DESIGNING OF MANIFOLD SYSTEM FOR LPG AND INDUSTRIAL GAS AT FKKSA'S LABORATORY

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requirements for the award of the degree of
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"I declare that I have read this thesis and in my opinion this thesis is adequate in terms of scope and quality for the purpose awarding a Bachelor's Degree of Chemical Engineering (Gas Technology)

Signature:…………………………………………….

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Date:

I hereby declare that this thesis entitled "Designing Of Manifold System For LPG And Industrial Gas At FKKSA's Laboratory" is the result of my own research except as cited in the 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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In the name of Allah the Most Gracious and Most Merciful

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ABSTRACT

Currently, Universiti Malaysia Pahang has several laboratories which required Liquefied Petroleum Gas (LPG) and industrial gas to run the experiments and other work related to the use of these gases. The equipments which use LPG and industrial gas are required continuously supply of these gases. Therefore, the manifold system shall be install to ensure that the LPG and industrial gas can be supplied without interruption such as running out of the gas. The scope of research work is about the gas demand where gaseous used by various equipments at the lab and type of gas that use at FKKSA Laboratory and safety aspect based on DOSH, Malaysian standards and Suruhanjaya Tenaga Guidelines. Have several steps to reach the objective of this project such as estimation of load demand, calculation number of gas cylinder based on gas demand, network study to identify length of tube, study of suitable area to locate the gas manifold based on standards and code, assessment in term of safety at the gas manifold area, proposed the location and selection of material for the tubing system between gas manifold system and the equipment, design the layout using PDMS software and the last one is about safety analysis. Based on the calculation, the number of gas cylinder required is about 55 cylinders and this gas can use for long period time because the capacity of gas supplied is enough for all equipment at the FKKSA laboratory run without running out of gas. About the safety, several aspect should be considered such as LPG storage safety, safe handling of compressed gases, hazard, general precautions and manifold cylinder location. Then, the layout design of tubing system will show us the flow of gas and the parameters of tubing like the actual length of tube. As conclusion, manifold system is relevant to install at FKKSA laboratory because the running out of gas during run the equipment can be avoid and will not give the problem when run the experiment using the equipment related with the gas consumption.

ABSTRAK

Universiti Malaysia Pahang mempunyai beberapa makmal yang memerlukan GPC dan gas industri untuk menjalankan eksperimen dan kerja lain yang berkaitan dengan penggunaan gas-gas tersebut. Alat-alat yang menggunakan GPC dan gas industri memerlukan bekalan gas yang berterusan. Oleh itu, sistem manifold seharusnya di pasang untuk memastikan GPC dan gas industri boleh dibekalkan tanpa gangguan. Skop kajian ini adalah tentang keperluan gas di mana gas digunakan oleh beberapa alat di makmal dan jenis gas yang digunakan dan tentang aspek keselamatan berdasarkan DOSH, MS 830 dan Panduan Suruhanjaya Tenaga. Terdapat beberapa prosedur untuk mencapai objektif kajian ini seperti anggaran penggunaan gas, pengiraan bilangan silider gas berdasarkan penggunaan gas, kajian rangkaian untuk mengenalpasti panjang tiub, kajian tentang kawasan yang sesuai untuk menempatkan manifold gas berpandukan piawaian dan kod, mencadangkan kawasan untuk menempatkan manifold gas dan pemilihan jenis tiub untuk sistem tiub antara manifold gas dan alat-alat kelengkapan, mereka bentuk lakaran menggunakan PDMS dan prosedur terakhir adalah tentang analisa keselamatan. Berdasarkan pengiraan, bilangan silinder gas yang diperlukan adalah sebanyak 55 silinder dan GPC dan gas industri boleh digunakan untuk jangka masa yang panjang kerana jumlah gas yang dibekalkan cukup untuk semua alat di makmal menjalankan eksperimen tanpa kehabisan gas. Berkaitan dengan keselamatan, beberapa aspek perlu diambil kira seperti keselamatan penyimpanan GPC, pengendalian gas tumpat, bahaya gas tumpat, langkah pencegahan yang menyeluruh and lokasi silinder manifold. Seterusnya, lakaran sistem tiub memberi gambaran aliran gas dan parameter tiub seperti panjang sebenar tiub. Kesimpulannya, sistem manifold adalah relevan untuk dipasang di makmal FKKSA kerana gangguan bekalan gas dapat dielakkan dan tidak memberi sebarang masalah semasa menjalankan eksperimen yang menggunakan alat yang berkaitan dengan penggunaan gas.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLE

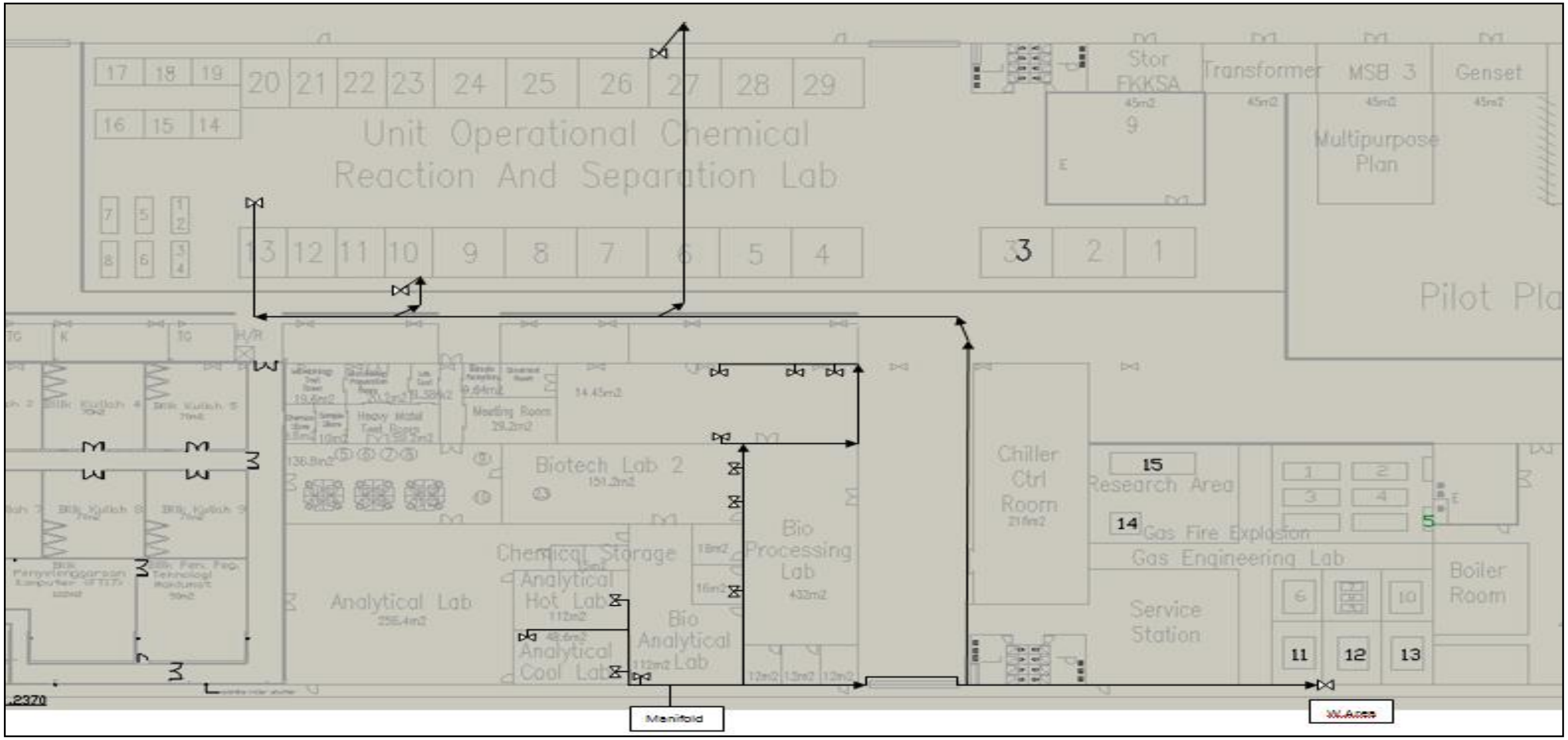

Figure 4.2: The flow of gases in the FKKSA laboratory

Table 4.1: The gas consumption by the equipment in FKKSA laboratory

	Flow Rate (kg/hour)											
Equipment	**No. of unit**	**N_2**	**O_2**	**CO_2**	**H_2**	**He**	**Argon**	**N_2O**	**Ethyne**	**Air**	**LPG**	**Pressure**
Fermenter 2L	*4*	*0.014*	*0.016*	*0.024*	-	-	-	-	-	-	-	*0.5 bar*
Fermenter 10L	*1*	*0.175*	*0.20*	*0.30*	-	-	-	-	-	-	-	*0.5 bar*
Fermenter 20L	*1*	*0.42*	*0.48*	*0.72*	-	-	-	-	-	-	-	*6 bar*
Fermenter 50L	*1*	*7.0*	*8.0*	*12.0*	-	-	-	-	-	-	-	*3 bar*
Gas Chromatography	*2*	*0.014*	-	-	*0.001*	*0.0002*	-	-	-	-	-	*0.7 bar*
Atomic Absorption Spectrophotometry	*2*	-	*0.08*	-	-	-	*0.02*	*3.268*	*0.288*	*0.08*	-	*1 bar*
Anaerobic Chamber	*1*	*0.2*	-	*0.18*	*0.01*	-	-	-	-	-	-	*0.7 bar*
CO2 Incubator	*1*	-	-	*0.05*	-	-	-	-	-	-	-	*1 bar*
Gas Absorption -Adsorption Unit	*1*	-	-	*1.842*	-	-	-	-	-	-	-	*1 bar*
Bomb Calorimeter	*1*	-	*0.0016*	-	-	-	-	-	-	-	-	*30 bar*
Pressure Swing Adsorption	*1*	*0.07*	-	*0.12*	-	-	-	-	-	-	-	*1 bar*
Supercritical Unit	*1*	-	-	*6.00*	-	-	-	-	-	-	-	*300 bar*
Gas Absorption Refrigeration Unit	*1*	-	-	-	-	-	-	-	-	-	*0.018*	*0.03 bar*
High Performance Liquid Chromatography	*2*	-	-	-	-	-		-	-	-	-	*1 bar*
Flame Propagation and Stability Unit	*1*	-	-	-	-	-	-	-	-	-	*0.02*	*0.5 bar*
Gas Meter Calibration	*1*	-	*1.6*	-	-	-	-	-	-	-	-	*0.04 bar*
Gas Combustion Laboratory Unit	*1*	-	-	-	-	-	-	-	-	-	*10.8*	*2 bar*
Gas Turbine Demonstration Unit	*1*	-	-	-	-	-	-	-	-	-	*26.34*	*5 bar*
Welding Set (GMAW)	*1*	-	-	*0.183*	-	-	*0.165*	-	-	-	-	*3 bar*
Welding Set (GTAW)	*1*	-	-	-	-	-	*1.2*	-	-	-	-	*3 bar*
Differential Scanning Calorimeter	*1*	*0.014*	*0.016*	-	-	-	-	-	-	*0.015*	-	*2 bar*
	TOTAL	*7.907*	*10.4*	*21.42*	*0.01*	*0.0002*	*1.385*	*3.268*	*0.288*	*0.095*	*37.18*	

CHAPTER 1

INTRODUCTION

1.1 Introduction

Manifolds are used to connect two or more cylinders of gas together increasing the supply volume available to provide a continuous flow when one cylinder is not sufficient and a tube trailer or other bulk supply is not practical. Manifolds are also used when a single cylinder of gas is not capable of supplying the required flow rate required by a process. In a single row configuration designed, manifolds are commonly fabricated for wall mounting with a row of cylinders in line beneath or in front of it. Double row manifolds and other custom configurations are available on request.

Beside that, to isolate individual cylinders on a manifold from service, the station valves are used. As recommendation, station valves are required for most laboratory applications as they are a valuable back up device in the event of a leaking pigtail or a defective check valve. Other than that, in high purity gas service it is most important that station valves used to maintain gas purity. Many commercial manifolds use packed valves that may cause atmospheric impurities to enter the gas stream as contaminants.

Usually, it has two types of pigtails to connect cylinders to the manifold header. Type one call is rigid pigtails made from brass or stainless steel tubing and type two or flexible pigtail made from stainless steel braided hose with either Teflon-lining or stainless steel inner core. Additional, Teflon-lined pigtail are used for routine applications while the stainless steel inner core pigtails are used for ultra high purity applications. More important information, either rigid pigtails or stainless steel inner core flexible pigtails are recommended for helium and hydrogen because these gases will diffuse through the wall of a Teflon-lined pigtail.

Check valves on the cylinder end of each pigtail must be always installed on manifolds used for flammable, toxic and corrosive gases. In some cases, to ensure that highly toxic gases are not released to the working environment during cylinder change outs, the purge assemblies are installed. Many applications required the highly toxic gas are always be supplied to the process. The flow of that gas can not be shut down or stop to replace empty cylinders and gas must feed for long periods when the system is unattended. In this case, a changeover manifold is the solution. Changeover manifolds can be used with any of the multiple station manifolds or with a single pigtail on each side.

The multi cylinder connection system, the system where is essentially modified version of manifold system, required two cylinders with one instrument. For example such as cylinder and bundle manifolds, bundle manifolds, multiple cylinder headers and manifold tutorial. It can be used all at a time or one at a time by only opening and closing the valve. This will simplify the operation and also improves the life of the regulators.

1.2 Problem statement

Currently, Universiti Malaysia Pahang has several laboratories which required Liquefied Petroleum Gas (LPG) and industrial gas to run the experiments and other work related to the use of these gases. FKKSA’s laboratory are divided in several areas where the certain areas are required the LPG and industrial gas to run various equipment which use for student training during laboratory session.

The equipments which use LPG and industrial gas are required continuously supply of these gases. So, the manifold system shall be install to ensure that the LPG and industrial gas can be supplied without interruption such as running out of the gas. Beside that, to install the manifold system, safety aspects should be prioritized according to standards and code such as MS 830, MS 930, DOSH and Suruhanjaya Tenaga Guidelines. Additional, the selection of the suitable area must be considered as not all areas can accommodate the gas cylinder.

1.3 Objective of the project

1. To design the manifold system of LPG and industrial gas for FKKSA laboratory.

2. To analyze or study the safety aspect.

1.4 Scope of research work

1. The gas demand
   Gaseous used by various equipments at the lab and type of gas that use at FKKSA Laboratory.

2. Safety aspect
   Data, rules and regulation was based on DOSH, Malaysian standards and Suruhanjaya Tenaga Guidelines.

1.5 Rationale and Significance

1.5.1 Rationale

The manifold system should be install to ensure that the gas can be supply continuously for the equipments.

1.5.2 Significance

To avoid the problem when run the equipment that used the gas such as running out of the gas.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

These studies are focus on the designing the manifold system of LPG and industrial gas for FKKSA laboratory and do the safety assessment. The gas manifold system basically consist the elements like gas cylinder, tubing system, valve, regulator and more. Zainal (2003) has state that gas manifold is use for domestic user, commercial and light industrial. In the engineering lab, where rate of gas consumption is high and it is much advantageous to use a manifold system. So, the capacity of manifolded cylinders must be determined such that enough gas is available to be piped to the appliances at all times. The tanks should be sized such that adequate pressure is maintained to operate the gas system at the rated gas demand of the appliances. Tank sweating will occur when the container is undersized (Suruhanjaya Tenaga).

Beside that, the safety aspect also should be considered because it involved the gas cylinder and flammable gas such as the location, range between the gas cylinder, the type of gas use and more. Other than that, the safety aspect is very important if we want to handle the gas cylinder and shortly, it related to the gas cylinder. It is because for to ensure the worker and public safety are always guaranteed. Before we go to discuss about the safety, we must know or have some information about gas cylinder that use in manifold system such as its properties, type, the material to design gas cylinder, the shape of gas cylinder and more.

Many people mention that the accommodation of gas cylinder is very simple things and does not look to the safety aspect. In reality, we must follow the standards and all rules and also all matters must be consider to accommodate the gas cylinder and will not harmful to consumers, the public and employees. It is because to avoid any accident to occur such as explosion when the gas cylinder is leakage.

2.2 Gas Manifold System

Manifolds and manifold systems are fluid-distribution devices. They range from simple supply chambers with several outlets to multi-chambered flow control units including integral valves and interfaces to electronic networks. Applications, port specifications, flow and pressure specifications, manifold circuit style and valve specifications are all important parameters to consider when searching for manifolds. Additional specifications to consider for manifolds and manifold systems include communication network, body materials, features and operating temperature.

Other than that, the manifold system also known as the multi cylinder connection system and it divided in several types. The example of multi cylinder connection as in Figure 2.1. It consists three of types such as cylinder and bundle manifolds, multiple cylinder headers and bundle manifolds as in the Figure 2.2, Figure 2.3 and Figure 2.4.

Figure 2.1: Multi Cylinder Connection System (Source: Globalspec website)

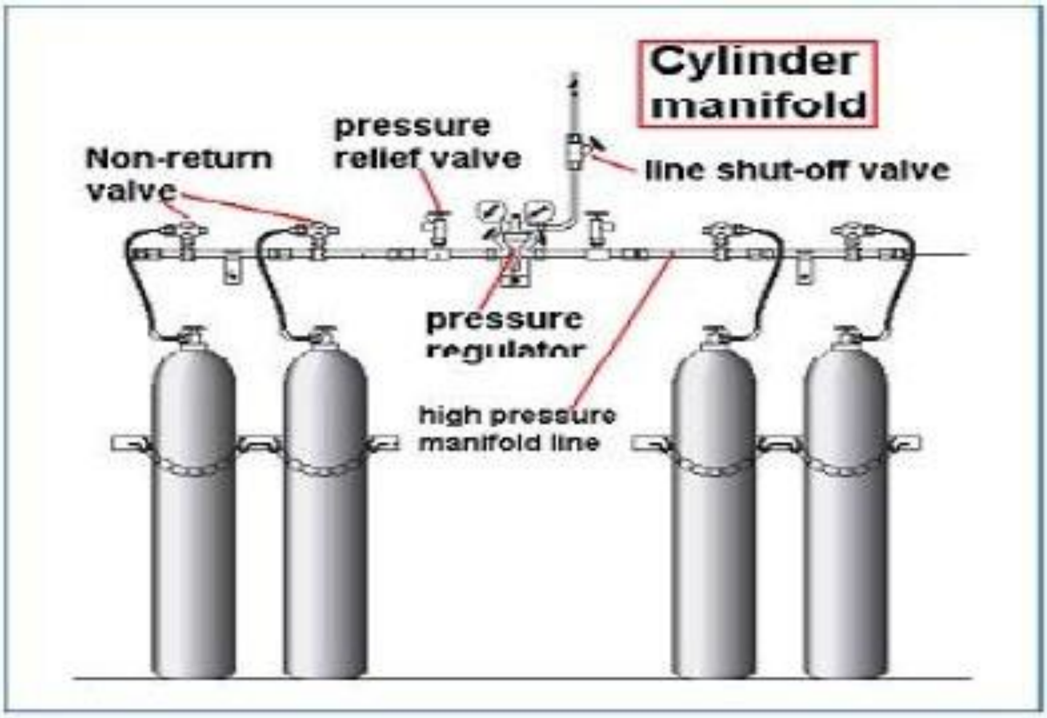

Figure 2.2: Cylinder Manifolds (Source: Globalspec website)

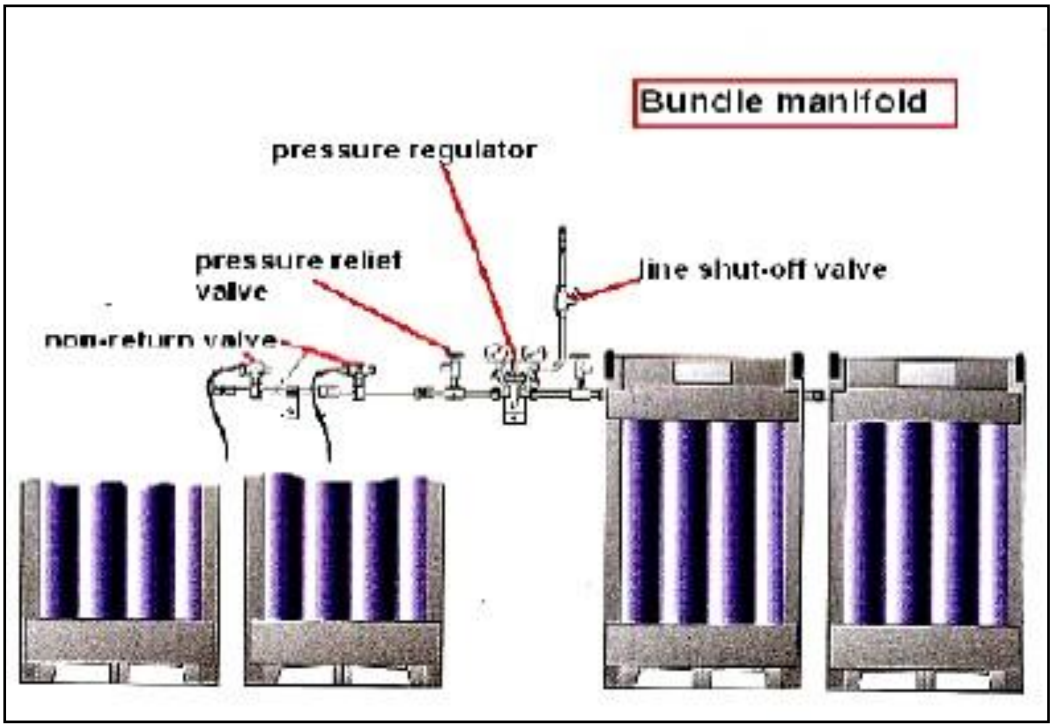

Figure 2.3: Bundle Manifolds (Source: Globalspec website)

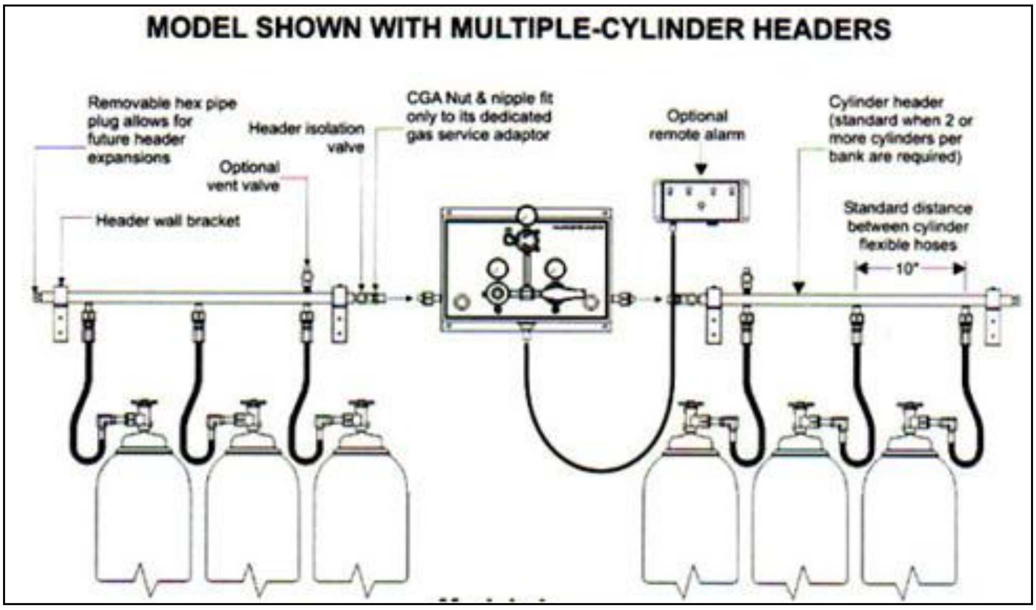

Figure 2.4: Multiple Cylinder Headers (Source: Globalspec website)

Common applications for manifolds and manifold systems include general purpose, gas, pneumatic or compressed air, pneumatic or vacuum, water, steam, marine, coolant, refrigerant, cryogenic, high temperature, hydraulic fluid, oil or fuel, slurry, high viscosity, general chemical, corrosive or solvent chemical, sanitary, food processing, and medical or pharmaceutical. With manifolds and manifold systems, the manifold circuit style can be series or parallel. In a series manifold, the pressure supply is ported through one valve to get to the next. In a parallel manifold, the inlet ports all share common pressure supply (Globalspec website).

In a manifold system, instead of having gas cylinders at each place of work, they are assembled at one centralised position in specially designed racks and connected by a manifold. The gas is then distributed by means of a pipeline to different workplaces. The manifold distributes LPG and industrial gases at a reduced pressure.

There are separate manifolds for LPG and other gas supplies. Additional, the gas manifold system has several advantages as the following:

a) Since gas cylinders have not been scattered throughout the work area, rather, they have been kept at a central place:
    i) The possibility of accidents is reduced.
    ii) More space is available at each workplace.
b) In case of fire, one can easily reach the cylinders.
c) There is more effective use of gases.
d) Cylinders are transported by less distance.
e) There is no replacement of cylinders inside the workshop.

In the manifold system can be install for the single stage regulator or double stage regulator.

In the single stage regulator system, the pressure will reduce from the cylinder pressure to the pressure of equipment takes place in single stage. Then, in the hoses, the pressure is controlled by applying pressure to the spring through an adjusting screw. The pressure is applies to a flexible rubber by the spring which is connected to the valve. The gas from the cylinder flows past the open valve and then it will enters the valve chamber and builds up pressure on the diaphragm. The valve closes the high pressure inlet and stops the flow of any more gas into the valve chamber when the pressure inside the valve is slightly greater than the spring tension supporting the diaphragm. The single stage regulators may be classified as follows depending upon the method used to close the seat mechanism and thereby control the gas flow:

a) Direct or nozzle type
   The seat is forced to close against the gas flow (away from the nozzle) by the incoming high pressure gas.

b) Inverse or stem type
   The incoming high pressure gas forces the seat toward the nozzle in the direction of the gas flow.

Beside that, because of a sudden expansion and resulting drop in initial pressure causes rapid cooling of the gas involved, the single stage regulator tends to freeze on cold weather. The moisture present in the gas will cause the formation of ice on or near the regulator nozzle and then will causes irregular seating of the seat and therefore substantial pressure fluctuations.

The double stage regulator is about the reduction of pressure take place in two stages and its principle is exactly same as in a single stage regulator. But the pressure is reduced in two stages instead of one where is using two diaphragms and two control valves and the pressure reduction ratio is less abrupt. The two stage regulator is used together with cylinders and manifolds and it stage may consist of:

a) Two inverse types of stages.
b) Two direct type stages.
c) First direct type stage and second inverse type stage. Two stage regulators of mixed stage type are the most common.

The same situation occurs in the first reduction stage of a two stage regulator where the second stage is not sufficiently affected to produce a noticeable pressure disturbance.

2.3 Gas Cylinder

Gas cylinders are used to store gases under high pressures. Gas cylinders can store both flammable gases such as acetylene and inert gases such as argon and carbon dioxide. The three main types of compressed gases that are stored in gas cylinders are liquefied gas, non-liquefied gas, and dissolved gas. Gas cylinders can be defined by four main characteristics such as type of gas, state of gas such as compressed, refrigerated, dissolved, cryogenic liquid, purity of gas, and type of cylinder. Size and pressure differs from country to country (Wikipedia).

This study will focus to the gas cylinder only. It is because at FKKSA Laboratory has a welding area where in this area consists gas cylinder. As we know that to apply the welding, usually we use the gas as one of the most important equipment. The position of the gas cylinder at the welding area is too close to the welding set is an important issue that should be considered based on safety. It can give any accidents to students and instructors if any actions are not taken. Therefore we must find information about the gas cylinder before we make a study about the safety aspects related to the gas cylinder.

2.3.1 History

The first cylinders were animal bladders used in the 18th century to contain gases as they were studied in laboratories. The method was slightly upgraded with gas bags made of oiled textile or silk with gilt paint. The first glimpse of cylinders as we know them today came from Germany in 1886, when Max and Reinhard Mannesmann developed a production method for manufacturing seamless steel tubes by extrusion. The method was soon adapted to the manufacture of gas cylinders, marking a significant step toward the dawn of the industrial gas business.

In 1891, Harrisburg Pipe and Pipe Bending Works received an onslaught of requests for shipping containers to hold anhydrous ammonia gas, the activating agent for making dry ice. In 1897, French engineer Georges Claude and colleague Albert Hess developed a method to safely compress acetylene; just two years after the inherently unstable gas began to be manufactured for commercial use. Claude and Hess discovered the gas was highly soluble and could be safely transported when dissolved in acetone and stored in a cylinder with porous mass filler material (Gas and Welding Distributors Association).

Two years later, a prominently placed carbon dioxide cylinder would further advance the cylinder business, when the Anheuser-Busch Brewery displayed a carbon dioxide cylinder from Harrisburg Steel Corporation to pump draft beer at the St. Louis Fair. Beer on tap became so popular that many saloons were renamed taprooms, giving carbon dioxide cylinders a starring role in watering holes across the nation. The gas shipping industry continued to grow through the recession of 1907, with an increased demand for cylinders of pure oxygen in 1908. Two years later, Germany began exporting low-carbon, lightweight cylinders.

In 1958, British manufacturing facility Luxfer Gas Cylinders developed a process using cold-indirect extrusion to offer an alternative: aluminum high-pressure gas cylinders, weighing 30 percent less than their steel predecessors. These cylinders were initially used to carry the carbon dioxide required for commercial beverage dispensing. In the early 1960s, NASA contracted rocket propulsion company Aerojet General to design and manufacture a lightweight composite cylinder for space application. The oil embargos and petroleum fuel price escalation in the 1970s put pressure on the industrial gas industry to trim the costs of shipping gas. Cylinders continued to evolve through the 1990s, and are available today with specialized coatings and improved threads, and in varying sizes and weights for an array of applications (Gas and Welding Distributors Association).

2.3.2 Types of Gas Cylinder

There are two basic types of compressed gas cylinders. Non-refillable cylinders are designed for one-time use and should never be refilled or reused. Refillable cylinders are made of steel or aluminum, and are designed for refilling and repeated use. Some cylinders have been in service for over 40 years. Most refillable cylinders have an open interior with walls of 1/4 inch steel and a reinforced neck and bottom. Because commonly used gases are highly pressurized (between 1,500 psig and 2,500 psig), cylinders must be maintained in good condition and protected from accidental damage at all times.

Some gases, such as carbon dioxide, are commonly used in both a liquid and gas form. Cylinders designed for such use have a siphon, or "dip", tube. A siphon serves as a drinking straw to pull the liquid from the bottom of the cylinder when needed. The valve pulls the gas vapors from the top of the cylinder when the gas form is required (VirginiaTech College website).

2.3.3 Material Construction and Properties

Gas cylinders can be made from aluminum, steel, alloys, and composite materials. Aluminium has characteristic as follows such as light weight, compact and portable, corrosion resistance, non-magnetic, average life span and safety aspects. This entire characteristic is very suitable for producing gas cylinder and makes the gas cylinder safe to use. Beside that, steel is more or less a linear elastic material. Unlike concrete, which is much weaker in tension than in compression, steel theoretically responds the same way in either tension or compression. In compression, steel can still behave plastically (Kirk N., Department of Energy, USA).

Alloys are metallic materials that include at least one metal and another element. Common alloys used are stainless steel, which is a combination of iron, chromium and nickel and for seamless aluminum, combination of aluminium, silicon and magnesium. It has a good characteristic such as resists stress cracking, and has good formability with medium strength, high corrosion resistance, strength at low temperatures, non toxic, heat conducting, non-sparking and more.

Other material construction of gas cylinder is composite material. Composite materials (or composites for short) are engineered materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure. Typically, most common composite materials, including fiberglass, carbon fiber, and Kevlar, include at least two parts, the substrate and the resin.

The composite material as obtained is very heterogeneous, very anisotropic, very light, high strength, do not yield, very fatigue resistant, do not corrode, not sensitive to the common chemicals, have excellent fire resistance, have medium to low level impact resistance and high temperature resistance (Gay D, Hoa S.V and Tsai S.W ,2009).

2.3.4 Specification Number and Service Pressure

Overfilling is a major cause of occupational injuries associated with the handling of compressed gas cylinders. If the specified filling density is exceeded, the cylinder becomes ‘liquid filled’ and too little vapor space is left in the cylinder preventing expansion of the gas at higher temperatures. This hydrostatic pressure can increase to the point where the cylinder ruptures. Overfilling is caused by failure to determine the capacity of the cylinder (expresses in cubic inches or water weight) or failure to properly determine the tare weight of the empty cylinder (William R. Mincks, Hal Johnston).

To avoid overfilling, know what the various marking stamped on the compressed gas cylinder mean, especially the specification number and the service pressure number. Both marks provide information which is essential for the safe handling of compressed gas cylinders (William R. Mincks, Hal Johnston).

The specification number refers to the specific regulations under which the cylinder was manufactured. The regulations detail what inspections are required, whether the cylinder may be refilled or must be disposed of after a single use, how is to be shipped and for what gases it is authorized. The regulations also state the authorized service pressure of the cylinder (William R. Mincks, Hal Johnston).

Although cylinders are now manufactured according to specifications set by the Department of Transportation (DOT), in the past specifications have been set by both the Interstate Commerce Commission (ICC) and by Bureau of Explosives (BE).

The specification number is preceded by either CRC (Canadian of Transport Commission) or BTC (Board of Transport Commissioners) (William R. Mincks, Hal Johnston).

When a cylinder is authorized for use at only one service pressure, no pressure is marked. In order to determine the authorized service pressure, consult the appropriate specification. Some specifications may authorize cylinder use at various pressures. In this case the design service pressure is marked on the cylinder immediately following the specification number. For example, in illustration A the number DOT 3E1800 indicates Department of Transportation specification 3E with a service pressure of 1800 psig. Certain cylinders (3A and 3AA) may be filled to 110% of marked service pressure if they quality by retest and care provided with frangible disc safety devices without fusible metal and are charged with non-liquid, non-flammable gas. These cylinders are marked with a plus sign following the hydrostatic retest date. Charging the cylinder in excess of its service pressure rating is unsafe. (William R. Mincks, Hal Johnston)

Figure 2.5 show the label of specification and service pressure of gas cylinder. DOT 3E1800 indicates Department of Transportation specification 3E with a service pressure of 1800 psig. The example of serial number of gas cylinder is 51602. Beside that, the other information shows on the gas cylinder such as manufacturer and inspector.

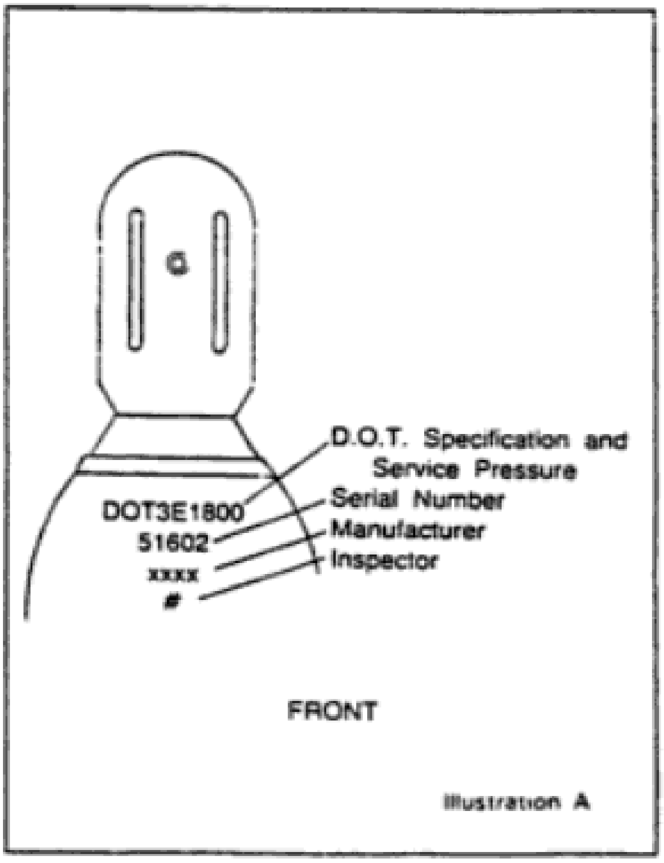

Figure 2.5: Label of Specification and Service Pressure of Gas Cylinder

2.3.5 Uses of Gas Cylinders

Gas cylinders are a convenient way to transport and store gases under pressure. These gases are used for many different purposes including:

1. Chemical processes
2. Soldering, welding and flame cutting
3. Breathing (driving, emergency rescue)
4. Medical and laboratory uses
5. Dispensing beverages
6. Fuel for vehicles (fork-lift trucks)
7. Extinguishing fires
8. Heating and cooking
9. Water treatment

2.3.6 The Main Hazards

Although the gas cylinder gives we many benefits but it still have disadvantages or weakness during applying the gas cylinder. The main hazards including:

1. Impact from the blast of a gas cylinder explosion or rapid release of compressed gas
2. Impact from parts of gas cylinders or valves that fail or any flying debris
3. Contact with the release gas or fluid such as chlorine
4. Fire resulting from the escaping of flammable gases or fluids such as liquefied petroleum gas
5. Impact from falling cylinders
6. Manual handling injuries

2.3.7 The Main Causes of Accidents

When we exposed to the hazards, the accidents maybe occur to us if the rules and regulations not complied with by the user. The main causes of accidents including:

1. Inadequate training and supervision
2. Poor installation
3. Poor examination and maintenance
4. Faulty equipment and design (badly fitted valves and regulators)
5. Poor handling
6. Poor storage
7. Inadequately ventilated working conditions
8. Incorrect filling procedures
9. Hidden damage

2.3.8 Safe Storage, Handling and Use

To use compressed gas cylinders safely, it is important that they are stored properly, handled correctly, used with the correct equipment, and that the properties of the gases they contain are fully understood. Cylinders, with their high internal pressure (up to 2,500 psig), are very hazardous when exposed to damage from falling over or tipping, heat, electric circuits, motion or vibration means anything that can cause a weakness or crack in the cylinder wall or shell. Such damage can cause the cylinder to rupture and explode sending sharp metal pieces, like shrapnel, blasting through the area (American Welding Society, 2005).

The Compressed Gas Association (CGA) has established a 0.300 inch (7.62 mm) maximum valve inlet diameter as a requirement to minimize the propulsion effect in case the valve is severed. This standard has the exception of valves used in liquefied gas services and fire control systems. Special design requirements and unique applications such as fire control systems, which require a high blow down flow, may dictate greater diameters. The actual outcome of a broken off valve depends on the design and pressure of the valve and cylinder. If the valve is broken off and the valve inlet opening meets the (CGA) requirements, the cylinder will rapidly release all its gas (which could be a health and/or flammability concern), cause a whistling sound, and possibly spin uncontrollably. If the valve inlet opening is different from the standard hole size used in most welding gases, such as those used for propane or butane and fire protection system cylinders, the cylinders may take off and become airborne (American Welding Society, 2005).

2.3.9 Guidelines To Store Cylinders

The gas cylinder is one of the main hazard materials and it should be store with the appropriate steps. Firstly, store the cylinders upright and secure them with a chain, strap or cable to a stationary building support or to a proper cylinder cart to prevent them from tipping or falling. Then, store the cylinders in a dry, well-ventilated area at least 20 feet from combustible material and completely close the valves, and keep the valve protection devices, such as caps or guards, securely in place. To ensure the users are not confused, mark the storage area with proper precautionary signs, such as flammable, oxidizer or toxic (American Welding Society, 2005).

Moreover, place them in a location where they will not be subject to mechanical or physical damage, heat or electrical circuits to prevent possible explosion or fire and keep cylinders away from vehicle traffic (American Welding Society, 2005).

2.3.10 Guidelines To Transport Cylinders

Most accidents or injuries involving cylinders happen when moving or handling the gas cylinders. Therefore, use the right equipment, correct procedures and sufficient number of persons to lift and move cylinders to avoid personal injury and cylinder damage. Beside that, the person also should be wearing the personal protective equipment (PPE) such as protective footwear, safety glasses and heavy gloves. When using a crane, be sure to use proper cradles, nets, boats or special platforms designed for this purpose to prevent the cylinders from falling. To prevent damage of cylinders, the users should be handling carefully to avoid dropping or banging the cylinders. Other than that, do not lift by the protective cap or guard or use magnets or slings to lift or move the cylinders since valves may be damaged or sheared off (American Welding Society, 2005).

2.3.11 Guidelines To Use Cylinders

During use the cylinders, keep it's upright and away from heat, sparks, fire, physical damage or electrical circuits to avoid rupture and explosion. To avoid gas accumulation, use it in a well ventilated area. In case the gas was leak, the air from surrounding of cylinder's area will bring the gas in this area to the surrounding and the concentration of the gas will decrease. In addition, the users should not bring the cylinders into a confined space because it will avoid inhaling the gas and possible suffocation from the accumulation of flammable, toxic or reactive gases.

Usually, the users will misuse gas cylinders because they are not alert with the guidelines of use the cylinders. Therefore, the first thing before use the gas, any persons must read, understand and follow all cylinder markings and labels to avoid misuse. Moreover, before connecting a regulator, stand to one side, and momentarily open the valve and then close it immediately. This procedure called cracking the valve where is done to clear the valve of dust or dirt that could enter the regulator. Then, open valves slowly by hand to avoid gauge damage. If a specific tool is required to open the valve, leave it in position so that the flow of gas can be stopped quickly in an emergency.

At the end use of gas cylinder, the valves should be close when not in use such as during breaks, lunch or end of shift to avoid any accident like explosion cause by gas leaks. Fire or explosions always occur if the users not comply with the guidelines. One of the factors of explosion is they let any oil or grease on the cylinders or regulators, particularly those containing Oxygen. Therefore, ensure that not have any oil and grease on the cylinders and as recommendation the cylinders must be check by inspector each week.

2.3.12 Maintenance of Gas Cylinders

As other equipment, the gas cylinders also have it's maintenance to ensure that it can use in good condition. Have several steps to do the maintenance of gas cylinders such as protect the markings on cylinders that identify the contents and mark the full or empty status on cylinders and mark all empty cylinders to avoid misunderstanding. Other than that, the users can not use the recessed top of the cylinder as a storage area for tools or material. Furthermore, if cylinders are leaking, isolate them outdoors and away from sparks or heat and call the appropriate people to take care of the problem.

2.3.13 Maintenance of Gas Cylinder and Associated Equipment

Maintenance of equipment is a requirement of the Pressure Systems Safety Regulations and the Provision and Use of Work Equipment Regulations. It is recommended that routine maintenance is as follows (Administrative Department Health and Safety, University of Liverpool):

a) Cylinders

   Visual check on condition of cylinder (mechanical damage, significant rusting or other damage). Cylinders of more than 10 years old should be taken out of use and returned to supplier.

b) Regulators

   As per manufacturers instructions but to include visual check of threads, seals and presence of contaminants. Regulators used only for "inert" gases are not a serious hazard in the event of failure and/or leakage. Failure is extremely unlikely to occur other than when adjusting the cylinder valve or regulator control, and thus remedial action could be taken. Regulators for these gases can remain in service until they cease to function properly, provided they are suitable for the increased cylinder pressures applied. Cylinder valves (unless of the knob or handle type), should only be opened and closed with the correct key. Undue force should not be used. Any cylinders with a valve that needs to be hammered shut should be marked and returned to the suppliers as soon as possible. This is particularly relevant with oxygen, as a leaking valve can cause a build up of oxygen rich atmosphere, which although not in it self flammable can assist a spark to become a serious fire, which in normal air would not occur. The neck of the cylinder head should be free of water, dust or grease before a regulator is attached.

c) Flashback arresters

As per manufacturers instructions but to include visual check of threads, seals and presence of contaminants. Check unit for flow restriction and check non return valves. If of a pressure sensitive type, flow in correct direction with valve tripped. Pressure sensitive shut off valves should be tested for correct operation. It also must to be replaced every 5 years or manufacturer's recommendations.

d) Hose assemblies

As per manufacturers instructions but to include visual check of threads and seals. Check whip restraints where fitted. Leak test joints at all pressures. Reverse hose to ensure the correct operation of non-return valve where fitted. Replacement and/or refurbishment to be determined by local conditions.

2.4 Liquefied Petroleum Gas

Liquefied petroleum gas also called LPG, GPL, LP Gas, or autogas and it is a flammable mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles. It is increasingly used as an aerosol propellant and a refrigerant, replacing chlorofluorocarbons in an effort to reduce damage to the ozone layer. Basically the LPG are using for rural heating, motor fuel, refrigeration and also for cooking. LPG is synthesised by refining petroleum or wet natural gas and is usually derived from fossil fuel sources, being manufactured during the refining of crude oil or extracted from oil or gas streams as they emerge from the ground

Liquefied Petroleum Gas (LPG) is a subcategory of petroleum products known as natural gas liquids that are produced along with and extracted from natural gas. The composition of LPG is either mixture of 70% butane 30% propane or 60% butane 40% propane depends on the situation or culture of certain country. LPG is also produced from the refining of crude oil via separation process in gas processing plant. LPG recovered from natural gas is free of unsaturated hydrocarbons such as propylene and butylenes. Much of propylene and butylenes are removed in the refinery to provide raw materials for plastic and rubber production and to produce high octane gasoline components.

LPGs are both volatile and flammable and must be stored and handled in special equipment such as bulk storage and tank. Standards for storing and handling LPG are published in Malaysia Standard (MS 830) Code of Practice For The Storage, Handling and Transportation of LPG.

2.4.1 Comparison between LPG and Natural Gas

The calorific value of LPG is 94 MJ/m^3 or 26.1 kWh/m^3 and for natural gas is 38 MJ/m^3 or 10.6 kWh/m^3. So, we can say that the calorific value of LPG is higher than natural gas and which mean that the LPG cannot simply be substituted for natural gas. The mixing ratio of LPG/air is about 60/40 and though this is widely variable based on the gases making up the LPG. The mixing ratios can be determined by calculating the Wobbe index of the mix and so that, the gas having the same Wobbe index are held to be interchangeable.

In emergency backup systems for many public, industrial and military installations, LPG-based synthetic natural gas (SNG) are used and also many utilities is use LPG peak shaving plants in times of high demand to make up shortages in natural gas supplied to their distributions systems. When the distribution infrastructure is in place, LPG-SNG installations are used during initial gas system introductions before gas supplies can be connected.

2.5 Industrial Gas

Industrial gas is a group of gases that are commercially manufactured and sold for uses in other applications. These gases are mainly used in industrial processes such as steelmaking, oil refining, medical applications, fertilizer and more. The industrial gas may be both organic and inorganic and these gas are produced by extraction from the air by a process of separation or are produced by chemical synthesis and it will take in the various forms such as compressed, liquid or solid (Universal Industrial Gases, Inc). Industrial gases are valued for one or more of the following properties:

a) Reactivity
b) Inertness
c) Coldness

These properties are utilized to produce specialty products, protect and maintain product quality, and lower operating costs in steelmaking, metals manufacturing and fabrication, petroleum refining, chemicals and pharmaceuticals manufacture, production of electronic equipment and components, the rubber and plastics industries, food and beverage processing, glass manufacture, healthcare, pulp and paper and environmental protection operations (Universal Industrial Gases, Inc).

Gases valued for reactivity like oxygen, hydrogen, methane, carbon dioxide and carbon monoxide. These gases are reacted with other materials and will produce the other material or component. The gases valued for inertness include helium, neon, argon, krypton, xenon, nitrogen and carbon dioxide. These gases are almost totally inert. Argon, helium, neon, krypton and xenon are noble gases that are extremely inert under all conditions. Applications based on inertness include blanketing of storage tanks and vessels that contain flammable liquids or powders (Universal Industrial Gases, Inc).

The other applications of industrial gas are for blanketing of materials that would degrade in air such as vegetable oil, spices and fragrances. Then, it also for maintaining controlled atmospheres for industrial activities such as growing silicon and germanium crystals, manufacturing precision electronic devices, welding and soldering, preventing light bulb filaments from burning; retarding evaporation of filaments with high molecular weight inert gases, sparging (bubbling gas through liquids) to reduce the amount of oxygen or other gases dissolved in a liquid, filling insulating spaces between multi-pane windows and creating non-flammable lighter than air devices such as balloons and dirigibles (Universal Industrial Gases, Inc).

2.6 Tubing System

A tubing system as the piping system where is used to transport liquids that are sealed to prevent vapors. Closed tubing systems help prevents fires due to flammable or combustible liquids. In other words, tubing system is the transmission system where is one or more segments of piping, usually interconnected to form a network, which transport gas from a gathering system, the outlet of a gas processing plant or a storage field to a high or low-pressure distribution system, a large volume customer or another storage field (ASME B31.8, 2003).

Tubing system is required and very important in my study because the tubing system will provide connection between the gas cylinder and various equipments in engineering lab. Therefore, the characteristics of a suitable tube must be considered so that we can create the tubing system that accordance with load demand required by the equipments. Actually, we have many options type of tube to create tubing systems. Examples of types of tube are like plumbing tube, steel tube, copper tube and aluminium tube.

Usually, the copper tube is use for tubing systems because it has the advantages such as low cost and high convenience, can apply for low and high pressure. Installing interior gas systems using flexible, durable copper tubing is quick and easy compared with traditional systems based on threaded iron pipe. For new one and two family dwellings, copper gas systems are often the least expensive solution. For present gas consumers, copper tube offers maximum ease of retrofit installation for adding new gas equipment and appliances after original construction.

Copper tubing can be used to supply both low pressure gas systems (those operating at less than 0.5 psig) and elevated pressure systems up to 5 psig. Currently, 2 psig systems are the most common elevated pressure systems used for industrial installations. Since elevated pressure means smaller pipe diameters, gas supply systems operating at 2 psig and higher are a perfect application for flexible copper gas tubing.

2.7 Plant Design Management System (PDMS) Software

PDMS as it is known in the 3D CAD industry, is a customizable, multi-user and multi-discipline, engineer controlled design software package for engineering, design and construction projects in, but not limited to, offshore and onshore oil and gas industry, chemical and process plants, mining, pharmaceutical & food industry, power generation and paper industries.

Picture below show us the 3D of the piping and tubing system design using PDMS software:

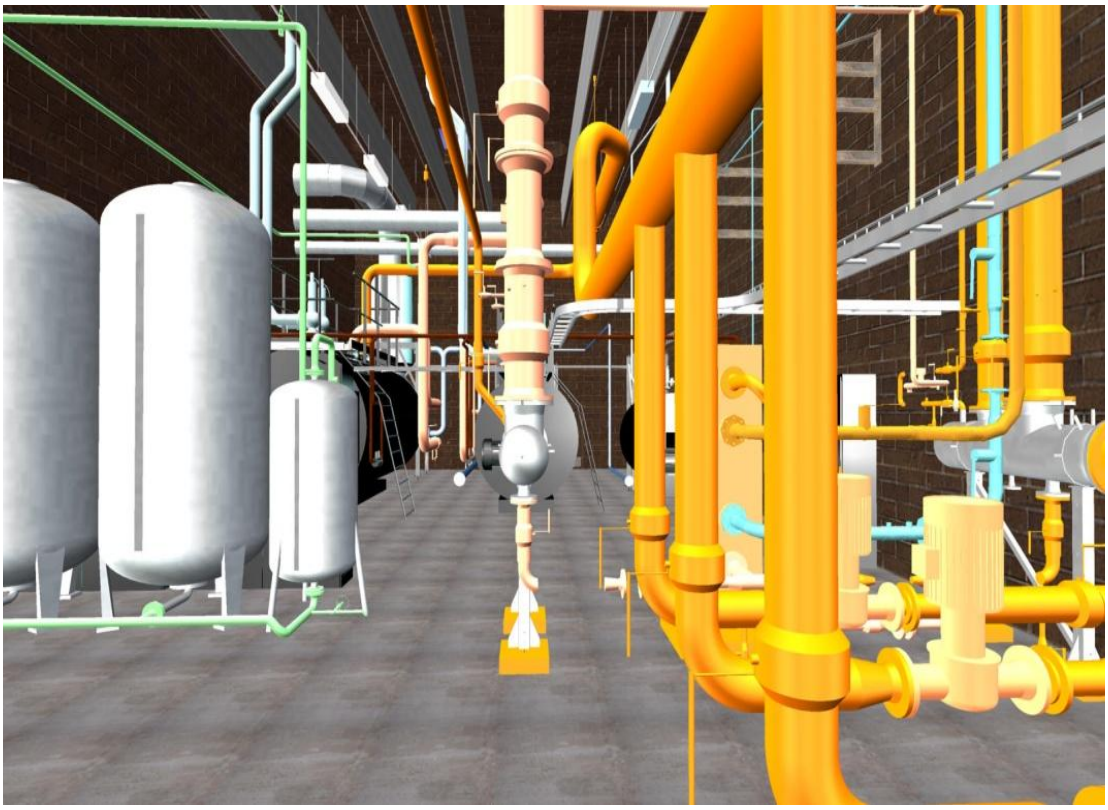

Figure 2.6: Simulation of Piping System using PDMS software

CHAPTER 3

METHODOLOGY

3.1 The Overall Methodology

Have several steeps to reach the objective of this project such as estimation of load demand, calculation number of gas cylinder based on gas demand, network study to identify length of tube, study of suitable area to locate the gas manifold based on standards and code, assessment in term of safety at the gas manifold area, proposed the location and selection of material for the tubing system between gas manifold system and the equipment, design the layout using PDMS software and the last one is about safety analysis.

3.1.1 Estimation of Load Demand

Estimation of load demand is about the measurement of flow rate the gas or gas consumption of all equipments which used the gas. The load demand means the value flow rate of gas used by the equipment in the laboratory. Basically, it can be measurement by manually which is observed during the equipment is running. Other than that, the load demand also can be measure by search in the internet and ask JP's laboratory.

3.1.2 Calculation number of gas cylinder based on gas demand

Based on the consumption of the gas, the number of gas cylinder required in manifold system can be calculate. Before that, the value of vaporization rate of the gas should be determined. It is because, calculation of the number of gas cylinder is equal to flow rate of gas per hour is divided to vaporization rate of gas as equation below:

No. of gas cylinder = Flow rate gas (kg/hour) ÷ vaporization rate of gas (kg/hour)

3.1.3 Network study to identify length of tube

Before the tubing system is drawing by using PDMS software, the network study of tubing connection between manifold system and equipment should be done. In this procedure, the length of tubing must be determined manually by using the rope and measure tape. Moreover, during measurement of the length, the location of equipment also must be identified because the direction of gas is depend on the position of the equipment in the laboratory.

3.1.4 Study of suitable area to locate the gas manifold

Study about suitable area to locate the gas manifold based on standards and codes such as Suruhanjaya Tenaga Guidelines, MS 830, MS 930 and more. It is very important to ensure the safety at the manifold area is in good condition. Therefore, the area of gas manifold should be complying with the regulation and standard. In this method, several locations are considered as the suitable area and only one of all these areas is choose for placing the gas manifold.

3.1.5 Assessment in term of safety at the gas manifold area

The assessment in term of safety means the study of safety based on the requirement, regulation, acts, standards and codes which refer to the several guidelines such as Malaysian Standard 830, Malaysian Standard 930 and Suruhanjaya Tenaga Guidelines and also from foreign standard such as American Welding Society (AWS), American Society of Mechanical Engineers (ASME), National Fire Protection Association (NFPA) and more. Basically, the safety aspect which will be considered such as about the distance of gas cylinder for several type of gases, the distance of gas cylinder from others like the door and window, the guidelines for use, storage and handling of gas cylinders.

3.1.6 Proposed the location and selection of material for the tubing system

The location is proposed and search about the suitable material for the tubing system. The location will be proposed after one of all the suitable areas is choose based on the requirement criteria from the codes and standards. Then, the selection of material construction of tube is make the survey about suitable type of tube for tubing system and it should be considered about the quality, availability, cost and advantages.

3.1.7 Design the layout using PDMS software

To show the flow of gas through the tubing system, it will done by design using PDMS software. Before drawing by using PDMS software, the direction of gas flow is drawing in 2D on the FKKSA's laboratory map. On this map also show the length of tube between gas manifold and the equipment or appliances in several areas in the laboratory. Then, the gas flow direction will draw by using PDMS software and the tube is show in 3D review and isometric review.

3.1.8 Safety analysis

The safety will be analyzed to make sure it follows the rules and regulations that have been set up. The safety aspect in manifold area will be discuss and make sure that this area is comply with the standards and codes. Basically, it will focus on the distance the gas cylinder with other materials and about the conditions at the area of gas manifold. The flow chart for this methodology is shown in Figure 3.1.

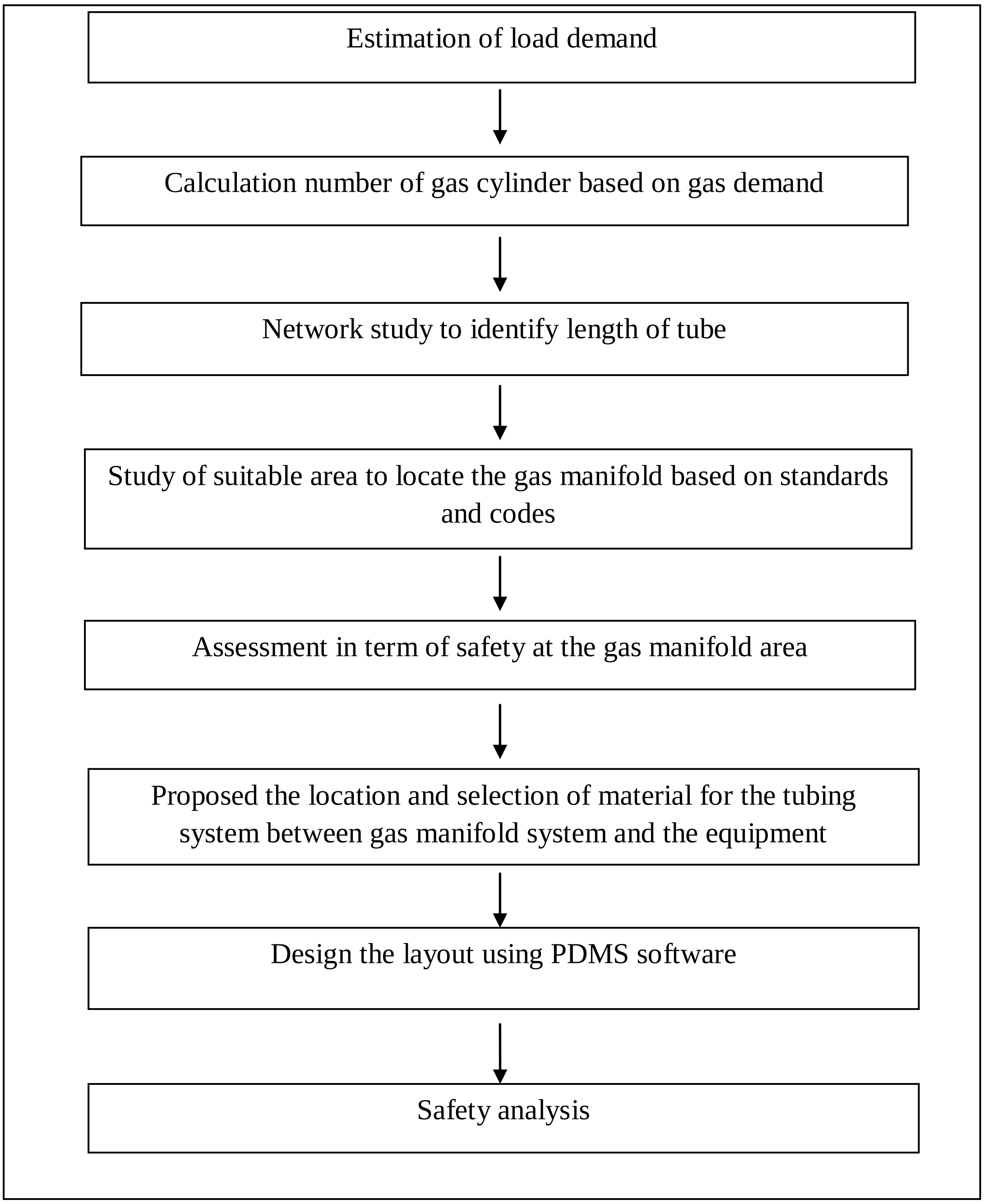

Figure 3.1: Flow chart of the methodology

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 Result

Number of gas cylinder is must be considered in designing of the manifold system. Actually the number of gas cylinder in manifold system is depending on the load demand of that gas use by the related equipment. Load demand means the gas consumption by any equipment and it can be measured by minute, hour or day. For example, the gas turbine use liquefied petroleum gas (LPG) is 300 m^3 per hour. Based on that value of consumption, the number of gas cylinder required can be determined and it used to supply this gas for certain time. And also the running out of gas can be *avoided*.

The calculation of the number gas cylinder based on the total gas consumption (kg/hour) and the vaporization rate of the gas (kg/hour). The total gas consumption for each gas can be measured by flow rate of gas enters the equipment and vaporization rate of the gas can be measured based on the latent heat of vaporization (kJ/kg).

Other than that, the tubing system also should be considered in designing of manifold system. The tubing system will show us the connection between the manifold and the related equipment. The designing of tubing system basically are using the Plant Design Management System (PDMS) Software. It will show the flow of gas from the cylinder to the equipment based on PDMS drawing and the parameters required.

Table 4.1 below show the gas consumption by the equipment in FKKSA's laboratory in flow rate (kg/hour) unit. Based on this table, the number of Fermenter 2L is 4 units and the gas pressure required is 0.5 bars. Beside that, the number of Fermenter 10L, Fermenter 20L and Fermenter 50L is 1 unit respectively and the gas pressure required is 0.5 bar, 6 bars and 3 bars respectively. Fermenter 2L, 10L, 20L and 50L used several gases such as Nitrogen, Oxygen and Carbondioxide to run the experiment. The other equipment is Gas Chromatography where the number of it is 2 units and gas pressure required is 0.7 bars and also used Nitrogen, Hydrogen and Helium gas to operate.

The number of Atomic Absorption Spectrophotometry is 2 units and the gas pressure required is 1 bar. Basically, it used Oxygen, Argon, Nitrous oxide, Ethylene and compressed air to run the experiment related with this equipment. Then, the number of Anaerobic Chamber is only 1 unit. This equipment used Nitrogen, Carbondioxide and Hydrogen gas to operate and gas pressure required is about 0.7 bars. Other than that, other equipment is CO_2 Incubator and only 1 unit at the laboratory. CO_2 Incubator used only Carbondioxide gas to operate and 1 bar gas pressure required.

In FKKSA's laboratory also has Gas Absorption-Adsorption Unit and the number of this equipment is 1 unit. It used Carbondioxide gas to run the experiment and the gas pressure required is about 1 bar. Beside that, the number of Bomb Calorimeter where is located in Unit Operational Chemical Reaction and Separation lab is only 1 unit. This equipment used Oxygen gas to operate and the gas pressure required is about 30 bars. Then, Pressure Swing Adsorption used Nitrogen and Carbondioxide gas to operate and the gas pressure required is about 1 bar.

Gas Absorption Refrigeration, Flame Propagation and Stability Unit, Gas Combustion Laboratory Unit and Gas Turbine Demonstration Unit used Liquefied Petroleum Gas or LPG to operate and the pressure required is about 0.03 bars, 0.5 bars, 2 bars and 5 bars respectively. Supercritical Unit used Carbondioxide gas as the gas to run the experiment and the pressure required is about 300 bars. Other than that, the welding set like GMAW and GTAW are used the same gas which is Argon gas and the pressure required when running is about 3 bars. But, GMAW can apply the other gas such as Carbondioxide gas as the shielded gas during weld the material. The last equipment is Differential Scanning Calorimeter where is located in

Analytical Cool lab. During run the experiment, this equipment used Nitrogen, Oxygen and compressed air and the pressure of all the gases is about 2 bars.

The total of equipments used the LPG and industrial gas at FKKSA's laboratory is about 27 equipments. Based on the Table 4.1, the total of Nitrogen, Oxygen, Carbondioxide, Hydrogen, Helium, Argon, Nitrous oxide, Ethylene, compressed air and LPG used are 7.907 kg/hour, 10.4 kg/hour, 21.42 kg/hour, 0.01 kg/hour, 0.0002 kg/hour, 1.385 kg/hour, 3.268 kg/hour, 0.288 kg/hour, 0.095 kg/hour and 37.18 kg/hour respectively.

Space untuk gambar 4.1!!!
Jgn isi apa-apa

Table 4.2: Heat of Vaporization and Evaporation Rate of Each Gas

Type of gas	Heat of Vaporization (kJ/kg)	Vaporization Rate (kg/hour)
Carbon dioxide	571.08	2.855
Nitrogen	198.38	0.992
Oxygen	212.98	1.065
Hydrogen	454.3	2.272
Argon	160.81	0.804
Compressed Air	198.7	0.994
Nitrous oxide	376.14	1.881
LPG	370	1.850
Acetylene	801.9	4.010
Helium	20.3	0.102

Table 4.2 above show the value of heat of vaporization and evaporation rate for the gases such as Carbon dioxide (CO_2), Nitrogen (N_2), Oxygen (O_2), Hydrogen (H_2), Argon, Compressed Air, Nitrous oxide (N_2O), Liquefied Petroleum Gas (LPG), Acetylene and Helium (He). The heat of vaporization and vaporization rate for CO_2 is 571.08 kJ/kg and 2.855 kg/hour respectively. For N_2, the heat of vaporization and vaporization rate is 198.38 kJ/kg and 0.992 kg/hour respectively. The heat of vaporization of O_2 is 212.98 kJ/kg and vaporization rate for this gas is about 1.065 kg/hour. Beside that, the value of heat of vaporization for H_2 gas is about 454.3 kJ/kg and vaporization rate is 2.272 kg/hour. Argon gas also have the heat of vaporization and vaporization rate where the value of both is about 160.81 kJ/kg and 0.804 kg/hour respectively.

The other gases like Helium, Acetylene, LPG, Nitrous oxide and compressed air also have the heat of vaporization and vaporization rate. For Helium, the heat of vaporization is 20.3 kJ/kg. This value is too small compared with the other gases and the vaporization rate is only 0.102 kg/hour. Then, for the LPG, Nitrous oxide, Acetylene and compressed air, the value of heat of vaporization are 370 kJ/kg, 376.14 kJ/kg, 801.9 kJ/kg and 198.7 kJ/kg respectively. The vaporization rate for these gases are 1.850 kg/hour, 1.881 kg/hour, 4.010 kg/hour and 0.994 kg/hour respectively. The vaporization rate of the gas is important to calculate the number of gas cylinder required for manifold system.

Table 4.3: Number of Gas Cylinder Required For Manifold System

Type of gas	**No. of cylinder required**
N_2	8
O_2	10
CO_2	*8*
H_2	1
He	1
Argon	2
N_2O	2
Acetylene	1
Air	1
LPG	21
Total	55

Table 4.3 above show the number of gas cylinder required for manifold system. This result based on the calculation by using equation below:

Number of cylinder = Total gas consumption per hour ÷ vaporization rate of gas

Based on the table above, 8 gas cylinders is required for Nitrogen and Carbondioxide, 10 gas cylinders is required for Oxygen, 1 gas cylinder is required for Hydrogen, Helium, Acetylene and compressed air, 2 gas cylinders is required for Argon and Nitrous oxide and lastly for LPG, the number of gas cylinder required is about 21 cylinders. As conclude, the number of gas cylinder for LPG is higher than other gases and it show that the LPG consumption is high during run the experiment.

The total of gas cylinder required for manifold system in this project is about 55 gas cylinders. Therefore, the area of gas manifold should be enough to place the gas cylinders. It is also because, have the certain distance between the gas cylinders based on type of the gases applied.

4.2 Discussion

4.2.1 Manifold System

Several equipments in the laboratory used the certain gas to operate. These gases included LPG, Carbondioxide (CO_2), Oxygen (O_2), Nitrogen (N_2), Hydrogen (H_2), Helium (He), Argon, Nitrous oxide (N_2O), Acetylene and Compressed air. Based on the load demand of each gases for each equipment, the total consumption gas of LPG is 37.18 kg/hour, CO_2 is 21.42 kg/hour, O_2 is 10.4 kg/hour, N_2 is 7.907 kg/hour, H_2 is 0.01 kg/hour, He is 0.0002 kg/hour, Argon is 1.385 kg/hour, N_2O is 3.268 kg/hour, Acetylene is 0.288 kg/hour and lastly for compressed air is 0.095 is kg/hour. Shortly, the manifold system for this project consist 10 types of gases.

Actually, the vaporization rate totally depends on its heat of vaporization. The heat of vaporization is the amount of heat required to convert a unit mass of a liquid at its boiling point into vapor without an increase in temperature. Therefore, the vaporization rate is related with the heat of vaporization. For example, the heat of vaporization for LPG and hydrogen is about 370 kJ/kg and 454.3 kJ/kg respectively and the value of evaporation rate is about 1.850 kg/hour and 2.272 kg/hour respectively. Based on that value, found that the vaporization rate of LPG is higher than hydrogen. It is because the energy required for LPG convert to vapor is lower than hydrogen. Briefly, the vaporization rate is directly proportional with the heat of vaporization.

Based on the calculation, the number of gas cylinder required is about 55 cylinders and this gas can use for long period time because the capacity of gas supplied is enough for all equipment at the FKKSA laboratory run without running of gas. Although the number of cylinder which based on calculation is too much, but we can reduce the number of gas cylinder to limit the use of space at the manifold area.

4.2.2 Location of Manifold

The manifold system consist several of gas cylinder and note that the gas cylinder is very dangerous especially to users and common people. Hence, the gas cylinder should be placed at the appropriate area where the codes and standard like Suruhanjaya Tenaga (ST) Guidelines, MS 830 and MS 930 as the guidelines during doing the survey of location of manifold. In this project, the manifold system is placed at the existing place because the characteristic of this area has met the regulation and standard which is enshrined in the ST Guidelines, MS 830 and MS 930.

Currently, the location of the gas manifold is located between the gas storage area and main entrance of FKKSA laboratory. The distance between manifold area and main entrance and gas storage is about 9 meters and 5 meters respectively. Based on MS 830, the cylinder should be located at a distance of at least 1 meter from the door and 5 meters from flammable or combustible liquid storage and other forms of combustible materials. Therefore, the location of existing area of gas manifold was complied the MS 830. Beside that, this area also has the good ventilation system where not have any resistance to block the air enter the manifold area.

Other than that, about in the manifold area, have the specific distance between the gas cylinders for each gas because gases can be flammable or combustible, explosive, corrosive, poisonous or toxic, inert, cryogenic, a combination of hazard and pyrophoric. Pyrophoric means the gases burns on contact with the air. The flammable gases such as LPG, Acetylene and Hydrogen will burn when these gases mixed with the oxidant and ignition source. In addition, the oxidant will support the combustion and example of oxidants gas is Oxygen and air. Beside that, the inert gas such as Nitrogen, Argon, Helium and Carbondioxide do not generally react with other materials bur these gases as asphyxiants where the leaking will displace air and human cannot breathe because not enough Oxygen or air.

Based on American Welding Society (AWS), the safe distance for gases other than LPG also must be considered because Acetylene and Hydrogen are the flammable gases. Therefore, keep Oxygen cylinders 20 feet away from fuel gas cylinders such as Acetylene or separate them with a non-combustible barrier such as a wall at least 5 feet high with a fire resistance rating of at least one half hour.

The minimum distance requirement of gas manifolds as in the Figure 4.1. Based on this figure, the minimum distance between the gas manifolds from the door is about 1 meter. Beside that, the gas manifolds also should be placed at least 150 mm below the window. The distance between the gas manifolds and the door and the window should be considered because to avoid the gas enter the building if leakaging of gas occur.

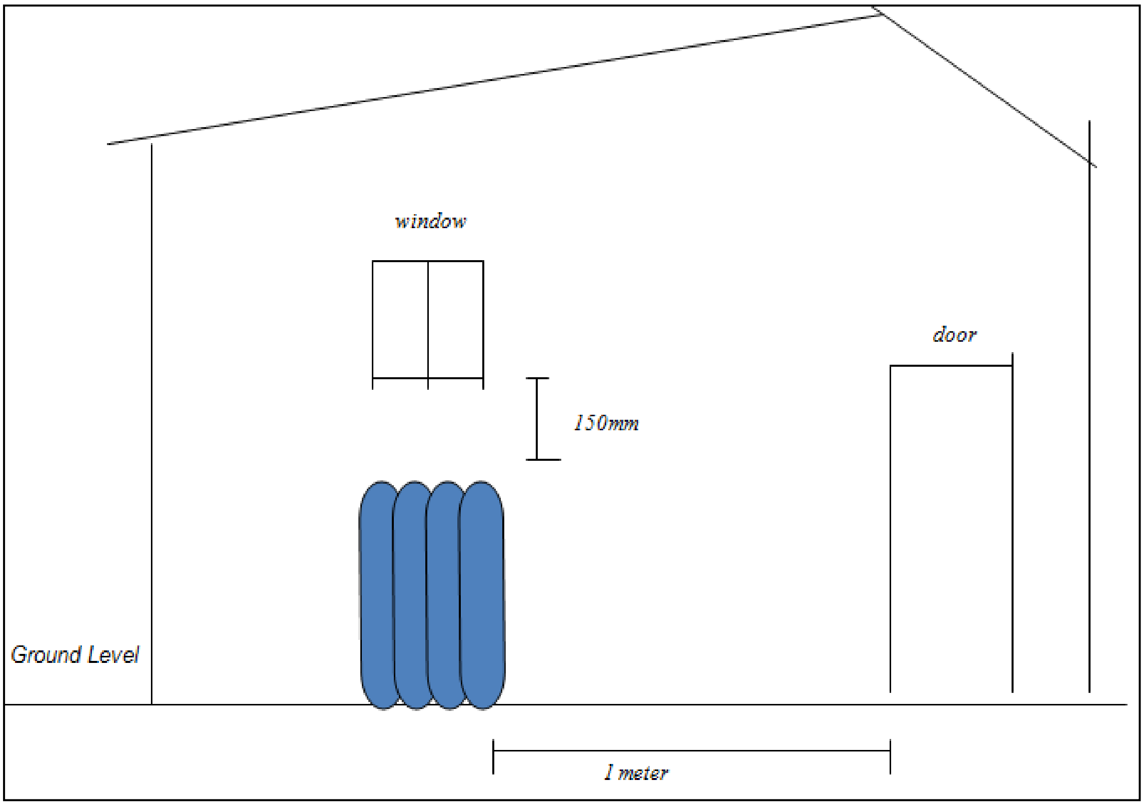

Figure 4.1: The minimum distance of gas manifold from the door and window (Malaysian Standard 830: Code of Practice for the Storage, Handling and Transportation of LPG)

4.2.3 Material Selection for Gas Tubing System

Normally, the gas tubing is made from stainless steel and copper. In this project, the gas tubing where the copper is the main material construction was selected because it is better than stainless steel. Copper tubing creates convenience, safety and ease of installation for builders and homeowners alike. Moreover, the copper tubing usually applied for water supply drainage, medical gas, heating ventilating and air conditioning (HVAC) and fire sprinkler systems. Copper tubing was selected as the type of gas tubing because it has several advantages which can give the benefits for users.

One of the advantages of copper tubing is copper tube's flexibility allows sharper bends, easier installation and particularly in confined spaces. Beside that, copper tubing can be snaked and routed easily through typical wall and ceiling construction. This makes it easier and more economical to bring all the advantages of modern gas service to more locations throughout new and renovated building. The equipments or appliances in the lab are located far away from the gas manifold area. Therefore, copper tubing is the right choice because it can be applied for long length, up to 100 feet standard and makes it possible to eliminate joints in walls, floors and ceilings. This improves safety by minimizing the potential for leaks. Other advantages of copper tubing such as can applied for low and high pressure, safe to use and low cost.

4.2.4 Design of Tubing System

Plant Design Management System (PDMS) software is using to design the tubing system between the gas manifold and appliances. Before start the designing, several aspects should be done such as survey the location of equipment, measure the length of tube between gas manifold and the appliances, drawing the flow of gas in 2D and lastly is drawing the flow of gas in 3D using PDMS software. In addition, the length of tube is the actual length where the measuring of the length is using the measure tape.

In addition, the tubing system involved 7 types of area in the laboratory like bio analytical lab, analytical cool lab, analytical hot lab, biotech lab 2, unit operation chemical reaction and separation lab, gas engineering lab and clean room at PERKASA building. The flow of gas in 2D drawing at the laboratory as in Figure 4.2.

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Jgn isi apa-apa

The layout of tubing system in 3D review and isometric review at several areas or location in the laboratory is drawing by using PDMS software as in Figure

4.3 and 4.4, tubing layout at Gas Engineering Lab, Figure 4.5 and 4.6, tubing layout at Bio Analytical Lab, Analytical Cool Lab and Analytical Hot Lab, Figure 4.7 and 4.8, tubing layout at Biotech Lab 2, Figure 4.9 and 4.10, tubing layout at Unit Operation Chemical Reaction and Separation Lab and lastly Figure 4.11 and 4.12, tubing layout at PERKASA Building.

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CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In the engineering lab, where the rate of gas consumption is high and it is much advantageous to use a manifold system. It is because the running out of gas during run the equipment can avoid and will not give the problem when run the experiment using the equipment related with the gas. Based on result, the consumption of LPG is higher than other gas. It is because the gas turbine and gas combustion laboratory unit were needs high flow rate of LPG during running.

During designing the manifold system, the safety aspect also must be considered to comply the regulation based on Suruhanjaya Tenaga Guidelines, MS 830 and MS 930. This regulation included about the area, location, conditions of area, the distance between the gas cylinder with other material and equipment and more. Failed to complying the regulations will give many effect like explosion and more unsafe condition for the student and public.

Other than that, the tubing system also should be considered in designing of manifold system where PDMS software is use to design the tubing connection between gas cylinder and equipment. Basically, during design the tubing system, the parameter such as length of tube, diameter of tube and coordinate the equipment should be considered.

5.1 Recommendation

The scope of this study was limited to only designing of manifold system for FKKSA laboratory. Therefore, it needs to be applying for other place such as at the cafeteria where is locate in front of FKKSA laboratory. As additional, the cafeteria is use LPG and the consumption of LPG at the cafeteria must be continuously to avoid any problem such as running out of the gas. Therefore, for the future research it should be considered about the consumption of LPG at the cafeteria because it will give more benefit to use.

Beside that, the costing of the tubing also should be considered at the future research. It is important to ensure the total cost of installation the gas manifolds and tubing in the laboratory. Moreover, the costing of tubing material can be calculated based on the data from PDMS software. It is because, at the end of drawing tubing using PDMS software, the number of equipment such as elbow, valve, flange, tee and the length and size of tube also determined. It will help the researchers or designers to determined the cost of installation tubing system.

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APPENDICES

Calculation

Vaporization Rate (Vaporization rate of LPG as basis = 1.85 kg/hour)

Since the vaporization rate is totally depends on the heat of vaporization, it can be calculated based on the vaporization rate of LPG as a basis. The heat of vaporization is at 1 atm and 0°C. The calculation of vaporization rate for each gas as shown below:

Vaporization rate of CO_2

Rate, kg/hour = 571.08 kj/kg × 1.85 kg/hour ÷ 370 kj/kg

= 2.855 kg/hour

Vaporization rate of Nitrogen

Rate, kg/hour = 198.38 kj/kg × 1.85 kg/hour ÷ 370 kj/kg

= 0.992 kg/hour

Vaporization rate of Oxygen

Rate, kg/hour = 212.98 kj/kg × 1.85 kg/hour ÷ 370 kj/kg

= 1.065 kg/hour

Vaporization rate of Hydrogen

Rate, kg/hour = 454.3 kj/kg × 1.85 kg/hour ÷ 370 kj/kg

= 2.272 kg/hour

Vaporization rate of Argon

Rate, kg/hour = 160.81 kj/kg × 1.85 kg/hour ÷ 370 kj/kg

= 0.804 kg/hour

Vaporization rate of Compressed Air

Rate, kg/hour = 198.7 kj/kg × 1.85 kg/hour ÷ 370 kj/kg

= 0.994 kg/hour

Vaporization rate of Nitrous oxide

Rate, kg/hour = 376.14 kj/kg × 1.85 kg/hour ÷ 370 kj/kg

= 1.881 kg/hour

Vaporization rate of Acetylene

Rate, kg/hour = 801.9 kj/kg × 1.85 kg/hour ÷ 370 kj/kg

= 4.010 kg/hour

Vaporization rate of Helium

Rate, kg/hour = 20.3 kj/kg × 1.85 kg/hour ÷ 370 kj/kg

= 0.102 kg/hour

Number of Gas Cylinder Required

Before to calculate the number of gas cylinder, the calculation of vaporization rate should be done because the calculation the number of gas cylinder required is depend on the vaporization rate of gas. Calculations of number of cylinder required are using equation below:

Number of cylinder = Total gas consumption per hour/vaporization rate of gas

1) Carbon dioxide:

Number of cylinder = (21.42 kg/hour)/ (2.855 kg/hour)
= *7.5*
= *8*

2) Nitrogen:

Number of cylinder = (7.907 kg/hour)/ (0.992 kg/hour)
= *7.97*
= *8*

3) Oxygen:

Number of cylinder = (10.4 kg/hour)/ (1.065 kg/hour)
= *9.765*
= 10

4) Hydrogen:

Number of cylinder = (0.011 kg/hour)/ (2.272 kg/hour)
= 0.004
= 1

5) Argon:

Number of cylinder = (1.385 kg/hour)/ (0.804 kg/hour)

= *1.72*

= 2

6) Compressed Air:

Number of cylinder = (0.095 kg/hour)/ (0.994 kg/hour)

= 0.1

= 1

7) Nitrous oxide:

Number of cylinder = (3.268 kg/hour)/ (1.881 kg/hour)

= 1.72

= 2

8) LPG:

Number of cylinder = (37.18 kg/hour)/ (1.850 kg/hour)

= 20.1

= 21

9) Acetylene:

Number of cylinder = (0.288 kg/hour)/ (4.010 kg/hour)

= 0.1

= 1

10) Helium:

Number of cylinder = (0.0002 kg/hour)/ (0.102 kg/hour)

= 0.002

= 1

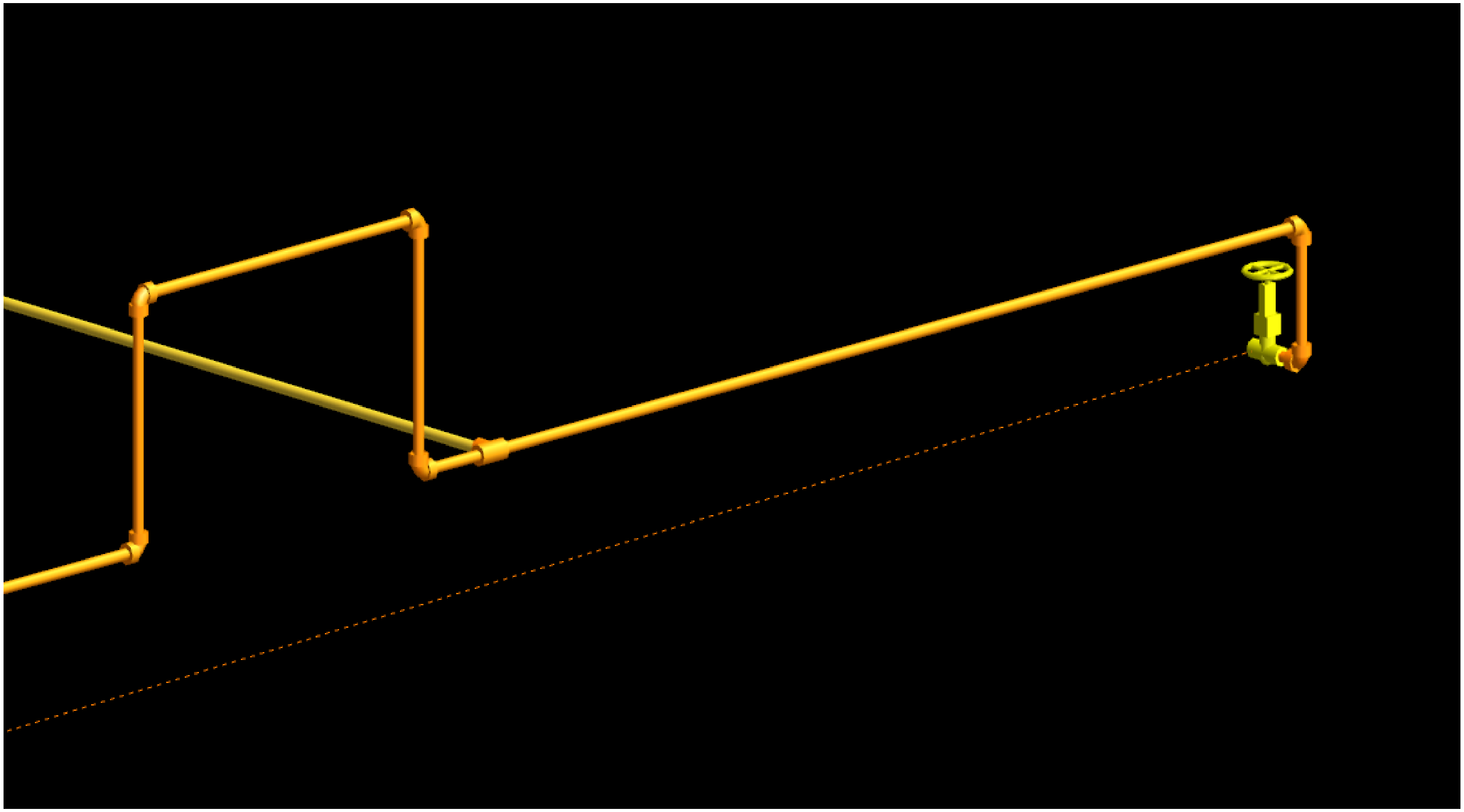

Figure 4.3: Tubing layout at Gas Engineering Lab (3D review)

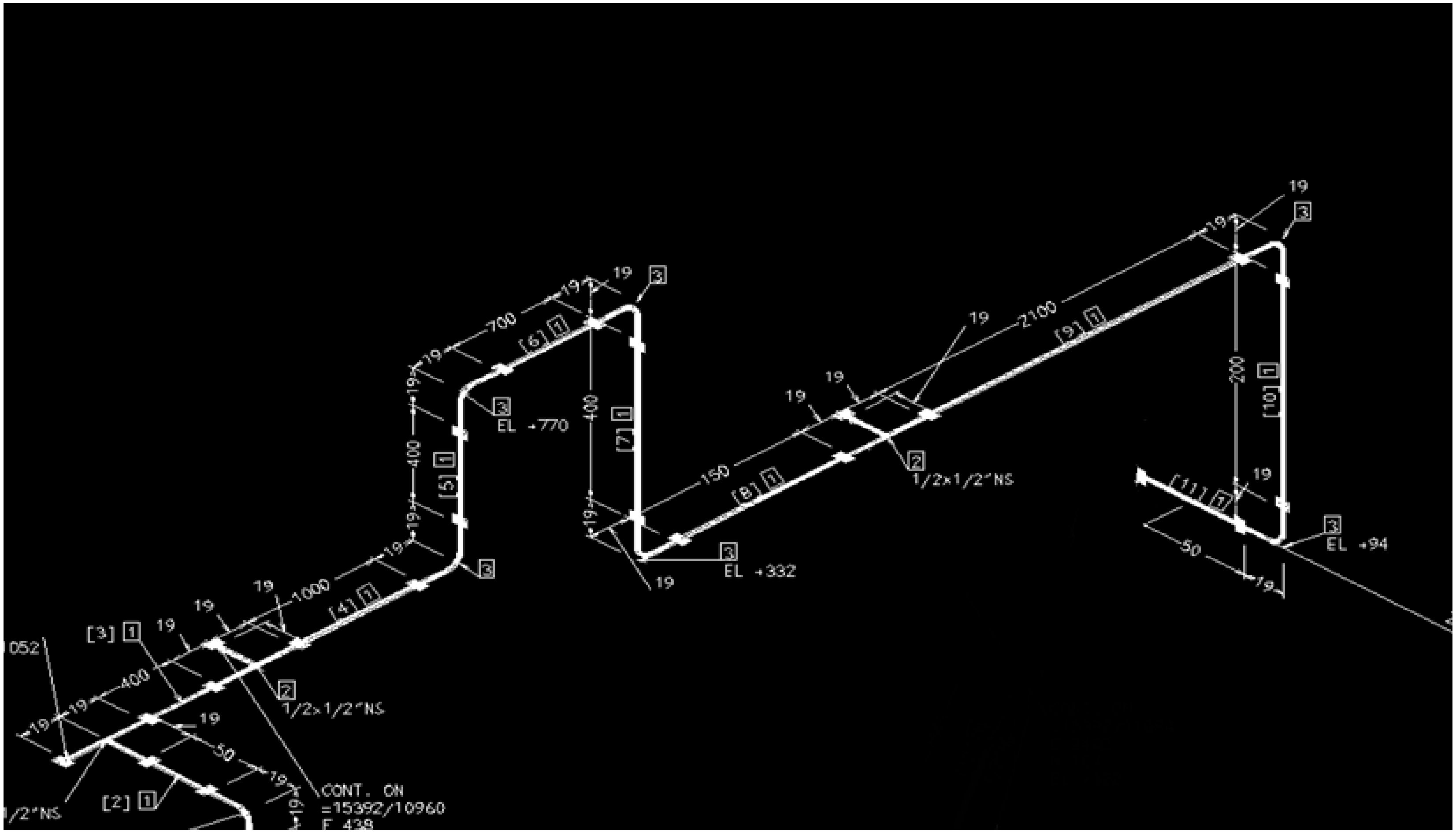

Figure 4.4: Tubing layout at Gas Engineering Lab (Isometric review)

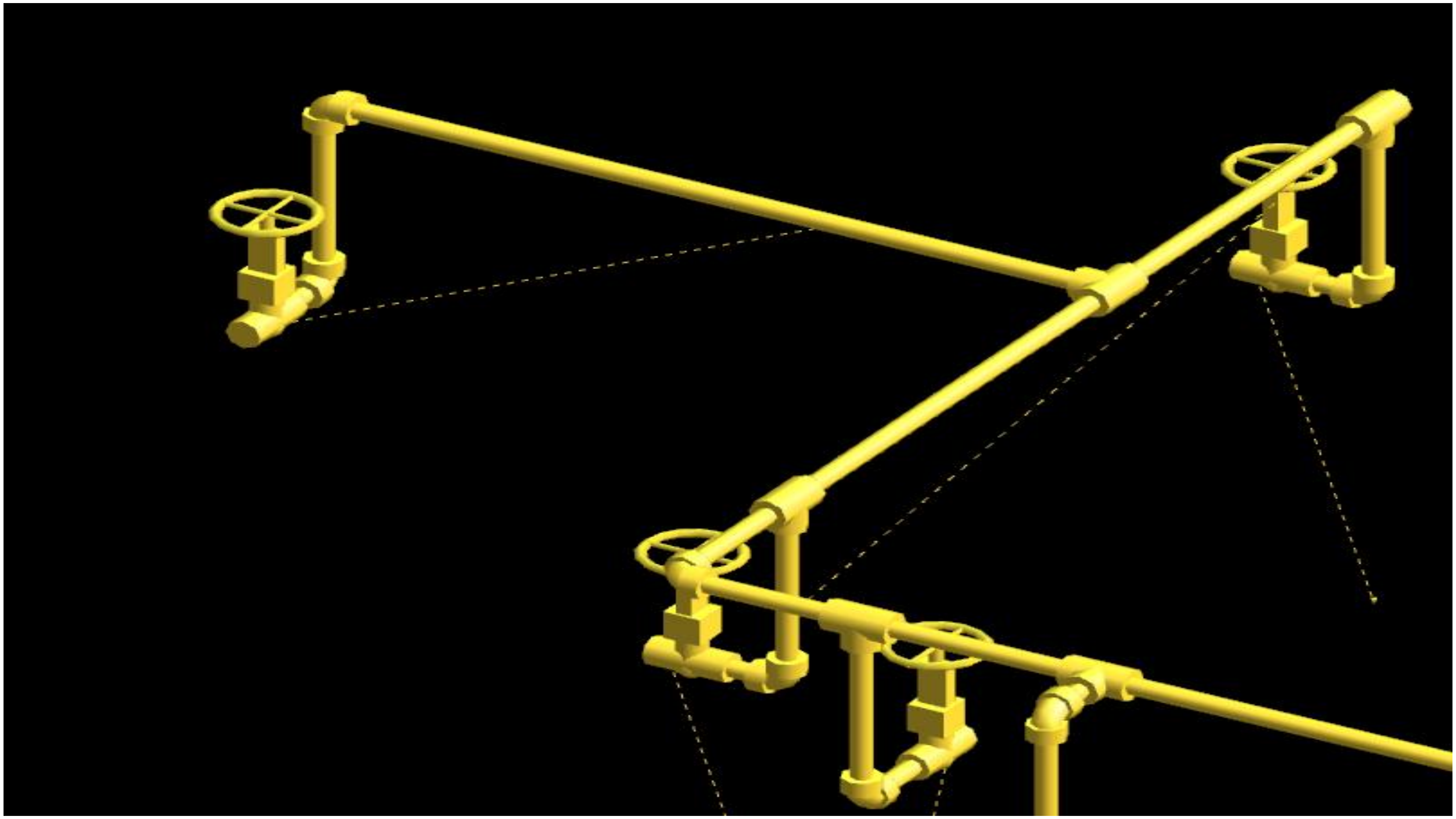

Figure 4.5: Tubing layout at Bio Analytical Lab, Analytical Cool Lab and Analytical Hot Lab (3D review)

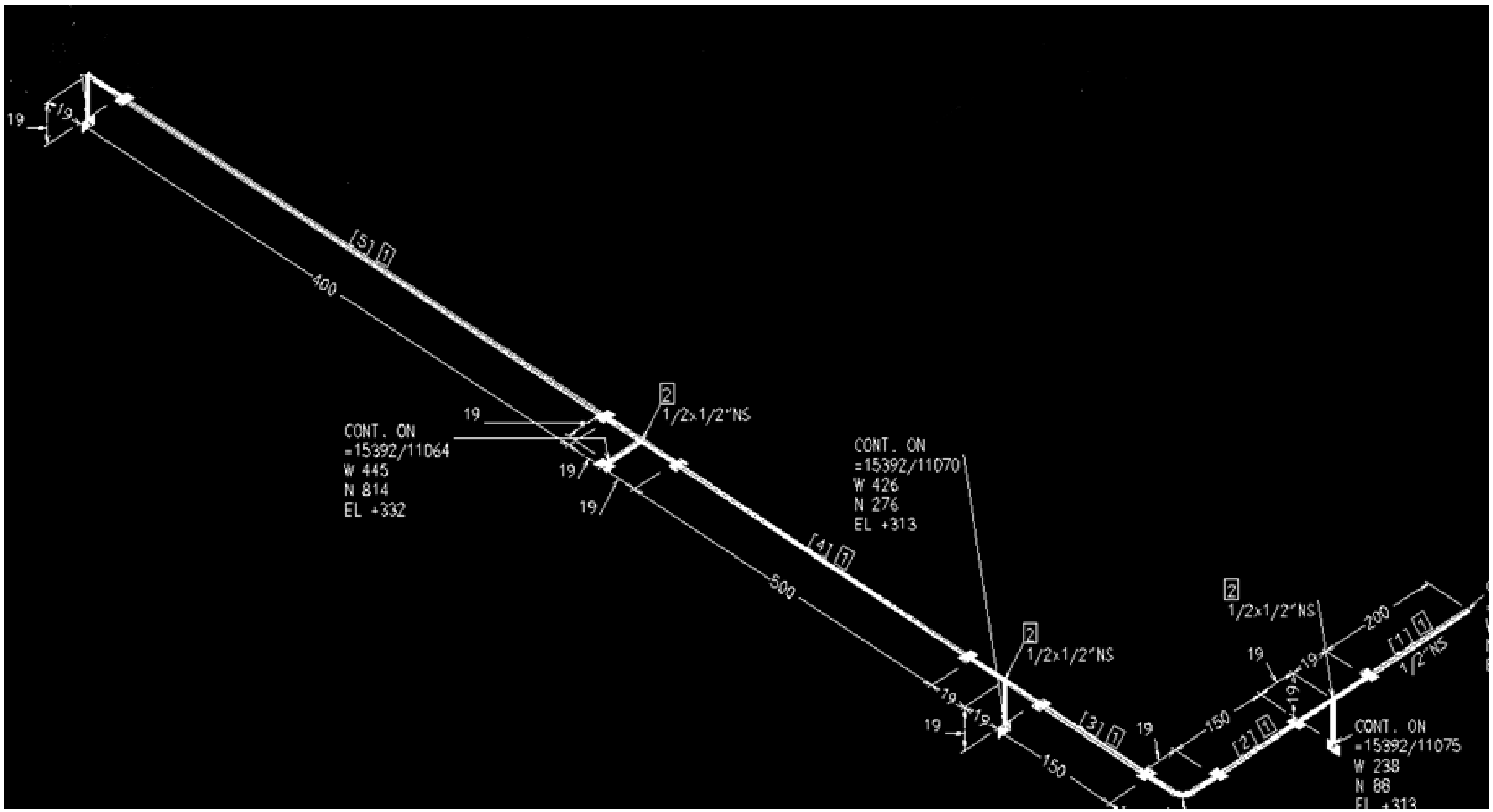

Figure 4.6: Tubing layout at Bio Analytical Lab, Analytical Cool Lab and Analytical Hot Lab (Isometric review)

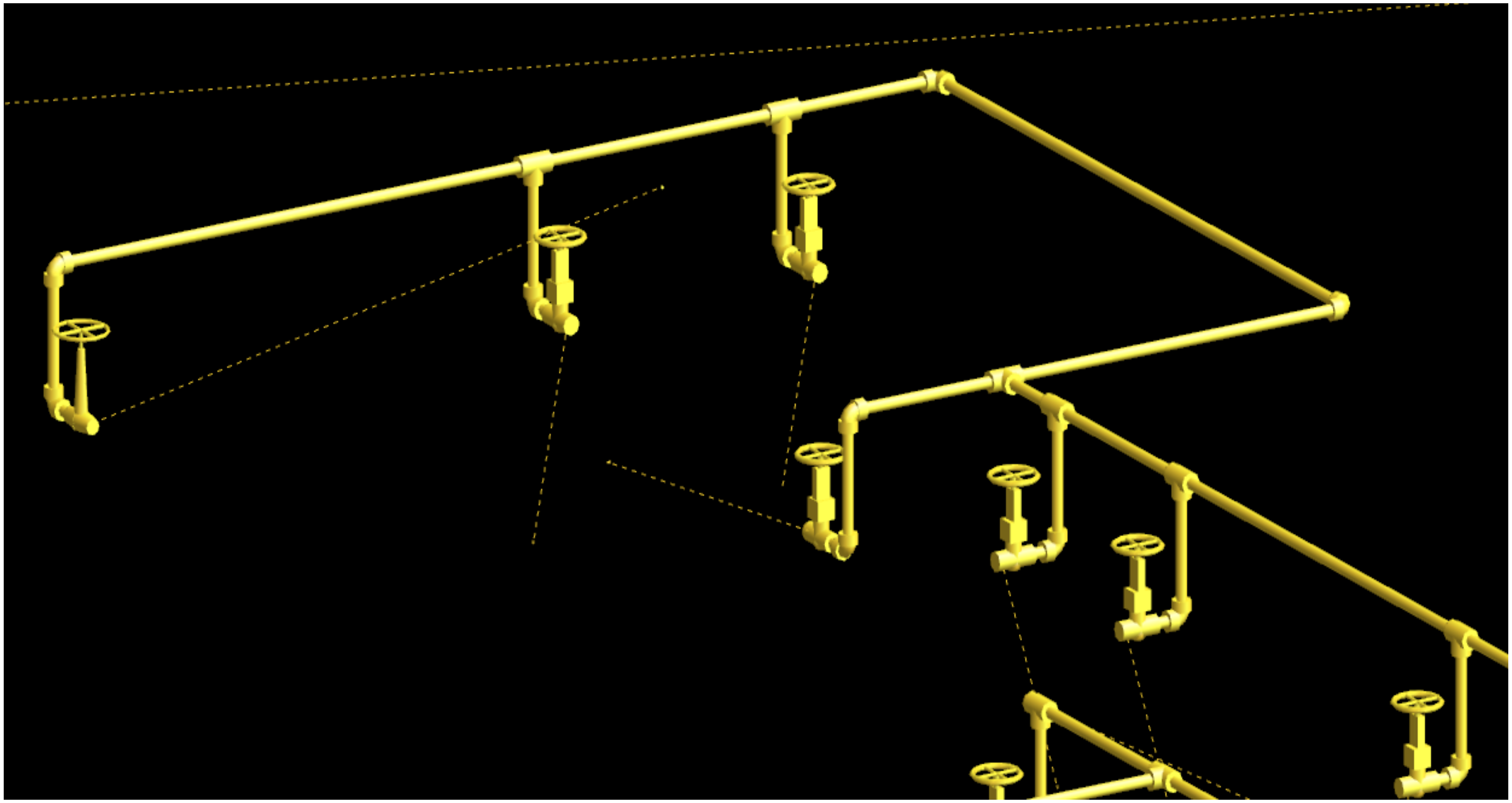

Figure 4.7: Tubing layout at Biotech Lab 2 (3D review)

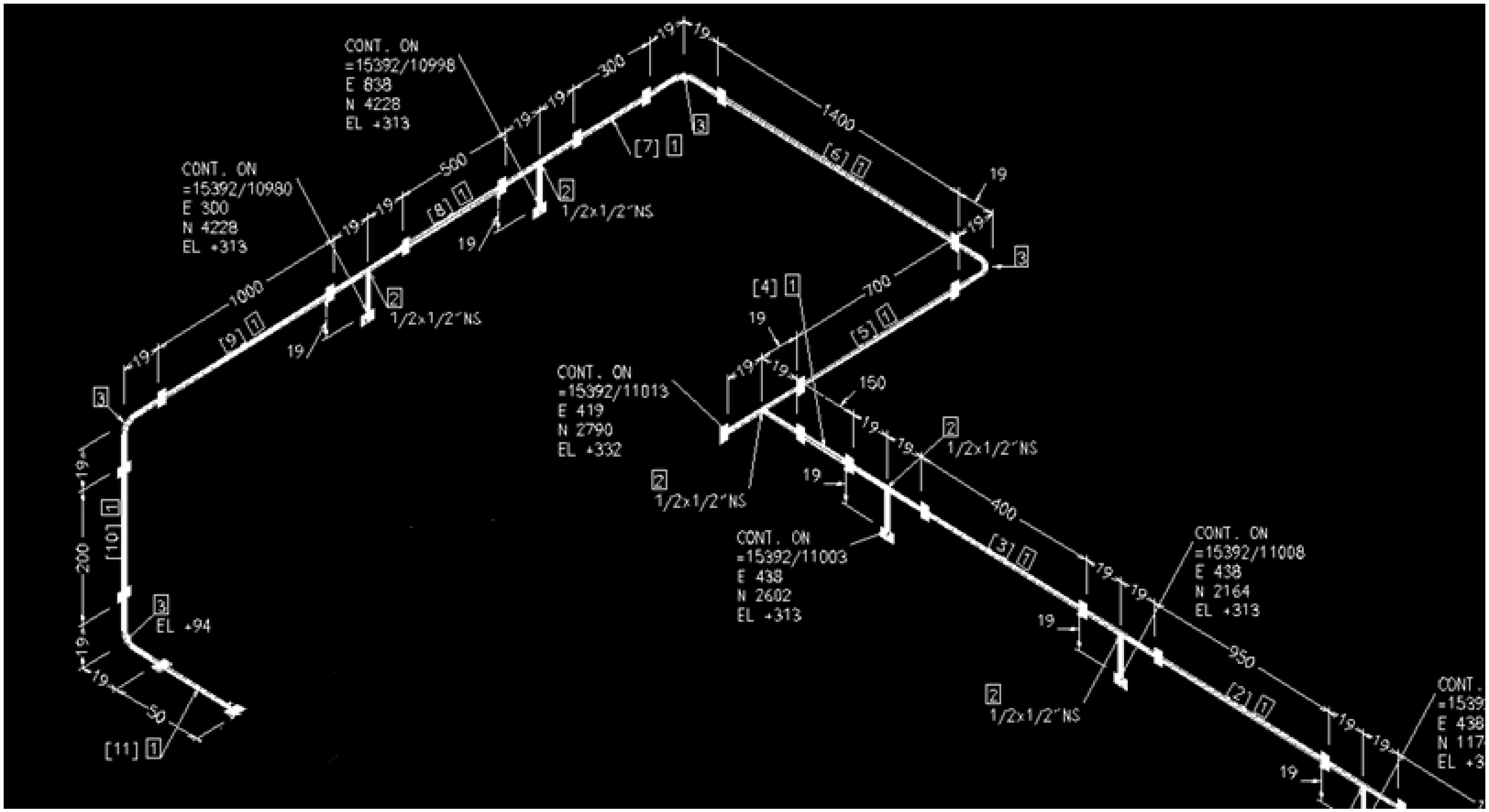

Figure 4.8: Tubing layout at Biotech Lab 2 (Isometric review)

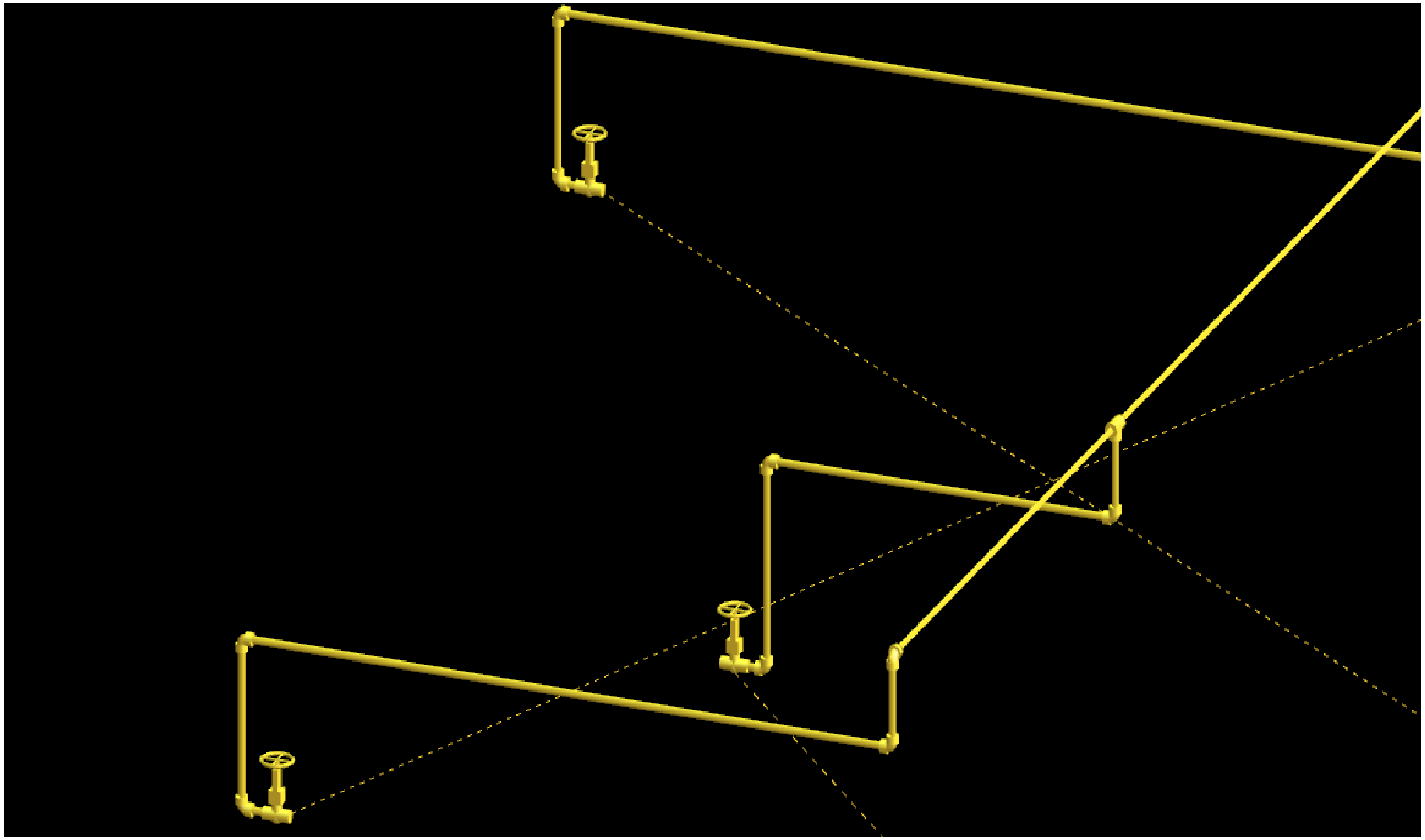

Figure 4.9: Tubing layout at Unit Operation Chemical Reaction and Separation Lab (3D review)

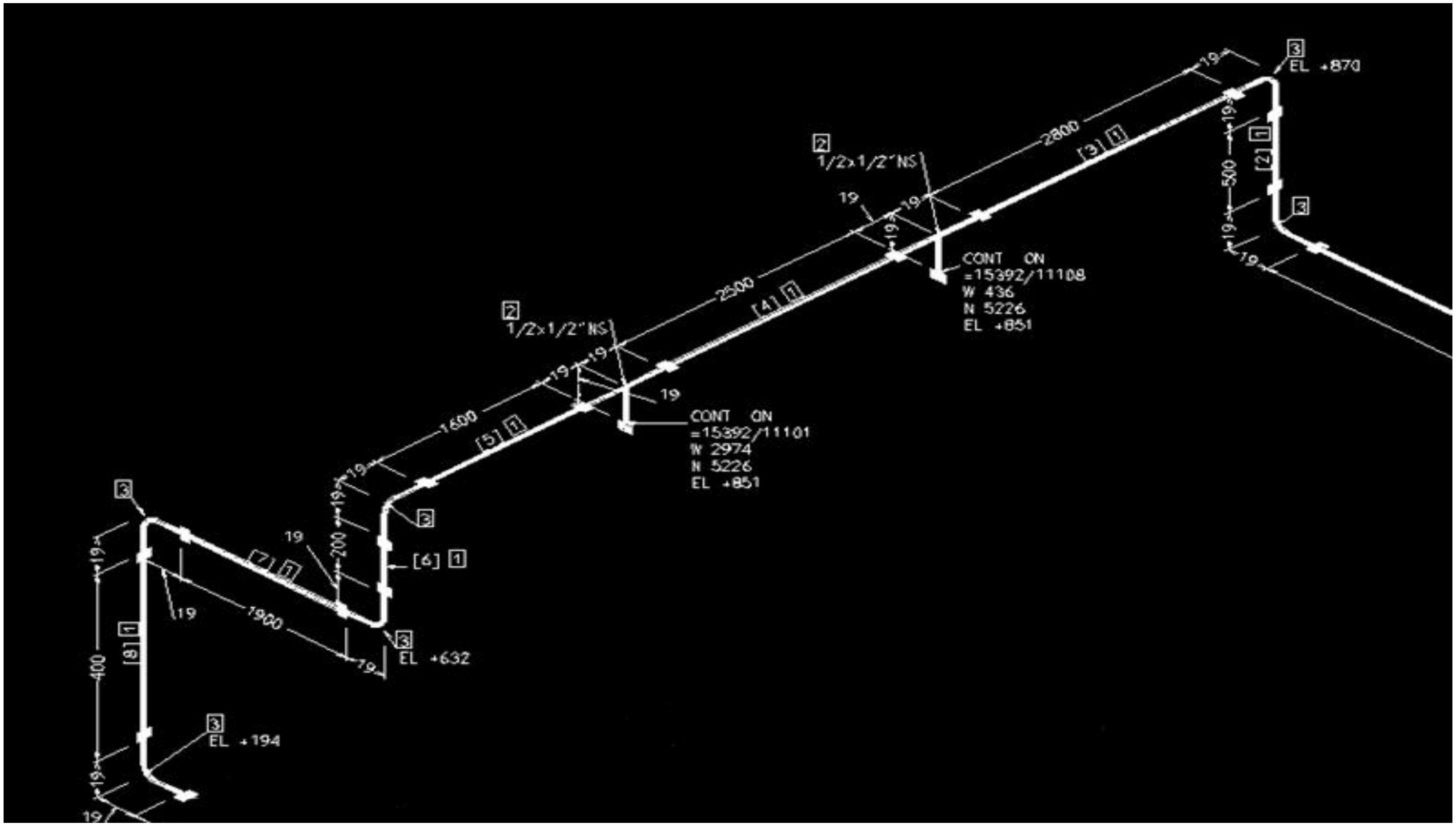

Figure 4.10: Tubing layout at Unit Operation Chemical Reaction and Separation Lab (Isometric review)

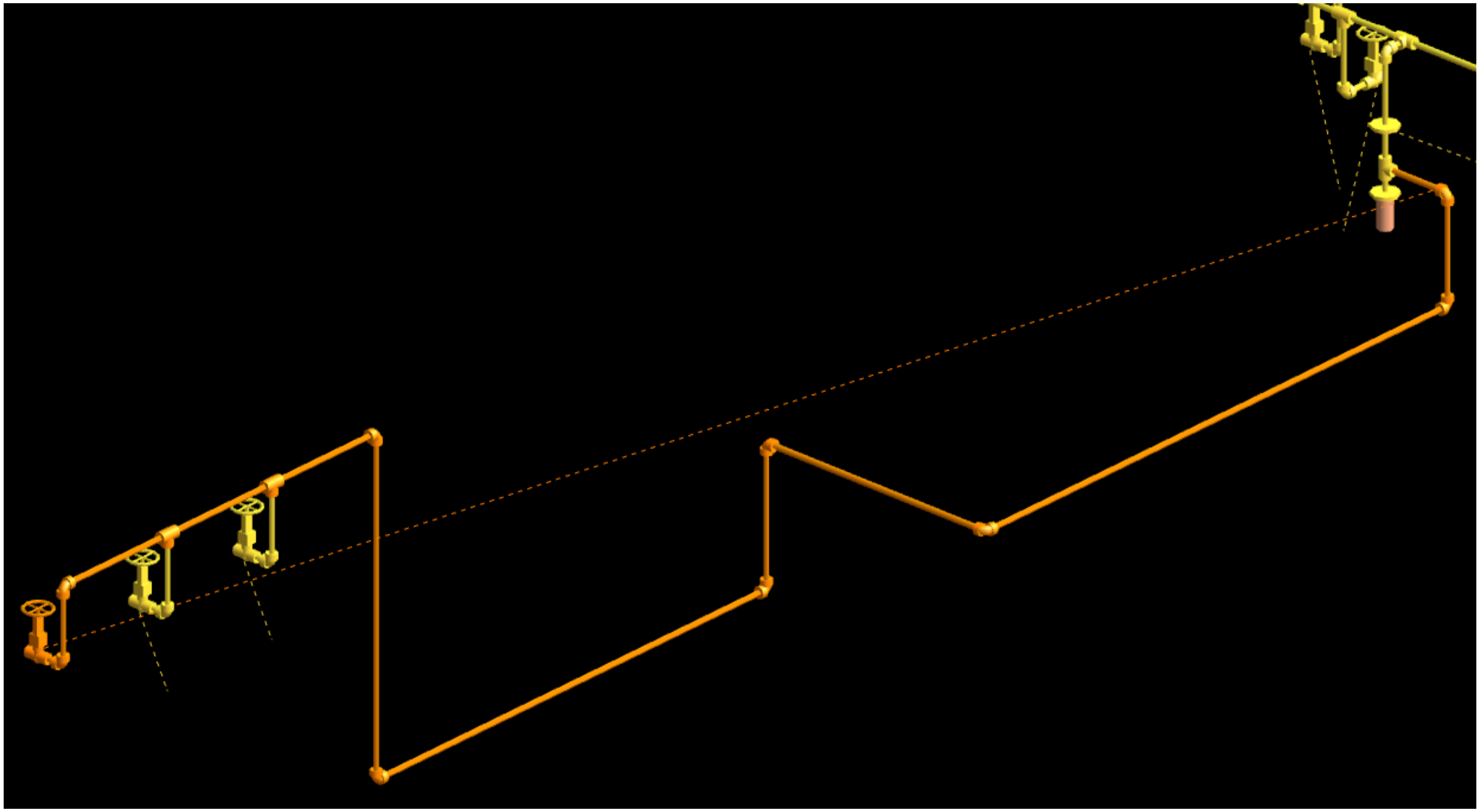

Figure 4.11: Tubing layout at PERKASA Building (3D review)

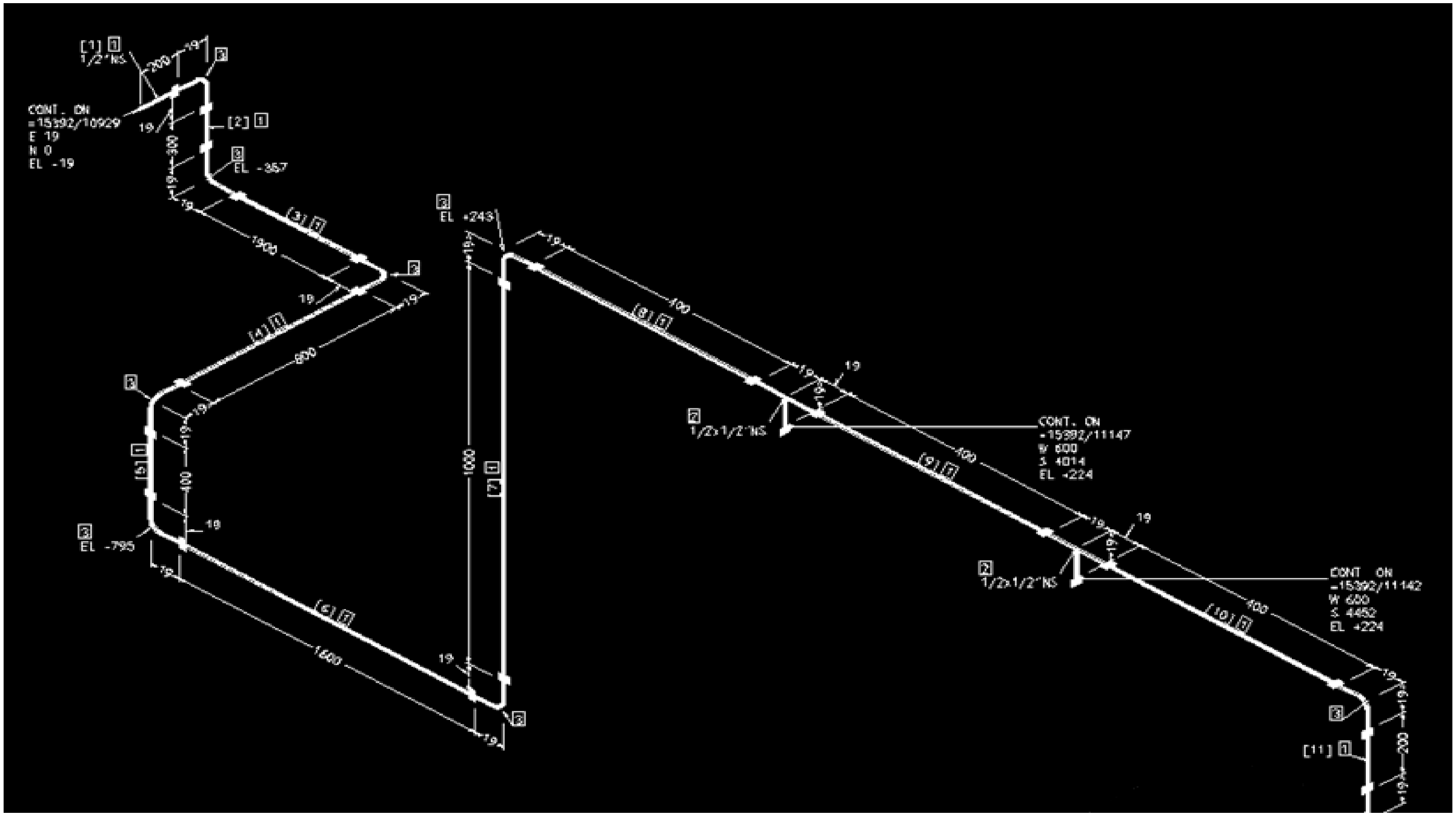

Figure 4.12: Tubing layout at PERKASA Building (Isometric review)