

STUDENT FEEDBACK FORM

Student: Tomas Griffiths

Assessment: Pneumatics and Hydraulics 1

Course: HNC Instrumentation Engineering

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills		
Engagement with a wide range of literature, including sources retrieved independently. Selection of relevant and credible sources. No referencing system applied.	30	17
2. Knowledge and Understanding Skills		
Competent knowledge of the basic underlying concepts and principles of fluid power systems. Exhibits very good understanding in most research areas. Good use of sectional component images and symbols. Used figures are referred to in the writing. Calculations are mostly correct and a good level of understanding is demonstrated.	60	42
3. Cognitive and Intellectual Skills	0	
4. Practical Application Skills	0	
5. Transferable Skills for Life and Professional Practice		
Work is accurate, coherent, fluent, well-structured and organised. Work is relevantly linked to current employment. Report presentation is an area for improvement.	10	6.5

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)

Late Submission Penalties (tick if appropriate)

Up to 1 week late (40% Max)

Over 1 week late (0%)

65.5 %

Tomas Griffiths Assignment

by Tomas Griffiths

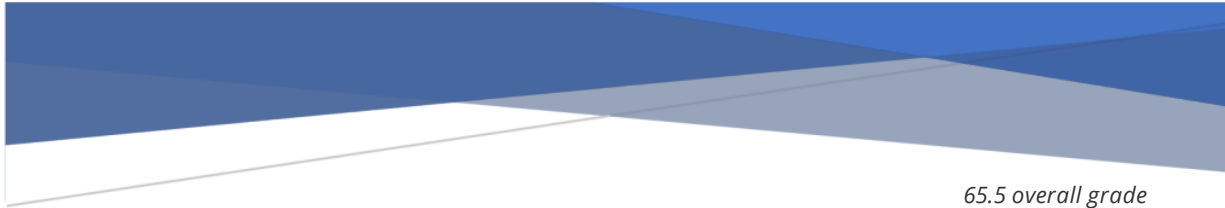
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Word count: 3079

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65.5 overall grade

PNEUMATICS & HYDRAULICS DEVICES AND CALCULATIONS

HNC Instrumentation Engineering

Pneumatics and Hydraulics

PCEE4010

Tomas Griffiths

□ Professional cover page for a technical report

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Include any conditioning of the air that might be required for a process of your choice.	4
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□ Content

Introduction

This assignment will provide an introduction to some key aspects of pneumatic and hydraulic systems and how they compare to each other. The assignment will cover power sources, pressure regulation, pressure drops, forces and gas laws.

□

Task 1 – Prime Movers and Conditioning

Task 1

1 - Discuss the operating principles of hydraulic and pneumatic systems.

Comment on the following as a minimum:

- Distinctions in operation and design.
- Performance variations.
- Industry applications.
- Health, safety and environmental factors.

There are many comparisons between hydraulic and pneumatic systems. A hydraulic system uses pressurised liquid as the driving force whereas pneumatic systems use air. Both systems need to have clean liquid and air as this can affect the performance of both systems. Different types of filters are commonly used within these systems to filter out any dirt particles or any other contaminants within the hydraulic system. For a pneumatic system the air needs to be clean dry air with no oil, only certain instances will the air have oil. This is used for lubrication for certain equipment. □

Hydraulic systems use pumps to achieve high pressure whereas a compressor is used in pneumatic systems. Hydraulic system working pressure will typically be around 700bar whereas a pneumatic system will run between 5-10bar, hydraulic systems will have a higher driving force than a pneumatic system for applications such as valves and equipment that use rams. For an example hydraulic control valves typically have a better level of control than that compared to pneumatic control valves. The downside to this however is that the hydraulic valve would typically need its own local facility or “skid” which means that it is only available in that set area of the plant, whereas pneumatic equipment can use the same air supply from the plant pneumatic air header. Both of these systems can be stored for later use, hydraulic fluid can be stored in accumulators and pneumatic air can be stored within air receivers or reservoirs. The need for storing these at pressure maybe due to the fact that some safety systems need to have a backup supply to carry out an action to make it safe, say if say a plant loses air, then a valve may need a boost of air pressure to close it to make the plant safe during an unplanned shutdown of the equipment/plant. An advantage to pneumatic systems over a hydraulic one is that air is nearly always available in large quantities which means it can meet demands and there won’t be a shortage of it. Common industry applications that use hydraulics are used are hydraulic jacks used for lifting tanks, slide valves used for refinery process control, machinery that uses hydraulic rams and cylinders such as diggers and cranes. □

Industry applications that use pneumatics include control valves at various plants such as the petrochemical, food and pharmaceutical industries, pneumatic torque wrenches and grit blast equipment. The health and safety risks to a hydraulic system is that it use hydraulic oil which if a leak occurs could damage the surrounding environment and could make personnel unwell if ingested or hurt from a pinhole leak within a hydraulic line. Slow-release leaks will also make the system slow down which would affect the equipment’s performance and efficiency, a leak within a pneumatic system don’t really have much effect, however it would be very noisy that could cause hearing □

damage to personnel in the area. Hydraulic oil is also flammable at certain temperatures which makes it a fire risk if it got out of containment and caught an ignition source. □

2 - Discuss the methods that can be used to compress air for a pneumatic system.

Include any conditioning of the air that might be required for a process of your choice.

There are many parts to compressing air for a pneumatic system but generally they consist of filters, compressors, dryers, receiver's, pipework, and instrumentation. The air is also required to be free from particles such as dust and other air born pollutants. Inlet air filters are used to decontaminate and help remove the atmospheric air of dust and debris. The location of the inlet air filters is also important as you should try to prevent contaminants, hazardous and flammable gases from being drawn into the Inlet air filters. The next stage to compressing air for a pneumatic system is the compressor stage. For example at Pembroke refinery there are two screw compressors that are fed by an inlet air filter, which use two compressors, these are compressor (A) which is driven by a steam turbine whilst compressor (B) by an electric motor which is used as the standby compressor, in case of the unlikely event of an electrical power trip or outage. Both of these compressors are fitted with blow off valves for pressure control. Once the air has left the compressor it then enters a silencer to dampen the sound. There are also four main types of compressors. These are reciprocating which include single-acting and double-acting compressors. Reciprocating compressors use a piston to compress air and store it. Single stage compressors use one piston whilst two stage compressors use two pistons, usually to obtain higher pressures. Rotary which include screw compressors used for the instrument air at Pembroke refinery that have rotors which include six female flutes and four male lobes that mesh towards each other compressing and storing the air. Vane type compressors have high speed rotating impellers which are directed towards a diffuser which converts the velocity of the air into pressure. Other types of compressors include centrifugal and axial compressors. After-Coolers are installed after the compressor to cool the hot air from the compressor discharge. After-coolers are typically fitted with a water trap to remove any water that may have been carried over in the compression process. Most water traps are usually of an automated type which will drain once a certain water level has been detected. Dryers are the next stage of a pneumatic system. Dryers are a moisture separator used to remove any condensates from the compressed air. Dryers are a crucial part of any pneumatic air system as some equipment won't run with condensation within the air. Wet pneumatic air is pre-filtered to remove bulk liquid, oil and water. Pre-filtered pneumatic air is then typically passed through air driers which could be dried by means of two blower motors. As the dried air exits the dryers the air will then commonly pass through another set of filters before heading off to the plant. The next stage of a pneumatic system is the air receiver section. An air receiver stores the compressed air from the compressors. Air receivers commonly have a sight glass on them so that the liquid level can be seen within the receiver. There will then be a system of valves to allow manual draining of the vessel. Air receivers are usually protected by means of a PSV, which is designed to lift at a designated pressure. The lift off pressure will be higher than that of the pneumatic air header pressure so that the PSV will not lift when the receiver gets up to pressure. Air receivers act as large storage containers for the pneumatic air in the event of a loss of power to the compressors. They are sized as to give the plant enough air to be able to shut down safely with the minimum required head pressure. □

3 - Discuss the construction and operation of two types of positive displacement pump used in hydraulics.

A Gear pump is a type of positive displacement pump that contains two or more gears to create vacuum force within the pump housing to drive the fluid within the pump. This fluid becomes trapped within the outer teeth of the gears transferring it from the suction of the pump to the discharge. Gear pumps come in two design types, these are external and internal gear pumps. External gear pump gears are positioned side by side to each other with the master gear attached to a drive shaft and drive shaft key being driven by a motor and the other gear as the slave gear. Internal gear pumps have the smaller gear or master gear which is placed within the larger slave gear. Gear pumps are rated for high pressures, are easy to maintain and have option for pumping viscous liquids, hence why they are very popular for hydraulic systems. Gear pumps however are only around 90% efficient which is not the best, this is due to the fact that these pumps suffer from cavitation and erosion from dirty liquids and air within the liquid being pumped. This can be avoided however by putting filters before the suction of the pump and maintaining a good fluid level within the pipelines. Due to the cavitation and erosion that gear pumps are susceptible too, the internal gears have side wear plates which are manufactured to be deliberately replaceable.

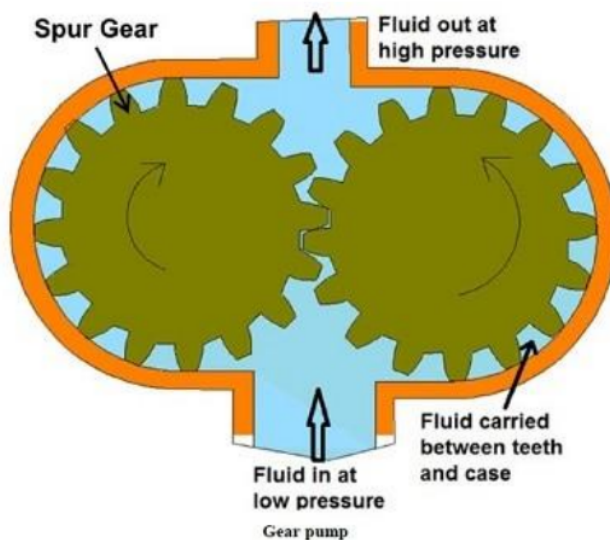


Figure 1 - Shows the Working Principle of an External Gear Pump

An Axial-Piston pump is commonly used in hydraulics due to their efficiency and capability of handling a wide range of pressures as well as being able to handle viscous fluids. The typical components of an axial-piston pump are the pistons which essentially transfer the fluid into and out of the pump and are the drivers of the fluid, the rotating barrel, which is the dynamic part of the pump, where the pistons are inserted into their specific slots so that when the barrel rotates, the pistons within do, displacing the liquid within the pump. The swash plate which is fixed to the driveshaft (the part attached to a motor and swash plate which drives the pump) is the interface for the external system and pistons. The swash plate is what the rotating barrel and pistons are attached to, as the swash plate rotates, the angle of the plate changes and the pistons draw liquid

through the suction side and then pump the fluid out of the pump and pull back down into the barrel once the fluid has been discharged. The port plate is the separating medium between the input port and output, where the fluid gets sent. Axial-Piston pumps have multiple pistons within a cylinder block that are parallel to one another which move in the same direction as the central drive shaft.

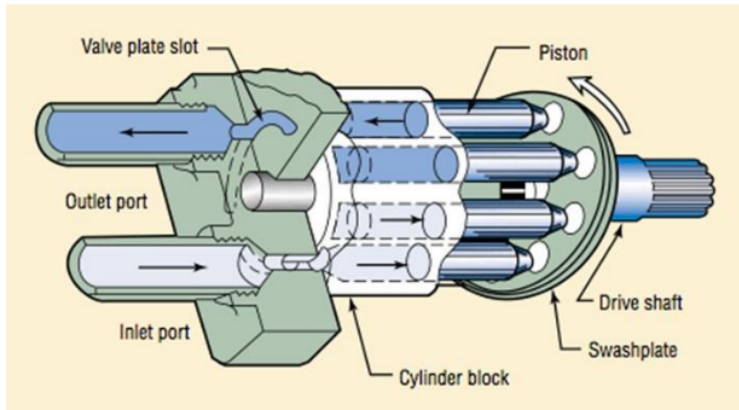


Figure 2 - Shows an Axial-Piston Pump

4 - Discuss the methods and construction of devices that can be used to control the pressure within a pneumatic system and a hydraulic system.

For a pneumatic system, air pressure regulators are very simple equipment that are used to lower the main air pressure supply from the plant to a pressure which is suitable for the air operated equipment. Most pneumatic equipment require clean, dry air, with no moisture content in the air. Filters are commonly used within the pressure regulator which can also be called an air filter regulator. Figure 3 shows a filter regulator. Filter regulators are used to ensure water and particulate removal and accurate control of downstream pressure, which is key in the safe supply of compressed air to pneumatic equipment such as valves and DCV's and ensures good performance of the equipment. Air filter regulators will collect debris and need be cleaned or replaced on a regular basis. Using figure 4 as a reference, the air supply is connected to the air inlet port and passes through the filtering chamber at the bottom of the regulator. When air is passed through the filter it removes any dirt particles and moisture in the incoming air which could potentially block components and pipework. From the filter chamber the air then goes into the valve assembly where the valve assembly is moved by the range spring pressing on the diaphragm. The range spring will then hold the valve assembly down until the output pressure is high enough to lift the diaphragm through an air passage within the regulator. The small spring within the valve assembly then closes the valve, air is then passed through a hole at the centre of the diaphragm and out of the vent to maintain balanced pressure across the diaphragm. If the outlet pressure is above the set pressure of the range spring, the air will begin to vent. When the outlet pressure is correct, the valve assembly opens to the correct set pressure and goes out the outlet port. If the outlet pressure is below the set pressure the valve assembly will stay open until the required pressure has been reached.

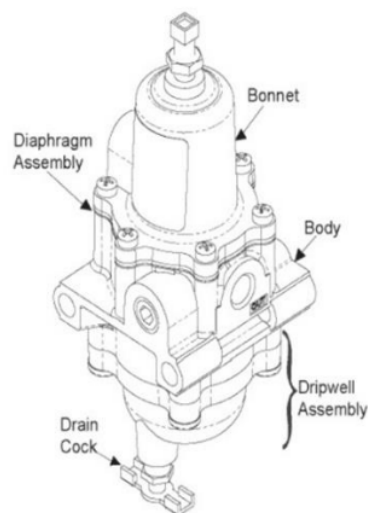


Figure 3 - Shows a Filter Regulator

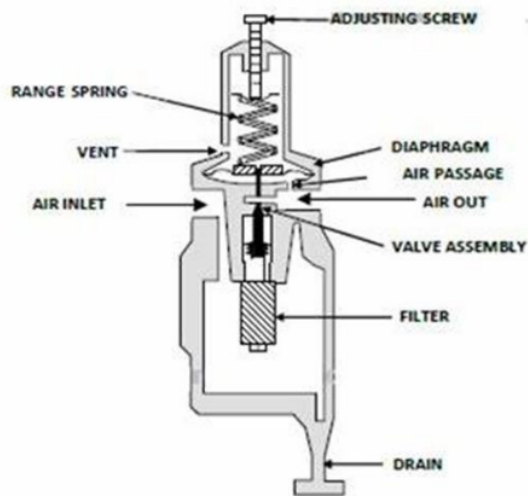


Figure 4 - Shows the components to an Air Filter Regulator

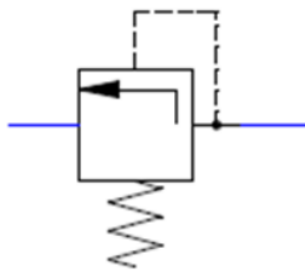


Figure 5 - Shows the Pneumatic symbol for a pressure regulator

For a hydraulic system, a pressure relief valve would typically be used to relieve the pressure of the system back to the tank if the system exceeds its maximum allowable working pressure. A relief valve is a safety device which its components consist of a spring loaded mechanism, an inlet port into the relief valve, an outlet port to the tank, a pressure adjustment screw if the relief valve is of the adjustable type otherwise the spring will be set to lift at a designated pressure, a poppet which is the mushroom shaped internal valve which the fluid comes into contact to and lifts to allow fluid to the tank. A PRV will also have a control chamber in which the poppet, spring and the internal section of the adjustment screw are found. Using figure 6 as a reference, a relief valve works on the basis of when an overpressure in the system occurs, the poppet raises to relieve the system of any excess pressure. This excess fluid will get drained back into the tank/reservoir and as the pressure within the system drops below the set value of the pressure relief valve spring the poppet will close off the inlet port of the pressure relief valve. A drain can also be found within the control chamber to empty the chamber of any excess fluid to prevent any damage that could occur within the control chamber.

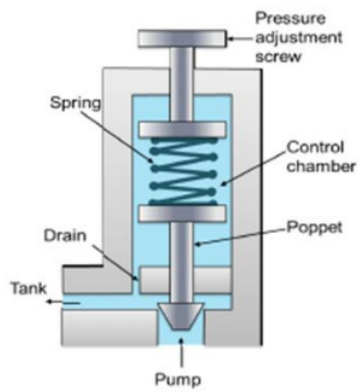


Figure 5.6.1 Pressure Relief Valve

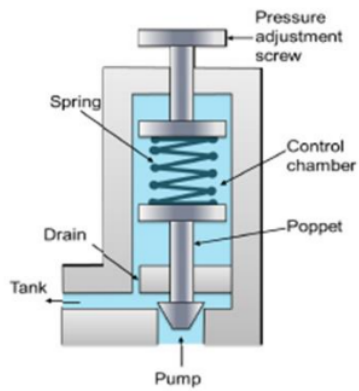


Figure 6 - Shows a pressure relief valve and its components

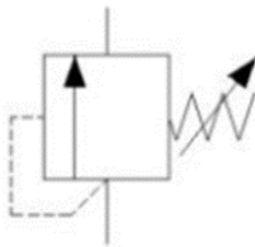


Figure 7 - Shows a hydraulic pressure relief valve symbol

Task 2 – Calculations

Task 2.

Question 1

Stage 1

Using N.T.P conditions pressure 101.3KPA 20°C temperature ★ *kPa should be written like this.*

$$P1= 101.3 \quad P2= 500$$

$$V1= 21 \quad V2=?$$

$$T1= 20 +273 (293) \quad T2= 45+273 (318)$$

$$V2 = \frac{P1 \times V1}{T1} = \frac{P2 \times V2}{T2} = \frac{P1 \times V1 \times T2}{T1 \times P2}$$

$$V2 = \frac{101.3 \times 21 \times 318}{293 \times 500} \quad V2 = \frac{676481.4}{146500} = 4.618\text{m}^3 \quad \square \text{ This is stage 1 compression}$$

Stage 2

$$P1= 500 \quad P2= 850$$

$$V1= 4.618 \quad V2=?$$

$$T1= 45 +273 (318) \quad T2= 70+273 (343)$$

$$V2 = \frac{P1 \times V1}{T1} = \frac{P2 \times V2}{T2} = \frac{P1 \times V1 \times T2}{T1 \times P2}$$

$$V2 = \frac{500 \times 4.618 \times 343}{318 \times 850} = \frac{791987}{2703000} = 2.93\text{m}^3 \quad \square \text{ This is stage 2 compression}$$

Question 2

$$P1= 850 \quad P2=?$$

$$V1= 6.5 \quad V2= 6.5 - (44 \times 0.0015) = 6.434$$

$$T1= 70 +273 (343) \quad T2= 45+273 (299)$$

$$P2 = \frac{P1 \times V1}{T1} = \frac{P2 \times V2}{T2} = \frac{P1 \times V1 \times T2}{T1 \times V2}$$

$$P_2 = \frac{850 \times 6.5 \times 299}{343 \times 6.434} = \frac{1651975}{2206.862} = 748.56 \text{ kPa}$$

Absolute Pressure = Gauge pressure + Atmospheric Pressure.

Gauge pressure = Absolute Pressure - Atmospheric Pressure.

Gauge pressure = 748.56 - 101.3 = 647.26 KPa □ Pressure

Question 3

$$\text{Air density } \rho = \frac{P}{RT}$$

where ρ is the density, P is pressure, R is gas constant, T is temperature

$$\rho = \frac{748.56}{287 \times 299} = 8.723 \times 10^{-3} \text{ Kg/m}^3 \quad \star \text{ Density correct - units are kg per cubic metre}$$

Question 4

$$D_1 = 72 \text{ mm} = 0.072 \text{ m}$$

$$D_2 = 22 \text{ mm} = 0.022 \text{ m}$$

$$A_1 = \pi r^2 = \pi \times 0.036^2 = 4.07 \times 10^{-3}$$

$$A_2 = \pi r^2 = \pi \times 0.011^2 = 0.38 \times 10^{-3}$$

$$\rho = 8.723 \text{ Kg/m}^3 \quad \star \text{ Shown correctly here}$$

$$\Delta P = \frac{E}{2} (V_1^2 - V_2^2) \quad V_1/V_2 = \frac{M}{e \times CSA}$$

$$V_1 = \frac{0.45}{8.723 \times 10^{-3} \times 4.07 \times 10^{-3}} = 12.67 \times 10^3$$

$$V_2 = \frac{0.45}{8.723 \times 10^{-3} \times 0.38 \times 10^{-3}} = 135.76 \times 10^3$$

$$\Delta P = \frac{E}{2} (V_1^2 - V_2^2) = \frac{8.723}{2} \times (12.67^2 - 135.76^2) =$$

-79.689 KPa □ Good application of Bernoulli's formula to solve for decreasing pressure.

Available pressure = 647.26 - 79.69 = 567.57 KPa

□ Correct

Question 5

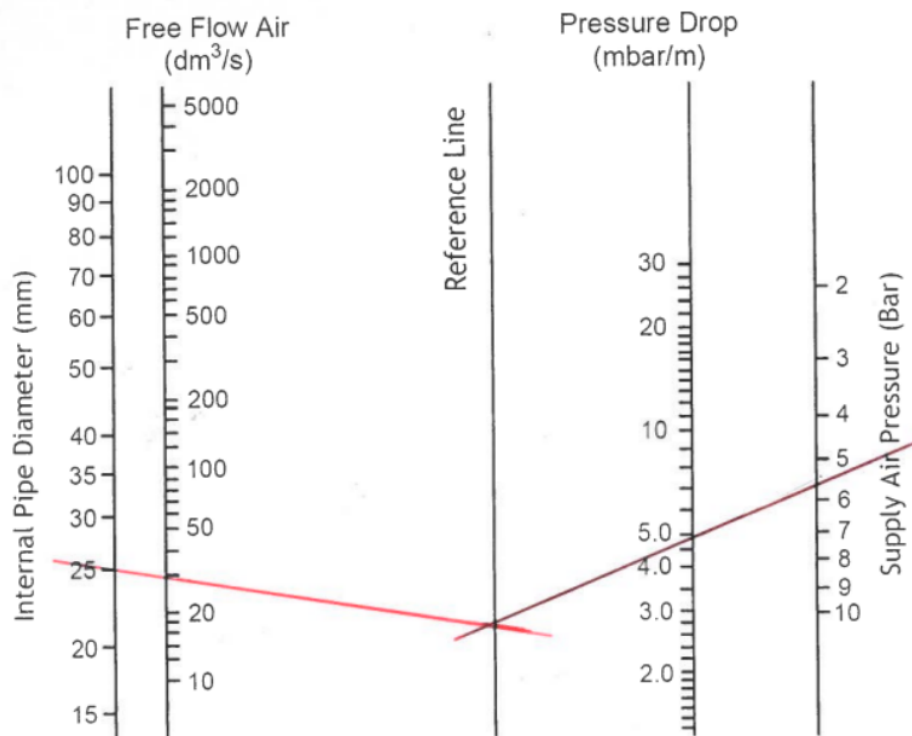


Figure 1 – Pressure Nomogram

Well applied

Figure 8 - Shows the Pressure Nomogram

Diameter = 25mm

free flow air = 30 dm³/s

supply air pressure = 5.6 bar

pressure drop = 5mbar/m □ Per metre

pressure loss per metre 5 x 48 = 240 dm³/s ★ This should be pressure drop though 48m (240mb)

available pressure at end of hose 567.57 - 24 = 543.57kPa

★ You should have converted 240mb into kPa then taken away from 567.57kPa

$$P = \frac{F}{A} = a = \pi r^2 = \pi \times 0.041^2 = 5.28 \times 10^{-3}$$

$$F = P \times A = 543.57 \times 10^3 \times 5.28 \times 10^{-3} = 2.87 \text{ kN} \quad \square \text{ Correct force}$$

$$F = M \times A = M = \frac{F}{A} = \frac{2.87 \times 10^3}{5.281 \times 10^{-3}} = 543.46 \text{ Kg} \quad \square \text{ A reasonable mass considering the gravity error.}$$

★ A is for acceleration due to gravity, not Area again.

★ This is a 'List of Figures' not an 'Appendix'. It should be placed after your 'Contents' page.

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□ Detailed labelling No need for 'Shows a.....' The correct layout is: e.g. 'Figure 3 - Filter Regulator'

□ A wide range of technical internet sources have been considered. ★ This should be a 'Reference List' and you should have in-text referencing throughout your work. It is difficult to see where the sources have been used in your writing.

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Tomas Griffiths Assignment

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

65/100

PAGE 1

Text Comment. 65.5 overall grade

Text Comment. □ Professional cover page for a technical report

PAGE 2

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PAGE 3

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Text Comment. ★ kPa should be written like this.

Text Comment. □ This is stage 1 compression

Text Comment. □ This is stage 2 compression

Text Comment. □ Pressure

Text Comment. ★ Density correct - units are kg per cubic metre

Text Comment. ★ Shown correctly here

Text Comment. □ Good application of Bernoulli's formula to solve for decreasing pressure.

Text Comment. □ Correct

Text Comment. Well applied

Text Comment. □ Per metre

Text Comment. ★ This should be pressure drop though 48m (240mb)

Text Comment. ★ You should have converted 240mb into kPa then taken away from 567.57kPa

Text Comment. □ Correct force

Text Comment. □ A reasonable mass considering the gravity error.

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PAGE 14

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PAGE 15

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Text Comment. □ Useful page numbering