NATIONAL CERTIFICATE III

PLUMBING

Student Learning Materials

TVET Authority

Ministry of Environment

ACKNOWLEDGEMENT

TVET Authority wishes to thank Ministry of Environment for facilitating development of the Occupational Standard and Instructional Materials for Water & Sewerage Courses through the Green Climate Fund.

Table of Contents

1. APPLY OCCUPATIONAL HEALTH AND SAFETY REQUIREMENTS 13
2. APPLY WORK ETHICS AND OPTIMIZE PROFESSIONALISM 32
3. PRACTICE EFFECTIVE WORKPLACE COMMUNICATION 44
4. PROVIDE EFFECTIVE CUSTOMER CARE 65
5. PERFORM COMPUTER OPERATIONS 82
6. PROVIDE FIRST AID 131
7. RESPOND TO FIRE 158
8. APPLY SCIENCE AND ENGINEERING MEASUREMENTS 174
9. PERFORM SAFE WORKSHOP PRACTICE 215
10. CARRY OUT SIMPLE CONCRETING AND RENDERING 300
11. PREPARE ESTIMATES AND READ LAYOUT 322
12. INSTALL DOMESTIC WATER PIPE SYSTEMS 327
13. INSTALL AND FIT OFF SANITARY FIXTURES 349
14. LOCATE CLEAR BLOCKAGES AND FIX LEAKS 369
15. INSTALL BELOW GROUND DOMESTIC WASTE WATER 383
16. FABRICATE AND INSTALL ROOF DRAINAGE COMPONENTS 400
17. PERFORM PLUMBING TO SUPPORT RAIN WATER HARVESTING SYSTEMS 414
18. REFERENCE 449

INSTRUCTION TO TRAINERS

Competency Based Training (CBT) and assessment - An introduction for trainers
Learning Materials presented here can be used to deliver competency-based training using the National Competency Standard developed for the respective occupation.

Competency
Competency refers to the ability to perform particular tasks and duties to the standard of performance expected in the workplace. It requires the application of specified knowledge, skills and attitudes relevant to effective participation, consistently over time and in the workplace environment. The essential skills and knowledge are either identified separately or combined.

Knowledge identifies what a person needs to know to perform the work in an informed and effective manner.

Skills describe the application of knowledge to situations where understanding is converted into a workplace outcome.

Attitude describes the founding reasons behind the need for certain knowledge or why skills are performed in a specified manner. Competency covers all aspects of workplace performance and involves:

- Performing individual tasks
- Managing a range of different tasks
- Responding to contingencies or breakdowns
- Dealing with the responsibilities of the workplace
- Working with others.

Unit of Competency
Like with any training qualification or program, a range of subject topics are identified that focus on the ability in a certain work area, responsibility or function. Each manual focuses on a specific unit of competency that applies in the hospitality workplace. In this manual a unit of competency is identified as a "unit". Each unit of competency identifies a discrete workplace requirement and includes:

- Knowledge and skills that underpin competency
- Language, literacy and numeracy
- Occupational health and safety requirements.

Each unit of competency must be adhered to in training and assessment to ensure consistency of outcomes.

Element of Competency
An element of competency describes the essential outcomes within a unit of competency. The elements of competency are the basic building blocks of the unit of competency. They describe in terms of outcomes the significant functions and tasks that make up the competency. In this manual, elements of competency are identified as an "element".

Performance criteria
Performance criteria indicate the standard of performance that is required to demonstrate achievement within an element of competency. The standards reflect identified industry skill needs. Performance criteria will be made up of certain specified skills, knowledge and attitudes.

Learning
For the purpose of this manual learning incorporates two key activities:

- Training
- Assessment.

Both of these activities will be discussed in detail in this introduction.

Today training and assessment can be delivered in a variety of ways. It may be provided to participants:

- On-the-job – in the workplace
- Off-the-job – at an educational institution or dedicated training environment
- As a combination of these two options.

No longer is it necessary for learners to be absent from the workplace for long periods of time in order to obtain recognized and accredited qualifications.

Learning Approaches
Student learning materials developed here can support delivery of training and the expected learning can be facilitated through the following avenues:

Competency Based Training (CBT)
This is the strategy of developing a participant's competency. Educational institutions utilize a range of training strategies to ensure that participants are able to gain the knowledge and skills required for successful:

- Completion of the training program or qualification
- Implementation in the workplace.

The strategies selected should be chosen based on suitability and the learning styles of participants.

Competency Based Assessment (CBA)
This is the strategy of assessing competency of a participant. Educational institutions utilize a range of assessment strategies to ensure that participants are assessed in a manner that demonstrates validity, fairness, reliability, flexibility and fairness of assessment processes.

Flexibility in Learning
Even with the use of this book, it is important to note that flexibility in training and assessment strategies is required to meet the needs of participants who may have learning difficulties. The strategies used will vary, taking into account the needs of individual participants with learning difficulties. However they will be applied in a manner which does not discriminate against the participant or the participant body as a whole.

Catering for Participant Diversity

Participants have diverse backgrounds, needs and interests. When planning training and assessment activities to cater for individual differences, trainers and assessors should:

- Consider individuals' experiences, learning styles and interests
- Develop questions and activities that are aimed at different levels of ability
- Modify the expectations for some participants
- Provide opportunities for a variety of forms of participation, such as individual, pair and small group activities
- Assess participants based on individual progress and outcomes.

The diversity among participants also provides a good reason for building up a learning community in which participants support each other's learning.

Participant Centered Learning

This involves taking into account structuring training and assessment that:

- Builds on strengths – Training environments need to demonstrate the many positive features of local participants (such as the attribution of academic success to effort, and the social nature of achievement motivation) and of their trainers (such as a strong emphasis on subject disciplines and moral responsibility). These strengths and uniqueness of local participants and trainers should be acknowledged and treasured
- Acknowledges prior knowledge and experience – The learning activities should be planned with participants‟ prior knowledge and experience in mind
- Understands learning objectives – Each learning activity should have clear learning objectives and participants should be informed of them at the outset. Trainers should also be clear about the purpose of assignments and explain their significance to participants
- Teaches for understanding – The pedagogies chosen should aim at enabling participants to act and think flexibly with what they know
- Teaches for independent learning – Generic skills and reflection should be nurtured through learning activities in appropriate contexts of the curriculum. Participants should be encouraged to take responsibility for their own learning
- Enhances motivation – Learning is most effective when participants are motivated. Various strategies should be used to arouse the interest of participants
- Makes effective use of resources – A variety of teaching resources can be employed as tools for learning
- Maximizes engagement – In conducting learning activities, it is important for the minds of participants to be actively engaged
- Aligns assessment with learning and teaching – Feedback and assessment should be an integral part of learning and teaching
- Caters for learner diversity – Trainers should be aware that participants have different characteristics and strengths and try to nurture these rather than impose a standard set of expectations.

Active Learning

The goal of nurturing independent learning in participants does not imply that they always have to work in isolation or solely in a classroom. On the contrary, the construction of knowledge in tourism and hospitality studies can often best be carried out in collaboration with others in the field. Sharing experiences, insights and views on issues of common concern,

and working together to collect information through conducting investigative studies in the field (active learning) can contribute a lot to their eventual success.

Active learning has an important part to play in fostering a sense of community in the class. First, to operate successfully, a learning community requires an ethos of acceptance and a sense of trust among participants, and between them and their trainers. Trainers can help to foster acceptance and trust through encouragement and personal example, and by allowing participants to take risks as they explore and articulate their views, however immature these may appear to be. Participants also come to realize that their classmates (and their trainers) are partners in learning and solving.
Trainers can also encourage cooperative learning by designing appropriate group learning tasks, which include, for example, collecting background information, conducting small-scale surveys, or producing media presentations on certain issues and themes. Participants need to be reminded that, while they should work towards successful completion of the field tasks, developing positive peer relationships in the process is an important objective of all group work.

Competency Based Training (CBT)

Principle of Competency Based Training
Competency based training is aimed at developing the knowledge, skills and attitudes of participants, through a variety of training tools.

Training Strategies
The aims of this curriculum are to enable participants to:

- Undertake a variety of subject courses that are relevant to industry in the current environment
- Learn current industry skills, information and trends relevant to industry
- Learn through a range of practical and theoretical approaches Be able to identify, explore and solve issues in a productive manner
- Be able to become confident, equipped and flexible managers of the future
- Be „job ready" and a valuable employee in the industry upon graduation of any qualification level.
- To ensure participants are able to gain the knowledge and skills required to meet competency in each unit of competency in the qualification, a range of training delivery modes are used.

Types of Training
In choosing learning and teaching strategies, trainers should take into account the practical, complex and multi-disciplinary nature of the subject area, as well as their participant's prior knowledge, learning styles and abilities. Training outcomes can be attained by utilizing one or more delivery methods:

Lecture/Tutorial
This is a common method of training involving transfer of information from the trainer to the participants. It is an effective approach to introduce new concepts or information to the learners and also to build upon the existing knowledge. The listener is expected to reflect on the subject and seek clarifications on the doubts.

Demonstration
Demonstration is a very effective training method that involves a trainer showing a participant how to perform a task or activity. Through a visual demonstration, trainers may also explain reasoning behind certain actions or provide supplementary information to help facilitate understanding.

Group Discussions
Brainstorming in which all the members in a group express their ideas, views and opinions on a given topic. It is a free flow and exchange of knowledge among the participants and the trainer. The discussion is carried out by the group on the basis of their own experience, perceptions and values. This will facilitate acquiring new knowledge. When everybody is expected to participate in the group discussion, even the introverted persons will also get stimulated and try to articulate their feelings.

The ideas that emerge in the discussions should be noted down and presentations are to be made by the groups. Sometimes consensus needs to be arrived at on a given topic. Group discussions are to be held under the moderation of a leader guided by the trainer. Group discussion technique triggers thinking process, encourages interactions and enhances communication skills.

Role Play
This is a common and very effective method of bringing into the classroom real life situations, which may not otherwise be possible. Participants are made to enact a particular role so as to give a real feel of the roles they may be called upon to play. This enables participants to understand the behavior of others as well as their own emotions and feelings. The instructor must brief the role players on what is expected of them. The role player may either be given a ready-made script, which they can memorize and enact, or they may be required to develop their own scripts around a given situation. This technique is extremely useful in understanding creative selling techniques and human relations. It can be entertaining and energizing and it helps the reserved and less literate to express their feelings.

Simulation Games
When trainees need to become aware of something that they have not been conscious of, simulations can be a useful mechanism. Simulation games are a method based on "here and now" experience shared by all the participants. The games focus on the participation of the trainees and their willingness to share their ideas with others. A "near real life" situation is created providing an opportunity to which they apply themselves by adopting certain behaviour. They then experience the impact of their behaviour on the situation. It is carried out to generate responses and reactions based on the real feelings of the participants, which are subsequently analyzed by the trainer.

While use of simulation games can result in very effective learning, it needs considerable trainer competence to analyses the situations.

Individual /Group Exercises
Exercises are often introduced to find out how much the participant has assimilated. This method involves imparting instructions to participants on a particular subject through use of written exercises. In the group exercises, the entire class is divided into small groups, and members are asked to collaborate to arrive at a consensus or solution to a problem.

Case Study
This is a training method that enables the trainer and the participant to experience a real life situation. It may be on account of events in the past or situations in the present, in which there may be one or more problems to be solved and decisions to be taken. The basic objective of a case study is to help participants diagnose, analyses and/or solve a particular problem and to make them internalize the critical inputs delivered in the training. Questions are generally given at the end of the case study to direct the participants and to stimulate their thinking towards possible solutions. Studies may be presented in written or verbal form.

Field Visit
This involves a carefully planned visit or tour to a place of learning or interest. The idea is to give first-hand knowledge by personal observation of field situations, and to relate theory with practice. The emphasis is on observing, exploring, asking questions and understanding. The trainer should remember to brief the participants about what they should observe and about the customs and norms that need to be respected.

Group Presentation
The participants are asked to work in groups and produce the results and findings of their group work to the members of another sub-group. By this method participants get a good picture of each other's views and perceptions on the topic and they are able to compare them with their own point of view. The pooling and sharing of findings enriches the discussion and learning process.

Practice Sessions
This method is of paramount importance for skills training. Participants are provided with an opportunity to practice in a controlled situation what they have learnt. It could be real life or through a make-believe situation.

Games
This is a group process and includes those methods that involve usually fun-based activity, aimed at conveying feelings and experiences, which are everyday in nature, and applying them within the game being played. A game has set rules and regulations, and may or may not include a competitive element. After the game is played, it is essential that the participants be debriefed and their lessons and experiences consolidated by the trainer.

Research
Trainers may require learners to undertake research activities, including online research, to gather information or further understanding about a specific subject area.

As National Competency Standards require Competency Based Assessment, following paragraphs provide an overview of the Competency Based Assessment.

Competency Based Assessment (CBA)

Principle of Competency Based Assessment
Competency based assessment is aimed at compiling a list of evidence that shows that a person is competent in a particular unit of competency. Competencies are gained through a multitude of ways including:

- Training and development programs

- Formal education
- Life experience
- Apprenticeships
- On-the-job experience
- Self-help programs.

All of these together contribute to job competence in a person. Ultimately, assessors and participants work together, through the „collection of evidence" in determining overall competence. This evidence can be collected:

- Using different formats
- Using different people
- Collected over a period of time.

The assessor, who is ideally someone with considerable experience in the area being assessed, reviews the evidence and verifies the person as being competent or not.

INSTRUCTIONS TO CANDIDATE

Introduction to trainee manual

Congratulations on joining this course. The "Student Learning Materials" developed and compiled here is a complete resource book developed in alignment to the respective National Competency Standard and hence will support the students to learn and understand comprehensive theoretical aspects related to the standard. This "Student Learning Materials" will be used for student learning and the method of instruction is called Competency Based Skill Training (CBST).

Aim of the training is to enable trainees to perform tasks and duties at a standard expected by employers. CBT seeks to develop the skills, knowledge and attitudes (or recognize the ones the trainee already possesses) to achieve the required competency standard.

While progressing with the training, make sure you participate with ongoing sessions and systematically develop the required theoretical knowledge and make sure to develop the theoretical competencies in all the units prescribed in the relevant National Competency Standard. Once each competency unit is learnt or the full set of competency units are covered, you may register and undertake the assessment. Do note that, formal assessments related to the TVET programs of Maldives are done by the TVET Authority and the assessments are undertaken within the principles of Competency Based Assessment.

CBA (Competency Based Assessment) involves collecting evidence and making a judgment of the extent to which a worker can perform his/her duties at the required competency standard.

What is a competency standard?

Competency standards are descriptions of the skills and knowledge required to perform a task or activity at the level of a required standard. You will find a description of each competency at the beginning of each Unit. The unit descriptor describes the content of the unit you will be studying in the Manual and provides a table of contents which are divided up into 'Elements' and its 'Performance Criteria'

An element is a description of one aspect of what has to be achieved in the workplace. The 'Performance Criteria' details the level of performance that needs to be demonstrated to be declared competent. There are other components of the competency standard:

- Unit Title: statement about what is to be done in the workplace
- Unit Number: unique number identifying the particular competency
- Contact hours: number of classroom or practical hours usually needed to complete the competency. We call them 'nominal' hours because they can vary e.g. sometimes it will take an individual less time to complete a unit of competency because he/she has prior knowledge or work experience in that area.

Competency based assessment requires trainees to be assessed in at least 2 – 3 different ways, one of which must be practical. Assessments will be carried out and includes work projects, written questions and oral questions. Your trainer and/or assessor may also use other assessment methods including 'Observation Checklist' and 'Third Party Statement'. An observation checklist is a way of recording how you perform at work and a third party statement is a statement by a supervisor or employer about the degree of competence they believe you have achieved. This can be based on observing your workplace performance, inspecting your work or gaining feedback from fellow workers.

Your trainer and/or assessor may use other methods to assess you such as:

- Journals
- Oral presentations
- Role plays
- Log books
- Group projects
- Practical demonstrations.

Remember your trainer is there to help you succeed and become competent. Please feel free to ask them for more explanation of what you have just read and of what is expected from you and best wishes for your future studies and future career.

UNIT 01

APPLY OCCUPATIONAL HEALTH AND SAFETY REQUIREMENTS

This unit of competency describes the skills and knowledge in applying various aspects of occupational health and safety to work and ensure safety and health of personnel undertaking workplace tasks

Introduction

Occupational Health and Safety remained as a crucial element of every workplace task as the process is designed to create a safe, healthy work environment for all. It can generally be considered as two separate entities.

Occupational Safety covers the risk factor in your workplace, and potential safety hazards that could possibly cause injury. Occupational Health, on the other hand, looks at potential health concerns and wellbeing. Think of Safety as an employee's physical well-being, and Health as everything else, including mental health.

Like all industrial tasks, any activity within the Water and Sanitation Sector (WATSAN) should give due importance and apply proper measures relevant to occupational health and safety aspects, no matter how big or small the task may be. Everyone including you and the employers has a responsibility to minimize those risks and reduce the likelihood of any workplace accident or mistreatment.

Whether you are an employee or an employer involved with the WATSAN works, it is our duty to apply and implement occupational health and safety tasks. Following are considered as Employer responsibilities:

- ✓ provision and maintenance of plant and systems of work that are crucial to complete the work tasks with safety and are risk free.
- ✓ provision of access to and exit from the workplace that is safe and without risk
- ✓ provision of adequate facilities and arrangements for welfare at work.

Likewise, employee responsibilities under the scope of health and safety aspects related to work are as follows:

- ✓ take reasonable care at work of your own health and safety and that of others who may be affected by what you do or do not do.
- ✓ do not intentionally or recklessly interfere with or misuse anything provided for your health and safety
- ✓ Co-operate with your employer on health and safety matters. Assist your employer in meeting their statutory obligations
- ✓ bring to your employer's attention any situation you think presents a serious and imminent danger
- ✓ bring to your employer's attention any weakness you might spot in their health and safety arrangements.

CLEAN WORK PREPARATION AREAS

Work areas remain as the most important site where work tasks are being performed and it is important that the work areas are always kept clean and healthy.

When you are attending work related to plumbing, operation of water plants, sewerage works, laboratory testing or any other works, it is important that the primary work areas is always kept clean and tidy. A messy workshop not only hampers your productivity, but it also can also be extremely hazardous.

According to experts, a messy workshop can be even more dangerous. That fact's especially true for various mechanical works that involve use of sharp tools and equipment. If you don't clean your workshop regularly, the tiny scraps that are produced through work preparation activities can cause accidents or long-term health and safety problems. To avoid such accidents, it is essential to keep your workplace tidy.

Overview of cleaning equipment across workshop areas

Whether its work area or any other cleaning operations, different cleaning equipment are used today.

There are many different types of equipment, like pressure cleaners, sweepers and polishers, but also vacuum cleaners. It is important to choose the right equipment for a certain cleaning job. Pressure cleaners are machines that use high-powered steam to get rid of stains and dirt. They are especially ideal for cleaning concrete regions such as walls, patios, and walkways. The next essential tool for commercial cleaning is sweepers. These are large machines with a rotatory sweeping head located underneath the front of the machine. A sweeper is controlled by a driver who sits on a commercial sweeper and use a driving wheel to steer the device. These are especially useful for cleaning vast outdoor areas like the pavement outside a huge commercial place or on roads. A carpet cleaner is another essential. These cleaners have the ability to remove stubborn stains from almost any carpet area.

Scrubbers are designed to clean stains from hard floored regions. They are ideal for use in huge commercial buildings that have wood or marble flooring. They come in either sit on form or handheld form. The type to choose depends on the size of the region you need to clean.

A polisher is another essential equipment when it comes to commercial cleaning. A polisher is able to turn a dirty hard floor it a brand new in a timely fashion. Polishers are usually used in institutions such as universities, schools, museums and hospitals. Sit-on polishers are perfect for larger spaces while handheld polishers are used on relatively small areas.

As we all know, a vacuum cleaner removes dust and dirt from both carpeted and hard floors. Commercial vacuum cleaners are usually more powerful than household vacuum cleaners. They are ideally packed with numerous features that allow you to reach and clean unreachable areas. There're also wet vacuum cleaners that are used to suck up water. Others come with a dry and wet function to allow you to switch between your preferred modes easily.

How to clean spillages across work area floors

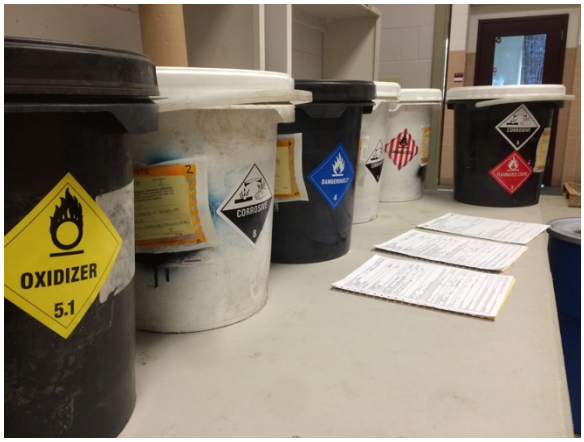
Oil, water and fuel spillages are potential Health and Safety Hazards in a home, workshop, garage or any workshop. It is vital that such spillages are quickly attended prior to slipping or falling that may injure you or your colleagues. Following are the basic steps of attending such spillages.

- ✓ Sprinkle sawdust, clay, coconut husks, or a commercial oil-absorbing product on the stain. If you have none of these products on hand, set paper towels on the floor to soak up any wet oil while you make a trip to the store.
- ✓ Allow the absorbent materials to work on the oil for 24 to 48 hours. Then, sweep up the debris with a broom and dustpan.
- ✓ Repeat with fresh absorbent materials as needed to remove any remaining oil.

Manage workplace wastage

Waste produced in work areas where engineering works are undertaken can be dangerous and need to be properly managed and handled.

Storing hazardous waste requires extra care. It should be stored under cover and in a bunded and secure area, or in an underground tank. Storage systems must contain any leaks or spills and prevent waste coming in contact with the ground or escaping to the environment via stormwater drains or gutters. And for proper handling of waste in referred eras, it is felt vital that consultations are made with Waste Management Corporation (WAMCO) or Environment Protection Agency (EPA).



CLEAN AND STORE EQUIPMENT

While repairing, it is important that through inspection is made on the determining faculty equipment and properly manage and handle them accordingly.

Collect used equipment, inspect for faults and, where necessary, remove from service

With the water plants and other industrial machineries, it is important that continuous inspections are undertaken to determine faulty parts that will affect operational efficiency of the system. For this reason, it is important that the faulty component or part is isolated and if possible, replaced on timely basis. Isolated parts may be either serviced or repair and it is vital that proper inspection is undertaken and repaired to be used for next time.

Use appropriate agents, apparatus and techniques to clean equipment

Dismantled parts need to be properly cleaned using appropriate cleaning methods prior to storing them for a safe, clean and hygienic environment within the work premises. Cleaning may consist of brushing, mopping, sweeping, dusting, polishing and wiping. The exact role and details of the cleaning process and the cleaning agents to be used will depend on the type of machinery being cleaned.

Pressure washers and water cannons are ideal for cleaning industrial equipment of grease and grime. These harmful materials act as abrasives and friction agents, contributing to issues in your machinery if they're left unaddressed.

Store clean equipment in the designated locations

After, the repair, the part or the equipment need to be properly stored.

MONITOR STOCKS OF MATERIALS AND EQUIPMENT

Maintaining adequate supply of spare parts and other equipment are vital for effective and smooth operation of water plants and similar machinery. Besides that, managing adequate stock of spare parts are vital for sustained provision of services.

Perform stock checks and maintain records of usage as directed

Stock checking, is the systematic process of checking the quantity of the inventory. This helps in the decision making of the company as the experts are able to understand if the stock that they currently have on hand will be able to meet the required production and the resultant output will meet the demand for replacement of spare parts for effective and smooth operation of the industrial machines or equipment. Proper management of stock levels need to be maintained with systematic recording to ensure services are not interrupted.

Store labelled stocks for safe and efficient retrieval

Stock items need to be properly labelled for easy retrieval as confusions may arise if the labels are not properly undertaken. For this purpose, following rules need to be applied when labelling.

- ✓ Labels should be durable and fixed in place (i.e., don't use magnets or labels that can be easily moved).
- ✓ Labels should be easy to read, preferably from across a room.
- ✓ Consider using easy-to-spot colors such as black on yellow or white on red. (If you decide that easy-to-spot colors are too "ugly" or you can't easily make new labels with the same color scheme, you may not want to do this.)
- ✓ It should be easy to change or create labels (use an office printer or label maker to make them).
- ✓ They should be mounted so as not to obstruct normal activity or get easily ripped off or damaged.
- ✓ They should show the FULL NAME of the location, and no two labels should be the same.

- ✓ They should have arrows that point to the location, making identifying the correct location easier, especially with shelf labels.

Inform appropriate personnel of impending stock shortages to maintain continuity of supply

Having stock sit idly on the shelves will pile up the storage and maintenance costs, risk wastage and even be susceptible to theft from staff. Conversely, not having enough stock will put your operation risk as you won't be able to keep up with the demand for replacement of parts. It is therefore vital to ensure proper personnel are continuously communicated for order placement for parts and maintain the engineering store at optimal level with spares for continued and sustained operational efficiency.

MAINTAIN SAFE WORKING ENVIRONMENT

For continued productivity, we all need to maintain a safe and healthy workplace. A safety and health management system, or safety program, can help to focus our efforts at improving work environment.

Participate in OHS activities within scope of responsibilities

Irrespective of the work being performed, it is mandatory that all participate in the occupational health and safety aspects related to the work being performed across the workplaces. A health and safety program are a definite plan of action designed to prevent accidents and occupational diseases. We all need to participate in the program being implemented under occupational health and safety scope across the different work practices. Because organizations differ, a program developed for one organization cannot necessarily be expected to meet the needs of another, although participation of all is vital and is considered as a responsibility of all involved with the different workplace tasks.

Use established safe work practices and PPE to ensure personal safety and that of other personnel

Depending on the nature of the work involved, work practices may vary and need to be reviewed and agreed upon and following are some examples of safe work practices. That need to be followed while undertaking work activities.

Construction (Health, Safety and Welfare Regulations)

These regulations lay down key requirements for the safety of construction sites:

- ✓ generally ensuring a safe place of work
- ✓ precautions against falls from height or into excavations

- ✓ protection against falling objects
- ✓ Protection against structural collapse (while work is taking place), i.e. the building falling down!
- ✓ safeguards when working in excavations
- ✓ prevention of drowning (falling into water)
- ✓ provision of safe traffic routes (on sites)
- ✓ Prevention and control of emergencies (site emergency evacuation procedures, etc.)
- ✓ provision of welfare facilities – WCs, washing facilities, canteens/rest areas, shower facilities (if required)
- ✓ Provision of site-wide issues – clean and tidy sites, adequate lighting, constant and fresh air supply, etc.
- ✓ Training, inspection and reports – proper training of staff, use of properly trained staff to do the work, proper supervision of staff and monitoring the work carried out by staff to ensure it is carried out in a safe manner.

The Electricity at Work Regulations

These regulations lay down requirements for safe working with electricity:

- ✓ duties of those involved in undertaking the electrical work
- ✓ systems, work activities and protective equipment
- ✓ strength and capability of electrical equipment
- ✓ insulation, protection and placing of conductors
- ✓ earthing and other suitable precautions
- ✓ integrity of reference conductors
- ✓ making connections
- ✓ means for protecting from excess current
- ✓ means of cutting off the supply and isolation
- ✓ precautions for work on equipment made dead
- ✓ work on or near live conductors
- ✓ working space, access and lighting
- ✓ competence to prevent danger and injury

Safety with Electrical Tools

The Electricity at Work Regulations lay down the requirements for electrical power tool safety. Here are some of the key requirements:

- ✓ low-voltage (cordless) power tools tend to be preferred to their mains fed counterparts, as they are safer to use
- ✓ on construction sites in particular, 110-volt power tools tend to be used as an alternative to the standard 240 volts found in domestic properties – lower voltage is again safer by design
- ✓ all power tools should be visually checked for signs of damage before they are used – damaged cables, plugs and casings, etc. Damaged tools must be taken out of service until disposed of or repaired
- ✓ all power tools should be subject to a Portable Appliance Test (PAT), this is a periodic check for electrical safety by a competent trained person, the recommended frequency of test for construction applications is three-

monthly; all tested appliances should include a test label showing that the appliance has passed the test and the date of the next test should be displayed

- ✓ a Residual Current Device (RCD) is a type of electrical protection device that can be used in the electrical circuit supplying the power tool in order to provide added protection to the user
- ✓ power tools, e.g. circular saws, may also be supplied with adjustable guards. The tool must always be used with the guard firmly in place – it's there to protect the user! On no circumstances must it be removed to make the job easier.

Safety with work at Heights

Falls from ladders account for a high proportion of accidents in the construction industry. Here are some of the key points of ladder safety:

- ✓ A ladder should only be used to gain access to a work platform such as a scaffold, or for short-term work of usually less than 30 minutes' duration. Work at heights for longer periods should be carried out using safer access equipment such as a mobile tower scaffold
- ✓ there are a number of classes of ladder – Class 1 (industrial ladders) should normally be used for construction activities
- ✓ the ladder should be checked for safety and for visible signs of damage each time it is used – if in any doubt the ladder should not be used
- ✓ care must be taken when transporting the ladder around site and when erecting it

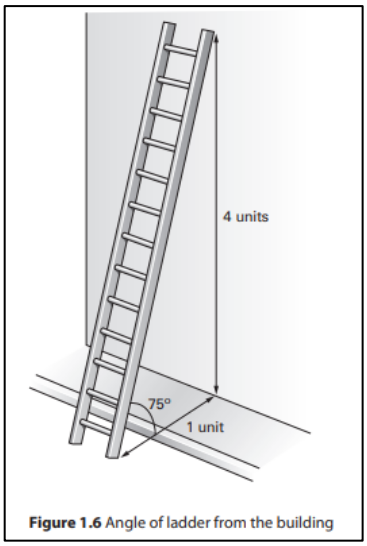
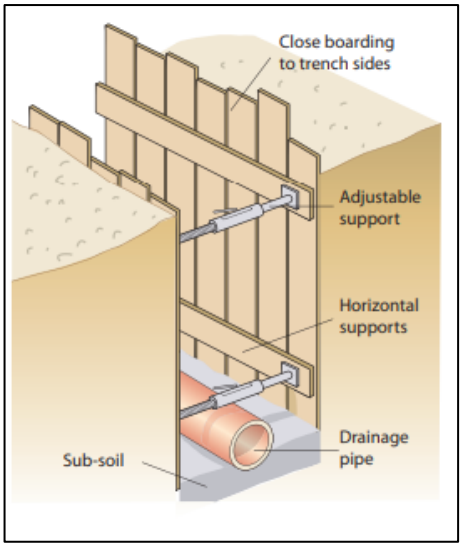


Figure 1.6 Angle of ladder from the building

- ✓ the ladder must only be used on firm, level ground.
- ✓ if the ladder is to be used on or near a public footpath or road, there should be barriers around its base
- ✓ the angle of the ladder to the building should be 75°, or 4 up to 1 out
- ✓ the ladder should preferably be secured at the top and bottom, footing by a co-worker is an alternative method of securing at the bottom
- ✓ the top of the ladder should project 1m or approximately five rungs above a working platform or roof access point.

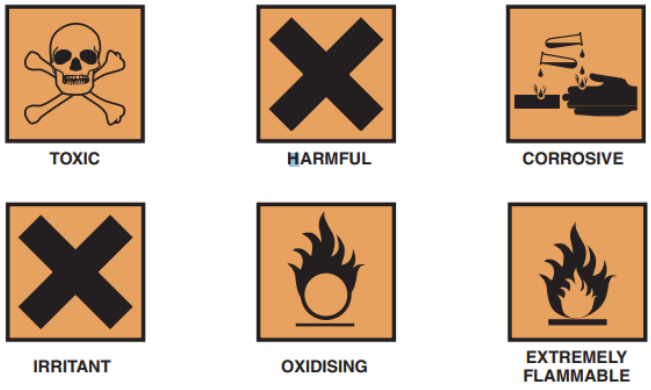
Safety with Work in excavations



Work in excavations can be particularly hazardous and therefore a risk assessment must be conducted before the work is commenced to ensure that proper control measures are applied to safely do the work. The following are typical measures:

- ✓ an assessment of the ground material type must be undertaken to determine the need for shoring
- ✓ only properly trained plumbers must work in excavations
- ✓ any work carried out should be in pairs, one plumber carrying out the work in the trench, the other passing tools and materials
- ✓ fencing must be erected around trenches over 2m in depth to prevent persons falling into the trench

Safety with work on hazardous substances



Work with hazardous substances falls under the COSHH Regulations, requiring an assessment of the risk of using the substance to be carried out before the work begins. Manufacturers of substances in support of the risk assessment process are required to adequately package the product, showing the dangers that the substance presents, and provide instruction on its use.

Hazardous substances tend to fall into the following categories:

- ✓ toxic – poisonous liquids and gases
- ✓ harmful – a general term that is used as a classification for many hazardous substances
- ✓ corrosive – products that may corrode such as bleach
- ✓ irritant – products, such as loft insulation, that may cause irritation to parts of the body
- ✓ extremely flammable – substances that may lead to fire, e.g. LPG
- ✓ oxidizing – these are substances that remove oxygen from the surrounding air, e.g. ABS cement for jointing plastic pipework

Work with LPG gas heating equipment

Work with gas heating equipment can be a particularly dangerous activity as it can lead to:

- ✓ risk of fire through the ignition of combustible substances in the vicinity of the work area. Many insurance companies, in order to provide insurance to

plumbing companies, require them to cease using LPG gas heating equipment at least 1 hour before leaving a site, so that any burning material is seen to be properly extinguished, and on high-risk jobs plumbing contractors may be asked to use a permit-to-work system.

- ✓ Risk of gas leakage:
    - gas heating equipment must be properly assembled and checked for leaks using soap solution
    - leaking gas, as it is heavier than air, will sink to the lowest points in a room, with the ability to form an explosive concentration
    - storage of cylinders should preferably take place in an open-air secure compound, all cylinder valves should be fully closed and protective dust caps should be in place, cylinders should be kept in an upright position.

Irrespective of the work u undertake, it is imperative that you wear proper personal protective equipment to ensure safe and healthy working condition for you and others.

Personal Protective Equipment

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits.

Report potential hazards and/or maintenance issues in own work area to designated personnel

Eye protection

Eye protection comes in the form of:

- ✓ safety glasses – a typical application could be lead welding
- ✓ safety goggles – these provide a higher level of protection than safety glasses, as they should fit closely to the face
- ✓ welding goggles – these include specialist coloured lenses.

Eye protection that is used to guard against the threat created by flying objects should include lenses that are of the high-impact resistant type.

Hand protection

Hand protection that is normally used in plumbing includes:

- ✓ general-purpose gloves – these helps protect against cutting or puncture wounds; an example of their use could be lifting concrete blocks or lifting steel tube
- ✓ specialist gloves – these are typically used to deal with hazardous substances such as dry ice used in pipe-freezing applications

- ✓ rubber gloves – these help protect against contact with used soil and waste systems and sanitary appliances. Gloves also provide protection against a disease known as dermatitis, which is caused by the hands coming into contact with materials classed as irritants.

Head protection

It is a mandatory requirement to wear a safety helmet on new-build and major construction sites. In addition, a safety helmet will need to be worn when work is taking place at heights or above the point where you are working – that could be in a trench. A safety helmet must:

- ✓ be properly adjusted to fit you
- ✓ be replaced if it becomes defective or dam

Foot protection

It is important to wear adequate foot protection for the majority of plumbing installation work carried out, owing to the weight of the components used. Adequate foot protection (which can be in the form of a safety shoe) usually includes:

- ✓ metal toe protection
- ✓ strong rubber soles and sturdy uppers. In addition, some forms of safety footwear can provide additional protection against electric shock.

Knee protection

Plumbing work can include a certain amount of kneeling, which can lead to painful conditions such as Housemaid's Knee. Knee protection should therefore be considered which can be in the form of:

- ✓ external fasten-on knee pads, or
- ✓ knee pads built into workwear.

Protective overalls

Protective overalls, alternatively known as workwear, will need to be worn for most plumbing activities. Protective overalls are available in many styles, they essentially:

- ✓ protect the worker's clothing
- ✓ assist in preventing the removal of hazardous or contaminated substances from the work-site. Disposable overalls are available and tend to be used for more specialist activities such as work on drains or sewers, or working with asbestos.

Ear protection

Ear protection should be worn when working in noisy areas or with equipment that generates high levels of noise. Ear protection is usually in the form of:

- ✓ ear defenders, or
- ✓ ear plugs.

The need to wear ear protection may be indicated by safety signs or through risk assessments carried out by construction or plumbing companies.

Respiratory protection

There are many forms of respiratory protection:

- ✓ simple dust mask – an example of its use could be working with loft insulation
- ✓ cartridge-type respirator – these can guard against a range of substances such as high levels of dust or fumes; different disposable cartridges are required to protect against different types of substances
- ✓ full breathing apparatus – usually used in specialist work in confined spaces such as drains or sewers.

FOLLOW INCIDENT AND EMERGENCY RESPONSE PROCEDURES

Workplace injuries cost employers significant cost of money every year. Therefore, it is vital that appropriate steps are taken to reduce the chances of injury, illness and property damage. An incident is an event or chain of events which has or could cause occupational injury, ill health, and/or damage (loss) to people, assets or reputation.

Identify incident and emergency situations

You are responsible not only for the safety and well-being of both your business and your workers. While it is not always possible to prevent accidents and disasters, they can be easier to cope with when you and your staff are prepared.

For this purpose, it is always important to review workplace tasks for the purpose of performing hazard assessment of the workplace to identify any physical or chemical hazards that may exist and could cause an emergency.

Report and record incident and emergency situations according to workplace procedures

The Reporting of accidents, injuries, or dangerous occurrences lays down the requirements for the reporting the following in advance.

- ✓ injuries – fatalities (including members of the public) or injuries to you or to the work colleague
- ✓ diseases that have the potential to spread among the staff

- ✓ Dangerous occurrences such as something that could have resulted in a reportable injury, due to the collapse of an excavation.

Detail of reportable accidents should be forwarded to the respective person in the workplace.

It is advised that the enterprises maintain an accident book for recording detail of all types of injury that occur while carrying out work, however minor. The accident book is used by the employing firm to monitor the level of accidents that occur and establish whether any additional safety controls are required to do the work.

If an accident occurs, an employee may be required to complete an accident report form; this should preferably be completed by the injured employee as soon after the accident as possible. If it is completed by a third party, then the employee must carefully check that the details are a clear identification of the events that took place, as once signed, an accident report could be used in legal proceedings!

Train staff to manage emergency procedures including use emergency equipment

It is critical to develop an effective disaster or crisis response strategy, no matter what industry your organization is involved in or what your geographic location is. Organizations must be able to respond quickly and competently should an emergency situation unfold. Having a response plan in place and ensuring staff members are both prepared and trained to respond to the emergency at hand are key to being successful.

Training staff in advance can, quite simply, mean the difference between life and death. Instead of being thrown in at the deep end in a real-life emergency situation, your employees will be more prepared to handle the situation, and therefore more likely to survive. Training also helps your employees to follow emergency plans which reduces the incidence of injuries and fatalities and also reduces damage to buildings, facilities and other property. Proper emergency response training also gives your employees instruction and guidance in using safety equipment such as hose reels, fire extinguishers and fire blankets which saves time in an actual emergency. It's important

that every single employee in your organization understands what to do in an emergency through education, training, drills, and written policies and procedures. They should know how to sound an alarm in the event of an emergency and know how to respond when one is activated. They should know which evacuation route they are expected to use.

MANAGEMENT OF WORKPLACE OCCUPATIONAL HEALTH AND SAFETY

Safety of workers (also known as worker safety and occupational health and safety) refers to the provision of a safe working environment, safe equipment, policies, and procedures in order to ensure workers' health and safety. Occupational Health and Safety issues in the immediate workplace are continuously assessed and action need to be taken to rectify the problem is reported or managed on timely basis.

Following are important aspects of health and safety and it is vital that the employees have developed basic knowledge and skills related to the following.

Understand the aspects of First aid

The requirements for providing first aid are laid down in the First Aid at Work Regulations, which require the employer to conduct a risk assessment of first-aid arrangements for the company, this will include establishing the need for first-aid kits and trained first-aiders.

The following shows the typical contents of a first-aid kit.

The kit should only contain items for first aid, no other medicines must be stored in the kit (this includes headache tablets). Where plumbers are working in domestic properties it is normal practice for a first-aid kit to be provided on each company vehicle and for each plumber to receive a basic level of first-aid training.

Typical areas for first-aid training

A typical first-aid course for a plumber will cover:

- ✓ electric shock – removing the casualty from a live supply using an insulating material such as wood; Cardio Pulmonary Resuscitation (CPR); dealing with unconsciousness (no sign of breathing)

- ✓ placing the injured person in the recovery position (so long as they do not bear signs of a damaged back), and keeping them warm until the emergency services arrive
- ✓ treatment for burns – flood the injury with cold clean water
- ✓ dealing with broken bones – prevention of movement at the site of the injury until it is properly secured and supported
- ✓ substance in the eye – bathing the eye in eye-wash (clean water).

Understand the aspects of Fire Respond

Fire safety

Plumbers need to be aware of the fire risk that may be associated with their work. Some of the dangers are:

- ✓ igniting combustible materials in the location of hot working
- ✓ faults caused by electrical work. In order for a fire to occur the following need to be present:
- ✓ fuel – combustible material
- ✓ oxygen – air supply
- ✓ heat – ignition source. Remove any of these three items and fire will not take place.

Classes of fire

Fires are classed into groups according to the fuel type:

- ✓ Class A – fires involving solid materials, extinguished by water
- ✓ Class B – fires involving flammable liquids, extinguished by foam or carbon dioxide
- ✓ Class C – fires involving flammable gases, extinguished by dry powder
- ✓ Class D – fires involving flammable metals, extinguished by dry powder.

Fire-fighting equipment

There are a variety of different types of fire-fighting equipment. In undertaking plumbing work you are more likely to come across the fire extinguisher as the main source of protection; here are some points to its use:

Type of extinguisher	Colour code	Main use
Water	Red	Wood, paper or fabrics
Foam	Cream	Petrol, oil, fats and paints
Carbon dioxide	Black	Electrical equipment
Dry powder	Blue	Liquids, gases, electrical equipment

- ✓ an extinguisher should be kept in the immediate work area when hot working, e.g. using LPG gas heating equipment
- ✓ a fire extinguisher should only be used when it is safe to do so, personal safety must come before attempts to contain a fire
- ✓ fire extinguishers should only be used by those trained in their use

- ✓ the following shows the colour coding for extinguishers for dealing with the different types of fire.

Action in the event of a fire

Your employer will normally have procedures for actions in the event of a fire; if it's a larger site then the client or main contractor will have their own procedures. Whatever the case, you must be familiar with those procedures, which will include:

- ✓ the various fire escape routes from the building
- ✓ the location of designated safe fire assembly points, which you must go to in the event of an emergency
- ✓ if you discover the fire
    - raise the alarm immediately
    - leave by the nearest exit
    - ensure that the emergency service is summoned

Summoning the emergency services

These procedures apply to a range of different type of emergencies including fire:

- ✓ find a telephone in a safe environment, well away from the emergency
- ✓ dial the emergency service number
- ✓ keep calm, and when asked by the operator, give the name of the emergency service required, e.g. fire
- ✓ when you get through, provide the location of the emergency first and then the nature of the emergency, e.g. fire in cellar; also provide details of any specialist hazards that the emergency service may encounter, e.g. storage of flammable liquids

When the call has been completed, ensure that someone is available to meet the emergency service and to show them the location of the incident

Occupational Health and Safety documents are provided to all work stations

It is important that all the enterprises follow moral and legal responsibility to provide a safe and healthy work environment for employees, clients and visitors. This commitment extends to ensuring that the organisation's operations do not place the local community at risk of injury, illness or property damage. For this purpose, an Occupational Health and Safety Manual need to be developed for the purpose of the following.

- ✓ Ensure employees are provided with a working environment that is safe and without risk to health;
- ✓ Implement and maintain safe systems of work;
- ✓ Consult with all employees on OHS matters;
- ✓ Take reasonable steps to ensure risk are controlled at the client's workplace;
- ✓ Monitor and review the effectiveness of measures to protect employees.

- ✓ Ensure compliance with legislative requirements and current industry standards;
- ✓ Provide employees with necessary information, instruction, training and supervision.

It is therefore vital that the referred Manual be distributed to all departments and ensure everyone is made aware of the occupational health and safety requirements of the respective organization.

UNIT 02

APPLY WORK ETHICS AND OPTIMIZE PROFESSIONALISM

This module covers the knowledge, skills and attitudes required in demonstrating proper work values and professionalism at work Besides ethical values, knowledge and skills also developed on maintaining integrity at work

Introduction

Work ethics and professionalism is defined as the capacity to demonstrate personal accountability and effective work habits, such as punctuality, working productively with others, and time workload management, and understand the impact of non-verbal communication on professional work image. The individual demonstrates integrity and ethical behavior, acts responsibly with the interests of the larger community in mind, and is able to learn from their mistakes.

Referred behavioral traits are vital to ensure all working useful team members for the benefits and wellbeing of their professions with enhanced productivity through their career and life.

PURPOSE OF WORK AND ALIGNING TO COMPANY'S HARMONY

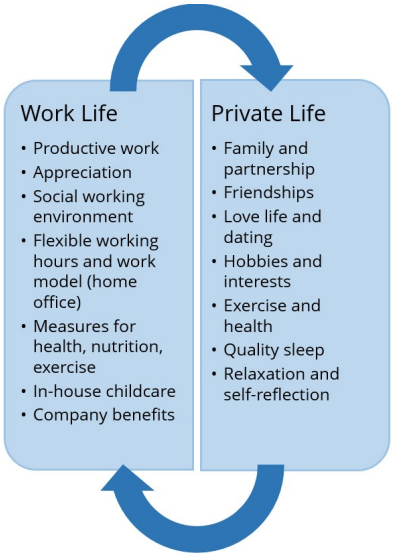
It is important that we have developed purpose to work and provide meaning to the work we do as they add values to the different jobs we perform. It is also believed that clear identification of the purpose and meaning to work are example of good work values and these values have a significant impact on employees' job satisfaction, and the success of businesses and teams.

Being aware of workers values, how such individual arrives at decisions on the importance, worth, or usefulness of something and gives strategic insights into managing teams, and in hiring the 'best fit'.

It is evident that staff are happier when their values align with their career choices.

It is a fact that the work adds economic value, generates sustainable well-being for the individual and his family. Besides the direct benefits to the individual, this is also important to strengthen and promote progress in the social fabric, and it is a major factor for constructively and productively integrating into the social environment they belong and to which they owe something.

While some careers allow a relaxed relationship between work and private life, many others demand significant reductions in the area of leisure and family. With this in mind, employers are becoming more aware of the growing expectations of their workforce in terms of the work-life balance. Companies are now considering how to achieve a



Personal and professional life should complement each other

work-life balance and implementing targeted measures to promote this. The goal is not only to make employees more productive, but also happier and more balanced.

APPLY WORK VALUES/ETHICS

Work values/ethic is a valuable attribute that employers look for in every industry. Showing the values associated with a good work ethic can increase employability and help to position for better job opportunities. Employees with excellent work values and ethics often receive for special projects and opportunities because they're reliable, dedicated and disciplined.

Work Values and Ethics Skills

Following are some of the important skills related to work values and ethics linked to any job being performed.

1. **Reliability**

Employees with a strong work ethic are very reliable. You can expect these individuals to be on time for shifts and meetings. They meet their deadlines and offer quality work. A reliable coworker makes an excellent teammate because they contribute fairly to projects.

2. **Dedication**

Part of a good work ethic is commitment and dedication to the job. They know how to focus on tasks without being distracted. These employees usually work until they finish their duties. They stay with one company for long periods of time.

3. **Discipline**

Discipline is an essential part of showing a good work ethic. Highly disciplined employees show determination and commitment to the job. They strive to meet or exceed expectations and seek opportunities to learn new skills and improve their performance.

4. **Productivity**

A strong work ethic translates to outstanding productivity. Productive employees often have a higher output than their counterparts. They complete projects early and do more than the minimum requirements.

5. **Cooperation**

A good work ethic is something that employees often spread to those around them by cooperating willingly on projects. They show good teamwork and readily assist others when needed.

6. **Integrity**

Professional integrity means holding oneself to high moral principles. Those with a strong work ethic also have outstanding integrity. They're honest, polite and fair to others.

7. **Responsibility**

Demonstrating strong work ethic requires a keen sense of responsibility. Those who are ethical and responsible hold themselves accountable for their actions. They will accept the blame for errors they've contributed to and proactively work to fix these issues.

8. Professionalism

Employees with a good work ethic almost always maintain their professionalism. They exhibit a professional attitude clear in the way they dress, speak and carry themselves. They're respectful, focused, organized and neat.
Strong work ethics/values are vital to position and progress through career irrespective of the job or industry in which the staff is working.

How to improve work values/ethic skills

Following techniques at work will help to improve and strengthen work values/ethic skills on any job being performed, irrespective how big or small the organization may be.

1. ***Act as an ambassador of the company***. Maintain a positive attitude toward the company in both professional and personal interactions. Seek ways to further the business even if they're outside the scope of your job. For example, a finance professional may pass a potential lead along to a sales representative.
2. ***Prioritize your professional responsibilities***. Maintain good attendance, return promptly from lunch and arrive for meetings early. Strive to make personal appointments that don't interfere with your work schedule and only take personal calls on your cell phone when you're at lunch.
3. ***Seek professional development***. Independently seek ways to improve your work performance, such as taking night classes, attending weekend seminars or reading industry publications.
4. ***Review your work.*** Submit thorough work that you have double-checked for quality and consistency. Manage your time properly so you can deliver projects early and give each task the time and attention it requires.
5. ***Show respect to others***. Speak politely to and about others in the workplace. Keep your interactions professional to show your respect for others.

Above skills need to be continuously developed among the staff and together as team towards development of company's values as whole.

DEAL WITH ETHICAL PROBLEMS

Irrespective of the job and size of the organization, any employee is bound to face ethical problems during their professional life and could happen across the places of work.

Common ethical problems

It is important that all are aware of ethical issue and following are some of the common ethical problems and issues.

1. Unethical Leadership

Having a personal issue with your boss is one thing, but reporting to a person who is behaving unethically is another. This may come in an obvious form, like manipulating

numbers in a report or spending company money on inappropriate activities; however, it can also occur more subtly, in the form of bullying, accepting inappropriate gifts from suppliers, or asking you to skip a standard procedure just once.

2. Toxic Workplace Culture

Organizations helmed by unethical leadership are more often than not plagued by a toxic workplace culture. Leaders who think nothing of taking bribes, manipulating sales figures and data or pressuring employees or business associates for "favors" (whether they be personal or financial), will think nothing of disrespecting and bullying their employees. With the current emphasis in many organizations to hire for "cultural fit," a toxic culture can be exacerbated by continually repopulating the company with like-minded personalities and toxic mentalities.

3. Discrimination and Harassment

Laws require organizations to be equal employment opportunity employers. Organizations must recruit a diverse workforce, enforce policies and training that support an equal opportunity program, and foster an environment that is respectful of all types of people. Unfortunately, there are still many whose practices break with existing guidelines. When discrimination and harassment of employees based on race, ethnicity, gender, disability or age occurs, not only has an ethical line been crossed but a legal one as well.

4. Unrealistic and Conflicting Goals

Your organization sets a goal—it could be a monthly sales figure or product production number—that seems unrealistic, even unattainable. While not unethical in and of itself (after all, having driven leadership with aggressive company goals is crucial to innovation and growth), it's how employees, and even some leaders, go about reaching the goal that could raise an ethical red flag. Unrealistic objectives can spur leaders to put undue pressure on their employees, and employees may consider cutting corners or breaching ethical or legal guidelines to obtain them. Cutting corners ethically is a shortcut that rarely pays off, and if your entire team or department is failing to meet goals, company leadership needs that feedback to revisit those goals and re-evaluate performance expectations.

5. Questionable Use of Company Technology

While this may feel like a minor blip in the grand scheme of workplace ethics, the improper use of the internet and company technology is a huge cost for organizations in lost time, worker productivity and company dollars. Such practices are not only misuse of company tools and technology, but it's also a misuse of company time. Whether you're taking hourly breaks to check your social media news feed or know that your coworker is using company technology resources to work on freelance jobs, this "little white lie" of workplace ethics can create a snowball effect.

6. Too frequent Coffee or Cigarette Breaks

Too frequent coffee or cigarette breaks contribute to loss of productive time to any

enterprises. Such breaks are vital to main continued productivity as staff feel relaxed and motivated with such breaks. However, break interval and frequency of such breaks need to be maintained at normal and acceptable to the company policies on taking breaks to ensure work ethics and values are not compromised.

All the above or any other ethical issues or values need to be dealt properly with shortest possible time to ensure workplace tasks attended by the staff is always remain focused and aligned to the productivity of different workplaces.

Solving Ethical Issues at Workplace

Following are strategies and methods on dealing with ethical issues at workplaces.

1. **Gather as much information as possible.**

Before taking action to solve an ethical issue, we need to have thorough understanding of that issue as possible. The problem may not be as straightforward as it first appears and it is important to gather enough information to determine what's going on. Gather all relevant facts concerning the issue at hand, and ensure we are not making assumptions. Everyone has their own personal and professional biases. Some of those biases are grounded in experience, but with limited facts or information, it could be skewed to perspectives and be lacking reality.

2. **Identify the parties involved**

Identify the parties involved and determine who else is involved in this issue. Involvement can be direct or indirect and on a direct level, those participating in the ethical violation are certainly involved. On an indirect level, those who will be impacted regardless of having no say in the issue are also involved. Among others, this can include coworkers, customers, and stockholders. It is important to determine who, among those involved. While fixing the issue, ensure the case is within your scope of duty and if not refer to the relevant seniors within the organization.

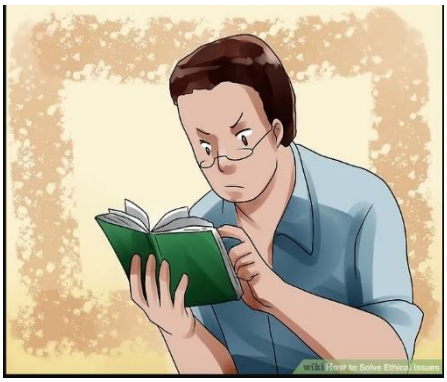
3. **Pinpoint the ethical issues involved.**

Instead of settling for a general sense that something is wrong, you need to ask yourself which ethical principles are being abused. Some ethical violations are more obvious than others. For instance, if you caught a coworker stealing expensive equipment, you could make the clear distinction that theft is wrong. In situations dealing with small violations or interdepartmental strife, though, the violation may not be as clear. Review the circumstances again and ask yourself which fundamental principle is

affected.

Possible options include violations of power, integrity, honesty, objectivity, professional competence, confidentiality, or fairness.

4. Review the company's standard procedure.



Find out if your company currently has an internal system set up for dealing with ethical issues like this. If you have a company manual or similar documentation, review it now. Look into the organization's policies concerning workplace ethics. Pay close attention to the chain of command. Find out who you should involve at which points, and the correct procedure for doing so. If the company doesn't have a set structure for dealing with ethical issues, you will need to determine who to go to using your own experience and understanding.

5. List and evaluate your options.

Think of every possible option available to you instead of settling for the most obvious. Write out each of these options and consider the impact each one might have. When evaluating your options, consider how each one fares in the light of your company's internal procedures, any external laws involved, and any general ethical values upheld by society as a whole. Predict the consequences that will result from each option. This includes both positive and negative outcomes. Understand that, in some circumstances, each option may come with both negative and positive consequences.

6. Execute the best option.

After reviewing all of your options, determine which is best and put it into practice. In most cases, the solution will require you to escalate the issue to an authority within the company. The correct person may depend upon who within the company is guilty of the violation. Moreover, if the highest authorities in the company are guilty, you may need to bring the violation to the attention of an external authority. The best option should address the ethical issue in a productive manner. If multiple ethical values are involved, your solution should usually correct as many violations as possible. Whatever option you choose, be prepared to stand by it. There will always be critics, and there is no guarantee that you can remain anonymous throughout the entire corrective process.

7. Keep a record as you monitor the outcome.

Unfortunately, your work doesn't end just because you've reported the issue. Keep an eye on how things progress to make sure that the issue is genuinely addressed. As a general rule, it's a good idea to document nearly everything in writing. This includes your own investigations, the reports you've filed, and the discussions you've had concerning this issue. You may need to use these written records to defend yourself later.

8. Take things to the next level when needed.

If the initial solution you implement doesn't work, keep trying. Continue through the hierarchy until you've exhausted every possibility. Don't be afraid of going above someone's head if he or she isn't getting the job done. Be reasonable when evaluating how that supervisor has handled things, but don't let yourself be bullied into submission by someone trying to sweep things under the rug.

MAINTAIN INTEGRITY OF CONDUCT IN THE WORKPLACE

Ability of staff to maintain professional integrity in the workplace has a powerful impact on productivity, performance and reputation. Behaving with professional integrity takes practice, strength of character and self-awareness. In this section, we will evaluate why professional integrity is important in the workplace and share techniques to help maintain own integrity and even create a culture of integrity throughout the entire organization.

Professional integrity is the practice of maintaining appropriate ethical behavior. It is the practice of showing strong adherence to moral and ethical principles and values such as honesty, honor, dependability and trustworthiness. People who behave with professional integrity generally uphold a moral standard of conduct, both in professional as well as personal endeavors. These standards govern how professionals conduct themselves, their work ethic and their communication practices.

Reasons for maintaining professional integrity in the workplace is important
Integrity is one of the most important attributes associated with the employees and the

reasons for maintaining professional integrity are summarized as follows.

- ✓ **Employee satisfaction**: Employees are typically happier working for someone who they believe is trustworthy and dependable, someone who would never ask them to compromise their own principles. Integrity in a supervisor has been linked to job satisfaction and engagement, employee health and even life satisfaction.
- ✓ **Reputation**: In order for people to trust you— both in- and outside of your organization— you need to behave with integrity. Investors need to trust you in order to consider investing in your business. Vendors need to trust that you will pay for goods and services. Maintaining professional integrity will allow you to build a strong reputation that will increase the trust and comfort others have in doing business with you
- ✓ **Clearer focus**: Consistently behaving with professional integrity means you have the energy to focus on what is important rather than wasting energy covering up bad practice.
- ✓ **Stronger sales**: Customers today are motivated to buy from companies that are socially and environmentally responsible. The most effective way to create a culture of integrity and ethical behavior is to behave with professional integrity.

Skills to be developed in maintaining integrity within the workplaces

Following skills need to be developed among the employees in order to maintain own professional integrity and encourage an entire culture of ethical behavior within the workplace.

1. Treat everyone the same

Integrity is about honesty, wholeness and being the same person in all situations and with all people. Treat supervisors, coworkers and even the intern with the same level of professionalism and respect, regardless of their level of seniority. The same applies to customers. Every customer should be given the best treatment, regardless of the level of service they pay for.

2. Reward honesty

Create a culture of integrity by encouraging others to be honest with you, even when they make costly mistakes. Reward honesty publicly and repeatedly until everyone on your team understands that it's always safe— and always the best idea— to be honest with you.

3. Admit your mistakes

Everyone makes mistakes and no one, from customers to employees, expects everyone to be perfect all the time. The key to behaving with professional integrity is admitting mistakes and apologizing when you're wrong. You must also demonstrate your regret through your actions and demeanor. You'll generally find that not only do people not

think less of you, they actually think more highly of you by your ability to admit error.

4. **Encourage teams to speak freely**

Encourage your team to come up with fresh and creative approaches to everyday business challenges you encounter. Team discussions regarding new ideas should be honest and critical, yet respectful and open-minded of other perspectives. Encourage your team to speak freely as well as give and receive constructive criticism to improve ideas.

5. **Conduct self-assessments**

Periodically evaluate whether you are behaving with professional integrity. Evaluate whether you are heavily influenced by stronger personalities, pressured by your boss or tempted by easy money. You could even ask a trusted coworker their objective viewpoint. Make a non-judgmental inventory of your own integrity and determine whether you need to take action based on potential areas of self-improvement.

6. **Keep your commitments**

If you want to develop a reputation as being someone who delivers on their promises, make a habit of always keeping your word. This means that yes needs to mean yes and no means no, without excuses or a change of conditions. This also means being on time— or even early— when you say you will be. It means demonstrating respect for others' time and notifying them right away if you'll be late.

7. **Put in maximum effort**

Putting all of your focus and effort into something to reach a goal is a character trait that others admire. It demonstrates a strong work ethic and a commitment to results for the betterment of the organization. Giving your work your maximum effort every day and being unwilling to give in to distractions speaks volumes about your integrity.

WORKPLACE EFFICIENCY

The three components of excellent service quality

Service quality is one of the most important competitive factors in today's business landscape. Here's how to make it excellent.

Defining excellent service is not a one-way street. It depends on how the customer experiences the service. That being said, one fact is without question; if the service quality is not sufficiently high, the service provider is likely to disappoint its customers regardless of their expectations.

Great service climate is a key to excellent service quality

The concept of service climate plays an important role in understanding how to deliver excellent service quality, as it captures what employees experience in terms of organizational practices regarding service delivery. It also influences employee motivation regarding service behavior.

If employees experience excellent service quality on the inside, they are more likely to be motivated to deliver excellent quality on the outside of the organisation. Thus a strong

service climate leads to service quality.
In order to create a great service climate and deliver excellent service quality, these three key components need to be in place:

Service Strategy

With a service strategy, the service provider can decide the service parameters, build the service value chain and design the internal service platform. The stronger each of these elements are - the better and more robust the service strategy will be.
Various studies have proven that an effective service delivery platform built on a solid service value chain concept greatly affects customer quality.
When managers ensure that service constantly is communicated as a strategic imperative, employees are likely to perceive service to be important. As a result, their behaviors towards customers are likely to reflect their orientation towards service excellence.

Service Performance

Research highlights that training, empowerment and rewards are the three most significant factors, which determine the level of performance and, in turn, lead to delivery of service strategy and excellent service quality.

Training

Training of service employees has long been identified as the most important factor behind higher service quality. For years, studies have proved that there is a strong correlation between the number of employee training hours and the degree of service quality.
To make it a success, the employer should focus on more than the basic service-specific competencies. The main emphasis should rather be on training of service management and other soft skills such as social skills, attitude and language abilities.
This will enhance the overall capabilities of service employees and improve the overall performance of the service system.

Empowerment

Empowerment means providing employees with enough autonomy to allow them to handle unforeseen situations and challenges and let them be more self-sufficient in their work.
Empowerment has five dimensions:

1. **Meaning**: the extent to which the employee experiences a task as personally meaningful
2. **Competence**: the extent to which the individual feels confident about their ability to perform the task
3. **Self-determination**: the degree of influence the individual has over how to perform the job
4. **Strategic autonomy**: the degree of influence an individual has on the content of the job
5. **Impact**: the degree of influence an individual has on their direct work environment

Empowerment motivates employees to greater service performance and creates a greater sense of accomplishment or satisfaction in their jobs by reducing dependency and encouraging teamwork.

Rewards

Service employees should be properly rewarded for their work. The term *reward* should in this context be understood as a broad term referring to more than just monetary reward. Contrary to common perceptions, monetary rewards play a much smaller role in aligning performance with the service organization's value and goals compared to non-monetary rewards. For both types of goals, it is of high importance that the goals are realistic and achievable and that the employee has been involved in the goal-setting process.

The intangible nature of services means that performance can be difficult to measure. Therefore employees must be trusted to monitor their own performance. Performance appraisals should include input from employees as well as customers and the appraisal results must be used in determining training needs.

Customer Results

As detailed above service quality is centered on the perception and experience of the customer. Hence, measuring and tracking customer results are ways to provide feedback to the service delivery chain and to increase the value of each customer relationship.
To make this successful it is of high importance that the service provider and the customer organization are aligned on the purpose, objective and goal of the service exchange.
If, for example, a customer organization aspires to become the world's greatest entertainment company, the service provider needs to ask: How can our company design a value proposition and our service delivery system to fulfill this customer vision?
If a customer would like the full benefit of an external service management provider, it is important to insist that the service provider both supports and understands the mission of the company. For this to happen the relationship must move from being input- or task-oriented to being collaborative.

UNIT 03

PRACTICE EFFECTIVE WORKPLACE COMMUNICATION

This unit covers the knowledge, skills and attitudes required to gather, interpret and convey information in response to workplace requirements

Introduction

Communication is the process of transmitting information and common understanding from one person to another. Communication in the workplace is critical to establishing and maintaining quality working relationships in workplaces.
It is more important than ever (in this highly competitive job-hunting environment) that students focus on improving their communication skills. Whether it is working at a parttime job or focusing more on graduate opportunities once you've finished your course, employers all say they want graduates who are 'expert communicators, team players, creative and innovative thinkers'. It does not seem to matter what industry you apply it to; most employers are saying the same thing – excellent communicators get the best paying jobs and the most rewarding careers.

OBTAIN AND CONVEY WORKPLACE INFORMATION

Better communication leads to a more productive workplace, which in turn increases a company's revenue. The consequences of poor and ineffective communication can be serious. Miscommunication between colleagues can lead to a halt in business operations. Miscommunication with customers often results in the loss of business. Good communication between colleagues and customers begins with effective communication skills and knowledge of successful workplace communication strategy.

Communication Channels

Communication channels are the means through which people in an organization communicate and interact with each other. Without the right communication channels in place, it becomes extremely challenging to align employees with the business goals, break down silos, and drive innovation in the workplace.

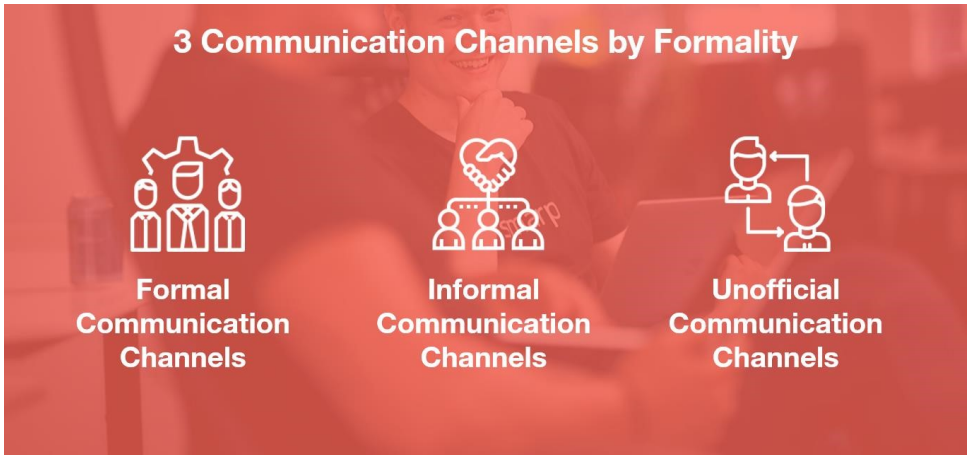
Types of Communication Channels

When looking at all the possible communication channels, we can segment them into two main groups:

1. Communication channels by formality
2. Communication channels by means of communication

Communication channels by formality

There are three different communications channels based on formality: formal, informal and unofficial.



1. **Formal communication channels**

Formal communication includes exchange of information such as the goals, policies and procedures of an organization. Some of the most common examples of formal communication include company business plans, strategy, goals, annual reports, agreements, company-wide communications, workplace safety guidelines and procedures, board presentations etc.

2. **Informal communication channels**

Informal communication channels are also used to deliver official business messages but in a more relaxed way. Some examples of informal communication include conversations at work addressing various issues that team members may have, lunch time conversations and continuous collaboration among team members.

3. **Unofficial communication channels**

In addition to official communication channels, there is also an unofficial mode of communication that is quite common in the workplace. Unofficial communication includes employee communication outside of work environment on topics not related to work.

Communication channels by mean

Besides formality, communication channels can be divided by mean. In other words, the way and tools employees use to communicate with each other. Three types of main means of communication in the workplace are as follows.

1. **Digital communication channels**

Electronic means of communication include various online tools that employees use to stay connected with each other and keep up with the company news and updates. Today, digital communication channels are the most popular and most used channels in the workplace. Some of the examples include email, internal communication platforms, employee collaboration software and intranets.

2. **Face-to-face communication**

Even though electronic means of conversation in the workplace are taking over, face-to-face communication is still extremely important. This mean is much more personal, and it has more human touch into it.

3. **Written communication**

This type of communication is almost completely dead within organizations. However, written communication is still necessary when important policies, letters, memos, manuals, notices and announcements are being communicated to the employees.

SPEAKING LANGAUGE AT AN OPERATIONAL LEVEL

Whether you are speaking in English or Dhivehi starting a conversation can be one of the most stressful things in life, but also one of the most rewarding. Being good at starting conversations is essential in your career and many other aspects of life. The following are examples of opening statements that can help you get the ball rolling.
Examples:

- ✓ How are you?
- ✓ How did your shift go?
- ✓ How's the weather today?
- ✓ Anything new today? Are you busy?
- ✓ What time do you finish work?
- ✓ Good morning.
- ✓ Good to see you.
- ✓ Nice to meet you.
- ✓ Where are you from?

Language Tips

Here are some suggestions for starting conversations:

- ✓ Research interesting things to talk about
- ✓ Before you approach somebody to talk, relax
- ✓ Be prepared to listen
- ✓ Avoid controversial subjects, complaining or gossip
- ✓ Be yourself!

Workplace interactions with colleagues

A good direction in your business, and therefore its success, is largely the ability to create and maintain social relationships, whether they are more ephemeral or more lasting and deeper.
In the workplace, anyone should be able to have a conversation with their colleagues and clients, and have a good attitude with them; but unfortunately it is not the most common. That is why we must learn to manage the way we interact with others.
There are some basic rules when it comes to building social relationships, which will be useful to us on a daily basis. Interacting with your coworkers in a positive way is crucial.

Identify the presence of your classmates

We mean to greet or recognize the other person who is close to you. A smile or a look is enough to show that you have seen that person, basically nothing but good education.

Work with the conversation

Starting the conversation yourself by telling your own experiences or asking the other person about your life is a good way to improve social relationships. In this way you will demonstrate your inclination to know that person more. By finding something that interests you or that you have in common, you will be creating the basis for future interactions. Do not forget to observe the details and focus on them, but always avoiding judging.

Share a bit of yourself

A conversation is not only based on asking and listening, it is an interaction between two people, in which both can and should contribute their views.
In this way, we must try not to fall into an "interrogation" and reveal our own feelings and opinions at the same time, since this will allow us to see our own perspective and create a true connection.

Empathy

It is the basic quality to develop when interacting with other people and that can be demonstrated in different ways. We refer to the ability to put ourselves in the place of the other person, and show a real interest in connecting with them. This desire is also demonstrated through our body gestures and facial expressions; such as smiling or bowing are examples of nonverbal language that convey an idea of attention for what the other person expresses.

Active listening

These tips will not help us, if we are not able to correctly attend to what our interlocutor is trying to convey to us.
If we join a conversation that has already begun, it is best to keep an eye on the rest of the people who participate and what they are commenting on. It is at the moment in which they arrive at a pause when you will be better received, and if you ask questions about what they have said and even offer a comment in reference to their statements, you will show true interest in your colleagues or clients.
Now is the time to implement all these tips and achieve with an open attitude, that your customers and colleagues are willing to collaborate, that they are more receptive to new opinions and challenges that there is a great working environment to achieve the success of your company.

Verbal instructions or requests are responded to at an operational level

When a supervisor or manager gives employee instructions to carry out a task, they expect that it will be done correctly. It is the responsibility of the employee to clarify the instruction or request to ensure no miscommunication of the supervisor's expectations. This unit will give you the language tools you need to confirm instructions or requests in order to avoid frustrating and embarrassing misunderstandings.

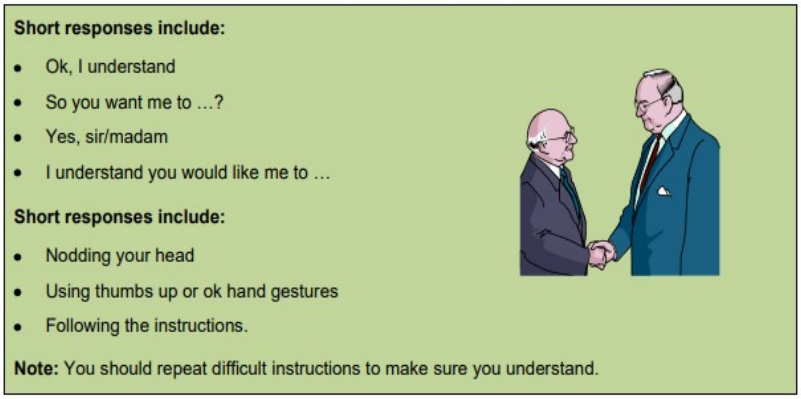
When you are given instructions it is important to confirm that you understand them and respond appropriately.

Confirm Understanding

You should use short responses and body language to confirm that you understand instructions.

Appropriate nonverbal communication

There are several ways nonverbal communication can support your ability to communicate effectively in the workplace, including:



- ✓ **Supports your message**. When having a conversation, participating in a meeting or engaging in conversation, nonverbal cues can emphasize and underscore the content of your message. For example, using hand gestures to indicate the importance of an idea may tell your listeners to pay attention to and remember a key point.

- ✓ **Communicates messages.** You may also use nonverbal communication completely to communicate with others. For example, if someone is explaining

a sentiment you admire and agree with, you might nod your head up and down to express solidarity.

- ✓ **Communicates intention**. Your body language may also intentionally or unintentionally express your current condition. For example, people may pick up nonverbal cues that you are being dishonest, unengaged, excited or aggressive.

- ✓ **Conveys feelings**. You can also use nonverbal communication to show your feelings, such as disappointment, relief, happiness, contentment and more.

- ✓ **Offers support.** Nonverbal cues are also a great way to show support. Whether it's a simple smile or pat on the back, action may speak louder than words in many cases.

- ✓ **Showcases your personality.** Nonverbal communication is a great way to show who you are. For example, a kind and optimistic person might frequently smile with open body language and offer friendly touches.

- ✓ **Indicates a desired action**. This might include inching toward a door to indicate your desire to leave the room, raising your hand to offer an idea or putting your hand out to meet someone new.

- ✓ **Deescalates tension**. Using a calm tone of voice, open body language, and directive gestures may help to resolve a difficult situation.

Simple requests

Whether it's a chance for more responsibility or a request for annual leave, making requests effectively in English is an important part of any English-speaking workplace. Ask in the wrong way and you can lose your chance of getting what you want or even make a bad impression on your colleagues so it's vital to get it right.
Follow these simple tips to make sure you get exactly what you want when you make a request in English.

Don't demand

People always resent being ordered around so make sure to avoid using imperatives when making requests. Saying, "Give me some time off" will never please your boss. Instead, start your request politely, for example, "I'd like to request some annual leave" or "I'd appreciate it if you could give me your feedback".

Eliminate "I need"

Always talking about what you"need" can make you sound bossy and offensive because it shows that you think your needs are more important than other people's. Use questions like "Could you please…?" and "Would you be able to…?" to sound more considerate and polite.

Avoid assumption

Even if you have an understanding boss, it's best not to make assumptions about being allowed to do certain things. If you want to leave early, it's much better to say "Would it be OK if I slipped out a bit early today?" than "I'm going to leave a bit early today". Think of the consequences of your request and what you will do to make up for any inconvenience caused. For example, if you need to leave a little early, explain when you will make up for the work you've missed.

Steer clear of accusations

If your manager seems to have forgotten about your request, don't accuse him or her of not doing the work by saying, "Where are those figures I asked for?" For a simple yet effective reminder, just say, for example, "I was wondering if you've had the chance to calculate those figures." It's a non-threatening way to remind your boss of something he or she promised to do.

Try a second time

If your manager has denied a request, it can be easy to just give up. Instead, check what the problems are with your request, explain clearly how you will solve them and then ask your manager to reconsider your request.
Remember, whenever you are making a request, considering how the other person will feel about it is a great way to guess how they will react. Think about the impact your request will have on the other person and bear in mind the tips above and you will be in a strong position to have your request granted.

Routine procedures

All organizations have rules for the transfer of information. Knowing how to use the different types of communication and following the correct procedures to ensure that information goes to the correct place and person.
Communication can be internal or external or both. Internal communication is between staff. External communication is between staff and guets or other community members including the media.
Routine workplace protocols exist for:

- ✓ written communication (sending and receiving information), and
- ✓ Verbal communication (giving and following instructions and messages).

Different forms of expression in English and Dhivehi

Students often ask me if we can use idioms and slang in professional situations – the answer is, it depends. Some expressions are not appropriate for the workplace, but there are many that you can use in conversations among co-workers and less formal emails.
In this unit, you'll learn 15 English idioms and phrasal verbs you CAN use at work.

Put Something Off

If you put something off, you delay doing it.
"I put off writing the report until the last day, and now I have to work overtime to finish it!"

Take Off

If something takes off, it increases or becomes popular very quickly.
"Sales have really taken off this year and the company is making record profits."

People Person

Somebody who is a people person is extroverted, has great social skills, and loves interacting with people.
"Ashley's been promoted to director of human resources. She'll do a great job – she's a real people person."

Crunch the Numbers

Crunching the numbers means to do a lot of calculations.
"After crunching the numbers, our accounting department informed us that we don't have enough money to buy the new equipment."

Have a Lot on Your Plate

If you have a lot on your plate, it means you have a lot of work and responsibilities at the moment.
"Sorry I didn't call you back sooner; I have a lot on my plate right now."

Selling Like Hotcakes

If a product is selling like hotcakes, it means a lot of customers are buying it very fast.
"The new product is selling like hotcakes. We'll need to produce more to keep up with the demand!"

Think Outside the Box

To think outside the box means to think in a creative way that is different from usual. "We need to come up with a really good advertising campaign. Let's try to think outside the box."

Win-Win Situation

A win-win situation is a cooperative agreement that is good for both people or companies.
"This partnership will bring increased publicity to their company and new customers to ours. It's a win-win situation."

Test The Waters

If you test the waters, you try something new to see if it will be successful or not.
"We're testing the waters to see if changing the product's packaging will increase sales."

Bang For The Buck

If something provides more bang for the buck, it means it has more value for the money spent.
"I think we should use online ads instead of TV commercials. They give more bang for the buck."

Learning Curve

The learning curve is the time it takes to learn an activity or system.

"Our database system has an easy learning curve – you'll be able to use it perfectly within a day."

Off The Top Of One's Head

If you know something off the top of your head, it means you know it immediately without needing to look for the information in books, on the internet, etc.
"I don't know the exact number off the top of my head, but I'd estimate that we spent about $400,000 on training for employees last year."

On The Back Burner

If a project is on the back burner, it means it is less important at the moment.
"The preliminary market analysis is on the back burner; I have some other projects that are taking priority."

In the Red / In the Black

If a company is in the red, it means it is operating with debt. A company operating in the black means that it has a profit.
"Our company ended the year in the red with a debt of $5,000,000."

Ramp Up

If you ramp up something, it means you increase it.
"We need to ramp up our efforts to find new customers."

MANAGE WORKPLACE CALLS AND MESSAGES

Speaking slowly and clearly, with pauses, is even more important when you're calling on a cell phone, because the sound produced over cell phones is already harder to hear than sound on a land line.

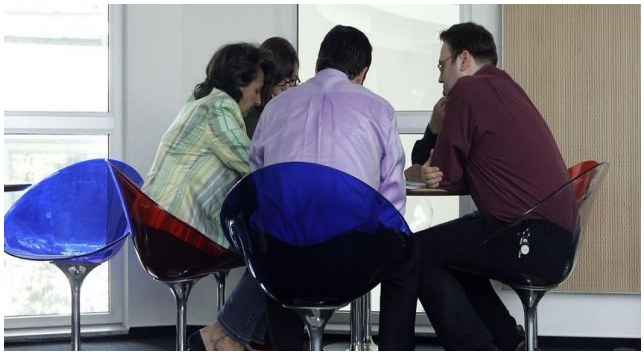
And what about your actual message?

Hi. (pause) My name is Jezra Kaye. (pause) That's J-E-Z-R-A, and my last name is K-A-Y-E. (pause) I'm calling about the bicycle you're selling. (pause) If it's still for sale, please call me at 123-456-7890. (pause) That's 1-2-3 (pause) 4-5-6 (pause) 7-8-9-0. (pause) Again, this is Jezra Kaye, calling about the bicycle, and I'll try you again later. (pause) Have a great day. As this example shows, a good phone message is a "paint by the numbers" exercise, where you fill in each pre-determined step with color. (This is true for good thank you notes, too.) When you've called someone else (presumably because you want something), you can make it easy for them to respond by:

Leave instructions that aren't a dead end. If you leave a phone number that doesn't have voice mail, specify that people should text. If you leave an email address, make sure it's one you actually check!

Even better, leave two ways for them to reach you in your original message, so that they can pick the one they like best.

WORKPLACE MEETINGS AND DISCUSSIONS



Every workplace will have staff meetings/team meetings, formal and informal discussions. When a business places a proper value on the time spent by people preparing for and attending meetings, it is quickly seen that they are a very expensive exercise.

Workplace meetings if not properly planned may not produce the best results and hence it is important that the meetings need to planned and organized.
Effective meeting procedures are essential to ensure that the maximum output is gained from a meeting.

Pre-requisites for a successful Meeting

For workplace meetings to be successful, following need to be planned and implemented.

1. **A clearly defined purpose for the meeting**

Ask questions such as; why are we meeting? What are we trying to achieve? Are we meeting for meetings sake? However, consider that at times the purpose of bringing people together for a meeting may be to achieve other important interpersonal objectives like team building, brain storming or group problem solving. Make sure that you clearly communicate the meeting purpose well before hand, this gives attendees time to gather ideas or research issues prior to attending the meeting.

2. **Advise people of the meeting in time for them to be able to attend**

It is amazing how often key people are left out of meetings or are not able to attend simply due to a lack of planning and sufficient notice.

3. **Set an agenda**

An agenda aims to keep discussions on track and to keep everyone focused on the issues. The agenda should be distributed to attendees before the meeting.

4. **Start and finish on time**

Make sure the meeting starts and finishes on time so participants feel that their time is valued and that they can plan for effective meeting participation to fit within their work load.

5. **Manage the participants**

It is important that every person feels their attendance and contribution is valued. People must be given the opportunity to express their opinion as well as recognizing they must also listen to others without interruption. Clear conflict management strategies must be in place.

HANDLE RELEVANT WORK-RELATED DOCUMENTATION

Whether big or small, all businesses use workplace documents that need to be properly managed to effectively maintain their business activities. Among them, some documents need to be always kept on site for compliancy purposes, while others are developed to ensure the efficient delivery of services and products to customers.

Types of Workplace Document

Documents play an essential role in protecting the interests of the business and business owners over the course of a company's lifetime. Here is a list of common workplace documents important for any businesses.

1. **Registration and Permit Certificates**

Whether it's a company or Sole Proprietorship, relevant registration certificates need to be carefully stored and kept as referred registration certificates may need to be produced for different purposes.

2. **Lease Contracts**

Companies big or small may have several lease contracts involving lease of the office space, equipment or land. Such lease contracts need to be properly managed and stored to ensure lease terms and other contractual terms are properly managed and implemented.

3. **Employment Contracts, Appraisal reports**

This contract sets and the appraisal reports need to be stored in order to minimize future disputes. Not every hire requires an employment agreement, but the document can be a useful if you want to dissuade certain new hires from leaving your company too soon, disclosing confidential information about your business, or going to work at a competitor. The contract should be reviewed by an experienced employment expert before given to an employee to sign.

4. **Warranty and Insurance Certificates**

Companies often procure expensive items that becomes part of their operational expenses and hence such equipment or tools may play a crucial role in the survival or growth of the enterprises.
For this purpose, it is important that the Warranty or Insurance Certificates be kept safe and accessible to ensure business operations remain smooth and healthy always.

5. **Memorandum of Understanding (MOUs)**

An MOU falls somewhere between a formal contract and a handshake. It documents any important conversations you have with suppliers, potential partners and others involved in the business. MOUs are great ways to lay out the terms of a project or relationship in

writing, but do not rely on the document to be legally binding.

6. Memos, Policies, Letters, Meeting Minutes

Memos, company policies, letters and meeting minutes are also important documents while managing and operating enterprises. Properly managing and them will ensure the operational process of the enterprises are linked to an official account of what was done or talked about at formal meetings, including any decisions made or actions taken. They can help settle a dispute about what happened or didn't happen in a past meeting.

7. Financial Records

Managing good financial records are vital to prepare accurate financial statements. These details will help with the decisions that are made for business management and growth purposes.
Whether big or small, any enterprise should maintain the following financial records.

- ✓ Profit & Loss (Income Statement)
- ✓ Balance Sheet
- ✓ Cash Flow Statements
- ✓ Payroll Processing Reports

These are just a few examples of financial information that might be needed for all the enterprises although specific requirements may vary depending on the size of the business and your industry.

8. Inventory Records

Whether big or small, inventory management of the enterprise is linked its growth as inventory management save money and allows to fulfill your customers' needs. In other words, it enables successful cost control of operations. Knowing what we have, what is in our warehouse, and how to manage the supply chain properly is the backbone of business.

Managing Workplace Document

Documents can get a little out of hand in an office, particularly when people are constantly exchanging contracts and notices. Although we're living in a technological age, there are still times paper copies are required and hence workplace documents need to be properly managed.

1. Re-Organize Your Workspace

This is the first and most important step to a more organized workplace. Take the time to go through your existing files and documents, and sort out which documents are important enough to be kept on file, and which ones need to be shredded. Any duplicates can be thrown away, and anything you haven't used in the last 6 months can be put into recycling. Be sure to clear out any drawers and filing cabinets so you can start from scratch and organize a system that works for everyone

2. Get Filing

There's good reason why filing cabinets are one of the most common forms of storage for documents, in the home and in the office. Broad headings will help to decrease filing time. However, you might want to consider adding subheadings to the more generalized folders to prevent cluttering and allow for easy finds

3. Label Clearly

This is vital to keeping your filing system organized and free of accidental category mixing. Document folders can be labelled in order of topic and purpose. Dates are also good to include within the subcategories. Alphabetically ordering files is another popular way of organizing documents. While organizing things alphabetically is a good idea, many organizers recommend keeping an index of all the document folder names, allowing you to keep track of added categories.

4. Sort Out Loose Documents

Some offices have baskets for documents that need to be filed or shredded. In order to keep on top of everything, it's best to get onto these documents as soon as you can to avoid piling up. Make sure you go through your 'to-file' basket carefully and filter out any documents you won't need in the immediate future, as well as duplicates.

5. Use Storage Boxes

Documents build up over time and sometimes a filing room isn't enough to store all your papers. To save room, you might look toward the good old-fashioned archive box. Choose between classic cardboard and the more modern and sleek plastic storage containers. Your filing system can still be applied on a smaller scale to these boxes, just store them horizontally and label them accordingly

6. Use a Digital Filing System

Now we live in a technological age, it's inevitable that you'll eventually move all your documents to an online filing system. You can still keep hard copies, but moving to a digital filing system saves a lot of time and money. Documents are all in one place and can be accessed on nearly any computer or mobile device.

Basics of bookkeeping

Bookkeeping is the process of recording company's financial transactions into organized accounts on a daily basis. It can also refer to the different recording techniques businesses can use. Bookkeeping is an essential part of accounting process for a few reasons. When you keep transaction records updated, it can generate accurate financial reports that help measure business performance. Detailed records will also be handy in the event of a tax audit.

Following details will outline different methods of bookkeeping, how entries are recorded, and the major financial statements involved.

Methods of bookkeeping

Before we begin bookkeeping, business must decide what methods will be used to maintain bookkeeping. When choosing, consider the volume of daily transactions the business has and the amount of revenue it earns. If it happens to be a small business, a complex bookkeeping method designed for enterprises may cause unnecessary complications. Conversely, less robust methods of bookkeeping will not suffice for large corporations.

1. Single-entry bookkeeping

Single-entry bookkeeping is a straightforward method where one entry is made for each transaction in your books. These transactions are usually maintained in a cash book to track incoming revenue and outgoing expenses. You do not need formal accounting training for the single-entry system. The single-entry method will suit small private companies and sole proprietorships.

2. Double-entry bookkeeping

Double-entry bookkeeping is more robust. It follows the principle that every transaction affects at least two accounts, and they are recorded as debits and credits. For example, if you make a sale for $10, your cash account will be debited for $10 and your sales account will be credited by the same amount. In the double-entry system, the total credits must always equal the total debits. When this happens, your books are "balanced."

3. Cash-based or accrual-based

The next step is choosing between a cash or accrual basis for your bookkeeping. This decision will depend on when your business recognizes its revenue and expenses. In cashbased, you recognize revenue when you receive cash into your business. Expenses

are recognized when they are paid for. In other words, any time cash enters or exits your accounts, they are recognized in the books. In the accrual method, revenue is recognized when it is earned. Similarly, expenses are recorded when they are incurred, usually along with corresponding revenues. The actual cash does not have to enter or exit for the transaction to be recorded.

How to record entries in bookkeeping

Generating financial statements like balance sheets, income statements, and cash flow statements helps you understand where your business stands and gauge its performance. For these reports to portray your business accurately, you must have properly documented records of your transactions. Keeping these records as current as possible is also helpful when reconciling your accounts.

Recording transactions begins with source documents like purchase and sales orders, bills, invoices, and cash register tapes. Once you gather these documents, you can record the transactions using journals, ledgers, and the trial balance. If you are a very small company, you may only need a cash register. The information can then be consolidated and turned into financial statements.

1. Cash registers

A cash register is an electronic machine that is used to calculate and register transactions. Usually, cash registers are used to record cash flow in stores. The cashier collects the cash for a sale and returns a balance amount to the customer. Both the collected cash and balance returned are recorded in the register as single-entry cash accounts. Cash registers also store transaction receipts, so you can easily record them in your sales journal.

Cash registers are commonly found in businesses of all sizes. However, they aren't usually the primary method of recording transactions because they use the single-entry, cash-based system of bookkeeping. This makes them convenient for very small businesses but too simplistic for enterprises.

2. The journal

The journal is called the book of original entry. It is the place where a business chronologically records its transactions for the first time. A journal can be either physical (in the form of a book or diary), or digital (stored as spreadsheets, or data in accounting software). It specifies the date of each transaction, the accounts credited or debited, and the amount involved. While the journal is not usually checked for balance at the end of the fiscal year, each journal entry affects the ledger. As we'll learn, it is imperative that the ledger is balanced, so keeping an accurate journal is a good habit to keep. This form is useful for double-entry bookkeeping.

3. The ledger

A ledger is a book or a compilation of accounts. It is also called the book of second entry. After you enter transactions in a journal, they are classified into separate accounts and then transferred into the ledger. These records are transcribed by accounts in the order: assets, liabilities, equity, income, and expenses. Like the journal, the ledger can also be physical or electronic spreadsheets.

A ledger contains a chart of accounts, which is a list of all the names and number of accounts in the ledger. The chart usually occurs in the same order of accounts as the transcribed records.
Unlike the journal, ledgers are investigated by auditors, so they must always be balanced at the end of the fiscal year. If the total debits are more than the total credits, it's called a debit balance. If the total credits outweigh the total debits, there is a credit balance. The ledger is important in double-entry bookkeeping where each transaction changes at least two subledger accounts.

4. Trial balance

The trial balance is produced from the compiled and summarized ledger entries. The trial balance is like a test to see if your books are balanced. It lists the accounts exactly in the following order: assets, liabilities, equity, income, and expenses with the ending account balance.
An accountant usually generates the trial balance to see where your business stands and how well your books are balanced. This can then be cross-checked against ledgers and journals. Imbalances between debits and credits are easy to spot on the trial balance. It is not always error-free, though. Any miscalculated or wrongly-transcribed journal entry in the ledger can cause an incorrect trial balance. It is best to look out for errors early, and correct them on the ledger instead of waiting for the trial balance at the end of the fiscal year.

Financial statements

The next, and probably the most important, step in bookkeeping is to generate financial statements. These statements are prepared by consolidating information from the entries you have recorded on a day-to-day basis. They provide insight into your company's performance over time, revealing the areas you need to improve on. The three major financial reports that every business must know and understand are the cash flow statement, balance sheet, and income statement.

The cash flow statement

The cash flow statement is exactly what its name suggests. It is a financial report that tracks incoming and outgoing cash in your business. It allows you (and investors) to understand how well your company handles debt and expenses. By summarizing this data, you can see if you are making enough cash to run a sustainable, profitable business.

1. The balance sheet

The balance sheet reports a business' assets, liabilities, and shareholder's equity at a given point in time. In simple words, it tells you what your business owns, owes, and the amount invested by shareholders. However, the balance sheet is only a snapshot of a business' financial position for a particular date. It must be compared with balance sheets of other periods as well. The balance sheet allows you to understand the liquidity and financial structure of your business through analytics like current ratio, asset turnover ratio, inventory turnover ratio, and debt-to-equity ratio.

2. The income statements

The income statement, also called the profit and loss statement, focuses on the revenue gained and expenses incurred by a business over time. There are two parts in a typical income statement. The upper half lists operating income while the lower half lists expenditures. The statement tracks these over a period, such as the last quarter of the fiscal year. It shows how the net revenue of your business is converted into net earnings which result in either profit or loss. The income statement does not focus on receipts or cash details.

3. Bank reconciliation

Bank reconciliation is the process of finding congruence between the transactions in your bank account and the transactions in your bookkeeping records. Reconciling your bank accounts is an imperative step in bookkeeping because, after everything else is logged, it is the last step to finding discrepancies in your books. Bank reconciliation helps you ensure that there is nothing amiss when it comes to your money.

MANAGE WORKPLACE CALLS AND MESSAGES

Answering calls promptly

Customers can use the phone to:

- ✓ Make reservations for food (breakfast-dinner)
- ✓ Check, query, modify or cancel arrangements already made
- ✓ Make enquiries about functions
- ✓ Seeks information about prices and products
- ✓ Lodge compliments and complaints

Failure to answer the telephone promptly and correctly can result in:

- ✓ Loss of revenue
- ✓ Loss of jobs
- ✓ Poor or negative customer relations
- ✓ Customers who are more difficult to deal with
- ✓ Reduced business image in the eyes of the customer

Staff also use the phone on behalf of and for business/kitchen related reasons to:

- ✓ Communicate with other staff or department
- ✓ Seek clarification about work directions
- ✓ Contact nominated people in the event of an emergency situation
- ✓ Provide feedback to management and co-workers
- ✓ Obtain help or stock

Common, big mistakes telephone users make is to:

- ✓ Not answer calls promptly
- ✓ Take the telephone for granted
- ✓ Believe use of the telephone comes naturally

An appropriate telephone manner must be applied when using the telephone:

- ✓ Using polite language at all times
- ✓ Using appropriate welcoming or greeting phrases
- ✓ Showing enthusiasm when taking a call
- ✓ Being friendly
- ✓ Making an offer of help to the caller Enterprise standards may relate to:

The use of appropriate greetings or welcoming phrases when answering the telephone. These may require you to:

- ✓ Greet the caller
- ✓ Identify the business
- ✓ Identify yourself
- ✓ Make an offer of assistance
- ✓ It is never acceptable to simply pick up the phone and say; Yes, or Hello

When placing a call 'on hold':

- ✓ Do it courteously
- ✓ Ask the caller if they want to be placed 'on hold'
- ✓ Listen to their answer and act accordingly
- ✓ Get back to all calls 'on hold' every 30 seconds

Offering assistance and establishing the purpose of the call

Always use a friendly tone when answering the phone
The key to answering caller enquiries is to be genuinely helpful:

- ✓ Focus just on the call
- ✓ Try to understand the caller's problem or situation
- ✓ Ask questions
- ✓ Put yourself in the caller's shoes
- ✓ Take time with the call
- ✓ Check the caller's level of satisfaction with what is being provided and what is happening with their call

When you have provided an appropriate greeting and welcome you need to: Quickly identify why the caller has phoned:

- ✓ Ask questions
- ✓ Never assume anything from one or two words spoken by the caller
- ✓ Use active listening
- ✓ Take brief notes

Repeating call details

Where you need to interrupt one call to answer another call, the following is a useful guide on how handle this situation:

- ✓ Excuse yourself from the caller you are talking to

- ✓ Answer the other incoming call and process it in some way, quickly
- ✓ Go back to the original caller, apologise for the interruption and continue on that call

Answering caller enquiries or transferring calls to respond effectively yourself to caller enquires:

- ✓ Identify exact nature of enquires as soon as possible
- ✓ Have resources handy you can refer to help deal with calls
- ✓ Develop a detailed internal telephone list
- ✓ To optimize customer service when answering caller enquiries:
- ✓ Put a smile in your voice
- ✓ Ensure the caller can see you are trying to help them
- ✓ Keep them informed
- ✓ Always be honest
- ✓ Refer to documents or other staff where you are unsure
- ✓ Realise as quickly as you can when you cannot help the caller anymore
- ✓ Try harder when you are on the telephone

To respond effectively yourself to caller enquires:

- ✓ Apologize-if appropriate- for the need to transfer the call
- ✓ Explain why you need to transfer the call
- ✓ Tell them who you want to transfer them to
- ✓ Ask permission to transfer their call
- ✓ Transfer the call and monitor it

If you are having difficulty obtaining answers to their questions:

- ✓ Ring
- ✓ Apologize
- ✓ Explain the situation
- ✓ Let them know you are still following up

Make a time to phone them back with the required answers Tips to follow when

- ✓ Transferring a telephone call include:
- ✓ Transfer calls promptly
- ✓ Locate the required person for the caller
- ✓ Not transferring calls to people you know are not there
- ✓ Only try to transfer a call once to an extension
- ✓ Give caller choices if the required person is unavailable

All promises made on the telephone must be kept, when promised, as promised Keeping promises made on the telephone:

- ✓ Build confidence
- ✓ Values and respects the caller
- ✓ Differentiates the business from others

Recording and passing on messages

Where a telephone message has to be taken, do so:

- ✓ Cheerfully
- ✓ Using the designated telephone message from

Making sure you capture all the information the caller gives you
Ensuring you get the details correct

- ✓ Repeating the message back to the caller to confirm it
- ✓ Thanking the caller

When a telephone message has been taken it must be passed on:

- ✓ To the appropriate person
- ✓ Promptly
- ✓ In hard copy form

It is never sufficient just to take a telephone message:

- ✓ Check the person has picked up their message
- ✓ Check they have acknowledged your email
- ✓ Speak to the person to ask if they have received the message

Most business use a standard form telephone message pad/form to record telephone messages:

- ✓ They are duplicate- top copy goes to receiver of message, bottom copy stays in book/pad

Relaying telephone messages

Check with the Supervisor for company procedures for relaying telephone messages. Options include:

- ✓ Placing in person's pigeon hole
- ✓ Pinning it on the staff notice board
- ✓ Sending the person an email
- ✓ Physically taking the message and handing to them
- ✓ Leaving the person, a voice message to let them know they leave a message
  Additional points to note regarding relaying telephone message include:
- ✓ Never leave telephone message in the telephone message book
- ✓ Always follow up on messages
- ✓ Relay all telephone messages promptly
- ✓ Notify Supervisor where messages have not or cannot be delivered

UNIT 04

PROVIDE EFFECTIVE CUSTOMER CARE

This unit addresses the importance of caring for customers. It is a very important unit related to providing effective customer care and will include greetings, identifying needs of, delivering quality customer care, handling of inquiries, complaints and managing angry customers

INTRODUCTION

Irrespective of the type of business we operate, customer service is often at the heart of a business which aims to provide an exceptional service that leaves the customer feeling valued and respected. Although providing an excellent service can involve extra resource, time and money, when you get it right it will enable you to stand out from your competition, maintain a positive reputation among future customers and encourage existing customers to purchase from your business again.

Remember, it is six times more expensive to acquire a new customer than to retain an existing customer.

Importance of good customer service

- ✓ Increase customer loyalty
- ✓ Increase the amount of money each customer spends with your business
- ✓ Increase how often a customer buy from you
- ✓ Generate positive word-of-mouth about your business

Even being a surf guide on the beach, or a waiter in the restaurant etc., there are many more reasons why customer service is important and many ways you can ensure you are delivering the service which creates the perfect experience for your customers. Customer service strategies included in the module are as follows.

- ✓ Greet customers and colleagues
- ✓ Identify and attend to customer needs
- ✓ Deliver service to customers
- ✓ Handle inquiries
- ✓ Handle complaints

GREET CUSTOMER AND COLLEAGUES

Greeting customers, and colleagues with first impression

Whether you are in a retail store, hotel, receptionist in a company or in any customer facing situation those first few seconds set the tone and create that crucial first impression that your customer will have about you and your company. This may sound simple but it is one of the most important skills you should acquire to be a professional service or customer care agent. and by the way, this applies also if you provide service over the phone you must work on developing a good warm greeting to your customer. Always remember that you only have a few seconds to make a great first impression.

Importance of greeting customers and colleagues

A lot of things happen within the first couple of minutes after a customer enters the workplace. They immediately do a visual assessment on how does your place of business look, is the merchandise appealing or is the place welcoming them. When you first greet the customer, you are selling yourself first, your business second, the experience third, and the merchandise/service last. You want to get the customer feeling comfortable as soon as they walk into your place of business.

Same applied to greeting colleagues as with greetings, bond between the working colleagues can be strengthened that lead to better working environment and enhanced productivity. Remember these 3 rules for effective greeting.

1. Good Eye Contact
2. Great Smile
3. Great Opener

Greetings can increase sales of the business and if we are providing any kind of service or in any professional business setting where you are tasked with greeting customers, here is how to do it professionally.
Possible Scenario: when a customer is approaching you at your work station:

- ✓ Step1: Introduction statement
- ✓ Step2: Gather info.
- ✓ Step3: Engage them in conversation
- ✓ Step4: Build bridges to the next step (whether it's making a sale or serving the customer)

These steps of greetings will create a warm relationship between you and the customers and also same applies to the colleagues working around you.
Greeting step 1- Your introduction statement: How about opening up with something like "Thanks for coming in!"
Think about it. Your customer has an infinite number of choices and a limited amount of time. They could have done anything and yet they came into your store/company.
Greeting step 2 - Gathering Free Information
After your warm, inviting and professional greeting, you want to engage the customer in conversation. This is how we recommend you do it. You want to exchange names for the sake of personalizing the interaction.
This is an example of how this might sound:
"Hi! Thanks for coming in! John at your service sir, Is this your first time in our store/company?"

This welcome accomplishes a number of things:
It welcomes the customer and puts them at ease. It expresses gratitude for their presence. It is also a form of compliment, because you are complimenting the decision, they have made in coming into the store/place of business. It provides the sales associate's name. It collects the customer's name, which can be used again throughout the sales process. This strengthens the relationship. There is nothing sweeter to the ears than hearing one's own name.
But, the key aspect of the above exchange is asking the customer if they have been in the store/business before – that is good information that can be useful to you later on in the conversation.
However, during this step of the greeting, your customer is providing all kinds of free information you can use during the upcoming conversation. You can use this free information to help you customize and personalize the offerings you make during the sales process, which leads you to step 3 and 4 to engage customers into conversation.

Second Scenario: When you approach customers wondering around in your work location/store/company...etc.
Imagine this scenario
The customer enters your store/place of business and a sales person approaches them and asks a question such as:
Can I help you?
Do you want any assistance?
Are you okay there?
What do you think the customer's answers will be?
No, thank you
I'm just browsing
I'm okay

1. Approaching Potential Customers

The point here is that you will get a greater response to sales questions if you first give the prospect a reason why they should answer. You will close more deals and increase sales. Before asking a question, you should state your credentials and give the buyer a potential benefit that they can gain from talking to you. This can take just a few seconds, but it sets the scene and gets the customers talking.
When you first approach a retail, customer tell them what you can do for them.
Tell them something, briefly about your experience, position in the business, qualifications, and how you can help them. Introduce yourself as an expert, an advisor, and someone that can help them to make informed choices.
So, let's see how we can change that
Here's how to increase sales by doubling the number of customers that talk to you. Write a new, brief, introduction that you will now use when approaching customers. The key elements of your new introduction are:

1. Your name
2. How you can help them (Experience, qualifications ...etc.)
3. An open question to start the conversation

It welcomes the customer and puts them at ease. It expresses gratitude for their presence. It is also a form of compliment, because you are complimenting the decision, they have made in coming into the store/place of business. It provides the sales associate's name. It collects the customer's name, which can be used again throughout the sales process. This strengthens the relationship. There is nothing sweeter to the ears than hearing one's own name.
Six Important things to remember about greeting:

1. Make the customer feel welcome and appreciated.
2. Make eye contact when greeting the customer.
3. Never address a customer from behind – that's scary and creates unwanted pressure.
4. Address customers from a reasonable distance -- no shouting across the store/work station.
5. Create your unique, memorable greeting
6. Never stop greeting! If you pass customers/colleagues in the store/company, make sure to acknowledge them with a friendly smile.

Good luck with your new customer encounters, remember these first few seconds are crucial so try to make the best of them and create your own unique great warm greeting.

IDENTIFY AND ATTEND TO CUSTOMER NEEDS

The hospitality industry is always associated with customer service. Many people see hospitality organizations, whether hotels or resorts, as a place to relax and take a break from their normal everyday stresses.
As we know, there are a wide variety of customers who frequent a hospitality organization, for many reasons. They may be customers utilizing:

- ✓ Accommodation –leisure, business or resident
- ✓ Food and Beverage –restaurants, bars, functions, room service, banquets
- ✓ Leisure facilities – pools, spa, sauna and gymnasium.

Regardless of the reason for their visit it is important that they receive quality service. Quality service is being able to use a combination of products and services, as a combined offering that at a minimum, meets the expectations of the consumer.

1. The customer

A customer can be seen as:

1. A person on the receiving end of what the business offers
2. Someone who is willing to pay a fair price for a quality product and wants to be neither over-charged nor under-served
3. The reason the company is in business
4. Someone who has certain needs and wants them filled and who, if we cannot fill them, will go to a competitor who will.

The quality of service is realized by the customer and is interpreted and perceived by him or her. As mentioned, his means that quality of service is not defined by those who deliver

it.
The point from the above is there is really not one “thing” called a customer. Customers are all individuals and come with individual needs and expectations.

2. Customer needs, wishes and expectations

Customer service revolves around us meeting or exceeding customer needs, wishes and expectations. It seems appropriate, then, to identify what these means.

Needs

These underlie wishes and expectations and are the things customers are unable to do without. They may be in a foreign town and simply cannot do without a bed for the night, a meal or beverage.

Wishes

These refer to the way in which our customer would prefer to satisfy a specific need, but they may not have the resources to meet these wishes. They may wish to stay in the luxury suite, dine at an internationally renowned, 5-star, fine dining restaurant and drink expensive, but they haven‟t got the money to pay for it so they settle for something else.

Expectations

These spring from the customers‟ needs and wishes but are also influenced by:

- ✓ The company’s image or reputation in the market
- ✓ The customer’s previous perceptions and their experience with the company
- ✓ The company’s advertising.

Customers know they can’t afford the luxury mentioned above, but as a result of our advertising and their previous experiences with us, they know they will get a clean and satisfactory room, wholesome food at value-for-money prices and a good range of drinks at fair prices to pick from, all delivered with great service. Our big problems start when what the customer actually experiences is at odds with their expectations.

3. How to identify customer needs, wishes and expectations

- ✓ To gain a real understanding of the customer’s needs, wishes and expectations, we should:
- ✓ Involve the customers in developing new services
- ✓ Use market research tools such as questionnaires, taste testing and observation to identify their likes and dislikes, needs and wants, expectations and experiences.

Organise and conduct a series of focus groups

Establish a regular meeting between the establishment and specifically chosen customers. The customers should represent across-section of your clientele and each focus group meeting should have a well-defined focus point. The person chairing the focus group guides discussion, debate, opinion, feedback about the topic and records the input from the focus group members. This information becomes the basis for management-staff discussion and eventual policy modification, or creation. Focus groups are an excellent way of bringing „customer focus" to your service standards and service delivery.

Actively listen to the customers

Prompt the customers to communicate with you, follow-up on non-verbal cues when they talk to you as body language often indicates a hidden desire to say something. Encourage them to expand and clarify problems and criticism.

Make decisions and act on the basis of the customer's motives, needs and expectations

We must operate in a way that focuses on what the customer wants rather than on what is easier for us, simpler for our 'in house' systems or in accord with what we have done in the past. We absolutely must be customer-focused as opposed to being self-focused.

Wear customer spectacles and see with the customer's eyes

We have to strive to find out what our establishment and our service looks like from the customers" point of view. We can become too obsessed on what the service looks like from the delivery viewpoint, when really the customer sees it from a „receival" viewpoint. We need to identify how our service looks from the other side. We can often think the service is great when the customer thinks it is appalling.

Actively look for customer feedback

We need to implement not only written response sheets and questionnaires, but also encourage staff to be proactive in soliciting verbal feedback from customers in a face-to-face setting such as at check-out, after they have finished their meal and via personal follow-ups with hosts and clients after functions.

Ask customers what elements or factors of service are of particular importance to them

Determine what they value and do not value. Sometimes, what we think is important isn't. This reinforces we must be customer-focused. We do not always know what the customer wants because their needs and preferences are always changing. If we don't change with them we risk losing patronage and market share. As the saying goes "customers are the school books from which we learn".

Analyse the market trends

We need to tap into any information generated by industry bodies to help to identify what is happening industry-wide or elsewhere within the industry, be that on a national or internationally basis. All peak bodies undertake some form of research and it is essential to read what the research finds.

Analyze the competitors

Check out the opposition. This can include becoming a customer there and getting first-hand knowledge about what they are doing, what they have to offer, their prices and their service levels, from making the booking right through to departure. Get hold of their advertising and analyse it. What image are they projecting? What offers are they making? How do we compare?

Meeting Customer Needs

Meeting customer needs is crucial for any business looking to retain and attract new customers. Because, as important as the discovery phase is, knowledge about what your customer needs from you is only as good as the way you use it. So, how do you meet customer needs?

This is where the going gets tough. Because, once you have knowledge and data around what your customer needs from you, the next step is integrating that knowledge into already existing processes.

Often this can mean revamping an entire marketing campaign.

You may even need to plan, build and execute on a brand-new facet of your product.

Each business will have to approach this step differently, but we've created a framework for how you can identify, understand and meet customer needs.

DELIVER SERVICE TO CUSTOMERS

Introduction

Once the different options to improve customer service have been identified, the next logical steps are to:

- ✓ Develop standards and plans for suitable options selected to improve customer service
- ✓ Communicate these standards to all staff so they are understanding what they need to do
- ✓ Provide information to colleagues regarding customer service standards
- ✓ Monitor customer service according to organisation policies and procedures to ensure standards are met
- ✓ Measure actual performance against standards

Develop standards and plans to address key quality service issues

The time spent actively considering your establishment's orientation to quality service issues should result in a set of standards and plans, which may or may not, be included in policies and procedures.

The important thing is they are developed, and they are in writing so everyone can be sure about them, understand what they mean, and know what is expected. Management needs to consider:

- ✓ Different areas for which standards and plans may be created
- ✓ Development process for plans and standards
- ✓ Identifying several approaches towards quality management for staff and customers.

The development processes

Developing quality customer service standards should incorporate the following considerations:

- ✓ Establish a "customer service" team of interested, experienced and dedicated staff – these will be your reference group and form the basis of the planning stage
- ✓ Look at what other venues are providing in terms of service – try to describe their service in writing wherever possible
- ✓ Identify the areas in the venue about which you believe there needs to be a customer service standard and a plan

Determine the standards to apply to the identified areas with reference to:

- ✓ Your image, reputation and advertising
  - ➢ Value-for-money for the customer
  - ➢ What the opposition is doing
  - ➢ Identified customer expectations

- ✓ Incorporate the standards into a formal plan – this plan should identify:
  - ➢ Dates for implementation
  - ➢ Dates for review
- ✓ Resources available to support the introduction of the standards – such as time, money, training
- ✓ Responsibilities related to the initiative – for training, explanations to staff, monitoring and reviewing
- ✓ Key Performance Indicators to be used to evaluate service delivery at the designated review dates.

These plans must next be shared with staff, explaining what is required and advising them of training etc. to support the initiative.
Take time to address any anxiety staff may have about the new requirements – anything new in the workplace tends to create anxiety and an effective manager takes the time to reassure staff, highlight the need for change and explain the benefits of it.
Possible areas for service standards and plans.
The precise nature of the standards and plans will vary between venues, and may even vary between departments within the same venue. For example, the service standard in the public bar may be different to the service standard in the cocktail bar.
Likewise, the topics covered will vary. In essence, most things occurring in a service industry like hospitality can have a service standard attached to them.

Most operators tend to rely on generic customer service training to provide the basics and then depend on the common sense and service ethic of staff to deliver on their expectations.
In some cases, this is effective, and in others it is not.
Topics where you can expect service standards to apply include the following:
Response times
The usual example is "We will answer the telephone before it rings X times". This is all well and good (and commendable too), but we must go further and address other service points such as:

- ✓ "We will return a phone call to someone who has contacted us within X minutes or hours"
- ✓ "We will have all room service food delivered to the room within X minutes"
- ✓ "Every guest in the restaurant will be greeted and presented with a menu or have a drink order taken within X minutes of entering the restaurant".

Service guarantees

This involves developing a statement about your service level and what you will do for the customer if such service is not provided.
Your statements in the "response times" area can provide a starting point for your service guarantee statements. Examples include things like:

- ✓ "If it's not there in 15 minutes, it's free"

- ✓ “If we don’t check you in within 2 minutes, it’s 20% off the bill”.

What opportunities present themselves in your venue for you to include in your service guarantee? When you develop such a guarantee it is usual to actively promote it so customers understand your commitment to them.

Pricing guarantees

Deals and packages are part and parcel of our industry, but there has to be a limit to them. The quickest way to go out of business is to constantly try to complete solely on the basis of price.

You have to be able to offer a price that reflects a fair profit, so the value adding may have to come from extra service, or some other “bonus” or perceived bonus in the eyes of the customer. This could be a late check out or valet parking.

However, pricing guarantees may mean staff must offer the lowest available price to callers rather than starting at the top and working down. It may mean if the guest’s bill shows a charge in excess of an advertised rate, a certain procedure applies – the charge may be removed, double the difference between the charged rate and the advertised rate may be deducted from the bill. Product quality

A statement may be developed about certain products and services. The customer receives a stated, pre-determined response such as a discount, gift, extra service, extra product, free XYZ if the product fails to comply or live up to the promise.

Monitor and enhance the quality of service

Simply because standards have been developed, reduced to writing, explained to staff and ratified by management, doesn’t mean they will always be implemented.

After all, people are only human, and as they say – to err is human!

What is required is some monitoring of customer service in the workplace to ensure standards are met in accordance with organisation policies and procedures.

Monitoring methods

The most important thing in monitoring service standard is the will to monitor them. You have to want to monitor them.

The most common problem is service standards are developed and communicated but not monitored. If service delivery standards are not monitored the result can be service standards quickly drop and this impacts adversely on repeat business, profit or levels of customer satisfaction.

The common monitoring methods are:

- ✓ Workplace observation – watching what goes on at work, reading customer body language and measuring waiting times
- ✓ Talking to customers – to get their feedback of service delivery
- ✓ Talking to staff – to get their impressions, to identify obstacles to planned service delivery standards
- ✓ Reading customer complaints and feedback
- ✓ Analyzing business statistics – a reduction in patronage can indicate a need for attention to be paid to customer service, and can also indicate needs in other areas such as price, product.

Areas to monitor and evaluate

Marketing activities are a recognised way of monitoring and evaluating many things and may include the use of customer surveys as well as evaluation of any promotions conducted by the venue such as advertising. This includes the use of billboards, direct mail, radio, TV, Internet and incentive promotions.

HANDLE CUSTOMER INQUIRIES

In today's competitive world, businesses need mechanisms to respond to inquiries or requests for help from existing and potential customers. Inquiry management need to be tackled systematically to ensure continued growth of business.
Important six tips for managing the workflow of your customer service inquiries for positive results are detailed below.

Develop a Proper Organizational Chart

The first step to managing your call center workflow is to set up a proper organizational chart. Your staff needs to know who is responsible for what, the tools at their disposal, and how customer service inquiries are assigned. Whether you're working with a small team or a large team, written documentation describing everyone's roles and responsibilities is essential.

Prioritize Support for Customer Service Inquiries

According to existing research, large percentage of customers expect help within five minutes, and most will give up immediately or after just one attempt to seek help. This is why it's essential to develop a categorized approach to customer service inquiries.

Categorize Inquiries

Once each customer service inquiry is prioritized, it should be segmented according to the type of request. In this way, the inquiry gets to the appropriate team member immediately for timely and effective responses.
First, it is important to define customer service categories, and then assign the correct people to each category based on their strengths and weakness.

Enable Self-Service

While a large percentage of customers prefer more complicated customer service inquiries to be handled by a live person, there are many query cases that can be handled by self-service. For issues that show up again and again, and for those customer service inquiries with simple answers, you do not need to waste time or money responding over the phone, in live chat, or through email.

Analyze the Data

Is your call center workflow working? You won't know if you don't measure the results and then analyze the data.
It's crucial that you set key performance indicators (KPIs) that you'll use to track the performance of your customer support team. Examples include everything from average handle time to average response time, average resolution time, ticket close rate, and more.

Test Different Approaches

Once you've analyzed the data to see how well you're handling your customer service inquiries, it's time to examine and test different approaches. There's no one-size-fits-all call center workflow. You'll need to constantly ask for feedback from your agents, get input from customers, and then edit how you handle your support queue.
Just make sure everyone in your support center is on the same page in regards to how to handle customer service inquiries through regular training.
There's no ideal way to handle your customer support queue. It's up to you and your team to decide what works best for you based on the volume of your calls, the number of channels you use, and the types of support tickets you receive.

HANDLE CUSTOMER COMPLAINTS

In this section, a 5-step process for handling customer complaints are detailed. Referred 5step process of handling customer complaints can be used to uncover the reason a complaint is received from a customer and to solve the problem in order to retain that customer.

Step 1: Dig deeper by asking the right questions
We should believe that even complaints from an angry customer can contain insights, and it should be our priority to seek out the point of friction. Further question and digging can help to get to the source of the issue.
Ask your customer questions like:

- ✓ What do you mean by…?
- ✓ Could you provide an example?
- ✓ Could you expand on that point further?

And ask yourself questions like:

- ✓ What other information do I need?
- ✓ What am I assuming here?
- ✓ Why is this complaint important?

Often, complaints are the result of problems that need to be solved. Asking the right questions helps you get to the root of the complaint, figure out if there's a way to resolve the issue, and determine if the complaint contains genuinely useful feedback.

Step 2: Identify the type of customer you're dealing with
When dealing with angry customers, react with firm politeness instead of responding rudely and avoid mirroring their confrontational behavior. When responding, avoid excuses and just get to the solution.
Customers who contact you frequently. Stay patient and avoid coming across as

frustrated when responding to these

When satisfied, they often become repeat customers and advocates for your company. Customers who don't want to complain and may just take their business elsewhere without ever letting to know there was a problem. We must actively reach out to these customers to solicit and resolve their complaints; otherwise, you may never hear their feedback.

Step 3: Respond to the customer quickly
When it comes to unhappy customers, a speedy response goes from being a nice-to-have to a necessity. Complaints are best resolved as soon as possible.
A customer leaving a feature request won't mind at all if it takes you a day to respond, but customers who are in a "pulling my hair out" situation want a resolution yesterday. Make responding to them a priority.
It can be useful to set up a folder that's separate from the main support queue where you can filter less-than-ecstatic messages. Here, the team can see immediately which emails are from customers who need help right away.

Step 4: Present a solution, and verify that the problem is solved
After you've identified the root cause of the customer's complaint, found a solution, and sent that solution to the customer, it's important to verify that the solution you proposed actually solved the problem. There are a couple of ways to do this:
If you can't verify that the solution is working, add this line to the end of your communication: "Please let me know if there's anything else I can do for you. I'm happy to help!"
In some cases, it may even be worth reaching back out to the customer after a few days have passed to make sure that everything is resolved.

Step 5: Log the complaint so you can track trends
If you've gotten one complaint from one customer about one specific issue over the last 10 years, that issue might not be worth addressing. But if you're getting multiple messages from multiple customers who all shared the same complaint, that's the beginning of a narrative. To identify high-volume complaints, you'll need a system for tracking them. At Help Scout, we use the Help Scout + Jira integration to track customer complaints so we can capture them, monitor how often we're hearing recurring concerns, and follow up with each customer directly when the issue has been resolved.
Whatever system you use, the key is to make it easy to capture meaningful complaints and track the volume of customers who are bringing up similar or identical issues.

HANDLE AND MANAGE ANGRY CUSTOMERS

While anger is a vital part of our range of emotions and is a legitimate feeling, it is how we respond to and express anger that can cause problems. Anger is a basic human emotion, common to all of us and it is OK to feel angry from time to time.
Anger is often associated with frustration. Anger may arise when things don't happen the

way we want or people don't act the way we would like. It's usually a reaction to a 'trigger' event or emotion, which can include feeling embarrassed, guilt or shame, jealousy, stress and a host of other reasons. When we are angry, there is nearly always an underlying need or want that has not been met. Sometimes this is something material (such as money) or it can be a desired emotion such as wanting to be respected or loved. Understanding our anger can be difficult, as it is often not immediately apparent where it is coming from. Sometimes anger is justified and appropriate to the situation, at other times it is not.

When anger starts to gets out of control, it can have enormous effects on our physical and mental health. It can also hurt your career and relationships with others.

Anger management strategies

Recognizing the signals of anger and becoming aware of how your anger works is the first step to change. Anger has signals in our bodies, our emotions, our thinking and our actions. The goal of anger management strategies is to not to suppress these emotions but reduce the 'heat' associated with your emotional feelings by offering alternatives that can help you manage them better. You can't get rid of, or avoid, the things or the people that may anger you, but you can learn to recognize anger warning signs and control your reactions.

Anger management techniques

Anger management techniques focus on recognizing the 'warning signs' that you're getting angry and implementing techniques that can help diffuse the anger before it escalates. There are many different strategies that can help you manage your anger before it gets out of hand.

- ✓ Time out – take a break for a bit
- ✓ Controlled breathing
- ✓ Use calming self-statements such as "Cool it. You can handle this."
- ✓ Relaxation skills
- ✓ Changing beliefs that contribute to anger
- ✓ Physical activity
- ✓ Problem solving strategies
- ✓ Write things down or compose an unsent letter
- ✓ Learn assertiveness skills
- ✓ Better Communication
- ✓ Work on responses that help with your anger – develop a list of things to say to yourself before, during and after situations in which you may get angry.

Know when to seek help

Learning to control anger is a challenge for everyone at times. Seek help for anger issues if your anger seems out of control, causes you to do things you regret or hurts those around you. There are heaps of resources out there to help manage your anger, such as support groups, books and courses. A qualified counsellor or psychologist can also help you manage other problems that may be associated with anger, such as depression, violence or personal relationships.

Steps for Dealing with Angry Customers

Customers get rude or angry for a variety of reasons; some justified, some not. But since you're in business to serve your customers, you'll likely encounter rude or angry individuals at one time or another. How you respond can make the difference between a customer who feels satisfied with the resolution and one who vows never to patronize your business again.

Here are tips for coping with a tense situation and hopefully resolving it to everyone's satisfaction:

1. **Remain calm.** When a customer starts yelling or being otherwise rude, there is nothing to be gained by responding in a similar manner. In fact, that will probably escalate hostilities. Maintain control of yourself, even if the customer's tirade makes you feeling like yelling yourself.
2. **Don't take it personally**. Remember, the customer is not angry with you, they are displeased with the performance of your product or the quality of the service you provide. Your personal feelings are beside the point.
3. **Use your best listening skills**. The first thing an angry customer wants is to vent. To do so, they need someone to listen—and, for better or worse, you are that person. Listening patiently can defuse a situation, as long as the customer feels acknowledged in his or her complaint. Hear them out. When they are done talking, summarize what you've heard and ask any questions to further clarify their complaint. Body language can be critically important here. Keep eye contact. Stand or sit up straight. Keep your arms uncrossed. Show how closely you're paying attention to their problem.
4. **Actively sympathize**. After the customer vents, he wants to know you understand where he's coming from and how he or she feels. Express sympathy for their unpleasant customer experience. Respect and understanding go a long way toward smoothing things over.
5. **Apologize gracefully**. Whether the customer's complaint is legitimate or not is really irrelevant. If you want her to stay a customer, you need to express an apology for the problem they are having (or perceive to be having). A simple, straightforward statement is often all that's needed: "I'm sorry you're not happy with our product. Let's see what we can do to make things right."
6. **Find a solution.** Once you understand why the customer is unhappy, it is time to offer a solution. Ask him what he feels should be done or put forward your own fair and realistic answer to the problem. In most cases, that's all the customer is looking for—and may result in providing some degree of satisfaction.
7. **Take a few minutes on your own.** After the situation has been resolved and the customer is on her way, it's helpful for you to take your own "time-out." Even if you've handled the situation in the most professional way possible, it's

still a stressful experience. Rather than let that stress linger inside you, take a short walk, treat yourself to a snack or find someone to talk to who makes you laugh. Then you'll be ready to once again engage with your customers

UNIT 05

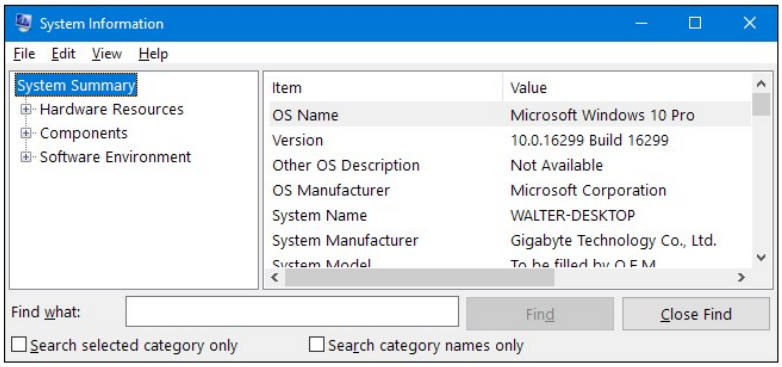
PERFORM COMPUTER OPERATIONS

This unit describes the performance outcomes, skills and knowledge required to start up a personal computer or business computer terminal; to correctly navigate the desktop environment; and to use a range of basic functions.

Introduction

Computer use is prevalent in many workplaces, and some companies may find functioning without them virtually impossible. As a result, computers have become an important part of how companies conduct business as well as how workers perform their job tasks. Computers can even impact where employees do their jobs, as they can often work many miles from their official place of business.

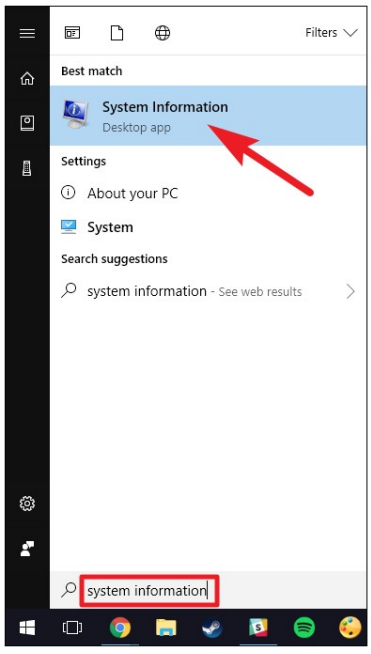
START COMPUTER, SYSTEM INFORMATION AND FEATURES



The System Information provides a quick way get information about your system, but how you open it depends on what version of Windows you're using. Here's how to do it.

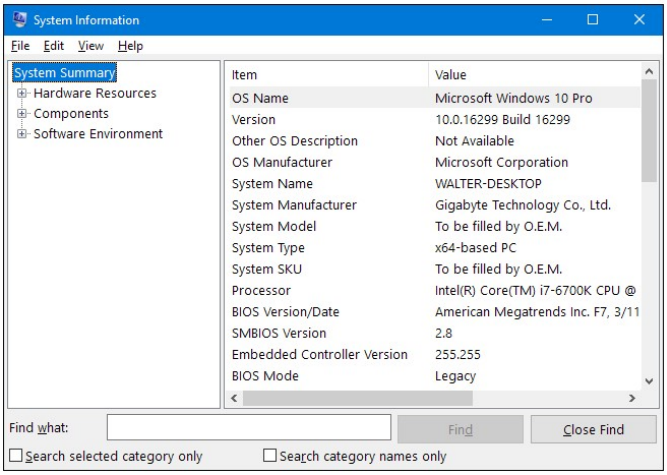
Windows 7 or 10: Use the Start Menu

If you're using Windows 7 or 10, hit Start, type "system information" into the search box, and then select the result.

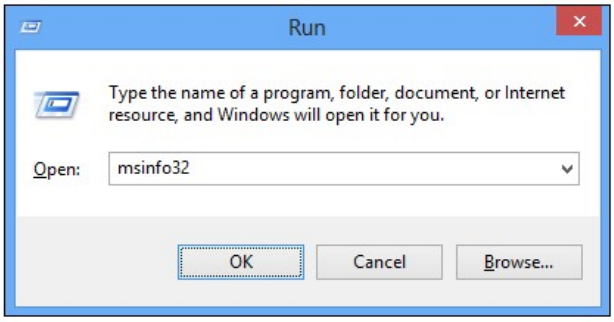


The System Information window opens, giving you access to all kinds of great information

about your PC's hardware and software environment.

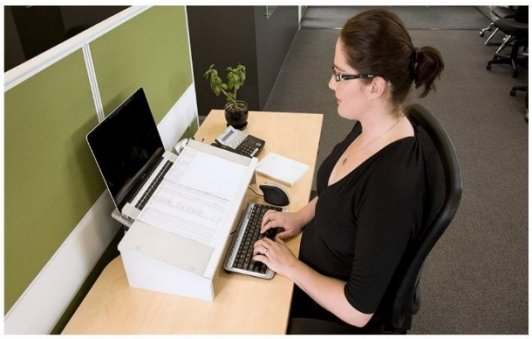


Windows 7, 8, or 10: Use the Run Box



For some reason, typing "system information" into a Start search doesn't work in Windows 8. Instead, you'll have to use the Run box, which you can also use in Windows 7 or 10 if you prefer.
Hit Windows+R to open the Run box. Type "msinfo32" into the "Open" field, and then hit Enter.
You should immediately see the System Information panel.
You can also find the msinfo.exe executable in the \Windows\System32 directory, should you want to make a shortcut for even easier access.

Adjust workspace, furniture and equipment to suit user ergonomic requirements



Are you sitting for long periods of time at a desk? Is your body feeling strained and causing discomfort? Sitting for long periods of time can have serious health issues, especially if your workstation is not set up correctly. Back Centre's occupational therapist can visit and assess your workstation and advise on the best adjustments and arrangements for your needs. An ergonomically correct workstation has all the best practices to help maintain a healthy posture and improve your health and productivity.
Here are some tips on how to set up your workspace.

Maintain a healthy posture

It's easy to adjust your workstation to fit your ergonomic requirements and maintain a

healthy posture. Ensuring that you're sitting comfortably in front of a computer is a great way to avoid pain and fix your posture for better health. Follow these steps to improve your posture and prevent lower back pain.

1. Adjust the chair height
   If your chair isn't at the correct height, you can adjust it by using the lever on the right-hand side. Adjust the chair to a height that is comfortable for you.
2. Ensure your feet are firmly on the floor
   Sit well back into the seat and check that your feet are firmly on the floor. If your feet aren't firmly flat on the floor, a footrest will be required to improve your posture.
3. Adjusting the chair angle
   An ergonomic office chair allows the seat to be adjusted horizontally or slightly angled. Usually, the lever for this is on the right toward the back.
4. Adjusting the backrest angle
   The lever for adjusting the backrest angle is usually on the right, showing backward and forwards arrows.
5. Setting the Backrest height
6. The Backrest can be adjusted by loosening the lever or knob at the base of the backrest. If there isn't a knob or lever, you most likely have a ratchet style adjustment.
7. Positioning the armrest height
8. If the armrest can be adjusted, position them so that they fit under the desk.
9. If you are taller than average, the above recommendations for adjusting your chair may not be suitable. Consider an Adjustable Standing Desk or a Sit Stand Workstation to bring the desk to your level.

To find out more about ergonomics for taller than the average height have a read of our blog article.

How to correctly set up your workspace

When setting up an ergonomically workstation, it's important to have everything in the correct place.
By following these tips we can help you set up your workspace to improve posture and provide the correct support.

- ✓ Adjust the location of the keyboard to be 10-15cm in front of the edge of the desk.
- ✓ The wrists should be straight and hovering over the desk.
- ✓ The mouse should be as close as possible to the keyboard.
- ✓ If you are using one monitor, position it directly in front. It should be an arm length away and angled slightly upward towards the eyes.
- ✓ A document holder should be ideally positioned between the monitor and the keyboard.
- ✓ Phone, calculators, and note-pads are all ideally positioned within easy reach.

Does your workstation require a footrest?

When setting up an ergonomic workstation, ensuring your legs and feet are well supported is crucial. If your feet aren't firmly flat on the floor, a footrest will be needed to improve your posture. A footrest will help in attaining the right foot elevation, leg and knee position. If you need more support to set up your workstation and struggling with poor posture contact Back Centre today to book in an Ergonomic Assessment to improve your posture.

Ensure work organization meets organizational and occupational health and safety (OHS) requirements for computer operation

Today's computer workstation has few hazards other than ergonomic that the typical worker will be exposed to if all components are functioning properly. Many injuries or illnesses associated with a computer workstation will be of an ergonomic nature and thus may be difficult to diagnose. Accurate and timely recording as outlined in OHS's Injury and Illness Recordkeeping and Reporting Requirements Safety and Health Topics Page can be a useful means of proactive intervention.

Standards

There are no specific OHS standards that apply to computer workstations or extremely low frequency electric and magnetic field exposure. Existing OHS standards on electrical safety, radiation exposure, and noise apply to all workplaces including office environments. In most cases, only a few general industry standards such as electrical or radiation hazards may apply.

Hazards and Solutions

Provides references that may aid in recognizing potential hazards associated at computer workstations and gives possible solutions to address those hazards.

Start computer or log on according to user procedures

How to start a computer?

Turning on your computer isn't always easy. Some manufacturers hide the 'on' button – for instance, on top of the case or flat on the front where you can't see it. When you get your computer, don't be embarrassed to ask: 'Where's the "on" button?'

Follow these step-by-step instructions to help you turn on your computer

Step 1: Find the 'on' button. It probably looks like this (but might be square or oblong!):

This is a typical PC **on** button, on the front, in the middle of the tower

This is a typical laptop **on** button. Most laptops have the **on** button just above the keyboard but below the screen

Step 2: Push the button.
On some computers, the button lights up when the computer is on. On laptops, there's often a light on the front that comes on. You may have to keep pushing for a couple of seconds to make this happen, but don't worry – you'll soon get to know how your computer works.
If nothing happens, there are a few things you can check easily:

- ✓ If you're using a laptop, the battery might be flat. So plug in the charger, plug the charger into the mains and let the laptop recharge. You can continue to use it while it's doing this.
- ✓ If you have a PC, make sure that the plug or any of the other wires haven't become disconnected.
- ✓ Ensure that the monitor is turned on. Most PC monitors have an 'on/off' button on the bottom corner of the screen (see below). The button often lights up green when the monitor is on.

Step 3: Now you need to log in.
If you're the only user of your computer, once it's turned on it may go straight to the desktop:

If you're using a public computer – for example, in a library – you'll be given instructions (and help if you ask for it) on how to log in.
If you're sharing your computer with other people, each one will usually have their own account. When you turn on the computer, the screen will look something like this:

When you click the icon above your name, you'll be asked for a password. The main user or administrator should set this up for you before you begin. Type in your password and click the arrow.

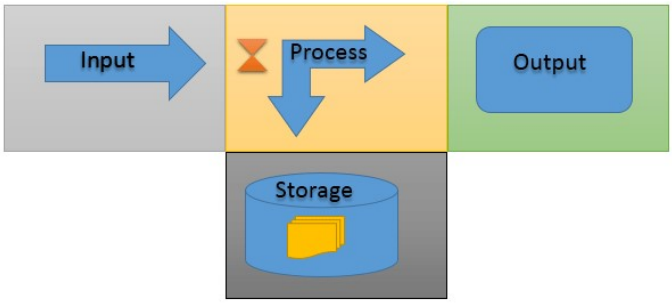
Top tip: surge protectors

If you have a PC, it's a good idea to buy a 'surge protector'. This prevents your computer being damaged if there's a sudden problem with your electricity supply. You can buy surge protectors that let you plug all your separate pieces of equipment into them, in addition to your computer. Then when you turn your computer on or off, this automatically turns them on or off, too.

Identify basic functions and features using system information

This unit explains the basic functions, operations, and characteristics of a computer. Learn the four major functions of a computer through diagrams and examples.
Taking data and instructions from a user, processing the data as per instructions, and displaying or storing the processed data, are the four major functions of a computer. These functions are also known as the input function, process function, output function, and storage function, respectively.

The following diagram shows an example of these functions.



To provide these functions, a computer uses its components or devices. Usually, components of a computer are designed to perform only one of these four functions. But, some specialized components or devices are designed to perform two, three or all four functions. For example, a hard disk can perform three functions: input (when files are read), storage (when files are saved), and output (when files are written).
Components or devices of a computer, based on the function in which they are used, can be classified into four major types: the input devices, output devices, storage devices, and processing devices. For example, if a component processes the given instructions, the component is known as the processing device. Or if a device displays the processed data, the device is known as the output device.

Input function and devices

A computer is a data processing machine. It does nothing until a user (or a script or a program) provides the data that needs to be processed and the instructions that tell it how to process the data.
Any standard device or component that a user uses to instruct a computer is known as the standard input device. In other words, a computer uses its standard input devices or components to get instructions from a user.
The most common input devices are the keyboard and mouse. Almost all modern computers have these devices. Other common input devices are scanners, microphones, USB drives, and webcams.
Input data and instruction can also be generated from a non-standard input device such as the hard disk and CD/DVD. For example, a batch file in the Windows system may instruct the CPU to execute a program or a script at a particular time.
Installation disks are another good example of non-standard input devices. Usually, they contain a script or an executable program that automatically starts the installation

process as soon as the disk is read.

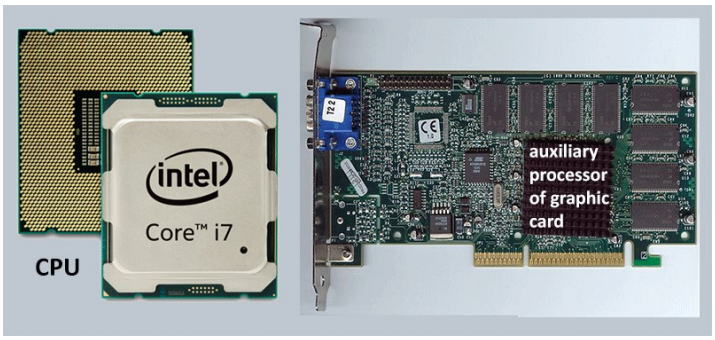
Process function and devices

Once the data and instructions are received by the input function, the computer starts the processing function. In this function, a computer processes the received data according to the instructions.

To process the input data according to the instructions, the computer uses the CPU. A CPU is the main processing component of a computer. It processes user instructions, executes scripts and programs, and runs commands of the OS that provide a platform for installing and using application software.

Other important processing components are auxiliary processors. Auxiliary processors are also known as onboard processors. Auxiliary processors are used in devices to enhance their functionalities. You can think of an auxiliary processor as the private CPU of a device. Only components or devices that provide the complex functionality such as Graphics cards, I/O devices, and network interface cards use auxiliary processors. For example, if a user draws an image, the auxiliary processor on the graphics card performs all calculations that require in drawing the image on the display device.

The following image shows a sample of both a CPU and an auxiliary processor.



The following table lists the main differences between a CPU and an auxiliary processor.

Output function and devices

CPU	Auxiliary processor
A CPU is a compulsory component. Without it, a computer does not work.	An auxiliary processor is an optional component.
A CPU is an individual component. It is installed separately in the system.	An auxiliary processor is an integrated part of a device. It can't be installed separately.
A CPU is designed to perform all types of tasks.	An auxiliary processor is designed to perform only a specific type of task.

After processing the input data, the CPU, auxiliary processor, or the process function sends the processed data to the output function or to the default or configured output device. By default, computers use monitors as the default output device.

Aside from monitor, a variety of output devices are also available. Each output device

presents the processed data in a different form, for example, a monitor, a printer, and a speaker displays, prints, and plays the processed data, respectively.
A user, based on his requirement, can connect and use two, three or more output devices to the computer. For example, after viewing the processed data, a user can send it to the printer for printing.

Storage function and devices

Storing data and information is the fourth major function of a computer. This function allows us to save the processed data for later use. To store data and information, a computer uses two types of storage components: temporary and permanent.

Temporary storage components are used to store data temporarily. Data stored in a temporary storage component is erased when the system is shutdown. RAM is a compulsory temporary storage component. A computer uses the ram to store the running applications and their data.

Permanent storage components are used to store data permanently. Data stored in a permanent storage component is not erased when the system is shutdown. The hard disk is the most common permanent storage component. Usually, all computers have at least one hard disk to store data. Other common permanent storage components or devices are external drives, USB drives, and CD/DVD.

The following image shows an example of both types of storage components.

Storage devices are also used in the input and output functions, allowing data to be saved (output function) and then accessed again later (input function).

Examples

The following table lists a few sample actions along with the name of devices and functions that are used when they are performed.

Action	Device	Function
A user running a text-editor program types the letter Z on the keyboard. The keyboard sends a code representing the letter Z to the CPU.	Keyboard	Input
The CPU processes the code and determines what letter was typed. Then the CPU sends instructions to the monitor to display the letter Z.	CPU	Process
The monitor displays the letter Z.	Monitor	Output
The user clicks the save button. The mouse sends a code representing the click.	Mouse	Input
The CPU processes the code and determines what action was clicked.	CPU	Process
The CPU saves the file on the disk.	Hard disk	Storage

Customize desktop configuration with assistance from appropriate persons

From the moment you first power on your new computer, you'll be asked to choose how to manage your privacy and security. But once you complete that short process, the fun begins: You can select backgrounds, configure your Start menu, and choose apps and shortcuts.

Windows offers many different ways to do the same thing—in this case, launch apps. The Windows 10 Start menu (accessed by clicking the Windows icon in the bottom-left corner) is an amalgamation of Windows 7's list of apps and the tiled interface of Windows 8. Right next to it is the Search box, where you can type an app name to launch it. And right next to that is the Taskbar, where you can pin frequently used apps for easy access. (Your currently active windows will also show up in the Taskbar.)

How you organize things will be a matter of preference. But consider a few suggestions.

To help you get started:

- ✓ If you prefer a list of apps, navigate to Settings > Personalization > Start, then toggle on Show most used apps. That will place your most frequently used apps at the top of the list, eliminating the need to scroll through them.
- ✓ If you right-click a tile or app and go to More > Pin to Taskbar, you can create a shortcut icon that will live on the row of icons on your Taskbar at the bottom of the screen. That will save you from opening Start. Remember, the more *If you select "Show most used apps" in the* icons you pin, the less space you'll have *Settings > Personalization > Start preferences,* for shortcuts to active windows. If you *Windows will group your most frequently used* hover over the Taskbar icons, you'll see *apps at the top of the stack* a popup thumbnail of each active windows within that app.

If you don't use the list of apps, just the tiles, you can toggle off the list entirely from the same menu. You can even open the Start menu in full-screen mode for a "Windows 8.1-like" experience.

Each of the tiles appears in one of three groups, which you can right-click to rename and move around. Right-clicking a tile allows you to adjust its size. That's useful for apps that update information, like Mail, Calendar, or News. Microsoft's diminished this last feature over time, however, so you may want to leave the icons small.

ORGANIZE FILES USING BASIC DIRECTORY AND FOLDER STRUCTURES

Create folders/subfolders with suitable names

Creating and assigning document folders and sub-folders
This unit will show you how to create document folders, how to organize your documents, add documents to those folders, and assign the documents out for signature in bulk. You'll be able to organize your documents in folders ("parent folders") and sub-folders ("child folders"). You'll also be able to assign these folders to individuals and groups for signature, eliminating the need to ask each individual separately to sign the documents. Also gives users the ability to assign multiple documents for signature at once to an individual or group.
The same rules go for folder security users can grant rights over a folder and every document within it at once, giving individuals or groups privileges to the entire folder and all its contents.

An introduction to folders

You'll notice the root documents folder is viewable from your find anything sidebar. This is the initial default level under which all your existing documents and folders will live. You can drag and drop folders and documents into other folders as needed if you've been assigned sufficient privileges over those folders.
Administrators will want to make sure to give the right users the necessary access to the appropriate folders.

Create folders/subfolders with suitable names

Creating a new folder

1. To create a new folder, simply navigate in your left sidebar menu to the parent folder you wish to nest the new folder in then click the three dots to the left of that parent folder name and select new folder from the menu that pops us.
2. Type in the new folder's name and click create.
3. The new sub folder/child folder will automatically appear under the parent folder.

Keep in mind that you can have multiple folders with the same name as long as they live under different parent folders. For example, the hr department folder and the communications department folders can both contain a sub/child folder called "policies."

Managing folder details

1. To manage a folder's details, hover over the folder name in the sidebar, click the three dots to the right of the folder title, then click manage.
2. This will bring up the folder record's general tab. Here, you can rename or delete the folder.
3. Adding existing documents to a folder

4. You can add documents to a folder, similarly to how you add members to a group.
5. Go to the content tab of your folder.
6. Click the document icon ( ) to the right of the add folders or documents drop-down list.
7. Click advanced filters to expand your filtering options.

Select the show only non-members option to only search documents and folders that don't already exist in your current destination folder, or to search both existing and not existing documents, select show members & non-members.

8. If you'd like to move any content from another folder, you can use the folder dropdown menu to choose the folder the document(s) currently live in. You will also want to use the name drop-down list to choose the name or keywords of the document(s) you'd like to move.
9. Click apply filter.
10. In the list that appears to the right, select the boxes next to the documents you'd like to move to your open folder. To select all documents listed, select the top checkbox. Click save. Your selected documents are now part of the current folder.

The example below shows the user used advanced filters and moved all of the documents from the "administrative policies" folder to the folder, "daily observation report."
Note: when using the top checkbox to select all documents, make sure you have the show only non-members option selected under advanced filters. Otherwise, you may accidentally copy over or remove documents of the same name from the destination folder. -

Creating a new document in a folder

1. To create a new document inside a folder, navigate in your left sidebar menu to the parent folder you wish to nest the new document.
2. Click the three dots to the right of the folder name.
3. Select new document from the drop-down menu that appears.
4. You can also create a new document by selecting new > document from the top menu bar.
5. A new document window will appear for you to either drag and drop an existing file from your computer, upload it by browsing your files, or create it from scratch.
6. If you don't have access to the root documents folder and try step 4, a pane will popup asking you to choose the folder in which to house the new document. The drop-down list will be populated with folders you already have edit rights over.

Note: you can reorganize your documents and folders into other folders later using the drag-and-drop feature, which will change their location for everyone on the site. See the organizing folders and documents section below for further instructions.

Save files with suitable names in appropriate folders

If you have write permission, you can create, copy, remove, and rename files and directories for the directory shown in the current directory browser. If you do not have write permission, you can still copy files and directories to another directory, or you can use equivalent functions, such as move file.

Naming files and folders

Naming conventions are rules which enable the titling of electronic and physical folders, documents and records in a consistent and logical way. This ensures that the correct records can be located, identified and retrieved from a filing system in a timely fashion, and that they are stored in an appropriate secure location. Ideally, the best time to think how to name and structure the documents and directories you create is at the start of a project.
The principles of naming conventions can equally be applied to electronic and physical files/folders/material.

Benefits of naming conventions

Naming records consistently, logically and in a predictable way will distinguish similar records from one another at a glance, and by doing so will facilitate the storage and retrieval of data. Through consistency and the application of logical standards we benefit from secure storage, and the ability to locate and access information.

File identifiability

Good practice dictates that all information (files, datasets, documents, or records) should be identifiable and traceable. This can be achieved by following good practices by applying referencing to all documents/files.

Document/file references will include:

- ✓ file name, or full file path including file name
- ✓ name/role of file author(s) or originator(s)
- ✓ date of creation, edit or event which is the subject of the document/file ✓ version number if applicabl3

Suggested file and folder naming conventions

1. Keep file and folder names short, but meaningful.
2. Avoid unnecessary repetition and redundant words in file names and file paths.
3. Use capital letters to delimit words, not spaces.
4. When including a number in a file name always give it as a two-digit number rather than one, i.e. 01, 02 … 99, unless it is a year or another number with more than two digits.
5. If using a date in the file name always state the date 'back to front', and use four digit years, two digit months and two digit days: yyyymmdd or yyyymm or yyyy or yyyyyyyy.

6. When including a personal name in a file name give the family name first followed by the initials.
7. Avoid using common words such as ‘draft’ or ‘letter’ at the start of file names, unless doing so will make it easier to retrieve the record.
8. Order the elements in a file name in the most appropriate way to retrieve the record.
9. The file names of records relating to recurring events should include the date and a description of the event, except where the inclusion of any of either of these elements would be incompatible with rule 2.
10. The file names of correspondence should include the name of the correspondent, an indication of the subject, the date of the correspondence and whether it is incoming or outgoing correspondence, except where the inclusion of any of these elements would be incompatible with rule 2.
11. The file name of an email attachment should include the name of the correspondent, an indication of the subject, the date of the correspondence, ‘attach’, and an indication of the number of attachments sent with the covering email, except where the inclusion of any of these elements would be incompatible with rule 2.
12. The version number of a record should be indicated in its file name by the inclusion of ‘d’ followed by the version number and, where applicable,‘d’ indicating ‘draft version’.
13. Avoid using non-alphanumeric characters in file names.

Rename and move folders/subfolders and files as required
Click the file or folder to select it.

- ✓ Click the organize button on the toolbar, and then click rename.
- ✓ with the name selected, type a new name, or click to position the insertion point, and then edit the name.

Press enter.

- ✓ Timesaver
- ✓ Right-click the file or folder you want to rename, click rename, type a name, and then press enter. You can also select the file, click the file name, type a name, and then press enter.

Did you know?

You can rename a group of files. Select all the files you want to rename, right-click one of the selected files, click rename from the shortcut menu, type a name, and then press enter. The group name appears with numbers in consecutive order

Identify folder/subfolder and file attributes

A file attribute (often just referred to as an attribute or a flag) is a specific condition in which a file or directory can exist.
An attribute is considered either set or cleared at any given time, which means it's either enabled or isn't.

Computer operating systems, like windows, can tag data with specific file attributes so that data can be treated differently than data with an attribute turned off.
Files and folders aren't actually changed when attributes are applied or removed, they're just understood differently by the operating system and other software.
What are the different file attributes?
A number of file attributes exist in windows, including the following:

- ✓ archive file attribute
- ✓ directory attribute
- ✓ hidden file attribute
- ✓ read-only file attribute
- ✓ system file attribute
- ✓ volume label attribute

The following file attributes were first available to the windows operating system with the ntfs file system, meaning they aren't available in the older fat file system:

- ✓ compressed file attribute
- ✓ encrypted file attribute
- ✓ indexed file attribute

Here are several additional, albeit more rare, file attributes recognized by windows:

- ✓ device file attribute
- ✓ integrity file attribute
- ✓ not content indexed file attribute
- ✓ no scrub file attribute
- ✓ offline file attribute
- ✓ sparse file attribute
- ✓ temporary file attribute
- ✓ virtual file attribute

Why are file attributes used?

File attributes exist so that you, or a program you're using, or even the operating system itself, can be granted or denied particular rights to a file or folder.
Learning about common file attributes can help you understand why certain files and folders are referred to as "hidden" or "read-only," for example, and why interacting with them is so different than interacting with other data.
Applying the read-only file attribute to a file will prevent it from being edited or changed in any way unless the attribute is lifted to allow write access. The read-only attribute is often used with system files that shouldn't be altered, but you could do the same with your own files that you'd rather someone with access not edit.
Files with the hidden attribute set will actually be hidden from normal views, making these files really difficult to accidentally delete, move, or change. The file still exists like every other file, but because the hidden attribute is toggled, it prevents the casual user from interacting with it. You can set windows to view hidden files and folders as an easy way to see these files without toggling the attribute off.
You can also combine attributes so that a file is, for example, not only hidden but also

marked as a system file and set with the archive attribute.
File attributes vs folder attributes
Attributes can be toggled on and off for both files and folders, but the consequences of doing so differ a bit between the two.
When a file attribute like the hidden attribute is toggled on for a file, that single file will be hidden, nothing else.
If the same hidden attribute is applied to a folder, you're given more options than to just hide the folder: you have the option to apply the hidden attribute to the folder alone or to the folder, its subfolders, and all of its files.
Applying the hidden file attribute to a folder's subfolders and its files mean that even after you open the folder, all the files and folders that are contained within it will be hidden as well. The first option of just hiding the folder alone would make the subfolders and files visible, but just hide the main, root area of the folder.
How file attributes are applied
Although all of the available attributes for a file have common names, which you saw in the lists above, they aren't all applied to a file or folder in the same way.
A small selection of attributes can be turned on manually. In windows, you can do this by right-clicking (or tap-and-hold on touch interfaces) a file or folder, opening its properties, and then enabling or disabling an attribute from the list provided.
In windows, a larger selection of attributes can also be set with the attrib command, available from command prompt. Having attribute control via a command allows thirdparty programs, like backup software, to easily edit file attributes.

Move folders/subfolders and files using cut and paste, and drag and drop techniques

Copying (and moving) files and folders

Windows 7 provides two basic methods for copying files and folders from one disk to another or from one folder to another on the same disk:

- ✓ drag and drop: you select items in one open explorer window and then drag them to another open explorer window (on the same or different disk), where you drop them into place.
- ✓ cut and paste: you copy or cut selected items to the windows clipboard and then paste them into another folder (on the same or different disk).

Using the drag-and-drop method

The technique of moving files and folders with the drag-and-drop method is really straightforward:

1. Open two separate explorer windows and arrange them on the windows 7 desktop with as little overlap as possible: the first is the source explorer window that contains the item(s) you want to move, and the second is the destination explorer window where these items are to be moved.

2. Tip to eliminate all overlap between the source and destination explorer window and thereby make it easy to drag from one to the other, right-click the taskbar and then choose either the show windows side by side option or the show windows stacked option from the shortcut menu that appears.
3. Select the item(s) you want to move in the first source explorer window.
4. While continuing to hold down the mouse button, drag the folder/document icon representing the selected items (and showing the number of items selected) to the destination explorer window.
5. Windows 7 displays a screentip that says move to such and such folder (where such and such a folder is the actual name of the destination folder). When you've positioned the icon somewhere within the destination explorer window, release the mouse button to drop the items there. They then appear in the destination window in the order (usually alphabetical by filename) that that explorer window currently uses.

To copy files with the drag-and-drop method rather than move them, you only have to vary these foregoing steps by remembering to hold down the ctrl key as you drag the selected items from the source explorer window to the destination window. Windows 7 lets you know that you're copying rather than moving the selected items by displaying a + (plus) sign under the folder/document icon and displaying a copy to such and such folder screentip when you reach a place in the destination folder where the items being copied can be dropped.

Tip when moving or copying files using the drag-and-drop method, you don't even have to bother opening the destination folder in its own window: just drag the folder/document icon representing the selected items from the source explorer window to the destination folder's icon and then drop it on this icon. Note that this drop-directly-on-the-destinationicon method works on shortcuts of other drives (both local and on your network) as well as shortcuts for folders and printers (to print the selected documents) on the windows 7 desktop.

Remember keep in mind that when you drag files or folders from one drive to another, windows 7 automatically copies the files and folders, instead of moving them. This copying means that you don't have to hold down the ctrl key when you intend to copy them from one disk to another. It also means that you must still delete them from their original disk after making the copies if you need to free up the disk space.

Warning dragging and dropping items from folder to folder is great because it's really fast. This method does have a major drawback, however: it's pretty easy to drop your file icons into the wrong folder. If you forget to undo your last action (ctrl+z), instead of panicking when you open what you thought was the destination folder and find that your files aren't there, locate them by using the search feature; see "searching for files" later in this part. Using the cut-and-paste method

Instead of turning to the drag-and-drop trick, you can use the cut-and-paste method, the oldest way of moving and copying items in windows. The the first, you cut or copy the

selected files or folders to a special area of the computer memory known as the windows clipboard. In the second, you paste the item(s) saved on the clipboard into the new folder. You can perform the cut, copy, and paste commands by selecting the cut, copy, and paste commands on the organize button on the explorer window's toolbar, or by using standard ctrl+x (cut), ctrl+c (copy), and ctrl+v (paste) keyboard shortcuts.

To move or copy files by cutting and pasting (using either method), follow these steps:

1. Open the folder with windows explorer (documents, computer, or network) that holds the subfolders or files that you're moving or copying.
2. Select all the items to be copied and then either press ctrl+c (or choose copy from the organize button's drop-down menu) or press ctrl+x (or choose cut from the organize button's drop-down menu).
3. Use the navigation pane in the explorer window to open the destination folder (that is, the one into which you're moving or copying the selected folder or file items).
4. Don't forget to click the folders button in the navigation pane to display the hierarchy of components and folders on your computer.
5. Press ctrl+v (or choose paste from the organize button's drop-down menu) to paste the items into the destination folder.

When using the cut-and-paste method to move or copy files or folders, keep in mind that you don't have to keep the folder with the files or folders you're moving or copying open during the paste part of the procedure. You can close this folder, open the folder to which you're moving or copying them, and then do the paste command. Just be sure that you don't use the copy or cut commands again in windows 7 until after you've pasted these files and folders in their new location.
If the classic menus are displayed in the explorer window, you can also access the cut, copy, and paste commands by choosing edit → cut, edit → copy, and edit → paste respectively from the source and destination explorer window's drop-down menus. If not, you can press ctrl+x to cut, ctrl+c to copy, and ctrl+v to paste.

Tip in addition, when the classic menus are displayed, you have access to the special edit → copy to folder and edit → move to folder commands (or if they're not displayed, you can press alt+ef for copy to folder and alt+ev for move to folder). When you choose either of these menu commands (after selecting the items to be moved or copied), windows 7 displays a copy items or a move items dialog box (depending upon which you command you choose). You then select the icon of the destination folder in the outline map of your system before clicking the move or copy button to perform the move or copy operation.
Remember keep in mind that if all you want to do is back up some files from your hard drive to a cd or dvd in your computer's cd-rom/dvd drive (d:, e: or some other letter), you can do so with the send to shortcut menu command. After selecting the files to copy, just right-click to open the shortcut menu attached to one of the file icons and then choose the correct drive on the send to menu, such as dvd-rw drive (d:). Oh, and one more thing: don't forget to insert a blank cd-rom or dvd or one to which you can append new files before you start this little operation.

Save folders/subfolders and files to appropriate media where necessary

When it comes to getting organized, you don't need to start from scratch. Windows comes with a handful of common folders that you can use as anchors to begin organizing your files. Here's a list of some of the most common folders you can store your files and folders in:

- ✓ documents. Use this folder to store your word-processing files, spreadsheets, presentations, and other business-oriented files.
- ✓ pictures. Use this folder to store all of your digital pictures, whether you get them from your camera, scanner, or in e-mail from other people.
- ✓ music. Use this folder to store all of your digital music, such as songs that you copy from an audio cd or download from the internet.
- ✓ videos. Use this folder to store your videos, such as clips from your digital camera, camcorder, or video files that you download from the internet.
- ✓ downloads. Use this folder to store files and programs that you download from the web.

There are many ways to find these folders. The easiest method is to open the personal folder, which gathers all of your common folders in one place. The personal folder isn't actually called "personal"—it's labeled with the user name that you used to log on to the computer. To open it, click the start button, and then click your user name at the top of the start menu's right pane.

Search for folders/subfolders and files using appropriate software tools

When you need to find a particular file, you'll often know that it's located somewhere in a common folder like documents or pictures. Unfortunately, actually locating the file you want might mean browsing through hundreds of files and subfolders— not an easy task. To save yourself time and effort, use the search box to find your file.

Restore deleted folder/subfolders and files as necessary

With data recovery, now anybody can recover data themselves, painlessly. Safe, complete data recovery is just a few clicks away: scan, preview and recover.
Latest powerful scanning algorithms, it can scan any mac-based hard drive or external hard drive without destroying any data, and lets you recover data in no time at all.
Complete recovery modes cover virtually all data loss scenarios, such as accidental deletion, formatting, improper operation etc.

- ✓ wizard mode recovery - simply answer 2 easy questions and the rest of the recovery will be finished by the program.
- ✓ lost data recovery - retrieve lost data emptied from your trash bin or deleted by command + delete
- ✓ partition recovery - recover data from lost, deleted, resized and corrupted partitions.
- ✓ resume recovery - save your scan results to perform data recovery later. Recover everything you need

- ✓ recover almost any file, including but not limited to documents, photos, video, music, email, and archive files.
- ✓ recover from any internal and external hard drive, sd card, usb flash drive, digital camera, memory cards, ipod, media player and other portable devices.
- ✓ restore data lost due to deletion, formatting, virus infection, improper operation, unexpected power failure, software crash and other unknown reasons.
- ✓ fully compatible with 10.8 (mountain lion), 10.7, 10.6 and 10.5.
- ✓ recover data from hfs+, hfsx, fat16, fat32, exfat, and ntfs files systems.

Preview recoverable files

How do you know whether each recoverable file is exactly what you want? Data recovery lets you preview lost files before they are recovered, help you recover data at your pace and quickly find the files you need.

- ✓ view photos in thumbnail or cover flow view and easily check image quality before recovery.
- ✓ preview video and audio files to check whether or not they're what you are searching for.
- ✓ open documents, email and archive files to see they're intact and the ones you need.
- ✓ only scan files of the selected file type to save time.
- ✓ find your files in seconds with file filters and folder trees.
- ✓ easily distinguish valid and invalid files before data recovery.
- ✓ recover lost files complete with original file names and file folders.

PRINT INFORMATION

Each file and document, and the programs used to open them, are different. Therefore, we are only able to give a basic overview of the steps in printing. These steps are a general guideline and may not apply to the document or file that you are trying to print. That being said, many programs have adopted a standard method of printing.

Before proceeding, make sure your printer is turned on, and is installed and configured correctly.

1. Open the document or file you want to print.
2. Near the top of the program window, look for a print icon that should resemble any of the below icons. As seen in the picture below, each of the icons resembles a printer with a piece of paper.

- or -

3. Open the document or file you want to print.
4. In the top portion of the program window or browser you're using, open the file menu by clicking file and then print from the drop-downmenu.

Once either of the above options is done, a print properties window appears and allows you to specify additional printing options (e.g., number of copies). Once you've selected the options, click ok or print to start the printing process.

Printing selected text or picture from an internet web page

For printer-friendly pages like computer hope, when you print a page, all navigation menus and other non-important sections are automatically removed. If you come across a web page that's not printer-friendly or if you only want to print a section of a page or picture, follow the steps below.

To print only sections of text or images, it may be easier to copythe text or picture, and paste it into a document. Once all information is gathered into a single document, you can print it out.

Print only a picture from a web page

To only print a picture contained on a web page, we recommend opening the picture by itself. To do this, right-click the image and select "open image in a new tab" or "open image." once the image is displayed by itself, press ctrl+p on a pc or cmd+p on an apple computer to start the print process. You can try these steps now on the image below.

SHUT DOWN A COMPUTER

Shutting down a computer closes all the programs that are open and exits the operating system safely so hardware isn't damaged and your operating system isn't corrupted.

Shut down in Windows 10

Press the Windows key on the keyboard, or click Start. The Start menu opens. In the Start

menu, click Power, then click Shut down.
-or-

Press Ctrl+Alt+Del and click the power button in the bottom-right corner of the screen.
-or-
From the Windows desktop, press Alt+F4 to get the Shut Down Windows screen shown here.

If you have no mouse, use the Tab key and arrow keys to switch between fields. Use the Enter key or the spacebar to select what is highlighted.

Shut down in Microsoft Windows 95, 98, NT, ME, 2000, and XP

All these versions of Microsoft Windows can be shut down through the Start menu. Press the Windows key on the keyboard or click Start. From the Start menu, click **Shut Down...**

BASIC WEB SKILLS/USING A WEB BROWSER

The Web, also known as the World Wide Web (WWW), is essentially a collection of an uncountable number of pages of information displayed on the Internet. It is an information-sharing tool that is growing at an unbelievable rate. According to a Google study, there are over a trillion unique web pages and over 4.5 million new websites are registered each month! You can view this information with the help of a "web browser"—a window that allows you to view online content (e.g., Internet Explorer, Mozilla Firefox, Safari, and Google Chrome). Because there is so much information on the Internet, and so many individual sites and pages, it would be nearly impossible to find what you were looking for by just "browsing" or flipping through sites, not only because of the sheer size of the collection, but also because you wouldn't know what address to go to! To deal with this, we use a web browser to access a search engine which allows us to search for a particular topic, word, or phrase.

The Internet is a communications network that connects computers from all around the world. To reach different websites, we use search engines like Google or Bing to search

for websites about a particular topic, word, or phrase. Just like you might use the library catalog to find a book or the phone book to find a business, search engines organize information and make it accessible for Internet users. If you can think of a topic, there is probably a website about it!

Locate and Open a Web Browser

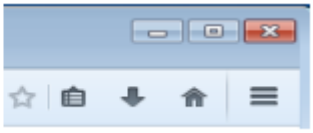
A web browser is a program that lets you see information and images on web sites. A browser reads the information on a web page and displays it on your computer screen. The three most popular web browsers are called "Microsoft Internet Explorer", "Mozilla Firefox", and "Google Chrome". You should be able to use at least one of these browsers at your local public library.

To open one of these browsers

Point to the browser's icon on the desktop (see images below) with your mouse and double-click on it with the left mouse button (alternatively, left-click once, and then press the "Enter" key). A window like the one pictured below should come up on the screen.

Using the Browser's Menu Options

Typical Menu Bars are not usually included in updated browsers. They now have menu options that can be accessed via icons on the right side of your screen, just below the X.



The picture on the left is of the Google Chrome menu icons. To access menu options, click on the icon with three horizontal lines. The picture on the right is of the Firefox menu icons. To access its menu options, click on the three horizontal lines icon, i.e., "Open Menu." To select one, point with your mouse and left-click once.

Each menu item contains many options. Here's a brief overview of the things you can do with each menu item:

- ✓ **Print**: Use this option to print your current web page.

- ✓ **File**: Here you can change your browser to and from Full Screen, Save, Find a word or phrase in a web page, and view suggested sites.
- ✓ **Zoom**: Zoom in or out to more easily view pages in your web browser.
- ✓ **View**: You can change the display of your browser here, including text size. Safety: Here you can manage your browsing history and activate filters for browsing.
- ✓ **Favorites or Bookmarks**: This is a place to store and access your favorite and most used websites. Access these options by clicking on the star icon.
- ✓ **Options**: These are more advanced settings for your web browser; most likely you will never need to use these options.
- ✓ **Help (or? icon):** If you need more help with the browser, try this menu item.

Using the Brower's Navigation Bar

The Navigation Bar is located directly above or below the Menu Bar and contains buttons that provide shortcuts to frequently used navigation and menu options, such as forward, back, stop, refresh, and home.

Firefox Navigation Bar:

Google Chrome Navigation Bar:

The following is a description of the most frequently used Navigation bar buttons:

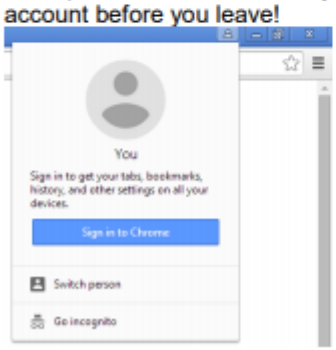
The **Back** button takes you back to the previous web page that you viewed.

The **Forward** button takes you forward to the web page that you viewed *before* you clicked "Back."

The **Refresh** button will reload the web page that you are currently viewing. Web pages (especially news sites) will change throughout the day, so it is important to refresh them periodically to see the most recent changes.

The **Stop** button will stop a web page from loading. If a page is taking a particularly long time to load, you can try clicking Stop, then Refresh. Sometimes the Stop button will only show up if a page is loading and will replace the Refresh button in the navigation bar.

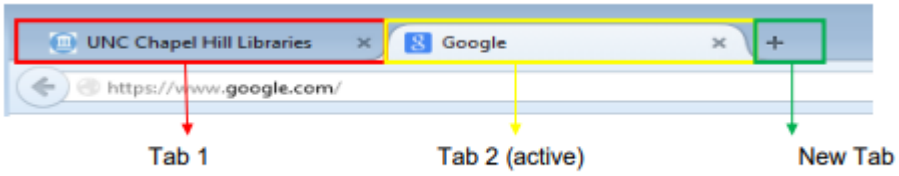
The **Home** button will take you to the webpage that opened when you first opened your browser window. If you are at a library, this is most likely the library's home page. It is possible to change your web browser's settings to open a different Home site. In Google Chrome, you will need to sign into your Google account (you have one if you have a Gmail address) in order to view your bookmarks and Home page. (See image below). You can do this on any computer, just make sure you sign out of your Google account before you leave!



The address bar is a long, white box where you will type the address of the site you wish to go to. We will learn more about web addresses and the address bar in a little bit.

Using Tabs

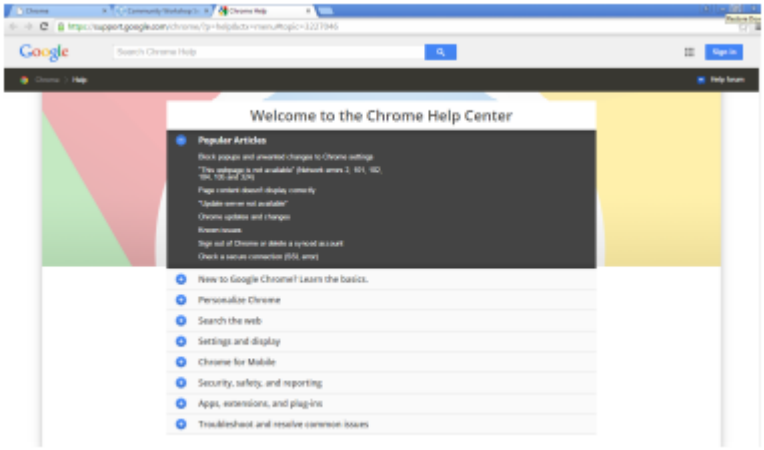
Tabs work just like tabbed dividers in a filing cabinet or a binder—they allow you to organize different pages while keeping them all accessible. You can open a new tab by going to File◊New Tab, OR by clicking the small button with the plus sign (+) to the right of the last tab, OR by holding down the control (CTRL) key and typing the letter 'T.'



The benefit of using tabs, instead of new windows, is that you can view multiple tabs within one window, and can switch between tabs very quickly by simply clicking on the tabs. In the example above, if I wanted to view the Google page, I would simply click the tab that says "Google." To switch back to the UNC page, I would click the tab that says "UNC." It is possible to have multiple windows open, and for each window to have more than one tab open.

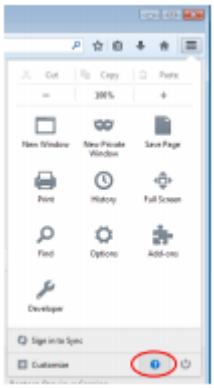
Using the Browser's Help Feature

As with many other programs, web browsers have Help features that you can use if you ever need a hand. The help feature can be found in the browser's menu options. To easily access Help options in Google Chrome, click the F1 key on your keyboard, or select the Help option in the horizontal lines menu.



In Firefox, you can access Help options by following these steps:

1. Left Click once on the icon that is three horizontal lines at the top right of your screen.
2. Slide the mouse down to the Question Mark (?) icon at the bottom of those menu options.
3. The icon will turn blue (meaning it is highlighted and ready to be selected).



4. Click once with the left mouse button to open specific help options

*It is important to note that all web browsers are not the same. Like different televisions that all display the same channels, all web browsers take you to the same Internet, but can be designed differently. The "Help" feature on many web browsers may not be found the way it is shown here, but there is very often a "Help" menu option, or a "Help" button

at the top of the browser window.

Feel free to explore the help features. You can even search for a particular item if it does not appear to be in the index. In fact, you can also search the Internet for help on a variety of topics using a search engine—your instructor can tell you how to do this!

Changing Text Size

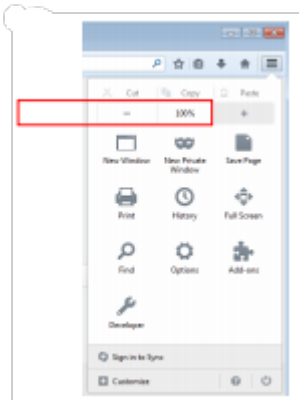
If you are not comfortable with the text size on a web page, you can zoom in or out according to your preferences. (Most browsers are defaulted to a 100% zoom – zooming in (+) makes things larger, and zooming out (-) makes them smaller).

In Google Chrome:

1. Left-Click once on the horizontal lines icon to open the menu options.
2. Move your mouse down to the "Zoom" option.
3. You can click on the + or – icons that surround the number in order to zoom in or out.

In Firefox:

1. Left-Click once on the three horizontal lines icon to open the menu options.
2. You will see at the top of the options that there is a 100% surrounded by a minus icon on the left and a plus icon on the right.



3. Left-click once on either the minus or the plus to zoom out or in – you can click more than once on either icon to continue to zoom out or in.

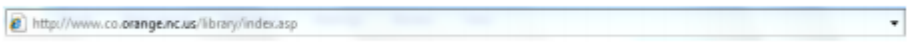
The appearance on the web page that you are currently looking at should change according to what you have chosen. This tool can be very useful, considering that web pages come in all shapes and sizes—it essentially magnifies or "zooms in" on the text so that it becomes easier to read!

WEBSITE ADDRESSES/URLS

Going to a Specific Web Address Every day, you are probably bombarded with web addresses. Web addresses are also called URLs, which stands for Universal Resource

Locator. On the radio, on television commercials, in the newspaper and magazines: "Visit us online at www.businessname.com!" Almost every business and organization has a website now. You can recognize websites because they will almost all start with "www" or "http" and end with ".com" ".org" ".edu" or ".gov" (these endings are called "extensions"). Recently, new specialized extensions were made available such as ".bike" and ".technology" and ".photography".
Here is an example of a typical web address: www.google.com
You would type this into your address bar to access Google's website.
Let's take a look at the anatomy of a web address:

Now that you know what a web site address looks like, you can go to a specific site by typing it in the browser's address bar, which is located just below the toolbar. Other popular websites include www.amazon.com, www.wikipedia.org, and www.youtube.com.
Here's another look at the address bar:



To go to a specific website, you'll need to:

1. Left-click once inside the white part of the address bar. This will highlight the address already in the bar. You can also click and drag your mouse from left to right to highlight the text.
2. Press Delete or Backspace to empty the address bar.
3. Type the new address into the address bar (e.g. www.wikipedia.org).
4. Press Enter on the keyboard. Voilà! The website should then appear on your screen:

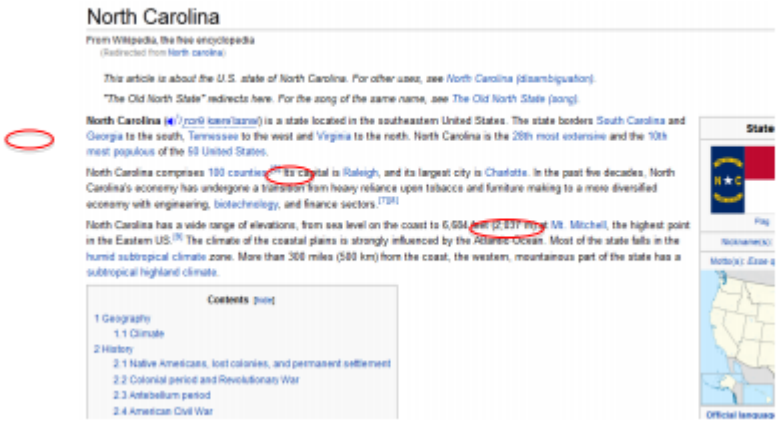
Following Links on a Web Page

A link (also called a hyperlink) is an underlined word or phrase or an image on a web page that links to either another place on the same page, or to an entirely different web page. You can tell that you are on a link when you slide the mouse over text or an image and your mouse pointer becomes a hand with a pointing finger.

Go ahead and type a topic into the search box on the Wikipedia site (for example, search for "North Carolina"), and then press Enter on your keyboard.

Run your mouse over the Wikipedia page that comes up. You'll notice that as you hover your mouse over any of the blue words, the words become underlined, your mouse arrow changes to a pointing hand, and (if you allow it to hover for a few seconds) a small description will appear below the link. This should also happen if you hover over any of the images on the page.

Let's follow a link! Try clicking one of the blue words that appears on the Wikipedia page that you are looking at—your instructor can assist you if you need help.



Here is how to do it:

1. Slide the mouse down to a word that is blue, or an image that causes your mouse pointer to turn into a hand.
2. When the pointer turns into a hand, click once with the left mouse button. You should now see a new page with text and other links. You can go back to the previous page by clicking on the "Back" button on the browser's toolbar.
   Practice going to different links! Remember that you can use the "Back" button to go back to the previous page or use the "Forward" button to return to the page you were looking at before you clicked "Back.

Using Search Engines

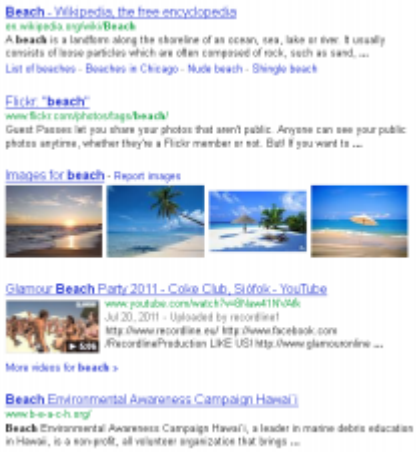
Finding Information with a Search Engine

To find information on the web, you will need to use a search engine. A search engine goes out and finds information for you on the World Wide Web. There are many search engines out available to use.

Google is currently the most popular search engine, but there are many others, such as Yahoo.com, Bing.com, and Ask.com. Today, we'll practice using Google.

Type the web address www.google.com into the address bar at the top of your screen. Then hit Enter on your keyboard.

This should bring up the Google homepage on your screen. A blinking cursor will appear in the text box to let you know you can start typing something. Type a word or a phrase that describes the information that you are looking for (the fewer words, the better—no need to use complete sentences!). For example, type the word "beach" into your search box to see what Google finds.



Refining Your Search

Try the following steps to narrow down your search:

- ✓ If you get too many "hits" (listed websites), try adding extra words that describe what you want— if that gives more instead of fewer results, put "and" between each word. For example, "beach and vacation" will find only pages where both of those words are included.
- ✓ Put phrases in quotation marks, e.g. "North Carolina governors," "Al Pacino," or "Orange County Main Library." This will find only those pages that contain these exact phrases.

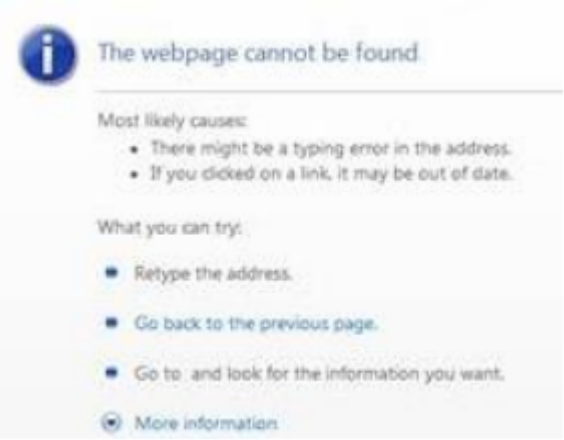
Understanding Error Messages

Sometimes you will type a website address but an error page comes up instead of the website. This happens from time to time. The most common cause for this is that you have typed the web address incorrectly. You can also sometimes get an error message when you click on a link on a web page. This often means that either the link is "broken," or the page no longer exists. An error page can mean a variety of things, including any of the following:

- ✓ The website is temporarily down

- ✓ The website does not exist anymore
- ✓ The link you clicked is broken (it was created incorrectly)
- ✓ Your browser can't open the site because of some restrictions
- ✓ Too many people are trying to access the site at once

There may be nothing you can do to rectify the situation. In this case, you might just have to move on and go to another website or choose another link. In this day and age, major websites usually never stay down for a long period of time. It is the equivalent of a major television network going down— many, many people are working very hard to bring it back up as soon as possible!



Navigating the Web

Identifying Advertisements

It is common to find advertisements on websites. Many of these advertisements are just trying to sell you things, but some of them are traps. They get you to enter your personal information and tell you that this is for a chance to win money or prizes, but most of the time it's just to get your email address so they can send you junk mail. In extreme cases, malicious websites may try to steal personal information such as your social security number or your credit card number to steal money from you or even your identity.

Some other advertisements will pop up and tell you that you need to "Click Here" because you have a virus and you need to clean up your computer or something similar. Again, these are just ways that a company tries to access your personal information or sell you something.

REMEMBER: You can always ignore advertisements, just like you can change the television channel at home. You are not forced to do anything on the Internet!

Viruses and Personal Safety

For your own safety, NEVER give out your personal information over the web to unsolicited advertisements or unknown websites. These are most likely not secure. If you are applying for or buying something from a legitimate organization or company, it will be done on a secure site. A secure site will display a little padlock somewhere in the browser:

In addition, the web address should begin with https://. The extra 's' in the web address means that the site is secure. It is a good idea only to make purchases from well-known, well-regarded sites, like www.amazon.com or www.target.com. You should also try to read companies' privacy policies before making a purchase.

Viruses are malicious programs that are loaded onto your computer without your knowledge. They can destroy or delete everything on your hard drive, such as your files and folders, or extract personal information. Your computer can become infected when you download pictures and files from the web or email messages, so avoid downloading files from the Internet unless you are sure it is safe. If you receive an e-mail from a friend with an attachment, especially if it seems strange, verify that they intended to send you the attachment before you open it.

Your home computer should be protected against viruses. You can equip it with virus protection software that stops viruses from attacking the computer's hard drive and your files. When you try to download something from the web, the virus protection software will scan the downloaded file or image to make sure that it does not contain any viruses.

MICROSOFT WORD 2016

What is Microsoft Word?

Word is used to "create beautiful documents, easily work with others, and enjoy the read." The types of documents you can create with Word include:

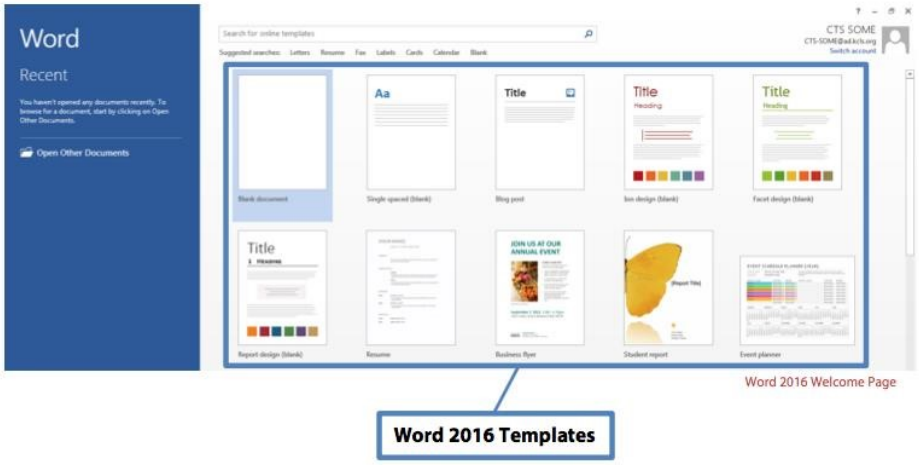
- ✓ Letters – personal, business (including résumés), creative or general notes
- ✓ Notices – basic flyers, menus, checklists

- ✓ Reports – for school, work or a special interest group

Word has excellent tools and a work area that resembles a sheet of paper. Word templates on the Welcome Page offer pre-designed documents. Browse them to visualize what is possible with Word. Click on a template to see a description and suggested use for the template.

Word 2016 welcome page

Open word 2016 from the computer desktop. On the welcome page, note the various popular templates available. Click "Facet Design (blank)" template for a full description. Click "Create" to open a document in this particular style.



Microsoft Word 2016 Interface

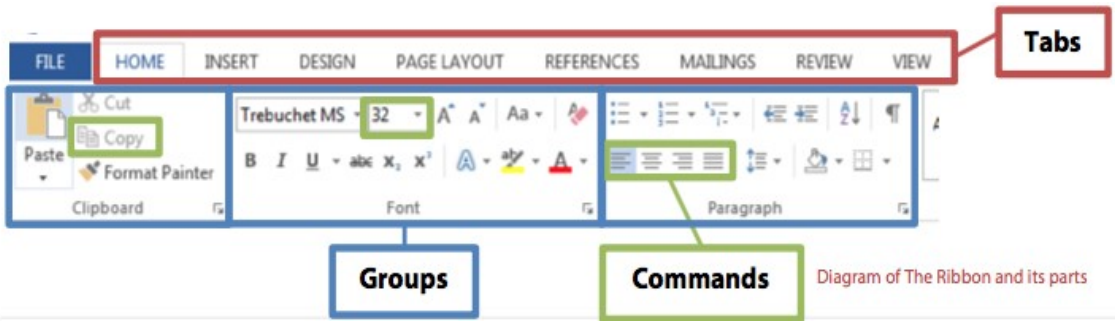
The way the tools and menus are organized in Word 2016 is known as the user interface. You will learn about *The Ribbon, Quick Access Toolbar, File Menu* and other key parts of Word.

The Ribbon

The Ribbon runs along the top, contains all the Word tools, and is organized into three parts:

- ✓ Tabs – represent a general activity area
- ✓ Groups – show related tools (commands) together
- ✓ Commands – a button, expandable menu, or a box for entering related information

Click the various Tabs: observe how the Groups and Commands change based on the selected tab.

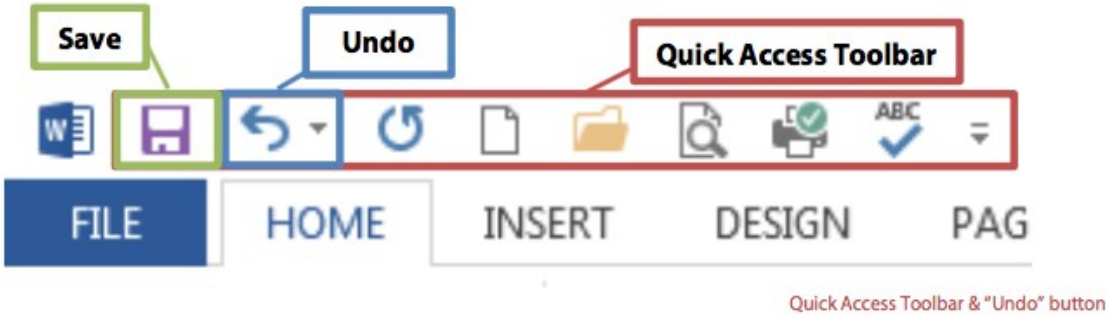


Quick Access Toolbar

The Quick Access Toolbar is above the Tabs and has commands used most often, including "Save".

Place the mouse arrow over each icon (do not click) to see the name and use for each icon. You may customize the commands in the toolbar if you click the black arrow at the end of the toolbar.

The Undo command "takes back" any changes made to the document. For example, type "Undo" in the blank document you have open, then click Undo in the Quick Access Toolbar. Undo keeps track of actions by sequence; if you accidentally erase (change) data in your file, click Undo right away to get it back. On that note, it is important to "save early and save often."



File Menu

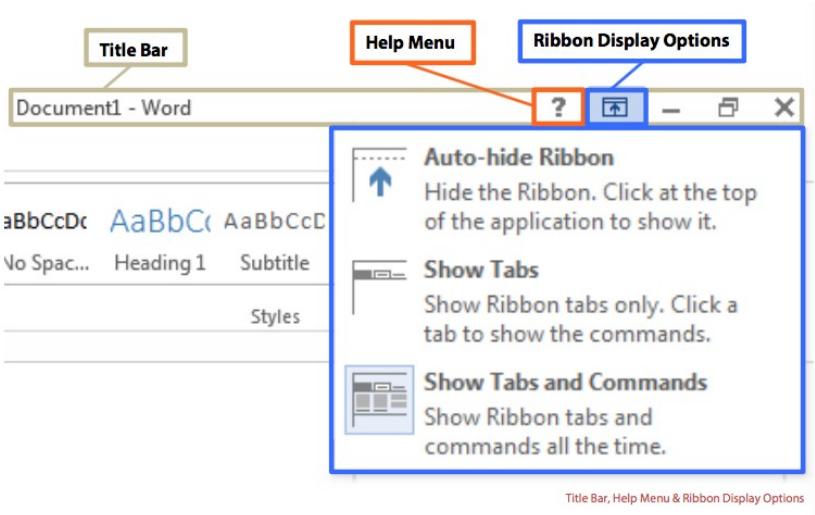
The File Menu contains actions at the file level. Click the blue "File" tab to the far left of the tabs. What you'll see is the "backstage" area. From here, you can create a **New** document, **Open** an existing one, **Save** changes to the current document, **Save As** a different file with a different name, **Print** the current document, and other options. Click the "back arrow" at the top to exit the backstage area.

Title Bar, Help Menu, Ribbon Display Options

The Title Bar shows the name of the program and the name (title) of your document. (Top-most bar in program window.) A new document has a temporary title, Document1, until you "Save As" with a different name. To the far right on the Title Bar is the Help Menu and Ribbon Display options.

The **Help Menu** has articles on using the software. Not sure how to perform a certain action or where to find a command? Click the question mark icon to browse Help articles, or search for specific topics.

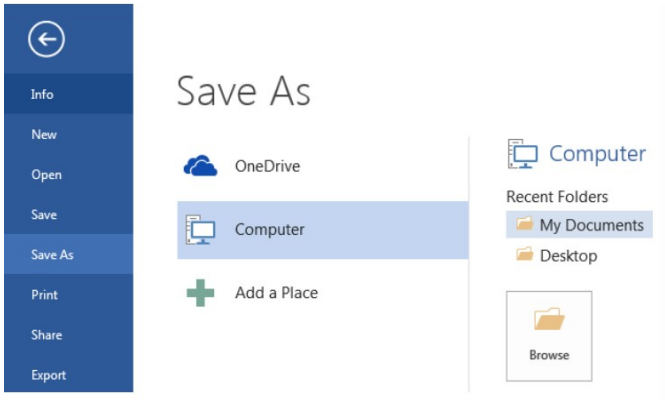
Ribbon Display options allow you to see more or less of the Ribbon and the work area, as a result. Take a moment to locate and explore these features in the Word program window.



Title Bar, Help Menu & Ribbon Display Options

Using Tools in Word

- ✓ Start learning about word processing by working in a Microsoft Word 2016 document.
- ✓ Save Your Work
- ✓ To make sure you don't lose your work on a document, you should "save early and save often." Let's start by saving the document you have open in Word 2016:
- ✓ Click the blue File Button near the Tabs. Learn more about "File Menu" on page 4.
- ✓ Click Save As. This option is for saving, or naming, a file for the first time. You may create different versions of a file by "saving as" a new name.
- ✓ Click "Computer".
- ✓ Click "My Documents" folder. On KCLS computers, files saved to "My Documents" folder are erased at the



Word 2016 Backstage View – "Save As" to "My Documents" on KCLS computers

end of your session. Consider a USB drive, or OneDrive for long-term storage.

- ✓ Name file "My Practice Document". Generally, choose a name that is easy to remember.
- ✓ Click Save.

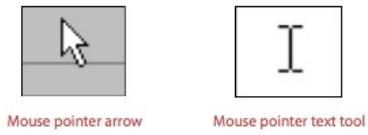
Get Ready for Typing

The main workspace in Word resembles a piece of paper on your screen. Note the vertical blinking line, the cursor, near the top left of the paper. Cursor and mouse pointer shape offer hints in Word.

1. The Cursor

The cursor indicates where text will appear as you type; it also indicates font size for that spot. Earlier, you created a document from the "Facet design (blank)" template on the Welcome Page. Note the size of the cursor next to the word "Title". What is the font size value for the word "Title"? (Look toward the Font Group in the ribbon.)
Now move your mouse pointer in front of the word "Heading" and left-click once. This moves the cursor. Note the cursor size and font size value in the font size box. What is the font size value?

2. Mouse Pointer Shape



You may have noticed the mouse pointer changes shape as you move to different areas in Word. The two most common shapes indicate different functions. The mouse pointer arrow is for clicking commands, or buttons in general. The mouse pointer text tool (I-Beam) is for selecting text or positioning cursor for typing. You will use the document you have open now to practice using various key Groups and Commands in the Word Ribbon. Let's select and change text in your document.

3. Selecting Text

Selecting text to make edits is an important word processing skill. A common way to select text is:

- ✓ Place mouse pointer text tool next to the text. In this case, place it next to next to "T" in "Title".
- ✓ Press the left mouse button.
- ✓ Drag it across the text.
- ✓ Let go of the left mouse button.
- ✓ Notice "Title" is selected (highlighted). Go ahead and type "My Practice Document".

Selecting Lines and Paragraphs

- ✓ To select a complete line of text (use paragraph in your practice document):

1. Place mouse pointer arrow in left margin next to line of text (arrow will point to the right).

2. Left-click once to select that line of text.

✓ To select several lines or a paragraph:

1. Place mouse pointer arrow in left margin next to line of text (arrow will point to the right).
2. Press (hold down) the left mouse button.
3. Drag to the end of the paragraph. Let go of the left mouse button.

✓ Next, you will use commands from the ribbon to edit text you have selected.

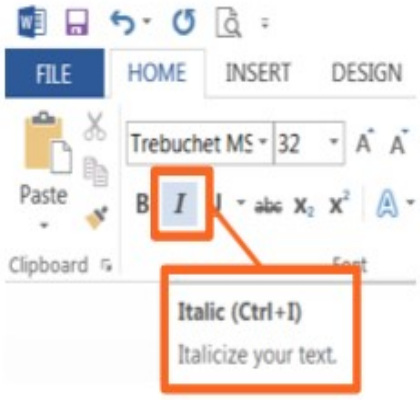
Home Tab

The Home Tab has the groups of commands that people use most often.

1. Font Group

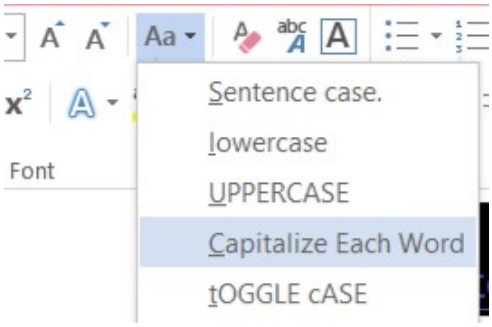
The Font Group contains commands that change the appearance of the font. Font is the set of characters (letters, numbers, punctuation, etc.) in a particular style. For example, the document you created from the "Facet design" template on the Welcome page uses "Trebuchet MS" font, but you can still use the font commands in your document.
Here's how to italicize text

- ✓ Select the word "Practice" in the document title.
- ✓ Click italics icon in Font Group (see screenshot).
- ✓ Notice Word automatically capitalized the first word in the sentence. If you want each word capitalized, as a title or header normally is, you may do it word by word or simply use Change Case.



To use Change Case command:

- ✓ Select "How to use this template".
- ✓ Click "Change Case" command.
- ✓ Click "Capitalize Each Word" in menu.



2. Style Group

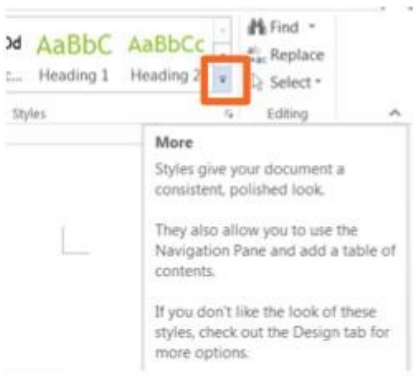
A document created from a template, like the one you opened earlier (Facet design blank), has pre-designed styles for different parts of the document, such as paragraphs and headers. To apply a different paragraph style:

- ✓ Select paragraphs under "How To Use This Template".
- ✓ Click "More" button in Styles Group. ✓ Click "Emphasis" command.

The text remains selected. You may continue modifying, including Undo, if you wish. To deselect, press left arrow (cursor placed at beginning of text), right arrow (cursor placed at end of text) or click in an area outside the selection.

To create a new heading (section):

- ✓ Click "More" button in Styles Group.
- ✓ Click "Heading 1".
- ✓ Type "Learning more about the home tab".
- ✓ Press "Enter" once.
- ✓ Type "The Home Tab contains the following Groups:"
- ✓ Press "Enter" once.

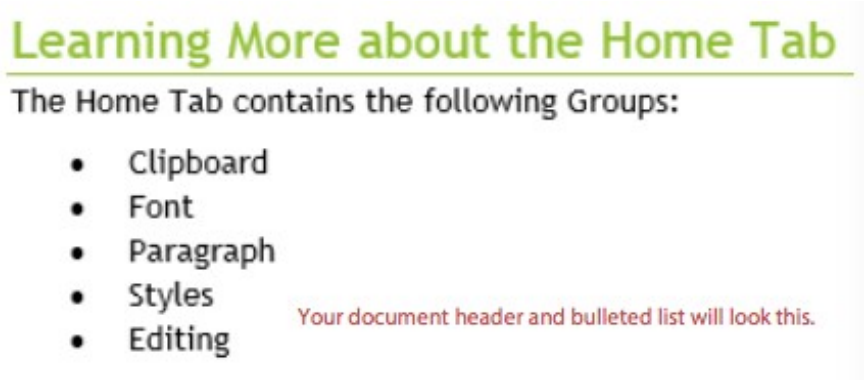


"More" button in the Styles Group

You now have a new header and introductory sentence. You will use commands from various groups at various times, so don't be surprised that you will use a command from the Paragraph Group next.

To create a bulleted list:

- ✓ Click "Bullets" command in Paragraph Group.
- ✓ Type "Clipboard".
- ✓ Press "Enter" once.
- ✓ Re-create list pictured to the right (Repeat step 2 & 3 for each word).
- ✓ After last item in your list, press "Enter" twice.



Your document header and bulleted list will look this.

Bullets are good for general lists of items. A numbered list is good for steps in a procedure or order. The steps to make a numbered list are the same, ex cept the icon for numbering is

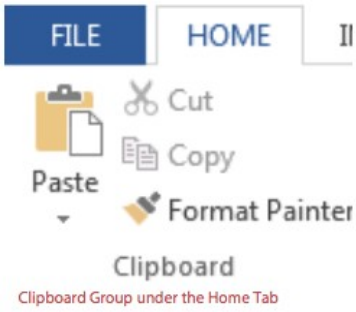
Clipboard Group

The Clipboard Group has the commands to do "copy and paste" and "cut and paste".

Before you start:

- ✓ Make a new sub-heading in your practice document.
- ✓ Use "Heading 2" style from Styles Group.
- ✓ Type "Clipboard Group".
- ✓ Press "Enter" once.

- ✓ Type two sentences on one line.
- ✓ "I want to live in a warm place. I am moving to Hawaii."



Clipboard Group under the Home Tab

To Copy and Paste text:

- ✓ Select the text (the line of text you just typed).
- ✓ Click "Copy" icon in Clipboard Group.
- ✓ Move cursor to area where you want to paste (right arrow, then "Enter" once).
- ✓ Click "Paste" icon in Clipboard Group.

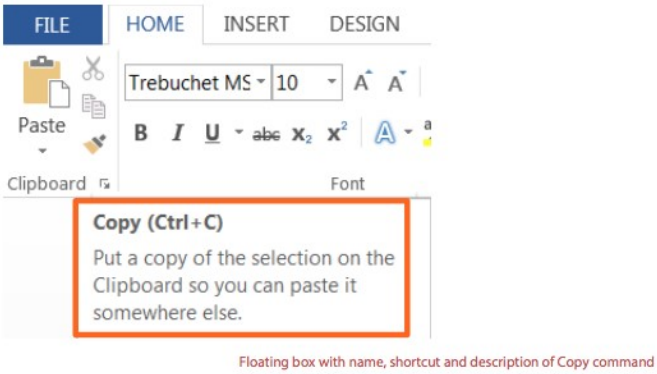
To Cut and Paste text**:**

- ✓ Select the text (the sentence "I am moving...").
- ✓ Click "Cut" icon in Clipboard Group.
- ✓ Move cursor to area where you want to paste (at beginning of first sentence on same line).
- ✓ Click "Paste" icon.

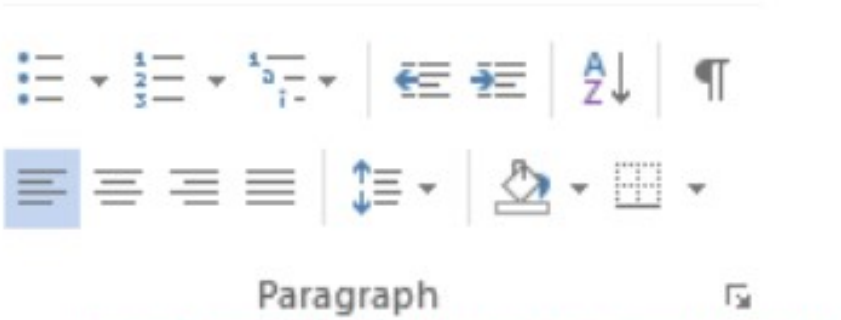
Can you think of a scenario where you might choose one command (Copy, Cut) over the other?

Paragraph Group

The Paragraph Group includes commands to adjust line and paragraph spacing and alignment.
Line spacing refers to when the text you're typing has reached the end of the line and moves down to the next line automatically. **Paragraph spacing** refers to any time you press the "Enter" key to start a new paragraph.



Floating box with name, shortcut and description of Copy command



Paragraph Group and "Line and Paragraph" command highlighted

Insert Tab

The Insert Tab commands insert different elements into your document like tables and illustrations.

Tables Group

You may choose preformatted tables or add the number of rows and columns you want. For this exercise, you will create a 3x5 table to track DVD's on loan to friends.
To insert a table into your document**:**

- ✓ Click the Add a Table icon under the Insert Tab.
- ✓ Select a 3-column, 5-row area in the grid.
- ✓ Left-click when you are ready to insert the table.

Apply a Table Style

- ✓ Click into the table to activate the Table Tools tab.
- ✓ Choose a new design from the Design Tab.

Illustrations

The Illustrations Group has commands to insert pictures, shapes, charts, and more.

How to insert a shape

- ✓ Click the Shapes button in the Illustrations Group
- ✓ Click the first shape (Explosion 1) in Stars and Banners.
- ✓ Place mouse pointer (cross) in a blank area.
- ✓ Click and drag your mouse to "draw" the shape.
- ✓ Let go of the mouse button when finished.

How to add text to a shape

- ✓ Place mouse pointer arrow in shape area.
- ✓ Click right mouse button once.
- ✓ Click "Add Text" from menu.
- ✓ Type "Hello".

How to move a shape

- ✓ Place mouse pointer over shape.
- ✓ Look for cross-like move arrow tool.
- ✓ Click and drag your shape to a new spot.

How to re-size a shape

- ✓ Click into the shape.
- ✓ Look for squares around the frame.
- ✓ Click and drag a frame square.
- ✓ Drag a corner out to enlarge proportionally.

Steps for inserting other types of illustrations are similar; try inserting another illustration on your own.

Keyboard Shortcuts

These shortcuts are a handy way to use the mouse less. Activate them by holding down one of the Ctrl (Control) keys on the keyboard and tapping the corresponding key. For some shortcuts, you have to highlight the text first. Follow your instructor's directions to apply these shortcuts to a document (if Paragraphs document is still open, use it as an example or write a few new sentences on a blank page).

Ctrl + P	**print**
Crtl + A	select all
Ctrl + C	copy
Ctrl + V	paste
Ctrl + X	cut
Ctrl + N	opens **new** window/document
Ctrl + S	save
Ctrl + Z	undo
Ctrl + Y	redo
Ctrl + B	bolds **text**
Ctrl + I	*italicizes* text
Ctrl + U	underlines text
Ctrl +]	enlarges text by one size
Ctrl + [	decreases text by one size
Ctrl + E	**centers text**
Ctrl + L	aligns text to the left
Ctrl + R	**aligns text to the right**

MICROSOFT EXCEL 2016

What is Microsoft Excel?

Excel is a spreadsheet program that allows you to store, organize, and manipulate data. Data can be text, numbers, and formulas. The data is entered into cells which are organized into columns and rows. Many people use Excel to keep a budget, use charts and graphs to show data, track sales for a business, and much more.

Microsoft Excel 2016 Interface

The Excel interface is where you see and use the tools in Excel on the screen. This includes the way the tools are organized and presented to you, the software user. You will learn about The Welcome Page, The Ribbon, Quick Access Toolbar, and File Tab.

The Welcome Page

When you first open Excel 2016, you will see the Welcome Page (see Figure 2). Take a moment to browse the many templates available for specific uses. Notice the Search Box near the top-center where you can search for templates for other uses.

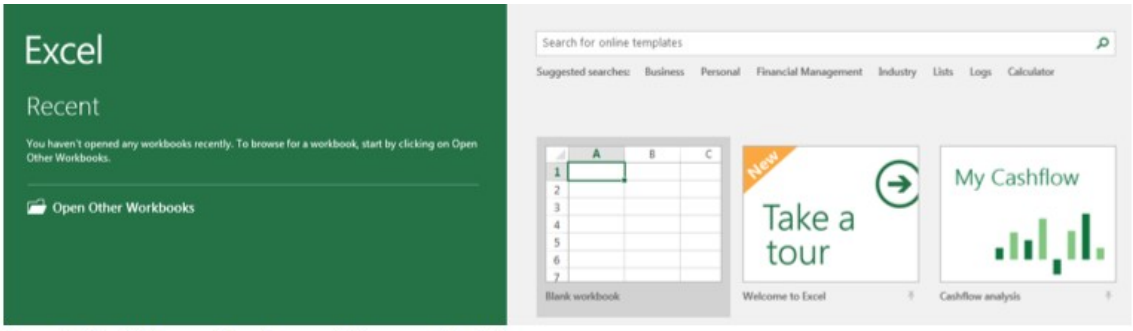


Figure 2 - Excel Welcome Page (zoomed in to upper left side)

The Ribbon

The Ribbon is a toolbox at the top of the screen. It's organized into three main parts

- ✓ Tabs – Tabs represent a general activity area. For example, the "Home" has the tools most often used, and the "Insert" tab has the tools to "put objects into" the work area.
- ✓ Groups – Groups show related "tools" together more specifically, like "Font" or "Alignment".
- ✓ Commands – A command is one of the actual "tools", which can be a button, expandable menu, or a box for entering information.

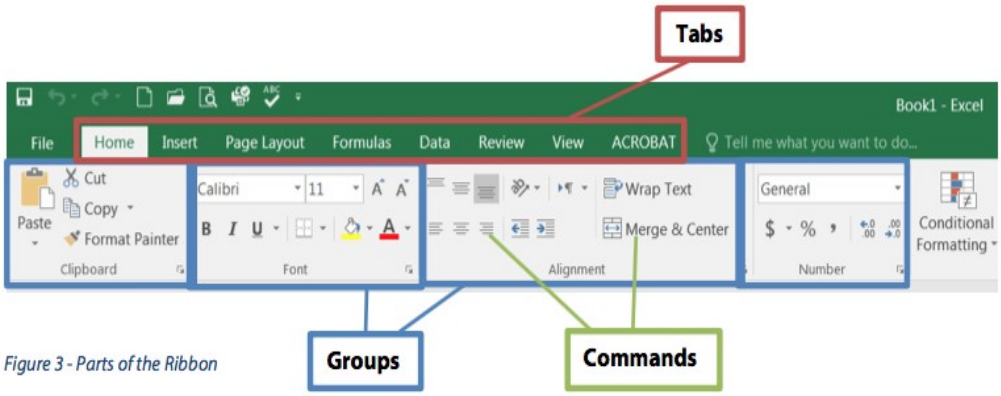


Figure 3 - Parts of the Ribbon

Quick Access Toolbar

The Quick Access Toolbar is above the Tabs and **has the commands used most often.** See below

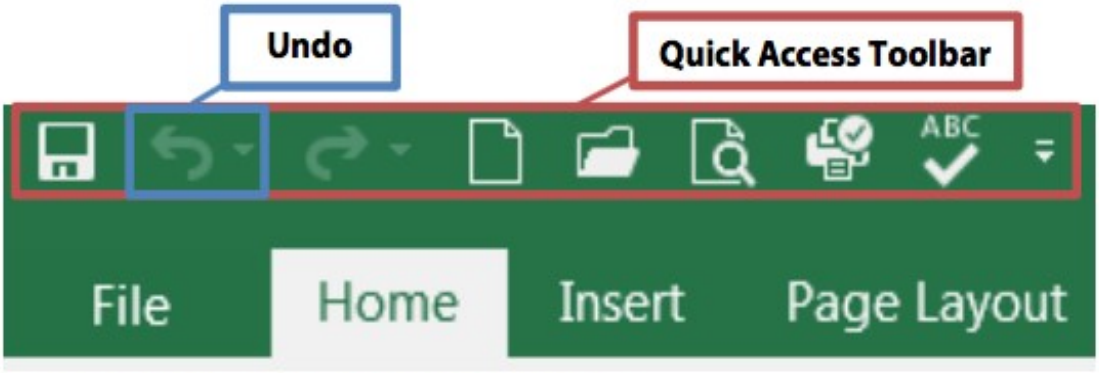


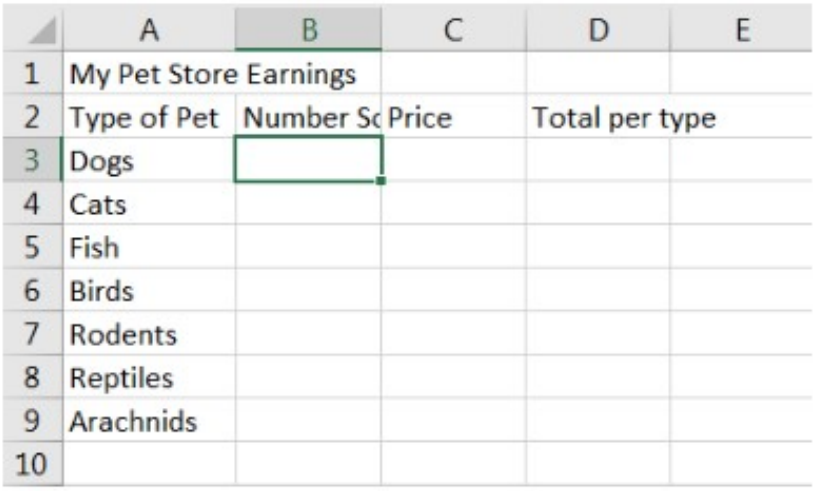
Figure 4 - Quick Access Toolbar & Undo button (zoomed in)

File Tab

The File Tab is where you can create a **New** document, **Open** an existing one, **Save** changes, **Save As** a different file with a different name, **Print** the current workbook, and many other options.

Basic Formatting - Labels

The words you type into a cell are called "labels". Excel has many formatting tools to make labels look better and easier to read. For example, the label "Number Sold" is too long to fit into a cell **B2**.



	A	B	C	D	E
1	My Pet Store Earnings				
2	Type of Pet	Number Sc	Price	Total per type	
3	Dogs				
4	Cats				
5	Fish				
6	Birds				
7	Rodents				
8	Reptiles				
9	Arachnids				
10					

Figure 6 - Worksheet with column labels

Try it! Select cell range **A1**:**E1** (click and drag from cell **A1** to **E1**). Click the "Merge and Center" command in the *Alignment Group* of the *Home Tab*. Now add a little style: click the "Good" command in the *Styles Group* of the *Home Tab*. Your worksheet should look like Figure 7.

Try it! Place the mouse pointer on the thin line between column letters "B" and "C". Double click, and the columns will automatically adjust to fit the text in column "B". Make the text in every column easy to read. Your worksheet should look like Figure 7. You may also click and drag to adjust the width of the column.

	A	B	C	D	E
1	My Pet Store Earnings				
2	Type of Pet	Number Sold	Price	Total per type	
3	Dogs				
4	Cats				
5	Fish				
6	Birds				
7	Rodents				
8	Reptiles				
9	Arachnids				
10					

Figure 7 - Formatting and columns adjusted

Basic Formatting - Values

The numbers you type into a cell are called "values". Working with values in Excel will begin to show you the power of the software.

Try it! Type the values you see in columns "B" and "C" in Figure 8. Click into cell **B3**, type

"27", then press "Enter" on the keyboard. Continue until you've added all the values in range **B3:C9**. Note: when typing the values in column "C" (prices), do not include the dollar sign.

	A	B	C	D
1	My Pet Store Earnings			
2	Type of Pet	Number Sold	Price	Total per type
3	Dogs	27	300	
4	Cats	20	160.5	
5	Fish	33	12	
6	Birds	26	45	
7	Rodents	18	25.5	
8	Reptiles	37	99.99	
9	Arachnids	43	80	

Figure 8 - Values in cell range B3:C9

Try it! Select cell range C3:C9. In the "Numbers" group under the "Home" tab, click the small arrow next to the dollar sign (Accounting Number Format) as seen in Figure 9. You will click "English (United States)," but browse the many options in the drop-down menu.

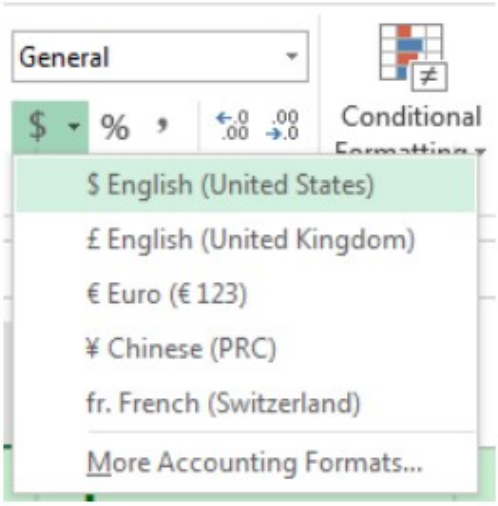


Figure 9 - "Accounting Number Format"

Calculating with Formulas

Let's learn how to perform basic calculations in Excel, called "formulas". For example, how much did the pet store make during this month from the sale of pet dogs?
Try it! Click into cell D3. Type the equal sign (=). Note: formulas always begin with an equal sign. Click cell B3. Type an asterisk (*). Note: in an Excel formula, an asterisk is used for multiplication. Click cell C3. Your worksheet should look like Figure 10. Press "Enter".

How much did the pet store earn from sales of pet dogs? Repeat these steps similarly for the "Cats" row. Hint: start in cell D4.

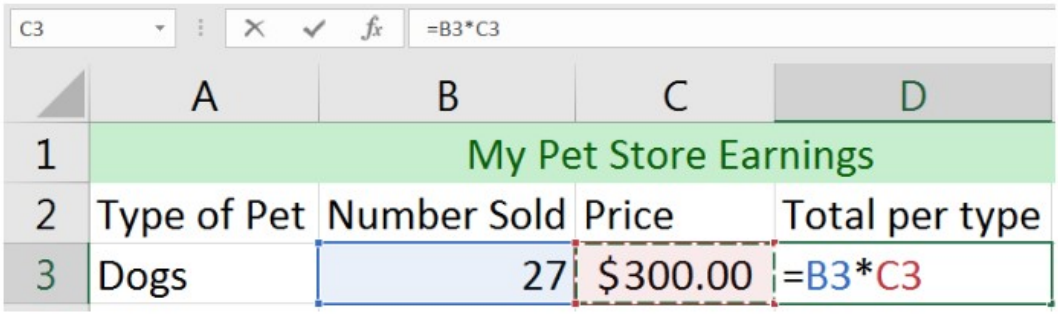


Figure 10 - Basic multiplication formula

Copy a Formula with Autofill

You can speed up your work by calculating one formula and copying it to make other calculations quickly and efficiently. This is a powerful feature in Excel called "Autofill". **Try it!** Select cell range **D3:D4**. Place your mouse over the "fill handle" in the bottom right corner of the selection. The mouse pointer changes from a large white cross to a thin black cross. Click and drag the fill handle down to cell **D9**. Release the mouse button and you observe the power of Autofill.

Try it! Let's suppose a store clerk misplaced a few receipts for rodent sales. Five more rodents sold than reported in the worksheet, so number of rodents sold is "23" and not "18". Make this change in cell **B7,** and press "Enter". Notice the Total dollar amount for "rodents sold" **(cell D7)** adjusts automatically (see Figure 11).

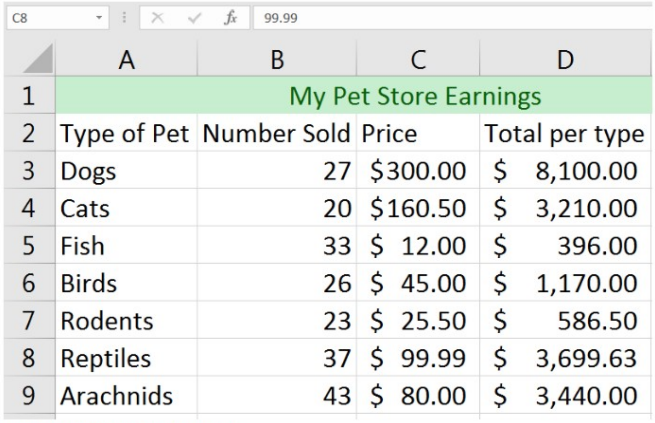


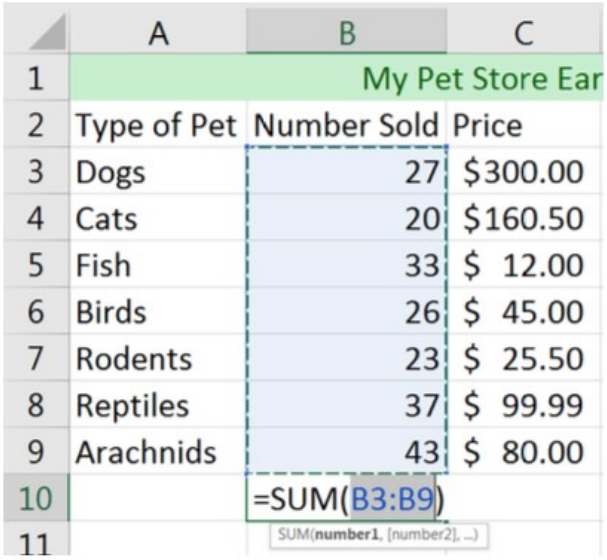
Figure 11 - Adjusted totals in cells B7 and D7

Quick Addition with AutoSum

"AutoSum" lets you quickly add values in a cell range.

Try it! Click in cell **B10**. Then, in the "Editing" group of the "Home" tab, click the command called "AutoSum". You should cell range **B3:B9** automatically selected and formula in cell **B10**. Press "Enter" and you will see the sum (total) of number of pets sold (see Figure 12). Note: you could also have manually written a formula that would look like this,

"**=B3+B4+B5+B6+B7+B8+B9**".



	A	B	C
1			My Pet Store Ear
2	Type of Pet	Number Sold	Price
3	Dogs	27	$300.00
4	Cats	20	$160.50
5	Fish	33	$ 12.00
6	Birds	26	$ 45.00
7	Rodents	23	$ 25.50
8	Reptiles	37	$ 99.99
9	Arachnids	43	$ 80.00
10		=SUM(B3:B9)	
11			

SUM(**number1**, [number2], ...)

Figure 12 - AutoSum command & the SUM function

Save Your Work

To make sure you don't lose your work on a document, you should "save early and save often." **Try it!**

- ✓ Click the File tab
- ✓ Click Save As
- ✓ Click "This PC"
- ✓ Click "My Documents"
- ✓ Type "My Pet Store Earnings" in the "File name" box 6. Click "Save"

UNIT 06

PROVIDE FIRST AID

This unit deals with the skills and knowledge required for the provision of essential first aid in recognizing and responding to emergency using basic life support measures.

ASSESS THE SITUATION

Identify physical hazards to own and others' health and safety

Introduction

When administering first aid your first concern must be to make sure you do not become a casualty of the situation. This means you must assess the situation you are facing and take time to identify the physical hazards that may be present to your own safety and that of others who may be present.

Defining First aid

First aid is any care given to an injured or ill person (called a 'casualty') before professional medical assistance (ambulance, paramedics, nurse, or doctor) arrives on the scene to take control of the situation.
First aid can include the provision of:

- ✓ Mouth-to-mouth resuscitation – if the casualty is not breathing
- ✓ Cardio-Pulmonary Resuscitation (CPR) – where there is no breathing and no pulse
- ✓ Control of bleeding – to limit blood loss
- ✓ Wound care – to limit blood loss and infection by covering wounds
- ✓ Treatment for burns and scalds – including treatment for electric shock
- ✓ Bandaging and splinting – to fractures and sprains.

Important points to note at the start

The following important points must always be taken into account when providing first aid:

- ✓ Protect yourself and others at all times against injury or harm – persons delivering first aid should not become casualties
- ✓ The casualty must be protected against further harm or injury
- ✓ Whenever there is a need to administer first aid make sure you notify your supervisor immediately to arrange for professional help to be called
- ✓ Wear protective gloves when administering first aid to protect against infection.

Types of hazards to be aware of

To protect first aid providers, bystanders and casualties against harm when providing first aid you must take care to identify physical and other hazards which may be present such as: Workplace and incident-specific hazards – including stock, plant, equipment, machinery, utensils and vehicles. It also includes the general environment in the form of heat, cold, wind, sunshine, rain
Hazards sometimes associated with casualty management – for example, first aid providers need to be aware there can be:

- ✓ A risk of being bitten
- ✓ Violence as a result of a casualty being confused and disoriented bodily fluids have the potential to contaminate and cause disease.

Some diseases are only spread through blood-borne viruses, but it is advisable to be alert to the potential dangers posed by all bodily fluids:

- ✓ Blood
- ✓ Saliva
- ✓ Urine and faeces

Mucus

- ✓ Pus
- ✓ Semen
- ✓ Sweat
- ✓ Tears.

You should always be safe and treat all body fluids as if they are infectious. Always wear protective gloves when providing first aid.
Risk of further injury to the casualty – which can be caused by a range of issues, for example:

- ✓ The casualty being burned by fire spreading toward them
- ✓ Something falling onto the casualty and adding to their existing injury.

How to identify hazards

The accepted ways to identify hazards when providing first aid are:

- ✓ Use common sense – this is the most important aspect
- ✓ Use your sense of sight – look for things that could present a problem or danger. Look carefully in all directions. Be alert to smoke, fire and emerging issues
- ✓ Use your sense of hearing – listen for escaping gas, crackling of flames or creaking of wood and metal
- ✓ Use your sense of touch –vibrations or heat
- ✓ Use your sense of smell –gas or smoke.

Also be prepared to listen to what people already at the scene may tell you about what they have identified as being hazards. They have the benefit of extra on-site experience with the casualty you will not have.
The important point here is you must never rush in and start first aid without first assessing the hazards posed by the situation you are facing.
Minimize immediate risk to self and health and safety of the casualty by controlling hazard/s in accordance with accepted practice

Introduction

If any hazards have been identified as a result of the evaluation undertaken when arriving „on scene", you must take action to minimize risk to yourself, the casualty and others before rendering first aid.

What you may be able to do

The action you need to take to minimize risk will depend on the hazard you have identified. Only act to address identified issues where they pose a risk.
Generally speaking, casualties should not be moved until they have been assessed as being safe to move but if there is a serious and immediate risk of extra injury to a casualty from an identified hazard it is standard practice to move them away from the hazard.
If uninjured bystanders are near an identified hazard, they must be told to move away to a safe location.
Whenever there is identified danger from fire, gas leaks or smoke the emergency fire authorities must be called.

Where there is an identified hazard from electricity, the electricity supply company or someone from within the workplace with knowledge of how to turn off the power must be contacted.
Other action may include:

- ✓ If there is a fire near the casualty – call the fire brigade, move the casualty out of the danger zone or fight the fire with nearby hoses, fire blanket or extinguisher
- ✓ If the casualty's situation is being made worse by rain or sunshine – provide cover to the person
- ✓ If gas is leaking from a damaged appliance – turn off the gas at the stop valve and make sure no one is smoking
- ✓ If unstable items are near-by and posing a risk of – either move the items or casualty
- ✓ If the casualty is in a position where they are likely to be run over by vehicles – move them or take action to stop traffic.

Protect the neck

If you ever have to move a casualty because they, or you, may be in danger, do whatever you can to protect the neck against movement. This is vitally important where the casualty is unconscious and you are unsure what injuries they have. To help protect the neck:

- ✓ Keep the casualty still – tell the casualty not to move
- ✓ Kneel behind the head and place your hands on either side to support it – with the head, neck and spine in a straight line
- ✓ Put rolled up towels, blankets, or clothing on each side of the casualty's head to keep it from moving.

Be prepared to use bystanders to help you

- ✓ Always be alert to the possibility of asking others to assist you by:
- ✓ Calling emergency services
- ✓ Moving items helping to move the casualty
- ✓ Using fire-fighting equipment.

This could include other staff, bystanders, customers, management, friends or family of the casualty. Remember others are often prepared and willing to help if they are told what to do.

Using the 'fireman's carry' to move casualties

The "fireman's carry" is used to move unconscious people or casualties who are unable to walk.
Do not use the fireman's carry if the casualty has an injured arm, leg, ribs, neck, or back.
The steps for the fireman's carry are:

- ✓ Place the casualty face down
- ✓ Grab the person around the waist, and help bring him or her to a standing position, facing you
- ✓ Keep one arm around his or her waist when you have him or her in the standing position grasp the casualty‟s right arm in your left hand and swing his or her arm around the back of your neck
- ✓ Pull him or her across your shoulders by bringing his or her raised arm around your neck and over your shoulder. In this position, the injured person's legs will be over one shoulder, and his or her arm and head will be over the other shoulder Reposition your hand from the person's waist to the back of his or her knee Lift yourself with the injured person into a standing position.

Assess casualty's vital signs and physical condition in accordance with accepted practice

Danger – assess situation and check for danger

Before you give first aid, you must assess to the best of your ability the situation. To re-cap, the important aspects are:

- ✓ Check for danger to yourself, the casualty and others. Look for obvious, immediate, life-threatening hazards such as fire, the possibility of a gas explosion, and electrical hazards
- ✓ If there is danger around, you will need to move yourself and your casualty to prevent further injury to anyone
- ✓ If you think the casualty has a spinal injury, take care to stop more damage to the spine by stopping movement of the casualty's neck and back.

Response – check to see if the person is conscious or unconscious

"Response‟ is a step enabling you to determine if the casualty is conscious or unconscious.

- ✓ Try and get a response from the casualty by gently tapping his or her shoulder and calling his or her name
- ✓ Avoid shaking them as this may worsen an existing injury
- ✓ Get a history – ask the casualty or any witnesses who saw the incident: what happened? Does the casualty have a neck or back injury? Does the casualty have an allergic reaction?
- ✓ Identify how the casualty feels. Ask: „how do you feel?‟, „do you feel dizzy or weak?‟, „do you have pain? Where? For how long?‟

Check the physical condition of the casualty – take a look at them and around them. Is there evidence:

- ✓ Of bleeding? Where from? How badly?
- ✓ Bones are broken?
- ✓ Of swelling, bites, burns, scalds?
- ✓ Of possible neck or back injury?

They are suffering allergic reactions – perhaps to food, sting or bite?
the casualty is in shock – symptoms of shock include:

- sweaty but cool skin, pale colour or bluish skin around the mouth
- shallow, fast breathing
- rapid pulse that becomes weaker

✓ As shock progresses, you will see the casualty has:

- anxiety – they will appear restless, agitated, worried
- unusual thirst
- yawning and sighing
- Nausea.

Airway – check to make sure the airway is free of obstructions

- ✓ If casualty is not breathing, open the airway by placing one hand on their forehead and gently tilt the head back by lifting the chin
- ✓ Remove any visible obstructions (vomit, mucus, saliva, false teeth, loose or broken teeth, food, tongue) from the mouth and nose to unblock the airways
- ✓ If obstructions are present the casualty will not be able to breathe and the obstruction will also impede the provision of rescue breathing/mouth-to-mouth resuscitation also known as ear (expired air resuscitation).

Breathing – check to determine if casualty if breathing

Check breathing by looking (to watch the rise and fall of chest), listening (to the sounds of inhaling and exhaling) and feeling for breathing (by placing your cheek next to their mouth and feeling for exhaled breath on your check) for up to 10 seconds. Is the casualty‟s breathing regular or irregular?
If casualty is not breathing, administer rescue breathing/mouth-to-mouth resuscitation/ear.
If casualty is breathing:

- ✓ Continue to monitor it to ensure they continue to breathe
- ✓ Apply rescue breathing if their breathing stops
- ✓ Note their respiration rate so it can be communicated to professionals when they arrive.

Vital signs – respiration rate

“respiration rate‟ is the rate at which the casualty is breathing.
To determine the respiration rate for a casualty, watch their chest or stomach rise and

fall for 15 seconds counting how many times it rises.
Multiply this figure by four to obtain respirations per minute.
Write down your findings so they can be passed on to professional medical help when they arrive.

Respiration rates

- ✓ The normal range of respiration rates in an adult when resting is 12 to 20 respirations per minute
- ✓ Respiration rate below 12 respirations per minute is called slow
- ✓ Respiration rate above 20 respirations per minute is rapid
- ✓ A breathing rate slower than 12 respirations per minute or faster than 20 respirations per minute may indicate a problem affecting the casualty's ability to get oxygen.

Circulation – check to see if the person has a pulse

- ✓ This will indicate whether or not their heart is beating
- ✓ Without a pulse, there is no heart beating and there is no circulation
- ✓ If you cannot detect a pulse, commence chest compressions
- ✓ If casualty is not breathing and there is no pulse, administer cpr (cardiopulmonary resuscitation) this is a first aid technique combining rescue breathing and external chest compressions.

How to find the pulse

It is important to take the pulse of a casualty to determine if their heart is till beating or not. No pulse means their heart is not beating and chest compressions must commence.
If there is no pulse and there is no sign of breathing, cpr (cardio-pulmonary resuscitation) must commence.
A good point for taking the pulse is the neck (carotid arteries). Place the middle and index fingers on the casualty's larynx (voice box).
Move the fingers to the side until you feel the groove (between the bone and the muscle) next to the trachea (wind pipe), then press on the groove until you feel the pulse.
Place the tips of your index and middle fingers over the pulse site and press gently. Using a watch with a second hand. Count the pulse for 15 seconds and then multiply by four to obtain beats per minute. Write down your findings.

Vital signs – pulse rate

A normal pulse rate for an adult when resting is 60 to 80 beats per minute.
The average is 72 beats per minute.
A resting pulse rate of more than 80 beats per minute is a higher than normal pulse rate. This can be caused by shock, bleeding, heat, dehydration, fever, pain or exercise.

Using history, signs and symptoms

If the casualty is conscious and able to talk, speak to them to obtain whatever history is available relating to their condition.
By putting the history, signs and symptoms together, you will have a better assessment

of the injury.

For example:

- ✓ The casualty's chest pain came on quickly
- ✓ The casualty has had chest pain for more than 10 minutes and is short of breath and sweating
- ✓ The casualty is experiencing pain in the chest that is spreading down the arms. They also feels weak and dizzy

Assessment – it is possible the person has suffered a heart attack. Get professional medical help immediately. Call for an ambulance if the casualty becomes worse, stop your assessment and treat the life-threatening condition. While waiting for help to arrive, you should:

- ✓ Give whatever first aid to the casualty you can
- ✓ Keep watching the casualty to see if their condition changes and record those changes. This could relate to changes to respiration, heart beats or level of consciousness
- ✓ Re-assure them they are going to be alright

APPLY BASIC FIRST AID TECHNIQUES

First aid in the injured is generally consists of a series of simple and in some cases, potentially life-saving procedures that an individual can be trained to perform with minimal equipment.

In fact, certain self-limiting illnesses or minor injuries may not require further medical care past the first aid intervention, but in other cases, first aid is only the first step in the treatment of injured persons.

The key aims of first aid in the injured can be summarized in three key points:

1. **Preserve life**: the overriding aim of all medical care, including first aid, is to save lives and minimise the threat of death.
2. **Prevent further harm**: also, sometimes called prevent the condition from worsening, or danger of further injury. This covers both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleeding which becomes serious.
3. **Promote recovery**: first aid also involves trying to start the recovery process from the injury, and in some cases might involve completing a treatment, such as in the case of applying a plaster to a small wound.

Key skills of first aid

Certain skills are considered essential to the provison of first aid to injured persons and apply before all others if indicated. Particularly the **"ABC"** of first aid, which focus on critical life- saving intervention, must be rendered before treatment of less serious injuries. ABC stands for *Airway*, *Breathing*, and *Circulation*.

Obstruction (choking) is a life-threatening emergency. For these reasons, when we get to the injured, care must first be brought to the his or her **airway (A)** to ensure it is clear.

Following evaluation of the airway, a first aid attendant would determine adequacy of **breathing (B)** and provide rescue breathing if necessary.
Assessment of **circulation (C)** is now not usually carried out for patients who are not breathing. First aiders must conclude indirectly that unconscious patients, without breathing have no circulation and go straight to chest compressions. Pulse checks may be done on less serious patients. Once the ABCs are secured, first aiders can begin additional treatments, as required.

First aid for wounds

A wound is any type of injury to the skin. In general, wounds can be classified as closed (where the skin stays intact) or open.

In open wounds, the skin is cracked open, leaving the underlying tissue exposed to the outside environment, which makes it more vulnerable to bleeding and infections.

In closed wounds, the skin is intact and the underlying tissue is not directly exposed to the outside world. Even with the skin intact, the damage can reach down to the underlying muscle, internal organs and bones. That is why these kinds of wounds can be complicated by severe bleeding, large bruises, nerve damage, bone fractures and internal organ damage.

Open wounds can be classified according to the object that caused the wound. The types of open wounds are:

- ✓ Incisions or incised wounds, caused by a clean, sharp-edged object such as a knife, razor, or glass splinter
- ✓ Lacerations, irregular tear-like wounds caused by some blunt trauma
- ✓ Abrasions, superficial wounds in which the topmost layer of the skin (the epidermis) is scraped off. Abrasions are often caused by a sliding fall onto a rough surface
- ✓ Avulsions, injuries in which a body structure is forcibly detached from its normal point of insertion.
- ✓ Puncture wounds, caused by an object puncturing the skin, such as a splinter, nail or needle.
- ✓ Penetrating wounds, caused by an object such as a knife entering and coming out from the skin.

The types of **closed wounds** are:

- ✓ Contusions, more commonly known as bruises, caused by a blunt force trauma that damages tissue under the skin.
- ✓ Hematomas, also called a blood tumor, caused by damage to a blood vessel that in turn causes blood to collect under the skin.

Crush injury is an injury that occurs because of pressure from a heavy object onto a body part or from squeezing of a body part between two objects. Depending upon their severity, crush injuries can be complicated by bleeding, bruising, broken bones, open wounds or socalled compartment syndrome. Compartment syndrome usually results from extreme swelling after an injury. The dangerously high pressure in the field of injury impedes the flow of blood to the affected tissues. Severe tissue damage can result, with loss of body

The following measures need to be taken in giving first aid to a victim of an open wound:

1. Stop the bleeding
2. Minor cuts and scrapes usually stop bleeding on their own. **Hematoma,**
3. If they don't, apply gentle pressure with a clean cloth or bandage. Hold the pressure continuously for 20 to 30 minutes and if possible, elevate the wound.

4. Clean the wound
5. Rinse out the wound with clear water. Soap can irritate the wound, so try to keep it out of the actual wound. If dirt or debris remains in the wound after washing, use tweezers cleaned with alcohol to remove the particles. To clean the area around the wound, use soap and a washcloth.

6. Cover the wound
7. If the bleeding slows, cover the wound with a clean dressing and bandage. Dressings and bandages can help keep the wound clean and keep harmful bacteria out. A dressing is a sterile pad or compress (usually made of gauze or cotton wrapped in gauze) used to cover wounds, to control bleeding and/or prevent further contamination. A dressing should be large enough to totally cover the wound, with a safety margin of about 2.5 cm on all sides beyond the wound. A bandage is used to secure a dressing in place and to apply pressure to bleeding wounds.

8. The following measures need to be taken in giving first aid to a victim of a closed wound:
9. Application of direct pressure, preferably with ice wrapped in a cloth, for several minutes, in order to arrest the bleeding as well as to reduce the swelling.
10. Elevation of the affected region will also support in reducing the pressure as well as the re-absorption process and it should be practiced as and when appropriate.

When to seek help from health professional:

- ✓ If the wound is in the head, chest or abdomen
- ✓ (unless it is minor).
- ✓ If there is blue, white or cold skin, numbness, tingling, loss of feeling, or the person is unable to move a limb below the wound.
- ✓ If your tetanus shots are not up to date, especially if the object that caused the puncture was dirty, such as a rusty nail or farm implement.
- ✓ If a deep wound to the foot occurred through a shoe.
- ✓ If an animal bite is severe and may need stitches, or if it is on the hand or face.
- ✓ If you are unable to remove an object from the wound.
- ✓ If signs of infection develop – increased pain, swelling, redness, tenderness – heat or red streaks extending from the wound – discharge of pus – fever of 38 °C with no other cause.

First aid for bleeding

Bleeding is the loss of blood escaping from the circulatory system. It arises due to either traumatic injury, underlying medical condition, or a combination and can occur *internally*, where blood leaks from blood vessels inside the body, or *externally*, either through a natural opening such as the mouth, nose, ear, urethra, vagina or anus, or through a break in the skin.

External bleeding is generally described in terms of the origin of the blood flow by vessel type. The basic categories of external bleeding are:

1. **Arterial bleeding**: As the name suggests, blood flow originating in an artery. With this type of bleeding, the blood is typically bright red to yellowish in color, due to the high degree of oxygenation. Blood typically exits the wound in spurts, rather than in a steady flow. The amount of blood loss can be copious, and can occur very rapidly.
2. **Venous bleeding**: This blood is flowing from a damaged vein. As a result, it will be blackish in colour (due to the lack of oxygen being transported) and will flow in a steady manner. Caution is still indicated; while the blood loss may not be arterial, it can still be quite substantial, and can occur with surprising speed without intervention.
3. **Capillary bleeding**: Capillary bleeding usually occurs in superficial wounds, such as abrasions. The colour of the blood may vary somewhat (distal portion of circulation with oxygenated and unoxygenated blood mixing), and will generally ooze in small amounts, as opposed to flowing or spurting.

Internal Bleeding is one of the most serious consequences of trauma. It may occur after any significant physical injury. There are two main types of trauma, and either may cause internal bleeding:

1. **Blunt trauma** - This kind of trauma happens when a body part collides with something else, usually at high speed. Blood vessels inside the body are torn

or crushed either by shear forces or a blunt object. Examples are car accidents, physical assaults, and most falls.

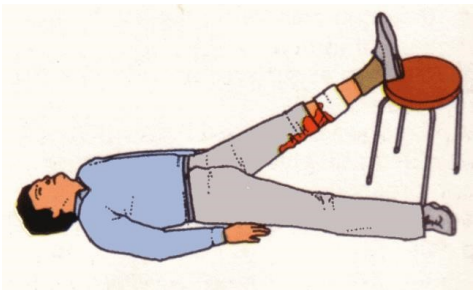
2. **Penetrating trauma** - This happens when a foreign object penetrates the body, tearing a hole in one or more blood vessels. Examples are gunshot wounds, stabbings, or falling onto a sharp object.

Almost any organ or blood vessel can be damaged by trauma and cause internal bleeding. The most serious sources of internal bleeding due to trauma are:

- ✓ Head trauma with internal bleeding (intracranial hemorrhage)
- ✓ Bleeding around the lungs (hemothorax)
- ✓ Bleeding around the heart (hemopericardium and cardiac tamponade)
- ✓ Tears in the large blood vessels near the center of the body (aorta, superior and inferior vena cava, and their major branches)
- ✓ Damage caused by trauma to the abdomen such as liver or spleen lacerations or perforation of other soft organs

Any of these signs of internal bleeding after a trauma should be treated as a medical emergency. The injured person needs to be evaluated in a hospital emergency room.
The following measures need to be taken in giving first aid to a victim of external bleeding:

1. Wash your hands to avoid infection and put on gloves
2. Lay on the injured person down and cover the person to prevent loss of body heat.
3. If possible, position the person's head slightly lower than the trunk or elevate the legs and elevate the site of bleeding
4. While wearing gloves, remove any obvious dirt or debris from the wound.
5. Don't remove any large or more deeply embedded objects. Your principal concern is to stop the bleeding.



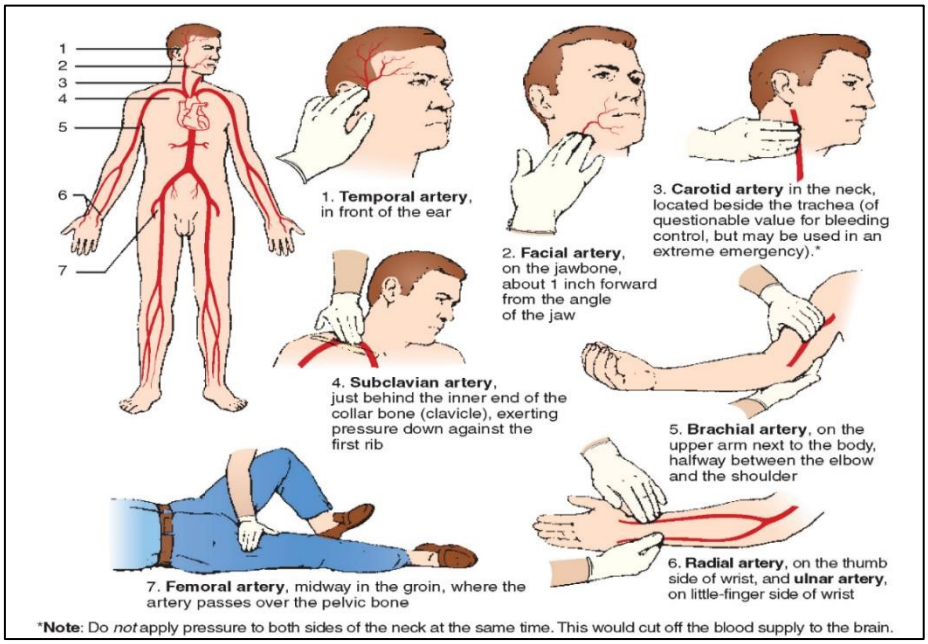
Apply pressure directly on the wound until the bleeding stops

- ✓ Use a sterile bandage or clean cloth and hold continuous pressure for at least 20 minutes without looking to see if the bleeding has stopped.
- ✓ Maintain pressure by binding the wound tightly with a bandage or clean cloth and adhesive tape.
- ✓ Use your hands if nothing else is available.


- ✓ If the bleeding continues and seeps through the gauze or other material you are holding on the wound, don't remove it. Instead, add more absorbent material on
- ✓ top of it


1. **Squeeze a main artery if necessary**

1. If the bleeding doesn't stop with direct pressure, apply pressure to the artery delivering blood to the area.
2. Squeeze the main artery in these areas against the bone. Keep your fingers flat.
3 With your other hand, continue to exert pressure on the wound itself.

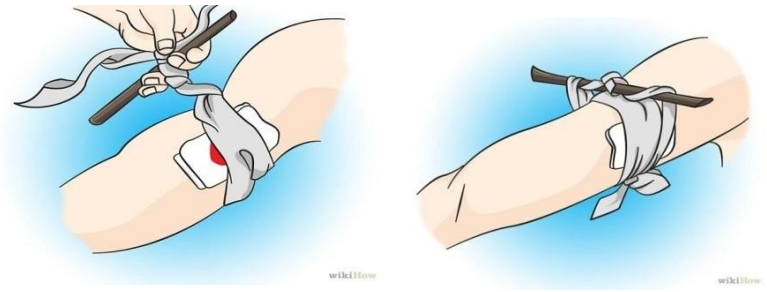


1. **Immobilize the injured body part once the bleeding has stopped**

    1. Leave the bandages in place and get the injured person to the emergency room as soon as possible.

2. **If continuous pressure hasn't stopped the bleeding and bleeding is extremely severe, a tourniquet may be used until medical help arrives or bleeding is controllable**

    1. It should be applied to the limb between the bleeding site and the heart and tightened so bleeding can be controlled by applying direct pressure over the wound.
    2. To make a tourniquet, use bandages 5 -10 cm (2 to 4 inches) wide and wrap them around the limb several times. Tie a knot, leaving loose ends long enough to tie another knot. A stick should be placed between the two knots. Twist the stick until the bandage is tight enough to stop the bleeding and then secure it in place.
    3. Check the tourniquet every 10 to 15 minutes. If the bleeding becomes controllable, (manageable by applying direct pressure), release the tourniquet.



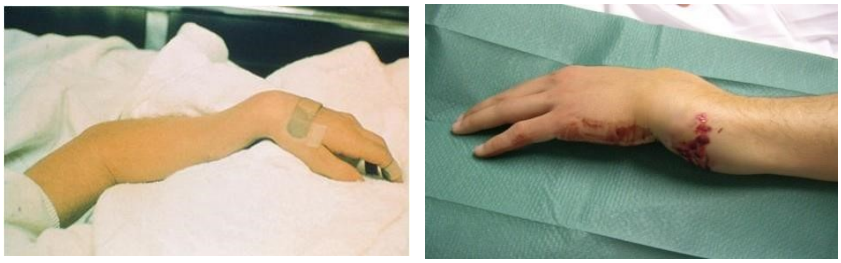
First aid for bone and joint injuries

Injuries of bones and joints can be bone fractures or dislocations and sprains of joints. A ***fracture*** is the medical term for a broken bone. There are many types of fractures, but the main categories are open, and closed.

- ✓ A closed fracture is when the bone breaks but there is no puncture or open wound in the skin.
- ✓ An open fracture is one in which the bone breaks through the skin. This is an important difference from a closed fracture because with an open fracture there is a risk of a deep bone infection.

The severity of a fracture depends upon its location and the
damage done to the bone and tissue near it. Serious *Closed and open fracture* fractures can lead to serious complications if not treated promptly. Possible complications include damage to blood vessels or nerves and infection of the bone (osteomyelitis) or surrounding tissue.

Fractures can be identified by symptoms that can be represented by the acronym DOTS: **D** for deformity, **O** for open wounds, **T** for tenderness and **S** for swelling



Symptoms of a broken arm

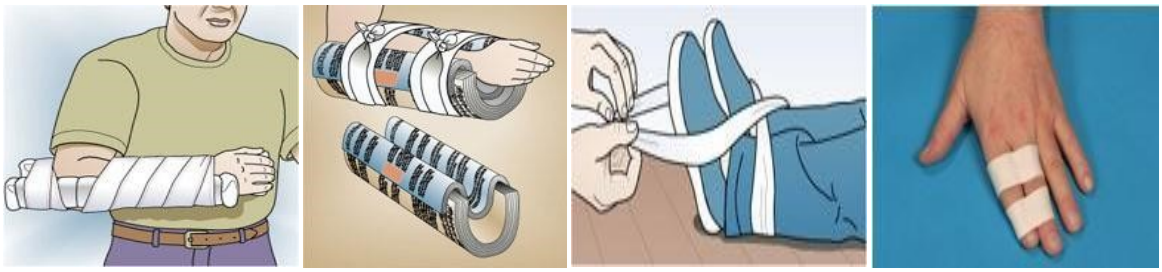
The following measures need to be taken in giving first aid to a victim with bone injury:

- ✓ Don't move the person except if necessary to avoid further injury. Take these actions immediately while waiting for medical help:
- ✓ Stop any bleeding
- ✓ Apply pressure to the wound with a sterile bandage, a clean cloth or a clean piece of clothing.

Immobilize the injured area

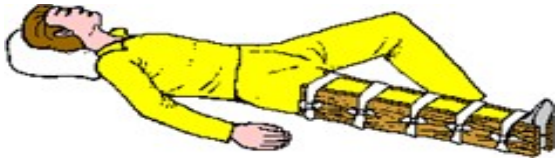
- ✓ Don't try to realign the bone or push a bone that's sticking out back in.
- ✓ If you've been trained in how to splint and professional help isn't readily available, apply a splint to the area above and below the fracture sites.

Splinting reduces pain, prevents further damage to muscles, nerves and blood vessels, prevents closed fracture from becoming open fracture and reduces bleeding and swelling. In an emergency, almost any firm object or material can serve as a splint such as sticks, boards, or even rolled up newspapers. If none can be found, use a rolled blanket or clothing. An injured body part can also be taped to an uninjured body part in order to prevent it from moving. For example, you can tape an injured finger to the finger next to it, or fractured leg to uninjured leg to keep it immobile (self-splint or anatomic splint).



Improvise materials and techniques for splinting

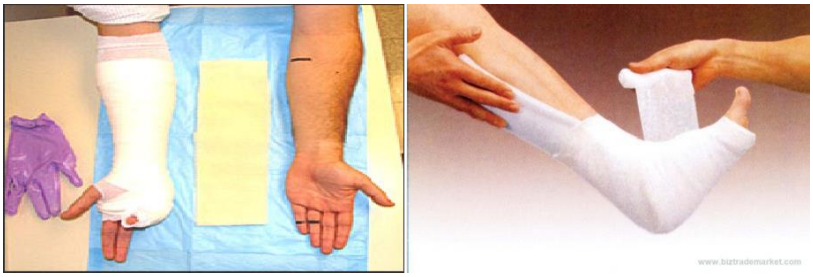
Splint must be well padded on the sides touching the body; if they are not properly padded, they will not fit well and will not adequately immobilize the injured part. Before applying splint open wounds must be covered. We have to immobilize in position found. A basic rule of splinting is that the joint above and below the broken bone should be immobilized to protect the fracture site. For example, if the lower leg is broken, the splint should immobilize both the ankle and the knee.



Splinting of the lover leg

Fasten splints in place with bandages, strips of adhesive tape, clothing, or other suitable materials

- ✓ Use opposite arm to measure lenght of splint !
- ✓ If possible, one person should hold the splints in position while another person fastens them.



Although splints should be applied snugly, they should never be tight enough to interfere with the circulation of the blood.

- ✓ When you are applying splints to an arm or a leg, try to leave the fingers or toes exposed
- ✓ If the tips of the fingers or toes become blue or cold, you will know that the splints or bandages are too tight.

You should examine a splinted part approximately every half hour and loosen the fastenings if the circulation appears to be impaired. Remember that any injured part is likely to swell, and splints or bandages that are otherwise applied correctly may later become too tight.

Apply ice packs to limit swelling and help relieve pain until emergency personnel arrive.

- ✓ Don't apply ice directly to the skin — wrap the ice in a towel, piece of cloth or some other material

Treat for shock

- ✓ If the person feels faint or is breathing in short, rapid breaths, lay the person down with the head slightly lower than the trunk and, if possible, elevate the legs.

Injuries of joints can be dislocations or sprains of joints.
A **dislocation** is an injury in which the ends of bones are forced from their normal positions. The cause is usually trauma resulting from a fall, an auto accident or a collision during contact or high-speed sports.

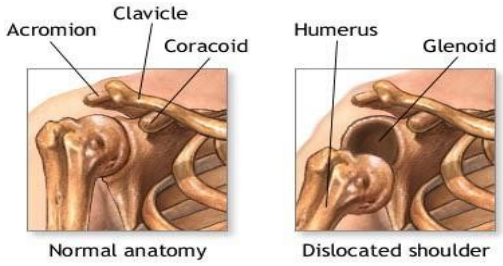


Figure 22. Normal and dislocated shoulder

A dislocation is likely to bruise or tear the muscles, ligaments, blood vessels, tendons, and nerves near a joint.

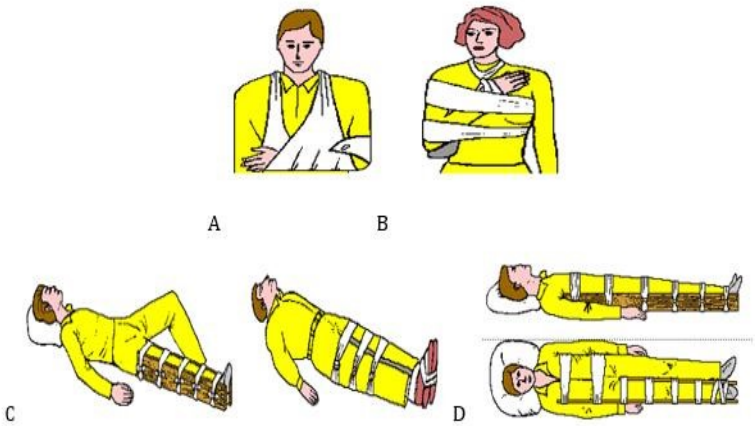
Rapid swelling and discoloration, loss of ability to use the joint, severe pain and muscle spasms, possible numbness and loss of pulse below the joint, and shock are characteristic symptoms of dislocations. The fact that the injured part is usually stiff and immobile, with marked deformation at the joint, will help you distinguish a dislocation from a fracture. In a fracture, there is deformity between joints rather than at joints, and there is generally a wobbly motion of the broken bone at the point of fracture.

A ***sprain*** is a stretching or tearing of ligaments — the tough bands of fibrous tissue that connect one bone to another in your joints. The most common location for a sprain is in ankle. Signs and symptoms will vary, depending on the severity of the injury but pain and swelling are the main symptoms.

The following measures need to be taken in giving first aid to a victim with joint injury:

1. For dislocations, splint and provide care as you would for fracture.
2. For sprains, use RICE procedure - R=rest, I=Ice, S=compression and E=elevation

In both cases seek medical care (Referral).


A
B
C
D

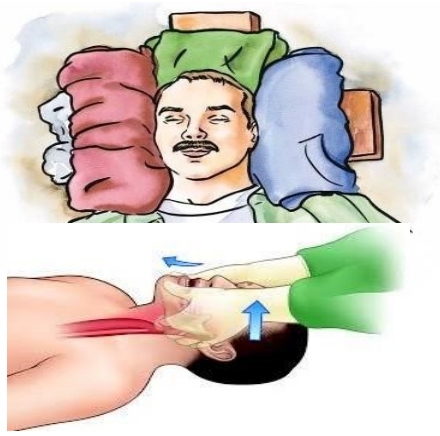
First aid for back and neck injury (spinal cord injury)

Any severe blow, fall, or other accident may result in injury to the neck, back, or spinal cord. Spinal cord injuries can cause long-term, irreversible damage and death. Symptoms can be loss of sensation, loss of motor functions (paralysis), loss of bowel/bladder functions, loss of involuntary functions like breathing, inability to control rate of heart beat, inability to sweat

The following measures need to be taken in giving first aid to a victim with suspected spinal cord injury:

1. Seek medical assistance immediately. Call for EMS (112) Until EMS arrives:

   - DO NOT move victim unless absolutely necessary to save victim's life.
   - DO NOT bend or twist victim's neck or body. Careful handling is extremely important.
   - Maintain position in which victim was found and immobilize head, neck, shoulders, and torso - roll up towels, blankets, jackets, or clothing, and place around head, neck, shoulders, and torso



2. If the person is not breathing or showing signs of circulation, begin CPR but do not lift the chin to open an airway. Instead, you should gently pull the jaw forward
3. If victim must be moved to perform rescue breathing, to clean mouth of vomit or in danger of further injury, enlist help at least one other person to keep victim's head, torso, and legs in straight line as you turn victim.

First aid for burns

Burns are thermal injury caused by exposure to excess heat. According to the depth of injury to the skin, we distinguish tree (or four) types of burns:

1. Burns that affect only the superficial skin are known as superficial or first-degree burns.
2. When damage penetrates into some of the underlying layers, it is a partial-thickness or second-degree burn.

3. In a full-thickness or third-degree burn, the injury extends to all layers of the skin.

Sometimes we talk about a fourth-degree burns when the injury affects deeper tissues, such as muscle or bone.

Symptoms and sign of various types of burns

Type	Layers involved	Appearance	Texture	Sensation	Healing Time	Prognosis	Example
Superficial (First degree)	Epidermis	Red without blisters	Dry	Painful	5–10 days	Heals well, Repeated sunburns increase the risk of skin cancer later in life!	
Superficial partial thickness (Second degree)	Extends into superficial (papillary) dermis	Redness with clear blister. Blanches with pressure.	Moist	Very painful	less than 2–3 weeks	Local infection/cellulitis but no scarring typically	
Deep partial thickness (Second degree)	Extends into deep (reticular) dermis	Yellow or white. Less blanching. May be blistering.	Fairly dry	Pressure and discomfort	3–8 weeks	Scarring, contractures (may require excision and skin grafting)	
Full thickness (Third degree)	Extends through entire dermis	Stiff and white/brown No blanching	Leathery	Painless	Prolonged (months) and incomplete	Scarring, contractures, amputation (early excision recommended)	
Fourth degree	Extends through entire skin, and into underlying fat, muscle and bone	Black; charred with eschar	Dry	Painless	Requires excision	Amputation, significant functional impairment and, in some cases, death.	

To distinguish a minor burn from a serious burn, the first step is to determine the extent of damage to body tissues. In order to determine the need for referral to a specialized burn unit, the American Burn Association devised a classification system. Under this system, burns can be classified as major, moderate and minor. This is assessed based on a number of factors, including total body surface area affected, the involvement of specific anatomical zones, the age of the person, and associated injuries. Minor burns can typically be managed at home, moderate burns are often managed in hospital, and major burns are managed by a burn center!

American Burn Association severity classification

ıAmerican Burn Association severity classification		
Minor	Moderate	Major
Adult <10% TBSA	Adult 10-20% TBSA	Adult >20% TBSA
Young or old < 5% TBSA	Young or old 510% TBSA	Young or old >10% TBSA
<2% full thickness burn	2-5% full thickness burn	>5% full thickness burn
	High voltage injury	High voltage burn
	Possible inhalation injury	Known inhalation injury
	Circumferential burn	Significant burn to face, joints, hands or feet
	Other health problems	Associated injuries

For minor burns, including first-degree burns and second-degree burns limited to an area no larger than 8 centimetresin diameter, take the following action:

1. Cool the burn.

- ✓ Hold the burned area under cool (not cold) running water for 10 or 15 minutes or until the pain subsides.
- ✓ If this is impractical, immerse the burn in cool water or cool it with cold compresses.
- ✓ Don't put ice on the burn

2. Cover the burn with a sterile gauze bandage

- ✓ Wrap the gauze loosely to avoid putting pressure on burned skin.
- ✓ Bandaging keeps air off the burn, reduces pain and protects blistered skin.

3. Take an over-the-counter pain reliever

✓ These include aspirin, ibuprofen , naproxen or acetaminophen ➢ Use caution when giving aspirin to children or teenagers. ➢ Talk to your doctor if you have concerns.

For major burns, call 112 or emergency medical help. Until an emergency unit arrives, follow these steps:

4. Don't remove burned clothing.

✓ However, do make sure the victim is no longer in contact with smoldering materials or exposed to smoke or heat.

5. Don't immerse large severe burns in cold water

✓ Doing so could cause a drop in body temperature (hypothermia) and deterioration of blood pressure and circulation (shock).

6. Check for signs of circulation (breathing, coughing or movement).

✓ If there is no breathing or other sign of circulation, begin CPR.

7. Elevate the burned body part or parts.

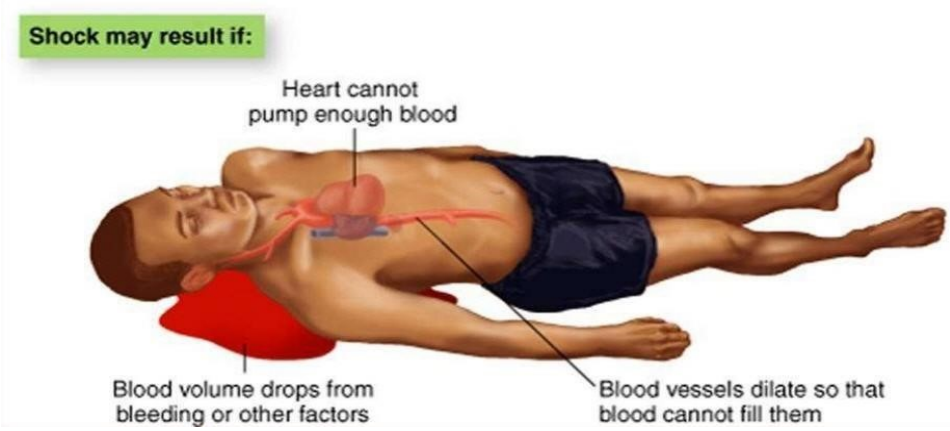
✓ Raise above heart level, when possible.

8. Cover the area of the burn

✓ Use a cool, moist, sterile bandage, clean, moist cloth or moist cloth towels

First aid for shocked

Shock may result from trauma, blood loss, an allergic reaction, severe infection, poisoning, severe burns or other causes.



When a person is in shock, his or her organs aren't getting enough blood or oxygen. If untreated, this can lead to permanent organ damage or death. Shock can be a life-

threatening problem. The best way to protect people from the serious damages that shock can have on the system is to recognize the symptoms before the person gets into serious trouble.
In most cases, only a few of the symptoms will be present, and many do not appear for some time. Common symptoms are:

- ✓ Pale, cold, clammy and moist skin
- ✓ Vacant or dull eyes, dilated pupils
- ✓ Anxiety, restlessness, and fainting
- ✓ Weak, rapid, or absent pulse
- ✓ Nausea and vomiting
- ✓ Shallow, rapid, and irregular breathing
- ✓ Excessive thirst
- ✓ Person may seem confused
- ✓ Look tired and fatigue

If you suspect shock, even if the person seems normal after an injury:

1. Call 112 or your local emergency number.
2. Have the person lie down on his or her back with feet higher than the head. If raising the legs will cause pain or further injury, keep him or her flat.
3. Check for signs of circulation (breathing, coughing or movement) and if absent, begin CPR.
4. Keep the person warm and comfortable by loosening any belts or tight clothing and covering the person with a blanket. Even if the person complains of thirst, give nothing by mouth.
5. Turn the person on his or her side to prevent choking if the person vomits or bleeds from the mouth.
6. Seek treatment for injuries, such as bleeding or broken bones.

MONITOR THE SITUATION

Call 911 instead of trying to take an injured or ill person to the hospital yourself. It seems like waiting for an ambulance will make it take longer to get help, but ambulance crews can start providing care as soon as they arrive. They can get the patient to hospital quickly, legally, and more safely.

1. Stay on the line with 911 and follow emergency instructions.
2. Stay calm and try to keep the patient calm.
3. Don't move a patient who was injured in an automobile accident or fall, or who was found unconscious.
4. If the patient is cold, cover them with a blanket.
5. Don't give an injured person anything to eat or drink (unless instructed by the 911 dispatcher).

6. Have someone watch for the ambulance and show the crew how to get to the patient. (This is especially important in an apartment or office building, or if your address is hard to see from the street).

PREPARE REQUIRED DOCUMENTATION

These efforts need to be kept parallel with documentation or in other words with systematic incident reports related to the various incidents occurring while the worker is on duty. Such reports will help the team or the organization with the following:

1. Incidents Reports will maintain alertness among all the stakeholders
   Most incident report forms identify the barriers that prevent adverse situations from developing into a major accident or disaster. Recording of the small to medium events will ensure major stakeholders of the organization is kept alert and hence reduce number of accidents or injuries to guests as well as to the staff of the organization.
2. Lessons learned within the organisation and benchmarks between industries
3. The gathered data can be used for comparisons both within and between organisations and industries. Even though the incident categories and types differ between industries, verticals and even functions, the habit of being aware in the field and documenting the observations is the same.
4. Reporting is cheaper than the costs of a major incident
5. The average cost of occupational accident ranges from thousands to tens of thousands of euros between industries and countries. Thus, even in a global organisation that has tens of thousands of employees and service-providers, the cost of maintaining the incident reporting program and/or software is many times cheaper than the cost of accidents or major incident.
6. Incident reporting is a key habit that creates culture
   Each organisational culture is a set of habits, values, thoughts and beliefs. In organization level development areas such as health, safety, quality and environment, the habits are the keystones that affect the culture the most. If you want to create safety culture, start collecting safety observations. If you want to create culture of quality improvement, start collecting quality observations. If you want to raise environmental awareness, start collecting environmental observations.

UNIT 07

RESPOND TO FIRE

This unit covers the competency required to carry out initial response to suppress a fire. It also includes the ability to identify the nature and classification of the fire, report the fire and carry out evacuation procedures.

PREPARE FOR FIRE

What is a fire?

Essentially, fire is very rapid oxidation. Rusting iron and rotting wood are common examples of slow oxidation. Fire, or combustion, is rapid oxidation as the burning substance combines with oxygen at a very high rate. Energy is given off in the form of heat and light. Because this energy production is so rapid, we can feel the heat and see the light as flames.

How fire happens

All matter exists in one of three states: solid, liquid or gas (vapour). The atoms or molecules of a solid are packed closely together, and those of a liquid are packed loosely. The molecules of a vapour are not really packed together at all and are free to move about.

In order for a substance to oxidise, its molecules must be well surrounded by oxygen molecules. The molecules of solids and liquids are packed too tightly for this to happen, and therefore only vapours can burn.

When a solid or liquid is heated, its molecules move about rapidly. If enough heat is applied, some molecules break away from the surface to form a vapour just above the surface. This vapour can now mix with oxygen. If there is enough heat to raise the vapour to its ignition temperature, and if there is enough oxygen present, the vapour will oxidise rapidly and it will start to burn.

What we call burning is the rapid oxidation of millions of vapour molecules. The molecules oxidise by breaking apart into individual atoms and recombining with oxygen into new molecules. It is during the breaking recombining process that energy is released as heat and light. The heat that is released is radiant heat, which is pure energy. It is the same sort of energy that the sun radiates and that we feel as heat. It radiates (travels) in all directions. Therefore, part of it moves back to the seat of the fi re, to the 'burning' solid or liquid (the fuel). The heat that radiates back to the fuel is called radiation feedback

Part of this heat releases more vapour, and part of it raises the vapour to the ignition temperature. At the same time, air is drawn into the area where the flames and vapour meet. The result is that there is an increase in flames as the newly formed vapour begins to burn.

Common Causes of Workplace Fires

Following are common causes of fire.

1. **Faulty Electrics** are a very common cause of workplace fires and include loose wires and antiquated or faulty equipment. Every employer needs to ensure that fixed electrical equipment is maintained on a regular basis.
2. **Flammable or combustible materials** represent a danger to your staff and your business. Every company should prioritize fire safety when undertaking risk assessments, and this is crucial in premises that hold any flammable or combustible materials or substances that must be stored appropriately stored and disposed of correctly. All staff should attend a fire safety training course to ensure correct procedure.
3. **Human Error** represents a common cause of fires in the workplace, be it the incorrect use of electrical equipment, burning food or leaving cooking unattended in the staff kitchen as well as lack of proper care or knowledge of procedures around flammable or combustible liquids and materials. Fire safety training is invaluable to avoid this.
4. **Negligence** may not seem a great deal different from human error but tends to be the result of sloppy or careless behaviour, or not following rules, regulation or correct procedures, from staff who should probably know better. Examples include the blocking or covering of machinery and equipment which requires venting thus causing overheating, not correctly disposing of cigarette ends, incorrectly storing flammable items – even paper – and overloading plug sockets. Again, robust fire training is imperative.
5. **Arson** is a common cause of fire around business premises, which can be particularly prone to vandalism. Such fires can rapidly spread if there are no proper fire control systems. If suitable, work places should install fire shutters and sprinkler systems to protect their property as far as possible; and deterrents such as CCTV and gating can deter potential vandals.

The fire triangle

The three things that are needed for combustion to take place are:

- ✓ fuel (to vaporize and burn)
- ✓ oxygen (to combine with fuel vapour)
- ✓ heat (to raise the temperature of the fuel vapour to its ignition temperature).

The fire triangle shows us that fire cannot exist without all three together:

- ✓ if any side of the fi re triangle is missing, a fire cannot start
- ✓ if any side of the fire triangle is removed, the fire will go out

The fire triangle (which is also known as the combustion triangle) is a simple model for understanding the chemical reaction which must occur to create a fire. It is composed of three elements – fuel, heat and oxygen – which must all be present for a fire to ignite. It also demonstrates the interdependence of these ingredients in creating and sustaining a fire and teaches us that removing any one of these elements would prevent or extinguish the fire.

Classes of fire

Classes of fire Combustible and flammable fuels have been broken down into five categories:

1. **Class A** fires are those involving organic solids such as paper or wood
2. **Class B** fires are those involving flammable liquids
3. **Class C** fires are those involving flammable gases
4. **Class D** fires are those involving metals
5. **Class F** fires are those involving cooking oils

Prevention of Fire

Fires can spread rapidly and once established, even a small fire can generate sufficient heat energy to spread and accelerate the fire to surrounding combustible materials. Fire prevention is largely a matter of common-sense and good housekeeping. For example, keep the workplace clean and tidy and remain conscious of possible fire happening at any time. Following activities need to be continuously performed in preventing fires from occurring in addition to having properly working fire safety systems to deal with a fire incident.

1. Risk Assessment

The first step in fire prevention is to assess the risks and record them in a risk register.7 This requires reviewing and assessing the means by which a fire might start and spread, the potential consequences and the available approaches to mitigate the risk. This includes assessing day-to-day operations, risks associated with periodic building and maintenance work and those arising from installing new equipment, or adopting new or changing technologies.

2. Fire prevention

Set out below are the principal actions that need to be taken to monitor the behaviour of workers and prevent fires from occurring:
Smoking is one of the greatest fire risks and it should be prohibited in all buildings and workplaces. Where there is no legal prohibition, smoking should only be allowed in designated smoking areas and fire-safe ashtrays and bins should be provided.

- ✓ Enforce good housekeeping practices; this includes implementing routines for the regular removal and disposal of waste.

- ✓ Establish and maintain out-of-hours inspection and security procedures, including means of preventing arson.
- ✓ Carry out routine checks, inspections, and tests, including monitoring the maintenance of heat generating equipment that could cause fires, chafing of cables, self-heating of cables due to electrical resistance and checks on fuel supplies and storage
- ✓ Issue and control work permit and associated procedures.
- ✓ Instruct and supervise contractors and subcontractors carrying out construction and maintenance operations within the building.
- ✓ Avoid conditions leading to gas and dust explosion hazards.
- ✓ Maintain integration with other systems (e.g. ventilation, communications).

3. Undertake regular fire risk assessment

The responsible person must ensure that a suitable and sufficient fire risk assessment of the premises is completed and reviewed on a regular basis.
A fire risk assessment is an organised and methodical look at the premises, the activities carried on there and the likelihood that a fire could start and cause harm to those in and around the premises. There is no set format or approach but a template is provided that may assist establishments in completing a fire risk assessment.
Where establishments feel that they do not have the necessary competency to complete a fire risk assessment they should seek the assistance of a competent person.

4. Follow fire precautions at all times

In the event of a fire occurring, there should be suitable measures in place to detect a fire, give warning of fire and that mitigate the spread of smoke and fire.

- ✓ Fire detection and warning systems should be installed
- ✓ Emergency lighting should be installed
- ✓ Firefighting equipment (fire extinguishers) should be installed
- ✓ Fire signs, notices and plans should be fitted
- ✓ Fire doors should be fitted in accordance with good practice and well maintained

5. Evaluate and ensure means of escape

The ability of the occupants of a building to evacuate in the case of fire is a fundamental aspect of fire safety. In the case of a fire, or indeed any other emergency, people should be able to turn away from the hazard and escape to the open air or other place of safety. Escape routes should be inspected regularly to check they are not obstructed and that fire exit doors are unlocked.

6. Undertake regular fire emergency planning

When a fire situation is detected, it is vital that establishments have in place appropriate procedures. All establishments need to prepare a fire emergency plan under the guidance of experts.

It is vital that the emergency plan is tested so as to ensure that all staff are aware of the procedures to be followed in the event of a fire. This can be achieved by undertaking a desktop exercise and also by completing regular fire drills (at least once every half-term).

7. Undertake regular training and sharing of information

To keep the staff up-to-date with prevention of fire, it is important that regular training and sharing of information is r continued within every workplace. All members of staff should receive instruction and training appropriate to their responsibilities. This training should:

- ✓ take account of the findings of the fire risk assessment
- ✓ explain the emergency procedures
- ✓ take account of the work activities and explain the duties and responsibilities of staff
- ✓ take place during normal working hours and be repeated periodically where appropriate
- ✓ be easily understood by staff and other people who may be present ✓ be tested by fire drills

8. Maintain record Keeping or Log Books

To prepare well, it is important that appropriate records are kept in a specified log book or file and the records need to be checked for accuracy. In particular, the log book need to include the following.

- ✓ Details of any significant findings from the fire risk assessment and any action taken
- ✓ Testing and checking of escape routes, including final exit locking mechanisms, such as panic devices, emergency exit devices and any electromagnetic devices;
- ✓ Testing of fire-warning systems, including weekly alarm tests and periodic maintenance by a competent person; recording of false alarms;
- ✓ Testing and maintenance of emergency lighting systems;
- ✓ Testing and maintenance of fire extinguishers, hose reels and fire blankets
- ✓ Recording and training of relevant people and fire evacuation drills;
- ✓ Maintenance and audit of any systems that are provided to help the fire and rescue service
- ✓ The fire emergency plan

CARRY OUT NOTIFICATION AND ASSESSMENT

Whether big or small, staff within every workplace to be competent to undertake assessment related to possible fires and handle notification of any such possibilities to his/her superiors on a timely manner to avoid fire related incidents across workplaces.

Continuous Assessment and Maintenance

All fire related equipment and the workplace sites which may pose as fire hazards must

be continuously assessed and repaired or maintained in accordance with regulatory requirements and good practice.

1. **Portable Fire Fighting Equipment**: All portable firefighting equipment has to be checked by a competent person on an annual basis (e.g. extinguishers, fire blankets and hoses).
2. **Fire Detection and Warning Systems (alarms):** Fire alarm tests need to be carried out in accordance with requirements. This requires weekly tests of the audible fire alarm system, quarterly and annual tests of all devices such as heat and smoke detectors, call points and sounders should also be carried out by a competent contractor.
3. **Emergency Lighting**: Emergency lighting should be tested by facility maintenance team on a regular basis to ensure the workplace is lit during emergency situations such as fire.
4. **Evacuation Paths**: Every workplace needs to have proper pathways worked out and displayed to the staff in the event of fire. Referred pathways and doors and need to be checked on regular basis to prevent fatalities and reduce damage to the staff in case of fire.

Following sections details the above parameters to ensure all staff is equipped with adequate knowledge and skills to undertake assessment and maintenance to carrying out initial notification of fire besides continuous assessment and maintenance of fire equipment,

Portable Fire-fighting equipment

Normally available fire-fighting equipment includes portable appliances such as extinguishers, buckets of sand or water and fire-resistant blankets. In larger premises you will find automatic sprinklers, hose reels and hydrant systems.

Portable Firefighting Equipment

Fire extinguishers

There are many types of fire extinguisher, each with a specific set of situations in which they may or may not be used. In particular, different fire extinguishers are used to manage different classes of fire and the various fire classes are detailed below.

Different classes of fire

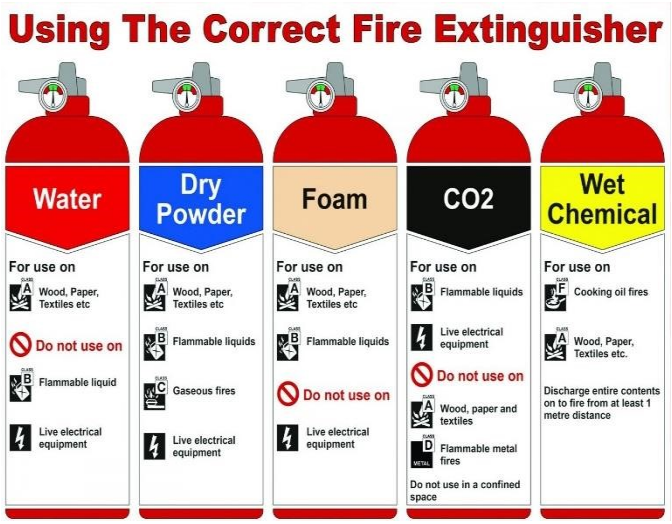
Selection of fire extinguisher

Selection of the fire extinguisher need to be carefully done based on the class of fire identified at various points of risk within the workplaces.

There are five main fire extinguisher types and include Water, Foam, Dry Powder, CO_2 and Wet Chemical. To ensure adequate protection and to meet current fire safety regulations, we need to have the right types of fire extinguisher at the premises.

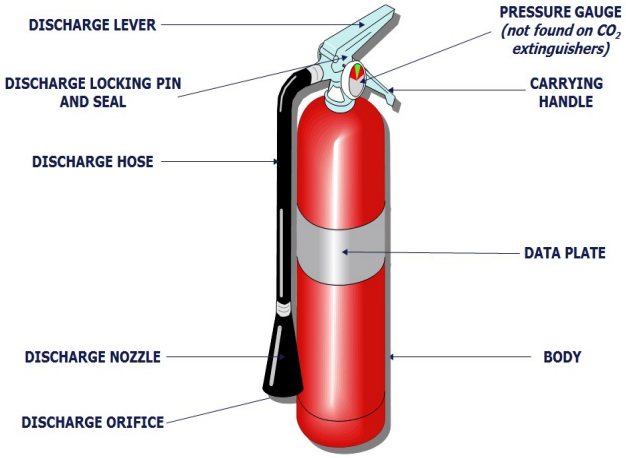
There are different 'classes' of fire, for which each extinguisher is designed to tackle. These classes are based on which fuels a fire starts with. It is the presence of these fuels within your business premises that will help determine which types of fire extinguisher you need and in which locations.

We also need the right type of fire extinguisher; you'll also need the right size and weight of each extinguisher.



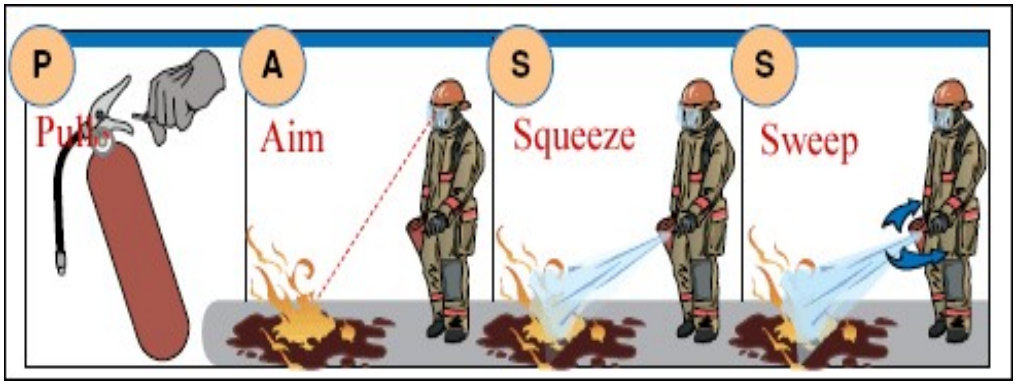
Components of fire extinguishers

Following are the components of the fire extinguishers.



Fire extinguisher operation-PASS

Whenever possible, use the buddy system when using a fire extinguisher. If you have doubt about your personal safety or if you cannot extinguish a fire, leave immediately and close the doors (do not lock them). Leave the area, but contact 911 to relay whatever information you have about the fire. Apply the following if you are using the fire extinguisher.



In short, follow the procedures leading to extinguishing fire.

- ✓ Pull the safety pin, this will allow you to discharge the extinguisher.
- ✓ Aim the extinguisher the base of the fire, this will allow you to hit the fuel.
- ✓ S- Squeeze the top handle or lever, this will release the pressurized extinguishing agent.
- ✓ S- Sweep the extinguisher hose from side to side until the fire is completely out.

Wait and carefully check that the fire is out and has not reignited. If it has reignited, spray again – but remember that a typical fire extinguisher usually provides only 60 seconds of extinguishing power.

Fire extinguisher maintenance

Regular inspection and if required, fire extinguishers to be properly maintained at all times.

- ✓ Fire extinguishers should be mounted on the wall to prevent being damaged.
- ✓ The area in front of the extinguisher shall be kept clear at all times.
- ✓ The pressure gauge should be in the green zone at all times.
- ✓ Fire extinguishers should be inspected on a monthly basis.
- ✓ Know the location of all fire extinguishers in your facility.

Protective equipment used

1. Bunker Gear

The common term 'bunker gear' refers to the coat, trousers and coverall elements of the protective ensemble. Other parts of the ensemble include the helmet, hood, boots and gloves.

Bunker gear may not be appropriate PPE for all incidents, considering the potential for heat stress, reduced mobility and added weight.

2. Fire Helmets

Firefighters exposed to the hazards of head injury must wear appropriate PPE, which may include helmets and protective hoods. A fire helmet is not designed to protect personnel from all conditions or hazards. It provides limited protection to the head when worn during structural firefighting activities.

3. Protective Hoods

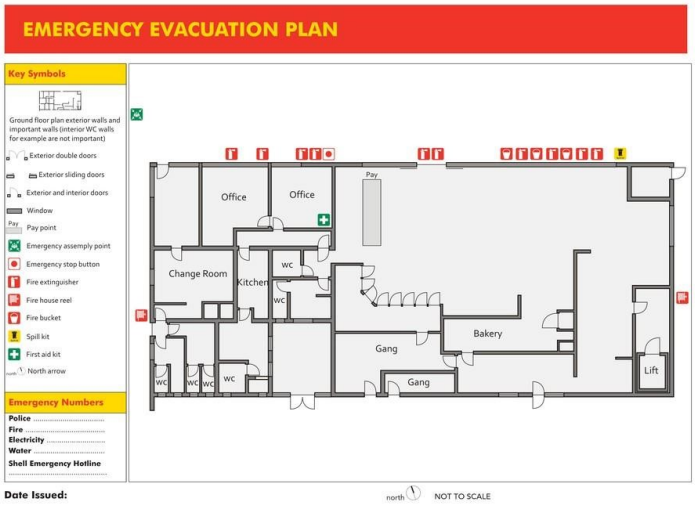
Protective hoods should be worn whenever there is a risk of injury from heat and/or flame to exposed skin. Helmet liners should be used in addition to protective hoods.

4. Boots and gloves

Fire fighters exposed to the hazard of foot or hand injury must wear protective boots or gloves appropriate the circumstances

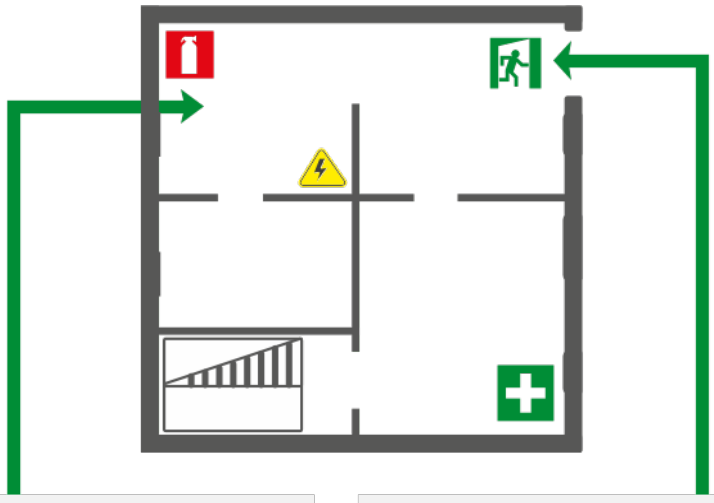
Apply emergency evacuation procedures

Fire represents one of the biggest **workplace safety threats** and can result in **serious injuries** or even **fatalities**. Workplace fires can also cause extensive **property damage**, and can render the worksite either destroyed or out of service indefinitely.



For these reasons, an effective **workplace fire evacuation plan** is important. In this article, we'll cover the workplace safety essentials to plan & create, update and implement thorough and effective workplace fire evacuation plans.

What to Do in Case of Fire in Your Workplace



Basic fire safety you must know for every worksite:

- Know the location of the fire extinguishers in the workplace.You should be aware where the nearest extinguisher is at all times.
- Know where your nearest emergency exits are.
- Know the difference between alarm signals to quicklyrecognize the situation.

If you discover a fire:

- Alert all other individuals within the workplace by activating the nearest fire alarm, shouting clearly or by using other procedures set in place by your company.
- Use the nearest exit to evacuate the workplace.
- Use a fire extinguisher to put the fire out. Be careful while doing this and do not attempt if yours or others safety is at risk or on large fires.

During evacuation of a worksite:

- Stay calm and evacuate the building immediately when you hear the fire alarm. For more check out our blog on evacuation checklists and procedures.
- Along the escape route, close (don't lock) all the doors and windows you pass by so that you can cut the fire and the smoke off from spreading to the other rooms.
- Go to the assembly point and alert your relevant supervisors that you are safe and outside the building.
- Adhere to any protocols put in place by your company

Fire Drills

Once a fire evacuation plan is created/updated, it's time to put that plan *into practice*. Literally practice, in this case, as your team must practice **fire drills** on a regular basis.

Effective fire drills are an *integral part* of your workplace safety plan.

Fire drills help **save lives** and **protect infrastructure** by getting the whole team on board with fire safety in the workplace.

Be sure to familiarize yourself and your coworkers with your company's fire procedure. Make sure this information is well known, posted, in manuals and quizzed/tested more than once.

Next, we'll explore some key universal safety procedures and tips for fire safety at your workplace.

Essential Fire Evacuation Safety for Every Worksite

No matter the size, shape or scope of your workplace or job site, there are essential fire evacuation steps to be taken by every team, organization or company.

Know the location of the **fire extinguishers** in the workplace.

Every worker must be aware where the **nearest extinguisher** is *at all times*. Know where your **nearest emergency exits** are. Know the *difference* between **alarm signals** to quickly recognize the situation. Knowing all of these can make all the difference in saving lives and preventing unnecessary damage.

EXTINGUISH FIRE

When fire breaks out, ensure, you undertake the following.

What You & Your Team Must Do When Fire Breaks Out

Catching fire in its earliest stage is *highly important* in both capping the **extent** of the fire and in **preventing injuries & fatalities** as a result of the fire.

Alert all other individuals within the workplace by activating the nearest fire alarm, shouting clearly or by using other procedures set in place by your company.

Use the nearest exit to evacuate the workplace.

Use a fire extinguisher to put the fire out. Be careful while doing this and do not attempt if your safety and/or the safety of others is at risk or on large fires.

Tips for Better Fire Evacuation of a Worksite

Stay calm and evacuate the building immediately when you hear the fire alarm. Along the escape route, close (*don't lock*) all the doors and windows you pass by so that you can cut the fire and the smoke off and prevent spreading to other areas of your workplace, and/or to neighboring facilities, residences, etc. Have the team go to their designated assembly point, then alert relevant supervisors that team members are safe and have successfully evacuated outside the building or work site.

	Fire extinguisher types	
Standard/Multi-purpose dry powder		
 Dry powder fire extinguisher	Colour	Blue
	Application	The powder 'knocks down' the flames. Safe to use on most kinds of fi re. Multi-purpose powders are more effective, especially on burning solids; standard powders work well only on burning liquids.
	Dangers	The powder does not cool the fi re well. Fires that seem to be out can re-ignite. Doesn't penetrate small spaces, like those inside burning equipment. The jet could spread burning fat or oil around.
	How to use	Aim the jet at the base of the flames and briskly sweep it from side to side.
Water		
 Water fire extinguisher	Colour	Red
	Application	The water cools the burning material. You can only use water on solids, like wood or paper. Never use water on electrical fi res or burning fat or oil.
	Dangers	The water can conduct electricity back to you. Water actually makes fat or oil fires worse – they can explode as the water hits them.
	How to use	Aim the jet at the base of the flames and move it over the area of the fire.
CO2		
 Carbon dioxide fire extinguisher	Colour	Black
	Application	Displace oxygen with CO_2 (a nonflammable gas). Good for electrical fires as they don't leave a residue.
	Dangers	Pressurized CO_2 is extremely cold. DO NOT TOUCH. Do not use in confined spaces.
	How to use	Aim the jet at the base of the flames and sweep it from side to side.

Foam/AFFF (Aqueous Film Forming Foam)		
	Colour	White or Cream
	Application	The foam forms a blanket or film on the surface of a burning liquid. Conventional foam works well only on some liquids, so it's not good for use at home, but AFFF is very
 Foam fire extinguisher		effective on most fi res except electrical and chip-pan fires.
	Dangers	'Jet' foam can conduct electricity back to you, though 'spray' foam is much less likely to do so. The foam could spread burning fat or oil around.
	How to use	For solids, aim the jet at the base of the flames and move it over the area of the fire. For liquids, don't aim the foam straight at the fire – aim it at a vertical surface or, if the fire is in a container, at the inside edge of the container.

When considering using a fire extinguisher remember the following points:

- ✓ never use a fi re extinguisher unless you have been trained to do so
- ✓ do not use water extinguishers on electrical fi res due to the risk of electric shock and explosion
- ✓ do not use water extinguishers on oils and fats as this too can cause an explosion
- ✓ do not touch the horn on CO2 extinguishers as this can freeze burn the hands
- ✓ do not use the CO2 extinguisher in a small room as this could cause suffocation
- ✓ read the operating instructions on the extinguisher.

UNIT 08

APPLY SCIENCE AND ENGINEERING MEASUREMENTS

This unit of competency covers the ability to manage the day-to-day running of science teaching laboratories and the preparation of practical experiments, demonstrations also determining simple drawings

APPLY BASIC MATHEMATICS

Perform Simple Workshop Calculations

Perform simple calculations on: fractions and decimals, calculations to a number of significant figures, decimal places

Definition of Fractions

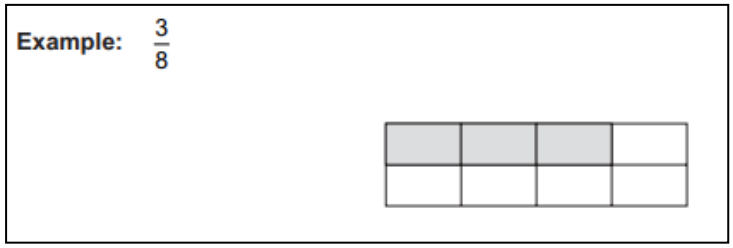
There are two types of fractions, both of which describe less than a whole object. The object can be an inch, a foot, a mile, a ton, a bundle of weld rods, other measurements, etc. The two types of fractions are:

1. Common fractions (fractions)
2. Decimal fractions (decimals)

Common fraction examples are: $\frac{1}{2}, \frac{3}{4}, \frac{5}{8}$
Decimal fraction examples are: .50, .75, .625

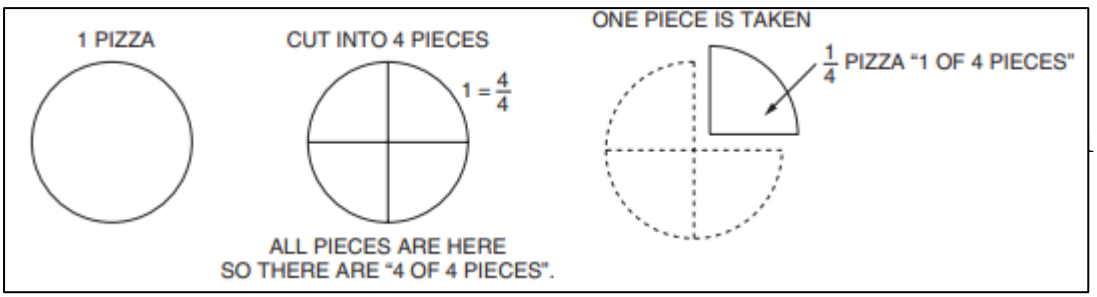
Basic principles

The bottom number (the denominator) of every fraction shows the number of pieces any one whole object is divided into; all pieces are of equal size. The top number (the numerator) shows information about that divided object.

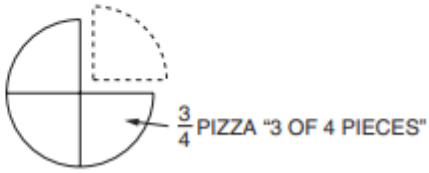


3 is the numerator, and 8 is the denominator. This fraction shows that an object has been divided into 8 equal pieces, and that 3 of those 8 pieces are shaded.

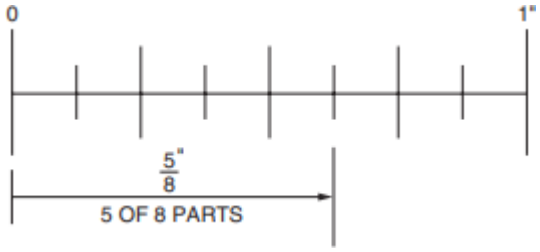
Let's work with other simple examples. If we have one whole unsliced pizza, we can divide it into pieces, and then make fractions about the pizza. This example is cut into 4 pieces (quarters). Fractions concerning this pizza will have the bottom number 4. To describe 1 of those pieces, the fraction is written 1 /4, ("1 of 4 pieces").



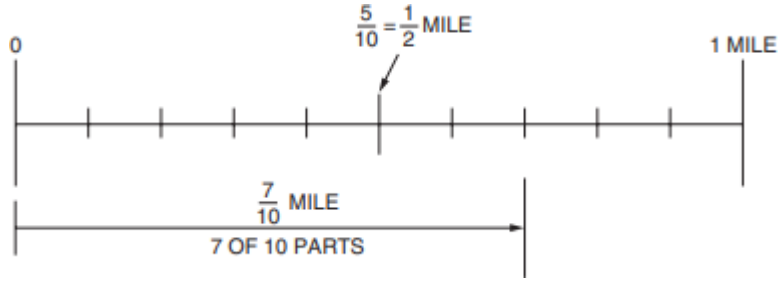
¾ indicates that "3 of 4 pieces" are still available.



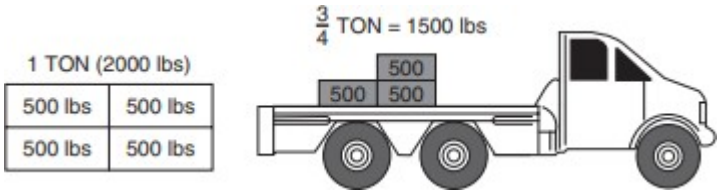
1. 5/8″ (five-eights inch) shows that an inch is divided into 8 parts and that 5 of those 8 parts have been measured.



2. 7/10 of a mile (seven-tenths mile) shows that a mile is divided into 10 parts, and we've measured 7 of those 10 parts.



3. 3/4 ton (three-fourths, or three-quarters of a ton) shows that a ton of hay (2,000 pounds) has been divided into 4 parts, and 3 of those 4 parts can be hauled on a flat-bed truck.



The fractions 5/8, 7/10, and 3/4 and their verbal descriptions "5 of 8 pieces," "7 of 10 parts," and "3 of 4 parts," give your mind a clear picture of each object, how many pieces it was cut up into, and how many of those pieces are being described. With this, you can give accurate information to anyone: a customer, a fellow worker, your foreman, or on a test you may be taking to get into an apprenticeship.

Decimal fractions are similar to common fractions in that they describe part of a whole object.
In decimals, an object is divided into tenths, hundredths, thousandths, etc. Welders, however, primarily work with tenths and hundredths.
Note: For all decimal problems in this workbook, round to hundredths (two "places" unless otherwise noted. You may round to three, or four, places if that place number is a 5 (i.e., .125 or .0625). Greater accuracy is achieved if only the final answer is rounded off, not the numbers used to arrive at the answer.
A decimal point separates the whole numbers from the parts, and the whole numbers are always to the left of the decimal point.
The first place after the decimal point is called tenths. The second place is called hundredths; and the third place is called thousandths.

Example:

Tenths	Hundredths		Thousandths
.758	.7	5	8

Tenths describes 1 whole object divided into 10 parts. Hundredths describes 1 whole object divided into 100 parts.

Rounding Off Decimals

"Rounding off" helps express measurements according to the needs of our trade. Welders generally round off to the nearest tenths or hundredths.

Rounding to tenths:

If the number directly to the right is 5 or more, increase the tenth-place number by 1. If the number directly to the right is 4 or less, the tenth-place number stays the same.

Examples:

.68 rounded to tenths is .7.
.64 rounded to tenths is .6.

Rounding to hundredths:

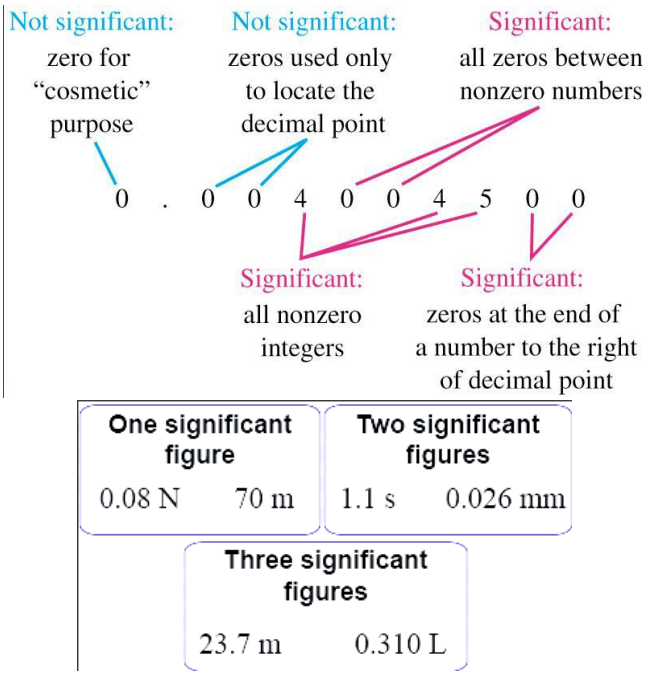
If the number directly to the right is 5 or more, increase the hundredth-place number by 1. If the number directly to the right is 4 or less, the hundredth-place number stays the same.

Examples:
.357 rounded to hundredths is .36.
.351 rounded to hundredths is .35

0s placed at the end of a decimal have no effect on the value. Examples:
.5 = .50
.50 = .500
0s placed in front of the decimal point have no effect on the value, as long as there are no whole numbers.
Example: .25 = 0.25

Significant figures

The significant figures of a number are digits that carry meaning contributing to its measurement resolution.



Estimation

To **estimate** means to find something close to the correct answer. In other words, you are approximate

9411 → 9000
3849 → 4000
9000 + 4000 = 13,000

Identify and use the multiples and sub-multiples of units

Formally agreed by the 11th General Conference on Weights and Measures (CGPM) in 1960, the SI is at the centre of all modern science and technology. The definition and realisation of the base and derived units is an active research topic for metrologists with more precise methods being introduced as they become available.

Base units

Physical Quantity	Name of Unit	Abbreviation
Mass	Kilogram	kg
Length	Meter	m
Time	Second	s[a]
Temperature	Kelvin	K
Amount of substance	Mole	mol
Electric current	Ampere	A
Luminous intensity	Candela	cd

Some prefixes

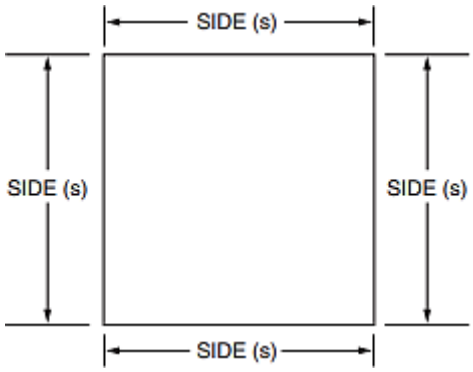
Prefix	Abbreviation	Meaning	Example
Giga	G	10^9	1 gigameter (Gm) $= 1 \times 10^9$ m
Mega	M	10^6	1 megameter (Mm) $= 1 \times 10^6$ m
Kilo	k	10^3	1 kilometer (km) $= 1 \times 10^3$ m
Deci	d	10^{-1}	1 decimeter (dm) $= 0.1$ m
Centi	c	10^{-2}	1 centimeter (cm) $= 0.01$ m
Milli	m	10^{-3}	1 millimeter (mm) $= 0.001$ m
Micro	μ[a]	10^{-6}	1 micrometer (μm) $= 1 \times 10^{-6}$ m
Nano	n	10^{-9}	1 nanometer (nm) $= 1 \times 10^{-9}$ m
Pico	p	10^{-12}	1 picometer (pm) $= 1 \times 10^{-12}$ m
Femto	f	10^{-15}	1 femtometer (fm) $= 1 \times 10^{-15}$ m

Table 1.2 Derived quantities and their units

Physic Quantity	Expression	Unit
Area	length × breadth	m^2
Volume	area × height	m^3
Velocity	displacement/ time	$m\ s^{-1}$
Acceleration	velocity / time	$m\ s^{-2}$
Density	mass / volume	$kg\ m^{-3}$
Pressure	force / area	$N\ m^{-2}$ or Pa

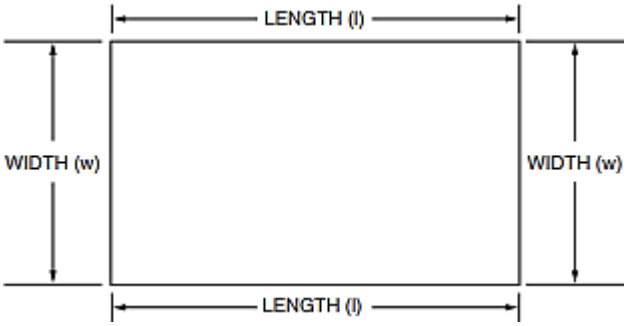
Perform calculations on: Perimeter and Area

The distance around a figure is called the "perimeter." Square
A four-sided figure, as shown below. All four sides are of equal length, and all four angles are 90°.



Rectangle

A four-sided figure, as shown below. The lengths are equal only to each other and the widths are equal only to each other. All four angles are 90°.

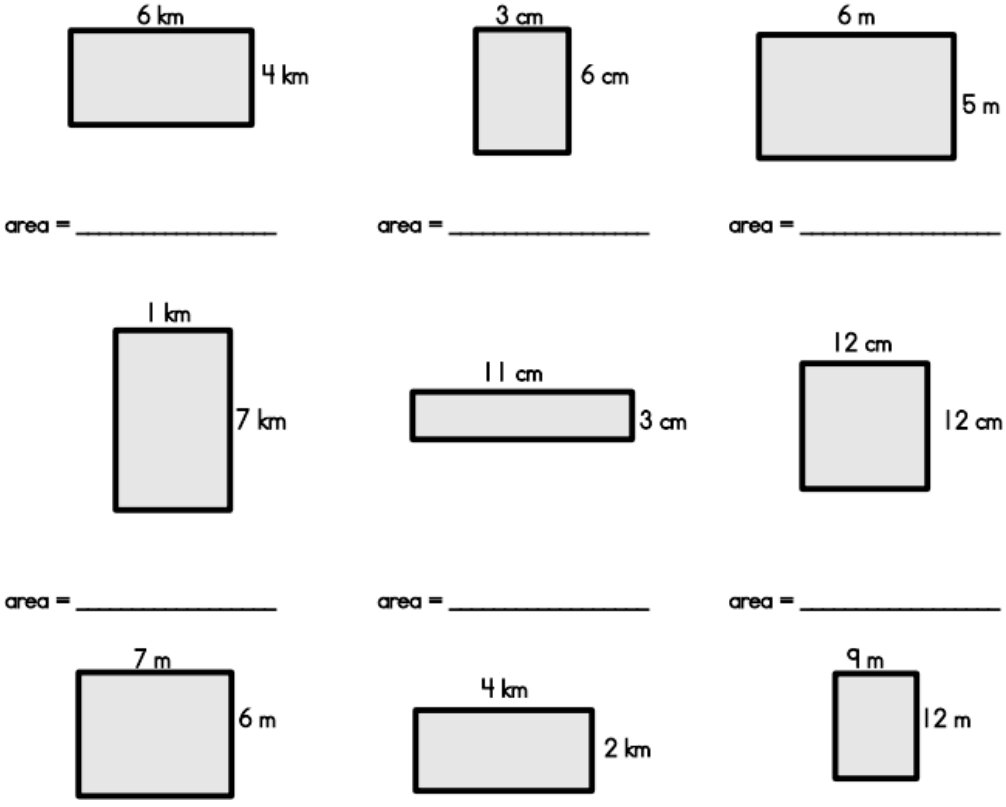


Area of Square

Formula: A= Side x Side

Area of Rectangle Formula: A= L x H

Find the area of each rectangle by multiplying.

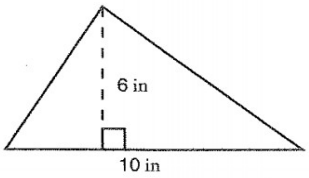


Area of triangle

Formula $A = \frac{1}{2}bh$

Examples: Find the area.

(a)

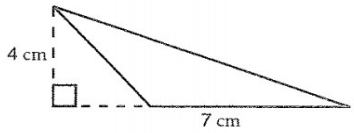


$A = \frac{1}{2}bh$

$A = \frac{1}{2}(10)(6)$

$A = 30 \text{ in}^2$

(b)



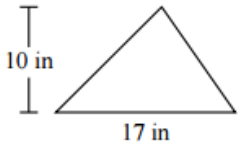
$A = \frac{1}{2}bh$

$A = \frac{1}{2}(7)(4)$

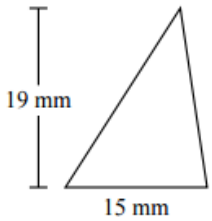
$A = 14 \text{ cm}^2$

Find the area of each triangle. Units are not to scale.

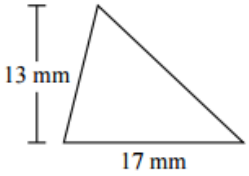
1)



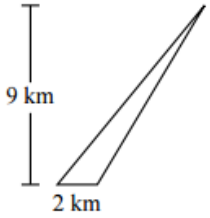
2)



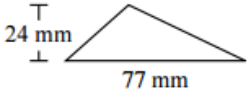
3)



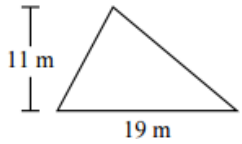
4)



5)

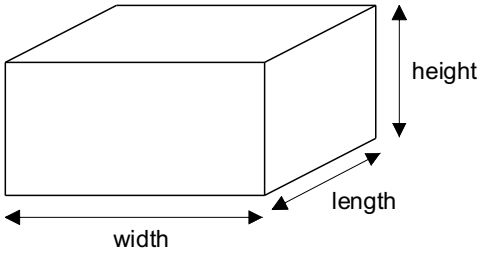


6)

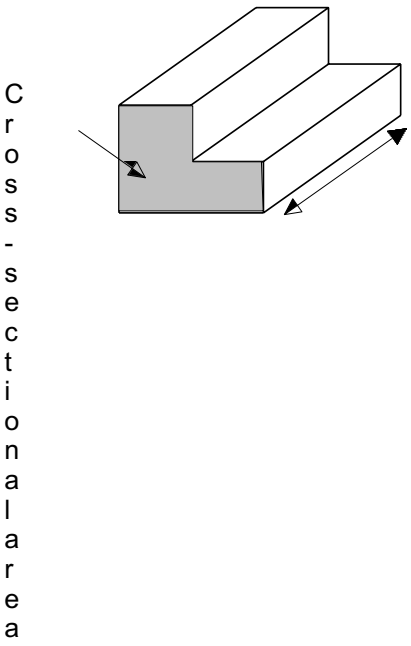


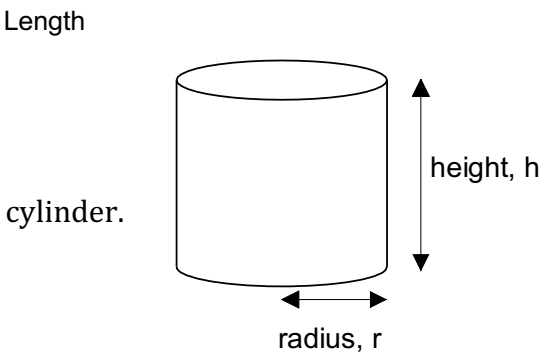
Volume and Surface Area

- ✓ Volume of **cuboid** = length × width × height



- ✓ Volume of **prism** = cross-sectional area × length





- ✓ Volume of cylinder = $\pi r^2 h$,

Where *r* is the radius and *h* is the height of the cylinder.

Example: 1

A cuboid measures 15 cm by 12 cm by 8 cm. Find the capacity of the cuboid. Give your answers in liters.
Solution:
Volume = 15 × 12 × 8 = 1440 cm^3.
As 1 litre = 1000 cm^3, the capacity of the cuboid = 1.44 litres.

Example: 2

A cylinder has a volume of 965 cm^3. If the height of the cylinder is 16 cm, find the radius. Give your answer to 2 significant figures.

Solution:
Substitute the information from the question into the formula for the volume of a cylinder:

Volume of cylinder = $\pi r^2 h$

$965 = \pi \times r^2 \times 16$

$965 = \pi \times 16 \times r^2$

$965 = 50.26548 \times r^2$

$19.198 = r^2$

$4.38156 = r$

So the radius of the cylinder is 4.4 cm (to 2 SF)

Exercise question

A can of drink has the shape of a cylinder. The can has a radius of 4 cm and a height of 15 cm. Calculate the volume of the cylinder. Give your answer correct to three significant figures.

Exercise question

Calculate the volume of the triangular prism.

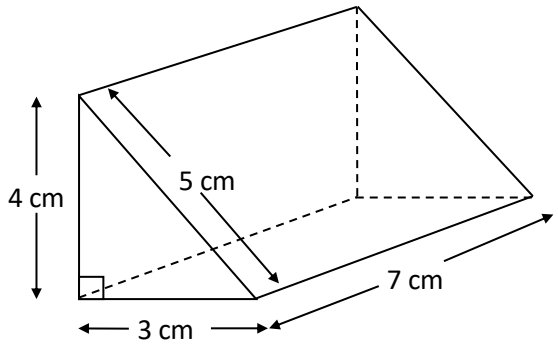
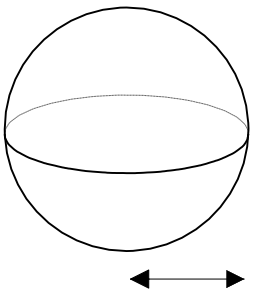


Diagram **NOT** accurately drawn

Volume of a sphere

Volume of a **sphere** = $\frac{4}{3}\pi r^3$



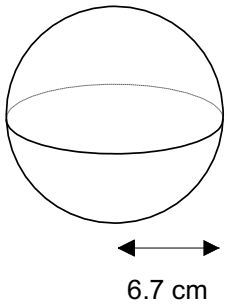
Example: 3

A sphere has a volume of 86.5 cm^3. Find the radius of the sphere. Solution:

A **hemisphere** is half a sphere. Example
The radius of a sphere is 6.7 cm. Find the volume.

Solution:
Substitute r = 6.7 cm into the formula

Volume = $\frac{4}{3}\pi r^3$

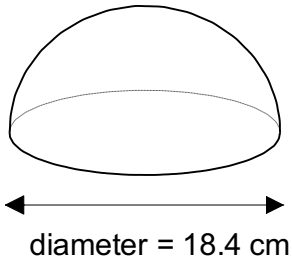


V = $\frac{4}{3} \times \pi \times 6.7^3$

V = 1259.833 (remember to use the cube button on your calculator)
V = 1260 cm^3 (to 3 SF)

Example: 2

Find the volume of the hemisphere shown in the diagram.



Solution:

The diameter of the hemisphere is 18.4 cm.
Therefore the radius is 9.2 cm.

Volume of the hemisphere = $\frac{1}{2} \times$ volume of sphere

$$= \frac{1}{2} \times \frac{4}{3} \pi r^3$$

$$= \frac{1}{2} \times \frac{4}{3} \times \pi \times 9.2^3$$

$$= \frac{1}{2} \times 3261.76$$

= 1630 cm^3 (to 3 SF)

Example 3:

A sphere has a volume of 86.5 cm3. Find the radius of the sphere.
Solution:

Substitute into the formula for the volume of a sphere: Volume = $\frac{4}{3} \pi r^3$

$$86.5 = \frac{4}{3} \pi r^3$$

So $86.5 = 4.18879 r^3$

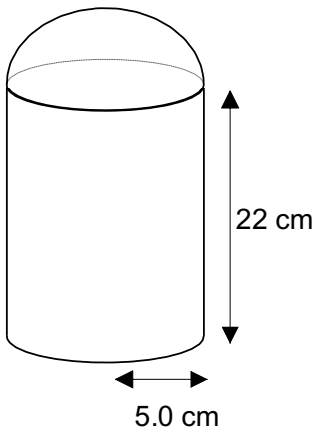
i.e. $20.65035 = r^3$

So r = 2.74 cm (to 3 SF) (cube rooting)

The sphere has radius 2.74 cm.

Examination style question

The object shown is made up from a cylinder and a hemisphere.
The cylinder has radius 5.0 cm and height 22 cm. Find the volume of the object.



Solution:

Volume of cylinder $= \pi r^2 h$

$= \pi \times 5^2 \times 22$

$= 1728$ cm^3 (to nearest whole number)

The hemisphere must also have radius 5 cm.

Volume of the hemisphere $= \frac{1}{2} \times$ volume of sphere

$= \frac{1}{2} \times \frac{4}{3} \pi r^3$

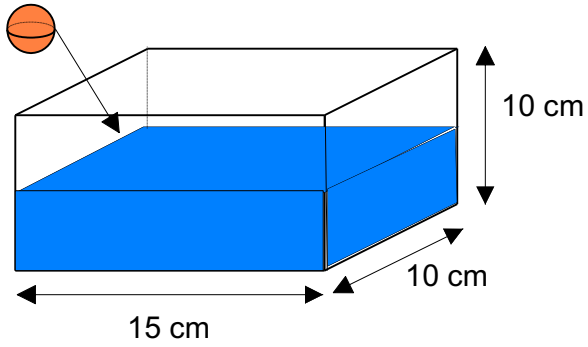
$= \frac{1}{2} \times \frac{4}{3} \times \pi \times 5^3$

$= 262$ cm^3

Therefore total volume of the object = 1728 + 262 = 1990 cm^3.

Example

A tank measures 15 cm by 10 cm by 10 cm. The tank is half-full of water.



A solid metal sphere with radius 2 cm is placed into the tank.
Assuming that the sphere sinks to the bottom of the tank, calculate the amount by which the water level in the tank rises.
Solution
As the sphere will be completely submerged, it will displace its volume of water.
Volume of sphere $= \frac{4}{3} \pi r^3 = \frac{4}{3} \times \pi \times 2^3 = 33.51$ cm^3.
Therefore, the water displaced is 33.51 cm^3.
The water displaced has the form of a cuboid with measurements 15 cm by 10 cm by h cm, where h is the height by which the water level rises.
So $15 \times 10 \times h = 33.51$
i.e. $h = 0.22$ cm
The water rises by 0.22 cm.

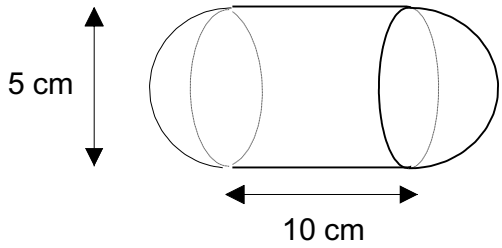
Examination question

A solid plastic toy is made in the shape of a cylinder which is joined to a hemisphere at both ends.

The diameter of the toy at the joins is 5 cm.

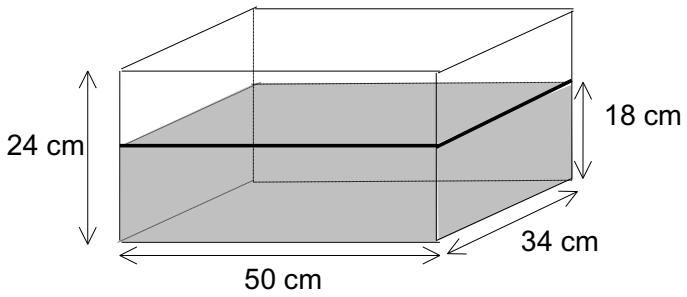
The length of the cylindrical part of the toy is 10 cm.

Calculate the volume of plastic needed to make the toy. Give your answer correct to three significant figures.



Examination question

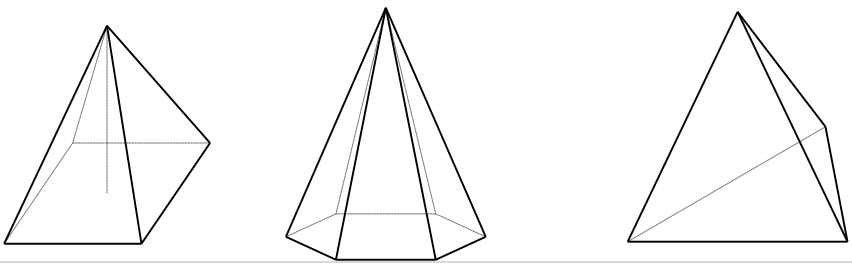
A water tank is 50 cm long, 34 cm wide and 24 cm high. It contains water to a depth of 18 cm.



Four identical spheres are placed in the tank and are fully submerged. The water level rises by 4.5cm. Calculate the radius of the spheres.

Volume of a pyramid

Pyramids come in a range of shapes. They can have bases which are any shape e.g. triangular, square, rectangular, circular etc.

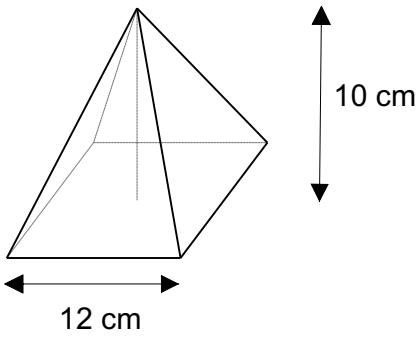


The volume of any **pyramid** can be found using the formula:

$$\text{Volume of } \textbf{pyramid} = \frac{1}{3} \times \text{base area} \times \text{height}$$

Example:

The pyramid shown has a square base. The square has sides of length 12 cm. The height of the pyramid is 10 cm. Find the volume.



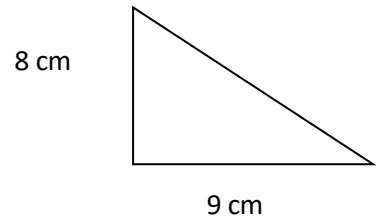
Solution:
The area of the square base is $12 \times 12 = 144$ cm^2
So, the volume of the pyramid is:

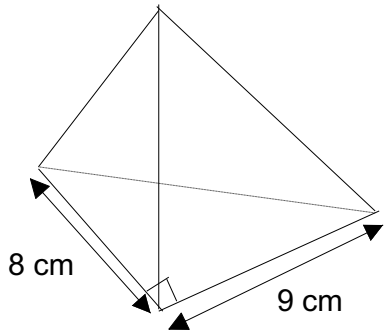
$$\text{Volume} = \frac{1}{3} \times 144 \times 10$$
$$= 48 \times 10$$
$$= 480 \text{ cm}^3.$$

Example: 2

The diagram shows a triangular-based pyramid. The base of the pyramid is a right-angled triangle. The volume of the pyramid is 325 cm^3. Find the height of the pyramid.

Solution:
The base of the pyramid is as shown:





The area of the base is $\frac{1}{2} \times 9 \times 8 = 36\,\text{cm}^2$.

Substitute information into the formula for the volume of a pyramid.

Volume of pyramid = $\frac{1}{3} \times \text{base area} \times \text{height}$

$325 = \frac{1}{3} \times 36 \times \text{height}$

$325 = 12 \times \text{height}$.

So, height = $325 \div 12 = 27.08$ cm (to 4 SF).

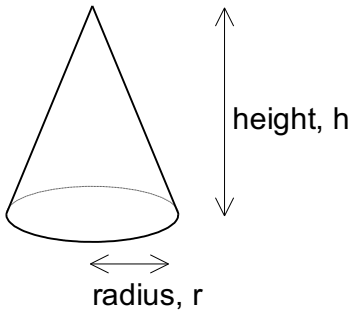
Volume of a cone

A cone is a pyramid with a circular base. Volume of cone = $\frac{1}{3}\pi r^2 h$

The formula for the volume of a cone is:

Volume of cone = $\frac{1}{3}\pi r^2 h$

Where *r* is the radius of the cone and *h* is the height of the cone.



Where *r* is the radius of the cone and *h* is the height of the cone.

Example 1

The base of a cone has a radius of 4 cm. The height of the cone is 6 cm. Find the volume of the cone. Leave your answer in terms of π.

Solution:

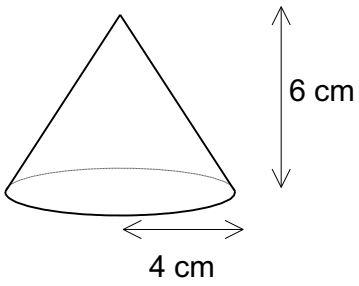
Substitute the information into the formula for the volume of a cone:

Volume of cone = $\frac{1}{3}\pi r^2 h$

$$= \frac{1}{3} \times \pi \times 4^2 \times 6$$

$$= 2 \times \pi \times 16 \qquad \text{(start by finding 1/3 of 6)}$$

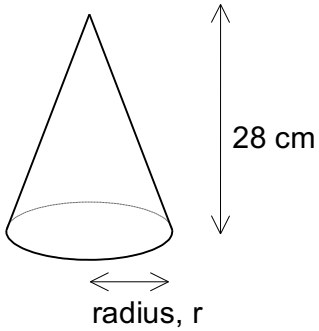
volume = 32π cm^3.



Example 2:

A cone has a volume of 1650 cm^3. The cone has a height of 28 cm.
Find the radius of the cone. Give your answer correct to 2 significant figures.

Solution:
Substitute information into the formula:



$$\text{Volume of cone} = \frac{1}{3}\pi r^2 h$$

$$1650 = \frac{1}{3} \times \pi \times r^2 \times 28$$

$$1650 = 29.32153r^2 \qquad \text{(evaluating } \frac{1}{3} \times \pi \times 28\text{)}$$

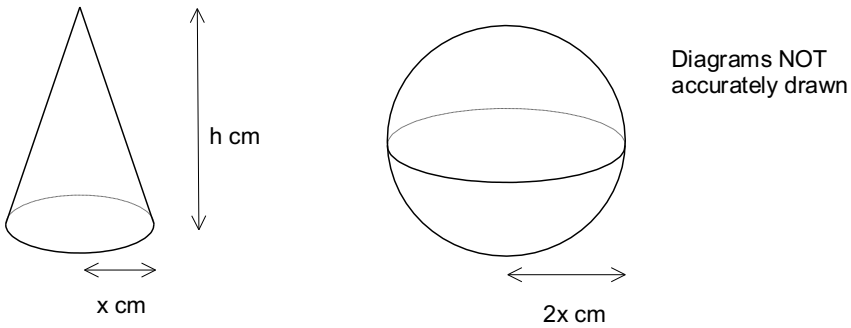
$$r^2 = 56.2726$$

i.e. r = 7.5 cm (to 2 SF)

The radius of the cone is therefore 7.5 cm.

Problem solving:

The radius of the base of a cone is x cm and its height is h cm. The radius of a sphere is $2x$ cm.



The volume of the cone and the volume of the sphere are equal.

Express h in terms of x.
Give your answer in its simplest form.

Solution:

The volume of the cone is $\frac{1}{3}\pi r^2 h = \frac{1}{3}\pi x^2 h$

The volume of the sphere is $\frac{4}{3}\pi r^3 = \frac{4}{3}\pi(2x)^3$ (note: the brackets around $2x$ are important)

$= \frac{4}{3}\pi \times 8x^3$ (cubing both 2 and x)

$= \frac{32}{3}\pi x^3$

As the sphere and the cone have the same volume, we can form an equation:

$\frac{1}{3}\pi x^2 h = \frac{32}{3}\pi x^3$

$\pi x^2 h = 32\pi x^3$ (Multiplying both sides by 3)

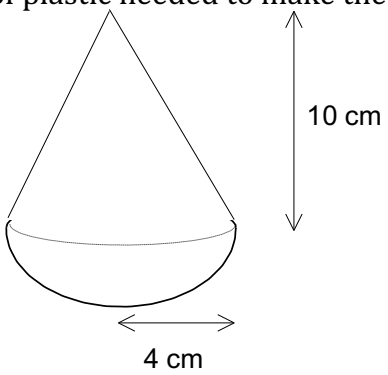
$x^2 h = 32x^3$ (Dividing both sides by π)

$h = 32x$ (Dividing both sides by x^2)

Past examination question

A child's toy is made out of plastic. The toy is solid.
The top of the toy is a cone of height 10 cm and base radius 4 cm.
The bottom of the toy is a hemisphere of radius 4 cm.

Calculate the volume of plastic needed to make the toy.



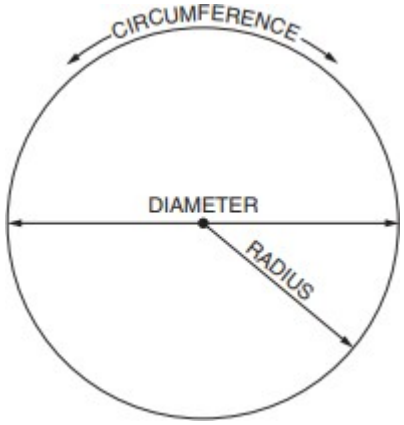
Geometry

Geometry is essential to welding. Several welding projects require you to understand, calculate and measure welds at different angles accurately. Moderate knowledge of geometrical measurements will make it easier for you to connect metals together while advanced knowledge will make it possible to work on complex projects.
Welders also use geometrical knowledge for calculating the length and size of various shapes and calculate the radius, diameter, and circumference for pieces that have a round shape.

In order to use geometrical angles, welders will also need to have the right drafting tools such as triangles. The triangles make it easier to connect 90, 45 & 60 degree angles together. A compass is also used for precise measurements and calculation of points between different angles. Both tools are helpful when creating joints and help ensure that they're square. They can also be used to determine the radius, diameter and circumference of a circle.

Identify the elements of a circle Parts

Circle: A circle is a closed curved object, all parts of which are equally distant from the center



Circumference: Circumference is the distance around a circle: it is similar in meaning to perimeter.
Symbol used is C.

Radius: The radius is a straight line measurement from the center, to the edge, of the circle: it is one-half the diameter. Symbol used is r.

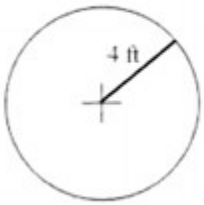
Diameter: The diameter is a straight line through the center of the circle, traveling from edge to edge. It divides the circle in half, and is equal in length to 2 radii. Symbol used is (D).
Diameter is designated on blueprints with the symbol Ø.

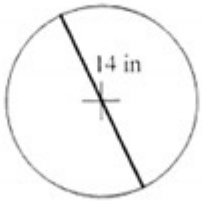
pi: The circumference of any circle is 3.1416 times the diameter of that circle. The number 3.1416 is represented by the Greek letter "pi". The symbol used is π. Welding shops round π to 3.14.

The formula for calculating the circumference of a circle is:

Area = πr^2

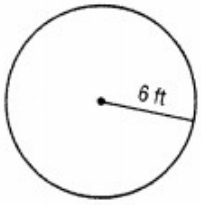
Examples: Find the area of the circle. Remember π = 3.14

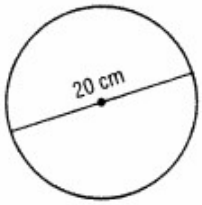
1. 

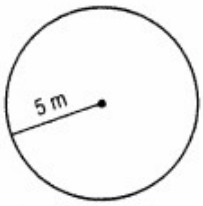
2. 

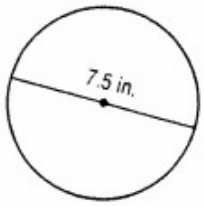
3. 

Find the circumference of each circle. Use 3.14 or $\frac{22}{7}$ for π. Round to the nearest tenth if necessary.

1. 

2. 

3. 

4. 

5. diameter = 15 km

6. radius = 21 mi

7. radius = 50 m

8. diameter = 600 ft

9. radius = 62 mm

10. diameter = 7 km

Identify and use the ratio of sides of 45° and 60° right angled triangles.

Trigonometry

Speaking of angles, welders must also possess a good understanding of trigonometry for creating angled structures. Trigonometry helps welders determine the area of the weld and the angle it should be created at for handling pressure under various environmental conditions.

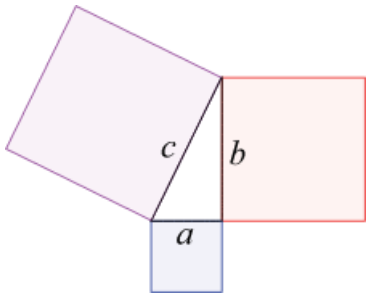
Trigonometry helps welders determine the strength of the weld and how joints should be made to ensure that they will not break with usage. The welder can test the strength of the joint without breaking it by applying module testing methods such as ultrasonic waves based on tangents, signs and cosigns. Testing methods help the welder determine imperfection in the weld and adjust it to create a durable structure.

Trigonometry is one of the more complex mathematical skills and takes time to master. It can be difficult to understand it if you aren't already good at geometry. The good part is that you can learn and improve your understanding of angled joints by taking a course in trigonometry.

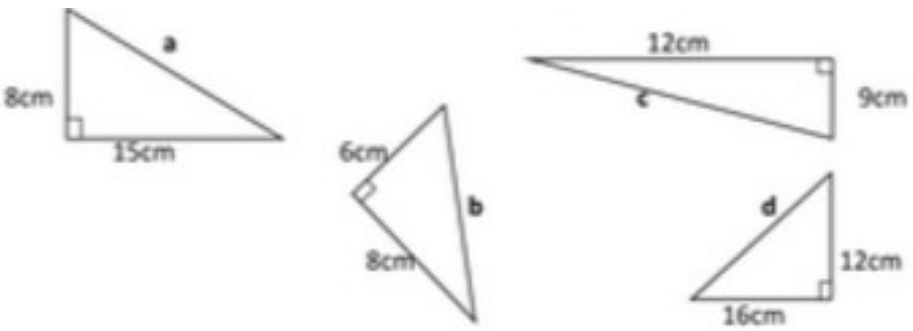
Pythagoras' Theorem

It states that the square of the hypotenuse (the side opposite the right angle) is equal to the sum of the squares of the other two sides.

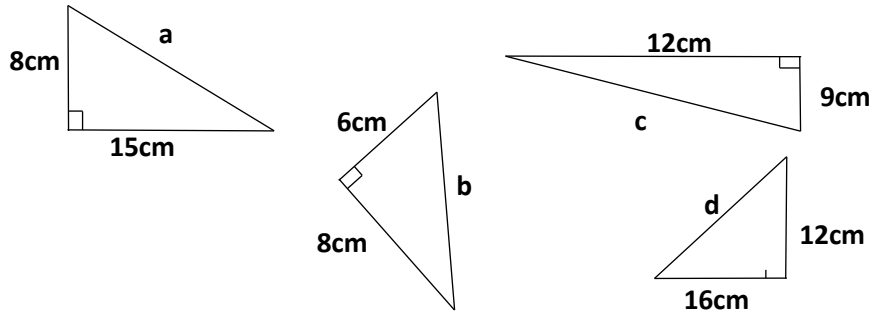
$a^2+b^2=c^2$



Find hypotenuse of following



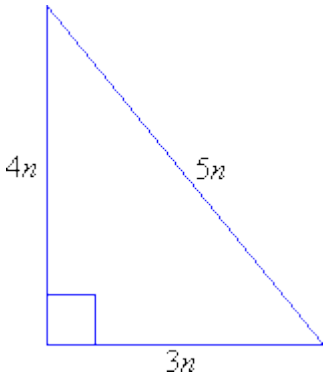
Using Pythagoras, find the length of the side labeled with letters.



3-4-5 Right Triangle

A 3-4-5 triangle is right triangle whose lengths are in the ratio of 3:4:5. When you are given the lengths of two sides of a right triangle, check the ratio of the lengths to see if it fits the 3:4:5 ratio.

Side1 : Side2 : Hypotenuse = 3n : 4n : 5n



Example 1:

Find the length of the hypotenuse of a right triangle if the lengths of the other two sides are 6 inches and 8 inches.

Solution:

Step 1: Test the ratio of the lengths to see if it fits the $3n : 4n : 5n$ ratio. $6 : 8 : ? = 3(2) : 4(2) : ?$

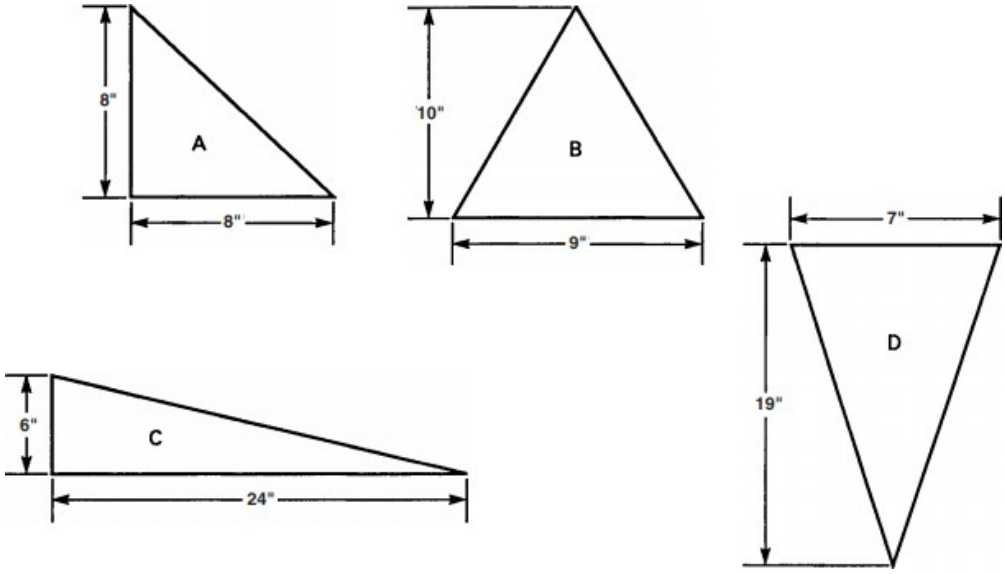
Step 2: Yes, it is a 3-4-5 triangle for $n = 2$.

Step 3: Calculate the third side $5n = 5 \times 2 = 10$

Answer:

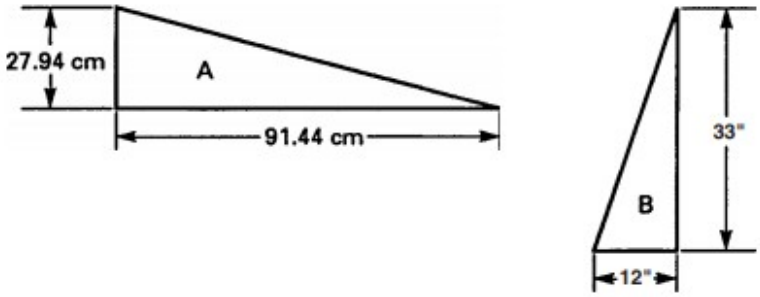
The length of the hypotenuse is 10 inches.

Solve simple workshop problems involving Pythagoras and right-angled triangles. These four triangular shapes are cut from sheet metal. What is the area of each piece in square inches?



1. Triangle A _____
2. Triangle B _____
3. Triangle C _____
4. Triangle D _____

Two pieces of sheet metal are cut into triangular shapes.



5. Find, in square centimeters, the area of triangle A. _____
6. Find, in square inches, the area of triangle B. _____

Convert Degrees Minutes Seconds to Decimal Degrees

Latitude and Longitude coordinates are often presented in degrees, minutes, and seconds, such as 39° 45' 30" (39 degrees, 45 minutes, 30 seconds). However, we can only plot values in decimal degrees. So, for example, 39° 45' is referred to as 39.75°

Converting from degrees, minutes, and seconds is actually quite easy. Consider the latitude value 39° 25' 30". This value needs to be converted to use it in Strater. There are 60 minutes in one degree and 3600 seconds in one degree. To convert minutes and seconds to decimal degrees, divide minutes by 60, divide seconds by 3600, and then add the results to obtain the decimal equivalent. Use the following formula to make the conversion:

Decimal degrees = Degrees + (Minutes/60) + (Seconds/3600)

For Example, to convert 39° 25' 30" to decimal degrees

1. First, convert minutes and seconds to their degree equivalents and add the results
   25'/60=0.4167°
   30"/3600=.0083°
2. and 0.4167° + 0.0083° = 0.425°
3. Then, add this number to the number of degrees. 39° + 0.425° = 39.425°
   So, the final result is: 39° 25' 30" = 39.425°

APPLY FUNDAMENTAL OF SCIENCE

Relative Motion in One and Two Dimensions

Motion does not happen in isolation. If you're riding in a train moving at 10 m/s east, this velocity is measured relative to the ground on which you're traveling. However, if another train passes you at 15 m/s east, your velocity relative to this other train is different from your velocity relative to the ground. Your velocity relative to the other train is 5 m/s west. To explore this idea further, we first need to establish some terminology.

Reference Frames

To discuss relative motion in one or more dimensions, we first introduce the concept of reference frames. When we say an object has a certain velocity, we must state it has a velocity with respect to a given reference frame. In most examples we have examined so far, this reference frame has been Earth. If you say a person is sitting in a train moving at 10 m/s east, then you imply the person on the train is moving relative to the surface of Earth at this velocity, and Earth is the reference frame. We can expand our view of the motion of the person on the train and say Earth is spinning in its orbit around the Sun, in which case the motion becomes more complicated. In this case, the solar system is the reference frame. In summary, all discussion of relative motion must define the reference frames involved. We now develop a method to refer to reference frames in relative motion.

Relative Motion in One Dimension

We introduce relative motion in one dimension first, because the velocity vectors simplify to having only two possible directions. Take the example of the person sitting in a train moving east. If we choose east as the positive direction and Earth as the reference frame, then we can write the velocity of the train with respect to the Earth as $\vec{v}_{TE} = 10\,\text{m/s}\,\hat{i}$ east, where the subscripts TE refer to train and Earth. Let's now say the person gets up out of /her seat and walks toward the back of the train at 2 m/s. This tells us she has a velocity relative to the reference frame of the train. Since the person is walking west, in the negative direction, we write her velocity with respect to the train as $\vec{v}_{PT} = -2\,\text{m/s}\,\hat{i}$. We can add the two velocity vectors to find the velocity of the person with respect to Earth. This relative velocity is written as $\vec{v}_{PE} = \vec{v}_{PT} + \vec{v}_{TE}$.

$$\vec{\mathbf{v}}_{PE} = \vec{\mathbf{v}}_{PT} + \vec{\mathbf{v}}_{TE}$$

Motion in Two Dimensions

Constant Velocity

An object moving with constant velocity must have a constant speed in a constant direction. Motion with constant velocity is one of the simplest forms of motion. This type of motion occurs when an object is moving (or sliding) in the presence of little or negligible friction, similar to that of a hockey puck sliding across the ice. To have a constant velocity, an object must have a constant speed in a constant direction. Constant direction constrains the object to motion to a straight path.

Newton's second law (F=ma) suggests that when a force is applied to an object, the object would experience acceleration. If the acceleration is 0, the object shouldn't have any external forces applied on it. Mathematically, this can be shown as the following:

$$a = \frac{dv}{dt} = 0 \;\Rightarrow\; v = \text{const.}$$

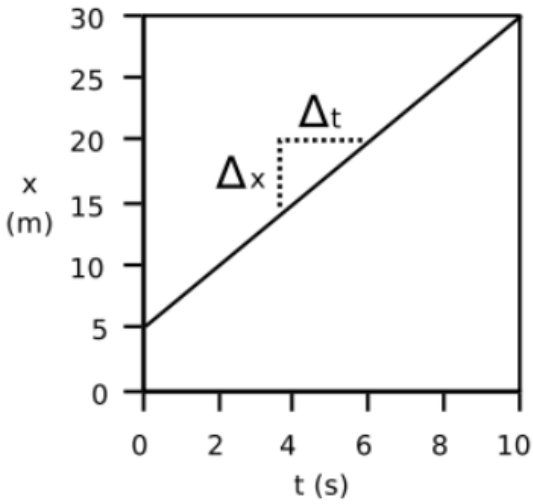
Key Points

- Constant velocity means that the object in motion is moving in a straight line at a constant speed.
- This line can be represented algebraically as: $x=x_0+vt$, where x_0 represents the position of the object at $t=0$, and the slope of the line indicates the object's speed.
- The velocity can be positive or negative, and is indicated by the sign of our slope. This tells us in which direction the object moves.

Key Terms

- **constant velocity**: Motion that does not change in speed nor direction.

If an object is moving at constant velocity, the graph of distance vs. time (x vs. t) shows the same change in position over each interval of time. Therefore, the motion of an object at constant velocity is represented by a straight line: $x=x_0+vt$, where x_0 is the displacement when t=0 (or at the y-axis intercept).

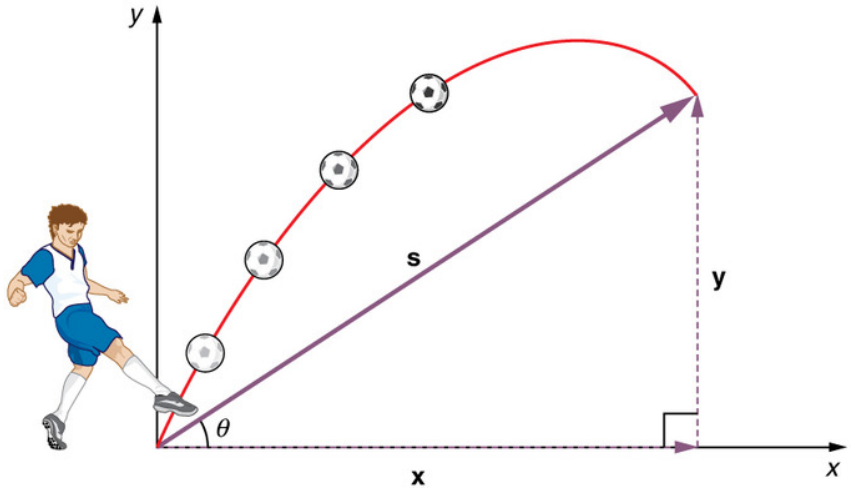


You can also obtain an object's velocity if you know its trace over time. Given a graph as in, we can calculate the velocity from the change in distance over the change in time. In graphical terms, the velocity can be interpreted as the slope of the line. The velocity can be positive or negative, and is indicated by the sign of our slope. This tells us in which direction the object moves.

Constant Acceleration

Analyzing two-dimensional projectile motion is done by breaking it into two motions: along the horizontal and vertical axes.

Projectile motion is the motion of an object thrown, or projected, into the air, subject only to the force of gravity. The object is called a projectile, and its path is called its trajectory. The motion of falling objects is a simple one-dimensional type of projectile motion in which there is no horizontal movement. In two-dimensional projectile motion, such as that of a football or other thrown object, there is both a vertical and a horizontal component to the motion.



The most important fact to remember is that motion along perpendicular axes are independent and thus can be analyzed separately. The key to analyzing two-dimensional projectile motion is to break it into two motions, one along the horizontal axis and the other along the vertical. To

describe motion we must deal with velocity and acceleration, as well as with displacement.

We will assume all forces except for gravity (such as air resistance and friction, for example) are negligible. The components of acceleration are then very simple: $a_y=-g=-9.81\frac{m}{s^2}$ (we assume that the motion occurs at small enough heights near the surface of the earth so that the acceleration due to gravity is constant). Because the acceleration due to gravity is along the vertical direction *only*, $a_x=0$. Thus, the kinematic equations describing the motion along the x and y directions respectively, can be used:

$$x = x_0 + v_x t$$

$$v_y = v_{0y} + a_y t$$

$$y = y_0 + v_{0y} t + \frac{1}{2} a_y t^2$$

$$v_y^2 = v_{0y}^2 + 2a_y(y - y_0)$$

We analyze two-dimensional projectile motion by breaking it into two independent one-dimensional motions along the vertical and horizontal axes. The horizontal motion is simple, because ax=0 and vx is thus constant. The velocity in the vertical direction begins to decrease as an object rises; at its highest point, the vertical velocity is zero. As an object falls towards the Earth again, the vertical velocity increases again in magnitude but points in the opposite direction to the initial vertical velocity. The x and y motions can be recombined to give the total velocity at any given point on the trajectory.

DEMONSTRATE SIMPLE DRAWING

Making a plumbing sketch or pipe diagram is a necessary step in the design process. As residential building plans do not typically include plumbing diagrams a sketch will assist both the designer and provide important information to the one installing the plumbing.

Sketching basics

Sketches are simple line diagrams that are not intended to provide great amounts of detail, but simply place ideas into a graphical form. Sketches are not drawn to scale as with blueprints, but should be proportionate. The old saying "A picture is worth a thousand words" is completely true when talking about piping arrangements; just imagine trying to describe the intended location of pipes in three dimensions using only the written word.

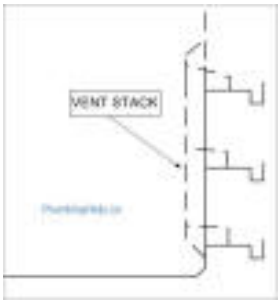
As your sketches become more refined additional information should be added; such as pipe sizes, fixture location, dimensions and plumbing fittings until your confident that someone else would understand your sketch and be able to follow it's design.

Types of plumbing sketches

There are two main types of plumbing sketches/drawings used by plumbers and mechanical designers to illustrate proposed plumbing layouts; which are, orthographic and isometric sketches.

Orthographic Sketching

Orthographic sketching is best described as a two dimensional drawing shown from a vantage point. Building plans for example are illustrated as if someone was looking down on them(top view), this is called a plan view and best describes horizontal features; such as underground piping for example.



Another common orthographic view is a front view; also called an elevation view. An elevation view is from the perspective of a person standing in front of a structure and best describes vertical features; such as a plumbing stack.

Isometric Sketching

An isometric sketch is a two dimensional drawing that creates the illusion of three dimensions using angular lines. This is the preferred drawing method for plumbers as it shows the most information about the piping layout.

Although an isometric drawing is the most complex to draw, it has definite advantages; such as showing both horizontal and vertical piping on a single drawing. Making an isometric sketch is accomplished by imagining yourself at the lowest point (downstream) in a plumbing system and drawing it as you would see it; if it was laid out from lower left to upper right.
When drawing on paper, an angle of 30 degrees (or increments thereof) is used to illustrate pipes running horizontally and vertical pipes are drawn straight up and down.

The one problem with an isometric sketch arises when pipes are on angles other than horizontal or vertical; such as 45 degree fittings. These "odd" angles are drawn as they would appear using 60 degree angles. When trying to draw circles in isometric drawings you will have to use an ellipse. A simple drawing tool called a triangle with the angles 30-60-90 will help you keep your drawing in the proper perspective. You can also purchase isometric graph paper or use printable graph paper.

UNDERTAKE RELEVANT MEASUREMENTS

In the previous Units, we have covered plumbing tools, material and pipes. Besides knowing the benefits and suitability of material in various tasks, a plumber must also be efficient in measurement of plumbing material with the help of measurement tools and be able to manage conversion of units easily. Similarly, a plumber should also be able to understand and read the various symbols used in plumbing drawings.

Plumbing material is needed as per the requirement of the plumbing work to be done and its plan. Plumbing fitting and fixtures are available in the market in different sizes and types. The size of the plumbing items can vary from inch to feet and metre in height. Plumbing items are also available as per volumetric capacity like water tanks, storage and flush tank, etc. Knowledge of various dimensions and sizes of plumbing items is crucial in the proper selection and purchasing of plumbing material in the market.

Measuring scale

Measurement of Length

A plumber uses the metallic tape, cloth tape, scale and foot rule for measuring. Metallic tape should be used for accuracy in the measurement. Metre and its divisions are printed on the measuring tape. The symbol of feet is (′) and the symbol of inch is (″). For example, the meaning of 4′-9″ is four feet nine inches. Both the systems, i.e., metric system and FPS (Foot-Pound-Second) system are used in plumbing measurement.

In metric systems:
metre = 10 decimetre (dm)
1 metre = 100 centimetre (cm)
1 metre = 1000 millimetre (mm)
10 millimetre = 1 centimetre (cm)
10 centimetre = 1 decimetre (dm)
10 decimetre = 1 metre (m)

In the FPS system:
feet = 12 inches
3 feet = 1 yard

Inter-relation of Metric and FPS system: Both type of systems can be interrelated, for taking length, in the following manner:
inch = 25.4 mm = 2.54 cm
1 metre = 39.37 inches = 1.09 yard

Measurement of Weight

Conversion Tables Weight

1 kilogram	= 10 hectograms
1 kilogram	= 100 decagram
1 kilogram	= 1000 gram
100 kilogram	= 1 quintal
1000 kilogram	= 1 metric ton
1 kilogram	= 2.2046 pounds

Length conversion

Length conversion is depicted in the following.

1millimetre (mm)	= 0.03937079 in, or about 1/25 in	
10 millimetre	= 1 centimetre (cm)	=0.3937079 in

10 centimetres	= 1 decimetre (dm)	=0.3937079 in
10 decimetres	= 1 metre (m)	= 39.37079 in, 3.2808992 ft, or 1.09361 yd
10 metres	= 1 decametre	= 32.808992 ft
10 decametres	= 1 hectometres	= 19.927817 rods
10 hectometres	= 1 kilometre (km)	= 1093.61 yd, or 0.621377 mile
10 kilometres	= 1 myriametre	= 6.21377 mile
1 inch	= 2.54 cm	1 foot = 0.3048 m 1 yard = 0.9144 m
1 rod	= 0.5029 decametre	1 mile = 1.6093 km

Measurement of Length

Length conversion is depicted in the following.

1 millimetre (mm) = 0.03937079 in, or about 1/25 in
10 millimetre = 1 centimetre (cm) = 0.3937079 in
10 centimetres = 1 decimetre (dm) = 3.937079 in
10 decimetres = 1 metre (m) = 39.37079 in, 3.2808992 ft, or 1.09361 yd
10 metres = 1 decametre = 32.808992 ft
10 decametres = 1 hectometres = 19.927817 rods
10 hectometres = 1 kilometre = 1093.61 yd, or 0.621377 metre

1 inch	**= 2.54cm, 1 foot = 0.3048 m, 1 yard = 0.9144 metre**
1 rod	**= 0.5029 decametre**
1 mile	**= 1.6093 kilometre**

Measurement of Volume

Conversion Table for Volume

Volume conversion is depicted in the following.
10 litres= 1 decilitre (dl) = 2.6417 gal, or 1.135 pk
10 decilitres = 1 hectolitre (Hl) = 2.8375 bu 10 hectolitres = 1 kilolitre (kl) = 61027.0515 cubic inch or 28.375 bu
1 cubic foot = 28.317
1 gallon (American) = 3.785 l
1 gallon (British) = 4.543 l
1 gallon = 4.546 litre

Measurement of density

Density conversion is depicted below.
1 lb/ft^3 = 16.018 kg/m^3
1 kg/m^3 = 0.0624 lb. /ft^3
1 lb/in^3 = 27.68 g/cm^3

Measurement of Pressure

Pressure conversion is depicted below.
1 lb/ft^2 = 4.8824 kg/m^3 = 1$lb/metre^2$ = 6.895 KgN/m^2
1 $lb/inch^2$ = 0.0703 kg/cm^3

Comprehensive Conversion Table

Millimetres	= 25.400	× inches
Metres	× 3.2809	= feet

Metres	= 0.3048	× feet
Kilometres	× 0.621377	= miles
Kilometres	= 1.6093	× miles
Square centimetres	× 0.15500	= square inches
Square centimetres	= 6.4515	× square inches
Square metres	× 10.76410	= square feet
Square metres	= 0.09290	× square feet
Square kilometres	× 247.1098	= acres
Square kilometres	= 0.00405	× acres
Hectares	× 2.471	= acres
Hectares	0.4047	× acres
Cubic centimetre	× 0.061025	= cubic inches
Cubic centimetre	= 16.3266	× cubic inches
Cubic metre	× 35.3156	= cubic feet
Cubic metre	= 0.02832	× cubic feet
Cubic metre	× 1.308	= cubic yard
Cubic metre	= 0.765	× cubic yard
Litres	× 61.023	= cubic inches
Litres	= 0.01639	× cubic inches

Litres	× 0.26418	= U.S. gallons
Litres	= 3.7854	× U.S. gallons
Grams	× 15.4324	= grains
Grams	= 0.0648	× grains
Grams	× 0.03527	= Ounces, avoirdupois
Grams	= 28.3495	× Ounces, avoirdupois
Kilograms	× 2.2046	= pounds
Kilograms	= 0.4536	× pounds

Tips

- ✓ To know the circumference of a circle, multiply its diameter by 3.1416.
- ✓ To calculate the diameter of a circle, multiply the circumference by 0.31831.
- ✓ To calculate the area of circle, multiply the square of the diameter by 0.7854.
- ✓ To calculate the circumference, multiply the radius of a circle by 6.283185.
- ✓ To calculate the area, multiply the square of the circumference of a circle by 0.07958.
- ✓ To calculate the area, multiply the half the circumference of a circle with half its diameter.
- ✓ To calculate the radius, multiply the circumference of circle with 0.159155.
- ✓ To calculate the radius, multiply the square root of the area of circle with 0.56419.
- ✓ To calculate the diameter, multiply the square root of the area of circle with 1.12838.
- ✓ To calculate the diameter of a circle equal in area to a given square, multiply a side of the square by 1.12838.
- ✓ To calculate the side of a square equal in area to a given circle, multiply the diameter by 0.8862.
- ✓ To calculate the side of a square inside a circle, multiply the diameter by 0.7071.
- ✓ To calculate the side of a hexagon inside in a circle, multiply the diameter of the circle by 0.500.
- ✓ To calculate the diameter of a circle inside in a hexagon, multiply the side of the hexagon by 1.7321.
- ✓ To calculate the side of an equilateral triangle inside in a circle, multiply the diameter of a circle by 0.866.
- ✓ To calculate the diameter of a circle inside in an equilateral triangle, multiply a side of the triangle by 0.57735.

- ✓ To calculate the area of the surface of a ball (sphere), multiply the square of the diameter by 3.1416.
- ✓ To calculate the volume of a ball (sphere), multiply the cube of the diameter by 0.5236.
- ✓ Doubling the diameter of a pipe increases its capacity four times.
- ✓ To calculate the pressure in pounds per square inch at the base of a column of water, multiply the height of the column in feet by 0.433.
- ✓ A gallon of water (U.S. standard) weighs 8.336 pounds and contains 231 cube inches. A cubic foot of water contains 7½ gallons, 1,728 cubic inches and weighs 62.425 pounds at a temperature of about 39°F. These weights change slightly and below this temperature.

Measuring instruments

Measuring tools

These are important tools in a workshop, which help the plumber to measure size and dimensions of various components of plumbing. Measuring tools are commonly used. A plumber should know the use and handling of these tools. The important measuring tools are steel rule, calliper, screw gauge, pressure gauge, etc.

Steel ruler

It is used to measure lengths and to draw straight lines (Fig. 4.2).

Steel ruler

Calliper

It is a tool used to determine the shorter lengths between two sides of an item. The tips of the calliper are kept to the distance to be measured; the calliper is then removed and the distance is measured between the tips with the ruler

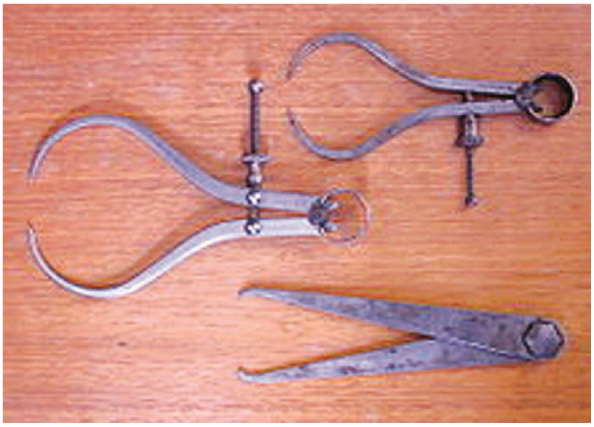


Fig. 4.3: Outside callipersFig. 4.4: Inside callipers

Screw gauge (Micro metre)

It is a device incorporating a calibrated screw used widely for precise measurement of small lengths. Proper handling of this tool is important in measuring any dimension

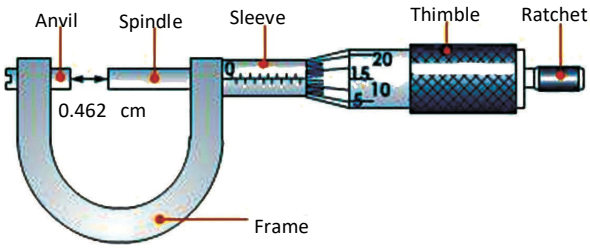


Fig. 4.5: Screw gauge

Fig. 4.6: Measuring tape

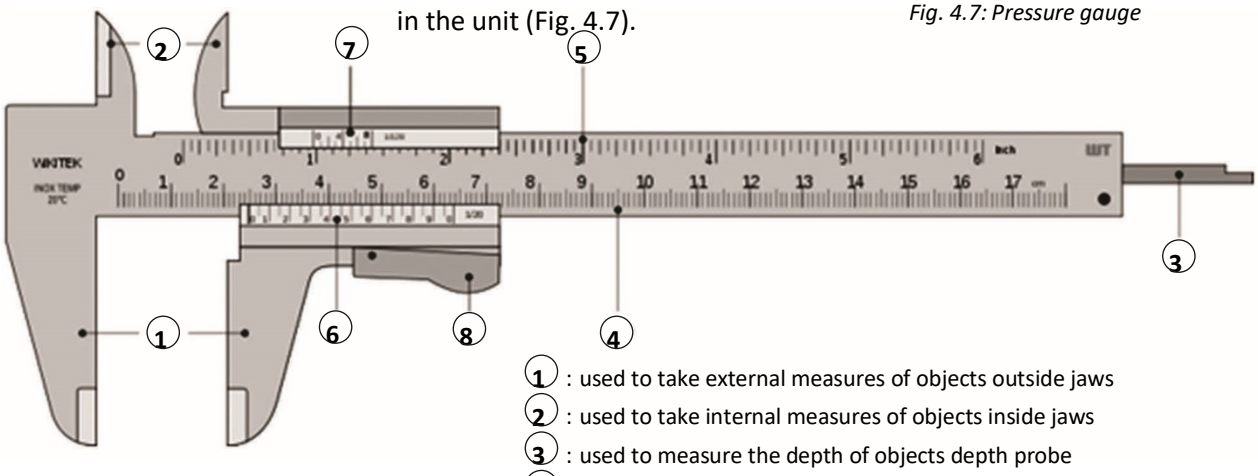
Measuring tape

It is used for measuring the dimension of plumbing items. Tapes are available in various lengths like 10 metres, 20 metres, etc.

Fig. 4.7: Pressure gauge

Pressure gauge

It is the instrument used for measuring the pressure in the unit (Fig. 4.7).



1 : used to take external measures of objects outside jaws
2 : used to take internal measures of objects inside jaws
3 : used to measure the depth of objects depth probe
4 : (cm) Main scale
5 : (inch) Main scale
6 : (cm) Vernier
7 : (inch) Vernier
8 : used to block movable part retainer

Fig. 4.8: Vernier calliper and its parts

Fig. 4.9: Vernier callipers

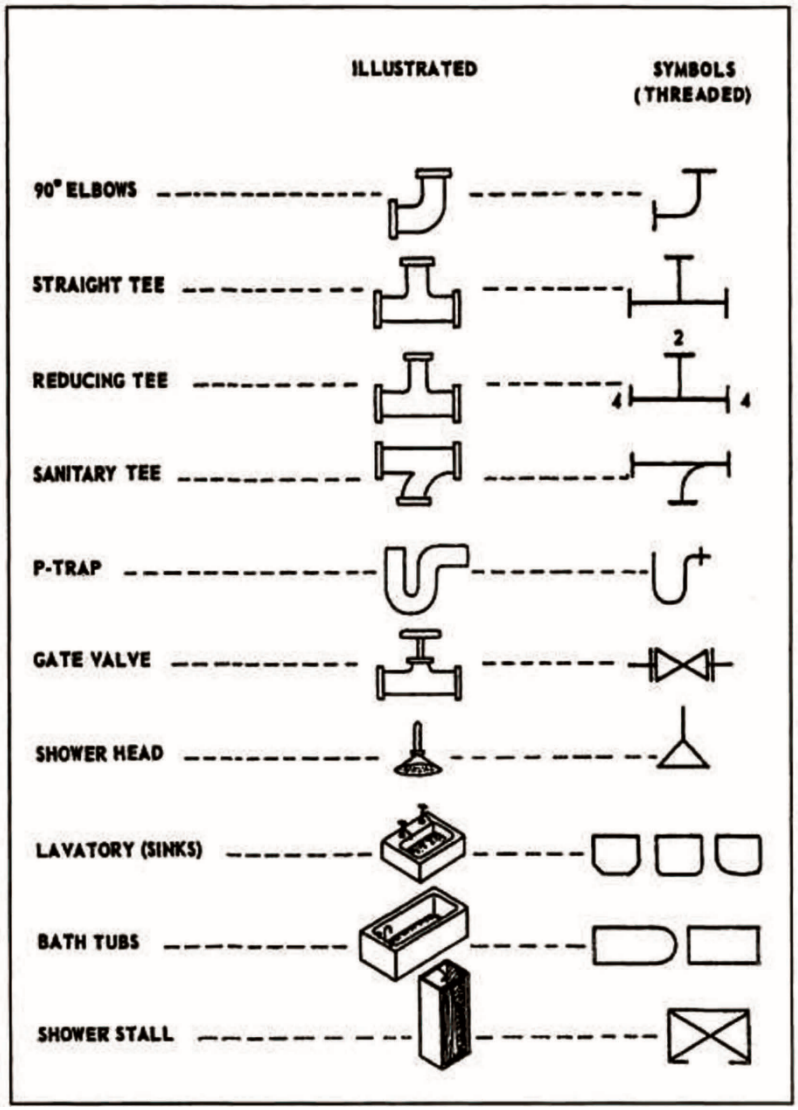
Vernier calliper

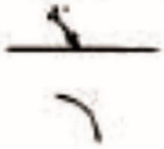
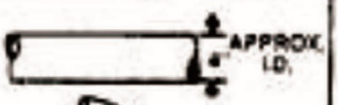
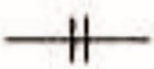
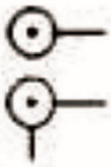
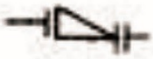
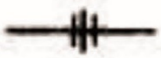
The metre scale is used to measure the length to the nearest millimetre only. For measuring smaller lengths precisely, Vernier calliper is used. **Vernier calliper** is a precision instrument used to measure the internal and external lengths. It is usually a manual calliper, as shown in Fig. 4.8 and Fig. 4.9.

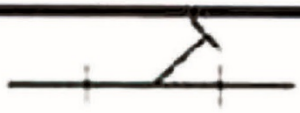
Plumbing symbols

Importance of plumbing symbols

A well-trained plumber does the installation of the fittings and fixtures as per the drawing given in the assembly sheet of the plumbing fixtures in the manufacturer's catalogue. These drawings consist of symbols, assembly of fixture and installation method. Identification of the symbols given in the drawings of fixtures makes the installation work easy for the plumber. Plumbing symbols are given in this Unit. The students should identify and learn the symbols so that it will be helpful in future.



ITEM	SYMBOL	SAMPLE APPLICATION (S)	ILLUSTRATION
PIPE	SINGLE LINE IN SHAPE OF PIPE- USUALLY WITH NOMINAL SIZE NOTED		
JOINT- FLANGED	DOUBLE LINE		
SCREWED	SINGLE LINE		
BELL AND SPIGOT	CURVED LINE		
OUTLET TURNED UP	CIRCLE AND DOT		
OUTLET TURNED DOWN	SEMICIRCLE		
REDUCING OR ENLARGING FITTING	NORMAL SIZE NOTED AT JOINT		
REDUCER CONCENTRIC	TRIANGLE		
ECCENTRIC	TRIANGLE		
UNION SCREWED	LINE		
FLANGED	LINE		

 Water Meter	Cold Water
Hot Water	Vent Line
Sanitary Waste	G Gas Pipe
 Gate Valve	 Water Heater Shut Off
 Water Closet	 Lavatory
 Water Heater	 Dishwasher
 Clothes Washer	 Floor Drain
 Clean Out	 Vent Thru Roof
 90 degree Elbow	 Pipe Turns Up
 Pipe turns Down	 Tee
 Union	 Cap

UNIT 09

PERFORM SAFE WORKSHOP PRACTICES

Students commencing a career in plumbing need to develop a good basic knowledge of mechanical fittings practices prior to proceeding to the development of Plumbing knowledge and skills

TOOLS USED IN MECHANICAL WORKSHOPS

Air Nozzles & Air Chucks

Air Nozzles

Safety Precautions: Compressed air and gases are dangerous. The nozzle should never be opened and pressed against the skin; this could inject air into your body and cause severe injury or death. Caution should be used in regards to the direction the nozzle is pointed and to the resulting hazardous airborne particulates (HAPS).

Usage: Air nozzles are used to blow loose contaminates from working surfaces. Air pressures can be adjusted at the regulator on the wall or by installing a cheater valve on the inlet side of the nozzle.

Air Chuck

Safety Precautions: Caution should be used when inflating tires, do not exceed the manufacturers P.S.I. limits.

Usage: Some air chucks have a built in gauge to monitor tire pressure as it is inflated. Inflate the tire by removing the valve stem cap and engaging the end of the chuck to the valve stem. If an audible sound of rushing air is not heard more pressure on the chuck will be required in order to compress the valve stem to the open position.

Hammers

Ball Peen Hammer

Safety Precautions: Using the wrong type of hammer for a given task will damage the tools or create a hazard. Hardened hammers used on hardened surfaces will shatter and send splinters in all directions.
Usage: Ball Peen hammers are heavy and have a lot of mass; they are used to move thick plate etc. They are never used on sheet metal; it would create more damage to the surface.

Rubber Mallet

Usage: Rubber mallets are like the brass hammer in that it will not leave surface damage on the metal being worked on. It is great for softer metals.

Nylon Face Hammer

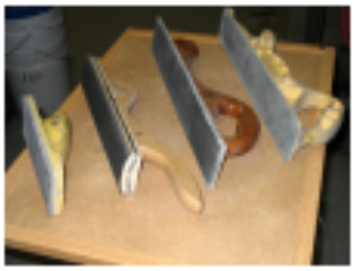
Usage: The nylon hammer with brass center offers mass and weight for use on softer metals.

Dead Blow Hammer

Usage: Dead Blow hammers have a plastic exterior with lead filler material, or shot, in the center. This gives weight and mass for moving softer metals without damage.

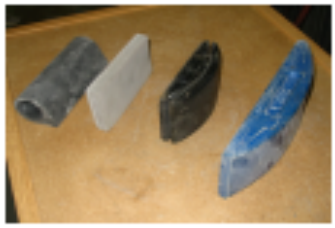
Hand Sanding Blocks

Hand Sanding Blocks



Usage: Hand Blocks come in many different sizes and shapes, like half round, 17 inch long, 9 inch long, they can also be adapted to use sticky backed sandpapers or hook and loop backed papers. Hand Blocks are used in shaping fillers or for the finishsanding phase of the repair. They also offer the most control of any type of shaping / cutting tool for body fillers and primers.

Rubber Blocks



Usage: Rubber sanding blocks are typically used in the finish sanding process (220-1500 grit). Sanding blocks help eliminate waves and level the surface. Rubber blocks can be used with wet or dry sandpapers.

Pliers. Snips, & Vice Grips

Pliers and Snips

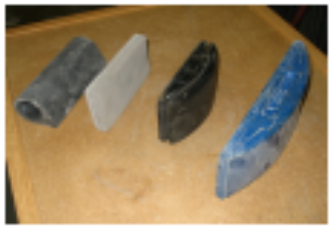
Usage: These electrical pliers have a wire cutting edge and wide jaws. The handle is insulated for shock resistance.

Channel Lock Pliers

Usage: Channel lock pliers are easily adjusted to fit all sizes of pipe or bolts.

Needle Nose Pliers

Usage: Needle nose pliers are used in hard to reach areas; side cutters are used to cut wire.



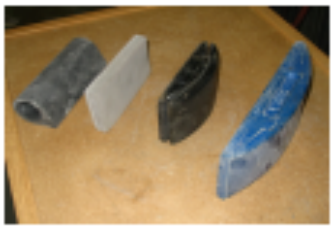
Side Cut Pliers

Usage: Needle nose pliers are used in hard to reach areas; side cutters are used to cut wire.

Assorted Vise Grips

Usage: Vise grips have a locking handle that will grip with out being held, they are used to hold metal pieces together for welding, bolting, or alignment process.

Right/Left Hand Tin Snips and Sheers



Usage: Rubber sanding blocks are typically used in the finish sanding process (220-1500 grit). Sanding blocks help eliminate waves and level the surface. Rubber blocks can be used with wet or dry sandpapers.

Ratchets

Assorted Ratchets

Usage: These ratchets have different size heads that is the main distinguishing factor, the square head (or drive), is measured on one side which gives a specific distance, thus we have a 1/2 inch drive ratchet on the left, a 3/8 drive ratchet in the middle, and 1/4 inch drive ratchet on the right. Ratchets are used in conjunction with sockets as a twisting devise to tighten or loosen bolts and nuts.

Breaker Bar and Cheater

Usage: Breaker bar is normally a 1/2 inch drive or larger. It is used to break loose stubborn bolts and nuts that have rusted tight. The cheater is used as an extension when slipped over the handle to gain more torque. This tool should only be used with impact sockets.

Safety Items

Safety Glasses

Face Shield

Usage: While in the lab area students and instructors should always wear protective clothing and eye protection. Students will not be allowed to be in the lab without safety glasses!

Latex Gloves

Usage: Needle nose pliers are used in hard to reach areas; side cutters are used to cut

wire.

Leather Gloves

Usage: Needle nose pliers are used in hard to reach areas; side cutters are used to cut wire.

Ear Plugs

Usage: Because of the wide variety of tools used in the labs, there will be high decibel levels at times, it is advisable to protect your hearing by using ear plugs during those times.

Scrapers & Chisels

1 Inch Scraper

Usage: Scrapers are useful in cleaning body filler spreaders and mixing boards, removal of double-sided tape from moldings, and removal of undercoating.

Air Chisel Bits

Air Chisel

Safety Precautions: Remember to always have this tool engaged with the work piece before turning it on, if you pull the trigger before it is engaged the chisel bit will shoot out like a bullet.
Usage: Needle nose pliers are used in hard to reach areas; side cutters are used to cut wire.

Wide Face Chisels

Usage: Wide face chisels are used to reshape body contours, and bodylines that have been altered after a collision. They are used in conjunction with sledgehammers.

Screwdrivers

Flat Screwdrivers

Safety Precautions: Do not direct working forces toward your body when using these tools, they can easily slip off the screw head and puncture anything in its path.
Usage: Flat head screwdrivers are used with flat head screws only. Don't use screwdrivers as pry bars they will break.

Phillips Screwdrivers

Usage: Philips head screwdrivers are shaped like a" +" on the head, and should only be used with corresponding size screws.

Sockets

Socket Set

Usage: This socket set has a variety of sockets, deep wall, regular wall, 6 point, 12 point, 1/2 drive, 3/8 drive, and 1/4 drive. The technician chooses the best tool for the job.

1/4, 3/8, 1/2 Inch Drive Sockets

Safety Precautions: The socket drive size must match the ratchet or damage will occur to the socket.
Usage: This example shows the drive side of a socket, the other side of the socket is designed to go over the bolt or nut.

6 Point vs. 12 Point Sockets

Usage: 6 and 12 point sockets are distinguished by the corresponding number of sides on the inside wall of the socket. Note the thickness of the wall of a 6-point socket. It is stronger than a 12-point socket, so it should be used for very tight bolts. It is possible to break the wall of a socket if too much torque is used.

Deep vs. Regular Wall Sockets

Usage: This image shows the height differences. A deep wall (the taller) socket is used to reach over a long threaded bolt to the nut for removal.

Impact vs. Regular Sockets

Usage: The impact socket is nearly twice the thickness of a regular socket. It is used in conjunction with an Air Impact Driver. Never use a regular socket with impact drivers; they will break the wall of the socket.

Wobbley Adapters

Usage: Wobbley adaptors can be made in any drive size, they are used as a universal joint to loosen bolts from a slight angle.

Assorted Extensions

Usage: Extensions allow the removal of deep hard to reach bolts and nuts. They come in all drive sizes; some will reduce or increase in drive size from one end to the other.

Tool Box

Tool Boxes

Usage: Once you start buying tools you will need a way to lock them up and keep an inventory of them; a toolbox is the answer. This is an example of an upper and lower box. You will want to start with a small upper box, and as you acquire more tools you can trade up in size and quality of toolboxes.

Upper Tool Box

Usage: Upper boxes are great for starters.

Wrenches

Combination Wrench

Usage: This wrench is open ended on one side and boxed on the other, also known as a combination end wrench. The boxed end is much stronger than the open end and will not flex apart when applying a lot of torque. Box ends can be 12 or 6 point, remember the 6-point is much stronger and will not allow the wrench to slip off or around the nut or bolt.

Open End Angle Wrench

Usage: The angle to this wrench allows access to hard to reach bolts and nuts.

Adjustable/Crescent Wrench

Pipe Wrench

Usage: Adjustable wrenches are used when availability of an end wrench is limited or not available. Pipe wrenches are used on pipes and other round objects that need to be tightened or loosened.

MAIN PLUMBING PIPES

There are five plumbing pipe materials that are — or were in the case of galvanized steel — most common: copper, galvanized steel, polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC) and cross-linked polyethylene (PEX).

1. **Copper Pipe**
   Copper is one of the most traditional materials for plumbing pipes and remains a popular option today. There are two main types of copper pipes that can be used together to outfit a whole plumbing system:

- ✓ **Rigid Copper:** Rigid, or hard, copper is used throughout a house or building for the water supply. The material can be cut into pieces and then soldered together. tight and flexibility is needed, such as in corners or in a supply line to your faucet.
- ✓ **Flexible Copper Tubing:** Flexible, or soft, copper is malleable and is used in short runs where space is

Copper Pipe Sizing

Copper piping comes in different sizes, labeled by the diameter, in millimeters, from one outside edge to another. The most popular sizes are 15 mm and 22 mm, but you can also get 18 mm piping and many sizes above 22, all the way up to 108 mm.
The other way of measuring rigid copper piping has to do with its thickness. There are three grades of thickness to choose from for use in plumbing:

- ✓ **Type M:** This type is the thinnest copper used in plumbing. It can usually be used for water piping, but it is more often used for drain, waste and vent (DWV) piping. This type works well for hot and cold supply lines in the home.
- ✓ **Type L:** This medium thickness tends to be the type of choice for transporting drinking water. As with Type M, this type works well for interior hot and cold supply lines.
- ✓ **Type K:** This type has the thickest walls, making it ideal for harsh conditions. Unlike Types M and L, Type K is the ideal choice for underground service lines.

Pros and Cons of Copper Pipes

Copper pipes have stood the test of time because of some important advantages they have, including:

- ✓ **Longevity:** Copper has proven to be a reliable material that can last at least 50 years.
- ✓ **Durability:** Copper is a sturdy material that is not prone to leakage or corrosion.
- ✓ **Safety:** Bacteria cannot thrive in copper pipes, and copper will not pollute water in any way, so it is safe to transport drinking water.
- ✓ **Recyclability:** When copper pipes eventually need to be replaced, the material can be recycled.
- ✓ **Temperature Tolerance:** Copper is able to stand up to extreme temperature changes, including hot and cold water.

With so many strengths, you may wonder why copper is not used for plumbing in every case. Copper is not always chosen because it does have some cons compared to other materials. Disadvantages of copper pipes include:

- ✓ **Financial Cost:** The main deterrent to using copper is the cost. The value of copper as a global commodity has gone up in recent years, so today, it will cost you approximately $285 for 100 feet of piping.
- ✓ **Environmental Cost:** Environmentally-conscious homeowners may be concerned about the fact that copper mining and manufacturing take a toll on the environment. So, although copper pipes last a long time and can be recycled, they are not considered a "green" product.

Galvanized Steel Pipes

Galvanized piping used to be the material of choice for residential plumbing, and it is still what many people picture when they think of a plumbing pipe. The steel pipes are coated in a layer of zinc, which is meant to prevent rusting. The ends of pipes are threaded so they can be screwed in to each other.

These pipes are undoubtedly strong, but they are no longer used much at all. Galvanized pipes are still sometimes used to transport non-potable water, but it is too prone to problems to transport potable water safely. While homes today are very rarely outfitted with galvanized steel pipes, homes whose plumbing was installed in the 1980s or before may still have them. If this is the case in your home, you should consider replacing these pipes right away.

Cons of Galvanized Steel Pipes

Though galvanized steel pipes are cheaper than copper, are strong and manage to resist rust for a time, these pros are far outweighed by the cons, which include:

- ✓ **Short Lifespan:** Galvanized steel pipes last about 20 to 50 years before they begin to break down. This lifespan may not seem too short, but it pales in comparison to the lifespans of many other piping materials.
- ✓ **Rust:** Especially in pipes with a small diameter, rust can build up inside over time. In some cases, the rust can break loose from the inside walls of the pipe and end up mixing with the water as it flows through. This discolors the water.
- ✓ **Lead Contamination:** If pipes become corroded, lead can leach into the water inside, making it unsafe to drink.
- ✓ **Clogs:** Over time, mineral build-up inside of galvanized pipes can begin to form clogs that block water flow.
- ✓ **Weight:** The downside to these pipes being very sturdy is that they are also extremely heavy. This makes them difficult to work with.
- ✓ **Vulnerability:** When galvanized pipes are damaged, the galvanization on the outside is compromised, which makes the pipe vulnerable to corrosion in a short amount of time.

Polyvinyl Chloride Pipes

Polyvinyl chloride, more commonly known as PVC, has become a popular choice for plumbing pipes in recent years. This material is a thermoplastic polymer. In other words, it is made out of a combination of plastic and vinyl. PVC pipes are rigid and are usually white, cream or grey in color. They are used most often for highly pressurized water, such as in a home's main water supply line. PVC pipes work in a variety of applications, including for transporting potable water and for draining.

Depending on the application, you can choose a particular thickness and configuration

designed to best support that application.

Pros and Cons of Polyvinyl Chloride Pipes

PVC pipes have gained popularity because of some important advantages they offer, including:

- ✓ Longevity: PVC is not subject to rust or corrosion, so unless it experiences some sort of unexpected damage, it can last indefinitely. Even the most durable metals used in plumbing pipes cannot live up to the impressive lifespan of PVC.
- ✓ **Ability to Handle Pressure:** PVC is often used for the main supply line that goes into your home because it is able to handle high water pressure.
- ✓ **Ease of Use:** PVC is extremely light compared to metal pipes, which makes it easy to transport and to work with. It is also easy to work with because there is no soldering required to connect pipes. Instead, pipes are essentially glued together.
- ✓ **Low Cost:** PVC is low in cost as well. Especially compared to copper, PVC is a very inexpensive option for plumbing pipes.
- ✓ While PVC has some marked advantages, it has a couple of disadvantages, too. These include:
- ✓ **Susceptibility to Warping:** PVC is not equipped to transport hot water. This is because, like most plastics, heat can cause the material to warp and melt.
- ✓ **Size:** Sizing options for PVC pipes are limited, which can be an issue at times. Even if your PVC piping is the perfect size, fittings used to connect PVC pipes can tend to be bulky, which can be problematic in tight spaces.

Chlorinated Polyvinyl Chloride

Chlorinated Polyvinyl Chloride, shortened to CPVC, is closely related to PVC. Though both materials are made from the same basic elements, the key difference is that CPVC is chlorinated. This chemical difference makes CPVC able to withstand temperature differences in a way that PVC cannot. For this reason, some building codes call for CPVC in place of PVC for transporting hot water.
Whereas PVC is typically only available in a sizing system called Nominal Pipe Size (NPS), CPVC comes in this sizing system as well as in Copper Tubing Size (CTS). As the name suggests, this sizing system mimics the same size graduations used by copper piping.

Pros and Cons of Chlorinated Polyvinyl Chloride

CPVC pipes share many of the advantages of PVC, plus one more:

- ✓ **Longevity**: Like PVC, since CPVC is a plastic material, it does not react to corrosive substances and does not rust, so its lifespan is indefinite.
- ✓ **Ability to Handle Pressure**: CPVC shares PVC's ability to handle high water pressure, making it a good material for a main water supply line.

- ✓ **Ease of Use**: CPVC is also quite lightweight, which makes it easy to move and work with. CPVC is also somewhat flexible.
- ✓ **Low Cost**: Though CPVC costs more than PVC, it is still a budget option compared to metal piping materials.
- ✓ **Temperature Tolerance:** CPVC is able to withstand extreme temperatures up to 200 degrees Fahrenheit. This equips CPVC to handle hot water transport.

CPVC does not have many clear disadvantages, though it may not always be the best choice. Cons include:

- ✓ **Indoor Application Only:** CPVC is vulnerable to breaking down if exposed to sunlight for extended periods of time.
- ✓ **Cost Compared to PVC:** Though cost was included as an advantage of CPVC, when comparing it directly to its close cousin, PVC, it does cost more.

Cross-Linked Polyethylene Pipes

Cross-Linked Polyethylene, or PEX for short, is another plastic material used for piping. Plastic pipes in general have become a popular type of pipe used in new homes. This particular plastic material is relatively new on the plumbing scene and can be used for a variety of plumbing applications. The major difference between PVC and PEX is that PEX pipes are flexible. This means they can be used in long, continuous runs.

In addition to being flexible, PEX is easy to cut and join together. The PEX system is designed to fit together with the combination of barbed fittings and crimping rings or cinch clamps. This method of joining pipes is in lieu of any soldering or gluing. The installation process is quick and easy, and the material is made to last. PEX piping can come coiled up in a flexible roll, wrapped in aluminum to keep its shape or in hard lengths.

Pros and Cons of Cross-Linked Polyethylene Pipes

To become the new favorite piping choice among many plumbers and homeowners, this material must come with some major advantages. These include:

- ✓ **Longevity:** PEX pipes, like PVC and CPVC, are completely rust and corrosion resistant. This means they can last indefinitely without needing to be replaced, unless they are broken somehow.
- ✓ **Flexibility:** PEX is flexible enough to make 90-degree turns with no problem. It can easily be snaked into walls — making it a great material for retrofitting — and it is able to extend across the length of a house with just one long piece.
- ✓ **Ease of Use:** PEX's flexibility makes it very easy to install. When joints are needed, no soldering or even gluing is required.
- ✓ **Temperature Tolerance:** Another important advantage of PEX over PVC is that PEX is able to withstand extreme temperatures. It can be used to transport hot water as well as cold.

- ✓ **Low Cost:** Like CPVC, PEX is more expensive than PVC, but, at about $30 per 100 feet of piping, is still significantly cheaper than copper.

PEX does have a few disadvantages, though one of these PEX plumbing disadvantages has largely been debunked. PEX pipe problems include:

- ✓ **Indoor Application Only:** PEX piping cannot be used in any outdoor applications since the plastic can be damaged by UV radiation. Of course, this is not really a disadvantage if you only plan to use PEX piping indoors.
- ✓ **Water Taste and Odor:** Some types of PEX pipes have been known to affect the taste and odor of drinking water, especially if the water has stayed in the pipes for some time.
- ✓ **Possible Safety Concerns:** There has been some concern and debate over whether PEX piping has the potential to contaminate drinking water due to the material's makeup. These concerns have largely been dispelled, however. Even the strictest environmental regulations in the U.S. now approve PEX piping, and research has shown that drinking water from PEX pipes does not involve health risks.

Additional Plumbing Pipes

Now that we have looked at some of the most common types of plumbing pipes, let's take a quick look at several others that are not quite as common. These include stainless steel, cast iron, polybutylene (PB) and high-density polybutylene (HDPE). We will also briefly discuss another type of pipe that is not intended for plumbing: black iron.

1. Stainless Steel Pipes

Stainless steel piping is actually more expensive than copper piping. A high price point, however, indicates a high level of quality. Stainless steel pipes are strong and corrosion-resistant. Because of their ability to resist corrosion, stainless steel pipes are the preferable choice in areas that are susceptible to it, such as coastal communities.
Stainless steel piping is available in both flexible and rigid versions, and it comes in a variety of sizes. Pipes are fitted together using couplings.

2. Cast Iron Pipes

Cast iron used to be a common piping material for drainage systems, particularly in the first half of the twentieth century, and it can still be found in many homes today. Cast iron is extremely strong, durable and heavy. Cast iron also reduces sound and is heat-resistant. Despite the advantages of strength and durability, though, a big disadvantage of cast iron is that it is susceptible to rust over time. In homes that have cast iron piping, if a pipe rusts all the way through, that section can be replaced with plastic piping, like PVC. Cast iron pipes come in various sizes, with the smallest usually being four inches.

3. Polybutylene Pipes

Polybutylene pipes, also referred to simply as PB pipes, were a popular choice for plumbing from the late 1970s to the mid-1990s. In fact, as many as 10 million homes built during that timeframe included polybutylene piping of some kind. Polybutylene is a type of plastic resin that was seen as a futuristic material, perfect for replacing copper.
These grey, plastic pipes were, and are, inexpensive and easy to work with. However, they fell out of favor because it was demonstrated that PB pipes were prone to leakage at the joints.

4. High-Density Polybutylene Pipes

High-Density Polybutylene pipes, also known as HDPE pipes, are one of the most popular choices for underground service lines, though they work in a variety of plumbing applications. This is due to HDPE's durability and ability to resist corrosion.
Some codes call for buried plastic lines to be made from HDPE instead of PVC. HDPE pipes are flexible, so they require minimal joints. Where they do require joints, heat fusion is used, making these pipes mostly leak-proof.

5. Black Iron Pipes

This type of piping is worth a mention, though it should be understood that it is not meant

to be used in plumbing applications. Black iron pipes were at one time a popular piping material for water supply, but today, they are only used for conveying natural gas or propane. Black iron is also a popular choice for fire sprinkler systems since it is especially effective at resisting extreme heat.

Main Plumbing Pipe Materials

There are five plumbing pipe materials that are — or were in the case of galvanized steel — most common: copper, galvanized steel, polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC) and cross-linked polyethylene (PEX).

1. Copper Pipes

Copper is one of the most traditional materials for plumbing pipes and remains a popular option today. There are two main types of copper pipes that can be used together to outfit a whole plumbing system:

- ✓ **Rigid Copper:** Rigid, or hard, copper is used throughout a house or building for the water supply. The material can be cut into pieces and then soldered together.
- ✓ **Flexible Copper Tubing:** Flexible, or soft, copper is malleable and is used in short runs where space is tight and flexibility is needed, such as in corners or in a supply line to your faucet.

Copper Pipe Sizing

Copper piping comes in different sizes, labeled by the diameter, in millimeters, from one outside edge to another. The most popular sizes are 15 mm and 22 mm, but you can also get 18 mm piping and many sizes above 22, all the way up to 108 mm.
The other way of measuring rigid copper piping has to do with its thickness. There are three grades of thickness to choose from for use in plumbing:

- ✓ **Type M:** This type is the thinnest copper used in plumbing. It can usually be used for water piping, but it is more often used for drain, waste and vent (DWV) piping. This type works well for hot and cold supply lines in the home.
- ✓ **Type L:** This medium thickness tends to be the type of choice for transporting drinking water. As with Type M, this type works well for interior hot and cold supply lines.
- ✓ **Type K:** This type has the thickest walls, making it ideal for harsh conditions. Unlike Types M and L, Type K is the ideal choice for underground service lines.

Pros and Cons of Copper Pipes

Copper pipes have stood the test of time because of some important advantages they have, including:

- ✓ **Longevity:** Copper has proven to be a reliable material that can last at least 50 years.
- ✓ **Durability:** Copper is a sturdy material that is not prone to leakage or corrosion.
- ✓ **Safety:** Bacteria cannot thrive in copper pipes, and copper will not pollute water in any way, so it is safe to transport drinking water.
- ✓ **Recyclability:** When copper pipes eventually need to be replaced, the material can be recycled.
- ✓ **Temperature Tolerance:** Copper is able to stand up to extreme temperature changes, including hot and cold water.

With so many strengths, you may wonder why copper is not used for plumbing in every case. Copper is not always chosen because it does have some cons compared to other materials. Disadvantages of copper pipes include:

- ✓ **Financial Cost:** The main deterrent to using copper is the cost. The value of copper as a global commodity has gone up in recent years, so today, it will cost you approximately $285 for 100 feet of piping.
- ✓ **Environmental Cost:** Environmentally-conscious homeowners may be concerned about the fact that copper mining and manufacturing take a toll on the environment. So, although copper pipes last a long time and can be recycled, they are not considered a "green" product.

2. Galvanized Steel Pipes

Galvanized piping used to be the material of choice for residential plumbing, and it is still what many people picture when they think of a plumbing pipe. The steel pipes are coated in a layer of zinc, which is meant to prevent rusting. The ends of pipes are threaded so they can be screwed in to each other.

These pipes are undoubtedly strong, but they are no longer used much at all. Galvanized pipes are still sometimes used to transport non-potable water, but it is too prone to problems to transport potable water safely. While homes today are very rarely outfitted with galvanized steel pipes, homes whose plumbing was installed in the 1980s or before may still have them. If this is the case in your home, you should consider replacing these pipes right away.

Cons of Galvanized Steel Pipes

Though galvanized steel pipes are cheaper than copper, are strong and manage to resist rust for a time, these pros are far outweighed by the cons, which include:

- ✓ **Short Lifespan:** Galvanized steel pipes last about 20 to 50 years before they begin to break down. This lifespan may not seem too short, but it pales in comparison to the lifespans of many other piping materials.

- ✓ **Rust:** Especially in pipes with a small diameter, rust can build up inside over time. In some cases, the rust can break loose from the inside walls of the pipe and end up mixing with the water as it flows through. This discolors the water.
- ✓ **Lead Contamination:** If pipes become corroded, lead can leach into the water inside, making it unsafe to drink.
- ✓ **Clogs:** Over time, mineral build-up inside of galvanized pipes can begin to form clogs that block water flow.
- ✓ **Weight:** The downside to these pipes being very sturdy is that they are also extremely heavy. This makes them difficult to work with.
- ✓ **Vulnerability:** When galvanized pipes are damaged, the galvanization on the outside is compromised, which makes the pipe vulnerable to corrosion in a short amount of time.

3. Polyvinyl Chloride Pipes

Polyvinyl chloride, more commonly known as PVC, has become a popular choice for plumbing pipes in recent years. This material is a thermoplastic polymer. In other words, it is made out of a combination of plastic and vinyl. PVC pipes are rigid and are usually white, cream or grey in color. They are used most often for highly pressurized water, such as in a home's main water supply line. PVC pipes work in a variety of applications, including for transporting potable water and for draining.
Depending on the application, you can choose a particular thickness and configuration designed to best support that application.

Pros and Cons of Polyvinyl Chloride Pipes

PVC pipes have gained popularity because of some important advantages they offer, including:

- ✓ **Longevity:** PVC is not subject to rust or corrosion, so unless it experiences some sort of unexpected damage, it can last indefinitely. Even the most durable metals used in plumbing pipes cannot live up to the impressive lifespan of PVC.
- ✓ **Ability to Handle Pressure:** PVC is often used for the main supply line that goes into your home because it is able to handle high water pressure.
- ✓ **Ease of Use:** PVC is extremely light compared to metal pipes, which makes it easy to transport and to work with. It is also easy to work with because there is no soldering required to connect pipes. Instead, pipes are essentially glued together.
- ✓ **Low Cost:** PVC is low in cost as well. Especially compared to copper, PVC is a very inexpensive option for plumbing pipes.

While PVC has some marked advantages, it has a couple of disadvantages, too. These include:

- ✓ **Susceptibility to Warping:** PVC is not equipped to transport hot water. This is because, like most plastics, heat can cause the material to warp and melt.

- ✓ **Size:** Sizing options for PVC pipes are limited, which can be an issue at times. Even if your PVC piping is the perfect size, fittings used to connect PVC pipes can tend to be bulky, which can be problematic in tight spaces.

4. Chlorinated Polyvinyl Chloride

Chlorinated Polyvinyl Chloride, shortened to CPVC, is closely related to PVC. Though both materials are made from the same basic elements, the key difference is that CPVC is chlorinated. This chemical difference makes CPVC able to withstand temperature differences in a way that PVC cannot. For this reason, some building codes call for CPVC in place of PVC for transporting hot water.
Whereas PVC is typically only available in a sizing system called Nominal Pipe Size (NPS), CPVC comes in this sizing system as well as in Copper Tubing Size (CTS). As the name suggests, this sizing system mimics the same size graduations used by copper piping.

Pros and Cons of Chlorinated Polyvinyl Chloride

CPVC pipes share many of the advantages of PVC, plus one more:

- ✓ **Longevity**: Like PVC, since CPVC is a plastic material, it does not react to corrosive substances and does not rust, so its lifespan is indefinite.
- ✓ **Ability to Handle Pressure**: CPVC shares PVC's ability to handle high water pressure, making it a good material for a main water supply line.
- ✓ **Ease of Use**: CPVC is also quite lightweight, which makes it easy to move and work with. CPVC is also somewhat flexible.
- ✓ **Low Cost**: Though CPVC costs more than PVC, it is still a budget option compared to metal piping materials.
- ✓ **Temperature Tolerance:** CPVC is able to withstand extreme temperatures up to 200 degrees Fahrenheit. This equips CPVC to handle hot water transport.

CPVC does not have many clear disadvantages, though it may not always be the best choice. Cons include:

- ✓ **Indoor Application Only:** CPVC is vulnerable to breaking down if exposed to sunlight for extended periods of time.
- ✓ **Cost Compared to PVC:** Though cost was included as an advantage of CPVC, when comparing it directly to its close cousin, PVC, it does cost more.

5. Cross-Linked Polyethylene Pipes

Cross-Linked Polyethylene, or PEX for short, is another plastic material used for piping. Plastic pipes in general have become a popular type of pipe used in new homes. This particular plastic material is relatively new on the plumbing scene and can be used for a variety of plumbing applications. The major difference between PVC and PEX is that PEX pipes are flexible. This means they can be used in long, continuous runs.

In addition to being flexible, PEX is easy to cut and join together. The PEX system is designed to fit together with the combination of barbed fittings and crimping rings or cinch clamps. This method of joining pipes is in lieu of any soldering or gluing. The installation process is quick and easy, and the material is made to last. PEX piping can come coiled up in a flexible roll, wrapped in aluminum to keep its shape or in hard lengths.

Pros and Cons of Cross-Linked Polyethylene Pipes

To become the new favorite piping choice among many plumbers and homeowners, this material must come with some major advantages. These include:

- ✓ **Longevity:** PEX pipes, like PVC and CPVC, are completely rust and corrosion resistant. This means they can last indefinitely without needing to be replaced, unless they are broken somehow.
- ✓ **Flexibility:** PEX is flexible enough to make 90-degree turns with no problem. It can easily be snaked into walls — making it a great material for retrofitting — and it is able to extend across the length of a house with just one long piece.
- ✓ **Ease of Use:** PEX's flexibility makes it very easy to install. When joints are needed, no soldering or even gluing is required.
- ✓ **Temperature Tolerance:** Another important advantage of PEX over PVC is that PEX is able to withstand extreme temperatures. It can be used to transport hot water as well as cold.
- ✓ **Low Cost:** Like CPVC, PEX is more expensive than PVC, but, at about $30 per 100 feet of piping, is still significantly cheaper than copper.

PEX does have a few disadvantages, though one of these PEX plumbing disadvantages has largely been debunked. PEX pipe problems include:

- ✓ **Indoor Application Only:** PEX piping cannot be used in any outdoor applications since the plastic can be damaged by UV radiation. Of course, this is not really a disadvantage if you only plan to use PEX piping indoors.
- ✓ **Water Taste and Odor:** Some types of PEX pipes have been known to affect the taste and odor of drinking water, especially if the water has stayed in the pipes for some time.
- ✓ **Possible Safety Concerns:** There has been some concern and debate over whether PEX piping has the potential to contaminate drinking water due to the material's makeup. These concerns have largely been dispelled, however. Even the strictest environmental regulations in the U.S. now approve PEX piping, and research has shown that drinking water from PEX pipes does not involve health risks.

Additional Plumbing Pipes

Now that we have looked at some of the most common types of plumbing pipes, let's take a quick look at several others that are not quite as common. These include stainless steel, cast iron, polybutylene (PB) and high-density polybutylene (HDPE). We will also briefly discuss another type of pipe that is not intended for plumbing: black iron.

1. Stainless Steel Pipes

Stainless steel piping is actually more expensive than copper piping. A high price point, however, indicates a high level of quality. Stainless steel pipes are strong and corrosion-resistant. Because of their ability to resist corrosion, stainless steel pipes are the preferable choice in areas that are susceptible to it, such as coastal communities.

Stainless steel piping is available in both flexible and rigid versions, and it comes in a variety of sizes. Pipes are fitted together using couplings.

2. Cast Iron Pipes

Cast iron used to be a common piping material for drainage systems, particularly in the first half of the twentieth century, and it can still be found in many homes today. Cast iron is extremely strong, durable and heavy. Cast iron also reduces sound and is heat-resistant.

Despite the advantages of strength and durability, though, a big disadvantage of cast iron is that it is susceptible to rust over time. In homes that have cast iron piping, if a pipe rusts all the way through, that section can be replaced with plastic piping, like PVC. Cast iron pipes come in various sizes, with the smallest usually being four inches.

3. Polybutylene Pipes

Polybutylene pipes, also referred to simply as PB pipes, were a popular choice for plumbing from the late 1970s to the mid-1990s. In fact, as many as 10 million homes built during that timeframe included polybutylene piping of some kind. Polybutylene is a type of plastic resin that was seen as a futuristic material, perfect for replacing copper.

These grey, plastic pipes were, and are, inexpensive and easy to work with. However, they fell out of favor because it was demonstrated that PB pipes were prone to leakage at the joints.

4. High-Density Polybutylene Pipes

High-Density Polybutylene pipes, also known as HDPE pipes, are one of the most popular choices for underground service lines, though they work in a variety of plumbing applications. This is due to HDPE's durability and ability to resist corrosion.
Some codes call for buried plastic lines to be made from HDPE instead of PVC. HDPE pipes are flexible, so they require minimal joints. Where they do require joints, heat fusion is used, making these pipes mostly leak-proof.

5. Black Iron Pipes

This type of piping is worth a mention, though it should be understood that it is not meant to be used in plumbing applications. Black iron pipes were at one time a popular piping

material for water supply, but today, they are only used for conveying natural gas or propane. Black iron is also a popular choice for fire sprinkler systems since it is especially effective at resisting extreme heat.

Joining Methods

Materials and Jointing Methods for Pipe and Tube Systems

1. Joint Methods Used for Pipe and Tube

Pipes are commonly joined by welding, by using pipe threads, or by using mechanical coupling. Process piping is usually joined by welding using a TIG or MIG process. The most common process pipe joint is the butt weld. The ends of pipe to be welded must have a certain weld preparation called an End
Weld Prep (EWP) which is typically at an angle of 37.5 degrees to accommodate the filler weld metal. Another form of jointing for heavy wall pipe is threading of which the most common form in Europe is the British standard pipe thread (BSP).
Copper pipes are typically joined by soldering, brazing, compression fittings, flaring, or crimping. Plastic pipes may be joined by solvent welding, heat fusion, or elastomeric sealing.
If frequent disconnection will be required, gasketed pipe flanges or union fittings provide better reliability than threads. Some thin-walled pipes of ductile material, such as the smaller copper or flexible plastic water pipes found in homes for example, may be joined with compression fittings.
Underground pipe typically uses a "push-on" gasket style of pipe that compresses a gasket into a space formed between the two adjoining pieces.
Push-on joints are available on most types of pipe. Under buried conditions, gasket-joint pipes allow for lateral movement due to soil shifting as well as expansion/contraction due to temperature differentials.
Large above ground pipe typically uses a flanged joint, which is generally available in ductile iron pipe and some others. It is a gasket style where the flanges of the adjoining pipes are bolted together, compressing the gasket into a space between the pipes.
Mechanical grooved couplings or Victaulic joints are also frequently used for frequent disassembly & assembly. Developed in the 1920s, these mechanical grooved couplings can operate up to 1,200psi working pressures and available in materials to match the pipe grade. Another type of mechanical coupling is a
Swagelok brand fitting; this type of compression fitting is typically used on small tubing under ¾" in diameter.
Other jointing methods such as welding and threading and have been dealt with in earlier units and therefore this unit will only concentrate on the following jointing techniques:

- ✓ Soldering
- ✓ Bronze Welding
- ✓ Compression joints
- ✓ Flange joints

2. Materials Used for Pipe and Tube

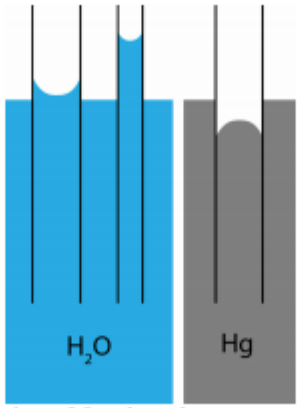
Many different materials are used for pipe and tube systems. The reason for their selection for different applications has been dealt with in Module 3, Unit
1, Piping Materials. For the purpose of this unit we will be dealing with the following materials:

- ✓ Carbon Steel
- ✓ Stainless steel
- ✓ Copper
- ✓ Plastic piping
- ✓ Glass and ceramic piping

Thermal Joining Process for Copper Tube and Fittings

1. Capillary Action Applied to Soldering

A well-known phenomenon, which many people find hard to believe, in which liquids can rise upwards between two surfaces. To demonstrate this phenomenon put a clear drinking straw into a glass of water; if the straw is squeezed together the water will rise even higher.
Capillary attraction is caused by the liquid adhering to the side walls of the straw and then, due to cohesion of the water molecules (the need to hold together), pulling itself up to the level of adherence, the water then adheres again to the sides of the straw and again the water pulls itself up to the level of adherence. This process continues until the weight of the water molecules is too great and pulling itself up the level of adhesion proves too much.
Thus it can be stated that capillary attraction is caused by the adhesion and cohesion qualities of liquids. The closer two surfaces are together, the higher the liquid will rise (see illustration below). Also should the surface be greasy or oily liquid will not readily adhere. But it can also cause problems and damage such as water passing between the laps in sheet weathering material.



Capillary action of water in tubes. (Note how the water rises higher in the narrower tube.)

2. Soldering and Capillary Action for

Soldered Joints

Soldering is a process in which two or more metal items are joined together by melting and flowing a filler metal into the joint, the filler metal having a relatively low melting point. The filler metal used in the process is called solder. Soldering is distinguished from brazing by use of a lower melting temperature filler metal; it is distinguished from welding by the base metals not being melted during the joining process. In the soldering process, heat is applied to the parts to be joined, causing the solder to melt and be drawn into the joint by capillary action and to bond to the materials to be joined by wetting action. After the metal cools, the resulting joints are not as strong as the base metal, but have adequate strength and water-tightness for many uses.

Because soldering relies on capillary action to draw the solder into the joint the surfaces need to be clean to get good adhesion. If capillary joints are used on mains water supply the solder used must be lead free. There are 2 types of soldering joints:

- ✓ Hard Soldering
- ✓ Soft Soldering

3. Hard Soldering

Hard Soldering is also known as silver soldering or cupro–techtic welding.

This is because the rod used has a small amount of silver added to it to lower its melting point and to allow the molten metal to flow more easily.

A special kit of tools has been designed by the Rothenberger company for use with this type of hard soldering. This kit allows the plumber to make straight joints, branches and reduces without the use of any fitting. This has a number of advantages for the plumber. Since less fittings are required there are considerable cost savings.

Silver Soldering requires a lot of heat and special torches are available for this.

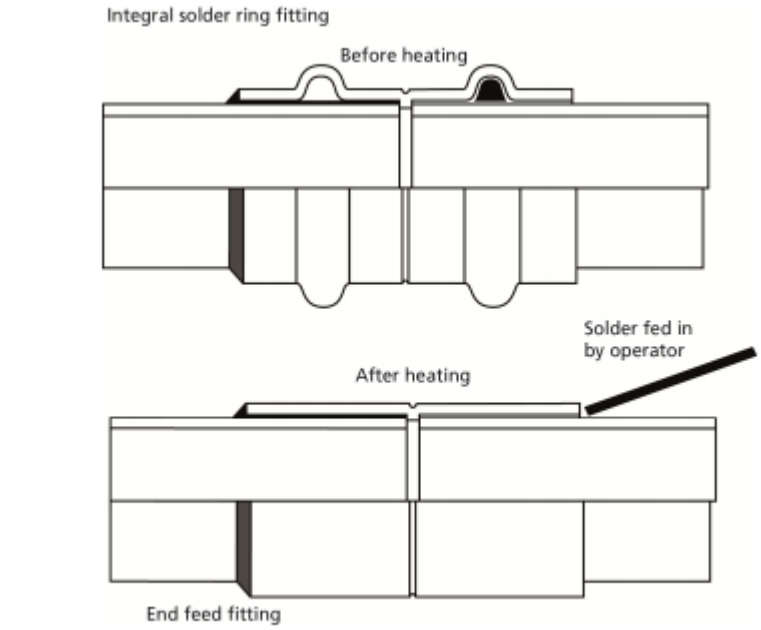
One is the air-acetylene torch which gives a mixture of air and propane. Both of these flames are hot enough to melt the silver solder rod but not the copper pipe. Oxyacetylene equipment may also be used but care must be taken not to melt the copper. No flux is required for this joint due to the high temperature

(600º - 500º).

The silver solder joint is one of the most reliable ways of jointing copper. The joint itself has almost the same characteristics as copper and it seldom leaks.

4. Soft Soldering

Soft soldering is a means of jointing pipe using traditional plumbers solder which is a mixture of tin and lead. A comprehensive range of fittings are available and the solder is usually incorporated into each one in the form of an integral ring. Fitting without this ring of solder are also available but are not as popular as the first type.



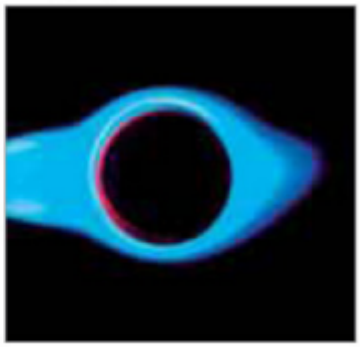
Soldered joints demonstrating capillary action (top joint integral solder ring, bottom joint solder fed by operator)

Soft soldering is characterized by the melting point of the filler metal, which is below 400 C and so a standard butane plumber's blowtorch or blowlamp is used. In fact too much heat is almost as bad as too little where soft soldering is concerned.

Because of the low temperature being used great care must be taken when preparing the joint. Both the outside of the pipe and the inside of the fitting must be thoroughly cleaned with steel wool or emery paper. Flux is then applied to both surfaces and the joint is then pushed together. All parts of the fitting must be prepared and jointed at the same time. Always try and do the lower joint first. When the heat is applied look for a small ring of solder which will appear at the face of the fitting. This is an indication that the solder is melting. Most plumbers like to add a small amount of solder to the joint to make sure the joint is sound. If too much solder is used the excess can be wiped off with a piece of rag or brown paper smeared with a small amount of flux.

Flux is applied to help clean the joint and should never be applied with the fingers or allowed come into contact with the skin as it is very corrosive. It should always be applied with a brush. When soft solder jointing is used in plumbing and heating systems always ensure the system is flushed out thoroughly to remove any excess or residue flux.

Soft soldering is a lot cheaper than using compression fittings but care must be taken when using this method to ensure that there are no leaking joints.



Soft Soldering central heating pipe *Flame heating action on joint*

5. Bronze Welding

A third common thermal process to join copper pipe is a method known as bronze welding. Although it is referred to as "welding", no melting of the parent metal takes place. However, the bond produced is equal in strength and comparable to a fusion weld.
Oxy-acetylene equipment is most satisfactory for this process as it is able to produce and intensely hot flame that gives controlled local heating.
A special brass rod is used to make the joint. This rod consists of approximately 60% copper and 40% zinc. It is necessary to add flux to the joint to enable the rod to adhere to the copper and to prevent oxidation. The flux may be used in powder form by dipping the heated end of the brass rod into it. An alternative method is to mix the flux with clean water to form a smooth paste which can be applied to the weld area and the filler rod with a small brush. Some brass rods have flux impregnated into them by the manufacturers.
The melting point of copper is 1,080ºC while the melting point of the brass filler rod is 850º-950ºC. A slightly oxidising flame should be used.
The main types of bronze welding joints used on copper pipe are:

- ✓ Bell Joint: Used on pipes in the vertical position. The lower pipe end is belled out to receive the top pipe.
- ✓ Butt Joint: Used to join pipes in the horizontal position.
- ✓ Branch Joint: Used for branch welds. The branch hole may be filled, cut or burned out.
- ✓ Reducing Joint: Used where it is necessary to join pipes of different sizes.
- ✓ Blank Welds Used to blank pipe ends.

Note: Many people refer to bronze welding as "brazing". While the materials and joint process are the same, the technique is slightly different. Brazing uses the principal of capillary attraction in the jointing

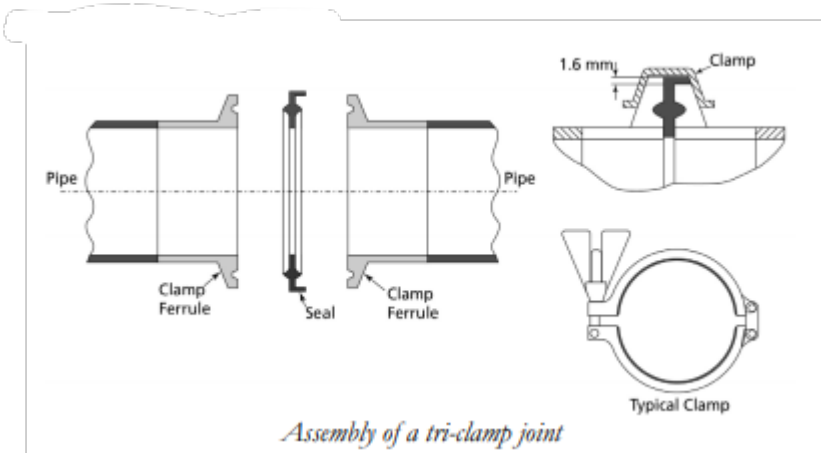
Tri-clamp and Compression Joints for Tube Systems

1. Tri-Clamp Joint for Hygienic Tube

Clamp fittings provide a crevice free joint and, depending on the clamp design, requires no tools for assembly or dismantling for cleaning. Provides quick method of regularly

opening up a system and often has some kind of closure device such as 'Triclover' clamp. Used where corrosion and contamination are particular hazards, as in the pharmaceutical industry. Also used in systems carrying warm semi-solids and viscous liquids, such as chocolate and tomato sauce, which must not cool in the line but tend to cause regular blockages.

Clamp fittings comprise four parts – two welding ferrules, a seal ring (gasket) and a clamp. The ends of the tubes and/or fittings to be joined have a welding ferrule fitted by welding. The joint is made by positioning the welding ferrules together, with a seal inserted between the faces, and then clamping the ferrules together. The clamp is not in contact with the contents of the pipe and may be made of any suitable material.



Assembly of a tri-clamp joint

2. Standards for Tri-Clamp Joints

There are a wide range of different standards for the tri-clamp fitting and it is important to ensure you have the correct one. There are subtle differences between the overall ferrule dimensions which can cause consternation when trying to seal a joint with the wrong seal or clamp. Some of the different standards for tri-clamp joints are as follows:

- ✓ ASME BPE 2004
- ✓ BS4825 Part 3
- ✓ BS Sch 5 and Sch 10
- ✓ DN32676 Series 2 (Standard and Non-standard)
- ✓ DN32676 Series 1 & 3
- ✓ ISO1127
- ✓ ISO2037
- ✓ Mini series ultra bore
- ✓

3. Introduction to Compression Joints

A quicker alternative to soldering a joint for tubing systems is to use compression fittings. Soldering light tubing requires a special skill while making a compression fitting requires only a wrench. If the segments of piping or tubing are of dissimilar metals or materials--if a segment of copper pipe to be joined to a segment of PVC pipe, for example--the

compression fitting is the optimum choice to make the joint. The fittings will also be made of one or more compatible materials appropriate for the connection.

Compression joints are frequently used for small gauge, thin-walled piping such as fuel lines, gas lines or potable water systems, (to avoid the use of lead solder). Compression fittings are also used extensively for hot and cold water faucets (taps) and toilet stop valves. These valves generally control water to one fixture, such as a toilet, to allow it to be serviced without turning off the water to the entire house. Compression fittings are well suited to this application, as these valves are usually located in confined spaces where copper pipe would be difficult to solder without creating a fire hazard.

4. How Compression Joints Work

As the name implies, compression fittings form a tight seal by applying a compressive force to the pipes and pipe fitting. The fitting is compressed against the pipe with a force sufficient to eliminate all space remaining in the joint, thus preventing fluid from leaking

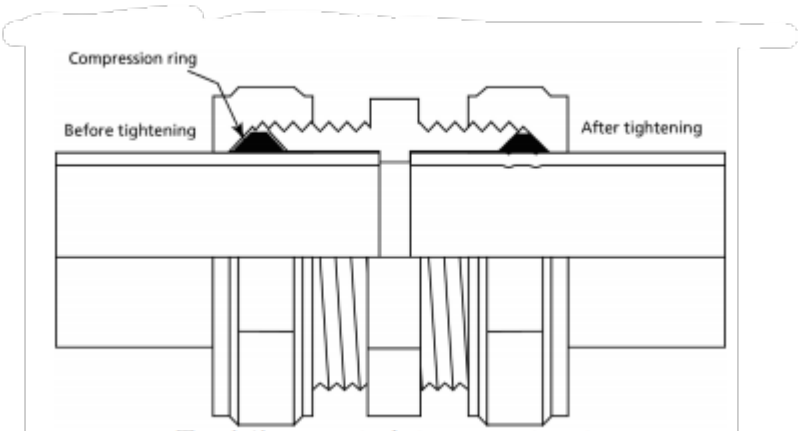
The compression fitting is composed of an outer compression nut and an inner ring called a compression ring. This brass ring is referred to as a ferrule or olive. This is usually made of brass or copper. When the nut is tightened, it clamps down on the ferrule, causing it to conform to the circumference of the pipe. Ferrules vary in shape and material but are most commonly in the shape of a bevelled ring and are most commonly made out of brass or according to the pipe material. To work properly, the ferrule must be oriented correctly. Typically the ferrule is fitted such that the longest sloping face of the ferrule faces away from the nut.

5. Types of Compression Joints

There are two common types of compression fitting, the standard (British, type-A/non-manipulative) and flare fittings (British, type-B/manipulative) compression joints. Standard fittings are generally used for water and compressed air connections, while the flare fittings are used for gas and high pressure lines.

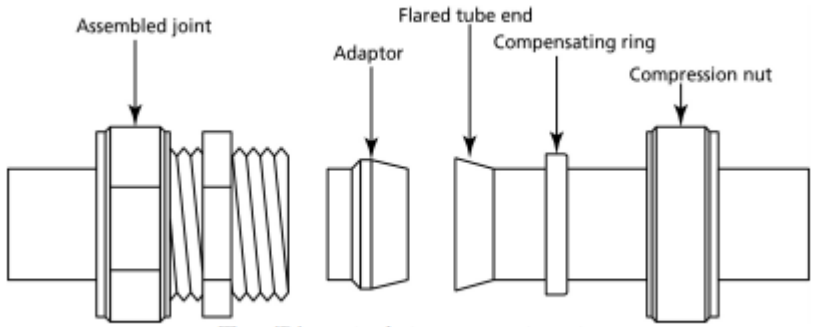
Non-Manipulative Compression Joint

The jointing method for the standard compression joint, illustrated below, simply consists of selecting the correct sized fitting for the tube, cutting the tube to the correct length, removing any burrs and checking that the tube end is clean and free from deep scores or other imperfections. If the tube end is oval it should be re-rounded with a suitable tool. Now the tube can be fully inserted into the fitting until it makes contact with the tube stop. Next tighten in accordance with the manufacturers instructions. For example:- tighten the compression nut by hand and a spanner until the compression ring grips the tube, so that it cannot be rotated by hand in the fitting. Now further tighten the nut one third to two thirds of a turn using two spanners, this is to cause the compression ring to bite into and slightly deform the tube.



Type 'A' non-manipulative compression joint

Manipulative Compression Joint The manipulative compression joint, as shown below, is designed to grip both the inner and outer surfaces of the tube, this results in a joint which can both support and tightly grip the soft condition tube for which it is designed. The jointing method consists of ensuring that the tube is of the correct specification and that the correct size of fitting is being used, next the tube is cut to length using a fine toothed hacksaw and the burrs moved inside and out. Slip the compression nut and compensating ring over the tube end and hammer the correct sized flaring tool or drift into the end of the tube to open out the end. Next check that the adaptor fits correctly into the end of the tube and the fitting body and tighten the compression nut first by hand and then with a spanner for about one full turn to produce a strong and leak-proof joint. The well known Swagelok brand of compression fittings are an example of this type of joint.



Type 'B' manipulative compression joint

Standard fittings require no modifications to the tubing. Flare fittings require modification of the tubing with a special tool.

3.6 Sealing a Compression Joints

The most important component in a compression seal is the compression ring itself. The ring is a thin piece of brass and is extremely prone to damage; therefore care should be used when installing them. It is important to the integrity of a compression fitting that excessive force is avoided in tightening the nut. If the fitting is over-tightened, the ferrule frequently deforms and the compression fitting fails. Over-tightening is the most common cause of leaks in compression fittings. Generally, compression fittings are tightened to "finger tight" and then tightened a half-turn more with a wrench. The actual amount

varies with the size of the fitting; a larger one requiring less. The fitting is then tested. If slight weeping is observed, the fitting is slowly tightened until the weeping stops.

Joint compound or thread seal tape is not applied to a compression fitting's threads. Joint compound and Teflon tape act to seal the threads from the water pressure in normal threaded connections, but serve little purpose in compression seals and may actually serve to weaken them. The compression is the means of sealing the joint, not the sealing of the threads themselves. Pipe compound or PTFE tape frequently leads to leaks in the fitting; in the case of Teflon tape, it allows a gap to form between the compression ring and nut. Joint compound is sometimes applied to the ferrule or olive to seal imperfections in the fitting, but really serves no purpose as the sealing is enacted through the compression ring itself. Rarely does joint compound or Teflon tape compensate for the loss of an air/watertight seal if the compression ring becomes "ovalled" (due to over-tightening while in a misoriented position, in relation to the compression nut), or if there is some factory defect in the product. In these instances, the compression fittings are simply replaced.

6. Advantages and Disadvantages of Compression Joints

Compression fittings are popular because they do not require soldering, so they are comparatively quick and easy to use. They require no special tools or skills to operate. They work at higher pressures and with toxic gases. Compression fittings are especially useful in installations that may require occasional disassembly or partial removal for maintenance etc, since these joints can be broken and remade without affecting the integrity of the joint. They are also used in situations where a heat source, in particular a soldering torch, is prohibited.

Compression fittings are not as robust as soldered fittings. They should be used in applications where the fitting will not be disturbed and not subjected to flexing or bending. A soldered joint is highly tolerant of flexing and bending (such as when pipes knock or shake from sudden pressure changes). Compression fittings are much more sensitive to these types of dynamic stresses. They are also bulkier, and may be considered less aesthetically pleasing than a neatly soldered joint.

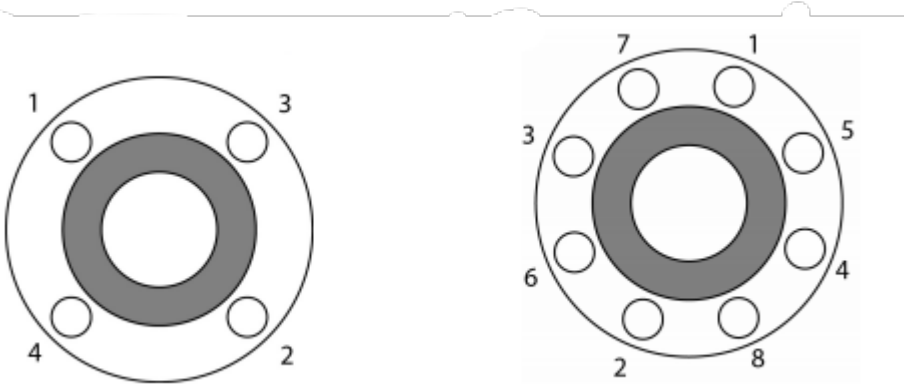
Flanged Pipe Joints

1. Assembling a Flange Joint

When assembling a flanged joint, always use a full complement of clean, new high strength bolts ensure that the new bolting material strength properties exceed the calculated bolt stress values to be generated in making the piping connection.

1. Always use flat washers on both sides of the connection.
2. Tighten all bolts until finger tight and ensure that joint and gasket are correctly aligned.
3. Tighten the flange bolts with a calibrated torque wrench to the specified bolt torques. Note: For anti-seize compounds, the torque values will be different.

4. Tighten the flange bolts with a torque wrench; using a "crisscross" pattern that alternately tightens the bolts located 180 degrees apart. (see illustration below for 4 hole and 8 hole flanges.)
5. Using this pattern, tighten the bolts in 20% increments of the final bolt torque until 80% of final bolt torque has been achieved.
6. For tightening to the final torque values, tighten bolts sequentially clockwise once around the flange. This will help ensure that the bolts are evenly stressed.
7. Care should be taken to avoid over-torqueing, which can cause damage to the gasket and the sealing surfaces.



Torqueing sequence for 4 hole and 8 hole flanges.

Note: When bolting together dissimilar materials, always tighten to the lowest recommended torque of the components in the joint. Using higher torques may cause excessive deformation of the "softer" material in the joint.

2. Pressure Testing Systems with Flanged Joints

Normally, after initial torque and re torque, a hydro test should be performed following ANSI requirements. Experience has shown that if the above procedure has been followed very few, if any, of the flange joints may fail the hydro test. If a flange joint does leak, first check the torque values, and then tighten in 10% increments over the specified bolt torques until sealed.
However, if 150% of the specified torque value is reached and the flange joint still leaks, stop and disassemble the flange joint. Something else is probably wrong such as a damaged flange face, damaged gasket or a misaligned joint.
Only after the pressure test has been successfully completed and any leaks corrected, can the pipeline can be signed off and commissioned.

3. Re-Torqueing Flanged Joints

Torque loss is inherent in any bolted joint. The combined effects of bolt relaxation, (approximately 10% during the first 24 hours after installation), gasket creep, and vibration in the system, thermal expansion and elastic interaction during bolt tightening contribute to torque loss. When torque loss reaches an extreme, the internal pressure exceeds the compressive force holding the gasket in place and a leak or blow-out occurs. A re-torque should be applied a minimum of 24 hours after the initial torque or after the

first thermal cycle. This allows for seating of the flanged joints and for relaxation of the bolts. If the system is to perform at elevated temperatures, it is recommended that hot water be circulated at the maximum operating temperature of the process (if possible) for a minimum of 24 hours. This allows for the pipe system to experience one thermal cycle. After cool down, re-torqueing of the system should be done. Torqueing should only be done on the system in the ambient, cooled state, never while the process is at elevated temperature, or excessive force could be applied to the flanged joints. Never disassemble a flange joint in a hot system. Wait until the system has cooled to ambient temperature.

4. Annual Re-Torqueing Flanged Joints

Re-torqueing should be done at least annually thereafter, especially if the process line experiences elevated temperatures or extreme ambient temperature situations. Torqueing should only be done on the system in the ambient, cooled state, never while the process is at an elevated temperature, as an excessive force will likely be applied to the flanged joints.

5. Gasket Selection for a Flanged Joints

It is important to select the correct gasket for the flanged joint. Properties such as system temperatures, pressures and chemical resistance of the gasket should all be considered. Proper gasket thickness is also important. The thicker the gasket, the higher the gasket creep which in turn can result in torque loss. On standard ANSI raised face flanges a 1.5mm thick gasket is normally recommended. Thinner gasket materials can take a higher gasket load and therefore higher internal pressures.

Fitting Types & Materials

Plumbing is all about pipes and fittings. Pipes establish the runs that bring or take water, with fittings controlling and manipulating the flow. Pipes are simple enough: they're straight, and come in different sizes. Pick the right material and length, and you're pretty much good to go. Fittings - for a plumber - are much the same. But for the average homeowner, there are a lot of fittings. Some can be perplexing, others downright intimidating once materials and sizing are considered. The sizing we'll explore in another article; for now, you can learn a little bit about the most common fittings found in your home's plumbing. Never again will you need to ask for "the thingy with the two ends that connects the two pipes at an angle"!

Different Fitting Types

Adapters

Adapters are used to extend runs, or to simply change the connection type at the end of a pipe. This allows dissimilar pipes to be connected, without the need for a more involved setup.

Adapters are available in most all standard materials: ABS, brass, copper, CPVC, malleable (galvanized and black), PVC, and stainless steel.

Bushings

Bushings are used to join pipes of different sizes, usually by reducing a larger fitting down to a smaller pipe. Bushings are usually - not always - threaded both inside and out, and take up very little space compared to a coupling or union, which accomplish the same goal.

Offered in: ABS, brass, chrome-plated brass, copper, CPVC, malleable (galvanized and black), PVC, and stainless steel.

Note: *Some fitting types, like bushings, have limitations placed on their use (or are not allowed at all) by some plumbing codes. Remember to check local plumbing codes prior to purchasing.*

Caps & Plugs

Caps are, surprisingly enough, used to cap a pipe end. Plugs do pretty much the same thing, but usually fit inside the fitting, and are threaded to allow for future use of the pipe. Caps can be threaded, glued, or soldered onto pipe (depending on its material).

Both are available in: ABS, brass, chrome-plated brass, copper, CPVC, malleable (galvanized and black), PVC, and stainless steel.

Couplings

A coupling is used to extend the run of a pipe, or change pipe sizes (in the case of a reducing coupling, also sometimes called a "bell" reducer due to its shape). Available with female threads, or unthreaded for either plastic gluing (solvent welding) or copper soldering, these are among the most-used of fittings.

Offered in: ABS, brass, chrome-plated brass, copper, CPVC, malleable (galvanized and black), PVC, and stainless steel.

Elbows

If you need to change the direction of flow, elbows are likely your best bet. Produced primarily in 90 and 45 degree angles (unique sizes like 22.5 and 60 are also available), elbows can be threaded or sweated, and are one of the most crucial fittings used in plumbing. Street elbows feature male and female threaded ends to easily connect differing pipes or fittings. Some unique elbows also feature a side outlet, making it act more like a tee with a bend.

Available in: ABS, brass, chrome-plated brass, copper, CPVC, malleable (galvanized and black), PVC, and stainless steel.

Flanges

Flanges are used to connect pipes. Pipe is threaded or welded to the flanges, which are then sealed together (usually with bolts). Flange connections are used extensively in industrial applications handling high pressures. They can also be found connecting residential pump systems. "Closet" (or toilet) flanges are found in the home mounting the toilet to the floor and drain beneath.

Offered in: brass, copper, malleable (galvanized and black), and PVC (for closet/toilet flanges).

Nipples

Nipples are a short stub of pipe, male-threaded at each end, that are used to connect straight pipe runs. Close nipples are threaded from each end along their whole length for particularly tight connections.

Available in: brass, chrome-plated brass, copper, malleable (galvanized and black), PVC, and stainless steel.

Tees

When more than one branch is required of a water supply, tees are the way to go. Essentially a long coupling with an outlet on the side, these fittings feature their outlets at 90° from the inlet, and are sized according to their "run" (the horizontal, or straight-through dimension of the fitting), and the side outlet (the "top" of the fitting, 90 degrees off the run). When the run of a tee is smaller than the side outlet, it's often referred to as a "bull head" fitting.

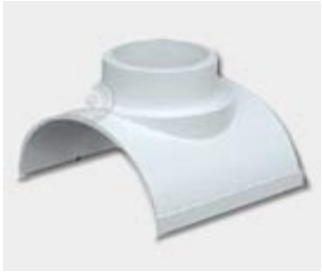
Tees are offered in ABS, brass, chrome-plated brass, copper, CPVC, malleable (galvanized and black), PVC, and stainless steel.

Crosses

"Cross" fittings are 4-way fittings that are essentially the combination of two tees. Many opt to use two tees instead.

Crosses are available in brass, malleable (galvanized and black), and PVC.

Saddle Tees



These fittings are used to quickly add a tee to an existing length of pipe, without having to cut and re-solder what's there. Most often, this takes place with irrigation systems to add a new sprinkler line. Also referred to as snap-tees, saddles are glued to the pipe, and after setting, the new hole is drilled. Saddle tees are offered only in PVC.

Unions

Unions are an alternative to couplings, when the latter are impractical or inconvenient. Whereas couplings (when not soldered) need to have pipe threaded into them, unions rely upon their own nut to create a seal between the pipe ends. This makes them the perfect choice for connecting two fixed pipes (that are unable to be threaded into a regular coupling), and make future repairs that much easier. Dielectric unions are used to join pipes of different metals by providing a barrier against galvanic corrosion. For all their benefits, unions do have drawbacks: they are not to be used with natural and LP gas.

They are available in in brass, chrome-plated brass, copper, CPVC, malleable (galvanized and black) PVC, and stainless steel.

Wyes

Wyes are primarily drainage fittings, and feature a 45° branch line designed to keep flow smooth. While sanitary tees are used with vertical drain connections, they can cause problems when used flat on a horizontal connection: those situations call for a wye.

These are available in brass, ABS, and PVC.

Common Fitting Materials

ABS

Acrylonitrile Butadiene Styrene, a black plastic used in drainage, sewer, waste and vents. ABS pipe/fittings as well as PVC have replaced much of the cast iron, lead, and steel pipes formerly used for DWV. Important to note is that no solvent cement (or primer) can totally "glue" (solvent weld) ABS to PVC plastic.

Brass

Made with a mixture of metal alloys: mostly copper and zinc, as well as small amounts of lead, tin, manganese, nickel, aluminum or iron. Brass fittings used for potable water usually have approximately 62-65% copper, 30-35% zinc and very small percentages of tin and lead. Brass works particularly well in hot water applications, and is highly resistant to corrosion.

Copper

Reddish-brown, non-ferrous metal widely used for household plumbing pipes. Copper is a relatively soft and often thin material, making threading difficult. As a result, most copper fittings are not threaded, and must be soldered to copper pipe.

CPVC

Chlorinated Polyvinyl Chloride is a plastic product designed for drinking water at temperatures up to 180 degrees (where code permits), and can generally withstand higher temperatures than standard PVC. The CPVC fittings we offer will not glue on PVC schedule 40 pipe.

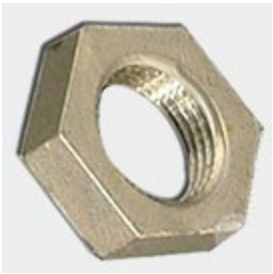
Malleable (Galvanised or Black)

Made from steel. Black iron is mostly used in gas and oil applications, and is often coated with black paint or lacquer. Galvanized fittings are coated with zinc to protect against rust and corrosion. Galvanized piping was widely used for home plumbing in the past, but no longer, due to leak issues over time. Galvanized fittings today are most often used for non-potable outdoor applications, and to repair existing galvanized systems.

PVC

A rigid, generally white plastic pipe. Used for waste and vent systems as well as cold water (underground) supplies outside of the house as well as used for sprinkler and irrigation pipes, sewers, drains, wastes and venting pipes and fittings. PVC in the plumbing business is generally white (Sch 40) but sometimes comes in other colors (in our industry gray is the second most popular, and is typically used for Sch 80 PVC). Another color you may see more frequently as water conservation efforts grow is purple, which is used to differentiate reclaimed or grey water systems from potable drinking water systems.

Stainless Steel



A combination of iron alloys and chromium, stainless steel is durable and offers excellent rust and corrosion resistance. Stainless steel comes in many types, with 304 and 316 being the most used in plumbing. Both are rated to pressures of 150 psi, with type 316 steel providing greater protection against chemical corrosion.

MEASURING INSTRUMENTS

Various kinds of measuring tools are used in automotive workshops and their main purpose is to enable safe, accurate and speedy measurement of work. To achieve this you must select the most appropriate tools and know how to use them correctly

General rules for using measuring tools:

Start Reading

1. Select the most suitable tool to carry out the job safely an effectively. The tool must be in good working condition and fre from fracture and jagged edges. Repair or replace as necessary.
2. Carry out regular tool maintenance to maximise the servic life and to ensure ongoing accuracy of the tool.
3. Read the tool manufacturer's operating instructions. Tools ca vary from

Correct too for the job

4. To reduce down time in searching for tools always return th tools to their correct position on the shadow board or in the container.
5. Ensure that tools are kept clean and free from grease or o This will prevent the grease or oil from being transferred to th customer's vehicle and will also assist the technician to maintai a firm grip of the tool.
6. Ensure that the tool is correctly calibrated before use. A fault measuring tool will provide inaccurate readings which coul prove to be expensive if relied upon.

Tag fault tools

7. Tools that are faulty, damaged or in need of calibration shoul be removed from service, tagged and reported to the worksho supervisor.
8. Only use tools for their intended purpose. Measuring tools ar precision instruments that have been designed for specif purposes. Using them outside specifications may cause damag premature wear or give unreliable results.
9. Always double check measurements. Refer to conversio charts for imperial and metric measurements

Very Important Safety Point

Safety when using measuring tools

- ✓ Some measuring tools have sharp edges so take care to avoid cuts.
- ✓ Never carry tools in pockets or throw tools to colleagues.
- ✓ Only use tools for their intended purpose.
- ✓ Steel measuring tools are conductive so avoid using near live wires or sources of heat.

Common tools

Common measuring tools used in automotive workshops include

- ✓ Calipers: Vernier calipers, digital calipers, internal and external calipers
- ✓ Micrometers: inside, outside and depth
- ✓ Steel rules
- Straight edges
- Measuring tapes

- Squares: engineer's, combination, T-squares and bev protractors
- Spirit levels

Vernier Calipers

The Vernier calipers are a hand held tool that allow an object to be measured in inches/mm to the second decimal place. Vernier calipers measure inside, outside and depth measurements. Verniers are made from stress relieved stainless steel and have precisely ground measuring surfaces to give an accurate reading on the scale. The scale is precisely etched onto the caliper bar and a standard set of Vernier calipers measure from zero millimetres to 152 millimetres.

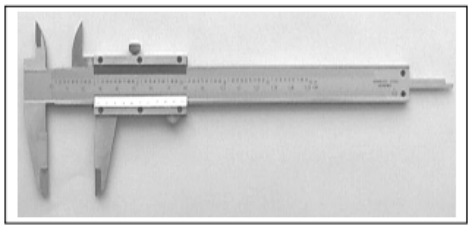
To understand the operation of Vernier calipers it important to appreciate their construction. They a constructed of two scales:

- ✓ Main scale, which is measured in millimetres or inches.
- ✓ Vernier scale, which is measured in fractions of a millimetre or an inch

Main Scale

The most common scale used today is the metric scale.

A Vernier caliper consists of:



1. Metric scale
2. Imperial scale
3. Main scale
4. Sliding Vernier scale
5. Outside measuring jaw
6. Inside measuring jaw
7. Depth gauge
8. Vernier scale lock screw
9. Thumb slide
10. Vernier scale size (1/50)

Vernier Scale

The three main applications of a Vernier scale are to measu outside diameters, inside diameters and depth.

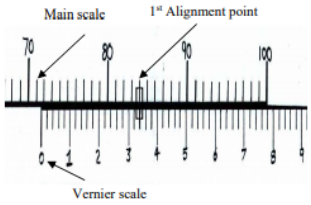
Reading the Vernier scale

Step 1

From the main scale (top row) take the reading in who millimetres up to the zero point on the Vernier scale.

Step 2

Using the Vernier scale (bottom row) locate the first point at which the Vernier scale is in alignment with the main scale.

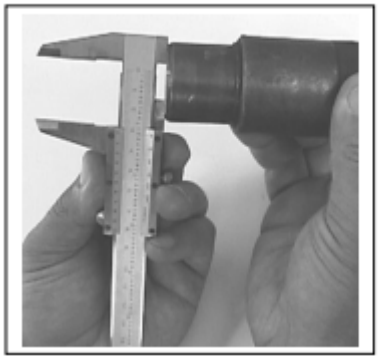


Step 3

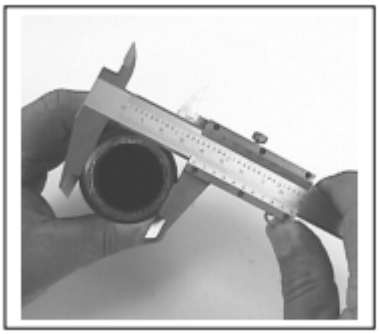
Add the readings together. A thumb lock is used to clamp th caliper sliding bars to enable the user to inspect closely whe measuring in awkward places. Calipers are also available wit a dial indicator gauge. It is recommended that eye protectic be worn when operating a Vernier caliper.

Internal Readin

Correct use of Vernier calipers

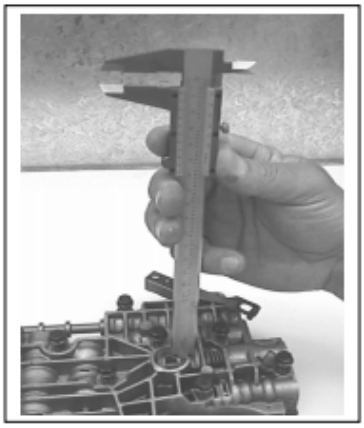


Ensure that both of the internal jaws a into the object to be measured.



When measuring outside diameter the placed fully into the Vernier jaws.

Depth Reading

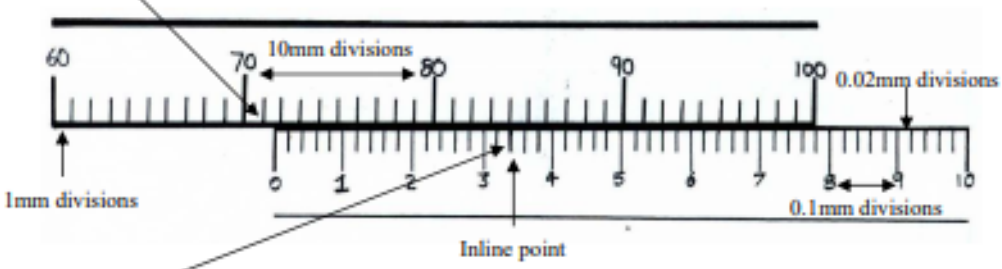


To measure depth, ensure that th measuring scale is flush against the side o

Reading the Vernier scale

Example One

The main scale reading = 71.00 millimetres

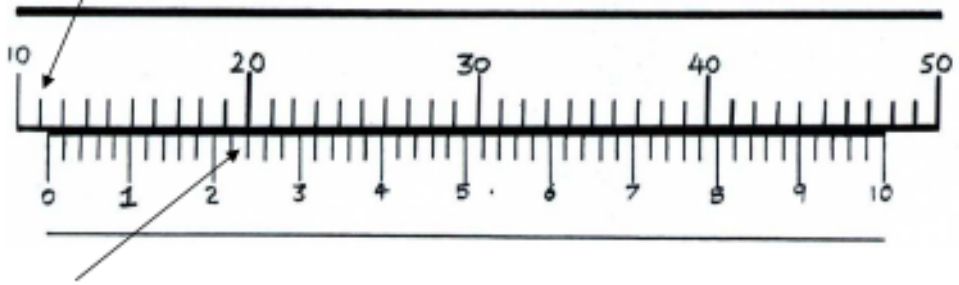


The Vernier scale reading =0.34 millimetres

Total reading = 71.00 + 0.34 = 71.34 millimetres

Example Two

The main scale reading = 11.00 millimetres



The Vernier scale reading =0.24 millimetres

Total reading = 11.00 + 0.24 = 11.24 millimetres

Main scale = 11.00 mm
Vernier scale = 0.20 mm
Inline point = 0.04 mm

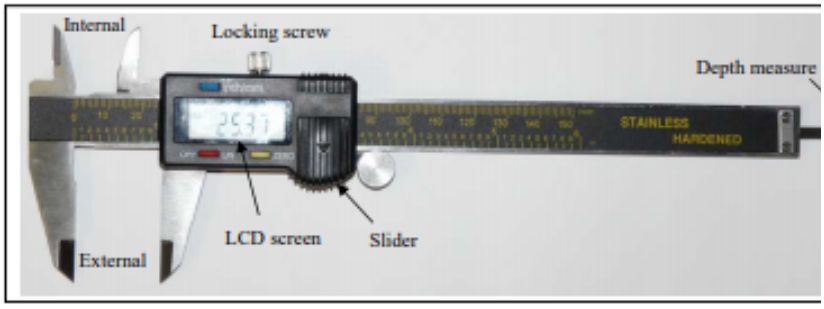
Total = 11.24 mm

Take Note **Storage and handling of Vernier calipers**

- Handle calipers carefully. Avoid dropping or bumpin Calipers are precision tools and any damage will affect th accuracy of readings taken.
- After use, the calipers should be cleaned and drie thoroughly. Wipe the sliding surfaces and measuring face If lubrication is required apply oil lightly to each part of th caliper.
- Check the slider moves free and smoothly. Adjust the s screw as required.
- Store calipers in their container. Do not expose to dire sunlight
- Ensure top pivot is secure and thread not damaged

Digital Calipers

Digital calipers can also be used to take internal, external and depth measureme
They provide accurate measurements and can be switched between imperial and met
A zero function allows for display to be reset at any point along the slide.



Calipers

Calipers can be used for measuring distances and scribing parallel lines, arcs
circles. The main types of calipers used in automotive workshops include:

Inside diameters

Internal calipers

- Internal calipers are used for measuring inside diameters.
- The measuring points of the internal calipers point away from each other.

Using internal calipers

1. Position the calipers centrally between the edges to be measured.
2. Adjust the calipers until both measuring points are in contact with the inner edges with slight drag.
3. Remove the calipers and measure the distance between the measuring points using a steel rule or a micrometer.

Outside diameters

External caliper

- External calipers are used for measuring outside diameters.
- The measuring points of the external calipers point towards each other.
- Can be used to compare the sizes of two parts.

Using external calipers

1. Position the calipers centrally between the outside edges to be measured.
2. Adjust the calipers until both measuring points are in contact with the outer edges with a slight resistance.
3. Remove the calipers and measure the distance between the measuring points using a steel rule or a micrometer.

Micrometers

Micrometers are precision made tools designed to measure inside, outside, and depth measurements to 0.01 mm. They are mainly used to determine the serviceability of components and are generally used on engine components such as:

Engine Components

- Crankshafts
- Bearing surfaces
- Cylinder bores
- Camshafts
- Hole depths
- Pin sizes
- Valve stems
- Pistons

Construction of an outside Micrometer

1. Thimble
2. Sleeve
3. Frame
4. Fixed anvil
5. Ratchet
6. Thimble locking mechanism
7. Datum line
8. Spindle

Reading the Outside Micrometer

The work to be measured is placed squarely between the spindle and the fixed anvil.

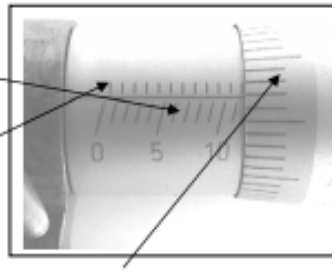
Turn the ratchet clockwise until the ratchet clicks, (two or three attempts are required to ensure the work is centralised).

Centralise the Wor

Apply the thimble locking mechanism and remove the work to allow a close inspect of the measuring scale.

The first reading is taken from the lower scale of the sleeve. Read the whole millimetre figure.

The upper scale on the sleeve shows measurements in 0.5mm graduations.

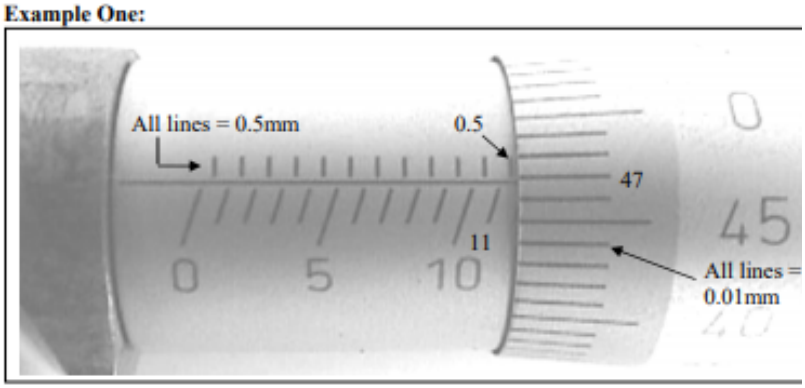


The next reading is taking from the scale on the thimble (this scale is measured 0.01mm graduations).

Outside Micrometer Reading

- The lower scale on the sleeve indicates the distance in whole millimetres.
- The upper scale on the sleeve indicates the distance in 0.5mm graduations.
- The upper and lower scales are read from left to right.
- The thimble scale indicates the distance in 0.01mm graduations and is read fro bottom to top.

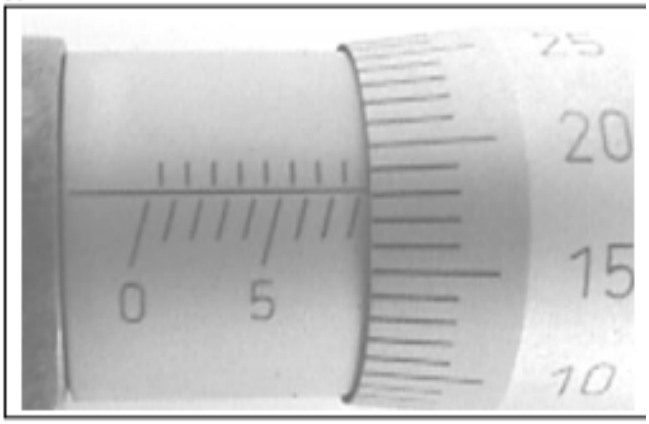
Example One:



Lower scale reading = 11.00 millimetres
Upper scale reading = 0.50 millimetres
Thimble scale reading = 0.47 millimetres

Outside micrometer reading =11.97 millimetres

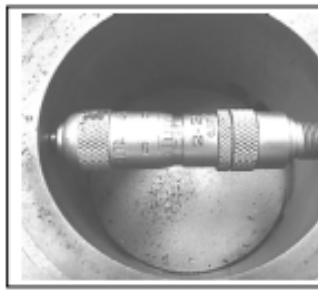
Example Two:



Lower scale reading = 8.00 millimetres
Upper scale reading = 0.00 millimetres
Thimble scale reading = 0.18 millimetres

Outside Micrometer reading = 8.18 millimetres

The inside micrometer is a precision tool designed to measure the inside diameter of an object.



Using an inside micrometer

An inside micrometer consists of:

- Spindle
- Thimble
- Anvils
- Extension piece (if required).

Inside Diameters

Reading the inside micrometer

Select an appropriate sized micrometer and anvil attachment for the hole to measured.

Place the inside micrometer into the hole and turn the thimble until both anvils touching the surfaces.

Adjust the inside micrometer to centralise in the hole.

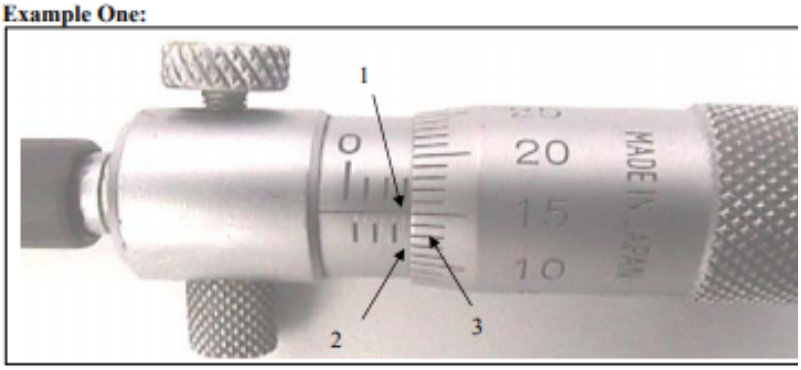
Remove the inside micrometer to allow a close inspection of the measuring scale.

The reading is taken in the same way as an outside micrometer reading.

Internal Micrometer Reading

1. The upper scale on the sleeve indicates the distance in whole millimetres.
2. The lower scale on the sleeve indicates the distance in 0.5mm graduations. upper and lower scales are read from left to right.
3. The thimble scale indicates the distance in 0.01 millimetre graduations and is from bottom to top.

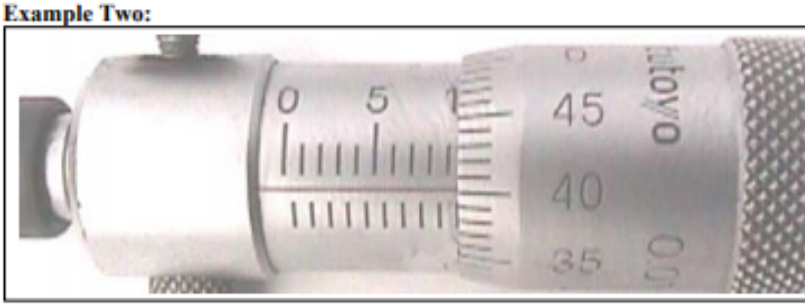
Example One:



Upper scale reading = 3.00 millimetres
Lower scale reading = 0.00 millimetres
Thimble scale reading = 0.15 millimetres

Internal micrometer scale reading = 3.15 millimetres

Example Two:



Upper scale reading = 9.00 millimetres
Lower scale reading = 0.00 millimetres
Thimble scale reading = 0.40 millimetres

Internal Micrometer Reading = 9.40 millimetres

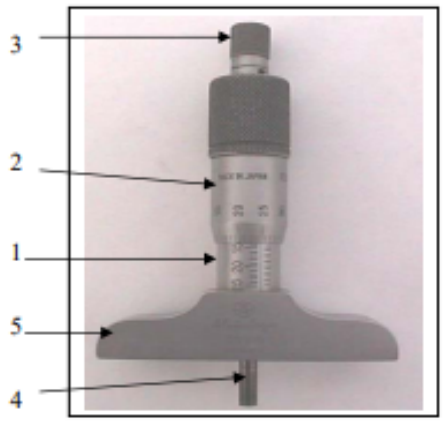
Depth Micrometers

Depth micrometer is a precision tool used to measure the depth of a hole or a step.

Measures hole depths

Construction of a Depth Micrometer

1. Sleeve
2. Thimble
3. Ratchet
4. Adjustable anvil
5. Frame



Right to Left

Reading a Depth Micrometer

Select an appropriate sized depth micrometer for the hole or step to be measured. Adjust the sleeve until the zero line on the thimble lines up with index line on the sleeve.

Ensure that the frame is sitting flat on top of the work.

Adjust the ratchet until the anvil reaches the bottom of the hole or step.

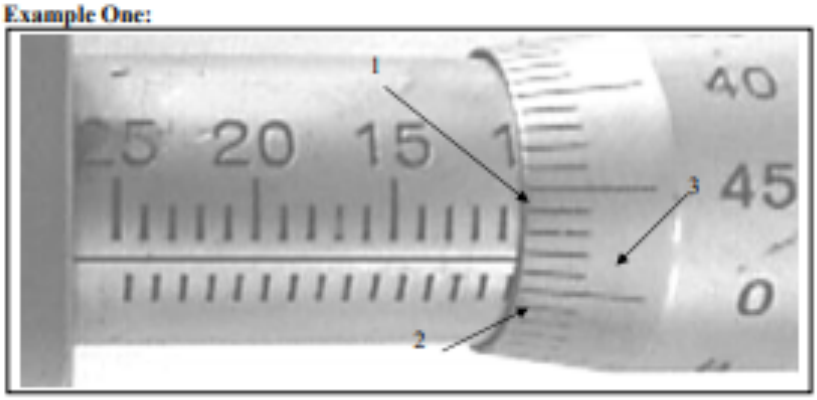
The measuring scale on the sleeve is read from right to left and the measuring scale on the thimble is read anti-clockwise.

Using a Depth Micrometer

The upper scale on the sleeve indicates the distance in whole millimetres.

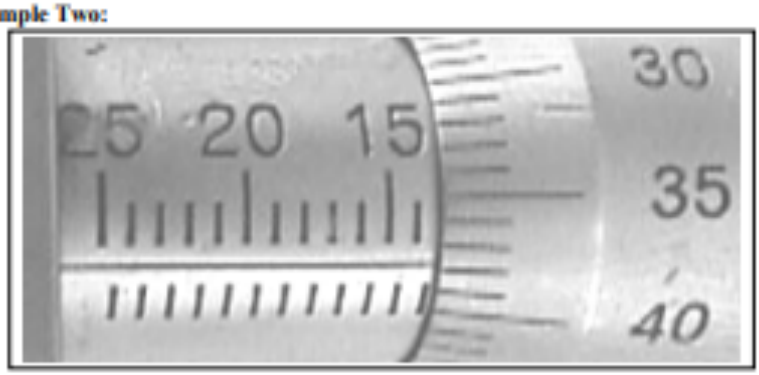
1. The lower scale indicates the distance in 0.5 millimetre graduations. The upper and lower scales are read from right to left.
2. The thimble scale indicates the distance in 0.01 millimetre graduations as in read from top to bottom.

Example One:



Upper scale reading	= 10.00 millimetres
Lower scale reading	= 0.00 millimetres
Thimble scale reading	= 0.48 millimetres
Depth Micrometer Reading	=10.48 millimetres

Example Two:



Upper scale reading	= 13.00 millimetres
Lower scale reading	= 0.00 millimetres
Thimble scale reading	= 0.38 millimetres
Depth Micrometer Reading	= 13.38 millimetres

Take Note Storage and handling of Micrometers

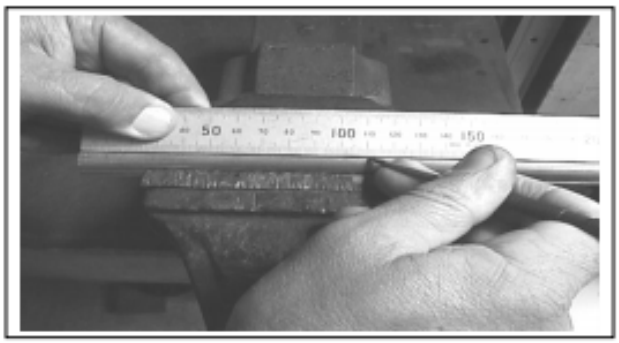
- ✓ Handle micrometers carefully. Avoid dropping or bumping. Micrometers are precision tools and any damage will affect the accuracy of readings taken.
- ✓ Before use wipe off any dust from the spindle, anvil and measuring faces.
- ✓ Allow the micrometer some time to adjust to room temperature.
- ✓ After use, the calipers should be cleaned and dried thoroughly. Wipe the sliding surfaces and measuring faces. If lubrication is required apply oil lightly to each part of the caliper.
- ✓ Check the slider moves free and smoothly. Adjust the set screw as required.

- Store calipers in their container. Do not expose to direct sunlight
- Ensure top pivot is secure and thread not damaged

Steel Rules

A standard steel rule is 30 cm long and is precision machined from steel with two straight edges with a metric and imperial measuring scale. It is used for general purpose measuring of components and metal measuring, scribing, marking and aligning.

General Measurin



Using a Steel Rule to measure work.

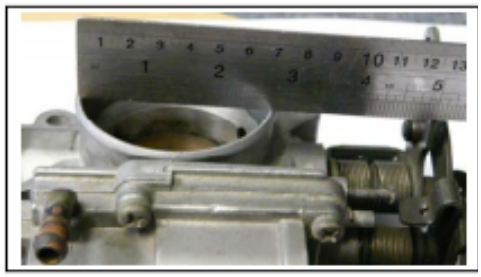
It is important that the steel rule is perfectly flat and straight with straight edges.

Flush wit surface

Using a steel rule

1. Position the steel rule straight across and flush with the surface to be measured. The rule should be held at an angle of 90° to the surface of the work and at 90° to both edges of the work.

2. Align the zero graduation on the steel rule with the work and measure the distance between the two points to determine the length of the work.

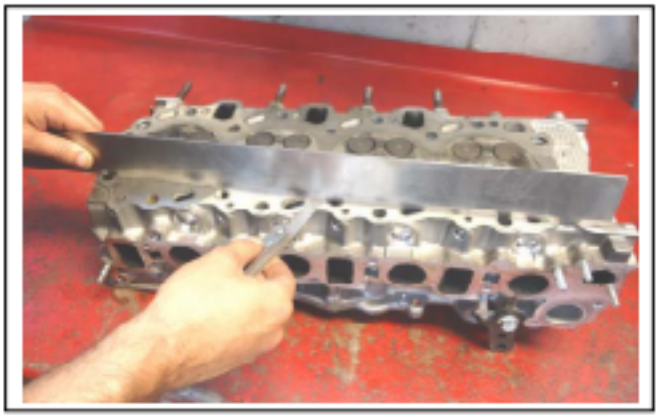


Steel rules should be oiled to prevent rusting when not in use.

Straight Edges

Determine Warpage

A standard straight edge is approximately one metre long. It constructed from precision machined steel and has tw straight edges and a measuring scale on one edge. The straigl edge is used with a feeler gauge to determine warp in cylinde heads, engine blocks and manifolds.



Using a Straight Edge with a Feeler Gauge to measure warp on a cylinder head.

Take Note

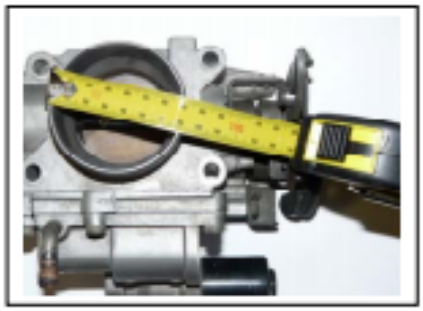
Storage and handling of steel rules and straight edges

- Handle rules and edges carefully. Avoid dropping c bumping. Remember these are precision tools and ar damage will affect the accuracy of readings taken.
- Rules and edges must never be exposed to an electric supply.
- After use, rules and edges should be cleaned and drie thoroughly.
- Steel rules should be stored in their protective plast covering provided by the manufacturer when not in use.
- Store rules and edges their protective cover and hang on shadow board.
- Never store rules or edges with loose tools.

Measuring Tapes

Retractable measuring tapes are used in the automotive industry for a variety of measuring activities such as measuring panels, suspension heights, lamp positions and wheel base dimensions. Measuring tape scales can be metric, imperial or a both.

Measuring tapes have a measuring scale stamped onto a curved metallic strip that retracts into a container. They are spring loaded so as soon as the tape is released it will return to the container. A stop mechanism on the container allows the tape to be held into position when extended.



A metal tab at the start of the ribbon allows for the tape to be attached at the start end so that measurements can be taken single-handedly.

Measuring tape sizes range from 2m to 10m. After use measuring tapes should be wiped with a clean rag to remove oil and grease and then stored in a tool box.

Squares

Squares are commonly used in panelbeating, fabrication and engineering workshops for measuring work where specific angles are required. Squares that may be used include:

- ✓ Engineer's square
- ✓ Combination square
- ✓ T-square
- ✓ Bevel protractor
- ✓

Engineer's Square

Datum lines

ENGINEER'S SQUARE

An engineer's square is a precision tool made of carbon steel and is used for measuring and checking angles of 90°, for marking out lines at right angles to the datum line and for squaring two pieces of work.

The engineer's square consists of two straight edges (marking blade, stock rest) joined together at an angle of 90°. It is important that the engineer's square is regularly calibrated.

Stock rest

Using an engineer's square

1. Before using the engineer's square ensure that the work surface is clean a of burrs.
2. Position the edge of the stock rest firmly against the work surface.
3. Move the stock rest until the marking blade is flat onto the surface of the
4. Evidence of clearance between the work surface and the marking blade ir that the work surface is warped.
5. To square two pieces of work, position the stock rest flat on one surfa align the marking blade with the side of the second work piece. To ens accuracy of alignment reposition the engineer's square 90° from the position and recheck.

An engineer's square should be handled and stored in the same manner as a steel

Take Note

Storage and handling of engineer's squares

- Store by hanging in its original container.
- Check blade and rest for security and damage
- Wipe clean and dry with a rag. To prevent rusting important to remove any moisture from the surface of th square.
- Apply a thin layer of oil before storing. Store in original cas away from other tools.

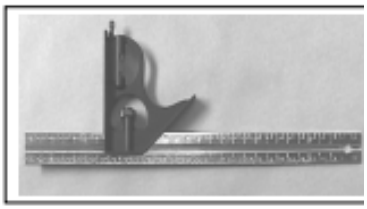
Combination Squares

Multipurpose Measure an Level

A combination square is a hand held tool that is precision mac and is designed as a multipurpose measure and level. It has 30cm steel rule blade with metric and imperial measurements, groove through the centre of the blade and a spirit lev attachment that travels along the groove.

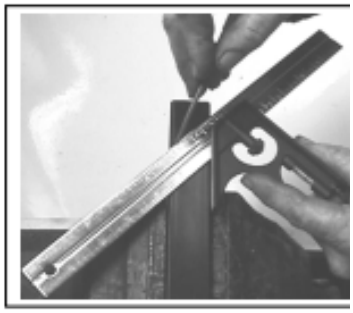
The spirit level attachment has a precision machined surface th runs at 90 degrees to the steel rule blade and a thumb screw t lock the spirit level attachment to the steel rule blade. combination square can be used to measure:

- Distance
- Depths
- Levels
- Inside right angles
- Outside right angles
- 45 degree angles



Construction

1. 12 inch steel rule.
2. Sliding frame.
3. 90 degree face to the rule.
4. 45 degree face to the rule.
5. Spirit level bubble.
6. Sliding frame lock nut.
7. Sliding frame groove in the centre of the steel rule.
8. Hanging hole for storage.



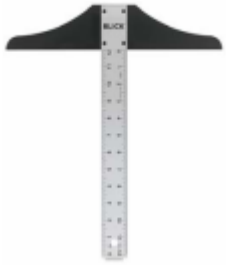
Scribing a 45° angle on a piece of work.

Take Note

Storage and handling of engineer's squares

- Wipe clean and dry with a rag. To prevent rusting it important to remove any moisture from the surface of th square.
- Ensure that the work is securely held.
- Do not over-tighten locking thread for blade.
- Apply a thin layer of oil before storing.
- Hang on a shadow board or store in original case away fro other tools.

T-Squares



The T-square is a good option when looking to draw and cut in a straight line.

Its name comes from its resemblance to the letter T. T-squares come in varying sizes.

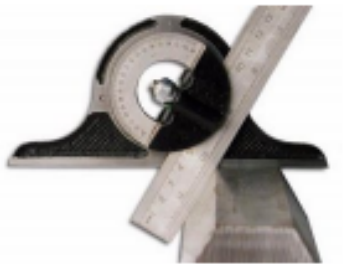
A T-square has two components - the long shaft called the "blade" and the short shaft called the "stock" or "head".

The T-square edge should be free of nicks and cracks in order to provide smooth, straight lines.

Most T-squares have a hole towards the end of the blade for hanging the tool up.

After use wipe the blade and stock with a clean rag and hang on a shadow board or store in its original container.

Bevel Protractors



A bevel protractor is a graduated circular protractor with one pivoted arm used for measuring or marking off angles. Sometimes Vernier scales are attached to give more precise readings.

The bevel protractor is used to establish and test angles to very close tolerances and can measure any angle from 0° to 360°.

The bevel protractor consists of a base, a graduated dial and a blade which is connected to a swivel plate (with Vernier scale) by a thumb nut and clamp.

The base is placed on the bottom side of the angle to be measured while the blade is placed on the opposite side. To measure the angle adjust the nut to release the blade and protractor which allows the protractor to be moved along the blade to fit an angle. When the edges of the base and blade are parallel, a small mark on the swivel plate coincides with the zero line on the graduated dial.

Since the spaces, both on the main scale and the Vernier scale, are numbered both to the right and to the left from zero, any angle can be measured.

Take Note **Storage and handling of engineer's squares**

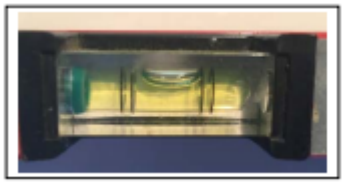
- ✓ Store by hanging.
- ✓ Keep free from oil and grease. Wipe clean with rag.
- ✓ Ensure that the work is securely held.

- ✓ Loosen securing bolts for the swivel plate before adjustments
- ✓ Do not over-tighten locking thread for blade or swivel plate.

Spirit Levels

A spirit level is an instrument designed to indicate whether a surface is horizontal or vertical. Used in the motor industry to check and calibrate workshop equipment.

The level has a machined true edge and contains a sealed glass tube partially filled with alcohol or other liquid, containing an air bubble whose position reveals whether a surface is perfectly level.



To use, place the level's frame on the object to be checked. Move the object until the bubble is in the centre of the vial within the indicator lines. This indicates the surface is flat.

The spirit levels edge should be free of nicks, dents and warpage in order to provide the most accurate reading when flat against an object. Make sure that the vials are not damaged. If broken, replace the entire level rather than just the vial. Longer levels typically have a hole on the end so they can be stored on a shadow board. Wipe with a clean rag after use.

Calibration

Measuring tools should be calibrated on a regular basis to ensure that they are measuring accurately. Usually a known measured standard device is used to test the accuracy of the tools. Measuring tools will lose some accuracy over time due to wear or tear, or may suffer immediate loss due to sudden electrical or mechanical impact. During the calibration process the tool may be reset to its factory settings.

APPLY SAFE ELECTRICAL SKILLS

Electricity can kill or severely injure people and cause damage to property. However, you can take simple precautions when working with or near electricity and electrical equipment to significantly reduce the risk of injury to you, your workers and others around you. This section provides a summary of those precautions.

What are the hazards?

The main hazards of working with electricity are:

- ✓ electric shock and burns from contact with live parts
- ✓ injury from exposure to arcing, fire from faulty electrical equipment or installations
- ✓ explosion caused by unsuitable electrical apparatus or static electricity igniting flammable vapours or dusts, for example in a spray paint booth

Electric shocks can also lead to other types of injury, for example by causing a fall from ladders or scaffolds etc.

What do I have to do?

You must ensure an assessment has been made of any electrical hazards, which covers:

- ✓ who could be harmed by them
- ✓ how the level of risk has been established
- ✓ the precautions taken to control that risk

The risk assessment should take into consideration the type of electrical equipment used, the way in which it is used and the environment that it is used in.
You must make sure that the electrical installation and the electrical equipment is:

- ✓ suitable for its intended use and the conditions in which it is operated
- ✓ only used for its intended purpose

In wet surroundings, unsuitable equipment can become live and make its surroundings live too. Fuses, circuit-breakers and other devices must be correctly rated for the circuit they protect. Isolators and fuse-box cases should be kept closed and, if possible, locked.
Cables, plugs, sockets and fittings must be robust enough and adequately protected for the working environment. Ensure that machinery has an accessible switch or isolator to cut off the power quickly in an emergency.

Maintenance

So far as is reasonably practicable , you must make sure that electrical equipment and installations are maintained to prevent danger.
Users of electrical equipment, including portable appliances, should carry out visual checks. Remove the equipment from use immediately and check it, repair it or replace it if:

- ✓ the plug or connector is damaged

- ✓ the cable has been repaired with tape, is not secure, or internal wires are visible etc
- ✓ burn marks or stains are present (suggesting overheating)

Repairs should only be carried out by a competent person (someone who has the necessary skills, knowledge and experience to carry out the work safely).
Have more frequent checks for items more likely to become damaged (eg portable electrical tools and equipment that is regularly moved, or used frequently or in arduous environments). Less frequent checks are needed for equipment less likely to become damaged (eg desktop computers etc).
Visual checks are not usually necessary for small, battery-powered items, or for equipment that works from a mains-powered adaptor (laptops or cordless phones etc). However, the mains-powered adaptor for such equipment should be visually checked.
Consider whether electrical equipment, including portable appliances, should be more formally inspected or tested by a competent person. Also think about the intervals at which this should be done.
An HSE leaflet Maintaining portable electrical equipment in low-risk environments can help you decide whether and when to test portable appliances in low-risk environments.
Make arrangements for inspecting and testing fixed wiring installations, ie the circuits from the meter and consumer unit supplying light switches, sockets, wired-in equipment (eg cookers, hairdryers) etc, to be carried out regularly so there is little chance of deterioration leading to danger. This work should normally be carried out by a competent person, usually an electrician

When is someone competent to do electrical work?

In this context, a competent person is someone who has the suitable training, skill and knowledge for the task to be undertaken to prevent injury to themselves and others.
A successfully completed electrical apprenticeship, with some post-apprenticeship experience, is one way of demonstrating technical competence for general electrical work.
More specialised work, such as maintenance of high-voltage switchgear or control system modification, is almost certainly likely to require additional training and experience.

Key points to remember

- ✓ Ensure that workers know how to use the electrical equipment safely
- ✓ Make sure enough sockets are available. Check that socket outlets are not overloaded by using unfused adaptors as this can cause fires
- ✓ Ensure there are no trailing cables that can cause people to trip or fall
- ✓ Switch off and unplug appliances before cleaning or adjusting them
- ✓ Ensure everyone looks for electrical wires, cables or equipment near where they are going to work and check for signs warning of dangers from electricity, or any other hazard. Checks should be made around the job, and remember that electrical cables may be within walls, floors and ceilings (especially when drilling into these locations) etc

- ✓ Make sure anyone working with electricity has sufficient skills, knowledge and experience to do so. Incorrectly wiring a plug can be dangerous and lead to fatal accidents or fires
- ✓ Stop using equipment immediately if it appears to be faulty – have it checked by a competent person
- ✓ Ensure any electrical equipment brought to work by employees, or any hired or borrowed, is suitable for use before using it and remains suitable by being maintained as necessary
- ✓ Consider using a residual current device (RCD) between the electrical supply and the equipment, especially when working outdoors, or within a wet or confined place (see HSE's electrical safety at work site)

Overhead electric lines

- ✓ Be aware of the dangers of working near or underneath overhead power lines. Electricity can flash over from them, even though machinery or equipment may not touch them
- ✓ Don't work under them when equipment (eg ladders, a crane jib, a tipper-lorry body or a scaffold pole) could come within a minimum of six metres of a power line without getting advice. Speak to the line owner, eg the electricity company, railway company or tram operator, before any work begins

Underground cables

- ✓ Always assume cables will be present when digging in the street, pavement and/or near buildings
- ✓ Consult local electricity companies and service plans to identify where cables are located

Tools & Equipment

When you work with appliance repair, you need to be familiar with working of the tools. You may already be familiar with the typical wrenches and screwdrivers, but you will need to know more, such as about voltage meters and even single and multiphase compressor testers. Therefore, it is necessary to be sure that you are equipped with enough knowledge to properly use the tools that will be needed. Always remember to take them when you are working on a job. Various tools and equipment are required for maintaining as well as erection of various electrical components. Therefore, it is necessary to know about various tools and equipment to operate them safely.

The various tools and equipment used by an electrical or electronic technician while working with electrical circuits are explained below:

1. Screw driver: It is used to turn, tighten or remove screws
2. Ratchet: It is used to allow rotary motion in only one direction and preventing the motion in opposite direction. It is used to tighten nuts of various sizes

3. Spanner: It is used to provide grip to apply torque for turning objects such as nut or a bolt. A spanner is available with variable diameter to tighten nuts and bolts of various sizes
4. Wrench: It is a hand tool used for tightening and loosening of the nuts and bolts These tools hold slippery or small nuts and bolts for loosening or tightening it.
5. Wire cutter and Plier: A wire cutter is used for striping and cutting wires whereas a plier is used to hold objects like nuts and bolts firmly also used for cutting metal wires
6. Tester: It is used to verify the presence of electric voltage in electrical equipment
7. Hammer: It is used to fix nails in walls and wood, fit parts, or forge metal and breaking different materials
8. Ladder: It is used to climb upwards to reach higher places (6 to 7 feet) in tall units of a control panel
9. Utility Knife: It is used to cut various objects, such as wires, cords, tapes and so on
10. Soldering or Desoldering Iron: It is used to embed/ remove the components on/from the panel
11. Soldering or Desoldering Station: It is used to hold the hot iron when it is not in use and adjust the temperature of the tip
12. Crimping Tool: It is used to cut various objects such as wires, cords, tapes and so on. It is also used to join wires with metal or plastic objects
13. Voltmeter: It is used to measure potential difference between two points in the electric circuit
14. Ammeter: It is used to measure current flow in a circuit
15. Watt meter: It is used to measure electrical power of any given circuit (in watts)
16. Megohmmeter or Megger: It is used to measure leakage in wires and earth resistance
17. Multimeter: It is used to measure various electrical quantities like resistance, voltage, current, etc

Tools and Equipment used for Cable Laying

Preparations of Cables and Equipment for Cable Laying Activities

Tools and equipment are used for various electrical activities. We should take care while handling the electrical wire laying. While laying the cables necessary precautions and health and safety practices for power related work should be observed as per standard rules. Important tools and equipment used for laying electrical wire (laying works) are given here.

Tools and Equipment used in Cable Laying Activities

Many tools are used for cable laying. These include cable pulling winch, cable guiding device and cable pulling grip, etc.

Cable Drums

Cable gets twisted during laying process. Drums are used to check or avoid twisting of cables. Cable drums (Figs 2.20 and 2.21) help the technicians with the laying of cables. Similarly angle rollers are also used for laying the cable (Fig. 2.22).

Pulling Methods and Calculations

Proper methods should be used while laying the cable in the field. Suitable equipment and tools must be used in this process. The cable drum should be mounted on jacks and the cable should be rolled off the drum gently avoiding kinks and twists. The free end in the case of heavy cables may be pulled with the help of a winch. Laying cable in an open trench presents no serious difficulty. The cable is first placed on rollers laid in the trench or on the ground above, which is then transferred to the bed of the trench. When laying cables in pipes and ducts, care should be exercised so as not to damage them during installation. The correct method of laying of cables for installation in a duct is shown in Fig. 2.23

Testing of Underground Cables

After laying cables underground or above the ground, proper testing is done to check the faults caused, if any, due to the laying. The cables are tested for short circuiting faults, discontinuity faults and earth fault. Murray and Varley loop tests are done to check these faults.

Tools Used for Erection and Maintenance

A lineman who is doing erection and maintenance work, cannot do his job without proper hand tools, which he carries around on a daily basis. Unlike tools used by any other worker, a lineman's tools require proper insulation, because these tools are used with electrical installations. The handles of these tools are coated with rubber to prevent the worker from getting electrocuted (Fig. 2.24).
Tools are important to carry out a job. The entire job being carried out by a technician is with the help of tools. The following tools are commonly used for working in a distribution system:

1. Combination Pliers

It is used for cutting, removing insulation, jointing and twisting the electric wires and cables even on live-line. A lineman's pliers have special design, which multiplies force through leverage. These pliers usually have grips for better handling than bare metal handles. The grips also have insulation for protection against electric shock when working with live circuits. A lineman's pliers are typically machined from forged steel. The two handles are precisely joined with a heavy-duty rivet that maintains the pliers' accuracy even after repeated use under extreme force on heavygauge wire

2. Adjustable Wrench

It is used to open and close nuts and bolts in case of proper size spanner not being available. Common sizes are 8" (Inch) to 12" (Inch). Adjustable wrenches are designed to provide a wide range of capacity in a single tool and are a convenient service wrench for distribution linemen. They are not intended to replace fixed opening wrenches for production or general service work. High dielectric insulated handle types are widely used by linemen and other electrical workers (Fig. 2.26).

3. Pipe Wrench

It is used to open, close, conduit GI pipes and valves. Common size is 10" (Inch). The design of the adjustable jaw allows it to lock in the frame, such that any forward pressure on the handle tends to pull the jaws tighter together. They are usually made of cast steel. Nowadays, aluminium is also used to construct the body of the wrench, while the teeth and jaw remain steel (Fig. 2.27).

4. Measuring Tape

It is used to measure the length of wires, cables and space. Use of measuring tape makes cable savings efficient for cleaning and reduces wastage. These are made of cotton or metal strips bearing size of 10' (feet) to 100' (feet) (Fig. 2.28).

5. Hammer

It is used to pierce nails, centre punch, rawl plug and chisel. Common sizes are 1, 2.5, 3 and 5 lbs (Pounds). A lineman's hammer is best suited to driving in big lag screws and hammering bolts in utility-pole work. They are also used by electricians to drive nails in hard places

6. Ratchet with Drill Bit (Hand Drill)

It is used to make holes on wooden cross arms and wooden cleats for tight fitting High Tension and Low Tension cables emanating from DP structures, or LT transformer bushings

7. Electric Drill Machine

It has the below mentioned properties:

- ✓ It is a portable electric powered tool used for drilling the surface
- ✓ It has a high speed motor to revolve the chuck.
- ✓ It is used to make holes smoothly and easily.

8. Bench Vice

A vice is a mechanical apparatus used to secure an object to allow work to be performed on it. In electrical works, cutting does play an important role. Cutting an electrical conduit has to be secure enough so that a smart cut is made. A bench vice (Fig. 2.32) is a perfect way to do this. Bench vice is used to grip the job (object) which has the following features:

- ✓ Base Plate (permanently fixed on the working table sides).
- ✓ Fixed Jaw (fixed with Base Plate)
- ✓ Moving Jaw (could be moved according to the thickness of job)

9. Chain Pulley

It is a pulley with depressions in the periphery of its wheel, or projections from it, made to fit the links of a chain. The desired capacity chain pulley is hooked at the centre to lift heavy load for loading and unloading at site (Fig. 2.33).

10. Tripod

It is a combination of three to four meter long 40 mm GI pipes hinged at upper end for making a tripod formation. Tripods are perfect for utility workers as they are portable and lightweight with high-strength anchor (Fig. 2.34).

11. Come Along Clamp

It is used while laying overhead lines. These are mainly used for holding conductors and ground wires in overhead transmission lines and various other industrial maintenance operations. These clamps are available in multiple diameter, weight and design that are ideal to use in electrical works. They are ideal to pull conductors as they are lightweight and compact in structure (Fig. 2.35).

12. Ratchet Device

It is a device consisting of a bar or wheel with a set of angled teeth in which a pawl, cog, or tooth engages, allowing motion in one direction only. Ratchets are widely used in machinery and tools as well as maintenance works (Fig. 2.36). The senior lineman normally works in a distribution sub-division of a Power Company (Discom). The recommended norms for tools and equipment for a distribution sub-division are almost same for all states. Electricians working in the field must have the following tools with them as given in Table 2.1.

Table 2.1 List of standard tools for an electrician

S. No.	Particulars	Quantity
1.	Chain pulley block (5 MT)	1
2.	Megger (1000 volts)	1
3.	Earth Tester	1
4.	Portable Drilling Machine	1
5.	Bamboo Ladder	2
6.	Steel Measuring Tape	1
7.	Pulling and lifting machine 3 tone	1
8.	Pipe wrench 3"(7.6 cm)	2
9.	Spirit Level	4
10.	Socket Spanner Set	2
11.	Ring Spanner Set	2
12.	Hammer	2

Fault Indicators and Protective Equipment

The flow of current towards an undesired path or abnormal stoppage of current is termed as fault. Fault indicators (Fig. 2.37) are devices which indicate the passage of fault current. When properly applied, they can reduce operating costs and reduce service interruptions by identifying the section of cable that has failed.

Dos and Dont's while working

1. Never touch a current carrying wire or conductor.
2. Never pull out a flexible cable while removing the plug from the mains.
3. Switch off the supply while checking any electrical appliance.
4. Never play with tools.
5. Handle tools carefully and be alert while working.
6. Never switch on supply unless you are sure about working of an appliance.
7. Ensure that proper earthing is provided for the appliance.
8. Seek guidance of your teacher in case of any doubt and do not try to experiment yourself.
9. Report any damage or breakdown to your teacher immediately.

Precautions

1. In DC measurements check polarities.
2. Select higher range for measurement initially and later select required range for accuracy.

Electric Circuits

An Electric circuit is an interconnection of various elements in which there is at least one closed path in which current can flow. An Electric circuit is used as a component for any engineering system. The performance of any electrical device or machine is always studied by drawing its electrical equivalent circuit. By simulating an electric circuit, any type of system can be studied for e.g., mechanical, hydraulic thermal, nuclear, traffic flow, weather prediction etc. All control systems are studied by representing them in the form of electric circuits. The analysis, of any system can be learnt by mastering the techniques of circuit theory. The analysis of any system can be learnt by mastering the techniques of circuit theory.

Elements of an Electric circuit:
An Electric circuit consists of following types of elements.
Active elements:
Active elements are the elements of a circuit which possess energy of their own and can impart it to other element of the circuit.

Active elements are of two types
a) Voltage source b) Current source

A Voltage source has a specified voltage across its terminals, independent of current flowing through it.
A current source has a specified current through it independent of the voltage appearing across it.
Passive Elements:
The passive elements of an electric circuit do not possess energy of their own. They

receive energy from the sources. The passive elements are the resistance, the inductance and the capacitance.
When electrical energy is supplied to a circuit element, it will respond in one and more of the following ways.
If the energy is consumed, then the circuit element is a pure resistor.
If the energy is stored in a magnetic field, the element is a pure inductor.
And if the energy is stored in an electric field, the element is a pure capacitor

Linear and Non-Linear Elements.
Linear elements show the linear characteristics of voltage & current. That is its voltage-current characteristics are at all-times a straight-line through the origin.
For example, the current passing through a resistor is proportional to the voltage applied through its and the relation is expressed as V I or V = IR. A linear element or network is one which satisfies the principle of superposition, i.e., the principle of homogeneity and additivity.
Resistors, inductors and capacitors are the examples of the linear elements and their properties do not change with a change in the applied voltage and the circuit current. Nonlinear element's V-I characteristics do not follow the linear pattern i.e. the current passing through it does not change linearly with the linear change in the voltage across it. Examples are the semiconductor devices such as diode, transistor.
Bilateral and Unilateral Elements:
An element is said to be bilateral, when the same relation exists between voltage and current for the current flowing in both directions.
Ex: Voltage source, Current source, resistance, inductance & capacitance.
The circuits containing them are called bilateral circuits.
An element is said to be unilateral, when the same relation does not exist between voltage and current when current flowing in both directions. The circuits containing them are called unilateral circuits.
Ex: Vacuum diodes, Silicon Diodes, Selenium Rectifiers etc.
Lumped and Distributed Elements
Lumped elements are those elements which are very small in size & in which simultaneous actions takes place. Typical lumped elements are capacitors, resistors, inductors.
Distributed elements are those which are not electrically separable for analytical purposes.
For example a transmission line has distributed parameters along its length and may extend for hundreds of miles.
The circuits containing them are called unilateral circuits.

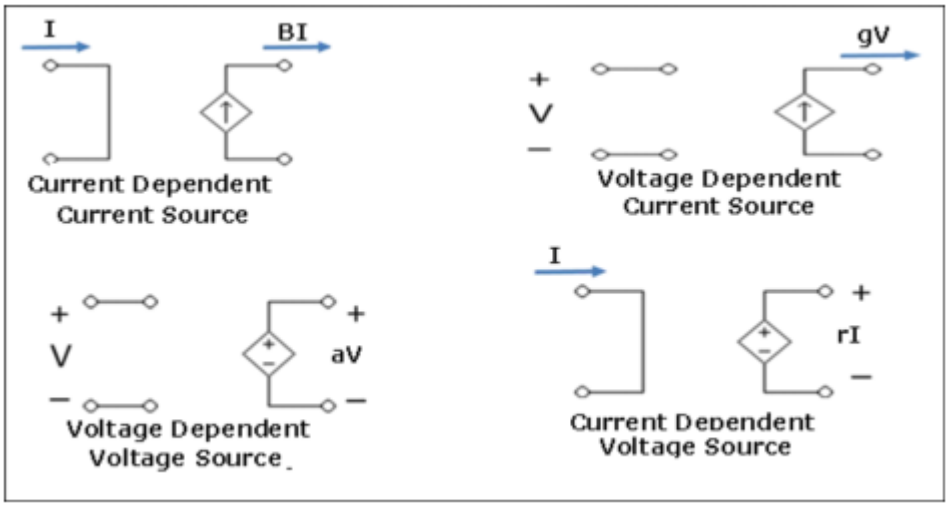
Types of Sources:

Independent & Dependent sources:
If the voltage of the voltage source is completely independent source of current and the current of the current source is completely independent of the voltage, then the sources are called as independent sources.
The special kind of sources in which the source voltage or current depends on some other

quantity in the circuit which may be either a voltage or a current anywhere in the circuit are called

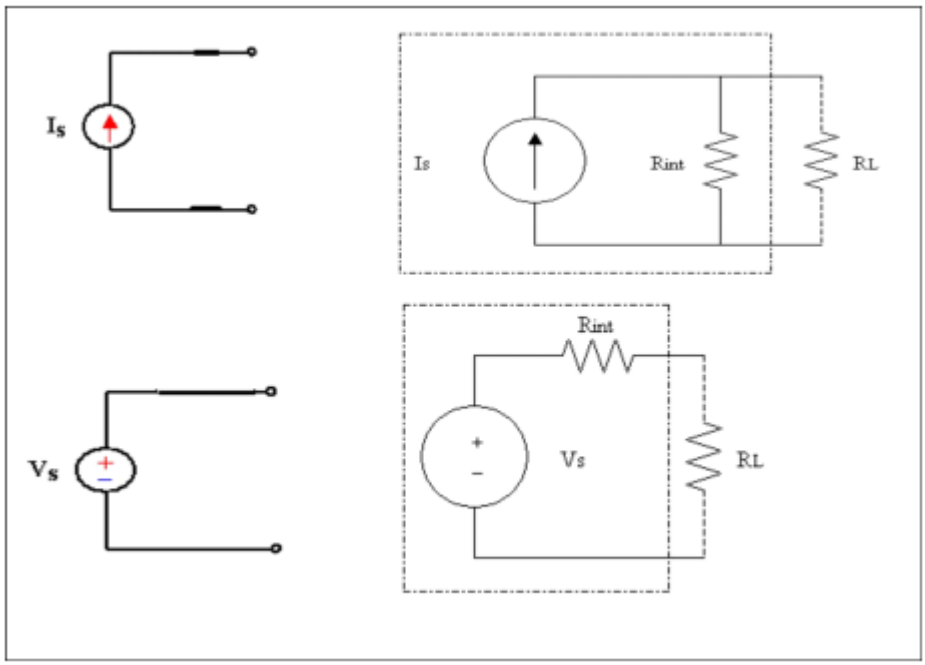
Dependent sources or Controlled sources.
There are four possible dependent sources:

- ✓ Voltage dependent Voltage source
- ✓ Current dependent Current source
- ✓ Voltage dependent Current source
- ✓ Current dependent Current source

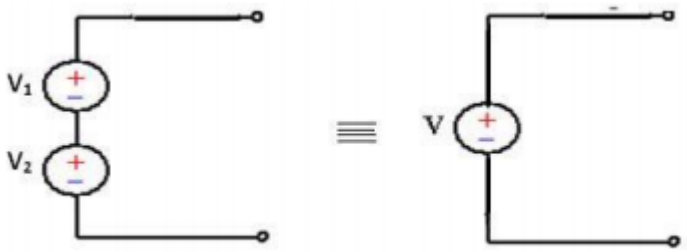


The constants of proportionalities are written as B, g, a, r in which B & a has no units, r has units of ohm & g units of mhos.
Independent sources actually exist as physical entities such as battery, a dc generator & an alternator. But dependent sources are used to represent electrical properties of electronic devices such as OPAMPS & Transistors.
Ideal & Practical sources:

1. An ideal voltage source is one which delivers energy to the load at a constant terminal voltage, irrespective of the current drawn by the load.
2. An ideal current source is one, which delivers energy with a constant current to the load, irrespective of the terminal voltage across the load.
3. A Practical voltage source always possesses a very small value of internal resistance r. The internal resistance of a voltage source is always connected in series with it & for a current source; it is always connected in parallel with it. As the value of the internal resistance of a practical voltage source is very small, its terminal voltage is assumed to be almost constant within a certain limit of current flowing through the load.
4. A practical current source is also assumed to deliver a constant current, irrespective of the terminal voltage across the load connected to it.

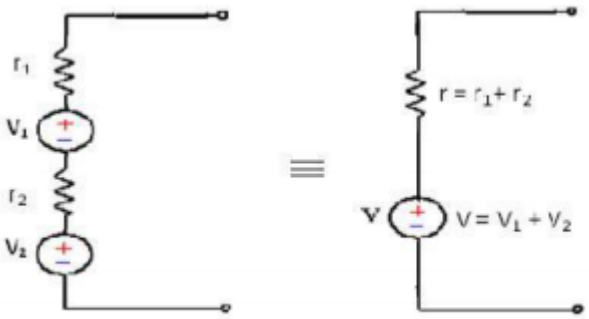


Ideal voltage source connected in series:

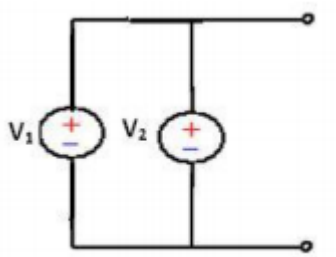


The equivalent single ideal voltage some is given by V= V1 + V2 Any number of ideal voltage sources connected in series can be represented by a single ideal voltage some taking in to account the polarities connected together in to consideration.

Practical voltage source connected in series:

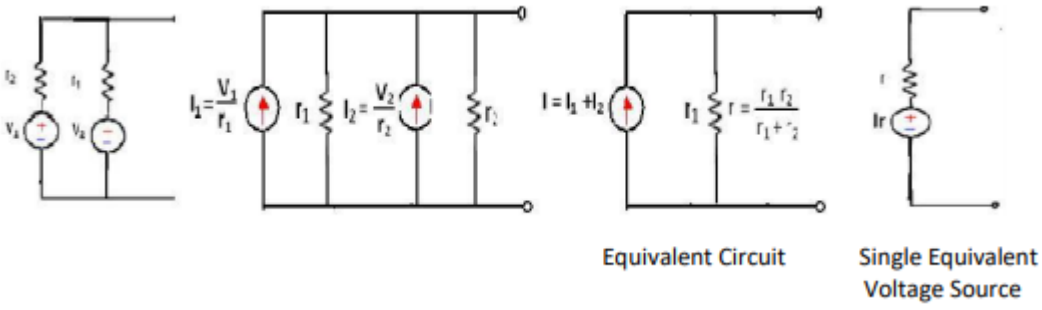


Ideal voltage source connected in parallel:

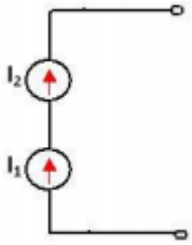


When two ideal voltage sources of emf's V1 & V2 are connected in parallel, what voltage appears across its terminals is ambiguous.
Hence such connections should not be made.
However if V1 = V2= V, then the equivalent voltage some is represented by V.
In that case also, such a connection is unnecessary as only one voltage source serves the purpose.

Practical voltage sources connected in parallel

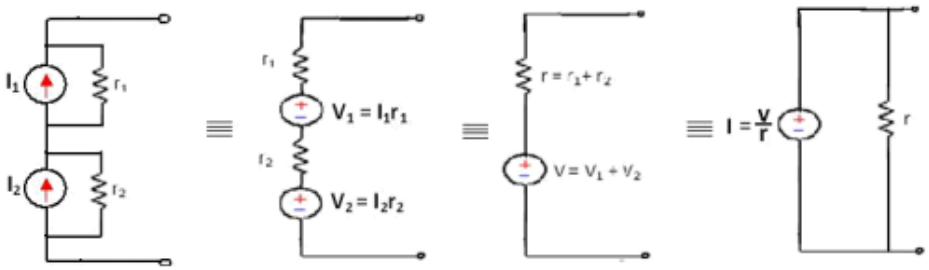


Ideal current sources connected in series:

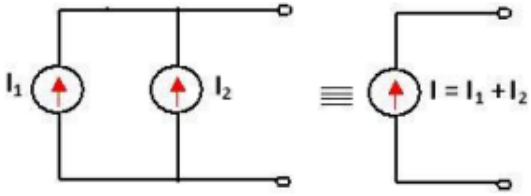


When ideal current sources are connected in series, what current flows through the line is ambiguous.
Hence such a connection is not permissible.
However, it I1 = I2 = I, then the current in the line is I.
But, such a connection is not necessary as only one current source serves the purpose.

Practical current sources connected in series:

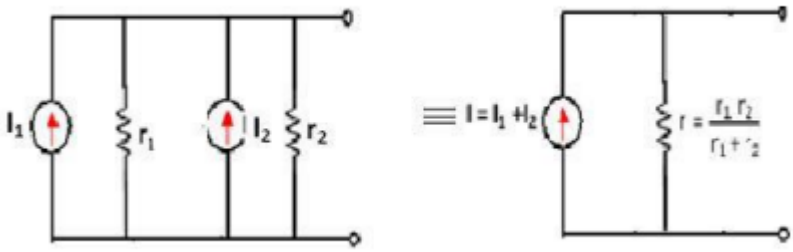


Ideal current sources connected in parallel

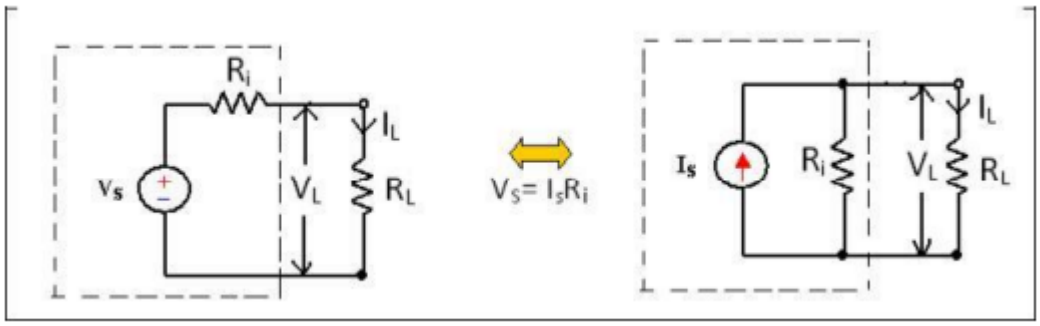


Two ideal current sources in parallel can be replaced by a single equivalent ideal current source.

Practical current sources connected in parallel



Source transformation: A current source or a voltage source drives current through its load resistance and the magnitude of the current depends on the value of the load resistance. Consider a practical voltage source and a practical current source connected to the same load resistance RL as shown in the figure



R1's in figure represents the internal resistance of the voltage source VS and current source IS.
Two sources are said to be identical, when they produce identical terminal voltage VL and load current
IL.
The circuit in figure represents a practical voltage source & a practical current source respectively, with load connected to both the sources.
The terminal voltage VL and load current IL across their terminals are same.
Hence the practical voltage source & practical current source shown in the dotted box of figure are equal.
The two equivalent sources should also provide the same open circuit voltage & short circuit current.

From fig (a)

$$IL = \frac{Vs}{R+R_L}$$

From fig (b)

$$IL = I \frac{r}{R+R_L}$$

$$\therefore \frac{Vs}{R+R_L} = I$$

$$VS = IR \quad \text{or } I = \frac{Vs}{R}$$

Hence a voltage source Vs in series with its internal resistance R can be converted into a current source

$I = \frac{Vs}{R}$, with its internal resistance R connected in parallel with it. Similarly a current source I in parallel with its internal resistance R can be converted into a voltage source V = IR in series with its internal resistance R.

R-L-C Parameters:
1. Resistance:
Resistance is that property of a circuit element which opposes the flow of electric current and in doing so converts electrical energy into heat energy.
It is the proportionality factor in ohm's law relating voltage and current.
Ohm's law states that the voltage drop across a conductor of given length and area of cross section is directly proportional to the current flowing through it

$$R \propto i$$

$$V = Ri$$

$$i = \frac{v}{R} = GV$$

Where the reciprocal of resistance is called conductance G. The unit of resistance is ohm and the unit of conductance is mho or Siemens.
When current flows through any resistive material, heat is generated by the collision of electrons with other atomic particles. The power absorbed by the resistor is converted to heat and is given by the expression

P= vi= i2R where i is the resistor in amps, and v is the voltage across the resistor in volts.

Energy lost in a resistance in time t is given by

$$W = \int_0^t p\,dt = pt = i^2Rt = \frac{v2}{R}t$$

2. Inductance:
Inductance is the property of a material by virtue of which it opposes any change of magnitude and direction of electric current passing through conductor. A wire of certain length, when twisted into a coil becomes a basic conductor. A change in the magnitude of the current changes the electromagnetic field.

Increase in current expands the field & decrease in current reduces it. A change in current produces change in the electromagnetic field. This induces a voltage across the coil according to Faradays laws of Electromagnetic Induction.

Induced Voltage $V = L\frac{di}{dt}$

V = Voltage across inductor in volts

I = Current through inductor in amps

$di = \frac{1}{L} v\,dt$

Integrating both sides,

$$\int_0^t di = \frac{1}{L}\int_0^t v dt$$

Power absorbed by the inductor $P = VI = Li\frac{di}{dt}$

Energy stored by the inductor

$$W = \int_0^t P\,dt = \int_0^t Li\,\frac{di}{dt}\,dt = \frac{Li^2}{2}$$

$$W = \frac{Li^2}{2}$$

Conclusions:

1. $V = L\frac{di}{dt}$
   The induced voltage across an inductor is zero if the current through it is constant. That means an inductor acts as short circuit to dc.
2. For minute change in current within zero time (dt = 0) gives an infinite voltage across the inductor which is physically not at all feasible. In an inductor, the current cannot change abruptly. An inductor behaves as open circuit just after switching across dc voltage.
3. The inductor can store finite amount of energy, even if the voltage across the inductor is zero.
4. A pure inductor never dissipates energy, it only stores it. Hence it is also called as a non– dissipative passive element. However, physical inductor dissipates power due to internal resistance.

Ex: The current in a 2H inductor raises at a rate of 2A/s .Find the voltage across the inductor the energy stored in the magnetic field at after 2sec.

Sol:

$$V = L\frac{di}{dt}$$

$$= 2X2 = 4V$$

Diagnosing Faults

Most home appliances take AC voltage, supplied to your house from the utility company, and use it to make heat, light, turn a motor or, commonly, all three at the same time. But when the appliance stops functioning, a logical approach to troubleshooting comes in handy. Fixing electrical problems and even tracing circuit breakers involves the use of basic tools.

You can, for example, check for proper voltage at each circuit component and even the condition of components and connections using functions found on tools like an Amprobe multimeter. It helps to be equipped to troubleshoot electrical problems. To make this less painful, you should have the following tools

- ✓ NCV – non-contact voltage detector (determines if power is flowing to a circuit to keep you safe)
- ✓ Digital multimeter (measures AC and DC voltage as well as continuity—whether you have a break in a wire)
- ✓ Screwdrivers (Phillips and flat head)
- ✓ Basic wire strippers
- ✓ Clamp meter (checks current draw—this is for more advanced troubleshooting and repairs)

How to Fix Electrical Problems Step by Step

Here is a recommended step-by-step troubleshooting method you can use to isolate and fix electrical problems near any home appliance problems using just a digital multimeter (DMM) and some basic tools:

1. Check the AC Supply Voltage

Believe it or not, some problems start at the source. Always ensure you have the proper AC voltage coming to an outlet or power supply.

To measure the AC supply voltage at a receptacle, first set the DMM (digital multimeter) function switch to Volts AC (VAC). If required, select a range *greater* than the voltage you expect to measure (greater than 120 volts). An auto-ranging meter automatically selects the most appropriate range for you. Next, connect the test leads (red and black) to the Voltage (V) and Common (C) ports on the meter.

The red multimeter probe tests the "hot" line and the black tests neutral or ground. Carefully, insert the red probe of the meter into the "hot" slot of the receptacle. This is typically the "short" or smaller slot. The black probe goes into the other vertical slot of the receptacle or the Ground slot.

The meter should read between 116 and 124 volts. The power cord from the appliance usually terminates with three wires: black, white, and green. Black (or less commonly, red) is usually the "hot" wire, white is "neutral", and the green wire should be ground.

You should also read almost no voltage between Neutral (long slot) and the Ground hole.

Troubleshooting Low or No Voltage

If you measure no voltage at the outlet, check to make sure the circuit breaker or switch controlling the receptacle is ON. Also, make sure the probes are sufficiently inserted into

the receptacle. You may need to angle them or move them around to be sure. If you DO detect voltage at the receptacle, you could have a problem in the power cord. That will be your next test.

If, however, you measure a voltage that's much lower than the expected ~120V, you may have a problem with a disconnected neutral (white) wire. Since, most of the time, wires don't "break in the middle" you might want to check to see if a neutral (white) wire corroded or came disconnected at an outlet or switch on the same circuit. Be sure to shut off the power before searching for broken neutral wires.

2. Check the Power Cord

Over time, and sometimes through accidents or flexing, the internal conductor in the power cord can break while appearing perfectly normal on the outside. To check a power cord, first disconnect it from the outlet. For this next part, you will need to gain access to the internal connections on your appliance. Never test any wires on an appliance still connected to an outlet!

Set your multimeter to the resistance or "Ohms" function and measure the resistance between each prong of the plug and the point where the power cord connects to the appliance. The flat, narrow blade on the plug should be connected to the black wire. The flat, wide blade goes to the white wire. The round pin connects to the green wire.
A good power cord will have less than one ohm of resistance from the plug to the end of each wire. Anything higher than one ohm may indicate a cord that is starting to break down and could become overheated when in use. Replace the entire power cord if any wire shows high resistance or "OL" is displayed on the meter.

3. Check the Current Draw – Advanced Users

Sometimes a low or high current draw indicates a motor problem. It can alert you to how to fix electrical problems when systems don't operate as they should. Current draw is measured by using a clamp accessory attached to your multimeter, or by using a clamp meter. If you don't know what this looks like, check out our Amprobe clamp meter review.

To make a current measurement, either connect the clamp accessory or grab the clamp meter. Accessories connect to the current jack and common jack of the multimeter. Clamp the jaw around one conductor (wire) of the circuit to be measured. Typically you can find the power cable split out at the appliance side, but please be careful or hire an electrician if you don't fully understand the risks here. Be careful not to clamp the jaw around both conductors, this will cancel the signal, showing zero current.

To make a current measurement with a clamp meter, select the AC current function and clamp the jaws around one conductor. The display will show the current being measured. What you are doing here is making sure the appliance is actually drawing current in the first place. An appliance that isn't working may simply not draw any electricity because it has a problem somewhere else and is failing internally.

4. Checking Switches

You can quickly troubleshoot electrical problems by checking onboard switches on small appliances. Make sure power is flowing through them and getting to its proper destination. You can verify this in a couple of ways. With the appliance plugged in, you can check both the input side and output side of the switch for voltage.

With the probe leads plugged into the Volts and Common inputs set the meter to the Voltage AC (VAC) mode. Touch the black probe to ground (the metal frame of the appliance) or to the neutral connector on the power cord (the white wire). Carefully touch the red probe to the connectors on the switch, first one side, then the other. With the

switch in the "ON" position, the voltage should be present on both input and output lugs.

Checking Continuity

Another way is to check the continuity through the switch. For this test, remove power from the switch first by unplugging the appliance.

Next, isolate the switch by removing the wire or wires from one side of the switch. Then, set the multimeter to the Continuity function and place one lead on the input lug of the switch and the other lead on the output lug of the switch. When the switch is on, the multimeter should sound the audible continuity signal and read about zero ohms. With the switch in the off position, the audible tone should stop and the meter will display "OL." If it doesn't, you have found your problem: a defective switch.

BASIC WORKSHOP PRACTICES

Marking out and measuring

Marking out and measuring is a critical part of manufacturing and is usually subject to a number of quality control checks. If components are marked out and measured wrongly before being cut out, there is no chance of them fitting together when they are assembled. Marking out and measuring tools These are the tools used for marking out and measuring that you need to know about:
Rules, squares, gauges, punches, templates, micrometres.
Rules
There are two basic types of rule: steel rule and steel tape. Both start at zero and have millimetre graduations.

Item	Name	Use	Advantages	Disadvantages
	steel rule	for measuring up to 300 mm in length	rigid form which means it will not bend and flex	ends can get worn, so the measurements are not accurate
	measuring tape	for making longer measurements up to 5 m	longer, so more versatile	can become twisted and break ends can break off, making them useless

Squares

There are a number of squares:

- ✓ try square
- ✓ mitre square
- ✓ engineer's square.

Both the try square and engineer's square are used to mark lines at 90° to an edge. A try square is used on timber and an engineer's square is used on metals. Both can be used for marking out plastics.

You can also use try squares and engineer's squares to check that a cut or an edge has been made at right angles to another. Hold the stock part of the square tightly against the edge that you have just cut. If you can see light between the two edges then the cut is not square.

A mitre square is used for marking out 45° or 135° angles on wood and plastic.

Take great care when using any form of square for marking out or checking, and ensure that it is being held firmly and tightly against the surfaces or edges of the material.

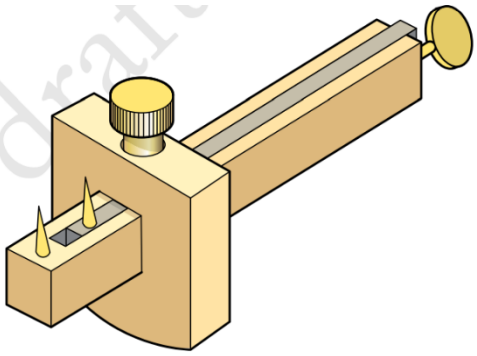
Item	Name and use
	**try square** marking out or checking right angles on wood or plastic
	**engineer's square** marking out or checking right angles on metal or plastic
	**mitre square** marking out or checking angles of 45° or 135°

Gauges

There are three basic types of gauge:

- ✓ marking gauge
- ✓ mortise gauge
- ✓ cutting gauge.

A marking gauge is used for marking lines parallel to the face edge and side on wood. It consists of a stock that slides up and down the stem, allowing various measurements to be set. The gauge should be set using a steel rule that has a zero end. The spur (sharp point) is pushed into the wood as the gauge is pushed or pulled along the length of the timber. It is important to hold the stock tightly against the edge of the timber to ensure that you mark a parallel line.



A cutting gauge is used for cutting across the grain. It is used in the same way as a marking gauge, but has a blade instead of a spur. The blade cuts the fibres across the grain, making it easier and neater to cut with a saw.

A mortise gauge has two pins; one pin is fixed and the other is adjustable. It is used for marking two parallel lines where a mortise and tenon joint is to be cut. The process of marking out is exactly the same as with the two other gauges.

Scribers

A scriber is used to scratch the surface of metal and plastic lightly. If you are using a scriber on metal, it is a good idea to apply a coat of engineer's blue. This is a spirit-based liquid that is applied to a metal surface. When the scriber is dragged across the engineer's blue it leaves a clean line, which can be easily seen.

Punches

Centre punches are used to make an indent in the surface where holes are to be drilled in metal, as shown in Figure 2.5. They provide a starting point for the drill and stop it skidding over the surface. Dot punches are used for marking the centres where dividers are to be used. They are similar to a centre punch, except that the tips are ground to a 60° rather than a 90° point.

Micrometers

A micrometer is a specialised instrument used to take very accurate measurements. The thimble, which rotates as the micrometer is tightened, has 50 equal divisions around its diameter, giving an accuracy of 0.01 mm. A reading is taken by adding all the visible whole numbers to the nearest 0.5 mm. The reading from the thimble, which will be between 0 and 0.49 mm, is added to the main reading to get the exact measurement. Although the micrometer provides a very accurate measurement, it can be difficult to learn how to read it.

Pipe cutting

Pipe Fabrication, also known as tube fabrication, is a broad category of industrial processes that manufacturers use to cut and shape pipes. Tube Fabrication covers cutting and sawing processes such as circular, band, friction, and more.

Pipe cutting is a large subcategory of pipe fabrication. Manufacturers usually precede it with fabrication processes like Tube Bending. Manufacturers use many techniques and a variety of Tube Forming Machines to create cut pipe products.

Pipe Cutting Techniques

Some of the most common tube cutting techniques include: abrasive cutting, band saw cutting, cold sawing, shearing, laser cutting and lathe cutting. Each operation has its benefits.

To decide which one(s) to use, manufacturers consider application requirements like: pipe thickness, pipe hardness, pipe toughness, pipe texture and requested product quantity.

Abrasive Cutting

Abrasive cutting is a manual cutting technique that works well for small product orders. Manufacturers perform it using an abrasive saw, also known as a chop saw or cut-off saw. Abrasive saws feature an abrasive disc that cuts or grinds through material.

Abrasives saws are effective at cutting tough materials like tile, metals, and concrete. The cut dimension depends on the abrasive machine. Some, for example, can cut materials as thick as 4 inches in outside diameter (OD), while others can handle only the thinnest

materials.

Abrasive cutting machines are simple to operate and need little or no plan. Also, the method is cheap and fast. However, abrasive cutting is not heat tolerant, it does not allow for tight tolerances and it usually causes heavy burring and kerf (slit or notch left behind by cutting tool). Furthermore, it is not does not work well on thick materials.

Band Saw Cutting

Band saw cutting is an electronic process used for voluminous cutting. The most general process for cutting pipe and tubes, band saw cutting handles a wide range of pipe and tube materials. They cut these raw tube materials into an equally wide range of shapes.

Band saws feature an unending band blade that has various tooth contours. Depending on the model, band saws usually rotate vertically or horizontally on two wheels. They also usually feature shuttles, which range in length between 20 inches and 24 inches. The shuttles allow them to cut their materials to virtually any length. Band saw cutting is generally fully automatic, and it often receives help from CNC technology.

The big advantage of band sawing is the fact that it allows manufacturers to cut such a wide range of shapes (I-beams, squares, channels, extrusions, rectangles, etc.). Band sawing does not, however, work well when paired with thin-walled pipes. It also creates burring and struggles to create tight tolerances.

Cold Saw Cutting

Cold saw cutting, or cold sawing, is a cutting method that involves the automated use of a cold saw. A cold saw features a circular blade kept well functioning with cutting lubricant. The blade is fixed in place and operates without heat.

Manufacturers use cold saws to cut small breathe (diameter) or lean walled pipes that require close tolerances. They also use it to cut several materials at once. Note that cold saws only create perpendicular and square cuts.

Because it does not use heat, cold sawing does not leave heat affected zones. This is a great benefit, because it means that any products cut via cold sawing will require fewer successive finishing touches (i.e. deburring)

Shearing

Tube shearing is a cutting technique that manufacturers carry out using a high-speed computerized shearing machine called a tube shear. The tube shear uses two shear plates and ID punches under intense tension.

Regardless of size or wall thickness, tube shear machines cut all material with maximum brink, or maximum limits. In this way, shearing is unique.

Two of the biggest benefits of tube shearing are agility and production volume. Shearing

can achieve high tolerances, and it is capable of an extremely high production rate. With shearing, the shorter the cut the higher the production rate. Usually, during an 8 hour run, tube shearing can produce up to 7,000 parts an hour. The main disadvantages of tube shearing are the fact that it is not expensive when used for small volume runs, and it has high tooling costs

Laser Cutting

During laser cutting, manufacturers use CNC controlled laser beams to cut materials with extreme precision. Lasers don't cut the material with force, but with heat. Thus, they creates very little distortion, narrow kerf and very few burrs. If they do leave any burrs, laser cutters can get rid of them.

Manufacturers use lasers to cut hard materials, like titanium. Operators can set lasers to run continuously while they do other work, so they can get more done at once. Because they offer such precision, operators can set them to cut out intricate markings, like number etchings and hole patterns.

Laser cutting does involve a costly investment. However, the results are always so excellent that it usually pays for itself.

Lathe Cutting

Lathe cutting is an older semi-automated pipe cutting technique. It works best with round, thin diameter tubing. Manufacturers perform lathe cutting using single spindle lathe machines. To begin the process, operators send hollow or solid pipe stock through the spindle, where at the end, a collet holds and rotates the stock. As the pipe rotates, tools from the lathe cut at it until it has all the right dimensions.

To add on secondary processes like deburring, grooving, boring or chamfering, manufacturers can attach tools or slides to the lathe machine. In this way, lathe cutting is diverse.

Lathe cutting takes a fairly long time to set up (between half an hour and hour) and lathe machines can only process one product at a time, but once the process gets going, production volume is high.

Cutting PVC pipe

Measure and Mark

Using a smaller tape measure for PVC projects. A small measuring tape is usually thinner too, and easier to stabilize around thin pieces of pipe.

Most often use a dry erase marker to mark on PVC tube because it dries quickly and wipes away quickly with a dry rag. We'll bust out the markers again when it's time to assemble parts too.

Taking careful measurements before cutting will save you time having to cut down new parts, and trips to the hardware store to get more pipe to correct your errors.

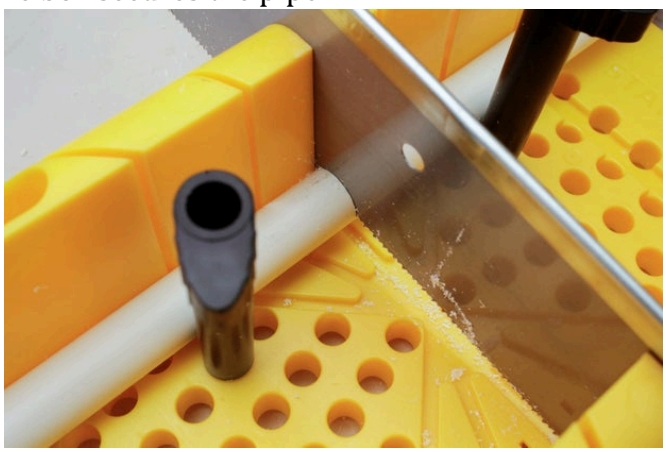
Tools for Cutting

PVC is very easy to cut. Most makers rely on three different tools to cut down lengths of PVC. They are: a ratcheting pipe cutter, a hacksaw, or a chop saw. Let's go over how to use these tools to cut down PVC pipe, in order of cost.

A ratcheting pipe cutter uses a stepped ratcheting arm to move a VERY SHARP blade through the tubular plastic. This tool is cheap and can get through pipe quickly. However, these cuts are not very precise. You are often left with crooked edges. I found with some practice, you can get good at making close-to-90-degree slices.
To use this tool, place a length of pipe into the jaws of the of the cutter, and repeatedly squeeze until the blade has cut all the way through the tube. Voila! Check the angle of your cut and if it's too wonky or crooked, consider using a hacksaw.

The hacksaw is only slightly more expensive than the ratcheting pipe cutter, but this is a key tool in any maker's arsenal. To cut PVC pipe with a hacksaw, I recommend using a miter box to ensure that you are getting the straightest cut.

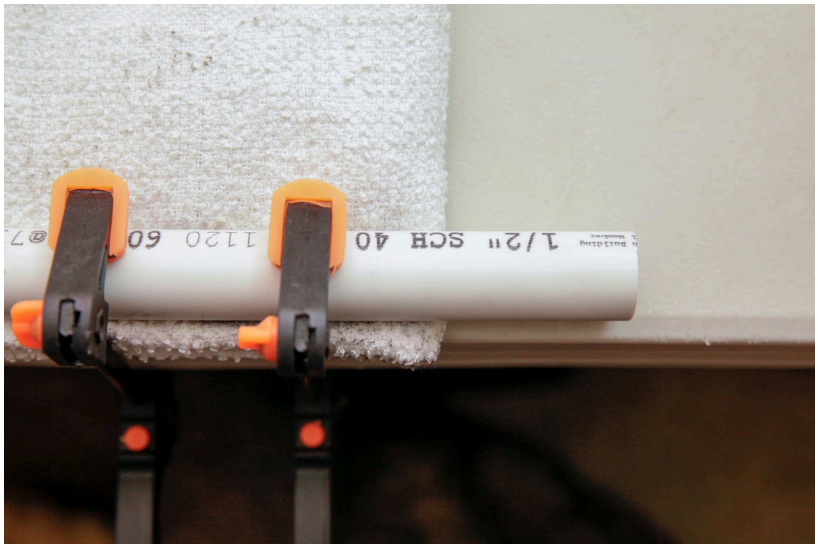
It's important to clamp down your pipe so it doesn't roll around while you are cutting it. The miter box I found has little pegs that help secure material so that I just have to clamp down the box, and the box secures the pipe.



This method of cutting pipe is slow and will leave you with burrs on your pipe. To remove burrs, you can pick at them with your fingers, use a deburring tool if you have one, or a piece of rough sandpaper if the burr is really stubborn. If you have to make a lot of precise cuts, you may want to consider using a chop saw instead.

If you have access to a chop saw to cut down PVC pipe, by all means, use that tool. It is fast and precise. You can get perfectly squared cuts with just a quick pass of the blade.

Securing PVC



Sometimes you will need to cut a piece of PVC down that won't fit into a miter box, and is too large for your ratcheting cutters. A hacksaw is still your best bet for making this kind of cut, but because PVC pipe is round, you need to prevent it from rolling or slipping when you're cutting or drilling.

To prevent the pipe from rolling around while cutting, try clamping it to the table. A lot of makers make notched wood or plastic jigs called V-blocks to create a grove that their pipes can be pressed into to be stabilized.

I have gotten pretty good results by putting a shop rag under a pipe and then using bar clamps to tighten it to a work table before I make a cut. I may clip the workbench with the hacksaw every once in a while, but it's few and far between.

Making Holes

The best way to make holes in PVC is by using a drill or rotary tool.

Using a drill is the best way to get perfectly circular holes in pipe. PVC is soft, you can use either wood or metal bits to make holes with a drill. For making larger holes, use a hole

saw with a mandrel to punch through the tube. A spade bit is not advised because of the way it removes material, the bit cannot properly 'grab' the curved surface like a hole saw can.

Using a rotary tool allows you to make shapes that are beyond the circle! Since the PVC machines so easily, you can use all the bits that your rotary tool comes with to experiment with making awesome designs and cut-outs. Rotary tools spin very fast, and it may cause the PVC to heat up if you aren't careful, or if you are using a bit that is too abrasive. Be sure to wear a respirator whenever you are heating PVC.

If you don't have a drill or rotary tool, all is not lost. Since PVC pipe is so soft, you can make small holes with screws or nails. Just drive them in with a screwdriver or hammer, and voila! Pipe punctured.

Deburring

It is important to deburr your pipe after cutting. Any loose plastic flakes will make it harder to fit your pipe into a joint.

One way to deburr pipe is with this awesome chamfer and deburring tool. It works a little bit like a pencil sharpener and can be used on both the inside and outside diameter of the pipe.
Running the chamfer tool along the circumference of the outside edge of the pipe, will result in a perfect 22° filleted edge. Ideal to glide into a PVC joint without snagging.
A slightly slower way to deburr and chamfer your edges is with a file or sanding block. Keep your sand paper at an almost parallel angle to the pipe to remove chips and flakes of plastic. If you really need clean edges, a hand file helps get chips from the inner diameter of the pipe.

UNIT 10

CARRYOUT SIMPLE CONCRETING AND RENDERING

This unit of competency specifies the outcomes required to perform minor repairs and undertake minor concreting and rendering tasks

PREPARE FOR WORK

Work health and safety

Potential hazards for workers in concrete manufacturing:

- ✓ Eye, skin and respiratory tract irritation from exposure to cement dust;
- ✓ Inadequate safety guards on equipment;
- ✓ Inadequate lockout/tagout systems on machinery;
- ✓ Overexertion and awkward postures;
- ✓ Slips, trips and falls; and
- ✓ Chemical burns from wet concrete

Cement Dust

Hazard: Exposure to cement dust can irritate eyes, nose, throat and the upper respiratory system. Skin contact may result in moderate irritation to thickening/cracking of skin to severe skin damage from chemical burns. Silica exposure can lead to lung injuries including silicosis and lung cancer.

Solutions:

- ✓ Rinse eyes with water if they come into contact with cement dust and consult a physician.
- ✓ Use soap and water to wash off dust to avoid skin damage.
- ✓ Wear a P-, N- or R-95 respirator to minimize inhalation of cement dust.
- ✓ Eat and drink only in dust-free areas to avoid ingesting cement dust.

Wet Concrete

Hazard: Exposure to wet concrete can result in skin irritation or even first-, second- or third-degree chemical burns. Compounds such as hexavalent chromium may also be harmful.
Solutions:

- ✓ Wear alkali-resistant gloves, coveralls with long sleeves and full-length pants, waterproof boots and eye protection.
- ✓ Wash contaminated skin areas with cold, running water as soon as possible.
- ✓ Rinse eyes splashed with wet concrete with water for at least 15 minutes and then go to the hospital for further treatment.

Machine Guarding

Hazard: Unguarded machinery used in the manufacturing process can lead to worker injuries.
Solutions:

- ✓ Maintain conveyor belt systems to avoid jamming and use care in clearing jams.

- ✓ Ensure that guards are in place to protect workers using mixers, block makers, cubers and metalworking machinery such as rebar benders, cutters and cage rollers.
- ✓ Establish and follow effective lockout/tagout procedures when servicing equipment.
- ✓ Be sure appropriate guards are in place on power tools before using them.

Falling Objects

Hazard: Workers may be hit by falling objects from conveyor belt systems, elevators or concrete block stacking equipment.
Solutions:

- ✓ Avoid working beneath cuber elevators, conveyor belts and stacker/destacker machinery.
- ✓ Stack and store materials properly to limit the risk of falling objects.
- ✓ Wear eye protection when chipping and cleaning forms, products or mixers.

Confined Spaces

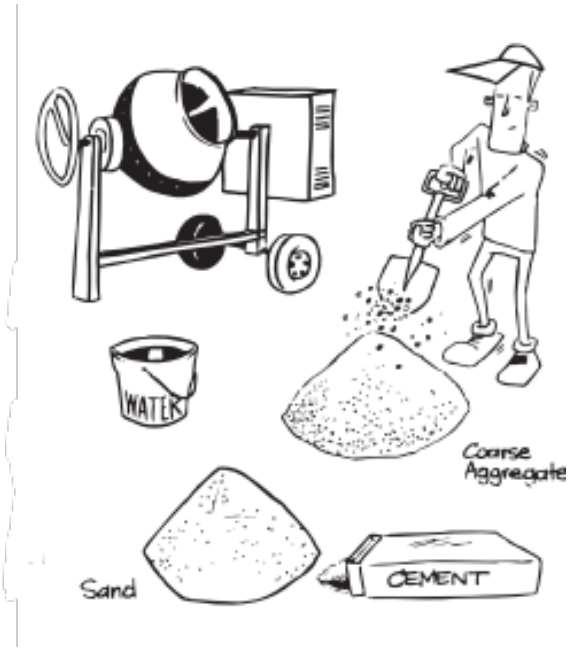
Hazard: Mixers and ready-mix trucks have confined spaces that pose safety risks for workers.
Solutions:

- ✓ Follow established procedures for confined space entry and work to assure safety.
- ✓ Guard against heat stress when cleaning truck mixer drums.
- ✓ Wear appropriate protective equipment to avoid silica exposure when removing concrete residues from inside truck mixer drums.

PLACE CONCRETE

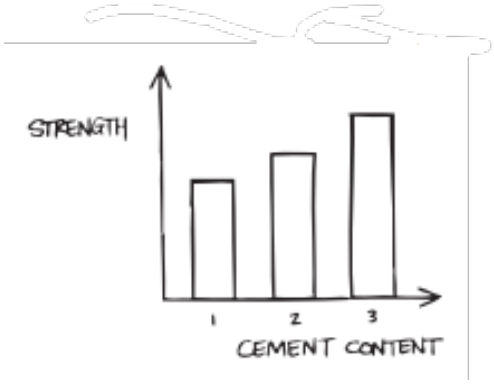
Proportioning and Mixing

A concrete mix is designed to produce concrete that can be easily placed at the lowest cost. The concrete must be workable and cohesive when plastic, then set and harden to give strong and durable concrete. The mix design must consider the environment that the concrete will be in; i.e. exposure to sea water, trucks, cars, forklifts, foot traffic or extremes of hot and cold.



Proportioning

Concrete is a mixture of cement, water, coarse and fine aggregates and (possibly) admixtures.
The proportions of each material in the mixture affects the properties of the plastic and hardened concrete. These proportions are best measured by weight. Measurement by volume is not as accurate, but is satisfactory for minor projects.

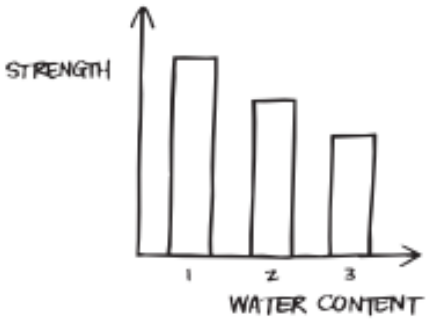


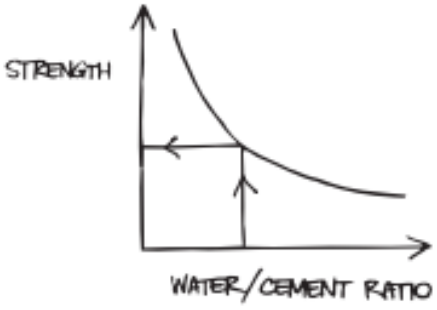
CEMENT CONTENT

As the cement content increases, so does strength and durability. Therefore, to increase the strength, increase the cement content of a mix.

Water Content

Adding MORE WATER to a mix gives a WEAKER hardened concrete. Always use as little water as possible, only enough to make the mix workable.



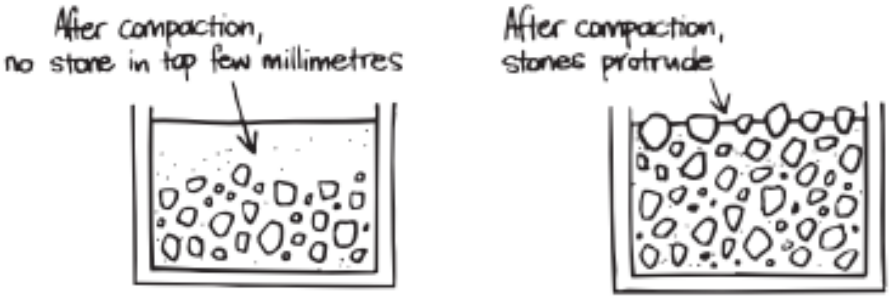


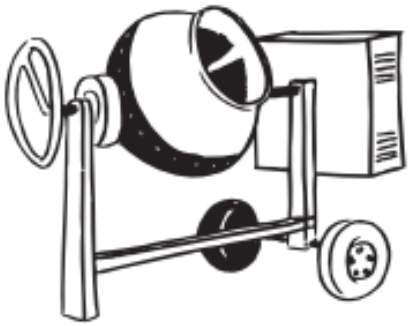
Water To Cement Ratio

As the Water to Cement ratio INCREASES, the strength and durability of hardened concrete DECREASES. To increase the strength and durability of concrete, decrease the Water/Cement ratio.

Aggregates

Too much fine aggregate gives a sticky mix. Too much coarse aggregate gives a harsh or boney mix.





Mixing

Concrete must be mixed so the Cement, Water, Aggregates and Admixtures blend into an even mix. Concrete is normally mixed by MACHINE. Machine mixing can be done on site or by a premixed concrete supplier. Premixed concrete is batched (proportioned) at the plant to the job requirements.

Truck Mixing

The materials are normally added to the trucks at batching plants and mixed for the required time and speed at the plant. The truck's drum continues to rotate to agitate the concrete during transportation to the site.

Site Mixing

When site mixing, begin by loading a MEASURED AMOUNT of coarse aggregate into the mixer drum. Add the sand before the cement, both in measured amounts.

NEVER USE A SHOVEL AS A MEASURE AS VOLUMES CAN VARY WIDELY.

Mix materials together until there is no visible sand in the mix.

Add enough water to get a workable mix.

Be careful not to overload the mixer. Too much concrete in the mixer means each batch takes longer to be properly mixed, which causes costly delays in the long run or it will not mix at all.

Always check how much the mixer holds so you know how much concrete can be produced at one time.

Avoid delays between batches to get maximum output.

Small quantities of concrete may be mixed by hand with a shovel. Mixing should be done on a clean board, or plate, or in a wheelbarrow. Mix the materials together until they are even. Then dish the material and add water. Use only enough water to get an even, workable mix.

Finish mixing.

Planning and Site Preparation

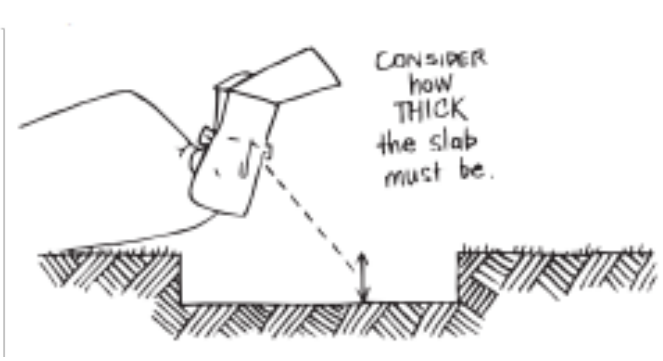
The most important step in placing concrete is planning. Always plan every step before any concrete is delivered. Proper planning avoids delays, wastage, segregation and problems which develop from these.

Safety

Workers on the site should always wear protective clothing, strong boots, helmets and eye protection. Always avoid direct contact with cement and never kneel in or touch the plastic concrete directly. Wear gloves and use barrier creams.
Ensure that anyone using heavy equipment, such as screeds or vibrators, has been properly trained.
The following steps should be taken before any concrete is placed.

Measurement

Measure and stake out the area to be concreted and consider how thick the slab must be. The thickness will depend on the weight the concrete must carry (ie a driveway carries the weight of a car and needs to be thicker than a garden path).

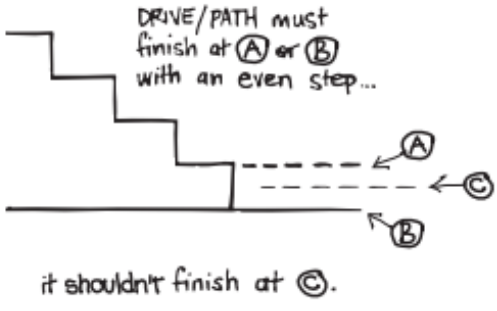


The Finished Level

Once the thickness of concrete has been established, work out where the concrete will finish. Concrete cannot finish too high against steps or the external house wall and should not cover any part of weepholes in the wall. The finished level determines how much digging or excavation must be done. Pavements must slope away from buildings and boundaries.

Steps

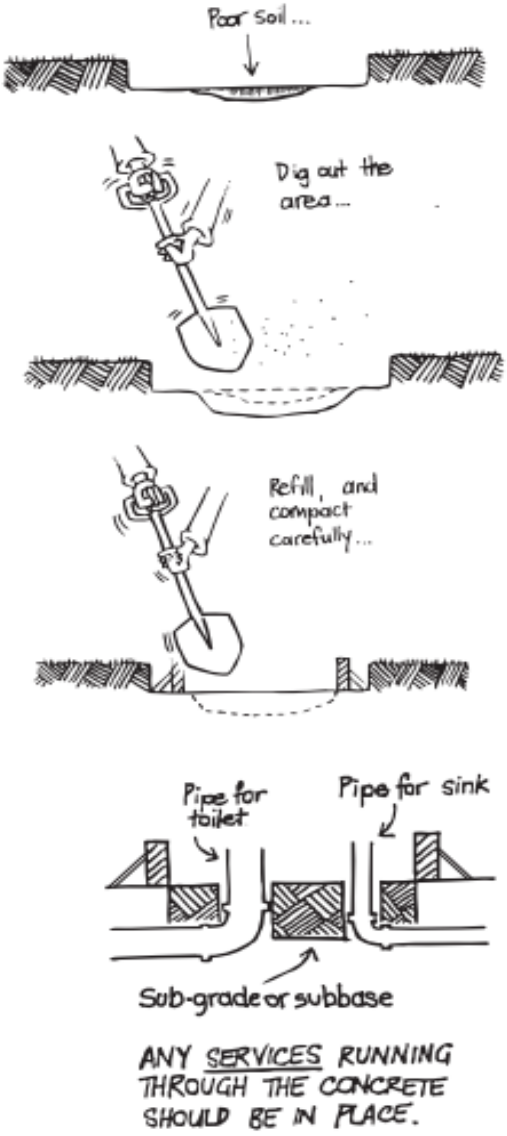
Steps must have equal risers.



Excavation

The ground should be excavated as required by the finished levels. Any roots or grass must be dug out until there is firm soil to place on. Always dig the hole wider than needed to allow

for the formwork. Try to keep the edges and corners square.



Subgrade

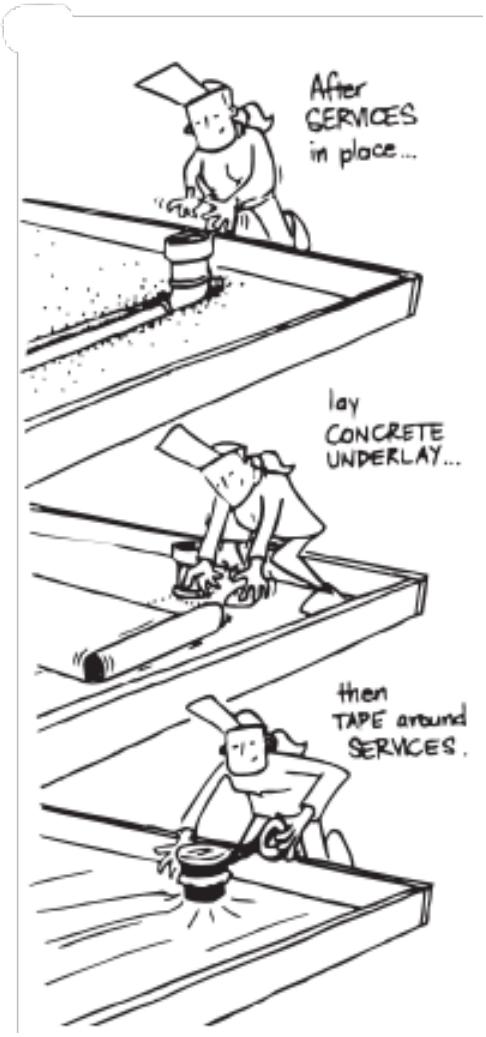
The soil a concrete pavement or floor rests on is called the subgrade. If the soil is soft or varies in softness, a layer of crushed rock (known as a subbase) should be provided. If there are only a few poor areas these can be dug out, refilled and compacted. It is important that the soil evenly supports the concrete. Many later problems can be avoided by properly preparing the subgrade.

Formwork

Formwork gives concrete its shape, Formwork should be properly braced so it is strong. It should not flex or move.

Services

Plumbing, heating or electrical services often run through a slab. These must be in place before any concrete is placed.



Underlay and Services

The underlay, or vapour barrier, is a heavy plastic covering the ground to minimise water vapour rising through the hardened concrete. Always overlap the sheets a minimum of 200 mm and do not tape them. Tape the edges of sheets only around drainage pipes or services which pass vertically through the concrete slab. Termite protection may be required around service penetrations, at joints and around the perimeter of the slab.

Reinforcement

Reinforcement can be used to increase the strength of concrete and/or to help control cracking. For house floors resting on the ground it is placed in the top 1/3 of slabs and in the bottom of thickening and beams. In strip footings, it is placed in the top and bottom. The reinforcement must be covered by a specified amount of concrete which protects the steel from rusting. This is called cover. The amount of cover depends on whether the slab is inside or outside, is in contact with the ground or protected by a membrane. It is measured to the top, side or bottom of the outer surface. Reinforcement should be securely held for slab on ground construction. Bars and mesh should overlap by a specified amount and at the corners of strip footings.

Access

Clear access must be provided to transport the concrete. If concrete is to be delivered by trucks make sure they have unrestricted access to the site in all weather conditions.

Placement

Ensure all planning and site preparation takes into account how concrete will be placed – allowing room for trucks, ramps for wheelbarrows, space for a pump, etc.

Joints

The position, type and number of joints should be planned well before the concrete is placed.

Wastage

Good planning and site preparation reduces wastage. Reducing wastage can cut costs, since up to 15% of concrete can be lost this way.

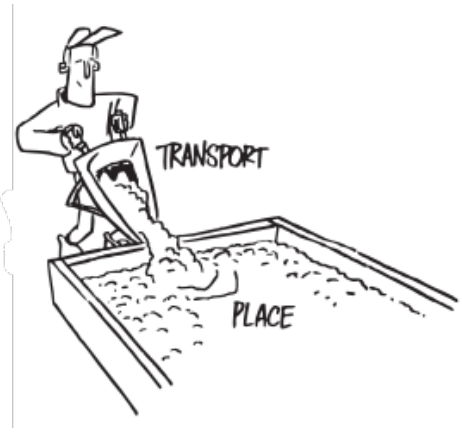
Transporting and Placing

When transporting and placing concrete, avoid:

- ✓ Delays
- ✓ Segregation and
- ✓ Wastage.

Transportation

The method used to transport concrete depends on which one is the most cost effective and easiest for the job size and site. Transport methods include: a concrete truck, a concrete pump, a crane and bucket, a chute, a conveyor or a hoist. For small jobs on which concrete cannot be placed directly from the truck chute, a wheelbarrow is the easiest way to transport it. Always transport concrete as little as possible on site to reduce problems of segregation and wastage.



Placing

When placing concrete be careful not to damage or move the formwork and reinforcement. Place concrete as near to its final position as possible.

Start placing from the corners of the formwork or, in the case of a sloping site,

from the lowest level.

Important Safety Information

When handling and using cement or fresh concrete, avoid skin contact. Wear suitable protective clothing.

Delays

Delays can cause the concrete to dry-out and stiffen. Delays are more of a problem on hot and/or windy days when the concrete will dry-out and stiffen more quickly.

To avoid delays, plan ahead. Check that all labour, tools and containers are ready and that all preparations for placing have been done before the concrete is delivered.

NEVER just add water to the concrete to make it more workable.

Segregation

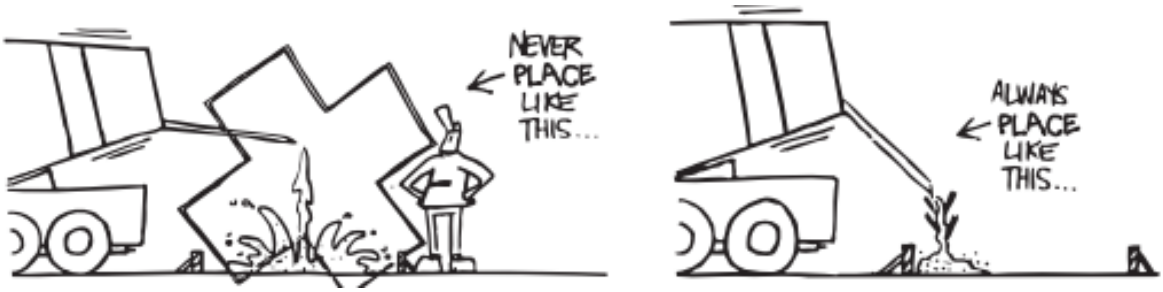
Segregation is when the coarse and fine aggregate, and cement paste, become separated. Segregation may occur when the concrete is mixed, transported, placed or compacted.

Segregation makes the concrete:

- ✓ Weaker,
- ✓ Less durable,
- ✓ And will leave a poor Surface Finish.

To avoid segregation:

Check the concrete is not 'too wet' or 'too dry'. Make sure the concrete is properly mixed. It is important that the concrete is mixed at the correct speed in a transit mixer for at least two minutes immediately prior to discharge. The concrete should be placed as soon as possible. When transporting the mix, load carefully. If placing concrete straight from a truck, place vertically and never let the concrete fall more than one-and-a-half metres.



Always place new concrete into the face of concrete already in place. When compacting with a poker vibrator be sure to use it carefully.

Never spread concrete sideways with a poker vibrator as this may cause segregation of the mix. Always be sure to vibrate concrete evenly.

Wastage

Wastage can be costly, especially on small jobs. To minimise wastage; mix, load, transport and place carefully

Formwork

Formwork gives concrete its SHAPE. Formwork provides a mould, into which concrete is placed. When concrete has hardened the formwork is removed.

Formwork must be:

- ✓ Accurate
- ✓ Strong, and
- ✓ Well made.

This is necessary so that the concrete will not leak from the joints, and so that the formwork will not sag, bulge or move and, especially in large construction, will be safe. The surface of the forms in contact with concrete affects how concrete will look. If the final appearance of the concrete is important, choose a material that will give the required surface texture.

Placement

Be sure that formwork is placed so it can be removed. If formwork is placed in awkward positions or tight corners it may be difficult to remove when the concrete has hardened.

It is helpful if formwork is:

- ✓ Simple to build,
- ✓ Easy to handle, and
- ✓ Re-useable.
- ✓

Formwork sections should be of simple design, not too big and of standard sizes if they are to be re-used.

Materials

Formwork is normally made from steel or timber. Timber formwork is easier to make while steel formwork will allow a greater number of re-uses. Formwork can be made on site or bought from formwork suppliers. Special forms made from various materials can be purchased for forming waffle slabs, circular columns and other special profiles.

Form Release Agent

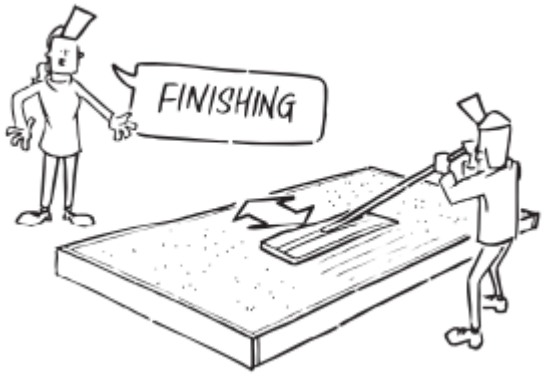
Form Oil should be applied to the inside of the formwork to stop it sticking to the concrete and thus make removal easier. Coat BEFORE the reinforcement is put in place.

Removal Times

Formwork may be left in place to help curing. Removal time will vary according to the weather. In cold weather, concrete will take longer to gain strength than in warm weather, removal times will therefore be longer. In mild conditions (around 20°C) 7 days is long enough to leave the forms in place, unless the concrete is suspended when other considerations apply.

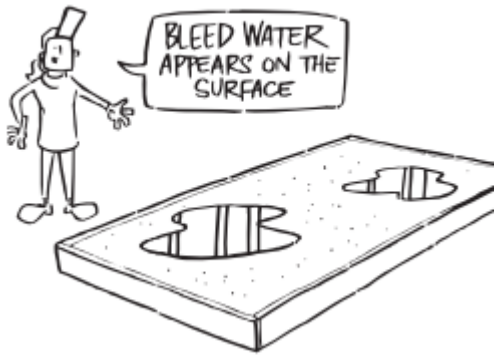
Finishing

Finishing is screeding, floating and/or trowelling the concrete surface to densify and further compact the surface layer of concrete, as well as giving it the look you want.



Finishing takes place in two stages:

- ✓ Initial and
- ✓ Final finishing.



No final finishing can begin while bleed water is present. Mixing bleed water with the surface paste will weaken it, possibly resulting in a dusty surface.

Initial Finishing

Concrete is first screeded to the level of the formwork, then bullfloated and left to set. In some cases screeding leaves a good enough finish, especially if floor coverings are to be used over the concrete. Water then appears on the surface of the concrete. This water is called bleed water. Excess bleed water can be removed by dragging an ordinary garden hose across the surface of the concrete. Never try to dry up the bleed water using stone dust or cement as this will weaken the concrete surface in the long run. Once the bleed water dries up and concrete can support a person's weight, with only a slight marking to the surface, the final finishing can begin.

Floating

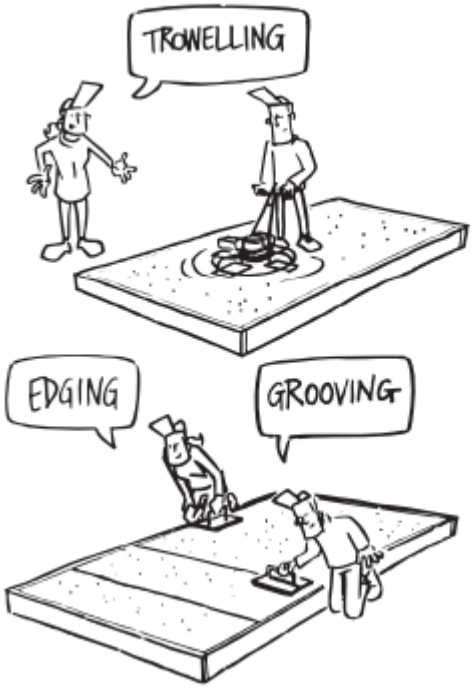
There may be two stages in floating:

- ✓ The bullfloat, which is part of the initial finishing.
- ✓ The power or hand float which is part of the final finishing.

Floating helps compact and level the surface and close minor cracks. Floating can be done by hand or with a power float. Power floating leaves a better finish than hand floating.

Final Finishing

This involves floating, trowelling, edging, jointing or patterning the concrete. Special finishes such as brooming, colouring or patterned finishes can be applied to the surface.



Trowelling

Trowelling leaves a dense, hard, smooth and durable surface. The surface should be trowelled TWICE. A well trowelled surface will be very smooth and can be slippery when wet. Trowelling can be done by hand or power trowel.

Edging and Grooving

All the edges of a slab should be finished with a special edging tool. This gives a neater and stronger edge, less prone to chipping. Joints should be planned before placing and are usually formed into the concrete during finishing.

Once any surface has been finished the concrete MUST be cured.

PLACE RENDERING

Cement-based renders, while typically used to provide a smooth flat finish over a rough surface, can also be used to improve the water-proofing of the surface and provide a decorative finish through the use of colour and various surface textures.

To achieve the best results from a render coating, it is important that:

- ✓ the render mix is suited to the background surface (the surface on which the render is applied;
- ✓ the appropriate surface preparation is carried out;
- ✓ it is properly applied to the correct thickness;
- ✓ the finished rendered surface is cured adequately.

Materials

Cement

Type GP (General purpose cement) or Type GB (Blended cement) complying with AS 3972 are suitable to use for render mixes.

Where a light-coloured render is required off-white cement should be used.

Lime

Hydrated lime or building lime is suitable. Lime is added to make the render creamier and easier to work with. It also assists to minimise cracking as it provides some elasticity to the render once it has hardened. It is good practice (but not essential) to soak the lime in an equal volume of water for 24 hours prior to use, as this will improve its performance in the mix.

Sand

Sand should be clean and free from clay and vegetable matter. In general, coarsely graded sands are suitable for undercoats whilst finer graded sands are appropriate for finishing coats. Plastering sands and finer, washed, concrete sands (which are also suitable for plastering) are readily available from retail hardware and building supply outlets.

Water

Water should be clean and free from impurities. Generally, water suitable for drinking can be used.

Admixtures

Admixtures are any products other than cement, lime and sand that may be added to the render. Chemical admixtures should comply with AS 1478 as applicable.

Generally, admixtures are not required for renders. However, if using admixtures they should be used strictly in accordance with the manufacturer's instructions, as overdosing may result in serious loss of strength and bond.

Cement-based renders can be used to provide a decorative finish through the use of colour and various surface textures.

If colouring the render mix with pigments (mineral oxides) the amount added should not exceed 10% of the weight of cement in the mix and should be thoroughly mixed with the other materials prior to the addition of water. Note that some pigments require the use of an off-white cement to achieve the required colour.

A sample of coloured render should be made and allowed to dry completely before commencing work to ensure the desired colour is achieved. This is particularly important with pre-mixed render products as the amount of cement in the mix is usually unknown.

Pre-bagged or dry-mix products

For small projects and even some larger ones, the simplest way to make render suitable for most applications is to purchase a pre-bagged render mix from a local hardware supplier. These dry-mixed products contain the correct blend of materials and only require the addition of water to produce a suitable render. They often include special additives to improve the ease with which they can be applied (workability), help the render bond to the background and reduce the risk of cracking. Also, for decorative finishes they can be trowelled, bagged or have other decorative patterns applied to the surface and be either coloured (with oxides) or painted.

Most dry-mixed render products are suitable for:

- ✓ masonry block, brick, concrete and stonework backgrounds
- ✓ internal or external locations
- ✓ single or multiple layers (or coats) depending on the thickness required.

Some backgrounds such as autoclaved aerated concrete (AAC) and off-form concrete may need special preparation and/or the use of a special dry-mix render product. The manufacturer's recommendations regarding the suitability of the product for the application required should always be checked, as specific applications such as rendering AAC and less permeable backgrounds may require a stronger mix.

For larger projects, replacing the convenience of using dry-mix products by purchasing the cement, lime, sand and any required additives separately, and mixing these together in the required proportions may be more economical, but care is required to use the correct proportions for the application.

Storage of Materials

Materials should be stored in a way that prevents deterioration or contamination.

Pre-bagged render mixes, cement and lime should be stored in bags off the ground in a dry environment such as a waterproof shed. The air circulation around the bags should be minimised and they should be used on a 'first-in/first-out' basis. Long storage periods of cement-based products should be avoided as their shelf life is in the order of 12 months.

Mixes and Applications

Render mixes should be matched to the background surface to be rendered and the conditions (internal or external) to which the render will be exposed. Table 1 provides material ratios for some applications. The ratios, such as 1:1:6, mean one part cement to

one part lime to six parts sand measured by volume.

Material ratio	Location	Application
1:0:3	Internal	Single coat Undercoat (two-part work
1:0:5	Internal	Finish coat (two-part work
1:0:5:4:5	External	Strong mix for strong backgrounds
1:1:6	External	Moderate strength fo porous and weak backgrounds
1:2:8	External	Final coat for wea backgrounds in sheltere situations

Site-Mixed Renders

Render can be mixed in one of two ways: in a mechanical mixer, or by hand on a board or in a wheelbarrow. Mechanical mixing is less strenuous and much more reliable than hand mixing. Hand mixing should therefore be used only for very small quantities. Mixers should not be overfilled and revolve at speeds recommended by the manufacturer.

Using a mechanical mixer

Step 1 Turn the mixer on and add about a litre of water to 'prime' the bowl.
Step 2 Add the sand, pigment (if any), and then the cement and lime.
Step 3 Blend together until a uniform colour is achieved.
Step 4 Add water slowly until a stiff mix that will 'sit up' on a trowel is achieved.
Step 5 Continue mixing for at least two to three minutes to ensure consistency.
Step 6 Empty/discharge the mixer. Repeat the process until the required amount of render has been produced.

Mixing by hand

Step 1 Measure all the required dry materials for the batch into a wheelbarrow or onto a board.
Step 2 Mix dry materials together until a uniform colour is achieved.
Step 3 Mound the material and form a crater in the centre.
Step 4 Add water slowly into the crater and turn the material into the water.
Step 5 Repeat Steps 3 and 4 until a stiff mix that will 'sit up' on a trowel is achieved.
Step 6 Continue turning and mixing the material for a couple of minutes to ensure all the sand is uniformly coated with paste.
Step 7 Use render.

Repeat the process until the required amount of render has been produced.

Note: Use only enough water to make a stiff mix. Also, render mixes which have stiffened, making them difficult to apply, should be discarded and not made more workable by the addition of extra water. The more water used, the weaker the mix and the greater the likelihood of shrinkage which may lead to bond failure or cracking.

Applying the Render

Initial surface preparation

Regardless of the background surface to be rendered, it should be free from laitance, paint, oil, dust and any dirt or other loose material that may prevent a good bond from forming between the background and the render.

The bond between the background surface and render is formed by the chemical reaction that occurs when the cement in the render mix comes into contact with water. As some of the mixing water is drawn into the background surface, carrying cement particles with it, the bond is improved. Any material on the surface of the background may thus prevent the formation of a good bond between the background and render.

Smooth, as well as dense background materials such as fibre-cement sheet are therefore difficult to bond to and usually require the fixing of metal lath or other material to the surface to allow the render to be mechanically fixed to the background, rather than relying on the render bonding to it.

Proprietary bonding agents, applied strictly in accordance with the manufacturer's instructions, may also be used to improve adhesion between the background surface and render. Table 2 indicates the preparation treatment necessary for a number of background surfaces prior to rendering.

Table 2: Background preparation

Background	Treatment
Smooth, strong and dense e.g. fibre-cement sheet	Fix metal lath clear of surface
Strong and porous e.g. standard bricks, concrete blocks, concrete	Rake joints (if appropriate) and apply dash coat
Weak/porous e.g. lightweight concrete, render undercoat	Dampen surface

Surface dampening

After initial preparation, weak and/or porous background surfaces such as lightweight concrete (eg Hebel blocks) and render undercoats (see below) should be dampened and allowed to dry back to a surfacedry condition immediately prior to rendering. This reduces excessive suction of water out of the render, but still enables a bond to be achieved to the weaker and open-textured backgrounds by allowing time for cement particles to also be drawn into the surface of the background material. Number of coats Depending on the unevenness of the background, a number of coats may be required to build the surface up to a flat finish. In this case, the initial coats are referred to as undercoats and the last coat is referred to as the final coat. Usually, one or two coats will be sufficient for most work and at least three days should be allowed between coats. The conditions to which the render will be exposed and the type of finish may also dictate the number of coats. Allow at least three days between coats.

Dash coats

For strong, yet porous backgrounds such as masonry blocks, bricks, concrete and stonework, a dash coat is usually applied to the surface. Dash coats are used to provide adequate bond between the background and the subsequent render coat. Site-mixed dash coats have the ratio of 1 part cement to 1 to 2 parts sand. The dash coat is flicked and splattered over the background to produce a rough finish to accept the render. It is not trowelled level or smoothed out in any way. The higher cement content of the dash coat allows it to bond more effectively to the background material.

Undercoats

Undercoats are normally applied by trowel. They should have a thickness between a minimum of 10 mm and a maximum of 15 mm. Once the render is firm it should be raked or scratched to provide a key for the next coat. Final coats Final coats are normally applied by trowel with a maximum thickness of 10 mm over the undercoat. If render is to be applied in a single coat, the maximum thickness should also be no more than 10 mm.

Working time

Renders should be applied within half an hour of mixing.

Decorative Finishes

A variety of decorative effects can be achieved using different finishing techniques on the final coats. These vary from simple bagging of the surface and patterns formed by trowelling the surface, to cutting pattern lines into the surface to give the impression of large blocks and stamping various patterns into the surface. The application of decorative render finishes can be difficult and specialist application by certified competent tradespeople is recommended.

Control Joints

Cement-based renders may crack for a number of reasons, eg shrinkage as the render dries out, or movement of the background material. With the careful placement of control joints, this unsightly cracking can be minimised.

Control joints should be formed to coincide with control joints in the background and at locations in the structure where movement is likely to occur. Control joints should extend the full depth of the render. Take particular care not to fill control joints in the background with any render. Weep holes should be carried through the render and a joint in the render must also be provided at all flashings, damp proof courses and at junctions of different materials.

Curing and Protection

Rendering in direct sunlight or exposed, windy areas should be avoided where possible.

Render should not be allowed to dry out quickly. All render coats, including dash coats, undercoats and final coats, should be kept damp for three days or until the next coat of render is applied. Clear or lightly-coloured plastic sheeting should be used to protect fresh render for the first three days. If uniform colour of the render is important, where

possible prevent the plastic sheeting from touching the render as the uneven curing conditions may lead to discolouration.

Protection is not normally required for internal renders provided the building will provide protection from the weather.

CLEAN UP

Remember to clean your equipment right away. Scrub the wheelbarrow and tools with a stiff-bristle brush before the concrete starts to harden. Once the concrete hardens, it's a bear to get off. Scrape excess concrete from the wheelbarrow and pile it on a piece of plastic. If it's a big pile, break it up into manageable chunks before it fully hardens. Dump the rinse water in an inconspicuous corner of your lot (it can kill grass). You can even dig a depression to contain the water and then cover the residue after the hole drains.

UNIT 11

PREPARE ESTIMATE AND READ LAYOUT

This unit covers the competencies required to plan and prepare estimates for and reading layouts

DETERMINE CUSTOMER REQUIREMENTS

Defining your target audience should be the first step in your plumbing marketing campaign. If you don't know who you are marketing to, then you aren't setting yourself up for success, after all you don't know who is going to see your efforts. By determining who your target audience is you create a road map for your plumbing marketing. Having a plan for your plumbing marketing will help keep you organized and help you reach your goals. Let's look at the steps to define who your target audience is.

In determining who your target audience is you are establishing who needs your service and who has already used your service. Not only should you be targeting new customers but reach out to existing customers as well. Existing customers can be very valuable to your plumbing business especially when they become repeat customers or refer new business to you.

When deciding who your target audience is consider the type of person who would be your ideal client. For the purpose of plumbing marketing this can be almost anyone, because everyone need a plumber. However when deciding who is your target audience is important to consider the area in which you provide service, as you don't want to not be able to fulfil service calls because they are too far away. Other things to consider when determining your target audience are: age, gender, and income level.

There are of course some groups of people you should be networking with as a plumber and those are other service professionals. By adding other service professionals to your target audience you can broaden your reach and create referral partners. This is beneficial to everyone involved. Other service professionals you should add to your target audience are:

- ✓ Real Estate Agents
- ✓ Property Management Companies
- ✓ Electricians
- ✓ Appliance Repairs Services
- ✓ Roofing Companies
- ✓ Landscape Architects
- ✓ General Contractors
- ✓ Interior Designers
- ✓ And other local businesses

PREPARING ESTIMATES FOR PLUMBING

Plumbers perform a variety of services related to pipes, plumbing fixtures, and even gas lines in your home. These professionals have hourly rates, as well as project rates, depending on the type of work that you need to be done. Plumbing costs can vary significantly from one project to the next.

Plumbing Drawings and Architectural Drawings

Read through all plumbing notes in the drawings so you don't miss any instructions that may explain additional work or materials involved. Also, take time to compare the plumbing drawings to the architectural drawings. They do not always give the same details and it can help you with your plumbing estimating.
Architectural Drawings take precedence over all trade drawings. The Architectural Detail drawings are next while the Trade Drawings are last.

Let's say you are putting together a tenant build-out estimate. Your plumbing drawings show fifteen (15) single-bowl kitchen sinks to furnish and install. However, when you go to the Architectural Drawing, it clearly shows double bowl under-counter mount stainless steel. If you didn't pick them up on the Architectural drawing, you would be responsible for providing them, if push came to shove.

General plumbing repair and service is rather affordable and is usually charged by service or job for something like pipe cleaning. For installing and repairing pipes, plumbers may charge by the hour or the square footage of the job. There are a number of other variables that factor to plumbing installation. In this cost guide, we will cover the most common plumbing installation jobs and their related costs.

Plumbing installation: by fixture, including materials, and labor cost.

Item	Cost
Toilet installation	**$250–$500**
Sink installation	**$200–$250**
Shower installation	**$1,200–$5,500**
Tub/Shower combo installation	**$1,000–$5,500**
Faucet installation	**$150–$350**
Water heater installation	**$1,100**
Washer installation	**$1,100**
Gas appliance installation: range, dryer, or furnace.	**$1,800–$4,800**
Water main piping and connection: replacement	**$600–$2,300**
New water main connection and pipe installation: new construction	**$1,500–$2,700**

Plumbing installation: 2,000 sq.ft. home, including all labor and materials.

Pipe Material	Cost per Square Foot	Quantity	Total Cost
Copper pipe upgrade/repipe	$2-$5	2,000	**$4,000–$10,000**
PEX: flexible plastic piping	$1-$2	2,000	**$2,000–$4,000**
Galvanized pipe	$1-$5	2,000	**$2,000–$10,000**
CPVC: hard plastic	$0.50-$1.00	2,000	**$1,000–$2,000**

Other considerations and costs

- ✓ If your home has lead pipes, you will require a special removal process (abatement). This incurs an additional fee and may also require you to leave the home during removal.
- ✓ Cast iron, galvanized steel, and polybutylene piping are also no longer used in homes due to various issues with breakage and deterioration. If these pipes are found in your home, a full replacement will be recommended. This could turn a simple repair into a big expense.
- ✓ Plumbers may also charge by the hour for their labor. This may be in addition to materials costs, or it may be included in their total cost. Be sure to ask for a breakdown of exactly what you are paying for.
- ✓ You can often get a discount on faucets and other fixture installations when they are part of a whole-house construction job that includes brand new plumbing lines and fixtures throughout.

PREPARING WORK PLAN

A plan for new plumbing starts with a map of the existing plumbing. Use color codes and these universally recognized symbols on your drawings to clearly denote each component of your plan.

If you have architectural drawings, make several photocopies of them. Otherwise, make several copies of an accurate scale drawing of the room. A gridded straightedge will help you draw parallel lines. You'll also need color pencils, an eraser, and a 30-60-90-degree triangle. Use grid paper and establish a scale, such as 1/2 inch equals 1 foot. Drawing to scale makes it easy to note any problems with the layout. It also helps in estimating materials.

To make a plumbing plan, first draw all fixtures to scale size and make sure they are not too close together. Mark the drain lines and vents for the fixtures, then add the supply lines. Make riser drawings to show vertical pipe runs as well.

Indicate pipe sizes and the exact type of every fitting so the inspector can approve them. Mark locations for valves, including stops at fixtures, and specify the type of valve. Make a shopping list of materials based on the drawings.

Elements of a Successful Plumbing Plan

Key Coding

It's a good idea to code your map to keep the different elements straight. Show drainpipes with solid lines and supply lines with broken lines. Indicate vertical runs with notes on the overhead view. Mark hot and cold supply lines with colored pencils and color-code drains and vents. Point to pipe sizes with a curved leader line to avoid mistaking the leader for a pipe. You might need to draw several versions of the plumbing plan before you get all the details right.

DWV Elevation

A drain-waste-vent (DWV) elevation describes the system that will carry water, waste, and air out of the house. This part of your plumbing plan should note the upward path of the stack, vents, and revents; the length of drainpipe runs; and traps. Its primary purpose is to show how the fixtures will be vented. It doesn't have to be drawn over an architectural drawing, although that can be helpful for reference.

Supply Drawing

A supply drawing indicates the estimated length of supply pipes. Be sure to include the pipe size as well. The main purpose of this drawing is to determine the minimum size of the pipes. Refer to this plumbing plan as you make your shopping list of materials to ensure you purchase the right sizes and lengths

UNIT 12

INSTALL DOMESTIC WATER PIPE SYSTEM

This unit of competency specifies the outcomes required to install and test water pipes across buildings. Water pipe system includes setting up water pipe network across the locations within the buildings such as installing water pipes systems in toilets, kitchen and other needful areas

Introduction

Notes compiled for this unit specifies the outcomes required to install and test water pipes across buildings. Water pipe system includes setting up water pipe network across the locations within and outside the building.

PLAN AND PREPARE

Prior to engaging with the implementation of the work, it is always important to take time and plan and prepare for the work tasks to be performed.

Obtain work instructions and relevant information

We need to be clear about what work you will be doing. Make sure you have everything about the job written down before you start. This includes what you will be doing, how you will be doing it and what equipment you will be using. Make sure you have all of the details about where you will be working. For example:

- ✓ ***The Site*** – Is there clear access for all equipment? Are there obstacles in the way? What are the ground conditions like? Is the site ready for your work to begin? Are there any 'out of bounds' areas you need to avoid?
- ✓ ***The Weather*** – Is there wind, rain or other bad weather? Is it too dark?
- ✓ ***Traffic*** – Are there people, vehicles or other equipment in the area that you need to think about? Do you need to get them moved out of the area? Do you need to set up barriers or signs?
- ✓ ***Hazards*** – Are there dangerous materials to work around or think about? Will you be working close to other people?

You also need to make sure you have all of the details about the kind of work you will be doing:

- ✓ ***The Task*** – What kind of material you will be using including types of pipes and fittings to be used?
- ✓ ***Plant*** – What type of plant will be used for the planned digging operations? How big is it? How much room does it need?
- ✓ ***Attachments*** – What equipment will you need complete the planned task?
- ✓ ***Communications*** – How are you going to communicate with other workers?
- ✓ ***Procedures and Rules*** – Do you need any special permits or licenses? Are there site rules that affect the way you will do the work e.g. contamination control requirements?

Obtain, identify and implement traffic management signage requirements

When pipelines are installed, it involves excavation of the ground. Excavation work generally means work involving the removal of soil or rock from a site to form an open face, hole or cavity, using excavators. Referred work process may be undertaken at construction sites, business or residential premise and also at public areas.

To implement safety of all involved, it is important to manage traffic, including all road users while the work takes place with a temporary traffic management plan. All work on a road or work that affects the normal operating condition of a road must have an approval from local authorities and need to be informed to all the relevant stakeholders.

Types of signs and the procedures those signs can be used is determined by the relevant authorities and it is important that related information is accessed and applied from the respective authorities.

Familiarize with plant, tools and equipment used for plumbing

Plumbing operations which involve installation of water pipe networks require services of excavating plants and collection of various tools and equipment.

Excavating Plant

An excavator is a self-propelled vehicle (either crawler or wheeled) with an upper structure, which can rotate 360 degrees. It can excavate, then swing and discharge materials.

The excavator uses a Hydraulic system to generate a Hydraulic force to control the mechanical arm of the machine. It also uses a chain wheel system for its movement.

Excavators are been used in large- and small-scale constructions. They are used for small housing projects to do a cut and fill, used in road construction, used in marine structures to place armors and large rocks, and also been used in larger sites to excavate, move construction material, remove construction waste etc.

Tools and equipment used for plumbing

This section deals with the function and care of common plumbing tools. After studying this section, you will be able to:

- ✓ Recognize and name each of the tools used by a plumber.
- ✓ Explain what each tool is designed to do.
- ✓ Select the proper tool in the proper size for the desired task.
- ✓ Explain and demonstrate how to maintain common plumbing tools.

1. Measuring and Layout Tools

Instruments that measure length, height, diameter, levelness, or plumb are classified as measuring and layout tools. Tools the plumber will use include tapes, rules, squares, levels, plumb bobs, chalk lines, compasses, and dividers.

Tapes

Many plumbers carry a steel tape measure, for its convenience. Since the blades of most tape measures retract into their cases at the push of a button, they can be quickly put away with one hand. A hook on the end permits the blade to catch on the end or edge of a piece of stock so that it can be pulled out to make the measurement.

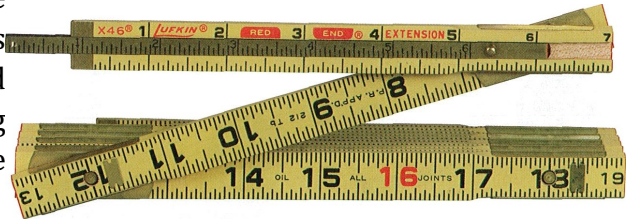
A

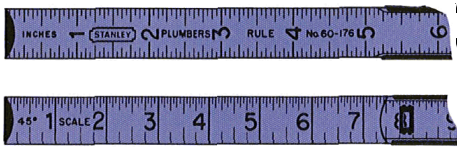
Steel tapes are available in different blade widths, with different measuring range capacities. Long tapes, have steel or fiber- glass blades. They are useful for locating terminal points for pipe or for measuring the length of pipe required for long runs.

Environmental requirements are identified from project environmental management plan, confirmed and applied to the allotted task.

Rules

Two types of folding rules continue to be available, even though most plumbers prefer wide steel tapes. The folding wood rule is equipped with a metal sliding extension. This can be used to take accurate internal measurements.

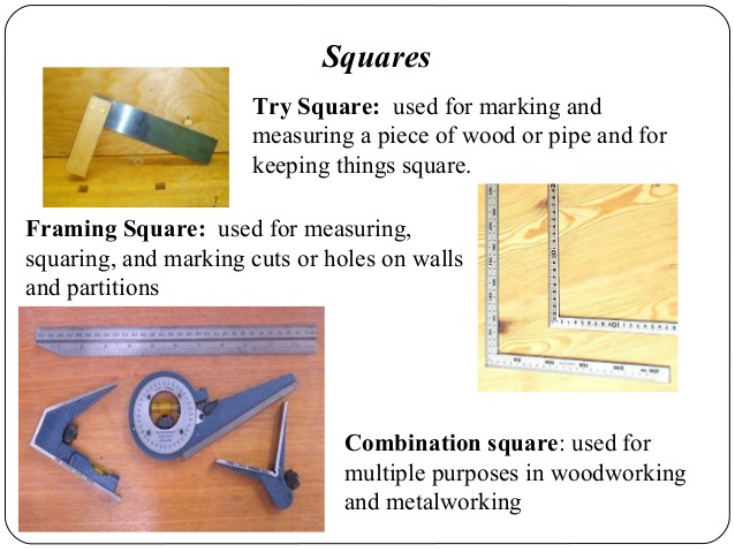




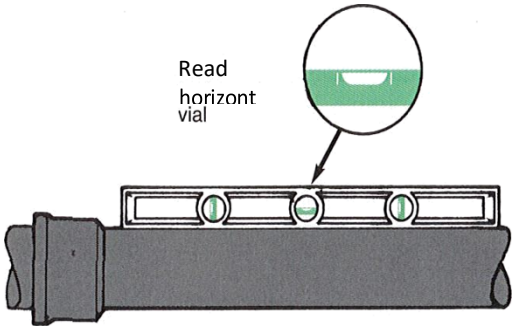
A plumber's rule, is a special type of folding rule. It has vertical markings on one side and a 45° scale on the other. It is avail- able in either 6' or 8' lengths. Metric rules are sold in 1- and 2-meter lengths.

Squares

There are three common types: the try square, the combination square, and the framing square. The try square, can be purchased with a 6" or 12" blade. The combination square, is equipped with a 12" blade that can be moved through a head. This head can measure 90° and 45° angles. The framing square, has a 24" blade and a 16" tongue.



Alignment Tools



When installing pipe and plumbing fixtures, it is often necessary to determine if the part is vertical or horizontal levels. Several tools are used for these purposes. The level, is used to check both positions. A good general-purpose level has at least three vials. One vial tests levelness when a parallel edge of the tool is against the part. The remaining vials test vertical alignment of an object regardless of which end of the level is up. Levels can be

purchased in a number of lengths, with 2' and 4' models the most popular. For plumbers, an aluminum or magnesium level is preferable to a wood level, because it is less likely to be damaged by moisture.

Besides the above, a builder's level is used in the construction field to set up level points and to check elevations. It is an optical instrument used mainly in surveying and building but is also useful for transferring, setting, or measuring horizontal levels. A builder's level consists of many parts:

- ✓ Telescope - holds lenses which magnify objects in the sight.
- ✓ Graduated Leveling Vial - used to level the telescope on its base.
- ✓ Graduated Horizontal Circle - marked by degrees, used for setting and reading angles.
- ✓ Leveling Screws - allows adjustments to be made to ensure the instrument is level in all positions.
- ✓ Focusing Knob - can be turned to make object appear crisp and clear.
- ✓ Base - area where the builder's level attaches to the tripod.
- ✓ Eyepiece - located at viewing end of telescope, can be turned to bring the crosshairs into focus.
- ✓ Horizontal Clamp Screw - holds the instrument in the horizontal position when tightened.
- ✓ Horizontal Tangent Screw - allows the instrument to be adjusted horizontally.
- ✓ Vernier Scale - moves when the telescope is turned to the left or to the right.

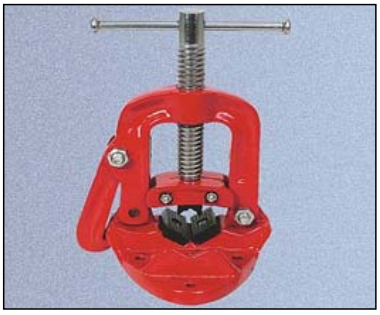
2. Other tools and equipment

Plumber requires different tools to perform various operations. The tools include Bench vice, Pipe vice, Pipe wrench, Chain wrench, Basin wrench, Spud wrench, Pipe cutter, Hack saw, Pipe die set, Pipe reamer, Pipe bending machine, Spanners, Pliers, Screw drivers, Chisels, Hammers, Cocking tools, Files, Taps, Drills and Drill machine, Chain pulley block, etc. Description of these tools is given below.

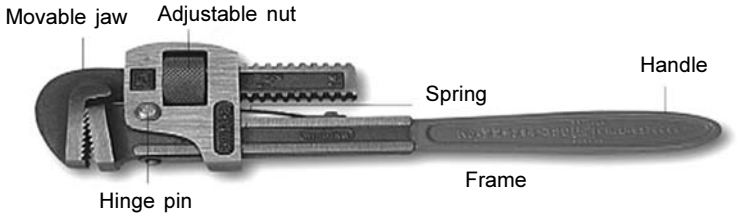
1. **Bench vice**: - Bench vice is used for holding flat or square work piece. This vice is fixed on the bench as the name indicates. There are two jaws one fixed and other movable. The bench vice is designated according to the length of the jaw. The bench vice is available in the market in various sizes out of which 50mm, 100mm,

125mm, 150mm and 200mm size are commonly used.

2. **Pipe vice**: - Pipe vice is used for holding the pipe for performing various operations. Jaws of pipe vice are of V-shaped unlike the jaws of bench vice which are flat. It is essential tool for plumber. The frame of pipe vice is made out of Malleable Iron. The jaws are made up of hardened carbon steel. Base is fastened to a bench provided with holes. The frame is self-locking with all cast components. Pipe vices are available in market in the various sizes for holding pipe size up to 37mm, 50mm, 63mm, 75mm and 100mm.



3. **Pipe wrench**: - One of the first tools people associate with plumbing is the pipe wrench. It's adjustable and has lots of play in the grip. Its teeth face inward. Plumber probably won't even have to lift it off the pipe he is turning. Normally, he shall need two pipe wrenches: one to hold the pipe steady and a second to remove the nut or other attachment. The pipe wrench is an adjustable wrench used for turning iron pipes and fittings with a rounded surface. The design of the adjustable jaw allows it to rock in the frame, such that any forward pressure on the handle tends to pull the jaws tighter together.



4. **Chain wrench:** -Chain wrench tongs are used for turning and fixing large diameter threaded pipes. Jaw with chain is attached to a lever. Chain is rotated around the pipe and the pipe is rotated in either direction. Common sizes of chain wrenches available are for holding up to 50 mm, 75mm, 100 mm, 150mm, 200mm, 250mm, and 300mm pipes.

5. **Pipe cutter:** - Pipe cutter is used to cut the pipe. The procedure for cutting the pipe is as follows. It is placed around a pipe and tightens so that it's just tight, it should not be over tightened, which might dent the pipe. Rotate the cutter around the pipe once or twice, then tighten it again. Repeat the process until the cutter breaks through the pipe, leaving a smooth cut. Normally these are available for cutting of pipe sizes of different diameters.

6. **Hack saw:** - Many hacksaws have a two-part adjustable frame and a pistol grip handle. Hacksaws are used by plumbers to cut pipes and occasionally by electricians to cut conduit. The hacksaw got its name because historically these saws did not cut smoothly.

7. **Spanners:** Spanners are used for fixing and opening nuts and bolts. Different types of spanners are available such as double ended spanner, ring spanners, socket spanners. The material used are Chrome Vanadium Steel / Carbon Steel. Spanners are available in set of different sizes

8. **Pliers:** Pliers are hand tools, used primarily for gripping objects by using leverage. Pliers are designed for numerous purposes and require different jaw configurations to grip, turn, pull, or crimp a variety of things. Many types of pliers also include jaws for cutting. Normally these are available in the sizes of 150mm, 175 mm and 200 mm lengths.

9. **Screw drivers:** The screwdriver is a device specifically designed to insert and tighten, or to loosen and remove, screws. The screwdriver comprises a head or tip which engages with a screw, a mechanism to apply torque by rotating the tip, and some way to position and support the screwdriver. A typical hand screwdriver comprises an approximately cylindrical handle of a size and shape to be held by a human hand, and an axial shaft fixed to the handle, the tip of which is shaped to fit a particular type of screw. The handle and shaft allow the screwdriver to be positioned and supported and, when rotated, to apply torque.

10. **Hammers:** A hammer is a tool meant to deliver blows to an object. The most common uses are for fitting parts, and breaking up objects. Hammers are often designed for a specific purpose, and vary widely in their shape and structure. Usual features are a handle and a head, with most of the weight in the head. Normally these are available with different sizes.

11. Files: Files are used for filing the surface. Files are manufactured from high carbon steel and heat treated. Files are classified as rough and smooth files according to its tooth and flat, round, half round, square, triangular, knife edge according to its shape. Normally rough files in flat & round of 250 mm length are used for plumbing work.

12. **Drills and drill machine**: A drill is a tool with a rotating drill bit used for drilling holes in various materials. The drill bit is gripped by a chuck at one end of the drill, and is pressed against the target material and rotated. The tip of the drill bit does the work of cutting into the target material, either slicing off thin shavings. Plumbers normally use hand operated drilling machine for drilling holes. All sizes of drill bits are available depending upon the size of hole to be drilled.

Identify and apply environmental requirements related to the project

Installing water underground water pipes involve earth digging and disturbing many other environments elements and hence special care need to be given when installing pipe networks.

During the digging process, make sure the process doesn't jeopardise previously installed pipes or cables and make sure the water pipe network layout drawing accounts for any such cables or pipes prior to the commencement of the work.

During digging and before placing the pipe network, make sure, the grounds are analyzed well to ensure longer life of the installed pipe network. It is important to note that environmental stress on critical pipe joints can cause cracking and severe fractures, which require immediate pipe repair to limit their effects. Factors like these, when compounded with high surface pressure, human error, or poor pipe structure, can easily result in full collapse.
Prior to pipe installation, it is also important to analyse particular digging areas as pipe strengths are influenced by sudden drops in temperature during winter months. When water freezes within underground pipe systems, it builds pressure exponentially, which may result in burst pipes. This is a high-risk factor that affects pipes of any size and material.

All of the above and other environmental conditions need to be reviewed prior to

installation of the water pipe networks.

SETOUT AND EXACAVATE

Next stage of the installations of the underground water network involve the following tasks that need to be performed in a systematic manner

Work area and materials are prepared to support efficient installation of the pipe work.

In preparing to undertake installation of underground water pipe network, it is important that adequate preparations are undertaken to ensure smooth and timely implementation of the work tasks.

As part of the preparations, make sure you perform the following.

- Reading the drawing prepared for the network installation
- Procure all the materials required for the installation task
- Make a list of tools and make sure they are readily available for task
- Relevant permits related to the tasks is obtained

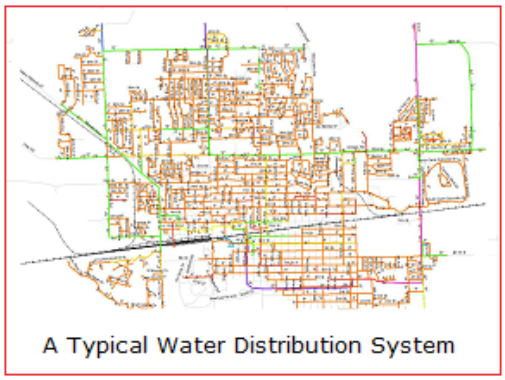
Dewatering requirements are determined and applied

To effectively implement the water pipe network, level of water is determined to ensure if the process of pipe installation require dewatering. Dewatering is used on most construction sites due to accumulated water in trenches and excavations or in places with an inadequate slope or high-water table. In such situations, pipe installation work will be affected.

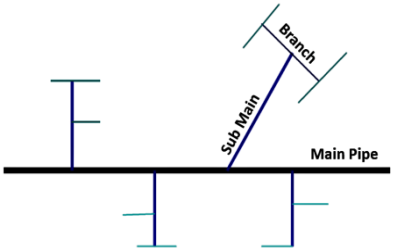
Trenches prepared after excavating need to be kept dry in order to smoothly install the pipe networks. However, if water level is low, dewatering arrangements need to be implemented as part of the pipe network installation.

Read and interpret job drawing for location, and other details

The Water Distribution System is a conveyance system moving water through miles of piping before reaching your tap. It is the essential link between the water supply source and the consumer. Pumps allow water to move through the system. Valves regulate water pressure and flow direction along the way.



A Typical Water Distribution System



Installation of pipe and its connections to the water distribution network and the homes needs to be assessed and evaluated prior to moving forward with the trench digging process. Such review and detailing will provide all the details and hence everyone involved with the planned digging operations be safe and effective.

Works are set out to specification

You also need to make sure you have all of the details about the kind of work you will be doing:

- ✓ ***The Task*** – What kind of material is being moved? How much is there to move? How long do you have to complete the work? Where will the load be discharged? Does it need a special type of bucket or attachment? Are there grades and levels that need to be achieved?
- ✓ ***Plant*** – What type of plant will be used? How big is it? How much room does it need?
- ✓ ***Attachments*** – What equipment will you need to shift the load safely? Is the equipment available?
- ✓ ***Communications*** – How are you going to communicate with other workers?
- ✓ ***Procedures and Rules*** – Do you need any special permits or licenses? Are there site rules that affect the way you will do the work e.g. contamination control requirements?

Plant operator is advised of excavation requirements and levels are monitored

Before start of any work, you need to provide all the details to the plant operator and let the operator understand details of the work involved as the work to be performed needs to be properly coordinated with all the relevant stakeholders. While discussing details of the work tasks, make sure following points are also discussed.

- ✓ Working out the path of movement for plant, vehicles and materials.
- ✓ Identifying hazards, and taking suitable actions to deal with them.
- ✓ Making sure all equipment, resources and workers are available for the task.

It is important to coordinate with other workers when you are inspecting and preparing the site to make sure everyone knows what is going on, what you are planning to do and what they need to do.

All workers on site must understand their own role and the roles of others before starting work. It helps to make sure work is done safely and efficiently.

Installation of mains pipe system support mechanism

It is important to use quality pipe supports in your process piping system, as good pipe support system will help the work being performed and such support mechanisms will help to attain the following.

1. ***Pipe supports should shield pipes from metal-to-metal contact.***
   What's so bad about metal-on-metal contact? After all, metal is supposed to be durable, right? The problem is that when metals rub against one another, it's destructive. One of the most common problems with metal-to-metal contact is galvanic corrosion. Not all metals get along when they're in physical contact with one another. Under the right circumstances, contact between dissimilar metals will kick off an electrochemical reaction and end up rusting one of the metals. A quality support will avoid this corrosion.

2. ***They protect against the rough abrasion of pipe movement.***
   Anyone who's run a fingernail down a chalkboard understands how movement can lead to scraping, abrasion, and damage. Simply put, friction-heavy objects rubbing up against one another causes destruction. In piping systems, the same deterioration happens when pipes rub up against other metals or concrete surfaces. As stable as your pipes may appear to be, they are probably still susceptible to some type of movement. Everything from subtle shifts and jolts to heavier vibrations and thermal expansion can cause pipes to grind across unprotected surfaces.

   Quality pipe supports will encourage the right kind of pipe movement and reduce destructive action. This may mean keeping pipes from bouncing or sliding from side to side while allowing them to move axially.

3. ***They perform under high compressive loads.***
   Pipes can be extremely heavy and forceful, and so the brunt of their weight has to go somewhere. Much of the time, that "somewhere" is a pipe support. Quality pipe supports will have a high compressive strength. Compressive strength dictates how much weight a support can handle before its performance suffers. The value here is easy to see. If a pipe support can't uphold the weight of a piping system, it could collapse and wreck the whole system.

4. ***They hold up in harsh environmental conditions.***
   Pipes are up against rough conditions. They carry corrosive materials like oil, gas, and chemicals. They're exposed to extreme hot and cold. They're out in salt-heavy or wet environments. Pipe supports need to withstand these same elements and help pipes thrive in them. In turn, quality pipe supports will be designed to hold up in the right conditions. This may mean ensuring that a support's makeup is geared toward protecting against high heat, frigid temperatures, and chemicals, as well as stopping heat transfer, discouraging ice formation, and helping pipes avoid pitting corrosion.

5. ***They provide a low coefficient of friction***
   When you dive onto a wet slip-and-slide, you will glide across the lawn. But if you dive onto wet concrete, you'll come to a sharp stop, tearing your skin in the process. Why is that? The answer is your coefficient of friction, and having a low coefficient of friction is an important quality to look for in a well-made pipe support. Simply put, coefficient of friction is a way to calculate friction. It accounts for both the friction between two objects and the force that's pressing them together.

   In piping, a simple example of a product with a low coefficient of friction is the Protek U-Bolt. It's a U-bolt, and so its bare metal surface would normally rub directly against metal pipes. However, in this case, the support includes a

thermoplastic coating that gives it a low coefficient of friction. This makes it easier for pipes to move axially and avoid damage.

INSTALL PIPELINE

With the preparation of the trench and after reviewing the drawing, it is time to install the pipeline and following procedures are applied with the pipe installation.

Pipes are lowered joined according to manufacturer specifications

There are various material types used for water mains, these include:

- ✓ Ductile Iron Pipe
- ✓ Polyvinyl Chloride (PVC)
- ✓ Concrete Steel Cylinder
- ✓ Polyethylene

All pipes and fittings shall be inspected carefully for any possible defects prior to installation and any pipe shows defects shall not be used for the works.

It is absolutely essential to ensure that the pipes are laid on a bed of granular materials to provide even and continuous support along the whole length of pipe. A thick bed of granular material free from large stone from trench excavation, gravel, and broken stone graded between 5mm to 10mm, coarse sand, sand and gravel mix are all acceptable as bedding material. The type of bedding material and its thickness is usually specified in the drawings. Caution tapes (warning tapes) shall be installed in the pipe trench 500 mm above the crest of the pipe for all diameters of pipes being installed.

Butt fusion method of welding shall generally be employed if the pipes being installed are PE pipes while other methods are used based on the type of pipes being used. Joining methods suitable for the pipe being installed need to be applied while joining them during the time of installation.

Pipes are placed and fittings, valves and flow control devices are fitted

While installing pipe networks, provisions need to be provided for the service connections, and perform installation of fittings, valves and flow control devices. While working with pipe, make sure thrust blocks are used when working with bends, tees, valves, reducers, end caps.

While laying the water pipe network, several fittings are used.

Pipe fittings allow pipes to be joined or installed in the appropriate place and terminated or closed wherever necessary. They can be expensive, require time, and different materials and tools to install. They are an essential part of piping systems. There are thousands of specialized fittings manufactured. Each type of pipe or tube requires its own type of fitting, but usually all pipe fittings share some common features.

The basic purpose of using pipe fittings in pipe systems is to connect the bores of two or more pipes or tubes. Pipe fittings are used in piping systems normally (i) to connect straight pipe or tubing sections, (ii) to adapt to different sizes or shapes, (iii) to branch or re-direct the piping system, (iv) if necessary to provide a jointing method if two dissimilar piping materials are used in the one system, and (v) for other purposes, such as regulating, measuring or changing the direction of the fluid flow or to connect up threaded pipe and equipment. They are also used to close or seal a pipe. Following are some of the fittings used.

Besides the fittings, flow control valves are used as valves perform various functions to regulate the operation of a water distribution system. This includes both shutting flow off completely and throttling it down to a lower flow rate. In the former, the pump may still be operating but unable to propel liquid forward, leading to possible damage to the pump if this is prolonged. Reducing allowable system flows increases the pump's operating head and could reduce its efficiency. Valves can be used to regulate the pressure within the pipeline distribution system. This is primarily done by pressure relief valves, which allow built up water or steam to escape, thus reducing pressure within the pipes and preventing it from getting too high.

Alignment level and grade are checked for conformance with design plans and specifications

While installing the water pipe network, make sure relevant inspections are carried out to ensure the network developed remain of high quality.

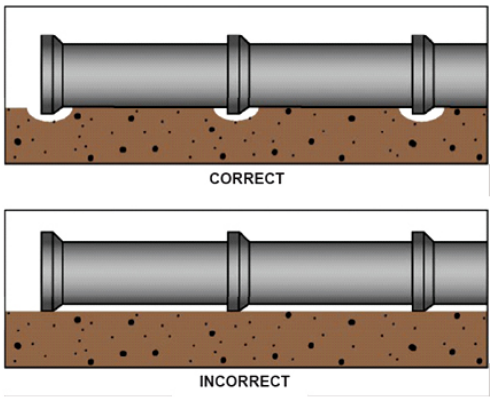
- ✓ Pipe network should be completely water tight and also remain undamaged either by traffic loads, vibrations or temperature and any strains of buildings.
- ✓ Pipe network in the premises should be designed for optimum discharge of water
- ✓ The pipe network should be laid and fixed that it does not pass by the side of any sewage line or refuse drain nor does it pass through any field of foul ground where dirt or city have been deposited and manure dumps.

- ✓ The pipe network should be laid and fixed so that it shell be accessible at anytime for attending to damages, leakages etc.
- ✓ The pipe network should be of adequate size to give the desired rate of flow.
- ✓ The pipe network should be divided into sections to facilitate repairs. These sections should be separated by valves in order that a section can be isolated for repairs keeping the rest of the distribution.

These activities and more need to be inspected as the installation of water pipe system are being formed;

Side support or overlay is positioned beside the pipes.

While installing the water pipe network, make sure the pipe installed inside the trench will check for overlay and support mechanisms.

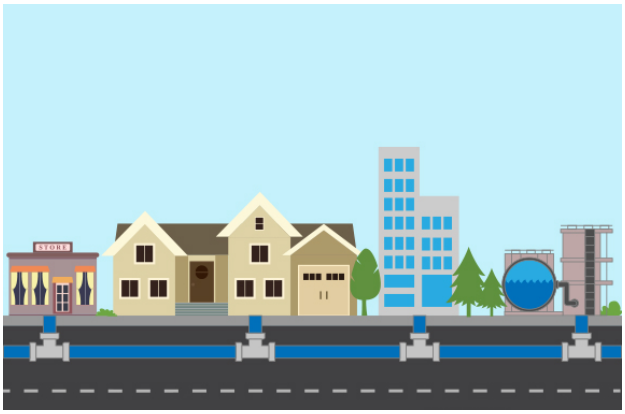


The bedding is the cushion material between the pipes and the foundation. Its function is to ensure uniform support for the pipeline both with regard to grade and hardness. A bedding specification must form part of any pipe laying specification as it influences the pipe strength required.

The best bedding material is granular and uniformly graded which assists in handling and spreading. It only needs sufficient compaction to ensure that laying tolerances are maintained when pipes are laid and backfilled. Holes (recesses) in bedding must be provided for the protruding socket to ensure uniform support of the barrel and hard point supports must be avoided.

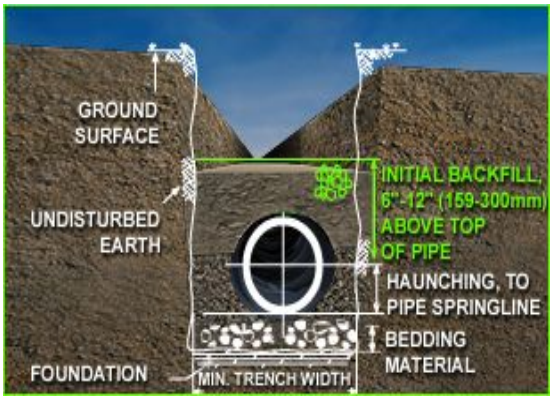
Main pipe system support structure is checked

In progressing with the pipe installation, it is time to check the support structure around the main pipe system.



A water pipe is any pipe or tube designed to transport drinking water to consumers. The varieties of water pipes include large diameter main pipes, which supply entire towns, smaller branch lines that supply a street or group of buildings, or small diameter pipes located within individual buildings. Water pipes can range in size from giant mains of up to 3.65 m in diameter to small 12.7 mm pipes used to feed individual outlets within a building. The pipe layout needs to be checked and secured prior to completing the ongoing pipe installations works.

Perform backfill procedures



Backfilling is the process of putting the soil back into a trench or foundation once excavation, and the related work has been completed. The backfill process requires skills and heavy equipment as well as knowledge of the specifications, contract requirements, and soil conditions. Every area of soil has unique characteristics, requiring different construction techniques to ensure optimum performance.

In case of backfilling a trench, fill the lower portion of the trench by depositing approved backfill and bedding material in layers of 6 inches maximum thickness, and compact with suitable tampers to the density of the adjacent soil until there is a cover of not less than 12 inches, using special care not to damage pipe and pipe coatings.

After soil is backfilled into a trench, the loose material is compacted using some mechanical means, such as a compactor, an excavator, or a "jumping jack"-type compactor.

TEST PIPE SYSTEM

Once the water pipe network is installed, it is important to undertake testing of the work being performed. However, prior to undertaking testing, following conditions need to be

fulfilled.

- ✓ Pressure testing is a potentially dangerous operation and all hazards should be addressed, including the establishment of exclusion zones where necessary.
- ✓ Prior to testing, the entire pipeline should be checked to ensure all debris and construction materials are removed from contact with the pipes and fittings.
- ✓ Where concrete anchor or thrust blocks are used no pressure testing should take place within 7 days of casting the blocks.
- ✓ All mechanical ring seal joints must be restrained either by sand bags, or by partial backfilling of the line leaving the joints open for visual inspection. All valves must be placed in the open position, and a valve provided at the end of the line to allow air to be vented from the line during filling.
- ✓ Where thermal fusion jointing has been used, no testing should take place until the joints have completely cooled to ambient temperature.
- ✓ Local EPA regulations need to be reviewed prior to performing tests.

Tests to be performed on the completed water pipe network

Following tests can be performed on the finished pipeline that has just been installed.

a. Swabbing or Pigging

Pigging (Swabbing) is the method of cleaning the inside of a pipeline by insertion of bullet shaped poly pigs or swabs into the pipeline system. Hydraulic or pneumatic pressure pushes the pig through the pipeline while it cleans the pipe and removes debris. To Swab or Pig water mains successfully depends on the size and type of pig used and the Method of Execution. The methodology of execution is similar to that of air scouring although they are completely different operations.

This operation not only removes the debris from the pipeline but the exit of each pig establishes condition of the internal bore. From this point we can introduce the appropriate pigs of varying sizes and property type to gradually remove the debris from the pipeline and restore the internal bore to near original size. Pigging is a thoroughly proven method of cleaning pipelines. It will prolong the life of the pipes, reduces or prevents replacement programs, and increases the period between cleaning cycles compared to other methods. Water flow rate is immediately increased, allowing pumps to operate more efficiently.

b. Pressure Test

Pressure testing or hydrostatic testing is the test which is carried out after the installation of any pipeline before it is put into use. The purpose of the pressure testing is to investigate the various limits of the pipeline which will test areas such as the reliability, maximum capacity, leaks, joint fittings and pressure. Without this information the pipe cannot be put into service and the owner/operators have no knowledge if the pipe meets the set requirements.

When testing pipelines, they are conducted under the industry's or customer's specifications, filling the vessel with an incompressible liquid, like water or oil. This examines the pipe for any leaks or changes in shape. Generally, dyes are added to the water in order to detect leaks with ease. When pressure testing, the amount of pressure put onto the vessel is always considerably more than the normal operating pressure. This is to allow for any unexpected pressure levels on the vessel for maximum safety.

c. Leakage Test

Leak testing and pressure testing are often used synonymously. However, pressure testing is a misnomer when referring to leak testing of piping systems. By definition, a pressure test is the procedure performed on a relief valve to test its set-point pressure. The intent, when pressure testing a relief valve, is not to check for leaks, but to test the pressure set point of the valve by gradually adding pressure to the relief valve until it lifts the valve off of the seat.

A leak test, on the other hand, is performed to check the sealing integrity of a piping system by applying internal pressure to a pre-determined limit, based on design conditions, then checking joints and component seals for leaks. It is not intended that the MAWP (maximum allowable working pressure) of a piping system be verified or validated.

d. Chlorination

In order to safeguard water quality and public health, it is required that private supply pipes are chlorinated and tested before a connection is allowed to the water main. Pipework chlorination is essential to ensure suitability and safety for the provision of drinking water.

Each chlorination commences with flushing of the system with clean drinking water in order to remove any debris and providing a clean base for the chlorination to take place.

Following the initial flush through, the system is filled to capacity with a chlorinated solution (minimum 50mg/l strength) which will remain for a minimum of 1 hour. After this contact period has been achieved, technicians will neutralize the chlorinated solution and dispose of it safely, flushing the system through again with clean water to remove any residual traces of chlorine.

The system is then again filled to capacity with clean drinking water, sitting once more for a minimum contact period of 1 hour. This final flushing water will then be sampled for chemical and microbiological analysis and the samples submitted to one of our laboratory partners to be analyzed and to be approved.

Test results are recorded and reported

With the completion of the pipeline installation and testing of the pipeline, we must prepare the project completion report. It is a document that will details various stages of project implementation and will include the following.

- ✓ Need to include a title page outlining the project title, its starting and ending date and name of the supporting as well as implementation agencies.
- ✓ Add the table of contents.
- ✓ Give an overview of the project with various activities involved.
- ✓ Describe the results and outcomes of the project.
- ✓ Include results of the tests performed on the pipeline after its installation.

The report with details of the test results will be submitted to the relevant authorities for their approval and perusal.

CLEAN UP

After the installation of the pipeline, it is important that proper cleaning is undertaken prior to completion of the tasks.

Work area is cleared and materials disposed of, reused or recycled

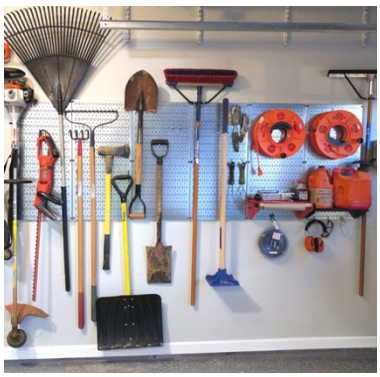
Trenching site need to be properly cleaned and during the cleaning operations, it is possible that debris related to pipe handling and installation process produced waste.

Collected waste from the trenching and pipe installation tasks can include variety of items and can be broken down into the following types:

- ✓ ***Plastic waste*** – This consists of bags, containers, jars, bottles and many other products that can be found in your household. Plastic is not biodegradable, but many types of plastic can be recycled. Plastic should not be mix in with your regular waste, it should be sorted and placed in your recycling bin.
- ✓ ***Paper/card waste*** – This includes packaging materials, newspapers, cardboards and other products. Paper can easily be recycled and reused so make sure to place them in your recycling bin or take them to your closest Brisbane recycling depot.

- ✓ ***Tins and metals*** – This can be found in various forms throughout your home. Most metals can be recycled. Consider taking these items to a scrap yard or your closest Brisbane recycling depot to dispose of this waste type properly.
- ✓ ***Ceramics and glass*** – These items can easily be recycled. Look for special glass recycling bins and bottle banks to dispose them correctly.

Plant, tools and equipment are cleaned, checked, maintained and stored



Several tools are used for the pipe installation tasks and it is important that all the tools are gathered back and properly cleaned.

In order to keep tools, clean all the tools need to be accounted and cleaning process be engaged.

During cleaning, all the tools and equipment used for the pipe installations works will be cleaned and properly stored at the end of the days operation.

UNIT 13

INSTALL AND FIT OFF SANITARY FIXTURES

This unit of competency specifies the outcomes required to install and fit off sanitary fixtures. It applies to the installation of sanitary plumbing, including the connection of discharge pipes to sanitary plumbing and drainage, including soil and waste fixtures

Introduction

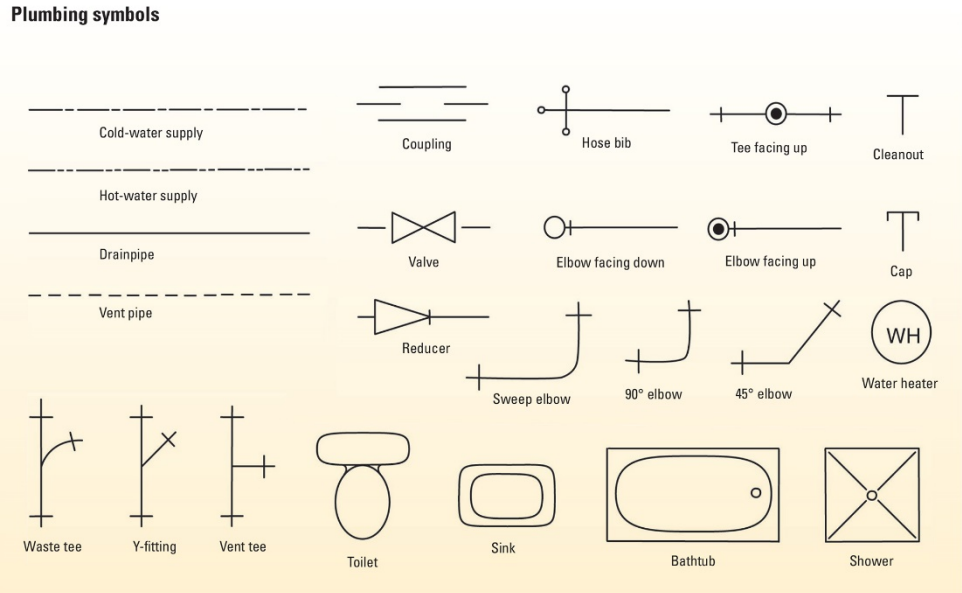
You must have seen plumbing and sanitary fittings and fixtures installed in the kitchen have, bathroom or toilets of your home, school or other buildings. Many people confuse the words plumbing fittings and plumbing fixtures. A plumbing fixture is a part that is connected to a plumbing system and carries water through a building. The most common plumbing fixtures are bathtubs, sinks, showers, tubs, toilets and faucets. While a fixture can be fixed into walls or the floor, a fitting is an item that can be hung by a hook, screw or nail.

PLAN SYSTEM LAYOUT

A well-planned diagram is essential for any remodeling project that involves major plumbing work. If you're renovating your kitchen or adding a new shower to an existing bathroom, for example, drawing up a plumbing plan allows you to map out the system beforehand, which will help ensure the process runs as smoothly as possible. Professional plumbers usually map a plumbing job in painstaking detail to prevent surprises during the project, and you should too if you're planning on completing the work yourself.

A plumbing drawing illustrates the system that will bring water in and take waste back out. It typically includes water supply lines, drains, vent pipes, valves, and fixtures such as toilets and sinks. These plans often use a variety of official plumbing symbols to denote different elements, and it's fairly easy to produce plan views and riser drawings either by hand or using a computer.

Making detailed drawings will save time and expenses later. Also, drawing the project helps you think through the job in detail, which can enable you to spot something that you might otherwise overlook. If you have all the necessary materials noted in the plan, it will almost certainly minimize extra trips to the plumbing supply store. A clear,



professional-quality plan can also be especially helpful for projects that require a

plumbing permit. Although a plan might not be required in order to obtain a permit, it will likely make your initial meeting with the building department more productive. Be sure to check your local plumbing codes before you begin.

How to Draw a Plumbing Plan

A plan for new plumbing starts with a map of the existing plumbing. Use color codes and these universally recognized symbols on your drawings to clearly denote each component of your plan.

If you have architectural drawings, make several photocopies of them. Otherwise, make several copies of an accurate scale drawing of the room. A gridded straightedge will help you draw parallel lines. You'll also need color pencils, an eraser, and a 30-60-90-degree triangle. Use grid paper and establish a scale, such as 1/2 inch equals 1 foot. Drawing to scale makes it easy to note any problems with the layout. It also helps in estimating materials.

To make a plumbing plan, first draw all fixtures to scale size and make sure they are not too close together. Mark the drain lines and vents for the fixtures, then add the supply lines. Make riser drawings to show vertical pipe runs as well.

Indicate pipe sizes and the exact type of every fitting so the inspector can approve them. Mark locations for valves, including stops at fixtures, and specify the type of valve. Make a shopping list of materials based on the drawings.

Elements of a Successful Plumbing Plan

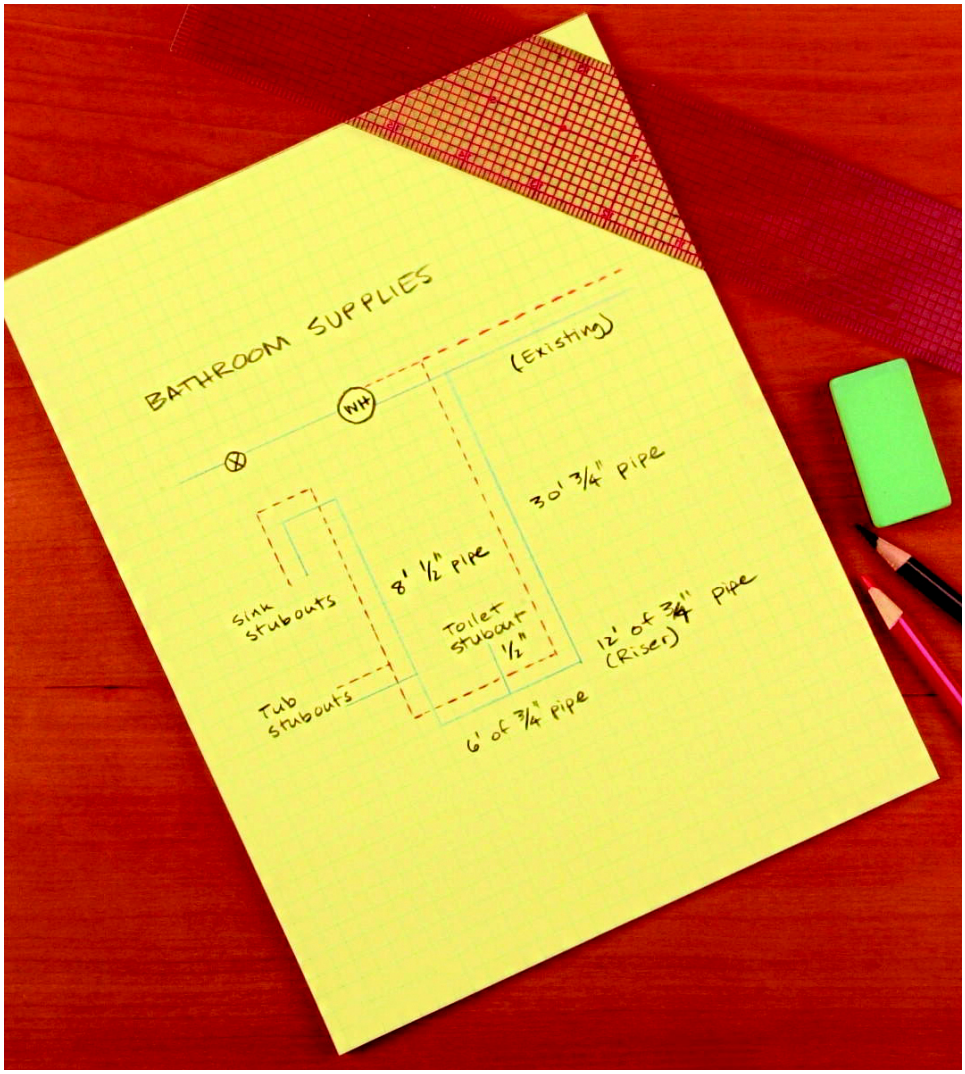
To help your DIY remodel go smoothly, make sure your plumbing plan includes these key elements.

Key Coding

It's a good idea to code your map to keep the different elements straight. Show drainpipes with solid lines and supply lines with broken lines. Indicate vertical runs with notes on the overhead view. Mark hot and cold supply lines with colored pencils and color-code drains and vents. Point to pipe sizes with a curved leader line to avoid mistaking the leader for a pipe. You might need to draw several versions of the plumbing plan before you get all the details right.

DWV Elevation

A drain-waste-vent (DWV) elevation describes the system that will carry water, waste, and air out of the house. This part of your plumbing plan should note the upward path of the stack, vents, and revents; the length of drainpipe runs; and traps. Its primary purpose is to show how the fixtures will be vented. It doesn't have to be drawn over an architectural drawing, although that can be helpful for reference.



Supply Drawing

A supply drawing indicates the estimated length of supply pipes. Be sure to include the pipe size as well. The main purpose of this drawing is to determine the minimum size of the pipes. Refer to this plumbing plan as you make your shopping list of materials to ensure you purchase the right sizes and lengths.

INSTALLATION REQUIREMENTS

Material Take Off

Before a vendor can bid for or begin a construction project, they have to know the types and quantities of the various materials required to complete it. This is to ensure a proper estimate of the costs and material requirements, and also to provide an indication of the labor costs associated with the installation or construction of the materials. This process is known as material take off (MTO), construction takeoff, or simply as takeoff. It's an essential part of a project estimation process.

For smaller projects, experienced builders should be able to compile a material estimate in their head, but a more complete process is necessary for major projects. One must

approach the task methodically to achieve the most accurate estimate possible. In addition to providing a highly accurate estimate of the costs and materials for yourself and your client, the MTO sheet helps the job run smoother because all the people working on the project have what they need.

Takeoff Document

The material takeoff document must have a list of all the materials required to complete the project, no matter what it is. This does not include any assets, such as equipment and tools that will also be required to complete the job but should include any and all raw and prefabricated tools, such as timber, sand, concrete, bricks, electrical cables, light fixtures, and plumbing pipes.
After listing the building materials, the MTO needs to specify the type of material, such as the type of electrical cable or specific grades of steel.

Key Types of Measurement Required

Count

You must count everything required for individual items from the studs required to complete the project to the number of light fixtures and faucets.

Length

Certain items, such as pipes and cables, are measured by length. You'll also need to know other dimensions, like diameter, but the information will be with the type of material that's required. You'll need to know how many of each length you'll require, and you'll need to allot extra length for elements such as switches, panels, and receptacles when it comes to electrical cable.

Area

Certain elements, such as flooring or the amount of paint you need will require the surface area measurement.

Volume

Measurements of volume will be required for certain materials, such as the amount of concrete required to lay the foundation, or the asphalt per yard to pour the parking lot outside the building.

Types of Material Takeoffs

Manual Takeoffs

This type makes use of traditional paper blueprints and plans. For this to work, the estimator needs to be able to accurately read the materials for the type of work quantified, whether it's general architectural drawings, an electrical schematic, a plumbing schematic, or something else. In addition to the diagrammatic representation of the project, the documents will contain symbols and notes that may indicate the type of required materials.
Work from these plans with colored pens, pencils, or markers so you can distinguish between all the items and types of materials. You can transfer the materials and quantities to spreadsheets or forms and worksheets you can use to work out the exact

material costs for each component.
Because paper blueprints can be pricey to produce, you may be required to use a clear plastic overlay instead of marking directly on the blueprint. As such, many estimators are making use of new technology to perform estimates digitally.
In the case of engineering projects, you may not be using blueprints, but a design document.

Digital Takeoffs

It's possible to use manual takeoffs to get an accurate estimate, but they can be labor intensive and complex. It can also cause errors if you get a measurement, calculation, or count wrong.
As more companies are producing digital blueprints, and there is available software to partially automate and streamline the takeoff process, many estimators are opting for a digital takeoff instead.
Though there are different specifications for the different software applications, all of them allow you to analyze a set of blueprints and enter the measurements and quantities. Some systems integrate with a quotation or bidding program so you can easily combine the two processes.

The Takeoff Process

The exact details of the process will vary depending on a variety of factors, including the software you're using, the type of job, the scale of the job, and your specialization as a mechanical, electrical, and plumbing engineering (MEP) estimator. While there will be slight differences in drawings and specifications, the general process remains the same regardless.

1. Count the Symbols

You must count the symbols to determine the number of components needed to complete the job. The drawings and blueprints you're working from will use standardized symbols to identify various elements such as switches, receptacles, and fixtures. Familiarize yourself with the symbols and what they mean. Non-standard components are generally identified with a key that's. included with the drawings.
Count each type of component individually. If you're doing this manually, you can use a tally counter that you click to add a unit. Though it helps to ensure accuracy, it can be time-consuming and tedious. You'll need to mark the symbols somehow to indicate that you've counted it, so you don't count it again. As you complete the count for a component, enter the quantity on the working scope sheet, and repeat until you'll worked through all pages of the blueprint and all the symbols. Then, add the totals for all the different components.

2. Measure the Circuits

You must also measure the circuits shown in the drawings. Before you begin, check the scale used for all the pages you measure. The scale dimensions are usually listed in the title of the drawing, but the scale may vary from page to page.
If you're not working from original blueprints, they may have been copied at a reduced size, so you must make sure the scale is accurate. If you doubt the information in front of

you, it's best to contact the designers or architect to be sure.
You'll want to have an architectural rule, mechanical and electronic measuring wheels, and scaled measuring tapes available. You can use the ruler and measuring tapes for quick measurements in small dimensions but using the measuring wheel is both accurate and convenient.
Measure the branch circuit for each component in the drawing and allow and add in drops at each of the switches. Some wheel devices allow you to program a set distance for drops and then press a key to add the distance. If the drops are standardized, this works, but if they are different sizes, you'll need to reset it each time.
It's possible there will be different circuits (two, three, or four-wire) on the same drawing. Trace each circuit with a colored pen after you've finished measuring and use the same color for the same type of circuit – such as red for two wire, green for three wire, and blue for four wire.

3. Calculate the Takeoff

Using the counts and measurements you came up with in the two previous steps, you can produce your takeoff figure. You should build in a small cushion for price fluctuations, and with this you can provide a fairly accurate cost of the materials involved in any given construction or engineering project. If you have the right time and motion data, you can also estimate the scale of the job to project labor costs and other expenses associated with the project.

PLUMBING FITTINGS

Various types of pipe fitting are available in plumbing systems for different purposes and functions. A pipe fitting is used in the plumbing system to join multiple pipes of same size or different sizes, to regulate the flow or to measure the flow. They are made, up of different materials like copper, iron, brass, PVC, etc. There are many different kinds of fittings, made from a variety of materials. Some of the most common types are as follows.

Types of fittings

1. Collar
2. Elbow
3. Gasket
4. Union
5. Reducer
6. Tee
7. Nipple
8. Trap

For a building, the plumbing system should be designed in a way that water is distributed uniformly, throughout the day. It should be ensured that a combination of fittings and fixtures is selected in such a way that uniform supply of water and discharge of water is maintained.

JOINING MATERIALS

Collar

While joining two pipes in the same length, collar is used. It is fitted at the end of the pipe (Fig. 4.1).

Fig. 4.1: Collars

Elbow

It is installed at the time of joining two pipes. With the help of an elbow, the direction of liquid is changed. Normally a 45 degree or 90 degree elbow is used. When the two sides of pipes differ in size, an elbow of reducing size is used. This is called reducing type elbow or reducer type elbow.

Elbows are categorised as follows.

Long Radius (LR) elbows

Here, the radius is 1.5 times the diameter of pipe.

Short Radius (SR) elbows

In this, the radius is 1.0 times the diameter of pipe.

45-degree elbow

This is used when the change in direction required is 45 degrees (Fig. 4.2).

90-degree elbow

This is used when the change in direction required is 90 degrees (Fig. 4.3).

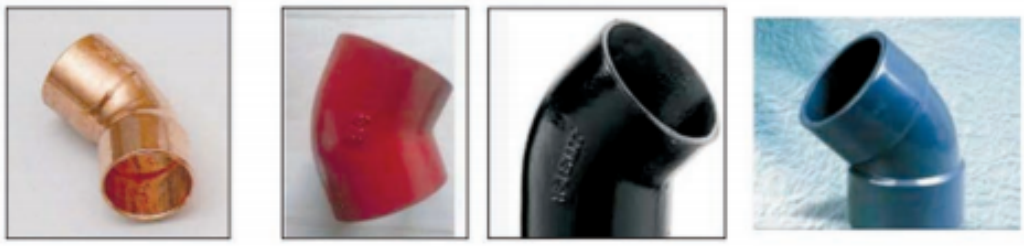


Fig. 4.2: Bend 45 degree

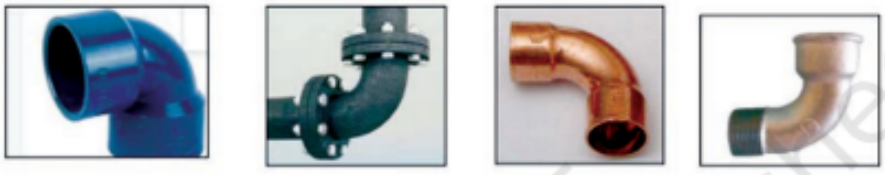


Fig. 4.3: Bend 90 degree

Fig. 4.3: Bend 90 degree

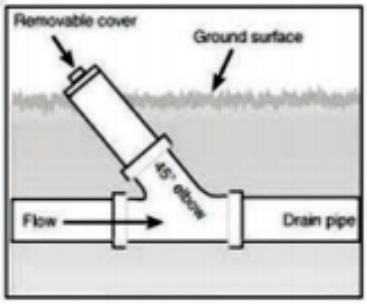


Fig. 4.4: Y-T joint

Fig. 4.5: Double Y-T joint-1

Fig. 4.6: Double Y-T joint-2

Fig. 4.7: T-trap

Gasket

They are mechanical seals, generally ring-shaped and fitted for sealing flange joints. A flange joint is a plate or ring to form a rim at the end of a pipe when fastened to the pipe. Gaskets are made as per by construction, materials and features. Important gaskets used are non-metallic, spiral-wound and ring-joint type

Fig. 4.8: Gasket

Union

When two ends of pipes are joined, the pipe fitting used is called a union. A union is made of three parts, namely a nut, a male end and a female end. The male and female ends are assembled with the support of the nuts, and necessary pressure is applied to connect the joint. Since the pairing ends of the union are interchangeable, the union can be changed easily in a short time

Fig. 4.9: Union

Reducer

It is used to connect pipes of different diameters. A reducer may be of various types like reducer tee, reducer elbow and reducer socket

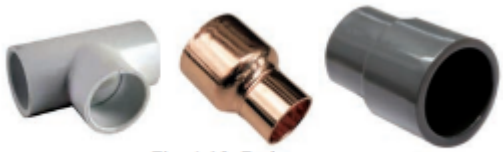


Fig. 4.10: Reducers

Tee

It is an important fitting with a side outlet at 900 to the run of the pipe. Tees connect pipes of various diameters and help in changing the direction of water or material in a pipe. Tees are made in various sizes like equal or unequal. The equal tee is most commonly used

Fig. 4.11: Single tee socket

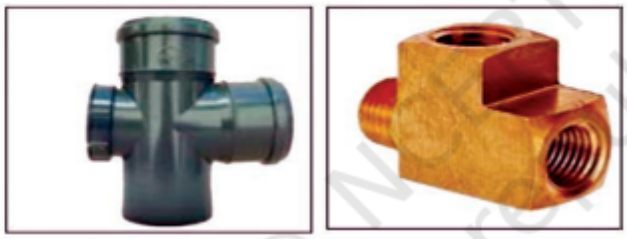


Fig. 4.12: Single tee socket

Fig. 4.13: Double tee socket

Fig. 4.14: Nipple

Nipple

It is a piece of pipe having thread at both sides, and could be used for short extension of plumbing lines. It can also be used for connecting two fittings within small distance

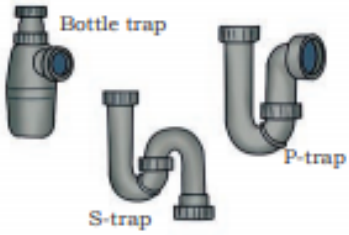


Fig. 4.15: Trap

Trap It is a fitting in a P-, U-, S- or J-shaped type Traps are fitted near a plumbing fixture. The trap bend is fitted to prevent sewer gases from entering the building. If the gases are inserted back into home, then it could lead to people inhaling foul smell, which could cause illnesses. It could even explode.

Fig. 4.16: Cross

Cross

When four pipes are joined, a cross is formed. It is also called a cross branch line or a four-way fitting (Fig. 4.16). This fitting has three outlets and one inlet. Cross fittings may deteriorate when temperatures change, because cross fitting is made at the centre of the four connection points.

Fig. 4.17: Offset

Offset

When an assembly of fittings on a pipeline makes one section of pipe out of line and parallel to a second section, then it is known as an offset (Fig. 4.17).

INSTALL AND FIT SANITARY FIXTURES

Bathtub

Installed in a bathroom, it is made of vitreous material, enamelled iron, plastic, marble, etc. Its length varies from 1.7 m to 1.85 m, the width is 70 cm×75 cm and the depth varies from 43 cm to 45 cm to the outlet end. Cold and hot water taps are provided for filling the tank, and an overflow pipe is provided for excess water drainage. A waste coupling with a waste seal trap is provided at the drain with a rubber plug as in the washbasin.

Fig. 4.18: Bathtub

Washbasin

It is provided for washing hands, face, etc. These are generally made of vitreous china, burnt fireclay, ceramic, enamel over steel, marble, glass, etc. Washbasins are available in different shapes, sizes and colours.

Fig. 4.19: Washbasin

Water closet

It is provided to receive human excreta directly from the user. It is connected through a suitable trap to the soil pipe and finally to a municipal sewer or septic tank. The excreta is flushed with the help of water from the cistern tank. There are two types of water closets.

Fig. 4.20: Water closet

1. Indian type
2. European type

Faucet

It is a device that controls the flow of liquid, especially water, from a pipe. It is also called a water tap. It is available in a bathroom, kitchen or sink, as per use.

Sink

It is a rectangular, shallow, waterproof tank made of concrete, vitreous china, fireclay, or stainless steel. It is used for cleaning utensils, clothes, etc. The flow of a sink is provided with a hole for fixing a waste coupling and a waste pipe.

Fig. 4.23: Flushing cistern

Flushing cistern

It is a small tank holding water for flushing urinals and water closets. It is made of cast iron, glazed earthenware, glazed vitreous, or any other material. Depending upon its size, a cistern can hold the following quantities of water—5 litres, 10 litres and 15 litres. A 10-litre cistern is the most common.

Fig. 4.24: Geyser

Geyser

It is used for heating water. It is available in different capacities, upto 25 litres, as per requirement.

INSTALL AND TEST PIPE SYSTEM

It refers to the act of placing or fixing in position a plumbing fixture such as a washbasin, a water closet, etc. Installation is an important step in fixing the components of a system as per the design. During the installation of plumbing system in a building, home or a housing colony, planning is done as per the standard procedure of designing. A good installation system prevents water leakage, allows optimum installation of the money spent and enhances the life of the plumbing fixtures. Instructions for installation are given either by the manufacturer on one's own or the specifications in the construction map. If the standard procedure is followed during the installation of plumbing system, it allows for smooth and efficient functioning of the system.

Important points before installation

Read the plumbing drawing

Study the drawing of the bathroom, washroom, kitchen or other places where installation is to be done. The drawing will help the Plumber General to understand various aspects of plumbing fittings, fixtures, distance and height to be maintained during installation.

Install the basic sanitary fixture

Fittings (faucets and valves) are used more often than any other part of the plumbing system. The best modern fittings selected should use chrome-plated brass as it bears the effect of water quality and has a high durability. They can be cleaned easily with soap and warm water.

Protection against backflow

The supply lines and fittings for every plumbing fixture should be installed in such a way that there is no backflow. There may be a backflow due to improper design.

Access for cleaning

Plumbing fixtures should be installed in such a way that they can have easy access for cleaning, for both the fixture and the area around the fixture.

Check for alignment and setting

The fixtures must be set level in proper alignment with the adjacent walls. As per the Indian Plumbing Association Code, a water closet, lavatory or bidet should not be set closer than 15 inches (381 mm) from its centre to any sidewall, partition, vanity or other obstruction, or closer than 30 inches (762 mm) centre-to-centre between toilets or adjacent fixtures. An 18-inch (457 mm) distance must be in front of the water closet or bidet to any wall, fixture or door. Water closet compartments should not be less than 30 inches (762 mm) wide and 60 inches (1524 mm) deep. There must be at least 18 inches (457 mm) clearance in front of a lavatory to any wall, fixture or door. A urinal shall not be set closer than 15 inches (381 mm) from the centre of the urinal to any sidewall, partition, vanity or other obstruction, or closer than 30 inches (762 mm) centre-to-centre between urinals.

Make floor and wall drainage connections

Connections between the drain and floor outlet plumbing fixtures must be made with a floor flange. The flange shall be attached to the drain and anchored to the structure. Connections between the drain and wall-hung water closets should be made with an approved extension nipple or horn adapter. The water closet must be bolted to the hanger with corrosion-resistant bolts or screws. Joints should be sealed with an approved elastomeric gasket or setting compound.

Check for floor flanges

Floor flanges for water closets or similar fixtures shall not be less than 1/8 inch (3.2 mm) thick for brass, 1/4 inch (6.4 mm) thick for plastic, and not less than a 2-inch (51 mm) caulking depth for cast-iron or galvanised malleable iron. Floor flanges of hard lead shall weigh not less than 0.7 kg and shall be composed of lead alloy with not less than 7.75

percent antimony (a chemical element which is a brittle, silvery-white metalloid) by weight. Closet screws and bolts shall be of brass. Flanges shall be secured to the building structure with corrosion-resistant screws or bolts.

Secure floor outlet fixtures

Floor outlet fixtures must be secured to the floor or floor flanges by screws or bolts of corrosion-resistant material.

Secure wall-hung water closet bowls

Wall-hung water closet bowls should be supported by a concealed metal carrier that is attached to building the structural members so that strain is not transmitted to the closet connector or any other part of the plumbing system.

Make water-tight joints

All the joints of fixtures close to the wall or floor must be sealed to prevent water from entering or passing through.

Plumbing in mental health centres

In mental health centres, pipes or traps should not be exposed, and fixtures must be bolted through walls.

Design of overflows

Where any fixture is provided with an overflow, the waste should be designed and installed in such a way that standing water in the fixture will not rise in the overflow when the stopper is closed, and no water will remain in the overflow when the fixture is empty.

Connection of overflows

The overflow from any fixture should be discharged into the drainage system on the inlet or fixture side of the trap. The only exception exists in case of the overflow from a flush tank serving a water closet or urinal, which should be discharged into the fixture served.

Access to concealed connections

Fixtures with concealed slip-joint connections should be provided with an access panel or utility space at least 12 inches (305 mm) in its smallest dimension or other approved arrangement so as to provide access to the slip connections for inspection and repair. Where such access cannot be provided, access doors shall not be required, provided that all joints are soldered, solvent cemented or screwed so as to form a solid connection.

Installation of a wall hung fixture

Step 1. Install the mounting board between the studs at the proper height, using the same method as for a wall-hung flush tank.
Step 2. Attach a hanger bracket on the finished wall using the proper length of wood screws at the recommended height. The metal bracket must be level.
Step 3. Place the lavatory on the bracket and push down. Make sure the lavatory is level.

Joining of pipes

Proper solvent cementing techniques are fundamental to the successful installation of pipes. Such techniques provide the basis for strong and durable solvent cement joints.

Solvent cementing

Also known as solvent welding, solvent cementing is a chemical process that uses a primer, or the cement itself, to soften the surface of a plastic pipe and fittings in order to weld, or fuse them together. When applied, the solvents soften and dissolve the top layer of the pipe and fitting material, loosening its molecular structure. A taper in the fitting socket creates an interference fit that ensures contact between the pipe and fitting. This allows the material to fuse to itself when the two pieces are connected. Solvent cementing is a fast, easy and highly reliable process that produces a joint, stronger than either the pipe or fitting alone.

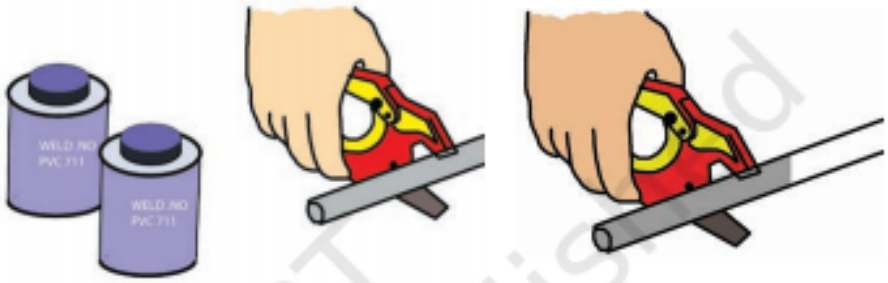


Fig. 4.26: Solvent cementing is the most popular kind of Chlorinated Polyyvinyl Chloride joining method

PVC glue is used as a solvent cement. It is an adhesive that is used to create an airtight seal that holds the PVC pipe and connection fittings together. Considering that the majority of piping installation failures are the result of improper cementing techniques, an understanding of the proper techniques required for joining, saves both time and money.

Procedure for solvent cementing

1. Inspect the pipe and fittings for overall appearance and compatibility. Obvious defects such as cracks, burrs and incompatible materials must be addressed as required. The joining surfaces must be clean and dry. In addition, the cement for the type and size of pipe and fittings should be determined. Also, remember both temperature and humidity may be issues to consider. Another detail that is often overlooked is the need to have the correct size applicator for the size of pipe. The size of the applicator should be about half the size of the pipe diameter in order to ensure proper and timely solvent cement coverage.

2. Cut the pipe with a cutter or saw in square to provide optimal bonding area..
3. De-burr the pipe with a chamfering tool or file to ensure proper contact between pipe and fitting. Remove all burrs from both the inside and outside of the pipe with a knife, file or reamer. Burrs can scrape channels into pre-softened surfaces or create hang-ups inside surface walls. Remove dirt, grease and moisture. A thorough wipe with a clean dry rag is usually sufficient.
4. Apply a heavy, even coat of CPVC primer (if necessary) to the fitting. Use the right applicator for the size of pipe or fittings being joined. The applicator size should be equal to 1/2 the pipe diameter. It is important that a satisfactory size applicator be used to help ensure that sufficient layers of cement are applied.
5. Apply a heavy, even coat of primer (if necessary) to the pipe end. The purpose of a primer is to pierce through and soften the surfaces so they can fuse together. The proper use of a primer and checking its softening effect provides assurance that the surfaces are prepared for fusion in a wide variety of conditions. Check the piercing or softening on a piece of scrap before you start the installation or if the weather changes during the day. Using a knife or other sharp object, drag the edge over the coated surface.

Fig. 4.27: Joining of elbow after application of solvent

Proper piercing has been made if you can scratch or scrape a few thousandths of the primed surfaces away. Because weather conditions do affect priming and cementing action, repeated applications to either or both surfaces may be necessary. In cold weather, more time is required.

6. Apply a heavy, even coat of CPVC cement (if necessary) to the fitting. Then apply to the pipeend. Stir the cement or shake can before using. Using the proper size applicator for the pipe size, aggressively work a full even layer of cement onto the pipe-end equal to the depth of the fitting socket. Do not brush it out to a thin paint type layer, as this will dry within a few seconds.
7. Insert the pipe into the fitting socket, rotating ¼ to ½ turn. Hold the pipe for 10 seconds, allowing the joint to set. A merit of using plastic pipes is that if you make a mistake, you can cut the section out and re-do it.
8. The joining is finished. The cure (drying) time depends on pipe size, temperature and relative humidity. If local codes permit, successful joints can be made without a primer using cement alone, but extra care must be taken during the installation. It is important that a good interference fit exists between the pipe and fittings. It is for this reason that we recommend that joints being made without a primer be limited to systems 2" and smaller for pressure applications (water systems only) or 6" and

smaller for drain waste vent (DWV) or non-pressure applications. Extra care must also be taken in applying the cement to make sure proper piercing (insertion) and softening of the pipe and fitting surfaces is achieved.

9. Joint strength develops as the cement dries. In the tight part of the joint, the surfaces will tend to fuse together; in the loose part, the cement will bond to both surfaces. These areas must be softened and pierced through. Piercing and softening can be achieved by the cement itself, by using a suitable primer or by the use of both primer and cement. For certain materials and in certain situations, it is necessary to use a primer. A suitable primer will usually slip into and soften the surfaces more quickly than cement alone.

UNIT 14

LOCATE, CLEAR BLOCKAGES AND FIX LEAKS

This unit of competency specifies the outcomes required to locate and clear blockages to sanitary plumbing and drainage with the use of mechanically operated drain clearing machines and attachments, and manually operated drain cleaning tools and equipment where applicable

Introduction

Water is, of course, a vital part of everybody's day-to-day life. As your water company, we have a responsibility to protect that water supply for everyone. Part of that involves finding and fixing leaks all over our region to make sure nothing is wasted, and we go to great lengths to make sure we're doing all we can to reduce and stop leakage.

PREPARE FOR WORK

Detecting and repairing leaks is one of the main components of water conservation.

Old or poorly constructed pipelines, inadequate corrosion protection, poorly maintained valves and mechanical damage are some of the factors contributing to leakage. Leak detection has historically assumed that all, if not most, leaks rise to the surface and are visible. In fact, many leaks continue below the surface for long periods of time and remain undetected. With an aggressive leak detection program, water systems can search for and reduce previously undetected leaks. Water lost after treatment and pressurization, but before delivered for the intended use, is water, money and energy wasted. Accurate location and repair of leaking water pipes in a supply system greatly reduces these losses. Once a leak is detected, the water utility must take corrective action to minimize water losses in the water distribution system.

Every industrial and commercial water system facility should implement cost effective water loss control measures that will minimize distribution system water losses. Water systems with pressurized distribution systems should promote water auditing, leak detection, and leak repair as a means to reduce operating costs and conserve water. The water audit can be used on systems with customer meters, while leak detection and repair can be used on any pressurized water system. The difference between produced water and the total of metered use and authorized non-metered use estimates is an indicator of the severity of unauthorized use problems or system water leaks.

Benefits of Leak Detection and Repair

Minimizing leakage in water systems has many benefits for water customers (and their suppliers). These benefits include:

- ✓ Improved operational efficiency.
- ✓ Lowered water system operational costs.
- ✓ Reduced potential for contamination.
- ✓ Extended life of facilities.
- ✓ Reduced potential property damage and water system liability.
- ✓ Reduced water outage events.
- ✓ Improved public relations.

Some added benefits of leak detection and repair that are difficult to quantify include:

- ✓ increased knowledge about the distribution system, which can be used to respond more quickly to emergencies and set priorities for replacement or rehabilitation programs;
- ✓ more efficient use of existing supplies and delayed capacity expansion;

- ✓ increased firefighting capability.

Leak detection and repair programs can lead other important water system activities, such as:

- ✓ inspecting hydrants and valves in a distribution system;
- ✓ updating distribution system maps;
- ✓ using remote sensor and telemetry technologies for ongoing monitoring and analysis of source, transmission, and distribution facilities. Remote sensors and monitoring software can alert operators to leaks, fluctuations in pressure, problems with equipment integrity, and other concerns; and
- ✓ inspecting pipes, cleaning, lining, and other maintenance efforts to improve the distribution system and prevent leaks and ruptures from occurring. Systems might also consider methods for minimizing water used in routine water system maintenance.

Types of Leaks

There are different types of leaks, including service line leaks, and valve leaks, but in most cases, the largest portion of unaccounted-for water is lost through leaks in supply lines. There are many possible causes of leaks, and often a combination of factors leads to their occurrence. The material, composition, age, and joining methods of the distribution system components can influence leak occurrence. Another related factor is the quality of the initial installation of distribution system components. Water conditions are also a factor, including temperature, velocity, and pressure. External conditions, such as stray electric current; contact with other structures; and stress from traffic vibrations, frost loads, and freezing soil around a pipe can also contribute to leaks.

Underground Leaks

The underground piping on either side of a water meter should be maintained. Leaks in underground plumbing can be caused by many different factors, including rusting through from age or from stray electric currents from other underground utilities that can prematurely rust metallic piping, driving over piping with heavy trucks or equipment, poor initial installation, freezing and thawing of a pipeline, leaking joints or valves, or transient high pressure events such as opening and closing valves or starting and stopping pumps quickly.
Signs of underground leaks include:

- ✓ Unusually wet spots in landscaped areas and/or water pooling on the ground surface.
- ✓ An area that is green, moldy, soft, or mossy surrounded by drier conditions.
- ✓ A notable drop in water pressure/flow volume.
- ✓ A sudden problem with rusty water or dirt or air in the water supply (there are other causes for this besides a leak).
- ✓ A portion of an irrigated area is suddenly brown/dead/dying when it used to be thriving (water pressure is too low to enable distant heads to pop up properly).
- ✓ Heaving or cracking of paved areas.

- ✓ Sink holes or potholes.
- ✓ Uneven floor grade or leaning of a structure.
- ✓ Unexplained sudden increase in water use, consistently high water use, or water use that has been climbing at a fairly steady rate for several billing cycles.

If any of these conditions exist at a property, there may be a leak. If a leak is suspected, a professional leak detection company may be required to pinpoint its exact location and a contractor hired to perform repairs. There are leak detection service companies listed in the yellow pages. Any utility contractor should be able to repair a leak once the location is known.

Leak Detection and Repair Strategies

There are various methods for detecting water distribution system leaks. These methods usually involve using sonic leak-detection equipment, which identifies the sound of water escaping a pipe. These devices can include pinpoint listening devices that make contact with valves and hydrants, and geophones that listen directly on the ground. In addition, correlator devices can listen at two points simultaneously to pinpoint the exact location of a leak.

Large leaks do not necessarily constitute the greatest volume of lost water, particularly if water reaches the surface where they are usually found quickly, isolated, and repaired. However, undetected leaks, even small ones, can lead to large quantities of lost water since these leaks might exist for a long time. Ironically, many small leaks are easier to detect because they are noisier and easier to hear using hydrophones. The most difficult leaks to detect and repair are usually those under stream crossings. Leak detection efforts should focus on that portion of the distribution system.

Active leak detection is crucial in identifying unreported water leakage and losses in the distribution system. Finding and repairing water losses through an active leak detection program will reduce water loss and, in many cases, save substantial money. Without a leak detection program, leaks may only be found when they become visible at the surface, or when major infrastructure collapses. Active leak control will reduce expensive emergency overtime repairs and the associated liability costs. The impact on customers is also greater in emergency repair situations as is the possible impact on other infrastructure (roads, sewers, utilities) and on the environment due to possible discharges of chlorinated water. Detecting leaks is only the first step in eliminating leakage. Leak repair is the more costly step in the process. On average, the savings in water no longer lost to leakage outweigh the cost of leak detection and repair.

Checking for Leaks

Identifying leaks can be difficult; however, at minimum the following should be performed:

- ✓ Inspect irrigation systems for obvious above ground leaks. Extremely wet areas above an underground pipe can be an indication of a broken pipe or joint.
- ✓ Examine equipment routinely and look at exposed pipes to see if you can visually see any leaking water.

- ✓ Compare your records with the same month of previous years. While the amount of water used will vary due to weather and processes, look for sharp increases in your consumption that could indicate a leak.

If you suspect a leak at your facility, take steps to get the leak fixed.

Using technology to detect leaks

With the majority of our network buried underground, it can be hard to locate the exact source of a leak, or spot it before it breaches the surface.
Any water that escapes from the network is wasted water, and we are working hard to minimise the level of water lost as it travels through the pipes.
Our teams are constantly monitoring our network, checking for subtle changes in flow rate and pressure that may indicate leaks. Their expertise, combined with the technology we use, means we manage to detect 60% of leaks before they become an issue for the public.

Drones and satellites

We use airborne technology to help us pinpoint leaks from the sky.
Drones and satellites can inspect large areas of our network, surveying the surface for changes in ground conditions, including a change in colour of vegetation.
They can also check chlorine levels and reach areas of our network that are hard to access, and relay information back to our experts.

Acoustic and pressure loggers

Acoustic loggers are a major part of our leak detection technology. They pick up vibrations from a leak when they're attached to a pipe. Those vibrations are reviewed by our technicians who can use that information to find a leak.
We often use these at night, when the network is at its quietest and there is less background noise. The loggers listen out for the distinctive sound patterns that escaping water produces.
We also have pressure loggers, permanently assessing the pressure levels in our pipes. These are able to detect changes in flow and pressure. If there is an unexpected drop in pressure, that suggests there may be a leak.
By placing one of these loggers at either end of a section of pipe that we are investigating, we can use the data they collect to triangulate the position of the leak.
We're then able to tell if the issue is on our network or on private pipework. If it's on our network, the data helps us to make sure we dig in the right place so we can get to work fixing it quickly. If the leak is on private pipework, we'll make sure we inform the tenant or homeowner so they know what to do next.

FIND AND REPAIR HIDDEN PLUMBING LEAKS & BLOCKAGE

Tub and shower: Splash leaks

Splash leaks are simply water escaping past a shower curtain or a shower door. Plumbers tell us it's the most common type of bathroom leak. Although it may sound minor, this leak causes major damage when water seeps into the subfloor where flooring meets the tub or shower. Before long the vinyl flooring or tiles begin to loosen. Even worse, the plywood subfloor delaminates and rots, requiring a huge, expensive tearout and replacement project.
Signs of trouble:

- ✓ Curling vinyl flooring or loose tiles next to the tub.
- ✓ Peeling paint or flaking, chalky-looking wood finish near the shower.
- ✓ Water stains on the ceiling or joists below.
- ✓ Mold spots on the wall or floor near the tub or shower.
- ✓ If you use a curtain, look for standing water on the floor after you shower.

How to find the source of a bathtub drain leaking:

- ✓ If you have a shower door, splash water all around the door and frame. Leaks around the frame may take five minutes or longer to show up.
- ✓ If the door has rubber gaskets or a rubber door sweep, check them for gaps.
- ✓ Also check for any gaps in the caulk where the shower or tub meets the flooring.

How to fix a leaking tub drain:

- ✓ Be sure to overlap sliding doors correctly when you close them. The inner door should be closest to the faucet.
- ✓ If you have a shower curtain rather than a door, make sure you close it completely when you shower, or add a splash guard.
- ✓ Seal a leaking frame by running a small bead of tub and caulk around the inside of the frame. Force the caulk into any gaps between the frame and the shower surround. Quickly wipe away all the excess caulk. When the caulk dries, test for leaks again.
- ✓ Replace any worn gaskets or door sweeps. Bring the old one to a home center or plumbing supply store and look for a matching replacement (be sure to get the correct size to fit).
- ✓ If the old caulk along the floor shows gaps, scrape it out and run a new bead.

Tub and shower: Drain leaks

Drain leaks allow water to sneak around the outside of the drain where it's connected to the tub or shower. This is especially common with plastic or fiberglass tubs and shower pans, since these materials flex slightly when you stand on them, often breaking the seal around the drain. These leaks can stain or destroy the ceiling below or rot floor joists. In the case of a tub set on a concrete slab, the leak will ruin flooring in the bathroom or adjoining rooms.

Signs of trouble bathtub drain leaking:

- ✓ Water stains on the ceiling or joists below.
- ✓ Loose flooring near the tub or damp floors in adjoining rooms (if the tub is on a concrete slab).

How to find the source of a leaking tub drain:

- ✓ If you can see the underside of the drain through an access panel or open ceiling, partially fill the tub and then release the water. In a shower, plug the drain with a rag and then release the water. Check the drains and traps for leaks from below through the access panel.
- ✓ If you don't have access to the underside of the drain, plug the drain and add enough water to form a small puddle around the drain (photo). Mark the edge of the puddle by setting a bottle of shampoo next to it. Then wait an hour. If the puddle shrinks, the drain is leaking. Don't rely on your tub stopper for this test; it may leak. Remove the stopper and insert a 1-1/2-in. test plug (find them at home centers). Remove the grate and use a 2-in. plug for a shower.

How to fix a bathtub drain leaking:

- ✓ To repair a tub drain, unscrew the drain flange from above. Then clean the flange and apply silicone caulk. Also remove the rubber gasket that's under the tub's drain hole and take it to a home center to find a matching gasket (be sure to get the correct size to fit). Slip the new gasket into place and screw in the drain flange.
- ✓ If you have access to a shower drain from below, tighten the ring nut that locks the drain to the shower pan. If that doesn't work, replace the drain assembly. If you don't have access beneath the drain, cut a hole in the ceiling below or replace the drain assembly with a WingTite drain.

Tub and shower: Tile leaks

Tile leaks occur when water seeps through deteriorating grout or caulk and gets into the wall behind the tile (Figure A). Depending on the materials used to set the tile, this can lead to tile falling off the wall, severe rotting of the wall framing, and damage to the subfloor, joists or ceiling below.

Signs of trouble:

- ✓ Loose tiles.
- ✓ Persistent mold.
- ✓ If the shower is against an exterior wall, you may find an area of peeling paint outside.
- ✓ Stains on the ceiling under the shower.

How to find the source:

- ✓ Examine the grout and caulk joints for gaps. You almost always find mold here.
- ✓ If you have loose tile behind the tub spout or faucet, open the access panel behind the faucet and look for dampness or stains.

How to fix it:

- ✓ Remove the old grout, caulk and loose tiles.
- ✓ If the surface behind the tile is still solid, you can reattach tiles, regrout and recaulk using tub and tile caulk.
- ✓ If more than a few tiles are loose or if the wall is spongy, you'll have to install new backer board and tile, or a fiberglass surround.

Toilet flange leaks

These leaks occur where the toilet meets the waste pipe below. They allow water to seep out at every flush, which will wreck flooring, rot the subfloor and joists, and damage the ceiling below.

Signs of trouble:

- ✓ Water seeping out around the base of the toilet.
- ✓ Loose or damaged flooring.
- ✓ Stains on the ceiling below.
- ✓ A toilet that rocks slightly when you push against it. This movement will eventually break the wax seal between the toilet and the closet flange.

How to find the source:
If you have ceiling stains, measure from stacked walls (right photo) before you go through the hassle of removing the toilet. If the stain is near the toilet, a leaking flange is the most likely source. Remove the toilet (Photo 2) and look for these leak sources:

- ✓ The flange is level with or below the surrounding floor surface.
- ✓ Cracks in the flange.
- ✓ Bolts or the slots they fit into are broken.
- ✓ The flange is loose, not screwed solidly to the subfloor.

How to fix it:

- ✓ If you don't find any of the problems listed above, reinstall the toilet with a new wax ring.
- ✓ If the flange is too low, install a plastic flange riser over the existing flange.
- ✓ If the flange or bolt slots are broken, install a metal repair flange.
- ✓ If the toilet rocks because the floor is uneven, slip toilet shims under the toilet when you reinstall it.

Sinks: Sink rim leaks

Sink rim leaks allow water to seep under the rim or the base of the faucet. They will gradually destroy your cabinets and countertops in kitchens and bathrooms.

Signs of trouble:

- ✓ Puddles, dampness or water stains inside the cabinet.
- ✓ Loose plastic laminate near sink.
- ✓ A loose faucet base.
- ✓ Deteriorating caulk around sink.

How to find the source:

- ✓ If you have a plastic laminate countertop, examine the underside of the countertop using a flashlight. Look for swollen particleboard or other signs of water damage.
- ✓ Dribble water around the sink rim and look for leaks (photo).

How to fix it:

- ✓ Tighten the faucet base by turning the mounting nuts underneath it.
- ✓ If the sink rim is caulked, scrape away the old caulk and recaulk.
- ✓ Tighten the clips under the sink rim that clamp the sink to the countertop.

Under Sink Plumping: Supply leaks

Supply leaks under the kitchen sink or bath vanity can go unnoticed for a long time since they're usually at the back of the cabinet. Water can run down the pipes into the floor or subfloor, rotting the sink base, the floor and the framing.

Signs of under sink plumbing trouble:

- ✓ Puddles, dampness or water stains under sink plumbing and inside the cabinet.
- ✓ Stains on the ceiling below.

How to find the source:

- ✓ Dab shutoffs and connections with a dry tissue or paper towel and look for wet spots (photo).
- ✓ Run the dishwasher and check for leaks under it.

How to fix it:

- ✓ If the valve stem on a shutoff valve drips, tighten the packing nut. If the leak doesn't stop, replace the valve.
- ✓ For other leaks at the shutoff valve or at the faucet, try tightening the compression nut first. If that doesn't stop the leak, disassemble the fitting, coat the ferrule or gasket with Teflon joint compound (available at home centers and hardware stores) and reassemble the connection.

Sinks: Drain leaks

Drain leaks in kitchens and bathrooms usually occur at the drain or at the slip joints in the drainpipe. Hidden behind boxes and bottles, these leaks can damage flooring, cabinets and even ceilings below before you notice them.

Signs of trouble:

- ✓ Puddles, water stains or a dank odor in the cabinet.
- ✓ Loose or damaged flooring in front of the sink.

How to find the source:

- ✓ Fill the sink bowls, then as they drain check all joints from the sink to the wall with a dry tissue (see photo above).
- ✓ Run and drain the dishwasher and check the waste hose connection.

How to fix it:

- ✓ For a slip joint leak, first tighten the slip nut. If that doesn't work, disassemble the joint, coat the washer with Teflon joint compound and reassemble.
- ✓ For a leak from the basket strainer, tighten the ring nut under the sink. If the leak continues, disconnect and remove the basket strainer. Reassemble it using plumber's putty as a sealant under the basket's rim.

PIPELINE BLOCKAGE UNPLUGGING

Introduction

Occasionally pipes become clogged by solids, which must be dislodged to restore flow. A range of traditional techniques are currently used, despite their hazards. Over-pressurizing a line to attempt blockage removal is a common method, but this is often unsuccessful and undesirable. Other traditional invasive techniques include sewer snakes and water jetting.

All plumbing systems develop clogs—there's no way to avoid it. We'll show you how to clear stubborn clogs in a kitchen sink, bathtub, toilet and floor drain.

These proven techniques will dislodge virtually any clog. If you can't clear a clog after a few attempts, make sure you admit defeat and turn the job over to a drain-cleaning service or licensed plumber. Exerting too much force can permanently damage a pipe or fixture.

Tools You'll Need to Unclog a Drain

- ✓ The first tool to reach for when trouble arises is a plunger. This plumber's friend clears clogs from most fixtures, including sinks, tubs and toilets. Every homeowner should keep one handy.
- ✓ To dislodge clogs located farther down the drainpipe, use a cable auger, or plumber's snake, a long, flexible steel cable wound around a spool that's fitted with a hand crank. Cable augers are available in lengths up to 100 feet, though a 25-foot model will suffice for most any household clog.
- ✓ A closet auger is specifically made for snaking out toilets. It, too, is equipped with a hand crank, but instead of a spool, the cable is encased in a rigid shaft. The auger end is bent at a precise angle to fit through the tight curves of a toilet trap.
- ✓ For a very large clog or one that's far from the fixture, rent an electric power auger. This machine—basically a large cable auger powered by an electric motor—is very effective at cutting through virtually any clog, even tangled tree roots. Before bringing home a power auger, be sure the rental agent shows you how to safely dispense and retrieve the cable.

Unclog a Sink

Remove Trap and Drain Pipe

Most minor sink clogs can be cleared with a plunger.

- ✓ Partially fill the sink with water, then start plunging.
- ✓ Vigorously work the plunger up and down several times before quickly pulling it off the drain opening. If it's a double-bowl kitchen sink, stuff a wet rag into one drain opening while you plunge the other one. If it's a bath sink, stuff the rag into the overflow hole. In both cases, the rag helps deliver the pressure directly to the clog.
- ✓ If plunging doesn't work, grab the cable auger and go to work under the sink.
- ✓ Remove the sink trap with a pipe wrench. The large, threaded coupling on PVC plastic traps can often be unscrewed by hand.
- ✓ Empty the water from the trap into a bucket, then make sure the trap isn't clogged.

Cut Through the Clog

- ✓ Remove the horizontal trap arm that protrudes from the stubout in the wall.
- ✓ Feed the cable into the stubout until you feel resistance.
- ✓ Pull out 18 inches of cable, then tighten the lock screw.
- ✓ Crank the handle in a clockwise direction and push forward at the same time to drive the cable farther into the pipe .
- ✓ Pull out another 18 inches of cable and repeat the process until you break through the blockage.

- ✓ If the cable bogs down or catches on something, turn the crank counterclockwise and pull back on the auger.
- ✓ Once the cable is clear, crank and push forward again.
- ✓ Retrieve the cable and replace the trap arm and trap. Turn on the hot-water faucet to see if the sink drains properly. If it doesn't, don't worry. Debris from the busted-up clog sometimes settles into a loose blockage.
- ✓ Partially fill the sink with hot water and use the plunger to clear the debris.
- ✓ Follow up with more hot water.

Clear a Floor Drain

Loosen Brass Plugs

In many basements, garages and laundry rooms there are floor drains that carry away wastewater from central air conditioners, washing machines, water heaters and snow-covered cars.
Over time, these drains collect large quantities of soap scum, laundry lint, sand and slimy bacteria that crystallize inside the long drainpipe. To break through these tough blockages, you'll need the extra clog-clearing muscle of an electric power auger.

- ✓ Rent a power auger with at least 50 feet of cable. Start by removing the strainer that covers the drain hole.
- ✓ Then, look for a clean-out plug on the side of the drain basin.
- ✓ Remove the plug with a wrench. That allows you to bypass the trap and feed the cable directly down the pipe.
- ✓ If the drain doesn't have a clean-out plug, you'll have to snake the cable through the trap; this is a somewhat more difficult approach.

Using a Power Auger

- ✓ Plug in the power auger and position it near the drain. Most models are fitted with a foot-pedal switch, leaving both of your hands free to guide the cable.
- ✓ Feed several feet of cable down the drainpipe. Set the motor for clockwise rotation, then step on the switch to start the cable turning.
- ✓ Push the cable into the pipe until you feel resistance or hear the motor start to bog down.
- ✓ Stop the motor, reverse the rotation and back out a few feet of cable.
- ✓ Switch back to clockwise rotation and feed the cable farther down the pipe. Repeat this back-and-forth procedure until the clog has been cleared away.
- ✓ Retrieve the cable and flush out the drainpipe by pouring several buckets of hot water down it. If the water still drains sluggishly, run about 2 feet of cable directly down the trap.
- ✓ Before replacing the clean-out plug, wrap Teflon tape around its threads; this will make it easier to unscrew the plug in the future. **Caution:** Failure to replace the clean-out plug will allow dangerous sewer gases to seep into the house.

CLEAN UP

Introduction

Plumbing issues, which every residential house faces occasionally, can create a dramatic situation or simply be a chronic hassle until you hire professional plumbing service. Whether you literally have a flood in your home due to the damaged pipes or the faucets are leaking or you simply need installation of a new plumbing system of pipes, high – quality plumbing service will handle the task. Unfortunately, after the mission with the

plumbers is completed successfully, your bathroom usually screams for deep and meticulous cleaning.

Cleaning of the shower

For truly deep cleaning, you will need some white vinegar and baking soda. To clean head of a shower, fill the plastic bag with white vinegar and leave it for the night. Meanwhile, make a mixture of white vinegar and baking soda, soak microfiber cloth with it and use it to scrub shower door thoroughly. Regular abrasive cleaning product should suffice for cleaning a tub. After all of these tasks, rinse the items first with hot and later with cold water. These procedures will eliminate all the dirt, mildew, scum, even bacteria growing over the shower head.

Cleaning large surfaces

The main areas you will have to clean after plumbing interventions are walls, ceilings and tiles. Let's assume that you swept all the big portions of dirt and dust and all you need to handle are dirty marks and stains on the walls, tiles and floor. Of course, you are free to use a tough brush and erosive cleaner and spend three days trying to clean thoroughly every inch of these wide surface. Fortunately, there's a handy trick that works as effectively, but it's easier and takes less time. Use some generic abrasive cleaner and apply it to these surfaces. Then run the hot water via shower and let the steam fill the bathroom. Close the windows and leave the bathroom for half an hour. Specific mixture of steam and cleaner applied across the walls and tiles will ease the cleaning of sticky layers with a common microfiber cloth.

Cleaning bathroom sink and toilet

When it comes to the toilet, people usually struggle with stubborn grout stains, everything else is easy to clean with common cleaner and toilet brush. Grout can also be wiped away via toilet brush if you soak it with vinegar before scrubbing. White vinegar is suitable for bathroom sink as well, but it is highly recommended to use some product for disinfection while cleaning faucets. Of course, after you are done with plumbing technicians and cleaning of your bathroom, change all the existing towels used by other people, since these are a perfect area for bacteria growth.

UNIT 15

INSTALL BELOW GROUND DOMESTIC WASTE WATER

This unit of competency specifies the outcomes required to install below ground sanitary drainage systems for sewage and waste discharge from sanitary fixtures to the authorities' approved point of connection

Introduction

This unit of competency specifies the outcomes required to install below ground domestic waste water to the authorities' approved point of connection.

PREPARE FOR WORK

Prior to undertaking the actual work related to the task of installing below ground sanitary drainage system for domestic waste water, following preparations tasks need to be performed.

Plans and specifications are obtained

We need to be clear about details of what work needs to be done. Make sure you have everything about the job written down before you start. This includes what you will be doing, how you will be doing it and what equipment you will be using. Make sure you have all of the details about where you will be working. For example:

- ✓ ***The Site*** – Is there clear access for all equipment? Are there obstacles in the way? What are the ground conditions like? Is the site ready for your work to begin? Are there any 'out of bounds' areas you need to avoid?
- ✓ ***Hazards*** – Are there dangerous materials to work around or think about? Will you be working close to other people?

You also need to make sure you have all of the details about the kind of work you will be doing:

- ✓ ***The Task*** – What kind of material you will be using including types of pipes and fittings to be used?
- ✓ ***Plant*** – What type of plant will be used for the planned digging operations? How big is it? How much room does it need?
- ✓ ***Attachments*** – What equipment will you need complete the planned task?
- ✓ ***Communications*** – How are you going to communicate with other workers?
- ✓ ***Procedures and Rules*** – Do you need any special permits or licenses? Are there site rules that affect the way you will do the work e.g. contamination control requirements?

Work health and safety, quality and environmental requirements analyzed

Due to the hazardous nature of the work involved in installing below ground sanitary drainage system for domestic waste water, following safety precautions are required.

- ✓ Wearing personal protective equipment
- ✓ Interpret safe and effective mechanisms for performing the tasks
- ✓ Safe operating of tools and equipment used for the operation.
- ✓ Employee safety training

It is expected that all the relevant actions will be undertaken to ensure everyone involved with the operations are kept safe while at work and this is called duty of care. To keep yourself and other workers safe you need to:

- ✓ Follow your instructions.
- ✓ Follow all workplace rules.
- ✓ Make sure all equipment is safe to use.
- ✓ Carry out your work safely.
- ✓ Report any problems.

If you think something is dangerous tell your boss or supervisor as soon as possible. Your worksite will also have instructions for working safely including:

- ✓ Emergency procedures, including using firefighting equipment, first aid and evacuation.
- ✓ Handling hazardous materials.
- ✓ Safe operating procedures.
- ✓ Personal protective clothing and equipment. Safe use of tools and equipment.

Tasks are planned and sequenced in conjunction with other stakeholders

Details of the planned work that involve installation of ground domestic waste water needs to be properly communicated with all the stakeholders. It is important to consult and communicate with other workers when you are inspecting and preparing the site to make sure everyone knows what is going on, what you are planning to do and what they need to do.

All workers on site must understand their own role and the roles of others before starting work. It helps to make sure work is done safely and efficiently. Fellow colleagues you may need to communicate include:

- ✓ People attending other tasks on the same site
- ✓ Maintenance workers.
- ✓ Service vehicle operators.

- ✓ Contractors.
- ✓ Site supervisors.

You must consult your workers and their health and safety representatives, if any, when deciding how to manage the risks while undertaking the work tasks.

Tools and equipment used for plumbing

This section deals with the function and care of common plumbing tools. After studying this section, you will be able to:

- ✓ Recognize and name each of the tools used by a plumber.
- ✓ Explain what each tool is designed to do.
- ✓ Select the proper tool in the proper size for the desired task.
- ✓ Explain and demonstrate how to maintain common plumbing tools.

1. Measuring and Layout Tools

Instruments that measure length, height, diameter, levelness, or plumb are classified as measuring and layout tools. Tools the plumber will use include tapes, rules, squares, levels, plumb bobs, chalk lines, compasses, and dividers.

Tapes

Many plumbers carry a steel tape measure, for its convenience. Since the blades of most tape measures retract into their cases at the push of a button, they can be quickly put away with one hand. A hook on the end permits the blade to catch on the end or edge of a piece of stock so that it can be pulled out to make the measurement.

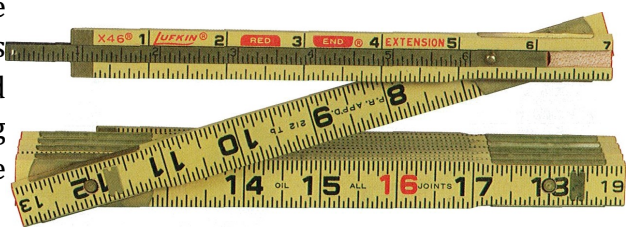
A

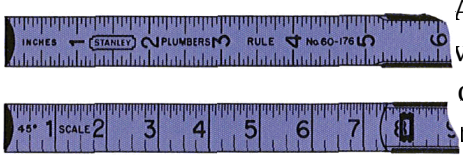
Steel tapes are available in different blade widths, with different measuring range capacities. Long tapes, have steel or fiber- glass blades. They are useful for locating terminal points for pipe or for measuring the length of pipe required for long runs.

Environmental requirements are identified from project environmental management plan, confirmed and applied to the allotted task.

Rules

Two types of folding rules continue to be available, even though most plumbers prefer wide steel tapes. The folding wood rule is equipped with a metal sliding extension. This can be used to take accurate internal measurements.

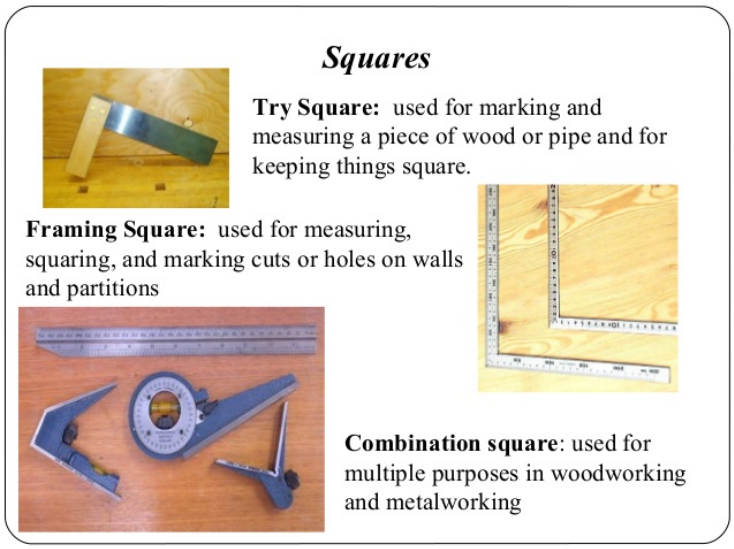




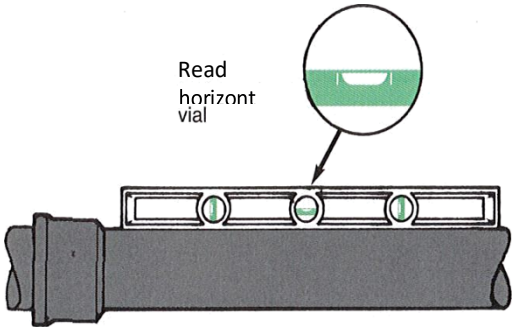
A plumber's rule, is a special type of folding rule. It has vertical markings on one side and a 45° scale on the other. It is avail- able in either 6' or 8' lengths. Metric rules are sold in 1- and 2-meter lengths.

Squares

There are three common types: the try square, the combination square, and the framing square. The try square, can be purchased with a 6" or 12" blade. The combination square, is equipped with a 12" blade that can be moved through a head. This head can measure 90° and 45° angles. The framing square, has a 24" blade and a 16" tongue.



Alignment Tools



When installing pipe and plumbing fixtures, it is often necessary to determine if the part is vertical or horizontal levels. Several tools are used for these purposes. The level, is used to check both positions. A good general-purpose level has at least three vials. One vial tests levelness when a parallel edge of the tool is against the part. The remaining vials test vertical alignment of an object regardless of which end of the level is up. Levels can be purchased in a number of lengths, with 2' and 4' models the most popular. For plumbers, an aluminum or magnesium level is preferable to a wood level, because it is less likely to be damaged by moisture.

Besides the above, a builder's level is used in the construction field to set up level points and to check elevations. It is an optical instrument used mainly in surveying and building but is also useful for transferring, setting, or measuring horizontal levels. A builder's level consists of many parts:

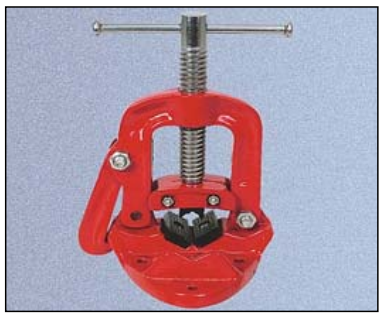
- ✓ Telescope - holds lenses which magnify objects in the sight.
- ✓ Graduated Leveling Vial - used to level the telescope on its base.
- ✓ Graduated Horizontal Circle - marked by degrees, used for setting and reading angles.
- ✓ Leveling Screws - allows adjustments to be made to ensure the instrument is level in all positions.
- ✓ Focusing Knob - can be turned to make object appear crisp and clear.
- ✓ Base - area where the builder's level attaches to the tripod.
- ✓ Eyepiece - located at viewing end of telescope, can be turned to bring the crosshairs into focus.
- ✓ Horizontal Clamp Screw - holds the instrument in the horizontal position when tightened.
- ✓ Horizontal Tangent Screw - allows the instrument to be adjusted horizontally.
- ✓ Vernier Scale - moves when the telescope is turned to the left or to the right.

2. Other tools and equipment

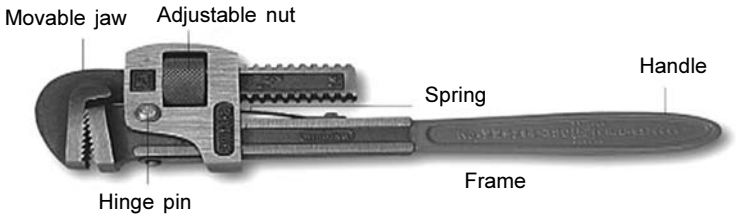
Plumber requires different tools to perform various operations. The tools include Bench vice, Pipe vice, Pipe wrench, Chain wrench, Basin wrench, Spud wrench, Pipe cutter, Hack saw, Pipe die set, Pipe reamer, Pipe bending machine, Spanners, Pliers, Screw drivers, Chisels, Hammers, Cocking tools, Files, Taps, Drills and Drill machine, Chain pulley block, etc. Description of these tools is given below.

1. **Bench vice**: - Bench vice is used for holding flat or square work piece. This vice is fixed on the bench as the name indicates. There are two jaws one fixed and other movable. The bench vice is designated according to the length of the jaw. The bench vice is available in the market in various sizes out of which 50mm, 100mm, 125mm, 150mm and 200mm size are commonly used.

2. **Pipe vice**: - Pipe vice is used for holding the pipe for performing various operations. Jaws of pipe vice are of V-shaped unlike the jaws of bench vice which are flat. It is essential tool for plumber. The frame of pipe vice is made out of Malleable Iron. The jaws are made up of hardened carbon steel. Base is fastened to a bench provided with holes. The frame is self-locking with all cast components. Pipe vices are available in market in the various sizes for holding pipe size up to 37mm, 50mm, 63mm, 75mm and 100mm.



3. **Pipe wrench**: - One of the first tools people associate with plumbing is the pipe wrench. It's adjustable and has lots of play in the grip. Its teeth face inward. Plumber probably won't even have to lift it off the pipe he is turning. Normally, he shall need two pipe wrenches: one to hold the pipe steady and a second to remove the nut or other attachment. The pipe wrench is an adjustable wrench used for turning iron pipes and fittings with a rounded surface. The design of the adjustable jaw allows it to rock in the frame, such that any forward pressure on the handle tends to pull the jaws tighter together.



4. **Chain wrench:** -Chain wrench tongs are used for turning and fixing large diameter threaded pipes. Jaw with chain is attached to a lever. Chain is rotated around the pipe and the pipe is rotated in either direction. Common sizes of chain wrenches available are for holding up to 50 mm, 75mm, 100 mm, 150mm, 200mm, 250mm, and 300mm pipes.

5. **Pipe cutter:** - Pipe cutter is used to cut the pipe. The procedure for cutting the pipe is as follows. It is placed around a pipe and tightens so that it's just tight, it should not be over tightened, which might dent the pipe. Rotate the cutter around the pipe once or twice, then tighten it again. Repeat the process until the cutter breaks through the pipe, leaving a smooth cut. Normally these are available for cutting of pipe sizes of different diameters.

6. **Hack saw:** - Many hacksaws have a two-part adjustable frame and a pistol grip handle. Hacksaws are used by plumbers to cut pipes and occasionally by electricians to cut conduit. The hacksaw got its name because historically these saws did not cut smoothly.

7. **Spanners:** Spanners are used for fixing and opening nuts and bolts. Different types of spanners are available such as double ended spanner, ring spanners, socket spanners. The material used are Chrome Vanadium Steel / Carbon Steel. Spanners are available in set of different sizes

8. **Pliers:** Pliers are hand tools, used primarily for gripping objects by using leverage. Pliers are designed for numerous purposes and require different jaw configurations to grip, turn, pull, or crimp a variety of things. Many types of pliers also include jaws for cutting. Normally these are available in the sizes of 150mm, 175 mm and 200 mm lengths.

9. **Screw drivers:** The screwdriver is a device specifically designed to insert and tighten, or to loosen and remove, screws. The screwdriver comprises a head or tip which engages with a screw, a mechanism to apply torque by rotating the tip, and some way to position and support the screwdriver. A typical hand screwdriver comprises an approximately cylindrical handle of a size and shape to be held by a human hand, and an axial shaft fixed to the handle, the tip of which is shaped to fit a particular type of screw. The handle and shaft allow the screwdriver to be positioned and supported and, when rotated, to apply torque.

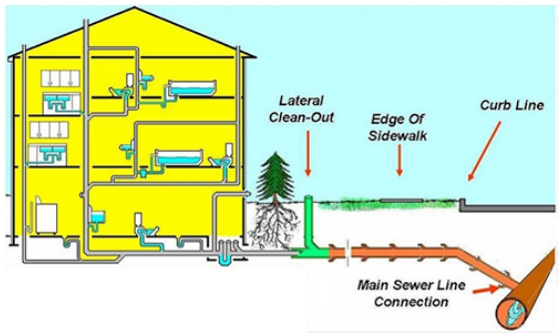
10. **Hammers:** A hammer is a tool meant to deliver blows to an object. The most common uses are for fitting parts, and breaking up objects. Hammers are often designed for a specific purpose, and vary widely in their shape and structure. Usual features are a handle and a head, with most of the weight in the head. Normally these are available with different sizes.

11. Files: Files are used for filing the surface. Files are manufactured from high carbon steel and heat treated. Files are classified as rough and smooth files according to its tooth and flat, round, half round, square, triangular, knife edge according to its shape. Normally rough files in flat & round of 250 mm length are used for plumbing work.

12. **Drills and drill machine**: A drill is a tool with a rotating drill bit used for drilling holes in various materials. The drill bit is gripped by a chuck at one end of the drill, and is pressed against the target material and rotated. The tip of the drill bit does the work of cutting into the target material, either slicing off thin shavings. Plumbers normally use hand operated drilling machine for drilling holes. All sizes of drill bits are available depending upon the size of hole to be drilled.

Location of underground services is identified

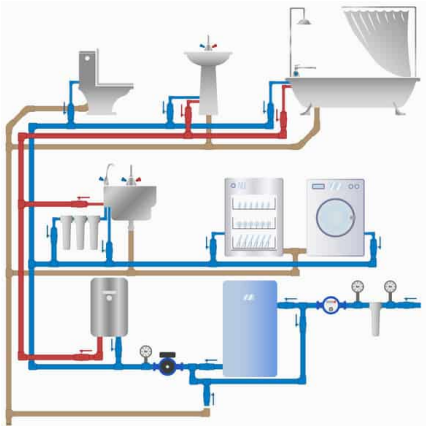
As all the waste water from the different sanitary ware used at home will be connected to the main sewer line, it is important that we locate the aide of the road where the public sewer line is installed to ensure the connection to the main sewer line is easy and straightforward.



Location of underground service and its direction will facilitate installation of catch pit that collects all the waste and sewer lines from the different sanitary ware installed at residential and commercial building are aligned for easy and hassle-free installation to the public sewer line. Besides identifying their location, we should contact the respective sewer line operator (utility providers of different islands) and gather information on undertaking connection from home to the public sewer line.

Work area is prepared to support efficient installation of sanitary drainage systems.

With the location of the underground public sewer line and its connection procedures, installation of catch pit within the residential and commercial building need to be designed and connection of all sanitary ware lines be determined. This information can then used to prepare plumbing and piping plan of the respect home or commercial facility.



With the finalized plumbing and piping plan, preparations need to be undertaken related to the below ground or any other pathways using which the pipeline shall run and hence the planned installation of sanitary drainage systems is completed with speed and efficiency.

IDENTIFY INSTALLATION REQUIREMENTS

With the developed plumbing and piping plan, details of pipeline installation requirements need to be gathered prior to commencement of the project.

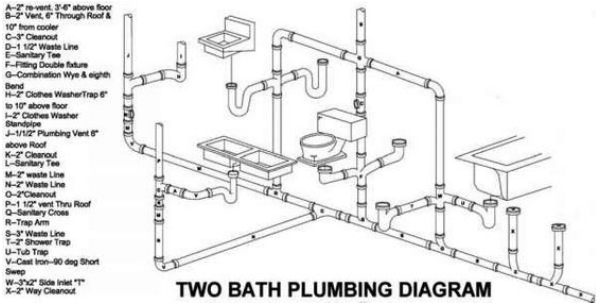
Quantity and type of materials required are calculated from existing plans

Obtain copy of the plumbing and piping plan prior to writing an estimate as development of an accurate quantity and types of materials required to undertake installation of below ground water will save time and energy to all involves. For the purpose of developing an accurate staminate of materials, make sure following points are observed.

1. ***Determine area of the building***

It is important to determine area or size of the building as size of the building will determine how big or small the plumbing task will be and the price of project will vary for different building sizes.

2. ***Count and determine how many water fixtures are there in the drawing***



We need to count and determine how many water fixtures, and this can be done by using the building drawing. With the counting of number of water fixtures, we can clearly visualise the pipe network required for the selected dwelling.

3. Determine how much excavations are involved

With the identification of the water fixtures and development of plumbing and pipe drawing, it is time to determine how much excavations will involve in setting the plumbing and pipe-line networks. Referred step is required to smoothly plan cost and timeline for completing the planned plumbing task.

4. Determine quantity and type of plumbing materials to be used

With these details, it is also time to determine quantity and types of materials that will be used to undertake the plumbing job. Referred process will facilitate determining pipe and fitting quantities with details of all the equipment that will be required to complete the planned plumbing project.

5. Preparation of a detailed plumbing estimate compiled and submitted

With all the details worked out, a comprehensive plumbing estimate s compiled and submitted to the client for approval.

Materials and equipment are identified, ordered and collected

With the approval of the plumbing estimate, all the materials included within the estimated are ordered. Referred list procured and the materials ordered are received and kept at the disposable of the personnel involved with the planned plumbing works.

Materials and equipment are checked for compliance

When you receive the order and prior to commencement of the plumbing task, it is important that proper inspection of the plumbing items is checked for compliance. This process will ensure quality of the work being performed and hence standard materials as per the agreed estimate is essential towards undertaking a successful plumbing job.

Sustainability principles and concepts are applied throughout the installation process.

As one of the skilled experts involved in home building and renovation processes, plumbers play an important role in delivering sustainable housing. Many interact directly with consumers, builders and renovators. During these conversations with their clients they can influence decisions about fixture and fitting purchasing, installation, operation and maintenance. In particular, plumbers can:

- ✓ install water-efficient fixtures and appliances, which reduces the amount of water and energy used and water disposed of down the drain;
- ✓ support water reuse and rainwater harvesting (where permitted), which can offset some of the treated municipal water used by a home and ease the strain on treatment plants and water sources;
- ✓ use high-quality and durable parts to reduce the need for frequent replacement and cut down on wasted materials; and
- ✓ provide homeowners with a calculation of utility cost savings associated with green features, including how long it will take to recover the cost of a high-efficiency fixture or appliance.

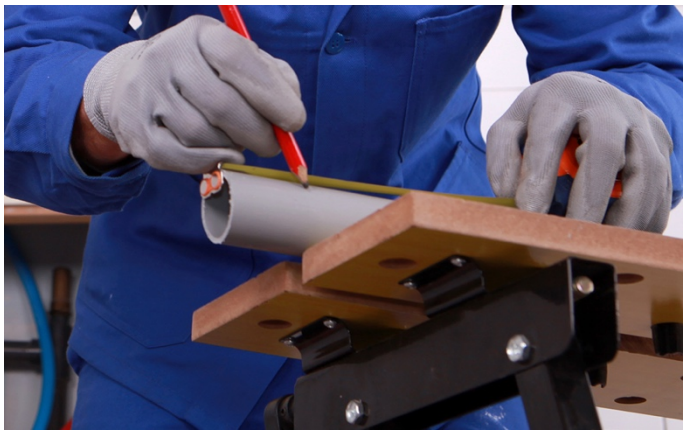
INSTALL SANITARY DRAINAGE SYSTEMS

With the identification of the installation requirements, it is time to install sanitary drainage system.

Setting out pipework according to plans and specifications

With preparations to undertake installation of drainage system, it is vital that the work begins with setting out pipe work according to plans and specifications. This can begin with measure of the drains between sanitary fixtures and in short, following activities are to be performed.

1. Lengths of the drainage pipe that flows between the sanitary fixtures are measured and pipes are cut accordingly.
2. Measure and cut branch drains in the same sequence.
3. Connections, gullies and other accessories at the heads of the branch drains, linking up with the work previously measured are located and placed close the point of connection.
4. Pipe support mechanism such as pipe clips and other fastening devices are identified and closely located with screws.
5. Measurements need to include all the drainage pipes up to the catch pit located within the boundary of the dwelling



Pipework is installed according to plans, specifications, standards

Using the measurements, pipe work is now installed to ensure the drainage line framework is completed. As most of the residential and commercial buildings in the

Maldives are installed with PVC drainage pipes, following paragraphs explain some basic steps that need to be maintained while installing the drainage pipelines.

- ✓ Step 1: Cut the pipe
  PVC pipe can be easily cut with an appropriate pipe-cutting tool.
- ✓ Step 2: Deburr and fit
  After cutting, clean shavings out of the pipe and smooth out the ragged edges (a process called deburring). Position the cut pipe with the proper PVC fittings in place to ensure the length is correct.
- ✓ Step 3: Clean and cement
  Clean the PVC pipe with an all-purpose pipe cleaner called a primer. Swab the primer around the inside of the pipe and the inside of the fitting. A special cement is used to hold the joint pieces of the pipe together. Coat the inner surface of the joint with cement and insert the PVC pipe. Make sure the glue has covered the entire joint.

- ✓ Step 4: Install pipe hangers
  Install pipe hangers to support the pipe and to ease stress on the joints. Follow recommendations from the distances from hanger to hanger, approximately every 4' (1.21 m). Protect the pipe from nails, screws and other abrasive materials.

Providing connections for alterations, additions or repairs to existing systems are made

With the ongoing installations of the plumbing network, further review needs to be undertaken and if required, provide connections for alterations or possible additions to the current building. Such provisions will ensure the pipeline installed has the capacity to accommodate alterations or additions without significantly changing the entire drainage system installed within the building.

Installation is checked for compliance with design drawings and specifications

At the end of the completion of the task that involves installation of the below ground domestic water system, inspection by a relevant expert need to be undertaken to assess and evaluate compliance of the work against drawings and specifications. Besides that, inspection involve systematic process of evaluating drainage systems to ensure smooth wastewater transitions from pipeline to sewage systems. Performing a drain inspection will alleviate future drainage problems such as poor workmanship, and other possible faults that may be associated with the completed project.

Installation is tested to comply with standards and relevant authorities' requirements.

Either water or air testing may be performed on non-pressure PVC pipelines such as drainage systems, depending on the availability of test water, or the ability to drain the test water away from the pipeline alignment after the testing is completed.

Water Testing

All sections of the installation should be sealed off and water introduced through a stand pipe to provide a static head of 3 metres above the top point in the PVC pipeline. All openings in the pipeline must be sealed, or plugged, before starting testing. A riser pipe should be fitted at the top point in the pipeline to allow a minimum water head of 1 meter at this point and a maximum of 5 metres at the lowest point to be applied.

The test water should be introduced evenly into the pipeline and brought up to pressure after allowing all entrapped air to be purged out of the line. The test pressure should be maintained for a minimum period of 15 minutes and all joints and connections should be inspected for leakage. Any defects detected should be repaired and the pipeline retested

Air Testing

Where water is unavailable, or undesirable, for testing then air testing may be performed. All openings must be sealed prior to testing, and air pumped slowly into the pipeline until a test pressure of 50KPa is reached. This test pressure should be maintained for a minimum time of 3 minutes, and if no leaks are detected, or pressure loss observed on the gauge, the air supply control valve should be turned off and the test pressure held for a minimum time of 1 minute. If the test gauge pressure reading has not fallen below 35KPa after this time, then the test should be discontinued.

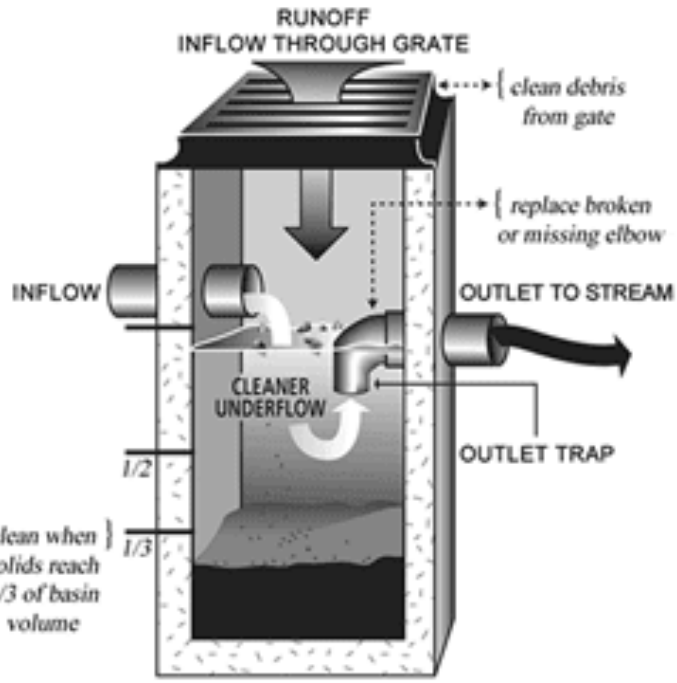
Should the test pressure drop below 35KPa after 1 minute, then the pressure should be returned to 50KPa and maintained until a full inspection of the pipeline has been completed. All joints and connections need to be individually inspected for leakage using a solution of water and detergent poured over any suspect joint. If a leak is present, it will cause the detergent solution to bubble, and foam.

DEVELOP CATCH PIT AND OIL TRAP

With sewerage or waste water disposal systems across domestic drainage systems, connections to the main sewerage line requires installation of the following as part of the domestic drainage system.

1. ***Establishment of catch pit***

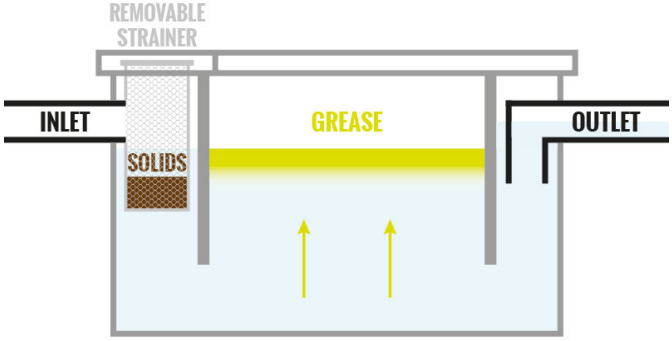
Catch pit remains as the last point of below ground domestic drainage system normally located within the boundary of the home within which the drainage pipelines are being installed.



A catch pit is typical crafted from masonry. This masonry could be brick, concrete block or concrete rings. It is constructed deep enough to be lower than the bottom of the sewer system in the street, by a few feet. There are at least two pipes installed through the walls of the basin. One pipe is the inlet pipe from the home and the other is the outlet pipe toward the sewer. There may be other pipes as well. The idea is; the laundry, floor drains, and kitchen sinks are the most likely origin of the contaminated water and would discharge through the catch basin. When the discharge enters the catch basin it would naturally separate. The solids would sink to the bottom. The gears scum and soap will float on the top. If the outlet pipe has a small elbow or bend it will only allow "clean" liquid to migrate out to the sewer system.

2. Establishment of oil trap

Everyday significant amount of grease and fat enter the sewerage system and they sticks to pipe walls, which can eventually lead to blockages while fats and oils damage waste water treatment equipment, costing municipalities millions in repairs. For these reasons, Utility Service Providers enforce all the food service operators to install oil trap within the boundary of the home. This is particularly important for venues that operate commercial kitchens as waste water from referred entities are causing blockages in internal pipes leading to expensive repairs and potential equipment downtime. Oil traps work on the basis that animal fats and vegetable oils (grease) are 10 to 15 percent less dense than water and that grease won't mix with water. Thus, fats and oils float on top of water.



When wastewater enters an oil trap, the flow rate is reduced enough so the wastewater is given enough time to cool and separate into 3 layers. The grease rises to the top inside the interceptor and is trapped

using a system of baffles. Solids settle at the bottom and the separated clear water escapes under an outlet baffle. Many oil traps also have strainers for collecting solid debris, which reduces the amount of solids that settle at the bottom of the trap.

Over time, solids and grease build-up, and if left to accumulate for long enough they can start to escape through the outlet and in some circumstances, they can back-up through the inlet. For this reason, the trap must be cleaned / pumped out on a regular basis.

CLEAN UP

After the installation of the pipeline, it is important that proper cleaning is undertaken prior to completion of the tasks.

Work area is cleared and materials disposed of, reused or recycled

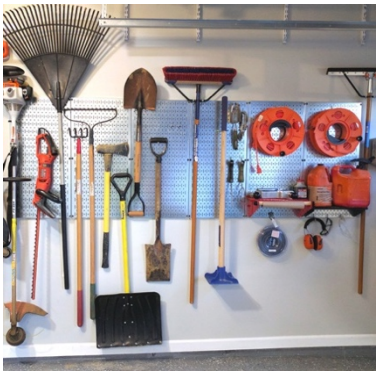
Trenching site need to be properly cleaned and during the cleaning operations, it is possible that debris related to pipe handling and installation process produced waste.

Collected waste from the trenching and pipe installation tasks can include variety of items and can be broken down into the following types:

- ✓ ***Plastic waste*** – This consists of bags, containers, jars, bottles and many other products that can be found in your household. Plastic is not biodegradable, but many types of plastic can be recycled. Plastic should not be mix in with your regular waste, it should be sorted and placed in your recycling bin.

- ✓ ***Paper/card waste*** – This includes packaging materials, newspapers, cardboards and other products. Paper can easily be recycled and reused so make sure to place them in your recycling bin or take them to your closest Brisbane recycling depot.
- ✓ ***Tins and metals*** – This can be found in various forms throughout your home. Most metals can be recycled. Consider taking these items to a scrap yard or your closest Brisbane recycling depot to dispose of this waste type properly.
- ✓ ***Ceramics and glass*** – These items can easily be recycled. Look for special glass recycling bins and bottle banks to dispose them correctly.

Plant, tools and equipment are cleaned, checked, maintained and stored



Several tools are used for the pipe installation tasks and it is important that all the tools are gathered back and properly cleaned.

In order to keep tools, clean all the tools need to be accounted and cleaning process be engaged.

During cleaning, all the tools and equipment used for the pipe installations works will be cleaned and properly stored at the end of the days operation.

UNIT 16

FABRICATE AND INSTALL ROOF DRAINAGE COMPONENTS

This unit of competency specifies the outcomes required to fabricate and installroof drainage components and rainwater collection mechanisms for residential roof systems

Introduction

Property drainage refers to the systems that transfer runoff from roofs, paved areas and other surfaces of a premise to a suitable outlet or disposal facility. The system involves gutters, downpipes, drains, pipes, swales and storage and treatment facilities. Typical property drainage components for residential and industrial premises are shown in Figure 4.1. Local authorities may place limitations on the amount of stormwater that can be drained to streets or trunk drainage systems, in order to reduce flooding and pollution. In these cases it is the responsibility of the property owner to provide infiltration or on-site detention facilities.

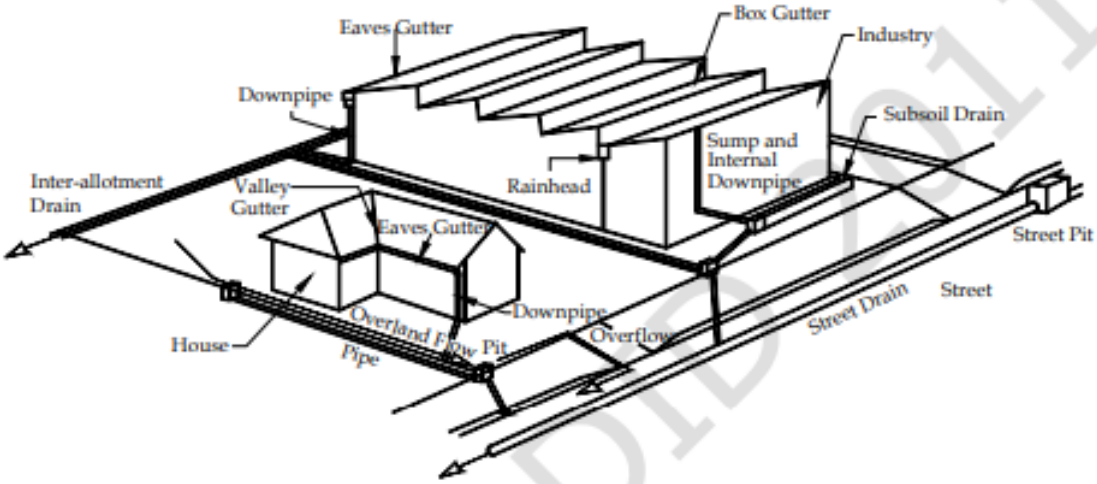


Figure 4.1: Typical Property Drainage Components

PREPARE FOR WORK

Roof drainage systems are essential to safeguard many households from the unexpected and costly water damages. Rainfalls occur every year and, if not properly rainproof, your house could be among the stats of damaged properties. Water can either penetrate your roof and ruin the interior furniture, or soak your foundation and weaken the basement. Such a shattered home, which could have been prevented by installing roof drains.

There are many benefits associated with roof drains installation: prevent property damages, save maintenance/repair costs, save energy costs, prevent molds build-up, protect electrical wiring, and increase the value of your home.

INSTALLATION REQUIREMNTS

Types of Roof drain

Roofs come in all shapes, sizes, and styles. From heavily pitched roofs to completely flat roofs, expansive buildings and small sheds, this wide variety result in a great diversity of drainage needs. While roof drainage makes most people think of gutters, which are an important element, there are a great many more types of roof drains that are used in addition to this oft-used solution.

As a property owner, roof maintenance and drainage maintenance are of utmost importance. After all, the roof protects your property from the elements day in and day out. It's in your best interest to keep your roof and roof drains in excellent condition with routine cleaning. But how do you clean your roof drains? It really depends on which type of roof drains you have installed. Not sure? Let us guide you through them:

Conventional Gutters

The typical pitched roof can usually use gravity for all drainage purposes. On a pitched roof, water simply glides off and into gutters, which direct water into an underground drainage system. This roof drain option is simple, inexpensive, keeps water from pouring all over the place and provides sufficient protection for doors and windows. In addition, it helps avoid water pooling around the property's foundation.

However, the downside is that gutters do require frequent cleaning. While there are some covered gutter systems, the majority are open, allowing leaves, twigs and other debris to get into the system and clog it up. In addition, water may freeze in gutters during colder months, which can result in damage.

How can you clean your gutters? First, make sure you tell someone that you'll be working on the gutters. When you do, it's essential to use a secure ladder rather than precariously crawling on the roof. Using a gloved hand, scoop out any debris, leaves, and twigs from your gutters. Also, check your downspouts and scoop out any debris from the bottom area.

Scuppers

Scuppers are popular for flat enclosed roofs, terraces and parapets. This type of roof drain consists of small holes cut in the side of the roof so that the water can drain out. Metal or rubber is typically used to flash the area around the hole so that water doesn't cause damage. After exiting the hole, scuppers typically connect to a downspout to direct the water to an underground drainage system. In other instances, the scuppers protrude from the building and allow the water to fall into a prepared space such as a gravel drainage area, below.

Luckily, these roof drains require very little maintenance. You can check to ensure that your downspouts aren't clogged periodically. All you need to do is do a quick walk around the roof and check the scuppers, removing any debris. Also, check the bottom of your downspouts for any potential debris.

Inner Drain

Also a popular option for flat roofs, an inner drain is a drain or drains in a slightly lower

area of the roof that connects to an interior pipe that leads to an underground drainage system. These drains typically have screens or protective barriers to prevent debris from washing down the pipe. Among the advantages of these drains is that there are no unsightly downspouts and gutters seen from the outside of the building and that there's little chance that pipes will freeze.
How do you clean them? Check your roof several times a year, using all necessary precautions, and look for debris in the sieves. Remove any debris and replace the sieves. Also, check the status of the sieves to see if any replacements are necessary. Any clogs will quickly show in pooling water on your roof. These situations typically require professional help, as inner drain systems are rather delicate.

Siphonic Drain

This sophisticated drain is designed to operate at full capacity, reducing the need for downspouts and underground drainage pipes. The system essentially sucks water from the roof into the system and keeps air from being drawn in, meaning that the pipes can handle more. These systems work on flat and pitched roofs.
To clean this type of drainage system, inspect the siphons themselves to check for debris pulled up against the screen and remove any that's there. This system also often involves gutters, meaning that you'll also have to routinely clean out gutters using a gloved hand to keep debris from entering the system.
Whenever working on the roof, make sure you use appropriate safety equipment such as a harness and also tell someone about the work you'll be doing so that they can be prepared to help in case of an accident.

ROOF DRAINAGE COMPONENTS & INSTALL ROOF DRAINAGE COMPONENTS

Roof drainage systems are located at the top of property drainage systems. Because the areas are usually small and there are fewer complications, roof drainage can be designed using simpler methods than those employed at larger scale drainage. This chapter applies to those buildings where roof drainage is specified for reasons of runoff conveyance and collection to storage/detention facilities as well as for comfort and safety of occupants and the protection of the building structure. The rules also apply to all inhabited buildings as well as industrial buildings and warehouses.

The methods given in this section are based on the Australian/ New Zealand Standard (AS/NZS 3500.3, 2003), adapted for Malaysian conditions. Eaves gutters are located on the outside of a building while box gutters and valley gutters are located within the plan area of the building and the intersecting sloping surfaces of a roof respectively (Figure 4.2).

a) Eaves b) Box

Figure 4.2: Roof Gutters

Roof Drainage Design Procedure

Catchment Area

The design approach for drainage of roofs is to determine the layouts and sizes of components, and then to analyse their behaviour in one or more design storms that will test the adequacy of the system.

The design procedure herein follows AS/NZS 3500.3 in recognising that wind causes the rain to slope, creating a horizontal component of rainfall, which becomes significant on vertical walls or sloping roofs. The direction of wind that results in the maximum roof catchment area should be selected. It is not sufficient to consider only the direction of prevailing winds. A maximum rainfall slope of 2 vertical to 1 horizontal is assumed. The roof catchment area (Ac) estimates, based on Figure 4.3, are given below:

For single sloping roof fully exposed to wind

$$A_c = A_h + \frac{A_v}{2}$$

where the meaning of terms is as shown in Figure 4.3. If the roof is partly shielded by another wall, the net vertical area Av is the area seen by looking in the same direction as the wind. The following formula is used

$$A_c = A_h + \frac{1}{2}(A_{v_2} - A_{v_1})$$

For the two adjacent sloping roofs

$$A_c = A_{h_1} + A_{h_2} + \frac{1}{2}(A_{v_2} - A_{v_1})$$

Roofs of larger buildings may have complex arrangements of catchments and drainage systems. Where it is difficult to define catchments, a conservative approach should be adopted, assuming the largest possible catchments.

Design Average Recurrence Intervals

Roof drainage shall use the ARIs set out in Table 4.1. The critical storm duration of 5 minutes should be adopted for all roofs unless special circumstances justify a longer duration.

Table 4.1: Design ARIs for Roof Drainage

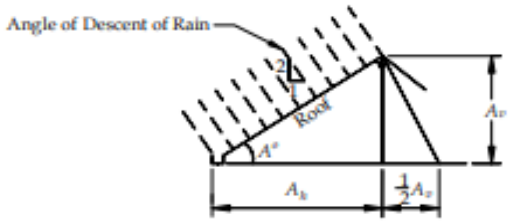
Property Type	Eaves Gutters	Valley and Box Gutters
All buildings	20 year ARI	100 year ARI

Notes :

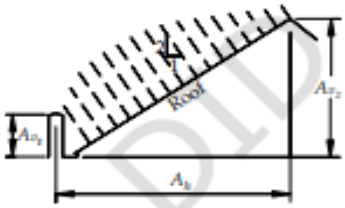
1. If water can flow back into the building, then overflow measures are required
2. A higher design ARI shall be adopted for buildings located on hillside area

Discharge Estimation

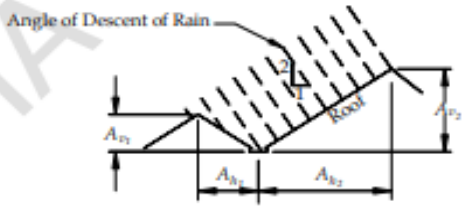
The 5 minute duration 20, 50 and 100 year ARI rainfall intensities for the particular location are obtained from the short-duration rainfall IDF method in Chapter 2, applied at the particular site..



(a) Single Sloping Roof Freely Exposed to the Wind



(b) Single Sloping Roof Partially Exposed to the Wind



(c) Two Adjacent Sloping Roofs

Figure 4.3: Sloped Roof Catchment Area Relationships

The roof flow produced by the design rainfall shall be calculated using the Rational Method, with runoff coefficient C = 1.0, which can be expressed by the following form:

$$Q = \frac{i.A_c}{3600}$$

where,

Q = Peak flow (L/s);
i = Rainfall intensity (mm/hr); and
A_c = Roof catchment area draining to a downpipe (m²).

Design of Eaves Gutters and Downpipes

For a simple sloping (gabled) roof, the eaves gutter should slope from one end to the downpipe location at the other end.

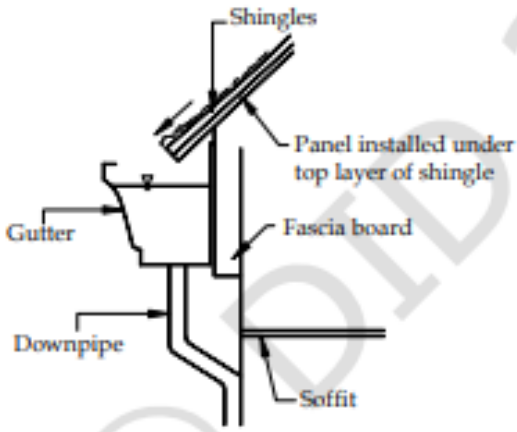


Figure 4.4: Cross Section of Eaves Gutter

The procedure for the design of an eaves gutter is as follows:

- ✓ Determine the catchment area to each downpipe;
- ✓ Determine the design 5 minute duration, 20 year ARI rainfall intensity; and
- ✓ Choose the gutter size from Design Chart 4.A1.

To provide adequate fall and minimise the risk of ponding, the minimum gradient of an eaves gutter shall be 1:500.

The minimum cross-sectional size of an eaves gutter shall be 4,000mm2 while the normal maximum 22,000mm2. If calculations indicate that a larger size is required, it is preferable to provide more downpipes rather than increasing the gutter size.

The required size of eaves gutter shall be determined from Design Chart 4.A1. This Chart is derived from Manning's formula with 'n' = 0.016 and S = 1/500. This is a simplified method because the effect of varying flow depth is neglected. When applying the design chart, Ac is the catchment area draining to a single downpipe.

Downpipe size is then determined from Table 4.2 to match the eaves gutter size. Downpipes may be either rectangular or circular. Note that for a given roof catchment

area, the size of downpipe will be the same irrespective of the slope of the eaves gutter.

If the listed size is not available, an alternative downpipe with equal or greater cross-sectional area than that shown may be substituted.

Table 4.2: Required Size of Downpipe for Eaves Gutter (AS/NZS 3500.3, 2003)

Eaves Gutter Size (mm^2)	Minimum Nominal Size of Downpipe (mm)	
	Circular	Rectangular
4,000	75	65 x 50
4,200		
4,600		75 x 50
4,800	85	
5,900		100 x 50
6,400	90	
6,600		75 x 70
6,700	100	
8,200		100 x 75
9,600	125	
12,800		100 x 100
16,000	150	125 x 100
18,400		
19,200	*Not applicable*	150 x 100
20,000		125 x 125
22,000		150 x 125

Design of Valley Gutters

Valley gutters are located between the sloping roof sections of a hipped roof (see Figure 4.1). The following points should be noted when designing systems incorporating valley gutters:

- ✓ Valley gutters should end at the high point of an eaves gutter; and
- ✓ The discharge from a valley gutter does not flow equally into both eaves gutters. Therefore the designer should allow at least 20% excess capacity in the sizing of the eaves gutters.

The profile of a valley gutter is shown in Figure 4.5.

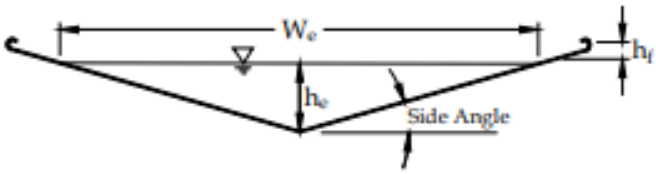


Figure 4.5: Profile of a Valley Gutter

The sizing guidelines in Table 4.3 are valid for the following conditions:

- ✓ Roof slope of not less than 12.5°;
- ✓ The nominal side angle of valley gutters is 16.5°; and
- ✓ The catchment area shall not exceed 20m2.

The procedure for the design of a valley gutter is as follows:

- ✓ Select the ARI;
- ✓ Determine the design 5 minute duration, 100 year ARI rainfall intensity; and
- ✓ Choose the girth size and dimensions from Table 4.3.

Table 4.3: Minimum Dimensions for Valley Gutters

Design Rainfall Intensity (mm/hr)	Minimum Dimension (mm)		
	Sheet Width	Effective Depth (h_e)	Effective Width (W_e)
≤ 200	355	32	215
201 - 250	375	35	234
251 - 300	395	38	254
301 - 350	415	40	273
351 - 400	435	43	292
> 400	455	45	311

Notes:

1. Freeboard (h_f) = 15 mm
2. The sheet width from which the valley is to be formed has been calculated on the basis of h_f = 15 mm and an allowance for side rolls or bends of 25 mm.

Design of Box Gutters and Downpipes

Box gutters are located within a building plan area (Figure 4.6). Gutters adjacent to a wall or parapet shall be designed as box gutters. The main principle in the design of box gutters is to avoid the potential for blockages, which would prevent the free runoff of roof water, and possibly cause water to enter the building. The design criteria of box gutter are as the followings:

- ✓ Box gutters must be straight (no bends);
- ✓ Cross-section shape must have a constant base width and vertical sides;

- ✓ Longitudinal slope must be between 1:200 and 1:40. Changes in slope are not permitted; and
- ✓ The gutter must discharge directly into a rainhead or sump at the downstream end without change of direction.

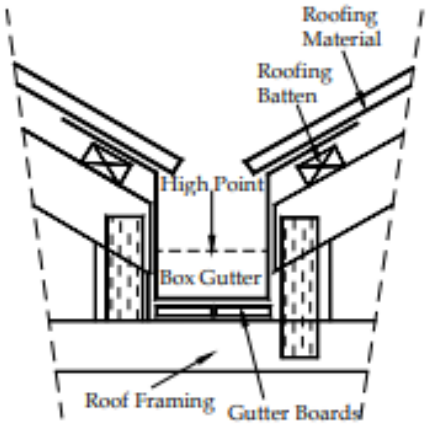


Figure 4.6: Box Gutter

Box gutters are connected to either rainheads or sumps with overflow devices. The minimum width of box gutters for commercial or industrial construction is 300mm. For residential construction, a minimum width of 200 mm is permitted but such gutters are more prone to blockage and should be subject to more frequent inspection and maintenance.

The procedure for design of a box gutter is as follows:

- ✓ Determine the catchment area draining to each downpipe (Equation 4.1);
- ✓ Determine the design 5 minute duration, 100 year ARI rainfall intensity;
- ✓ Select the width and slope of the box gutter to suit the building layout; and
- ✓ Read off the minimum depth of the box gutter from Design Chart 4.A3. This minimum depth must be used for the full length of the box gutter. If a sloping box gutter is built with a horizontal top edge for architectural reasons, the minimum depth requirement still applies. When applying the design chart, the catchment area obtained is for draining to a single downpipe.

Rainheads and Downpipes

Box gutters shall discharge via a rainhead or sump, to a downpipe. The required size of downpipe from a box gutter is determined from Design Chart 4.A3 (AS/NZS 3500.3, 2003). The sizing principle is to limit the maximum capacity of the downpipe in order to prevent slugs of unstable flow. The graph does not permit very deep, or very shallow rainheads. The minimum depth of water in the rainhead is limited to about half of the diameter of the downpipe. Above this depth, orifice flow conditions apply. A standard rainhead is shown in Figure 4.7. It includes an overflow to safely discharge flow from the box gutter even if the downpipe is blocked. The design flow of a rainhead shall not exceed 16 L/s.

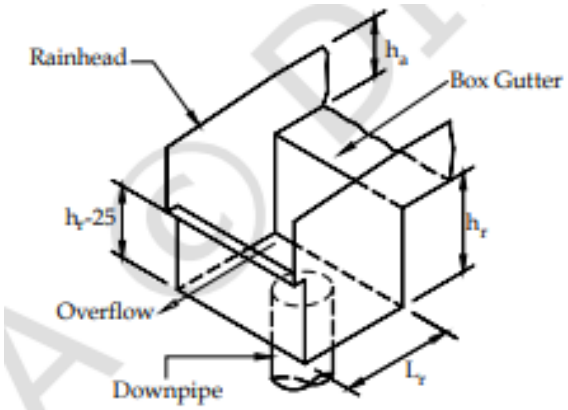


Figure 4.7: Typical Rainhead

Also designers are to observe the followings:-

- ✓ Width of rainhead is equal to the width of box gutter. The rainhead must be sealed to the box gutter;
- ✓ The depth of a rainhead, hr must be at least 1.25 x equivalent diameter of a rectangular downpipe (hr≥ 1.25De) or 1.25 x internal diameter of a circular downpipe (hr≥ 1.25Di).
- ✓ There is an overflow weir at a lower level than the sole of the box gutter; and
- ✓ The rainhead to be fully seated to the box gutter and the front of the rainhead left open above the overflow weir.

1.3.6.2 Sumps

Sumps are located at the low point of a box gutter, which slopes towards the sump in both directions. A standard sump is shown in Figure 4.8. All sumps must be provided with an overflow to prevent overtopping of the box gutter even if the downpipe is blocked. Two types of overflow devices are permitted for use

1. ***Side Overflow Device***

This device is shown in Figure 4.8. This design has been in use world-wide for many years. It is only suitable for box gutters, which run parallel and adjacent to a parapet wall.

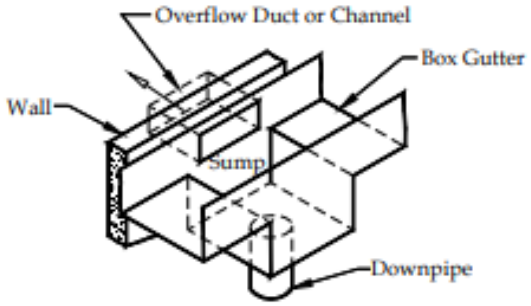


Figure 4.8: Typical Sump and Side Overflow

2. High Capacity Overflow Device

As shown in Figure 4.9 this device design is developed in Australia (Jones and Kloti, 1999). It is anticipated that further research will be conducted into developing overflow devices suitable for Malaysian conditions.

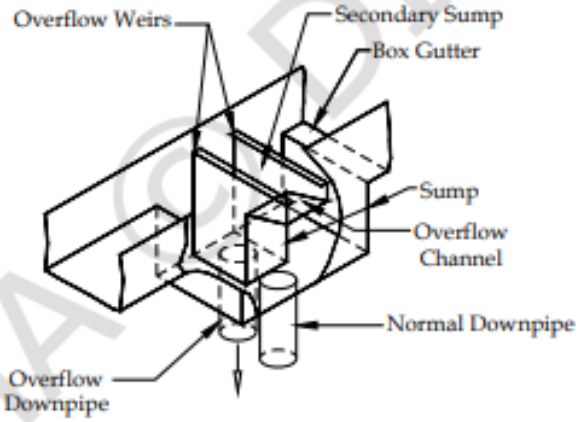


Figure 4.9: Sump with Alternative Overflow Devices

Property Drainage

General

The drainage system proposed within allotments depends upon the topography, the importance of the development and the consequences of failure. The drainage systems collect water from roofs (via downpipes), surfaces of areas around buildings, and flows onto the property from adjacent allotments in major storm. In areas with suitable soils and water table conditions, stormwater may be infiltrated directly into the soil, rather being directed to the street drainage system (Chapter 8).

Design Average Recurrence Intervals

Elements in the property drainage systems shall be designed to contain flows from minor storm events of ARI not less than that specified in Table 4.4.

The property drainage systems shall be designed to ensure that overflows in a major storm event do not present a hazard to people or cause significant damage to property.

Drainage to the Rear of Properties

Where the natural ground level does not permit drainage by gravity to the street drain or gutter, it will be necessary to either fill the site to obtain a fall to the street, or alternatively, to provide a piped drain through an adjoining private property or properties, to discharge the runoff from the site by gravity.

Open drains shall not be permitted at the rear of private lots because they are difficult to

maintain.

Any piped drain in private property, which serves an adjoining property, shall be protected by a drainage easement. Such easements shall be free of any building encroachments, including eaves footing and shall contain a single pipe only. Full details of any proposed easement is to be submitted to the regulatory authority for approval and this easement shall be registered with the authority prior to release of the building plans.

Drainage on Hillside Area

In common practice, although the roofs of buildings are designed to collect storm water, there is no provision to effectively drain them to the perimeter drain surrounding the buildings. The concentrated runoff from the roof eaves is sometimes much higher than the direct impact due to rainwater and this can cause ground erosion.

Buildings in which roof gutters are omitted shall not be permitted in hillside areas. This type of roof drainage would have unacceptable consequences in term of concentrated runoff on potentially unstable hill slopes.

The 20 year ARI standard for roof eaves gutters (Table 4.1) should be increased to 50 year ARI in hillside areas. The standard for box gutters is governed by other factors, and does not change.

Properly designed gutters must be provided to collect stormwater from the roof and convey it to the formal property drainage system, either open drains or pipes. As a general principle, it is desirable to directly connect all significant impervious areas to the lined drainage system.

Property drainage shall be installed at or below ground level, to maximise the interception of surface runoff. The creation of ponding areas due to poor grading of property drainage is not permitted.

Drainage through Public Reserves

Where a low level property adjoins a public reserve, the construction of drainage line through the reserve generally will not be permitted and alternative methods of drainage should be investigated, including:

- ✓ construction of a pipeline through an adjoining private property; and
- ✓ a pump out system.

Construction of a drainage line through a public reserve may be permitted by the regulatory authority, only in situations where the applicant provides satisfactory proof that the alternatives have been investigated and found to be impractical.

Where drainage through a public reserve is permitted, the applicant is required to enter into a licence agreement with the regulatory authority, subject to the payment of a one

off licence fee under the respective agreement covering any installation, legal or other costs associated with the preparation and execution of the licence agreements, together with an amount considered appropriate towards the improvement of the respective reserve.

Pipes on public streets and land that drain developments are permitted, provided that they are built to the approval authority's standards and ownership is transferred to the authority. It is not permitted where the proposed drainage system will cause a conflict with other drainage systems or services.

Rainwater Harvesting and Detention

Rainwater tanks may be provided to collect flow from roof and gutter systems. These tanks can be used to:

- ✓ provide water supplies; and/or
- ✓ provide on-site detention storage. The design of rainwater tanks for water supply is covered in Chapter 6 while the design of on-site detention storage in Chapter 5. Note that any tank volume provided for detention is additional to that set aside for water supply storage.

CLEAN UP

Tools and equipment are cleaned, checked, maintained and stored

Several tools are used for the pipe installation tasks and it is important that all the tools are gathered back and properly cleaned.
In order to keep tools, clean all the tools need to be accounted and cleaning process be engaged.
During cleaning, all the tools and equipment used for the pipe installations works will be cleaned and properly stored at the end of the days operation.

UNIT 17

PERFORM PLUMBING TO SUPPORT RAIN WATER HARVESTING SYSTEMS

This unit of competency specifies the outcomes required to design systems for the collection, storage, distribution and re-use of rainwater for drinking and nondrinking uses, including irrigation, toilet flushing and other uses approved by relevant authorities

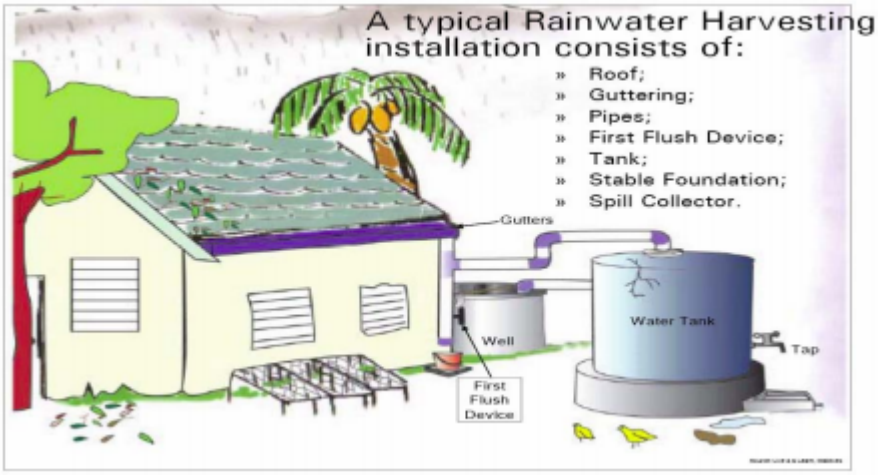
Basics of Rain Water Harvest System

Rain Water Harvesting is a technology used for collecting water from surface on which it falls and storage of this water for use when needed. It is an oldest method of collecting water for domestic uses. There are two main techniques of rainwater harvesting, namely:

1. Storage for future use
2. Recharge into the ground

Water can be collected either from rooftops or from the ground or a combination of both. Rainwater harvesting systems can vary widely in scope and complexity. It can be the simple collection of rainwater from the rooftop of a house or collection from a large complex (school or office) for domestic uses or recharge into the ground.

1. Components of a Rainwater Harvesting System



All rainwater-harvesting systems comprise three basic components irrespective of the size of the system.

1. Catchment Area/Roof: The surface upon which the rain falls; the roof has to be appropriately sloped preferably towards the direction of storage and recharge.
2. Gutters and Downspouts: The transport channels from catchment surface to storage; Gutters and/or Down pipes have to be designed depending on site, rainfall characteristics and roof characteristics.
3. Cisterns or storage tanks: Sumps, tanks etc. where collected rain-water is safely stored or recharging the Ground water through open wells, bore wells or percolation pits etc.

Briefly the system involves collecting water that falls on roof of a house made of impervious material during rain storms, and conveying it by an aluminum, PVC, wood, plastic or any other local material including bamboo drain or collector to a nearby covered storage unit or cistern. Rainwater yield varies with the size and texture of the catchment area. A smoother, cleaner and more impervious roofing material contributes to better water quality and greater quantity.

Rainwater systems are decentralised and independent of topography and geology. They deliver water directly to the household, relieving the burden of water carrying, particularly from women and children. Implementation is similar to managing the installation of on-site sanitation and once systems are in place they are owned by the householders who can manage their own water supply.

Rainwater harvesting systems can serve households or communities of various sizes. Household systems generally catch rain from the rooftops of homes and store it in tanks adjacent to the homes. Water is drawn from the tanks by means of taps at the base of the tanks. In some cases rainwater may be reticulated within a house using a pump/pressure system. Alternatively the tank may be partly buried and a hand pump used to withdraw water. In cases community systems the roofs of large community buildings, such as churches and schools, are used as catchment surfaces and the water is stored in large tanks adjacent to these buildings. Alternatively, if no suitable catchment surface is available, a separate catchment surface is built adjacent to, or directly over, the water storage tank. Residents of the community walk to these tanks, draw water from a tap at the base of the tank, and transport it back to their homes for drinking or cooking.

Materials commonly used in the construction of the roofs are corrugated aluminum and galvanized iron, concrete, asphalt or fiberglass shingles, tiles with a neoprene-based coating, which is used primarily in rural areas. Roofs are generally sloped to avoid pounding and roof coatings are required to be non-toxic.

The effective roof area and the material used in constructing the roof influence the collection efficiency and water quality. Because natural roofing materials attract rodents and insects, and often yield contaminated and coloured water, most people find them objectionable for use as a collecting surface. In such cases, specially-constructed ground surfaces (concrete, paving stones, or some kind of liner) or paved runways can also be used to collect and convey rainwater to storage tanks or reservoirs. These surfaces should be fenced to prevent the entry of people and animals.

Conveyance systems usually consist of gutters and drain pipes that deliver rainwater from the catchment area into the storage tanks. The conveyance systems should be of inert material to avoid adverse affects on water quality. Ground catchments would normally use pipes and/or open channels to convey rainwater to the storage tanks/reservoirs.

The rainwater ultimately is stored in a storage tank, which should also be constructed of inert material. Reinforced concrete, Ferro cement, fiberglass, polyethylene, or stainless steel has been found to be suitable. Storage tanks may be constructed as part of a building or may be a separate unit some distance away.

2. Influencing Factors

Among the several factors that influence the rainwater harvesting potential of a site, eco-

climatic conditions and the catchment characteristics are considered to be the most important.

Rainfall Quantity:

Rainfall is the most unpredictable variable in the calculation and hence, to determine the potential rainwater supply for a given catchment, reliable rainfall data are required, preferably for a period of at least 10 years. Also, it would be far better to use rainfall data from the nearest station with comparable conditions.

Rainfall Pattern:

The number of annual rainy days also influences the need and design for rainwater harvesting. The fewer the annual rainy days or the longer the dry period, the more will be the need for rainwater collection in a region. However, if the dry period was too long, big storage tanks would be needed to store rainwater. Hence in such regions, it is more feasible to use rainwater to recharge ground water aquifers rather than for storage.

Catchment Area Characteristics:

Runoff depends upon the area and type of the catchment over which it falls, as well as surface features. All calculations relating to the performance of rainwater catchment systems involve the use of runoff coefficient to account for losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation, which will all contribute to reducing the amount of runoff. (Runoff coefficient for any catchment is the ratio of the volume of water that runs off a surface to the volume of rainfall that falls on the surface).

The collection efficiency accounts for the fact that all the rainwater falling over an area cannot be effectively harvested, because of evaporation, spillage etc. Factors like runoff coefficient and the first-flush diverter are taken into account when estimating the collection efficiency.

The rain water is harvested in following manner.

- Collect rain water from the roof top
- Drain it down from the pipes
- Store it in a tank
- Treat it if required
- Draw it for use

3. Requirements for Roof water Harvesting

For roof water harvesting to be viable there are a number of environmental requirements:-

- ✓ Rainfall should be over 50mm/month for at least half of the year (unless other sources are extremely scarce)

- ✓ Local roofs should be made from impermeable materials such as iron sheets or tiles
- ✓ There should be an area of at least 1m2 near each house upon which a tank can be constructed
- ✓ There should be some other water source, either ground water or (for secondary uses) surface water that can be used when the stored rainwater runs out

4. Benefits of Rainwater Harvesting

Rainwater harvesting provides the long-term answers to the problem of water scarcity. Rainwater harvesting offers an ideal solution in areas where there is sufficient rain but inadequate ground water supply and surface water resources are either lacking or are insufficient. Rainwater harvesting system is particularly useful in remote areas as it has the ability to operate independently. The whole process is environment friendly. There are a number of ways in which water harvesting can benefit a community – water harvesting enables efficient collection and storage of rainwater, makes it accessible and substitutes for poor quality water. Water harvesting helps smoothen out variation in water availability by collecting the rain and storing it more efficiently in closed stores or in sandy riverbeds. In doing so, water harvesting assures a continuous and reliable access to water.

A water harvesting system collects and stores water within accessible distance of its place of use. While traditional sources are located away from the community, collecting and storing water close to households, villages greatly enhances the accessibility and convenience of water supplies.

The rainwater collected can be stored for direct use or can be recharged into the ground water to improve the quality of ground water and rise in the water levels in wells and bore wells that are drying up as well as reduce the soil erosion as the surface runoff is reduced. Rainwater harvesting is an ideal solution to water problems in areas having inadequate water resources and helpful in mitigation of the effects of drought and attainment of drought proofing.

Water harvesting provides an alternative source for good quality water (rainwater is the cheapest form of raw water) seasonally or even the year round. This is relevant for areas where ground water or surface water is contaminated by harmful chemicals or pathogenic bacteria or pesticides and/or in areas with saline surface water. The rainwater harvesting systems can be both individual and community/utility operated and managed.

Rainwater collected using various methods has less negative environmental impacts compared to other technologies for water resources development. The physical and chemical properties of rainwater are usually superior to sources of ground water that may have been subjected to contamination. Rainwater is relatively clean and the quality

is usually acceptable for many purposes with little or even no treatment.

Rainwater harvesting technologies are flexible and can be built to meet almost any requirements. Construction, operation, and maintenance are not labour intensive. Predictions regarding global warming could have a major effect in significantly increasing water demand in many cities. At the same time increased evaporation from reservoirs and reduced river flows in some areas may decrease the available surface water supplies. A greater uncertainty regarding yields from major reservoirs and well fields is likely to make investments in the diversification of water sources, better water management and water conservation even more prudent in future.

The role of rainwater harvesting systems as sources of supplementary, back-up, or emergency water supply will become more important especially in view of increased climate variability and the possibility of greater frequencies of droughts and floods in many areas. This will particularly be the case in areas where increasing pressure is put on existing water resources.

In urban areas, scarcity and accelerating demand of water is a major problem and it can be reduced by rainwater harvesting, using various existing structures like rooftops, parking lots, playgrounds, parks, ponds, flood plains, etc. to increase the ground water table, which saves the electric energy to lift the ground water because one metre rise in water level saves 0.40 kilowatt hour of electricity. Subsequently it can also reduce storm drainage load and flooding in city streets.

5. Limitations of the system:

Rainwater harvesting systems are completely dependent upon the frequency and amount of rainfall. There will be shortages during dry spells or prolonged droughts, which can be exacerbated by low storage capacities. If greater storage capacities are provided, the additional construction and operation costs may be expensive for some households. Leakages from cisterns can cause the damages to the foundation of building and may increase construction cost that may have adverse effect on home ownership. Also the water may become contaminated if the storage tanks are not adequately covered, and uncovered or poorly covered storage tanks can be unsafe for small children. Contamination can also occur from dirty catchment areas. Water treatment is infrequent in many countries due to lack of adequate resources and lack of treatment may lead to health risks. Similarly neglect in routine maintenance can also impair the quality of water and affect health. In the case of community systems, people have to walk significant distances for water if a distribution system is not in place. All systems require maintenance to minimize wastage through broken gutters, drainpipes, leaking storage tanks or outlet taps.

6. Main drivers and key factors determining the feasibility of rainwater harvesting

Feasibility is defined as something that is practicable or achievable. A series of interlinked factors determine the feasibility of rainwater harvesting in rural areas. Rainwater

harvesting becomes viable when the following factors become acceptable together and also separately:

a. Water availability: The volume of rainfall and rainwater collected should meet a significant part of the water needs of the household. The technology features of the system and water management practices have a direct effect on water availability.
b. Acceptability: Use of rainwater harvesting for drinking and other purposes has to be culturally accepted by the users. The positive impacts, i.e. the benefits, that the rainwater harvesting system brings to the community influences the level of acceptability towards the RWH system. The users are able to give expression to how valuable rainwater harvesting is to them. An analysis of the benefits that rainwater harvesting offers to the users will help to determine whether the amount of water collected makes a difference.
c. Cost of the system: The cost of installing a rainwater harvesting system should not be substantially higher than other water supply options suitable for the community of study. The availability of credit and financial resources also determines the ability to install rainwater harvesting systems.
d. Water quality: quality of rainwater should be safe for human consumption. Operation and maintenance needs to be done properly to ensure good quality water.
e. Policy: Regulations and guidelines for implementers and users need to be put in place to ensure the effectiveness of rainwater harvesting programmes and risk minimisation.

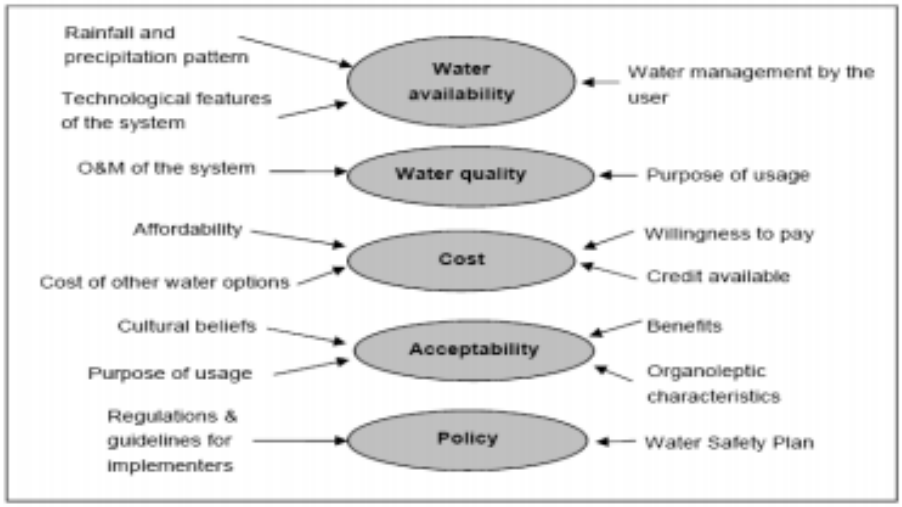


Fig: Main drivers and key factors determining the feasibility of RWH

(Source: Feasibility of rain water harvesting in Nepal-WHO)

7. A checklist:

- ✓ Rainfall and catchment must be sufficient to meet with the demand
- ✓ Deign should be appropriate in respect of affordability and maintenance

- ✓ Technical skills and construction materials should be available locally
- ✓ The system should have better quality of water and should have positive impact on health
- ✓ All reasonable alternatives water supply arrangements be considered before going for RWH
- ✓ Using other options of water in combination with RWH should also be considered
- ✓ Willingness to maintain the system (cleaning and repairing) should persist

DESIGN ASPECTS

Effectiveness of rain water harvesting depends on appropriate design of the system. Be it storage or a recharge structure, an improperly designed system will lead to operational problems, thereby raising the operation and maintenance costs. It may even lead to nonfunctioning of the system.

For designing rain water harvesting system rain fall data is required. Preferably data for a period of ten years will be useful. The more reliable and specific the data is for the location, the design will be better. The rainfall data information can be available from the ministry of environment (weather), water resources or agriculture. Airport authorities in the area can also have such data.

The quantity of water available from a rainwater harvesting system depends on the size of the catchment surface, the percentage catchment surface area that is guttered, the efficiency of the gutters in transporting the water, and the size of the storage tank. If a catchment surface is too small, it may not provide sufficient water to fill the tank. Furthermore, the rainfall pattern and user-demand are also factors that must be taken into account. Thus effective rain water harvesting will depend on optimum match between,

1. Rainfall data
2. Roof area
3. Water storage capacity
4. Daily consumption rate

For designing a RWH system and deciding the size of storage tank it is essential that following factors are taken in to consideration.

1. Estimate the water demand by considering three factors
    a. Number of persons in family
    b. Uses of water (quantity)
    c. Alternative sources of water for other uses
2. Consider the duration of dry spell (non rainy period)

3. Decide the quantity of rain to be harvested considering following factors
    d. Intensity and frequency of rain
    e. Size of the roof surface
    f. Availability of material and labour

Water demand

Water demand varies depending on the area and water requirement of a family. In the areas where water is very scarce people may use less water. Common norm of water requirement per person is considered as 20 litres per day. For other domestic uses like toilets, floor washing, cleaning etc locally available water (ground water) can be used even if it is of little inferior quality. The water demand is calculated by the following formula

Demand = water use X family members X 365 days

Suppose the water use is 20 litres per person per day and there are 5 members in s family then water demand for one year will be, 20 lpcd X 5 members X 365 days =36,500 litres per year

Average water demand per month will be 3000 litres.

For a dry period of four months the required minimum storage capacity is,

3000 L X 4 months = 12,000 litres

Water supply is calculated by following formula,

Supply = rainfall (mm/year) X area (sq m) X Runoff coefficient

For example if the rainfall per year is 800 mm then a metal sheet roof of 80 m^2 area will supply,

800 X 80 X 0.8 = 51,200 litres per year

Runoff and run off coefficient

Runoff is the term applied to the water that flows away from a catchment after falling on its surface in the form of rain. Runoff can be generated from both paved and unpaved catchment areas of buildings. Runoff coefficient is the factor, which accounts for the fact that all the rainfall falling on a catchment cannot be collected. Some rainfall will be lost from the catchment by evaporation and retention on the surface itself. The rain water collection efficiency is measured in terms of runoff coefficient. If the collection efficiency of a roof material is 80 % then the runoff coefficient is 0.8. The type of roofing material determines the runoff coefficient for designs and the runoff coefficients for roof materials

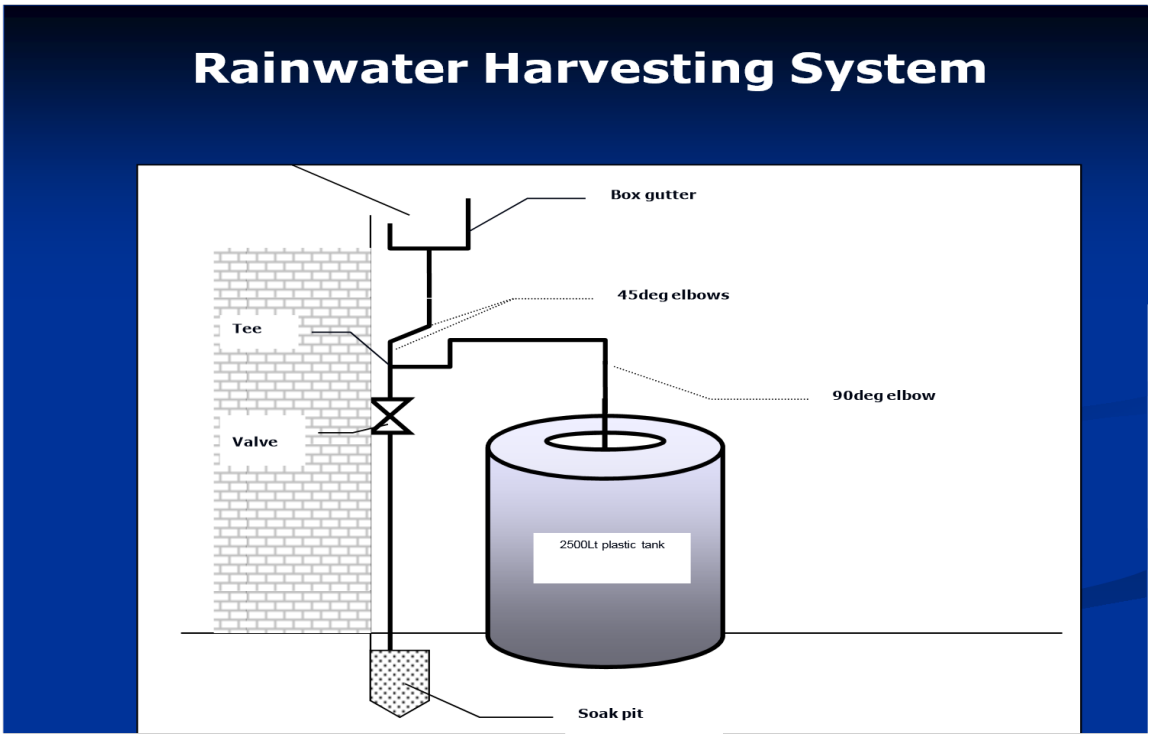
used in Maldives are given below.

Roof material	**Runoff coefficient**
Sheet metal	0.8 to 0.85
Cement tiles	0.62 to 069
Clay tiles (Machine made)	0.30 to 0.39
Clay tiles (Hand made)	0.24 to 0.31

Roof Catchment

In rain water system component design, the roof material of the building or house is the first choice of the system component. Rainwater can be collected from most forms of roof. Tiled roofs, roofs sheeted with corrugated mild steel etc., are preferable, since they are the easiest to use and will give the cleanest water. Thatched or palm leafed surfaces are also feasible; although they are difficult to clean and can often taint the run-off. Asbestos sheeting or lead-painted surfaces should be avoided. If the house is small to catch up required rainfall additional roof/catchment as open sided shed can be built near house or attached with house.

The rain amount and household water demand varies from place to place and family to family respectively. Thus prior to designing rainwater harvesting system, knowing roof size is most important for each household for effective rainwater harvesting. The second consideration will be of roof material. Smoother the surface better the quality and quantity of water. However the quality and quantity of rain water from different roof is a function of roof material, climatic conditions, and the surrounding environment. The runoff from a roof is directly proportional to the quantity of rainfall and the plan area of the roof. For every 1mm of rain a square meter of roof area will yield 1 litre of water, less evaporation, spillage losses and wind effects.



Roof materials

Roofs can be made from a variety of materials. Roofs made from grass and those likely to generate toxic materials are not recommended.
The typical roofing material include the following,

- ✓ Galvanized corrugated iron or plastic sheets, or tiles.
- ✓ Thatched roofs made from palm leaves (coconut and palms with tight thatching are best). Other thatching materials and mud discolor and contaminate (through rats) the rainwater.
- ✓ Unpainted and uncoated surface areas are best. If paint is used it must be nontoxic (no lead-based paints).
- ✓ Asbestos-cement roofing does not pose health risks - no evidence is found in any research. However, the airborne asbestos fibers from cutting, etc. do pose a serious health risk if inhaled.
- ✓ Timber or bamboo is also used for gutters and drainpipes; for these materials regular replacement is better than preservation. Timber parts treated with pesticides to prevent rotting should never come into contact with drinking water.

Of them most significant is galvanized steel sheets which is easily available in Maldives. It retains less contamination than rougher surfaces and the runoff coefficient of metal is high. Metal sheets are zero porous so rain losses from the metal roofing will be less. In contrary to metal sheet, clay and concrete tiles are both porous. Concrete and clay tiles/concrete materials are also easily available in the local market but more than 10% rain may be lost due to its texture and evaporation. To reduce water losses, porous part can be reduced by coating fine cement or painting but still probability of bacteria growth

in cement or clay tiles is higher than metal roof. If care is taken in maintaining roofs, serious water contamination from roofing is rare. Sever air pollution, lead fitting and toxic paint in roof may contaminate the rainwater as it runs from roof.

Suitable materials include:

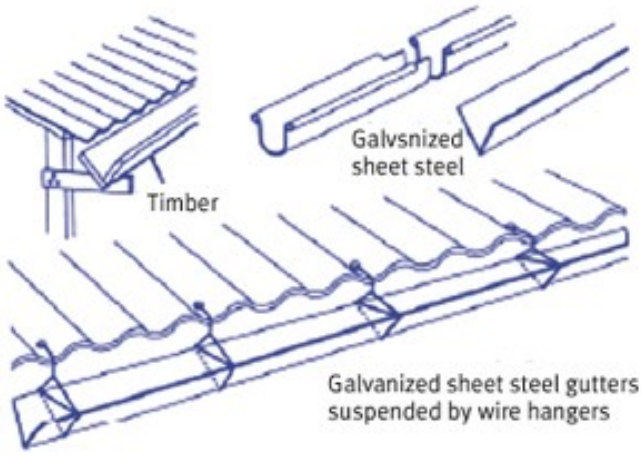
The efficiency of rainwater collection depends on the materials used, the construction, maintenance and the total rainfall. A commonly used overall efficiency figure is 0.8. If cement tiles are used as roofing material, the year-round roof runoff coefficient is some 75%, while clay tiles collect usually less than 50% depending on the production method.

Plastic and metal sheets do best with an efficiency of 80-90%.

Gutters and down pipes

Gutters are channels fixed to the edges of roof all around to collect and transport rainwater from the roof to the storage tank. These must be properly sized, sloped and installed to maximize efficiency and minimize water loss. Gutters come in a wide variety of shapes and forms, ranging from the factory made PVC type to home-made gutters using bamboo or folded metal sheet. Gutters are usually fixed to the building just below the roof and catch the water as it falls from the roof. For effective operation of RWH, a well designed and carefully constructed gutter system is crucial. 90% or more of the rainwater collected on the roof will be drained to the storage tank if the gutter and down pipe system is properly fitted and maintained. Common materials for gutters and down pipes are metal and plastic; which are available locally. But also cement-based products, bamboo and wood can be used. With high intensity rains, rainwater may shoot over the conventional gutter, resulting in a low production; splash guards can prevent this spillage. To keep leaves and other debris from entering the system, the gutters can have a continuous leaf screen made of quarter-inch wire mesh in a metal frame installed along the length of the gutter and a screen or wire basket at the head of the downspout. Or, just clean out gutters regularly.

Gutters can be prepared in semi-circular and rectangular shapes. Locally available material such as plain galvanized iron sheet can be easily folded to required shapes to prepare semi-circular and rectangular gutters. Semi-circular gutters of PVC material can be readily prepared by cutting the PVC pipes into two equal semi-circular channels. Bamboo poles can also be used for making gutters if they are locally available in sufficient quantity. Use of such locally available materials reduce the over all cost of the system.



Source: Water Aid

Manufacture of low- cost gutters

Factory-made gutters are usually expensive and beyond the reach of the poor people, if indeed available at all in the local marketplace. They are seldom used for very low-cost systems. The alternative is to make gutters from materials that can be found cheaply in the locality. There are a number of techniques that have been developed to help meet this demand; one such technique is described below

V-shaped gutters from galvanised steel sheet can be made simply by cutting and folding flat galvanised steel sheet (Figure ----). Such sheet is readily available in most market centres (otherwise corrugated iron sheet can be beaten flat) and can be worked with tools that are commonly found in a modestly equipped workshop. One simple technique is to clamp the cut sheet between two lengths of straight timber and then to fold the sheet along the edge of the wood. A strengthening edge can be added by folding the sheet through 90o and then completing the edge with a hammer on a hard flat surface. The better the grade of steel sheet that is used, the more durable will be the product.

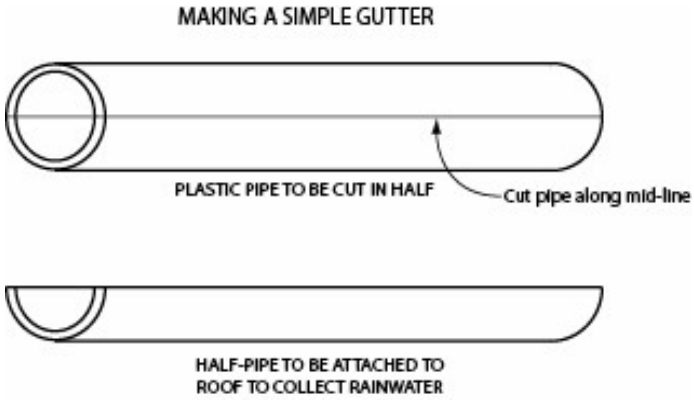


Figure: Cutting plastic pipe into half to make gutter

Plastic pipes may be cut into half to make gutters (Figure --- above). This requires only a

saw and some clamps to fix the half-pipes to roofs. It may be made quickly and cheaply in areas where plastic pipes are available.

The rainwater is collected in guttering placed around the eaves of the building. Low cost guttering can be made up from 22 gauge galvanised mild steel sheeting, bent to form a 'V' and suspended by galvanised wire stitched through the thatch or sheeting.

The guttering drains to a down-pipe which discharges into a storage tank. The downpipe should be made to swivel so that the collection of the first run-off can be run to waste (the first foul flush), thus preventing accumulated bird droppings, leaves, twigs and other vegetable matter, as well as dust and debris, from entering the storage tank.

Sometimes a collecting box with a mesh strainer (and sometimes with additional filter media) is used to prevent the ingress of potential pollutants. The guttering and down pipes should be sized so as to be capable of carrying peak volume of run-off; in the tropics this can occur during high intensity storms of short duration.

Size of gutter

The roof size, roof material and its slope are important to design the gutter size. The maximum discharge in gutters at end point can be estimated from rainfall intensity, roof size, roof slope, roof material and gutter slope. The calculation makes more complication and may not easily understandable by layman. A guide to the gutter widths and down pipe diameter (adapted from Still and Thomas 2003, Davis and Lambert 2002) is depicted in table below. Lead cannot be used as gutter solder as slightly acidic quality of rain could dissolve lead which is hazardous to human health.

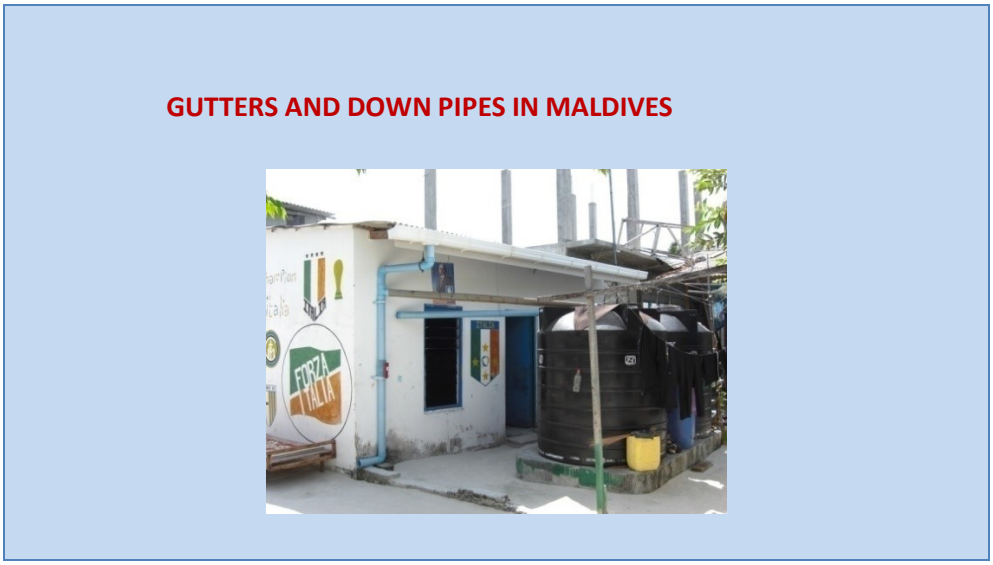
Roof area m^2	Gutter width, mm	Down pipe, mm
17	60	40
25	70	50
34	80	50
46	90	63

66	100	63
128	125	75
208	150	90

Table: Required gutter width and down pipe size

Down pipe

Down pipe is the pipe, which carries the rainwater from the gutters to the storage tank. Down pipe is joined with the gutters at one end, and the other end is connected to the filter unit of the storage tank. PVC or GI pipes of diameter 50 mm to 75 mm (2 inch to 3 inch) are commonly used for down-pipe. Bamboo can also be used wherever available in suitable size.



In Maldives both PVC and galvanized gutters are used for rain channeling. PVC gutters do not rust and are of light weight, whereas, galvanized steel gutter may start rusting if proper care is not taken. Little acidic rain may corrode roof chemical materials that will flow into tank. A little Inclined in gutter is necessary to maintain free flow condition and cleanliness. Little inclined gutter retains less debris. Plastic gutters fitted are designed with Splash guard. Slope the gutters one-sixteenth inch per one foot of gutter to assure proper downward flow. Place the gutter hangers about every three feet. The outside face of the gutter should be lower than the inside face to assure drainage away from the building wall. Gutters should be placed one-quarter inch below the slope line of the roof

so that debris can clear without knocking down the gutter.

The following table gives an idea about the diameter of pipe required for draining out rainwater based on rainfall intensity and roof area:

Sizing of rainwater pipe for roof drainage

Diameter of pipe (mm)	**Average rate of rainfall in mm/h**					
	50	75	100	125	150	200
50	13.4	8.9	6.6	5.3	4.4	3.3
65	24.1	16.0	12.0	9.6	8.0	6.0
75	40.8	27.0	20.4	16.3	13.6	10.2
100	85.4	57.0	42.7	34.2	28.5	21.3
125	-	-	80.5	64.3	53.5	40.0
150	-	-	-	-	83.6	62.7

Source: National Building Code of India

Leaf Screens/Roof Washers:

To keep leaves and other debris from entering the system, the gutters should have a continuous leaf screen, made of 1/4 inch wire mesh in a metal frame, installed along their entire length, and a screen or wire basket at the head of the down pipe. Gutter hangers are generally placed every 3 feet. The outside face of the gutter should be lower than the inside face to encourage drainage away from the building wall. Where possible, the gutters should be placed about 1/4 inch below the slope line so that debris can clear without knocking down the gutter.

To prevent leaves and debris from entering the system, mesh filters should be provided at the mouth of the drain pipe. Further, a first-flush (foul flush) device section should be provided in the conduit before it connects to the storage container. If the stored water is to be used for drinking purposes, a sand filter should also be provided.

First Flush Device:

First flush or the rain diverter is provided to flush off the first rain before it enters the storage tank. The first flush water will be most contaminated by particulated matter, bird droppings, and other material laying on the roof (debris, dirt and dust). When the first rains arrive, it is essential to prevent this unwanted material to go into the storage tank. This can cause contamination of water collected in the storage tank thereby rendering it unfit for drinking and cooking purposes.

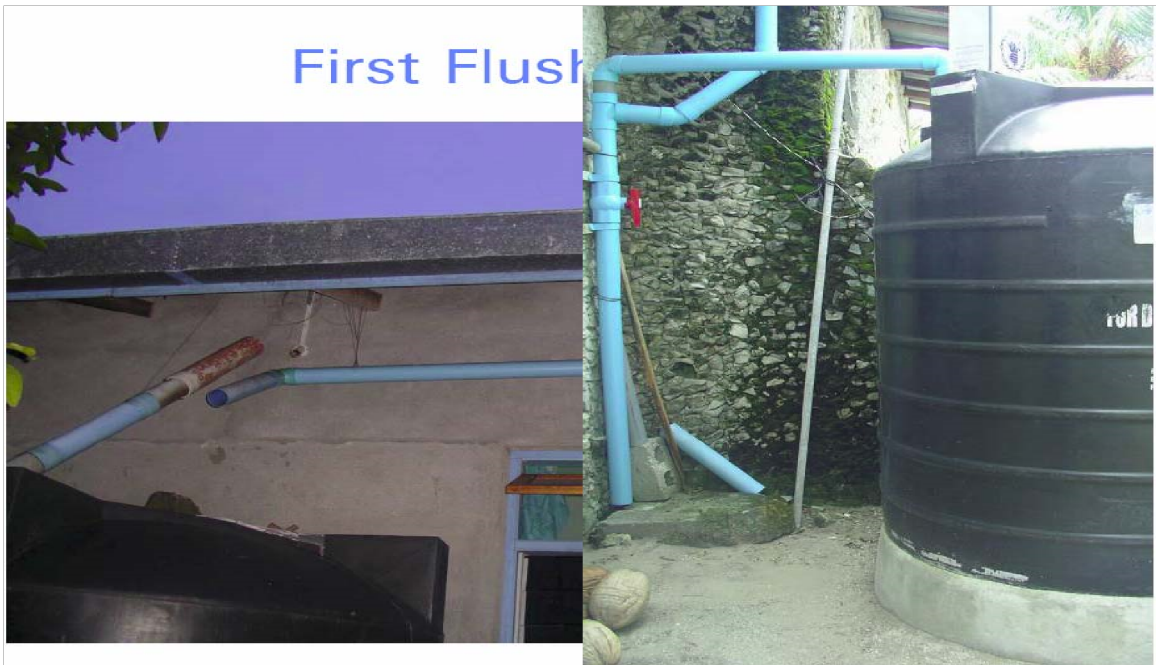
After screening gutters a first flush device is incorporated in the Rooftop Rainwater Harvesting Systems to dispose off the 'first flush' water so that it does not enter the tank.

This device will improve the quality of water lengthen the life of system components and reduce overall maintenance.

There are two such simple systems. One is based on a simple manually operated arrangement, where by, the down pipe is moved away from the tank inlet and replaced again once the first flush water has been disposed.

In another simple and semi-automatic system, a separate vertical pipe is fixed to the down pipe with a valve provided below the "T" junction. After the first rain is washed out through first flush pipe, the valve is closed to allow the water to enter the down pipe and reach the storage tank.

First flush diverters are fitted in most of the houses In Maldives. The diverter is manual type and operated during start of rainfall. Generally in islands people diverts the rain water in storage tank after they notice clear water starts coming from first flush diverters. The water from first flush diverters flow through their surface drainage and at some places it is diverted to well for groundwater recharge. Automatic first flush diverter is not seen in Maldives.



Filter Unit

The filter unit is a container or chamber filled with filter media such as coarse sand, charcoal, coconut fiber, pebbles and gravels to remove the debris and dirt from water that enters the tank. The container is provided with a perforated bottom to allow the passage of water. The filter unit is placed over the storage tank. Commonly used filters are of two types. One is a Ferro cement filter unit, which is comparatively heavy and the other is made of either aluminum or plastic bucket. The latter is readily available in market and has the advantage of ease in removing, cleaning and replacing.

Another simple way of filtering the debris and dust particles that came from the roof along with rainwater is to use a fine cloth as filter media. The cloth, in 2 or 3 layers, can be tied to the top of a bucket or vessel with perforations at the bottom.

SYSTEM COMPONENTS

Design of storage tanks

Storage tank is used to store the water that is collected form the Rooftops. In the rain water harvesting system storage tank is usually the most expensive part (almost 90 % of the total cost). It is therefore essential that careful design is made to provide optimal storage capacity while keeping the cost as low as possible. The design should be durable, watertight and cost effective. It should take in to consideration the appropriate volume with respect to the catchment area, rainfall conditions and water demand. Local materials, skills, cost, personal preferences and other external factors are other important considerations. Care should be taken to protect collected water from contamination.

The volume of the storage tank can be determined by knowing the water demand of a family as calculated above. Once the water demand is known, depending upon the requirement and affordability of family the storage tank or cistern can be decided. Important factors to incorporate into the design of a storage tank include adequate capacity; overflow protection; inclusion of a manhole for easy access and inspection. Tank size varies depending on the rainfall pattern and the water demand. When there are long dry spells, roof collection area and the tank size will be large but the wise use of water (good management) and use of alternative water for non drinking uses will significantly reduce the required roof area and the storage capacity.

There are an almost unlimited number of options for storing water. Common vessels used for very small-scale water storage in developing countries include plastic bowls and buckets, jerry cans, clay or ceramic jars, cement jars, old oil drums, empty food containers, etc. Some of the most popular tanks used in rainwater harvesting are High Density Poly Ethylene (HDPE) rainwater tanks. These tanks are most favored because of the various advantages they have. Firstly they can be used above the ground or can be kept even below the ground. They are very light in weight and easy to carry around. They are UV resistant and compared to other varieties, the HDPE tanks are less expensive. Fiberglass rainwater tanks are another popular type of rainwater storage tank. The biggest advantage they have is that they are resistant to rust and chemical corrosion. Fiberglass rainwater tanks can also withstand extreme temperatures.

The different types of materials used to construct rain water storage tank include Ferro cement, bricks and blocks, concrete, metals, plastic, wood and fiber glass. The Ferro cement tanks are usually constructed above ground level because of the advantages, such as,

a. ease in finding structural problems/leaks,

b. easy to maintain and clean and
c. easy to draw water. It is difficult to detect the leaks and take corrective measures in case of under ground tanks. Water from under ground tanks cannot be drawn by gravity. Some kind of manual or power lifting devices need to be used for drawing the water. Further, in coastal areas, under ground tanks are prone to water contamination due to fluctuation in groundwater table and leakage of stored water.

The storage tank is provided with a cover on the top to avoid the contamination of water from external sources. A lid covers the manhole avoiding exposure of stored water to the outside environment. The storage tank is provided with pipe fixtures at appropriate places to draw the water, to clean the tank and to dispose of the excess water. They are named tap or outlet, drainpipe and over flow pipe respectively. PVC or GI pipes of diameter 20 mm to 25 mm (¾ inch to 1 inch) are generally used for this purpose.

Open topped vessels such as buckets and drums are not recommended for collection of rain water for drinking purpose as contamination may easily enter in such open storage vessels. Storage tanks should be opaque to prevent the light to reduce algal growth. Also thinner walled tanks will tend to heat up in hot climate so if the tanks are not shaded, thicker walled Ferro cement or concrete is preferred.

Water storage tanks used in Maldives

Storage tanks and cisterns

For storing larger quantities of water, the system will require a tank or a cistern. The storage tanks are normally above-ground storage cistern are below-ground storage vessel. These can vary in size from one cubic meter or so (1000 liters) up to hundreds of cubic meters for large projects. The typical maximum size for a domestic system is 20 or 30 cubic meters. The choice of system will depend on a number of technical and economic considerations listed below.

- ✓ Space availability
- ✓ Options available locally
- ✓ Local traditions for water storage

- ✓ Cost of purchasing new tank
- ✓ Cost of materials and labour for construction
- ✓ Materials and skills available locally
- ✓ Ground conditions
- ✓ Use of RWH – whether the system will provide total or partial water supply

One of the main choices will be whether to use a tank or a cistern. Both tanks and cisterns have their advantages and disadvantages. Table below summarizes the pros and cons of each:

	Tank (above ground)	Cistern (under ground)
Pros	• Above ground structure allow easy inspection for leakages • Many existing designs to choos from • Can be easily purchased 'off-th shelf' • Can be manufactured from wide variety of materials • Easy to construct fro traditional materials • Water extraction can be b gravity in many cases • Can be raised above ground lev to increase water pressure	• Generally cheaper due to low material requirements • Not vulnerable to water loss by ta left open • Require little or no space abov ground • Unobtrusive • Surrounding ground gives suppo allowing lower wall thickness, ar thus lower costs • Water is cooler
Cons	• Require space • Generally more expensive • More easily damaged • Prone to attack from weather • Failure can be dangerous	• Water extraction is mo problematic, often requiring pump • Leaks are more difficult to detect • Contamination of the cistern fro groundwater is more common • Tree roots can damage th structure • There is danger to children ar small animals if the cistern is le uncovered • Flotation of the cistern may occur groundwater level is high and th cistern is empty. • Heavy vehicles driving over cistern can cause damage

Ferro cement tanks

Tanks of larger capacity can be made of Ferro cement, which are cheaper to construct than tanks made of masonry, block work, reinforced concrete etc, and do not require the rendering with waterproof cement mortar that masonry and block work often need.

Above ground level, tanks are constructed with a plain or reinforced concrete base, cylindrical walls of Ferro cement and a roof of Ferro cement, or sometimes mild steel sheeting.

The construction of Ferro cement walls is carried out by first assembling a cylindrical mesh of chicken wire and/or fence wire reinforcement, with or without the aid of formwork. On to this, a cement-rich mortar of 3:1 sand: cement is applied by trowel and built up in layers of about 15 mm to a finished thickness of between 30 to 100 mm, depending on wall height and tank diameter.

Thicker walls may have two layers of mesh. The mesh helps to control local cracking and the higher walls may call for the provision of small diameter vertical steel reinforcing bars for bending resistance.

Sometimes barbed fence wire is wound spirally up the wall to assist with resistance to ring tension and stress distribution.

Effective curing of the mortar between the trowelling of each layer is very important and affects the durability of the material and its resistance to cracking. Mortar should be still green when the next layer is placed.

This means that the time gap between layers should be between 12 and 24 hours. The finished material should then be cured continuously for up to 10 days under damp Hessian, or other sheeting.

A Ferro cement tank is easy to repair and, if the mortar has been properly applied and cured, should provide long service as a water-retaining structure at a fraction of the cost of a reinforced concrete structure.

Waste water collection pit:

A small pit is dug in the ground, beneath the tap of the storage tank and constructed in brick masonry to make a chamber, so that a vessel could be conveniently placed beneath the tap for collecting water from the storage tank. A small hole is left at the bottom of the chamber, to allow the excess water to drain-out without stagnation.
Size of collection pit shall be 60 cm x 60 cm x 60 cm.

A checklist for design

1. System components
   A typical rain water collection system for domestic use will consist of following key components
      a. Catchment area
      b. Conveyance system
      c. Storage tank

2. Design the appropriate roof for rain water collection
    a. Only the roof water should be collected for drinking and cooking purposes
    b. A flat roof with gentle slope will drain water towards the storage tank
    c. Provide clean and impervious roof made from non toxic materials
    d. Lead based paints should be avoided
    e. Sloping roof should have gutter (plastic or other available material) to collect water and channel it down to down pipe
    f. Roof should be neat and easy to clean when required
3. Conveyance system (Gutters and down pipes)
    a. Easy access for inspection and maintenance should be provided
    b. PVC pipes resistant to UV rays can be a best choice
    c. Sufficient gradient should be provided in the gutters for free flow to down pipes
    d. Provide course filter and first flush devices before the water enters the down pipe
4. Storage system
    a. Decide the location properly where to install storage tank (ground level or underground) and away from places of contamination like toilets, septic tanks etc
    b. Select the type of storage tank (HDPE or cement concrete or other)
    c. Provide an overflow pipe to direct the excess water to suitable place (may be another storage tank!)
    d. Wire mesh to cover storage tank inlet
    e. Provide a well covered manhole for easy access and inspection of the tank
    f. Provide tank tap or draw off pipe at sufficient height to draw water
    g. Storage area should be accessible for maintenance and repairs
    h. Storage tank must be impervious to light to prevent growth of algae and bacteria.

Methods to protect rainwater quality include appropriate system design, sound operation and maintenance and use of first flush devices and treatment. Treatment is mainly appropriate as a remedial action if contamination is expected. First flush devices can be effective in reducing levels of contamination if properly maintained. Good system design, operation and maintenance are generally the simplest and most effective means of protecting water quality.

Precautions

To protect the quality of rain water collected and to be used for drinking and cooking purposes, following precautions should be taken.

1. Catchment surface or the roof top should be impervious roof made from smooth, clean non-toxic material.
2. Roof surface should always be kept clean and free of debris. . Roof over which waterfalls should be cleaned before rain fall. Over hanging branches above the catchment surface should be removed
3. Rain water collection tanks should be designed to protect the water from contamination by leaves, dust, insects, vermin and other pollutants. The grill at the terrace outlet for rainwater arrests most of the debris carried by the water from the rooftop like leaves, plastic bags and paper pieces.
4. The suitable type of first flushing device to be installed and initial 10 to 15 minutes of runoff should be diverted.
5. The water collected from roof top only, should be stored in storage tank for direct use.
6. Tanks should preferably be sited away from the trees and with good fitting lid and kept in clean condition. Trim trees and brushes near the area to prevent animals from entering the storage tanks
7. In coming water to the storage tank should be filtered or screened and allowed to settle to take out foreign matter. A coarse filter and/or foul flush device should be fitted to intercept water before it enters the tank for removing leaves and other debris.
8. Taps or draw-off pipes on tanks should be at least five centimeters above the tank floor (more if debris accumulation rates are high). A tank floor sloping towards the sump can greatly aid tank cleaning.
9. No sunlight should enter the inside of tank otherwise algae will grow producing slime and smell. Keep water storage tanks shaded and use non-transparent tanks to prevent sunlight from fostering bacteria growth.
10. The area surrounding to the tank should be kept in good sanitary condition and entry of animals near the tank should be prevented (by fencing)
11. Keep children away from the storage tank area
12. Pools of water gathering around the storage tank should be drained away
13. Storage tanks should not allow any entry of insect inside the tank to prevent mosquito breeding and spread of Malaria and Dengue. Wire or nylon mesh should cover all inlets to prevent any insects and other creatures from entering the tank.
14. If the water is to be used for drinking, always use some type treatment system to deal with the potential bacteria.

Table showing possible routes of water contamination

No	Contaminant	Source	Prevention/Removal
1	Particulate matter (Dust and dirt)	Atmospheric pollution, blowing wind	Control of air pollution, first flush, regular cleaning
2	Dissolved gases and salts	Air pollution, sea spray and leaching of tank material	
3	Colour, odour and taste	Leaves, debris, bird	Flushing of tank before use

		dropping, paints, tank sediments	advised to avoid it
4	Heavy metals	Paint coating on roof, metal piping	
5	Bacteria and pathogen	Birds droppings, dead animals, falty handling c water, open tanks	
6	Mosquito larvae	Mosquitoes laying eggs in gutters and tanks	Cleaning of gutters and tank cover the tank opening with lid, avoid water spillage in surrounding areas.

Rain water and health

Good drinking water quality is essential for the health and well-being of all people. Criteria for safe drinking water quality warrants,

1. Water is clean and does not have bad smell or taste
2. Water has no chemicals or substances that would cause harm to the health
3. There are no bacteria or any other microorganisms that may cause water borne illnesses like diarrhea or typhoid etc.

To protect human health, water sources must be protected against contamination and the conveyance system should be maintained in a good condition.

Rain water collection systems are commonly believed to provide safe drinking water without treatment because the collection areas (roofs) are isolated from many of the usual sources of contamination (e. g. sanitation system).

Occurrence of pathogens is generally lower in rainwater than in unprotected surface waters and the presence of nonbacterial pathogens could be minimized. Higher microbial concentrations are generally found in the first flush of rain water and the level of contamination reduces as the rain continues. Apart from contamination, rainwater tanks which do not have adequate mosquito protection present a health risk of because the water provides a suitable habitat for mosquito breeding. Certain types of mosquitoes can be vector of arboviruses including dengue viruses. It is possible to treat water if mosquitoes are present but the best way is to prevent mosquitoes entering the tank.

Rain waters are very low in dissolved minerals but slightly acidic as it dissolves carbon dioxide rendering it relatively aggressive. Rain water can dissolve heavy metals and other impurities from materials of catchment and storage tank. Normally, chemical concentrations in rain water are within acceptable limits, however possibility of zinc and lead leaching from metallic roofs and storage tanks can not be ruled out.

Rain water lacks minerals like calcium, magnesium, iron and fluoride, which are considered essential for health. However most of them are derived from food.

Mosquito breeding

Mosquito breeding in roof water harvesting systems has been associated with reported outbreaks of malaria and dengue in several locations. However, storage systems have usually been described as poorly designed and maintained, particularly in the case of unscreened and open-topped tanks. Gutters are also quoted as an important breeding site, particularly if they are incorrectly installed or installed with a low gradient so they do not drain properly, allowing water to pool in the gutter and/or debris to build-up. The 'out of sight out of mind' nature of many parts of a rainwater catchment system is seen as a particular problem. Many parts of the systems are above eye-level and do not receive the attention they need – gutters are not cleaned and screens and covers are not checked regularly. Even a well screened tank will often allow insects to enter, mainly as "tight fitting lids" tend not to be as tight fitting as they appear. It is not uncommon to find adult mosquitoes in rainwater tanks. Mosquito eggs are also found as they can be laid by the adult directly in the tank or in the gutters and then washed into the tank with the next rains. A fair proportion of these eggs will hatch out to become larvae, which present an aesthetic problem. However, the main issue from a public health viewpoint is whether adult mosquitoes emerge from tanks and represent an increase in the total population. Mosquito larvae go through four stages before they pupate and emerge as adults. Larvae eat bacteria and protozoan but these organisms are rare in well designed rainwater tanks that don't allow the entry of light. Laboratory studies have found that in the absence of nutrients, larvae don't develop beyond the third stage and therefore adult mosquitoes don't develop under those conditions. RWH systems are also reported to be only a fraction of the available breeding sites for mosquitoes and so should be considered as a part of a larger effort to mitigate their breeding.

Protection of rainwater quality

Quality of rainwater assumes greater importance when it is to be used for drinking purposes including cooking and washing hands. If this water has to be used directly for drinking purpose, then quality of water must be ascertained before use. The water used for drinking should comply with the provisions of guidelines for drinking water quality.

The best initial step to protecting water quality is to ensure good system design. Water quality will generally improve during storage provided sunlight and living organisms are excluded from the tank and fresh inflows do not stir up any sediment. The steps suggested in Table on previous page be followed while designing the system.

Proper operation and maintenance of rainwater harvesting systems helps to protect water quality in several ways. Regular inspection and cleaning of catchment, gutters, filters and tanks reduce the likelihood of contamination. Water from other sources should not be mixed with that in the tank.

Treatment: Treatment of stored rainwater only makes sense if it is done properly and if hygienic collection and use of the water will ensure it does not suffer from recontamination

Water Treatment

The cleanliness of the roof in a rainwater harvesting system most directly affects the quality of collected water. The cleaner the roof and other parts of the system (gutters, pipes and storage tank), less treatment is required. We have seen above in protecting the water quality that removal of hanging tree branches, preventing access of rodents, lizards and other small animals, selection of proper materials (roofs, pipes storage tanks) and paints can help to protect the quality and avoid treatment. For keeping the water quality potable, a plain galvanized roof or a metal roof with epoxy or latex paints and not asphalt paints are recommended.

There are several types of treatment possible, the most common being chlorination, boiling, filtration and exposure to ultraviolet or natural sunlight.

Chlorination

Chlorination is most appropriately used to treat rainwater if contamination is suspected due to the rainwater being coloured or smelling bad. It should only be done if the rainwater is the sole source of supply and the tank should first be thoroughly inspected to try to ascertain the cause of any contamination.

Chlorination is done with stabilised bleaching powder (calcium hypochlorite - $CaOCl_2$) which is a mixture of chlorine and lime. Chlorination can kill all types of bacteria and make water safe for drinking purposes. About 1 gm (approximately 1/4 tea spoon) of bleaching powder is sufficient to treat 200 litres of water.

Chlorine tablets

Chlorine tablets are easily available in the market. One tablet of 0.5 g is enough to disinfect 20 litres (a bucketful) of water.

Boiling

Boiling is a very effective method of purification and very simple to carry out. Boiling water for 10 to 20 minutes is enough to remove all biological contaminants.

Direct sunlight

This can also be used to kill many of the harmful bacteria in water by exposing it in clear glass or plastic bottles for several hours. Although feasible in some circumstances, the water must be clear, the weather fine and the water cooled overnight before

consumption.

UV Radiation

Ultra violet (UV) light can be used to kill bacteria, viruses and cysts by exposure to UV light. Turbidity or the suspended particles in water should be removed before treatment otherwise pathogens can hide in the particles and the treatment will not be effective. UV lights do not leave any residue or bye product so problem of smell or taste like chlorine can be eliminated. They use minimum power for operation. The operation manual will be provided by the manufacturer.

Treatment Method	**Place or location**	**Result/ removal impurity**
Pruning of hangi tree branches	Over the rooftop	Prevents leaves and bir droppings
Leaf screens strainers	Gutters and down pipes	Prevent leaves and oth debris from entering the ta
First flush diverte	Before the storage tank, the down pipe	Reduces particulate a suspended matter
Filtering	Inlet of tank	Retains small impurities
Settling	Within tank before tap	Settles out particulate or
		suspended matters
Disinfection	Before water use	Kills microorganisms
Activated charcoa	After chlorination or befo water use	Removes excess chlorine a odour or colour
Cleaning of tanks remove botto sediments	Storage tank	Elimination of turbidity a odour etc.
Care in handli water while use	At household level	Prevents human bor contamination of water

Operation and Maintenance

Rainwater harvesting systems require minimal attention with respect to their operation. Maintenance is generally limited to the annual cleaning of the tank and regular inspection of the gutters and down pipes. Maintenance typically consists of the removal of the removal of dirt, leaves and other accumulated material. Such cleaning should take place annually before the start of the rainy season. However cracks in storage tank can create major problems and should be repaired immediately. Additional care is required to protect the structures from damage and contamination by people and animals. The O & M serves two purposes: to provide good quality of water by protecting it from contamination and keeping the system in good working condition.

Contamination of water as a result of contact with certain materials can be avoided by using appropriate materials during construction, or selecting tanks made from acceptable materials. The major concern is to prevent the entry of contaminants into the

tank while it is being replenished during a rainstorm. Bacterial contamination can be minimized by keeping the rooftop surfaces and drains clean. The main causes of bacterial pollution are from debris, bird and animal droppings, and insects that enter the tank. The following maintenance guidelines should be considered in the operation of rainwater harvesting systems:

A procedure for eliminating the "foul flush" after a long dry spell deserves particular attention. The first part of each rainfall should be diverted from the storage tank since this is most likely to contain undesirable materials which have accumulated on the roof and other surfaces between rainfalls. Generally, water captured during the first 10 minutes of rainfall during an event of average intensity is unfit for drinking purposes. The quantity of water lost by diverting this runoff is usually about 14L /m2 of catchment area.

The storage tank should be checked and cleaned periodically. All tanks need cleaning; their designs should allow for this. Cleaning procedures consist of thorough scrubbing of the inner walls and floors. Use of chlorine solution is recommended for cleaning, followed by thorough rinsing.

Care should be taken to keep rainfall collection surfaces covered, to reduce the likelihood of rodents, lizards, mosquitoes, and other pests using the cistern as a breeding ground. Residents may prefer to take care to prevent such problems rather than have to take corrective actions, such as treating or removing water, at a later time.
Disinfection of the cisterns or storage tanks is necessary if the water is found to be contaminated (impart smell or growth of algae etc).

Gutters and down pipes need to be periodically inspected and cleaned carefully. Periodic maintenance must also be carried out on any pumps used to lift water to selected areas in the house or building. More often than not, maintenance is done only when equipment breaks down.

Community systems require the creation of a community organization to maintain them effectively. Similarly, households must establish a maintenance routine that will be carried out by family members.

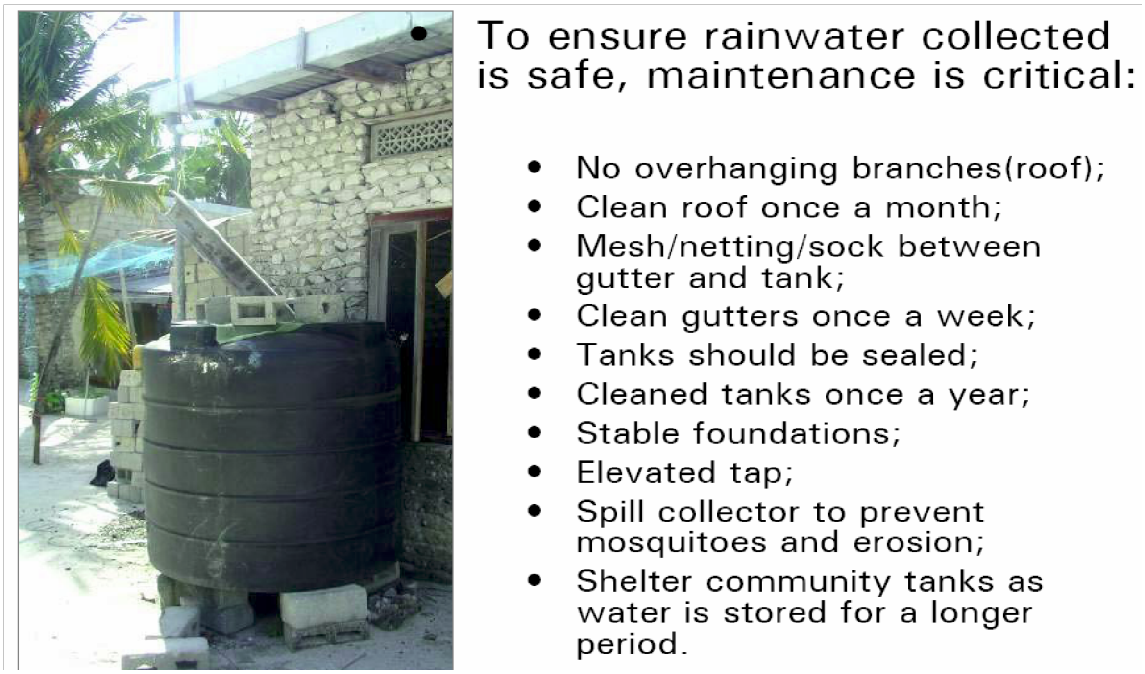
Maintaining water quality at a level where health risks are minimized. In many systems, this involves chlorination of the supplies at frequent intervals.

Problems usually encountered in maintaining the system at an efficient level include the lack of availability of chemicals required for appropriate treatment and the lack of adequate funding.

Community systems require community involvement and organisation for effective maintenance, while household systems require a correspondingly smaller scale involvement by residents. In some cases, where the water is pumped, periodic, preventive maintenance is required on the small pumps that lift water to selected areas of a house or building, or provide public supply from underground storage tanks.

Additional requirements for ground catchments include fencing the paved catchment to keep out trespassing animals that can affect water quality, cleaning the paved catchment of leaves and other debris, and repairing large cracks in the paved catchment that result from soil movements, earthquakes, and/or exposure to the elements

Problems commonly encountered in maintaining the system at an efficient operating level are the lack of availability of chemicals required for appropriate treatment and the lack of adequate funding.



Source: UNICEF

Part	**Maintenance**	**Frequency**
Roof	Wash off roof with wat when dust /di accumulates diverti wash off away from tar inlet	Monthly and especial after a long period of d weather or heavy wind
	Sweep off leaf litter	Regularly and especial after heavy winds and ju before the rains set in.
	Trim and cut trees arour roof	When required
	Repair damages to ro (broken tiles or cracke water proofing etc)	At the earliest and befo the rainy season
	Paint using lead fr paints	If the rust is four present

Gutters and down pipes	Clean and wash out bi droppings, leaves etc wi water	Check monthly ar especially after a lor period of dry weather heavy wind. Check dai during rainy period
	Ensure proper slope gutters and down pip for steady flow	During installation ar after heavy rains
	Repair leaks in gutter down pipes and elbows	When required
Filters	Clean filters	Before and after rai season
First flush device	Check and clean	Before and after the rai season and after eve roof top cleaning
Tank	Clean	Before and after rai season
	Repair leaks	As required but at th earliest
	Cut nearby tree roots	If underground tank
	Ensure lid is sturdy ar secure	At all times
	Ensure there are no ga where insects can enter	At all times
	Secure fasten inse screen over the end overflow pipe	At all times

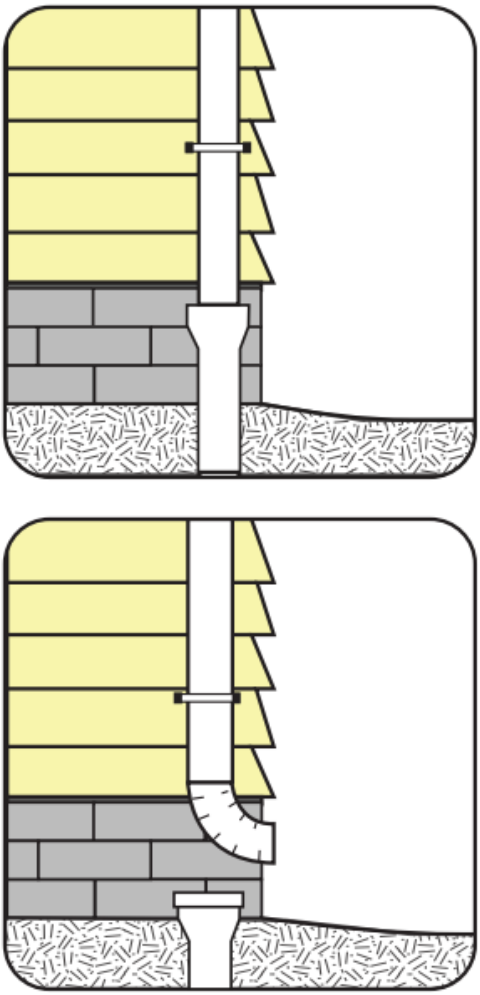
Checklist

1. Keep the roof catchment clean
2. Cut tree branches that overhang the roofs
3. Use an installed first flush (or foul flush) device,
4. Conduct regular inspection and cleaning of gutters
5. Clean gutters, down pipes and first flush devices
6. Monitor tank levels
7. Check and clean the storage tank periodically
8. Cover and ventilate the tank
9. Repair leaks
10. Provide water treatment as necessary
11. Avoid stagnation of water on the roof, in the gutters and near storage tank
12. Change filters regularly
13. Perform disinfection of water (if required)
14. Get tested water quality periodically
15. Adopt efficient water use practices

PLUMBING TASKS

Rainwater is usually conveyed from the catchment area to cisterns or rain barrels by gutters connected to downspouts. It is important to avoid joint seams in a gutter system, because they can catch debris and promote the growth of bacteria and algae. For this reason, a half round gutter is better than a square one, which is more likely to catch debris. Gutters should have an outer edge higher than the roof-side edge, have splash guards at roof valleys, and slope towards downspouts. Seamless gutters should slope at approximately one-sixteenth inch per 10-foot length of gutter, and all gutters should be installed in accordance with the manufacturer's guidelines for hangers and connection points (approximately one bracket every 30 inches).

If replacing your gutters, consider using full length gutter screens. For screens to continue to be effective, they must be cleaned regularly. An established cleaning regimen will prevent debris build up, which can be a fire hazard, act as a growing medium for bacteria, and/or block water from entering the gutter.



Downspouts convey water from gutters to the storage tank. The number of downspouts needed depends on the surface area of the roof and intensity of rainfall. As a general rule, a 3- to 4-inch downspout accommodates about 1,200 square feet of roof area. Angles in the downspout pipe should not exceed 45 degrees to reduce the likelihood of debris accumulating in the angles and blocking rainwater flows. Downspouts can be fitted with filtration devices such as rain heads and leaf eaters, which exclude leaves and debris. Downspouts are the most common means of moving water from a raised surface to a storage facility.

Downspout Disconnection and Tie-ins

Most downspouts connect directly to the sewer system and may need to be disconnected to allow for rainwater harvesting. If necessary, downspouts should be disconnected high enough above the cistern or rain barrel so that an elbow and additional pipe section can be added and still allow the rainwater to flow downward by gravity to the storage tank. The lower section of the downspout should be cut near the ground surface and sealed with a cast iron pipe cap with a no-hub band to prevent sewer gases from escaping or sewage backing up and overflowing through the cut pipe. Some downspouts are on the street-side of the building with no ready route to the backyard. Others are located inside

a building's walls. These situations require site-specific solutions and often consultation with a plumbing professional. Here are some possible scenarios and solutions:

- ✓ Buildings with garages below street grade often have the downspout connecting to sewer laterals on the ceiling of the garage. Downspout(s) can be disconnected there and routed to the desired location. A downward slope from downspout to tank is required so that water does not back up into the downspout.
- ✓ If a downspout is within a building's wall but near the location of the storage tank, the wall can be opened to access the pipe. (If the pipe is in an interior wall, disconnection is less feasible because of increased cost and potential disruption to the building.) This option should be discussed with a professional plumber to identify the most appropriate and cost-effective solution and to minimize the amount of reconstruction necessary.
- ✓ If a downspout is located within a building's wall and in an inaccessible location, it might be possible to cap the top of the downspout at roof level and redirect rainwater to a new downspout.

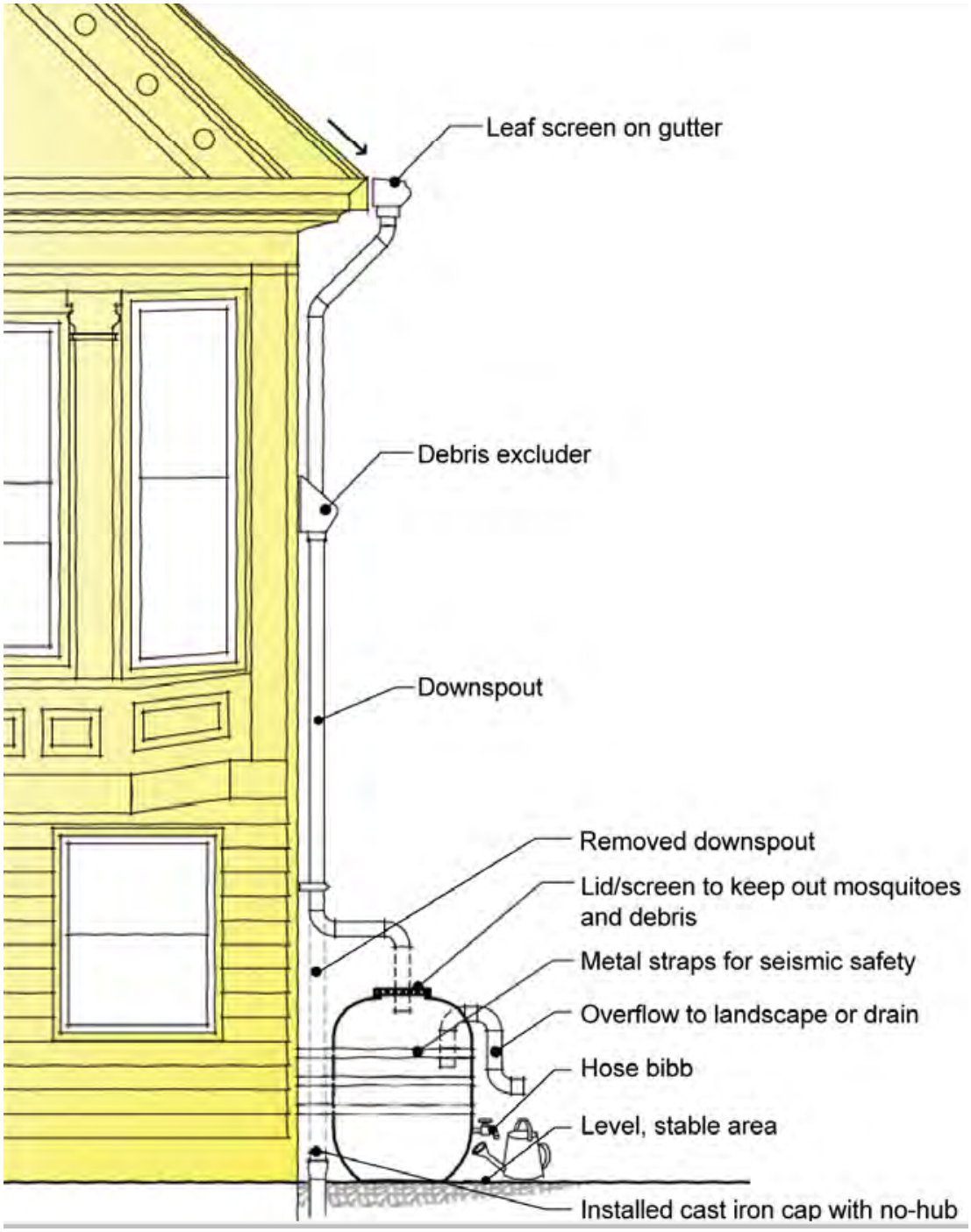
Debris Removal

As rainwater travels across a catchment surface, it can pick up leaves and debris. Common devices for debris removal include screens on gutters, debris excluders on downspouts and first-flush diverters on the downspout connection. Water quality and minimum treatment depend on the end use of the collected rainwater. Debris excluders or similar devices will prevent the accumulation of leaves, needles, and other debris from entering the storage tank. In addition to larger debris, rainwater can dissolve or pick up materials too fine for the screens to filter out. To catch these pollutants, the first portion of rainwater from any rain event that flows off the catchment area should be diverted, or "flushed," from the storage tank. This "first-flush" of water, which carries the highest concentration of dust, pollen, animal feces, pesticides and/or other airborne residues, should be diverted from the storage tank to ensure higher quality water enters the tank.

Many types of first-flush diverters are readily available; all must be installed "upstream" of the storage tank. The simplest first-flush diverter consists of a PVC standpipe connected to a downspout. The standpipe acts as a storage device to collect the initial rainwater runoff; after it fills up, cleaner rainwater flows into the storage tank.

A ball-valve first-flush system is a common system that is similar to a standpipe first-flush system except it has a floating ball that seals off the top of the diverter pipe when the pipe is full, allowing clean water to move into the storage tank. More refined first-flush systems can include removable filter inserts that provide additional filtration.

Rain head and First flush diverter



PREPARE DOCUMENTATION

Documentation plays a crucial role in any treatment setting. Documentation helps assure continuity of care. There are many important moments in treatment. Proper documentation can help the practitioner to recall those moments. Behaviors and emotions can help tell a story; being able to discover patterns can help to uncover reasons for certain behavior. Documentation is a very simple tool to help any practitioner is unveiling patterns. It can help track the progress in addressing thought patterns and unhealthy behaviors. If a practitioner isn't utilizing the tool of documentation it would

prove to be very difficult to make continual progress on any one area, let alone multiple areas.

In every field, it's important to minimize as much risk as possible. Documentation is a great tool in protecting against lawsuits and complaints. Documentation help ensure consent and expectations. It helps to tell the narrative for decisions made, and how yourself or the client responded to different situations. In this same manor, it is important to record information that can help support the proper treatment plan and the reasoning for such services. There are many legal and regulatory requirements in this field, and proper documentation helps to maintain compliance. If documentation isn't up to par it could affect licenses and or accreditation. It would be difficult to defend or explain one's actions to a licensing board without the supporting documentation.

Documentation is one of the most vital parts in the course of treatment. It has a vast multitude of purposes. It assures the quality of services rendered, the continuity of care, and protections for the client, as well as the practitioner. It maintains compliance for legal and accreditation purposes. It helps to direct the course of treatments as well the ability to afford such treatments. Documentation plays so and integral part in any practitioner's process, it would wise to maximize the usefulness of documentation. Documentation is so important in any treatment process; the lack of documentation not only may seem negligible but could quite possible be deemed negligible. It is impossible to plan a course of treatment without proper documentation. It would be able to measure the growth or progress in treatment without solid documentation. It's unfair to the client, your team members, and any future practitioners.

18.REFERENCE

REFERENCES

1. https://images.template.net/wp-content/uploads/2015/08/Writing-a-Project-Proposal-PDF1.pdf
2. https://www.fool.com/the-blueprint/project-proposal/
3. http://www.distance.vic.edu.au/wp-content/uploads/2015/09/HELPSHEET-The-Research-Process.pdf
4. https://www2.hawaii.edu/~halina/ExpDesWk/ResSteps.pdf
5. https://samples.jbpub.com/9781449627843/Chapter1.pdf
6. https://onlinepubs.trb.org/onlinepubs/nchrp/cd-22/manual/v1appendixb.pdf
7. https://www.tpp.ac.nz/assets/Uploads/Report-Writing.pdf
8. https://grimsby.ac.uk/documents/highereducation/skills/Structure-of-Reports-Learnhigher.pdf
9. https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_687610.pdf
10. https://www.cancerwa.asn.au/resources/2011-12-01-How-to-Manage-Work-Health-and-Safety-Risks.pdf
11. https://rambolevy11.files.wordpress.com/2014/11/initiate-computer-system-1.pdf
12. https://towardsdatascience.com/data-types-in-statistics-347e152e8bee
13. https://www.iimdirect.com/blog/data-entry/7-steps-data-entry-system-implementation/
14. https://www.wgtn.ac.nz/lals/research/projects/language-in-the-playground-project/publications/lip5.pdf
15. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC88200/kg301514_120p_e3%20(2)_01.07.2013.pdf
16. http://www.ijnglt.com/files/Vol%202%20Issue%201/Kiran%20Prakash.pdf
17. https://fitforwork.org/blog/maintenance-of-equipment-in-the-workplace/
18. https://extranet.who.int/lqsi/sites/default/files/attachedfiles/LQMS%203-4%20Equipment%20maintenance%20programme.pdf
19. https://ncert.nic.in/textbook/pdf/kect107.pdf
20. https://hvacr.vn/diendan/resources/so-tay-xu-ly-nuoc-mathematics-manual-for-water-and-wastewater-treatment-plant-operators-2014.67/download?version=71
21. https://ocw.mit.edu/courses/mechanical-engineering/2-007-design-and-manufacturing-i-spring-2009/related-resources/drawing_and_sketching/
22. http://www.minddecider.com/Articles.Tasks_management.htm
23. https://www.thespruce.com/how-to-create-a-daily-routine-2648007

24. https://www.siteware.co/en/strategic-management/what-is-work-routine-management/
25. http://www.sciencebits.com/vector_algebra#:~:text=Scalars%3A%20Scalars%20are%20mathematical%20entities,a%20magnitude%20and%20a%20direction.&text=Physical%20examples%20include%20forces%2C%20velocities%2C%20momenta%20and%20locations
26. https://www.csus.edu/indiv/m/mackj/chem142/kinetics.pdf
27. https://www.physicsclassroom.com/class/circles/Lesson-1/Mathematics-of-Circular-Motion
28. https://www.physicsclassroom.com/class/newtlaws/Lesson-2/The-Meaning-of-Force
29. https://byjus.com/physics/law-of-conservation-of-energy/
30. https://www.physicsclassroom.com/class/momentum/Lesson-1/Momentum
31. https://www.physicsclassroom.com/class/waves
32. https://ncert.nic.in/ncerts/l/kech105.pdf
33. https://www.wilhelmsen.com/globalassets/marine-products/welding/documents/wilhelmsen-ships-service---unitor-welding-handbook.pdf
34. https://welderportal.com/welding-tools-and-their-uses/
35. https://local.ecollege.ie/Content/APPRENTICE/liu/pipefitting/pdf/M3_U5_Pipe%20Joining.pdf
36. https://www.ccohs.ca/oshanswers/hsprograms/house.html
37. https://www.marleyplumbinganddrainage.com/media/1190/soil-waste-design-installation-manual.pdf
38. https://ccc.govt.nz/assets/Documents/Consents-and-Licences/construction-requirements/approved-contractors/Trench-Support-Best-Practice-Guideline-2-February-2017.pdf
39. https://www.cedd.gov.hk/filemanager/eng/content_435/trench_excavations.pdf
40. https://www.emerson.com/documents/automation/control-valve-handbook-en-3661206.pdf
41. http://www.festo-didactic.com/didactic/Demos/Pneumatik/data/1017/misc/aktoren_und_ausgabegeraete-en.pdf
42. https://www.meprogram.com.au/wp-content/uploads/2018/03/MFE3004AdditionalPT5.pdf

43. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Procurement/Corporate-Procurement/Lot_3i_-_ADB-ITB-MZFO-2016-0109_-_Fire__Security_Project_Description_MZFO.pdf
44. https://www.ifsta.org/sites/default/files/Chapter14_FICE8.pdf
45. https://www.dmme.virginia.gov/de/LinkDocuments/HandbookWaterHeating.pdf
46. https://www.nrel.gov/docs/fy01osti/26465.pdf
47. https://www.waterheaterleakinginfo.com/electric-water-heater-installation/
48. https://www.who.int/water_sanitation_health/hygiene/plumbing15.pdf
49. http://siglercommercial.com/wp-content/uploads/2017/10/02-Chilled-Water-Piping-Pumps.pdf
50. https://www.waterworld.com/home/article/14070974/pump-maintenance-101
51. https://swab.zlibcdn.com/dtoken/39b0d97d53a66cbbf6d795f561a55322
52. https://bunker2.zlibcdn.com/dtoken/1973341ab17354399b72a3d4d9550855
53. http://www.fieldandcivilengineering.co.uk/prepare-drainage-construction/
54. https://www.researchgate.net/publication/325189144_Discussion_on_construction_methods_and_precautions_of_building_water_supply_and_drainage
55. https://www.teagasc.ie/media/website/animals/dairy/DesignInstallationDrainageSystem.pdf
56. http://riograndewater.org/media/1071/b-6229-understanding-and-installing-drainage-systems.pdf
57. https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_192256.pdf
58. https://www.legislation.gov.au/Details/F2016L00394
59. https://www.superiorgroundcover.com/install-a-foundation-drainage-system/
60. https://www.water.org.uk/wp-content/uploads/2019/03/Appendix-C-to-draft-sewerage-Sector-Guidance-Design-and-Construction-Guidance.pdf
61. https://continuingeducation.bnpmedia.com/courses/bk-lighting/best-practices-for-site-preparation-and-installation-of-ingrade-fixtures/2/
62. https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=32418.wba
63. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=21


PLUMBING