

Module 6

Drinking Water Distribution – Pipes

Summary

When developing a water safety plan, the important aspects of distributing drinking water must be considered. This module explains these aspects of water distribution and they are: the most commonly used types of pipes, advantages and disadvantages of different materials used for water supply networks and households, and the importance of adequately chosen materials and the complexity of the materials.

Objectives

The pupils can describe some types of pipes used for drinking water supply networks. They know the advantages and disadvantages of the most common used materials and learn how to identify lead, copper and iron pipes.

Key words and terms

Metal pipes, cast iron, galvanised iron, copper, lead, plastic pipes, PVC and PE, asbestos cement, corrosion, freezing

Preparation/materials

Materials	Preparation
Questionnaires for water supplier and citizens	Copies of questionnaires (see module 19.)

Drinking water distribution – pipes

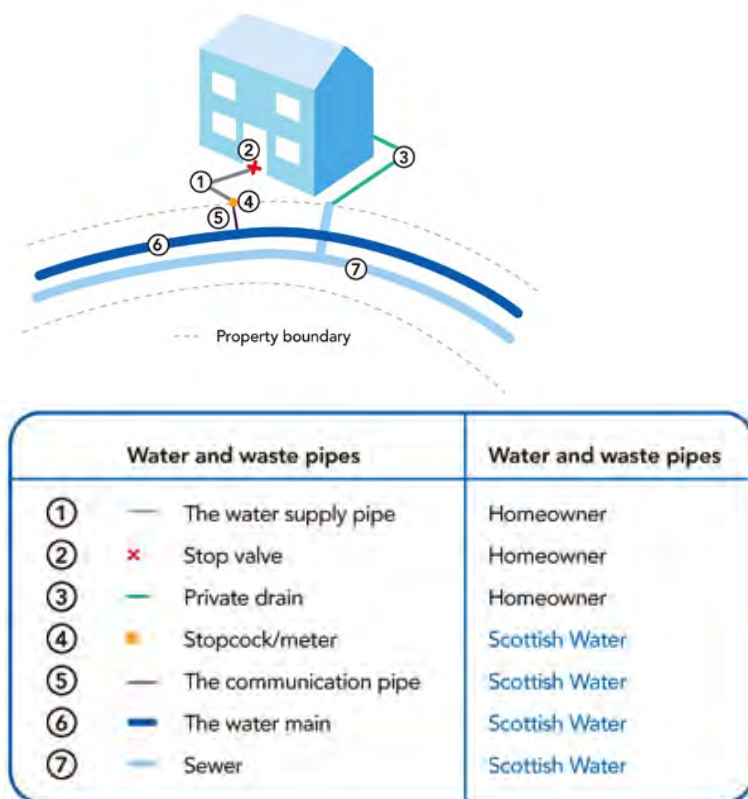
Introduction

Pipes used to distribute drinking water are made of plastic, concrete or metal (e.g. galvanised iron or copper). All of them have some advantages and disadvantages, yet the properties of each pipe material should fulfil some specified requirements.

Many water quality factors, including the chemistry and characteristics of the water (e.g. pH, salts that are dissolved in the water), lead to the corrosion of pipes used in water distribution. The corrosiveness of water is principally controlled by monitoring and adjusting the pH through the concentrations of calcium or phosphates in the water. The water supplier should address these factors and eventually treat the water, which will lead to reduced corrosion (see also module 5 and 7). Also, appropriate materials for the distribution of drinking water need to be selected.

Pipes for drinking water distribution should be suitable for the transport of water. In many countries norms have been established on the minimal required quality of the pipes. When in contact with water or soil, the material should be resistant (corrosion-proof) to possible chemical reactions and the material should not allow toxic substances to be released into the water. Furthermore, the pipes have to be resistant against a specified internal and external pressure.

In most countries, the water supplier has the responsibility for the network and water quality that ends at the water meter of the households. Within the house, the owner or customer carries the responsibility for his/her pipes and other water or treatment tools. The diagram and table below show an example from Scotland, which is replicable for many countries.



Graphic 1: Water supply

Source: www.Scottishwatersupply.co.uk

1. The most common materials used for transporting drinking water

1.1. Metal pipes

Cast iron and ductile cast iron pipes

The use of cast iron pipes has a long tradition. In the 19th and 20th century, they found wide spread use as pressure pipes for the transport of water and gas or as sewage and drainage pipes. Currently, there is nearly no new manufacturing of cast iron pipes. Cast iron is relatively inexpensive but, nowadays, higher quality materials for water networks are available. For example ductile iron, also known as ductile cast iron, spheroidal graphite iron is much more flexible and elastic, due to its nodular graphite inclusion.

For the production of cast iron or ductile iron pipes, minerals and other metals are added to the so-called *pig iron*. Pig iron is an intermediate product of smelting iron ore. The dosage of quantities added depends on the wished properties of the final product. For long-lasting service, corrosion protection of the iron is needed. Often Ductile pipes are somewhat resistant to internal corrosion and very often the surface is covered with Polyurethane (PUR), bitumen or cement mortar.

Galvanised iron pipes

One of the popular materials for transporting water is galvanised iron. Iron has been, and still remains, one of the most popular metals used in large scale construction. Though due to the instability of the material, iron pipes have to be coated in order to reduce its weak corrosive persistence. By galvanising (zinc-coating) the pipes, the quality increases. Zinc-coating contains a mixture of several metals, in which zinc is the main component. In many countries, special requirements for the composition of the metals are established. Galvanised pipes are sensitive to corrosion, such as cast-iron pipes. Therefore, water that comes in contact with galvanised pipes should have non-corrosive properties, and have certain hardness and pH. If drinking water is disinfected with free chlorine, an increase in corrosion of the iron materials can be expected. Elevating the pH of water counteracts the corrosive effect of chlorinated water on iron.

Iron pipes that are in contact with soil are mostly lined with cement (cement-lining). A minimal amount of welding seams increases the stability of pipes. Galvanised iron pipes are rather cheap and easy to handle, but have a relatively short live time.



The purpose of the distribution within the house will influence the selection of the materials

Copper pipes

Experts favour copper pipes mainly because of their universality. They are suitable for plumbing systems and heating, as well as gas pipeline installations. A great advantage is that chlorinated water has no or a very low impact on copper pipes. Furthermore, copper has proven bactericidal properties, which hinder the development of bacteria inside the pipes. International experience from operating with such tubes shows that their flawless use in plumbing and heating systems lasts from 50 to 100 years. Of course, as with all other

products, copper pipes also have some limitations in terms of application. They do not tolerate very acidic or very alkaline water, and very soft or very hard water. Hence, the water supplier has to be aware of eventual corrosive properties of drinking water towards copper pipes. Brand new installed copper pipes lack the protection layer of limestone (calcium sediments) and release some copper into the drinking water. Depending on the hardness of the water, a layer of limestone develops in the pipes after some months, serving as protection.



Copper pipes are characterised by durability and reliability, but are relatively expensive.

Lead pipes

For many centuries and in many countries, lead pipes were the favourite material for water pipes within the distribution network and for installation within houses. After the early 1900's, the installation of lead pipes was increasingly substituted by other materials such as copper or galvanised iron, and after the sixties by plastic pipes. The frequency of the appearance of lead pipes within the water distribution systems varies from country to country. Lead pipes can be affected by corrosion and release lead into the drinking water. Besides the drinking water pipes, faucets or fittings of brass, or solder used to seal joins in plumbing, may also contain elements of lead.

Due to the high toxicity of lead, lead pipes are not used any more for the drinking water supply.

1.2. Plastic pipes

The raw material needed to make most plastics comes from petroleum and natural gas. Due to their relatively low costs, ease in manufacture, versatility, and imperviousness to water, plastics are used in an enormous and expanding range of products: from paper clips to pipes intended for transporting drinking water. Plastic has replaced many common materials such as cement and metals within drinking water networks.

Plastics are often preferred than metals due to a number of inherent advantages: plastic piping is lightweight and does not require an open flame for joining the flexibility of plastic can simplify the installation. Plastics are typically lower in cost and resist the corrosion and scaling that plague metals in some applications. However, indication of the mitigation of synthetic chemical contaminants from plastic pipe materials to water may exist. These contaminants likely occur at low "safe" levels, but are sufficient to generate odour and taste concerns in some cases. Another disadvantage of some types of plastic pipes is that they have lowered resistance to chlorinated water.

The most common types of plastics used in the drinking water distribution are presented in the following.

PE (Polyethylene) pipes

Depending on the product quality, there are high-density polyethylene (HDPE), medium density (MDPE) and low-density (LDPE) pipes. The level of density expresses the pressure that the pipes can sustain. For locations enduring high pressure or weights, like streets, HDPE pipes are used.



Plastic pipes and fittings are more and more widely used for indoor and outdoor water distribution systems

Performances of PE pipes of different manufacturers show different possible temperature ranges in terms of application and usually range between -20 and +90 °C. Tubes of the PE group are resistant to ultraviolet rays. PE pipes are widely used for water and sanitation systems. High-quality PE pipes have a long lifetime (50 years) and are easy to maintain. They have a high impact strength and show resistance to cracking, even at low temperatures. PE pipes are also stable in water and do not tend to corrode. Nevertheless, due to weak or improper connections, leakages in distribution networks with plastic pipes are not uncommon.

PVC (Polyvinyl chloride) pipes

PVC is the third most widely produced plastic after PE and PP (polypropylene). PVC is widely used in construction because it is cheap, durable and easily workable. This material accounts for 66% of the water distribution market in the USA. In sanitary sewer pipe applications, it accounts for 75%. PVC pipes belong to the cheapest types of pipes, but the material tends to get brittle in the long-term. The usage of PVC is controversial, particularly because of the harmful chemicals (e.g. Dioxins) which may be released in the environment during its production and final disposal (burning).



*Asbestos cement pipes have been used widely for drinking water distribution and there are many kilometres of them to be found all over the world.
Source photo: the Environmental consultancy;
<http://www.asbestosguru-oberta.com/A-CMyths&Facts.html>*

1.3. Asbestos-cement pipes

Asbestos cement is a mixture of cement and primarily *chrysolite*, or i.e. Portland cement and white asbestos. Asbestos cement pipes have been widely used for drinking water distribution and there are many kilometres of it to be found all over the world. According to the results of long-lasting monitoring, no concerns have appeared for the health of consumers receiving the drinking water from asbestos cement pipes. So far, no programmes have been established to replace asbestos cement pipes. However, staff working within the

asbestos industry and working with asbestos pipes are exposed to the inhalation of asbestos fibres. There is consistent evidence that the inhalation of asbestos fibres is hazardous to health (carcinogenic). Only a few countries still install asbestos cement pipes, primarily because of issues regarding handling and economics.

2. Common causes of damage to water pipes

Poor quality of materials and improper installation

Poor quality of pipe materials and improper installation will shorten the pipes lifetime and make them more prone to leaches and bursts. Poor pipe quality may facilitate the infiltration of chemicals into the drinking water and make pipes more sensible for corrosion. In many countries, the pipe quality conditions for distribution of drinking water include: the size of pipes, the composition, the properties and quality of the materials. The age of the water pipes, their state of maintenance and the quality of water influence their strength, durability and safety. The older the pipes become, the more brittle and more prone they are to fractures. Unsuitable or low-quality materials for plumbing or connecting the pipes can contaminate the drinking water with pollutants such as lead or make the water taste odd.

Installing drinking water pipes and/or connecting households to the network is not a task for laymen, but for professionals. Improperly installed pipes often result in the infiltration of contaminants or a break/leakage within the network.

Besides the quality and installation of the pipes, the arrangement of the network is also a key factor for safety. For example, the installation of valves within the distribution network is essential. Valves can isolate incidents of pipe breakages and contamination events and limit the risk of the surrounding network. Valves can also prohibit the backflow of water within the network.



*Graphic 2. A poor quality of the installed pipes will shorten the lifetime of the pipes and are more prone to leaches and bursts.
Source drawing: <http://alpharetta.olx.com>*

Corrosion

Depending on the properties, water can cause chemical reactions with metals and cement pipes, which is called corrosion. Pipes that are corroding release metals into the drinking water. There is also a risk that the pipe will start to leak or crack, increasing the risk of infiltration from microorganisms. Corrosion control is used to manage acidity, alkalinity and other water qualities that affect pipes and equipment used to transport water. Often, the so-called *Langelier Saturation Index* (LSI) is used for indicating the corrosive properties of water. The LSI ($LSI = \text{measured pH} - \text{pH}_s$) indicates if the water will precipitate, dissolve, or be in equilibrium with calcium carbonate. If the LSI is more than 0, the calcium will precipitate and produce a protecting layer on the interior of the pipes; if the LSI is less than 0, the water is considered corrosive. This corrosion control is a task for the water supplier. Besides the interior corrosion, exterior corrosion of the pipes can also happen, caused by the

reaction of soil and water. Therefore, a protection layer, of e.g. bitumen, is often applied on the exterior side of the network pipes.

Freezing

If the temperature falls below the freezing point, there is a risk of the pipes freezing. Because the volume of frozen water increases, frozen pipes will crack and then burst, spilling large amounts of water. In unheated spaces, the pipes should be emptied because the pipes cannot be protected against freezing temperatures. In outside areas with cold winters, water pipes have to be protected against freezing temperatures by burying the pipes deep enough into the ground. The depth of the pipes in the ground depends on the climate and can vary from up to 2 meters down in the ground.

Too much pressure

If the pipes or joints are not in good shape, or if the water pump does not function properly, high pressure could result within the water pipes, which could cause rupture and breakage of the pipes.

3. Practical issues

3.1. How to recognise plastic, lead, copper or iron pipes?

Plastic piping is found in newer homes and is distinctive in appearance. It can be blue, black, white, grey or colourless, and can often have glued or threaded joints. Scratching plastic piping will not create a significant mark. Tapping plastic piping will produce a hollow sound.

Copper piping is very common and can be identified due to its bronze/copper colour that resembles the appearance of a one-cent piece or penny. Joints are usually made with copper fittings and solder, or with brass or bronze fittings. When you scratch a copper pipe, a shiny copper coloured line will become visible. A green stain will be apparent where moisture or water has been in contact with the copper pipe.



Lead is usually dull grey or silver in colour

Lead piping is used in older homes, usually built before 1950 or 1970 (depending on the country). Lead is usually dull grey or silvery in colour, is relatively bendable and it can be scratched and scraped easily. A good way to identify lead piping is to scratch the surface with a coin or similar object; if it is lead, a grey or silver colour will appear.

Iron piping can be identified by its hardness, black paint, or rusty finish. Iron pipes are usually much more difficult to scratch than pipes made out of other material.



Ductile iron pipes

Source photo:

<http://images.mitrasites.com/ductile-iron-pipe.html>

3.2. Actions to reduce metal intake via drinking water

- Anytime the water in a particular faucet has not been used for six hours or longer, "flush" cold water pipes by letting the water run until it becomes as cold as it will get. The more time water remains in the pipes, the more lead or copper it may contain.
- The only way to be sure of the amount of lead or other metal in the household water is to have it tested by a competent laboratory. The water supplier may be able to offer information or assistance with testing. Testing is especially important for apartment dwellers, because flushing may not be effective in high-rise buildings with lead-soldered central piping.
- If cases of corrosion within the network or household installation occur frequently, the water supplier should be contacted. Drinking water should be treated at the plant to make it less corrosive.
- If lead pipes release lead into the drinking water, the best way to reduce the lead intake, via the drinking water, is an exchange of the pipes.

4. Exercises and Questions

- Name the 3 most common categories of pipe materials.
- Name examples for metal and plastic pipes, and discuss their advantages and disadvantages in using them.
- Give some examples for possible reasons of a damaged water pipe.
- Which property/ies of water support the material to turn corrosive?
- Distinguish between lead, copper, plastic and iron pipes by scratching their surfaces.
- How should you behave if there is suspicion of lead in the drinking water?

WSP related activities

- Investigate the type of pipes used within the public network with the support of the water supplier.
- How is the distribution network organised? (Are there several zones, branches, etc?)
- Is it possible to isolate sections of the network in case of repairs or failures?
- Does the provided water provoke corrosion?
- Is the quality of the provided water treated in order to avoid corrosion?
- Investigate the type of pipes used within the local households (observation, questionnaires, etc.).
- Carry out a survey on corrosion products within the households (questionnaires or interviews).
- Carry out a survey on leakages within the network supported by the water supplier, by your own observation and interviews among citizens.
- Discuss what should be done in case of doubts about the drinking water quality, and if and how water analyses on contamination by heavy metals could be organised.

5. Text sources and further reading

InspectAPedia, (2012). Galvanized Iron Water Supply Piping, & Galvanized Drain Piping. Available from http://www.inspectapedia.com/plumbing/Galvanized_Iron_Pipes.htm

United States Environment Protection Agency (EPA), (2012). Basic Information about Copper in Drinking Water. Available from <http://water.epa.gov/drink/contaminants/basicinformation/copper.cfm>

United States Environment Protection Agency (EPA), (2012). Lead in Drinking Water. Available from <http://water.epa.gov/drink/info/lead/index.cfm>

Hard Water (2012). Available from http://en.wikipedia.org/wiki/Hard_water