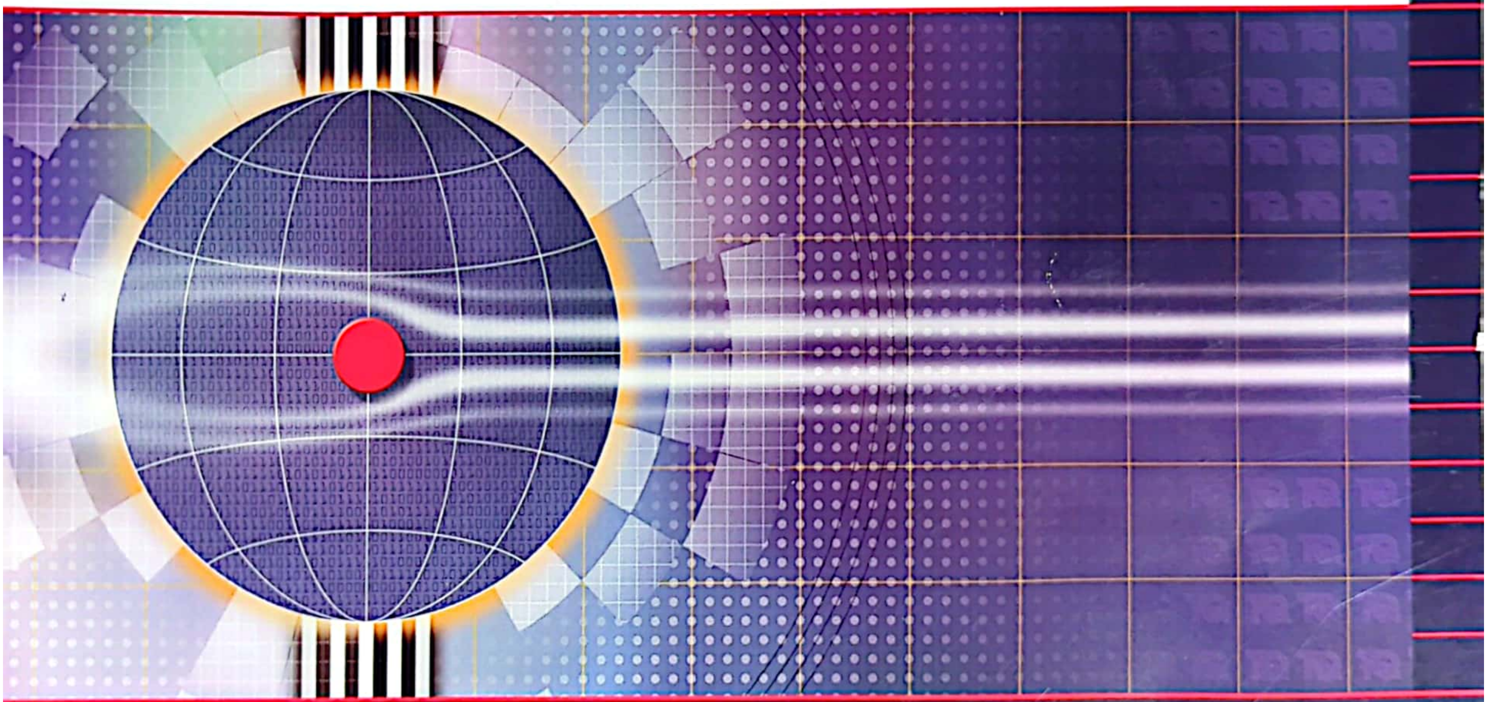
TecQuipment

H34

Pipework Energy Losses

User Guide



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TecQuipment supply a Packing Contents List (PCL) with the equipment. Carefully check the contents of the package(s) against the list. If any items are missing or damaged, contact TecQuipment or the local agent.

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TecQuipment

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SECTION 1.0 Introduction

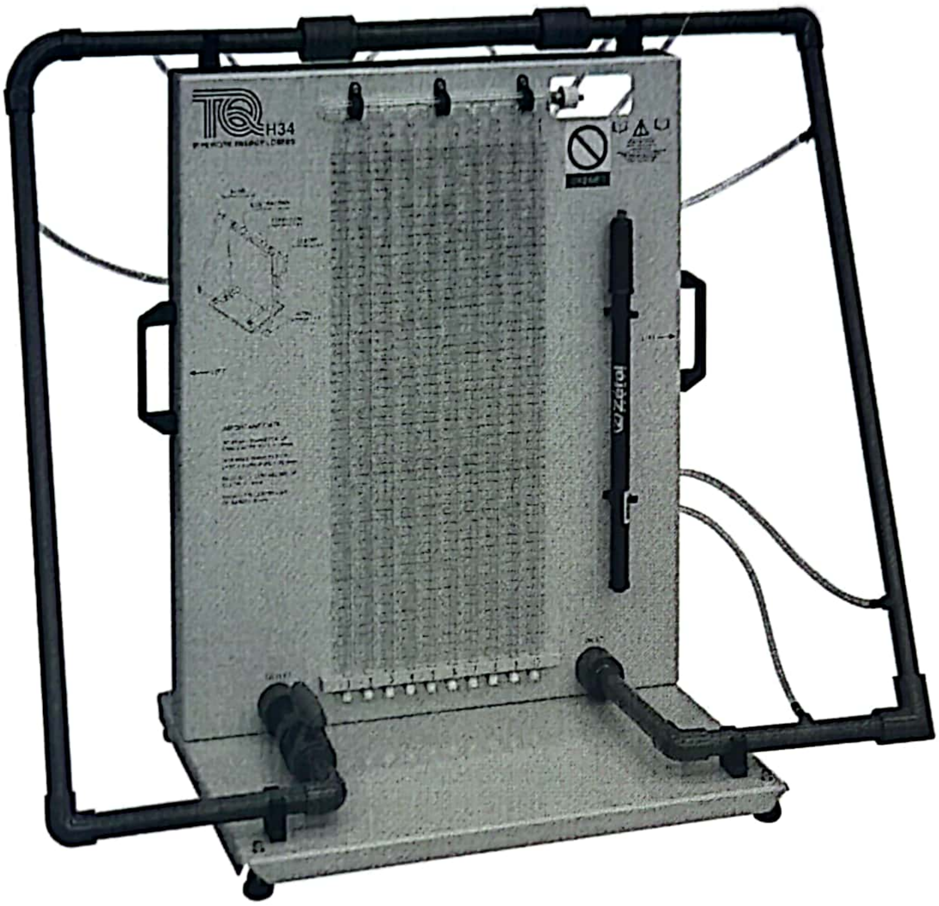

Figure 1 The H34 Pipework Energy Losses

Almost all runs of pipework contain fittings such as:

- bends
- changes in diameter
- junctions
- valves

The constrictions and changes in flow direction due to pipework fittings cause pressure losses. These losses are additional to those due to friction at the pipe wall. Losses at fittings usually contribute significantly to the overall loss through the pipework, so it is important to have reliable information about them. The TecQuipment Pipework Energy Losses (H34) product fits onto either of TecQuipment's Hydraulic Benches to investigate losses in various typical fittings over a range of flow rates.

SECTION 2.0 Description

2.1 General

The equipment shown in Figure 2 provides a circuit of pipework, made of rigid plastic parts, supported in the vertical plane from a baseboard with a vertical panel at the rear. TecQuipment have made the product to fit on the top of either the H1 or H1d Hydraulic Benches. The bench then provides the water supply and flow measurement for the experiments.

CAUTION *Do not connect this equipment to a water supply of greater than 2 bar.*

The pipework includes:

- Mitre bend
- Elbow bend
- Sudden enlargement in pipe diameter
- Sudden contraction in pipe diameter
- Large radius bend

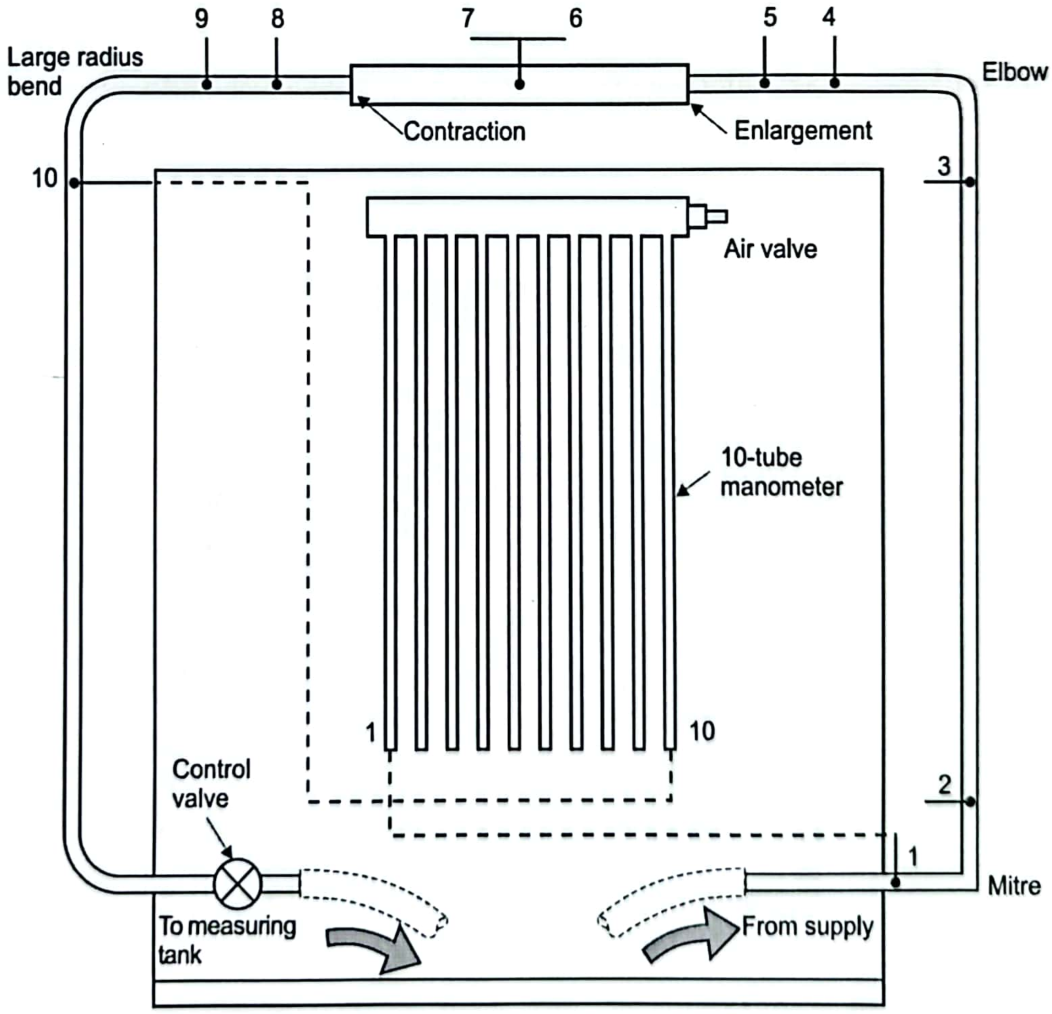

Figure 2 General Arrangement of Apparatus

Each fitting has pressure tappings upstream and downstream of the fitting. The tappings connect to a multitube manometer with ten tubes. A scale behind the manometer allows you to read the relative water levels in the manometer.

NOTE *The water levels you measure are not actual pressures in mmH_2O with respect to atmosphere. They are the relative pressures each side of the fittings.*

From Figure 2, you can see that the elbow for example has tappings 3 and 4 at its upstream and downstream pipework. Note that the short section of larger bore pipework at the enlargement and contraction shares a single tapping to manometer tubes 6 and 7. These tubes should always show the same value. If they do not, you will find that some air has become trapped in one of the tubes.

An air valve at the manifold of the manometer allows you to purge air from the pipework before the experiment. It also allows you to use the hand pump to add air pressure to the manifold. This will equally offset the pressure readings down the vertical scale so that you can read them.

A hand-operated valve at the outlet allows you vary the flow rate through the pipework. This is important, as an upstream valve could introduce flow disturbance that would affect your results.

Adjustable feet allow you to level the product before your experiments.

Handles on each side of the vertical panel are to help you lift the equipment.

CAUTION *Never use the pipework to lift the equipment. Always use the handles.*

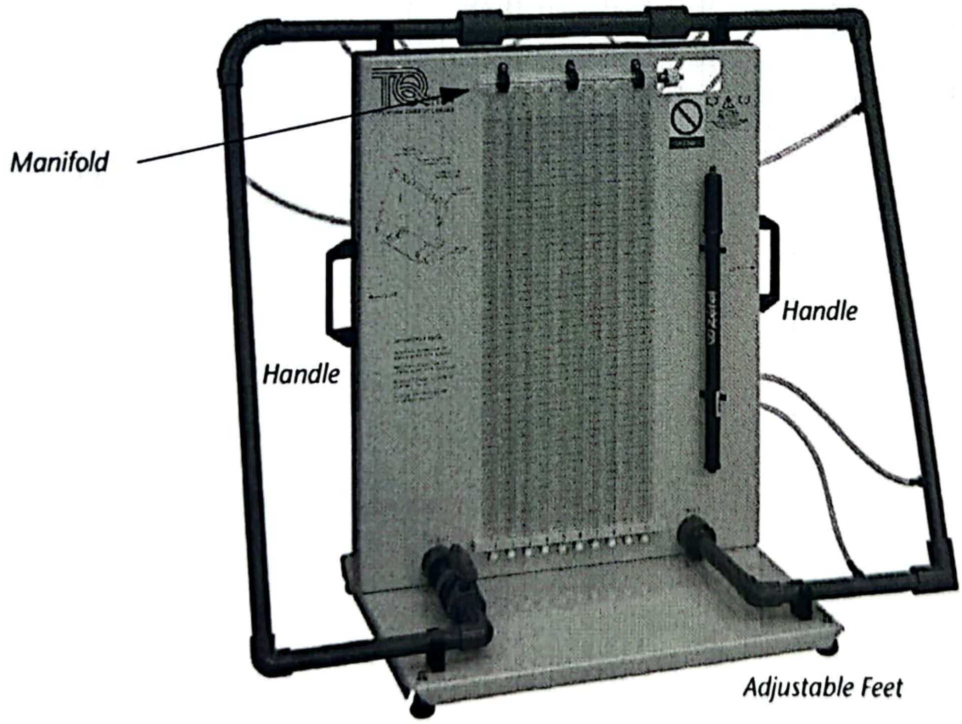

Figure 3 Front View

2.2 Technical Details

Item	Details
Dimensions	980 mm wide, 460 mm front to back and 800 mm high
Weight	12 kg
Maximum Pressure	2 bar
Operating Environment	Indoor (laboratory) Altitude up to 2000 m Temperature range 5°C to 40°C Maximum relative humidity 80% for temperatures up to 31°C, decreasing linearly to 50% relative humidity at 40°C
Smaller Bore Pipe	Internal bore D_1 = 22 mm, so $A_1 = 3.8 \times 10^{-4}$ m^2
Larger Bore Pipe (between enlargement and contraction)	Internal bore D_2 = 28.4 mm, so $A_2 = 6.33 \times 10^{-4}$ m^2
Elbow	Radius to centre line 14 mm Internal bore = D_1 = 22 mm diameter
Bend	Radius to centre line 50 mm Internal bore = D_1 = 22 mm diameter
Mitre	Internal bore = D_1 = 22 mm diameter
Sound levels	Less than 70 dB(A)

SECTION 3.0 Installation

The terms **left, right, front** and **rear** of the apparatus refer to the operators' position, facing the unit.

NOTE

- *A wax coating may have been applied to parts of this apparatus to prevent corrosion during transport. Remove the wax coating by using paraffin or white spirit, applied with either a soft brush or a cloth.*
- *Follow any regulations that affect the installation, operation and maintenance of this apparatus in the country where it is to be used.*

3.1 Handling

Always use the handles to lift and move the equipment. Never use the pipework.

3.2 Installation

1. Make sure your hydraulic bench is filled to its correct level with clean, cool water.

NOTE *For best results, always use clean cold water that has a low mineral content. Water with a high mineral content can cause the manometer tubes to become cloudy and may affect your results.*

2. Put the H34 on the top of the H1 or H1d hydraulic bench (not included).

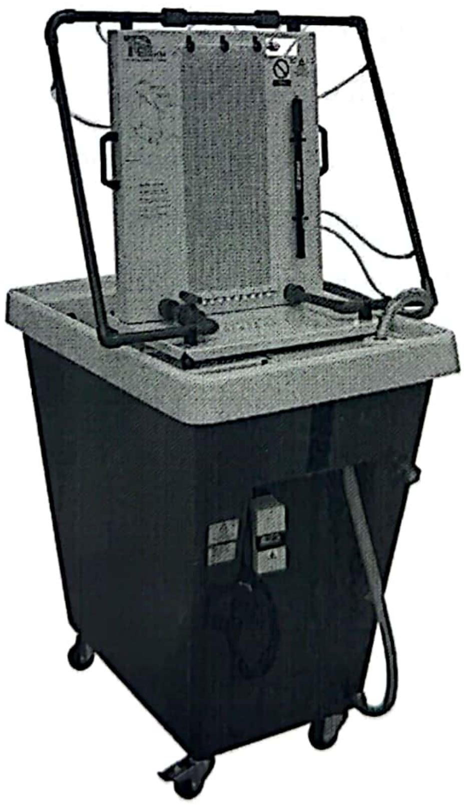

Figure 4 The H34 on Top of a H1d Hydraulic Bench

3. Use the fixings supplied to connect the outlet of your hydraulic bench (not supplied) to the inlet of the H34. See Figure 5.

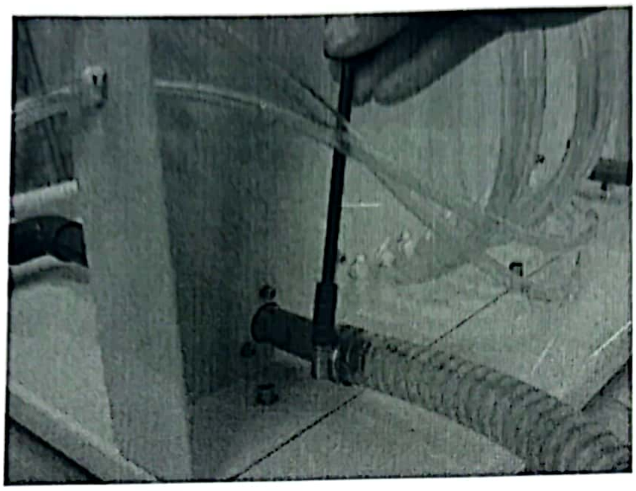

Figure 5 Connect the Outlet of Your Hydraulic Bench to the Inlet of the H34

4. Fit the short piece of pipe supplied to the outlet of the H34. Direct this outlet pipe into the volumetric tank of the H1d Volumetric bench, or the hole in the middle of the H1 Gravimetric bench.

NOTE *Direct your outlet pipework to minimise splashes. This helps to reduce any air bubbles entering the water system and affecting your results.*

5. Use the adjustable feet to level the H34.

6. Start the pump of the hydraulic bench and fully open its delivery valve.

7. Fully open the outlet valve of the H34 to allow water to pass along the pipework.

8. Slowly shut the H34 outlet valve and check for water leaks.

9. Switch off the hydraulic bench pump, fully open the outlet valve and allow water to drain from the equipment.

SECTION 4.0 Theory

4.1 Notation

Description	Symbol	Units
Head	h or H	mH_2O or mmH_2O where shown
Total head loss	ΔH	mH_2O or mmH_2O where shown
Measured head loss between two pressure points	Δh	mH_2O or mmH_2O where shown
Velocity	V	$m.s^{-1}$
Velocity (upstream and downstream)	V_u and V_d	$m.s^{-1}$
Velocity in the smaller bore pipe	V_1	$m.s^{-1}$
Velocity in the larger bore pipe	V_2	$m.s^{-1}$
Velocity (at a vena contracta)	V_c	$m.s^{-1}$
Volume Flow	Q	$m^3.s^{-1}$
Pressure	P	Pa or $N.m^{-2}$
Internal Pipe Diameter	D	m
Internal Pipe Diameter (upstream and downstream)	D_u and D_d	m
Cross sectional area	A	m^2
Cross sectional area (upstream and downstream)	A_u and A_d	m^2
Cross sectional area at a vena contracta	A_c	m^2
Radius	R	m
Acceleration due to gravity	g	9.81 $m.s^{-2}$

4.2 Conversions

1000 Litres of water = 1 cubic metre of water.

So, 1000 $L.s^{-1}$ = 1 $m^3.s^{-1}$

and 0.1 $L.s^{-1}$ = 0.0001 $m^3.s^{-1}$

1 kg of water = roughly 1 Litre of water at room temperature.

4.3 Loss of Total Head (H) at a fitting

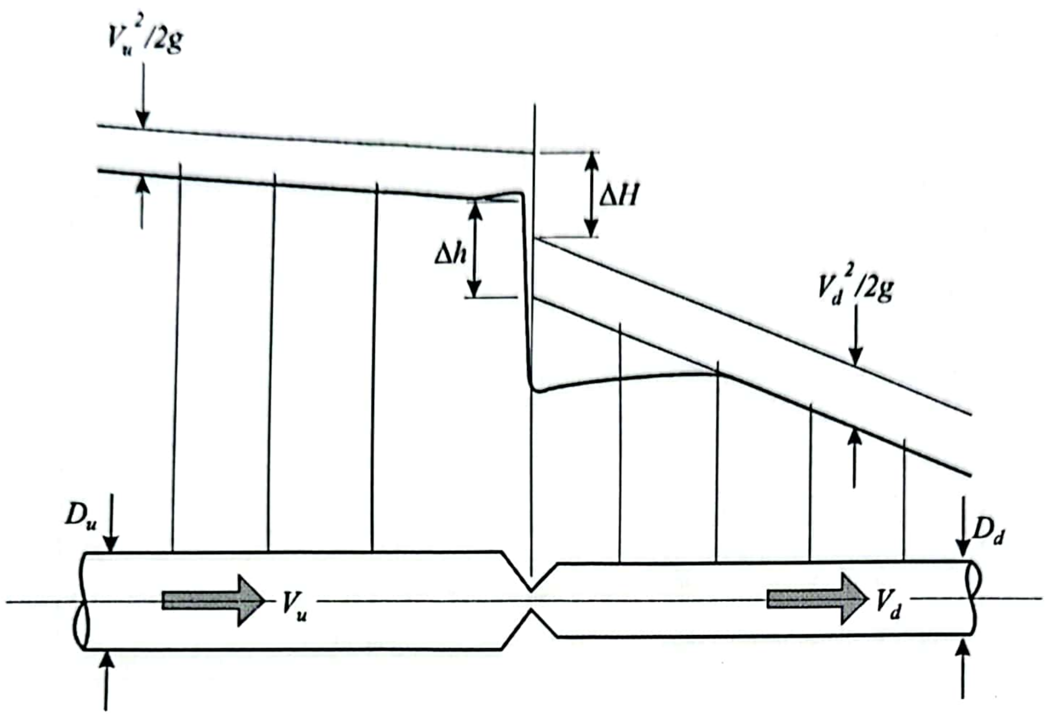

Figure 6 Schematic Representation of Loss at a Pipe Fitting

Figure 6 shows water flowing at velocity V_u along a pipe of diameter D_u towards a pipe fitting such as a bend or a valve, but shown for simplicity as a simple restriction in the cross-section of the flow. Downstream of the fitting, the water flows along a pipe of some other diameter D_d, along which the flow velocity is V_d. The figure shows the variation of piezometric head along the pipe run, as would be shown by numerous pressure tappings at the pipe wall.

In the region of undisturbed flow, far upstream of the fitting, the distribution of velocity across the pipe remains unchanged from one cross-section to another; this is the condition referred to as 'fully developed pipe flow'. Over this region, the piezometric head falls, with a uniform, mild gradient, as a result of the effect of constant friction at the pipe wall in fully developed pipe flow. Close to the fitting, however, there are sharp and substantial local disturbances to the piezometric head, caused by rapid changes in direction and speed as the water passes through the fitting. In the downstream region, these disturbances die away, and the line of piezometric head returns asymptotically to a slight linear gradient, as the velocity distribution gradually returns to the condition of fully developed pipe flow.

You can predict the piezometric head loss Δh due to the fitting by extrapolating the upstream and downstream lines of linear friction gradient to the plane of the fitting. To find loss of total head ΔH you must allow for the velocity heads in the upstream and downstream runs of pipe.

4.4 Velocity Head

Hydraulic head is the height or elevation of the surface of a fluid above a datum level. Usually shown in units of distance such as metres or millimetres of water. ***Velocity head*** is the energy in the liquid due to its movement. However, it is also shown in units of distance.

$$\text{Velocity Head} = \frac{V^2}{2g} \qquad (1)$$

4.5 *Head Loss and Dimensionless Loss Coefficient (K) for the Fittings*

Figure 6 shows that the total head loss (ΔH) across the constriction is equal to the sum of the head loss across the fitting (Δh) and the energy loss (velocity head difference $V^2/2g$):

$$\Delta H = \Delta h + \frac{V_u^2}{2g} - \frac{V_d^2}{2g} \qquad (2)$$

To simplify the head loss comparison between fittings, textbooks and engineers use a dimensionless ***loss coefficient*** K for the pipe or fitting.

The loss coefficient is the division of the ***total head loss*** by the velocity head in either the upstream or the downstream pipe (the choice depending on the context, shown later). This gives:

$$K = \frac{\Delta H}{V_u^2/2g} \quad \text{or} \quad K = \frac{\Delta H}{V_d^2/2g} \qquad (3)$$

For the fittings in the equipment, upstream and downstream pipe diameters and therefore velocities are identical, so we may simplify the definition to:

$$K = \frac{\Delta H}{V^2/2g} \qquad (4)$$

Also, because there is no velocity head change, then $\Delta H = \Delta h$ ***for the fittings***, so:

$$K = \frac{\Delta h}{V^2/2g} \qquad (5)$$

where V is the flow velocity in either the upstream ***or*** the downstream pipe run*.

NOTE

** The velocity head $V^2/2g$ used here is based simply on the mean flow velocity V. Because the velocity varies across the pipe cross-section, from zero at the wall to a maximum at the centre, the velocity head in this non-uniform flow is somewhat higher, being typically 1.05 to 1.07 $V^2/2g$.*

From Equation (5), a chart of the measured head change across the fittings against the velocity head for a range of flow rates will produce a good average of the results, from which you can measure the gradient to find K. A 'best fit' line should pass through the origin 0,0.

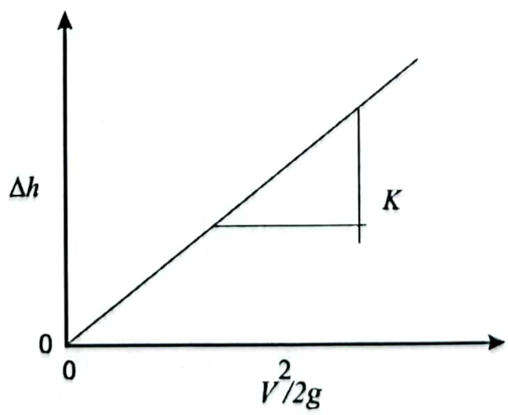

Figure 7 Using a chart to Find K

For best accuracy of pressure loss across a fitting you need long sections of straight pipe (of 60 pipe diameters or more) to establish the best positions for the pressure tappings over a range of flow rates. However, this would make a larger and more expensive product with only marginal gains in accuracy. The pressure tappings in the H34 are outside the regions of severe disturbance of the fittings, giving reasonable accuracy for Δh on each fitting.

The standard laws of flow are only accurate for a given range of flow for a given fitting, unless you add other correction factors, such as Reynolds number. Therefore, high flow rates may give excess disturbance and unusual scatter in the results, especially in the enlargement and contraction, so the experiment procedure asks to avoid these extremes.

4.6 Flow Through Bends

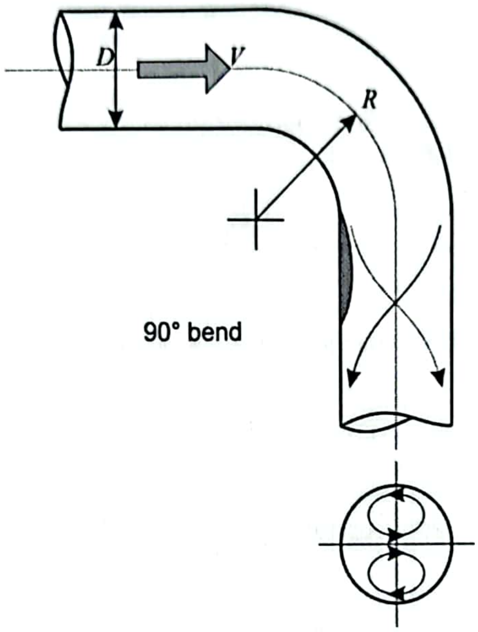

Figure 8 Flow Through a bend

Figure 8 shows flow around a 90° bend which has a constant circular cross-section of diameter D. The radius of the bend is R, measured to the centre line. The curvature of the flow as it passes round the bend is caused by a radial gradient of piezometric head, so that the piezometric head is lower at the inner surface of the pipe than at its outer surface.

As the flow leaves the bend, these heads start to equalise as the flow loses its curvature, so that piezometric head begins to rise along the inner surface. This rise causes the flow to separate, so generating mixing losses in the subsequent turbulent reattachment process. Additionally, the radial gradient of piezometric head sets up a secondary cross-flow in the form of a pair of vortices, having outward directed velocity components near the pipe centre, and inward components near the pipe walls. When superimposed on the general streaming flow, the result is a double spiral motion, which persists for a considerable distance in the downstream flow, and which generates further losses that are attributable to the bend.

The value of the loss coefficient K is a function of the geometric ratio R/D; as this ratio increases, making the bend less sharp, we would expect the value of K to fall. The smallest possible value of R/D is 0.5, for which the bend has a sharp inner corner. For this case, the value of K is usually about 1.4. As R/D increases, the value of K falls, reducing to values which may be as low as 0.2 as R/D increases up to 2 or 3. Note that for a mitre corner, R/D is zero, but the values of K are around 1.4 to 1.6.

Figure 9 shows typical loss coefficients for three different types of bend, showing that the easier the flow path (or the larger the R/D value), the lower the K value. There is also a slight dependence on Reynolds Number Re, but for most purposes this is small enough to be ignored.

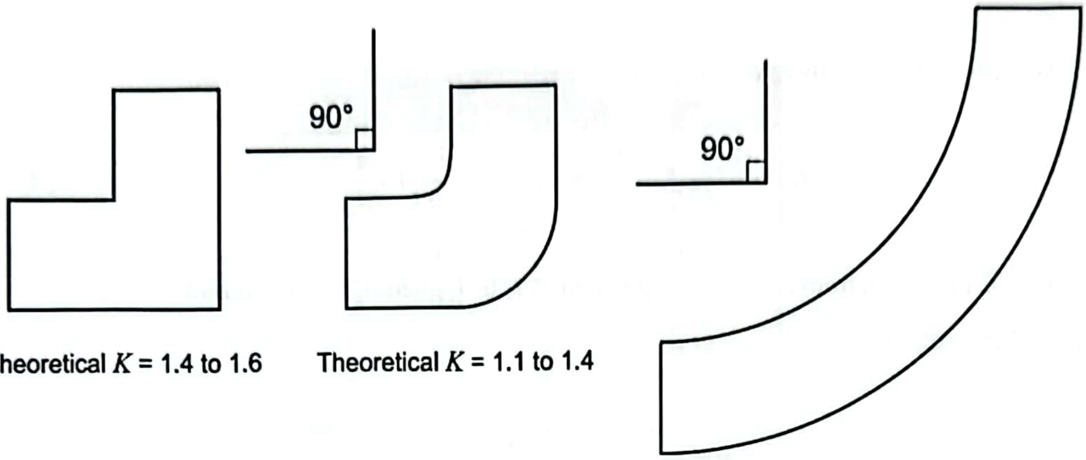

Figure 9 Typical Loss Coefficient for the Three Different Bends

4.7 *Flow through Enlargements and Contractions*

Sudden Enlargement (or Expansion)

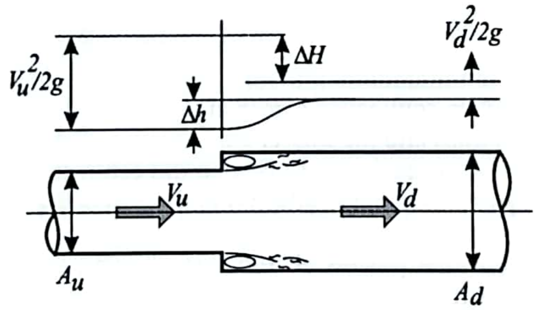

Figure 10 Flow Through an Enlargement

In the enlargement shown in Figure 10, the flow separates at the exit from the smaller pipe. This forms a jet which diffuses into the larger bore, and re-attaches to the wall some distance downstream.

The vigorous turbulent mixing, resulting from the separation and re-attachment of the flow, causes a loss of total head. The piezometric head in the emerging jet, however, starts at the same value as in the pipe immediately upstream, and increases through the mixing region, so rising across the enlargement. Figure 10 shows these changes in total and piezometric head, neglecting the small effect of friction gradient.

Assuming that the piezometric pressure on the face of the enlargement to be equal to that in the emerging jet, and that the momentum flux is conserved, the loss of total head may be shown to be:

$$\Delta H = \frac{(V_u - V_d)^2}{2g} \qquad (6)$$

The corresponding rise in piezometric head is:

$$\Delta h = \frac{2V_d(V_u - V_d)}{2g} \tag{7}$$

The loss coefficient K is, in this case, best related to the ***upstream*** velocity V_u, so that:

$$K = \frac{(V_u - V_d)^2/2g}{V_u^2/2g} = \left[1 - \frac{V_d}{V_u}\right]^2 = \left[1 - \frac{A_u}{A_d}\right]^2 \tag{8}$$

This shows K increasing from zero when A_u/A_d equals 1, to 1 when A_u/A_d falls to zero.

Sudden Contraction

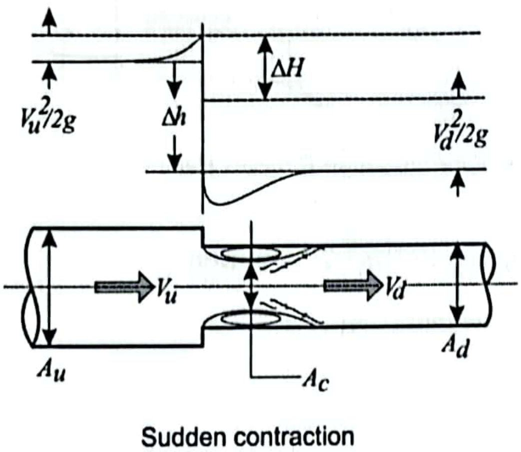

Figure 11 Sudden Contraction

Consider lastly the case of the sudden contraction shown in Figure 11. The flow separates from the edge where the face of the contraction leads into the smaller pipe, forming a jet which converges to a contracted section of cross-sectional area or 'vena contracta' A_c. Beyond this contracted section there is a region of turbulent mixing, in which the jet diffuses and re-attaches to the wall of the downstream pipe.

The losses occur almost entirely in the process of turbulent diffusion and re-attachment. The losses are therefore expected to be those due to an enlargement from the contracted area A_c to the downstream pipes area A_d. Following the result of Equation (6), the expected loss of total head in contraction is:

$$\Delta H = \frac{(V_c - V_d)^2}{2g} \tag{9}$$

The obvious choice of reference velocity in this case is V_d, so the loss coefficient K becomes:

$$K = \left[\frac{V_c}{V_d} - 1\right]^2 = \left[\frac{A_d}{A_c} - 1\right]^2 \tag{10}$$

Consider now the probable range of values of A_d/A_c. If the value of the pipe contraction ratio is 1.0, so A_d/A_u = 1.0, there will be no separation of the flow, so A_d/A_c = 1.0. Also, Equation (10) then gives a zero value of K.

If, however, the contraction is very severe, where A_d/A_u approaches 0, then you would expect a K value of nearer to 0.5.

Table 1 shows the results of calculations for a contraction that you will see in several fluid mechanics textbooks. It shows the theoretical K value based on diameter or area ratio for the dimensions each side of the contraction.

D_l/D_2 or A_d/A_u or A_l/A_2	K
0	0.5
0.2	0.45
0.4	0.38
0.6	0.28
0.8	0.14
1.0	0

Table 1 Typical K values for Different Diameter or Area Ratios in a Sudden Contraction

Finding K for the Enlargement and Contraction

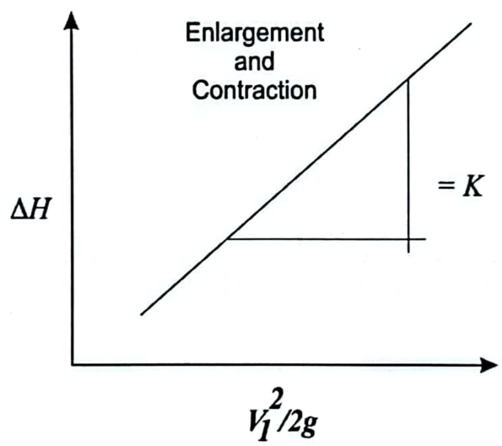

Figure 12 Finding K for the Enlargement and Contraction

For the ***enlargement***, the total head loss ΔH is a sum of the measured head difference across the enlargement (Δh) and the loss due to the change in velocity head. So, for the enlargement:

$$\Delta H = \Delta h + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} \qquad (11)$$

and from theory, the upstream velocity is the greatest influence for the enlargement, giving:

$$\Delta H = K\frac{V_u^2}{2g} \qquad (12)$$

which for the ***enlargement*** having an upstream of the smaller diameter pipe gives

$$\Delta H = K\frac{V_1^2}{2g} \qquad (13)$$

Therefore

$$K = \frac{\Delta H}{V_1^2/2g} \qquad (14)$$

For the ***contraction***, the total head loss ΔH is again the sum of the measured head loss (Δh), and the loss due to the change in velocity head, but in reverse to the expansion.

$$\Delta H = \Delta h + \frac{V_2^2}{2g} - \frac{V_1^2}{2g} \qquad (15)$$

and from theory, the downstream velocity is the greatest influence for the contraction, giving:

$$\Delta H = K\frac{V_d^2}{2g} \qquad (16)$$

which for the ***contraction*** having a downstream of the smaller pipe gives:

$$\Delta H = K\frac{V_1^2}{2g} \qquad (17)$$

and therefore:

$$K = \frac{\Delta H}{V_1^2/2g} \qquad (18)$$

So, you need a chart of total head loss ΔH against $V_1^2/2g$ to give a gradient of K for both the contraction and enlargement. A best fit line should pass through the origin (0,0) of the chart.

4.8 Finding Velocities

Fluid velocity is a simple mathematical division of the volume flow (in $m^3.s^{-1}$) and the area (in m^2) through which it passes.

For the fittings, the velocity is the volume flow divided by the area of the smaller bore pipe.

For the enlargement and contraction, there are two velocities, one in the smaller bore pipe and the other in the larger bore pipe.

For the fittings

$$V_1 = Q\,(\mathrm{m^3.s^{-1}})/A_1\,(\mathrm{m^2})$$

For the enlargement and contraction

$$V_1 = Q\,(\mathrm{m^3.s^{-1}})/A_1\,(\mathrm{m^2})$$
$$V_2 = Q\,(\mathrm{m^3.s^{-1}})/A_2\,(\mathrm{m^2})$$

SECTION 5.0 Experiment Procedure

5.1 *Water Splashes*

You may splash water around this equipment in use. Wear suitable clothing and wipe up any spills immediately to prevent slipping.

5.2 *Flow Rates and Best Results*

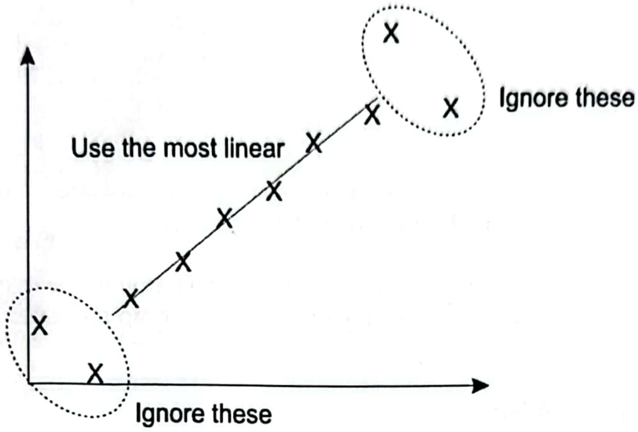

Figure 13 Scatter due to High and Low Flow Rates

Higher flow rates may tend to give excess scatter due to turbulence in the pipework - more noticeable with the elbow, contraction and enlargement. Lower flow rates may give excess scatter due to the increased percentage in reading errors and low pressures - again more noticeable with the elbow, contraction and enlargement. For these reasons, TecQuipment recommend that at least for the enlargement and contraction, you take a full range of results and choose the most linear portion for analysis, avoiding any areas of scatter at the higher and lower flow rates.

5.3 *Removing Air Bubbles*

NOTE *Trapped air bubbles in the pipework and the manometer tubes will affect your results. Always make sure you have removed air bubbles before taking readings.*

1. Set up the equipment on the hydraulic bench as described. (See "Installation" on page 7)
2. Fully open the H34 valve.
3. Start the hydraulic bench pump and fully open its delivery valve.
4. Wait a few seconds for water to pass around the H34 pipework.
5. Slowly shut the H34 valve.
6. Hold a small container (not supplied) at the air valve of the manometer manifold, ready to catch any water that you may spill. See Figure 14.

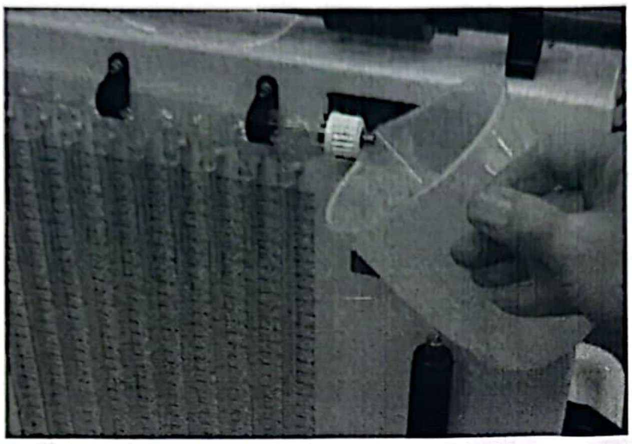

Figure 14 Use a Container (not supplied) to catch water

7. Press the centre of the air valve and allow air to escape from the manometer tubes until the manifold becomes full of water and the larger bubbles of air have escaped.

8. Slowly open and shut the H34 outlet valve to move trapped air around the manometer pipes until they pass up to the manometer manifold. You can gently massage or tap the tubes with your finger to help.

5.4 Using the H34 Outlet Valve

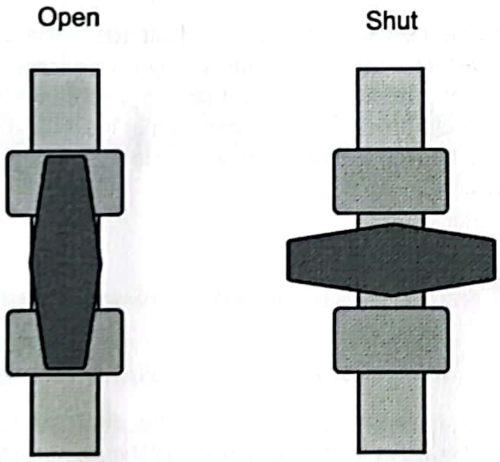

Figure 15 The Outlet Valve

The outlet valve is downstream of the fitting to avoid creating flow disturbance through the fittings. However, if you shut or open the valve very quickly, you may cause a water hammer effect. This effect causes sudden and large pressure waves in the pipework, which may damage the equipment or add unwanted air bubbles. For these reasons, TecQuipment recommend that you ***avoid sudden opening and shutting of the valve.*** The valve is fully open when its handle is in line with its pipework (see Figure 15).

5.5 Using the Manometer Tubes

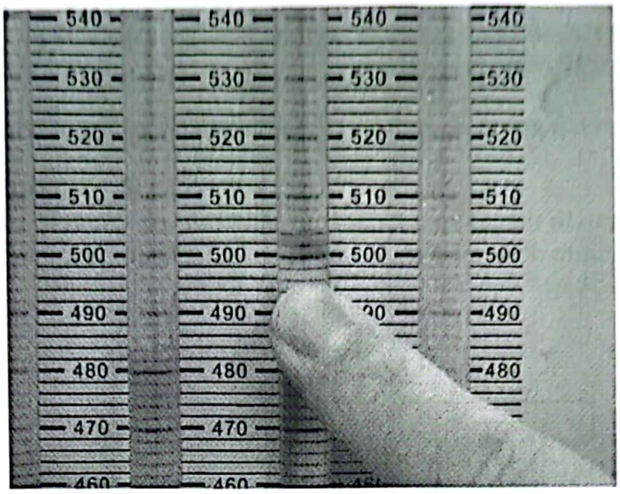

Figure 16 Gently Push the Pipes

Sometimes, it may be difficult to compare the scale with the water level. If you gently push the tube back to the scale, the scale appears more clearly in relation to the water level.

5.6 Experiment Procedure

1. Create a blank results table similar to Table 2.

2. Make sure you have removed any trapped air bubbles from the pipework (See "Removing Air Bubbles" on page 17), and the equipment is level.

3. With the hydraulic bench pump operating and its outlet valve fully open, slowly shut the H34 outlet valve.

4. Connect the hand pump to the H34 manometer manifold air valve. Add air pressure to the manifold to force the water in the tubes down until they show roughly 340 mm (see Figure Figure 17. Check that all tubes show the same value. If not, then check that the equipment is level and look for trapped air.

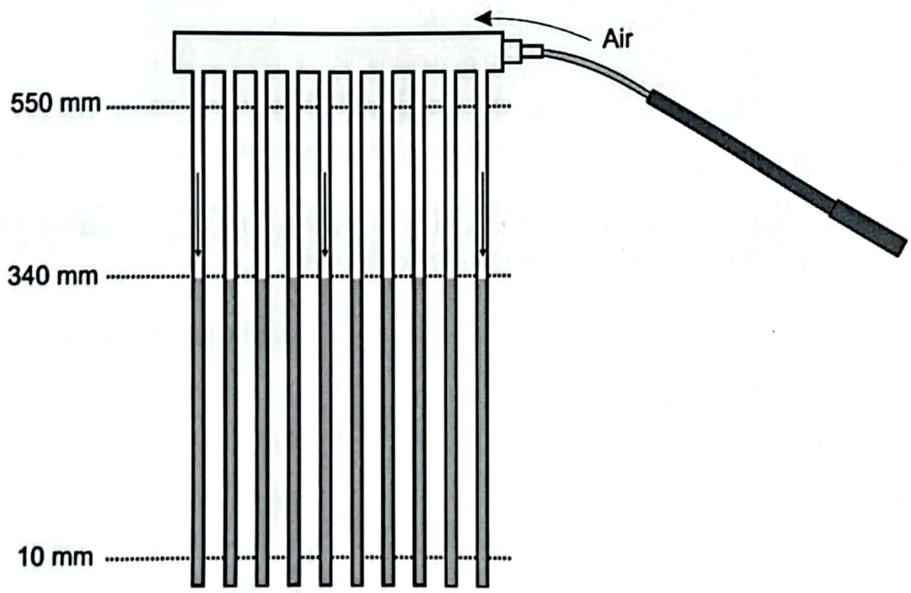

Figure 17 Initial Setup

5. Remove the air pump and slowly open the H34 outlet valve until roughly 3/4 open and tube 1 reaches roughly 550 mm (full scale). Tapping 10 should be around 10 mm - 20 mm (near bottom scale). If necessary, adjust the hydraulic bench flow slightly or add more air pressure to the manifold until tube 1 and tube 10 are both readable on the scale and near its upper and lower limits. This gives a good starting point for the experiments (see Figure 18).

NOTE *Always make adjustments slowly and carefully.*

6. Wait for up to a minute to allow readings to stabilize and check that tubes 6 and 7 show the same value.

7. Check the flow rate using the hydraulic bench (remember to convert weight into volume if you use the gravimetric bench).

8. Record the heights of the water in the tubes. Note that measuring the flow can temporarily affect the pressure from the bench, affecting the heights, so make sure you have finished measuring flow before recording height.

9. Slowly turn the H34 outlet valve to lower the height at tapping 1 by roughly 20 mm and repeat the flow measurement and height measurement.

10. Continue in 20 mm steps of tapping until you have at least eight sets of results or until the valve is almost shut (levels will become flat).

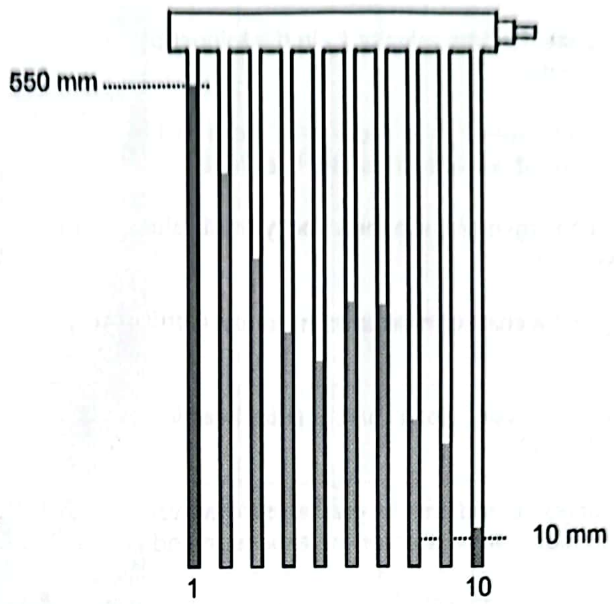

Figure 18 Ready For Experiments

Quantity (litres) or Weight (kg) of Water	Time (seconds)	Flow Rate ($L.s^{-1}$)	Tube Height (mmH_2O)									
			1	2	3	4	5	6	7	8	9	10

Table 2 Blank Results Table

5.7 Results Analysis

1. Copy your results into a second blank table, similar to Table 3, where for example you subtract tube height 2 from tube height 1 to give the head loss across the mitre bend in mmH_2O.

2. For each flow rate, calculate the flow velocity V_1 in the thinner pipe and V_2 in the thicker pipe between the expansion and contraction.

3. Calculate the velocity head values $V_1^2/2g$ and $V_2^2/2g$. Note that if you use velocity in $m.s^{-1}$, the velocity head is in metres, so you must convert to mm for the charts.

4. For the contraction and enlargement, use the velocity head values with the measured head loss (Δh) to find the total head loss (ΔH).

5. For each of the bends, plot a chart of ***measured*** head loss (vertical axis) against velocity head for the smaller bore pipe ($V_1^2/2g$).

6. For the contraction and expansion, plot a chart of ***total*** head loss (vertical axis) against velocity head for the smaller bore pipe ($V_1^2/2g$).

7. Add a best fit line to your results and find the gradients to give value of K. Remember to ignore any excess scatter at the lower and higher flow rates for the expansion and contraction.

8. For the expansion and contraction, calculate the relevant area, diameter or velocity ratio to predict the K value.

Compare your values with those given in the theory. Can you explain any errors or differences?

If you were to design a pipe system for minimal losses, what fittings and methods would you choose?

Give reasons why mitre bends are not often seen on commercial small-bore pipework.

Flow Rate	V_1	$V_1^2/2g$	V_2	$V_2^2/2g$	Measured Head Loss Δh (mm H_2O)					Total Head Loss ΔH (mm H_2O)	
					Mitre	Elbow	Enlargement	Contraction	Bend		
($L.s^{-1}$)	($m.s^{-1}$)	(mm)	($m.s^{-1}$)	(mm)	1 - 2	3 - 4	5 - 6	7 - 8	9 -10	Enlargement	Contraction

Table 3 Results Analysis Table

SECTION 6.0 Typical Results

These results are typical only. Your actual results may differ slightly, due to water conditions such as cleanliness and temperature.

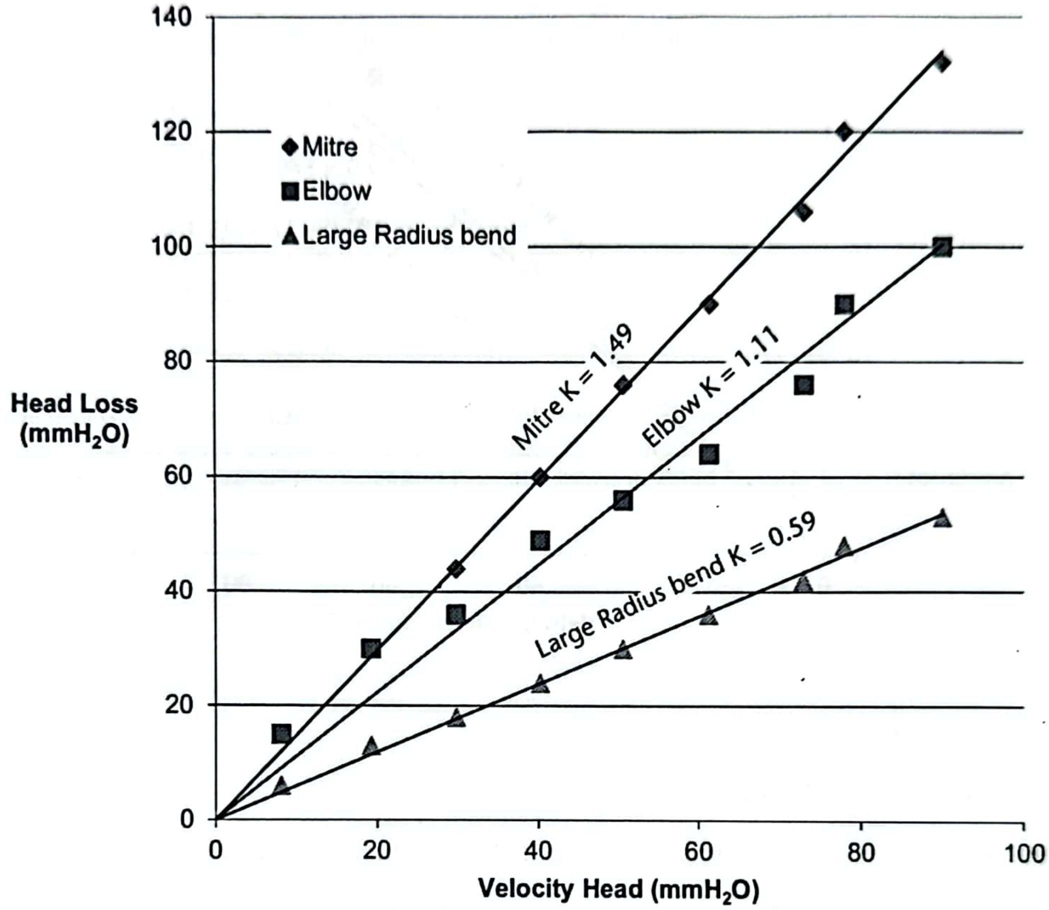

Figure 19 Typical Results

The theoretical losses are based on perfectly smooth pipework and fittings. The pipework and fittings on the H34 are of industrial standard (as in a real application) and not perfectly smooth, so expect losses nearer to the upper range of the theoretical values.

The experiments should show that for best performance, any pipe system should be uniform with smooth internal walls and minimal bends. Where bends are essential, they should have a larger radius.

The results fit well into the theoretical values for the mitre, elbow and bend on the equipment tested, showing smooth pipes.

Typical calculation for the Mitre:

Flow rate = 25 Litres of water in 60 seconds = flow rate of $0.41667\ L.s^{-1} = 0.00041667\ m^3.s^{-1}$

Tapping 1 = 450 mm, tapping 2 = 360 mm. Difference = head loss of 90 mmH_2O

Pipe area $A_1 = 0.00038\ m^2$

Velocity $V_1 = 0.00041667/0.00038 = 1.096\ m.s^{-2}$

Velocity head $V_1^2/2g = 1.2/19.62 = 0.061$ m = 61 mm

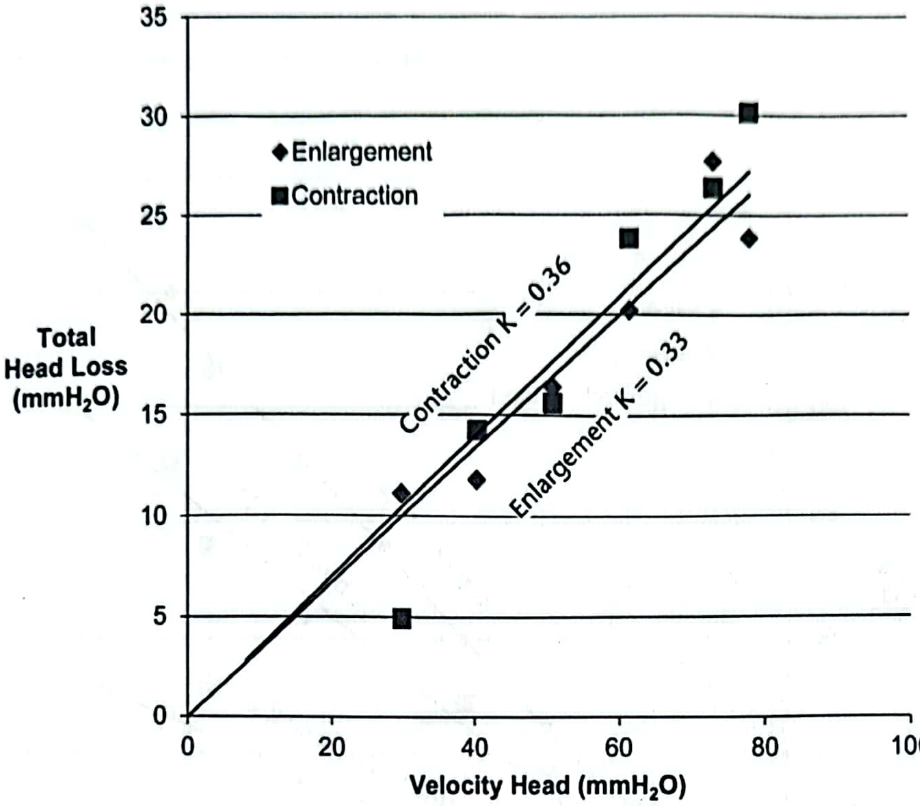

Figure 20 Typical Results

Typical calculation for the enlargement:

Flow rate = 25 Litres of water in 60 seconds = flow rate of 0.41667 $L.s^{-1}$ = 0.00041667 $m^3.s^{-1}$

Tapping 5 = 244 mm, tapping 6 = 263 mm. Difference = head loss of -19 mmH_2O

Pipe areas A_1 = 0.00038 m^2 and A_2 = 0.00063 m^2

K from area ratio = $(1- 38/63)^2$ = 0.16

Velocity V_1 = 0.00041667/0.00038 = 1.096 $m.s^{-1}$

Velocity V_2 = 0.00041667/0.00063 = 0.658 $m.s^{-1}$

Velocity head $V_1^2/2g$ = 1.2/19.62 = 0.061 m = 61 mm

Velocity head $V_2^2/2g$ = 0.433/19.62 = 0.022 m = 22 mm

Total head loss = -19 mm +61 mm -22 mm = 20 mm

The actual results for the enlargement gives a gradient of around 0.33 which is in a similar order of magnitude but slightly higher than that predicted by the area ratio. This suggests a slightly larger head loss than predicted, possibly due to actual pressures and velocities being affected by turbulence throughout the range of flow rate.

Typical calculation for the contraction:

Flow rate = 25 Litres of water in 60 seconds = flow rate of 0.41667 $L.s^{-1}$ = 0.00041667 $m^3.s^{-1}$

Tapping 7 = 263 mm, tapping 8 = 200 mm. Difference = head loss of 63 mmH_2O

Pipe areas A_1 = 0.00038 m^2 and A_2 = 0.00063 m^2

K from area ratio = (38/63) = 0.6, which from Table 1 gives a value of roughly 0.28.

Velocity V_1 = 0.00041667/0.00038 = 1.096 $m.s^{-2}$

Velocity V_2 = 0.00041667/0.00063 = 0.658 $m.s^{-2}$

Velocity head $V_1^2/2g$ = 1.2/19.62 = 0.061 m = 61 mm

Velocity head $V_2^2/2g$ = 0.433/19.62 = 0.022 m = 22 mm

Total head loss = 63 mm +22 mm -61 mm = 24 mm

The actual results for the contraction gives a gradient of around 0.36 which is in a similar order of magnitude but slightly higher than that predicted by the area ratio. This suggests a slightly larger head loss than predicted, possibly due to actual pressures and velocities being affected by turbulence throughout the range of flow rate.

SECTION 7.0 Useful Textbooks

Understanding Hydraulics

by Les Hamill

Second Edition

Published by Palgrave Macmillan

ISBN-10: 0333779061

Mechanics of Fluids

by B.S Massey

Revised by John Ward-Smith

Ninth Edition

Published by CRC Press

ISBN-10: 0415602602

SECTION 8.0 Maintenance, Spare Parts and Customer Care

Drain water from the equipment when not in use. Store the equipment in a dry and dust-free area, suitably covered.

To clean the apparatus, wipe clean with a damp cloth - do not use abrasive cleaners.

Regularly check all fixings and fastenings for tightness, adjust where necessary.

NOTE *Renew faulty or damaged parts with an equivalent item of the same type or rating.*

8.1 Spare Parts

Check the Packing Contents List to see what spare parts we send with the apparatus.

If you need technical help or spares, please contact your local TecQuipment agent, or contact TecQuipment direct.

When you ask for spares, please tell us:

- Your name
- The full name and address of your college, company or institution
- Your email address
- The TecQuipment product name and product reference
- The TecQuipment part number (if you know it)
- The serial number
- The year it was bought (if you know it)

Please give us as much detail as possible about the parts you need and check the details carefully before you contact us.

If the product is out of warranty, TecQuipment will let you know the price of the spare parts.

8.2 Customer Care

We hope you like our products and manuals. If you have any questions, please contact our Customer Care department:

Telephone: +44 115 954 0155

Fax: +44 115 973 1520

Email: **customer.care@tecquipment.com**

For information about all TecQuipment products visit:

www.tecquipment.com

TecQuipment

Air Valves

TecQuipment's
Fluid Mechanics Products
Instruction Sheets

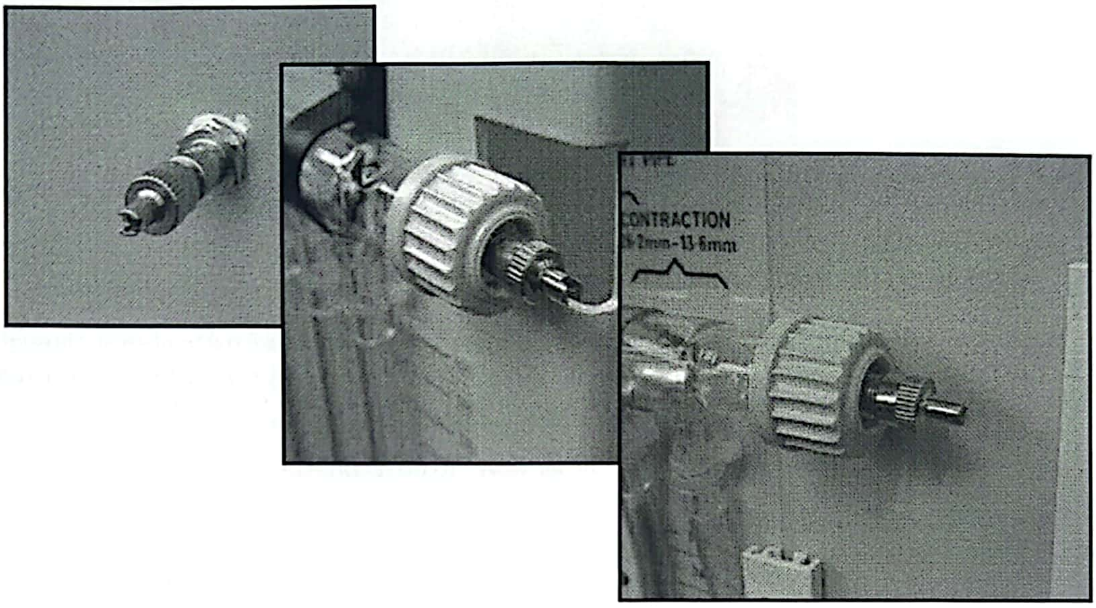

Figure 21 Typical Air Valves on Some of TecQuipment's Products

Many of the products in TecQuipment's Fluid Mechanics range use air valves at the tops of manometers or piezometers. The valves keep the air in the manometer tubes to allow you to offset the pressure range of the manometer or piezometer.

The valves are similar to valves used in vehicle tyres and include a special cap. The hand pump supplied with the equipment is similar to those used for bicycle tyres, except that TecQuipment remove the cross-shape part of the flexible pipe.

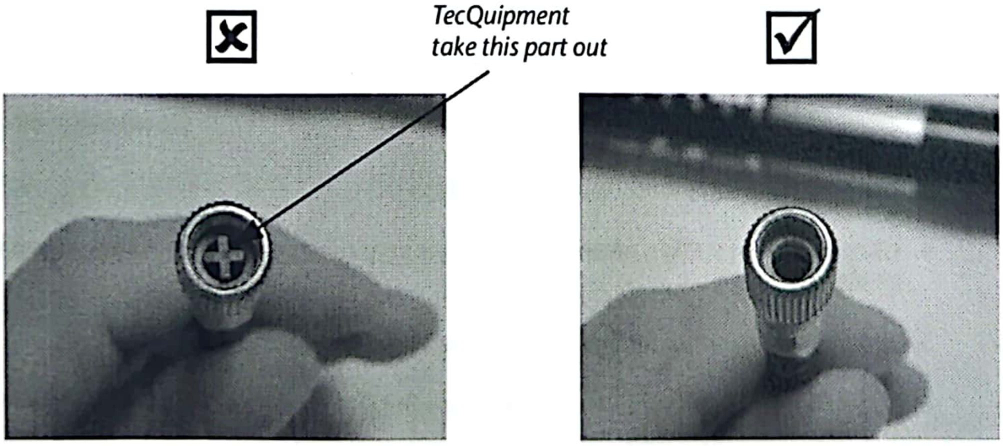

Figure 22 TecQuipment Remove the Cross-shape Part of the Flexible Pipe

Normally, when you connect the flexible pipe to an air valve, the cross-shape piece in the flexible pipe pushes open the valve as you pump air with the hand pump. With TecQuipment fluid mechanics products, this could allow water back out through the valve. For this reason TecQuipment remove the cross-shape piece. Without the cross-shape piece, only pressurised air can go through the valve in one direction, and no water can come back out.

Figure 23 The Hand Pump and Flexible Pipe

When you first use the hand pump with the air valve, you may find it hard to push air through the valve. This is because the valve is new and you do not have the cross-shape piece to help push it open. The valve will open more easily after you have pumped air through it a few times.

You may need some practice to use the air valve. To do it correctly:

1. Unscrew the cap from the valve.

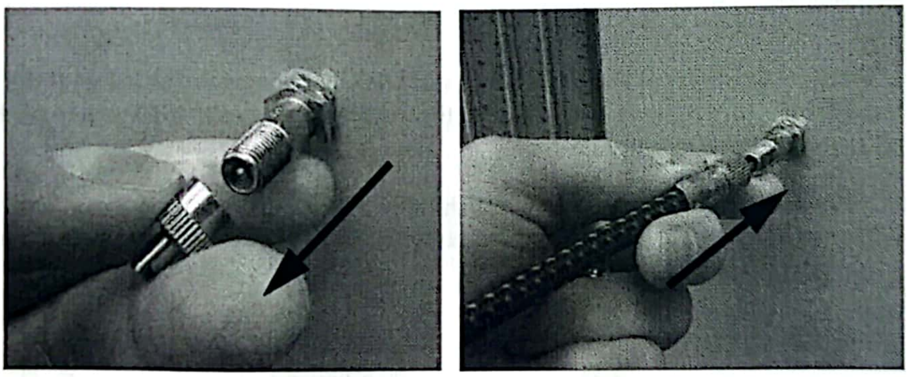

Figure 24 Unscrew the Cap and Fit the Pipe

2. Connect the flexible pipe to the valve.

3. Connect the hand pump to the flexible pipe.

4. Using complete strokes, ***slowly and firmly*** pump the hand pump to force air into the manometer or piezometer.

5. Unscrew the hand pump and flexible pipe and refit the valve cover.

6. To let air back out through the air valve, use the end of the special cap to press on the inner part of the valve (see Figure 25).

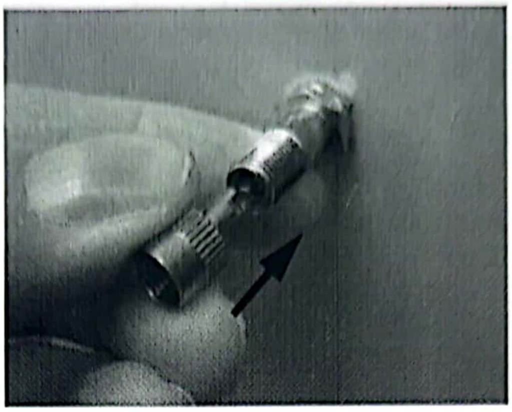

Figure 25 To Let Air Out - Use the End of the Special Cap to Press the Inner Part of the Valve

WARNING ***Take care when you let air back out from the air valve. Water may come out!***

Clean up any water spills immediately.

If using the hand pump is too difficult, the valve may be stuck. If you need to check the valve is working, use the special cap to unscrew the valve, then gently press the end of the valve. It should move easily and return back to its original position (see Figure 26).

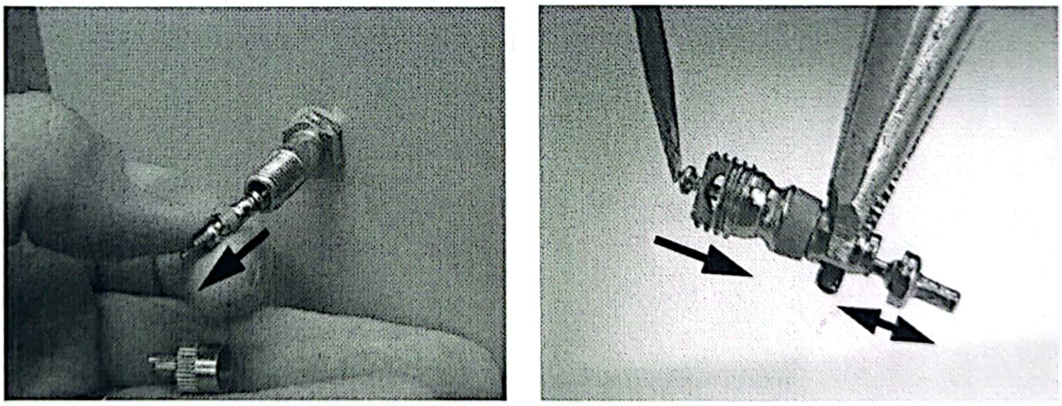

Figure 26 Unscrew the Valve and Check it

If the valve does not move easily, then contact TecQuipment Customer Services for help.

Telephone: +44 115 9722611

Fax: +44 115 973 1520

Email: **customer.care@tecquipment.com**

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