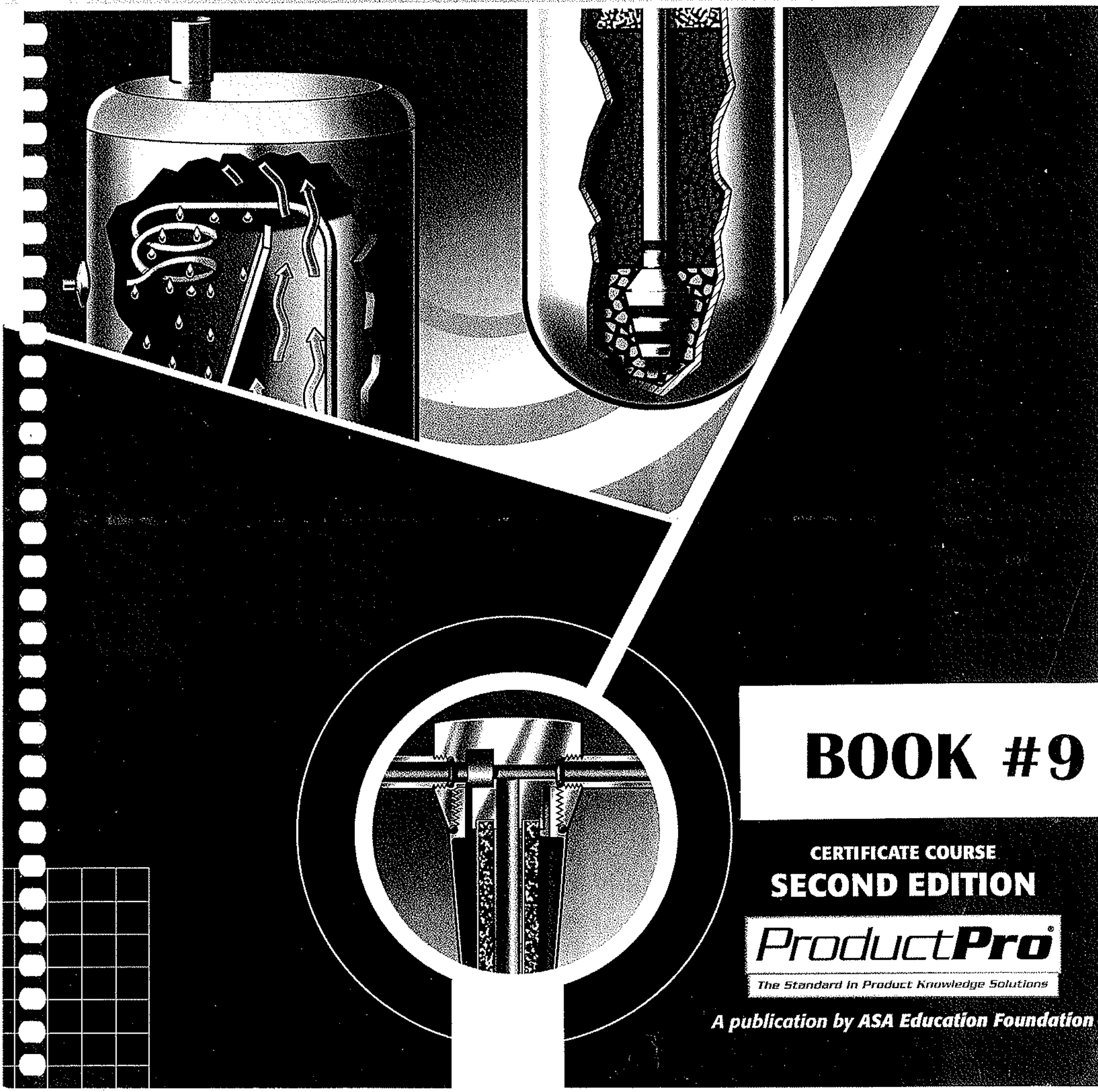
ASA UNIVERSITY

Specialty Products

Residential Water Processing©



BOOK #9

CERTIFICATE COURSE

SECOND EDITION

ProductPro®

The Standard in Product Knowledge Solutions

A publication by ASA Education Foundation

Specialty Products

Residential Water Processing©

from the

American Supply Association Education Foundation

Residential Water Processing© provides new warehouse, counter, and sales personnel with an overview of the operation and components of residential water processing. It is NOT intended to provide the kind of complex, technical data which would enable employees to plan or install water treatment, filtration, disinfection, or distillation systems. This course includes definitions of common industry terms, descriptions of the components and functions of residential water processing systems, and other information that will help employees serve their customers more effectively.

ProductPro®

The Standard in Product Knowledge Solutions

HEADQUARTERS

ASA Education Foundation
1200 N. Arlington Heights Road
Suite 150
Itasca, IL 60143

tel: 630.467.0000
fax: 630.467.0001
web: www.asa.net
e-mail: info@asa.net

ASA Education Foundation

Welcome to the *ProductPro® Product Knowledge Training* series!

The Plumbing-Heating-Cooling-Piping (PHCP) and Industrial PVF industry is an important business channel. The products we sell keep people healthy, comfortable, and productive. In the United States, there are 4,000 PHCP/ Industrial PVF wholesaler-distributor locations; they generate billions of dollars in wholesale sales. It is an exciting and very competitive industry, and running a successful company requires cooperative efforts from educated and motivated employees.

To sell products in such a competitive atmosphere, it is crucial that all employees understand the products we sell. All of us need to be knowledgeable enough to provide our customers with the products they need to keep their operations running smoothly and their employees productive.

What you will learn from this training

This ProductPro® course contains information that gives you an overview of common water problems and the techniques used to solve them. The course includes definitions of common industry terms, descriptions of the major technologies, and other information that will help you serve your customers effectively when they come to buy water conditioning equipment. You will learn to describe some of the most common residential problems and suggest at least one possible approach that might solve each problem. In addition, you will learn to help your customers choose the appropriate water treatment system to meet their particular needs.

Since water treatment can be rather complex, it is especially important that you take any training available to you about the water treatment equipment or chemicals that your company carries. It is important not to make claims that equipment can solve any problems other than those your manufacturer indicates can be solved by a particular kind of equipment or chemicals.

How the course is organized

The ProductPro® courses are divided into separate chapters. Within each chapter you will read about a particular category of product and then test your progress with a short quiz that you can correct yourself. The course provides a glossary of terms at the back of the book to help you develop the vocabulary needed to enhance your ability to communicate well with your customers and colleagues. The glossary terms are highlighted in the text.

At the end of each self-correcting quiz, you will find *Applying What You've Learned* exercises so you can use the new information that you have learned within your own company. Once you understand the basic concepts presented, know the important facts, and can confidently answer the questions correctly on all the quizzes, you are ready to take the final course exam.

THIS COURSE INCLUDES AN ONLINE FINAL EXAM

This course is limited to a single user. When you are ready to take the final exam to earn your Certificate of Completion, please contact ASA at info@asa.net. ASA staff will contact you about how to register for the final exam.

Some hints for successful course completion

Read the learning objectives

Read the learning objectives at the beginning of each chapter. They will tell you what you should know when you complete the chapter. Go back after you read the material and ask yourself whether you are confident in your command of the material. If you are not, reread anything that you did not understand. Ask your supervisor or colleagues questions to help clarify the material you did not "get" the first time.

Search for the important ideas

Use a highlighter marker or a pen to highlight or underline the most important points as you read. Think about how each idea relates to the rest of the chapter. Write notes in the margins about points you don't understand or about how the material you read applies to your own company.

Ask lots of questions

Ask your supervisor or mentor about any points you do not understand. Particular questions you'll want to ask include whether the products you are studying are carried by your company, how well they sell, and how important they are in the overall inventory.

Apply what you are learning to your job

Always think about what you have just read or learned. Compare your company's products to the products you have read about in the book. Do the *Applying What You've Learned* exercises using the real setting of your job.

Pace yourself in your studying

Don't try to complete the course all at once. You will remember what you learn more effectively if you make sure you understand each chapter thoroughly before you move on to the next.

Be proud of what you have accomplished

When you successfully complete the course, be sure to proudly display your course certificate. You earned it. Then consider moving on to the other courses in this series:

- *Domestic Water Heaters©*
- *Domestic Water Well Pumps©*
- *Sump, Sewage and Effluent Pumps©*
- *Residential Hydronic Heating Systems©*

Commit to learning something new every day

This course is just one step in developing your professional knowledge and your career skills. Read industry trade journals, study the manufacturers' literature, and attend any training the manufacturers offer. Listen to what company and industry experts says. Continue to enthusiastically take any additional training your company offers.

Visit the ASA Education Foundation website at www.asa.net regularly to find out about other learning opportunities to advance your career.

Acknowledgements

Developing new editions of the ProductPro® product knowledge training courses is an ambitious undertaking. During the creation and revision of this course, many individuals shared their expertise, input, and resources to significantly improve the interest and energy in the program.

We wish to thank John Menard of Metro Filter Sales, Inc. who thoroughly and diligently reviewed the course text, quizzes, illustrations, and final exam to ensure accurate and highly readable instructions. His expertise and experience insures that the content demonstrates a high level of real world application that immediately can be put to use in employees' day-to-day duties.

We also want to thank those organizations that gave permission to use their illustrations. These organizations include Cuno Consumer Products, Chemical Engineering Corp., CUNO Inc., and Water Quality Association.

The Foundation expresses it very special gratitude to the visionaries who established and led the charge to develop the Karl E. Neupert Endowment Fund. Contributions that established the Fund were provided by hundreds of manufacturers, wholesalers, and individuals who recognized the need for a permanent endowment fund that would endure the ASA Education Foundation's ability to provide programs needed by the industry in perpetuity. Their generous contributions continue to make a major impact on the education and training opportunities available to the industry. We are deeply grateful for their commitment.

– The ASA Education Foundation

Table of Contents

continued

Table of Contents

continued

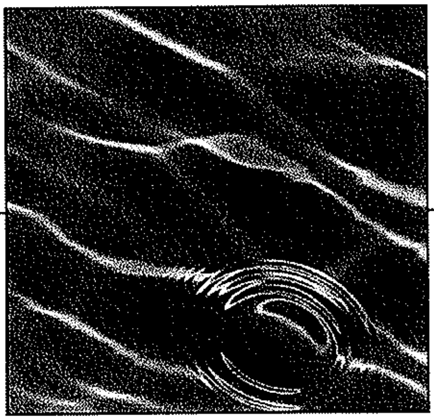
Table of Contents

1 INTRODUCTION TO WATER

LEARNING OBJECTIVES

When you finish this Chapter, you will be able to:

1. Recognize common residential water processing terms.
2. Describe the five basic kinds of water contaminants found in the United States.
3. Compare and contrast drinking water, utility grade water, and household grade water.
4. Discuss the five considerations that must be taken into account when planning a water treatment program for a consumer.



RESIDENTIAL WATER PROCESSING

Importance of Water

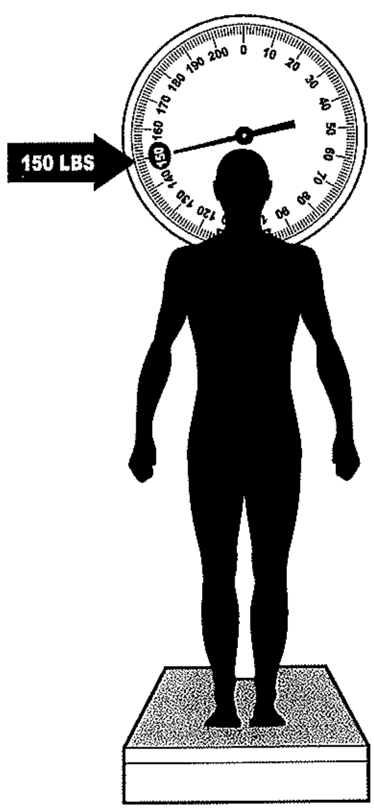
Water is essential for all living things, both plants and animals. Our human bodies are approximately 70 percent water, measured in terms of volume.

A man who weighs approximately 150 pounds is carrying between 70 and 80 pints of water within his body. Our bodies cannot function without water. We lose about five pints of water per day through perspiration, evaporation, and excretion.

To remain healthy, we must drink enough water to replace the water we lose each day. Because water is so necessary to us, we must do all that we can to be sure that the water we drink is clean and free of germs and harmful contaminants which would make us sick or cause damage to our bodies.

Unfortunately, much of the world's water is not as clean and pure as it once was. Some of it is so contaminated that it is unhealthy for human beings to drink.

70% OF BODY VOLUME IS WATER



150 Pounds means 70 to 80 Pints of Water

SP 5.1.01

Chemical Make-up of Water

A water molecule is made up of two atoms of hydrogen and one atom of oxygen. The chemical abbreviation for water is H_20.

Technically speaking, any substances other than hydrogen and oxygen can be considered contaminants. All natural water, even a sparkling "clean" mountain stream, contains some contaminants or impurities.

CHEMICALLY PURE WATER, which contains only hydrogen and oxygen atoms, is found only in laboratories or manufacturing plants.

Drinking water usually is not, and does not need to be, chemically pure. Drinking water must be pure enough, however, to cause no diseases or damage to our bodies. It must be safe to drink.

Water Treatment

For many years now, municipalities (cities and towns) have been treating water to kill disease-causing microbes. Microbes are organisms (bacteria, viruses, cysts, algae, etc.) so tiny they can only be seen by microscope. There are thousands, perhaps millions, of kinds of microbes in the world. Comparatively speaking, only a small number are known to cause disease. The disease-causing ones are called **PATHENOGENIC MICROBES.**

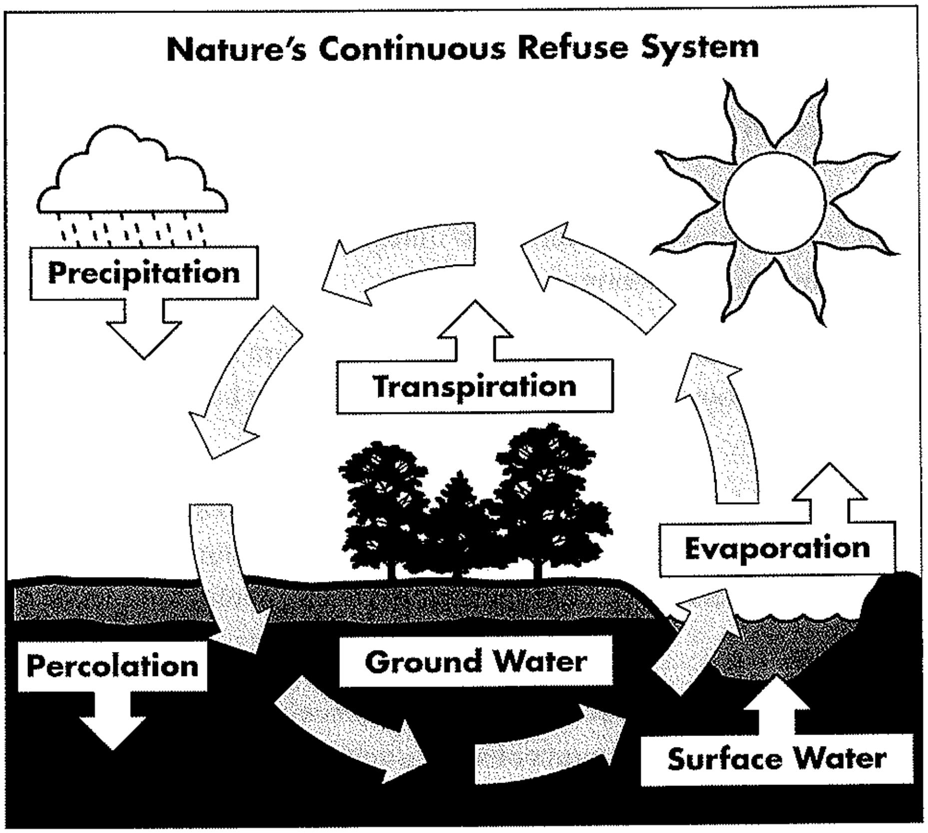
The process of treating water to get rid of pathenogenic microbes is called **DISINFECTION**. The **U.S. ENVIRONMENTAL PROTECTION AGENCY (U.S. EPA)** and the states have set standards about what kinds of microbes and other contaminants must be
controlled or eliminated to make drinking water safe. Water which has been disinfected and meets these standards which make it safe to drink is called **POTABLE WATER.** Public water systems must show that their water supplies are potable.

However, medical and governmental researchers are always concerned that there are other kinds of contaminants which might make water unsafe to drink. Many of these possibly dangerous contaminants are chemicals which result from human activities, such as manufacturing or farming.

The Hydrologic Cycle

All of the water we have has been here since the beginning stages of the formation of the earth. We cannot make new water, except, perhaps, in small quantities in laboratories. All the water in our lakes, streams, and oceans is recycled by Nature and used over and over again. Mother Nature's water recycling process, which involves precipitation and evaporation of the earth's water, is called the **HYDROLOGIC CYCLE**.

HYDROLOGIC CYCLE



SP 5.1.02

Water from the oceans, streams, lakes, and ponds is evaporated by the sun, forms into clouds, and then is returned to earth as rain, snow, or other forms of precipitation.

Some of the water from precipitation seeps through soil and rock and is captured in deep underground channels called aquifers and some of it may remain there for thousands of years. It is from aquifers that we may draw well water. Some of the water in the aquifers or in underground streams flows fairly quickly, by underground routes, into rivers, lakes, or oceans.

But most of the rainwater (or snow melt) runs off directly into streams or rivers-which eventually run into the oceans-or into oceans, lakes, and ponds. This water in the rivers, streams, oceans, lakes, and ponds is once again evaporated by the sun and starts the cycle all over again.

In each step of the hydrologic cycle, however, it is possible for the water to dissolve and pick up impurities.

Impurities in Water

A **SOLVENT** is a liquid in which other substances dissolve. Because water dissolves many kinds of substances, water is called the "universal solvent." This is why natural water contains many different kinds of impurities.

The rain falling through the air may pick up pollutants from factories and from automobile exhaust. This is how "acid rain," which is harmful to plant life in forests and fish in lakes, develops.

Decaying plants and animal matter in the soil through which a stream flows may be picked up. For example, natural organic substances are often found in rivers, lakes, and streams. **ORGANIC SUBSTANCES** are substances which contain the chemical element, carbon.

NATURAL ORGANIC SUBSTANCES are substances which were once part of living things: plants or animals, such as parts of leaves, sticks, decaying matter, or substances formed by the interaction of water and such materials.

Minerals in the rock through which water flows will contaminate the water. Iron, for example, is found in well water in many parts of the U.S. because it is found naturally in the rock and soil.

Water running off farm fields may contain nitrates, nitrites, and ammonia from fertilizers and manure and also agricultural chemicals from **PESTICIDES** used to control insects or **HERBICIDES** used to control weeds.

Chemical and industrial wastes from factories, processing plants, and construction sites may be dumped into rivers or lakes. Sometimes waste materials and chemicals stored in dumps or pits leak into underground water sources, surface water, or wells.

Leakage from sewage treatment plants, sewer lines, livestock feed lots, or septic systems can contaminate water sources with dangerous disease-causing germs.

Even household plumbing pipes can contaminate drinking water if the pipes are deteriorated or are soldered with lead solder.

Kinds of Water Contaminants

There are five basic kinds of water contaminants found in the United States:

1. **MICROBES** (bacteria, viruses, cysts, algae and other types).
2. **TURBIDITY** (sometimes called sediment or **PARTICULATES**) are solid particles (dirt, leaf or other natural organic particles, rust, sand, etc.) suspended in the water.
3. **DISSOLVED INORGANIC SUBSTANCES** are dissolved substances not containing carbon. Many inorganic substances, such as minerals (calcium, magnesium, iron etc.) occur naturally in soil or rock formations. Heavy metals, such as lead and cadmium, may enter water supplies from industrial plants or bad plumbing.
4. **SYNTHETIC ORGANIC CHEMICALS (SOCS)** are organic substances which are man-made, such as petroleum-based products like gasoline or fuel oils. Synthetic organic chemicals also include insecticides and herbicides from farms; industrial solvents from factories; degreasers used in homes, factories, and auto shops.

   VOLATILE ORGANIC CHEMICALS (VOCS) are synthetic organics which turn into gases at lower temperatures than most organics. One common class of VOCs is the **TRIHALOMETHANES (THMS)**, which are formed when natural organic matter decays in water which has been chlorine-treated. For example, chloroform is a THM.
5. **RADIOLOGICAL SUBSTANCES** are materials which give off some kind of radiation, such as radon or radium.

Reducing Water Contaminants

Water treatment systems maintained by cities and towns (called **MUNICIPAL WATER SYSTEMS**) put raw, untreated water from lakes, rivers, or wells through water treatment processes to reduce the number of pathenogenic microbes, particulates and organic matter, and inorganics (minerals).

Municipal water systems are required by law to meet certain standards related to certain contaminants and to make their water potable according to the standards of the U.S. Environmental Protection Agency (U.S. EPA).

The most commonly used method of disinfection is **CHLORINATION**. Chlorine (which comes in several forms) is used to kill or inactivate microbes. Chlorination used over the past approximately 100 years has tremendously reduced such previously common waterborne diseases as typhoid and cholera.

Although chlorine disinfection has generally been effective for removing microbes, one category of microbes, called cysts, have proven to be resistant to the chlorine disinfection treatment. **CYSTS** form very hard shells around themselves and these shells make the microbes very resistant to chemicals, including chlorine.

One pathenogenic cyst which people have known about for quite some time is **GIARDIA LAMBLIA**. Giardia is very often found in water in wilderness areas with abundant wildlife and the intestinal illness it produces is therefore sometimes called "beaver fever"—although Giardia is also carried by many other animals.

A more recently identified cyst is **CRYPTOSPORIDIUM**, which causes intestinal illness and caused thousands of people to become ill in Milwaukee in 1992. Smaller outbreaks in several other cities have also been caused by Cryptosporidium.

Another discovery that has caused concern about the use of chlorine is the discovery that using chlorine may create additional problems. The chlorinated water combines with natural acids from decaying plant matter (and with other chemicals) to form trihalomethanes (THMs), which are suspected of being carcinogens (cancer-causing agents).

Because of these new discoveries about cysts and about chlorine, newer methods of disinfection, including a varied form of chlorine called **CHLORAMINE**, are coming into use in municipal treatment plants.

Water Potability Requirements

Municipal water systems must meet U.S. EPA requirements regarding potability and other contaminants, including turbidity and other regulated contaminants. Such systems are required by law to provide public reports of the kinds and amounts of contaminants which are in water as it leaves the treatment plant.

However, other non-municipal systems may have to meet potability requirements and certain EPA requirements too because they are defined as **PUBLIC WATER SYSTEMS**. Under the 1996 Safe Drinking Water Act, a public water system is a system that produces potable water and has 15 or more outlets or serves 25 or more customers at least 60 days per year.

This means that rural restaurants, rural schools, out-of-the city subdivisions, and other businesses or institutions on individual wells may be considered public water systems.

Such businesses as campgrounds, parks, and transient trailer parks may be classified as **SMALL PUBLIC WATER SYSTEMS** (serving up to 10,000 people per year) and may have to meet certain EPA reporting and treatment requirements because they serve the public.

The requirements that must be met vary according to the type and size of the system, and state requirements may be stricter than federal EPA requirements. According to U.S. EPA figures, there are more than 50,000 small public water systems in the U.S., many of which may be looking for residential-type water treatment equipment in the future in order to meet stricter requirements under the new law.

Because many of these small systems may serve a building, or just a few buildings, and because they do not have the money to create multi-million dollar municipal-style treatment plants, these small systems are possible customers for the kind of equipment discussed in this course. The U.S. EPA has officially recognized that this type of equipment may be especially appropriate for small systems such as listed above. HOWEVER: most of the equipment discussed in this book is designed for use on water already meeting potability standards, **so small systems must ensure potability first of all.**

The kinds of impurities found in water vary from place to place, even from building to building within a city or town. The report from the city water system refers to the water leaving the city plant, but the water is carried long distances through city distribution pipes. The distance between the home and the treatment plant affects content. Also the water must go through the piping system in the building, which can affect content.

Approximately 20 percent of the drinking water in the United States is water from privately owned wells. Well waters vary depending upon the rock or soil surrounding the well and upon the piping system of the home or building.

Many private well owners do not know exactly what kinds of contaminants may be in their well water because they have not had the water tested. Because private wells are not municipally treated, it is the responsibility of the well owner to make sure the water is potable and safe to drink. Well owners should make sure that their water passes all potability tests and should consider testing for other contaminants if there are possible reasons (factories, landfills, or heavy agriculture nearby, for example) for concern.

While some contaminants produce symptoms such as smell or staining of clothes or fixtures, others do not. The only way to know what is in the water supply of a building is to have it tested.

State-certified laboratories must do the testing for microbes and potability. The state can provide a list of certified laboratories, or the county water authority or the extension agency may have such a list available. Testing for other contaminants may have to be done by labs approved by the state environmental department.

As previously stated, if the private well serves a public water system, the system will probably be subject to certain regulations.

Water Treatment by Public Water Systems

The **SAFE DRINKING WATER ACT OF 1974 (SDWA)**, the 1986 amendments to the SDWA, and the reauthorized Safe Drinking Water Act of 1996 require the United States Environmental Protection Agency (U.S. EPA) to create rules about the treatment of drinking water by public water systems.

The EPA has developed a list of Primary and Secondary contaminants which places limits (called **MAXIMUM CONTAMINANT LEVELS** or MCLs) on how much of each contaminant is acceptable in drinking water. Additional contaminants and regulations are added from time to time.

Primary contaminants are those which have been identified as clearly posing health risks and these are enforceable by the U.S. EPA through the public water systems. Secondary contaminants are recommended for water systems, but some of these contaminants relate only to conditions which make the water unpleasant (bad taste, bad odor) but not necessarily health risks. Secondary contaminant MCLs are not enforced by EPA.

Visit the EPA's Website at http://www.epa.gov/safewater/contaminants for a complete list and more details.

Many municipal treatment systems are old and will need improvements to be able to meet the new regulations in the 1996 Safe Drinking Water Act. And many cities and towns do not have the money to upgrade their treatment facilities very rapidly.

Therefore, residential-type water conditioning equipment such as that described in this volume will be in demand by homeowners, small businesses, and small public water systems. Some public water systems are already considering recommendation of such equipment for individual households as a cheaper way to meet certain contaminant requirements.

NATIONAL PRIMARY DRINKING WATER REGULATIONS (NPDWRS) or primary standards are legally enforceable standards that apply to public water systems. Primary standards protect public health by limiting the levels of contaminants in drinking water.

PARTIAL LIST OF U.S. EPA REGULATED DRINKING WATER CONTAMINANTS

Primary Contaminants			
Microorganisms	Organics	Inorganics	Radionuclides
Cryptosporidium	Aldacarb	Arsenic	Alpha particles
Giardia lamblia	Atrazine	Asbestos	Beta particles and photon emitters
Heterotrophic plate count	Benzene	Copper	Radium 226 and Radium 228 (combined)
Legionella	Chlordane	Fluoride	Uranium
Total Coliforms (including fecal coliform and E. Coli)	Ethylbenzene	Lead	
Turbidity	Lindane	Mercury	
Viruses (enteric)	Methoxychlor	Nickel	
	Tetrachloroethylene	Nitrates/Nitrites	
	Trihalomethanes	Sulfate	
	Vinyl chloride		

Secondary Contaminants		
Aluminum	Fluoride	pH
Chloride	Foaming Agents	Silver
Color	Iron	Sulfate
Copper	Manganese	Total Dissolved Solids
Corrosivity	Odor	Zinc

NATIONAL SECONDARY DRINKING WATER REGULATIONS (NSDWRS) or secondary standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.

There are two reasons it is important to know what is in the water to be treated:

1. In order to know what equipment to recommend to reduce the contaminant or solve the known water problem; and
2. To be sure that there are no other substances or conditions in the water that would prevent the equipment from operating effectively.

Some water problems present obvious symptoms, such as the scum that forms around the bath tub from hardness in the water, or the red iron stains on the laundry.

Even if such obvious symptoms are present, some water testing may still be needed to determine exactly what is causing the problem and how bad it is: How hard is the water? How much iron is there? How much sediment?

Other contaminants may have no easily detectable symptoms or may interact with each other to complicate analysis. Other substances or water conditions which may not be causing problems detected by the customer may, however, cause your recommended equipment to work less effectively than predicted.

Testing Water

The contractor, salesperson, or customer may take the water sample for testing. There are several approaches to getting the actual testing done. Some wholesalers or manufacturers may prefer that their contractors perform some tests in the field using test kits purchased from the wholesaler or manufacturer. Sometimes the customer may use the kits and do the simple testing. There are some advantages to field testing. The customer won't have to wait for test results and will have less time to decide not to buy. Also, some contaminants may change in concentration if there is too much time between taking the sample and having the sample analyzed. For service calls, it is helpful to use on-site testing.

However, the contractor must be quite sure that he knows how to take the sample properly and how to read the analysis properly. Contractors who feel sure that they understand the testing procedures may want to do simple testing in the field and use their wholesalers or manufacturers for backup analysis.

Other wholesalers or manufacturers prefer that the contractor just take the water samples and send them to the wholesaler for analysis.

Wholesalers who handle water conditioning equipment can perform testing for simple contaminants such as hardness, iron, and pH (acidity). But wholesalers and contractors should probably depend on their manufacturers for detailed analysis or more complicated testing as well as for resulting recommendations for equipment. Still other wholesalers will have arrangements with the manufacturer so that test water samples will be sent directly to the manufacturer's lab (or other chosen lab) for analysis.

Wholesalers and manufacturers are NOT generally equipped to test for microbes, heavy metals (lead, cadmium), dissolved synthetic organics, or radiologic pollutants. Testing for these contaminants must be done by a certified laboratory recommended by the state. Any testing done for primary contaminants—those indicated by U.S. EPA as health contaminants—should probably be analyzed by a certified laboratory.

Available Tests

Among the tests which should be available from the wholesaler/manufacturer are:

- Hardness (Calcium, Magnesium)
- Turbidity (Particulates: undissolved solid matter)
- Total Dissolved Solids (TDS) (Minerals)
- Acidity (pH)
- Alkalinity (Acts as a check on the accuracy of the acidity test)
- Sodium
- Chloride (Road Salt)
- Iron
- Sulfate (High sulfates prevent effective operation of equipment)

In addition to the above tests, private wells often need to be tested for:

- Nitrates (from fertilizer run off)
- Manganese (often found with iron in well water)
- Microbes (because private well water has not been certified as potable by a municipality)

If it is known that rock formations or soil of the area contain other undesirable inorganics, or there is reason to believe the water may contain synthetic organics, additional testing should be done at a certified laboratory.

Municipal water systems are required to regularly test their water supplies against U.S. EPA standards and to notify water users if any contaminants are at levels higher than recommended MCs. These systems are required to make available information about the makeup of the water.

As mentioned before, private well owners must be responsible for the safety of the water themselves.

In either case, if there is reason to believe that the drinking water contains dangerous levels of pathenogenic microbes, contains lead or other heavy metals, has synthetic organic materials, or is contaminated by radiological pollutants, it is important that the water be tested by a certified laboratory.

State health departments certify labs to test for microbes. However, laboratories which test for other contaminants may be certified by the state environmental agency. If the water is to be tested for several kinds of contaminants, it may be necessary to use several different labs.

To locate state-certified labs, contact the local or state department of public health (for microbial tests) and/or the state environmental agency (for other tests).

In rural areas, the county extension agent may know where well owners may get water tested.

Some labs do not yet test for synthetic organic substances. However, if the homeowner has reason to believe that these chemicals may be in the water supply, such testing should be done, as many of these chemicals are considered quite dangerous in drinking water.

Sometimes it may be necessary to locate laboratories through the Yellow Pages (hard copy or online at Yellowpages.com™) or other locations on the Web. Ask for evidence that the lab is state-certified; be sure to get several estimates; and be sure that labs will test for the suspected contaminants that are of concern.

Grades of Water

In previous sections we have been discussing the requirements to provide **DRINKING WATER**—water which is safe for human drinking and cooking.

However, much of the water used by a home or a business does not have to be as pure and clean as drinking and cooking water.

In fact, there are various "grades" of water which are used by homeowners and small business owners.

UTILITY GRADE WATER is water that is used to water the lawn, wash down the driveway, or wash the car. On a farm, utility water might be used for irrigation or fire fighting.

In general, this is water just as it comes from the well or the municipal water system and is piped to outdoor faucets. Mostly it needs to be wet! No conditioning is needed.

Some factories or processing plants have even lower quality water because the water they use may be recirculated and may not need to be even as clean as utility grade water.

HOUSEHOLD GRADE WATER is water used for household cleaning, laundry, and bathing.

Household grade water should be clean, comparatively free of particles of dirt, free of any impurities that would stain laundry, free of high levels of calcium and magnesium which cause hard water scum, and non-corrosive so that it won't eat up plumbing and appliances. Most people also want household water to be free of offensive odors and color.

Treating Water

When treating household grade water, the conditioning processes are generally done as **WHOLE-HOUSE WATER CONDITIONING**. This means that the treatment affects all of the water from all outlets inside the whole house.

The treatment equipment is placed at the "point-of-entry" into the house from the outside water lines. For this reason, whole-house treatment is also called **POINT-OF-ENTRY (POE) WATER CONDITIONING**.

Equipment for whole-house treatment is usually placed in the basement or utility room.

Household grade water may require filtering to remove sediment and particulates, treatment to remove iron and manganese, softening to remove excess calcium and magnesium (hardness), carbon filtration to remove some odors and colors, and/or special treatments to remove the "rotten egg" smell of hydrogen sulfide.

In some cases, the water will need to be treated for corrosivity, which may be related to highly acidic or highly **ALKALINE WATER**.

Well water may require chlorination or ultraviolet treatment to kill bacteria.

Drinking water is water to be used for drinking or cooking. In addition to all of the requirements mentioned above for house-hold grade water, drinking water must taste good and be free of any contaminants (microbes, inorganics, organics) which might be harmful to human health.

Treatment of drinking/cooking water is very often done **POINT-OF-USE (POU)**, at the faucet from which drinking water is to be drawn. This way only the water which is actually used for drinking is treated. Point-of-use equipment may be hooked into a water line serving the existing faucet and placed either under the sink or on a counter-top.

Some units require that a separate faucet be purchased for use with the equipment. Other devices attach directly onto the existing faucet in place of the usual aerator.

This point-of-use placement requires that most of the family draw their drinking water from the kitchen faucets. For this, and other reasons, some families prefer to treat their drinking water on a whole-house basis, though this is generally more expensive.

Water Treatment Strategies

When planning the treatment strategies for solving household water problems, it is important to keep in mind the uses for the various grades of water.

It may be too expensive to treat all of the water coming into the house, especially if the problem really affects only drinking water. Chlorine taste leftover from municipal treatment is often treated at point of use because nobody cares if water for laundry or dishwashing tastes like chlorine.

Some problems are not dangerous at all, but only "aesthetic problems" which make the

water unpleasant to use, such as a harmless but unpleasant smell.
In this case, whole house treatment may be desirable, because few people want to bathe in water that smells fishy. When treatment is planned, it is important to consider what the problems are, how much of the water needs to be treated, what is the most effective treatment, what the customer wants, and how much treatment costs. Because many homes will have several water problems, it is often necessary to use several different water treatments in the same house.

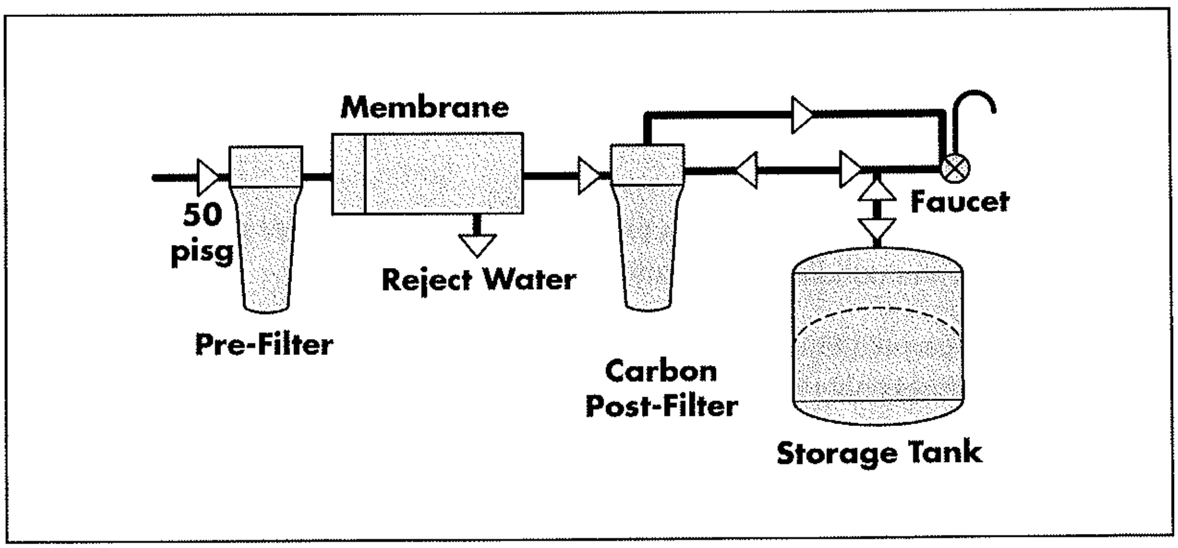
Often two problems are related to each other. For example, in an older home, the plumbing pipes may be a source of lead contamination. In addition to treating drinking water at point-of-use to remove lead, it is advisable to consider whole-house treatment to neutralize the acid in the water (if the water is acidic) to lessen the leaching of lead from pipes and lead solder.

A home may have several completely unrelated problems which require installation of a well-planned sequence of treatment processes. It is important to plan out the flow of water so that all equipment works efficiently and the various problems are solved effectively.

For example, reverse osmosis point-of-use treatment may be needed to remove nitrates (often found in water in rural areas) from drinking water and an activated carbon filter may be needed to remove a disagreeable "fishy" smell caused by harm-less organic matter in the lake from which the water comes.

Because reverse osmosis membrane filters are easily clogged, a prefilter to remove sediment is often used to prevent premature clogging of the membrane and make the reverse osmosis unit more efficient.

TYPICAL RO SYSTEM WITH PRESSURIZED STORAGE TANK



SP 5.1.03

If the water in the home mentioned above is being drawn directly from the lake—without being treated by a public water system—it will be necessary for the family to disinfect the drinking water to assure that it is potable.

Disinfection of the drinking water by chlorination, ultraviolet, or ozonation should be done before the water is run through the activated carbon filter because "raw" water which has not been disinfected contains microbes which may grow and multiply on the carbon's surface.

However, some reverse osmosis filter membranes are destroyed by chlorine. So if chlorination (which is a whole house process) is used to disinfect, the chlorine left in the water from chlorine disinfection must be removed, usually with a carbon pre-filter cartridge, before the water is run through the membrane.

Just as no single test will test for all possible water contaminants, no single treatment method will work on all possible water problems.

Planning an effective treatment for a home water system with several problems requires a basic understanding of water chemistry, an understanding of what various types of equipment can and cannot do, and an understanding of how treatment of water by one method could affect the workings of the other types of treatment used in the overall household treatment system.

It is absolutely essential that salespeople who assist in the planning of residential water conditioning systems and selling of water conditioning equipment be thoroughly familiar with the manufacturer's product literature and take advantage of all training offered by the manufacturer(s) whose equipment they sell.

IT IS IMPORTANT THAT SALESPEOPLE MAKE NO CLAIMS ABOUT THE EFFECTIVENESS OF ANY PIECE OF EQUIPMENT UNLESS IT IS CLEARLY STATED IN THE MANUFACTURER'S LITERATURE THAT THE EQUIPMENT CAN SOLVE THE PARTICULAR PROBLEM.

Both the **WATER QUALITY ASSOCIATION (WQA)** and the **NSF INTERNATIONAL** test water conditioning equipment performance against water quality industry standards. Manufacturers generally have a choice about whether to have their equipment tested since such testing is usually not required by law. However, a legitimate use of the WQA gold seal or the NSF mark on equipment or sales literature shows that the equipment met the recommended standard.

REVIEW QUIZ – INTRODUCTION TO WATER

Answers appear on page 24

DIRECTIONS: Carefully read each question and circle the correct answer. There is only one correct answer per question. When you have finished, check your answers.

1. Chemically pure water is made up of almost no other molecules except hydrogen and
   a. carbon dioxide.
   b. oxygen.
   c. carbon.
   d. solvents.

2. Microscopic organisms which cause diseases are called
   a. synthetic organic chemicals.
   b. volatile organic chemicals.
   c. pathenogenic microbes.
   d. radiological substances.

3. Substances that were once part of living things or substances formed by the interaction of water and these substances are called
   a. solvents.
   b. organic substances.
   c. natural organic substances.
   d. dissolved inorganic substances.

4. Another name for solid particles such as leaves, dirt, or other natural organic particles, is
   a. microbe.
   b. turbidity.
   c. herbicide.
   d. trihalomethane.

REVIEW QUIZ – INTRODUCTION TO WATER

Answers appear on page 24

5. All of the following are common types of primary water contaminants in the United States EXCEPT
   a. Alkalinity
   b. Total Dissolved Solids (TDS)
   c. Turbidity
   d. Microbes

6. Which type of water system serves 25 or more customers, produces potable water, and has 15 or more outlets?
   a. Municipal
   b. Public
   c. Private
   d. Community

7. What percentage of the drinking water in the United States comes from private wells?
   a. 70 percent
   b. 50 percent
   c. 40 percent
   d. 20 percent

8. Which of the following is an important reason to know what is in the water being treated?
   a. To be able to recommend treatment equipment to solve the known water problems
   b. To be able to recommend the least expensive solution to the water problems
   c. To know how many potential chemicals are in the water
   d. To determine the number of potentially deadly viruses in the water

9. Water that is used for irrigation on a farm is called
   a. drinking water.
   b. household grade water.
   c. utility grade water.
   d. conditional water.

REVIEW QUIZ – INTRODUCTION TO WATER

Answers appear on page 24

10. One type of microbe that has proven to be resistant disinfection by chlorine is
    a. copper.
    b. chloramine.
    c. cyanide.
    d. cysts.

APPLYING WHAT YOU HAVE LEARNED:

By observing and asking questions, fill in the blanks. If you are not sure of the answers, ask your supervisor.

A. List several tests which should be available from the wholesaler to test water quality.

____

____

____

B. List some methods that might be used to find a certified water testing laboratory.

____

____

____

ANSWERS TO REVIEW QUIZ

CHAPTER 1

INTRODUCTION TO WATER

Answers to REVIEW OF INTRODUCTION TO WATER (pages 20 – 22)

1. b. oxygen.
2. c. pathenogenic microbes.
3. c. natural organic substances.
4. b. turbity.
5. b. Total Dissolved Solids (TDS)
6. b. Public
7. d. 20 percent
8. a. To be able to recommend treatment equipment to solve the known water problems
9. c. utility grade water.
10. d. cysts.

Applying what you have learned:

A. Tests available from the manufacturer could include: Hardness, (Calcium, Magnesium), Turbidity (Particulates: undissolved solid matter), Total Dissolved Solids (TDS) (Minerals), Acidity (pH), Alkalinity (Acts as a check on the accuracy of the acidity test), Sodium Chloride (Road Salt), Iron, and Sulfate (High sulfates prevent effective operation of equipment).

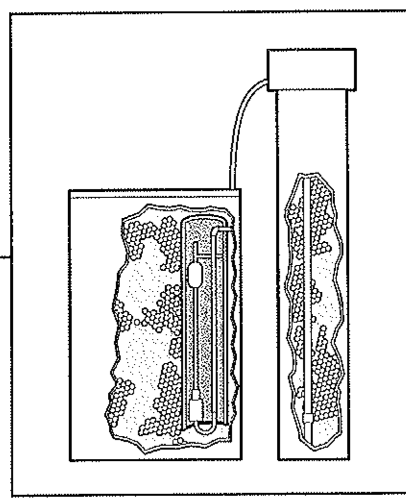
B. Call the state or public health department or environmental agency. Call the county extension agent; check the Yellow Pages or the Web.

2 ION EXCHANGE WATER TREATMENT

LEARNING OBJECTIVES

When you finish this Chapter, you will be able to:

1. Explain why and how hardness is measured in water.
2. Describe the three basic parts of a water softener unit and compare their functions.
3. Describe the types of control devices used to trigger regeneration when needed.
4. Discuss how the efficiency of a water softening unit is measured.
5. Compare and contrast the two-bed system and the mixed-bed system of deionization.



WATER TREATMENT

Ion Exchange Water Treatment Basics

The most common kind of water processing is water softening. Water softening technology has been available for residential use for many years and the public is familiar with it.

WATER SOFTENING is the process of removing the minerals calcium and magnesium (in their chemical forms called "carbonates" or "bicarbonates") from "hard" water, which otherwise has high levels of these natural minerals.

HARD WATER is recognized by the homeowner when a scum or scale forms around the bathtub. This scum is formed when water containing high levels of calcium and magnesium is heated.

The hardness of water is usually measured in **GRAINS PER GALLON** (gpg), **MILLIGRAMS PER LITER** (mg/L), or **PARTS PER MILLION** (ppm) of calcium or magnesium. Ppm and mg/L are equal to each other. That is, one part per million is equal to one milligram per liter.

In the water treatment industry, a general definition of hard water is water with more than three grains per gallon of calcium and magnesium.

Although the commonly used definition of hard water is three grains per gallon, more precise measurements of hardness are needed under certain conditions such as for scientific work, some kinds of manufacturing, or in boiler systems.

The table below shows the degrees of hardness of water set by the Water Quality

MODEL B RADIATION BASEBOARD

DEGREES OF WATER HARDNESS		
Level of Hardness	Grains/gallon	Parts/million or milligrams/liter
Soft	Less than 1.0	Less than 17.0
Slightly hard	1.0 to 3.5	17.1 to 60
Moderately hard	3.5 to 7.0	60 to 120
Hard	7.0 to 10.5	120 to 180
Very hard	10.5 and above	180 and above

Association.

For both homes and businesses, soft water has many advantages. The lack of scum and scale makes household or custodial cleaning easier. Soft water improves domestic cleaning processes including laundry, dishwashing, and housecleaning. Cosmetic cleansing products and soaps for personal hygiene clean better in soft water.

Preventing hard-water scale buildup also prevents scale buildup in plumbing pipes and allows water heaters to work more efficiently.

As we will see later, water softening is always a point-of-entry (whole-house) treatment because all of the water needs to be softened to produce the benefits listed above.

Water Softening Alternatives

One concern sometimes expressed about use of water softening systems is the addition of small amounts of sodium to drinking water.

As we shall see in the next few sections, the customary process of softening water requires the use of common salt (sodium chloride) as a regenerant. Although the amount of sodium left in the water is extremely small; the actual amount of sodium which enters the water depends upon the hardness of the incoming water to be softened.

In situations where individuals drinking the water are on medically-supervised sodium-restricted diets, one or more hard water faucets may be left (by bypassing the softener) to provide drinking water which has not been softened.

Another alternative is to use **POTASSIUM CHLORIDE** as a regenerant instead of sodium chloride. Potassium chloride is commercially available for use in softeners, although it is more expensive.

Or a point-of-use (countertop or undersink) water processing unit, such as a reverse osmosis system or distiller, may be installed to remove virtually all sodium (both naturally-occurring sodium and softener-produced sodium) from the drinking water.

Ion Exchange Process

The usual process for softening water for residential / small commercial use is the chemical process of ion exchange.

An **ION** is an atom or group of atoms with a positive or negative electrical charge.

Calcium, magnesium, and sodium all have ions with positive charges.

The **ION EXCHANGE PROCESS** is a reversible chemical process in which ions from an insoluble permanent material (called the ion exchanger or the resin) are exchanged for other ions in a solution surrounding the exchanger. The ion exchange process can be used to remove many different kinds of ions, depending upon which kind of ion exchanger is used.

In a water softener unit, the undesirable calcium and magnesium ions in the hard water are exchanged for the more desirable sodium (or potassium) ions from the ion exchanger resin in the water softener. This substitution "softens" the water.

- An ion which has a positive charge is called a **CATION** (pronounced *CAT eye on*).
- An ion which has a negative charge is called an **ANION** (pronounced *AN eye on*).

Because calcium, magnesium, and sodium ions are cations, the water softening process is called **CATION EXCHANGE**.

In an ion exchange process, cations can be exchanged only for other cations, and anions can be exchanged only for other anions.

The ion exchanger from which the sodium ions are taken is usually a synthetic material which looks much like sand. This is called the **CATION EXCHANGE RESIN**.

There are several kinds of cation exchange resin in use. Check with your manufacturer if you need to learn the name of the exchange resin used.

Water Softening Cycle

However, the exchange process which softens the water is only half of what must occur in a water softening system.

A water softener goes through two cycles: the softening cycle and the regeneration cycle.

Eventually, after a large volume of hard water goes through the resin, almost all the sodium ions have been used up and replaced in the resin by calcium and magnesium. The resin has been "exhausted" and can no longer soften water effectively.

It is then necessary to **REGENERATE** or "recharge" the resin by reversing the original process and putting more sodium ions back into the resin. To do this, the homeowner (or a service man from the company that sold the unit) must regularly add softener salt (sodium chloride or potassium chloride) to the softener unit.

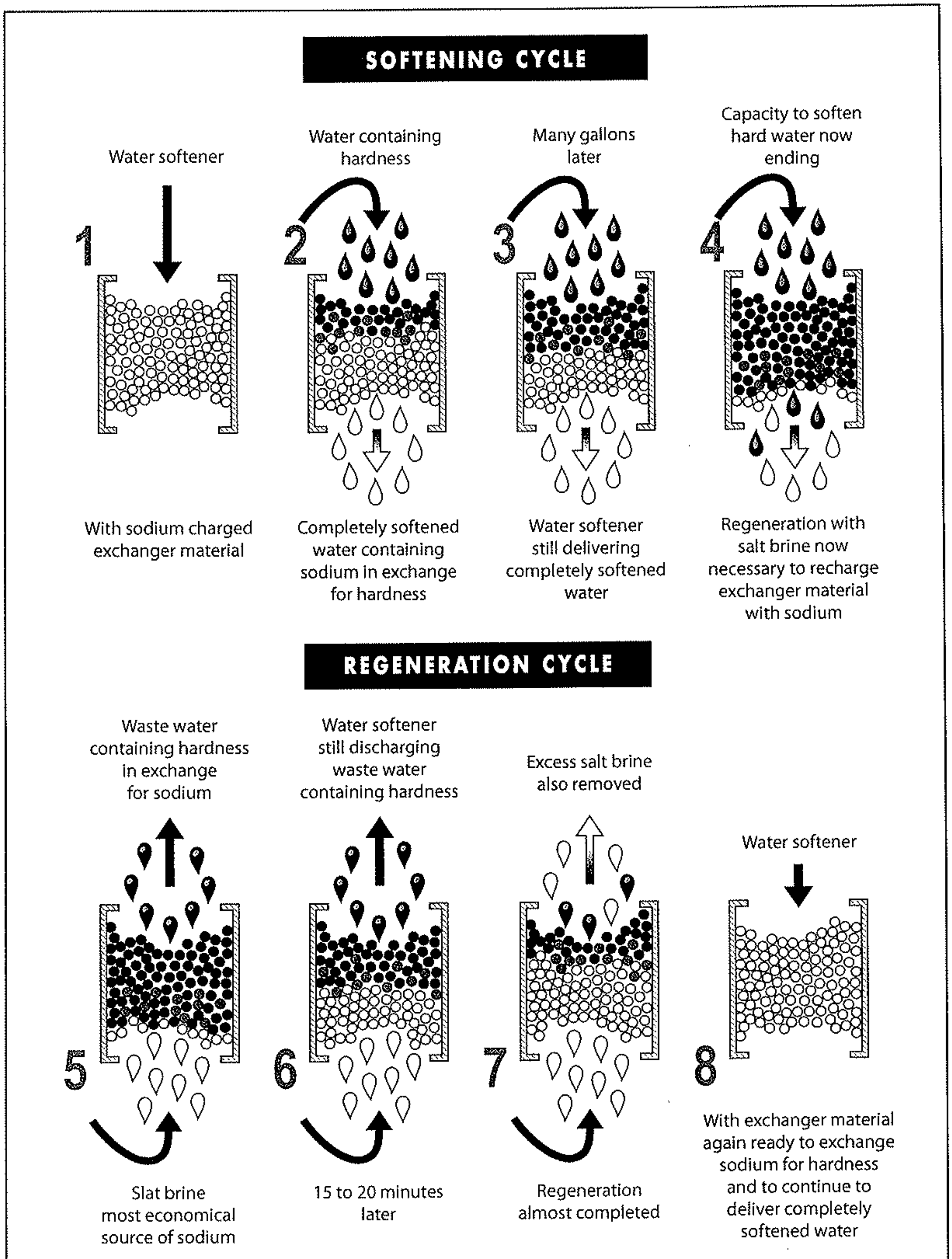
By flushing the softener tank with brine (salt water) created when softener salt is added, the softener resin is "regenerated"—that is, the sodium ions from the brine replace calcium and magnesium ions which have been left in the cation exchange resin as the result of having softened many gallons of hard water.

One of several different types of control devices may be used to trigger **REGENERATION** when needed:

- A timer, usually set for early morning hours, may automatically kick off regeneration every so many days.
- A flow meter may measure the amount of water that has passed through the system and start the recharging process at a set volume of water.
- A sensor may sense when the resin is exhausted and set off the regeneration cycle.

The illustration on the next page shows what happens during the two cycles of a water softener.

HOW WATER SOFTENER EXCHANGERS WORK



NOTE: Counter - current brining.

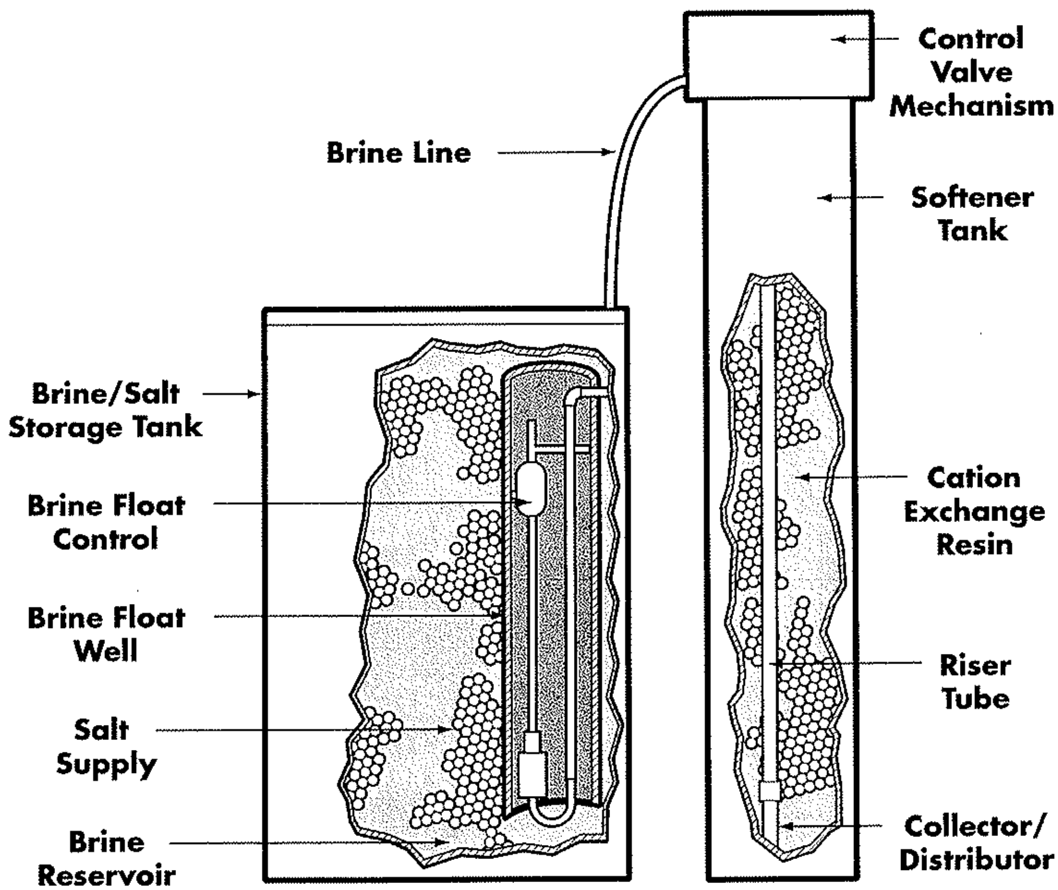
System Components

A water softener system has three basic components:

1. A pressurized resin tank (or softener tank) containing a bed of cation exchange resin;
2. A container, or **BRINE TANK**, to store the salt and provide the necessary mechanical system to create brine; and
3. The controls to regulate the proper timing and operation of the two cycles.

Some models of softeners come with the brine tank that is completely separate from the resin tank, but many modern softeners have both the resin tank and the brine tank enclosed within the same housing module.

HOME WATER SOFTENER WITH AUTOMATIC CONTROLLER FOR REGENERATION AND SERVICE



Note: Not all manufacturers use brine floats.

SP 5.2.02

Choosing the Proper System

The efficiency of water softeners is measured in grains of hardness removed per pound of salt and/or total grains of hardness removed per regeneration. It is important to have a good idea how hard the customer's water is in order to provide the proper size softener for his/her needs.

The water usage of the home, apartment, or business to be served may also affect the choice of softener model needed. It is better to have greater capacity than needed rather than having an undersized unit.

If the homeowner is to service his/her own unit, the frequency of regeneration and the amount of salt needed may be important factors in model choice. These factors may be particularly important if lifting and carrying of replacement salt is likely to be a problem.

Removing Dissolved Minerals

In most cases, natural water has several kinds of dissolved minerals in it, in addition to calcium and magnesium, because water is such a good solvent. The dissolved mineral content of water is measured in milligrams per liter (mg/I) or parts per million (ppm) of **TOTAL DISSOLVED SOLIDS (TDS)**.

Water which has a low level of TDS is considered corrosive or **AGGRESSIVE WATER**. **CORROSIVE WATER** will eat away or dissolve metals, including steel or lead plumbing pipes or lead solder.

Because some water which is naturally soft, without much hardness, is also corrosive, some people previously felt that water which had been softened by cation exchange would be more corrosive. However, a recent long-term study performed by the U.S. EPA, financed by both the EPA and the Water Quality Association, showed that water softened by cation exchange will NOT be more corrosive than that particular water was when it entered the softener. This is because the amount of TDS is not really reduced; salt just replaces the calcium and magnesium and the TDS count remains basically the same.

Most cation exchange water softeners will also remove small amounts of iron and manganese which are dissolved in the water.

Dissolved iron is often called *clear water iron* because you cannot see it in water. However, clear water iron can cause brown stains on plumbing and laundry fixtures.

The iron removal capacity of a softener is indicated in ppm per pound of salt. If there are large amounts of iron in the water, other kinds of water treatment (discussed later in this course) must be used to remove it.

In fact, large amounts of iron in the water will cause a softener to be less efficient, and pre-treating the water for iron **BEFORE** it comes into the cation exchange softener is probably advisable.

Anionic Nitrate Reduction System

A different kind of ion exchange process is sometimes used as a point-of-entry treatment to remove nitrate and sulfate in much the same way that water softeners remove calcium and magnesium.

In many agricultural regions of the United States, groundwater has been found to contain high levels of **NITRATE**. This is often due to many years of use of nitrogen fertilizers. Sometimes sulfate is found with the nitrate.

High nitrate levels in drinking water are very dangerous for children, especially fetuses, babies, and young children.

Young animals, like young humans, are especially endangered by high nitrate/sulfate levels, and water supplies for livestock feed-lots must often be treated for high nitrates.

Ion exchange treatment to remove nitrate/sulfate is done with an **ANION EXCHANGE RESIN**, instead of the cation resin used for water softening.

The anionic nitrate reduction system is, however, regenerated with salt, like a water softener. For various chemical reasons, it is usually recommended that the nitrate-bearing water be softened before it is run through the anion resin to reduce the nitrates.

WARNING! Under some conditions, if it is not working correctly, the anion exchange system could actually INCREASE the level of nitrate (called "dumping") in the processed water, as well as making the water corrosive. **Contact your manufacturer for technical details about this problem.**

For this, and other reasons, some experts believe point-of-use methods are better for treating nitrates. This may not be practical, of course, for a large operation such as a feedlot.

Since nitrates need to be removed only from drinking water, not from the utility or household grades of water in a home, nitrates may be removed by use of point-of-use treatment systems, including reverse osmosis and **DISTILLATION**.

It is important that both the untreated and the treated water be retested periodically because nitrate levels in ground water tend to increase with time. Why is it important to regularly test water with high nitrate content?

In areas where water passes through marshy or peaty soils, water may have a yellow color which is noticeable when the water stands in large quantities, such as in a bathtub.

The yellow color comes from special acids called **TANNINS**. The tannins are not considered dangerous to health, but the color is annoying and can become really objectionable. Removal of this yellow color is sometimes difficult.

Water containing high amounts of tannins may be treated with a special anion exchange resin, which is regenerated with salt. The color removal unit is usually installed so that the water flows through the tannin-removal unit AFTER the water has been softened. Iron must also be removed before using this treatment.

Many other dissolved minerals can be removed by the ion exchange process—either by cation exchange, anion exchange, or a combination of both cation and anion exchange processes.

Combined Processes or Deionization

The use of combined processes, cation exchange and **ANION EXCHANGE**, to remove almost all of the ionic content is called **DEIONIZATION** or *demineralization*. The resulting water is called demineralized, **DEIONIZED**, or ultrapure water.

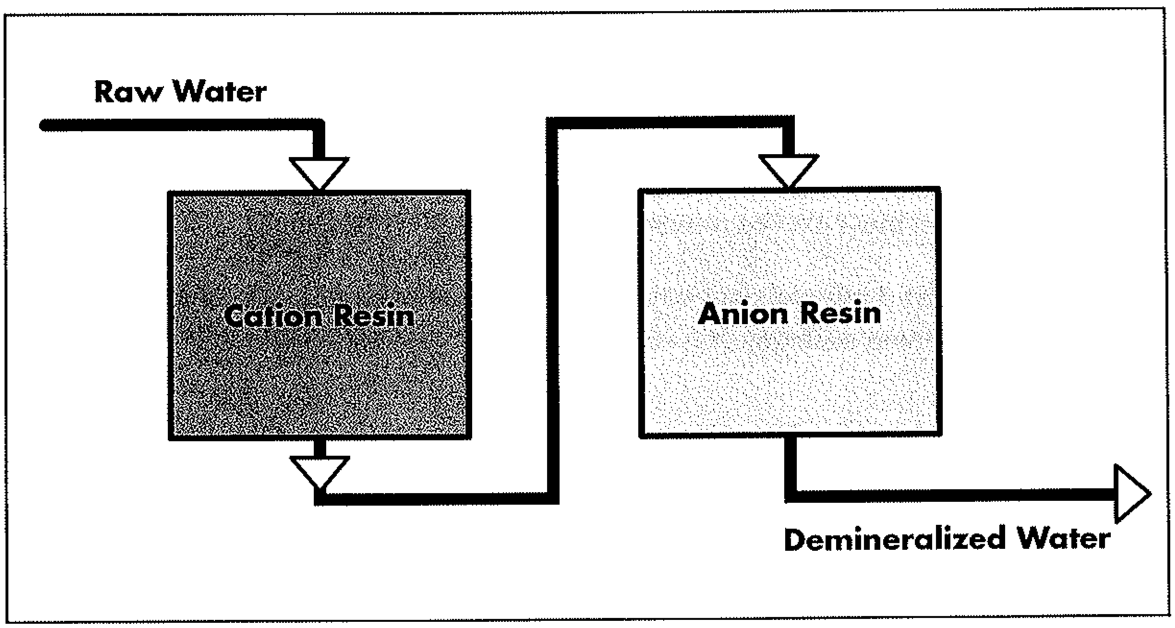
The term "ultrapure" as used here refers to lack of minerals (or other ionic substances) and does not mean that the water has been purified for drinking. Often industrial-use ultrapure water is NOT safe for drinking because it has not been disinfected.

Deionization is used almost exclusively for commercial, industrial, or medical purposes and not for home water treatment. One form of deionization is **DEALKALIZATION**, which is often used to treat water for boiler systems. The deionization processes are quite complicated and generally require the choice of special resins and use of strong chemicals for regenerants. An in-depth discussion of this process is beyond the scope of this course.

Two-Bed System

Sometimes deionization requires two separate beds of resin, one containing cation exchange resin and the other containing anion exchange resin. This is called a **TWO-BED SYSTEM**. Cation resin is regenerated with hydrochloric acid and anion resin with sodium hydroxide (commonly called "lye" or "caustic soda").

TWO BED SYSTEM



SP 5.2.03

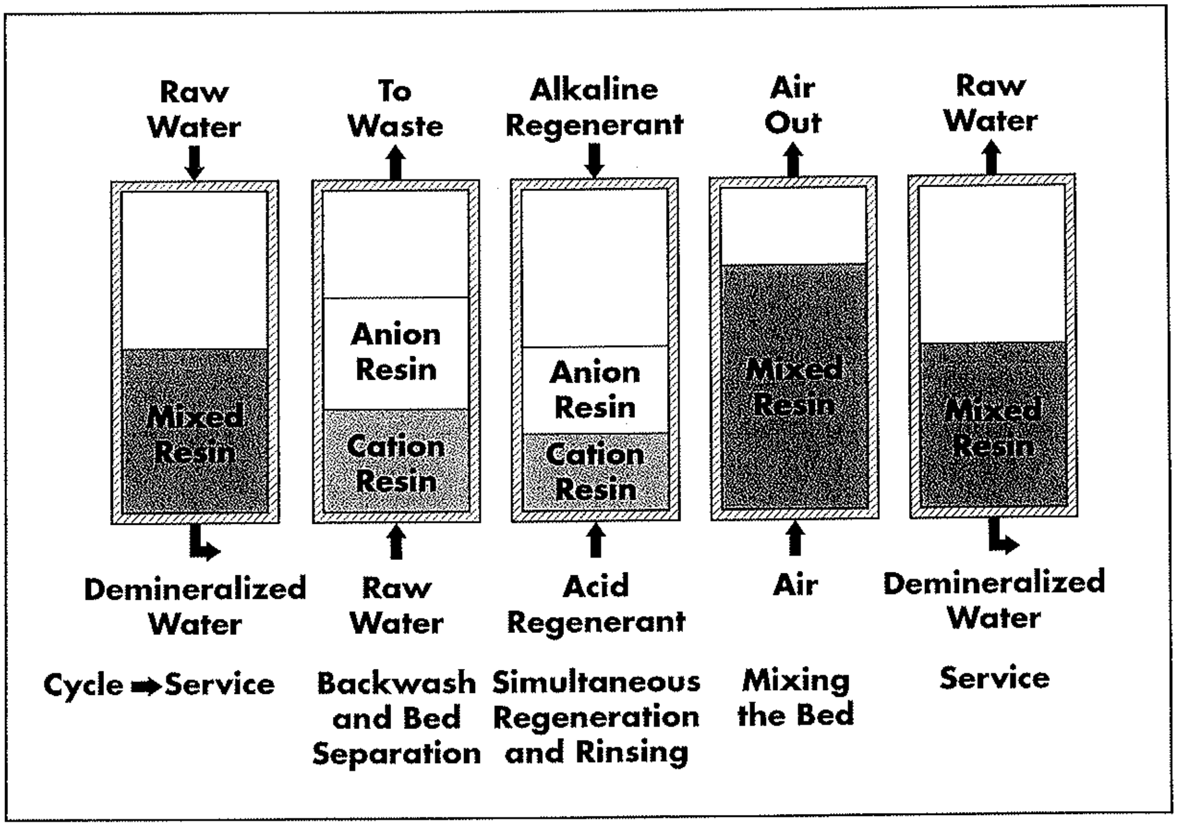
Mixed-Bed System

Some deionization processes use systems with **MIXED BEDS** which contain both cation resins and anion resins in one bed. The use of a mixed bed allows one resin bed to remove both cations and anions and produce deionized water.

During the backwash regeneration cycle, two different types of regenerant chemicals must be used and the mixed bed is actually separated, temporarily, into anion and cation resin beds because the two resins have different densities. After regeneration is complete, air is fed into the tank and the two kinds of resins fall back into mixed form. Regenerating a mixed bed is a very complicated process and is almost never done "in the field." The tank is usually returned to the manufacturer for regeneration.

Some minerals, even though they may be naturally found in a water source, are considered harmful in drinking water if they are at levels above the MCs established by the U.S. Environ-mental Protection Agency. Some mineral only make the water taste bad, such as the salty taste of chloride.

MIXED BED SYSTEM (Batch type-for illustration purposes only)



SP 5.2.04

Among the minerals which can be partially or totally removed by cation exchange, anion exchange or deionization are calcium, magnesium, iron, manganese, nitrate, chloride, arsenic, fluoride, lead, zinc, cadmium, copper, selenium, barium, and radium 226 and 228.

What can be removed depends upon the form of exchange resin used and upon the chemical forms of the minerals present in the particular water.

It is necessary to depend upon the manufacturer's literature to determine what kinds of substances can be removed by a particular conditioning unit. It is very important that you do not sell a treatment system for the purpose of removing anything other than what the manufacturer clearly says this system can remove.

Ion exchange is usually a whole-house (point-of-entry) process. However, small in-line replaceable cartridges containing ion exchange resins for point-of-use demineralization are also available. These cartridges are usually installed on single faucet lines under kitchen sinks or wherever drinking water is drawn. What can be removed by any cartridge depends upon what material is used as exchange resin.

REVIEW QUIZ – ION EXCHANGE WATER TREATMENT

Answers appear on page 44

DIRECTIONS: Carefully read each question and circle the correct answer. There is only one correct answer per question. When you have finished, check your answers.

1. In the water treatment industry, the definition of "hard water" is water with more than 3 grains of
   a. calcium and magnesium.
   b. calcium and sodium.
   c. sulfate and iron.
   d. iron and calcium.

2. Water softening is the process of
   a. adding calcium, magnesium, and other minerals to water.
   b. removing sodium and calcium from water.
   c. removing calcium and magnesium from water.
   d. adding sulfates to water.

3. In order to be called "soft" water, how many grains of calcium or magnesium must the water contain?
   a. 7.0 to 10.5
   b. 3.5 to 7.0
   c. More than 1.0
   d. Less than 1.0

4. In the water treatment industry, water with more than 10.5 grains of calcium per gallon is considered
   a. very hard.
   b. hard.
   c. moderately hard.
   d. slightly hard.

REVIEW QUIZ – ION EXCHANGE WATER TREATMENT

Answers appear on page 44

5. The purpose of the regeneration cycle of a water softener is to
   a. prevent scale buildup in plumbing pipes.
   b. put more sodium ions back into the resin.
   c. remove many different kinds of ions.
   d. regulate the timing and operation of the tank.

6. All of the following are basic components of a water softener EXCEPT
   a. Resin tank
   b. Brine tank
   c. Storage tank
   d. Control valve

7. What is one way the efficiency of a water softening system is measured?
   a. Grains of hardness removed per pound of salt
   b. Grains of salt removed per pounds of brine
   c. Grains of calcium per gallon
   d. Grains of bicarbonates per gallon

8. What is another name for dissolved iron in plumbing fixtures?
   a. Sodium
   b. Cation
   c. Clean water iron
   d. Strained water iron

9. In cation exchange water softening, the hardness ions are exchanged for
   a. potassium or sodium.
   b. nitrates.
   c. sulfates.
   d. resin or sodium.

10. Which of the following is the most frequent cause of high levels of nitrates in drinking water?
    a. Pathenogenic cysts
    b. Acid rain
    c. Industrial waste
    d. Agricultural run-off

REVIEW QUIZ – ION EXCHANGE WATER TREATMENT *Answers appear on page 44*

11. Which process is typically used is remove nitrates, which are especially dangerous for infants and young children, from drinking water?
    a. Cation exchange resin
    b. Anion exchange resin
    c. Dealkalization
    d. Deionization

12. All of the following statements are important for people to remember when dealing with water treatment systems EXCEPT
    a. Contact the manufacturer for technical details if the anion exchange system increases the levels of nitrate in the water.
    b. Not all minerals can be removed by a particular ion exchange treatment system.
    c. Treatment systems may be sold for removing more minerals from the system than the manufacturer states.
    d. Some minerals in drinking water may be harmful if they are at levels

REVIEW QUIZ – ION EXCHANGE WATER TREATMENT

Answers appear on page 44

APPLYING WHAT YOU HAVE LEARNED:

By observing and asking questions, fill in the blanks. If you are not sure of the answers, ask your supervisor.

A. Based on your reading and general knowledge of products, list at least three things a client should consider before purchasing a drinking water purification system.

____

____

____

B. In your opinion, why is it especially important for infants and young children to drink pure water?

____

____

____

ANSWERS TO REVIEW QUIZ

CHAPTER 2

ION EXCHANGE WATER TREATMENT

Answers to REVIEW OF ION EXCHANGE WATER TREATMENT (pages 39 – 42)

1. a. calcium and magnesium.
2. c. removing magnesium and calcium from water.
3. d. Less than 1.0
4. a. very hard.
5. b. To put more sodium ions back into the resin
6. c. Storage tank
7. a. Grains of hardness removed per pound of salt
8. c. Clean water iron
9. a. potassium or sodium.
10. d. Agricultural run-off
11. b. Anion exchange resin
12. c. Treatment systems may be sold for removing more minerals from the system than the manufacturer states.

Applying what you have learned:

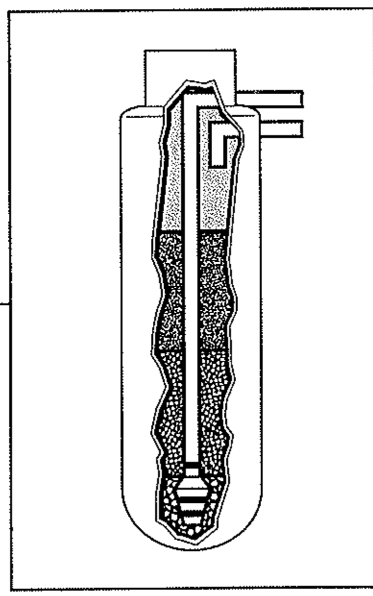
A. Answers may vary but some of the concerns a client might have include: (1) how much purified water is needed per day for drinking and cooking; (2) which contaminants are actually in the water and which ones might occasionally show up (request a report from the water supplier or have the water tested); (3) which contaminants the client is interested in removing; (4) the total cost of the product; (5) whether the product is certified to perform as advertised; (6) whether the product provides safe, good tasting water at a reasonable cost; (7) how much maintenance is required.

B. Answers may vary but could include a discussion of a child's developing immune and detoxification systems. Exposure to trace levels of chlorine, toxic chemicals and lead in drinking water during childhood years has been linked to increased risks of disease and learning disorders in later years. Pure water helps to collect and cleanse these harmful toxins from the body.

3 FILTRATION TREATMENT

LEARNING OBJECTIVES
When you finish this Chapter, you will be able to:

1. Discuss the common reasons that filters are used.
2. Summarize the factors that determine which media is used in a filter.
3. Explain what radon is and discuss the circumstances in which it is dangerous to humans.
4. Summarize the reverse osmosis process and explain why it is used.
5. Name the parts of a typical reverse osmosis process and explain each part's purpose.



FILTRATION

Filter Basics

As used in the field of water conditioning, the word **FILTER** is used loosely to mean porous material through which water is made to flow in order to remove some undesirable substance.

A "porous" material is a material with lots of tiny channels or passages (usually called "pores") through which water passes.

However, there are a number of different kinds of filters and different filters use different methods to remove contaminants.

The kind of filters that most people immediately think of when they hear the word "filter" is the kind that acts as a sieve or screen to strain out particles and pass water through. This kind of filter, such as a sand filter, for example, is a **MECHANICAL FILTER**. A mechanical filter depends upon the straining mechanism and does not depend upon any chemical reaction with the particles.

Other filters, carbon filters primarily, work by causing contaminants to stick to the outside of the particles of the filtering material. There are also filters that react chemically with the contaminants in such a way that the contaminant is changed chemically, removed, or no longer harmful.

Some filters are designed for point-of-entry use; others are basically for point-of-use. Point-of-use filters are very often cartridges with replaceable filter elements and may be placed under the sink, attached to faucets, or even incorporated into countertop appliances such as pour-through pitchers. Point-of-entry filters may be tank-style filters, which need to be backwashed from time to time, or they may be cartridge-type.

You can see that the word filter has more meanings than most people realize. Each kind of filter has its special uses and several kinds will be discussed in this course. However, the main emphasis will be upon those kinds of filters which are commonly used in homes and small businesses.

To find out what kinds of problems can be solved by a specific filter or filtration system, carefully read the literature p by the manufacturer and take any training offered about filters you sell.

Filter Rating

Filters are rated in terms of the size of the particles which will be screened out. The unit of measurement for such particles is called the micron. A **MICRON** is equal to one millionth of a meter, or .00003937 inch. The symbol for the micron is μ. Particles smaller than 30 to 40 microns in size cannot be seen by the naked eye.

Note: The term "micron" and its symbol were abolished in 1967. The approved metric system term for the same length is micrometer (symbol, μm). Nonetheless, "micron" is still the term most commonly used in certain fields, including semiconductor fabrication.

However, there are two kinds of micron ratings: nominal ratings and absolute ratings. A **NOMINAL FILTER RATING** indicates the approximate or average size particle which will be filtered out. Generally about 85% of that size particle (10 microns, for example) are likely to be filtered out.

An **ABSOLUTE FILTER RATING** is an exact rating that means essentially all (99.9%) particles of specified size or larger will be removed.

Whether an absolute-rated filter or a nominally-rated filter is needed depends upon what you are removing. If, for example, a filter is to be used to screen out something that affects health, such as a Cryptosporidium cyst, it is extremely important that the filter have an absolute rating which indicates that it will remove that size particle. Crypto cysts, for example, need a filter with an **absolute rating** of one micron. Using a nominally-rated filter could result in some people who drink the water getting sick.

Filter specifications will also tell the water flow rates in gallons per minute (gpm) under which the filter will operate effectively. Filters are generally not for use on hot water lines. The manufacturer's specifications will usually tell the water temperature range within which the filter should be used.

Mechanical Filtering Mechanisms

There are two basic types of mechanical filtering mechanisms in use today: (1) loose media filters and (2) membranes.

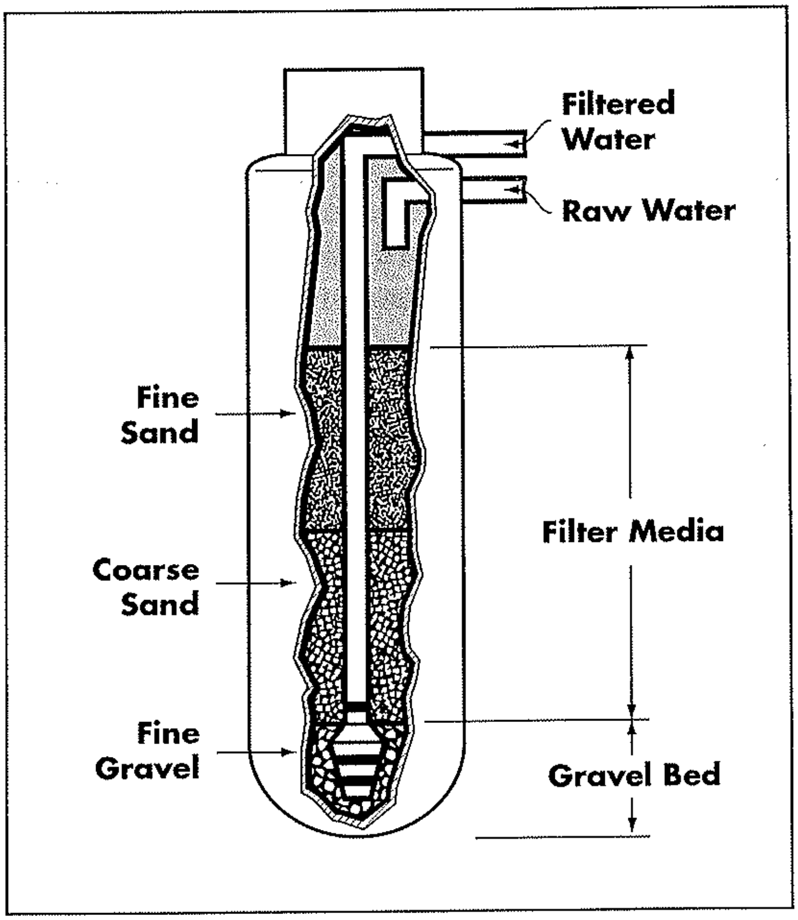
- **LOOSE MEDIA FILTERS** use millions of small loose granules of solid material to physically trap undesirable particles.
- **MEMBRANES** are thin film-like sheets of fabric or fiber, either natural or man-made, which have tiny pores and are used to mechanically separate out certain substances. Membranes are discussed in a later section on reverse osmosis.

Loose media filters may come as tank-type filters (which need to be backwashed from time to time) or as cartridges with replaceable filter elements. Media filters may be either point-of-use or point-of-entry.

The material used to do the straining or blocking is called the filter *medium*. The plural form of *medium* is **MEDIA**, not *mediums*. Because many filters contain more than one medium, the plural form of the word (media) is more widely used—although often incorrectly used as if it were singular. The word *media* is also used to refer to the resin used in a water softener or other ion exchange process.

Tank-style media filters usually must be back-washed on a regular basis to remove accumulated particles and debris. Cartridge-style filters must be replaced for the same reason.

LOOSE MEDIA FILTER



SP 5.3.01

Many kinds of materials are used as filter media. Some commonly-used materials are sand, gravel, cellulose, aluminum silicate, calcite (from marble or limestone), activated carbon, and **MANGANESE GREENSAND**. The media used in a filter or filtration system depends upon what water problems the manufacturer intends the filter to solve.

Treating Turbid Water

A common use of filters is to treat water which is cloudy or dirty. The small suspended (floating) solid particles that make the water look cloudy are called sediment. **SEDIMENT** is suspended particles of matter which are heavy enough to eventually settle to the bottom of a tank or body of water if the water were allowed to remain still and calm. However, the constant flow of water through a household system can keep sediment stirred up.

When sediment is stirred up and suspended in the water, it makes the water look cloudy or dirty, and the water is said to be **TURBID WATER**. Turbidity is a measure of the amount of solid matter in the water. Turbidity is rated according to **NEPHELOMETRIC TURBIDITY UNITS (NTU)**. Potable water should not exceed 0.5 NTU.

Turbidity can result from particulates of silt, or sand, or from small particles of iron or rust in the water. Particulates from decaying natural organics can cause turbidity. Water from a new well or from a well with a defective well screen is especially likely to be turbid. If the water supply is drawn from a lake, turbidity may result if the lake is "stirred up" by a large storm.

Even water treated by municipal water systems can be turbid.

A homeowner may notice turbidity because the water appears cloudy when it is in a clear container. However, even water which does not look very cloudy may have considerable sediment or particulate matter in it. Clogging in faucet aerators and shower heads may be other signs of turbid water. Stains on clothing or fixtures may indicate rust particles in the water.

Sediment Filters

A **SEDIMENT FILTER** mechanically separates solid particles from the water by catching the particles in the filter pores or between the granules of the media.

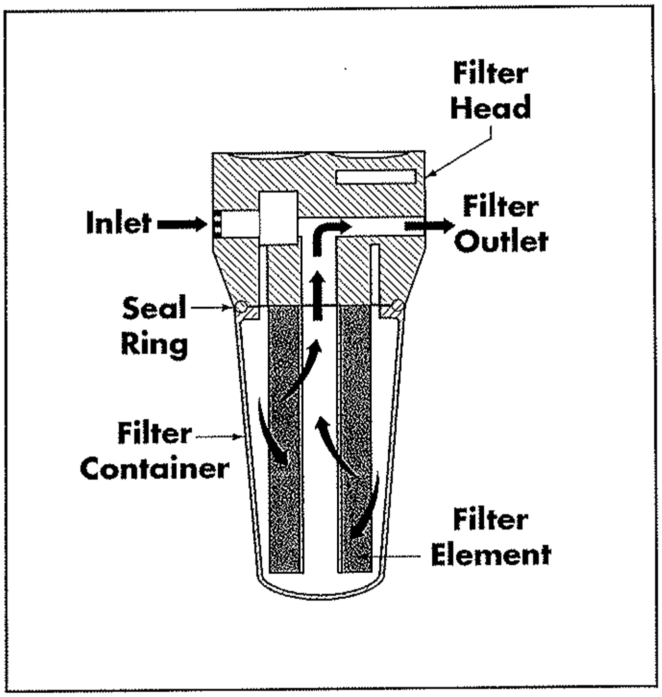
Disposable cartridges to treat turbid water are usually available for whole-house systems to provide cleaner water for bathing and laundry as well as for drinking and cooking.

Many filters used for screening out turbidity are made of layers of paperlike material (often cellulose) or tightly wound fabric which traps the unwanted particles.

Disposal sediment filter cartridges are also available for many point-of-use systems. Some of these also have a layer of carbon for removing odors and unpleasant tastes. In order for the cartridge filters to effectively treat water, they **must be replaced** on the timetable given by the manufacturer.

Sediment filtration may be only one part of a whole-house treatment system that treats many other problems too. It is often advisable to use a sediment pre-filter before a softener or before using finer filters such as **A/C FILTERS** (activated carbon) or reverse osmosis filters. The sediment pre-filter prevents the early clogging of the softener media or other filters.

SEDIMENT FILTER



SP 5.3.02

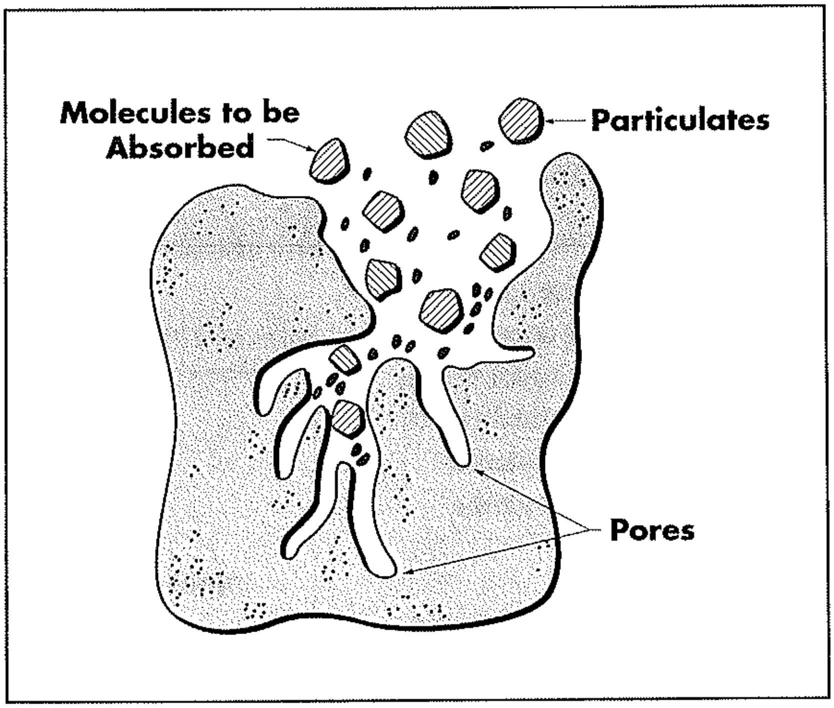
Carbon Filters are Widely Used

Many filters use activated carbon as the filter medium. Because it has so many uses, activated carbon is probably the most widely used filter in the water processing industry.

ACTIVATED CARBON is carbon which has been specially treated to remove impurities from the carbon and to enlarge the pores to make it more effective as a filter medium. Activated carbon is used in powdered, granulated, or block form, depending upon the specific use for the filter.

ACTIVATED CARBON FILTERS may also be called "activated charcoal filters." One reason activated carbon is so effective is because it has tremendous surface area which is exposed to the water. Depending upon the quality of the carbon, one pound of activated carbon can have a surface area which is equal to many acres!

ACTIVATED CARBON GRANULE



SP 5.3.03

The Process of Adsorption

In addition to the fact that activated carbon is porous and works like other filters to mechanically trap particles, activated carbon also filters by a process called adsorption.

ADSORPTION is the chemical process in which molecules of a liquid, gas, or dissolved substance stick to the surface of another material.

Molecules of certain substances stick to activated charcoal in a way similar to a nail sticking to a magnet.

Activated carbon filters are so useful because they act as mechanical filters for small amounts of turbidity and also adsorb many kinds of molecules, especially organics. If the turbidity count is high in the incoming water, however, a sediment pre-filter will help your customer make the best use of the carbon filter.

Activated carbon will adsorb and remove from drinking water many of the dangerous **SYNTHETIC ORGANIC CHEMICALS** (SOCs) and **VOLATILE ORGANIC CHEMICALS** (VOCs) including trihalomethanes (THM), carbon tetrachloride, Lindane, PCB, PCE, and other chemicals used in the petroleum, chemical, agricultural industries.

Activated carbon is also used to remove TCE (trichloroethylene) which is absorbed into the skin through bath and shower water.

WARNING! If an activated carbon filter is not properly used, it can increase the amount of or "dump" VOCs or SOCs in the processed water. In order to prevent dumping, make sure you understand the capacity and uses of the carbon filters you sell.

Activated carbon is commonly used for removing excess chlorine.

Water which has been treated with chlorine in community treatment systems or wells may have a chlorine odor and cause an unpleasant taste in coffee, tea, juices and other drinks made with water.

Activated carbon filters are often used as final "polishers" in multi-part conditioning treatment systems because the carbon will remove objectionable tastes caused by dissolved minerals or chemicals, and it will remove odors (such as fishy/musty/earthy odors) which may be caused by tiny particles of harmless natural organic matter.

However, the strong smell of "rotten eggs," caused by hydrogen sulfide gas in the water, will probably NOT be successfully removed by use of activated carbon. Additional treatment, which is discussed elsewhere in this course, will be needed.

Radon Reduction

Whole-house activated carbon filters are sometimes used to remove low levels of radon, a radioactive gas, from well water. **RADON** develops as a result of decaying uranium in the rocks and soil around the well.

Drinking water with radon in it is not dangerous. Breathing in radon is considered hazardous because it is believed to increase the chances of lung cancer.

Radon in drinking water escapes in small doses as the water goes through the faucet aerator. Radon is not a problem if the source of water is a lake, stream, or river.

In general, radon is not a problem with community-treated water because in the aeration process at the treatment plant, the radon escapes into the air.

If there is radon in the water, it can escape into the air in the house as a result of the heating and agitation of the water, such as during a bath or shower or while laundry or dishwashing is being done. Persons showering or doing the laundry may breathe in the radon... although some experts feel this would not expose the person to enough radon to be harmful.

Radon gas may also seep into the house through basement windows, or through drains, cracks in basement walls or floors, or openings around water pipes, gas mains, etc.

If the amount of radon in the water is high, the radon released from the water PLUS the radon seeping in from the soil may raise the levels in the homes to dangerous levels. If the homeowner tests his or her home and finds the level of radon IN THE AIR to be above acceptable levels, he/she should make use of a reputable contractor with expertise in radon reduction methods to look at treating both the house and the water.

If carbon filters are used, they must be whole-house filters of rather large size (two-to-four cubic feet of granulated activated carbon) and the filters should be placed outside the house away from heavy human traffic because the carbon becomes radioactive. A shield around the carbon tank is also often recommended, especially if the tank is near living areas.

Because of the radioactivity, the carbon must be disposed of in the manner that the state requires for radioactive waste.

The whole issue of radon reduction is very complicated. Be sure to ask your manufacturer what is recommended for radon.

Some states forbid the use of carbon for radon reduction. And for reasons outlined above, many people recommend other methods for radon reduction.

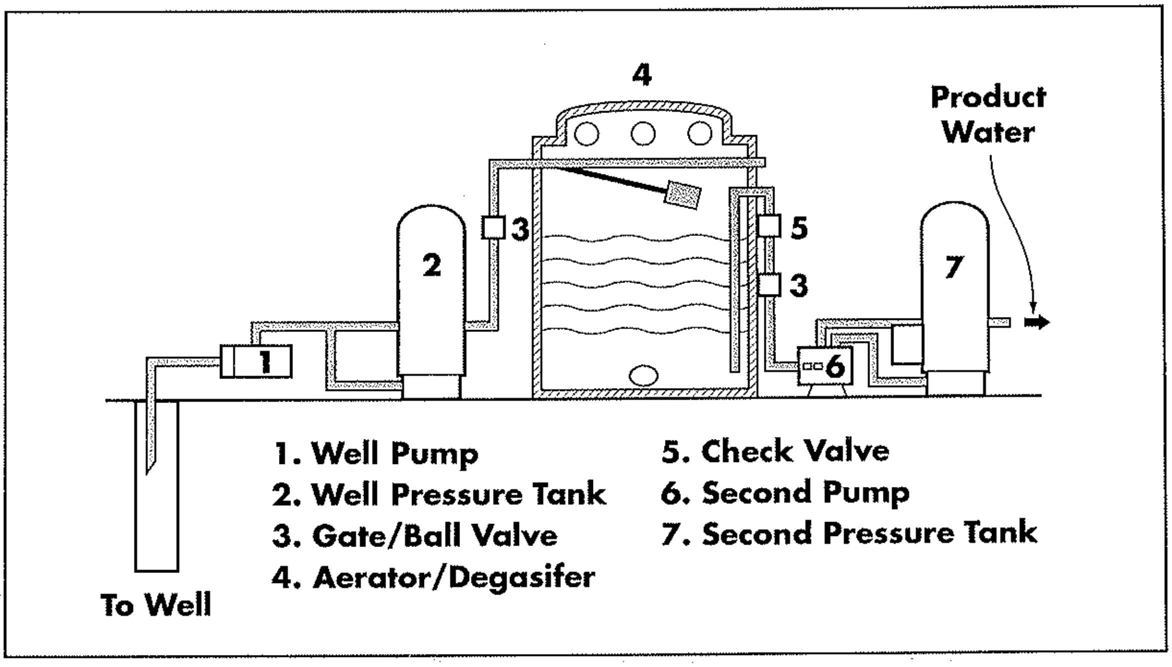
Non-pressured Aeration for Radon Reduction

Another, perhaps less hazardous, method for reduction of radon in water is non-pressurized aeration.

Residential aerators have fiberglass, plastic, or stainless steel tanks which hold 150-250 gallons of water. They are equipped with special nozzles and vent lines to separate the radon (or any gas) and the gas is blown or vented to the outside. The radon dissipates harmlessly in the outside air.

The tanks do not become radioactive and do not have to have shields to protect people. There is also no radioactive waste.

RESIDENTIAL SIZED OPEN-GRAVITY AERATION SYSTEM



SP 5.3.04

Using Activated Charcoal Filters

Activated charcoal filters are used in both whole-house water treatment systems and in point-of-use systems.

Activated carbon filters are often built into multiple-use filter systems which use several kinds of media in order to treat a number of different kinds of water problems.

Many whole-house filters have beds of granular activated charcoal in large tanks, an arrangement which is similar to a water softener. Beds of carbon must be backwashed and rinsed regularly to remove the adsorbed molecules and suspended solids (turbidity) which fill up the pores in the carbon granules. Eventually the carbon bed will become exhausted and will have to be replaced.

Carbon filter tanks often have automatic back-washing devices. Some tanks, however, require manual backwashing.

Government sources have recommended that activated charcoal filters with automatic backwashing NOT be used for radon reduction or for removal of SOCs or VOCs, since frequent backwashing lessens the effectiveness of the removal process.

The direction of waterflow (up or down) in the filter is related to the types of contaminants to be removed.

Another reason for backwashing is to remove any bacteria or organisms which might have built up in the carbon granules.

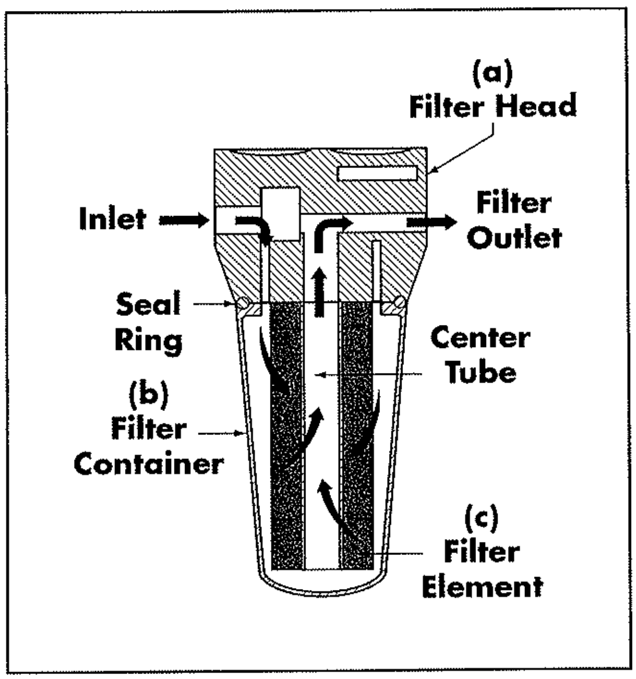
Damp carbon can encourage the growth of microbes—even in potable water—if the carbon is not backwashed and/or replaced soon enough. While research indicates that the bacteria which are likely to grow in activated carbon are not harmful to health, it is important that you do NOT use charcoal filters for water which has not been certified to be potable.

Disposable Point-of-use Cartridges

Recently-developed activated carbon filtering systems use disposable point-of-use cartridges which can simply be replaced. This eliminates the need for backwashing.

To be sure that the filter is operating efficiently, it is extremely important that cartridge be replaced on schedule. Some systems have monitoring devices which indicate when a cartridge needs to be changed or may even shut the system down if the cartridge has exceeded its recommended lifetime.

TYPICAL SINGLE-FAUCET DISPOSABLE CARTRIDGE FILTER



SP 5.3.05

The Water Quality Association suggests that activated carbon cartridges be replaced at least every three months. Check with the instructions from your manufacturer about the life of your carbon filter cartridges and remind your customers that they need to change them regularly.

Osmosis and Osmotic Pressure

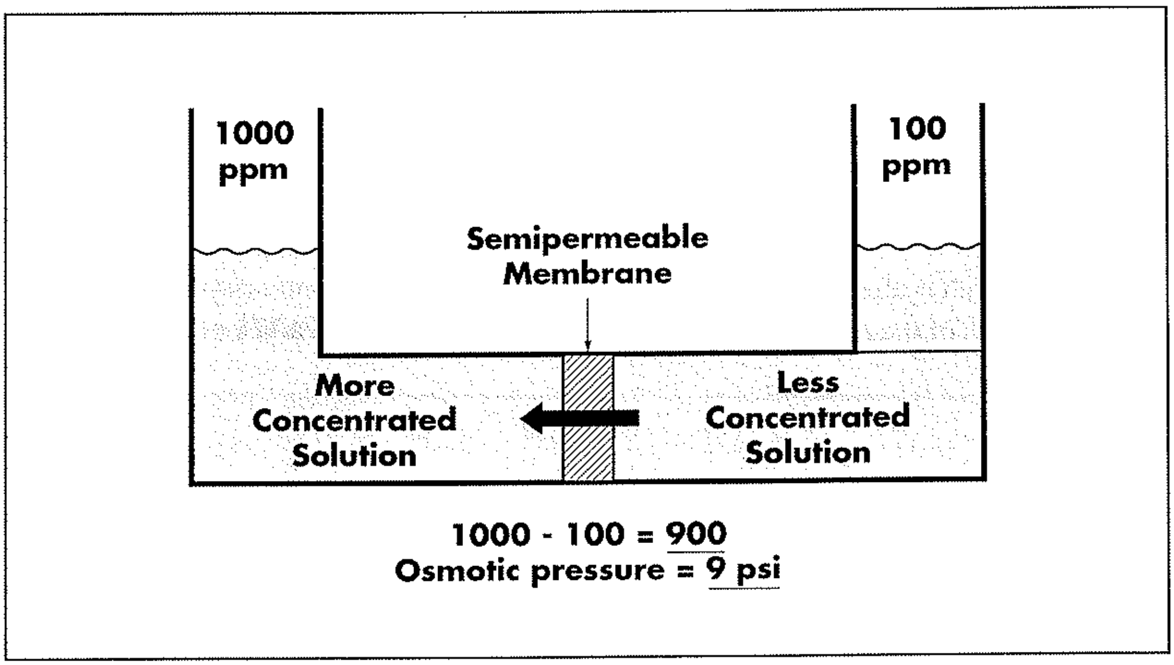
When fluid seeps through a seemingly solid barrier, such as a cell wall or a rubber sheet, the process is called osmosis. **OSMOSIS** is the natural process in which a liquid containing a lower amount of dissolved solids (a less concentrated solution) pass through a semi-permeable membrane (in our bodies the membrane is a cell membrane) into a more concentrated solution. When the concentration of the fluid is the same on both sides of the barrier, osmosis stops.

For example, if a solution of sugar water is separated by a porous membrane from a quantity of water with fewer molecules of any other substance, the molecules of the purer water will pass through the membrane into the sugar water, diluting the sugar water. The sugar solution would not, **under natural conditions,** pass into the purer water.

The natural pressure created by the movement from low to high concentration is called the **OSMOTIC PRESSURE.**

The osmotic pressure can be calculated by subtracting the concentration level of Total Dissolved Solids (in ppm) of the less concentrated solution from the concentration level (in ppm) in the more concentrated solution—and then dividing by 100. This gives you the osmotic pressure in pounds per square inch.

HOW OSMOSIS WORKS



SP 5.3.06

Reverse Osmosis Process

Reverse osmosis technology has been known for more than 100 years, but the process was originally developed for removing salt from sea water. Later in this 20th century the technology has been adapted for residential water conditioning. Reverse osmosis is a reversal of the natural process called "osmosis," which is the process by which moisture moves from cell to cell in living things.

The reverse osmosis (RO) process is used to remove molecules of heavier dissolved contaminants from water. Residential reverse osmosis systems are manufactured for both whole-house and point-of-use installation.

In **REVERSE OSMOSIS**, water containing dissolved impurities is forced through a thin, filmy **SEMIPERMEABLE MEMBRANE**, trapping the molecules of dissolved impurities behind the membrane but allowing some water molecules to pass through the membrane. The contaminants which are "rejected" (removed) by the membrane (which looks much like cellophane or plastic film food wrap) are sent to the reject drain.

Water containing dissolved impurities is really a solution. A **SOLUTION** is a liquid with some other substance (solid, gas, other liquid) dissolved into it. A "concentrated solution" has many molecules of the dissolved substance.

In reverse osmosis technology, the concentration of the solution (the water to be cleaned) is measured in parts per million (ppm) of Total Dissolved Solids (TDS).

The contaminated water fed through the filter membrane is called the **FEED WATER**, while the cleansed water is called product water or **PERMEATE** (because it has "permeated"—or passed through—the filter membrane.)

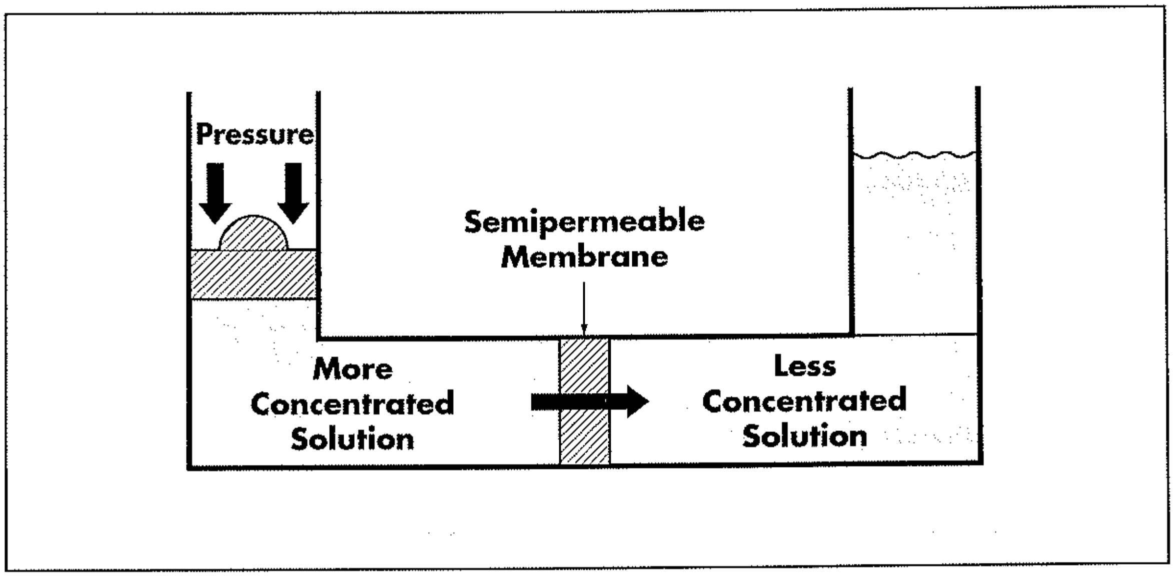
The water which is stopped and does not go through the membrane contains concentrated amounts of the rejected contaminants is called **CONCENTRATE** or *reject water*.

How Reverse Osmosis Works

In reverse osmosis, the natural process of osmosis is really reversed. Enough artificial pressure (water pressure from the household water system or a booster pump) is applied to overcome osmotic pressure and force reversal of osmotic flow.

The higher the water pressure, the more clean product water is pushed through the membrane and the more product water comes through into the storage tank.

HOW REVERSE OSMOSIS WORKS



SP 5.3.07

RO Cannot Remove All Contaminants

The RO process can remove many different contaminants. RO is often used to remove molecules of dissolved heavy inorganics such as: heavy metals (lead, zinc, copper, cadmium), chloride, nitrates, fluoride, arsenic, and sodium.

RO membranes cannot be used to filter out many kinds of smaller, lighter contaminants or to remove undesirable odors or color. A carbon filter is needed for these.

Reverse osmosis for drinking water should not be used on water that is not potable, because RO is not designed for use in place of disinfection. In fact, if there are too many microbes in the feed water, they might grow in the wet membrane.

While sediment and iron will be strained out by the membrane, they very quickly clog up the membrane and cause the RO system to stop working effectively. Calcium and magnesium will create a layer of hardness on the membrane and make it less effective.

Pre-treatment is needed to remove these contaminants from the feed water prior to RO. Lack of good pre-treatment is a primary reason why some RO systems do not operate as well as expected.

It is important to know what your RO systems will remove and not to sell an RO system to remove anything except what your manufacturer says the system will remove. Furthermore, knowing exactly what is in the feed water will help to protect the RO system and make it work more effectively and efficiently.

The only way to know which substances can be removed by a specific RO filter or system is by reading the manufacturer's literature very carefully. It is important that you sell an RO unit only to remove contaminants suggested by the manufacturer.

Ask your sales manager or manufacturer's representative for training about the many ways reverse osmosis can be used and how to help your customers keep ROs operating effectively.

Reverse Osmosis Systems

To make their RO systems provide the best possible water, most manufacturers sell whole RO systems, instead of just a membrane filter.

A first step, even before the actual RO system, may be to soften the water and treat it for iron.

A typical under-sink RO system includes:

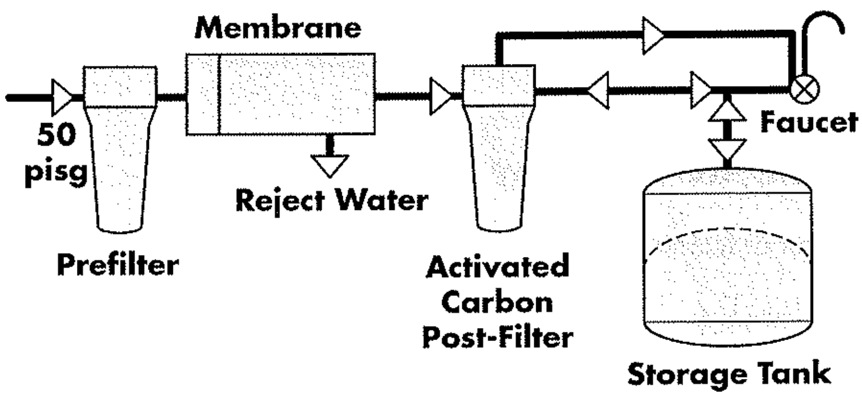
- A pre-filter for sediment
- The RO membrane module
- A pressurized storage tank
- An activated carbon post-filter
- A drain for the concentrate containing the "rejected" contaminants
- A special faucet for treated water

Some systems use a carbon filter as a pre-filter, especially if it is desirable to filter out the chlorine. Some systems use BOTH carbon pre-filters and carbon post-filters.

Although the drawing below shows the carbon post-filter before the storage tank, many systems now place the carbon post-filter between the storage tank and the faucet because the carbon helps eliminate possible tastes or odors from the tank bladder.

Filters and RO membranes are usually replaced by the use of cartridges. Some systems have monitors and indicators to let the owner know when the membrane cartridge needs changing. Following the replacement schedule of the manufacturer is extremely important for effective usage.

TYPICAL RO SYSTEM WITH PRESSURIZED STORAGE TANK



SP 5.3.08

Membranes in RO Filters

The membranes in use in residential reverse osmosis systems are usually made of cellulose acetate (in one of several formulas) or thin film of composite. Different membranes have different advantages which your manufacturer's sales and training materials should describe. As always, what is in the water to be treated will help determine what kind of membrane or system is appropriate. Be sure to learn about the ROs you sell.

Cellulose acetate membranes **require that feed water be chlorinated**, because the chlorine is needed to prevent bacteria from growing on the filter membrane. The bacteria would clog the filter and cause deterioration of the membrane.

Thin film composite membranes **require that the chlorine be removed from feed water** because chlorine will destroy the membrane.

Water from private wells is not always chlorinated; municipally treated water usually is chlorinated. RO filters must be chosen properly to meet manufacturers' guidelines on chlorination.

Most manufacturers specify certain other chemical limits under which the RO filter will work effectively. The water must be tested to be sure it falls within these limits.

If these limits aren't met by the feed water, then the manufacturer may specify certain kinds of pre-treatment of the water before it may be fed through the RO membrane.

It is important that pre-treatment recommendations be followed; otherwise the water may not be effectively treated and/or the membrane will need to be replaced too often.

Factors Affecting RO Efficiency

There are a number of factors that influence how effectively an RO system works.

Some basic factors are the:

- pressure of the feed water
- temperature of the feed water
- amount of iron in the feed water
- amount of turbidity in the feed water
- level of TDS in the feed water
- amount of acid in the water

Manufacturers usually indicate factors which affect performance. For example, most manufacturers specify the hardness levels allowable in feed water. If the hardness is too great, the feed water must be softened prior to reverse osmosis.

The manufacturer recommends an acceptable temperature range for the feed water. Like motor oil, the viscosity of water is affected by its temperature. Generally the warmer the water, the more product water you get because colder water does not flow as quickly and does not pass through the membrane as easily. However, water which is too hot can destroy the membrane.

For homes in the northern part of the country, the temperature of the water in the pipes could affect the efficiency of the system. Freezing of a membrane must be prevented too.

Most manufacturers indicate the acceptable amounts of iron in the feed water. Excess iron will clog the membrane. Therefore excess iron may require pre-treatment.

Excess acid in the feed water will destroy the membrane, so feed water with acidity above the recommended range may need to be neutralized before being fed into the RO system.

The manufacturer will indicate the maximum ppm of TDS that the membrane can handle. The capacity of the membrane must be large enough to bring the water to an acceptable level.

For an RO system to operate efficiently, the household water pressure must be high enough to force water through the membrane. Higher pressure means more product water at the same or better quality. However, too much pressure could rupture the membrane.

The water pressure must fall within the manufacturer's recommended pressure range, given in **POUNDS PER SQUARE INCH (PSI)**, for the system to produce the maximum amount of product water and the minimum amount of reject water.

Generally speaking, it requires about one pound per square inch (psi) of pressure for each 100 ppm of TDS to overcome the natural osmotic pressure. (Remember that reverse osmosis makes the water flow in the opposite direction to natural flow.)

It is best if the home water system pressure falls at the top end of the range. For low water pressure, most manufacturers offer special pumps.

A system which is not working efficiently produces a very high amount of concentrate which is rejected and runs to drain.

It is not uncommon for inefficient systems to produce 10 gallons of reject water for each gallon of clean product water.

Even efficient systems may require 3 gallons of feed water for every gallon of product water produced.

If there is no shut-off valve in the point-of-use system, the water will continue to run through the filter and into the reject drain even if the storage tank is full.

For the sake of water conservation, a shut-off valve is usually available either as standard equipment or as an option.

Some whole-house RO systems are installed within the water line, and there is no reject water to be lost down the drain.

Rating Residential RO Systems

Residential reverse osmosis systems, whether whole-house systems or point-of-use systems, are rated in terms of:

- Maximum TDS level which can be treated.
- **REJECTION RATE**, which is the percentage of TDS removed. For example, a rejection rate of 90% means 90% of the contaminants in the feed water are removed by the RO.
- Daily capacity in gallons of product water. Residential ROs at point-of-use typically produce between two and twelve (2-12) gallons per day.

It is important that the water be tested to determine the level of TDS in the water so that the proper RO system can be chosen.

It is very important that a system be sized according to the manufacturer's specifications for water pressure, water temperature, and possible pre-treatment conditions.

Because the RO process is affected by so many factors, RO suppliers should offer a post-sale testing and service program to be sure the customer's system continues to function well.

Service contracts usually include changing pre-treatment filters, replacement of membrane based upon rejection rate performance, annual change of the carbon postfilter, and sanitizing of the whole system (including the storage tank) on at least an annual basis.

REVIEW QUIZ – FILTRATION TREATMENT

Answers appear on page 70

DIRECTIONS: Carefully read each question and circle the correct answer. There is only one correct answer per question. When you have finished, check your answers.

1. Which of the following type of filter has pores that strain out particles from the water?
   a. Porous filter
   b. Mechanical filter
   c. Carbon filter
   d. Straining filter

2. What information does a nominal filter rating provide?
   a. The exact size of the smallest particle which will allow 99.9% of such particles to be filtered out
   b. The average amount of particle that will be filtered out
   c. The average size of the particle which will allow 85% of such particles to be filtered
   d. The exact size of the smallest particle which will allow 85% of such particles to be filtered out

3. A filter is rated according to the size particles they can remove. How are these particles measured?
   a. Metric units
   b. Millimeters
   c. Microns
   d. Media

4. What percentage of particles of four microns or larger would a filter with a nominal rating of four (4) microns be expected to screen out?
   a. 50%
   b. 75%
   c. 85%
   d. 99.9%

5. What percent of particles of eight microns or larger would a filter with an absolute rating of eight (8) microns be expected to remove?
   a. 50%
   b. 85%
   c. 99.9%
   d. 100%

REVIEW QUIZ – FILTRATION TREATMENT

Answers appear on page 70

6. Assume that crypto cysts, with particles of one micron, are present in the water. Should the client choose a filter with an absolute rating or a nominal rating?
   a. Filter with an absolute rating of one micron to remove that size particle
   b. Filter with an absolute rating of three microns to remove that size particle
   c. Filter with a nominal rating so the average sized particles will be filtered out
   d. Filter with a nominal rating so 85% of the particles will be filtered out

7. The sand and gravel used in a filter to strain out particles are called what part of the filter?
   a. Membrane
   b. Element
   c. Media
   d. Gravel bed

8. What is the measure of solid particles suspended in water which make water look cloudy called?
   a. Micron
   b. Turbidity
   c. Maximum contaminant levels (mcls)
   d. Milligram per liter (mg/L)

9. What is the chemical process which makes contaminant particles stick to activated carbon called?
   a. Adhesion
   b. Absorption
   c. Neutralization
   d. Dealkalization

10. Why does activated carbon work well as a mechanical filter?
    a. It uses millions of loose granules of solid material to trap particles.
    b. It uses osmosis to lower the amount of dissolved solids in the water.
    c. It has a large surface area which makes it an effective filter medium.
    d. It filters out every impurity in the water.

11. For what purpose is activated carbon is very commonly used as a filter?
    a. To remove turbidity
    b. To reduce PCBs
    c. To remove excess chlorine
    d. To eliminate sulfide gas

REVIEW QUIZ – FILTRATION TREATMENT

Answers appear on page 70

12. Activated carbon is used to remove all of the following are man-made chemicals used in industries such as the petroleum industry EXCEPT
    a. Volatile organic chemicals (VOCs)
    b. Carbon tetrachloride
    c. Trichloroethylene
    d. Sulfide gas

13. If used for radon reduction in the home, where should activated carbon filters be placed?
    a. Heaviest human traffic areas in the house
    b. Several locations around the house
    c. Outside the house
    d. Basement of the house

14. When radon is removed by activated carbon, how is the used carbon treated?
    a. Disposed of as garbage
    b. Disposed of as radioactive waste
    c. Recycled as activated carbon
    d. Removed from the filter

15. What is the natural pressure created by the movement of fluid from low to high concentrations called?
    a. Absorption
    b. Osmosis
    c. Concentrate
    d. Osmotic

16. In reverse osmosis, water is forced through the membrane by pressure from the
    a. filter head.
    b. well pressure tank.
    c. carbon filter tank.
    d. booster pump.

REVIEW QUIZ – FILTRATION TREATMENT

Answers appear on page 70

17. What happens if iron and sediment are not removed by pre-treatment before reverse osmosis?
    a. The filter will not work.
    b. Sediment will clog the membrane.
    c. The system will have to be replaced.
    d. Iron and sediment will be removed more slowly.

18. Do reverse osmosis systems work better with warm water or cold water?
    a. Warm water because it flows more slowly through the membrane.
    b. Cold water because it flows more slowly through the membrane.
    c. Cold water because it flows more quickly through the membrane.
    d. Warm water because it flows more quickly through the membrane.

APPLYING WHAT YOU HAVE LEARNED:

By observing and asking questions, fill in the blanks. If you are not sure of the answers, ask your supervisor.

A. List three types of filters your company sells.

____

____

____

B. Explain how carbon filters work and why you might recommend them to a client.

____

____

____

ANSWERS TO REVIEW QUIZ

CHAPTER 3

FILTRATION TREATMENT

Answers to REVIEW OF FILTRATION TREATMENT (pages 65 – 68)

1. b. Mechanical filter
2. c. The average size of the particle which will allow 85% of such particles to be filtered
3. c. Microns
4. d. 85%
5. c. 99.9%
6. a. Filter with an absolute rating of one micron to remove that size particle
7. c. Media
8. b. Turbidity
9. b. Absorption
10. c. It has a large surface area which makes it an effective filter medium.
11. c. To remove excess chlorine
12. d. Sulfide gas
13. c. Outside the house
14. b. Disposed of as radioactive waste
15. d. Osmotic
16. d. booster pump.
17. b. Sediment will clog the membrane.
18. d. Warm water because it flows more quickly through the membrane.

Applying what you have learned:

A. Answers will vary by company.

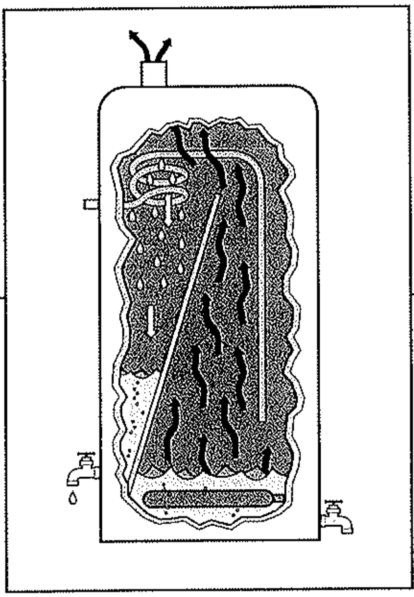
B. Discussion might include some or all the following information. Carbon filtering is a method of water purification that uses a piece of activated carbon to remove contaminants and impurities, utilizing chemical adsorption. Each piece of carbon is designed to provide a large section of surface area, in order to allow contaminants the most possible exposure to the filter media. One pound of carbon contains a surface area of approximately 125 acres. This carbon is generally activated with a positive charge and is designed to attract negatively charged water contaminants. Carbon filters are most effective at removing chlorine, sediment, and volatile organic compounds (VOCs) from water. They are not generally effective at removing minerals, salts, and dissolved inorganic compounds.

4 DISTILLATION AND PH CONTROL

LEARNING OBJECTIVES

When you finish this Chapter, you will be able to:

1. Explain why distillation is used and discuss any drawbacks of the distillation process.
2. Compare and contrast air-cooled, water-cooled, and counter-top batch distillers.
3. Describe the pH scale and explain what it measures.
4. Discuss why calcite and/or magnesia filters are used to treat acid water.
5. Describe the usual treatments for alkaline water.



DISTILLATION

The Distillation Process

A simple and effective water conditioning process which is easily understood by the consumer is the distillation process.

DISTILLATION is the process in which a liquid is converted into vapor by heating, then condensed back into a purified liquid by cooling, and finally collected for use.

A distiller can be used to remove almost all kinds of contaminants: microbes, inorganics, organics, and particulates. Most distillers also make use of a small carbon filter to adsorb organics which may be vaporized into gas. Distillation can be used with well water, municipally-treated water, or even untreated water such as water from a lake or stream.

The distillation process can even be used for disinfecting non-potable water. Check with your manufacturer to see what kinds of pre-treatment might be recommended before using any of the distillers you sell.

Putting water through the distillation process several times can produce water which is very pure, even pure enough for use in scientific laboratories. Home distiller units do not usually produce water as pure as would be needed in a laboratory.

The distillation process, as used with residential distillers, is a slower process than other water treatment processes, so the process is often used for point-of-use production of water for drinking and cooking rather than for whole-house water supplies.

The main drawbacks are that distillers require electricity and produce heat during operation.

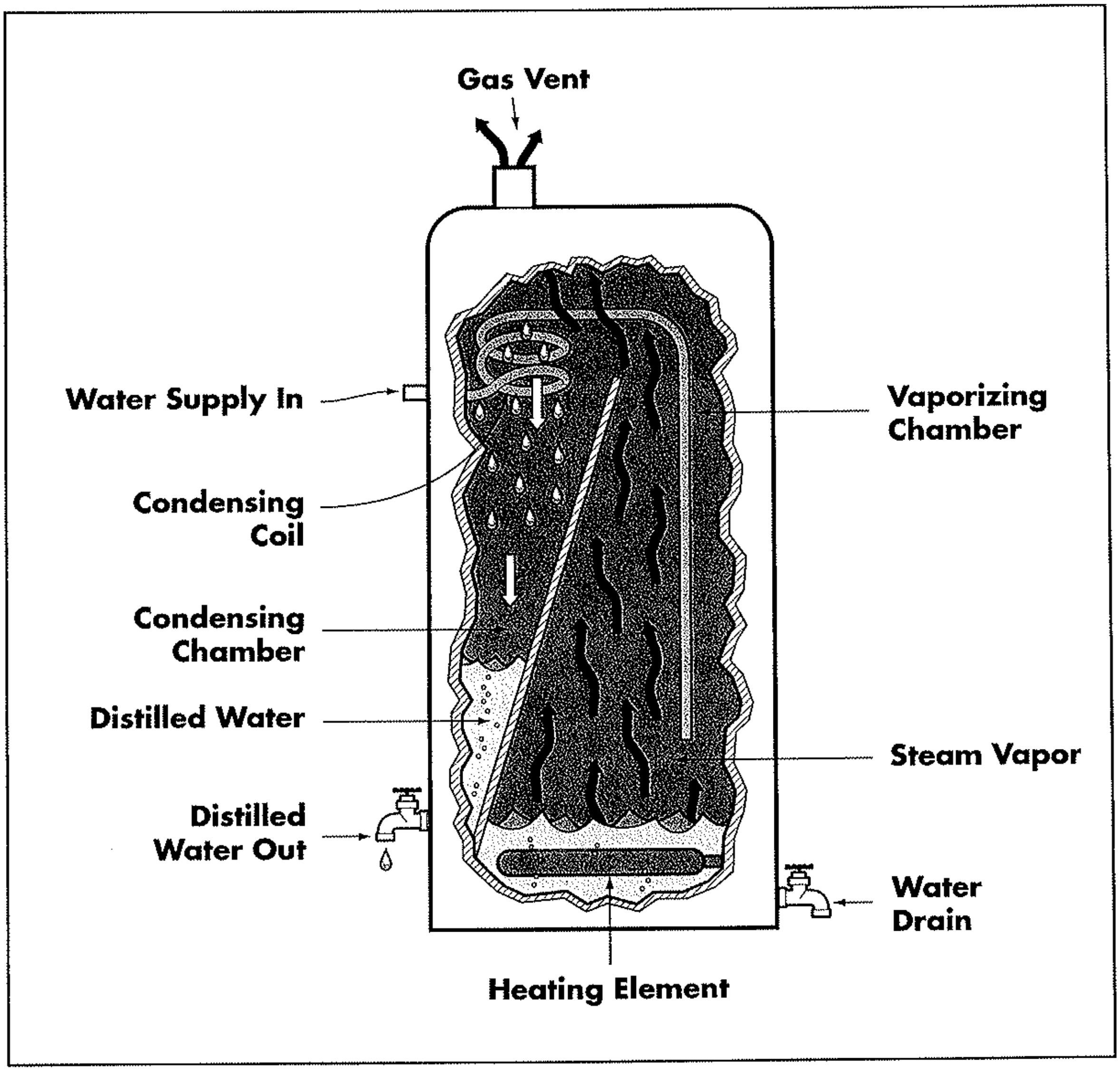
Nevertheless, the combination of distillation with a carbon filter has the advantage that it will work for reducing virtually all kinds of contaminants, including microbes.

The distillation process purifies water because of the fact that impurities have different boiling points than water.

The drawing on page 74 shows how a residential water-cooled distillation unit works.

The cold feed water enters through coils that also serve as condensing coils. The water is heated by the electric heating element at the bottom of the vaporizing chamber.

TYPICAL HOME DISTILLER



SP 5.4.01

As the water is heated, gases which boil more quickly (because they have lower boiling points than water) escape through the vent.

The boiling water turns into steam, which rises to the top of the vaporization chamber and comes in contact with the cooler condensing coils. The distilled water condenses in the condensing chamber and is collected at the bottom of the chamber where it can be drawn out for use.

Dissolved solids and contaminated liquids, if any, which boil more slowly (have higher boiling points) than water remain in the bottom of the vaporizing chamber where they can be flushed out.

Water-Cooled Distillers

WATER-COOLED DISTILLERS, like the one pictured on the previous page, use some of the feed water to cool the condensing coils and to flush the contaminants in the bottom of the tank.

It takes from 4 to 7 gallons of waste water (called "brine") to produce one gallon of distilled product water using an automatic water-cooled distiller.

Sometimes this waste water can be used for other household purposes.

It is important to realize that the waste water draining from a water-cooled distiller will be hot. The user should make sure that the waste water plumbing system can handle the hot water.

In addition to the waste water flushing out the contaminants, regular cleaning of both the vaporization and condensation chambers is needed to remove accumulated scale buildup.

Residential distillers use electric heating elements to produce steam. All use standard electric current: 110 or 120 volt AC.

According to the Water Quality Association, distillers require three to five kilowatt hours per gallon of product water.

And all distillers give off some heat.

A large whole-house distiller which is designed to provide water for several different locations in the house can give off as much heat as a small room heater. This heat may require venting in warm climates or in summer.

It is especially important to control the temperature of the room if an **AIR-COOLED DISTILLER** is installed, because the distiller unit will not work effectively if the room is so warm that the cooling mechanism can not keep the condensing coils cool.

The need to more closely control room temperature must be considered when a customer chooses an air-cooled distiller unit.

An air-cooled unit does, however, have the advantage that no extra water is flushing down the drain as coolant.

Types of Distillers

Distillers come in various models and sizes.

- Automatic distillers with reservoir tanks are the most convenient, because the user simply opens the reservoir tap for distilled water.
- Automatic models refill, startup, and shut down automatically by use of various floats, switches and valves.
- Semi-automatic models operate automatically but may come without a reservoir tank; therefore the distiller has to be manually shut down when the small storage container is full.
- **BATCH DISTILLERS**, which are usually rather small, must be filled manually and produce only as much product water as is in the batch.

However, batch distillers have the advantage that they boil all the water put in. There is no waste water to deal with.

Counter-top batch distillers are convenient for small amounts of drinking water, are very portable, and are often used in recreational vehicles, fishing and hunting cabins, and vacation homes.

Distillers produce very high quality water and remove very high percentages (98% or 99%) of most impurities.

Unlike filtering systems, distillers also remove microbes: the microbes are killed when the water reaches boiling temperature. This means the distiller can be used on feed water from a wide variety of sources. The feed water need not be potable. Contact your manufacturer for any recommended pre-treatment recommendations.

Rating Distillers

Distillers are rated on how many gallons of product water they can produce in a day.

The range of production for residential distillers is from 3 to 12 gallons per day.

The distillation process may be too slow and expensive to produce water for house cleaning and laundry. And the water produced is much purer than needed for such tasks.

Although large distiller units can produce enough water to be stored and then piped to several locations in the house, the distillation process is considered basically a point-of-use process since the water produced is for drinking and cooking.

The Problem of Acid Water

If homeowners find that their tap water has a bluish-green tint to it, or if they find green or blue-green stains on sinks or porcelain bathroom fixtures, they should suspect that the problem is acid water.

Reddish-brown stains from rust or iron in the water may also indicate water is acidic.

Of course, testing the tap water will also show if the water is high in acid.

Acid water can also eat into metal cookware, eat through metal pipes, and corrode faucets and other brass fittings.

ACID WATER may also eat away at lead pipes (often found in older homes) and lead solder used in the joining of pipes. Lead in the drinking water causes a health hazard.

Acid water will also dissolve iron out of galvanized steel plumbing pipes. Because of its tendency to eat away at metals, acid water is called "aggressive water" or "corrosive water."

Acid water is a fairly common problem in some areas of the country.

The pH Scale

Acidity of a solution is so important that it was convenient to create a special **pH SCALE** for its measurements. In 1909, the Danish biochemist Sören Sörensen invented the pH scale for measuring acidity. The pH scale measures how acidic or basic a substance is.

Note: The acidity or alkalinity of water is related to the number of hydrogen ions present.
The chemical reason for why water is acid or alkaline (the opposite of acid) is too complex to be explained here. If you wish a chemical explanation of acidity, a good chemistry book from the library will provide this explanation.

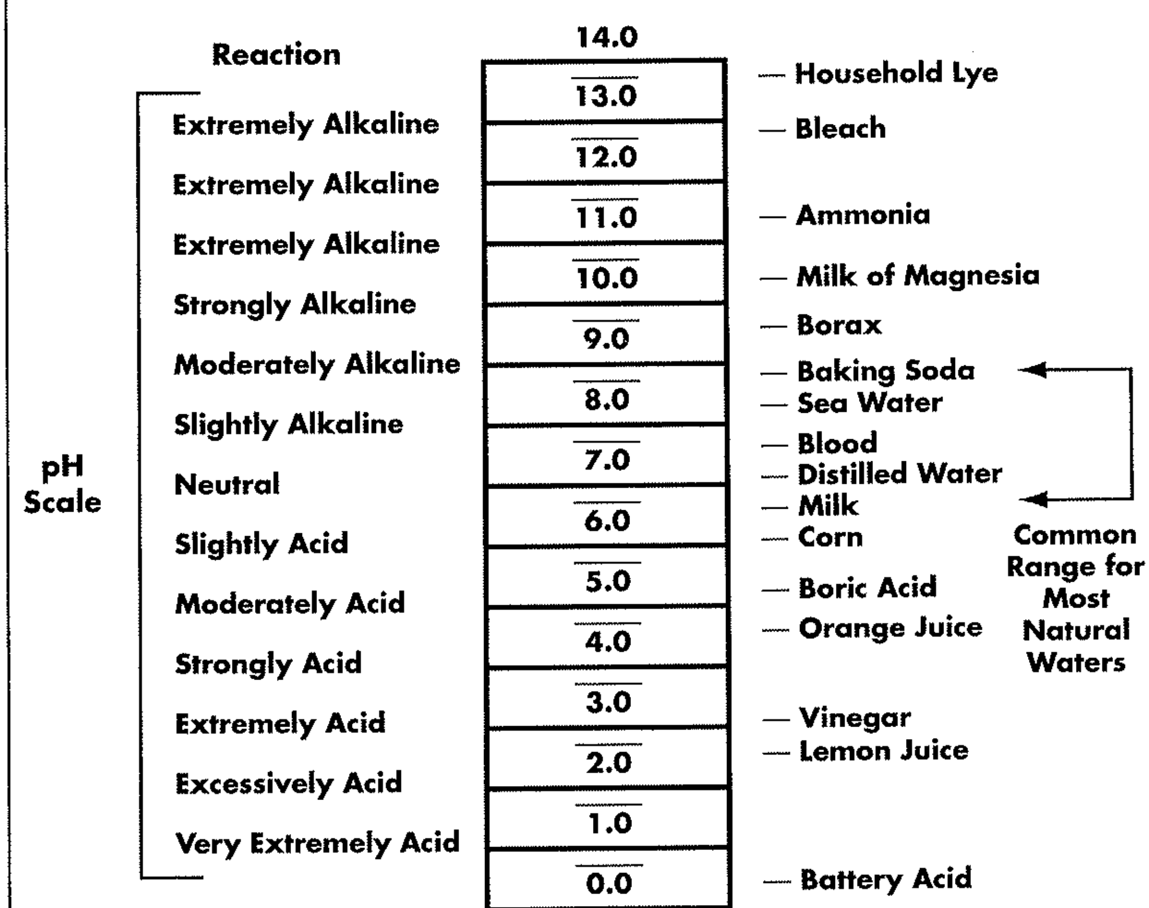
The pH scale ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic. A pH greater than 7 is basic.

For purposes of this discussion, acid water is water which measures below 7.0 on the pH scale, which is the scale for determining acidity or alkalinity.

The opposite of an acid is an "alkali" or a "base." Alkaline water is any water which measures above 7.0 on the pH scale. At 7.0 pH, water, or any other solution, is said to be "neutral," that is, neither an acid nor a **BASE.**

The pH scale showing the pH ratings of some common substances is shown in the following graph.

CALCITE CARBONATE MEDIA BED



Note: U.S. Safe Drinking Water pH range: 6.5 to 8.5

SP 5.4.02

You are undoubtedly familiar with acids and bases in everyday life. Below are some acids and bases and their places on the pH scale.

You will probably realize, from looking at the scale, that both strong acids and strong bases can cause metals to "corrode" or disintegrate.

The scale is set up in such a way that a reading of 4.0 is ten times as acid as 5.0.

A base with a pH count of 9.0 is ten times more alkaline than one with a count of 8.0.

The Process of Neutralization

Because water that is neither acid nor alkaline is neutral, the process of trying to correct acidity or alkalinity is called **NEUTRALIZATION**.

Because acids and bases are at opposite ends of the pH scale, adding an alkali to a solution which is basically acid will de-crease the acidity and move the pH count up.

The opposite solution to alkalinity is also true: adding an acid solution to a base will decrease the alkalinity and lower the pH.

An acid is said to "neutralize" a base; an alkali will neutralize an acid.

The most common kind of acid in water is carbonic acid which is formed when carbon dioxide is dissolved in water.

However, certain kinds of minerals can also combine with water to form acid water. Mineral acids are especially common in mining areas.

Neutralizing Filters

One common way to treat acid water is to feed the water through a **CALCITE FILTER**. The calcium dissolves in the feed water and raises the pH.

Calcite, which is a form of calcium, is found in ground limestone and is alkaline.

Magnesium, which is also alkaline, may also be used as a neutralizing filter for acid water.

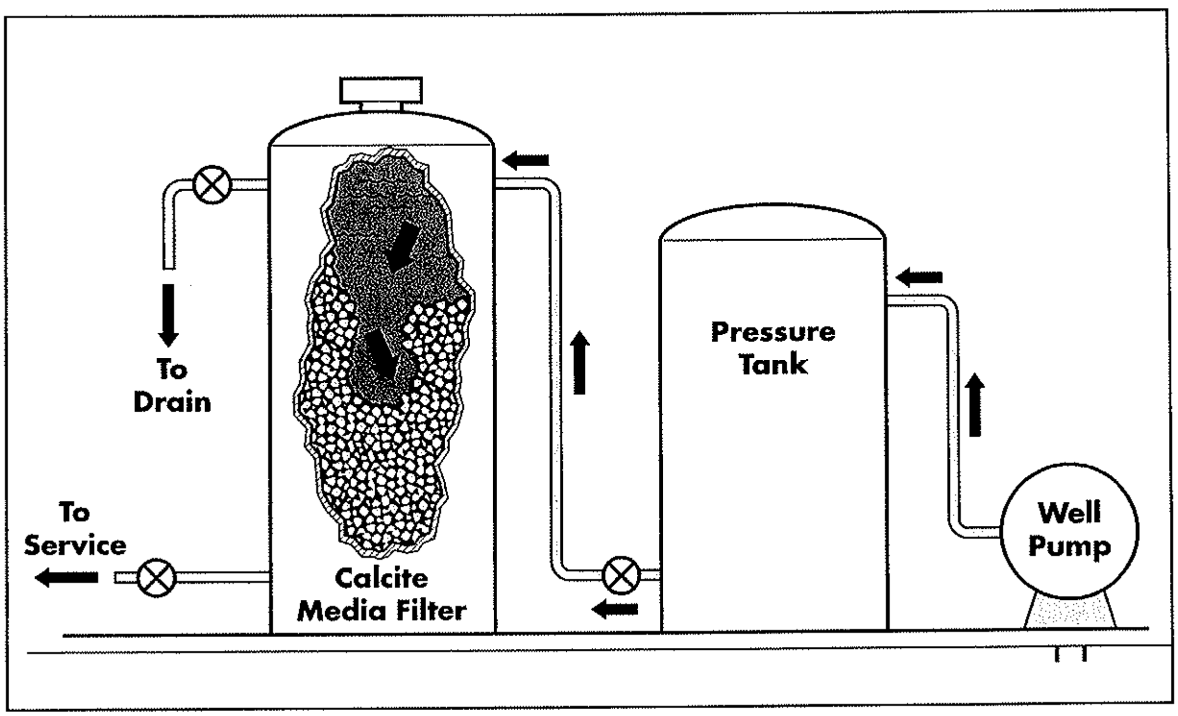
Or a mixed-media filter bed, which includes both calcite and magnesia (magnesium oxide) may be used.

It is important that the bed of calcite be deep enough and the flow rate of the feed water be slow enough to allow enough contact time between the filter and the feed water. However, the flow rate of the water system must be adequate for backwashing.

It is better for the neutralization filtering system to be somewhat oversized rather than being undersized for the tested pH value of the feed water. A neutralization filter which is too small will not totally solve the acidity problem.

The manufacturer's specifications will indicate the pH range that the filter will treat and the required water flow rate in gallons per minute (gpm). Using this information and the result of the pH testing, a properly-sized neutralization filter can be chosen.

CALCITE CARBONATE MEDIA BED, NEUTRALIZER-FILTER FOR PH MODIFICATION OR TURBIDITY FILTRATION



SP 5.4.03

Neutralizer filters come in upflow and downflow designs. Each has it advantages. Check with your manufacturers about the advantages of the various models your company sells.

Depending upon the design of the filter, calcite, magnesia, or calcite/magnesia neutralizing filters may need to be backwashed regularly. The flow rate of the water for backwashing and the number of minutes in the backwashing cycle are important in keeping the filter operating effectively.

Because calcium and magnesium are heavy materials, it is very important that the water flow rate be great enough and backwash cycle long enough to adequately backwash the media beds in such filters. An 8-to-12 gpm backwash rate for at least 10 minutes, depending upon the neutralizer media used, is recommended by the Water Quality Association. Water with iron content requires a longer backwash cycle.

Since the alkaline filter medium is dissolved in the feed water, replacement of the medium will be required from time to time.

Because calcium and magnesium are the two minerals which usually cause hard water, if a calcite or magnesia filter is used for pH, it may be necessary to follow neutralization with a softener.

When testing regularly to be sure that the acid water is being neutralized, hardness testing should also be done to determine whether a softener is needed.

A water softener after the neutralizer filter will be mandatory if the home is equipped with a tank-less water heater and/or an instantaneous point-of-use water heater as hardness will clog the heating coil or heating chamber.

Chemical-feed Method

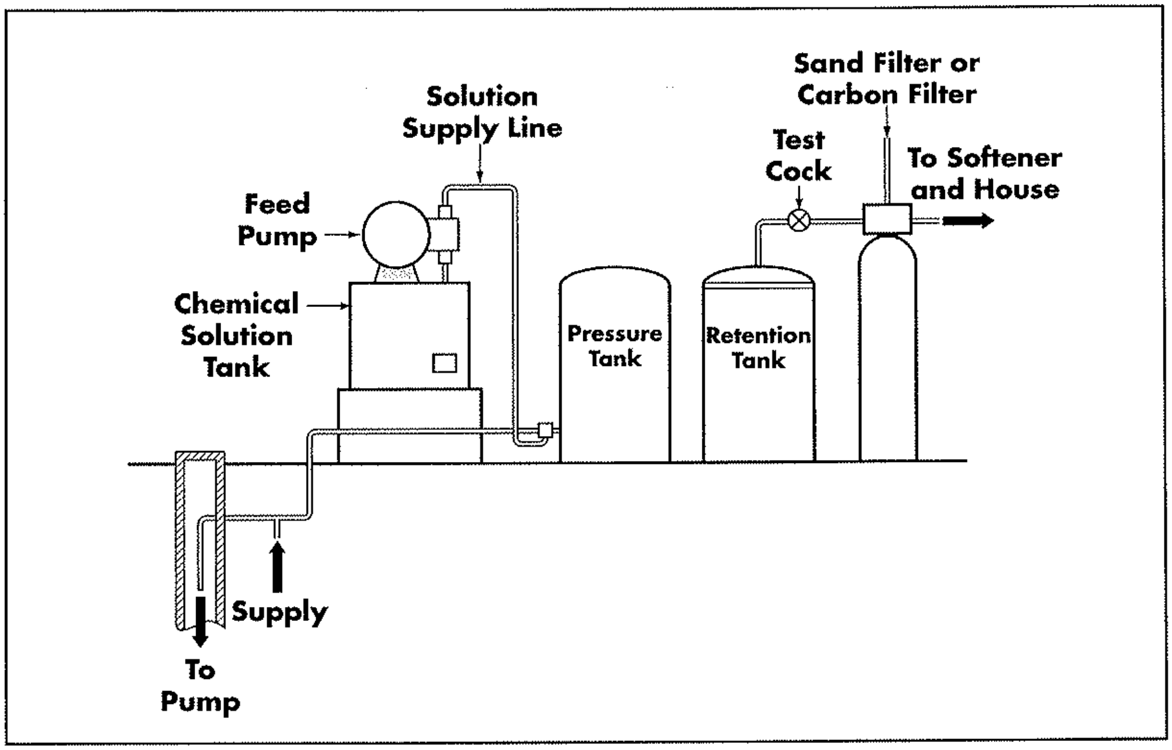
An alternative method for neutralizing acid water is to feed a **SODA ASH (SODIUM CARBONATE)** and water solution directly into a retention tank piped into the untreated water. The retention tank provides time for the soda ash solution to effectively raise the pH of the untreated water.

The amount of soda ash that needs to be fed in must be determined by pH testing of the water to be treated. Regular monitoring by pH testing is required.

Soda ash does not contain calcium or magnesium and therefore does not add hardness to the water.

This chemical-feed method requires use of a chemical solution tank and a small feed pump. This method of acid reduction has a special advantage for use in private water supplies (wells, ponds, lakes) which also need to be disinfected.

CHEMICAL FEED PUMP ARRANGEMENTS



SP 5.4.04

It is possible to feed a combination of soda ash and a chlorine solution (**HYPOCHLORITE** as bleach) for disinfection at the same time so that one solution tank and one pump can provide both.

When a low pH problem exists, it is also possible that there is a high iron content.

This is likely to be true of well water, which frequently has high levels of both acid and iron because the acidic water will dissolve the iron from the surrounding soil and rocks.

Acid in the water may also dissolve the iron in galvanized steel pipes in plumbing systems and therefore cause rust particles or a high iron content in tap water.

If a homeowner has a problem with high acidity, the water should also be tested for iron content.

Following calcite/magnesia acid neutralization with water softening to remove hardness may also serve to remove low levels of some kinds of iron.

However, higher levels of iron will require special treatment.

Combination treatment methods for both acid neutralization and iron removal can be used successfully.

Symptoms of iron in water will be discussed later in the course. Iron removal treatment will also be discussed at that time.

Protecting Pipe Lining

Under certain conditions, a treatment which coats the plumbing pipes with a hard microscopically-thin lining is used to protect them from corrosion from acidic water or from buildup of scale from hard water.

The materials (usually **PHOSPHATES** or **SILICATES**) to build the lining are continually fed into the water supply from a tank or a cartridge. The materials are approved as safe food-grade additives by the U.S. government.

Although the thin lining protects steel or lead pipes, the lining does not neutralize the acid to prevent corrosion of cookware or glassware, nor does it soften the water.

For certain kinds of homes and certain levels of corrosivity, the use of phosphate or silicate coatings for the pipes may provide some useful solutions to scale or corrosion.

If your manufacturer offers phosphate-or silicate-coating treatments, read the literature carefully about their use and ask for training in when to suggest such products.

Although much less common than acid water, water which has a high pH (above 7.0) can be a problem. Sometimes this alkaline water may result from community treatment systems which use lime or ammonia as part of the treatment process.

A pH reading of 9.0 and higher is considered highly alkaline and may need to be treated.

At high pH levels, alkaline water can also corrode metals including brass, zinc, copper, aluminum, and iron. When alkaline water is heated, it can also combine with hardness to form a scale on metal surfaces. At highly alkaline levels, the water can dry out skin and hair and create a "soda-like" taste in the water.

Treatment for Alkaline Water

As you might suspect, the treatment for alkaline water is to use the chemical-feed method to feed in an acid which will neutralize the high pH.

Acetic acid (or white vinegar from the supermarket) may be fed in with a chemical-feed pump to bring the pH level down.

Higher levels of alkalinity may require stronger acids, including citric acid or alum.

The use of very strong acids, such as sulfuric acid, can be hazardous and must be handled very carefully.

These strong, hazardous acids are usually for business or commercial use rather than for use in home treatment.

The anion exchange will also reduce alkalinity, lowering the pH of the water. Contact your manufacturer for information about this use of anion exchange.

REVIEW QUIZ – DISTILLATION AND PH CONTROL

Answers appear on page 90

DIRECTIONS: Carefully read each question and circle the correct answer. There is only one correct answer per question. When you have finished, check your answers.

1. What is the main advantage of using distillers as a water conditioning process?
   a. They remove microbes.
   b. They reduce the inorganics.
   c. They are less expensive than reverse osmosis.
   d. They work on all contaminants.

2. Distillers must be carefully placed in the house because they produce
   a. impurities.
   b. heat.
   c. steam.
   d. contaminated liquids.

3. All of the following are advantages of an air-cooled distiller EXCEPT
   a. No extra water is required for use as a coolant.
   b. It works well in a warm room.
   c. No extra water is flushed down the drain as a coolant.
   d. The vaporized solvent is condensed into a reusable solvent.

4. One advantage of small batch-type distillers is that they produce no
   a. waste water.
   b. impurities.
   c. contaminated liquids.
   d. heat.

5. How many gallons of product water per day do residential distillers usually produce?
   a. 1 to 5 gallons
   b. 3 to 6 gallons
   c. 3 to 12 gallons
   d. 12 to 15 gallons

REVIEW QUIZ – DISTILLATION AND PH CONTROL

Answers appear on page 90

6. How does a distiller remove microbes?
   a. Microbes are removed during the filtering process.
   b. Microbes are killed when the water reaches boiling temperature.
   c. Microbes are removed by pressure and the temperature of the feed water.
   d. Microbes are killed with the pH balance is restored to a neutral state.

7. Because acid water can eat through metal pipes, it is often called by what other name?
   a. Neutral water
   b. Alkaline water
   c. Aggressive water
   d. Disruptive water

8. On the pH scale, where will acidic water register?
   a. Above 7.0
   b. Between 7.0 and 9.0
   c. Between 7.0 and 10.0
   d. Below 7.0

9. What happens when an alkaline solution (base) is added to an acidic solution?
   a. Nothing.
   b. The alkaline solution is neutralized.
   c. The acidic solution is neutralized.
   d. Both the alkaline and acidic solutions are neutralized.

10. All of the following are acids on a pH scale EXCEPT
    a. Orange juice
    b. Vinegar
    c. Corn
    d. Ammonia

11. Why does the medium need to be replaced regularly in an acid-neutralizing filter?
    a. The medium dissolves in the water.
    b. The medium becomes hard.
    c. The medium is completely used.
    d. The medium evaporates into the air.

REVIEW QUIZ – DISTILLATION AND PH CONTROL

Answers appear on page 90

12. Following an acid-neutralizer filter, why may a water softener be needed?
    a. Acid in the water may dissolve the iron in galvanized steel pipes.
    b. The filter puts calcium and magnesium into the water.
    c. The filter will remove stains from bathroom fixtures.
    d. Acid in the water will corrode faucets and brass fittings.

13. When a chemical feed method is used, how does one determine the amount of soda ash needed?
    a. Tank size
    b. Amount of sodium carbonate required
    c. pH testing
    d. Manufacturer's guidelines

14. If a homeowner has a problem with high acidity, for what else should the water be tested?
    a. Phosphate
    b. Household lye
    c. Ammonia
    d. Iron

15. Why are phosphate or silicate pipe-coating treatments used?
    a. Highly alkaline water will corrode metals.
    b. A softener can remove iron low levels of some kinds of iron.
    c. A lining on the pipes protects them from corrosion.
    d. Feed acids lower the pH level.

REVIEW QUIZ – DISTILLATION AND PH CONTROL

Answers appear on pages 90 - 91

APPLYING WHAT YOU HAVE LEARNED:

By observing and asking questions, fill in the blanks. If you are not sure of the answers, ask your supervisor.

A. Describe how the distillation process works.

____

____

____

B. Briefly explain what the pH scale measures.

____

____

____

ANSWERS TO REVIEW QUIZ

CHAPTER 4

DISTILLATION AND PH CONTROL

Answers to REVIEW OF DISTILLATION AND PH CONTROL (pages 85 – 88)

1. d. They work on all contaminants.
2. b. heat.
3. b. It works well in a warm room.
4. a. waste water
5. c. 3 to 12 gallons
6. b. Microbes are killed when the water reaches boiling temperature.
7. c. Aggressive
8. d. Below 7.0
9. c. The acidic solution is neutralized.
10. d. Ammonia
11. a. The medium dissolves in the water.
12. b. The filter puts calcium and magnesium into the water.
13. c. pH testing
14. d. Iron
15. c. A lining on the pipes protects them from corrosion.

Applying what you have learned:

A. Answers may vary but should include a general description of the process. Water distillation is the process of boiling water in a chamber creating steam. As the vapor rises, it passes through cooling coils and collects as pure water. All of the contaminants are left behind in the boiling tank and gases that vaporize at temperatures lower than the boiling point of water are released through volatile gas vents. It is highly effective in removing all inorganic, organic and radionucleotide contaminants. These include heavy metals, ammonia, nitrate, chloride, fluoride, radium 226, industrial organic contaminants, and pollutants.

Answers to REVIEW OF DISTILLATION AND pH CONTROL (pages 85 – 88)

Applying what you have learned (cont.):

B. Answers may vary but should include a description of the acids, alkali, and neutral solutions.

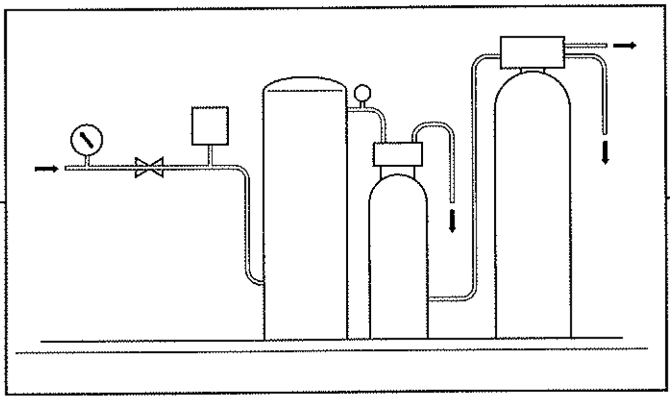
- A solution's "pH" is a rough measure of its acidity. The "p" stands for "potenz" (this means the potential to be) and the "H" stands for Hydrogen. It might seem odd that the more acid a solution is, the lower the pH is, but acids all produce Hydrogen ions.
- The pH of distilled water is 7.0: this is neutral. Any solution with a pH below 7.0 is an acid and any solution with a pH above 7.0 is an alkali.
- Acidic solutions have a pH between 1 and 6.9—your stomach contains HCl it is pH2.
- Alkaline solutions have a pH between 7.1 and 14—your small intestine is pH 9.0.
- Neutral solutions are neither acidic nor alkaline so their pH is 7.0.

5 SPECIAL PROBLEMS

LEARNING OBJECTIVES

When you finish this Chapter, you will be able to:

1. Recognize common residential water problems based on symptoms.
2. Recommend solutions to common residential water problems.
3. Compare and contrast common methods of treating water.
4. Discuss what services manufacturers provide to wholesalers and their sales people.



SPECIAL PROBLEMS

Treating Problem Impurities

As discussed earlier, water may contain impurities from natural or artificial sources. These impurities may cause health problems, damage equipment or plumbing, or make the water undesirable. The water should be tested by an independent laboratory to determine the specific impurities and level of contamination before a treatment method is selected.

There are three very troublesome impurities: iron, manganese, and hydrogen sulfide gas, which need special treatment techniques. Each of these are discussed in the following sections.

The Problem of Iron

Iron removal is the most complex of these problems. Iron is found in water in four different chemical forms: ferrous iron, ferric iron, chelated iron, and iron bacteria. The treatment depends partly upon the form of iron present in the water supply to be treated.

If the water contains substantial amounts of iron (in any form), basically a two-step process must be followed:

1. Cause the iron to combine with oxygen (**OXIDIZE**) and solidify (**PRECIPITATE**)
2. Filter the solid iron particles out of the water

Types of Iron

Iron which is totally dissolved in water is called **FERROUS IRON** or clear water iron.

It is not possible to see ferrous iron in the water, but if there is enough of it (more than 0.30 ppm), it will cause rusty brown stains on laundry and porcelain plumbing fixtures.

If such stains appear, water testing can tell how much iron is in the water. Ferrous iron can also cause a metallic taste in water and water-based drinks.

Ferrous iron will remain in the ferrous state if the water does not come into contact with the oxygen in the air.

Iron is very common in well water. In pumping well water, an air-tight system from pump to water softener should keep iron dissolved.

If the quantity of ferrous iron is not too great—five (5.0) ppm is a number often given—the iron can be removed by a cation exchange water softener at the same time that calcium and magnesium hardness are removed. Under some conditions softeners can take out more than the five ppm.

However, iron removal by cation exchange will only work effectively if the pH of the feed water is 6.8 or higher.

Acid water may require pretreatment to neutralize the acid before running the water through the softener if iron reduction is to be effective.

More frequent regeneration of the softener will also be necessary if it is to remove clear water iron effectively.

Manufacturers will state in specifications how much ferrous iron can be removed by their water softeners.

Water which contains higher levels of ferrous iron or iron in other forms requires other conditioning techniques.

When ferrous iron is exposed to the oxygen in the air, it generally is converted to ferric iron.

FERRIC IRON is iron that has solidified ("precipitated") and would eventually settle out to the bottom of a container or body of water if the water were left undisturbed. Essentially, ferric iron particles are very small pieces of rust.

Water containing iron molecules in the process of changing from ferrous iron to ferric iron will be a rusty color. Water containing ferric iron is often called red water.

Ferric iron may also be present in water when acidic water eats into galvanized steel pipes in the plumbing system.

If red water is exposed to oxygen and left alone to stand quietly, the iron will precipitate and slowly settle to the bottom.

This is why water supplies taken from surface water sources, such as lakes, reservoirs, and ponds are less likely than well water to contain iron. The iron settles to the bottom of the lake.

However, drinking water which is passed through the piping system in a home is not exposed to very much oxygen but is continually stirred up by movement through the pipes.

Therefore water conditioning treatments for higher levels of iron are designed to cause the iron to precipitate out and then to filter out the solid iron particles.

Water containing ferrous iron may contain iron bacteria.

IRON BACTERIA are living organisms which thrive by using ferrous iron as an energy source to help them live.

Iron bacteria actually cause the ferrous iron to precipitate into ferric iron, which they then store within their cells.

These bacteria form slimy, jelly-like rust-colored masses which clog pipes and cause water to taste and smell bad.

These bacteria colonies are most often noticed in the flush tanks of toilets, where they will also cause the water to have a shimmery rainbow-like slick on the surface.

From time to time these brown bacteria masses will break loose in big gobs or "slugs" and pass into the piping system, where they cause clogging and slow the rate of water flow.

Because these organisms are living creatures, which grow and reproduce, they are very difficult to get rid of permanently.

In some water from surface sources (lakes, ponds) the iron in the water may be in the form of chelated iron.

CHELATED IRON (pronounced *KEY lay ted*) is iron which has combined with another substance to form a strong, stable molecule which does not change its chemical form easily.

Chelated iron does not precipitate and settle out, so it can not be removed by filtration.

Because some of the substances which combine with iron to form chelated iron are organic substances, chelated iron is often called *organic iron.*

Because chelated iron stays suspended in the water, it may be called *colloidal iron.*

Colloidal particles are very small particles which will not settle out of a solution. They are halfway between truly dissolved particles and suspended solid particles.

Treating Iron with Oxidation

When oxygen combines chemically with another substance, the process is **OXIDATION**.

Rust is the result of oxidation taking place when iron in solid form (steel pipes or cast iron furniture left unprotected in the yard) is exposed to oxygen and moisture.

As we have seen, when oxygen is combined with ferrous iron in lake water, the iron precipitates, becomes ferric iron, and settles out to the bottom of the lake.

Water conditioning treatments for removing iron (other than the cation exchange process already discussed) are designed to bring about oxidation so that the iron will precipitate and can be filtered.

However, different forms of iron require different methods to bring about oxidation.

The Problem of Manganese

If iron is present in a water supply, the chances are very good that manganese, in one or more chemical forms, is also present.

Manganese, and manganese bacteria, can cause clogging of pipes and fittings. Manganese will cause a black sediment in tap water which will make the water turbid.

The same water conditioning methods which remove iron are used to remove manganese.

However, manganese is much more difficult to precipitate, requiring about twice as much oxygen to cause precipitation.

Much of the rest of the discussion of iron removal will also include information about manganese removal, since methods are the same.

Treating Manganese with Oxidation

One of the oldest methods of treating water to remove unwanted substances is to expose it to the air to allow the oxygen in the air to chemically oxidize the unwanted elements.

The process of exposing a quantity of water to the air in the atmosphere is called **AERATION**. You may have seen this process being used by municipal water treatment plants where the water is actually sprayed into the air by use of pumps and aerators.

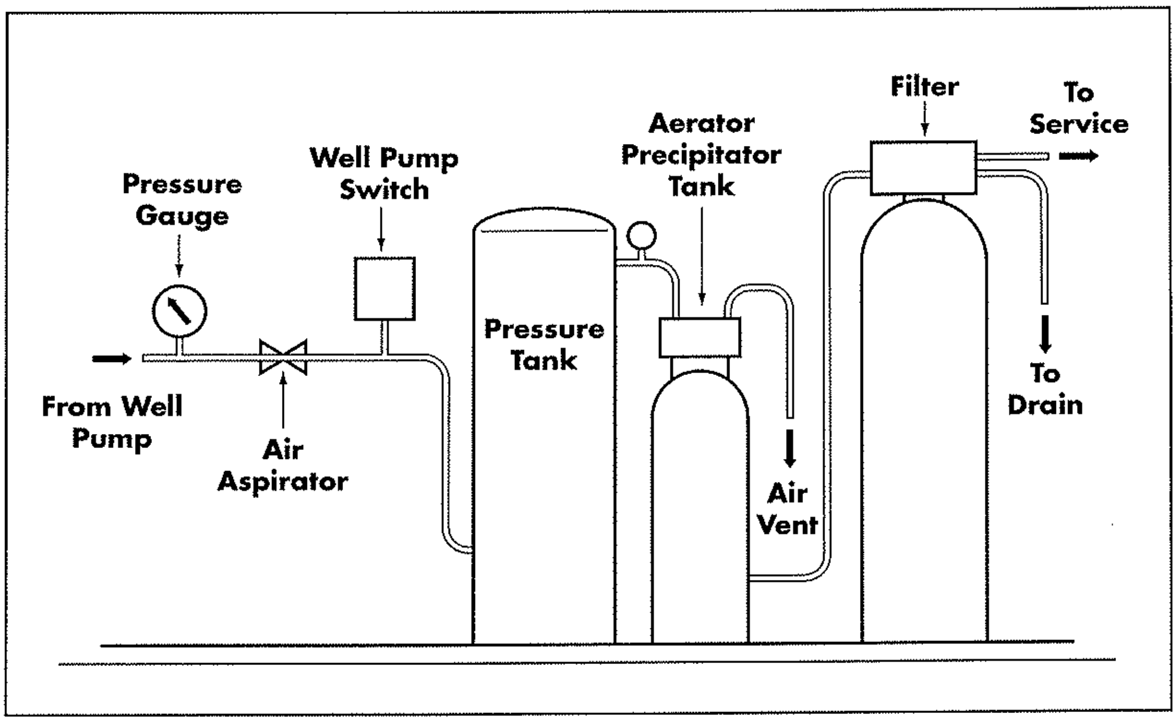
Residential water conditioning methods often use pressure aerators to bring about oxidation. Such aeration systems work like the one pictured below.

An air aspirator sucks air into ("aspirates") the piping system carrying the water. The air-rich water is stored in a pressure tank until it is drawn into the aerator/precipitator tank. In the precipitator tank, some of the oxygen in the air combines with the iron and manganese molecules, which precipitate out.

The remaining air rises to the top, where it is vented; water containing precipitated iron (and manganese) is then pumped to the filter. Such a system requires no chemicals and uses only air from the atmosphere. However, the water flow rate must be adequate.

Organic (chelated) iron can NOT be successfully treated by this method.

DOMESTIC TYPE PRESSURE AERATION/FILTER SYSTEM



SP 5.5.01

Treating Manganese with an Oxidizing Filter System

Another widely-used method for treating iron is the oxidizing filter system.

An **OXIDIZING FILTER** oxidizes the iron, which converts the dissolved ferrous iron into ferric iron. Then the precipitated manganese/iron is filtered out through the granulated filter material.

The oxidizing filter is usually some material coated with manganese dioxide. One of the most common oxidizing filter media is called **MANGANESE GREENSAND**.

A synthetic material called **ZEOLITE** is often used as an oxidizing filter medium.

Manganese dioxide filters are effective for water containing medium levels of iron and manganese.

Manufacturer's specifications will indicate the level of iron (in ppm) which can be treated by a particular filter.

However, acid water should be pre-treated before using the manganese dioxide filter.

Periodic backwashing is needed to remove the precipitated iron; the backwashing requires a considerable volume of water at a good flow rate.

Before selection of such a system, the manufacturer's recommendations about the gallons per minute (gpm) flow rate should be carefully considered.

From time to time the filter itself must be regenerated by passing an oxidizing solution through it to replace the oxygen content of the filter. **POTASSIUM PERMANGANATE** is a common regenerant and oxidizer used in water treatment.

Treating Manganese with the Chemical-feed Method

If high levels of iron, iron bacteria, or chelated iron are present in the water, stronger oxidizing agents must be used.

For these difficult problems, a chemical-feed system with a special pump may be used to feed oxidizing chemicals from a solution tank into the water being pumped. A properly-sized retention tank is necessary. (See the Chemical-feed Method diagram on page 82.)

Chlorine in the form of dry pellets may also be used for the chemical feed process.

The two chemicals which are commonly used are chlorine (in the form of hypochlorite, which is household bleach) and potassium permanganate.

The strength of the chlorine or permanganate solutions and the length of time the iron must be exposed to the chemicals (in the retention tank) will depend upon the level of iron.

Very often, only trial and error will determine the necessary solution strength and exposure time.

If iron bacteria are growing throughout the plumbing system, it may be necessary to use heavily chlorinated water (on a one-time basis, it is hoped) to flush the entire plumbing system.

A filter will be needed to remove the precipitated iron, and possibly to remove dead bacteria also. A carbon filter may be needed to take out the excess chlorine.

USE OF OXIDIZING CHEMICALS MAY AFFECT WHAT OTHER KINDS OF FILTERING TREATMENTS CAN BE USED. CONTACT YOUR MANUFACTURER ABOUT THIS.

One advantage of using chlorine or potassium permanganate is that both of these chemicals will disinfect the water as well as remove the iron and manganese.

Most common microbes (except cysts), not just iron and manganese bacteria, are killed by use of these two chemicals.

Therefore this method can be used to treat water which would otherwise not be potable.

Household bleach is often fed into the water supply to remove iron and bacteria along with soda ash to neutralize acid water.

Of course, these are strong chemicals. Care must be taken in preparing the dosage to be used and in handling the chemicals. And these chemicals must be flushed out of the system before the water is actually drinkable.

The Problem of Hydrogen Sulfide Gas

Another bothersome component of some water supplies is **HYDROGEN SULFIDE**, which is the gas that causes water to smell like rotten eggs.

This gas dissolved in water produces "sulfur water," which not only smells bad but can tarnish silverware and corrode metals.

Treating Hydrogen Sulfide Gas with Oxidation

Several oxidation methods which are used to remove iron and manganese will also get rid of hydrogen sulfide gas.

For example, the use of a pressure aerator and filter system will also get rid of some hydrogen sulfide, which will escape through the vent at the top of the aerator/ precipitator tank. However, this may not remove all of the dissolved gas.

Non-pressurized ("open gravity") aerator systems, though traditionally used in municipal systems, are available for residential systems and will work even on higher levels of hydrogen sulfide gas. However a non-pressurized aerator system also requires a second pump and second tank to re-pressurize the water system.

The use of manganese oxide filters will also help reduce hydrogen sulfide. Very small amounts of hydrogen sulfide may even be removed by activated charcoal filters.

The use of chlorine or potassium permanganate is very useful in removing the objectionable, foul-smelling gas.

If the rotten egg smell is found to be present in water which has been softened or filtered, but the smell is NOT in the untreated tap or well water, sulfur bacteria may be growing in the plumbing system.

It may be necessary to chlorinate the entire plumbing system: both hot and cold piping systems plus the storage tank and hot water tank to get rid of the sulfur bacteria.

The manufacturer's specifications for iron removal systems will generally state whether or not those systems will also remove hydrogen sulfide.

The Problem of Lead

Lead is known to be very harmful to human health. Lead poisoning is especially dangerous to infants, children, and developing fetuses.

Lead-contaminated drinking water is a problem of special importance in the plumbing industry, because much of the lead in residential drinking water comes from the household plumbing system.

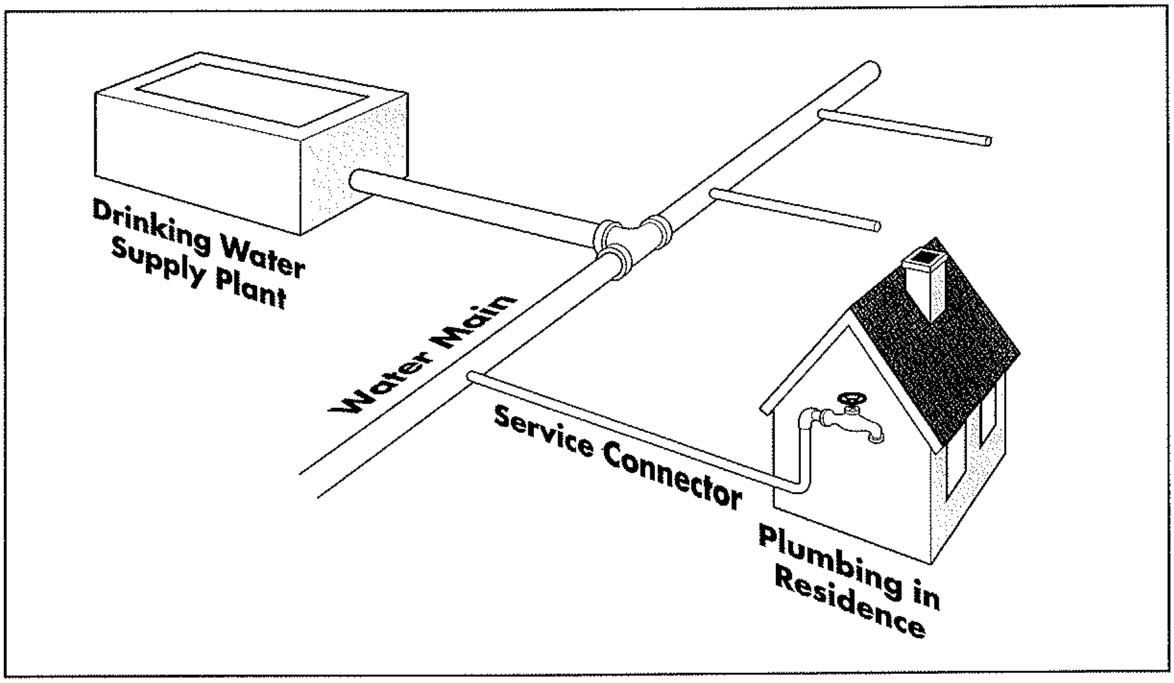
Most of the lead gets into drinking water AFTER the water leaves the local public water treatment system. The service connectors between the water main in the street and the home may contain lead, especially in older cities and towns.

It is believed that most lead in the drinking water comes from lead pipes used in older homes and from lead in solder used to join copper piping.

Restrictions which now ban lead in solder used for drinking water systems should help lessen the problem, but homes built before this law must still face the problem of lead-bearing solder and drinking water.

Several health and government agencies are also concerned about whether lead can be leached into drinking water from drinking fountains, water coolers, and faucets. Further testing may be required for these products.

DRINKING WATER SUPPLY SYSTEM



SP 5.5.02

Lead in Drinking Water Caused by Corrosion

The lead in the lead pipes and in the solder gets into the water because of corrosion.

CORROSION is the eating away of metal, in this case the pipe or soldered joints, caused by a chemical reaction. Reaction between water and metal pipes or solder will cause corrosion.

In cases where copper pipe is joined to other kinds of metal pipe, an electro-chemical reaction can cause corrosion.

Corrosion directly exposes the lead in the pipes and solder to the water.

Homes at Risk

Homes especially at risk for lead in the drinking water are:

1. Older homes, especially those built before 1930.
2. Homes with metal water pipes (especially copper) that were built before lead solder was outlawed.
3. Homes with corrosive water.
4. Homes in which water sits in the pipes for six hours or more without any water being drawn from the faucets.
5. Homes in which electrical equipment (such as telephone lines) is grounded to the water pipes.

Older homes, especially those in which the plumbing was installed before 1930, are likely to have lead pipes in the water system.

Lead pipes are dull gray in color and so soft that they are easily scratched by a metal key.

If the community water system was installed before 1930, it is quite possible that the service connectors between the water main and house are also made of lead.

Older homes are also more likely to have pipes which are deteriorating and crumbling, so that the lead in pipes or the lead-containing solder is exposed to the water.

Prior to the law prohibiting the use of lead solder for pipes carrying potable water, some solder used contained as much as 50% lead. Concern about the lead leaching into drinking water was the reason for the law being passed.

However, scientific data shows that even in houses built after 1930 but before the "no-lead-in-solder-law" are not as much at risk after they became five years old. By the end of the fifth year, a mineral coating has begun to buildup on the inside of the pipes. If the water is not too corrosive and the pipes are in good shape, this coating will help in insulating the water from the lead.

For the safety of everyone, especially children, it is important that the no-lead solder law be obeyed.

Corrosive water eats away the mineral coating on the pipes and destroys the pipes themselves. This destruction releases the lead in the pipes and the solder (or in any other fitting or appliance that might contain lead anywhere) into the water.

Corrosive water may be water that is acidic (with a low pH reading) or highly alkaline (with a high pH reading). Various kinds of minerals can increase corrosivity. High oxygen content can make water corrosive.

Some water is naturally corrosive due to the geographic features through which it flows. Other water is corrosive because of contaminants which seep into the water from mines, factories, or disposal sites.

Corrosive water can be effectively treated, as discussed elsewhere in this course, in order to lessen destruction of piping and leaching of lead from pipe and solder.

Please review page 38 for a discussion of the recent long-term study performed by the U.S. EPA, financed by both the EPA and the Water Quality Association, relating to softened water and corrosivity.

Hot Water Dissolves More Lead

Homes in which water sits in pipes for six hours or more without any water being drawn from the faucets are more likely to have a lead problem, if, of course, the house has lead pipes, copper pipes soldered with lead solder, or lead service connectors.

The longer water is exposed to lead pipes or lead solder, the greater the contamination.

Running the cold water from the faucet until the water feels very cold will flush out the water which has been in the pipes for a long time. Allowing it to run for an additional 15 seconds after it becomes cold, may be enough to flush out the service connectors too. (In high rise buildings with very large pipes, this technique does not work effectively).

Water for drinking and cooking should NEVER be drawn from the hot water faucet if there is danger of lead contamination. Hot water will dissolve more lead than cold water.

Sometimes electrical equipment, such as telephones or even the household electrical system, is grounded by connection to the water pipes. The electricity running through the ground wire will increase the rate of corrosion and the leaching of lead from pipes.

HOWEVER: THESE WIRES SHOULD NEVER BE REMOVED EXCEPT BY A QUALIFIED ELECTRICIAN WHO THEN WILL INSTALL ANOTHER SAFE GROUNDING SYSTEM!!!!

The Process of Testing Water

If a home or business is likely to have lead in the water, the water should be tested. Since lead in drinking water produces no taste, color, or smell, testing of the water is the only way to determine if there really is lead in a household's drinking water.

Tests should be done using two water samples: a "first draw" water sample which is drawn after the water has been in the pipes for six hours or longer without any being drawn AND a "fully flushed" sample drawn after flushing until the water is very cold, using the procedure described above. This will show how effective the flushing process is.

As with all health effects testing, a certified laboratory should probably be used to assure reliability.

Under the Safe Drinking Water Act, the limit for lead in drinking water is 0.015 parts per million.

If the lead content of the water is at or above these limits, and especially if there are children in the household, special treatment for lead removal and reducing water corrosivity should be considered.

The U.S. EPA says that the ultimate goal is for there to be NO lead at all in U.S.

drinking water.

Lead Removal

Corrosivity is generally treated by changing the pH of the water by neutralization, which is discussed elsewhere in this volume.

Reverse osmosis and distillation, installed at point-of-use, can be used to remove lead from water for drinking.

Of course, if these devices are installed only at the kitchen faucet, family members must be instructed to drink the water only from this faucet or from water bottles containing water drawn from this faucet.

Replacing old and deteriorating pipes can also help in lowering the lead levels.

The U.S. Environmental Protection Agency is extremely concerned about lead in drinking water. All wholesalers and their employees should try to keep up with regulations on, and research about, lead in drinking water.

Certified Testing Labs

Most of the water conditioning processes described in this course are for use on potable water, which has already been disinfected to remove pathenogenic microbes.

It is not safe to drink any water which is not absolutely known to be potable, not even water from "beautiful, clear mountain streams." Clear mountain streams could still have Giardia cysts and other possible contaminants.

It is assumed that any water that has been treated by a city, town, or other local governmental agency is potable.

If water has not been municipally treated, the only way to be sure water is biologically safe is to have it tested by a certified testing service which specializes in testing for microbes.

Your local or state public health agency can probably recommend laboratories which are certified for testing for potability.

Most wholesalers, manufacturers, or other organizations which test water for purposes of selling filters or water conditioners ARE NOT qualified to test for potability (microbes).

Laboratories certified for testing for environmental contaminants (synthetics, inorganics, radioactive substances) are NOT certified to test for microbial contaminants.

The Need for Disinfection

All water of uncertain quality should be disinfected before using it for drinking, food washing or preparation, washing dishes, brushing teeth, or making ice. In addition to having a bad odor and taste, contaminated water can contain microorganisms (germs) that cause diseases such as dysentery, cholera, typhoid, and hepatitis.

Several processes discussed here can be used for disinfecting water.

Disinfection by Chlorination

Chlorination is the most common method of disinfecting water, both in community treatment plants and for whole-house treatment of water from private sources

The chlorination process (using hypochlorite) has been described earlier in this volume in connection with iron removal.

You will recall from earlier discussions in this volume, however, that cysts, including Giardia lamblia and Cryptosporidium, are generally not killed by use of chlorine disinfection. While these microbes are not necessarily common in well-constructed wells, if there is any concern about them, there are filters available (with VERY small pores) that are specifically rated for removal of these particular microbes. The typical filter will not remove these cysts.

If organic matter decays in chlorinated water, by-products of the disinfection process, such as trihalomethanes, can be produced. Private water systems using chlorination for disinfection should probably be routinely tested for THMs.

Use of chlorine may require after-treatment with activated carbon to remove the taste and smell of the chlorine.

Disinfection by Distillation

The distillation process, which is described earlier in this course, can also be used for disinfection of drinking water.

Distillation requires no chemicals and removes almost all other impurities in addition to disinfecting the water. For removal of certain volatile organics or gasses, a carbon filter is usually part of the distiller unit.

Small batch distillers, often countertop types, are becoming more popular because they are portable and can be used for recreational vehicles, hunting and fishing cabins, and vacation homes.

Disinfection by the Ultraviolet (UV) Process

Another method of disinfection which is sometimes used is disinfection by ultraviolet (UV) process. **ULTRAVIOLET DISINFECTION** is a process which uses ultraviolet light rays to kill bacteria, viruses, and other microorganisms. Cysts are not effectively killed by ultraviolet.

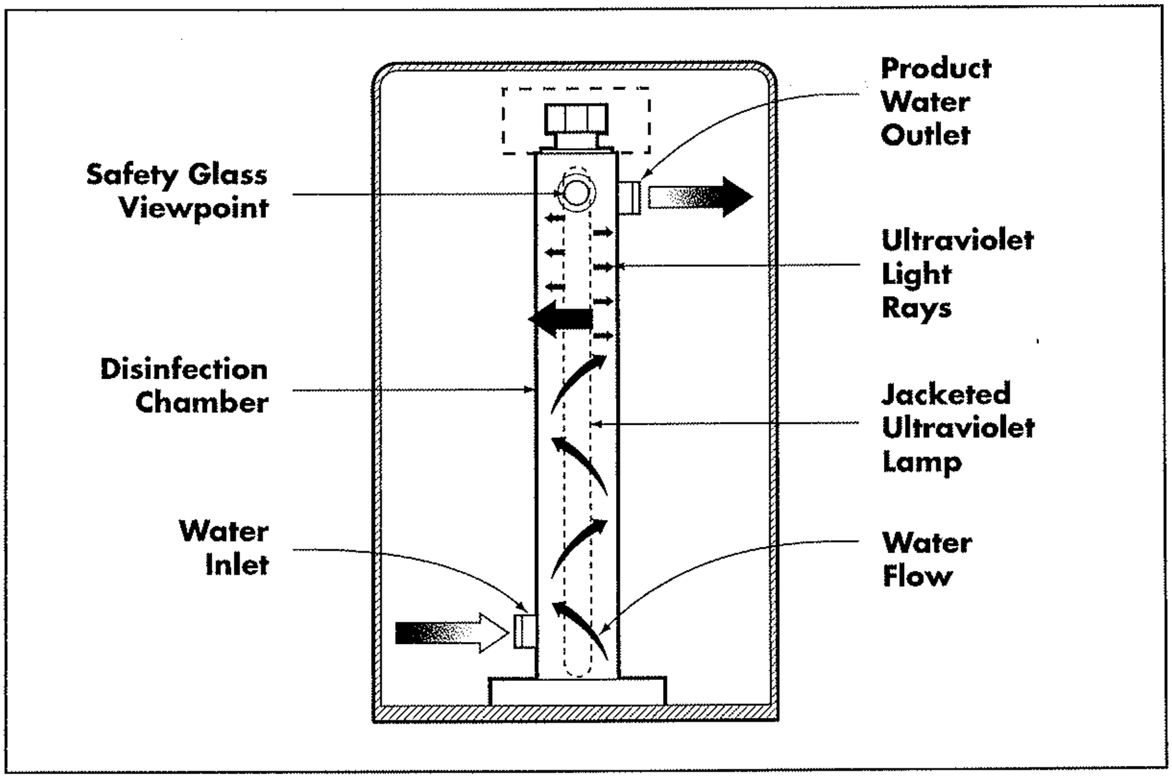
Residential UV is usually used at point-of-entry (whole house) and systems are available for flow rates from about four gpm to about 30 gpm. Ultraviolet treatment is faster than chlorination but UV requires that the UV lamp be replaced yearly, which can be expensive. However, chlorination requires monthly maintenance and usually a carbon filter to take out the chlorine taste and smell.

Water that is to be treated by ultraviolet must generally be pre-treated because turbidity (sediment) allows the microbes to hide behind the particulates so that UV cannot reach them.

If the feed water has iron or manganese or hardness, these contaminants must be reduced to very low levels because they can foul the quartz jacket tube that shields the UV lamp from the water. Such fouling reduces the amount of UV light that gets into the water.

All UV units should have alarms that warn the user if the UV lamp fails, because if no ultraviolet light is being produced, there is nothing to kill the microbes.

TYPICAL DOMESTIC-STYLE ULTRAVIOLET SYSTEM



SP 5.5.03

The manufacturer's directions about water flow rates, bulb replacement, and pre-treatment of feed water should always be followed carefully.

Disinfection by Ozonation

OZONATION is a water treatment process that destroys bacteria and other micro-organisms through an infusion of ozone, a gas produced by subjecting oxygen molecules to high electrical voltages. **OZONE**, a special form of oxygen, is a very powerful disinfectant. The ozone gas is bubbled through the water to be treated. However, ozone is chemically unstable and the oxygen does not stay in the ozone form for very long. Ozone cannot be stored or transported; it has to be generated on site.

Ozonation is every effective for inactivating Cryptosporidium, bacteria, and other naturally-occurring organisms. Ozonation also can reduce the formation of trihalomethanes (THMs), which result from the interaction of chlorine and naturally-occurring organic material in the source water. Ozonation is widely used in Europe and is used by some municipal treatment plants in the U.S.

While commercial and industrial ozonators often use liquid oxygen, residential units can make use of oxygen in the surrounding air.

It is very important that manufacturer's directions regarding the amount of ozone generated and the contact time between the ozone and the water be followed. Pre-treatment recommendations should also be followed.

If your company sells ozone equipment, be sure to read the manufacturer's literature and take any training offered about ozone treatment.

In addition to selling the conditioning equipment, your wholesale firms will probably sell various accessories such as:

A. Testing kits
B. Replacement filters or cartridges
C. Chemicals (such as softener salt) for regeneration or backwashing
D. Chemicals (such as hypochlorite or potassium permanganate) for those processes which require chemical feed as part of the treatment process.
E. Pipes and fittings needed for installation of the equipment.

As you probably have realized by now:

- There is NO single test that will test for all contaminants.
- There is NO single treatment that will successfully treat EVERY common water problem.
- There are several methods for removing most kinds of contaminants.

Some water problems require a combination approach using several different methods for effective removal of the problem substances or conditions.

On the following page is a chart showing some of the solutions to common water problems. This is only a brief summary and is not sufficient to determine exactly which technologies should be used in any particular case.

Check with your manufacturer any time that there is any possible question about treatment techniques.

Wholesalers and their salespeople must depend upon their manufacturers:

- To provide literature and training related to the manufacturer's specific products.
- To provide assistance in water testing.
- To provide training on how to help customers (both contractors and consumers) solve their individual water problems.

- To provide follow-up assistance in helping the customer service and maintain the equipment.

Water Treatment Products Chart

WATER TREATMENT PRODUCTS CHART

Process	Contaminants or Problems						
	Turbidity	Inorganics	Organics	Microbes	Radioactives	Odor / Taste	Corrosivity
Softening		X Hardness Some Iron			X Radium #		
Deionization	X			X	Radium #	X Organic odor	
Filtration	X	X Solidified Iron (Rust)	X Cysts (Approved Filters Only) #				
Activated Carbon	X+		X		X Radon #	X Chlorine	
Reverse Osmosis	X+	X					
Distillation	X	X	X	X	X	X	X
Neutralization	X Ferric Iron	X Iron (Lead: helps prevent lead leaching)					X
Oxidation Aeration		X Iron & Manganese			X	X Hydrogen sulfide gas	
Disinfection				X			

+ Not an efficient use for this process, should pre-treat.
** Not the main use for this process, but is affected by it.*
 # See text for special considerations about this use.

REVIEW QUIZ – SPECIAL PROBLEMS *Answers appear on page 118*

DIRECTIONS: Carefully read each question and circle the correct answer. There is only one correct answer per question. When you have finished, check your answers.

1. Why can ferrous iron be a problem for homeowners?
   a. It is poisonous to most people.
   b. Ferrous iron is responsible for damage to distillation systems.
   c. Brown stains can appear on porcelain fixtures.
   d. Ferrous iron cannot be removed from the water.

2. How much ferrous iron must be present before the homeowner is likely to notice iron symptoms?
   a. 0.10 ppm
   b. 0.20 ppm
   c. 0.30 ppm
   d. 0.40 ppm

3. What can be done to make sure iron in well water stays dissolved in water so it can be treated by cation exchange?
   a. Be sure to pre-treat the water to neutralize the acid.
   b. Be sure the pumping system from the well to the softener is air tight.
   c. Be sure the quantity of ferrous iron is not too great.
   d. Be sure to contact the manufacturer to obtain its specifications.

4. What must be done to acid water if a cation exchange process is to be used for iron removal?
   a. Pre-treat the water to neutralize the acid.
   b. Pre-treat the water to increase the acid level.
   c. Filter the solid iron particles out of the water.
   d. Cause the iron to oxidize and precipitate.

5. Why is water taken from a lake less likely than well water to contain iron?
   a. Well water is generally pre-treated before use.
   b. The iron in lake water is less dense.
   c. Iron evaporates from lakes and ponds.
   d. Iron settles to the bottom of the lake.

REVIEW QUIZ – SPECIAL PROBLEMS *Answers appear on page 118*

6. A homeowner might expect iron bacteria in the water for all of the following reasons EXCEPT
   a. Jellylike masses in the flush tank
   b. Water smells bad
   c. Water tastes bad
   d. Water contains high levels of fungus

7. Why are iron bacteria so difficult to get rid of in a water supply?
   a. They cannot be seen.
   b. They grow and reproduce.
   c. They have no taste or smell.
   d. They slowly clog the piping system.

8. Why is chelated iron so difficult to treat?
   a. It is made up of organic substances.
   b. It forms strong, stable molecules.
   c. It does not settle out and cannot be filtered.
   d. It contains colloidal particles with settle out of a solution.

9. What is the process of oxygen combining with another substance called?
   a. Oxidation
   b. Cation exchange
   c. Neutralization
   d. Precipitation

10. When might a homeowner suspect there is manganese in the water supply?
   a. Jellylike masses in the flush tank
   b. pH of the water is lower than 7.0
   c. Tap water has a black sediment
   d. Rotten egg smell

REVIEW QUIZ – SPECIAL PROBLEMS

Answers appear on page 118

11. What are two chemical oxidizing agents commonly used for removing high levels of iron?
    a. Chlorine and carbon
    b. Chlorine and potassium permanganate
    c. Hydrogen sulfide and carbon
    d. Bleach and chlorine

12. Why would a homeowner suspect hydrogen sulfide in the water?
    a. Jellylike masses in the flush tank
    b. pH of the water is lower than 7.0
    c. Tap water has a black sediment
    d. Rotten egg smell

13. What might a homeowner suspect if softened water smells like rotten eggs but water directly from the well does not?
    a. Pre-treatment will be necessary before a softener will remove iron.
    b. There are lead pipes in the home plumbing system.
    c. Sulfur bacteria is present in the plumbing system.
    d. The turbidity must be treated to remove particulates.

14. Where does most of the lead in drinking water come from?
    a. Untreated well water
    b. Local public treatment system
    c. Water coolers and faucets
    d. Household plumbing system

15. All of the following types of homes are especially likely to have lead in the drinking water EXCEPT
    a. Homes with corrosive water
    b. Homes built after 1970
    c. Homes with metal water pipes
    d. Homes built before 1930

REVIEW QUIZ – SPECIAL PROBLEMS

Answers appear on page 118

APPLYING WHAT YOU HAVE LEARNED:

By observing and asking questions, fill in the blanks. If you are not sure of the answers, ask your supervisor.

A. What are two things you might recommend that your client consider before purchasing a water treatment system?

____

____

____

B. What does your company offer in terms of water treatment solutions?

____

____

____

ANSWERS TO REVIEW QUIZ

CHAPTER 5

SPECIAL PROBLEMS

Answers to REVIEW OF SPECIAL PROBLEMS (pages 113 – 116)

1. c. Brown stains can appear on porcelain fixtures.
2. c. 0.30 ppm
3. b. Be sure the pumping system from the well to the softener is air tight.
4. a. Pre-treat the water to neutralize the acid.
5. d. Iron settles to the bottom of the lake.
6. d. Water contains high levels of fungus
7. b. They grow and reproduce.
8. c. It does not settle out and cannot be filtered.
9. a. Oxidation
10. c. Tap water has a black sediment
11. b. Chlorine and potassium permanganate
12. d. Rotten egg smell
13. c. Sulfur bacteria is present in the plumbing system.
14. d. Household plumbing system
15. b. Homes built after 1970

Applying what you have learned:

A. Answers may vary but might include:
(1) identify all problems with the source water requiring correction; (2) obtain costs of the equipment and installation; (3) find out about the operation costs and required or routine maintenance; and (4) evaluate manufacturer's literature and specs to be sure nothing in the water is harmful to the equipment.

B. Answers will vary by company

THIS COURSE INCLUDES AN ONLINE FINAL EXAM

This course is limited to a single user. When you are ready to take the final exam to earn Certificate of Completion, please contact ASA at info@asa.net. You will be contacted about how to register for the exam.

GLOSSARY OF TERMS

Absolute filter rating: Rating for a filter that will remove 99.9% of particles of the specified size (in microns) or larger. For example, a one-micron absolute filter will remove virtually all particles of one micron or larger.

A/C filter: Activated carbon filter.

Acid water: Water which measures less than 7.0 on the pH scale. Acid water is one kind of corrosive water.

Activated carbon: Carbon which has been specially treated to remove impurities and to enlarge the pores to make the carbon a more effective filter medium.

Activated carbon filter: Filter which uses activated carbon granules as the filter medium. Activated carbon filters work both by mechanically filtering out solid particles and by adsorbing certain molecules. (*SEE* Adsorption). Also called activated charcoal filter.

Activated charcoal filter: *SEE* Activated carbon filter.

Adsorption: The chemical process in which molecules of a liquid, gas, or dissolved substance stick to the surface of an adsorbent material. Activated carbon is an adsorbent material.

Aeration: Exposing a quantity of water to the air in the atmosphere, often by spraying water into the air. Aeration is often used as a means of adding oxygen to the water in order to oxidize iron or to re-lease dissolved gases (such as hydrogen sulfide).

Aggressive water: *SEE* Corrosive water.

Air-cooled distiller: A distiller which makes use of the air in the surrounding room or area to cool the heat from distillation.

Alkali: *SEE* Base.

Alkaline water: Water which measures higher than 7.0 on the pH scale. Alkaline water can be corrosive water.

Anion: (pronounced *"An' eye on"*) An ion with a negative charge.

Anion exchange: An ion exchange process in which anions in a solution are exchanged with anions from the anion exchange resin.

Anion exchange resin: Resin used to bring about the anion exchange process.

Base: A substance that measures higher than 7.0 on the pH scale. *Also called an alkali.*

Batch distiller: A small distiller which must be filled and emptied manually and produces only as much product water as the distiller tank will hold at anyone time.

Beaver fever: *SEE* Giardia lamblia.

Brine tank: The tank that stores the salt and provides the system to create brine for regenerating a water softener.

Calcite filter: A commonly-used neutralization filter which uses calcium carbonate (calcite), a base, to treat acid water.

Cation: (pronounced *"Cat' eye on"*) An ion which has a positive charge.

Cation exchange: An ion exchange process in which cations in a solution are exchanged for cations on the cation exchange resin. The cation exchange process is the process used in water softening.

Cation exchange resin: Resin which will bring about the cation exchange process.

Chelated iron: (pronounced *"KEY'lay ted"*) Iron which has combined with another substance to form a strong, stable molecule which does not change its chemical form easily. *Also called colloidal iron and organic iron.*

Chemical-feed method: Method of feeding a chemical into water using a chemical solution tank, a small feed pump, and often a retention tank.

Chemically pure water: Water containing only hydrogen and oxygen atoms—no other substances. Chemically pure water is usually only found in laboratories, medical situations, or specialized manufacturing. A more current term is *ultrapure water.*

Chloramine: A varied form of chlorine (chlorine plus ammonia) often used for disinfection by municipal water systems. Chloramines are used instead of chlorine to avoid the formation of trihalomethanes and similar chlorination by-products.

Chlorination: The process of feeding chlorine (often in the form of hypochlorite, which is household bleach) into water. Chlorination is used to kill microbes and to oxidize dissolved iron.

Clear water iron: *SEE* Ferrous iron.

Colloidal iron: *SEE* Chelated iron.

Concentrate: The water containing the contaminants that did not go (were rejected) through a reverse osmosis membrane but goes instead to drain. *Also called reject water.*

Concentrated solution: A solution with many molecules of the dissolved substance in it.

Contaminant: Any substance in water other than hydrogen or oxygen, especially if the substance is undesirable for the use to which the water will be put.

Corrosive water: Water which will eat away or "corrode" metal. Acid water, alkaline water, water with high oxygen content, water containing high levels of certain inorganics, or water with very low TDS counts may be corrosive. *Also called aggressive water.*

Corrosion: The eating away of metal caused by a chemical or electrochemical reaction. The reaction between water and some metals, especially iron and lead, will cause corrosion.

Cryptosporidium: A cyst which causes intestinal illness. The most famous outbreak caused bythis cyst was in Milwaukee in 1992, where thousands were infected.

Cysts: Microbes which form very hard shells around themselves, making them resistant to disinfection methods, including chlorine. Two well-known cysts are Giardia lamblia and Cryptosporidium.

Dealkalization: The reduction of the amount of alkalinity in a water. Often accomplished by use of a combination of cation and anion exchange and frequently used in treatment of boiler water.

Deionization: The removal of most ionic substances (largely inorganics) from water by use of the combination of cation exchange and anion exchange. *Also called demineralization.*

Deionized water: Water which has had most of the ionic (mostly inorganic) content removed by the deionization process. *Also called demineralized water.*

Demineralization: *SEE* Deionization.
Disinfection: The process of removing pathenogenic microbes from drinking water.

Dissolved inorganic substances: Dissolved minerals (including dissolved metals). Dissolved inorganic substances are measured as parts per million (ppm) of Total Dissolved Solids.

Distiller: Treatment unit used in the distillation process. *SEE* Distillation.

Distillation: The process of heating a liquid until it turns to vapor (water vapor is steam), then cooling it until it condenses back into a purified liquid, which is then collected for use.

Drinking water: Water safe for human drinking and cooking.

Feed water: The water fed into a water conditioning device to be treated or cleaned.

Ferric iron: Iron which has formed solid particles in the water. *Also called red water iron.*

Ferrous iron: Iron which is totally dissolved in water and not visible to the naked eye. *Also called clear water iron.*

Filter: A device which will remove solid particles or "contaminant" molecules (or change their chemical form) from water by passing the water through a porous material. There are several types of filters used in water conditioning including mechanical (sediment) filters, adsorptive filters, oxidizing filters, neutralizing filters, and reverse osmosis membranes.

Filter rating: *SEE* Absolute filter rating; nominal filter rating.

Giardia lamblia: A cyst which can cause intestinal illness, sometimes called beaver fever because the cyst is often carried by wildlife. Like other cysts, Giardia lamblia has proved to be resistant to the usual disinfection methods.

Gpg (grains per gallon): Unit of measure of hardness in water.

Gpm (gallons per minute): Measure used for flow rates.

Grains per gallon (gpg): Measure used for hardness in water.

Hard water: Water which contains high levels, usually measured in grains per gallon (gpg), of the minerals calcium and magnesium (in the forms of calcium and magnesium carbonates or bicarbonates.) A general definition is "water with three (3) gpg or more" but there are degrees of hardness and softness.

Herbicides: Agricultural chemicals; usually synthetic organics, used to control weeds.

Household grade water: Water used for household cleaning and bathing.

Hydrogen sulfide gas: A gas which, when dissolved in water, produces the "rotten egg" smell of sulfur, and gives you sulfur water. This gas can be difficult to remove.

Hydrologic cycle: The natural cycle by which the earth's water is recycled, including precipitation, movement of precipitated water through the earth into streams, rivers, lakes, and oceans, and evaporation of water from these bodies of water into clouds to produce more precipitation.

Hypochlorite: An oxidizing chemical (household bleach) often fed into water with a feed pump for disinfection or iron removal.

Ion: An atom or group of atoms with a positive or negative charge.

Ion exchange process: A reversible chemical process in which ions from a chemically-prepared insoluble permanent material (called the *ion exchanger* or the *medium* or the *resin*) are exchanged for other ions in a solution surrounding the exchanger. *SEE* Anion exchange; cation exchange; resin

Ion exchanger: *SEE* Resin.

Iron bacteria: Living organisms which thrive by using ferrous iron as an energy source to help them live.

Loose media filters: Filters which use millions of loose granules of solid material to physically trap and separate out undesirable particles in the water.

Manganese greensand: An oxidizing filter medium often used for oxidation of iron and manganese.

Maximum Contaminant Levels (MCL): Limits set by the U.S. Environmental Protection Agency, under the authority of the Safe Drinking Water Act, indicating the maximum amounts of certain contaminants allowed in drinking water treated by public water systems.

MCL: Maximum Contaminant Levels.

Mechanical filter: A filter which mechanically separates particulates from the water by catching the particulates in the pores of, or between the granules of, the filter medium.

Media: *SEE* Medium.

Media filters: *SEE* Loose media filters.

Medium: The material in a filter which traps, blocks, or chemically alters undesirable particles or molecules, thus removing them from the product. Also may refer to the resin in an ion exchange process. Plural form is *media*.

Mg/L: Milligrams per liter.

Microbes: Organisms so tiny they can only be seen through a microscope. Bacteria, viruses, cysts, some algae, and some other organisms are all microbes.

Micron: One millionth of a meter, or .00003937 inch. The micron is the unit used to measure the size of particles in water. The symbol for the micron is μ.

Micron rating: *SEE* Absolute filter rating; nominal filter rating.

Milligram per liter (mg/L): A unit of measure used in measuring Total Dissolved Solids (mineral content) of water or other liquids. In most water solutions, 1 mg/I equals 1 ppm (part per million.

Mixed-bed ion exchange system: An ion exchange system which contains both cation and anion resin in a single "mixed" bed. Mixed beds of resin are used for deionization.

Municipal water system: A water system operated by a city, town, or other local governmental body.

NSF International, The Public Health and Safety Company™: International organization which tests equipment in the water and food service industry to industry standards. Located at 789 Dixboro Road, P.O. Box 130140, Ann Arbor, Michigan 48113-0140. Phone: 800.673.6275; Fax: 734.769.0109

National Primary Drinking Water Regulations (NPDWRS): The EPA issues legally enforceable standards that apply to public water systems. These primary standards protect public health by limiting the levels of contaminants in drinking water.

National Secondary Drinking Water Regulations (NSDWRS): The EPA recommends non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

Natural organic substances: Plant or animal matter, usually decaying or decayed, found in water supply sources. Substances may occur as sediment or larger pieces of matter.

Nephelometric turbidity units (NTU): The unit of measure for turbidity. The measurement uses the amount of light deflected by the particles in the water as a measure of the turbidity. One NTU is considered quite turbid.

Neutral water: Water that is neither acid nor alkaline. Neutral water measures at or very near 7.0 on the pH scale.

Neutralization: The process of chemically correcting the acidity or alkalinity of water by bringing the water closer to a pH level of 7.0 (neutral).

Neutralization filter: A filter which chemically changes the water by bringing the pH level of the water closer to neutral (7.0 pH).

Nitrate: A form of nitrogen which often builds up in the soil that has been continually fertilized with nitrogen fertilizer; nitrates are often washed off into water supply.

High levels of nitrates in drinking water are dangerous for both young human beings and farm animals.

Nominal filter rating: Rating for a filter that will remove 85% of particles with an average size as indicated in the rating. For example, a 20 micron nominal filter would remove 85% of articles with approximately a 20 micron size or larger.

NTU: *SEE* Nephelometric turbidity units.

Organic iron: *SEE* Chelated iron.

Organic substances: Substances which contain the element carbon. There are natural organic substances and synthetic organic chemicals.

Osmosis: The natural process in which a liquid containing a lower amount of dissolved solids (a less-concentrated solution) will pass through a semi-permeable membrane into a more concentrated solution. *SEE* also Reverse osmosis.

Osmotic pressure: The natural pressure created by osmosis. Osmotic pressure can be measured and calculated. Osmotic pressure must be overcome by household water pressure or a pump to create reverse osmosis.

Oxidation: The process of oxygen combining chemically with another substance. When oxygen combines with ferrous iron (to produce ferric iron) or oxygen (air) combines with solid iron materials (to produce rust), oxidation has occurred.

Oxidizing filter: A filter containing enough oxygen for oxidation to take place with one or more substances contained in the water passing through the filter.

Ozonation: A process of oxidizing contaminants, including microbes, by use of ozone. The process is used as a disinfectant as well as for other uses.

Ozone: A special form of oxygen sometimes used in ozonation as a disinfectant and oxidizer.
Parts per million (ppm): A unit of measure used for measuring Total Dissolved Solids (mineral content) in water. In most water solutions, one part per million equals 1 milligram per liter.

Particulates: Solid (not dissolved) particles suspended in water. Similar to sediment, but some particulates won't settle out. Particulates in water are also called *turbidity*.

Permeate: The product water that passes through the reverse osmosis membrane.

Pesticides: Chemicals, generally synthetic organics, used to destroy insects or other small animals considered undesirable. Often used in farm areas to protect crops.

pH scale: The scale used to measure acidity or alkalinity in liquids. A reading of 7.0 is "neutral"—neither acid or alkaline. Below 7.0 indicates acidity; above 7.0 indicates alkalinity.

Phosphates: Natural substances sometimes fed into a water system (in the form of polyphosphates) to coat the inside of pipes and protect them from scale buildup and corrosivity.

POE: Point-of-entry.

Point-of-entry (POE): Water conditioning water conditioning that takes place at or near the point where the water enters the house from the outside. *Also called whole-house water conditioning.*

Point-of-use (POU): Water conditioning water conditioning that takes place at the point of water use, that is, at the faucet. Point-of-use systems treat drinking and cooking water.

Polyphosphates: *SEE* Phosphates.
Potable water: (pronounced *"POE' tuh bul"*) Water which has had pathenogenic microbes removed (or inactivated) and is considered safe for drinking.

Potassium chloride: An alternate regenerant that can be used instead of salt (sodium chloride) in water softeners. Used if there are health concerns or environmental concerns about the small amount of salt left in the water from regeneration.

Potassium permanganate: An oxidizing chemical which is often fed into water to oxidize iron in the water or used as a regenerant for oxidizing filters. It is also a disinfectant.

POU: Point-of-use.

Ppb (parts per billion): Lead and many synthetic organics are measured in parts per billion.

ppm (parts per million): This is a way of expressing very dilute concentrations of substances. Just as per cent means out of a hundred, so parts per million or ppm means out of a million. Usually describes the concentration of something in water or soil.

Psi (pound per square inch): A unit of measure for pressure.

Precipitate: (*as a verb*) To solidify and come out of solution. When ferrous (dissolved) iron combines with oxygen, it precipitates out of the water solution and turns into solid iron particles. (*as a noun*) The solid iron is a precipitate. Product water the treated water that has already been through a conditioning process, whatever process that is.

Public water system: A water system that produces potable water and has 15 or more outlets or serves 25 or more customers at least 60 days per year. (USEPA definition) *SEE* Small public water system.

Radiological substances: Substances, including radium and radon, which give off radioactive energy.

Radon: A radioactive gas that develops as uranium decays.

Recharging: *SEE* Regeneration.

Red water: Water that contains particles of ferric iron.

Red water iron: *SEE* Ferric iron.

Regenerant: A chemical solution used to regenerate exhausted ion exchange resin. *SEE* Regeneration.

Regeneration: The process of using an appropriate chemical solution (regenerant) to replace the needed ions on an ion exchange resin after the resin has become exhausted and will no longer produce the desired ion exchange process. Regeneration (also called *recharging*) restores the resin so that it can be placed back in service for which it was intended.

Reject water: *SEE* Concentrate.

Rejection rate: The percent of Total Dissolved Solids removed (rejected) by an RO membrane.

Residual: The amount of a particular substance left in the water after a water treatment process. For example, chlorine is usually left (by deliberate design) in the water after it is treated at municipal water plant. The left over chlorine helps protect the water in the distribution system from the growth of microbes.

Resin: The medium used in an ion exchange system. The resin is insoluble permanent material, usually granules of a synthetic organic substance (typically divinyl-benzene, a plastic) which is treated with appropriate substances in order to furnish ions to be exchanged with ions of the mineral(s) to be removed. Also called the *ion exchanger.* Resin comes in anion or cation forms.

Resin tank: The tank that contains the resin in a water softener or other ion exchange unit.

Reverse osmosis (RO): The process in which water containing high amounts of contaminants (a "concentrated solution") is forced through a semipermeable membrane filter into water containing fewer molecules of contaminants (a "less concentrated solution"). In the filtering process, many of the contaminants are trapped by the membrane and sent down the drain with the reject water. This process is the opposite of the naturally occurring process called *osmosis.*

RO: Reverse osmosis.

Safe Drinking Water Act (SDWA): The national law (originally passed in 1974, amended in 1986, and reauthorized in 1996) that requires the U.S. Environmental Protection Agency to create standards for contaminants for drinking water systems serving 25 people or more for an average of 60 days per year. *SEE* Maximum contaminant levels.

Sediment: Particles of solid matter which are heavy enough to settle to the bottom of a body or container of water if the water is allowed to remain calm and still. Means much the same as particulates except some particulates do not settle out. Particulates or sediment in water are also called *turbidity*.

Sediment filter: A filter which mechanically filters out sediment.

Semi-permeable membrane: The thin, filmy, flexible material used as a filter in a reverse osmosis unit. Water molecules will "permeate" (pass through) the filter, but contaminants will not.
Silicates: Substances used for the same purposes as phosphates, to coat pipes and control corrosive water.

SOCs: Synthetic organic chemicals.

Small public water system: A public water system serving up to 10,000 people per year. (USEPA definition)

Soda ash (sodium carbonate): A base often used by chemical feed in a water solution to treat acid water.

Solution: A liquid with some other substance (solid, gas, other liquid) dissolved in it.

Solvent: A liquid in which other substances will dissolve.

Sulfur water: *SEE* Hydrogen sulfide gas.

Synthetic organic chemicals (SOC): Organic substances which are man made. Herbicides, pesticides, and various industrial chemicals are synthetic organics. Synthetic organic chemicals are considered harmful but are often difficult to remove from water.

Tannins: Acids, caused by water flowing through swampy, peaty soil, which cause the water to have an objectionable yellow color.

TDS: Total Dissolved Solids.

THM: Trihalomethanes.

Total Dissolved Solids (TDS): The amount of inorganic (mineral) content in the water. Measured either in parts per million (ppm) or milligrams per liter (mg/l).

Trihalomethanes (THM): A class of volatile organic chemicals which are formed when natural organic matter decays in chlorinated water.

Turbid water: Water which has sediment or other particulates stirred up and floating in it so that the water looks cloudy or dirty.

Turbidity: The measure of the amount of suspended solid matter in the water. Turbidity is measured in nephelometric turbidity units. One unit of turbidity is considered very high.

Two-bed ion exchange system: An ion exchange system, used for deionization, which uses two separate beds of resin: one bed of cation resin, another of anion resin.

Ultrapure water: Water which has been highly treated to remove most minerals and ionic substances. However, ultrapure water is not necessarily safe to drink because it may not have been disinfected. Ultrapure water is usually used in manufacturing, such as in the manufacture of semiconductor chips. Older term was *chemically pure water*.

Ultraviolet disinfection (UV): A process by which water can be disinfected by use of ultraviolet light rays.

U.S. Environmental Protection Agency (USEPA): Federal agency that sets and oversees standards for drinking water.

USEPA: *SEE* U.S. Environmental Protection Agency.

Utility grade water: Water for general uses such as watering the lawn or washing the car.
UV ultraviolet: *SEE* Ultraviolet disinfection.

VOC: Volatile organic chemicals.

Volatile organic chemicals (VOC): Synthetic organic chemicals which turn into gas at lower temperatures than most organics do.

Water-cooled distiller: A distiller that uses some of the feed water to cool the condensing coils.

Water Quality Association (WQA): The international trade association for the point-of-use and point-of-entry water treatment industry. WQA provides educational materials, and it tests equipment to industry standards. Located at 4151 Naperville Road, Lisle, Illinois 60532-1088. Phone 630.505.0160. Web site: **www.wqa.org**

Water softening: The process of removing calcium and magnesium (in the forms of calcium and magnesium carbonates or bicarbonates) from "hard water" which contains high levels of these minerals. Water softening is a cation exchange process.

Whole-house water conditioning: *SEE* Point-of-entry water conditioning.

Zeolite: A synthetic material used as an oxidizing filter medium.

APPENDIX

Use this chart only as an education tool.

REFER TO YOUR MANUFACTURER'S LITERATURE FOR SOLVING ANY SPECIFIC PROBLEM

SYMPTOMS, CAUSES, AND POSSIBLE TREATMENTS FOR COMMON WATER PROBLEMS		
SYMPTOM	POSSIBLE CAUSE	POSSIBLE TREATMENT
Dirty scum around tub or sink	Hard water	Water softening
Rusty stains on porcelain or laundry / water may be clear or reddish colored	Iron in water, possibly also corrosive water	· If iron content not too high, water softener · For high iron,forced oxidation (chemical feed or aeration) and filter out particles · Treat corrosive water
Yellow water	Tannins (acids) from swampy soil	Anion exchange or chlorination plus filtration
Bluish-green water, green stains on porcelain	Acid water working on copper pipes	Neutralization of acid
Black cast to water / black sediment / black stains on laundry and porcelain	Manganese in water (often with iron)	Same treatment as iron but stronger and longer
Chlorine smell	Too much chlorine from chlorination treatment	Activated carbon filter
Fishy / musty / earthy smell	Various harmless natural organics	Activated carbon filter
Rotten egg smell, yellow or black stains on porcelain	Hydrogen sulfide gas	· For low levels in non-acidic water, manganese greensand · For high levels, feed chlorine, follow with activated carbon filter · Aeration also a possibility
Turbidity	Sediment stirred up in water source / defective well screen / iron particles	· Sediment filter · New well screen · Iron removal techniques

INDEX

G

H

I

L

M

N

O

P

R

S

T

V

W

Specialty Products

Residential Water Processing©

Residential Water Processing© provides new warehouse, counter, and sales personnel with an overview of the operation and components of residential water processing. The course includes definitions of common industry terms, descriptions of the components and functions of residential water processing systems, and other information that will help employees serve their customers more effectively.

Residential Water Processing© will help your employees:

- Describe, in basic terms, how common water treatment technologies work
- Describe some of the common residential water problems
- Use terminology needed to correctly discuss the treatment of common residential water system problems

Residential Water Processing© is one of six ProductPro® courses in Specialty Products:

1. Domestic Water Heaters©
2. Domestic Water Well Pumps©
3. Sump, Sewage and Effluent Pumps©
4. Residential Hydronic Heating Systems©
5. Residential Water Processing©
6. Introduction to HVACR©

What is ProductPro®?

The ProductPro® program includes 13 courses in the four areas of product knowledge that are most important to today's wholesale distributor:

- Basics of PHCP/Industrial PVF – 3 courses
- Fixtures and Faucets – 1 course
- Industrial Valves – 3 courses
- Specialty Products – 6 courses

Each ProductPro® course includes registration with ASA Education Foundation, comprehensive, job-relevant instruction; quizzes; final exams; and certificate of completion. For complete information on all ProductPro® courses and formats call 630.467.0000 or visit the ASA Education Foundation website at www.asa.net.

HEADQUARTERS

ASA Education Foundation
1200 N. Arlington Heights Road
Suite 150
Itasca, IL 60143

tel: 630.467.0000
fax: 630.467.0001
web: www.asa.net
e-mail: info@asa.net

ASA Education Foundation

40 - RWP 100 | 01.14