UNIVERSITY OF NAIROBI

THE USE OF DIFFERENT TYPES OF PIPES FOR TRANSMISION OF WATER IN KENYA

By Wanyonyi W. Amon, F16/1315/2010

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Abstract.

Pipeline water transmission has replaced the traditional means of water conveyance in Kenya e.g. walking to the streams or using donkeys to carry water. This has greatly boosted the supply of portable water for use especially in irrigation and domestic use. The main advantages of pipeline water transmission include efficiency in supply, saving of time and effective management of the scarce resource.

Effective management of water through an efficient supply system has however been hampered by the ignorance of the engineering guidelines in pipeline installation. According to statistics from the Assistant Director in the section of water services providers, almost 65% of the water tapped by the water services providers has been going to waste through leakages from pipe bursts and usually goes unaccounted for. This is a great issue of concern since Kenya is a water scarce country. The country only uses about 3 billion cubic meters of water in a year and the little water must therefore be conserved for economic use.

Improvement of the different pipe types has taken place over the ages to facilitate the effective transmission of water. Plastic pipes e.g. UPVC, HDPE, polyethylene and PPR have emerged and their use have greatly increased in Kenya due to cost effectiveness and convenience in their installation and application. Analysis of the ***balance between the costs of the various pipe types and their ability to be applied effectively in different ground rock conditions*** in Kenya is a major component of this project. Correct piping would save the country a great amount of water. This entails standard methods of installation and joining if pipes to mitigate leakage at joints and pipe bursts as frequently witnessed in various regions in Kenya.

Dedication

I dedicate this research project to my parents, siblings, colleagues, friends and lecturers for their invaluable support, love and encouragement in the course of my studies. May the Almighty God bless them abundantly.

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Doshi hardware & industries ltd

General industries ltd – GIL

Metroplastics Kenya ltd.

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List of abbreviations

a. GI – Galvanized iron
b. PPR – polypropylene Random pipes
c. HPDE – High density polypropylene
d. UPVC – unplasticized polyvinyl chloride
e. PVC – polyvinyl chloride
f. PE - polyethylene
g. ABS – acrylonitrile butadiene styrene
h. CPVC – post chlorinated polyvinyl chloride
i. PB - polybutylene
j. PP – poly propylene
k. PVDF – polyvinylidene fluoride
l. BS – British Standard

CHAPTER ONE

INTRODUCTION

1.1 GENERAL INTRODUCTON.

Water is a basic need for every living thing; human beings, animals, plants and even microorganisms. In Kenya, water is tapped from various sources for example dams, underground from boreholes and wells, rivers, springs, lakes, rain water etc. and is transmitted to the final user through various means. Pipeline transmission is the major and large scale form of transmission of water from points of treatment in different dams and reservoirs to the homesteads and factories far away. Pipes are also used in transmission of water in buildings, to the farms and animal feeding points in every homestead. They are also used in irrigation farm projects.

It's therefore of concern to the engineers to design efficient systems of water supply to the final consumers, using the best suited pipes and bearing in mind the following factors:

a) Costs of installing and maintaining different pipe systems.
b) Population density and water demand.
c) Major uses of water needed in an area e.g. irrigation, industrial use and for home activities in available homesteads.
d) Nature of supply area in altitude, slope (terrain) and rock type.
e) Safety of the transmitted water in quality of consumption and protection against contamination of the water in supply systems.
f) Variation of the climatic conditions of the area hence fluctuations in demand at different times of the year.
g) Proximity of areas to the sources of supply.

NOTE; A lot of water is lost during distribution through leakages from the pipe system and this is of major concern to my research in this project. The plastic pipes are the ones majorly misused leading to great losses.

1.2 PROBLEM STATEMENT

Kenya is a water scarce country. The major water sources have been shrinking gradually with time and there is need to have a deliberate and consistent effort to conserve and use the available water resources economically in view to conserve and maintain the resources. Efficient water transmission to the final user is a key component in attaining this goal since most losses occur during transmission. Health concerns, efficiency of supply and corrosion prevention are also matters of concern in pipeline transmission of water.

Effective laying of water pipes is vital in preventing them from breakage and hence ensuring efficient transmission. There is thus need to study and analyze the best methods of application of this knowledge to preserve our scarce water.

Of prime importance is also cost minimization in the installation and maintenance of water transmission systems in the country, achieved through selection of the best suited and most economical pipe type.

PLATE 1 Collection of water from different sources by Kenyans. Source: waterproject.org/water-in-crisis-Kenya

1.3 OBJECTIVE OF THE STUDY

1. To establish the most suitable and economical types of pipe to be used in different regions of the country.
2. Of major concern is the analysis of water wastage through the pipes and in particular the plastic pipes with focus on how plastic pipes are being misused in the country
3. To observe the most suitable ways of laying pipes on the ground and its importance in the maintenance of pipelines and hence protection from damage.

1.4 LINK WITH CURRENT AND EMERGING ISSUES IN THE COUNTRY

I. Water shortage has been a yearly occurrence in several regions in Kenya, especially during the dry seasons occasioned by droughts.

II. The high rate of population growth in our country needing more efficient systems to supply the growing population with clean water.

III. The need to minimize the water losses to minimum possible levels and creation of flexible supply systems with the growing demand without needing total redesign of the systems.

IV. Discovery of rich and superfluous underground water resources in Turkana-Lotikipi basin, a very dry area with severe drought and food shortage – aquifers estimated to hold over 250 billion m^3 of water, enough to serve the country for up to 70 years (according to the report released by the environment minister, Judy Wakhungu in November 2014)

V. Rapid infrastructural development, e.g. roads, power systems etc. which are intertwined with water supply and distribution systems.

VI. Development of new irrigation schemes to boost the country's food reserve as a strategy to reduce hunger and malnutrition in the country in the ***Vision 2030***. Example, Nzyawa and Muuo projects in Makueni County, Ciambaraga project in Tharaka Nithi serving about 135 farmers and Mwicuri irrigation project in Nyeri County serving about 250 farmers.

VII. Demonstrations by residents of Narok County reported in may 2015 over lack of water for use in their homes and very distant sources

PLATE 2 Drought occurrence and it effects. Source- water.org/country/Kenya

PLATE 3 Current water supplies to homesteads in Machakos County- Maji Mashinani initiative

1.5 PROJECT BREAKDOWN: SCOPE

This project is divided into two parts; part 1 and part 2. Part 1 deals with the relevant literature review whereas part 2 is concerned with the actual study. The report majorly focuses on the following aspects of water transmission in Kenya

1. Water supply in Kenya
2. Use of pipes in water transmission
3. Types of pipes in use in Kenya
4. Factors influencing the choice of pipe type
5. Suitability of different pipe types in different environments
6. Dynamics in water transmission caused by varying population growth and expansion in urban centers.

7. Cost comparison of the pipes
8. Plastic pipes and water wastage in Kenya
9. Sanitation and health issues
10. Pipe installation requirements.

PLATE 4 Tapped natural fountain at shimo la Tewa in Kitale, a place where locals come to fetch water and carry it on their back to their homes for use.

1.6 FIELD TESTS ACTIVITIES ON PIPE USAGE AND WATER TRANSMISSION

1. Flow and pressure measurement
2. Analyzing water losses and the specific amounts putting focus on different ways through which water is being wasted.
3. Establishing discharge and efficiency characteristics
4. Analysis of pipe joints
5. Interview of water service providers to establish their satisfaction with the pipe system in delivering water to consumers.
6. Observing the depths that pipes are laid in different places in relation to rock structure.
7. Internal diameter and velocity profiles at intersection probe flow measurement points.
8. Interview to residents of various places on their satisfaction with the water transmission system to their premises.

CHAPTER TWO

LITERATURE REVIEW

2.1 WATER SUPPLY IN KENYA.

In the traditional setup and in the remote areas in Kenya, water has always been fetched by women and girls from various sources, some even several kilometers away.

PLATE 5 Young ladies carrying water home in Narok County Source- water.org/country/Kenya.

In bid to improve on water delivery, pipes were developed and have evolved over the years to create an efficient delivery system for the water to places even miles away from the water points.

According to the Joint Monitoring Program's2012 report, access to safe water supplies throughout Kenya is about 59% and access to improved sanitation is only 32%. There is still an unmet need in rural and urban areas for both water and sanitation. Kenya faces challenges in water provision with erratic weather patterns in the past few years causing droughts and water shortages. Kenya also has a limited renewable water supply and is classified as a water scarce country. The major water towers are ***the Mau ranges*** and ***the Abbadares*** but have been invaded over time and cannot provide enough water for the ever escalating Kenyan population. Rural to Urban migration contributes to challenges in sanitation, as people crowd into cities and urban growth is unregulated. The piping system is also a major contributing factor because a lot of water is wasted through leakages and bursting of pipes where there is sufficient water supplied.

Due to lack of access to water and sanitation, diarrhoea is second to pneumonia in deaths in children under five years of age. Water, sanitation and hygiene related illnesses and conditions are the number one cause of hospitalization in children under age five. Access to water and sanitation also contribute to time savings for women, more hours in school for girls, and fewer health costs. This could be achieved if an efficient, effective and very hygienic system is implemented in all areas inhabited in Kenya. Water at the natural sources can just be treated, pumped to higher grounds and piped to distant users by gravity to help mitigate all the aforementioned problems.

2.2 CATEGORIES OF WATER CONSUMPTION IN KENYA

Domestic – e.g. drinking, cooking, ablution, sanitation, laundry, garden watering, and bathing pools.

Trade and industry–e.g. factories, power stations, shops, hotels, hospitals, schools and in offices.

Agriculture -e.g. horticulture, greenhouses, dairies, and livestock farms, etc.

Public use e.g. parks, schools, hospitals, street watering, sewer flushing and firefighting

2.3 FACTORS AFFECTING WATER USE

2.3.1 Characteristics of population

The economic status of a community heavily influences the scale of water use. Wealthy customers tend to have a higher per capita use compared to poor customers.

2.3.2 Climate

Warm, dry climates call for higher water demands unlike wet humid areas. In very cold climates, water may have to be wasted at faucets to prevent freezing in pipes.

2.3.3 Industry and commerce

Manufacturing plants require large amounts of water depending on the extent of operations and the type of industry.

2.3.4 Social amenities in the town

A large supply is needed in schools, hospitals, parks and other social places if present in an area.

2.3.5 Farming practices

Large farms that require irrigation consume a huge amount of water and hence will have a huge demand.

2.4 WATER TRANSMISSION IN KENYA.

A comprehensive and detailed research study on the best pipe systems has to be put in place in order for the whole country to enjoy *a stable, hygienic and efficient system* of water supply. This is also necessary for water quality control as well as supply management through monitoring of meters and usage to each supply unit. Furthermore the demand in given towns will only be satisfied when the correct sizes and types of pipes are installed; those that will meet the demand without the risk of *pipe bursts and air bubbles* being present in the pipes.

Water in Kenya is transmitted from supply points to the vast population by various means; pipes, Lorries, physical transportation using donkeys and to a worse extend in remote areas, people themselves go to streams to carry water in cans and buckets. These modes where animals and people are involved in water transmission are however unsafe since constant visits to the water sources lead to pollution through dumping and general disturbance. There is also a lot of time wastage through travelling to and from the water collection points which renders this mode totally inefficient and uneconomical. The mode is also tiresome since a lot of physical energy is needed in carrying the water.

PLATE 6 Water transportation means. Source: water.org/country/Kenya.

Pipeline transmission is therefore the most effective mode of conveying water to the general population for their different uses. It's therefore of uttermost importance to ensure development of the pipe system which can effectively and efficiently transmit water, taking into consideration hygiene, pollution control, fast delivery and conservation of this precious natural resource.

Of uttermost importance is the fact that pipes, their lining materials and joints must not cause a water quality hazard, apart from being suitable to the soil conditions of the areas of application and the climate as well.

2.5 WATER LOSSES

2.5.1 Distribution losses

Leakage from mains and service pipes upstream of consumer's meters or property boundary; leaks from valves, hydrants and washouts, leakage and overflows from service reservoirs.

2.5.2 Consumer wastage

I. Leakage and wastage in the consumers' premises
II. Leakage from their supply pipes.
III. Misuse of water by consumers.

2.5.3 Metering and other losses

Source meter errors, supply meter errors, unauthorized or unrecorded consumption. Furthermore, many domestic supplies are not metered and so a lot of water goes unaccounted for.

NOTE; A lot of water is lost during distribution through leakages from the pipe system and this is of major concern to my research in this project. The plastic pipes are the highly misused in Kenya leading to great losses.

2.6 PIPES

Definition of pipe:

A pipe is a tube or hollow cylinder made of metal, plastic or any other materials used for conveyance of water, oil, gas and any other fluid substances from point to point.

Water pipes are tubes that carry pressurized and treated fresh water to buildings and as well as inside the buildings. They are mostly made of polyvinyl chloride (PVC/UPVC), ductile iron, steel, cast iron, polypropylene, polyethylene, copper, or lead (the use of lead pipes however is no longer preferred due to the poisoning effect of lead as a hard metal.)

The pipes also come in different sizes and grades according to the intended use and the scale of operation they are being put to. However, there are other factors that also dictate the grade and material type to be used in a given area.

Pipes are also used in sprinkling water to the farms through irrigation and this specifically requires long and flexible pipes to be moved easily and afterwards be rolled together and packed.

2.6.1 BACKGROUND INFORMATION ON DEVELOPMENT OF PIPES IN THE EARLY TIMES AND CHANGES TO DATE.

Pipes have developed since the early ages where wood was used as a pipe material in Britain and china to deliver water from distant places to homes. The development is also linked to the smoking pipes used by many people around the globe. With time the wooden pipes were found inefficient and susceptible to damage and rotting, leading to the invention of lead pipes in the early ages.

However, the lead pipes lead to a very great hazard since ingestion of lead ions has devastating effects to the functioning of animals and their genetic disorders in general. The pipes have therefore evolved, through the copper and zinc pipes to the later invention of ductile iron pipes and galvanized iron which have been in use for long up to date.

With the development of plastic molding technology and the need to be economical in material use, invention of plastic pipes has led to the manufacture of a vast variety of plastic pipes e.g. UPVC, PPR and polyethylene to transmit both drinking and waste waters. A lot of improvement is still being undertaken on the transmission aspects to help reduce the costs and at the same time improve the safety and quality of transmission depending on the vast climatic and geological conditions around the world.

2.6.2 TYPES OF PIPES USED IN WATER TRANSMISSION

Pipes found in waterworks systems in Kenya are generally of the following materials;

1. Galvanized iron (GI)
2. Cast/ grey iron
3. Ductile iron
4. Steel
5. UPVC (un-plasticized polyvinylchloride)
6. PVC(polyvinyl chloride)

7. Polyethylene (PE)
8. GRP (glass reinforced plastic)
9. Pre-stressed concrete, cylinder or non-cylinder (PSC)
10. Reinforced concrete cylinder (RC)
11. HDPE and LDPE
12. PPR

Other materials include ***copper and lead*** which tend to be found in service pipes, plumbing, common connections and other small diameter mains

2.6.3 FACTORS INFLUENCING THE CHOICE OF PIPE MATERIAL

1. Cost of material is a major factor
2. Ease of handling and suitability of use
3. Chemical resistivity
4. Corrosion effect to the pipe
5. Frictional resistivity of the material to water flow
6. Strength of material
7. Ability to withstand high temperatures
8. Flexibility of pipe with soil type of a given area
9. Degradation when exposed to given environmental and physical conditions
10. Ability to withstand pressure from the supply source

The principal factors however are the technical consideration, price, local experience and skill, ground conditions, preference and standardization. Another important factor is the ability of the pipes to be made in small sizes for preferred use. All these points are elaborated in later chapters.

2.6.4 CONTRAST BETWEEN DIFFERENT PIPES AND ADAPTATIONS TOTHE APPLICATION AREAS

2.6.4.1 GI PIPES

They are used mainly as the supply pipes on the main water lines for treated .mostly medium pipes are used. They vary in diameter from 15mm to 150mm. LENGH MOSTLY 6METRES

CASES WHERE THEY ARE MOSTLY USED

1. Rocky grounds.
2. Places where the pipeline crosses roads and busy paths.
3. Where water theft needs to be controlled.

PLATE 7 GI Pipe across mamlaka road, Nairobi.

Advantages

i. They are robust
ii. Are more difficult to tap into illegally by those who want to steal
iii. Are easy to join

Disadvantage

i. Are so expensive
ii. They are very disruptive and difficult to lay
iii. Corroded in some soils
iv. Unsuitable for drinking water when the metal gets corroded.

2.6.4.2 DUCTILE IRON PIPES

Also used as distribution pipes. Similar to galvanized iron, they are robust and difficult to tap into illegally.

Disadvantages

i. Need to coated depending on the soil to prevent rusting
ii. Rubber gaskets at joints can be damaged as pipes are joined leading to contamination
iii. Are expensive

2.6.4.3 ALLUMINIUM PIPES

Aluminum tubes used to be more popular on the market as a pipe due to its light weight, durable and easy construction, which can be more suitable for using in home improvement. It gradually did not have the market. The products are however being phased out gradually.

Advantages:

i. The price is cheaper.
ii. Can be arbitrary curved bow.
iii. Smooth surface.
iv. Construction is convenient.

Disadvantages:

i. Easy to aging
ii. The pipe joint leakage phenomenon appears easily.
iii. Have a very short life span

2.6.4.4 PPR PIPES. (POLYPROPYLENE RANDOM PIPES)

PPR pipes are designed for Hot and Cold water supply and heating applications and it is suitable for different applications listed below:

I. Hot and cold water supply in residential,
II. industrial, commercial & public projects
III. Solar applications

IV. Compressed air systems
V. Drinking water and liquids
VI. Watering systems for greenhouses & gardens
VII. Transportation of aggressive fluids
VIII. Water purifying plants
IX. Radiator heating
X. Traditional heating systems

Their sizes range from 20mm to 110mm in thicknesses while lengths vary too e.g. mostly 4 meters and in rolls of 100 meters.

PLATE 8 PPR pipes **(www.plasticpipesgroup.com)**

FEATURES AND BENEFITS

1. Light weight, easy and quick assembly
2. Most suitable for carrying drinking water
3. Excellent corrosion and chemical resistance
4. Bacteriologically neutral

5. Low thermal conductivity
6. Safe and watertight joints
7. Reduce heat loss
8. High impact strength
9. Resistance to scaling
10. Resistance to frost
11. Usable in seismic areas
12. Resistance to abrasion
13. Resistance to stray current
14. Eco-friendly
15. Long operational durability
16. Economical in the overall capacity.

They are safe and reliable can be used up to 50 years.

Disadvantages:

I. The construction technical requirements higher.
II. They need to use special tools and professionals to undertake construction in order to ensure system safety.

2.6.4.5 HDPE Pipes (High density polythene)

High-density polyethylene (HDPE) is a polyethylene thermoplastic made from petroleum. It is known for its large strength-to-density ratio. The density of HDPE can range from 0.93 to 0.97 g/cm3 or 970Kg/m3. The difference in strength exceeds the difference in density, giving HDPE a higher specific strength. It is also harder and more opaque and can withstand much higher temperatures (120 °C for short periods, 110 °C continuously). High-density polyethylene, unlike polypropylene, cannot withstand normally required autoclaving conditions. The lack of branching is ensured by an appropriate choice of catalyst (e.g., Ziegler-Natta catalysts) and reaction conditions.

HDPE pipes are best preferred for industrial, Domestic and irrigation purpose.

They have been preferred over other available resources due to varied salient features:

1. Strong and resilient
2. Light weight
3. Length as required

4. Better flow characteristics
5. Hygienic &Odourless
6. Energy saving
7. Leak proof
8. Chemical Resistant
9. Economical
10. Long Lasting
11. Maintenance free

They are effectively applied in water supply in irrigation field, sprinkler irrigation, bio-gas transportation, drawing water from pump set for distribution, most suitable for submersible pump and jet pumps and distribution of water in water projects. Their sizes vary from about 16mm to 110mm.

Disadvantages

I. Can't be used in certain conditions of soil e.g. that contaminated with oils and petrol
II. Need to be joined together correctly to avoid contamination

PLATE 9 HDPE pipes **(www.plasticpipesgroup.com)**

2.6.4.6 UPVC – UNPLASTICISED POLYVINYLCHLORIDE

UPVC pipes with Elastomeric Sealing Ring type joints are best preferred for supply of water for rural and urban areas, for irrigation and water supply in hilly areas where temperature is very low and in desert areas where the temperature is at maximum.

Elastomeric Sealing Ring fit pipes have been preferred over other available resources in the mentioned areas due to the following salient features.

1. Strong and durable
2. Light weight
3. Convenient joining
4. Better flow characteristic
5. Energy saving
6. Leak proof
7. Resistant to rusting, chemical action, weathering & scale formation
8. Odourless and hygienic
9. Long lasting & maintenance free

PLATE 10 UPVC borehole pipes **(www.plasticpipesgroup.com)**

APPLICATIONS

Domestic: Supply of potable water in house and residential buildings.

Agriculture: Supply of water for irrigation of crops.

Other: Supply of water for irrigation and consumption in hilly areas where temperature is very low and in desert areas where the temperatures are the maximum.

Disadvantages

I. Can be damaged by exposure to sunlight
II. Joints are glued making them prone to leakages
III. Need proper bedding when laying e.g. sand
IV. Pressure from sharp objects can puncture it leading to leakages and contamination

PLATE 11 UPVC PIPES for underground water mains **(www.plasticpipesgroup.com)**

2.6.4.7 PVC PIPES

PVC pipe has made a tremendous improvement in plumbing. It replaces cast iron and galvanized pipe in almost all situations. Light weight and easy to work with, PVC is available in many different sizes. Fittings and related materials are readily available at all plumbing and hardware stores. Furthermore, they are more affordable for our economy and hence their preference over metal pipes.

PLATE 12 PVC pipe (**www.plasticpipesgroup.com*****)***

What is PVC?

PVC pipe is made from the plastic, "polyvinyl chloride." It is used in construction of drains, as vents, and to handle waste in buildings. It is rigid, lightweight, and strong. Because of PVC pipe's ease of installation, it is ideal for drain applications under kitchen sinks and bathroom vanities. The many fittings available for attaching PVC make it universal in all settings except very high temperature applications. It works much better for plumbing than the old standard cast iron pipe because it does not need to be hot soldered, is resistant to almost any alkaline or toxic substance, and is easy to install. There are two types, which are defined in standards -- type 40, for personal homes, and type 80, used in industrial settings.

Some Advantages

•Easy to install and hence low installation cost
• chemically resistant
• Strong
• Fire resistant
• High internal corrosion resistance
• Immune to galvanic or electrolytic attack
• Free from toxicity, odorless and tasteless
• Low friction loss
• Low thermal conductivity

PLATE 13 Some PVC pressure fittings (*www.plasticpipesgroup.com*)

Various matters of concern about PVC are; design life of pipe, possibility of recycling, resistance to UV rays, resistance to fire etc.

Design life-PVC, because of its composition, will last for the design life of the home in which it is installed. Because it is rustproof and chemical resistant, a design life of 100 years is typical.

Recycling - The pipe can be pulverized and returned to the extrusion process to manufacture new pipe. There are currently no standards for this. Because of its long life, PVC hasn't had a lot of exposure to recycling.

Resistance to UV rays - Because of its inherent design PVC pipe contains stabilizers that protect the pipe against attack by UV rays present in sunlight. Some discoloration may occur. Several years of exposure may see slight reduction in the impact resistance of the material. By painting the exposed pipe with a latex paint (don't use oil based) this problem is virtually eliminated.

Fire resistance - Like any plastic, PVC pipe will melt if subjected to high temperatures. However, it stops that process immediately when the fire source is removed. Studies show that PVC pipe in a typical installation is less than 1 percent of all combustible materials in a building.

2.6.4.7.1 Comparison between PVC and UPVC pipes

The main difference between PVC and UPVC is that UPVC doesn't contain phthalates or BPA. This makes it safer for transporting water, as well as making it fire-resistant.
Because of the concerns of plasticizers being ingested by people and an animals it is better to ensure that only UPVC pipe is used in potable water applications. For the purpose of drain pipe it is acceptable to use straight PVC pipe. PVC pipe is often used to distribute water that people aren't going to drink. It's also used to insulate electric cables. The UPVC versions often replace wood when building window frames and sills. The UPVC pipe variant also often replaces pipes made of cast iron for drains, waste piping, downspouts and gutters.

Many people use PVC instead of metal, as PVC is much easier to cut than metal, and it's also easy to use glue together. In addition, PVC is still fairly tough, so not much strength is lost. Most plastic piping around the globe is actually UPVC because of how resistant it is to degradation caused by chemicals, high and low temperatures and various pressure points. The UPVC version of piping is less flexible than regular PVC, but it's also more recyclable.

Application

UPVC is used in transmission of drinking water while PVC is best suited for waste water transmission from various points of use.

Manufacture

PVC and UPVC are largely made of the same material. Polyvinylchloride is a polymer that can be heated and molded to create very hard, strong compounds such as piping. Because of its rigid properties once it's formed, manufacturers frequently blend additional plasticizing polymers into PVC. These polymers make PVC pipe more bendable and, generally, easier to work with than if it remains unplasticized. Those plasticizing agents are left out when UPVC is manufactured making it nearly as rigid as cast iron pipe.

2.6.4.7.2 Abuse of PVC and UPVC pipes

Due to their cheap prices and ease of transportation and fixing, the PVC and UPVC pipes are being greatly abused through

i. incorrect installation
ii. exposure to sunlight and laying on the surface
iii. operation by unqualified persons
iv. laying on rocky grounds
v. poor fixing of joints

2.6.4.8 PE PIPES

Have the following unique characteristics

1. High density
2. Good flexibility
3. Bear strong shocks and twists in earthquakes
4. Long performance life of 50 year

5. High density, good flexibility, bears strong shocks and twists in earthquakes, resists wear and tear
6. Shock resistant
7. Does not cause bacteria
8. Will not cause secondary pollution
9. Has good corrosion resistance
10. Resists fractures and handles extreme temperatures (-40 ~ 40oC)
11. Has long performance life and can be used for 50 years under normal situations
12. Lightweight and easy to weld
13. Safe connections
14. Clean and non-toxic

USES

a) Mainly used for municipal administration water supplies, buildings' water
b) supply, chemicals, food, material, prints, pharmaceutical, light industry,
c) papermaking and metallurgy
d) For water and other liquids
e) Used in irrigation, telecommunications lines, sleeve pipes, as well as all facets
f) of chemical industry
g) Liquid transports pipeline of industry and irrigates pipeline for farming

Disadvantages

i. Can be damaged by exposure to sunlight
ii. Joints are glued making them prone to leakages
iii. Need proper bedding when laying e.g. sand
iv. Pressure from sharp objects can puncture it leading to leakages and contamination

OTHER PIPE TYPES

2.6.4.9 ASBESTOS CEMENT PIPES

Are majorly used as distributor pipes and used to be a cheap option. The limitation was that they proved to fracture very fast and also the water quality was highly compromised.

2.6.4.10 ABS (acrylonitrile butadiene styrene)

ABS is used for the conveyance of potable water, slurries and chemicals. Most commonly used for DWV (drain-waste-vent) applications.

2.6.4.11 CPVC (post chlorinated polyvinyl chloride)

CPVC is resistant to many acids, bases, salts, paraffinic hydrocarbons, halogens and alcohols. It is not resistant to solvents, aromatics and some chlorinated hydrocarbons.

2.6.4.12 PB-1 (polybutylene)

PB-1 is used in pressure piping systems for hot and cold potable water, pre-insulated district heating networks, and surface heating and cooling systems. Key properties are the weldability, temperature resistance, flexibility and high hydrostatic pressure resistance. One standard type, PB 125, has a minimum required strength (MRS) of 12.5 Mega Pascal. It also has low noise transmission, low linear thermal expansion, no corrosion and calcification.

2.6.4.13 PP (polypropylene)

Polypropylene is suitable for use with foodstuffs, potable and ultra-pure waters, as well as within the pharmaceutical and chemical industries.

2.6.4.14 PVDF (polyvinylidene fluoride)

PVDF has excellent chemical resistance which means that it is widely used in the chemical industry as a piping system for aggressive lines.

2.6.5 INSTALLATION OF PLASTIC PIPES – A CASE STUDY WITH PVC PIPES

PLATE 14 Installation of PVC pipes for water supply **(wikipedia.org/wiki/plastic-pipework)**

Pipe installation one of the most important aspects that determine the ***durability of the pipelines and hence the conservation of water and prevention from contamination***. Precaution therefore has to be taken so that this is done in the most perfect way to conserve the pipes for a longer duration. A proper analysis is done in chapter 4 of this project.

Procedure

1) PVC can be cut easily. It can be cut with a hacksaw, but abrasive disks are made for miter saws that work better to get a straight edge. A joint that is skewed due to pipe not being cut straight can throw off the entire run of pipe.

2) After cutting, all shavings are cleaned out of the pipe and the inside edges deburred. When the pipe is cut to the proper length, it's laid out on the floor with fittings in place to determine if the length is correct. If the length is found proper, installation can proceed.

3) The pipe must be cleaned with all-purpose pipe cleaner, called primer. The primer is swabbed around the end of the pipe and the inside of the fitting to ensure there are no contaminants that can get in the way of adhesion. PVC is joined with a special type of cement. The cement sets up very quickly, so you must be ready to go as soon as it is applied.

The inner surface of the joint is coated with cement then the pipe inserted and turned round to ensure the glue has covered the entire joint. Care should be taken to ensure the pipe is seated correctly in the joint.

4) Once the PVC pipe is in place, and proper length has been determined, pipe hangers are installed to support the pipe. This eases strain on the joints that could lead to possible leakage. Recommended distances from hanger to hanger, usually every 4 feet is used, allowing for movement in expansion and contraction. The pipe must be protected from nails & sharp objects.

2.6.6 PIPE FAILURE

They are mostly linked to improper installation practices and methods in the field.

Main Causes of Pipe Failure are:

1) Improper System Engineering/Installation

i. Inadequate provision for linear thermal expansion
ii. Excess use of Cement
iii. Insufficient amount of Cement
iv. Wrong Clamps used or Clamps too tight
v. Incompatible fire caulk used
vi. Contact of outside of pipe with incompatible material (e.g., solder flux)

2) Improper Operation

i. Exposure to freezing temperatures without freeze protection
ii. Over-pressurization
iii. Pulsating water pressure
iv. Use of incompatible materials around pipes

3) Contamination

Both Internal and external for example,

i. Use of contaminated antifreeze
ii. Contaminants from metal water supply piping; e.g., antimicrobial (MIC inhibitor) linings.

iii. Incompatible Fire Caulk
iv. Use of incompatible (black Proset) grommets to seal pipe against hole in concrete.
v. Contact with incompatible plastic coated wires
vi. Exposure to hot solder flux
vii. Exposure to hot polyurethane foam insulation

4) Manufacturing defects

i. Dirty extrusion die
ii. Incomplete resin consolidation
iii. High stresses in pipe wall due to rapid cooling
iv. Occlusions, char particles, voids
v. Filler/pigment not well distributed

5) Abuse by Distributor

i. Store in sun
ii. Damage during transport due to careless handling.

2.6.7 COMPONENTS OF PLASTIC PRESSURE PIPE SYSTEMS

Pipes, fittings, valves, and accessories make up a plastic pressure pipe system. The range of pipe diameters for each pipe system varies. However, the size ranges from 12 to 400 mm (0.472 to 15.748 in) and $^3/_8$ to 16 in (9.53 to 406.40 mm). Pipes are extruded and are generally available in: 3 m (9.84 ft)4 m (13.12 ft), 5 m (16.40 ft.), and 6 m (19.69 ft) straight lengths and 25 m (82.02 ft), 50 m (164.04 ft), 100 m (328.08 ft), and 200 m (656.17 ft) coils for HDPE Pipe fittings come in many sizes: tee 90° equal (straight and reducing), tee 45°, cross equal, elbow 90° (straight and reducing), elbow 45°, short radius bend 90° socket/coupler (straight and reducing), union, end caps, reducing bush, and stub, full face, and blanking flanges. Valves are molded and also come in many types: ball valves, butterfly valves, spring-, ball-, and swing-check non-return valves, diaphragm valves, knife gate valve, globe valves and pressure relief/reduction valves. Accessories are solvents, cleaners, glues, clips, backing rings, and gaskets.

2.7 PROBLEMS ASSOCIATED WITH PIPELINE TRANSMISSION OF WATER.

i. Bursting of pipes leading to water wastage.
ii. Friction generation as water moves in the pipes.
iii. Dynamics with pressure changes with the altitude.
iv. Stealing of the pipes by the public.
v. Effects of corrosion e.g. rusting.
vi. Danger of contamination in case of a burst.
vii. Theft of water pipes as well as illegal connections.
viii. The difficulty of forecasting the future demand of water.
ix. Contamination of water through some points.
x. Insufficient water.
xi. Freezing of water in pipes.

CHAPTER THREE

METHODOLOGY

My area of study was mainly in ***industrial area, Nairobi***, since its where major pipe manufacturing industries in Kenya are located. It's also where all different types of pipes are sold in bulk to other hardware shops in Kenya and to major water supply agencies. I also surveyed for prices in shops around the CBD especially along Duruma road where there are many hardware shops on both sides of the road.

In the analysis of pipe misuse and consequently water loss, I carried out a field study in Kayole area in Nairobi where the ***Nairobi City water and sewerage company*** is involved in extension of water services. I also interviewed the manager in charge of maintenance and repair to get more information pipe transmission aspects in the field.

An interview to the director in charge of water services providers in the ministry of water at ***Maji House*** was important in getting more specific data on the amount of water lost during transmission in Kenya.

All this was possible after I obtained an introduction letter from the department of civil Engineering chairperson***. (See appendix A***)

The following were the subsections in my study and the major areas of interest in the project:

1. Cost comparison of various pipe types in relation to their use (Source; hardware and pipe manufacturing industries)
2. Observation of leaking pipes and hence water losses estimation
3. Interviews on various aspects of water transmission to water service providers
4. Observations of leakages and incorrect pipe installations in different water projects for analysis

3.1 Comparison of the prices of various types of pipes used in Kenya

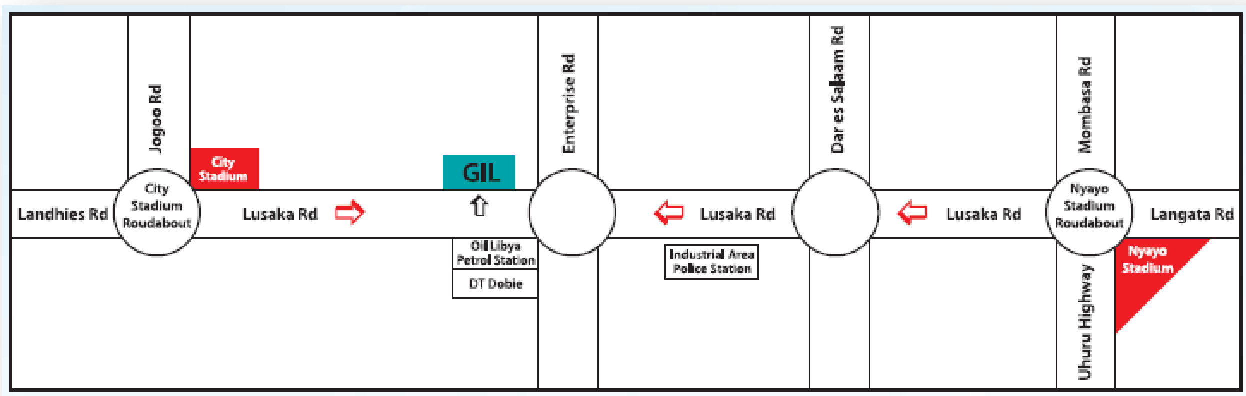


Figure: guide map to GIL Company in Nairobi.

The pricelist from the major industries, all in industrial area in Nairobi were sampled as follows:

I. General industries limited along Lusaka road
II. Doshi hardware and company limited
III. Metroplastics Kenya limited
IV. Polypipes Kenya limited

Small scale hardware shops in the CBD were also sampled, majorly along Duruma road and Munyu road as well as shops in Kayole, kangemi and Eastleigh. Some of the shops include;

1. Japan hardware and paints
2. Bright-sun ventures hardware
3. Mwaro hardware

The major aim was to compare the prices and as well get statistics on the most widely used pipes from the level of purchases.

The average prices from the shops were computed and tabulated for comparison and analysis.

3.2 Observation of leaking pipes

An observation was made on pipe bursts and misuse of pipes especially in the plastic pipes and mistakes in installing of the pipes which lead to frequent pipe bursts and hence immense loss of water through leakages. This data was mainly collected in Kayole area in Nairobi where the Nairobi City Water and Sewerages Company was undertaking its project. Recording was done through taking of photos. (***See plates 15-20)***

3.3 Interviews on various aspects of water transmission to water service providers

Lastly, there was interviewing of people from different estates in Nairobi county and western Kenya on their satisfaction in water delivery systems and in the usage of their pipeline systems

To get much more valid statistics on water supply, data was sought from the ***Nairobi city water and Sewerage Company***, the ***national water conservation and Pipeline Corporation*** as well as from the Director in the section of ***water services providers in Maji house*** (ministry of water)

3.3.1 THE FORMULATED QUESTIONAIRE

Guiding Questions

i. What are the basic factors that your company uses to select the type of pipe to use in water transmission in a given area?
ii. What are the most preferred pipes and what makes them liked over the others?
iii. Kindly give an estimate of the different pipe types used generally in different projects that your company has been involved.
iv. What factors have been causing pipe bursts along the transmission lines?
v. What do you think is the best way of minimizing or preventing the factors above?
vi. How are pipes handled so as to minimize water loss and at the same time prevent inconvenience to water users?
vii. What are the best practices in lying of pipes that you would recommend to help in maintaining the pipes and enabling them to last longer as well as preventing interference of the pipe network from the environment?

viii. How is the general cost of water pipe installation and maintenance minimized?

ix. Could you estimate, by quantifying the average amount of water wasted annually through pipe faults in Nairobi

3.4 Observations of pipe installations in different water projects for analysis

Pipes were observed in various places with keen interest on the faults in installation and joining mistakes committed, which would render the pipeline vulnerable to damage and bursts. The comparison of different metric series of pipes was done through analyzing the sample pipes at Nairobi Water Company.

Recording of the data was done through taking of various photos, a sample of which is in the analysis given ***chapter 4.*** For the prices, the pricelist were collected from the shops and the levels of sales in each category of pipes inquired from the sales persons.

CHAPTER FOUR

RESULTS AND ANALYSIS OF DATA

4.1 PRICES OF THE PIPES

4.1.1 General lists

Table 1 PE PRESSURE PIPES (6MTS)

Size(mm)	PN6	PN8	PN10	PN12.5	PN 16	PN 20	PN 25
12mm	-	-	-	-	-	104.00	-
16mm	-	-	-	-	-	144.00	-
20mm	-	-	-	-	165.00	228.00	-
25mm	-	-	-	210.00	261.00	345.00	-
32mm	-	272.00	290.00	341.00	423.00	558.00	-
40mm	344.00	366.00	231.00	538.00	661.00	889.00	-
50mm	461.00	572.00	680.00	840.00	1020.00	1382.00	-
63mm	727.00	901.00	1072.00	1340.00	1632.00	2195.00	-
75mm	996.00	1245.00	1531.00	1889.00	2314.00	3069.00	-
90mm	1454.00	1803.00	2194.00	2720.00	3324.00	4438.00	-
110mm	1916.00	2399.00	2939.00	3673.00	4515.00	5461.00	6617.00
125mm	2500.00	3125.00	3818.00	4724.00	5758.00	7049.00	8569.00
140mm	3161.00	3861.00	4809.00	5909.00	7233.00	8839.00	10697.00
160mm	4129.00	5029.00	6309.00	7759.00	9460.00	11571.00	14046.00
180mm	5112.00	6350.00	7903.00	9753.00	11986.00	14670.00	17753.00
200mm	6325.00	7950.00	9797.00	12094.00	14811.00	18023.00	21893.00
225mm	7988.00	9957.00	12314.00	15307.00	18761.00	22890.00	-
250mm	10000.00	12345.00	15270.00	18748.00	23032.00	28196.00	-
280mm	12468.00	15444.00	19066.00	23638.00	28931.00	35357.00	-
315mm	15656.00	19595.00	24251.00	29775.00	36662.00	44793.00	-
355mm	19935.00	24817.00	30721.00	37807.00	46616.00	56799.00	-
400mm	25302.00	31553.00	38945.00	48137.00	59009.00	72093.00	-

Table 2 UPVC PRESSURE PIPES IMPERIAL SERIES

INCHES	PN9	PN12	PN15
3/8	-	-	138.00
½	-	-	197.00
¾	-	-	277.00
1	-	-	409.00
1 ¼	-	524.00	635.00
1 ½	-	679.00	831.00
2	859.00	1045.00	1308.00
3	1776.00	2304.00	2817.00
4	3263.00	4292.00	5159.00
6	7048.00	9270.00	11233.00
8	10890.00	14210.00	17191.00
10	16873.00	22003.00	26687.00
12	23733.00	30997.00	37701.00

Table 3 PPR PIPES – 4MtS

SIZE (MM)	PN10		PN 16		PN20	
	Packaging	price/pipe	Packaging	price/pipe	Packaging	price/pipe
20mm	40	205.00	40	240.00	40	285.00
25mm	30	264.00	30	390.00	30	440.00
32mm	20	400.00	20	640.00	20	700.00
40mm	15	624.00	15	960.00	15	1060.00
50mm	10	1000.00	10	1500.00	10	1680.00
63mm	5	1620.00	5	2360.00	5	2960.00
75mm	1	2700.00	1	3500.00	1	4300.00
90mm	1	3520.00	1	5000.00	1	5920.00
110mm	1	5300.00	1	7600.00	1	9400.00

Table 4 HDPE PIPES Meters

OD SIZE n(MM)	CLASS 1 2.5kg/sq.cm	CLASS2 3.5kg/sq.cm	CLASS 3 4.0kg/sq.cm	CLASS 4 6.0kg/sq.cm	CLASS 5 10.0kg/sq.cm	CLASS 6 16.0kg/sq.cm
16mm	-	-	14.00	17.00	22.00	35.00
20mm(0.5’’)	--	12.00	15.00	22.00	29.00	36.00
25mm(0.75’’)	-	23.00	27.00	36.00	41.00	57.00
32mm(1’’)	-	30.00	35.00	48.00	67.00	93.00
40mm(1.25’’)	-	43.00	59.00	68.00	102.00	144.00
50mm(1.5’’)	-	66.00	75.00	104.00	158.00	220.00
63mm(2’’)	-	95.00	117.00	162.00	248.00	350.00
75mm(2.5’’)	113.00	135.00	158.00	225.00	349.00	497.00
90mm(3’’)	151.00	187.00	230.00	327.00	495.00	714.00
110mm(4’’)	225.00	281.00	345.00	486.00	732.00	1062.00

The average values for each category of pipes are as tabulated below. The prices are wholesale prices from major industries e.g. Doshi industries limited and the Metroplastics Kenya limited. Those from small shops differ slightly according to location and the most preferred type in the areas of location.

Table 5 GI pipes.

Sizes (inches)	Class A- light	Class B- medium	Class C- heavy
½	900	1100	1400
¾	1200	1400	1850
1	1800	2200	2800
1 ¼	2300	2700	3700
1 ½	2900	3200	4300
2	3800	4500	6050
3	4500	8200	10500
4	5700	1200	15300
6	10000	19800	24180
8	-	28300	35300
	-	-	-

Table 6 UPVC

Size	PN 6	PN 10	PN 16	PN 20
3/8	-	-		100
½	-	-	180	120
¾	-	260	280	200
1	-	350	400	310
1 ¼	250	580	600	475
1 ½	450	900	950	750
2	650	1350	1500	1200
3	1400	2500	3100	1800
4	1700	3100	4000	2500
6	2800	4200	5000	3700
8	3700	5500	6400	4800
10	4500	7000	8500	6200
12	6000	9300	10700	7900
14	7700	11500	14000	10000
16	9600	14700	18100	13000
18	12000	18400	22100	17200
20	15000	23300	27500	22100
22	19000	29500	35400	27000
24	24500	37000	45000	33800

4.1.2 OBSERVATION OF THE MIDDLE/AVERAGE PIPES' SERIES

Table 7 PPR

Size (inches)	Pipe/ price		
	PN 10	PN 16	PN 20
½	200	250	275
¾	250	390	450
1	400	640	700
1 ¼	600	1000	1100
1 ½	1000	1550	1700
2	2650	2400	2900
3	3500	5000	5900
4	5200	7500	9500

Table 8 HDPE PIPES (Meters)

OD SIZE in (MM)	Prices per meters.			
	CLASS 2	CLASS 4	CLASS 5	CLASS 6
16mm	-	15.00	22.00	35.00
20mm(0.5'')	10.00	22.00	30.00	38.00
25mm(0.75'')	23.00	35.00	40.00	57.00
32mm(1'')	30.00	50.00	67.00	95.00
40mm(1.25'')	42.00	68.00	100.00	145.00
50mm(1.5'')	65.00	105.00	160.00	220.00
63mm(2'')	95.00	160.00	250.00	350.00
75mm(2.5'')	135.00	225.00	350.00	498.00
90mm(3'')	185.00	325.00	495.00	715.00
110mm(4'')	280.00	485.00	730.00	1060.00

Table 9PE PRESSURE PIPES (6Meters)

Size(mm)/ inches	PN6	PN10	PN 16	PN 20	PN 25
16mm 3/8	-	-	-	144.00	-
20mm ½	-	-	165.00	228.00	-
25mm ¾	-	-	261.00	345.00	-
32mm 1	-	290.00	423.00	558.00	-
40mm 1 ¼	344.00	231.00	661.00	889.00	-
50mm 1 ½	461.00	680.00	1020.00	1382.00	-
63mm 2	727.00	1072.00	1632.00	2195.00	-
75mm 2 ½	996.00	1531.00	2314.00	3069.00	-
90mm 3	1454.00	2194.00	3324.00	4438.00	-
110mm 4	1916.00	2939.00	4515.00	5461.00	6617.00
125mm 5	2500.00	3818.00	5758.00	7049.00	8569.00
140mm 6	3161.00	4809.00	7233.00	8839.00	10697.00
160mm 8	4129.00	6309.00	9460.00	11571.00	14046.00
180mm 10	5112.00	7903.00	11986.00	14670.00	17753.00
200mm 12	6325.00	9797.00	14811.00	18023.00	21893.00
225mm 14	7988.00	12314.00	18761.00	22890.00	-
250mm 16	10000.00	15270.00	23032.00	28196.00	-
280mm 18	12468.00	19066.00	28931.00	35357.00	-
315mm 20	15656.00	24251.00	36662.00	44793.00	-
355mm 22	19935.00	30721.00	46616.00	56799.00	-
400mm 24	25302.00	38945.00	59009.00	72093.00	-

Note that the comparison is only on the major pipes commonly used in transmission of drinking and irrigation water today. Most pipes like copper and aluminum are very rare currently on the market. The GI pipes series has only 3 classes; light, medium and heavy.

4.1.3 THE OVERAL COMPARISSON OF COST

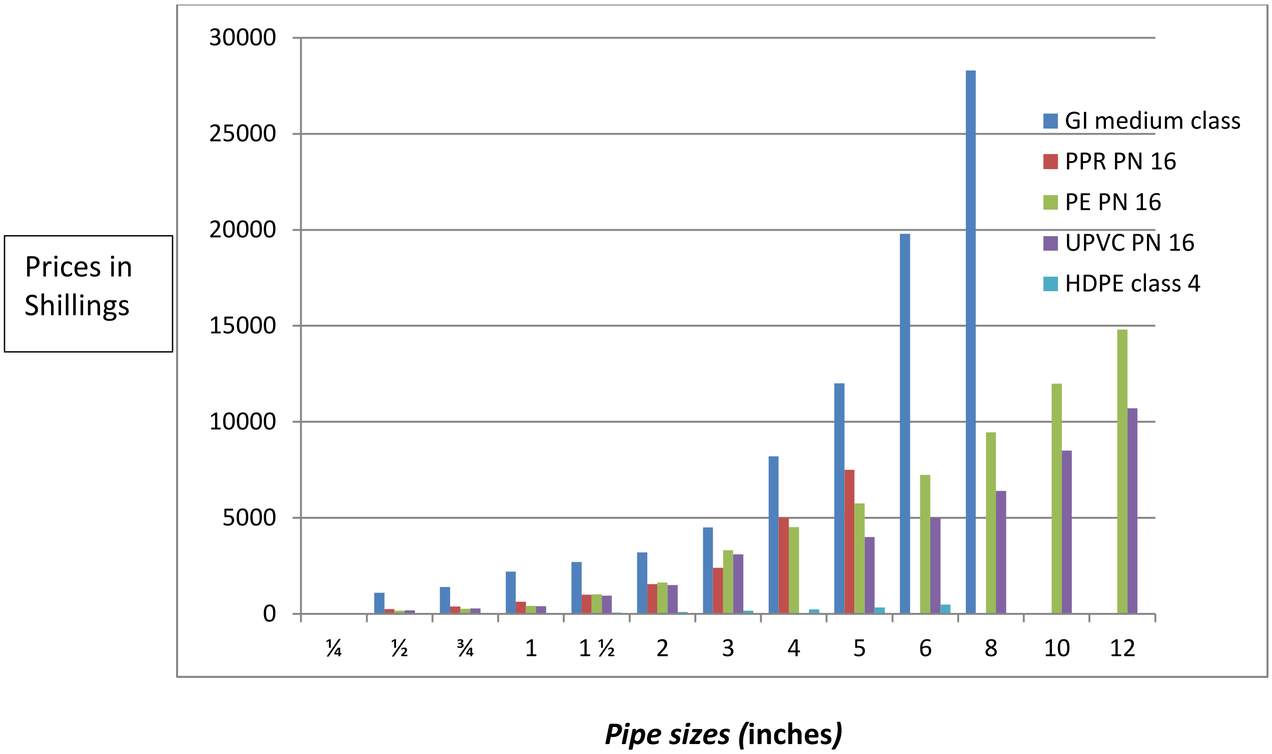
Only the middle classes from each category of pipes are used in this comparison process for the major categories of pipes found in the shops

Table 10 average values for the medium series of the main pipe types

PIPE/ SIZE OF PIPES	COST OF THE PIPES				
	GI medium class	PPR PN 16	HDPE class 4	PE PN 16	UPVC PN 16
¼			15.00	-	-
½	1100	250	22.00	165.00	180
¾	1400	390	35.00	261.00	280
1	2200	640	50.00	423.00	400
1 ½	2700	1000	68.00	1020.00	950
2	3200	1550	105.00	1632.00	1500
3	4500	2400	160.00	3324.00	3100
4	8200	5000	225.00	4515.00	-
5	12000	7500	325.00	5758.00	4000
6	19800		485.00	7233.00	5000
8	28300		-	9460.00	6400
10	-		-	11986.00	8500
12			-	14811.00	10700

NB –For all the pipe types, prices increase as the metric sizes increase**.**

HDPE pipes are much more expensive than PVC, UPVC, PPR and PE pipes but the units of their sale given here are shorter i.e price is per metre.



ANALYSIS

The GI pipes are very expensive when compared to the plastic ones. The HDPE pipes are sold in terms of cash per unit weight but project virtually higher than the other plastic pipes followed by the PPR and the PE pipes.

UPVC is the lowest in price of the plastic pipes and it's also found in much larger metric series of up to over 20 inches.

4.2 LEVELS OF PURCHASE

It was observed that the most purchased pipes in the small shops were the PPR pipes, taking up to almost 60% 0f their sales. The sales persons attributed this to the suitability of the PPR pipes in internal plumbing, ease to fix and ability to withstand high pressure.

In the projects where water is transmitted to very long distances, for instance in rural areas, the UPVC pipes are dominant taking up to 70% 0f the purchase.

The HDPE pipes and ethylene pipes are used as an alternative in the same kind of transmission though their levels of purchase are much lower.

The GI pipes take up just about 15 - 20% of the total sales in the purchase list except in manufacturing regions and where a lot of machinery passes over the surface.

The percentage taken by other pipes is much lower but PVC takes over 90% in waste water transmission and is therefore one of the most highly bought pipes.

4.3 FINDINGS FROM INTERVIEWS

From the interview to ***the ministry of water officials in Maji house***, it was apparent that plastic pipes account for over 90% of water mains in Kenya. The GI pipes are only used where it's inevitable, for instance the terrain cannot allow, very rocky underlying soils and at places where pipes have to cross roads, valleys and trenches.

The choice according the cost is apparent from the comparison table above since GI pipes are way much expensive. Furthermore, they are very heavy and hence hard to deal with in the field.

It was apparent that the PPR and polyethylene pipes (PE) are being preferred much more of recent because of the fact that they can be supplied in long pieces and so the work of joining after every few meters is highly reduced.

The assistant Director in the water service providers section responded by saying that the loss of water (That which is unaccounted for) incurred by the water providers is way up to **70 %** of the total water supplied in worst conditions. A few water service providers however, have a capacity of about 55 % loss in the water tapped for distribution to the users. These losses are attributed to the following factors in the field;

1. Poor workmanship
2. Failure to adhere to the design specifications (grade of pipe in relation to slope) – many pressure excesses lead to pipe bursts and immense loss of water.
3. Poor laying of pipes exposing them to radiation which consequently reduces the durability of the pipes to a very large extend.
4. Lack of monitoring in the design and laying of pipes
5. Incorrect reading of meters by employees in the service boards.
6. Illegal connection

The GI pipes are used in plenty in Nairobi slum areas mainly because most projects are funded by donors like World Bank who also supply the pipes. This is mainly because they have an efficient distribution and minimize water theft by the locals.

4.4 Observation of pipes in the field- leakages and general laying


PLATE 15 Leakage from a main pipe at the Kemu towers, university way roundabout. Water oozing from the ground where the burst had occurred


PLATE 16 Visible burst pipe that caused much water wastage

Immense water was lost from the pipe burst above since it also took over a week before repair was done yet water was continuously being transmitted. The consequent pool of water that was formed as a result of the leakage is illustrated in ***plate 17.***

PLATE 17 A visible pool of water at the university way- Uhuru highway roundabout in December 2014 due to the burst above.

PLATE 18 PPR pipe exposed on the surface in Soweto village kayole

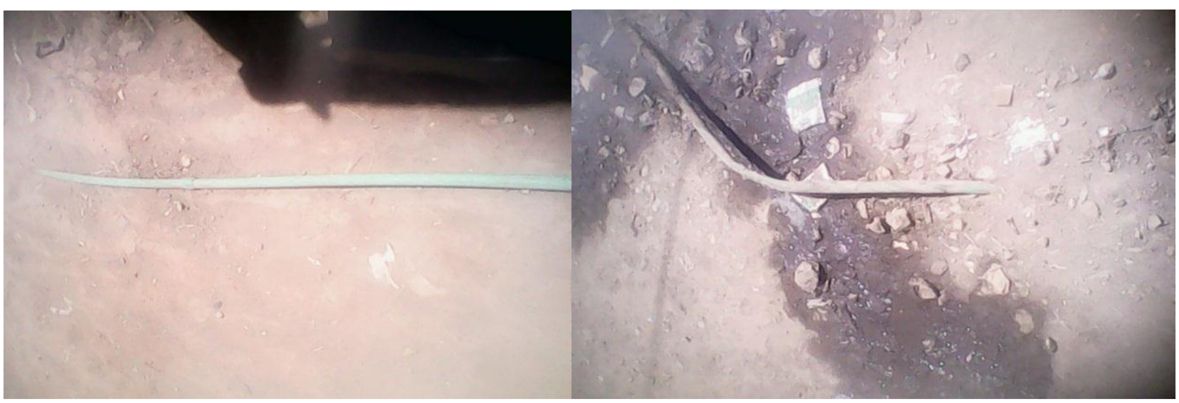


PLATE 19 Pipes on the surface

Plate 19 shows wrong surface installation of pipes and hence the consequences of the same, e.g. dislocation of the pipes by moving machines and humans that get in contact with the pipeline. This leads to pipe breakage and hence loss of water and unnecessary expenses on repair, yet if correctly installed, the damage could be prevented.

PLATE 20 comparisons of metric sizes of 3inch PVC pipes

***PLATE 21 C**omparing different metric series of PVC pipes*

Different metric series of pipes are designed to transmit water at a given pressure and that is why any attempt to replace a given series with a lesser and cheaper one would lead to bursting of the pipe and consequently water loss and interruption in supply.

PLATE 22 Different types of pipes in Mukuru Kwa Njenga.

Plate 22 shows PPR and GI pipes over damped matter. One of the pipes is disconnected at the joint and this is very dangerous to the safety of the transmitted water.

PLATE 23 Water leakage in Shimo La Tewa; Kitale

PLATE 24pipe leakage in Zambezi; Kikuyu

The plates 23 and 24 above show some cases of immense water leakages that are just a sample of the many cases around the country. Some pipes break due to excessive internal pressure or due to external loads. Unfortunately some stay for so long before being detected and repair, hence immense loss of water.

CHAPTER FIVE

DISCUSSION

5.1 Comparison of pipe parameters

It is evident that plastic pipes are being used in huge numbers among Kenyans in water transmission to their homes and in commercial practices such as irrigation, transmission into houses and in general supplies. This is because of their low costs, convenience in use and ease of installation. On the hygiene side of view, most plastics are convenient for supplying drinking water, e.g. PPR, UPVC, P.E and HDPE. Most are flexible and so easy to use.

5.1.1 GI PIPES

The GI pipes are advantageous in places where the landscape is rocky and at places where pipes have to cross other infrastructural facilities e.g. roads since they are hard and not easily damaged. Their use is limited though due to their heavy weight and hence inconvenience in transportation and handling. The process of handling the GI pipes is also tedious and requires many joints at close distances of ***6metres***. This is however advantageous in places where strict control of supply and rationing of water is required since several lines can be closed and opened at convenient durations by the service providers workers. On the side of resistance to corrosion, the GI pipes are very vulnerable especially in water containing several important mineral salts and as well as in saline soils like the black cotton soils. In these types of soils, the GI pipes can only have a durability of about 15 years before damage through corrosion.

GI pipes get well anchored in the ground and can’t be swept away easily even in areas that experience flooding. This makes them also suitable for use in such areas. They can also not be tapped into easily by illegal users and hence ensure safety of water. This is in line with the field characteristics reviewed ***in chapter 2 subsection 2.6.4.1.***

Also of great disadvantage is the fact that corrosion of these metallic pipes is hazardous to living organisms since the heavy metals when ingested cause very harmful health effects including causing cancer.

5.1.2 POLYETHYLENE PIPES

From the new trends in water supply, a lot of preference is now being given to the polyethylene pipes (that's according to the response from the Assistant Director in the sector of water services providers – ***section 4.3***). These pipes can supply a far distance without the tedious work of joining the pipes since they can be manufactured in great lengths saving greatly on time and money. Furthermore, it's at the joints that are incorrectly fitted that leakage starts in common pipe connections observed. A disadvantage of this however is the uncontrolled supply and immense water wastage in case of a leakage along the length. These leaking points may also take time to discover if they happen deep in the ground.

A Poly pipe advantage is the ability to package it in 100' or 300' rolls, instead of rigid 20' lengths like PVC. Some people really appreciate the storage and transport ease. P.E pipes are much easier to handle and transport than PVC and GI pipes.

Polyethylene is obviously very flexible. Installers like being able to make sharper bends without using fittings. It is a softer plastic.

When full of water, PVC pipe will shatter if the water is allowed to freeze. Polyethylene pipes tend to be a little more forgiving. Thus P.E pipes tend to be favored more in freezing climates.

In response, the irrigation industry has said Poly pipe should only be used after the control valves for the zone piping, or to install a master valve at the water source. The Poly pipe should not be used in continuous pressure situation. Newer press-in fittings are mitigating this problem. Reliable water-tight pipe networks are now possible with Poly pipe. However, the irrigation industry still recommends using Poly pipe for zone piping, not main lines.

5.1.3 HDPE

It's another version of Poly pipe is growing in use for larger jobs. High density Polyethylene pipe is a heavier plastic, so it can handle higher pressures and makes a very durable pipe system.

HDPE tends to be used for pipe diameters over 3″. Smaller sizes are not as readily available.

Fittings and pipe coupling joints are a "fused" type. The pipe or fitting ends are cut straight, cleaned-up, and heated via a fusing machine. Once at temperature, the ends are pressed together. It is said the fuse joint, when properly fused, is stronger than the pipe itself.

Because the HDPE pipe system technically becomes one piece of pipe (no fittings) it eliminates the biggest source of pipe system failures (the fittings). HDPE systems have proven exceptionally reliable. Use is rapidly growing for golf course irrigation systems and we now see more use on large commercial irrigation job sites.

However, most irrigation contractors have not yet installed HDPE pipe so they don't know how to use the fusing machines or even how to order the pipe and fittings. Indeed, HDPE pipe and fittings below 4″ are not readily available in all areas and will likely be a special order with additional costs for shipping. Some will seek permission to substitute PVC in place of HDPE when bidding jobs specified with HDPE pipe.

HDPE costs more and takes longer to install than PVC. While it can be modified later on, it is more time consuming than a PVC pipe system.

If damaged, it can be repaired using special in-hole fusing units with patch on repair fittings. The service person must have access to a repair fuser and know how to use it.

5.1.4 PPR PIPES

These are the most widely bought pipes – from ***section 4.2***. This is attributed to their extensive use in internal plumbing. They can withstand very high pressure and are also flexible as observed in from the results in chapter 4. Their flexibility and resistance to damage by the ultraviolet rays also makes them suitable for surface water connection especially if it would be so costly in doing underground installation. They can be easily transported and installed since they are easy to join using the joint fittings that are supplied with the pipes.

Furthermore, the pipes are very easy to join since they have a wide range of joints and could even be joined very easily to the GI pipes at distribution points. The pipes are very affordable too and so can be bought without much straining on users budget.

Their main disadvantage is that their construction technical requirements are higher and there is need to use special tools and professionals to undertake construction in order to ensure system safety and efficiency. ***Refer section 2.6.4.4.***

5.1.5 UPVC PIPES

UPVC pipes are the most widely used pipes for large scale and long distance water transmission in the country ***(Refer section 4.3)***. Because of its lows prices, it's very economical and affordable to use on large scale water transmission. The UPVC pipes are able to expand and contract moderately under increased internal pressure by water and this helps to minimize bursts. They are also inert and resistant to chemical corrosion hence safety of drinking water.

The UPVC pipes however, have several limitations:

They are not flexible and so have to be distributed in short lengths of 6 meters each. This makes them tedious to transport and a lot of labour is required in installation. Furthermore, the presence of very many joints renders the mains vulnerable to leakages at the pipe joints. UPVC pipes are only suited for underground installation since on surface installation would expose them to ultra violet rays that damage them with time.

PLATE 25 Underground installation of UPVC pipes

5.2 WATER LOSSES

Immense water loss occurs mainly from pipe leakages. A lot of water goes unaccounted for ***(about 55-70% as noted earlier in section 4.3 and from plates15, 16, 17, 23 and 24)*** and so there is need to have an efficient system of locating points of leakages and doing a fast repair. This would increase the percentage of water that is accounted for and consequently the conservation of the same. Kenya uses just over 3 billion cubic metre of water and many areas still face acute water shortage. If water loss can be reduced then the amount used could rise higher with more people getting water.

Much more water is lost through leakages and overflow from service reservoirs and water towers, illegal connections, meter tampering or by-passing and by third party damage to the pipe network.

Others losses include the unmeasured legitimate use e.g.:

i. Legal connections with no payment requirements e.g. watering green areas and flowers
ii. Legal connection but consumption not billed
iii. Demand for fire fighting
iv. Street cleaning and sewer flushing by the county council
v. Old unmaintained meters

It therefore calls for extra vigilance and professionalism in water systems management. ***Refer to appendix C***

5.3 PIPE INSTALLATION – SURFACE AND UNDERGROUND

5.3.1 Underground Installation of PE Piping

To the common citizen, the concept of underground pipeline installation sounds relatively straight forward: a) dig a trench) lay the pipe in the trench, and c) fill the trench back in. While this simplified perspective of pipeline construction may be appealing, it does not address the engineering concepts involved in the underground installation of a pipeline. The steps below show the concept of a pipe soil system and the importance that the soil and the design and preparation of the back-fill materials play in the long-term performance of a buried pipe structure. Specific terminology and design concepts relating to the underground installation of PE pipe are fully discussed here. This includes fundamental guidelines regarding trench design and the placement and subsequent backfill of the PE pipe. It is felt that a comprehensive presentation of these design and installation principles may assist the engineer or designer in utilizing PE pipe in a range of applications that require that it be buried beneath the earth.

In general there are two objectives to achieve in an installation. The first is to provide an envelope of embedment to protect the pipe from mechanical damage from impact or hard objects (cobbles, boulders) in the soil. The second is to provide support against earth and live load pressures, where this is required. The envelope surrounding the pipe is referred to as the "embedment". The earth and live loads are supported by the combination of the pipe's stiffness and the embedment's stiffness. Lower DR pipes will carry more of the load and require less support from the soil. When support from the embedment is needed by the pipe to resist earth and live loads, the embedment material is often compacted. The trench backfill placed on top of the embedment material may also be compacted. Compaction of trench backfill immediately above the pipe facilitates the redistribution of some of the load away from the pipe and into the side-fill soil.

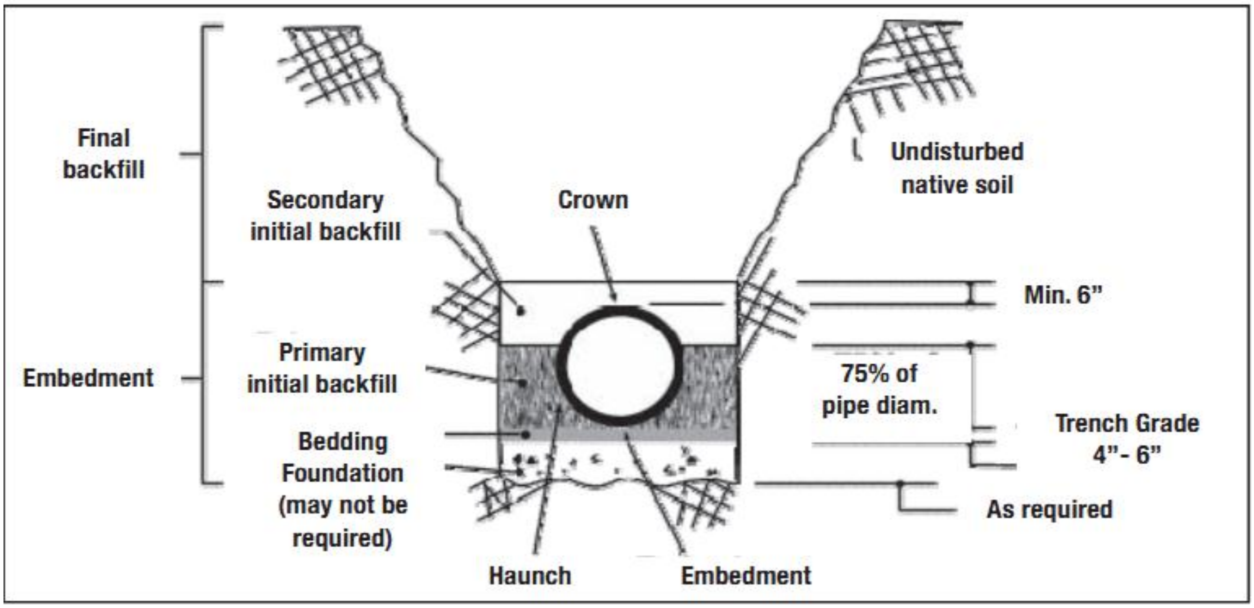


Figure 2: pipe trench

Note: When groundwater levels are expected to reach above pipe, the secondary initial backfill should be a continuation of the primary initial backfill in order to provide optimum pipe support. Minimum trench width will depend on site conditions and optimum pipe support. Minimum trench width will depend on site conditions and embedment materials.

Foundation - A foundation is required only when the native trench bottom does not provide a firm working platform for placement of the pipe bedding material.

Initial Backfill - This is the critical zone of embedment soil surrounding the pipe from the foundation to at least 6 inches over the pipe. The pipe's ability to support the load and resist deflection is determined by the ability of embedded materials and the quality of its placement. Within the initial backfill zone are bedding, haunch, primary, and secondary zones.

Bedding - In addition to bringing the trench bottom to required grade, the bedding levels out any irregularities and ensures uniform support along the length of the pipe.

Haunch - The backfill under the lower half of the pipe (haunches) distributes the superimposed loadings. The nature of the haunch material and the quality of its placement are one of the most important factors in limiting the deformation of PE pipe.

Primary Initial Backfill - This zone of backfill provides the primary support against lateral pipe deformation. To ensure such support is available, this zone should extend from trench grade up to at least 75 percent of the pipe diameter. Under some conditions, such as when the pipe will be permanently below the ground water table, the primary initial backfill should extend to at least 6 inches over the pipe.

Secondary Initial Backfill - The basic function of the material in this zone is to distribute overhead loads and to isolate the pipe from any adverse effects of the placement of the final backfill.

Final Backfill - As the final backfill is not an embedment material, its nature and quality of compaction has a lesser effect on the flexible pipe. However, arching and thus a load reduction on the pipe is promoted by a stiff backfill. To preclude the possibility of impact or concentrated loadings on the pipe, both during and after backfilling, the final backfill should be free of large rocks, organic material, and debris. The material and compaction requirements for the final backfill should reflect sound construction practices and satisfy local ordinances and sidewalk, road building, or other applicable regulations.

The engineer must therefore evaluate the site conditions, the subsurface conditions, and the application objectives to determine the extent of support the pipe may need from the surrounding soil. Where the pipe burial depth is relatively deep, where subsurface soil conditions are not supportive of pipe, where surface loads or live loads are present, or where the pipe DR is high, the engineer will generally want to prepare a specific installation specification. These applications would include many rural transmission and distribution water lines, many force main sewer lines, and many process water lines. Typically these lines contain pressure pipes installed at shallow depths which are sufficiently stiff to resist the minimal earth load. In some cases a pipeline may contain sections that require specific engineering such as a section that crosses a road.

5.3.1.1 Simplified Installation Guidelines for Pressure Pipe

(Small diameter pressure pipes usually have adequate stiffness and are usually installed in such shallow depths that it is unnecessary to make an internal inspection of the pipe for deflection.)

A quality job can be achieved for most installations following the simple steps that are listed below. These guidelines apply where the following conditions are met:

i. Pipe Diameter of 24-inch or less
ii. SDR equal to or less than 26
iii. Depth of Cover between 2. 5 feet and 16 feet
iv. Groundwater elevation never higher than 2 feet below the surface
v. The route of the pipeline is through stable soil

Examples of soils that normally do not possess adequate stability for this method are mucky, organic, or loose and wet soils.

5.3.1.1.1 Trenching

In unbraced or unsupported excavations, proper attention should be paid to slopping the trench wall to a safe angle. Consult the local codes. All trench shoring and bracing must be kept above the pipe. The length of open trench required for fused pipe sections should be such that bending and lowering the pipe into the ditch does not exceed the manufacturer’s minimum recommended bend radius and result in kinking. The trench width at pipe grade should be equal to the pipe outer diameter (O. D.) plus 12 inches.

5.3.1.1.2 De-watering

For safe and proper construction the groundwater level in the trench should be kept below the pipe invert. This can be accomplished by deep wells, well points or sump pumps placed in the trench.

5.3.1.1.3 Bedding

Where the trench bottom soil can be cut and graded without difficulty, pressure pipe may be installed directly on the prepared trench bottom. For pressure pipe, the trench bottom may undulate, but must support the pipe smoothly and be free of ridges, hollows, and lumps. In other situations, bedding may be prepared from the excavated material if it is rock free and well broken up during excavation. The trench bottom should be relatively smooth and free of rock. When rocks, boulders, or large stones are encountered which may cause point loading on the pipe, they should be removed and the trench bottom padded with 4 to 6 inches of tamped bedding material. Bedding should consist of free-flowing material such as gravel, sand, silty sand, or clayey sand that is free of stones or hard particles larger than one-half inch.

5.3.1.1.3 Placing Pipe in Trench

PE pressure pipe up to about 8" in diameter and weighing roughly 6 lbs. per ft or less can usually be placed in the trench by hand. Heavier, larger diameter pipe will require handling equipment to lift, move, and lower the pipe into the trench. Pipe must not be dumped, dropped, pushed, or rolled into the trench. Appropriate safety precautions must be observed whenever persons are in or near the trench

5.3.1.1.4 Pipe Embedment

The embedment material should be a coarse grained soil, such as gravel or sand, or a coarse grained soil containing fines, such as a silty sand or clayey sand. The particle size should not exceed one-half inch for 2 to 4-inch pipe, three-quarter inch for 6 to 8-inch pipe and one inch for all other sizes. Where the embedment is angular, crushed stone may be placed around the pipe by dumping and slicing with a shovel.

Where the embedment is naturally occurring gravels, sands and mixtures with fines, the embedment should be placed in lifts, not exceeding 6 inches in thickness, and then tamped. Tamping should be accomplished by using a mechanical tamper. Compact to at least 85 percent Standard Proctor density as defined in ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort, (12 400 ft-lb./ft^3 (600 KN-m/m))." Under streets and roads, increase compaction to 95 percent Standard Proctor density.

5.3.1.1.5 Trench Backfill

The final backfill may consist of the excavated material, provided it is free from unsuitable matter such as large lumps of clay, organic material, boulders or stones larger than 8 inches, or construction debris. Where the pipe is located beneath a road, place the final backfill in lifts as mentioned earlier and compact to 95 percent Standard Proctor Density.

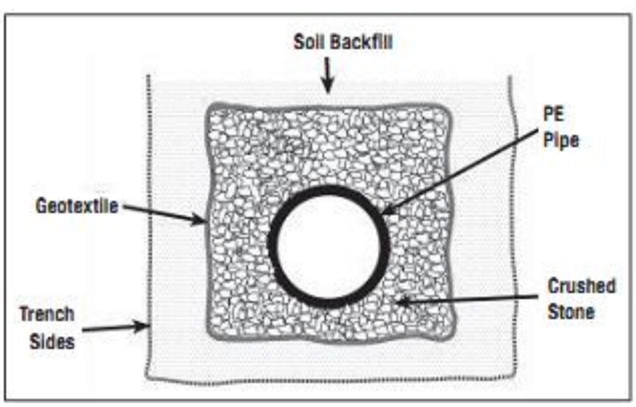


Figure 3: Installed underground pipe

5.3.2 Surface installation Guideline.

These types of installations may be warranted by any one of several factors.

i. One is the economic considerations of a temporary piping system.
ii. Another is the ease of inspection and maintenance
iii. Thirdly is simply that prevailing local conditions and even the nature of the application itself may require that the pipe be installed above ground.

PE pipe provides unique joint integrity, toughness, flexibility, and low weight. These factors combine to make its use practical for many "above-ground" applications. This resilient material has been used for temporary water lines, various types of bypass lines, dredge lines,

This chapter presents design criteria and prevailing engineering methods that are used for above-ground installation of PE pipe. The effects of temperature extremes, chemical exposure, ultraviolet radiation, and mechanical impact are discussed in detail. Engineering design methodology for both "on-grade" and suspended or cradled PE pipe installations are presented and illustrated. (Refer ***to plates 18 &19)***

Design criteria

Conditions and effects can influence the behavior and thus design of pipes above the ground includes:

1. Temperature – there is exposure to a range of temperatures during day and night as well as during different seasons which greatly influence expansion and contractions of different magnitudes
2. Chemical exposure – pipes should not be susceptible to rust, rot, corrode or be subjected to galvanic corrosion. Exposure to strong oxidizing agents chemically attack pipes, both metal and plastic compromising their performance properties.
3. Ultraviolet radiation – due to exposure to the sun, UV rays can produce deleterious effects on plastic pipe materials and so clear consideration must be done first.
4. Potential mechanical impact or loading e.g. passing vehicles or people that would deform and finally destroy the pipe with time.

5. Internal pressure – there are no support materials on the pipe surface on the surface and so it must be clearly designed to withstand the pressure.

The expansion or contraction for an unrestrained PE pipe can be calculated using the following equation;

$\Delta L = \alpha\ (T_2 - T_1)\ L$

ΔL= theoretical change in length

$\Delta L > 0$ is expansion and $\Delta L < 0$ is contraction

α= Coefficient of linear expansion

T_1 = initial temperature

The pipes must therefore be free to move due to expansion and contraction. In many cases, support materials must be provided and the sag analyzed.

All these will help in increasing the design life of pipes and reducing water loses effectively especially through plastic pipes.

5.4 DISTRIBUTION PIPELINE SYSTEMS MAINTANANCE

5.4.1 Checking network performance

This is done through the regular inspection of valves and joints, getting consumer complaints and keeping a water quality record.

5.4.2 Mains rehabilitation and cleaning

Done to maintain pressure and prevent interruption to supply. Repairing of bursts and flushing of mains should be regularly done.

5.4.3 Pipe lining methods

Cement mortar and epoxy resin linings may be applied to internal surfaces of cast iron mains to improve the hydraulic capacity and reduce the discolorations caused by corrosion.

5.4.4 Pipe replacement

Old and corroded pipes and system parts should be replaced in a swift way to avoid interruption in supply.

CHAPTER SIX

CONCLUSION & RECCOMMENDATIONS

6.1 CONCLUSION

A. Tremendous development has occurred in the field of pipeline transmission of water in Kenya. A variety of plastic pipes have replaced the metallic pipes that have been used for ages to a great extent. The plastic pipes take up 90% of the total number of pipes used in Kenya in water transmission currently. The major concern of the water consumers in the country is to get clean and uncontaminated water which is safe for both human and animal use, besides the major application in irrigation. The main drive that has led to great adoption of the plastic pipes is their low cost. The pipes are very affordable and are also safe for transmission. These mainly include the UPVC, HDPE, PPR and the P.E (polyethylene pipes).

B. The GI pipes are greatly used in rocky grounds and in places where the pipeline has to cross other structures e.g. roads. The GI is on great use in Nairobi because most of the water projects are funded by the World Bank, which supplies the materials to the Nairobi water company. This however has no justification for use especially in the cotton soils. The cost of the iron pipes is also too high for the common Kenyan citizen.

C. The study has achieved its main objective of analyzing the different preferences of people to use different types of pipes and linking the percentage of use to the main factors that are attractive to people, e.g.

- Cost
- Convenience in handling
- Ease of installation
- Resistance to corrosion hence durability
- Hygiene and prevention of contamination
- Flexibility and adaptability in irrigation

D. The ease of use and application of the plastic pipes has however led to pipe abuse to a great extent that the scarce water resources available has ended up wasted. The main causes of wastage being the burst of pipes owing to the inappropriate installation and neglect of the design instructions. In the end the cheap pipes have caused great expenses with the water services providers losing up to 60 -70% of the amount of water that should be consumed and paid for. This renders the water transmission very inefficient and therefore strict measures must be taken to mitigate the loss.

E. The water available in the dams and in the aquifers could be sufficient to serve all Kenyans including those in the arid areas if efficient connections can be created and maintained. The solution is therefore in an effective pipeline system to convey water to vast areas.

6.2 RECOMMENDATIONS

1. Correct installation methods for pipes both on the surface and underground should be undertaken to increase their durability.
2. Strict adherence to the design specifications and engineering guidelines (being vigilant) during the construction of water transmission systems.
3. Frequent checks and maintenance of the pipeline system. This should include active leakage monitoring through various methods e.g. sounding and noise correlation.
4. Protection of plastic pipes from sharp objects and undue pressure loads on the surface which may cause pipe bursts.
5. Correct choice of pipes considering application, e.g. irrigation and internal house fittings.
6. The technical advice given must be followed to the latter in any project for it to be successful.
7. Differentiating ground and fresh water sources for supply since their mineral content differs and ground water mainly may contain a lot of ions that may cause quick corrosion to the metallic pipes.
8. Taking of personal responsibility to conserve water, e.g. closing of taps after fetching water and monitoring of storage tanks to avoid overflow whenever pumps are used to fill the raised tanks to allow for gravity flow.
9. Prompt repair of damaged lines to avoid continuous leakage hence water loss.

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APPENDICES

NAIROBI WATER
Improving Reliability

NAIROBI CITY WATER & SEWERAGE COMPANY LTD.
KAMPALA RD, P. O. Box 30656-00100, Nairobi, Kenya
Tel: +254 20 3988000
Email: info@nairobiwater.co.ke
www.nairobiwater.co.ke

ISO 9001 REGISTERED FIRM
KEBS

NCWSC/HR/TRG.15/Vol.2/2/GO/aw 6th march, 2015

Amon Wafula Wanyonyi,
University of Nairobi,
P. O. Box 30197-00100,
Nairobi, Kenya.

Dear Amon,

RE: DATA COLLECTION

Reference is made to your letter on the above subject.

I am glad to inform you that permission has been granted to you to collect data on Analysis of pipe transmission of water in Kenya generated subject to the following conditions:

- That the Nairobi City Water and Sewerage Company Limited shall not be held responsible for any injury/ Loss suffered due to your negligence during your research
- That you will not qualify for any salary /allowances during the research period
- That the data so collected/created will not be used to malign the name of the Company in any manner whatsoever
- That the research will be used for (and limited to) academic purposes only
- That your activities will not in any way interfere with routine operations of the Company
- That you will not take photographs of the Company's facilities without written authority from the Managing Director Nairobi City Water and Sewerage Company Ltd.
- That you will be required to submit a Copy of your report to the Managing Director (through this Office), on Completion of your research.

If these Conditions are acceptable to you, please report to **O & M Manager – Kampala**

By a copy of this letter, the above officer will accord you the necessary support.

Yours faithfully,

George Okech
For: Human Resource Manager

Improving Reliability...

METRO PLASTICS KENYA LIMITED

Price List

WEF: 01/06/2011

PPR PIPES AS PER KS ISO - 15874

SIZE	Price per 4 meters Length		Price per meter	
	PN 20	PN 16	PN 20	PN 16
20mm	350.00	260.00	87.50	65.00
25mm	550.00	400.00	137.50	100.00
32mm	900.00	650.00	225.00	162.50
40mm	1,380.00	1,100.00	345.00	275.00
50mm	2,100.00	1,650.00	525.00	412.50
63mm	3,400.00	2,500.00	850.00	625.00

55%

- ***All above prices are in Kenya Shillings & INCLUSIVE of VAT.***
- ***Prices are subject to change without prior notice.***

P. O. Box No. :- 78485-00507 NAIROBI
Address :- Viwandani, Nadume Close, Off Lunga Lunga Road, Industrial Area, Nairobi, KENYA
Telephone Nos. :- +254 020 551 097 / 8 / 9
Fax Nos. :- +254 020 552 892 / 551 088
Mobile Nos. :- +254 733 550 355 / 727 533 619

ORANGE WIRELESS HOTLINES :-
Telephone Nos. :- 020 216 7 315 / 6 / 7
Fax Nos. :- 020 216 7 318 / 9
Direct Sales Dept. Fax No. :- 020 267 9 264

E mail Ids. :- sales@metrogroup.co.ke
info@metrogroup.co.ke

1.

METRO PLASTICS KENYA LIMITED

Price List

WEF: 01/06/2011

PVC PRESSURE PIPES as per KS 06-149 Part: 3

SIZE (Imperial)	PN 6 Class : B	PN 10 Class : C	PN 12.5 Class : D	PN 16 Class : E
½" (21mm)	-	-	-	240.00
¾" (26mm)	-	-	225.00	330.00
1" (33mm)	-	310.00	360.00	460.00
1 ¼" (42mm)	360.00	470.00	610.00	730.00
1 ½" (48mm)	450.00	610.00	820.00	970.00
2" (60mm)	675.00	950.00	1,220.00	1,485.00
2 ½" (75mm)	1,040.00	1,530.00	1,900.00	2,370.00
3" (88mm)	1,490.00	2,100.00	2,660.00	3,240.00
4" (114mm)	2,600.00	3,500.00	4,440.00	5,330.00
6" (168mm)	5,220.00	7,450.00	9,700.00	11,650.00
9" (250mm)	8,300.00	11,700.00	15,000.00	18,000.00

Less Discount. 25%. 5%.

- **Above prices are in KENYA Shillings and inclusive of VAT per length of 6 meters**
- **Prices are subject to change without prior notice.**

P. O. Box No. :- 78485-00507 NAIROBI
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info@metrogroup.co.ke

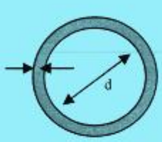
PRICE LIST NO: IL/126/2014
W.E.F: 13TH OCTOBER, 2014

BLACK AND GALVANISED STEEL PIPES (Threaded both sides and unsocketed)
AS PER KS 06-259 (BS 1387/85)
PRICE PER LENGTH OF 6 METERS IN K.SHS.
PRICE LIST - W.E.F 13TH OCTOBER, 2014

	BLACK		GALVANISED	
CLASS A (LIGHT)	**WEIGHT IN KG**	**NEW PRICE**	**WEIGHT IN KG**	**NEW PRICE**
1/2"	5.77	670	6.08	885
3/4"	8.52	964	8.92	1,256
1"	12.18	1,340	12.66	1,850
1 1/4"	15.66	1,760	16.20	2,283
1 1/2"	19.74	2,230	20.55	2,920
2"	25.08	2,800	26.31	3,840
2 1/2"	35.52	3,950	36.81	5,706
3"	41.88	4,350	43.17	6,691
4"	61.20	6,800	64.52	10,001
	BLACK		**GALVANISED**	
CLASS B (MEDIUM)	**WEIGHT IN KG**	**NEW PRICE**	**WEIGHT IN KG**	**NEW PRICE**
1/2"	7.38	900	7.71	1,130
3/4"	9.54	1,078	9.96	1,404
1"	14.76	1,600	15.23	2,200
1 1/4"	19.02	2,130	19.66	2,771
1 1/2"	21.90	2,530	22.73	3,203
2"	31.02	3,776	31.92	4,498
2 1/2"	39.78	4,838	41.10	6,371
3"	51.84	6,284	53.10	8,230
4"	74.40	8,300	77.93	12,079
5"	100.20	10,437	103.45	16,764
6"	118.80	12,828	122.45	19,843
8"	166.26	19,091	175.20	28,391
10" (4.50mm)	177.23	24,500	188.00	31,128
	BLACK		**GALVANISED**	
CLASS C (HEAVY)	**WEIGHT IN KG**	**NEW PRICE**	**WEIGHT IN KG**	**NEW PRICE**
1/2"	8.76	940	9.08	1,418
3/4"	11.46	1,436	11.82	1,846
1"	17.94	2,399	18.47	2,884
1 1/4"	23.22	2,490	23.81	3,719
1 1/2"	26.82	3,464	27.53	4,365
2"	37.44	4,661	38.22	6,059
2 1/2"	48.12	6,327	49.19	8,260
3"	61.80	6,450	62.51	10,496
4"	88.20	10,270	91.34	15,337
5"	109.80	10,852	113.21	20,074
6"	130.80	16,000	136.37	24,180
8"	190.92	27,000	199.20	35,321
10" (6.00mm)	234.90	34,000	243.00	43,658

ALL PRICES ARE SUBJECT TO V.A.T
PRICES ARE SUBJECT TO CHANGE WITHOUT PRIOR NOTICE

Special lengths can also be supplied to reduce wastage – Price on prorata



uPVC Pressure Pipe, KS ISO 1452-2: 2009

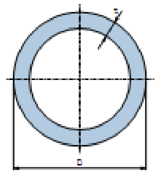
Size inch	PN 9	PN 12	PN 15
1/2'			193.00
3/4'			273.00
1'			399.00
1 1/4'		510.00	618.00
1 1/2'		662.00	810.00
2'	838.00	1,028.00	1,276.00

uPVC Pressure Pipe, KS ISO 1452-2:2009

SIZE. mm	PN 6	PN 8	PN 10	PN 12.5	PN 16	PN 20	PN 25
12mm						91.00	
16mm						126.00	
20mm					178.00	220.00	
25mm				225.00	280.00	333.00	
32mm		266.00	283.00	332.00	413.00	490.00	
40mm	335.00	357.00	421.00	524.00	645.00	780.00	
50mm	450.00	558.00	664.00	819.00	975.00	1,213.00	
63mm	709.00	879.00	1,046.00	1,307.00	1,592.00	1,927.00	
75mm	986.00	1,233.00	1,515.00	1,870.00	2,291.00	2,739.00	
90mm	1,439.00	1,785.00	2,173.00	2,693.00	3,290.00	3,954.00	
110mm	1,708.00	2,137.00	2,620.00	3,271.00	4,023.00	4,866.00	5,896.00
125mm	2,228.00	2,784.00	3,401.00	4,209.00	5,131.00	6,281.00	7,635.00
140mm	2,839.00	3,468.00	4,320.00	5,308.00	6,491.00	7,940.00	9,609.00
160mm	3,709.00	4,517.00	5,667.00	6,970.00	8,498.00	10,394.00	12,617.00
180mm	4,592.00	5,704.00	7,099.00	8,761.00	10,767.00	13,177.00	15,947.00
200mm	6,063.00	7,620.00	9,390.00	11,591.00	14,195.00	17,274.00	20,983.00
225mm	7,718.00	9,620.00	11,897.00	14,789.00	18,126.00	22,115.00	
250mm	9,663.00	11,927.00	14,753.00	18,113.00	22,253.00	27,242.00	
280mm	12,046.00	14,921.00	18,421.00	22,838.00	27,952.00	34,161.00	
315mm	15,127.00	18,932.00	23,430.00	28,767.00	35,421.00	43,277.00	
355mm	19,260.00	23,977.00	29,680.00	36,527.00	45,039.00		
400mm	24,446.00	30,485.00	37,627.00	46,508.00	57,013.00		

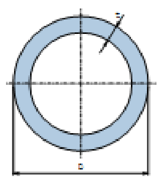
PPR PIPES

AQUAPIPE PP-R PIPE (PN 10)



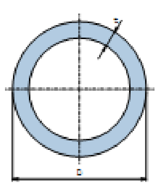
D(mm)	t(mm)	l(mm)	Kg/m	Price per 4m length
20	2,3	4000	0,128	-
25	2,3	4000	0,193	-
32	2,9	4000	0,260	-
40	3,7	4000	0,416	-
50	4,6	4000	0,630	-
63	5,8	4000	1,009	-
75	6,8	4000	1,405	-
90	8,2	4000	2,027	-
110	10,0	4000	3,026	-

AQUAPIPE PP-R PIPE (PN 16)



D(mm)	t(mm)	l(mm)	Kg/m	Price per 4m length
16	2,3	4000	0,099	-
20	2,8	4000	0,148	208.00
25	3,5	4000	0,230	338.00
32	4,4	4000	0,370	554.00
40	5,5	4000	0,568	831.00
50	6,9	4000	0,890	1,299.00
63	8,6	4000	1,405	2,044.00
75	10,3	4000	2,024	3,031.00
90	12,3	4000	2,836	4,330.00
110	15,1	4000	4,307	6,582.00

AQUAPIPE PP-R PIPE (PN 20)



D(mm)	t(mm)	l(mm)	Kg/m	Price per 4m length
16	2,7	4000	0,109	-
20	3,4	4000	0,172	247.00
25	4,2	4000	0,264	381.00
32	5,4	4000	0,427	606.00
40	6,7	4000	0,660	918.00
50	8,3	4000	1,024	1,455.00
63	10,5	4000	1,637	2,563.00
75	12,5	4000	2,339	3,724.00
90	15,0	4000	3,358	5,127.00
110	18,3	4000	4,931	8,140.00

HDPE PIPES (PE 80)

O/D (MM)	5.0 Kg / Sq.cm	6.0 Kg / Sq.cm	8.0 Kg / Sq.cm	10.0 Kg / Sq.cm	12.5 Kg / Sq.cm	16.0 Kg / Sq.cm	20.0 Kg / Sq.cm
16mm						24	27
20mm					31	35	44
25mm				40	45	57	65
32mm			52	61	75	88	104
40mm		70	78	95	115	137	163
50mm	87	104	121	147	179	214	255
63mm	137	165	193	235	285	341	402
75mm	173	213	263	322	384	464	552
90mm	251	305	379	463	556	669	792
110mm	368	460	566	684	829	996	1,188
160mm	790	972	1,185	1,450	1,760	2,110	2,510
180mm	990	1,220	1,500	1,840	2,225	2,265	3,170
200mm	1,230	1,515	1,855	2,260	2,750	3,300	4,000
225mm	1,550	1,920	2,350	2,870	3,475	4,175	5,000

HDPE PIPES (PE 100)

O/D (MM)	6.0 Kg / Sq.cm	8.0 Kg / Sq.cm	10.0 Kg / Sq.cm	12.5 Kg / Sq.cm	16 Kg / Sq.cm	20.0 Kg / Sq.cm	25.0 Kg / Sq.cm
16mm						25	28
20mm					33	37	46
25mm				42	47	60	68
32mm			58	64	79	92	110
40mm		74	88	100	121	144	172
50mm	94	110	136	155	189	225	269
63mm	146	174	218	248	300	359	423
75mm	180	221	273	334	398	481	573
90mm	260	317	392	479	576	693	821
110mm	382	477	586	709	859	1,032	1,231
160mm	820	1,010	1,230	1,505	1,825	2,185	2,600
180mm	1,030	1,270	1,560	1,910	2,310	2,765	3,285
200mm	1,275	1,570	1,930	2,340	2,850	3,420	4,065
225mm	1,600	2,000	2,440	3,000	3,600	4,325	5,140

HDPE DUCT (SILICONE LINED)

SILICORE®

O/D (MM)	5.0 Kg / Sq.cm	6.0 Kg / Sq.cm	8.0 Kg / Sq.cm	10.0 Kg / Sq.cm	12.5 Kg / Sq.cm	16.0 Kg / Sq.cm	20.0 Kg / Sq.cm
16mm						31	35
20mm					40	45	57
25mm				51	58	74	84
32mm			67	79	97	114	136
40mm		85	101	124	150	178	212
50mm	107	128	157	191	233	278	332
63mm	169	201	251	306	371	443	523
75mm	225	277	342	419	500	603	718
90mm	326	397	492	601	723	870	1,030
110mm	479	598	735	889	1,078	1,295	1,544
160mm	1,027	1,264	1,541	1,885	1,398	2,743	3,263

Class A - Light	Kgs/6mtr	Mombasa	Eldoret	Nairobi
½"	6.08	860.00	900.00	885.00
¾"	8.92	1,220.00	1,280.00	1,256.00
1"	12.66	1,800.00	1,890.00	1,850.00
1¼"	16.20	2,215.00	2,330.00	2,283.00
1½"	20.55	2,840.00	2,980.00	2,920.00
2"	26.31	3,730.00	3,920.00	3,840.00
2½"	36.81	5,560.00	5,820.00	5,706.00
3"	43.17	6,520.00	6,820.00	6,691.00
4"	64.52	9,740.00	10,195.00	10,001.00

Class B - Medium	Kgs/6mtr	Mombasa	Eldoret	Nairobi
½"	7.71	1,100.00	1,155.00	1,130.00
¾"	9.96	1,365.00	1,430.00	1,404.00
1"	15.23	2,140.00	2,245.00	2,200.00
1¼"	19.66	2,690.00	2,830.00	2,771.00
1½"	22.73	3,120.00	3,270.00	3,203.00
2"	31.92	4,370.00	4,595.00	4,498.00
2½"	41.10	6,205.00	6,495.00	6,371.00
3"	53.10	8,020.00	8,390.00	8,230.00
4"	77.93	11,770.00	12,310.00	12,079.00
5"	103.45	16,350.00	17,075.00	16,764.00
6"	122.45	19,350.00	20,210.00	19,843.00
8"	175.20	27,690.00	28,920.00	28,391.00

Class C - Heavy	Kgs/6mtr	Mombasa	Eldoret	Nairobi
½"	9.08	1,380.00	1,445.00	1,418.00
¾"	11.82	1,800.00	1,880.00	1,846.00
1"	18.47	2,810.00	2,940.00	2,884.00
1¼"	23.81	3,620.00	3,790.00	3,719.00
1½"	27.53	4,260.00	4,450.00	4,365.00
2"	38.22	5,910.00	6,175.00	6,059.00
2½"	49.19	8,060.00	8,410.00	8,260.00
3"	62.51	10,245.00	10,685.00	10,496.00
4"	91.34	14,970.00	15,610.00	15,337.00
5"	113.21	19,620.00	20,415.00	20,074.00
6"	136.37	23,630.00	24,590.00	24,180.00
8"	199.20	34,525.00	35,920.00	35,321.00

GENERAL INDUSTRIES LTD.
An ISO 9001:2008 Certified Company

GIL PRICE LIST

W.E.F 1ST MARCH 2013

PRESSURE PIPES (6MTS)

Size (MM)	PN6	PN8	PN 10	PN 12.5	PN 16	PN 20	PN 25
12mm	-	-	-	-	-	104.00	-
16mm	-	-	-	-	-	144.00	-
20mm	-	-	-	-	165.00	228.00	-
25mm	-	-	-	210.00	261.00	345.00	-
32mm	-	272.00	290.00	341.00	423.00	558.00	-
40mm	344.00	366.00	431.00	537.00	661.00	889.00	-
50mm	461.00	572.00	680.00	840.00	1,020.00	1,382.00	-
63mm	727.00	901.00	1,072.00	1,340.00	1,632.00	2,195.00	-
75mm	996.00	1,245.00	1,531.00	1,889.00	2,314.00	3,069.00	-
90mm	1,454.00	1,803.00	2,194.00	2,720.00	3,324.00	4,438.00	-
110mm	1,916.00	2,399.00	2,939.00	3,673.00	4,515.00	5,461.00	6,617.00
125mm	2,500.00	3,125.00	3,818.00	4,724.00	5,758.00	7,049.00	8,569.00
140mm	3,161.00	3,861.00	4,809.00	5,909.00	7,233.00	8,839.00	10,697.00
160mm	4,129.00	5,029.00	6,309.00	7,759.00	9,460.00	11,571.00	14,046.00
180mm	5,112.00	6,350.00	7,903.00	9,753.00	11,986.00	14,670.00	17,753.00
200mm	6,325.00	7,950.00	9,797.00	12,094.00	14,811.00	18,023.00	21,893.00
225mm	7,988.00	9,957.00	12,314.00	15,307.00	18,761.00	22,890.00	-
250mm	10,001.00	12,345.00	15,270.00	18,748.00	23,032.00	28,196.00	-
280mm	12,468.00	15,444.00	19,066.00	23,638.00	28,931.00	35,357.00	-
315mm	15,656.00	19,595.00	24,251.00	29,775.00	36,662.00	44,793.00	-
355mm	19,935.00	24,817.00	30,721.00	37,807.00	46,616.00	56,799.00	-
400mm	25,302.00	31,553.00	38,945.00	48,137.00	59,009.00	72,093.00	-

uPVC PRESSURE PIPES IMPERIAL SERIES

INCHES	PN9	PN12	PN 15
3/8	-	-	138.00
1/2	-	-	197.00
3/4	-	-	277.00
1	-	-	409.00
1 1/4	-	524.00	635.00
1 1/2	-	679.00	831.00
2	859.00	1,054.00	1,308.00
3	1,776.00	2,304.00	2,817.00
4	3,263.00	4,292.00	5,159.00
6	7,048.00	9,270.00	11,233.00
8	10,890.00	14,210.00	17,191.00
10	16,873.00	22,003.00	26,687.00
12	23,733.00	30,997.00	37,701.00

ABOVE PRICES ARE INCLUSIVE OF 16% VAT
TERMS: STRICTLY CASH
THIS PRICE LIST CANCELS ALL OTHER PREVIOUS PRICE LISTS

General Industries Limited
P.O. Box 41682, 00100 Nairobi, Kenya
Tel: +254 (20) 556112, 556390, 558536 • Fax: 558533
Email: info@gil.co.ke
Head Office - Lusaka Road, Industrial Area - Nairobi
Branch: Liwatoni Road (Previous Coastal Bottlers),
Ganjoni - Mombasa
Tel: +254 (02) 2326539, 0732 545000, 0717 545000
Fax: 2319913 • Email: infomsa@gil.co.ke
Website: www.gilkenya.com

General Industries Ltd | 1

PPR PIPES - 4 Mts

PN10 SIZE (MM)	Packing	Price/Pipe	PN16 SIZE (MM)	Packing	Price/Pipe	PN20 SIZE (MM)	Packing	Price/Pipe
20mm	40	205.00	20mm	40	240.00	20mm	40	285.00
25mm	30	264.00	25mm	30	390.00	25mm	30	440.00
32mm	20	400.00	32mm	20	640.00	32mm	20	700.00
40mm	15	624.00	40mm	15	960.00	40mm	15	1,060.00
50mm	10	1,000.00	50mm	10	1,500.00	50mm	10	1,680.00
63mm	5	1,620.00	63mm	5	2,360.00	63mm	5	2,960.00
75mm	1	2,700.00	75mm	1	3,500.00	75mm	1	4,300.00
90mm	1	3,520.00	90mm	1	5,000.00	90mm	1	5,920.00
110mm	1	5,300.00	110mm	1	7,600.00	110mm	1	9,400.00

HDPE PIPES - Mts

OD SIZE (MM)	CLASS 1 2.5kgs/sq.cm	CLASS 2 3.5kgs/sq.cm	CLASS 3 4.0kgs/sq.cm	CLASS 4 6.0kgs/sq.cm	CLASS 5 10.0kg/sq.cm	CLASS 6 16.0kgs/sq.cm
16mm	-	-	14.00	17.00	22.00	35.00
20mm (0.5")	-	12.00	15.00	22.00	29.00	36.00
25mm (0.75")	-	23.00	27.00	36.00	41.00	57.00
32mm (1")	-	30.00	35.00	48.00	67.00	93.00
40mm (1.25")	-	43.00	59.00	68.00	102.00	144.00
50mm (1.5")	-	66.00	75.00	104.00	158.00	220.00
63mm (2")	-	95.00	117.00	162.00	248.00	350.00
75mm (2.5")	113.00	135.00	158.00	225.00	349.00	497.00
90mm (3")	151.00	187.00	230.00	327.00	495.00	714.00
110mm (4")	225.00	281.00	345.00	486.00	732.00	1,062.00

THE ABOVE PRICES ARE EXCLUSIVE OF 16% VAT
PRICES ARE SUBJECT TO CHANGE WITHOUT PRIOR NOTICE
THIS PRICE LIST CANCELS ALL OTHER PREVIOUS PRICE LISTS

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