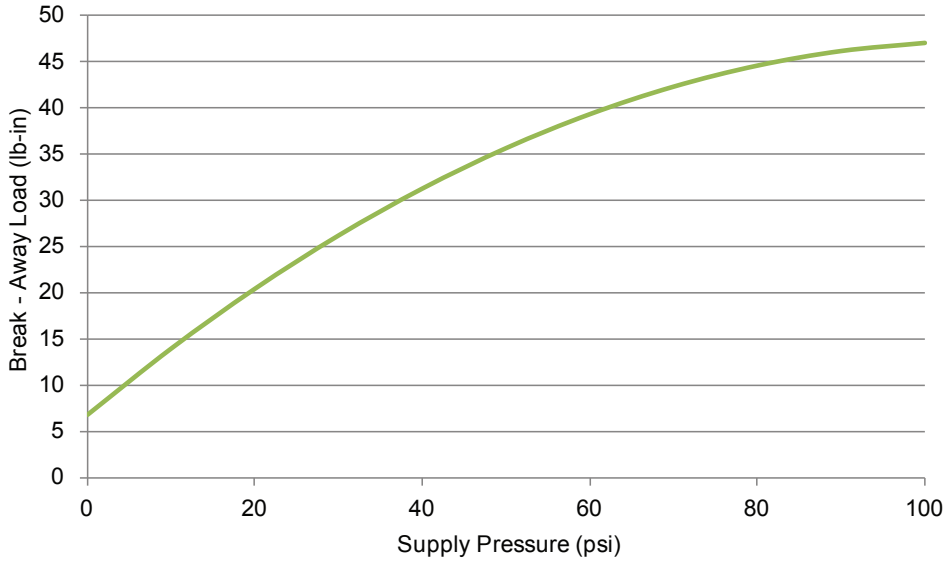
The break-away point has been characterized in *Figure 3.5* through *Figure 3.7* below and is a function of air pressure supplied. In *Figure 3.5*, the axial break-away is defined as 0.010" axial displacement.

Figure 3.5—Axial Break-Away



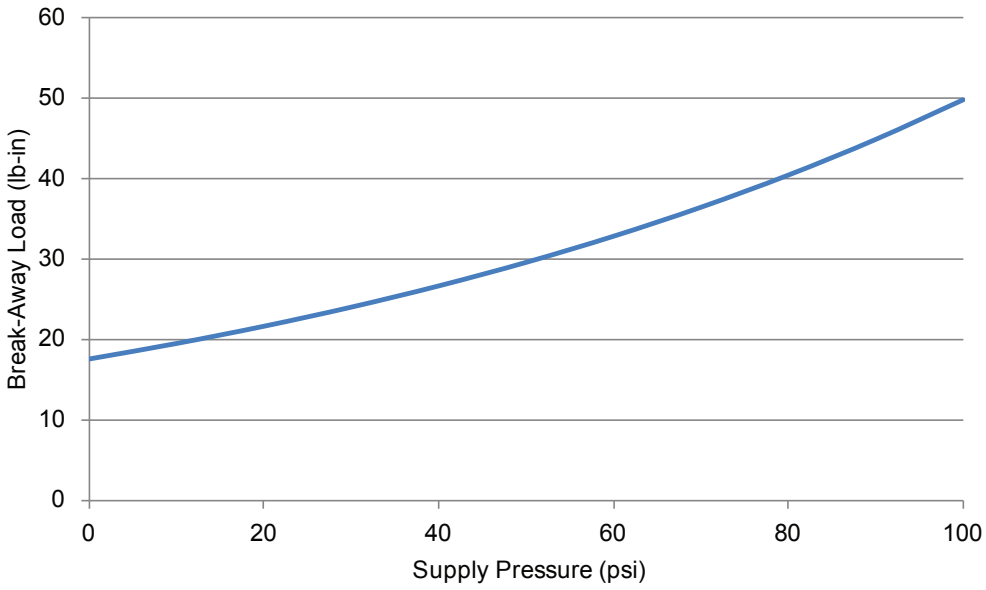
In *Figure 3.6*, the X-Y moment break-away is defined as 0.1° angular displacement.

Figure 3.6—Moment X-Y Break-Away



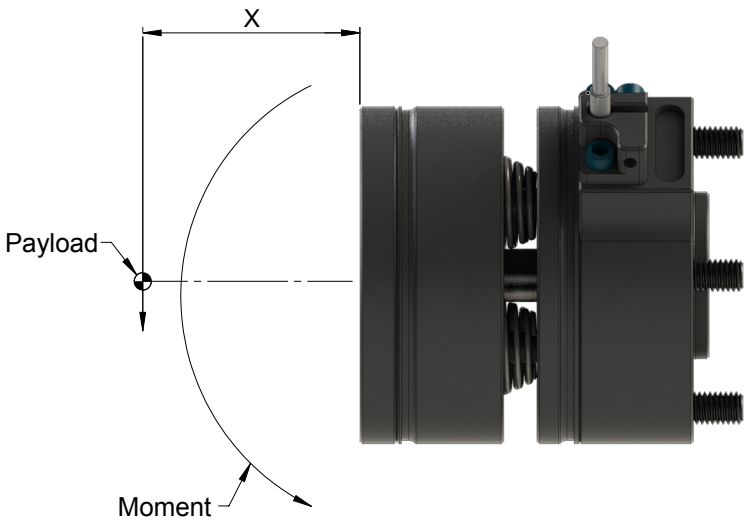
In *Figure 3.7*, the Z Moment break-away is defined as 0.1° torsional displacement.

Figure 3.7—Moment Z Break-Away



In some cases, it may be useful to estimate loads and deflections BEYOND the beak-away point. Refer to *Figure 3.8* for an estimate of the expected angular deflection (rotation about the X or Y axis) as a function of the applied moment X-Y load and the air pressure supplied. For more information, refer to *Section 10—Drawings*. Refer to *Figure 3.8* for calculating static X-Y moment, which is a function of the payload weight and distance to the payload center of gravity.

Figure 3.8—Calculating Moment X-Y



$M = P (X)$

Where:

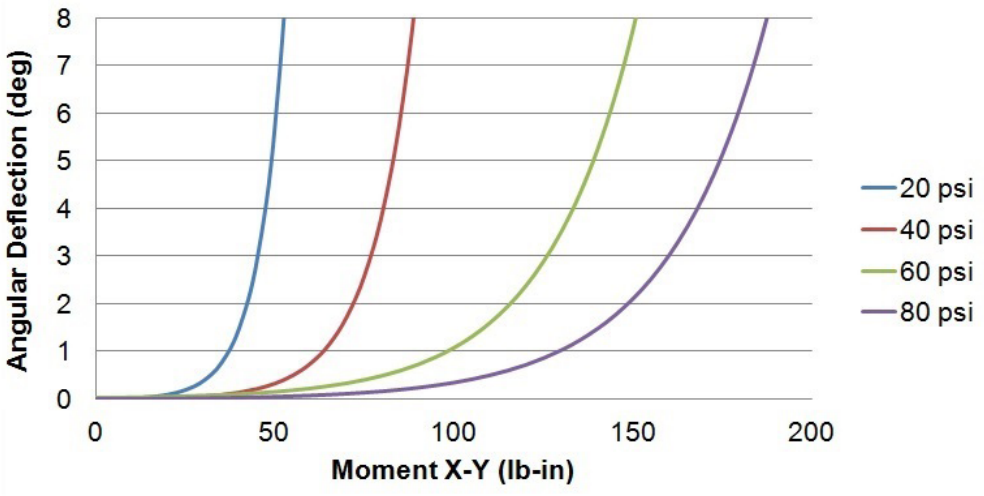
M : maximum moment (in-lbs).

P : customer payload weight (customer tooling and workpiece) (lb).

X : distance from the compensator's tool plate to the payload's center of gravity (in).

Refer to *Figure 3.9* to determine an estimate of the expected angular deflection (rotation about the X or Y axis) as a function of the applied moment X-Y load and the air pressure supplied.

Figure 3.9—Static Loading Moment Stiffness



NOTICE: The user is discouraged from relying on estimated stiffness values near the device's extreme operating limits.

Depending on the application, it may be necessary to further limit the payload in order to factor in acceleration or deceleration of the device during robot motion.

4. Installation

WARNING: Do not perform maintenance or repair on the compensator unless the compensator is safely supported or removed from the robot, all energized circuits (e.g. electrical, air, water, etc.) are turned off, pressurized connections are purged, and power discharged from the circuits in accordance with the customer's safety practices and policies. Injury or equipment damage can occur with the compensator not supported or removed and energized circuits on. Safely remove the compensator, turn off and discharge all energized circuits, purge all pressurized connections, verify all energized circuits are de-energized before performing maintenance or repair on the compensator.

WARNING: All pneumatic fittings and tubing must be capable of withstanding the repetitive motions of the application without failing. The routing of electrical and pneumatic lines must minimize the possibility of over stressing, pullout, or kinking the lines. Failure to do so can cause critical electrical and/or pneumatic lines to malfunction and might result in injury to personnel or damage to equipment.

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 Compensator mounts to the robot wrist (refer to *Figure 4.1*) using the captive mounting screws supplied. The customer tooling attaches to the compensator's tool plate with customer supplied fasteners that are installed in the tool plate's tapped holes.

All fasteners used to mount the compensator to the robot and customer's tooling should have thread locker applied, and be tightened to a torque value as indicated in *Table 4.1*. The recommended values in this table are based on engineering standards.

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

Table 4.1—Fastener Size, Class, and Torque Specifications

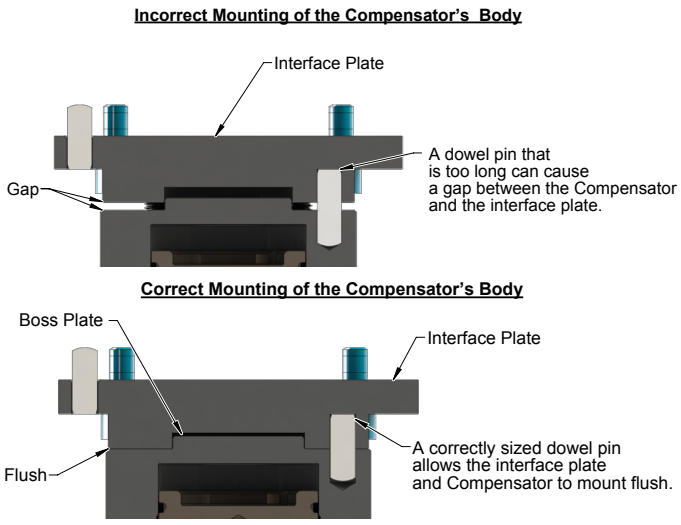
Mounting Conditions	Fastener Size and Property Class	Recommended Torque	Thread Locker
Compensator to Interface plate, Supplied (4) captive M6 socket head cap screws	M6 x 10 Class 8.8		Pre-applied Adhesive or Loctite® 242
	Socket Low- Head Cap Screw	80 in-lbs (9 Nm)	
Customer tooling to Compensator Tool Plate, (4) Customer supplied M6 fasteners	M6 x 1.0 Class 12.9		
	Socket head cap	90 in-lbs (10.2 Nm)	
	Socket flat head cap	60 in-lbs (6.78 Nm)	

4.1 Robot Interface

The compensator's body is typically attached to the robot arm. An interface plate can adapt the compensator to a specific robot arm. Alignment features (dowel holes and bosses) accurately position and bolt holes secure the compensator to the robot arm or an interface plate. Custom interface plates are available from ATI upon request. (Refer to *Section 10—Drawings*.)

CAUTION: Do not use dowel pins that are too long or do not allow the interface plate and Compensator's body to mate flush. Using dowel pins that are too long will cause a gap between the interface plate and the Compensator's body and damage to the equipment. Use dowel pins that do not extend further than allowed by the Compensator's body.

CAUTION: Do not use more than two alignment features when securing the Compensator to an interface plate. Using more than two alignment features can cause damage to the equipment. Use either two dowel pins or a single dowel pin along with a boss/recess feature to align the Compensator with the interface plate.



If the customer chooses to design and build a robot interface plate, consider the following points:

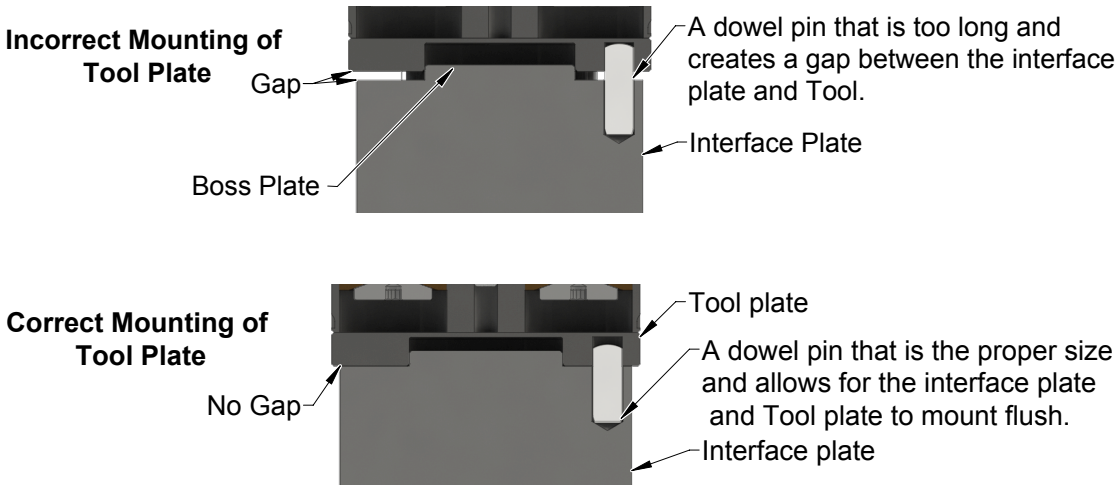
- The interface plate should include bolt holes for mounting and either two dowel pins or a dowel pin and a boss for accurate positioning on the robot and Compensator. The dowel pins prevent rotation. Refer to the robot manual for robot mounting features.
- The thickness of the interface plate must be sufficient to provide the necessary thread engagement for the mounting bolts.
- Dowel pins must not extend out from the surface of the interface plate farther than the depth of the dowel holes in the Compensator's body.
- If a boss is used on the Compensator, a recess of proper depth and diameter must be machined into the interface plate to correspond with the boss on the Compensator.
- Mounting bolts that are too long can create a gap between the interface plate and the Compensator.
- The interface plate must provide rigid mounting to the Compensator.

4.2 Tool Interface

The tool plate is attached to the customer's tooling. An interface plate can adapt the tool plate to the customer's tooling. Alignment features (dowel holes) accurately position and bolt holes secure the Tool plate to the customer's tooling. Custom tool interface plates can be supplied by ATI to meet customer's requirements (Refer to *Section 10—Drawings*).

CAUTION: Do not use dowel pins that are too long or do not allow the interface plate and tool plate to mate flush. Using dowel pins that are too long will cause a gap between the interface plate and the tool plate and damage the equipment. Use dowel pins that do not extend further than allowed by the tool plate.

CAUTION: Do not use more than two alignment features when securing the Compensator to an interface plate. Using more than two alignment features can cause damage to the equipment. Use either two dowel pins or a single dowel pin along with a boss/recess feature to align the Compensator with the interface plate.



If the customer chooses to design and build a tool interface plate, consider the following points:

- The interface plate should include bolt holes for mounting and either two dowel pins or a dowel pin and a boss for accurate positioning on the customer tooling and the tool plate. The dowel and boss features prevent unwanted rotation.
- The interface plate should include bolt holes for mounting and dowel pin holes for accurate positioning on the customer tooling and tool plate. The dowel pins prevent rotation.
- The thickness of the interface plate must be sufficient to provide the necessary thread engagement for the mounting bolts.
- Dowel pins must not extend out from the surface of the interface plate farther than the depth of the dowel holes in the tool plate.

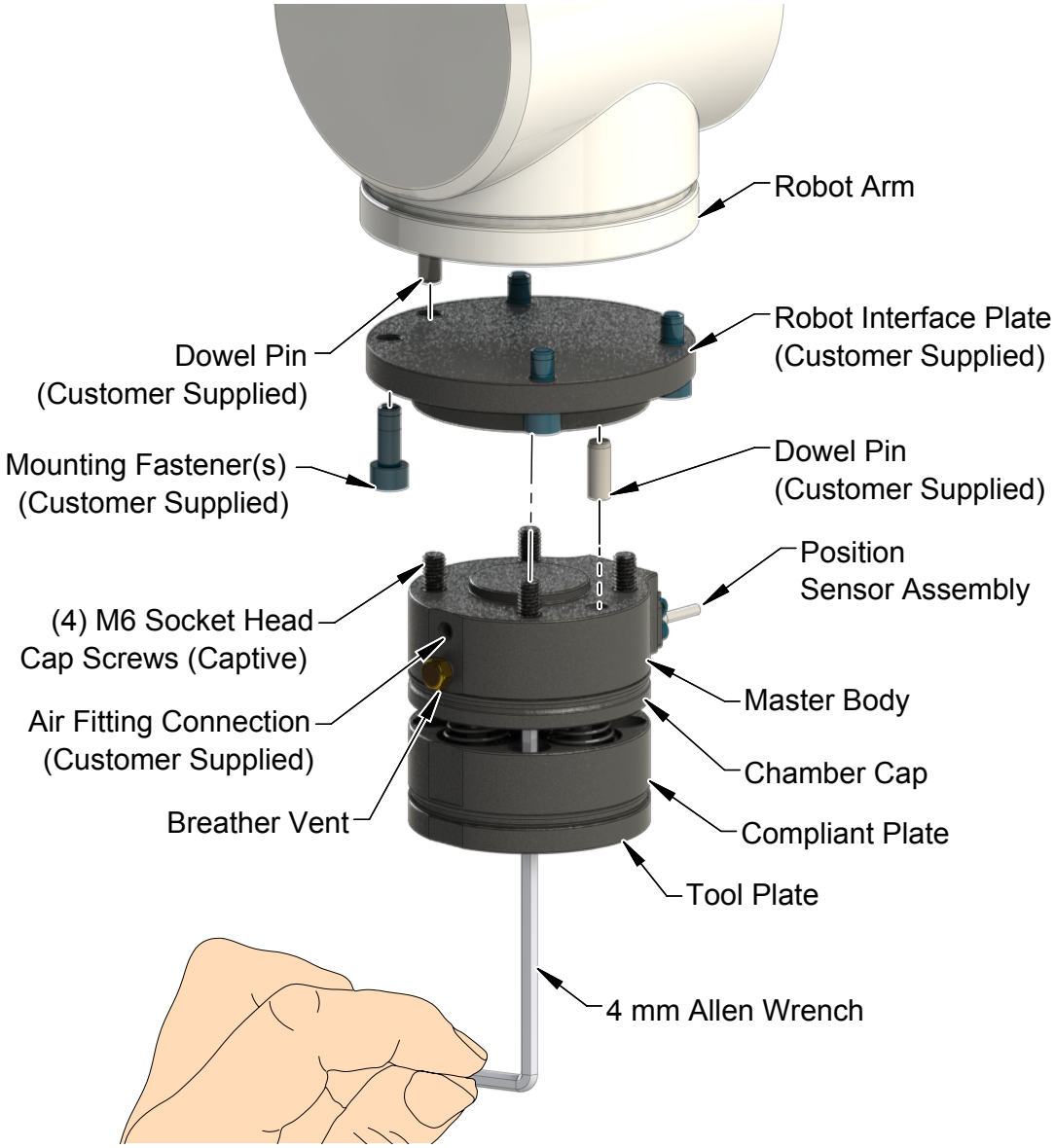
4.3 Installing the Compensator to the Robot

Tools required: *4 mm Allen® wrench (hex key)*

Supplies required: *Loctite® 242, Clean rag*

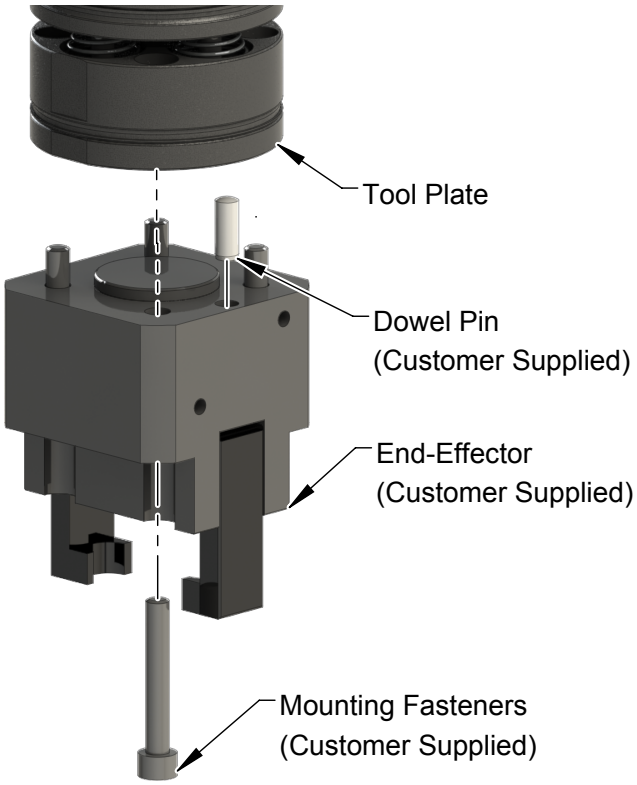
1. Clean the mounting surfaces.
2. If required, attach the interface plate to the robot. Secure with customer supplied fasteners.
3. With the Compensator in the unlocked position, secure the Compensator to the robot.
   a. Apply Loctite 242 to the exposed threads of the (4) M6 captive socket head cap screw.
   b. Insert a 4 mm Allen wrench through the holes of the tool plate.
   c. Using the Allen wrench, secure the Compensator to the robot with the (4) captive socket head cap screws. Tighten to 80 in-lbs (9 Nm).
4. Attach sensor and pneumatic cables to the connections.

Figure 4.1—Installing the Compensator to the Robot



5. Once the compensator is attached to the robot, the customer tooling or tool interface plate can be attached. Refer to *Figure 4.2*.

Figure 4.2—Installing the Customer Tooling to the Compensator



6. Secure the customer tooling or tool interface plate to the tool plate of the compensator using the customer supplied (4) M6 fasteners. Refer to *Table 4.1* for proper torque and Loctite specifications. Refer to *Section 10—Drawings* for mounting details.
7. After installation is complete, the compensator is ready for into normal operation.

4.4 Removing the Compensator from the Robot

Tools required: *4 mm Allen wrench*

1. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
2. Remove air and sensor cables from the connections as required for service.
3. Remove the (4) M6 mounting fasteners securing the customer tooling or tool interface plate to the conpensator.
4. Supporting the compensator, use an Allen wrench to loosen the captive fasteners securing the compensator to the robot or interface plate.
5. Remove the compensator.

4.5 Electrical Connections

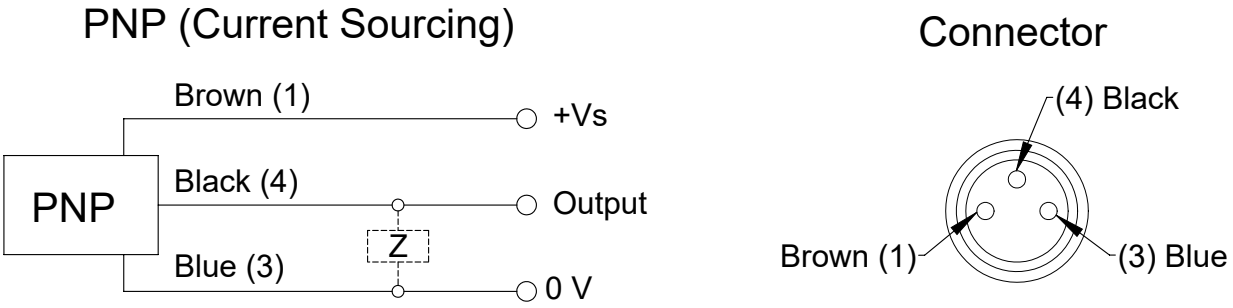
The master body of the compensator has a proximity sensor.

4.5.1 PNP Type Sensors

The PNP sensors are 4 mm cylindrical inductive proximity sensor.

Table 4.2—PNP (Current Sourcing)	
Description	**Value**
Voltage Supply Range	10-30VDC
Output Circuit	PNP make function (NO)

Figure 4.3—PNP Type Lock, Unlock and RTL Sensors

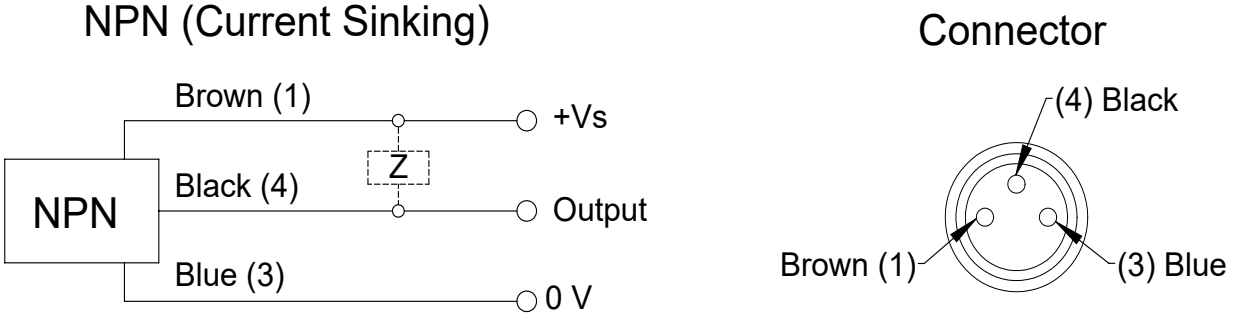


4.5.2 NPN Type Sensors

The NPN sensors are 4 mm cylindrical inductive proximity sensor.

Table 4.3—NPN (Current Sinking)	
Description	**Value**
Voltage Supply Range	10-30 VDC
Output Circuit	NPN make function (NO)

Figure 4.4—NPN Type Lock, Unlock and RTL Sensors



5. Operation

The compensator has a pneumatically driven mechanism that makes the compensator more rigid and requires a continuous supply of clean, dry non-lubricated air 60 - 100 psi (4.1 – 6.9 Bar) and filtered to 40 microns or better.

CAUTION: Safe, reliable operation of the compensator's locking mechanism is dependent on a continuous supply of compressed air at a pressure of 60 to 100 psi.

5.1 Centered

The compensator has a nominal reset (or center) position, which is achieved when proper seating has occurred between conical surfaces among internal components. The reset position can also be described as a state of zero compliance.

To achieve this reset position, the device relies on both pre-load from a set of internal compression springs and from the supply of air pressure to the internal reset piston.

5.2 Compliant

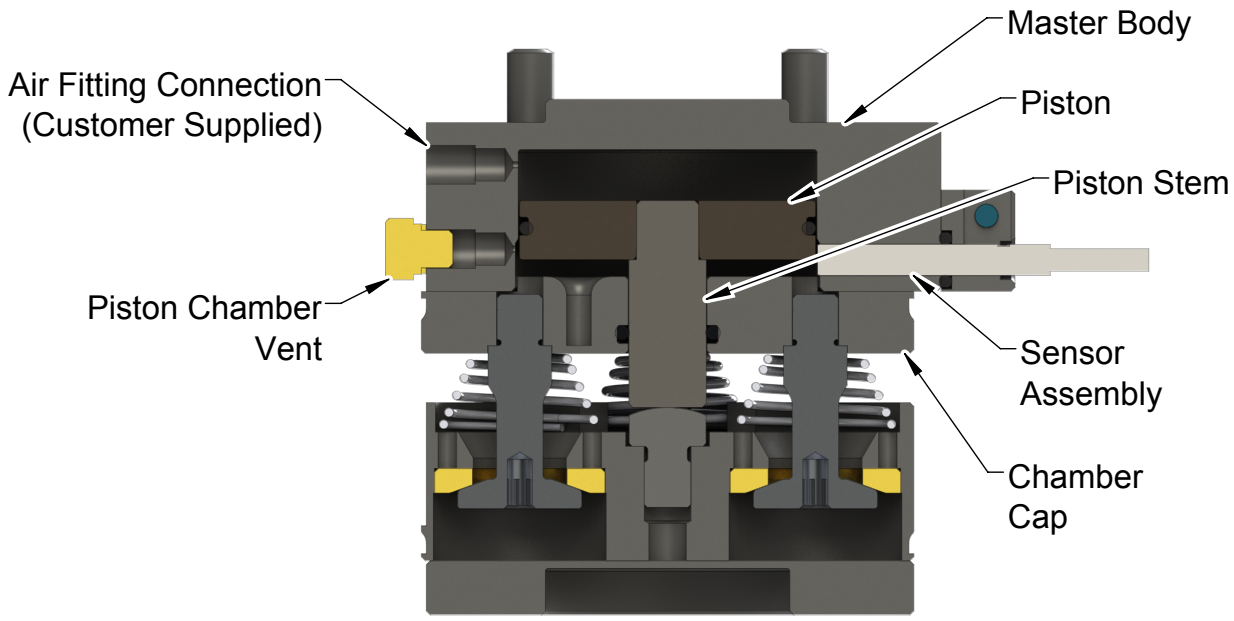
To decrease the compliance stiffness, decrease the air pressure supplied to the device. Even if air pressure is removed entirely, a small amount of compliance stiffness remains due to the pre-load of the internal springs.

To increase the compliance stiffness, increase the air pressure supplied to the device. Maximum air pressure of 30 psi (2.1 bar). For the re-center (lock) function, unit may supplied with up to 100 psi (6.9 bar) but forcing compliance under these conditions is not recommended as it may reduce service life.

5.3 Optional Sensing of Compliance

An optional proximity sensor provides detection of compliance in the device, which is useful in some applications. In order for the sensor to be functional, the unit will need a minimal air pressure supply of 5 - 10 psi (.3 -.7 Bar) so that the piston stem actively contacts the spherical rest button in the compliant plate. When the sensor is "ON", the compensator is ***not*** experiencing compliance. During compliance, the piston is moved and the sensor switches "OFF", indicating contact between the customer tooling and the work piece.

Figure 5.1—Sensor for Pressurized and Vented Modes

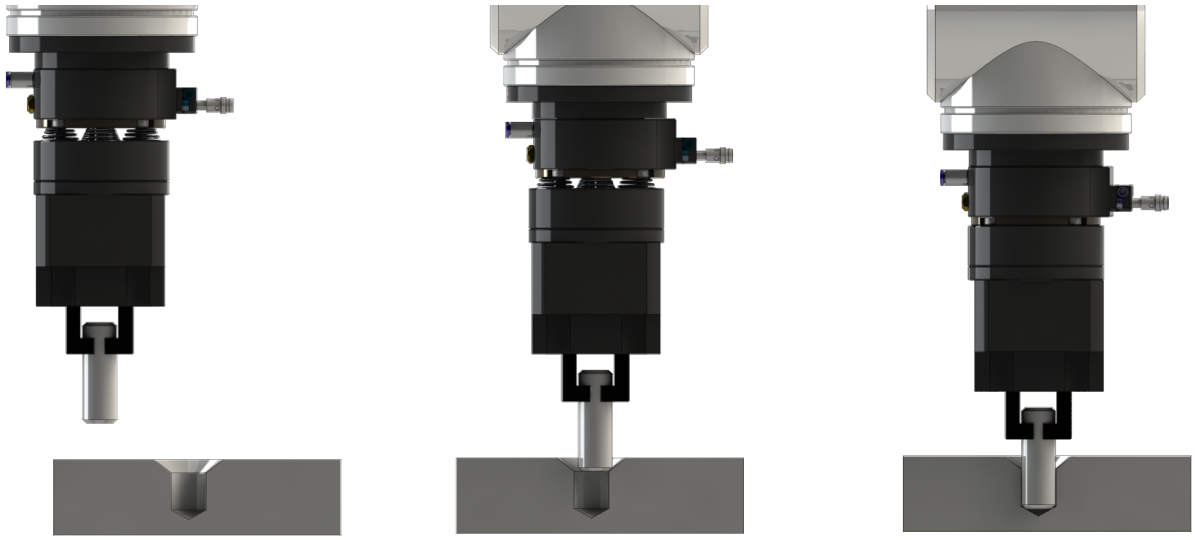


5.4 Operation of Inserting a Part

The compensator can be used in a part insertion operation. The compensator allows for misalignment of the robot and work piece in the lateral, compressive, torsional, and angular directions.

The compensator may to be used in slip-fit “peg-in-hole” type operations, refer to *Figure 5.2*. The peg-in-hole example is an application involving the insertion of one part into another. There are a variety of peg-in-hole type applications that include the following: dowel pin insertion, mold alignment, washer insertion, bearings into housings, and shafts into bearings.

Figure 5.2—Part Insertion



Robot moves to an insertion position above the work piece.

Robot moves to insert pin.

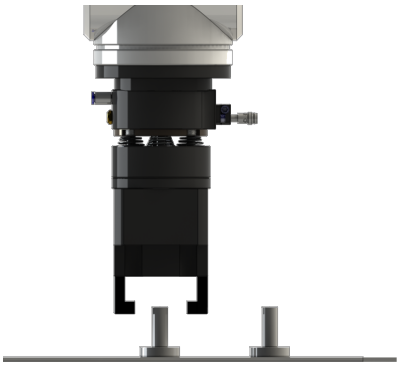
The compensator’s compliance allows the pin to center in the chamfered hole.

Robot inserts the pin into the hole.

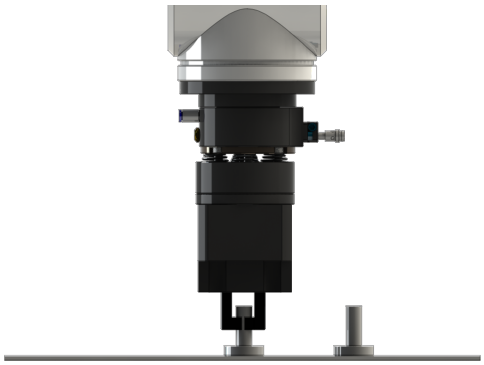
5.5 Operation of Picking a Part

The compensator can be used in a part picking operation; refer to *Figure 5.3* and *Figure 5.4*. The compensator allows for misalignment of the robot and work piece in the lateral, compressive, torsional, and angular directions. The compensator can center the work piece for placement.

Figure 5.3—Pick Part Operation Lateral Direction



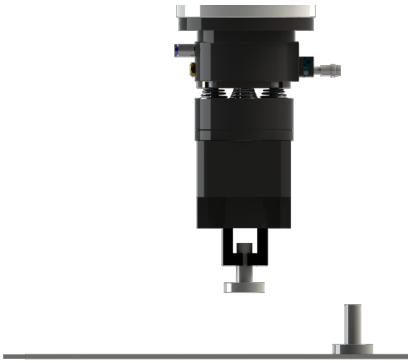
The robot positions above the work piece so that it can pick a part.



The robot grippers close.

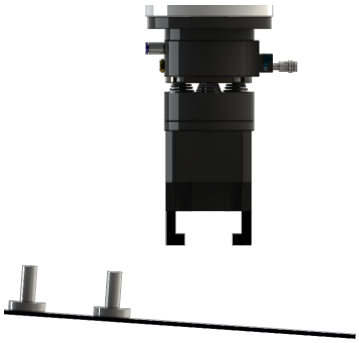
Then accounting for the position of the workpiece and robot, the compensator offsets.

Air pressure is supplied, the compensator becomes rigid.



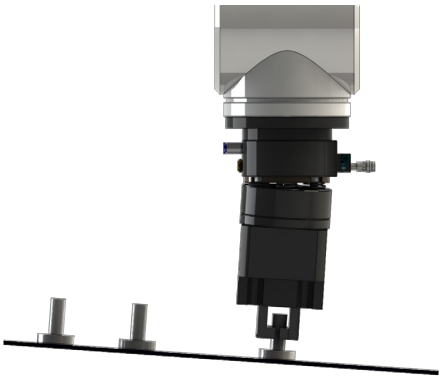
The robot removes the part from the work piece.

Figure 5.4—Pick Part Operation Compressive, Angular and Torsional Direction



Robot moves to a position above the part.

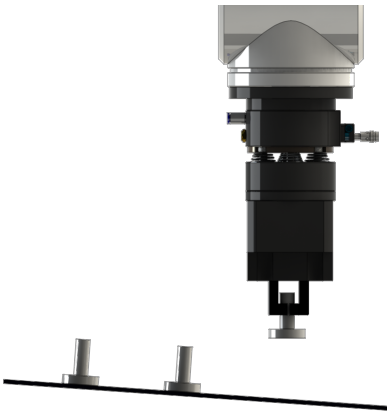
Robot picks up the part.



The robot grippers close.

The compensator offsets to account for the position of the robot and part.

As air pressure is supplied, the compensator becomes rigid.



The robot removes the part.

6. Maintenance

Under normal conditions, no special maintenance is necessary; however it is recommended that periodic inspections be performed to assure long-lasting performance and to assure that unexpected damage has not occurred. Refer to *Section 6.1—Preventive Maintenance* for a schedule and items that should be visually inspected at regular intervals.

WARNING: Do not perform maintenance or repair on the compensator unless the compensator is safely supported or removed from the robot, all energized circuits (e.g. electrical, air, water, etc.) are turned off, pressurized connections are purged, and power discharged from the circuits in accordance with the customer's safety practices and policies. Injury or equipment damage can occur with the compensator not supported or removed and energized circuits on. Safely remove the compensator, turn off and discharge all energized circuits, purge all pressurized connections, verify all energized circuits are de-energized before performing maintenance or repair on the compensator.

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.

6.1 Preventive Maintenance

The compensator provides a long life with regular maintenance. A visual inspection and preventive maintenance schedule is provided in the *Table 6.1* below depending upon the application. Assembly details are provided in *Section 10—Drawings* of this manual.

Table 6.1—Preventative Maintenance Checklist

Application(s)	Compliance Cycle Frequency	Inspection Schedule
General Usage, Material Handling	More than 1 per minute	Weekly
	Less than 1 per minute	Monthly
Wet or Humid Environments	All	Weekly
Welding/Servo/Deburring, Foundry Operations (Dirty Environments)	All	Weekly
Mounting Fasteners		
□ Inspect mounting fasteners, verify they are tight and have the proper torque. Refer to *Table 4.1*.		
Interface Connections		
□ Inspect pneumatic connection for cuts in hose, abrasions, or wear. If signs of wear are apparent, tighten connections and secure lines so that they allow freedom of movement during operation and do not rub or obstruct other components. □ Inspect electrical cable for cuts, abrasions, or wear. If signs of wear are apparent, check connections and secure cables so that they allow freedom of movement during operation and do not rub or obstruct other components.		
Overload Pins, Conical Compression Springs, and Chamer Washers		
□ Inspect the overload pins and conical compression springs. If bent, worn, or damaged, replace. Refer to *Section 7.2.1—Overload Pins, Conical Compression Springs, and Chamfer Washers Replacement.*		
Spherical Rest Button		
□ Inspect spherical rest button for wear, abrasion, and cuts. If worn or damaged, replace. Refer to *Section 7.2.2—Spherical Rest Button Replacement*.		

7. Troubleshooting and Service Procedures

The following section provides troubleshooting information to help diagnose conditions with the Compensator and service procedures to help resolve these conditions.

WARNING: Do not perform maintenance or repair on the compensator unless the compensator is safely supported or removed from the robot, all energized circuits (e.g. electrical, air, water, etc.) are turned off, pressurized connections are purged, and power is discharged from the circuits in accordance with the customer's safety practices and policies. Injury or equipment damage can occur with the compensator not supported or removed and energized circuits on. Safely remove the compensator, turn off and discharge all energized circuits, purge all pressurized connections, verify all energized circuits are de-energized before performing maintenance or repair on the compensator.

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.

7.1 Troubleshooting

The system contains few components and provides trouble free operation once properly installed. The following table is provided to assist with troubleshooting the system.

Table 7.1—Troubleshooting

Symptom	Cause	Resolution
Compensator's piston will not move (or sensor does not indicate air is moving the piston).	Insufficient or no air pressure supply to the master body's air fitting	Verify proper air pressure is supplied. Refer to *Section 5—Operation*.
	Debris is caught between the chamber cap and compliant plate.	Remove the debris between the chamber cap and compliant plate.
	Optional Boot Accessory is damaged	Inspect the boot and garter springs for damage. Replace, if necessary. Refer to *Section 7.2.4—Optional Flex Boot Replacement*.
	O-ring seals are worn.	Contact ATI for service.
The unit is centered but the Centered signal does not read "on" (true).	Insufficient or nor air pressure supply to the piston.	Verify proper air pressure is supplied. Refer to *Section 5—Operation*.
	Sensor cable is damaged or loose connection	Inspect the sensor cables for damage or loose connection. If loose, re-connect. If damaged, replace.
	Sensor assembly is damaged.	Replace the sensor sub-assembly as necessary. Refer to *Section 7.2.3—Sensor Assembly Replacement*.

Table 7.1—Troubleshooting		
Symptom	**Cause**	**Resolution**
Compensator has lost lateral and/or torsional compliance.	Debris is caught inside the cavities within the compliant plate, or in the space between the compliant plate and the chamber cap.	Remove the debris caught inside cavities within the compliant plate, or in the space between the compliant plate and the chamber cap.
	The overload pins or chamfer washers are damaged.	Inspect overload pins and chamfer washers for damage. If worn or damaged, replace. Refer to *Section 7.2.1—Overload Pins, Conical Compression Springs, and Chamfer Washers Replacement*.
Compensator has lost compressive compliance	Debris is caught inside the cavities within the compliant plate, or in the space between the compliant plate and the chamber cap.	Remove the debris caught inside cavities within the compliant plate, or in the space between the compliant plate and the chamber cap.
	The conical compression springs, overload pins and/or chamfer washers are damaged.	Inspect overload pins and conical compression springs. If worn or damaged, replace. Refer to *Section 7.2.1—Overload Pins, Conical Compression Springs, and Chamfer Washers Replacement*.
Compensator has lost angular compliance	The overload pins have come loose.	Inspect the overload pins, removing the tool plate if necessary, for looseness at the threaded connection. Re-install overload pins with recommended thread lock and torque. Refer to *Section 7.2.1—Overload Pins, Conical Compression Springs, and Chamfer Washers Replacement*.
	Debris is caught inside the cavities within the compliant plate, or in the space between the compliant plate and the chamber cap.	Remove the debris caught inside cavities within the compliant plate, or in the space between the compliant plate and the chamber cap.
	The conical compression springs, overload pins and/or chamfer washers are damaged.	Inspect overload pins and conical compression springs. If worn or damaged, replace. Refer to *Section 7.2.1—Overload Pins, Conical Compression Springs, and Chamfer Washers Replacement*.
	The spherical rest pin and/or valve stem are damaged.	Inspect the spherical rest button for damage. If damaged, replace. Refer to *Section 7.2.2—Spherical Rest Button Replacement*. Inspect the valve stem for damage. If damaged contact ATI.

7.2 Service Procedures

The following service procedures provide instructions for inspection, adjustment, test or replacement of components.

7.2.1 Overload Pins, Conical Compression Springs, and Chamfer Washers Replacement

Parts required: *Refer to Section 8.1—Compensator Serviceable Parts.*

Tools required: *2.5 and 3 mm Allen wrench*

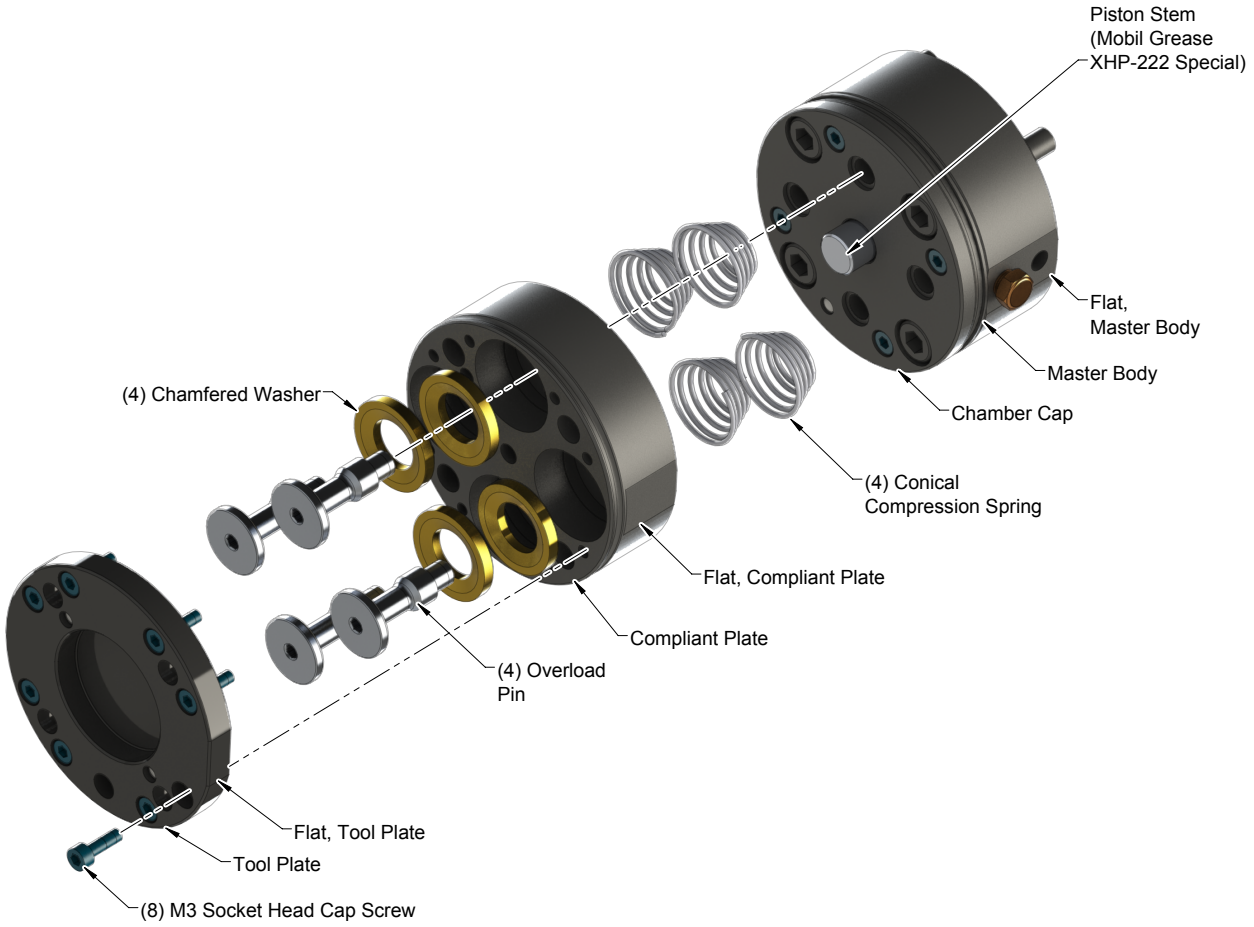
Supplies required: *Mobile Grease® XHP-222 special grease, clean rag*

1. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
2. Remove the customer tooling from the compensator and remove the compensator from the robot. Refer to *Section 4.4—Removing the Compensator from the Robot*.
3. Using a 2.5 mm Allen wrench, remove the (8) M3 socket head cap screws securing the tool plate to the compensator. Refer to *Figure 7.1*.
4. Using a 3 mm Allen wrench, remove the (4) overload pins and discard.
5. Remove the compliant plate from the compensator and set aside.

6. Remove the (4) conical compression springs and discard.
7. Use a clean rag to remove existing lubricant and debris from the bores and surfaces of the tool plate, compliant plate, and chamber cap.

NOTICE: Use MobilGrease XHP222 Special grease to lubricate the mechanism and O-rings. Note: MobilGrease XHP222 Special is a NLGI #2 lithium complex grease with molybdenum disulfide.

Figure 7.1—Replacement of Overload Pins and Conical Compression Springs



8. Apply XHP-222 special grease to the piston stem.
9. Install the new (4) conical compression springs over the chamber cap's threaded holes for the overload pins.
10. Install the (4) new chamfer washers into the compliant plate.
11. Insert the (4) chamfer washers into the compliant plate with the chamfer facing outward away from the springs.
12. Apply XHP-222 special grease to the washers' sides that face the bottom of the overload pins heads and internal bores of the compliant plate.
13. Apply Loctite primer 7649 to the threads of the of the new overload pins.
14. Apply Loctite 242 to the threads of the overload pins.
15. Install the compliant plate over the conical compression springs. Verify the flats of the master body and compliant plate are aligned. Ensure the large end of each compression spring is properly nested in the corresponding counterbore in the compliant plate.

16. Pass each overload pin through the chamfer washer, compliant plate, and conical compression spring. Secure using a 3 mm Allen wrench. Tighten to 52 in-lbs (5.9 Nm).
17. Assemble the tool plate to the compliant plate with the dowel pins and flats aligned.
18. Secure the tool plate to the compliant plate with the (8) M3 socket head cap screws. Tighten to 12 in-lbs (1.4 Nm).
19. Install the compensator to the robot, and attach the customer tooling to the compensator. Refer to *Section 4.3—Installing the Compensator to the Robot*.
20. After the procedure is complete, resume normal operation.

7.2.2 Spherical Rest Button Replacement

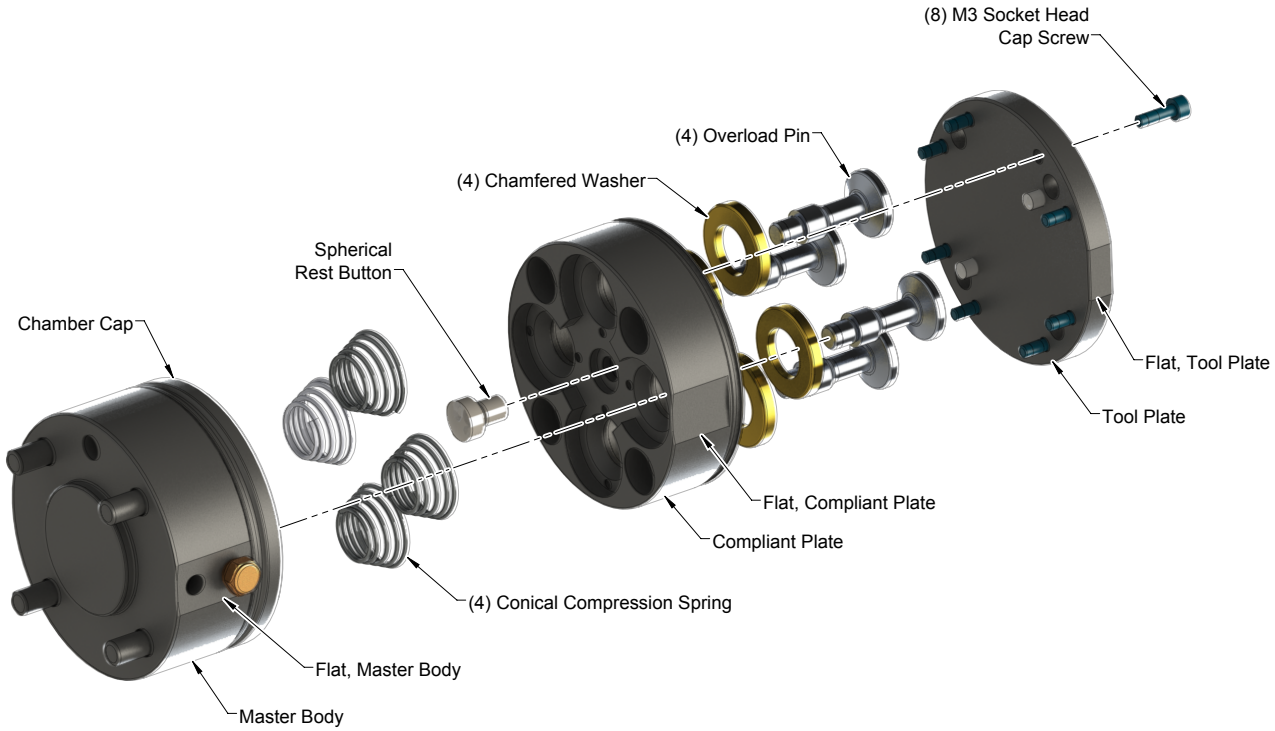
Parts required: *Refer to Section 8.1—Compensator Serviceable Parts.*

Tools required: *2.5 and 3 mm Allen wrench, Arbor press with appropriate sized draft pins*

Supplies required: *Mobile Grease XHP-222 special grease, clean rag*

1. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
2. Remove the customer tooling from the compensator, and remove the compensator from the robot. Refer to *Section 4.4—Removing the Compensator from the Robot*.
3. Using a 2.5 mm Allen wrench, remove the (8) M3 socket head cap screws securing the tool plate to the compensator. Set aside the socket head cap screws and tool plate.
4. Use the 3 mm Allen wrench to remove the (4) overload pins and set aside.
5. Remove the compliant plate from the compensator and set aside.
6. Remove the (4) conical compression springs and set aside.
7. Press the spherical rest button out of the compliant plate and discard.
8. Use a clean rag to remove existing lubricant and debris the bores and surfaces of the tool plate, compliant plate, and chamber cap.

Figure 7.2—Replacement of Spherical Rest Button



9. Press the new spherical rest button into the compliant plate.

NOTICE: Use MobilGrease XHP222 Special grease to lubricate the mechanism and O-rings. Note: MobilGrease XHP222 Special is a NLGI #2 lithium complex grease with molybdenum disulfide.

10. Apply XHP-222 special grease to the piston stem. Refer to *Figure 7.1*.
11. Place the (4) conical compression springs over the chamber cap's holes for the overload pins. Refer to *Figure 7.2*.
12. Apply XHP-222 special grease to the washers' sides that face the bottom of the overload pins' heads and internal bores of the compliant plate.
13. Apply Loctite primer 7649 to the threads of the overload pins.
14. Apply Loctite 242 to the threads of the overload pins.
15. Install the compliant plate over the conical compression springs. Verify the flats of the master body and compliant plate are aligned. Ensure the large end of each compression spring is properly nested in the corresponding counterbore in the compliant plate.
16. Pass each overload pin through the compliant plate, chamfer washer, and conical compression spring. Secure using a 3 mm Allen wrench. Tighten to 52 in-lbs (5.9 Nm).
17. Assemble the tool plate to the compliant plate with the dowel pins and flats aligned.
18. Secure the tool plate to the compliant plate with the (8) M3 socket head cap screws. Tighten to 12 in-lbs (1.4 Nm).
19. Install the compensator to the robot, and attach the customer tooling to the compensator. Refer to *Section 4.3—Installing the Compensator to the Robot*.
20. After the procedure is complete, resume normal operation.

7.2.3 Sensor Assembly Replacement

The sensor is very reliable and normally does not need to be replaced. Exhaust all other possible solutions, check continuity, air supply, lubrication, and pneumatic components prior to testing or replacing the sensor.

Parts required: *Refer to Section 8.1—Compensator Serviceable Parts.*

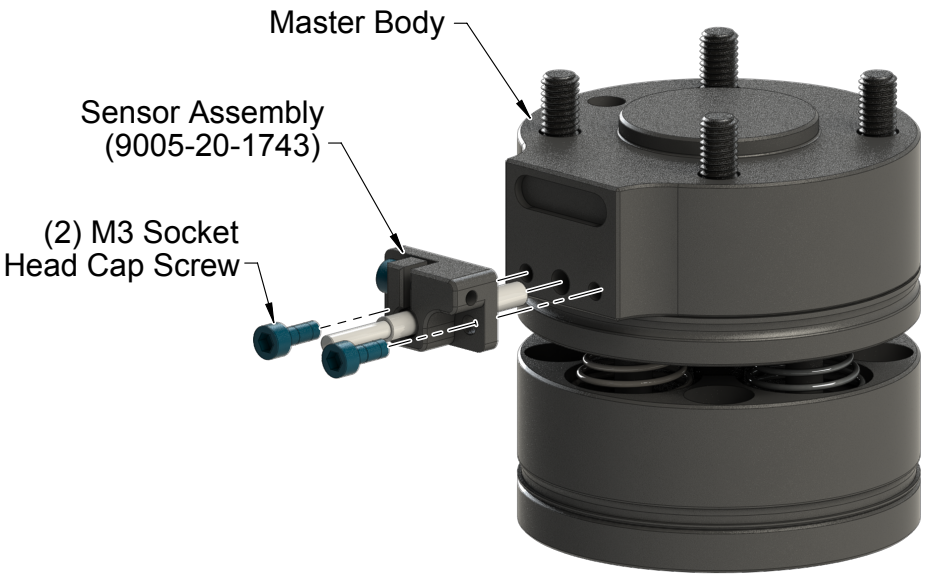
Tools required: *2.5 mm Allen wrench*

1. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
2. Disconnect the sensor cable.
3. Remove the (2) M3 socket head cap screws that secure the sensor assembly to the master body of the compensator. Refer to . Pull the sensor assembly straight out from the master body.
4. To test the suspect sensor, connect the sensor cable and place a ferrous target in front of the proximity sensor to confirm that the sensor is functional. The sensor signal should read “on” (true), and the sensor should illuminate.
    a. If the sensor is not functioning properly, replace. Disconnect the sensor cable and discard.
    b. If the sensor is functioning properly, reinstall.

> **CAUTION:** The sensor assemblies are precision aligned and permanently assembled at the factory. Do not attempt to disassemble and rebuild.

5. Insert the sensor assembly into the master body of the compensator as shown in . Make sure the O-ring is in place and seated properly on the back side of the sensor assembly.
6. Secure the sensor assembly using the (2) M3 socket head cap screws. Tighten to 12 in-lbs (1.4 Nm).
7. If applicable, connect the sensor cable connector.
8. Confirm the operation of the sensor by applying air pressure to the air fitting and then checking to see that the LED illuminates on the sensor.
9. After the procedure is complete, resume normal operation.

Figure 7.3—Sensor Replacement

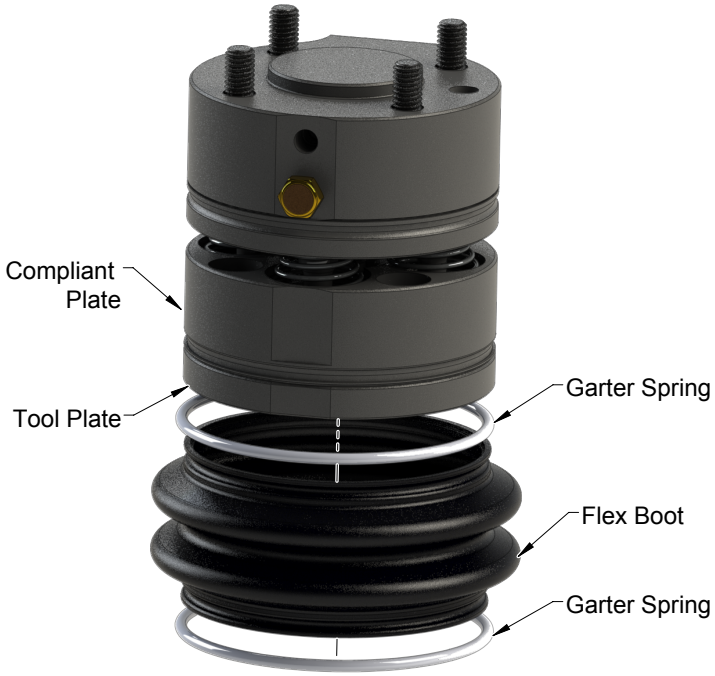


7.2.4 Optional Flex Boot Replacement

Parts required: *Refer to Section 8.2—Accessories.*

1. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
2. Remove the (2) garter springs retaining the flexible boot to the grooves in the chamber and tool plates of the compensator. Refer to *Figure 7.4*.
3. Slide the new flexible boot over the tool plate and onto the compensator.
4. Secure the flexible boot using (2) garter springs. Make sure the garter springs fit tightly in the grooves of the compliant plate and tool plate.
5. After the procedure is complete, resume normal operation.

Figure 7.4—Flexible Boot Replacement



8. Serviceable Parts

8.1 Compensator Serviceable Parts

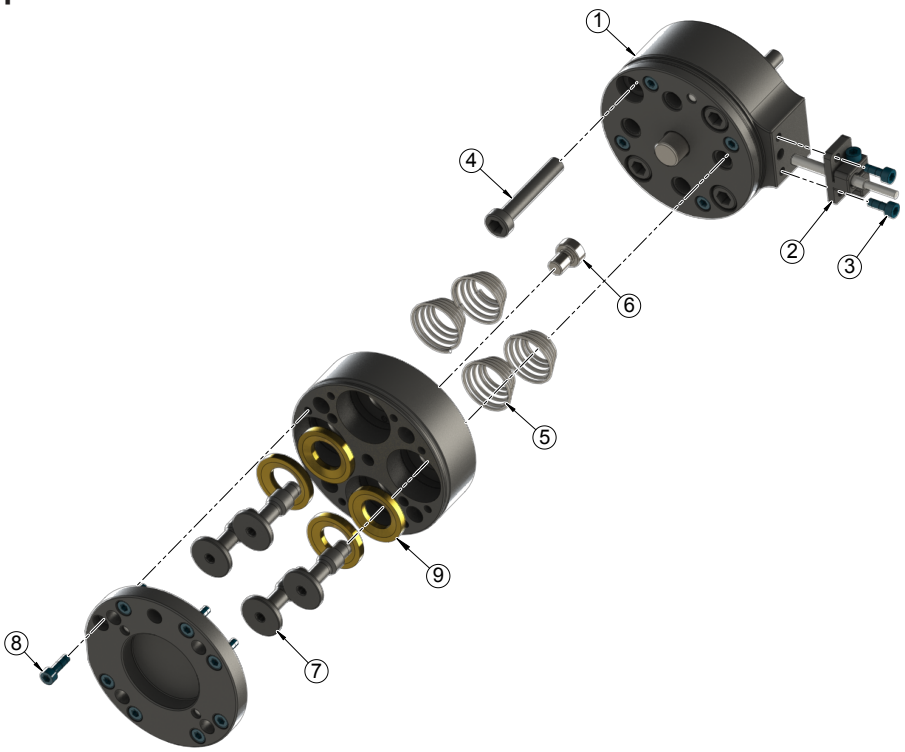


Table 8.1—Universal Compliance Compensator			
Item No.	**Qty**	**Part Number**	**Description**
1	1	9117-U1K-050-SA-M-2131-L	Universal Compliance Compensator, 31.5 Boss, 50mm BC, NPN Sensor, Hardwired 5m Cable , M5 Port, 2131 Tool IP, Locking
		9117-U1K-050-SB2-M-2131-L	Universal Compliance Compensator, 31.5 Boss, 50 mm BC, PNP Sensor, Hardwired 0.25 m Cable and 90° LED Pico, M5 Port, 2131 Tool interface plate, Locking
		9117-U1K-050-SB2-M-2131-L-C1	Universal Compliance Compensator, 31.5 Boss, 50mm BC, PNP Sensor, Hardwired 0.25m Cable, 90 Deg LED Pico, M5 Port, 2131 Tool IP, Locking, with Flexible Boot
2	1	9005-20-1743	PNP Sensor Assembly, Hardwired 0.25 m Cable and 90° LED Pico
		9005-20-1744	NPN Sensor Assembly, Hardwired 0.25 m Cable and 90° LED Pico
3	2	3500-1058008-15A	M3X8 Socket Head Cap Screw, Class 12.9, Blue dyed Magni-565, ND Microspheres Epoxy, Yellow
4	4	3500-1066035-13	M6 X 35 Socket Head Cap Screw, Low Head, Black-Oxide Class 8.8 Alloy Steel
5	4	3610-1707500-20	Conical Compression Spring 3/4” L, 0.85” X 0.50” OD, 7.99 lbs/in, SS
6	1	3700-15-2156	Spherical Head Rest Button
7	4	3700-15-2126	U1-050 Overload Pin
8	8	3500-1058010-15A	M3X10 Socket Head Cap Screw, Class 12.9, Blue dyed Magni-565, ND Microspheres Epoxy, Yellow
9	4	3700-15-2127	UCC 050 Chamfer Washer

8.2 Accessories

Table 8.2—Accessories			
Item No.	**Qty**	**Part Number**	**Description**
*	*	9005-15-5012	Flexible Boot Kit for UCC-050

9. Specifications

Table 9.1—Specifications		
Specification	**Values**	**Comments**
Max Payload	5 kg (11.0 lb)	See also Max Static Moment ratings.
X/Y Lateral Compliance	± 2.7 mm (0.11 in)	Some axial compliance coincides. See also Note A
X/Y Axis Rotation	± 3°	See Notes A, B
Z Axis Rotation	± 8°	See Note A
Z Axial Compression	6.1 mm (0.24 in)	See Note A
Max Static Moment X/Y	2.26 Nm (20 lbf-in)	For zero deflection under 3g robot accelerations.
Max Static Moment Z	1.13 Nm (10 lbf-in)	For zero deflection under 3g robot accelerations.
Positional Repeatability (X-Y)	+/- 0.15 mm (0.006 in)	-
Spring Force Min/Max	35.6/92.1 N (8.0/20.7 lbf)	Total at 0 psi supply pressure and min/max axial compliance.
Weight	0.6 kg (1.4 lb)	Includes optional sensor.
Nominal Operating Pressure	5.5 bar (80 psi)	Used to determine ratings.
Compliance Stiffness Tuning	2.1 bar (30 psi)	Max Pressure See Note C
Rated Service Life	1 million cycles	See Note B
Compliance Sensor	PNP or NPN	See Note D
Robot Mounting	ISO 50 mm BC, (4) M6 SHCS, (1) 6 mm Dowel, 31.5 mm Boss	-
Tool Mounting	ISO 50 mm BC, (4) M6 SHCS, (1) 6 mm Dowel, 31.5 mm Recess	Default “-2131” tool plate, if included. See Note E.

Note:

A. Compliance allowed in all directions simultaneously, but max compliance cannot be reached in all directions simultaneously.

B. Compliance limit for rated service life. Internal hard stops allow up to ± 8° but reduced spring life should be expected.

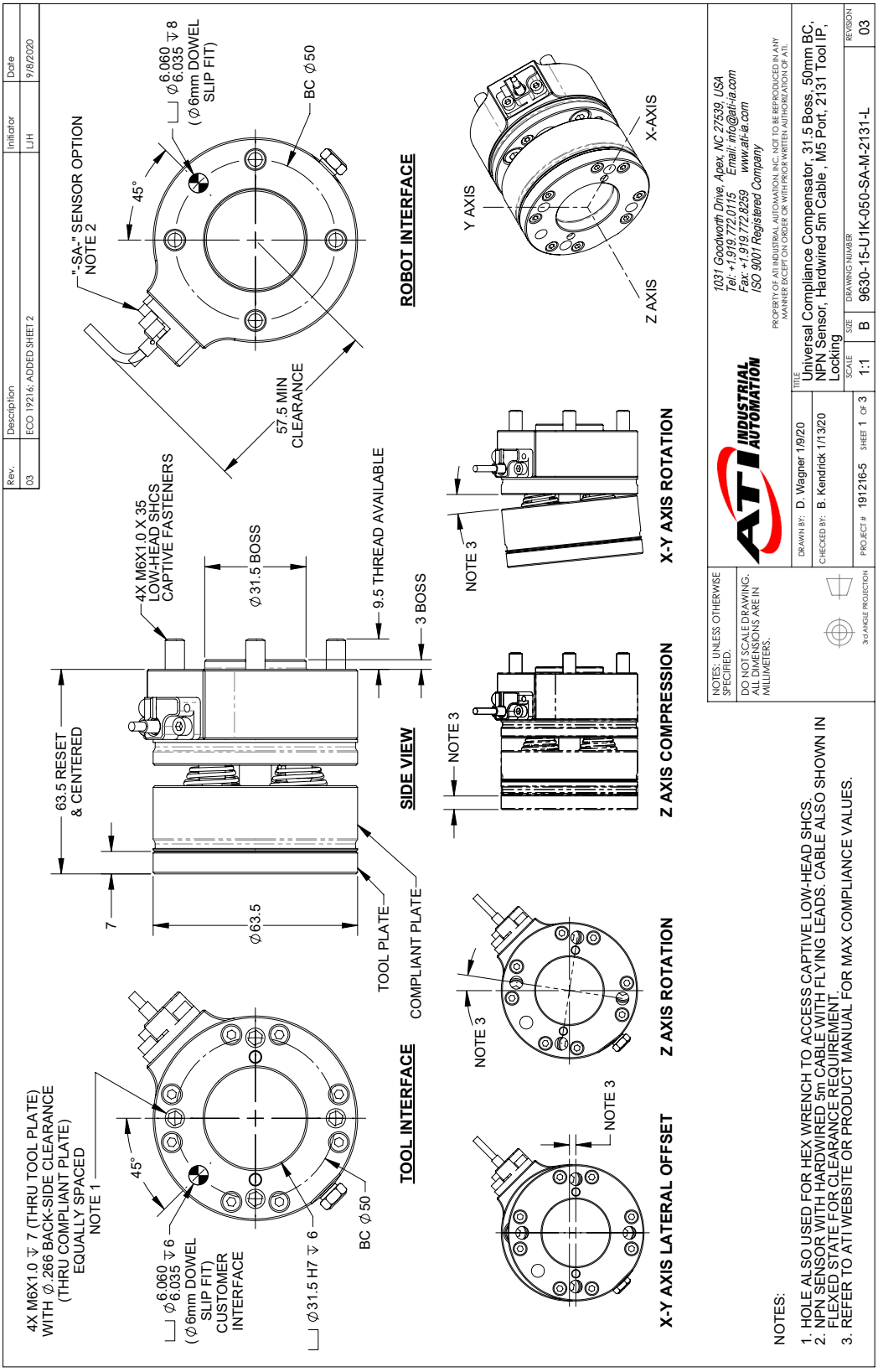
C. Tune compliance stiffness by varying lock pressure between 0-30 psi. Forcing compliance above 30 psi may reduce service life.

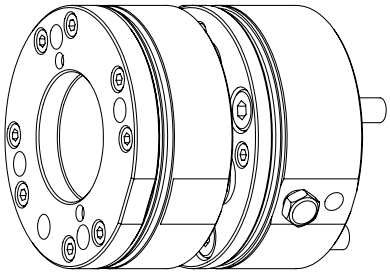
D. Sensor Options: SB2 – 3 wire DC PNP with 0.25m lead and 90 Deg LED M8 Quick Connect / S0 - No sensor.

E. Tool Plate Options: 0000 - Omit ISO Tool Plate / XXXX - Custom tool plate, available upon request.

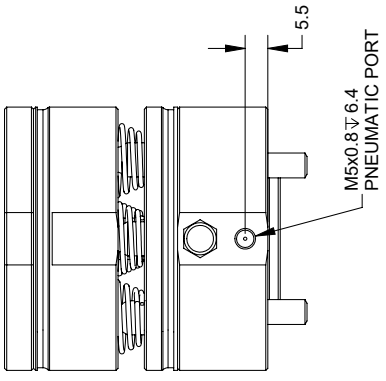
10. Drawings

10.1 9630-15-U1K-050-SA-M-2131-L





PNEUMATIC PORT LOCATION



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DO NOT SCALE DRAWING. ALL DIMENSIONS ARE IN MILLIMETERS.

DRAWN BY: D. Wagner 1/9/20

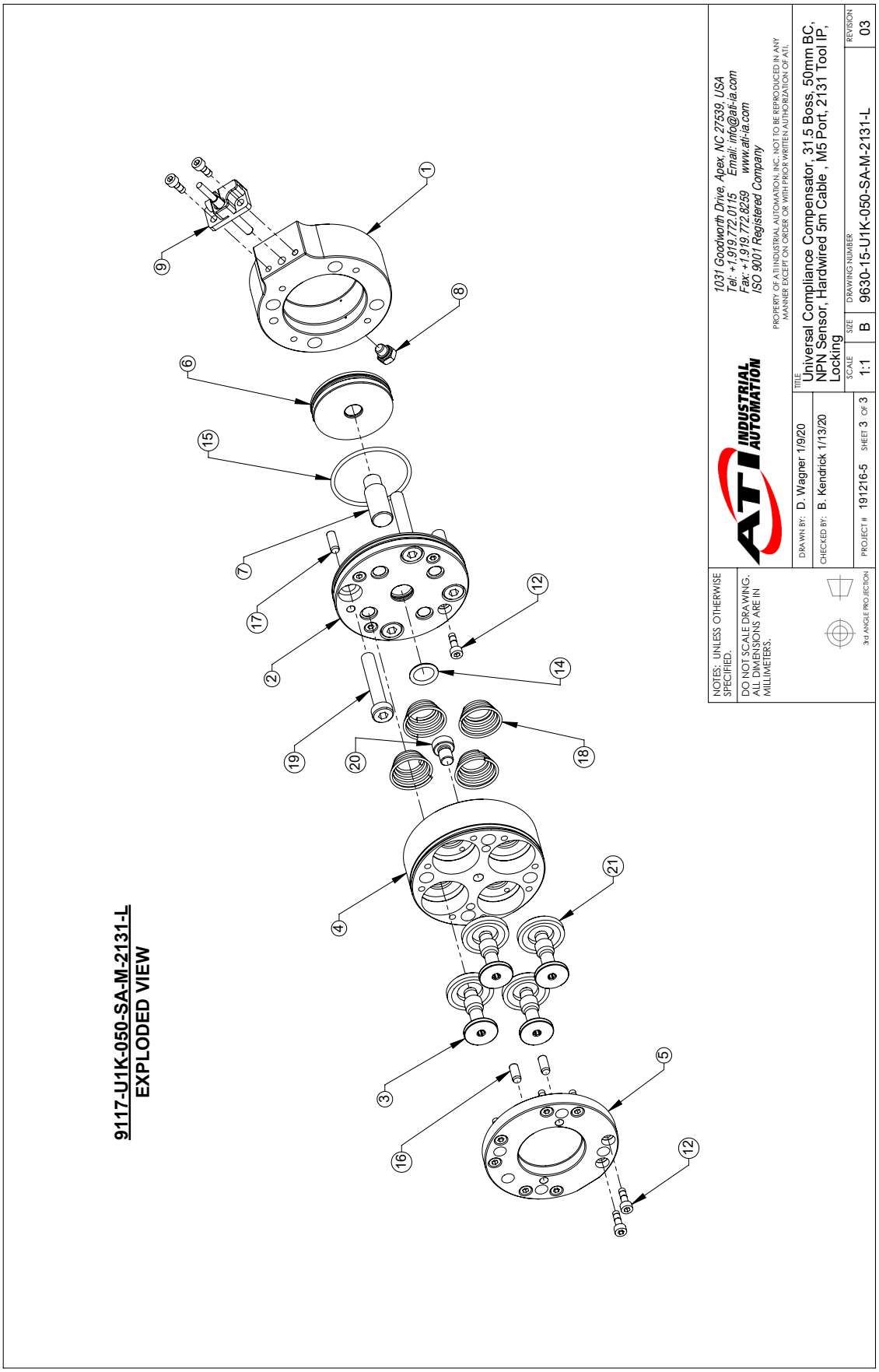
CHECKED BY: B. Kendrick 1/13/20

TITLE: Universal Compliance Compensator, 31.5 Boss, 50mm BC, NPN Sensor, Hardwired 5m Cable , M5 Port, 2131 Tool IP, Locking

SCALE: 1:2 | SIZE: B | DRAWING NUMBER: 9630-15-U1K-050-SA-M-2131-L | REVISION: 03

3rd ANGLE PROJECTION

PROJECT # 191216-5 SHEET 2 OF 3


9117-U1K-050-SA-M-2131-L
EXPLODED VIEW
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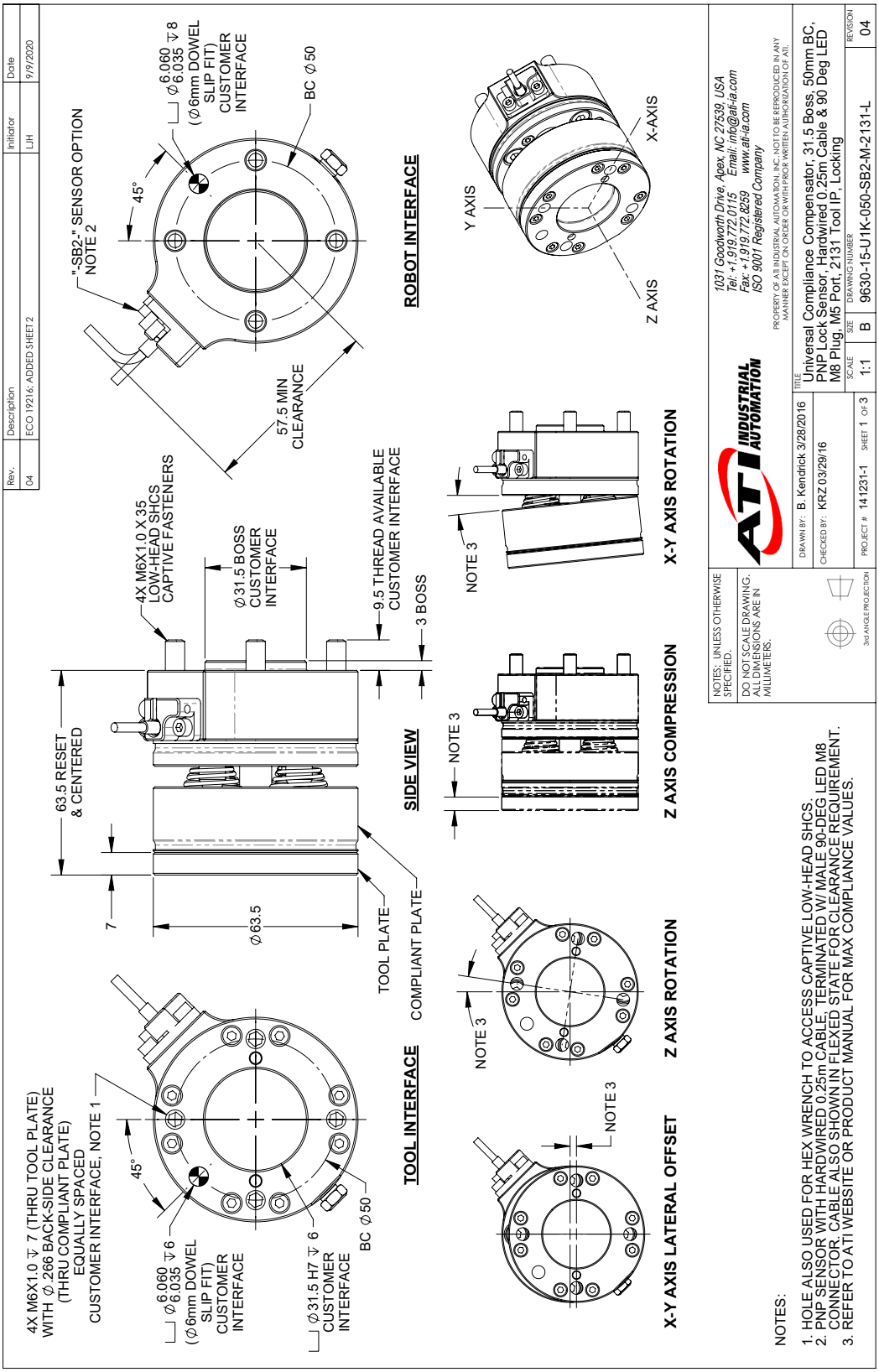
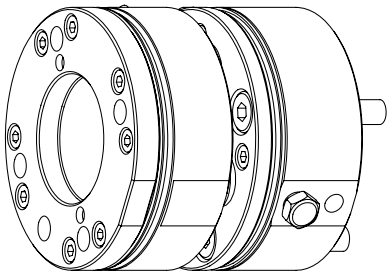
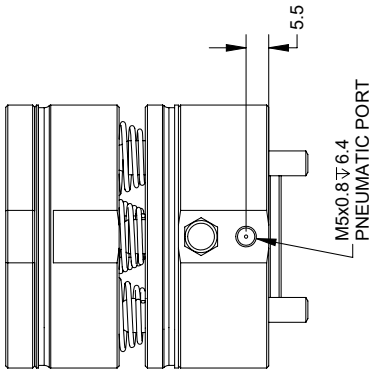
PROJECT # 191216-5 SHEET 3 OF 3
3rd ANGLE PROJECTION
TITLE
Universal Compliance Compensator, 31.5 Boss, 50mm BC, NPN Sensor, Hardwired 5m Cable , M5 Port, 2131 Tool IP, Locking
SCALE 1:1
SIZE B
DRAWING NUMBER 9630-15-U1K-050-SA-M-2131-L
REVISION 03

10.2 9630-15-U1K-050-SB2-M-2131-L







PNEUMATIC PORT LOCATION

NOTES: UNLESS OTHERWISE SPECIFIED.

DO NOT SCALE DRAWING. ALL DIMENSIONS ARE IN MILLIMETERS.

3rd ANGLE PROJECTION

DRAWN BY: B. Kendrick 3/28/2016

CHECKED BY: KRZ 03/29/16

PROJECT # 141231-1 SHEET 2 OF 3

TITLE: Universal Compliance Compensator, 31.5 Boss, 50mm BC, PNP Lock Sensor, Hardwired 0.25m Cable & 90 Deg LED M8 Plug, M5 Port, 2131 Tool IP, Locking

SCALE 1:2 | SIZE B | DRAWING NUMBER 9630-15-U1K-050-SB2-M-2131-L | REVISION 04

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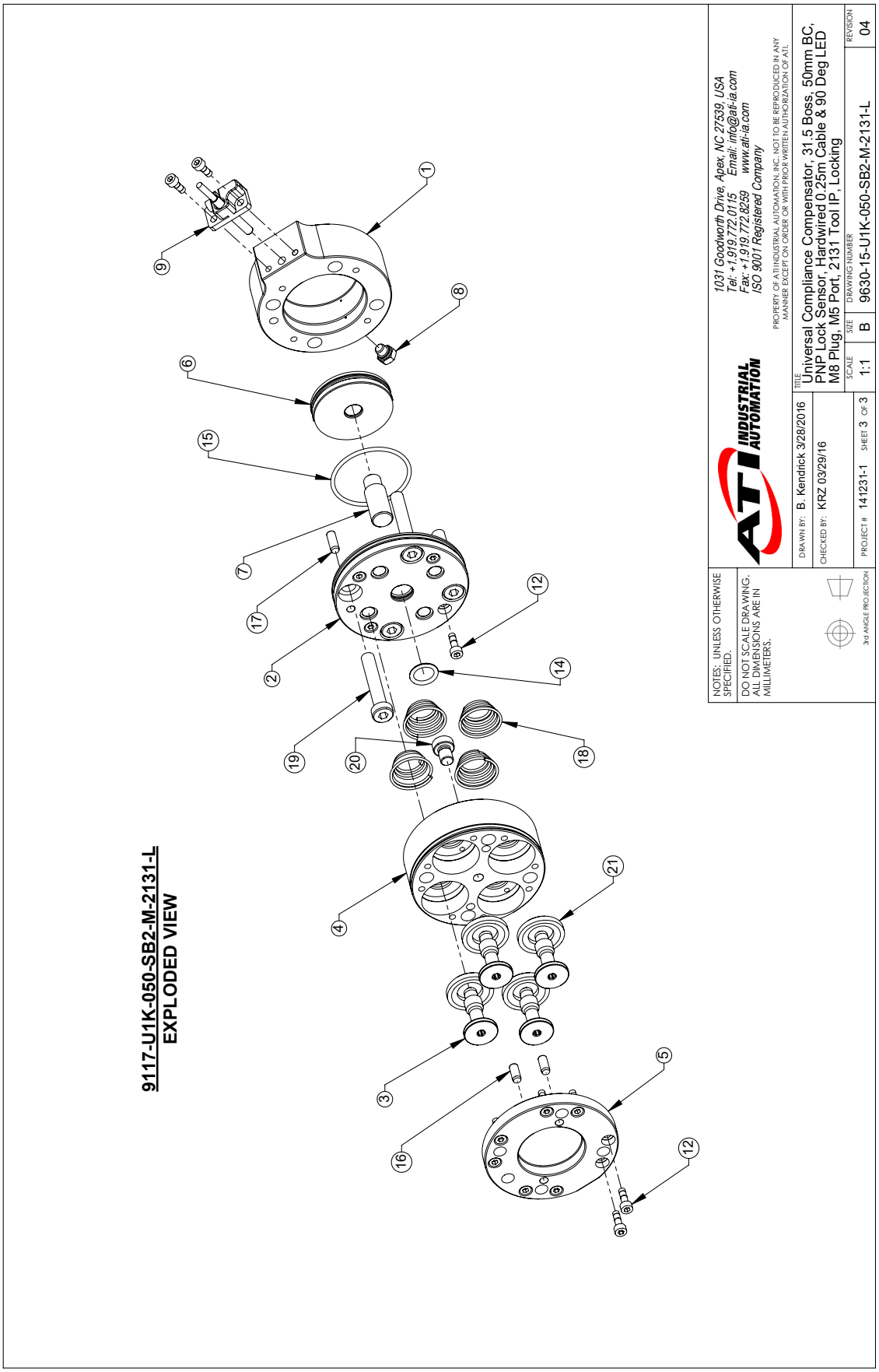
9117-U1K-050-SB2-M-2131-L
EXPLODED VIEW
1
2
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20
21
NOTES: UNLESS OTHERWISE SPECIFIED.
DO NOT SCALE DRAWING. ALL DIMENSIONS ARE IN MILLIMETERS.
3rd ANGLE PROJECTION
DRAWN BY: B. Kendrick 3/28/2016
CHECKED BY: KRZ 03/29/16
PROJECT # 141231-1 SHEET 3 OF 3
TITLE
Universal Compliance Compensator, 31.5 Boss, 50mm BC, PNP Lock Sensor, Hardwired 0.25m Cable & 90 Deg LED M8 Plug, M5 Port, 2131 Tool IP, Locking
SCALE 1:1
SIZE B
DRAWING NUMBER 9630-15-U1K-050-SB2-M-2131-L
REVISION 04
INDUSTRIAL AUTOMATION
1031 Goodworth Drive, Apex, NC 27539, USA
Tel: +1.919.772.0115 Email: info@ati-ia.com
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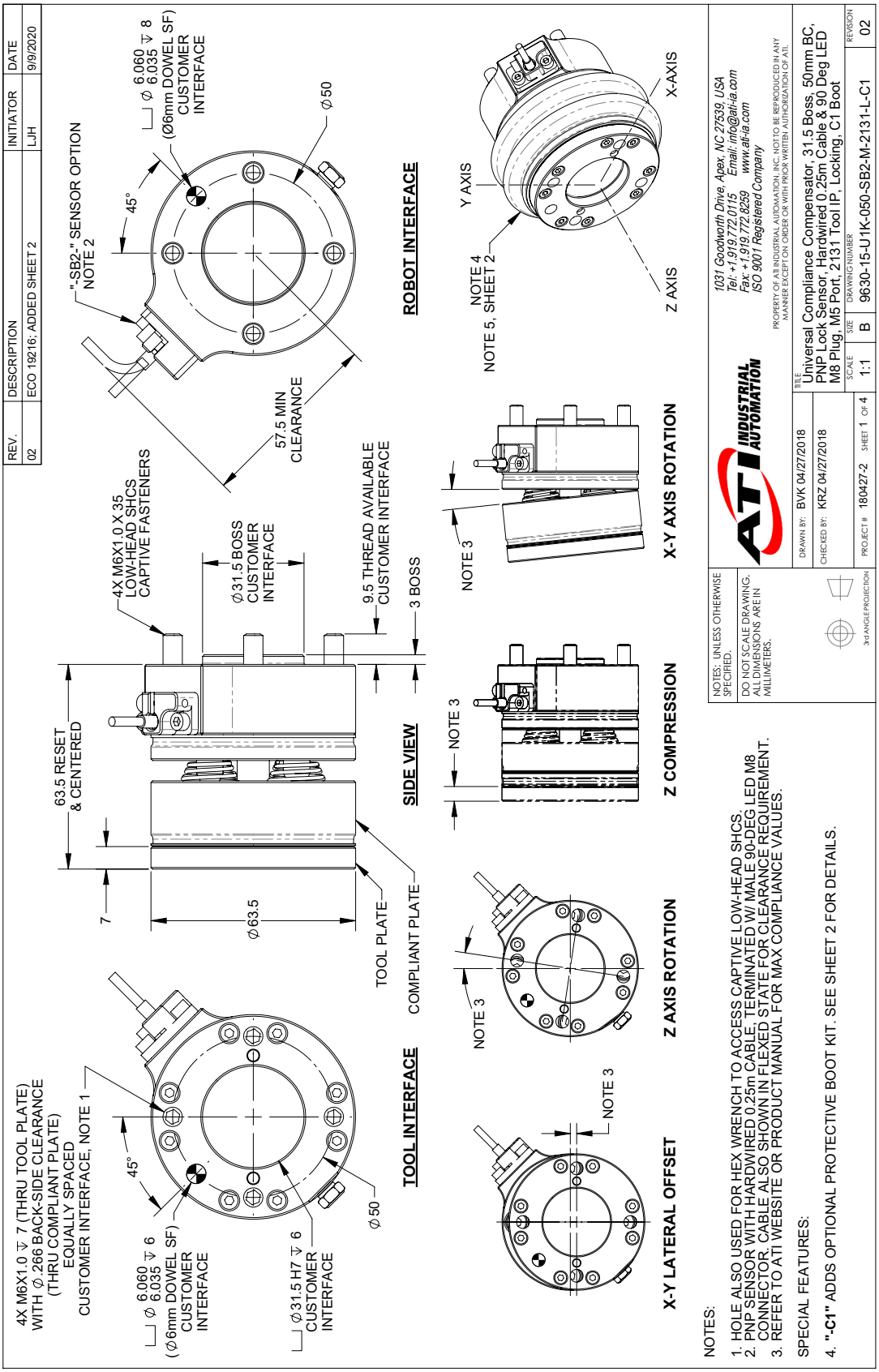
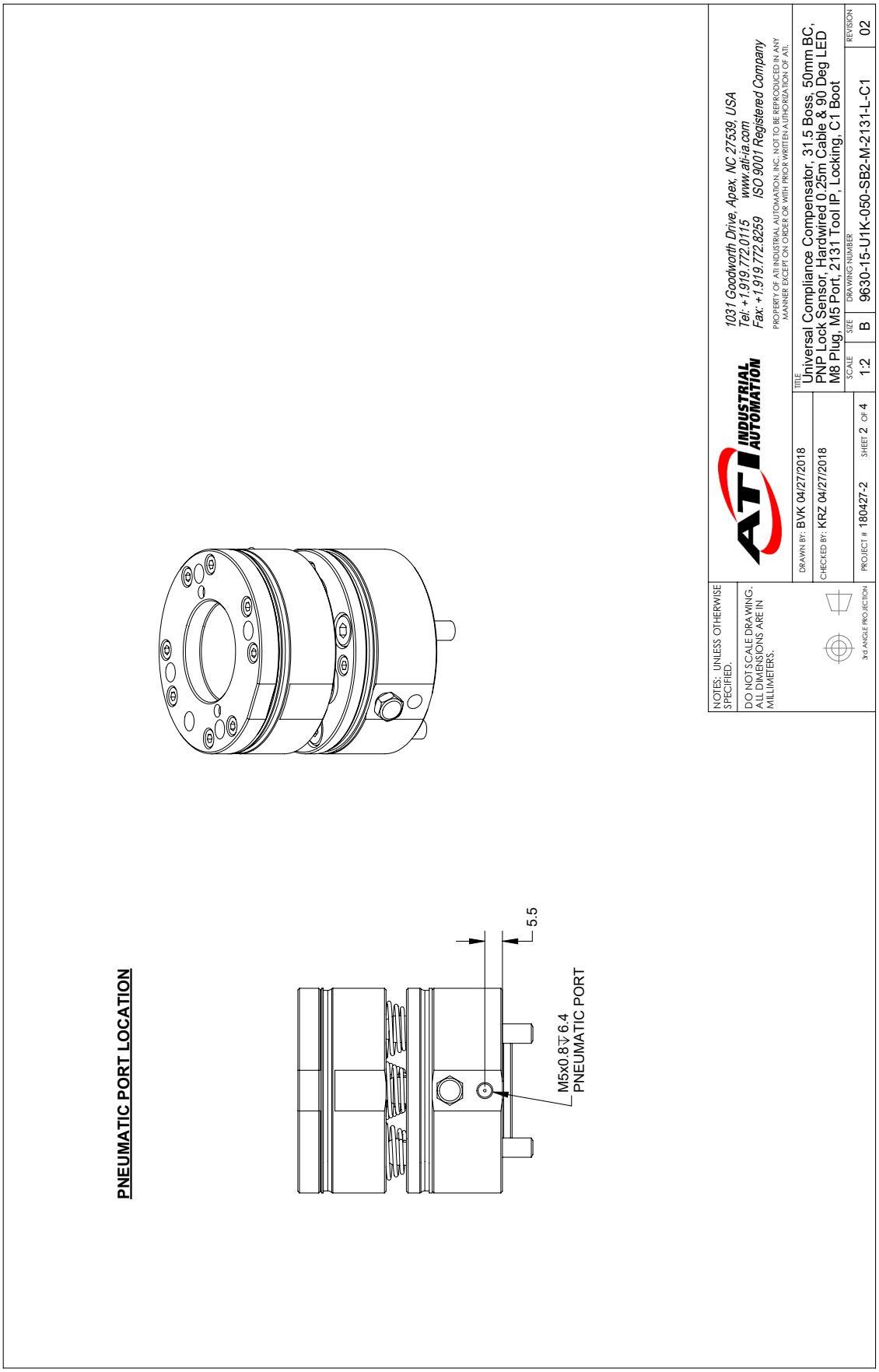
10.3 9630-15-U1K-050-SB2-M-2131-L-C1




PNEUMATIC PORT LOCATION
5.5
M5x0.8↧6.4
PNEUMATIC PORT
1031 Goodworth Drive, Apex, NC 27539, USA
Tel: +1.919.772.0115 www.ati-ia.com
Fax: +1.919.772.8259 ISO 9001 Registered Company
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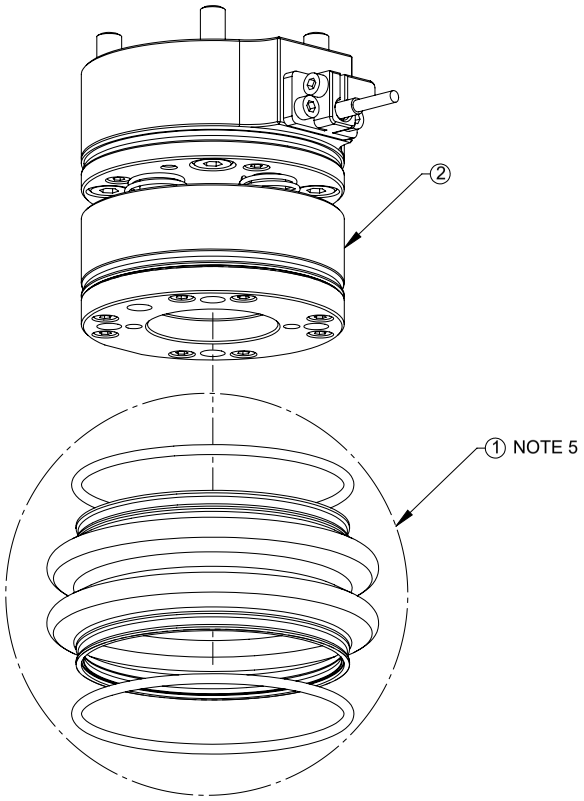
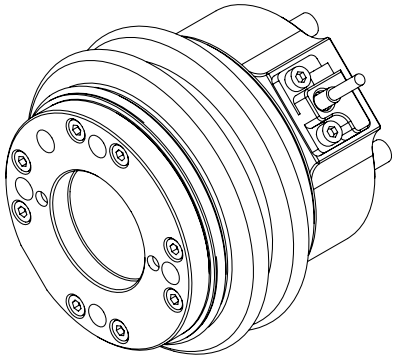
INDUSTRIAL AUTOMATION
NOTES: UNLESS OTHERWISE SPECIFIED.
DO NOT SCALE DRAWING. ALL DIMENSIONS ARE IN MILLIMETERS.
DRAWN BY: BVK 04/27/2018
CHECKED BY: KRZ 04/27/2018
TITLE
Universal Compliance Compensator, 31.5 Boss, 50mm BC, PNP Lock Sensor, Hardwired 0.25m Cable & 90 Deg LED M8 Plug, M5 Port, 2131 Tool IP, Locking, C1 Boot
SCALE 1:2
SIZE B
DRAWING NUMBER 9630-15-U1K-050-SB2-M-2131-L-C1
REVISION 02
3rd ANGLE PROJECTION
PROJECT # 180427-2
SHEET 2 OF 4

UNIT SHOWN WITH OPTIONAL "-C1" PROTECTIVE BOOT KIT
PART # 9117-U1K-050-SB2-M-2131-L-C1

EXPLODED VIEW



ASSEMBLED VIEW



ITEM NO.	QTY	PART NUMBER	DESCRIPTION
1	1	9005-15-5012	Flexible Boot Kit for UCC-050
2	1	9117-U1K-050-SB2-M-2131-L	Universal Compliance Compensator, 31.5 Boss, 50mm BC, PNP Lock Sensor, Hardwired 0.25m Cable & 90 Deg LED M8 Plug, M5 Port, 2131 Tool IP, Locking

NOTES:

5. BOOT KIT COMES BAGGED SEPERATELY. SEE PRODUCT MANUAL FOR ASSEMBLY INSTRUCTIONS.

NOTES: UNLESS OTHERWISE SPECIFIED.

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3rd ANGLE PROJECTION

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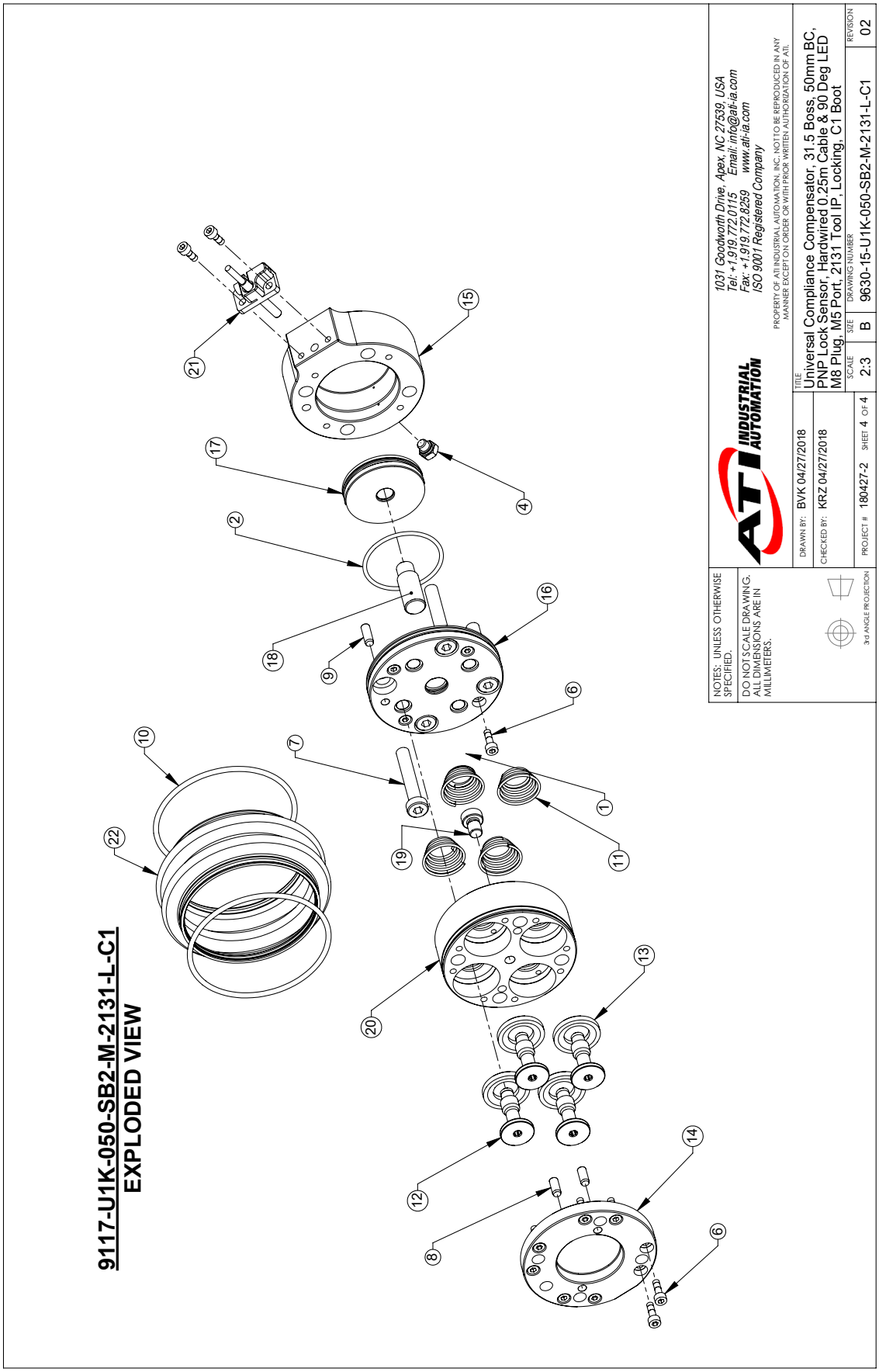
DRAWN BY: BVK 04/27/2018
CHECKED BY: KRZ 04/27/2018
PROJECT # 180427-2 SHEET 3 OF 4

TITLE: Universal Compliance Compensator, 31.5 Boss, 50mm BC, PNP Lock Sensor, Hardwired 0.25m Cable & 90 Deg LED M8 Plug, M5 Port, 2131 Tool IP, Locking, C1 Boot

SCALE	SIZE	DRAWING NUMBER	REVISION
1:1	B	9630-15-U1K-050-SB2-M-2131-L-C1	02


9117-U1K-050-SB2-M-2131-L-C1
EXPLODED VIEW
1031 Goodworth Drive, Apex, NC 27539, USA
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DRAWN BY: BVK 04/27/2018
CHECKED BY: KRZ 04/27/2018
TITLE
Universal Compliance Compensator, 31.5 Boss, 50mm BC, PNP Lock Sensor, Hardwired 0.25m Cable & 90 Deg LED M8 Plug, M5 Port, 2131 Tool IP, Locking, C1 Boot
SCALE 2:3
SIZE B
DRAWING NUMBER 9630-15-U1K-050-SB2-M-2131-L-C1
REVISION 02
PROJECT # 180427-2 SHEET 4 OF 4
3rd ANGLE PROJECTION

11. 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 to Purchaser that robotic Compensator 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. 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. 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 accrued.

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.

Unless otherwise agreed in writing by ATI, all designs, drawings, data, inventions, software and other technology made or developed by ATI in the course of providing products and services hereunder, and all rights therein under any patent, copyright or other law protecting intellectual property, shall be and remain ATI's property. The sale of products or services hereunder does not convey any express or implied license under any patent, copyright or other intellectual property right owned or controlled by ATI, whether relating to the products sold or any other matter, except for the license expressly granted below.

In the course of supplying products and services hereunder, ATI may provide or disclose to Purchaser confidential and proprietary information of ATI relating to the design, operation or other aspects of ATI's products. As between ATI and Purchaser, ownership of such information, including without limitation any computer software provided to Purchaser by ATI, shall remain in ATI and such information is licensed to Purchaser only for Purchaser's use in operating the products supplied by ATI hereunder in Purchaser's internal business operations.

Without ATI's prior written permission, Purchaser will not use such information for any other purpose or provide or otherwise make such information available to any third party. Purchaser agrees to take all reasonable precautions to prevent any unauthorized use or disclosure of such information.

Purchaser will not be liable hereunder with respect to disclosure or use of information which: (a) is in the public domain when received from ATI; (b) is thereafter published or otherwise enters the public domain through no fault of Purchaser; (c) is in Purchaser's possession prior to receipt from ATI; (d) is lawfully obtained by Purchaser from a third party entitled to disclose it; or (f) is required to be disclosed by judicial order or other governmental authority, provided that, with respect to such required disclosures, Purchaser gives ATI prior notice thereof and uses all legally available means to maintain the confidentiality of such information.