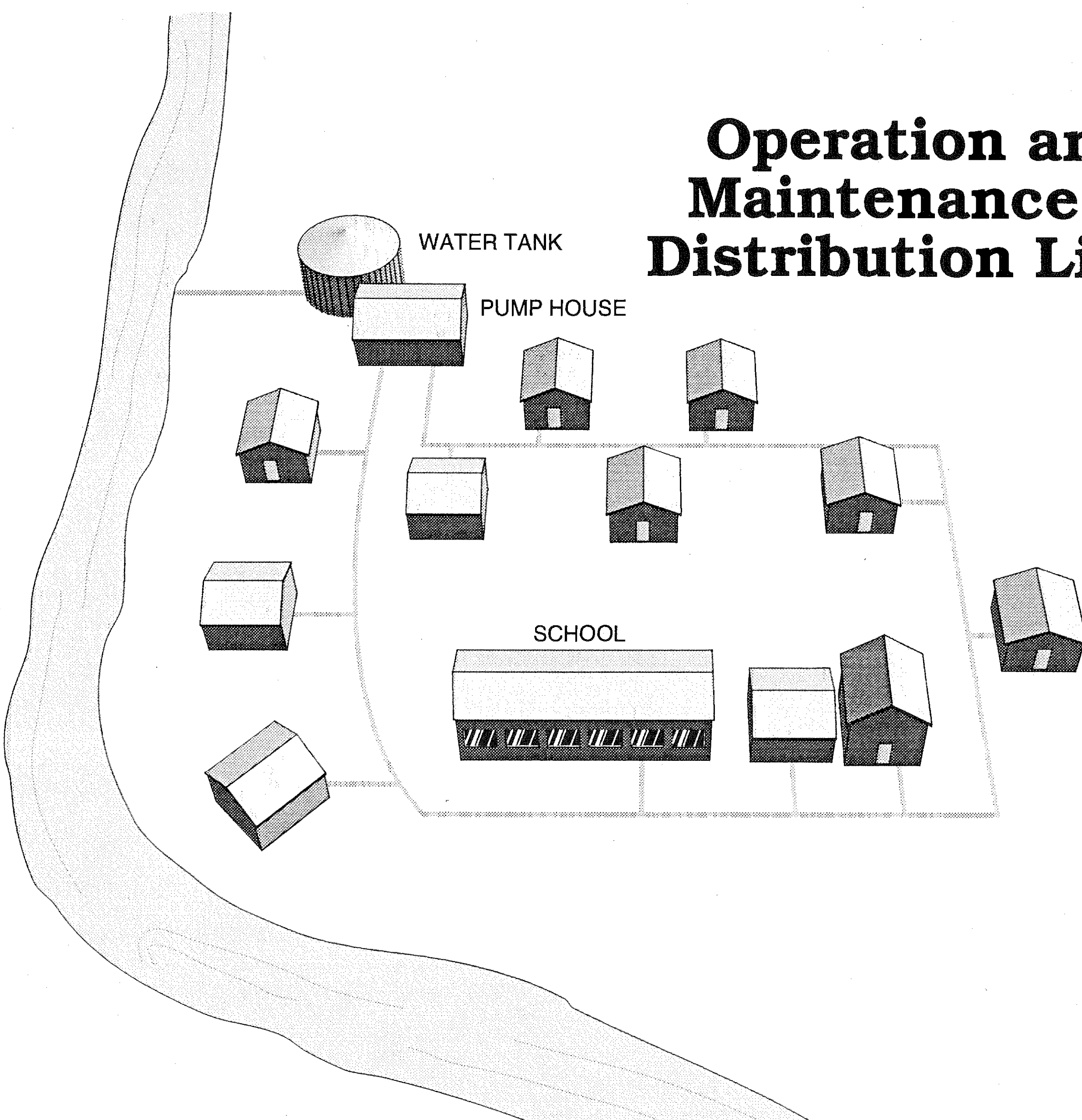
O & M of Small Water Systems



Operation and Maintenance of Distribution Lines

Alaska Department of Environmental Conservation
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O & M of Small Water Systems

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TABLE OF CONTENTS

O & M of Distribution Lines

O & M OF DISTRIBUTION LINES

WHAT IS IN THIS MODULE?

1. The main functions of a water distribution system.
2. The routine monitoring process and requirements of a water distribution system.
3. How to maintain the water quality in a water distribution system.
4. A process for systematic flushing of a water distribution system.
5. Routine water line inspection procedures.
6. Typical leak detection process.
7. Common line repair fittings.
8. Typical line repair procedures.
9. Typical methods of thawing frozen mains.
10. Typical methods of protecting lines from freezing.

KEY WORDS

- As-built drawings
- Chlorine residual
- DCIP
- Dresser type coupling
- HDPE
- Iron bacteria
- Organics
- PVC
- Repair band
- Unaccounted for water
- Utilidor
- Velocity

MATH CONCEPTS DISCUSSED

- Dilutions
- Velocity
- Detention time

SCIENCE CONCEPTS DISCUSSED

- Corrosion
- Turbulence in pipes
- Watts Law
- Anaerobic bacteria
- Facultative bacteria

SAFETY CONSIDERATIONS

- Mixing sodium hypochlorite
- Confined spaces
- Cave-in protection
- High current

MECHANICAL EQUIPMENT DISCUSSED

- HDPE
- PVC
- DCIP
- Fire Hydrants

- Valves
- Flow Diverter
- Haul truck
- Full circle repair band
- Cast iron coupling
- Pressure gauge
- Utilidor
- Watering point
- Dresser coupling

O & M OF DISTRIBUTION LINES

INTRODUCTION

Lesson Content

This module on the O & M of distribution systems is focused on the operation and maintenance of piped water systems found in public water systems providing services to Alaskan rural communities of populations less than 500. Generally the module provides information on distribution water quality monitoring, normal operating procedures, line flushing and main line repairs.

Not in the Lesson

Details of the operation and maintenance of fire hydrants, valves, storage reservoirs and household service connections are not in this module. O & M of this equipment can be found in other modules.

Class B & C Systems

The distribution system in many Class B and C systems is composed of the internal building plumbing system. Because this system must be installed to meet plumbing codes and not water works industry standards it is not discussed in this module.

Cost Factors

In most communities the water distribution system is their largest single capital investment. In order to preserve this investment careful attention should be paid to the proper operation and maintenance of the system.

Primary Function

The basic function of a water distribution system is to transport the water from the treatment facility to the customer. In addition distribution systems may also provide fire protection.

System Criteria

In order to provide this basic function in a proper manner, criteria have been established for distribution systems. Basically, distribution systems should provide adequate and reliable water to the customer.

Adequate

Adequate means providing all the water the customer needs, and at a pressure of not less than 20 psi. Adequate also means that the water that is provided meets the customers needs for quality.

Reliable

Reliable means that the customer can expect to obtain all the water they need anytime they need it. In other words, they can expect that there will be water at the tap.

Maintain Quality

As part of being adequate and reliable the system must be operated in a way so that the quality of the water does not deteriorate between the treatment facility and the customer.

Fire Reserve

In some communities, there is an expectation by the customer that adequate reserves are present for fire protection. If there are fire hydrants on the system the customer has every right to make this assumption, and the purveyor has the responsibility to fulfill this expectation.

TYPES OF SYSTEMS

Piped

The most traditional water distribution system is the piped system. There are two types of piped systems, the conventional system and the completely looped circulating system. The circulating system is common in the Arctic. The classic piped system includes main lines, valves, fire hydrants, reservoirs, services connections and pressure reducing stations.

Watering Point

In many villages in Alaska and Canada watering points substitute for a normal distribution system. These are systems with one or more specific points in the village where the customer can obtain water. This is the modern version of the community well. In some villages there is a combination of a circulating system and watering points. The watering points are used by those customers who have homes away from the piped system.

Haul System

The third type of system found in Alaska and Canada is the haul system. With the haul system, water is delivered using a truck and tank or a snow machine and tank. The water is delivered on order in much the same manner as fuel oil in the lower 48. The following is a description of the materials and equipment found in these three systems.

MONITORING THE SYSTEM

MAPPING

Types of Maps

The type of mapping system available to the operator is dependent on who designed the distribution system and the age of the system. Maps may vary from non-existent to details showing a horizontal (plan) and vertical (profile) view of the system, as provided by most engineering firms, PHS and VSW.

Blueprint or Map?

Maps are the common term used by operators while blueprint is a term commonly used by engineers and contractors. They are in fact the same item.

Aerial Photos

It is normal, as a part of a construction project for the design team to provide an aerial map of the community. The street boundaries and utilities are sketched directly on the aerial map. This type of map is often much easier to read than the standard blueprints, because the land forms and buildings appear familiar.

Function of Maps

The original blueprints were drawn as communication tools used by the design engineers to communicate with the construction crews. They gave specific guidelines that allow the construction crews to install pipelines and related material so that they meet with the engineers' specifications. The **as-built**[1] prints are used by the operator to locate pipelines and related components.

What As-builts Should Have

Each as-built print of a water distribution system should indicate:

- Line location
- Line material type
- Date of installation
- Fire hydrant locations
- Customer service connection locations
- Valve locations

Operating Maps

The operator uses the as-built drawings to develop operating maps that show:

- Bacteriological sample sites
- **Chlorine residual**[2] sample sites
- System pressure reading points

[1] **As-Built** - Drawings or blueprints that represent the conditions at the conclusion of construction rather than the proposed conditions at the start of construction.
[2] **Chlorine Residual** - The amount of chlorine left in solution after a period of time. For instance with new water lines, the reaction time is 24 hours. The residual is usually expressed in mg/L.

READING BLUEPRINTS

The short section of this module is offered as a guide to reading standard plan and profile drawings as provided by VSW, PHS and some engineering firms.

DEFINITIONS

In order to understand this discussion on blueprints, is it necessary to start with a review of the definitions of the words in the glossary.

Bench Mark

A bench mark is a vertical reference point. While it is commonly thought of as a brass cap in a concrete monument that defines an elevation, it can be as simple as a nail in a tree, an "X" on a curb or a point on a stake. Fundamentally it is a reference point used to establish position elevations. It may or may not be associated with sea level.

Plan

The plan is a drawing or blueprint that shows a horizontal view (looking down) on the ground. The plan view treats the ground as flat. It does not show any changes in elevation.

Profile

The profile view is the vertical view of the construction area. It is a cross section through the earth. With construction blueprints profiles are placed below the plan view and on the same page. (See page 56)

Grade

This term is used with two different, but related meanings. One defines grade as the established elevation of the ground or road surface. The other defines grade as the slope of the ground or the bottom of a trench. To be "on grade" commonly means that the bottom of a trench is at the correct depth and slope.

Traverse

A traverse is nothing more than a line on the ground. It is commonly established by a survey team. In pipe laying, a traverse is either run down the center of the pipeline or offset from the center of the pipe by 5 to 10 feet. (This is not a random offset. It is either 5 or 10 feet.) The traverse is established by driving stakes in the ground or nails in the asphalt. These stakes and nails are called hubs.

Station

This is the location of an item on the blueprint. The station is typically the distance from the beginning of the project. This location is painted either on the stake or on the pavement.

Scale

This the size relationship between the map and the ground. A typical scale for a plan is 1"=100' (one inch equals 100 feet). This means that one inch on the blue print is equal in distance to 100 feet on the ground.

Elevation

While this is often confused with grade, it is different. Elevation has two meanings. First, it is the distance above or below sea level. Secondly, it is the vertical distance above or below a bench mark.

North Arrow

Each blue print should have a north arrow to allow you to reference the direction of the project. This "north" is a general north, and does not indicate either magnetic north or true north.

With this background you are now ready to proceed to the blue prints.

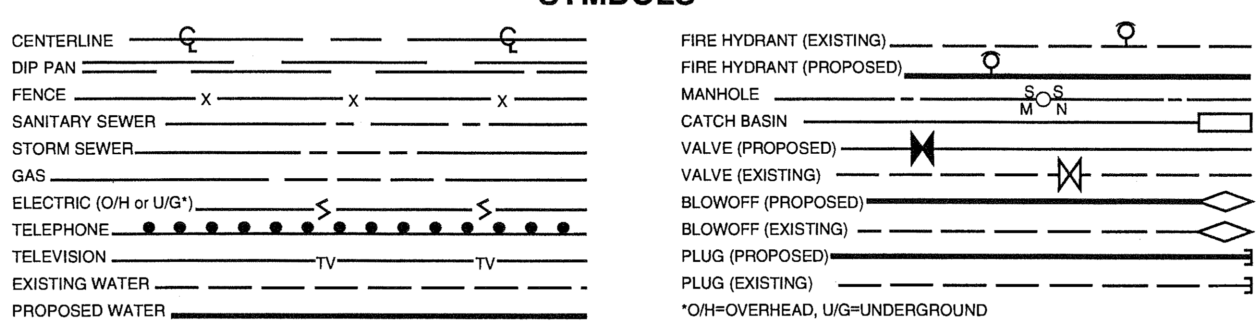
Abbreviations & Standard Symbols

One of the major keys to reading blueprints and maps is understanding and using the key or legend for abbreviations and symbols. There is no standard set of abbreviations and symbols, therefore we offer the following as an example of these items.

ABBREVIATIONS

A	Anode		
ACT	Actual	INV	Invert
BFV	Butterfly Valve	MJ	Mechanical Joint
BOP	Bottom of Pipe	N,S,E,W	North, South, East, West
BOV	Blowoff and valve	PH	Pothole
CB	Catch Basin	PL	Property line
CMP	Corrugated metal pipe	PP	Power pole
CR	Curb return	PSI	Pounds per square inch
CRA	Concrete reverse anchor	PUPS	Short lengths of pipe
CTRB	Concrete thrust reaction block	PVC	Polyvinyl chloride pipe
D.C. (38)	Style 38 Dresser Coupling	RCP	Reinforced concrete pipe
D.C. (39)	Style 39 Dresser Coupling	RED	Reducer
DEFL.	Deflect	SJ	Slip joint
D.I.P.	Ductile Iron Pipe	SS	Sanitary Sewer
EL.	Elevation	STA	Station
FLG.	Flange	STS	Storm sewer
GR. BK. (OR V.P.I.)	V.P.I. Grade Break	TOP	Top of pipe
HYD. ASSY.	Fire Hydrant assembly	TS	Test station
		WL	Water Line

SYMBOLS



READING A BLUEPRINT

The following discussion is based on the drawing found on page 9. This is a standard plan and profile drawing for a six inch ductile cast iron line in Klukwan.

Page Layout

Looking at page 9, you can see that the top half of the page is the plan view and the bottom half of the page is the profile view.

Scale

When looking at a plan and profile the first things to look for are the scale and the north arrow. The scale on the plan and profile is next to the north arrow. Typical scales are 1 inch equals 50 feet and 1 inch equals 100 feet. On page 9 the scale is 1" = 50' for the horizontal. The vertical scale is used only on the profile and will be discussed later.

Location of Profile

The profile is typically below the plan, with the horizontal scale being the same for both drawings.

Scale

However, the vertical scale (depth) is different on the profile. The typical scale for depth is 1 inch equals 5 feet. This exaggerates the vertical scale significantly and gives an untrue perspective of the slope of the line. This is done for the ease of reading the profile. If the profile were the same scale as the plan, the slope would be so flat that it would be nearly impossible to identify what it was. The scale is located below the north arrow on the right side of the drawing.

North Arrow

The north arrow could be located anywhere on the drawing but is typically along the right hand side. It is important as you move from drawing to drawing to keep track of the north arrow in order to maintain reference.

Plan & Profile

With the VSW maps the majority of the information is provided on the profile map.

Station Numbers

Station numbers are read as follows: a station of 1+66.32 is read as 166.32 feet. — Notice we drop the + out of the station and read the remaining figure as feet and tenths and hundreds of feet.

Fittings identified by Station #

The locations of all valves and other fittings are identified by station numbers.

Symbols

Use the legend of symbols and station number to identify the following items:

Tie to New Hydrant

Station 4+ 05

Line Lengths

The length of line is written under or along side of the line on the profile portion of the drawing. In our example this line is 1500LF, meaning 1,500 lineal feet.

Depth

The depth of the trench is also indicated alongside of the pipeline. In our example the trench depth is 7 feet. This is indicated as 7' BURY.

Service Connections

The service connections are only shown on the plan view. Notice that each service is measured from the curb stop to the corners of the building. For instance a services that is close to station 7+97 has two measurements, 15.5 feet and 8.5 feet.

Match Line

MATCH LINES are reference markings between drawings. If you were to remove the next page and attach it to the one you are working on, they would line up at the match line. A match line to sheet two is shown at station 15+00.

OPERATING MAP

Functions

As mentioned above the operating map is used to show sampling points and system pressures.

Sampling Bac-T

The map on page 11 is for Sand Point, Alaska, a community of 1000. This community is required to take two bacteriological samples each month. Bacteriological sampling points have been established at the hydropneumatic pumping stations, lot 4 of block 9, lot 4 of block 12 and lot 13 of block 12. These sampling points are on lines built at different times and are under different pressures. The four points should give a good representation of the quality of water in the system.

Sampling Frequency

Each month a sample will be collected from two of these points. For instance, in January sample points 1 & 3 could be sampled. In February sample points 2 and 4 would be sampled. In March the sampling would return to points 1 & 3.

Sampling Chlorine

Three chlorine residual sampling points have been established, lot 14 of block 13, lot 4 of block 10 and lot 1 of block 1. Each of these points should be checked daily. An alternate site would be the hydropneumatic pump station. This could be substituted for the sit at lot 4 of block 10.

MONITORING PRESSURE

Normal

The pressure in the distribution system should not drop below 20 psi at any time and it is desirable that it not rise above 100 psi. To assure that the system pressure is maintained between these levels the system pressure should be monitored daily.

Determining System Pressures

By observing the pressure at the highest and lowest elevation points in the system and then comparing the pressure to the plant pressure, it is possible to determine the pressure at these points by observing the pressure at the plant.

Read and Record

The system pressure should be read at the high demand time of the day and recorded each day.

Example:

The pressure at the plant is 65 psi. The pressure at the highest elevation in the community is 45 psi. The pressure at the lowest point is 80 psi.

Subtracting the low pressure from the lowest desirable pressure, we obtain;

45 psi - 20 psi = 25 psi

Subtracting this pressure from the plant pressure we obtain:

65 psi - 25 psi = 40 psi

When the pressure at the plant is 40 psi the pressure at the highest elevation could be assumed to be 20 psi.

Subtract the pressure at the highest point from the maximum desirable pressure, we obtain;

100 psi - 80 psi = 20 psi

Adding this to the plant pressure we obtain;

65 psi + 20 psi = 85 psi

When the pressure at the plant is 85 psi the pressure at the lowest elevation will be 100 psi.

QUALITY MONITORING

Introduction

Monitoring for water quality requires tracking customer complaints about odor and taste, dirty water and low pressure, sampling for coliform bacteria, testing for chlorine residuals, testing for corrosion (lead and copper), and preventing the deterioration of water quality.

TASTE & ODOR

Types of T & O

Taste and odor complaints should be separated as to chlorine related and other. If possible, each taste and odor complaint should be investigated, and the results noted in writing. One method of identifying patterns of taste and odor problems is to make the complaints on

a map of the community using colored stick pins. The number of complaints and the follow-up action should be part of the monthly report to the council. The most common method of dealing with taste and odor problems that are not related to raw water quality is to flush the lines.

Taste & Odor and Chlorine

One of the most common taste and odor complaints is chlorine. As a result of these complaints most operators will reduce the chlorine residual to a minimum. This process often is the primary cause of chlorine related taste and odors. One of the major causes of chlorine related T & O is the reaction between chlorine and organic compounds. These reactions can take hours or days to complete. As a result, water that left the plant with no T & O becomes a problem in the distribution system, because as the reaction takes place taste and odors are produced. One of the best methods of resolving this is to increase the chlorine dosage rate. This process is described below under the title of chlorine residual.

BACTERIOLOGICAL MONITORING

Sample Frequency

The size of systems described in this module are all under 500 population and therefore are required to sample for coliform bacteria no more than once each month. Details on this process are described in the module on monitoring.

CHLORINE RESIDUAL MONITORING

Residual Levels

The current regulations (1993) require that a chlorine residual of at least 0.2 mg/L be present where the water enters the distribution system and that a measurable trace be present at all points in the system. As a practical manner, most operators prefer to have 0.2 mg/L free chlorine at all points in the system. This may require much higher residuals where the water leaves the plant, clearwell or storage tank. In large systems free chlorine residuals of 2.0 mg/L fee leaving the treatment plant are common.

Residual Deterioration

If the chlorine residual deteriorates rapidly after it leaves the plant, it is a good indication of organic slime growths (called biofouling) in the lines or the **organics**[3] in the raw water were not sufficiently removed or oxidized. One method of determining the cause of chlorine deterioration and thus reducing T & O complaints is described below.

CHLORINE T & O SOLUTION

Free & Total Residual

At the point where the water enters the distribution system and at least one point in the system, measure the free and total chlorine. If at either point the free is less than 85% of the total, odor and taste will also be a problem.

3 **Organic** - Chemical substances of animal or vegetable origin, made basically of carbon structure.

Example

The total chlorine residual entering the system is 0.4 mg/L and the free is 0.3 mg/L. Find what percent 0.3 is of 0.4. 0.3 mg/L ÷ 0.4 mg/L X 100 = 75%. This is too low. It is an indication that there are unoxidized organic compounds in the water.

Entering System

If free and total are nearly the same leaving the water treatment plant, then increase the chlorine dosage rate. Monitor the residuals. Usually there will be a slight elevation in residual and in a few hours it will drop. After the residual goes up check free and total chlorine residuals. If the difference between the free and total residuals increases, increase the dosage a second time. If this process does not resolve the problem, call VSW, PHS or your regional DEC office for assistance.

In System

If there is a difference between free and total chlorine residuals in the system but not leaving the plant then flush the system. Repeat the testing process after flushing. An increase in chlorine dosage may be necessary to reduce the rate of growth of the slime producing microorganisms.

Heated Water

Water that is heated, even to 45 °F or 55°F can rapidly increase the growth rate of slime producing microorganisms. During the months that the water is heated, higher chlorine residuals may be required.

LEAD & COPPER

EPA Regulations

At the time of the production of this material, the State of Alaska was not finished with its version of the lead and copper rule. Therefore, the material presented here is in compliance with the EPA regulations.

Problem With Lead

After several years of testing, it has been concluded that lead has no health benefit and is harmful in very low levels in the blood. Lead affects nearly every portion of the body in a negative way. With children it can cause brain damage, comas, convulsions and death. Other problems in children are a decrease in growth rates, loss of hearing and the inability to maintain a steady posture.

Problem With Copper

Copper on the other hand is needed for good health and beneficial at low levels. However, at elevated levels copper can cause nausea and diarrhea.

MCL Levels

Because of the severe problems associated with lead a MCL of 0.015 mg/L has been established with a goal of zero. Copper on the other hand, because it has some health benefits at low levels has an MCL of 1.3 mg/L.

Sources

If there is no lead or copper in the raw water supply, then where does it come from. The primary sources of lead and copper in water systems are the result of corrosion of the piping material in the distribution system and household. Copper pipe and lead from lead solder joints are the two primary sources of elevated copper and lead in rural Alaska water systems.

Blue Ring

One of the common customer complaints that would be an indicator of corrosive water with elevated levels of copper is the complaint about a blue or green ring around white bathroom fixtures. This ring is primarily copper.

Monitoring Requirements

This is the only drinking water regulation that requires that samples be collected from inside of a home. The EPA guidelines state that the first choice for sample sites are those of high risk. The only high risk sites from the list that match for rural Alaska are homes built using lead solder on the plumbing and built after 1982. If none of these exist in your community then select sites in the same way that other monitor sites are selected.

Number of Samples

For a community with a population of 101 to 500, 10 samples are to be collected and tested for lead and copper. For systems with a population of less than 100, 5 samples are to be collected and tested for lead and copper.

Frequency of Sampling

The first samples were to be collected and tested by July 31, 1993. After that, samples are to be collected every six months. This does not mean that all ten samples must be collected at once. One sample must be collected from each sample site once every six months. With ten sample sites, two samples could be collected every 18 days and meet the requirement.

Results - Below MCL

If after three years the levels of lead and copper levels of 90% of the samples are below the MCL, the testing frequency may be reduced to once every three years.

Results - Above MCL

If the results of any test set exceeds the MCL in 10% of the samples, the community may be required to install corrosion control techniques, treatment techniques and a public education program.

Sampling Method & Location

Sampling procedures and sample sizes should be selected in cooperation with the laboratory that will be testing the sample. The sample must be collected from a cold water tap in the kitchen or bathroom of a residence. The water must have been standing motionless for at least six hours before sampling. This is called a first draw sample. **Do not flush the line prior to sampling.**

Information Sources

Information is available on the lead copper program from the ADEC Regional office or:

AWWA	EPA, Alaska Operations Office
6666 West Quincy	410 Willoughby Ave, Suite100
Denver, CO 80235	Juneau, AK 99801
1-800-366-0107	(907) 586-7619

CORROSION & CORROSION CONTROL

INTRODUCTION

This portion of the module deals with the theoretical process of internal and external destruction of pipe and fittings by corrosion. The discussion includes the process of **electrochemical**[4] corrosion, stray electrical currents and bacterial corrosion. This section also provides information on the use of cement lining for internal protection and the use and installation of poly-encasement, sacrificial anodes and **cathodic protection**[5] for external protection.

CORROSION - BASIC THEORY

Associated With Water

Since there are numerous processes of corrosion, less frequently occurring corrosion such as disinfection and stress corrosion will not be discussed. This module concentrates on four processes that are commonly found in water systems. These include chemical corrosion, electrochemical corrosion, corrosion resulting from stray electrical currents and corrosion resulting from bacteria (primarily sulfur reducing bacteria). For the sake of discussion, we will refer to all of these as corrosion. The water works industry, while researching various causes, has at the same time looked primarily for solutions. The solutions are based on **empirical**[6] evidence and, as a result, the theory of the exact causes of corrosion takes a back seat.

CHEMICAL CORROSION

Pitting from Acids in the Soil

Chemical corrosion can cause localized pitting of the pipe as well as pitting of an entire section of pipe. There are many types of chemical corrosion, the most common being the corrosion caused by the acids in the water within the soil surrounding the pipe. These acids may be naturally occurring in the soil or may be the result of bacteriological action in the soil.

Aggressive Water

Another type of chemical corrosion is the result of the chemical instability of the water in the soil. Water that is chemically unstable is referred to as aggressive. For example, when water that is not saturated with iron is placed next to an iron pipe, the iron in the pipe is drawn into solution by the aggressive unstable water. This results in a deterioration of the surface of the iron pipe, commonly throughout the length of the pipe.

Low pH - High in Gas

In general, waters or soils that have a low pH, and/or are high in gases such as oxygen or carbon dioxide are

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[3] **Organic** - Chemical substances of animal or vegetable origin, made basically of carbon structure.
[4] **Electrochemical** - The result of an electrical and chemical reaction such as when a metal goes into solution as an ion or reacts in water with another element to form a compound resulting in a flow of electrons.
[5] **Cathodic protection** - Reduction or elimination of corrosion by making the metal a cathode by means of an impressed D. C. current and the attachment of a sacrificial anode.
[6] **Empirical** - Relying or based solely upon experiment and observation rather than theory.

considered aggressive and will contribute to chemical corrosion of the exterior of metal pipe.

ELECTROCHEMICAL CORROSION

Start with Chemical Reaction

This process of corrosion starts with a chemical reaction that leads to an electrical phenomenon that causes a deterioration of the metal material. Here is basically how the process works.

Dissimilar Metals

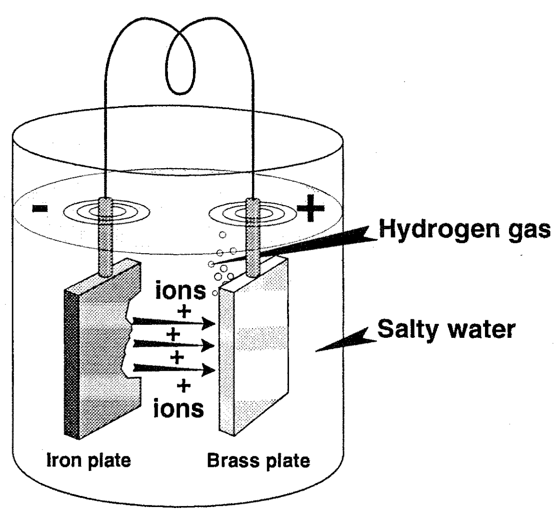
First you need two dissimilar metals. This could be a new pipe and an old pipe, (even if they are the same basic material, the coating on the old pipe has changed, thus it acts like a different piece of metal) or two different types of metal, such as bronze and steel, or steel and cast iron. Even subtle differences in a piece of metal can cause enough of a change to start the reaction. A common subtle difference would result from cutting threads on a pipe. The exposed threads have a different surface coating than the remainder of the pipe. Consequently there are two dissimilar metals.

Electrolyte Solution

Next we need an **electrolyte**[7] into which the two dissimilar metals are immersed. An electrolyte is any solution capable of allowing an electrical current to flow. The higher the concentration of dissolved salts in the solution the greater the ability to pass an electrical current through the solution.

A Battery

What we now have is a small battery. Looking at the diagram below, the two dissimilar metals we have chosen are brass and iron. The electrolyte is water with a small amount of salt added to improve the current flow. This device is called a **galvanic cell**[8] which is another name for a battery.



[7] **Electrolyte** - A solution of ions that will allow an electrical current to pass.
[8] **Galvanic cell** - A cell consisting of two dissimilar metals in contact with each other and with a common electrolyte.

The Galvanic Cell

Lets take a closer look at the galvanic cell and at the mechanics of the process.

Chemical Reaction

In this galvanic cell, a chemical reaction takes place between the electrolyte and the iron plate. This reaction causes some positively charged ions to leave the iron plate and enter the solution. This chemical reaction leaves the iron plate electrically negatively charged. The brass plate is now positive in its electrical relationship to the iron plate.

Electrical Imbalance

This electrical imbalance causes the electrons to flow from the iron plate through the wire to the brass plate. From the brass plate they will flow into the solution to combine with positive ions in solution. The iron plate is referred to as the **anode**[9] and the brass plate the **cathode**[10]. The anode is electrically negative and the cathode is electrically positive. It is the anode which will deteriorate.

Hydrogen Bubble Build-up

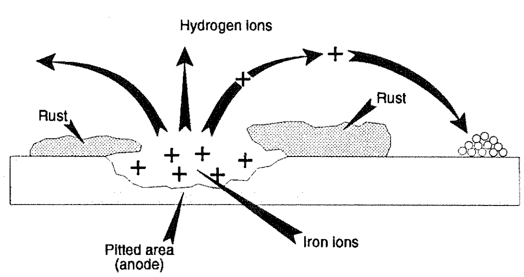
The electrical charge and the chemical reaction on the cathode will cause a buildup of hydrogen gas on the surface of the cathode. If this buildup is allowed to continue, the entire surface will be covered with gas bubbles. The bubbles will act as an insulator and stop the electrical reaction. This process is referred to as **polarization**[11].

Relationship to a Pipe

So much for the galvanic cell. What about the reaction in a single section of pipe? Well, the reaction is very much the same. Although, a piece of DCI pipe is made uniformly, there are always imbalances in the coating thickness and exact chemical makeup. Corrosion will result at any point where an imbalance occurs or where a chemical reaction can take place that allows positive ions to leave the pipe. The reaction is the same as in the galvanic cell. The ions enter solution leaving a negative charged point.

Formation of Rust

Where the ions leave the pipe they can combine with hydrogen or oxygen to form deposits of iron hydroxide and oxide rust at the anode area. Under some circumstances these deposits can actually seal the area and stop corrosion.



[9] **Anode** - The negative pole of a galvanic cell. The point at which destruction occurs.
[10] **Cathode** - The positive pole of a galvanic cell. The point at which deposits occur.
[11] **Polarization** - The shift in electrode potential resulting from the effects of current flow.

Natural Dissimilar Metals

An imbalance that gives us two dissimilar metals can be two metals of the same type with different coatings or the same piece of metal with the coating thinner at one point or two actual dissimilar metals.

CORROSION FROM STRAY ELECTRICAL CURRENT

Stray Electrical Current

The presence of stray electrical current, especially direct current, will cause a destruction of metal material that is very similar to the electrochemical corrosion. In this instance the stray electrical current enters the pipe at some point and travels along the pipe to an exit point.

Destruction at Entry Point

At the electron entry point some of the positive ions from the pipe leave the pipe and combine with the electrons and then are carried away into solution, or into the ground, or form oxides that build up at the point of entry. In any case, the loss of ions from the pipe causes a destruction of the pipe at the point of electron entry.

BACTERIOLOGICAL CORROSION

Iron & Sulfur Bacteria

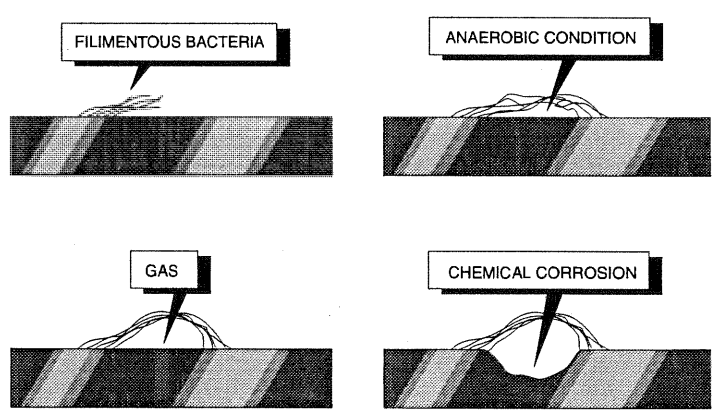
Both iron and sulfur reducing bacteria can cause corrosion internally and externally. However, the iron reducing bacteria appear to cause the greatest damage internally, while the sulfur reducing bacteria appear to cause the most damage externally.

Bacterial Growth

Iron reducing bacteria are **filamentous organisms**[12]. They will attach to the wall of a pipe and grow in both length and number. They obtain their energy from iron in the water and, to a small degree, from iron in the pipe. As they grow in length they will attach the free end of their filamentous sheath to the pipe, thus covering a small portion of the pipe.

Anaerobic Conditions

The sheaths will combine and form a hard surface made up of iron compounds. The surface will not allow air to pass, causing an anaerobic condition to form under the sheath next to the pipe. These condi-



[12] **Filamentous organism** - An organism that grows in a thread or filamentous form.

tions foster a low pH zone. At the same time, the bacteria produce various gases, one of which is Hydrogen Sulfide (SO_2).

Formation of Sulfuric Acid

The SO_2 combines with the water to form a weak concentration of Sulfuric Acid (H_2SO_4) which chemically deteriorates the pipe. In addition, the gas causes the filamentous sheath to be pushed away from the pipe forming a bubble. These bubbles are referred to as **tubercles**[13].

Sulfur Reducing Bacteria

Sulfur reducing bacteria work in a similar way. They live in anaerobic conditions and reduce sulfur that is found in the soil or water that surrounds a pipe. The result is hydrogen sulfide gas. This gas will then combine with water to form sulfuric acid, which is very corrosive to metallic pipe.

TYPES OF PROTECTION - A GENERAL DISCUSSION

Types of Protection

Metal pipe must be protected both internally and externally from the situations described above.

INTERNAL PROTECTION

Cement Mortar Lining

Ductile cast iron pipe is commonly protected internally by lining it with cement mortar. This prevents the attachment of bacteria to the cast iron. The bacteria are unable to attach because of the smoothness of the cement, and because the high pH of the cement is an unfavorable environment.

Flushing

Unlined pipe can be cleaned by frequent flushing and cleaning with a pig. Flushing is only effective if done frequently enough to prevent a large growth of the bacteria, and if the velocity is high enough to remove attached bacteria (usually 2.5 ft/sec). The use of a cleaning pig will clear the pipe of tubercles. Best results are obtained when this is a frequent practice, rather than to wait until the pipe line has deteriorated prior to cleaning.

EXTERNAL PROTECTION

Three Types

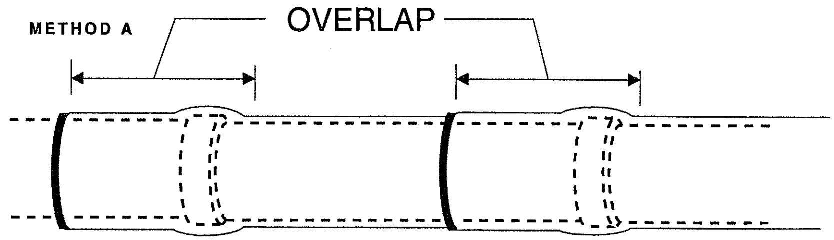
There are three external protection practices. They include encasement of the pipe in polyethylene bags, the installation of sacrificial magnesium anodes and the use of cathodic protection.

Polyethylene Encasement

The polyethylene encasement is by far the most common protection device. This works best when the corrosiveness of the soil is classed as low to medium. The bag that is placed over the pipe is neither air nor water tight. It serves as an insulator against stray electrical current, and it retards electrochemical corrosion by serving as a barrier between the soil and the pipe, thus chemical reactions are not allowed to get

13 **Tubercles** - Knob like mounds resulting from biological actions that cause localized corrosion.

started. Water that enters between the bag and the pipe will start an electrochemical reaction. However, this small amount of water is trapped and non-moving. The water's chemical balance is soon changed and the cathode on the pipe becomes polarized, thus stopping the corrosion.



Sacrificial Anodes

When the corrosion potential is above medium, the poly bag is assisted by the installation of sacrificial anodes of magnesium. Metals can be arranged in what is called a galvanic series. The series is a ranking of the direction of corrosion (when combining two dissimilar metals it allows you to determine which one will corrode). Magnesium is much more likely to corrode than iron. Thus when an anode of magnesium is attached to the iron it begins the corrosion process sending ions out into the soil through the magnesium. The magnesium anode corrodes, therefore protecting the pipe. Because it is designed to be destroyed, it is referred to as a sacrificial anode.

Continuity

The use of the anode is only effective if all of the lengths of pipe are connected together electrically. This is usually accomplished by welding a small strap from the pipe bell to the spigot at each joint.

Cathodic Protection

Cathodic protection uses a special anode with the addition of a low voltage direct current. This direct current, applied to the pipe, assures that the current flow will always be such that the anode is the device that is destroyed and not the pipe. Cathodic protection is primarily used in conditions of high corrosion risk.

MAINTAINING WATER QUALITY

CAUSES OF DETERIORATION

Introduction

There are many factors that contribute to the deterioration of water quality in a water distribution system. Common factors include, pH, water temperature, alkalinity, type of piping material and the level of microorganisms. (Chlorine does not kill all microorganisms.) Among the common causes of deterioration are:

Organic Growths

Organic growths on the walls of pipes can contribute to the deterioration of the pipe wall, produce organic compounds that when combined with chlorine produce odor and taste problems and can contribute to elevated levels of iron and manganese.

Low Spots

All water distribution systems have low spots in the main lines. Organic materials settle in these low spots. Bacteriological activity (consumption of the organics as food) in these low spots, increase the number of organisms and their by products. Some of the by-products, such as gases and oils cause odor and taste problems directly. Other by products such as hydrogen sulfide, when combined with water produce sulfuric acid with destroys metal pipe. Some by-products, when combined with chlorine cause odor and taste.

Groundwater Silts

Groundwater silts are primarily inorganic material. Silts from groundwater supplies, can contribute to elevated levels of iron and manganese. These same silts, can deteriorate the impellers of pumps, and the measuring chambers of water meters.

Surface Water Silts

Surface water silts are usually a combination of organic and inorganic material. The inorganic material primarily contributes to dirty water complaints and deterioration of pumps and water meters. The organic materials contribute to the growth of organic slimes and bacteria. These same silts can also contribute directly or indirectly to taste and odor problems.

Iron Bacteria

Iron bacteria[14] is a general name given to a number of bacteria that produce similar problems in water systems. Iron bacteria are generally aerobic, filamentous bacteria. They oxidize soluble iron and manganese. The precipitates that they produce accumulate in their sheaths and cell walls. When present in large numbers they produce slimes and tubercles large enough to reduce the carrying capacity of pipe lines, they increase chlorine demand and their sloughing can lead to customer complaints of red or black water. For information see the section on corrosion.

[14] **Iron Bacteria** - 1) Those bacteria capable of withdrawing iron present in their aqueous habitat and of depositing it in the form of ferric hydroxide on or in the mucilaginous sections. 2) Those chemoautotrophs which are capable of oxidizing iron as their sole energy source.

Chlorine O & T

The basic problems and suggested solutions to chlorine related odor and taste are discussed above. The health issue with chlorine related problems is the secondary health issue. When customers taste or smell chlorine, who are used to drinking water with no chlorine, they are offended and in some cases believe there is a health risk associated with the chlorine. As a result they seek water from sources which looks and smells good but may be contaminated with pathogenic organisms.

System Design

Some systems are designed so that it is difficult to maintain water quality. Systems with numerous dead ends, oversized pipe, no or few blow-offs all make it very difficult to maintain water quality.

PROBLEM SUMMARY

Taste & Odor

Deterioration of water quality in a distribution is not normally a direct health risk. As was mentioned earlier, taste and odor problems cause customers to seek sources of water that are not safe but taste and smell good.

Chlorine Residual

Increased growth of organic slimes, and accumulations of silts in low spots all reduce the chlorine residual in the system. This reduces the systems ability to deal with any contamination that may enter the system as well as increasing odor and taste complaints.

Metal Pipe

All metal pipe is subject to deterioration by iron bacteria. The nodules they produce, reduce flow capabilities of the line and deteriorate the pipe wall.

Maintaining Water Quality

The most common methods of maintaining water quality are to maintain an appropriate chlorine residual level and flush the lines using a systemic approach.

FLUSHING

Frequency of Flushing

The frequency of flushing is dependent upon four related factors;

- the type of piping material in the distribution system,
- the normal system **velocity**[15],
- the quality of the water entering the distribution system,
- the design of the system.

Each of these factors plays a unique part in determining the overall need and the frequency of flushing the system or segments of the system. You should consider each independently and then consider their combined effect when determining the frequency for your system.

[15] **Velocity** - The speed at which water moves, expressed in feet per second.

Once a Year

As a general rule all systems should be flushed once a year. The factors described above, when considered, may indicate the need for a more frequent flushing program.

FLUSHING PROCESS

Velocity 2.5 ft/sec

Past practices has determined that when the velocity in the distribution system is less than 2.5 feet per second silt will settle in the low points and biological growths will appear on pipe walls. If the normal operating velocity of a system is 2.5 feet per second or greater the need to flush that portion of the system is drastically reduced. Even dead end lines that serve high use customers may not need frequent flushing if the normal operating velocity is greater than 2.5 feet per second.

PREPARATION

The flushing process starts by using a map of the system and laying out the flushing sequence. The flushing of a system should start at the sources and proceed systematically to the farthest point. In the development of a plan of action the following guidelines should be used.

Laterals

Flush past a lateral before flushing the lateral.

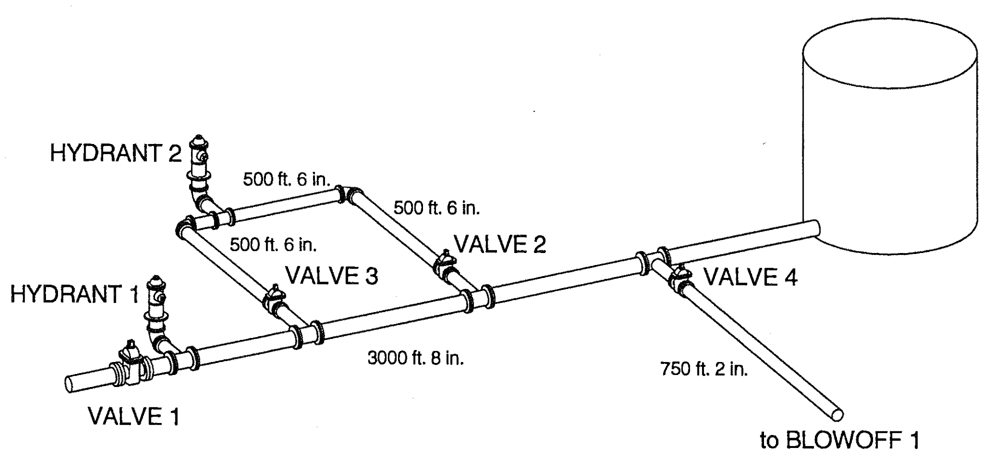
Loops

Loops should be flushed in steps.

- Shut off one side of the loop.
- Open a hydrant or blow-off at the end of the loop and flush.
- Open the closed valve and close the open valve, repeating the flushing process.

EXAMPLE

The example below of a small part of a water system will be used to describe the sequence of events necessary in an effective flushing program.



Step 1 - Lines and Sequence

Mark line sizes and lengths on the map and determine the flushing sequence. Which valves will need to be closed and which opened. How will each lateral and loop be flushed.

Example:

1. The reservoir would first be cleaned and refilled.
2. The flow sequence would be as follows:
   - Hydrant #1 would be flushed first (If the system pressure can be sustained from a second source or reservoir then valve #1 would be shut off during the flushing of hydrants # 1 and 2 and blow-off #1)
   - Valve #2 would be closed and hydrant #2 would be flushed.
   - Valve #2 would then be opened and valve #3 closed and hydrant #2 again flushed.
   - Valve #3 would then be turned on and Blow-of #1 would then be flushed.

Step 2 - Obtaining Proper Flow

Determine the flow necessary to obtain a velocity of 2.5 ft per second. Table 1 below can be used to make this determination. These flow rates should be marked on the map.

Table 1. Approximate Flow Rates Required to Create 2.5 fps Velocities in Various Size Pipes

Pipe Size inches	Flow Rate gpm	Pipe Size inches	Flow Rate gpm
1 1/2	15	6	220
2	25	8	400
2 1/2	40	10	610
3	55	12	880
3 1/2	75	14	1200
4	100	16	1565
5	150	18	1980

Example:

The flow rates and volumes were calculated as follows and placed on the map.

Flow rates are obtained from table #1 as follows

Hydrant #1 - 8" line = 400 gpm

Hydrant #2 - 6" line = 220 gpm

Blow-off #1 - 2" line = 25 gpm

Step 3 - How to Reach 2.5 ft/sec

One of the major problems in the proper operation of a flushing program is obtaining the flushing velocity of 2.5 feet per second. Most systems are equipped with fire hydrants or blow-offs that can be used to flush the system. The table below (table 2) gives information on the number of 2.5 inch fire hydrant nozzles required to reach this velocity. An alternative of the actual nozzle opening size is also provided. This table was developed on the assumption that a pressure of at least 40 psi is maintained in the system at all times. If the pressure is less than 40 psi the flow rate in gpm can be used to determine the number and/or nozzle size necessary.

Table 2. Flow and number of hydrant nozzles needed to flush various pipe sizes

Pipe Size in.	Flow Required to Produce 2.5-fps Velocity gpm	Orifice Size	Number of Hydrant Outlet Nozzles 2 1/2"
4	100	15/16	1
6	220	1 3/8	1
8	390	1 7/8	1
10	610	2 5/16	1
12	880	2 13/16	1
14	1200	3 1/4	2
16	1565	3 5/8	2
18	1980	4 3/16	2

Based on residual pressure of 40 psi

Step 4 - Time Required

The fourth step in developing a flushing program is to determine the amount of time required to flush each segment of line. This can be accomplished by:

- Determining the length of each line.
- Determining the volume in each line, using table 3.
- Determine the flow rate from table 1.
- Dividing the volume by the flow rate to obtain time in minutes.

Table 3. Capacities of Various Size Pipes

Pipe Size inches	Capacity gallons/foot	gallons/mile
1 1/2	0.092	485
2	0.164	863
2 1/2	0.255	1,330
3	0.368	1,943
3 1/2	0.501	2,645
4	0.654	3,453
5	1.020	5,386
6	1.470	7,762
8	2.620	13,834
10	4.080	21,542
12	5.875	31,020
14	7.996	42,219
16	10.444	55,144

Example:

The volume of water needed and the time requirement is then calculated. The volume of water is obtained from table 3.

- Hydrant #1 — 2.62 gal/ft x 3,000 ft = 7,860 gal

7,860 gal ÷ 400 gal/min = 20 min.

- Hydrant #2 with Valve #3 closed

1.470 gal/ft x 1,000 ft = 1,470 gal

1,470 gal ÷ 220 gal/min = 7 min.

- Hydrant #2 with valve #2 closed

1.470 gal/ft x 500 ft = 735 gal

735 gal ÷ 220 gal/min = 4 min.

- Blow off #1 0.164 gal/ft x 750 ft = 123 gal

123 gal ÷ 25 gal/min = 5 min.

Map

This data should be written on the map next to each fire hydrant.

Step 5 - Gallons Used

The final step in preparing for a flushing program is to determine the volume of water that will be used. In step 4 the volume and time required were calculated. The actual time needed to flush a line may be twice the estimated time. Therefore, in estimating the volume of water to be used, calculate a range for the estimated time and for double this time.

Record Volume To Be Used

This estimated volume should be recorded. This value is then used to determine the impact of the flushing on the storage, pumping and treatment facilities.

OFFICE PROCEDURES

Time of Year

The first step in undertaking a flushing program is to determine the time of year and the frequency of the flushing. As described above each utility needs to determine their needs based on piping material, water quality and normal distribution system velocity. The selection should be made so as to disturb normal operations as little as possible. This means that most utilities choose to flush either during the late fall or the early spring. This allows them to avoid the heavy demand periods.

Time of Day

After the time of year and frequency have been determined the time of day needs to be selected. This should be based on the impact on the customer, the availability of the crew and the safety of the crew. Some utilities choose to flush during the day when crews are readily available. Others choose to flush at night thus avoiding problems with traffic and with dirty water complaints.

Critical Customers

Prior to the start of the flushing all **critical customers** need to be identified and notified. Critical customers could include hospitals, restaurants, commercial laundries, large boilers, individual dialysis machine users, large air conditioners and other industrial applications where a drop in water pressure or the presence of dirty water would cause a problem. Each of these customers needs to be considered individually. By working directly with these customers a schedule that allows you to flush and allows them to continue operation can normally be worked out. The approach that the utility should take is that the flushing program helps to assure water quality for each and every customer. This is not an emergency action it is a normal industry practice.

Customer Notification

Each customer should be notified concerning the flushing program. The notice can include written information inserted along with the bill, press releases and door hangers. The information should include the fact that this is not being done because of some problem with water quality, but is a part of normal practice to maintain water quality. The water that is used is not wasted but is used to perform the task of flushing small accumulation of debris from the water lines. The material that collects in the water line poses no health hazard but it can cause odor and taste problems and cause a increase in turbidity. They should also be told that should they discover dirty water in their tap shortly after the flushing program they should proceed to the tap that is furthest removed from the main. They should run water from this tap until the water runs clear. This will prevent dirty water from entering the water heater. With this type of information the customer will be much more willing to participate in the flushing program.

FIELD PROCEDURE

Equipment and Personnel

A two person crew is usually best for performing this task. One person spends a considerable amount of time running from hydrant to valve and back again. The individuals must be familiar with the distribution system, valve location, critical users, special pressure zones and pump stations. The equipment requirements include:

- Flow diverter.
- Valve wrenches - at least 2.
- Fire hydrant spanner wrenches - special hydrant wrenches for **utilidor**[16] hydrants.
- Radios.
- One of more lengths of fire hose.
- The map with sequence, number of nozzles and time requirements noted.

PRECAUTIONS

When undertaking a line flushing program there are several precautions that should be considered.

Critical Users

Special precautions should be taken to assure that critical users are not placed in a harmful position. The critical users would include individuals on kidney dialysis machines, hospitals and any other customers who would be severely hampered by a drop of water pressure or dirty water.

Pressure

Do not allow the pressure at any point in the distribution system to drop below zero. If there is this potential then a gauge should be placed at this point. The gauge should be monitored during flushing and the hydrant or blow-off throttled sufficiently to prevent this occurrence.

Actual Nozzle Size

It is much easier to use the 2 1/2 inch nozzles on the hydrant for the actual flushing and thus the actual flow will normally be greater than the calculated. This is because the calculated is based on the minimum nozzle size required to meet the 2.5 fps velocity.

Actual Water Use

The flow and actual flush time could be noted and recorded. The differences in data could be used to adjust the flow times for the next time.

[16] **Utilidor** - An above or below ground conduit used to hold pipe and other utilities in Arctic environments. Commonly heated with forced air or copper hot water of glycol loops.

SEQUENCE

1. Install any traffic and/or pedestrian controls that may be necessary.
2. Identify and inspect catch basins and the flow path for flush water.
3. Install flow diverter and canvas if necessary. (The flow diverter protects the street and traffic, the canvas protects the property adjacent to the hydrant or blow-off)
4. Slowly open the hydrant until it is completely open.
5. Record the start time.
6. From the flush record determine the amount of time required.
7. Measure and record the flow.
8. Observe and record the condition of the water.
9. Record the time required for this section to come clear.
10. When it is necessary to shut off a valve (or turn on a normally closed valve) it should be marked on the map. After the valve has been returned to its original position the marking should be erased.

ROUTINE OPERATION

Introduction

The quantity and type of activities required for routine operation of a distribution system is dependent on the type and age of the system as well as environment. For instance an above ground utilidor system requires much closer observation in the winter than the summer. None the less, each distribution system has some general operation and inspection requirements. The following are some of the more common activities.

LEAK DETECTION

Visual

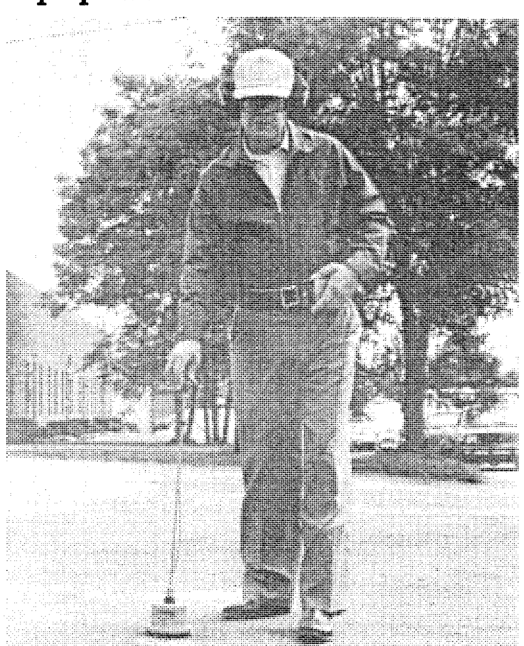
Visual inspection of roads and ditches as well as drops in pressure or sudden unexplained increases in consumption can provide information on possible leaks. Utilidors must be opened in order to inspect for leaks. It is difficult to detect leads in Arctic pipe placed above or below ground. Water exiting from the joints of Arctic pipe or a utilidor is a good indication of a leak.

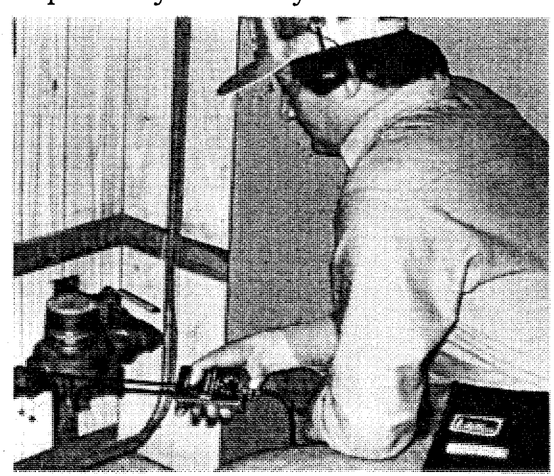
Testing

When free running water is observed in a ditch or on the street, it can be tested for the presence of chlorine or fluoride. Fluoride, because it does not dissipate rapidly, is very effective for this test. If either or both of the chemicals are present it is apparent that the source of the water is a leak in the distribution system.

Aquaphone

A special listening device called and aquaphone can be used to find leaks. Listening at fire hydrants and valve boxes will help to identify and locate leaks. In order for this device to be effective, the operator will have had to make periodic tests at various locations in the system, when no leaks were present. Comparing the sounds is a quick way to identify a leak.





Leak Detection Equipment Courtesy of Heath Consultants

Commercial Testing

There are commercial organizations that have shown they are very effective in identification of leaks in buried lines. In recent years the cities of Craig and Seldovia have both used these companies with very satisfactory results.

Isolation

Another way to identify which section of a system is leaking is to isolate the section. A pressure gauge is placed on the section and valves closed to isolate the area. If there is a leak the gauge will fall rapidly. If there is no leak the gauge may fall slowly, as a result of natural leakage around valves.

OTHER INSPECTION CONSIDERATION

Pressure

The system pressure should be observed and recorded daily. As mentioned above this pressure should not drop below 20 psi at the highest point in the community.

Water Quality

Water quality control usually is accomplished by maintaining a trace of chlorine residual throughout the system, flushing on a routine frequency and collecting the appropriate bacteriological samples. The key to water quality is customer satisfaction. A portion of the water quality maintenance process should be a systematic process of recording and responding to customer complaints.

Temperature

In Arctic and sub-Arctic environments the distribution system water temperature can be critical. On circulating systems, maintaining a velocity of 5 feet per second and a return temperature of above 35° F is critical. Even if the system is not a circulating system, observing and recording distribution system temperatures on a routine basis can provide information on potential freezing problems.

Utilidors

Above and beyond the distribution piping itself the utilidor should be inspected frequently throughout the winter for potential problems. All hatches and joints should be maintained in a water tight condition. The internal temperature should not drop below 35 °F. The interior should be inspected regularly for the accumulation of water. The accumulation could result from a leak in a line or the exterior of the utilidor. In any case the cause should be identified quickly and repairs made before the accumulation causes a frozen line.

CALCULATIONS

Lost Water

One of the key monthly calculations performed by the operator is the calculation of the percent of lost water in the system. Lost water is the difference between the water produced and the water sold.

Produced water - Sales = Lost water

When a system does not have meters this calculation cannot be done.

Percent Unaccounted

The percent **unaccounted for water**[17] is determined by dividing the lost water by the production.

[17] **Unaccounted for Water** - Water that was not sold or can not be accounted for in any measurable way. Normally does not include water used for fire suppression, line flushing and other routine maintenance.

Lost Water/ Produced water X 100 = % unaccounted for water.

Exceeds 15%

When the unaccounted for water exceeds 15% it is time to initiate a meter replacement or leak detection program. All unaccounted for water is an increase cost to the utility. Increased cost in power consumption to pump the water and increased chemical cost. In one community the water consumption was 600 gpdpc. An investigation of the system indicated that the unaccounted for water was 72%. If this water were being treated and heated during the winter the extra costs to the community are excessive.

COMMON REPAIRS

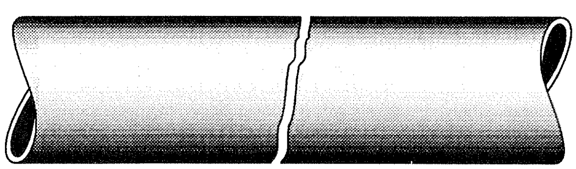
LEAKS AND BREAKS

Types

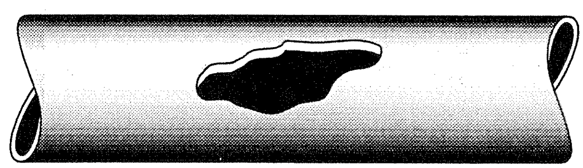
There are a wide variety of leaks and breaks in water system main lines. These are normally divided into four categories;

- A break around a line called a circumvential break.
- Holes
- A lengthwise break called a longitudinal break.
- Small holes - called pin holes.
- Leakage at a joint.

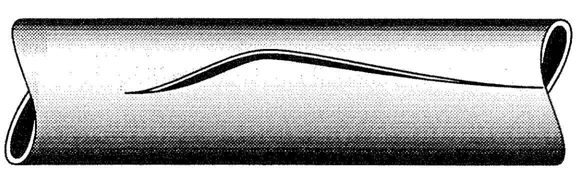
The key to properly repairing the break is determined by the type of break and the selection of the proper fitting.



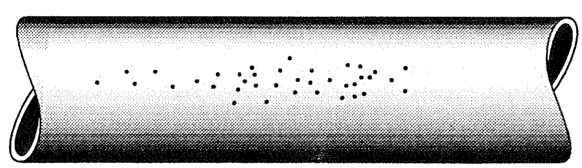
CIRCUMVENTIAL BREAK



HOLE



LONGITUDINAL BREAK



PIN HOLES

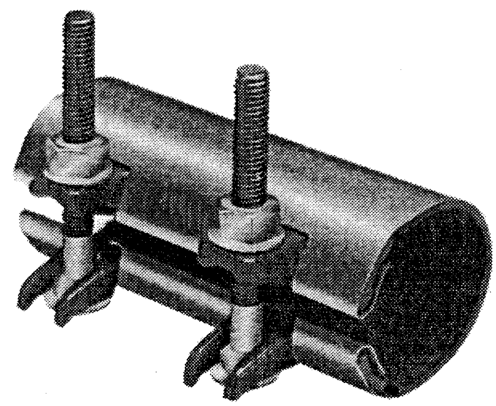
REPAIR FITTINGS

Introduction

There are five common repair fittings used on **PVC**[18], **DCIP**[19], steel and occasionally on **HDPE**[20] pipe.

Repair Bands

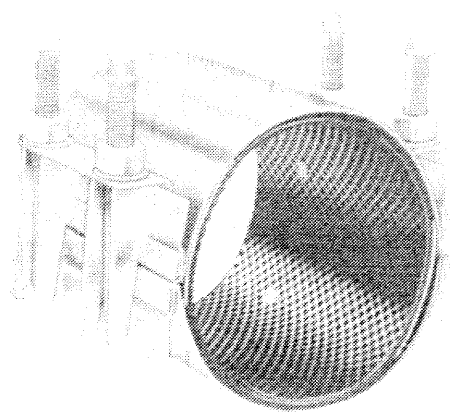
Repair bands[21], also called "band-aids" are the most common repair fitting. They are normally made from stainless steel with a resilient lining placed on the inside. One or more corrosion resistant bolts are used to clamp the band to the pipe. The manufacturers make these bands in diameters to fit a specific pipe size. For instance a band that fits 2 inch OD pipe will not fit around 2-inch standard steel pipe (schedule 40 pipe). The bands come in lengths of 3", 7.5", 10 and 12". Repair bands are used to repair small holes on steel and PVC pipe.



Repair Band
Courtesy of Rockwell International

Full Circle Bands

Full circle repair bands are made of one or two pieces of stainless steel, lined with a resilient material. These bands are sized for specific outside diameters of pipe. Like the repair bands they are manufactured in 3", 7.5", 10 and 12" lengths. Full circle repair bands are used to repair large holes and circumvential breaks on all types of pipe.

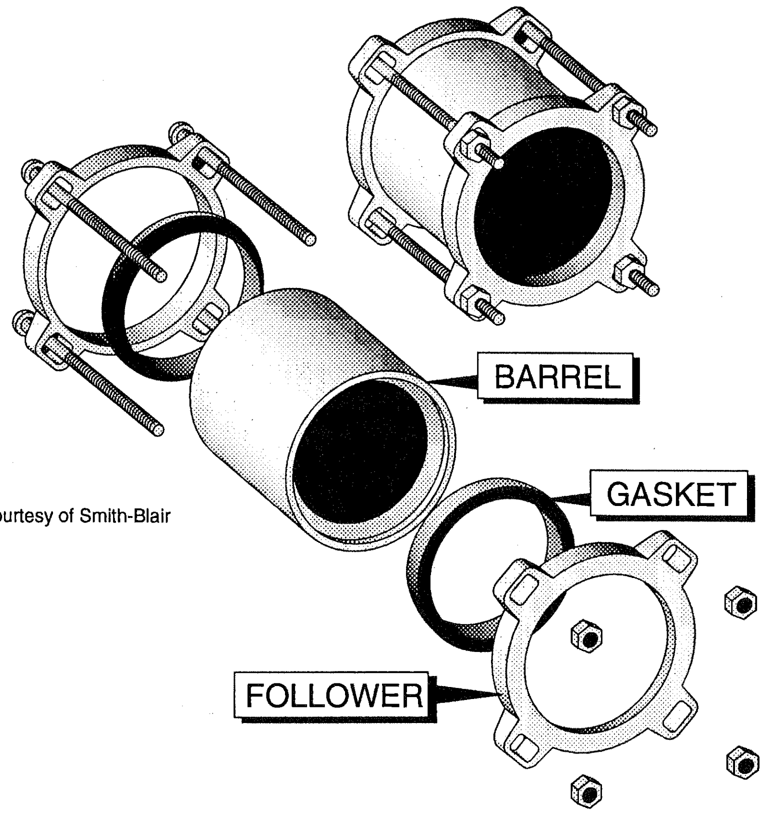


Full Circle Repair Band
Courtesy of Ford Meter Box Co.

18 **PVC** - Poly Vinyl Chloride. A plastic pipe made by forcing heated plastic through a die.
19 **DCIP** - Ductile Cast Iron Pipe - Cast iron pipe, that is made by injecting magnesium into the molten cast iron developing a material of exceptional strength.
20 **HDPE** - High density polyethylene pipe.
21 **Repair Band** - A device used to repair leaks in pipes. Usually made of stainless steel and lined with a resistant face.

Cast Iron Couplings

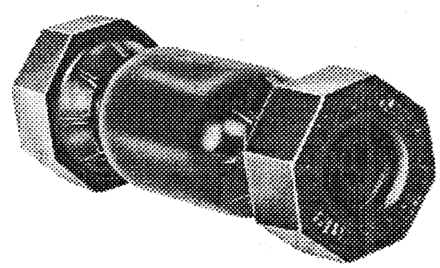
Cast iron couplings are commonly called **Dresser™ couplings**[22]. They are made of a steel or cast iron cylinder, two followers, two gaskets and a series of bolts. The follower and gaskets are placed over the two ends of a pipe. The ends are placed inside of the cylinder. Tightening the bolts, seals the gasket between the cylinder and the pipe. Cast iron couplings are selected for a specific pipe size. They can be used to replace a section of pipe. Special couplings are manufactured that allow the connection of two pipes of different sizes.



Courtesy of Smith-Blair

Compression Coupling

The compression coupling is similar to the cast iron coupling. The difference is the method of compressing the gasket. With the compression coupling the gasket is sealed by threading the followers onto the cylinder rather than using bolts. The compression coupling is commonly used on pipes of 2 inch and smaller.



Compression Coupling
Courtesy of Rockwell International

[22] **Dresser coupling** - A specific manufacturer and a slang term used to describe a cast iron coupling used to connect two pipes of the same or different sizes using a cylinder, followers, resilient gaskets and a series of bolts.

Fitting	Use For			
	Pin Holes	Large holes	Longitudinal break	Circumvential break
Repair Bands	X			
Full Circle Band	X	X	X	If they are short
Cast Iron Coupling			X	Replace section
Compression Fitting				Replace section

REPAIR PROCEDURE

Introduction

Because it is not possible to predict the circumstances associated with a specific break or leak, writing a specific procedure is impossible. Therefore, we offer the following guidelines, to be adapted to a specific condition.

1. Shutdown line - leave some pressure so that the system pressure remains positive. This will reduce the possibility of contamination.
2. Set up traffic control. Traffic control is required for snow machines, three wheelers, and pedestrians as much as it is for automobiles.
3. Excavate where necessary.

   If it is a utilidor then open the utilidor.

   • In Alaska if excavation is deeper than 3 feet then shoring is required.
4. Dewater the trench or utilidor.
5. With Arctic pipe, cut back the insulation making a clean square cut.
6. Disinfect repair parts. Make a 1% solution by placing 1/4 cup of 5% household bleach in 1 gallon of water.
7. Make the repair.
8. Pressurize line and test the repair.
9. If Arctic pipe, patch the jacket.
10. Fill excavation or dry and enclose the utilidor.
11. Clean-up the work area. Leaving a trench partially covered for a long period of time is a safety hazard and poor public relations.

THAWING

Prevention

The best method used for thawing in areas where a line could freeze is prevention. Maintain the return temperature on circulating systems at or above 35°F. Maintain utilidors above 35°F. Keep circulating pumps running so that the velocity stays above 5 ft/sec. However, in the best systems freezing will occur. The first problem is to find the location of the frozen section of line.

Location

Location can be determined by checking individual homes to determine if the main is frozen between two or more homes or the problem is a frozen service.

Methods

Once the frozen line is located a thawing technique must be selected. The technique selected is dependent on the piping material used, the equipment available and the local conditions. There are three methods commonly used in rural Alaska, hot air heat guns, high pressure water and steam.

Hot Air Guns

The hot air systems work best on small diameter HDPE lines. The key is melt the ice without damaging the line. Do not hold the heater in one place for more than a few seconds.

High Pressure

One of the common effective methods of thawing small diameter lines is with the use of the high pressure washier or jet unit. This device produces a pressure of 2200 psi at a flow of 5.2 gpm. The water can be heated win an in line heater to 50°F to 180°F. The what is pumped at high pressure through a small diameter line that is hand fed into the frozen line. The pressure and heat are used to thaw the line. This unit has been effective at temperatures as low as minus 10°F.

Steam

A steam unit, similar the high pressure unit is also commonly used to thaw water lines. A positive displacement pump is used to pump 500°F steam at 1.5 gpm through a small line. The small line is hand fed into the frozen pipe. The steam is produced by a oil fired boiler that uses kerosine or No. 1 fuel oil.

Electrical

While electrical thawing has been used to thaw frozen steel and copper lines its use is discouraged. The use of electric thawing can cause house fires and is ineffective with plastic lines.

USING HIGH PRESSURE OR STEAM UNITS

There are several manufacturers producing devices that use a small diameter (1/4 to 1/5 inch) polyethylene (PE) tube and hot water to thaw lines. In order to use the device:

- The line must be disconnected
- A shut-off valve such as a ball valve placed on the line.
- A special fitting placed over the end of the line.
- Hot water is pumped through the small PE pipe.
- The PE pipe is pushed inside of the frozen line.
- The water (cold or warm) or steam is under a pulsing pressure and as it thaws the ice, the water or steam and thawed water flow back out around the PE pipe or exit through a special tee fitting that is attached to the end of the pipe.

O & M OF DISTRIBUTION SYSTEMS

WORKSHEET

1. The primary function of a water distribution system is to:

_______ a. Allow a means of collecting fees for using water

_______ b. Provide fire protection

_______ c. Transport water from the treatment plant to the customer

_______ d. Circulate water to prevent it from freezing

_______ e. Provide a means of obtaining water for showers and drinking

2. The two criteria for a water distribution system is that it must be ________ and ______.

_______ a. Economical

_______ b. Adequate

_______ c. Large enough

_______ d. Made from good materials

_______ e. Reliable

3. The pressure in a water distribution system should never drop below ________ psi.

_______ a. 10 psi

_______ b. 20 psi

_______ c. 30 psi

_______ d. 40 psi

_______ e. 60 psi

4. A map or blueprint that shows a cross-section of the earth is called the _______.

_______ a. Plan

_______ b. Cross section

_______ c. Vertical view

_______ d. Profile

_______ e. Underground view

5. On a blueprint what is a station?

_______ a. Fire hydrants

_______ b. Horizontal Location

_______ c. Distance to the end of the project

_______ d. Points of interest on a project

_______ e. Location of the pipe joints

6. A job begins at station 1+00 and stops at station 45+50. A fire hydrant is located at station 15+00. How far is it from the beginning of the project?

_______ a. 150 feet

_______ b. 300 feet

_______ c. 3000 feet

_______ d. 1400 feet

_______ e. 2950 feet

7. The pressure at the treatment plant is 85 psi and the pressure at the highest house in the community is 45 psi. What will be pressure be at the treatment plant when the pressure at this house is 20 psi.

_______ a. 60 psi

_______ b. 110 psi

_______ c. 40 psi

_______ d. 25 psi

_______ e. 45 psi

8. If there is a series of taste and odor complaints concerning chlorine and the residual leaving the plant is 0.3 mg/L. What would you suggest is the best course of action?

_______ a. Reduce the chlorine dosage

_______ b. Flush the system

_______ c. Stop feeding chlorine

_______ d. Provide bottled water to those that complain

_______ e. Increase chlorine dosage

9. If the free chlorine residual is less than _____ percent of the total chlorine residual, taste and odor problems will most likely be present.

_______ a. 10%

_______ b. 15%

_______ c. 85%

_______ d. 95%

_______ e. 25%

10. The MCL for lead is __________.

_______ a. 0.5 mg/L

_______ b. 0.003 mg/L

_______ c. 0.015 mg/L

_______ d. 1.3 mg/L

_______ e. Zero

11. The MCL for copper is ____________.

_______ a. 0.5 mg/L

_______ b. 0.003 mg/L

_______ c. 0.015 mg/L

_______ d. 1.3 mg/L

_______ e. Zero

12. For a community of 100 ____ lead and copper samples should be collected every six months.

_______ a. 5

_______ b. 10

_______ c. 15

_______ d. 2

_______ e. 6

13. Complaints about a blue or green ring on bathroom fixtures is an indication of high concentrations of ___________.

_______ a. Iron

_______ b. Manganese

_______ c. Lead

_______ d. Hardness

_______ e. Copper

14. To properly flush a distribution line the velocity should be at least ___________.

_______ a. 1 ft/sec

_______ b. 2.5 ft/sec

_______ c. 5 ft/sec

_______ d. 7.5 ft/ sec

_______ e. 3 ft/sec

15. Two methods of heating a utilidor are?

_______ a. Electric heaters every 100 feet

_______ b. Forced air heaters

_______ c. Oil loop, circulating systems

_______ d. glycol loop circulating systems

_______ e. Electric induction heaters

16. The chlorine residual entering a distribution system should be at least __________.

_______ a. 5 mg/L

_______ b. 0.5 mg/L

_______ c. 0.1 mg/L

_______ d. 0.2 mg/L

_______ e. 2 mg/L

17. 500 feet of 2 inch line would hold ________ gallons

_______ a. 82

_______ b. 25

_______ c. 500

_______ d. 110

_______ e. 106

18. A system produced 510,000 gallons per day. After reading the water meters and taking into account all water used for fire suppression and other maintenance activities only 420,000 gallons could be accounted for. What is the percent unaccounted for water?

_______ a. 10%

_______ b. 18%

_______ c. 82%

_______ d. 42%

_______ e. 26%

19. The proper fitting for fixing a hole 1 inch in diameter in a DCIP would be the ...

_______ a. Repair band

_______ b. Compression coupling

_______ c. Full circle repair band

_______ d. Cast iron coupling

_______ e. Wooden plug