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PROPOSED THE NEW DESIGN NEW AIR AND DEIONIZED WATER PIPING SYSTEM AT FKKSA'S LABORATORY

MUHAMMAD HAIDAR HUSSIEN

A thesis submitted in partial fulfillment of the
requirements for the award of the degree of
Bachelor of Chemical Engineering (Gas Technology)

Faculty of Chemical and Natural Resources Engineering
Universiti Malaysia Pahang

NOVEMBER 2010

I declare that this thesis entitled "PROPOSED THE NEW DESIGN NEW AIR AND DEIONIZED WATER PIPING SYSTEM AT FKKSA'S LABORATORY" is the result of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree."

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DEDICATION

Special dedication for my beloved Ayah (Hussien Bin P. Mohidin), and Mak (Hamidah Bt Baba)

A billion appreciations to my supervisor (Siti Zubaidah Binti Sulaiman), all my lecturers, and friends.

Thanks a lot for all cares and supports.

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ABSTRACT

The air and deionized water piping recently is drawn 3D by using Plant Design Management System (PDMS). The PDMS is used worldwide not only for piping design but it can design as big as plant, factory and offshore platform. The main objective for this research is to design new air and deionized water piping system for improving recent piping system to make sure it can support the increasing demand of deionized water and air due to new equipments installation. The faculty of chemical and natural resources (FKKSA) laboratory is used as model for the drawing. Pressure drop is the main calculation for piping. It will determine either fluid will flow smoothly and reach the next point of the pipe. For the calculation, initial pressure of air is 125 psi and deionized water is 18 psi. The pressure drop percentage must not exceed 30 percent or otherwise the fluid cannot reach the next point of pipe. As the result, the fluid will flow to the final point of pipe because the pressure drop percentage is not exceeding 30 percent. Piping materials also crucial for piping and it is depends on the type of fluid. Deionized water piping use cross linked polyethylene (PEX) because of it corrode resistant, resist with high temperature and will use only few fittings but air use smart pipe that made of 6035-T5 calibrated alloy aluminium and coated with blue powder that is non flammable and 100 percent recyclable. In conclusion, the new air and deionized water piping system can support the demand of additional equipments in FKKSA's laboratory.

ABSTRAK

Sistem perpaipan air tidak berion dan udara telah dilukis meggunakan 'Plant Design Management System' (PDMS). PDMS telah digunakan di seluruh dunia bukan sahaja untuk rekaan perpaipan tetapi juga untuk mereka kilang dan platfom di laut. Objektif utama untuk kajian ini adalah untuk menaiktaraf system paip sedia ada untuk memastikan ia boleh menampung peningkatan permintaan air tidak berion dan udara disebabkan pemasangan peralatan baru. Makmal Fakulti Kejuruteraan Kimia dan Sumber Asli (FKKSA) telah digunakan sebagai model untuk projek ini. Penurunan tekanan adalah pengiraan terpenting untuk perpaipan. Ia akan menentukan sama ada bendalir akan mengalir dengan lancar dan sampai ke titik paip seterusnya. Bagi tujuan pengiraan, tekanan bagi udara adalah 125 psi dan air tidak berion adalah 18 psi. Peratus penurunan tekanan mestila tidak melebihi 30 peratus atau bandalir tidak sampai ke titik seterusnya dalam paip. Bahan untuk membuat paip juga sangat penting dan ia bergantung kepada jenis bendalir. Air tidak berion menggunakan Polyethylene bersilang (PEX) kerana is tahan karat, tahan suhu tinggi dan menggunakan hanya sedikit penyambung tetapi udara menggunakan 'Smart pipe' yg dibuat menggunakan 6035-T5 aluminium aloi dan disalut menggunakan serbuk biru yang tidak terbakar dan 100 peratus boleh dikitar semula. Kesimpulannya, system perpaipan air tidak berion dan udara yang baru boleh menampung pemintaan disebabkan pemasangan peralatan tambahan di dalam makmal FKKSA.

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LIST OF ABBREVIATIONS AND SYMBOLS

PDMS	-	Plant Design Management System
FKKSA	-	Fakulti Kejuruteraan Kimia dan Sumber Asli
PEX	-	Cross Linked Polyethylene
PVC	-	Polyvinyl chloride
CPVC	-	Chlorinated Polyvinyl Chloride
NPS	-	Nominal Pipe Size
MS	-	Malaysian Standard
PE	-	Polyethylene
F	-	Fabricated
H	-	Strain Hardened
W	-	Solution Heat Treated
T	-	Heat Treatment
BC	-	Before Christ
$\mathbf{m^3}$	-	Meter Cube
2D	-	2 Dimension
$\mathbf{\Delta P}$	-	Pressure Drop
P	-	Density
f	-	Friction Coefficient
L	-	Length
v	-	Velocity
$\mathbf{^oF}$	-	Degree Farenheit
D	-	Internal Pipe Diameter
g	-	Gravitational Force

L	-	Length
ΔH	-	Vertical Elevation
kg	-	Kilogram
m	-	Meter
3D	-	3 Dimension
LNG	-	Liquid Natural Gas

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Piping is essential in many types of industries. It is used worldwide to transfer fluid either oil, gas and also water. In oil and gas industries, piping is used to transfer oil and gas from transmission line to distribution line. It has being choose as medium to transfer such those things because of cost if compare with gas than being transport with lorry. Other than that, piping can transfer gas easily without compression. For example, it is needed to have compression to transport LNG (Liquid natural gas), thus the cost will increase. Cost is very crucial in industries. All things that involve in industries deal with benefits, cost and safety.

In laboratories worldwide, piping has become heart for any process involve. Any equipments that involve process such as heat exchanger, reactor or spray dryer use piping to run the process. The type of piping material used is depends on fluid run through it. However, cost still must be the first consideration to choose material used in piping.

In piping, pressure drop is important to make sure either the fluid can reach the end point or not. The pressure demand for every end point is important to estimate the initial pressure. Other than that, the pipe length, diameter, elevation, flow rate and bending also influence the pressure drop. If one of this parameter is miss or wrong, neither the piping will broke down due to the high velocity of fluid nor fluid not reach end point due to high pressure drop.

Besides that, material used for piping must be taken as consideration depends on the usage of the piping. For water, Polyvinyl chloride (PVC) pipe, galvanized iron pipe and chromed copper used. Air use galvanized steel, copper and PVC for it piping. Normally, PVC is taken as first choice for piping materials compared with others because it is lighter and cheaper. Due to certain circumstances like high pressure fluid and place that need durable pipe material, it is recommended to used hardier pipe to avoid any hazard.

1.2 Problem statement

Recently, FKKSA's laboratory is using a lot of deionized water for running the equipments in the laboratory. For the time being, it can used to support the equipments needed. If there is other equipment installed in the laboratory, the piping maybe cannot support the new equipments. Thus, there must be new piping system design to make sure the demand can be fulfilled. Otherwise, there must be difficulties or damages occur when new equipments installed. There are many things to be considered to make sure the design suite with the demand. The pressure drop, pipe length, pipe material and the regulation and act must be considered or the will be other problem involve like machine cannot operate as expected or machine broke down.

1.3 Project objectives

The objectives of this project are:

1. To design new piping system in FKKSA's lab.
2. To make sure the fluid can reach the end point due to pressure drop.

3. To make sure the piping system meets MS1063:2002, Malaysian Standard for fluid piping requirements.

1.4 Scope of research project

In order to achieve the objective, the following scopes of research work have been made:

1) The piping specification

   It is compulsory to know well about pipe specification, type of pipe material, diameter of the pipe and also the pipe length for Plant Design Management System (PDMS) matter. Besides that, the fluid that involve in new piping system design in FKKSA's laboratory is water and compressed air.

2) The pressure drop calculation

   Pressure drop must be identified to make sure the fluid will reach endpoint. The pipe length, diameter, elevation, flow rate and bending also must be taken into account to make sure the calculation for pressure drop is accurate.

3) The safety aspect and requirements

   The piping must follow MS1063:2002 that is Malaysian Standard for fluid piping. It is to make sure the air and piping system is in safe to be use.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of piping system

Piping is a system of pipes used to transport fluids (liquids and gases) from one location to another (Majid & Yaacob, 2001; McKetta & John, 1992). It is easy to transport the fluid using the piping system because piping can save cost, good in term of safety and easy to handle and maintain. Normally, for water, piping system is used from the pump house, go to the tower and distribute to residential, commercial and industrial customers. Other than that, gases like carbon dioxide or nitrogen is transfer normally from the storage tank placed in the building itself use piping system.

2.2 Design of pipeline

There are a few steps must to be done to establish pipeline system (Cornell et. al, 1959). The steps are:

1) Market survey

   Market survey is important to make sure the load demand needed. Load demand means the quantity of fluid needed by customers or equipments for operation. Besides that, in business, the important of market survey is to make sure company not having losses due to more expenditure from profit.

2) Pipe size and working

Pipe size can control the pressure of the pipe. Smaller pipe size or diameter contributes to high pressure of the fluid. There are standard pipe size called nominal pipe size (NPS). The nominal pipe size is based on inches. Wall thickness can be identified using NPS by referred to the pipe schedule.

Table 2.1: The list of NPS ⅛ to NPS 3½ wall thickness

Wall thickness inches (millimeters)							
NPS	**DN mm**	**OD inches**	**SCH 5**	**SCH 10**	**SCH 30**	**SCH 40**	**SCH 80**
⅛	**6**	0.405 in	0.035 in	0.049 in	0.057 in	0.068 in	0.095 in
¼	**8**	0.540 in	0.049 in	0.065 in	0.073 in	0.088 in	0.119 in
⅜	**10**	0.675 in	0.049 in	0.065 in	0.073 in	0.091 in	0.126 in
½	**15**	0.840 in	0.065 in	0.083 in	—	0.109 in	0.147 in
¾	**20**	1.050 in	0.065 in	0.083 in	—	0.113 in	0.154 in
1	**25**	1.315 in	0.065 in	0.109 in	—	0.133 in	0.179 in
1¼	**32**	1.660 in	0.065 in	0.109 in	0.117 in	0.140 in	0.191 in
1½	**40**	1.900 in	0.065 in	0.109 in	0.125 in	0.145 in	0.200 in
2	**50**	2.375 in	0.065 in	0.109 in	0.125 in	0.154 in	0.218 in
2½	**65**	2.875 in	0.083 in	0.120 in	0.188 in	0.203 in	0.276 in
3	**80**	3.500 in	0.083 in	0.120 in	0.188 in	0.216 in	0.300 in
3½	**90**	4.000 in	0.083 in	0.120 in	0.188 in	0.226 in	0.318 in

The table represent the standard nominal pipe size and and wall thickness for piping. The NPS is use in piping because there are inner and outer diameters for piping. It will way to choose piping become easier.

3) Pipe specification

Specification of the pipe means the material used, length and diameter of the pipe. The material used depend on the pressure involve and the fluid flow through the pipe.

4) Map of tentative route

The route of the pipe must be drawn first to make the pipe easily to construct. A systematic drawing must be drawn to make sure the position of the pipe is correct.

5) Total estimation of cost

Estimation of the cost is important for industries to know either the piping is profitable or not. The cost includes piping material, bending, process cost to combine the pipe and worker cost.

6) Construction

When all of the processes for piping construction accomplished, construction can be ran. Precaution must be taken to make sure construction is in safety condition.

7) Testing

After construction accomplished, testing must be ran to ensure the piping can be used and resist the pressure. Water can be used for testing because it is not dangerous.

8) Putting in service

After testing done, the piping will have last check and can be used. The piping must be maintained to make sure it is efficient to be used from day to day.

2.3 Standards and codes

For piping normally, the codes that being used are MS1063:2002 It is important to follow it to make sure the safety of people that involve in it and also the government acceptance for the piping.

2.3.1 Protection of pipeline from hazard

There are hazard that can happen accidently to pipeline such as flood and landslide. It will destroy the pipeline if the pipeline not construct properly. There are a few steps should be taken for precaution such as (Mohitpour, et. al., 2003) :

1) Constructing revetment
   Revetment used for piping protection from any physical damage. Normally, the revetment is placed if the pipeline is at underground.

2) Preventing corrosion
   Corrosion must be prevented to make sure it not reduce the efficiency of the pipe. Normally, the material used for water piping is material that not corrodes easily.

3) Increasing wall thickness
   Increasing wall thickness is important to protect piping. Increasing wall thickness will increase the cost of the project but for long term, it is good way for preventing hazard.

4) Installing anchor
   Anchor is clamp for pipe that used to protect pipe from hazard. Normally, anchor is used if piping is in the ground or beside wall.

It is important to make sure the steps are taken because any damage will increase the cost and cause losses.

2.3.2 Piping underground in the building

For piping under building, there are a few steps should be taken to prevent accident (Antaki, 2003). There are:

1) The piping should encase in an approved conduit designed to withstand the superimposed loads.
2) The piping should extend to the accessible and usable portion of building and the portion is conduit terminate.
3) The space between conduit and piping should be sealed
4) The piping that is touching the earth or the thing that can corrode it should be protected with suitable ways.

2.3.3 Pipe sizing for piping system

The sizing for piping system must follow several factors to make sure the piping in a condition (Antaki, 2003). The factors are length of piping, number of fitting, specific gravity of gas, diversity factor, prediction of future demand, maximum gas demand and allowable pressure loss from the supply point to equipment.

2.4 Plastic piping material

Plastic is strong and cheap material that can be used in piping. It is used for several type of fluid that not corrode it like water. It upper limit temperature is 150^{o}F (Willoughby & Woodson, 2002).

2.4.1 Polyvinyl chloride (PVC)

PVC is dangerous if it is in fire because it can release toxic gas. For code and standard, it is compulsory to follow the standard (Frankel, 2010) that is for interior water pipe pressure use D-2241, D-1785 and D-272, fittings use D- 2665 and plastic pipe and fittings use CS-272

2.4.2 Clorinated polyvinyl chloride (CPVC)

Modified from PVC and has extra chlorine on it, and can extent it temperature limit to 200^{o}F. It must follow the following standard (Frankel, 2010). For piping the standard used is ASTM D-2846, F-441 and F-442. For fitting standard used the F-437, F-438 and F-439

2.4.3 Polyethylene (PE)

Polyethylene is widely use for it superior toughness, ductility, flexibility and ability to dampen water shock. It can be used for gas distribution piping and potable water. The upper service temperature limit is 150^{o}F. It can be used within chemical because of it flexibility and normally used as drainage material. There are 4 types of PE pipe and it is classified as type 1, 2, 3 and 4 follow the density of resin used. The 4 is the highest density is called HDPE. The normally used PE pipe is type 3 and 4 (Frankel, 2010).

2.4.4 Overall advantages of plastic pipe

Plastic pipe has it advantages based on the material involve. The advantages make it commonly used nowadays beside of it cost that cheapest compared to other material. The advantages of the plastic material are (Chasis, 1988):

1) Corrosion resistance

   Plastic is corrosion resistance because of it non conductivity. It can be buried in acidic and alkaline soil with no special casing.

2) Low thermal conductivity

   The advantages may give the plastic type resist any non-uniform temperature of fluid inside the pipeline.

3) Flexibility

   It can minimize the expansion or contraction because of it flexibility.

4) Low friction loss

   It can transfer fluid use less horsepower than metal and non-metallic pipe. Low friction loss and corrosion resistance make it can be use in small diameter and save cost.

5) Long life

   Due to it resistance to most of corrosion factors, it is long life. For example, there is 25 years installed plastic pipe be examined and there is only a little degradation found.

6) Lightweight

It is light and is easy to carry and the cost for transport and install can be reduced.

7) Colored piping

The plastic piping is easy to colored thus it is easy to labeled and identified

2.4.5 Non-Ferrous Pipe

Non-ferrous pipe and fitting materials are metallic materials with a non-iron matrix. For example, aluminium, copper and nickel.

1) Aluminium Alloys

Aluminum is obtained by mining and processing aluminum ore which contains aluminum oxide, iron, silicon and impurities. It is reactive with oxygen and forms a strong protective oxide layer. The 1000 series means pure aluminum, 2000 series means aluminium cuprum alloys, 3000 series means aluminium manganese alloys, 4000 series means aluminium silicone alloys, 5000 series means aluminium manganese alloys, 6000 series means aluminium carbon alloys, and 7000 series means aluminium zink alloys. The four digit number of Aluminum alloys is usually followed by a letter that identifies the type of heat treatment applied to the material. For example F is as-fabricated, H is strain hardened, W is solution heat-treated, T corresponds to other heat treatment.

2) Nickel Alloys

Nickel is a ductile metal, high strength and good corrosion resistance, it make the stainless steel, which is why close to half the production of nickel is used as stainless steel alloy. Nickel based alloys are valuable in corrosive or high temperature applications

3) Copper Alloys

Copper, bronze and brass have been used to make pipes as early as 3000 BC because they are soft, easy to form, and corrosion resistant in water service. A common copper tube material is ASTM B 88, available in three tubing sizes that is K, L and M.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The design process in FKKSA's lab started with collecting information about the piping. Then, the elevation from ground and pipe length is observed. The piping is observed whether it needs to be adjusted and the area of adjustment is specified. The 2D drawing is drawn. Next, the 3D drawing is started using PDMS.

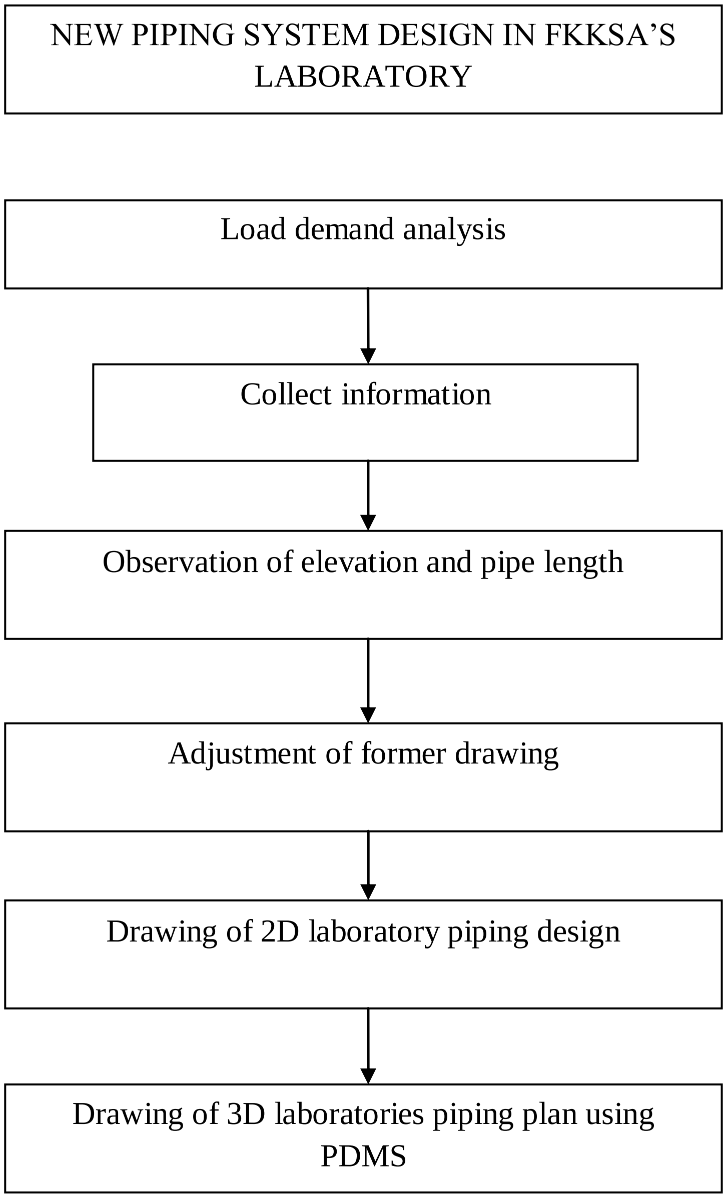

Figure 3.1 New deionized water and air piping

3.2 New piping system design in FKKSA's laboratory

The new piping system design is based on the latest piping and equipments in the laboratory. There are many things to do because the piping elevation is high. Other than that, there are several upgrade been done to make sure the pipeline is compatible and easy to identify.

3.2.1 Load demand analysis

Load demand analysis is used to know either pressure supply from initial point enough or not. If enough, the load demand can be identify. The load demand of deionized water in FKKSA’s laboratory is about 170 m3/day and air 80 m3/day.

3.2.2 Collect information

There is several important information that are collected to run the PDMS. Firstly, the size of the pipe that is 3/2 inch,1/2 and 1 inch. The piping is divided into several parts to make the task easily. There are only 2 type of fluid flow through the pipe involve that is water and compressed air pipe. The temperature is negligible because the change in it is small.

3.2.3 Observation of elevation and length

The number of tee and the bend of the pipe also must be considered because it influences the length of the piping. The elevation of the piping from ground must be evaluated because it influenced the work in PDMS. The elevation of piping is based on estimation that from aboveground.

3.2.4 Adjustment of former drawing

The former drawing is adjusted to make it follow what has been plan. It is important to make double or triple check before doing 2D drawing to make sure the position of the piping accurate.

3.2.5 Drawing of 2D laboratories piping design

2D laboratories piping design need to be done before proceed to 3D design in PDMS. It is to make sure no mistake is done in PDMS drawing. The position of the piping is draw properly to make sure the length is correct. Any mistake in position will influence the length thus will destroy the PDMS drawing.

3.2.6 Drawing of 3D laboratories piping plan using PDMS

This is the crucial part of all in the project. First of all, the coordinate (0,0,0) must be set to make sure position of the pipe is same as the real one. There must be equipment or at least the tee must be put to know the real position of piping. After the entire preliminary step is done, the drawing can be drawn as 2D design.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The result of new air and water piping system is divided into three that is calculation, drawing in plant design management system (PDMS) and materials for the new piping system. The calculation part consists of flow rate and pressure drop calculation after new piping drawing is designed. The material and methodology used in the project were described in Chapter 3. In this research, the air and water source is from tank between FKKSA's laboratory and former mechanical's laboratory. The deionized water source is from chiller room and the air source is from air compressor room at the former mechanical laboratory.

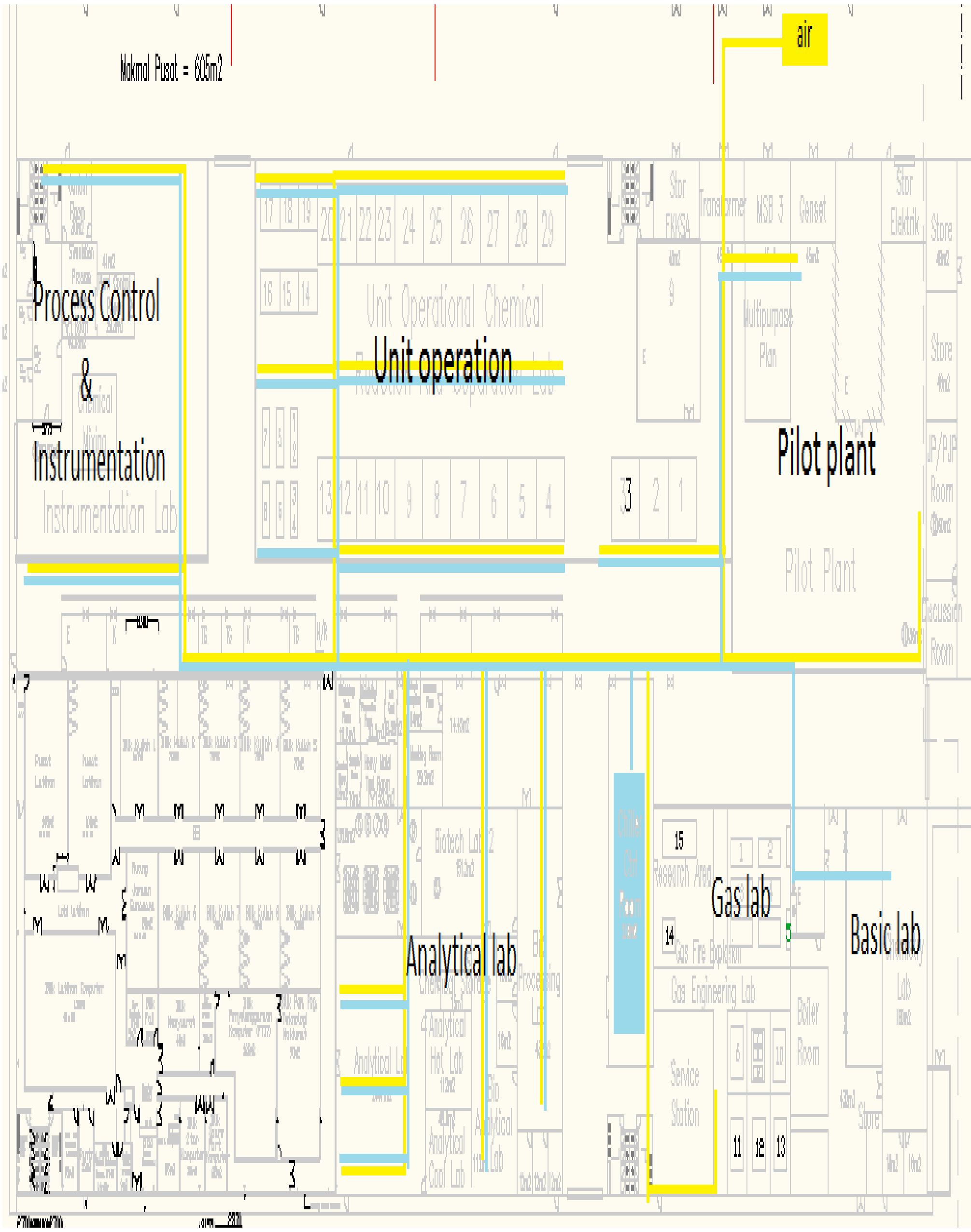

Figure 4.1 FKKSA's laboratory air and deionized water piping

The yellow line indicates air piping system and the light blue indicates deionized water. There are 6 parts in the laboratory yhat is process control and instrumentation area, pilot plant area, analytical laboratory area, basic laboratory area and gas laboratory area.

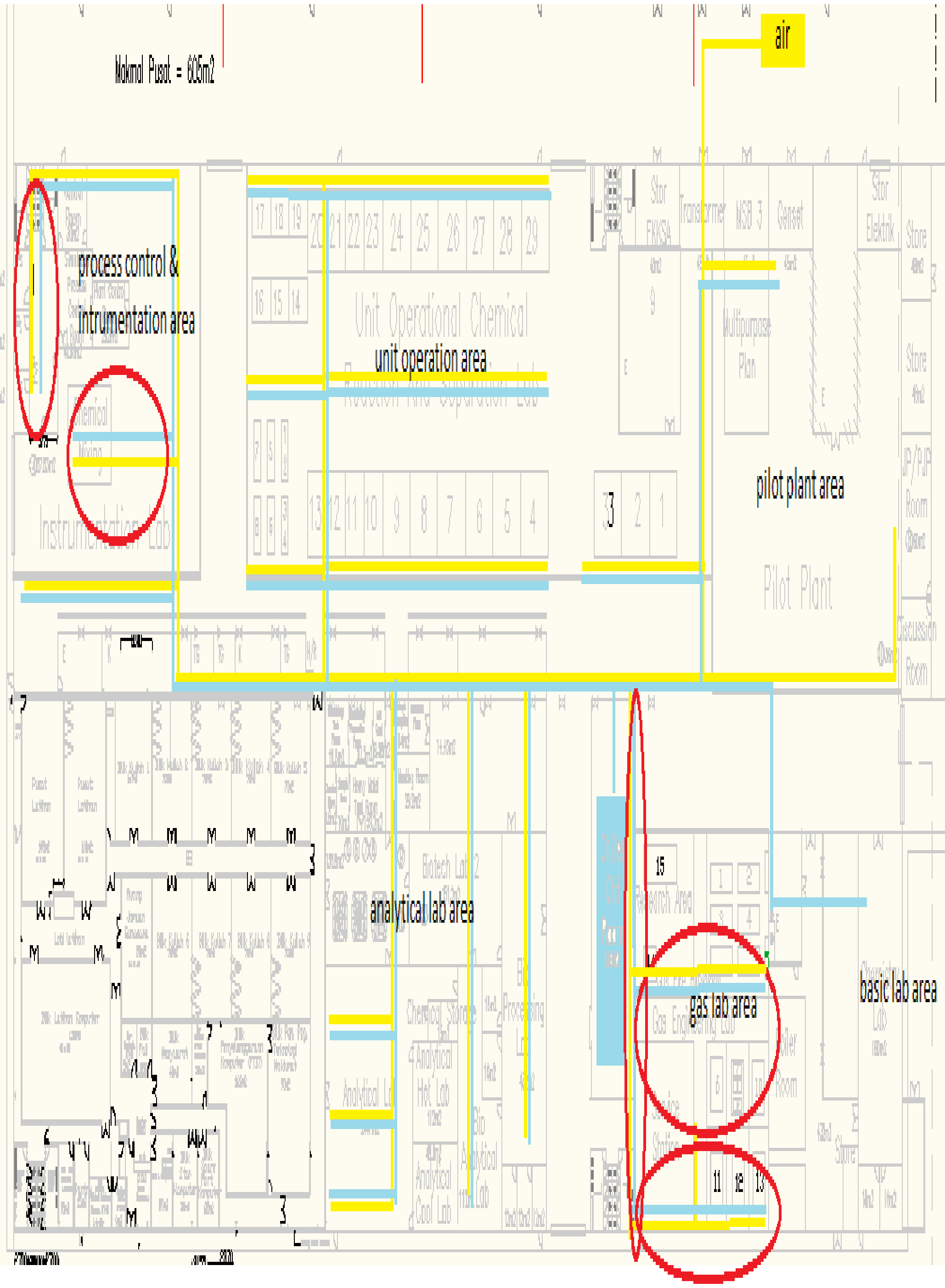

Figure 4.2 FKKSA's laboratory air and deionized water piping proposed

The yellow line indicates air piping system, the light blue indicates deionized water and the red circle indicates the new piping system. The additional piping is located in gas laboratory area and process control and instrumentation area due to additional equipments.

4.2 Result

4.2.1 Calculation for Pressure drop and flow rate

There are 2 fluids involve in the calculation of flow rate and pressure drop that are air and deionized water. The parameter involve is internal pipe diameter and pipe length. The friction coefficient is depend on type of piping. The velocity is constant that is 0.25 m/s.

Pressure drop formula for piping that not have any elevation

$$\Delta P = \frac{PfLv^2}{2D}$$

ΔP = PRESSURE DROP DUE TO FRICTION IN PIPE
P = DENSITY (water-998.2kg/m^3)/(air-1.225 kg/m^3)
f = FRICTION COEFFICIENT (0.0385)
L = PIPE LENGTH
v = VELOCITY
D = INTERNAL PIPE DIAMETER

Pressure drop formula for piping that involve elevation

$$\Delta P = Pg\Delta H$$

ΔP = PRESSURE DROP DUE TO FRICTION IN PIPE
P = DENSITY
g = GRAVITIONAL FORCE (9.81m2/s)
ΔH = VERTICAL ELEVATION

1) Air pressure drop and flow rate calculation

The parameter involves in pressure drop for air calculation is pipe diameter and pipe length. If one of the parameter is changed, it will change the pressure drop. The constant involve is inlet and outlet velocities, friction coefficient and density. The density for air is 1.225 kg/m^3. The friction coefficient for metal in air is 2. The constant will change automatically if the parameter is changed. The result for pressure drop for air is stated below:

Table 4.1 Air pressure drop for pilot plant

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Pilot plant area					
1	8.61875	2.5	0.0254	8.61868	$7.0614\text{x}10^{-5}$
2	8.61868	6	0.0254	8.61799	0.00069
3	8.61799	26	0.0254	8.61725	0.00074
4	8.61725	4.5	0.0254	8.61712	0.00013
5	8.61712	6	0.0254	8.61780	-0.00069
6	8.61780	15	0.0127	8.61695	0.00086

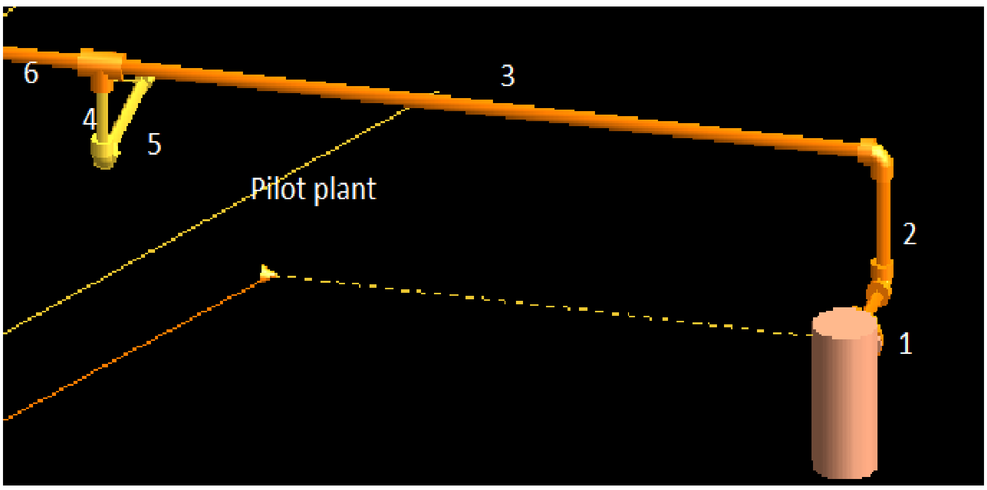

Figure 4.3 Air piping system for pilot plant

The pressure drop in the pilot plant is small. There are negative pressure drop means the pressure is added to the pipeline pressure due to flow of air that is downward. The tank pressure is 8.61875 bar.

Table 4.2 Air pressure drop for unit operation area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Unit operation area					
7	8.61875	75	0.0254	8.61470	0.00215
8	8.61470	8	0.0254	8.61447	0.00023
9	8.61447	4	0.0254	8.61492	-0.00046
10	8.61492	46	0.0127	8.61229	0.00264
11	8.61492	1	0.0127	8.61487	5.7284×10^{-5}
12	8.61447	9.5	0.0254	8.61420	0.00027
13	8.61420	4	0.0254	8.61465	-0.00046
14	8.61465	46	0.0127	8.61202	0.00264
15	8.61465	1	0.0127	8.61196	5.7284×10^{-5}
16	8.61420	11	0.0254	8.61388	0.00032
17	8.61388	1.5	0.0254	8.61405	-0.00017
18	8.61405	46	0.0127	8.61142	0.00264

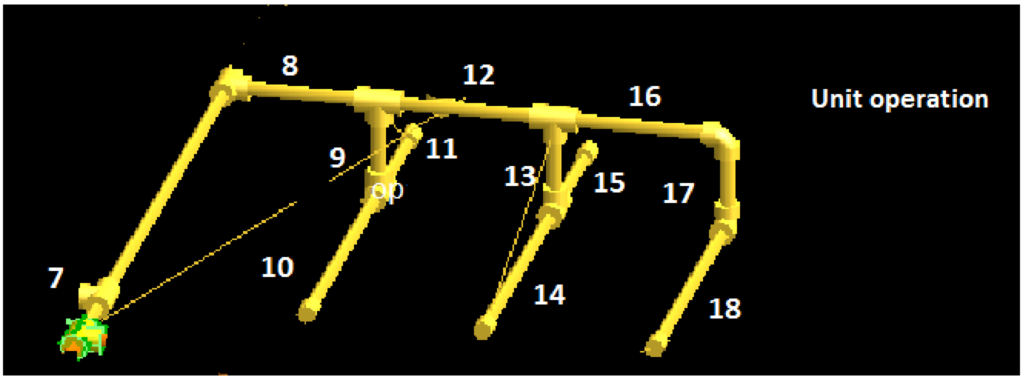

Figure 4.4 Air piping system for unit operation area

Table 4.3 Air pressure drop for process control and instrumentation area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Process control and instrumentation area					
19	8.61470	22	0.0254	8.61407	0.00063
20	8.61407	8	0.0254	8.61383	0.00023
21	8.61383	4	0.0254	8.61429	-0.00046
22	8.61383	23	0.0127	8.61341	0.00066
23	8.61341	28.5	0.0254	8.61259	0.00082
24	8.61259	25	0.0254	8.61188	0.00072
25	8.61188	2	0.0254	8.61210	-0.00023
26	8.61210	0.5	0.0127	8.61208	$2.8642x10^{-5}$

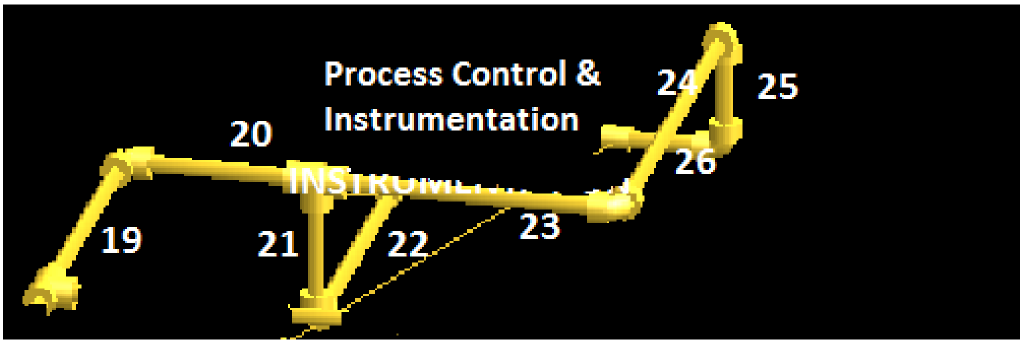

Figure 4.5 Air piping system for process control and instrumentation area

There are new piping in process control and instrumentation laboratory that is pipe 25 and 26. The pressure drop at pipe 24 and 25 is small and indicates the air can flow. The Process Control and Instrumentation area use air piping for it process control and instrumentation equipments.

Table 4.4 Air pressure drop for pilot plant 2 area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Pilot plant 2					
27	8.61685	3	0.0254	8.61407	0.00036
28	8.61707	7.5	0.0254	8.61686	0.00021
29	8.61383	5.2	0.0127	8.61745	-0.00059

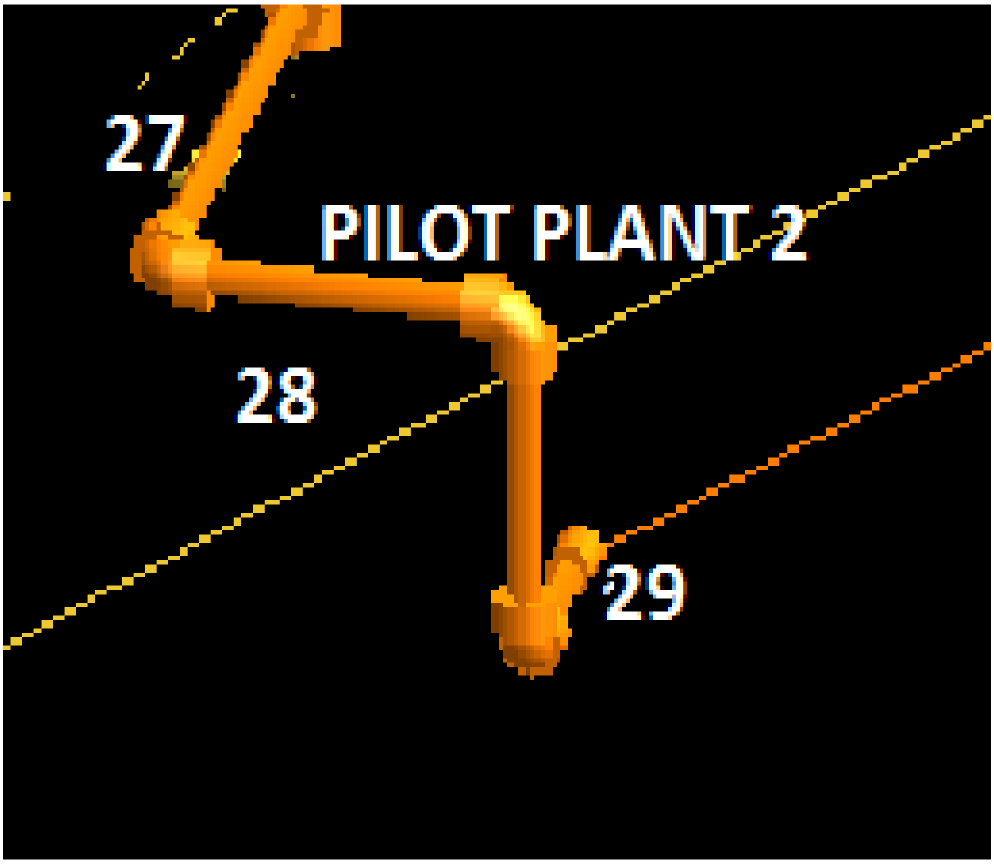

Figure 4.6 Air piping system for pilot plant area

The pressure drop in pilot plant 2 shows it can flow well like formerly. Pilot plant 2 has only 3 point of pressure.

Table 4.5 Air pressure drop for gas laboratory area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Gas laboratory area					
30	8.61685	22	0.0254	8.61622	0.00063
31	8.61622	5.5	0.0254	8.61606	0.00016
32	8.61527	1	0.0127	8.61000	5.7284×10^{-5}
33	8.61527	5	0.0254	8.61591	0.00014
34	8.61685	10.5	0.0254	8.61654	0.00030

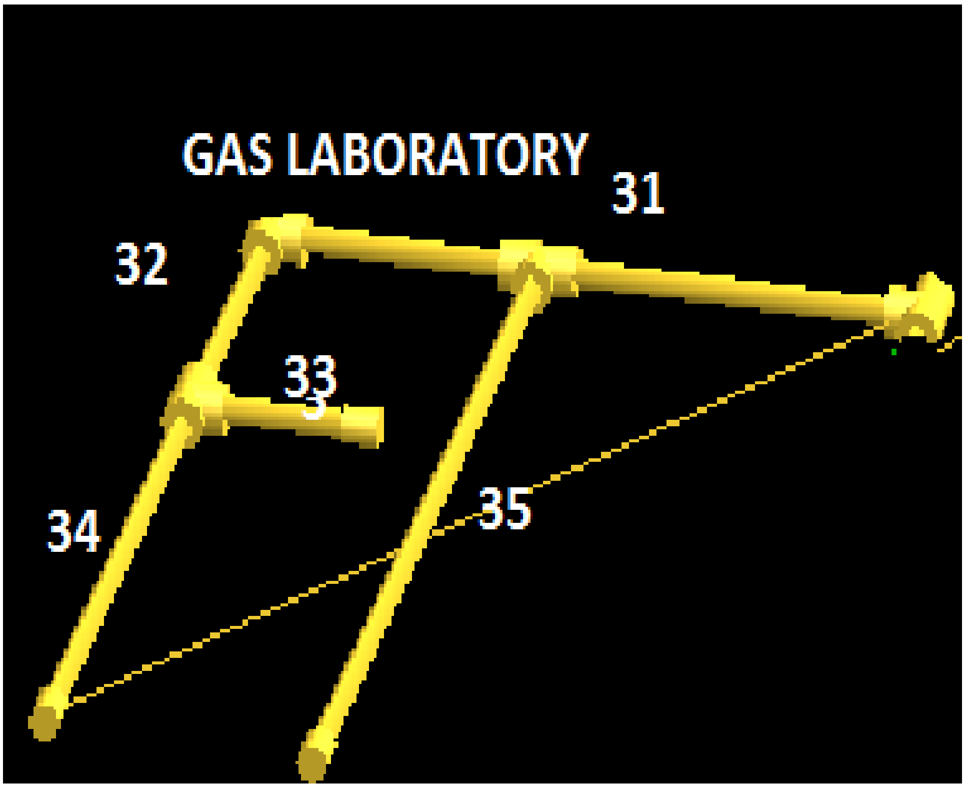

Figure 4.7 Air piping system for gas laboratory area

Gas laboratory area has 2 new pipes that is pipe 34 and 35. The pressure for the two pipes shows that the air can flow steadily because the pressure drop is so small.

2) Deionized water pressure drop and flow rate calculation

The parameter involve in pressure drop for water calculation is pipe diameter (D) and pipe length (L).. If one of the parameter is changed, it will change the pressure drop. The density of the water is 998 kg/m^3. The friction factor used for PVC pipe is 0.5 The constant involve velocities, friction factor and density. The constant will change automatically if the parameter is changed. The result for pressure drop for water is stated below:

Table 4.6 Deionized water pressure drop for pilot plant area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Process control and instrumentation area					
1	1.2411	1	0.0381	1.23696	0.00409
2	1.23696	3	0.0381	0.94319	0.29377
3	0.94319	2	0.0381	0.93501	0.00819
4	0.93501	4.5	0.0381	0.91658	0.01842
5	0.91658	8	0.0381	0.88383	0.03275
6	0.88383	6	0.0381	1.47137	-0.58754
7	1.47137	15	0.0127	1.28716	0.18422
8	0.88383	16	0.0381	1.22166	0.06550

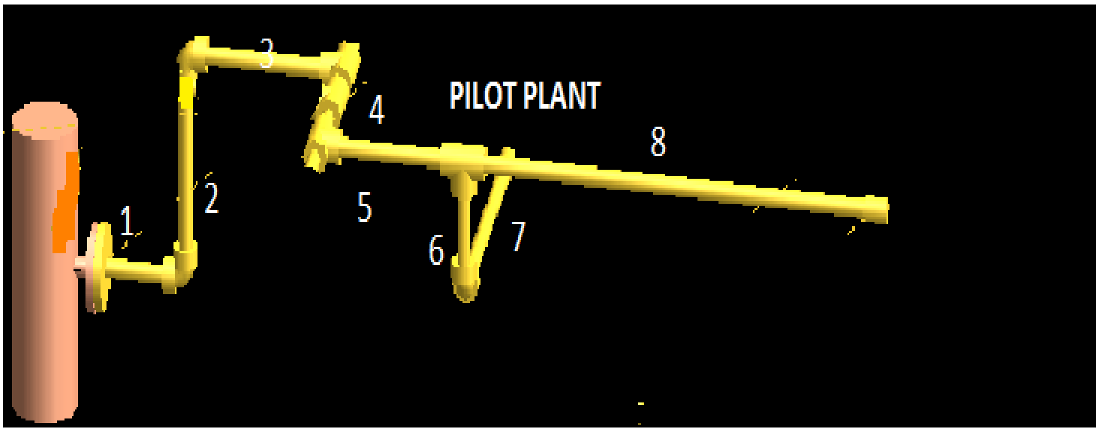

Figure 4.8 Deionized water piping system for pilot plant area

The figure shows deionized tank that is placed in chiller room. The pressure of the deionized water tank is 1.2 bar. Pipe 2 pressure drop is high due to the upward flow of the deionized water.

Table 4.7 Deionized water pressure drop for unit operation area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Unit operation area					
9	0.93501	75	0.0381	0.64640	0.28860
10	0.64640	8	0.0381	0.61365	0.032749
11	0.61365	4	0.0381	1.00534	-0.39169
12	1.00534	46	0.0127	0.44041	0.56492
13	1.00534	1	0.0127	0.99306	0.01228
14	0.61365	9.5	0.0381	0.57476	0.03888
15	0.57476	4	0.0381	0.96645	-0.39169
16	0.96645	46	0.0127	0.40152	0.56492
17	0.96645	1	0.0127	0.95417	0.01228
18	0.57476	11	0.0381	0.52973	0.04503
19	0.52973	1.5	0.0381	0.67661	-0.14688
20	0.67661	46	0.0127	0.11169	0.56492

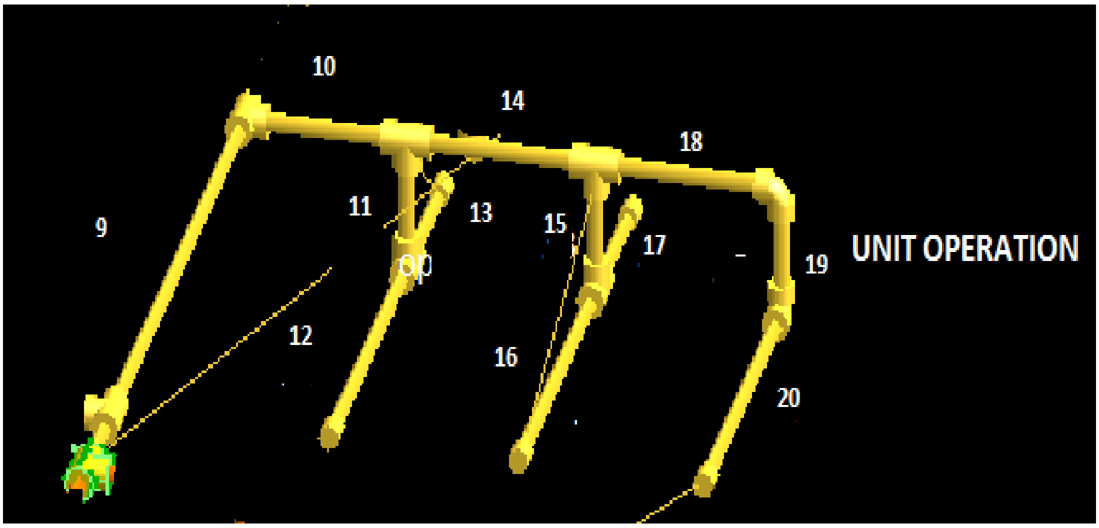

Figure 4.9 Deionized water piping system for unit operation area

The deionized water can flow steadily through unit operation pipe but in pipe 20, the water is slow. The deionized water can flow although it is slow. The slow water flow is due to length of the pipe that is long.

Table 4.8 Deionized water pressure drop for process control and instrumentation area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Process control and instrumentation area					
21	0.64640	22	0.0381	0.55634	0.09006
22	0.55634	8	0.0381	0.52359	0.03274
23	0.52359	4	0.0381	0.94803	-0.39169
24	0.94803	23	0.0127	0.66557	0.28246
25	0.55634	28.5	0.0381	0.43967	0.11666
26	0.43967	25	0.0381	0.33732	0.10234
27	0.33732	2	0.0381	0.53317	-0.19584
28	0.53317	0.5	0.0127	0.52703	0.00614

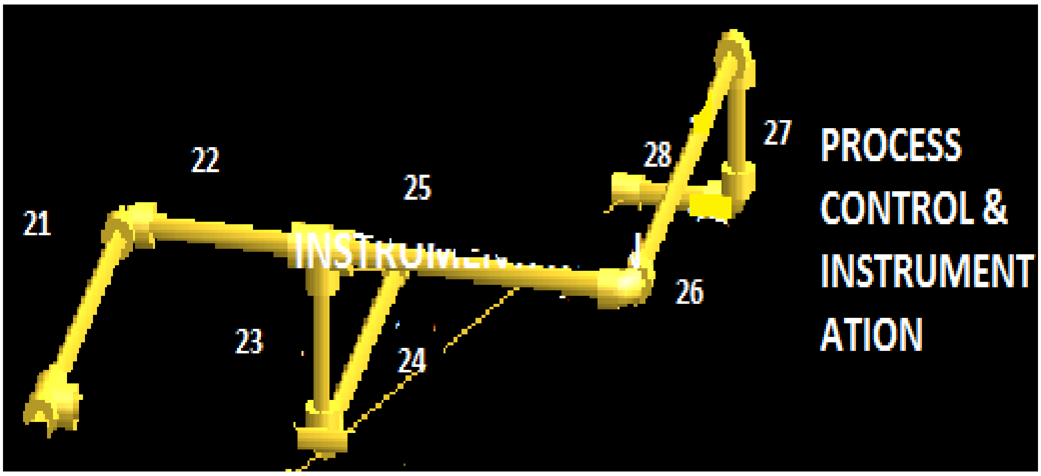

Figure 4.10 Deionized water piping system for process control and instrumentation area

Deionized water can flow steadily even there is new piping which is piping 27 and 28. The length do not contributes to high pressure drop.

Table 4.9 Deionized water pressure drop for basic laboratory area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Basic laboratory					
30	0.88383	3	0.0381	0.87155	0.01228
31	0.87155	1	0.0381	0.96947	-0.09792
32	0.96947	8	0.0381	0.93672	0.03274
33	0.93672	15.5	0.0381	0.87327	0.06345
34	0.87327	4	0.0381	0.85690	0.01637
35	0.85690	4	0.0127	0.80777	0.04912

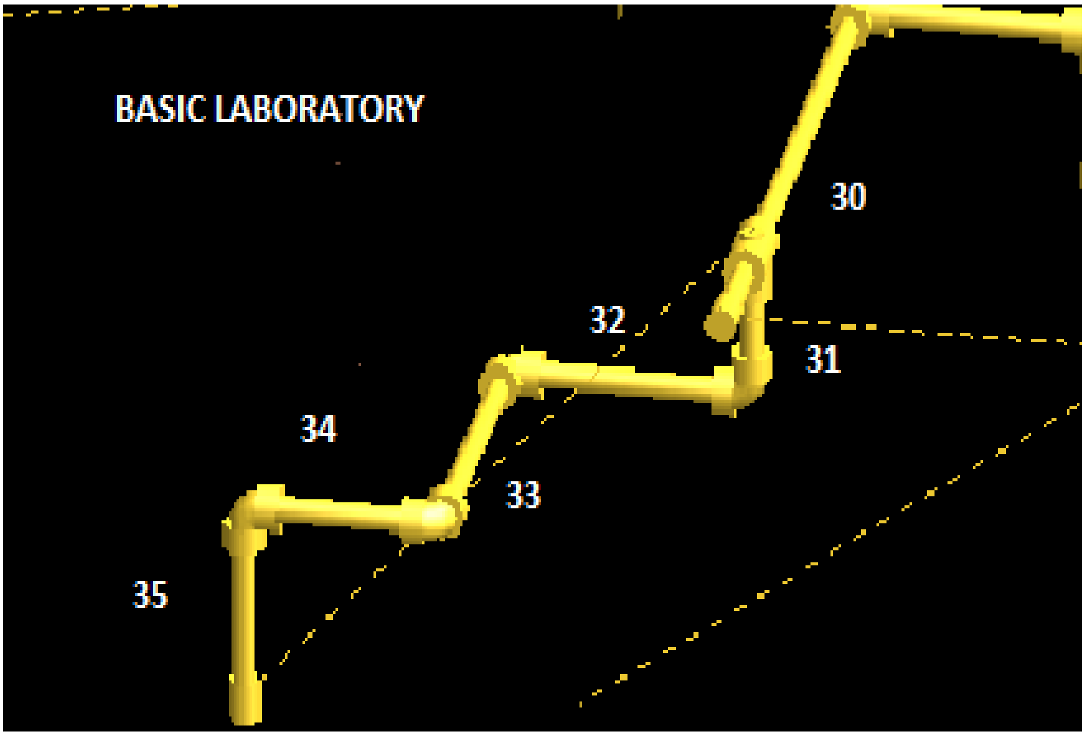

Figure 4.11 Deionized water piping system for basic laboratory area

Table 4.10 Deionized water pressure drop for gas laboratory area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Gas laboratory					
36	0.91658	22	0.0381	0.82652	0.09006
37	0.82652	14.5	0.0381	0.76716	0.05935
38	0.82652	14.5	0.0381	0.76716	0.05935

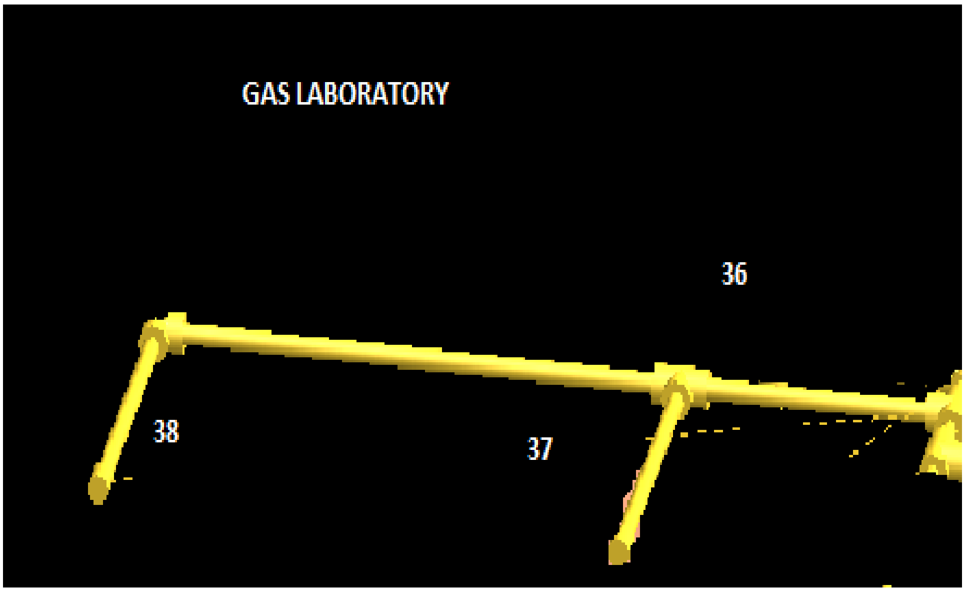

Figure 4.12 Deionized water piping system for gas laboratory area

Deionized water piping in gas laboratory area is new. The pipe is 36, 37 and 38. The pressure drop shows it can operate steadily.

4.2.2 Drawing in plant design management system (PDMS)

In PDMS, there must be an initial point (0,0,0) that represent (X,Y,Z). Next, the piping system is create with nozzle first. Next, the tank and nozzle is set to make sure it coordinates is suitable each other and the tail and head is set. After that, the next pipe equipments for example elbow, cap or tee is choose. To make new branch, There must be new head and tail.

1) PDMS for air

Air initial point (0,0,0) is at air tank that is at former mechanical's laboratory. The flow for PDMS and pressure drop calculation must start from the air tank. The air is compressed to make sure it is in high pressure.

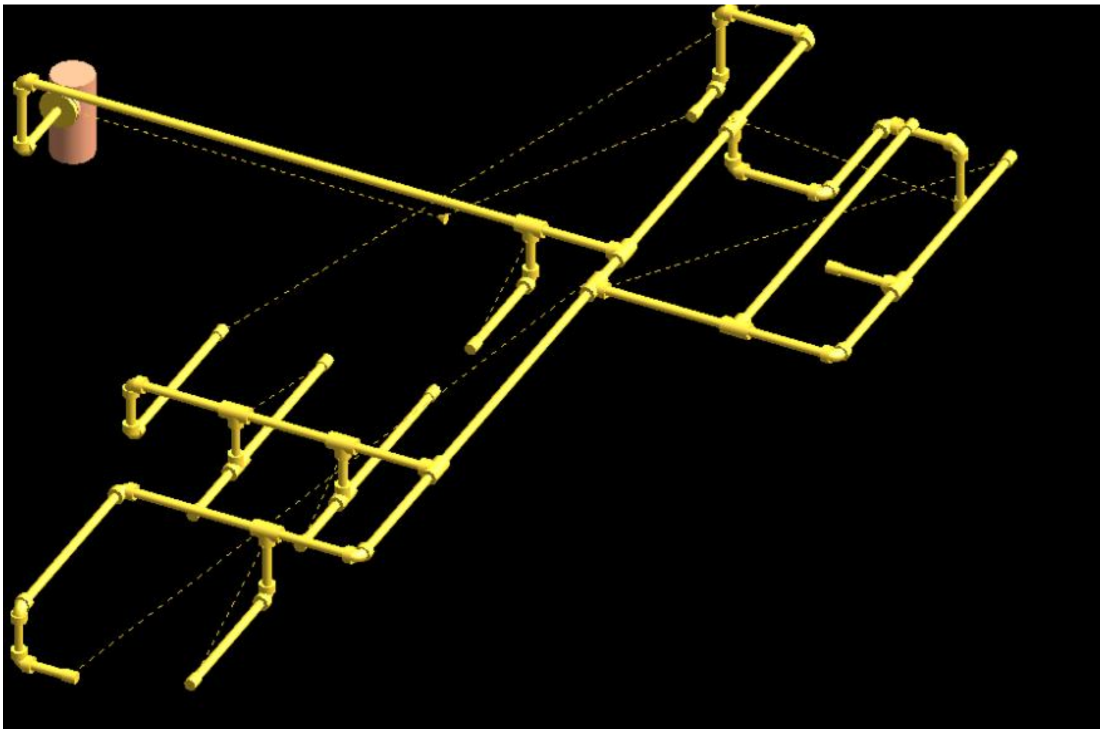

Figure 4.13 PDMS drawing for air third isometric view

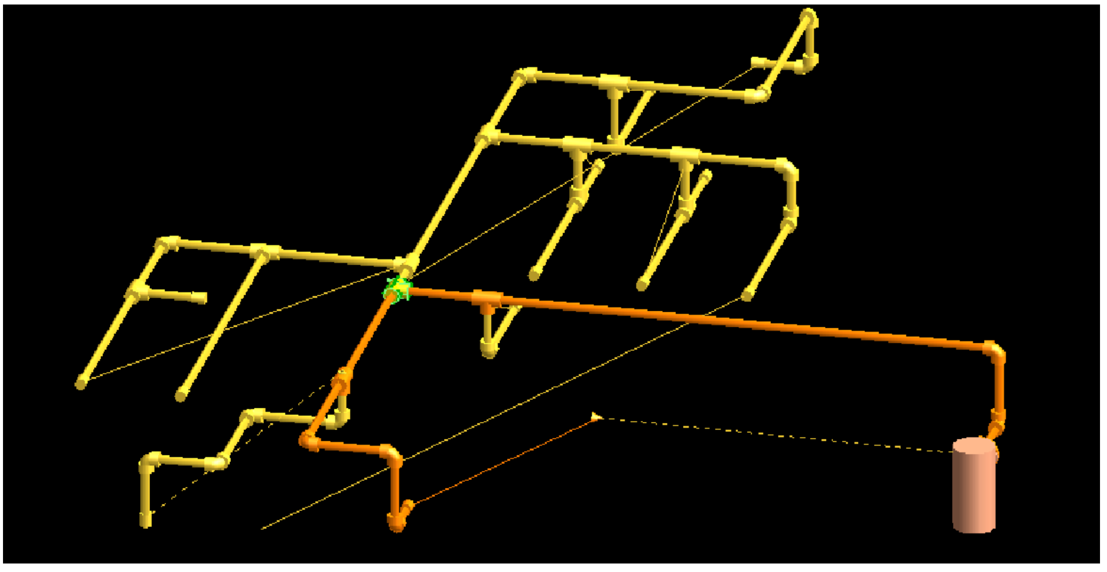

Figure 4.14 PDMS drawing for air

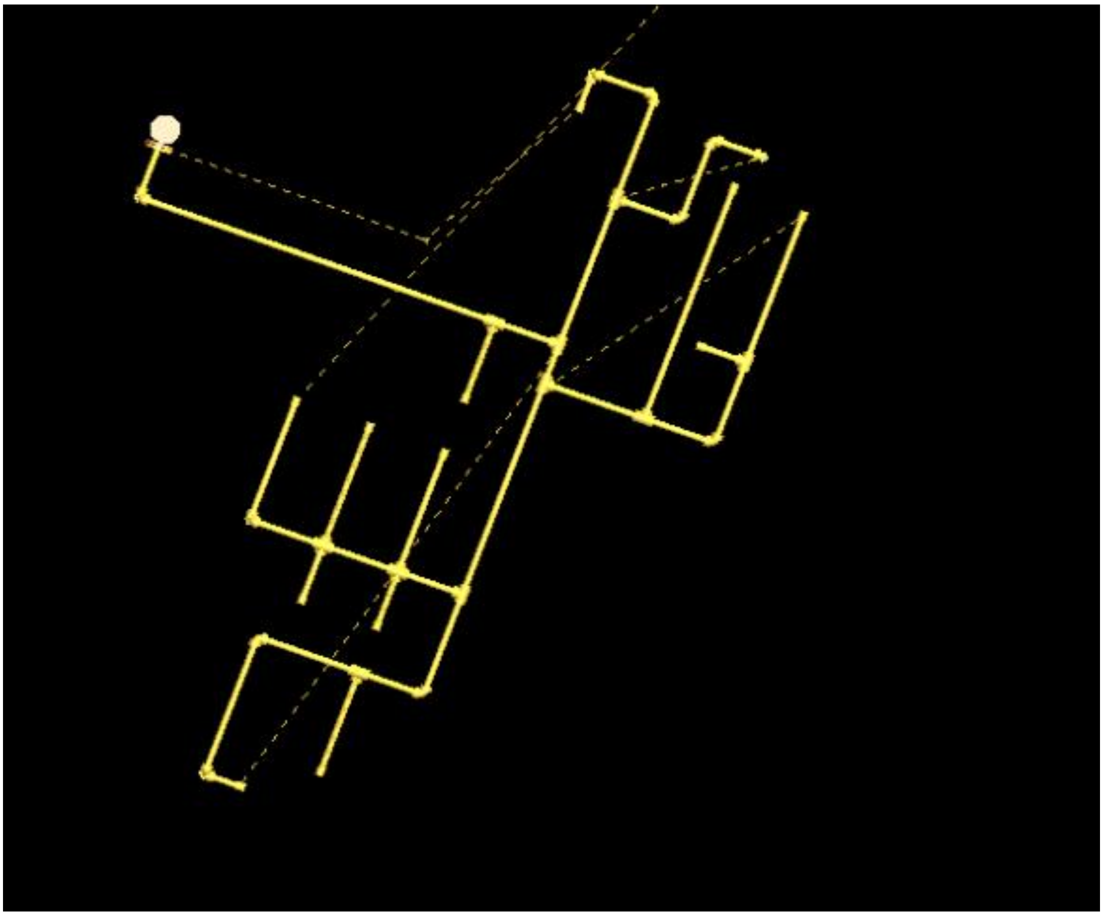

Figure 4.15 PDMS drawing for air in plan view

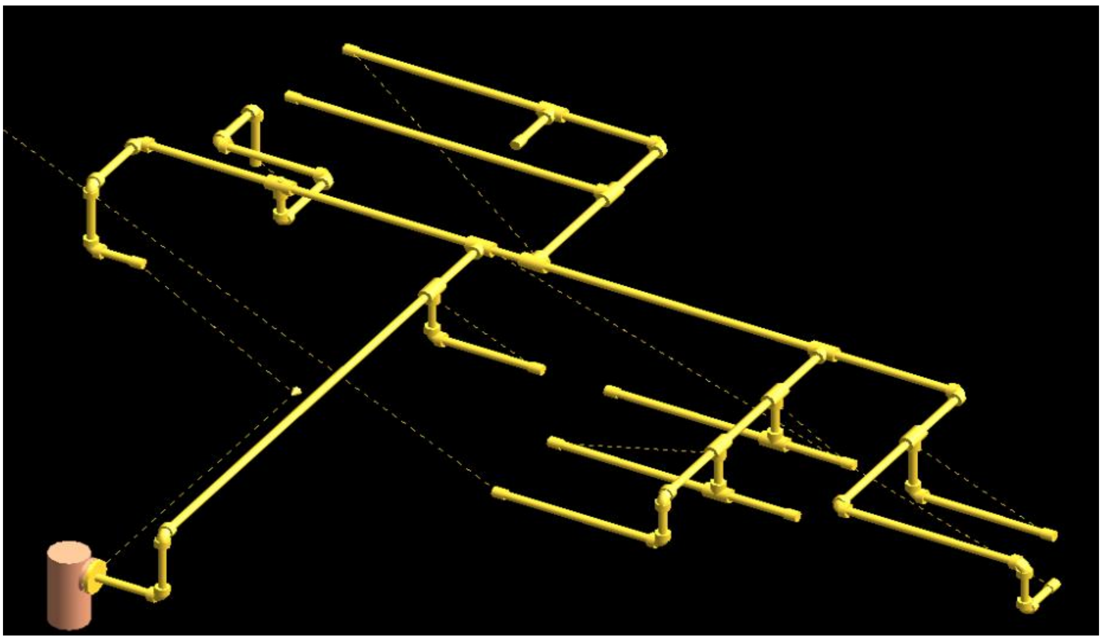

Figure 4.16 PDMS drawing for air first isometric view

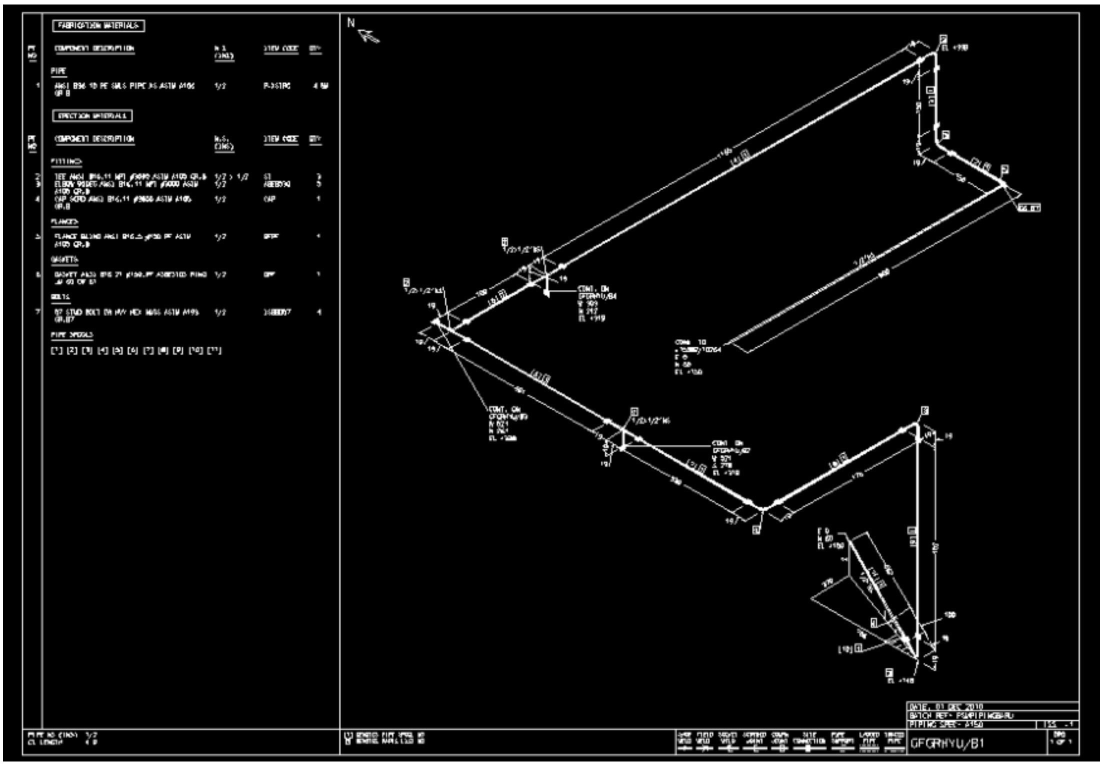

Figure 4.17 Isometric for air piping system

Isometric figure for air piping system indicates the length of the piping and elevation. Other than that, in the left box mention the pipe specification and pipe equipment. This view is only can be activated when only piping is in the plane.

2) PDMS for deionized water

Deionized water initial point (0,0,0) is at deionized water tank that is in chiller room. The chiller room is beside the gas laboratory. The chiller room must be starting point for PDMS drawing and pressure drop calculation.

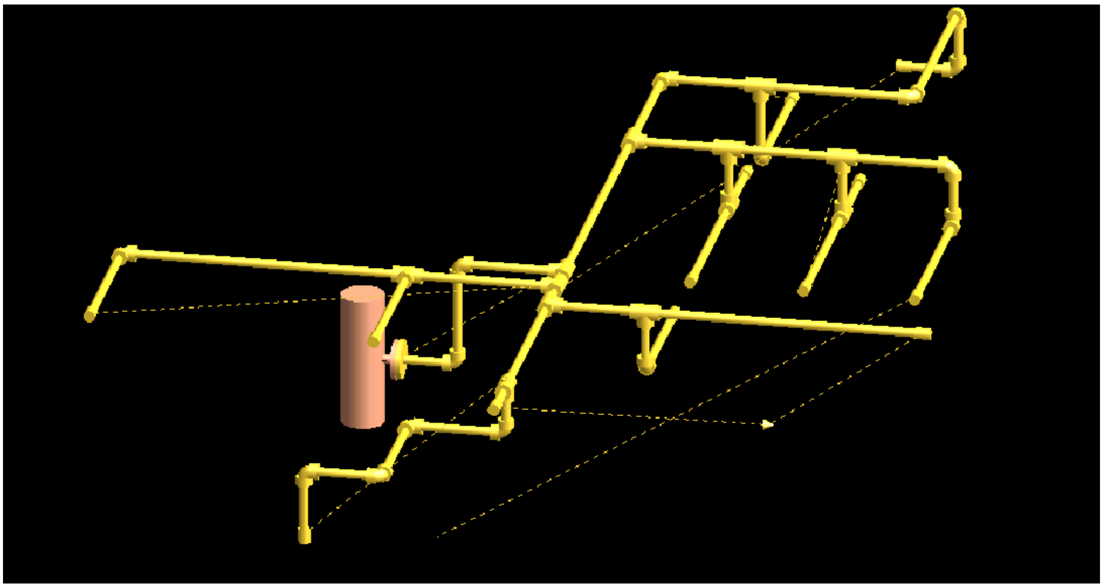

Figure 4.18 PDMS drawing for deionized water

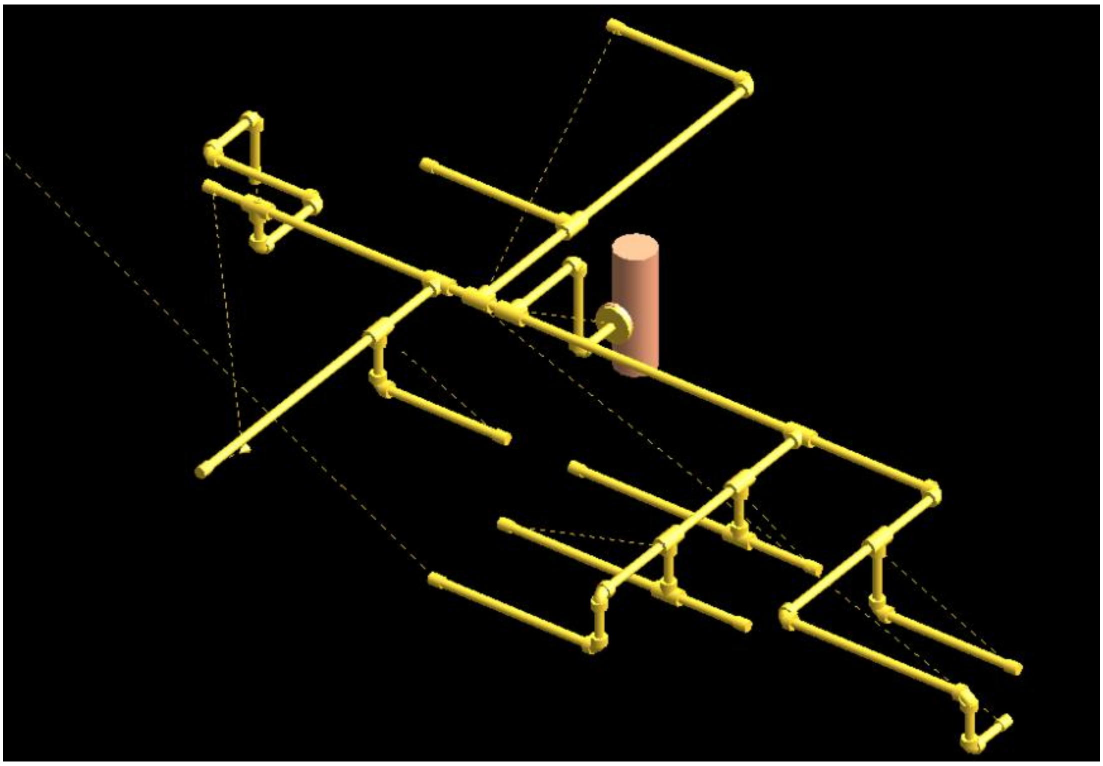

Figure 4.19 PDMS drawing for deionized water first isometric view

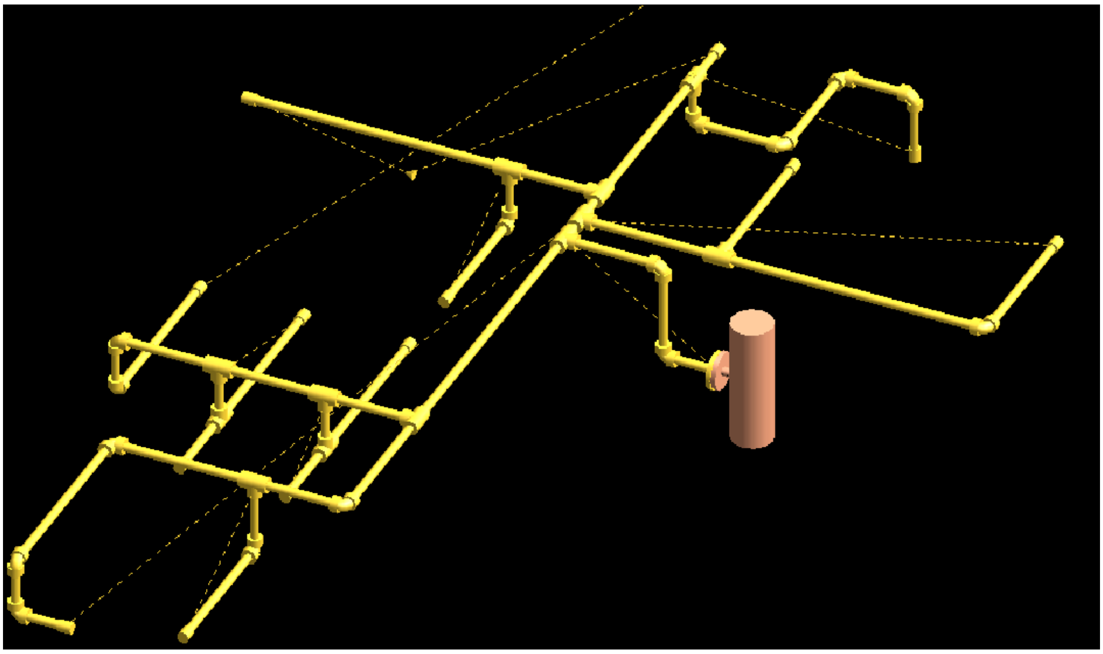

Figure 4.20 PDMS drawing for deionized water fourth isometric view

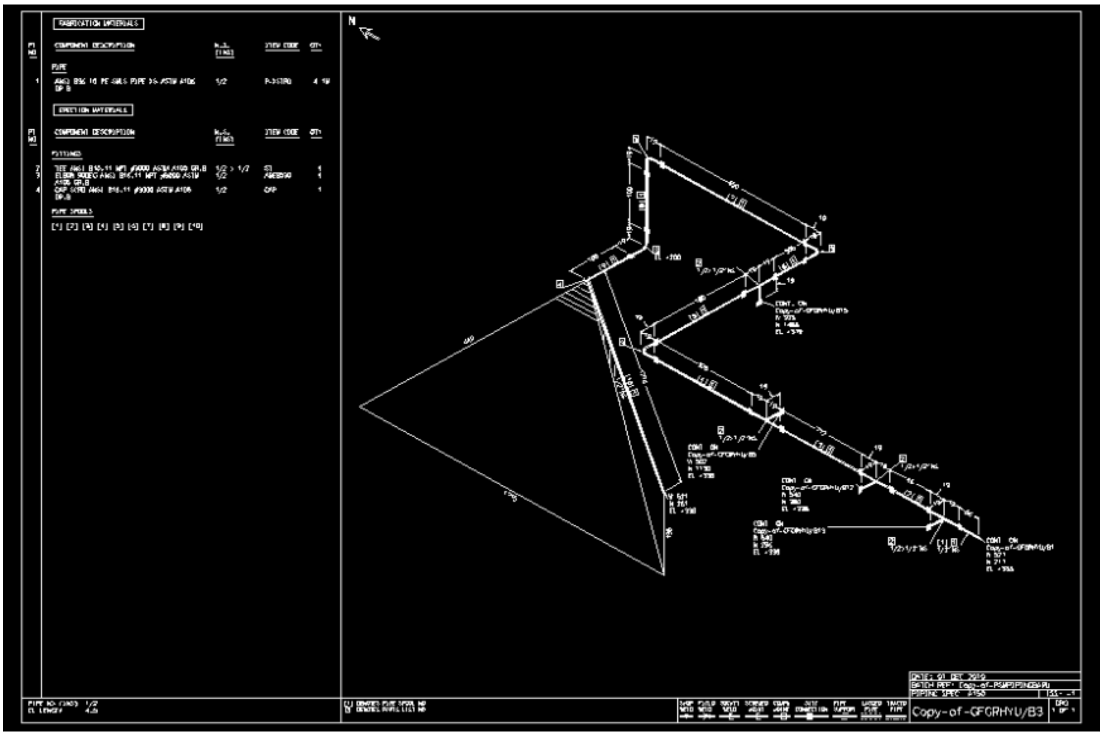

Figure 4.21 Isometric for deionized water piping system

The isometric view for deionized water piping system above show that the pipe is in good condition

4.3 Discussion

The pressure drop indicates that the air and deionized water is able to flow from its initial point to final point when the pressure drop is below 30 percent from initial pressure.

Table 4.11 Air pressure drop percentage for FKKSA's laboratory

Inlet pressure (bar)	Pressure drop (bar)	Pressure drop percentage (%)
Pilot plant area		
8.61875	7.0614×10^{-5}	0.000819
8.61868	0.00069	0.008006
8.61799	0.00074	0.008587
8.61725	0.00013	0.001508
8.61712	0.00069	0.008007
8.61780	0.00086	0.009979
Unit operation area		
8.61875	0.00215	0.024950
8.61470	0.00023	0.002670
8.61447	-0.00046	0.005340
8.61492	0.00264	0.030645
8.61492	5.7284×10^{-5}	0.000665
8.61447	0.00027	0.003134
8.61420	-0.00046	0.005340
8.61465	0.00264	0.030647
8.61465	5.7284×10^{-5}	0.000665
8.61420	0.00032	0.003715
8.61388	-0.00017	0.001974
8.61405	0.00264	0.030648

Process control and instrumentation area		
8.61470	0.00063	0.007313
8.61407	0.00023	0.002670
8.61383	-0.00046	0.005340
8.61383	0.00066	0.007662
8.61341	0.00082	0.009520
8.61259	0.00072	0.008360
8.61188	-0.00023	0.002671
8.61210	$2.8642x10^{-5}$	0.000333
Pilot plant 2		
8.61685	0.00036	0.004178
8.61707	0.00021	0.002437
8.61383	-0.00059	0.006849
Gas laboratory area		
8.61685	0.00063	0.007311
8.61622	0.00016	0.001857
8.61527	$5.7284x10^{-5}$	0.000665
8.61527	0.00014	0.001625
8.61685	0.00030	0.003482

Table 4.12 Deionized water pressure drop percentage for FKKSA' laboratory

Inlet pressure (bar)	Pressure drop (bar)	Pressure drop percentage (%)
Pilot plant area		
1.2411	0.00409	0.329546
1.23696	0.29377	23.74935
0.94319	0.00819	0.868330
0.93501	0.01842	1.970032
0.91658	0.03275	3.573065
0.88383	-0.58754	66.47659

Unit operation area		
0.93501	0.28860	30.86598
0.64640	0.032749	5.066368
0.61365	-0.39169	63.82954
1.00534	0.56492	56.19194
1.00534	0.01228	1.221477
0.61365	0.03888	6.335859
0.57476	-0.39169	68.14844
0.96645	0.56492	58.45310
0.96645	0.01228	1.270630
0.57476	0.04503	7.834574
0.52973	-0.14688	27.72733
0.67661	0.56492	83.49271
Process control and instrumentation area		
0.64640	0.09006	13.93255
0.55634	0.03274	5.884891
0.52359	-0.39169	74.80853
0.94803	0.28246	29.79442
0.55634	0.11666	20.96919
0.43967	0.10234	23.27655
0.33732	-0.19584	58.05763
0.53317	0.00614	1.151603
Basic laboratory		
0.88383	0.01228	1.389407
0.87155	-0.09792	11.23516
0.96947	0.03274	3.377103
0.93672	0.06345	6.773636
0.87327	0.01637	1.874563
0.85690	0.04912	5.732291
Gas laboratory area		
0.91658	0.09006	9.825656
0.82652	0.05935	7.180709
0.82652	0.05935	7.180709

The new water piping will use cross-linked polyethylene (PEX) as it materials because of its advantages. The advantages are it does not corrode or develop leaks, chlorine resistant and will use fewer fittings, connections, elbow than existence pipe and flexible means easy to be bended around corners or through floors.

PEX can be used in high-temperature because the cross-linking raises the thermal stability of the material under load. As a result, the resistance to environmental stress cracking, creep, and slow crack growth are greatly improved over polyethylene.

PEX tubing is light and can withstand operating temperatures of up to 93° C. Sizes of normal PEX tubing range from 3/8-inch to over 2 inches.

For new air piping system, the material that will be used is smart pipe. It is constructed of 6035-T5 calibrated alloy aluminium and coated with blue powder outside. It is non flammable and 100% recycleable. The connectors are made of nitrile gasket seals. The fittings are non-flammable nylon and resistant to ultraviolet (UV) ray.

The size of the piping is 4 inches inner diameter to ½ inches inner diameter. The piping can resist pressure until 13 bar and temperature from -20oC to 60oC. The piping material need component suitable with it condition. There are many components available that is straight union, elbow, tee, cross connectors, reducing fittings, gooseneck drops, ball valves, bracket, hanger, snap shut pipe clips, expansion and flex hoses and also couplers.

The smart pipe is chosen compare galvanized iron because galvanized iron only exterior is coated. It also will rust and leak. The inside of galvanized iron is rough and can make pressure drop higher. It also needs labour intensive installation but smart pipe is easy to install

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, there must be changes in FKKSA's laboratory for new equipment purposes. Any change in piping will affect pressure drop thus it will determine either the fluid will reach the new equipment or not. The usage of PDMS to design the plan is very important to make the plant view look real.

5.2 Recommendation

For the recommendation, the new cooling water and steam piping system should be constructed rather than air and deionized water piping system in future because it is relate each other. Besides that, if there is new equipments need to be installed; there should be improvement of this design. The pressure drop will change depend on the demand of the new equipment. Other than that, if there is any new material for piping that is better than previous one, it should be used to make sure the efficiency of the piping better.

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APPENDICES

A1 Friction Coefficient

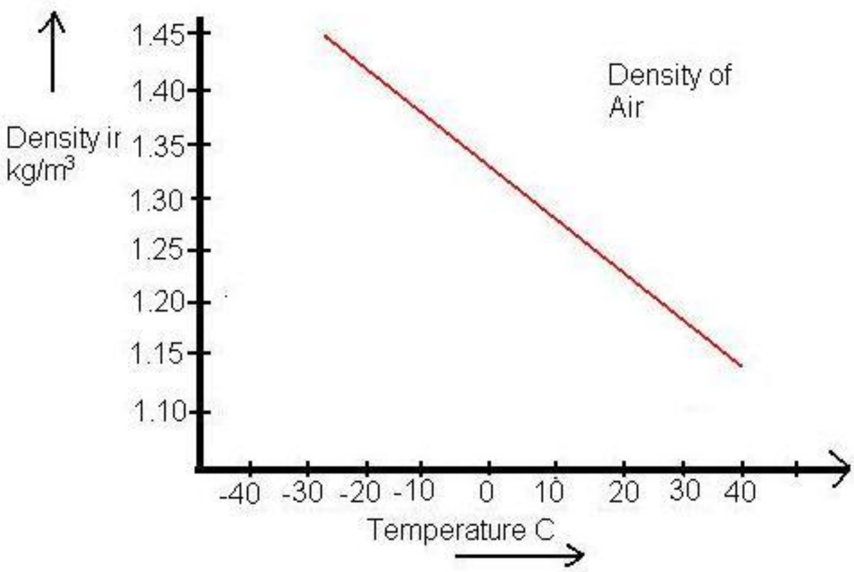
Material	friction coefficient
Clean metals in air	0.8-2
Clean metals in wet air	0.5-1.5
Steel on soft metal (lead, bronze, etc)	0.1-0.5
Steel on ceramics (sapphire, diamond, ice)	0.1-0.5
Ceramics on ceramics (eg carbides on carbides)	0.05-0.5
Polymers on polymers	0.05-1.0
Metals and ceramics on polymers (PE, PTFE, PVC)	0.04-0.5
Boundary lubricated metals (thin layer of grease)	0.05-0.2
High temperature lubricants (eg graphite)	0.05-0.2
Hydrodynamically lubricated surfaces (full oil film)	0.0001-0.0005

A2 Water Density

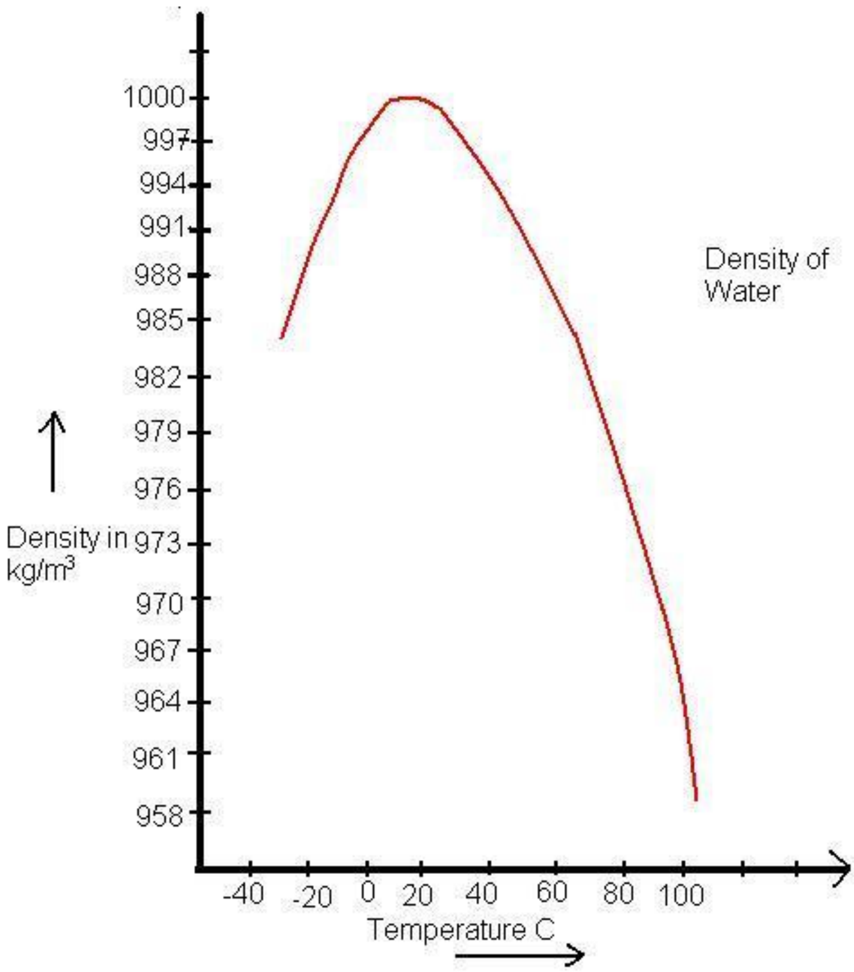
Temperature in °C	Density in kg / m^3
+100	958.4
+80	971.8
+60	983.2
+40	992.2
+30	995.65
+25	997.0479
+22	997.7735
+20	998.2071
+15	999.1026
+10	999.7026
+4	999.9720
0	999.8395
-10	998.117
-20	993.547
-30	983.854

A3 Air Density

Temperature in °C	**Density in kg / m^3**
-25	1.423
-20	1.395
-15	1.368
-10	1.342
-5	1.316
0	1.293
+5	1.269
+10	1.247
+15	1.225
+20	1.204
+25	1.184
+30	1.164
+35	1.146



A4 Graph of air density



A5 Graph of Deionized Water density

A6 Air pressure drop for pilot plant

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Pilot plant area					
1	8.61875	2.5	0.0254	8.61868	7.0614×10^{-5}
2	8.61868	6	0.0254	8.61799	0.00069
3	8.61799	26	0.0254	8.61725	0.00074
4	8.61725	4.5	0.0254	8.61712	0.00013
5	8.61712	6	0.0254	8.61780	-0.00069
6	8.61780	15	0.0127	8.61695	0.00086

A7 Air pressure drop for unit operation area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Unit operation area					
7	8.61875	75	0.0254	8.61470	0.00215
8	8.61470	8	0.0254	8.61447	0.00023
9	8.61447	4	0.0254	8.61492	-0.00046
10	8.61492	46	0.0127	8.61229	0.00264
11	8.61492	1	0.0127	8.61487	5.7284×10^{-5}
12	8.61447	9.5	0.0254	8.61420	0.00027
13	8.61420	4	0.0254	8.61465	-0.00046
14	8.61465	46	0.0127	8.61202	0.00264
15	8.61465	1	0.0127	8.61196	5.7284×10^{-5}
16	8.61420	11	0.0254	8.61388	0.00032
17	8.61388	1.5	0.0254	8.61405	-0.00017
18	8.61405	46	0.0127	8.61142	0.00264

A8 Air pressure drop for process control and instrumentation area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Process control and instrumentation area					
19	8.61470	22	0.0254	8.61407	0.00063
20	8.61407	8	0.0254	8.61383	0.00023
21	8.61383	4	0.0254	8.61429	-0.00046
22	8.61383	23	0.0127	8.61341	0.00066
23	8.61341	28.5	0.0254	8.61259	0.00082
24	8.61259	25	0.0254	8.61188	0.00072
25	8.61188	2	0.0254	8.61210	-0.00023
26	8.61210	0.5	0.0127	8.61208	2.8642×10^{-5}

A9 Air pressure drop for pilot plant 2 area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Pilot plant 2					
27	8.61685	3	0.0254	8.61407	0.00036
28	8.61707	7.5	0.0254	8.61686	0.00021
29	8.61383	5.2	0.0127	8.61745	-0.00059

A10 Air pressure drop for gas laboratory area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Gas laboratory area					
30	8.61685	22	0.0254	8.61622	0.00063
31	8.61622	5.5	0.0254	8.61606	0.00016
32	8.61527	1	0.0127	8.61000	5.7284×10^{-5}
33	8.61527	5	0.0254	8.61591	0.00014
34	8.61685	10.5	0.0254	8.61654	0.00030

A11 Deionized water pressure drop for pilot plant area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Process control and instrumentation area					
1	1.2411	1	0.0381	1.23696	0.00409
2	1.23696	3	0.0381	0.94319	0.29377
3	0.94319	2	0.0381	0.93501	0.00819
4	0.93501	4.5	0.0381	0.91658	0.01842
5	0.91658	8	0.0381	0.88383	0.03275
6	0.88383	6	0.0381	1.47137	-0.58754
7	1.47137	15	0.0127	1.28716	0.18422
8	0.88383	16	0.0381	1.22166	0.06550

A12 Deionized water pressure drop for unit operation area

Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Unit operation area					
9	0.93501	75	0.0381	0.64640	0.28860
10	0.64640	8	0.0381	0.61365	0.032749
11	0.61365	4	0.0381	1.00534	-0.39169
12	1.00534	46	0.0127	0.44041	0.56492
13	1.00534	1	0.0127	0.99306	0.01228
14	0.61365	9.5	0.0381	0.57476	0.03888
15	0.57476	4	0.0381	0.96645	-0.39169
16	0.96645	46	0.0127	0.40152	0.56492
17	0.96645	1	0.0127	0.95417	0.01228
18	0.57476	11	0.0381	0.52973	0.04503
19	0.52973	1.5	0.0381	0.67661	-0.14688
20	0.67661	46	0.0127	0.11169	0.56492

A13 Deionized water pressure drop for process control and instrumentation area

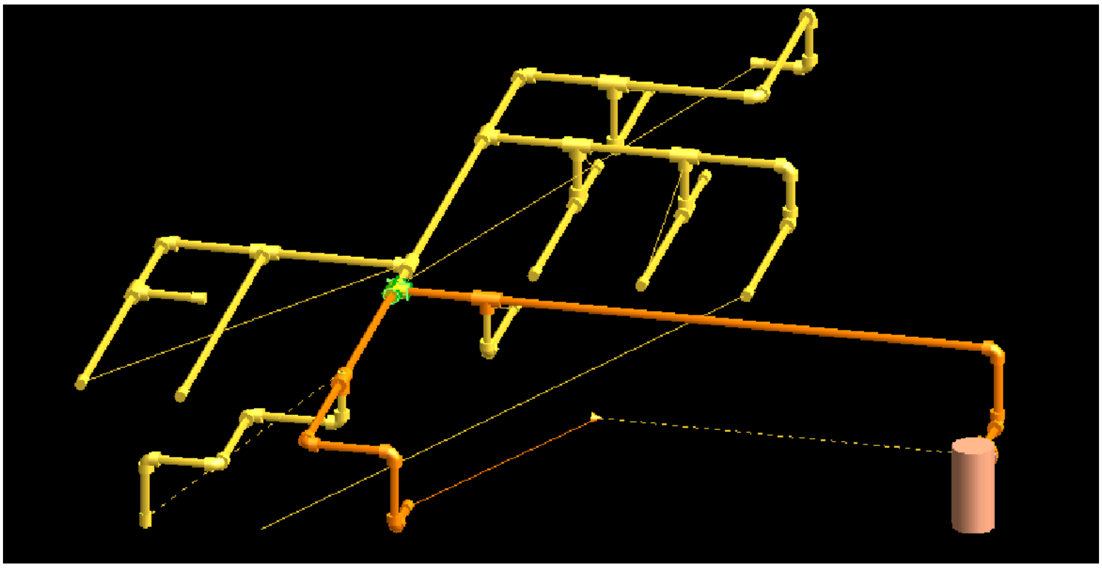
Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Process control and instrumentation area					
21	0.64640	22	0.0381	0.55634	0.09006
22	0.55634	8	0.0381	0.52359	0.03274
23	0.52359	4	0.0381	0.94803	-0.39169
24	0.94803	23	0.0127	0.66557	0.28246
25	0.55634	28.5	0.0381	0.43967	0.11666
26	0.43967	25	0.0381	0.33732	0.10234
27	0.33732	2	0.0381	0.53317	-0.19584
28	0.53317	0.5	0.0127	0.52703	0.00614

A14 Deionized water pressure drop for basic laboratory area

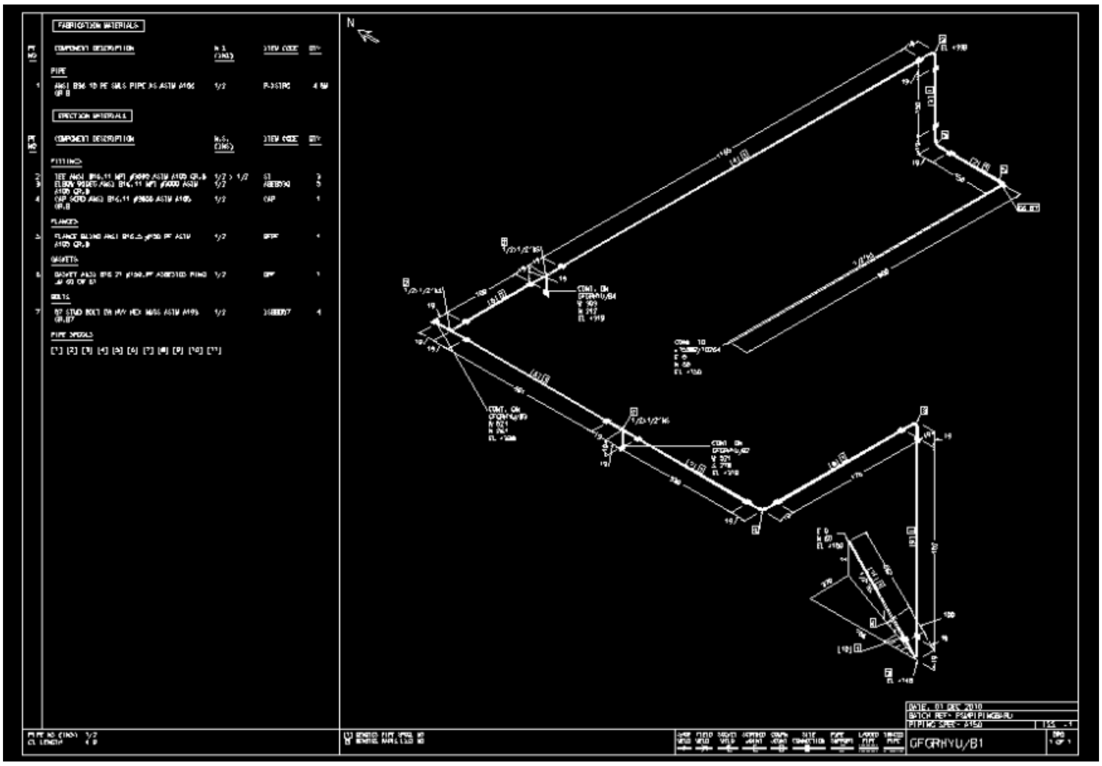
Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Basic laboratory					
30	0.88383	3	0.0381	0.87155	0.01228
31	0.87155	1	0.0381	0.96947	-0.09792
32	0.96947	8	0.0381	0.93672	0.03274
33	0.93672	15.5	0.0381	0.87327	0.06345
34	0.87327	4	0.0381	0.85690	0.01637
35	0.85690	4	0.0127	0.80777	0.04912

A15 Deionized water pressure drop for gas laboratory area

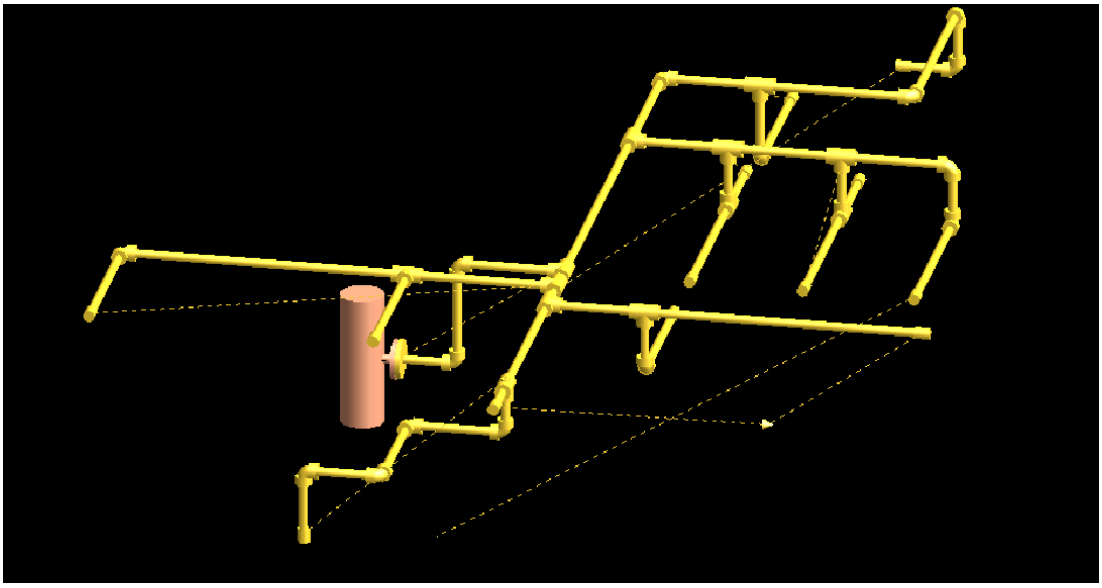
Pipe	Inlet pressure (bar)	Length (m)	Diameter (m)	Outlet pressure (bar)	Pressure drop (bar)
Gas laboratory					
36	0.91658	22	0.0381	0.82652	0.09006
37	0.82652	14.5	0.0381	0.76716	0.05935
38	0.82652	14.5	0.0381	0.76716	0.05935



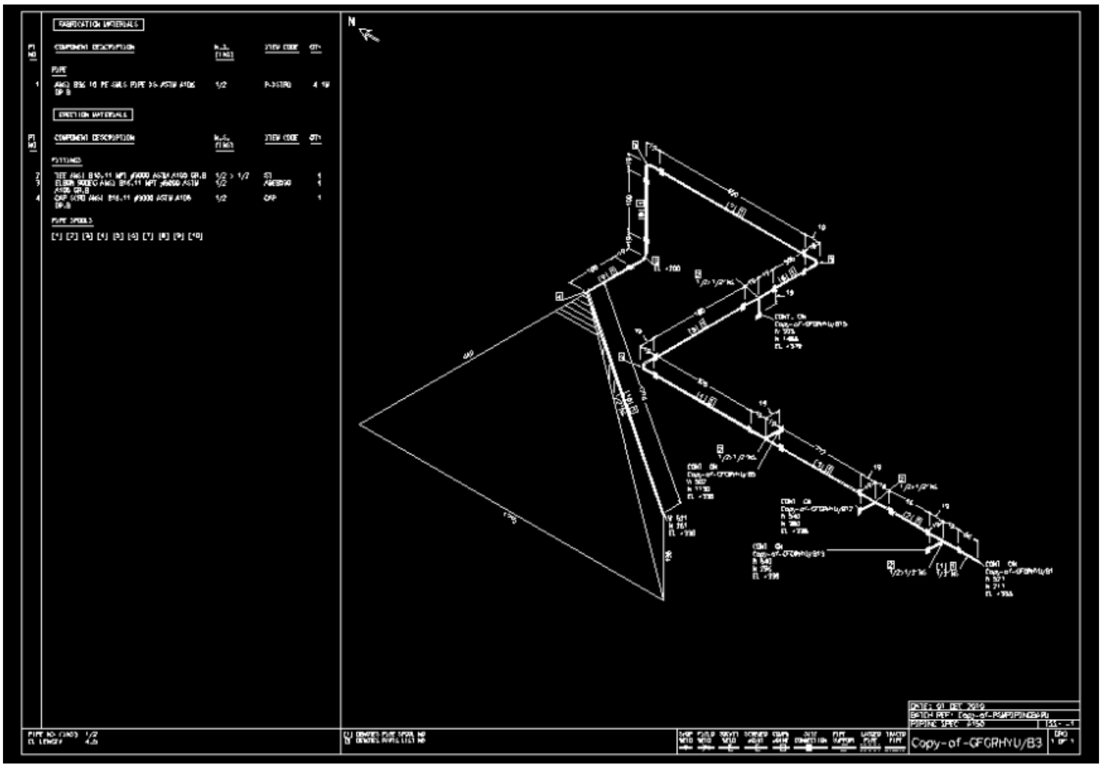
A16 PDMS drawing for air



A17 Isometric for air piping system



A18 PDMS drawing for deionized water



A19 Isometric for deionized water