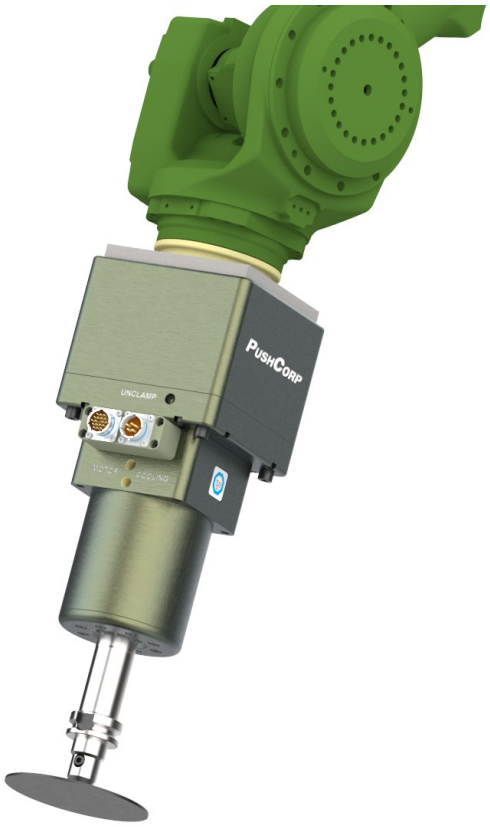
0605 / 1503
Series High Speed Servo Motor



Manual

PUSHCORP, INC.

Dallas, Texas

February, 2023

! CAUTION !

Do NOT apply air pressure to release the Collet while the servo motor is rotating. The servo motor spindle must be *FULLY STOPPED* before actuating the Collet.

Do NOT overheat the servo motor. Supply the motor cooling water to maintain a temperature below 176 ˚F (80 ˚C).

Do NOT start or stop the servo motor instantaneously. Doing so will damage the motor and power amplifier.

All *PushCorp, Inc.* electrical cables are rated for high twist and flex robotic applications with a minimum cable bending radius specification of 125mm (5 in). Cable damage resulting from failure to abide by this specification will not be covered under warranty.

Do NOT use safety rated IO. These pulse at an extremely high rate and the servo amplifier will turn off the IO as a result.

Table of Contents

1.0 Limited Warranty

Duration:

One year from date of delivery to the original purchaser.

Who gives this warranty (warrantor):

PushCorp, Inc.
Telephone: (972) 840-0208

Corporate Address:
P. O. Box 181915
Dallas, Texas 75218

Shipping Address:
3001 W Kingsley Rd
Garland, Texas 75041

Who receives this warranty (purchaser):

The original purchaser (other than for purposes of resale) of the *PushCorp, Inc.* product

What products are covered by this warranty:

Any *PushCorp, Inc.* industrial equipment or accessory supplied or manufactured by the Warrantor.

What is covered under this warranty:

Defects in material and/or workmanship which occur within the duration of the warranty period.

What is NOT covered in this warranty:

A. IMPLIED WARRANTIES, INCLUDING THOSE OF MERCHANT-ABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE LIMITED TO ONE YEAR FROM THE DATE OF ORIGINAL PURCHASE. Some states do not allow limitations on how long an implied warranty lasts, so the above limitations may not apply to you.

B. ANY INCIDENTAL, INDIRECT, OR CONSEQUENTIAL LOSS, DAMAGE or EXPENSE THAT MAY RESULT FROM ANY DEFECT, FAILURE, MALFUNCTION OF THE *PUSHCORP, INC.* PRODUCT. Some states do not allow the exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you.

C. Any failure that results from an accident, purchaser's abuse, neglect, unauthorized repair or failure to operate the products in accordance with the instructions provided in the owner's manual(s) supplied with the product.

Responsibilities of the Warrantor under this warranty:

Repair or replace, at Warrantor's option, products or components which have failed within the duration of the warranty period.

Responsibilities of the purchaser under this warranty:

A. Deliver or ship the *PushCorp, Inc.* product or component to PushCorp, Inc. Service Center, Dallas, TX. Freight and insurance costs, if any, must be borne by the purchaser.

B. Use reasonable care in the operation and maintenance of the product as described in the owner's manual(s).

When warrantor will perform repair or replacement under this warranty:

Repair or replacement will be scheduled and serviced according to the normal work flow at the service center, and depending on the availability of replacement parts. Purchasers requiring quicker repair may receive such with payment of a *PushCorp, Inc.* predetermined expediting fee.

This Limited Warranty gives you specific legal rights and you may also have other rights which vary from state to state.

2.0 General Overview

This manual will cover both the PushCorp 0605 and 1503 Series Servo Motors as they share many common components. The 0605 and 1503 (motor) are capable of continuously producing 5 and 3 horsepower, and spinning up to 6000 rpm and 15000 rpm respectively. The motors come in two models; a model SM0605 or SM1503 utilizing a manual collet, and a STC0605-BT30 or STC1503-BT30 automatic version which allows changing out tools via a BT30 toolholder. These versions utilize identical motor windings, and power amplifiers. Differing only in a few physical dimensions and how they secure the media. Each of these motors provide a convenient and effective means to spin and/or change any number of different media types to support a fully automated workcell.

The Servo Manual (SM) models have a manually tightened collet that is a cost-effective alternative to the automatic version. The “SM” models use the same motor winding and housing as the automatic “STC”, but without the automatic clamping mechanism. The manual Collet is a standard ER-20 series collet designed to clamp a ½ inch (12.7 mm) diameter Toolholder. The user may choose different sized collets in the ER-20 series, ranging from .031-.500 inch (1mm – 13mm).

The Servo Tool Changer (STC) automatic tool-changing models, actuate pneumatically to secure the BT30 style toolholder. They are comprised of four primary components: a high-torque Servo Motor, a pneumatic actuator, high force Belleville springs, and a component to clamp a Toolholder. The STC version uses a drawbar to pull the Collet/Gripper in. High force Belleville springs located at the back of the Servo Motor tension the drawbar. Actuating the large pneumatic actuator, located in the Clamping Housing, opens the Collet/Gripper. During pressurization the cylinder contacts the Belleville springs and compresses them to drive the Collet/Gripper out, releasing the Toolholder. There is no mechanism to forcibly eject the Toolholder from the Collet, so gravity or a capturing mechanism must be used.

The STC models use a 30 taper to grip a standard BT30 toolholder. This design locks the toolholder in the 30 tapered shaft and resists large pull out forces. The shaft does not have locking keys, so motor indexing for tool change is not required. The STC motors are fail-safe, in that no air pressure is required to hold the Toolholder. Therefore, the Toolholder will remain held in the Collet/Gripper even when the air pressure is un-expectantly lost. Likewise, applying air pressure to a single input port via a simple manual or electrically operated valve opens the Collet/Gripper and releases the Toolholder. The clever mechanical design always isolates the motor bearings from the drawbar tension. This greatly improves reliability by allowing the motor shaft to spin freely and never be subject to any clamping forces. All PushCorp motors use sealed bearings to ensure a long life. The bearings have additional contamination protection from a PushCorp proprietary contact shaft seal. This special seal eliminates the need for constant purge air.

During operation the motor generates considerable heat due to the high torque and compact size of the motor. Excessive operating temperatures will significantly reduce the life of the motor. Water Cooling is required to keep the unit within the internal temperature operating range. The motor should never be allowed to exceed a temperature of 176 ˚F (80 ˚C). Continuously operating the unit above 176 ˚F (80 ˚C) will cause the rotor to de-magnetize and the bearings to fail. High temperatures will

also cause the O-rings that seal the cooling water channels to fail, possibly filling the motor with water. PushCorp has provided flow through water cooling on the motor to allow high duty cycles without overheating.

Simple reliable construction combined with high torque and precision speed controlled servo technology make the *PushCorp* Servo Motor line a rugged, state-of-the-art tool capable of providing flexible, cost-effective operations.

3.0 Installation & Operation

3.1 Mounting the spindle motor

3.1.1 Mounting to a PushCorp AFD compliant tool

The motors are designed to attach directly to the Carriage of any *PushCorp* AFD1000/70 Force Device. There are two standard attachment options. The SM version uses a Mounting Plate, and the STC motor uses the Clamping Housing for attachment.

The Parallel-Axis configuration is shown in Figure 1, where the motor attaches to the AFD Carriage with a Parallel Bracket. The Parallel Bracket is positioned on the Carriage and attached using the four (4) supplied M6x1x20mm Socket Head Cap Screws. The motor is then attached to the Parallel Bracket, as shown, with two (2) M6x1x20mm Socket Head Cap Screws into the front of the Motor Housing. Two (2) M6x1 Socket Head Cap Screws pass through the Clamping Housing/Mounting Plate (length is dependent on motor SMxxxx = 25mm, STCxxxx-BT30 = 145mm). The fasteners must be tightened to the torque specified in Section 4.0.

To attach the motor to an AFD in a Perpendicular-Axis configuration, position the Clamping Housing/Mounting Plate over the Carriage as shown in Figure 2. Then secure the unit using four (4), M6x1 Socket Head Cap Screws (length is dependent on motor SMxxxx = 25mm, STCxxxx-BT30 = 145mm). Tighten the fasteners to the torque specified in Section 4.0. 5mm Dowel pins can be inserted and glued into the Carriage to align the motor. The Clamping Housings and Mounting Plate have pre-drilled clearance dowel holes for this configuration.

CAUTION: Make sure that the M6x1 fasteners do not exceed a depth of 0.40" (10 mm) into the AFD Carriage Helicoils or damage will occur.

CAUTION: Do not press Dowel Pins into the AFD Carriage, this will damage the linear rails.

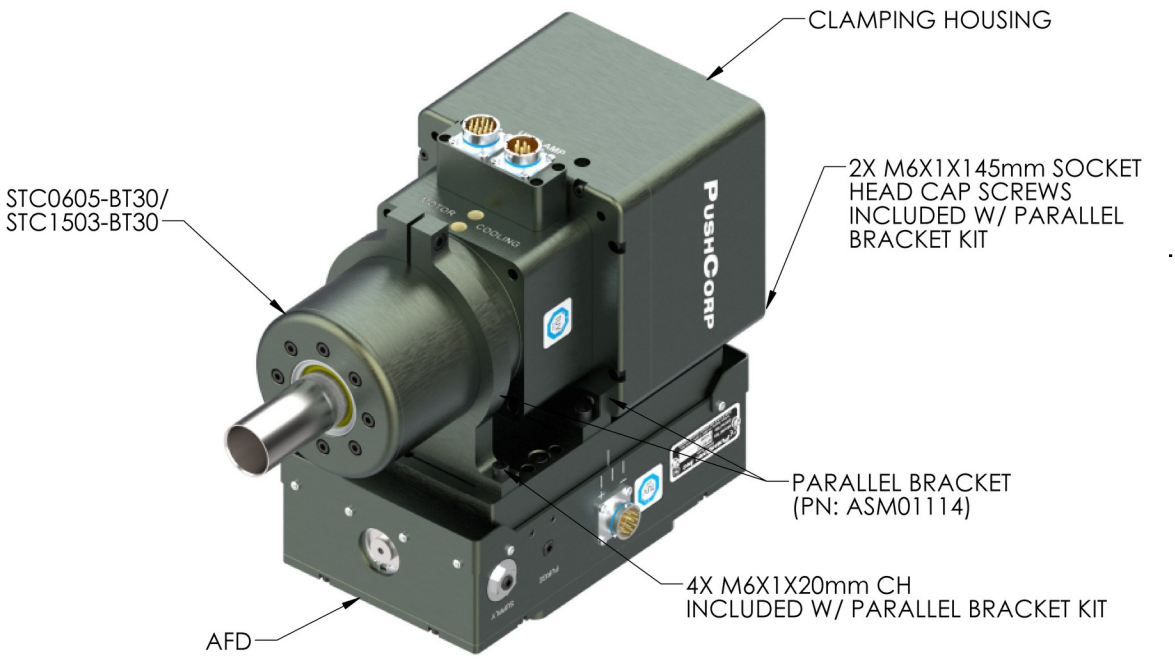


Figure 1: Spindle Motor Parallel-Axis Configuration

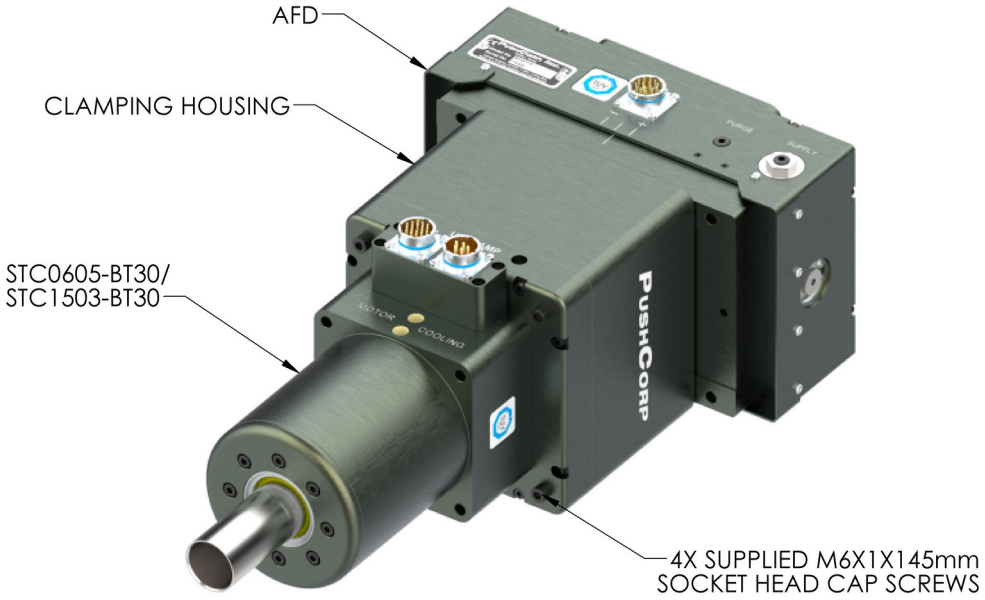


Figure 2: Spindle Motor Perpendicular-Axis Configuration

3.1.2 Mounting Directly to a Robot

For some processes compliance and force control are not required. The motor can be mounted directly to the robot. This robotic system is equivalent to a 5-axis machining center with a very large work volume and lower positional accuracy. Certain product types and processes are well suited for a Robotic Machining Center (RMC).

The motor can be attached to the robot mounting flange using a customer supplied mounting plate. For direct mounting it is recommended that a breakaway clutch is installed. The breakaway clutch will help protect the motor in the event of a robot crash. Loads on the motor shaft of over 300 lb (136 kg) radially and 150 (68 kg) axially will damage the bearings.

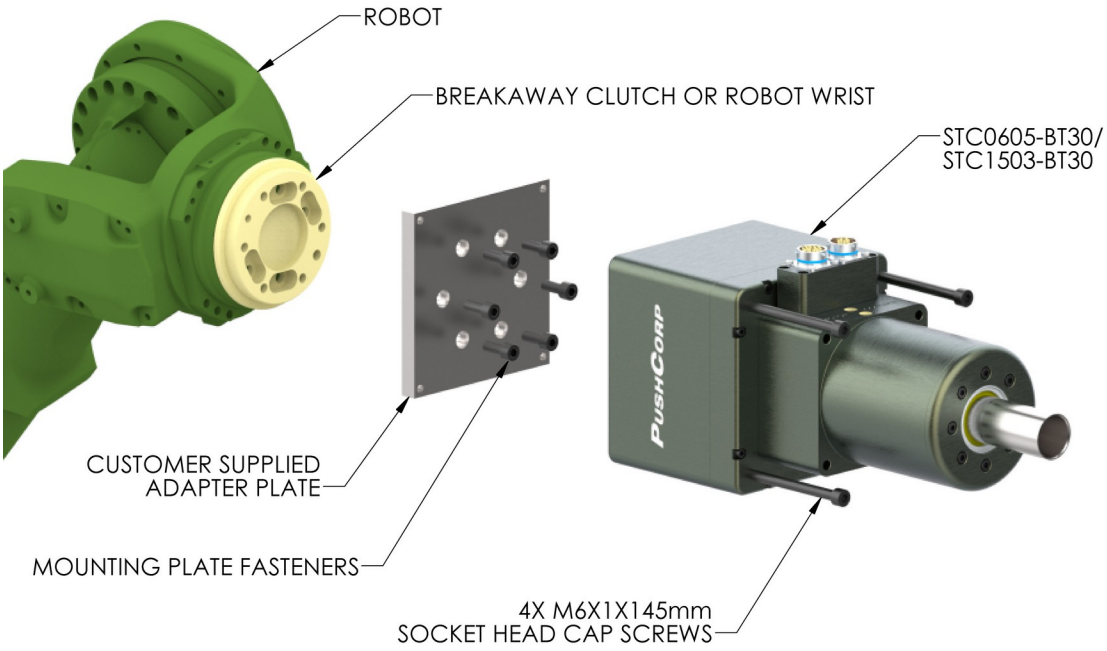


Figure 3: Spindle Motor Direct Mounting

To mount the motor, first attach the customer supplied Mounting Plate to the Robot Mounting Flange or to the Breakaway Clutch, per the manufacturer's specifications. Once the Mounting Plate is secured, place the motor against the Mounting Plate and install (4) four, M6x1, Socket Head Cap Screws (length is dependent on motor SMxxxx = 25mm, STCxxxx-BT30 = 145mm). (See Figure 3) Tighten the fasteners to the torque specified in Section 4.0.

3.2 Media and Tool Presentation

Media and tool presentation refers to how various disks, drill bits, router bits, etc. are presented so that a robot may maneuver the motor into position to grasp the Toolholder reliably. It is ultimately the user's responsibility to provide a means to present the media and/or tooling in an effective and repeatable way for a given application.

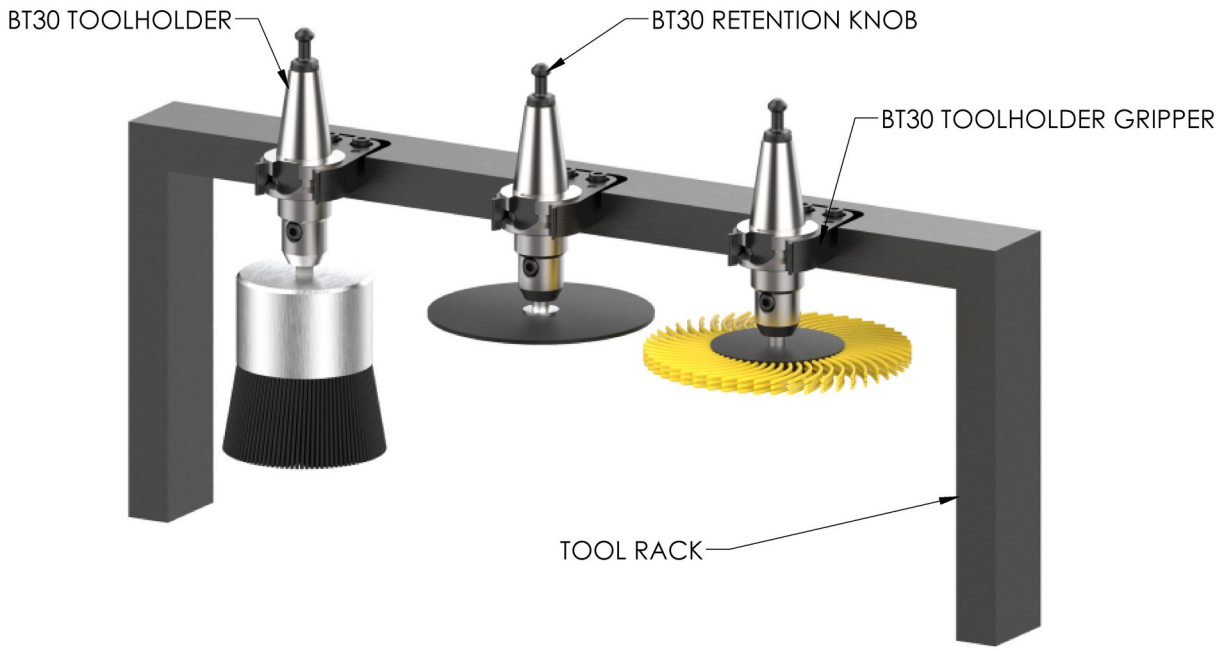


Figure 4: Sample media and tooling presentation scheme

As shown above, in Figure 4, many types of media and tools may be accurately located in a Tool Cradle. A robot can then be taught approach paths and docking locations to reliably bring the motor down over the Toolholders and grasp them. The motor's Collapsing Collet allows 0.015 in. (0.38 mm) diametrical clearance around the Toolholder when open. The Toolholder must have a taper that mates to a Tapered Holder mounted in the Tool Cradle. The Tapered Holder requires a slot to allow the Toolholder to pass through. This same method is applicable to the motor's design.

3.3 Tool and Media Specification

3.3.1 SM Toolholder Specification

The motors are designed to grasp a ½ inch (12.7 mm) diameter steel shaft. Figure 6 shows the Toolholder dimensions required for the motor to operate properly. Notice that the end of the Toolholder can be tailored to any needed configuration to attach to various disk back-up pads, drill bits, router bits, grinding stones, etc. If desired, *PushCorp, Inc.* can fabricate custom Toolholders, at an additional cost, based on customer supplied drawings and specifications. To prevent interference between the Toolholder and the Collet an 11° taper must be included in all Toolholder designs.

Toolholders should be manufactured from carbon or stainless steel with a hardness less than Rc40. The surface finish on the Toolholder Clamping Surface should be Ra 16 – 32. To accurately locate the Toolholder axially the front flat surface of the Collet can be used. This means that the Toolholder Clamping Surface and taper must be shorter than the Collet depth. When using the Collet face for positioning some form of compliance must be used on the Tool Cradle to prevent wedging the Collet in too tightly, or damaging the motor bearings.

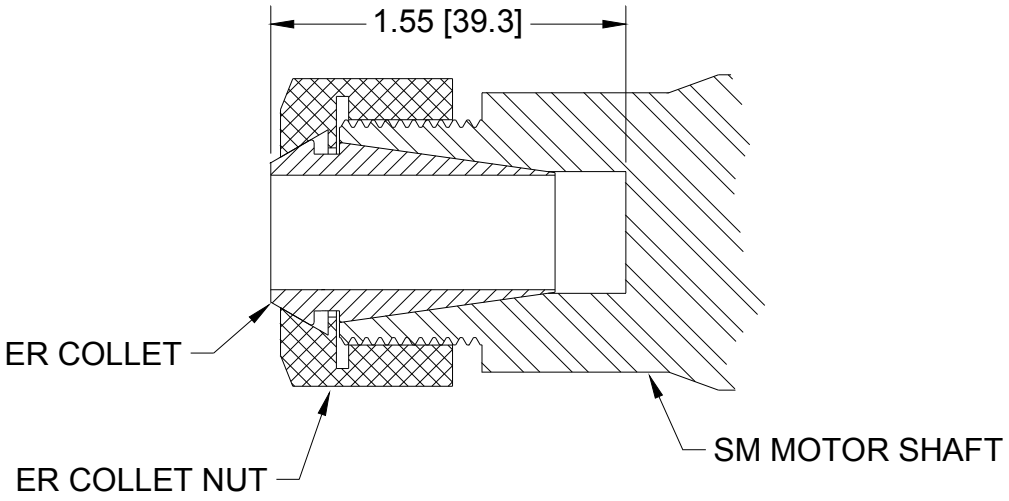


Figure 5: SM Collet Drawing

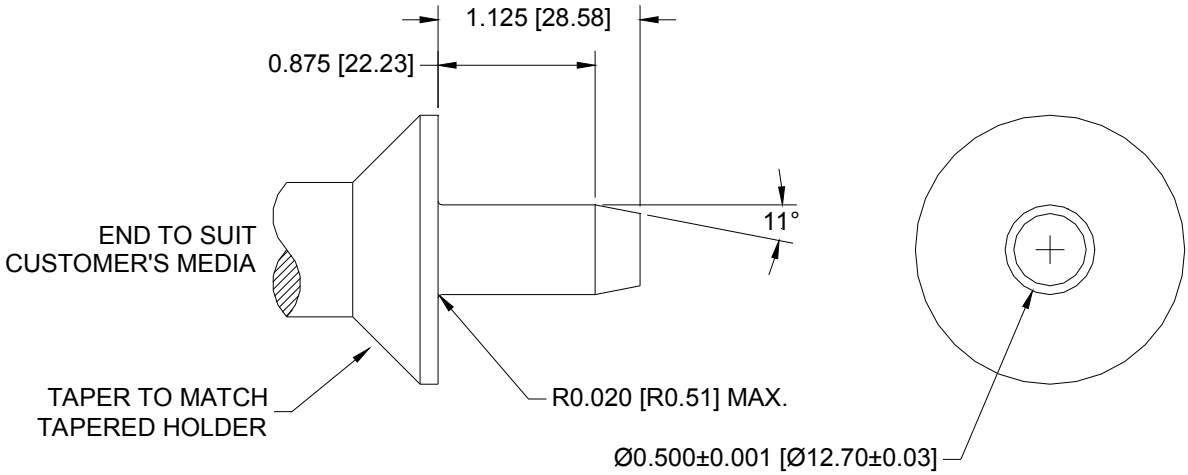


Figure 6: SM Toolholder Drawing

3.3.3 BT30 Toolholder Specification

The STC-BT30 motor is designed to grip a BT30 toolholder. The BT30 toolholder is a standard machine tool style and may be purchased from several sources including, MSC (www.msc.com), and J & L Industrial Supply (www.jlindustrial.com). The Customer can also make their own BT30 toolholder to handle special media (See Figure 7 for toolholder dimensions). The toolholder must be equipped with a Parlec (www.parlec.com) retention knob, part number 3003TRK, or equivalent. Figure 8 shows the Parlec retention knob with the required dimensions.

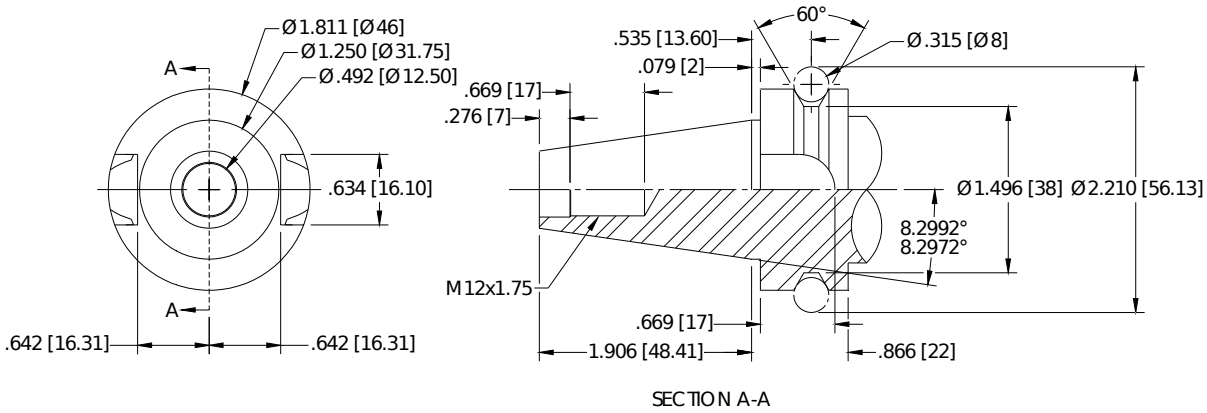


Figure 7: STC-BT30 Toolholder Dimensions

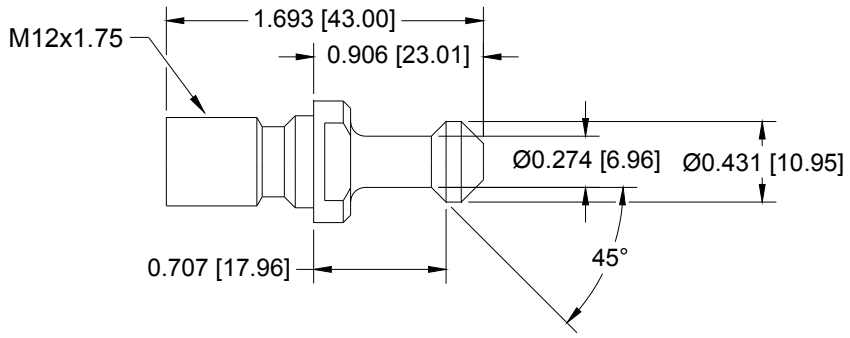


Figure 8: BT30 Retention Knob

3.4 SM Collet Operation

The Collet for the SM motor is tightened and loosened manually. The Motor Shaft must be held using the Motor Shaft Flats, while the Collet Nut is turned, see Figure 11. Turning the Collet Nut clockwise forces the Collet into the Motor Shaft causing it to clamp around the Toolholder. To loosen the Collet, rotate the Collet Nut counter-clockwise. If the Collet is to be removed, continue rotating the Collet Nut counter-clockwise and the Collet Nut and Collet will come off together. The Collet is an ER Series (DIN 6499 Form B) Size 20. The recommended tightening torque for the Collet Nut depends on the bore diameter of the Collet. For Collet bore diameters 0.276 – 0.512 in. (7.0 – 13.0 mm) the recommended tightening torque is 60 lb.-ft. (80 N·m), and not to exceed 75 lb.-ft. (100 N·m). For Collet bore diameters 0.039 – 0.256 in. (1.0 – 6.5 mm) the recommended tightening torque is 24 lb.-ft. (32 N·m), and not to exceed 30 lb.-ft. (40 N·m).

CAUTION: Tightening toques greater than recommended will permanently deform the collet cavity of the toolholder.

3.4.1 SM Collet Assembly and Removal

To assemble the Collet insert the Collet Groove into the Eccentric Ring of the Collet Nut at the mark on the bottom of the Collet Nut. Push the Collet in while rotating the Collet up, until it clicks in. See Figure 9.

To remove the Collet, first unscrew the Collet Nut from the Motor Shaft. After the Collet Nut is unscrewed, press on the face of the Collet while simultaneously pushing sideways on the back of the Collet until it disengages from the Collet Nut. See Figure 9.

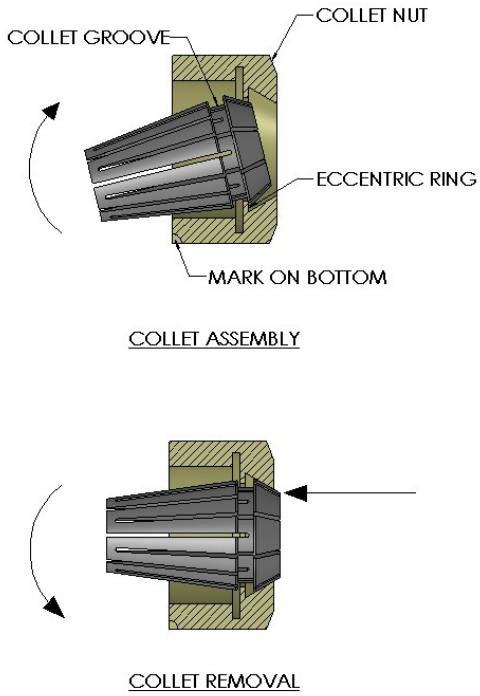


Figure 9: SM Collet Assembly and Removal

Improper assembly or removal of the Collet can permanently destroy the concentricity of the Collet and may also result in a damaged Collet Nut.

NOTE: Only attach Collet Nuts with correctly assembled Collets, to the Motor Shaft! Never place the Collet into the Motor Shaft without first assembling the Collet into the Collet Nut.

NOTE: Never clamp oversized, or undersized, Toolholders! E.g., never use a ⌀11-12mm Collet to clamp a ⌀12.2mm Toolholder. Always use the corresponding Collet for the Toolholder being used.

NOTE: Insert the Toolholder the full length of the Collet for best results, if possible. However, never insert the Toolholder less than 2/3 of the Collet bore length. Improper tool insertion can permanently deform the Collet and will result in excessive run-out.

3.5 Pneumatic Connection

All STC versions of the motor requires a dry, non-lubricated, filtered air supply, with a minimum pressure of 90 psi (6.2 bar) and a maximum pressure of 100 psi (6.9 bar). Failure to provide supply air to these specifications can degrade performance and will void any warranty repairs concerning pneumatic components. If the supply air pressure is too low then the unit will be unable to fully release the Toolholder. Exceeding the maximum air pressure could result in permanent damage to the STC.

The pneumatic supply system should be configured as shown in Figure 10 . A manual or electrically operated valve may be used to energize the STC for Toolholder release, but the valve must exhaust **ALL** line pressure when unenergized. PushCorp highly recommends the installation of a quick exhaust valve in the Supply Line to the STC; the quick exhaust valve should be mounted as close to the STC unit as possible. This will minimize the distance exhaust air needs to travel, thus decreasing the time needed for the unclamp cylinder to actuate. Pressure in the line will cause internal components to come into contact. This will either cause the motor not to spin, or cause very high internal forces, eventually friction welding components together. A pressure sensor capable of sensing below 0 psi should be installed in the supply line between the exhaust valve and the STC. PushCorp recommends the pressure sensor from IFM (PN: 7694); it has the capability to sense a pressure range of -14.5 psi – 145 psi.

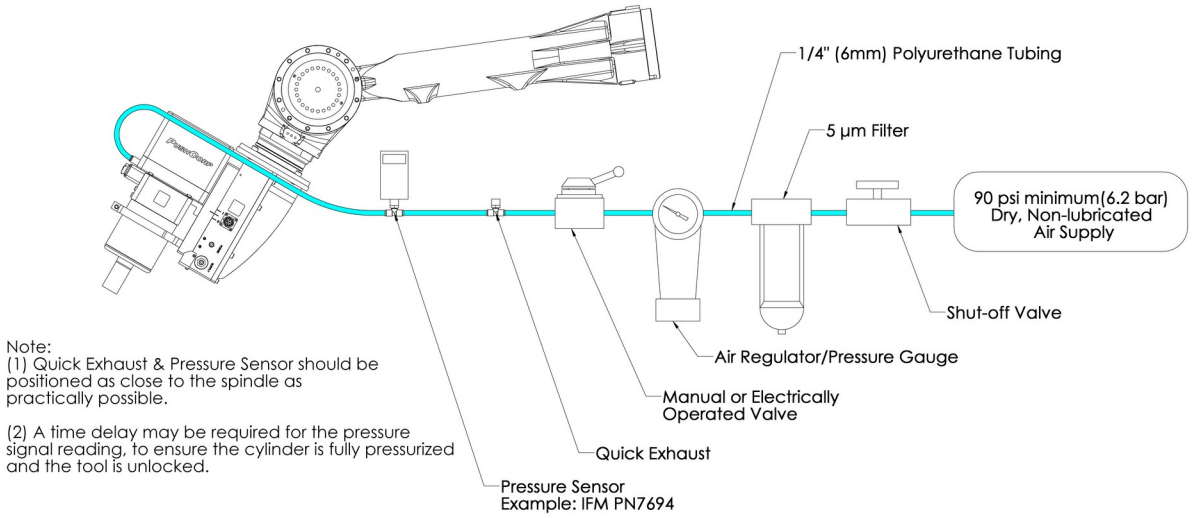


Figure 10: Pneumatic Connections

The STC and STC-BT30 motors are provided with ¼ inch and 6 mm diameter tubing push-lock fittings for installation in the R 1/8 (Metric) Collet Unclamp Port located on the top of the Clamping Housing (See Figure 11). Remove the shipping plug and install the desired size push-lock fitting. If another type of fitting is desired, unscrew the existing fitting and replace it with any fitting having an R 1/8 (Metric) thread. Be sure to use a thread seal product and do not over tighten the fitting.

The Unclamp Supply Line to the device should be 1/4 inch or 6 mm diameter flexible polyurethane tubing. The tubing should be routed to the device such that there are no kinks and that there is plenty of slack to allow for manipulator motion. Before inserting the tubing into the STC air fitting, open the Shut-Off Valve to blow out any contaminates which may be in the Unclamp Supply Line. The tubing can now be pushed into the self-locking fitting located on the Clamping Housing as shown in Figure 11. Charge the Unclamp Supply Line with compressed air and verify that there are no air leaks and that there is a minimum of 90 PSI (6.2 bar) at the STC. If a minimum air pressure cannot be achieved, then an auxiliary air compressor or booster pump must be installed.

NOTE: PushCorp recommends SMC quick exhaust valves, part number AQ-3-40F-06-00 for 6 mm diameter tubing or part number AQ-3-40F-07-00 for 1/4 inch diameter tubing.

NOTE: PushCorp highly recommends the use of flexible polyurethane tubing as opposed to nylon tubing. This is because nylon tubing tends to crimp shut when it is bent.

To remove the Unclamp Supply Line for service, make sure the air pressure is discharged, then while pushing inward on the fitting's plastic ring, simultaneously pull the tubing out. Cover or plug the self-locking fitting any time the Unclamp Supply Line is not connected. This will keep contaminants from entering.

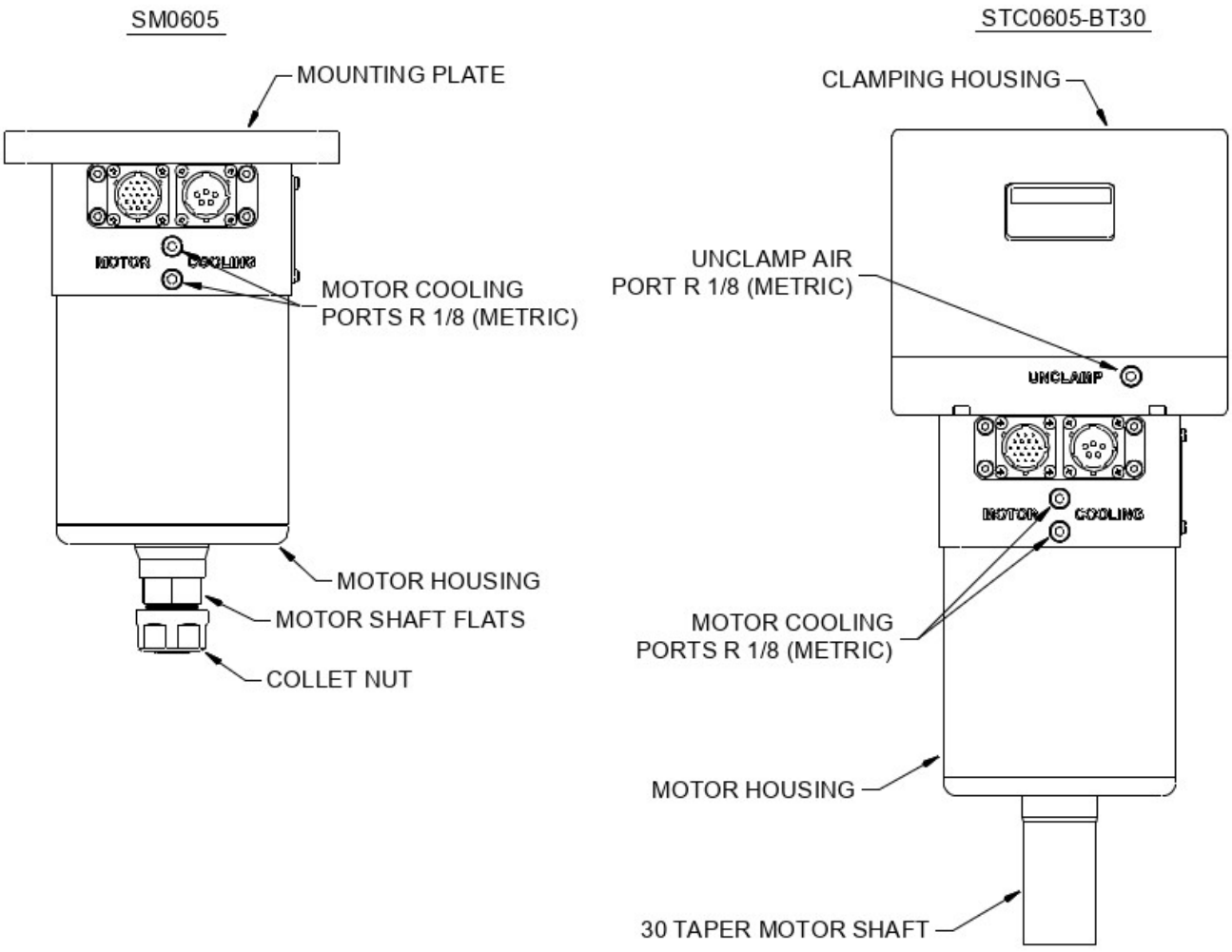
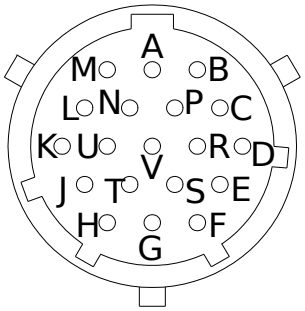


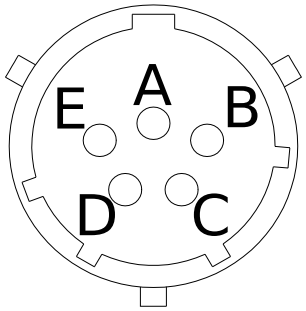
Figure 11: 0605/1503 External Features

3.6 Electrical Connections

The 0605/1503 servo motor has two electrical connections, the Motor Power and Motor Feedback (See Figure 12). If PushCorp supplies the cables and amplifier the tool should be easily connected to the amplifier. If the customer wishes to use their own cables and/or amplifier the pin-outs for the Motor Power and Motor Feedback connectors are shown below in Figure 12. The Collet release mechanism of the 0605/1503 Series relies solely on air pressure to operate; it requires no electrical connections.



FEEDBACK CONNECTOR



POWER CONNECTOR

FEEDBACK PIN-OUTS

PIN	SIGNAL
A	HALL + SUPPLY
B	HALL - SUPPLY
C	HALL C
D	HALL B
E	HALL A
F	THERMISTOR
T	THERMISTOR
V	SHIELD

POWER PIN-OUTS

PIN	SIGNAL
A	MOTOR A
B	MOTOR B
C	MOTOR C
D	GROUND
E	SHIELD

Figure 12: Electrical Connector Pin-outs

CAUTION: Do not run the Motor Power Cable in close proximity to any feedback or control cables because of possible electrical noise problems.

3.6.1 AKD2G Servo Amplifier – Default Electrical Connections

This amplifier is already properly configured for a PushCorp spindle. No further configuration is required if the below settings will work for your application.

Analog Interface

Connector	Pin	Function
X21	A1	Analog-In 1+ : +/-10VDC Command Velocity
X21	A2	Analog-In 1- : +/-10VDC Command Velocity
X21	B1	Analog-Out 1 : 0 - 10VDC Velocity Monitor
X21	B2	AGND : Analog GND
CASE		Shield

Digital Interface

Connector	Pin	Function
X21	A3	Digital-In 1 : Fault Reset Input
X21	A4	Digital-In 2 : Run Input
X21	A5	Enable : Enable Drive Input
X21	B3	+24VDC : Digital Output Supply
X21	B4	DGND : Digital I/O Common
X21	B5	BTB/RTO : Ready To Operation (Dry Contact)
X21	B6	BTB/RTO : Ready To Operation (Dry Contact)
X21	B7	Digital-Out 1 : Motor Overload Warning
X21	A11	STO-A-A1 : Safety Torque Off A Input
X21	B11	STO-B-A1 : Safety Torque Off B Input

For more information an instruction manual is available at:

http://www.pushcorp.com/Manuals/Kollmorgen_AKD2G_Instruction_Manual.pdf

3.6.2 S724 Servo Amplifier – Default Electrical Connections

This amplifier is already properly configured for a PushCorp spindle. No further configuration is required if the below settings will work for your application.

Analog Velocity Mode

+/-10VDC Analog Input for command velocity

Analog Interface

Connector	Pin	Function
X3B	9	-Analog-In 1 – Command Velocity
X3B	10	+Analog-In 1 – Command Velocity
X3B	13	AGND - Shield

Digital Interface

Connector	Pin	Function
X3A	1	Enable – Enable Drive Output
X3A	2	Digital-In 1 – Fault Reset
X3A	6	Digital-Out 1 – Fault Present
X3A	7	Digital-Out 2 – At Zero Speed
X3B	14	BTB/RTO – Ready To Operation (Dry Contact)
X3B	15	BTB/RTO – Ready To Operation (Dry Contact)
X3B	16	DGND – Digital 0VDC Common

Optional Analog Output (MUST HAVE ANALOG CARD INSTALLED IN SLOT 3)

Connector	Pin	Function
X3C	17	Analog Out 1 - Velocity Feedback
X3C	18	AGND
X3X	19	Analog Out 2 - Motor Load Feedback
X3C	20	AGND

For more information an instruction manual is available at:

http://www.pushcorp.com/Manuals/Kollmorgen_S724_Instruction_Manual.pdf

For all other questions please contact:

PushCorp Tech Support: 1.972.840.0208, 8am – 5pm Central Time
Kollmorgen Tech Support: 1.540.633.3545, 8am – 5pm Eastern Time

3.6.3 Hall Motor Timing Chart

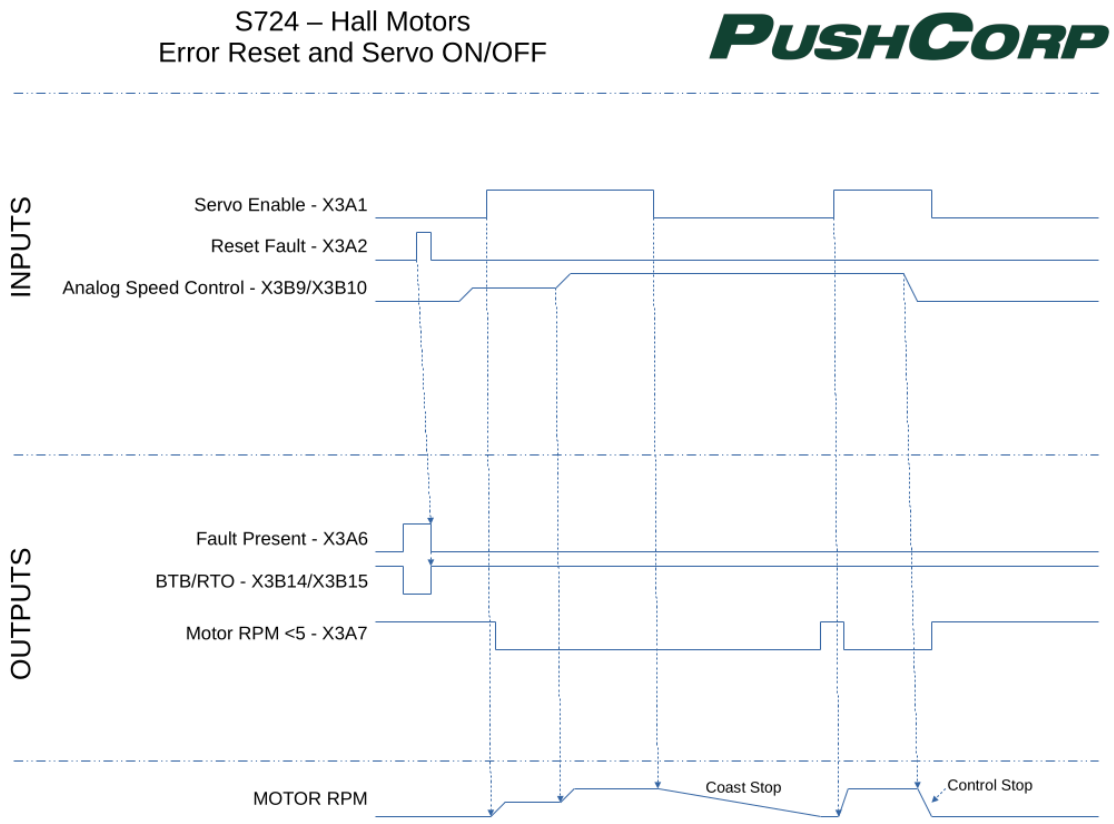


Figure 13: Hall Motor Input/Output

3.7 Motor Cooling

The 0605/1503 Series have a compact, high speed, Servo Motor which requires water cooling. The motor is designed to operate below a temperature of 176 ˚F (80 ˚C). The optimal motor temperature range is 122 – 140 °F (50 – 60 °C). The motor contains cooling channels in the Motor Housing surrounding the motor stator. These channels allow efficient removal of the heat. The coolant enters and exits the Motor Housing through two Motor Cooling Ports as shown in Figure 11. Either of these Motor Cooling Ports can be used as an input, the other would then become an output.

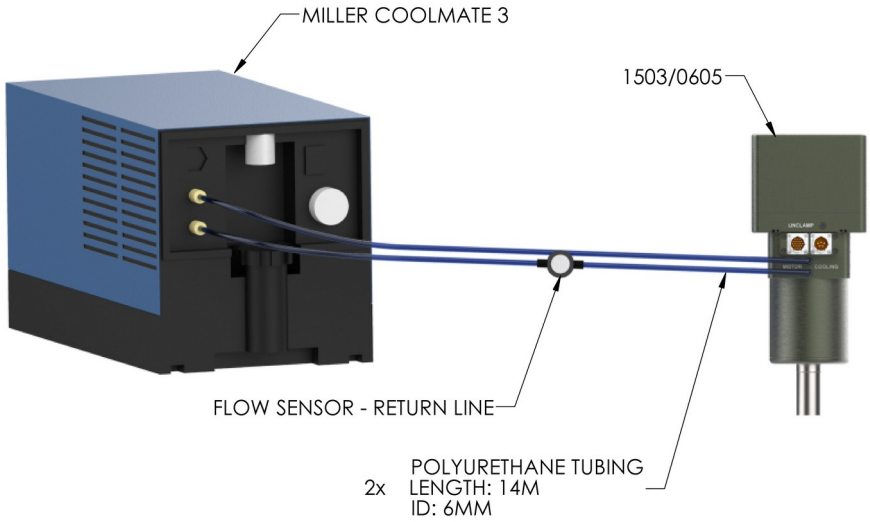


Figure 14: Spindle Cooling with Cooling Unit

A closed-loop water cooling system must be used and requires a separate cooling unit per spindle that circulates water through the Motor Housing to remove the heat. Typical cooling units are comprised of a pump, liquid to air heat exchange, and a fan. These units are commercially available from several manufacturers (e.g. Miller Coolmate 3, www.millerwelds.com). The cooling unit should be sized based on the motor power output of the motor being used with an overall motor efficiency of 90% and the motor load conditions. See section 4.0 of this manual for motor output ratings for the motor being used. In the case of a closed-loop water cooling system, all of the coolant is recirculated in the system, and no continuous supply of discharge is required. Our standard offering is the Miller Coolmate 3, which you can see in Figure 14, PCI PN PAR03962. In this case the return line is the bottom connection; it is recommended that a flow sensor is installed inline with this port and wired back as part of the control circuit. PushCorp recommends the IFM flow sensor (PN SBG12IF0FRKG). This will ensure the coolant is circulating completely through the motor and back to the cooler. Domestically, PushCorp provides Miller's pre-mixed glycol base aluminum protecting coolant (Miller PN 043-809 – PCI PN PAR04028). Any coolant which matches the parameters of this coolant may be used.

NOTE: Connecting two motors to a single Coolmate could yield inadequate cooling and reduce the life of the servo unit. The life of the motor is directly related to the operational temperature, so proper cooling is critical.

Again, it is recommended to constantly monitor the motor temperature during operation to ensure that it does not overheat. In addition, PushCorp recommends that one Miller Coolmate 3 (or equivalent) should be used per motor.

3.8 Monitoring Motor Temperature

As previously stated, the motor is designed to operate below a temperature of 176 °F (80 °C) and within an optimal range of 122-140 °F (50-60 °C). In many situations it is desirable to monitor the internal motor temperature to ensure that the maximum temperature rating is not exceeded, and that the optimal temperature range is maintained. To facilitate this, the motor has a thermistor that is embedded in the motor windings. The thermistor connection is provided on the Motor Feedback Connector as shown in Figure 12. The thermistor temperature signal is a logarithmic function of the output resistance. The graph shown in Figure 15 illustrates the internal motor temperature versus the thermistor output resistance. In the graph, a temperature of 212 ˚F (100 ˚C) corresponds to a resistance of 1000 ohms. If the thermistor indicates a resistance of less than 1000 ohms then the motor should be immediately shut down before thermal damage occurs.

The motor also contains a thermal cutoff switch. If the temperature exceeds 212 ˚F (100 ˚C) the motor will stop running until it has cooled off. **This feature should not be used to control the motor temperature.** The thermal cutoff is designed to operate only when all other precautions have failed.

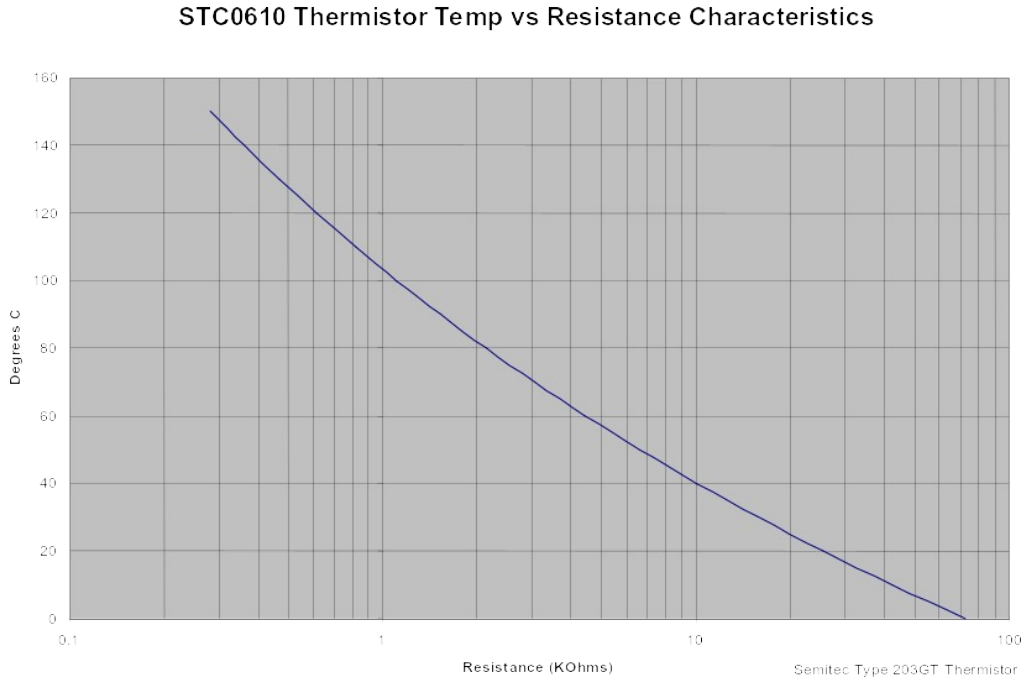


Figure 15: Thermistor Chart

The following equation can be used to calculate the motor temperature based on the measured thermistor resistance:

$$T = \frac{1}{\frac{1}{T_0} + \frac{1}{\beta} \cdot \ln\left(\frac{R}{R_0}\right)} - 273.15 \qquad T = \frac{1}{\frac{1}{298.15} + \frac{1}{4282} \cdot \ln\left(\frac{R}{20}\right)} - 273.15$$

OR

T is temperature in C

R is resistance of the thermistor in Kohms from the motor

ln() is the natural logarithm function (Base *e)*

Given Values

R_0 = 20 KOhm – The R_{25} value from the thermistor data sheet

β = 4282 “B value” from the thermistor data sheet

T_0 = 298.15K reference temperature in Kelvins from the thermistor data sheet

NOTE: Thermistor type - Semitec 203GT-2

3.9 STC Spindle Tool Change

PushCorp STC spindles have the ability to switch tool holders out using pneumatic actuation. The STC0605 & STC1503 use a keyless BT30 toolholder, which provides strong holding torque and tool retention. To properly change out a tool, the following steps are recommended to avoid damaging the spindle, toolholder or gripper fingers.

Before Attempting Tool Change, Make Sure:

- Spindle is not rotating - Motor RPM < 5 feedback signal is ON
- If using retention knob not supplied by PushCorp, verify the dimensions match the illustration in section 3.3.3
- Make sure pressure does not remain supplied at the unclamp port for an extended period of time or this will result in damage to the spindle's pneumatic cylinder

Tool Change Sequence:

1. Robot moves the end effector i.e. Servo Tool Changer (STC) to dock toolholder in the gripper/fingers/nest
2. Once fully docked, pressurize the "unclamp" port with at least 90 psi (6.2 bar) not to exceed 100 psi (6.9 bar).
3. Using a pressure sensor, such as IFM PN7694, verify that you have achieved at least 90 psi, again not to exceed 100 psi (refer to Figure 10 for connection set up)
4. Robot moves STC away from toolholder gripper/fingers/nest
5. Robot positions STC above the next tool holder
6. Robot moves STC toward the toolholder until the shaft and toolholder's tapers are fully seated against each other, then depressurize the "unclamp" port
7. Using a pressure switch that can sense below 0 psi such as the IFM PN7694, verify 0 psi (0 bar) at "unclamp" port
8. Robot moves out and away from gripper/fingers/nest removing the tool holder from the gripper/fingers/nest

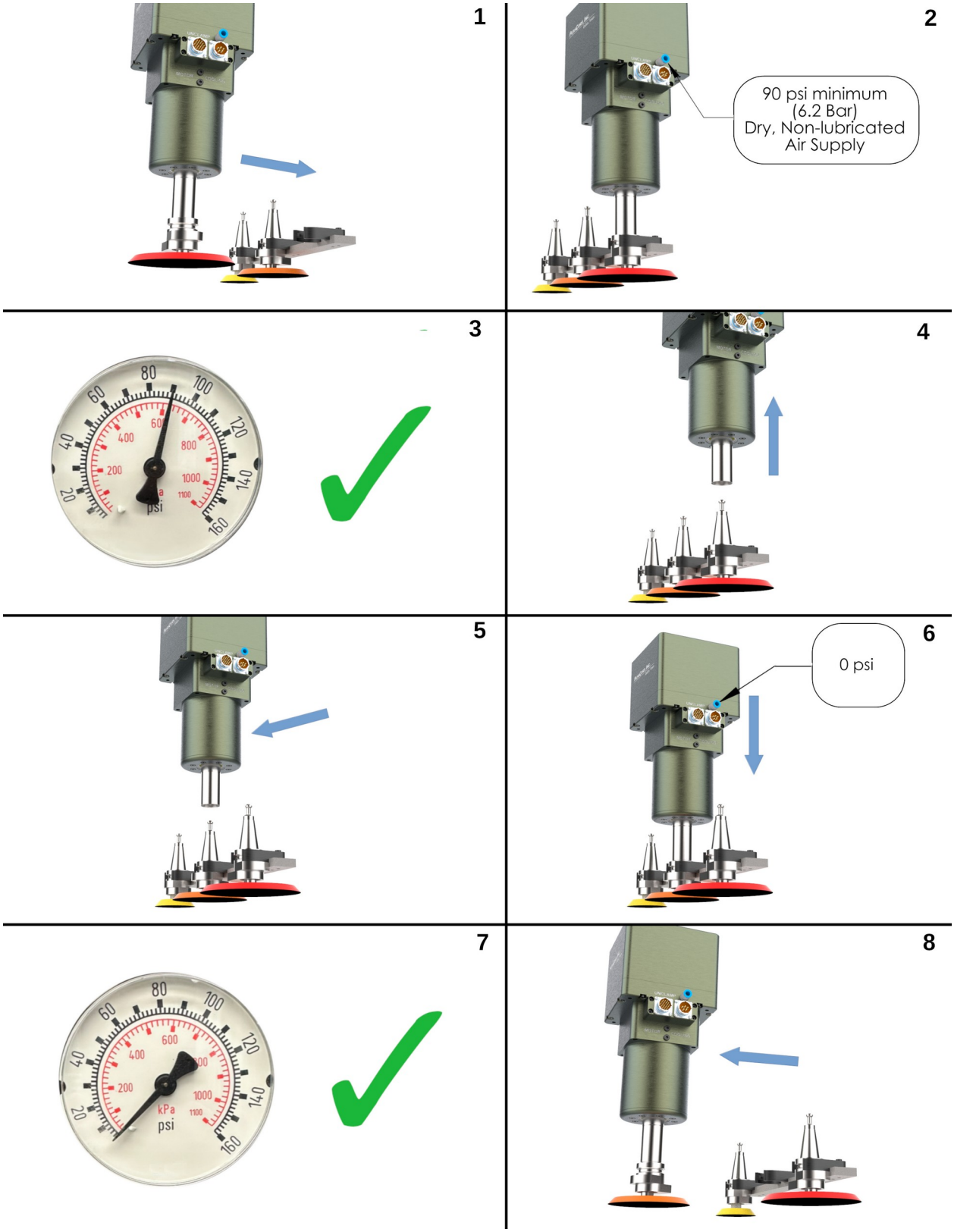


Figure 16: STC Spindle Tool Change Sequence

4.0 Technical Specifications

0605 MOTOR SPECIFICATIONS:

Supply Voltage: 240-480 VAC, 3-Phase +/-10%
Please contact techsupport@pushcorp.com *for supply voltages less than 480 V*
Power: 5.0 hp (3.7 kW)
Continuous Stall Torque: 5.6 lb.-ft. (7.6 N·m)
Minimum Speed: 60 RPM
Maximum Speed: 6000 RPM
Speed Regulation: 5% (Reversible)
Shaft Maximum Axial Load: 150 lb. (666 N)
Shaft Maximum Radial Load: 300 lb. (1332 N)
Weight:
SM0605 – 15.9 lb (7.2 kg)
STC0605-BT30 – 28 lb. (12.7 kg)
Operating Temperature: Optimal: 122 – 140 ˚F (50 – 60 ˚C)
Maximum: 176 ˚F (80 ˚C)
Thermal Cutoff: 212 ˚F (100 ˚C)
Max. Coolant Pressure: 60 psi (4.1 Bar)

1503 MOTOR SPECIFICATIONS:

Supply Voltage: 240-480 VAC, 3-Phase +/-10%
Please contact techsupport@pushcorp.com *for supply voltages less than 480 V*
Power: 3.0 hp (2.2 kW)
Continuous Stall Torque: 2.57 lb.-ft. (3.5 N·m)
Minimum Speed: 60 RPM
Maximum Speed: 15000 RPM
Speed Regulation: 5% (Reversible)
Shaft Maximum Axial Load: 150 lb. (666 N)
Shaft Maximum Radial Load: 300 lb. (1332 N)
Weight:
SM1503 – 15.9 lb (7.2 kg)
STC1503-BT30 – 28 lb. (12.7 kg)
Operating Temperature: Optimal: 122 – 140 ˚F (50 – 60 ˚C)
Maximum: 176 ˚F (80 ˚C)
Thermal Cutoff: 212 ˚F (100 ˚C)
Max. Coolant Pressure: 60 psi (4.1 Bar)

COLLET SPECIFICATIONS:

Holding Torque:
SM – 10 lb.-ft. (20.3 N·m) minimum
STC-BT30 – N/A
Toolholder:
SM – Ø0.5 inch (12.7mm) standard
STC-BT30 – BT30 toolholder
Clamping Supply Air:
Dry, Non-lubricated, 90 psi (6.2 bar) Min., 100 psi (6.9 bar) Max.
Requires power amplifier and cables.
For specific dimensions see www.pushcorp.com for detail drawings.

TORQUE SPECIFICATIONS:

Fastener Tightening Torque Specs					
Fastener Size	Torque			Minimum Depth	
	in.-lbs.	ft.-lbs.	N·m	in.	mm
M4 x .7	50	4.2	5.6	0.17	4.3
M5 x .8	85	7.1	9.6	0.21	5.3
M6 x 1	140	11.7	15.8	0.25	6.3
M8 x 1.25	348	29.0	39.3	0.33	8.4
M10 x 1.5	600	50.0	67.8	0.41	10.5

Specifications subject to change without notice.

5.0 Preventative Maintenance Schedule

It is highly recommended to adhere to the preventative maintenance schedule in order help extend the longevity of the specified PushCorp, Inc. equipment. Failing to do so could cause a loss in functionality as well as a decrease in product life.

PUSHCORP, INC. SPINDLES			
Maintenance	**Weekly**	**Monthly**	**3 Months**
Remove chips from the ID of the shaft	X		
Remove debris from spindle/spindle housing	X		
Check that the connectors are not bent/damaged	X		
Check for flow in the motor cooling and unclamp ports		X	

Agency/Organization:_____

Date Completed:_____