Fluidic Muscle DMSP/MAS

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At a glance

High initial force and acceleration
- Initial force up to 10 times higher than a conventional cylinder of the same diameter
- Highly dynamic response, even at high loads

Judder-free operation
- No mechanical parts moving against one another
- Completely jolt-free with extremely slow movements

Simple positioning
- Controlled by means of pressure using the simplest technology without displacement encoders

Hermetically sealed design
- Separation between operating medium and atmosphere
- Ideal for dusty and dirty environments
- Robust design
- Zero leakage

Mode of operation

Fluidic Muscle is a tensile actuator which mimics natural muscular movement. It consists of a contraction system and appropriate connectors. The contraction system is formed by a pressure-tight length of rubber hose, sheathed in high-strength fibres. The fibres create a rhomboidal pattern with a three-dimensional grid structure. When internal pressure is applied, the hose expands in its peripheral direction, thus creating a tensile force and a contraction motion in the muscle's longitudinal direction. The usable tensile force is at its maximum at the start of the contraction and then decreases in a virtually linear manner as a function of stroke.

An efficient operating range is provided with contractions of up to 15% of the nominal length.

The applications of Fluidic Muscle are as follows:
– Single-acting actuator
– Pneumatic spring

Note

Fluidic Muscle is intended for use as a tensile actuator only. The expansion in the peripheral direction cannot be used for clamping purposes, since external friction could cause damage to the muscle.

Fluidic Muscle DMSP, with press-fitted connections

→ 8

The Fluidic Muscle DMSP with press-fitted connections is the result of a thorough analysis of the requirements specification that already existed for the Fluidic Muscle MAS. The resulting new development is therefore considerably lighter, more compact and durable.

- More compact design with more muscle, achieved thanks to a 25% more compact cross section.
- Up to 30% less weight, which translates into a superb force/weight ratio.
- Choice of three integrated adapter variants.

Fluidic Muscle MAS, with screwed connections

→ 18

The Fluidic Muscle MAS is characterised by a long service life that is made possible through the use of optimised materials. The Fluidic Muscle MAS is also available with an adapter and force-safety device.

- The force-safety device makes it possible to limit the lifting force, which can for instance protect against trapping objects.
- Use of customer-specific adaptation options.

Sizing the muscle

Sizing software

Sizing should be carried out using the MuscleSIM software.

This software can be downloaded from ➔www.festo.com.

Graphical sizing

Apart from sizing the muscle using the software, it is also possible to define the length of the muscle with the aid of force/displacement diagrams.

Graphical sizing of the muscle is explained with the aid of two examples ➔ 32.

Force curve and load cases

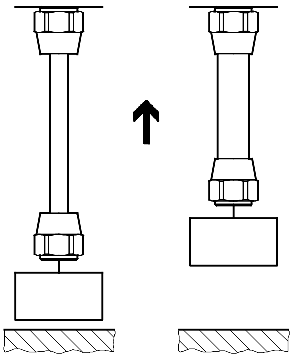
The nominal length of the pneumatic muscle is defined in the non-pressurised, load-free state. It corresponds to the visible muscle length between the connections. The muscle extends when it is pretensioned by an external force. When pressurized, on the other hand, the muscle contracts, i.e. its length decreases.

Single-acting actuator

Sizing examples ➔ 32

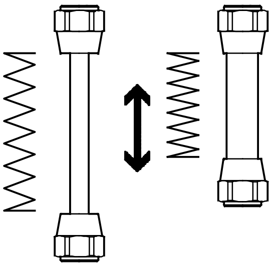
In the simplest case, Fluidic Muscle operates as a single-acting actuator against a constant load. Assuming that this load is permanently attached to the muscle, it will project from its initial position when in the extended non-pressurised state. This operating status is ideal with regard to the technical properties of Fluidic Muscle: when pressurised, a Fluidic Muscle pretensioned in this way develops maximum force with optimum dynamic characteristics and minimum air consumption. The usable force is also at a maximum in this case. If a Fluidic Muscle is required to be free of forces in the extended state, for example to allow a load to be attached, a holding force must first be developed for lifting purposes, leaving a small force component for the motion itself.

Load = Constant



Fluidic Muscle behaves like a spring with a changing external force: it follows the direction of action of the force. With Fluidic Muscle, both the pretensioning force of this “pneumatic spring” and its spring stiffness can be varied. Fluidic Muscle can be operated as a spring with constant pressure or constant volume. These produce different spring characteristics that enable the spring effect to be matched perfectly to a given application.

Pressure/volume = Constant



Note

If the muscle is fed with compressed air and the volume blocked, the pressure in the muscle can increase significantly when the external force is varied. The service life of the Fluidic Muscle depends on the contraction, the operating pressure and the temperature ➔34.

High operating frequencies or high loads can lead to a temperature rise.

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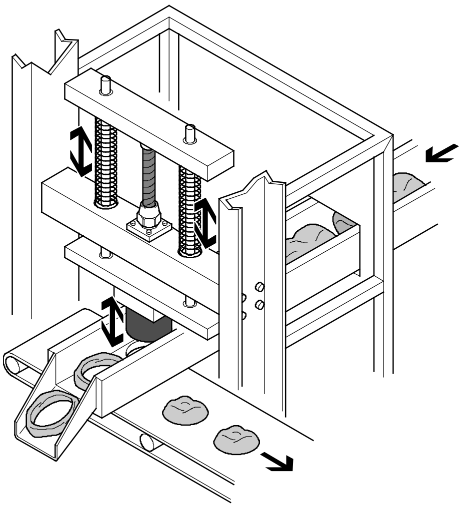
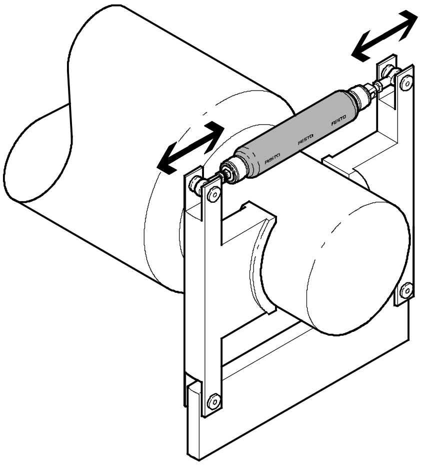
Force and dynamism

Drive for tab punching



Very high cycle rates are possible with the muscle, on the one hand because of its low weight and on the other because it has no moving parts (e.g. piston). The simple construction – one muscle pretensioned using two springs – replaces a complicated toggle lever clamping system using cylinders. This makes a frequency increase of 3 to 5 Hz possible. Over 50 million load fluctuations can be achieved in this way.

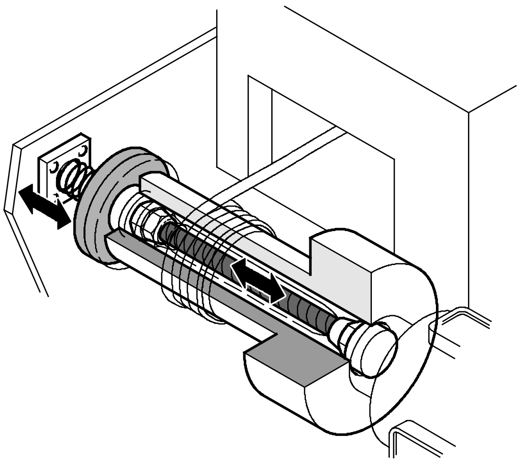
Emergency stop for rollers



The fluidic muscle is setting new standards in applications that require fast response times. The emergency stop for rollers demands both speed and force. Long machine downtimes in the event of malfunctions can thus be prevented.

Judder-free movements

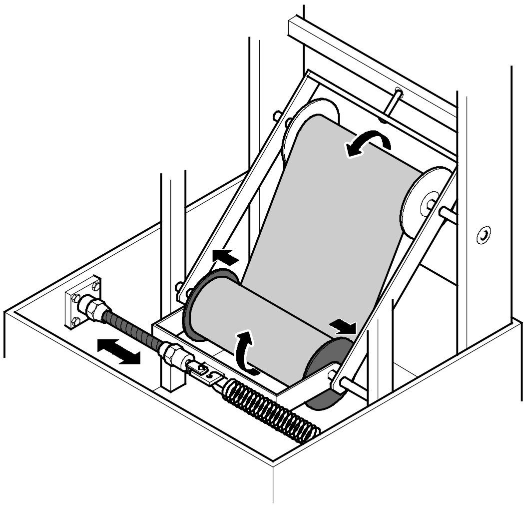
Brake actuator for rewinding equipment



The friction-free muscle allows uniform and gentle braking of the pay-out reel, ensuring highly precise winding at constant speed. Control is provided by a proportional control valve whose signals are regulated via force sensors.

Judder-free movements

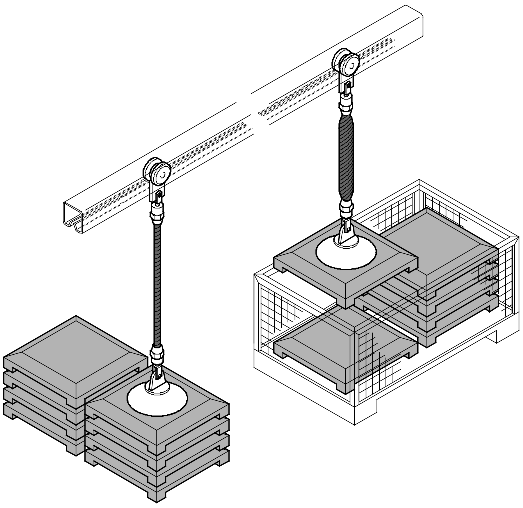
Belt edge control for winding processes



The aim:
uniform winding of paper, foil or textiles.
The requirement:
a friction-free drive with quick and immediate response characteristics.
The solution:
Fluidic Muscle. The drum attached to a moving frame is displaced by a pneumatic muscle as soon as the sensor detects misalignment. This means that the winding edge control is 100% efficient.

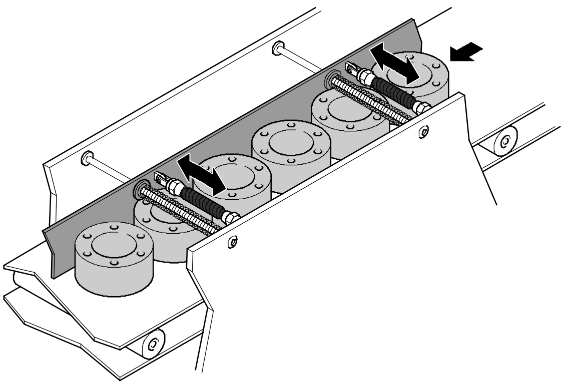
Simple positioning systems

Simple lifting device for manipulating concrete slabs and car wheel rims



Approximate intermediate positions? No problem with pressure regulation. The workpieces can be raised or lowered as required by pressurising or exhausting the muscle via a hand lever valve. Muscle lengths up to 9 m facilitate various types of application.

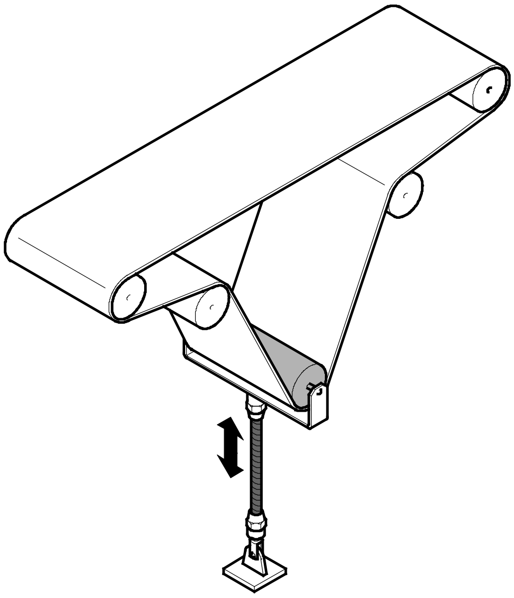
Adjusting the width of conveyor belts



With small batch sizes, it is often necessary to adapt entire system sections to different component dimensions after a short period of time. This task can be performed with the fluidic muscle in cases where an approximate adjustment is sufficient.

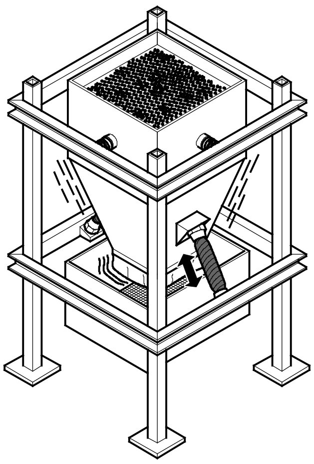
Harsh environmental conditions

Belt tensioner for conveyed goods



In dusty or dirty environments, a hermetically sealed fluidic muscle has a major advantage over conventional drives. This seal cannot wear. It is a sturdy, contractible tube that copes with the tough demands of the cement industry with ease.

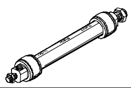
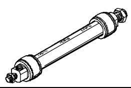
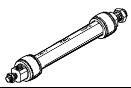
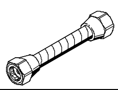
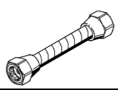
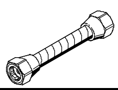
Drive for a vibratory hopper



Hoppers and silos are susceptible to the problem of parts jamming during feeding. Fluidic Muscle facilitates stepless regulation of a pneumatic shaker between 10 and 90 Hz, thereby guaranteeing continuous delivery.

Fluidic Muscle DMSP/MAS

Product range overview

Function	Version	Type	Inside dia. [mm]	Nominal length [mm]	Lifting force [N]	Max. permissible pretensioning	Max. permissible contraction	Operating pressure [bar]	➔ Page/Internet
Single-acting, pulling	**Fluidic Muscle with pressed connection**								
		**DMSP**	10	40 ... 9000	0 ... 630	3% of nominal length	25% of nominal length	0 ... 8	8
		**DMSP**	20	60 ... 9000	0 ... 1500	4% of nominal length	25% of nominal length	0 ... 6	8
		**DMSP**	40	120 ... 9000	0 ... 6000	5% of nominal length	25% of nominal length	0 ... 6	8
	Fluidic Muscle with screwed connections								
		**MAS**	10	40 ... 9000	0 ... 630	3% of nominal length	25% of nominal length	0 ... 8	18
		**MAS**	20	60 ... 9000	0 ... 1500	4% of nominal length	25% of nominal length	0 ... 6	18
		**MAS**	40	120 ... 9000	0 ... 6000	5% of nominal length	25% of nominal length	0 ... 6	18

Note

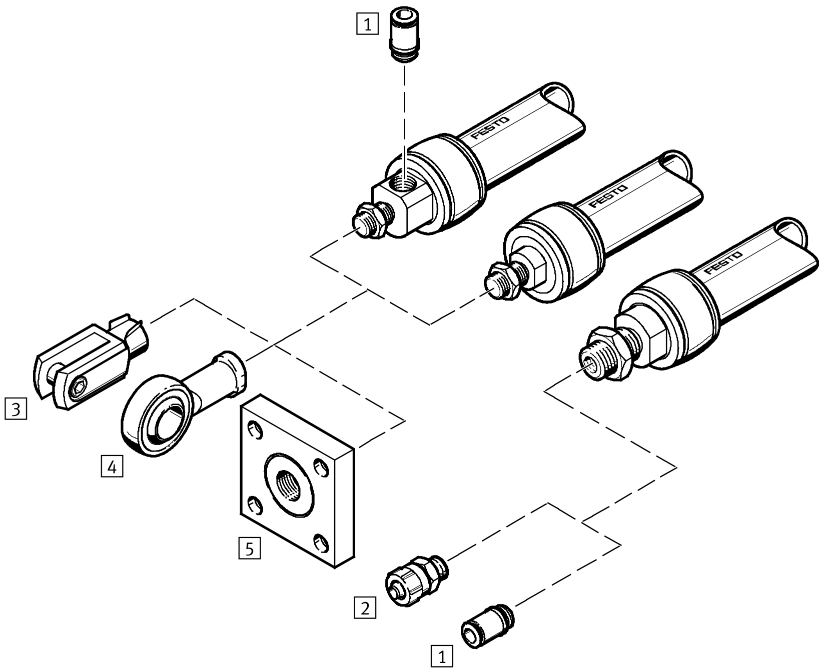
When replacing a Fluidic Muscle MAS and accessories MXAC (first-generation products available until 06/2005) as listed in the table opposite with a Fluidic Muscle MAS and mounting accessories MXAD as described in this document (part numbers ➔ 28), please consult your contact person at Festo. Compatibility cannot be guaranteed in all cases due to changes in installation dimensions.

To be discontinued

Fluidic Muscle MAS		Mounting accessories MXAC	
Part No.	Type	Part No.	Type
187 594	MAS-10-N-...-AA-MCFK	187 591	MXAC-B10
187 595	MAS-10-N-...-AA-MOFK	187 592	MXAC-A10
187 617	MAS-20-N-...-AA-MCHK	187 593	MXAC-R10
187 618	MAS-20-N-...-AA-MCGK	187 614	MXAC-B16
187 619	MAS-20-N-...-AA-MOHK	187 615	MXAC-A16
187 605	MAS-40-N-...-AA-MCKK	187 616	MXAC-R16
187 606	MAS-40-N-...-AA-MCIK	187 602	MXAC-B20
187 607	MAS-40-N-...-AA-MOKK	187 603	MXAC-A20
		187 604	MXAC-R20

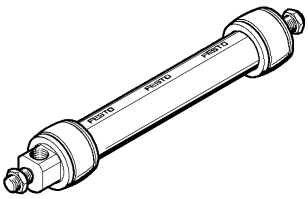
Fluidic Muscle DMSP, with press-fitted connections

Peripherals overview

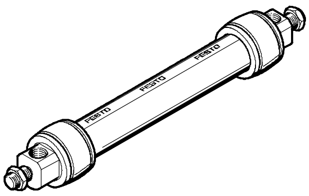


Variants

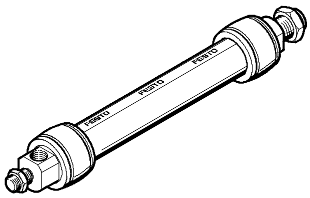
Pneumatic connection, radial, at one end, RM-CM



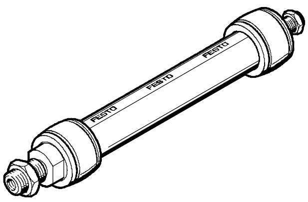
Pneumatic connection, radial, at both ends, RM-RM



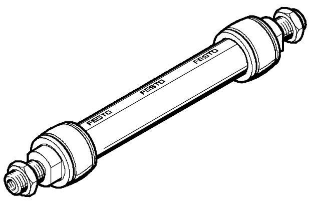
Pneumatic connection, radial and axial, RM-AM



Pneumatic connection, axial, at one end, AM-CM



Pneumatic connection, axial, at both ends, AM-AM



Mounting attachments and accessories

	Brief description	→ Page/Internet
1 Push-in fittings QS	For connecting compressed air tubing with standard external diameters	quick star
2 Quick connectors CK	For connecting compressed air tubing with standard internal diameters	ck
3 Rod clevis SG	Permits swivel motion of the Fluidic Muscle in one plane	17
4 Rod eye SGS	With spherical bearing	17
5 Coupling pieces KSG/KSZ	For compensating radial deviations	17

Fluidic Muscle DMSP, with press-fitted connections

Type codes

DMSP	–	10	–	500N	–	RM	–	CM

Drive function	
Single-acting, pulling	
DMSP	Fluidic Muscle

Internal dia. [mm]

Nominal length [mm]	
...N	40 ... 9000

First connection	
RM	Pneumatic connection, radial
AM	Pneumatic connection, axial

Second connection	
RM	Pneumatic connection, radial
AM	Pneumatic connection, axial
CM	No pneumatic connection

Fluidic Muscle DMSP, with press-fitted connections

Technical data

- Size
  10 … 40 mm
- Nominal length
  40 … 9000 mm
- Lifting force
  0 … 6000 N

General technical data				
Size		10	20	40
Pneumatic connection		G1⁄8	G1⁄4	G3⁄8
Design		Contraction membrane		
Mode of operation		Single-acting, pulling		
Internal dia.	[mm]	10	20	40
Nominal length	[mm]	40 … 9000	60 … 9000	120 … 9000
Max. additional load, freely suspended	[kg]	30	80	250
Max. permissible pretensioning1)		3% of nominal length	4% of nominal length	5% of nominal length
Max. permissible contraction		25% of nominal length		
Max. hysteresis		≤ 3% of nominal length	≤ 2.5% of nominal length	
Max. relaxation		≤ 3% of nominal length		
Repetition accuracy		≤ 1% of nominal length		
Max. perm. offset of connections		Angle tolerance: ≤ 1.0°		
		Parallelism tolerance: ± 0.5% (up to 400 mm nominal length), ≤ 2 mm (from 400 mm nominal length)		
Type of mounting		With accessories		
Assembly position		Any (an external guide is required if lateral forces occur)		

1) The max. pretensioning is achieved when the max. permissible freely suspended useful load is attached.

Operating and environmental conditions				
Size		10	20	40
Operating pressure	[bar]	0 … 8	0 … 6	
Operating medium		Compressed air in accordance with ISO 8573-1:2010 [7:–:–]		
Note on operating/pilot medium		Operation with lubricated medium possible (in which case lubricated operation will always be required)		
Ambient temperature	[°C]	–5 … +60		
Corrosion resistance class CRC2)		2		

2) Corrosion resistance class 2 according to Festo standard 940 070
Components requiring moderate corrosion resistance. Externally visible parts with primarily decorative surface requirements which are in direct contact with a normal industrial environment or media such as coolants or lubricating agents.

Forces [N] at max. permissible operating pressure			
Size	10	20	40
Theoretical force	630	1500	6000

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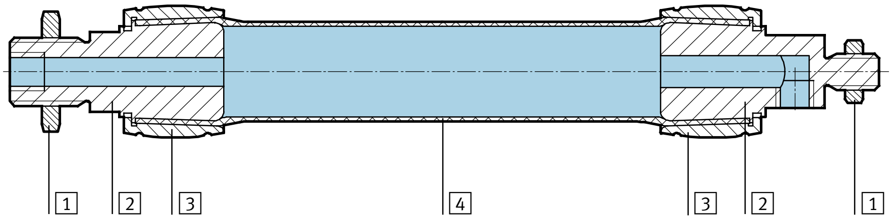
Weight [g]				
Size		10	20	40
Basic weight at 0 m length	RM-CM	58	169	675
	RM-RM	66	182	707
	RM-AM	75	202	767
	AM-CM	66	189	735
	AM-AM	83	222	827
Additional weight per 1 m length		94	178	340

Materials

Sectional view



Fluidic muscle		
1	Nut	Galvanised steel
2	Flange	Wrought aluminium alloy, clear anodised
3	Sleeve	Wrought aluminium alloy, clear anodised
4	Membrane	Chloroprene, aramide

Permissible force F [N] as a function of the contraction h [%] of the nominal length

Force/displacement diagrams and sizing ranges

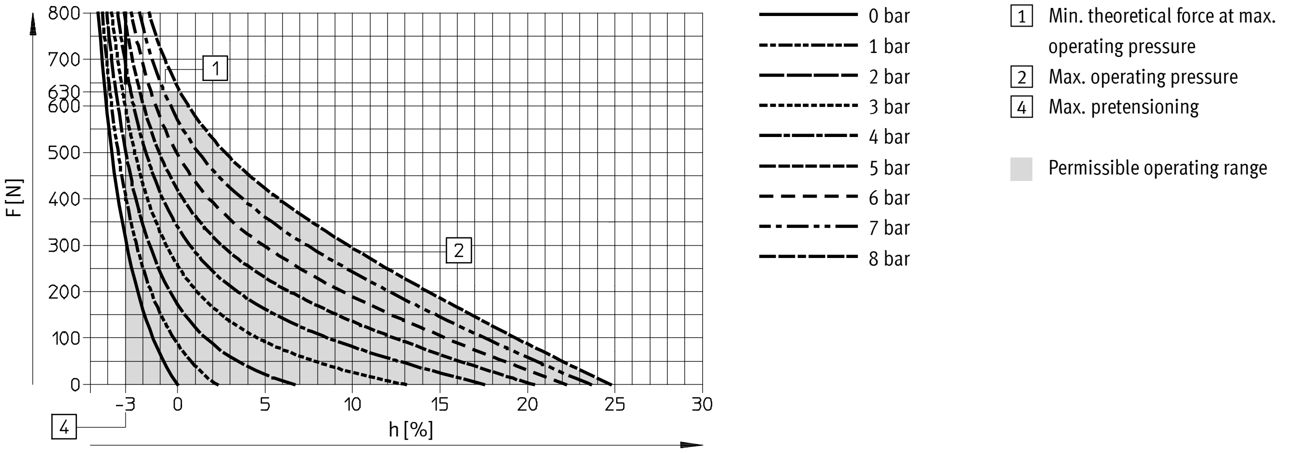
The limit for "freely suspended" loads is derived from the contraction. With the Fluidic Muscle DMSP-10-..., a loosely attached additional load of 30 kg results in 3% pretensioning (see diagram).The limits specified in the technical data must be complied with when using the fluidic muscle. The diagrams below illustrate the operating range of the fluidic muscle, depending on the diameter, within the boundary lines illustrated below.

Using the diagrams

1. The upper limit of the grey area describes maximum permissible force.
2. The right limiting curve of the grey area describes the maximum permissible operating pressure.
3. The right vertical limit of the grey area describes the maximum permissible contraction.
4. The left limit of the grey area describes the load limit of the muscle defined by the maximum pretensioning.

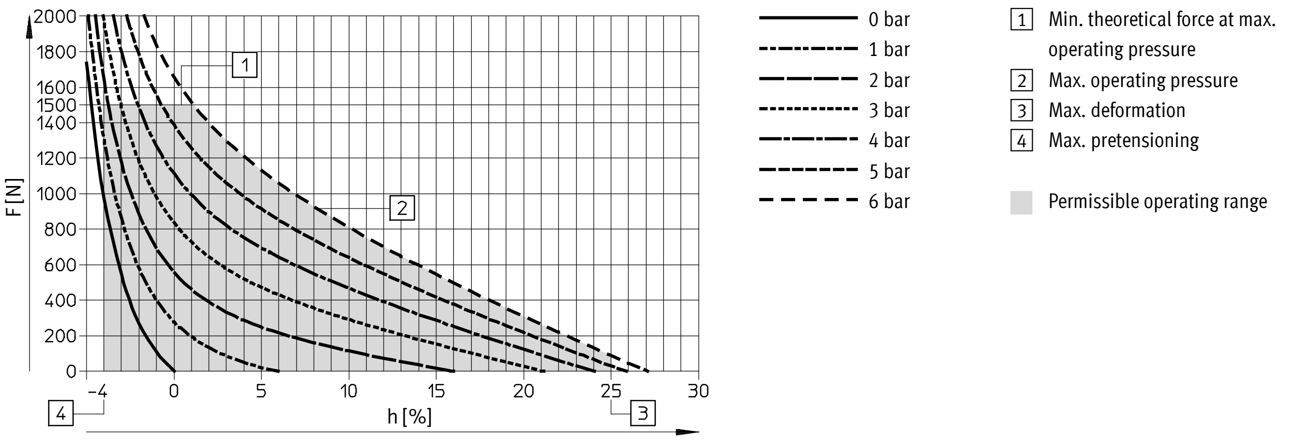
Operating range DMSP-10-100N-...

Sizing examples → 32



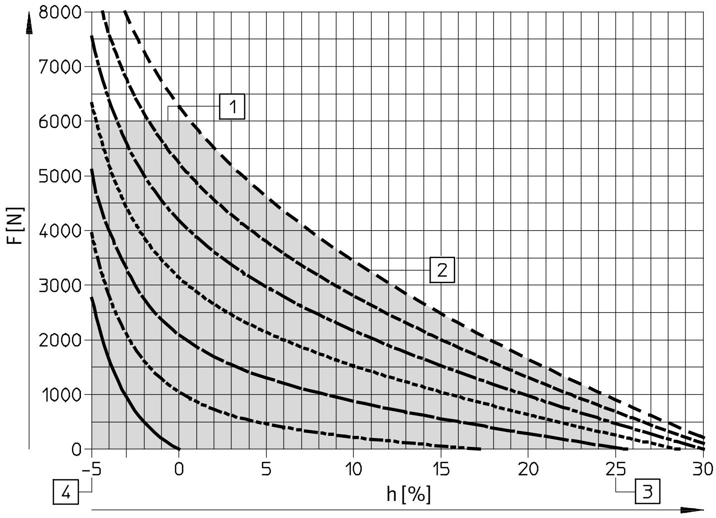
Operating range DMSP-20-200N-...

Sizing examples → 32



Operating range DMSP-40-400N-...

Sizing examples ➔ 32



0 bar	1 Min. theoretical force at max. operating pressure
1 bar	2 Max. operating pressure
2 bar	3 Max. deformation
3 bar	4 Max. pretensioning
4 bar	
5 bar	
6 bar	Permissible operating range

Note

The diagrams were determined using muscles with standard length (standard length = 10x internal dia.), sizing should therefore be carried out using the Fluidic Muscle sizing software. The software is available at the address ➔ www.festo.com. Approximate sizing is possible using the force/displacement diagram. Properties that influence the dependence between force and displacement, such as material properties, manufacturing deviations and nominal length, are not taken into account in these diagrams. The theoretical force can therefore increase by up to ten per cent. Deviations can be compensated by means of pressure adaptation up to the maximum permissible operating pressure.

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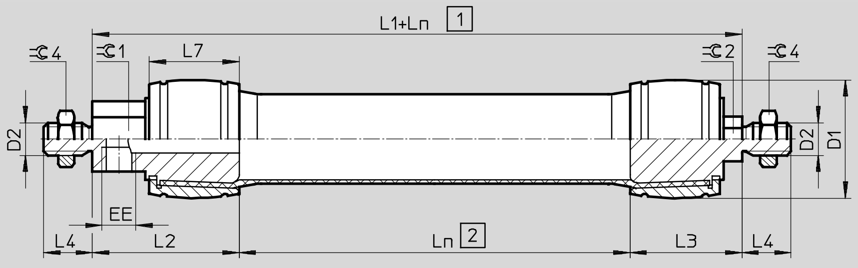
Dimensions

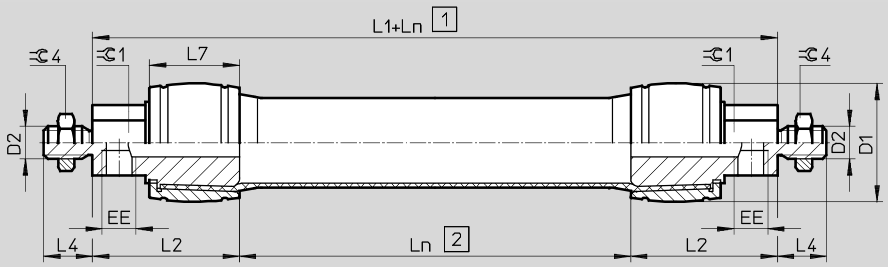
Download CAD data ➔ **www.festo.com**

RM-CM – pneumatic connection, radial, at one end



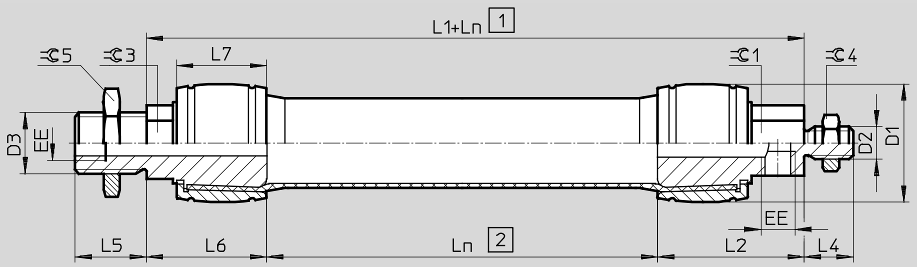
1 Fitting length
2 Nominal length

RM-RM – pneumatic connection, radial, at both ends



1 Fitting length
2 Nominal length

AM-RM – pneumatic connection, axial and radial



1 Fitting length
2 Nominal length

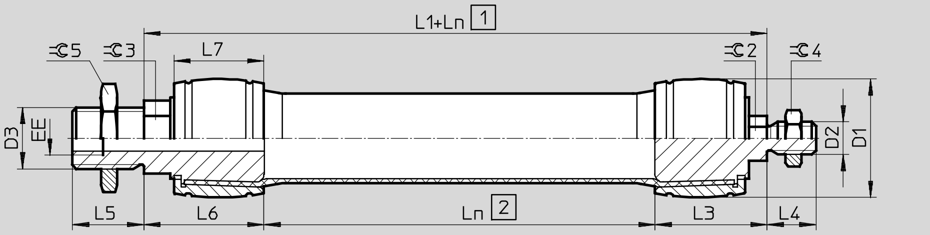
Size	D1	D2	D3	EE2)	Ln1)		L1			L2
	max.				min.	max.	RM-CM	RM-RM	AM-RM	
10	22	M8	M16x1.5	G1⁄8	40	9000	62	72	63	36
20	35	M10x1.25	M20x1.5	G1⁄4	60		95	113	97	56.5
40	57	M16x1.5	M30x1.5	G3⁄8	120		127	144	131	72

Size	L3	L4	L5	L6	L7	=C1 2)	=C2 2)	=C3 2)	=C4	=C5
10	26	15	16	27	19	14	10	17	13	24
20	38.5	20	18	40.5	30	19	12	20	17	30
40	55	24	35	59	44	30	19	30	24	46

1) Tolerance < 100 mm ±1 mm, 100 … 400 mm ±1%, > 400 mm ±4 mm.
2) Parallel orientation of the spanner flats on the left and right connection side can lead to deviations (for production reasons).

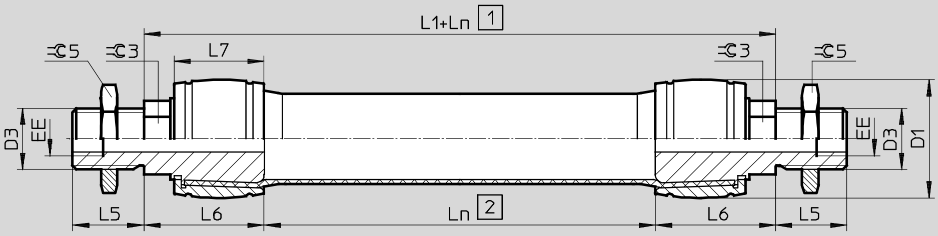
Dimensions Download CAD data ➔ **www.festo.com**

AM-CM – pneumatic connection, axial, at one end



1 Fitting length
2 Nominal length

AM-AM – pneumatic connection, axial, at both ends



1 Fitting length
2 Nominal length

Size	D1	D2	D3	EE	Ln[1]		L1		L3
	max.				min.	max.	AM-CM	AM-AM	
10	22	M8	M16x1.5	G⅛	40	9000	53	54	26
20	35	M10x1.25	M20x1.5	G¼	60		79	81	38.5
40	57	M16x1.5	M30x1.5	G⅜	120		114	118	55

Size	L4	L5	L6	L7	=C1[2]	=C2[2]	=C3[2]	=C4	=C5
10	15	16	27	19	17	10	17	13	24
20	20	18	40.5	30	19	12	20	17	30
40	24	35	59	44	30	19	30	24	46

1) Tolerance < 100 mm ±1 mm, 100 ... 400 mm ±1%, > 400 mm ±4 mm.
2) Parallel orientation of the spanner flats on the left and right connection side can lead to deviations (for production reasons).

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M Mandatory data

Module No.	Function		Size		Nominal length		First connection		Second connection
541 403 541 404 541 405	DMSP		10 20 40		40 … 9 000		RM AM		CM RM AM
Ordering example									
541 404	**DMSP**	–	**20**	–	**5 000 N**	–	**AM**	–	**RM**

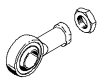
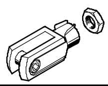
Ordering table

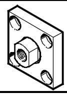
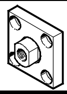
	Size		10	20	40	Conditions	Code		Enter code
M	Module No.		**541 403**	**541 404**	**541 405**				
	Function		Fluidic Muscle with press-fitted connections				**DMSP**		DMSP
	Size	[mm]	10	20	40		**-…**		
	Nominal length	[mm]	40 … 9000	60 … 9000	120 … 9000		**-…N**		-…N
	First connection		Radial, male thread Connecting thread / supply port				**-RM**		
			M8 / G⅛	M10x1.25 / G¼	M16x1.5 / G⅜				
			Axial, male thread Connecting thread / supply port				**-AM**		
			M16x1.5 / G⅛	M20x1.5 / G¼	M30x1.5 / G⅜				
	Second connection		Closed, male thread Connecting thread				**-CM**		
			M8	M10x1.25	M16x1.5				
			Radial, male thread Connecting thread / supply port				**-RM**		
			M8 / G⅛	M10x1.25 / G¼	M16x1.5 / G⅜				
			Axial, male thread Connecting thread / supply port				**-AM**		
			M16x1.5 / G⅛	M20x1.5 / G¼	M30x1.5 / G⅜				

Transfer order code

	DMSP	–		–	**… N**	–		–	

Ordering data Technical data ➔ piston rod attachment

Designation	For size	Part No.	Type
Rod eye SGS			
	10	**9 255**	**SGS-M8**
	20	**9 261**	**SGS-M10x1,25**
	40	**9 263**	**SGS-M16x1,5**[1]
Rod clevis SG			
	10	**3 111**	**SG-M8**
	20	**6 144**	**SG-M10x1,25**
	40	**6 146**	**SG-M16x1,5**[1]

Designation	For size	Part No.	Type
Coupling piece KSG			
	10	–	
	20	**32 963**	**KSG-M10x1,25**
	40	**32 965**	**KSG-M16x1,5**
Coupling piece KSZ			
	10	**36 124**	**KSZ-M8**
	20	**36 125**	**KSZ-M10x1,25**
	40	**36 127**	**KSZ-M16x1,5**

Note

1) Subjecting the DMSP-40 to dynamic loading results in certain limitations with regard to the technical data due to the accessories. Basis: nominal load, friction torque at μ = 0.2:
   - Endurance limit at 6000 N: 1 million load cycles (higher values upon request)
   - Endurance limit at 4000 N: 10 million load cycles

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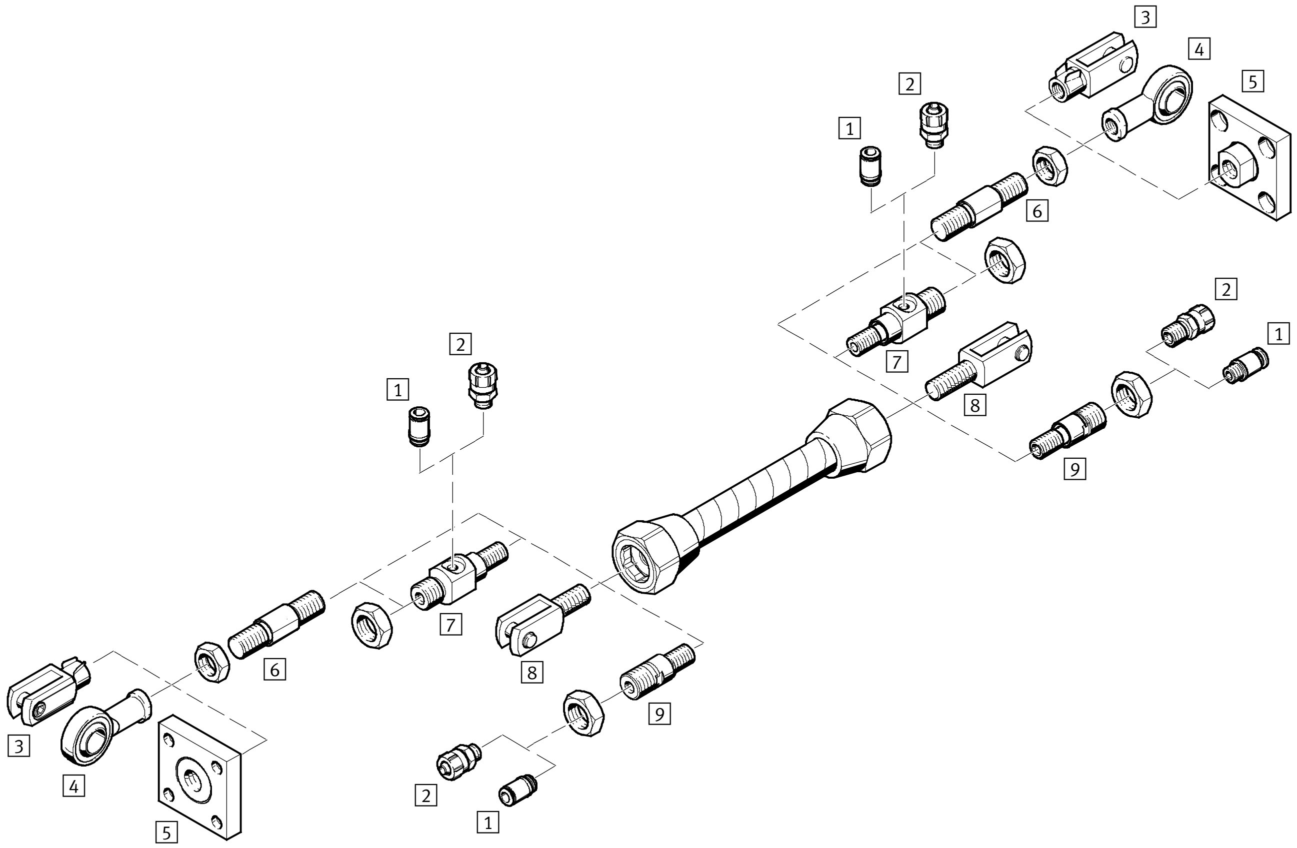

Mounting attachments and accessories		
	Brief description	→ Page/Internet
1 Push-in fittings QS	For connecting compressed air tubing with standard external diameters	quick star
2 Quick connectors CK	For connecting compressed air tubing with standard internal diameters	ck
3 Rod clevis SG	Permits a swivelling movement of the fluidic muscle in one plane	31
4 Rod eye SGS	With spherical bearing	31
5 Coupling pieces KSG/KSZ	For compensating radial deviations	31
6 Threaded rod MXAD-T	For connecting drive accessories	31
7 Radial adapter MXAD-R	For connecting drive accessories and the air supply in radial direction	30
8 Rod clevis SGA	With male thread for direct mounting on fluidic muscle	31
9 Axial adapter MXAD-A	For connecting drive accessories and the air supply in axial direction	30

Fluidic Muscle MAS, with screwed connections

Type codes

MAS	–	10	–	500N	–	AA	–	MC	–	K	–	ER	–	EG

Drive function	
Single-acting, pulling	
MAS	Fluidic Muscle

Internal dia. [mm]

Nominal length [mm]	
...N	40 ... 9000

Material	
AA	Standard material (chloroprene, aramide)

Connection type	
MC	Open at one end
MO	Open at both ends

Connection type	
K	With force compensator
O	Without force compensator

Accessories supplied loose	
Adapter	
ER	1 adapter for radial air supply, at one end
EA	1 adapter for axial air supply, at one end
BR	2 adapters for radial air supply, at both ends
BA	2 adapters for axial air supply, at both ends
RA	1 adapter for radial and 1 adapter for axial air supply
Mounting	
EG	1 threaded rod for mounting, at one end
BG	2 threaded rods for mounting, at both ends

Fluidic Muscle MAS, with screwed connections

Technical data

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Size
10 … 40 mm

Nominal length
40 … 9000 mm

Lifting force
0 … 6000 N

General technical data				
Size		10	20	40
Pneumatic connection		→ Adapter MXAD-… from page 30		
Design		Contraction diaphragm		
Mode of operation		Single-acting, pulling		
Internal dia.	[mm]	10	20	40
Nominal length	[mm]	40 … 9000	60 … 9000	120 … 9000
Max. additional load, freely suspended	[kg]	30	80	250
Max. permissible pretensioning[1]	Without force compensator	3% of nominal length	4% of nominal length	5% of nominal length
	With force compensator	3% of nominal length	3% of nominal length	3% of nominal length
Max. permissible contraction		25% of nominal length		
Max. hysteresis		≤ 3% of nominal length	≤ 2.5% of nominal length	
Max. relaxation		≤ 4% of nominal length		≤ 3% of nominal length
Repetition accuracy		≤ 1% of nominal length		
Type of mounting		With accessories		
Assembly position		Any (an external guide is required if lateral forces occur)		

1) The max. pretensioning is achieved when the max. permissible freely suspended useful load is attached.

Operating and environmental conditions				
Size		10	20	40
Operating pressure	[bar]	0 … 8	0 … 6	
Operating medium		Compressed air in accordance with ISO 8573-1:2010 [7:–:–]		
Note on operating/pilot medium		Operation with lubricated medium possible (in which case lubricated operation will always be required)		
Ambient temperature	[°C]	–5 … +60		
Corrosion resistance class CRC[2]		2		

2) Corrosion resistance class 2 according to Festo standard 940 070
Components requiring moderate corrosion resistance. Externally visible parts with primarily decorative surface requirements which are in direct contact with a normal industrial environment or media such as coolants or lubricating agents.

Forces [N] at max. permissible operating pressure			
Size	10	20	40
Theoretical force	630	1500	6000
Force compensation	400	1200	4000

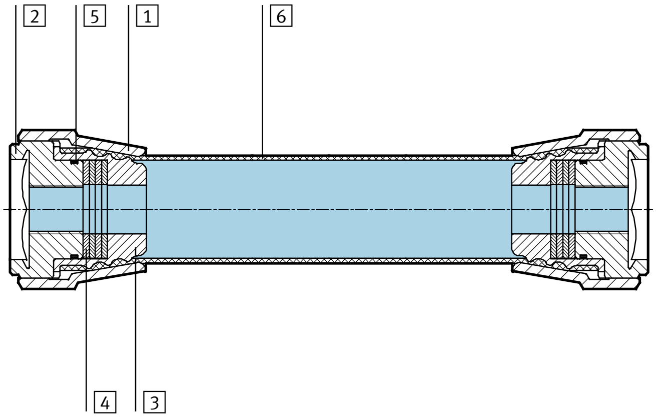
Fluidic Muscle MAS, with screwed connections

Technical data

Weight [g]				
Size		10	20	40
Basic weight at 0 m length		77	238	673
Additional weight per 1 m length		94	178	340
Connection without force compensator	MO	38	114	331
	MC	39	124	342
Connection with force compensator	MO	49	153	521
	MC	49	153	521

Materials

Sectional view



Fluidic muscle		
1	Union nuts	Wrought aluminium alloy, clear anodised
2	Flange	Wrought aluminium alloy, blue anodised
3	Internal cone	Wrought aluminium alloy, clear anodised
4	Cup springs	Steel
5	Sealing ring	Nitrile rubber
6	Diaphragm hose	Chloroprene, aramide
–	Adhesive	Loctite 243 (thread locking agent)
–	Lubricant	Klüberplex BE 31-102
	Note on materials	Copper, PTFE and silicone-free

Permissible force F [N] as a function of the contraction h [%] of the nominal length

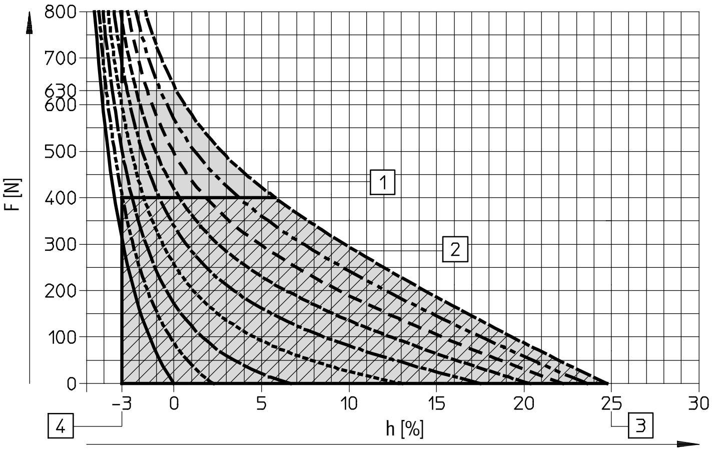
The limit for “freely suspended” loads is derived from the contraction. With the Fluidic Muscle MAS-10-..., a loosely attached additional load of 30 kg results in 3% pretensioning (see diagram). The limits specified in the technical data must be complied with when using the fluidic muscle. The diagrams below illustrate the operating range of the fluidic muscle, depending on the diameter, within the boundary lines illustrated below.

Using the diagrams

1. The upper limit of the grey area describes maximum permissible force.
2. The right limiting curve of the permissible operating ranges describes the maximum permissible operating pressure.
3. The right vertical limit of the permissible operating ranges describes the maximum permissible contraction.
4. The left limit of the permissible operating ranges describes the load limit of the muscle defined by the maximum pretensioning.

Operating range MAS-10-100N-...

Sizing examples → 32



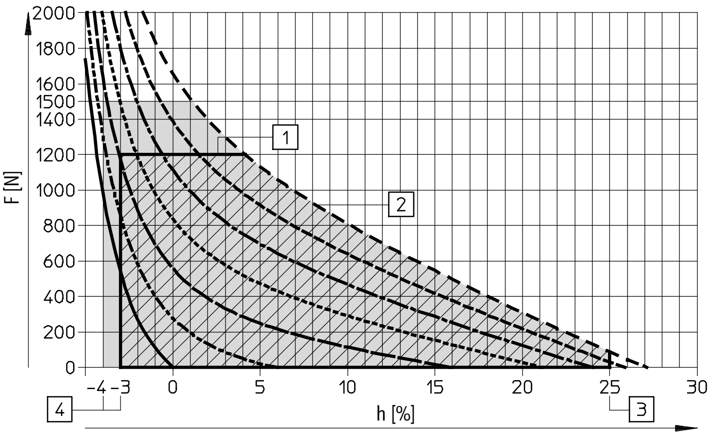
0 bar
1 bar
2 bar
3 bar
4 bar
5 bar
6 bar
7 bar
8 bar

[1] Force compensation with MAS-10-...-K
[2] Max. operating pressure
[3] Max. deformation
[4] Max. pretensioning

Permissible operating range for MAS-10-...
Permissible operating range for MAS-10-...-K

Operating range MAS-20-200N-...

Sizing examples → 32



0 bar
1 bar
2 bar
3 bar
4 bar
5 bar
6 bar

[1] Force compensation with MAS-20-...-K
[2] Max. operating pressure
[3] Max. deformation
[4] Max. pretensioning

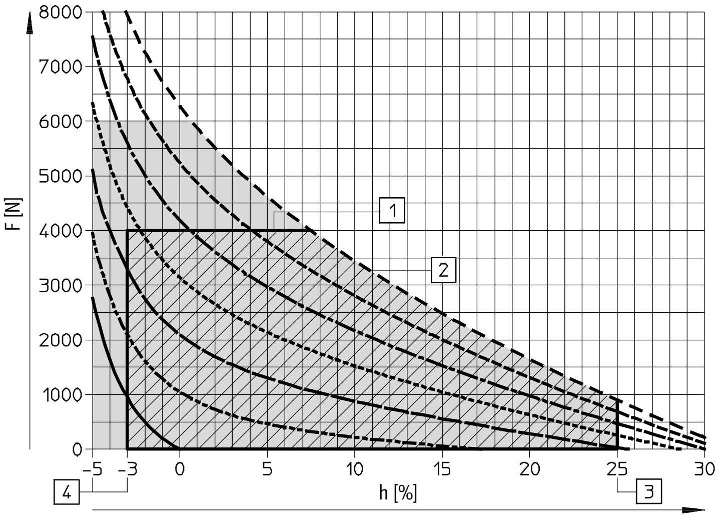
Permissible operating range for MAS-20-...
Permissible operating range for MAS-20-...-K

Fluidic Muscle MAS, with screwed connections

Technical data

Operating range MAS-40-400N-...

Sizing examples → 32



0 bar
1 bar
2 bar
3 bar
4 bar
5 bar
6 bar

1 Force compensation with MAS-40-...-K
2 Max. operating pressure
3 Max. deformation
4 Max. pretensioning

Permissible operating range for MAS-40-...

Permissible operating range for MAS-40-...-K

Note

The specified pretensioning applies to the design without force compensation – the diagrams were determined using muscles with standard length (standard length = 10x internal dia.), sizing should therefore be carried out using the Fluidic Muscle sizing software. The software is available at the address → www.festo.com. Approximate sizing is possible using the force/displacement diagram. Properties that influence the dependence between force and displacement, such as material properties, manufacturing deviations and nominal length, are not taken into account in these diagrams. The theoretical force can therefore increase by up to ten per cent. Deviations can be compensated by means of pressure adaptation up to the maximum permissible operating pressure.

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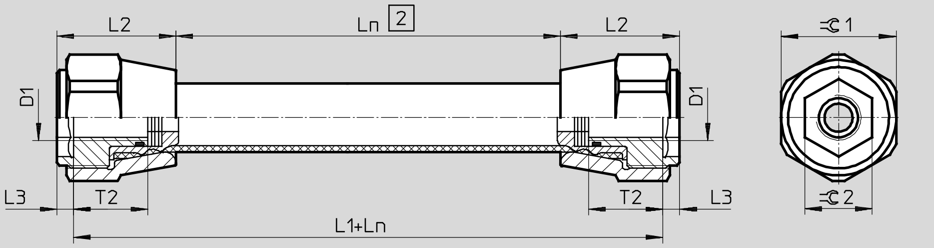
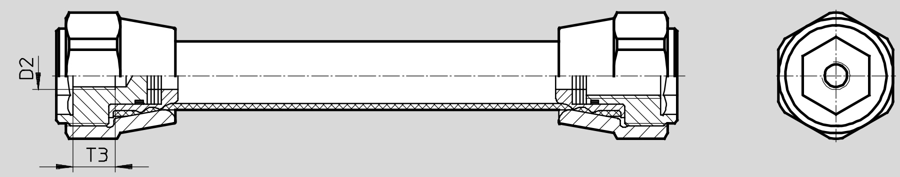
Dimensions – without force compensation Download CAD data ➔ **www.festo.com**

MO-O – open at both ends



2 Nominal length

MC-O – open at one end



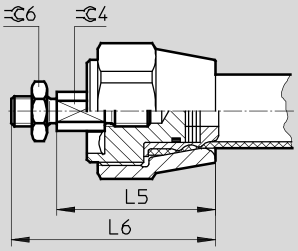
Size	D1	D2	Ln		L1
			min.	max.	
10	M10x1.25	M10x1.25	40	9000[1]	60.2
20	M16x1.5	M10x1.25	60		73
40	M20x1.5	M16x1.5	120		95

Size	L2	L3	T2	T3	⊐C1	⊐C2
10	34.1	4	10	10	27	17
20	42.5	6	26.5	15	41	24
40	55.5	8	21.8	20	60	41

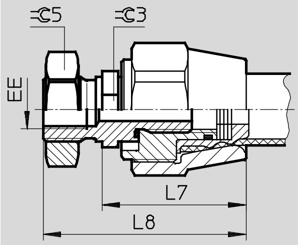
1) Tolerance ≤ 100 mm ±1 mm, 100 … 400 mm ±1%, > 400 mm ±4 mm.

Dimensions – without force compensation Download CAD data ➔ **www.festo.com**

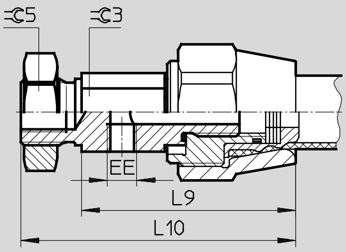
EG – open at one end, with threaded rod



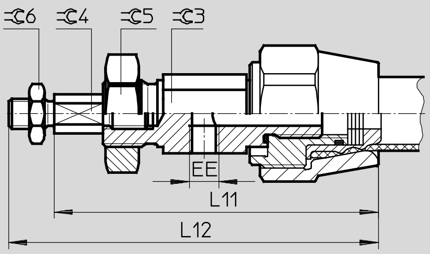
EA/BA – pneumatic connection, axial, one end/both ends



ER/BR – pneumatic connection, radial, one end/both ends



ER/BR-EG/BG – pneumatic connection, radial with threaded rod, one end/both ends



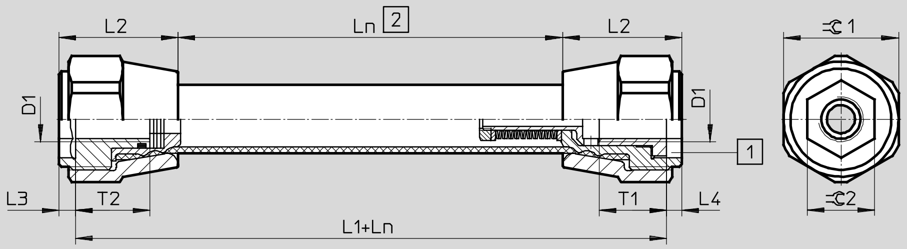
Size	EE		L5	L6	L7	L8	L9
	Axial	Radial					
10	G1⁄8	M5	46.1	61.1	42.6	60	58.2
20	G1⁄4	G1⁄8	52.5	67.5	49	69	71
40	G3⁄8	G1⁄4	67.5	91.5	63	101	93

Size	L10	L11	L12	=C3	=C4	=C5	=C6
10	75.6	96.6	111.6	17	11	24	17
20	91	107	122	24	11	32	17
40	131	151	175	36	17	46	24

Dimensions – with force compensation

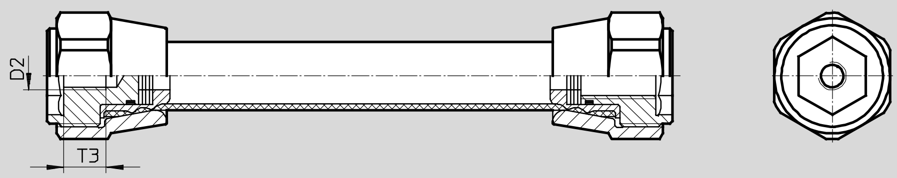
Download CAD data → www.festo.com

MO-K – open at both ends



1 Force compensator
2 Nominal length

MC-K – open at one end



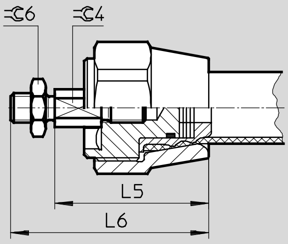
Size	D1	D2	Ln		L1	L2
			min.	max.		
10	M10x1.25	M10x1.25	40	9000 1)	61.7	34.1
20	M16x1.5	M10x1.25	60		73.5	42.5
40	M20x1.5	M16x1.5	120		96.5	55.5

Size	L3	L4	T1	T2	T3	=⊂1	=⊂2
10	4	2.5	15	10	10	27	17
20	6	5.5	24	26.5	15	41	24
40	8	6.5	30	21.8	20	60	41

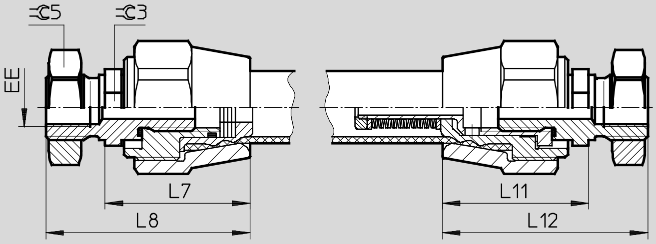
1) Tolerance ≤ 100 mm ±1 mm, 100 … 400 mm ±1%, > 400 mm ±4 mm.

Dimensions – without force compensation Download CAD data → **www.festo.com**

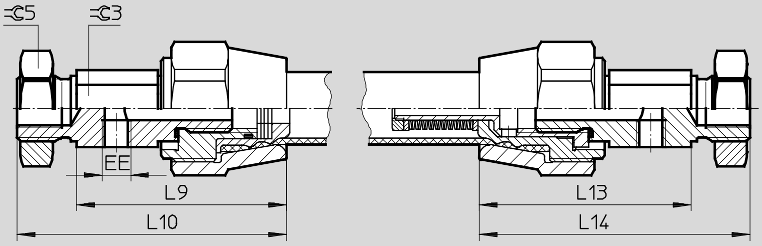
EG – open at one end, with threaded rod



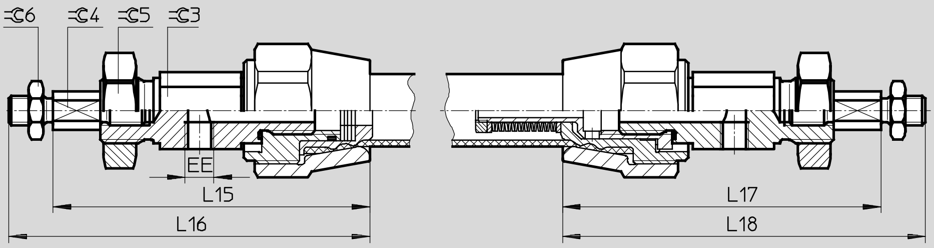
EA/BA – pneumatic connection, axial, one end/both ends



ER/BR – pneumatic connection, radial, one end/both ends



EA/BA-EG/BG – pneumatic connection, radial with threaded rod, one end/both ends



Size	EE		L5	L6	L7	L8	L9	L10	L11	L12
	Axial	Radial								
10	G1⁄8	M5	46.1	61.1	42.6	60	58.2	75.6	44.1	61.5
20	G1⁄4	G1⁄8	52.5	67.5	49	69	71	91	49.5	69.5
40	G3⁄8	G1⁄4	67.5	91.5	63	101	93	131	64.5	102.5

Size	L13	L14	L15	L16	L17	L18	=C3	=C4	=C5	=C6
10	59.7	77.1	96.6	111.6	98.1	113.1	17	11	24	17
20	71.5	91.5	107	122	107.5	122.5	24	11	32	17
40	94.5	132.5	151	175	152.5	176.6	36	17	46	24

FESTO

M Mandatory data							O Options	
Module No.	**Function**	**Inside dia.**	**Nominal length**	**Material**	**Connection type**	**Connector type**	**Adapter**	**Mounting**
534 201 534 202 534 203	MAS	10 20 40	...N	AA	MC MO	K O	ER EA BR BA RA	EG BG
Ordering example								
534 201	**MAS** –	**10** –	**500N** –	**AA** –	**MC** –	**K** –	**ER** –	**EG**

Ordering table

	Size	10	20	40	Condi-tions	Code	Enter code
M	Module No.	**534 201**	**534 202**	**534 203**			
	Function	Fluidic Muscle with screwed connections				**MAS**	MAS
	Internal dia. [mm]	10	20	40		**-...**	
	Nominal length [mm]	40 ... 9000	60 ... 9000	120 ... 9000		**-...N**	
	Material	Standard material (chloroprene)				**-AA**	-AA
	Connection type	Fluidic Muscle open at one end				**-MC**	
		Fluidic Muscle open at both ends				**-MO**	
	Connector type	Screwed connections with force compensator				**-K**	
		Screwed connections without force compensator				**-O**	
O	Adapters, supplied loose	1 adapter for radial air supply, at one end			1	**-ER**	
		1 adapter for axial air supply, at one end			1	**-EA**	
		2 adapters for radial air supply, at both ends			2	**-BR**	
		2 adapters for axial air supply, at both ends			2	**-BA**	
		1 adapter for radial and 1 adapter for axial air supply			2	**-RA**	
	Mountings, supplied loose	1 threaded rod for mounting, at one end			3	**-EG**	
		2 threaded rods for mounting, at both ends			4	**-BG**	

1 **ER, EA** Not in combination with connection type MO.
2 **BR, BA, RA** Not in combination with connection type MC.
3 **EG** In combination with connection type MO only permissible in combination with adapter BR, RA.
4 **BG** In combination with connection type MC only permissible in combination with adapter ER.
In combination with connection type MO only permissible in combination with adapter BR.

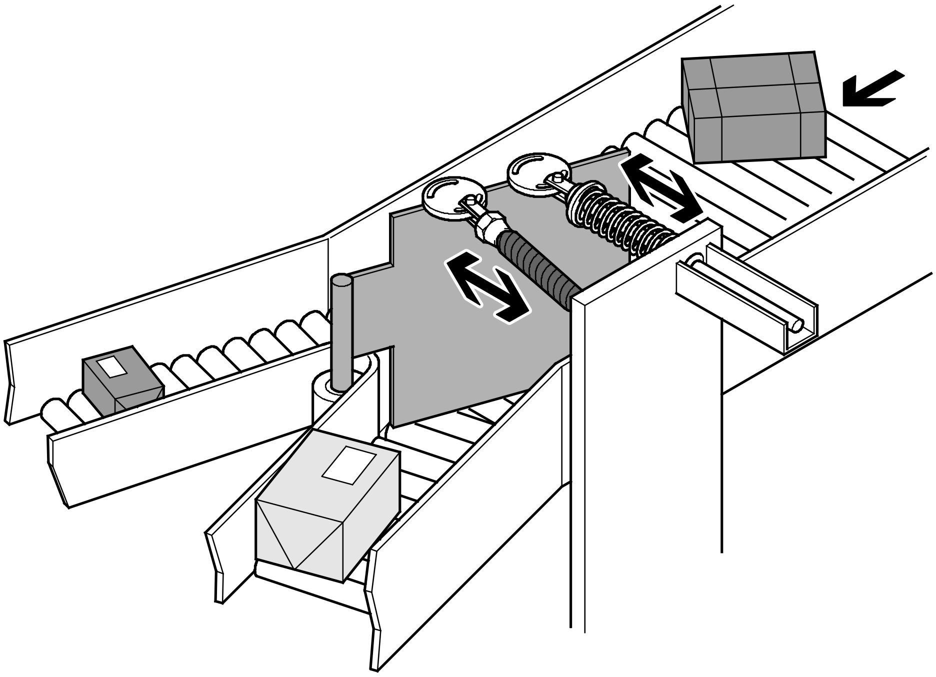
Transfer order code

	MAS –	–	–	**AA** –	–	–	–	

Force and dynamism

Drive for sorting

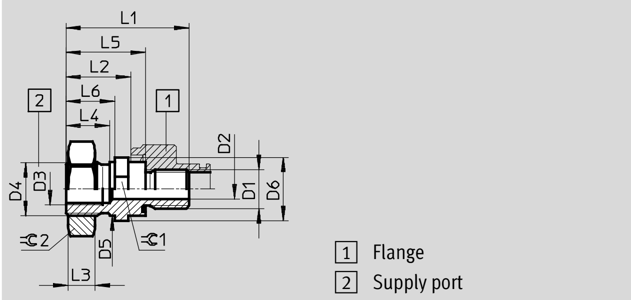
The ideal drive for sorting tasks and stop functions in delivery processes thanks to the muscle's high speed and good acceleration behaviour. The short response times mean that cycle rates can be increased considerably.



FESTO

Axial adapter MXAD-A
(order code EA/BA/RA)

Material:
Adapter: Anodised aluminium
Nut: Brass
Seal: Nitrile rubber



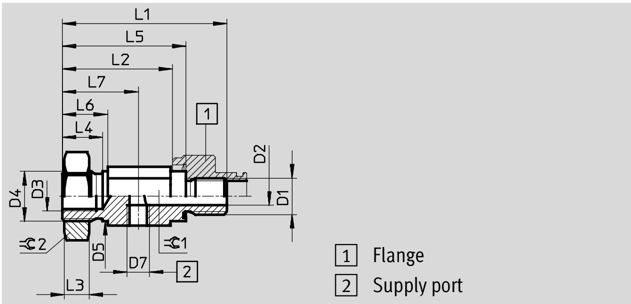
Dimensions and ordering data

For size	D1	D2 ∅	D3	D4	D5 ∅ h11	D6 ∅	L1	L2	L3
10	M10x1.25	5	G⅛	M16x1.5	16	20	39.9	25.9	8
20	M16x1.5	8	G¼	M22x1.5	22	26	50.5	26.5	11
40	M20x1.5	10	G⅜	M30x1.5	30	40	73.5	45.5	8

For size	L4	L5	L6	=©1	=©2	Weight [g]	Part No.	Type
10	15.4	29.9	17.4	17	24	33	**534 400**	**MXAD-A10**
20	18	32.5	20	24	32	69	**534 402**	**MXAD-A16**
40	35	53.5	38	36	46	184	**534 404**	**MXAD-A20**

Radial adapter MXAD-R
(order code ER/BR/RA)

Material:
Adapter: Anodised aluminium
Nut: Brass
Seal: Nitrile rubber



Dimensions and ordering data

For size	D1	D2 ∅	D3	D4	D5 ∅ h11	D7	L1	L2	L3
10	M10x1.25	5	M10x1.25	M16x1.5	16	M5	55.5	41.5	8
20	M16x1.5	8	M10x1.25	M22x1.5	22	G⅛	72.5	48.5	11
40	M20x1.5	10	M16x1.5	M30x1.5	30	G¼	103.5	75.5	8

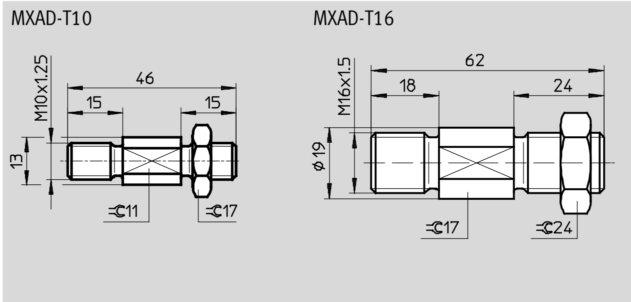
For size	L4	L5	L6	L7	=©1	=©2	Weight [g]	Part No.	Type
10	15.4	45.5	17.4	26.7	17	24	44	**534 401**	**MXAD-R10**
20	18	54.5	20	33.5	24	32	109	**534 403**	**MXAD-R16**
40	35	83.5	38	56	36	46	263	**534 405**	**MXAD-R20**

Fluidic Muscle MAS, with screwed connections

Accessories

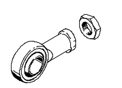
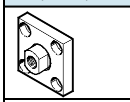
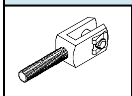
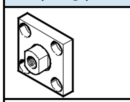
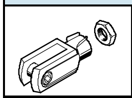
Threaded rod MXAD-T
(order code EG/BG)

Material:
Aluminium



Dimensions and ordering data				
For size	Suitable for threaded connection	Weight [g]	Part No.	Type
10/20	M10x1.25	40	**187 597**	**MXAD-T10**
40	M16x1.5	140	**187 609**	**MXAD-T16**

Ordering data — Technical data → piston rod attachment

Designation	For size	Part No.	Type	Designation	For size	Part No.	Type
Rod eye SGS[1]				Coupling piece KSG[1]			
	10	**9 261**	**SGS-M10x1,25**		10	**32 963**	**KSG-M10x1,25**
	20	**9 261**	**SGS-M10x1,25**		20	**32 963**	**KSG-M10x1,25**
	40	**9 263**	**SGS-M16x1,5**		40	**32 965**	**KSG-M16x1,5**
Rod clevis SGA				Coupling piece KSZ[1]			
	10	**32 954**	**SGA-M10x1,25**		10	**36 125**	**KSZ-M10x1,25**
	20	**32 954**	**SGA-M10x1,25**		20	**36 125**	**KSZ-M10x1,25**
	40	**10 768**	**SGA-M16x1,5**		40	**36 127**	**KSZ-M16x1,5**
Rod clevis SG[1]							
	10	**6 144**	**SG-M10x1,25**				
	20	**6 144**	**SG-M10x1,25**				
	40	**6 146**	**SG-M16x1,5**				

1) Threaded rod MXAD-T... is required.

Note

When replacing an existing Fluidic Muscle MAS and the corresponding mounting accessories → 7

Example 1
Lifting a constant load

A Fluidic Muscle is to be used to engage free of forces with a constant load of 80 kg on a supporting surface and raise this a distance of 100 mm. The operating pressure is to be 6 bar.

The size (diameter and nominal length) of the fluidic muscle is to be found.

Note

The sizing should be performed using the Fluidic Muscle sizing software, as the diagrams describe only a muscle of standard length (standard length = 10x internal dia.). The software is available at the address → www.festo.com.

The limits specified in the technical data must be complied with when using the muscle.

General conditions	Values
Required force at rest	0 N
Required stroke	100 mm
Required force in contracted state	approx. 800 N
Operating pressure	6 bar

Solution method

Step 1
Determining the required muscle size

Determine the most suitable muscle diameter on the basis of the required force. The required force is 800 N.

MAS-20-... or MAS-40-... are available for selection.

Step 2
Entering load point 1

Load point 1 is entered into the force/displacement diagram for the MAS-20-...

Force F = 0 N
Pressure p = 0 bar

Step 3
Entering load point 2

Load point 2 is entered into the force/displacement graph.

Force F = 800 N
Pressure p = 6 bar

Step 4
Reading the length change

The change in the length of the muscle is read between the load points on the X axis (contraction in %).

Result:
9.6% contraction.

Step 5
Calculating the nominal length

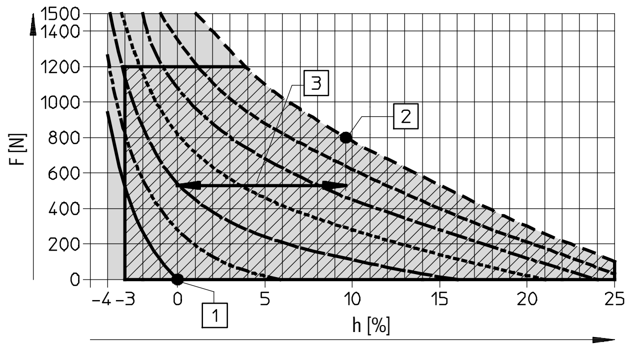
The required nominal muscle length for a stroke of 100 mm is obtained by dividing by the contraction in %.

Result:
100 mm / 9.6% ~ 1042 mm.

Step 6
Result

A Fluidic Muscle with a nominal length of 1042 mm should be ordered.

In order to attach a load of 80 kg free of forces and lift this 100 mm, a MAS-20-1042N-AA-... is required.



0 bar
1 bar
2 bar
3 bar
4 bar
5 bar
6 bar

1 Load point 1
2 Load point 2
3 Length change = 9.6%

FESTO

Example 2
Use as a tension spring

In this example, the muscle is to be used as a tension spring.

The size (diameter and nominal length) of the fluidic muscle is to be found.

Note

Sizing should be performed using the Fluidic Muscle sizing software, as the diagrams describe only a muscle of standard length (standard length = 10x internal dia.). The software is available at the address → www.festo.com.

The limits specified in the technical data must be complied with when using the muscle.

General conditions	Values
Required force in extended state	2000 N
Required force in contracted state	1000 N
Required stroke (spring length)	50 mm
Operating pressure	2 bar

Solution method

Step 1
Determining the required muscle size

Determine the most suitable muscle diameter on the basis of the required force. The required force is 2000 N, therefore an MAS-40-... is selected.

Step 2
Entering load point 1

Load point 1 is entered into the force/displacement diagram for the MAS-40-...

Force F = 2000 N
Pressure p = 2 bar

Step 3
Entering load point 2

Load point 2 is entered into the force/displacement graph.

Force F = 1000 N
Pressure p = 2 bar

Step 4
Reading the length change

The change in the length of the muscle is read between the load points on the X axis (contraction in %).

Result:
8.7% contraction.

Step 5
Calculating the nominal length

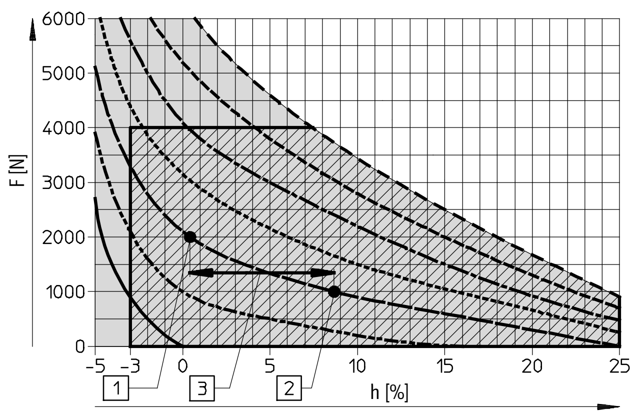
The required nominal muscle length for a stroke of 50 mm is obtained by dividing by the contraction in %.

Result:
50 mm / 8.7% ~ 544 mm.

Step 6
Result

A Fluidic Muscle with a nominal length of 544 mm should be ordered.

For use as a tension spring with a force of 2000 N and a spring travel of 50 mm, a ... is required.



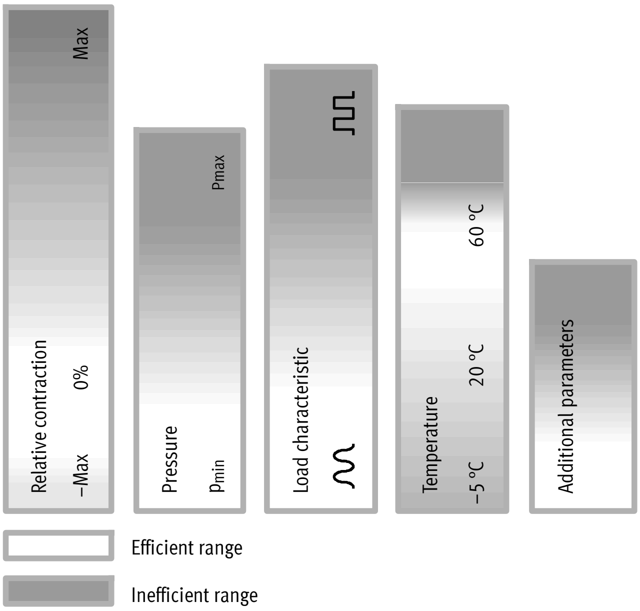
0 bar
1 bar
2 bar
3 bar
4 bar
5 bar
6 bar

[1] Load point 1
[2] Load point 2
[3] Length change = 8.7%

FESTO

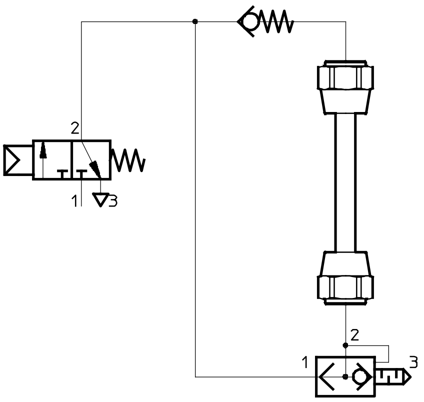
Service life (bar height = meaning / influence)

Optimisation through selection of suitable parameters



The service life of the fluidic muscle is between 100000 and 10 million switching cycles for typical applications. Optimisations can be made using the information from the left diagram. The service life thus increases due to a reduction in the relative contraction (use of a longer muscle). It is also recommended that the pressure be reduced, which is possible because the fluidic muscle is more powerful with lower relative contraction. This measure also improves the service life.

Reducing the thermal load



The service life of the Fluidic Muscle depends on the contraction, the operating pressure and the temperature. High operating frequencies or high loads can lead to a temperature rise. Targeted pressurisation on one side and venting on the other side enables. the thermal load on the component to be reduced and the service life of the fluidic muscle to be increased (only with fluidic muscle open at both ends).