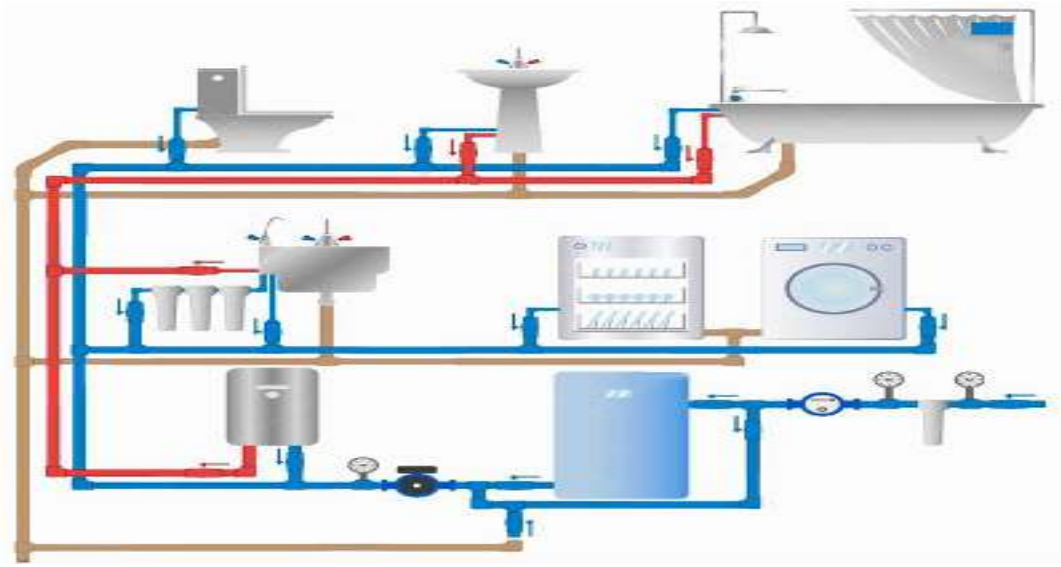
PLUMBING INSTALLATION LEVEL III

Based on October 2023, Curriculum Version II



Module Title: - Installation and Commissioning hot and cold water services

Module code: EIS PLI3 M11 1023

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Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

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Acknowledgment

The Ministry of Labor and skill wishes to thank to MOLS experts, TVET trainers, university instructors and industry experts who contribute their time and professional experience to the development of this Training module for plumbing installation.

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Acronyms

AV..... Air Vent

B..... Boiler

BD.....Bidet

BT .....Bath Tub

CW .....Cold Water

FD .....Floor Drain

FL .....Flow line

HW .....Hot Water

HWB .....Hand Wash Basin

KS .....Kitchen Sink

MH .....Man Hole

RD .....Roof Drain

S .....Sink

ST .....Septic Tank

V .....Vent

VS.....Vent Stack

WC .....Water Close

WH .....Water Heater

YD .....Yard Drain

Introduction to Module

Hot and Cold water systems in buildings are used for washing, cooking, cleaning and other specialized functions. Cold water for buildings is also known as potable water. Non-potable is supplied in some countries; this is not for drinking or cooking. Water services should be designed and installed in accordance with the recommendations of EBCS/Ethiopian building cod and standard/, the Water Regulations, relevant statutory regulations, byelaws, other relevant Ethiopian Standards and manufacturers' recommendations.

This module is designed to meet the industry requirement under the plumbing installation occupational standard, particularly for the unit of competency: installation and commissioning hot and cold water service.

This module covers the units:

- Basics for hot and cold water service
- Installation requirement of hot and cold water service
- Connections and test service
- Commission water services

Learning Objective of the Module

- Internalize basics for hot and cold water service
- follow installation requirement of hot and cold water service
- Install connections and follow test testing procedure
- Define commission water services

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Read the identified reference book for Examples and exercise

Unit one – Basics for hot and cold water service

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Drawings and specifications
- Safety (OHS) requirements
- Terminologies
- Planning and sequencing tasks
- Material, tools and equipment

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Obtain drawings and specifications.
- Adhere Safety (OHS).
- Identify the terminologies and symbols of hot and cold water service
- Plan and sequence tasks.
- Identify material, tools and equipment

Overview of hot and cold water

Hot and Cold water systems in buildings are used for washing, cooking, cleaning and other specialized functions. Cold water for buildings is also known as potable water. Non-potable is supplied in some countries; this is not for drinking or cooking. Water services should be designed and installed in accordance with the recommendations of EBCS/Ethiopian building cod and standard/, the Water Regulations, relevant statutory regulations, byelaws, other relevant Ethiopian Standards and manufacturers' recommendations.

1.1. Drawing and specifications

Design drawings are developed to a level of detail necessary to prepare a clear, coordinated visual depiction of all aspects of the works. Major project elements including overall layout, earthworks equipment, mechanical, electrical, structural, and water supply systems are designed and depicted through coordinated scale drawings and detailed elevations and plans.

Technical specifications describe the project design and construction practices, technical standards, specifications and principles to be followed during construction.

Technical specifications may specify a performance goal (a performance specification) or procedures used to meet the performance goal (design specification). A performance specification permits flexibility and change.

In general, the scope and detail of technical specifications will depend on the nature and complexity of the project. Technical specifications should form part of all construction projects. The level of adherence to the design drawings and technical specifications ultimately determines the quality of the project and influences the performance of the constructed works.

The objectives of the design drawings and technical specifications are to

- Provide a detailed record of the design of the project
- Set standards for the technical aspects required in the construction
- Set standards for the execution of the construction
- Set standards for documenting the design, tendering and construction process.

Design drawings

Design drawings for construction contain all the information necessary for the construction contractor to bid on and build a particular project.

Typically, the preparation of design drawings provides a detailed record of the design and structural requirements of the works. A contract or tender document often references design drawings.

Design drawings should show details on layout, measurements, plan, cross-sectional and vertical profiles.

This information is prepared as scale drawings of the works to be constructed. Design drawings should be presented in such a way that

- The project can easily be understood
- They visually communicate the concept to the lot feeder and the construction contractor
- They are legible
- They include all information from previous revisions and updates.

The design drawings should include the following aspects

- Site layout and the location of the works to be constructed
- Plan views
- Detailed designs and cross-sectional profiles of the works
- Dimensions and units gradients
- Titles and scales that meet the required standards and units
- Adequate labeling
- Elevations that are referenced to meters
- Be dated and signed by the designer

Technical specifications

Specifications describe the products, materials, and work required by a construction contract. They do not include cost, quantity, or drawn information, and so need to be read alongside other information such as quantities, schedules, and drawings

A contract or tender document often references technical specifications about the specific requirements and construction standards for various elements of a project. This includes how the work will be done, the quality of workmanship and methods of testing.

Typically, construction projects require construction of various elements and use of various materials. More than one technical specification may be required for the whole project. For example, a construction project may require individual technical specifications for

- Earthworks
- Erosion and sediment controls
- Concrete works
- Building works
- Electrical systems

For small projects, the material and construction specifications may be documented in the form of notes on the design drawings. For larger projects, a separate specification document is more practical. Designers will usually have suitable standard technical specification documents.

However, as a guide a specification might include

- Descriptive title, number, identifier etc. Of the specification
- Date of last effective revision and revision designation
- A logo or trademark to indicate the document copyright, ownership and origin
- Table of Contents (TOC) if the document is long
- Person or office responsible for questions on the specification,
- Updates and deviations
- The significance, scope or importance of the specification and its intended use
- Terminology, definitions and abbreviations to clarify the meanings of the specification
- References and Standards used or to be complied with
- Test methods for measuring all specified characteristics
- Material requirements: physical, mechanical, electrical, chemical

- Targets and tolerances
- Acceptance testing, including performance testing requirements and tolerances
- Workmanship
- Certifications required
- Safety considerations and requirements
- Environmental considerations and requirements
- Approval authority considerations and requirements
- Quality control requirements, acceptance sampling, inspections, acceptance criteria
- Person or office responsible for enforcement of the specification
- Completion and delivery
- Provisions for rejection, reinsertion, rehearing, corrective measures

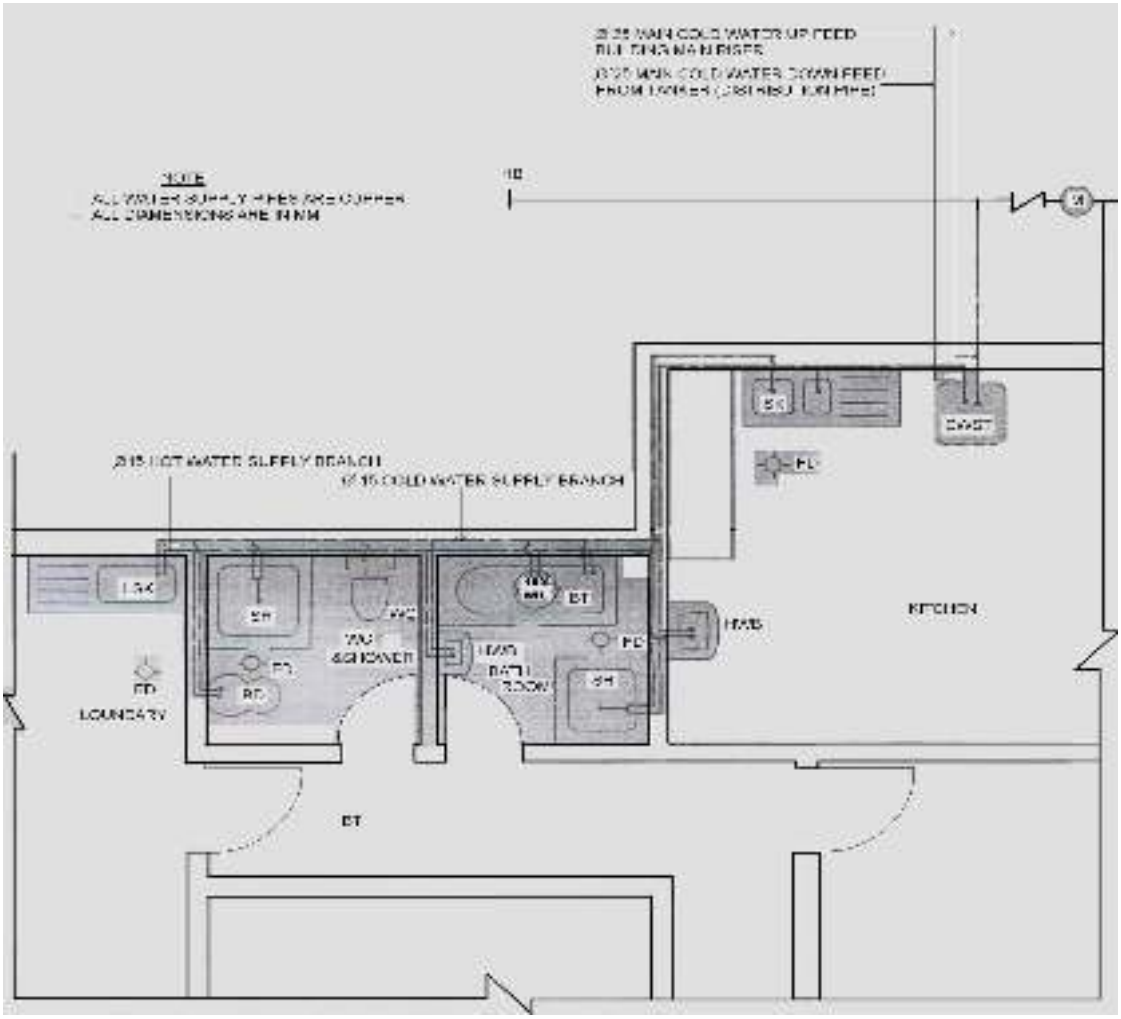


Figure 1. 1 Sample plumbing plan

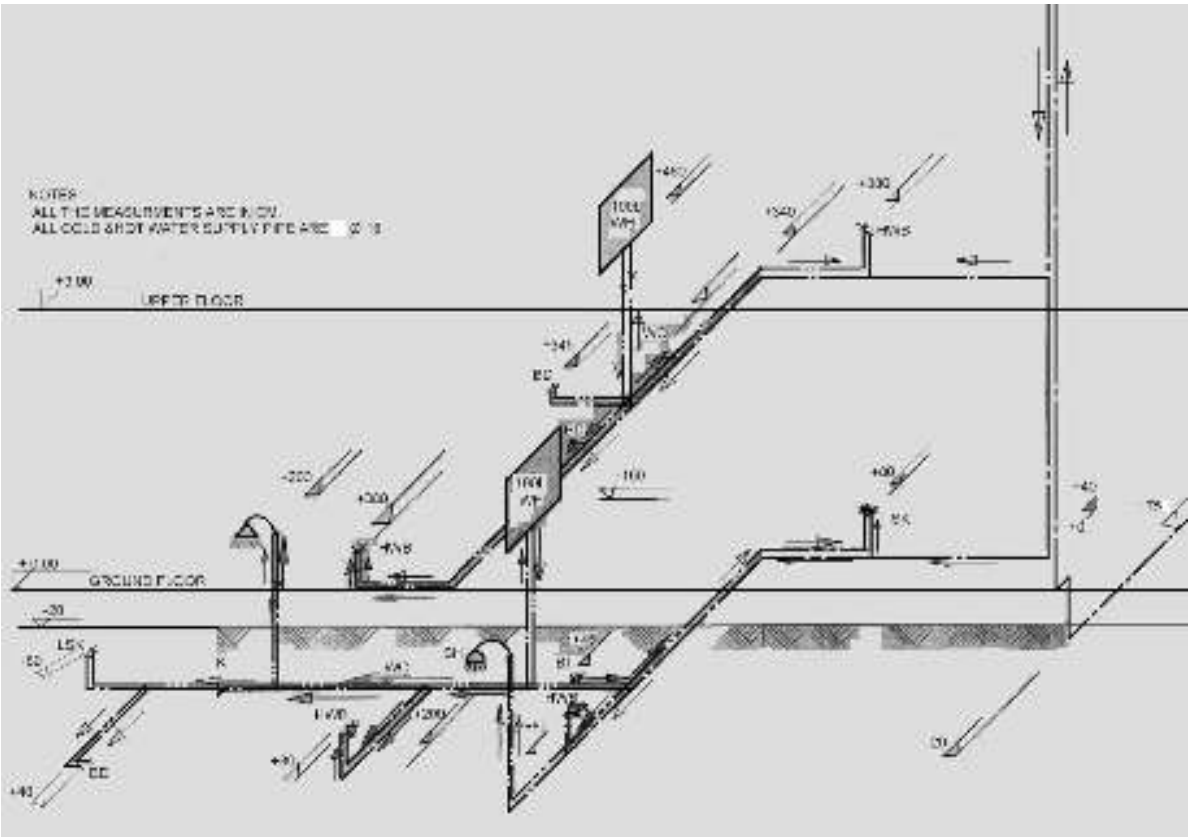


Figure 1. 2 Sample riser diagram of G^{+1} residential

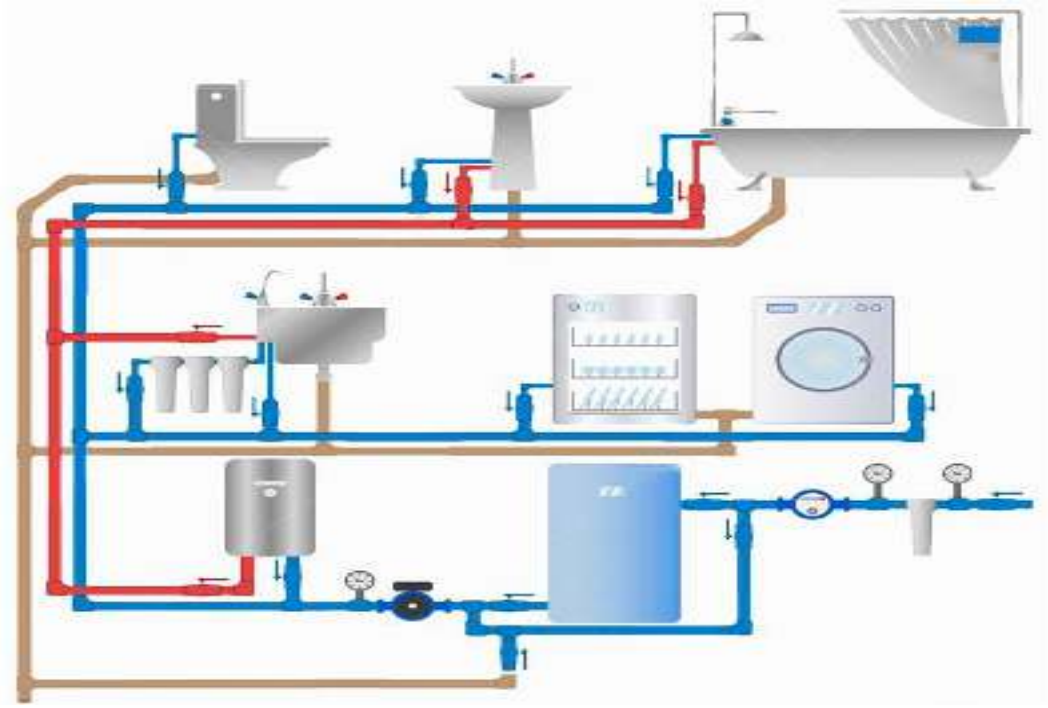
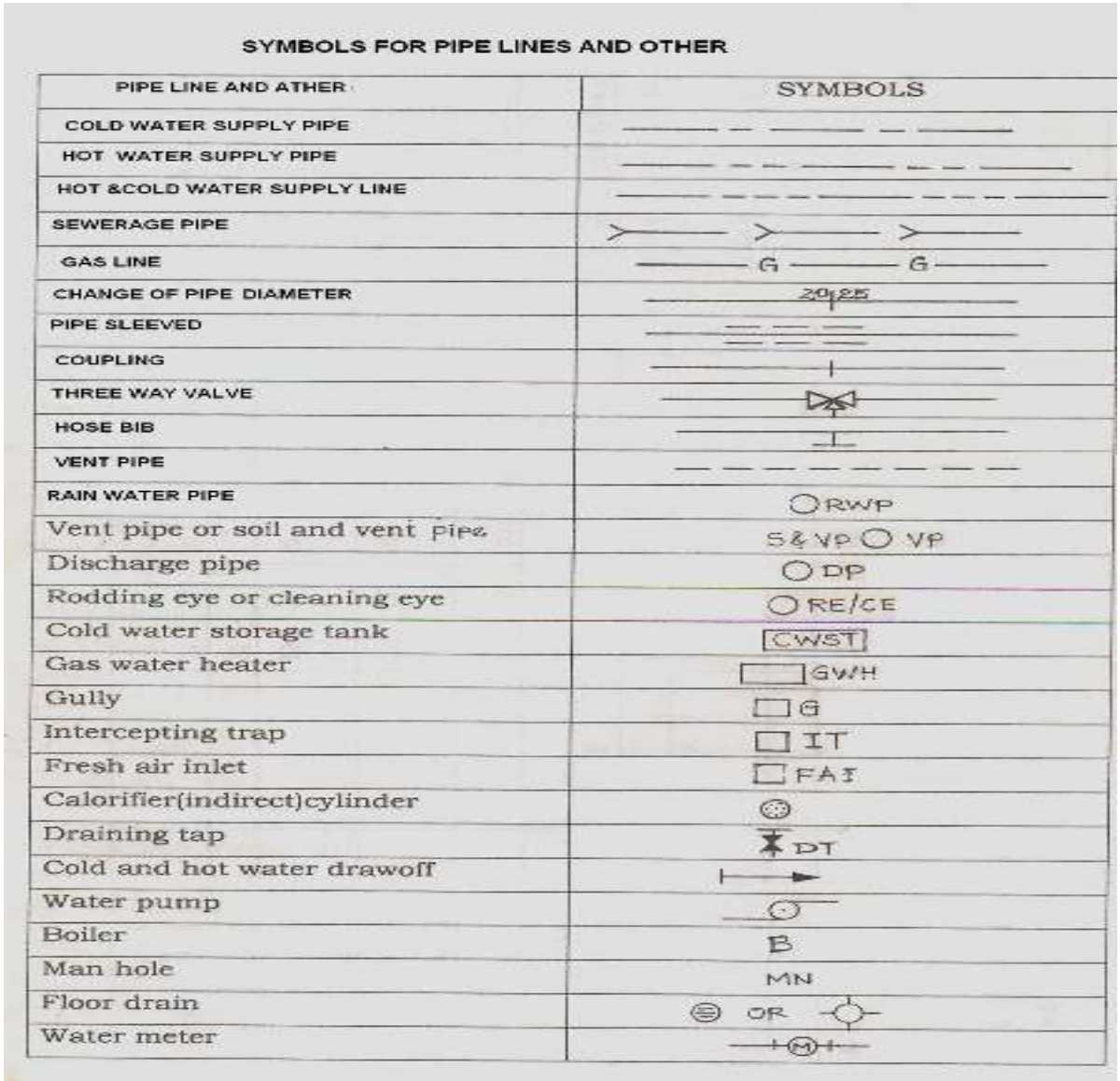


Figure 1. 3 Sample riser diagram of G^{+1} residential

1.1.1. Symbols of plumbing system

The plumbing symbols are the basic elements to show the functions. Symbol-based communication is often used by individuals who are unable to communicate using speech alone and who have not yet developed, or have difficulty developing literacy skills. Symbols offer a visual representation of a word or idea. The following are some of symbols and abbreviations in hot and cold water service system.



SYMBOLS FOR PIPE LINES AND OTHER

PIPE LINE AND ATHER	SYMBOLS
COLD WATER SUPPLY PIPE	
HOT WATER SUPPLY PIPE	
HOT &COLD WATER SUPPLY LINE	
SEWERAGE PIPE	
GAS LINE	G G
CHANGE OF PIPE DIAMETER	20ø25
PIPE SLEEVED	
COUPLING	
THREE WAY VALVE	
HOSE BIB	
VENT PIPE	
RAIN WATER PIPE	RWP
Vent pipe or soil and vent pipe	S&VP VP
Discharge pipe	DP
Rodding eye or cleaning eye	RE/CE
Cold water storage tank	CWST
Gas water heater	GWH
Gully	G
Intercepting trap	IT
Fresh air inlet	FAI
Calorifier(indirect)cylinder	
Draining tap	DT
Cold and hot water drawoff	
Water pump	
Boiler	B
Man hole	MN
Floor drain	OR
Water meter	M

Figure 1. 4 Symbols of plumbing system

Symbol	Description	BS 1192 Ref.	Application
	pump (centrifugal)	7.609	
	pump (circulating)	7.608	
	automatic air vent	7.224	
	insulation	2.209 2.210	
s	sink (elevation)		s
wb	wash basin (elevation)		wb
	bidet (elevation)		
	bath (elevation)		
wc	water closet (WC) (elevation)		
	urinal bowl (elevation)		

Figure 1. 5 Symbols of plumbing system

1.2. Safety Requirement (OHS)

Personnel engaged in the operation and maintenance of water supply is dealing with important and dangerous equipment and devices. Important in a sense is that the water supply is life matter to the community and dangerous in that the electrical or mechanical parts can cause death or harm if not operated and maintained safely with knowledge.

Hence, safety measures shall always be considered or safety training should be provided to operators and maintenance personnel. Operation and maintenance procedures for electromechanical equipment shall be over ruled by the specific manufacturer's manual provided with the specific equipment, and only in the absence of the manufacturer's manuals that procedures of this manual can be applied.

To start with the safety measures, the utility shall be equipped with:

- A complete first aid kit with alcohol, medicines, bandages, splints, etc.
- A complete set of compulsory tools shall be procured by the utility and be used appropriately.
- One fire extinguisher at the generator house
- Never dismantle any component without proper knowledge to inspect
- Never dismantle any piece or part before knowing that an appropriate and working part is available at the utility.

For all maintenance services,

- The operator should ensure that he has adequate illumination,
- Sufficient work space and secure footing.
- He should not wear loose clothing and jewelry near moving parts.
- He should wear gloves, a safety hat, safety boats and safety goggles as required.

1.2.1. Safety Precautions when using tools

A high percentage of accidents in operation and maintenance are caused by improper use of tools. In this regard, there are several safety measures to be taken, listed as:

- Select the proper tool for the specific job
- Inspect tools and repair or replace damaged or worn once.
- Do not leave tools in places where they may fall and hurt others.
- Do not use tools on moving machinery or equipment
- Allow sufficient clearance and ensure solid footing when preparing to use tools.
- Learn and apply the proper method for using the tool
- Wear eye protection when using impact tools, chipping, wire brushing etc.

1.2.2. Safety precautions when handling electrical equipment:

- It is good practice to wear rubber gloves when starting electric motors
- Operators should be required to stand on rubber mats or wear rubber shoes when handling switch gear.
- During any electrical repair, the power line feeding the equipment to be repaired should be isolated
- High voltage circuits and panels should be repaired only by competent electricians
- Do not touch equipment, cables or any metal that touches, or is in danger of touching, high voltage lines.
- Only approved and inspected extension cords should be used.
- Electric hand tools should always be grounded.
- No electric equipment is to be handled while in contact with water.

1.2.3. Personal Protective Equipment

Appropriate PPE should always be wear whilst working in and around the generator set. Wear a hard hat, protective glasses, gloves and other protective equipment, as required by generator set location.

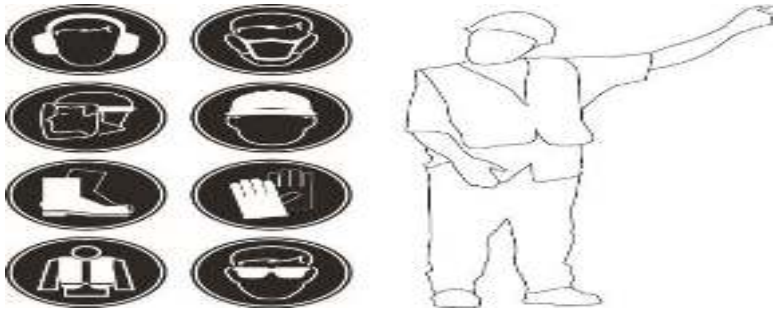


Figure 1. 6 Typical PPE to be wear by an Operator

When work is performed around a pump engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.

- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the pump engine.
- Ensure that all protective guards and all covers are secured in place on the engine.

Never put maintenance fluids into glass containers. Glass containers can break.

- Use all cleaning solutions with care.
- Report all necessary repairs.
- Unless other instructions are provided, perform the maintenance under the following conditions:
- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

1.2.4. General Hazard Information

- Pressurized Air and Water
- Pressurized air and/or water (not recommended) can cause debris and/or hot water to be blown out which could result in personal injury.
- When pressurized air is used, wear protective clothing, protective shoes and eye protection. Eye protection includes goggles or a protective face shield.

1.2.5. Containing Fluid Spillage

Care must be taken to ensure that fluids are contained during inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

1.2.6. Disposal of Waste

Improper disposal of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations. Always use leak proof containers when you drain fluids. Do not pour waste onto the ground, down a drain, or into any source of water.

1.2.7. Fire and Explosion

- All fuels, most lubricants, and some coolant mixtures are flammable.
- Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire.
- Fire may cause personal injury and property damage.
- Do not allow any flammable materials to accumulate on the engine.
- Store fuels and lubricants in properly marked containers away from unauthorized persons.
- Store oily rags and any flammable materials in protective containers.
- Do not smoke in areas that `are used for storing flammable materials.
- Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.
- The batteries must be kept clean; the covers (if equipped) must be kept on the cells.

Warning

- Do not charge a frozen battery, this may cause an explosion.
- Ensure the generator set room is properly ventilated.
- Keep the room, the floor and the generator set clean. When spills of fuel, oil, battery electrolyte or coolant occur, they should be cleaned up immediately.
- Never store flammable liquids near the engine.
- Avoid refilling the fuel tank while the engine is running.
- Do not attempt to operate the generator set with any known leaks in the fuel system.

Fire Extinguisher

- Fuels and fumes associated with generator sets can be flammable and potentially explosive. Proper care in handling these materials can dramatically limit the risk of fire or explosion. However, safety dictates that fully charged BC and ABC fire extinguishers are kept on hand.
- Personnel must be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

Figure 1. 7 Exhaust Gases

1.3. Terminologies in hot and cold water service

The development, construction, installation and maintenance of hot and cold water supply systems are vital areas of concern for public health. Water quality is by turns a political, environmental and technical issue. It is governed by legislation, water regulations, building regulations and technical standards intended to safeguard quality.

At present it is not a legal requirement that anyone installing or repairing domestic water services should be properly qualified. However, the installer or repairer can be prosecuted for offences under the water regulations or could be prosecuted under civil law by a householder. With increasing pressure to maintain the highest standards of health and safety and to prevent waste, misuse or contamination of water it is important that technical knowledge is up-to-date.

Definitions

The following definitions are used:

Backflow a flow of water in the opposite direction to that intended. It includes back siphon age, which is backflow caused by siphon age.

Building any structure (including a floating structure) whether of a permanent character or not, and whether movable or immovable, connected to the water supplier's mains.

cavity wall any wall whether structural or partition that is formed by two upright parts of similar or dissimilar building materials suitably tied together with a gap formed between them which may be (but need not be) filled with insulating material.

Chase a recess that is cut into an existing structure.

Cover a panel or sheet of rigid material fixed over a chase, duct or access point, of sufficient strength to withstand surface loadings appropriate to its position.

Inspection access point a position of access to a duct or chase whereby the pipe or pipes therein can be inspected by removing a cover which is fixed by removable fastenings but does not necessitate the removal of surface plaster, screed or continuous surface decoration.

Cistern means a fixed container for holding water at atmospheric pressure.

Combined Feed and Expansion Cistern means a cistern for supplying cold water to a hot water system without a separate expansion cistern.

Combined Temperature and Pressure Relief Valve means a valve cap- able of performing the function of both a temperature relief valve and a pressure relief valve.

Concealed Water Fitting means water fitting that:

- Is installed below ground;
- passes through or under any wall, footing or foundation;
- Is embedded in any wall or solid floor;
- Is enclosed in any chase or duct; or
- Is in any other position which is inaccessible or renders access difficult.

Contamination includes any reduction in chemical or biological quality of water due to raising its temperature or the introduction of polluting sub- stances.

Distributing Pipe means any pipe (other than a warning, overflow or flush pipe) conveying water from a storage cistern, or from hot water apparatus supplied from a cistern and under pressure from that cistern.

Overflow Pipe means a pipe from a cistern in which water flows only when the water level in the cistern exceeds its normal maximum level.

Pressure Flushing Cistern means a WC flushing device that utilizes the pressure of water within the cistern supply pipe to compress the air and thus increase the pressure of water available for flushing a WC pan.

Pressure Relief Valve means a pressure-activated valve which opens automatically at a specified pressure to discharge fluid.

Primary Circuit means an assembly of water fittings in which water circulates between a boiler or other source of heat and a primary heat exchanger inside a hot water storage vessel.

Secondary Circuit means an assembly of water fittings in which water circulates in supply pipes or distributing pipes to and from a hot water storage vessel.

Secondary System means that part of any hot water system comprising the cold feed pipe, any hot water storage vessel, water heater and flow and return pipework from which hot water is conveyed to all points of draw-off.

Stop Valve means a valve, other than a servicing valve, for shutting off the flow of water in a pipe.

Temperature Relief Valve means a valve which opens automatically at a specified temperature to discharge water.

Vent Pipe means a pipe open to the atmosphere which exposes the system to atmospheric pressure at its boundary.

Warning Pipe means an overflow pipe whose outlet is located in a position where the discharge of water can be readily seen.

Cold Water means water at a temperature less than 85°F.

Hot Water means water at a temperature of 110°F (43°C) or higher. Hot and cold water are made of the same type of molecules. Each molecule has one oxygen and two hydrogen atoms. The difference between them is the speed of the molecules jiggling around.

1.4. Quality assurance

1.4.1. Introduction to quality assurances

Quality assurance is a part of quality management that makes sure that everybody is doing everything properly in every stage of the production process**.** Quality assurance is a way of preventing errors or defects in manufactured goods or services.

A quality assurance system aims to boost customer confidence. It also attempts to improve the company's credibility. Additionally, it focuses on improving work processes and efficiency so that the company can compete with rivals more effectively. The word 'quality' refers to how good something is. It contrasts with the word 'quantity. 'If somebody says '**how much** 'or '**how many**,' they are referring to quantity. If, on the other hand, they say '**how good**,' they are referring to quality.

1.4.2. Quality assurance – part of quality management

Quality assurance (QA) is part of quality management, which refers to everything a company does to make sure that it produces and delivers its goods and services to specifications and at the appropriate cost.

People who work in quality management pay attention to product and service quality and also the means to achieve it. Four main components make up quality management:

- Quality planning.
- Quality assurance.
- Quality control.
- Quality improvement.

Figure 1. 8 Quality assurance

1.4.3. Quality Assurance on water supply installation

Quality Assurance: a system of documented procedures and plans established to ensure that the water monitoring program produces data of known precision and bias. This includes staff training programs, calibration processes, written procedures and record keeping. The local supplier of cooling water variable speed pumping system must have relevant expertise in all aspects of design, application engineering, installation, programming, interfacing, commissioning and after sales service. Supplier must have, as a minimum, commissioned 25 sets of cooling water.

A water supply system includes everything from the collection of the source water through to the point of use. When developing this QAP for the General Store water supply system the following questions were addressed:

- What problems could occur between the water source and the point of use?
- How can they be prevented or fixed?
- How do you know that the problem has been prevented or fixed?

The answers to these questions help to determine how to:

- Assess and protect the quality of the source water
- Make sure treatment processes are appropriate, maintained and working properly

- Regularly test the water quality
- Make the water supply safe if contamination has occurred
- Make sure that water users are warned and/or provided with safe drinking water if the normal supply is found to be unsatisfactory or the quality cannot be guaranteed.

Keeping the water supply system safe involves:

- Identifying who is responsible for the system and who will respond to issues
- Understanding hazards to your water sources
- Making sure the water is stored and distributed safely
- Treating the water to remove or control any contamination
- Monitoring the quality of the water and the integrity of the water supply system

1.5. Planning and sequencing tasks

Planning is a complex process that can take many forms. There are different kinds of planning and different ways of planning. There are many planning tools. Knowing what kind of planning is needed for what situation is a skill in itself. This toolkit is intended to help you sort out what kinds of planning you need when, and the tools that are appropriate to your needs. The toolkits that deal with strategic planning, action planning and monitoring and evaluation will give you more details of how to carry out the actual processes.

Planning is the systematic process of establishing a need and then working out the best way to meet the need, within a strategic framework that enables you to identify priorities and determines your operational principles. Planning means thinking about the future so that you can do something about it now. This doesn't necessarily mean that everything will go according to plan. It probably won't. But if you have planned properly, your ability to adjust, without compromising your overall purpose, will be that much greater.

These six processes are performed in chronological order and represent the 6-step process in developing a project schedule**.**

- Plan Schedule Management.
- Define Activities.
- Sequence Activities.
- Estimate Activity Resources.
- Estimate Activity Durations.
- Develop Schedule.

Keep planning and organizing work activities simple in order maximize effectiveness.

- Determine Specific Tasks. Brainstorm all required tasks throughout the day.
- Prioritize and Sequence Tasks. Group tasks together.
- Set Realistic Timetables.
- Remove Potential Distractions

1.6. Materials, tools and equipment

1.6.1. Hot water and cold water materials

Water supply pipes are the pipes which carry drinking water from the boundary of a property into the property itself. They are important in light of the need to reduce leakage and concerns over lead in drinking water supplies, yet their ownership and responsibility is often confused.

Various types of pipes are used for water supply system including metallic and non-metallic pipes.Most common types of pipes used for water supply system are:

- Galvanized Iron Pipes – Metal pipe
- Mild Steel Pipes metal pipe
- Poly Vinyl Chloride pipes - non- metal pipe
- High Density Poly Ethylene Pipes - nonmetal pipe
- Ductile Iron Pipes For water mains,

Mainly GI and MS pipes or even large HDPE pipes are used,while for branch/service pipes, most commonly used are galvanized iron and HDPE/PVC pipes.

Pipe fittings

Pipe fittings are components used to join pipe sections together with other fluid control products like valves and pumps to create pipelines.

A fitting is used in pipe and plumbing systems to connect straight pipe or tubing sections, to adapt to different sizes or shapes, and for other purposes, such as regulating or measuring fluid flow.

Figure 1. 9 Plumbing fittings

Valves: Valves are equipment designed to stop or regulate flow of any fluid (liquid, gas, condensate, stem, lorry, etc.) in its path. Various types of valves are available depending upon the type of construction as follows:

1. Gate valve - used for isolation only
2. Plug valve - used for isolation
3. Globe valve – used for throttling
4. Butterfly valve - used for isolation as well as throttling
5. Check valve - used for preventing reverse flow (non-return)
6. Diaphragm valve - used for isolation as well as throttling
7. Ball valve - used for isolation only

Plumbing Fixtures

Plumbing fixture is a part (such as a sink, toilet, faucet, etc.) that is attached to a system of pipes that carry water through a building

Plumbing fixtures are receptacles intended to receive water, liquid or water-carried waste and discharge them into the drainage system. Plumbing fixtures comes in varieties of style and accessories designed to match with the room for cosmetic reasons.

Some of sanitary fixtures are:-

- Shower
- Hand wash basin
- Water closet
- Kitchen sink and other

1.6.2. Tools and equipment

Selection of material handling equipment is an important decision as it affects both cost and efficiency of handling system. You must use hand and power tools correctly and safely in all aspects of the construction industry, and at all worksites and locations.

Hand and power tools have improved significantly in recent years, and an increasing range is available for almost every task and for different types of materials. Improvements in design and technology now make tools and equipment more widely available, less expensive, and generally more reliable with correct use and maintenance.

Improved instructions are available from manufacturers and suppliers, and guidelines and codes of practice assist to illustrate correct use and to identify hazards and risks.

1.6.3. Identifying tools and equipment for installing hot and cold water supply

- **Measuring tools: -** used to measure the length of pipe

Tap rule

Rollo meter

- **Marking tools: -** used to marking the measured pipe and other apparatus**.**
    - Pen
    - Scriber
    - Pencil
- **Cutting tools:** - this type of hand tools is used to cutting different type of pipe**.**

Hack saw

Pipe cutter

- **Treading tools: -** treading tools are used to cutting the internal and external thread of pipe for preparing pipe for fixing with fittings

Diestock: - for external thread

Taps: - for internal thread

- **Fastening and loosening tools: -** this is used to fixing and loosening pipes and fitting's and nuts

Pipe wrench

Adjustable spanner

Screwdriver/flat Philips/

- **Holding tools: -** this is bench vice, pipe vise, chain vise

Pipe vice

chain vise

- **Bending tools: -** this type of hand tools used to bending the pipe for different purpose

Hand bender

Hydraulic pipe bender and Manual pipe benders

Preparing work areas to support the efficient installation of hot and cold water service

1. Cleaning Work area.

- All excess material should not be wasted, but used or safely removed from site according to appropriate legislation.
- Identify the installation types that are likely to be produced and aim to reduce the amount of waste as much as possible, through identifying routes to reuse or recycle materials.
- Control access to storage areas to minimize risk of theft or damage.
- .Store any materials away from sensitive locations in fenced off areas.
- Label all waste storage and skips, detailing the type of waste.
- Employ a just-in-time policy to deliver materials in order to reduce the storage time on site.

2. Cleaning Tools and equipment

Proper tools and equipment are essential for the effective operation of any civil works site. Equipping the construction site with the correct tools and equipment plays an essential role in achieving timely and good quality results. For every construction activity there is an optimal combination of tools, equipment and labor.

Depending on the nature and content of the works, the technical staff needs to know which tools to use and how to effectively combine them with manual labor. Once on site, equipment requires trained operators and supervisory staff who are proficient in its operation and maintenance.

Faulty equipment is a common reason for delays on construction sites.

A major responsibility of the project management is to ensure that tools and equipment are maintained in a good condition and are readily available when required for the various work activities. In such cases, using light construction equipment can increase the efficiency of work.

Finally, tools and equipment need regular maintenance, requiring good workshop facilities, a reliable supply of spare parts and qualified mechanical stat.

Self-check -1

Directions: Answer all the questions listed below.

Part I: Fill in the blank space

1. _____ are equipment designed to stop or regulate flow of any fluid
2. _____ is used to fixing and loosening pipes and fitting's and nuts

Part-II: Choose the correct answer from the given alternatives

1. _____ is the systematic process of establishing a need and then working out the best way to meet the need.

   A. Excavation B. Panning

   C. Plumbing D. All

a. _____Describe the products, materials, and work required by a construction contract.

   A. Document B. Specification

   C. Data D. All

Part- III: write the answer briefly for the following question.

1. What is the difference between plan and specification?
2. Define the term planning?
3. Define hot water?
4. List basic plumbing tools and equipment for water supply installation?

Note: **Satisfactory rating - 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Unit two – Installation requirement of hot and cold water service

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Hot and Cold water service
- Sustainability principles and concepts
- material and equipment estimation

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Obtain hot and cold water service
- Follow sustainability principles and concepts with regulatory body
- Identify materials and equipment is estimated from drawings or job specification.

2.1. Hot and cold water service

Cold water and hot water supply systems are elementary systems that are present in every building. Ethiopian building codes and standard for cold and hot water supply systems includes the design of the pipe route, the pipe size, location of water tanks and sizing of pumps.

2.1.1. Hot water service

Hot water is an essential building service used for washing, cleaning, drinking, cooking, and heating and so on. It requires energy to heat water, and the type of hot water system installed in a building has a direct impact on its energy consumption. The main design considerations are the fuel type that will be used, whether the hot water will be generated locally or centrally and whether it will be stored, or generated on demand.

Components of a typical hot water system are:

1. The central heating system which supplies hot water to radiators located around a building. Radiators are heat exchanging devices that use the heat from hot water (or sometimes steam) to warm the surrounding space.
2. Domestic hot water supplied to taps and sometimes to appliances. Domestic hot water' as water that has been heated for cooking, food preparation, personal washing or cleaning purposes. This can be generated instantaneously when there is a demand, or stored in a hot water cylinder/tank. The term 'domestic' is used irrespective of the type of building in which the hot water system is installed (i.e. it does not have to be a domestic building).

Types of hot water system

1. Localized Hot Water System:

It is a single point heater system, which heats water locally (i.e. one heater will serve one appliance /fixture). It is installed at some height above the fixture; hence less pipe work is needed.

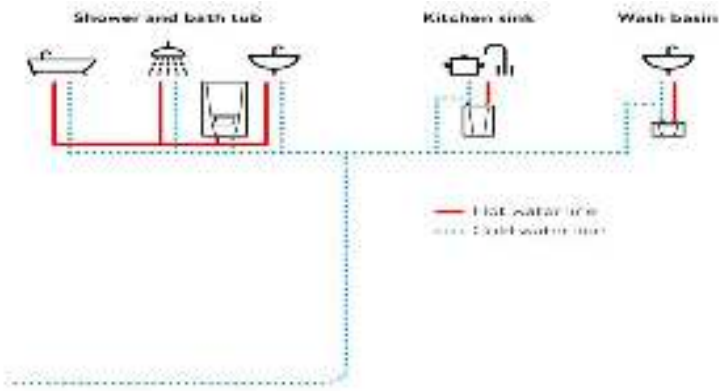


Figure 2. 1 Localized Hot Water System

2. Centralized Hot Water System:

It is a multiple point heater system, which heats water for all appliances/fixtures. Here one heater will serve hot water to all appliances of a house. It is installed at a place from where it is convenient to supply water at all fixtures.

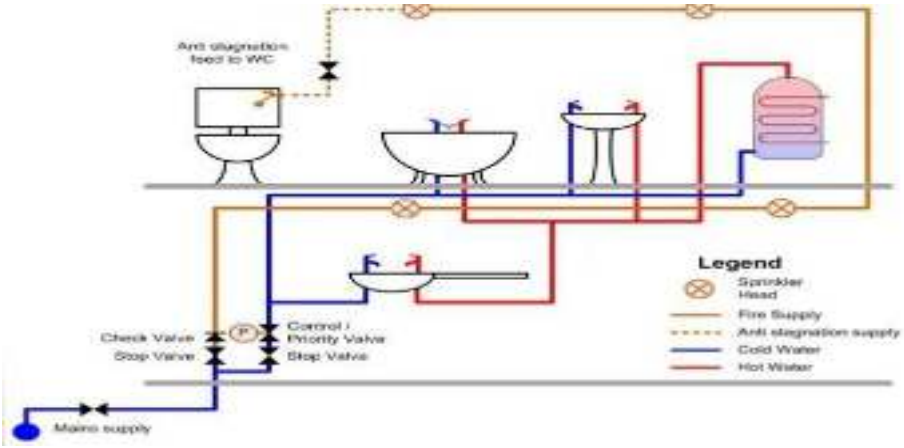


Figure 2. 2 Centralized hot water system

Depending upon the number of appliances to be served with hot water in a house, hot water system is either localized or centralized. For more number of appliances centralized hot water system is beneficial (3 – 4 bathrooms one water heater will supply hot water at all fixtures) and for less number of appliances, localized hot water system is beneficial for a row house with 1 - 2 bathroom/s separate heater for each bathroom is provided. Hot water system in a house consists of water heater, hot water pipes and taps (faucets).

Cold water is fed to water heater, where it gets heated and it is then conveyed through hot water pipes to the faucets and appliances.

However, using a centralized hot water system may need extra care, as occurrences of the common problems such as noisy pumps, cold spots, leaks or radiators often need bleeding; are very common.

Water Heaters either work on electricity or are fuel powered (combustion of wood, coal, charcoal, gas, oil) or uses renewable energy sources i.e. Solar Energy.

Methods of water heating

Based on the method of heating water, water heaters are of two types:

1. Instantaneous Water Heater:/ tank less water heater/

Instantaneous water heater consists of switch, small pressure vessel with heat exchanger and a pilot lamp (a lamp that lights up when heater is ON). When hot water tap is turned on, cold water passes through heat exchanger via pipes, where it is heated and hot water flow comes out of the tap. It is installed when small quantity of water is required for long duration of time and at any time. Geysers are the instantaneous water heaters for household water heating. It gives continuous hot water supply all time without storing it.

2. Storage type water heater:

These are designed to store hot water. It consists of a thermally insulated vessel (tank), thermostats (an indicator device that blinks when water is heated), one or more electric heating elements and hot water pipes. In storage type water heater, water is first collected in tank. The water in tank is heated. It is then supplied at various appliances. Storage type water heaters are used where a large quantity of water is required over a short duration of time, such as bathtubs.

It does not provide hot water supply continuously as water is first filled in the container (heater), and then it is heated.

Once the hot water is emptied from tank, one has to wait for water in tank to get heated. Solar Water Heater, boiler, Electrical hot water tank are types of Storage type Water Heater. It is mandatory that in hot water system the pressures of the hot water and the cold water should be made equal at each fixture, especially where mixing faucets are to be used.

Source energy for water heater system

There are different ways of heating water. Depending on the resources available the technologies used can be:

- Electric water heaters
- Solar water heaters
- Gas water heaters

1. **Electric water heaters**: an electric water heater is an appliance that uses electricity, instead of gas, to heat the water that will be used throughout a home. Electric water heaters can heat water in a tank, or is tank less, and can also heat water in a central location, or at the point of use. Water heater works is by simply converting the electrical energy into heat through the heating element to raise the temperature of the water to a particular degree.

Figure 2. 3 Electric water heaters

2. Solar water heaters

Solar energy (sun rays) is used for heating water. Water is easily heated to a temperature of 60-80o C. Solar water heater of Solar water heaters (SWHs) of 100-300 liters capacity are suited for domestic use. Larger systems can be used in restaurants, canteens, guest houses, hotels, hospitals. The device has collectors which absorb the radiations of sun and converts it into heat. Then, with the help of circulating pumps, this heat is passed to a water tank. Thermal regulators trigger this exchange only when the collector is hotter than the water inside the tank.

Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive, which don't.

Figure 2. 4 Solar water heater

3. Gas water heater

A gas water heater is a tank that heats water from a gas-fired burner located at the bottom of the tank. Cost, convenience and efficiency are some of the advantages of gas for heating your home's water. In addition to being cheaper than electricity, a natural gas supply is more reliable. In the event of a power outage, your gas supply isn't affected. However they involve a more complex and costly installation process, especially if the home has multiple bathrooms. They have a lower life span compared to an electric water heater

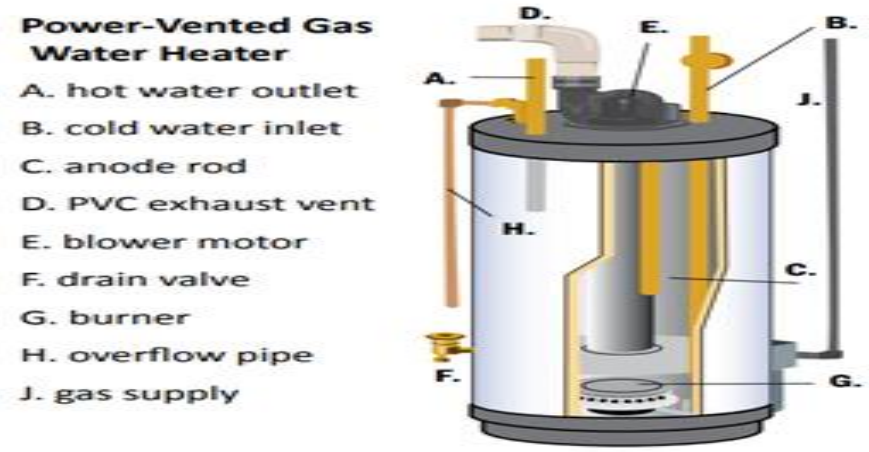


Figure 2. 5 Gas water heater

Component of a hot water supply system

Here is a list of the common components you will find in a hot water supply system:

Hot water cylinder – this is where the hot water for household uses is stored. Its size depends on the number and types of fixtures installed in your house.

Boiler – used to heat up water, as needed, and send it to the cylinder. Some boiler systems are also designed to produce and store hot water even without relying on cylinder storage; these are called combination boilers.

Pumps – moves the heated water from the boiler through pipes inside your home, into radiators and hot taps.

Controls – controls when heating begins and stops, depending on whether there's demand for hot air or not. The controls may be manual (timer-operated), semi-automatic (thermostat), or fully automatic (weather compensator).

Storage tanks – allow you to use an additional source of heating for your hot water needs, mainly renewable energy sources such as solar power or heat pumps. These storage tanks are quite large because they need enough space to hold all the heated water from your primary heating source (usually an oil-fired boiler).

Heat loss from the pipe

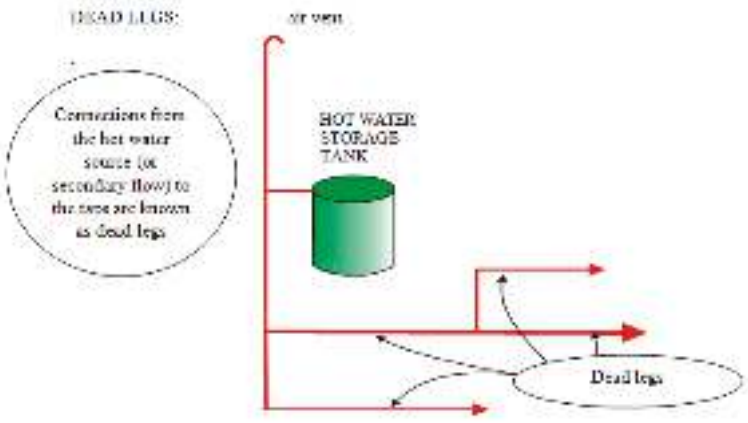


Figure 2. 6 dead legs

Dead legs occur in hot water systems where water does not move for a period of time. In central systems there are pipework linking the central supply with the draw-off points. Between draw-offs the water in the pipe will cool and the next draw off will involve running the cold water to waste before it reaches the tap, creating dissatisfaction, waste of water and heat.

In these systems in order to keeps consumption within reasonable limits dead legs of pipework serving hot-water taps are governed to following maximum lengths:

Table2. 1 Limits of pipe length

Pipe diameter	Maximum Length (m)
20 mm	12 m
25 mm	7.6 m
More than 25 mm	3 m
Spray taps	1 m

Avoid Dead Legs

To avoid dead legs in plumbing systems there are two common approaches;

1. Install a secondary return pipe.
2. Maintain the water temperature at all times with trace heating.

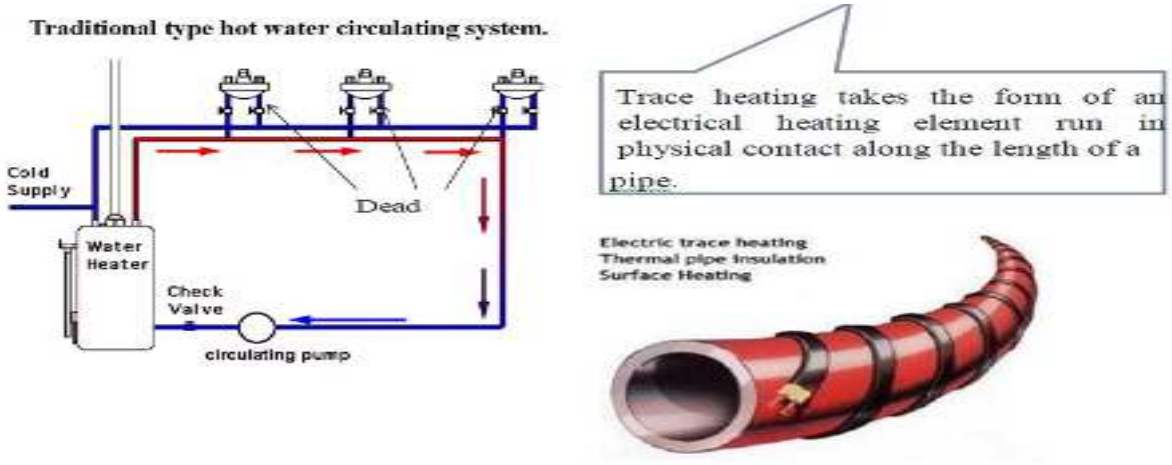


Figure 2. 7 dead legs avoiding mechanisms

Estimation of hot -water storage

The following table used to indicate average daily demand of one person for each activity and the average demand of hot water for public institutions

Table2. 1 daily demand of one person

APPLIANCE	VOLUMES OF HOT WATER (Liters)
WAS H BASIN	
Hand wash	1.5
Wash	3
Hair wash	6
SHOWER	13
BATH	70
WASHING MACHINE	70
SINK	
Wash up	15
Cleaning	5

Table2. 2- Public institution hot water demand

Hot Water Consumption vs. Occupants						
Type of building	Consumption per occupant		Peak demand per occupant		Storage per occupant	
	liter/day	*gal/day*	*liter/hr*	*gal/hr*	*liter*	*gal*
Factories (no process)	22 - 45	5 - 10	9	2	5	1
Hospitals, general	160	35	30	7	27	6
Hospitals, mental	110	25	22	5	27	6
Hostels	90	20	45	10	30	7
Hotels	90 - 160	20 - 35	45	10	30	7
Houses and flats	90 - 160	20 - 35	45	10	30	7
Offices	22	5	9	2	5	1
Schools, boarding	115	25	20	4	25	5
Schools, day	15	3	9	2	5	1

2.1.2. COLD WATER SERVICE

Cold water means water at a temperature less than 85°F. The benefits of drinking cold water are endless. Drinking cold water can help you

- lose weight,
- Hydrate your body and even boost your metabolism rate.
- While cold water has a lot of health benefits,

It is important to understand that you should not consume cold water if you have a cold, cough or flu.

Components of Cold Water Systems

Cold water systems are typically composed of several components, including a storage tank, a pump, a pressure regulator, and a water treatment system. The storage tank is used to store water and ensure a steady supply of cold water throughout the day. The pump is responsible for moving water through the distribution system, while the pressure regulator ensures that the pressure is maintained at a safe level. Finally, the water treatment system is used to purify the water and remove any impurities or contaminants.

The cold water supply system has the following components:

- Cold water tank
- Rising main
- Water meter
- Stop valve
- Water mains
- Cold water storage tank

Water meter

To measure the amount of water used, a water meter is installed at the beginning of the supply pipe. The water meter works on the principle of displacement or velocity giving a reading in meters per hour. It is made of a cast iron or cast steel body with an inner mechanism that can be removed with little difficulty for servicing.

Water meters are generally classified as either positive displacement meters, which are more precise and intended for measuring large flow rates, or velocity type meters, which use impeller blades to measure flow rate and are suited for smaller flows such as those found in residential homes. Modern domestic water meter designs fall into one of three categories: single-jet (velocity), multi-jet (displacement), and oval gear type (displacement).

Stop valve

The stop valve is usually located next to the water meter. It is a brass valve that can be turned to shut off the water supply. This typically takes the form of a gate valve (shown below) or a ball valve. The stop valve is sometimes referred to as a stopcock, and it allows for simple water isolation for installations such as taps, showers, and toilets.

Stop valves are generally installed in areas where there isn't already another type of isolation method. For example, if your house has copper pipes instead of plastic pipes, you may have an isolation valve fitted onto each tap as well as having an overall stopcock fitted before the rising main from the meter.

Rising main

Water is a serious business. It's vital to your health, and it gets turned on and off in your house multiple times a day (or, at least, it should). If there's one thing that can go wrong with any water system—and there are many—it's a rising main. Essentially, this is where the water pressure from your house rises above the threshold of the pipes' capacity. Every pipe immediately starts pouring water into every other pipe until all of them overflow or back up into the street. In turn, this can cause problems with your toilet flushing, sprinklers flowing erratically in your yard and garden, and even just dripping water on people waiting for the bus.

Cold water flow rates for sanitary appliances for small installations may be found from the table below

Table2. 3 - Flow rates for sanitary appliances

Approximate hot or cold water demand	Flow rate (l/s)
Basin (spray tap)	0.05
Basin (tap)	0.15
Bath (private)	0.30
Bath (public)	0.60
Flushing cistern	0.10
Shower (nozzle)	0.15
Shower (100mm rose)	0.40
Sink (15mm tap)	0.20
Sink (20mm tap)	0.30
Wash fountain	0.40

2.2. Sustainability principles and concepts

A definition of sustainability is important because we need to agree on what 'sustainability' is before we can implement it. The EA Sustainability Policy (second paragraph) states, 'For our members, sustainability means that future generations will enjoy environmental, social and economic conditions that are equal to or better than those enjoyed by the present generation.

The principles of sustainability are the foundations of what this concept represents. Therefore, sustainability is made up of three pillars: the economy, society, and the environment. These principles are also informally used as profit, people and planet.

The five principles of sustainable development are as follows:

- Conservation of the ecosystem or the environment.
- Conservation of biodiversity of the planet.
- Sustainable development of the society.
- Conservation of human resources.
- Population control and management.

The concept of (environmental) sustainability arose out of the growing recognition that human activity is affecting many of the Earth's critical resources not only locally but now also at a global scale, and with potential effects on human as well as ecological health.

Among the many problems, there has been depletion of ocean fisheries, over-exploitation of the great aquifers, an unprecedented rate of species loss, increasing problems of waste disposal, and changes to the gaseous composition of the lower and middle atmosphere.

Recognition of such problems led to the notion of sustainability, which implies development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In the 1980's a major initiative was established under the aegis of the United Nations to address issues of environmental sustainability.

Its Agenda 21is a comprehensive plan of action to be taken globally, nationally and locally. Principles of sustainable development are now intrinsic to several of the Millennium Development Goals (MDG)[2] eight anti-poverty targets that the world committed to achieving by 2015, adopted in 2000, aimed at an array of issues that included slashing poverty, hunger, disease, gender inequality, and access to water and sanitation.

These were updated to the UN Sustainable Development Goals. Otherwise known as the Global Goals, they build on the MDG, showing the value of a unifying agenda underpinned by goals and targets.

2.3. Material and equipment estimation

A material estimate is also known as a quantity takeoff, a construction takeoff or a material takeoff. It refers to taking off information from the blueprints about the materials and how much of them are needed for the build.

2.3.1. Material identification and estimation

1. Material identification

The operation and maintenance of water systems involves the use of a variety of types of materials, usually considered in two categories — supplies and spare parts. Supplies refer to consumable items, often purchased in bulk, usually for general use, such as paint, cleaning rags, lubricating oil, bolts, and common pipe fittings. "Spare parts" refers to specific replacement components associated with particular facilities, equipment or machinery, such as bearings, gaskets, or other specific components.

Sometimes it will be difficult to label a particular item a supply or a part. Such precise definitions are not really important, however. These distinctions are merely a device for cost estimating. The main point is to recognize that some items are multipurpose items which are used regularly and some have specific uses. The basic process for estimating material costs is to determine what items will be needed, how much of each, and the unit costs of each. Thus, information will be needed on:

- Details on all equipment, facilities, and components in the system;
- Details on the nature and frequency of O&M tasks to be performed;
- Unit costs for parts and supplies to be used.

In any water system planning effort, information on these topics will be generated. The engineering design should have complete information on the first item. An O&M plan should have information on the second. Any available records will help in estimating corrective maintenance tasks.

Local cost data will have to be collected for the third topic. Developing a complete, comprehensive list of materials should take a considerable amount of work, but, unfortunately, a detailed tabulation of material needs is the only way to an accurate cost estimate of materials.

A detailed list of parts and supplies will also be very useful in project planning, project operations, and procurement planning; therefore, effort spent in planning now will pay off later.

Estimating Material Requirements

The starting point for the analysis would be a list of equipment, machinery, or facilities in the water system. Whether the project is a completely new system, or an expansion of an existing one, the engineering studies should provide a complete design for:

- Intake structures;
- Reservoirs;
- Pumping stations;
- Transmission pipelines;
- Treatment plants;
- Elevated storage tanks;
- Distribution piping;

However this course is focuses on distribution system of hot and cold water supply system.

Table2. 4- Sample format of material identification for given project

No	Material type	Specification	Quantity
Pipes			
1.	Pipe	Galvanized ½ inch	4
2.	Pipe	Ppr ½ inch	2
Fittings			
3.	Flanged tee	Flanged pipe	10
4.	Gully trap	U - PVC type	5
Fixtures			
5.	Water closet with all accessories	Aqua	4
6.	Shower tap		3

2. Material estimation

Costs Once a list of the material annual costs can be tabulated each item and adding up these items and quantities has been developed, the by multiplying annual quantity by unit price for products. Unit costs should be available from local suppliers or from records of previous purchases of these materials. It will be important to ensure that correct unit costs are used. Unit costs often vary considerably from place to place and year to year. Table 2. 6, which follow, show some sample unit costs for galvanized water pipe for a variety of countries.

In all locations, costs increase with diameter, as expected. The costs vary widely, however, from one country to the next. In Ethiopia, for example, where pipe is imported, costs can be higher than in locations where pipe is produced locally or in a neighboring country. Additionally based on transportation cost the price of material is varying in different region and zones.

The next table shows that the example of average prices of different hot and cold water service materials

Table 2. 5- Sample format of material identification for given project

No	Types of material	Size	unit	Quantity	Unit cost	Unit price ETB
1.	Galvanized steel pipe	½ inch	Pcs	1	750	750
2.	Galvanized steel pipe	¾ inch	Pcs	1	950	950
3.	HDPE pipe	½ inch	Meter	1	50	50
4.	HDPE pipe	¾ inch	Meter	1	60	60
5.	PPR pipe	½ inch	Pcs	1	400	400
6.	PPR pipe	¾ inch	Pcs	1	500	500
7.	PVC pipe	50 mm	Pcs	1	400	400
8.	PVC pipe	110mm	Pcs	1	600	600
9.	UPVC	110mm	Pcs	1	950	950
10.	GS elbow	½ inch	Pcs	1	40	40
11.	GS tee	½ inch	Pcs	1	40	40
12.	GS gate valve	½ inch	Pcs	1	150	150
					Total project material cost	4890 ETB

2.3.2. Equipment identification and estimation

1. Equipment identification

Equipment is a tangible long-term asset that benefits a business over several years of use. Computers, trucks and manufacturing machinery are all examples of equipment. They are tangible because they have a physical form—unlike intangible assets (such as patents, trademarks or copyrights) that do not. In this course the required equipment are:-

- Pressure testing
- Polypropylene random welding machine

Equipment estimation

As indicate above there are two equipment that are required to work each hot and cold water service

No	Items	Specification	Quantity	Price /ETB
1.	Pressure testing	5 bar	1	7500
2.	Ppr welding machine	½ Inch to 2 Inch	1	8000
		Total equipment cost		15500

Self-check - 2

Directions: Answer all the questions listed below.

Part I: Fill in the blank space

1. _____ is a multiple point heater system, which heats water for all appliances/fixtures
2. _____ electric water heater is an appliance that uses electricity, instead of gas

Part-II: Choose the correct answer from the given alternatives

1. _____ heater consists of switch, small pressure vessel with heat exchanger and a pilot lamp (a lamp that lights up when heater is ON)

   A. Instantaneous heater B. solar heater

   D. Gas heater D. All

2. _____ Is a tangible long-term asset that benefits a business over several years of use..

   B. Consumable material B. equipment

   C. pipe D. All

Part- III: write the answer briefly for the following question.

1. How dead legs occur?
2. Define Agenda 21?

Note: **Satisfactory rating - 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Unit three – Connections and test service

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Installation method and procedure
- Testing connections

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Obtain installation method and procedure
- Follow testing procedure of connections

3.1. Installation method and procedure

3.1.1. Methods of water supply installation

Water supply is the provision of water by public utilities, commercial organizations, community endeavors or by individuals, usually via a system of pumps and pipes. The methods of installations are

1. Direct water supply

In a direct system water is supplied at mains pressure to all cold water taps/faucets, WC (toilets) cisterns and a cold water storage cistern/tank if hot water is to be supplied from an open vented (low pressure) hot water cylinder.

This is an 'unbalanced' cold water system because the cold water outlet pressure at taps/faucets is higher than the hot water from the open vented cylinder. To have a balanced cold water system the cold water storage cistern must be removed and the open vented hot water cylinder replaced with a mains pressure supplied unvented hot water cylinder. The pipe circuit for cold water distribution in the home branches off after the pressure reducing valve on the supply pipe thereby balancing the system enabling equal cold and hot water pressure at all draw-offs (outlets).

However, the trade off with the use of an unvented cylinder is that you no longer have stored cold water for toilet flushing in the event of a mains water failure. With a direct cold water system you have the advantage of being able to draw drinking water from any cold water taps/faucets in the house.

Advantages of direct water system

1. Save in pipework in multistory buildings.
2. Fresh drinking water is available at all draw-off points
3. Cold water distribution pipe from the cistern being omitted
4. In systems without cistern there is no risk of polluting the water from this source

Disadvantages of direct water system

1. There is a danger of foul water from the sanitary fittings being siphoned back into the main water
2. During peak periods, there is a tendency for the lowering of pressure If there is a main burst, there is no store of water.

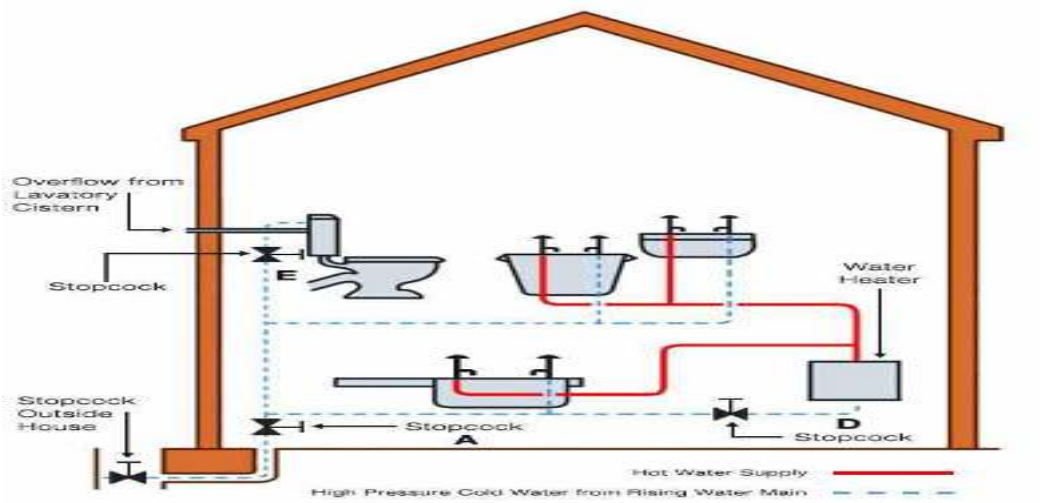


Figure 3. 1- Direct water supply

2. Indirect water supply

An indirect cold water system is when water is supplied to the house at mains pressure, this water is fed directly to a cold water storage cistern via the supply pipe called the 'rising main'.

A branch pipe off the rising main delivers drinking water to the kitchen and garden tap/faucet, cold water to all other taps/faucets and appliances is provided indirectly from the cold water storage cistern (not for drinking) under gravity pressure not mains pressure.

The hot water storage cylinder is also supplied with cold water from the same cistern. With an indirect cold water system there is always a temporary back up of stored water in the event of a mains failure. Also, because it is a low pressure system it is generally quieter therefore eliminating noise like 'water hammer' which can occur when high pressure water tries to negotiate tight bends in the pipework.

Indirect cold water systems do slightly reduce the risk of impure water being siphoned back into the mains water supply by having fewer outlets (taps/faucets and appliances) connected to the mains supply.

However, this can easily be protected against in both the direct and indirect cold water system by installing a non-return valve or check valve immediately after the main stop-valve supplying water to the house. This would be good practice.

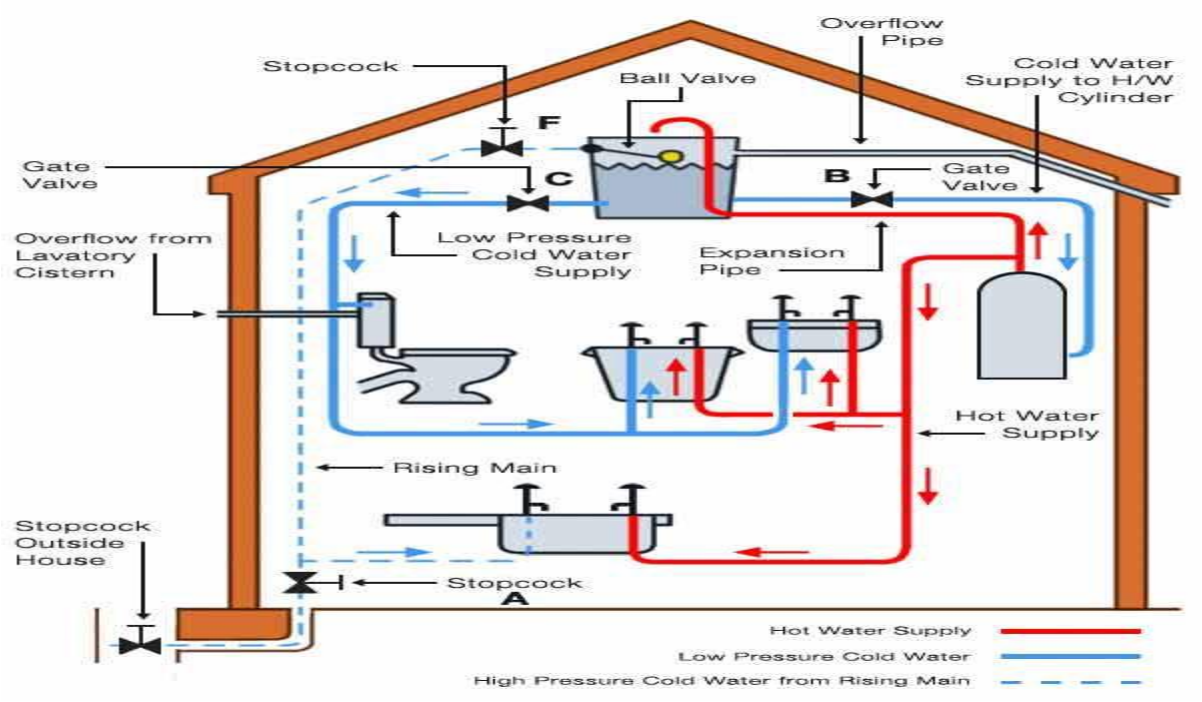


Figure 3. 2- Direct water supply

Advantages of indirect water system

1. Large capacity cistern provides a reserve of water during interruption of supply
2. Water pressure on the taps supplied from the cistern is reduced, which minimizes wear on taps and noise, therefore there is no tendency of pipe bursting
3. Fitting supplied with water from the cistern are prevented from causing pollution of the drinking water by back siphon age
4. Lower demand on the water main

Disadvantages of indirect water system

1. Longer pipe runs are required
2. A larger storage cistern is necessary
3. Fresh Drinking Water is only available at the kitchen sink (or single point)

3.1.2. Labels and signage for non-drinkable water services

Labels are written or printed matter accompanying an article to furnish identification or other information. Signage is any printed material in a store that guides or informs customers, such as posters. Safety labels are most commonly made of an adhesive backed vinyl material to apply directly to a surface; and. safety signs are constructed from a hard-backed material designed to attach to walls, doors, fencing and more.

Big warning signs may reveal dangerous locations or lead people to safe zones. Smaller tags, such as allergy caution labels and electrical hazard stickers, may alert consumers of the presence of harmful components. Some of labels and signage of non-drinkable water services are as follow:

Figure 3. 3 labels and signage of plumbing work

3.1.2. Hot and cold water installation procedure

Water installation means an assembly of pipes, fittings and apparatus which are used to convey or store water for consumption or use by the occupant of the home.

The procedure of hot and cold water installation

- Prepare for work
- Protect your personal and environmental safety
- Read and interpret plan and specification

- Identify the required hand tools
- Identify and estimate the quantity of material
- Measure, cut and fix jointing of cold and hot water pipe lines.
- Install sanitary fixtures like, WC, KS, and other appliances based on drawing and plan.
- Test the water line based on testing procedures.
- Clean up your work place.

3.2. Installation testing and recording

All newly installed mains must be pressure and leakage tested prior to final acceptance Pipeline testing also known as hydrostatic testing, pipeline testing is used to test the integrity of a pipeline. This is used in the commissioning stage as well as during pipeline maintenance programs. The pipeline products used during this process include pipeline plugs and testers.

Hydrostatic test

Hydrostatic testing is the process of pressurizing a hose or pressure vessel with water to a specific pressure. Holding the pressure for a duration of time, and testing for strength and leaks. Hydrostatic (or hydraulic) pressure testing evaluates the strength, integrity, and reliability of pipework, vessels, and other components designed to contain fluids or gases.

After the pipework, components, and system have been installed and inspected, it will be filled with a liquid – typically water – before pressuring it to a specified or calculated level. This pressure will normally be above the system's maximum operating pressure to check for any leaks, deformations, or weaknesses.

Simultaneous or separate pressure and leakage tests may be performed. The test durations and pressures for each option are specified in Table 3.1 If separate tests are made, the pressure test should be conducted prior to the leakage test.

Table 3. 1- Test durations and pressures for each option

Procedure	Test Pressure	Duration of Test
Simultaneous Pressure & Leakage Test	150% of working pressure* at point of test, but not less than 125% of normal working pressure at highest elevation.	2 Hours
Separate Pressure Test	150% of working pressure* at point of test, but not less than 125% of normal working pressure at highest elevation.	1 Hour
Separate Leakage Test	150% of working pressure* of segment tested.	2 Hours

*Working pressure is defined as the maximum anticipated sustained operating pressure. However, in no case shall the test pressure exceed the pressure rating for the pipe,

1. Hydrostatic testing for water leak detection

The purpose of the leakage test is to establish that the section of main being tested, including all joints, fittings and other appurtenances, will not leak or that leakage is within acceptable limits. If the leakage test is to be performed simultaneously with the pressure test, the system should be allowed to stabilize at the test pressure before conducting the leakage test.

Equipment necessary for conducting the leakage test includes a pump equipped with a make-up reservoir and a pressure gauge for measuring water pressure in the main. In addition, there must be an accurate method for measuring the quantity of water pumped into the main being tested. Methods used to measure water volume include a calibrated make-up reservoir, a calibrated positive-displacement pump, or a water meter.

The specified test pressure for the leakage test is the same as for the pressure test and the test should be conducted for at least 2 hours in duration. Leakage is defined as the quantity of water that must be supplied into the main in order to maintain the water pressure within 5 psi of the specified test pressure after the pipe has been filled with water and air expelled.

2. Pressure test

The purpose of the pressure test is to locate defects in materials or workmanship. Before testing, the pipeline must be backfilled and braced sufficiently to prevent movement under pressure.

If concrete thrust blocks are used, sufficient time must be allowed before testing to ensure that the concrete has cured sufficiently. The test ends also should be restrained to withstand thrusts potentially developed under the test pressures.

A pressure test should be conducted at 150% of the working pressure in the line. The working pressure is defined as the maximum anticipated sustained operating pressure in the line being tested. Care must be taken not to exceed the pressure rating of pipes, valves, fittings, thrust restraints, or other appurtenances. Pressures in the main may exceed the specified test pressure if the water pressure is read from a gauge located at a high point in the main.

Potable water is introduced into the main through a temporary connection to a hydrant, corporation stop in the new main or valve connection with the existing line.

Corporation stops may be required at high points in the line if there are insufficient valves to release air from the main. It is important to completely expel air from each section of the main to be tested. Compressed entrapped air may amplify surges within the main or cause erroneous pressure test results.

After filling the main with water and expelling air, a pump is utilized to increase the water pressure within the line up to the required test pressure and to maintain that pressure. An accurate method for measuring the amount of water pressure within the line must be provided. A key criterion for the pressure test is that the measured water pressure within the main (after reaching the required test pressure) should not vary by more than 5 psi during the duration of the test.

While the line is under pressure, the system and all exposed pipe, fittings, valves, and hydrants should be examined for leakage. Any damaged or defective pipe, fittings, valves, hydrants, or joints should be repaired or replaced and the pressure test repeated until satisfactory results are obtained.

Table 3. 2- Pressure and leakage test equipment

The standard hydrostatic test procedure for pipelines entails the following steps:

1. Fill the pipeline with a liquid, mostly water, unless its material is incompatible with water.
2. Apply pressure to the pipeline to bring it to its acceptable test pressure. This pressure is usually greater than the pipeline's design working pressure.
3. Hold the pressure for a required timeframe to examine the pipeline for possible leakages.
4. Depressurize the pipeline after confirming that the test is complete and meets the specifications and industry standards.

Self-check – 3

Directions: Answer all the questions listed below.

Part I: Fill in the blank space

1. _____ is the provision of water by public utilities, commercial organizations, community endeavors or by individuals, usually via a system of pumps and pipes
2. _____ is when water is supplied to the house at mains pressure, this water is fed directly to a cold water storage cistern'

Part-II: Choose the correct answer from the given alternatives

1. _____ are written or printed matter accompanying an article to furnish identification or other information

   A. fire B. Board

   E. hydrant D. Labels

2. _____ Is any printed material in a store that guides or informs customers, such as posters?

   A. Signage B. Paper

   C. pipe D. All

Part- III: write the answer briefly for the following question.

1. List the advantage and dis advantage of direct water supply?
2. List the advantage and dis advantage of indirect water supply?

Note: **Satisfactory rating - 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Operation Sheet one

Operation Title: hot and cold water installation

Purpose: To know the procedure and installation mechanism of cold water service with drainage system

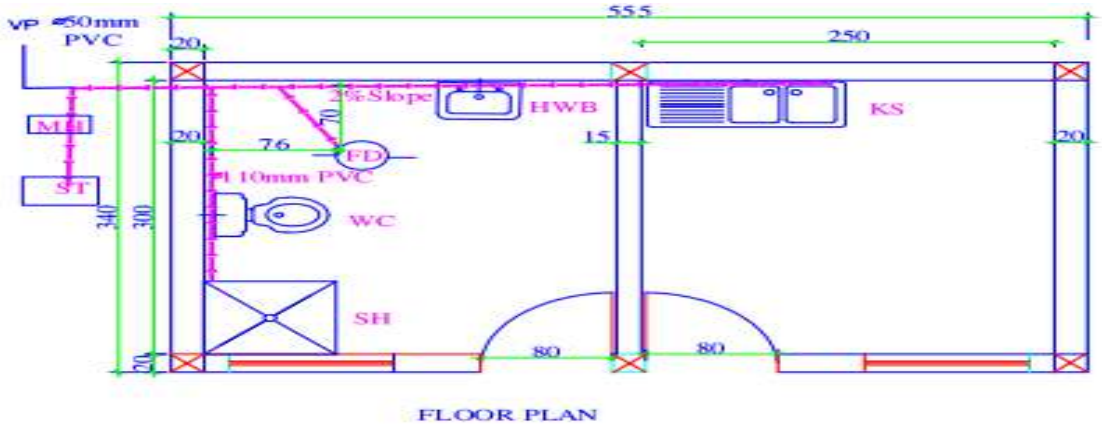
Conditions for the operations:

- Safe working area
- Appropriate working cloths fit with the body

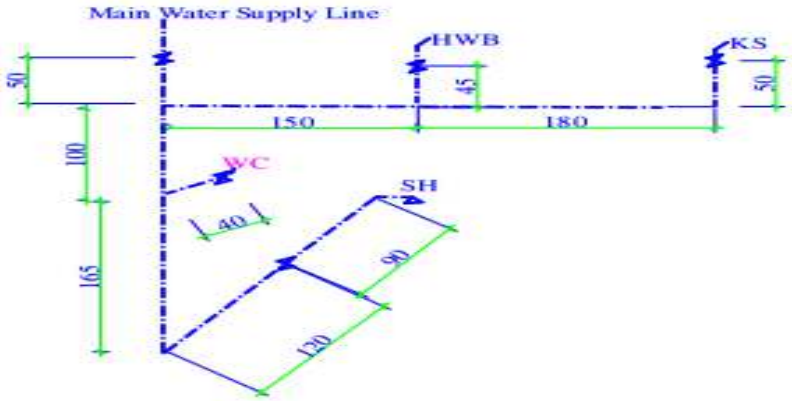
Equipment Tools:

- Meter
- Pipe cutter
- Die stock
- Pipe wrench
- Pipe vise
- Remer
- Scriber
- Pressure testing
- Adjustable spanner
- Screw driver /flat and Philips/

Quality Criteria: Assured performing of all the activities according to the procedures



FLOOR PLAN



Riser Diagram for Water Supply Line
All dimension are in cm

Project 1 – cold water supply for residential building

All supply line must be galvanized steel pipe with (3/4¨ for main line pipe and ½ inches for riser pipe).

1. Drainage system should be installed in PVC Ø50mm and Ø 110mm.
2. The hand wash basin may be wall hang or pedestal type.
3. Use 2% slope for drainage line.
4. All measurement are in CM / centimeter/
5. Allowable tolerance of water supply and drainage line is +/-3mm
6. Project allowable time 4:00 hr

Precautions:

- Wearing proper clothes, eye glass, glove
- Make working area hazard free
- Read and interpret plan and specification

Steps in doing the task

1. Read the drawing of cold water supply and identify the material that is required for the project based on the following table. /for 30 minutes/

Table 3. 3Answer sheer for material identification

No	Material type	Specification	Quantity
Pipes			
1.			
2.			
Fittings			
3.			
4.			
Fixtures			
5.			

2. Clean the working area from any kind of hazardous material and prepare working area for doing activity
3. Prepare the required hand tools and materials based on the given design
4. Measure each of pipe , mark and cut
5. Fix each of pipes with fittings and cheek as a design
6. Install all of sanitary fixtures as a drawing.
7. Measure, cut, and fix pvc/ poly venial chloride pipe to pvc fittings by using fire heating.
8. Cheek the measurement, the pressure and leakage through the water supply line and drainage lines.
9. Apply quality standard as per project quality requirements

Operation Sheet two

Operation Title: hot and cold water installation

Purpose: To know the procedure and installation mechanism of hot and cold water service

Conditions for the operations:

- Safe working area
- Appropriate working cloths fit with the body

Equipment Tools:

- Meter
- Pipe cutter
- Die stock
- Pipe wrench
- Pipe vise
- Remer
- Scriber
- Pressure testing
- Adjustable spanner
- Screw driver /flat and Philips/

Quality Criteria: Assured performing of all the activities according to the procedures

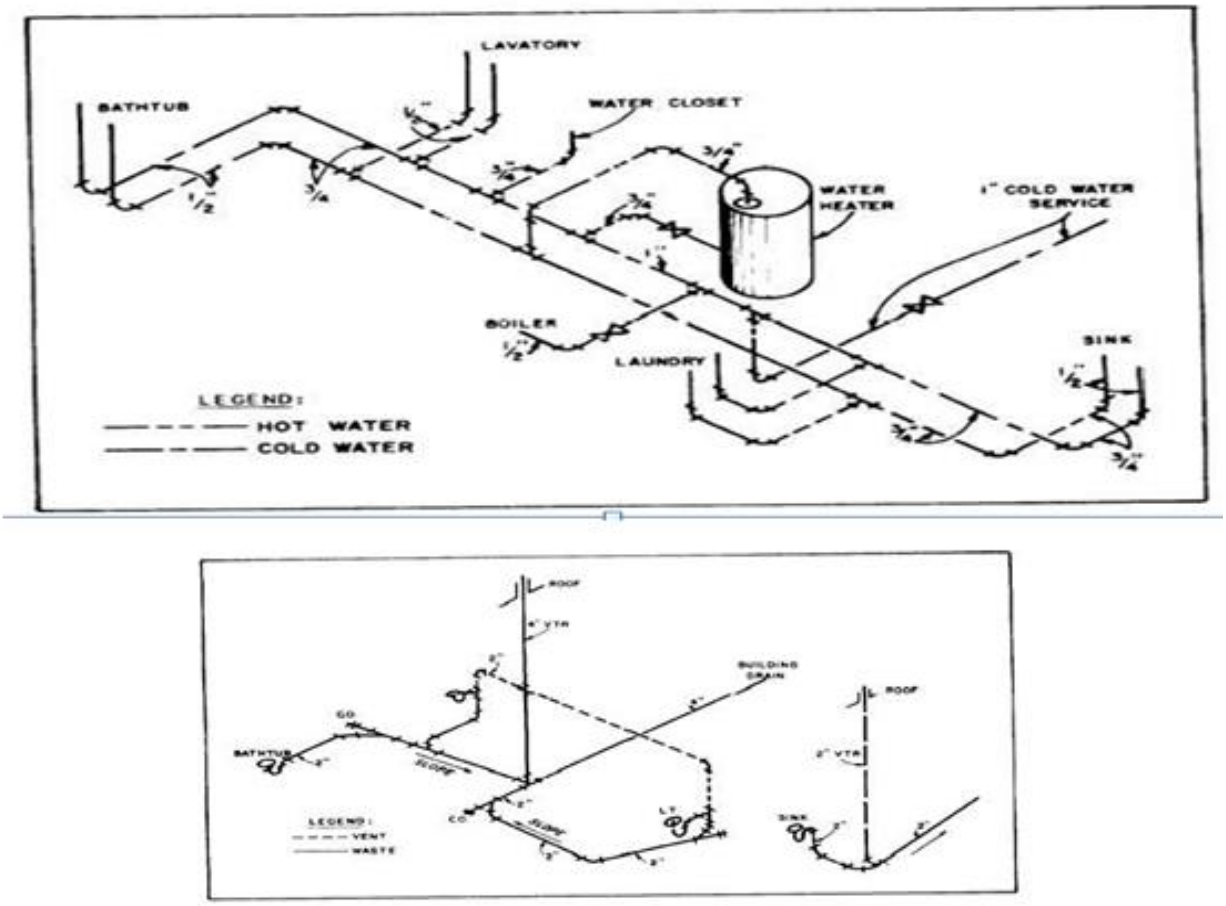


Figure 8-25.-Example of a waste and soil risers diagram.

Project 2 – cold and hot water supply for residential building

1. All supply line must be galvanized steel pipe with (3/4¨ for main line pipe and ½ inches for riser pipe).
2. Drainage system should be installed in PVC Ø50mm and Ø 110mm.
3. The hand wash basin may be wall hang or pedestal type.
4. Use 2% slope for drainage line**.**
5. All measurement are in CM / centimeter/
6. Allowable tolerance of water supply and drainage line is +/-3mm
7. The instructor will give you each measurement of pipe lines based on the space of your workshop.

Precautions:

- Wearing proper clothes, eye glass, glove
- Make working area hazard free
- Read and interpret plan and specification

Steps in doing the task

1. Read the drawing of cold water supply and identify the material that is required for the project based on the following table. /for 30 minutes/

Table 3.2 Answer sheer for material identification

No	Material type	Specification	Quantity
Pipes			
1.			
2.			
Fittings			
3.			
4.			
Fixtures			
5.			

2. Clean the working area and prepare working area for doing activity
3. Prepare the required hand tools and materials based on the given design
4. Measure each of pipe , mark and cut
5. Fix each of pipes with fittings and cheek as a design
6. Install all of sanitary fixtures as a drawing.
7. Fix the water heater and Connect the inlet and outlet pipe
8. Measure, cut, and fix pvc/ poly venial chloride pipe to pvc fittings by using fire heating.
9. Cheek the measurement, the pressure and leakage through the water supply line and drainage lines.
10. Apply quality standard as per project quality requirements

Operation Sheet three

Operation Title: hot and cold water installation

Purpose: To know the procedure and installation mechanism of hot and cold water service

Conditions for the operations:

- Safe working area
- Appropriate working cloths fit with the body

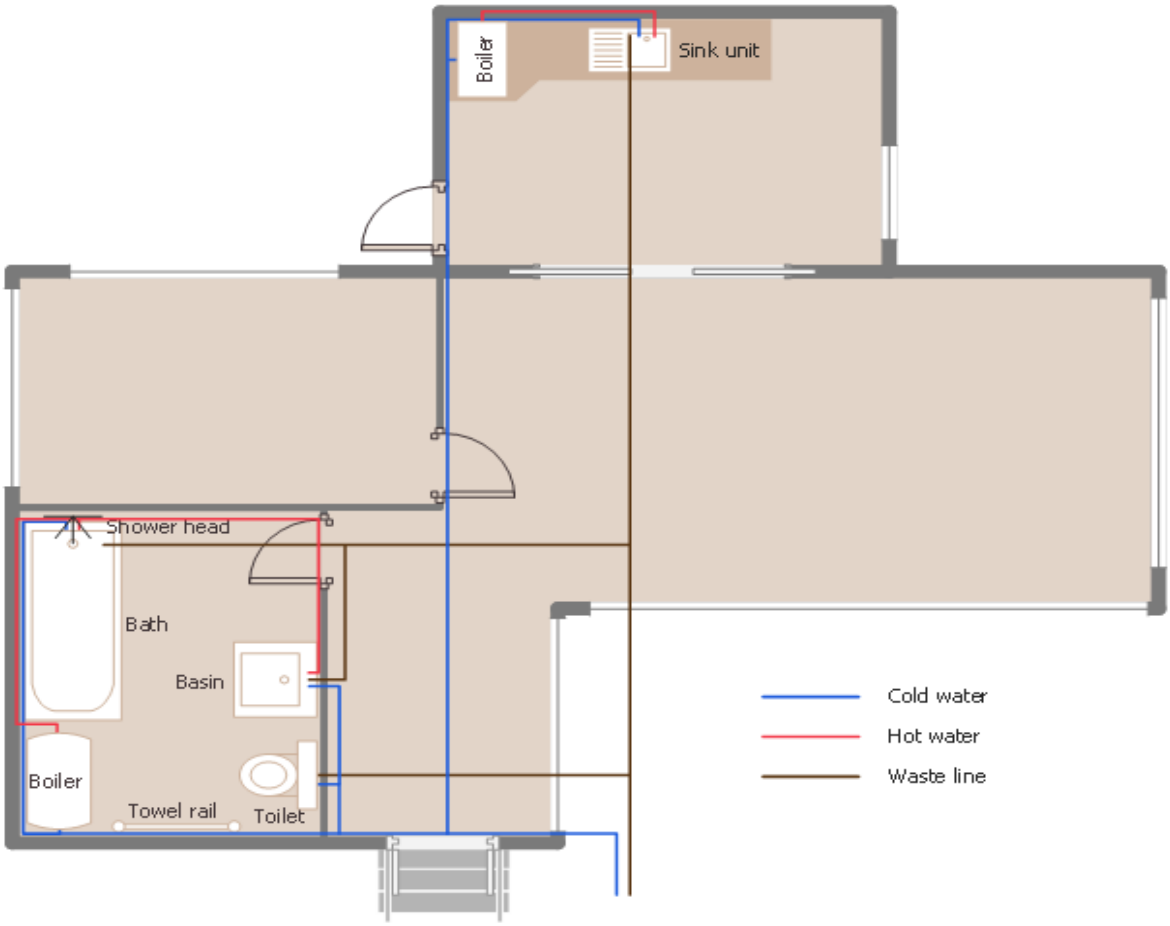
Equipment Tools:

- Meter
- Pipe cutter
- Die stock
- Pipe wrench
- Pipe vise
- Remer
- Scriber
- Pressure testing
- Adjustable spanner
- Screw driver /flat and Philips/

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- Wearing proper clothes, eye glass, glove
- Make working area hazard free
- Read and interpret plan and specification



Project 3 – cold and hot water supply for residential building

All supply line must be galvanized steel pipe with (3/4¨ for main line pipe and ½ inches for riser pipe).

1. Drainage system should be installed in PVC Ø50mm and Ø 110mm.
2. The hand wash basin may be wall hang or pedestal type.
3. Use 2% slope for drainage line**.**
4. All measurement are in CM / centimeter/
5. Allowable tolerance of water supply and drainage line is +/-3mm
6. The instructor will give you each measurement of pipe lines based on the your workshop.

Steps in doing the task

1. Read the drawing of cold water supply and identify the material that is required for the project based on the following table. /for 30 minutes/

Table 3.3 Answer sheer for material identification

No	Material type	Specification	Quantity
Pipes			
1.			
2.			
Fittings			
3.			
4.			
Fixtures			
5.			
6.			

2. Clean the working area from any kind of hazardous material and prepare working area for doing activity
3. Prepare the required hand tools and materials based on the given design
4. Measure each of pipe , mark and cut
5. Fix each of pipes with fittings and cheek as a design
6. Install all of sanitary fixtures as a drawing.
7. Fix the water heater and Connect the inlet and outlet pipe
8. Measure, cut, and fix Pvc/ poly venial chloride pipe to Pvc fittings by using fire heating.
9. Cheek the measurement, the pressure and leakage through the water supply line and drainage lines.
10. Apply quality standard as per project quality requirements

LAP Test

Practical Demonstration

Name: _____ Date: _____
Time started: _____ Time finished: _____

Instruction: Perform the following tasks

Task 1: Prepare your own simple floor plan with riser diagram and with three sanitary fixtures.

Task 2： Prepare the required hand tools and materials based on the given design

Task 2:.Measure each of pipe, mark and cut

Task 3: Fix each of pipes with fittings and cheek as a design

Task 4: Install all of sanitary fixtures as a drawing.

Task 5: Measure, cut, and fix pvc/ poly venial chloride pipe to pvc fittings by using fire heating.

Task 6: Cheek the measurement, the pressure and leakage through the water supply line and drainage lines.

Unit four – Commissioning water services

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Flushing service lines
- Commissioning blue water

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Obtain flushing service
- Follow commissioning procedure of water supply system

4.1. Flushing service lines

Line flushing is a process which uses highly pressurized water to remove sediment from water lines, and is one of the most effective ways to clean pipes. Sediment builds up in areas that are often difficult to get to, and can block different parts of various pipes.

All pipelines shall be flushed by the Contractor after all hydrostatic pressure tests and disinfections operations have been performed and accepted by the Engineer's Representative. After draining the chlorine solution the pipe system shall be flushed with potable water until the free chlorine content is between 2 to 4 milligrams per litter.

Line flushing is one of the most effective ways to clean pipes. Sediment builds up in areas that are often difficult to get to, and can block different parts of various pipes. This makes flushing lines the most effective way of dealing with sediment deposit. The high-pressure water runs through every corner of your pipes, flushing out anything that shouldn't be in there.

Sediment build-up is going to occur no matter where you get your water from – most of us get city water, but this process is especially important for people with wells. Either way, there are minerals in the water, or these minerals will eventually start to accumulate in your pipes. There are a few potential consequences. First, you might notice your water pressure begin to change. When water has to flow past a large sediment deposit, it's going to take longer to come out of your faucet.

Another consequence is that your pipes will begin to deteriorate more rapidly. In areas where sediment has built up, the pressure being applied to your pipe walls is going to increase. Over time, this pressure can begin to wear down the interior walls of your pipes, leading to leaks. Flushing your pipes regularly is a form of routine maintenance that can help prevent these leaks.

Residential line flushing might not be the most common practice, but it's one that's rooted in hard data. Cities flush their water lines all the time for the exact reasons described above; sediment build-up is inevitable anytime water touches a solid surface.

Flushing service is basic if your water service has been shut off and recently restored; your pipes need to be flushed for 30 minutes to ensure your safety. Water sitting stagnant in pipes may contain lead, copper and other sediments that are not safe for drinking and cooking.

4.2. Commissioning water service

4.1.1. Types of water based on color

From a scientific perspective, there are two types of freshwater on earth: blue water and green water. 'Blue water' is water in rivers and lakes, groundwater and the water frozen in glaciers and the polar ice caps. Freshwater is also found in plants, the soil and rain – experts call this ‘green water’. Sludge

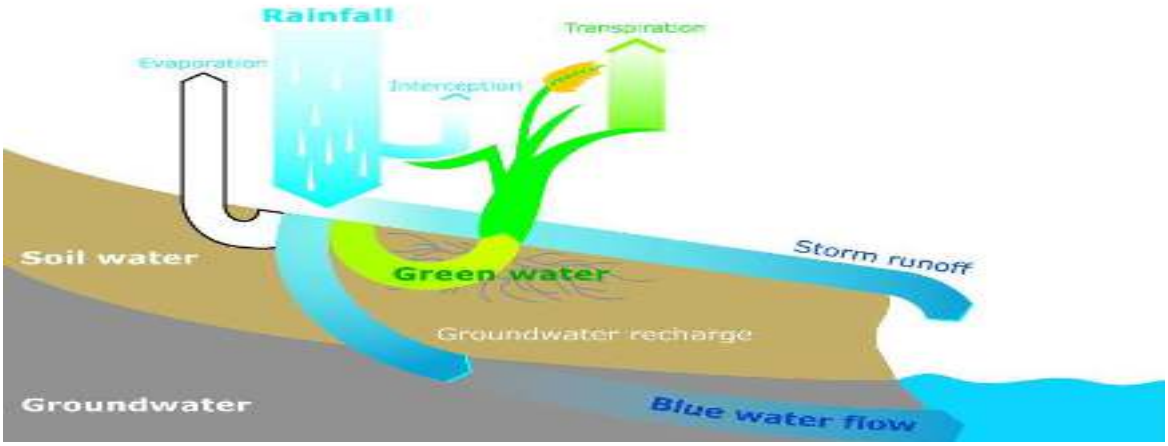


Figure 4. 1– blue water and grean water

4.1.2. Commissioning blue water

Commissioning a system or major component is the process of putting it into safe and effective operation leading to its handover for everyday operation and use by the customer. Coming at the end of a job, time pressures can sometimes lead to commissioning not taking place correctly with the result being the ‘unraveling’ of all the good work that has gone before it during the design and installation phases.

It goes without saying that a customer is highly unlikely to appreciate leakage from a system component a few days after neither installation nor a situation where some radiators in a system are falling far short of providing the desired room temperatures.

In fact most areas of legislation underpinning the installation of plumbing and heating systems and components place great weight on the commissioning process and mandatorily require the issue of commissioning records as part of the handover process in order to demonstrate that everything is safe and functioning correctly.

Legislation includes –

- Gas Safety Regulations
- Building Regulations
- Water Regulations
- Electricity at Work Regulations

As an example, under Building Regulations there's a requirement to correctly commission an above ground sanitation system – requiring a range of tests to be completed to put the system into effective operation.

When it comes to commissioning residential systems then full commissioning details are laid down across a range of different documents including regulation approved documents, Ethiopian Standards and manufacturer instructions.

Invariably the commissioning process for most systems is a three phase process –

1. **Visual inspection** – check to make sure that everything has been installed correctly and is compliant with regulation/standard requirements e.g. the position of the flue termination from a boiler
2. **Soundness test** – the testing process to charge the system and make sure it's leak free, this may include elevating the pressure inside the system/component for a fixed time period in order to check that it's sound and leak free.
3. **Performance test** – this is the part of the process where a range of tests are carried out to make sure that the system/component is delivering the required outcomes associated with its initial design e.g. the flow rate from taps and valves is as per the specification.

In addition, under certain areas of legislation e.g. Water Regulations, a copy of the sign off record demonstrating compliance with the regulations is issued to the enforcement body.

In summary, the work to complete, correct commissioning needs to be accomplished.

Self-Check - 4

Directions: Answer all the questions listed below.

Part I: Fill in the blank space

1. _____ is a process which uses highly pressurized water to remove sediment from water lines, and is one of the most effective ways to clean pipes
2. _____ is water in rivers and lakes, groundwater and the water frozen in glaciers and the polar ice caps

Part-II: Choose the correct answer from the given alternatives

1. _____ are checking to make sure that everything has been installed correctly and is compliant with regulation/standard requirements

   A. Performance test B. Soundness test

   B. Visual inspection D. All

2. _____ Is also found in plants, the soil and rain – experts call this 'green water'. Sludge

   A. Grey water B. blue water

   C. fresh water D. All

Part- III: write the answer briefly for the following question.

1. What is commissioning in hot and cold water supply?
2. What is the purpose of flushing line?

Note: Satisfactory rating - 2 points and above Unsatisfactory - below 2 points

You can ask you teacher for the copy of the correct answers.

Reference

- R.H. Garrett, EngTech, President of the National Association of Plumbing Teachers Plumber of the Year 1988 for British Standards Institution
- Basics of Water Supply System- Training Module for Local Water and Sanitation Management
- HOT WATER AND SUPPLY SYSTEMS Prepared by Eng .Nadia Badarneh
- Water Supply (Water Fittings) Regulations 1999. HMSO
- BPEC Level 2 Diploma in Plumbing Foundation
- Section 6 – H/602/2697 Understand and apply domestic cold water system installation and maintenance techniques
- Commissioning Plumbing Systems Advisory Leaflet No. 9-05-01 April 2021

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