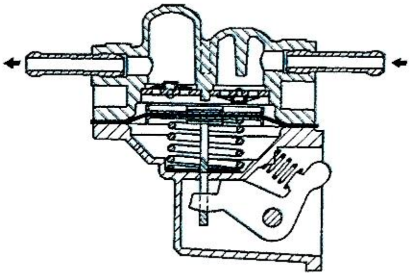
-DIAPHRGAMS

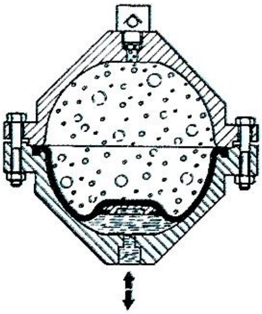
FUNCTION AND TYPES

Diaphragms are moving partition-walls used for hermetic separation of two chambers containing fluids under different pressures. A diaphragm is characterized with easy moving and high sensitivity to pressure changes, which result with a shorter or longer stroke in the pressurization direction. The diaphragm mobility depends on the materials used and dimensions, and with long strokes on the profile.

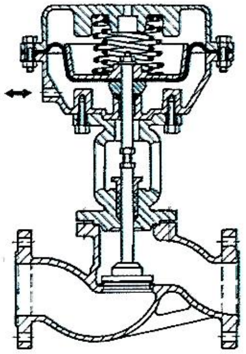
According to the application there are three types of diaphragms: regulating diaphragms, pump diaphragms and separating (partition) diaphragms.



Regulating diaphragms



Separating diaphragms



Pump diaphragms

Regulating diaphragms transduce the regulating pressure of the control medium into the lever force, which further actuates the control or regulating device.

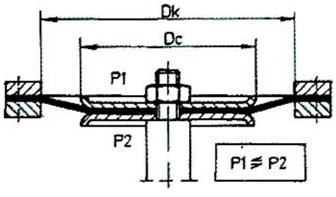
Pump diaphragms transduce the lever force into the fluid pressure.

Separating diaphragms are used for separating a hydraulic accumulator in two pressure equilibration vessels, which is achieved by their little intrinsic resistance.

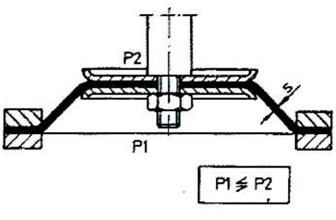
There are numerous advantages of application of diaphragms in regulating, measuring and indicating, and particularly in pneumatic instruments, compared to alternative designs based on a piston and seal:

- exceptional sealing performance (effect),
- maintenance free,
- lubrication free,
- no pressure loss due to friction,
- "stick-slip" effect free,
- low rate of wear (extrusion),
- long operating life,
- low rate of required surface precision,
- low rate of required dimensional precision of the housing,
- high sensitivity and proportional dependence between stroke and pressure in the case of regulating function.

According to the profile there are flat diaphragms, saucer diaphragms, short stroke diaphragms and long stroke diaphragms.



Flat diaphragm



Saucer diaphragm

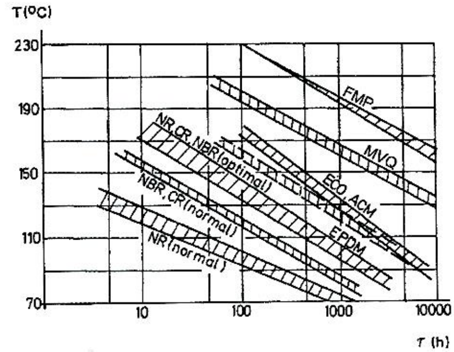
MATERIALS

Elastomers

It is recommended that the selection of the material or compound of materials suitable for a specific application be made by the diaphragm manufacturer. The factors determining the selection of the material are primarily the function of the diaphragm, chemical, thermal and mechanical loads under operation, costs and processing characteristics of the material.

When selecting the base elastomer, attention is to be to the following characteristics

- chemical resistance of the material in a medium;
- physical and mechanical properties of the material, like: strength, elasticity, flexibility, resistance to fatigue, etc.;
- resistance to ozone.



Temperature and period limits of application of certain elastomers tested in hot air

Acrylonitrile-butadiene-rubber (NBR) is used for diaphragms operating in compressed air or mineral oils. Special molds (materials) based on this rubber are resistant to natural gas, propane, petrol, etc.

Natural rubber (NR) is characterized with high tensile strength, elasticity and good cold flexibility. Appropriate additives improve its resistance to oils.

Chlorobutadiene rubber (CR) is characterized with good cold flexibility. It is resistant to air, and it is generally used for fabric reinforced diaphragms in pneumatic valves.

Silicone rubber (MVQ) (Vinyl-methyl-polysiloxane) is used where materials resistant to high temperatures are required, foodstuff industry, medical equipment, electronics, etc.

Fluoro-rubber (FPM) is characterized with high resistance to high temperatures and chemicals, and low gas permeability.

Ethylene-propylene-diene-rubber (EPDM) is often used for manufacture of diaphragms. It is resistant to hot and cold water and water steam. Special molds based on this rubber can be used in foodstuff industry.

Butyl-rubber (IIR) is gas impermeable. It is resistant to water and brake fluids.

Polyester-urethane-rubber (AU) is characterized with good physical and chemical properties, elasticity and resistance to wear in particular. It is resistant to effects of greases, oils and oxidizing agents.

Elastomers most commonly used for manufacture of diaphragms are given in Table 1.

Table 1.

Base polymer	PPT designation	°ShA hardness ± 5	Temperature range °C		Application
NBR	50 NBR 10.1 60 NBR 14.1	50 60	-30	+100	Mineral greases and oil Aliphatic hydrocarbons Mineral transmission fluids Vegetable greases and oils Air Water
	70 NBR 11.2	70	-40	+80	Air and oiled air Lubricant greases based on lithium Water
CR	40 CR 07.1 60 CR 10.1 70 CR 11.1	40 60 70	-40	+100	Weathering effects Drinking and sea water Freon types 11 and 12
NR	60 NR 14.1	60	-50	+80	Brake fluids based on glycol Diluted acids and bases Alcohols and water
	70 NR 16.2	70	-45	+80	
EPDM	50 EPDM 10.1 60 EPDM 10.1	50 60	-40	+100	Brake fluids Oils and greases based on silicone Acids and bases Air and ozone Water and water steam
MVQ	70 MVQ 05.1	70	-60	+200	Hot air and inert gases Ozone UV rays Mineral oils with high aniline point

Diaphragms can also be manufactured from other PPT materials, not listed in this table, depending on their application

Reinforcement fabrics

Unreinforced elastomer diaphragms should be used only when the large pressure variations do not occur. In cases where large pressure variations occur, reinforced diaphragms are to be used, due to elongation caused by pressure. Diaphragms are mainly reinforced by synthetic fabrics. The reinforcement fabric can be located on the nonpressurized side or on both sides. When selecting the fabric, care should be taken of the operating temperature range, the compatibility of the fabric and the elastomer, and the possibility of deformation necessary at manufacture of diaphragms.

Polyester fabric is characterized by easy breakdown of crystalline structure (easily deformed) when subject to a load, and it is suitable for very deep diaphragms (large h).

Polyamide fabric has a more stable crystalline structure and is hard to deform by a load. Its tie with the elastomer is good, which provides for a long operating life of diaphragms.

Cotton fabrics are used as a reinforcement in cases when not very long life time and high temperatures are required.

DIMENSIONAL TOLERANCES

The rate of dimensional accuracy of pressed rubber parts is lower than with metal parts, due to properties of elastomers. The following table contains tolerances of pressed diaphragms:

Diameter D		Unreinforced diaphragms	Reinforced diaphragms
from	10 to 16 mm Ø	± 0,20 mm	± 0,40 mm
over	16 to 25 mm Ø	± 0,25 mm	± 0,50 mm
over	25 to 40 mm Ø	± 0,35 mm	± 0,60 mm
over	40 to 63 mm Ø	± 0,40 mm	± 0,80 mm
over	63 to 100 mm Ø	± 0,50 mm	± 1,00 mm
over	100 to 160 mm Ø	± 0,70 mm	± 1,30 mm
over	160 mm Ø	± 0,5 %	± 0,8 %

Tolerances of wall thickness of pressed diaphragms are given in the following table

Wall thickness S	Tolerance
up to 3	± 0,10 mm
over 3 to 6 mm	± 0,15 mm
over 6 to 10 mm	± 0,20 mm

The tolerances given in the tables are applied most often. The user and the manufacturer can agree on closer tolerances, if it is required by the instrument into which the diaphragm is to be installed.

THE REQUIREMENTS DETERMINING THE SELECTION

Basic data

The following data are required for a correct selection of diaphragm:

- type of instrument into which the diaphragm is to be installed,
- diaphragm stroke,
- working and test pressures,
- force as the function of the stroke per effective peripheral surface,
- properties of the medium,
- extreme and operating temperatures,
- frequency of stroke,
- required life time of the diaphragm, etc.

Basic dimensions

The profile and size of a diaphragm are determined as the function of stroke length and operating pressure. The proper stroke of a diaphragm is recommended for optimum function and long operating life. The values recommended in the table are to be taken as the limit values. The stroke (H) longer than the recommended one causes an excessive deformation and permanent damage to the diaphragm.

Cylinder diameter (Dc) and piston diameter (Dk) determine the rolling fold (V):

$$V = 0{,}5 \times (Dc - Dk)$$

The most commonly applied ratio is Dk = 0.7 Dc.

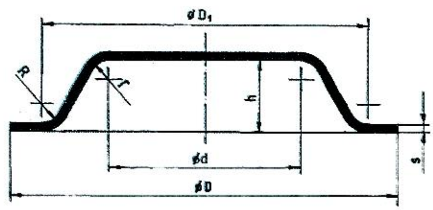
Diaphragm profile	Stroke =f(Dc,Dk,V)	Pressure load	
		single-acting	double-acting
Flat diaphragms	± H = 0,05 Dc		x
Sauce diaphragms	± H = 0,15 Dc		x
Short-stroke diaphragms	± H = 0,15 Dc	x	
Long-stroke diaphragms	± H = 0,85 Dc	x	

When selecting a diaphragm, the following requirement is to be satisfied: the diaphragm depth (h) is to be equal to or larger than half of the total stroke (Hu):

$$h \leq 0{,}5\ Hu$$

DIAPHRAGMS FOR AIR BRAKING SYSTEMS

Pneumatic systems are used increasingly more for control and actuation in modern technologies. They include reinforced diaphragms with low friction, cold flexible and resistant to media.



Dimensions list

Nominal size	Ø D	Ø d	Ø D1	h	S	PTT reference number
6"	108,7	47,2	92	28	3,2	6817027
9"	127,8	65,3	111	31,2	3,2	6817035
12"	138,8	80,9	122	24,8	3,2	6817043
12"	139,0	79,4	119,4	28,5	3,2	6817118
16"	156,4	95,4	140	31,2	3,2	6817050
16"	156,4	91	136,8	45	3,2	6809487
20"	168	104,6	149,2	31,2	3,2	6816409
20"	168	103	148,4	46	3,2	6809495
24"	179	115,6	160,2	31,2	3,2	6816417
24"	179	111	159,4	38	3,2	8742967
24"	179	115	159,4	46	3,2	6817100
27"	191	121	171,4	47	3,2	8359861
30"	201,2	134,3	182,5	34,35	3,2	6816425
30"	201,2	130	181,6	46	3,2	6817100
36"	224,2	144,1	203,2	40,7	3,2	6817068

Order example: 6809487 Diaphragm 16"