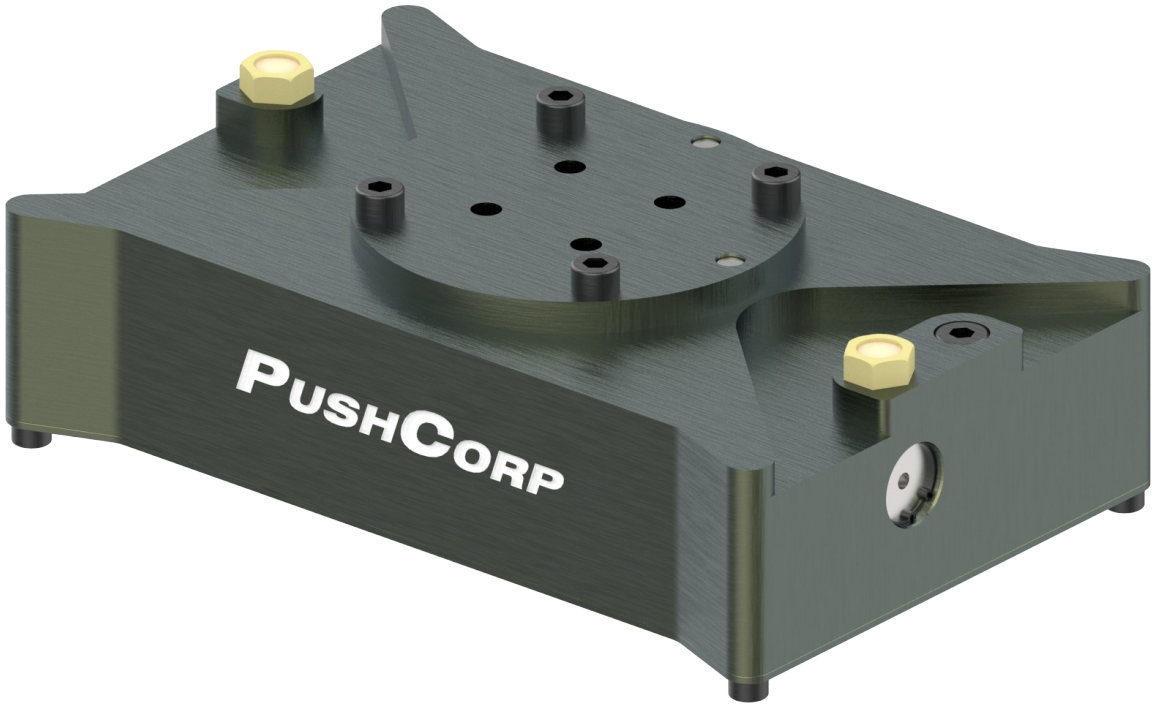
# *AFD52*

# Adjustable Force Device

# **Manual**




**PUSHCORP, INC.**

**Dallas, Texas**

November, 2001 PAR01642-1

**HANDLE WITH CARE**

**DO NOT DROP**

**DO NOT USE LUBRICATED AIR.**

**This device requires a dry, non-lubricated 80 psi (5.5 bar) maximum air supply filtered to 5 µm and a 0.3 micron oil mist separator.**

**Non-compliance with these requirements will void the manufacturer's warranty.**

**(See Section 3.4)**

**All fasteners, mounting holes and pipe threads on this tool are METRIC.**

**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.**

# *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.* Adjustable Force Device or Adjustable Force Device 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

The *PushCorp, AFD52* Passive Micro AFD is designed for low force applications on small capacity robots. As such, the *AFD52* is simple and light weight, but it still incorporates several innovative features. The *AFD52* uses glass pneumatic cylinders with graphite pistons, and linear ball bearings to reduce operating friction and increase force accuracy. It can be configured to mount on many low capacity robots. The Micro AFD may also be supplied to apply only a positive force, the AFD51, or both positive and negative forces, the AFD52.

The *AFD51* requires the user to supply at least one pressure regulator to control the force output. If an AFD52 is specified then two regulators are required. The AFD has been constructed with low friction components, so that the force output resolution is highly dependent on the regulator accuracy. The regulator can be manual or electrically adjustable based on the user's application requirements. If a constant force is required and the AFD orientation does not change, a manual regulator is sufficient. If the force and/or AFD orientation changes during the process, then an electrically controlled proportional regulator is required. In some cases the process equipment weight must be taken into account so that a constant force can be applied regardless of the AFD orientation. This situation requires calculation of the regulator pressure based on the process equipment weight and AFD orientation.

All these features combine to make the *PushCorp AFD52* Adjustable Force Devices rugged and reliable, capable of delivering consistent results in any number of industrial applications.

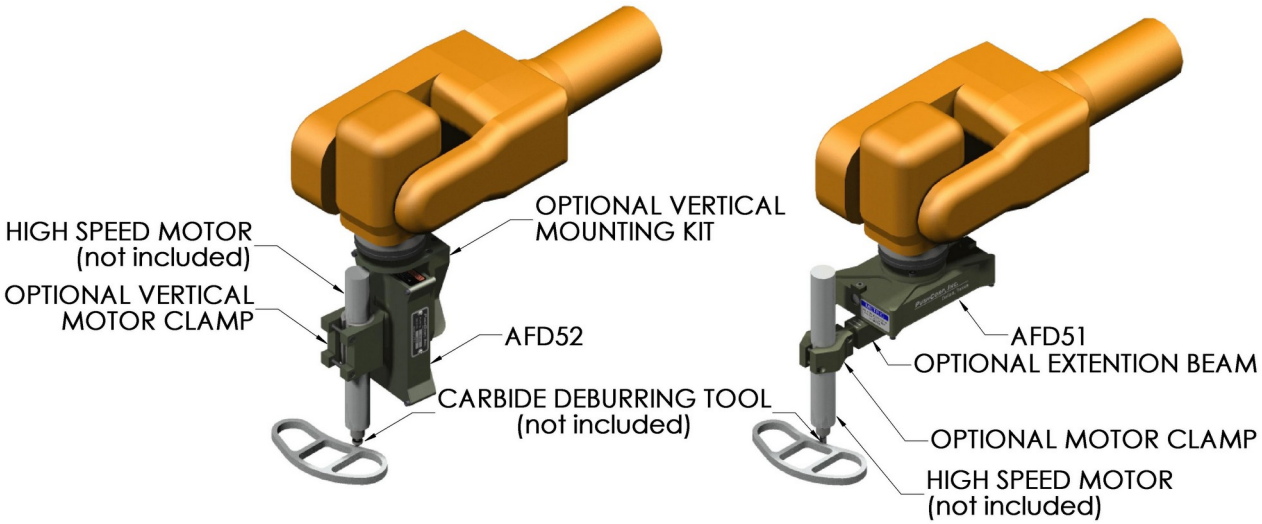



Figure 1. Examples of *AFD52 & AFD51* Mounting

# 3.0 Installation

## 3.1 Mounting Process Equipment

The *AFD52* Adjustable Force Device can accommodate different process equipment and configurations. Examples of two mounting configurations are shown in Figure 1. The tooling can be oriented parallel or perpendicular to the Carriage axis of translation, although it is important to note that the AFD can apply force only in the direction of Carriage translation.

When mounting to the Carriage care should be taken. An incorrectly designed process equipment mounting bracket can deform the Carriage causing internal Linear Rail misalignment. A symptom of Carriage deformation is “slop” or “binding” of the Carriage. A deformed or loose Carriage will damage the Linear Rails and degrade the consistency of your process. The Carriage preload is correctly set at the factory and should not require adjustment. If the Carriage becomes loose or binds after installing the process equipment mounting bracket, then the brackets must be removed and the problem corrected. *PushCorp, Inc*. can design and fabricate mounting brackets to user supplied specifications as an option.

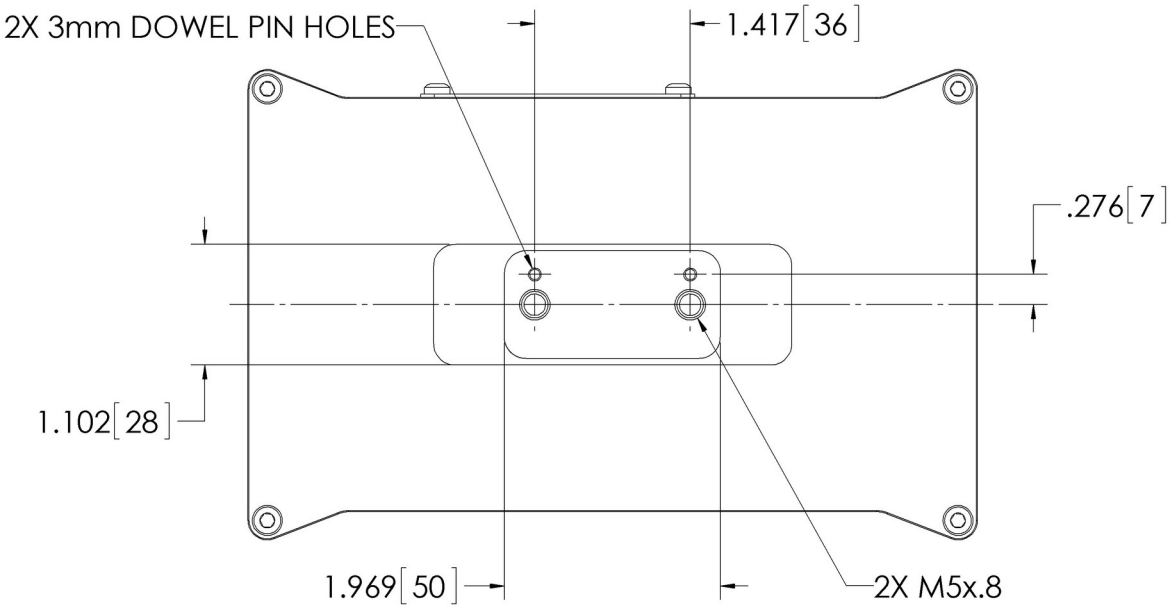



Figure 2. Carriage bolt hole pattern

The Carriage has (2) two M5x0.8 mounting holes with a depth of 0.3 inch (7.5 mm) to provide secure attachment. The fasteners must thread in the proper distance to avoid helicoil pull-out at the recommended tightening torque (See Section 6.0). The mounting holes are spaced as shown Figure 2 above. The Carriage also incorporates (2) two 3 mm diameter dowel pins. These are provided to assure correct process equipment mounting alignment and orientation.

### 3.2 Mounting the *AFD52*

The basic configuration of the *AFD52* force device allows attachment to a stationary fixture or a manipulator mounting flange. There are three mounting options for the AFD, these are shown in Figure 3.

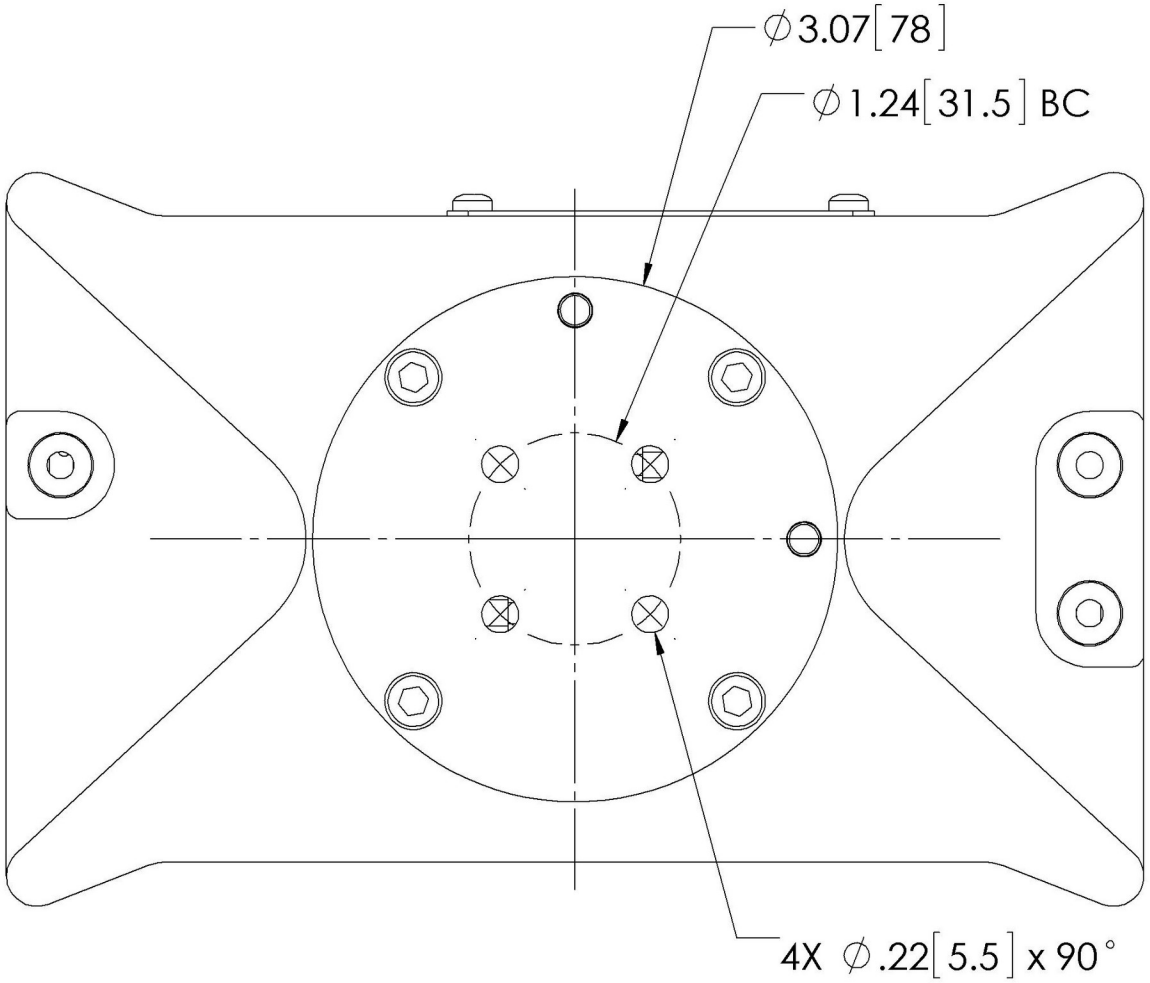



Figure 3. *AFD52* Mounting Options

Options 2 and 3 are supplied with two mounting plates as shown in Figure 4. Two mounting plates are required if the standard mounting option 1 does not allow sufficient clearance. To attach the *AFD52* to a manipulator mounting flange using options 2 or 3: First, attach the Robot Mounting Plate to the robot; second, attach the AFD Plate to the AFD, with the supplied fasteners; last, attach the two plates with the supplied fasteners. The standard mounting option 1 utilizes an AFD Plate only. To attach the AFD to the robot: first, attach the AFD Plate to the robot mounting flange; then, attach the AFD to the AFD Plate with the supplied fasteners. Should these options not cover the desired application, PushCorp, Inc. can engineer and supply mounting plates for the application.

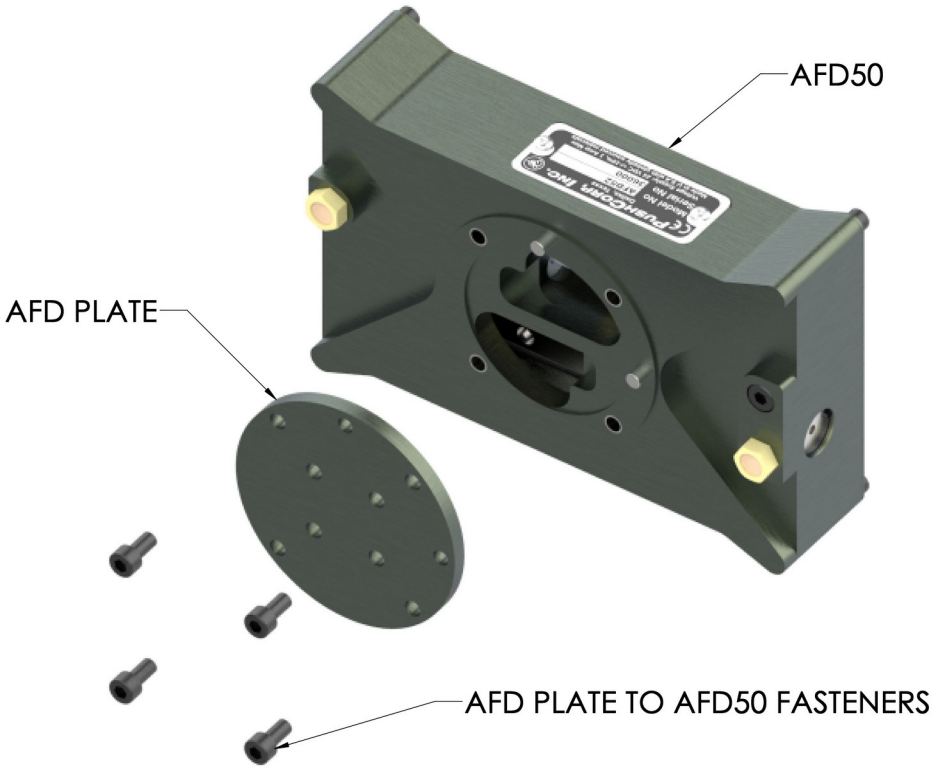



Figure 4. Mounting Sequence Option 2 or 3

**CAUTION: The Fastener Tightening Torque Specs chart in Section 6.0 should be used to determine proper fastener length and torque. This is to prevent pull-out of the helicoil inserts.**

### 3.3 Maximum Carriage Load Calculations

The Linear Rail bearings that support the *AFD52* Carriage have been selected to provide optimal performance with respect to capacity, size, and low friction. To ensure continued optimal performance it is very important not to overload these bearings. The following diagrams and associated equations allow your application to be checked for excessive loading.

It is important to note that these equations require the use of Metric units. The necessary conversions are provided for your convenience. Insert your actual maximum applied force and process equipment weight (W) and overhang distances (D) to calculate a value that is less than the maximum Bearing Load (L) of 25 N. Some applications are a combination of the three cases and must be combined. If your application is not similar to any of the designs shown here, or if the information is not clear, please contact *PushCorp* Technical Support for assistance.

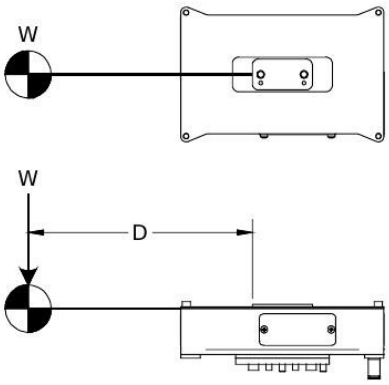
**W** = Maximum Applied Force (N)
**D** = Load Overhang (mm)
**L** = Bearing Load (N)

= Concentrated Load Position

1 lbf. = 4.44 N
1 in. = 25.4 mm
1 N = 0.102 kg

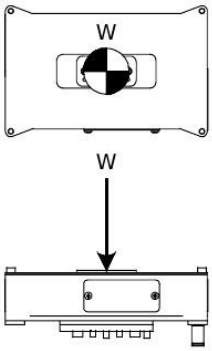
**Case 1**

$$L = \frac{W \times (D + 77.5)}{420} < 25$$




**Case 2**

$$L = \frac{W}{52} < 25$$




**Case 3**

$$L = \frac{W \times (D + 25)}{420} < 25$$

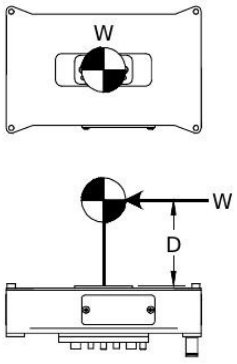



Figure 5. Carriage Load Calculations

### 3.4 Pneumatic Supply

The *AFD52* Adjustable Force Devices require a dry, non-lubricated, 5 μm filtered, 80 psi (5.5 Bar) maximum air supply. Failure to provide supply air to these specifications can degrade performance and will void any warranty repairs concerning pneumatic components. Filtered air is required to prevent foreign material from entering the AFD.

The pneumatic supply system should be configured as shown in the Figure 6.

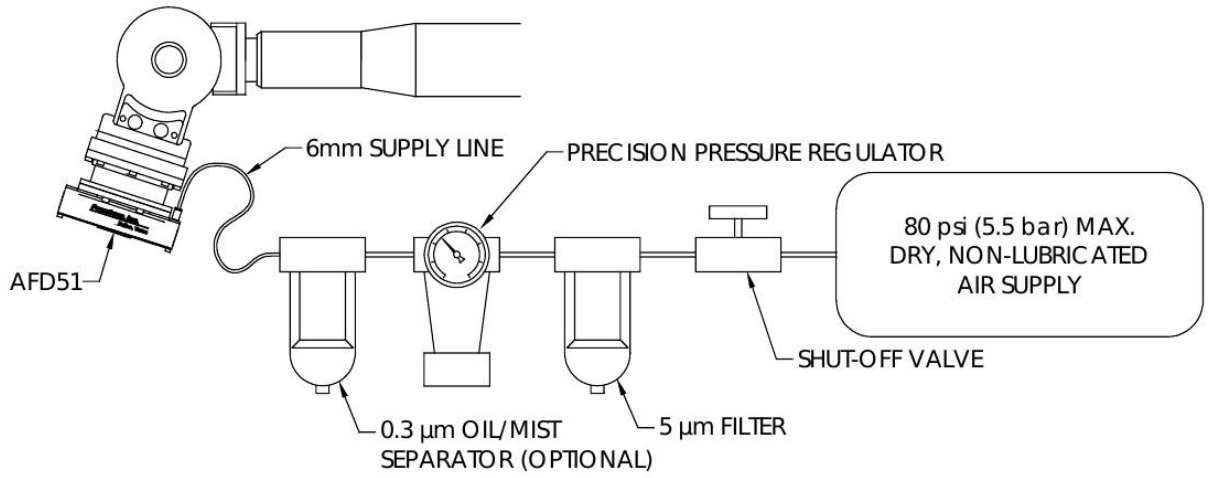



Figure 6. Pneumatic configuration

If water condensation is a problem in your air supply system, an air dryer device is highly recommended. The ideal solution is an industrial chiller dryer capable of reducing the dewpoint to less than 32˚ F (0˚C). Moisture inside the AFD will cause premature failure that will not be covered under warranty.

The *AFD52* relies on positive air pressure within the device housing to impede the infiltration of contaminate particles. It is important to provide a continuous compressed air supply to the device at all times if the work environment contains airborne particles. If the work environment is clean during non-operational periods, the air supply to the device may be shut off using a standard Shut-off Valve.

A Purge Port on the *AFD52* (See Figure 7.) provides a pneumatic connection to supply this air flow. The port accepts a metric R 1/8 tapered pneumatic fitting. *PushCorp, Inc.* can provide fittings for English or metric tubing. The input pressure to the purge port can range from 10 PSI to 30 psi (0.7 – 2.1 bar) with a flow rate of 0.5 to 2.0 SCFM (14 – 56 l/min) depending on the application. The purge air must be dry and non-lubricated, however it need only be filtered to 20 microns.

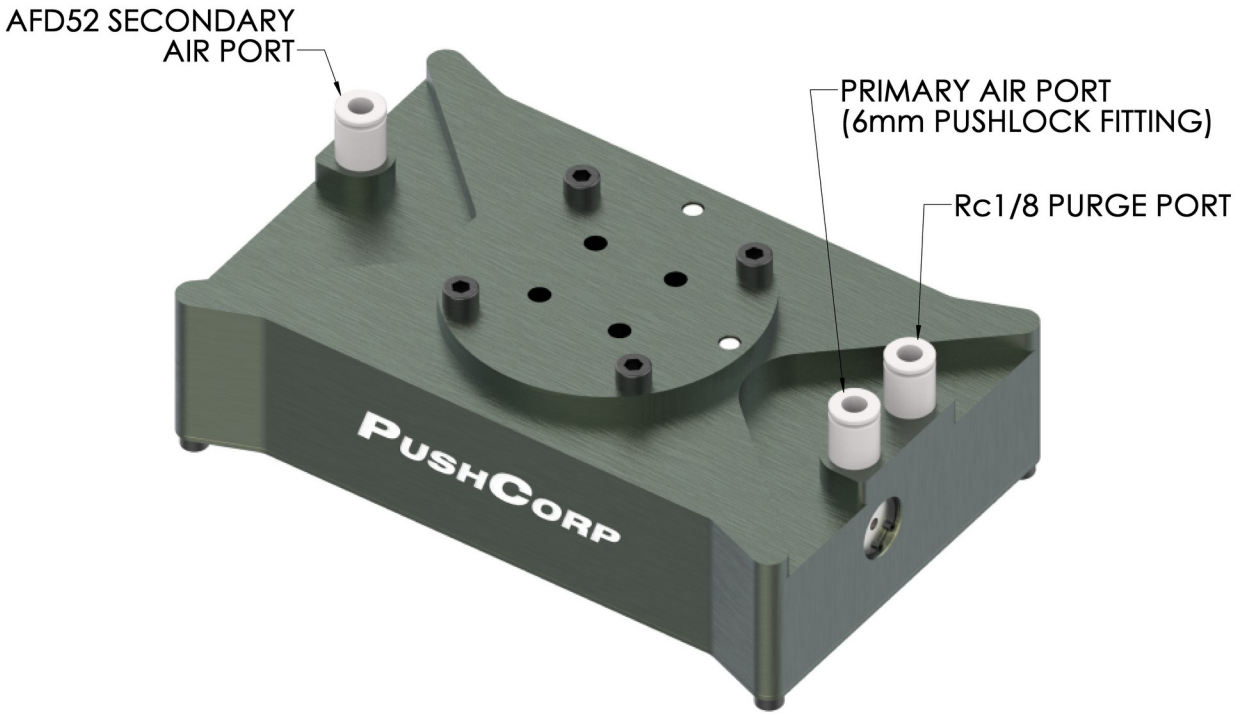



Figure 7. *AFD52* air connections

The Supply Line and Purge Line to the device should be 6 mm or 1/4 inch diameter flexible polyurethane tubing. The tubing should be routed to the AFD such that there are no kinks and that there is plenty of slack to allow for manipulator motion. Before inserting the Supply Line or Purge Line into the air fitting, open the supply valve to blow out any contaminates which may be in the tubing. The tubing can now be pushed into the self-locking fitting located on the top of the AFD. Charge the Supply Line with compressed air and verify that there are no air leaks and that there is sufficient air pressure.

**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. This severely limits airflow to the tool and causes instability.**

To remove the tubing for service, first discharge all air pressure in the system, 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 Supply Line or Purge Line is not connected. This will keep any contaminants from entering the AFD.

# 4.0 Adjusting Carriage Preload

The required preload on the *AFD52* Carriage Linear Rails has been set at the factory for optimal performance and, in general, should not require adjustment. Normally the Carriage will only require adjustment after removal for service. Should the Carriage require adjustment contact PushCorp, Inc. or return the AFD for re-adjustment.

# 5.0 Achieving Desired Force

The *AFD52* is a passive force device that requires the user to provide pressure to the pneumatic actuator. Pressure in the actuator results in an output force at the Carriage. If the AFD is always in the horizontal position or does not change orientation achieving the desired output force is easy. However, if the AFD changes orientation the pressure must be varied along the robot path.

Two system variables have to be considered when achieving a desired output force: the Weight carried by the AFD, and the angle of the Carriage with respect to gravity. The angle of the Carriage must be known so that the Weight can be compensated for. The Weight is the sum of the process equipment and the AFD Carriage itself. This value can be back calculated from the area and pressure in the pneumatic actuator. The best method to determine the Weight is with a calibrated load cell. The angle of the Carriage to the Gravity Vector is defined as shown below in Figure 8.

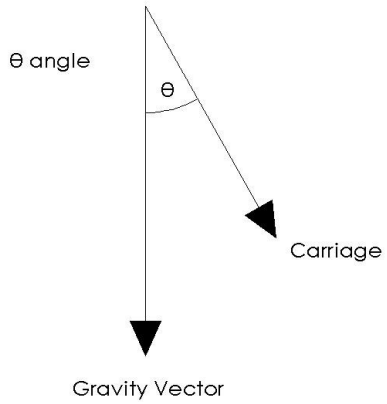



Figure 8. Definition of the Carriage angle.

The *AFD52* is available in two configurations, the AFD51, and the AFD52. The AFD51 has a single-acting pneumatic actuator, so it may only apply positive forces. The AFD52 has two identical single-acting actuators acting in opposite directions. This allows the AFD52 to apply both positive and negative forces. The area of the cylinder is 0.105 $in^2$ (67.74 $mm^2$), so for every one psi (0.07 bar) of supply pressure the tool applies 0.105 lbs. (4.67 N) of force. This makes the *AFD52* very easy to setup. To apply a 5.5 lbs. (24.5 N) force just set the supply pressure to 53 psi (3.7 Bar). This, however, does require the user to supply at least one (the AFD52 requires two) precision pressure regulator to accurately adjust the applied force. These may be either manually or electrically controlled proportional pressure regulators. The force output repeatability and resolution is directly related to the quality of the pneumatic regulator.

The following are equations defining the applied force from each of the *AFD52'*.

AFD51 (Single Acting) Applied Force:

$$F_a = (0.1 \times P_s) + (W + 0.7)\cos(\theta) \quad \text{English units}$$
$$F_{am} = (6.67 \times P_s) + 9.81 \times (W + 0.3)\cos(\theta) \quad \text{Metric units}$$

Where:

$F_a$ = Net AFD applied force (lbs.)
$F_{am}$ = Net AFD applied force (N)
$P_s$ = Supply pressure (psi or bar)
$W$ = Weight (lbs. or kg)
$\theta$ = Carriage angle relative to gravity (See Figure 6)

AFD52 (Double Acting) Applied Force:

$$F_a = F_p - F_n + (W + 0.7)\cos(\theta) \quad \text{English units}$$
$$F_{am} = F_{pm} - F_{nm} + 9.81 \times (W + 0.3)\cos(\theta) \quad \text{Metric units}$$

Where:

$F_a$ = Net AFD applied force (lbs.)
$F_{am}$ = Net AFD applied force (N)
$F_p$ = Force in positive direction $= (0.1 \times P_{sp})$ (lbs.)
$F_n$ = Force in negative direction $= (0.1 \times P_{sn})$ (lbs.)
$F_{pm}$ = Force in positive direction $= (6.45 \times P_{sp})$ (N)
$F_{nm}$ = Force in negative direction $= (6.45 \times P_{sn})$ (N)
$P_{sp}$ = Positive side supply pressure (psi or bar)
$P_{sn}$ = Negative side supply pressure (psi or bar)
$W$ = Weight (lbs. or kg)
$\theta$ = Carriage angle relative to gravity (See Figure 6)

# 6.0 Technical Specifications

Maximum Applied Force: 8.4 lbs. (37.4 N)
Maximum Payload: 8 lbs. (4 kg)
Tool Weight: AFD51 2.5 lbs. (1.1 kg)
AFD52 2.5 lbs. (1.1 kg)
Force Scale Factor: 0.105 lbs/psi (6.67 N/bar)
Temperature: 50˚ to 122˚ F (10˚ to 50˚ C)
Humidity: 5% to 95%, Non-Condensing
Supply air: Non-lubricated, Dry, 5µm Filtered, 80 psi (5.5 bar) Max.

*Specifications subject to change without notice.*

**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 |

# 7.0 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 AFD** | | | | |
|---|---|---|---|---|
| **Maintenance** | **Weekly** | **Monthly** | **3 Months** | **6 Months** |
| Remove debris from AFD | X | | | |
| Check that the connectors are not bent/damaged | X | | | |
| Check to see if the carriage moves back and forth easily | X | | | |
| Measure the supply and purge lines at the tool for recommended pressure/flow and ensure no losses in the pneumatic supply | | X | | |
| Check filters for contamination – replace if dark yellow/brown | | X | | |
| Replace filter cartridge(s) | | | | X |

Agency/Organization:_____

Date Completed:_____