

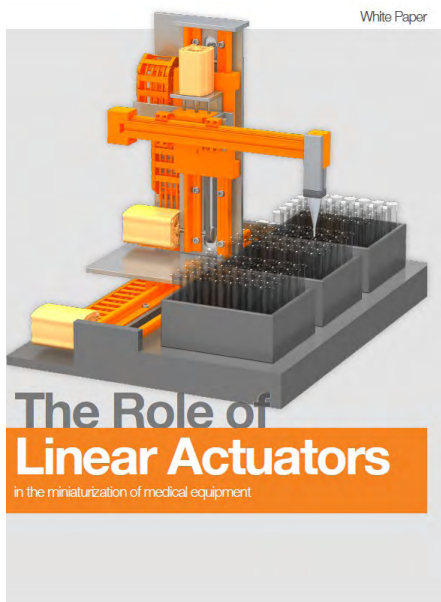
Bring increased precision to surgical robots with optimized lead screw assemblies

Surgical robotics is a booming industry that has steadily been gaining momentum for decades. Companies like Intuitive Surgical have achieved truly impressive feats with their industry-leading da Vinci robots. But that doesn't mean there are no challenges or hangups in designing these robots. Strict requirements regarding cleanliness, precision, maintenance needs, and more all have to be met to ensure patient safety and health.

An underused solution to help meet many of these needs is dryspin lead screw technology from igus. dryspin® assemblies are maintenance-free, highly precise – with 0.1mm of axial play in standard nuts, and 0.02mm in low-clearance nuts – and do not use any grease or oil for lubrication. Read on to discover more benefits of dryspin lead screws, and how they can further improve surgical robot design.



Lead screws in surgical robots



The Role of Linear Actuators

in the miniaturization of medical equipment

Lead screws are essential to surgical robots, translating the rotation of motors into precise linear motion. While a motor spins quickly to generate power, a lead screw uses its threads to push a mating nut forward or backward. This is what allows a robotic arm to extend and retract tools with sub-millimeter accuracy, or maneuver end-of-arm tooling within a surgical cavity.

The importance of lead screws to the overall design of a surgical robot lies in three key areas: miniaturization, safety, and sterilization.

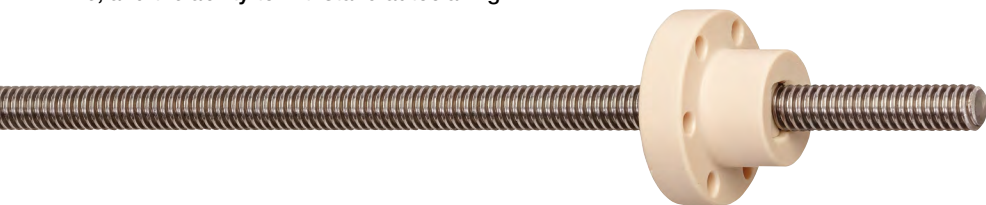
Miniaturization: Unlike ball screws, which require bulky internal channels for recirculating ball bearings, lead screws are incredibly simple and compact. igus can manufacture lead screws with diameters as small as 3mm. This smaller form factor allows surgical robots to be designed for tighter spaces and leaves more room within the operating area for doctors to move around.

Safety: Certain lead screws offer self-locking capability, meaning that the screw won't back drive under the weight of the application. This is essential for safety if the robot were to lose power, as it ensures the robot arm and any tooling will remain in place — avoiding potential harm to patients.

Sterilization: Surgical environments demand extreme cleanliness. This means surgical robots and their components must undergo extensive sterilization between operations. Lead screws that utilize self-lubricating polymer nuts can withstand processes such as autoclaving and chemical washdowns with no loss to performance or increase in maintenance needs, making them ideal for these strict environments.

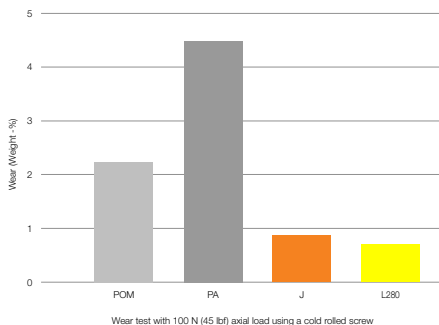
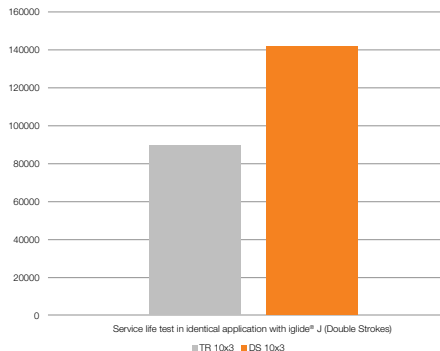
Unique advantages of dryspin lead screws

dryspin lead screws from igus, unlike many standard industrial lead screws, utilize dry-running plastic nuts rather than greased metal ones. This, along with the availability of a unique thread geometry, gives dryspin lead screws several unique advantages not possible with other lead screw types, such as maintenance-free operation, an extended and highly predictable service life, and the ability to withstand autoclaving.

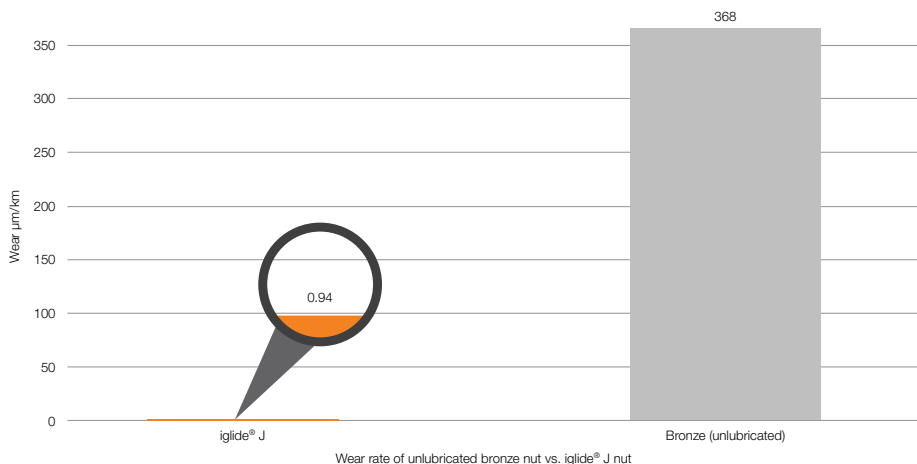


Maintenance-free operation: Many lead screw assemblies rely on greased metal nuts to operate smoothly. While this can be effective, it requires manual relubrication which can be time consuming and costly. Lubricants also present hygiene concerns, especially in surgical applications. dryspin lead screws are completely dry-running, eliminating the need for grease and maintenance efforts and ensuring hygienic operation.

Extended service life: No matter the application, the longer a solution can last the better. A long service life minimizes maintenance or replacement efforts, maximizes uptime, and improves reliability. Proprietary dryspin lead screws with high helix threads are able to achieve a 30% longer service life over other thread profiles due to an optimized wear surface.



The plastic nut material used in dryspin lead screw nuts also contributes to a longer service life due to its resistance to wear and minimal friction. Compared to both bronze nuts and other plastic nuts like POM and PA, optimized dryspin plastic nuts exhibit greatly decreased wear rates – sometimes as little as 0.2% of the wear of alternative materials.



Withstands autoclaving: dryspin assemblies are dry-running, meaning they do not rely on external lubricants or grease to operate. They are also resistant to moisture and corrosion. These are both major advantages in surgical robotics, as it eliminates the need to lubricate the assembly after each instance of autoclaving – a sanitization process that uses high-temperature, pressurized steam to disinfect equipment.

Design concerns

No matter the type of lead screw assembly used or where it is sourced from, there are universal design concerns that need to be kept in mind to ensure success within an application. These include the max RPM of the application, how the lead screw is supported at the ends, and the dimensions of the screw itself.

Maximum RPM

The biggest factor when talking about the speed of a lead screw application is its total RPM (rotations per minute). The ideal RPM of a lead screw assembly varies depending on both the lead of the screw and its thread profile.

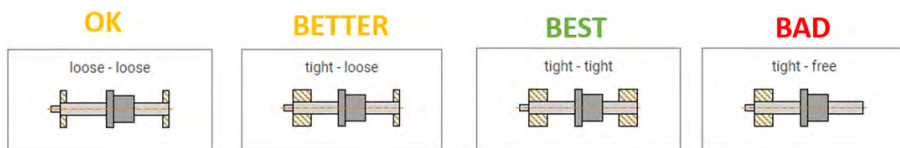
The lead of a screw is the distance traveled by the nut per rotation. This means as lead increases, RPM needs to decrease to maintain an identical speed. However, an increased lead will also increase drive torque.

The thread profile of a lead screw also needs to be taken into account, as different profiles will begin generating noise at different RPM. For trapezoidal and ACME screws, this is typically 150RPM. For dryspin high helix screws, 300RPM is the point at which noise can become a factor.

End support

There are three primary ways to secure the end of a lead screw: unsecured, meaning there is nothing supporting the screw; loose, where a simple bushing or bearing is used; and tight, where a clamp and ball bearing are used together. Understanding which methods are best suited for surgery robots will ensure successful operation and avoid poor performance that could potentially lead to patients being harmed.

Unsecured lead screws are almost never recommended for any application. An unsecured end can lead to whipping during operation, which results in extreme noise and a vastly reduced lifespan of the assembly. Even the slowest-moving and sturdiest assemblies can suffer from an unsecured end.



Loose = bushing/bearing
Tight = Clamp & ball bearing
Free = Nothing

Loosely secured lead screws use just a bushing for securing. This is better off for slow, hand-driven applications to avoid potential whipping due to clearance. However, even in these types of applications it is not always best to use loose securing.

Fixed securing uses a clamp and radial ball bearing to support the lead screw, leaving little-to-no clearance. This is ideal in motorized applications or any application where precision is key — such as surgical robotics.

Lead screw dimensions

Lead screw dimensions are a major factor in overall performance of a lead screw assembly. The length of the screw directly impacts the recommended diameter of the screw — designing an assembly outside of these recommendations can lead to deflection of the screw, causing increased noise and wear.

As a rule of thumb, lead screws should remain under 1,000mm in length if possible. Consult the table below for diameter recommendations for various lead screw lengths.

Lead Screw Length	Recommended Lead Screw Diameter
300mm–999mm	10mmØ+
1,000mm–1,499mm	18mmØ+
1,500mm–2,000mm	20mmØ+
>2,000mm	A different mechanism such as a belt drive may be needed.

Conclusion

The evolution of surgical robotics highlights a constant drive toward greater precision and reliability. As the industry continues to grow, the components powering these machines must meet increasingly rigorous standards for miniaturization, safety, and sterilization.

By utilizing dryspin lead screw technology, designers can overcome the traditional hangups of greased metal components. These assemblies provide a maintenance-free, hygienic solution that withstands the harsh conditions of autoclaving while offering a significantly extended service life. When paired with proper design considerations—such as fixed end supports and optimized screw dimensions—dryspin assemblies ensure that surgical robots maintain the sub-millimeter accuracy required for patient safety.

Ultimately, integrating high-performance, self-lubricating lead screws is an essential step in refining the next generation of surgical robots, ensuring they remain as precise and dependable as the surgeons who operate them.