

TITLE: Designing a Butterfly Valve – Fluid Flow Assessment

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We have been discussing fluid flow around an object and through a pipe. This assignment consolidates and builds upon this. A request was issued for investigation into structural and fluid problems with regards to a butterfly valve.

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Reynolds Number (Crane Co., 2013)

Discuss Reynolds number. Why is this important, how does it influence the flow around the butterfly valve and estimate what the Reynolds number is of the fluid flowing around the butterfly valve?

The Reynolds Number is a dimensionless value which helps to determine whether the given flow within a pipe will be laminar or turbulent. It is a ratio of inertial forces to viscous forces. The equation for Reynolds Number is given as $Re = \frac{dvp}{\mu}$. This calculation as shown in the equation is dependant on four factors, the diameter of the pipe, the velocity, the density of the fluid and the viscosity.

In Engineering we typically state that if the Reynolds number is below 2000 the flow is laminar and if it is above 4000 the flow is turbulent. Between these figures the flow is within the critical zone. This critical zone is unpredictable and has both laminar and turbulent regions.

An assembly which contains a butterfly valve is inserted into a pipeline which forms the outlet of a 5m high storage tank that contains petroleum at atmospheric pressure. From the butterfly valve we can see that the pipe diameter is 194mm as shown below.

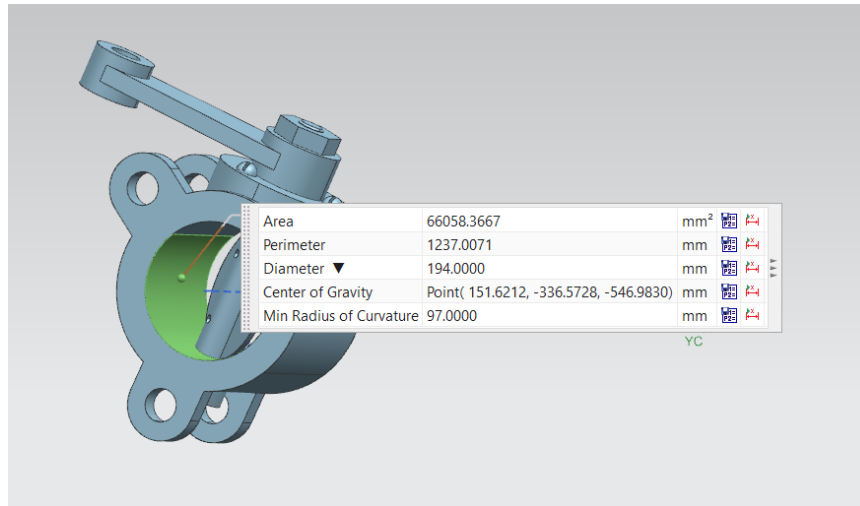


Figure 1: Pipe Diameter

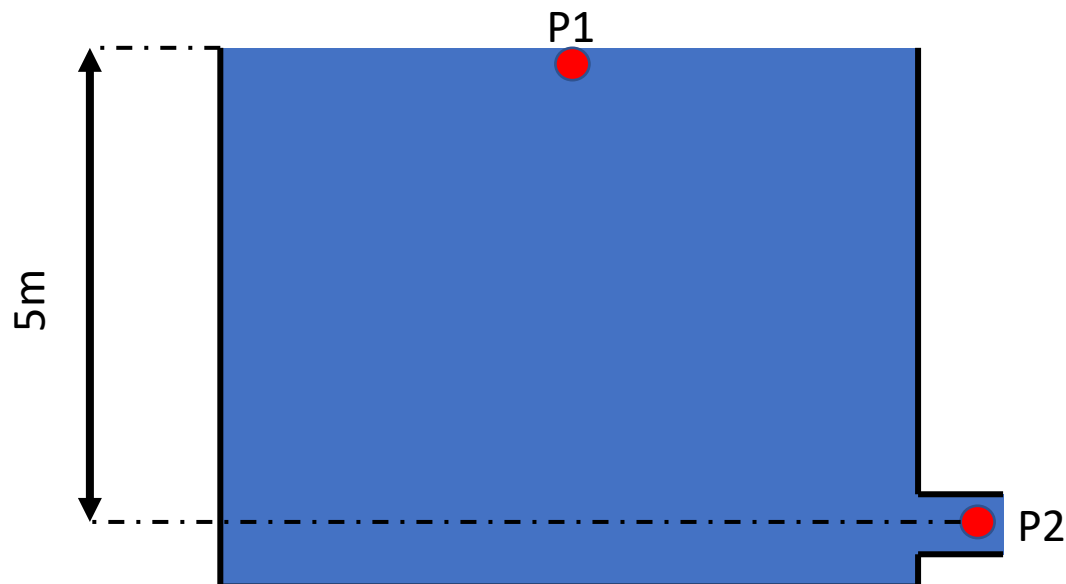


Figure 2: Illustration for Example

Bernoulli's Equation (Crane Co., 2013)

Pressure		Kinetic Energy		Potential Energy		
↓		↓		↓		
P_1	+	$\frac{1}{2}\rho v^2$	+	ρgh	=	Constant

Assumptions

Assuming steady state conditions, Incompressible fluid and negligible friction caused by viscous forces

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho gh_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho gh_2$$

We can assume the pressure at P1 and P2 are both open to atmosphere

$$P_{ATM} + \frac{1}{2}\rho v_1^2 + \rho gh_1 = P_{ATM} + \frac{1}{2}\rho v_2^2 + \rho gh_2$$

$$\frac{1}{2}\rho v_1^2 + \rho gh_1 = \frac{1}{2}\rho v_2^2 + \rho gh_2$$

We can also assume the velocity at v1 is 0 due to the speed the water would decrease in the tank when compared to the outlet.

$$0 + \rho gh_1 = \frac{1}{2}\rho v_2^2 + \rho gh_2$$

$$\rho gh_1 = \frac{1}{2}\rho v_2^2 + \rho gh_2$$

This is the expected outcome for position 1 as all the energy is stored as potential energy. The height at position 2 is 0 and as such the equation is as follows.

$$\rho gh_1 = \frac{1}{2}\rho v_2^2 + 0$$

$$\rho gh_1 = \frac{1}{2}\rho v_2^2$$

This is also the expected outcome for position 2 as all the energy in position 2 is kinetic energy in the form of velocity. Rho now cancels leaving the below.

$$gh_1 = \frac{1}{2}v_2^2$$

This can be rearranged to give the final equation of

$$v_2 = \sqrt{2gh_1}$$

$$v_2 = \sqrt{2 \times 9.81 \times 5}$$

$$v_2 = \sqrt{98.1}$$

$$v_2 = 9.90\text{m/s}$$

The Reynolds Number (Crane Co., 2013)

$$Re = \frac{\text{Inertial Forces}}{\text{Viscous Forces}}$$

$$Re = \frac{ud}{\mu}$$

Where μ is the kinematic viscosity of petroleum (Light/Medium Crude oil estimated)

Assuming Kinematic Viscosity (estimated) = $2.6 \times 10^{-5} \text{ m}^2/\text{s}$

$$Re = \frac{9.9 \times 0.194}{2.6 \times 10^{-5}}$$

$$Re = 73869.23$$

$Re > 2000$ = Turbulent flow

Laminar flow

$$u = \frac{2000 \times \mu}{d}$$

$$v = \frac{2000 \times 2.6 \times 10^{-5}}{0.194}$$

$$v = 0.268 \text{ m/s}$$

The maximum possible velocity that would give laminar flow is 0.268m/s or using $Q=uA$ 7.92L/s

Boundary Layer Flow (CENGEL & GHAJAR, 2011)

Discuss boundary flow around the butterfly valve and relate this to the separation and the turbulence around the valve, particularly the rivets that hold the valve onto the central shaft. Discuss why you think that valve has been designed like this and the cost implications of such a design.

When a fluid flows over a surface, the flowing fluid at the surface comes to a stop. The velocity at this point becomes zero. This phenomenon is known as the no-slip condition and is caused when a fluid gets 'stuck' to a surface due to the viscous effect.

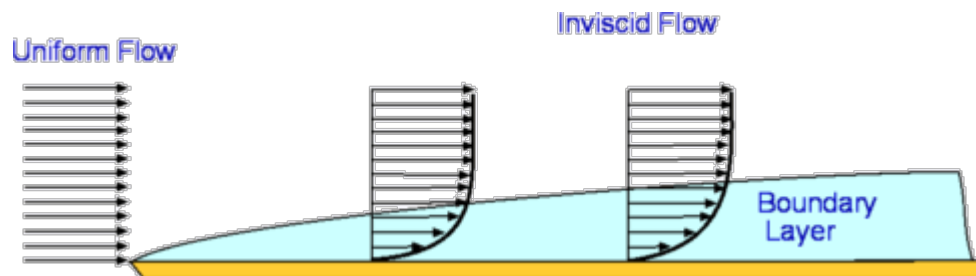


Figure 3: Boundary Layer - Velocity Gradient (Poudel, 2021)

When fluid flows over the fluid at the surface it is slowed due to friction. This acts somewhat like a column of marbles resting atop one another. The movement towards the bottom of the stack is more restricted. As the fluid moves further away from the surface, the friction at the fluid layers decrease and a velocity profile is created.

As fluid flows through a pipe, the fluid layers in contact with the surface become zero. The layers on top of these stopped fluid particles slow down due to the friction.

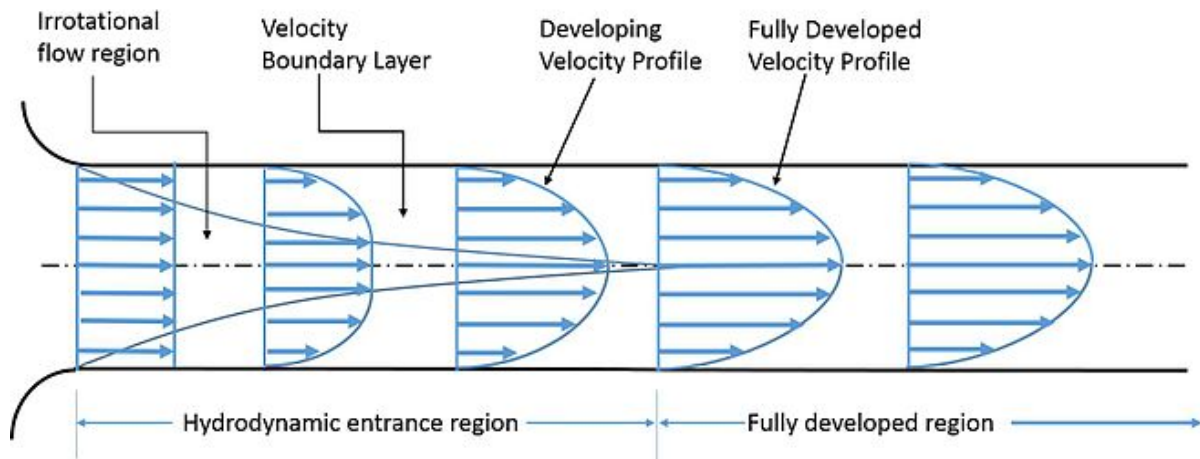


Figure 4 Boundary Layer and Velocity Profile in a pipe (Cengel & Cimbala, 2006)

As the length increases the boundary layer moves towards the centre of the pipe until a fully developed velocity profile is created. To maintain mass flow rate the velocity at the centre of the pipe increases.

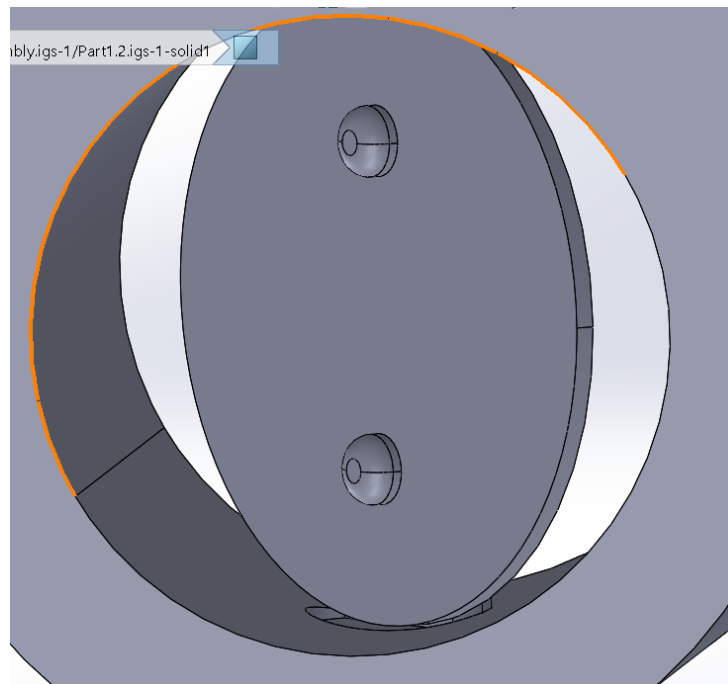


Figure 5 - Butterfly Valve Rivet Close Up

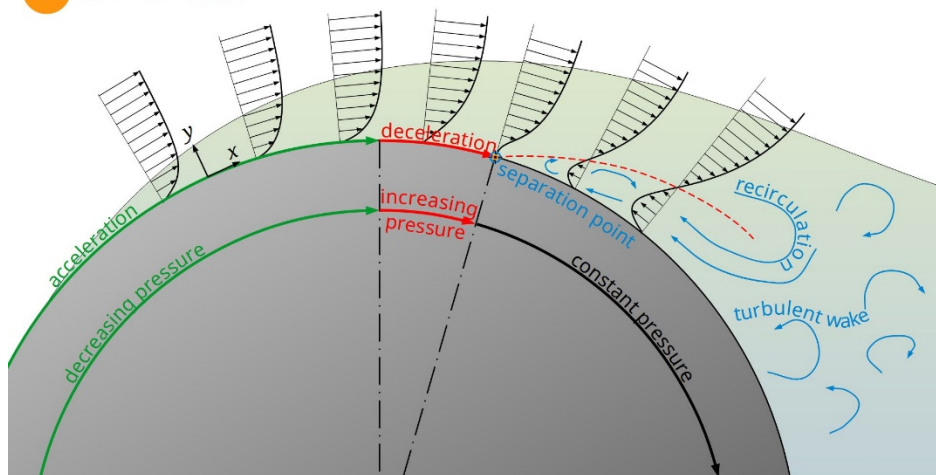


Figure 6 - Boundary Layer Separation (TEC-science , 2021)

As the fluid flows over the first half of the rivets the pressure will decrease as the velocity increases. Due to this increase in the velocity of the fluid, the boundary layer will become thinner. As this surface is rounded, the fluid will remain close to the surface and boundary layer separation will not occur. However, as the fluid begins to flow over the second portion of the rivet, the pressure in the direction of flow increases and the fluid speed decelerates. The fluid outside of this point can now overcome the fluid at the separation point and potentially reverse its direction. This reversal will create more turbulence and losses through the pipework. The rivets are rounded as opposed to using hexagonal bolts to secure the disk to the plate because rough surfaces will affect flow and it is generally good design practise to design surfaces for flow with blends or radius. Although this separation will occur, the losses will be minimal in comparison to the separation around the stem when the valve is fully open.

Butterfly valves are typically a low cost industrial product. Butterfly valves have small footprint, are easy to install and typically have a low pressure drop value when compared to other common designs such as globe valves. The simple design consists of a stem, body, and disk and as such means that there are very little components to go wrong. For small butterfly valves the torque is relatively low however, in larger than DN50 sizes the torque can become an issue. Where this is the case designs often need to incorporate a wheel or actuator to aid the operator in use. A potential issue with this design is the number of bolting holes around the sealing surface. It is likely that leakage would be experienced around the sealing surface with this design, and as such, the number of bolting holes would need to increase. In general, this valve has been designed in this way for the purpose of cost and ease of manufacture.

Implication of Glass fibre reinforced plastic

This butterfly valve is to be manufactured from glass fibre reinforced plastic. Discuss the implications of this in terms of the performance of the valve. Relate this to the historical, current, and future developments of such components. You should include reference to technical literature, industry standards and codes of practice.

Glass fibre reinforced plastics are polymer mixtures which includes strands of glass called fibres. This is the most common method to reinforce or strengthen plastics. Glass filled polymers (GFP) are used extensively throughout industry. The most common method for creating products with GFP is via the use of injection moulding. These parts can also be extruded and machined from bar stock as well as

3D printed. Glass filled products are very common and can be found in a wide range of application from consumer products to industrial products. Some common uses of GFP are within valves, valve seats, pipework, actuators, and enclosures.

For thermoplastic butterfly valves there are two main standards that would require adherence to during design and manufacture. These are ISO 16136:2006 Industrial valves — Butterfly valves of thermoplastics materials and Pressure equipment directive 97/23/EC.

A typical material used for injection moulding plastic valves is Glass Reinforced Polypropylene (GF-PP). This material provides good dimensional stability when moulding, high rigidity, heat resistance, chemical resistance, and strength. It is also easy to process making it ideal for injection moulding.

The benefit of using this material for the manufacture of butterfly valves is the weight and cost savings. As the body is injection moulded it would be consistent and quick to produce.

There are implications of using this material however and these pertain to the temperature rating, UV degradation and tool wear. GF-PP has a typical temperature range of 10 – 80 degrees Celsius. This does not mean the valve is rated at maximum pressure within this range and often a temperature pressure graph will be given for the material, this is often dictated by the material standard.

UV degradation relates to the affect UV light has on polymers. Ultraviolet light is absorbed by the plastic and free radicals are created. The polymer chains begin to breakdown and the material loses strength. This may have some implication on where the valves can be used and if any extra process steps or coating need to be applied to the material to help counteract these inherit issues.

The final problem with glass filled injection moulded parts are due to the increased abrasion. This means that tools should be made from a hardwearing material such as stainless steel. This will increase the initial upfront cost of the product.

When using materials such as plastics it is important to select a suitable factor of safety during design and testing. For pressure vessels typically the FoS (Factor of Safety) accepted within the industry is between 3.5 and 6. This aligns with Crane's general guidance and typically, plastic actuators (pressure vessel) and valves are designed with a FoS of at least 5. Validation of plastic pressure vessels at pressure/size ranges follow PED (Pressure Equipment Directive) standards which require a suitable test method and documentation of test. Attached in the appendices are examples of both burst testing and PED testing of valves and actuators that meet documentation requirements.

Modelling Techniques for fluid flow

Discuss what modelling techniques could be used to simulate the fluid flow through this valve. Discuss the advantages and the disadvantages of the tools highlighted.

When simulating fluid flow through a valve the most common practice is the use of computational fluid dynamics software. Computational fluid dynamics (CFD) is the process of modelling the flow of fluids and using computer software to solve it mathematically. It requires segmenting the model into small points and shapes. Each segment is used to solve partial differential equations. When all segments are combined a solution for the whole problem can be determined. By splitting the mesh into small segments, it removes the complexity and allows the user to create a solution. The problems could be solved by hand but due to the thousands of calculations that would need to be undertaken this would not be practical and prone to errors. Instead, computer software is used to

solve the repetitive equations. This, however, can still take a large amount of time to solve even when using computer software.

The main advantage of CFD is during the design or modification of new products. Often when designing a new product, several designs will be modelled and submitted for CFD analysis. The benefit here is that CFD will give the user a good understanding of which designs are best. To further speed up the acquisition of data, less accurate simulations/mesh are/is used for the large number of designs and as these designs are altered more towards the final product the accuracy of the CFD is increased. This is done for the time saving element. Using CFD saves a huge amount of time and money in the design stage. With physical testing of prototypes requiring design and manufacturing, which can cost a huge amount of money and time especially if multiple prototypes and modifications are made.

CFD often gives a much greater understanding of flow of fluid and issues that may be faced when compared to the traditional physical testing. For a specific problem that is occurring within a valve such as cavitation, CFD is often used to pinpoint what is causing the issue. This may be more difficult to solve using traditional real physical testing.

A Disadvantage of CFD however is that for high accuracy, a large amount of computing power is often required. This can extend the time it takes to solve a model into days and weeks. It is often a requirement for companies to solve large models with the use of supercomputers.

Another disadvantage is that the accuracy of the model largely depends on the mesh and setup etc. and as such the user operating the CFD software require a great deal of knowledge and experience to ensure the accuracy of the modelling solution.

In practice, it is not advisable to use solely CFD modelling as this approximates a physical solution. As such, CFD is used in conjunction with physical testing for the verification of the solution. For the acquisition of data such as flow coefficient (Cv) values it is always advised that these values are determined with physical flow testing.

Physical testing of prototype (British Standards Institution, 2016)

During the development of this component, it is proposed that a prototype is produced and tested in a laboratory to understand the fluid flow through this valve and also to correlate it to the simulation carried out in task 4. Discuss how you think this experiment should be carried out and how the acquisition of data should be obtained and compared to the simulation

With all valves an important step in the design and verification is physical testing to ensure the real word requirements are met. Some valve standards, such as, for the use in fire hydrants require a specified Cv for a particular size of valve. In these cases, it is critical that the valves meet these requirements during physical testing and often require an auditor to validate that the valves conform to the standard.

For physical valve flow testing there are requirements for testing methodologies and methods for data acquisition documented in BS EN 60534-2-3:2016. This standard is comprehensive, and it would not be practical to include all the data within it. This flow testing method allows for the determination of many variables used for equations of flow.

The basics flow system as required in this standard is shown below. (British Standards Institution, 2016)

A basic flow test system is shown in figure 1.

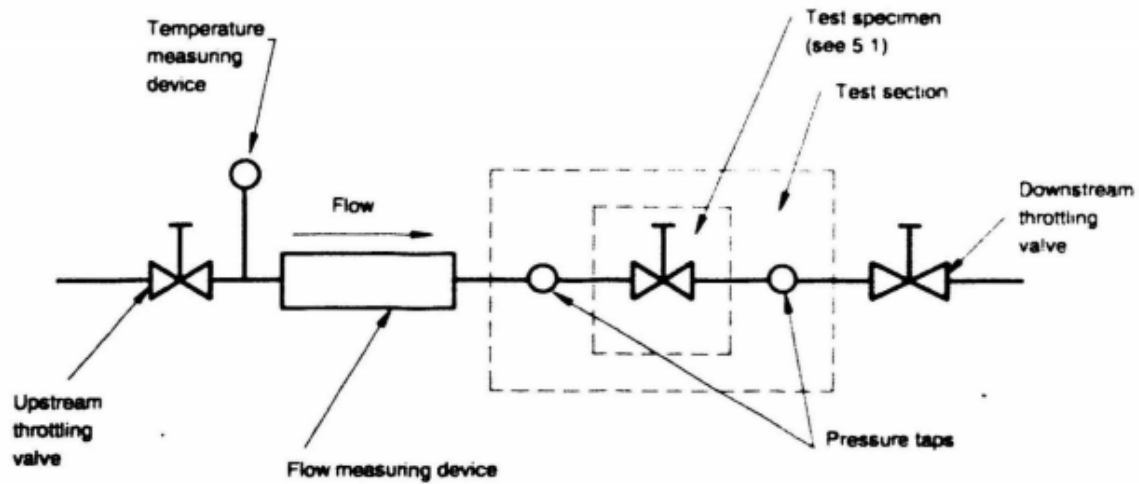


Figure 7 - Basic Flow Test System (British Standards Institution, 2016)

The pipework that is upstream and downstream of the valve being tested are required to be the same size as the connection of the valve tested.

The throttling valves are used to alter and control the pressure differential across the valve and maintain specific pressures. There is specific guidance on: the configuration of the pressure taps in regard to their location, the straight length of pipe before and after the taps, the pressure tap diameter, the pressure tap height and the orientation of the taps within the pipeline (British Standards Institution, 2016)

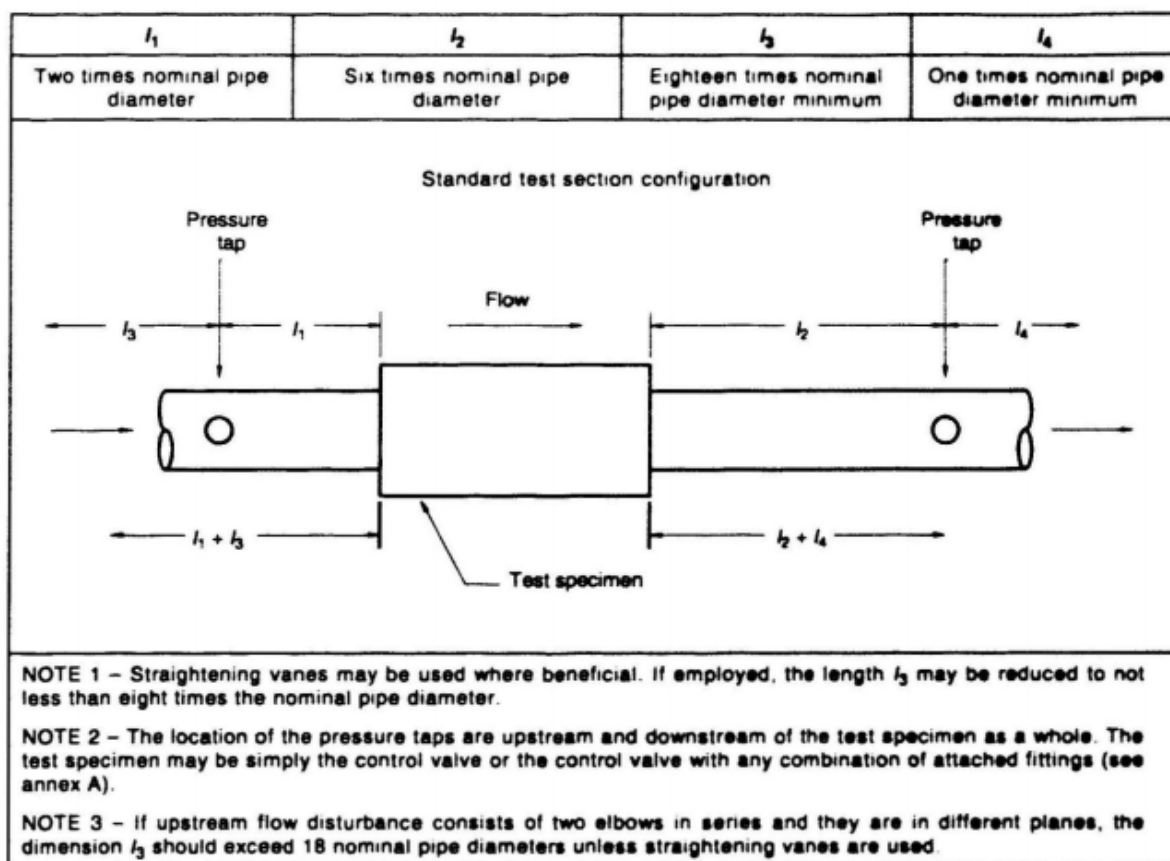


Figure 8 - Standard Test Configuration (British Standards Institution, 2016)

Testing would be carried out with water as the test media, in accordance with the British standard flow capacity test procedures (British Standards Institution, 2016), and our internal Crane flow test procedure found in the appendices.

In accordance with (British Standards Institution, 2016) the following data shall be recorded: Valve travel, inlet pressure, outlet pressure, inlet temperature, volumetric flow rate, barometric pressure, descriptions of the system, fluid and test specimen and deviations from standard.

For the test procedure to test the valve see Appendix 1 – Test procedure (Page 18)

The data is then used to calculate the coefficient of flow as shown in appendix 1 in addition to other calculations as specified in the standard. For accuracy and to ensure consistent and reliable data a minimum of 3 pressure drop measurements shall be taken. The data recorded can be used to compare the accuracy of the CFD modelling assuming the same conditions are used. It is important to note that typically the flow testing is carried out with the valve in various open conditions i.e., 0 – 100% open. This is also carried out when conduction CFD modelling on valves to understand how the positions of the valve affect flow of fluid.

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Appendix 1 – Crane Flow Test Procedure

Section 6

R & D Department Procedures Manual

6.4.6 Procedure for flow testing valves

6.4.6.1 Flow rig

The equipment has been designed and constructed by CPFT personnel and conforms generally to the relevant British Standard for flow testing – BS EN 60534-2.3.

There are 4 main lines or circuits supplied by a common reservoir situated outside the buildings. The reservoir capacity is approximately 20,000 gallons.

10mm Line: This is for small valves and the flow meter installed has a maximum normal flow capacity of approximately 6 US galls/min. It is therefore used mainly for cases when accurate flow characteristics of very small bore valves are required. The line is served by the same pump as the 1" and 3" lines.

1" Line: This accommodates valves from 1/4" to 1 1/4" bore. It is served normally by a medium sized pump of capacity 500 galls/min, but if required a larger pump of 1000 galls/min. capacity can be used.

4" Line: This circuit runs parallel with the smaller circuit and will accommodate valve sizes from 40mm to 80mm bore. It is also served by the same pump system as the smaller lines. Which line is pumped is determined by the isolating valves upstream and downstream of the test valve.

12" Line: This accommodates valves from 100mm to 300mm bore. It is served by up to 4 pumps each of which can deliver 1000 galls/min. If high pumping pressures are required it is possible to use pumps 1 and 2 into the same manifold; this can achieve pressures of 80 to 90 psi.

6.4.6.1.1 Pipe diameters and pipe changing:

In order to test valves, pipework of the same nominal bore of the valve should be used. To accommodate different valve lengths a specially designed telescopic joint is utilised to eliminate the need for a wide variety of special length pipe adaptors.

6.4.6.1.2 Drain pump

The small pump situated in the base of the 12" circuit is a means of draining water from the line on completion of a test and transferring it back to the reservoir. This minimises loss of water from the reservoir and the need for constant topping up.

6.4.6.2 Calculation of flow coefficients

The simplified formula used to calculate the flow coefficient is as follows:-

$$Q = C_v \sqrt{P/S.G.}$$

where

- Q = flow rate in US gallons/min
- Cv = flow coefficient
- P = pressure drop across the valve in psi

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SG = specific gravity of the line fluid. As this is normally water (SG =1) it can be ignored at normal temperatures.

More details regarding these parameters and their calculation can be obtained from the relevant standards.

6.4.6.3 Flow meters and Converters

The flow rate is measured by non-contacting electromagnetic flow meters. For all except the smallest, these consist of a detector head, which is installed in the line upstream of the test valve, connected to a converter. This latter unit provides the power for the detector head, but also conditions and amplifies the electrical signal to produce a 4-20mA output. This output is fed to a gauge on the converter and is also available for provision to other recording devices. By the use of range switches on the front of the converters, it is possible to measure a wide range of flow rates (actually the flow meters measure flow speed in feet per second) accurately. The setting of the dials on the front of the converter gives the value of the full scale flow reading in fps. The small flow meter does not have this facility for rapid range changes and can be regarded as having a fixed flow range.

6.4.6.4 Pressure drop measurement

The pressure drop across the valve is the difference in pressure between the upstream and downstream sides of the valve. To measure this pressure drop accurately, tapings are made into the pipeline at set distances - 2 diameters upstream and 6 diameters downstream, as defined by the Standard. Flexible pipes are then connected to these tapings and two principal methods are used to measure the pressure difference.

The first method is to use a single column mercury manometer. The pressure difference on this is read in inches of mercury, and from this, it is possible to convert to psi in order to calculate the Cv. (It should be remembered, however, that because of the fact that there is water above the mercury column, the conversion to psi must take account of this).

When very, high, pressure drops are encountered (above about 40" Hg) it is not possible to use the manometer but it is possible to use the upstream and downstream pressure gauges to give a reasonably accurate value.

In most cases, however, the manometer is used only as a guide to pressure drop, and accurate measurement, for the purposes of calculation, is made by the differential pressure transducer, which is fitted in parallel with the manometer and gauges. This converts the pressure difference into a 0-20mA signal.

6.4.6.5 Computer data acquisition and recording

To automate and generally speed up the flow testing of valves, a computer is used to measure the important parameters of flow and pressure drop and carry out the necessary calculations. A basic program has been written which effectively leads the operator through the setting up of the required values, takes the readings from the instruments, converts them to the appropriate units, and then calculates the flow coefficients.

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Briefly, the signals from the flow meters and the pressure transducer are converted to voltages (0-5V in the case of the pressure transducer and 1-5V in the case of the flow meters). These voltage signals are then connected, via a terminal panel, to a Strawberry Tree data acquisition board installed into the computer. When the flow program is loaded the computer can read and process the data coming into the board.

6.4.6.6 Control of flow and pressure drop

To calculate the Cv of a valve, it is required that the mean is taken of at least 3 readings at different pressure drops. The pressure drop across the valve (and hence flow rate through it) can be controlled in a number of ways but, principally, by the use of an upstream by-pass valve and a downstream throttling valve. The by-pass valve reduces flow through the valve by diverting a proportion of flow back to the reservoir before it arrives at the flow meter. Obviously opening this valve decreases the upstream pressure and hence pressure drop.

The throttling valve is situated downstream of the test valve. By closing this valve the flow is decreased and the downstream pressure is increased, so pressure drop across the valve is increased.

In a nutshell, opening the by-pass valve reduces flow and pressure drop; opening the throttling valve increases flow and pressure drop. It is usual, when carrying out flow tests, to use both valves to achieve the required values.

6.4.6.7 Test procedure

1. Select the appropriate flow test line and pipework size.
2. Assemble pipework ensuring the correct positioning of the pressure tapplings, i.e. 2 pipe diameters upstream and 6 pipe diameters downstream. Also, if possible, the tapplings should be positioned horizontally.
In the case of the 12" line the 3 necessary pipe sections have been stamped A, B and C on the flange ends in order to aid assembly for optimum alignment.
3. Assemble test valve, either to the BSTD flanges provided, or for screwed valves, directly to the pipe ends.
4. Secure the nylon pressure tapplings. Care should be taken to ensure that the upstream and downstream tapplings are connected the right way round.
5. Open pump isolating valve(s).
6. Open test line isolating valves and start the pump(s).
7. Close the downstream and upstream isolating valves and switch off the pump. This leaves the test section full of water.
8. Switch on the relevant flow meter and converter and allow to warm up for 10 minutes. (NOTE: flow meters should not be switched on when the line is empty).
9. Switch on the computer and load the Flow program. Run the program to check that the readings of pressure drop and flow are zero. If they are not then, in the case of the pressure transducer, run the calibration program. In the case of the flow meter, check the zero on the converter.
10. Switch on the pump(s).
11. Open the upstream and downstream valves.
12. Open the relevant valves in the pressure circuit to connect the pressure tapplings to the manometer/pressure transducer.

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13. Bleed the manometer using the manometer isolating valves. i.e. bleed each tube separately. Take care not to let the mercury rise above the top or below the bottom of the column as this will result in contamination of the system and loss of mercury in the mercury reservoir.

14. Carefully close the manometer equalising valve.

15. Choose a converter setting that gives a reasonably high reading on the converter gauge: between 12 and 16 mA is best. Do not go any higher.

16. Ensure that the blue switch box is set at the correct number, i.e. 1 for the .375" flowmeter, 2 for the 1", 3 for the 4" and 4 for the 12".

17. Run the computer program and enter data as required.

18. Check that the manometer readings agree with those shown on the screen.

19. By manipulating the by-pass and throttling valves, a minimum of three readings should be taken at each test valve setting.

For A type valves readings should be taken at pressure drops of approximately 16, 11 and 7 inches of mercury.

For KB type valves, readings should be taken at pressure drops of 11, 8 and 5 inches of mercury.

If these figures cannot be achieved then pressure drops as near as possible should be used. Do not use very low pressure drops (say, less than 3 inches of mercury, because the accuracy is not adequate at these levels).

20. If the complete valve characteristic is required then repeat for 5%, 10% or 20% open intervals as required. To finish, re-test at 100% open. If a plotted curve is required then use the "techni-curve" program installed on the flow computer.

21. When testing is completed: -

- a) open manometer equalisation valve.
- b) close upstream and downstream valves and by-pass valves.
- c) switch off pump(s)
- d) close manometer upstream and downstream valves.
- e) switch off flowmeter
- f) open drain valve
- g) switch off computer

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Section 6
R & D Department Procedures Manual
PHOTOGRAPHS
Photograph 1 - General layout view 1 (exhibit 6.3)

Item No.	1	Telescopic joint
	2	1" line pressure control valve
	3	"Start up" switches
	4	12" by-pass valve
	5	4" by-pass valve
	6	Tank return flow line

Photograph 2 - General layout view 2 (exhibit 6.4)

Item	1	Test valves
	2	Inlet isolation valve
	3	Pressure tapings
	4	Flow line 4" - 12"
	5	Flow line 1.25" - 4"
	6	Flow line 0.5" - 1"
	7	Flow line 8 – 10mm

Photograph 3 - Test control valves (exhibit 6.5)

Item	1	1" line pressure control valve
	2	4" line pressure control valve
	3	1" and 4" by-pass valve
	4	Manometer

Photograph 4 - Flow meters (exhibit 6.6)

Item	1	10mm line flow meter
	2	1" line flow meter
	3	4" line flow meter

Photograph 5 - Supply flow pumps (exhibit 6.7)

Item	1	Pumps 1 to 5
	2	Butterfly valve - isolate
	3	Supply from tank isolation valve

Photograph 6 – Test panel (exhibit 6.8)

Item	1	% Flow meter
	2	Flow converter

Photograph 7 - Schematic flow rig layout (exhibit 6.9)

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Exhibit 6.3 - Photograph 1: General layout of flow rig - view 1

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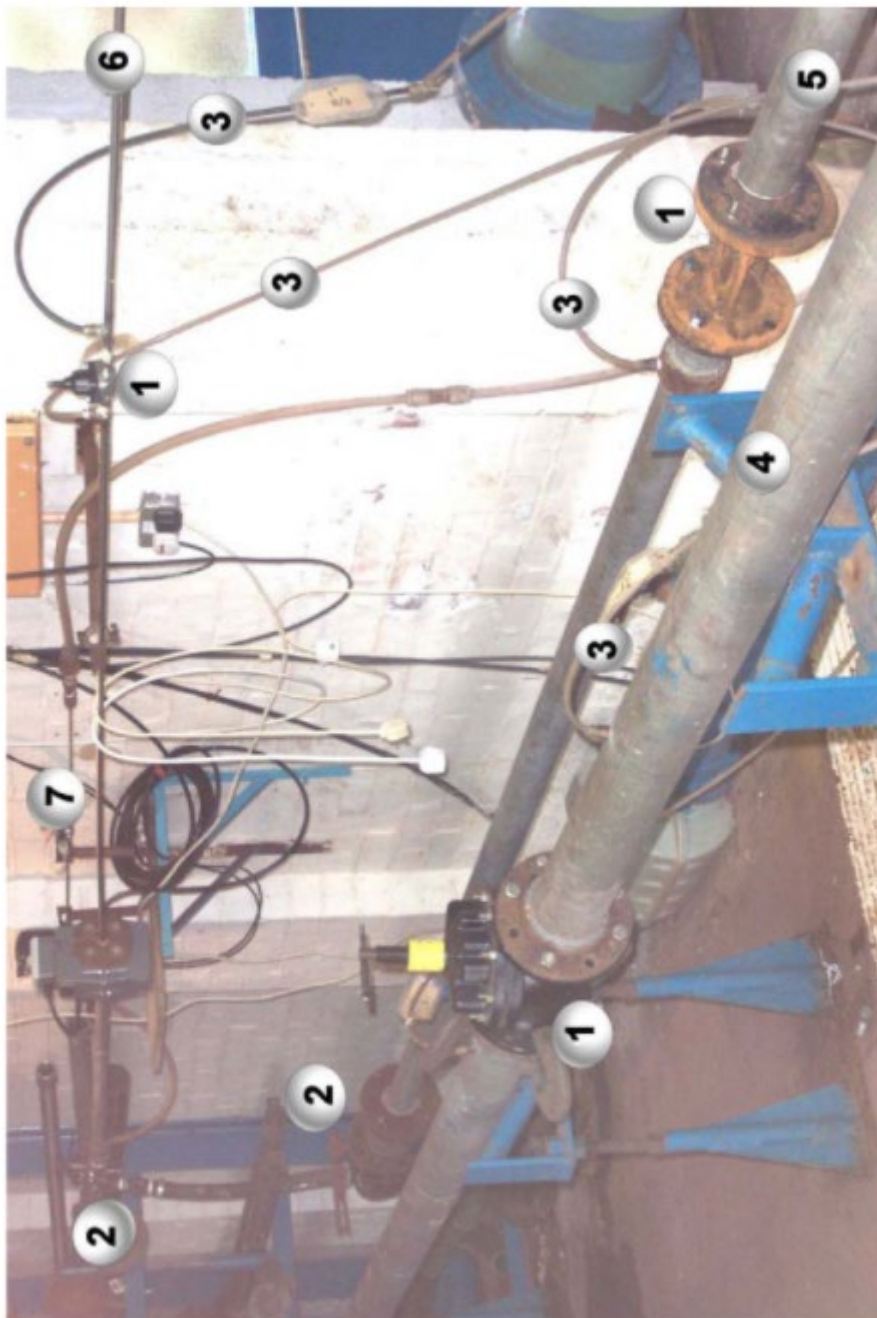


Exhibit 6.4 - Photograph 2: General layout of flow rig - view 2

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Exhibit 6.5 - Photograph 3: test control valves

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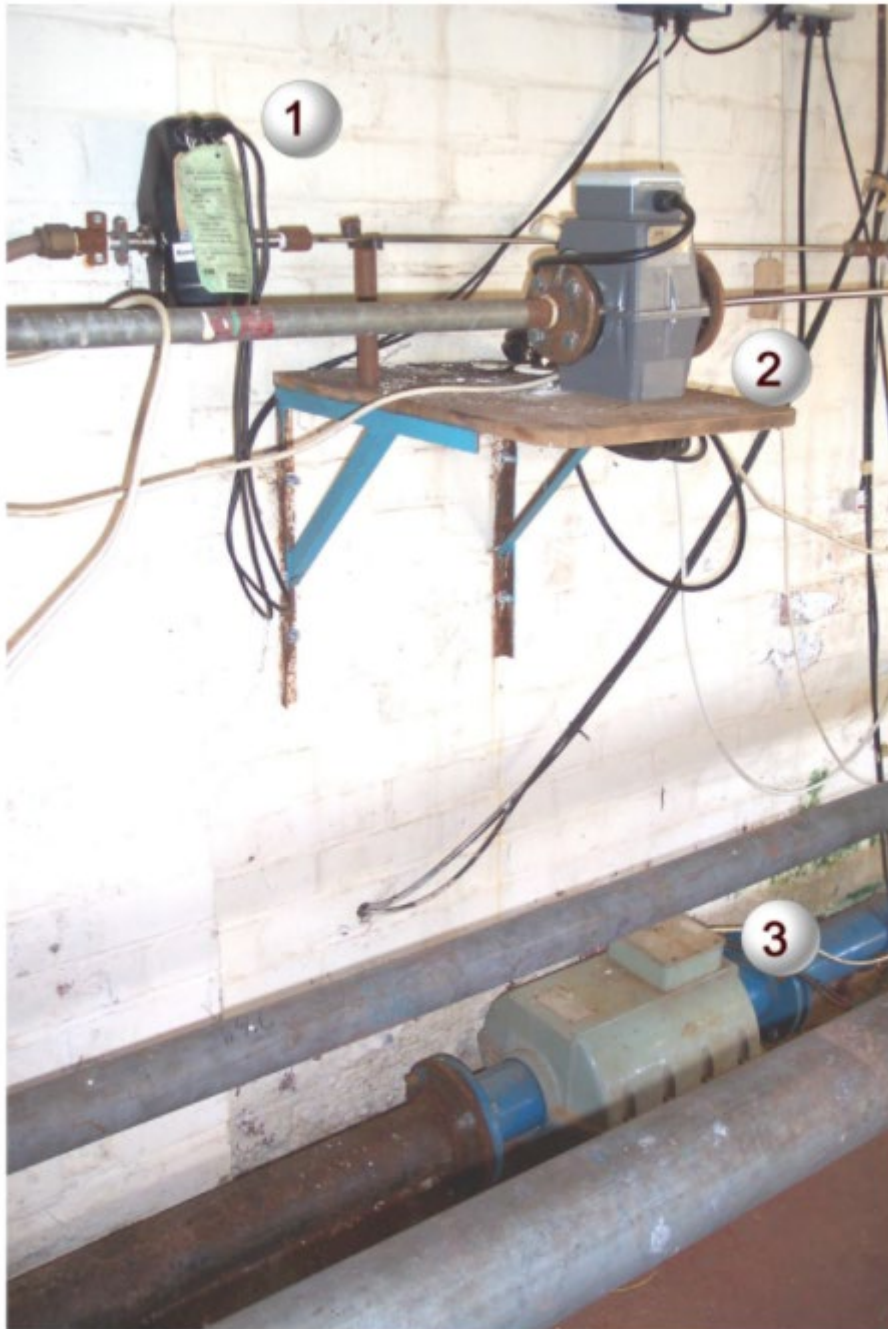


Exhibit 6.6 - Photograph 4: flow meters

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Exhibit 6.7 - Photograph 5: supply flow pumps

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Section 6

R & D Department Procedures Manual



Exhibit 6.8 - Photograph 6: test panel

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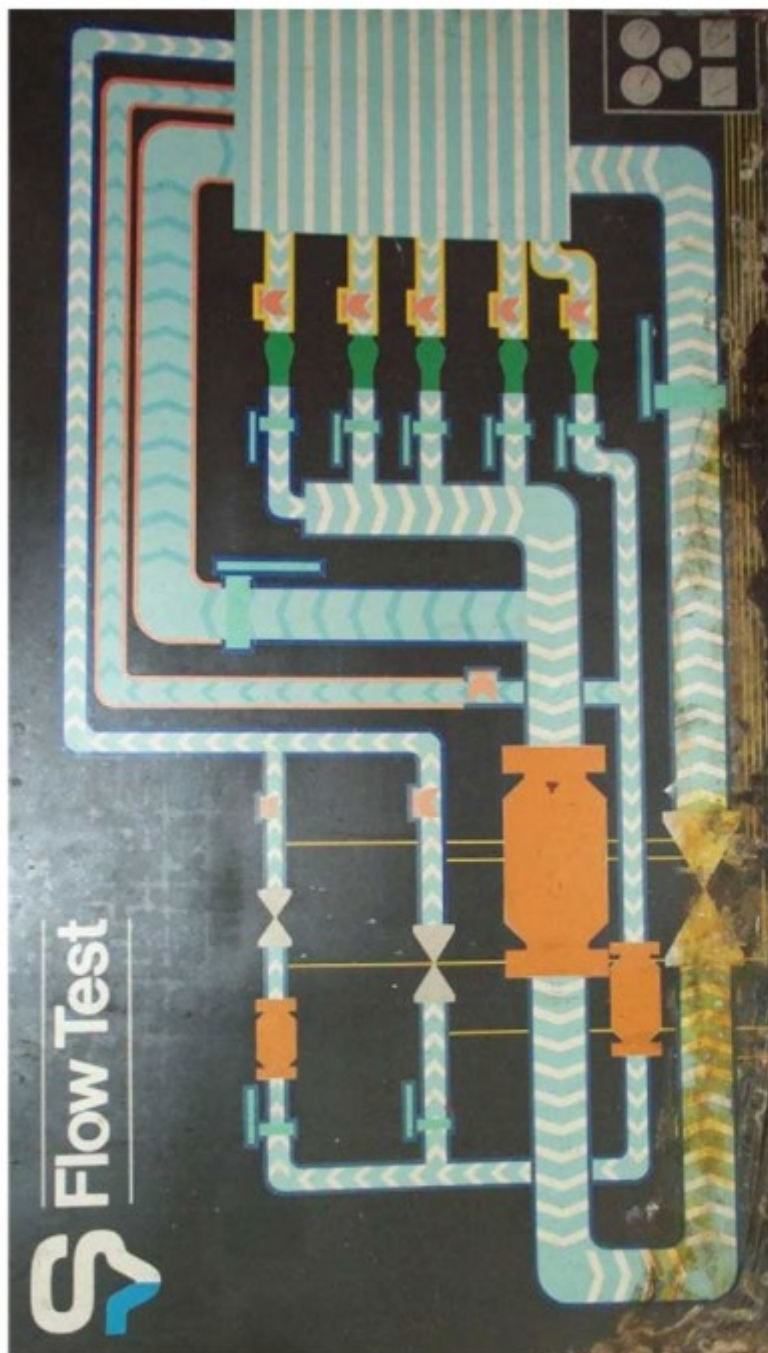


Exhibit 6.9 - Photograph 7: schematic layout

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Appendix 2 – Burst Test Example

CRANE							
CRANE ChemPharma Flow Solutions							
EC Bonnet Hydraulic Shell Test							
Report No.	QBS	9020					
Date of Submission		7/2/2021					
Bonnet Size (DN)		40					
Product Code		A-040 M&N8737					
Material Batch No.		62191567F					
Material Batch No. Changed from last		No					
MFI & Ash Test Required		No					
Sample Size Tested		2					
Identification No's.		2	17				
Test Procedure: As specified in the Testing Manual							
Identification No.	Failure Pressure (bar)	Mode of Failure					
2	53	Failed around base of bonnet thread					
17	53	Failed around base of bonnet thread					
Average	53						
Minimum Permissible Failure Pressure		30					
Burst Pressure Test Result	PASS						
Minimum Permissible Failure Pressures							
Actuator Size (DN)	8	10	15	20	25	40	50
Failure Pressure (bar)	40	50	50	40	40	30	30
Comments							
Air leakage from inlet port boss	No						
Quantity of base inserts wasted							
Additional comments							
Date Clock	MM			YY			
	6			2021			
Date Clock Correct	Yes						
Overall Result	BATCH PASSED						
Tested By	A. Hobbs						
Date of Test	7/20/2021						
Research & Development Department				Development Laboratories			
SF111 "b"							

Appendix 3 – PED Example

BS EN12516-3:2002									
VALVES – SHELL DESIGN STRENGTH – PART 3: EXPERIMENTAL METHOD – TEST REPORT									
Valve Size	DN100	Valve P/T Rating	10						
Manufacturers Name	CRANE Process Flow Technologies Ltd. Saunders								
Product Identification	19K2010	Diaphragm Grade	425						
Body Details									
Drawing Number	9489C 009489	Rev	L V	Material Grade	Grey Cast Iron (BS EN 1561 grade: 5.1301)				
Drawing Thickness * Location 1	15.375	Measured Thickness	Location 1	15.5	X1	1.008130081			
Location 2	7.4375		Location 2	10	X2	1.344537815			
Location 3	7.4375		Location 3	10	X3	1.344537815			
Location 4			Location 4		X4				
X Factor Body	1.34453782	Note: Highest Value of X1, X2, X3 etc. to be used							
Specified Material Property	250 Rm	Actual Material Property (Certified)	289.85	Y	1.1594				
C Factor	3.5	K Body = C body · X body max · Y body			5.456				
Cover / Bonnet Details									
Drawing Number	120029 120029C	Rev	D G	Material Grade	Grey Cast Iron (BS EN 1561 grade: 5.1301)				
Drawing Thickness * Location 1	16.5	Measured Thickness	Location 1	17.5	X1	1.060606061			
Location 2	7.5		Location 2	9.3	X2	1.24			
Location 3			Location 3		X3				
Location 4			Location 4		X4				
X Factor Cover / Bonnet	1.24	Note: Highest Value of X1, X2, X3 etc. to be used							
Specified Material Property	250 Rm	Actual Material Property (Certified)	260	Y	1.04				
C Factor	3.5	K cover/bonnet = C cover/bonnet · X cover/bonnet max · Y cover/bonnet			4.5136				
Test Pressure									
PS	10	K max	5.456	PT = K max · PS	54.56				
Test Result (Delete as appropriate)	Pass	Test Date	05/05/2021	Testers Signatur	A.Hobbs				
Observations:									
Tested to 55 bar No visible damage observed.									
Test Sheet 19K2010 - Body Cert 9489CAST 009489 120029 120029C									