aerospace
climate control
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filtration
fluid & gas handling
hydraulics
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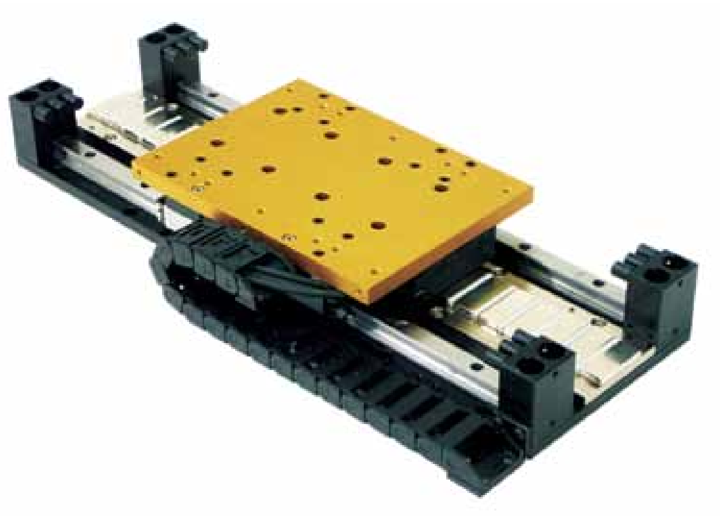
sealing & shielding



Trilogy Linear Motor Positioners

Parker核心代理商

Parker

北京润诚时代科技有限公司

自动化事业部

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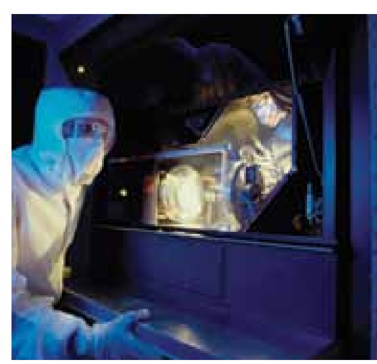

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A Fortune 300 company with annual sales exceeding $10 billion and more than 400,000 customers in 43 countries, Parker Hannifin is the world's leading supplier of innovative motion control components and system solutions serving the industrial, mobile, and aerospace markets. We are the only manufacturer offering customers a choice of electromechanical, hydraulic, pneumatic, or computer-controlled motion systems.

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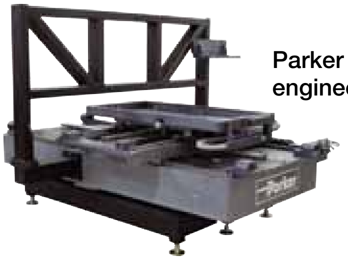
Parker's team of highly qualified application engineers, product development engineers, and system specialists can turn pneumatic, structural, and electromechanical products into an integrated system solution. Moreover, our Selectable Levels of Integration™ allows you to choose the appropriate system, subsystem, or component to meet your specific need.



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Parker also has the industry's largest global distribution network, with more than 8,600 distributors worldwide. Each of these locations maintains ample product inventory to keep your downtime to a minimum. And many distributors have in-house design capabilities to support your system and subsystem requirements.

Throughout the design process, Parker's factory-trained electromechanical engineers work hand in hand with you and day or night at 1-800-C-Parker. Our operators will connect you with a live, on-call representative who will identify replacement parts or services for all motion technologies.

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Parker's best-in-class technology training includes hands-on classes, Web-based instruction, and comprehensive texts for employees, distributors, and customers. Parker also provides computer-based training, PowerPoint presentations, exams, drafting and simulation software, and trainer stands.

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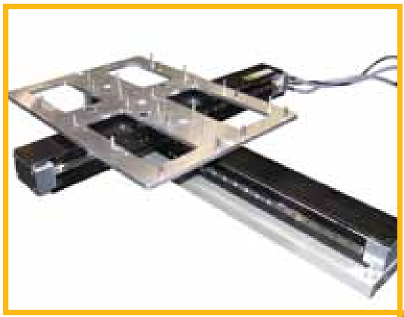
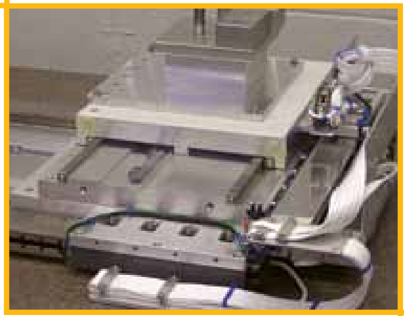
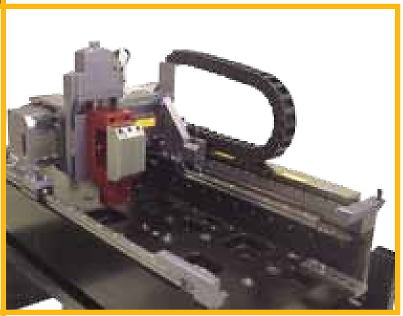
PERFORMANCE

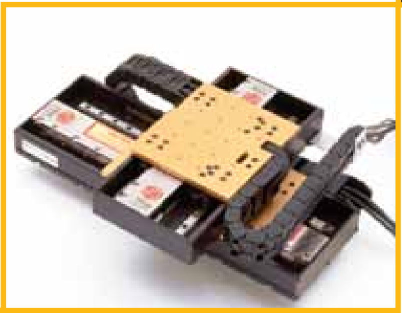


PRECISION



ACCURACY





SPEED

Parker Hannifin has been providing innovative automation solutions for decades. This spirit of innovation continues within the exploding market of linear motor technology. In 2003, Parker acquired Trilogy Corporation, one of the most recognizable brands in linear motors. The powerful combination of Parker's and Trilogy's patented linear motor solutions gives automation and robotics customers distinct performance enhancements and cost of ownership benefits over competing technologies. With a full complement of linear motor components and fully engineered positioning systems, Parker has the right solution to increase productivity and to enhance the accuracy and dynamic performance of your machine.

Linear Motor Advantages

- High Speeds
- High Accelerations
- Fast Response – 100 times that of a mechanical system
- Stiffness – spring rate better than a mechanical system
- Zero Backlash – direct drive technology
- Maintenance Free Operation – mechanical simplicity due to reduced component count
- Long Travels Without Performance Loss
- Suitable for Vacuum and Extreme Environments

Applications

- Semiconductor and Electronics
- Flat Panel and Solar Panel Manufacturing
- Medical and Life Sciences
- Machine Tools
- Optics and Photonics
- Large Format Printing, Scanning and Digital Fabrication
- Packaging and Material Handling
- Automated Assembly

Parker has one of the broadest offerings in available linear motor technologies. From component or "kit" style motors, packaged positioning tables, to complete custom engineered systems, Parker can provide a solution for any linear motion requirement.

Component Motors

- Ironless Motors – ultra high performance and zero cogging
- Ironcore Motors – highest power per package size
- Slotless Motors – good linear force, smooth translation, low cost

Industrial Grade Positioners

- Pre-engineered, ready-to-run packages
- Drive / amplifier connectorization
- High dynamic velocity and accelerations
- High precision

Precision Grade Positioners

- Pre-engineered, ready to run packages
- Drive / amplifier connectorization
- Extremely high precision
- Miniature positioners available

Multi-axis Capability

- Standard transition brackets available
- Custom configurations
- Dowel pinning for superior orthogonality
- Cable Management

Custom Engineered Systems

- Let Parker's extensive motion design experience, systematic project management process, and global infrastructure solve your most demanding motion problems.
- Collaborative development cycle aligns customer goals and rigorous performance specifications with a complete engineered solution.

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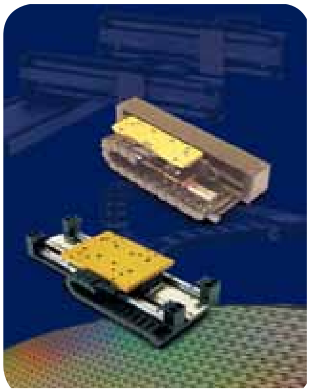


Linear Motor Engineering Reference Guide

1. Advantages of linear motors

1.1 What are linear motors?

Simply stated, a linear motor is the same as a rotary motor that has been "unwrapped." They operate exactly the same as rotary motors, where the same electromagnetic equations that describe how a rotary motor produces torque now describe how a linear motor produces a direct force.

In many applications, linear motors offer distinct advantages over conventional rotary drive systems. When using a linear motor, there is no need to couple the motor to the load by means of intermediate mechanical components such as gears, ballscrews, or belt drives. The load is directly connected to the motor. Therefore, there is no backlash or elasticity from the moving elements. Thus, the dynamic behavior of the servo control is improved and higher levels of accuracy are achieved.

The absence of a mechanical transmission component results in a drive system with low inertia and noise. In addition, mechanical wear only occurs in the guidance system. As a result, linear motors have better reliability and lower frictional losses than traditional rotary drive systems.

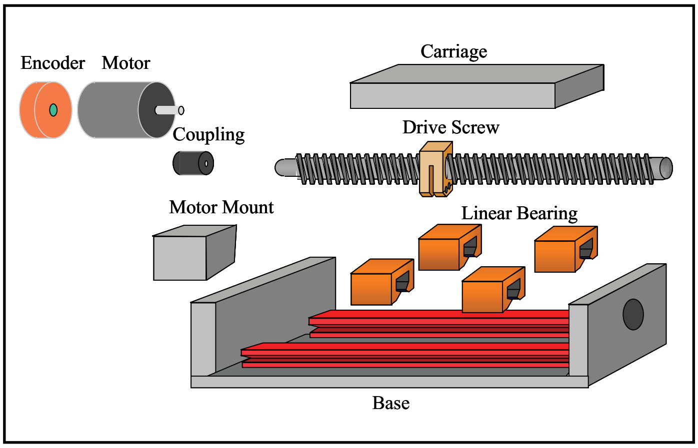


Fig. 1: Precision table fitted with ballscrew drive

1.2 Differences in construction

The differences in construction between a direct-drive linear motor and a conventional rotary drive system are shown in (Fig. 1 and Fig. 2,) using the examples of a linear motor drive and a ballscrew drive. Due to the absence of mechanical transmission elements converting rotary movement into linear movement, the axis fitted with a linear motor has a much simpler mechanical construction, resulting in a low-inertia drive for highly dynamic applications. Though not always required, the linear motor table is equipped with a linear encoder, which provides extremely accurate positional feedback.

Though the linear encoder in (Fig. 2) can be considered a high-cost component, the selection of the feedback system can be optimally suited to the requirements of the application. For instance, Parker offers extremely high-resolution optical encoders for applications with demanding precision requirements. In addition, Parker offers lower-resolution, low-cost magnetic encoders for applications where overall system cost is a concern. Actually, it is not uncommon for a linear motor with an economical form of feedback to outperform and actually cost the same or even less than a rotary system using a precision ground ballscrew.

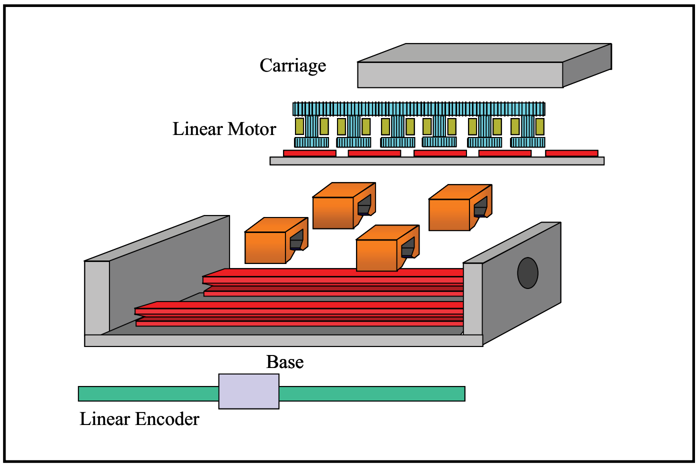


Fig. 2: Precision table fitted with linear motor

Fig. 3: Linear motor components include a separate coil and magnet rail

Fig. 4: Linear motor positioning systems include a base, bearings, carriage, feedback and typically cable management

2.0 Types of linear motors

There are many different types of linear motors. Each type exhibits its inherent advantages and benefits to the user. Parker manufactures 3 styles of linear motors – ironless, ironcore, and an interesting variant known as the "slotless" design.

Linear motors are either offered as individual components or complete systems. Components, or "kits" (Fig. 3), consist of a motor coil and separate magnet rail. The coil assembly is known as the "forcer" or sometimes as the "primary" element. The forcer generally consists of the motor coil and an attachment plate or mounting bar which allows the coil to connect to the carriage.

The motor cables typically exit from one side of the package. The magnet track is sometimes referred to as the "secondary" element. Depending on the type of linear motor used, the magnet track can either be a single row of magnets or a double-sided configuration offering balanced attraction forces.

A complete linear motor system (Fig. 4) is typically made up of the individual motor components, base, bearings, feedback elements, and cable management.

By selecting linear motor components, the user is given an economical solution and is allowed complete flexibility with respect to integration into the machine. However, this requires a high degree of specific knowledge on the part of the machine builder. The designing engineer must have an understanding of the motor characteristics, linear feedback technology, cooling methods, and the performance of the servo amplifier and control system.

By selecting integrated linear motor positioning systems, the design engineer is given a pre-engineered, robustly designed, fully tested package. This takes the worry out of designing and aligning bearings, encoders, heat sinks, cables, connectors, travel stops, and limit / home sensors. Parker linear motor tables provide all this and more in easily mounted and ready-to-run packages.

2.1 Ironcore motors

Ironcore motors consist of a forcer which rides over a single magnet rail (Fig. 5). The forcer is made of copper windings wrapped around iron laminations. The back iron provides an efficient path for the magnetic flux to circulate between the motor and the magnet rail. In addition, there is an efficient path for heat to escape the motor. This ironcore design allows for extremely high forces and efficient cooling. In fact, the ironcore design offers the highest force available per unit volume. Finally, the ironcore design is economically attractive because only one row of magnet material is required.

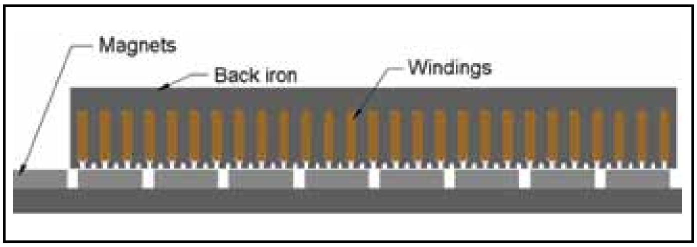


Fig. 5: Ironcore linear motor

One of the drawbacks of the ironcore design is that the motor has a high attractive force between the forcer and the magnet track. The attractive force can range from 5 – 13 times the rated force of the motor. This force must be supported by the bearing system of the motor. In addition, the high attractive force makes installation more challenging than other linear motor designs.

Another drawback of the ironcore design is the presence of cogging forces. Cogging occurs when the iron laminations exert a horizontal force on the motor in order to line up with their preferred positions over the magnets. Cogging limits the smoothness of motion systems because the force generated by the motor must change with position in order to maintain a constant velocity.

Parker Trilogy has developed a patent-pending Anti-Cog technology that virtually eliminates cogging and allows ironcore motors to be used in applications where only ironless motors were considered before. This offers the machine builder a powerful combination of extremely high force and smooth operation in an economical package.

To summarize the advantages and disadvantages of ironcore motors:

Ironcore advantages:

- **High Force per Size** - Uses laminations to concentrate the flux field.
- **Lower Cost** - Open face design only uses one row of magnets.
- **Good Heat Dissipation** - Because of laminations and large surface area, heat can be removed easily.

Ironcore disadvantages:

- **Normal attractive force** – 5 to 13 times greater than force generated.
- **Cogging** – Limits the smoothness of motion and creates velocity ripple. *This is counteracted by Parker Trilogy's patent pending Anti-Cog technology.*

Parker Trilogy offers ironcore motors both as components and as pre-engineered, fully integrated positioning systems. Please refer to the catalog for the **RIPPED Series** Ironcore Linear Motors and the **TR Series** Ironcore Linear Motor Positioners (Fig. 6 and Fig. 7).

Fig. 6: Ripped Series Ironcore Linear Motor

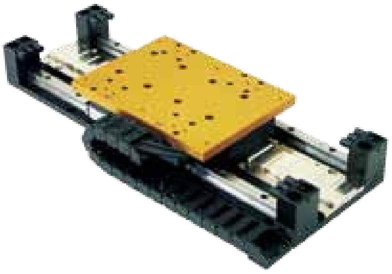


Fig. 7: Parker Trilogy's TR Series Ironcore Linear Motor Positioner

2.2 Ironless Motors

Ironless motors consist of a forcer which rides between dual magnet rails (Fig. 8). They are also known as “aircore” or “U-channel” motors. The forcer does not have any iron laminations in the coil – hence the name ironless. Instead, the copper windings are encapsulated and located in the air gap between the two rows of magnets. Because the motors are ironless, there are no attractive forces or cogging forces between the forcer and the magnet track.

In addition, the forcers have lower mass than their ironcore counterparts. What results is a motor design that allows for extremely high accelerations and overall dynamic performance. The ironless design has zero cogging and the lack of attractive force allows for extended bearing life and, in some applications, the ability to use smaller bearings.

While the high dynamic performance and zero cogging motion make the ironless motors a powerful design, they are not as thermally efficient as their ironcore counterparts. A small contacting surface area and a long thermal path from the winding base to the cooling plate makes the full-load power of these motors low. In addition, the dual row of magnets increases the overall cost of these motors in relation to the generated force and stroke length.

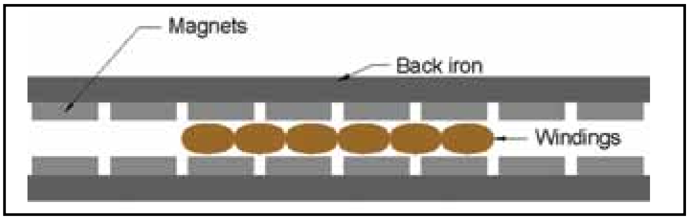


Fig. 8: Ironless Linear Motor

Parker Trilogy’s patented I-beam shape and overlapping winding design provides very high forces in a compact package. In addition, the design is more thermally efficient than tradition ironless motor designs.

By overlapping the windings (Fig. 9) instead of arranging them side-by-side, Parker Trilogy is able to provide a motor with a very high power density. The result is a package size considerably smaller than competitive motors with similar force capabilities.

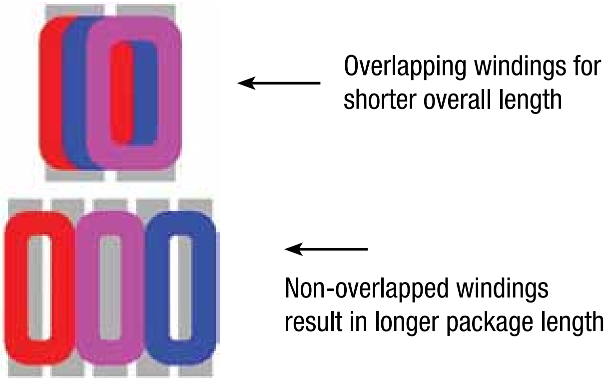


Fig. 9: Overlapping Windings

Parker Trilogy creates the I-beam shape by flaring out the end turns of the motor at a 90-degree angle. The end turns of a linear motor coil do not contribute to the horizontal force component of the motor. Instead of producing force, the end turns simply produce heat. Parker’s I-beam shaped design allows for better heat transfer between the motor coils and the heat sink by increasing the contacting surface area between components (Fig. 10). The combination of overlapped windings and the I-Beam shape creates a more thermally efficient motor than most traditional ironless motors. As a result, the payload will experience less thermal expansion due to heat from the motor. In high precision applications, thermal expansion can adversely affect the overall system accuracy. Parker Trilogy motors will help maintain system accuracy by running at lower operating temperatures than our competitors. In addition, there are added benefits of the I-beam shape by lowering the overall profile height and creating a stiffer mechanical structure.

What results is a compact motor design with high force and extraordinary thermal characteristics.

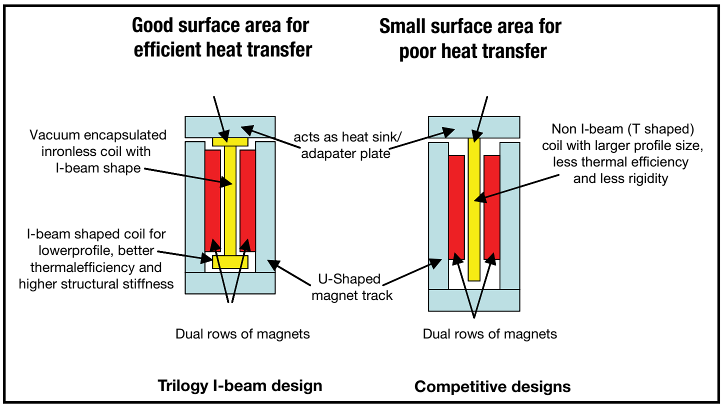


Fig. 10: Parker Trilogy’s Patented I-Beam Design

To summarize the advantages and disadvantages of ironless motor designs:

Ironless advantages:

- **No Attractive Force** - Balanced dual magnet track. Safe and easy to handle. No forces to deal with during assembly.
- **No Cogging** - Ironless forcer for zero cogging and ultimate smoothness.
- **Low Weight Forcer** - No iron means higher acceleration and deceleration rates, higher mechanical bandwidth.
- **Air Gap Forgiving** - easy to align and install.

Ironless disadvantages:

- **Heat dissipation** - Higher thermal resistance. Parker Trilogy's I-beam design helps mitigate this issue.
- **Power per package** - Lower RMS power when compared to ironcore designs.
- **Higher cost** - Uses twice as many magnets.

Parker Trilogy offers ironless motors in both component kits and complete pre-engineered positioning systems. Please refer to the catalog for the "***I-Force***" and "***ML50***" ironless linear motors and the "***T Series***" linear motors positioners (Fig. 11 and 12).

Fig. 11: ML50 Ironless Linear Motor

Fig. 12: T2D Series Linear Motor Positioner

2.3 Slotless Motors

Slotless motors are an interesting variant of linear motor which combines several of the design elements of ironcore and ironless motors. In a slotless motor (Fig. 13), the forcer has no iron toothed laminations. The coils are wound without iron and are located underneath a "back iron" plate. The forcer then operates along a single magnet row. The slotless motor design can be thought of as a sort of hybrid between ironcore and ironless linear motor designs.

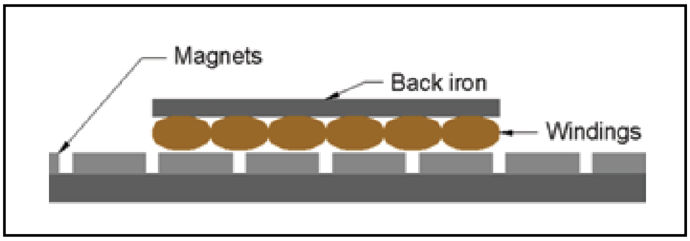


Fig. 13: Slotless Linear Motor

What results is a motor with the following characteristics:

Slotless linear motor advantages:

- Single-row magnet bar
- Lower cost (compared to ironless design)
- Better heat dissipation (compared to ironless design)
- More force per package size (compared to ironless design)
- Lighter weight and lower inertia forcer (compared to ironcore design)
- Lower attractive forces (compared to ironcore designs) – extended bearing life and smaller bearings in some applications
- Less cogging (compared to ironcore designs)

Slotless linear motor disadvantages:

- Some attractive force and cogging
- Air gap is critical
- Less efficient than both ironcore and ironless – more heat to do the same job

Parker offers slotless motors in both component kits and precision positioning systems. Please refer to this catalog under 400LXR Positioners or to the “SL Series” linear motor section on www.parkermotion.com (Fig. 14 and 15).

Fig. 14: SL Series Slotless Linear Motors

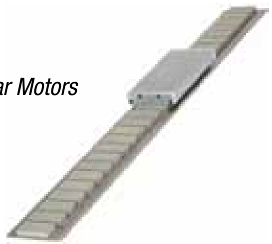


Fig. 15: 404LXR Slotless Linear Motor Positioning System

3.0 Guide Systems

Even though a linear motor system lacks the rotary transmission components of traditional positioning systems, the user is still required to provide some sort of linear guide / bearing. Typically, a linear bearing must be selected based on high speed and acceleration capability, long service life, high accuracy, low maintenance costs, high stiffness, and low noise. Other considerations may include, for example, the site space available, the mounting accuracy (flatness, parallelism, inclination), and the thermal expansion.

Different guide systems are available to fulfill these requirements:

- Slide bearings (dry running or hydrodynamic)
- Hydrostatic bearings
- Aerostatic bearings (air bearings)
- Track rollers (steel or plastic roller wheels)
- Rolling-contact bearings (square rail, cross roller, or round rail)
- Magnetic bearings

In practice, slide bearings, rolling-contact bearings, and air bearings are the most popular. For applications with low demands on precision and load-bearing capacity, dry-running slide bearings may be a suitable option. Guide systems based on rolling-contact like square rail and cross roller bearings exhibit good stiffness and excellent load-bearing capability. In addition, they offer excellent straightness and flatness over the length of travel. Air bearings offer the ultimate in performance. With practically no limits to max speed and acceleration and virtually no breakaway forces, air bearings are the best solution for ultra-high precision applications.

4.0 Servo Control and Feedback

Linear motors can offer the ultimate in high precision and motion dynamics. However, overall system performance is dependent on other components – particularly the servo controller and feedback mechanism used. In this section, we will examine how linear motors are commutated, how their position is sensed, and how it is important to have an adequate controller to optimize system performance.

Figure 16 shows the traditional cascaded structure of servo motor control. The same structure can be applied to linear motors. One advantage is that the position sensor can typically be located right at or closer to the load, thus improving the overall accuracy of the system.

One drawback is that the lack of a traditional mechanical transmission results in the effects of external forces being significantly greater. For this reason, the quality of the position signal (resolution and accuracy) and the performance of the servo controller (sampling time, trajectory update, and control algorithms used) are of prime importance in determining the degree of “positional stiffness” that can be achieved.

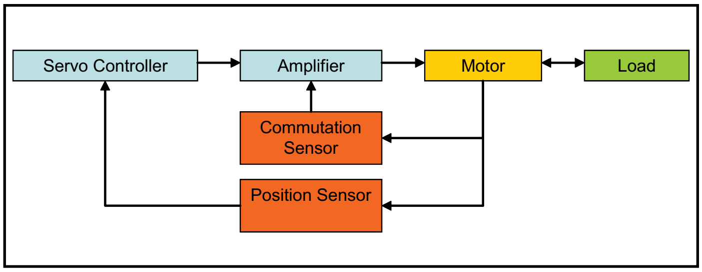


Fig 16(a): Servo Motor Control (position sensor located at motor)

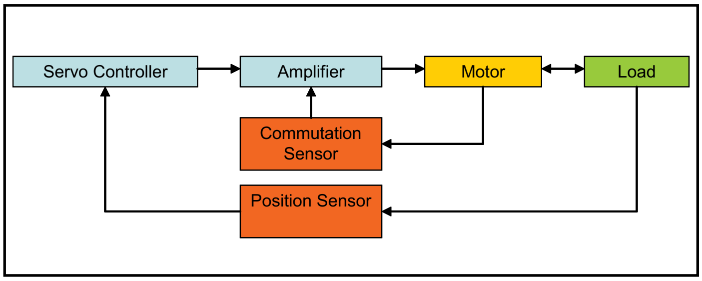


Fig 16(b): Servo Motor Control (position sensor located at load)

4.1 Commutation of the motor

In traditional rotary servo systems, it is important for the amplifier to know the position of the rotor. This way it can properly switch current through the motor phases in order to achieve the desired rotation of the shaft. Many times, three digital Hall effect sensors (spaced 60 degrees or 120 degrees apart) are used in order to provide positional information of the shaft within 6 states.

The same principle applies to linear motors. The amplifier must know the position of the forcer in relationship to the magnet rail in order to properly switch the windings. Rather than aligning the Hall effect devices (HEDs) within one complete revolution of the shaft, the Halls are matched to the magnetic pole pitch of the motor. The "pole pitch" is the linear distance traveled within one electrical cycle of the motor and is analogous to one revolution of a rotary motor.

Once the amplifier establishes the position of the forcer within the electrical cycle, it will then switch the motor phases whenever a transition occurs in the Hall states. This is known as *trapezoidal commutation.*

In most modern servo amplifiers, the position of the forcer need only be determined upon power up and enabling of the drive. Once the initial position is recognized, the drive can commutate off of the position sensor, which provides significantly higher resolution feedback than the digital HEDs. This allows the motor to be sinusoidally commutated. Sinusoidal commutation provides a smoother switching sequence resulting in less disturbances and less heat.

Another method of sinusoidal commutation is through the use of analog Hall effect devices. Analog Halls produce a sinusoidal signal as they pass over the magnetic poles of the magnet track. Analog Halls have also been used as an inexpensive method of providing positional feedback as well as commutation feedback. However, these devices are susceptible to picking up noise which can affect commutation – which in turn, affects smoothness of travel.

In some applications, HEDs are not desired – either from a cost savings standpoint, reduced wiring / component count, or other application specific standpoint. However, the servo drive must still be able to recognize the position of the motor forcer. In this case, **automatic commutation** can be achieved with a properly equipped servo drive. **Parker's Compax3** drive/control has an "auto-commutation with test movement" function that automatically establishes the commutation angle. In this system, the Compax3 applies a test signal which induces small movements in the motor upon power up. The physical size of these movements can be quite small – as small as 10 electrical degrees (less than 2 mm on many linear motors), so there is no need to worry about the motor "*jumping.*" In addition, the test signals are "softened" such that system jerk is minimized.

4.2 Positional Feedback

There are a variety of methods to provide linear positional feedback to the motion controller. There are analog transducers, rack-and-pinion style potentiometers, and laser interferometers, to name a few. Each has its own level of accuracy and cost. But far and away the most popular feedback device for linear motor positioning systems is the linear encoder.

Most linear encoders provide an incremental pulse train that provides discrete "counts" back to the motion controller as the encoder "read head" moves along a "linear scale." Typically, the read head is mounted close to the load and the linear scale is applied to the positioner base. There are two popular styles of linear encoders – optical and magnetic.

Optical encoders use reflected light scanning techniques to provide feedback with extremely high resolution and accuracy. Optical encoders are capable of providing feedback in the nanometer resolutions. Magnetic encoders use inductive scanning techniques to offer significantly more economical feedback, but have considerably lower accuracy and resolution. Magnetic encoders can typically offer resolutions down between the 1 to 5 micron range.

A third variation of linear encoder is the Sine encoder. The Sine encoder produces analog sine and cosine signals instead of discrete pulses. Many modern motion controllers have the ability to interpolate these analog signals into extremely fine resolutions. For example, the Compax3 controller can interpolate a 1 Vpp signal into 14 bits, i.e., the sine/cosine signal period is divided into 16,384 counts. A typical pitch period of a Sine encoder is 1mm, thus the resolution can be interpolated down to 62 nm in the controller.

All of these encoders provide incremental positioning information. Hence, it is necessary to establish a *home position* any time positional information is lost by the controller, i.e., power down. In some applications it is necessary to have *absolute feedback* where the actual position of the motor is known immediately and no homing sequence is required. Some encoder manufacturers are now making absolute linear encoders that transfer data using a synchronous serial interface (SSI). Parker's **Aries** family of servo drives support absolute feedback transmitted via SSI. Please contact your Parker representative for further details.

Fig. 17: Parker ACR Controller and Aries Drives

When using linear encoders it is critically important to have proper mounting of the scanner (read) head. Inadequate mounting may cause mechanical resonance effects and errors in the measured position caused by vibration of the sensor head. In this case, the achievable bandwidth of the control loop – and hence, the maximum positioning stiffness – is reduced considerably. In some cases, large gaps of positional information are lost entirely, rendering the system totally inaccurate.

If the linear scale is not aligned straight with the guide bearings, accuracy can be affected in the form of “cosine errors.” (Fig. 18) shows a representation of how linear encoder scale misalignment can cause cosine errors.

The actual distance traveled will be L, where **L=Lenc(cosΘ)**. The size of the error will be **error = Lenc(1 – cosΘ)**. Thus, it is important to pay attention to the mounting of the read head as well as providing robust attachment and accurate alignment of the linear scale.

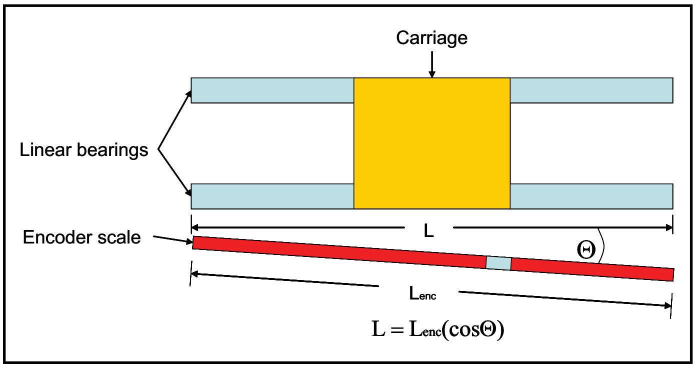


Fig. 18: Cosine errors caused by encoder scale misalignment

4.3 Servo Control –

Due to the direct drive nature of linear motors, there are no intermediate mechanical components or gear reductions to absorb external disturbances or shock loading. As a result, these disturbances have a significantly greater impact on the control loop than they would when using other technologies. For this reason, it is extremely important to have a controller with fast trajectory update rates. In addition, it is important to have a controller which allows you manipulate “feedforward” control of speed, acceleration, and jerk. These parameters allow the user to minimize tracking errors during acceleration, deceleration, and during external disturbances.

By defining parameters like jerk within your move profile, the tracking accuracy of highly dynamic moves can be improved, stresses on the mechanical system can be reduced, and excitation of mechanical resonances can be minimized. In addition, payloads that must be handled gently can still have optimized move profiles with the implementation of jerk-limited setpoint generation. Parker’s **ACR** and **Compax3** families of controllers allow optimization of all feedforward parameters and provide extremely fast trajectory update rates for superior control of linear motors.

Another common control challenge of linear motor systems is the control of gantry robots. Unlike belt- and screw-driven gantries where the transmissions of parallel axes can be mechanically connected, linear motor gantries have no mechanical coupling whatsoever. If tight control is not provided between these axes, binding and mechanical damage can occur. Traditional “master – follower” control schemes do not work well with gantries because the follower axis can bind but the master axis will be unable to recognize it.

Parker’s **ACR** series of controllers have a *gantry lock function* which provides skew compensation for gantry systems. By locking the feedback of each axis into the servo loop of the other, perfect coordination between axes is established to prevent binding and mechanical damage.

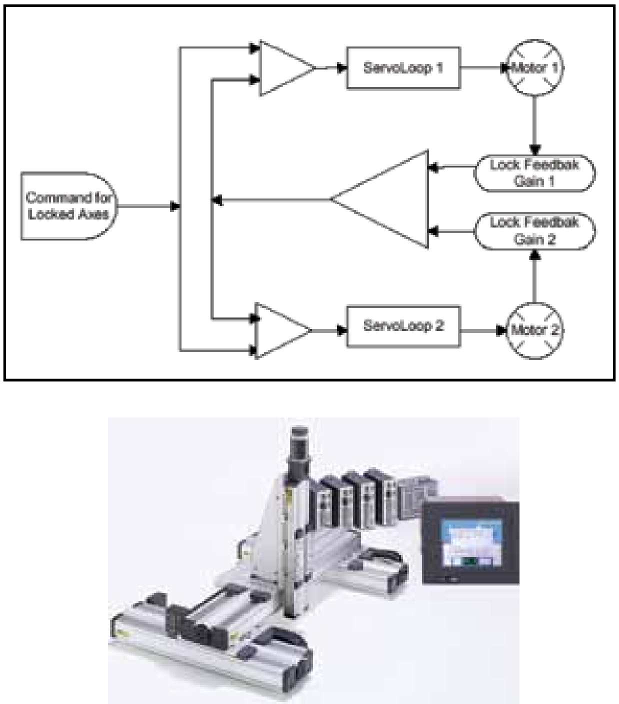


Fig. 19: Parker’s ACR Controller Gantry Lock Feature

5.0 Packaged Linear Motor Positioners

As we have learned here, there are a lot of elements that affect precision in a linear motor system. Accuracy is affected by the bearing technology, structural stability, mounting and precision of the feedback system, and the capabilities of the controller. In addition, other variables such as mechanical stiffness and vibration can play a large part in the overall error budget of a machine.

As a result, it takes a reasonable amount of expertise to integrate all the components into a precision linear motor system. Many machine builders and laboratory equipment users tend to have expertise in their particular processes rather than in the integration of components. In addition, many systems integrators do not have the time to model, analyze, and implement linear motor designs.

For these reasons, several designers have chosen to purchase pre-packaged, pre-engineered linear motor positioners. By leaving the design and integration work to their vendors, they can deliver cost effective precision motion control solutions to their customers in an extremely short time to market. Components are performance matched for fast response, high acceleration, smooth translation, high velocity, and quick settling time. In addition, positioners can have a variety of flexible connectorization options, cable tracks, and mounting options – including multi-axis compatibility.

Parker offers a variety of packaged linear motor positioners to fit most any application.

- Industrial-grade positioners for high force, high motion dynamics, and high precision
- Precision-grade positioners for extremely high positional accuracy
- Miniature precision-grade positioners for lab automation, photonics, electronics and other applications requiring high accuracy in a small form factor

Fig. 20: MX80L Miniature Linear Motor Stage

6.0 Linear motors compared against other technologies

It has been well established that linear motors offer the ultimate in high dynamics and high precision. However, many machine builders have cost sensitive budgets and will often look to common rotary-to-linear technologies to solve their positioning needs. This section will take a hard look at these competing technologies and will show the long-term benefits switching to linear motors.

6.1 Belt Drives

Belts and pulleys are the workhorses of the automation world. They provide high speeds and reasonable positioning repeatability for an economical component cost. But there are inherent limitations to using belt drives. A belt drive system will typically consist of the following components:

- High tensile strength belt
- Pulleys
- Gearbox, for inertia matching
- Motor and coupling
- Carriage attached to belt
- Roller bearings or slider element

All the torsional windup, backlash, and belt stretching of these components contribute to inaccuracies in the system. Typical repeatability of a belt drive system is around ± 0.2 mm whereas repeatability for a common linear motor system can be ± 1µ. Even then, the belts must be optimally tensioned and the bearings preloaded. Also, the feedback is connected to the motor and not the load. This contributes to even further inaccuracies in the system.

Additionally, all of these components are “spring like” by nature and cause ringing and delays in settling time. So while belt drive systems can operate at high speeds, they can be difficult to tune for dampening and quick settling. This problem only gets worse at longer lengths, as belts tend to sag the longer they have to span. Eventually, the belt drives become limited in how long they can travel due to the unavoidable sag.

Finally, belt-driven systems can be maintenance intensive. Belts can lose tensioning over time and even skip teeth. Sliding bearings can break down. Couplings can slip or be misaligned. All of these problems force the user to shut down valuable production time in order to maintain the actuator.

Linear motors, by their direct-drive nature, are virtually maintenance free. As long as the bearings are properly lubricated, there is little else to do in order to maintain the positioner. Because all of the mechanical transmission components are gone, linear motor positioners do not suffer from torsional windup, backlash, belt stretch, or settling problems. They are extremely responsive and settle extraordinarily quick. They can match or exceed the acceleration and speed characteristics of a belt drive while positioning far more accurately. Finally, there are no limitations as to how long a linear motor travels. The dynamic performance stays exactly the same, no matter what the distance traversed.

6.2 Screw Drives

Screw driven positioning systems are very common for relatively high-precision positioning applications. They are cost-effective and offer varying degrees of precision depending on the needs of the application. A screw-driven system typically consists of the following components:

- Ballscrew or leadscrew that is precision ground or rolled
- Ball nut or sliding nut
- Motor
- Motor block and coupling
- Carriage
- Linear guide – typically square rail, cross roller, or round rail

Leadscrews are typically inefficient, less than 50% in most cases. While they are cost effective, the nut tends to wear due to friction. In addition, the accuracy and repeatability can suffer with leadscrews as most are not precision ground. Ballscrews, approaching 90% efficiency, come in precision ground or rolled packages. However, they still wear over time, suffer from torsional windup, and have a tendency to exhibit backlash. These problems factor into lost precision and slower settling times. In both cases, speeds are limited by the thread pitch and the length of the screw. As screws become longer, they tend to "whip" at higher speeds. Thus, they come nowhere near the speed and acceleration capabilities of linear motors. Eventually, there comes a point where screws become so long, they are difficult and unwieldy to manufacture.

Finally, like belt drives, screw-driven systems must be maintained. Eventually nuts wear, couplings slip, and screws need to be replaced - again, shutting down production and costing the user valuable time and money.

Since linear motor positioners have no intermediate mechanical transmissions, they do not suffer from the drawbacks of screw drives. In addition, they are not limited by length or by the dynamic performance related to length. One drawback to linear motors is that they are not inherently sufficient for vertical applications that require braking. Typically, this problem can be overcome by adding a pneumatic, spring-based, or weight-based counterbalance.

6.3 Comparing Costs

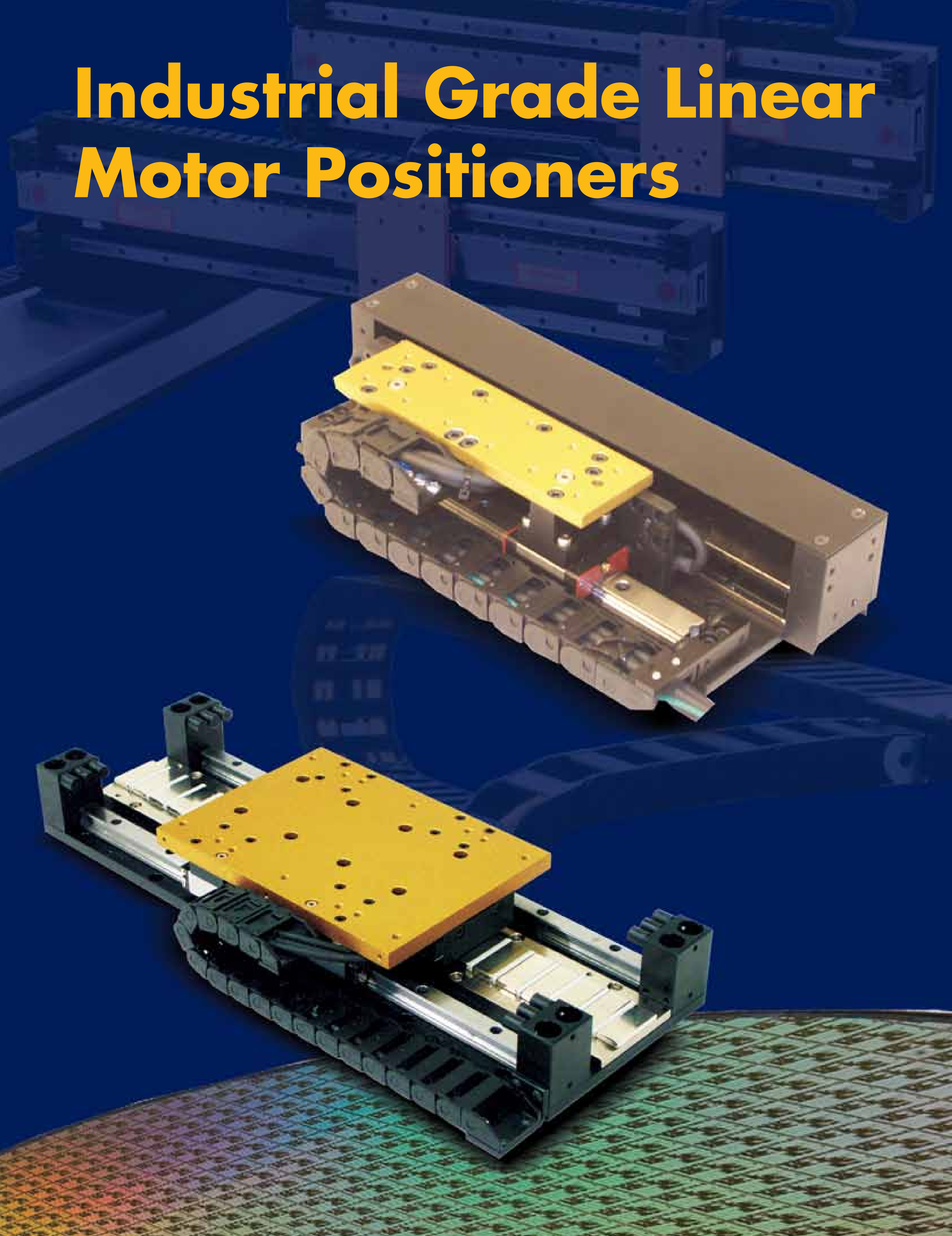
In most cases, the upfront cost of purchasing a linear motor system will be more expensive than belt- or screw-driven systems. However, in certain cases the cost can be similar or even less. Many machine builders requiring an extra degree of accuracy will buy a precision-ground ballscrew and add linear encoder feedback. Typically, the added cost of these components will drive the overall cost of the positioner to be higher than that of a linear motor system. In addition, improved manufacturing methods and increased volumes are driving down the cost of linear motors. Over time, users will see the price gap close dramatically. Finally, when comparing the overall cost of ownership (factoring in maintenance and down time), linear motors become considerably less expensive.

7.0 The Future of Linear Motors

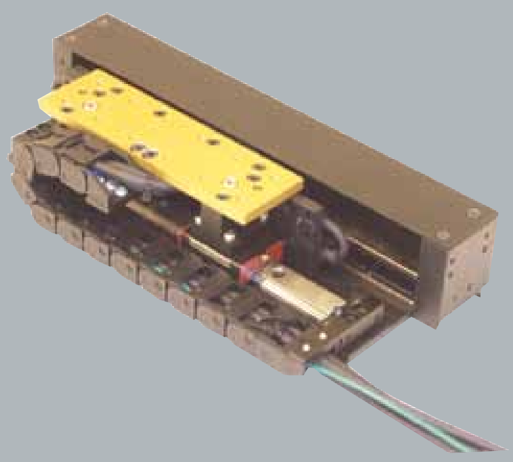
The field of linear motors will develop dynamically in the future. As costs continue to fall and as innovations continue to rise, more and more industries will begin to adopt linear motor technology. Their high dynamics, high precision, and virtually maintenance-free operation will appeal to traditional users of rotary-to-linear transmissions.

In the early days of linear motors, only the high-tech industries like semiconductor and electronics adopted the technology. Eventually, industries like machine tool latched on to the inherent benefits of direct drives and now account for nearly 1/3rd of all linear motor sales. Now we are seeing new markets like material handling, packaging, medical, and food processing begin to switch out the belts, screws, and even pneumatics for linear motors. All of these new customers are beginning to push the technology to a critical mass and widespread acceptance. Indeed, it looks like linear motors will be making a breakthrough impact on the entire world of manufacturing.

Industrial Grade Linear Motor Positioners



I-FORCE Ironless Linear Positioners



Parker Trilogy's I-Force linear positioners utilize our high-performance I-Force ironless linear motors in a pre-engineered, easily integrated, ready-to-run package. The principal design goal for these positioners is to achieve high performance at an economical cost while preserving the design flexibility to accommodate customization.

Trilogy's positioners have selectable single- or dual-bearing to match the performance and cost requirements for each application. In addition, they are designed to connect together using transition plates for XY or multi-axis configurations. Options include a variety of cable management systems in addition to bellows and hard covers.

Flexibility, multi-axis compatibility, and ease of customization make the I-Force linear positioners a superior choice for high performance and value.

- Trilogy positioners use ground steel or aluminum bases for flatness and parallelism because aluminum extrusions often do not meet the accuracy requirements for straightness and flatness.
- Trilogy has single- or dual-bearing rail positioners to better match the performance and cost requirements for each application.
- Every positioner includes a magnetic encoder for industrial environments or an optical encoder with resolutions down to 0.1um (0.000 04").
- Dual-rail positioners have bellows as a standard option.
- Multiple carriage options are available on all positioner series.
- Different cable track widths available for added stiffness and rigidity
- Different cable track widths available as custom options for user payload tubes and cables

T1D Specifications

PERFORMANCE		LINEAR MAGNETIC ENCODER 5.0µm	1.0µm	RENISHAW ENCODER OPTIONS (Note 5) 0.5µm	0.1µm
Peak Velocity	in/s [m/s]	275 [7]	100 [2.5]	120 [3]	15 [0.4]
Resolution	in [µm]	0.0002 [5]	0.000 04 [1.0]	0.000 02 [0.5]	0.000 004 [0.1]
Repeatability	in [µm]	±0.0004 [±10]	±0.000 8 [2.0]	±0.000 06 [1.5]	±0.000 04 [1.0]
Accuracy – LME		±(30µm +50µm/m)	±(25µm +50µm/m)		
Accuracy – Renishaw				±(5µm +30µm/m)	

Note: For travels less than 1 meter, accuracy should be calculated at 1 meter

MOTOR MODEL		110-1	110-2
Peak Force	N	108.5	202.5
	lb	24.4	45.5
Continuous Force	N	24.5	45.4
	lb	5.5	10.2
Peak Power	W	938	1641
Continuous Power	W	47	82

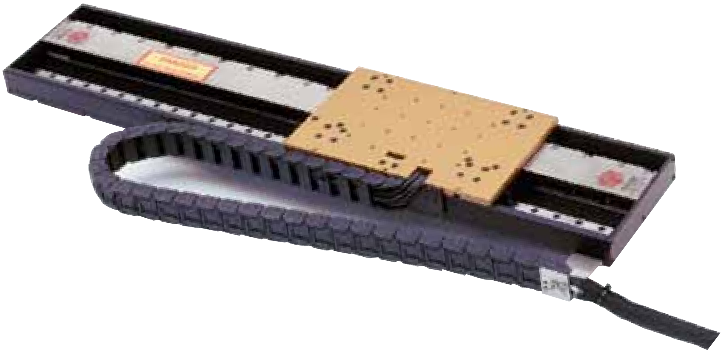
ACCURACY	STANDARD	LASER ALIGNMENT OPTION
Straightness restrained on flat surface in [µm]	±0.000127 in/in [±127µm/m]	±.0000127 in/in
Flatness restrained on flat surface in [µm]	±0.013 [±330]	

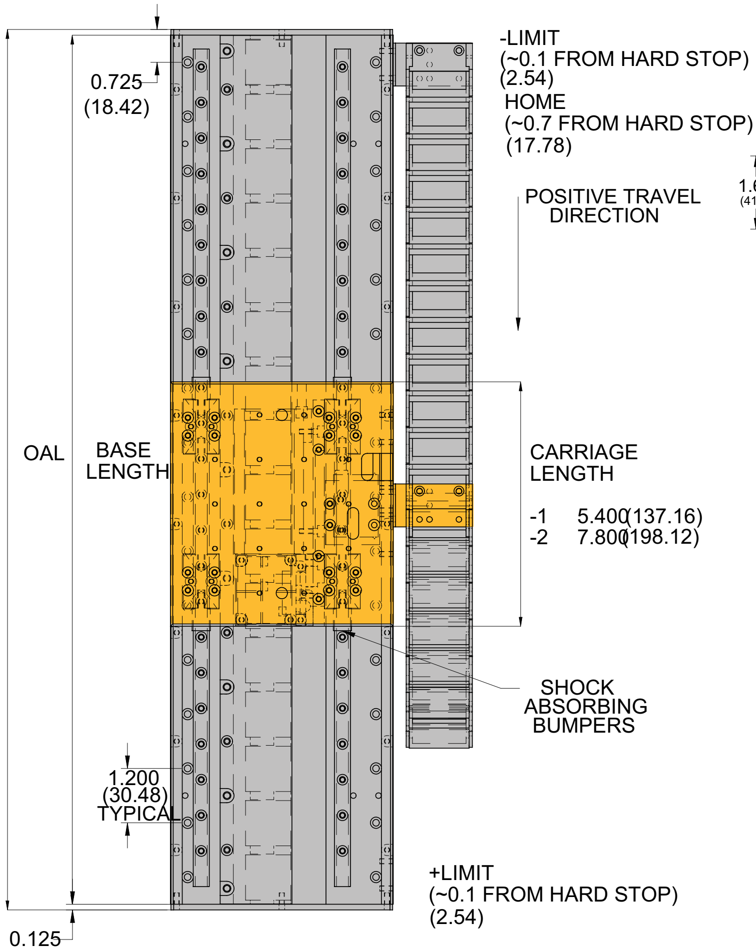
Note: Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005in/ft

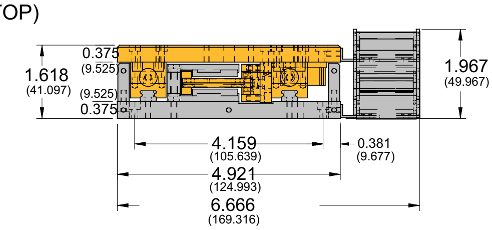
LOAD		- 1	- 2
Vertical (Fv) see note 11	lbs [kg]	30 [13, 5]	30 [13, 5]
Side (Fs) see note 11	lbs [kg]	15 [6, 8]	15 [6, 8]
Moments–Roll (Mr) see note 11	lb-ft [N-m]	15 [20]	15 [20]
Moments–Pitch (Mp) see note 11	lb-ft [N-m]	52 [70]	52 [70]
Moments–Yaw (My) see note 11	lb-ft [N-m]	52 [70]	52 [70]

Dimensions shown in inches.

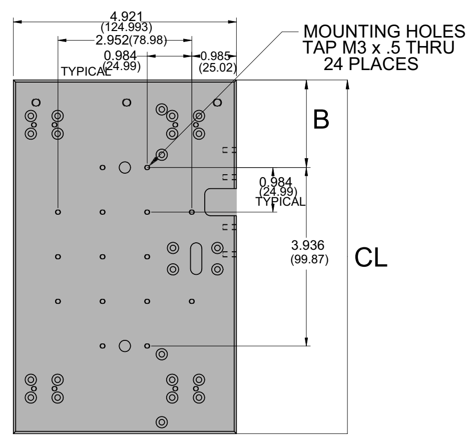
- Moving Carriage Assembly
- Stationary Base Assembly







w/ std size 73 cable track



TOTAL TRAVEL = OAL - 0.200" (50.8 mm) - CARRIAGE LENGTH
OAL = BASE LENGTH + 0.250" (6.35 mm)
BASE LENGTH = MULTIPLE OF 2.400" (60.96)

CARRIAGE SIZE				
	-1	mm	-2	mm
CL	5.400	137.16	7.800	198.12
B	0.732	18.59	1.932	49.07
Coil	110-1	110-1	110-2	110-2

PERFORMANCE		LINEAR MAGNETIC ENCODER 5.0µm	1.0µm	RENISHAW ENCODER OPTIONS (Note 5) 0.5µm	0.1µm
Peak Velocity	in/s [m/s]	275 [7]	100 [2.5]	120 [3]	15 [0.4]
Resolution	in [µm]	0.0002 [5]	0.000 04 [1.0]	0.000 02 [0.5]	0.000 004 [0.1]
Repeatability	in [µm]	±0.0004 [±10]	±0.000 8 [2.0]	±0.000 06 [1.5]	±0.000 04 [1.0]
Accuracy – LME		±(30µm +50µm/m)	±(25µm +50µm/m)		
Accuracy – Renishaw				±(5µm +30µm/m)	

Note: For travels less than 1 meter, accuracy should be calculated at 1 meter

MOTOR MODEL		110-1	110-2
Peak Force	N	108.5	202.5
	lb	24.4	45.5
Continuous Force	N	24.5	45.4
	lb	5.5	10.2
Peak Power	W	938	1641
Continuous Power	W	47	82

ACCURACY	STANDARD	LASER ALIGNMENT OPTION
Straightness restrained on flat surface in [µm]	±0.000127 in/in [±127µm/m]	±.000013 in/in [±13 µm/m]
Flatness restrained on flat surface in [µm]	±0.013 [±330]	

Note: Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005in/ft

PHYSICAL		- 2	- 3
Carriage Assembly	lbs [kg]	1.10 [0,50]	1.50 [0,68]
Base Assembly			
T1SD Aluminum (0.250'' thick))	lbs/ft [kg/m]	2.25 [3,35]	··········►
T1SA Aluminum (0.375'' thick))	lbs/ft [kg/m]	2.78. [4,13]	··········►
Carriage Length	in [mm]	3.40 [86,4]	5.80 [147,3]
Coil Bar Length	in [mm]	3.20 [81,3]	5.60 [142,2]

LOAD		- 1	- 2
Vertical (Fv) see note 11	lbs [kg]	25 [11, 3]	25 [11, 3]
Side (Fs) see note 11	lbs [kg]	13 [5, 7]	13 [5, 7]
Moments–Roll (Mr) see note 11	lb-ft [N-m]	11 [15]	11 [15]
Moments–Pitch (Mp) see note 11	lb-ft [N-m]	44 [60]	44 [60]
Moments–Yaw (My) see note 11	lb-ft [N-m]	44 [60]	44 [60]

NOTES

1 Total travel (in) = BASE LENGTH - 1.6 (40.64 mm) - CARRIAGE LENGTH.

2 Maximum base length is 40.8˝, 1m

3 Aluminum base is black anodized.

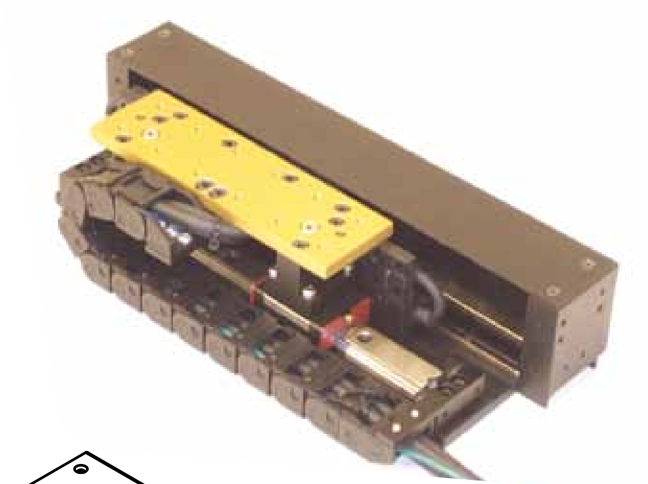
4 For complete motor specifications, refer to 110 series motor data sheet.

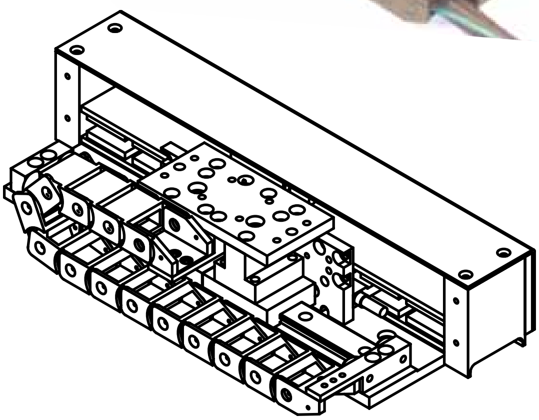
5 Renishaw encoder, RGH24 series, available in 0.05µm, 0.1µm, 0.5µm, 1.0µm, 5.0µm.

7 Standard cable track provided is Igus 07.20.018.

8 Specification subject to change without notice.

9 Listed specifications based on motor size and typical performance requirements. Bearing manufacturer specifications exceed listed specifications.





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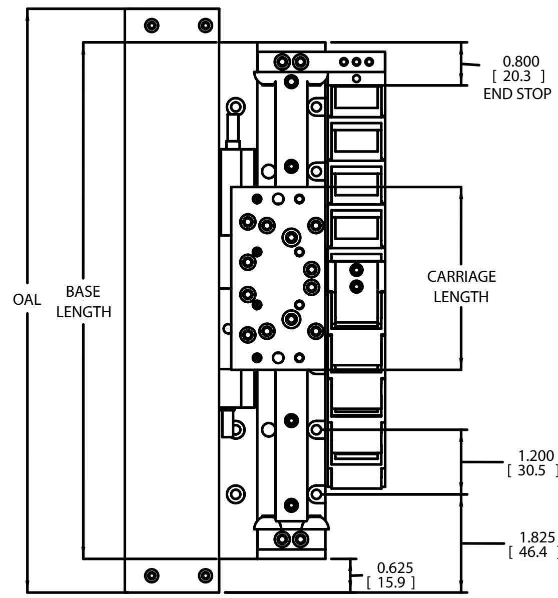
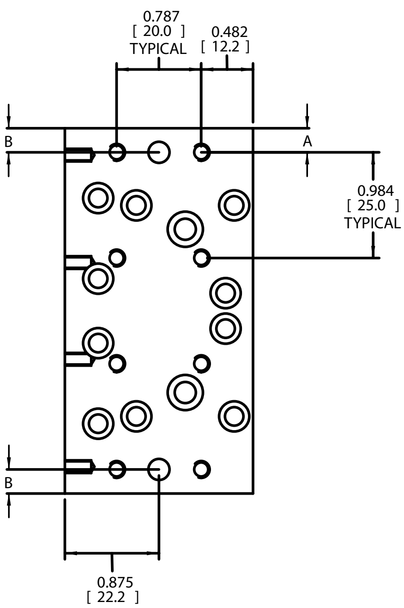
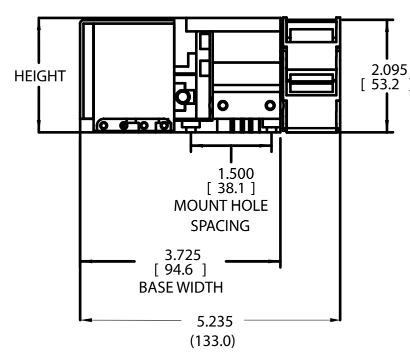






OAl = BASE LENGTH + 1.25 IN (31.75)
TRAVEL = BASE LENGTH - 1.6 - CARRIAGE LENGTH
TRAVEL (mm) = BASE LENGTH - 40.64 - CARRIAGE LENGTH

CARRIAGE TABLE		
COIL SIZE	-1	-2
CARRIAGE LENGTH	3.4 [86.4]	5.8 [147.3]
A (1ST MOUNTING HOLE)	0.224 [5.7]	0.440 [11.2]
B (DOWEL PIN HOLE)	0.224 [5.7]	0.440 [11.2]

T2D Specifications

PERFORMANCE		Linear Magnetic Encoder 5.0µm	Linear Magnetic Encoder 1.0µm	Renishaw Encoder Options (Note 5) 0.5µm	Renishaw Encoder Options (Note 5) 0.1µm
Peak Velocity	in/s [m/s]	275 [7]	100 [2.5]	120 [3]	15 [0.4]
Resolution	in [µm]	0.0002 [5]	0.000 04 [1.0]	0.000 02 [0.5]	0.000 004 [0.1]
Repeatability	in [µm]	±0.0004 [±10]	±0.000 8 [2.0]	±0.000 06 [1.5]	±0.000 04 [1.0]
Accuracy – LME		±(30µm +50µm/m)	±(25µm +50µm/m)		
Accuracy – Renishaw				±(5µm +30µm/m)	

Note: For travels less than 1 meter, accuracy should be calculated at 1 meter

MOTOR MODEL		210-2	210-3	210-4
Peak Force	N	255.8	375.0	494.2
	lb	57.5	84.3	111.1
Continuous Force	N	57.4	84.1	110.3
	lb	12.9	18.9	24.8
Peak Power	W	1583	2261	2940
Continuous Power	W	79	113	147

ACCURACY	Standard	Laser Alignment Option
Straightness restrained on flat surface in [µm]	±0.000127in/in [±127µm/m]	±.0.0000127 in/in [±13µm/m]
Flatness restrained on flat surface in [µm]	±0.003 + 000254 in/in [±76 + 254µm/m]	

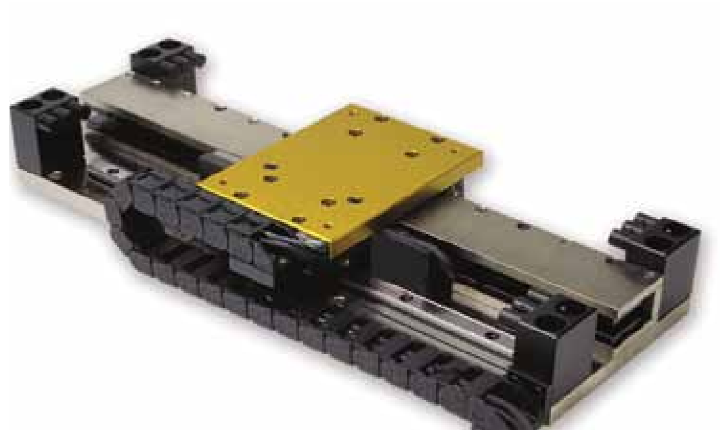
Note: For travels less than 1 meter, Flatness should be calculated at 1 meter
Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005in/ft

PHYSICAL		- 2	- 3	- 4
Carriage Assembly	lbs [kg]	3.10 [1,4]	4.10 [2,1]	5.50 [2,5]
Base Assembly				
T2DA Aluminum (0.375" thick)	lbs/ft [kg/m]	10.80 [16,1]		
T2DB Aluminum (0.500" thick)	lbs/ft [kg/m]	11.70 [17,4]		
T2DS Steel (0.500" thick)	lbs/ft [kg/m]	18.10 [26,9]	→	→
Carriage Length	in [mm]	4.20 [106,7]	6.60 [167,6]	9.00 [228,6]
Coil Bar Length	in [mm]	7.20 [182,9]	9.60 [243,8]	12.00 [304,8]

LOAD		- 2	- 3	- 4
Vertical (Fv) see note 11	lbs [kg]	60 [27,1]	80 [36,3]	100 [45,3]
Side (Fs) see note 11	lbs [kg]	40 [18,1]	60 [27,2]	60 [27,2]
Moments–Roll (Mr) see note 11	lb-ft [N-m]	40 [53]	60 [80]	60 [80]
Moments–Pitch (Mp) see note 11	lb-ft [N-m]	100 [134]	200 [270]	200 [270]
Moments–Yaw (My) see note 11	lb-ft [N-m]	100 [134]	200 [270]	200 [270]

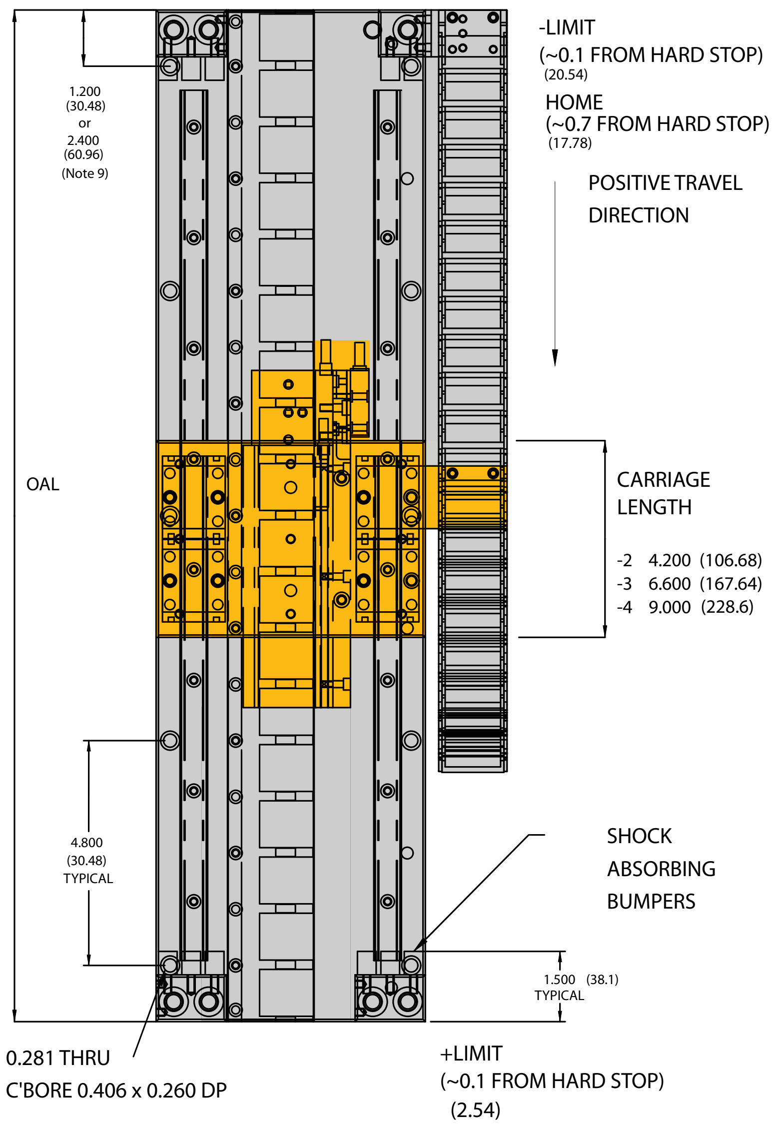
NOTES

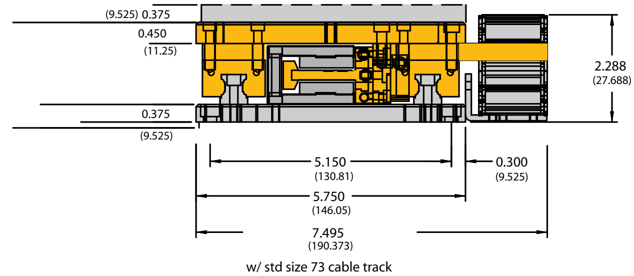
1. Total travel = OAL – 3.00˝ (76.2 mm) – carriage length.
2. Maximum base length is 120˝ (3048 mm).
3. Aluminum base is black anodized. Steel base is nickel plated.
4. For complete motor specifications, refer to 210 series motor data sheet.
5. Renishaw encoder, RGH24 series, available in 0.05µm, 0.1µm, 0.5µm, 1.0µm, 5.0µm.
6. Cables extend past base by approximately 0.6˝ when carriage is at negative hard stop.
7. Cable Track extends 0.175˝ higher than carriage mounting surface. It is recommended to use optional Spacer Plate for custom mounting holes.
8. Standard cable track provided is Igus 07.30.018.
9. Base mounting holes are equidistant, 1.200" (12.0, 16.8, 21.6....) or 2.400" (9.6, 14.4, 19.2, 24.0....) from each end depending on base length.
10. Specification subject to change without notice.
11. Listed specifications based on motor size and typical performance requirements. Bearing manufacturer specifications exceed listed specifications.

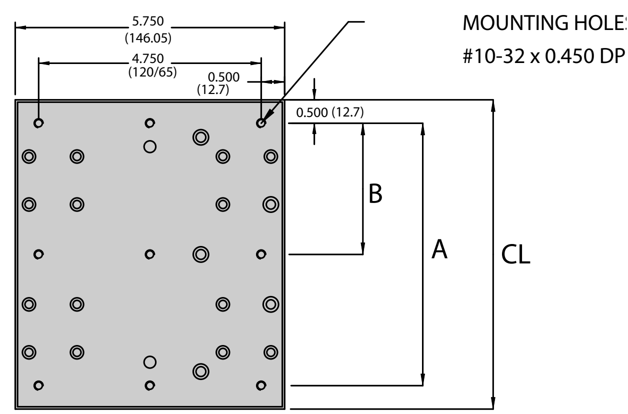


0.375 THICK CARRIAGE SPACER PLATE (optional)
(9.525)

Dimensions shown in inches.
- Moving Carriage Assembly
- Stationary Base Assembly



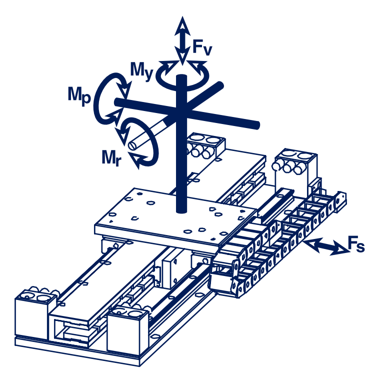




TOTAL TRAVEL = OAL - 3.00" (76.2 mm) - CARRIAGE LENGTH

OAL = MULTIPLE OF 2.400" (60.96)

CARRIAGE SIZE	- 2	mm	- 3	mm	- 4	mm
CL	4.200	106.68	6.600	167.64	9.000	228.6
A	3.200	81.28	5.600	142.24	8.000	203.80
B	—	—	2.800	71.12	4.000	101.60
COIL	210-2		210-3		210-4	



T2S Specifications

PERFORMANCE		LINEAR MAGNETIC ENCODER 5.0µm	LINEAR MAGNETIC ENCODER 1.0µm	RENISHAW ENCODER OPTIONS (Note 5) 0.5µm	RENISHAW ENCODER OPTIONS (Note 5) 0.1µm
Peak Velocity	in/s [m/s]	275 [7]	100 [2.5]	120 [3]	15 [0.4]
Resolution	in [µm]	0.0002 [5]	0.000 04 [1.0]	0.000 02 [0.5]	0.000 004 [0.1]
Repeatability	in [µm]	±0.0004 [±10]	±0.000 8 [2.0]	±0.000 06 [1.5]	±0.000 04 [1.0]
Accuracy – LME		±(30µm +50µm/m)	±(25µm +50µm/m)		
Accuracy – Renishaw				±(5µm +30µm/m)	

Note: For travels less than 1 meter, accuracy should be calculated at 1 meter

MOTOR MODEL		210-2	210-3	210-4
Peak Force	N	255.8	375.0	494.2
	lb	57.5	84.3	111.1
Continuous Force	N	57.4	84.1	110.3
	lb	12.9	18.9	24.8
Peak Power	W	1583	2261	2940
Continuous Power	W	79	113	147

ACCURACY	STANDARD	LASER ALIGNMENT OPTION
Straightness restrained on flat surface in [µm]	±0.000127 in/m [±127mm/m]	±0.0000127 in/in [±13mm/m]
Flatness restrained on flat surface in [µm]	±0.003 +.000254 in/in [±76 + 254µm/m]	

Note: For travels less than 1 meter, Flatness should be calculated at 1 meter
Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005in/ft

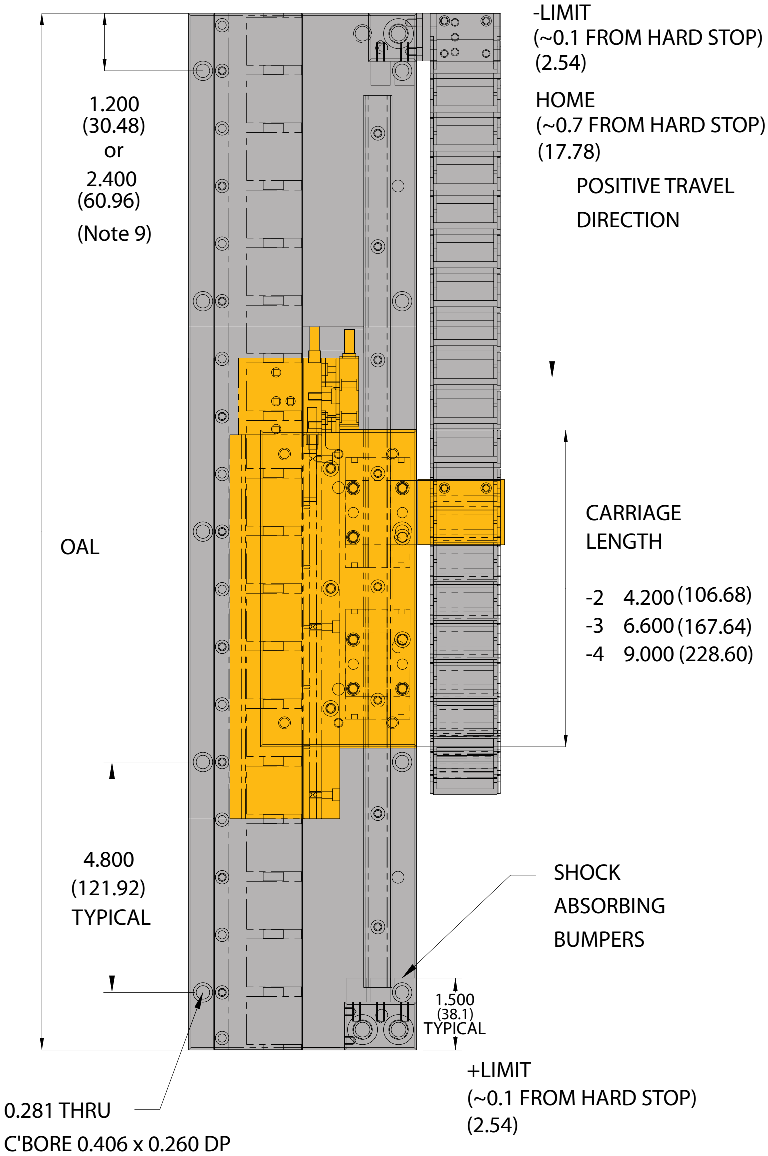
PHYSICAL		- 2	- 3	- 4
Carriage Assembly	lbs [kg]	2.10 [0,95]	3.10 [1,38]	3.80 [1,70]
Base Assembly			→	→
T2SA Aluminum (0.375" thick)	lbs/ft [kg/m]	9.10 [13,5]	→	→
T2SB Aluminum (0.500" thick)	lbs/ft [kg/m]	9.90 [14,7]		
T2SS Steel (0.500" thick)	lbs/ft [kg/m]	15.10 [22,5]	→	→
Carriage Length	in [mm]	4.20 [106,7]	6.60 [167,6]	9.00 [228,6]
Coil Bar Length	in [mm]	7.20 [182,9]	9.60 [243,8]	12.00 [304,8]

LOAD		- 2	- 3	- 4
Vertical (Fv) see note 11	lbs [kg]	40 [18,1]	50 [22,7]	60 [27,2]
Side (Fs) see note 11	lbs [kg]	20 [9,1]	30 [13,6]	30 [13,6]
Moments–Roll (Mr) see note 11	lb-ft [N-m]	20 [27]	30 [40]	30 [40]
Moments–Pitch (Mp) see note 11	lb-ft [N-m]	50 [67]	100 [135]	100 [135]
Moments–Yaw (My) see note 11	lb-ft [N-m]	50 [67]	100 [135]	100 [135]

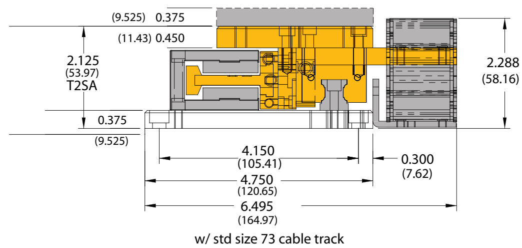
NOTES

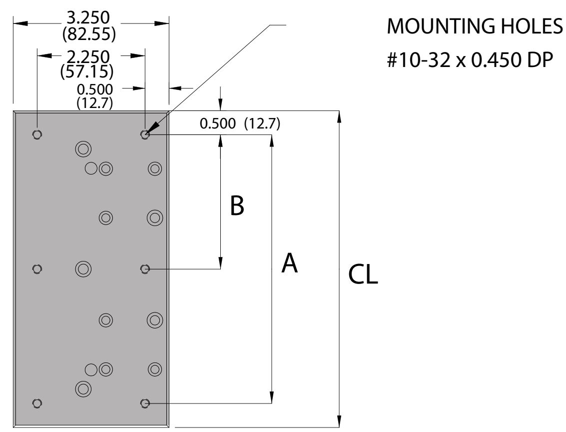
1. Total travel = OAL – 3.00˝ (76.2 mm) – carriage length.
2. Maximum base length is 120˝ (3048 mm).
3. Aluminum base is black anodized. Steel base is nickel plated.
4. For complete motor specifications, refer to 210 series motor data sheet.
5. Renishaw encoder, RGH24 series, available in 0.05µm, 0.1µm, 0.5µm, 1.0µm, 5.0µm.
6. Cable extends past base by approximately 0.6" when carriage is at negative hard stop.
7. Cable Track extends 0.175˝ higher than carriage mounting surface. It is recommended to use optional Spacer Plate for custom mounting holes.
8. Standard cable track provided is Igus 07.30.018.
9. Base mounting holes are equidistant, 1.200" (12.0, 16.8, 21.6....) or 2.400" (9.6, 14.4, 19.2, 24.0....) from each end depending on base length.
10. Specification subject to change without notice.
11. Listed specifications based on motor size and typical performance requirements. Bearing manufacturer specifications exceed listed specifications. ments. Bearing manufacturer specifications exceed listed specifications.

Dimensions shown in inches.
- Moving Carriage Assembly
- Stationary Base Assembly



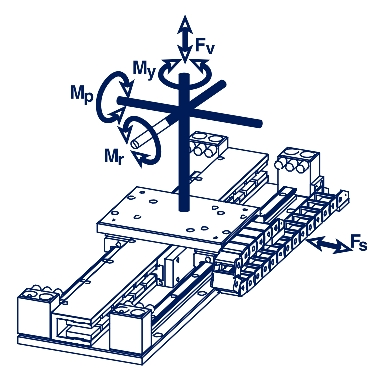
0.375 THICK CARRIAGE SPACER PLATE (optional)
(9.525)





TOTAL TRAVEL = OAL - 3.00" - CARRIAGE LENGTH
= OAL - 76.2 mm - CARRIAGE LENGTH

OAL = MULTIPLE OF 2.400" (60.96)



CARRIAGE SIZE						
	- 2	mm	- 3	mm	- 4	mm
CL	4.200	106.68	6.600	167.64	9.000	228.60
A	3.200	81.28	5.600	142.24	8.000	203.20
B	—	71.12	2.800	101.60	4.000	101.64
COIL	210-2		210-3		210-4	

PERFORMANCE		LINEAR MAGNETIC ENCODER 5.0µm	1.0.1µm	RENISHAW ENCODER OPTIONS (Note 5) 0.5µm	0.1µm
Peak Velocity	in/s [m/s]	275 [7]	100 [2.5]	120 [3]	15 [0.4]
Resolution	in [µm]	0.0002 [5]	0.000 04 [1.0]	0.000 02 [0.5]	0.000 004 [0.1]
Repeatability	in [µm]	±0.0004 [±10]	±0.000 8 [2.0]	±0.000 06 [1.5]	±0.000 04 [1.0]
Accuracy – LME		±(30µm +50µm/m)	±(25µm +50µm/m)		
Accuracy – Renishaw				±(5µm +30µm/m)	

Note: For travels less than 1 meter, accuracy should be calculated at 1 meter

MOTOR MODEL		310-2	310-3	310-4	310-5	310-6
Peak Force	N	409.3	600.0	790.0	980.0	1170.0.1
	lb	92.0	135.1	177.2	220.3	263.2
Continuous Force	N	91.6	133.9	176.2	219.3	262.0
	lb	20.6	30.1	39.6	49.3	589
Peak Power	W	1885	2693	3500	4308	5116
Continuous Power	W	4	135	179	215	256

ACCURACY	STANDARD	LASER ALIGNMENT OPTION
Straightness restrained on flat surface in [µm]	±0.000127in/in [±127µm/m]	±.000013 in/in [13µm/m]
Flatness restrained on flat surface in [µm]	±0.003 + .000254 in/in [±76 + 254µm/m]	

Note: For travels less than 1 meter, Flatness should be calculated at 1 meter
Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005in/ft

PHYSICAL		- 2	- 3	- 4	- 5	- 6
Carriage Assembly	lbs [kg]	4.60 [2,1]	6.70 [3,0]	8.10 [3,7]	9.50 [4,3]	11.00 [5,0]
Base Assembly						
T3DA Aluminum (3.375˝ thick)	lbs/ft [kg/m]	15.75 [23,4]	►	►	►	►
T3DB Aluminum (0.500˝ thick)	lbs/ft [kg/m]	16.88 [25,1]	►	►	►	►
T3DS Steel (0.500˝ thick)	lbs/ft [kg/m]	25.27 [37,6]	►	►	►	►
Carriage Length	in [mm]	4.20 [106,7]	6.60 [167,6]	9.00 [228,6]	11.40 [289,6]	13.80 [350,5]
Coil Bar Length	in [mm]	7.20 [182,9]	9.60 [243,8]	12.00 [304,8]	14.40 [365,8]	16.80 [426,7]

LOAD		- 2	- 3	- 4	- 5	- 6
Vertical (Fv) see note 11	lbs [kg]	120 [54]	150 [68]	180 [81]	210 [95]	240 [108]
Side (Fs) see note 11	lbs [kg]	80 [36]	100 [45]	100 [45]	100 [45]	100 [45]
Moments–Roll (Mr) see note 11	lb-ft [N-m}	80 [107]	100 [134]	100 [134]	100 [134]	100 [134]
Moments–Pitch (Mp) see note 11	lb-ft [N-m}	160 [214]	300 [402]	300 [402]	300 [402]	300 [402]
Moments–Yaw (My) see note 11	lb-ft [N-m}	160 [214]	300 [402]	300 [402]	300 [402]	300 [402]

NOTES

1 Total travel = OAL – 3.00˝ (76.2 mm) – carriage length.

2 Maximum base length is 120˝ (3048 mm).

3 Aluminum base is black anodized. Steel base is nickel plated.

4 For complete motor specifications, refer to 310 series motor data sheet.

5 Renishaw encoder, RGH24 series, available in 0.05.0µm. 0.1µm, 0.5µm, 1.0µm, 5.0µm.

6 Cable extends past base by approximately 0.6" when carriage is at negative hard stop.

7 Cable Track extends 0.175˝ higher than carriage mounting surface. It is recommended to use optional Spacer Plate for custom mounting holes.

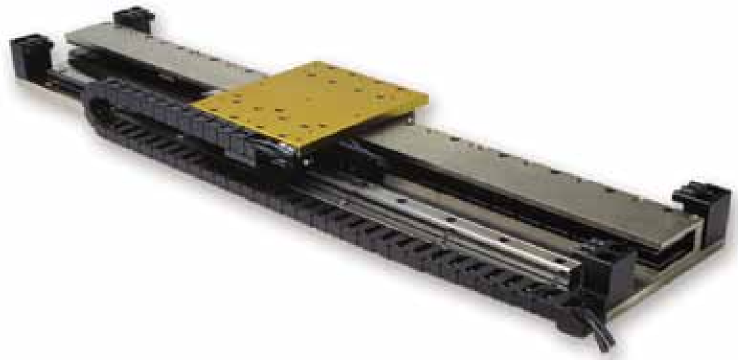
8 Standard cable track provided is Igus 07.30.018.

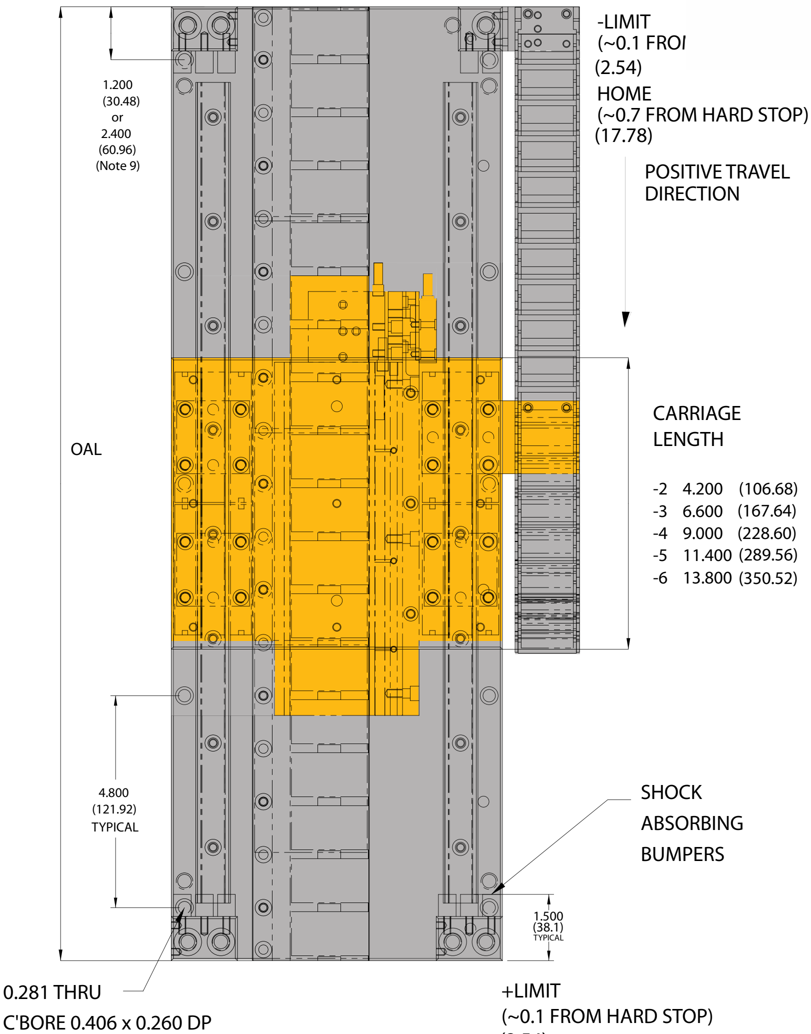
9 Base mounting holes are equidistant, 1.200˝ (12.0, 16.8, 21.6...) or 2.400˝ (9.6, 14.4, 19.2, 24.0...) from each end depending on base length.

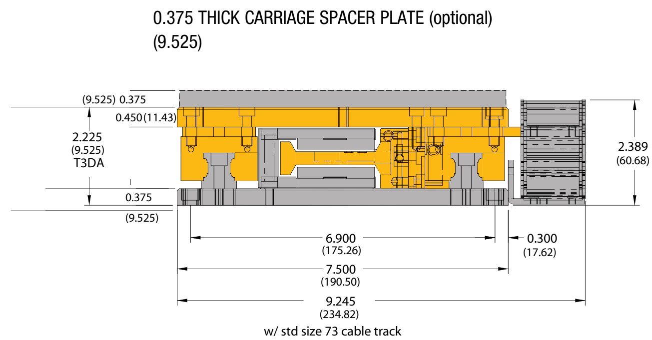
10 Specification subject to change without notice.

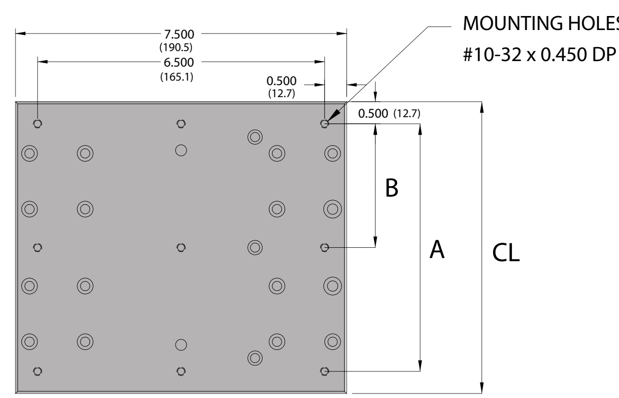
11 Listed specifications based on motor size and typical performance requirements Bearing manufacturer specifications exceed listed specifications.

Dimensions shown in inches.
- Moving Carriage Assembly
- Stationary Base Assembly

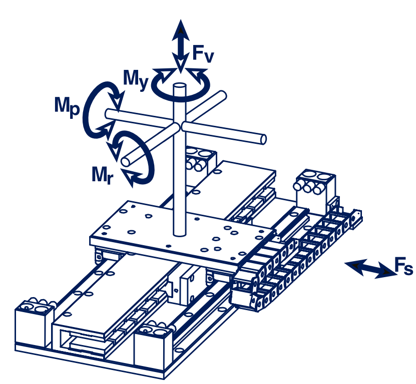








TOTAL TRAVEL = OAL - 3.00" (76.2) - CARRIAGE LENGTH
OAL = MULTIPLE OF 2.400" (60.96)



CARRIAGE SIZE

	-2	mm	-3	mm	-4	mm	-5	mm	-6	mm
CL	4.200	106.68	6.600	167.64	9.000	228.60	11.400	289.56	13.800	350.52
A	3.200	81.28	5.650	142.24	8.000	203.20	10.400	264.16	12.800	325.12
B	—		2.800	71.12	4.000	101.60	5.200	132.08	6.400	162.56
COIL	310-2		310-3		310-4		310-5		310-6	

T3S Specifications

PERFORMANCE		LINEAR MAGNETIC ENCODER 5.0µm	1.0.1µm	RENISHAW ENCODER OPTIONS (Note 5) 0.5µm	0.1µm
Peak Velocity	in/s [m/s]	275 [7]	100 [2.5]	120 [3]	15 [0.4]
Resolution	in [µm]	0.0002 [5]	0.000 04 [1.0]	0.000 02 [0.5]	0.000 004 [0.1]
Repeatability	in [µm]	±0.0004 [±10]	±0.000 8 [2.0]	±0.000 06 [1.5]	±0.000 04 [1.0]
Accuracy – LME		±(30µm +50µm/m)	±(25µm +50µm/m)		
Accuracy – Renishaw				±(5µm +30µm/m)	

Note: For travels less than 1 meter, accuracy should be calculated at 1 meter

MOTOR MODEL		310-2	310-3	310-4	310-5	310-6
Peak Force	N	409.3	600.0	790.0	980.0	1170.0.1
	lb	92.0	135.1	177.2	220.3	263.2
Continuous Force	N	91.6	133.9	176.2	219.3	262.0
	lb	20.6	30.1	39.6	49.3	589
Peak Power	W	1885	2693	3500	4308	5116
Continuous Power	W	4	135	179	215	256

ACCURACY	STANDARD	LASER ALIGNMENT OPTION
Straightness restrained on flat surface in [µm]	±0.000127 [±127µm/m]	±.00013 in/in [±13µm/m]
Flatness restrained on flat surface in [µm]	±0.003 + .00254 in/in [±76 + 254µm/m]	

Note: For travels less than 1 meter, Flatness should be calculated at 1 meter
Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005in/ft

PHYSICAL		- 2	- 3	- 4	- 5	- 6
Carriage Assembly	lbs [kg]	3.00 [1,4]	4.40 [2,0]	5.50 [2,5]	6.40 [2,9]	7.40 [3,3]
Base Assembly						
T3SA Aluminum (3.375˝ thick)	lbs/ft [kg/m]	13.30 [19,8]	▶	▶	▶	▶
T3SB Aluminum (0.500˝ thick)	lbs/ft [kg/m]	14.25 [21,2]	▶	▶	▶	▶
T3SS Steel (0.500˝ thick)	lbs/ft [kg/m]	21.24 [31,6]	▶	▶	▶	▶
Carriage Length	in [mm]	4.20 [106,7]	6.60 [167,6]	9.00 [228,6]	11.40 [289,6]	13.80 [350,5]
Coil Bar Length	in [mm]	7.20 [182,9]	9.60 [243,8]	12.00 [304,8]	14.40 [365,8]	16.80 [426,7]

LOAD		- 2	- 3	- 4	- 5	- 6
Vertical (Fv) see note 11	lbs [kg]	80 [36]	100 [45]	120 [54]	140 [63]	160 [72]
Side (Fs) see note 11	lbs [kg]	30 [13]	50 [22]	50 [22]	50 [22]	50 [22]
Moments–Roll (Mr) see note 11	lb-ft [N-m}	35 [47]	50 [67]	50 [67]	50 [67]	50 [67]
Moments–Pitch (Mp) see note 11	lb-ft [N-m}	75 [100]	150 [201]	150 [201]	150 [201]	150 [201]
Moments–Yaw (My) see note 11	lb-ft [N-m}	75 [100]	150 [201]	150 [201]	150 [201]	150 [201]

NOTES

1 Total travel = OAL – 3.00˝ (76.2 mm) – carriage length.

2 Maximum base length is 120˝ (3048 mm).

3 Aluminum base is black anodized. Steel base is nickel plated.

4 For complete motor specifications, refer to 310 series motor data sheet.

5 Renishaw encoder, RGH24 series, available in 0.05.0µm. 0.1µm, 0.5µm, 1.0µm, 5.0µm.

6 Cable extends past base by approximately 0.6" when carriage is at negative hard stop.

7 Cable Track extends 0.175˝ higher than carriage mounting surface. It is recommended to use optional Spacer Plate for custom mounting holes.

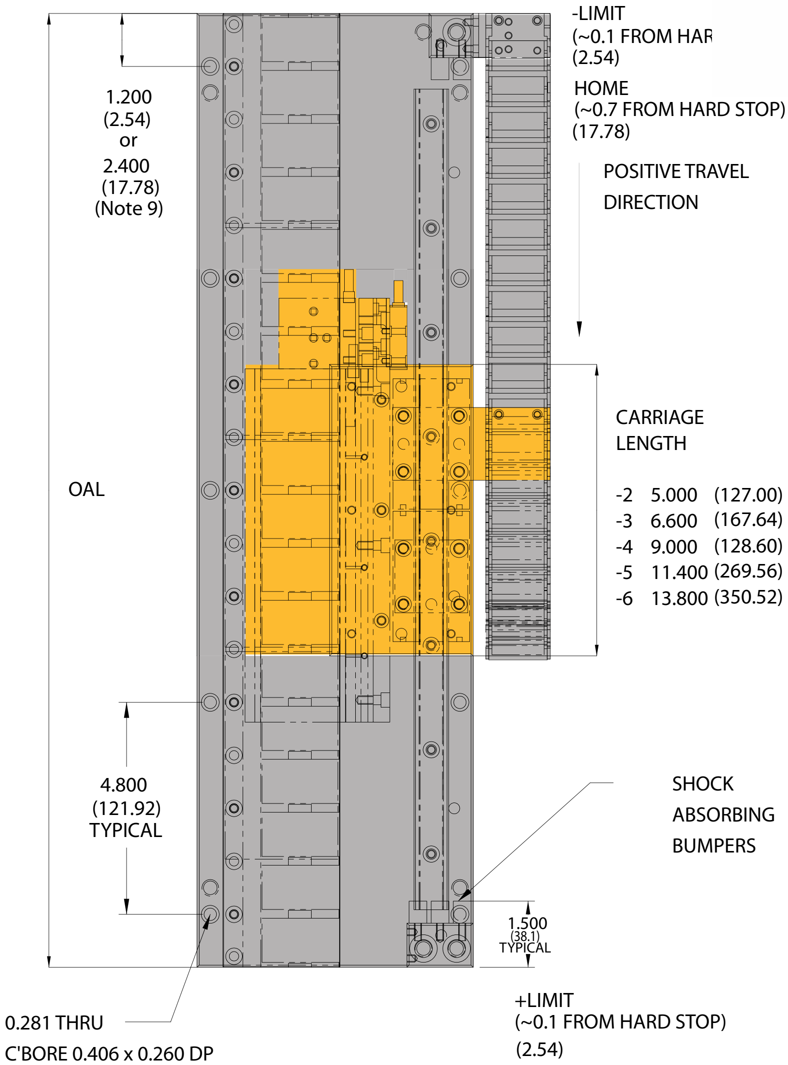
8 Standard cable track provided is Igus 07.30.018.

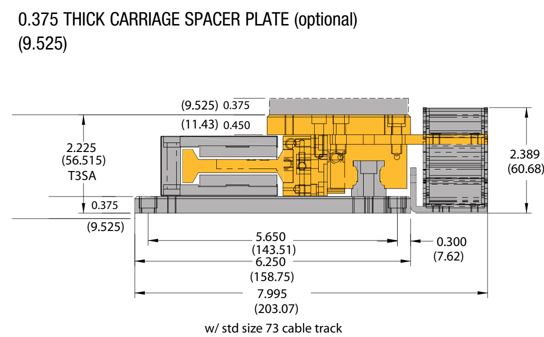
9 Base mounting holes are equidistant, 1.200˝ (12.0, 16.8, 21.6...) or 2.400˝ (9.6, 14.4, 19.2, 24.0...) from each end depending on base length.

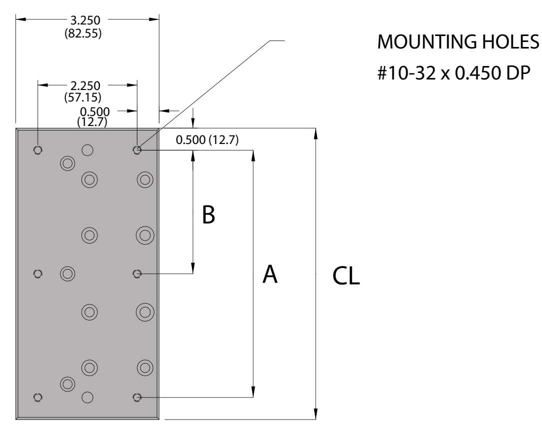
10 Specification subject to change without notice.

11 Listed specifications based on motor size and typical performance requirements Bearing manufacturer specifications exceed listed specifications.

Dimensions shown in inches.
- Moving Carriage Assembly
- Stationary Base Assembly

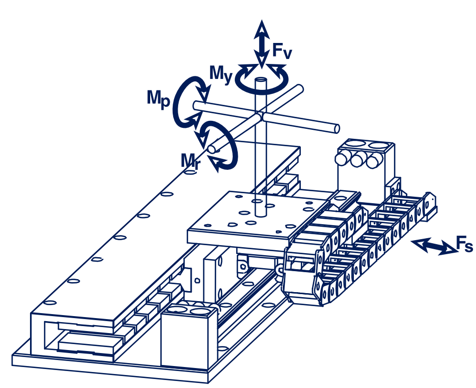






TOTAL TRAVEL = OAL - 3.00" (76.2) - CARRIAGE LENGTH
OAL = MULTIPLE OF 2.400" (60.96)

CARRIAGE SIZE										
	-2	mm	-3	mm	-4	mm	-5	mm	-6	mm
CL	5.000	127.00	6.600	167.64	9.000	228.60	11.400	289.56	13.800	350.52
A	4.000	101.60	5.650	142.24	8.000	203.20	10.400	264.16	12.800	325.12
B	2.000	50.8	2.800	71.12	4.000	101.60	5.200	132.08	6.400	162.56
COIL	310-2		310-3		310-4		310-5		310-6	



T4D Specifications

PERFORMANCE		LINEAR MAGNETIC ENCODER 5.0µm	1.0µm	RENISHAW ENCODER OPTIONS (Note 5) 0.5µm	0.1µm
Peak Velocity	in/s [m/s]	275 [7]	100 [2.5]	120 [3]	15 [0.4]
Resolution	in [µm]	0.0002 [5]	0.000 04 [1.0]	0.000 02 [0.5]	0.000 004 [0.1]
Repeatability	in [µm]	±0.0004 [±10]	±0.000 8 [2.0]	±0.000 06 [1.5]	±0.000 04 [1.0]
Accuracy – LME		±(30µm +50µm/m)	±(25µm +50µm/m)		
Accuracy – Renishaw				±(5µm +30µm/m)	

Note: For travels less than 1 meter, accuracy should be calculated at 1 meter

MOTOR MODEL		410-2	410-3	410-4	410-6	410-8
Peak Force	N	1041.4	1523.6	2006.3	2967.2	3928.1
	lb	234.1	342.5	451.0	667.0	883.0
Continuous Force	N	233.1	340.8	448.9	663.7	878.6
	lb	52.4	76.6	100.9	149.2	197.5
Peak Power	W	2835	4050	5265	7695	10125
Continuous Power	W	142	203	263	385	506

ACCURACY	STANDARD	LASER ALIGNMENT OPTION
Straightness restrained on flat surface in [µm]	±0.000127 in/in [±127µm/m]	±.000013 in/in [±13µm/m]
Flatness restrained on flat surface in [µm]	±.003 + .000254 in/in [±76 + 254µm/m]	

Note: For travels less than 1 meter, Flatness should be calculated at 1 meter
Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005in/ft

PHYSICAL		- 2	- 3	- 4	- 6	- 8
Carriage Assembly						
T4DB Aluminum	lbs [kg]	9.0 [4,1]	14.9 [6,8]	18.1 [8,2]	24.1 [10,9]	30.2 [13,7]
T4DS Steel	lbs [kg]	13.29 [6,0]	22.20 [10,1]	28.46 [12,9]	40.51 [18,4]	52.59 [23,9]
Base Assembly						
T4DB Aluminum	lbs/ft [kg/m]	29.4 [43,8]	►	►	►	►
T4DS Steel	lbs/ft [kg/m]	39.3 [58,5]	►	►	►	►
Carriage Length	in [mm]	4.80 [121,9]	8.15 [207,0]	11.50 [292,1]	18.20 [462,3]	24.90 [632,5]
Coil Bar Length	in [mm]	10.00 [254]	13.36 [339]	16.72 [424]	23.44 [595]	30.16 [766]

LOAD		- 2	- 3	- 4	- 6	- 8
Vertical (Fv) see note 11	lbs [kg]	200 [90]	250 [113]	300[136]	400 [181]	400 [181]
Side (Fs) see note 11	lbs [kg]	150 [68]	150 [68]	150 [68]	150 [68]	150 [68]
Moments–Roll (Mr) see note 11	lb-ft [N-m}	100 [133]	150 [200]	150 [200]	150 [200]	150 [200]
Moments–Pitch (Mp) see note 11	lb-ft [N-m}	200 [266]	400 [532]	400 [532]	400 [532]	400 [532]
Moments–Yaw (My) see note 11	lb-ft [N-m}	200 [266]	400 [532]	400 [532]	400 [532]	400 [532]

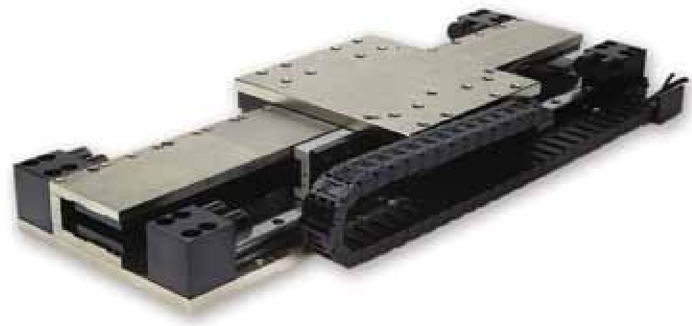
NOTES

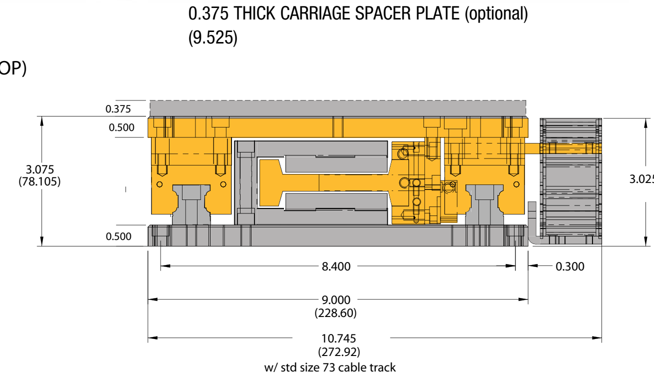
1 Total travel = OAL – 5.50” (139.7 mm) – carriage length.
2 Maximum base length is 120” (3048)
3 Aluminum base is black anodized. Steel base is nickel plated.
4 For complete motor specifications, refer to 410 series motor data sheet.
5 Renishaw encoder, RGH24 series, available in 0.05.0µm. 0.1µm, 0.5µm, 1.0µm, 5.0µm.
6 Cable extends past base by approximately 0.6” when carriage is at negative hard stop.
7 Cable Track extends 0.175” higher than carriage mounting surface. It is recommended to use optional Spacer Plate for custom mounting holes.
8 Standard cable track provided is Igus 07.30.028.
9 Base mounting holes are equidistant, 1.680” (16.80, 23.52....) or 3.360” (20.16, 26.88....) from each end depending on base length.
10 Specification subject to change without notice.
11 Listed specifications based on motor size and typical performance requirements Bearing manufacturer specifications exceed listed specifications.

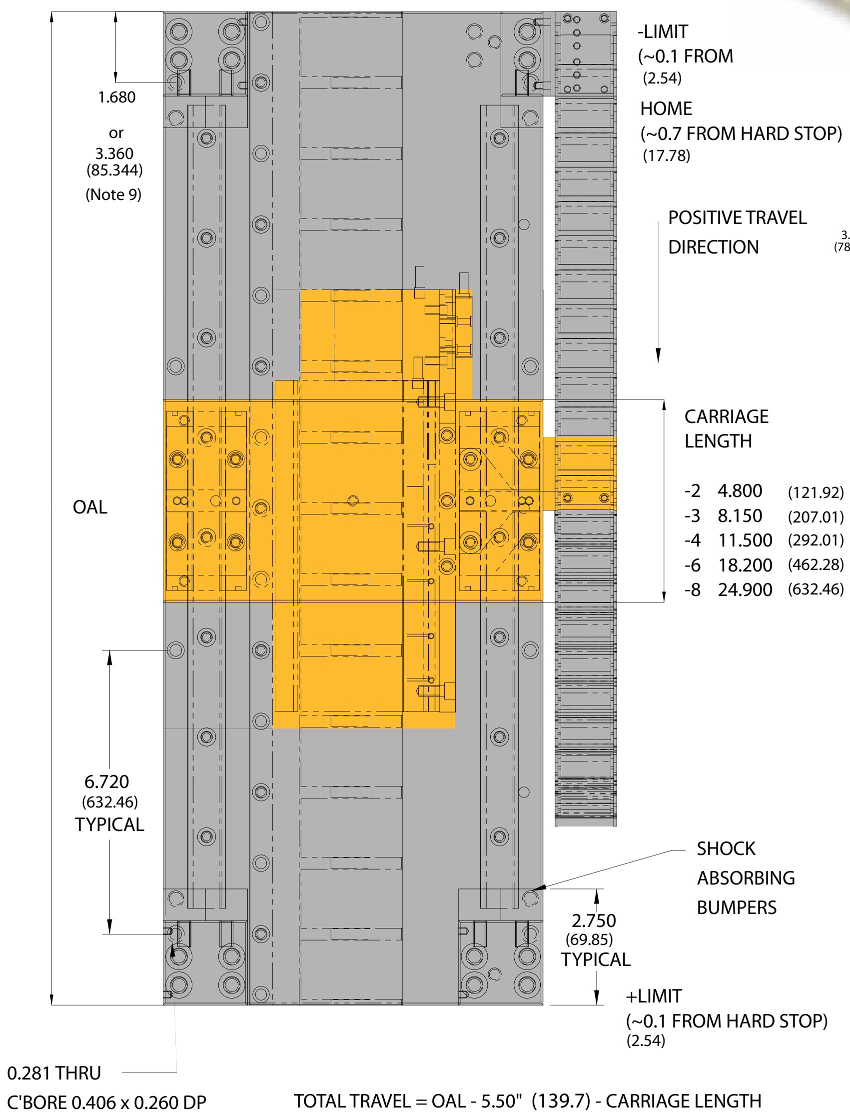
Dimensions shown in inches.

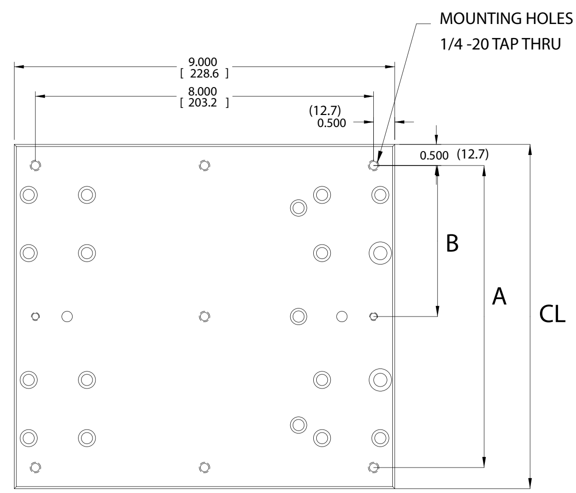
● Moving Carriage Assembly

● Stationary Base Assembly





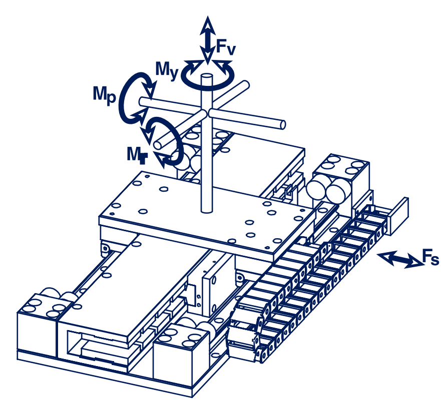




TOTAL TRAVEL = OAL - 5.50" (139.7) - CARRIAGE LENGTH

OAL = MULTIPLE OF 3.360" (85.34)

CARRIAGE SIZE										
	-2	mm	-3	mm	-4	mm	-6	mm	-8	mm
CL	4.800	121.92	8.150	207.01	11.500	292.10	18.200	462.28	24.900	632.46
A	3.800	96.52	7.150	181.61	10.500	266.70	17.200	436.88	23.900	607.66
B	—	—	3.575	90.805	5.250	133.35	8.600	218.44	11.950	303.53
COIL	410-2		410-3		410-4		410-6		410-8	



T4S Specifications

PERFORMANCE		LINEAR MAGNETIC ENCODER 5.0µm	1.0µm	RENISHAW ENCODER OPTIONS (Note 5) 0.5µm	0.1µm
Peak Velocity	in/s [m/s]	275 [7]	100 [2.5]	120 [3]	15 [0.4]
Resolution	in [µm]	0.0002 [5]	0.000 04 [1.0]	0.000 02 [0.5]	0.000 004 [0.1]
Repeatability	in [µm]	±0.0004 [±10]	±0.000 8 [2.0]	±0.000 06 [1.5]	±0.000 04 [1.0]
Accuracy – LME		±(30µm +50µm/m)	±(25µm +50µm/m)		
Accuracy – Renishaw				±(5µm +30µm/m)	

Note: For travels less than 1 meter, accuracy should be calculated at 1 meter

MOTOR MODEL		410-2	410-3	410-4	410-6	410-8
Peak Force	N	1041.4	1523.6	2006.3	2967.2	3928.1
	lb	234.1	342.5	451.0	667.0	883.0
Continuous Force	N	233.1	340.8	448.9	663.7	878.6
	lb	52.4	76.6	100.9	149.2	197.5
Peak Power	W	2835	4050	5265	7695	10125
Continuous Power	W	142	203	263	385	506

ACCURACY	STANDARD	LASER ALIGNMENT OPTION
Straightness restrained on flat surface in [µm]	±0.000125in/in [±127µm/m]	±0.000013 in/in [±13µm/m]
Flatness restrained on flat surface in [µm]	±0.003 + .000254 in/in [±76 + 254µm/m]	

Note: For travels less than 1 meter, Flatness should be calculated at 1 meter
Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005in/ft

PHYSICAL		- 2	- 3	- 4	- 6	- 8
Carriage Assembly						
T4SB Aluminum	lbs [kg]	6.5 [3,0]	10.3 [4,7]	13.0 [5,9]	17.8 [8,1]	22.7 [10,3]
T4SS Steel	lbs [kg]	8.78 [4,0]	14.22 [6,5]	18.47 [8,4]	26.49 [12,0]	34.54 [15,7]
Base Assembly						
T4SB Aluminum	lbs/ft [kg/m]	26.7 [39,8]	→	→	→	→
T4SS Steel	lbs/ft [kg/m]	34.9 [52,0]	→	→	→	→
Carriage Length	in [mm]	4.80 [121,9]	8.15 [207,0]	11.50 [292,1]	18.20 [462,3]	24.90 [632,5]
Coil Bar Length	in [mm]	10.00 [254]	13.36 [339]	16.72 [424]	23.44 [595]	30.16 [766]

LOAD		- 2	- 3	- 4	- 6	- 8
Vertical (Fv) see note 11	lbs [kg]	150 [68]	175 [79]	175 [79]	200 [90]	200 [90]
Side (Fs) see note 11	lbs [kg]	75 [34]	75 [34]	75 [34]	75 [34]	75 [34]
Moments–Roll (Mr) see note 11	lb-ft [N-m}	50 [66]	100 [133]	100 [133]	100 [133]	100 [133]
Moments–Pitch (Mp) see note 11	lb-ft [N-m}	100 [133]	200 [266]	200 [266]	200 [266]	200 [266]
Moments–Yaw (My) see note 11	lb-ft [N-m}	100 [133]	200 [266]	200 [266]	200 [266]	200 [266]

NOTES

1 Total travel = OAL – 5.50˝ (139.7 mm) – carriage length.

2 Maximum base length is 168˝, 4.2 meters.

3 Aluminum base is black anodized. Steel base is nickel plated.

4 For complete motor specifications, refer to 410 series motor data sheet.

5 Renishaw encoder, RGH24 series, available in 0.05µm, 0.1µm, 0.5µm, 1.0µm, 5.0µm.

6 Cable extends past base by approximately 0.6” when carriage is at negative hard stop.

7 Cable Track extends 0.175˝ higher than carriage mounting surface. It is recommended to use optional Spacer Plate for custom mounting holes.

8 Standard cable track provided is Igus 07.30.028.

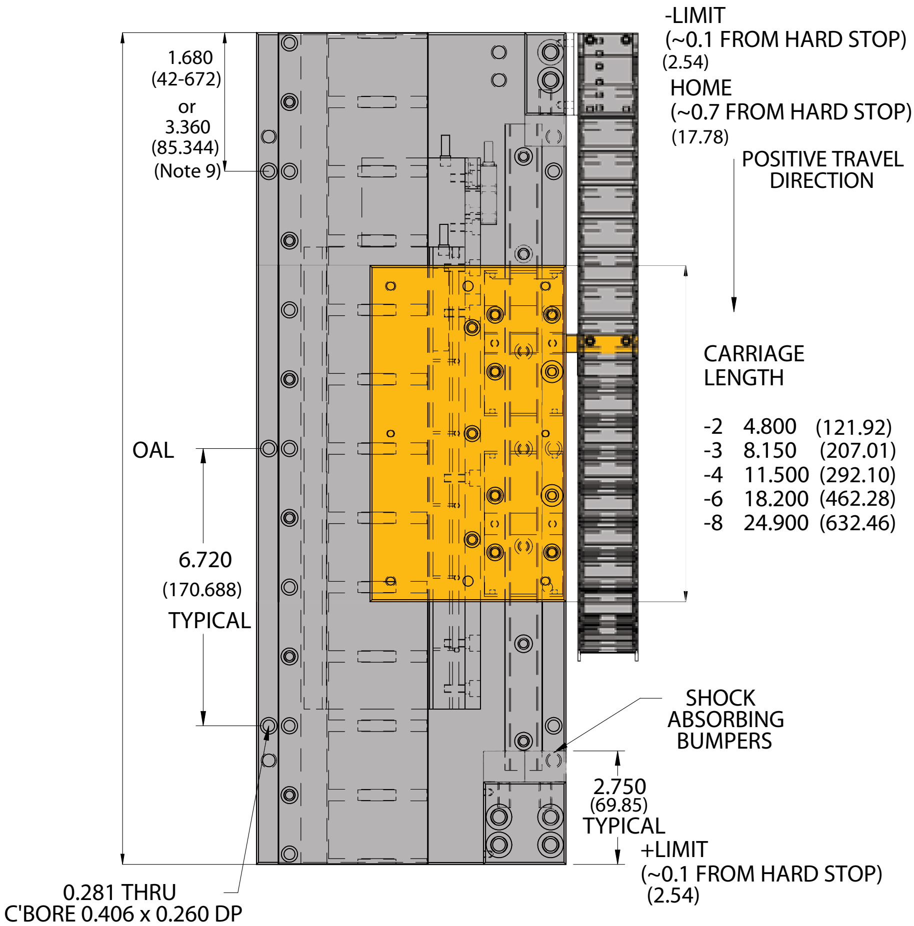
9 Base mounting holes are equidistant, 1.680” (16.80, 23.52....) or 3.360” (20.16, 26.88....) from each end depending on base length.

10 Specification subject to change without notice.

11 Listed specifications based on motor size and typical performance require Bearing manufacturer specifications exceed listed specifications.

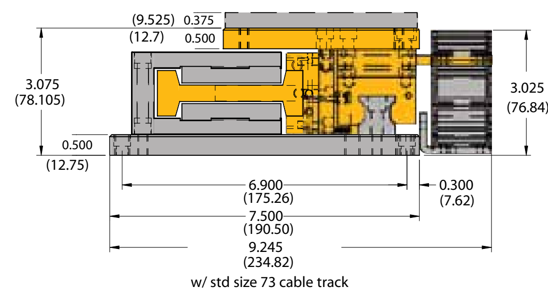
Dimensions shown in inches.

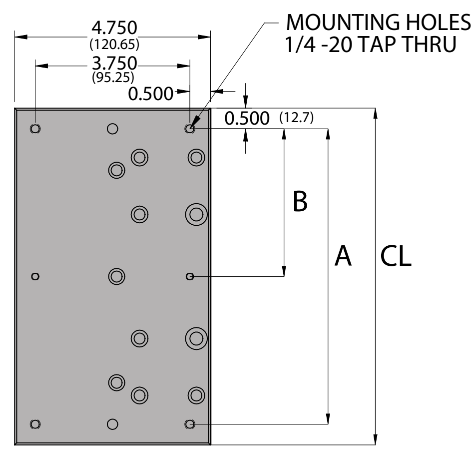
- Moving Carriage Assembly
- Stationary Base Assembly

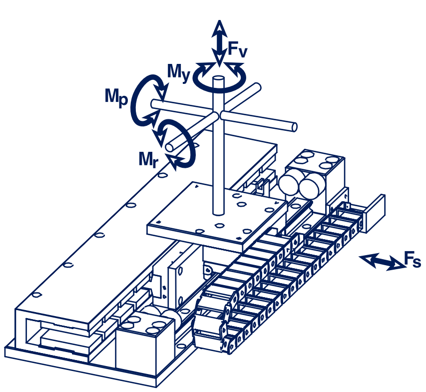


TOTAL TRAVEL = OAL - 5.50" (139.7) - CARRIAGE LENGTH
OAL = MULTIPLE OF 3.360" (985.34)

0.375 THICK CARRIAGE SPACER PLATE (optional)
9.525







CARRIAGE SIZE										
	-2	mm	-3	mm	-4	mm	-6	mm	-8	mm
CL	4.800	121.92	8.150	207.01	11.500	292.10	18.200	462.28	24.900	632.46
A	3.800	96.52	7.150	181.61	10.500	266.70	17.200	436.88	23.900	607.66
B	—	—	3.575	90.805	5.250	133.35	8.600	218.44	11.950	303.53
COIL	410-2		410-3		410-4		410-6		410-8	

T1S-T1D

Order Example:

T	1	D	A	012	3	N	S	B	A	G	2

Series
T = Open Positioner

Motor Coil Series
1 = 110 Motor Coil

Bearing Rail Configuration
D = Dual Bearing Rails
S = Single Bearing Rails

Base Material
A = 3/8˝ Al

Length of Base
XXX = Length of base In inches
Max.: 33.6˝
Min.: 9.6˝
Increment: 2.4˝

* Truncate base length in part number. Example: for a 16.8 inch base, "XXX" equal "016"

T1S Base Length = Travel (increments of 2.4˝ [60.96mm]) +1.6˝ [40.64] + carriage length
T1D Base Length = Travel Travel (increments of 2.4˝ [60.96 mm]) -0.05˝ [1027 mm] + carriage length

Coil Size
1 = 1 pole, T1S 3.4˝ (86.4 mm)
2 = 2 pole T1S 5.8˝ (147.3 mm)
T1D 5.4˝ (137.6 mm)
T1D 7.8˝ (198.12 mm)
T1S 3.4˝ (86.4 mm)

Cooling
N no cooling

Winding Type
S Series
P Parallel

Cable track
0 = None
2 = Std.

Connector
Cable Connectorization
A = Aries
B = Flying Leads
C = Compax3
G = Gemini
V = ViX
Z = no cables

*Connectorized cables only available with Connector Box

Cable length
Cable Length
A = 1 Meter Flying Leads
B = 3 Meter Flying Leads
C = 7.5 Meter Flying Leads
L = 3 Extension Cables (with Connector Box)
M = 7.5 Extension Cables (with Connector Box)
Z = Connector Box ONLY (no extension cables)

*Flying leads – cable measured from last cable carrier link
*Extension Cables – cable measured from connection box at end of base

Encoder
A = LME, 1um
B = LME, 5um
Q = Renishaw, 5um
L = Renishaw, 1um
M = Renishaw, 0.5m
P = Renishaw, 0.1um
R = Renishaw, 1 V p-p sine/cosine
X = No encoder

Order Example:

T	2	D	A	012	3	N	S	B	A	B	3

Series
T = Open Posititioner
B = Bellows Posititioner

Motor Coil Series
2 = 210 motor coil

Bearing Rail Configuration
D = Dual Bearing Rails
S = Single Bearing Rails
* Bellows positioners not available in single rail

Base material
A = 0.375˝ Al

Length of Base
XXX = Length of base In inches
Max.: 120˝*
Min.: 9.6˝
Increment: 2.4˝

* Truncate base length in part number. Example: for a 16.8 inch base, "XXX" equal "016˝

T1S Base Length = Travel (increments of 2.4˝ [60.96 mm]) +3.0˝ [76.2] + carriage length
T1D Base Length = Travel Travel (increments of 2.4˝ [60.96 mm])

Coil size
2 = 2 pole, 4.2 in (106.68 mm)
3 = 3 pole, 6.6 in (106.64 mm)
4 = 4 pole, 9.0 in (228.60 mm)

Cooling
N no cooling

Winding Type
S Series
P Parallel

Encoder
A = LME 1 um
B = LME 5 um
Q = Renishaw 5 um
L = Renishaw 1 um
M =Renishaw 0.5 um
P = Renishaw 0.1 um
R = Renishaw IV p-p sine/cosine
X = No Encoder

Cable length
A = 1 Meter Flying Leads
B = 3 Meter Flying Leads
C = 7.5 Meter Flying Leads
L = 3 Extension Cables (with Connector Box)
M = 7.5 Extension Cables (with Connector Box)
Z = Connector Box ONLY (no extension cables)

*Flying leads – cable measured from last cable carrier link
*Extension Cables – cable measured from connection box at end of base
*7.5 Meter Flying Lead Cables available on:
All bases with LME encoder
All bases with Renishaw encoder under 86˝
For bases with Renishaw encoder over 86˝ the cable length (CL) will be CL = 10M - (base length in meters + 0.3M)

Connector
Cable Connectorization
A = Aries
B = Flying Leads
C = Compax3
G = Gemini
V = ViX
Z = no cables

*Connectorized cables only available with Connector Box

Cable track
0 = (no track)
3 = (standard)

*Consult factory for longer lengths.

Order Example:

T	3	D	B	012	3	N	S	B	A	C	3

Series
T = Open Positioner
B = Bellows Positioner

Motor Coil Series
3 = 310 Motor Coil

Bearing Rail Configuration
D = Dual Bearing Rails
S = Single Bearing Rails
* Bellows positioners not available in single rail

Base Material
B = 1/2˝ Al

Length of Base
XXX = Length of base In inches
Max.: 118˝
Min.: 9.6˝
Increment: 2.4˝

* Truncate base length in part number. Example: for a 16.8 inch base, "XXX" equal "016˝
Base Length = Travel (increments of 2.4˝ [60.96mm]) +3.0˝ [76.2 mm] + carriage length

Coil Size
2 = 2 pole T3S 5.0˝ [127 mm], T3D 4.2˝ [106.68]
3 = 3 pole 6.6˝ [167.64 mm]
4 = 4 pole 9.0˝ [228.60 mm]
5 = 5 pole 11.4˝ [289.56 mm]
6 = 6 pole 13.3˝ [350.62 mm]

Cooling
N no cooling

Winding Type
S Series
P Parallel

Encoder
A = LME, 1um
B = LME, 5um
Q = Renishaw, 5um
L = Renishaw, 1um
M = Renishaw, 0.5m
P = Renishaw, 0.1um
R = Renishaw, 1 V p-p sine/cosine
X = No encoder

Cable length
Cable Length
A = 1 Meter Flying Leads
B = 3 Meter Flying Leads
C = 7.5 Meter Flying Leads
L = 3 Extension Cables (with Connector Box)
M = 7.5 Extension Cables (with Connector Box)
Z = Connector Box ONLY (no extension cables)

*Flying leads – cable measured from last cable carrier link
*Extension Cables – cable measured from connection box at end of base
*7.5 Meter Flying Lead Cables available on:
All bases with LME encoder
All bases with Renishaw encoder under 86˝
For bases with Renishaw encoder over 86˝ the cable length (CL) will be CL = 10M - (base length in meters + 0.3M)

Connector
Cable Connectorization
A = Aries
B = Flying Leads
C = Compax3
G = Gemini
V = ViX
Z = no cables

*Connectorized cables only available with Connector Box

Cable track
0 = None
3 = Std.

Order Example:

T	4	D	B	XXX	3	N	S	B	A	B	4

Series
T = Open Posititioner
B = Bellows Posititioner

Motor Coil Series
4 = 410 motor coil

Bearing Rail Configuration
D = Dual Bearing Rails
S = Single Bearing Rails
* Bellows positioners not available in single rail

Base material
B = 1/2˝ Al

Length of Base
XXX = Length of base in inches
Max.: 120˝ *
Min.: 13.44˝
Increment: 3.36˝

* Truncate base length in part number. Example: for a 16.8 inch base, "XXX" equal "016˝

Base Length = Travel (increments of 2.4˝ [60.96mm]) +5.5˝ [39.7 mm] + carriage length

Coil size
2 = 2 pole 4.8˝ [121.92 mm]
3 = 3 pole 8.15˝ [207.01 mm]
4 = 4 pole 11.5˝ [292.10 mm]
6 = 6 pole 18.2˝ [462.28 mm]
8 = 8 pole 24.9˝ [632.46 mm]

Cooling
N no cooling

Winding Type
S Series
P Parallel

*Consult factory for longer lengths.

Encoder
A = LME 1 um
B = LME 5 um
Q = Renishaw 5 um
L = Renishaw 1 um
M = Renishaw 0.5 um
P = Renishaw 0.1 um
R = Renishaw IV p-p sine/cosine
X = No Encoder

Cable length
A = 1 Meter Flying Leads
B = 3 Meter Flying Leads
C = 7.5 Meter Flying Leads
L = 3 Extension Cables (with Connector Box)
M = 7.5 Extension Cables (with Connector Box)
Z = Connector Box ONLY (no extension cables)

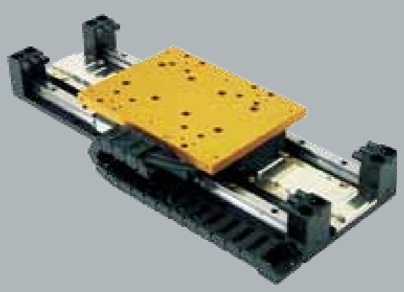
*Flying leads – cable measured from last cable carrier link
*Extension Cables – cable measured from connection box at end of base
*7.5 Meter Flying Lead Cables available on:
All bases with LME encoder
All bases with Renishaw encoder under 86˝
For bases with Renishaw encoder over 86˝ the cable length (CL) will be CL = 10M - (base length in meters + 0.3M)

Connector
Cable Connectorization
A = Aries
B = Flying Leads
C = Compax3
G = Gemini
V = ViX
Z = no cables

*Connectorize cables only available with Connector Box

Cable track
0 = (no track)
4 = (standard)

RIPPED Ironcore Linear Positioners



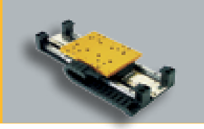
Parker Trilogy's RIPPED linear positioners utilize our high-performance RIPPED ironcore linear motors in a pre-engineered, easily integrated, ready-to-run package. These positioners are engineered to achieve high performance at an economical cost while preserving design flexibility to accommodate customization. Combined with RIPPED ironcore motors – with their patent-pending anti-cog technology, these linear motor tables produce extremely smooth motion and can be used in many applications where ironless motors traditionally were needed.

Trilogy's positioners utilize high-precision square rail bearings. In addition, they are designed to connect together using transition plates for XY or multi-axis configurations. Options include a variety of cable management systems in addition to bellows and hard covers.

High force capability, multi-axis compatibility, and ease of customization make the RIPPED ironcore linear positioners an optimal choice for high performance and value.

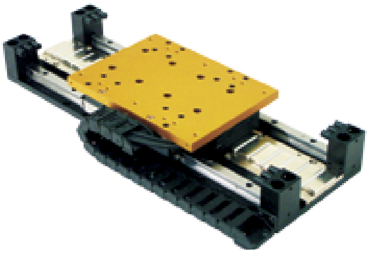
Features

- Standard lengths to 3 meters
- Extended lengths as standard options
- Incremental length of 60mm for TR10 and TR16
- Incremental length of 80mm for TR07
- Stainless cover options for TR07, TR10 and TR16
- Maximum cover length of 144"
- Optical or magnetic encoders
- Optical encoders; 1.0um, 0.50um, 0.10um
- Magnetic encoder: 5.0um
- Magnetic Home and End-of-Travel limits



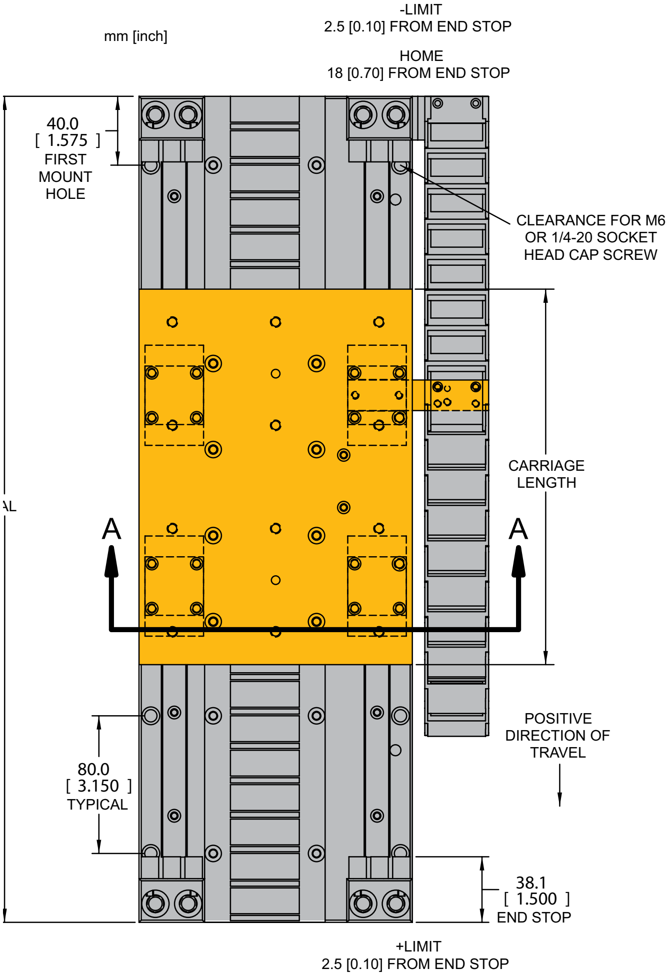
TR07

open design

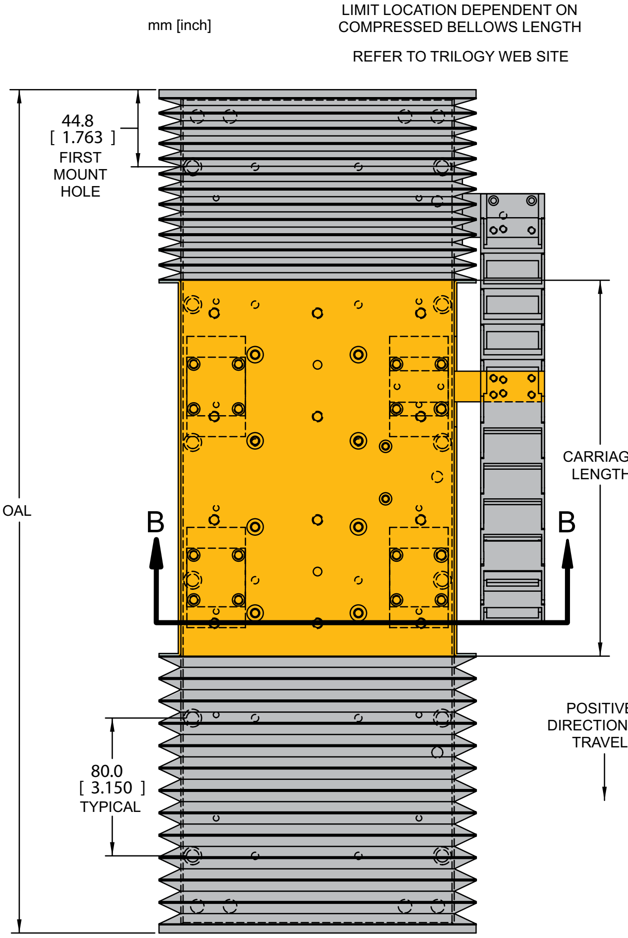


BR07

bellows design

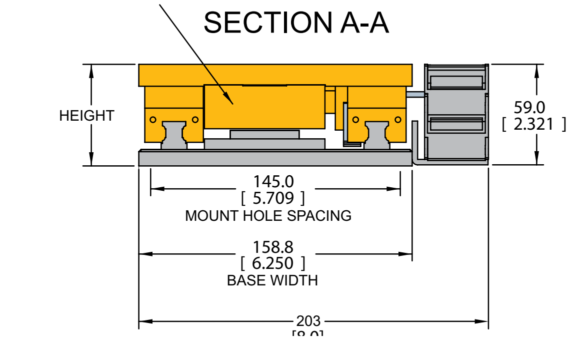


TRAVEL (mm) = OAL - 76.2 - CARRIAGE LENGTH
OVERALL LENGTH (OAL) = MULTIPLE OF 80 mm UP TO 3040 mm

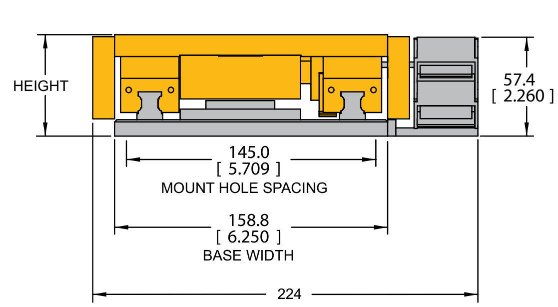


REFER TO TRILOGY WEB SITE FOR TRAVEL
BASE LENGTH = MULTIPLE OF 80 mm UP TO 3040 mm
OAL = BASE LENGTH + 9.5 mm

SECTION A-A

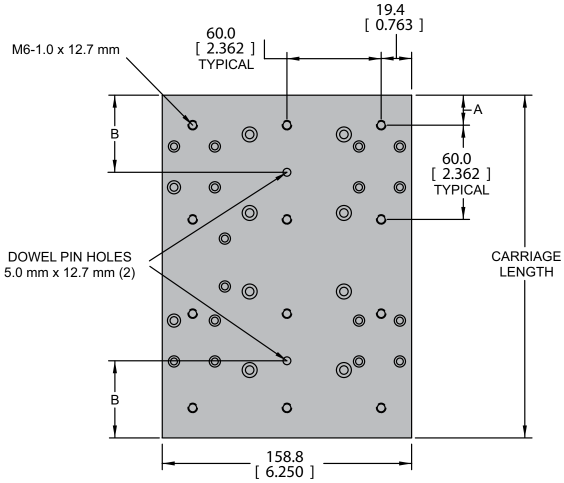


SECTION B-B



OVERALL WIDTH (OAW)			
IGUS CABLE TRACK	PART NO. DESIGNATOR	TR07 mm [in]	BR07 mm [in]
07-20-18	Custom	193 [7.6]	214 [8.4]
07-30-18	3	203 [8.0]	224 [8.8]
07-40-18	Custom	213 [8.4]	234 [9.2]
07-50-18	Custom	223 [8.8]	244 [9.6]
07-64-18	Custom	237 [9.3]	258 [10.2]

TR07/BR07 CARRIAGE

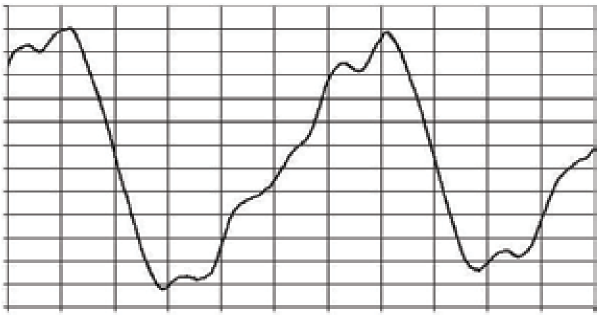


CARRIAGE LENGTH			
COIL SIZE	-1	-2	-3
TR07/BR07 CARRIAGE	218.2 [8.591]	378.2 [14.890]	538.2 [21.189]
A (1st MOUNT HOLE)	19.1 [0.752]	9.1 [0.358]	29.1 [1.146]
NUMBER OF MOUNTING HOLES	12	21	27
B (DOWEL PIN HOLE)	49.1 [1.933]	99.1 [3.901]	119.1 [4.689]

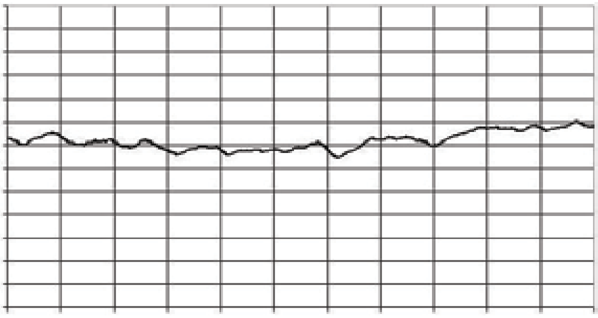
Smooth operation with Anti-Cogging features –

Parker Trilogy's RIPPED Series Ironcore Positioners utilize Parker's patent pending Anti-Cogging techniques for superior smoothness. Traditional ironcore motors exhibit cogging forces when the internal iron laminations exhibit a horizontal force on the motor when trying to line up with their "preferred" positions over the magnets. Cogging limits the overall smoothness of the motion system.

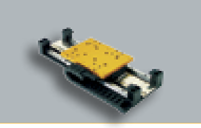
Parker Trilogy has developed an Anti-Cogging technological breakthrough that virtually eliminates cogging and allows ironcore motors to be used in applications where only ironless motors were used before. This offers the user a powerful combination of extremely high force and smooth operation in an economical package.



Typical Ironcore Positioner Cogging Forces



Cogging forces with Parker Trilogy's patent-pending Anti-Cog Technology



PERFORMANCE

ENCODER		LINEAR MAGNETIC ENCODER		RENISHAW OPTICAL ENCODER		
		1.0 µm	5.0 µm	0.5 µm	1.0 µm	5.0 µm
Part Number Designator		A	B	M	L	Q
Encoder Model		LME1	LME5	RGH24Z	RGH24X	RGH24D
Peak Velocity	m/s [in/s]	2.5 [100]	7 [275]	3 [120]	5 [200]	5 [200]
Resolution	µm [in]	1.0 [0.00004]	5.0 [0.0002]	0.5 [0.00002]	1.0 [0.00004]	5.0 [0.0002]
Repeatability	µm [in]	±2.0 [±0.00008]	±10.0 [±0.0004]	±1.5 [±0.00006]	±2.0 [±0.00008]	±10.0 [±0.0004]
Accuracy - LME		±(25 µm + 50 µm/m)	±(30 µm + 50 µm/m)			
Accuracy - Renishaw				±(5 µm + 30 µm/m)		±(10 µm + 30 µm/m)

Note: For travels less than 1 meter, accuracy should be calculated at 1 meter

MOTOR MODEL		R07-1	R07-2	R07-3
Peak Force	N	587	1174	1761
	lb	132	264	396
Continuous Force	N	154	308	462
	lb	35	69	104
Peak Power	W	3600	7200	10800
Continuous Power	W	180	360	540

ACCURACY

	< 1 meter	> 1 meter
Base Length	< 1 meter	> 1 meter
Straightness restrained on a flat surface µm [in]	±127µm/m [±0.000127 in/in]	±127µm/m [±0.000127 in/in]
Flatness restrained on a flat surface µm [in]	±330 [±0.013]	±76 + 254µm/m [±0.003 +.000254 in/in]

Note: Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005 in/ft

PHYSICAL

COIL SIZE		-1	-2	-3
Carriage Assembly				
TR07	kg [lb]	3.5 [7.7]	6.3 [13.9]	9.1 [19.9]
BR07	kg [lb]	3.6 [7.9]	6.5 [14.2]	9.3 [20.4]
Base Assembly (0.375" thick aluminum)				
TR07A	kg/mm [lb/in]	0.0128 [0.714]	------------------>	---------------------->
BR07A	kg/mm [lb/in]	0.0131 [0.733]	------------------>	---------------------->
Base Assembly (0.500" thick aluminum)				
TR07B	kg/mm [lb/in]	0.0141 [0.791]	------------------->	----------------------->
BR07B	kg/mm [lb/in]	0.0145 [0.810]	------------------->	----------------------->

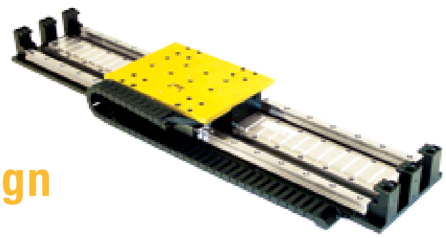
LOAD (Recommended)

COIL SIZE		-1	-2	-3
Vertical (Fv) see note 4	kg [lb]	100 [220]	150 [330]	200 [440]
Side (Fs) see note 4	kg [lb]	50 [110]	75 [165]	100 [220]
Moments-Roll (Mr) see note 4	N-m [lb-ft]	50 [37]	75 [55]	100 [74]
Moments-Pitch (Mp) see note 4	N-m [lb-ft]	100 [74]	250 [184]	400 [295]
Moments-Yaw (My) see note 4	N-m [lb-ft]	100 [74]	250 [184]	400 [295]

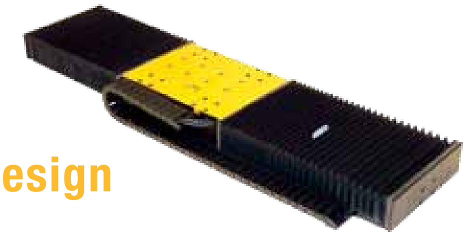
NOTES

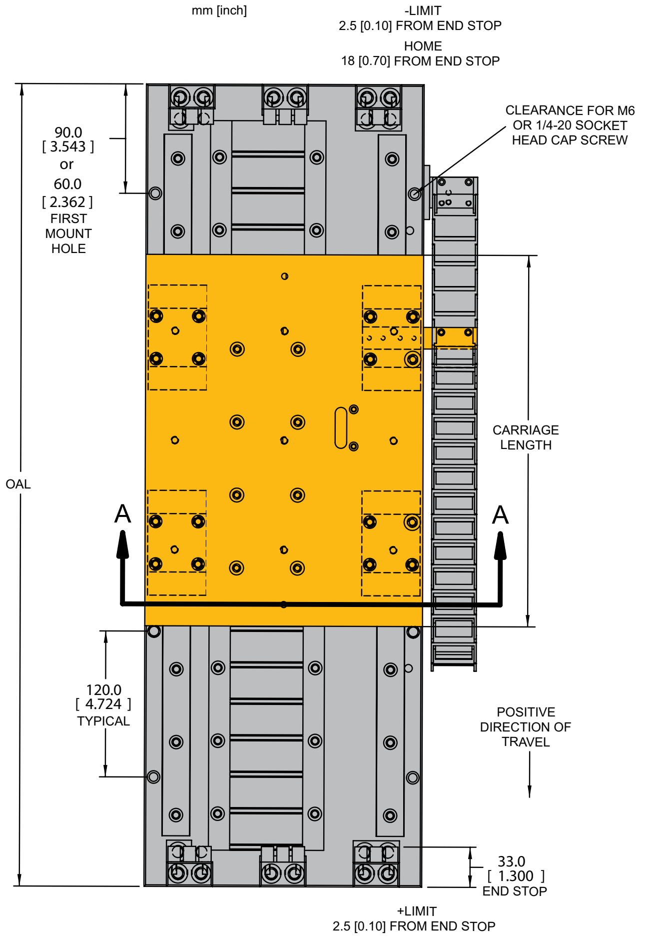
1. Maximum base length is 3040 mm (limited by maximum single piece bearing rail).
2. Refer to R07 motor data sheet for complete motor specifications.
3. Motor force must be derated by 50% in a "stalled motor" operating condition.
4. Recommended loads based on motor size and typical performance requirements (consult factory if desired loads are greater).
5. Specifications subject to change without notice. Most current brochure available online in PDF format.
6. Refer to website for Ironcore Motor Safe Handling and Cautionary guidelines.

TR10
open design

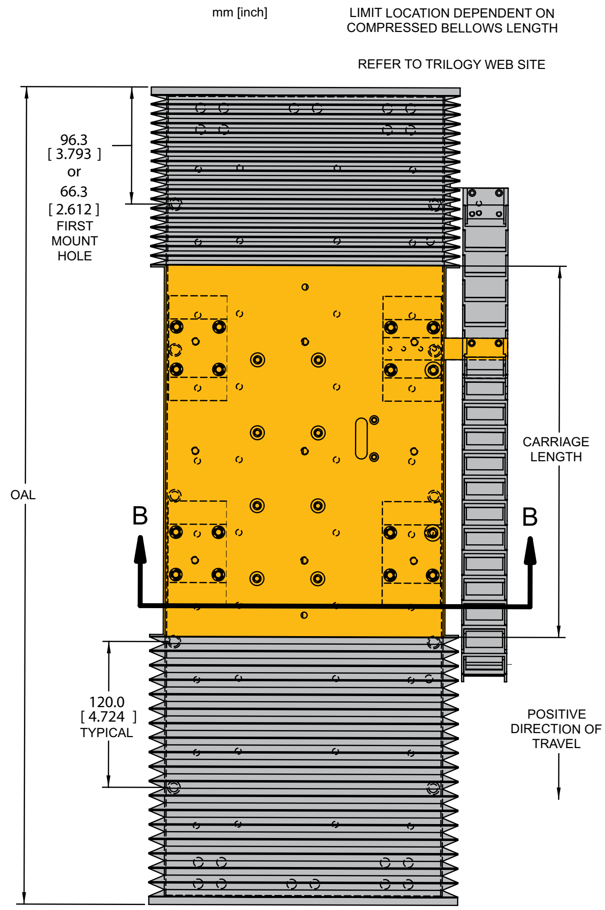


BR10
bellows design

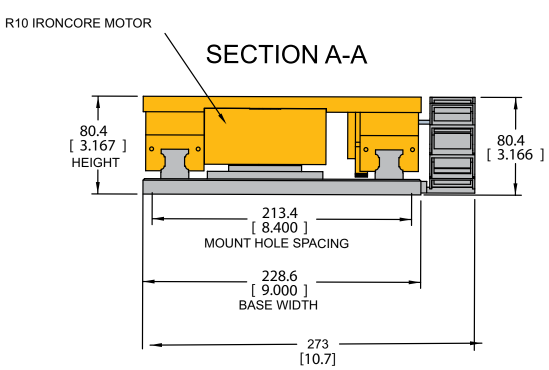


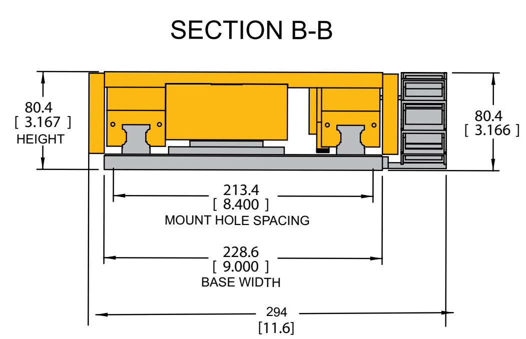


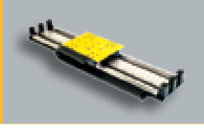
TRAVEL (mm) = OAL - 66.0 - CARRIAGE LENGTH
OVERALL LENGTH (OAL) = MULTIPLE OF 60 mm UP TO 4080 mm



REFER TO TRILOGY WEB SITE FOR TRAVEL
BASE LENGTH = MULTIPLE OF 60 mm UP TO 4080 mm
OAL = BASE LENGTH + 12.7 mm



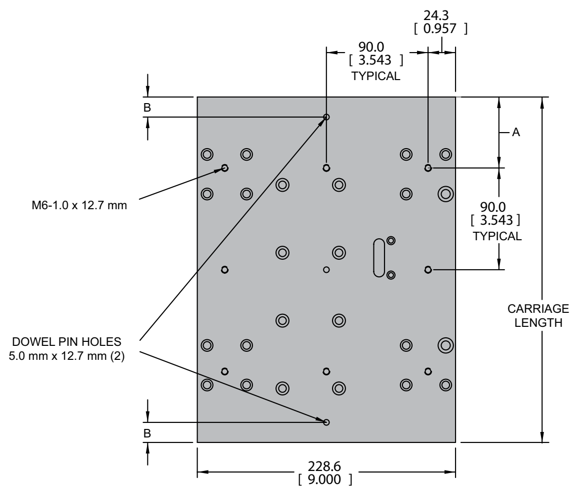




OVERALL WIDTH (OAW)			
IGUS CABLE TRACK	PART NO. DESIGNATOR	TR10 mm [in]	BR10 mm [in]
07-20-18	Custom	263 [10.4]	284 [11.2]
07-30-18	3	273 [10.7]	294 [11.6]
07-40-18	Custom	283 [11.1]	304 [12.0]
07-50-18	Custom	293 [11.5]	314 [12.4]
07-64-18	Custom	307 [12.1]	328 [12.9]

CARRIAGE LENGTH			
COIL SIZE	-1	-2	-3
TR10/BR10 CARRIAGE	305.5 [12.027]	545.5 [21.475]	785.5 [30.924]
A (1st MOUNT HOLE)	62.7 [2.470]	47.7 [1.879]	77.7 [3.060]
NUMBER OF MOUNTING HOLES	9	18	24
B (DOWEL PIN HOLE)	17.7 [0.699]	92.7 [3.651]	212.7 [8.375]

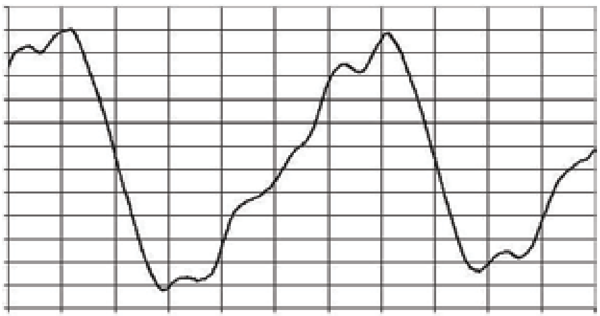
TR10/BR10 CARRIAGE



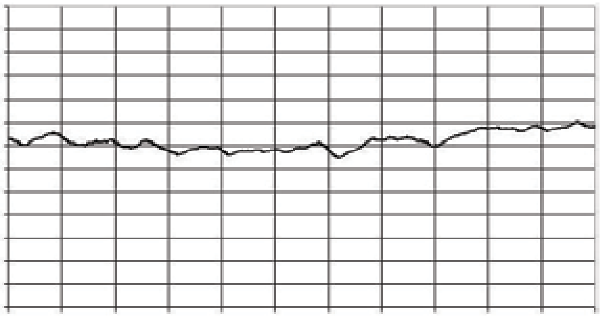
Smooth operation with Anti-Cogging features –

Parker Trilogy's RIPPED Series Ironcore Positioners utilize Parker's patent pending Anti-Cogging techniques for superior smoothness. Traditional ironcore motors exhibit cogging forces when the internal iron laminations exhibit a horizontal force on the motor when trying to line up with their "preferred" positions over the magnets. Cogging limits the overall smoothness of the motion system.

Parker Trilogy has developed an Anti-Cogging technological breakthrough that virtually eliminates cogging and allows ironcore motors to be used in applications where only ironless motors were used before. This offers the user a powerful combination of extremely high force and smooth operation in an economical package.



Typical Ironcore Positioner Cogging Forces



Cogging forces with Parker Trilogy's patent-pending Anti-Cog Technology

TR10 Specifications

PERFORMANCE

ENCODER		LINEAR MAGNETIC ENCODER		RENISHAW OPTICAL ENCODER		
		1.0 µm	5.0 µm	0.5 µm	1.0 µm	5.0 µm
Part Number Designator		A	B	M	L	Q
Encoder Model		LME1	LME5	RGH24Z	RGH24X	RGH24D
Peak Velocity	m/s [in/s]	2.5 [100]	7 [275]	3 [120]	5 [200]	5 [200]
Resolution	µm [in]	1.0 [0.00004]	5.0 [0.0002]	0.5 [0.00002]	1.0 [0.00004]	5.0 [0.0002]
Repeatability	µm [in]	±2.0 [±0.00008]	±10.0 [±0.0004]	±1.5 [±0.00006]	±2.0 [±0.00008]	±10.0 [±0.0004]
Accuracy - LME		±(25 µm + 50 µm/m)	±(30 µm + 50 µm/m)			
Accuracy - Renishaw				±(5 µm + 30 µm/m)		±(10 µm + 30 µm/m)

Note: For travels less than 1 meter, Accuracy should be calculated at 1 meter

MOTOR MODEL		R10-1	R10-2	R10-3
Peak Force	N	1366	2731	4097
	lb	307	614	921
Continuous Force	N	374	747	1121
	lb	84	168	252
Peak Power	W	6098	12196	18294
Continuous Power	W	305	610	915

ACCURACY

Base Length	< 1 meter	> 1 meter
Straightness restrained on a flat surface µm [in]	±127µm/m [±0.000127 in/in]	±127µm/m [±0.000127 in/in]
Flatness restrained on a flat surface µm [in]	±330 [±0.013]	±76 + 254µm/m [±0.003 + .000254 in/in]

Note: Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005 in/ft

PHYSICAL

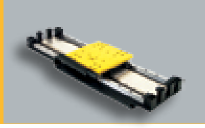
COIL SIZE		-1	-2	-3
Carriage Assembly				
TR10	kg [lb]	9.5 [20.9]	17.1 [37.5]	24.6 [54.2]
BR10	kg [lb]	9.7 [21.3]	17.4 [38.2]	25.1 [55.2]
Base Assembly (0.500" thick aluminum)				
TR10B	kg/mm [lb/in]	0.0186 [1.042]	------------------>	---------------------->
BR10B	kg/mm [lb/in]	0.0194 [1.084]	------------------>	---------------------->

LOAD (Recommended)

COIL SIZE		-1	-2	-3
Vertical (Fv) see note 4	kg [lb]	200 [440]	250 [550]	300 [660]
Side (Fs) see note 4	kg [lb]	100 [220]	125 [275]	150 [330]
Moments-Roll (Mr) see note 4	N-m [lb-ft]	100 [74]	125 [92]	150 [111]
Moments-Pitch (Mp) see note 4	N-m [lb-ft]	200 [148]	400 [295]	600 [443]
Moments-Yaw (My) see note 4	N-m [lb-ft]	200 [148]	400 [295]	600 [443]

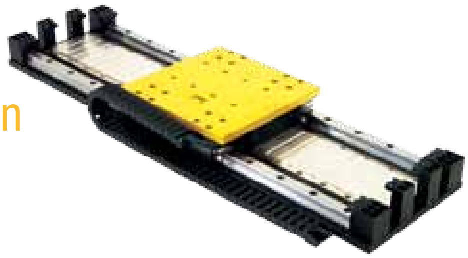
NOTES

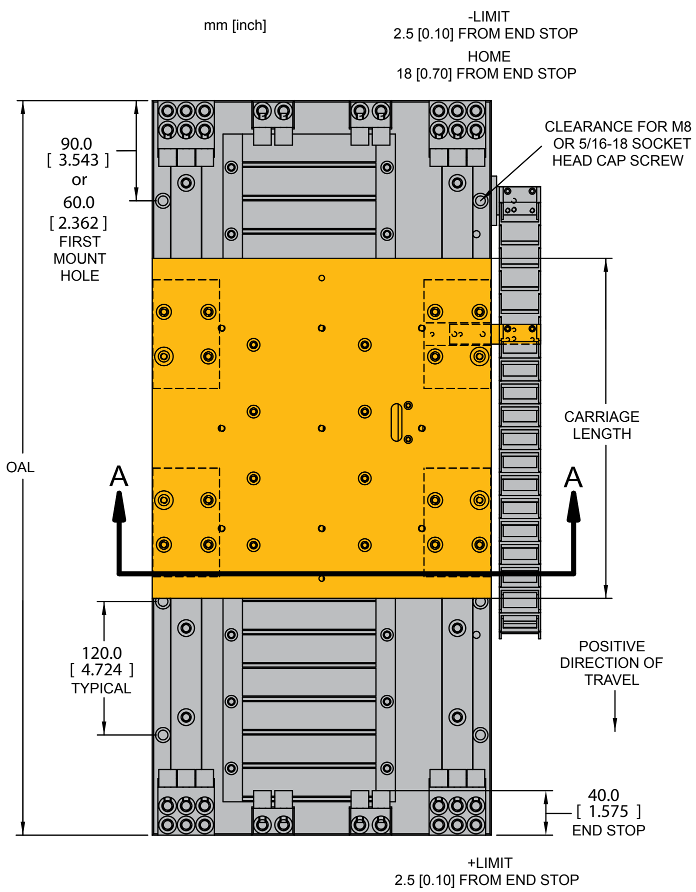
1. Maximum base length is 3040 mm (limited by maximum single piece bearing rail).
2. Refer to R10 motor data sheet for complete motor specifications.
3. Motor force must be derated by 50% in a "stalled motor" operating condition.
4. Recommended loads based on motor size and typical performance requirements (consult factory if desired loads are greater).
5. Specifications subject to change without notice. Most current brochure available online in PDF format.
6. Refer to website for Ironcore Motor Safe Handling and Cautionary guidelines.



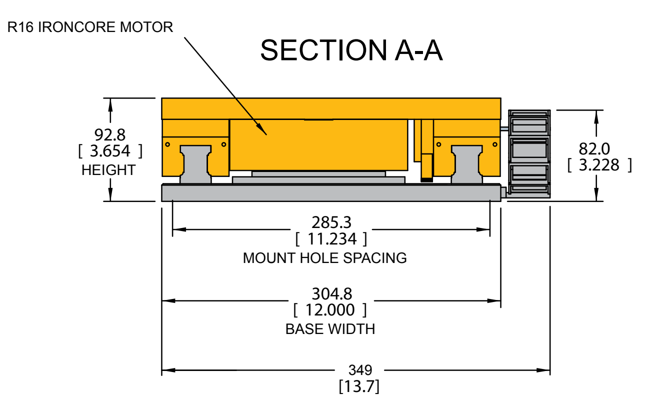
TR16

open design



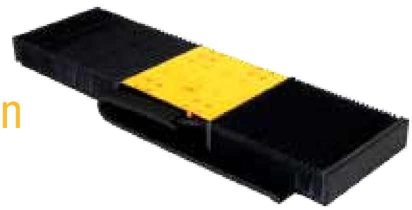


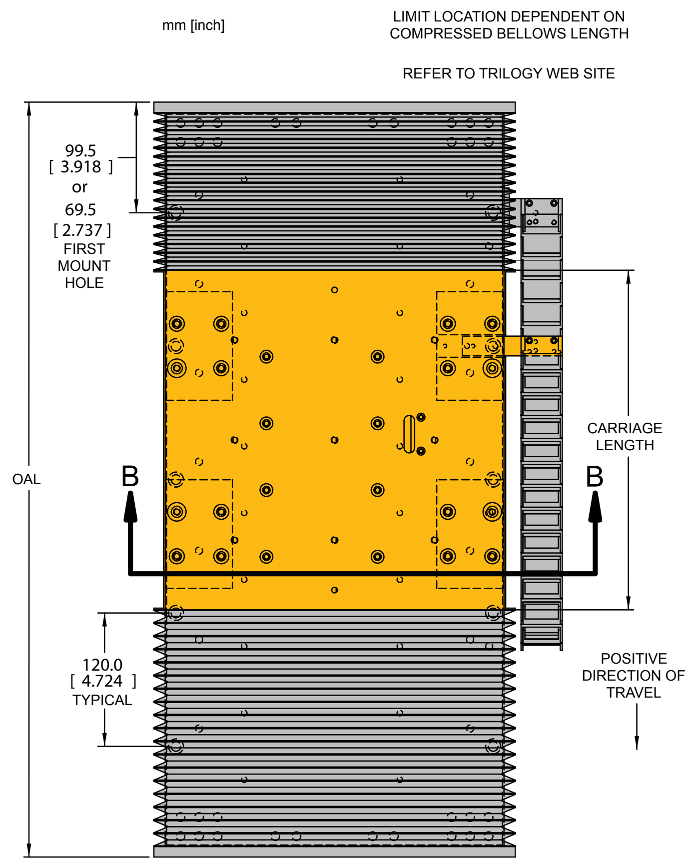
TRAVEL (mm) = OAL - 80.0 - CARRIAGE LENGTH
OVERALL LENGTH (OAL) = MULTIPLE OF 60 mm UP TO 4080 mm



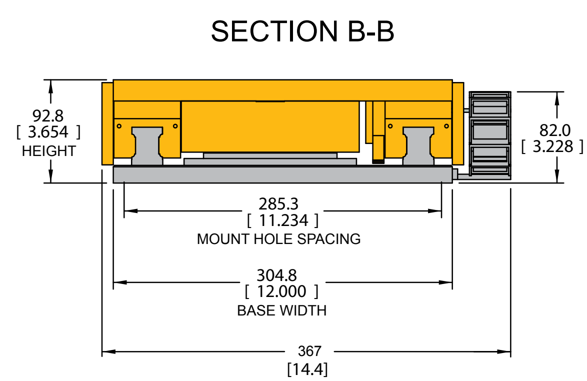
BR16

bellows design





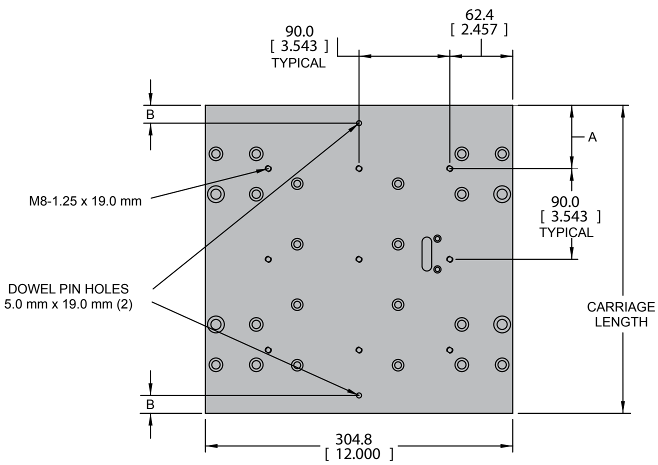
REFER TO TRILOGY WEB SITE FOR TRAVEL
BASE LENGTH = MULTIPLE OF 60 mm UP TO 4080 mm
OAL = BASE LENGTH + 19.1 mm



OVERALL WIDTH (OAW)			
IGUS CABLE TRACK	PART NO. DESIGNATOR	TR16 mm [in]	BR16 mm [in]
07-20-18	Custom	339 [13.3]	357 [14.1]
07-30-18	3	349 [13.7]	367 [14.4]
07-40-18	Custom	359 [14.1]	377 [14.8]
07-50-18	Custom	369 [14.5]	387 [15.2]
07-64-18	Custom	383 [15.1]	401 [15.8]

CARRIAGE LENGTH			
COIL SIZE	-1	-2	-3
TR16/BR16 CARRIAGE	305.5 [12.027]	545.5 [21.475]	785.5 [30.924]
A (1st MOUNT HOLE)	62.7 [2.470]	47.7 [1.879]	77.7 [3.060]
NUMBER OF MOUNTING HOLES	9	18	24
B (DOWEL PIN HOLE)	17.7 [0.698]	92.7 [3.651]	212.7 [8.375]

TR16/BR16 CARRIAGE



Smooth operation with Anti-Cogging features –

Parker Trilogy's RIPPED Series Ironcore Positioners utilize Parker's patent pending Anti-Cogging techniques for superior smoothness. Traditional ironcore motors exhibit cogging forces when the internal iron laminations exhibit a horizontal force on the motor when trying to line up with their "preferred" positions over the magnets. Cogging limits the overall smoothness of the motion system.

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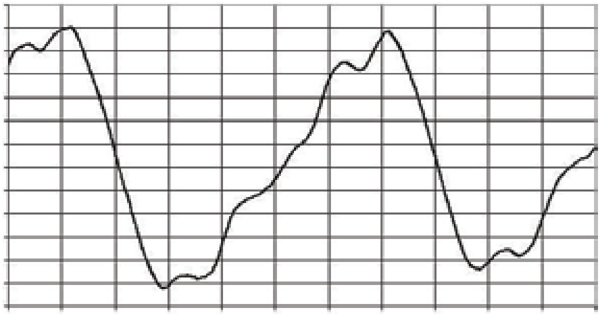
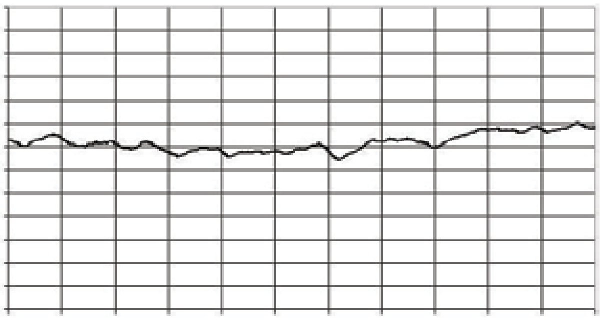


Typical Ironcore Positioner Cogging Forces



Cogging forces with Parker Trilogy's patent-pending Anti-Cog Technology

PERFORMANCE

ENCODER		LINEAR MAGNETIC ENCODER		RENISHAW OPTICAL ENCODER		
		1.0 µm	5.0 µm	0.5 µm	1.0 µm	5.0 µm
Part Number Designator		A	B	M	L	Q
Encoder Model		LME1	LME5	RGH24Z	RGH24X	RGH24D
Peak Velocity	m/s [in/s]	2.5 [100]	7 [275]	3 [120]	5 [200]	5 [200]
Resolution	µm [in]	1.0 [0.00004]	5.0 [0.0002]	0.5 [0.00002]	1.0 [0.00004]	5.0 [0.0002]
Repeatability	µm [in]	±2.0 [±0.00008	±10.0 [±0.0004]	±1.5 [±0.00006]	±2.0 [±0.00008]	±10.0 [±0.0004]
Accuracy - LME		±(25 µm + 50 µm/m)	±(30 µm + 50 µm/m)			
Accuracy - Renishaw					±(5 µm + 30 µm/m)	±(10 µm + 30 µm/m)

Note: For travels less than 1 meter, Accuracy should be calculated at 1 meter

MOTOR MODEL		R16-1	R16-2	R16-3
Peak Force	N	2478	4955	7433
	lb	557	1114	1671
Continuous Force	N	743	1487	2230
	lb	167	334	501
Peak Power	W	7065	14130	21195
Continuous Power	W	353	707	1060

ACCURACY

	< 1 meter	> 1 meter
Base Length	< 1 meter	> 1 meter
Straightness restrained on a flat surface µm [in]	±127µm/m [±0.000127 in/in]	±127µm/m [±0.000127 in/in]
Flatness restrained on a flat surface µm [in]	±330 [±0.013]	±76 + 254µm/m [±0.003 + .000254 in/in]

Note: Straightness/Flatness specifications based on system mounted to surface of flatness ±0.0005 in/ft

PHYSICAL

COIL SIZE		-1	-2	-3
Carriage Assembly				
TR16	kg [lb]	14.1 [31.0]	24.7 [54.4]	35.3 [77.7]
BR16	kg [lb]	14.3 [31.5]	25.0 [55.1]	35.8 [78.8]
Base Assembly (0.625" thick aluminum)				
TR16E	kg/mm [lb/in]	0.0318 [1.778]	------------------>	--------------------->
BR16E	kg/mm [lb/in]	0.0327 [1.825]	------------------>	--------------------->

LOAD (Recommended)

COIL SIZE		-1	-2	-3
Vertical (Fv) see note 4	kg [lb]	250 [550]	350 [770]	450 [990]
Side (Fs) see note 4	kg [lb]	125 [275]	175 [385]	225 [495]
Moments-Roll (Mr) see note 4	N-m [lb-ft]	125 [92]	175 [129]	225 [166]
Moments-Pitch (Mp) see note 4	N-m [lb-ft]	250 [184]	500 [369]	750 [553]
Moments-Yaw (My) see note 4	N-m [lb-ft]	250 [184]	500 [369]	750 [553]

NOTES

1. Maximum base length is 3040 mm (limited by maximum single piece bearing rail).
2. Refer to R16 motor data sheet for complete motor specifications.
3. Motor force must be derated by 50% in a "stalled motor" operating condition.
4. Recommended loads based on motor size and typical performance requirements (consult factory if desired loads are greater).
5. Specifications subject to change without notice. Most current brochure available online in PDF format.
6. Refer to website for Ironcore Motor Safe Handling and Cautionary guidelines.

How to order - TR07

Order Example:

TR	07	A	0480	3	N	S	B	A	B	3

Series
- **TR** = Open Positioner
- **BR** = Bellows Positioner

Motor Coil Series
- **07** = R07 Motor Coil

Base Material
- **A =** 3/8" Al

Length of Base
- **XXXX** = Length of base In millimeters

Min.: 400mm
Increment: 80mm
Max.: 3040mm

*Base Length = Travel + 76.2 + Carriage length
carriage length 1 pole = 218.2 mm
2 pole = 378.2 mm
3 pole = 536.2 mm
Tr only, consult factory for BR length

Coil Size
- **1** = 1 pole
- **2** = 2 pole
- **3** = 3 pole

Cooling
- **N =** None

Winding
- **S** Series
- **P** Parallel (2-pole coil only)
- **T** Triple (3-pole coil only)

Encoder
- **A =** LME 1 um
- **B =** LME 5 um
- **Q =** Renishaw 5 um
- **L =** Renishaw 1 u=m
- **M =** Renishaw 0.5 um
- **P =** Renishaw 0.1 um
- **R =** Renishaw lV p-p sine/ cosine
- **X** = None

Cable length
- **A =** 1 Meter Flying Leads
- **B =** 3 Meter Flying Leads
- **C =** 7.5 Meter Flying Leads
- **L =** 3 Extension Cables (with Connector Box)
- **M =** 7.5 Extension Cables (with Connector Box)
- **Z =** Connector Box ONLY (no extension cables)

**Flying leads – cable measured from last cable carrier link
*Extension Cables – cable measured from connection box at end of base
*7.5 Meter Flying Lead Cables available on:
All bases with LME encoder
All bases with Renishaw encoder under 2184mm
For bases with Renishaw encoder over 2184mm the cable length (CL) will be
CL = 10M - (base length in meters + 0.3M)

Cable Connectorization
- A = Aries
- B = Flying Leads
- C = Compax3
- G = Gemini
- V = ViX
- Z = no Cable

*Connectorized cables only available with Connector Box

Cable track
- 0 = None
- 3 = Std.

Order Example:

TR	10	B	0480	3	N	S	B	A	B	3

Series

TR = Open Positioner

BR = Bellows Positioner

Motor Coil Series

10 = R10 Motor Coil

Base Material

B = 1/2” Al

Length of Base

XXXX = Length of base In millimeters

Max.: 3040mm
Min.: 480mm
Increment: 60mm

*Base Length = Travel + 66 + Carriage length
carriage length 1 pole = 305.5 mm
2 pole = 545.5 mm
3 pole = 785.5 mm
Tr only, consult factory for BR length

Coil Size

1 = 1 pole

2 = 2 pole

3 = 3 pole

Cooling

N = None

Winding

S Series

P Parallel (2-pole coil only)

T Triple (3-pole only)

Encoder

A = LME 1 um

B = LME 5 um

Q = Renishaw 5 um

L = Renishaw 1 um

M = Renishaw 0.5 um

P = Renishaw 0.1 um

R = Renishaw 1 IV p-p sine/cosine

X = None

Cable length

A = 1 Meter Flying Leads

B = 3 Meter Flying Leads

C = 7.5 Meter Flying Leads

L = 3 Extension Cables (with Connector Box)

M = 7.5 Extension Cables (with Connector Box)

Z = Connector Box ONLY (no extension cables)

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Cable Connectorization

A = Aries

B = Flying Leads

C = Compax3

G = Gemini

V = ViX

Z = no Cable

*Connectorized cables only available with Connector Box

Cable track

0 = None

3 = Std.

How to order - TR16

Order Example:

TR	16	A	0480	3	N	S	B	A	B	3

Series
TR = Open Positioner
BR = Bellows Positioner

Motor Coil Series
16 = R16 Motor Coil

Base Material
A = 5/8” Al

Length of Base
XXXX = Length of base In millimeters
Max.: 3040mm
Min.: 480mm
Increment: 60mm

*Base Length = Travel + 80 + Carriage length
carriage length 1 pole = 305.5 mm
2 pole = 545.5 mm
3 pole = 785.5 mm
Tr only, consult factory for BR length

Coil Size
1 = 1 pole
2 = 2 pole
3 = 3 pole

Cooling
N = None

Winding
S Series
P Parallel (2-pole coil only)
T Triple (3-pole coil only)

Encoder
A = LME 1 um
B = LME 5 um
Q = Renishaw 5 um
L = Renishaw 1 um
M = Renishaw 0.5 um
P = Renishaw 0.1 um
R = Renishaw IV p-p sine/cosine
X = None

Cable length
A = 1 Meter Flying Leads
B = 3 Meter Flying Leads
C = 7.5 Meter Flying Leads
L = 3 Extension Cables (with Connector Box)
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Cable Connectorization
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V = ViX
Z = no Cable
*Connectorized cables only available with Connector Box

Cable track
0 = None
3 = Std.

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2. Payment: Payment shall be made by Buyer net 30 days from the date of delivery of the items purchased hereunder. Amounts not timely paid shall bear interest at the maximum rate permitted by law for each month or portion thereof that the Buyer is late in making payment. Any claims by Buyer for omissions or shortages in a shipment shall be waived unless Seller receives notice thereof within 30 days after Buyer's receipt of the shipment.

3. Delivery: Unless otherwise provided on the face hereof, delivery shall be made F.O.B. Seller's plant. Regardless of the method of delivery, however, risk of loss shall pass to Buyer upon Seller's delivery to a carrier. Any delivery dates shown are approximate only and Seller shall have no liability for any delays in delivery.

4. Warranty: Seller warrants that the items sold hereunder shall be free from defects in material or workmanship for a period of 12 months from date of shipment from Parker Daedal. THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO ITEMS PROVIDED HEREUNDER. SELLER MAKES NO OTHER WARRANTY, GUARANTEE, OR REPRESENTATION OF ANY KIND WHATSOEVER. ALL OTHER WARRANTIES, INCLUDING BUT NOT LIMITED TO, MERCHANTABILITY AND FITNESS FOR PURPOSE, WHETHER EXPRESS, IMPLIED, OR ARISING BY OPERATION OF LAW, TRADE USAGE, OR COURSE OF DEALING ARE HEREBY DISCLAIMED. NOTWITHSTANDING THE FOREGOING, THERE ARE NO WARRANTIES WHATSOEVER ON ITEMS BUILT OR ACQUIRED WHOLLY OR PARTIALLY, TO BUYER'S DESIGNS OR SPECIFICATIONS.

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6. Changes, Reschedules and Cancellations: Buyers may request to modify the designs or specifications for the items sold hereunder as well as the quantities and delivery dates thereof, or may request to cancel all or part of this order, however, no such requested modification or cancellation shall become part of the contract between Buyer and Seller unless accepted by Seller in a written amendment to this Agreement. Acceptance of any such requested modification of cancellation shall be at Seller's discretion, and shall be upon such terms and conditions as Seller may require.

7. Special Tooling: A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture items sold pursuant to this contract. Such special tooling shall be and remain Seller's property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller which is utilized in the manufacture of the items sold hereunder, even if such apparatus has been specially converted or adapted for such manufacture and not withstanding any charges paid by Buyer. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special tooling or other property in its sole discretion at any time.

8. Buyer's Property: Any designs, tools, patterns, materials, drawings confidential information or equipment furnished by Buyer, or any other items which become Buyer's property, may be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

9. Taxes: Unless otherwise indicated on the face hereof, all prices and charges are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale or delivery of the items sold hereunder. If any such taxes must be paid by Seller or if Seller is liable for the collection of such tax, the amount thereof shall be in addition to the amounts for the items sold. Buyer agrees to pay all such taxes or to reimburse Seller therefore upon receipt of its invoice. If Buyer claims exemption from any sales, use or other tax imposed by any taxing authority, Buyer shall save Seller harmless from and against any such tax, together with any interest or penalties thereon which may be assessed if the items are held to be taxable.

10. Indemnity For Infringement of Intellectual Property Rights: Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade dress, trade secrets or similar rights except as provided in this Part 10. Seller will defend and indemnify Buyer against allegations of infringement of U.S. patents, U.S. trademarks, copyrights, trade dress and trade secrets (hereinafter 'Intellectual Property Rights'). Seller will defend at its expense and will pay the cost of any settlement or damages awarded in an action brought against Buyer based on an allegation that an item sold pursuant to this contract infringes the Intellectual Property Rights of a third party. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If an item sold hereunder is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at its sole expense and option, procure for Buyer the right to continue using said item, replace or modify said item so as to make it non infringing, or offer to accept return of said item and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to items delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination or use in a system of any item sold hereunder. The foregoing provisions of this Part 10 shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual Property Right. If a claim is based on information provided by Buyer or if the design for an item delivered hereunder is specified in whole or in part by Buyer, Buyer shall defend and indemnify Seller for all costs, expenses or judgments resulting from any claim that such item infringes any patent, trademark, copyright, trade dress, trade secret or any similar right.

11. Force Majeure: Seller does not assume the risk of and shall not be liable for delay or failure to perform any of Seller's obligations by reason of circumstances beyond the reasonable control of Seller (hereinafter 'Events of Force Majeure'). Events of Force Majeure shall include without limitation, accidents, acts of God, strikes or labor disputes, acts, laws, rules or regulations of any government or government agency, fires, floods, delays or failures in delivery of carriers or suppliers, shortages of materials and any other cause beyond Seller's control.

12. Entire Agreement/Governing Law: The terms and conditions set forth herein, together with any amendments, modifications and any different terms or conditions expressly accepted by Seller in writing, shall constitute the entire Agreement concerning the items sold, and there are no oral or other representations or agreements which pertain thereto. This Agreement shall be governed in all respects by the law of the State of Ohio. No actions arising out of the sale of the items sold hereunder of this Agreement may be brought by either party more than two (2) years after the cause of action accrues.

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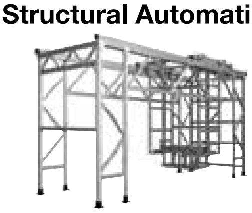

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