Characteristic curve of a pump

Fundamentals

Hydraulic pumps transform mechanical into hydraulic energy. They thus form the “heart” so to speak of the hydraulic system.
In choosing a pump for a particular application a range of aspects must be taken into account; these include flow rate, operating pressure, efficiency, speed range, viscosity of the hydraulic fluid and the controllability of system flow and/or pressure etc.
In addition to these aspects, the suitable pump for a particular application can be chosen from a number of different designs (e.g. gear pumps, vane pumps, radial piston pumps, axial piston pumps). The pump used in the hydraulic training unit is a swashplate piston style pump. This type of pump can be designed as either fixed or variable displacement and the actual installed pump has a pressure compensated type controller. i.e. the flow rate is constant until a maximum pressure setting is reached. Information regarding the exact installed pump can be found in the trainer system handbook.

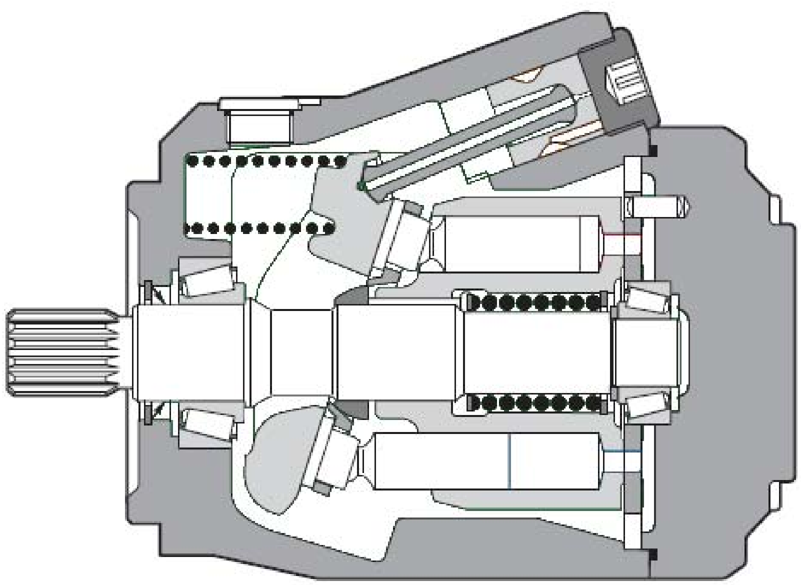


Fig. 1 Axial piston pump – Swashplate design

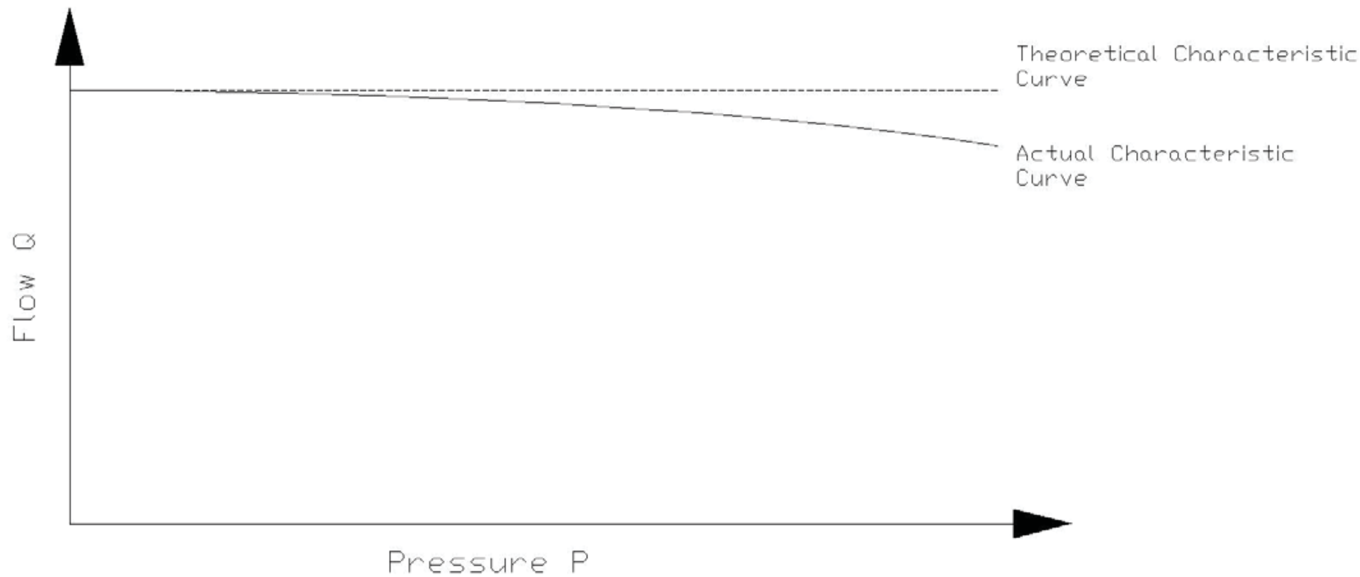


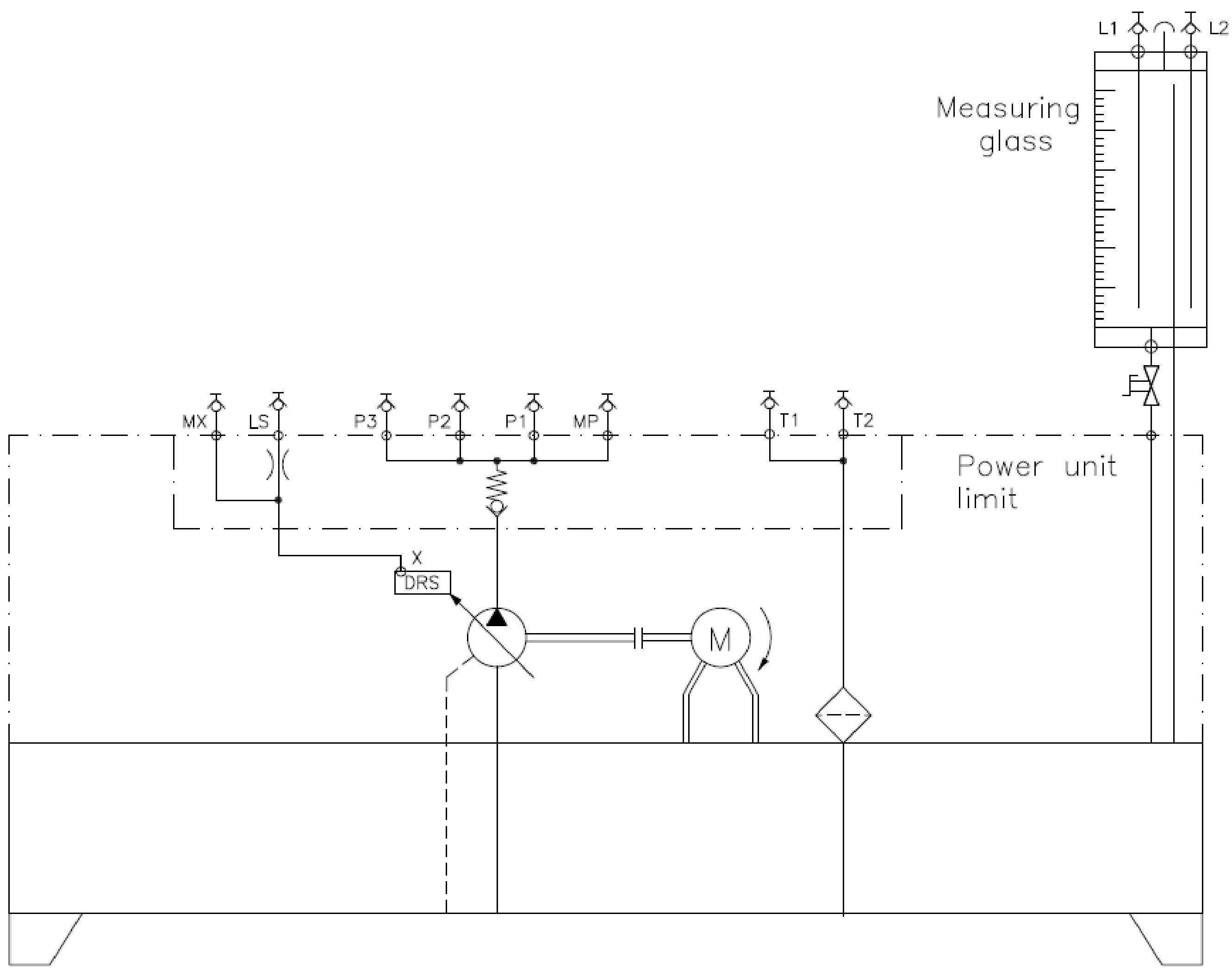
Fig. 3 Characteristic curve of a pump

Description of experiment

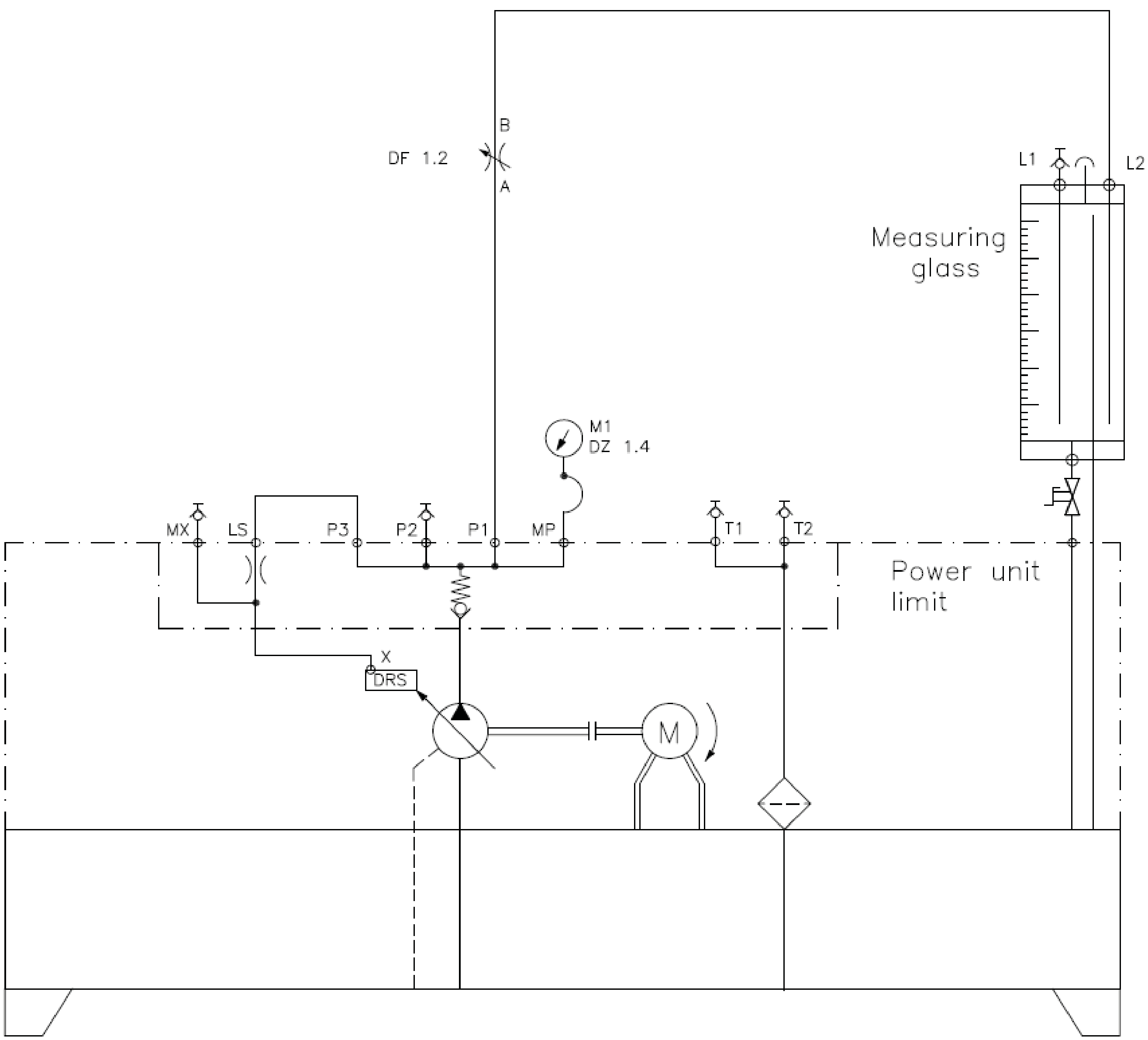
In this experiment you will determine the characteristic curve of the positive displacement pump used in the hydraulic trainer. You will adjust the resistance to flow thereby increasing the pressure at the outlet of the pump. As a variable hydraulic resistance you can utilize a throttle valve and you can thus measure the flow characteristic curve at several points.

Description of exercise

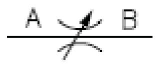
Work out a circuit with which the characteristic curve of the pump can be measured and sketch it on the following page. Hint: To control the flow rate and cause a resistance at the pump outlet you will need a throttle valve, to read the pressure you require a pressure gauge. The flow rate is measured with the measuring glass and stop watch.

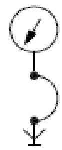


L1
L2
Measuring glass
MX
LS
P3
P2
P1
MP
T1
T2
Power unit limit
X
DRS
M


B
DF 1.2
A
L1
L2
Measuring
glass
M1
DZ 1.4
MX
LS
P3
P2
P1
MP
T1
T2
Power unit
limit
X
DRS
M

Preparation of experiment
Have the following equipment on hand:

1 Throttle valve DF1.2 

1 Pressure gauge DZ 1.4 

Pressure hoses
Stop watch

Before beginning the experiment read the **Rules for hydraulic trainer operation** sheet.

Setting up the experiment
Set up the circuit observing the following points:
1. Make sure the pump is switched off and the hydraulic circuit is not pressurized.
2. Mount the individual components on the training stand grid and interconnect them according to the hydraulic schematic

Experimental layout
Experimental procedure
Steps in the experimental procedure:
1. Has your instructor checked the constructed circuit?
2. Check again that all connection hoses are firmly coupled. (pull/turn to test)
3. Ensure the red E-STOP button is not engaged on either of the starters. (rotate the button to reset)
4. Open the drain valve on the bottom of the measuring glass
5. Open throttle valve DF1.2 completely
6. Switch on the pump via the green START push button.

a) Measure the pressure at the pressure gauge and the time it takes to fill 1 litre of oil into the measuring glass. i.e. Close the shut-off valve on the measuring glass and measure the time between oil level readings of 1 litre and 2 litre..
b) Enter the pressure measured time in the table in the column marked throttle “OPEN”
c) Switch off the pump via the red STOP push button and drain the measuring glass by opening the shut-off valve. When the measuring glass is empty, close the shut-off valve again.

Experiment

We will use the throttle valve to create a pressure at the pump outlet and then measure the flow at various pressure levels.

a) Begin closing off throttle valve DF 1.2 until a pressure of 15 bar can be read at pressure gauge.

b) Measure the time it takes to fill 1 litre of oil into the measuring glass. i.e. Close the shut-off valve on the measuring glass and measure the time between oil level readings of 1 litre and 2 litre..

c) Enter the measured time in the table

d) Switch off the pump via the red STOP push button and drain the measuring glass by opening the shut-off valve. When the measuring glass is empty, close the shut-off valve again.

e) Continue the experiment according to the table, following the exact procedure described under b).

f) Switch off the pump.

g) Conventionally the flow rate is given as litre per minute (l/m). We will also follow this convention. We can calculate this flow rate using the following formula.

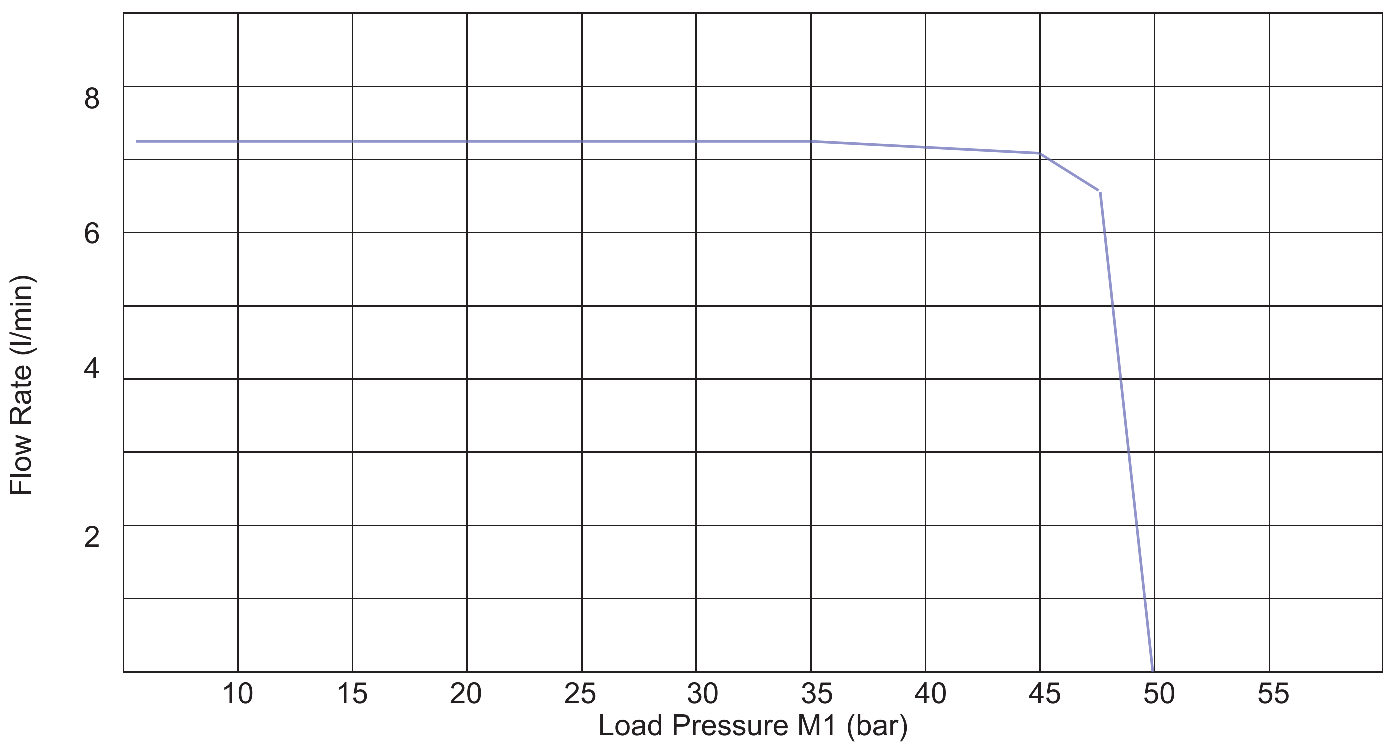
$$Q = \frac{\text{volume (1litre)}}{\text{measured time (sec)}} \text{ x } \frac{\text{60 seconds}}{\text{1 minute}}$$

$$Q = \frac{60}{\text{measured time (sec)}}$$

Evaluation

	Throttle open										Throttle closed
Pressure (p) bar	2	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**47.5**	**50**	50
Volume (V) litre	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Time (t) second	8.28	8.26	8.28	8.28	8.28	8.29	8.25	8.35	8.53	8.94	------	-------
Flow (Q) l/min	7.25	7.26	7.25	7.25	7.25	7.23	7.27	7.18	7.03	6.71	0	0

Table: Experiment 1



Characteristic curve

Rexroth
Bosch Group

Explanation of experimental results

If you compare the curve that you have drawn with that shown in fig. 3, a much steeper drop off can be seen in your curve. The explanation can be found in the fact that the pressure compensator of the pump is set to 50 bar (725 psi) in order to limit the maximum possible pressure. At a pressure of almost 50 bar the pump begins to destroke towards minimum displacement in order to limit the maximum pressure at its outlet port. In this range the characteristic curves of the pump output and the controller are superimposed.

A pressure compensator is required because of the mode of operation of the pump:

If the displacement of the pump remains unchanged then the pump always delivers the same flow. Without a pressure safeguard, the pressure would either increase beyond the loading limits of the material or the motor control would cut out due to overloading of the drive motor. Another cause of the drop-off of the characteristic curve could possibly be a fall in the speed of the drive motor at high loads (pressure).

Conclusions

I. The smaller the area opening of a throttle the greater the increase in pressure.

II. With variable displacement pumps, the outlet flow is reduced to nearly zero when the pressure set on the pump compensator is reached.

III. Leakage in the variable displacement pump returned to the reservoir via an external drain line.

IV. The pressure at the pump outlet increases as the result of resistance to flow in the hydraulic circuit.

V. Name three common pump designs.

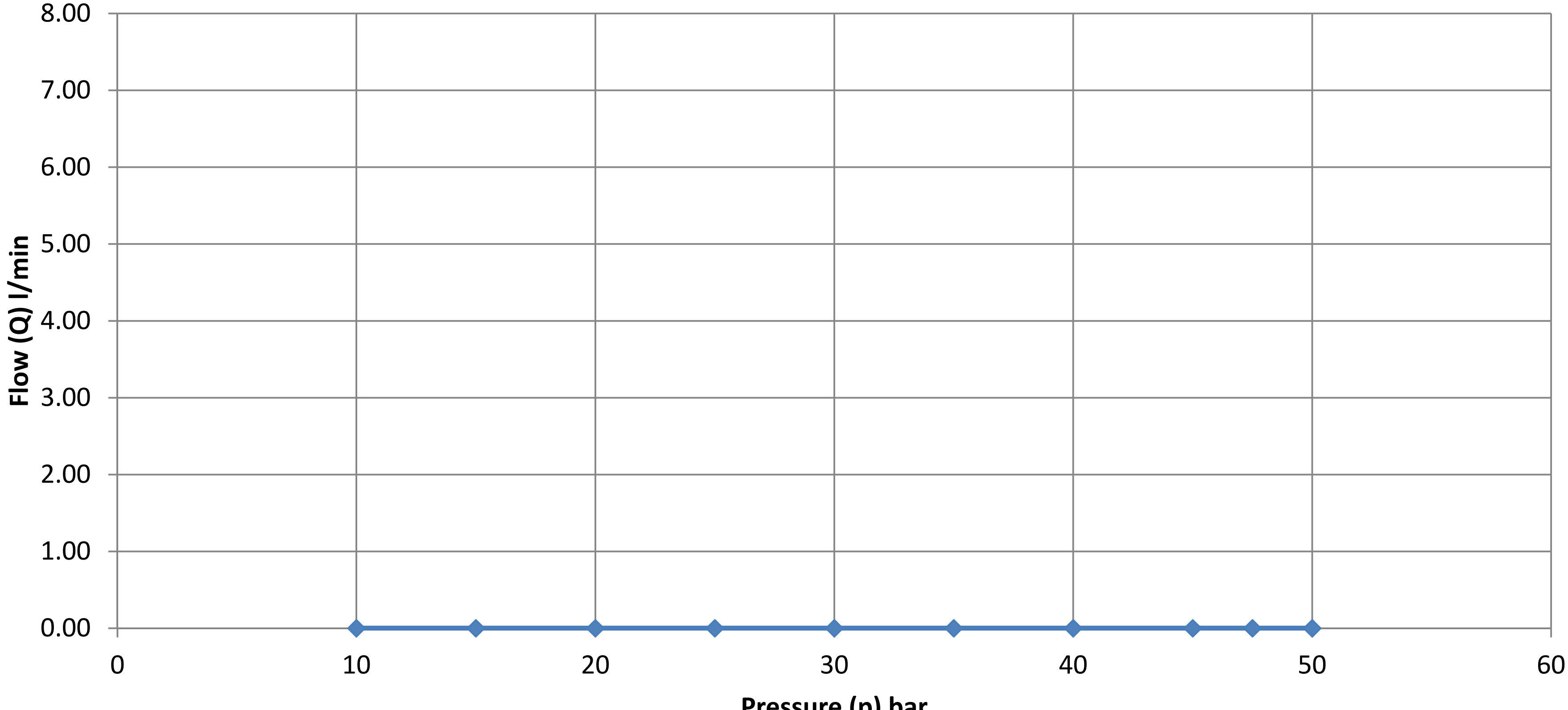
Gear (internal, external)

Vane (balanced, unbalanced)

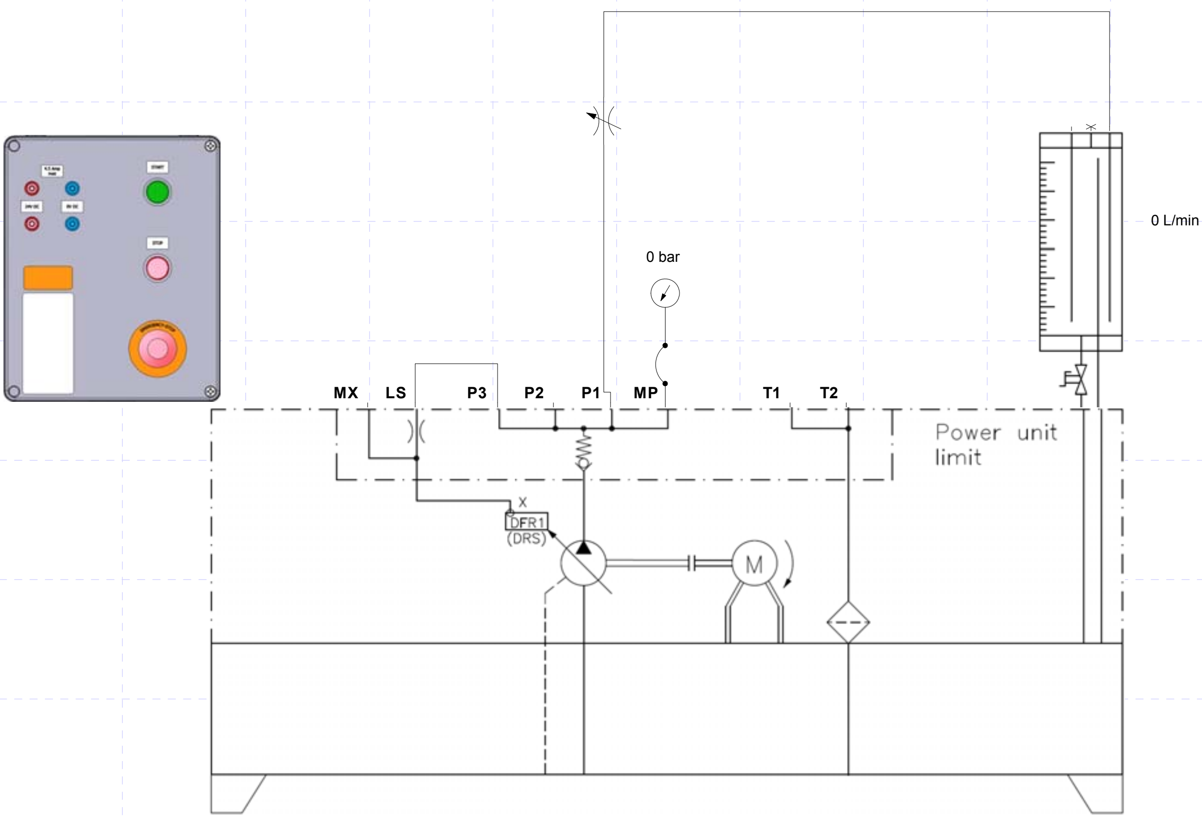
Piston (radial, axial (bent axis, swashplate))

Evaluation

	Throttle open											Throttle closed
Pressure (p) bar		10	15	20	25	30	35	40	45	47.5	50	
Volume (V) litre	1	1	1	1	1	1	1	1	1	1	1	1
Time (t) Seconds												
Flow (Q) l/min	0	0	0	0	0	0	0	0	0	0	0	0



Characteristic Curve



Characteristic Curve of a Pump