PHASE 1 INSTRUMENTS

Project Write-up

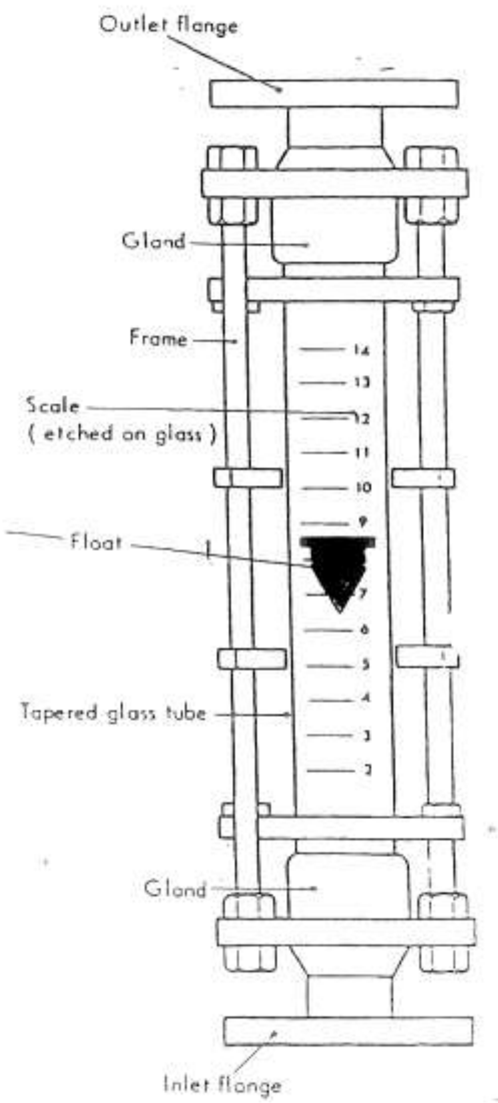
Name:…………………………………………… Group:……………………………..

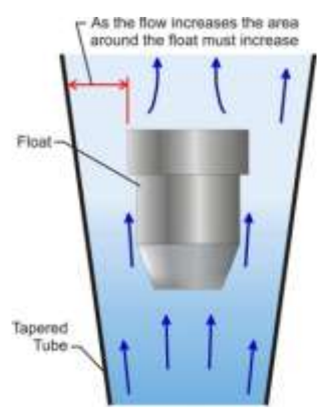
MODULE TITLE: Flow Measurement MODULE No: I-7

PROJECT DESCRIPTION: Rate of Flow or Inferential Devices – Variable Area (VA) Meter

PROJECT No: F1 OBJECTIVE Nos: 1,2,8, 9.

PROJECT WRITE UP SHEET





PROJECT WRITE UP SHEET

Principle/Theory of Operation

Where on the VA meter is the highest pressure created?

What types of fluid are these restricted to?

How could one be altered to provide a simple flow switch?

PHASE 1 INSTRUMENTS

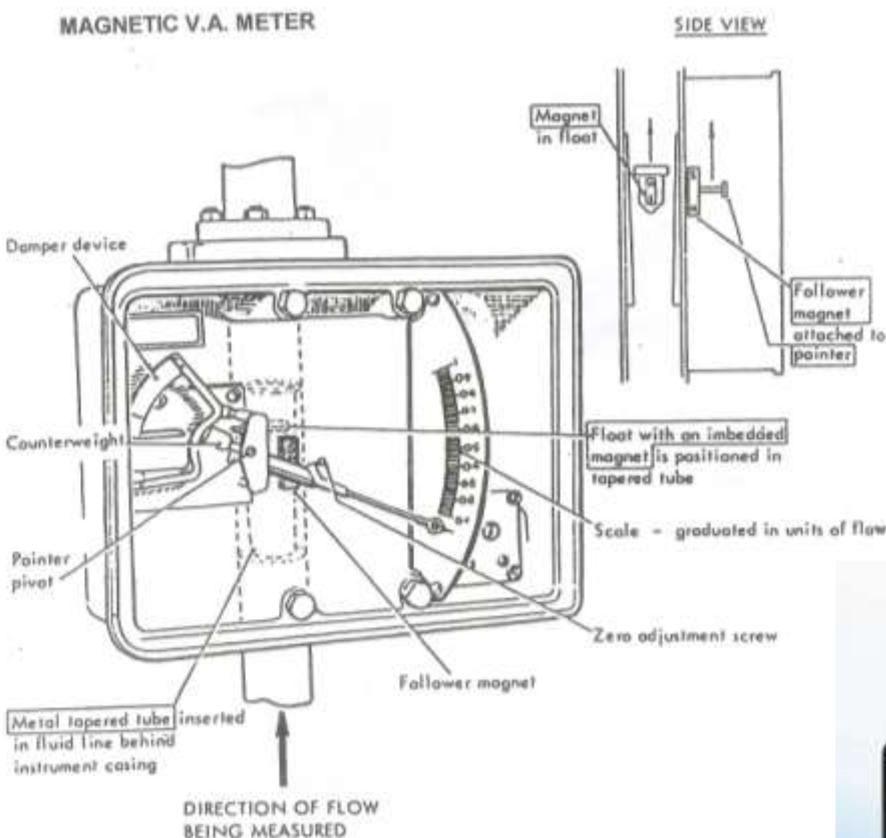
Project Write-up

Name:…………………………………………… Group:……………………………..

MODULE TITLE: Flow Measurement MODULE No: F1 001 1

PROJECT DESCRIPTION: Rate of Flow or Inferential Devices – Magnetic V.A. Meter

PROJECT No: F2 OBJECTIVE Nos: 1,2,8, 9.



PROJECT WRITE UP SHEET

Principle/Theory of Operation

What is the tube normally made from?

PHASE 1 INSTRUMENTS

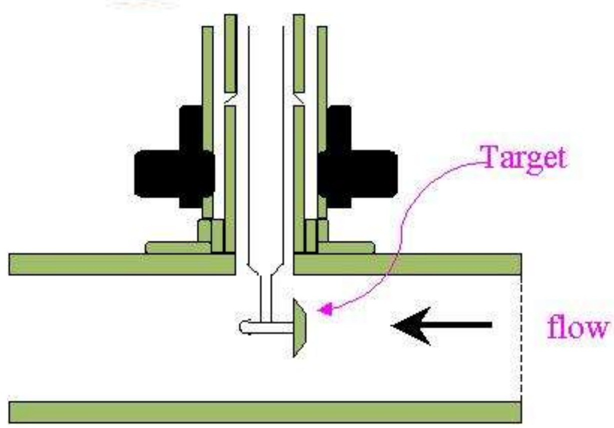
Project Write-up

Name:…………………………………………… Group:……………………………..

MODULE TITLE: Flow Measurement MODULE No: F1 001 1

PROJECT DESCRIPTION: Rate of Flow or Inferential Devices – Target. Meter

PROJECT No: F3 OBJECTIVE Nos: 1,2,8, 9.



PROJECT WRITE UP SHEET

Principle/Theory of Operation

What do modern electronic systems use to generate the output?

What sizes are normally available?

Why aren't these used for accurate flow measurement?

PHASE 1 INSTRUMENTS

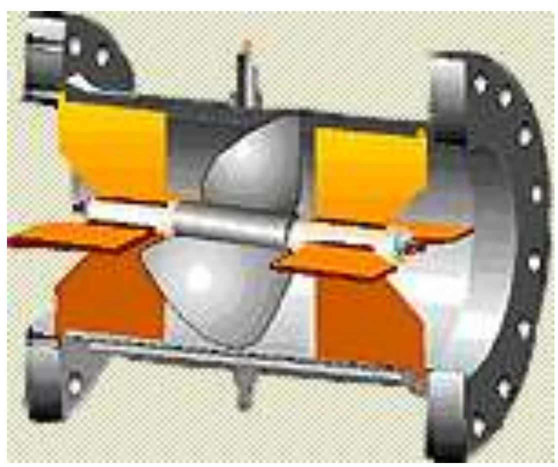
Project Write-up

Name:…………………………………………… Group:……………………………..

MODULE TITLE: Flow Measurement MODULE No: F1 001 1

PROJECT DESCRIPTION: Rate of Flow or Inferential Devices – Turbine Meter

PROJECT No: F4 OBJECTIVE Nos: 1,2,8, 9.



PROJECT WRITE UP SHEET

Principle/Theory of Operation

What is the other name for these meters?

How long must the pipe be straight for prior to the meter and why?

What is the typical pressure drop across the meter?

Name two gases these could measure?

On what form of transport might these meters be found?

PHASE 1 INSTRUMENTS

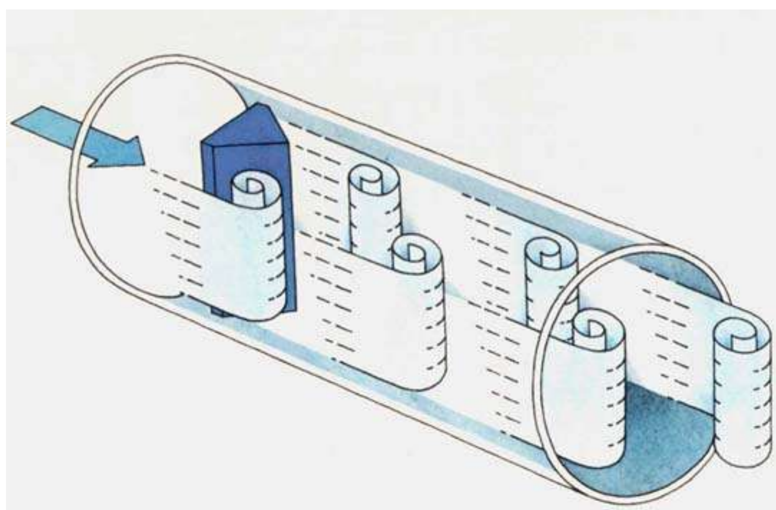
Project Write-up

Name:…………………………………………… Group:……………………………..

MODULE TITLE: Flow Measurement MODULE No: F1 001 1

PROJECT DESCRIPTION: Rate of Flow or Inferential Devices – Vortex Meter

PROJECT No: F5 OBJECTIVE Nos: 1,2,8, 9.



PROJECT WRITE UP SHEET

Principle/Theory of Operation

Who described vortices in water and when?

What is the obstruction called and where do the vortices form?

Name three methods of sensors used.

Why is the best shape for a bluff body, delta shaped?

What will determine the sensor type and shape?

How must the meter NOT be mounted?

PHASE 1 INSTRUMENTS

Project Write-up

Name:…………………………………………… Group:……………………………..

MODULE TITLE: Flow Measurement MODULE No: F1 001 1

PROJECT DESCRIPTION: Rate of Flow or Inferential Devices – Electromagnetic (E.M.) Meter

PROJECT No: F6 OBJECTIVE Nos: 1,2,8, 9.

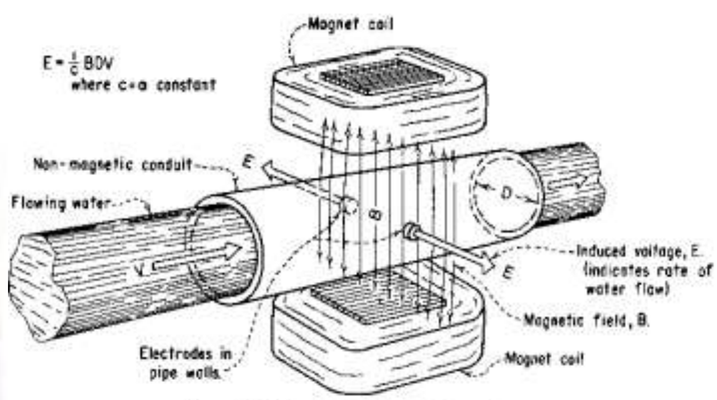


Figure 14-8.—Schematic view of a magnetic flowmeter.

PROJECT WRITE UP SHEET

Principle/Theory of Operation

When were these types of meters developed?

What types of liquids are not suitable for this meter?

What doesn’t affect the measurement?

Name 3 advantages of these types of flowmeters?

PHASE 1 INSTRUMENTS

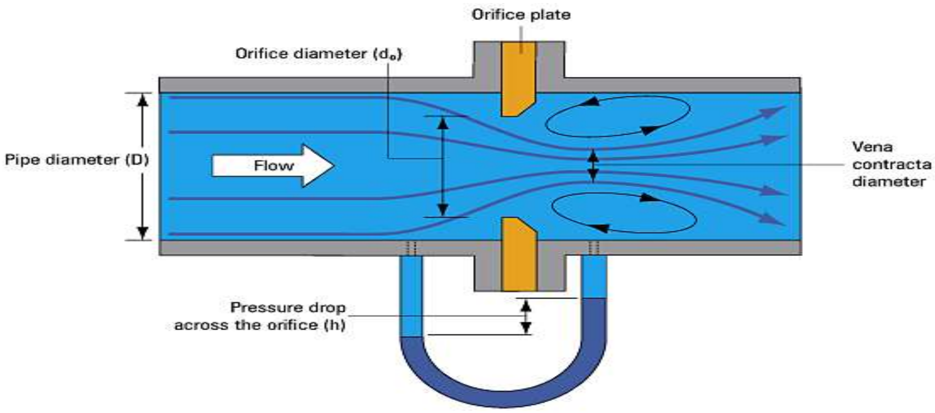
Project Write-up

Name:…………………………………………… Group:……………………………..

MODULE TITLE: Flow Measurement MODULE No: F1 001 1

PROJECT DESCRIPTION: Rate of Flow or Inferential Devices – Orifice Plates (D/P Devices)

PROJECT No: F7A OBJECTIVE Nos: 1, 3, 4, 5, 6, 7, 8.



PROJECT WRITE UP SHEET

Principle/Theory of Operation

What type of transmitter would be used to measure the pressure drop?

What is the formula to calculate flow rate from pressure drop?

What determines the diameter of the hole in the plate?

What is the purpose of the bypass on the d.p. cell?

Applications and Configurations

Orifice Plate Application Summary (Refer to table below)

Orifice Type	Fluid Type								
	Gas (Vapour)		Liquid				Reynolds Number Range	Nominal Line Sizes Normally Used	
	Clean	Dirty	Clean	Dirty	Viscous	Corrosive		mm	in
Concentric - Square Edge	■		■	▨		▨	>2000	15 to 1,500	1/2 to 60
Concentric - Quadrant Edge			■	▨	■	▨	200 to <10,000	25 to 150	1 to 6
Concentric - Conical Edge			■	▨	■	▨	200 to <10,000	25 to 150	1 to 6
Eccentric - Square Edge	▨	■	▨	■		▨	>10,000	100 to 350	4 to 14
Segmental - Square Edge	▨	■	▨	■		▨	>10,000	100 to 350	4 to 14

Notes:
- ■ Designed for this application
- ▨ Normally applicable for this application
- (blank) Not designed for this application

PHASE 1 INSTRUMENTS

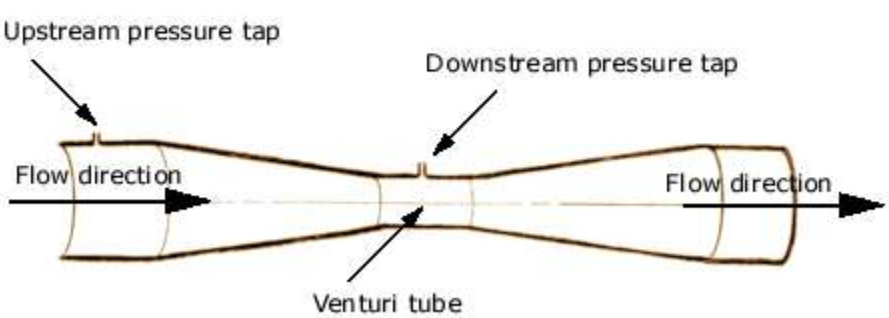
Project Write-up

Name:…………………………………………… Group:……………………………..

MODULE TITLE: Flow Measurement MODULE No: F1 001 1

PROJECT DESCRIPTION: Rate of Flow or Inferential Devices – Venturi Tube (D/P Devices)

PROJECT No: F7B OBJECTIVE Nos: 1, 3, 4, 5, 6, 7, 8.



PROJECT WRITE UP SHEET

Principle/Theory of Operation

Write the equation for calculating the output of a transmitter measuring flow.

When the flowrate is 50% of the maximum, what percentage is the pressure drop across the venture tube?

Besides the pipe diameter, what determines the pressure recovery of a venture tube?

What are integral orifices used for and where might they be found?

PHASE 1 INSTRUMENTS

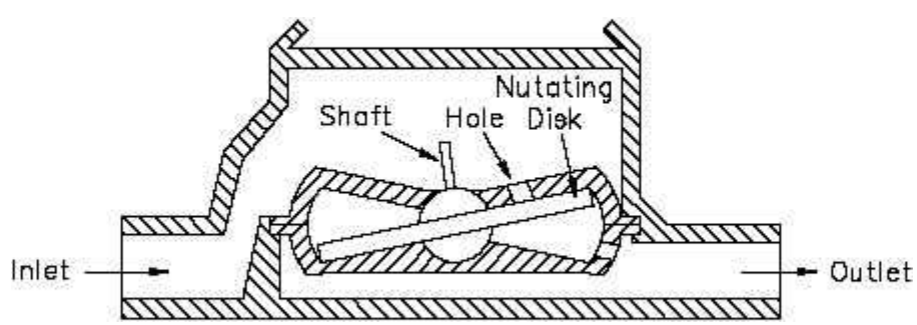
Project Write-up

Name:…………………………………………… Group:……………………………..

MODULE TITLE: Flow Measurement MODULE No: F1 001 1

PROJECT DESCRIPTION: Quantity Meters – Nutating Disc (Positive Displacement Type)

PROJECT No: F8 OBJECTIVE Nos: 1, 8, 9.



PROJECT WRITE UP SHEET

Principle/Theory of Operation

Where is this type of meter predominately used?

How many chambers is the meter divided into?

How is the cam connected to the display?

Besides the rotary piston type list three other types of positive displacement meters?

PHASE 1 INSTRUMENTS

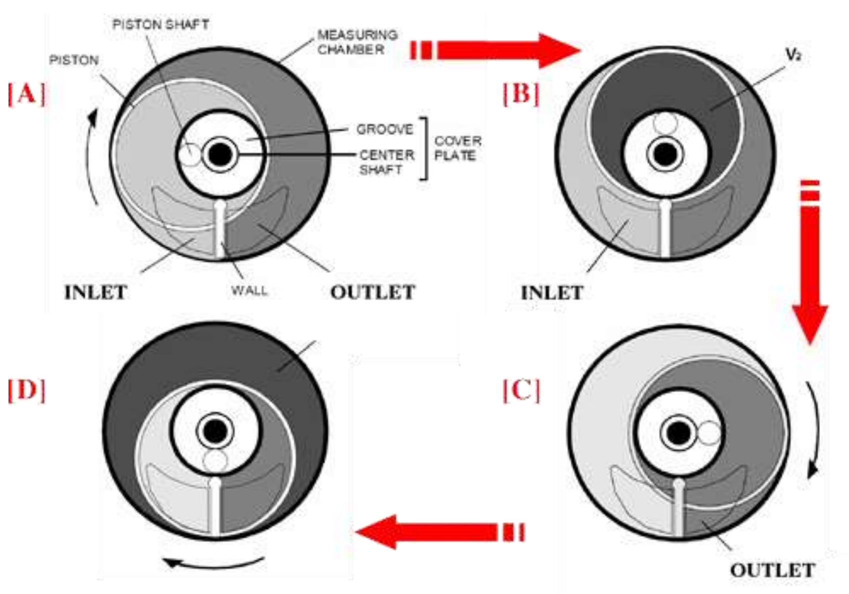
Project Write-up

Name:…………………………………………… Group:……………………………..

MODULE TITLE: Flow Measurement MODULE No: F1 001 1

PROJECT DESCRIPTION: Quantity Meters – Oscillating/Rotary Piston (Positive Displacement Type)

PROJECT No: F9 OBJECTIVE Nos: 1, 8, 9.



PROJECT WRITE UP SHEET

Principle/Theory of Operation

Where would this type of meter be commonly found?

What pipe diameters are they commonly used on?

PHASE 1 INSTRUMENTS

FLOW MEASUREMENT (Module F1 001 1)

PROJECT F10 – FLOW QUESTIONNAIRE:

1. Fluid through a pipe can be either streamlined (laminar) or………………………

2. Flow measurement can be categorised as either:

   ……………………………or………………………………. and can be sub-divided into:

   a) ………………………………..

   b) ………………………………..

   c)………………………………..

   Typically ………………………… …………………. meters measure……………… of flow, whereas ……………………………………. meters measure flow…………

3. If the flowrate through a pipe is reduced to half maximum flow, the differential pressure produced across the orifice or Venturi tube would reduce to……………%. This is because the relationship between the flow rate and the D/P being measured is……………………………..

   Venturis recover approximately……………..% of the pressure by altering the ……………………………………, whilst only approx……………% of the pressure is recoverable using orifice plates. Venturis, however, can be……………………………….and expensive to produce, due to their size and construction.

4. Orifice plates and Venturi tubes manipulate flow through a pipeline and the ……………… …………………………….. produced across these devices is measured using a ………………………………………. between the high pressure (HP) side and the …………………………. ……………………. which is the point of ………………………….. ……………….. and ……………………….

5. A Vortex meter works by creating an area of …………………………………… and …………pressure by shedding………………………………around an obstruction known as a ……………………………. This device creates a signal as a result of these pressure changes, which is proportional to the rate of flow.

6. A more common name for the V.A. meter is a………………….............

   These must be installed ………………………………………in the pipeline.

   They can easily be broken by ……………………………the glass during overhaul. It is also important to ensure that the ……………………………………..are fitted before installing the flowmeter in the process line.

7. An E.M. meter works on ……………………………Law of ………………….. ……………..……induction. As the conductor or …………………………………process liquid passes through the…………………………………..created by a …………………………around a pipeline, an ……………………………is induced through the liquid. This is detected by two………………………………………and converted to a suitable output which is directly proportional to the flowrate. The meter must be kept…………………… of liquid, otherwise output readings would become ………………………. For safety reasons, this device must be ………………….. as the coil voltage is normally………………………….. The fluid most suitable for an E.M. meter would be either………………………… or……………………………….. It must also be an……………………………

   A typical application of an E.M. meter would be the flow measurement of ……………………………………

8. (a) How does a V.A. meter work and how/where would you take your readings?

8. (b) What changes would you make to convert this device into one which would provide an external flow indication and/or transmittable signal?

9. An orifice plate is designed to generate a…………………………. ……………………across it which changes proportionally to flowrate. The relationship between these is………………………………… A…………………………..is used to measure this and produces a proportional output. The location of the transmitter would be…………………. the line for liquids and ……………………………. for gases. In standard practice (i.e.non-viscous fluids), the orifice would have a ………………………………….. on the………………………pressure or downstream side. In liquid flow installations, the effects due to…………………………can be eliminated by a process called ……………………………………….

10. A Turbine meter is categorized as……………………………., due to the fact that it measures the…………………of the……………………………….rotation which is directly proportional to the flowrate.

11. (a) An orifice installation is designed to develop a differential pressure of 100"w.g. at a maximum flowrate of 500 cubic meter/hour. Calculate what the flowrate would be if the differential being measured was at:

(a) 25"w.g.
(b) 50"w.g.
(c) 75"w.g.

(b) What would be the outputs for the flowrates you have just calculated for:

(a) A pneumatic transmitter
(b) An electronic transmitter

FORMULAE FOR CALCULATING FLOW RATE.

$$\text{FLOW RATE} = \sqrt{\frac{\text{Measured D / P}}{\text{Max. D / P}}} \times \text{Max. Flow Rate}$$

FORMULAE FOR CALCULATING INDICATOR READINGS.

$$R = A + \left[(B - A) \times \left(\frac{Q}{Qm} \right)^2 \right]$$

R = Indicator reading
A = *Reading at zero Flow*
B = Reading at full scale.
Q = Actual Flow Rate
Qm = Maximum Flow Rate

Example :

A pneumatic transmitter is installed on a flow loop. Maximum flow is 100 cu.m / hr.Calculate the indicator reading for half flow rate.

For 3 - 15 psi Pneumatic Tx

$$R = 3 + \left[(15 - 3) \times \left(\frac{50}{100} \right)^2 \right]$$

$$R = 3 + (12 \times \frac{1}{4})$$

$$R = 3 + 3 = \underline{\textbf{6 PSI}}$$

For 4 - 20 mA Electronic Tx

$$R = 4 + \left[(20 - 4) \times \left(\frac{50}{100} \right)^2 \right]$$

$$R = 4 + (16 \times \frac{1}{4})$$

$$R = 4 + 4 = \underline{\textbf{8 mA}}$$

Technical Training Enterprise Ltd

Phase 1 Instruments

Flow Measurement (Module No. F1 001 1)

Project F11:

Carefully read all instructions before commencing project

All equipment should be checked and calibrated before installation.

Your working design/drawing should be clearly labeled and show all pneumatic and electrical connections/including polarities).

To re-enforce areas already covered during Phase 1 Instruments, you are now required to design and build a simulated flow/indicator alarm loop (FIA) which incorporates the following equipment:

a. Foxboro 13A Pneumatic Transmitter (Input Range See T.O. Output 0.2 – 1.0 bar). The pressure input will simulate the pressure drop produced by the flow across the venture/orifice plate.

b. Pressure Switch (to be set at half maximum flow rate to give a low flow alarm). This should be connected to the output of the D/P cell

c. A method of showing the operation of (b)

d. Pressure to Current Transducer (P/I)

e. A mA indicator showing the output of the P/I

f. Current to Pressure Transducer (I/P)

g. A method of indicating the output of the I/P

The system should be arranged so that the O/P of the Tx feeds the pressure switch, the P/I, the mA meter and then the I/P.

Flow Exercise 2

Name :- ……………………….

READ EVERYTHING CAREFULLY

- Connect 50psi air supply to bottom connection underneath blue valve
- Connect 20psi supply to DP cell and output of DP cell to P3 on Wally box
- Connect P1 of Wally box to Inst connection on control valve
- Connect 20 psi to Supply on control valve

1. Adjust P1 regulator pressure to obtain an output from the DP cell of 1 Bar on P3. Make a note of the rotameter reading (take reading off white scale plate)
2. Adjust P1 and record the rotameter values in the table below.
3. Plot a graph of your findings

D.P. Cell output	**Rotameter reading**
0.2 Bar	
	50
0.4 Bar	
0.6 Bar	
0.8 Bar	
1.0 Bar	

100% (1.0)

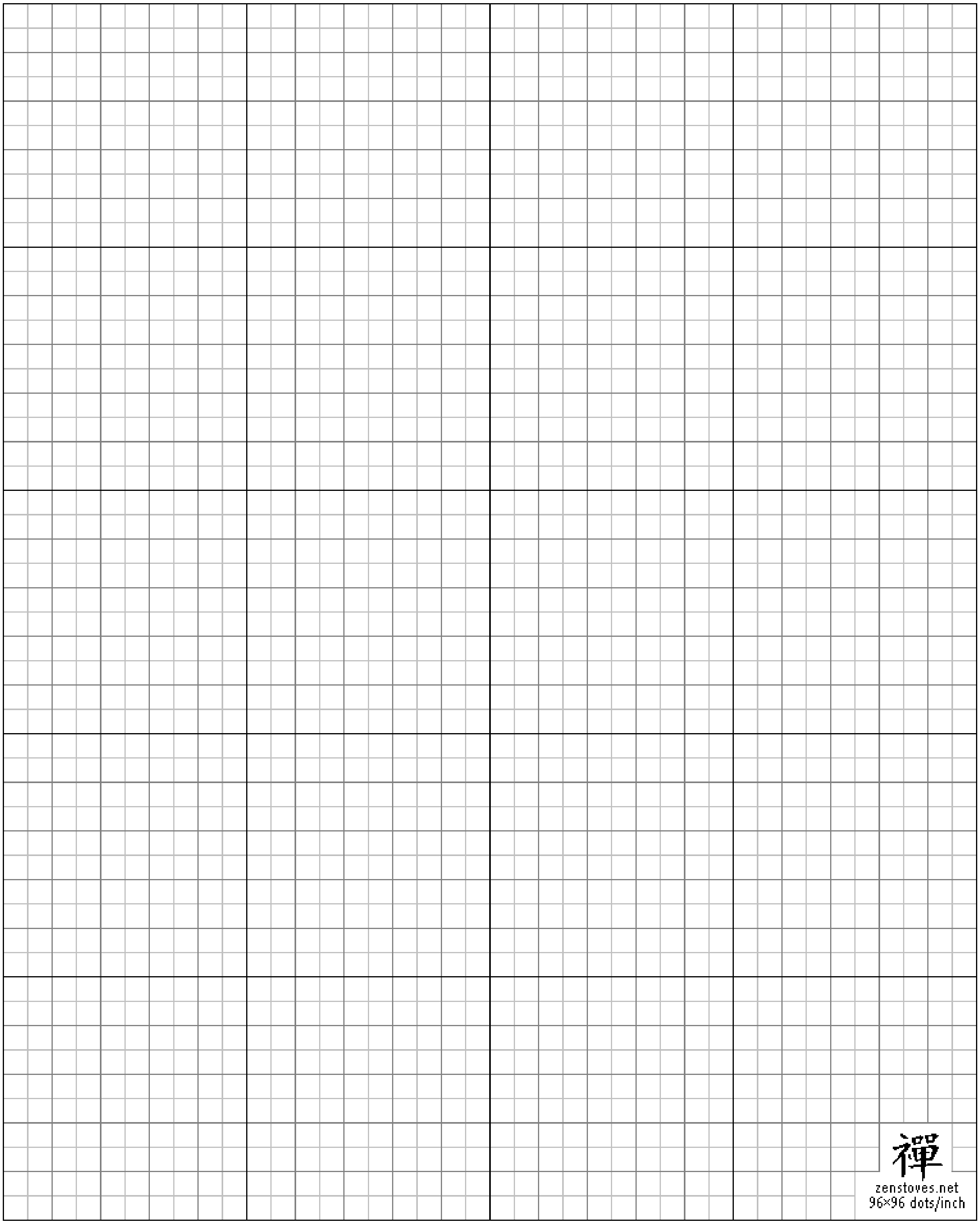
75% (0.8)

50% (0.6)

25% (0.4)

0% (0.2)

DP Cell
O/P



Rotameter Flow reading

Cost of Inaccurate Calibration

This exercise is to demonstrate the financial impact that calibration accuracy has on a business.
In this example the maximum flow rate through the system is 200 litres per minute of petrol. That equates to 288000 (10m) litres per day or approx 230 tonnes.

At present petrol costs approx £1.33 per litre, although the cost of production is about 50 pence/litre.

First of all, assume the instrument error is 0.5%

Using graph 1, determine what the flow rate error is (l/min) when the flow is lower than 50 litres/hour. Calculate the cost to the firm, if the error is a negative one i.e. the instrument reads lower than actual and the product is basically given away.

Answer - _________ litre/day Cost £_________

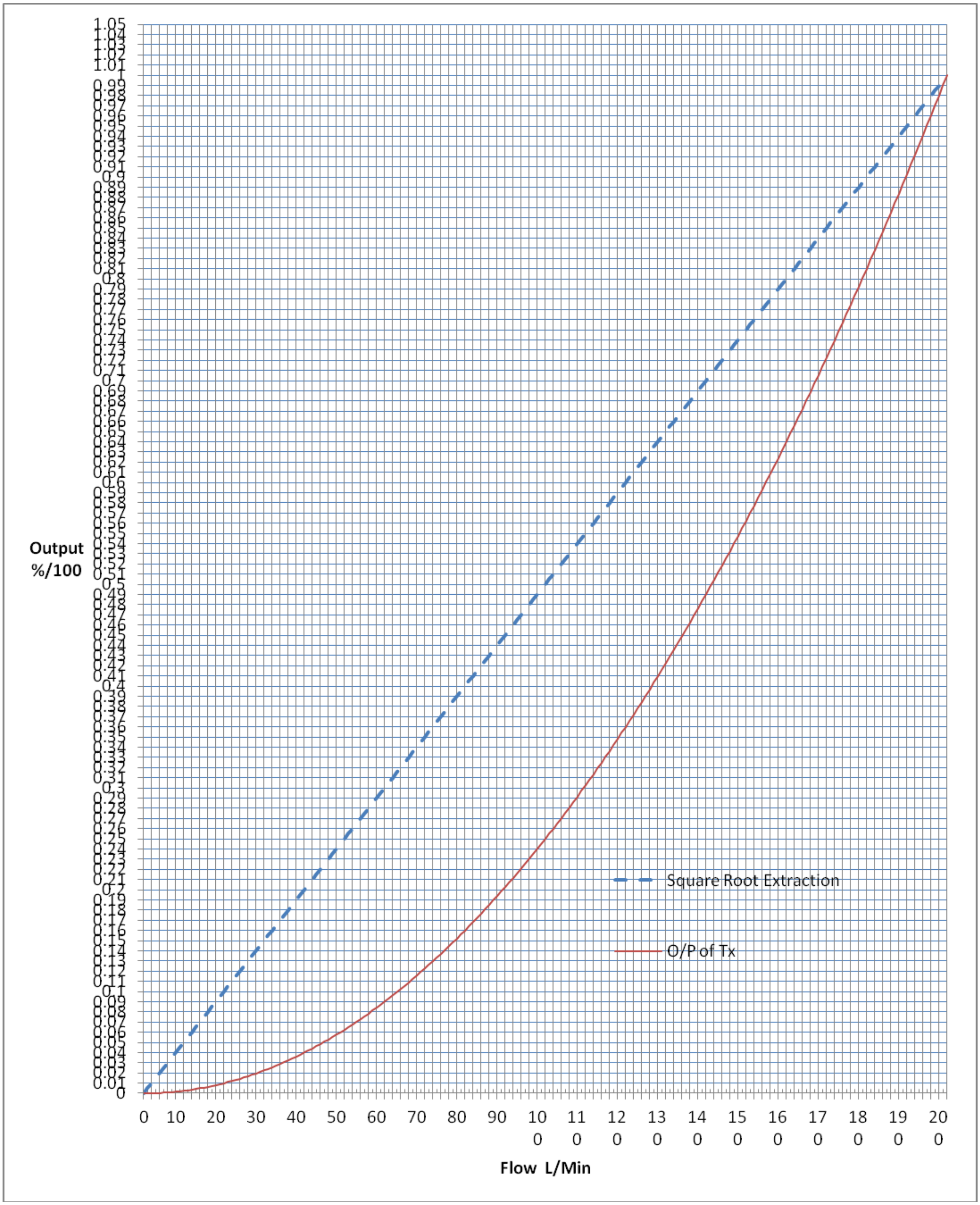
Using graph 2, determine what the flow rate error is (l/min) when the flow is greater than 180 litres/hour. Calculate the cost if the error is a negative again.

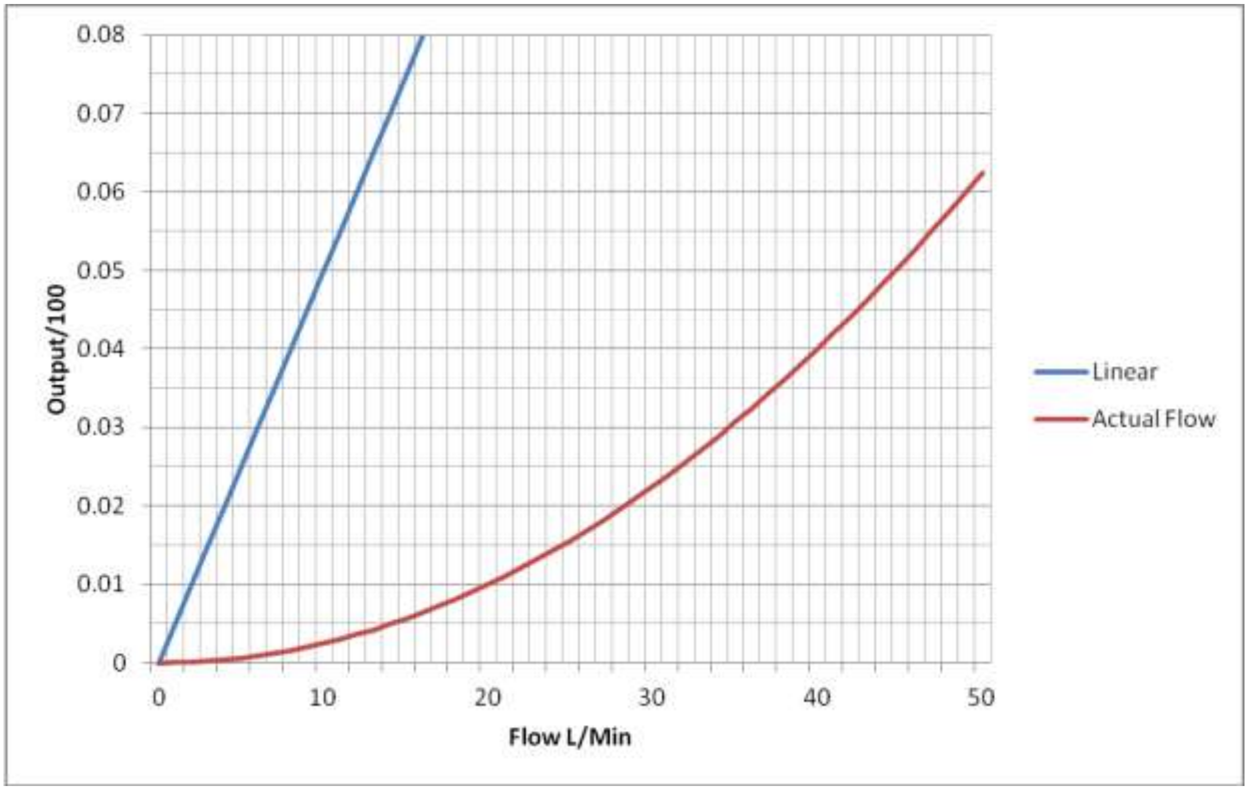
Answer - _________ litre/day Cost £_________

Repeat the above using an error of 3%

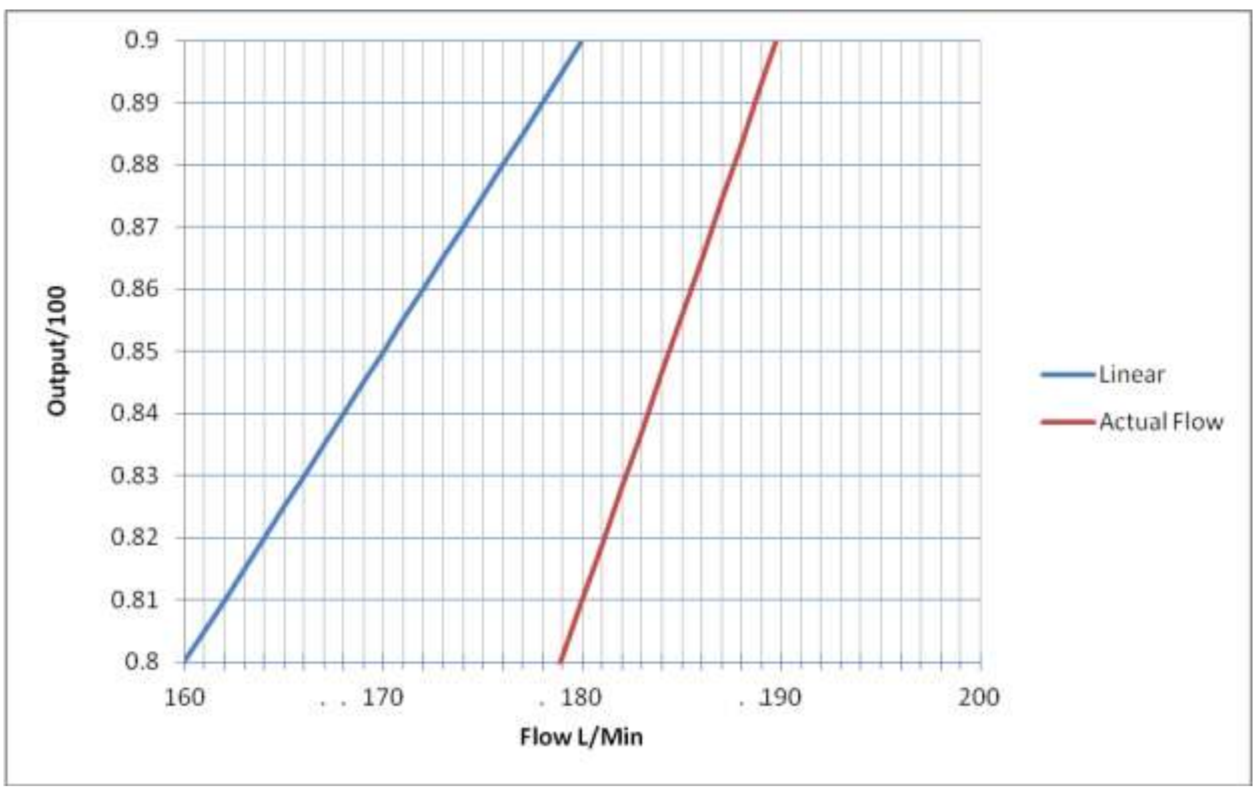
Answer - _________ litre/day Cost £_________
Answer - _________ litre/day Cost £_________

What is 0.5% error in mA? ____________


Output %/100
0 10 20 30 40 50 60 70 80 90 10 11 12 13 14 15 16 17 18 19 20
0 0 0 0 0 0 0 0 0 0 0
Flow L/Min
Square Root Extraction
O/P of Tx



Graph 1



Graph 2