SWS100-1.2
Servo Weld Shaver

Manual

PUSHCORP, INC.
Dallas, Texas

April, 2001  PAR00918-1
! WARNING!
REMOVE SERVO MOTOR
ELECTRICAL POWER
before replacing Slot Cutter inserts
or servicing weld shaver.

! WARNING!
SAFETY GLASSES ARE ALWAYS REQUIRED
Insert breakage or shatter resulting from improper use presents great potential for eye injury.

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.
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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 MERCHANTABILITY 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, 2345 Merrit Drive, Garland, TX 75041. 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, Inc.* SWS100-1.2 Servo Weld Shaver provides a convenient and effective means to accurately remove excess material from a surface. The Weld Shaver is designed to remove random, inconsistent surface features such as seam welds, parting lines, and flashing, leaving behind a known, consistent, smooth surface. The SWS100-1.2 works best on soft materials such as silicon bronze and aluminum. The Weld Shaver is ideal for use in applications where force-based, abrasive-only operations fail. The Weld Shaver/AFD combination forms a unique system where force and positioning control are used to perform accurate machining operations with a robot.

The SWS100-1.2 enables accurate surface machining by utilizing Tracking Wheels to follow over the surface profile. Force control is used to hold the Tracking Wheels firmly against the surface. This arrangement allows the Weld Shaver to maintain contact with complex surfaces while compensating for any robot/part misalignment.

The SWS100-1.2 is comprised of two primary components: a Slot Cutter assembly, and a high torque Servo Motor.

The machining operation is performed by a 4 inch diameter Slot Cutter with replaceable Inserts. The Slot Cutter has a maximum machining width of 0.77 inch (19.4 mm) to remove weld beads, parting lines, or flashing with a single pass. The position of the Tracking Wheels can be adjusted from 0.1 inch (2.5 mm) above the surrounding surface to 0.1 inch (2.5 mm) below. In addition to producing a consistent surface, using the SWS100-1.2 can produce significant cost savings since one set of Inserts can often out last hundreds of abrasive disks.

A Servo Motor provides the power to turn the Slot Cutter, and allows precision adjustable speed control through RS-242 serial, and ±10V analog interfaces. The SWS100-1.2 uses a 1.2 Horsepower motor with a speed range of 0 to 5200 RPM. The belt and pulley drive provides a 2:1 gear ratio which halves the speed and doubles the output torque at the Slot Cutter. The Servo Motor allows the shaver to control Slot Cutter speed (RPM) within 5%. The projected life of this high quality Servo Motor is over 30,000 hours.

Simple reliable construction combined with high torque, precision speed controlled servo technology make the *PushCorp* SWS100-1.2 Servo Weld Shaver a rugged, state-of-the-art technology capable of providing flexible, cost-effective weld machining operations.
3.0 Installation

3.1 Mounting the SWS100-1.2

The SWS100-1.2 Servo Weld Shaver is designed to attached directly to the Carriage of any PushCorp AFD1000/70 Adjustable Force Device. Figure 1 below illustrates how the unit is mounted to the Carriage.

![Mounting Diagram](image)

Figure 1. Mounting the SWS100-1.2

The SWS100-1.2 attaches to the Carriage with M6x1 fasteners provided by PushCorp. If these fasteners are not available, refer to Figure 1 for the proper length and location.

**NOTE:** Make sure that the M6x1 fasteners do not exceed a depth of 0.40 inch (10 mm) into the Carriage or damage can occur.

To mount the SWS100-1.2, first detach the Belt Cover by removing the (6) six M4x.7 Socket Head Cap Screws to allow access. Position the SWS100-1.2 over the Carriage mounting holes and insert the fasteners into the holes. Refer to Figure 1 to insure that the proper length fastener is used. Tighten the fasteners to the torque specified in Section 6.0. Replace the Belt Cover and tighten the (6) six M4x.7 fasteners to the torque specified in Section 6.0.

3.2 Vacuum Hose Attachment

The Vacuum Tube shown in Figure 1 is used to evacuate chips resulting from the machining operation. The Shaver can be operated without a vacuum system, but chips will accumulate in the cutter housing. It is therefore recommended that a vacuum system be used with the Shaver. A flexible hose should be placed over the 1.5 inch (38 mm) diameter Vacuum Tube and secured with a hose clamp. The chips produced by the Shaver are very sharp and are traveling at a high velocity, so the vacuum hose will wear and must be periodically replaced. The flow rate and amount of vacuum required will depend on many factors and must be determined by the user.
3.3 Electrical Connections

To use the SWS100-1.2 it is necessary to connect the power supply, Servo Motor power, and resolver cables correctly. Please refer to the Servo Motor documentation for information regarding these connections. PushCorp provides special high-flex robotic power and resolver cables for the Weld Shaver. The direction of the Slot Cutter rotation (Figure 2) is very important and is set in the Servo Amplifier. PushCorp can provide answers to most questions regarding the servo drive system and will be responsible for any warranty issues.

4.0 Operation

4.1 Setting the Depth of Cut

![Diagram of Depth of Cut Adjustment](image)

Figure 2. Depth of Cut Adjustment

Adjusting the Shaver’s depth of cut is accomplished by raising or lowering the Tracking Wheels (Figure 2). Raising the tracking wheels to the maximum position will result in an approximately 0.1 inch (2.5 mm) deep slot. Lowering the tracking wheels to their lowest position will cause the cutter to be offset approximately 0.1 inch (2.5 mm) above the surface. Adjusting the Tracking Wheels to the middle position will produce a cut that is flush with the surface.

**CAUTION:** Remove all power from the Servo Motor before performing any adjustments to the SWS100-1.2 Weld Shaver.

To adjust the depth of cut, first loosen both of the Depth Adjustment Locking Screws approximately ½ turn.
CAUTION: It is extremely important that the Depth Adjustment Locking Screws are released before the Depth Adjustment is rotated. Failure to release the Depth Adjustment Locking Screws will damage the mechanism and require the unit to be returned to the factory service center for a non-warranty repair.

Rotate the Depth Adjustment with a 19 mm wrench to move the Tracking Wheels relative to the Cutter. Rotating the Depth Adjustment one complete revolution will result in the Tracking Wheels moving 0.039 inches (1 mm). A straight edge can be placed on the Tracking Wheels to adjust the Inserts to cut flush with the surface. In other cases it is most expeditious to approximate the initial setting and fine tune the cutter depth with sample passes. Once a depth-of-cut has been selected, the (2) two M6x1 Depth Adjustment Locking Screws should be re-tightened to the torque specified in Section 6.0 before beginning machining operations.

4.2 Setting Feeds and Speeds

Speed and Feed are the most important factors to consider for best results in milling. Improper Feed and Speed often cause low production, poor work quality and unnecessary wear to the Inserts. In milling, Speed is measured in peripheral feet per minute, (revolutions per minute times the Slot Cutter circumference in feet). This is frequently referred to as the Cutting Speed. In general use lower Speed for hard materials, tough materials, abrasive materials, heavy cuts, maximum Insert life. Use higher Speed ranges for: softer materials, light cuts, better finishes, maximum production rates. Table 1 gives approximate Cutting Speed starting values for some common materials. Additional information can be found in Machinery’s Handbook or from the Insert manufacturer.

<table>
<thead>
<tr>
<th>Work Material</th>
<th>Cutting Speed (ft./min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>1000</td>
</tr>
<tr>
<td>Silicon Bronze</td>
<td>1500</td>
</tr>
<tr>
<td>Cast Iron</td>
<td>300</td>
</tr>
<tr>
<td>Steel</td>
<td>450</td>
</tr>
</tbody>
</table>

Table 1. Cutting Speed for various materials.

Feed is usually measured in inches per minute. It is the product of Feed per Cutter Insert times revolutions per minute times the number of Inserts in the Slot Cutter. Feed per Cutter Insert affects chip thickness which is a very important factor in Insert life. Very thin, or feather-edge chips dull cutting edges more rapidly than thick chips. In general, the highest possible Feed per Cutter Insert will usually produce longer Insert life. However, excessive feeds may also overload the Cutter Inserts and cause breakage or chipping of the cutting edge. As a guideline, use higher Feeds for: heavy, roughing cuts, easily machined materials, high tensile strength materials, abrasive materials. Use lower Feeds for: light and finishing cuts, difficult to machine materials, low tensile strength materials. A typical Feed per Cutter Insert for the SWS100-1.2 is 0.003 inch (.08 mm). The Robot Feed rate is the speed that the robot moves the Weld Shaver across the part in inches per minute.

\[
\text{Servo Motor RPM} = \text{Cutting Speed} \times 1.91 = (\text{Rev./min.}) \quad (\text{Eq. 1})
\]

\[
\frac{\text{Robot Feed Rate}}{4 \times \text{Servo Motor RPM}} = (\text{in./Cutter Insert}) \quad (\text{Eq. 2})
\]

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Robot Feed Rate $= 4 \times \text{Feed/Cutter Insert} \times \text{Servo Motor RPM} = \text{(in./min.)} \quad \text{(Eq. 3)}$

The above equations are provided to help determine initial settings for the Weld Shaver. These equations apply only to the SWS100-1.2 Weld Shaver and should not be used for any other machines.

To help illustrate the use of the equations, the following Example Problems are provided:

**Example Problem (1)**

Determine the Servo Motor RPM for a Silicon Bronze weld seam.

Material: Silicon Bronze $\rightarrow$ Cutting Speed $= 1500$ (ft./min.) \quad \text{(See Table 1)}

Servo Motor RPM $= 1500 \times 1.91 = 2865$ (Rev./min.) \quad \text{(Eq. 1)}

**Example Problem (2)**

Determine the Feed / Cutter Insert for a Robot Feed Rate of 60 (in./min.) and a Servo Motor Speed of 2865 (Rev./min.).

$$\text{Feed / Cutter Insert} = \frac{60}{4 \times 2865} = 0.005 \text{ (in./Cutter Insert)} \quad \text{(Eq. 2)}$$

**Example Problem (3)**

Determine the Robot Feed Rate based on a 0.003 (in./Cutter Insert) and a Servo Motor RPM of 2865 (Rev./min.).

$$\text{Robot Feed Rate} = 4 \times 0.003 \times 2865 = 34.4 \text{ (in./min.)} \quad \text{(Eq. 3)}$$

### 4.3 Problems and Corrective Measures

Table 2 shows some of the more common troubles encountered and the recommended corrective measures involving variations in Cutting Speed (Servo Motor RPM) and Feed (Robot Feed Rate).

<table>
<thead>
<tr>
<th>Problem</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of rigidity (Robot Flexing)</td>
<td>Increase Cutting Speed, reduce Feed</td>
</tr>
<tr>
<td>Excessive abrasion on the tool</td>
<td>Reduce Cutting Speed, increase Feed</td>
</tr>
<tr>
<td>Chipping of the cutting edge</td>
<td>Reduce Feed/Cutter Insert</td>
</tr>
<tr>
<td>Burning of the cutting edge</td>
<td>Reduce Cutting Speed</td>
</tr>
<tr>
<td>Cratering of cemented carbide</td>
<td>Reduce Feed and Cutting Speed</td>
</tr>
<tr>
<td>Chatter</td>
<td>Try other combinations of Feed and Cutting Speed</td>
</tr>
</tbody>
</table>

Table 2. Troubles and Corrective Measures

### 4.4 Teaching the Weld Shaver Path

Teaching the path over the part surface is greatly simplified because of the force device’s compliant stroke. The force control and 0.8 inch (20 mm) carriage stroke of the AFD allows the Weld Shaver to easily maintain consistent contact with the part surface. The required force is highly dependant on the application, however a 10 lbs. applied force is usually a good starting point. If the force is too low, the Tracking Wheels can rise from the surface or the Weld Shaver might vibrate. Either of these problems can also be caused by improper Feed and Cutting Speed. Conversely,
applying too much force can cause the surface to deflect or deform and places unnecessary loads on the Tracking Wheels.

It is important to keep both Tracking Wheels in contact with the surface at all times during the machining operation. Allowing one of the Tracking Wheels to raise off the surface will result in the Slot Cutter also rising.

The Tracking Wheels should straddle the weld seam to produce the best results. The distance between the Tracking Wheels is 1.0 inch. Remember, the Weld Shaver only follows the part surface. Therefore any dirt, contamination, or weld spatter will affect the quality of the process.

5.0 Maintenance

5.1 Changing Cutter Inserts

The Slot Cutter provides Cutter Insert location plus adjustable width and indexing capabilities. The Cutter Inserts are retained securely in position by Locking Wedges which permit the Inserts to be “indexed” without removing the Locking Wedges from the Cutter. Specifically, effective Slot Cutter widths can be precisely set from 0.48 to 0.76 inches (12 – 19 mm).

CAUTION:  Remove all power from the Servo Motor before changing Cutter Inserts.

WARNING:  Insure Wedge Retaining Screws are securely tightened into the Slot Cutter, before rotating with the Servo Motor.

Set up Procedure

1. Determine the necessary width of material to be milled.

2. Loosen the Wedge Retaining Screw (3/32 Hex Key) shown in Figure 3 and remove or index the dull Cutter Insert.

3. Insure that the Slot Cutter is clean, paying particular attention to the Locking Wedge.

Figure 3. Changing Cutter Inserts.
4. Hand position the Cutter Insert between the Locking Wedge and the Slot Cutter shoulder with the desired Cutter Insert overhang. The amount of Cutter Insert overhang determines the actual cutting width.

CAUTION: The maximum Cutter Insert overhang is 0.150 inch (3.8 mm) on each side. Do not allow the Cutter Insert to overhang the Slot Cutter excessively. Doing so may cause damage to the SWS100-1.2 or the Cutter Insert.

5. Securely tighten the Wedge Retaining Screw with a torque of 25 in.-lb. (3 N-m).

6. Continue this process until all (8) eight Cutter Inserts are replaced or correctly indexed.

NOTE: Most Cutter Inserts can be indexed (i.e., rotated) 90° or 180°, depending on the type.

5.2 Replacing the Chip Shield

The Chip Shield, shown in Figure 3, can become worn or damaged during the operation of the Weld Shaver. To remove the Chip Shield loosen the (2) two M4x.7x12 socket Head Cap Screws ¼ turn. Take the old Chip Shield out and slide a new Chip Shield (PushCorp Part No. PAR00869-1) under the Shield Holder. Tighten the (2) two M4x.7x12 Socket Head Cap Screws to the torque shown in Section 6.0.

CAUTION: The Chip Shield is made of thin spring steel, and has sharp edges.

5.3 Replacing the Drive Belt

The Drive Belt used in the Weld Shaver transfers power from the Servo Motor to the Slot Cutter. The Drive Belt has been sized to handle the largest possible peak Servo Motor torque, so that fatigue will most likely be the cause of any belt failure. It is not unusual for a belt of this type to perform for thousands of hours, however actual performance is highly dependant on the application.

One of the benefits of small synchronous belt drives is lower belt pre-tensioning in comparison to other belt drives. However, proper installation tension is still important in achieving the best possible performance. In general terms, belt pre-tensioning is needed for proper belt/pulley meshing to prevent belt ratcheting under peak loading, to compensate for initial belt tension decay, and to pre-stress the drive framework.

CAUTION: Remove all power from the Servo Motor before servicing the SWS100-1.2 Weld Shaver.
Drive Belt Replacement Procedure

1. Remove the (6) six M4x.7 Socket Head Cap Screws securing the Belt Cover to provide access to the Drive Belt.

2. Loosen the (4) four M6x1 Button Head Socket Screws, shown in Figure 4, approximately ¼ turn. This will allow the Servo Motor to move, but constrain the Driver Pulley to remain essentially parallel to the Driven Pulley during re-tensioning.

3. Move the Servo Motor (Driver Pulley) in the slots toward the Driven Pulley. This is the shortest distance between the two pulleys.

4. Slide the Drive Belt over the Driven Pulley (no flanges) until it is clear, and slip the Drive Belt off of the Driver Pulley.

5. To install the new Drive Belt, first slide it over the Driver Pulley and then slide it over the Driven Pulley. It is absolutely critical that the belt teeth are correctly meshed with the teeth on both of the pulleys. This is accomplished by moving the Servo Motor away from the Driven Pulley while rotating the pulleys in opposite directions by hand.

6. Proceed to Section 5.4 to set the proper Drive Belt tension.

5.4 Setting the Proper Drive Belt Tension

Applying the proper Drive Belt tension is a very important factor in the life of the belt and the Servo Motor. Too little tension will allow the Drive Belt to jump teeth on the pulleys. Too much tension will cause premature failure of the Servo Motor bearings. For the Shaver, the required tension in each belt segment is 23 lbs., which results in a separation force of 50 lbs. between the Driver and Driven Pulleys.
The main problem with tensioning the Drive Belt is accurately applying a 50 lb. separation force with tools readily available on the factory floor. A Tension Boss (Figure 5) has been provided on the Belt Housing to allow the use of a Pry Tool. Placing the Pry Tool on top of the Tension Boss and underneath the Servo Motor Flange allows the Drive Belt to be easily tensioned. This lever/fulcrum creates a force multiplier of 12 times with the Tension Force 12 inches (300 mm) from the Tension Boss.

With the Weld Shaver in the vertical position, as shown in Figure 5, the Tensioning Force at 12 inches (300 mm) will be 5 lbs (22 N). Once the proper Tensioning Force has been applied, tighten the (4) four M6x1 Button Head Socket Screws to the torque specified in Section 6.0. Replace the Belt Cover and re-install the (6) six M4x.7 Socket Head Cap Screws. Tighten the M4x.7 Socket Head Cap Screws to the torque specified in Section 6.0.

CAUTION: **Never** operate the SWS100-1.2 Weld Shaver without the Belt Cover properly installed.
6.0 Specifications

Tool Weight: 15 lbs. (6.8 kg)

MOTOR SPECIFICATIONS:
- Power: 1.2 hp (895 W)
- Continuous Torque: 1.14 lb-ft (1.5 N-m)
- Maximum RPM: 5600 RPM
- Supply Voltage: 253 VAC, 3f, 50 / 60 Hz

Requires power supply, amplifier and cables.

CUTTER SPECIFICATIONS:
- Diameter: 4 inch
- No. Inserts: 8
- Cutter Insert Type: CTA-4
- Cutting Width: 0.48 - 0.76 in. (12 – 19 mm)

For specific dimensions see www.pushcorp.com for detail drawings.

Specifications subject to change without notice.

<table>
<thead>
<tr>
<th>Fastener Size</th>
<th>Torque</th>
<th>Minimum Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.-lbs.</td>
<td>ft.-lbs.</td>
</tr>
<tr>
<td>M4 x .7</td>
<td>50</td>
<td>4.2</td>
</tr>
<tr>
<td>M5 x .8</td>
<td>85</td>
<td>7.1</td>
</tr>
<tr>
<td>M6 x 1</td>
<td>140</td>
<td>11.7</td>
</tr>
<tr>
<td>M8 x 1.25</td>
<td>348</td>
<td>29.0</td>
</tr>
<tr>
<td>M10 x 1.5</td>
<td>600</td>
<td>50.0</td>
</tr>
</tbody>
</table>