Linear Actuators,
Lead Screws and Nuts

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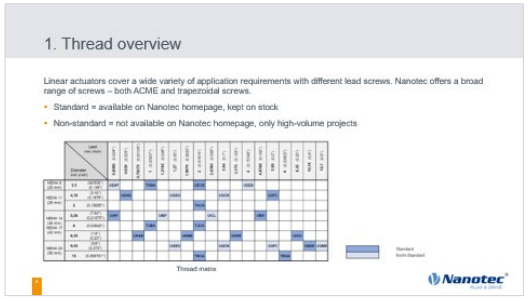
Overview

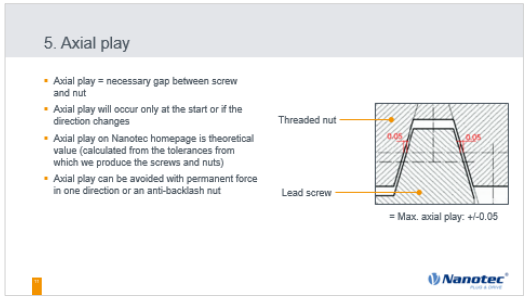


1. Thread overview

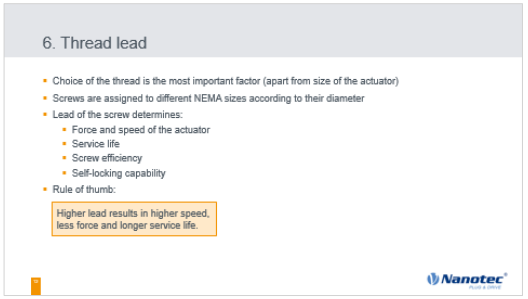
2. Linear actuators

3. Lead screws

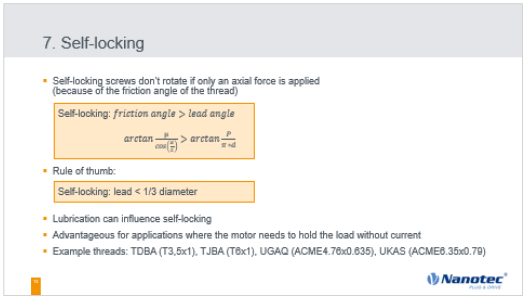
4. Threaded nuts



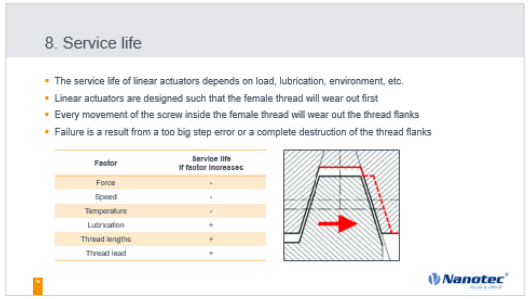
5. Axial play



6. Thread lead



7. Self-locking



8. Service life

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1. Thread overview

Linear actuators cover a wide variety of application requirements with different lead screws. Nanotec offers a broad range of screws – both ACME and trapezoidal screws.

- Standard = available on Nanotec homepage, kept on stock
- Non-standard = not available on Nanotec homepage, only high-volume projects

	Diameter mm (inch) / Lead mm (inch)		0,6096 (0,024")	0,635 (0,025")	0,79375 (0,03125")	1 (0,03937")	1,2192 (0,048")	1,27 (0,05")	1,5875 (0,0625")	2 (0,07874")	2,4384 (0,096")	2,54 (0,1")	3,175 (0,125")	4 (0,15748")	4,8768 (0,192")	5,08 (0,2")	6 (0,23622")	6,35 (0,25")	10,16 (0,4")	12,7 (0,5")
NEMA 8 (20 mm)	3,5	(69/500") (0,138")	UEAP			TDBA				UECB				UEEB						
NEMA 11 (28 mm)	4,76	(3/16") (0,1875")		UGAQ				UGBG				UGCN				UGFC				
	5	(0,19685")								THCA										
NEMA 14 (35 mm) NEMA 17 (42 mm)	5,56	(7/32") (0,21875")	UIAP				UIBF				UICL				UIEV					
	6	(0,23622")				TJBA				TJCA										
	6,35	(1/4") (0,25")			UKAS				UKBN				UKDE					UKGI		
NEMA 23 (56 mm)	9,53	(3/8") (0,375")						UQBG				UQCN				UQFC			UQKE	UQMS
	10	(0,393701")								TSCA							TSGA			

Standard
Nicht-Standard

Thread matrix

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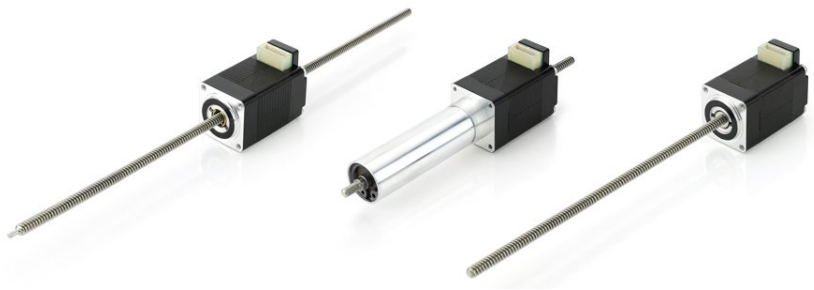
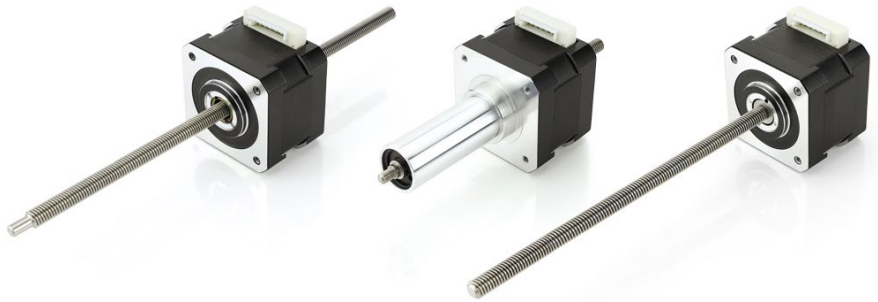
2. Linear actuators

NEMA 8



NEMA 17



NEMA 11

NEMA 23

NEMA 14

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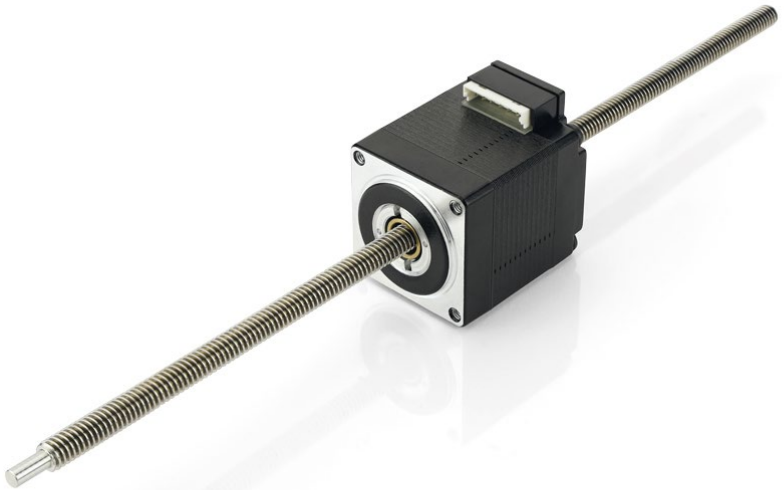
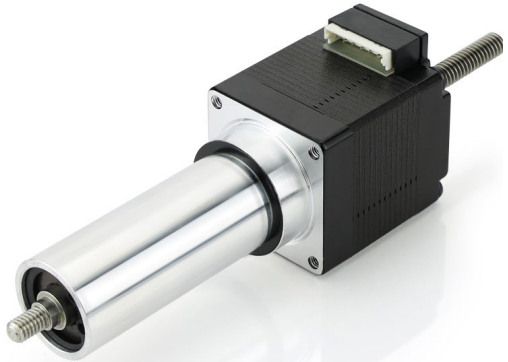
2.1 Types of linear actuators



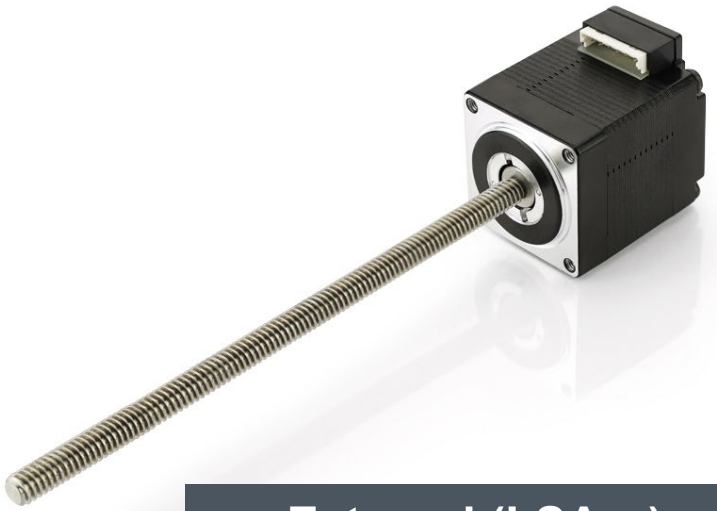
Non-captive (LA…)

- Customized screws
- Long strokes
- Anti-rotation / guidance of the screw required



Captive (LGA…)

- Easy and ready to use
- Strokes of up to 70 mm
- Anti-rotation built-in



External (LSA…)

- No traversing screw
- Compact design
- Anti-rotation / guidance of the nut required

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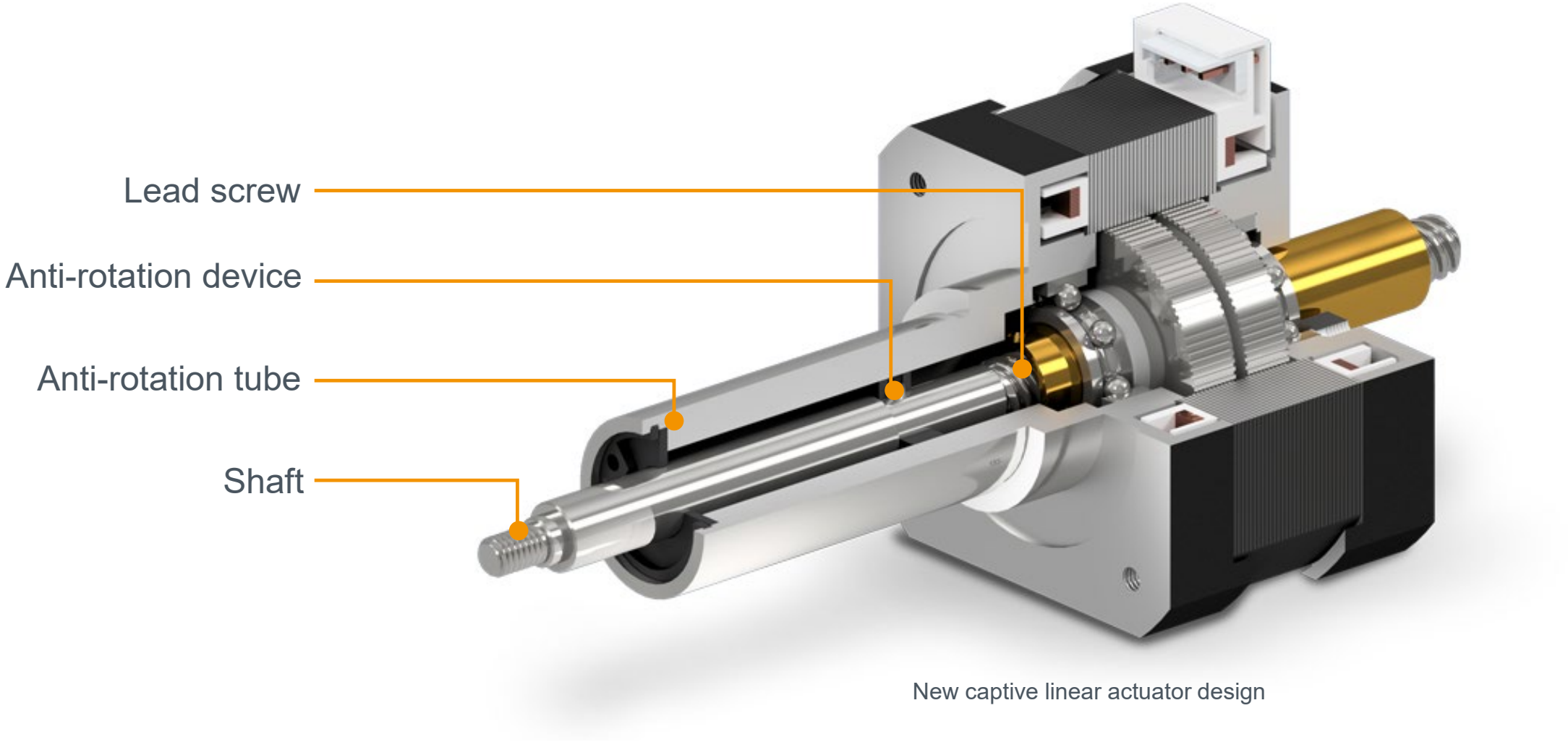
2.2 Design of linear actuators



New captive linear actuator design

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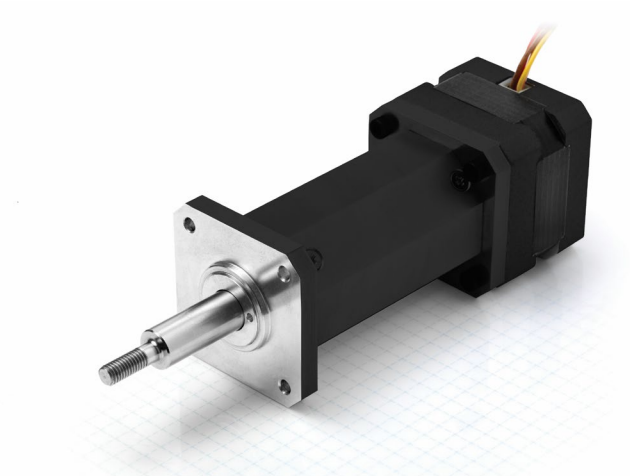
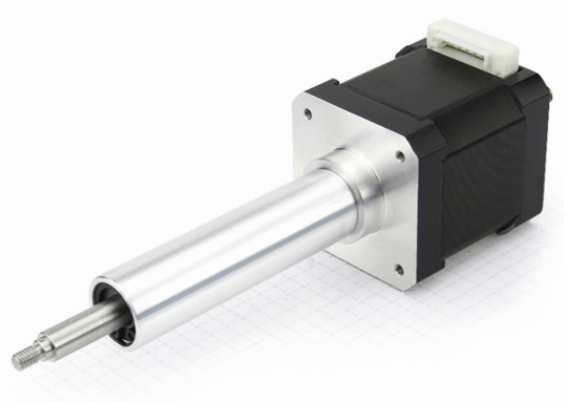
2.3 New line of linear actuators

- Better price
- About 20% more force / torque
- Connector instead of cable
- Available with or without second shaft
- More precise and compact
- Anti-rotation for captive linear actuators



Old captive linear actuator

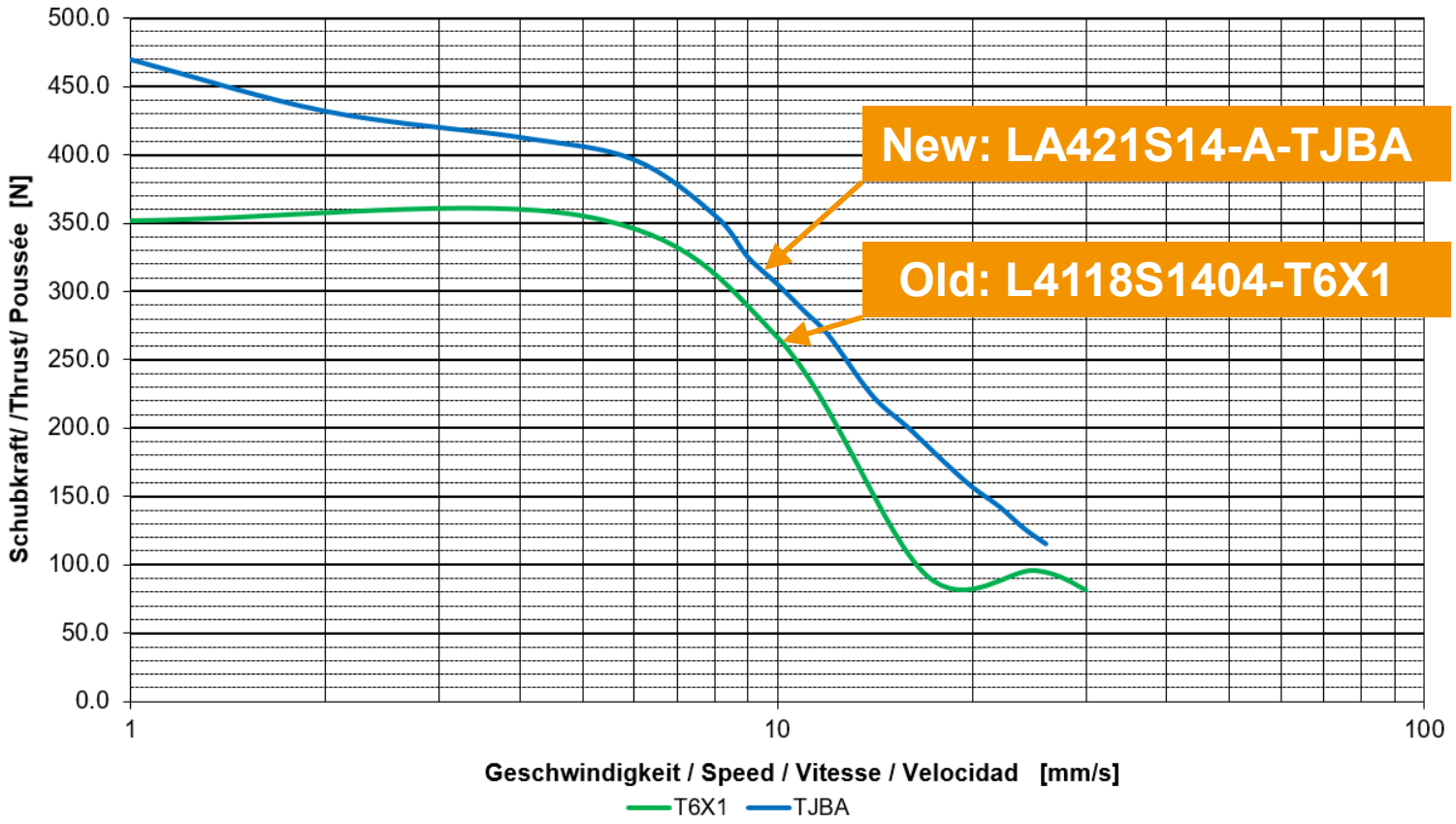


New captive linear actuator

Series	NEMA	Diameter [mm]	Lead [mm]	Resolution [µm/step]	Max. force [N]	Max. speed [mm/s]
20	8	3.50	0.61 – 4.00	3.0 – 20.0	Up to 46	Up to 60
28	11	4.76 – 5.00	0.635 – 5.08	3.2 – 25.4	Up to 210	Up to 100
42	17	5.56 – 6.35	0.79 – 6.35	4.0 – 31.8	Up to 470	Up to 100

2.4 Comparison of old and new linear actuators

- Linear actuator: NEMA 17, size S, 1.4 A per winding
- Thread = TJBA (T6x1)



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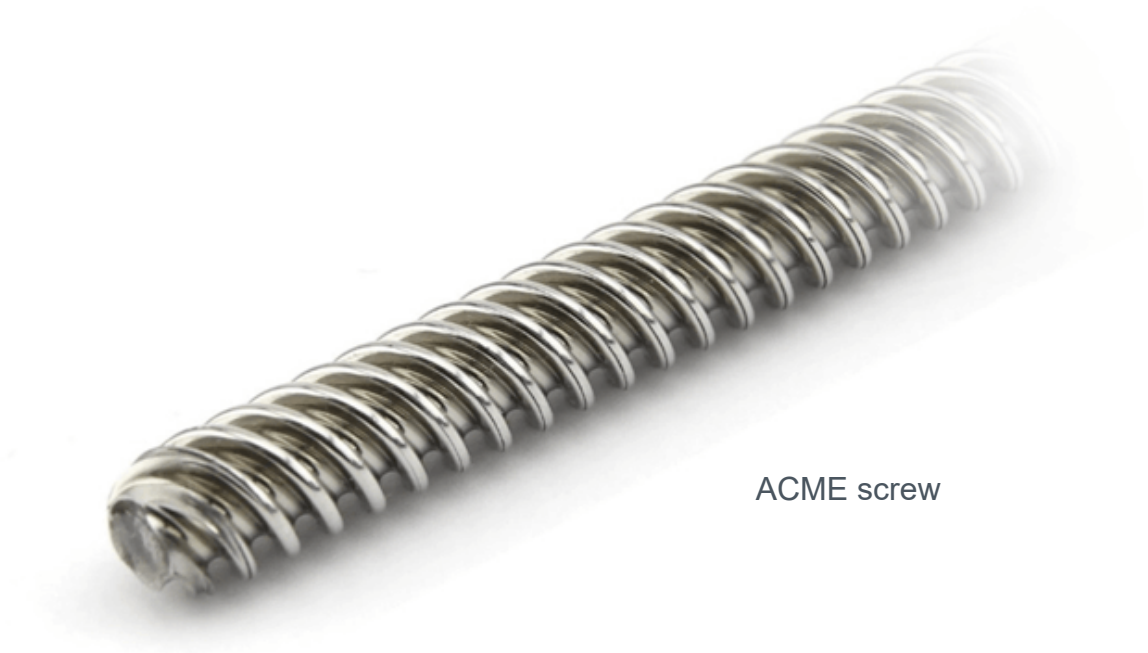
3. Lead screws

- Lead screws manufactured in China
- Better price
- More variety
- Better control over dimensions and quality
- DLC coating for high-volume projects possible (about +20% service life)



ACME screw

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4. Threaded nuts

- Change from PEEK to POM
- Better price
- Easier to manufacture
- Longer service life
- Less operating noise
- Less dust generation
- Anti-backlash nuts to reduce axial play

POM threaded nuts

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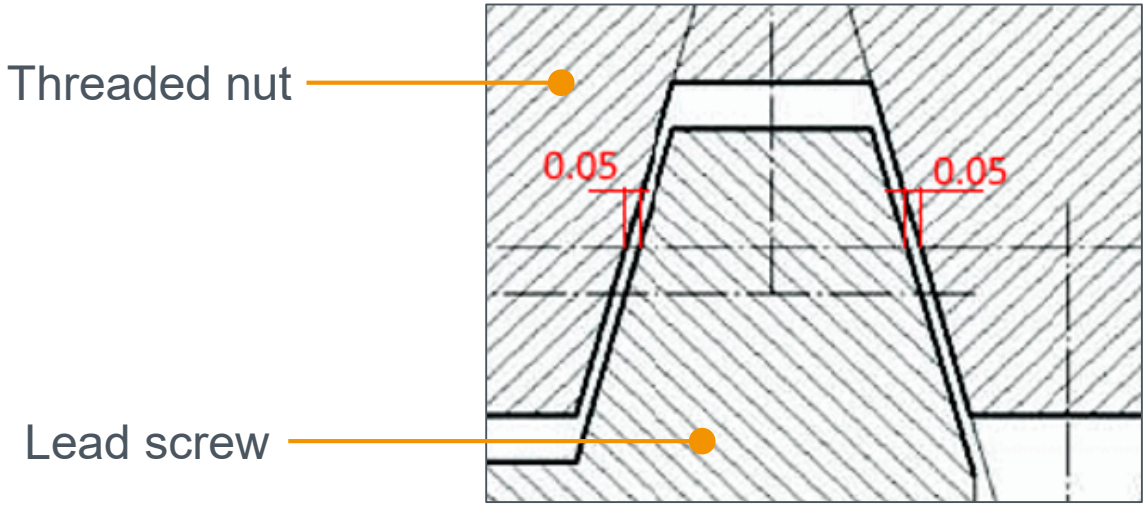
5. Axial play

- Axial play = necessary gap between screw and nut
- Axial play will occur only at the start or if the direction changes
- Axial play on Nanotec homepage is theoretical value (calculated from the tolerances from which we produce the screws and nuts)
- Axial play can be avoided with permanent force in one direction or an anti-backlash nut



= Max. axial play: +/-0.05

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6. Thread lead

- Choice of the thread is the most important factor (apart from size of the actuator)
- Screws are assigned to different NEMA sizes according to their diameter
- Lead of the screw determines:
  - Force and speed of the actuator
  - Service life
  - Screw efficiency
  - Self-locking capability
- Rule of thumb:

Higher lead results in higher speed, less force and longer service life.

7. Self-locking

- Self-locking screws don't rotate if only an axial force is applied (because of the friction angle of the thread)

Self-locking: $friction\ angle > lead\ angle$

$$arctan\frac{\mu}{cos\left(\frac{\alpha}{2}\right)} > arctan\frac{P}{\pi * d}$$

- Rule of thumb:

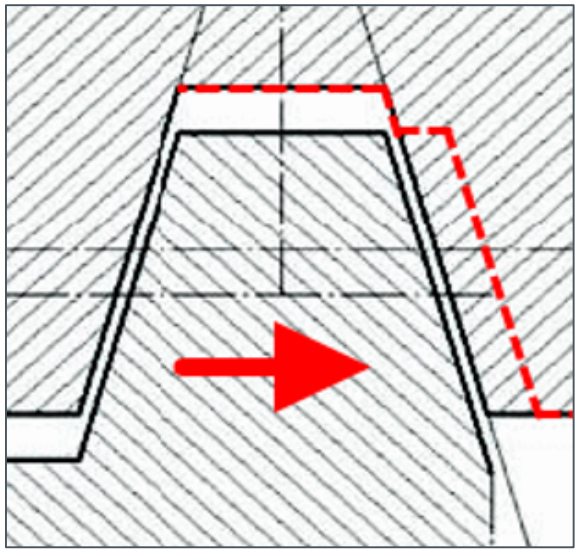
Self-locking: lead < 1/3 diameter

- Lubrication can influence self-locking
- Advantageous for applications where the motor needs to hold the load without current
- Example threads: TDBA (T3,5x1), TJBA (T6x1), UGAQ (ACME4.76x0.635), UKAS (ACME6.35x0.79)

8. Service life

- The service life of linear actuators depends on load, lubrication, environment, etc.
- Linear actuators are designed such that the female thread will wear out first
- Every movement of the screw inside the female thread will wear out the thread flanks
- Failure is a result from a too big step error or a complete destruction of the thread flanks

Factor	Service life if factor increases
Force	-
Speed	-
Temperature	-
Lubrication	+
Thread lengths	+
Thread lead	+



8.1 Calculation of service life

- Service life is calculated with the help of a tool* designed by Nanotec
- Service life estimates are backed up by service life tests
- Output in km, hours, days or cycles

Required Information

- Linear actuator type (LA, LGA or LSA)
- Linear actuator size (NEMA)
- Force
- Speed

Additional Information (optional)

- Stroke
- Required service life

*Tool is for Nanotec internal use only

	Profile 1	Profile 2	Profile 3
Selection of thread code	TSGA (10x6)		

Input					
Symbol	Description	Unit	Value 1	Value 2	Value 3
F	Axial force	N	200.0		
vf	Speed	mm/s	30.0		
l	Length of female thread	mm	22.0		
h	Stroke (2 strokes = 1 cycle)	mm	50.0		

Constants			
Symbol	Description	Unit	Value
x	Ratio of bearing thread flanks	-	0.75
k	Wear rate POM/steel	10^-6 mm³/Nm	1.03
hzul,%	Permissible wear depth	%	30
pzul	p-limit POM material	N/mm² = MPa	5.00
pvzul	pv-limit POM material	MPa*m/s	0.40

Output					
Symbol	Description	Unit	Value 1	Value 2	Value 3
p	Contact pressure	N/mm² = MPa	1.1069		
pv	pv-value	MPa*m/s	0.1485		
L	Service life in days	d	33		
L	Service life in hours	h	798		
Lh	Service life in cycles	-	861.429		
L	**Service life**	**km**	**86.14**		

Service life calculation tool

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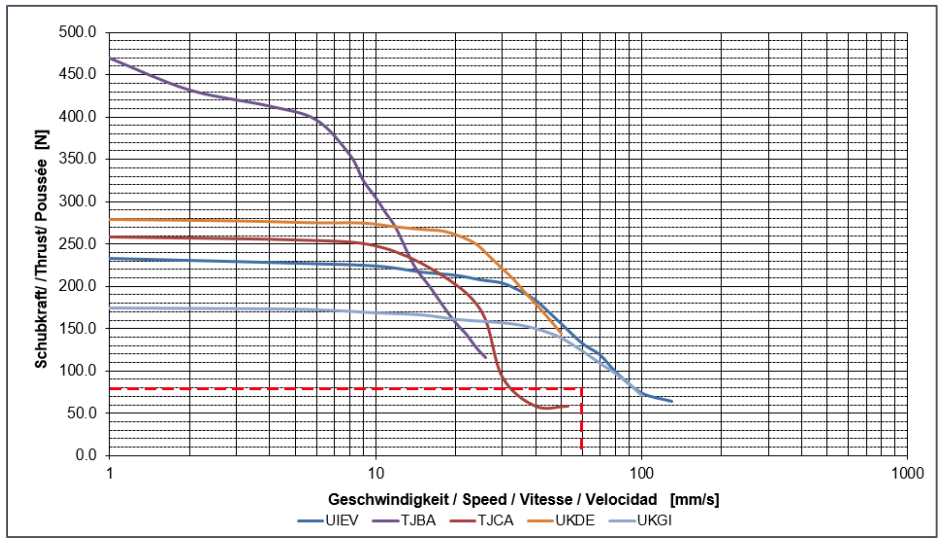
8.2 Example calculation of service life

- Application requirement example: **80 N, 60 mm/s, NEMA 17, LSA, best possible service life**
- Linear actuator: LSA421S14 → external nut, thread length = 19.05 mm
- Possible threads to fulfill requirements: UIEV (ACME5.56x4.88), UKGI (ACME6.35x6.35)



- Service life calculation: UIEV = 56.29 km; UKGI = 99.39 km
- Proposal: LSA421S14-A-UKGI-152 (+ LSNUT-AAAE-UKGI)

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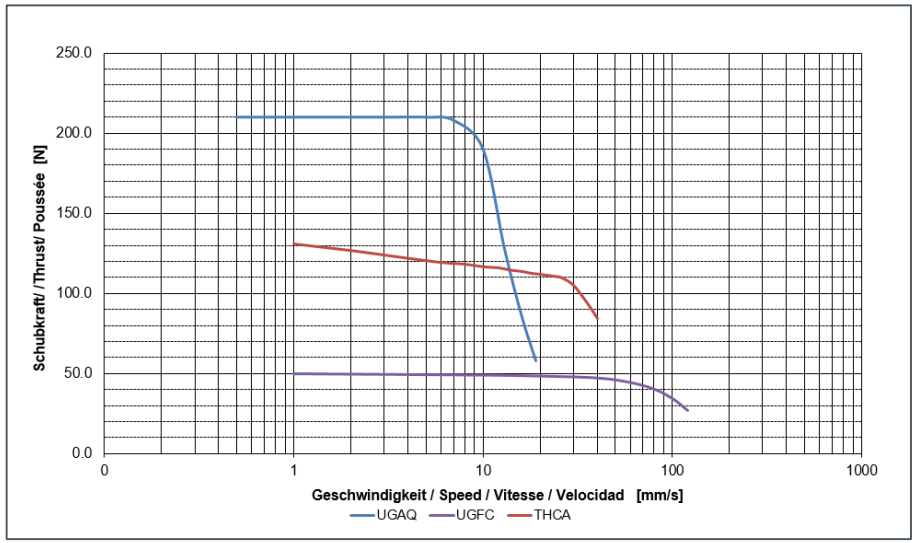
8.3 Example calculation 2

- Application requirement example: **10 mm/s, NEMA 11, LGA, 15 km service life required**
- Linear actuator: LGA281S10 → internal nut, thread length = 15 mm
- Possible max. force, which thread?



- Service life calculation for 15 km: UGAQ = 13.2 N; THCA = 79.8 N; UGFC = 262.5 N (max. force 50N)
- Proposal: LGA281S10-A-THCA-019 with 80 N

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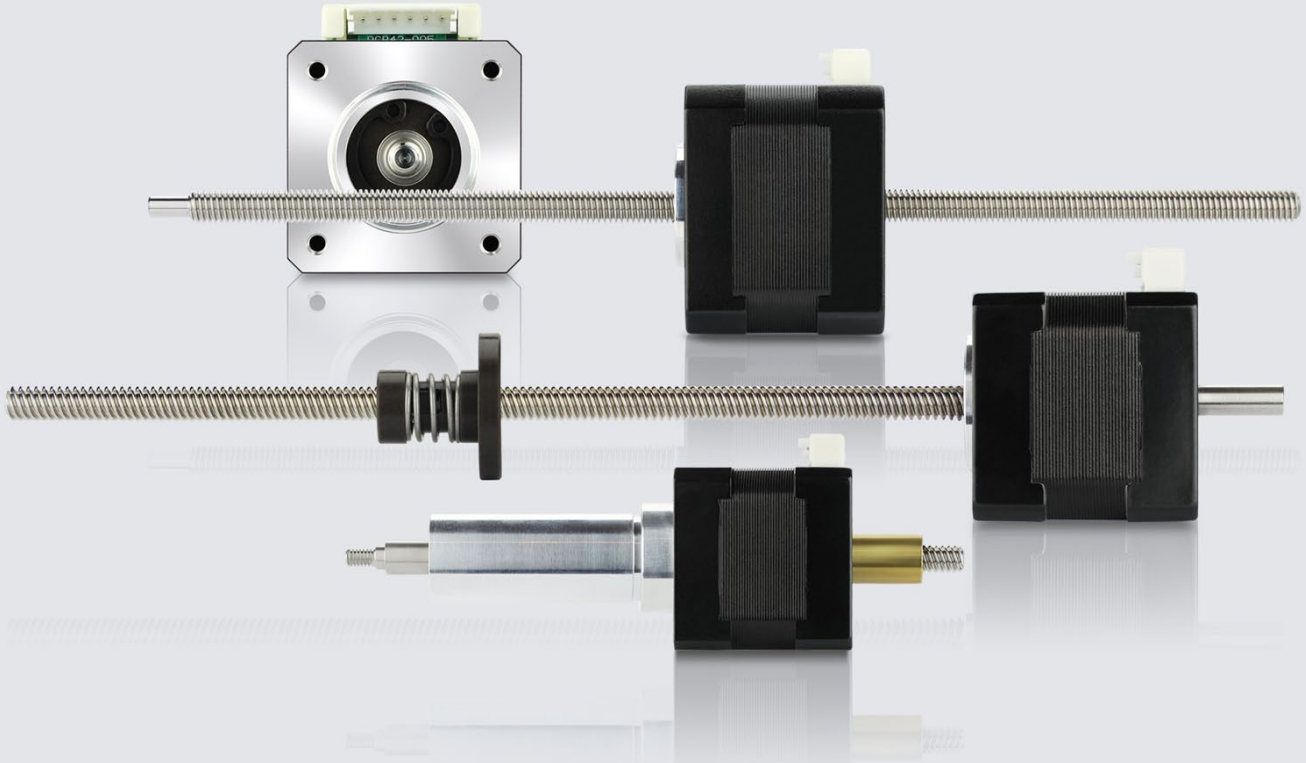

Linear Actuators

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