CHAPTER 7

HYDRAULIC ACTUATORS

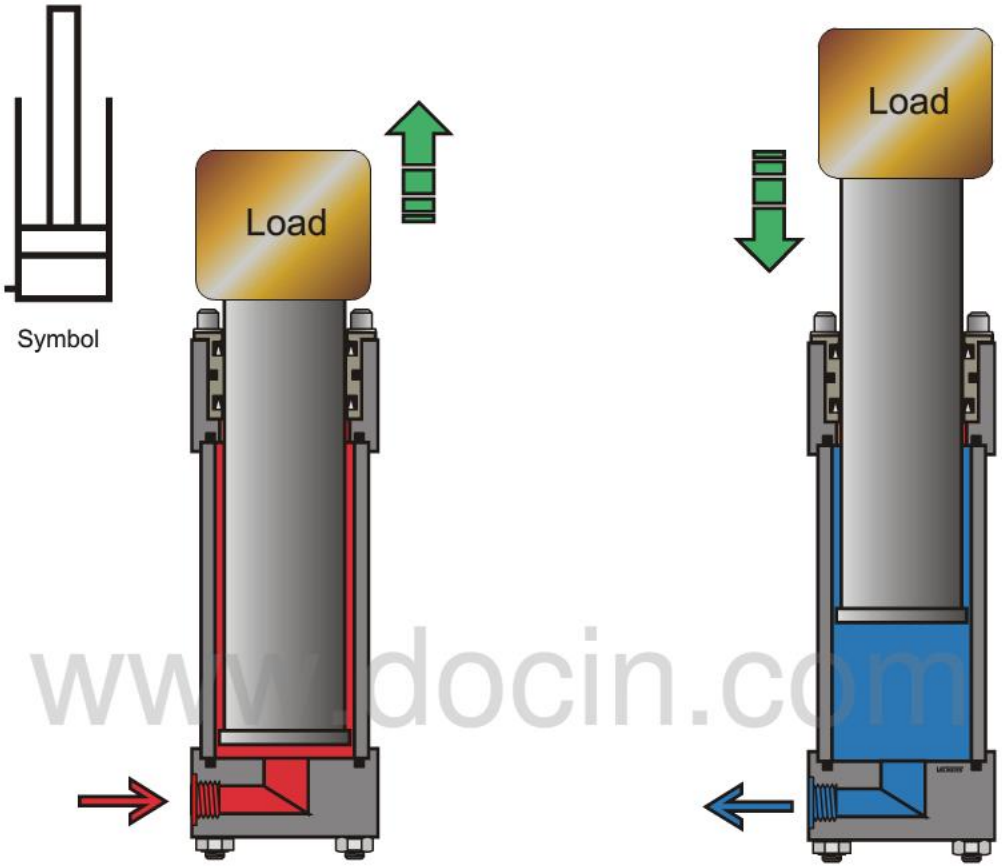


Figure 7-1 Ram Cylinder

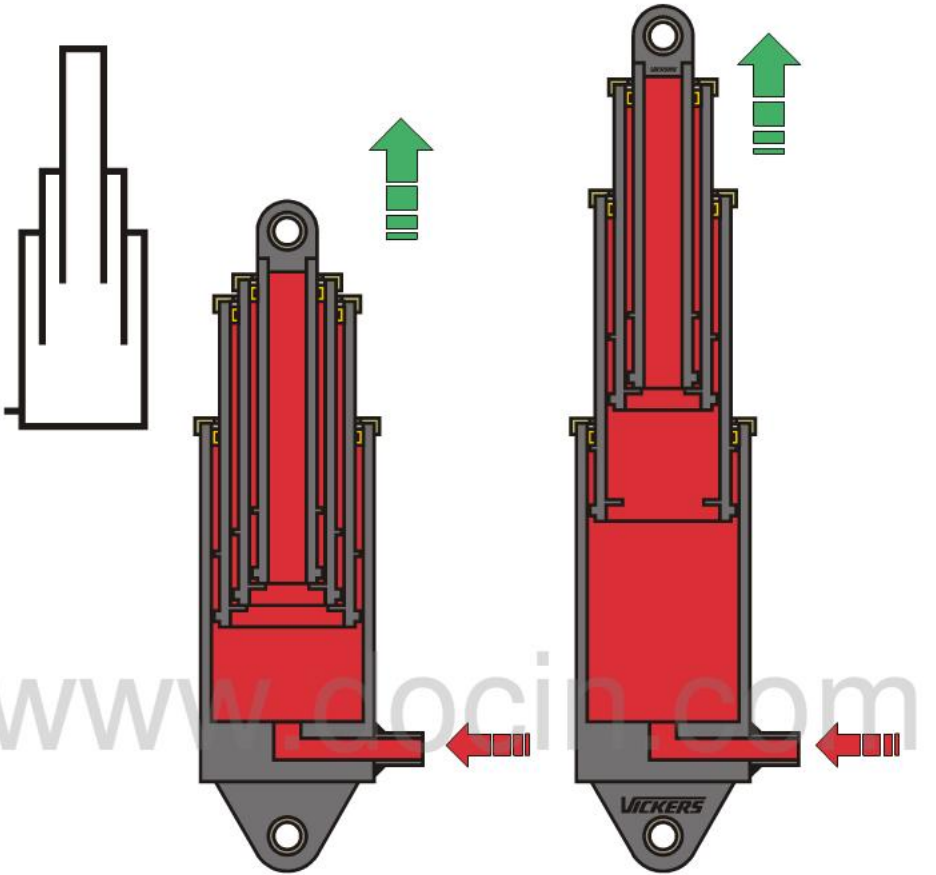


Figure 7-2 Single acting telescope cylinder

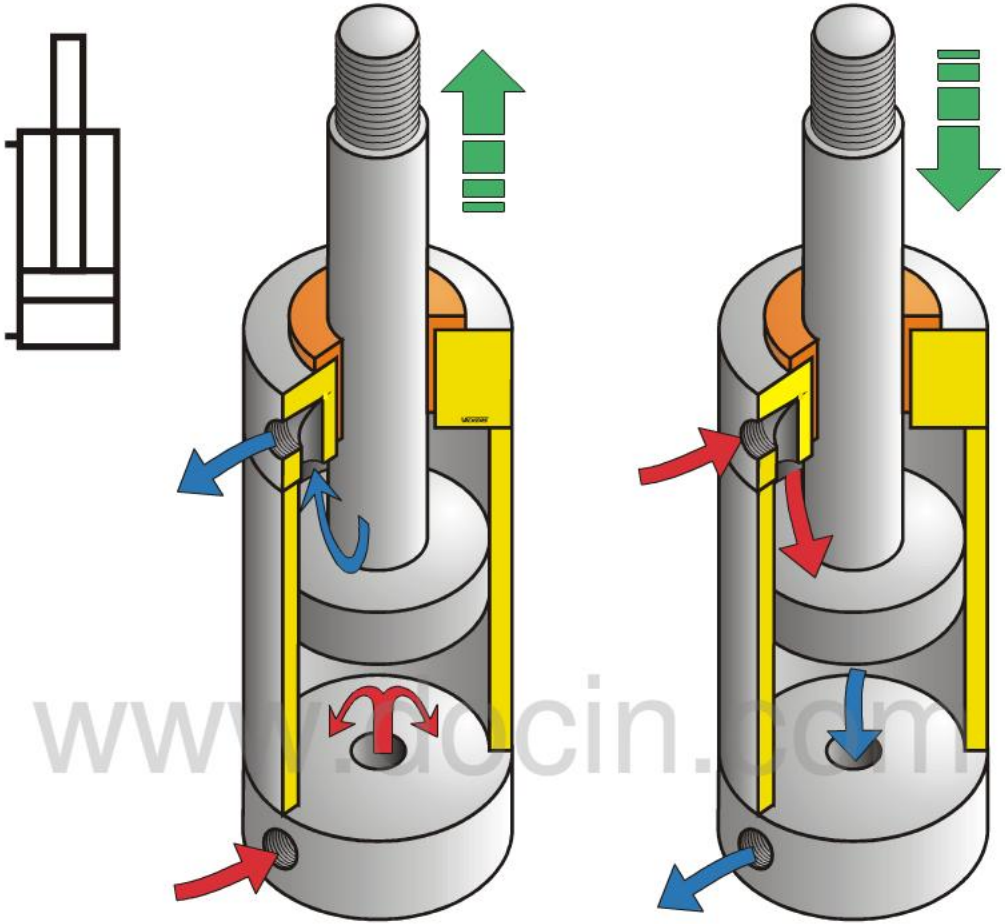


Figure 7-3 Basic double acting cylinder

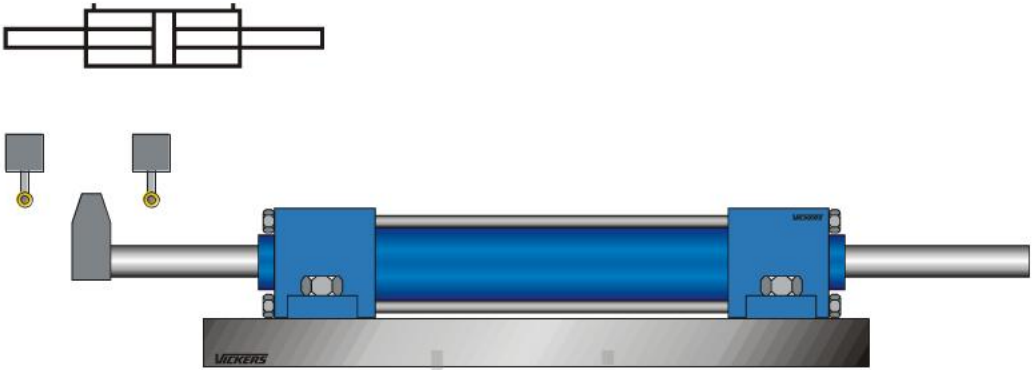


Figure 7-4 Double rod cylinder

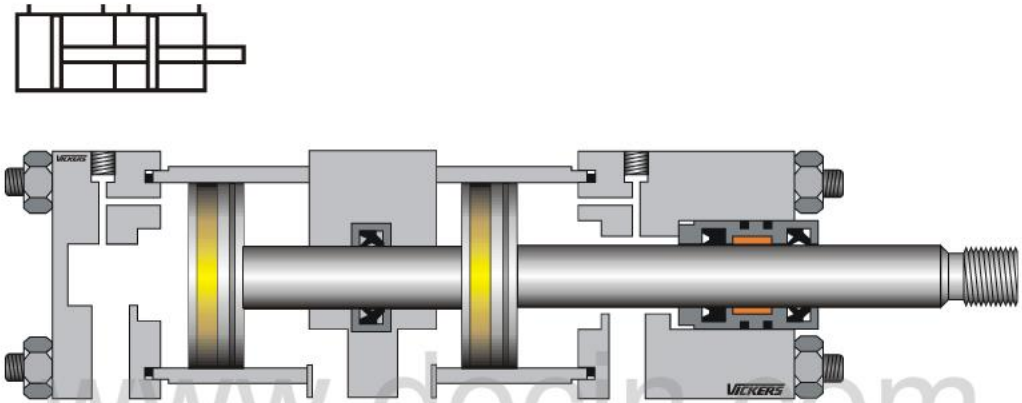


Figure 7-5 Tandem cylinder

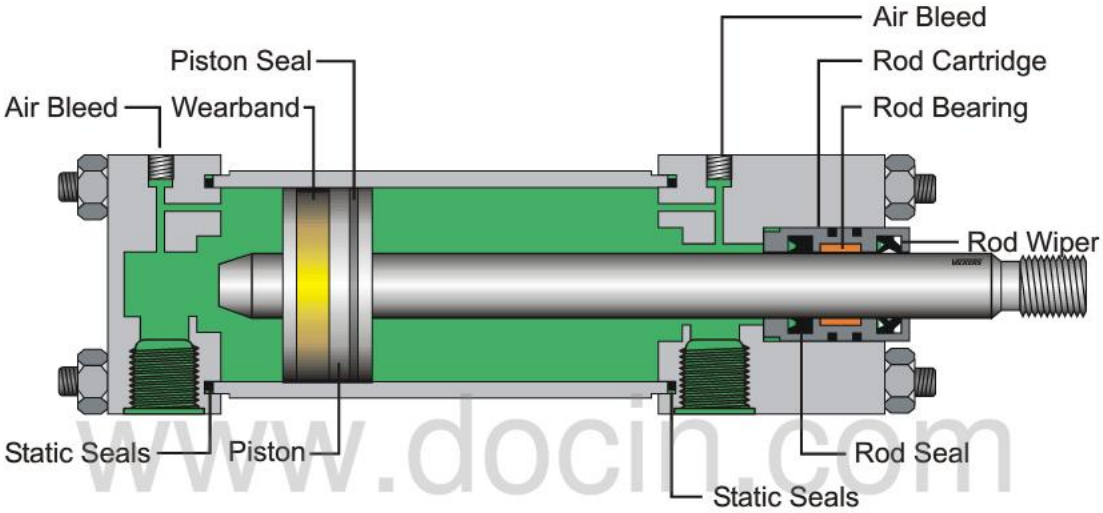


Figure 7-6 Typical cylinder construction

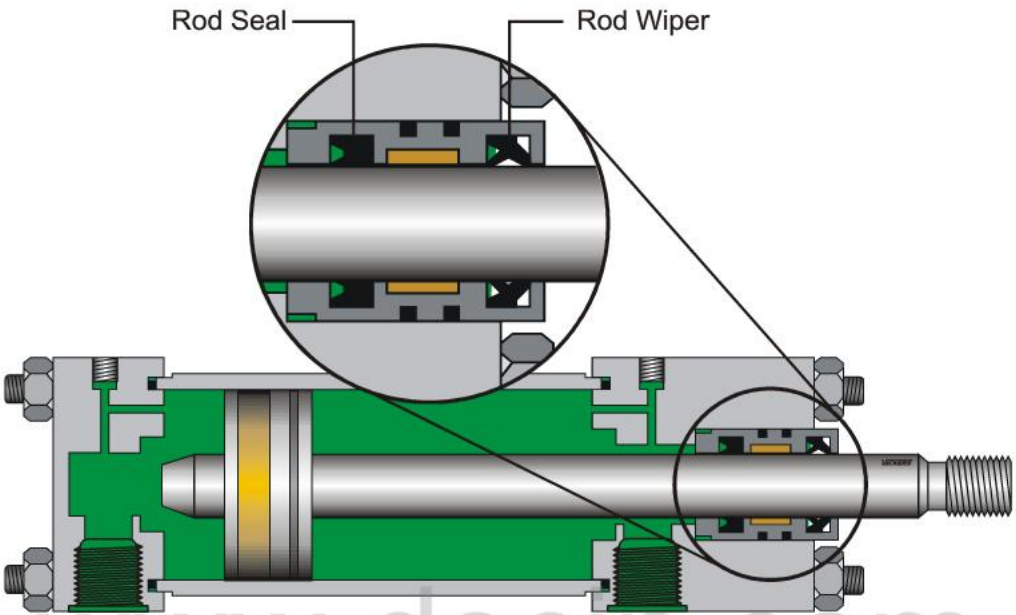


Figure 7-7 Rod seal and wiper design

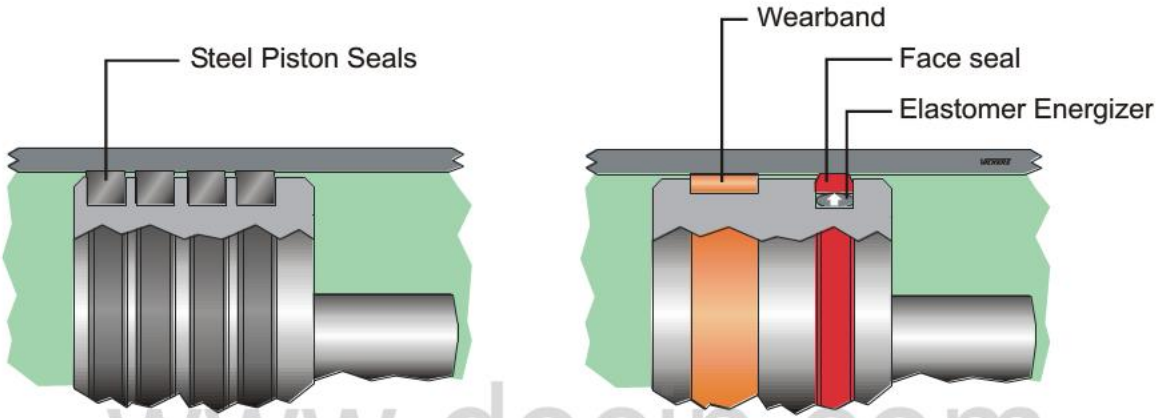


Figure 7-8 Metal sealing rings

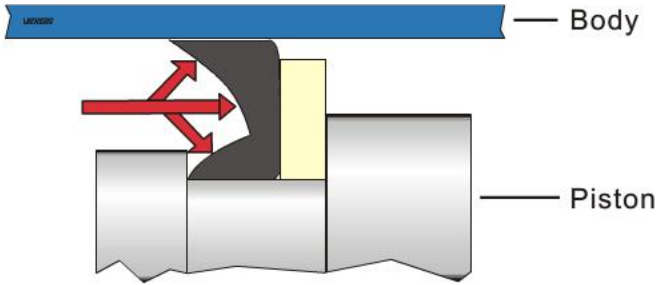


Figure7-9 Pressure tightens the seal to improve sealing

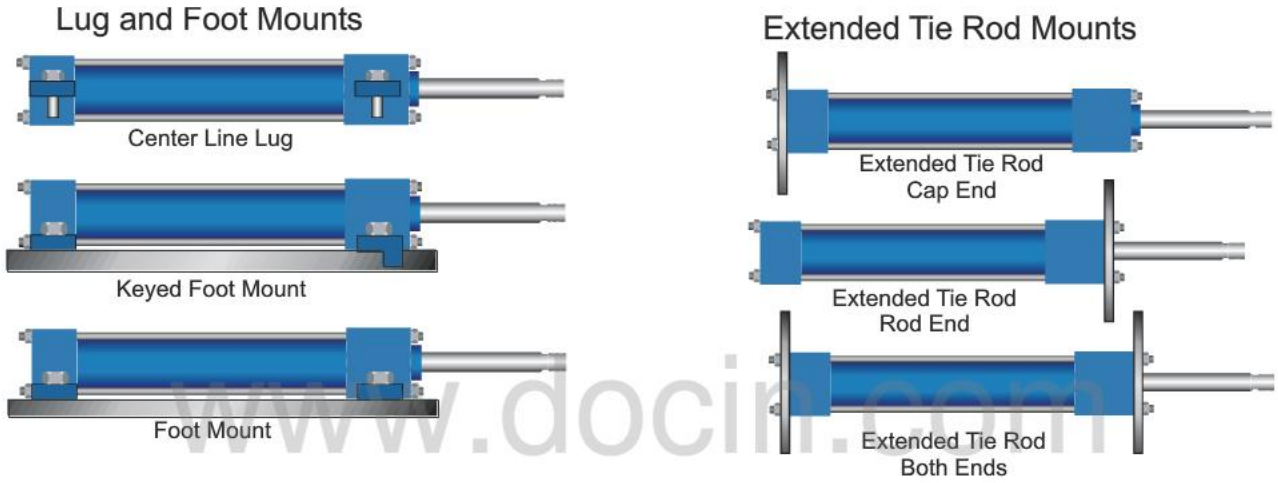


Figure 7-10 Cylinder mounting methods

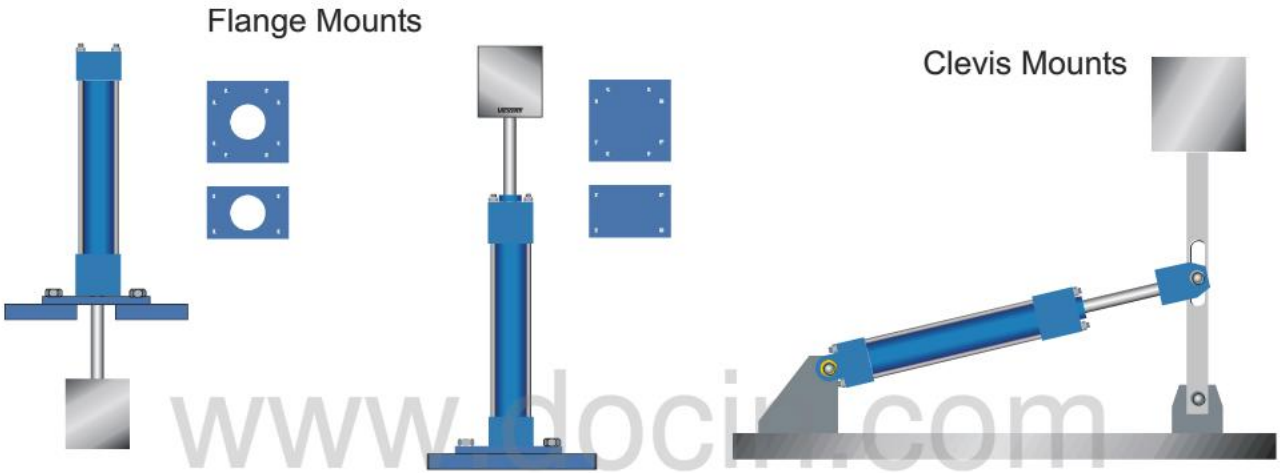


Figure 7-10 Cylinder mounting methods

Trunnion Mounts

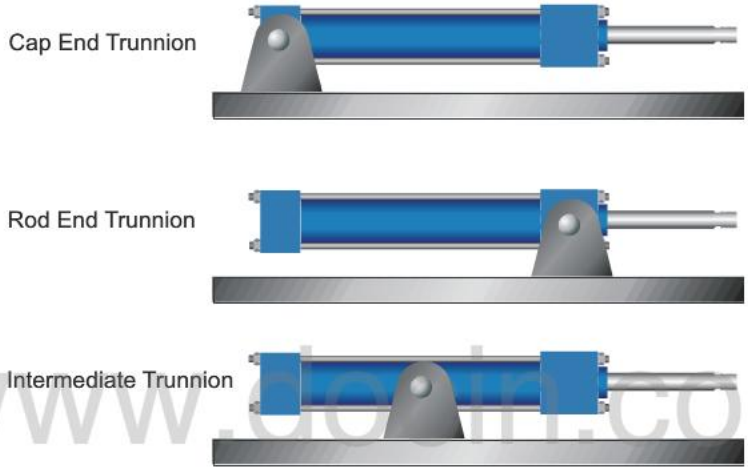


Figure 7-10 Cylinder mounting methods

Change	Speed	Load Pressure	Max Force
Increase relief valve setting	No effect	No effect	Increase
Decrease relief valve setting	No effect	No effect	Decrease
Increase gpm	Increase	No effect	No effect
Decrease gpm	Decrease	No effect	No effect
Increase cylinder diameter	Decrease	Decrease	Increase
Decrease cylinder diameter	Increase	Increase	Decrease

Table 7-1 Summary of effects of application changes on cylinder performance

Cyl. Bore Dia. Inch	Piston Rod Dia. Inch	Work Area Square Inch	Hydraulic Working Pressure PSI						Fluid Required per In of Stroke		Port Size Dia Inch	Fluid Velocity @ 15 ft/sec	
			500	750	1000	1500	2000	3000	Gal.	Cubic Inch		Flow gpm	Piston Velocity in/sec
1-	- 5/8 1	1.767 1.460 .982	883 730 491	1325 1095 736	1767 1460 982	2651 2190 1473	3534 2920 1964	5301 4380 2946	.00765 .00632 .00425	1.767 1.460 .982	½	11.0	24.0 29.0 43.1
2	- 1 1 3/8	3.141 2.356 1.656	1571 1178 828	2356 1767 1242	3141 2356 1656	4711 3534 2484	6283 4712 3312	9423 7068 4968	.01360 .01020 .00717	3.141 2.356 1.656	½	11.0	13.5 18.0 25.6
2-	- 1 1 3/8 1	4.909 4.124 3.424 2.504	2454 2062 1712 1252	3682 3093 2568 1878	4909 4124 3424 2504	7363 6186 5136 3756	9818 8248 6848 5008	14727 12372 10272 7512	.02125 .01785 .01482 .01084	4.909 4.124 3.424 2.504	½	11.0	8.6 10.3 12.4 16.9
3-	- 1 3/8 1 2	8.296 6.811 5.891 5.154	4148 3405 2945 2577	6222 5108 4418 3865	8296 6811 5891 5154	12444 10216 8836 7731	16592 13622 11782 10308	24888 20433 17673 15462	.0359 .0295 .0255 .0223	8.296 6.811 5.891 5.154	¾	20.3	9.4 11.5 13.3 15.2
4	- 1 2 2	12.566 10.161 9.424 7.657	6283 5080 4712 3828	9425 7621 7068 5743	12566 10161 9424 7657	18849 15241 14136 11485	25132 20322 18848 15314	37698 30483 28272 229781	.0544 .0440 .0408 .0331	12.566 10.161 9.424 7.657	¾	20.3	6.2 7.7 8.3 10.2

Table 7-2 Data for various size cylinders

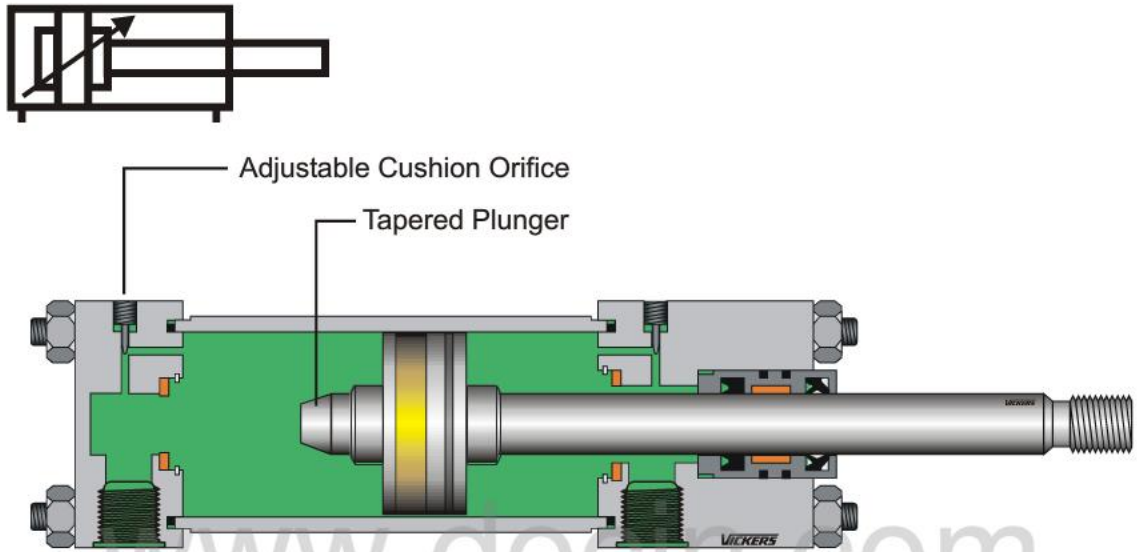


Figure 7-11 Cylinder with extension and retraction cushions

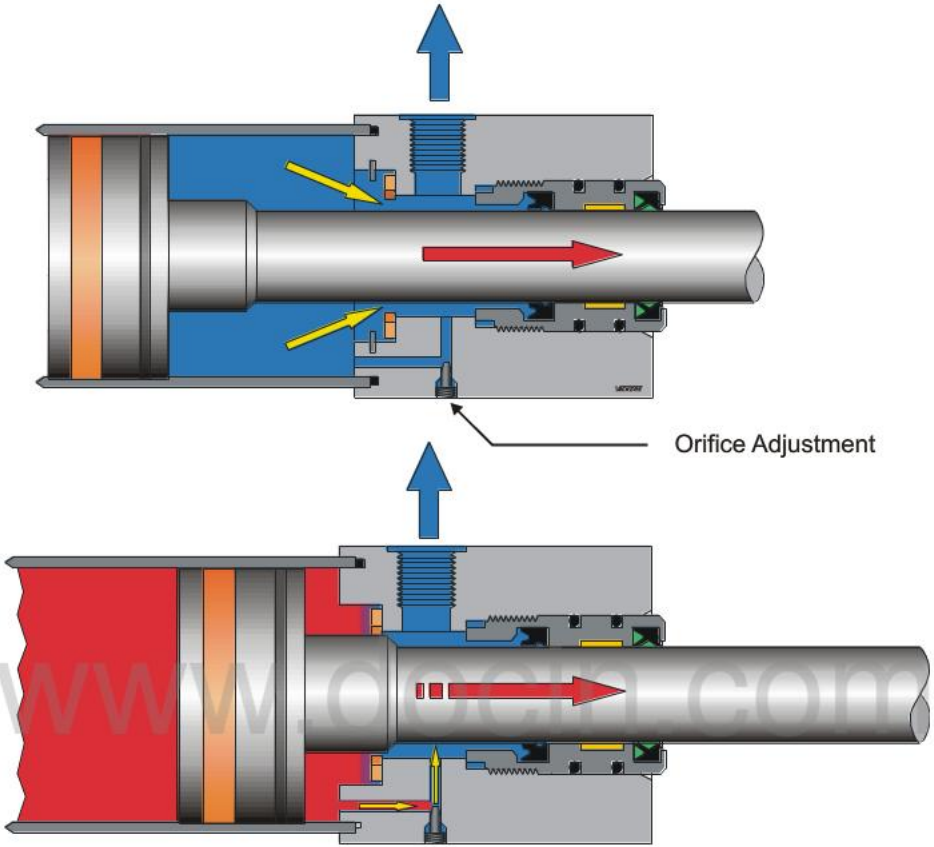


Figure 7-12 Rod end cushion during cylinder extension

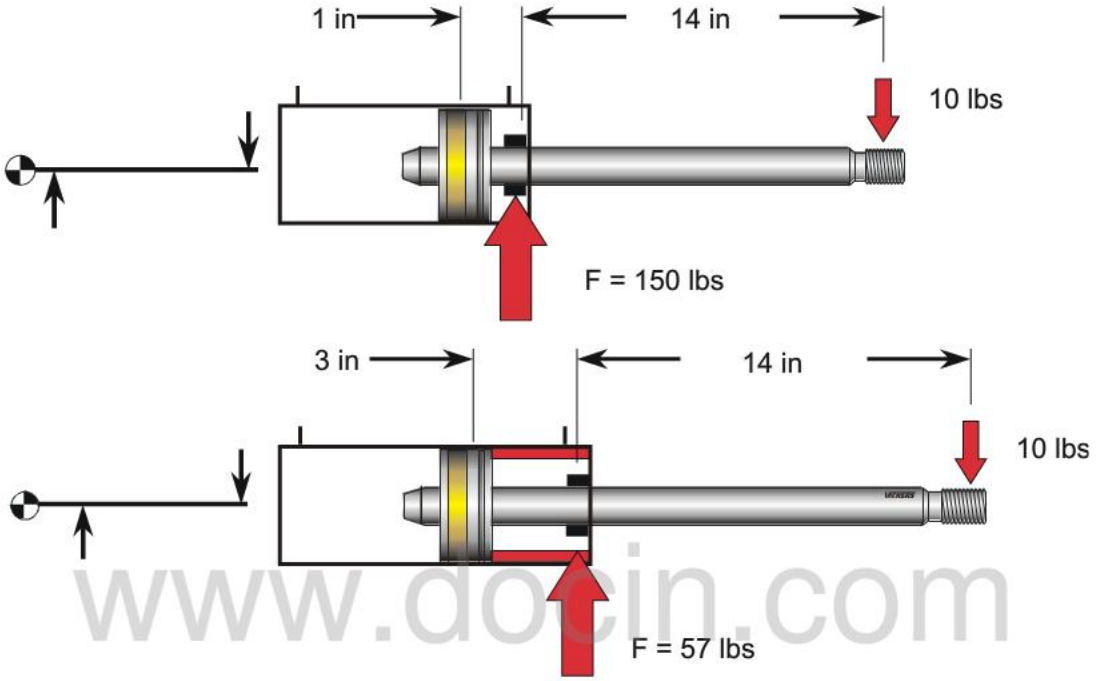


Figure 7-13 A stop tube provides better cylinder rod support

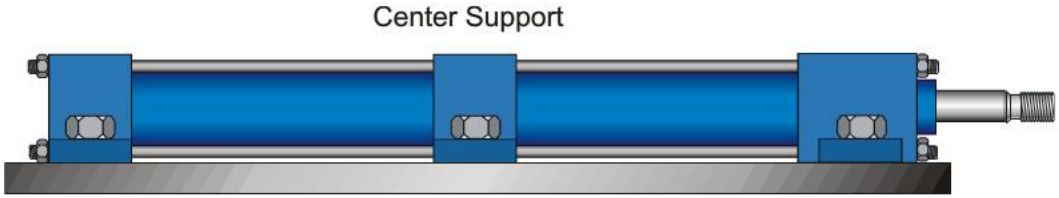


Figure 7-14 Tie rod spacer and center support

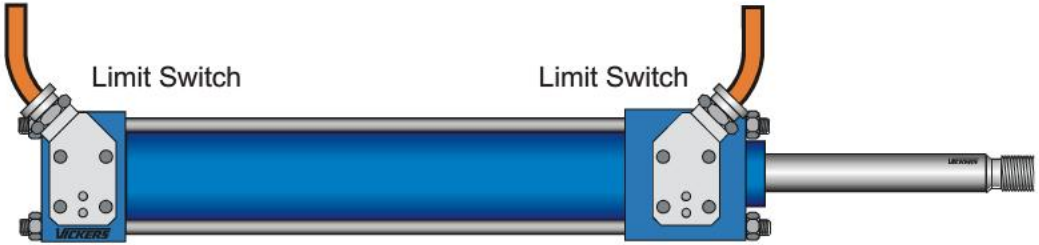


Figure 7-15 Cylinder with limit switches

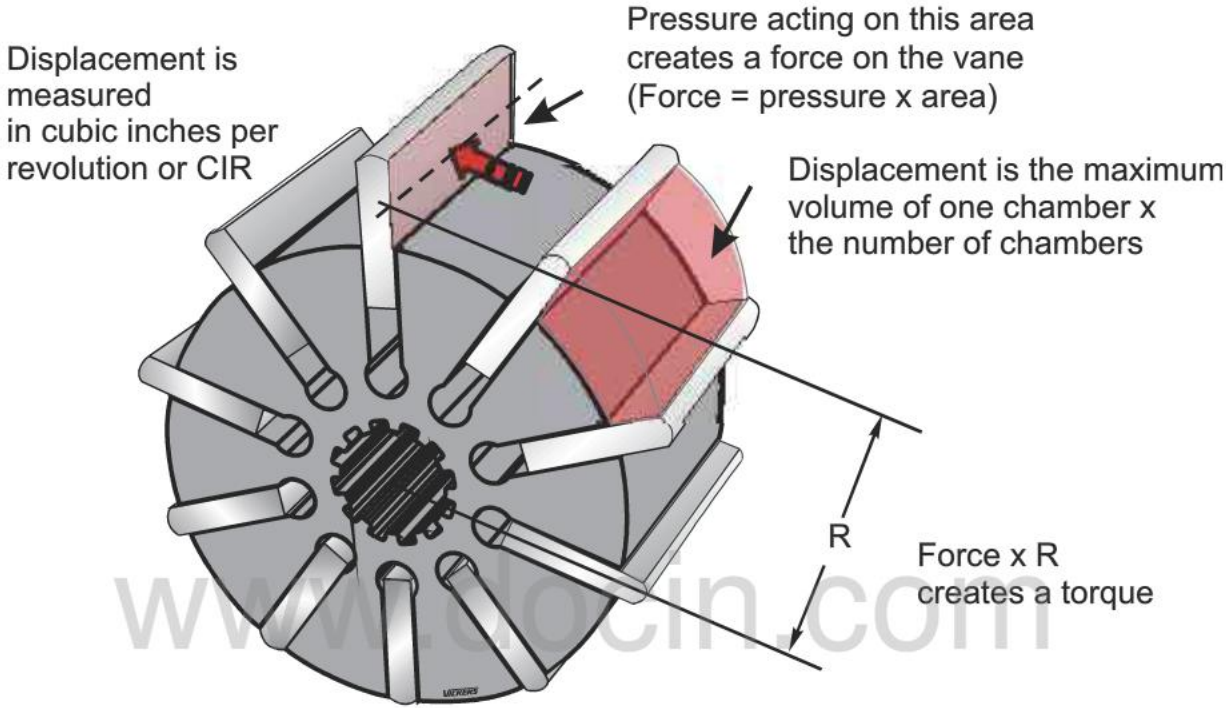


Figure 7-16 Displacement is the quantity of fluid that effects one shaft revolution

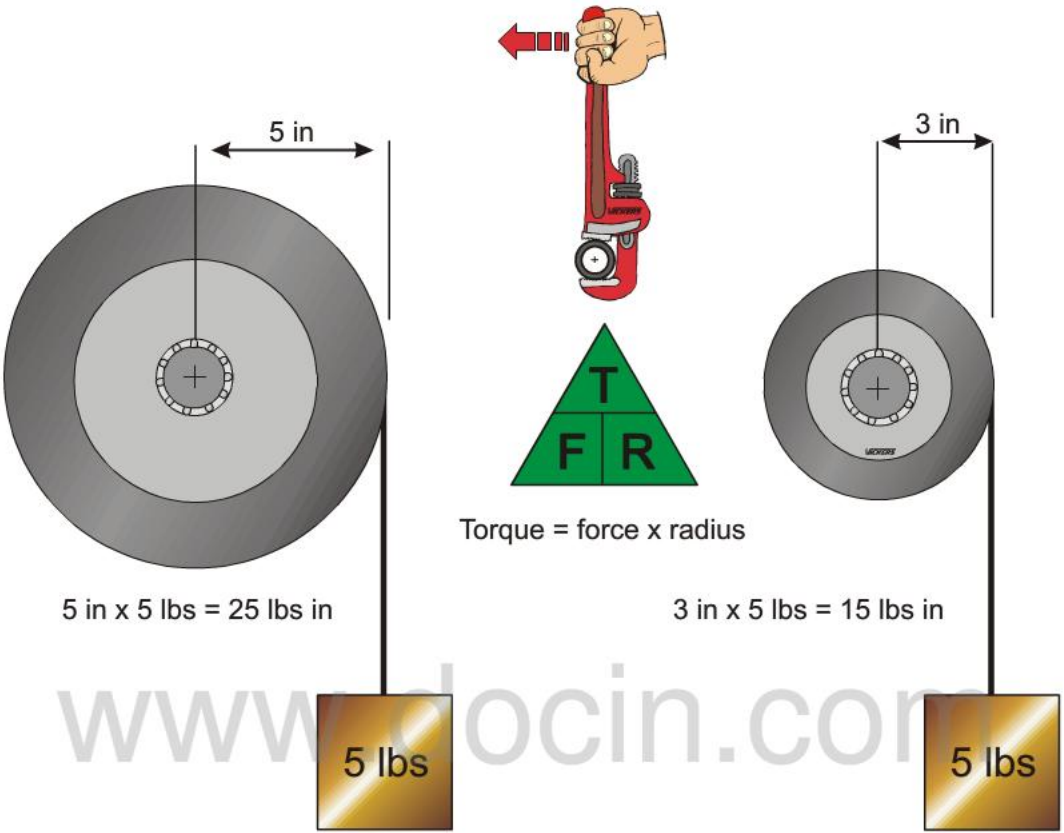
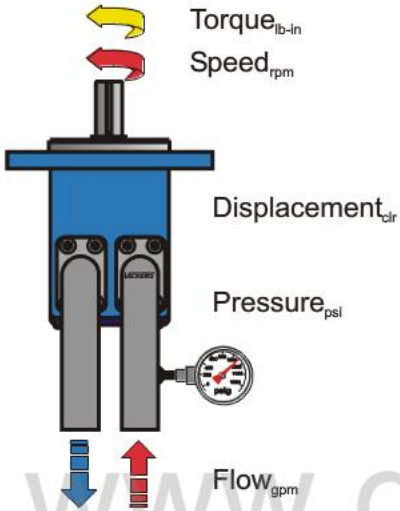


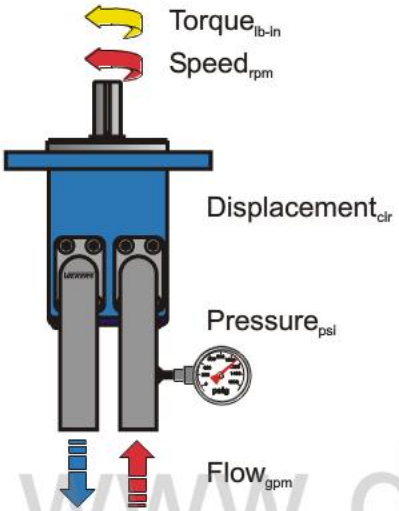
Figure 7-17 Torque equals load multiplied by radius



$$\text{Torque}_{lb\text{-}in} = \frac{\text{Pressure}_{psi} \times \text{Displacement}_{cir}}{2\pi}$$

$$\text{Pressure}_{psi} = \frac{\text{Torque}_{lb\text{-}in} \times 2\pi}{\text{Displacement}_{cir}}$$

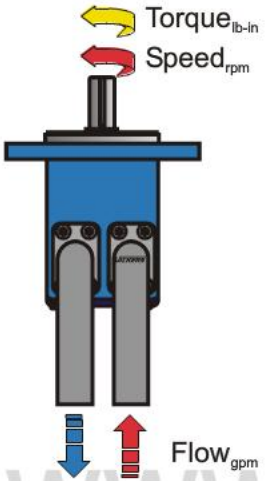
Figure 7-18 Hydraulic motor torque formula



$$Speed_{rpm} = \frac{Flow_{gpm} \times 231}{Displacement_{cir}}$$

$$Flow_{gpm} = \frac{Displacement_{cir} \times Speed_{rpm}}{231}$$

Figure 7-19 Hydraulic motor speed formula



$$\text{Horsepower}_{mech} = \frac{\text{Torque}_{lb\text{-}in} \times \text{Speed}_{rpm}}{63025}$$

$$\text{Horsepower}_{mech} = \frac{\text{Torque}_{lb\text{-}ft} \times \text{Speed}_{rpm}}{5252}$$

Figure 7-20 Hydraulic motor horsepower formula

Change	Speed	Load Pressure	Max Torque
Increase relief valve setting	No effect	No effect	Increase
Decrease relief valve setting	No effect	No effect	Decrease
Increase gpm	Increase	No effect	No effect
Decrease gpm	Decrease	No effect	No effect
Increase displacement cir	Decrease	Decrease	Increase
Decrease displacement cir	Increase	Increase	Decrease

Table 7-3 Summary of effects of application changes on motor operations

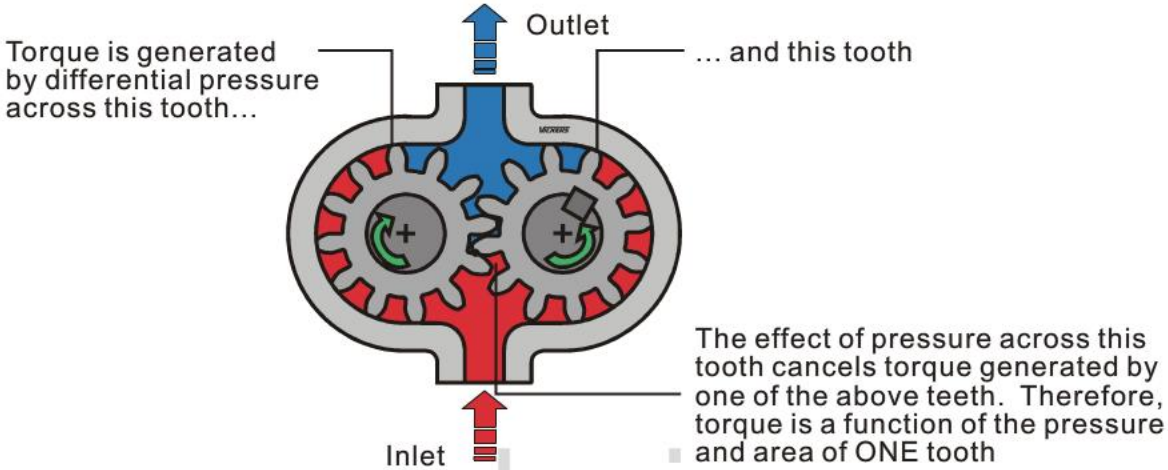


Figure 7-21 Torque generation in an external gear motor

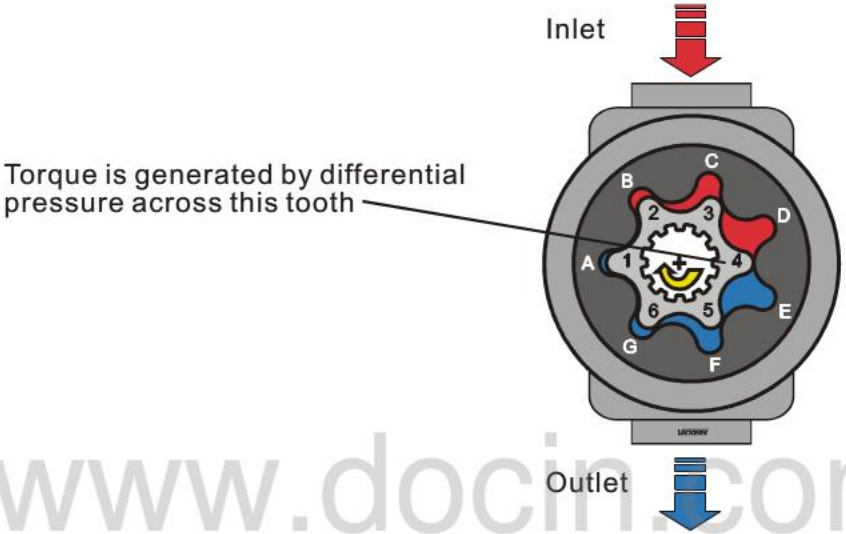


Figure 7-22 Cross section of a direct drive gerotor motor

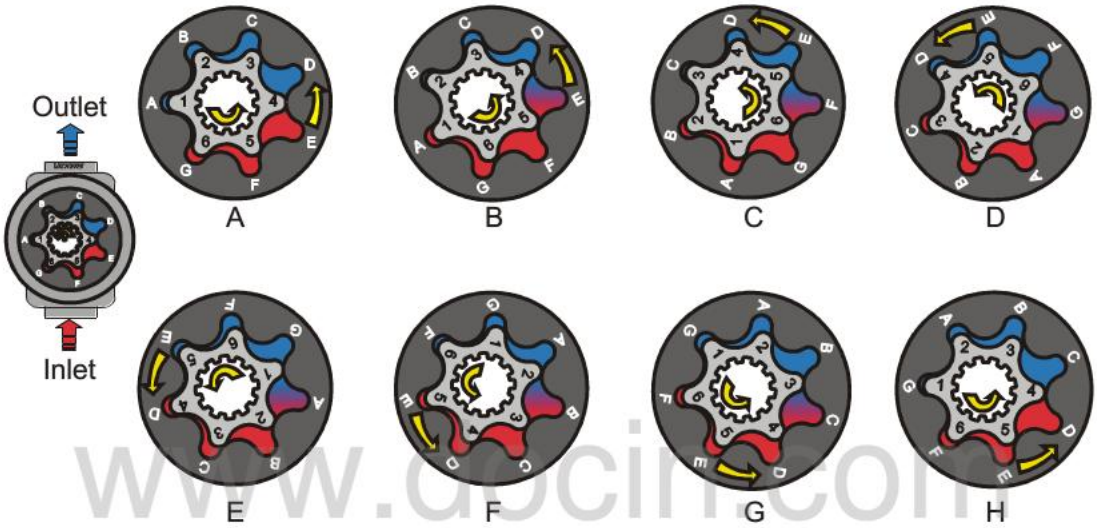


Figure 7-23 Sequence of direct drive gerotor motor

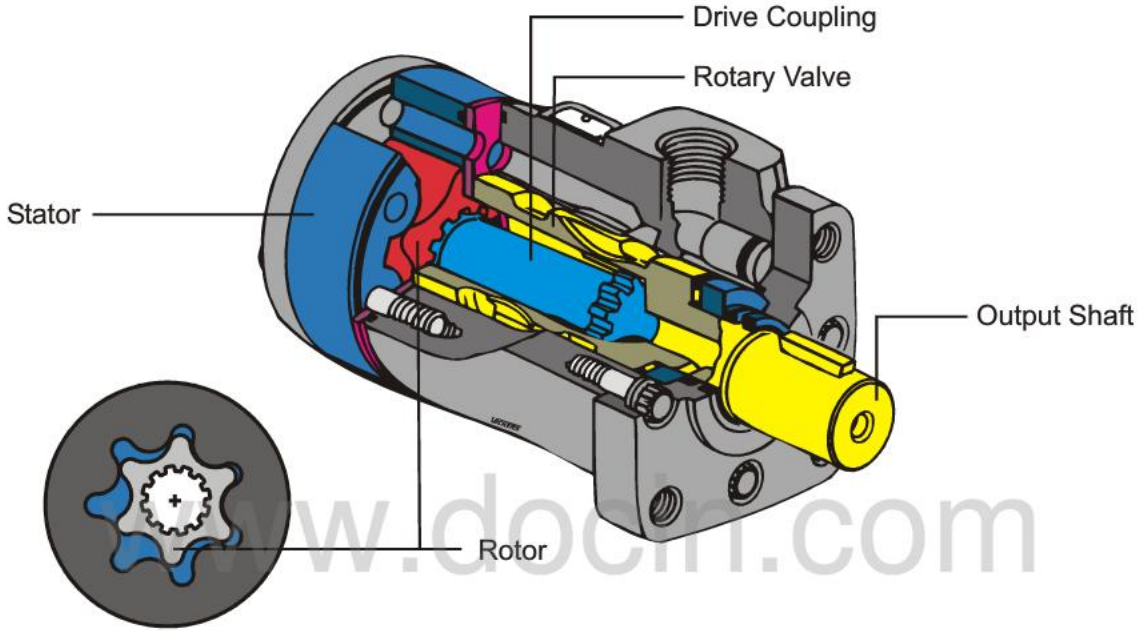
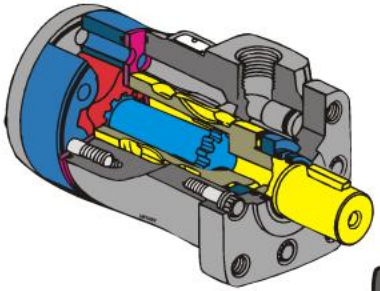
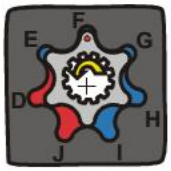


Figure 7-24 An orbiting gerotor motor





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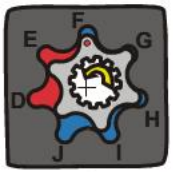

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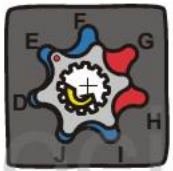

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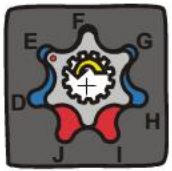

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Figure 7-25 Sequence of an orbiting gerotor motor

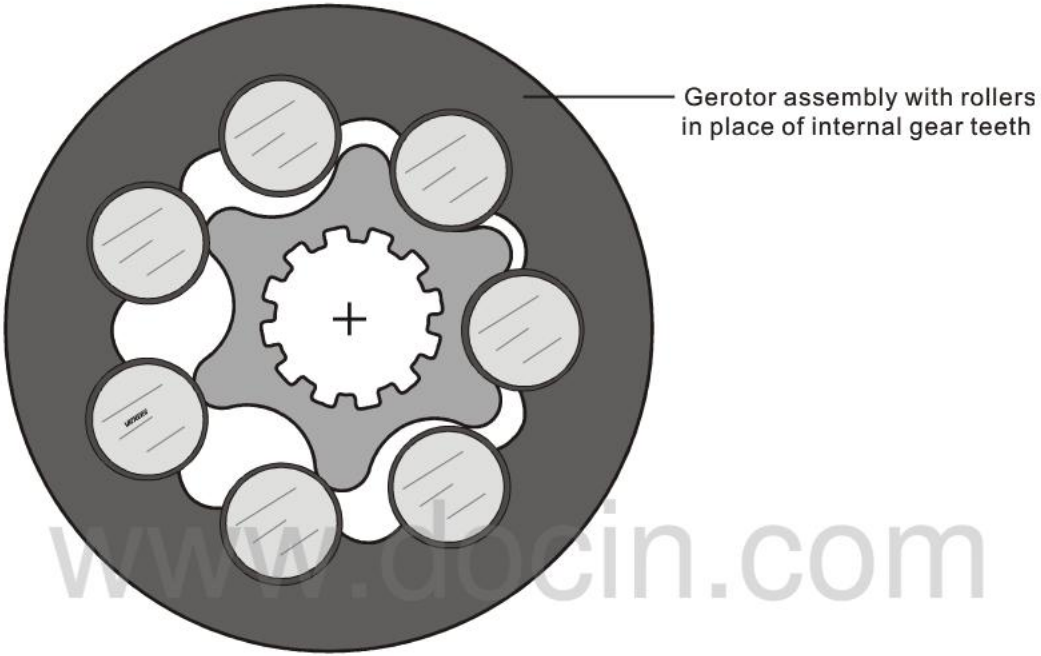

Figure 7.26 Roller-vane gerotor motor

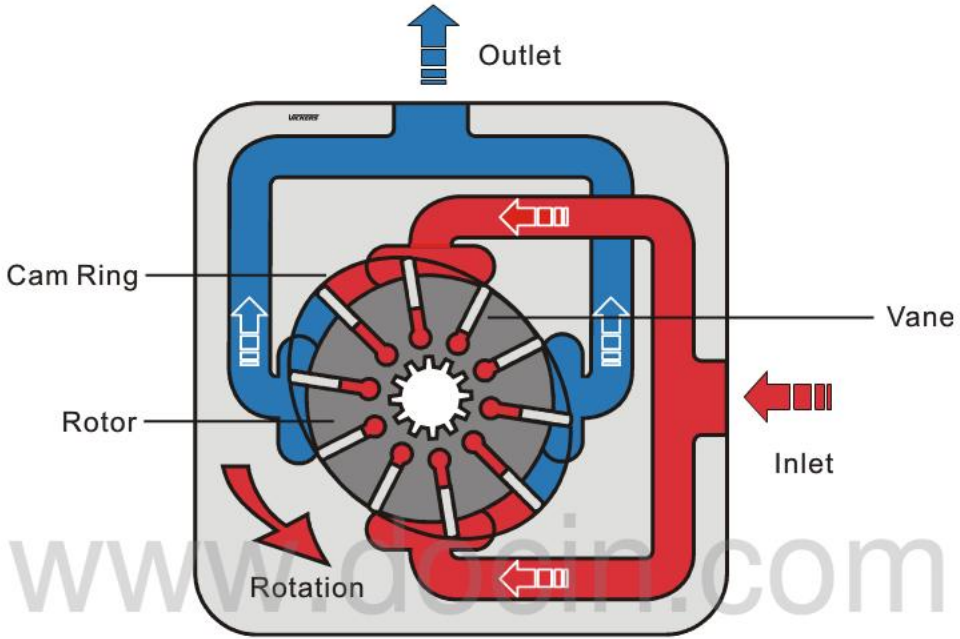

Figure 7-27 Cross section of a balanced vane motor rotating group

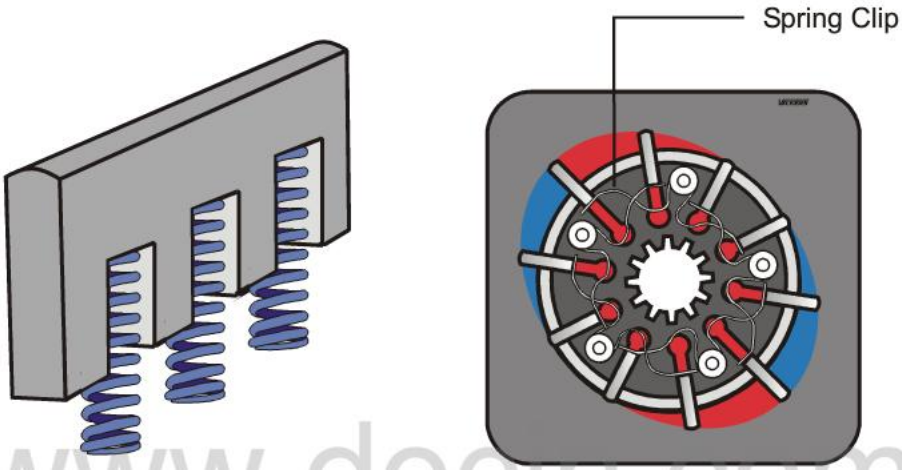

Figure 7-28 Springs or spring clips keep the vanes against the cam

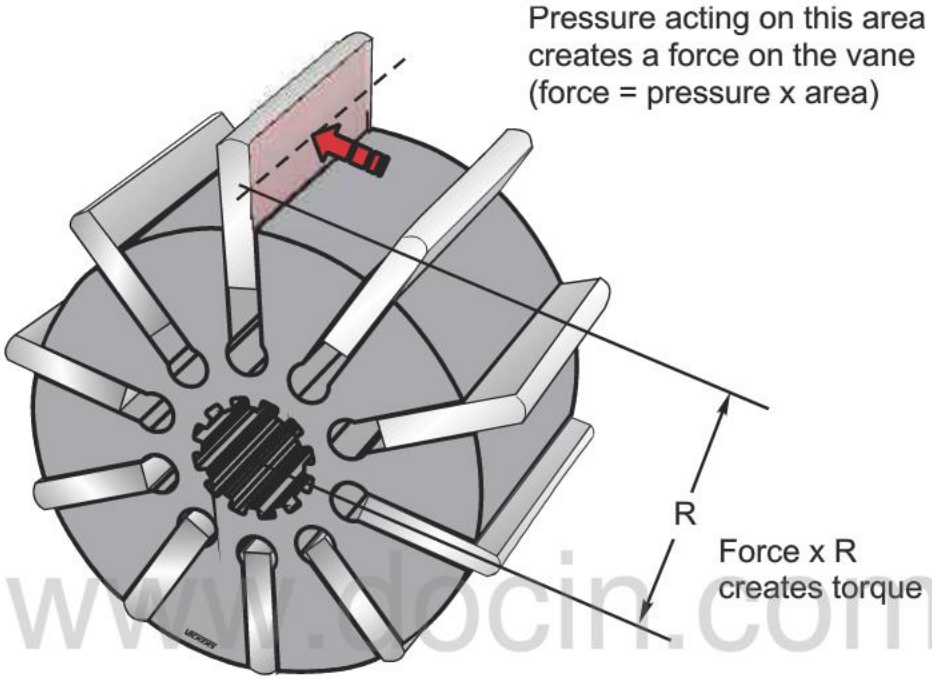

Figure 7-29 Pressure acting on a vane creates torque on the drive shaft

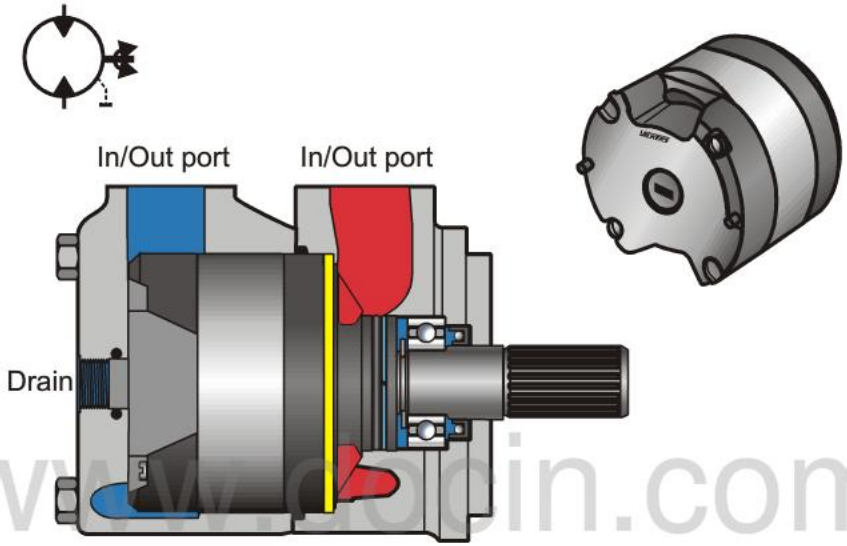

Figure 7-30 High performance vane motor cartridge design

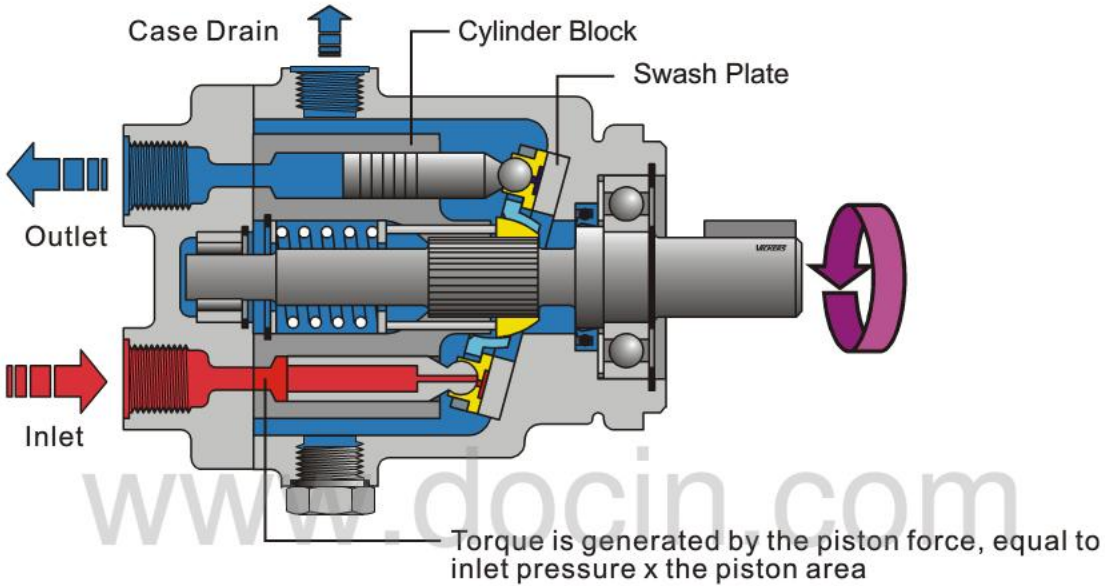

Figure 7-31 Fixed displacement in-line piston motor

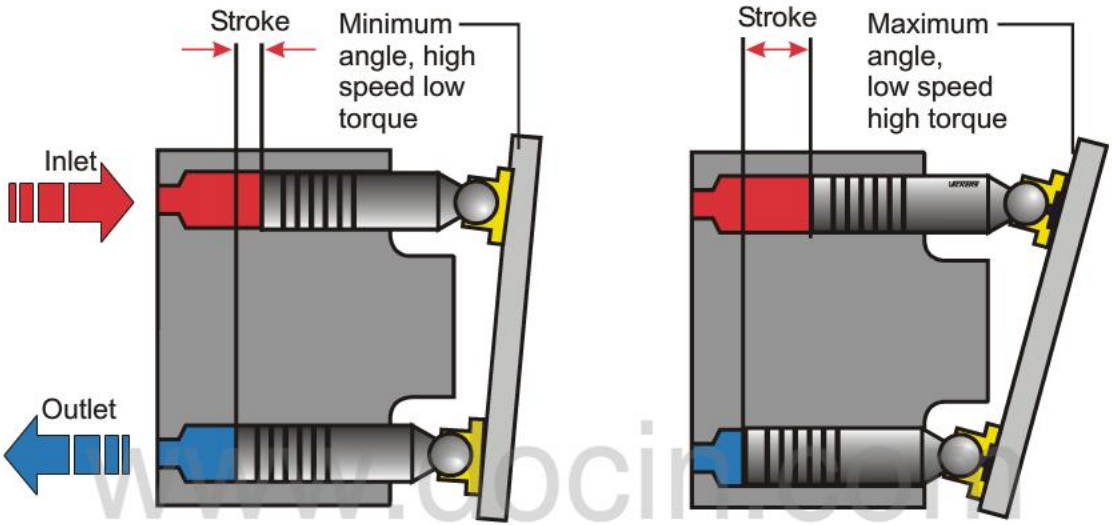

Figure 7-32 Swash plate angle determines the torque and speed relationship

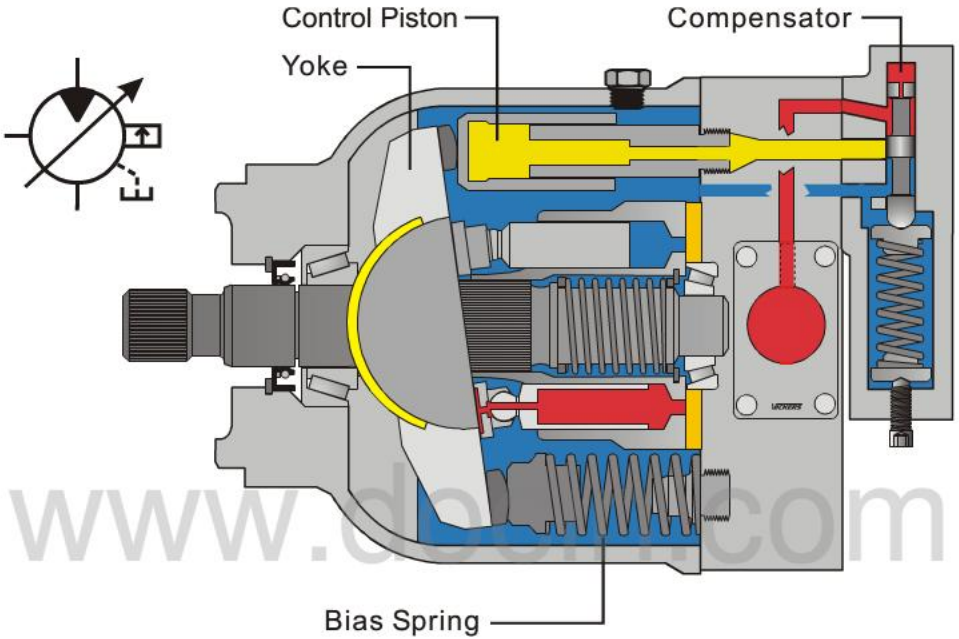

Figure 7-33 Variable displacement in-line piston motor

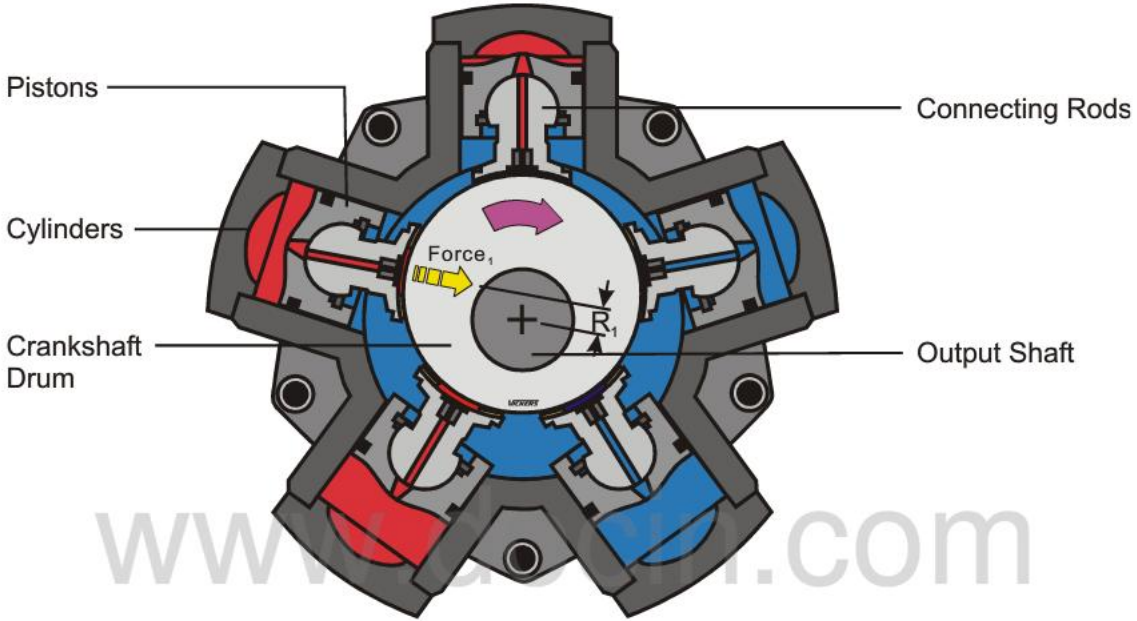

Figure 7-34 Radial piston motor

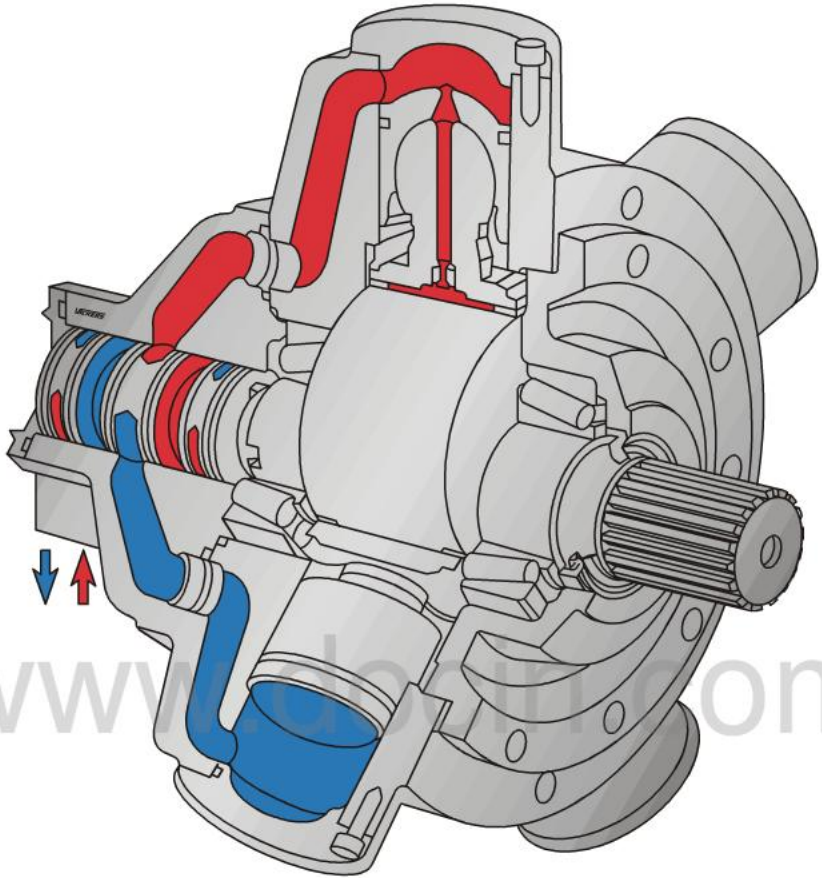

Figure 7-35 Inlet and outlet porting in a radial piston motor

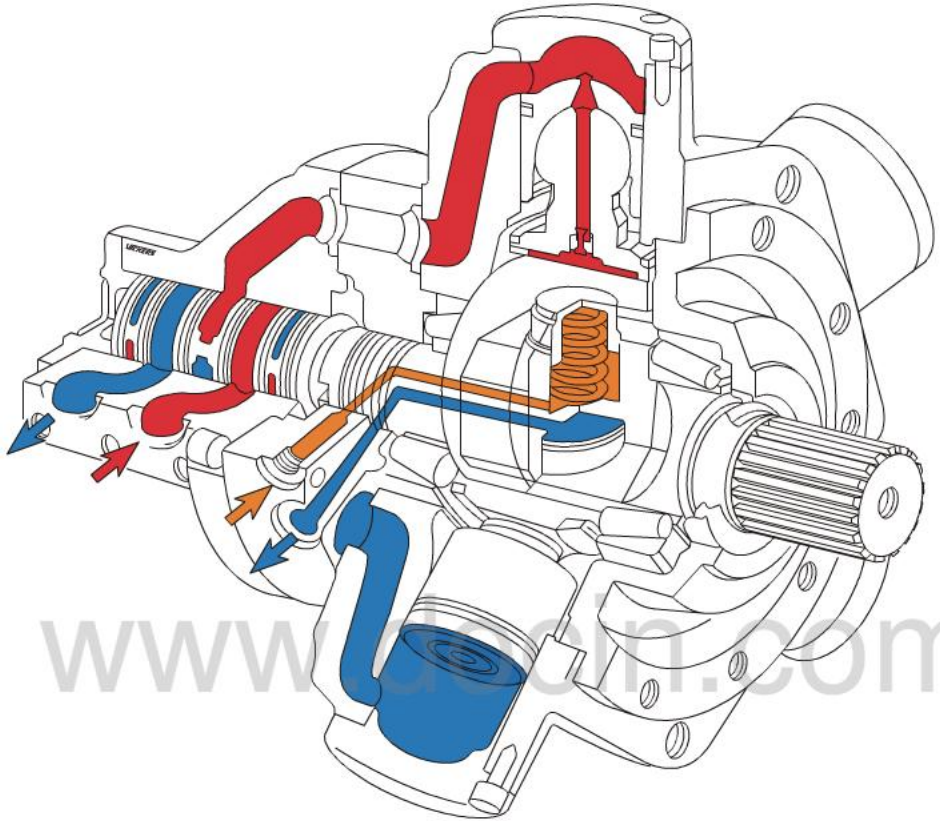

Figure 7-36 Variable displacement radial piston motor

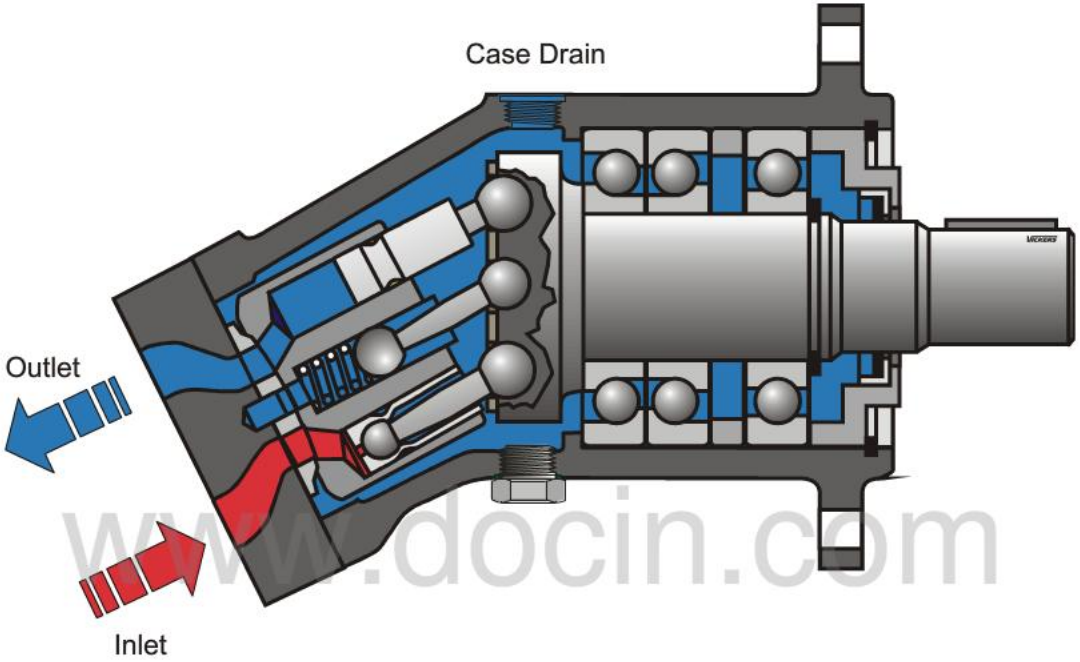

Figure 7-37 Bent axis piston motor

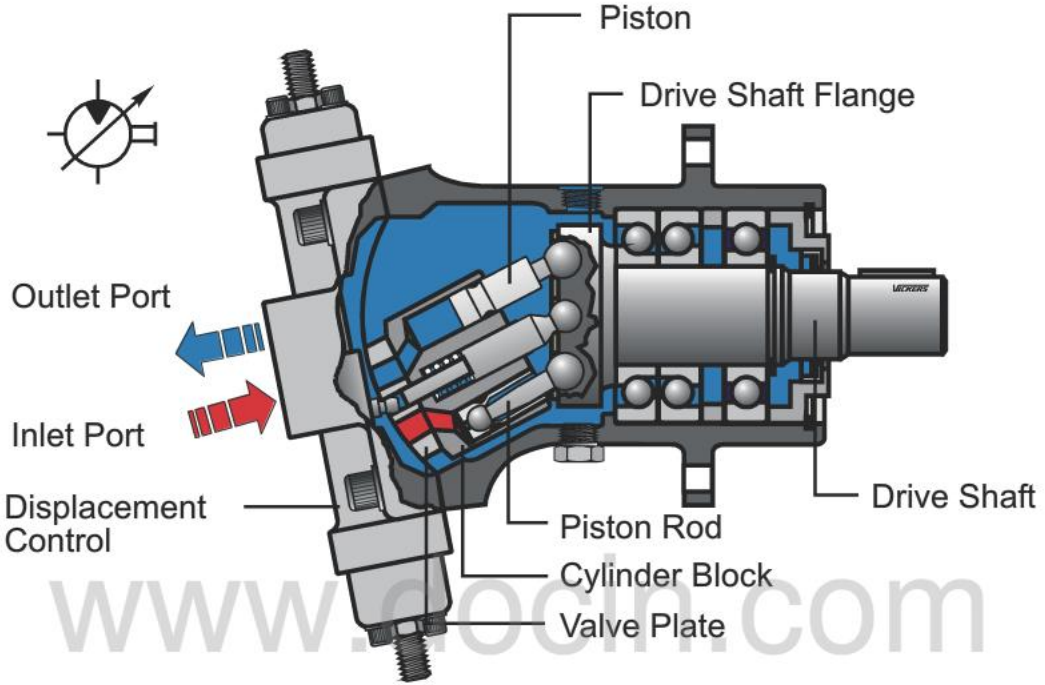

Figure 7-38 Variable displacement bent axis piston motor

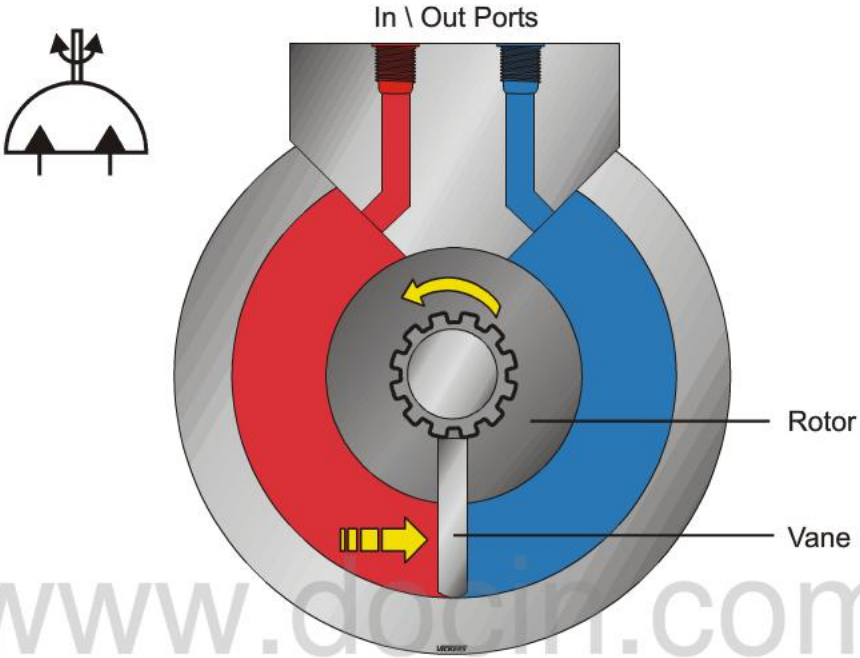

Figure 7-39 Limited rotation actuator