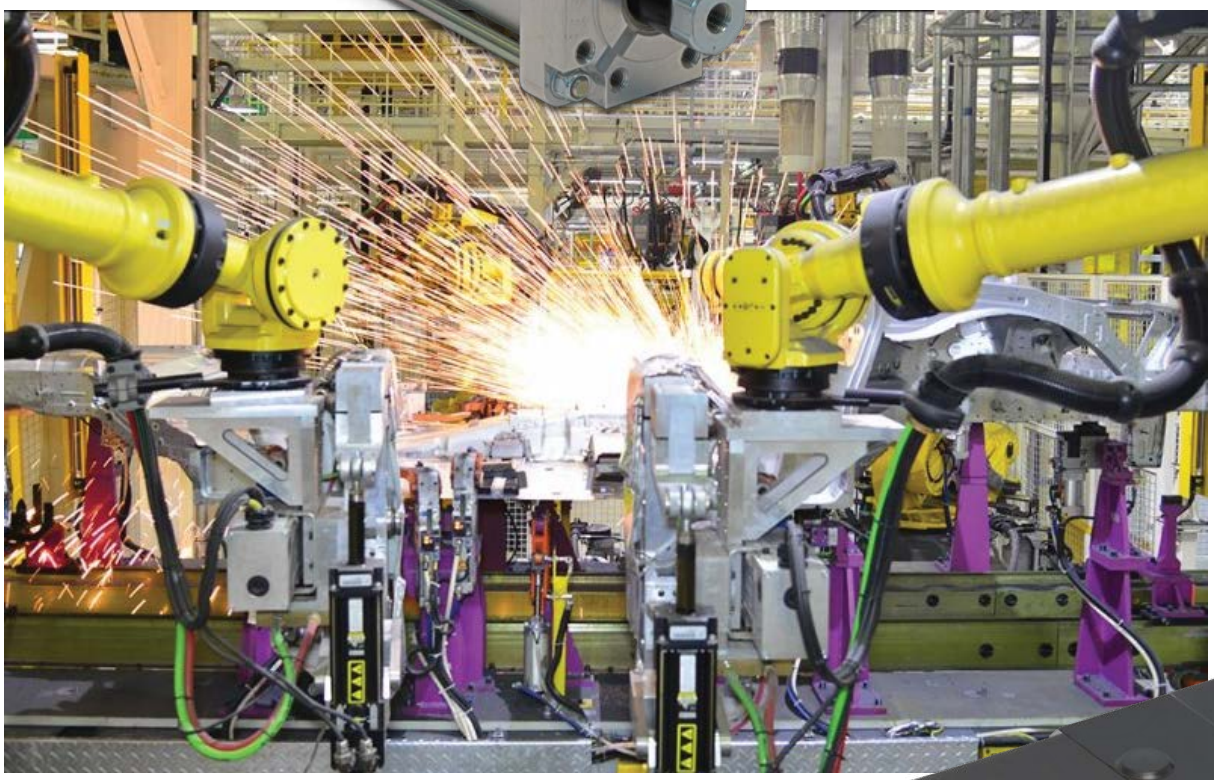
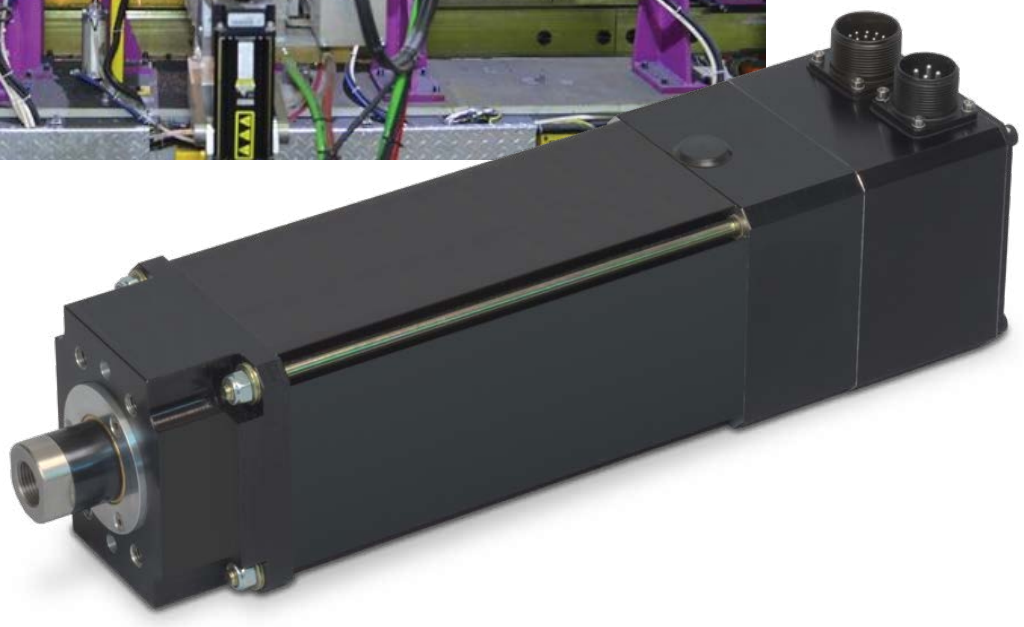
Tolomatic™
EXCELLENCE *IN MOTION*

WELDING SOLUTIONS





STANDARD & CUSTOM ACTUATORS

Tolomatic is the #1 RSW Actuator Manufacturer

Tolomatic is the world's leading manufacturer of integrated servo actuators for resistance spot welding used by the world's top weld gun OEM's and numerous global vehicle manufacturers.

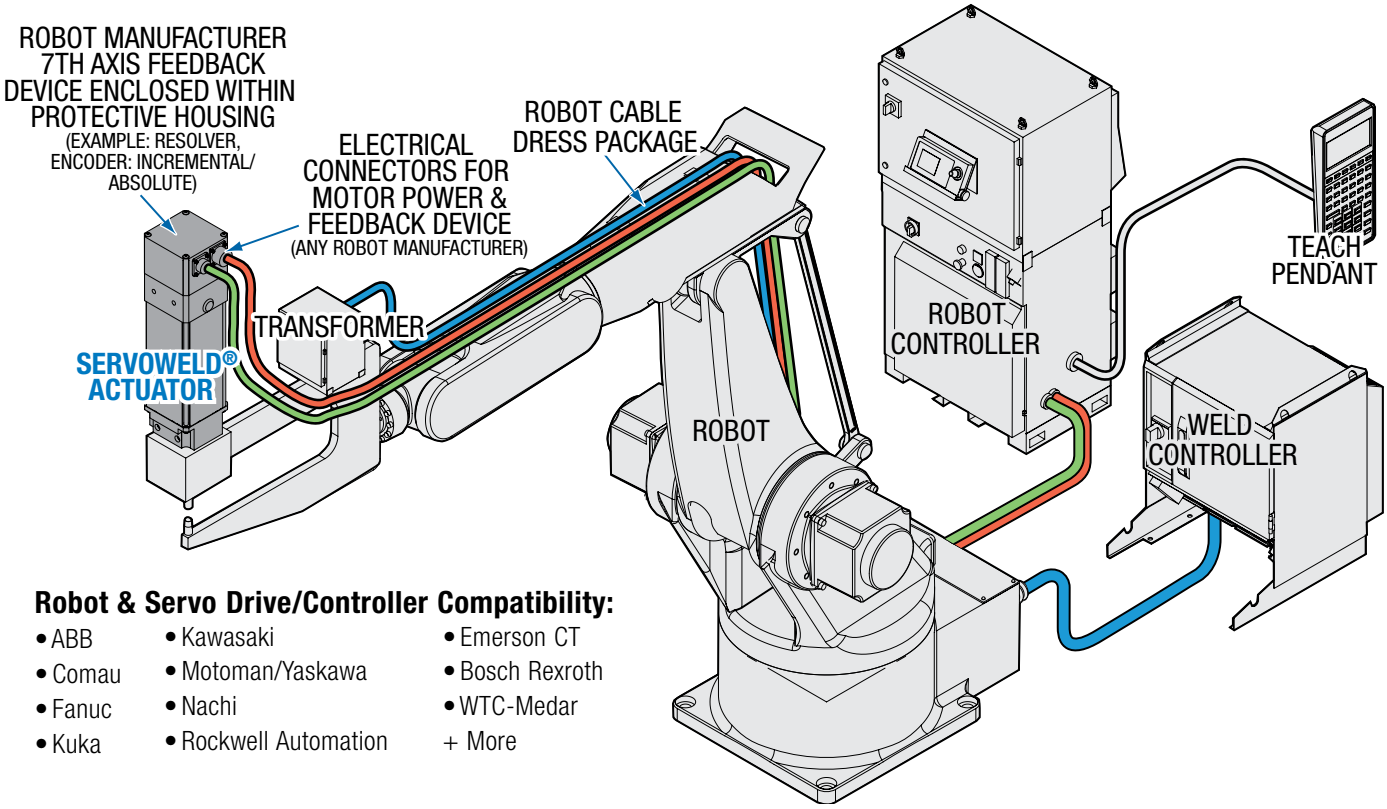
Superior Integrated Servo Motor Actuators

Tolomatic's ServoWeld family of integrated servo actuators are designed for best-in-class performance with the factors that are most important for resistance spot welding gun applications.

NUMBER OF WELDS/ PRODUCT LIFE	Tolomatic's superior roller screw design has the **highest dynamic load rating for more welds** than any competitive technology (other roller screws, ball screw, pneumatic).
FORCE REPEATABILITY	Skewed winding designed for welding minimizes motor cogging and **provides industry best actuator force repeatability:** • ±3 % Over the Lifetime of the Actuator
EFFICIENCY	All elements of actuator (winding, screw, rod scraper, bearings) are designed to optimize the efficiency of the actuator system and provide the **most energy efficient solution on the market.**
WELDS/ MINUTE	All elements of the actuator (winding, screw, rod scraper, bearings) are designed to last and run as cool as possible in welding applications, with the ability to add water cooling as an option. This means **more welds per minute than any competitive technology** (other roller screws, ball screw, pneumatic).
WEIGHT	Tolomatic integrated servo actuators minimize weight when designed into the weldgun. Additionally, Tolomatic can customize actuators for a specific weldgun applications to provide **industry leading light weight designs.**
LIFETIME COST	By building the longest lasting, most efficient and highest weld per minute actuators on the market, Tolomatic actuators provide the **lowest total cost per spot weld.**

ServoWeld Applications

Typical Robotic ServoWeld Installation

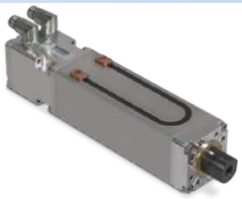


Robot & Servo Drive/Controller Compatibility:

- ABB
- Comau
- Fanuc
- Kuka
- Kawasaki
- Motoman/Yaskawa
- Nachi
- Rockwell Automation
- Emerson CT
- Bosch Rexroth
- WTC-Medar

+ More

Tolomatic Offers the Broadest, Most Capable Family of Integrated Servo Actuators for Resistance Spot Welding

Model:	GSWA	SWA/SWB	CSWX
			
Number of Welds[1] (millions):	20+	20+ *(10+ SWB)*	30+ *(20+ CSW)*
Re-lubrication without Disassembly:	Yes[4]	Yes	Yes
Peak Force:	24.5 kN *[5,500 lbf]*	24.0 kN *[5,395 lbf] SWA* 22.0 kN *[4,950 lbf] SWB*	18.0 kN *[4,047 lbf] CSWX* 15.6 kN *[3,500 lbf] CSW*
Actuator Output Force[2] **(Lifetime)** Repeatability:	±3%	±3% *(±5% SWB)*	±3%
Weight (size 33,3)[3] **(size 44,4)**[3]:	8.3 kg *[18.3 lb]* 13.8 kg *[30.4 lb]*	7.2 kg *[15.9 lb]* 14.2 kg *[31.2 lb]*	min: 10.2 kg *[22.6 lb]*
Water Cooling:	Optional	Optional	Optional
Manual Override:	Optional	No	Optional
Full Force Direction:	Push and Pull	Push	Push and Pull

[1] Based on properly lubricated ServoWeld unit used as recommended in user manual. Weld schedule, tip force, environment and lubrication are factors in the total number of welds achievable with ServoWeld actuators.

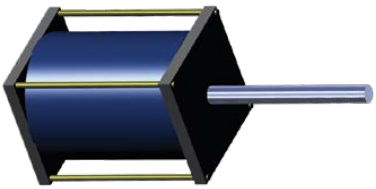
[2] At weld force [3] Weight varies with choice of feedback device and mounting options [4] Some exceptions, see GSWA user manual

ServoWeld: Best-in-Class Integrated Servo Actuators

- **Most welds and longest life** with highest DLR (dynamic load rating) roller screws
- **Most welds per minute** with highest efficiency skewed windings and roller screw
- **Best weld force repeatability** due to low cogging skewed winding servo motor
- **Light weight, compact designs** fit any robot carried weld gun
- **Lowest total cost of ownership** with longest lasting, most efficient actuator solution

Improved Technology, Better Performance

Air cylinders, and competing servo actuator designs can't compare to ServoWeld®



AIR CYLINDER

- High electric utility cost
- Frequent repair and maintenance
- Reduced weld quality, poor force repeatability
- Greater tooling & tip wear due to "bang-bang" movements
- Force, speed & stroke not easily programmed
- More configurations required to address varying weld schedule requirements
- Low efficiency (typically ≤20%)

SERVO: Reverse-parallel motor configuration, belt driven

- Size and weight create payload challenge (increase of 10% to 30% compared with an integrated design)
- Mechanical linkage of belt is not as responsive as direct drive
- Transmission belt is a potential failure point and maintenance item
- Force repeatability suffers with belt/pulley backlash

SERVO: - Integrated motor with segmented laminations

- Force repeatability suffers due to increased cogging of segmented stator
- Less welds per minute as more heat is generated from more current to overcome cogging torque
- Higher cogging torque results in force repeatability variation with position changes, potentially compromising weld quality
- Segmented stator design does not offer the performance (welds per minute & efficiency) of skewed windings

Roller Screws vs. Ball Screws

Roller Screw

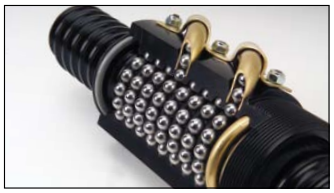
Capable of handling heavy loads, planetary roller screws contain precision ground rollers engaged with a precision ground screw and a precision ground nut. When compared with a ball screw of the same size and lead the roller screw components are designed with a finer pitch, providing more points of contact and a larger contact radius. This results in less stress per point of contact.

- Higher DLR = longer life
- Higher loads per given size actuator
- Allows for smaller, lighter weight actuator

ROLLER AND BALL SCREW ACTUATOR PERFORMANCE COMPARISONS

	ROLLER SCREW	BALL SCREW
Dynamic load rating	Very High	Medium
Lifetime	Very long, many times greater than ball screw	Moderate
Shock Loads	Very high	Moderate
Relative Space Required	Minimal	Moderate
Maintenance	None to Minimal	Minimal

Ball Screw

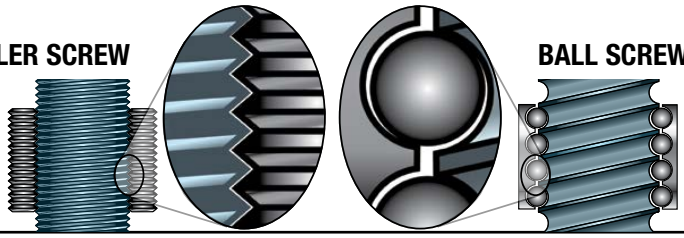


Capable of handling moderate loads, ball screw nut assemblies contain multiple ball bearings that cannot be made below a minimum size. When compared to a roller screw of similar size and lead, the ball bearings' radius requires a courser pitch resulting in fewer points of contact. Combined with the smaller contact radius and a design that allows the bearings to contact each other this limits the ball screw's DLR leading to lower forces and shorter life.

DLR (Dynamic Load Rating) is an industry standard term that represents an applicable constant load (in direction and magnitude) where a ball bearing device (or power screw) will achieve 1,000,000 revolutions of rated life or L10 life estimation at 90% reliability.

PLANETARY ROLLER SCREW

Roller screws have significantly more contact points in the same space compared to ball screws



BALL SCREW

Standard vs. Inverted Roller Screws

Standard Roller Screw

Standard roller screws are case (surface) hardened before precision grinding, resulting in a much deeper case hardness depth and much higher DLR. The deeper surface hardness and higher DLR give this design a large advantage in life (and managing lubrication) over the inverted design.

- Higher DLR = longer life
- 100x deeper hardening
- Easier to re-lubricate

STANDARD AND INVERTED ROLLER SCREW ACTUATOR PERFORMANCE COMPARISONS

		STANDARD	INVERTED
Manufacturing Method		Precision Ground	Mixed
Case Hardness Depth		~1.0 mm (~100x greater)	~0.01 mm
Screw DLR	**Size 3**	53.6 kN 12,050 lbf	~25.8 kN ~5,800 lbf
	Size 4	73.3 kN 16,479 lbf	~36.9 kN ~8,300 lbf
Lubrication Maintenance		NO removal or disassembly required	Must remove and disassemble the front of actuator

Standard roller screws have a 100x deeper case *(surface)* hardening depth and are easier to maintain lubrication

Inverted Roller Screw

Inverted roller screws use a process other than grinding to economically create threads along the internally threaded nut. Because of this, the hardening process is performed after the internally threaded nut is machined. The required hardening process results in a much shallower case hardness depth and softer threads than Standard roller screws. This leads to a significantly lower DLR (lower life) and more challenges with maintaining lubrication.

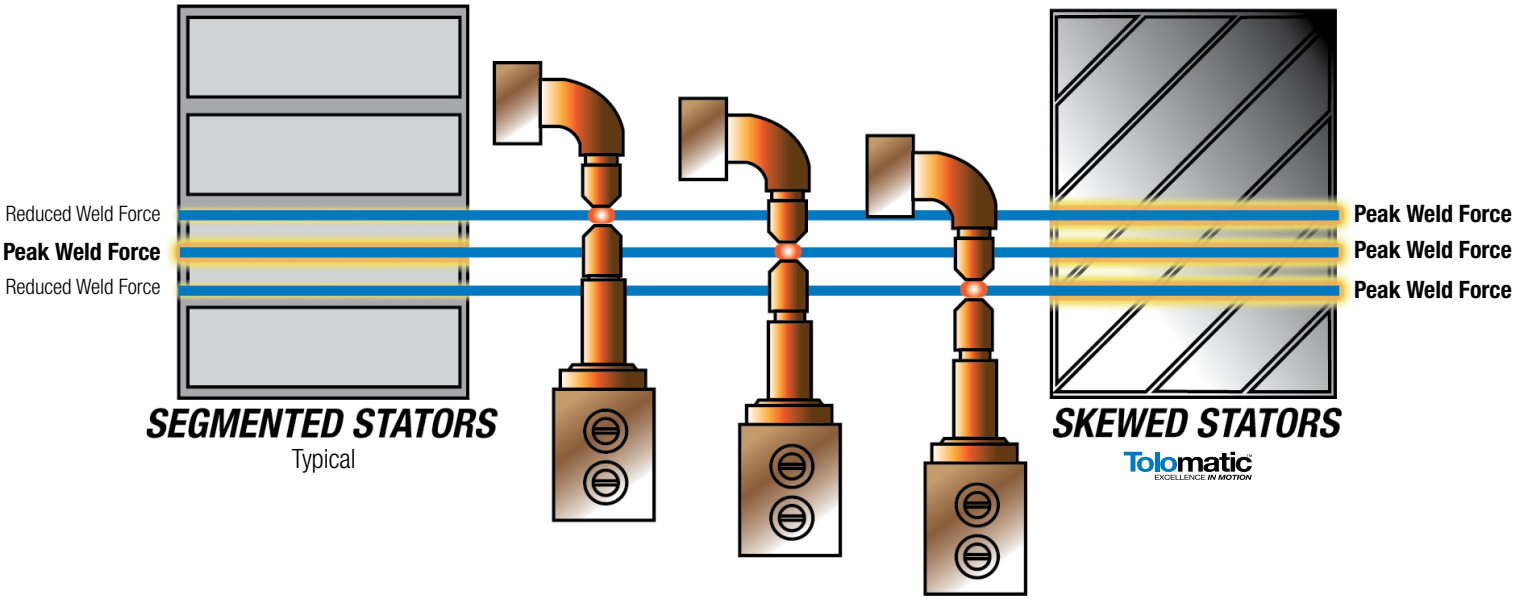
Superior Force Repeatability and Weld Quality

The ServoWeld Integrated Motor Actuator Design Offers Superior Weld Force Repeatability in a Compact Package

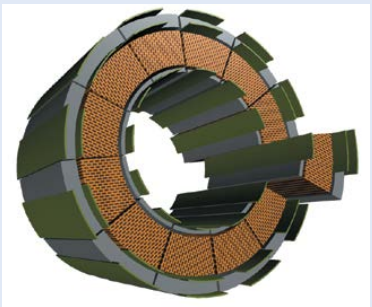
ServoWeld integrated motor actuators use an 8 pole, hollow core rotor with skewed stator laminations. This allows the magnets to remain over multiple windings throughout the weld cycle. The result is maximum torque efficiency and consistent force output at any location along the actuator stroke, independent of weld cap wear.

The result:

- Low cogging torque for better repeatability
- Better force repeatability independent of position
- Higher quality welds



As the weld gun tips close on a part, the final position of the servo actuator's thrust rod is dependent on the metal thickness and tolerances, weld cap wear, etc. When the thrust rod reaches its final position and finishes the "squeeze", the motor rotor stops turning. The illustration above represents various final positions (the orange ovals between the weld tips, representing the weld nugget "squeeze" in the RSW cycle) and the varying positions of the motor rotor magnets (the straight blue lines) in comparison to the servo motor windings. The diagonal lines in the skewed stators represent the laminated motor windings used in the ServoWeld actuator. At any point the rotor magnets stop, they are always positioned in an orientation that provides peak performance. In contrast, the segmented stator windings will only provide peak performance when the rotor is positioned in the center of the segmented stator phase.



Typical

Segmented Stators

By nature of their design, segmented stators limit the number of weld positions that deliver optimal torque and repeatability.

Skewed Stators

The ServoWeld actuator has skewed stator laminations for low cogging torque and better repeatability, independent of tip position.

Resistance Spot Welding (RSW) With ServoWeld® Actuators

ServoWeld Actuators Offer RSW Users a Higher Level of Performance When Compared to Pneumatic Actuators

Higher Quality Welds

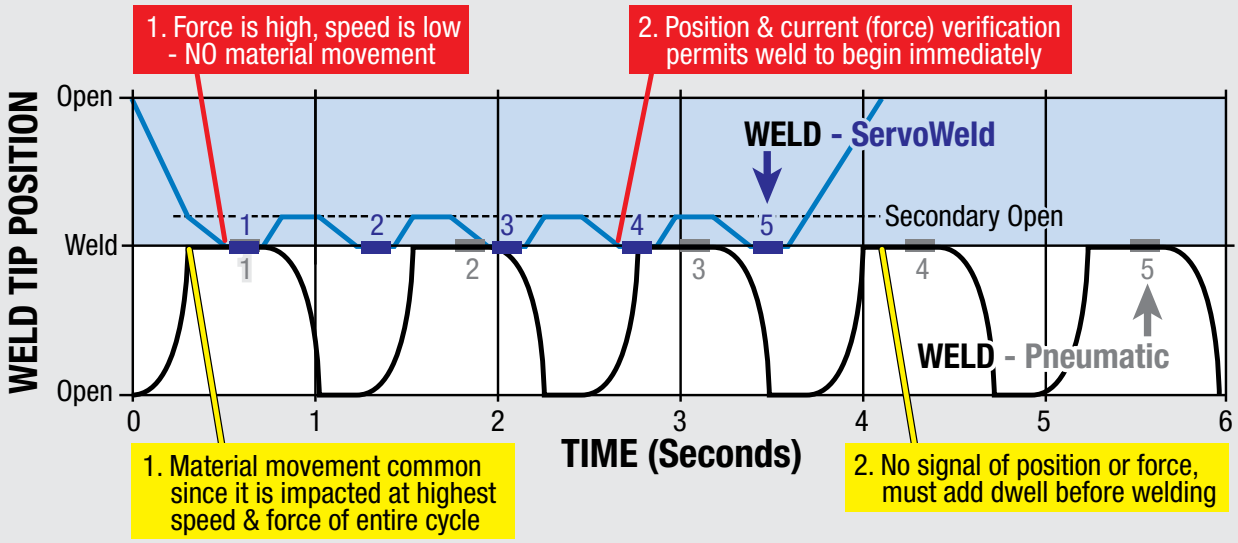
- Force repeatability for consistent welds
- "Soft-touch" position and speed control for high repeatability and eliminates high impact effects on part and weld gun for reduced wear
- Position and force can be recorded for each weld
- Position data from feedback device can provide data for weld cap wear and lost cap detection capability

Complete Manufacturing Flexibility

- Using weld or robot controls, the ServoWeld actuator can be easily programmed to accommodate model or tool changes.
- Existing 6-axis robots can be retrofitted with multiple ServoWeld actuators to achieve all the advantages that servo welding offers.
- Operation can be coordinated with robot axis movement.

Faster Welding Cycles

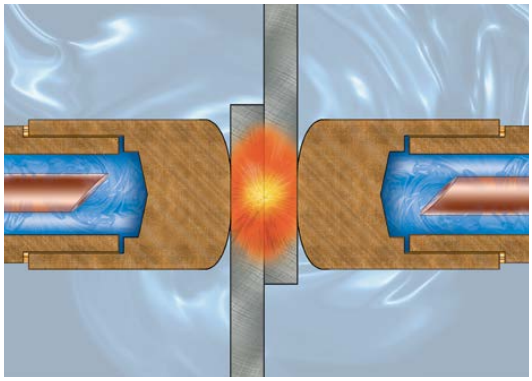
- "At-force" indication allows for immediate welding (pneumatic actuators require a dwell time)
- Programmable open positions of the gun tips shorten move times between welds.



ServoWeld completes this weld sequence faster because:

1. Weld begins as soon as weld force is achieved, no dwells
2. Gun is opened only enough to move to next weld

With ServoWeld there is no dwell time needed so weld begins as soon as weld force is achieved. Efficiency is improved since the gun tips only open enough to move onto the next weld.



Weld Nugget Formation

This illustration shows how a weld nugget is formed. The tips of the weld gun are programmed to close rapidly then slow to a 'soft touch' speed as they come in contact with the part for reduced part impact and low expulsion resulting in higher quality welds.

ServoWeld Advantages over Pneumatic Cylinders

For many years the RSW industry has been abandoning pneumatic actuators for electric actuators. Accuracy, speed, efficiency, force repeatability and total cost of ownership have all made ServoWeld the preferred choice when converting to all electric manufacturing.

LOWER LIFETIME COST

- ServoWeld offers longer overall service life: Roller Screw/Roller Nut: 10 to 20+ million welds (Pneumatic actuators have a typical service life of 3 M welds, and require regular preventative maintenance.)

ZERO MAINTENANCE

- ServoWeld actuators provides zero maintenance for 10 M, delivering increased productivity and less downtime. Pneumatic actuators require rebuilding or replacing.

HIGHER EFFICIENCY

- Increased energy efficiency over pneumatics providing payback often less than a year. (Typically less than 20% of the energy of a pneumatic system is converted to usable work.)

FLEXIBILITY AND ADAPTABILITY

- Fewer configurations required: Wide force range minimizes required configurations for varying force and stroke requirements. (Able to replace 35 to 40 different pneumatic cylinders by stocking 3 different ServoWeld models.)
- Supports multiple weld schedules, easily accommodating different materials and thicknesses. Easily re-deployed on new programs.

BETTER WELD QUALITY & FORCE REPEATABILITY

- ServoWeld actuators provides the industry best force repeatability over the entire life of the actuator. The result: consistent, high quality welds

IMPROVED WELD CAP LIFE

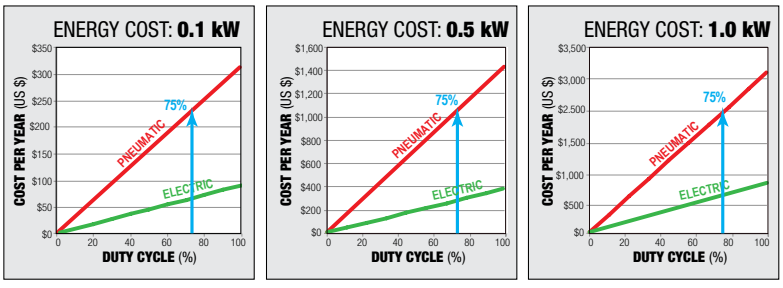
- Impact force in pneumatic systems can cause weld cap deformation. Weld cap life improvements with ServoWeld range from 5 - 35%, depending on application.

MINIMAL ENVIRONMENTAL IMPACT

- Less energy, noise and contamination than pneumatically powered systems which employ air exhaust.

Calculating the Power Costs of an Application

1. POWER-OUT (kW) = Velocity (m/sec) x Force (N) ÷ 1,000 (converted to kN)
2. POWER-IN (kW) = Power-Out (kW) ÷ Efficiency (%)
3. COST OF APPLICATION $ = (Power-In) x (Hours/year) x (Electricity Cost)



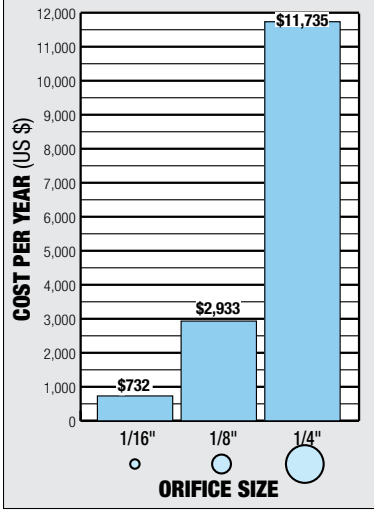
0.3 m/sec; 300N
12 in/sec; 62 lbf

0.2 m/sec; 2,500N
8 in/sec; 565 lbf

0.15 m/sec; 7,000N
6 in/sec; 1,570 lbf

ASSUMPTIONS: Electric Efficiency 79%; Pneumatic Efficiency 22%; Cost kW/hr $0.07

The Cost of an Air Leak



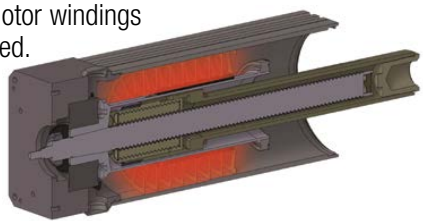
Costs calculated using electricity rate of $0.07 per kWh, with constant operation and an efficient compressor.

Source: Improving Compressed Air System Performance, A Sourcebook for Industry published by the Office of Industrial Technologies, US Department of Energy

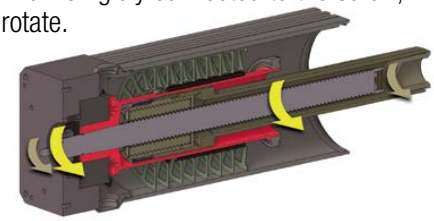
How it Works

The illustrations below show how the inner components of the ServoWeld actuator work together to provide optimal performance. For clarity, only the extend movement is shown.

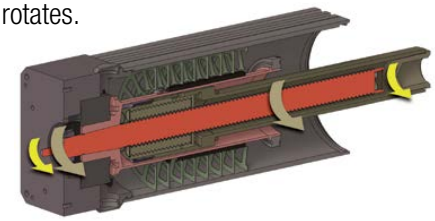
1. The servo motor windings are energized.



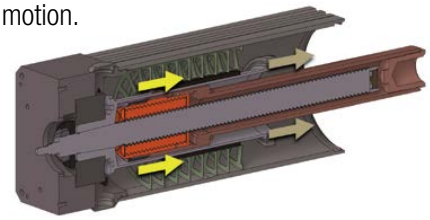
2. The rotor, which is rigidly connected to the screw, begins to rotate.



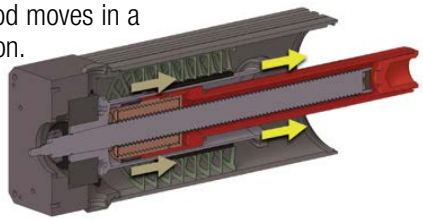
3. The screw rotates.



4. The nut, mechanically captured by the thrust rod, moves in a linear motion.



5. The thrust rod moves in a linear motion.

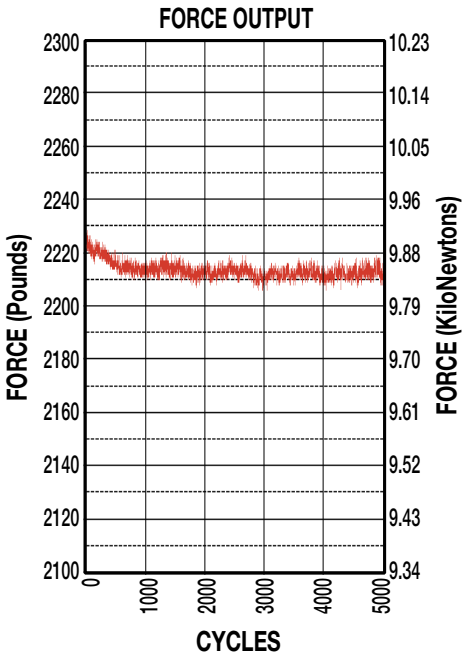


Tested Performance Results

Tolomatic's ServoWeld actuators (with roller screw/nut selection) are designed and built to maintain ±3% force repeatability throughout the actuator life.

The data presented in the "ServoWeld Force Output" chart below was collected from a ServoWeld® configured unit with a roller screw and low-voltage windings.

The force output data in this chart is from ServoWeld actuator run at a fixed current. Each sample is representative of a single "weld cycle."



DATA POINTS OF INTEREST:

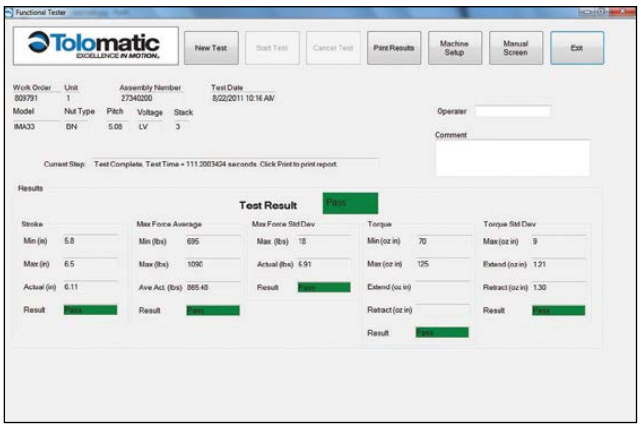
- The overall range of 5,000 samples is 120 N (27 lbf), or less than 1.2% of nominal.
- The drop in force from cold start is 0.5% nominal (appr.), which means the weld-to-weld force variation is relatively constant regardless of temperature.
- Standard deviation remains relatively constant regardless of weld force, which means repeatability improves relative to higher weld forces. Tolomatic measures repeatability as (6) (Std. Dev.)/Nominal Force.

Complete Verification Testing is Performed on Every Actuator

Every ServoWeld actuator has to pass rigorous testing at our factory. With this extra quality step we provide peace of mind to our customers and enable them to start their production faster, worry free!

We verify the performance of each individual unit before delivery to ensure they conform to Tolomatic's high standard of performance.

Functional unit testing for hundreds of cycles quantifies stroke, length, torque under no load, input current vs force standard deviation.



Testing parameter results in progress for the Functional Test procedure.

Final system test ensures the feedback device is properly aligned with the ServoWeld motor poles.

1. High POT (High Potential/High Voltage Test)
This standard electric motor test procedure is a 3-part test that checks the insulation system of the assembly to verify proper armature and thermal wire insulation.

2. Electronic phasing of ServoWeld® and feedback device (Encoder, Resolver, Feedback Device)
Using a fixed current and a specially designed fixture the feedback device is physically and electronically aligned relative to the phasing of the ServoWeld motor.

3. Functional Testing
Performed with Tolomatic motion control components and dedicated data acquisition equipment. Operated for hundred of cycles, this test quantifies these parameters - stroke length, torque under no load, input current vs force average, input current vs force standard deviation - using an electronic load cell in conjunction with data acquisition equipment.

4. Tolomatic System Test
Using a single-axis control unit the test ensures that the feedback device is properly aligned with the poles of the ServoWeld motor.

ServoWeld Application Guidelines

SIDE LOADING: Some weld gun designs may subject the actuator to excessive side loading, reducing overall service life. The GSWA33, GUIDED actuator will accommodate side loading. For other ServoWeld configurations, measures are required, especially in "C" style designs, to limit side loading. For life optimization Tolomatic recommends side loads of less than 5% of axial load (thrust rod output force) for all roller screw configurations and less than 1% of axial load for all ball screw configurations.

For maximum service life, external guiding is recommended to minimize side loading to the thrust rod and provide consist weld gun movable tip/fixed tip alignment throughout service life.

THRUST ROD WIPER/SCRAPER: The thrust rod wiper/scraper assembly is field replaceable. For maximum service life, measures should be taken to reduce/eliminate contamination, weld slag, and water in the thrust rod wiper/scraper interface area. Implementation of industrial thrust rod boot and/or deflective device can be effectively utilized in this area.

CABLES: Shielded power & feedback cables are recommended to minimize electrical noise/grounding issues. Electrical noise or inadequate grounding can corrupt the feedback device signal.

RSW SERVO SYSTEM CALIBRATION: RSW weld gun servo system consists of robot 7th axis amplifier, robot feedback device, robot RSW software, weld gun chassis, & ServoWeld.

For optimal RSW weld gun servo system performance the calibration process should include maximum weld tip force from the production weld schedule, tip dress force, and multiple weld tip forces in-between. Utilizing all the available robot manufacturer force table inputs will provide best RSW weld gun servo system performance. The same weld tip part contact speed should be used for both RSW weld gun servo system calibration and production weld schedule.

WELD TIP/PART CONTACT SPEED: Tolomatic testing confirms the highest ServoWeld repeatability (**INPUT CURRENT** verses **OUTPUT FORCE**) at a weld tip part contact speed of 25mm/second or less. Speeds greater than 25mm/second can create "impact contribution" to the weld force. This impact contribution to the weld force deteriorates prior to completion of the weld cycle.

ROBOT CARRIED APPLICATIONS: Robot carried RSW gun applications have reduced exposure to water pooling/water ingression by virtue of the continuous robot movement and various RSW gun positions. In addition, in robot carried applications positioning of the RSW gun can be programmed as part of the weld cap change program/routine to eliminate ServoWeld exposure to water. (ServoWeld above weld caps)

ROBOT MANUFACTURER SERVO FILE: Robot manufacturer servo parameter files for operation of ServoWeld are available only from the robot manufacturer. Each robot manufacturer creates 3rd party motor servo parameter files, validates operation of ServoWeld via their 7th axis, and maintains servo motor parameter file for operation of ServoWeld.

TOOL CHANGER APPLICATIONS: Weld gun storage fixture in cell should position weld gun so movable electrode is not loading ServoWeld thrust rod - back driving the ServoWeld. Weld gun tips should be positioned to weld gun closed at low force prior to disconnect from robot/tool changer. Consider ServoWeld configured with integral brake option.

FIXED/PEDESTAL APPLICATIONS: One of the more challenging RSW applications is a pedestal RSW gun, ServoWeld mounted vertical – thrust rod up. Measures should be taken to reduce and/or eliminate the ServoWeld to water exposure, water pooling/spray in the access areas of the ServoWeld unit to maximize overall service life.

- Pedestal RSW guns that can be mounted with the ServoWeld vertical – thrust rod down should be considered.
- Pedestal RSW guns that must be mounted with the ServoWeld vertical – thrust rod up should be mounted at an angle of a least 10 – 15° to minimize water pooling.
- Water channels on interfacing mounting components of the ServoWeld/RSW Gun to minimize water pooling
- Any RSW gun applications that are suspect for water exposure should utilize an external deflector (bib) or a thrust rod boot to keep the water away from the thrust rod wiper/scraper interface area.
- Any RSW gun application that is suspect for water exposure should consider utilizing a manual shut-off valve in the water saver circuit at the RSW gun. Shutting off the water prior to weld cap change can significantly reduce water exposure issues in the RSW gun environment.
- Pedestal RSW gun applications should have the mating electrical connectors (90 degree) on the cable dress package facing down with the cable dress cables looped to reduce water ingression via the electrical connectors (power/feedback).
- Allow adequate cable length so the cables are not in tension.
- Molded mating electrical connectors on the cable dress package for pedestal RSW gun applications
- Confirming full engagement of the cable dress connector to the appropriate mating receptacle on ServoWeld.

The Tolomatic Difference Expect More From the Industry Leader:

INNOVATIVE PRODUCTS

Unique linear actuator solutions with Endurance Technology℠ to solve your challenging application requirements.

FAST DELIVERY

The fastest delivery of catalog products... Built-to-order with configurable stroke lengths and flexible mounting options.

ACTUATOR SIZING

Online sizing that is easy to use, accurate and always up-to-date. Find a Tolomatic electric actuator to meet your requirements.

YOUR MOTOR HERE

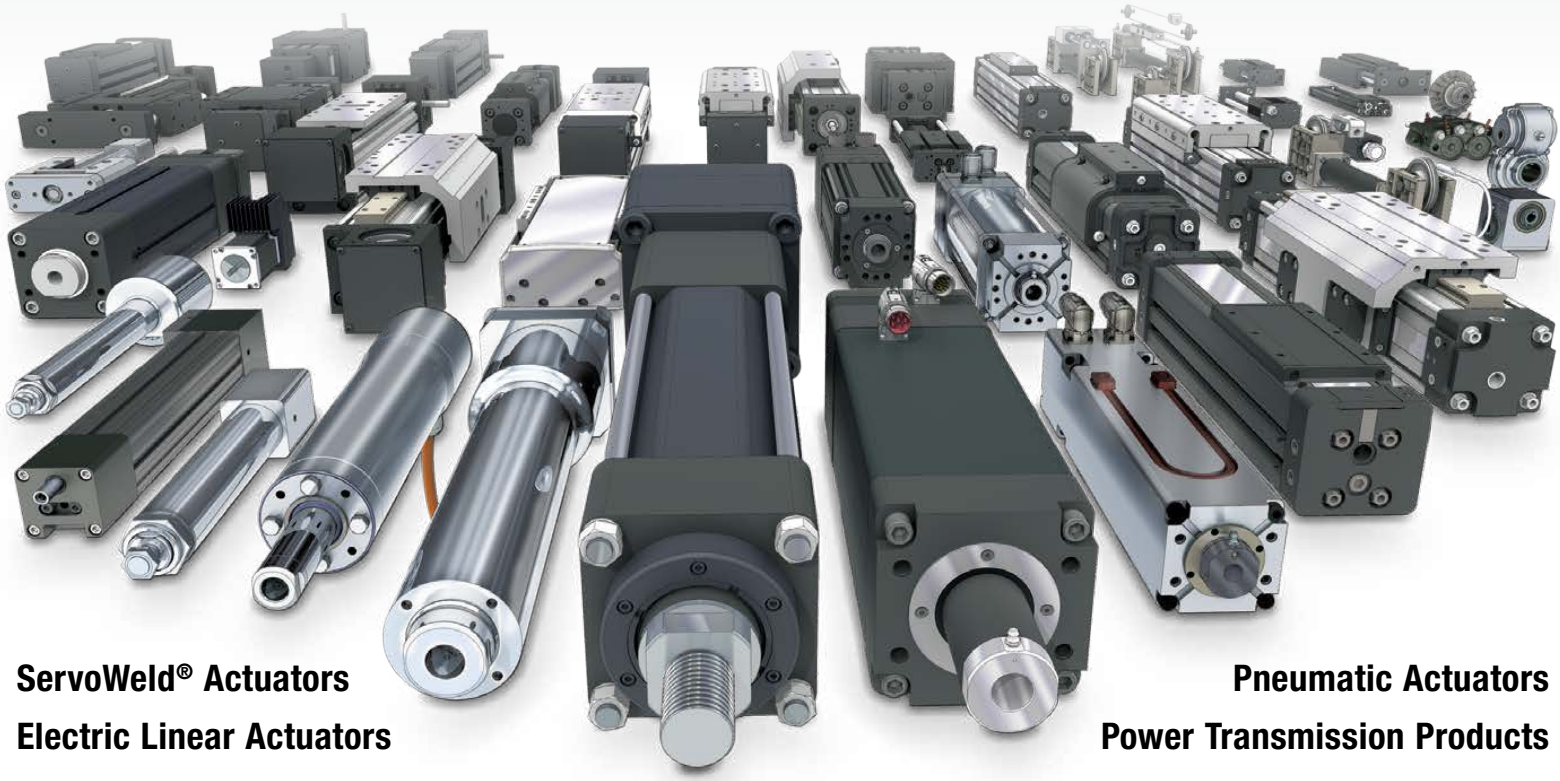
Match your motor with compatible mounting plates that ship with any Tolomatic electric actuator.

LIBRARY

Easy to access CAD files available in the most popular formats to place directly into your assembly.

TECHNICAL SUPPORT

Extensive motion control knowledge: Expect prompt, courteous replies to any application and product questions from Tolomatic's industry experts.



ServoWeld® Actuators

Electric Linear Actuators

Pneumatic Actuators

Power Transmission Products

Tolomatic™

EXCELLENCE *IN MOTION*

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202110190757

LITERATURE NUMBER: **2750-4003_03**