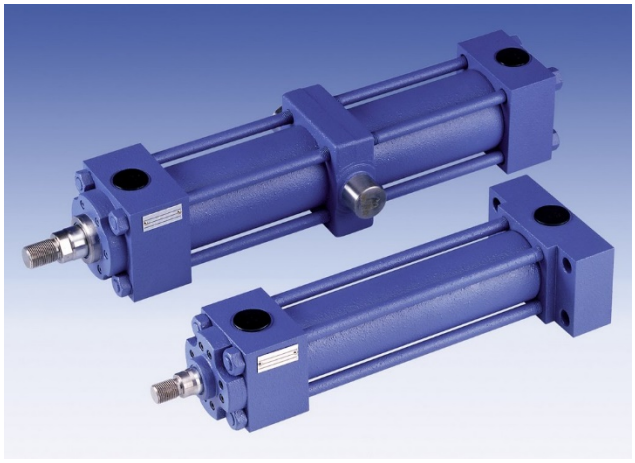
Fundamentals:
Cylinders are available as both single acting (ram type) and double acting. Double acting cylinders can be of either double rod or single rod design. By far the most common double acting cylinder is the single rod or differential type cylinder.

Objective:
Investigate and understand the operation and performance of a single rod design hydraulic cylinder.

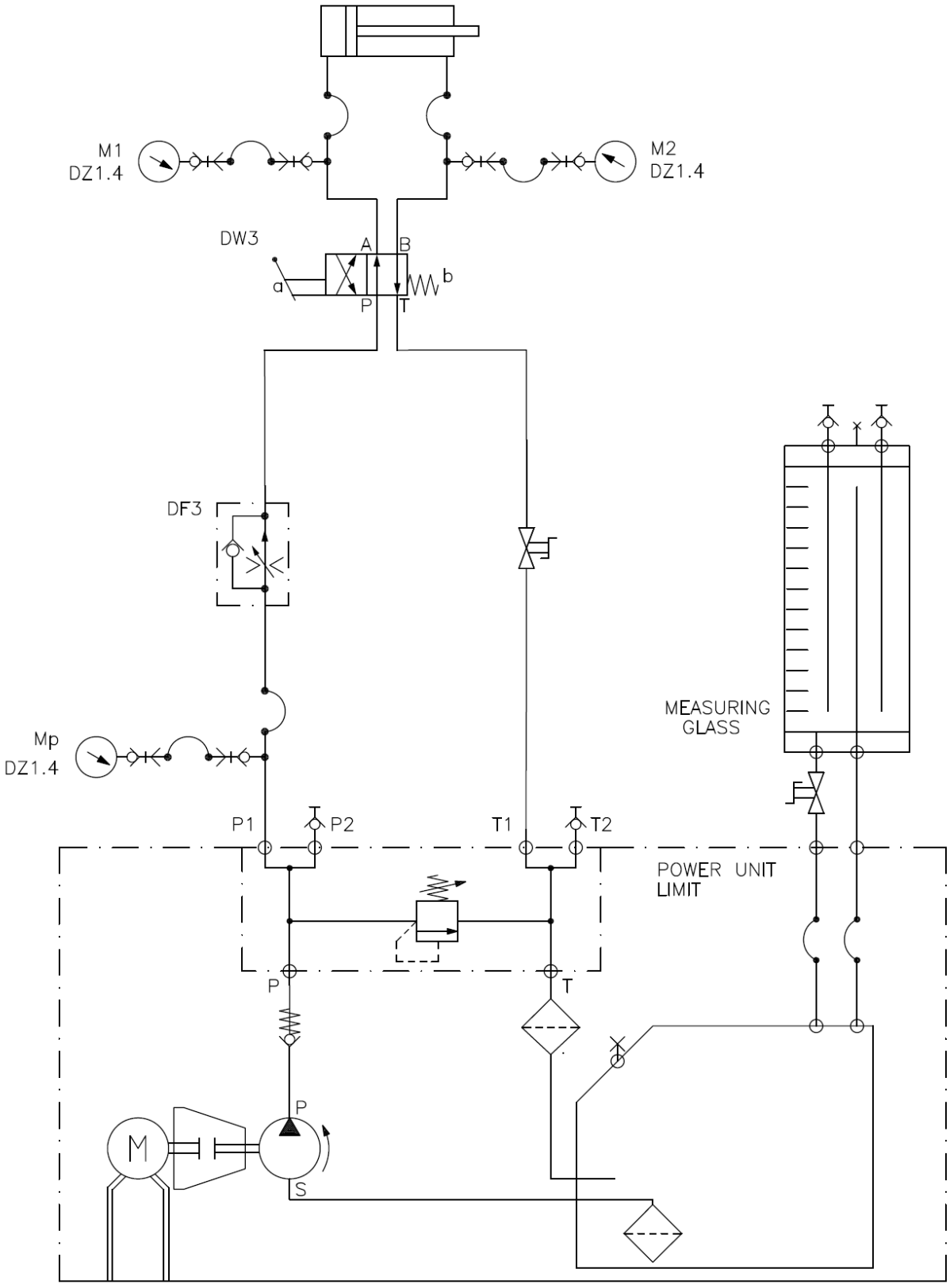
Connections:
Utilizing the schematic on the following page as a guide follow these steps to connect a circuit on the hydraulic trainer.

1) Mount the flow control ‘DF3’, Directional valve ‘DW3’ and differential cylinder ‘ZYL’ on the mounting grid and lock them.
2) The shut-off valve ‘DZ2.1’ is a line mounted component so therefore it can be connected directly to the ‘T’ port of directional valve ‘DW3’
3) Using hoses c/w gauge connector, connect from directional valve ‘DW3’ port ‘A’ to the cap end of the cylinder and from port ‘B’ to the rod end of the cylinder.
4) Mount three pressure gauges ‘DZ1.4’ on the mounting grid where they can be easily read
5) Connect the capillary hose of the pressure gauges:
   Gauge ‘pS’ to the gauging point connector upstream of flow control ‘DF3’
   Gauge ‘M1’ to the gauging point connector on the cap end side of the cylinder
   Gauge ‘M2” to the gauging point connector on the rod end side of the cylinder
6) Use appropriate length hoses to interconnect the remainder of the circuit.

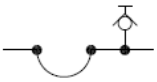
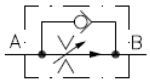
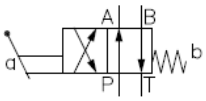
Mill type design cylinders

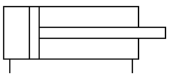
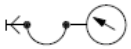


Tie-rod design cylinders


M1
DZ1.4
M2
DZ1.4
DW3
A
B
a
b
P
T
DF3
Mp
DZ1.4
MEASURING
GLASS
P1
P2
T1
T2
POWER UNIT
LIMIT
P
T
P
M
S

Components:
You will require the following components:

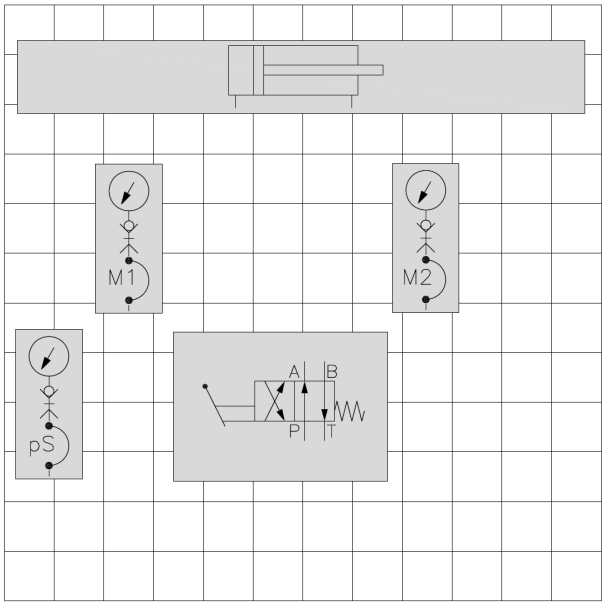
3x	Hose assembly c/w gauge connection	
1x	Flow control valve DF3	
1x	Directional control valve DW3	

1x	Shut-off valve	
1x	Cylinder	
1x	Pressure gauge DZ1.4	

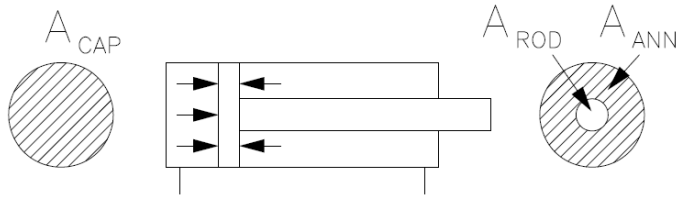
Pressure hoses

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

Component layout



Part I – Calculations



Cylinder bore = 1”

A_{CAP} = 0.79 in^2

Rod diameter = 5/8”

A_{ROD} = 0.31 in^2

$A_{ANN} = A_{CAP} - A_{ROD}$

A_{ANN} = 0.79 in^2 - 0.31 in^2

A_{ANN} = 0.48 in^2

Part II – Cylinder Speeds

Procedure

Steps in the experimental procedure:

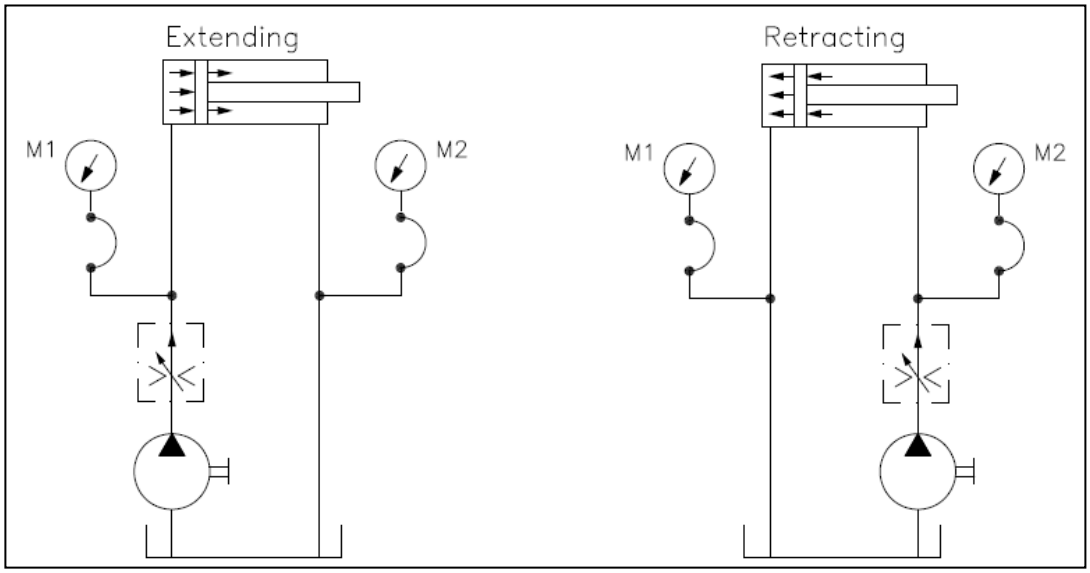
1. Has your instructor checked the constructed circuit?
2. Check again that all connection hoses are firmly coupled. (pull/turn to test)
3. Ensure the red E-STOP button is not engaged on either of the starters. (rotate the button to reset)
4. Set the shut-off valve ‘DZ2.1’ to the open position (handle in line with flow).
5. Completely close the flow control valve ‘DF3’ (setting 0 on the scale)
6. Switch on the pump via the green START push button.

Instructions

a) Open the flow control valve ‘DF3’ and the cylinder should begin to extend.
b) Confirm that shifting the directional control valve DW3 causes the cylinder to reverse direction
c) Set the flow control valve to scale position 4
d) Retract the cylinder and hold the directional valve to keep it in the retracted position
e) Release the directional control valve handle and measure and record the time it takes for the cylinder to reach its end of stroke position as well as the pressures at gauges M1 and M2 while it is extending.
f) Now measure and record the time it takes for the hydraulic cylinder to retract as well as the pressures at gauges M1 and M2 while retracting

t_{ext} = 7.4 sec. p_{M1} = 0 psi p_{M2} = 0 psi

t_{ret} = 4.1 sec. p_{M1} = 0 psi p_{M2} = 110 psi



Simplified Schematic

Part III – Cylinder Pressures

Instructions

a) Allow the cylinder to extend completely
b) Shift the directional control valve ‘DW3’ to retract the cylinder
c) While the cylinder is retracting close the shut-off valve ‘DZ2.1’ and note what happens. Why?

When the shut-off valve is closed the cylinder stops because we are blocking the return flow from the cylinder back to the reservoir

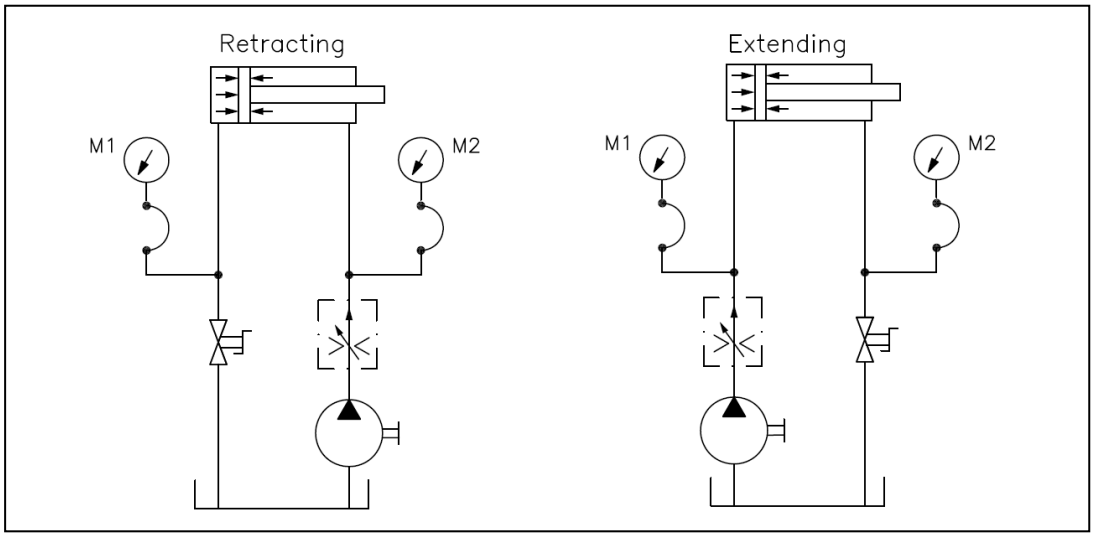
Record the pressure seen at the pressure gauges

p_{M1} = 435 psi p_{M2} = 725 psi

d) Open the shut-off valve ‘DZ2.1’ once again to allow the cylinder to retract the cylinder completely
e) Release the handle of the directional control valve ‘DW3’ to allow the cylinder to extend.
f) While the cylinder is extending close the shut-off valve ‘DZ2.1’ and note what happens.

Record the pressure seen at the pressure gauges?

p_{M1} = 725 psi p_{M2} = 1150 psi



Simplified Schematic

Conclusions

The maximum pressure at the pump outlet is limited to 725 psi

1 In part II what was the maximum pressure reached on gauge M1 or M2 while the cylinder was moving? 110 psi

Why was this pressure lower than 725 psi?
Oil takes the path of least resistance. This is the highest resistance in the hydraulic circuit

What was causing this pressure?
The resistance of the oil flowing through the hoses and fittings is causing this pressure

2 Based on the available system pressure of 725 psi what maximum force would be available from the installed cylinder?

F_{ext} = 570 lb

F_{ret} = 350 lb

3 Describe the relationship between the calculated cylinder areas, the extend and retract speeds of the hydraulic cylinder and the forces which you calculated above.

A_{cap}/A_{ann} = 1.64:1

F_{ext}/F_{ret} = 1.64:1

V^{ret}/V_{ext} = 1.64:1

4 Describe what is causing the high pressure in the rod end side of the cylinder when we try to extend with the shut-off valve closed. Intensification is causing this high pressure

5 Calculate the flow rate required to:

Extend the cylinder at a velocity of 15 in/sec

$$Q = \frac{60 \times 24 \text{in/sec} \times 0.48 \text{ in}^2}{231 \text{ in}^3/\text{gal}}$$

Q= 2.99 gpm

Retract the cylinder at a velocity of 24 in/sec

$$Q = \frac{60 \times 15 \text{in/sec} \times 0.79 \text{ in}^2}{231 \text{ in}^3/\text{gal}}$$

Q= 3.07 gpm

Note to instructor:
The pressure in question 1 occurs in the cap end of the cylinder during retraction because of flow intensification - higher flow = higher pressure loss. Since we have a small area on the rod end of the cylinder an even higher pressure is required here to overcome this back pressure.