

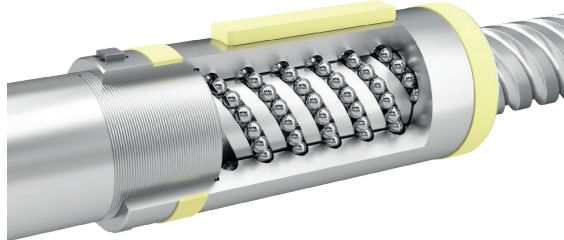


Ball screw drive versus planetary roller actuators

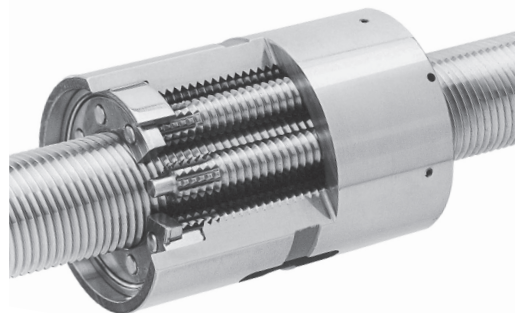


ENGINEERING YOUR SUCCESS.

Ball screw and planetary roller screw used for electro-mechanic cylinders



Ball screw drive



Planetary roller screw

It is not difficult to see: the nut of a ball screw drive is quite compact, while that of the planetary roller screw is quite voluminous.

Again and again the argument comes across that at planetary roller screw drives linear contact takes place between the rolling elements and the thread, whereas at the ball screw drive, there is only point contact (more precisely contact ellipse). And because the permissible surface pressure is almost the same for hardened steels, it is often concluded that electro-mechanic cylinders including a planetary roller screw has a higher load capacity. However, this is only partially true. And in the case of electro-mechanic cylinders, it is often FALSE!

In an electro-mechanic cylinder, the screw drive is typically enclosed by a profile. So it is not the diameter of the threaded rod that is decisive, but the outside diameter of the nut (which must fit into the enclosure). And because the planets need quite a lot more of space with the planetary roller screw drive, the threaded rod diameter must be smaller than the threaded rod diameter of a ball screw drive with the same outside nut diameter. The load capacity of a screw drive depends largely on its threaded rod diameter. Therefore the apparently obvious line contact advantage of the planetary roller drive is marginalized by the smaller thread rod diameter, sometimes even vice versa.

The load capacity of a screw drive is usually specified with the dynamic load rating, which is theoretically calculated using complicated formulas or also empirically determined. This so-called C_{dyn} is specified in unit [N] and means that the screw drive will experience 1 000 000 revolutions at exactly this axial load.

In the case of ball screw drives, the load rating depends on the number of rolling elements and disproportionately on their diameter (a ball twice as large gives about 4.3 times the load rating).

Parker ETH125M20 in detail



Below is a concrete comparison using the example of the Parker Hannifin ETH125M20 and comparable competitor cylinders:

ETH125M20 has a ball screw drive with 63 mm diameter and 20 mm pitch and may be loaded up to a maximum axial force of 114 kN according to the catalog.

However, this is not the load rating! We do not specify this in the catalog, since the load rating of 248 000 N could suggest that the cylinder can absorb this axial force. Rather, we specify a much more manageable size in the technical data table, namely the ETH125M20 has a life time of 2 500 km at 49 600 N average axial load. This is a point in the life time diagram, which can be found on the following pages in the catalog. If you now know that the axial force reciprocally influences the life time in a third power (double force corresponds to only one eighth of the service life), the dynamic load rating can be calculated using the rule of three:

49 600 N equals 2 500 km

Which axial force then results in 20 km (corresponding to 1 000 000 revolutions with a 20 mm pitch)?

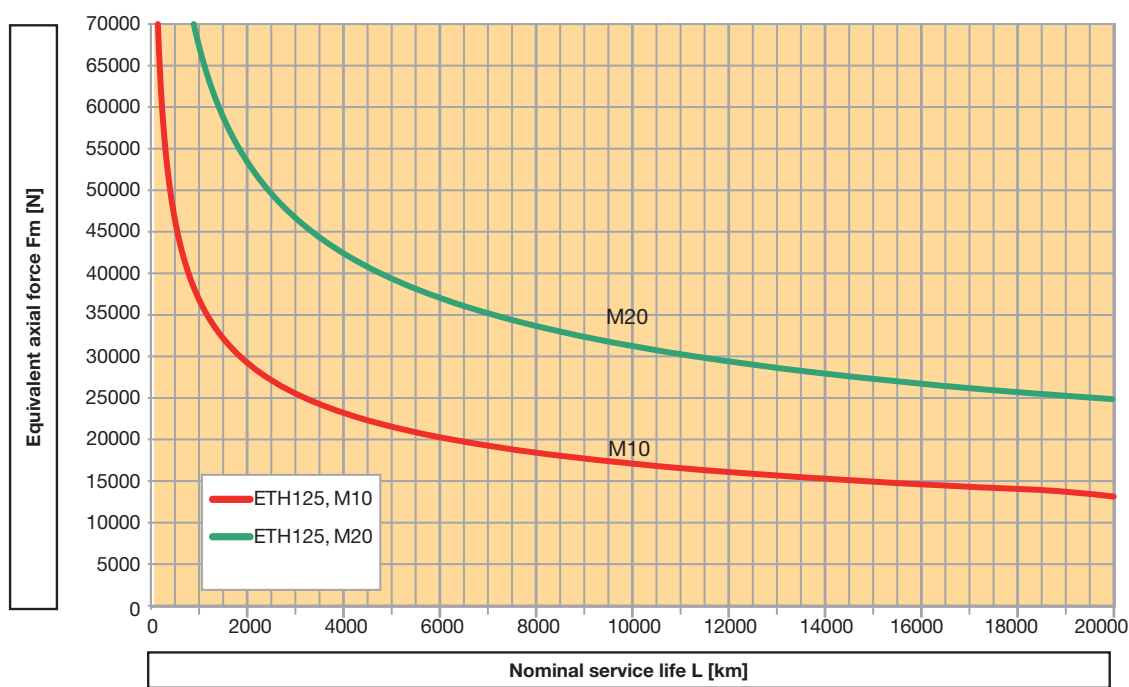
2 500 km is 125×20 km $\Rightarrow$ third root of 125 results in 5

$\Rightarrow$ dynamic load rating $49\,600\text{ N} \times 5 = 248\,000\text{ N}$.

In marketing terms, this large number would of course be much better than our catalog restriction of just 114 000 N (due to the fact that not only the ball screw drives into the maximum permissible axial force). In our opinion, it is also confusing and suggestive - we don't want that!

Calculation example ETH125M20 for service life:

With an average load of 30 000 N, a life time of approximately 11 300 km is determined. This can be done using C_{dyn} , the specification 2 500 km at 49 600 N or simply read from the diagram.



Incidentally, you can immediately see from this diagram that the 10 mm pitch has a considerably shorter life time, namely 1 851 km at 30 000 N, which is essentially due to the significantly smaller balls.

The supposedly „cheaper gear ratio“ with a pitch of 10 mm compared to 20 mm can usually be compensated by adjusting the gear ratio when using a gearbox.

Comparable roller screw cylinder

A cylinder with comparable outside dimensions is equipped with a planetary roller screw using a 48 mm diameter shaft, compared to the 63 mm diameter of the ETH125. Load rating of the planetary roller screw 48x10 (diameter x pitch) is 211 000 N

30 000 N average axial load is a factor of 0.142 from 211 000 N, reciprocal 7.033. As a result, the life time will be $7.033^3 \times 1\,000\,000$ revolutions, i.e. 3 480 km at 30 000 N average axial load.

By the way, the design of the same 125 size cylinder with ball screw drive and with a pitch of 20 mm the cylinder has a load rating of 130 800 N.

With an average axial load of 30 000 N, this results in $4.36^3 \times 1\,000\,000$ revolutions corresponding to 1 657 km.

Planetary roller screw cylinder with integrated servo motor

Looking on load rating values and outside dimensions of planetary roller screw equipped cylinders with integrated servo motors the mismatch of load rating and outside square size will be carried to extremes. Obviously the integration of the active parts of the motor into the cylinder body need additional installation space that results in a thinner threaded rod than used for a classical cylinder design with external servo motor.

An available cylinder with planetary roller screw and integrated servo motor has outside square dimensions of 177.8 mm at a dynamic load rating of 101 420 N at 12.7 mm pitch (=1/2").

At an average axial load of 30 000 N, the load rating value of 101 420 N represents factor 3.38 of 30 000 N average axial load. Therefore the calculated life time will be $3.38^3 \times 1\,000\,000$ revolutions or 491 km.

For comparison: The outside square dimensions of the ball screw equipped ETH125 cylinder with 20 mm pitch represents 150 mm at a load rating of 248 kN.

		Pitch	Load rating	Life time expectation @ 30kN
		[mm]	[kN]	[km]
Parker Hannifin ETH125M20	Ball screw	20	248	11 300
Comparable size 125 cylinder	Planetary roller screw	10	211	3 480
Cylinder with integr. motor	Planetary roller screw	12.7	101.4	491

Conclusion

The diameter of a planetary roller screw nut is larger than the outside diameter of a ball screw nut. Therefore electromechanic cylinders with the same outside (square) dimensions are equipped with thinner threaded rods when using planetary roller screws than they are using ball screws. This reduced diameter of the threaded rod marginalize the theoretical load rating advantage of the roller screw. Caused of the larger pitch available for ball screw equipped electromechanics cylinders, the life time expectation is even longer.

When searching for the right technology for your electric cylinder application have a detailed look into the load rating capabilities of the complete cylinder and don't trust only the physical basic characteristics of ball screw and planetary roller screw.

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About Parker

Parker designs and manufactures a broad array of linear actuators featuring a modular and therefore flexible structure. They reflect Parker's long practical experience in the field of handling technology. In addition, we have developed special solutions for various applications, such as clean-room applications, hasardous environments as well as food industry.

The mechanical components can be combined to create multi-axis systems with the aid of a range of attachments and accessories.

Parker is committed to helping make our customers more productive and more profitable through our global offering of motion and control products and systems.

For more information <http://www.parker.com>

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