GAS RETICULATION SYSTEM DESIGN FOR UNIVERSITI MALAYSIA PAHANG GAMBANG CAMPUS

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requirements for the award of the degree of
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MAY, 2008

"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)."

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Date : 13 May 2008

I declare that this thesis entitled "Gas Reticulation System Design For Universiti Malaysia Pahang Gambang Campus" 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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ABSTRACT

The main objective of this project is to design a distribution system for natural gas and LPG to the facilities in Universiti Malaysia Pahang (UMP). This system will be designed to take into account of the potential use of natural gas and LPG in UMP such as for combine heat power (CHP) unit, air conditioning, and gas consumption unit. Gas either natural gas and LPG are direct source of energy which is more cost effective as compared to electricity per unit of energy value utilized. UMP is a small campus with approximately consists of 4000 students. The location of UMP is near to the transmission line or gas source and also next to future bio based industrial development. With the existing transmission line in PGU 1 and the nearest city gate in Gambang, it is a convenient way to tap the natural gas from city gate to Universiti Malaysia Pahang. In UMP also has gas engineering lab that require natural gas and LPG as feed fuel for it equipments to operate. The objectives of study are to design a utilization system and to analyze the feasibility of the system to achieve the overall target decided earlier. The electricity bill is higher which consumed by air conditioner in lab, classrooms, offices, and etc. Thus, there is a need to identify alternative energy source to plant campus that is cheaper, safe, and efficient. It is also to set benchmark or working example of an energy efficient system. The scopes of this project are to design the reticulation system, to determine the gas consumption and demand, and to calculate the cost of this project which specific for piping cost and construction. The method that been used are to calculate all the piping size and gas load demand by using certain formula according to standard such as MS930 and ASME B31.8. Gapis Software is to verify the manual calculation that already made either correct or not.

ABSTRAK

Objektif utama projek ini adalah untuk melakar satu sistem pengagihan untuk gas asli dan gas petroliam cecair ke kemudahan di Universiti Malaysia Pahang (UMP). Sistem ini akan dilakarkan untuk kegunaan alat yang menggunakan gas asli dan gas petroliam cecair seperti "combine heat power (CHP) unit dan penghawa dingin. Gas sama ada gas asli dan gas petroliam cecair adalah tenaga sumber terus yang mana adalah lebih efektif kos untuk dibandingkan dengan kos elektrik untuk satu unit nilai tenaga yang diutilitikan. UMP adalah sebuah kampus yang kecil yang mempunyai lebih kurang 4000 pelajar. Lokasi UMP adalah berdekatan dengan talian transmisi atau sumber gas dan juga bersebelahan dengan pembangunan industri berasaskan bio. Dengan adanya talian transmisi yang sedia ada dan juga "city gate" yang berdekatan di Gambang, ianya adalah jalan yang mudah untuk menyedut gas asli dari "city gate" ke Universiti Malaysia Pahang. Di UMP juga terdapat makmal kejuruteraan gas yang memerlukan gas asli dan gas petroliam cecair sebagai gas masuk untuk peralatan berfungsi. Objektif belajar adalah untuk melakar satu sistem utiliti dan untuk membuat analisis tentang keberkesanan sistem tersebut untuk mencapai target keseluruhan yang telah ditentukan awal. Bil elektrik adalah sangat tinggi dimana digunakan oleh alat penghawa dingin di makmal, kelas, pejabat, dan sebagainya. Oleh itu, ini memerlukan satu alternatif sumber tenaga pada kampus yang murah, selamat, dan effisien. Ianya juga untuk menjadikan sebagai penanda aras atau contoh pekerjaan untuk sistem tenaga yang effisien. Skop projek ini adalah untuk melakar sistem retikulasi, untuk menentukan penggunaan gas dan keperluan, dan untuk mengira kos projek dimana spesifik kepada kos paip dan pembinaan. Kaedah yang digunakan adalah mengira semua ukuran paip dan keperluan gas dengan menggunakan rumus yang berkaitan mengikut piawai seperti MS930 dan ASME B31.8. Perisian Gapis adalah untuk membuktikan kiraan manual yang telah dibuat benar atau tidak.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

The attraction to convert to natural gas utilization over other fuels including the electricity is because the reliability and stability of piped natural gas supply as compared with other fuels. In term of transmission line, if compared to electricity, the electric power in current from power plant to the customer will loss at the transmission line and need a generator to power up the current. The efficiency of power plant is below 40% and this is why the electricity cost is higher and expensive. For natural gas, the gas will flow through the transmission line in stability and continuously without having loss of load. The use of natural gas, a clean environment friendly fuel has contributed to a reduction in emissions. With increasing environmental consciousness and responsibility on the part of industries in Malaysia, the benefit as becoming an important consideration in future and a step forward towards sustainable development for the country.

As the fuel of the future, natural gas has received ardent support in the development of other areas of applications. A number of the new and improved applications of natural gas have been successfully implemented in the market. Some of the applications, however, have yet to be commercially viable even though they are technically proven. The viability of these applications depends among others, on equipment cost, alternative fuel cost and local regulatory conditions.

1.2 Problem statement

UMP is a small campus with approximately consists of 4000 students. All of the lecture hall, classrooms, and offices are using air conditioner and for the laboratory, the chiller unit consumed lots of electricity to operate. In FKKSA Lab also, there are boiler and absorption chiller which are currently using electricity to operate, thus the cost of operation is really expensive. Thus, from these equipments will lead to the high cost electricity bill for UMP every month. But if using the natural gas for this equipment, the cost of operation will reduce and are cheaper than using electricity. The location of UMP is near to the transmission line or gas source and also next to future bio based industrial development. With the existing transmission line in PGU 1 and the nearest city gate in Gambang, it is a convenient way to tap the natural gas from city gate to Universiti Malaysia Pahang. In UMP also has gas engineering lab that require natural gas and LPG as feed fuel for it equipments to operate. In Universiti Malaysia Pahang, there are few of laboratories and building that are potential to develop a gas center that using a natural gas. The Combined Heat Power (CHP) in FKKSA Lab currently using compressed natural gas (CNG) which is in bulk storage. When the CHP running, all the CNG are fully used and there is not enough supply of natural gas for the next run. Then, the CNG needs to be refill and to refill the CNG, need to order and to wait for the delivery. In term of time, it’s not worthy. In additional, in FKKSA Lab, the gas house which is consists of gas consumption equipment is already built and the construction of gas natural is reasonable for that situation. For the student cafeteria, currently they are using the LPG bulk storage for cooking. For same situation, the LPG is only in a bulk storage and not a continuous supply like natural gas, therefore they need to get a new LPG bulk storage when the current LPG is going to finish. In Universiti Malaysia Pahang map and FKKSA Lab map, there is a future development which is potentially that the new development will need or use the natural gas.

1.3 Objectives of the project

The objectives of this project are :

1. To design a gas reticulation system in Universiti Malaysia Pahang Campus .

2. To ensure this system is compatible for natural gas as well as LPG

3. To make an economic assessment on this design

4. To meet a safety requirement in the system

1.4 Scope of research work

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

1. The gas demand

The usage and consumption of gas in Universiti Malaysia Pahang. The major part of gas consumption is Combined Heat Power (CHP) and other equipment in FKKSA Lab and student cafeteria. And also for the future development in Universiti Malaysia Pahang that will use natural gas.

2. The design pipe routing

By referring to the Universiti Malaysia Pahang Map and other relevant information, the network piping calculation can be made by calculating the loads of consumption using a certain formula and also determine the classification of steel-pipe construction either use type A, B, C, or D construction. The GaPis software is been used to draft and draw pipeline and to choose the most reasonable piping network drawing.

3. Cost

The capital cost of natural gas construction which is including current prices of natural gas and the current price of pipeline. It is the most effective when the cost of gas construction is small and at the same time the safety aspect is attached together. In short, safety aspect is included with low cost of gas construction.

CHAPTER 2

GAS TRANSMISSION & DISTRIBUTION SYSTEM DESIGN

2.1 Introduction of Gas System

In gas system design, there are two categories of system which are transmission and distribution. For transmission, it only refer to natural gas where the natural gas will deliver from upstream to downstream by using transmission line. Meanwhile for distribution, it can consist of natural gas and liquefied petroleum gas. Distribution is where the fuel either natural gas or liquefied petroleum gas is distributed to consumer.

The hydrocarbon route is started from the gas reservoirs which is consists of either non associated gas or associated gas. Then, from the wellhead which the drilling process is undergo, this gas will suck out and will through the process of gas/liquid separation and gas treating. These process are being done at the oil platform at the offshore. The treated gas then will compressed and will deliver and transfer to the onshore gas processing plant via subsea pipeline transmission. At gas processing plant, this gas will undergo separation process under distillation column. After the distillation process finished and the natural gas is collected, then the natural gas will compressed back and will distribute to the market and consumer. The natural gas will delivered from gas processing plant to gas markets via transmission line and will distributed to consumer after the city gate via distribution line.

For distribution of liquefied petroleum gas (LPG), it is not using any transmission or distribution pipeline to deliver to consumer. This is because LPG is in liquid form thus it is stored inside a tank which is either bulk storage or manifold tank and it is delivered to customer via a lorry tanker. From the manifold system or bulk system, LPG is distributed via a pipeline which is consists of 1^{st} stage regulator, 2^{nd} stage regulator, valves, and meters before connected to the internal piping for residential, commercial, and industrial customers.

2.2 Properties of Fuel Gas

There are 2 types of fuel gas that will use in this project which are natural gas and liquefied petroleum gas. One of the fuel that mentioned will be use as alternative fuel or backup fuel. In this project, the main fuel that will use is natural gas. Therefore, the liquefied petroleum gas will be the alternative fuel or backup fuel.

2.2.1 Natural Gas

Natural gas is made up chiefly of the paraffin (alkenes C_nH_{2n+2}) compound methane (CH_4). It may also contain ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}) and others. Unlike other fossil fuels, natural gas contains no sulphur and non-reacting ash/dust and is an ideal fuel. Natural gas is a mixture without fixed composition.

Ersoz et al. (2006) studied that natural gas (methane, ethane, propane, and butane) was the most famous and the best fuel for hydrogen rich gas production due its composition from lower molecular weight. They found that the highest fuel processing efficiency was achieved with natural gas steam reforming at about 98%.

Natural gas is a major source of electricity generation through the use of gas turbines and steam turbines. Particularly high efficiencies can be achieved through combining gas turbines with a steam turbine in combined cycle mode. Natural gas burns cleaner than other fossil fuels, such as oil and coal, and produces less carbon dioxide per unit energy released. For an equivalent amount of heat, burning natural gas produces about 30% less carbon dioxide than burning petroleum and about 45% less than burning coal.

Combined cycle power generation using natural gas is thus the cleanest source of power available using fossil fuels, and this technology is widely used wherever gas can be obtained at a reasonable cost. Fuel cell technology may eventually provide cleaner options for converting natural gas into electricity, but as yet it is not price-competitive. Also, the natural gas supply is expected to peak around the year 2030, 20 years after the peak of oil. It is also projected that the world's supply of natural gas could be exhausted around the year 2085.

2.2.2 Liquefied Petroleum Gas

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* [16] 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.

2.3 Transmission System

Natural gas is transported to market by long-distance pipelines. The design and construction of these pipelines is of interest, as well as of the compressor stations which provide the motive power. Protection from corrosion is an important aspect in completing a project. Once the gas has reached the market area, it is often sold to a distributor through a city gate station. Pressure regulation, metering, and odorization normally take place at this point. Gas flows through low-pressure distribution systems to the domestic and commercial market.[4] In transmission pipeline, the standards that has been referred are based on ASME B31.8 and MS 930.

In Malaysia, natural gas is delivered in form of crude oil to the gas processing plant in Kerteh. There, natural gas was processed and then is distributed to all over Peninsular Malaysia via transmission line known as Peninsular Gas Utilization (PGU). There was Gas Transmission Operations Centre in Segamat under Petronas Gas Berhad which monitored and analyzed the natural gas starting from GPP in Kerteh throughout Peninsular Malaysia. From the transmission line, natural gas then is distributed to consumer via distribution pipeline which is starting from the last flanged of city gate to the gas consumer. [5]

With tremendous expansion of markets for natural gas in the past few years, the concept of pipeline design has changed considerably. Formerly, a pipeline to supply a specific market was designed to handle its present load plus a moderate growth of perhaps 15 to 30 percent. Today, a pipeline is designed at maximum diameter, with a minimum number of compression stations in order not to exceed a reasonable unit transportation cost at the present market demand. [4]

For the transmission pipeline which is in high pressure, the formulas that always been used are the Panhandle, Fritzsche's, Fully Turbulent, Mueller, IGT Distribution, Spitzglass, and Weymouth. The Panhandle formula or slight modifications of it are in most common use in the natural gas industry for design of cross-country pipelines and transmission pipelines.

The formula for Panhandle is :

$$Q = 435.87e\left(\frac{To}{Po}\right)^{1.07881} x \left(\frac{P1^2 - P2^2}{G^{0.8539}TL}\right)^{0.5394} x \left(d^{2.6182}\right) \qquad (2\text{-}1)$$

(*Cornell et. al., 1959. Transmission to Market. In: Handbook of Natural Gas Engineering. New York: McGraw Hill. 625-654*)

Where :

Q	= flow rate measured at T_0 and P_0, cu ft/day
E	= pipeline efficiency
T_0	= temperature base, ^{0}R
P_0	= pressure base, psia
P_1	= inlet pipeline pressure, psia
P_2	= outlet pipeline pressure, psia
G	= gravity of gas
T	= mean flowing temperature, ^{0}R
L	= length of pipe, miles
d	= internal pipe diameter, in.

2.3.1 City Gate Station

The purpose of city gate station is to meter gas volumes delivered, control pressures by regulation, and introduce the proper quantity of odorant into gas stream. Proper selection of the number, capacity, and location of city gate station depends upon the overall transmission, storage, and distribution system design.

A city gate station must be designed carefully. It is the source of supply to the distribution system and the cash register for the local utilities' gas purchase. In general, large distribution systems should be supplied from two or more stations, so that the outage of one station can be offset by the operation of emergency capacity in the other stations. High pressure transmission mains within populated areas must meet extra and costly material specifications under the 1955 ASA B31.1 code for pressure piping. Location of terminal points of high pressure transmission mains at city gate station must consider present and future real estate development. Location must also be considered for availability of electricity, telephone and accessibility by adequate roads.[4]

2.4 Distribution System

Mains, services, and meters required to distribute gas to the ultimate consumers constitute the gas distribution system. The design of new systems and additions to and renewals of existing systems is a branch of gas engineering in itself. The primary objective of a good design is to able to supply the market demand of any customer in the system with a minimum capital investment consistent with sound safety practices. [4]

The ultimate in successful design is to able to offer adequate gas service economically to any customer within the service or franchised area. The degree to which a distribution system fails to provide such service reflects upon the engineering-design practices of the utility involved. [4]

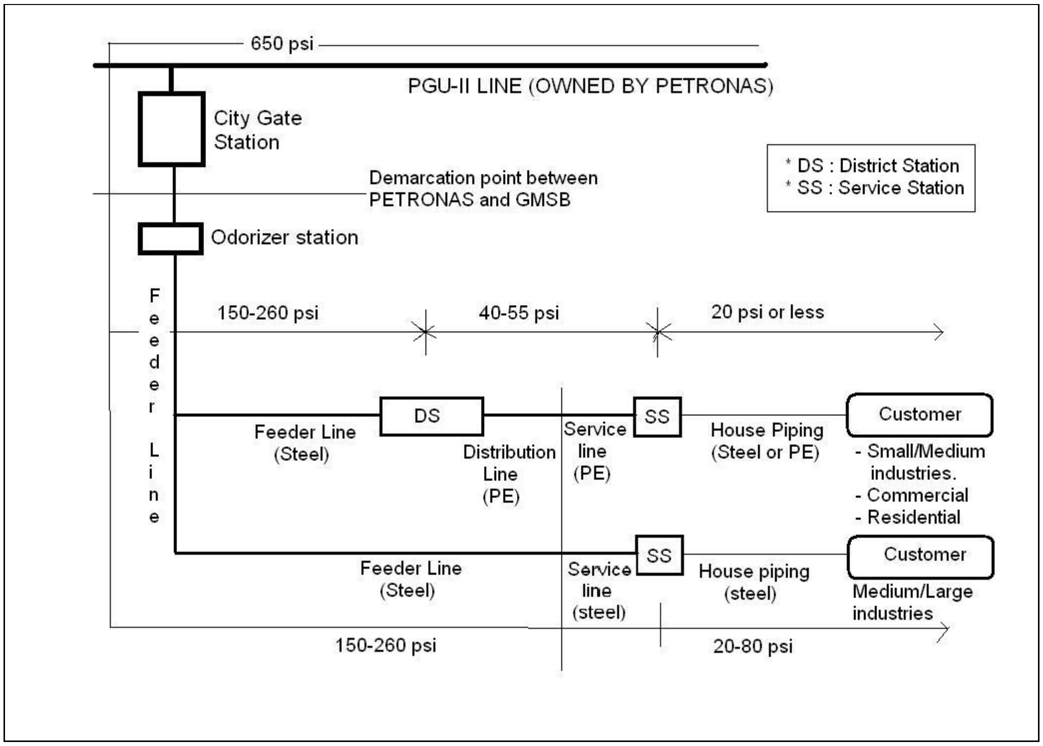

Figure 2.1 : Outline of gas Malaysia natural gas supply system.
(*K. Yamaguchi, 1994. Outline of Gas Malaysia Natural Gas Supply System. In: Gas Malaysia Sdn. Bhd. Technical Department. Malaysia.)*

In designing a pipeline network, various types of formulas have been used. Normally, for distribution pipelines, the formulas that always been used are Pole, NFPA54, Clifford, and Cox's. Depending on certain gas company, specific formula is been used. For PETRONAS Bhd., it used the Fully Turbulent Formula in designing their transmission pipelines which is PGU. For Gas Malaysia Sdn. Bhd. which handling in distribution of gas is using Cox's and NFPA 54 as formula in designing the pipelines. [1] [3] [5]

Methods widely used to solve the gas distribution pipe sizing are :

1) NFPA No. 54 (National Fire Protection Association) (MS 930)
2) Clifford Method (MS 930)
3) Cox's Formula
4) Pole's Formula

Cox's equation is used for designing gas pipeline systems which are for distribution purposes. The inlet pressure must be more than 29.4 kPag.

Cox Formula :

$$Qs = k\sqrt{\frac{(P_1^2 - P_2^2)D^5}{(S)(L)}} \quad (2\text{-}2)$$

$$P_2 = \sqrt{P_1^2 - \frac{(S)(L)\left(Q_s^2\right)}{\left(k^2\right)\left(D^5\right)}} \quad (2\text{-}3)$$

(*Malaysian Standard ,1986. Code of Practice For The Installation of Fuel Gas Piping Systems and Appliances. Malaysia, MS 930.)*

Where ,

Qs	= Flow of fluid between the nodes (Sm³/hr)
S	= Specific Gravity
P_1 and P_2	= Absolute pressure (kPa.abs) at node 1 and node 2
D	= Pipe inner diameter (mm)
L	= Pipe length between the nodes (m)

2.4.1 Specifications and Functions of Station Design

In any station either district or service station, there are general design that need to comply in order to build the station. The materials of pipe, fittings and equipments shall be carbon steel. The piping shall be sized so that the gas flow velocity in the station is 20m/sec or less approximately. The thickness of pipe/fitting shall be schedule 80 for any size of less than 2 inch and schedule 40 for any size of 2 inch or larger. The maximum capacity of regulator shall be at least 30% bigger than the expected maximum gas flow rate downstream. The mesh size of filter element shall be 50 micron or less (250 mesh or more). [3]

Table 2.1 : Specifications of station design [5]

District Station	Service Station
a) The combination of worker and monitor regulators shall be applied. b) The worker shall be of unloading type while the monitor shall be of loading type. c) Relief valve with 100% capacity shall be used as an overpressure protection device. d) The set point of relief valve shall be 10% higher than that of monitor regulator. e) The minimum difference in set points between main and stand-by workers shall be 5 psi. f) The set point of main monitor shall be equal to that of stand-by monitor.	a) The single stream system with by-pass line shall be applied basically. b) The slam shut valve shall be used basically as an overpressure protection device. The set point of slam shut valve shall be 50% higher than that of worker. c) The monitor regulator may be used as an overpressure protection device instead of slam shut valve when the continuous supply is taken into consideration seriously. d) The relief valve with 10% capacity shall be used to partially discharge the overpressure to atmosphere. It will effective for small and temporary overpressure. e) Y-strainer shall be installed the inlet size of gas meter. f) Turbine type gas meter shall be employed basically because it is economical and strong against the dust in supplied gas. Rotary type gas meter may be employed for commercial and small industrial customers.

The function of station is to reduce the upstream supply pressure and to control the downstream pressure at constant irrespective of fluctuation of gas consumption volume by customer.

Service station is installed in the customer's premises to supply gas to the one concerned customer. District station is installed in the road reserve to supply gas to multiple customers through distribution/service line and service station downstream.

Table 2.2 : Function of district and service stations.[5]

District Station	Service Station
1. Control the downstream pressure at the pre-adjusted pressure irrespective of gas consumption volume and upstream pressure fluctuations. 2. Trap Dust, grease and other foreign materials included in the supply gas. 3. Discharge all of supply gas to atmosphere for safety when the downstream pressure exceeds the pre-determined level due to regulator failure. (100% relief). 4. Record the upstream and downstream pressure for operation/maintenance purpose.	1. Control the downstream pressure at the pre-adjusted pressure irrespective of gas consumption volume and upstream pressure fluctuations. 2. Trap Dust, grease and other foreign materials included in the supply gas. 3. Discharge some amount of supply gas to atmosphere for safety when the downstream pressure exceeds the pre-determined level due to regulator failure. (10% relief). 4. Shut-off gas supply to customer by operating valve automatically to avoid the serious accident caused by overpressure. 5. Register the gas consumption volume by gas meter. 6. Record the upstream and downstream pressure for operation/maintenance purpose.

2.4.2 Basic Layout of District Station and Service Station

Since the district station supplies gas to the multiple customers, it shall keep on supplying gas even if regulator fails or station maintenance work is conducted. In order to ensure the continuous supply, the stand-by line shall be provided. Other than the major equipments, the following equipments will be installed :

1. Isolation valve
2. Pressure gauge
3. Insulating flange
4. Spark gap
5. Purge valve
6. Differential pressure gauge
7. Pressure sensing line

Since any equipment located upstream of worker regulator is subject to high pressure of 150 to 260 psi, the flange shall be of ANSI class 300 (max. 720 psi) up to the worker regulator. Flange rating after the worker regulator shall be of ANSI class 150 (max. 275 psi).

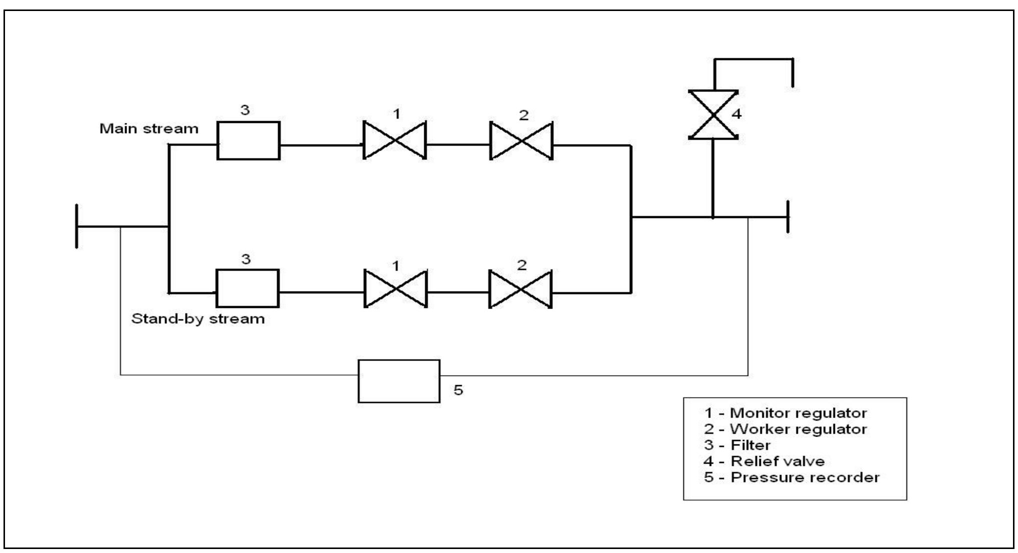

Figure 2.2 : Layout of district station (*K. Yamaguchi, 1994. Outline of Gas Malaysia Natural Gas Supply System. In: Gas Malaysia Sdn. Bhd. Technical Department. Malaysia*)

Basically the single stream service station will be installed because of economical reason. However the gas supply will be interrupted or controlled roughly by the manual valve operation when the worker fails or the station maintenance work is conducted. Monitor regulator may be installed to replace slam shut valve when the continuous gas supply is taken into consideration seriously. Other than major equipments, the following equipments will be installed :

1. Isolation valve
2. Pressure gauge
3. Insulating flange
4. Spark gap
5. Volume corrector (if required)
6. Purge valve
7. Differential pressure gauge
8. Pressure sensing line
9. Straightening vane

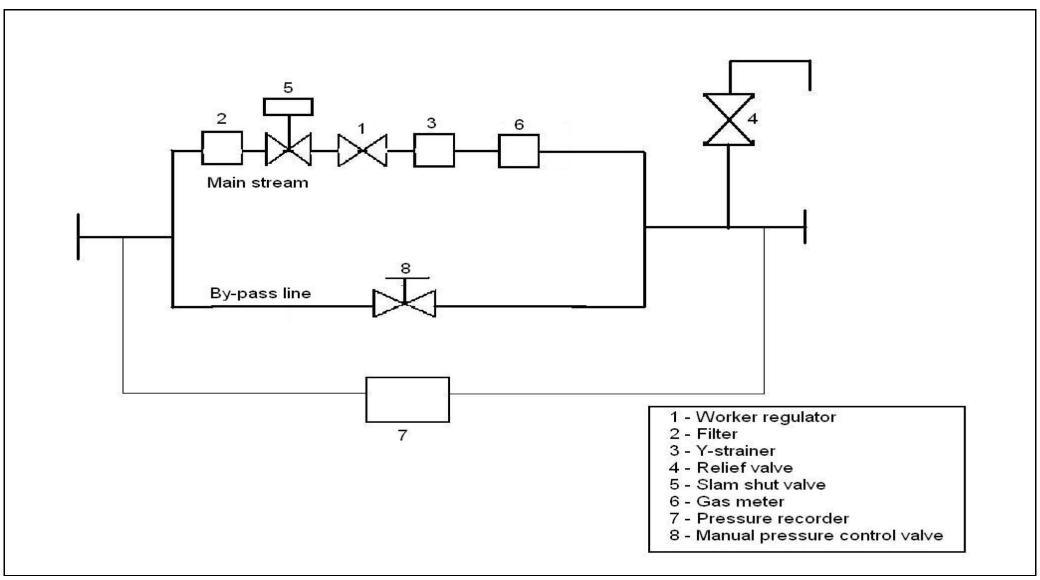

Figure 2.3 : Layout of service station (*K. Yamaguchi, 1994. Outline of Gas Malaysia Natural Gas Supply System. In: Gas Malaysia Sdn. Bhd. Technical Department. Malaysia*)

2.4.3 Distribution of Liquefied Petroleum Gas

For liquefied petroleum gas distribution, it is not same as natural gas in term of continuity of gas supply and the distribution of the gas. For liquefied petroleum gas, it is stored inside a tank before the gas is distributed to the customer via a pipeline. The allowable operating pressure for the bulk tank is around 80-100 psig while for the piping of the gas starting from the tank to the customer is 5 psig for residence and commercial and 20 psig for industrial.[2]

In Figure 2.3, it is shows that there are two types of LPG distribution system which is type one is the gas from LPG tank will distributed to customer via pipeline which is controlled by the regulator at regulator station. For the second type, the gas need to vaporize first before flow to the regulator station and then will flow to the oil separator which is in this stage, the oil will separated in vapor form and not in liquid form before distribute to the customers.

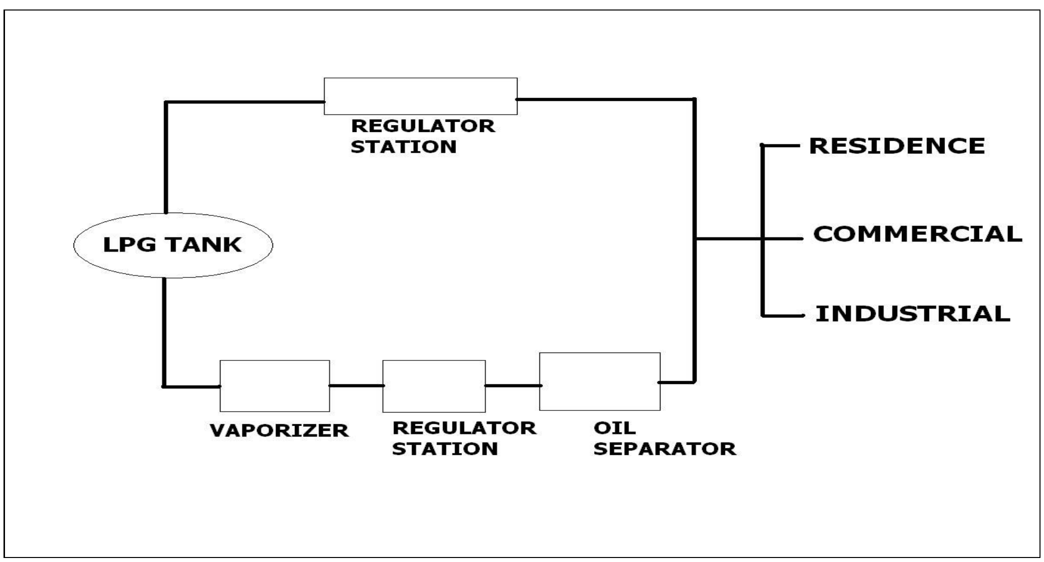

Figure 2.4 : Layout of LPG distribution outline (Ir. Chong Kim Tham, 2005. *Safety Aspect of Natural Gas Distribution System.* Malaysia. Gas Malaysia Sdn. Bhd.)

2.4.4 Design Of Pipeline

Cornell et. al. (1959) mentioned that before the pipeline project can be done/establish , there are some steps that must be done. These steps is a simple guidelines which already be done from the previous engineer/contractor that dealt with pipeline project. Steps in a pipeline project are :

1. Market survey – immediate and prospects for growth.
2. Pipe size and working pressure.
3. Pipe specifications.
4. Map of tentative route.
5. Bill of materials.
6. Total cost estimate.
7. Certificate of convenience and necessity.
8. Right of way.
9. Construction survey.
10. Construction contract.
11. Construction.
12. Testing.
13. Putting in service.

For routing process, some criteria need to consider earlier before any project will begin. It is consists of :

1. Maps

This is where the area between supply & delivery should be examined and determine either the route is possible or not to choose so that the selected route is free from any constraints and other problem that will arise.

2. Survey

After the maps is determined and analyzed and the selected route has been drafted, then the visual survey will undergo to examined and to get the analysis for the selected route which is to avoid any obstacles that may face such as :

1. Congested underground plant
2. Unstable structures
3. Natural ground level altered
4. Subsidence or side slip
5. Running ground or gravel ; traffic loaded routes
6. Aggressive soil
7. Close to cathodic protection systems or stray d.c earth current.
8. Direct underneath overhead cables
9. Internal piping, through circulating duct, chimney, gas vent, ventilating duct, enclosed staircase, elevator shaft, electricity, facility room, excessive vibration area, corrosive areas, concrete slab, soil partition.

Piping systems and supports must be designed for strength and structural integrity in addition to meeting flow, pressure drop, and pump power requirements. Consideration must be given to stresses created by the following :

1. Internal pressure.
2. Static forces due to weight of the piping and the fluid.
3. Dynamic forces created by moving fluids inside the pipe.
4. External loads caused by seismic activity, temperature changes, installation procedures, or other application-specific conditions.

The American Society of Mechanical Engineers (ASME), the National Fire Protection Association (NFPA), and others develop standards for such considerations.

2.5 Standards And Codes

In this project, reference are made based on the existing codes and standards such as ASME B31.8, MS 830, MS 930, NFPA, and ASTM. Therefore, some words are already been extracted and summarized in order to make it in form of article review. For distribution design, it is majorly referred to Malaysia Standard as this standard has been used formerly in gas distribution project in Malaysia. For further review, other standard will be used such as ASME B31.8 and NFPA.

2.5.1 Design, Installation, And Testing

In this code, it intended to be adequate for public safety under all conditions that will be encountered in the gas industry. Conditions that may cause additional stress in any part of a line or its appurtenances shall be provided for using good engineering practice. [3]

2.5.2 Class Locations

The standards classify populated areas by the number of people who live, work, attend school, or otherwise gather in the area. The standard defines a class location unit as an area that extends 220 yards on either side of the center line of any continuous one-mile length of pipeline.

Class location units are used in a number of ways to define requirements for building, testing, and inspecting the gas system. In general, the more heavily populated the unit, the stricter the pressure testing requirements.

Table 2.3 : Class location definitions in constructing of gas pipeline [1]

Class Location	Definition
Class 1 Location	Any class location unit that has 10 or fewer buildings intended for human occupancy.
Class 2 Location	Any class location unit that has more than 10 but fewer than 46 buildings intended for human occupancy.
Class 3 Location	1) Any class location unit that has 46 or more buildings intended for human occupancy ; or 2) Any area where the pipeline lies within 100 yards of either : * A building , or * A small, well-defined outside occupied by 20 or more persons 5 days a week for 10 weeks in any 12 months period.
Class 4 Location	Any class location unit where the building are mostly 4 or more stories above ground.

2.5.3 Protection of Pipelines and Mains From Hazards

For natural hazards such as washouts, floods, unstable soil, landslides or other conditions that may cause serious movements of the pipelines, reasonable precautions shall be taken to protect the pipeline such as :

1. increasing the wall thickness
2. constructing revetments
3. preventing erosion
4. installing anchors

If the pipelines and mains cross areas that are normally under water (i.e. lakes, bays, or swamps), sufficient weight or anchorage shall be applied to the line to prevent from floatation. [3]

2.5.4 Clearance Between Pipelines or Mains and Other Underground Structures

If there any buried pipeline and any other underground structure not used in conjunction with the pipeline, there shall be at least 6 in. of clearance between them. If there any buried gas main, there shall be at least 2 in. of clearance between it. But, if such clearance cannot be attained, precautions to protect the main shall be taken such as installation of insulating material or casing. [3]

2.5.5 Allowable Maximum Operating Pressure

The coverage of piping systems is limited to the maximum operating pressure of 420 kPa (gauge) [60 psig] except that piping systems for gas-air mixture within the flammable range are limited to maximum pressure of 70 kPa (gauge) [10 psig].

Coverage of piping systems includes design, materials, components, fabrication, assembly, installation, testing, inspection, operation and maintenance. Coverage of gas utilization equipment and related accessories includes installation, combustion and ventilation air, and venting. [1]

2.5.6 Maximum Design Operating Pressure

In MS 930 (1986), it is stated that the maximum design operating pressure for piping systems located inside buildings shall not exceed 5 psig unless approved by the authority having jurisdiction and one or more of the following conditions are met:

1. The piping system is welded.
2. The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation.

3. The piping is located inside buildings or separate areas of buildings used exclusively for :

    a) industrial processing or heating.
    b) research
    c) warehouse
    d) boiler or mechanical equipment rooms

2.5.7 Piping Underground

In ASME B31.8 (2003), it is mentioned that the underground gas piping should be installed with enough clearance from any other underground structure to avoid contact therewith, to allow proper maintenance and to protect against damage that might result from proximity to other structures. In addition, underground plastic piping shall be installed with sufficient clearance, or shall be insulated, from any source of heat so as to prevent the heat from impairing the serviceability of the pipe.

Where soil conditions are unstable and setting of piping or foundation walls or heavy vehicular traffic may occur, adequate measures shall be provided to prevent excessive stressing of the piping. Piping shall be buried a sufficient depth or covered in a manner so as to protect the piping from physical damage. Consideration should be given to protecting the piping from physical damage when it passes through flower beds, shrub beds and other such cultivated areas.

Underground piping systems should be installed with at least 450 mm of cover. The cover may be reduced to 300 mm if external damage to the pipe is not likely to result. If a minimum of 300 mm of cover cannot be maintained, the pipe shall be installed in conduit or bridged.

The trench shall be graded so that the pipe has a firm, substantially continuous bearing on the bottom of the trench. The backfilling shall be exercised to see that the pipe is not floated from its firm bearing on the trench bottom and in manner to provide firm support under the pipe.

2.5.8 Piping Underground Beneath Building and Protection Against Corrosion

When the installation of gas piping underground beneath buildings is unavoidable, the piping shall be encased in an approved conduit designed withstand the superimposed loads. The condition shall extend into a normally usable and accessible portion of the building and at the portion where the conduit terminates in the building.

The space between the conduit and the gas piping shall be sealed to prevent the possible entrance of any gas leakage. If the end sealing is of a type that will retain the full pressure of the pipe, the conduit shall be designed for the same pressure as the pipe. [3]

Gas piping in contact with earth, or other material which may corrode the piping, shall be protected against corrosion in an approved manner. When dissimilar metals are joined underground, an insulating coupling or fitting shall be used. Piping shall not be laid in contact with cinders.

Uncoated threaded or socket welded joint shall not be used in piping in contact with soil or where internal or external crevice corrosion may occur. [3]