PRESSURE MANAGEMENT IN PIPE DISTRIBUTION SYSTEM AT KUANTAN DISTRICT

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ABSTRACT

Pressure Management in Pipe Distribution System at Kuantan District

In pipe distribution system, there is a lot problem occur if pressure not handling in proper way, this is because it will affect water delivery rate, demand rate, pressure rate and other side problems. Based On (O'Day, 1987), there are low pressure and high head loss problems in pipe. The effective of the pipe distribution design are in question because this factor will abruptly change effectiveness of pressure, automatically will let the change in pressure management task. The purpose of this study is to determine the effectiveness of pressure management taken by PAIP after executed a pressure setting by follow KPI value at Kuantan and methods taken to solve pressure problem at Paya Bungor. The data were obtained from 53 pressure gauge of Kuantan district piping distribution system. The findings of the study divided into two parts based on the objective which is uncover method of pressure management that solved low pressure and demand rate. Besides that, for the past two months of this implementation range pressure, the percentage of two months data was calculated and also the percentage of effectiveness after one year. The contributing factors for effectiveness to increase are pressure management that PAIP taken. Therefore, the result will analyses what are the method and numbers to solved pressure problems. The significant of this study is to get maximum pressure effectiveness toward better pressure rate and less problem encounter in the future.

ABSTRAK

Pengurusan Tekanan dalam Sistem Pengagihan Paip di Daerah Kuantan

Dalam sistem pengedaran paip, ada banyak masalah berlaku jika tekanan tidak diuruskan dengan cara yang betul, ini kerana akan memberikan kesan kepada kadar penghantaran air, kadar permintaan, kadar tekanan dan masalah sampingan yang lain. Menurut, (O'Day, 1987), terdapat tekanan rendah dan masalah kehilangan tekanan tinggi dalam paip. keberkesanan reka bentuk paip agihan berada dalam soalan kerana faktor ini akan mengubah keberkesanan tekanan dan secara automatik akan membenarkan perubahan dalam tugas pengurusan tekanan. Tujuan kajian ini adalah untuk menentukan keberkesanan pengurusan tekanan yang diambil oleh PAIP selepas dilaksanakan dengan nilai set tekanan mengikut standard KPI di Kuantan dan kaedah yang diambil untuk menyelesaikan masalah tekanan di Paya Bungor. Data yang diperolehi adalah daripada 53 tolok tekanan system paip agihan di daerah Kuantan. Hasil kajian ini dibahagikan kepada dua bahagian berdasarkan objektif yang mendedahkan kaedah pengurusan tekanan yang menyelesaikan tekanan yang rendah dan kadar permintaan. Selain itu, selama dua bulan langkah pengurusan tekanan ini dilaksanakan, peratusan keberkesanan untuk dua bulan data dikira dan untuk peratusan keberkesanan selepas satu tahun. Faktor-faktor yang menyumbang kepada dalam meningkatkan keberkesanan ini ialah pengurusan tekanan yang PAIP dilaksanakan. Oleh itu, hasilnya akan menganalisis apakah kaedah dan nilai untuk menyelesaikan masalah tekanan. Kepentingan kajian ini adalah untuk mendapatkan keberkesanan tekanan maksimum untuk kadar tekanan yang lebih baik serta pengurangan masalah di masa hadapan.

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LIST OF ABBREVIATIONS

PRVs	Pressure reducing valves
PAIP	Perbadanan Air Pahang
ASME	American Society of Mechanical Engineers
ANSI	American national standards institute
HVAC	Heating Ventilation and Air Conditioning
API	American petroleum institute
NPS	Nominal Pipe Size
NB	Nominal BorE
DN	Nominal Diameter"
STD	Standard
XS	Extra Strong
XXS	Double Extra Strong
ID	Pipe Internal Diameter
WDS	Water distribution system
H	Residual pressure head
MPH	Minimum pressure head
PATs	Pump as turbine
DMA	District metered area
BEP	Best efficiency point
PVC	Plasticized polyvinyl chloride
AC	Asbestos-Cement
GJMC	Greater Johannesburg Metropolitan Council
R	Rand(currency of south Africa)
PKLN	Program Latihan Khidmat Negara
WTP	Water treatment plant
JBAP	Jabatan Air Pahang

MDG	Millions of Gallons per Day
DI	Ductile iron pipe
HDPE	High-density polyethylene
Upvc	unplasticized polyvinyl chloride
MS	Mild steel pipe
H	Head
KPI	Key Performance Indicators
VSD	Variable speed drive
VFD	Variable frequency drive
RPM	Rotations per minute
FELDA	Federal Land Development Authority
PFC	Pressure flow control
SYABAS	Syarikat Bekalan Air Selangor

LIST OF SYMBOLS

ΔHFF	Fitting Friction
V	Velocity
G	Acceleration
mm	Millimeter
Q	Flow Rate
H	Head
N	Rotational Speed
η	Efficiency
P	Pressure
L	Leakage

CHAPTER 1

INTRODUCTION

1.1 Introduction

The pipe distribution system is the essential link between the water supply source and the consumer. Mainly, there are basically two main layouts of a distribution network, loop and branching configuration. So, purpose of water distribution actually is to supply the system's users with the amount of water demanded and to supply water with adequate pressure under various loading conditions (nadiatul, 2008). In the process of designing the water distribution networks one of the most uncertain quantities is the value of demands at the network's nodes. Therefore, it is important to take the uncertainty of demand into account when designing new water systems or extending existing one that actually could lead to pressure management for some point. The obstacle is to constraint having to be imposed as a minimum pressure head requirement at nodes, that in turn depend on uncertain variables (demand).

Also, for the design of pipe distribution, we need to consider the certain factors to get the requirement design plan. One of the most important factors is pressure. The management of pressure is important to pipe distribution because the problem always relates to pressure. This is because the energy within a fluid in part depends on its flow under pressure (Jeffrey A.Gilbert, 2005). Many water systems are designed based on the minimum level of pressure required for the demand types, but in many cases no consideration is made for maximum pressure levels (Thornton, 2004).

Pressure is the effect of a force applied to a surface or the amount of force acting per unit area, theoretically known to us. So, for water as a fluid component have a fluid pressure at some point between particle of water and for water distribution system it called as closed conduits. The concept of closed conduits is fluid either static or dynamic, when the fluid can move as in either a pipe or by compression an air gap in closed container. In dynamic condition, the pressure change because of gravity or elevation and distances to destination like house or school from the nearest water distribution station. Actually, service pressure are typically maintain by pumps, with head loss increase in pipeline elevations acting to reduce pressure and decrease in pipeline elevation to increase pressure. Booster pumps use when long distance and significant changes in elevation to maintain pressure (Velon and Johnson, 2000).

The problem that pressure will create at pipe distribution if not maintaining normally is highly divided into two conditions, high and low pressure effect. High pressure effect most likely is breaks in water distribution pipelines or mains. A leakage at the joint or valve also pipe is the effect of high pressure in the system. With low pressure effect, the process of supplying water will be slow created opportunities for backflow or seepage that could allow contaminants to enter drinking water. A place with high elevation and long distance will have problem to get water supply when pressure is low. (Sam Perry, 2009)

Pressure can be affected by several factors (SEV11):

i. Its height and distance in relation to the reservoir it's supplied from.
ii. The condition and size of the service pipe.
iii. Peak demand conditions.

The energy equation represents elevation, pressure and velocity forms of energy. With energy losses consist of minor and major losses that affect the pressure in the pipeline. Major losses due to friction between the moving fluid and inside walls of the duct. Minor losses due to fittings such as elbows or valves are involved. The elevation that energy equation represent can be interpreted to the high level of one location and more detailing are needed if the location is a hill or mount terrain like in Pahang terrain where in Malaysia, we can find the most highest mount, Mount Tahan. So relatively, with such level of elevation there should be a problem involving how pressure can cover the elevation to maintain water distribution to distribute water. Thus, pressure management is crucial problem where pressure management not only cover the leakage problem but also pressure problem solving.

Pressure management is for leakage control, can be defined as "The practice of managing system pressures to the optimum levels of service ensuring sufficient and efficiently supply to legitimate uses and consumers, while reducing unnecessary, unwanted or excess pressures, eliminating transients and faulty level controls all of which cause the distribution system to leak unnecessarily". In many cases of pressure management addresses not only on the effect of real losses but also the cause of making it one of the most efficient tools for sustainable control of real losses.

Pressure management programs often have positive impacts to the loss of reduction and revenue recovery, especially in relation to theft and authorized unbilled consumption. Where customers have roof tanks, pressure management often improves effectiveness of ball valve closure, and improves metering accuracy by reducing the duration of extremely low flows which some meters cannot record.

1.2 Problem statement

Pressure is one of the roots of many problems occur in the water distribution system from the old days till now and even future. Although pressure is one of the easiest parameters to set and measure in pipe distribution design, level of effectiveness of pressure still far from perfect condition required by many countries. But in Japan, the link between pressure and leakage are associated with following standard relationship that the leakage rate varies with pressure of 1% change in pressure will typically change the average leakage rate by 1.15% (Lambert, 2003).

Based On (O'Day, 1987), there are low pressure and higheatad loss problems due to main tuberculation ithe pipepe. The effective of the pipe distribution design are in question because of this factor which abruptly change the effectiveness of pressure and automatically influence in pressure management task.

There are many factors that affecting the effectiveness of pressure in water distribution design such as fitting, pipe size, inaccurate pressure installed, tuberculation and etc. Although many changes and modification have been carried out, this problem still occurs. For example, a pressure reducing valves (PRVs) is used to prevent hydraulic grade from exceeding a set value of the energy grade line. In recent years the application of turbines or pumps operating as turbines (PATs) appeared as an alternative and sustainable solution to either control the pressure management of the design water distribution or to produce energy (M. Giugni, 2009).

1.3 Objective

i. Identified problem and methods that influence pressure effectiveness in pipe system at Paya Bungor.
ii. To analyse the method propose to increase the effectiveness of pressure management and calculate the percentage of effectiveness for upcoming years at Kuantan district.

1.4 Scope of Project

In order to achieve the project's objective, the following scopes are identified:

i. Five types that affect pressure will be analysed and they are pumps and turbine, fittings and valves, leakage, tuberculation and geographical condition.
ii. Only PRV's and booster pump method to target to increase the pressure effectiveness in pipe distribution is being studied.
iii. Acquire pressure data from Perbadanan Air Pahang (PAIP) and analyse it.

iv. Site with pressure problem such as leakage, low pressure or high pressure and supply will be selected.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the literatures that are related to pressure in water distribution and how the pressure increases its effectiveness. This chapter will review on type of pressure, factors affecting pressure effectiveness, common problem due to pressure, different types of analysis on pressure and method to solve pressure problem.

2.2 Pressures

Pressure is defined as force per unit area. It is usually convenient to use pressure rather than force to describe the influences upon fluid behaviour. The standard unit for pressure is the Pascal, which is a Newton per square meter. For an object sitting on a surface, the force pressing on the surface is the weight of the object, but in different orientations it might have a different area in contact with the surface and therefore exert a different pressure.

$$Pressure = \frac{Force}{Area} = \frac{F}{A}$$

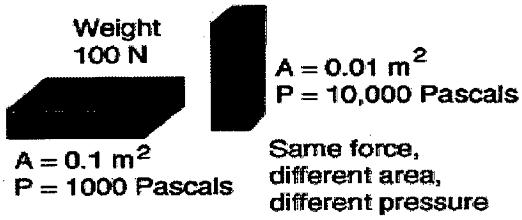

Figure 2.1: The explanation of pressure theory (Nave, 1998)

2.2.1 Pressure calculation

There are many physical situations where pressure is the most important variable. If you are peeling an apple, then pressure is the key variable: if the knife is sharp, then the area of contact is small and you can peel with less force exerted on the blade. If you must get an injection, then pressure is the most important variable in getting the needle through your skin: it is better to have a sharp needle than a dull one since the smaller area of contact implies that less force is required to push the needle through the skin. (Nave, 1998)

When you deal with the pressure of a liquid at rest, the medium is treated as a continuous distribution of matter. But when you deal with a gas pressure, it must be approached as an average pressure from molecular collisions with the walls. The pressure in a fluid can be seen to be a measure of energy per unit volume by means of the definition of work. This energy is related to other forms of fluid energy by the Bernoulli equation.

$$P = \frac{Force}{Area} = \frac{F}{A} = \frac{F \cdot d}{A \cdot d} = \frac{W}{V} = \frac{Energy}{Volume}$$

Equation 2.1: Formula of pressure by Bernoulli equation (Nave, 1998)

2.2.2 Water Distribution Pressure

i. A minimum residual pressure of 20-psi shall be maintained throughout the water distribution system under any condition. (Services, 2011)

ii. Where the pressure at the service tap exceeds 80 psi, the provisions of the Uniform Statewide Building Code shall apply. Pressures may exceed 80-psi for areas where the finish floors are less than 70-feet in elevation. (Services, 2011)

2.3 Factor affecting the effectiveness of pressure in water distribution.

These are the factor that will affect the pressure effectiveness in water distribution:

i. Pipe fitting
ii. Pipe size
iii. Tuberculation and corrosion
iv. Peak demand condition
v. Geographical condition
vi. Inaccurate pressure installed

2.3.1 Pipe fitting

Pipe fitting is a joint connection between two pipes to where ever way we want, to connect whatever size pipe. And comply with 'ASME/ANSI B16 - Standards of Pipes and Fittings'. Pipe fittings are basically used for installations and repairing of piping and tubing system in various facilities. The fitting find application in different settings: manufacturing, HVAC, refineries, nuclear-powered super carriers, hydraulics power plant construction, etc. They are also used in commercial building and residential apartments. These fittings are available in different dimensions, materials and finishes based upon the specific application. So, the pipe fitting will affect pressure in term of head losses as frictional losses in the piping system and it's depending on a K factor (Fluide Design, 2007).

$$\Delta H_{FF}(ft\ \ fluid) = K\frac{v^2(ft/s)^2}{2g(ft/s^2)}$$

Equation 2.2 : Fitting friction formula (Fluide Design, 2007)

The fitting friction ΔHFF can be calculated based on the following formula K is a factor based on the type of fitting and v is the velocity in feet/second and g is acceleration due to gravity. The K factors refer to table 2.1 and 2.2.

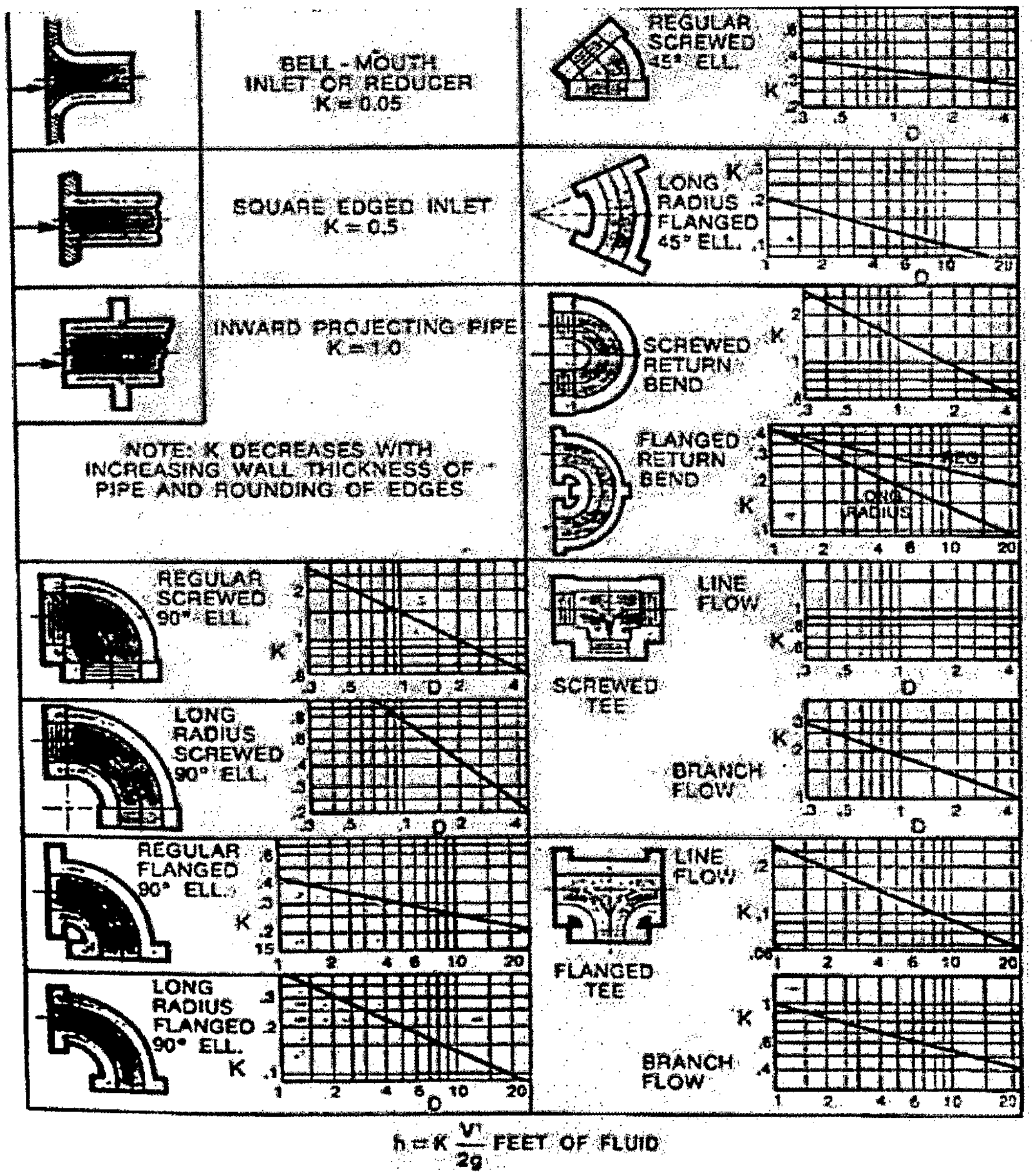

Table 2.1: Pressure head loss coefficient factor K (Fluide Design, 2007).

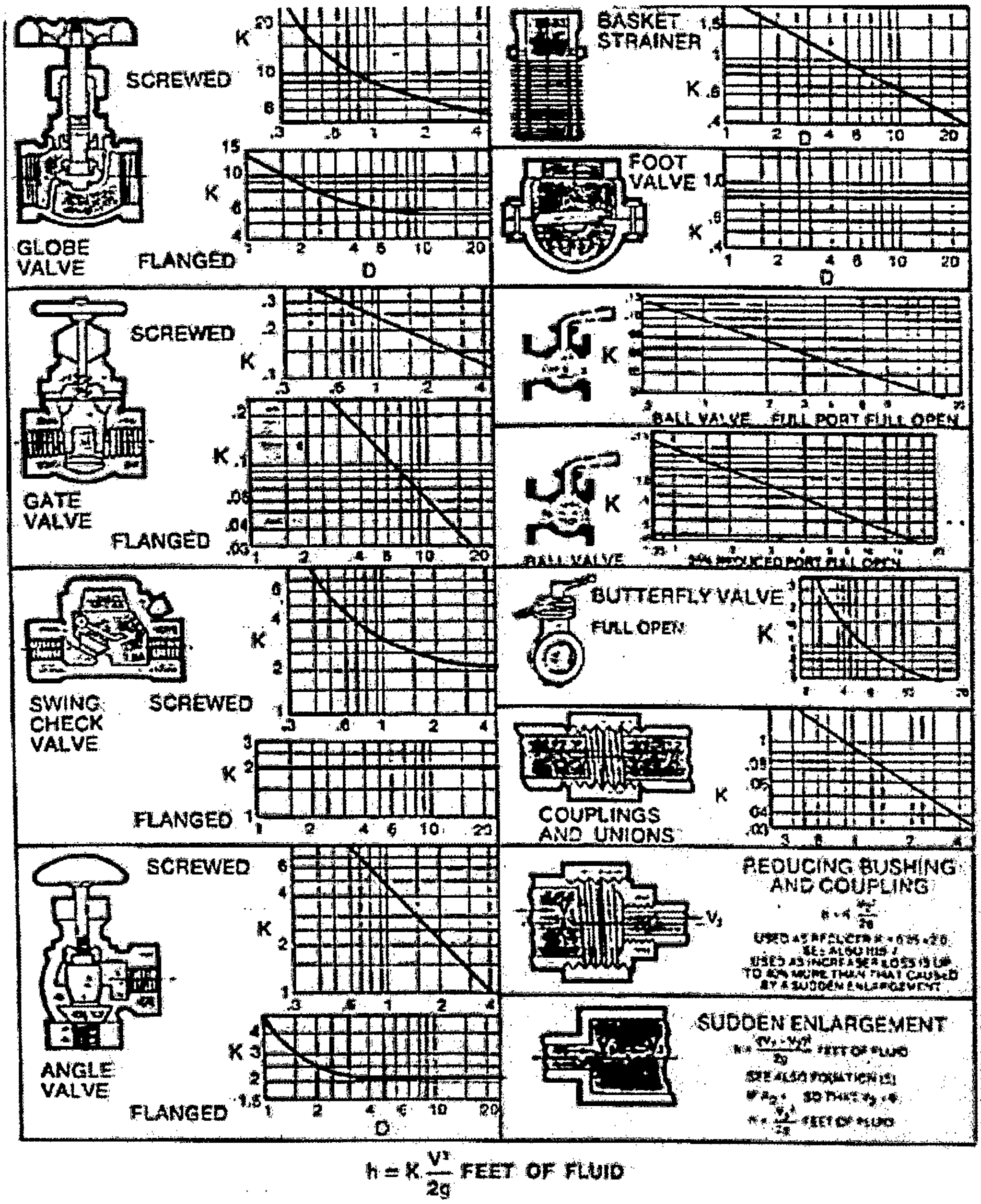

Table 2.2: Pressure head loss coefficient factor K (Fluide Design, 2007).

2.3.2 Pipe Size

For the pipe diameter, there are two common pipe size standards: the American (ANSI/ASME/API) standard, which is in imperial units, and the European (DIN) system which uses metric units. In the American system, the pipe diameter is known as "Nominal Pipe Size" (NPS) or "Nominal Bore" (NB). In the European system, it is known as the "Nominal Diameter" (DN). The most common standard diameters are as follow: 0.5 inch (15 mm), 0.75 inch (20 mm), 1 inch (25 mm), 1.5 inch (40 mm), 2 inch (50 mm), 3 inch (80 mm), 4 inch (100 mm), 6 inch (150 mm), 8 inch (200 mm), 10 inch (250 mm), 12 inch (300 mm), 14 inch (350 mm), 16 inch (400 mm), 18 inch (450 mm), 20 inch (500 mm), 22 inch (550 mm) and 24 inch (600 mm) - further sizes up to 36 inch are also available. It should be noted that some intermediate standard pipe sizes are available commercially, such as 5 inch (125 mm), however these are less common. (saylor, 2011)

For pipe sizes with a NB of 14 inch (DN 350 mm) and above, the nominal bore is the same as the pipe Outside Diameter (OD). Confusingly, for pipe sizes with a NB of 12 inch (DN 300 mm) and below, the nominal bore and outside diameter are different. For example, a pipe with a 12 inch NB (DN 300 mm) has an OD of 12.75 inches, or 324 mm. (saylor, 2011)

The pipe schedule sets the pipe wall thickness. Obviously increasing the wall thickness of the pipe increases the mechanical strength of the pipe, allowing it to handle higher design pressures. The available schedule are 5S, 10S, 10, 20, 30, 40S, STD, 40, XS (Extra Strong), 60, 80, 100, 120, 140, XXS (Double Extra Strong) and 160. So for pipe of 12 inch NB (DN 300 mm) with a pipe schedule 5S has a wall thickness of 0.156 inches (4 mm) with the order of the increasing wall thickness. As the schedule is increased, so does the wall thickness and it should be noted that not all pipe schedules are available for all pipe size. (saylor, 2011)

Pipe Internal Diameter (ID) used in line sizing calculations. So, as the pipe schedule changes, the internal diameter of the pipe changes. The ID can be easily calculated, as long as the pipe NB / DN and schedule are known. The pipe ID is given by the pipe NB minus double the pipe wall thickness (which can be obtained from the pipe schedule). It is worth bearing in mind that wall thicknesses come within a specified tolerance, depending on the engineering standard used - a typical wall thickness tolerance is 12.5%. This means that the actual internal pipe diameter may vary slightly from that mention above. So, pipe sizes actually affect the pressure by frictional loss, roughness and the diameter of pipe.

2.3.3 Tuberculation and corrosion

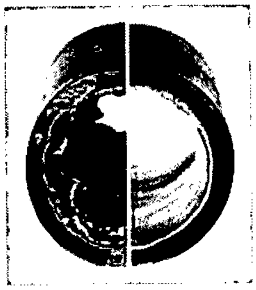

Figure 2.2: Tuberculation and corrosion pipe galvanized (Wasserstrom, 2011)

Development small mounds of corrosion products on the inside of iron pipe. These tubercules roughen the inside of the pipe, increasing the resistance to water flow. And, with the resistance increase, flow of water became more chaotic inside the pipe because of pressure increase and the water also got dirty of the corrosion along the pipe. What more important is, it also the reason why leakage occur. After high pressure in pipe because of the tuberculation, thickness of pipe will decrease and by time, it burst and hole is form wherever the pipe wall cannot restrain the pressure. (Wasserstrom, 2011)

Aesthetic effects that are a result of corrosion of iron are characterized by "pitting" and are one of a consequence of the deposition of ferric hydroxide and other products and the solution of iron; this is known as tuberculation. (J.E Singley, 1984)

Tuberculation reduces the hydraulic capacity of the pipe. Corrosion of iron can cause customer complaints of reddish or red-dish-brown staining of plumbing fixtures and laundry. Corrosion of copper lines can cause customer complaints of bluish or blue-green stains on plumbing fixtures. Sulfide corrosion of copper and iron lines can cause a blackish colour in the water. (Eric Pearce, 2013)

The by-products of microbial activity (especially iron bacteria) can cause a foul tastes and odours in the water. The economic effects of corrosion may include the need for water main replacement, especially when tuberculation reduces the flow capacity of the main. Tuberculation increases pipe roughness, causing an increase in pumping costs and reducing distribution system pressure. Tuberculation and corrosion can cause leaks in distribution mains and household plumbing. Corrosion of household plumping may require extensive treatment, public education, and other actions under the Lead and Copper Rule. Other effects of corrosion include short service life of household plumbing caused by pitting. The buildups of mineral deposits in the hot water system mayeventually restrict hot water flow. Also the structural integrity of steel water storage tanks may deteriorate, causing structural failures. Steel ladders in clear wells or water storage tanks may corrode, introducing iron into the finished water. Steel parts in flocculation tanks, sedimentation basins, clarifiers, and filter may also corrode.

2.3.3.1 Types of Corrosion

Three types of corrosion occur in water mains: galvanic, tuberculation, and pitting:

i. Galvanic: When two dissimilar metals are in contact and are exposed to a conductive environment, a potential exists between them and current flows. This type of corrosion is the result of an electrochemical reaction when the flow of electric current is an essential part of the reaction. (Kruger, 2001)

ii. Tuberculation: This refers to the formation of localized corrosion products scattered over the surface in the form of knob-like mounds. These mounds increase the roughness of the inside of the pipe, increasing resistance to water flow and decreasing the C-factor of the pipe. (Eric Pearce, 2013)

iii. Pitting: Localized corrosion is generally classified as pitting when the diameter of the cavity at the metal surface is the same or less than the depth. (Greene, 1967)

2.3.4 Peak Demand Condition

The pressure in a water distribution system (WDS) is at a minimum when the flows and subsequent head losses in the pipes are at a maximum – a state termed 'peak demand'. On the other hand, the pressure is a maximum when the flow is at a minimum – normally at night-time while most consumers are asleep and industries are shut down. Despite pressure management initiatives and subsequently reduced leaks being valuable and effective, the minimum residual pressure in reticulation systems during peak demand conditions are used as a design criterion to size infrastructure. (McKenzie and Bhagwan, 1999)

The residual pressure head (H), measured in metres, is used in this text to denote 'water pressure'. For the purpose of this text the minimum value of H under peak demand conditions is simply termed the 'minimum pressure head' (MPH). The minimum value of H occurs under peak demand conditions. The MPH could be described as the lowest pressure at the most critical demand node in a WDS under maximum demand. These critical low-pressure nodes are normally the ones at relatively high elevations and relatively far from the supply points. During hydraulic modelling of water networks such critical 'low-pressure' nodes are identified and are then used by analysts as baseline values to ensure that minimum criteria for H are met throughout the entire network

2.3.5 Geographical Condition.

This factor commonly for height and length of the pipe system from reservoir, dam, water tank and how big the area of the water distribution. So far, what concerns the most is the elevation of one place. For example, most dam built at the top of river system to generate enough pressure for supplying the water throughout the whole system and if the pressure is not enough, booster pump will be installed at certain location where water will be kept in one big tank and when the tank full, the station will pump the water using booster pump and then can get enough far for supplying the water.