Block F: Commission and Service

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Plumbing Apprenticeship Program Level 4

SkilledTradesBC

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Competency F1: Test and Service Sanitary and Storm Drainage Systems

Learning Task 1

Describe the Maintenance and Repair of Drainage, Waste, and Venting (DWV) Systems

After a drainage, waste, venting system has been installed, there is a set of processes and practices followed to ensure the continuous and efficient operation of the piping and its components. Even a little water damage can be costly to repair and cause health concerns if mould and mildew begin to grow. A leak in the sanitary system can expose occupants to harmful substances and gases.

To avoid disasters, such as a sump pump failure or a kitchen sink overflow, regular maintenance should be performed by home occupants, building managers, and service plumbers. All maintenance should be done in accordance with the manufacturer's guidelines.

Pumps

Pumps found in our DWV and storm systems can include:

- Sump Pumps
- Sewage Ejector Pumps

If a building is below the water table, groundwater will need to be contained and discharged away from its foundation. That is the job of a sump pump. Like any other appliance or fixture, a sump pump requires regular maintenance to keep it functioning properly.

Figure 1. Basement Sump Pump

A sump pump system includes a motor, a pump, float sensors, and discharge piping. The NPC requires that the discharge piping has a union, a backwater valve, and an isolation valve.

Unless a home has been subject to flooding, an annual inspection is the usual recommendation for sump pump maintenance. Larger commercial buildings may have more regular checks. The pump's pit should be inspected, and any excess debris removed to avoid blockages. If you are inspecting a very large pit, you may need it to be vacuumed before a thorough check can be performed. Make sure to disconnect the pumps power supply before draining the pit so that the pump does not run dry. Once the pit is cleared perform the following check list:

- Check the pump's screen for dirt buildup
- Ensure the float or floats can move freely
- Check the piping for damage
- Check the pump's backup power supply (battery)

After inspection of the pit and pump, do a trial run. Fill the pit with water, energize the pump, and make sure it is discharging up and away from the building. Watch for any leaks in the discharge piping. Between the pump and check valve, you will notice water escaping. That is the weeping hole and is necessary to help vent the discharge pipe to avoid air lock. Except for the pipe's weeping hole, no other water should escape.

Sewage ejector pumps are essentially the same as sump pumps, but discharge sewage rather than storm and ground water. If a building's lowest point is below that of the city sewer or septic tank, a sewage ejector pump must be used. For example, if a homeowner decides to add a bathroom to their basement, often a sewage ejector pump will be required to pump waste up and out to the city sewer. Waste is drained to a sump and pumped out as needed.

In commercial buildings, there can be multiple sumps and sewage ejectors that require regular inspection and maintenance.

Sumps are considered a confined space and should not be entered unless you are properly trained and ticketed.

Backwater Valves

Backwater valves are a one-way flow control valve installed in a drainage system. Under normal conditions it allows the wastewater to drain out of the system, but if a reversal of flow should occur, the valve is forced closed and protects the interior of the building from sewage backup.

Backwater valves (Figure 2) are required to protect fixtures and drainage openings that are installed below grade, such as in a basement, where the possibility exists for the municipal sewage or storm water systems to become overloaded and force wastewater back through your drains. Backwater valves are also required on any subsoil drainage pipe that connects into the sanitary drain, to protect it from sewage backups.

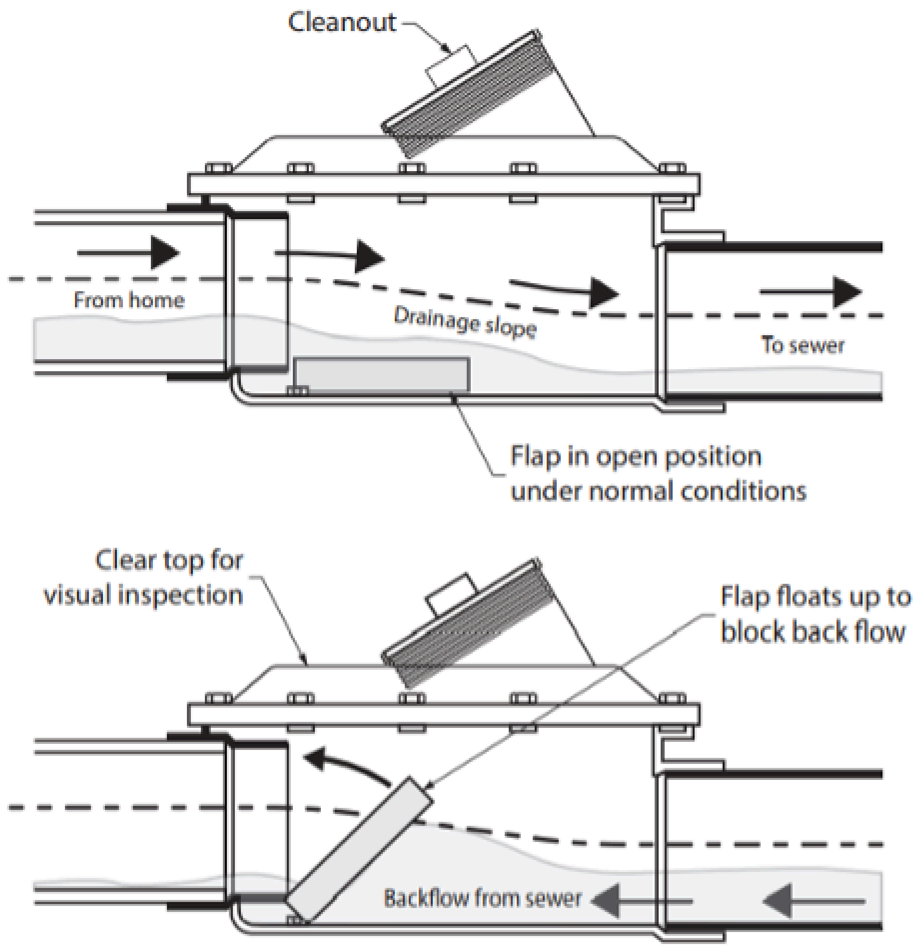

Figure 2. Backwater Valve Operation

To maintain a backwater valve, the following checks can be performed:

- Locate your backwater valve and remove the plug or panel.
- Shine the flashlight around the area and look for debris. Debris stuck in the gate can cause the sewer backwater valve to stop working.
- Clean the area. Flush the valve with a bucket of water to clear debris from the gate area. If that doesn't work, scrub the area to remove it.
- Once clean, move the gate back and forth to make sure it moves without any problems. If it's stiff or you see rust, oil it a little bit.
- Check the O-ring on the backwater valve. If it's cracked or damaged, replace it.
- Replace the plug or panel on top of the valve.

Baffles, Filters, and Strainer Baskets

Baffles, filters, and strainers are used to help separate solids from liquid waste. As the solids collect, the baffles, filters, and strainers can become clogged and ineffective. Therefore, they require cleaning or replacement to maintain effectiveness. Baffles and filters are commonly found in septic systems. (Figure 3) Baffles are inside the tank, while filters are on the inlet and outlet piping, but the terms are sometimes used interchangeably.

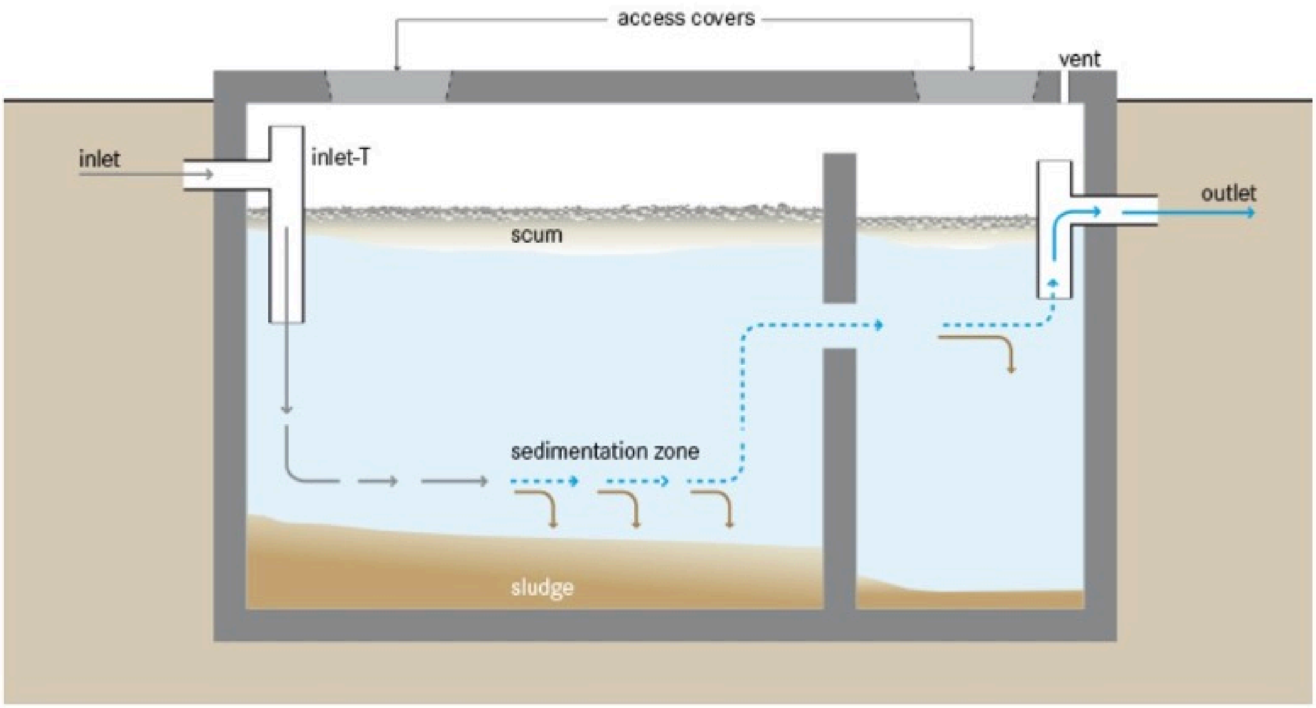

Figure 3. Septic Tank Arrangement

The baffles and filters can be inspected visually at the accesses covers and cleaned, cleared, or changed when necessary. An inlet filter can become clogged, for example, by too much toilet paper being flushed. A baffle scraper or rod can be used to clear away large solids and restore draining.

Strainer baskets are also used in the DWV system to separate solids from liquid and reduce the load travelling down the drain. Strainer baskets such as the ones found in kitchen sinks must be cleared manually (Figure 4).

Figure 4. Kitchen sink strainer basket

Interceptors

Grease and organic interceptors are drainage equipment located between kitchen drain lines and sanitary sewer lines. Grease interceptors capture the fats, oil, and grease (FOG) flowing down kitchen drains and stop them from flowing to the sewer. Organic interceptors capture food waste. An organic interceptor is permitted to be installed upstream of a grease interceptor and both require maintenance.

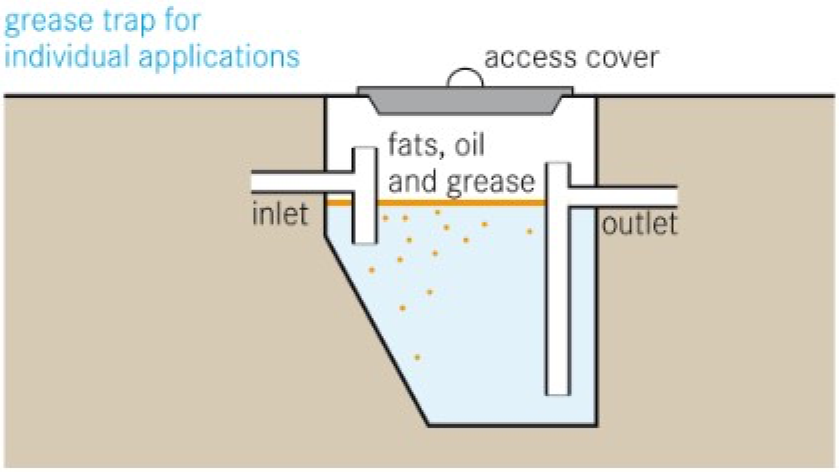

Figure 5. Grease Interceptor

An interceptor (Figure 5) will have an access cover that allows for the cleaning. Large solids are pulled or vacuumed out of the trap, the lid and the sides scraped down and debris vacuumed out. The lids, trap sides, and parts are then cleaned with soap and room-temperature water. Proper disposal is necessary after removing grease from the interceptor and service personnel must follow the jurisdiction's guidelines when doing so.

Drain Cleaning Equipment

Video inspection equipment uses a remote video camera to inspect underground sewers and drains. These machines are not meant to clear stoppages, so the drain is typically cleared first using a cleaning auger. They provide an excellent way to detect and locate obstructions or damage that impedes or stops the flow of drainage lines. Video inspections can detect such common problems as:

- Root-bound drainage lines
- Pipe collapse and cracks
- Running inline traps
- Negative grade sloping
- Pipe sagging
- Offset joints
- Sludge build up

The video camera equipped with LED lighting is fed down the drain or sewer line from a reel on the surface to a recording monitor. A service technician receives the live picture and views it on a monitor as the video records to a flash drive or DVD archive for future reference.

Pipe Locators

On some models of video inspection equipment, the camera is equipped with a radio transmitter. The camera/transmitter assembly sends a signal to a receiver on the ground surface indicating the camera location and depth of burial. This information can be used if the line must be excavated and repaired.

Drain Augers

A drain auger is a long, flexible metal cable that rotates in a circular motion and is powered by hand or electrically. On some models the attachment that goes on the end can be changed to meet specific job requirements. The drain auger is inserted and rotated into a drain until it reaches the obstruction. The auger then displaces, retrieves or reduces the obstruction so the drain can flow freely.

There are several different types of drain augers for home and commercial use:

- Hand auger
- Closet auger
- Power drum auger for small-diameter piping
- Power drum auger for large-diameter piping

Hand Auger

The hand auger (Figure 6) uses a drum to contain the cable and keep it from tangling and kinking. These tools are useful for clearing small diameter sink and bathtub drains (up to 2″ NPS) when the obstruction has yet to solidify. Do not attempt to send this auger through toilet bowls, because the exposed wire cable might damage the porcelain finish. Also, due to the large bowl passageway and the cable's small diameter, the cable can be become tangled when rotated. Some hand augers can be attached to an electric drill, giving it more power to force it through the clog.

Figure 6. Drain Auger

Closet Auger

The closet auger, named after the "water closet," feeds a relatively short cable through a hook shaped length of metal tubing. The hook shape makes it easier to feed the cable into the toilet. A plastic boot on the end of the cable protects the finish of the visible porcelain. Since most toilet clogs occur in the integral trap, the short cable is sufficient to break up or retrieve most clogs.

Power Drum Augers (Small-Diameter Piping)

This power auger consists of a drum containing a length of cable (15 m/50′ of ¼" or 5/16″; or 10 m/35′ of 3/8″) that is generally mounted on the end of a variable-speed electric drill. This hand-held drain cleaner can clear clogs in lines from 32 mm to 75 mm (1¼"–3″) in diameter in awkward and tight spaces. The motor also has a quick-reversing switch to help release the cable should it get caught in a drain line. The rotation of the drill is used to unspool and drive the cable down a pipe. The cable is gripped by a chuck that must be loosened by hand for the cable to be loosened and manually fed into the drain and must again be hand-tightened to lock the cable in place. When the cable reaches the clog, the tip begins digging into and loosening the material. This is where an electric power drum auger offers many benefits over a manual version. Using a hand auger, you are limited to the power you can generate and maintain with your hands alone. With a power auger, you can slowly ease up the pressure you are applying to a clogged drain in order to be more effective at getting rid of the obstruction.

Power Drum Augers (Large-Diameter Piping)

This power tool consists of a cable 30 m (100′) or sometimes 15 m (50′) long wrapped inside a metal drum or cage-like spool, which is turned by a reversible electric motor. These tools are incredibly powerful, using low internal gear ratios to move slowly but with enough force to break apart or cut tough material. These machines are too heavy for one person to carry, so they are typically equipped with a frame with two wheels, allowing it to be rolled around like a dolly. To use this type of tool, position the auger a few feet away from the cleanout and plug its power cord into a nearby grounded electrical outlet. Most augers have a foot pedal that allows the motor to be controlled hands-free; set this down in a convenient location. (Figure 7)

Figure 7. Power Drum Auger

Pull out the cable and feed it into the pipe a few feet, then press the pedal to start spinning the cable (and cutter head) in the normal (clockwise) rotation. While the auger is spinning, pull the cable off the spool and feed it into the drain a foot or so at a time. In addition to powering the cutting action, the rotation helps the cable work its way through bends in the drain pipe. If the cable meets resistance, it could be an offset or obstruction. In either case, don't try to force the cable forward. Back off the cutter head by retracting the cable a bit, then feed it in again.

When the cutter encounters an obstruction, it may grab the material and stop turning while the cable keeps spinning. The cable is a tightly wound torsion spring, so you can let it wind up for a few rotations but going too far can break it. Let the energy build up a little bit, then pull the cable back to free the cutter blade; the cable will instantly spin back to its normal position. If the cutter gets stuck and you can't get the cable unwound, stop the auger rotation, hit the reverse switch on the motor, and rotate the auger backward. Then pull the cutter free before resuming in the clockwise rotation. Once the cable returns to the normal position, start feeding it in again.

Repeat the process until the drain is clear. Often, it's necessary to pull the cable all the way back out to check the cutter head for roots and other debris. Advantages of electric drain cleaners include the ability to clean long sections of sewer drain and the ability to remove solid objects such as tree roots. Machines using flexible attachments can easily negotiate multiple 90-degree bends while maintaining their effectiveness and without damaging the pipe.

Water Jetters

This is a method of cleaning or unclogging drains and sewers using high-pressure water to remove debris. High-pressure water jetters usually operate with water pressures up to 28 000 kPa (4000 psig) with flow rates of 9 to 113 litres (2 to 25 gal.) of water per minute. The pressure of the water jet propels a highly flexible hose through lines measuring 32 to 100 mm (1¼" to 4″), blasting through sludge, soap and grease blockages. As you pull the hose back, it power scrubs the line, flushing debris away and restoring drain lines to their free-flowing capacity. Because of the introduction of water into an already plugged line, the drainage pipe is ideally cleaned from the downstream end of the pipe, and the hose propels itself upstream.

When it is impossible to clean from the lower end of the pipe, the pipe must be water jetted several times to remove all the debris. Water jetters can be truck-mounted and may carry up to 6800 litres (1500 gal.) of water for large sewer cleaning jobs, or they can be mounted on a trailer and pulled by a large van or small truck. Smaller water jetters can be mounted on a cart for residential and light commercial applications. When using this type of tool for a residential job, be aware of any cross-contamination issues. Consider the location of your source water: does it come from a tank in your truck or from a hose bib on the property?

Air Blasters

Air blaster drain cleaners use accelerated carbon dioxide, air or other gas to rupture the obstruction membrane. Accelerated gas creates a force on standing water that can dislodge clogs that accumulate close to drain openings but are too far away from the drain opening to be removed with a plunger. Unlike drain augers, air blasters do not pose any risk of scratching the surfaces of ceramic sinks, bathtubs and toilets. Disadvantages of air blaster drain cleaners include a limited cleaning range in pipes that do not contain standing water and, in general, ineffectiveness for unclogging blocked main sewer drains. Safety considerations for air blaster drain cleaners include a requirement to wear eye protection and, when using an air-burst cleaner that uses compressed gas cartridges, careful handling of unused cartridges

Steam Cleaning

Unlike air- and water-jet systems, steam cleaning is an entirely different process. The steam cleaner uses steam's expansion to accelerate water droplets, at the boiling point, to a high velocity. The closer the steam cleaner's nozzle is to the surface to be cleaned, the higher the temperature and velocity of the water/steam mixture, and the more rapid the cleaning action. The temperature of the water/steam mixture drops quickly as the distance between the nozzle and the surface to be cleaned increases.

Consequently, for drain-cleaning applications, the nozzle should be held close to the inner surfaces to achieve the best results.

Shop Vacuum

Most shop vacuums have an output blower mode that should be powerful enough to clear small drain obstructions. Place the end of the vacuum hose firmly over the drain and seal the edges to maintain output pressure. Make sure any other drain openings are closed or tightly plugged. In blower mode, quickly turn the power on and off repeatedly until you dislodge the clog from the drain. Leaving the blower to run continuously for a long period of time can damage your pipes (or the vacuum, if its air flow is restricted)

Now complete Self-Test 1 and check your answers.

Self-Test 1

Self-Test 1

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Learning Task 2

Describe Troubleshooting and Repair of Drainage, Waste, and Venting (DWV) Systems

Regular maintenance of a drainage, waste, venting, and storm systems will help prevent problems. However, it is inevitable that issues will arise. When called out for service, there are different ways to troubleshoot and repair system issues.

The goal of troubleshooting is to determine why something does not work as expected and then repair the problem. The first step in the troubleshooting process is to verify the faults in the system. Some common faults are:

- Tree roots
- Settling
- Physical damage
- Fatbergs
- Pipe failure
- Human Error

Faults

Tree roots

Trees and shrubs are a great addition to your landscape, providing fresh air, beauty, and shade when mature. However, uncontrolled root growth under the ground can cause them to quickly encroach on your sewer lines, resulting in thousands of dollars worth of damage to your plumbing system. Tree roots may also infiltrate a septic system and cause damage and drainage troubles.

When tree roots have invaded your drainage system, depending on the extent of damage, there are only so many options for repair. Broken pipes must be dug up and replaced. However, in some cases companies can feed a new pipe through the existing one eliminating the need for the system to be dug up and possibly saving the occupant money.

Settling

There are several reasons why a building's foundation is settling. One of the most common reasons foundations settle is because the soil underneath wasn't correctly compacted before construction began. Material that was buried underneath your foundation could start to degrade, leaving behind voids or pockets. Or the soil underneath your foundation is made of too much clay, which is expanding and shrinking based on moisture content.

Settling can cause pipes to lose their grade and begin to backflow. Placing a level on the lowest piping could indicate if this is the reason for trouble. Also, you may see cracks in the building's foundation signifying that settling has occurred.

Once settling has been discovered, back grading pipes must be fixed. In many cases, the pipes must be dug up, relevelled, and backfilled or backups will continue.

Physical Damage

Most of the DWV system is vulnerable to physical damage. Damage is caused by things ranging from cars to rodents. Natural movement in the system as water flows and movement caused by vehicles driving near pipes can, overtime, loosen clamps and create damage and leaks. Small cracks become larger and leaks and pipes become clogged with pest infestations.

If pipes have been broken due to physical damage, they will need to be replaced. A pest infestation may require more than a service plumber to fix the problem, but the pipe must be cleared of an infestation to restore proper draining.

Fatbergs

Fatbergs are large lumps of fatty gunk in the sewer system which can set as hard as concrete. They are caused by fat, oil and grease being disposed of incorrectly down sinks and drains, and then accumulating over time.

Once found, removal of a fatberg is difficult. They become hard and dense and must be chipped away with shovels or high-pressure water jets. They can be broken down into smaller pieces that float away to the nearest sewer or they are removed manually with buckets.

Figure 8. Dried Fatberg found in London sewer

Pipe Failure

General corrosion and sediment build-up can create leaks and blockages. Natural soil movement over time causes sagging sewer lines, which can become a problem when the low spots create repeat blockages, ruptures, or leaks. Maintenance will help extend a DWV system's lifespan, but eventually parts of it will require repair or replacement.

Human Error

One thing to keep in mind is that a toilet is not a garbage can. People will toss just about anything down the drain with the predictable consequence being a clog. Kitchen sinks clog with grease and egg shells, while toilets can clog with toys and remote controls. Flushable wipes have become a recent culprit of clogs in the DWV system. Customers should be advised that nothing should flushed down a toilet other than toilet paper.

A service plumber must locate and clear blocks in the drainage piping by means of a camera inspection, auger, hydro jetter, or any other equipment necessary.

Troubleshooting Checklist

When responding to a service call for a DWV system, here are some things to try and look for to help troubleshoot the problem:

- All drains are backing up at once. When the toilet is flushed, the toilet, sink, and showers all start to overflow, there is a clog in a main pipe somewhere
- When the toilet is flushed the water is bubbling or gurgling. This can indicate a partial blockage.
- Indentations in the yard may indicate a break in the line or a sagging pipe. Changes to grass are also an indicator of sewer leaks. Soggy patches or extra green patches of grass could mean sewage is coming up from the pipes below and fertilizing your lawn
- Smell. If it smells like sewage, it's probably sewage
- Mold. Leaking sewage pipes mean moisture in places you don't want moisture. This can cause fungi and mold to grow in seemingly strange areas of a home. If there are mold spots, look for other signs of sewer damage
- Drains are slow. If the drains are slow, it could be the start of a larger clog
- Pest infestation. If there is evidence of a rodent infestation, rodents could be coming in from the sewage pipes

Safe Work Practices

Safety

Drains and sewer can carry bacteria and other infectious micro-organisms or materials that can cause death or severe illness. Avoid exposing eyes, nose, mouth, ears, hands and cuts and abrasions to wastewater or other potentially infectious materials during drain and sewer cleaning operations. Safe and effective use of drain-cleaning equipment requires service personnel to use personal protective equipment (PPE) while working on sewer or drain lines.

Two important safety items essential to drain cleaning are:

- Safety glasses or goggles with side shields
- Gloves
- Eye protection is an important safeguard against flying solid objects or pathogenic liquids, which can become airborne when the tension on a cable is suddenly released. Gloves protect a technician's hands from sharp objects and are especially important for the hand that guides the cable into and out of the drain. Sudden release of a stoppage causes the cable to spin rapidly enough to burn or cut bare hands.

Service personnel also need to be aware of the risks presented by ponding water from backed up drains. One good safety practice is to stand on boards or a solid pallet to prevent electrical shock from grounding through water. As with any power tool, always check the safety features of the equipment provided by the manufacturer before taking it to the job site.

Since drain cleaners can suddenly hit blocks or stoppages, you should never force them through the blockage. The best practice is to use short forward and reverse movements of the cable to prevent jamming and breakage. The cable drum should be cleaned before it is returned to storage because bacteria and pathogens can be transferred during handling even after the job has been completed.

Confined Space

WorkSafeBC defines a confined space an enclosed or partially enclosed area that is big enough for a worker to enter. The space may be enclosed on all sides (for example, a bin or tank), or as few as two sides (for example, an enclosed conveyor). Confined spaces are not designed for someone to work in regularly.

A sump or septic tank are both examples of confined spaces and should not be entered without the proper training.

Test and Return to Service

In accordance with the NPC, any design, installation, extension, alteration, renewal, or repair of a plumbing system must satisfy the testing requirements. Before returning a system to service you must ensure that it is properly tested.

Drainage Tests

Water Pressure Test

A water pressure test shall consist of applying a water column of at least 3 m (10′) to all joints. In making a water pressure test, every opening except the highest shall be tightly closed with a testing plug or a screw cap, and the system or the section shall be kept filled with water for 15 minutes.

Air Pressure Tests

Air pressure tests shall be conducted in accordance with the manufacturer’s instructions for each piping material. Air shall be forced into the system until a pressure of 35 kPa (5 psig) is created, and this pressure shall be maintained for at least 15 minutes without a drop in pressure.

Final Tests

Where a final test is requested and made, every trap shall be filled with water, and the bottom of the system being tested shall terminate at a building trap, test plug or cap. Smoke from smoke generating machines shall be forced into the system, and when the smoke appears from all roof terminals they shall be closed. A pressure equivalent to a 25 mm (1″) water column shall be maintained for 15 minutes without the addition of more smoke. The smoke referred to above may be omitted provided the roof terminals are closed and the system is subjected to an air pressure equivalent to a 25 mm water column maintained for 15 minutes without the addition of more air.

Ball Tests

Where a ball test is conducted, a hard ball dense enough not to float shall be rolled through the pipe. The diameter of the ball shall be not less than 50 mm (2″) where the size of the pipe is 75 mm (3″) or more, or 25 mm where the size of the pipe is less than 75 mm.

Now complete Self-Test 2 and check your answers.

Self-Test 2

Self-Test 1

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Media Attributions

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Learning Task 3

Describe the Testing of Manholes, Catch Basins, and Piping for Sewers

Manholes, catch basins, and piping for sewers are required by code to be tested using an acceptable test method and then pass an inspection. Improperly installed components could allow unsanitary conditions to occur inside a building and allow toxic gases to enter. If an alteration to the system occurs after the test and inspection, the piping system will have to be re-tested and inspected.

Types

Sensory

Before any water, air, or otherwise is used for testing, a plumber can do a visual inspection for any obvious signs where a leak could occur. All clamped joints should be inspected and checked for tightness. Glued joints will have signs of primer or glue to confirm they were properly connected. Catch basins or manholes may have visible cracks that can be repaired before adding water for testing. If older pipe is being tested, be sure to check for excessive external corrosion that can lead to cracking of the piping.

Hydrostatic

A hydrostatic or water test is the most common test used after installation. This is the recommended test in most plumbing codes, weather permitting. To test the sewer piping, the pipe must plugged at its most down steam end. Fill the system with water at the highest point, if available. Filling the system slowly should allow any air in the system to escape as the water rises in the pipe. All air entrapped in the system should be expelled prior to beginning the test. Failure to remove entrapped air may give faulty test results. As per the NPC, a 3m water column must be maintained for 15 minutes for a successful inspection.

To test catch basins or manholes, plug the inlets and outlets. Fill the basin or manhole with water. Ensure the water level remains constant verifying that there are no leaks.

Smoke and Air

When a system has been completely installed and some sections may be obscured from view, a smoke test may be required by engineers, architects, or plumbing codes to find leaks in the piping. A thick, penetrating smoke produced by one or more smoke machines is introduced into the bottom of the system through a suitable opening. As the smoke appears at the highest point, the opening is closed off and the introduction of smoke is continued until a pressure equal to 25 mm (1”) of water is built up and maintained for 15 minutes without the addition of more smoke. Under this pressure, smoke should not be visible at any point, connection, or fixture. Smoke testing can identify sections of the sanitary sewer system that have defects such as cracks, leaks or faulty connections that allow rainwater to enter the underground pipe network.

Two types of smoke are currently offered for smoke testing:

- smoke candles
- smoke fluids

To use a smoke candle, simply place one on the fresh air intake side of the blower. Once the candle has been ignited, the exiting smoke is drawn in with the fresh air and blown down into the system. This type of smoke is formed by a chemical reaction and has a high content of atmospheric moisture. It is very visible even at low concentrations and extremely effective at finding leaks.

A smoke fluid system involves injecting a smoke fluid (usually a petroleum-based product) into a heating chamber such as the engine exhaust muffler of a portable blower engine. The smoke is then exhausted into the fresh air intake side of the blower. Smoke fluids do not consistently provide the same quality of smoke because, as fluid is injected into the heating chamber, it immediately begins to cool the heating surface. The heating chamber will eventually reach a point where it is not hot enough to completely convert all the fluid to smoke, and it will then produce thin, wet smoke that is difficult to see. This can happen quickly, depending on the rate of fluid flow. Some manufacturers have taken steps to address this issue and now offer insulated heating chambers to help maintain necessary temperatures.

An air test may also be used when weather could cause standing water in a system to freeze or when testing piping above sensitive or expensive equipment. The system is filled using an air compressor

Mandrel

A mandrel test is the inspection inside underground pipes and sewer conduits. This happens after new construction or maintenance. This test is usually issued by the cities to test the public sewer lines. This test will show whether the pipe has bent under stress and pressure of the soil above.

The mandrel is cylindrical in shape and constructed with an odd number of evenly spaced arms or prongs, with a minimum 9 in number. (Figure 9) The minimum diameter of the circle scribed around the outside of the mandrel arms is equal to the allowable deflection.

The deflection test (Figure 9) is conducted by pulling the test device through a completed sewer run, from manhole to manhole. If the mandrel gets caught in the pipeline and cannot be pulled through the line in one straight pass, the line will fail inspection.

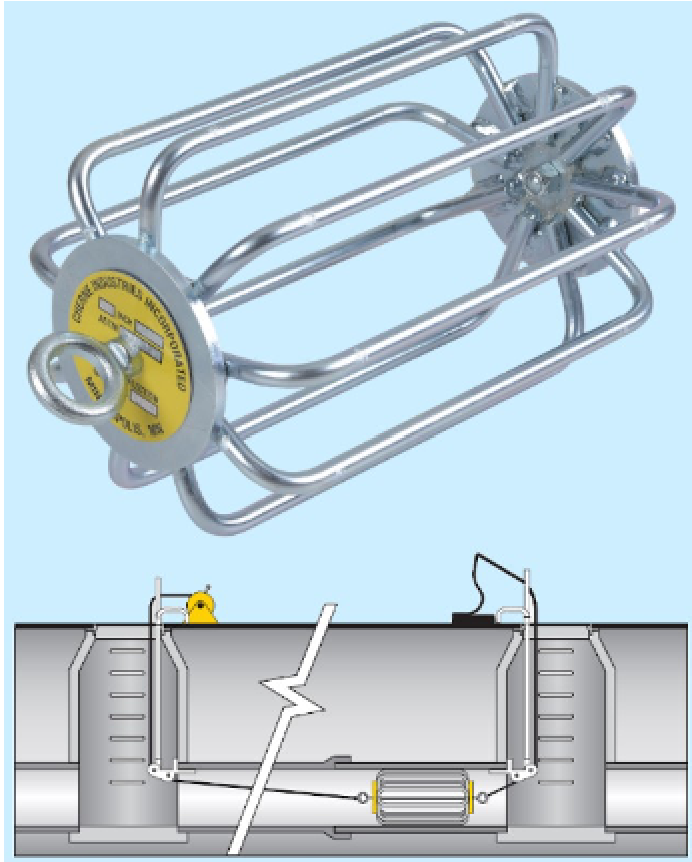

Figure 9. Mandrel and mandrel test from manhole to manhole

Equipment

Inflatable Test Balls

Inflatable test balls are blown up using a bicycle pump. Once placed in the opening to be plugged, use the pump to inflate the ball to its rated PSI. The PSI rating of the test ball will be imprinted on the test ball and should not be exceeded.

Test Plugs

Whether the test is by water, air or smoke, all openings in the test section must be sealed. Test plugs are often used in industry because they may be used repeatedly and are therefore cheaper to use than one-time-only test caps. Test plugs are available in several configurations, such as inflatable for use in a line cleanout or inflatable for use in a wye fitting.

Figure 10. Inflatable test ball and plug

Faults

When testing any part of the DWV system there are many faults that could be discovered. Once found these faults require repair or replacement and a retest shall be performed.

Cracks

If a manhole, catch basin, or sewer pipe has a crack or multiple cracks, it will not be able to hold water during a test. Once a crack is discovered repair will be in order.

Corrosion

Corrosion is caused by an electrochemical reaction between metal and another substance. When this happens, the metal in a pipe loses electrons. They are transferred from the metal to the other substance. As corrosion continues, the metal breaks down further and this causes rust, leaks, and clogs.

Oxygen is known to degrade metal through internal oxidation. Since water contains oxygen, it will cause pipes to rust over time. Corrosion can be minimized with water treatment such as maintaining a neutral PH level, but no piping will last forever and will eventually need to be replaced.

Figure 11. Corroded cast iron pipes

Inadequate Flow

Flow into a catch basin, manhole and through piping should be smooth. Using water from a hose, test out the system. Get a good flow of water going through the most upstream catch basin and look for leaks or problem areas that should be fixed before the back-filling process. If there are issues with flow, this will need to be investigated and resolved before an inspection.

Piping Failure

Pipes could fail for several reasons. Common ones being poorly supported pipes lead to sagging and the loosening of clamps, bad workmanship, and manufacturer defects. Pipes will fail overtime due to wear and tear, internal and external corrosion and damage, and physical damage. These conditions can be detected with proper testing procedures.

Specifications, Codes, and Regulations

The BC Plumbing Code is intended to ensure the quality and functionality of plumbing systems and to protect the health of the occupants of the premises where a plumbing system is to be installed, as well as the health of the public in general. As a result of this intent, drainage and venting pipes are required by Code to be pressure tested after installation of each phase of the project.

The term authority having jurisdiction, commonly referred to as AHJ, covers a variety of regulating organizations. In our trade, the most common application is in reference to the building official responsible for Plumbing Code and regulation enforcement. For the building official, the limits may be the Building and Plumbing Codes adopted by the jurisdiction. Quite often, local AHJ may require a DWV installation to meet by-laws or regulations that address local conditions before they will give approval. Some examples of local regulations could include using piping materials that are suitable for local soil conditions, or the depth that piping must be buried to prevent freezing.

Return to Service

In accordance with the NPC, any design, installation, extension, alteration, renewal, or repair of a plumbing system must satisfy the testing requirements. Before returning a system to service you must ensure that it is properly tested.

Documentation

The procedure and requirements for a certificate of approval or passed inspection can vary widely from jurisdiction to jurisdiction and with the type of structure. Some projects may require certification from the installer that the plumbing system functions according to the approved design.

Now complete Self-Test 3 and check your answers.

Self-Test 3

Self-Test 3

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Learning Task 4

Describe Maintenance Procedures for Manholes, Catch Basins, and Piping for Sewers

Inspection

A manhole is a composite or concrete chamber installed at specific intervals along sewer lines, that allow access to the pipes entering and exiting them (Figure 12). Sometimes referred to as inspection chambers, manholes allow inspection, cleaning, and maintenance of sewers without needing to dig them up. They are normally installed at every bend, junction, change of gradient or change of diameter of the sewer. The sewer line between any two manholes is normally laid straight with consistent gradient to minimize the chance of blockages forming at any point between manholes.

The NPC code 2.4.7.3. ensures that manholes area accessible by requiring the following:

1. A manhole, including the cover, shall be designed to support all loads imposed upon it.
2. A manhole shall be provided with
    a. a cover that provides an airtight seal if located within a building
    b. a rigid ladder of a corrosion-resistant material where the depth exceeds 1m, and
    c. a vent to the exterior if the manhole is located within a building
3. A manhole shall have a minimum horizontal dimension of 1m, except that the top 1.5m may be tapered from 1m down to a minimum of 600 mm at the top.
4. A manhole in a sanitary drainage system shall be channeled to direct the flow of effluent.

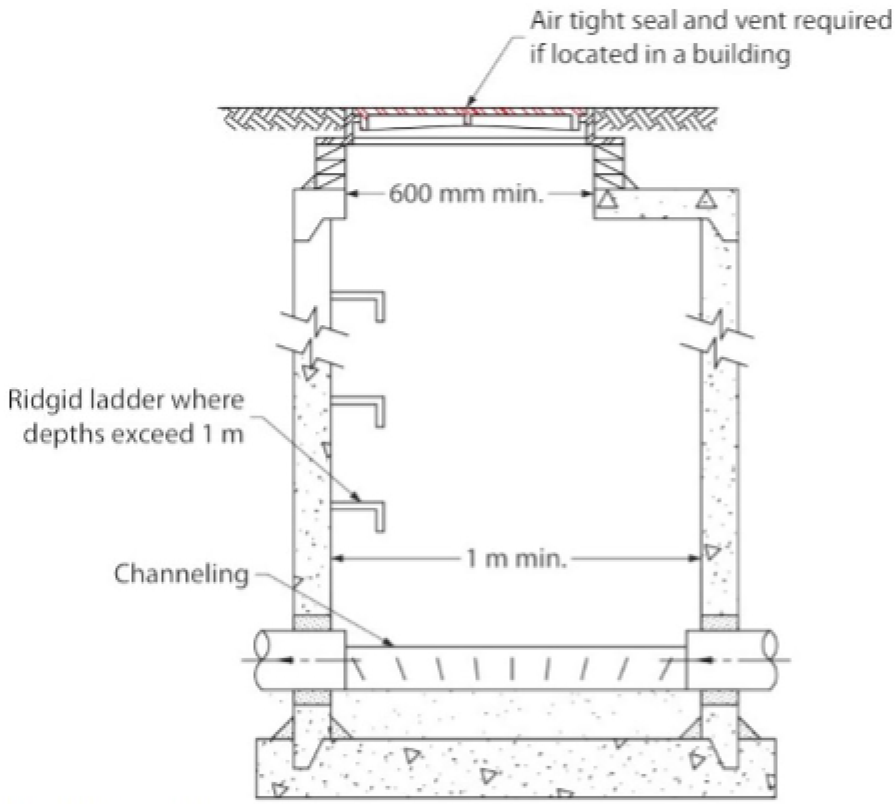

Figure 12. Sanitary Manhole

A catch basin or storm drain is a curbside drain with the sole function of collecting rainwater from our properties and streets and transporting it to local waterways through a system of underground piping, culverts and/or drainage ditches. Storm drains can also be found in parking lots and serve the same purpose. (Figure 13) The catch basin grate can be lifted for access and inspection.

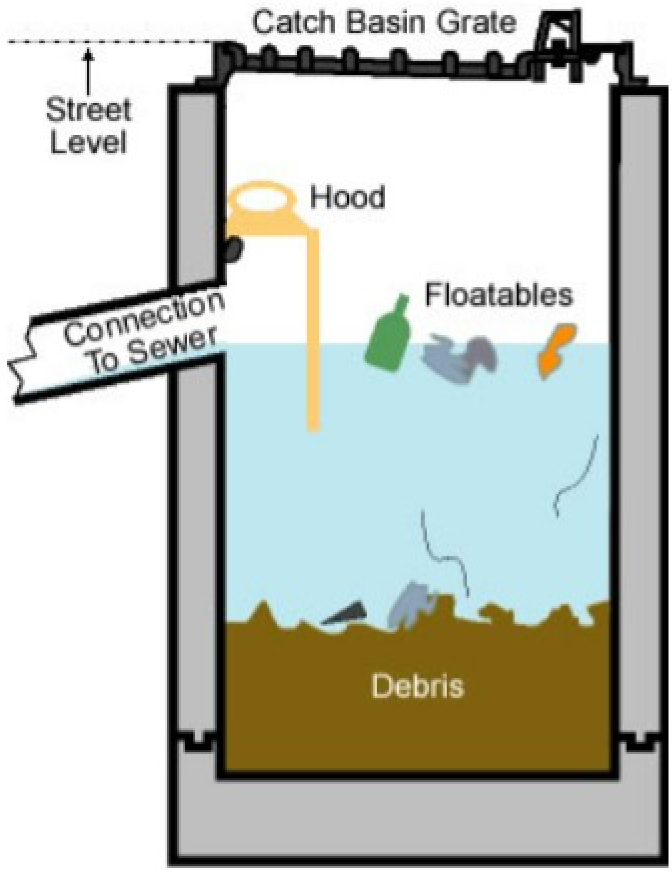

Figure 13. Street level catch basin

Piping for sewers is the pipe exiting a structure and is connected to a building drain 1 m outside a wall of a building and that leads to a public sewer or private sewage disposal system. Typically, this piping is installed, maintained, repaired, and replaced by the city or with their permission.

Schedules

Typical maintenance schedules call for an annual inspection of manholes, catch basins and the sewer piping although these checks may be required at more regular intervals if the system collects excess amounts of dirt and debris. The best time of year to clean out a catch basin is late summer or early fall. This ensures the unit will function properly and continue to direct storm and sewer water away from the building during the season's highest rainfall.

Testing

Smoke

A smoke test can be performed on sewer pipes by introducing smoke into the piping and confirming none is escaping through smalls leaks. Smoke testing can be helpful in identifying leaks in spots that are hard to see or when the weather requires its use. During smoke testing, field crews blow air and smoke into the sanitary sewer system and monitor where smoke escapes. If smoke permeates up through the ground, it indicates a break in the sewer line. (Figure 14)

Figure 14. Smoke testing a sewer

Cameras

A camera can be used to inspect catch basins, manholes, and sewer pipe. A high-resolution sewer pipe camera is fastened to the end of a flexible rod (Figure 15). A professional then inserts the rod, along with the camera into the pipes to check for problems. Using a flexible rod permits for more improved mobility inside pipes and sewer lines.

Figure 15. Camera Inspection

Specifications, Codes, and Regulations

The BC Plumbing Code is intended to ensure the quality and functionality of plumbing systems and to protect the health of the occupants of the premises where a plumbing system is to be installed, as well as the health of the public in general. As a result of this intent, drainage and venting pipes are required by Code to be pressure tested after installation of each phase of the project.

The term authority having jurisdiction, commonly referred to as AHJ, covers a variety of regulating organizations. In our trade, the most common application is in reference to the building official responsible for Plumbing Code and regulation enforcement. For the building official, the limits may be the Building and Plumbing Codes adopted by the jurisdiction. Quite often, local AHJ may require a DWV installation to meet by-laws or regulations that address local conditions before they will give approval. Some examples of local regulations could include using piping materials that are suitable for local soil conditions, or the depth that piping must be buried to prevent freezing.

Tools and Equipment

Snakes

Snakes can be an easy, effective way to remove clogs in sewer pipes and maintain efficient drainage. Depending on the size of the clog and pipe, maintenance staff can choose from multiple options including hand augers, closet augers, and powered augers. Snakes also have several detachable heads that can be selected based on the job at hand. These heads include ones for cutting through grease, hair, and even hardened mud. (Figure 16).

Figure 16. Drain snake attachable heads

Jetters

A hydro jetter can clean more efficiently than snaking alone (Figure 17). Snaking can remove clogs, but some particles are often left behind. Hydro jetting is environmentally friendly, and no punitive chemicals are used just high pressure water.

Figure 17. Hydro Jetter

Cameras

Video inspection equipment uses a remote video camera to inspect underground sewers and drains. Proper maintenance will sometimes require visual confirmation that piping and components are in good condition. A video can be taken and saved to a USB drive to document the procedure and findings of the inspection.

Vacuum Trucks

Vacuum trucks may be required when inspecting a manhole or catch basin. (Figure 18) They are equipped with a pump and a tank for removal of fluid in the manhole or catch basin. Vacuum trucks can pump out contents and allow for access to a pump, inlet and outlet piping. Once a manhole or basin is emptied, service personnel can climb in and perform maintenance tasks such as clearing a pump, baffle, or filter of any excess debris. This is also an opportunity to check for damage to a pump or the piping.

Figure 18. Sewage Vacuum Truck

Isolation

Maintenance for a manhole, catch basin, or sewer piping may require the isolation of system components. A drainage system has challenges when attempting to isolate its parts. Mainly, it is difficult to stop occupants from using their fixtures that are connected to a sanitary sewer. Steps can be taken to attempt to lessen their use by way of signs in large buildings and communication from building managers. Maintenance for storm systems is best done on dry days to eliminate rainwater from entering the system while performing maintenance tasks.

Manholes and catch basins can be isolated at the inlets and outlets, however, service personnel must take care when removing things like test plugs because there could be waste or rainwater building behind the plug.

Return to Service

In accordance with the NPC, any design, installation, extension, alteration, renewal, or repair of a plumbing system must satisfy the testing requirements. Before returning a system to service you must ensure that it is properly tested. When returning a system to service it is recommended to notify the users of the system that maintenance is complete.

Documentation

The procedure and requirements for a certificate of approval or passed inspection can vary widely from jurisdiction to jurisdiction and with the type of structure. Some projects may require certification from the installer that the plumbing system functions according to the approved design.

Now complete Self-Test 4 and check your answers.

Self-Test 4

Self-Test 4

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Learning Task 5

Describe Troubleshooting Procedure for Manholes, Catch Basins, and Piping for Sewers

The goal of troubleshooting is to verify the problem or problems in a system and then repair or replace as needed. When attempting to determine the faults in a manhole, catch basin, or the piping for sewers, it is important that the work is done safely following all Worksafe BC guidelines. Also, using the proper equipment will help identify problems as quickly as possible.

Verify Reported Problem

When responding to a call for service, personnel must gather as much information as they can about the issues. Some common problems with manholes and catch basins are that captured debris can take a long time to dry. During summer months, the moist debris creates an environment that is ideal for insects to breed and cause clogs. They may need to be exterminated. Also, as water pools around catch basins, they have the potential to cause a sinkhole. They may need to be dug out and back filled. A sinkhole could also break the sewer piping connected to the manhole or catch basin. If a sinkhole is the cause of the problem, the sewer piping should be thoroughly checked for cracks or breaks.

Safe Work Practices

Confined Space

Confined Spaces WorkSafeBC's OSH Regulation: Part 9 includes this definition of a confined space: "confined space", except as otherwise determined by the Board, means an area, other than an underground working, that:

- is enclosed or partially enclosed
- is not designed or intended for continuous human occupancy
- has limited or restricted means for entry or exit that may complicate the provision of first aid, evacuation, rescue, or other emergency response service, and
- is large enough and so configured that a worker could enter to perform assigned work.

A space may also be a permit-required confined space if it has a hazardous atmosphere, the potential for engulfment or suffocation, a layout that might trap a worker through converging walls or a sloped floor, or any other serious safety or health hazard. The current Confined Spaces standard is a component of provincial Worker Compensation Board (WCB) legislation.

Figure 19. Confined space equipment

The following are examples of some of those requirements for safe entry of confined spaces.

- Preparation: Before workers can enter a confined space, employers must provide pre-entry planning. This includes:
- Having a competent person evaluate the work site for the presence of confined spaces, including permit-required confined spaces.
- Once the space is classified as a permit-required confined space, identifying the means of entry and exit, proper ventilation methods, and elimination or control of all potential hazards in the space.
- Ensuring that the air in a confined space is tested before workers enter, and at specified intervals thereafter, for oxygen levels, flammable and toxic substances, and stratified atmospheres.
- If a permit is required for the space, removing, or controlling hazards in the space and determining rescue procedures and necessary equipment.

If the air in a space is not safe for workers, ventilating or using whatever controls or protections are necessary so that employees can safely work in the space. The employer must implement additional specific requirements in the OHS legislation regarding hazard assessment. Workers are responsible for carrying out their work in a manner that does not endanger them or their fellow workers. Workers must cooperate with their employer by following safe work procedures and using the equipment provided to complete the job safely. 12 Industry Training Authority BC Confined Spaces Air Quality Hazards Air quality hazards are the most immediate of the concerns regarding confined space entry. Those concerns can originate from things such as:

- Insufficient amount of oxygen for the worker to breathe

- Toxic gases that could make the worker ill or cause the worker to lose consciousness
- The presence of asphyxiants. Simple asphyxiants are gases which can displace oxygen in the air. Low oxygen levels (19.5 percent or less) can cause symptoms such as rapid breathing, rapid heart rate, clumsiness, emotional upset, and fatigue. As less oxygen becomes available, nausea and vomiting, collapse, convulsions, coma and death can occur. Unconsciousness or death could result within minutes following exposure to a simple asphyxiant. Asphyxiants include argon, nitrogen, or carbon monoxide. It is important to note that wherever there is ferrous piping present, the rusting process can use up the available oxygen in a confined space, contributing to the likelihood of asphyxiation.

Shoring

Since manholes, catch basins, and piping for sewers are installed in slab or underground, it is often necessary to do some digging to access the areas to be inspected for faults. If a trench is to be made that is more than 4’ deep, Worksafe BC requires that shoring be used to ensure the safety of any worker entering the trench. The sides of a trench must be supported by sheet piling or shoring that meet Worksafe BC minimum standards or sloped to an angle no more than 3’ horizontal to every 4 vertical feet. Approved trench boxes (Figure 20) can also be used as an alternate to sloping.

Figure 20. Trench box shoring

Inspection

Manholes covers can be lifted off and, using a light, an inspection can be performed.

To inspect a catch basin first sweep any leaves, garbage, and debris away from the grate to ensure it does not block the flow of stormwater. The grate can then be lifted and the inside inspected.

Inspection for both manholes and catch basins can be performed every three months to check sediment build up, or floating oil levels. This will help determine rate of accumulation so a maintenance schedule can be established. If either component continues to be more than one third full in an annual inspection, then it should be cleaned more frequently. If a catch basin is collecting things like woody debris, then it should be cleaned on a more regular schedule.

Now complete Self-Test 5 and check your answers.

Self-Test 5

Self-Test 5

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Learning Task 6

Describe Repair Procedures for Manholes, Catch Basins, and Piping for Sewers

After discovering damage to a catch basin, manhole, or piping for sewers, it is important to alert the proper authority. Commonly it is the city that will call for a repair to be performed with proper approvals in place.

Tools and Equipment

Before anything can be repaired, service personnel will need access to the catch basin, manhole, and piping. To open the lid, a manhole cover hook is used (Figure 21) These hooks make opening a manhole much easier on a person's back and easier to open a cover that may have become jammed with debris or deformed overtime.

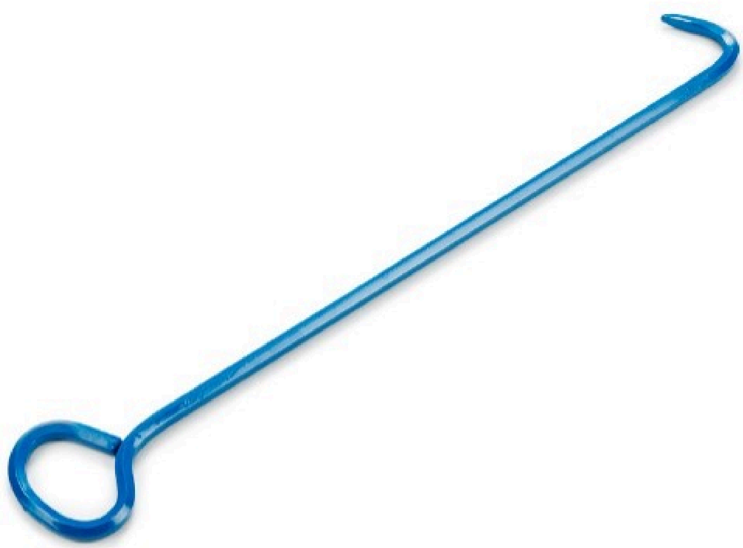

Figure 21. Manhole cover hook

Hand tools such as flashlights, shovels, and access rope will be essential in a tool kit for working on these components and should be part of a repair tool kit. A camera inspection can help locate where a fault has occurred, therefore camera equipment is an essential part of the repair process.

A manhole is considered a confined space and should only be entered by authorised personnel. (Figure 22) Depending on the type and size of catch basin, they too could be considered a confined space. If so, confined space equipment must be properly set up for any required repairs.

Figure 22. Authorized worker entering a catch basin

When entering a manhole or catch basin, the proper PPE needs to be considered. If the space has potential for any harmful substances, such as chemical cleaners, or sewage, appropriate clothing must be worn. A respirator may also be recommended depending on the condition of the air. (Figure 23) Before entering, check your personal protection equipment for tears in coveralls or gloves or any damage to your respirator or goggles and replace if any defects are found.

Figure 23. Respirator

Isolation

Repairs on a manhole, catch basin, or sewer piping may require the isolation of system components. A drainage system has challenges when attempting to isolate its parts. Mainly, it is difficult to stop occupants from using their fixtures that are connected to a sanitary sewer. Steps can be taken to attempt to lessen their use by way of signs in large buildings and communication from building managers. Maintenance for storm systems is best done on dry days to eliminate rainwater from entering the system while performing maintenance tasks.

Manholes and catch basins can be isolated at the inlets and outlets, however, service personnel must take care when removing things like test plugs because there could be waste or rainwater building behind the plug.

Repair and Replace Components

Once a fault has been discovered, repair or replacement may be necessary. Since manholes, catch basins, and sewer pipe are installed in the ground often digging up the damaged component will be needed.

A manhole that is in the street can create a bump in the road that requires removal. A worker can chip up the concrete around the manhole or special equipment can be used to cut out the top of the manhole, replace it with a shorter piece, and the concrete that was removed when the top was cut out repoured around the manhole. (Figure 24) This scenario would require the cooperation of the city and permits in place before a repair can occur.

A catch basin can also be excavated with the proper equipment and replaced if a fault has been detected. The piping upstream of a catch basin will likely need to be cut to free the catch basin, then reconnected once the basin is replaced and

When damage has happened to the sewer piping, the city, town, or village will need to be involved in its repair. A camera inspection will help locate a fault and repairs can be done depending on the issue. If a small part of the sewer is back grading, that portion could be replaced. However, if there are multiple spots that are incorrectly pitched, the entire pipe may need to be removed and replaced. If cracks or corrosion has occurred, that pipe will also need to be replaced.

Figure 24. Repair of a manhole

To clean a catch basin, carefully lift the catch basin lid and scoop out all debris. Using the shovel dig out any compacted soil inside the catch basin. Ensure that the catch basin drain is completely free of roots and debris. Discard debris, dirt, and trash where it can't re-enter the catch basin.

Testing

In accordance with the NPC, any design, installation, extension, alteration, renewal, or repair of a plumbing system must satisfy the testing requirements. Before returning a system to service you must ensure that it is properly tested.

Return to Service

In accordance with the NPC, any design, installation, extension, alteration, renewal, or repair of a plumbing system must satisfy the testing requirements. Before returning a system to service you must ensure that it is properly tested.

After successfully testing the repaired or replaced components and before returning a system to service, it is always advisable to inform the occupants of a home or building. Once that is done, ensure that all equipment is cleared

Documentation

Whenever a repair is performed on a component a record should be made and kept on file. Basic information to be recorded should include the component location, the dates of inspection, conditions noted during the inspection, the dates a repair was performed, and notes on the repair performed.

The procedure and requirements for a certificate of approval or passed inspection can vary widely from jurisdiction to jurisdiction and with the type of structure. Some projects may require certification from the installer that the plumbing system functions according to the approved design.

Now complete Self-Test 6 and check your answers.

Self-Test 6

Self-Test 6

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Competency F2: Commission and Service Water Services and Distribution Systems

Learning Task 1

Describe the testing of water service and distribution systems

Water service pipes are vital components of any water supply system, responsible for delivering clean and reliable water to residential, commercial, and industrial buildings. Ensuring the functionality, efficiency, and reliability of these pipes is crucial to maintain a sustainable water distribution network. Testing water service pipes during installation, maintenance, or troubleshooting processes plays an important role in identifying potential issues, verifying compliance with regulatory standards, and delivering optimal performance.

Safe Work Practices

Pressure testing can be a dangerous task. Implementing and following safe work practices is needed to minimize accidents, injuries, and fatalities in the construction industry. Always follow safe work practices, use the proper PPE, and refuse any work you believe to be unsafe

Types

Pressure testing is used to evaluate the strength and integrity of water service pipes. It involves pressurizing the system with water or air to a specified pressure level and monitoring for any pressure drops that could indicate leaks or weak points. Testing helps identify potential issues before the system is put into operation and can help reduce future failures and costly repairs.

Hydrostatic

Hydrostatic testing is a common method used to assess the integrity and strength of water service pipes.

Before conducting the test, make sure that the water service pipes are properly installed and securely connected. The pipes should be clean and free from any debris that could obstruct the flow or affect the accuracy of the test.

The section of the water service pipe that needs to be tested should be isolated from the rest of the water supply system. This is done by closing valves or using temporary plugs to prevent water from flowing in or out of the test section.

The isolated section of the water service pipe is filled with water. Slowly introduce water into the system through a temporary connection or by using existing connections and once the pipes are filled, a pump or other pressurization equipment is used to increase the pressure inside the pipes. The pressure is raised to a level specified by the AHJ or industry standards. Common pressure levels for testing residential water service pipes are around 100 psi to150 psi.

After reaching the desired pressure allow the pipes to stabilize During this time, the pressure should be monitored to ensure it remains constant. This allows the pipes to be inspected for any leaks or visible signs of stress.

A visual inspection is performed to check for any signs of leakage, such as water dripping or spraying from the pipes, joints, or fittings. Additionally, any noticeable changes in pressure or visible deformities in the pipes may indicate a problem.

If there are no leaks or other issues observed during the stabilization period, the pipes are considered to have passed the hydrostatic test. However, if leaks or failures are detected, repairs or further investigation may be required to rectify the problems before the system can be returned to service.

Compressed Gas

Similar to hydrostatic testing, using compressed gas, usually air, to assess the system's strength is another reliable method. Compressed gas can be a cost-effective alternative to water pressure testing since air is readily available and eliminates the need for water supply during the testing process. This method can save costs associated with water usage, especially in areas where water availability or disposal can be a challenge It is generally quicker than water pressure testing. It allows for rapid pressurization and stabilization of the system, reducing the overall testing time This efficiency is beneficial for construction projects where time is critical and delays need to be minimized. By using compressed gas, water service pipes can be tested in a dry state, mitigating potential risks associated with water leaks or damage This aspect is advantageous when testing pipes in colder climates, where water freezing can cause complications during traditional water pressure testing.

Before conducting the test, it is important to check that the water service pipe is compatible with compressed gas. The pipe material, joints, and connections should be able to withstand the pressure exerted by the compressed gas. Inspect the water service pipe for any visible defects, ensuring that it is properly installed and connected. Confirm that all valves, fittings, and joints are securely tightened. Clear the pipe of any debris or obstructions that may affect the test.

Connect the compressed gas source, usually an air compressor, to the water service pipe and check for an airtight seal. Gradually increase the gas pressure to the desired level while closely monitoring the pressure gauge Allow the system to stabilize for a specific duration to confirm the pipe is holding. After the stabilization period, visually inspect the pipe and its connections for any signs of leaks, such as bubbling or hissing sounds. Conduct a thorough examination of the entire system, including joints, fittings, valves, and any exposed sections of the pipe Use appropriate leak detection equipment, such as soapy water or gas leak detectors, to identify the leaks.

Tools and Equipment

Several tools and pieces of equipment will be used to perform a pressure test and subsequent inspection of the water service piping.

Gauges

Pressure gauges are used to measure and monitor the pressure levels within the water service piping system. They help ensure that the pressure is within the required range and assist in detecting any anomalies or pressure drops that may indicate leaks or other issues.

Pumps

As discussed above, when hydrostatic tests are performed, a pump (Figure 1) can be used to increase the pressure in the piping to a desired level. The pump is connected often to a hose bibb or drain and water in pumped into the already full piping to increase the pressure Both manual and powered pumps can be used depending on the required pressure.

Figure 1. Ridgid Pressure Hand Test Pump

Compressor

When performing a compressed gas test, a compressor is used to increase the pressure in the piping system. The compressor is connected to an existing or temporary valve in the piping and compressed air is introduced until the required pressure is reached. Compressors will generally require an electrical energy source but can use fuel to power their motors if no electricity is available.

Codes and Regulations

AHJ

Water service pipes must comply with specific regulatory standards to ensure water quality, health, and safety for consumers. Testing is necessary to verify that the materials, design, and installation meet the required standards and guidelines. Before working on water service lines, you will be required to contact the local authorities for permission and instruction.

Components

Water meters, isolation valves, cross connection devices, check valves, expansion devices, pumps, post indicator valves, and fire hydrants are all components found in water service piping systems.

Water Meters

A water meter is a device used to measure the volume of water consumed by a residential, commercial, or industrial property. It is typically installed at the point where the water service line enters the building or property. The primary purpose of a water meter is to accurately record the amount of water used, which is essential for billing purposes and water resource management.

Water meters are mechanical devices that consist of a chamber or housing with an inlet and an outlet, along with a mechanism that measures and registers the flow of water passing through the meter. As water flows through the meter, it causes a rotor or turbine to spin, and this rotation is translated into a volume measurement.

There are various types of water meters available, including:

- Positive Displacement Meters.
- Velocity Meters
- Compound Meters
- Smart Meters

Positive displacement meters are meters that have a rotating chamber with a fixed volume, and they measure water flow by counting the number of chamber rotations.

Velocity meters are meters that measure the velocity of water flow and use this information to calculate the volume passing through the meter. Examples include turbine meters, electromagnetic meters, and ultrasonic meters.

Compound meters combine the features of positive displacement and velocity meters to accurately measure both low and high flow rates.

Smart water meters are equipped with advanced technology, such as wireless communication capabilities and data logging. They can provide real-time consumption data and remotely transmit the information to utility companies for billing and monitoring purposes.

Water meters are typically owned and maintained by the water utility company or the relevant local authority. They are sealed to prevent tampering and unauthorized access. Regular maintenance and periodic testing may be conducted to ensure the accuracy and reliability of the meter readings.

Isolation Valves

Isolation valves allow for a shut down of service to an entire system or portions of the system as needed. Common isolation valves include gate, ball, globe, and diaphragm valves.

Cross Connection Control Devices

Cross-connection devices, also known as backflow prevention devices and assemblies, are used to prevent the backflow of contaminated or non-potable water into the public drinking water supply. They are essential in maintaining the safety and integrity of the water distribution system.

Some familiar examples are:

- Air Gaps
- Atmospheric Vacuum Breaker (AVB)
- Pressure Vacuum Breaker (PVB)
- Reduced Pressure Backflow Assembly (RP)
- Double Check Valve Assembly (DCVA):

An air gap is the simplest and most effective form of backflow prevention. It is a physical separation between the potable water outlet and any potential sources of contamination. It creates a vertical space or visible break between the water outlet and the receiving vessel, ensuring that contamination cannot occur.

An atmospheric vacuum breaker is a valve that allows air to enter the plumbing system when there is a drop in pressure, preventing a siphoning effect. It is typically installed on plumbing fixtures such as faucets, hose bibs, or irrigation systems.

A pressure vacuum breaker creates a barrier against backflow by using a spring-loaded check valve and an air inlet valve An AVB can be used in irrigation systems.

An RP assembly is a more sophisticated backflow prevention device used for high-risk applications. It consists of two check valves with a pressure relief valve between them.

A double check valve assembly is a backflow prevention device that uses two check valves to prevent backflow. It is commonly used in residential and low-hazard commercial applications.

Check Valves

Check valves can be used to maintain pressures within the system when a backflow event has occurred or supply pressures fluctuate They are typically installed in-line with the piping system and are a directional fitting therefore their orientation is essential to ensure proper function. They can be installed vertically or horizontally but must be installed following the manufactures’ instructions.

Pumps

There are various types of pumps used in water service piping to facilitate the movement, supply, and distribution of water. Their selection will be determined by the needs of the system. Some examples are:

- Centrifugal Pumps
- Submersible Pumps
- Booster Pumps
- Reciprocating Pumps
- Jet Pumps

Centrifugal pumps are widely used in water service piping systems. They work by converting rotational energy from an electric motor into kinetic energy in the fluid, which creates the necessary pressure to move water through the piping system. Centrifugal pumps are known for their simplicity, efficiency, and ability to handle a wide range of flow rates and pressures.

Submersible pumps are designed to be immersed in water, typically installed in wells or underground water sources. They are used for water supply in residential, commercial, or agricultural applications. Submersible pumps are highly efficient and self-priming, capable of pushing water vertically to the surface.

Booster pumps are used to increase the pressure of water in a piping system. They are commonly installed in buildings or areas where the available water pressure is insufficient to meet the demands of the occupants or processes. Booster pumps are typically centrifugal pumps that are installed in-line with the existing water service piping to provide the necessary pressure boost.

Reciprocating pumps, also known as positive displacement pumps, use a piston or diaphragm to create pressure and move water through the piping system. They are used in applications where a consistent flow rate is required, such as irrigation systems, firefighting systems, or in water treatment plants.

Jet pumps are used in water service piping systems where a suction lift is required, such as extracting water from a well or underground source Jet pumps use a combination of centrifugal force and suction to draw water into the pump and propel it through the piping system.

Post Indicator Valves

A post indicator valve (Figure 2) is used as the valve operator for automatic fire sprinkler and standpipe systems where the system main valve is located underground.

Figure 2. Post indicator valve

Fire Hydrants

Fire hydrants provide firefighters with quick access to the water supply to help suppress fires. They are placed throughout communities to allow for widespread coverage and are a vital component of fire protection infrastructure.

Inspection

Thorough inspection of the water service piping is an important and ongoing task. It is part of the installation, testing, commissioning, and maintenance of the system. All inspections should be documented and made available to service personnel for future work.

Documentation

Documenting the testing process provides a clear record of the activities performed, verifies compliance with regulations, and serves as a reference for future maintenance or troubleshooting. It is important to follow any specific documentation requirements or guidelines provided by local authorities, regulatory bodies, or industry standards when testing a water service pipe.

Now complete Self-Test 1 and check your answers.

Self-Test 1

Self-Test 1

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Learning Task 2

Describe the commissioning of water service and distribution systems

Commissioning a water service pipe and distribution system is the process of putting newly installed or repaired water pipes into service, making certain that it operates as intended, and the water is safe for consumption. After pipes have passed the static testing, commissioning proves they function properly under dynamic conditions along with the components connected to the distribution piping.

Pre-Check

Before commissioning a water service pipe, inspect the site for the necessary utilities and infrastructure such as water supply connections and shut offs, backflow prevention devices, and drainage systems. Inspect all piping materials, including pipes, valves, fittings, and connectors, confirm they meet the specified standards and are free from defects or damage. Check for proper labeling and certification markings on the materials and verify the piping passed the required pressure tests.

Hazards

When commissioning a water service pipe, there are several hazards that need to be addressed to work safely. Potential hazards include:

- Pressure hazards
- Chemical hazards

If the pipes have passed a static pressure test, a failure is unlikely, but that risk remains since the system will now be running and pressures will be fluctuating. When there is a risk of the pipe bursting, it can lead to property damage, personal injury, or flooding. If a pipe bursts or fails under pressure, there is a possibility of flying debris, such as fragments of the pipe or fittings, which can cause injuries.

Depending on the nature of the water being tested, there may also be chemical hazards present. For example, if the water contains high levels of chlorine, a pipe failure could result in a chemical spill endangering the health of individuals and the environment.

Safe Work Practices

To minimize hazards when commissioning, follow proper safety procedures by wearing appropriate PPE, such as safety goggles, gloves, and protective clothing, to protect against potential flying debris or chemical exposure. Follow manufacturer guidelines and recommended pressure limits for the pipes being tested. Conduct the testing in a controlled environment and be aware of any nearby objects or people that may be affected by a potential pipe failure. Have emergency procedures in place, such as an emergency shutdown plan, access to first aid kits, and knowledge of the location of emergency exits and safety showers/eyewash stations. Even try to keep a safe distance from the pipe being commissioned.

Chemical Treatment

Commissioning water service pipes includes confirming that the water is safe for drinking. Chemical treatment can be used to disinfect the water and maintain its quality. Some common methods of chemical treatment for potable water are:

- Chlorination
- Ozonation
- pH Adjustment

Chlorine is commonly used to disinfect water and kill harmful microorganisms, such as bacteria and viruses. It can be added to the water in the form of chlorine gas, liquid chlorine (sodium hypochlorite), or solid chlorine compounds (calcium hypochlorite). The dosage of chlorine is calculated to achieve effective disinfection without exceeding safe limits.

Ozone is a powerful oxidizing agent and disinfectant. It is effective in destroying bacteria, viruses, and organic contaminants. Ozone is typically produced using specialized ozone generators and injected into the water.

pH adjustment is necessary to optimize the effectiveness of disinfection and to control corrosion. The addition of acids or bases can be done to achieve the desired pH range for water disinfection and stability.

It is important to follow proper dosing guidelines and adhere to local regulations and standards when using chemicals for water treatment. Regular testing will be required to confirm that the chemical treatment is effective and the water remains safe for consumption.

Purging

Purging a water service piping involves removing unwanted substances from the pipe system to ensure proper water flow, prevent air pockets and remove contamination.

Air

Purging a pipe with air is an effective way to remove water or other fluids from a pipe or to clear out any obstructions. Air is compressed and introduced into the pipe with pressure and forces out liquids, debris, and sediment.

Chemical

Chemicals are often used to disinfect water to make it potable. New water service piping and pipes that have been drained for repair or replacement, must be purged with chlorine to replenish the required safe water drinking levels. Any addition of chemicals will require that it be measured and added in a safe manner and according to that jurisdiction's code. Care should be taken to wear the proper PPE and testing the chemical levels will need to be arranged and performed before the piping is put back into service.

Test Water

If chemicals have been used to disinfect water intended for drinking, the water must be tested for the present levels and must not exceed the amounts laid out in codes like the Safe Drinking Water Act or the AHJ. As an example, to test the chlorine content in water, you can use a chlorine test kit or a chlorine test strip (Figure 3). These kits are available at pool supply stores, hardware stores, or online. Use a clean container to collect a sample of the water being tested. Make sure the container is free of any residues or contaminants that could affect the test results. Some test kits require mixing reagents to create a test solution, while others may have pre-filled reagent capsules or test strips. Prepare the solution as instructed. Dip the test strip into the water sample or add the test solution to the water sample, depending on the specific instructions. Make sure the strip is fully immersed or that the solution is thoroughly mixed with the sample. The test kit instructions will specify the required waiting time for accurate results. Avoid disturbing the strip or the solution during this waiting period. After the designated waiting time, compare the color of the test strip or the solution against a color chart provided with the test kit. The color change will indicate the chlorine content in the water sample. Note the chlorine concentration indicated by the test kit and record the results for future reference and to submit to the local authority.

Figure 3. Chlorine test strips

Flushing

Flushing water piping helps remove debris, sediments, and stagnant water. Flushing a dead end is a large part of the regular maintenance procedures carried out in communities, but can be first performed during commissioning. If dead ends are not flushed, the stagnant water will lose its chlorination and potentially become unsafe for consumption.

Commissioning Equipment

Commissioning water service piping involves several pieces of equipment. The equipment used can vary depending on the size and complexity of the project and include:

- Pressure Gauges
- Flow Meters
- Pressure Testing Equipment
- Water Quality Testing Equipment

Pressure gauges are used to measure and monitor the pressure levels within the water service piping system. They help ensure that the pressure is within the required range and assist in detecting any anomalies or pressure drops that may indicate leaks or other issues.

Flow meters are employed to measure the rate of water flow through the piping system. They provide valuable, visual information about the water flow characteristics and assist in assessing the performance of the system.

Pressure testing equipment such as hydrostatic test pumps, pressure regulators, and pressure relief valves. These tools help apply and control the required pressure during testing and ensure that the piping system can withstand the expected operating conditions.

Water quality testing equipment is used to analyze and assess the chemical and physical properties of the water. This includes pH meters, turbidity meters, conductivity meters, and test kits for testing parameters like chlorine levels, hardness, or other specific contaminants.

Start-up

Permits

Permits may be required for commissioning water service piping. Permits are a commitment to adhere to certain authorities and their specific rules. These include compliance with building codes, calling for any mandatory inspections, hiring competent professionals, properly documenting jobs, and maintaining public safety.

Permits can be obtained through the building inspection office in the area. A fee and processing time will be needed before commissioning will be approved and can begin.

AHJ

Water service pipes must comply with specific regulatory standards to ensure water quality, health, and safety for consumers. Similar to obtaining permits, before working on water service lines, you will be required to contact the local authorities for permission and instruction. Rules will vary from one jurisdiction to another.

Electrical Supply Connections

Many of the components connected to the water supply and, therefore, the water service piping, require electricity to draw water, distribute water, and track the water being used. As part of the commissioning process, it is important to check those components.

Hot water tanks

Electric water heaters require a 240-volt dedicated circuit, which serves only the water heater and no other appliances or devices. On demand systems require a dedicated 120-volt circuit.

Water treatment equipment

Water treatment equipment, such as an UV lamp, require electricity to work and its electrical outlets should be tested as part of the commissioning process.

Pumps

Like the other equipment discussed above, pumps will usually have an electrical component that should be checked when commissioning. Pumps typically run using a 120-volt circuit.

Heat tracing

By providing controlled heat, heat tracing prevents freezing or maintains the required temperature in pipes, vessels, or equipment. It is commonly used in industries such as oil and gas, chemical processing, power generation, and water and wastewater treatment, where temperature control is critical for operational efficiency and safety. Heat tracing will also be found on pipes run in the crawl spaces of residences and must be energized before temperatures drop below freezing.

Water meters

Water meters are typically the responsibility of the local utility company. They can be visually checked to confirm functionality. As water passes through the meter, it will record the volume which will be accessible by a remotely read transmitter.

Figure 4. Water meter

Codes and Regulations

AHJ

Maintain comprehensive documentation throughout the commissioning process. This includes recording test results, inspection reports, material certifications, and any deviations or modifications made during installation. Proper documentation is essential for compliance, future reference, and troubleshooting.

Manufacturer's Documentation

Valves test

Important valves such as cross connection assembly check valves or pressure reducing valves should be tested for proper operation when commissioning a water service and distribution system.

Cross connection control assemblies

Cross connection control assemblies are required to be tested annually or when repairs or replacements are completed on the piping those assemblies protect. Only qualified personnel are authorized to test the assemblies. When commissioning a water system, make sure that all assemblies are up to date or re-tested as needed.

Pressure reducing valve (PRV) set points

A PRV works to maintain a set downstream pressure. Confirm it is installed in the appropriate location within the water supply system, downstream of the main water supply line and before any branching lines or fixtures that require reduced pressure. PRVs have an adjustable pressure setting. Using a wrench or pliers, adjust the pressure setting on the valve to the desired level. With the pressure reducing valve installed and adjusted, test the valve's operation by slowly opening and closing the downstream water outlet or faucets. Observe how the valve responds to changes in flow and pressure. The valve should open and close smoothly, maintaining the desired pressure within the set range. Attach a pressure gauge to a downstream faucet or outlet to monitor the pressure. Gradually open the faucet and observe the pressure gauge. Ensure that the pressure remains within the desired range as set by the PRV. Make any necessary adjustments to the valve if the pressure deviates from the desired range. Inspect the pressure reducing valve and all connections for any signs of leaks. Ensure that all fittings are tight and secure. Address any leaks promptly by tightening connections or replacing faulty components. Keep a record of the commissioning process, including the pressure setting, any adjustments made, pressure readings, and any observations or notes regarding the valve's performance. This documentation can be helpful for future reference, maintenance, and troubleshooting.

Now complete Self-Test 2 and check your answers.

Self-Test 2

Self-Test 2

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Learning Task 3

Describe the maintenance of water service and distribution systems

The maintenance of water service piping involves regular inspections, preventive measures, and necessary repairs to ensure the proper functioning and longevity of the piping system.

Maintenance Schedules

A maintenance schedule is a planned and organized approach to performing regular maintenance tasks and inspections on equipment, systems, or facilities. It outlines the frequency and scope of maintenance activities to verify that piping and equipment are properly maintained, optimized for performance, and prevent any future issues or breakdowns. Maintenance schedules can vary depending on the type of piping or equipment being maintained, but here are some elements typically included:

- Task List
- Frequency
- Responsible Parties
- Documentation
- Prioritization
- Resources
- Review and Updates

Regularly review and update the maintenance schedule to reflect any changes in equipment, usage patterns, or feedback from maintenance personnel. Continuous improvement ensures the effectiveness and relevance of the maintenance program.

Maintenance required for a water service piping system will vary, however, there are certain items that will be common to most. For example, regular flushing and cleaning of the water service piping to remove sediments, debris, or mineral deposits that may accumulate over time. Flushing the system helps maintain water quality, prevent blockages, and optimal flow rates. Dead ends in piping runs will be included in a maintenance schedule.

Implementing corrosion prevention measures to protect the water service piping from corrosion and deterioration. This can include applying protective coatings or linings to the pipes, installing sacrificial anodes or corrosion inhibitors, or implementing cathodic protection systems. This will require regularly inspecting and maintaining any corrosion protection measures in place.

Maintenance may also include conducting pressure tests to assess the integrity of the water service piping; pressurizing the system to a predetermined level and monitoring for any pressure drop that may indicate leaks or other issues. This test helps identify weak points in the piping system and makes sure it can continue withstand normal operating pressures.

Conducting regular visual inspections of the water service piping to identify any visible signs of damage, corrosion, leaks, or deterioration. Look for wet spots, discolouration, loose fittings, or any other abnormalities. Inspect both the exposed sections of the piping and areas that are concealed within walls, ceilings, or underground.

Inspecting and maintaining valves, fittings, and other components associated with the water service piping. Confirm that valves are functioning properly, exercise them regularly to prevent sticking, and repair or replace any faulty or damaged valves or fittings. Lubricate moving parts as needed.

AHJ

It is important to follow any local regulations, guidelines, and manufacturer recommendations regarding the maintenance of water service piping. Adhering to a proactive maintenance routine helps extend the lifespan of the piping system, prevents water loss, ensures water quality, and minimizes the risk of costly repairs or failures.

Tools and Equipment

Locating underground water service pipes can be a challenging task but there are several methods and tools available to help in the process such as the following:

- Utility drawings
- Electromagnetic pipe locators
- Ground penetrating radar (GPR)
- Pipe tracing equipment
- Water flow and leak detection
- Visual inspection and probing

Contact your local water utility or municipal department responsible for water supply. They often maintain records and drawings indicating the locations of water service pipes. These drawings may provide guidance on the approximate route and depth of the pipes.

Electromagnetic pipe locators (Figure 5) are specialized devices that can detect the presence of metallic pipes underground. They work by emitting an electromagnetic signal that is received by the locator when it passes over the pipe. This method is effective for finding metallic water pipes.

Figure 5. Electromagnetic pipe locator

GPR (Figure 6) is a non-destructive geophysical method that uses radar pulses to create images of subsurface structures. GPR can help locate buried pipes, including water service pipes, by detecting differences in material density and composition. It is particularly useful for identifying non-metallic pipes like plastic or PVC.

Figure 6. Ground penetrating radar

Pipe tracing equipment utilizes conductive cables or rods that can be inserted into pipes. A transmitter is then used to send an electrical signal through the cables, allowing the user to track and trace the route of the pipes using a receiver. This method works well for metallic and some non-metallic pipes.

If there is suspicion of a leak in the water service pipe, use water flow and leak detection equipment to trace the path of the underground pipe. By monitoring water flow or using acoustic methods to listen for leaks, it can often identify the general area where the pipe is located.

In some cases, there may be the opportunity to visually identify signs of the underground water service pipes. Look for valve boxes (Figure 7), manhole covers, or other access points that indicate the presence of underground infrastructure. Additionally, probing the ground with a long rod or metal detector may help locate pipes if they are close to the surface.

Figure 7. Curb stop valve cover

Isolation

Proper and safe isolation is a non-negotiable when performing maintenance on a system. Never open valves or cut into pipes before it is confirmed that there is no risk for a blowout which can cause injury and costly water damage.

Before performing any shut down, inform the local water utility or service provider about your intention to take the water service line out of service. They may have specific requirements or procedures to follow. Find the main water valve that controls the flow of water to the service line. Use a wrench or valve key to turn the main water valve clockwise until it is fully closed and drain any remaining water. This step will also help relieve pressure in the system. If the water service line serves multiple properties or units, inform the occupants about the temporary interruption in water supply. Provide them with an estimated timeline for when the service will be restored. Always keep a record of the work done, including photographs if necessary.

Testing

Perform leak detection procedures to identify and address any leaks in the water service piping. This can involve monitoring water meters for unexplained increases in water consumption, using leak detection equipment, or conducting visual inspections of joints, connections, and fittings.

Implement and maintain appropriate cross-connection control measures to prevent contamination of the water service piping. Regularly inspect and test backflow prevention devices or other cross-connection control devices to verify they are functioning correctly.

Return to Service

If any portion of a water service distribution system has been shut down, drained, received repair or replacement, it must be returned to service to restore water supply. All work shall be accurately documented after piping is tested. Once the pipe reconnected, it is important to perform a pressure test and check for leaks. If the water service pipe is located underground, backfill the trench to code specifications. Install any necessary protective measures, such as insulation or sleeves, to safeguard the pipe from external factors. Notify all necessary parties that the water is back on, and accurately document the work performed.

Documentation

Documentation of the commissioning process is important. Documentation relies on the information being thorough, accurate, and accessible to maintenance staff. Using a template makes the information easy to understand by everyone. Information should be concise and clearly written. Keep all supporting documentation with notes along with the maintenance schedule. (Figure 8)

SAMPLE PREVENTIVE MAINTENANCE SCHEDULE										
Asset	Preventive Maintenance	Frequency								
		Daily	Weekly	Every 2 Weeks	Monthly	Quarterly	Every 6 Months	Annually	Every x Years	As Needed
Structures	Exterior Walls				x					
	Brick and Masonry				x					
	Arches	x								
	Canopies	x								
	Awnings	x								
	Eaves	x								
	Garage or Parking Lots						x			
Roofing	Tiles and Shingles						x			x
	Gutter						x			x
	Drains						x			x
	Wall Connections						x			x
	Solar Panels						x			x
	Leak Survey						x			x
Openings	Doors							x		
	Windows							x		
	Gates							x		
Lighting	Bulbs		x							
	Connections		x							
	Switches		x							
	Screws and Gaskets		x							
Electrical	Power Supply	x								
	Wires								x	
	Full Professional Inspection								x	
Plumbing	Irrigation System							x		
	Water Heater							x		
	Boiler							x		
	Refrigerant							x		
	Sewage Pumps							x		
	Restroom Fixtures							x		x
	Leak Survey							x		
HVAC	Cleaning						x			
	Pumps							x		
	Air Filter Replacement				x		x			
	Condenser Coil						x			
	Energy Efficiency Check						x			
	Calibrate Sensors						x			
	Chillers and Boilers							x		
Fire Safety Equipment	Fire Extinguishers							x		
	Inspect Door and Crawl Spaces*			x	x					
	Sprinkler System							x		
	Fire Alarms				x					
	Emergency Exit Signs						x			
Special Machinery**	Machine 1									
	Machine 2									
	Machine 3									

Figure 8. Sample building maintenance schedule [Image Description]

Now complete Self-Test 3 and check your answers.

Self-Test 3

Self-Test 3

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Image Descriptions

Figure 8. "Sample Preventive Maintenance Schedule" image description: An "x" indicates that the given preventive maintenance happens at the given frequency. *[Skip Table]*

Figure 4. Sample Preventive Maintenance Schedule

Preventive Maintenance	Daily	Weekly	Every 2 weeks	Monthly	Quarterly	Every 6 months	Annually	Every X Years	As Needed
Structures: Exterior Walls				x					
Structures: Brick and Masonry				x					
Structures: Arches	x								
Structures: Canopies	x								
Structures: Awnings	x								
Structures: Eaves	x								
Structures: Garage or Parking Lots						x			
Roofing: Tiles and Shingles						x			x
Roofing: Gutter						x			x
Roofing: Drains						x			x
Roofing: Wall Connections						x			x
Roofing: Solar Panels						x			x
Roofing: Leak Survey						x			x
Openings: Doors							x		
Openings: Windows							x		
Openings: Gates							x		

Lighting: Bulbs		x							
Lighting: Connections		x							
Lighting: Switches		x							
Lighting: Screws and Gaskets		x							
Electrical: Power Supply	x								
Electrical: Wires								x	
Electrical: Full Professional Inspection								x	
Plumbing: Irrigation System							x		
Plumbing: Water Heater							x		
Plumbing: Boiler							x		
Plumbing: Refrigerant							x		
Plumbing: Sewage Pumps							x		
Plumbing: Restroom Fixtures							x		x
Plumbing: Leak Survey							x		
HVAC: Cleaning						x			
HVAC: Pumps							x		
HVAC: Air Filter Replacement				x		x			

HVAC: Condenser Coil						x			
HVAC: Energy Efficiency Check						x			
HVAC: Calibrate Sensors						x			
HVAC: Chillers and Boilers							x		
Fire Safety Equipment: Fire Extinguishers							x		
Fire Safety Equipment: Inspect Door and Crawl Spaces*			x	x					
Fire Safety Equipment: Sprinkler Systems							x		
Fire Safety Equipment: Fire Alarms				x					
Fire Safety Equipment: Emergency Exit Signs						x			
Special Machinery: Machine 1**									
Special Machinery: Machine 2**									
Special Machinery: Machine 3**									

[Return to Figure 4]

Learning Task 4

Describe the troubleshooting and repair of water service and distribution systems

Troubleshoot

When troubleshooting a water service pipe, it involves identifying and addressing issues or problems related to the pipe's functionality, performance, or integrity.

Verify Reported Problem

Determine the specific problem or symptoms associated with the water service pipe. This could include low water pressure, leaks (Figure 9), unusual noises, discoloration, or other irregularities.

Use a pressure gauge to measure the water pressure at different faucets or fixtures within the property. Compare the readings with the recommended pressure range for your area. Low or inconsistent pressure could indicate a problem within the water service pipe.

Conduct a thorough leak detection process. This can involve checking for visible leaks, listening for the sound of running water when no fixtures are in use, or using specialized leak detection equipment, such as electronic leak detectors or thermal imaging cameras, to identify hidden leaks.

Ensure that the water supply to the property is turned on and functioning correctly. Verify if other faucets or fixtures in the building are experiencing similar issues, as this can help determine if the problem is isolated to a specific area or if it affects the entire system.

Figure 9. Water main break

Inspection

Visually inspect the visible portions of the water service pipe, both indoors and outdoors, for any signs of damage, leaks, or loose connections. Look for wet spots, corrosion, or rust on the pipes, fittings, or valves. Examine the valves, fittings, and connections associated with the water service pipe. Ensure they are properly installed, not damaged, and free from obstructions or blockages that could restrict water flow.

If you observe issues with water discoloration, odor, or taste, test the water quality to determine if it meets the desired standards. Water quality problems can be caused by issues within the service pipe, such as corrosion or contamination.

Isolation

Isolating a leaking pipe is crucial to prevent further water damage and address the issue effectively.

It is important to locate and shut off the water supply to the affected area as quickly as possible. Depending on the situation, there may be different options to consider like an individual pipe shut-off valve or the main water shut-off valve. When trouble-shooting water service piping the municipality may be required to shut down a portion of the main water supply.

Carefully examine the leaking pipe to determine the cause and severity of the leak. Identify the source of the leak, such as a crack, loose fitting, or damaged joint. Assessing the damage will help decide on the appropriate repair method.

Repair

Depending on the severity of the leak and the available resources, a temporary repair may be needed until a permanent solution can be implemented. This can involve using pipe clamps (Figure 10) or rubber patches to temporarily seal a leak.

Figure 10. Temporary pipe repair clamp

When a permanent repair can be performed there are several factors to be considered such as:

- Access to the pipe
- Type of materials
- Permits and AHJ
- Personnel requirements

If the pipe is more than 4’ below the surface, excavation and shoring will need to be arranged.

Make sure to have plenty of fittings, pipe, and tools on hand before isolating the piping to limit the amount of time the supply is out of service and limit the time it takes going back and forth from a wholesaler.

Always inform the proper authorities of the work to be done before beginning. Road closures or even flaggers could be needed if the repair will affect traffic patterns.

Go over repair plans with the crew or crews before isolating the piping and ensure safety and emergency procedures are understood.

Safe Work Practices

Remember to prioritize safety during troubleshooting and repairs. If you encounter any hazardous situations or suspect significant damage to the water service pipe, it is important to take appropriate precautions to keep yourself and others safe.

Confined space

A confined space refers to an enclosed or partially enclosed area with limited means of entry and exit and is not intended for continuous human occupancy. Confined spaces are typically characterized by limited access points, restricted airflow, and the potential for hazardous conditions to develop. These spaces can pose risks to the health and safety of individuals who enter or work within them.

Examples of confined spaces are:

- Tanks (e.g., storage tanks, fuel tanks)
- Silos
- Vessels (e.g., boilers, pressure vessels)
- Pipelines
- Sewers
- Tunnels
- Underground vaults
- Ductwork or utility access points

It is important to note that not all enclosed spaces are considered confined spaces. For a space to be officially classified as a confined space, it must meet specific criteria defined by applicable regulations and standards, such as the presence of hazardous atmospheres, limited entry or exit, or other recognized hazards.

Working in confined spaces requires careful planning, hazard assessment, and appropriate safety precautions. Employers and workers must be trained on the potential risks associated with confined spaces and follow established procedures for entry, ventilation, communication, personal protective equipment (PPE), and emergency response. Regulatory bodies often have specific guidelines and regulations in place to ensure the safety of individuals working in confined spaces.

Shoring

It is crucial to consult with a qualified engineer or shoring specialist to determine the most appropriate shoring method based on the specific soil conditions, trench dimensions, and regulatory requirements. Following proper shoring practices and ensuring regular inspections of the shoring system during excavation work are essential for the safety of workers and the prevention of trench collapses. If an excavation is required to access piping, shoring will be required if that excavation will create a trench more than 4’ deep.

Tools and Equipment

During the commissioning of the water service pipe and distribution piping, there may be a need for certain tools and equipment. Ones to have available are:

- Pipe Cutter
- Pipe Wrench
- Adjustable Wrench

- Teflon Tape
- Pipe Thread Sealant
- Pressure Gauge
- Pressure Test Pump
- Safety Gear

Also keeping an inventory on hand of common pipe fittings such as couplings, elbows, tees, and valves is always a good practice.Bottom of Form

Repair or Replace Components

As discussed above, once the problem has been identified and the decision has been made to repair or replace the affected piping, collecting a list of required tools, materials, and personnel will be necessary. The problem piping will be isolated, and the piping will be removed and replaced. After a successful repair, testing will be done and documentation will be completed.

Testing

Once the repair is complete, close any open components. Then slowly turn the main water shut-off on to gradually restore water flow. As the water flows back into the pipes, it is common for air to become trapped in the system. Open the highest and furthest components connected to the isolated section of the pipes and let the water run until a steady flow of water is achieved. This process helps release any trapped air and ensures proper water circulation. Check for any leaks or irregularities in the repaired section and make sure the repair has been successful.

Return to Service

Before a repair or replacement can be considered complete, test the water pressure at various points connected to the isolated section of the pipes. Confirm that the pressure is within the normal range. If there are significant pressure fluctuations or other issues, it may indicate a problem within the system that requires further investigation or adjustment. Depending on the duration of the isolation period and the condition of the water in the pipes, it may be necessary to flush and purge the system. Run water through the pipes for an extended period to remove any stagnant water or sediments that may have accumulated. If this is a repair to a main, it may require a boil water notice to the affected houses. This will need to be coordinated with the proper local authorities.

Documentation

Documenting the testing process provides a clear record of the activities performed, verifies compliance with regulations, and serves as a reference for future maintenance or troubleshooting. It is important to follow any specific documentation requirements or guidelines provided by local authorities, regulatory bodies, or industry standards when testing a water service pipe.

Now complete Self-Test 4 and check your answers.

Self-Test 4

Self-Test 4

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Media Attributions

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- Figure 10. "Temporary pipe repair clamp"from Rollee is used for educational purposes under the basis of fair dealing.

Competency F3: Install Plumbing Fixtures and Appliances

Learning Task 1

Describe the commissioning of fixtures and appliances

By commissioning a fixture or appliance, you verify that it is fully functional, meets quality standards, and is ready for operation. This process helps identify and address any issues or deficiencies before the equipment is put into service which will minimize the risk of failures, malfunctions, or safety hazards.

Tools and Equipment

Whether commissioning a tap, a home, or an entire commercial building, certain tools and equipment will be needed. Here are some of the basics:

- Screwdrivers
- Adjustable wrenches
- Pliers
- Pipe wrench
- Electrical tester/multimeter
- Level
- Tape measure
- Pipe cutter
- Putty knife
- Wire strippers
- Compressor
- Safety equipment

Multiple screwdrivers may be needed to open panels, secure brackets, or connect wiring. Adjustable wrenches are useful for tightening or loosening nuts, bolts, or hose connections. Pliers will be needed for gripping and manipulating small parts or wires. Electrical testers are used for checking voltage, continuity, and electrical connections to ensure safe installation. A pipe cutter is handy for plumbing connections involving threaded pipes or fittings. A knife will be useful for scraping off old sealants, adhesives, or caulk before installing or replacing components. Wire strippers (Figure 1) will be necessary if you need to work with electrical wires and strip the insulation for proper connections.

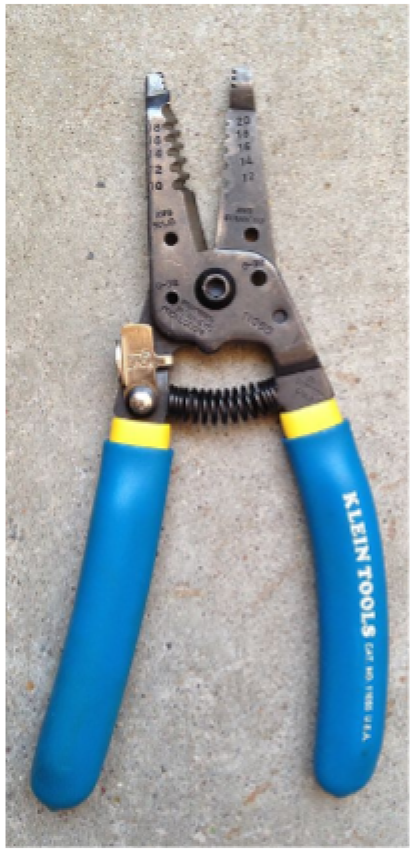

Figure 1. Wire strippers

A compressor will be needed where pressure testing is required. It's always important to consider safety, so have gloves, safety glasses, and potentially a dust mask or respirator, depending on the appliance and the work involved.

System Check/Test

A big part of the commissioning process is doing a comprehensive system check and test. Ideally, when you are doing a test on an appliance, you allow the appliance to run through its entire cycle.

For example, a thorough system check for a dishwasher may follow this sequence:

- Read the dishwasher manual
- Load the dishwasher
- Check the dishwasher settings
- Add dishwasher detergent
- Close the dishwasher door securely
- Start the test cycle
- Observe the dishwasher operation

- Listen for water filling the dishwasher
- Check if the dishwasher drains properly
- Look for any leaks
- Test the heating and drying function (if applicable)
- Check for error codes (if applicable)
- Evaluate the cleanliness of the dishes

If you notice any issues during the test, refer to the dishwasher manual for troubleshooting advice. If any leaks occur, check the connection between the water supply line and the dishwasher and the dishwasher's drain and its connection to the sanitary system. Make sure the connections are tight and proper sealants are used. Many threaded connections will use Teflon, but if the connection has a rubber washer, Teflon is not required.

An example of commissioning a boiler may go something like this:

- Visually inspect the boiler and its surroundings, leaks, or corrosion. Check the vents and flues to ensure they are clear and not blocked.
- For boilers with a sight glass, check the water level to ensure it is within the recommended range. If the boiler uses a low-water cutoff device, verify that it is functioning correctly. You will need to isolate the make up water and the supply and return lines. Call for heat, and slowly drain the boiler. The low water cut off should stop the burner when the water drops below the allowable level.
- Use a pressure gauge to check the boiler's pressure. The pressure should be within the recommended operating range, as specified in the manufacturer's guidelines. Those can be found on the manufacture's website if you don't have the documentation.
- If the boiler is a gas or oil-fired boiler, inspect the combustion chamber for any signs of soot, carbon buildup, or debris.
- Conduct a flue gas analysis to measure the boiler's combustion efficiency and ensure it is not producing dangerous levels of carbon monoxide (CO). The expected levels is found in the manufacture's specifications.
- Test the boiler's safety devices, including the pressure relief valve, temperature and pressure relief (TPR) valve, and any other safety controls. Flow switches can be tested by isolating the supply or return to stop the flow.
- Observe the boiler during startup and operation to ensure it follows the correct firing sequence. This includes proper ignition, flame detection, and burner operation.
- If the boiler is atmospherically vented, verify that the boiler room has adequate ventilation to allow for the safe discharge of combustion gases.
- Monitor the water temperature in the boiler to ensure it matches the desired set point and meets the requirements for the application.
- Check the entire heating system, including pipes, radiators, and valves, for any leaks. Leaks can lead to reduced efficiency and potential damage to the boiler and surrounding

components.

Manufacturers' Specifications

Manufacturers' specifications are a guide for the installation of products (Figure 2) that meet predefined quality standards, safety regulations, and customer expectations. They provide a set of standards and requirements that a product must meet to guarantee quality and performance. They outline the desired characteristics, features, and functionalities of the product, serving as a benchmark for manufacturers to follow during the installation process.

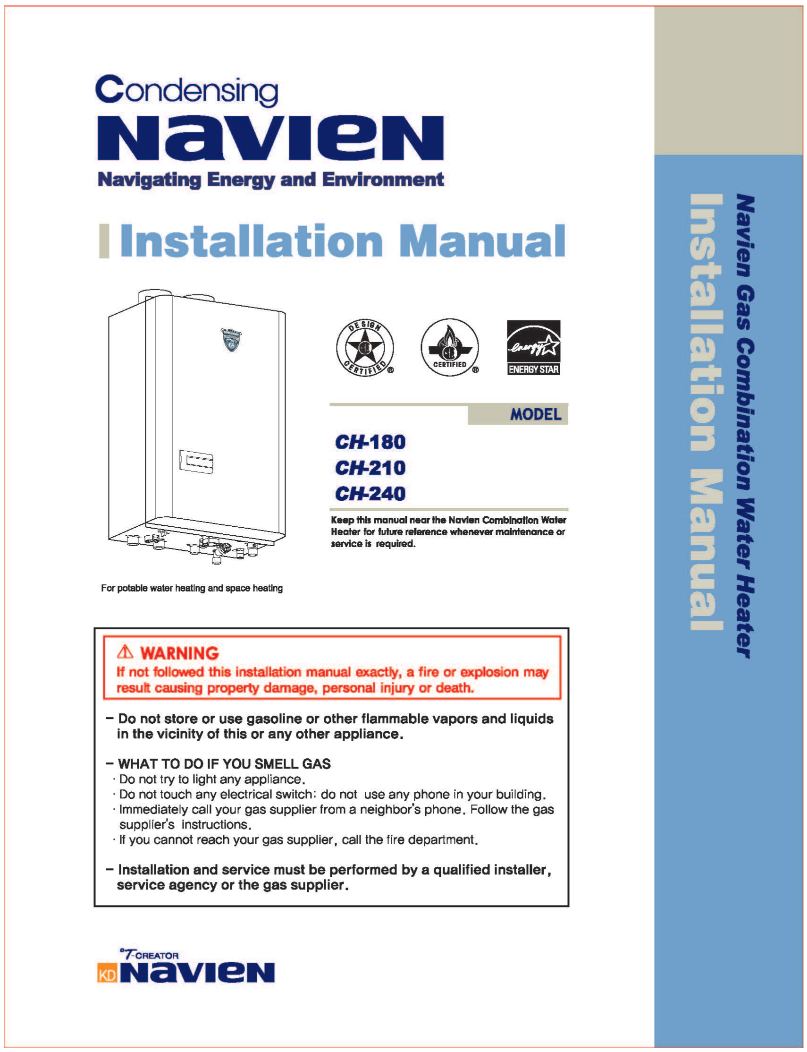

Figure 2. Navien Installation Manual

Specifications often include safety guidelines and regulatory requirements that products must meet. Compliance with these specifications helps protect consumers from potential hazards or risks associated with the product. In many industries, products need to work together seamlessly or be compatible with other components or systems. Specifications provide guidelines on the dimensions, interfaces, and technical requirements necessary for interchangeability. Specs also define the expected performance and functionality of a product. They outline parameters such as speed, capacity, power consumption, accuracy, durability, and other relevant characteristics.

Specs can play a crucial role in warranty agreements. They define the acceptable limits, operating conditions, and usage guidelines for the product. Manufacturers may refer to these specifications to determine if a product qualifies for warranty coverage and to assess any potential misuse or abuse that may void the warranty, therefor it is important to follow their instructions when installing a fixture or appliance and in the subsequent inspection. Specifications also provide a basis for troubleshooting and support, allowing service personnel to identify and address issues effectively.

Inspection

Inspectors work for local government agencies, building departments, or other regulatory bodies. They play a crucial role in maintaining the integrity and safety of plumbing systems in communities and contribute to the overall quality of construction projects. When plumbing work is completed, it is important to have that work inspected. Arrange an inspection with the local agency with advanced notice and don't forget that part of an inspectors' job is to help you along the way. If there are questions or concerns about how to install an appliance or fixture to code, an inspector can help. Custom fixtures or appliances

Adjustments

During the commissioning process, it is likely that some deficiencies will be discovered. Document those findings and make arrangements to have them fixed. Easy fixes can be done immediately, however, equipment malfunctions will need to logged and reported back to the manufactures so that they can provide further instruction. Remember that warranties need to be considered when making adjustments. Do not perform any fixes that would compromise the integrity of the warranty. After adjustments have been made, the fixture or appliance will be recommissioned before return it to service.

Documentation

Documenting the testing process provides a clear record of the activities performed, verifies compliance with regulations, and serves as a reference for future maintenance or troubleshooting. It is important to follow any specific documentation requirements or guidelines provided by local authorities, regulatory bodies, or industry standards when commissioning fixtures and appliances.

Inform End-User of Operation

When you have completed the commissioning and testing of an appliance you should inform the customer. Show them the appliance or fixture and demonstrate that it is ready for use. Provide any necessary instructions for future care. If you are billing the customer, provide a detailed invoice that includes a breakdown of the charges, including parts and labour. Clearly explain the invoice if necessary. Accept payment and issue a receipt or pass along the relevant billing information to your company. Clean up any mess created during the service and always leave the customer's premises in the same condition as you found it, or better.

Now complete Self-Test 1 and check your answers.

Self-Test 1

Self-Test 1

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- Figure 2. "Navien Installation Manual" from Navien is used for educational purposes under the basis of fair dealing.

Learning Task 2

Describe the servicing of fixtures, trim, and appliances

Servicing a plumbing fixture typically involves inspecting, repairing, cleaning, or replacing components to the fixture's proper functioning. It is important to get as much information from the client and then perform a thorough analysis.

Interpret Client Information

Each customer's complaint is unique, and it's important to approach them with an open mind, patience, and a desire to resolve the issue. Effective interpretation of customer complaints can lead to better problem-solving, improved customer relationships, and opportunities for business growth. Not to mention less call backs.

Interpreting a customer's complaint involves understanding the underlying issue or concern they are expressing. Give your full attention to the customer and actively listen to their complaint. Let them express their concerns without interruption.

Determine the primary problem or dissatisfaction the customer is expressing and if the customer's complaint is unclear or vague, politely ask for further details or examples to better understand the situation. Clarifying questions can help fill in any gaps and provide a clearer picture of the problem. Asking the customer to show you the problem and recreate it can be helpful for the upcoming troubleshooting.

Consult relevant company policies, procedures, or product specifications to determine if the customer's complaint aligns with established guidelines. Make sure to document any deviations from the proper installation procedures since that may affect the warranty.

Provide a solution or propose steps to resolve the issue. Offer alternatives, such as a replacement, repair, refund, or other appropriate actions, depending on the nature of the complaint and your company's policies. Many companies will not work on older hot water tanks, faucets, or other appliances, therefore you must inform the customer or your company's policies.

Once you have covered all those bases, proceed as necessary. Arrange for a time to resolve the issue or complete the fix immediately. Consider time for ordering and gathering parts, tools, and equipment before proceeding.

Inspection

Repairs and alterations are expected to be completed in accordance with local codes and inspected by a local authority. Inspectors are required for both plumbing and gas installations. Along with compliance to code, inspectors will check for things such as checking the proper permitting was established, the fixture or appliance has been properly tested, and investigating any incidents, accidents, and safety violations.

Tools and Equipment

Before starting the servicing process, gather the required tools and materials based on the specific fixture you'll be working on. This may include wrenches, screwdrivers, pliers, replacement parts, sealants, lubricants, and cleaning supplies. Remember that you will need to test the fixture or appliance, so you may need a compressor and products for a leak test. Always have a knife for cutting silicone and caulking. Consider your PPE before starting the service. Have gloves, and safety glasses, and anything task specific to your work.

System Check/Test

Before disassembling a fixture or appliance, perform a test. Run the faucet, call for heat, and try to recreate the issue. If you can identify problems before taking the component apart, it will help with safer, faster repair. After a safe shut down, carefully disassemble the fixture to access the internal components that need attention. This may involve removing screws, nuts, or other fasteners that hold the fixture together. Refer to the manufacturer's instructions or plumbing diagrams if necessary. Once you have access, check for damage. Clean all working parts and replace all broken parts. Refer to the manufacturer's instructions for guidance on repairs and expected outcomes when doing a system check.

Manufacturers' Specifications

Most manufacturers provide detailed specifications in the product manuals or documentation that accompany the product. These documents outline the technical details, features, performance parameters, and operating instructions specific to the product. Product manuals are often available in print form or as downloadable PDF files from the manufacturer's website.

The official website of the manufacturer is a common source for accessing product specifications. Manufacturers often provide comprehensive product information, including detailed specifications, on their websites. Look for a dedicated product page or a section that provides specifications and technical details for the specific product you are interested in.

If the product is available for purchase through online retailers or distributors, they often include manufacturers' specifications on the product listing page. These specifications may be extracted from the official product documentation or provided directly by the manufacturer.

Some industries maintain databases or resources that compile manufacturers' specifications for various products. These databases can be accessed online or through industry-specific publications or directories. Examples include technical databases for electronic components, automotive specifications, industrial equipment specifications, etc.

Manufacturers often showcase their products at trade shows, exhibitions, or industry conferences. Attending these events allows you to interact directly with the manufacturers and obtain detailed specifications for their products. You may receive brochures, data sheets, or product catalogs that contain comprehensive specifications.

If you cannot find the desired specifications through the above channels, reaching out to the manufacturer directly is an option. Manufacturers typically have customer support channels, such as phone or email, where you can inquire about product specifications. They can provide you with the necessary documentation or direct you to the appropriate resource.

Remember to have the specific product model or part number available when searching for manufacturers' specifications, as this information is crucial for accurate results.

Isolation

Locate the shut-off valves that control the water supply to the fixture you'll be servicing. Turn off the water supply by closing the valves clockwise. If there are no individual shut-off valves, you may need to shut off the main water supply to the building.

Figure 3. Shut off valves.

Always know where the main shut offs (Figure 3) are for any service. Any isolation that requires shutting services off to units other than the one requiring work will need to be prearranged with a building manager or the other affected occupants. Shutting off gas may require isolating the appliance at the meter and may need to be arranged with the city. Do not isolate fixtures or appliances if you haven't checked what other fixtures, appliances, or houses will be affected.

Clean/Repair/Replace

Clear any debris or sediment buildup using appropriate cleaning tools or chemicals. For example, you might use a wire brush or pipe cleaner to remove scale or grime. Ensure the components are thoroughly cleaned before proceeding.

If any parts are damaged or malfunctioning, repair or replace them as needed. This could involve replacing washers, O-rings, gaskets, valves, cartridges, or other specific components based on the fixture type. Follow manufacturer guidelines and use compatible replacement parts.

Once the necessary repairs or replacements have been made, reassemble the fixture in the reverse order of disassembly. Ensure all connections are tight but avoid over-tightening, as it can cause damage or leaks.

Adjustments

If you notice any leaks or issues during testing, make the necessary adjustments. Tighten connections, reapply sealants, or troubleshoot further to resolve any problems. You must be able to guarantee that the fixture is operating smoothly and without any leaks before signing off.

Return to Service

Clean up any residual water, debris, or tools from the work area. Once you're confident that the fixture is functioning properly and you have made any necessary adjustments, restore the water supply by opening the shut-off valves. After opening the shut-offs, monitor the fixture and confirm that there are no hidden leaks or issues.

Verify Operation

Turn on the water or gas and carefully and inspect for any leaks around the fixture or connections. Check for proper water flow and functionality by operating the fixture's handles, knobs, or switches. Test both hot and cold water settings, as well as any other features specific to the fixture. Use soapy water or a leak detector on all gas connections. Run the fixture or appliance. Allow fixtures to run for a good amount of time and inspect all the attached piping to confirm that it is water or gas tight. Do not rush through the testing part of a service call. When you leave the site, you should be confident the fixture or appliance was operating as per the manufacturer's instructions and complies with the local codes.

Documentation

Documenting a service call is important for record-keeping, communication, and future reference. Here are some key points that can be documented for a service call:

- Note the date and time of the service call establishing a timeline for the work performed and provides a reference point for any subsequent actions or discussions.
- Accurately record the customer’s name, address, contact number, and any other relevant contact details to keep an accurate service history.
- Document the reason for the service call as explained by the customer. Include details of the plumbing issue, such as the type of fixture involved (sink, toilet, shower, etc.), specific symptoms or problems reported, and any additional information provided by the customer.
- Describe the initial assessment of the issue. Note any observations, tests performed, or diagnostic steps taken to identify the cause of the issue. Document the initial findings and any relevant measurements or readings taken during the assessment.
- Provide a detailed account of the work performed during the service call. Describe the repairs, replacements, adjustments, or maintenance tasks carried out to address the plumbing issue. Include specific details of the parts used, tools employed, and techniques applied. If multiple tasks were performed, break them down into separate sections for clarity.
- List the materials, parts, or consumables used during the service call. Include the specific names, sizes, quantities, and any relevant part numbers. This information is essential for tracking inventory, estimating costs, and ensuring accurate documentation.
- Document any challenges, complications, or unexpected issues encountered during the service call. Describe how these challenges were addressed or resolved, and note any additional steps taken to overcome them. This information can be helpful for future reference or if follow-up actions are required.
- Provide recommendations or suggestions to the customer regarding future maintenance, upgrades, or potential issues that may arise. Include any advice that was offered to guarantee the customer’s plumbing system operates optimally and to help prevent future problems.
- Record any significant communication or discussions with the customer during the service call. Note any agreements made, changes in scope, or additional instructions provided. This helps maintain clear documentation of customer interactions and ensures effective communication between the plumber and the customer.
- Summarize the final assessment of the plumbing system after the work was completed. Note any improvements, repairs completed, or issues resolved. Confirm that the plumbing fixture is functioning properly and that any reported symptoms or problems have been addressed.
- When required, obtain the customer’s signature or approval on the documented service call. This confirms that the customer is satisfied with the work performed and serves as a record of their agreement.
- Document any recommended follow-up actions, such as future inspections, scheduled maintenance, or additional repairs that may be required. This ensures that all necessary steps are recorded and can be addressed in a timely manner.

The thorough documentation of a service call, creates a comprehensive record of the work performed, maintains accurate information for future reference, and provides a clear communication channel between the service provider and the customer. Many service technicians understand that clear and honest communication with a customer can be the difference between generating and losing business.

Now complete Self-Test 2 and check your answers.

Self-Test 2

Self-Test 2

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- Figure 3. “Shut off valves” from All House Related Solutions is used for educational purposes under the basis of fair dealing.

Competency F4: Install Hydronic Systems

Learning Task 1

Describe testing procedures for hydronic systems, components, and controls

Safe Work Practices

Safety is no accident. When testing a hydronic system, safe working practices are just as important as with any other task. Testing includes pressurizing pipes, checking electrical connections, and identifying and fixing problems. Each one has inherent dangers and needs to be addressed before work begins.

Lock-out/Tag out

Much equipment used in hydronic systems will need to be safely locked out before testing can be performed. Remember that a lock out procedure is not just electrical, but all potential energy. Make sure pressure is relieved and all components have stopped spinning before performing any tests. When working around others, inform all workers on or near the hydronic system that it will be locked out for testing. Identify all potential energy sources in the hydronic system. These may include electrical power supplies, fuel supplies (e.g., natural gas, oil), and stored thermal energy. Turn off all electrical power supplies to the system, including circuit breakers or disconnect switches that control pumps, controls, and any other electrical components. A water heater may have a dedicated 120V or 240V circuit breaker that should be switched to off. Remember to use appropriate lockout/tagout procedures to secure these switches in the off position.

If the system is powered by natural gas, propane, or oil, shut off the fuel supply to the boiler or furnace. Drain the water or fluid from the hydronic system to relieve residual pressure. Use drain valves or vents to facilitate this process. Close isolation valves on the supply and return lines to isolate the system from other connected components or zones. Potential energy may still be present. bleed valves or vents should be opened to release any remaining pressure in the system. This step will prevent water or fluid from spraying when components are disconnected.

On larger systems use lockout/tagout procedures to physically lock and tag all energy sources and isolation points to prevent accidental re-energization. Each lock should be identified with the name of the person who applied it and the reason for the lockout.Verify that all energy sources are disconnected, and there is no power supply or pressure left in the system.

Codes and Regulations

AHJ

AHJ stands for Authority Having Jurisdiction. AHJ is typically a government agency, department, or official responsible for enforcing and interpreting specific codes, standards, regulations, or laws within a jurisdiction. Here's a more detailed explanation of the concept:

The term jurisdiction refers to a specific geographical area or administrative division, such as a city, where certain rules and regulations apply. Different jurisdictions may have their own set of codes and standards.

Authority refers to the power or responsibility vested in a particular entity or individual to enforce and oversee compliance with the applicable regulations and codes within that jurisdiction. The role and responsibilities of an AHJ can vary widely depending on the jurisdiction and the specific codes or standards they are tasked with enforcing. AHJ can be consulted for a number of things including: plan review, permit Issuance, inspections, code interpretation, enforcement, safety oversight, environmental regulations, and zoning.

Manufacturers' Specifications

Before performing any tests, make sure to consult the manufacturer's specifications to confirm all piping and components are properly installed. All guidelines should be followed so that safety and warranties are maintained.

Inspection Types

Information can be gathered before pressurizing a system. Inspection types such as visual pre-checks, and sensory checks can be used to confirm proper functioning of a hydronic system.

Visual Pre-Check

Examine the entire system, including pipes, fittings, valves, pumps, and heat emitters (radiators, baseboard heaters, etc.), for any signs of water leaks. Moisture, water stains, or puddles around components indicate leaks. Check all connections for tightness and security. Loose fittings or connections can lead to leaks. Look for signs of corrosion on metal components, such as pipes, valves, and radiators. Corroded areas may appear discolored or pitted. Check that insulation on pipes and components is intact and in good condition. Damaged insulation can lead to heat loss and reduced system efficiency. Inspect air vents to confirm they are correctly positioned and functioning.

Sensory

A sensory inspection of a hydronic system involves using senses (sight, touch, and hearing) to detect potential issues or irregularities in the system's operation. This type of inspection can help identify visible and audible clues that may indicate problems with the system. Touch pipes, radiators, and other heat emitters to check for temperature irregularities. Cold spots or uneven heating may indicate flow or balancing issues. Use a hand or a paper towel to check for moisture around components. Dampness or water accumulation can signal leaks or condensation issues. Pay attention to any unusual sounds coming from the system, such as gurgling, hissing, banging, or whistling. Unusual noises may indicate air or water flow problems, cavitation, or issues with pumps or valves. Listen for the sound of circulating pumps. Pumps should operate smoothly without excessive noise. If unusual or loud noises are heard from a pump, it may require attention. Cavitation has often been described as hearing gravel running through the pump. Air vents may make noise when releasing trapped air.

Pressure

A pressure inspection can yield useful information about the system. Stable pressures indicate that the system is working as it should and there are no leaks. Comparing a system's current pressure to those at initial installation will confirm the system's pressure stability. Pressure can be inspected at different points in the system by attaching pressure gauges to valve ports and checking pressure.

Thermal

Like pressure inspections, a thermal inspection can be done to gather information. Scan the entire hydronic system using the thermal camera. Check for uneven heat distribution, cold spots, or temperature variations. Look for signs of blockages, leaks, or temperature differences along the length of the pipes. Inspect the heat source for any hotspots or irregular temperature patterns. Verify that insulation is intact and effective in preventing heat loss or gain.

Tools and Equipment

A pressure gauge is used to measure the system's water pressure. It helps ensure that the system pressure falls within the recommended operating range. A thermometer is used to measure the water temperature within the hydronic system. It's crucial for verifying that the system is delivering the desired heating or cooling temperature. An infrared thermometer allows for quick measuring of the temperature of pipes, radiators, or terminal units without direct contact. This can be useful for spot-checking temperatures in different parts of the system. A flow meter measures the flow rate of water within the system. It helps ensure that the flow rate matches the design specifications and can be crucial for system balancing.

If the system includes a boiler, a combustion analyzer is essential for monitoring combustion efficiency and emissions. It measures parameters like oxygen and carbon monoxide levels in flue gases. If the hydronic system is a chilled water system or uses refrigerant for cooling, a manifold gauge set is used to measure refrigerant pressures and temperatures. It helps diagnose and troubleshoot cooling issues. A multimeter is a versatile tool for measuring electrical voltage and resistance. It can be used to check electrical connections, circuits, and components within the system. This gauge is useful for measuring the pressure drop across filters, strainers, or other components in the system. It helps identify potential flow restrictions. If the system includes a circulation pump, equipment may be needed to test the pump's performance, such as a flow meter, pressure gauge, and power meter to measure energy consumption. Bleed keys (Figure 1) are used to open bleed valves on radiators or terminal units to release trapped air from the system.

Figure 1. Radiator bleed key

Don't forget to have a bucket or container on hand to collect water when bleeding air from the system. Towels or rags are useful for cleaning up any spills. Depending on the specific tasks involved, use safety gear such as gloves, safety glasses, or hearing protection.

Test Medium

Fluid

Water testing will locate leaks in the system. A visual inspection for leaks can be done and any leaks fixed before the system is put into operation. If the system will be exposed to freezing temperatures, make sure to use an antifreeze such as glycol for a fluid test.

Compressed Air

Air testing will also expose leaks in the system. By filling with air, leaks can be detected with the use of soapy water, and the risk of water damage is eliminated. Compressed air does create moisture and if the pipes and components are exposed to freezing temperatures, damage could occur.

Inert Gases

When it is not possible to test using air or water, an inert gas can be used. When temperatures drop below freezing, there is a risk that the moisture from air or a fluid testing medium will freeze, expand, and damage the piping and components. If the equipment may be subject to freezing, inert gases such as nitrogen or argon are common choices. This testing procedure would be performed the same as a compressed air pressure test, however, instead of air, a cylinder of the inert gas would be connected to the system and used to fill the pipes to the desired pressure.

Procedures

Filling

Before beginning, check that the system is completely shut down and that all electrical power to pumps, boilers, and other components is turned off. Identify the drain and fill points on the hydronic system. These are typically located at the lowest point in the system for draining and at a convenient point for filling. Use clean, deionized water or a water/antifreeze mixture suitable for the climate and system requirements. Make sure the water is at room temperature. Close any isolation valves on the system that may be open. This includes zone valves, isolation valves on the boiler or heat source, and any other open valves in the system. If there is a drain point, connect a hose to it and place the other end in a suitable drainage area or container. Open the drain valve slowly to allow air to enter the system, which helps with draining. Allow the water to drain completely from the system. Open bleed valves on radiators or other high points in the system to aid drainage. Once the system is drained, close the drain valve.

To fill, connect a hose to the fill point, ensuring that it is secure. Open the fill valve or connection slowly to allow water to enter the system. Monitor pressure gauges. As the system fills with water, bleed air from high points in the system. Open bleed valves or bleed screws on radiators or terminal units until water flows steadily. Continue filling until the system is pressurized to the recommended level. Inspect the system for any leaks during and after filling. Check all connections, valves, and joints. Once the system is filled and all air is purged, close the fill valve. Check the system pressure and make sure it remains within the recommended operating range.

Draining

Identify the drain points on the system, located at the lowest points. If available, attach a hose to the drain valve and place the other end in a suitable drainage area. Slowly open the drain valve to allow water to drain from the system. Open bleed valves at high points to aid in draining and release air locks. Once the system is drained, close the drain valve securely. Open bleed valves or bleed screws on radiators or terminal units to release any remaining air in the system. After draining, inspect the system for any issues and perform any necessary maintenance or repairs before refilling.

Purging

Purging a hydronic heating or cooling system is a crucial step to remove air or gas pockets that can reduce the system’s efficiency and heating/cooling performance. Air in the system can lead to reduced heat transfer, noisy operation, and potential damage to system components. Locate the air vents or purge valves in the hydronic system. These are typically located at high points in the system, such as on radiators, baseboards, or near the top of piping loops. Confirm that the system pressure is within the recommended operating range. If it’s too low, add water to the system through the fill valve until it reaches the proper pressure. If the system has automatic air vents, they should release air on their own when the system operates. Monitor these vents for signs of air being purged, such as air bubbles or water droplets. If an automatic vent is not functioning correctly, it may need to be replaced or serviced.

If the system has manual air vents, use a screwdriver or bleed key to slowly open the vent. Air will escape, followed by water. Be prepared to collect the purged water. The water may be discolored initially as air is purged, but it should become clear once all the air is removed. Close the manual vent once water flows steadily without air bubbles. Go to each air vent or purge valve in the system and repeat the process until all air is purged. After purging air, check the system pressure again to confirm it's within the recommended range. Adjust if necessary. Inspect the system for any signs of leaks, especially around the manual air vents that were opened. Tighten any connections if necessary. Turn the system back on and allow it to operate normally. Monitor the system for any unusual noises or performance issues. Proper purging should result in improved heating/cooling performance and reduced noise.

Return to Service

Before returning a system to service, make sure to inform any workers in the area. Inform the occupants or building managers when needed.

Documentation

Keep records of any issues or observed irregularities during inspection and testing. This information can be helpful for troubleshooting and maintenance. Documenting the testing process provides a clear record of the activities performed, verifies compliance with regulations, and serves as a reference for future maintenance or troubleshooting. It is important to follow any specific documentation requirements or guidelines provided by local authorities, regulatory bodies, or industry standards when commissioning fixtures and appliances.

Now complete Self-Test 1 and check your answers.

Self-Test 1

Self-Test 1

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/plumbing4f/?p=132#h5p-15

Media Attributions

- Figure 1. "Radiator bleed key"by Sil10napel from Wikimedia Commons is licensed under a CC BY-SA 4.0 licence.

Learning Task 2

Describe commissioning procedures for hydronic systems, components, and controls

Design requirements

Designing a hydronic system (Figure 2) involves several important requirements for efficient and effective operation. To start, a heat loss calculation determines the heating or cooling load for the space or building that the hydronic system will serve. This calculation considers factors like sun exposure, insulation, window sizes, climate, and occupancy to determine the required heating or cooling capacity. Appropriate components are chosen for the system needs, including boilers or heat sources, pumps, piping, radiators, or other terminal units, expansion tanks, and controls. These components must be sized correctly for the load. The piping layout is designed with even heat distribution or cooling in mind. Proper pipe sizing, insulation, and lay out are crucial to minimize heat loss and maintain system efficiency. An appropriate heat transfer fluid must be determined, usually water or water mixed with an antifreeze solution such as glycol and it must be maintained at the right temperature and pressure to prevent freezing or overheating.

Thermostats and control valves help maintain the desired temperature within the space. Many systems include zoning to allow for temperature control in different areas. The system is balanced so that each radiator or terminal unit receives the correct flow of water, preventing uneven heating or cooling. Flow control valves or balancing valves have this job. Pressure relief valves, backflow preventers, and temperature controls must be installed to protect against system failures and keep the system safe.

Pipes and components are properly insulated to minimize heat loss and maintain system efficiency. This is especially important for outdoor piping and equipment.

Correct pump sizing is critical to efficiently circulate water through the system. Variable-speed pumps may be used to modulate flow rates based on demand. Water quality is monitored and clean, deionized water should be used. Regular maintenance is required to prevent corrosion, scale buildup, and other issues that can affect system performance. Considerations should be made so that the hydronic system integrates well with other HVAC components, such as air handlers, heat exchangers, and ventilation systems. Energy-efficient systems are designed by using high-efficiency boilers or heat sources, properly sized pumps, and efficient controls that can adjust based on load.

Consider ease of access for maintenance and repairs. Burners will need to be pulled out and cleaned. Hot surface igniters will need to be replaced. Make sure that components are accessible and that there is a maintenance plan in place. Follow all local building codes, regulations, and standards applicable to hydronic systems and comply with safety and environmental requirements.

Keep detailed records and documentation of the system design, installation, and maintenance. Always keep the manufacturer’s materials with the equipment. This information is valuable for troubleshooting and future modifications. Test the system thoroughly before handing it over to the building owner or occupants and confirm that it operates according to design specifications.

Figure 2. Hydronic System

Safety features

Safety features in a hydronic system are needed for protecting both the system itself and the occupants of the building. These features are designed to prevent accidents, minimize risks, and keep the system operating safely.

A pressure relief valve is installed on the boiler or pressure vessel to prevent over pressurization. It automatically opens to release excess pressure if the system pressure exceeds a safe limit. In gas-fired systems, flame safeguard controls monitor the presence of a flame. If the flame is lost or fails to ignite properly, these controls shut down the burner to prevent gas buildup and potential explosions. An expansion tank is part of a closed-loop hydronic system. It accommodates the expansion and contraction of the fluid due to temperature changes, preventing excessive pressure buildup.

Air vents help remove trapped air from the system, which can reduce efficiency and impair performance. Proper air elimination helps maintain safe and efficient operation. Backflow preventers are installed to prevent the contamination of the potable water supply by the hydronic system. They that water in the hydronic system flows in one direction only.

Temperature and pressure gauges provide visual monitoring of the temperature and pressure within the system, allowing operators to identify potential issues. Circulator pumps may have overload protection features that shut down the pump if it becomes overloaded or blocked, preventing damage to the pump.

Zone valves and zone control systems allow for the isolation of individual heating or cooling zones, ensuring that only the necessary areas receive heating or cooling, which can improve safety and efficiency. An easily accessible emergency shutoff switch can be used to quickly deactivate the entire system in case of an emergency.

Figure 3. Emergency shut off switch

Systems that involve combustion or are atmospherically vented, such as gas-fired boilers, must meet ventilation and combustion air requirements to verify proper air supply and prevent the buildup of harmful gases. In systems that use combustion, CO detectors can be installed to monitor CO levels and provide an alarm if dangerous levels are detected.

In some commercial or industrial applications, fire suppression systems may be integrated with hydronic systems to provide added protection in the event of a fire.

Limits

High temperature limit controls monitor the temperature of the fluid in the system. If the fluid temperature exceeds a predetermined limit, the control shuts down the heating source to prevent overheating.

Figure 4. Operating or limit aquastat

Low water cut offs or LWCO devices are designed to protect boilers from damage caused by low water levels. If the water level in the boiler drops below a safe threshold, the LWCO shuts down the burner to prevent overheating.

Temperature drop

In a hydronic heating or cooling system, the term "temperature drop" refers to the difference in temperature between the supply (hot) and return (cold) water or fluid in the system as it circulates through various components and zones. This temperature drop is a critical parameter in hydronic systems and plays a significant role in system performance and efficiency. The specific target temperature drop in a hydronic system can vary depending on factors like design, climate, and system type. System designers and installers aim to achieve an appropriate temperature drop to meet the heating or cooling needs of the building efficiently. Temperature drop or the ▲T is typically 20 degrees.

In a hydronic heating system, the primary function is to transfer heat from the heat source (e.g., boiler, heat pump) to the spaces being heated (e.g., rooms, floors). In a cooling system, the goal is to remove heat from the spaces. The heated or chilled water or fluid is distributed through a network of pipes to various zones or heat emitters (e.g., radiators, baseboard heaters, underfloor heating, or cooling coils). The water is initially sent out from the heat source as "supply water" at a specific temperature.

As the supply water flows through the heat emitters or cooling coils, it releases or absorbs heat, depending on whether it's a heating or cooling system. This process results in the supply water's temperature changing. The now "return water" is the water that has completed its circuit through the distribution system and has absorbed or released heat. It returns to the heat source at a different temperature.

The temperature drop is the difference in temperature between the supply water leaving the heat source and the return water returning to it. In a heating system, this temperature drop represents the amount of heat that was delivered to the zones. In a cooling system, it represents the amount of heat that was removed from the zones.

The temperature drop is an important parameter for several reasons:

- A larger temperature drop typically indicates that more heat (or cooling) has been transferred to the spaces, which is more efficient. Smaller temperature drops may suggest that the system is not delivering as much heating or cooling as desired.
- Understanding the temperature drop helps in balancing the system. Balancing involves adjusting flow rates and control settings to confirm that each zone receives the right amount of heating or cooling. Zones with a larger temperature drop may require adjustments to achieve balance.
- Many hydronic systems use temperature sensors to control the operation of the heat source or chillers. These sensors monitor the return water temperature, and if it deviates from the desired setpoint, the system adjusts accordingly.
- Maintaining an appropriate temperature drop ensures that the system operates efficiently, which can save energy and reduce operating costs.
- Accurate control of the temperature drop helps maintain consistent and comfortable indoor temperatures throughout the building.
- Monitoring the temperature drop can be helpful for diagnosing issues in the system. For example, if the temperature drop is too small, it may indicate insufficient heat transfer, while a very large drop could suggest overworking the equipment.

System balancing

Balancing a hydronic system allows for efficient operation and even heat or cooling distribution throughout a building. Balancing involves adjusting the flow rates of water in different parts of the system, such as radiators or heating/cooling zones, to achieve a uniform temperature and optimal performance.

Before starting the balancing process, gather information about the hydronic system, including its design, components, and specifications. Examine the original design plans and specifications to understand how the system was intended to operate. This information will serve as a reference point during the balancing process. Measure the flow rates of water in the various branches or zones of the hydronic system. This can be done using flow meters, pressure gauges, or temperature sensors. Monitor the pressure differential across different components of the system, such as valves, pumps, and heat emitters (e.g., radiators or underfloor heating systems). Pressure differentials can indicate imbalances in flow rates. Use balancing valves or adjustable flow control valves at key points in the system to regulate the flow of water. These valves can be adjusted to restrict or increase the flow as needed. Focus on individual zones within the system, such as specific rooms or areas. Adjust the flow rates to achieve the desired temperature and comfort level in each zone.

For radiators or baseboard heaters, balance the flow by partially closing or opening radiator valves.

For underfloor heating systems, use flow restrictors or manifold adjustments to balance flow to different loops. Determine whether the system operates on a constant flow or variable flow basis. Constant flow systems maintain a consistent flow rate, while variable flow systems adjust flow based on demand. For variable flow systems, use differential pressure control valves to maintain stable pressure differentials across components. Monitor temperature differentials between the supply and return lines of the system. Adjust flow rates to maintain the desired temperature differential, to allow for efficient heat transfer. Install hydronic balancing valves in critical locations to simplify and enhance the balancing process. These valves provide visual indicators of flow rates and pressure differentials, making adjustments easier. Periodically re-measure flow rates, pressure differentials, and temperature differentials to make sure that the system remains balanced. Make further adjustments as necessary to maintain consistent performance.

Flow rates (zones)

Flow rates determine the volume of water circulating through the system and directly impact its performance and efficiency. The design flow rate is the flow rate of water that the system is designed to operate at to meet the heating or cooling load of the space or building. It is typically calculated during the system design phase based on factors like the building's size, insulation, climate, and desired temperature differential. Flow rates in hydronic systems are often measured in gallons per minute (GPM). The design flow rate is usually specified in GPM to maintain required heating or cooling capacity.

The pump flow rate is the rate at which the system's circulation pump moves water through the pipes and components. It should match the design flow rate for efficient operation. The pump's flow rate is typically adjustable to accommodate changes in system demand.

In larger hydronic systems with multiple heating or cooling zones, each zone may have its own flow rate requirement. The flow rate can be adjusted for individual zones using zone valves or variable-speed circulators to maintain the desired temperature in each area.

Balancing flow rates involve adjusting the flow of water to different radiators, coils, or terminal units within the system. This provides even heating or cooling throughout the space. Balancing valves or flow control valves may be used for this purpose.

Delta-T or (ΔT) represents the temperature difference between the supply and return water in the hydronic system. A larger delta-T indicates more efficient heat transfer. By controlling the flow rate and adjusting it to maintain the desired delta-T, you can optimize the system's efficiency. Some hydronic systems incorporate a low flow cutoff to prevent the flow rate from dropping below a certain threshold, which can cause issues such as insufficient heat transfer or equipment damage.

In modern hydronic systems, variable-speed pumps are often used to modulate flow rates based on system demand. These pumps can adjust their speed to maintain the desired flow rate and optimize energy efficiency.

When commissioning a system, the minimum and maximum flow rates must be known. Confirm that the flow rates in the system fall within the manufacturer's recommended minimum and maximum flow rate limits for the various components, including boilers, heat exchangers, and terminal units.

Air Flow

Balancing a forced-air heating system involves adjusting various components within the system for even heat distribution to different areas or zones of your home. It may also involve some trial and error to get right.

Gather information about your heating system, including the number and location of supply registers (vents), return air grilles, and the layout of your home. Determine which areas of your home are consistently too hot or too cold. This will help you focus your balancing efforts. Before balancing, check that your ductwork is clean and free of obstructions. Dirty or blocked ducts can impede airflow and affect system performance. Also check that your air filters are clean and in good condition. Clogged filters can restrict airflow and reduce system efficiency. Adjust the dampers or louvers on supply registers. These are typically found on or near the registers themselves. Closing dampers partially reduces airflow to that area, while opening them increases it. Start with the registers in problem areas.

After adjusting the registers, monitor the temperature in each room or zone to see if it improves. Use a thermometer or a smart thermostat with multiple sensors to gather data. If you have a zoned heating system, each zone can be adjusted individually to control the flow of warm air. Adjust the dampers or controls in each zone to balance the temperature. Make sure that there is proper return airflow in each zone or room. A lack of return air can disrupt airflow and affect system balance. Check for blocked or closed return air grilles. If balancing is still challenging, consider other measures such as adding or relocating supply registers, insulating or sealing ducts, or upgrading your heating system to one with variable-speed blower fans for more precise control.

To maintain a balanced system, perform regular maintenance tasks, including changing filters, cleaning ducts, and inspecting dampers and registers. Keep in mind that the balancing needs of your forced-air heating system may change with the seasons. You may need to readjust the dampers and registers as temperatures fluctuate.

Balancing a forced-air heating system may require some trial and error to achieve the desired comfort levels throughout your home. Be patient and systematic in your approach and remember that it’s essential to maintain proper airflow while balancing to avoid putting undue strain on the heating system.

Flow directions

In a hydronic heating or cooling system, the flow direction refers to the movement of the heat transfer fluid, typically water or a water-glycol mixture, through the various components and pipes within the system. Understanding the flow directions is important for proper system operation and troubleshooting.

The supply side of the hydronic system is where the heated or chilled fluid originates. It starts at the heat source, such as a boiler for heating or a chiller for cooling. The flow direction on the supply side is from the heat source towards the distribution components.

From the heat source, the hot or cold fluid is pumped into a network of pipes and distribution components. These components include pumps, zone valves, distribution manifolds, and balancing valves.

In a hydronic system, different areas or zones within a building may have their own circulator pumps or zone valves. These pumps or valves control the flow of the heat transfer fluid into specific zones. The flow direction within each zone can vary depending on the design of the system but generally circulates through radiators, baseboard heaters, underfloor heating, or other heat emitters to provide heating or cooling.

After the heat transfer fluid has passed through the heat emitters in each zone, it returns to the heat source to be reheated or re-cooled. The return side of the system collects the fluid from the various zones and directs it back to the heat source. The flow direction on the return side is from the zones back to the heat source.

The heat source, which can be a boiler, chiller, or other heating/cooling equipment, receives the fluid from the return side. Here, the fluid's temperature is adjusted based on the system's requirements. After the temperature adjustment, the fluid is pumped back into the supply side to continue the circulation process.

Flow direction can be controlled and adjusted using various valves, pumps, and zone control components within the system. Properly balancing the system, ensuring even flow distribution, and avoiding flow restrictions are essential for efficient operation and maintaining comfort levels in different zones of a building. Additionally, the flow direction may change based on the specific design and configuration of the hydronic system.

Control Sequence

The control sequence of a hydronic heating or cooling system outlines how the various components and controls within the system work together to maintain the desired temperature and comfort conditions in a building. The control sequence can vary depending on the specific system design and application. Here is a general overview of a typical control sequence for a hydronic heating system:

Start-Up Sequence:

1. Thermostat Call for Heat
   The control sequence begins when the thermostat detects a need for heating. This can be triggered by a drop in room temperature below the setpoint.
2. Zone Valve or Circulator Activation
   The thermostat sends a signal to open the zone valve or activate the circulator pump for the respective heating zone.
3. Boiler Activation
   If the system uses a boiler, the thermostat signal also activates the boiler (ie. burner). The boiler starts heating the water or fluid in the hydronic system.
4. Primary Circulator Activation
   In larger systems with multiple zones, there may be a primary circulator pump that moves heated water from the boiler to a distribution manifold.

5. Distribution Sequence
   A distribution manifold directs heated water to individual zones or circuits. Each zone has its own branch or circuit with a zone valve or circulator pump.
6. Zone Valve or Circulator Operation
   In each heating zone, the zone valve opens or the circulator pump activates, allowing heated water to flow through the zone's piping.
7. Heat Emitter Activation
   Heated water from the distribution manifold enters the heat emitters, such as radiators, baseboard heaters, or underfloor heating loops. Heat emitters transfer heat to the space, raising the room temperature.
8. Temperature Sensors
   Temperature sensors (usually in the return line) monitor the temperature of the heated water returning from the zones.
9. Control logic, often part of a control panel or system controller, compares the return water temperature to the setpoint temperature. If the return water is colder than the setpoint, the system continues to operate to raise the temperature.
10. Modulating or Staging:
    In more advanced systems, modulating controls adjust the boiler's or burner's firing rate to match the heating load precisely. This increases energy efficiency. In systems with multiple boilers or stages, additional units activate as needed to meet the demand.
11. End of Heating Cycle
    When the thermostat detects that the room temperature has reached the setpoint, it sends a signal to shut down the zone valve or circulator pump for the heating zone.
12. Post-Purge
    Some systems incorporate a post-purge cycle to remove residual heat from the heat emitters and prevent overheating.
13. System Rests
    The system rests until the next thermostat call for heat.

The control sequence for a hydronic cooling system is similar but involves cooling equipment like chillers or air handlers and is initiated when the thermostat calls for cooling.

Sensor checks

A hydronic heating system typically uses water or another liquid to transfer heat throughout a building. While there may not be as many sensors in a hydronic system compared to some other types of HVAC (heating, ventilation, and air conditioning) systems, there are still key components and sensors that should be checked regularly.

Supply and return temperature sensors measure the temperature of the water entering and leaving the heating system. Discrepancies between these temperatures can indicate issues with heat transfer or flow.

System pressure sensor monitors the pressure within the hydronic system. It helps guarantee that the system operates within the recommended pressure range.

Flow switch or flow sensor monitors the flow rate of the water circulating through the system. It helps maintain adequate flow for proper heat exchange.

Pressure relief valves monitor that the system pressure doesn't exceed safe levels by releasing excess pressure. This valve should be tested periodically for proper functioning.

Automatic Air Vents help remove air bubbles from the system, which can improve heat transfer and make sure it's functioning correctly to prevent airlocks.

Boiler temperature controls like aquastats, monitor and control the temperature of the water in the boiler.

A circulator provides proper water circulation through the system. Check for proper operation and any unusual noises.

System pressure gauges indicate the current pressure in the hydronic system and keep the pressure within the recommended range.

Some systems have water hardness sensors that can be important to prevent scale buildup in the system.

Piping configuration

Hydronic systems use various piping configurations to distribute hot or cold water (or other heat transfer fluids) for heating, cooling, or domestic hot water applications. The choice of piping configuration depends on the system's design, purpose, and the specific requirements of the installation.

Series Piping – In series piping, the water flows consecutively through each heat emitter (e.g., radiators or baseboard heaters) one after the other. This is a simple and common configuration for single-zone heating systems.

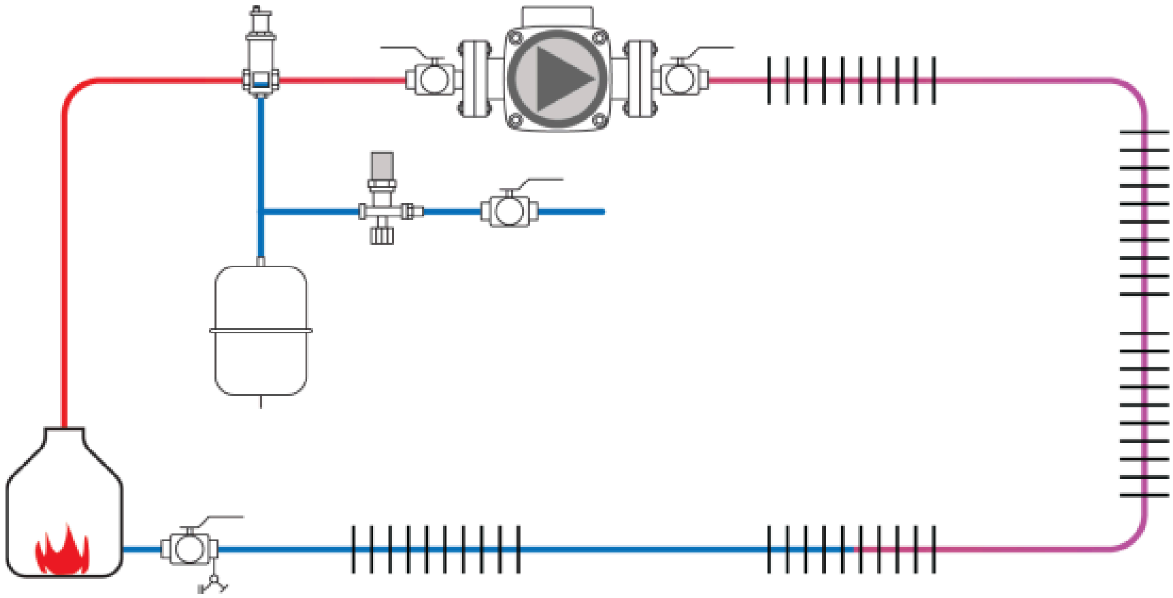

Figure 5. Series piping

Parallel Piping – Parallel piping involves running separate supply and return lines to each heat emitter in parallel. It allows for individual control of each heat emitter and is commonly used in multi-zone heating systems.

Reverse Return Piping – In a reverse return piping configuration, the supply water is piped to the farthest heat emitter in the circuit first, and then it returns through the remaining heat emitters in reverse order. This helps balance flow rates and offers even heat distribution in multi-zone systems.

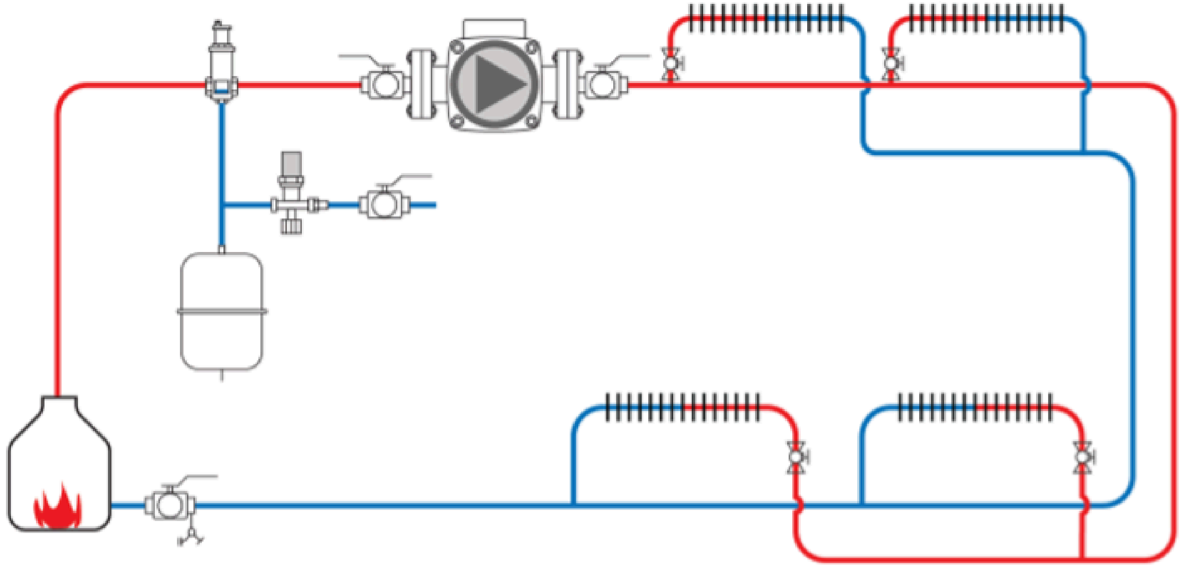

Figure 6. Reverse return piping

Home Run Piping – Home run piping simplifies distribution by running a separate supply and return line directly to each heat emitter from a central distribution manifold. It offers precise control and is often used in radiant floor heating systems.

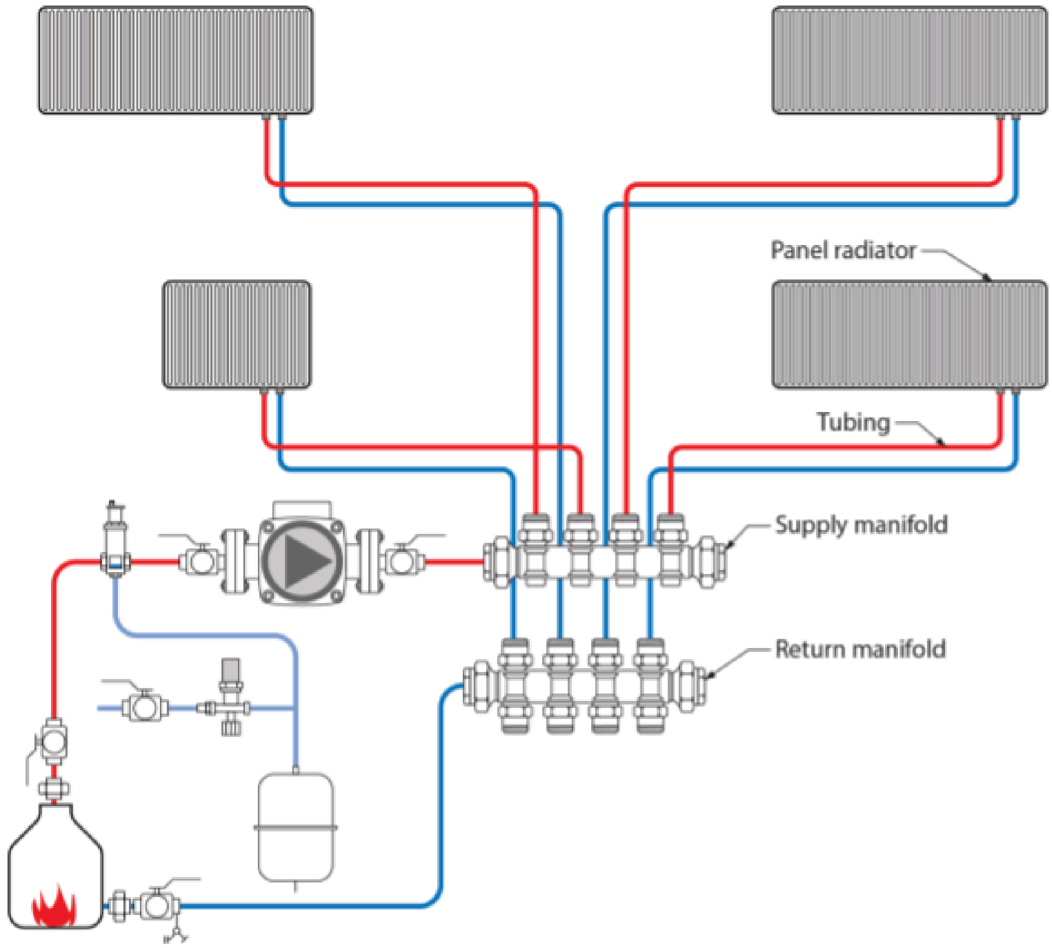

Figure 7. Home run piping

Primary-Secondary Piping (Hydraulic Separation) – Primary-secondary piping separates the primary loop (e.g., boiler loop) from the secondary loops (e.g., zone loops) with a heat exchanger or hydraulic separator. This prevents temperature fluctuations in the primary loop from affecting the secondary loops and allows for efficient operation of multiple zones.

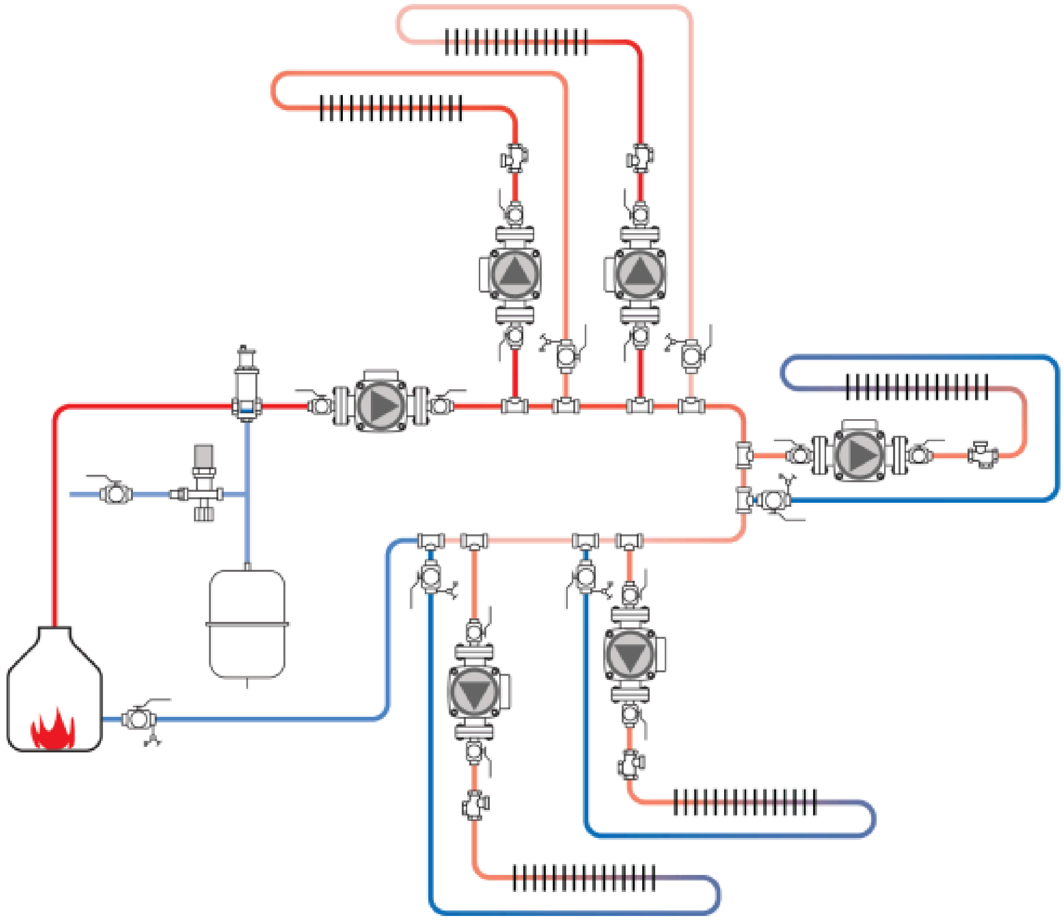

Figure 8. Primary secondary piping

Direct Return Piping – Direct return piping is a straightforward method where the return water from each heat emitter goes directly back to the boiler or heat source. It's suitable for smaller systems with few zones.

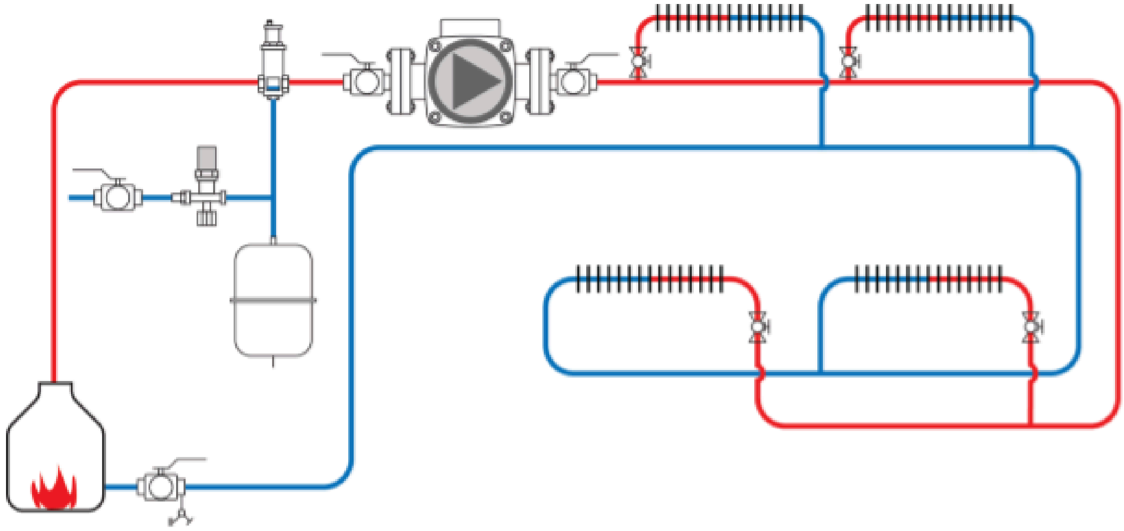

Figure 9. Direct return piping

Tree or branch piping is a configuration commonly used in radiant floor heating systems. It involves running supply and return lines from a central manifold to each branch or zone.

In some hydronic systems, such as fan coil units for heating and cooling, two-pipe or four-pipe configurations may be used. Two-pipe systems use the same pipes for both heating and cooling, while four-pipe systems have separate pipes for each.

Air Removal

Air in a hydronic (hot water or chilled water) system can be problematic and have several adverse effects.

Air in the system can form pockets or bubbles that act as insulators, hindering the transfer of heat or cooling. This can lead to reduced system efficiency, uneven heating or cooling, and longer system runtimes, increasing energy consumption and costs. It can accumulate in high points or dead-end sections of the piping, creating airlocks or blockages that impede the flow of water. This can result in reduced circulation, reduced heat delivery to radiators or heat emitters, and potential system overheating or damage.

Air pockets can create noise in the system, causing gurgling, hissing, or banging sounds as water flows past or attempts to displace the air. This noise can be disruptive and annoying, especially in residential settings.

Air can cause pump cavitation, which is the formation of vapor cavities or bubbles in the pump impeller due to reduced pressure. Cavitation can lead to pump damage, reduced pump performance, and increased maintenance costs.

Air can introduce oxygen into the hydronic system. Oxygen, when in contact with metals in the system, can promote corrosion, leading to the deterioration of pipes, radiators, and other components. Corrosion can reduce the system's lifespan and lead to costly repairs.

Air can also carry contaminants or particulates into the system, which can accumulate in components like valves, pumps, and heat exchangers. This can lead to reduced system performance and clogs.

In heating systems, air can disrupt the even distribution of heat, resulting in cold spots and uneven temperatures within rooms. This can lead to discomfort for occupants.

To address these issues and maintain the optimal performance of a hydronic system, we need to remove air from the system and prevent its reintroduction. This is typically achieved through the following methods:

Regularly bleeding air from high points or air vents within the system helps remove trapped air pockets, installing automatic air elimination devices (air vents or automatic air purgers) in strategic locations within the system can help remove and collect air.

Proper system design that includes air separators, expansion tanks, and purging valves can help minimize air entrainment and promote efficient air removal.

Cross Connection Controls

Cross-connection controls are important safety devices used in hydronic systems to prevent the potential contamination of potable (drinking) water with non-potable water or other substances. In hydronic systems, these controls are primarily employed to safeguard the potable water supply from any backflow or back-siphonage of heating or cooling fluids, chemicals, or contaminants.

Backflow preventers are mechanical devices that prevent the reverse flow of water from a hydronic system into the potable water supply. They come in various types, including double-check valves, reduced pressure backflow assemblies (RP), and vacuum breakers.

Reduced pressure backflow assemblies (RP) are commonly used in hydronic systems. They include two check valves and a relief valve, which is opened when there is a drop in pressure, preventing any backflow into the potable water system.

Air gaps are physical separations between the potable water supply and the hydronic system, achieved by installing a gap or air break between the two systems. An air gap is considered the most reliable method of cross-connection control.

Dual check valves are two independent check valves installed in series to provide a barrier against backflow. They are commonly used in small-scale hydronic systems.

Pressure vacuum breakers (PVBs) are devices used to protect against back-siphonage. They are often installed at the highest point in a hydronic system to provide a barrier against potential contaminants entering the potable water supply.

Atmospheric vacuum breakers (AVBs) are simple, cost-effective devices that prevent back-siphonage. They are typically used in residential and smaller hydronic systems.

Reduced pressure detector assemblies (RPDA) are advanced backflow preventers that not only prevent backflow but also provide monitoring and notification capabilities. They are used in larger, more complex hydronic systems.

Double check detector assemblies (DCDA) are similar to dual check valves but include monitoring capabilities to detect potential backflow events. They are often used in commercial and industrial settings.

The specific type of cross-connection control device used in a hydronic system depends on factors such as system size, complexity, and local plumbing codes and regulations. In many regions, it is a legal requirement to install and maintain cross-connection control devices to protect the potable water supply and maintain public health and safety.

Regular inspection, testing, and maintenance of these devices are needed to make sure the system is functioning correctly and providing the necessary protection. Additionally, cross-connection control devices should be installed by qualified professionals who are knowledgeable about local plumbing codes and regulations.

Make-up Water Line

The makeup water line in a hydronic heating system is a pipe or connection that provides a means for adding fresh water to the system when needed. It serves several important functions.

Over time, hydronic systems may lose water due to evaporation, leaks, or other factors. The makeup water line allows you to replenish the system with water to maintain the proper water level.

Adding makeup water helps maintain the desired pressure within the hydronic system. Adequate pressure is necessary for the proper circulation of the heating or cooling fluid (usually water or a water-glycol mixture) and the efficient operation of components like pumps, boilers, and radiators.

Makeup water can help prevent the buildup of air within the system, which can hinder heat transfer and system performance. By adding water, you can displace any air that may have entered the system.

The makeup water line should be equipped with a backflow preventer to protect the upstream water from any system contamination.

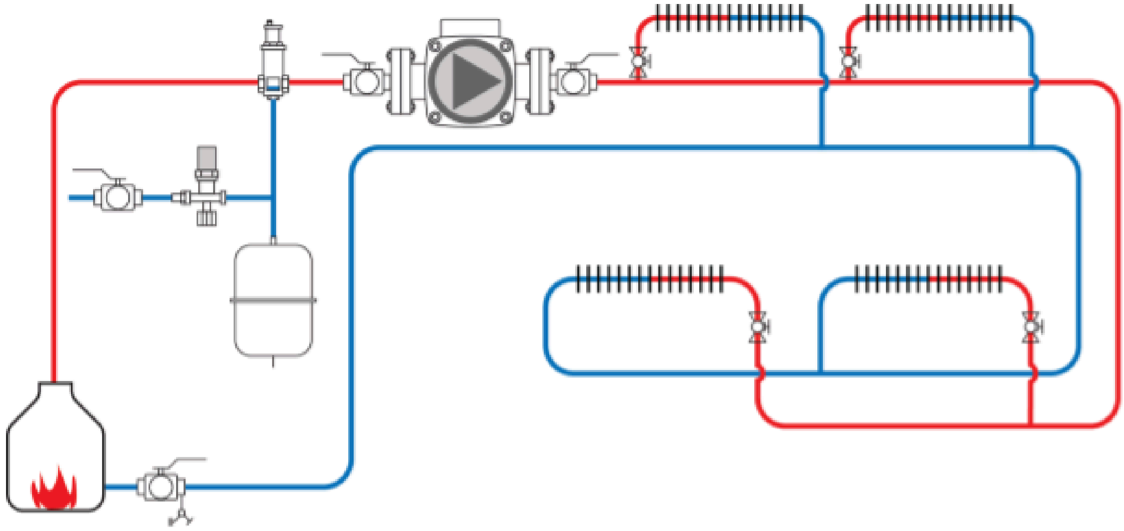

Figure 10. Direct return piping indicating make up water line

Here's how the makeup water line typically works in a hydronic system:

The makeup water line is connected to the system at a point where it can safely introduce water into the system, such as near the boiler or expansion tank.

It may include an isolation valve to control the flow of makeup water into the system. This valve can be manually operated or automated.

In some systems, an automatic makeup water valve is used. This valve is equipped with a float or pressure-sensing mechanism that opens when the system pressure drops below a certain setpoint. It automatically adds makeup water to the system as needed to maintain the desired pressure.

Some makeup water systems may incorporate a backflow preventer to ensure that water flows into the system but doesn't backflow into the potable water supply, preventing contamination.

It's recommended to monitor and control the makeup water carefully to prevent overfilling the system, which can lead to pressure issues or damage. Systems often have a pressure relief valve that can discharge excess pressure if necessary.

Properly maintaining the makeup water system and monitoring the hydronic system's water level and pressure are crucial for the safe and efficient operation of the hydronic heating or cooling system. Regular inspections and maintenance, including checking for leaks and ensuring the makeup water line is functioning correctly, are essential to prevent issues and maintain system performance.

Now complete Self-Test 2 and check your answers.

Self-Test 2

Self-Test 2

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Learning Task 3

Describe the maintenance of hydronic systems, components, and controls

Proper maintenance of a hydronic system helps keep it efficient and reliable. Regular maintenance helps prevent issues, extends the system's lifespan, and maintains comfort levels.

Routine visual inspections of system components, including pipes, valves, pumps, and heat emitters (radiators, baseboard heaters, underfloor heating, etc.) should be performed to keep a system running smoothly. Always look for signs of leaks, corrosion, or damage.

Manufacturers' Specifications

Always refer to the manufacturer's specifications before making any repairs or alterations to a system.

Schedules

A maintenance schedule helps track that all necessary tasks are performed at the appropriate intervals. The specific maintenance schedule for each hydronic system may vary depending on factors like system size, complexity, and local conditions. Some items typically included in preventative maintenance schedules in typical intervals are as follows:

Daily or Weekly Maintenance

Visual inspection – visual inspection of the system components for any issues such as leaks, loose connections, or unusual noises.

Pressure and temperature checks – monitor system pressure and temperature and compare to system expectations outlined in the manufacturer's specifications.

Monthly Maintenance

Air vent inspection – check air vents for proper functioning and bleed air from radiators or heat emitters.

Check for leaks – Inspect the entire system for water leaks, especially at pipe connections, valves, and around pumps.

Quarterly Maintenance (Every 3 Months)

Flushing and cleaning – flush and clean the system to remove sediment, debris, or corrosion buildup especially in heat exchangers, strainers, and filters.

Inspect expansion tank – check the expansion tank's pressure and condition. Test that it's not waterlogged. If it is, drain and recharge or replace it.

Inspect and clean filters – if the system includes filters or strainers, check and clean them regularly to prevent blockages and maintain system efficiency.

Clean heat emitters – clean radiators, baseboard heaters, or underfloor heating components to remove dust and debris that can hinder heat transfer.

Annual Maintenance

Pumps – Inspect and service the circulator pumps, lubricating and cleaning them as necessary.

Verify that zone valves, control valves, and other system controls are functioning correctly.

Water quality analysis – test the water quality, including pH levels and mineral content. Treat the water as needed to control pH levels and prevent scaling or corrosion.

Heating Season (Fall/Winter)

Before the heating season begins, ensure that the system is in good working order. Check and calibrate thermostats and verify that all zone valves are functioning correctly.

Cooling Season (Spring/Summer)

Before the cooling season begins, inspect, and test the system components used for cooling, such as chillers, cooling towers, or fan coil units.

Periodic Maintenance

Balancing Zones – adjust zone valves, control settings, or balance the system as needed to ensure even heating or cooling distribution to all areas of the building.

Sensory Inspection

As discussed in Learning Task 2, use senses to detect potential issues. Seeing leaks, hearing odd noises, and feeling for irregularities, are all effective ways to gather information about the condition of a hydronic system. That information can be used to help perform maintenance on the system and troubleshoot problems when they arise.

Lubrication

Lubricating a centrifugal pump typically means lubricating the pump's bearings. (Figure 11) It is important to note that specific lubrication requirements and procedures may vary depending on the pump manufacturer and model. Always refer to the manufacturer's instructions and guidelines for lubrication and maintenance.

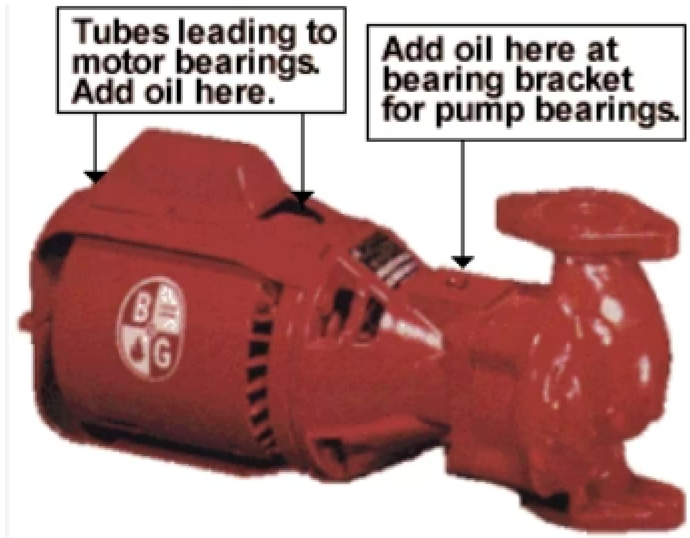

Figure 11. Lubrication ports in a pump

When lubricating a pump, the procedure often goes as follows:

Turn off the pump and check that the electrical power to the pump motor is disconnected to prevent accidental startup. Find the locations of the pump bearings. Centrifugal pumps normally have two bearings: the drive-end bearing and the non-drive-end bearing. Before applying lubricant, clean the bearing housings and surrounding areas to remove any dirt, dust, or debris that could contaminate the lubricant. Consult the pump manufacturer's recommendations to select the appropriate lubricant for your specific pump. The lubricant should be compatible with the pump's operating conditions, temperature, and type of bearings (e.g., ball bearings or sleeve bearings). Depending on the type of lubrication system your pump uses, you may need to prepare lubrication equipment, such as a grease gun or oiling system, to deliver the lubricant to the bearings.

If using grease, apply the appropriate amount of grease to a grease gun. Attach the grease gun to the grease fitting or nipple on the bearing housing. Pump the grease into the bearing until you see fresh grease emerging from the bearing seals or until the manufacturer's recommended quantity is reached. Stop pumping when you observe the purged grease, as over-greasing can cause damage.

If using oil, ensure the oil reservoir is filled to the recommended level. Properly prime and deliver a continuous flow of oil to the bearings. While applying lubricant, check the pump and bearings for any signs of excess heat, unusual noise, or vibration. If you notice any abnormalities, stop the lubrication process, and investigate the issue. After lubricating the bearings, confirm that the lubricant has been evenly distributed and is visible at the seals or oiling points. Once lubrication is complete and the lubrication system is functioning correctly, reconnect electrical power to the pump motor.

Fluids

Poor water quality, including high mineral content and contamination, can contribute to the degradation of system components. Proper water treatment and filtration can help reduce wear and tear on the system.

If glycol is used in the system for freeze protection, monitoring and maintaining the correct glycol concentration is crucial. Inadequate glycol levels can lead to freezing and damage to components.

Wear

Over time, several components will experience wear and degradation. The pipes in a hydronic system are subjected to temperature fluctuations and the flow of water or glycol over time. Pipes may develop corrosion, rust, or scale buildup, which can reduce their efficiency and lead to leaks. The bearings and seals in pumps can wear out, leading to reduced pump efficiency or even pump failure. Boilers can experience wear and tear due to the constant heating and cooling cycles. Components like heat exchangers may develop scale or corrosion, reducing their efficiency. Regular maintenance and descaling can help mitigate these issues. Control valves and zone valves will wear in their seals and moving parts, leading to leaks or reduced functionality. The diaphragm or bladder inside the expansion tank can degrade, affecting the tank's ability to perform its function. Air vents can become less effective, potentially allowing air to accumulate in the system. Pressure relief valves can wear out or become corroded, leading to improper operation. The insulation on pipes, valves, and components can degrade over time, leading to heat loss and reduced system efficiency. Electrical components such as control panels, thermostats, and wiring may degrade over time due to factors like temperature fluctuations and wear.

Noise

Unusual noises in a hydronic heating or cooling system can be indicative of various problems that need attention. Gurgling or bubbling sounds typically indicate the presence of air in the system. This can lead to reduced heat transfer and inefficient operation. Air trapped in the pipes or radiators, insufficient system purging or bleeding, leaks that allow air to enter the system may all be the culprit.

Hissing or whistling sounds could indicate high water velocity or flow restrictions within the system. This can result from obstructed or partially closed valves, overly high pump speed, blockages in pipes, from mineral deposits or debris or inadequate system balancing.

Loud banging or hammering noises, also known as water hammer, are typically caused by sudden changes in water pressure. This can occur when water flow is abruptly stopped or redirected, check valves or zone valves close rapidly or there are loose or damaged pipe hangers or supports.

Clicking or ticking sounds may be due to thermal expansion and contraction of metal components as the system heats up and cools down. This is a normal occurrence but can be amplified if the system lacks proper expansion tanks or if there are loose or poorly insulated pipes.

Harsh sounds like grinding or screeching noises suggest issues with system components, like the pumps or circulators. Other causes could be worn or damaged bearings in the pump, misaligned or damaged impellers or lack of pump lubrication.

Cavitation is often described as a gravel-like noise and occurs when air is drawn into the pump, causing bubbles to collapse. This results from low water levels in the system, leaks or air infiltration, or a pump operating at too high a speed.

Boiling or kettle-like noise, indicates that the system is overheating. This is caused by insufficient water flow through the boiler or heat source, scaling or mineral buildup on heat exchanger surfaces or incorrect temperature settings on the boiler.

Vibrations and rattling sounds occur when components, such as pipes or radiators, are not securely fastened or when there is inadequate insulation to dampen vibrations.

Leaks

Leaks in a hydronic system are visual indicators of issues. When a water stain, or puddle of water is found, make sure to do a thorough investigation for the cause. Some leaks need to be monitored over time as they are hard to track back to the source. Small water spots can be marked and watched for enlargement, while larger or active leaks must be dealt with quickly. Pressure drops, temperature fluctuations, and noises can all be indicators of leaks.

When trying to find a leak, a dye test can be used if all else fails. Dye testing involves adding a fluorescent dye to the system's water or glycol. The dye is not visible under normal lighting conditions but fluoresces under UV light. After adding the dye, inspect the system with a UV light source. Any leaks will be visible as fluorescent traces.

Now complete Self-Test 3 and check your answers.

Self-Test 3

Self-Test 3

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- Figure 11. "Lubrication ports in a pump" from Xylem is used for educational purposes under the basis of fair dealing.

Learning Task 4

Describe troubleshooting and repair procedures for hydronic systems, components, and controls

Client Consultation

A service call happens when a problem is noticed. Much information can be gathered by the client calling for service. Take time to speak with the client before beginning the troubleshooting process.

Inspection/Testing

Sensory

When beginning a diagnosis, use visual indicators like water spots to help find issues such as leaks or a discharging relief valve. Carefully touch the pipes and components, feeling for temperature anomalies that might indicate thermal disequilibrium. Listen to the system for unusual noises that could point towards an overworked pump or unwanted air.

Diagnostic

Troubleshooting something like a no heat service call for a hydronic heating system involves a systematic approach to identify and address the underlying issue causing the lack of heat. There are no short cuts and referencing the manufacturer's specifications is a good place to start.

Other steps to follow may go like this:

- Ensure the thermostat is set to the desired temperature and heating mode (e.g., "Heat" or "Auto").
- Verify that the fan setting is on "Auto" or "On". Test the thermostat – raise the thermostat temperature by a few degrees above the current room temperature to check if the heating system responds.
- Check the power supply – confirm that the heating system has power. Check circuit breakers and switches to ensure they are in the "On" position. Verify that the heating system's emergency switch is in the "On" position.
- Ensure that there is an adequate supply of fuel (e.g., gas, oil) to the heating system.
- Check air filters – inspect and replace dirty or clogged air filters. Restricted airflow can cause overheating and system shutdown.
- Examine the heating equipment – inspect the boiler or furnace for any visible issues, such as loose wires, damaged components, or unusual noises.

- Check for error codes or indicator lights on the equipment's control panel.
- Reset the system – if the boiler or furnace has a reset button, try resetting it to see if the system restarts.
- Verify pump operation – listen for the circulator pump operating. If it's silent, there may be an issue with the pump. Check for signs of circulation, such as water movement or temperature changes in the system.
- Check radiators or heat emitters – touch each radiator or heat emitter to see if it's warm or cold. Uneven heating may indicate air in the system or a circulation problem. Bleed air from radiators if necessary.
- Zone valves – confirm that zone valves are opening and closing as they should. Ensure that thermostat wires and control connections are secure.
- Review error codes – if your heating system has a control panel or display, note any error codes displayed, and consult the system manual or manufacturer for guidance.
- High-temperature limit switch – reset the high-temperature limit switch on the heating equipment (if applicable). This switch can trip in response to overheating.

Monitoring

Implement a maintenance program that includes regular inspections, monitoring of system parameters (pH, oxygen levels), and water quality testing. Keep an eye on the system's performance, especially during the initial hours or days after repairs or venting an airlock.

Lock out/Tag out

Hydronic systems have hazardous energy sources, such as electrical, mechanical, hydraulic, pneumatic, chemical, and thermal energy. Lockout/tagout controls these energy sources, making it impossible for them to be accidentally or unintentionally activated during maintenance or servicing. This prevents accidents related to energy release. Proper LOTO procedures protects the safety and well-being of workers. LOTO also safeguards the integrity of equipment and machinery. When maintenance or repairs are performed on powered equipment, there's a risk of damage if it is not properly de-energized and locked out. Preventing damage to expensive machinery saves both time and money.

Isolate Components

A hydronic system can have many components that could require isolation when troubleshooting. Many will have an electrical source, while others work with the system flow. When performing repairs, proper isolation will be needed to maintain safety. The hydronic system may need to be powered off and all electrical power to pumps, boilers, and other components disconnected. Check for dedicated circuit breakers that can be switched off. A furnace will have a 'on off' switch close by. Most hydronic systems are equipped with isolation valves that allow you to isolate specific components or zones. These valves are typically found on both the supply and return sides of the component. Remember that even after isolating a component, there may be trapped air within the isolated section. Use bleed valves or air vents to release any air from the isolated section to prevent airlocks.

Conditions for Repair/Replacement

Thermal anomalies

- Air in the system
- Flow imbalances
- Blockages or restrictions
- Cavitation
- Scaling and corrosion
- Improper circulation
- Thermostat issues
- Lack of system balancing
- Improper expansion tank functionality
- Incorrect boiler operation
- Inadequate insulation
- Water quality issues
- Thermal expansion and contraction

Any one of these conditions could be the culprit of a thermal anomaly. Once the cause is identified, steps can be taken for repair. Air can be bled from high points and heat emitters. Balancing valves used to better meet design flow requirements. Water conditioners can be added to improve the water quality. An expansion tank can be drained, recharged, or replaced. Pumps and insulation can be repaired and thermostats check for functionality.

Leaks

The repair method you choose will depend on the type and size of the leak. If the leak is at a threaded connection, use a pipe wrench to tighten the fitting. Be careful not to overtighten and potentially damage the threads. If a valve or component is damaged and causing the leak, replace it with a new one. The replacement component must match the specifications of the original. For small to moderate leaks on pipes, you can use pipe repair clamps designed for temporary or emergency repairs. For minor leaks or small cracks, you can apply pipe sealant or pipe repair tape to seal the area. Make sure the surface is dry and clean before applying. For major leaks, the pipes or components will need to be isolated with a nearby valve or a whole system shutdown, and then replaced.

Corrosion

Corrosion can lead to equipment damage, reduced heat transfer, and system inefficiencies. Choose corrosion-resistant materials like stainless steel, brass, or copper for pipes, fittings, valves, and heat exchangers. Proper system design helps prevent corrosion. The system must be designed to minimize the presence of oxygen in the water, as oxygen can promote corrosion. Closed-loop systems with minimal air infiltration will be best for eliminating air. Air elimination devices, such as air vents are needed to remove dissolved oxygen and trapped air from the system.

Maintain water quality by using demineralized or deionized water with low mineral content, which can reduce the risk of scale and corrosion. Properly treat and condition the water to control pH levels and minimize the potential for scaling or acidic corrosion. Use chemical inhibitors or water treatment chemicals that are specifically designed to prevent corrosion. These chemicals can create a protective layer on metal surfaces, inhibiting corrosion.

In some cases, cathodic protection systems can be employed to protect metal components from corrosion. These systems use sacrificial anodes or impressed current systems to protect vulnerable metals from corrosion.

Before commissioning a new system, flush it thoroughly to remove any debris, flux, or contaminants. Regularly flush and clean the system as part of routine maintenance to prevent the buildup of corrosion-inducing particles.

A relatively new product is a magnetic filter. Magnetic filters or dirt separators in the system are used to capture and remove ferrous particles that can promote corrosion. Expansion tanks must be correctly installed and sized for the system to accommodate thermal expansion without introducing excessive oxygen. Seal potential points of oxygen ingress, such as improperly sealed air vents or improperly fitted components. Consider using non-metallic components (such as plastic or composite materials) in areas of the system where corrosion is a concern. Ensure proper venting of the system to remove air and reduce the presence of oxygen. Maintain water temperatures within the recommended range for your specific system to minimize the potential for corrosion.

Control Malfunction

If a control is malfunctioning, it will need to be repaired or replaced. The replacement part will need to meet the system specifications and may require a system shut down and draining for installation. Removal of a component can be difficult and potentially dangerous. Make sure shut down procedures are followed and potential pressure is relieved before loosening a component. Also, confirm the supports around the component are secure and will hold the weight of the surrounding piping before removing anything.

Vibration

Excessive vibration can lead to accelerated wear and tear on system components. Vibrations can disrupt the smooth flow of water or glycol in the system. This can lead to flow restrictions, uneven heat distribution, and reduced system efficiency. Vibration often produces audible noise, which can be disruptive and annoying to building occupants. This noise can interfere with comfort levels and may lead to complaints. Vibrations can loosen pipe connections, valve seals, and other fittings in the system. This can result in leaks, which not only waste water but also pose potential structural and property damage risks. Vibrations can contribute to system imbalance, causing some areas of a building to receive inadequate heating or cooling while others receive too much. Excessive vibration can compromise the structural integrity of system components, such as pipe supports or hangers. This poses safety risks, as components may become dislodged or fail catastrophically.

Properly securing and fastening pipes and components to minimize movement. Balancing the system to ensure even flow distribution. Using vibration-dampening materials or isolators (Figure 12) to reduce vibration transmission. Installing expansion tanks and flexible connectors to absorb thermal expansion and contraction.

Figure 12. Isolation pads

Irregular Flow

- Air in the system
- Blockages or restrictions
- Imbalanced flow distribution
- Pump problems
- Valve malfunctions
- Thermal expansion and contraction
- Cavitation
- Piping issues
- System imbalance
- Water quality issues
- Pump cavitation

Like thermal anomalies, irregular flow can be cause by a list of things. After troubleshooting the system and identifying the issue or issues, steps can be taken to repair or replace the culprit.

Air Lock

An airlock in a hydronic heating or cooling system can disrupt the flow of water, reduce the system's efficiency, and lead to issues like uneven heating or cooling.

- Turn off the power to the hydronic system to prevent electrical hazards.
- Determine the location of the airlock by observing the symptoms, such as reduced flow or gurgling noises in the system. Common locations for airlocks include pipes, radiators, or components like zone valves.
- If the airlock is in a radiator or heat, use a radiator key or a suitable tool to open the bleed valve at the top of the radiator. Turn it counterclockwise slightly until you hear air escaping. Allow the air to escape until a steady stream of water comes out without sputtering or hissing. Be prepared to catch any water that comes out. Close the bleed valve by turning it clockwise. Repeat this process for all affected radiators or heat emitters.
- If the airlock is in pipes or components, such as pumps, valves, or zone controls, you can use manual venting to release the trapped air. Locate the air vent or bleeder valve on the affected component. These are typically small, screw-like devices. Place a container or bucket under the vent valve to catch any water that may come out. Use a wrench or pliers to open the vent valve by turning it counterclockwise. Be cautious, as air or water may escape. Wait until all the air has been expelled and a steady stream of water flows from the vent valve. Close the vent valve by turning it clockwise. Repeat this process for all affected components.
- After venting air from the radiators and components, turn the heating or cooling system back on. Verify that water flows evenly through the system without any unusual noises. Monitor the system for any signs of air returning. If air continues to be a problem, you may need to investigate further for underlying issues, such as leaks or improper system design.

Return to Service

After completing repairs, slowly open any isolation valves that were closed during maintenance to allow the flow of water or glycol through the system. If components were isolated, open any bleed valves or air vents to release any trapped air in the system. Start with the highest points in the system and work your way down. Continue bleeding until only water flows, without air bubbles.

Monitor the system pressure gauges to ensure that the pressure remains within the recommended operating range and make necessary adjustments. Go through the sensory checks, also making adjustments as needed. Call for heat and confirm that the system responds. Allow the system to operate for a period of time, monitoring it closely for any irregularities, leaks, or performance issues. If the hydronic system serves a building, inform the occupants or building managers that the system is back in operation and complete the client consultation.

Documentation

Documenting the troubleshooting and repair process provides a clear record of the activities performed, verifies compliance with regulations, and serves as a reference for future maintenance or troubleshooting. It is important to follow any specific documentation requirements or guidelines provided by local authorities, regulatory bodies, or industry standards when commissioning fixtures and appliances.

Now complete Self-Test 4 and check your answers.

Self-Test 4

Self-Test 4

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Version	Date	Change	Details
1.00	May 6, 2025	Book published.	