

**INDUSTRIAL GAS PIPING SYSTEM FOR
CHEMICAL ENGINEERING LABORATORY
UNIVERSITI MALAYSIA PAHANG**

ROSMIMIE BINTI ABDULLAH

Thesis submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Chemical Engineering (Gas Technology)

**Faculty of Chemical & Natural Resources Engineering
UNIVERSITI MALAYSIA PAHANG**

JULY 2013

©ROSMIMIE BINTI ABDULLAH (2013)

ABSTRACT

Industrial gas piping system for Faculty of Chemical and Natural Resources Engineering (FKKSA) laboratory is used to supply industrial gas to the equipments in clean room laboratory. The gases that are supplied to the laboratory are Nitrogen (N₂), Carbon Dioxide (CO₂), Oxygen (O₂), Hydrogen (H₂), Helium (He), Compressed Air, Nitrous Oxide (N₂O), Acetylene (Ace) and Argon (Ar). These gases are used for specific equipment such as fermenter, gas chromatography (GC), and Atomic Absorption Spectroscopy (AAS). These equipments are used for research and training. The piping systems are generally stainless steel tubing with 3/8 inch and 1/4 inch tube outside diameters. There are five rooms in the cleanroom laboratory that involved with piping system, and they are BioTech Analytical Laboratory, BioTech Animal & Plant Cell Culture Room, BioTech Processing Scale Up Laboratory 1, BioTech Processing Scale Up Laboratory 2, Analytical Hot Laboratory, and Analytical Cool Laboratory.

Generally, part of this piping system has already stopped from operating because of suspected leakage occurring in the system. This leakage can contribute to the economic loses as the gas escaped to the surrounding continuously. As small quantity of gases escape will greatly affect the cost (F. J. Callahan, 1993). There are cases where gases are supplied directly from cylinder to the equipment without a proper piping system. This is not complying with MS 830 clause 11.3 “the cylinder shall not be stored in a building or part thereof or structures attached thereto when the building is used as an educational institution”. The consequence from this non-compliance may cause the possibilities of inhaled gases by the public and lead to suffocation from the accumulation of flammable or reactive gases. In order to solve the problem, leak test should be conducted. However, this is not simple. It should be done with correct procedure by referring to appropriate standard. Similar goes to the cylinder storage area, it does not have enough signage as stated by MS 830 clause 10.7 “the messages in the form of signs shall be clearly displayed at the storage area”. The warning notice shall be in letters of at least 50mm high. Thus, this research is aim to identify the safety of the existing industrial gas piping system at selected laboratory and also to improve the existing system based on acceptable standards.

Basically in this research, it involves site surveying, measurement, collecting data, discussion and documentation. Start with measuring the length of piping in selected room using measuring tape as the original drawing of the system was missing. Then, the drawing of the system is done by using AutoCAD. Next is to calculate the number of cylinder needed for the leak test for the piping system. After the calculation, the cost of leak test was estimated. Then, step by step procedure to conduct leak test are performed according to ASME B31.3. This procedure can be a reference to laboratory owners who want to conduct leak test in the future. The analysis of the safety in for the system is also carried out.

From calculation, it shows that the volume of gas needed for test is 34281 ft³ at atmospheric pressure which is equal to 228 ft³ at 2200 psig. From this volume, supply pressure can be calculated and for all piping, the supply pressure calculated is generally higher than test pressure. Thus, only one cylinder is needed for all piping system. For safety analysis, it showed that eighteen items is complying with standards and ten items is not complying with the standards. This should be improved so that the system is safe to be used in the laboratory.

TABLE OF CONTENTS

SUPERVISOR’S DECLARATION	IV
STUDENT’S DECLARATION	V
<i>Dedication</i>	VI
ACKNOWLEDGEMENT	VII
ABSTRACT.....	VIII
ABSTRAK.....	IX
TABLE OF CONTENTS.....	X
LIST OF FIGURES	XII
LIST OF TABLES	XIII
LIST OF ABBREVIATIONS.....	XIV
1 INTRODUCTION	1
1.1 Motivation and statement of problem	1
1.2 Objectives.....	2
1.3 Scope of this research.....	2
1.4 Main contribution of this work	2
1.5 Organisation of this thesis	3
2 LITERATURE REVIEW	4
2.1 Overview	4
2.2 Introduction.....	4
2.3 Components and fittings used in existing gas piping system.....	7
2.3.1 Pressure regulator	8
2.3.2 Pressure gauge	9
2.3.3 Valve.....	10
2.3.4 Fittings	12
2.4 Pressure test method.....	16
2.4.1 Pneumatic test.....	16
2.4.2 Leak test solution	17
2.4.3 Test Procedure (According to ASME B31.3).....	17
2.4.4 Safety precaution during conducting the test.....	17
2.4.5 Gas cylinder	18
2.4.6 Specific Hazard Class	19
2.5 Industrial gases.....	20
	X

2.5.1	Helium gas	20
2.5.2	Carbon dioxide.....	20
2.5.3	Oxygen.....	21
2.5.4	Nitrogen	21
2.5.5	Hydrogen	22
2.5.6	Nitrous Oxide.....	23
2.5.7	Acetylene	23
2.5.8	Argon	24
2.5.9	Compressed Air	24
2.6	General Code and Standard used	24
2.6.1	Code and standard used	25
3	MATERIALS AND METHODS.....	26
3.1	Introduction	26
3.2	Collecting data	27
3.4	Analysing	29
3.3	Documentation	31
4	RESULTS AND DISCUSSION	32
4.1	Overview	32
4.2	Introduction	32
4.3	Result on Test Medium for Leakage Test	32
4.3.1	Drawing using AutoCAD	32
4.3.2	Calculation of volume of test material needed for leak test	32
4.3.3	Estimation of the Cost of Leak Test	41
4.4	Result for Safety Observation on the Existing Piping System.....	43
4.4.1	Safety analysis of the system	49
4.4.2	Recommendation	52
5	CONCLUSION.....	54
5.1	Conclusion.....	54
5.2	Future work	54
	REFERENCES.....	55
	APPENDICES	57

LIST OF FIGURES

Figure 2-1: Pressure regulator used in the existing system	9
Figure 2-2: Pressure gauge	10
Figure 2-3: Isolation/Needle Valve.....	11
Figure 2-4: Fujikin Ball Valve.....	12
Figure 2-5: Fujikin Plug Valve	12
Figure 2-6: Swagelok Union.....	13
Figure 2-7: Swagelok Reducing Union	13
Figure 2-8: Swagelok Tee.....	14
Figure 2-9: Swagelok Reducing Union Tee	14
Figure 2-10: Swagelok Union Elbow	15
Figure 2-11: Swagelok Cap	15
Figure 2-12: Proper Safety Attire in Handling Gas Cylinder	18
Figure 3-1: Measuring Tape	27
Figure 3-2: Parts of Existing Piping System.....	28
Figure 4-1: Helium Gas Piping System	35
Figure 4-2: Nitrous Oxide Piping System.....	36
Figure 4-3: Oxygen Piping System.....	37
Figure 4-4: Carbon Dioxide Piping System.....	38
Figure 4-5: Nitrogen Piping System	39
Figure 4-6: Nitrogen Cylinder Gas (Source: ASCOTORCH.com)	41
Figure 4-7: Snoop Solution for Leak Test (Source: Swagelok Malaysia)	42
Figure 4-8: Laboratory Layout	43
Figure 4-9: Hazard Signage	52

LIST OF TABLES

Table 2-1: Specification of the Existing System	5
Table 2-2: List of equipment in the laboratory	6
Table 2-3: Quantity of Components and Fittings	7
Table 2-4: Quantity of Components and Fittings	8
Table 3-1: Size and Volume of Nitrogen at Given Pressure.....	29
Table 4-1: Summary of Pipe Volume Calculation.....	40
Table 4-2: Summary Leak Test Detection	40
Table 4-3: Gas Storage 1,2 and 3.....	44
Table 4-4: Biotech Processing Scale Up Lab 1	45
Table 4-5: Analytical Cool Lab	46
Table 4-6: Analytical Hot Lab	47
Table 4-7: Bio Micro Lab	48
Table 4-8: Animal Cell Room	48
Table 4-9: Safety Analysis of the System.....	40
Table 4-2: Summary Leak Test Detection	40
Table 4-2: Summary Leak Test Detection	40
Table 4-2: Summary Leak Test Detection	40

LIST OF ABBREVIATIONS

<i>ASME</i>	American Society of Mechanical Engineers
<i>MS</i>	Malaysian Standard
<i>AAS</i>	Atomic Absorption Spectroscopy
<i>GC</i>	Gas Chromatography
<i>MAWP</i>	Maximum Allowable Working Pressure
<i>ISO</i>	International Standards Organization

1 INTRODUCTION

1.1 Motivation and statement of problem

Chemical Engineering Laboratory, University Malaysia Pahang is using piping system to supply industrial gases to the equipment in the clean room. The gases that was supply in the laboratory was Nitrogen (N₂), Carbon dioxide (CO₂), Oxygen (O₂), Hydrogen (H₂), Helium (He), Compressed Air, Nitro Oxide (N₂O), Acetylene (Ace) and Argon (Ar). These gases were used for specific equipment such as fermenter, gas chromatography (GC) and Atomic Absorption Spectroscopy (AAS). The existing gas piping system is using manifold system. The capacity of each cylinder used is about 50 liter water capacity. The diameter of the cylinder is approximately 230 millimeter. In general, this existing industrial gas piping system is not effective as there were some leakage occurs in the pipeline system.

This project is conducted because there is some problems occur on the existing gas piping system. The leakage of the system causes the gas supplied directly from the cylinder to the equipment as the gas piping system is no longer can be used. This type of connecting is not complying with standard. According to MS 830, the cylinder cannot bring into a confined space to avoid inhaling the gas and possible suffocation from the accumulation of flammable, toxic or reactive gases. Besides that, the leakages also contribute to the economic losses as the gas is escape to the surrounding. A small quantity of gases escape will affect greatly as the gas is continuously used. This system can be improved by repairing or replace some of the parts from the system with new one.

Another problem in the existing system is the installation of the system is not completely complying with standard. According to MS 830, 2003 the cylinder storage shall be stored away from drain. However, the storage of cylinder at FKKSA laboratory is beside the drain. In addition, the storage also does not have enough signs displayed. According to standard, the signs and notices shall be clearly displayed at the storage area. The signs need to be displayed are no smoking sign, no naked light sign, nearby material is a fire risk sign and no hand phone sign.

Site visit has been done on the industrial gas piping system for Chemical Engineering Laboratory, University Malaysia Pahang. This project is to improve the existing industrial gas piping system for FKKSA laboratory to make it more systematic, safe, and to overcome all the weaknesses of the existing system. Basically it involves site surveying, measurement, collecting data, discussion and documentation.

1.2 Objectives

The following are the objectives of this research:

- To determine the volume of test medium needed for leakage detection on existing piping system in order to improve the integrity of the piping system
- To identify the safety noncompliance of the existing industrial gas piping system at selected laboratory

1.3 Scope of this research

In order to improve the existing gas piping system, the scope of research is more focusing on:

- i) Determines the weaknesses of the system and makes some recommendation to enhance the existing piping system
- ii) Surveying whether the system is comply with standards or not
- iii) Study on how to detect leakage on the system and calculate the required capacity of inert gas (Nitrogen) needed for the leak test
- iv) Draw existing gas piping system as the original drawing is missing to measure the length of the pipe

1.4 Main contribution of this work

This project is very useful for chemical engineering laboratory, University Malaysia Pahang because this project will come out with a solution and also some recommendation to improve the system. Besides that, it will be more effective and safe to use. Importantly, at the end of this project, the drawing of the entire existing gas piping system will be done. Since the old drawing is missing, the new drawing can be a reference before doing leak test and for future piping planning.

1.5 Organisation of this thesis

The structure of the remainder of the thesis is outlined as follow:

Chapter 2 provides a literature review of this research. The literature review is based on the existing piping system at laboratory. Site visit to the laboratory is done in order to collect data. From all the data, literature review can be done. Besides that, in this chapter also review the theoretical and methodology that contribute to this research. The theory and method is generally based on company standard and applicable standard such as ASME, MS 830 and soon. Furthermore, it also explains about the properties of every gas that used in the laboratory. Most importantly, the theory about the leakage causes is also stated in this chapter.

Chapter 3 gives a methodology that used for this research. Basically this research involves site surveying, measurement, collecting data, discussion and documentation. Begin with a visit to cleanroom to collect data for this project. The length of pipe is measured. Besides that, all fittings used in existing piping system is recorded. Next, the drawing for existing gas piping system is draw using AutoCAD. Lastly, an investigation is conducted to determine the safety of the existing system. Then all data is documented in this thesis.

Chapter 4 is the heart of the thesis which consist of result and discussion of the research. The result shows the drawing of the existing piping system using AutoCAD with appropriate symbol. Then, the length of the pipe is tabulated in the table as well as the volume of pipe. This chapter also describe the steps to calculate the number of cylinder need for the leak test.

Chapter 5 draws together a summary of the thesis and outlines the future work which can be done to improve the research.

2 LITERATURE REVIEW

2.1 Overview

In this review, there are three important topics that will be discussed. First, review on background of the existing industrial gas piping system. Second, the data collected on the existing system. Last but not least, the data that will be used to calculate the test medium needed for leak test.

2.2 Introduction

This literature review is based on the system and design of the existing industrial gas piping system in FKKSA laboratory. In this chapter, all the equipment and fittings used in the existing system is explained. Besides that, the information on safety and leakage is clearly stated based on applicable standard.

2.3 Background on the existing industrial gas piping system

The industrial gas piping system in FKKSA laboratory was generally used products from Swagelok. The system mainly used 3/8 in. and 1/4 in. tube OD size. The tube material used is stainless steel. The operating pressure of this existing piping system is 1.5 bars. Design pressure is unknown as the existing drawing for the system is missing. Therefore, the design pressure is estimated by taking pressure regulator reading. From that reading, it shown that the highest reading for outlet pressure is 5 bars. Assume 5 bars as maximum allowable working pressure (MAWP). Design pressure is the maximum pressure that the system that can be exposed to and sets the system relief valve at the same pressure. This should be below MAWP and based on company standards can vary from 10% to 25% above the maximum operating pressure of the system. Thus, take 25% above MAWP, so the design pressure will be 6.25 bars. This piping was used to supply gas to the equipment in the laboratory. The gases used are compressed gases. The pipe length to supply the gases was quite long. However, parts of the pipeline was no longer can be used. This problem occurs since year 2012. The laboratory owner connects the gas cylinder to the line. However, the cylinder is empty within one day. It shows that leakage is occurring on the system. The leakage might due to corrosion of the tube. The internal or external corrosion of the tube can reduce the

wall thickness that can eventually develop into a leakage (E. S. Menon, 2011). Moreover, fitting failures such as valve and pressure regulator can also contribute to the leakage. Some pressure regulators are very sensitive. In addition, the system failure might also be due to the seals that connect to the piping are corroded. Usually a major leak occurs at the fitting where seals are used to connect the pipe and the fittings. The analysis will be carried out to calculate the test medium needed and the cost required for leak test. Table 2-1 below shows the specification of the existing system.

Table 2-1: Specification of the Existing System

No	Item	Specification
1	Tube material	316 Stainless steel
2	Tube diameter	1/4 inch, 3/8 inch, 1/2 inch
3	Operating pressure	1.5 bar
4	Pressure regulator	Inlet pressure 206 bar Outlet pressure 5 bar
5	Jointing	Seamless
6	Ball valve	Fujikin & Swagelok
7	Paint	Dark red

There are five rooms in cleanroom laboratory that involved piping system which are BioTech Analytical Laboratory, BioTech Animal & Plant Cell Culture Room, BioTech Processing Scale Up Laboratory 1, BioTech Processing Scale Up Laboratory 2, Analytical Hot Lab, and Analytical Cool Lab. These rooms consist of different equipment that used for training and research by students as well as lecturers. Table 2-2 shows the list of equipment in the laboratory.

Table 2-2: List of equipment in the laboratory

No	Equipment	Brand / Model	Status	Location
1	Atomic Absorption Spectrometer (AAS)	Model Z-5000 Series Polarized Zeeman (HITACHI)/Japan	Existing equipment	Analytical Cool Lab
2	Differential Scanning Calorimeter	DCS Q1000		
3	Surface Tension Analyzer	Surfer Analyzer	New equipment	
4	Gas Chromatography-mass spectrometry	Agilent 5975C MSD G 3171A	Existing equipment	Analytical Hot Lab
5	Gas Chromatography	Agilent G 3440A		
6	Gas Chromatography	Agilent G 890N		
7	Gas Chromatography (Thermo)	Agilent K 0723B001 300000		
8	Fermenter 20L Sartorius	Bio stat C		Biotech Processing Scale up Lab
9	Fermenter 20L Sartorius	Bio stat D		
10	Bactron Anaerobic Chambers		New equipment	
11	Laminar Air Flow	ESCO AHC-4AI	Existing equipment	Bio Macro Lab
12	CO ₂ Incubator	-		Animal Cell Room

2.3 Components and fittings used in existing gas piping system

Generally, Swagelok tube fitting is a sequential phase, controlled action sealing and gripping device. It consisting wide variety of configuration making it as the first choice. All fitting is used from Swagelok Company and the component, such as valve is used from Fujikin and also from Swagelok. There are two types of pressure regulator used in this existing piping system which is single stage pressure regulator and double stages pressure regulator. The number of components and fittings used in the existing system is tabulated in the Table 2-3 below:

Table 2-3(a): Quantity of Components and Fittings

	Pipe length	Pressure regulator	Ball valve	Union	Branch Tee
H ₂	27090	3	3	4	2
He	28400	4	4	6	2
N ₂	32040	5	5	5	1
O ₂	22780	2	2	5	1
Compressed air	31580	6	6	4	3
N ₂ O	16256	3	3	1	2
Ace	16495	3	3	1	2
Ar	17030	4	4	0	2
O ₂ line 2	56745	1	3	2	1
CO ₂ line 2	56924	1	3	2	1
N ₂ line 2	57263	1	4	2	1
Total	362603	33	40	32	18

Table 2-4(b): Quantity of Components and Fittings

	Elbow	Reducing tee	Pressure Gauge	Cap
H ₂	0	0	4	0
He	0	1	6	0
N ₂	1	1	5	0
O ₂	0	0	2	0
Compressed air	1	1	6	0
N ₂ O	0	0	3	0
Ace	0	0	3	0
Ar	0	1	5	0
O ₂ line 2	0	3	1	1
CO ₂ line 2	0	3	1	1
N ₂ line 2	0	3	1	0
Total	2	13	37	2

2.3.1 Pressure regulator

Pressure regulator limits excess inlet gas pressure to a constant outlet pressure. It controls outlet pressure by balancing an adjustable spring force against the forces caused by inlet and outlet pressures. The spring force is adjusted by turning the handle, which sets the desired outlet pressure. There are two types of pressure regulator which are single stage regulator and double stage regulator. Single stage regulator contains a

single diaphragm and poppet. The high pressure gas enters the regulator through the inlet pressure chamber. It passes into the low pressure chamber through the valve stem. The flow is adjusted by turning the regulating knob. Turning it clockwise compresses the diaphragm which pushes the valve stem open, so increasing the gas flow through the regulator. Two stage regulators work in much the same way as single stage regulators with one main difference. Rather than having one diaphragm and poppet, they have two. The first stage reduces the pressure, but as the cylinder empties, the pressure exerted on the first stage decreases allowing the flow to increase. This second stage is constructed in a similar manner to the first, but the pressure being exerted on the second diaphragm and valve stem is less.

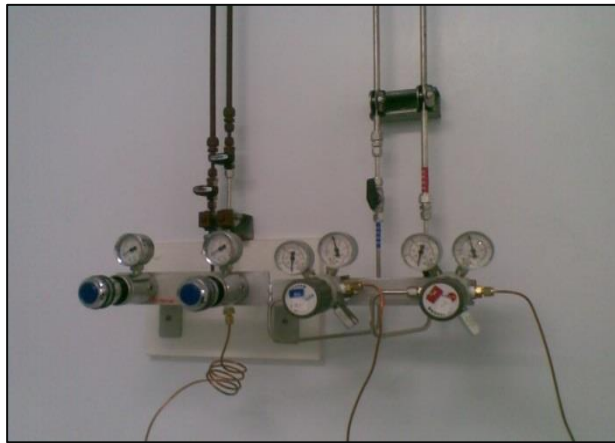


Figure 2-1: Pressure regulator used in the existing system

2.3.2 Pressure gauge

Pressure gauge is a measurement device which determines the pressure in a compressed gas or liquid. Pressure gauges are widely used all over the world, for instance, monitoring the pressure in a process. There are many different styles of pressure gauge available, designed for various purposes. Like others measurement device, these gauges can and should be calibrated periodically to confirm that they are working correctly when they are used for sensitive operations. Whatever various forms and materials they use, a pressure gauge is designed to measure pressure from gases, liquids, vapour's or solid bodies in many applications and industries. Due to the volatile nature some of these sources can take, pressure gauges and pressure instruments can fail for a multitude of reasons. Protecting and inspecting pressure instruments on a regular basis will help prevent failure and keep operations running smoothly.

There are few types of pressure gauge. First, industrial pressure gauges are stainless steel gauges designed for the oil and gas, alternative fuels, chemical manufacturing, petrochemical and mobile hydraulics industries. An industrial pressure gauge is suitable for media that will not obstruct the pressure system. Second, low pressure gauges are suitable for corrosive environments and gaseous or liquid media that will not obstruct the pressure system. It is suitable for chemical, petrochemical, plant construction, pneumatic systems and cleanrooms. Next are absolute pressure gauges which used to measure absolute pressure without the effect of barometric pressure variation. It also used when monitoring condensation pressures and vapour pressures of liquids. There is much more type of pressure gauge can be found in industry.



Figure 2-2: Pressure gauge

2.3.3 Valve

There are three types of valve used in the existing system which are Needle valve, Ball valve and plug valve. The valve used is from Swagelok and Fujikin brand. Needle valve only used for oxygen line. Needle valve can provide excellent flow control, depending on design, leak-tight shut-off. They consist of a long stem with a highly engineered stem-tip geometry that fits precisely into a seat over the inlet. The stem is finally threaded, enabling precise flow control. Needle valves help protect fragile gauges that might otherwise be damaged by high amounts of a pressurized substance's release.

Ball valve is designed for on-off control. Quarter–turn actuation starts or stops flow by positioning a metallic ball in a straight- through flow path. The ball has a large hole through the centre of it, and when the hole is lined up with the flow path, it enables flow. When it is turned 90 from the flow path, it stops the flow. The body of ball valves

may be made of metal, plastic or metal with a ceramic centre. The ball is often chrome plated to make it more durable. Ball valves are used extensively in industrial applications because they are very versatile, supporting pressures up to 1000 bar and temperatures up to 482°F (250°C). Sizes typically range from 0.2 to 11.81 inches (0.5 cm to 30 cm). They are easy to repair and operate. In this existing piping system, ball valve used is from Fujikin. Figure 2-4 shows the specification of the valve.

Plug valves are either cylindrical or conically tapered. Conical valves are equipped with a handle attached to one end of the plug which allow better handling and control of the flow of the fluid whenever the device is opened or closed. There are many different models of plug valves, and among them is the two-port valve, which is simple to use and allows the fluid or gas to flow whenever it is opened, as well as stop the flow each time the valve is shut closed.


	<p>Type: Isolation / Needle valve</p> <p>Size: 3/8"</p> <p>Connection: Compression</p> <p>Wetted Material: 316 Stainless Steel</p> <p>Seats and Seals: PTFE</p> <p>Pressure Range PSIG: Up to 5000</p> <p>Temperature Rating: Up to 450</p> <p>Flow Coefficient (Cv): 0.73</p>
---	--

Figure 2-3: Isolation/Needle Valve


	<p>Type: Ball Valve</p> <p>Size: 3/8"</p> <p>Connection: Compression</p> <p>Wetted Material: 316 Stainless Steel</p> <p>Seats and Seals: PTFE</p> <p>Pressure Range PSIG: Up to 1600</p> <p>Temperature Rating: Up to 450</p> <p>Flow Coefficient (Cv): NA</p>
---	--

Figure 2-4: Fujikin Ball Valve

	<p>Type: Plug Valve</p> <p>Size: 1/4"</p> <p>Connection: Compression</p> <p>Wetted Material: 316 Stainless Steel</p> <p>Seats and Seals: PTFE</p> <p>Pressure Range PSIG: Up to 2500</p> <p>Temperature Rating: Up to 150 °F</p> <p>Flow Coefficient (Cv): 1.6</p>
---	--

Figure 2-5: Fujikin Plug Valve

2.3.4 Fittings

A fitting is used in pipe systems to connect straight pipe or tubing sections, to adapt to different sizes or shapes, and for other purposes, such as regulating or measuring fluid

flow. There are five types of fittings used in the existing piping system. These fittings are from Swagelok. The specification of the fittings is shown in figure below:


	<p>Type: Union</p> <p>Size: 3/8"</p> <p>Connection: Swagelok tube fittings</p> <p>Wetted Material: Super Duplex Stainless</p> <p>End connection 1 size: 3/8"</p> <p>End connection 2 size: 3/8"</p>
---	---

Figure 2-6: Swagelok Union

A union is designed to allow quick and convenient disconnection of pipes for maintenance or fixture replacement. A union provides a simple transition, allowing easy connection or disconnection at any future time. A standard union pipe is made in three parts consisting of a nut, a female end, and a male end. When the female and male ends are joined, the nuts then provide the necessary pressure to seal the joint. Since the mating ends of the union are interchangeable, changing of a valve or other device can be achieved with a minimum loss of time. Figure 2-7 show Swagelok reducer. A reducer allows for a change in pipe size to meet flow requirements of the system, or to adapt to existing piping of a different size.


	<p>Type: Reducing Union</p> <p>Connection: Swagelok tube fittings</p> <p>Wetted Material: Super Duplex Stainless</p> <p>End connection 1 size: 3/8"</p> <p>End connection 2 size: 1/4"</p>
---	---

Figure 2-7: Swagelok Reducing Union

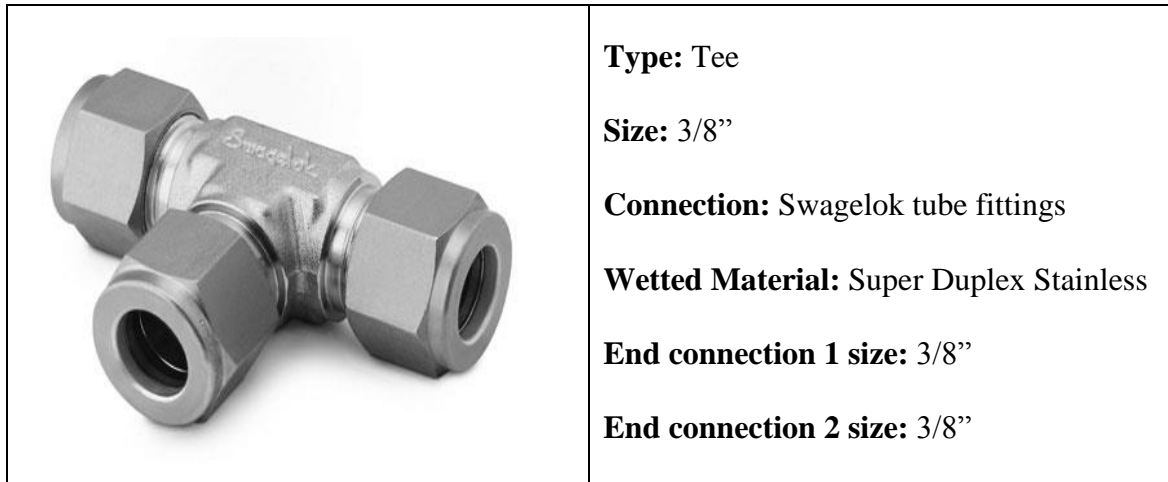


Figure 2-8: Swagelok Tee

A tee is the most common pipe fitting. It is available with all female thread sockets, all solvent weld sockets, or with opposed solvent weld sockets and a side outlet with female threads. It is used to either combine or split a fluid flow. It is a type of pipe fitting which is T-shaped having two outlets, at 90° to the connection to the main line. It is a short piece of pipe with a lateral outlet. A tee is used for connecting pipes of different diameters or for changing the direction of pipe runs. They are made of various materials and available in various sizes and finishes. They are extensively used in pipeline networks to transport two-phase fluid mixtures. When the size of the branch is same as header pipes, equal tee is used and when the branch size is less than that of header size, reduced tee will be used. Figure 2-9 show reducing tee from Swagelok.

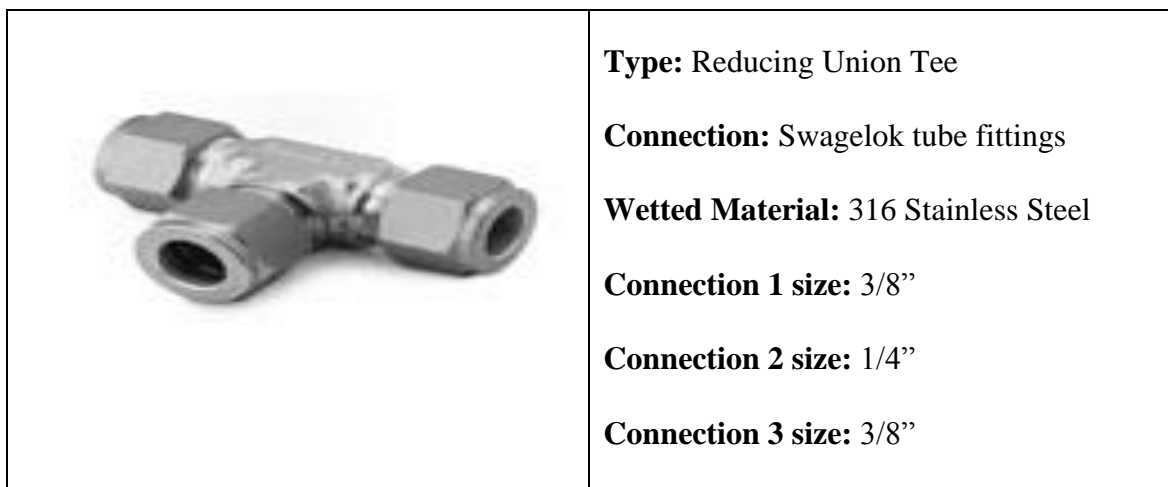


Figure 2-9: Swagelok Reducing Union Tee


	<p>Type: Union Elbow</p> <p>Size: 3/8"</p> <p>Connection: Swagelok tube fittings</p> <p>Wetted Material: 316 Stainless Steel</p> <p>End connection 1 size: 3/8"</p> <p>End connection 2 size: 3/8"</p>
---	--

Figure 2-10: Swagelok Union Elbow

An elbow is a pipe fitting installed between two lengths of pipe or tubing to allow a change of direction, usually a 90° or 45° angle, though 22.5° elbows are also made. The ends may be machined for butt welding, threaded (usually female), or socketed, etc. When the two ends differ in size, the fitting is called a reducing elbow or reducer elbow.


	<p>Type: Cap</p> <p>Size: 1/4"</p> <p>Connection: Swagelok tube fittings</p> <p>Body Material: Aluminium</p>
---	--

Figure 2-11: Swagelok Cap

Cap is usually liquid or gas tight, which covers the end of a pipe. A cap is used like plug, except that the pipes cap screws or attaches on the male thread of a pipe. A cap may have a solvent weld socket end or a female threaded end and the other end closed off. In piping systems that use threads, the cap has female threads. Industrial caps can be round, square, rectangular, U-shaped, I-shaped and may have a round hand grip or a flat hand grip.

2.4 Pressure test method

Pressure test method used is divided into a few parts which are calculation on the volume of pipeline and cylinder size needed for the test. There were many methods can be used to detect leakage. The common method used in industries is hydrostatic test. Alternative test methods can be used are pneumatic test, hydrostatic-pneumatic test, initial service leak test, sensitive leak test and last but not least, alternative test method replacement of hydrostatic leak testing for a closure or tie-in welds. In this project, it is recommended to use pneumatic for testing.

2.4.1 Pneumatic test

Pneumatic test is one of the pressure tests that can be conducted to verify the system integrity and the leak tightness. A pneumatic test implies hydrostatic test but it used gas instead of water as medium. The gas used usually inert gas or air. In determining the pressure capacity of a system, all ports to the system are closed except one through which gases is added until either the pressure rating for the system is achieved, the pressure cannot be achieved due to leaks in the system.

A pneumatic test is more dangerous than a hydrostatic test due to the higher energy content of a compressed gas. This type of test is limited to lower pressures or smaller system. Pneumatic test is also useful to detect fine leaks path which may never be found in hydrostatic test.

There were several precautions to do pneumatic test because it is not as safe as hydrostatic tests for several reasons. Test pressure for pneumatic test is always less compared to hydrostatic test pressure. According to ASME Section VIII Division 1 pneumatic test pressure is 1.1 times of design pressure whereas hydrostatic test pressure is 1.3 times of design pressure.

Senior staff or authorized personnel should be involved to monitor the test. Before testing, personnel must ensure that all testing connections are installed and secure. During the test, soapy water should be applied to every fitting along the pipeline to identify which parts contribute to the leakage. The advantage of this type of test is it was easy to clean after the test. It also does not give side effects on the pipeline.

2.4.2 Leak test solution

For leak detector solution, the Snoop liquid is suitable to use. Snoop liquid leak detectors detect gas leaks in hard-to-reach areas. This snoop liquid can be obtained from Swagelok. It has advantages in term of characteristic which are:

- Sustained bubble action works even on very small leaks and vertical surfaces.
- Flexible snooper tube extends for hard-to-reach areas.
- Noncorrosive, non-flammable formula does not contain chlorine.
- Contains corrosion inhibitor for added protection.
- Formula dries clean, without staining

It can be obtained in various sizes such as 59mL, 236 mL and 3.8 L (Swagelok web catalogue).

2.4.3 Test Procedure (According to ASME B31.3)

- a) Calculate test pressure at 1.1 x design pressure.
- b) Pressurize test circuit with air or nitrogen to a gage pressure, which is the lesser of one-half the test pressure or 25 psig.
- c) Perform a preliminary check of all joints.
- d) If no leaks are found, or all leaks are repaired, continue to increase pressure in stages, allowing piping strains to equalize until the test pressure is reached.
- e) Hold test pressure for 10 minutes then reduce to the design pressure.
- f) Hold design pressure for 10 minutes or for a period of time required to examine all joints and seals for leaks.
- g) If leaks are found, release pressure, repair leaks and start again. If not, the system is ready for service.

2.4.4 Safety precaution during conducting the test

While the test is in progress, all station personnel must be kept out of the testing area. Personnel who are involved in testing must stand behind a barrier to ensure their safety, and the testing area must be marked as a dangerous site. The section of pipeline being tested must be supervised at all times during the test. Leakage or rupture during testing can result in property damage or serious injury. All piping in the test section must be restrained prior to testing so that no movement occurs. Before testing begins, personnel