PNEUMATIC ACTUATORS – RACK & PINION

CONTENT

1. Application

Rack & pinion pneumatic actuators are rotary actuators used for turning, opening, closing, mixing, oscillating, positioning, steering and many more mechanical functions involved in restricted rotation. Mostly they are used for the automation of quarter turn valves, like ball, plug and butterfly valves.

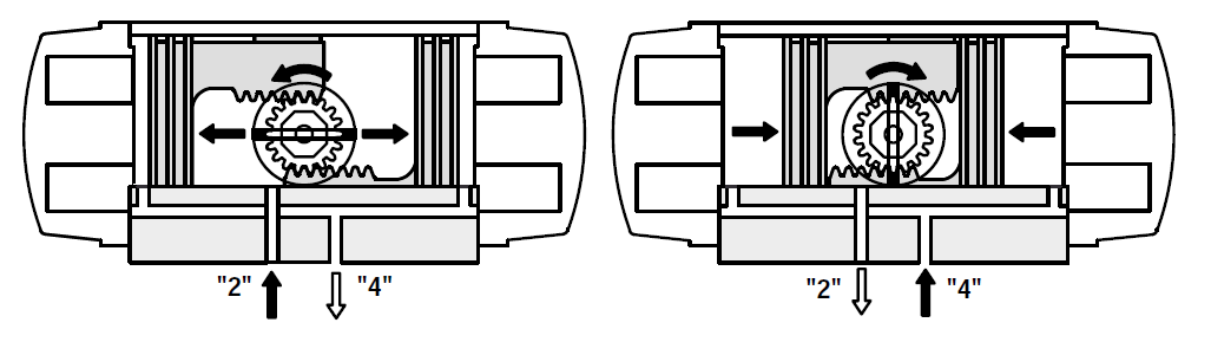
Pneumatic rack & pinion actuators convert the energy of compressed air by means of a pneumatic cylinder to an oscillating rotary motion. The clean, and processed gas required by this actuator is provided via a central compressed air station, which usually support a range of pneumatic devices in a process.

Pneumatic rack & pinion actuators are generally durable, suited for hazardous environments and have a low cost, in addition they require low maintenance and provide a high torque compared with their size.

2. Double acting actuators

In a double acting actuator, air is supplied to chambers on both sides of the piston. Higher air pressure on one side drives the piston to the other side.
These types of actuation are used when works need to be performed in both directions.
An advantage of double acting is the constant output force through a full rotation range. The disadvantage is the need for compressed air for movement in both directions and a lack of defined position in case of power or pressure failure.

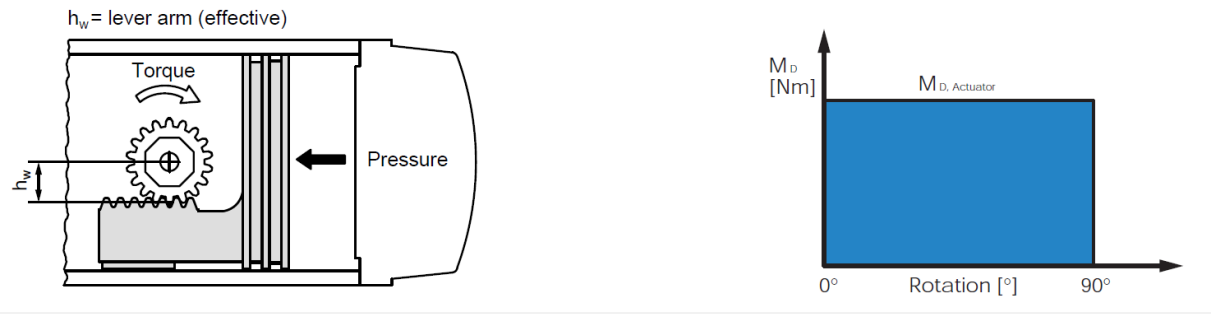
2.1 Principle of operation



If the port “2” is under pressure and the port “4” evacuated, both pistons are moving into the end positions and a turning of the drive shaft is the result.

If the port “4” is under pressure and the port “2” is de-aerated. The pistons are moved into the middle position. This has as a result a turning of the drive shaft.

With the rack & pinion construction the output torque of an actuator is obtained by multiplying the piston force (given by the air pressure) by the pitch shaft radius (lever arm) as shown in the below picture less the force lost by friction (efficiency). Because of this concept, the output torque is linear as shown in the diagram in both clockwise and counterclockwise rotation.



The suggested safety factor for double acting actuators in normal working conditions is 15% to 20%.

2.2 Sizing example for double acting actuator

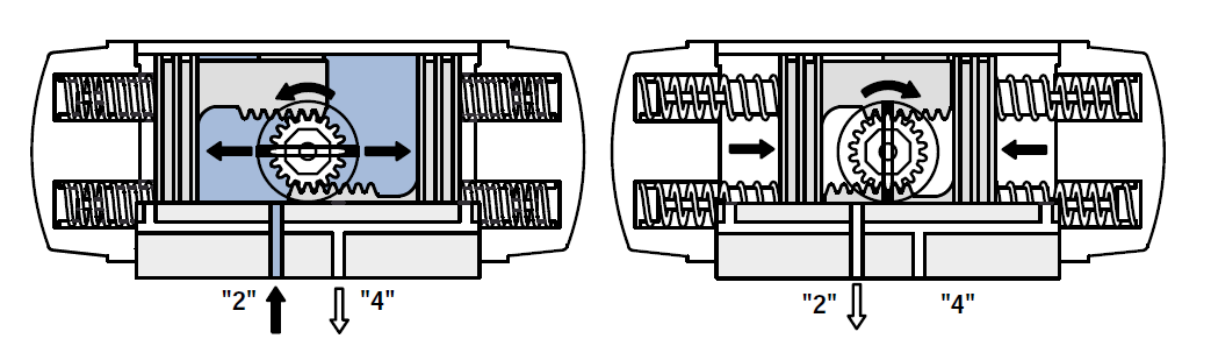
Butterfly valve torque defined by the manufacturer of the valve	40 Nm
Safety factor	40 Nm + 20% = 48 Nm
Minimum air supply pressure available	5 bar

The double acting ET actuator that produces a minimum of 48 Nm at 5 bar air pressure is the type DA-0060

3. Single acting actuators

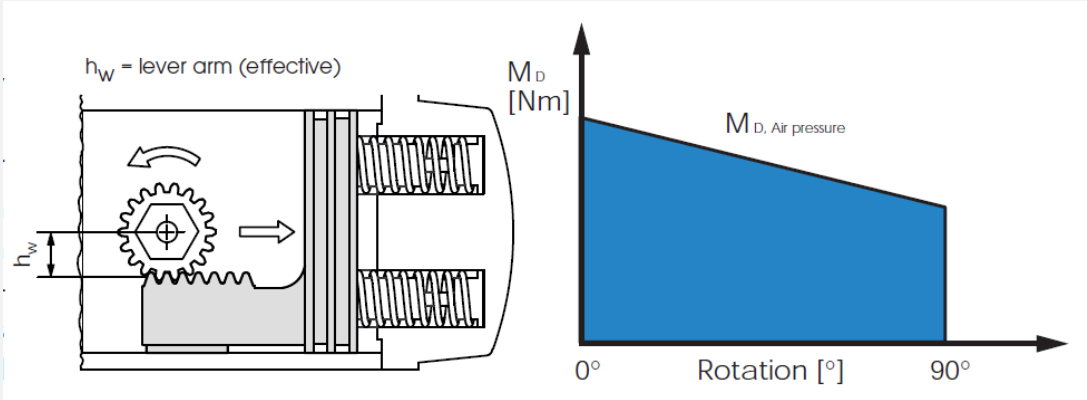
In a single acting actuator, air is supplied to one side of the piston and is responsible for the movement of the piston in only one direction. The movement in the opposite direction is performed by a mechanical spring. Single acting actuators conserve compressed air, but perform in only one direction, but the spring brings the actuator in a defined position (e.g. safe position of the valve) by the spring. A disadvantage is the inconsistent output force through the full stroke due to the opposing spring force.

3.1 Principle of operation

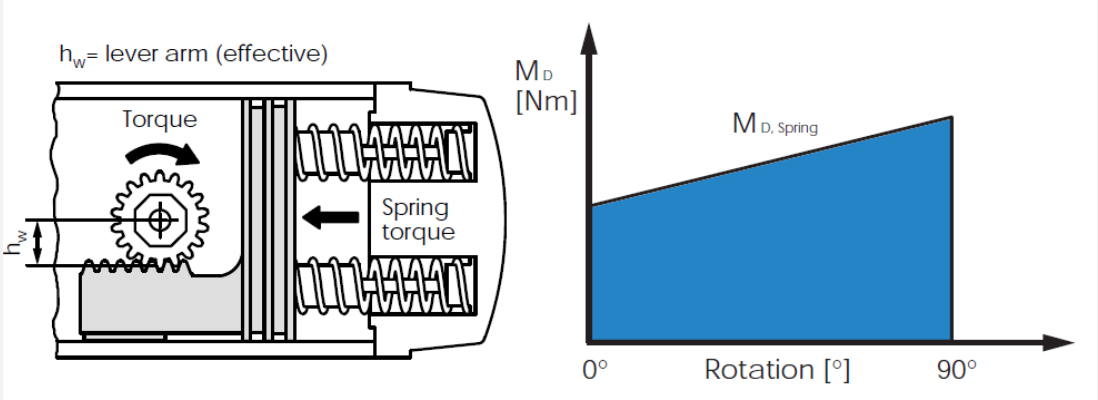


If the port “2” is under pressure and port “4” is evacuated, both pistons are moving into the end positions and compress the springs. The result is a turning of the drive shaft.
By the spring force a fail-safe position by air or power loss is guaranteed.
In spring return applications, the output force is obtained in two different operations. Each operation produces different values of torque in relation to the stroke position (0° or 90°).

First case – movement generated by air pressure
The output torque is generated by the air pressure applied at port “2” after compressing the springs. In this case air forces the piston from the 0° to the 90° position and consequently the torque starts from a high value and during the stroke it constantly decreases until 90° due to the natural force that the springs generate (oppose) when they are compressed.



Second case – movement generated by the springs
The output torque is generated by the force that springs release onto the pistons when the air fails. In this case the torque, starting from 90° position, constantly decreases until 0° because of the springs extending.



ET spring return actuators are designed to produce y balanced torque in the two conditions explained above when the number of springs per side is equal to the air pressure supply (4 bar – 4 springs each side).
For certain applications it is possible to achieve (where desired) an unbalanced torque by changing the relation between the number of springs per side and air pressure in bar (e.g. 6 springs and 5.5 bar or vice versa).

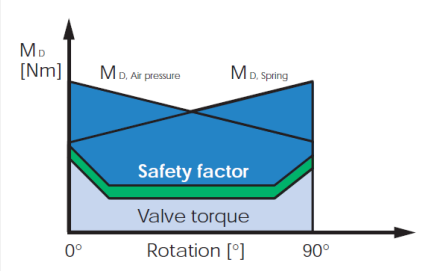
In spring return applications two conditions can be achieved: air failure to close or to open the valve. The suggested safety factor for spring return actuators in normal working conditions is 20% to 25%

3.2 Sizing example for single acting actuator – Spring to close (when air fails)

Butterfly valve torque defined by the manufacturer of the valve	80 Nm
Safety factor	80 Nm + 20% = 96 Nm
Minimum air supply pressure available	5 bar

The spring return actuator type selected is the SC300 – 5, based on the following values

Spring stroke 0°	105 Nm
Spring stroke 90°	165 Nm
Air stroke 0°	172 Nm
Air stroke 90°	112 Nm

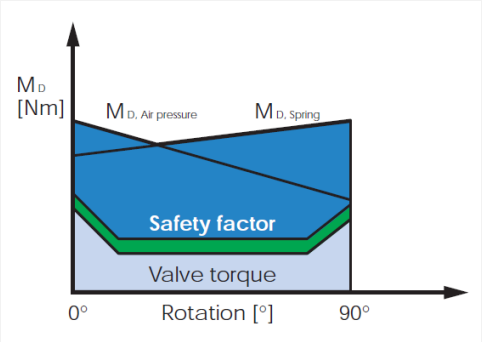


3.3 Sizing example for single acting actuator – Spring to open (when air fails)

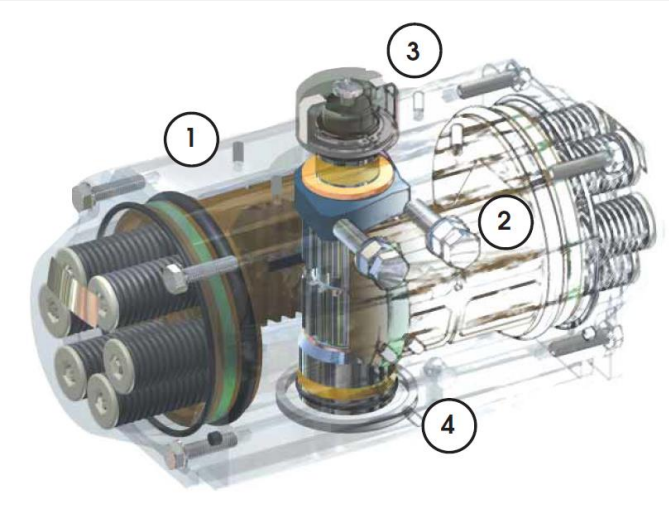
Butterfly valve torque defined by the manufacturer of the valve	45 Nm
Safety factor	45 Nm + 20% = 54 Nm
Minimum air supply pressure available	5,5 bar

The spring return actuator type selected is the SC150 – 5, based on the following values

Spring stroke 0°	50,7 Nm
Spring stroke 90°	78,8 Nm
Air stroke 0°	95,6 Nm
Air stroke 90°	67,5 Nm



4. Main features of EXaL pneumatic rack & pinion actuators



1 – Body

The aluminum body is inside and outside completely coated with ALODUR, with the advantage of extremely abrasion resistance, low surface roughness and optimal resistance

2 – External stroke adjustment

When mounting the actuator on the valve, both end positions can be adjusted with a precise cam system. The rotation angle is easily changeable from 0° to 15° and from 75° to 90°.
All adjustments of the end positions are possible without disassembling the unit.

3 – Multifunction indicator

The position of the multifunctional indicator is quickly adapted for a parallel or 45° position.
A visual indication is realized through colored inserts (white and red). The inserts are variable to fit.
Switches of different types can be installed in this indicator:

- Mechanical or IFM sensors
- Proximity switches (P+F, TURCK, etc.)
- Multiport valve indication

4 – Connections

Available according to ISO 5211, DIN 3337 (F03 till F25), ISO 1 (CNOMO) and NAMUR for flexible usability and exchangeability.

5. Materials / protection

Protection	Parts and Protection				Suitable for	Not recommended for
	Body	End-caps	Drive shaft	Pistons		
Material	EN AW 6063	GD-Al Si 8.5 Cu 3.5 Fe	C22	GD-Al Si 8.5 Cu 3.5 Fe	General service	Caustic soda, strong acids or basic solutions
Description	ALODUR	Chromatized + polyester coating	Carbon steel + ENP	Anodized black		
Coating	30-35 µm	80-90 µm	25-30 µm	15-20 µm		
Color	Light grey	Light grey RAL 9007		black		
Process	The coating is achieved through a special method which uses brushing <and sandblasting followed by electrochemical oxidation of the aluminum surface.					
Advantages	Good corrosion resistance, very high surface hardness for abrasion resistance.					

6. Type number composition

ET-SC-0010-4-U-F05F07-17-A-N-S

Type
DA: Double acting
SC: Single acting, fail close
SO: Single acting, fail open

Size
See table below

Qty of springs at each side
(only for single acting type)

Type
U: upgrade

Flange connection
See table below

Special versions
F: special color
S: quick action
H: high temperature
T: low temperature
Y: Centering ring

Driveshaft
N: with scale ring (standard
Z: Multifunction indicator

Coating
A: standard
Others see list below

Shaft
See table below

6.1 Sizes

Size	Flange to ISO 5211	Shaft	Air connection	Weights in kg	
				DA	SC/SO
00010	F03 / **F04**	9/**11**	G 1/8"	0,75	1,00
00015	**F04**	9/**11**	G 1/8"	1,10	1,30
00030	F03/F04/**F05**	9/11/**14**	G 1/8"	1,60	1,90
00060	F04/**F05**/F07	11/**14**/17	G 1/8"	2,70	3,00
00100	**F05/F07**	14/**17**	G 1/8"	3,80	4,40
00150	**F07/F10**	**17**/22	G 1/4"	5,20	6,00
00220	**F07/F10**	17/**22**	G 1/4"	8,00	9,40
00300	**F07/F10**	17/**22**	G 1/4"	10,00	12,40
00450	**F10/F12**	22/**27**	G 1/4"	14,20	17,00
00600	**F10/F12**	22/**27**	G 1/4"	18,00	21,50
00900	F12/**F14**	27/**36**	G 1/4"	24,30	32,70
01200	F12/**F14**	27/**36**	G 1/4"	34,30	43,60
02000	F14/**F16**	36/**46**	G 3/8"	54,60	69,00
03000	F14/**F16**	36/**46**	G 1/2"	76,30	95,50
04000	**F16**[2]/F25[3]	**46**[2]/55[3]	G 1/2"	118,00	150,00
05000	**F25**	**55**	G 1/2"	127,00	169,00
10000	F25[2]/F30[3]	55[2]/75[3]	G 1/2"	170,00	230,00

[2] for SC/SO types Standard versions are marked bold

[3] for DA types

Important note

It is absolutely necessary that the air supply is done in the size of the air connection, or larger. If the air supply has a smaller size, the actuator will start to "jump" because the quantity of air received is not enough for a smooth operation.

7. Maximal torque at the connection flange according to DIN EN ISO 5211

In Nm

F03	F04	F05	F07	F10	F12	F14	F16
32	63	125	250	500	1000	2000	4000

F25	F30	F35	F40	F48	F60
8000	16000	32000	63000	125000	250000

8. Coating – Protection - Serviceability

Type	Part and protection				
	Body	**End caps**	**Drive shaft**	**Pistons**	**Suitable for**
A	ALODUR	Chromatized and polyester coated	Carbon steel + ENP	Normal anodized	General service
Coating color	30 – 35 µm bright SS	80 – 90 µm SS RAL 9007	25 - 30 µm	15 – 20 µm black	
B	ALODUR + PTFE coating	Chromatized and polyester coated	Carbon steel + ENP	Normal anodized	General service, acid or basic solutions in low concentration
Coating color	30-35 / 25-30 µm light grey	80 – 90 µm SS RAL 9007	25 - 30 µm	15 – 20 µm black	
D	ALODUR + PTFE coating	Chromatized and PTFE coated	Carbon steel + ENP	Normal anodized	Aggressive environment acid or basic solutions
Coating color	30-35 / 25-30 µm light grey	80 – 90 µm light grey	25 - 30 µm	15 – 20 µm black	
E	ALODUR + PTFE coating	Chromatized and PTFE coated	Stainless steel	Normal anodized	Acid or basic solutions, seawater
Coating color	30-35 / 25-30 µm light grey	80 – 90 µm light grey		15 – 20 µm black	
P	ALODUR	Resin impregnated + hard anodized	Carbon steel + ENP	Normal anodized	Acid or basic solutions, seawater
Coating color	30 – 35 µm bright SS	30 – 35 µm bright SS	25 - 30 µm	15 – 20 µm black	
EC	ALODUR + EPOXY	Chromazized + EPOXY	Stainless steel	Normal anodized	General service, acid or basic solutions in low concentration
Coating color	80 – 95 µm blue grey	80 – 95 µm blue grey		15 – 20 µm black	

9. Ambient conditions for the use

Air supply	Filtered, lubricated or dry air, non-corrosive media, dew point -20°C, particle size < 30 µm
Temperature range	Standard version: -20°C till +80°C Low temperature version: -40°C till +80°C High temperature version: -15°C till +150°C
Maximum pressure	8 bar

10. Dimensioning of an actuator

To dimension an actuator which should be installed on a valve, following data is required:

- Type of valve (ball, butterfly, plug, etc.)
- Action (double or spring return)
- For spring return actuators, the fail position (valve open or closed)
- Function (on-off or modulating)
- Required torque (break to open, run to open, end to open, break to close, run to close and end to close)
- Maximum allowable torque of the valve (MAST)
- Overlapping angle of the seats on the ball or plug
- Air supply pressure (maximum and minimum)
- Required closing and opening time
- Coupling form to the valve (ISO 5211 or any other)
- If the coupling and adaptor to the valve stem should be part of the supply (in this case the drawing of the valve top works must be supplied).

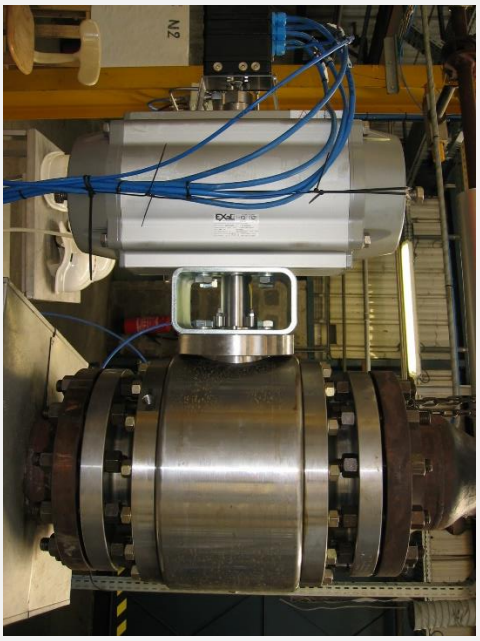
11.Automation of an actuator

An actuator can be supplied with automation components like filter pressure regulator for the air supply, solenoid valves, booster valves, limit switches, positioners, etc.

12.Test certificates

Salt spray test (certificate Nr. SAC/655/98)
Kesternich test in accordance with ISO 3231 (or ASTM G87) (condensation cycle test in acidic environment; certificate Nr. SAC/299/98)
Classification for installation on ships (certificate DET NORSKE Nr. P-12465)
GOST Russia (certificate Nr 7435773, PPC 00-26447)


EXaL
TECHNOLOGY
SPRING RETURN
Part turn actuator EN ISO 5211
Type and Model:
Serial number: 10033499
ET-S000015-EU
Output torque at 6 bar
F04-N-DS-11 A
max. 12 Nm, min. 7,9 Nm
Anc. attachment AA 1
Pressure connection G1/8
Max. pressure 8 bar
OperatingTemp.: -40°C/ +80°C
II 2GD c T95°C/T.F.:ATX09AT
IEC61508:bis SIL3

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