Water Treatment:

The water used in HVAC systems requires a variety of treatments to maintain a water quality level that promotes system reliability by preventing scaling, corrosion, and other harmful effects.

Tap water, while safe to drink, may contain impurities such as minerals and gases that could harm an HVAC system if used untreated.

The strength or level of concentration of an impurity dissolved in water is often expressed in parts per million (ppm).

An alternate unit of measure, grains per gallon (gpg), is sometimes used. Grains per gallon can be converted to parts per million by multiplying grains per gallon by 17.

The metric equivalent of a one part per million concentration is one milligram per liter (mg/l).

Untreated water typically contains many substances including dissolved solids. Dissolved gases are not usually included in most water analyses.

Water may contain substances that increase its alkalinity, a water quality parameter in which the pH is higher than 7.

The pH scale ranges from zero (extremely acidic) to 14 (extremely alkaline) with a pH of 7 being neutral.

Using untreated water in an HVAC system can result in decreased capacity and efficiency, and can cause premature failure of the water-handling components of the system.

Internal corrosion can be caused by acid, oxygen, and other gases dissolved in the water or it can be caused by electrolysis.

Chemical inhibitors can be added to water to reduce the rate of corrosion, scale formation, and slime production.

Scale is a coating of mineral matter that precipitates out of water as it is heated and cooled. It can reduce the ability to transfer heat in heat exchangers.

Biological growth such as algae and mold can cause damage in moist cooling tower environments if sufficient nutrients, proper temperature, and proper pH are present.

A condition called fouling occurs when suspended solid matter such as silt, oil, and corrosion products accumulate and clog orifices and heat transfer surfaces.

Open re-circulating systems use cooling towers or evaporative condensers to cool the water leaving the cooling system condenser for reuse.

The cooling tower water must be treated because it can absorb acidic gases and other contaminants from the air and the cooling tower environment can nourish the growth of algae and bacteria.
To help control the buildup of mineral solids and control microbiological pitting, various chemicals are added to the cooling tower water.

Sulfuric acid is often added when pH control is needed because of high hardness or alkalinity in the makeup water.

If enough acidic gases are absorbed from the air, tower water becomes very acidic with a correspondingly low pH. The addition of caustic or alkali to acidic water can help restore the pH.

A procedure called blow-down (bleed-off) involves a continuous draining and discarding of the cooling tower water to help control scaling and corrosion.

The bleed rate for most systems should be about one-half to one per hour per ton of capacity.

The addition of polymers to cooling tower water helps control silt deposits by keeping silt in suspension. This allows the silt to accumulate in the tower basin where it can be manually removed during maintenance.

The growth of algae and slime in cooling towers can produce a host of problems including water blockages, high head pressure, and corrosion.

Chemical algaecides or bactericides help control these growths, aided by periodic shock treatments with chlorine-based chemicals.

Closed re-circulating systems are closed loop systems in which water is continuously re-circulated through a sealed system where it does not have contact with the air.

Closed systems do not absorb airborne contaminants, but they can receive corrosion-producing oxygen dissolved in fresh makeup water.

The use of chemicals such as chromates, if not prohibited by local codes, helps control corrosion in closed systems.

Scale formation is normally not a problem in chilled-water systems, but can be a problem in hot-water systems.

The water used in steam boilers should be clean and chemically treated to reduce hardness, which will minimize scale formation and corrosion.

Boiler corrosion can be caused by acidic water (low pH) or by the dissolved oxygen present in boiler makeup water.

Oxygen and other corrosive gases can be mechanically eliminated from the system using a de-aerator or by using scavenger chemicals.
Acidic corrosion can be controlled by maintaining the boiler water pH between 11 and 12 through the use of alkaline water treatment chemicals. The P-alkalinity should be maintained between 300 and 700 ppm.

Minerals dissolved in water form scale as the water containing the minerals evaporates into steam inside the boiler.

The dissolved minerals can be removed by treating the water before it enters the boiler.

Colloidal substances can be added to the boiler water to attract and hold dissolved minerals in a fluid sludge that is easily removed from the boiler by blowdown.

Sludge, a deposit formed by salts and other solids present in boiler water, settles out in low areas of the boiler where it must be periodically removed to prevent clogging.

Foaming hinders steam production and can be prevented by filtering makeup water to remove impurities, or by adding anti-foaming agents to the boiler water.

Priming allows impurities to enter the steam and be carried throughout the system. It is caused by rapid changes in boiler water levels or violent discharges of bursting bubbles.

Carryover is a condition in which water solids are entrained in the steam even if there is no sign of foaming or priming.

The American Boiler Manufacturers Association provides guidelines for the maximum total solids allowed in boiler water.

The installation of a steam separator in the supply line can help eliminate solids introduced into the steam as the result of carryover.

In addition to chemicals, water can be treated using various mechanical or physical devices.

Mechanical filtration devices are used mainly to trap suspended solids circulating in a system.

Strainers are closed container with a cleanable screen element. They can be manually cleaned or may be self-cleaning.

Cartridge filters use a disposable filter cartridge to remove very small, suspended particles. There are depth types and surface types.

Surface-type filters can normally handle higher flow rates than depth-type filters and are considered to have the better removal efficiency, size for size, of the two.

Multimedia filters contain layers of different media designed to trap increasingly smaller particles as the water passes through.
Backwashing, a procedure that reverses water flow through the filter, must be done on a regular basis to prevent the multimedia filter from becoming clogged.

Bag-type filters use a filter bag instead of a filter cartridge to remove particles. There are disposable and cleanable versions available.

Centrifugal separators operate by using centrifugal force to move heavier particles suspended in the water to the edges of the separation chamber.

Evaporators use a distillation process to remove concentrations of solids and organic contaminants and also to disinfect the water.

As the water boils, vapor is drawn off, condensed, and returned to the system. The impurities remain in the distillation chamber where they can be easily removed.

Water softeners use a sand-like substance called zeolite to remove the minerals from hard water before it enters the boiler.

As the hard water filters through the zeolite, sodium is released and calcium and magnesium, the minerals responsible for hardness, are absorbed.

De-aerators are typically used in steam systems to remove air and other non-condensibles from the system feedwater.

Small, timer-controlled chemical feeders are available that automatically supply water treatment chemicals to the system.

An understanding of the types of water problems to be encountered and how to correct them using chemicals is required prior to installing an automatic chemical feeder system.

A blowdown separator helps control corrosion by separating steam from water and removing dissolved solids.

Water treatment systems have to be properly maintained to maintain system operational efficiency.

Use a commercially available water analysis test kit to test water systems on a regular basis.

When sending water samples to a lab for analysis, include a data sheet that provides the lab with information about the water system being tested.

Regular maintenance must be performed on cooling towers and open re-circulating systems to prevent the spread of disease.

Establish a schedule so that required maintenance actions and tests are done on a regular basis and not overlooked.
After an installation or major repair, clean the internal water system of protective oils, films, dirt, and other debris.

Check the water system if scale inhibitors fail to control the scale buildup as predicted.

Sediments can be removed from the bottom of a boiler using the bottom blowdown valve. The sediments are washed out with the water being discharged.

Skimming removes oil and other impurities from the surface of the water using the surface blowdown valve.

Use an approved boiler-cleaning compound and follow the manufacturer’s instructions to clean a boiler with an exceptional amount of dirt or sludge.

Use a standard form to record boiler operating parameters and water conditions so that trends indicating a potential problem can be spotted.

Many of the chemicals used to treat or clean water systems may be harmful to equipment if improperly applied. These chemicals are often hazardous to humans.

1. Water without dissolved substances does not exist naturally. Pure water is obtained only through extensive and expensive treatment. Water is an effective solvent that dissolves gases from the air, minerals from the soil, and even materials from the piping and other components through which it flows. Water easily dissolves various minerals and organic chemicals. These impurities, and not the water itself, are the main cause of problems in HVAC systems. Even though the quality of a water supply makes it safe to drink, the water can still contain minerals and gases that may be extremely harmful if the water is used untreated in HVAC systems.

2. The characteristics of water supplied to a given system can vary widely over time. This can be because more than one source is being used or because the characteristics of a single supply source have changed, such as in the case of a lake or river. Table 1 shows a hypothetical example of the many kinds of substances that can be found in an untreated water supply. Note that only dissolved solids are listed in the table. This is because most water analyses omit the dissolved gases.

3. The amount of carbon dioxide in water can be either measured directly or estimated from the water’s pH and total alkalinity. Alkalinity is a measure of water’s buffering capacity, which allows it to counteract the amount of pH reduction from the addition of acids. Water with low alkalinity will experience a greater reduction in pH from the addition of acid than water of higher alkalinity. Water above a pH value of 7.0 is considered to be alkaline. Alkalinity is measured using two indicators: the phenolphthalein alkalinity (P-alkalinity) measures the strong alkali present; the M-alkalinity (methyl orange alkalinity) or total alkalinity measures all the alkalinity in the water. The term pH is a measure of alkalinity or acidity of water. The pH scale ranges from 0 (extremely acidic) to 14 (extremely alkaline) with a pH of 7 being neutral (Figure 1). Specifically, the pH defines the relative concentration of hydrogen ions and hydroxide ions. As pH increases, the concentration of hydroxide ions increases.
4. The hardness of a water sample indicates the amount of dissolved calcium (limestone) salts and/or magnesium in the water. Both calcium and magnesium ions may result from several dissolved chemical compounds. For example, scale occurs as a calcium compound such as calcium bicarbonate, calcium chloride, or calcium sulfate.

5. Corrosion is a state of deterioration or the wearing away of metal surfaces within a system. It can occur both internally and externally to system units. External corrosion appears as rust or oxidation. Internal corrosion can be caused by acids, oxygen, and other gases present in the water. It can also be caused by electrolysis. Electrolysis is the process of changing the chemical composition of a material by passing electrical current through it. Corrosion occurs in the following forms:

6. Corrosion control is typically done with simple mechanical filtration and the use of inexpensive chemical inhibitors such as sodium silicate or phosphate-silicate mixtures. An inhibitor is a chemical substance that reduces the rate of corrosion, scale formation, or slime production.

7. The range of pH in cooling tower water is typically maintained between 7.5 and 8.5. Sulfuric acid is generally used when pH control is needed because of high hardness or alkalinity in the makeup water. The sulfuric acid is used to increase the solubility of calcium, thereby reducing the potential for scaling. If enough acidic gases are absorbed, the water can become very acidic with a correspondingly low pH. This requires that the pH of the recirculating water be carefully regulated by adding caustic or alkali. Because the acid is introduced into the recirculating water from the air and not from the makeup water, the correct amount of caustic or alkali that must be added to maintain the pH level cannot be calculated and is usually determined by trial and error.

8. In addition to chemical treatments, corrosion and scaling are controlled by a procedure called bleed-off. In an open recirculating system, this procedure involves continuous controlled draining and throwaway (wasting) of a quantity of the existing system water to help maintain impurities within acceptable levels. The bleed rate for most systems should be about 0.5 to 1 gallon per hour per ton of capacity.

9. In chilled-water systems, scale formation is normally not a problem even if the makeup water is fairly hard. Hot-water systems are more likely to have problems with scale formation due to the higher temperatures. Because a high pH value promotes the buildup of scale, avoid using water with a high pH level whenever possible.

10. Because makeup water is used, periodic blowdowns are also necessary to control chloride and hardness levels. To minimize corrosion, the boiler water pH should be maintained between 11 and 12 by an alkaline water treatment using soda ash, caustic soda, sodium silicate, or sodium phosphates. Note that the P-alkalinity should be maintained between 300 and 700 ppm. Maintaining high pH levels helps prevent corrosion, but it also promotes the formation of scale; therefore, scale inhibitors must be used in conjunction with high pH levels.

11. Sludge is a deposit formed by salts and other solids present in boiler water. It appears as lumps or thick masses of material that settle out in the low points of a boiler like a layer of mud. Some sludge in a system occurs naturally. Other sludge is produced on purpose by water treatment. Minerals that exist in water cannot be destroyed, but with the use of proper chemicals, the properties of these minerals can be changed to make them manageable by turning them into
nonadhering sludge. Regardless of its source, if not controlled, sludge can insulate tubes, clog boiler circulation, and may bake out or harden, causing overheating and high operating temperatures. Sludge is removed by the periodic blowdown of the boiler. In extreme cases, a thorough cleaning of the boiler with a chemical product may be necessary.

12. Foaming is a condition caused by high water surface tension due to a scum buildup from oil, grease, and/or sediment on the surface of the boiler water. Foaming prevents steam bubbles from breaking through the water surface and hinders steam production. The trapped bubbles rise and fill the steam space, resulting in impurities being entrained in the steam and then carried over into the steam system. Once impurities enter the steam system, they can form deposits which damage heaters and other system components. Foaming is commonly controlled by filtration, antifoaming agents, and water treatment to remove solid impurities. Common antifoaming chemicals include organic materials such as polymerized esters, alcohols, and amides. Periodic surface blowdown is also done to help minimize foaming. Surface blowdown is covered later in this module.

13. Filters are classified as depth-type or surface-type filters. Depth-type filters capture particles throughout the thickness of the filtering medium. These filters are typically made from yarns or resin-bonded fibers that normally increase in density toward their center. Surface-type filters are thin-media filters made from pleated paper or similar material. These filters are designed to capture particles at or near the surface. Surface-type filters can normally handle higher flow rates because the pleats increase the surface area for filtration and have a better removal efficiency than an equivalent size depth filter.

14. Multimedia filters consist of a filter tank containing three or four layers of different media. The different grain sizes and types of filtering media provide for depth filtration mainly to increase the capacity of the filter to hold suspended solids. This increases the length of time between backwashing. Backwashing is a procedure that reverses the direction of water flow through the filter by forcing the water into the bottom of the filter tank and out the top. Backwashing must be performed on a regular basis to prevent accumulated particles from clogging the filter.

15. Hardness is a measure of the amount of calcium and magnesium in the water, as hardness rises so does the potential for scaling.